Technical Information

SUNNY TRIPOWER 12000TL-US / 15000TL-US / 20000TL-US / 24000TL-US / 30000TL-US

Grid Support Utility Interactive Inverters

ENGLISH

STPTL-US-GridServices-US-TI-en-13 | Version 1.3

Table of Contents

1 Grid Support Utility Interactive Inverters

1.1 Content and Structure of this Document

In this document, the advanced inverter functions (see Section 1.2, page 3) as well as the SMA inverters equipped with these functions (see Section 1.3, page 3) are presented in accordance with the current UL 1741 SA "Grid Support Utility Interactive Inverters and Converters".

In addition, the advanced inverter functions are presented in detail (see Section 2, page 4). The following structure is being used:

- Function description in accordance with UL 1741 SA "Grid Support Utility Interactive Inverters and Converters" with the most important key values
- Implementation of the individual functions with SMA invertes via Speedwire/Webconnect parameters or Modbus registers (SMA Modbus or SunSpec Modbus)
- Maximum value tested
- Minimum value tested
- Value tested according to CPUC Rule 21 or tested average

Depending on the product, the functions can be configured via the user interface of the inverter or a communication product (e.g. SMA Cluster Controller). Depending on the availability, the configuration can also be performed using SMA Modbus or SunSpec Modbus. Information on how to change operating parameter can be found in the respective documentation at www.SMA-Solar.com.

1.2 Advanced Functionality of SMA Inverters

Inverters convert direct current into grid-compliant alternating current. If the grid voltage or grid frequency exceeds the thresholds specified by the grid operator, the grid-tied inverters must stop to feed in alternating current and disconnect from the utility grid in accordance with local standards and directives.

Inverters are also able to modulate their output power to support the utility grid interactively. Inverters react to changes in the utility grid by varying their power factor for example or by achieving an improved grid stability using other grid management services.

With the growth of the PV industry and a rising proportion of PV power in allover power generation, it becomes increasingly important that PV inverters make a significant contribution to improved grid stability and grid services. The prerequisite for this is the smart grid interconnection of PV inverters with an advanced inverter function to the grid in accordance with the current UL 1741 SA "Grid Support Utility Interactive Inverters and Converters".

1.3 Interactive SMA Inverters

The following SMA inverters feature from firmware version 02.83.03.R advanced inverter functions in accordance with the current UL 1741 SA "Grid Support Utility Interactive Inverters and Converters":

- STP 12000TL-US-10 (Sunny Tripower 12000TL-US)
- STP 15000TL-US-10 (Sunny Tripower 15000TL-US)
- STP 20000TL-US-10 (Sunny Tripower 20000TL-US)
- STP 24000TL-US-10 (Sunny Tripower 24000TL-US)
- STP 30000TL-US-10 (Sunny Tripower 30000TL-US)

2 Function Description

2.1 Islanding Detection "Anti Islanding"

The islanding detection function detects the formation of unwanted electrical islands and disconnects the inverter from the utility grid. Unwanted islanding can occur when at the time of utility grid failure, the load in the shut-down sub-grid is roughly equivalent to the current feed-in power of the PV system or battery storage system. With active islanding detection, the inverter continuously checks the stability of the utility grid. If the utility grid is intact, this has no impact on the utility grid and the inverter continues to feed in. Only if an unwanted electrical island has formed will the inverter disconnect from the utility grid.

The islanding detection function is activated by default.

2.2 Grid Support Depending on Grid Voltage "Low/High Voltage Ride-Through"

Three thresholds for minimum grid voltage and two thresholds for maximum grid voltage are defined in accordance with UL 1741 SA during grid support depending on the grid voltage "Low/High Voltage Ride-Through (L/H VRT)". Each maximum threshold may be exceeded and each minimum threshold may be undershot for a certain time. The permitted overvoltage and undervoltage ranges are derived from these thresholds and time frames.

