Type Certificate

Applicant:	**Huawei Technologies Co., Ltd.**	
Address:	Administration Building, Headquarters of Huawei Technologies Co., Ltd., Bantian, Longgang District, Shenzhen, 518129 P.R. China	

Type of power generating unit:	**Grid-tied photovoltaic inverter**	**SUN2000-168KTL-H1**	**SUN2000-185KTL-H1**
Technical data:	Rated active power:	150 kW	175 kW
	Rated apparent:	150 kVA	175 kVA
	Max. apparent power:	168 kVA	185 kVA
	Nominal voltage:	800 V (3P+ PE)	
	Nominal frequency:	50 Hz	
Firmware version:		**V300R001**	

Validated type model:	Model file:	Huawei_19-0650_0_TR4_SUN2000-168-185KTL_V1.zip
	Identification number (MD5):	231c3a9d556ca31639da30839c3f73d0

Grid connection regulation:
VDE-AR-N 4110:2018-11 – Technical requirements for the connection and operation of customer installations to the medium voltage network (TCR medium voltage) [1]
VDE-AR-N 4120:2018-11 – Technical requirements for the connection and operation of customer installations to the high voltage network (TCR high voltage) [2]

Pertinent standards / Guidelines:
Technical guidelines: FGW TR 3 Rev. 25 [3], FGW TR 4 Rev. 09 [4], FGW TR 8 Rev. 09 [5]

The power generating units, stated in the certificate, were tested and certified according to the technical guidelines referenced to the grid connection regulation. The electrical characteristics fulfil the requirements of the grid connection regulation:

- Quasi-steady-state operation
- Dynamic network stability (reactive current characteristic according to TCR medium voltage & TCR high voltage)
- Active power output and network security management
- Active power adjustment as a function of the grid frequency
- Protection technology and protection settings on generating unit level (Note in annex p.45) *
- Power quality

There are no restrictions or deviations. (* A connecting terminal plate has to be installed separately if necessary.)

The manufacturer has provided proof of certification of the quality management system of his production facility in accordance with ISO 9001

The certificate includes the following information:

- technical data of the power generating unit, the auxiliary equipment used and the software version used;
- schematic structure of the power generating units;
- summarized information on the properties of the power generating unit.

The certificate is comprised of 77 pages (including Annex of 76 pages).

BV project number	:	**19TH0240**			
Certificate no.	:	**19-0650_0**	**Certification scheme**	:	**NSOP-0032-DEU-ZE-V01**
Issued	:	**2019-12-23**	**Valid until**	:	**2024-12-22**

Certification body

Holger Schaffer

DAkkS Deutsche Akkreditierungsstelle D-ZE-12024-01-00

Certification body of Bureau Veritas Consumer Products Services Germany GmbH accredited according to DIN EN ISO/IEC 17065

Description of the revisions of certificate 19-0650_0	
Rev. 0	First issue

Annexes included in certificate 19-0650_0

Contents

1. Annex 1 – Guidelines, test reports and documents

This certificate is based on following guidelines, test reports and documents:

Reference	Guidelines
[1]	Technische Regeln für den Anschluss von Kundenanlagen an das Mittelspannungsnetz und deren Betrieb (TAR Mittelspannung), VDE-AR-N 4110:2018-11 / *Technical requirements for the connection and operation of customer installations to the medium voltage network (TCR medium voltage), VDE-AR-N 4110:2018-11*
[2]	Technische Regeln für den Anschluss von Kundenanlagen an das Hochspannungsnetz und deren Betrieb (TAR Hochspannung), VDE-AR-N 4120:2018-11 / *Technical requirements for the connection and operation of customer installations to the high voltage network (TCR high voltage), VDE-AR-N 4120:2018-11*
[3]	Technische Richtlinien für Erzeugungseinheiten und –anlagen TEIL 3 (TR3), Bestimmung der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie für deren Komponenten am Mittel-, Hoch- und Höchstspannungsnetz, Revision 25, Stand 01.09.2018 / *Technical Guidelines for Power Generating Units and Systems PART 3 (TG3), Determination of the Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well for their Components in Medium-, High- and Extra-High Voltage Grids, Revision 25, Dated 01/09/2018*
[4]	Technische Richtlinien für Erzeugungseinheiten und –anlagen TEIL 4 (TR4), Anforderungen an Modellierung und Validierung von Simulationsmodellen der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie deren Komponenten, Revision 09, Stand 01.02.2019 / *Technical Guidelines for Power Generating Units and Systems PART 4 (TG4), Demands on Modelling and Validating Simulation Models of the Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well as their Components, Revision 09, Dated 01/02/2019*
[5]	Technische Richtlinien für Erzeugungseinheiten, -anlagen und Speicher sowie für deren Komponenten TEIL 8 (TR8), Zertifizierung der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie für deren Komponenten am Stromnetz, Revision 09, Stand 01.02.2019 / *Technical Guidelines for for Power Generating Units, Systems and Storage Systems as well as for their Components PART 8 (TG8), Determination of the Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well for their Components in Medium-, High- and Extra-High Voltage Grids, Revision 09, Dated 01/02/2019*
[6]	Kurzschlussströme in Drehstromnetzen Teil 0: Berechnung der Ströme, DIN EN 60909-0 (VDE 0102):2016-12 / *Short-circuit currents in three-phase a.c. systems Part 0: Calculation of currents (IEC 60909-0:2016)*

Reference	Test reports
[7]	19TH0240_TR3_0 TG3 test report according to FGW TG3 Rev.25, issued by Bureau Veritas Consumer Products Services Germany GmbH on 19. Dec. 2019
[8]	19TH0240_TR4_0 TG4 test report according to FGW TG4 Rev.09, issued by Bureau Veritas Consumer Products Services Germany GmbH on 17. Dec. 2019
[9]	19TH0240_TR8_0 TG8 evaluation report according to FGW TG8 Rev.09, issued by Bureau Veritas Consumer Products Services Germany GmbH on 20. Dec. 2019
[10]	19TH0240_TR3_0_excerpt-part_1_0 Extract from the TG3 test report, issued by Bureau Veritas Consumer Products Services Germany GmbH on 19. Dec. 2019

1. Annex 1 – Guidelines, test reports and documents	
[11]	19TH0240_TR3_0_excerpt-part_2_0 Extract from the TG3 test report, issued by Bureau Veritas Consumer Products Services Germany GmbH on 19. Dec. 2019
[12]	19TH0240_TR3_0_excerpt-part_3_0 Extract from the TG3 test report, issued by Bureau Veritas Consumer Products Services Germany GmbH on 19. Dec. 2019

The compliance to the grid connection regulation of the power generating units is shown by the results in the test report (*19TH0240_TR3_0*) which includes all type tests stated in the certificate. The type tests were conducted by Bureau Veritas Consumer Products Services Germany GmbH.

The compliance to the grid connection regulation of the simulation models is verified by the validation report (*19TH0240_TR4_0*). The simulations were conducted by Bureau Veritas Consumer Products Services Germany GmbH.

The summary of the grid connection regulation compliant certification of the units

- SUN2000-168KTL-H1
- SUN2000-185KTL-H1

is stated in the certification report (*19TH0240_TR8_0*).

Reference	Certification-relevant documents provided by manufacturer
[13]	Manufacturer’s certificate on specific data of a Photovoltaic Converter, dated 18/12/2019: F.0_Huawei_SUN2000-168KTL_Manufacturer certificate_V01 F.0_Huawei_SUN2000-185KTL_Manufacturer certificate_V01
[14]	Parameter list, dated 18/12/2019: F.2_Huawei_SUN2000-168-185KTL_Parameter list_V1.0
[15]	Manufacturer’s declaration for compliance to technical requirements of the VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11, dated 18/12/2019: F.4_Huawei_SUN2000-168-185KTL_Declaration of manufacturer_V1.0

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

2.1. Technical data of the power generating unit (Manufacturer's data) [13]

Herstellerbescheinigung zu spezifischen Daten eines Photovoltaik-Wechselrichters vom Typ SUN2000-168KTL-H1

Manufacturer's certificate on specific data of a Photovoltaic Converter of the type SUN2000-168KTL-H1

Datum / Date: 2019-12-18 — **Seite/Page 1/1**

1	**Allgemeines und Ausgangsgrößen**			**General and Output values**
1	Hersteller	HUAWEI TECHNOLOGIES CO.,LTD.		manufacturer
2	Typenbezeichnung	SUN2000-168KTL-H1		type name
3	Einspeisung (einphasig/dreiphasig)	three-phase		no. of phases (single-phase/three-phase)
4	Nennscheinleistung	150	kVA	rated apparent power
5	Nennwirkleistung	150	kW	rated active power
6	AC-Nennspannung	800	V	rated AC-voltage
7	AC-Nennfrequenz	50	Hz	rated frequency
8	Beitrag zum Stoßkurzschlussstrom (i_p nach IEC 60909-0)	0.1225	kA	contribution to initial short circuit current (i_p according to IEC 60909-0)
2	**DC Eingangsgrößen**			**DC Input**
1	Min. MPP-Spannung	500	V	min. MPP voltage
2	Max. MPP-Spannung	1500	V	max. MPP voltage
3	Max. PV-Eingangsspannung	1500	V	max. DC input voltage
4	Max. PV-Eingangsstrom	234	A	max. DC input current
5	Max. Modulleistung	171.5	kW_p	max. peak power
3	**Wechselrichter-Leistungsteil**			**Converter-Power section**
1	Hersteller	HUAWEI TECHNOLOGIES CO.,LTD.		manufacturer
2	Typenbezeichnung	SUN2000-168KTL-H1		type name
3	Nennscheinleistung	150	kVA	rated apparent power
4	Art (HF/NF-Trafo, trafolos)	Without		generic type (HF/LF-transformer, without)
5	Taktfrequenz	18	kHz	pulse rate of inverter
6	Art der Leistungsregelung (MPPT)	Advanced Climb		generic type of power control (MPPT)
7	Software-Version	V300R001		software version
4	**Sonstige elektrische Komponenten**			**Other electric components**
1	Art der Netzkopplung	3 ~ + PE		generic type of interconnection
2	- Hersteller	HUAWEI TECHNOLOGIES CO.,LTD.		- manufacturer
3	- Typenbezeichnung	SUN2000-168KTL-H1		- type
4	Netzschutz integriert (Ja/Nein)	Yes		integrated grid protection (Yes/No)
5	Netzschutzhersteller	HUAWEI		grid protection manufacturer
5	- Typenbezeichnung	SUN2000-168KTL-H1		- type
7	Typenbezeichnung der Abschalteinheit (angesteuert vom Netzschutz)	Hongfa Electroacoustic HF167F-140/12-H3F		circuit breaker type controlled by the grid protection
8	Oberschwingungsfilter (ja/nein)	Yes		harmonic filter (yes/no)
5	**Typenprüfung**			**Type test**
1	Prüfbehörde	Bureau Veritas CPS		testing authority
2	Aktenzeichen	19TH0240		reference
3	Seriennummer des Wechselrichters	6T1979057521		serial number of converter

Anschrift des Herstellers
Address of manufacturer

Administration Building, Headquarters of Huawei Technologies Co.,Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C

Stempel, Datum, Unterschrift
stamp, date, signature

18.12.2019 Xu Bin

Der Hersteller des PV-Wechselrichters bestätigt, dass der PV-Wechselrichter, dessen elektrischen Eigenschaften in den Prüfberichten abgebildet sind, hinsichtlich seiner technischen Daten mit den o.g. Positionen identisch ist.

The manufacturer of the PV-Converter confirms that the PV-Converter whose power quality is measured and depicted in the test reports, is identical with the above entries with regard to its technical data

F.0 BUREAU VERITAS CPS Germany – Manufacturer's declaration / V01 09/19

Figure 1 – Manufacturer's certificate on specific data of a Photovoltaic Converter - SUN2000-168KTL-H1 from [13]

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

Herstellerbescheinigung zu spezifischen Daten eines Photovoltaik-Wechselrichters vom Typ SUN2000-185KTL-H1

Manufacturer's certificate on specific data of a Photovoltaic Converter of the type SUN2000-185KTL-H1

Datum / Date: 2019-12-18 **Seite/Page 1/1**

1	**Allgemeines und Ausgangsgrößen**			**General and Output values**
1	Hersteller	HUAWEI TECHNOLOGIES CO.,LTD.		manufacturer
2	Typenbezeichnung	SUN2000-185KTL-H1		type name
3	Einspeisung (einphasig/dreiphasig)	three-phase		no. of phases (single-phase/three-phase)
4	Nennscheinleistung	175	kVA	rated apparent power
5	Nennwirkleistung	175	kW	rated active power
6	AC-Nennspannung	800	V	rated AC-voltage
7	AC-Nennfrequenz	50	Hz	rated frequency
8	Beitrag zum Stoßkurzschlussstrom (i_p nach IEC 60909-0)	0.1349	kA	contribution to initial short circuit current (i_p according to IEC 60909-0)
2	**DC Eingangsgrößen**			**DC Input**
1	Min. MPP-Spannung	500	V	min. MPP voltage
2	Max. MPP-Spannung	1500	V	max. MPP voltage
3	Max. PV-Eingangsspannung	1500	V	max. DC input voltage
4	Max. PV-Eingangsstrom	234	A	max. DC input current
5	Max. Modulleistung	188.8	kW_p	max. peak power
3	**Wechselrichter-Leistungsteil**			**Converter-Power section**
1	Hersteller	HUAWEI TECHNOLOGIES CO.,LTD.		manufacturer
2	Typenbezeichnung	SUN2000-185KTL-H1		type name
3	Nennscheinleistung	175	kVA	rated apparent power
4	Art (HF/NF-Trafo, trafolos)	Without		generic type (HF/LF-transformer, without)
5	Taktfrequenz	18	kHz	pulse rate of inverter
6	Art der Leistungsregelung (MPPT)	Advanced Climb		generic type of power control (MPPT)
7	Software-Version	V300R001		software version
4	**Sonstige elektrische Komponenten**			**Other electric components**
1	Art der Netzkopplung	3 ~ + PE		generic type of interconnection
2	- Hersteller	HUAWEI TECHNOLOGIES CO.,LTD.		- manufacturer
3	- Typenbezeichnung	SUN2000-185KTL-H1		- type
4	Netzschutz integriert (Ja/Nein)	Yes		integrated grid protection (Yes/No)
5	Netzschutzhersteller	HUAWEI		grid protection manufacturer
5	- Typenbezeichnung	SUN2000-185KTL-H1		- type
7	Typenbezeichnung der Abschalteinheit (angesteuert vom Netzschutz)	Hongfa Electroacoustic HF167F-140/12-H3F		circuit breaker type controlled by the grid protection
8	Oberschwingungsfilter (ja/nein)	Yes		harmonic filter (yes/no)
5	**Typenprüfung**			**Type test**
1	Prüfbehörde	Bureau Veritas CPS		testing authority
2	Aktenzeichen	19TH0240		reference
3	Seriennummer des Wechselrichters	6T1979057521		serial number of converter

Anschrift des Herstellers
Address of manufacturer

Administration Building, Headquarters of Huawei Technologies Co.,Ltd., Bantian, Longgang District, Shenzhen, 518129, P.R.C

Stempel, Datum, Unterschrift
stamp, date, signature

18.12.2019 Xu Bin

Der Hersteller des PV-Wechselrichters bestätigt, dass der PV-Wechselrichter, dessen elektrischen Eigenschaften in den Prüfberichten abgebildet sind, hinsichtlich seiner technischen Daten mit den o.g. Positionen identisch ist.

The manufacturer of the PV-Converter confirms that the PV-Converter whose power quality is measured and depicted in the test reports, is identical with the above entries with regard to its technical data

F.0 BUREAU VERITAS CPS Germany – Manufacturer's declaration / V01 09/19

Figure 2 – Manufacturer's certificate on specific data of a Photovoltaic Converter - SUN2000-185KTL-H1 from [13]

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer’s data)

2.2. Description of the power generating unit

Description of the power circuit (Figure 3)

The photovoltaic converter converts DC voltage, generated by photovoltaic modules, into AC voltage.

The units are three-phase.

The input and output are protected by SPDs to Earth. The unit is providing EMI filtering at the PV input and output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit can operate in case of one error.

The internal control is redundant built. It consists of Microcontroller master ARM (U101) and slave ARM (U100).

The master ARM (U101) which can control the relays by switching signals; measures the voltage, frequency, AC current, DC-injection current, insulation resistance and residual current. In addition it tests the array isolation impedance and the RCMU circuit before each start up.

The slave ARM (U100) is user for detecting grid voltage, grid frequency and residual current, also can open the relay, and communicate with Main ARM (U101) each other.

The unit provides two relays in series on each phase. When single-fault applied to one relay, an error code will appear on display panel, another redundant relay provides basic insulation maintained between the PV array and the mains. All the relays are tested before start up. Both ARM can open the relays.

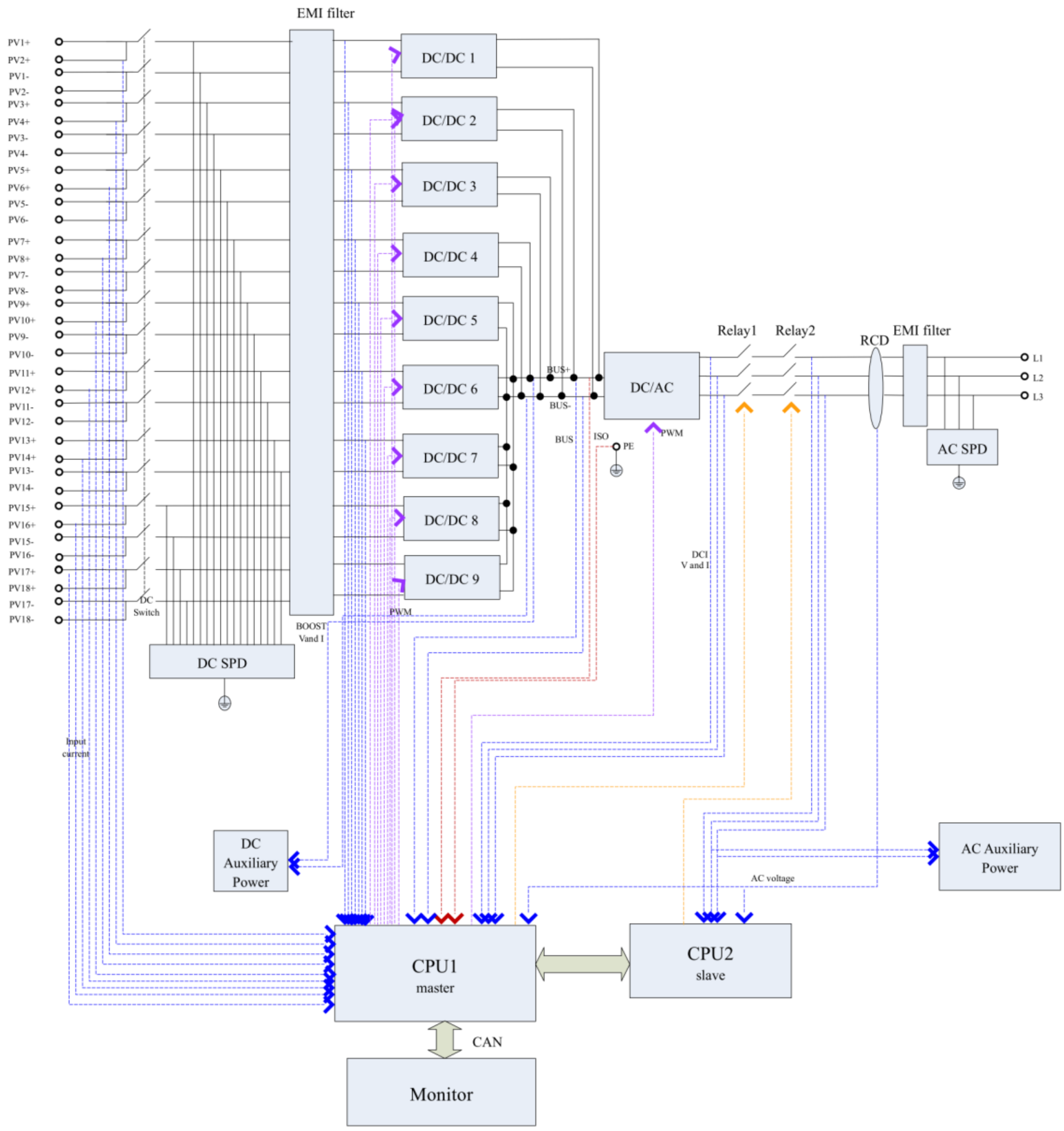


Figure 3 – Block diagram of the power circuit

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

Description of the differences of the models within a series:

The units in der series are identical hardware platform. The implemented control and firmware is identical in all units. There is no difference regarding AC behavior between the PGU-types apart from the power rating deviation and current limitation of each unit.

Description of the remote control in a typical installation (Figure 4) *(Manufacturer's data)***:**

A Smart Logger (data collector) can be connected to a SUN2000 system (including up to 30 units recommended by manufacturer) connected in series via RS485 communication cable (using MODBUS-RTU communication protocol). The length of the communication cable should be limited to max. 1000 m (for RS485 bus using 9600 baud rate). A wireless communication device can be connected to the Smart Logger via dry contact for active / reactive power control. The Ethernet-interface and corresponding WebUI "*Data Collector Web*" are available for setting / controlling active / reactive power and parameter configuration.

There are no differences regarding the setpoint accuracy and settling / response times between the interfaces / software tools.

Hereby, the pick up of a new setpoint of P, Q and cosφ is guaranteed within 2 s.

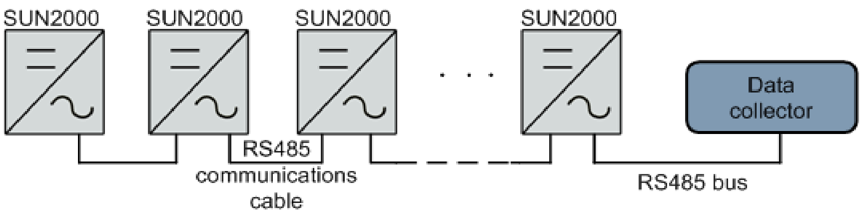


Figure 4 – Scheme of an installation

Description of the connection to the remote control receiver (Figure 5) *(Manufacturer's data)***:**

A generating station can receive the signal from the State Load Dispatch Centre or Regional Load Dispatch Centre for regulation of the active and reactive power output uisng the Smart Logger (data acquisition device).

The remote control receiver can be connected to the Smart Logger using dry contact for active / reactive power control, which is connected to the inverters via RS485/MBUS.

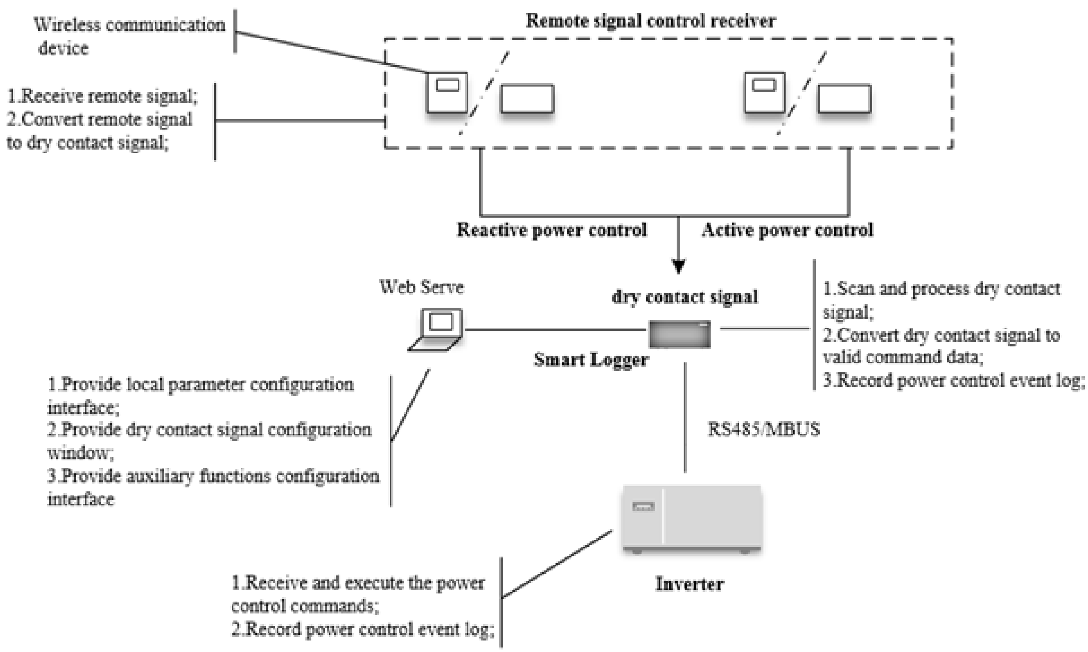


Figure 5 – Connection of the remote control receiver in an installation

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

2.3. Description of software version and interfaces

Following is the software and firmware version used for the TG3 testing [14]:

4. Main Components of the regulating system

Main components of the control system with firmware and software	
Main component(s) of the control system	Control system integrated in the PGU
Firmware version	V300R001
Software version	V300R001

Figure 6 – Software and firmware version used for the TG3 testing from [14]

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

Following are the interfaces provided for active and reactive power setting [14]:

BUREAU VERITAS	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
	Ansprechpartner / *Customer Contact:*	Bin Xu Website: http://www.huawei.com Email: support@huawei.com	BV-Kontakt / *BV Contact:*	Weizhao Zheng Tel: +49 40 74041 - 2267 weizhao.zheng@de.bureauveritas.com

6. Description for reading out parameters

Reading out the parameters

☒ The parameters can be read out using the following software.

Name:	SmartLogger WebUI and SUN2000 APP
Version:	SmartLogger:V200R002 SUN2000 APP:3.2.00.002

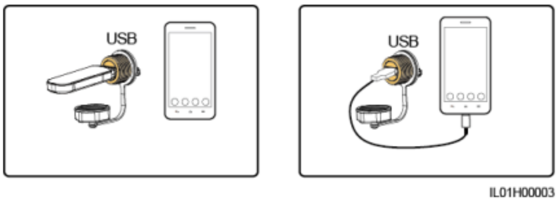
☐ The parameters can be read out using the display in the control system.

7. Interfaces

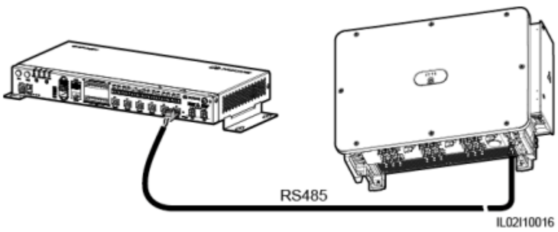
7.1. Active power specification

Interfaces for the active power reduction by defined setpoint
Following interfaces for control of the active power provision are provided on the PGU level:

- connect a mobile phone that runs the SUN2000 app to the inverter using a Bluetooth module, a WLAN module, or a USB data cable for active power setting using parameter *Fixed active power derated* or *Active power percentage derating*;

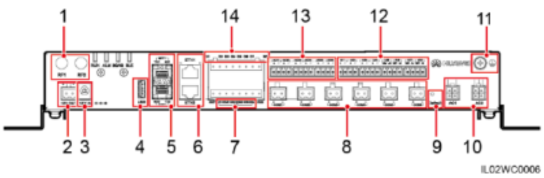


- connect the inverter to Smartlogger via MBUS or RS485 for active power setting using the WebUI using the parameter *Fixed active power derated* or *Active power percentage derating*.



