TEST REPORT

EN 50549-1:2019

Requirements for generating plants to be connected in parallel with distribution networks - Part 1-1: Connection to a LV distribution network - Generating plants up to and including Type B

Report reference number ..... :	**AQTG-ESH-P23041258**
Date of issue..... :	2024-04-08
Total number of pages ..... :	155
Testing laboratory name..... :	**Bureau Veritas Consumer Products Services Germany GmbH**
Address ..... :	Businesspark A96, 86842 Türkheim, Germany
Accrediation..... :	ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12024-03-00
Applicant's name ..... :	**SRNE Solar Co.,Ltd**
Address ..... :	4-5F,Building13A,Taihua Wutong Industrial Park ,Gushu Development Zone ,Hangcheng Street, Baoan 518102 Shenzhen, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Test specification	
Standard..... :	EN 50549-1:2019 With deviations for Poland for type A
Certificate ..... :	**Certificate of compliance**
Test report form number..... :	EN 50549-1
Master TRF..... :	Bureau Veritas Consumer Products Services Germany GmbH
Test item description ..... :	**Solar Hybrid Inverter**
Trademark ..... :	SRNE
Model / Type..... :	HESP4840S100-H, HESP4846S100-H, HESP4850S100-H, HESP4855S100-H, HESP4860S100-H

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Model / Type.....:	**HESP4840S100-H**	**HESP4846S100-H**	**HESP4850S100-H HESP4855S100-H**	**HESP4860S100-H**
Max.DC voltage.....:	500 V			
MPPT voltage range.....:	120-450 V			
Max. PV current.....:	16 A/16 A			
Rated grid voltage.....:	L/N/PE, 230 V, 50 Hz			
Rated AC Output current.....:	17,4 A	20 A	24 A	26 A
Rated AC Output active Power.:	4000 W	4600 W	5500 W	6000 W

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Testing Location ..... :	**LCIE China Company Limited**
Address ..... :	Building 4, No, 518, Xinzhuan Road, Caohejing, Songjiang High-Tech Park, Shanghai, P,R, China (201612)
Tested by (name and signature) ..... :	Joell Qin
Approved by (name and signature) ..... :	Robin Wu
Manufacturer's name ..... :	**SRNE Solar Co.,Ltd**
Manufacturer's address..... :	4-5F,Building13A,Taihua Wutong Industrial Park ,Gushu Development Zone ,Hangcheng Street, Baoan 518102 Shenzhen, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Factory name ..... :	**SRNE SOLAR CO.,LTD Dongguan Branch**
Factory address ..... :	Room 301, Building 5th, Fuxing Rd No.36, Chang'an Town, Dongguan City, Guangdong Province, China PR

Document History

Date	Internal reference	Modification / Change / Status	Revision
2024-04-08	Joell Qin	Initial report was written	0

Supplementary information:

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Test items particulars

Equipment mobility..... :	Permanent connection
Operating condition..... :	Continuous
Class of equipment ..... :	Class I
Protection against ingress of water.. :	IP65 according to EN 60529
Mass of equipment [kg]..... :	22 kg for all models

Test case verdicts

Test case does not apply to the test object ..... :	N/A
Test item does meet the requirement..... :	P(ass)
Test item does not meet the requirement..... :	F(ail)

Testing

Date of receipt of test item ..... :	2023-04-15
Date(s) of performance of test..... :	2023-05-20 to 2023-11-17 and 2024-03-22 to 2024-03-29

General remarks:

The test result presented in this report relate only to the object(s) tested. The report shall state compliance of the tested objects with the requirements of EN 50549-1. This report shall not be reproduced in part or in full without the written approval of the issuing testing laboratory.

”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

Throughout this report a comma is used as the decimal separator.

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This Test Report consists of the following documents:

1. Test Report
   - 4.4 Normal operating range
   - 4.5 Immunity to disturbances
   - 4.6 Active response to frequency deviation
   - 4.7 Power response to voltage variations and voltage changes
   - 4.8 EMC and power quality
   - 4.9 Interface protection
   - 4.10 Connection and starting to generate electrical power
   - 4.11 Ceasing and reduction of active power on set point
   - 4.13 Requirements regarding single fault tolerance of interface protection system and interface switch
2. Annex No. 1 – Parameter table
3. Annex No. 2 – Datasheet of the relay
4. Annex No. 3 – Pictures of the unit
5. Annex No. 4 – Test equipment list

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Copy of marking plate

Solar Hybrid Inverter

Model Name	HESP4860S100-H
Ingress protection	IP65
Operating Temperature Range	-25~60°C(>45°C derating)
Inverter topology	Non-isolated
Over voltage category	III(AC) , II(DC)
Protective class	I
Max.Parallel	6
PV INPUT:	
Max. DC input power	4500W/4500W
Absolute max. voltage	500Vd.c./500Vd.c.
MPPT voltage range	120Vd.c.-450Vd.c.
Max. input current	16Ad.c./16Ad.c.
Isc PV	27Ad.c./27Ad.c.
AC INPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	40Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	9200VA
Nominal power	9200W
Power factor	0.8 leading to 0.8 lagging
AC OUTPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	26Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	6000VA
Nominal power	6000W
AC output power factor	0.8 leading to 0.8 lagging
Battery:	
Battery type	Li-ion/Lead-acid
Battery voltage range	40Vd.c.-60Vd.c.
Max. charge/discharge current	100Ad.c./135Ad.c.

SN:

5min RoHS COMPLIANT

Manufacturer:SRNE Solar Co.,Ltd

Address:4-5, Building13A Taihua Wutong Industrial Park Gushu Development Zone, Hangcheng Street, Baoan 518102 Shenzhen, Guangdong Province PEOPLE'S REPUBLIC OF CHINA

WARNING FIRE HAZARD:
SUITABLE FOR MOUNTING ON CONCRETE
OR OTHER NON-COMBUSTIBLE SURFACE ONLY
CAUTION:THE DC AND AC BREAKER MUST
HAVE BEEN TURNED OFF BEFORE SERVICING

MADE IN CHINA

Solar Hybrid Inverter

Model Name	HESP4855S100-H
Ingress protection	IP65
Operating Temperature Range	-25~60°C(>45°C derating)
Inverter topology	Non-isolated
Over voltage category	III(AC) , II(DC)
Protective class	I
Max.Parallel	6
PV INPUT:	
Max. DC input power	4000W/4000W
Absolute max. voltage	500Vd.c./500Vd.c.
MPPT voltage range	120Vd.c.-450Vd.c.
Max. input current	16Ad.c./16Ad.c.
Isc PV	27Ad.c./27Ad.c.
AC INPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	40Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	9200VA
Nominal power	9200W
Power factor	0.8 leading to 0.8 lagging
AC OUTPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	24Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	5500VA
Nominal power	5500W
AC output power factor	0.8 leading to 0.8 lagging
Battery:	
Battery type	Li-ion/Lead-acid
Battery voltage range	40Vd.c.-60Vd.c.
Max. charge/discharge current	100Ad.c./130Ad.c.

SN:

5min RoHS COMPLIANT

Manufacturer:SRNE Solar Co.,Ltd

Address:4-5, Building13A Taihua Wutong Industrial Park Gushu Development Zone, Hangcheng Street, Baoan 518102 Shenzhen, Guangdong Province PEOPLE'S REPUBLIC OF CHINA

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Solar Hybrid Inverter

Model Name	HESP4850S100-H
Ingress protection	IP65
Operating Temperature Range	-25~60°C(>45°C derating)
Inverter topology	Non-isolated
Over voltage category	III(AC) , II(DC)
Protective class	I
Max.Parallel	6
PV INPUT:	
Max. DC input power	4000W/4000W
Absolute max. voltage	500Vd.c./500Vd.c.
MPPT voltage range	120Vd.c.-450Vd.c.
Max. input current	16Ad.c./16Ad.c.
Isc PV	27Ad.c./27Ad.c.
AC INPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	40Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	9200VA
Nominal power	9200W
Power factor	0.8 leading to 0.8 lagging
AC OUTPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	24Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	5500VA
Nominal power	5500W
AC output power factor	0.8 leading to 0.8 lagging
Battery:	
Battery type	Li-ion/Lead-acid
Battery voltage range	40Vd.c.-60Vd.c.
Max. charge/discharge current	100Ad.c./130Ad.c.

SN:

5min RoHS COMPLIANT

Manufacturer:SRNE Solar Co.,Ltd

Address:4-5, Building13A Taihua Wutong Industrial Park Gushu Development Zone, Hangcheng Street, Baoan 518102 Shenzhen, Guangdong Province PEOPLE'S REPUBLIC OF CHINA

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Solar Hybrid Inverter

Model Name	HESP4846S100-H
Ingress protection	IP65
Operating Temperature Range	-25~60°C(>45°C derating)
Inverter topology	Non-isolated
Over voltage category	III(AC) , II(DC)
Protective class	I
Max.Parallel	6
PV INPUT:	
Max. DC input power	3500W/3500W
Absolute max. voltage	500Vd.c./500Vd.c.
MPPT voltage range	120Vd.c.-450Vd.c.
Max. input current	16Ad.c./16Ad.c.
Isc PV	27Ad.c./27Ad.c.
AC INPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	40Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	9200VA
Nominal power	9200W
Power factor	0.8 leading to 0.8 lagging
AC OUTPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	20Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	4600VA
Nominal power	4600W
AC output power factor	0.8 leading to 0.8 lagging
Battery:	
Battery type	Li-ion/Lead-acid
Battery voltage range	40Vd.c.-60Vd.c.
Max. charge/discharge current	100Ad.c./118Ad.c.

SN:

5min RoHS COMPLIANT

Manufacturer:SRNE Solar Co.,Ltd

Address:4-5, Building13A Taihua Wutong Industrial Park Gushu Development Zone, Hangcheng Street, Baoan 518102 Shenzhen, Guangdong Province PEOPLE'S REPUBLIC OF CHINA

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Solar Hybrid Inverter

Model Name	HESP4840S100-H
Ingress protection	IP65
Operating Temperature Range	-25~60°C(>45°C derating)
Inverter topology	Non-isolated
Over voltage category	III(AC) , II(DC)
Protective class	I
Max.Parallel	6
PV INPUT:	
Max. DC input power	3000W/3000W
Absolute max. voltage	500Vd.c./500Vd.c.
MPPT voltage range	120Vd.c.-450Vd.c.
Max. input current	16Ad.c./16Ad.c.
Isc PV	27Ad.c./27Ad.c.
AC INPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	40Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	9200VA
Nominal power	9200W
Power factor	0.8 leading to 0.8 lagging
AC OUTPUT:	
Nominal voltage	L/N/PE 230Va.c.
Rated/Max. current	17.4Aa.c.
Nominal frequency	50/60Hz
Rated/Max. apparent power	4000VA
Nominal power	4000W
AC output power factor	0.8 leading to 0.8 lagging
Battery:	
Battery type	Li-ion/Lead-acid
Battery voltage range	40Vd.c.-60Vd.c.
Max. charge/discharge current	100Ad.c./100Ad.c.

SN:



Manufacturer:SRNE Solar Co.,Ltd

Address:4-5, Building13A Taihua Wutong Industrial Park Gushu Development Zone, Hangcheng Street, Baoan 518102 Shenzhen, Guangdong Province PEOPLE'S REPUBLIC OF CHINA

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General product information:

SRNE

USER MANUAL



Solar Hybrid Inverter

HESP4840S100-H | HESP4846S100-H | HESP4850S100-H
HESP4855S100-H | HESP4860S100-H

V2.0

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MODEL	HESP4840S100-H	HESP4846S100-H	HESP4850S100-H HESP4855S100-H	HESP4860S100-H
Parametry wyjściowe falownika				
Nominalna moc wyjściowa AC	4000W	4600W	5500W	6000W
Maksymalna moc szczytowa AC	8000VA	9200VA	11000VA	12000VA
Nominalne napięcie wyjściowe AC	230V（jedna faza）（200/208/220/240V regulowane）			
Błąd napięcia wyjściowego	±5%			
Maks. obciążenie indukcyjne (przez silnik elektr.)	3KM	4KM	4KM	4KM
Częstotliwość nominalna AC	50/60Hz ± 0.3Hz			
Przebieg napięcia na wyjściu	Czysta sinusoida			
Czas przełączania	10ms（typowy）			
Przeciążenie	Po wyzwoleniu zabezpieczenia przeciążeniowego falownik podejmie pracę na wyjściu po 3 minutach, 5 kolejnych przeciążeń spowoduje wyłączenie wyjścia aż do momentu zrestartowania falownika. (102%<obciążenie<125%): alarm i wyłączenie wyjścia po 5min; (125% < obciążenie < 150%) : alarm i wyłączenie wyjścia po 10s. Obciążenie > 150% : alarm i wyłączenie wyjścia po 5s.			
Dane wyjściowe prądu przemiennego AC				
Nominalna moc wyjściowa AC	4000W	4600W	5500W	6000W
Maksymalna moc szczytowa AC	8000VA	9200VA	11000VA	12000VA

Współczynnik mocy	0.8 wyprzedzający do 0.8 opóźniający	0.8 wyprzedzający do 0.8 opóźniający	0.8 wyprzedzający do 0.8 opóźniający	0.8 wyprzedzający do 0.8 opóźniający
Napięcie nominalne AC	220/230V	220/230V	220/230V	220/230V
Nominalna częstotliwość AC	50/60Hz	50/60Hz	50/60Hz	50/60Hz
Nominalny prąd wyjściowy AC	17.4A	20A	24A	26A
Maksymalny prąd wyjściowy AC	19.1A	22A	26.4A	28.6A
THD	<3%	<3%	<3%	<3%
Akumulator				
Obsługiwane typy akumulatorów	Li-ion /Kwasowo-ołowiowy / Zdefiniowany przez użytkownika			
Nominalne napięcie akumulatorów DC	48V (minimalne napięcie startowe 44V)			
Zakres napięcia DC	40-60V			
Maksymalny prąd DC ładowania z generatora	60A			
Maksymalny prąd DC ładowania z sieci	60A			
Maksymalny hybrydowy (mieszany) prąd ładowania DC	100A			
Parametry wejściowe sieci PV				
Ilość wejść MPPT	2			

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Maksymalna moc wejściowa DC generatora PV	3000W+3000W	3500W+3500W	4000W+4000W	4500W+4500W
Maksymalny prąd wejściowy DC	16/16A			
Maksymalny prąd zwarciowy DC generatora PV	27A/27A			
Maksymalne Napięcie obwodu otwartego DC generatora PV	500V			
Zakres napięcia pracy MPPT DC	120-450V			
Parametry wejściowe sieć / Generator				
Zakres napięcia wejściowego AC	90-280V			
Zakres częstotliwości	50/60Hz			
Maksymalny prąd bocznikowy AC	40A			
Efektywność				
Sprawność mechanizmu MPPT	99.9%			
Sprawność maksymalna	97.5%			
Sprawność EURO	97%			
Zabezpieczenia				
Ochrona przepięciowa wejścia PV	TAK			
Zabezpieczenie przed pracą wyspową	TAK			
Zabezpieczenie przed odwrotną polaryzacją łańcucha PV	TAK			
Wykrywanie rezystora izolacyjnego	TAK			
Monitorowanie prądu resztkowego	TAK			
Zabezpieczenie nadprądowe wyjścia	TAK			
Zabezpieczenie przed zwarciem wyjścia	TAK			
Zabezpieczenie przed przepięciami	DC typ II/AC typ II			
Kategoria zabezpieczenia napięciowego	DC typ II/AC typ III			
Certyfikaty				
Normy dotyczące sieci	EN50549-1,G99,NRS-097,CEI 021,VDE-ARN-4105,UNE217002			
Bezpieczeństwo	IEC62109-1, IEC62109-2			
EMC	EN61000-6-1, EN61000-6-3, FCC 15 class B			
RoHS	TAK			
Pozostałe dane				
Maksymalna ilość falowników połączonych równolegle	6			
Zakres temperatur pracy	-25~60℃,>45℃ tryb obniżonej mocy			
Zakres wilgotności	0-100%			
Gwarancja	5 lat			

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Poziom hałasu	<60dB
Stopień ochrony	IP65
Metoda chłodzenia	Radiator + inteligentne chłodzenie wymuszone
Autokonsumpcja	<100W
Wymiary	556*345*182mm
Waga	22kg
Komunikacja	RS485 / CAN / USB / styk bezpotencjałowy
Moduły zewnętrzne (opcjonalne)	Wi-Fi / GPRS

The Solar converter converts DC voltage into AC voltage.

The input and output are protected by varistors to earth. The unit is providing EMC filtering at the input and output towards mains. The output is switched off redundant by the high power switching bridge and two series of relay in series. This assures that the opening of the output circuit will also operate in case of one error.

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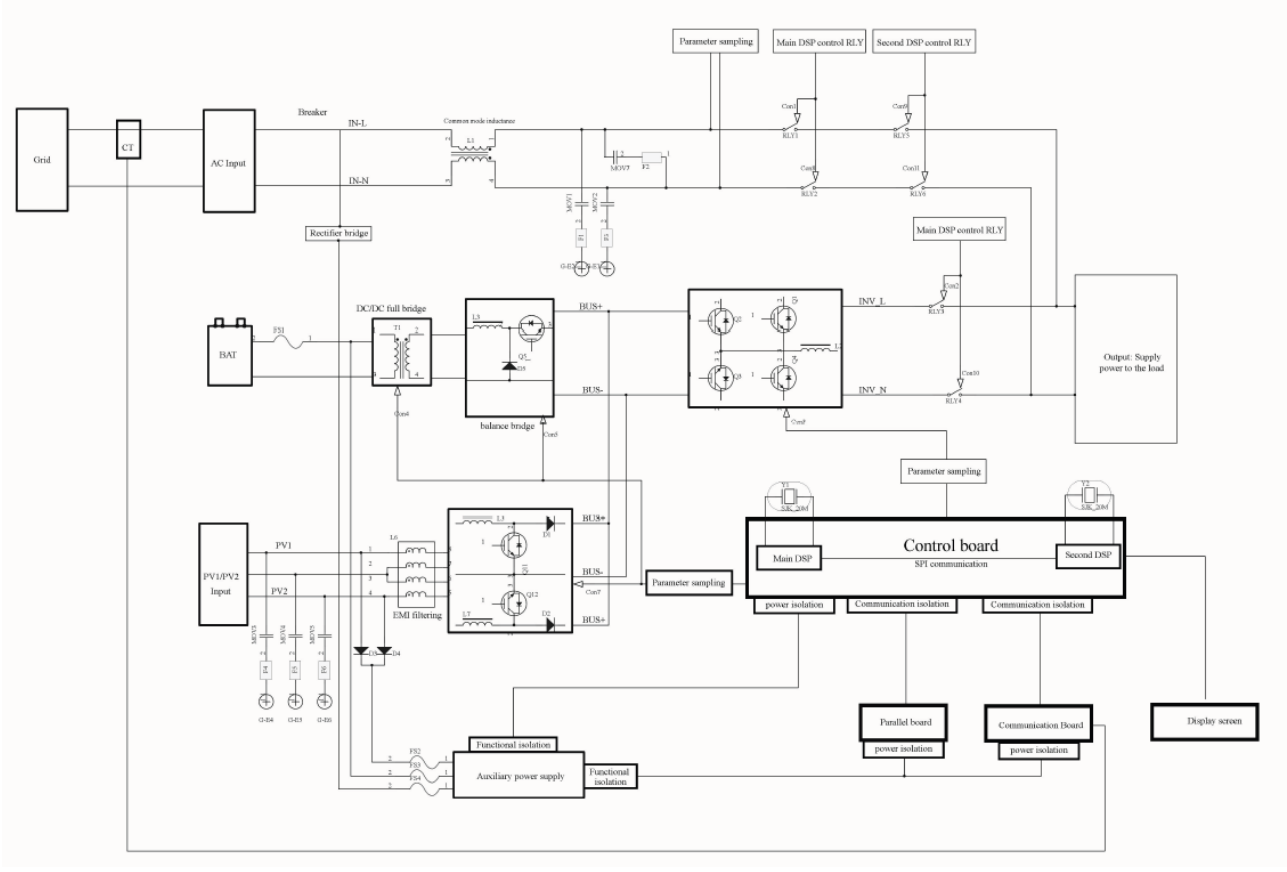
Description of the power circuit:

The unit provides two control DSP(U50 & U51), the main DSP(U50) and second DSP(U51) can control relays, measures voltage, frequency, AC current with injected DC, insulation resistance.

The voltage and frequency measurement is achieved with resistors in serial which are connected directly to line and neutral. The master controllers get these signals and calculate the data.

The unit provides one relay in series in each phase. The relays are tested before each start up. In addition the power bridge can be stopped by master controllers

Figure 1 – Block Diagram for All model



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Description of the differences of the models within a series:
None.