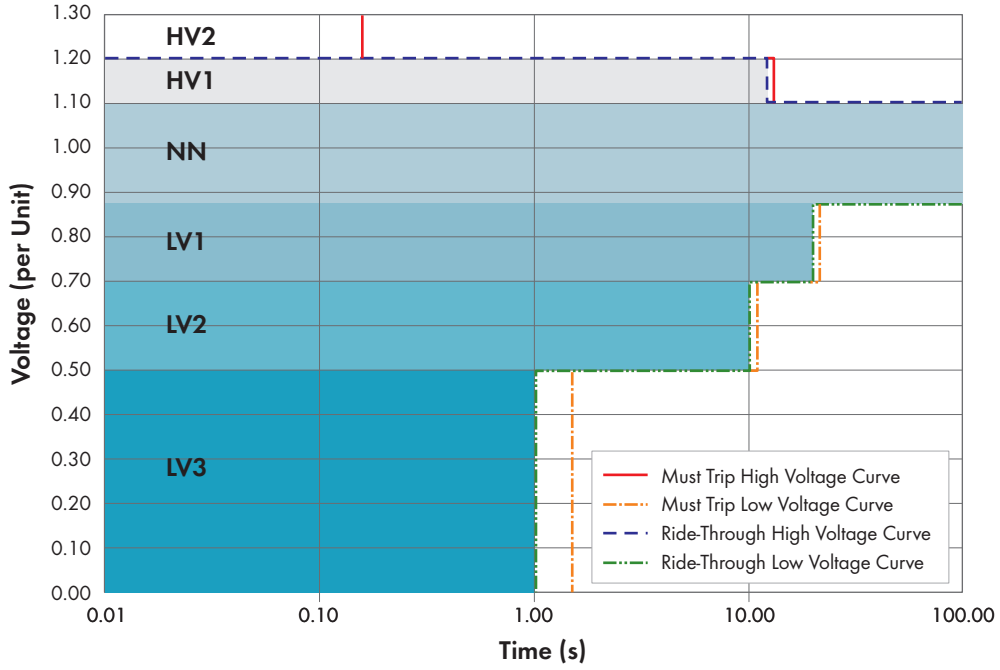

Figure 1: Overvoltage and undervoltage ranges for grid support in accordance with the "Low/High Voltage Ride-Through"

Designation	Description
Voltage (per unit)	Nominal voltage of the connected inverter
Must Trip High Voltage	This curve specifies the thresholds within which the shutdown process of the inverter must be completed when permitted voltage values are exceeded.
Must Trip Low Voltage	This curve specifies the thresholds within which the shutdown process of the inverter must be completed when permitted voltage values are undershot.

Designation	Description
Ride-Through High Voltage	In the operating mode "Mandatory Operation", this curve specifies how long the inverter must continue feeding in when permitted voltage values are exceeded. In the operating mode "Momentary Cessation", this curve specifies how much time the inverter has to reduce its output power to zero when permitted voltage values are exceeded.
Ride-Through Low Voltage	In the operating mode "Mandatory Operation", this curve specifies how long the inverter must continue feeding in when permitted voltage values are undershot. In the operating mode "Momentary Cessation", this curve specifies how much time the inverter has to reduce its output power to zero when permitted voltage values are undershot.
HV	Overvoltage range
NN	Range around nominal grid voltage
LV	Undervoltage range

The inverter continuously checks the grid voltage. The inverter reacts to non-permitted overvoltages and undervoltages in accordance with the set operating mode:

- Operating mode "Mandatory Operation"

  In the operating mode "Mandatory Operation", the inverter continues to feed in up to a set point in time (Ride Through) and then starts the shutdown process. The operating mode "Mandatory Operation" is always active. You can configure the thresholds of the overvoltage or undervoltage ranges via the parameters listed in the corresponding table.

- Operating mode "Momentary Cessation"

  In the operating mode "Momentary Cessation", the inverter reduces its output power to zero up to a set point in time (Ride Through) and then starts the shutdown process. The operating mode "Momentary Cessation" is always active. You can configure the thresholds for one overvoltage and one undervoltage range via the parameters listed in the corresponding table. When the grid voltage is outside the specified voltage range, the inverter operates in "Mandatory Operation" mode.

The time within which the shutdown process must be completed is saved in the inverter via an adjustable parameter defining the time interval before the latest possible shutdown time (Must Trip).