- connect the inverter to Smartlogger via MBUS or RS485, the digital interfaces DI1, DI2, DI3, DI4 of the Smartlogger can be connected to the dry contacts for active power setting.

Figure 2-4 SmartLogger2000-10/10-B/11-B bottom



14	DI1–DI8	Digital parameter input	Connects to a dry contact input. GND1 and GND2 are grounding ports for DI signals.

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

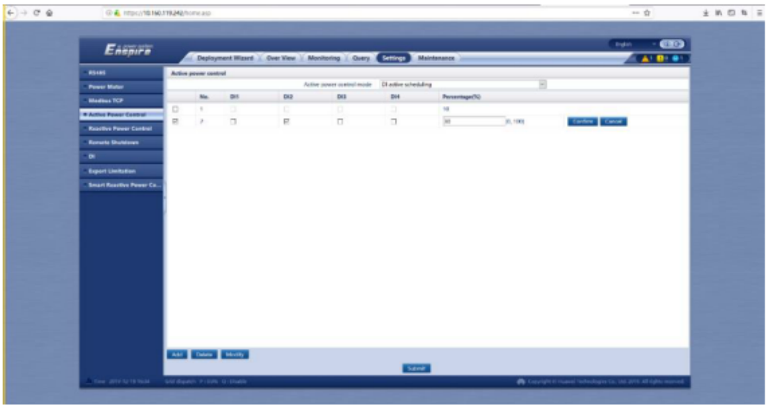
BUREAU VERITAS 1828	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
	Ansprechpartner / *Customer Contact:*	Bin Xu Website: http://www.huawei.com Email: support@huawei.com	BV-Kontakt / *BV Contact:*	Weizhao Zheng Tel: +49 40 74041 - 2267 weizhao.zheng@de.bureauveritas.com

8.1.2 DI Active Scheduling

NOTICE

- When setting this function, ensure that the DI port for customized control is not occupied. Otherwise, the setting will fail.
- Before setting this function, ensure that the SmartLogger is properly connected to the Ripple Control Receiver.

Parameter	Description
Active Power Control Mode	Set this parameter to **DI active scheduling**.
DI **NOTE** The DI parameters include **DI1**, **DI2**, **DI3**, **DI4**, and **Percentage(%)**.	• Supports 16 levels of percentages. • "√" indicates a low level. When DI+ and DI– are connected, the four DI ports of the SmartLogger are low-level ports. If not connected, the ports are high-level ports. • The percentage levels of DI1–DI4 should differ from each other. Otherwise, an abnormal command will be generated. • If the actual input DI signal is inconsistent with that configured on the WebUI, the SmartLogger controls the inverter to work at full power and the Abnormal Reactive Schedule alarm is raised.

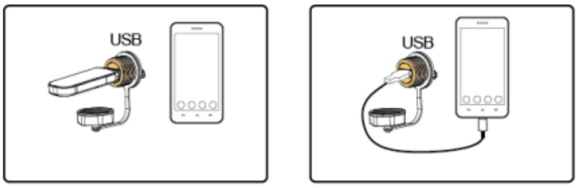


7.2. Reactive power specification

Interfaces for the provision of reactive power
Following interfaces for control of the reactive power provision are provided on the PGU level:

- connect a mobile phone that runs the SUN2000 app to the inverter using a Bluetooth module, a WLAN module, or a USB data cable for:
  - *Power factor fix control*
  - *Reactive power fix control*
  - Q-P characteristic curve
  - Q-U characteristic curve

  setting;



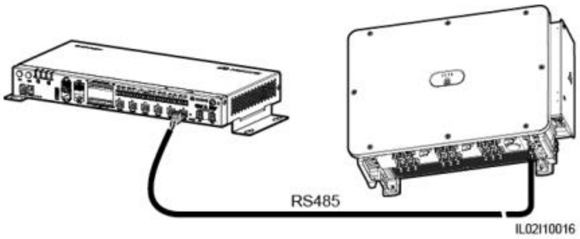
IL01H00003

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

BUREAU VERITAS	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
	Ansprechpartner / *Customer Contact:*	Bin Xu Website: http://www.huawei.com Email: support@huawei.com	BV-Kontakt / *BV Contact:*	Weizhao Zheng Tel: +49 40 74041 - 2267 weizhao.zheng@de.bureauveritas.com

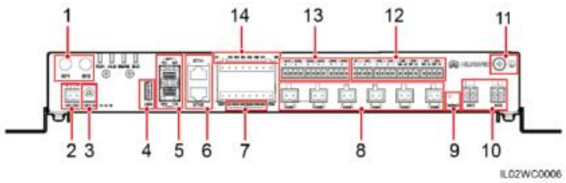
- connect the inverter to Smartlogger via MBUS or RS485, the following reactive power control functions:
  - *Power factor fix control*
  - *Reactive power fix control*
  - Q-P characteristic curve
  - Q-U characteristic curve

  can be set using the WebUI.



- connect the inverter to Smartlogger via MBUS or RS485, the digital interfaces DI5, DI6, DI7, DI8 of the Smartlogger can be connected to the dry contacts for power factor (cosφ) setting.

Figure 2-4 SmartLogger2000-10/10-B/11-B bottom



14	DI1–DI8	Digital parameter input	Connects to a dry contact input. GND1 and GND2 are grounding ports for DI signals.

8.2.2 DI Reactive Scheduling

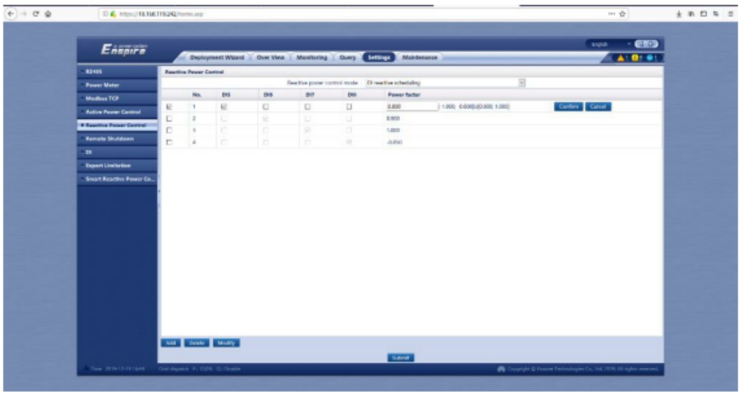
NOTICE

- When setting this function, ensure that the DI port for customized control is not occupied. Otherwise, the setting will fail.
- Before setting this function, ensure that the SmartLogger is properly connected to the Ripple Control Receiver.

Parameter	Description
Reactive power control mode	Set this parameter to **DI reactive scheduling**.
DI **NOTE** The DI parameters include **DI5**, **DI6**, **DI7**, **DI8**, and **Power factor**.	• Sixteen levels are supported for power factors. • "√" indicates a low level. When connecting to GND2, the four DI ports of the SmartLogger are low-level ports. If not connected, the ports are high-level ports. • The percentage levels of DI5–DI8 should differ from each other. Otherwise, an abnormal command is generated. • If the actual input DI signal is inconsistent with that configured on the WebUI, the SmartLogger controls the inverter to work at full power and the Abnormal Reactive Schedule alarm is raised.

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

BUREAU VERITAS	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
	Ansprechpartner / *Customer Contact:*	Bin Xu Website: http://www.huawei.com Email: support@huawei.com	BV-Kontakt / *BV Contact:*	Weizhao Zheng Tel: +49 40 74041 - 2267 weizhao.zheng@de.bureauveritas.com



F.2 BUREAU VERITAS CPS Germany – Parameter list / V01 05/19
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Figure 7 – Interfaces provided for active and reactive power setting from [14]

3. Annex 3 – Extract from the test report

3.1. Power quality [10]

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

4.3.2 Switching operations / *Schalthandlungen*

SUN2000-185KTL-H1 (FW: V300R001)

Case of switching operation / *Art der Schalthandlung*	Start-up at $P_{available}$ < 10%P_n / *Einschalten bei $P_{verfügbar}$ < 10%P_n*			
Max. number of switching operations / *Max. Anzahl Schalthandlungen*, N_{10} (Manufacturer's data / *Herstellerangabe*)	20			
Max. number of switching operations / *Max. Anzahl Schalthandlungen*, N_{120} (Manufacturer's data / *Herstellerangabe*)	240			
Grid impedance angle / *Netzimpedanzwinkel*, ψ_k	30°	50°	70°	85°
Flicker step factor / *Flickerformfaktor*, $k_f(\psi_k)$	0,12	0,10	0,06	0,05
Voltage change factor / *Spannungsänderungsfaktor*, $k_u(\psi_k)$	0,18	0,16	0,14	0,11
Case of switching operation / *Art der Schalthandlung*	Switch-on at $P_{available}$ = 100%P_n / *Einschalten bei $P_{verfügbar}$ = 100%P_n*			
Max. number of switching operations / *Max. Anzahl Schalthandlungen*, N_{10} (Manufacturer's data / *Herstellerangabe*)	20			
Max. number of switching operations / *Max. Anzahl Schalthandlungen*, N_{120} (Manufacturer's data / *Herstellerangabe*)	240			
Grid impedance angle / *Netzimpedanzwinkel*, ψ_k	30°	50°	70°	85°
Flicker step factor / *Flickerformfaktor*, $k_f(\psi_k)$	0,47	0,37	0,23	0,12
Voltage change factor / *Spannungsänderungsfaktor*, $k_u(\psi_k)$	1,03	0,81	0,51	0,24
Case of switching operation / *Art der Schalthandlung*	Service shutdown at $P_{available}$ = 100%P_n *Serviceabschaltung bei Nennleistung*			
Max. number of switching operations / *Max. Anzahl Schalthandlungen*, N_{10} (Manufacturer's data / *Herstellerangabe*)	1			
Max. number of switching operations / *Max. Anzahl Schalthandlungen*, N_{120} (Manufacturer's data / *Herstellerangabe*)	12			
Grid impedance angle / *Netzimpedanzwinkel*, ψ_k	30°	50°	70°	85°
Flicker step factor / *Flickerformfaktor*, $k_f(\psi_k)$	0,11	0,09	0,05	0,03
Voltage change factor / *Spannungsänderungsfaktor*, $k_u(\psi_k)$	1,04	0,82	0,51	0,24

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*	
Description of the service disconnection procedure / *Beschreibung der Durchführung einer Serviceabschaltung*	1. Shutdown the unit using „Start/Stop control“ / *Abschaltung der Einheit mittels „Start/Stop control“* 2. Turn off the AC switch between the unit and the power grid / *Trennen den AC-Schalter vom Netz* 3. Turn off both DC switches / *Trennen den DC-Schalter von den Energiequellen*

Note / *Anmerkung*:

$S_{k,fic}/S_n$ in the fictitious grid was set to / *Das Kurzschlussverhältnis im fiktiven Netz wurde gesetzt zu*: 20.

For the same SCR $S_{k,fic}/S_n$ in the fictitious grid, the flicker step and voltage change factors of the *SUN2000-185KTL-H1* can be applied to the *SUN2000-168KTL-H1* directly. /
Für das gleiche Verhältnis $S_{k,fic}/S_n$, die Flickerstufen- und Spannungsänderungsfaktoren des SUN2000-185KTL-H1 *können auf den* SUN2000-168KTL-H1 *direkt übertragen werden.*

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

4.3.3 Flicker

SUN2000-168KTL-H1 (FW: V300R001)

Grid impedance angle / *Netzimpedanzwinkel*, ψ_k	30°	50°	70°	85°
Operating point / *Betriebspunkt*, [% P_n]	Flicker coefficient / *Flickerkoeffizient*, $c(\psi_k)$			
0 - 5	0,47	0,48	0,57	0,62
10	0,41	0,45	0,56	0,62
20	0,35	0,43	0,55	0,60
30	0,34	0,45	0,60	0,65
40	0,37	0,46	0,60	0,66
50	0,36	0,48	0,64	0,70
60	0,41	0,69	0,99	1,10
70	0,39	0,70	1,04	1,20
80	0,39	0,67	0,98	1,11
90	0,40	0,70	1,01	1,15
100	0,40	0,73	1,07	1,22
P_{max} (112)	0,55	0,88	1,22	1,37
Max. Flicker coefficient / *Max. Flickerkoeffizient*, $c(\psi_k)$	0,55	0,88	1,22	1,37
Max. Short-term flicker / *Max. Kurzzeitflickerstörfaktor*, P_{st}	0,03	0,04	0,06	0,07

Reactive power setpoint during testing / *Blindleistungsvorgabe während der Prüfungen* [kvar]:	0
Ratio $S_{k,fic}/S_n$ in the fictitious grid used for analysis / *Das für die Auswertung genutzte Verhältnis* $S_{k,fic}/S_n$:	20

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

SUN2000-185KTL-H1 (FW: V300R001)

Grid impedance angle / *Netzimpedanzwinkel*, ψ_k	30°	50°	70°	85°
Operating point / *Betriebspunkt*, [% P_n]	Flicker coefficient / *Flickerkoeffizient*, $c(\psi_k)$			
0 - 5	0,32	0,27	0,27	0,32
10	0,31	0,31	0,38	0,42
20	0,32	0,31	0,41	0,46
30	0,30	0,35	0,46	0,50
40	0,30	0,38	0,49	0,54
50	0,34	0,52	0,73	0,81
60	0,32	0,53	0,76	0,86
70	0,35	0,54	0,77	0,87
80	0,37	0,57	0,81	0,91
90	0,40	0,63	0,89	1,00
100	0,41	0,65	0,91	1,03
P_{max} (106)	0,49	0,69	0,97	1,13
Max. Flicker coefficient / *Max. Flickerkoeffizient*, $c(\psi_k)$	0,49	0,69	0,97	1,13
Max. Short-term flicker / *Max. Kurzzeitflickerstörfaktor*, P_{st}	0,02	0,03	0,05	0,06

Reactive power setpoint during testing / *Blindleistungsvorgabe während der Prüfungen* [kvar]:	0
Ratio $S_{k,fic}/S_n$ in the fictitious grid used for analysis / *Das für die Auswertung genutzte Verhältnis* $S_{k,fic}/S_n$:	20

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

4.3.4 Harmonics / *Oberschwingungen*

SUN2000-168KTL-H1 (FW: V300R001)

Harmonics / *Harmonische*

Rated current / *Nennstrom* [A]: 108,3

P [%P_n]	0 - 5	10	20	30	40	50	60	70	80	90	100	P_{max}	Max.
Order / *Ordnung*	I_h [%I_n]												
1	2,12	10,15	20,25	30,35	40,42	50,42	60,50	70,52	80,51	90,50	100,41	111,96	111,96
2	0,11	0,13	0,10	0,09	0,10	0,11	0,11	0,11	0,09	0,09	0,11	0,18	0,18
3	0,13	0,11	0,13	0,12	0,11	0,13	0,13	0,16	0,13	0,15	0,14	0,09	0,16
4	0,09	0,04	0,06	0,05	0,03	0,04	0,04	0,06	0,09	0,10	0,11	0,11	0,11
5	0,23	0,57	0,67	0,64	0,46	0,41	0,31	0,26	0,18	0,23	0,22	0,27	0,67
6	0,02	0,02	0,05	0,05	0,03	0,04	0,06	0,07	0,07	0,08	0,08	0,09	0,09
7	0,34	0,44	0,37	0,38	0,27	0,25	0,25	0,29	0,32	0,32	0,33	0,35	0,44
8	0,03	0,04	0,07	0,07	0,07	0,08	0,09	0,10	0,10	0,10	0,09	0,09	0,10
9	0,05	0,06	0,04	0,05	0,05	0,05	0,06	0,07	0,06	0,06	0,06	0,05	0,07
10	0,05	0,03	0,03	0,05	0,05	0,05	0,05	0,06	0,08	0,08	0,08	0,09	0,09
11	0,62	0,43	0,42	0,52	0,57	0,53	0,40	0,30	0,22	0,18	0,16	0,15	0,62
12	0,01	0,03	0,04	0,05	0,05	0,05	0,06	0,07	0,08	0,08	0,08	0,08	0,08
13	0,30	0,33	0,40	0,29	0,16	0,23	0,27	0,27	0,26	0,25	0,23	0,22	0,40
14	0,03	0,04	0,06	0,08	0,09	0,09	0,09	0,10	0,10	0,11	0,11	0,13	0,13
15	0,06	0,07	0,07	0,08	0,09	0,08	0,08	0,09	0,09	0,09	0,08	0,11	0,11
16	0,05	0,05	0,07	0,08	0,09	0,11	0,12	0,13	0,14	0,15	0,16	0,14	0,16
17	0,31	0,33	0,28	0,36	0,22	0,21	0,27	0,23	0,19	0,17	0,17	0,14	0,36
18	0,02	0,03	0,02	0,06	0,07	0,07	0,07	0,08	0,09	0,10	0,10	0,10	0,10
19	0,11	0,29	0,20	0,15	0,29	0,24	0,13	0,24	0,33	0,35	0,33	0,33	0,35
20	0,02	0,04	0,03	0,08	0,10	0,10	0,10	0,11	0,12	0,15	0,14	0,14	0,15
21	0,06	0,04	0,04	0,07	0,10	0,10	0,08	0,09	0,10	0,11	0,10	0,11	0,11
22	0,02	0,03	0,05	0,07	0,09	0,09	0,10	0,12	0,13	0,14	0,15	0,15	0,15
23	0,23	0,18	0,17	0,13	0,25	0,15	0,08	0,14	0,18	0,19	0,19	0,14	0,25
24	0,02	0,02	0,03	0,03	0,07	0,06	0,06	0,07	0,07	0,07	0,08	0,09	0,09
25	0,09	0,16	0,12	0,25	0,11	0,25	0,24	0,19	0,25	0,30	0,31	0,34	0,34
26	0,01	0,02	0,02	0,03	0,08	0,08	0,08	0,07	0,08	0,11	0,12	0,12	0,12
27	0,03	0,04	0,04	0,08	0,09	0,11	0,10	0,09	0,10	0,11	0,12	0,13	0,13
28	0,02	0,02	0,02	0,03	0,07	0,07	0,07	0,08	0,09	0,09	0,09	0,10	0,10
29	0,13	0,08	0,10	0,06	0,05	0,07	0,10	0,06	0,08	0,11	0,12	0,13	0,13
30	0,01	0,01	0,02	0,02	0,04	0,05	0,04	0,04	0,04	0,05	0,06	0,06	0,06
31	0,05	0,05	0,16	0,09	0,18	0,11	0,19	0,14	0,15	0,18	0,19	0,22	0,22
32	0,01	0,01	0,01	0,02	0,04	0,04	0,04	0,04	0,04	0,06	0,07	0,08	0,08
33	0,02	0,04	0,04	0,04	0,06	0,06	0,06	0,05	0,06	0,07	0,06	0,08	0,08
34	0,01	0,01	0,01	0,01	0,04	0,05	0,05	0,06	0,05	0,06	0,06	0,07	0,07
35	0,06	0,08	0,04	0,09	0,08	0,05	0,08	0,08	0,06	0,09	0,10	0,10	0,10
36	0,01	0,01	0,01	0,01	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,05	0,05
37	0,05	0,02	0,03	0,12	0,11	0,09	0,12	0,11	0,10	0,12	0,14	0,15	0,15
38	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,03	0,03	0,04	0,04	0,05	0,05
39	0,02	0,03	0,03	0,04	0,04	0,05	0,06	0,05	0,05	0,05	0,05	0,05	0,06
40	0,01	0,01	0,01	0,01	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,05	0,05
41	0,03	0,07	0,08	0,09	0,07	0,09	0,07	0,09	0,07	0,08	0,09	0,10	0,10
42	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03
43	0,04	0,08	0,09	0,06	0,07	0,10	0,07	0,09	0,08	0,09	0,11	0,12	0,12
44	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03
45	0,03	0,04	0,05	0,04	0,04	0,06	0,06	0,05	0,05	0,05	0,05	0,05	0,06
46	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03
47	0,02	0,06	0,08	0,08	0,09	0,07	0,08	0,08	0,08	0,08	0,09	0,10	0,10
48	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
49	0,03	0,06	0,06	0,07	0,07	0,06	0,06	0,07	0,07	0,08	0,09	0,10	0,10
50	0,01	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02
THC [%I_n]	0,94	1,08	1,10	1,13	1,03	0,97	0,89	0,85	0,87	0,93	0,94	0,98	1,13

Maximum values over harmonic order (from 2nd order, I_h = f(h)) / *Maximalwerte über Oberschwingungsordnung*: 0,67

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

Interharmonics / *Zwischenharmonische*

Rated current / *Nennstrom* [A]: 108,3

P [%P_n]	0 - 5	10	20	30	40	50	60	70	80	90	100	P_{max}	Max.
f [Hz]	I_h [%I_n]												
75	0,04	0,03	0,04	0,04	0,05	0,06	0,06	0,07	0,08	0,09	0,10	0,11	0,11
125	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,05	0,04	0,04	0,05	0,05	0,05
175	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,03	0,04	0,04
225	0,04	0,05	0,03	0,05	0,05	0,05	0,05	0,05	0,04	0,04	0,04	0,04	0,05
275	0,05	0,06	0,04	0,05	0,06	0,06	0,06	0,06	0,03	0,04	0,03	0,03	0,06
325	0,04	0,05	0,03	0,05	0,05	0,05	0,05	0,05	0,03	0,04	0,04	0,03	0,05
375	0,04	0,06	0,04	0,05	0,06	0,06	0,06	0,05	0,03	0,03	0,03	0,03	0,06
425	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,02	0,03	0,03	0,03	0,03
475	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03
525	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,03	0,03	0,03	0,03
575	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03
625	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03
675	0,02	0,03	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
725	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
775	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
825	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,03	0,04
875	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04
925	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04
975	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04	0,04
1025	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,05	0,05	0,04	0,05
1075	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04
1125	0,01	0,03	0,03	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04
1175	0,01	0,03	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04
1225	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,04	0,04	0,04	0,04
1275	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04
1325	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03
1375	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03
1425	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03
1475	0,01	0,02	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03
1525	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03
1575	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1625	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1675	0,01	0,01	0,01	0,02	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1725	0,01	0,01	0,02	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1775	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1825	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1875	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1925	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1975	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

Higher Frequencies components / *Höhere Frequenzen*

Rated current / *Nennstrom* [A]: 108,3

P [%P_n]	0 - 5	10	20	30	40	50	60	70	80	90	100	P_{max}	Max.
f [Hz]							I_h [%I_n]						
2,1	0,05	0,10	0,12	0,11	0,10	0,14	0,11	0,13	0,11	0,13	0,15	0,16	0,16
2,3	0,04	0,08	0,09	0,09	0,10	0,10	0,10	0,09	0,10	0,10	0,11	0,12	0,12
2,5	0,05	0,09	0,09	0,09	0,09	0,08	0,08	0,09	0,08	0,10	0,10	0,11	0,11
2,7	0,05	0,09	0,10	0,11	0,10	0,10	0,11	0,10	0,11	0,11	0,12	0,13	0,13
2,9	0,06	0,13	0,15	0,15	0,14	0,13	0,12	0,11	0,11	0,11	0,11	0,11	0,15
3,1	0,06	0,09	0,10	0,11	0,12	0,12	0,12	0,12	0,10	0,10	0,10	0,10	0,12
3,3	0,04	0,10	0,10	0,11	0,12	0,12	0,12	0,12	0,12	0,13	0,13	0,13	0,13
3,5	0,05	0,10	0,11	0,13	0,13	0,14	0,15	0,15	0,14	0,15	0,14	0,14	0,15
3,7	0,04	0,05	0,05	0,07	0,09	0,10	0,11	0,11	0,12	0,11	0,12	0,12	0,12
3,9	0,03	0,06	0,07	0,09	0,10	0,11	0,11	0,12	0,12	0,13	0,12	0,13	0,13
4,1	0,03	0,06	0,05	0,05	0,05	0,08	0,10	0,12	0,13	0,14	0,14	0,14	0,14
4,3	0,03	0,04	0,04	0,05	0,06	0,07	0,07	0,08	0,08	0,10	0,10	0,11	0,11
4,5	0,02	0,04	0,04	0,04	0,04	0,05	0,07	0,09	0,10	0,12	0,12	0,12	0,12
4,7	0,03	0,04	0,04	0,04	0,04	0,04	0,05	0,06	0,07	0,10	0,12	0,13	0,13
4,9	0,02	0,03	0,04	0,04	0,05	0,04	0,05	0,04	0,05	0,06	0,07	0,09	0,09
5,1	0,02	0,03	0,04	0,04	0,03	0,04	0,04	0,04	0,05	0,06	0,08	0,10	0,10
5,3	0,02	0,04	0,04	0,04	0,04	0,04	0,05	0,04	0,04	0,05	0,05	0,07	0,07
5,5	0,02	0,03	0,04	0,04	0,04	0,04	0,05	0,04	0,04	0,04	0,04	0,05	0,05
5,7	0,02	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04	0,04
5,9	0,02	0,03	0,03	0,03	0,03	0,04	0,05	0,04	0,04	0,04	0,04	0,04	0,05
6,1	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,05	0,04	0,04	0,04	0,04	0,05
6,3	0,02	0,02	0,02	0,02	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04	0,04
6,5	0,02	0,02	0,02	0,02	0,03	0,03	0,04	0,05	0,04	0,04	0,04	0,04	0,05
6,7	0,02	0,02	0,02	0,02	0,02	0,02	0,04	0,04	0,04	0,04	0,04	0,04	0,04
6,9	0,02	0,02	0,02	0,02	0,02	0,02	0,04	0,03	0,04	0,04	0,04	0,04	0,04
7,1	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,04	0,04	0,04	0,04	0,04	0,04
7,3	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04
7,5	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,04	0,03	0,03	0,03	0,03	0,04
7,7	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03
7,9	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,1	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,3	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,5	0,02	0,03	0,03	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,7	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,9	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03

Note / *Anmerkung*:

The stated harmonics are maximum values of all 3 phases. / *Die angegebenen Harmonischenwerte sind Maximalwerte über alle 3 Phasen.*

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

SUN2000-185KTL-H1 (FW: V300R001)