The product was tested on:
The test performed on model HESP4860S100-H is valid for model HESP4840S100-H, HESP4846S100-H, HESP4850S100-H, HESP4855S100-H, since it is identical in hardware and just power derated by software

HESP4860S100-H	SR-23110200005-301339-T01
	
HESP4855S100-H	SR-23110200005-301520-T01
	
HESP4850S100-H	SR-23110200005-301497-T01

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HESP4846S100-H	SR-23110200005-301496-T01



HESP4840S100-H	SR-23110200005-301495-T01



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Hardware Version:

Model	HESP4840S100-H, HESP4846S100-H, HESP4850S100-H, HESP4855S100-H, HESP4860S100-H
Hardware Version	Machine version:V3.0, Power board version:V1.0, Control board version: V1.0

Software Version:

Model	HESP4840S100-H, HESP4846S100-H, HESP4850S100-H, HESP4855S100-H, HESP4860S100-H
Software Version	V2.85

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Conformity statements are decided in accordance with IEC GUIDE 115:2021 Procedure 2 (accuracy method), unless otherwise normatively specified or contractually agreed.

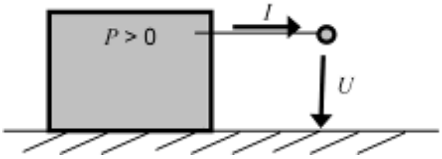
The following suffixes are used for variables in tables and figures:

- “P_n” for the nominal active power:
  $P_n = U_n \times I_n \times \cos \varphi_n$ (single-Phase); $P_n = \sqrt{3}\, U_n \times I_n \times \cos \varphi_n$ (three-Phase)
- “P_M” for the momentary power
- “(c)” for over-excited
- “(i)” for under-excited

Active and reactive power:

The regarded system of the voltage and current vectors is the load view (Figure 2):

- If the inverter feeds to the grid the active power is measured with negative sign. For the sake of reading the document the measured active infeed power has a positive sign



- If the inverter consumes inductive reactive power the reactive power is marked “inductive” or has a positive sign.
- If the inverter consumes capacitive reactive power the reactive power is marked “capacitive” or has a negative sign.

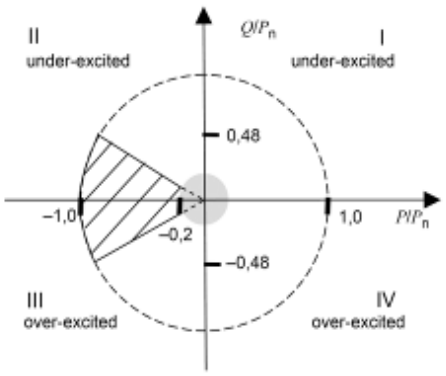


Figure 2

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Default interface protection settings according EN 50438:2013:			
Parameter	**Max. disconnection time**	**Min. operate time**	**Trip value**
Over voltage (stage 1) [a]	3s	-	230V +10% (253V)
Over voltage (stage 2)	0,2s	0,1s	230V +15% (264,5V)
Under voltage	1,5s	1,2s	230V -15% (195,5V)
Over frequency	0,5s	0,3s	52Hz
Under frequency	0,5s	0,3s	47,5Hz
Reconnection settings for voltage		$0,85U_n$ (195,5V) ≤ U ≤ $1,10U_n$ (253V)	
Reconnection settings for frequency		49,5 Hz ≤ f ≤ 50,1 Hz	
Reconnection time		≥ 60 s	
Active power gradient after reconnection		$10\%P_{Emax}$ / per minute	
Permanent DC-injection		0,5% of rated inverter output current or 20mA	
Loss of mains according EN 62116 (LoM)		Inverter shall disconnect within 2s.	

The stated currents and voltages are 'true r.m.s.'-values.
The voltages in this table are
- phase-to-neutral in 230V single phase systems and 230/400V systems,
- phase-to-phase in a multiphase 230V system.

[a] Over voltage – stage1: 10 min-mean-value corresponding to EN 50160.
Tolerances on trip values:
- Voltage: ±1% of U_n
- Frequency: ±0,05Hz
- Disconnection time : ±10%

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EN 50549-1:2019, clause 4: Tests		
Clause	**Test requirement (According to table C.1)**	**Result**
4.4	Normal operating range	**P**
4.5	Immunity to disturbances	**P**
4.6	Active response to frequency deviation	**P**
4.7	Power response to voltage variations and voltage changes	**P**
4.8	EMC and power quality	**P**
4.9	Interface protection	**P**
4.10	Connection and starting to generate electrical power	**P**
4.11	Ceasing and reduction of active power on set point	**P**
4.12	Remote information exchange	**N/A**
4.13	Requirements regarding single fault tolerance of interface protection system and interface switch	**P**

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EN 50549-1:2019: Normal operating range			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.4.2	Operating frequency range	EN 50438, Annex D.3.1	**P**
4.4.3	Minimal requirement for active power delivery at underfrequency	EN 50438, Annex D.3.2	**P**
4.4.4	Continuous operating voltage range	EN 50438, Annex D.3.1	**P**

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4.4.2 Operating frequency range 4.4.4 Continuous operating voltage range			P
Setting values	Over-voltage [V]:	253	
	Under-voltage [V]:	195,5	
	Over-frequency [Hz]:	51,5	
	Under-frequency [Hz]:	47,5	

- Test 1: U = 195,5 V; f = 47,5 Hz; P = 1,00 Sn; cosφ = 1; Period of test 30 minutes
- Test 2: U = 195,5 V; f = 48,5 Hz; P = 1,00 Sn; cosφ = 1; Period of test 30 minutes
- Test 3: U = 253,0 V; f = 51,5 Hz; P = 1,00 Sn; cosφ = 1; Period of test 30 minutes
- Test 4: U = 230,0 V; f = 50,0 Hz; Voltage Phase jumps Change +20 degrees P = 1,00 Sn; cosφ = 1
- Test 5: U = 230,0 V; f = 50,0 to 50,5 Hz;RoCoF=1Hz/s; P = 1,00 Sn; cosφ = 1; Period of test 0,5 seconds

Test : HESP4860S100-H

Test sequence	Voltage [V]	Frequency [Hz]	Output power [W]	Cos φ
Test 1	195,70	47,50	5926,61	0,9914
Test 2	195,70	48,50	5927,76	0,9917
Test 3	253,39	51,50	5948,02	0,9921
Test 4	230,55	50,00	5955,56	0,9910
Test 5	230,53	50,50	5957,60	0,9916

Note:

Test method refer clause D.3.1 of EN 50438:2013.

During the tests the interface protection was disabled.

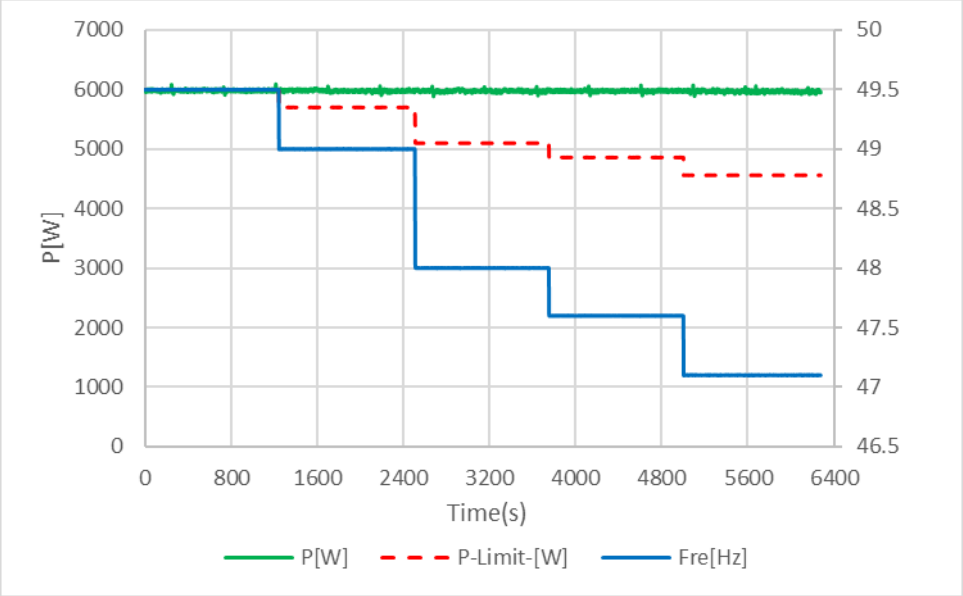
Operation at reduced power is allowed during test 1/2, equal to the maximum power that can be supplied on reaching the maximum output current limit ($P \geq 0,85\ S_n$).

During the sequence of test 3, automatic adjustment to reduce power in the case of over-frequency was disabled.

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4.4.3	Minimal requirement for active power delivery at under-frequency	P

Graph of frequency a) to e):



Test : HESP4860S100-H

	Switch to:				
5-min mean value (each)	a) 49,50 Hz	b) 49,00 Hz	c) 48,00 Hz	d) 47,60 Hz	e) 47,10 Hz
Frequency [Hz]:	49,50	49,00	48,00	47,60	47,10
Active power [W]:	5985,04	5977,44	5977,23	5977,24	5970,34
$\Delta P/P_n$ [%] :	-0,25	-0,38	-0,38	-0,38	-0,49

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Test:

Test method refer clause A.7.3.2 ofG99/1-4

The frequency should then be set to 49,5 Hz for 5 minutes. The output should remain at 100% of registered Capacity.

The frequency should then be set to 49,0 Hz and once the output has stabilised, held at this frequency for 5 minutes.The Active Power output must not be below 99% of registered Capacity.

The frequency should then be set to 48,0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The Active Power output must not be below 97% of registered Capacity.

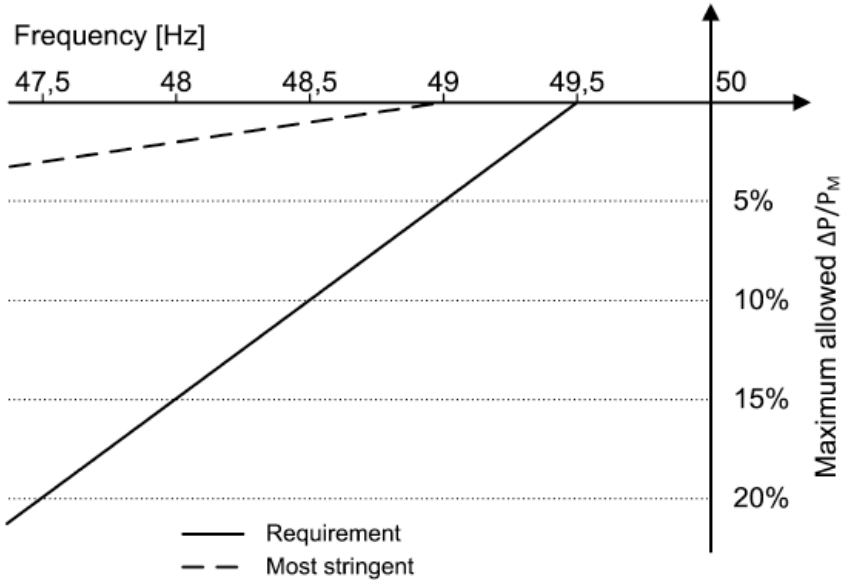
The frequency should then be set to 47,6 Hz and once the output has stabilised, held at this frequency for 5 minutes. The Active Power output must not be below 96.2% of registered Capacity.

The frequency should then be set to 47.1 Hz and held at this frequency for 20s. The Active Power output mus not be below 95.0% of registered Capacity and the Synchronous Power Generating Module must not trip in less than the 20s of the test.

Assessment criterion:

The test is passed when the micro-generator

- does not disconnect from the network on a network frequency change at the operating points a) to c),
- continues to feed in 100% P_n in b) and
- the power reduction in point c) is less or equal to the power reduction of 10 % P_M per 1 Hz drop.



Maximum allowable power reduction in case of under-frequency

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EN 50549-1:2019: Immunity to disturbances			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.5.2	Rate of change of frequency (RoCoF) immunity	G99/1-4:2019, clause A.7.1.2.6	**P**
4.5.3	Low voltage ride through (LVRT)		**P**
4.5.4	High voltage ride through (HVRT)		**P**
4.7.4	Zero current mode for converter connected generating plants		**P**

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4.5.2 Rate of change of frequency (ROCOF) immunity	P

Test : HESP4860S100-H

	Start Frequency	Change	End Frequency	Confirm no trip
Positive Frequency drift	49Hz	+2Hz/sec	51Hz	No trip
Negative Frequency drift	51Hz	-2Hz/sec	49Hz	No trip

Note:

Test method refer clause A.7.1.2.6 of G99/1-4:2019.

Hold for 10 s

Manufacturers considering new designs should allow for the RoCoF where stability is required to be increased to, up to 2Hz per second, as proposed in the new European network codes, which are expected to come into force over the period 2014/2015. Under these conditions RoCoF will cease to be an effective loss of mains protection and is unlikely to be permitted in future revisions of this document.

For the step change test the SSEG should be operated with a measureable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 seconds to complete the test. The SSEG should not trip during this test.

For frequency drift tests the SSEG should be operated with a measureable output at the start frequency and then the frequency changed in a ramp function at 0,95Hz per second to the end frequency. On reaching the end frequency it should be maintained for a period of at least10 seconds. The SSEG should not trip during this test.

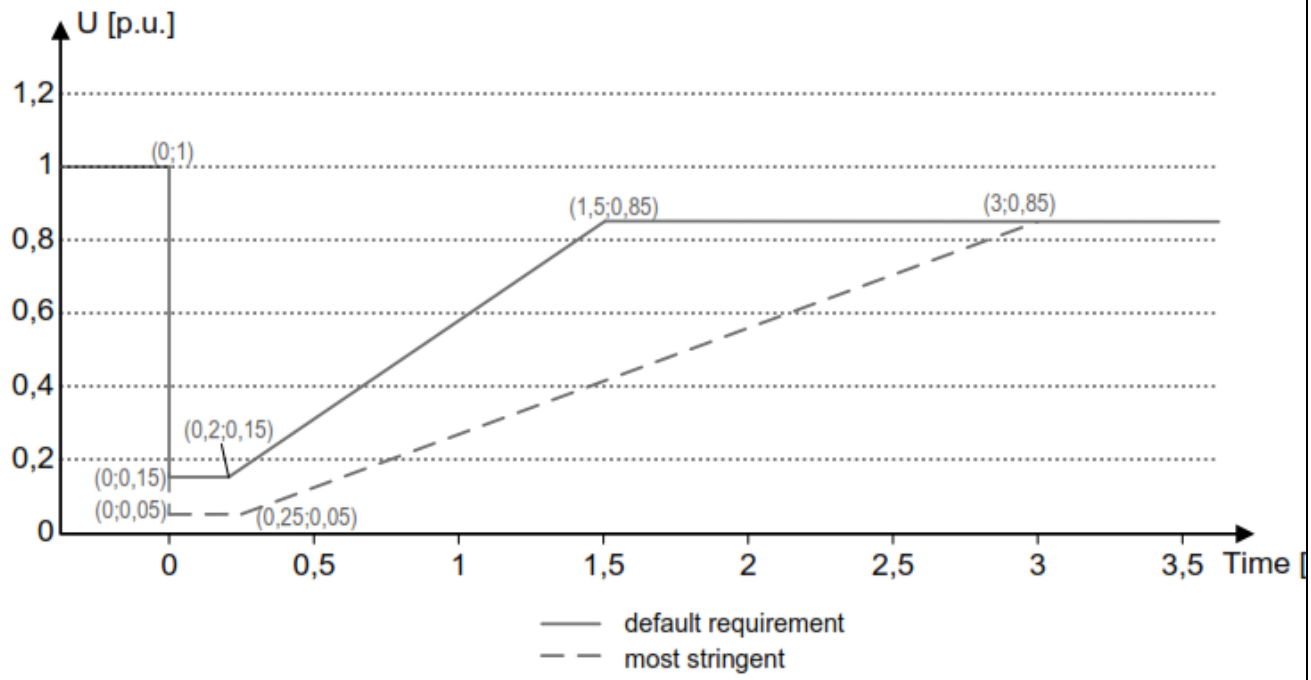
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4.5.3	**Low voltage ride through (LVRT)**	**P**
4.7.4	**Zero current mode for converter connected generating plants**	

Test: HESP4860S100-H

General:

Generating modules shall be capable of staying connected to the distribution network as long as the voltage at the point of connection remains above the voltage-time curve of Figure 7. The voltage is relative to Un. The smallest phase to neutral voltage or if no neutral is present the smallest phase to phase voltage shall be evaluated. The responsible party may define a different UVRT characteristic. Nevertheless, this requirement is expected to be limited to the most stringent curve, indicated in Figure 7. This means that the whole generating module has to comply with the UVRT requirement. This includes all elements in a generating plant: the generating units and all elements that might cause its disconnection. For the generating unit, this requirement is considered to be fulfilled if it stays connected to the distribution grid as long as the voltage at its terminals remains above the defined voltage-time diagram. After the voltage returns to continuous operating voltage range, 90 % of pre-fault power or available power whichever is the smallest shall be resumed as fast as possible, but at the latest within 3 s unless the DSO and the responsible party requires another value.



Notes on test conditions:

Voltage dips are typically performed on an AC simulator.

The test method refer to IEC 62910:2017-05 and FGW TR3, Rev. 25 for details on test setup.

Test name convention:

[voltage dip level].[dip type].[active power operating point], e.g. “1.A.1”

1. voltage dip level: Depends on voltage-time-characteristic of standard
2. dip type: Symmetric/Asymmetric (A, C, D, B,…) according to definitions in https://www.wind-fgw.de/wp-content/uploads/2017/01/Arbeitsdokument_AG_Pruefeinrichtungen.pdf
3. active power operating point:

1) Partial load: e.g. 0,1 x P_{Emax} to 0,3 x P_{Emax}
2) Full load: e.g. more than 0,9 x P_{Emax}

Note:

For every kind of voltage dip a test without load has to be performed in order to prove that the test condition was fulfilled. The voltage has to drop to at least the defined depth level. An exception can be considered in case no current is supplied during dips.

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4.5.3 4.7.4	Low voltage ride through (LVRT) Zero current mode for converter connected generating plants						P
Test ref. No.	**Voltage dip to (p.u. / U_n)**	**Phases / Dip type**	**duration (ms)**	**P set point (p.u. / P_{rE})**	**Q set point (Q / p.u.)**	**Comment**	**Measured recovery time [ms]**
1.A.1	0,03	3 / A	250	1,0	0,00	Symmetrical	183
1.A.2		3 / A		0,2			813
1.D.1		2 / D		1,0		Asymmetrical	N/A
1.D.2		2 / D		0,2			N/A
1.B.1		1 / B		1,0		Single phase	N/A
1.B.2		1 / B		0,2			N/A
2.A.1	0,31	3 / A	1300	1,0	0,00	Symmetrical	1320
2.A.2		3 / A		0,2			1320
2.D.1		2 / D		1,0		Asymmetrical	N/A
2.D.2		2 / D		0,2			N/A
2.B.1		1 / B		1,0		Single phase	N/A
2.B.2		1 / B		0,2			N/A
3.A.1	0,82	3 / A	3000	1,0	0,00	Symmetrical	3022
3.A.2		3 / A		0,2			3022
3.D.1		2 / D		1,0		Asymmetrical	N/A
3.D.2		2 / D		0,2			N/A
3.B.1		1 / B		1,0		Single phase	N/A
3.B.2		1 / B		0,2			N/A
Note:							

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Graph of LVRT test one

Test : HESP4860S100-H

List of tests	Voltage dip to (p.u.)	Limit for fault duration [ms]	Duration fault [ms]	Recover time [ms]	Limit percentage of Injected current after 60ms [p.u. In]	Percentage of Injected current after 60ms [p.u. In]	Limit percentage of Injected current after 100ms [p.u. In]	Percentage of Injected current after 100ms [p.u. In]	Result
1.A.1 – three-phase symmetrical fault (P = 1)	0,03	≥ 250	259	183	≤0,2 p.u	0,067	≤0,1 p.u	0,016	P
1.A.2 – three-phase symmetrical fault (P = 0,2)	0,03	≥ 250	260	813	≤0,2 p.u	0,328	≤0,1 p.u	0,213	P
2.A.1 – three-phase symmetrical fault (P = 1)	0,31	≥ 1300	1320	404	≤0,2 p.u	0,076	≤0,1 p.u	0,031	P
2.A.2 – three-phase symmetrical fault (P = 0,2)	0,31	≥ 1300	1320	242	≤0,2 p.u	0,030	≤0,1 p.u	0,023	P
3.A.1 – three-phase symmetrical fault (P = 1)	0,82	≥ 3000	3022	252	--	--	--	--	P
3.A.2 – three-phase symmetrical fault (P = 0,2)	0,82	≥ 3000	3022	287	--	--	--	--	P

Assessment criterion:

If the voltage on the generator terminals falls below <0.8 U_n and if the generator terminals exceed the voltage of> 1.15 U_n (start of fault), PV generators must pass through voltage dips without any current being drawn into the grid Network operator (limited dynamic network support).