Overview of Settings for the Operating Mode "Mandatory Operation"

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum	Rule 21
Overvoltage range HV1	Voltage monitoring lower maximum threshold	40452	cannot be controlled via SunSpec Modbus	100% Vnom	120% Vnom	110% Vnom
	Voltage monitoring lower max. threshold trip. time	40456		100 ms	60000 ms	13000 ms

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum	Rule 21
Overvoltage range HV2	Voltage monitoring median maximum threshold	40448	cannot be controlled via SunSpec Modbus	100% Vnom	120% Vnom	120% Vnom
	Voltage monitoring median max. threshold trip.time	40450		100 ms	59000 ms	160 ms
Additional overvoltage range*	Voltage monitoring of upper maximum threshold as RMS value	41115	cannot be controlled via SunSpec Modbus	100% Vnom	120% Vnom	–
	Voltage monitoring of upper max. thresh. as RMS value for tripping time	41117		100 ms	59000 ms	–
Undervoltage range LV1	Voltage monitoring lower minimum threshold	40458	cannot be controlled via SunSpec Modbus	45.00% Vnom	100% Vnom	88% Vnom
	Voltage monitoring lower min. threshold trip. time	40462		100 ms	60000 ms	21000 ms
Undervoltage range LV2	Voltage monitoring of median minimum threshold	40464	cannot be controlled via SunSpec Modbus	45.00% Vnom	100% Vnom	70% Vnom
	Voltage monitoring median min. threshold trip.time	40466		100 ms	60000 ms	11000 ms
Undervoltage range LV3	Voltage monitoring of lower minimum threshold as RMS value	41111	cannot be controlled via SunSpec Modbus	45.00% Vnom	100% Vnom	50% Vnom
	Voltage monitoring of lower min.threshold as RMS value for tripping time	41113		100 ms	60000 ms	1500 ms

* The additional overvoltage range is not required in accordance with UL 1741 SA. However, it can be optionally set.

Overview of Additional Settings for the Operating Mode "Momentary Cessation"

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum	Rule 21
Overvoltage range HV	PWM inverse voltage, dynamic grid support configuration for PM overvoltage	cannot be controlled via SMA Modbus	cannot be controlled via SunSpec Modbus	100% Vnom	120% Vnom	110% Vnom
	PWM inversion delay, dynamic grid support configuration for PM overvoltage	cannot be controlled via SMA Modbus				
Undervoltage range LV	PWM inverse voltage, dynamic grid support configuration	40256	40483	45.00% Vnom	100% Vnom	50% Vnom
	PWM inversion delay, dynamic grid support configuration	40258	40485			

2.3 Grid Support Depending on Power Frequency "Low/High Frequency Ride-Through"

Two thresholds both for minimum power frequency and maximum power frequency are defined in accordance with UL 1741 SA during grid support in dependence of the power frequency "Low/High Frequency Ride-Through (L/H FRT)". Each maximum threshold may be exceeded and each minimum threshold may be undershot for a certain time. The permitted ranges for exceeding or falling below the set frequency are derived from these thresholds and time frames.

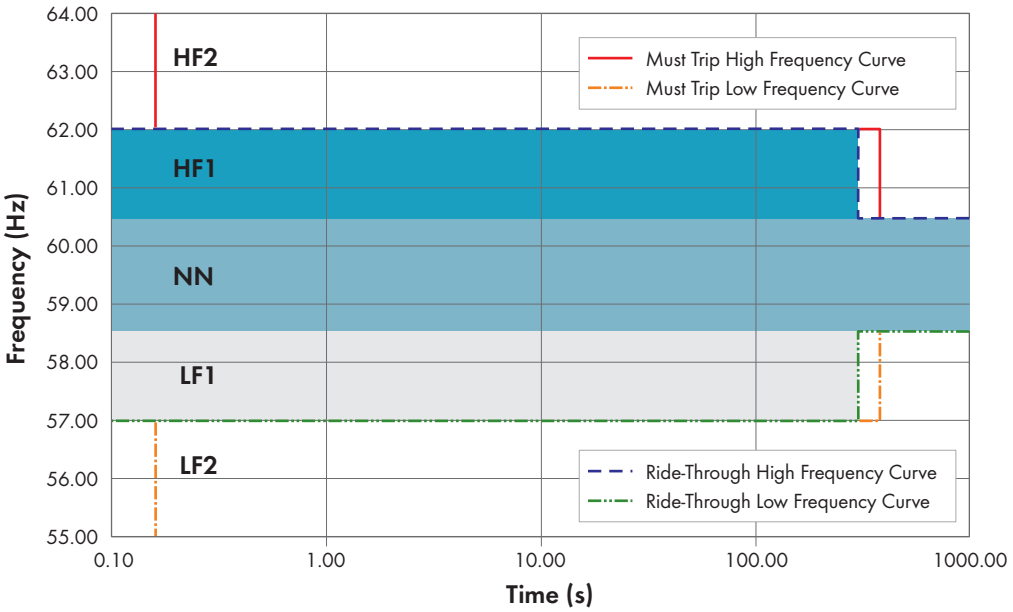

Figure 2: Ranges for exceeding or falling below the set frequency during "Low/High Frequency Ride-Through"