Harmonics / *Harmonische*

Rated current / *Nennstrom* [A]: 126,3

P [%P_n]	0 - 5	10	20	30	40	50	60	70	80	90	100	P_{max}	Max.
Order / *Ordnung*	I_h [%I_n]												
1	2,14	10,16	20,25	30,34	40,38	50,45	60,46	70,50	80,40	90,37	100,27	105,58	105,58
2	0,07	0,06	0,08	0,08	0,10	0,15	0,16	0,18	0,22	0,21	0,21	0,30	0,30
3	0,12	0,12	0,12	0,14	0,11	0,14	0,16	0,19	0,13	0,17	0,18	0,10	0,19
4	0,06	0,05	0,06	0,04	0,06	0,07	0,08	0,09	0,12	0,13	0,14	0,13	0,14
5	0,30	0,51	0,41	0,27	0,18	0,31	0,24	0,20	0,16	0,17	0,18	0,15	0,51
6	0,02	0,02	0,05	0,03	0,04	0,05	0,06	0,06	0,06	0,07	0,06	0,07	0,07
7	0,20	0,36	0,49	0,41	0,31	0,27	0,28	0,32	0,32	0,34	0,37	0,35	0,49
8	0,02	0,03	0,05	0,04	0,05	0,06	0,07	0,08	0,09	0,08	0,08	0,09	0,09
9	0,03	0,04	0,03	0,04	0,05	0,04	0,05	0,05	0,04	0,05	0,04	0,06	0,06
10	0,03	0,03	0,05	0,04	0,06	0,07	0,07	0,09	0,08	0,08	0,07	0,08	0,09
11	0,55	0,37	0,35	0,50	0,47	0,36	0,26	0,18	0,16	0,12	0,10	0,12	0,55
12	0,01	0,01	0,05	0,04	0,05	0,05	0,06	0,06	0,07	0,06	0,06	0,07	0,07
13	0,26	0,23	0,35	0,15	0,19	0,22	0,22	0,24	0,22	0,18	0,16	0,40	0,40
14	0,03	0,03	0,05	0,08	0,08	0,08	0,09	0,11	0,11	0,10	0,09	0,10	0,11
15	0,06	0,06	0,07	0,06	0,07	0,05	0,07	0,07	0,07	0,07	0,09	0,06	0,09
16	0,03	0,03	0,08	0,08	0,09	0,10	0,11	0,13	0,13	0,14	0,13	0,11	0,14
17	0,26	0,32	0,23	0,32	0,17	0,24	0,21	0,16	0,16	0,14	0,11	0,10	0,32
18	0,01	0,02	0,03	0,06	0,07	0,06	0,07	0,07	0,08	0,08	0,08	0,09	0,09
19	0,12	0,23	0,13	0,26	0,22	0,12	0,19	0,29	0,28	0,27	0,26	0,62	0,62
20	0,01	0,03	0,04	0,08	0,09	0,10	0,10	0,13	0,14	0,14	0,14	0,12	0,14
21	0,05	0,04	0,05	0,08	0,09	0,08	0,11	0,11	0,10	0,09	0,12	0,10	0,12
22	0,02	0,02	0,04	0,09	0,09	0,09	0,09	0,11	0,12	0,13	0,12	0,13	0,13
23	0,21	0,10	0,05	0,10	0,15	0,03	0,10	0,15	0,14	0,14	0,11	0,20	0,21
24	0,01	0,02	0,03	0,05	0,05	0,05	0,06	0,06	0,07	0,08	0,08	0,09	0,09
25	0,06	0,17	0,15	0,16	0,17	0,22	0,15	0,22	0,26	0,27	0,29	0,66	0,66
26	0,01	0,01	0,02	0,06	0,07	0,08	0,07	0,09	0,11	0,12	0,12	0,11	0,12
27	0,03	0,03	0,04	0,07	0,07	0,07	0,06	0,06	0,09	0,08	0,09	0,08	0,09
28	0,01	0,02	0,02	0,07	0,07	0,07	0,07	0,08	0,08	0,09	0,08	0,10	0,10
29	0,10	0,06	0,02	0,10	0,05	0,08	0,05	0,08	0,09	0,11	0,11	0,13	0,13
30	0,01	0,01	0,02	0,03	0,04	0,04	0,04	0,04	0,05	0,06	0,06	0,06	0,06
31	0,04	0,02	0,10	0,14	0,07	0,15	0,12	0,13	0,15	0,16	0,17	0,40	0,40
32	0,01	0,01	0,02	0,02	0,04	0,05	0,04	0,05	0,06	0,07	0,08	0,07	0,08
33	0,02	0,03	0,03	0,05	0,05	0,06	0,05	0,06	0,06	0,05	0,06	0,07	0,07
34	0,01	0,01	0,01	0,03	0,05	0,05	0,05	0,05	0,06	0,06	0,06	0,06	0,06
35	0,03	0,08	0,09	0,03	0,06	0,06	0,07	0,06	0,08	0,09	0,09	0,07	0,09
36	0,01	0,01	0,01	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04
37	0,04	0,06	0,06	0,05	0,10	0,09	0,09	0,09	0,11	0,12	0,12	0,27	0,27
38	0,01	0,01	0,01	0,01	0,02	0,03	0,03	0,03	0,04	0,05	0,05	0,04	0,05
39	0,02	0,03	0,03	0,04	0,05	0,06	0,05	0,05	0,05	0,05	0,05	0,05	0,06
40	0,01	0,01	0,01	0,01	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04
41	0,02	0,04	0,04	0,07	0,07	0,05	0,07	0,07	0,08	0,09	0,09	0,07	0,09
42	0,01	0,01	0,01	0,01	0,02	0,03	0,02	0,02	0,02	0,03	0,03	0,03	0,03
43	0,02	0,06	0,06	0,08	0,07	0,06	0,08	0,07	0,08	0,09	0,10	0,19	0,19
44	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03
45	0,03	0,04	0,04	0,04	0,05	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,05
46	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,03
47	0,02	0,06	0,07	0,05	0,05	0,07	0,07	0,07	0,07	0,09	0,09	0,07	0,09
48	0,01	0,01	0,01	0,01	0,02	0,02	0,01	0,01	0,02	0,02	0,03	0,02	0,03
49	0,02	0,04	0,05	0,03	0,04	0,06	0,06	0,06	0,07	0,08	0,09	0,13	0,13
50	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02
THC [%I_n]	0,83	0,91	0,92	0,93	0,81	0,82	0,76	0,83	0,84	0,85	0,87	1,34	1,34
Maximum values over harmonic order (from 2nd order, I_h = f(h)) / *Maximalwerte über Oberschwingungsordnung*: 0,66													

3. Annex 3 – Extract from the test report

BUREAU VERITAS

Extract from the test report - Part 1: Power Quality

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4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

Interharmonics / *Zwischenharmonische*

Rated current / *Nennstrom* [A]: 126,3

P [%P_n]	0 - 5	10	20	30	40	50	60	70	80	90	100	P_{max}	Max.
f [Hz]	I_h [%I_n]												
75	0,02	0,03	0,03	0,04	0,04	0,05	0,06	0,07	0,08	0,09	0,10	0,14	0,10
125	0,01	0,02	0,02	0,03	0,03	0,04	0,04	0,04	0,06	0,06	0,06	0,06	0,06
175	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04
225	0,01	0,02	0,02	0,02	0,02	0,04	0,04	0,04	0,06	0,07	0,07	0,06	0,07
275	0,01	0,01	0,02	0,02	0,02	0,05	0,04	0,04	0,05	0,05	0,05	0,05	0,05
325	0,01	0,01	0,02	0,02	0,02	0,04	0,04	0,04	0,06	0,06	0,06	0,05	0,06
375	0,01	0,02	0,02	0,02	0,02	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04
425	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,03
475	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
525	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,03
575	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03
625	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02	0,03
675	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03
725	0,01	0,02	0,02	0,02	0,02	0,03	0,02	0,03	0,03	0,03	0,03	0,02	0,03
775	0,01	0,02	0,03	0,02	0,02	0,03	0,02	0,03	0,03	0,03	0,03	0,03	0,03
825	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,03	0,04
875	0,02	0,03	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,03	0,04
925	0,01	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,03	0,04
975	0,01	0,03	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04
1025	0,01	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,03	0,04
1075	0,01	0,02	0,03	0,03	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04
1125	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04
1175	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04
1225	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04
1275	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,04	0,05	0,04
1325	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03
1375	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,03	0,03
1425	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02
1475	0,01	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02
1525	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02
1575	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02
1625	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1675	0,01	0,01	0,01	0,01	0,01	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02
1725	0,01	0,01	0,01	0,01	0,01	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02
1775	0,01	0,01	0,01	0,01	0,01	0,02	0,01	0,02	0,02	0,02	0,02	0,02	0,02
1825	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02
1875	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02
1925	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02
1975	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,01

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

Higher Frequencies components / *Höhere Frequenzen*

Rated current / *Nennstrom* [A]: 126,3

P [%P_n]	0 - 5	10	20	30	40	50	60	70	80	90	100	P_{max}	Max.
f [Hz]	I_h [%I_n]												
2,1	0,03	0,08	0,08	0,10	0,11	0,09	0,11	0,10	0,11	0,13	0,14	0,21	0,14
2,3	0,03	0,07	0,08	0,07	0,08	0,09	0,08	0,09	0,09	0,10	0,10	0,08	0,10
2,5	0,04	0,07	0,07	0,06	0,06	0,08	0,07	0,08	0,08	0,09	0,10	0,14	0,10
2,7	0,04	0,07	0,10	0,10	0,10	0,10	0,08	0,09	0,10	0,10	0,11	0,13	0,11
2,9	0,06	0,12	0,11	0,11	0,11	0,10	0,10	0,09	0,09	0,10	0,10	0,08	0,12
3,1	0,05	0,09	0,09	0,10	0,10	0,10	0,10	0,09	0,09	0,09	0,09	0,10	0,10
3,3	0,04	0,07	0,10	0,10	0,10	0,10	0,10	0,10	0,11	0,11	0,11	0,09	0,11
3,5	0,05	0,09	0,09	0,10	0,12	0,13	0,12	0,12	0,12	0,12	0,11	0,07	0,13
3,7	0,03	0,05	0,06	0,07	0,08	0,09	0,09	0,10	0,10	0,10	0,09	0,07	0,10
3,9	0,03	0,06	0,06	0,08	0,09	0,10	0,10	0,10	0,11	0,11	0,12	0,06	0,12
4,1	0,03	0,05	0,04	0,05	0,06	0,09	0,11	0,11	0,12	0,12	0,12	0,05	0,12
4,3	0,02	0,03	0,04	0,04	0,05	0,06	0,07	0,07	0,09	0,09	0,10	0,06	0,10
4,5	0,02	0,03	0,04	0,03	0,04	0,05	0,07	0,09	0,10	0,10	0,10	0,05	0,10
4,7	0,02	0,04	0,04	0,04	0,04	0,04	0,05	0,06	0,09	0,10	0,11	0,04	0,11
4,9	0,02	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,06	0,07	0,09	0,05	0,09
5,1	0,01	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,06	0,08	0,09	0,05	0,09
5,3	0,02	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04	0,05	0,07	0,05	0,07
5,5	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,05	0,04	0,05
5,7	0,01	0,02	0,02	0,03	0,03	0,04	0,03	0,03	0,03	0,04	0,04	0,04	0,04
5,9	0,01	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04	0,03	0,04
6,1	0,01	0,02	0,02	0,03	0,03	0,04	0,04	0,04	0,03	0,03	0,04	0,03	0,04
6,3	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
6,5	0,01	0,02	0,02	0,02	0,02	0,04	0,04	0,04	0,04	0,03	0,04	0,03	0,04
6,7	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,03	0,04
6,9	0,01	0,01	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
7,1	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
7,3	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
7,5	0,01	0,01	0,01	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
7,7	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
7,9	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,1	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,3	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,5	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,7	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
8,9	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03

Note / *Anmerkung*:

The stated harmonics are maximum values of all 3 phases. / *Die angegebenen Harmonischenwerte sind Maximalwerte über alle 3 Phasen.*

3. Annex 3 – Extract from the test report

4.3 SYSTEM PERTURBATIONS / *NETZRÜCKWIRKUNGEN*

4.3.5 Unbalances of the current / *Umsymmetrien des Stroms*

SUN2000-185KTL-H1 (FW: V300R001)

P [%P_n]	P_+* [kW]	U_{1+}* [V]	U_{1-}* [V]	I_{1+}* [A]	I_{1-}* [A]	u_i* [%I_{1+}]
0 - 5	3,70	463,21	1,75	2,66	0,07	2,63
10	17,77	463,23	1,73	12,78	0,09	0,67
20	35,45	463,27	1,74	25,51	0,10	0,40
30	53,14	463,29	1,73	38,23	0,16	0,43
40	70,74	463,33	1,71	50,90	0,18	0,36
50	88,38	463,37	1,69	63,58	0,24	0,37
60	105,95	463,41	1,69	76,21	0,27	0,36
70	123,49	463,46	1,68	88,82	0,32	0,36
80	140,95	463,51	1,67	101,37	0,28	0,28
90	158,46	463,57	1,66	113,94	0,32	0,28
100	175,86	463,64	1,66	126,44	0,34	0,27
106	185,21	463,67	1,66	133,15	0,28	0,21
Maximum unsymmetry / *maximale Unsymmetrie* u_{imax} (≥10%P_n)					0,67	

Note / *Anmerkung*:
The current unbalance of the *SUN2000-185KTL-H1* can be applied to the *SUN2000-168KTL-H1* directly. /
Die Unsymmetrie des SUN2000-185KTL-H1 *können auf den* SUN2000-168KTL-H1 *direkt übertragen werden.*

Figure 8 – Results of power quality from [10]

3. Annex 3 – Extract from the test report

3.2. Active power [7] & [11]

4.1 ACTIVE POWER OUTPUT / *WIRKLEISTUNGSABGABE*

4.1.1 Active power peaks / *Wirkleistungsspitzen*

SUN2000-168KTL-H1 (FW: V300R001)

Active power peaks / *Wirkleistungsspitzen* [kW]		Normalised active power peaks / *Normierte Wirkleistungsspitzen* [p.u. base / *Basis* P_n]		Number of 10-minute records used / *Anzahl der verwendeten 10-Minuten-Datensätze*
$P_{0,2}$	168,50	$p_{0,2} = P_{0,2}/P_n$	1,12	2
P_{60}	167,91	$p_{60} = P_{60}/P_n$	1,12	
P_{600}	167,87	$p_{600} = P_{600}/P_n$	1,12	

SUN2000-185KTL-H1 (FW: V300R001)

Active power peaks / *Wirkleistungsspitzen* [kW]		Normalised active power peaks / *Normierte Wirkleistungsspitzen* [p.u. base / *Basis* P_n]		Number of 10-minute records used / *Anzahl der verwendeten 10-Minuten-Datensätze*
$P_{0,2}$	185,95	$p_{0,2} = P_{0,2}/P_n$	1,06	2
P_{60}	185,66	$p_{60} = P_{60}/P_n$	1,06	
P_{600}	185,61	$p_{600} = P_{600}/P_n$	1,06	

Note / *Anmerkung*:

The units in the series provide overload capacity (see technical data of the units on p.2). The tests show the maximum active power (P_{max}) of the units.

Die Einheiten in der Produktfamilie verfügen Überlastfäigkeit (siehe technische Daten der Einheiten auf S.2). Die Prüfungen zeigen die max. Wirkleistung (P_{max}) der EZE.

3. Annex 3 – Extract from the test report

4.1 ACTIVE POWER OUTPUT / *WIRKLEISTUNGSABGABE*

4.1.2 Operating power limited by grid operator / *Leistungsbegrenzter Betrieb durch den Netzbetreiber*

The unit is able to run at reduced power. / *Die EZEs können mit reduzierter Leistung betrieben werden.*	☒ Yes / *Ja*	☐ No / *Nein*
Disconnection from the grid at external active power set-points at / *Trennung vom Netz bei Wirkleistungssollwertvorgabe von*:	At 0% setpoint the PGU stays connected without power feeding. The PGU can be disconnected from grid using the “Start/Stop control” or set the parameter “Shutdown at 0% power limit” to “Enable”. / *Bei 0% sollwertvorgabe bleibt die EZE am Netz ohne Einspeisung. Die EZE kann mittels Parameter “Start/Stop control” oder “Shutdown at 0% power limit” vom Netz getrennt werden.*	
SUN2000-168KTL-H1 (FW: V300R001)		
Max. deviation of power setting / *Maximale Sollwertabweichung der Wirkleistung*	Exceeding / *Überschreitung*: 0,5 kW	Undercut / *Unterschreitung*: -1,1 kW
Settling time of the power output after a change in set-point with minimal gradient: / *Einschwingzeit der Leistung für einen Sollwertsprung mit minimalem Gradienten:* ±0,350 P_{max}/s	$P_{70\%} \rightarrow P_{50\%}$	Time / *Zeit*: 39,6 s Gradient: -0,350%P_{max}/s
	$P_{50\%} \rightarrow P_{70\%}$	Time / *Zeit*: 38,0 s Gradient: 0,350%P_{max}/s
Settling time of the power output after a change in set-point with maximum gradient / *Einschwingzeit der Leistung für einen Sollwertsprung mit maximalem Gradienten*: ±0,640 P_{max}/s	$P_{90\%} \rightarrow P_{10\%}$	Time / *Zeit*: 105,2 s Gradient: -0,638%P_{max}/s
	$P_{10\%} \rightarrow P_{90\%}$	Time / *Zeit*: 105,0 s Gradient: 0,641%P_{max}/s
SUN2000-185KTL-H1 (FW: V300R001)		
Max. deviation of power setting / *Maximale Sollwertabweichung der Wirkleistung*	Exceeding / *Überschreitung*: 1,0 kW	Undercut / *Unterschreitung*: -0,7 kW
Settling time of the power output after a change in set-point with minimal gradient: / *Einschwingzeit der Leistung für einen Sollwertsprung mit minimalem Gradienten:* ±0,350 P_{max}/s	$P_{70\%} \rightarrow P_{50\%}$	Time / *Zeit*: 40,6 s Gradient: -0,350%P_{max}/s
	$P_{50\%} \rightarrow P_{70\%}$	Time / *Zeit*: 40,6 s Gradient: 0,351%P_{max}/s
Settling time of the power output after a change in set-point with maximum gradient / *Einschwingzeit der Leistung für einen Sollwertsprung mit maximalem Gradienten*: ±0,640 P_{max}/s	$P_{90\%} \rightarrow P_{10\%}$	Time / *Zeit*: 111,2 s Gradient: -0,642%P_{max}/s
	$P_{10\%} \rightarrow P_{90\%}$	Time / *Zeit*: 111,6 s Gradient: 0,637%P_{max}/s

3. Annex 3 – Extract from the test report

4.1 ACTIVE POWER OUTPUT / *WIRKLEISTUNGSABGABE*

4.1.3 Active power feed-in as a function of grid frequency / *Wirkleistungseinspeisung in Abhängigkeit der Netzfrequenz*

SUN2000-185KTL-H1 (FW: V300R001)		
Overfrequency / *Überfrequenz*	Mean power gradient at overfrequency / *Mittlerer Gradient der Wirkleistung zum Zeitpunkt der Frequenzüberhöhung*	Mean gradient / *Mittlerer Gradient* -39,97%P_{mom}/Hz
	Max. Settling time / *Max. Einschwingzeit*	0,4 s
	Power gradient after recovery of overfrequency / *Gradient der Wirkleistung nach Rückkehr aus Überfrequenz*	Mean gradient / *Mittlerer Gradient:* 9,0%P_n/min Max. gradient / *Max. Gradient:* 10,0%P_n/min
Underfrequency / *Unterfrequenz*	Mean power gradient at underfrequency / *Mittlerer Gradient der Wirkleistung zum Zeitpunkt der Frequenzunterschreitung*	Mean gradient / *Mittlerer Gradient* 39,71%P_{mom}/Hz
	Max. Settling time / *Max. Einschwingzeit*	0,4 s
	Power gradient after recovery of underfrequency / *Gradient der Wirkleistung nach Rückkehr aus Unterfrequenz*	Mean gradient / *Mittlerer Gradient:* -9,0%P_n/min Max. gradient / *Max. Gradient:* -10,0%P_n/min

Note */ Anmerkung*:

The settling time and active power gradient results of the *SUN2000-185KTL-H1* can be applied to *SUN2000-168KTL-H1* directly. /

Die Einschwingzeiten und Gradienten der Wirkleistung des SUN2000-185KTL-H1 *können auf den* SUN2000-168KTL-H1 *direkt übertragen werden.*

Figure 9 – Results of active power control from [11]

3. Annex 3 – Extract from the test report

The PGUs are able to be operated at reduced power [7].

At 0% setpoint the PGUs stay connected without power feeding. The PGUs can be disconnected from grid using the “Start/Stop control” or set the parameter “Shutdown at 0% power limit” to “Enable” (see *Annex 5 – Certification-relevant parameters*).

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4.1 ACTIVE POWER OUTPUT

4.1.2 Operating power limited by grid operator

a) Determine the setpoint accuracy

SUN2000-168KTL-H1 (FW: V300R001)

Active power step	Setpoint value		Actual value		Deviation	
[%Pn]	[kW]	[%Pn]	[kW]	[%Pn]	[kW]	[%Pn]
Max. (112)	168,0	112,0	167,4	111,6	-0,6	-0,4
100	150,0	100,0	149,0	99,4	-1,0	-0,6
90	135,0	90,0	133,9	89,3	-1,1	-0,7
80	120,0	80,0	118,9	79,3	-1,1	-0,7
70	105,0	70,0	105,5	70,4	0,5	0,4
60	90,0	60,0	90,5	60,3	0,5	0,3
50	75,0	50,0	75,4	50,3	0,4	0,3
40	60,0	40,0	60,3	40,2	0,3	0,2
30	45,0	30,0	45,2	30,2	0,2	0,2
20	30,0	20,0	30,1	20,1	0,1	0,1
10	15,0	10,0	15,0	10,0	0,0	0,0
0	0,0	0,0	0,0	0,0	0,0	0,0

	Power setpoint [%Pn]	Deviation [kW]	Deviation [%Pn]
Maximum active power above the defined setpoint (1-minute mean)	70	0,5	0,4
Maximum active power below the defined setpoint (1-minute mean)	80	-1,1	-0,7
Grid disconnection at xx% of Pn	*		

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4.1 ACTIVE POWER OUTPUT

SUN2000-185KTL-H1 (FW: V300R001)

Active power step	Setpoint value		Actual value		Deviation	
[%Pn]	[kW]	[%Pn]	[kW]	[%Pn]	[kW]	[%Pn]
Max. (106)	185,0	105,7	184,7	105,6	-0,3	-0,2
100	175,0	100,0	175,6	100,3	0,6	0,3
90	157,5	90,0	157,1	89,8	-0,4	-0,2
80	140,0	80,0	140,5	80,3	0,5	0,3
70	122,5	70,0	122,1	69,8	-0,4	-0,2
60	105,0	60,0	105,5	60,3	0,5	0,3
50	87,5	50,0	87,0	49,7	-0,5	-0,3
40	70,0	40,0	70,4	40,2	0,4	0,2
30	52,5	30,0	51,8	29,6	-0,7	-0,4
20	35,0	20,0	35,2	20,1	0,2	0,1
10	17,5	10,0	18,5	10,6	1,0	0,6
0	0,0	0,0	0,1	0,1	0,1	0,1

	Power setpoint [%Pn]	Deviation [kW]	Deviation [%Pn]
Maximum active power above the defined setpoint (1-minute mean)	10	1,0	0,6
Maximum active power below the defined setpoint (1-minute mean)	30	-0,7	-0,4
Grid disconnection at xx% of Pn	*		

Figure 10 – Results of active power control from [7]

3. Annex 3 – Extract from the test report

The active power gradient is implemented on the PGU level.

Only one Interface for specifying active power implemented on the PGU. Separate specifying active power by grid operator and direct seller is not possible. For prioritization of different setpoints must be carried out on the plant level e.g. in the superimposed PGS controller.