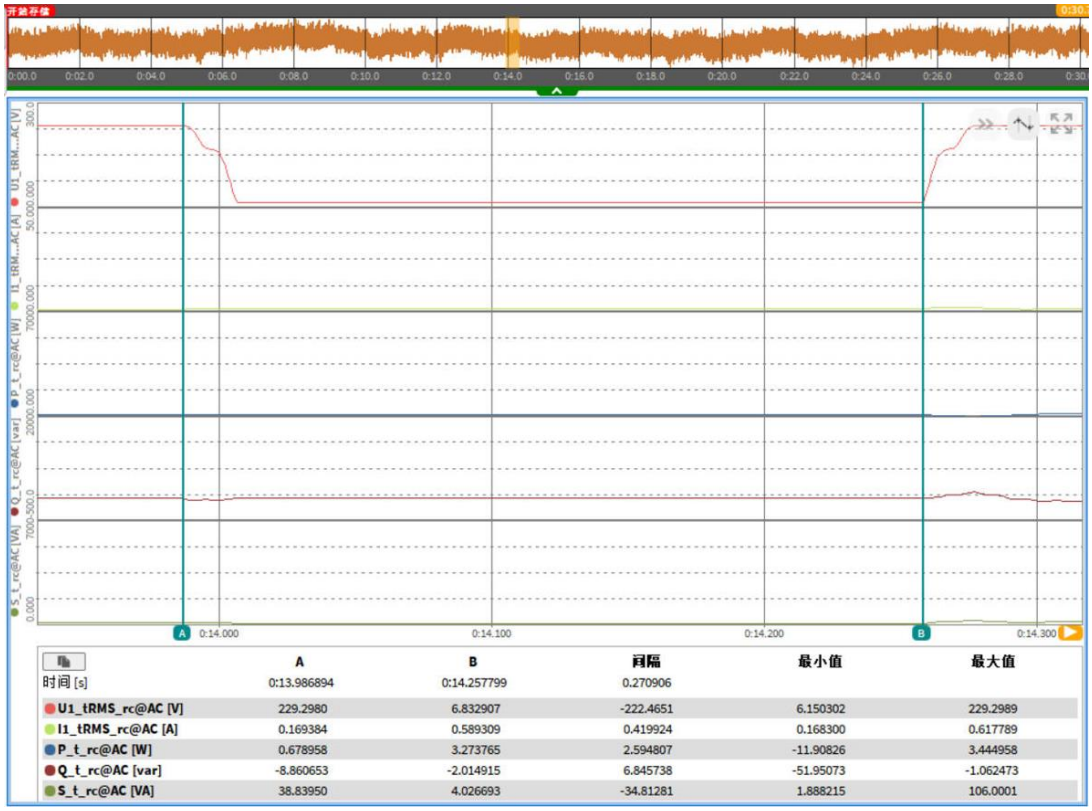
This requirement is met if, for a voltage dip below 0.8 U_n or at a voltage increase above 1.15 U_n, the injected current of the generating unit (s) and / or the memory 60 ms after occurrence of this voltage dip in any outer conductor 20% of the rated current Ir and does not exceed> 10% I_r after 100 ms.
(Refer VDE-AR-N 4105:2018-11 and VDE V 0124-100:2020-06)

After the voltage returned to continuous operating voltage range of -15% U_n to +10% U_n, 90 % of pre fault power shall be resumed as fast as possible, but at the latest within 1 s.

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No load graph of FRT tests

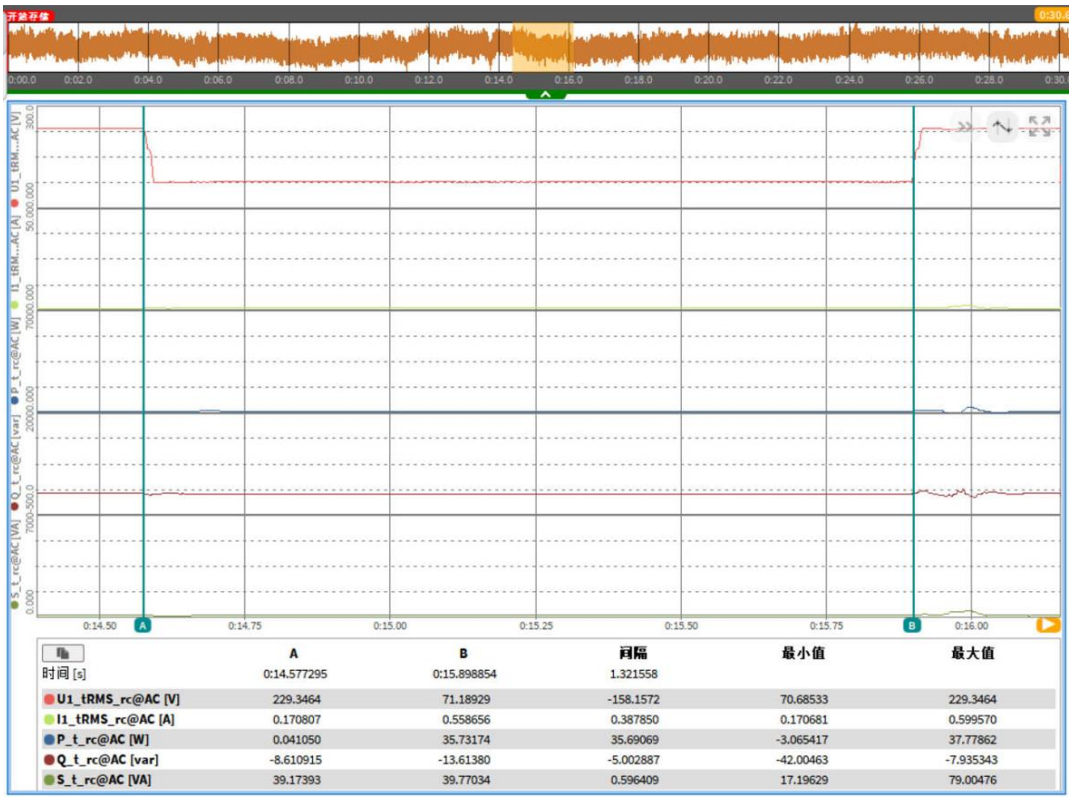
No load Test: 1.A.1(symmetrical; V/Vnom = 0,03; duration = 250ms)



	A	B	间隔	最小值	最大值
时间 [s]	0:13.986894	0:14.257799	0.270906		
U1_tRMS_rc@AC [V]	229.2980	6.832907	-222.4651	6.150302	229.2989
I1_tRMS_rc@AC [A]	0.169384	0.589309	0.419924	0.168300	0.617789
P_t_rc@AC [W]	0.678958	3.273765	2.594807	-11.90826	3.444958
Q_t_rc@AC [var]	-8.860653	-2.014915	6.845738	-51.95073	-1.062473
S_t_rc@AC [VA]	38.83950	4.026693	-34.81281	1.888215	106.0001

No load graph of FRT tests

No load Test: 2.A.1(symmetrical; V/Vnom = 0,31; duration = 1300ms)

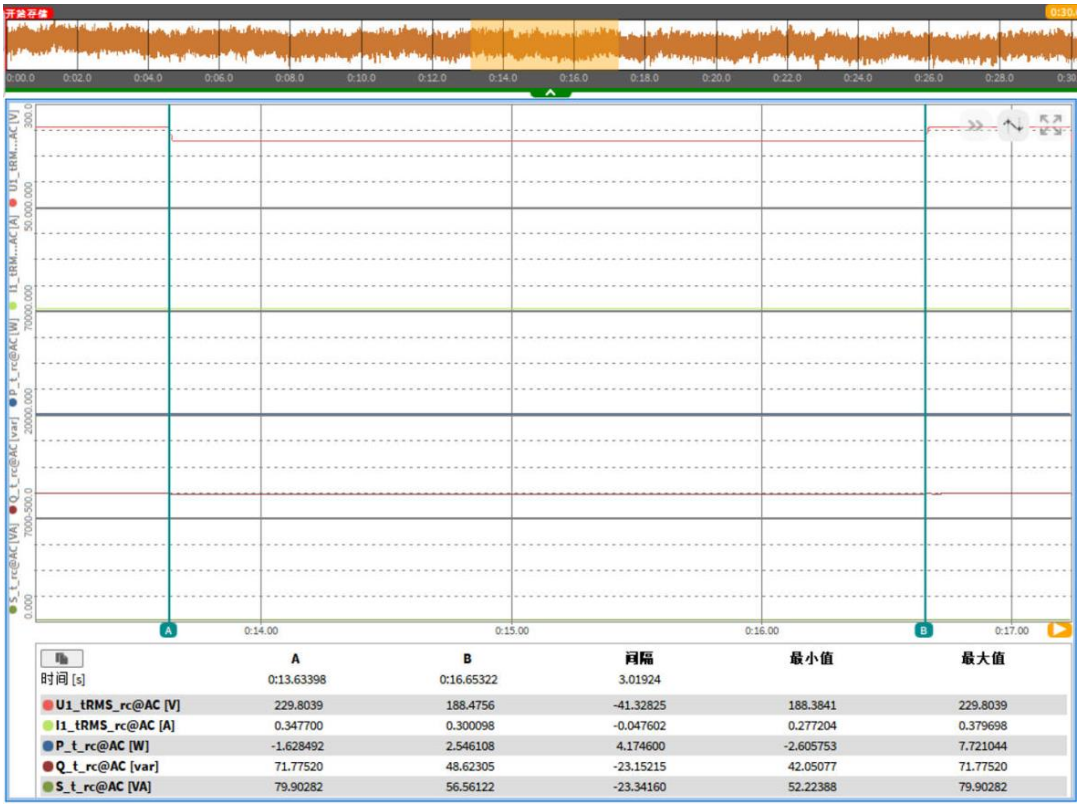


	A	B	间隔	最小值	最大值
时间 [s]	0:14.577295	0:15.898854	1.321558		
U1_tRMS_rc@AC [V]	229.3464	71.18929	-158.1572	70.68533	229.3464
I1_tRMS_rc@AC [A]	0.170807	0.558656	0.387850	0.170681	0.599570
P_t_rc@AC [W]	0.041050	35.73174	35.69069	-3.065417	37.77862
Q_t_rc@AC [var]	-8.610915	-13.61380	-5.002887	-42.00463	-7.935343
S_t_rc@AC [VA]	39.17393	39.77034	0.596409	17.19629	79.00476

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No load graph of FRT tests

No load Test: 3.A.1(single phase; V/Vnom = 0,82; duration = 3000ms)



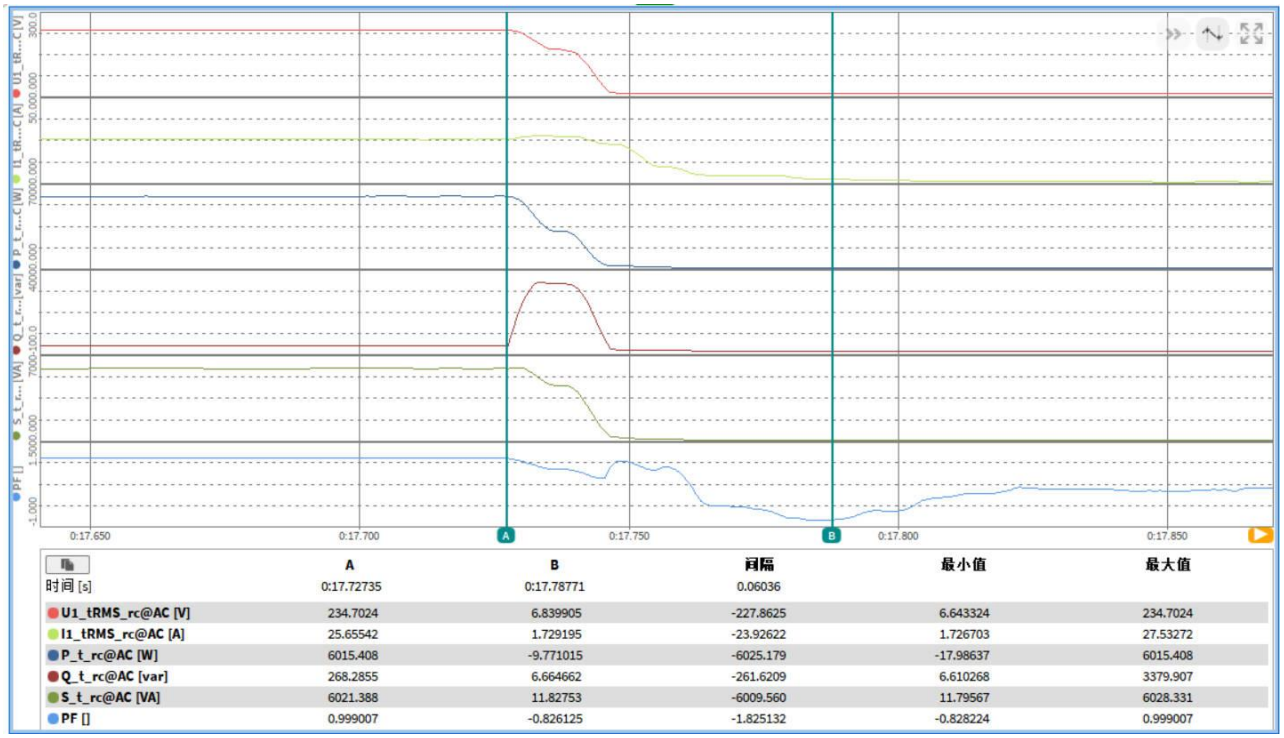
	A	B	间隔	最小值	最大值
时间 [s]	0:13.63398	0:16.65322	3.01924		
U1_tRMS_rc@AC [V]	229.8039	188.4756	-41.32825	188.3841	229.8039
I1_tRMS_rc@AC [A]	0.347700	0.300098	-0.047602	0.277204	0.379698
P_t_rc@AC [W]	-1.628492	2.546108	4.174600	-2.605753	7.721044
Q_t_rc@AC [var]	71.77520	48.62305	-23.15215	42.05077	71.77520
S_t_rc@AC [VA]	79.90282	56.56122	-23.34160	52.22388	79.90282

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Graph of FRT tests

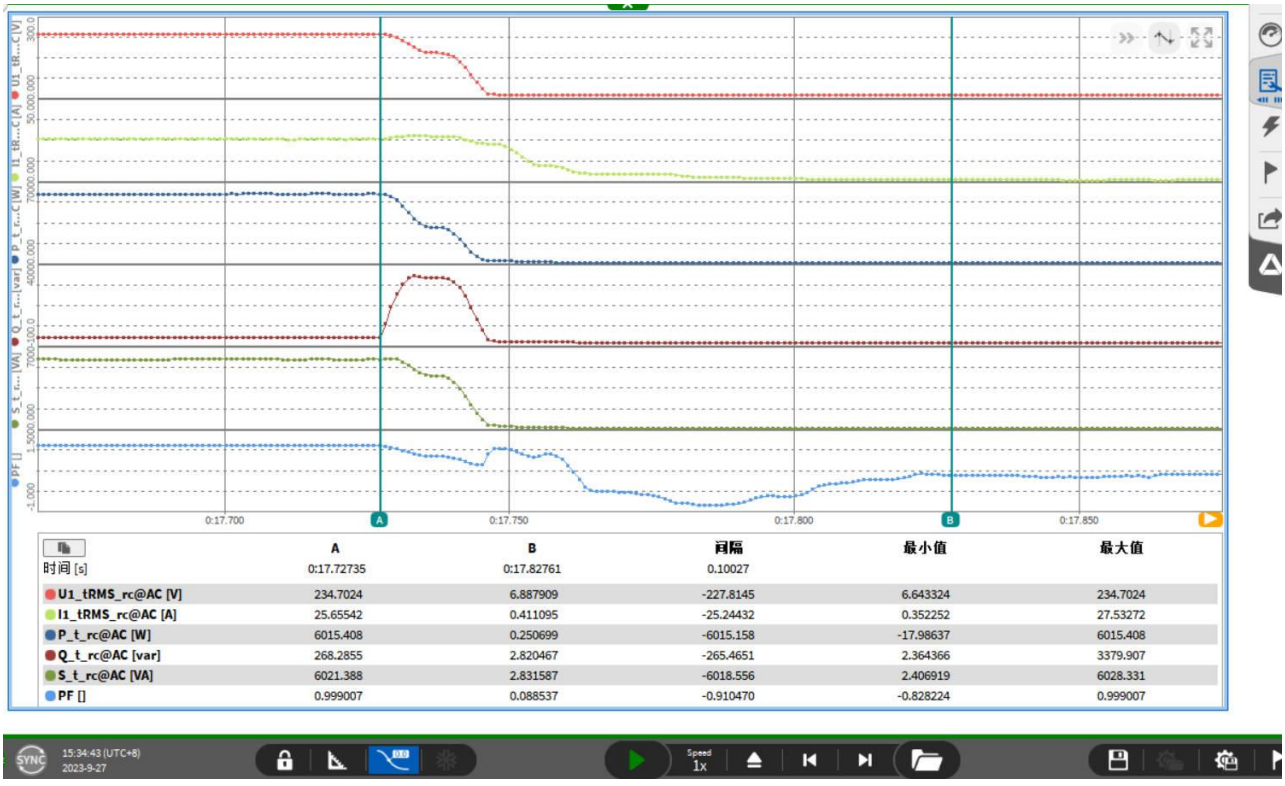
Test no. 1.A.1 – symmetrical fault (U/U_{nom} = 0,03) P > 0,9

0~60ms



时间 [s]	A 0:17.72735	B 0:17.78771	间隔 0.06036	最小值	最大值
U1_tRMS_rc@AC [V]	234.7024	6.839905	-227.8625	6.643324	234.7024
I1_tRMS_rc@AC [A]	25.65542	1.729195	-23.92622	1.726703	27.53272
P_t_rc@AC [W]	6015.408	-9.771015	-6025.179	-17.98637	6015.408
Q_t_rc@AC [var]	268.2855	6.664662	-261.6209	6.610268	3379.907
S_t_rc@AC [VA]	6021.388	11.82753	-6009.560	11.79567	6028.331
PF []	0.999007	-0.826125	-1.825132	-0.828224	0.999007

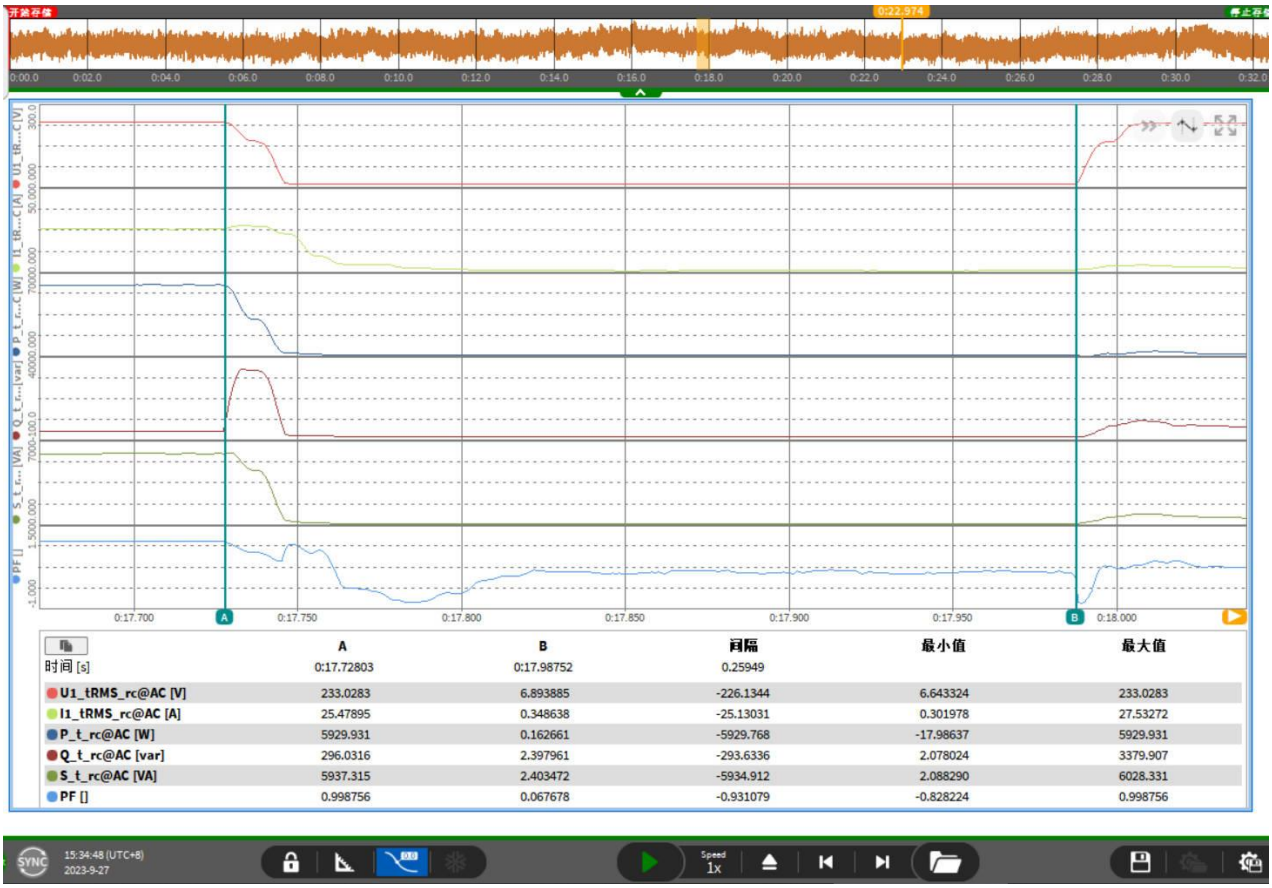
0~100ms



时间 [s]	A 0:17.72735	B 0:17.82761	间隔 0.10027	最小值	最大值
U1_tRMS_rc@AC [V]	234.7024	6.887909	-227.8145	6.643324	234.7024
I1_tRMS_rc@AC [A]	25.65542	0.411095	-25.24432	0.352252	27.53272
P_t_rc@AC [W]	6015.408	0.250699	-6015.158	-17.98637	6015.408
Q_t_rc@AC [var]	268.2855	2.820467	-265.4651	2.364366	3379.907
S_t_rc@AC [VA]	6021.388	2.831587	-6018.556	2.406919	6028.331
PF []	0.999007	0.088537	-0.910470	-0.828224	0.999007