Designation	Description
Must Trip High Frequency	This curve specifies the thresholds within which the shutdown process of the inverter must be completed when permitted frequency is exceeded.
Must Trip Low Frequency	This curve specifies the thresholds within which the shutdown process of the inverter must be completed when permitted frequency is undershot.
Ride-Through High Frequency	This curve specifies how long the inverter must continue feeding in when permitted frequency is exceeded.
Ride-Through Low Frequency	This curve specifies how long the inverter must continue feeding in when permitted frequency is undershot.

The inverter continuously checks the power frequency. The inverter continues to feed in up to a set point in time (Ride Through) when the frequency is exceeded or undershot and then starts the shutdown process. The time within which the shutdown process must be completed is saved in the inverter via an adjustable parameter defining the time interval before the latest possible shutdown time (Must Trip).

The grid support in dependence of the grid frequency is activated by default. You can configure the thresholds via the parameters listed in the following table. The inverter always operates in "Mandatory Operation" mode during grid support in dependence of the grid frequency.

Overview of the Required Settings

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum	Rule 21
Exceeding range of frequency HF1	Frequency monitoring lower maximum threshold	40432	cannot be controlled via SunSpec Modbus	50 Hz	66 Hz	60.5 Hz
	Frq. monitoring lower max. threshold trip. time	40434		100 ms	1000000 ms	300000 ms
Exceeding range of frequency HF2	Frequency monitoring upper maximum threshold	40428	cannot be controlled via SunSpec Modbus	50 Hz	66 Hz	62 Hz
	Frq. monitoring upper max. threshold trip. time	40430		100 ms	1000000 ms	160 ms
Permitted range if frequency LF1 falls below a specific value	Frequency monitoring upper minimum threshold	40436	cannot be controlled via SunSpec Modbus	44 Hz	60 Hz	58.5 Hz
	Frq. monitoring upper min. threshold trip. time	40438		100 ms	1000000 ms	300000 ms
Permitted range if frequency LF2 falls below a specific value	Frequency monitoring lower minimum threshold	40440	cannot be controlled via SunSpec Modbus	44 Hz	60 Hz	57 Hz
	Frq. monitoring lower min. threshold trip. time	40442		100 ms	1000000 ms	160 ms

2.4 Ramp Rate During Normal Operation "Normal Ramp Rate"

In the parameter **Active power gradient in feeding operation**, it can be defined how the inverter gradually ramps up to the set active power and reactive power during normal operation (e.g. after a parameter change or power fluctuations in loads or sources). This means that the inverter gradually increases the power per second by the rate of increase set in this parameter. The rate of increase is set to 10000% by default. You can configure the rate of increase via the parameters listed in the table.