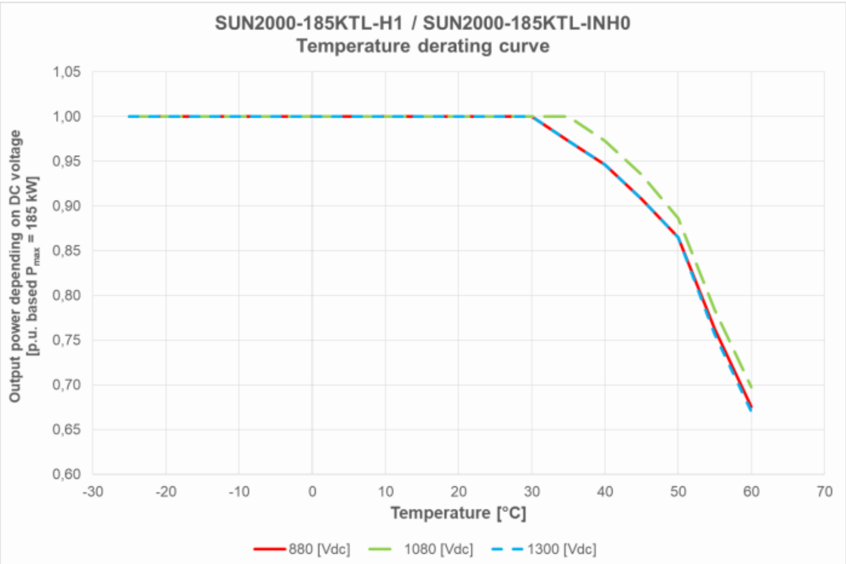
The max. active power output of the PGU is dependent on ambient temperature [15]:

Herstellererklärung zur Einhaltung der technischen Anforderungen der VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11
Manufacturer's declaration for compliance to technical requirements of the VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11
Datum / *Date*: 2019-12-19

Anhang 5 / Annex 5:

Active power output dependent on ambient temperature:

SUN2000-185KTL-H1 Temperature derating curve			
Temperature [°C]	Output power depending on DC voltage [kW]		
	880 [Vdc]	1080 [Vdc]	1300 [Vdc]
-25	185	185	185
-20	185	185	185
-15	185	185	185
-10	185	185	185
-5	185	185	185
0	185	185	185
5	185	185	185
10	185	185	185
15	185	185	185
20	185	185	185
25	185	185	185
30	185	185	185
35	180	185	180
40	175	180	175
45	168	173	168
50	160	164	160
55	141	145	140
60	125	129	124



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3. Annex 3 – Extract from the test report

Herstellererklärung zur Einhaltung der technischen Anforderungen der VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11
Manufacturer's declaration for compliance to technical requirements of the VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11
Datum / *Date*: 2019-12-19

SUN2000-168KTL-H1 Temperature derating curve			
Temperature [°C]	Output power depending on DC voltage [kW]		
	880 [Vdc]	1080 [Vdc]	1300 [Vdc]
-25	168	168	168
-20	168	168	168
-15	168	168	168
-10	168	168	168
-5	168	168	168
0	168	168	168
5	168	168	168
10	168	168	168
15	168	168	168
20	168	168	168
25	168	168	168
30	168	168	168
35	168	168	168
40	168	168	168
45	168	168	168
50	160	164	160
55	141	145	140
60	125	129	124

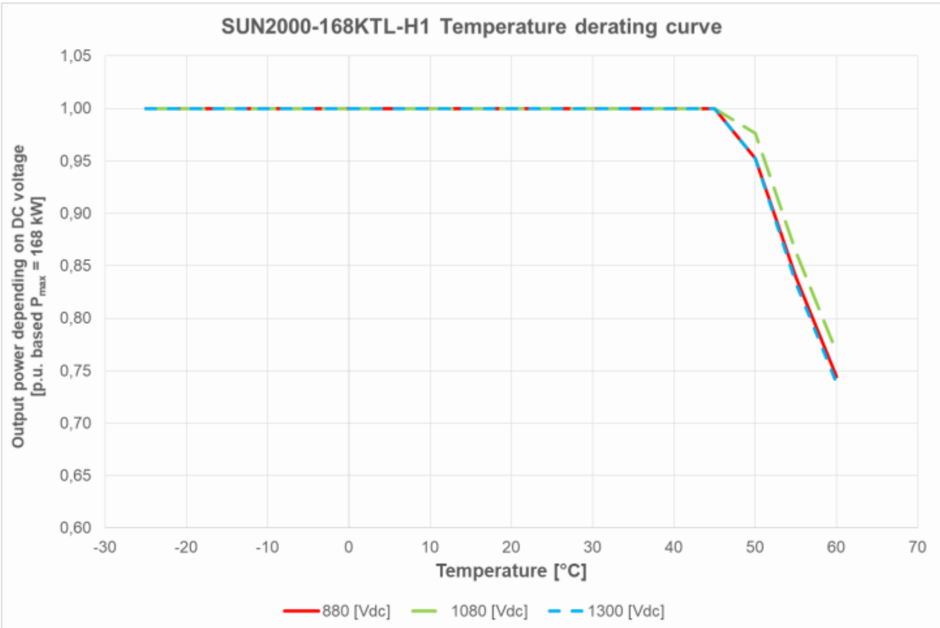

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Figure 11 – Active power output dependent on ambient temperature from [15]

3. Annex 3 – Extract from the test report

3.3. Reactive power [11]

4.2 Reactive power provision / *Blindleistungsbereitstellung*

4.2.1 Reactive power response in the normal operation (Q = 0 kvar) / *Blindleistungsverhalten im Normalbetrieb (Q = 0 kvar)*

4.2.2 Measuring the maximum reactive power range (PQ diagram) / Vermessung des maximalen Blindleistungsstellberich (PQ-Diagramm)

SUN2000-168KTL-H1 (FW: V300R001)

	P/P_n [%]	Q_{ind} [kvar]	Q_0 [kvar]	Q_{cap} [kvar]	P/P_n [%]	Q_{ind} [kvar]	Q_0 [kvar]	Q_{cap} [kvar]
Control of reactive power in normal operation mode and maximum reactive power range / *Blindleistungsverhalten im Normalbetrieb und maximaler Blindleistungsstellbereich*	0 … 5	-100,9	---	100,7	60	-101,2	---	100,2
	10	-101,0	---	100,6	70	-101,4	---	100,1
	20	-101,1	---	100,6	80	-101,5	---	100,1
	30	-101,1	---	100,5	90	-100,8	---	99,2
	40	-101,2	---	100,7	100	-76,6	---	74,6
	50	-101,1	---	100,3	P_{max}	-1,0	---	-1,0

SUN2000-185KTL-H1 (FW: V300R001)

	P/P_n [%]	Q_{ind} [kvar]	Q_0 [kvar]	Q_{cap} [kvar]	P/P_n [%]	Q_{ind} [kvar]	Q_0 [kvar]	Q_{cap} [kvar]
Control of reactive power in normal operation mode and maximum reactive power range / *Blindleistungsverhalten im Normalbetrieb und maximaler Blindleistungsstellbereich*	0	-111,6	0,1	111,5	60	-112,2	0,5	110,8
	10	-111,6	0,1	111,3	70	-112,3	0,6	110,7
	20	-111,8	0,2	111,2	80	-112,4	0,7	110,6
	30	-111,8	0,3	111,1	90	-98,4	0,8	96,4
	40	-111,9	0,4	111,0	100	-61,4	0,9	59,1
	50	-112,1	0,4	110,9	P_{max}	-1,2	1.0	-1,2

Note / *Anmerkung*:

The reactive power results in the normal operation of the *SUN2000-185KTL-H1* can be applied to *SUN2000-168KTL-H1* directly. /

Die Blindleistungsergebnisse im Normalbetrieb des SUN2000-185KTL-H1 *können auf den* SUN2000-168KTL-H1 *direkt übertragen werden.*

3. Annex 3 – Extract from the test report

4.2 Reactive power provision / *Blindleistungsbereitstellung*

4.2.3 Measuring separate operating points in the voltage-dependent PQ diagram / *Vermessung einzelner Arbeitspunkte des spannungsabhängigen PQ-Diagramms*

SUN2000-168KTL-H1 (FW: V300R001)

Working points of the voltage dependent P-Q-diagram / *Arbeitspunkte des spannungsabhängigen P-Q-Diagramms*

WP / *AP*	U/U$_n$ [%]	P/P$_n$ [%]	Q [kvar]
1 ind.	90,0	0,6	-100,8
2 ind.	90,1	9,6	-100,9
3 ind.	90,1	19,6	-100,9
4 ind.	90,1	29,6	-101,0
5 ind.	90,1	39,5	-101,1
6 ind.	90,1	49,5	-101,1
7 ind.	90,1	59,5	-101,3
8 ind.	90,1	69,5	-101,4
9 ind.	90,1	79,5	-95,2
10 ind.	90,1	89,7	-72,1
11 ind.	90,2	99,8	-29,4
1 cap. / *kap.*	90,1	1,4	100,9
2 cap. / *kap.*	90,1	10,4	100,7
3 cap. / *kap.*	90,1	20,3	100,6
4 cap. / *kap.*	90,1	30,3	100,5
5 cap. / *kap.*	90,3	40,3	100,4
6 cap. / *kap.*	90,4	50,3	100,4
7 cap. / *kap.*	90,5	60,3	100,2
8 cap. / *kap.*	90,6	70,3	100,2
9 cap. / *kap.*	90,7	80,3	93,7
10 cap. / *kap.*	90,7	90,2	70,5
11 cap. / *kap.*	90,2	100,1	27,7

WP / *AP*	U/U$_n$ [%]	P/P$_n$ [%]	Q [kvar]
1 ind.	110,1	0,6	-100,8
2 ind.	110,1	9,6	-100,9
3 ind.	110,1	19,6	-101,0
4 ind.	110,1	29,6	-101,1
5 ind.	110,1	39,6	-101,2
6 ind.	110,1	49,6	-101,2
7 ind.	110,1	59,5	-101,3
8 ind.	110,1	69,5	-101,4
9 ind.	110,1	79,5	-101,5
10 ind.	110,1	89,5	-100,8
11 ind.	110,1	99,6	-76,5
12 ind.	110,2	113,0	-1,0
1 cap. / *kap.*	110,1	1,4	100,8
2 cap. / *kap.*	110,1	10,4	100,7
3 cap. / *kap.*	110,1	20,4	100,6
4 cap. / *kap.*	110,1	30,4	100,5
5 cap. / *kap.*	110,1	40,5	100,7
6 cap. / *kap.*	110,1	50,3	100,3
7 cap. / *kap.*	110,1	60,3	100,2
8 cap. / *kap.*	110,1	70,3	100,2
9 cap. / *kap.*	110,1	80,3	100,1
10 cap. / *kap.*	110,2	90,3	99,2
11 cap. / *kap.*	110,2	100,2	74,7
12 cap. / *kap.*	110,2	113,0	-1,0

3. Annex 3 – Extract from the test report

4.2 Reactive power provision / *Blindleistungsbereitstellung*

SUN2000-185KTL-H1 (FW: V300R001)

Working points of the voltage dependent P-Q-diagram / *Arbeitspunkte des spannungsabhängigen P-Q-Diagramms*

WP / *AP*	U/U_n [%]	P/P_n [%]	Q [kvar]
1 ind.	90,0	0,5	-111,3
2 ind.	90,0	9,6	-111,4
3 ind.	90,0	19,6	-111,6
4 ind.	90,0	29,7	-111,7
5 ind.	90,0	39,7	-111,9
6 ind.	90,1	49,7	-112,0
7 ind.	90,1	59,7	-112,1
8 ind.	90,1	66,1	-112,2
9 ind.	90,1	79,6	-94,4
10 ind.	90,1	89,7	-60,3
11 ind.	90,1	96,4	-1,1
1 cap. / *kap.*	90,1	1,3	111,2
2 cap. / *kap.*	90,1	10,4	111,2
3 cap. / *kap.*	90,1	20,4	111,1
4 cap. / *kap.*	90,1	30,4	111,0
5 cap. / *kap.*	90,1	40,5	110,9
6 cap. / *kap.*	90,1	50,5	110,8
7 cap. / *kap.*	90,1	60,5	110,7
8 cap. / *kap.*	90,1	68,1	110,7
9 cap. / *kap.*	90,1	80,6	92,6
10 cap. / *kap.*	90,1	90,5	58,3
11 cap. / *kap.*	90,1	96,3	-1,1

WP / *AP*	U/U_n [%]	P/P_n [%]	Q [kvar]
1 ind.	110,0	0,6	-111,6
2 ind.	110,0	9,6	-111,7
3 ind.	110,0	19,7	-111,8
4 ind.	110,0	29,7	-111,9
5 ind.	110,0	39,7	-112,0
6 ind.	110,0	49,8	-112,0
7 ind.	110,1	59,8	-112,2
8 ind.	110,1	69,8	-112,3
9 ind.	110,1	79,9	-112,4
10 ind.	110,1	90,0	-98,4
11 ind.	110,1	100,1	-61,4
12 ind.	110,1	107,2	-1,2
1 cap. / *kap.*	110,1	1,3	111,4
2 cap. / *kap.*	110,1	10,4	111,3
3 cap. / *kap.*	110,1	20,4	111,2
4 cap. / *kap.*	110,1	30,5	111,1
5 cap. / *kap.*	110,1	40,5	111,0
6 cap. / *kap.*	110,1	50,5	110,8
7 cap. / *kap.*	110,1	60,6	110,7
8 cap. / *kap.*	110,1	70,5	110,6
9 cap. / *kap.*	110,1	80,6	110,6
10 cap. / *kap.*	110,1	90,6	96,3
11 cap. / *kap.*	110,1	100,5	59,1
12 cap. / *kap.*	110,1	107,1	-1,2

3. Annex 3 – Extract from the test report

4.2 Reactive power provision / *Blindleistungsbereitstellung*		
4.2.4 Reactive power following setpont / *Blindleistung nach Sollwertvorgabe*		
SUN2000-168KTL-H1 (FW: V300R001)		
Control of reactive power through set-point signal / *Blindleistungsregelung durch Sollwertvorgabe*	☐ Power factor / *Verschiebungsfaktor*	☒ Reactive power / *Blindleistung*
	P_{bin} at / *bei* Q_{max}	50% P_n
Longest settling time / *Längste Einschwingzeit*	Parameter	Settling time / *Einschwingzeit*
	Standard time / *Standardzeit* (125% Q_{max} /s)	1,6 s ($+Q_{max} \rightarrow -Q_{max}$)
	t < 60 s (1,660% Q_{max}/s)	118,0 s ($+Q_{max} \rightarrow -Q_{max}$)
SUN2000-185KTL-H1 (FW: V300R001)		
Control of reactive power through set-point signal / *Blindleistungsregelung durch Sollwertvorgabe*	☐ Power factor / *Verschiebungsfaktor*	☒ Reactive power / *Blindleistung*
	P_{bin} at / *bei* Q_{max}	50% P_n
Longest settling time / *Längste Einschwingzeit*	Parameter	Settling time / *Einschwingzeit*
	Standard time / *Standardzeit* (125% Q_{max} /s)	1,8 s ($+Q_{max} \rightarrow -Q_{max}$)
	t < 60 s (1,660% Q_{max}/s)	117,4 s ($+Q_{max} \rightarrow -Q_{max}$)
Control of reactive power through set-point signal / *Blindleistungsregelung durch Sollwertvorgabe*	☒ Power factor / *Verschiebungsfaktor* [1)]	☐ Reactive power / *Blindleistung*
	P_{bin} at / *bei* Q_{max}	50% P_n
Longest settling time / *Längste Einschwingzeit*	Parameter	Settling time / *Einschwingzeit*
	Fast settling time / *Schnelle Einschwingzeit* (3τ = 5 s)	6,2 s ($+Q_{max} \rightarrow -Q_{max}$)
	t < 60 s (3τ = 60 s)	73,2 s ($+Q_{max} \rightarrow -Q_{max}$)
Note / *Anmerkung*: For country code setting VDE-AR-N 4110:2018-11, the cosφ control function shows PT1 behaviour. The settling time was determined using a tolerance band of ±2% P_n. / *Für Ländereinstellung VDE-AR-N 4110:2018-11 die cosφ Regelungsfunktion zeigt PT1 Verhalten. Die Einschwingzeit wurde mit einem Toleranzband von ±2% P_n bestimmt*		
Control of reactive power through set-point signal / *Blindleistungsregelung durch Sollwertvorgabe*	☐ Power factor / *Verschiebungsfaktor*	☒ Reactive power / *Blindleistung*
	P_{bin} at / *bei* Q_{max}	50% P_n
Set-point accuracy of reative power / *Einstellgenauigkeit der Blindleistung*	Set-point / *Sollwert*	Measured value / *Istwert*
	-55,50 kvar	-56,36 kvar
	0,00 kvar	-1,68 kvar
	55,50 kvar	54,91 kvar

3. Annex 3 – Extract from the test report

4.2 Reactive power provision / *Blindleistungsbereitstellung*		
Control of reactive power through set-point signal / *Blindleistungsregelung durch Sollwertvorgabe*	☐ Power factor / *Verschiebungsfaktor*	☒ Reactive power / *Blindleistung*
	P_{bin} at / *bei* Q_{max}	100%P_n
Set-point accuracy of reative power / *Einstellgenauigkeit der Blindleistung*	Set-point / *Sollwert*	Measured value / *Istwert*
	-55,50 kvar	-56,03 kvar
	0,00 kvar	-1,4 kvar
	55,50 kvar	55,82 kvar
Control of reactive power through set-point signal / *Blindleistungsregelung durch Sollwertvorgabe*	☒ Power factor / *Verschiebungsfaktor*	☐ Reactive power / *Blindleistung*
	P_{bin} at / *bei* Q_{max}	50%P_n
Set-point accuracy of power factor / *Einstellgenauigkeit des Verschiebungsfaktors*	Set-point / *Sollwert*	Measured value / *Istwert*
	0,845 (ind.)	0,845 (ind.)
	1,000	1,000
	0,845 (cap.)	0,845 (cap.)
Control of reactive power through set-point signal / *Blindleistungsregelung durch Sollwertvorgabe*	☒ Power factor / *Verschiebungsfaktor*	☐ Reactive power / *Blindleistung*
	P_{bin} at / *bei* Q_{max}	100%P_n
Set-point accuracy of power factor / *Einstellgenauigkeit des Verschiebungsfaktors*	Set-point / *Sollwert*	Measured value / *Istwert*
	0,800 (ind.)	0,800 (ind.)
	1,000	1,000
	0,800 (cap.)	0,799 (cap.)

Note / *Anmerkung*:

The reactive power, power factor and settling time results of the *SUN2000-185KTL-H1* can be applied to *SUN2000-168KTL-H1* directly. /

Die Ergebnisse von Blindleistung, Verschiebungsfaktor und Einschwingzeit des SUN2000-185KTL-H1 *können auf den* SUN2000-168KTL-H1 *direkt übertragen werden.*

3. Annex 3 – Extract from the test report

4.2 Reactive power provision / *Blindleistungsbereitstellung*

4.2.5 Q(U) control / *Q(U) Regelung*

4.2.6 Q(P) control / *Q(P) Regelung*

4.2.7 Reactive power Q with voltage limitation function / *Blindleistung Q mit Spannungsbegrenzungsfunktion*

Remark / *Anmerkung:*	The Q(U), Q(P) and reactive power Q with voltage limitation function were tested, please see test report. / *Die Q(U)-, Q(P)-Regelung und Blindleistung Q mit Spannungsbegrenzungsfunktion wurden geprüft, diese sind im Prüfbericht hinterlegt.*

Figure 12 – Results of reactive power control from [11]

3. Annex 3 – Extract from the test report

Description of methods for the reactive power supply:

The control of the reactive power on the lowest level of the controller is realized by Q-regulation.

The *SUN2000-168KTL-H1* und *SUN2000-185KTL-H1* provide setting of the reactive power by:

a) Settable Q-parameter (range: +/- 60%P_{max}) [1)]
b) Settable cosφ-set-parameter (range: +/- 0,8)) [1)]
c) Configurable Q(U)-characteristic line (No. of supporting points: 10) [1), 2)]
d) Configurable Q(P)-characteristic line (No. of supporting points: 10) [1)]

Note:

[1)] For country code setting VDE-AR-N 4110:2018-11:
for all abrupt set-point changes, the reactive power control methods b), c) and d) (see above) provide PT1 (1st order lowpass) filtering effect.

For country code setting VDE-AR-N 4120:2018-11:
for all abrupt set-point changes, the reactive power control methods c) (see above) provides PT1 (1st order lowpass) filtering effect.

[2)] The PGUs in the series provide only one kind of Q(U) control function (methods c), see above), the Q(U)-characteristic line is free programmable using up to 10 supporting points.

The provided Q(U) control function was used both for test *4.2.5 Q(U) control* and *4.2.7 Reactive power Q with voltage limitation function* according to [3].

Description of the reactive power provision within the voltage corridor (*Manufacturer's data)*

The power provision is limited by the maximum apparent current and maximum apparent / active power (the *SUN2000-168KTL-H1* provides 12,0%P_n and the *SUN2000-185KTL-H1* provides 5,7%P_n overload capacity (i.e. $P_{max,SUN2000\text{-}168KTL\text{-}H1}$ = 112,0%P_n, $P_{max,SUN2000\text{-}185KTL\text{-}H1}$ = 105,7%P_n).

The reactive power is prioritised versus the active power.

A maximum reactive power provision of 60%S_{max} (using Q set-point) or cosφ = 0,8 (using cosφ set-point) is possible.

At overvoltage the apparent / active power threshold limit the injected power. At undervoltage the apparent current limitation will also contribute.

The continuous provision is possible within the voltage corridor 80%U_n through 120%U_n and the frequency range between 47,5 and 52,0 Hz

A permanent active power reduction can be applied by setting parameters *Plimilt* and *Pmaxref* (the following applies: Plimilt ≤ Pmaxref ≤ P_{max}. Default: Plimilt = Pmaxref = P_{max}.).
The value of *Plimilt* will then be the new active power limitation which will not be exceeded during operation of the PGU, while *Pmaxref* will be the new reference for the P set-point control . Any signal for a setpoint of 100%Pmaxref, by the ripple control receiver or other P-parameter setpoint, causes the PGU to inject the new lower P_{max}-value (active power higher than new lower P_{max}-value will never be injected). The reference power for percentage or p.u. in this limited mode is the new lower Pmaxref-value.

The power control is therefore based on the following values:

PGU	Apparent current limit [A]	Active / Apparent power limit [kW / kVA]
SUN2000-168KTL-H1	122,5	168 / 168
SUN2000-185KTL-H1	134,9	185 / 185

3. Annex 3 – Extract from the test report

The resulting voltage dependent PQ operating points as follows [15]:

Herstellererklärung zur Einhaltung der technischen Anforderungen der VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11
Manufacturer's declaration for compliance to technical requirements of the VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11
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Anhang 4 / Annex 4:

Operating points in the voltage dependent PQ diagram:

SUN2000-168KTL-H1		
Un=1.0 / 1.05 / 1.1 / 1.15 p.u.		
P (kW)	Q (kvar)	
168	0	0
149.70	96.30	-96.30
135.00	100.00	-100.00
120.00	100.80	-100.80
105.00	100.80	-100.80
90.00	100.80	-100.80
75.00	100.80	-100.80
60.00	100.80	-100.80
45.00	100.80	-100.80
30.00	100.80	-100.80
15.00	100.80	-100.80
0.00	100.80	-100.80
Un=0.95 PU		
P (kW)	Q (kvar)	
161.2	0	0
150.50	57.80	-57.80
135.20	87.80	-87.80
120.00	100.80	-100.80
105.00	100.80	-100.80
90.00	100.80	-100.80
75.00	100.80	-100.80
60.00	100.80	-100.80
45.00	100.80	-100.80
30.00	100.80	-100.80
15.00	100.80	-100.80
0.00	100.80	-100.80
Un=0.9 PU		
P (kW)	Q (kvar)	
152.8	0	0
150.50	29.10	-29.10
135.20	71.70	-71.70
120.00	100.80	-100.80
105.00	100.80	-100.80
90.00	100.80	-100.80
75.00	100.80	-100.80
60.00	100.80	-100.80

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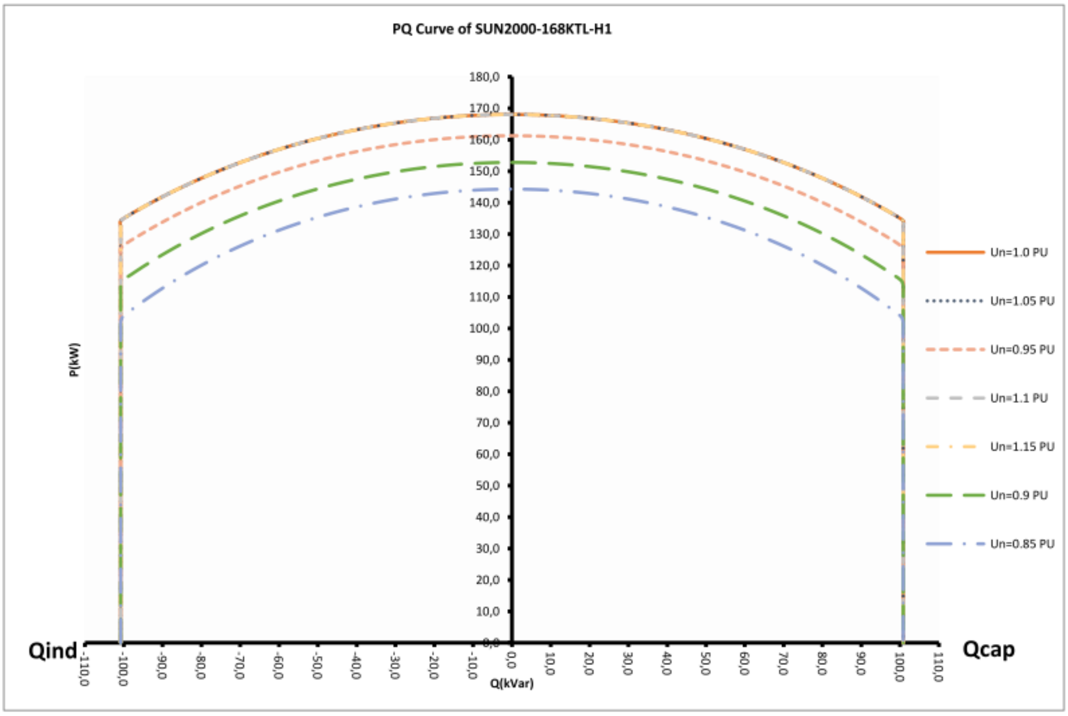
45.00	100.80	-100.80
30.00	100.80	-100.80
15.00	100.80	-100.80
0.00	100.80	-100.80
Un=0.85 PU		
P (kW)	Q (kvar)	
144.3	0.00	0.00
134.70	51.70	-51.70
119.60	80.70	-80.70
105.50	98.40	-98.40
90.00	100.80	-100.80
75.00	100.80	-100.80
60.00	100.80	-100.80
45.00	100.80	-100.80
30.00	100.80	-100.80
15.00	100.80	-100.80
0.00	100.80	-100.80



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Herstellererklärung zur Einhaltung der technischen Anforderungen der VDE-AR-N 4110:2018-11 / VDE-AR-N 4120:2018-11
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SUN2000-185KTL-H1 / SUN2000-185KTL-INH0		
Un=1.0 / 1.05 / 1.1 / 1.15 p.u.		
P (kW)	Q (kvar)	
185	0	0
175.75	57.77	-57.77
157.25	97.45	-97.45
148.00	111.00	-111.00
140.00	111.00	-111.00
122.50	111.00	-111.00
105.00	111.00	-111.00
87.50	111.00	-111.00
70.00	111.00	-111.00
52.50	111.00	-111.00
35.00	111.00	-111.00
17.50	111.00	-111.00
0.00	111.00	-111.00
Un=0.95 PU		
P (kW)	Q (kvar)	
177.6	0	0
174.90	57.80	-57.80
156.80	83.40	-83.40
148.90	96.70	-96.70
139.90	109.30	-109.30
122.50	111.00	-111.00
105.00	111.00	-111.00
87.50	111.00	-111.00
70.00	111.00	-111.00
52.50	111.00	-111.00
35.00	111.00	-111.00
17.50	111.00	-111.00
0.00	111.00	-111.00
Un=0.9 PU		
P (kW)	Q (kvar)	
-	-	-
168.2	0.00	0.00
157.10	60.30	-60.30
148.50	79.00	-79.00
139.50	94.10	-94.10
122.50	111.00	-111.00
105.00	111.00	-111.00
87.50	111.00	-111.00

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70.00	111.00	-111.00
52.50	111.00	-111.00
35.00	111.00	-111.00
17.50	111.00	-111.00
0.00	111.00	-111.00
Un=0.85 PU		
P (kW)	Q (kvar)	
-	-	-
158.9	0.00	0.00
156.90	24.90	-24.90
148.30	56.90	-56.90
140.30	74.60	-74.60
121.70	102.10	-102.10
105.00	111.00	-111.00
87.50	111.00	-111.00
70.00	111.00	-111.00
52.50	111.00	-111.00
35.00	111.00	-111.00
17.50	111.00	-111.00
0.00	111.00	-111.00

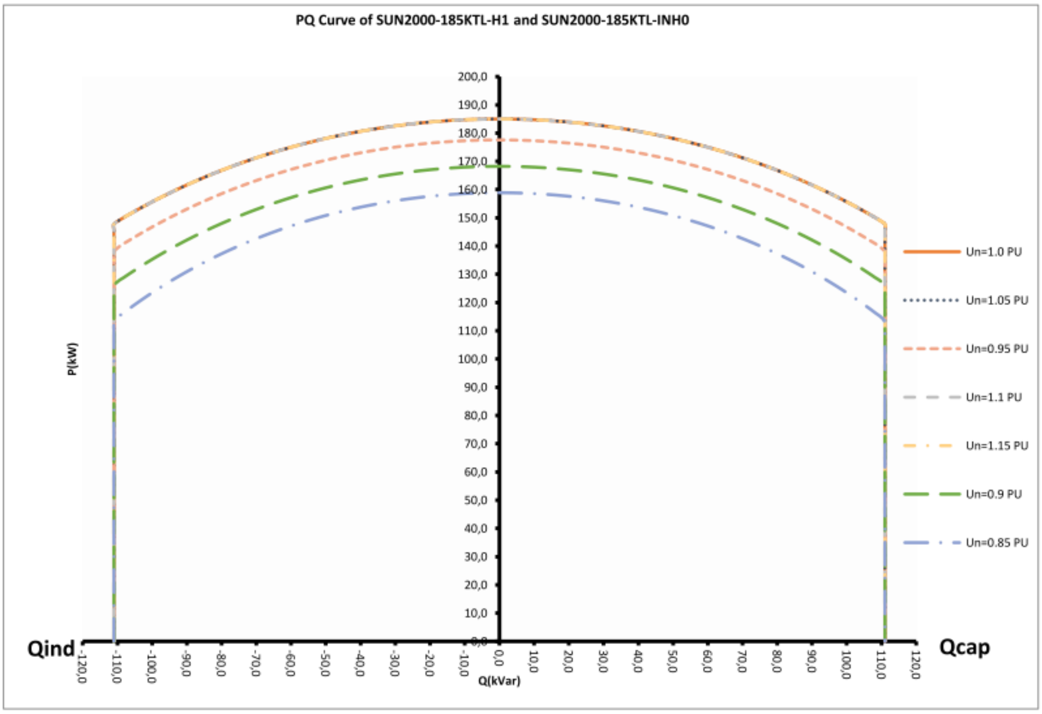

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Figure 13 – Voltage dependent PQ operating points from [15]

3. Annex 3 – Extract from the test report

3.4. Protection system (on PGU level) [12]

The following tests were carried out on the PGU integrated protection relay and the generating unit switch, the possible parameter setting of the PGU integrated protection relay is documented in [14], see *Annex 5 – Certification-relevant parameters*:

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Extract from the test report - Part 3: Protection system

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4.4 PGU DISCONNECTION FROM THE GRID / *PGU DISCONNECTION FROM THE GRID*

SUN2000-185KTL-H1 (FW: V300R001)

☒ The test of the whole trip circuit led to a successful shut down. /
Die Prüfung der Gesamtwirkungskette führte zu einer erfolgreichen Abschaltung.