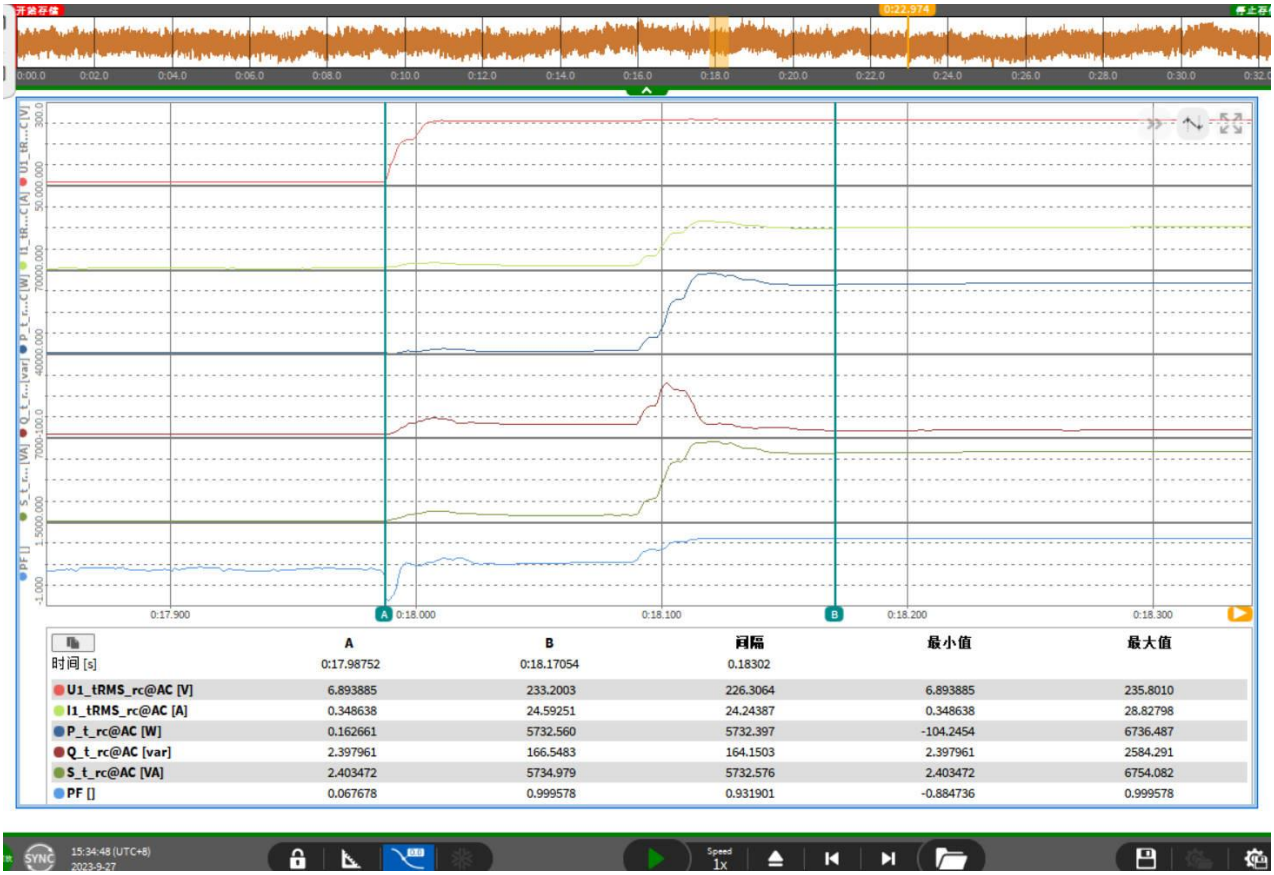
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Duration time



	A	B	间隔	最小值	最大值
时间 [s]	0:17.72803	0:17.98752	0.25949		
U1_tRMS_rc@AC [V]	233.0283	6.893885	-226.1344	6.643324	233.0283
I1_tRMS_rc@AC [A]	25.47895	0.348638	-25.13031	0.301978	27.53272
P_t_rc@AC [W]	5929.931	0.162661	-5929.768	-17.98637	5929.931
Q_t_rc@AC [var]	296.0316	2.397961	-293.6336	2.078024	3379.907
S_t_rc@AC [VA]	5937.315	2.403472	-5934.912	2.088290	6028.331
PF []	0.998756	0.067678	-0.931079	-0.828224	0.998756

Recovery time of active power



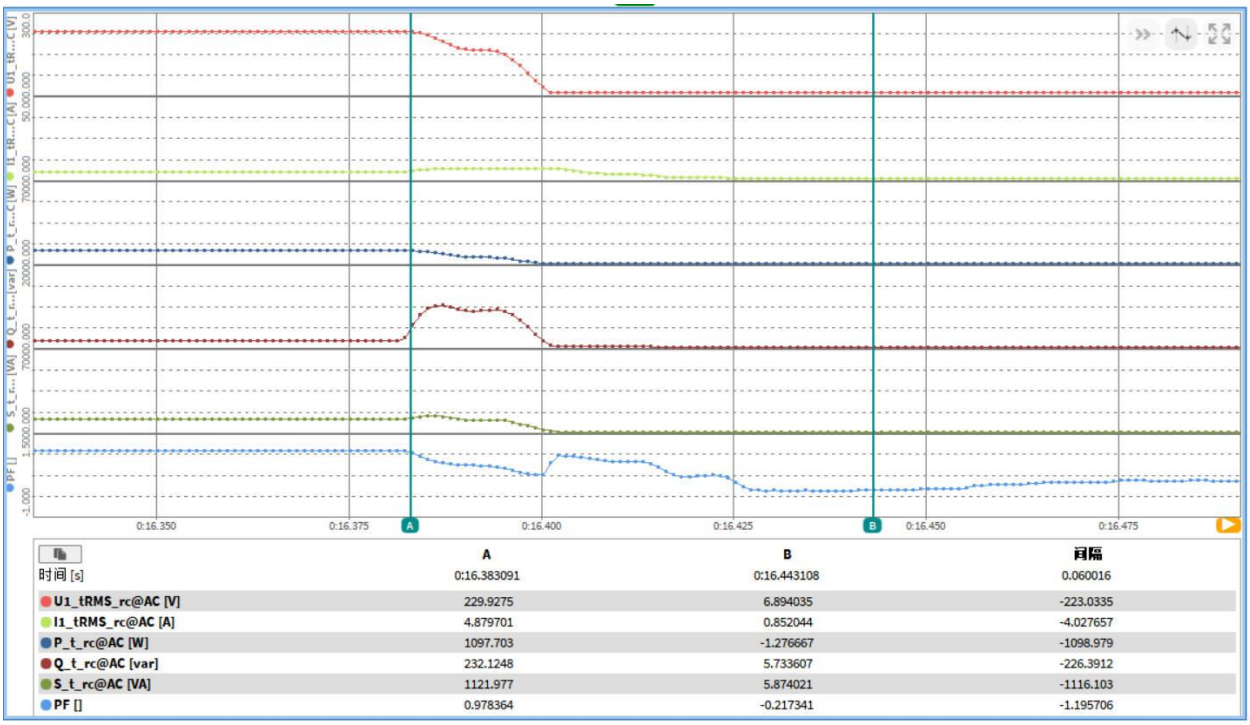
	A	B	间隔	最小值	最大值
时间 [s]	0:17.98752	0:18.17054	0.18302		
U1_tRMS_rc@AC [V]	6.893885	233.2003	226.3064	6.893885	235.8010
I1_tRMS_rc@AC [A]	0.348638	24.59251	24.24387	0.348638	28.82798
P_t_rc@AC [W]	0.162661	5732.560	5732.397	-104.2454	6736.487
Q_t_rc@AC [var]	2.397961	166.5483	164.1503	2.397961	2584.291
S_t_rc@AC [VA]	2.403472	5734.979	5732.576	2.403472	6754.082
PF []	0.067678	0.999578	0.931901	-0.884736	0.999578

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Graph of FRT tests

Test no. 1.A.2 – symmetrical fault (U/Unom = 0,03) P= 0,1 - 0,3

0~60ms

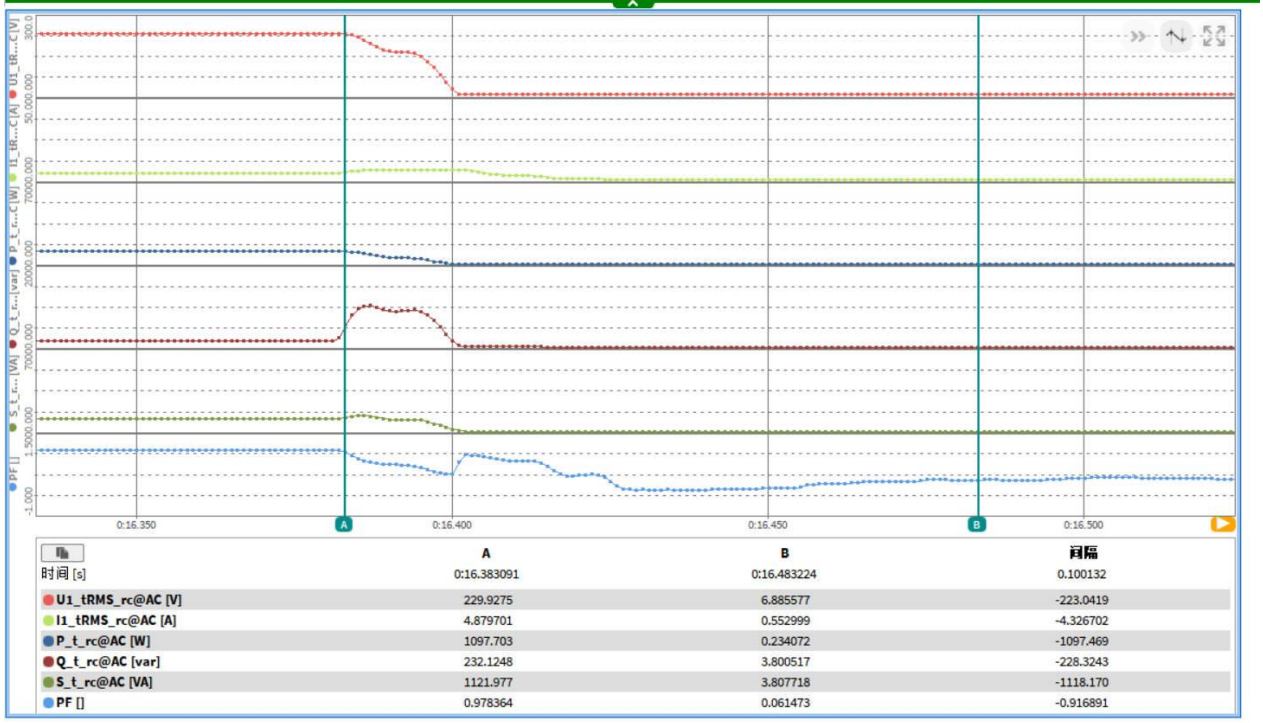


时间 [s]	A 0:16.383091	B 0:16.443108	间隔 0.060016
U1_tRMS_rc@AC [V]	229.9275	6.894035	-223.0335
I1_tRMS_rc@AC [A]	4.879701	0.852044	-4.027657
P_t_rc@AC [W]	1097.703	-1.276667	-1098.979
Q_t_rc@AC [var]	232.1248	5.733607	-226.3912
S_t_rc@AC [VA]	1121.977	5.874021	-1116.103
PF []	0.978364	-0.217341	-1.195706



0~100ms



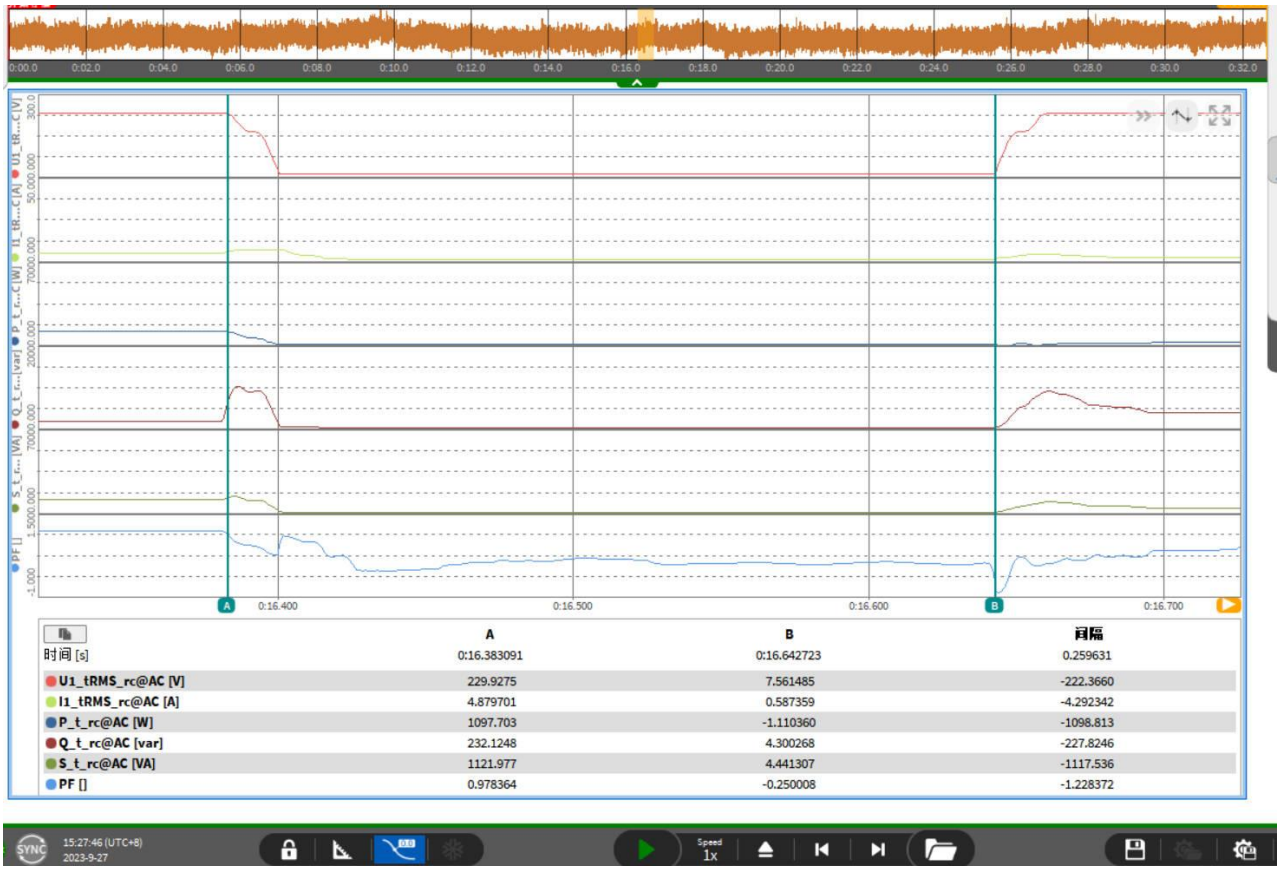


时间 [s]	A 0:16.383091	B 0:16.483224	间隔 0.100132
U1_tRMS_rc@AC [V]	229.9275	6.885577	-223.0419
I1_tRMS_rc@AC [A]	4.879701	0.552999	-4.326702
P_t_rc@AC [W]	1097.703	0.234072	-1097.469
Q_t_rc@AC [var]	232.1248	3.800517	-228.3243
S_t_rc@AC [VA]	1121.977	3.807718	-1118.170
PF []	0.978364	0.061473	-0.916891