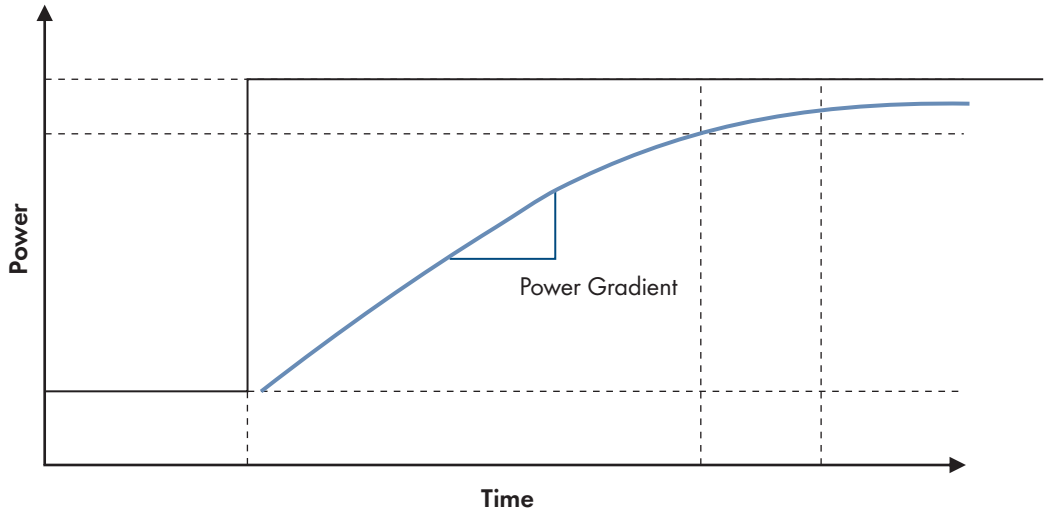

Figure 3: Characteristic curve for inverter ramp-up in "Normal Ramp Rate" mode

Overview of the Required Settings

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum	Rule 21
Rate of increase "Power Gradient" for ramp-up of defined power	Active power gradient in feeding operation	41201	40285	0.167% Inom/s	100% Inom/s	100% Inom/s

2.5 Ramp-Up After Grid Fault "Soft Start Ramp Rate"

Via the function "Soft Start Ramp Rate", you can define how the inverter is to begin with active power feed-in after a grid fault: The rate of increase for active power feed-in has the same specifications as the function "Normal Ramp Rate". The function "Soft Start Ramp Rate" is deactivated by default. You can activate the function. For this, set the parameter **Activation of active power gradient for reconnection after grid fault** to **On**. After the activation, the inverter reconnects by default with a rate of increase of 20% of the nominal current per second. You can change the rate of increase via the parameters listed in the table.

In addition, a preset time delay of 300 s is activated. After the energy supply is restored, the inverter will wait for the set delay before feeding into the grid again so that the utility grid can stabilize first. You can change the time of delay via the parameters listed in the table.

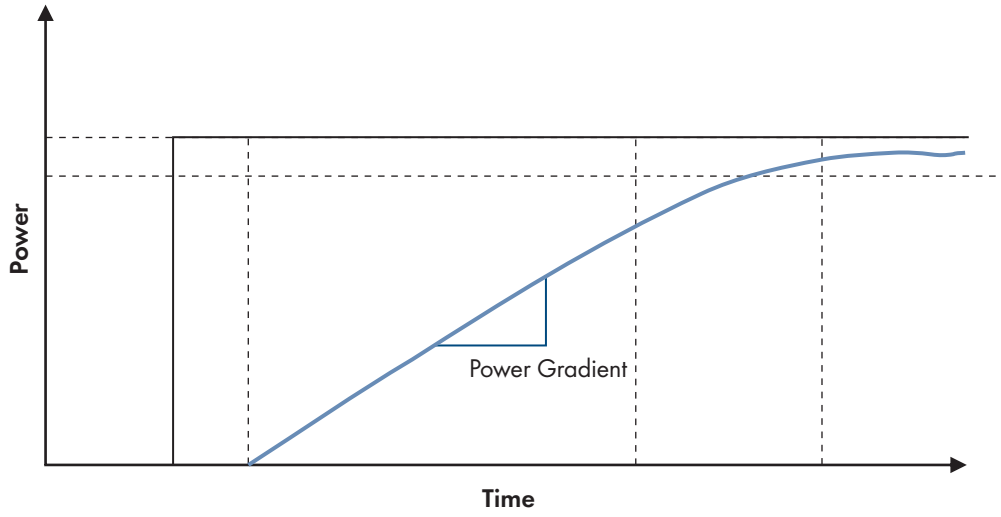

Figure 4: Characteristic curve for inverter ramp-up according to the "Soft Start Ramp Rate" function

Overview of the Required Settings

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum	Rule 21
Rate of increase "Power Gradient" for ramp-up of defined power	Reconnect gradient after grid fault	cannot be controlled via SMA Modbus	cannot be controlled via SunSpec Modbus	0.083% Inom/s	100% Inom/s	100% Inom/s
Time delay during reconnection after a grid failure	Reconnection time upon short interruption	cannot be controlled via SMA Modbus	cannot be controlled via SunSpec Modbus	–	–	–

2.6 Fixed specification of a power factor cos φ "Specified Power Factor"

The reactive power is controlled as a function of a fixed power factor cos φ.