	Setting / *Einstellwert* [p.u. U_n] / [Hz] Value / *Schwelle*	[ms] Time / *Zeit*	Release value / *Auslösewert* [p.u. U_n] / [Hz] min.	max.	Disconnection time / *Abschaltzeit* [ms] min.	max.	Resetting ratio / *Rückfallverhältnis*
Overvoltage protection / *Spannungssteigerungsschutz*: U>	1,000	100000 [1)]	0,998	1,000	100024	100027	☒ ≥ 0,98
	1,250	50	1,249	1,250	79,0	87,8	☐ < 0,98
Overvoltage protection / *Spannungssteigerungsschutz*: U≫	1,000	100000 [1)]	0,993	1,003	100019	100040	----
	1,300	50	1,299	1,299	72,5	79,5	----
Undervoltage protection / *Spannungsrückgangssschutz*: U< [2)]	0,150	50	0,148	0,149	71,4	94,9	☒ ≤ 1,02
	1,000	100000 [1)]	0,998	1,000	100025	100028	☐ > 1,02
Undervoltage protection / *Spannungsrückgangssschutz*: U≪ [2)]	0,150	50	0,148	0,149	82,3	94,2	----
	1,000	100000 [1)]	0,997	1,000	100022	100042	----
Overfrequncy protection / *Frequenzsteigerungsschutz*: f>	50,00	100000 [1)]	50,00		100047		----
	57,50	50	57,50		85		----
Overfrequncy protection / *Frequenzsteigerungsschutz*: f≫	50,00	100000 [1)]	49,99		100045		----
	57,50	50	57,49		92,8		----
Underfrequncy protection / *Frequenzrückgangssschutz*: f<	42,50	50	42,50		90,4		----
	50,00	100000 [1)]	50,00		100045		----
Underfrequncy protection / *Frequenzrückgangssschutz*: f≪	42,50	50	42,50		83,5		----
	50,00	100000 [1)]	50,00		100030		----
Operating time of circuit breaker / *Eigenzeit der Abschalteinheit* [ms] (Manufacturer's data / *Herstellerdaten*)	≤ 30	☒ by measurement / *aus Messung*		☐ by test certificate / *aus Prüfzertifikat*		☒ from manufacturer specification / *aus Herstellerangabe*	

Note / *Anmerkung*:

1) The trip time range is settable between 0 and 7200 s, during the test the max. delay was limited to 100 s, according to manufacture, this has no influence on the evaluation algorithm of the grid monitoring. /
Der Einstellbereich der Frequenz-und Spannungsüberwachung liegt zwsischen 0 und 7200 s. Bei der Prüfung wurde die max. Verzögerung auf 100 s begrenzt. (Herstellerklärung) Dies hat keinen Einfluss auf das Auswertungsverfahren der Frequenz-und Spannungsüberwachung.

2) The min. settable threshold of the untervltage protection is 15%U_n. /
The min. einstellbare Schwelle des Unterspannungsschutzes liegt bei 15%U_n.

The results of the *SUN2000-185KTL-H1* can be applied to the *SUN2000-168KTL-H1* directly. /
Die Ergbenisse des SUN2000-185KTL-H1 *können auf den* SUN2000-168KTL-H1 *direkt übertragen werden.*

3. Annex 3 – Extract from the test report

4.5 VERIFICATION OF CONNECTION CONDITIONS / *NACHWEIS DER ZUSCHALTBEDINGUNGEN*

1) Connection without previous protection trigger / *Zuschalten ohne vorherige Schutzauslösung*

SUN2000-185KTL-H1 (FW: V300R001)

	Range / Bereich [p.u. U_n] / [Hz]	Cut in occured within the given range / *Zuschaltung erfolgte im angegebenen Berich*	
Voltage / *Spannung*:	0,90 – 1,10	☒ Yes / *Ja*	☐ No / *Nein*
Frequency / *Frequenz*:	47,5 – 50,2	☒ Yes / *Ja*	☐ No / *Nein*

2) Connection after triggering of the decoupling protection / *Zuschalten nach Auslösung der Entkupplungsschutzes*

SUN2000-185KTL-H1 (FW: V300R001)

	Range / Bereich [p.u. U_n] / [Hz]	Cut in occured within the given range / *Zuschaltung erfolgte im angegebenen Berich*	
Undervoltage / Unter*spannung*:	< 0,95	☐ Yes / *Ja*	☒ No / *Nein*
Underfrequency / Unter*frequenz*:	≤ 49,9	☐ Yes / *Ja*	☒ No / *Nein*
Overfrequency / Über*frequenz*:	≥ 50,1	☐ Yes / *Ja*	☒ No / *Nein*

Note / *Anmerkung*:
The results of the *SUN2000-185KTL-H1* can be applied to the *SUN2000-168KTL-H1* directly. /
Die Ergbenisse des SUN2000-185KTL-H1 *können auf den* SUN2000-168KTL-H1 *direkt übertragen werden.*

Figure 14 – Results of grid protection from [12]

3. Annex 3 – Extract from the test report

The function of the integrated grid monitoring and disconnection is independent from other parameters and functions.

The grid monitoring functions can be maintained for at least 5 s during grid voltage loss.

The loss of power supply for the grid monitoring results in a non-delayed triggered disconnection.

The generating units monitor the phase-to-phase voltages.

The three phase-to-phase voltages are logical OR connected to trigger the operation of the separation device.

An external monitoring relay can trigger the power generating unit's integrated breakers (by digital input).

Description of the interface for on-site testing

The PGU does not provide test terminals for on-site testing. For necessary on-site testing, an external monitoring relay with corresponding test terminals must be installed and the PGU's monitoring parameters must be set accordingly. The integrated grid monitoring/protection parameters can be checked via remote control (Smartlogger / App).

3. Annex 3 – Extract from the test report

3.5. Self-protection [14]

According to [14] if the connection voltage exceeds 1490 V (line-to-line peak value) will lead to a non-delayed self-protection tripping.

3. Annex 3 – Extract from the test report

3.6. Quasi-static operation [7]

Manufacturer's data from [7]

The unit can be continuously operated within the voltage / frequency range of 80%U_n and 120%U_n / 47.5 Hz and 52 Hz. The operating range of voltage and frequency can also be limited using the protection functions.

3. Annex 3 – Extract from the test report

3.7. Fault ride through capability [7]

Within the adjustable parameter ranges of the grid monitoring the PGU can ride throuth the symmetrical and asymmetrical faults accoding to the Fault Ride-Through (FRT) limit curve for a Type 2 power generating plant specified in [2].

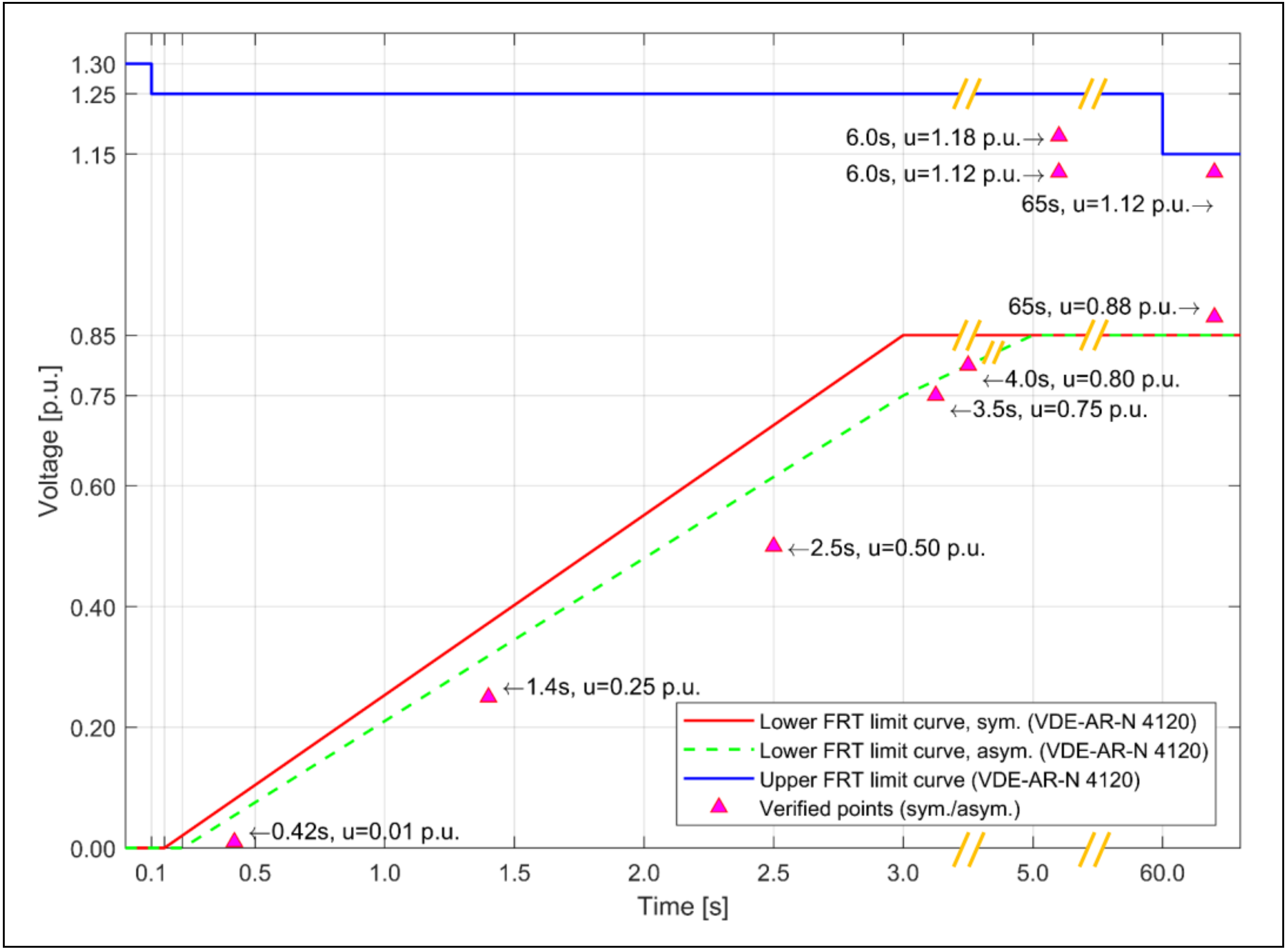

Figure 15 – Verified Fault Ride-Through (FRT) limit curve from [7]

3. Annex 3 – Extract from the test report

3.8. Short-circuit current contributions

In the following the test results from [7] are summarized:

SUN2000-168KTL-H1

Ergebnis	0.1			0.2			0.3			0.4		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	0,044	0,044	0,044	-	-	-	0,482	0,997	0,518	-	-	-
17	0,044			-			0,523			-		
22	1,004			-			1,004			-		
23	0,003			-			0,003			-		
28 2)	0,005			-			0,005			-		
32	1,004			-			1,004			-		
51 - 53	148,0	153,7	179,7	-	-	-	208,7	180,7	106,0	-	-	-
54 - 56	0,560	0,932	0,856	-	-	-	0,933	0,458	0,476	-	-	-
57 - 59	1,030	1,029	1,030	-	-	-	1,029	0,430	0,601	-	-	-
60 - 62	1,030	1,027	1,029	-	-	-	1,031	0,427	0,604	-	-	-
63 - 65	1,026	1,028	1,028	-	-	-	1,028	0,422	0,607	-	-	-
66 - 68	0,233	0,225	0,226	-	-	-	0,207	0,214	0,211	-	-	-
69 - 71	0,998	0,998	1,001	-	-	-	0,997	0,998	0,999	-	-	-
74	0,329			-			0,325			-		

Ergebnis	25.1			25.2			25.3			25.4		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	0,280	0,281	0,279	-	-	-	Die EZE ist in der Lage, mehrfach aufeinanderfolgende Spannungseinbrüche durchzufahren. / *The PGU is able to ride through several consecutive voltage dips.*			0,540	0,993	0,565
17	0,280			-						0,636		
22	1,004			-						1,004		
23	0,003			-						0,003		
28 2)	0,005			-						0,005		
32	1,004			-						1,004		
51 - 53	152,0	159,3	135,7	-	-	-				174,0	130,7	125,0
54 - 56	0,898	0,963	0,586	-	-	-				0,875	0,254	0,621
57 - 59	1,030	1,028	1,031	-	-	-				1,025	0,438	0,588
60 - 62	1,030	1,029	1,032	-	-	-				1,028	0,429	0,602
63 - 65	1,031	1,029	1,033	-	-	-				1,026	0,423	0,605
66 - 68	1,030	1,029	1,033	-	-	-				1,026	0,420	0,607
69 - 71	1,029	1,029	1,032	-	-	-				1,025	0,416	0,610
74	0,318			-						0,325		

Ergebnis	25.5			50.1			50.2			50.5		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-			-			-			-		
22	-			-			-			-		
23	-			-			-			-		
28 2)	-			-			-			-		
32	-			-			-			-		
51 - 53	-	-	-	-	-	-	-	-	-	-	-	-
54 - 56	-	-	-	-	-	-	-	-	-	-	-	-
57 - 59	-	-	-	-	-	-	-	-	-	-	-	-
60 - 62	-	-	-	-	-	-	-	-	-	-	-	-
63 - 65	-	-	-	-	-	-	-	-	-	-	-	-
66 - 68	-	-	-	-	-	-	-	-	-	-	-	-
69 - 71	-	-	-	-	-	-	-	-	-	-	-	-
74	-			-			-			-		

Ergebnis	50.3			50.4			50.6			75.1		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	0,645	0,997	0,665	-	-	-	-	-	-	-	-	-
17	0,744			-			-			-		
22	1,004			-			-			-		
23	0,003			-			-			-		
28 2)	0,005			-			-			-		
32	1,004			-			-			-		
51 - 53	195,0	133,7	152,7	-	-	-	-	-	-	-	-	-
54 - 56	0,936	0,217	0,778	-	-	-	-	-	-	-	-	-
57 - 59	1,004	0,392	0,616	-	-	-	-	-	-	-	-	-
60 - 62	1,007	0,394	0,616	-	-	-	-	-	-	-	-	-
63 - 65	1,013	0,420	0,595	-	-	-	-	-	-	-	-	-
66 - 68	1,012	0,415	0,598	-	-	-	-	-	-	-	-	-
69 - 71	1,018	0,413	0,605	-	-	-	-	-	-	-	-	-
74	0,324			-			-			-		

3. Annex 3 – Extract from the test report

Ergebnis	75.2			75.3			75.4			75.5		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	-	-	-	0,760	0,759	0,755	-	-	-	-	-	-
17	-			0,758			-			-		
22	-			1,003			-			-		
23	-			0,003			-			-		
28 2)	-			0,671			-			-		
32	-			0,194			-			-		
51 - 53	-	-	-	163,7	163,0	166,3	-	-	-	-	-	-
54 - 56	-	-	-	0,932	0,999	0,989	-	-	-	-	-	-
57 - 59	-	-	-	1,035	1,034	1,035	-	-	-	-	-	-
60 - 62	-	-	-	1,036	1,033	1,036	-	-	-	-	-	-
63 - 65	-	-	-	1,033	1,034	1,035	-	-	-	-	-	-
66 - 68	-	-	-	1,031	1,027	1,034	-	-	-	-	-	-
69 - 71	-	-	-	1,024	1,019	1,035	-	-	-	-	-	-
74	-			0,027			-			-		

Ergebnis	75.6			75.7			75.8			80.1		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	-	-	-	-	-	-	0,821	0,997	0,834	-	-	-
17	-			-			0,880			-		
22	-			-			1,003			-		
23	-			-			0,003			-		
28 2)	-			-			0,000			-		
32	-			-			0,202			-		
51 - 53	-	-	-	-	-	-	144,0	81,7	87,3	-	-	-
54 - 56	-	-	-	-	-	-	0,630	0,212	0,418	-	-	-
57 - 59	-	-	-	-	-	-	0,906	0,267	0,646	-	-	-
60 - 62	-	-	-	-	-	-	0,916	0,271	0,649	-	-	-
63 - 65	-	-	-	-	-	-	0,939	0,285	0,658	-	-	-
66 - 68	-	-	-	-	-	-	0,982	0,296	0,695	-	-	-
69 - 71	-	-	-	-	-	-	0,980	0,294	0,699	-	-	-
74	-			-			0,019			-		

Ergebnis	80.2			85.1			110.1			110.2		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	-	-	-	-	-	-	1,093	1,006	1,090	-	-	-
17	-			-			1,062			-		
22	-			-			1,004			-		
23	-			-			0,003			-		
28 2)	-			-			0,005			-		
32	-			-			1,005			-		
51 - 53	-	-	-	-	-	-	141,3	147,0	126,0	-	-	-
54 - 56	-	-	-	-	-	-	0,926	0,958	0,784	-	-	-
57 - 59	-	-	-	-	-	-	0,912	0,958	0,784	-	-	-
60 - 62	-	-	-	-	-	-	0,906	0,959	0,783	-	-	-
63 - 65	-	-	-	-	-	-	0,905	0,959	0,774	-	-	-
66 - 68	-	-	-	-	-	-	0,905	0,957	0,772	-	-	-
69 - 71	-	-	-	-	-	-	0,897	0,954	0,754	-	-	-
74	-			-			0,000			-		

Ergebnis	110.3			115.1			115.2			-		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	1,122	1,126	1,120	-	-	-	-	-	-	-	-	-
17	1,123			-			-			-		
22	1,003			-			-			-		
23	0,003			-			-			-		
28 2)	0,000			-			-			-		
32	0,202			-			-			-		
51 - 53	49,0	55,3	60,0	-	-	-	-	-	-	-	-	-
54 - 56	0,257	0,309	0,271	-	-	-	-	-	-	-	-	-
57 - 59	0,281	0,288	0,279	-	-	-	-	-	-	-	-	-
60 - 62	0,280	0,281	0,278	-	-	-	-	-	-	-	-	-
63 - 65	0,282	0,283	0,285	-	-	-	-	-	-	-	-	-
66 - 68	0,288	0,301	0,295	-	-	-	-	-	-	-	-	-
69 - 71	0,292	0,306	0,300	-	-	-	-	-	-	-	-	-
74	0,000			-			-			-		

3. Annex 3 – Extract from the test report

Note:
Die Ergebnisse in der Tabelle sind anhand der Tabelle 4-70 in FGW TR3 (Rev.25) wie folgt durchnummeriert /
The results in the table are numbered according to Table 4-70 in FGW TR3 (Rev.25) as follows :

[1] A / B / C kennzeichnen die Phase-Phase-Spannungen (L12, L23, L31) oder die Phasenströme (L1, L2, L3). /
A / B / C indicate the phase-phase voltages (L12, L23, L31) or the phase currents (L1, L2, L3).

[2] Untererregter / induktiver Blindstrom hat ein negatives Vorzeichen, übererregter / kapazitiver Blindstrom hat ein positives Vorzeichen, das Vorzeichen der Blindleistung ist gleich wie Blindstrom. /
Under-excited / inductive reactive current has a negative sign, over-excited / capacitive reactive current has a positive sign, the sign of the reactive power is the same as the reactive current.

[3] Test für Mehrfachfehler zu nachweisen, dass die EZE in der Lage ist, mehrfach aufeinanderfolgende Spannungseinbrüche durchfahren zu können. /
Test for mutiple faults to proven the PGU is able to ride through several consecutive voltage dips.

Nr.:	Parameter	Phasenbezug, Bezugszeit, Wert [Einheit] / *Phase reference, Reference time, Value [unit]*
16	Istwert Spannungseinbruchtiefe / Spannungserhöhung / *Measeured value of voltage drop / increase* (L12, L23, L31)	Phase-Phase, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U_n]
17	Istwert Spannungseinbruchtiefe / Spannungserhöhung / *Measeured value of voltage drop / increase*	Mitsystem / *Pos. seq.*, Phase-neutral, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U_n]
22	Spannung / *Voltage*	Mitsystem / *Pos. seq.*, Phase-neutral, t1 - 60s bis t1) [p.u. U_n]
23	Spannung / *Voltage*	Gegensystem / *Neg. seq*, Phase-neutral, t1 - 60s bis t1) [p.u. U_n]
28 [2]	Blindstrom / *Reactive current*	Mitsystem / *Neg. seq.*, t1 - 60s bis t1) [p.u. I_n]
32	Wirkleistung / *Active Power*	Gesamt / *Total*, t1 – 10s ... t1 [p.u. P_n]
51 - 53	Kurzschlussströme Scheitelwerte / *Short-circuit currents, peak value* (L1,L2,L3)	t1 ... t1 + 20ms [A]
54 - 56	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 ... t1 + 20ms [p.u. I_n]
57 - 59	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 80ms ... t1 + 100ms [p.u. I_n]
60 - 62	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 130ms ... t1 + 150ms [p.u. I_n]
63 - 65	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 280ms ... t1 + 300ms [p.u. I_n]
66 - 68	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 480ms ... t1 + 500ms [p.u. I_n]
69 - 71	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 980ms ... t1 + 1000ms [p.u. I_n]
74	Anschwingzeit Wirkstrom / *Response time of active current*	Mitsystem / *Pos. seq.* [s]

Figure 16 – Summary results of short-circuit current contributions - SUN2000-168KTL-H1

The following reference values are applied for calculation of the p.u. values specified in the table above:

	SUN2000-168KTL-H1	SUN2000-185KTL-H1
Rated active power, P_n [kW]	150	175
Rated voltage (phase-to-phase), U_n [V]	800	
Rated current, I_n [A]	108,3	126,3

3. Annex 3 – Extract from the test report

SUN2000-185KTL-H1

Ergebnis	0.1			0.2			0.3			0.4		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	0,050	0,051	0,051	0,050	0,051	0,051	0,478	0,993	0,519	0,485	1,006	0,525
17	0,051			0,051			0,524			0,530		
22	1,004			1,003			1,004			1,003		
23	0,004			0,004			0,004			0,004		
28 2)	0,005			0,001			0,005			0,001		
32	1,004			0,202			1,004			0,202		
51 - 53	170,7	184,7	191,3	177,3	141,0	192,0	231,3	206,7	138,3	190,7	128,0	79,0
54 - 56	0,564	0,900	0,903	0,652	0,511	0,806	0,937	0,432	0,505	0,779	0,465	0,317
57 - 59	1,024	1,022	1,027	1,025	1,020	1,028	1,029	0,430	0,601	1,031	0,425	0,607
60 - 62	1,025	1,023	1,028	1,023	1,021	1,028	1,031	0,428	0,604	1,031	0,424	0,608
63 - 65	1,026	1,019	1,026	1,023	1,021	1,028	1,030	0,427	0,605	1,030	0,423	0,608
66 - 68	0,239	0,235	0,231	0,170	0,168	0,167	0,214	0,221	0,216	0,186	0,181	0,182
69 - 71	1,000	0,995	1,001	0,203	0,200	0,202	1,000	0,994	1,000	0,202	0,200	0,202
74	0,329			0,043			0,327			0,060		

Ergebnis	25.1			25.2			25.3			25.4		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	0,286	0,286	0,284	0,288	0,288	0,286	Die EZE ist in der Lage, mehrfach aufeinanderfolgende Spannungseinbrüche durchzufahren. / *The PGU is able to ride through several consecutive voltage dips.*			0,540	0,991	0,568
17	0,286			0,287						0,638		
22	1,004			1,003						1,004		
23	0,004			0,004						0,004		
28 2)	0,005			0,001						0,005		
32	1,004			0,202						1,004		
51 - 53	182,0	188,0	141,3	181,7	141,0	180,0				166,7	161,3	160,7
54 - 56	0,994	0,867	0,605	0,751	0,456	0,716				0,554	0,215	0,610
57 - 59	1,023	1,022	1,025	1,025	1,024	1,027				1,024	0,442	0,586
60 - 62	1,024	1,023	1,025	1,025	1,024	1,027				1,026	0,430	0,600
63 - 65	1,024	1,023	1,026	1,025	1,024	1,027				1,027	0,432	0,599
66 - 68	1,025	1,022	1,024	1,025	1,023	1,025				1,025	0,419	0,608
69 - 71	1,028	1,023	1,028	1,028	1,022	1,028				1,025	0,416	0,610
74	0,319			0,045						0,322		

Ergebnis	25.5			50.1			50.2			50.3		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	0,542	0,996	0,571	0,478	0,478	0,474	0,479	0,479	0,475	0,648	0,995	0,668
17	0,641			0,477			0,478			0,746		
22	1,003			1,004			1,003			1,004		
23	0,004			0,004			0,004			0,004		
28 2)	0,001			0,005			0,001			0,005		
32	0,202			1,000			0,202			0,998		
51 - 53	202,0	94,0	114,3	160,3	180,0	181,7	175,0	183,7	155,7	224,7	140,3	175,0
54 - 56	0,778	0,306	0,485	0,636	0,862	0,977	0,565	0,782	0,553	0,920	0,208	0,778
57 - 59	1,025	0,417	0,609	1,029	1,026	1,029	1,030	1,028	1,030	1,001	0,378	0,628
60 - 62	1,026	0,423	0,604	1,028	1,026	1,028	1,030	1,027	1,030	1,003	0,380	0,627
63 - 65	1,026	0,424	0,604	1,032	1,027	1,030	1,030	1,027	1,030	1,006	0,401	0,608
66 - 68	1,027	0,421	0,607	1,032	1,028	1,031	1,031	1,028	1,030	1,006	0,395	0,612
69 - 71	1,025	0,415	0,612	1,026	1,020	1,031	1,026	1,020	1,030	1,004	0,390	0,615
74	0,054			0,315			0,039			0,308		