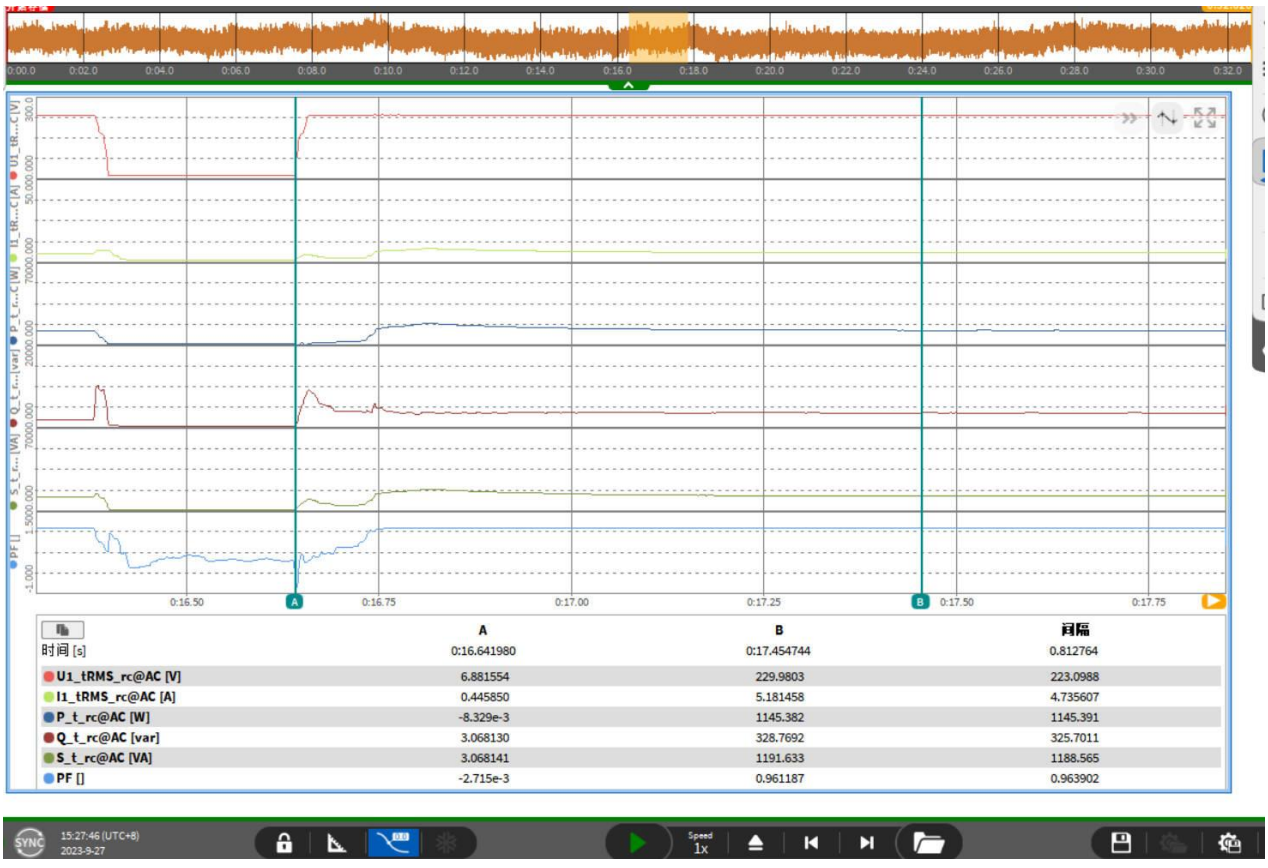


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Duration time



Recovery time of active power

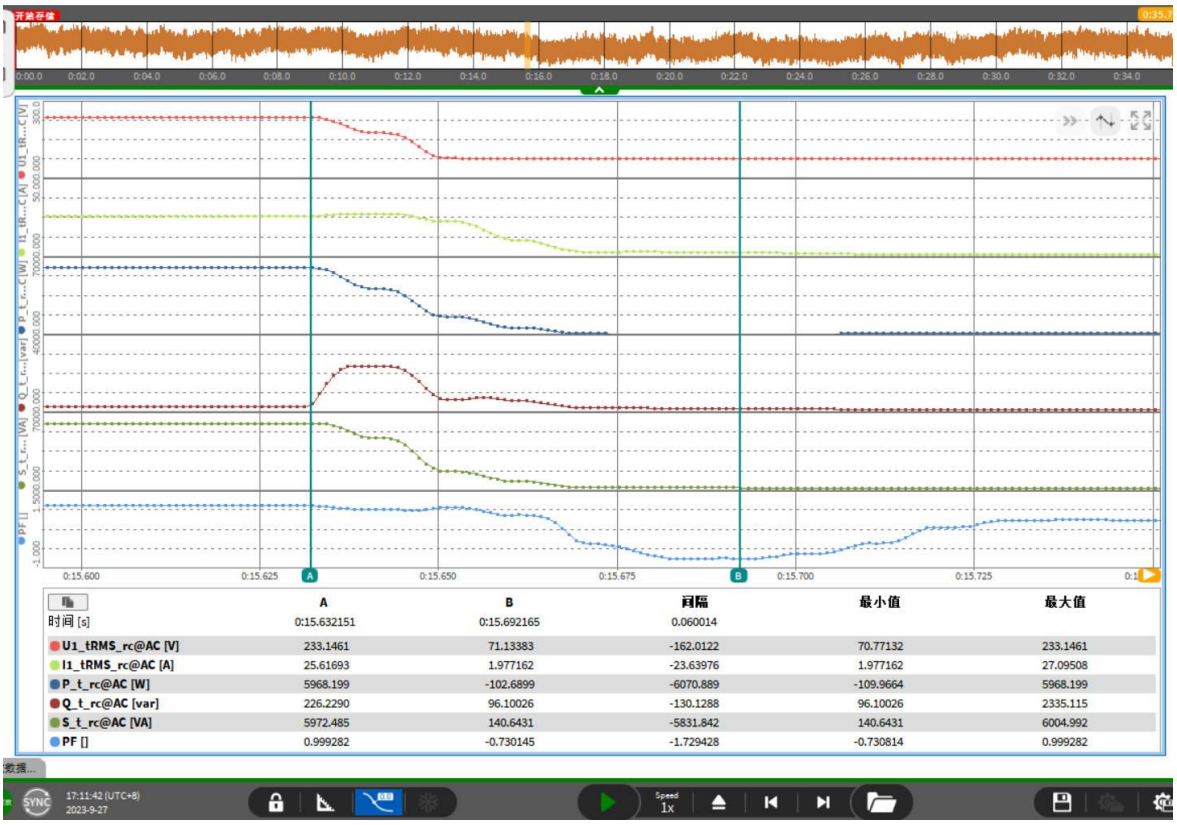


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Graph of FRT tests

Test no. 2.A.1 – symmetrical fault (U/U_{nom} = 0,31) P > 0,9

0~60ms



	A	B	间隔	最小值	最大值
时间 [s]	0:15.632151	0:15.692165	0.060014		
U1_tRMS_rc@AC [V]	233.1461	71.13383	-162.0122	70.77132	233.1461
I1_tRMS_rc@AC [A]	25.61693	1.977162	-23.63976	1.977162	27.09508
P_t_rc@AC [W]	5968.199	-102.6899	-6070.889	-109.9664	5968.199
Q_t_rc@AC [var]	226.2290	96.10026	-130.1288	96.10026	2335.115
S_t_rc@AC [VA]	5972.485	140.6431	-5831.842	140.6431	6004.992
PF []	0.999282	-0.730145	-1.729428	-0.730814	0.999282

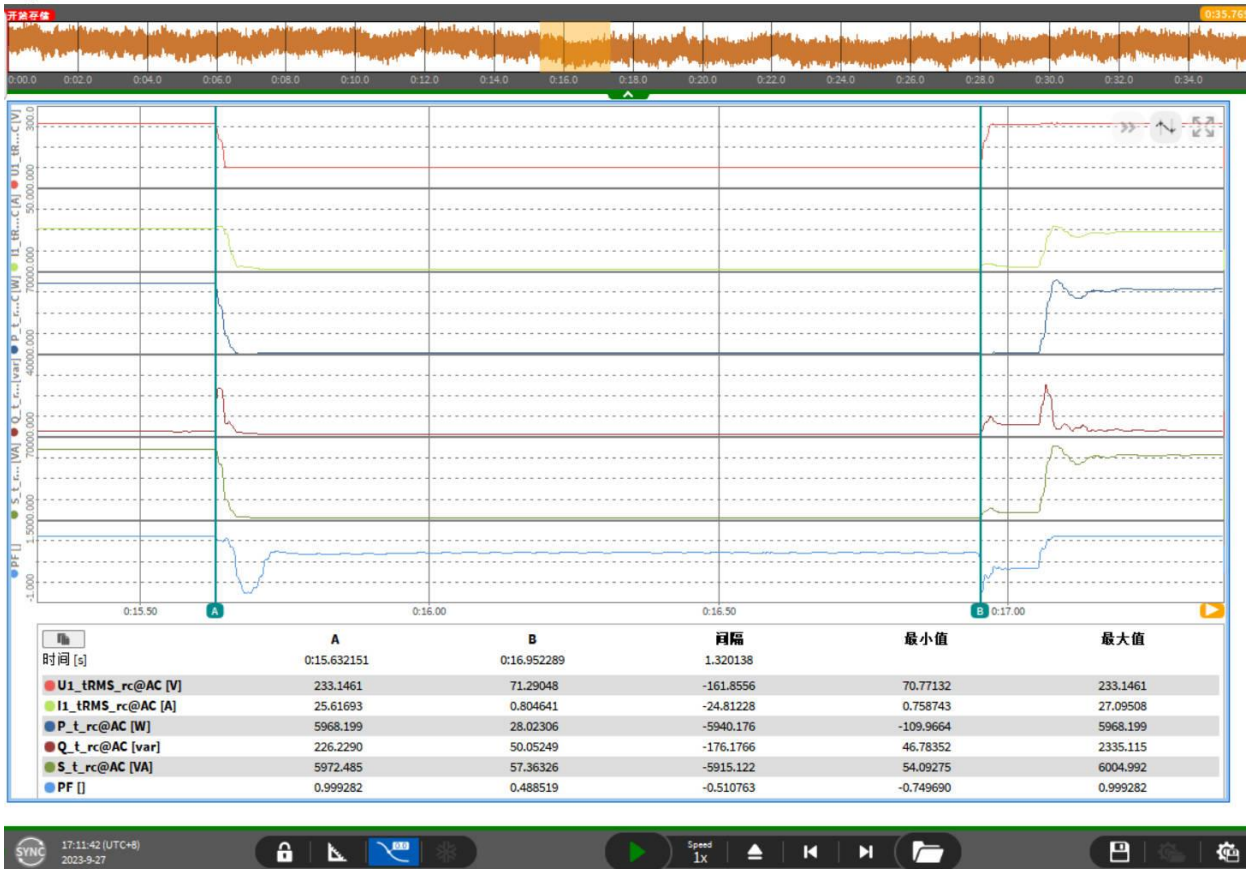
0~100ms



	A	B	间隔	最小值	最大值
时间 [s]	0:15.632151	0:15.732160	0.100009		
U1_tRMS_rc@AC [V]	233.1461	71.27893	-161.8671	70.77132	233.1461
I1_tRMS_rc@AC [A]	25.61693	0.800628	-24.81630	0.798369	27.09508
P_t_rc@AC [W]	5968.199	30.09616	-5938.103	-109.9664	5968.199
Q_t_rc@AC [var]	226.2290	48.48681	-177.7422	48.48681	2335.115
S_t_rc@AC [VA]	5972.485	57.06794	-5915.417	56.91411	6004.992
PF []	0.999282	0.527374	-0.471908	-0.749690	0.999282

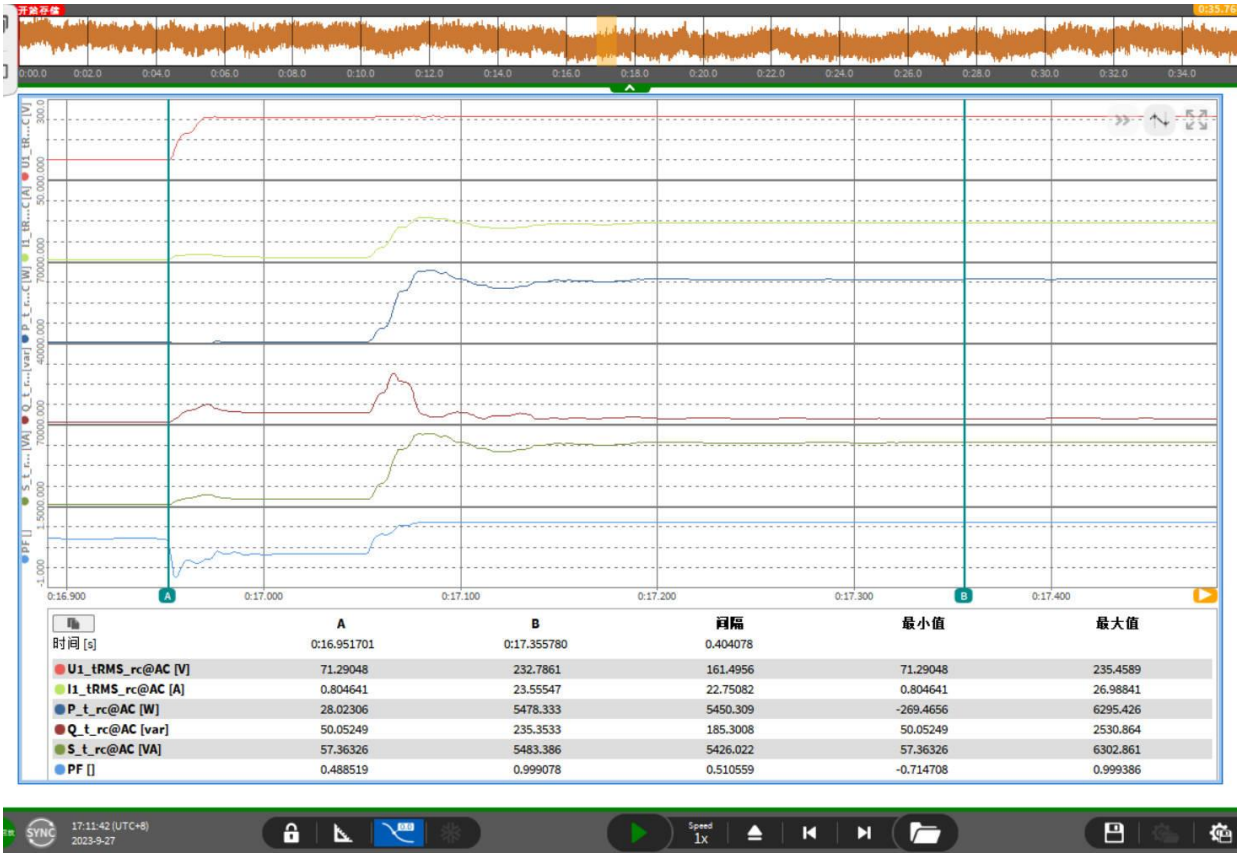
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Duration time



时间 [s]	A 0:15.632151	B 0:16.952289	间隔 1.320138	最小值	最大值
U1_tRMS_rc@AC [V]	233.1461	71.29048	-161.8556	70.77132	233.1461
I1_tRMS_rc@AC [A]	25.61693	0.804641	-24.81228	0.758743	27.09508
P_t_rc@AC [W]	5968.199	28.02306	-5940.176	-109.9664	5968.199
Q_t_rc@AC [var]	226.2290	50.05249	-176.1766	46.78352	2335.115
S_t_rc@AC [VA]	5972.485	57.36326	-5915.122	54.09275	6004.992
PF []	0.999282	0.488519	-0.510763	-0.749690	0.999282

Recovery time of active power



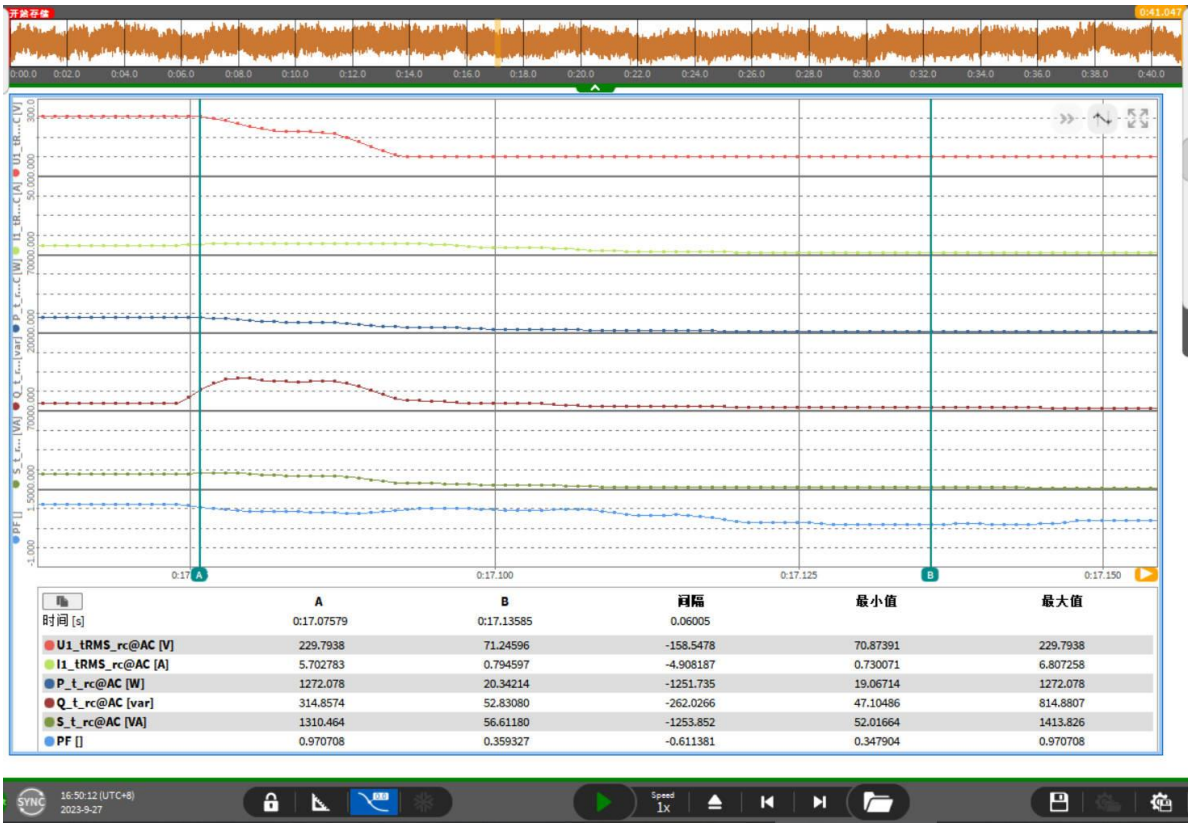
时间 [s]	A 0:16.951701	B 0:17.355780	间隔 0.404078	最小值	最大值
U1_tRMS_rc@AC [V]	71.29048	232.7861	161.4956	71.29048	235.4589
I1_tRMS_rc@AC [A]	0.804641	23.55547	22.75082	0.804641	26.98841
P_t_rc@AC [W]	28.02306	5478.333	5450.309	-269.4656	6295.426
Q_t_rc@AC [var]	50.05249	235.3533	185.3008	50.05249	2530.864
S_t_rc@AC [VA]	57.36326	5483.386	5426.022	57.36326	6302.861
PF []	0.488519	0.999078	0.510559	-0.714708	0.999386

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Graph of FRT tests

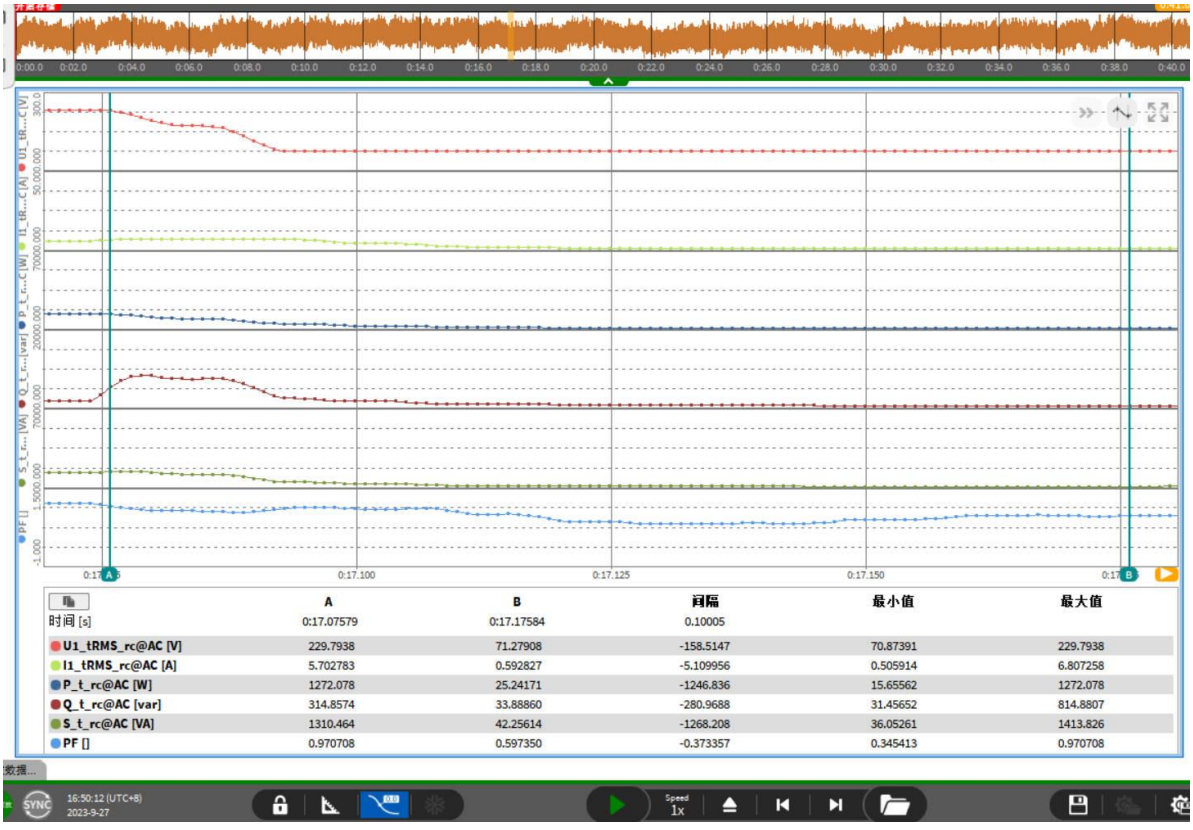
Test no. 2.A.2 – symmetrical fault (U/Unom = 0,31) P= 0,1 - 0,3

0~60ms



时间 [s]	A 0:17.07579	B 0:17.13585	间隔 0.06005	最小值	最大值
U1_tRMS_rc@AC [V]	229.7938	71.24596	-158.5478	70.87391	229.7938
I1_tRMS_rc@AC [A]	5.702783	0.794597	-4.908187	0.730071	6.807258
P_t_rc@AC [W]	1272.078	20.34214	-1251.735	19.06714	1272.078
Q_t_rc@AC [var]	314.8574	52.83080	-262.0266	47.10486	814.8807
S_t_rc@AC [VA]	1310.464	56.61180	-1253.852	52.01664	1413.826
PF []	0.970708	0.359327	-0.611381	0.347904	0.970708