This function is activated by default and the power factor is set to 1 by default. You can configure the power factor and the excitation type of the power factor via the parameters listed in the table.

$$P = S \cdot \cos \varphi$$

$$\cos \varphi = \frac{P}{S} = \frac{0.90\ W}{1\ VA} = 0.90$$

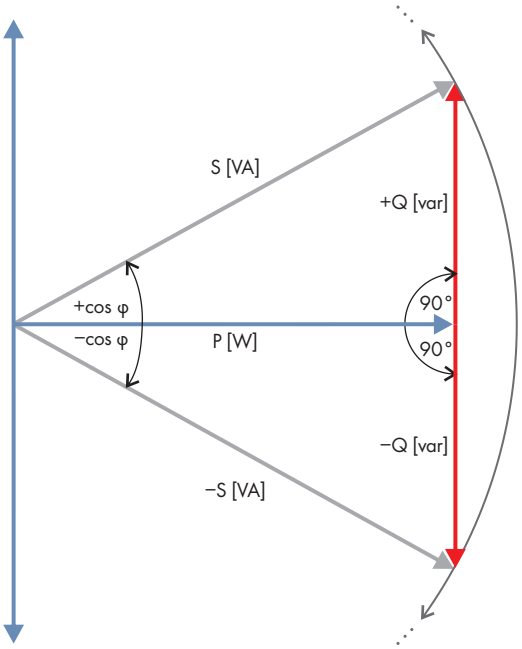

Figure 5: Diagram "Specified Power Factor (cos φ)" with calculation example

Overview of the Required Settings

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum	Mean value
Power factor cos φ	cosPhi setpoint, cosPhi config., direct specif.	40206	cannot be controlled via SunSpec Modbus	0.8	0.8	1
Excitation of the power factor cos φ (+Q /-Q)	cosPhi excit.type, cosPhi config., direct spec.	40208		–	–	–

2.7 Reactive Power Control as a Function of Grid Voltage "Volt-Var Mode"

The reactive power is controlled as a function of the grid voltage. By supplying reactive power, the inverter performs voltage-stabilizing measures in the event of overvoltage or undervoltage. The parameterization is carried out by means of a reactive power/voltage characteristic curve.

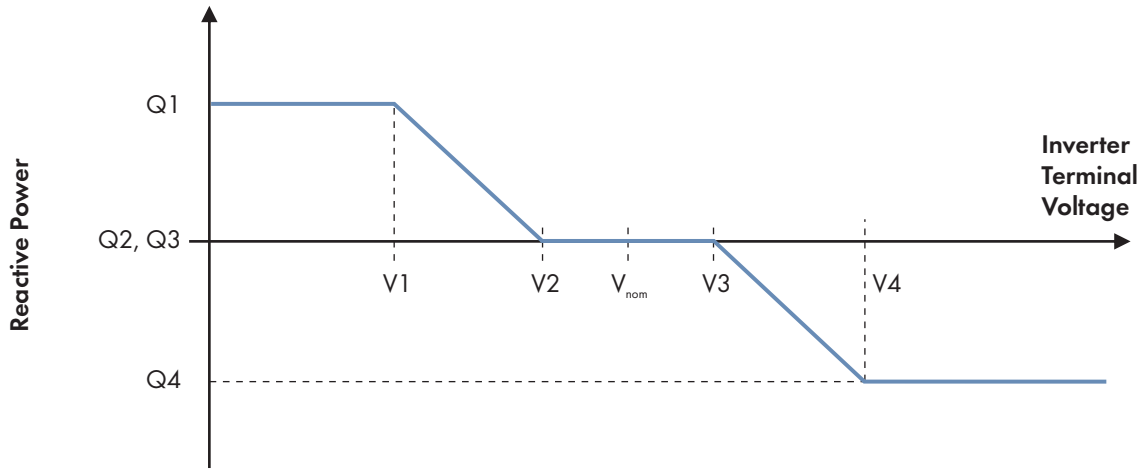

Figure 6: Characteristic curve "Volt-Var" (in this example Q2 and Q3 are the same.)

A quotient is derived from the ratio of the current grid voltage to nominal grid voltage. When the grid voltage is equal to the defined nominal voltage, the reactive power feed-in is zero. If the grid voltage changes and exceeds or falls short of a defined threshold, the inverter reacts according to the voltage/reactive power characteristic curve by adjusting its reactive power feed-in. Four values can be set for each voltage quotient and the applicable reactive power setpoints separately defined. Four interpolation points can be defined through this parameterization. Thus, the reactive power/voltage characteristic curve can be flexibly configured.