Ergebnis	50.4			50.5			50.6			75.1		
	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)	A 1)	B 1)	C 1)
16	0,649	0,998	0,670	0,501	0,501	0,498	0,663	1,004	0,660	0,765	0,763	0,758
17	0,748			0,500			0,751			0,762		
22	1,003			1,003			1,003			1,004		
23	0,004			0,004			0,004			0,004		
28 2)	0,001			0,001			0,001			0,005		
32	0,202			0,202			0,201			1,004		
51 - 53	188,0	70,0	124,7	61,7	63,0	46,7	81,7	49,3	55,7	186,7	186,3	186,0
54 - 56	0,738	0,232	0,510	0,203	0,209	0,165	0,241	0,124	0,140	0,959	1,012	1,004
57 - 59	0,989	0,324	0,670	0,063	0,062	0,063	0,056	0,047	0,035	0,978	0,977	0,982
60 - 62	0,990	0,325	0,670	0,063	0,062	0,062	0,055	0,047	0,035	0,979	0,978	0,983
63 - 65	0,992	0,324	0,673	0,062	0,062	0,062	0,054	0,048	0,034	0,979	0,979	0,984
66 - 68	1,010	0,417	0,593	0,062	0,061	0,062	0,055	0,048	0,035	0,974	0,982	0,985
69 - 71	1,010	0,411	0,600	0,061	0,061	0,061	0,054	0,048	0,036	0,976	0,987	0,988
74	0,044			0,121			0,067			0,039		

3. Annex 3 – Extract from the test report

Ergebnis	75.2			75.3			75.4			75.5		
	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]
16	0,754	0,755	0,750	0,767	0,765	0,759	0,753	0,754	0,749	0,769	0,768	0,763
17	0,753			0,764			0,752			0,767		
22	1,003			1,003			1,003			1,003		
23	0,004			0,004			0,004			0,004		
28 [2]	0,001			0,636			-0,634			0,001		
32	0,202			0,194			0,196			0,202		
51 - 53	90,7	94,7	93,0	189,3	191,0	194,0	119,3	64,0	95,3	169,0	162,7	167,0
54 - 56	0,341	0,371	0,334	0,943	0,975	1,008	0,353	0,341	0,360	0,618	0,610	0,660
57 - 59	0,532	0,530	0,531	1,030	1,027	1,029	0,311	0,317	0,313	0,895	0,890	0,892
60 - 62	0,526	0,525	0,531	1,030	1,027	1,029	0,310	0,316	0,313	0,895	0,893	0,891
63 - 65	0,544	0,542	0,549	1,029	1,027	1,029	0,304	0,309	0,305	0,951	0,949	0,953
66 - 68	0,557	0,555	0,562	1,028	1,023	1,033	0,289	0,295	0,290	0,983	0,976	0,998
69 - 71	0,569	0,568	0,574	1,017	1,012	1,032	0,286	0,292	0,286	0,986	0,978	1,010
74	0,034			0,039			0,013			0,012		

Ergebnis	75.6			75.7			75.8			80.1		
	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]
16	0,823	0,999	0,824	0,819	1,000	0,823	0,825	0,996	0,836	0,811	0,809	0,805
17	0,878			0,876			0,881			0,808		
22	1,004			1,003			1,003			1,004		
23	0,004			0,004			0,004			0,004		
28 [2]	0,005			0,001			0,001			0,005		
32	1,004			0,202			0,202			0,999		
51 - 53	159,0	108,0	168,7	95,0	24,7	91,3	172,3	85,3	109,7	178,3	181,0	181,3
54 - 56	0,851	0,586	0,932	0,498	0,114	0,446	0,847	0,320	0,528	1,003	0,957	0,967
57 - 59	0,838	0,563	0,940	0,505	0,114	0,449	0,897	0,266	0,637	0,973	0,974	0,977
60 - 62	0,839	0,563	0,941	0,505	0,113	0,449	0,898	0,266	0,638	0,973	0,974	0,977
63 - 65	0,839	0,562	0,941	0,513	0,105	0,454	0,942	0,287	0,663	0,975	0,977	0,980
66 - 68	0,842	0,552	0,942	0,533	0,114	0,466	0,958	0,295	0,674	0,975	0,979	0,980
69 - 71	0,839	0,538	0,941	0,540	0,120	0,471	0,961	0,297	0,679	0,972	0,983	0,982
74	0,072			0,000			0,007			0,008		

Ergebnis	80.2			85.1			110.1			110.2		
	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]
16	0,861	0,997	0,859	0,884	0,886	0,880	1,094	1,007	1,089	1,093	1,007	1,088
17	0,903			0,883			1,063			1,062		
22	1,004			1,003			1,004			1,003		
23	0,004			0,004			0,004			0,004		
28 [2]	0,005			0,001			0,005			0,001		
32	0,998			0,202			1,004			0,202		
51 - 53	159,7	127,3	171,0	60,3	60,3	59,7	166,3	172,3	150,3	53,7	63,7	43,7
54 - 56	0,864	0,684	0,931	0,323	0,320	0,317	0,920	0,956	0,785	0,262	0,296	0,115
57 - 59	0,849	0,669	0,953	0,313	0,311	0,312	0,914	0,957	0,780	0,257	0,302	0,125
60 - 62	0,850	0,671	0,955	0,313	0,311	0,312	0,907	0,956	0,779	0,256	0,305	0,125
63 - 65	0,854	0,672	0,957	0,322	0,320	0,319	0,905	0,956	0,772	0,258	0,305	0,126
66 - 68	0,847	0,649	0,957	0,327	0,325	0,326	0,904	0,954	0,767	0,264	0,309	0,123
69 - 71	0,847	0,648	0,957	0,326	0,327	0,336	0,895	0,949	0,749	0,275	0,319	0,115
74	0,046			0,000			0,000			0,000		

Ergebnis	110.3			115.1			115.2			-		
	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]	A [1]	B [1]	C [1]
16	1,124	1,126	1,119	1,184	1,186	1,179	1,184	1,186	1,178	-	-	-
17	1,123			1,183			1,182			-		
22	1,003			1,004			1,003			-		
23	0,004			0,004			0,004			-		
28 [2]	0,001			0,005			0,001			-		
32	0,202			1,004			0,202			-		
51 - 53	62,7	59,7	60,3	145,7	140,3	154,0	63,3	63,7	71,7	-	-	-
54 - 56	0,302	0,289	0,300	0,666	0,502	0,611	0,323	0,269	0,338	-	-	-
57 - 59	0,280	0,281	0,280	0,911	0,930	0,921	0,360	0,375	0,365	-	-	-
60 - 62	0,276	0,278	0,276	0,912	0,927	0,915	0,362	0,377	0,362	-	-	-
63 - 65	0,284	0,280	0,284	0,907	0,921	0,914	0,364	0,377	0,361	-	-	-
66 - 68	0,286	0,293	0,286	0,912	0,924	0,919	0,386	0,397	0,383	-	-	-
69 - 71	0,293	0,306	0,294	0,913	0,924	0,919	0,394	0,406	0,391	-	-	-
74	0,000			0,023			0,000			-		

3. Annex 3 – Extract from the test report

Note:
Die Ergebnisse in der Tabelle sind anhand der Tabelle 4-70 in FGW TR3 (Rev.25) wie folgt durchnummeriert /
The results in the table are numbered according to Table 4-70 in FGW TR3 (Rev.25) as follows :

[1] A / B / C kennzeichnen die Phase-Phase-Spannungen (L12, L23, L31) oder die Phasenströme (L1, L2, L3). /
A / B / C indicate the phase-phase voltages (L12, L23, L31) or the phase currents (L1, L2, L3).

[2] Untererregter / induktiver Blindstrom hat ein negatives Vorzeichen, übererregter / kapazitiver Blindstrom hat ein positives Vorzeichen, das Vorzeichen der Blindleistung ist gleich wie Blindstrom. /
Under-excited / inductive reactive current has a negative sign, over-excited / capacitive reactive current has a positive sign, the sign of the reactive power is the same as the reactive current.

[3] Test für Mehrfachfehler zu nachweisen, dass die EZE in der Lage ist, mehrfach aufeinanderfolgende Spannungseinbrüche durchfahren zu können. /
Test for mutiple faults to proven the PGU is able to ride through several consecutive voltage dips.

Nr.:	**Parameter**	**Phasenbezug, Bezugszeit, Wert [Einheit] /** ***Phase reference, Reference time, Value [unit]***
16	Istwert Spannungseinbruchtiefe / Spannungserhöhung / *Measeured value of voltage drop / increase* (L12, L23, L31)	Phase-Phase, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U_n]
17	Istwert Spannungseinbruchtiefe / Spannungserhöhung / *Measeured value of voltage drop / increase*	Mitsystem / *Pos. seq.*, Phase-neutral, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U_n]
22	Spannung / *Voltage*	Mitsystem / *Pos. seq.*, Phase-neutral, t1 - 60s bis t1) [p.u. U_n]
23	Spannung / *Voltage*	Gegensystem / *Neg. seq*, Phase-neutral, t1 - 60s bis t1) [p.u. U_n]
28 [2]	Blindstrom / *Reactive current*	Mitsystem / *Neg. seq.*, t1 - 60s bis t1) [p.u. I_n]
32	Wirkleistung / *Active Power*	Gesamt / *Total*, t1 – 10s ... t1 [p.u. P_n]
51 - 53	Kurzschlussströme Scheitelwerte / *Short-circuit currents, peak value* (L1,L2,L3)	t1 ... t1 + 20ms [A]
54 - 56	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 ... t1 + 20ms [p.u. I_n]
57 - 59	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 80ms ... t1 + 100ms [p.u. I_n]
60 - 62	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 130ms ... t1 + 150ms [p.u. I_n]
63 - 65	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 280ms ... t1 + 300ms [p.u. I_n]
66 - 68	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 480ms ... t1 + 500ms [p.u. I_n]
69 - 71	Kurzschlussströme 1-Perioden-Effektivwert / *Short-circuit currents, 1-period RMS value* (L1,L2,L3)	t1 + 980ms ... t1 + 1000ms [p.u. I_n]
74	Anschwingzeit Wirkstrom / *Response time of active current*	Mitsystem / *Pos. seq.* [s]

Figure 17 – Summary results of short-circuit current contributions - SUN2000-185KTL-H1

The following reference values are applied for calculation of the p.u. values specified in the table above:

	SUN2000-168KTL-H1	**SUN2000-185KTL-H1**
Rated active power, P_n [kW]	150	175
Rated voltage (phase-to-phase), U_n [V]	800	
Rated current, I_n [A]	108,3	126,3

For the test cases which did not carried out on the PGU *SUN2000-168KTL-H1,* the FRT behaviour of the *SUN2000-185KTL-H1* can be applied to *SUN2000-168KTL-H1*. The current peak values and current rms values of the *SUN2000-185KTL-H1* can be applied to *SUN2000-168KTL-H1* scaled (by the factor $I_{n,SUN2000\text{-}168KTL\text{-}H1}$ / $I_{n,\ SUN2000\text{-}185KTL\text{-}H1}$)

3. Annex 3 – Extract from the test report

Parameters necessary for calculating the short-circuit currents as specified in DIN EN 60909-0 (VDE 0102) [6] (*Manufacturer's data* from [15]):

	SUN2000-168KTL-H1	SUN2000-185KTL-H1
R.m.s. value of the source current for three-phase fault, I_{skPF}	122,5	134,9
R.m.s. value of the source current for two-phase fault, $I_{(1)sk2PF}$	122,5	134,9
R.m.s. value of the source current for single-phase fault, $I_{(1)sk1PF}$	122,5	134,9
Negative-sequence short-circuit impedance (manufacturer information for integer k-factors only), $Z_{(2)PF}$	0,5	

Table 1 - Parameters necessary for calculating the short-circuit currents according to DIN EN 60909-0

4. Annex 4 – Validated simulation model

4.1. General information about the simulation model [8]:

Simulation environment used for creation of the PGU model:	PowerFactory 2017 SP1 (x64)	
Simulation environment used for conducting simulation/validation:	PowerFactory 2017 SP9 (x64)	
Data format of the simulation model:	.pfd (PowerFactory model file)	
Identification number of the validated model of the generating unit:	File name: Huawei_19-0650_0_TR4_SUN2000-168-185KTL_V1.zip MD5 - Checksum: 231c3a9d556ca31639da30839c3f73d0 **Archive content:** **Encrypted PowerFactory model for PGU *SUN2000-168KTL-H1*:** File name: Huawei_VDE4120&4110_SUN2000-168KTL-H1_Enc_V1.1.pfd MD5 - Checksum: 8d43a83e68500a2f05ce15539c9cbc9 **Encrypted PowerFactory model for PGU *SUN2000-185KTL-H1*:** File name: Huawei_VDE4120&4110_SUN2000-185KTL-H1_Enc_V1.5.pfd MD5 - Checksum: 7300dbdbd838d0bbcd57314f2beae4a9	
Certification the PGU according to:	☒ VDE-AR-N 4110:2018-11 ☒ VDE-AR-N 4110:2018-11	
Available model documentation:	20191206_User Manual of DIgSILENT Model for Huawei Inverter SUN2000-168KTL-H1 VDE4120&4110_V1.1.pdf (Date: 06.12.2019) 20191206_User Manual of DIgSILENT Model for Huawei Inverter SUN2000-185KTL-H1 VDE4120&4110_V1.1 (Date: 06.12.2019)	
Model type:	☐ EMT model	☒ RMS model
The model is suitable for	☒ static simulation ☒ simulation of symmetrical and asymmetrical faults	☒ dynamic simulation ☐ only simulation of symmetrical faults
Implemented FRT modes:	☒ Full dynamic grid support ☒ Limited dynamic grid support	
Is k-factor adjustable?	☒ yes	☐ no
Further functions implemented in the model:	See *4.3 Model parameters [8]*	
Is a simulation on a PGS configuration with SCR = 5 possible?	☒ yes	☐ no, for a stable simulation the SCR has to be limited to: ___

4. Annex 4 – Validated simulation model

4.2. Description of the PGU simulation model [8]:

The simulation models of the *SUN2000-168KTL-H1* and *SUN2000-185KTL-H1* are implemented in DIgSILENT PowerFactory Version 2017 SP1. In time-domain the static generator model acts as an current source and is suitable for RMS simulations. It is recommended that the integration step size to be set to 1 ms for the simulations.

Description of the main control circuit (Figure 18):

The PV inverter is represented by the built-in PowerFactory element *Static Generator*. The behaviour of dynamic model is determined by the DSL models connected to the *Static Generator* as showed in *Figure 18*.

- The (measurement element) *PQ_Meas* measures the active and reactive power;
- The (measurement element) *Ulv_Meas* determines positive and negative sequency of voltage;
- The (measurement element) voltage transformer *VT* located to the terminal *LV* and measures the three phase voltage on the secondary side of the transformer;
- The (measurement element) phase locked loop *PLL_prot* determines the frequency for grid protection and phase angle for calculation of the pos. / neg. sequency of active / reactive current references;
- The (measurement element) phase locked loop *PLL* determines the phase angle for active and reactive current control;
- The model *Pf Changes* reproduces the active power behavior of the converter in case of overfrequency;
- The model *Q_Control* determines the reactive current reference according to the reactive power set value in consideration of the measured voltage;
- The model *Udc_Control* determines the active current reference according to the active power set value in consideration of the measured voltage;
- The model *Curr_Ctrl* detects the FRT events and calculates the pos. / neg. sequency of active / reactive current references in consideration of the current limitation;

The model *Protection* disconnects the static generator from grid in case of a voltage or frequency grid fault longer than the protection set delay.

Detection of FRT event:

The implementation of the FRT detection is identical to the implementation in the PGU:

- If the minimum (for LVRT) or maximum (for HVRT) value of the three phase-to-phase voltages exceeds the activation threshold (default: Un ± 10%Un), a FRT event will be detected.
- A FRT event will be detected if an abrupt voltage change occurs (the absolute difference between the actual value of the positive and negative sequence voltage and the 1s (50 periods) average of the positive and negative sequence exceeds the activation threshold (default: 5%U_n).

Voltage reference for additional reactive current calculation:

The reference voltage is the 60 s (default setting, settable in the simulation model using parameter *Tu*, see *4.3 Model parameters [8]*) average of the positive and negative sequence voltage before fault occurs.

The voltage reference will not be updated during faults.

4. Annex 4 – Validated simulation model

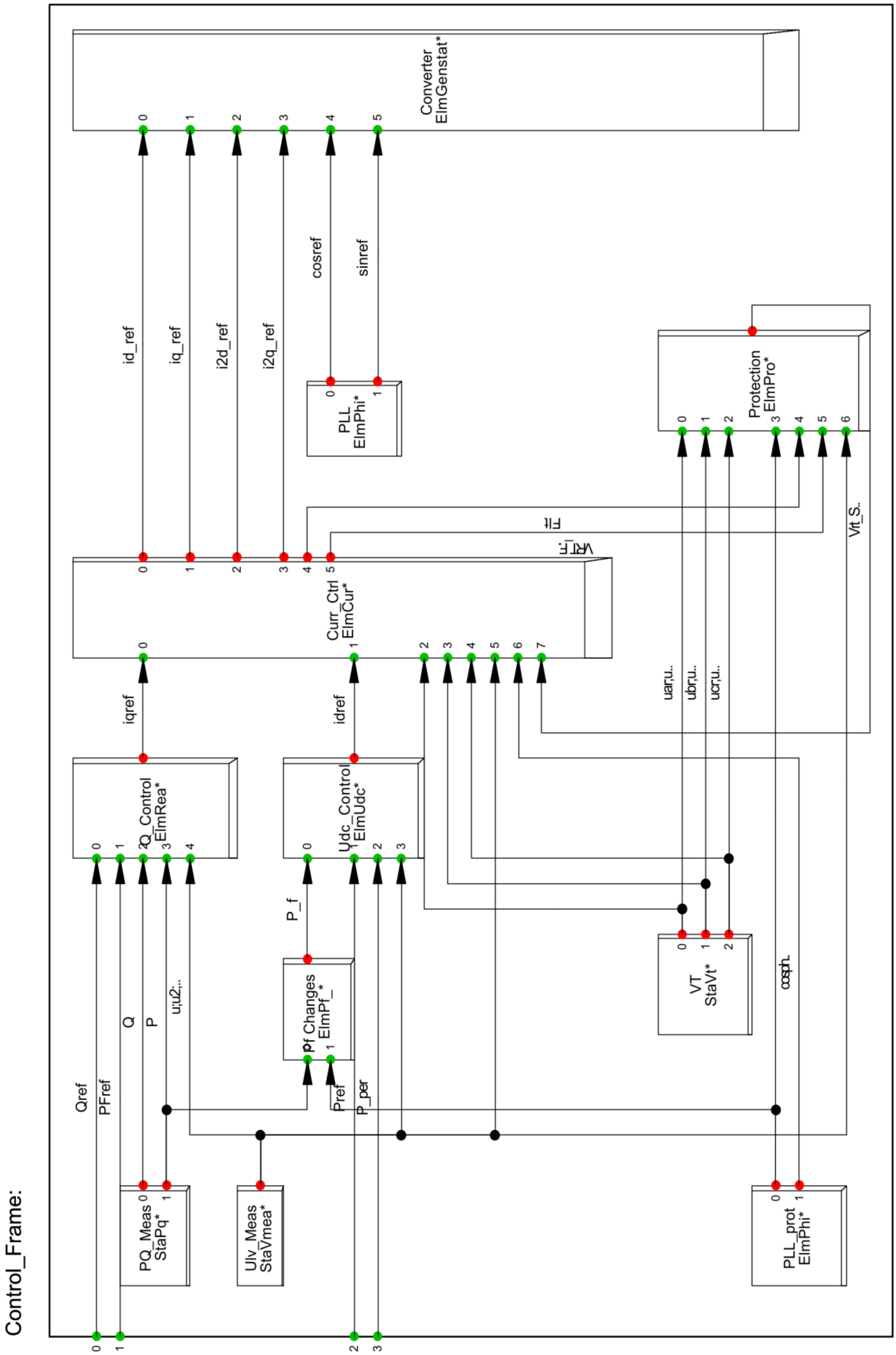

Figure 18 – Control frame of the simulation model

4. Annex 4 – Validated simulation model

Description of the interface to DC input and AC output (Figure 19):

The PV converter is connected to AC mains via the 0,80 kV three phase busbar (which is the measuring point of the above mentioned voltage measuring elements) and also contains the relays of the internal disconnection function.

In time-domain simulations the static generator model acts as a current source, no explicit primary energy conversion is omplemented.

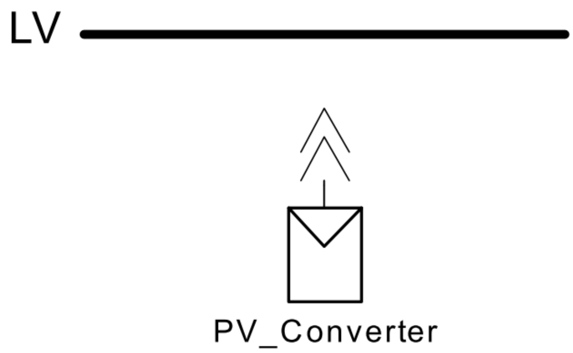

Figure 19 – Interface of the model towards the simulation environment

4. Annex 4 – Validated simulation model

4.3. Model parameters [8]

Description of the accessible parameterization of the model:

The ranges of the following parameters need to be selected in a sensible way: i.e. using the default values or parameter ranges stated in the TG 3 parameters (see *Annex 5 – Certification-relevant parameters*).

Figure 20 shows the composite model *DynamicModel* which references to *Control_Frame* showed in Figure 18 and connects to the common models

- *Pf_Control*;
- *Q_Control*;
- *P_Control*;
- *Idq_Control*;
- *Protection*.

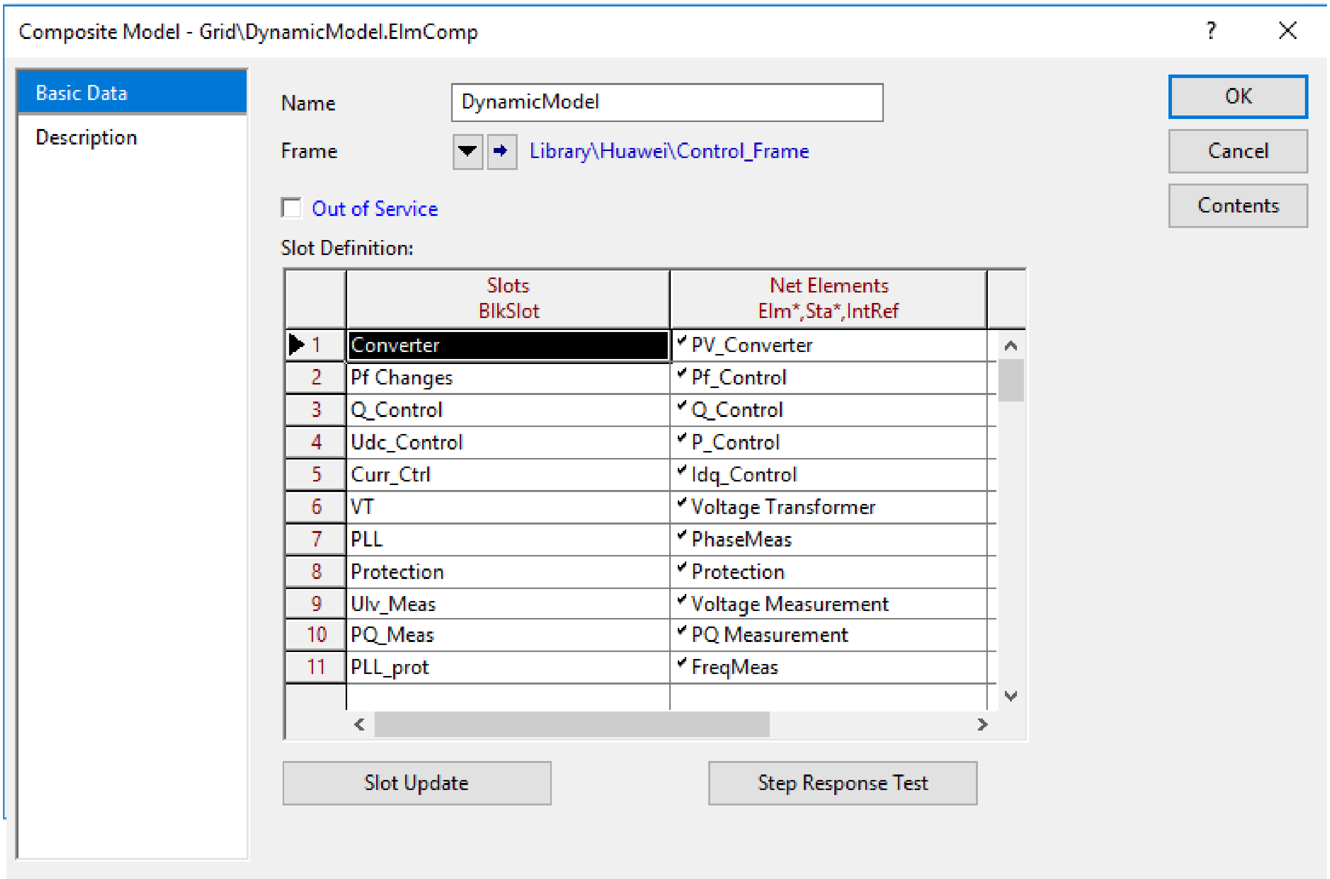

Figure 20 – Composite model *DynamicModel* references to *Control_Frame*

4. Annex 4 – Validated simulation model

A4. Model parameters

Parameter name	Parameter description	Unit	Default
Static Generator – Grid\PV_Converter.ElmGenstat (Basic Data\General)			
Nominal Apparent Power	Nominal apparent and active power rating of the inverter	[kVA]	*SUN2000-168KTL-H1*: 150 *SUN2000-185KTL-H1*: 175
Power Factor	Default reactive power setting	[-]	1
Parallel Machines	Number of inverters simulated by one model block	[-]	1
Common Model – Grid\DynamicModel\Pf_Control.ElmDsl			
Pf_enable	0: p(f) control function disable 1: p(f) control function enable	[-]	1
f_enable	Frequncy threshold exceeds which begins power reduction	[Hz]	50,2
f_reset	Frequncy threshold below which the PGU returns to norml operation	[Hz]	50,15
f_Limit	Overfrequency limit	[Hz]	51,5
Pf_slope	Power reduction slope	[p.u./Hz] (base P_M)	0,4
Pt_slope	Power recovery slope	[p.u./min] (base P_n)	0,1
Pmax	max active Power	[p.u.] (base P_n)	*SUN2000-168KTL-H1*: 1,12 *SUN2000-185KTL-H1*: 1,057
Common Model – Grid\DynamicModel\Q_Control.ElmDsl			
Smax	Maximum apparent power	[p.u.] (base P_n)	*SUN2000-168KTL-H1*: 1,12 *SUN2000-185KTL-H1*: 1,057
Mode	0: Q setpoint control 1: cosφ setpoint control 2: cosφ(P) control function [1)] 3: Q(U) control function [1)]	[0/1/2/3]	0
Ramp_Q	Number of inverters simulated by one model block	[p.u./s] (base P_n)	0,75
Qmin	Minimum reactive power	[p.u.] (base P_n)	*SUN2000-168KTL-H1*: -0,672 *SUN2000-185KTL-H1*: -0,6343
PFmin	Minimum power factor	[-]	-0,8
Qmax	Maximum reactive power	[p.u.] (base P_n)	*SUN2000-168KTL-H1*: 0,672 *SUN2000-185KTL-H1*: 0,6343
PFmax	Maximum power factor	[-]	0,8
Common Model – Grid\DynamicModel\P_Control.ElmDsl			
Mode	0: P setpoint control in p.u. based P_n 1: P setpoint control in % based P_n	[0/1]	0
Pmax	Maximum active power	[p.u.] (base P_n)	*SUN2000-168KTL-H1*: 1,12 *SUN2000-185KTL-H1*: 1,057
RateP	Active power control ramp rate	[p.u./s] (base P_n)	1,25