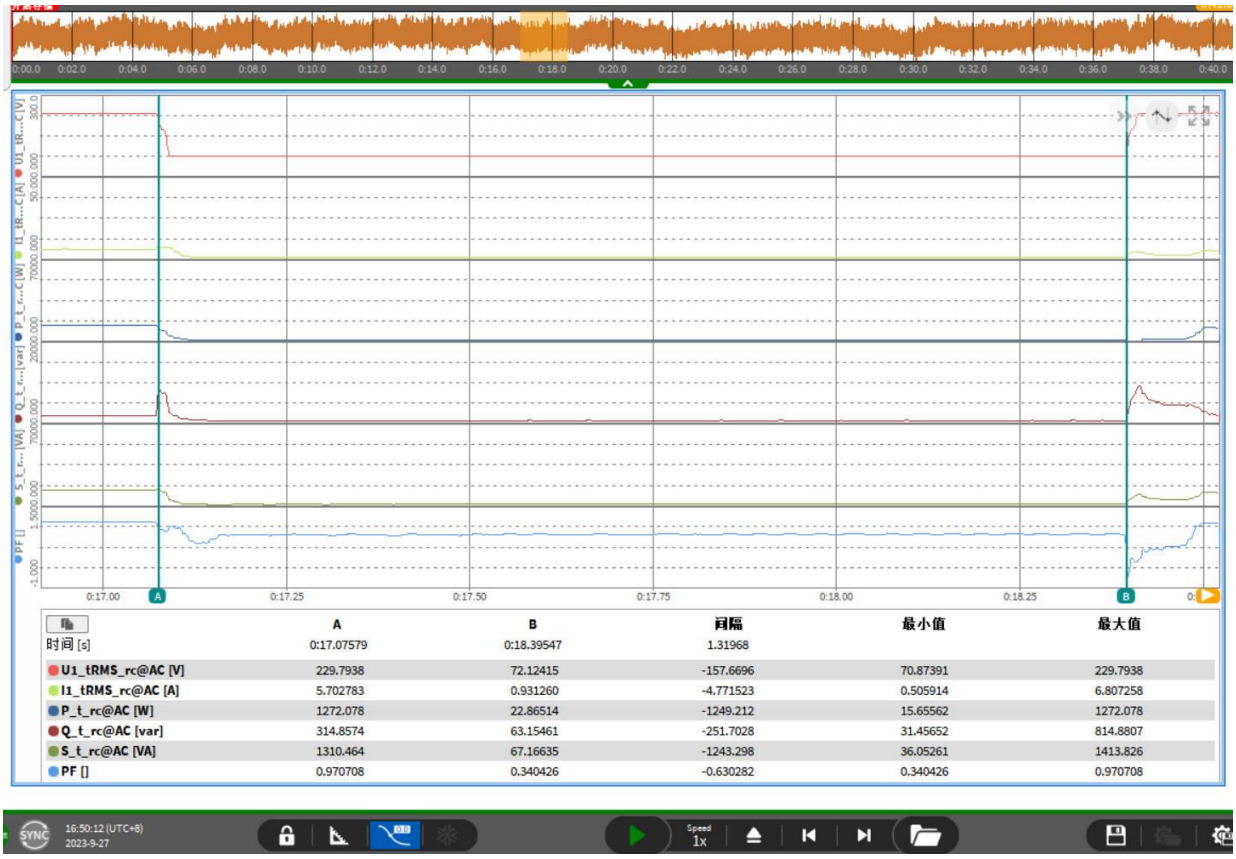
0~100ms



时间 [s]	A 0:17.07579	B 0:17.17584	间隔 0.10005	最小值	最大值
U1_tRMS_rc@AC [V]	229.7938	71.27908	-158.5147	70.87391	229.7938
I1_tRMS_rc@AC [A]	5.702783	0.592827	-5.109956	0.505914	6.807258
P_t_rc@AC [W]	1272.078	25.24171	-1246.836	15.65562	1272.078
Q_t_rc@AC [var]	314.8574	33.88860	-280.9688	31.45652	814.8807
S_t_rc@AC [VA]	1310.464	42.25614	-1268.208	36.05261	1413.826
PF []	0.970708	0.597350	-0.373357	0.345413	0.970708

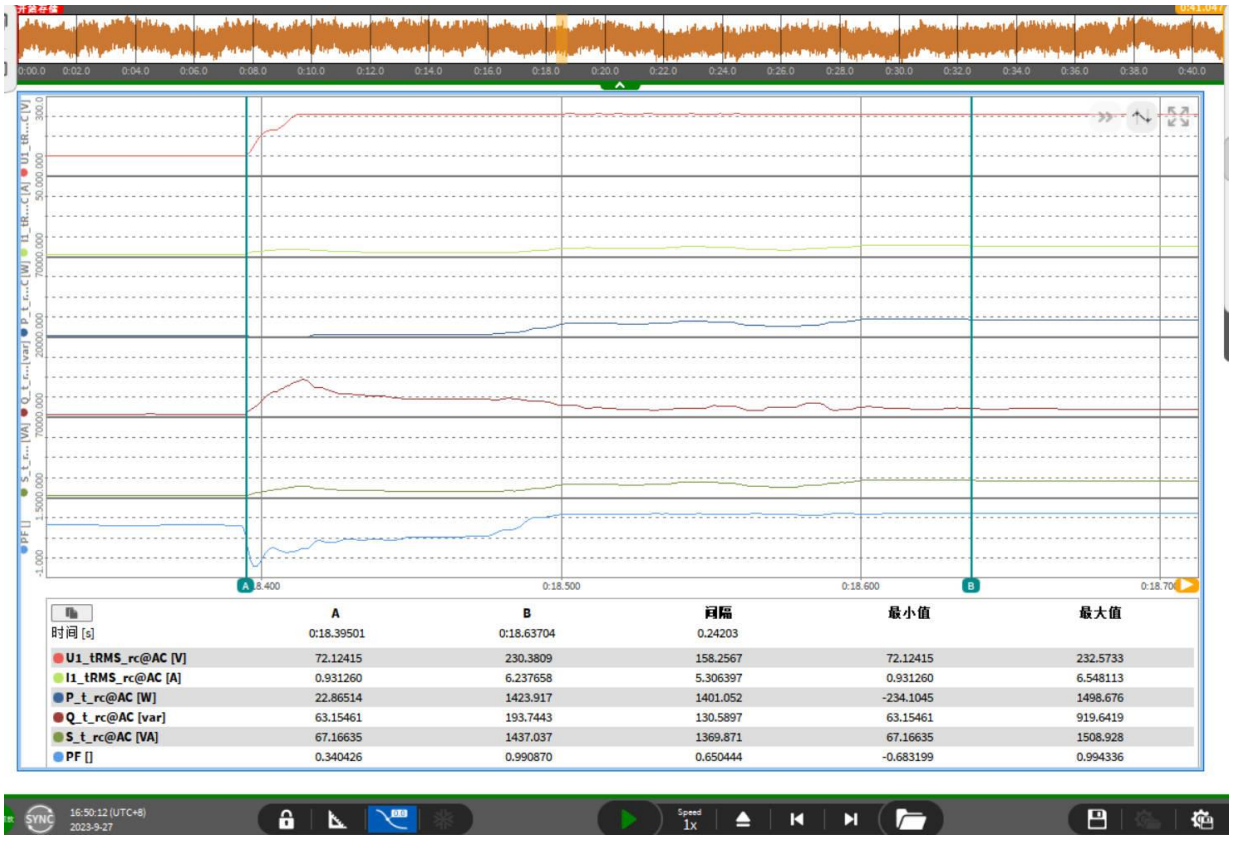
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Duration time



	A	B	间隔	最小值	最大值
时间 [s]	0:17.07579	0:18.39547	1.31968		
U1_tRMS_rc@AC [V]	229.7938	72.12415	-157.6696	70.87391	229.7938
I1_tRMS_rc@AC [A]	5.702783	0.931260	-4.771523	0.505914	6.807258
P_t_rc@AC [W]	1272.078	22.86514	-1249.212	15.65562	1272.078
Q_t_rc@AC [var]	314.8574	63.15461	-251.7028	31.45652	814.8807
S_t_rc@AC [VA]	1310.464	67.16635	-1243.298	36.05261	1413.826
PF []	0.970708	0.340426	-0.630282	0.340426	0.970708

Recovery time of active power



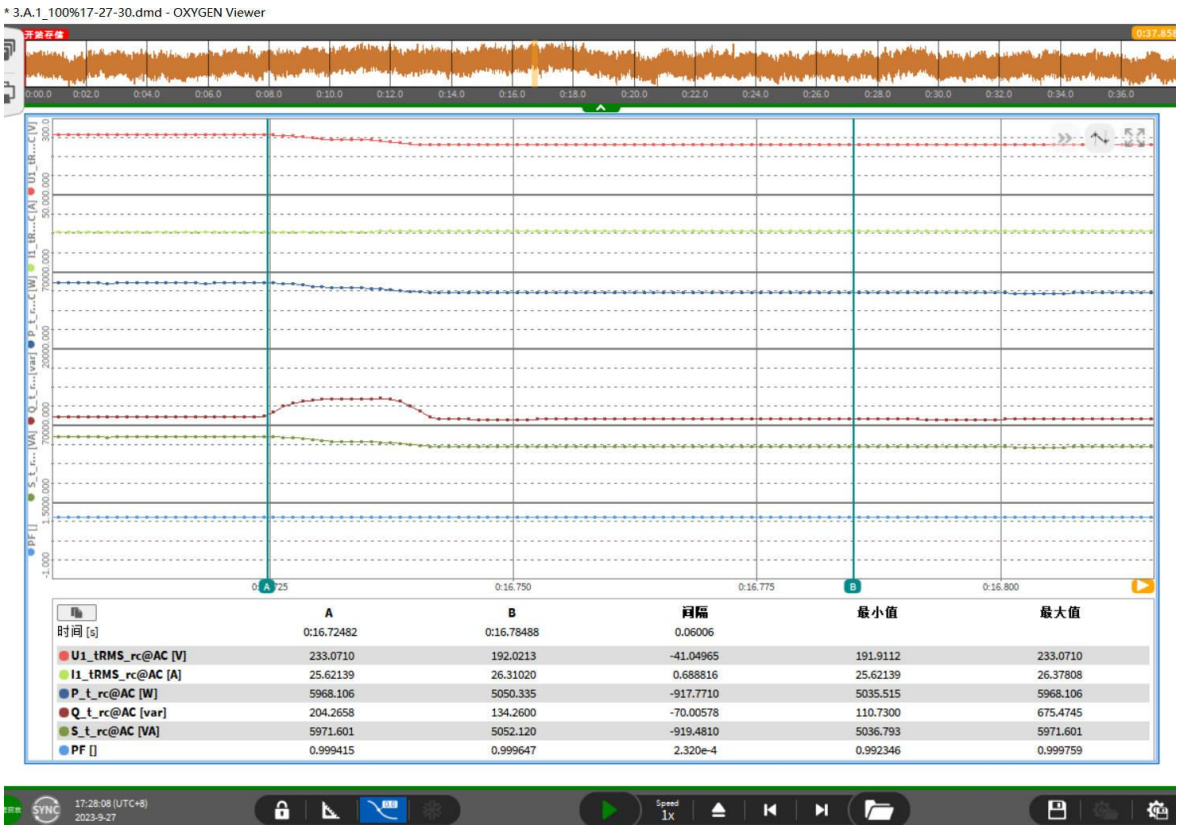
	A	B	间隔	最小值	最大值
时间 [s]	0:18.39501	0:18.63704	0.24203		
U1_tRMS_rc@AC [V]	72.12415	230.3809	158.2567	72.12415	232.5733
I1_tRMS_rc@AC [A]	0.931260	6.237658	5.306397	0.931260	6.548113
P_t_rc@AC [W]	22.86514	1423.917	1401.052	-234.1045	1498.676
Q_t_rc@AC [var]	63.15461	193.7443	130.5897	63.15461	919.6419
S_t_rc@AC [VA]	67.16635	1437.037	1369.871	67.16635	1508.928
PF []	0.340426	0.990870	0.650444	-0.683199	0.994336

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Graph of FRT tests

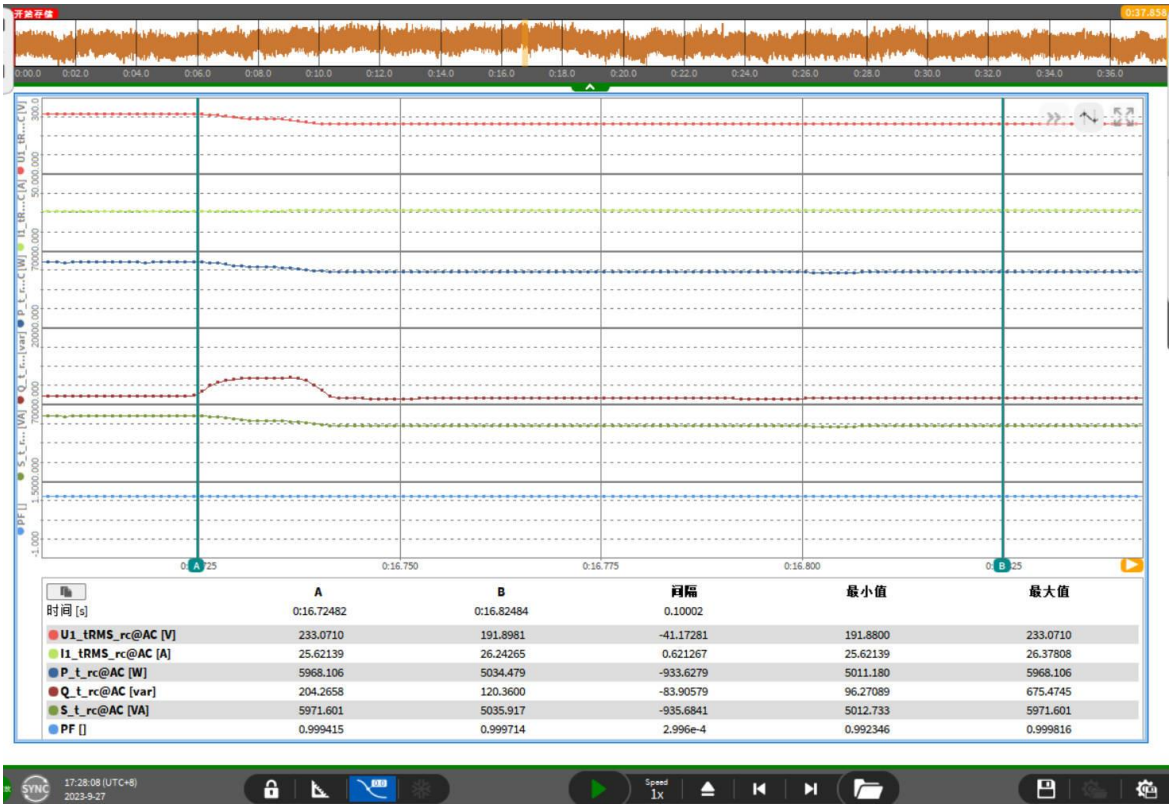
Test no. 3.A.1 – symmetrical fault (U/U_{nom} = 0,82) P > 0,9

0~60ms



时间 [s]	A 0:16.72482	B 0:16.78488	间隔 0.06006	最小值	最大值
U1_tRMS_rc@AC [V]	233.0710	192.0213	-41.04965	191.9112	233.0710
I1_tRMS_rc@AC [A]	25.62139	26.31020	0.688816	25.62139	26.37808
P_t_rc@AC [W]	5968.106	5050.335	-917.7710	5035.515	5968.106
Q_t_rc@AC [var]	204.2658	134.2600	-70.00578	110.7300	675.4745
S_t_rc@AC [VA]	5971.601	5052.120	-919.4810	5036.793	5971.601
PF []	0.999415	0.999647	2.320e-4	0.992346	0.999759

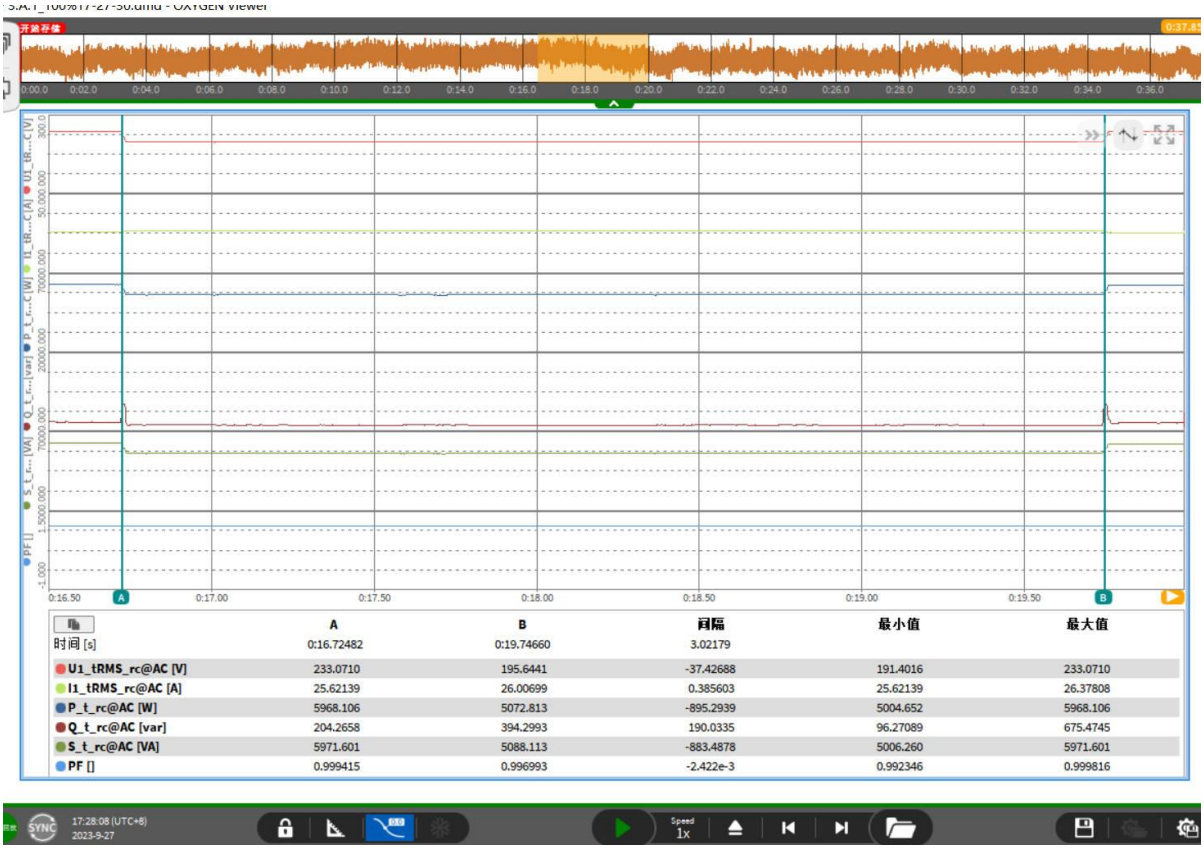
0~100ms



时间 [s]	A 0:16.72482	B 0:16.82484	间隔 0.10002	最小值	最大值
U1_tRMS_rc@AC [V]	233.0710	191.8981	-41.17281	191.8800	233.0710
I1_tRMS_rc@AC [A]	25.62139	26.24265	0.621267	25.62139	26.37808
P_t_rc@AC [W]	5968.106	5034.479	-933.6279	5011.180	5968.106
Q_t_rc@AC [var]	204.2658	120.3600	-83.90579	96.27089	675.4745
S_t_rc@AC [VA]	5971.601	5035.917	-935.6841	5012.733	5971.601
PF []	0.999415	0.999714	2.996e-4	0.992346	0.999816

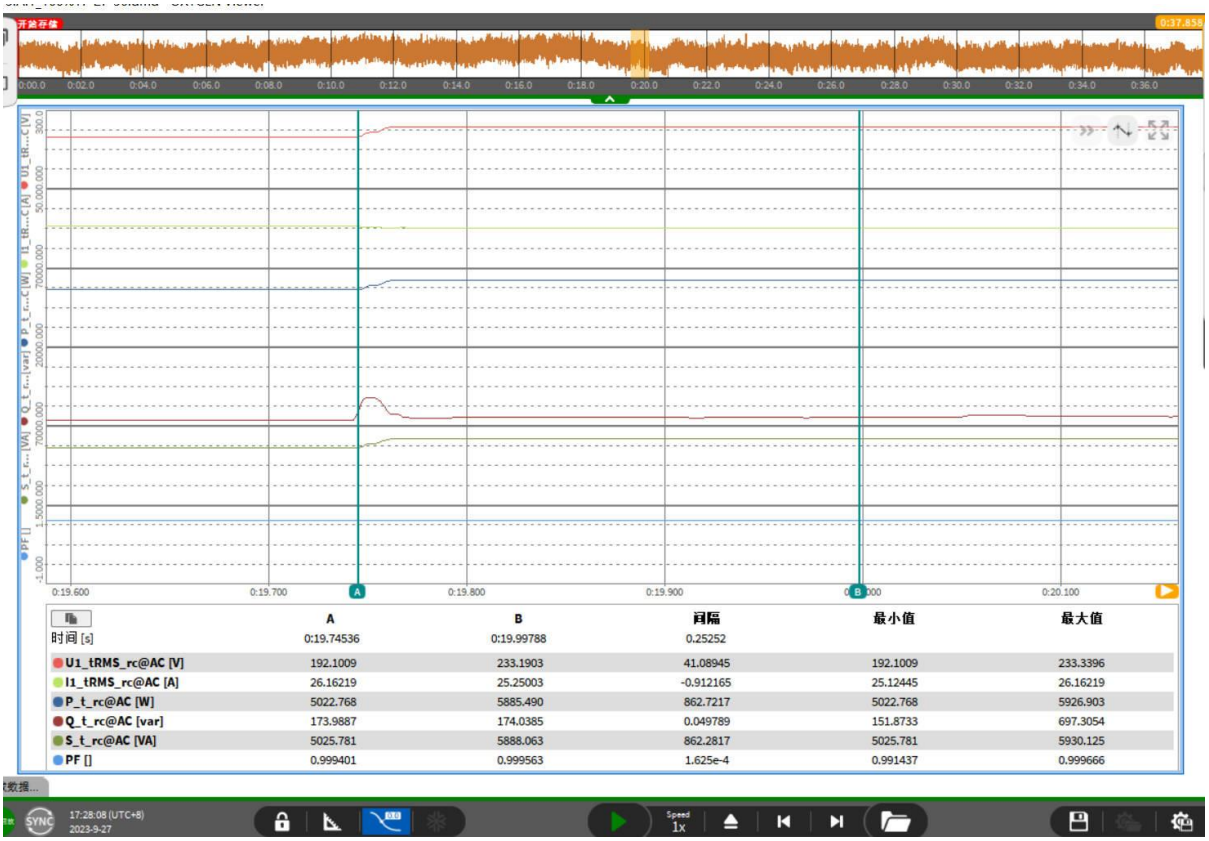
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Duration time