The reactive power control as a function of grid voltage is deactivated by default. To activate the function, the parameter **Operating mode of stat.V stab., stat.V stab. config.** must be set to **Reactive power charact. curve**. You must activate the characteristic curve after activating the function. For this, the parameter **Activation of the characteristic curve [B]** must be set to **On** and the parameter **Characteristic curve number [B]** to **2**. You can change the configuration of this characteristic curve via the parameters listed in the table.

Overview of the Required Settings

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Least Aggressive	Mean value	Most Aggressive
Voltage V1	X values charact. curve 1	41077	40410	92.0% Vnom	96.09% Vnom	97.83% Vnom
Voltage V2		41081	40412	96.0% Vnom	98.0% Vnom	100.0% Vnom
Voltage V3		41085	40414	104.0% Vnom	102.0% Vnom	100.0% Vnom
Voltage V4		41089	40416	108% Vnom	103.91% Vnom	102.17% Vnom

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Least Aggressive	Mean value	Most Aggressive
Reactive Power Q1	Y values charact. curve 1	41079	40411	15.0% Pnom	30.0% Pnom	60.0% Pnom
Reactive Power Q2		41083	40413	0	0	0
Reactive Power Q3		41087	40415	0	0	0
Reactive Power Q4		41091	40417	-15.0% Pnom	-30.0% Pnom	-60.0% Pnom

2.8 Active Power Limitation Depending on Power Frequency "Frequency-Watt Mode"

In the case of active power limitation depending on power frequency, the inverter constantly checks the connected power frequency and if necessary regulates the active power feed-in.

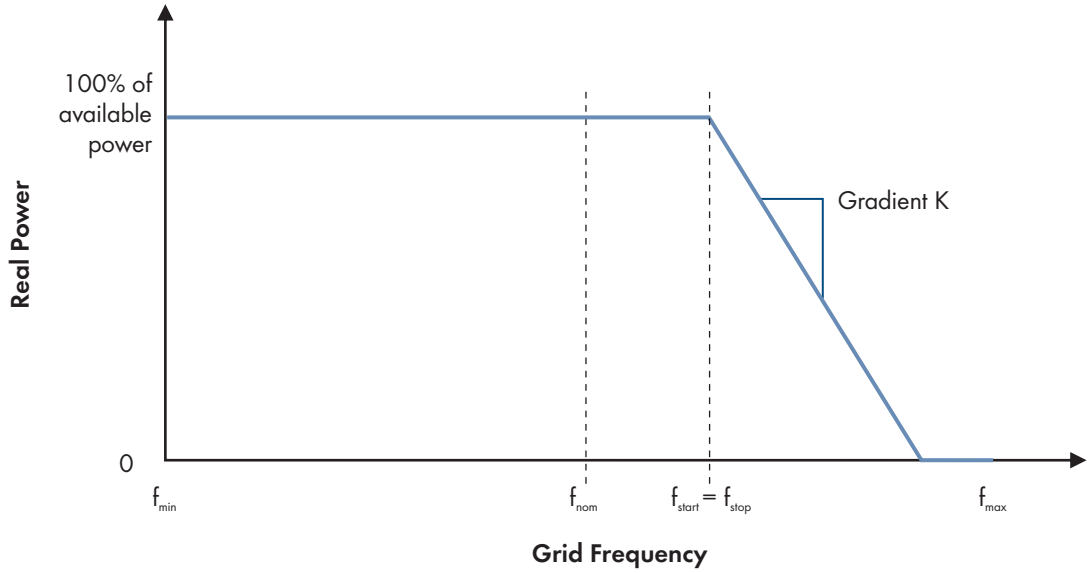

Figure 7: Characteristic curve "Frequency-Watt"

If the grid frequency exceeds a defined starting frequency, the inverter reduces the active power feed-in by a defined gradient. When the power frequency is dropping, the inverter increases the active power again by this defined gradient. In order to map the required characteristic curve in accordance with UL 1741 SA, the starting frequency and the stopping frequency must be set to the same value in the inverter.

The active power limitation depending on power frequency is deactivated by default. To activate the function, the parameter **Operating mode of active power reduction in case of overfrequency P(f)** must be set to **Linear gradient**. After activating the function, you can configure the characteristic curve via the parameters listed in the table.