4. Annex 4 – Validated simulation model

A4. Model parameters

Parameter name	Parameter description	Unit	Default
Common Model – Grid\DynamicModel\Current_Control.ElmDsl			
Smax	Apparent power limit	[p.u.] (base P_n)	*SUN2000-168KTL-H1*: 1,12 *SUN2000-185KTL-H1*: 1,057
imax	Current limit	[p.u.] (base I_n)	*SUN2000-168KTL-H1*: 1,13 *SUN2000-185KTL-H1*: 1,068
Unom	Nominal line voltage	[V]	800
Tmu	Voltage filter time constant	[s]	0,001
Tq	Pre-fault reactive current time constant	[s]	1
Tcc	Equiv. converter reaction time (Internal time delay of the control algorithm, *(specific to simulation model)*)	[s]	0,001
Iq_pre	0: reactive current before fault will not be taken in to account for calculation of the reactive current injection 1: reactive current before fault will be taken in to account for calculation of the reactive current injection	[0/1]	1
Ramp_I	Post-fault current ramp rate	[p.u.] (base I_n)	2,5
imax1	Current limit during symmetrical faults	[p.u.] (base I_n)	1
imax2	Positive sequence current limit during asymmetrical faults	[p.u.] (base I_n)	1
Id_lim	Lower limit of the active current reference during grid faults	[p.u.] (base I_n)	0,1
imax2_neg	Negative sequence current limit during asymmetrical faults	[p.u.] (base I_n)	1
Ut_OV	HVRT voltage threshold	[p.u.] (base U_n)	0,1 (above U_n)
Ut_UV	LVRT voltage dead-band	[p.u.] (base U_n)	0,1 (belowU_n)
K-Hvrt	HVRT Slope di_q/du characteristic (range: 0 - 6)	[-]	2
K-Lvrt	LVRT Slope di_q/du characteristic (range: 0 - 6)	[-]	2
Ut_AV	FRT activation threshold due to abrupt voltage change	[p.u.] (base U_n)	0,05
Udz	FRT deadband hysteresis	[p.u.] (base U_n)	0,02
LVRT_EN	0: LVRT disable 1: LVRT enable	[0/1]	1
HVRT_EN	0: HVRT disable 1: HVRT enable	[0/1]	1
ZeroCurrMode	0: Limited dynamic grid support disable 1: Limited dynamic grid support enable	[0/1]	0
Tu	Pre-fault voltage time constant (pre-fault voltage averaging interval)	[s]	60

4. Annex 4 – Validated simulation model

A4. Model parameters

Parameter name	Parameter description	Unit	Default
Common Model – Grid\DynamicModel\ Protection.ElmDsl			
Umax	Tripping threshold for 1st level of overvoltage protection	[p.u.] (base U_{nom})	1,12
Tmax	Tripping delay for 1st level of overvoltage protection	[s]	1800
Umax_II	Tripping threshold for 2nd level of overvoltage protection	[p.u.] (base U_{nom})	1,25
Tmax_II	Tripping delay for 2nd level of overvoltage protection	[s]	66
Umax_III	Tripping threshold for 3rd level of overvoltage protection	[p.u.] (base U_{nom})	1,3
Tmax_III	Tripping delay for 3rd level of overvoltage protection	[s]	0,2
Umin	Tripping threshold for 1st level of undervoltage protection	[p.u.] (base U_{nom})	0,87
Tmin	Tripping delay for 1st level of undervoltage protection	[s]	3600
Umin_II	Tripping threshold for 2nd level of undervoltage protection	[p.u.] (base U_{nom})	0,8
Tmin_II	Tripping delay for 2nd level of undervoltage protection	[s]	6
fmax	Tripping threshold for overfrequency protection	[p.u.] (base f_{nom})	1,02
Tf_max	Tripping delay for overfrequency protection	[s]	1800
fmax_II	Tripping threshold for 2nd level overfrequency protection	[p.u.] (base f_{nom})	1,03
Tf_max_II	Tripping delay for 2nd level overfrequency protection	[s]	0,1
fmin	Tripping threshold for underfrequency protection	[p.u.] (base f_{nom})	0,98
Tf_min	Tripping delay for underfrequency protection	[s]	1800
fmin_II	Tripping threshold for 2nd level underfrequency protection	[p.u.] (base f_{nom})	0,95
Tf_min_II	Tripping delay for 2nd level underfrequency protection	[s]	0,1
VRTProc_Select	0: high priority for grid protection function 1: high priority for fault ride-through tripping curve function [2)]	[0/1]	0
fnom	Nominal grid frequency	[Hz]	50
Unom	Nominal line voltage	[V]	800
Tmu	Time constant for voltage measurement	[s]	0,01

4. Annex 4 – Validated simulation model

A4. Model parameters

Note:

[1)] The cosφ(P)- and Q(U)-curve can be defined under "*Common Model – Grid\DynamicModel\Q_Control.ElmDsl - Basic Data\Advanced 1*" (for details see model user guide (*A2. General information, 2.5 Description of the provided model documentation*))

[2)] The fault ride-through tripping curve can be defined under "*Common Model – Grid\DynamicModel\Protection.ElmDsl - Basic Data\Advanced 1*" (for details see model user guide (*A2. General information, 2.5 Description of the provided model documentation*))

Figure 21 – Accessible parameters of the model from [8]

4. Annex 4 – Validated simulation model

4.4. Model application guide [8]

It is recommended by the manufacturers that use a fixed integration step size of 1 ms for the simulations.

Description of the steps for integration of the simulation model in a power generating system project (Manufacturer's information) [8]

1. Import the project "Huawei_VDE4120&4110_SUN2000-xxxKTL-H1_Enc_Vy.y" into PowerFactory 2017 SP1 (or later version), where xxx represents the PGUs of *SUN2000-168KTL-H1* or *SUN2000-185KTL-H1*, y.y represents the latest model version.
2. Activate the power plant project. Copy the model template in the project "*Huawei_VDE4120&4110_SUN2000-xxxKTL-H1_Enc_Vy.y*" under the folder *Library\Templates* into the folder *Library\Templates* of power plant project.
3. Select the imported model template from the Drawing Toolbox on the right-hand pane of the PowerFactory GUI and place the converter model into the single-line diagram.
4. Edit the parameters in the DLS models under guidance of manufacturer.
5. Edit the active and reactive power operating point on the *Load Flow* page of the static generator.
6. Calculate the load flow and ensure that there are no warnings or error messages.
7. Calculate the initial conditions (RMS simulation, symmetrical or unsymmetrical network representation, recommended integration step size: 1 ms constant step size).
8. Define network events and select the variables to be recorded.
9. Start the simulation, plot result variables and observe the converter behaviour.

4. Annex 4 – Validated simulation model

4.5. Scope of the validation and plausibility tests [8]

The simulation model was checked for validity and plausibility according to TG 4 for following test scenarios:

- Validating all TG3 FRT tests (chapter 5 in [4])
- Plausibility tests on single model for different
  - fault types;
  - voltage depth;
  - pre-fault voltages
  - pref-fault active powers
  - pref-fault reactive powers
  - k-factors

  (chapter 5.5.2 in [4])
- Validating the P-Q diagram measured according to TG3 Chapters 4.2.2 and 4.2.3 (chapter 5.5.2.1 in [4])
- Plausibility checks of the steady-state operation (chapter 5.5.2.2 in [4])
- Plausibility tests for typical PGS configuration (SCR = 8) for different
  - fault types;
  - voltage depth;
  - pre-fault voltages
  - pref-fault active powers
  - pref-fault reactive powers
  - k-factors

  (chapter 5.5.3.1 in [4])
- Simulating of unsuccessful automatic reconnection on the PGS configuration with SCR = 5 (chapter 5.5.3.2 in [4])
- Active power reduction with over-frequency on single model (chapter 5.5.4.1 in [4])

For all the test scenarios the simulation ran stably without any error messages and showed satisfying behaviour.

4. Annex 4 – Validated simulation model

4.6. Results of Validating simulation models (PGU) [8]

Summary of validation results - SUN2000-168KTL-H1

Test label according to TG3, chapter 4.6 - Behavior during grid disturbance - Table 4-68 and 4-69		Positive Sequence												Negative Sequence											
		P			Q			I_w			I_b			P			Q			I_w			I_b		
		MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
U_rest < 0,05	Pre	0,044	0,001	0,001	0,003	0,000	0,000	0,014	0,001	0,001	0,004	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,013	0,001	0,001	0,005	-0,003	0,003
0.1 according to IEC	Fault	0,025	0,006	0,018	0,055	-0,003	0,005	0,419	0,366	0,407	0,112	-0,094	0,105	0,001	0,000	0,000	0,000	0,000	0,000	0,015	0,003	0,001	0,002	0,002	0,001
3ph / Full Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,003	0,005	-0,002	0,003	0,003	-0,001	0,003	0,005	-0,003	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,001	0,000	0,001	0,003	-0,002	0,002
U_rest < 0,05	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U_rest < 0,05	Pre	0,005	0,001	0,001	0,071	0,000	0,001	0,032	0,001	0,001	0,074	0,000	0,001	0,002	0,000	0,000	0,001	0,000	0,000	0,036	0,000	0,000	0,015	-0,002	0,002
0.3 according to IEC	Fault	0,060	-0,026	0,012	0,119	0,013	0,014	0,108	-0,042	0,022	0,168	0,019	0,025	0,045	0,014	0,021	0,225	0,006	0,008	0,190	0,028	0,046	0,146	0,000	0,009
2ph / Full Load / Kp = 2, Kn=2	Post	0,003	0,000	0,002	0,006	-0,003	0,003	0,003	0,000	0,002	0,006	-0,003	0,004	0,000	0,000	0,000	0,000	0,001	0,001	0,001	0,001	0,001	0,003	0,000	0,003
U_rest < 0,05	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,20 ≤ U_rest ≤ 0,30	Pre	0,045	0,000	0,000	0,001	0,000	0,000	0,015	0,001	0,001	0,001	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,014	0,001	0,001	0,004	-0,003	0,003
25.1 according to IEC	Fault	0,004	-0,001	0,003	0,064	0,006	0,005	0,020	0,004	0,010	0,031	0,026	0,025	0,001	0,000	0,000	0,000	0,000	0,000	0,020	0,002	0,002	0,002	0,000	0,001
3ph / Full Load / Kp = 2, Kn=2	Post	0,002	-0,002	0,003	0,005	-0,001	0,002	0,007	0,000	0,003	0,005	-0,002	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,001	0,003	-0,001	0,001
0,20 ≤ U_rest ≤ 0,30	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25.2 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,20 ≤ U_rest ≤ 0,30	Pre	0,034	0,000	0,001	0,040	0,000	0,001	0,018	0,001	0,001	0,042	0,000	0,001	0,001	0,000	0,000	0,001	0,000	0,000	0,018	0,001	0,001	0,009	-0,002	0,002
25.4 according to IEC	Fault	0,052	-0,014	0,008	0,089	0,009	0,009	0,085	-0,018	0,012	0,147	0,019	0,020	0,036	0,013	0,014	0,134	0,002	0,002	0,187	0,037	0,039	0,133	-0,004	0,005
2ph / Full Load / Kp = 2, Kn=2	Post	0,002	-0,001	0,002	0,006	-0,001	0,002	0,003	-0,001	0,002	0,005	-0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,001	0,001	0,003	-0,001	0,002
0,20 ≤ U_rest ≤ 0,30	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25.5 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,45 ≤ U_rest ≤ 0,60	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50.1 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Full Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,45 ≤ U_rest ≤ 0,60	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50.2 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,45 ≤ U_rest ≤ 0,60	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50.5 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Full Load / Kp = 2, Kn=2 / Limited Mode	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,45 ≤ U_rest ≤ 0,60	Pre	0,008	0,000	0,000	0,050	0,000	0,001	0,036	0,001	0,001	0,052	0,000	0,001	0,002	0,000	0,000	0,001	0,000	0,000	0,037	0,000	0,001	0,014	-0,002	0,002
50.3 according to IEC	Fault	0,032	-0,010	0,011	0,090	0,011	0,011	0,044	-0,014	0,016	0,180	0,011	0,011	0,021	0,011	0,012	0,089	0,006	0,006	0,161	0,045	0,046	0,147	-0,001	0,006
2ph / Full Load / Kp = 2, Kn=2	Post	0,002	-0,001	0,001	0,003	-0,001	0,002	0,002	0,000	0,002	0,003	-0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,001	0,001	0,001	-0,001	0,001
0,45 ≤ U_rest ≤ 0,60	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50.4 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,45 ≤ U_rest ≤ 0,60	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50.6 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Full Load / Kp = 2, Kn=2 / Limited Mode	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,70 ≤ U_rest ≤ 0,80	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.1 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Full Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

4. Annex 4 – Validated simulation model

Test label according to TG3, chapter 4.6 - Behavior during grid disturbance - Table 4-68 and 4-69		Positive Sequence												Negative Sequence											
		P			Q			I_w			I_b			P			Q			I_w			I_b		
		MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
0,70 ≤ U_rest ≤ 0,80	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.2 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,70 ≤ U_rest ≤ 0,80	Pre	0,019	0,000	0,000	0,008	0,001	0,001	0,021	0,000	0,000	0,003	0,002	0,002	0,001	0,000	0,000	0,000	0,000	0,000	0,018	0,001	0,001	0,006	0,000	0,000
75.3 according to IEC	Fault	0,040	-0,028	0,028	0,061	0,016	0,016	0,054	-0,036	0,036	0,154	0,025	0,026	0,001	0,000	0,000	0,003	0,000	0,000	0,032	0,004	0,004	0,083	-0,007	0,008
3ph / Partial Load / Kp = 2, Kn=2	Post	0,004	-0,001	0,001	0,005	0,001	0,002	0,004	0,000	0,001	0,008	0,002	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,001	0,001	0,001	0,000	0,000
0,70 ≤ U_rest ≤ 0,80	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.4 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,70 ≤ U_rest ≤ 0,80	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.5 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 4, Kn=4	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,70 ≤ U_rest ≤ 0,80	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.6 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Full Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,70 ≤ U_rest ≤ 0,80	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75.7 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,70 ≤ U_rest ≤ 0,80	Pre	0,013	0,000	0,000	0,033	-0,001	0,001	0,014	0,001	0,001	0,036	-0,001	0,001	0,002	0,000	0,000	0,003	0,000	0,000	0,024	-0,001	0,001	0,027	-0,001	0,001
75.8 according to IEC	Fault	0,032	0,004	0,008	0,027	0,011	0,016	0,037	0,005	0,010	0,034	0,015	0,021	0,013	0,007	0,007	0,032	0,004	0,003	0,123	0,061	0,061	0,049	0,019	0,018
2ph / Partial Load / Kp = 4, Kn=4	Post	0,003	0,000	0,001	0,005	-0,002	0,002	0,003	0,000	0,001	0,005	-0,002	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,002	-0,001	0,001	0,002	0,000	0,001
0,75 ≤ U_rest ≤ 0,85	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80.1	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Full Load / Kp = 2, Kn=2, Limited Mode	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,75 ≤ U_rest ≤ 0,85	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80.2	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Full Load / Kp = 2, Kn=2, Limited Mode	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0,85 ≤ U_rest ≤ 0,90	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85.1 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U_rest ≥ 1,10	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
110.1 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Full Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U_rest ≥ 1,10	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
110.2 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U_rest ≥ 1,10	Pre	0,131	-0,001	0,001	0,009	0,000	0,000	0,121	-0,001	0,001	0,009	0,000	0,000	0,001	0,000	0,000	0,001	0,000	0,000	0,050	-0,001	0,001	0,025	-0,001	0,001
110.3 according to IEC	Fault	0,009	-0,001	0,001	0,025	-0,002	0,003	0,006	-0,001	0,001	0,020	-0,002	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,036	0,006	0,006	0,028	-0,005	0,005
3ph / Full Load / Kp = 2, Kn=2	Post	0,001	0,000	0,000	0,006	0,000	0,002	0,001	0,000	0,000	0,006	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,002	-0,001	0,001	0,002	0,000	0,000
U_rest ≥ 1,15	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115.1 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Full Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U_rest ≥ 1,15	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115.2 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3ph / Partial Load / Kp = 2, Kn=2	Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 22 – Summary of validation results - SUN2000-168KTL-H1 from [8]

4. Annex 4 – Validated simulation model

Summary of validation results - SUN2000-185KTL-H1

Test label according to TG3, chapter 4.6 - Behavior during grid disturbance - Table 4-68 and 4-69		Positive Sequence												Negative Sequence											
		P			Q			I_w			I_b			P			Q			I_w			I_b		
		MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
U_rest < 0,05	Pre	0,046	0,000	0,000	0,002	0,000	0,000	0,006	0,001	0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,008	-0,003	0,003	0,002	-0,001	0,001
0.1 according to IEC	Fault	0,032	0,008	0,020	0,086	-0,001	0,009	0,417	0,349	0,380	0,189	-0,097	0,108	0,014	0,000	0,000	0,019	0,000	0,000	0,105	0,002	0,007	0,137	0,005	0,006
3ph / Full Load / Kp = 2, Kn=2	Post	0,002	-0,003	0,003	0,004	-0,001	0,002	0,002	-0,002	0,003	0,004	-0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,003	-0,003	0,003	0,002	-0,001	0,001
U_rest < 0,05	Pre	0,006	0,000	0,000	0,001	0,000	0,000	0,017	0,000	0,000	0,001	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,016	-0,001	0,001	0,005	0,000	0,000
0.2 according to IEC	Fault	0,046	0,017	0,021	0,090	-0,001	0,010	0,416	0,372	0,385	0,196	-0,101	0,112	0,012	0,000	0,000	0,023	0,001	0,001	0,080	0,002	0,006	0,161	0,006	0,007
3ph / Partial Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,001	0,001	0,000	0,001	0,003	-0,001	0,001	0,001	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,001	-0,001	0,001	0,001	0,000	0,000
U_rest < 0,05	Pre	0,024	0,000	0,000	0,059	0,000	0,000	0,025	0,001	0,001	0,062	0,000	0,000	0,002	0,000	0,000	0,001	0,000	0,000	0,026	-0,003	0,003	0,015	-0,001	0,001
0.3 according to IEC	Fault	0,053	-0,019	0,010	0,124	0,015	0,016	0,101	-0,035	0,020	0,164	0,019	0,027	0,044	0,015	0,021	0,229	0,012	0,012	0,193	0,031	0,047	0,162	0,005	0,007
2ph / Full Load / Kp = 2, Kn=2	Post	0,002	0,000	0,002	0,002	-0,001	0,002	0,005	0,000	0,002	0,002	-0,002	0,003	0,000	0,000	0,000	0,000	0,001	0,001	0,003	-0,003	0,003	0,002	0,001	0,002
U_rest < 0,05	Pre	0,014	0,000	0,000	0,034	0,000	0,000	0,022	0,000	0,000	0,035	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,033	-0,001	0,001	0,003	0,000	0,000
0.4 according to IEC	Fault	0,055	-0,012	0,009	0,118	0,013	0,016	0,103	-0,024	0,019	0,176	0,015	0,024	0,044	0,017	0,022	0,223	0,005	0,008	0,194	0,034	0,049	0,172	0,000	0,010
2ph / Partial Load / Kp = 2, Kn=2	Post	0,003	0,000	0,001	0,001	-0,001	0,001	0,003	0,000	0,001	0,001	-0,002	0,002	0,000	0,000	0,000	0,000	0,001	0,001	0,002	-0,001	0,001	0,001	0,002	0,002
0,20 ≤ U_rest ≤ 0,30	Pre	0,053	0,000	0,000	0,003	0,000	0,000	0,006	0,001	0,001	0,004	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,003	-0,003	0,003	0,005	-0,001	0,001
25.1 according to IEC	Fault	0,077	-0,003	0,002	0,076	0,005	0,004	0,090	-0,002	0,006	0,170	0,020	0,021	0,010	0,000	0,000	0,015	0,000	0,000	0,109	-0,001	0,002	0,146	0,000	0,003
3ph / Full Load / Kp = 2, Kn=2	Post	0,015	-0,003	0,003	0,006	-0,001	0,003	0,015	-0,001	0,003	0,006	-0,001	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,004	-0,002	0,003	0,004	-0,001	0,001
0,20 ≤ U_rest ≤ 0,30	Pre	0,017	0,000	0,000	0,002	0,000	0,000	0,030	0,000	0,000	0,002	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,029	-0,001	0,001	0,001	0,000	0,000
25.2 according to IEC	Fault	0,085	0,000	0,002	0,052	0,006	0,005	0,089	0,003	0,005	0,129	0,021	0,022	0,009	0,000	0,000	0,016	0,000	0,000	0,087	-0,001	0,002	0,157	-0,001	0,003
3ph / Partial Load / Kp = 2, Kn=2	Post	0,002	-0,001	0,001	0,001	0,000	0,001	0,002	0,000	0,001	0,001	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,002	-0,001	0,001	0,001	0,000	0,000
0,20 ≤ U_rest ≤ 0,30	Pre	0,049	0,000	0,000	0,034	0,000	0,000	0,002	0,000	0,000	0,036	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,005	-0,003	0,003	0,005	-0,001	0,001
25.4 according to IEC	Fault	0,070	-0,010	0,007	0,107	0,016	0,016	0,107	-0,015	0,011	0,233	0,022	0,023	0,044	0,014	0,014	0,172	0,009	0,008	0,270	0,039	0,041	0,232	0,004	0,004
2ph / Full Load / Kp = 2, Kn=2	Post	0,003	0,001	0,002	0,004	-0,002	0,003	0,004	0,001	0,003	0,004	-0,003	0,003	0,000	0,000	0,000	0,000	0,001	0,001	0,004	-0,003	0,003	0,002	0,001	0,003
0,20 ≤ U_rest ≤ 0,30	Pre	0,009	0,000	0,000	0,022	0,000	0,000	0,016	0,000	0,000	0,023	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,022	-0,001	0,001	0,002	0,000	0,000
25.5 according to IEC	Fault	0,070	-0,004	0,006	0,114	0,016	0,015	0,108	-0,007	0,010	0,174	0,021	0,022	0,040	0,014	0,015	0,170	0,006	0,006	0,253	0,040	0,043	0,187	0,000	0,002
2ph / Partial Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,001	0,001	-0,001	0,002	0,003	-0,001	0,001	0,001	-0,002	0,002	0,000	0,000	0,000	0,000	0,001	0,001	0,001	-0,001	0,001	0,001	0,001	0,002
0,45 ≤ U_rest ≤ 0,60	Pre	0,053	0,000	0,000	0,002	0,000	0,000	0,005	0,001	0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,005	-0,003	0,003	0,002	-0,001	0,001
50.1 according to IEC	Fault	0,051	-0,003	0,002	0,052	0,009	0,008	0,053	-0,005	0,003	0,043	0,022	0,022	0,006	0,000	0,000	0,012	0,000	0,000	0,082	0,001	0,001	0,160	-0,004	0,005
3ph / Full Load / Kp = 2, Kn=2	Post	0,003	-0,004	0,004	0,002	0,000	0,001	0,004	-0,002	0,003	0,002	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,003	-0,003	0,003	0,002	-0,001	0,001
0,45 ≤ U_rest ≤ 0,60	Pre	0,018	0,000	0,000	0,001	0,000	0,000	0,032	0,000	0,000	0,001	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,029	-0,001	0,001	0,001	0,000	0,000
50.2 according to IEC	Fault	0,047	-0,002	0,002	0,063	0,009	0,008	0,047	-0,003	0,004	0,044	0,022	0,022	0,005	0,000	0,000	0,011	0,000	0,000	0,070	0,001	0,001	0,152	-0,004	0,006
3ph / Partial Load / Kp = 2, Kn=2	Post	0,002	-0,001	0,001	0,001	0,000	0,001	0,002	0,000	0,001	0,001	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,001	-0,001	0,001	0,001	0,000	0,000
0,45 ≤ U_rest ≤ 0,60	Pre	0,014	0,000	0,000	0,001	0,000	0,000	0,032	0,000	0,000	0,001	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,027	-0,001	0,001	0,003	0,000	0,000
50.5 according to IEC	Fault	0,008	0,006	0,005	0,006	0,004	0,004	0,015	0,011	0,011	0,009	0,008	0,008	0,001	0,000	0,000	0,001	0,000	0,000	0,012	0,000	0,000	0,011	0,000	0,000
3ph / Full Load / Kp = 2, Kn=2 / Limited Mode	Post	0,002	0,000	0,001	0,001	0,000	0,000	0,002	0,000	0,001	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,001	-0,001	0,001	0,001	0,000	0,000
0,45 ≤ U_rest ≤ 0,60	Pre	0,022	0,000	0,000	0,043	0,000	0,000	0,027	0,001	0,001	0,045	0,000	0,000	0,002	0,000	0,000	0,001	0,000	0,000	0,027	-0,003	0,003	0,015	-0,001	0,001
50.3 according to IEC	Fault	0,052	0,008	0,008	0,091	0,005	0,006	0,074	0,010	0,011	0,191	0,007	0,008	0,019	0,010	0,010	0,115	0,007	0,006	0,156	0,041	0,042	0,211	0,009	0,008
2ph / Full Load / Kp = 2, Kn=2	Post	0,002	0,004	0,005	0,004	-0,003	0,003	0,002	0,004	0,005	0,004	-0,003	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,004	-0,003	0,003	0,002	0,000	0,002
0,45 ≤ U_rest ≤ 0,60	Pre	0,013	0,000	0,000	0,022	0,000	0,000	0,024	0,000	0,000	0,023	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,028	-0,001	0,001	0,005	0,000	0,000
50.4 according to IEC	Fault	0,077	0,001	0,016	0,082	0,009	0,010	0,103	0,000	0,021	0,182	0,010	0,013	0,020	0,011	0,011	0,116	0,006	0,006	0,155	0,043	0,045	0,209	0,010	0,009
2ph / Partial Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,001	0,005	-0,002	0,003	0,003	0,000	0,001	0,005	-0,003	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,001	-0,001	0,001	0,001	0,001	0,001
0,45 ≤ U_rest ≤ 0,60	Pre	0,014	0,000	0,000	0,020	0,000	0,000	0,024	0,000	0,000	0,021	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,027	-0,001	0,001	0,006	0,000	0,000
50.6 according to IEC	Fault	0,042	-0,004	0,005	0,019	0,009	0,009	0,055	-0,005	0,006	0,024	0,012	0,012	0,003	-0,003	0,003	0,003	0,001	0,001	0,027	-0,011	0,010	0,045	0,004	0,004
2ph / Full Load / Kp = 2, Kn=2 / Limited Mode	Post	0,003	0,000	0,001	0,005	0,000	0,002	0,003	0,000	0,001	0,005	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,003	-0,001	0,001	0,002	0,000	0,000
0,70 ≤ U_rest ≤ 0,80	Pre	0,018	0,000	0,000	0,004	0,000	0,000	0,031	0,001	0,001	0,004	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,020	-0,003	0,003	0,008	-0,001	0,001
75.1 according to IEC	Fault	0,143	-0,014	0,015	0,089	-0,001	0,002	0,174	-0,019	0,020	0,129	-0,002	0,004	0,002	0,000	0,000	0,003	0,000	0,000	0,051	0,004	0,004	0,071	-0,006	0,007
3ph / Full Load / Kp = 2, Kn=2	Post	0,002	-0,002	0,002	0,005	-0,001	0,002	0,005	0,000	0,003	0,005	-0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,003	-0,003	0,003	0,002	-0,001	0,001