	A	B	间隔	最小值	最大值
时间 [s]	0:16.72482	0:19.74660	3.02179		
U1_tRMS_rc@AC [V]	233.0710	195.6441	-37.42688	191.4016	233.0710
I1_tRMS_rc@AC [A]	25.62139	26.00699	0.385603	25.62139	26.37808
P_t_rc@AC [W]	5968.106	5072.813	-895.2939	5004.652	5968.106
Q_t_rc@AC [var]	204.2658	394.2993	190.0335	96.27089	675.4745
S_t_rc@AC [VA]	5971.601	5088.113	-883.4878	5006.260	5971.601
PF []	0.999415	0.996993	-2.422e-3	0.992346	0.999816

Recovery time of active power



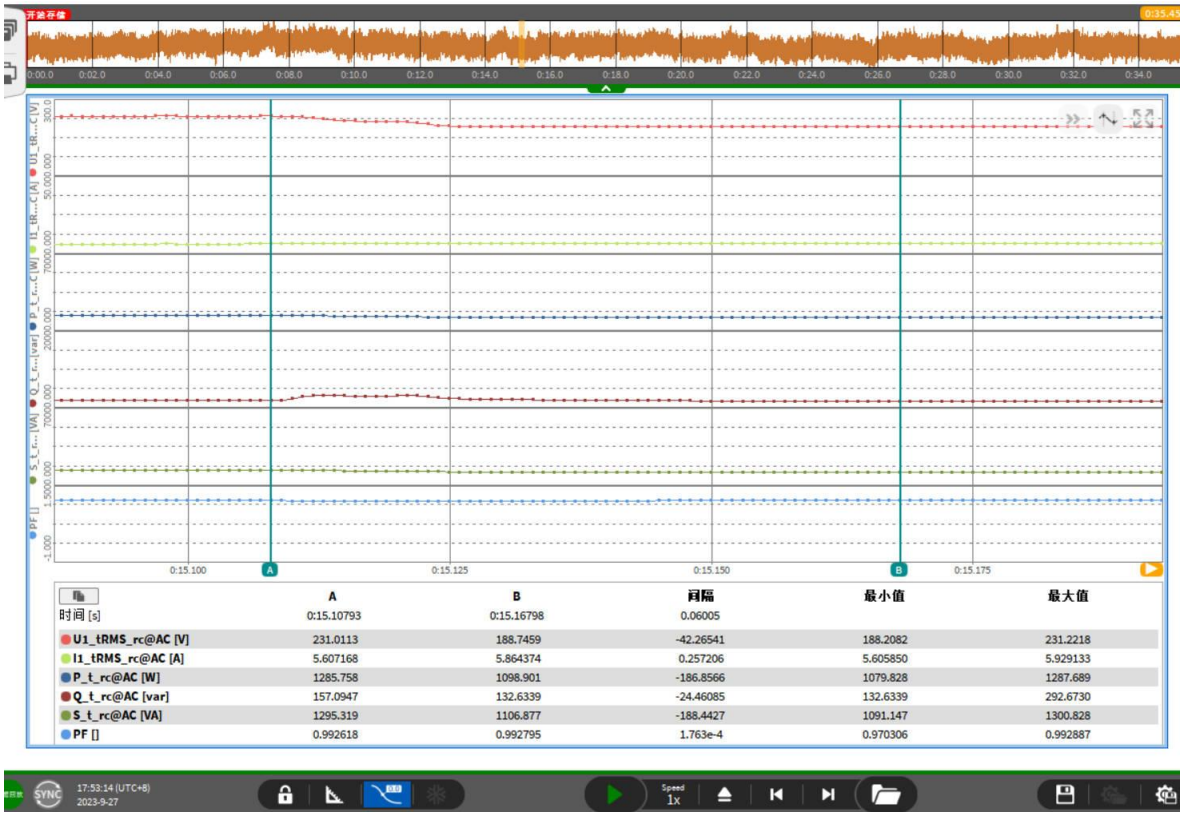
	A	B	间隔	最小值	最大值
时间 [s]	0:19.74536	0:19.99788	0.25252		
U1_tRMS_rc@AC [V]	192.1009	233.1903	41.08945	192.1009	233.3396
I1_tRMS_rc@AC [A]	26.16219	25.25003	-0.912165	25.12445	26.16219
P_t_rc@AC [W]	5022.768	5885.490	862.7217	5022.768	5926.903
Q_t_rc@AC [var]	173.9887	174.0385	0.049789	151.8733	697.3054
S_t_rc@AC [VA]	5025.781	5888.063	862.2817	5025.781	5930.125
PF []	0.999401	0.999563	1.625e-4	0.991437	0.999666

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Graph of FRT tests

Test no. 3.A.2 – symmetrical fault (U/Unom = 0,82) P= 0,1 - 0,3

0~60ms



时间 [s]	A 0:15.10793	B 0:15.16798	间隔 0.06005	最小值	最大值
U1_tRMS_rc@AC [V]	231.0113	188.7459	-42.26541	188.2082	231.2218
I1_tRMS_rc@AC [A]	5.607168	5.864374	0.257206	5.605850	5.929133
P_t_rc@AC [W]	1285.758	1098.901	-186.8566	1079.828	1287.689
Q_t_rc@AC [var]	157.0947	132.6339	-24.46085	132.6339	292.6730
S_t_rc@AC [VA]	1295.319	1106.877	-188.4427	1091.147	1300.828
PF []	0.992618	0.992795	1.763e-4	0.970306	0.992887

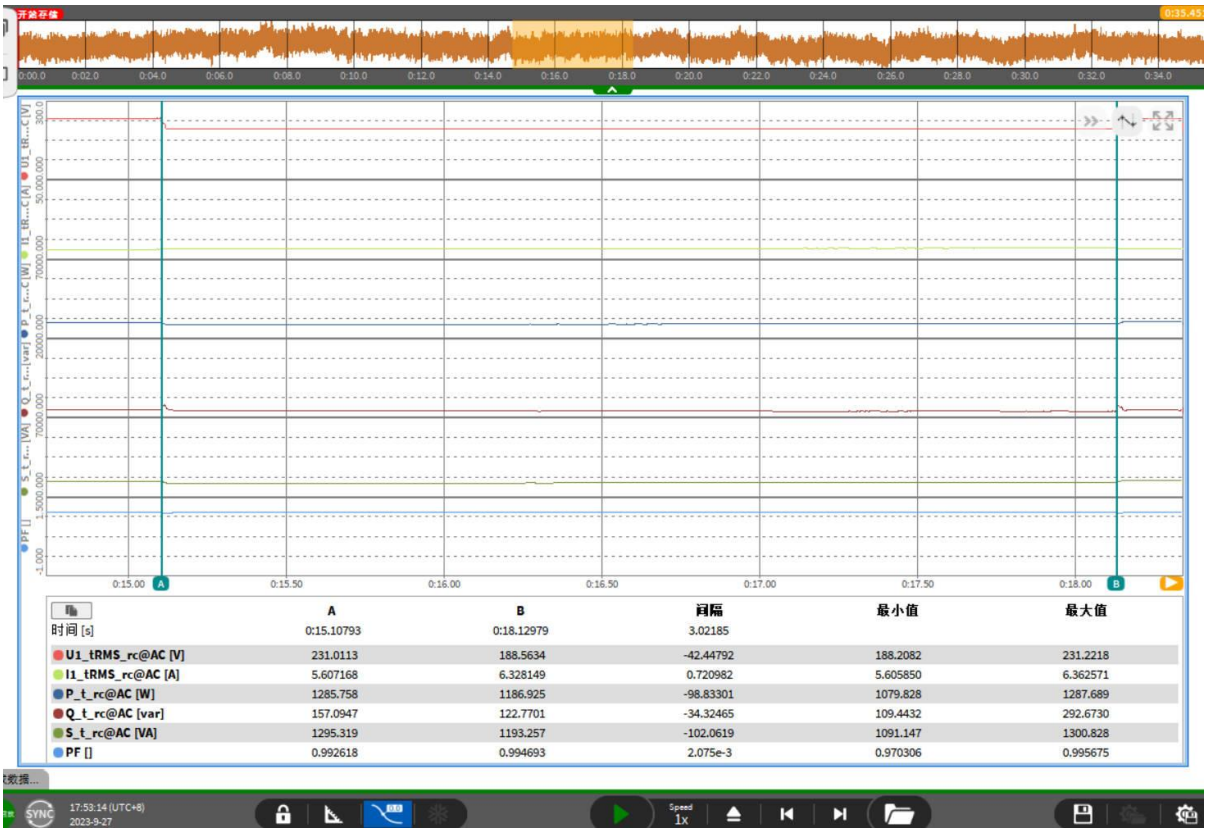
0~100ms



时间 [s]	A 0:15.10793	B 0:15.20798	间隔 0.10005	最小值	最大值
U1_tRMS_rc@AC [V]	231.0113	188.7455	-42.26582	188.2082	231.2218
I1_tRMS_rc@AC [A]	5.607168	5.892865	0.285697	5.605850	5.929133
P_t_rc@AC [W]	1285.758	1103.677	-182.0809	1079.828	1287.689
Q_t_rc@AC [var]	157.0947	137.8442	-19.25050	128.1277	292.6730
S_t_rc@AC [VA]	1295.319	1112.252	-183.0676	1091.147	1300.828
PF []	0.992618	0.992291	-3.278e-4	0.970306	0.993296

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Duration time



	A	B	间隔	最小值	最大值
时间 [s]	0:15.10793	0:18.12979	3.02185		
U1_tRMS_rc@AC [V]	231.0113	188.5634	-42.44792	188.2082	231.2218
I1_tRMS_rc@AC [A]	5.607168	6.328149	0.720982	5.605850	6.362571
P_t_rc@AC [W]	1285.758	1186.925	-98.83301	1079.828	1287.689
Q_t_rc@AC [var]	157.0947	122.7701	-34.32465	109.4432	292.6730
S_t_rc@AC [VA]	1295.319	1193.257	-102.0619	1091.147	1300.828
PF []	0.992618	0.994693	2.075e-3	0.970306	0.995675

Recovery time of active power



	A	B	间隔	最小值	最大值
时间 [s]	0:18.12970	0:18.41750	0.28780		
U1_tRMS_rc@AC [V]	188.5634	230.2129	41.64946	188.5634	230.8388
I1_tRMS_rc@AC [A]	6.328149	6.038199	-0.289950	5.757785	6.328149
P_t_rc@AC [W]	1186.925	1383.445	196.5203	1149.980	1391.940
Q_t_rc@AC [var]	122.7701	135.5619	12.79187	122.7701	269.0772
S_t_rc@AC [VA]	1193.257	1390.071	196.8137	1178.326	1402.131
PF []	0.994693	0.995233	5.403e-4	0.975944	0.995444

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4.5.4 **4.7.4**	**High voltage ride through (HVRT)** **Zero current mode for converter connected generating plants**	**P**

HESP4860S100-H

Generating modules, except for micro-generating plants, shall be capable of staying connected to the distribution network as long as the voltage at the point of connection remains below the voltage-time curve of Figure 8.

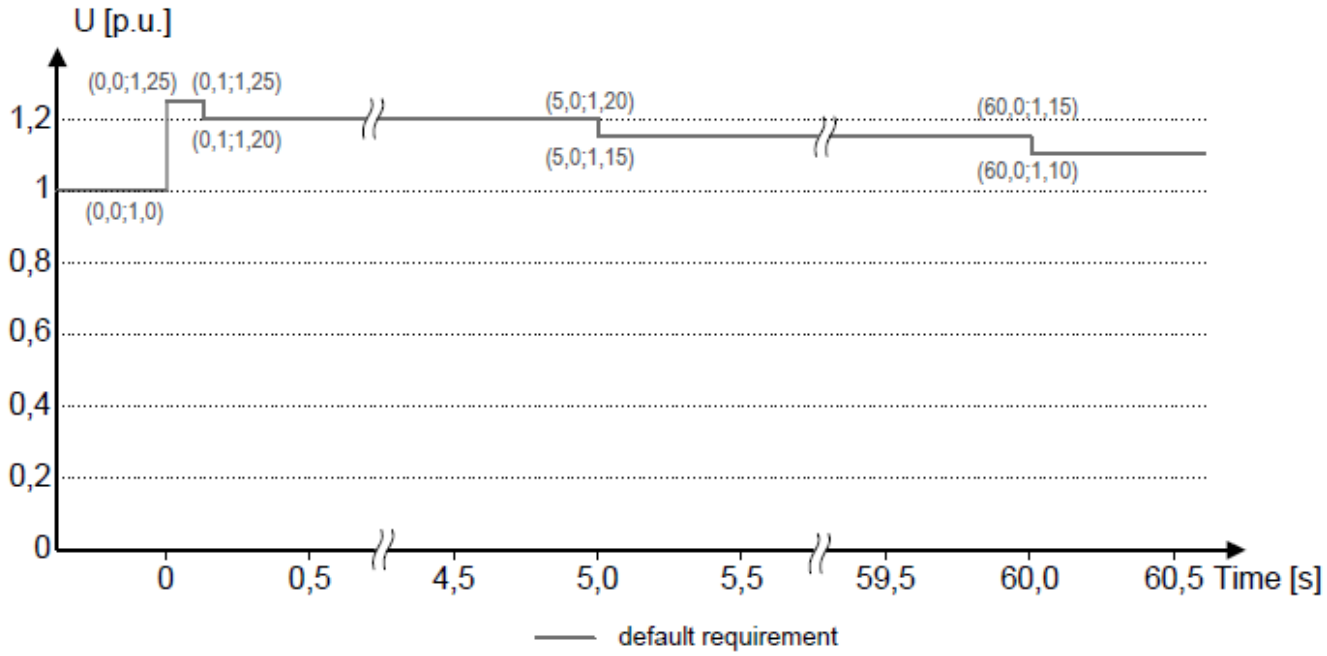


Figure 8 — Over-voltage ride through capability

Notes on test conditions:

Voltage dips are typically performed on an AC simulator.

The test method refer to IEC 62910:2017-05 and FGW TR3, Rev. 25 for details on test setup.

Test name convention:

[voltage dip level].[dip type].[active power operating point], e.g. “1.A.1”

4. voltage dip level: Depends on voltage-time-characteristic of standard
5. dip type: Symmetric/Asymmetric (A, C, D, B,…) according to definitions in https://www.wind-fgw.de/wp-content/uploads/2017/01/Arbeitsdokument_AG_Pruefeinrichtungen.pdf
6. active power operating point:
3) Partial load: e.g. 0,1 x P_{Emax} to 0,3 x P_{Emax}
4) Full load: e.g. more than 0,9 x P_{Emax}

Test results of HVRT

#	Voltage dip [%]	Dip type	duration [ms]	P set point [%]	Measured recovery time [ms]
OV1	1,25	Symmetrical	100	100	774
OV2	1,20	Symmetrical	5000	100	898
OV3	1,15	Symmetrical	60000	100	846

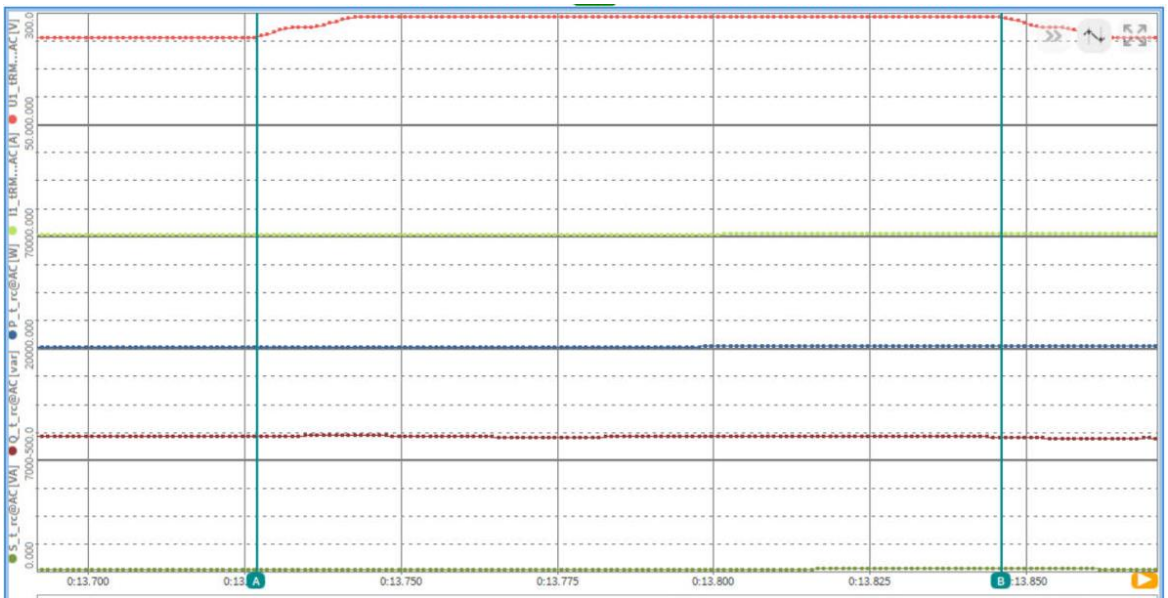
Note:

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4.5.4 **4.7.4**	**High voltage ride through (HVRT)** **Zero current mode for converter connected generating plants**	**P**

No load graph of HFRT tests

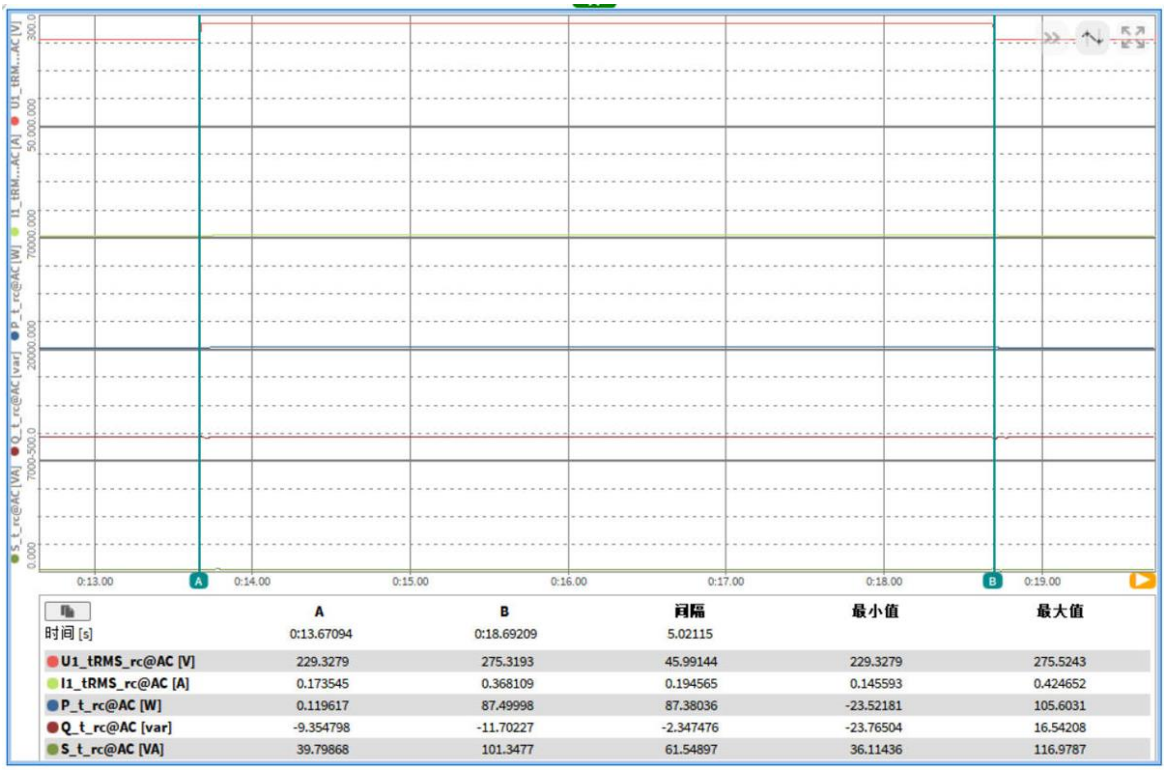
No load Test: OV1(symmetrical; V/Vnom = 1,25; duration = 100ms)