Overview of the Required Settings

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Minimum	Maximum
Frequency F1	X values charact. curve 3	40378	40503	62.000 Hz	60.010 Hz
Frequency F2		40380	40505	65.500 Hz	60.779 Hz
Active Power P1	Y values charact. curve 3	40402	40504	100% Pnom	100% Pnom
Active Power P2		40404	40506	0	0

2.9 Active Power Limitation Depending on Grid Voltage "Volt-Watt Mode"

The active power is controlled as a function of the grid voltage. By supplying active power, the inverter performs voltage-stabilizing measures in the event of overvoltage. The parameterization is carried out by means of an active power/voltage characteristic curve.

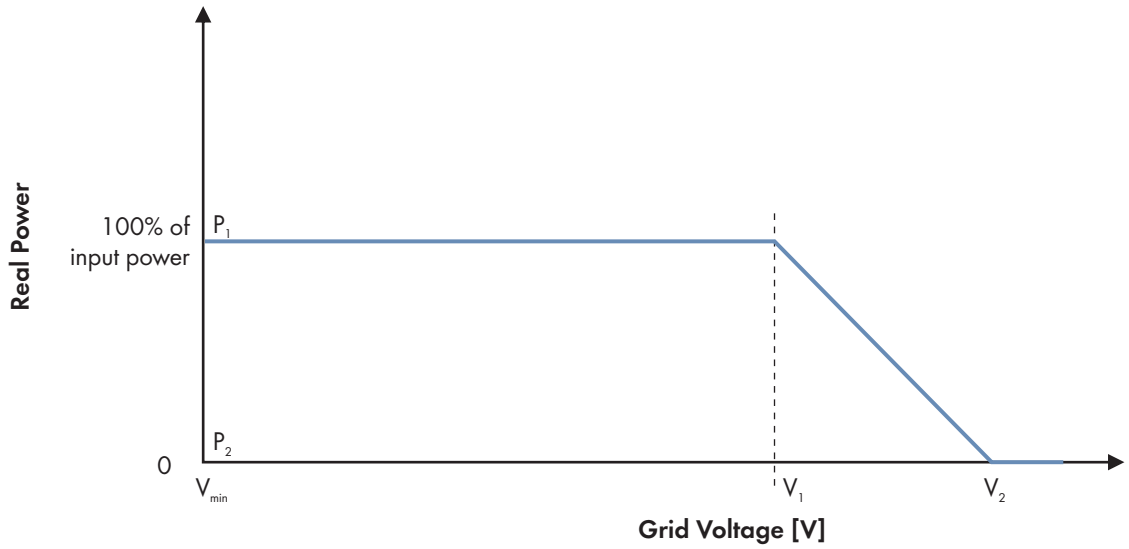

Figure 8: Characteristic curve "Volt-Watt"

A quotient is derived from the ratio of grid voltage to nominal voltage. When the grid voltage is equal to the defined nominal voltage, the active power feed-in is zero. If the grid voltage changes and exceeds or falls short of a defined threshold, the inverter reacts according to the voltage/active power characteristic curve by adjusting its active power feed-in. Two thresholds can be set for each voltage quotient and the applicable active power setpoints separately defined. Via the voltage quotients and the respective active power setpoints, two interpolation points can be preset for the active power/voltage characteristic curve.

The active power limitation depending on power frequency is deactivated by default. To activate the function, the parameter **Activation of the characteristic curve, configuration of characteristic curve mode** must be set to **On**. You must activate the characteristic curve after activating the function. For this, the parameter **Activation of the characteristic curve [A]** must be set to **On** and the parameter **Characteristic curve number [A]** to **1**. You can change the configuration of this characteristic curve via the parameters listed in the table.

Overview of the Required Settings

Required settings in accordance with UL 1741 SA	Parameter name with Speedwire/ Webconnect	Register number with SMA Modbus	Register number with SunSpec Modbus	Min. tilt angle	Max. tilt angle at max. start voltage	Max. tilt angle
Voltage V1	X values charact. curve 1	41029	40570	103.00% Vnom	105.0% Vnom	103.0% Vnom
Voltage V2		41033	40572	108.0% Vnom	108.0% Vnom	106.0% Vnom
Active Power P1	Y values charact. curve 1	41031	40571	100.0% Pnom	100.0% Pnom	100.0% Pnom
Active Power P2		41035	40573	0	0	0


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