4. Annex 4 – Validated simulation model

Test label according to TG3, chapter 4.6 - Behavior during grid disturbance - Table 4-68 and 4-69		Positive Sequence												Negative Sequence											
		P			Q			I_w			I_b			P			Q			I_w			I_b		
		MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE	MXE	ME	MAE
0,70 ≤ U_rest ≤ 0,80	Pre	0,023	0,000	0,000	0,002	0,000	0,000	0,027	0,000	0,000	0,002	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,018	-0,001	0,001	0,003	0,000	0,000
75.2 according to IEC	Fault	0,157	-0,005	0,006	0,103	0,004	0,007	0,211	-0,006	0,007	0,144	0,006	0,013	0,003	0,000	0,000	0,004	0,000	0,000	0,094	0,002	0,003	0,108	-0,003	0,004
3ph / Partial Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,001	0,005	0,000	0,001	0,003	0,000	0,002	0,005	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,002	-0,001	0,001	0,001	0,000	0,000
0,70 ≤ U_rest ≤ 0,80	Pre	0,022	0,000	0,000	0,005	0,003	0,003	0,026	0,000	0,000	0,006	0,004	0,004	0,001	0,000	0,000	0,000	0,000	0,000	0,014	0,000	0,000	0,006	-0,002	0,002
75.3 according to IEC	Fault	0,062	-0,029	0,029	0,045	0,012	0,012	0,067	-0,037	0,037	0,081	0,020	0,020	0,002	0,000	0,000	0,002	0,000	0,000	0,043	0,004	0,004	0,067	-0,009	0,010
3ph / Partial Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,001	0,008	0,002	0,002	0,003	-0,001	0,001	0,009	0,003	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,000	0,003	-0,001	0,002
0,70 ≤ U_rest ≤ 0,80	Pre	0,018	0,000	0,000	0,011	-0,001	0,001	0,023	0,000	0,000	0,004	-0,001	0,001	0,001	0,000	0,000	0,000	0,000	0,000	0,019	-0,001	0,001	0,010	0,001	0,001
75.4 according to IEC	Fault	0,143	-0,002	0,003	0,114	0,006	0,010	0,162	-0,001	0,002	0,134	0,008	0,012	0,002	0,000	0,000	0,004	0,000	0,000	0,060	0,004	0,004	0,100	-0,001	0,001
3ph / Partial Load / Kp = 2, Kn=2	Post	0,002	-0,001	0,001	0,006	-0,001	0,002	0,002	0,000	0,001	0,009	-0,002	0,003	0,000	0,000	0,000	0,000	0,000	0,000	0,002	-0,002	0,002	0,002	0,001	0,001
0,70 ≤ U_rest ≤ 0,80	Pre	0,022	0,000	0,000	0,001	0,000	0,000	0,025	0,000	0,000	0,001	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,015	-0,001	0,001	0,002	0,000	0,000
75.5 according to IEC	Fault	0,145	-0,014	0,014	0,118	0,011	0,018	0,170	-0,017	0,017	0,168	0,018	0,030	0,005	0,000	0,000	0,007	0,000	0,000	0,125	0,004	0,006	0,149	-0,015	0,017
3ph / Partial Load / Kp = 4, Kn=4	Post	0,003	-0,001	0,001	0,001	0,000	0,001	0,003	-0,001	0,001	0,001	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,001	-0,001	0,001	0,001	0,000	0,000
0,70 ≤ U_rest ≤ 0,80	Pre	0,051	0,000	0,000	0,020	0,000	0,000	0,030	0,001	0,001	0,021	0,000	0,000	0,002	0,000	0,000	0,002	0,000	0,000	0,030	-0,003	0,003	0,034	-0,001	0,001
75.6 according to IEC	Fault	0,040	0,001	0,004	0,089	-0,002	0,002	0,040	0,003	0,004	0,110	-0,002	0,002	0,008	0,003	0,003	0,024	0,003	0,003	0,095	0,027	0,027	0,120	0,019	0,018
2ph / Full Load / Kp = 2, Kn=2	Post	0,002	0,001	0,001	0,001	0,000	0,001	0,003	0,002	0,002	0,001	-0,001	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,004	-0,003	0,003	0,002	-0,001	0,001
0,70 ≤ U_rest ≤ 0,80	Pre	0,031	0,000	0,000	0,021	0,000	0,000	0,022	0,000	0,000	0,023	0,000	0,000	0,002	0,000	0,000	0,002	0,000	0,000	0,030	-0,001	0,001	0,030	0,000	0,000
75.7 according to IEC	Fault	0,032	-0,006	0,007	0,025	0,005	0,007	0,047	-0,007	0,007	0,020	0,006	0,009	0,004	0,003	0,003	0,016	0,001	0,001	0,060	0,026	0,026	0,026	0,007	0,006
2ph / Partial Load / Kp = 2, Kn=2	Post	0,003	0,000	0,001	0,001	0,000	0,000	0,003	0,000	0,001	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,002	-0,001	0,001	0,001	0,000	0,000
0,70 ≤ U_rest ≤ 0,80	Pre	0,031	0,000	0,000	0,024	0,000	0,000	0,021	0,000	0,000	0,025	0,000	0,000	0,002	0,000	0,000	0,002	0,000	0,000	0,033	-0,001	0,001	0,031	0,000	0,000
75.8 according to IEC	Fault	0,048	-0,014	0,014	0,051	0,017	0,021	0,063	-0,014	0,014	0,042	0,022	0,027	0,006	0,005	0,005	0,027	0,003	0,003	0,054	0,045	0,046	0,030	0,017	0,016
2ph / Partial Load / Kp = 4, Kn=4	Post	0,003	-0,001	0,001	0,001	0,000	0,001	0,003	0,000	0,001	0,001	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,001	-0,001	0,001	0,001	0,000	0,001
0,75 ≤ U_rest ≤ 0,85	Pre	0,021	0,000	0,000	0,006	0,000	0,000	0,025	0,001	0,001	0,006	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,018	-0,003	0,003	0,017	-0,001	0,001
80.1	Fault	0,030	-0,020	0,021	0,070	0,005	0,007	0,052	-0,026	0,027	0,096	0,006	0,009	0,001	0,000	0,000	0,002	0,000	0,000	0,038	0,004	0,004	0,061	-0,005	0,005
3ph / Full Load / Kp = 2, Kn=2, Limited Mode	Post	0,003	-0,001	0,001	0,005	-0,001	0,001	0,006	0,002	0,002	0,005	-0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,004	-0,003	0,003	0,002	0,000	0,001
0,75 ≤ U_rest ≤ 0,85	Pre	0,015	0,000	0,000	0,016	0,000	0,000	0,027	0,001	0,001	0,016	0,000	0,000	0,002	0,000	0,000	0,001	0,000	0,000	0,038	-0,003	0,003	0,008	-0,001	0,001
80.2	Fault	0,022	0,006	0,006	0,043	0,005	0,006	0,021	0,007	0,007	0,041	0,006	0,007	0,002	0,002	0,002	0,005	0,004	0,004	0,025	0,023	0,023	0,042	0,025	0,024
2ph / Full Load / Kp = 2, Kn=2, Limited Mode	Post	0,003	-0,001	0,001	0,006	-0,001	0,001	0,002	0,000	0,002	0,006	-0,001	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,004	-0,002	0,003	0,002	-0,001	0,001
0,85 ≤ U_rest ≤ 0,90	Pre	0,012	0,000	0,000	0,030	0,000	0,000	0,010	0,000	0,000	0,035	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,009	-0,001	0,001	0,007	0,000	0,000
85.1 according to IEC	Fault	0,033	-0,001	0,001	0,097	0,000	0,000	0,040	-0,002	0,002	0,109	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,020	0,004	0,004	0,039	-0,004	0,004
3ph / Partial Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,001	0,001	0,000	0,000	0,003	-0,001	0,001	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,001	-0,001	0,001	0,001	0,000	0,000
U_rest ≥ 1,10	Pre	0,055	-0,001	0,001	0,058	0,000	0,001	0,097	-0,001	0,001	0,055	0,000	0,001	0,003	0,000	0,000	0,003	0,000	0,000	0,062	-0,004	0,004	0,056	-0,001	0,001
110.1 according to IEC	Fault	0,043	-0,032	0,032	0,104	0,000	0,002	0,043	-0,029	0,029	0,097	0,000	0,002	0,002	0,001	0,001	0,006	0,000	0,000	0,062	0,018	0,018	0,105	-0,004	0,006
2ph / Full Load / Kp = 2, Kn=2	Post	0,002	0,000	0,001	0,006	0,000	0,002	0,002	0,001	0,002	0,006	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,004	-0,003	0,003	0,002	0,000	0,001
U_rest ≥ 1,10	Pre	0,038	0,000	0,000	0,027	0,000	0,000	0,043	0,000	0,001	0,026	0,000	0,000	0,002	0,000	0,000	0,002	0,000	0,000	0,043	-0,001	0,001	0,029	0,000	0,000
110.2 according to IEC	Fault	0,008	0,000	0,000	0,074	0,004	0,004	0,018	0,000	0,000	0,067	0,004	0,003	0,002	-0,002	0,002	0,006	0,000	0,000	0,053	-0,031	0,031	0,052	-0,002	0,004
2ph / Partial Load / Kp = 2, Kn=2	Post	0,003	0,000	0,000	0,005	0,000	0,002	0,003	0,000	0,000	0,005	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,001	0,003	0,001	0,001
U_rest ≥ 1,10	Pre	0,097	-0,001	0,001	0,083	0,000	0,001	0,084	-0,001	0,001	0,077	0,000	0,001	0,001	0,000	0,000	0,000	0,000	0,000	0,038	-0,001	0,001	0,025	0,000	0,000
110.3 according to IEC	Fault	0,018	-0,002	0,002	0,166	-0,006	0,006	0,014	-0,002	0,002	0,149	-0,005	0,005	0,000	0,000	0,000	0,000	0,000	0,000	0,039	0,007	0,007	0,023	-0,006	0,006
3ph / Full Load / Kp = 2, Kn=2	Post	0,003	0,000	0,000	0,005	-0,001	0,002	0,003	0,000	0,000	0,005	-0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,004	-0,001	0,001	0,001	0,000	0,000
U_rest ≥ 1,15	Pre	0,020	0,001	0,001	0,002	0,000	0,000	0,029	0,001	0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,024	-0,003	0,003	0,013	-0,001	0,001
115.1 according to IEC	Fault	0,072	-0,006	0,003	0,165	-0,002	0,007	0,020	-0,005	0,003	0,118	-0,002	0,005	0,001	0,000	0,000	0,000	0,000	0,000	0,052	0,006	0,006	0,054	-0,005	0,005
3ph / Full Load / Kp = 2, Kn=2	Post	0,003	-0,001	0,002	0,002	0,002	0,002	0,006	-0,002	0,002	0,002	0,001	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,003	-0,003	0,003	0,001	-0,001	0,001
U_rest ≥ 1,15	Pre	0,127	-0,001	0,001	0,076	0,000	0,000	0,133	-0,001	0,001	0,070	0,000	0,000	0,002	0,000	0,000	0,002	0,000	0,000	0,077	-0,001	0,001	0,066	0,000	0,000
115.2 according to IEC	Fault	0,006	-0,004	0,003	0,118	-0,002	0,007	0,014	-0,003	0,003	0,078	-0,001	0,005	0,001	0,000	0,000	0,000	0,000	0,000	0,051	0,007	0,007	0,054	-0,006	0,006
3ph / Partial Load / Kp = 2, Kn=2	Post	0,003	0,000	0,000	0,004	0,000	0,002	0,003	0,000	0,001	0,004	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,001	0,000	0,001	0,002	0,000	0,001

Figure 23 – Summary of validation results - SUN2000-185KTL-H1 from [8]

5. Annex 5 – Certification-relevant parameters

Parameter list from [14]:

BUREAU VERITAS	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
	Ansprechpartner / *Customer Contact:*	Bin Xu Website: http://www.huawei.com Email: support@huawei.com	BV-Kontakt / *BV Contact:*	Weizhao Zheng Tel: +49 40 74041 - 2267 weizhao.zheng@de.bureauveritas.com

Parameter list of SUN2000-(168KTL-H1, 185KTL-INH0, 185KTL-H1)

1. General information regarding the Parameter list

Manufacturer:	Huawei Technologies Co., Ltd.
Created by:	Bin Xu
Created on:	2019-12-18
Revised on:	V1.0

2. Information regarding the power generating unit

Type designation	Rated power [kW]	Rated active current [A] (at cosφ = 1)
SUN2000-185KTL-H1	175	126.3
SUN2000-168KTL-H1	150	108.3
SUN2000-185KTL-INH0	160	115.5

3. Parameter set during the measurement

If no noted otherwise the following standard parameters were used during the measurement.

All adaptations to the standard parameters used during the measurement were documented in the TG3 test report.

4. Main Components of the regulating system

Main components of the control system with firmware and software	
Main component(s) of the control system	Control system integrated in the PGU
Firmware version	V300R001
Software version	V300R001

5. Relevant parameters for the electrical behaviour

No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
General parameter settings (rated values or reference values)						
1	Pn	Rated active power	kW	parameter not adjustable		*SUN2000-185KTL-H1*: 175 *SUN2000-168KTL-H1*: 150 *SUN2000-185KTL-INH0*: 160
2	Smax	Max apparent power	kVA	parameter not adjustable		*SUN2000-185KTL-H1*:185 *SUN2000-168KTL-H1*: 168

5. Annex 5 – Certification-relevant parameters

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No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
						SUN2000-185KTL-INH0: 185
3	Un	Rated voltage	V	parameter not adjustable		800
4	In	Rated current	A	parameter not adjustable		*SUN2000-185KTL-H1*: 126.3 *SUN2000-168KTL-H1*: 108.3 *SUN2000-185KTL-INH0*: 115.5
5	Fn	Rated frequency	Hz	parameter not adjustable		50
Active power peaks						
6	Pmax	Maximum active power limit	kW	parameter not adjustable		*SUN2000-168KTL-H1*: 168.000 *SUN2000-185KTL-H1*: 185.000 *SUN2000-185KTL-INH0*: 185.000
7	Maximum active power	Plimilt	kW	0.100	Pmax	Pmax
8	Active power baseline	Pmaxref	kW	0.100	Pmax	Pmax
Operating power limited by grid operator						
9	Shutdown at 0% power limit	Shutdown at 0% power limit function enable	---	Disable / Enable		Disable
10	Active power change gradient	Active power change gradient	%Pmaxref/s	0.100	1000.000	125.000
11	Fixed active power derated	Fixed active power derated	kW	0.0	Plimilt	Plimilt
12	Active power percentage derating	Active power percentage derating	%Pmaxref	0.0	100.0	100.0
13	Reactive power change gradient	Reactive power change gradient	%(0.6Smax)/s	0.100	1000.000	125.00
14	Reactive power adjustment time	Reactive power adjustment time [1)]	s	1	120	10

Note:

1)

- For country code setting VDE-AR-N 4110:2018-11:
  for all abrupt set-point changes, the reactive power control methods Q(U), Q(P), PF provide PT1 (1st order lowpass) filtering effect, in this case the time constant parameter *Reactive power adjustment time* will be effective and corresponding to 3τ.
- For country code setting VDE-AR-N 4120:2018-11:
  for all abrupt set-point changes, the reactive power control methods Q(U) provides PT1 (1st order lowpass) filtering effect, in this case the time constant parameter *Reactive power adjustment time* will be effective and corresponding to 3τ.

5. Annex 5 – Certification-relevant parameters

	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
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No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
Active power feed-in as a function of grid frequency						
15	Overfrequency derating	Overfrequency derating function enable	---	Disable / Enable		Disable
16	Trigger frequency of over frequency derating	Start frequency P(f) (Start of frequency regulation - power reduction)	Hz	40.00	60.00	50.20
17	Quit frequency of over frequency derating	Quit frequency P(f) (End of frequency regulation - power reduction)	Hz	40.00	60.00	50.15
18	Cuttoff frequency of over frequency derating	End frequency P(f) (End of frequency regulation - power reduction)	Hz	40.00	60.00	51.50
19	Cutoff power of over frequency derating	End power P(f) (End of power of frequency regulation - power reduction)	%PM	0	100	48
20	Power recovery gradient of overfrequency derating	Power recovery gradient when quit overfrequency derating	%Prated/min	1	6000	10
21	Underfrequency rise power	Underfrequency derating function enable	---	Disable / Enable		Disable
22	Trigger frequency of underfrequency rise power	Start frequency P(f) (Start of frequency regulation - power rise)	Hz	40.00	60.00	49.80
23	Quit frequency of underfrequency rise power	Quit frequency P(f) (End of frequency regulation - power rise)	Hz	40.00	60.00	49.90
24	Cuttoff frequency of underfrequency rise power	End frequency P(f) (End of frequency regulation - power rise)	Hz	40.00	60.00	47.5
25	Cutoff power of underfrequency rise power	End power P(f) (End of power of frequency regulation - power rise)	%PM	0	100	92
26	Power recovery gradient of underfrequency rise power	Power recovery gradient when quit underfrequency rise power	%Prated/min	1	6000	10

Note:

The required gradient (or droop) of the frequency dependent active power derating can be defined using the Parameters *Trigger frequency of over frequency derating*, *Cuttoff frequency of over frequency derating* and *Cutoff power of over frequency derating*.

The required gradient (or droop) of the frequency dependent active power increasing can be defined using the Parameters *Trigger frequency of underfrequency rise power*, *Cuttoff frequency of underfrequency rise power* and *Cutoff power of underfrequency rise power*.

5. Annex 5 – Certification-relevant parameters

BUREAU VERITAS	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
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No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
Active power gradient following disconnection from the grid						
27	Soft start time after grid failure	The soft start time the active power from 0 to power rated after fault	s	1	1800	600
Reconnection time following disconnection from the grid						
28	Grid connection duration after power grid recovery	Time until reconnection	s	0	7200	600
Reactive power provision						
a) Power factor fix control						
29	**Power factor**	Cos phi specifications	---	[-1.000,-0.800] U [0.800,1.000]		1.000
b) Reactive power fix control						
30	Reactive power	Q specifications	kvar	-0.6·Smax	0.6·Smax	0.0
c) Q-U characteristic curve [2]						
Note: [2] The Q-U characteristic curve is free programmable with up to 10 supporting points.						
31	Trigger power ratio	Q(U) function trigger power ratio of Pmax	%Pmax	10	100	20
32	Characteristic curve points	Number of Q-U characteristic curve	---	2	10	*VDE 4110*: 3 *VDE 4120*: 4
33	U/Un(A)	Q(U) characteristic node 1 U	%Un	80.0	136.0	*VDE 4110*: 96.0 *VDE 4120*: 94.0
34	Q/S(A)	Q(U) characteristic node 1 Q	/Smax	-0.600	0.600	*VDE 4110*: 0.330 *VDE 4120*: 0.330
35	U/Un(B)	Q(U) characteristic node 2 U	%Un	80.0	136.0	*VDE 4110*: 100.0 *VDE 4120*: 96.0
36	Q/S(B)	Q(U) characteristic node 2 U	/Smax	-0.600	0.600	*VDE 4110*: 0.000 *VDE 4120*: 0.000
37	U/Un(C)	Q(U) characteristic node 3 U	%Un	80.0	136.0	*VDE 4110*: 104.0 *VDE 4120*: 104.0
38	Q/S(C)	Q(U) characteristic node 3 Q	/Smax	-0.600	0.600	*VDE 4110*: -0.330 *VDE 4120*: 0.000
39	U/Un(D)	Q(U) characteristic node 4 U	%Un	80.0	136.0	*VDE 4120*: 106.0
40	Q/S(D)	Q(U) characteristic node 4 Q	/Smax	-0.600	0.600	*VDE 4120*: -0.330
d) Q-P characteristic curve [3]						
Note: [3] The Q-P characteristic curve is free programmable with up to 10 supporting points.						

5. Annex 5 – Certification-relevant parameters

BUREAU VERITAS 1828	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
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No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
41	Characteristic curve points	Number of Q-P characteristic curve	-	2	10	5
42	P/Pmax(A)	Q(P) characteristic node 1 P (Only VDE 4110 effective)	%Pmax	0.0	100.0	10.0
43	Q/Qmax(A)	Q(P) characteristic node 1 Q (Only VDE 4110 effective)	/Smax	-0.600	0.600	0.000
44	P/Pmax(B)	Q(P) characteristic node 2 P (Only VDE 4110 effective)	%Pmax	0.0	100.0	50.0
45	Q/Qmax(B)	Q(P) characteristic node 2 Q (Only VDE 4110 effective)	/Smax	-0.600	0.600	0.000
46	P/Pmax(C)	Q(P) characteristic node 3 P (Only VDE 4110 effective)	%Pmax	0.0	100.0	60.0
47	Q/Qmax(C)	Q(P) characteristic node 13 Q (Only VDE 4110 effective)	/Smax	-0.600	0.600	-0.050
48	P/Pmax(D)	Q(P) characteristic node 4 P (Only VDE 4110 effective)	%Pmax	0.0	100.0	90.0
49	Q/Qmax(D)	Q(P) characteristic node 4 Q (Only VDE 4110 effective)	/Smax	-0.600	0.600	-0.330
50	P/Pmax(E)	Q(P) characteristic node 5 P (Only VDE 4110 effective)	%Pmax	0.0	100.0	100.0
51	Q/Qmax(E)	Q(P) characteristic node 5 Q (Only VDE 4110 effective)	/Smax	-0.600	0.600	-0.330
PGU disconnection from the grid						
52	10 minute OV protection	10 minute voltage average value protection point	V	800.0	1200.0	1000.0
53	10 minute OV protection time	10 minute voltage average value protection time	ms	50	7200000	200
54	Level-1 OV protection	Level 1 over voltage protection point	V	800.0	1200.0	896.0
55	Level-1 OV protection time	Level 1 over voltage protection time	ms	50	7200000	*VDE 4110*: 180000 *VDE 4120*: 1800000
56	Level-2 OV protection	Level 2 over voltage protection point	V	800.0	1200.0	1000.0
57	Level-2 OV protection time	Level 2 over voltage protection time	ms	50	7200000	66000
58	Level-3 OV protection	Level 3 over voltage protection point	V	800.0	1200.0	1040.0
59	Level-3 OV protection time	Level 3 over voltage protection time	ms	50	7200000	200

5. Annex 5 – Certification-relevant parameters

BUREAU VERITAS	Firma / *Company:*	Huawei Technologies Co., Ltd.	Projekt-Nr. / *Project-no.:*	19TH0240
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No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
60	Level-1 UV protection	Level 1 under voltage protection point	V	120.0	800.0	696.0
61	Level-1 UV protection time	Level 1 under voltage protection time	ms	50	7200000	*VDE 4110*: 66000 *VDE 4120*: 3600000
62	Level-2 UV protection	Level 2 under voltage protection point	V	120.0	800.0	640.0
63	Level-2 UV protection time	Level 2 under voltage protection time	ms	50	7200000	6000
64	Level-1 OF protection	Level 1 over frequency protection point	Hz	50.00	60.00	51.00
65	Level-1 OF protection time	Level 1 over frequency protection time	ms	50	7200000	1800000
66	Level-2 OF protection	Level 2 over frequency protection point	Hz	50.00	60.00	51.50
67	Level-2 OF protection time	Level 2 over frequency protection time	ms	50	7200000	100
68	Level-1 UF protection	Level 1 under frequency protection point	Hz	40.00	50.00	49.00
69	Level-1 UF protection time	Level 1 under frequency protection time	ms	50	7200000	1800000
70	Level-2 UF protection	Level 2 under frequency protection point	Hz	40.00	50.00	47.5
71	Level-2 UF protection time	Level 2 under frequency protection time	ms	50	7200000	100
Connection conditions						
72	Auto start upon grid recovery	Enable Auto start upon grid after grid fault	---	Disable/Enable		Enable
73	Grid reconnection voltage upper limit	Limit value connection U>	V	800.0	1088.0	880.0
74	Grid reconnection voltage lower limit	Limit value connection U<	V	360.0	800.0	760.0
75	Grid reconnection frequency upper limit	Limit value connection f>	Hz	50.00	60.00	50.10
76	Grid reconnection frequency lower limit	Limit value connection f<	Hz	40.00	50.00	49.90
Response during grid faults						
77	LVRT	LVRT enable	---	Enable/Disable		Enable
78	LVRT triggering threshold	LVRT triggering threshold	V	400.0	800.0	720.0

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5. Annex 5 – Certification-relevant parameters

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No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
79	LVRT reactive power compensation factor	k factor	---	0.0	10.0	2.0
80	HVRT	HVRT enable	---	Enable/Disable		Enable
81	HVRT triggering threshold	LVRT triggering threshold	V	800.0	1088.0	880.0
82	HVRT reactive power compensation factor	k factor	---	0.0	6.0	2.0
83	VRT exit hysteresis threshold	VRT exit hysteresis threshold	V	16.0	80.0	16.0
84	Grid voltage protection shield during HVRT/LVRT	Grid voltage protection shield during HVRT/LVRT	---	Enable/Disable		Enable
85	Zero current due to power grid fault	Zero current due to power grid fault	---	Enable/Disable		Enable
86	Grid voltage jump triggering threshold	Grid voltage jump triggering threshold	%Un	3.0	30.0	5.0
LVRT Characteristic Curve						
87	Characteristic Curve points	Number of LVRT characteristic curve points	---	2	10	5
88	t(A)	LVRT characteristic node 1 t	ms	0	60000	0
89	U(A)	LVRT characteristic node 1 U	%Un	0	100	100
90	t(B)	LVRT characteristic node 2 t	ms	0	60000	0
91	U(B)	LVRT characteristic node 2 U	%Un	0	100	0
92	t(C)	LVRT characteristic node 3 t	ms	0	60000	220
93	U(C)	LVRT characteristic node 3 U	%Un	0	100	0
94	t(D)	LVRT characteristic node 4 t	ms	0	60000	3000
95	U(D)	LVRT characteristic node 4 U	%Un	0	100	75
96	t(E)	LVRT characteristic node 5 t	ms	0	60000	5000
97	U(E)	LVRT characteristic node 5 U	%Un	0	100	85
Self-protection						
98	Line voltage peak value protection point	Line voltage peak value protection point, exceeds which a non-delayed self-protection tripping occurs	V	parameter not adjustable		1490 ($1.32 \cdot U_n$)

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Figure 24 – Parameter list from [14]