	A	B	间隔	最小值	最大值
时间 [s]	0:13.7269666	0:13.8460184	0.1190518		
U1_tRMS_rc@AC [V]	232.0910	286.3723	54.28127	232.0910	287.0512
I1_tRMS_rc@AC [A]	0.160786	0.484424	0.323638	0.146868	0.484424
P_t_rc@AC [W]	-3.085099	100.2831	103.3682	-32.58588	103.0719
Q_t_rc@AC [var]	-1.770398	-21.69543	-19.92504	-21.69543	25.42555
S_t_rc@AC [VA]	37.31701	138.7256	101.4086	37.31701	138.7256

No load graph of HFRT tests

No load Test: OV2(symmetrical; V/Vnom = 1,20; duration = 5000ms)



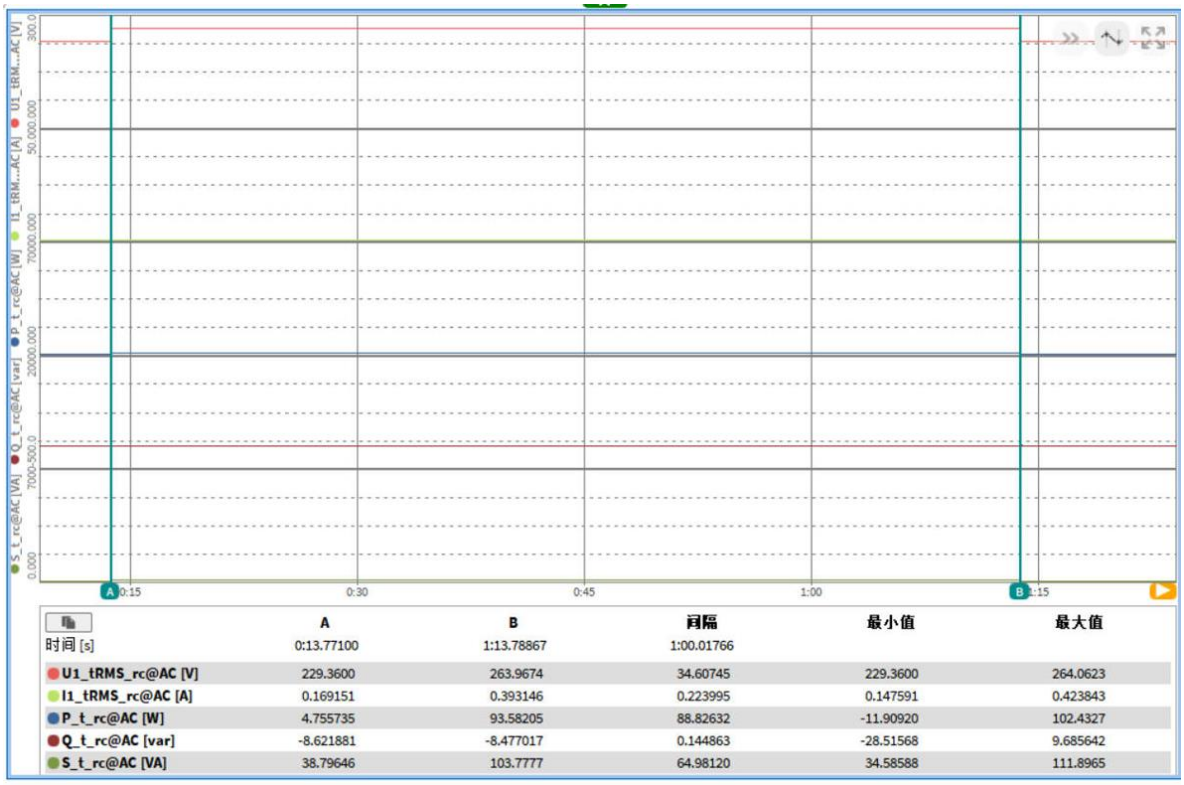
	A	B	间隔	最小值	最大值
时间 [s]	0:13.67094	0:18.69209	5.02115		
U1_tRMS_rc@AC [V]	229.3279	275.3193	45.99144	229.3279	275.5243
I1_tRMS_rc@AC [A]	0.173545	0.368109	0.194565	0.145593	0.424652
P_t_rc@AC [W]	0.119617	87.49998	87.38036	-23.52181	105.6031
Q_t_rc@AC [var]	-9.354798	-11.70227	-2.347476	-23.76504	16.54208
S_t_rc@AC [VA]	39.79868	101.3477	61.54897	36.11436	116.9787

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4.5.4 **4.7.4**	**High voltage ride through (HVRT)** **Zero current mode for converter connected generating plants**	**P**

No load graph of HFRT tests

No load Test: OV3(symmetrical; V/Vnom = 1,15; duration = 60000ms)



	A	B	间隔	最小值	最大值
时间 [s]	0:13.77100	1:13.78867	1:00.01766		
U1_tRMS_rc@AC [V]	229.3600	263.9674	34.60745	229.3600	264.0623
I1_tRMS_rc@AC [A]	0.169151	0.393146	0.223995	0.147591	0.423843
P_t_rc@AC [W]	4.755735	93.58205	88.82632	-11.90920	102.4327
Q_t_rc@AC [var]	-8.621881	-8.477017	0.144863	-28.51568	9.685642
S_t_rc@AC [VA]	38.79646	103.7777	64.98120	34.58588	111.8965

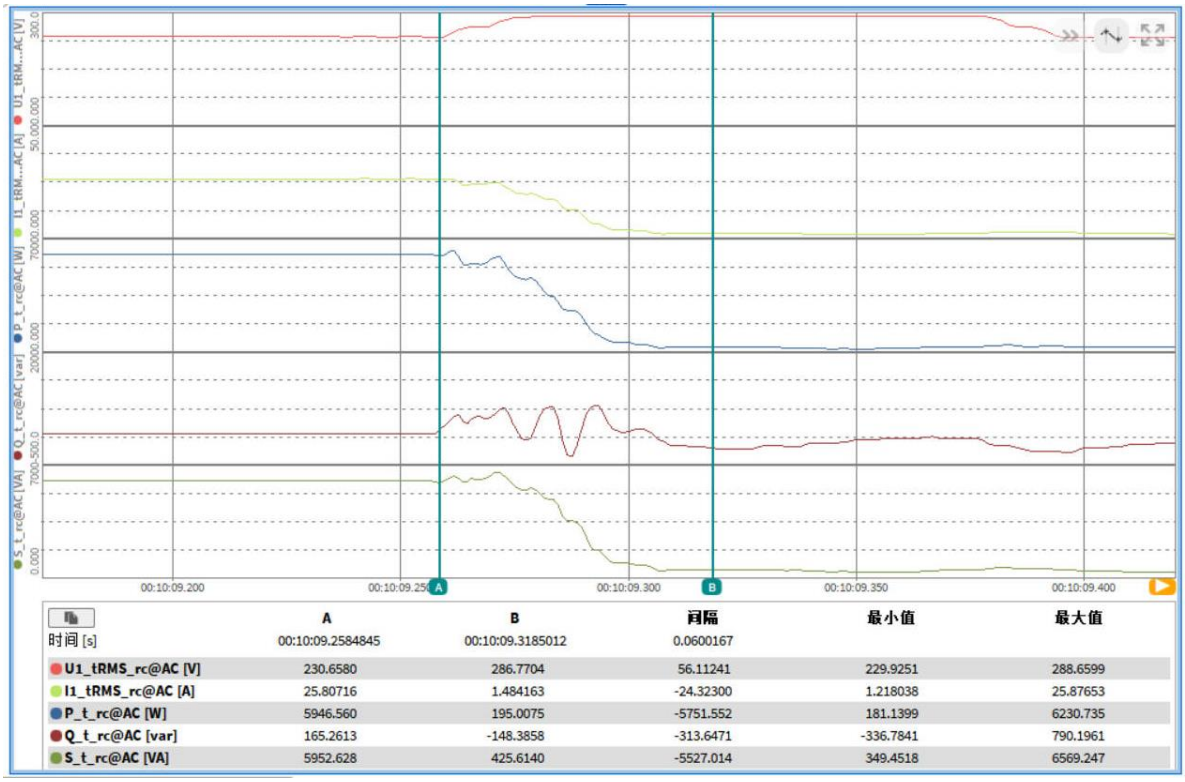
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4.5.4 **4.7.4**	**High voltage ride through (HVRT)** **Zero current mode for converter connected generating plants**	**P**

graph of HFRT tests

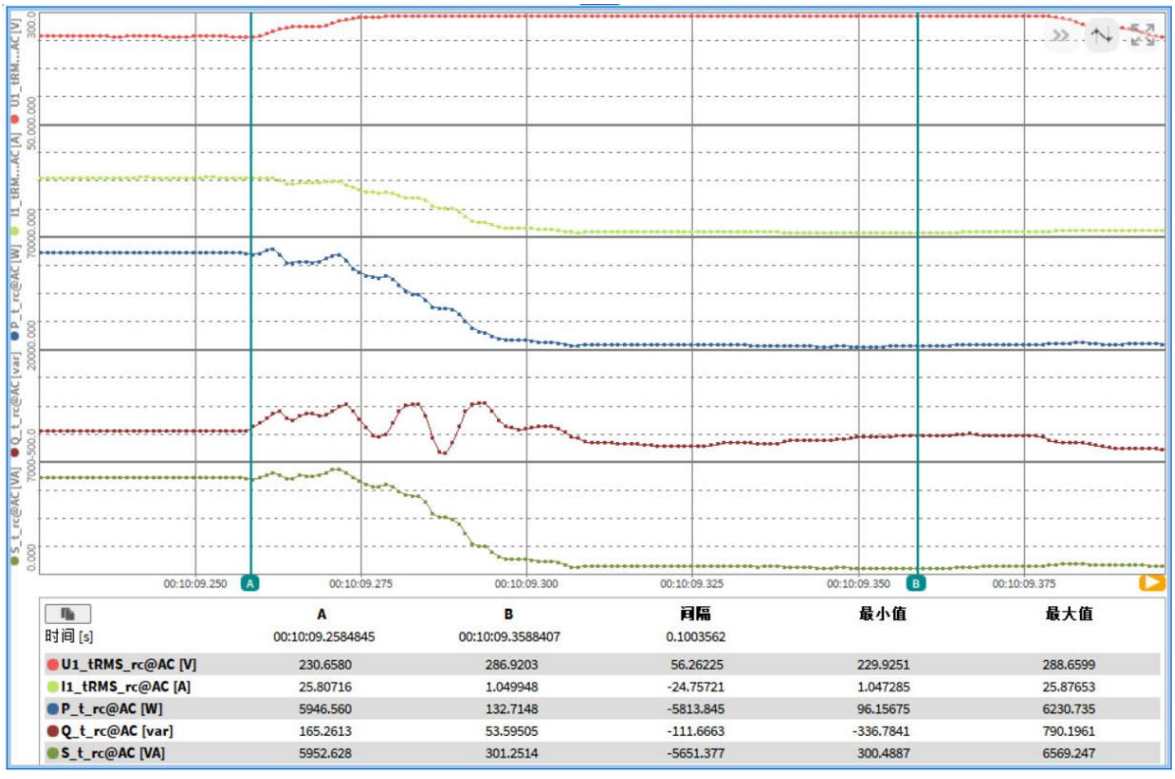
load Test: OV1(symmetrical; V/Vnom = 1,25; duration = 100ms)

0~60ms



时间 [s]	A 00:10:09.2584845	B 00:10:09.3185012	间隔 0.0600167	最小值	最大值
U1_tRMS_rc@AC [V]	230.6580	286.7704	56.11241	229.9251	288.6599
I1_tRMS_rc@AC [A]	25.80716	1.484163	-24.32300	1.218038	25.87653
P_t_rc@AC [W]	5946.560	195.0075	-5751.552	181.1399	6230.735
Q_t_rc@AC [var]	165.2613	-148.3858	-313.6471	-336.7841	790.1961
S_t_rc@AC [VA]	5952.628	425.6140	-5527.014	349.4518	6569.247

0~100ms

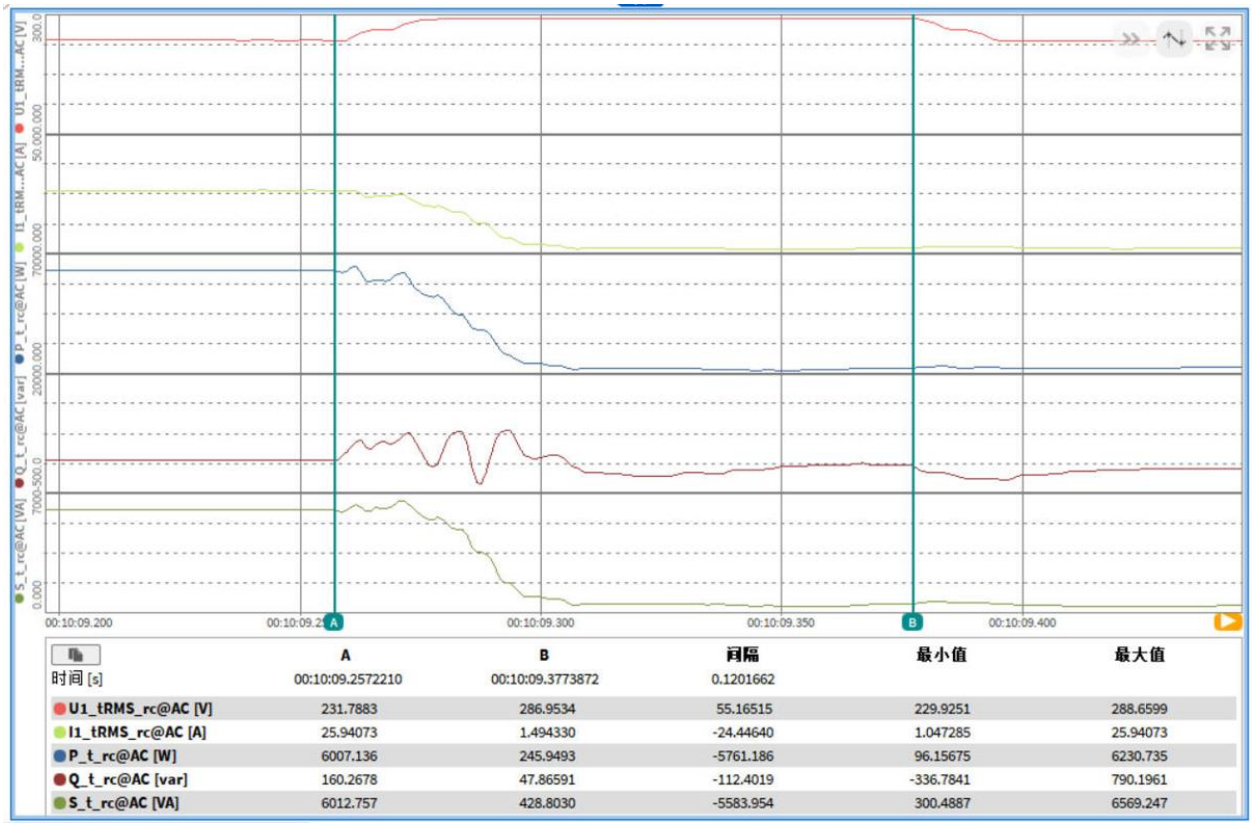


时间 [s]	A 00:10:09.2584845	B 00:10:09.3588407	间隔 0.1003562	最小值	最大值
U1_tRMS_rc@AC [V]	230.6580	286.9203	56.26225	229.9251	288.6599
I1_tRMS_rc@AC [A]	25.80716	1.049948	-24.75721	1.047285	25.87653
P_t_rc@AC [W]	5946.560	132.7148	-5813.845	96.15675	6230.735
Q_t_rc@AC [var]	165.2613	53.59505	-111.6663	-336.7841	790.1961
S_t_rc@AC [VA]	5952.628	301.2514	-5651.377	300.4887	6569.247

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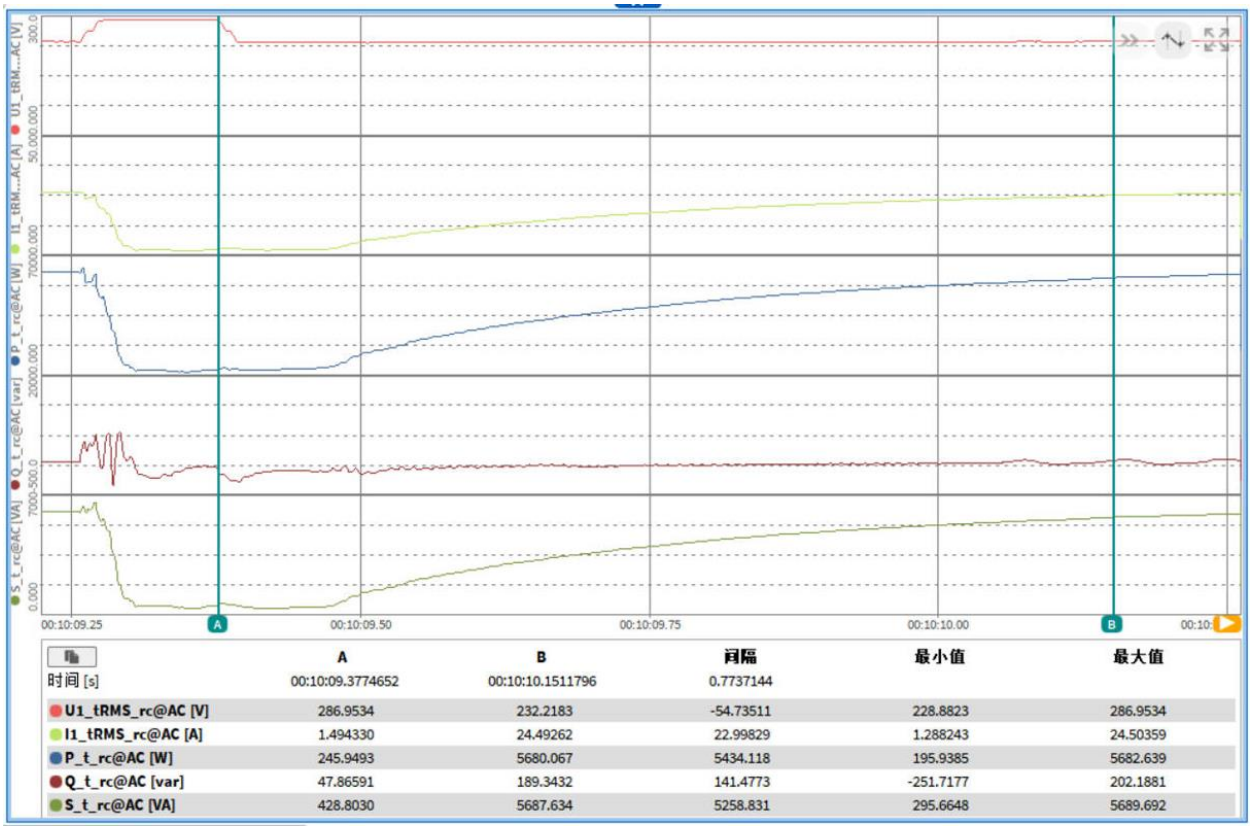
4.5.4 **4.7.4**	**High voltage ride through (HVRT)** **Zero current mode for converter connected generating plants**	**P**

Duration time



时间 [s]	A 00:10:09.2572210	B 00:10:09.3773872	间隔 0.1201662	最小值	最大值
U1_tRMS_rc@AC [V]	231.7883	286.9534	55.16515	229.9251	288.6599
I1_tRMS_rc@AC [A]	25.94073	1.494330	-24.44640	1.047285	25.94073
P_t_rc@AC [W]	6007.136	245.9493	-5761.186	96.15675	6230.735
Q_t_rc@AC [var]	160.2678	47.86591	-112.4019	-336.7841	790.1961
S_t_rc@AC [VA]	6012.757	428.8030	-5583.954	300.4887	6569.247

Recovery time of active power



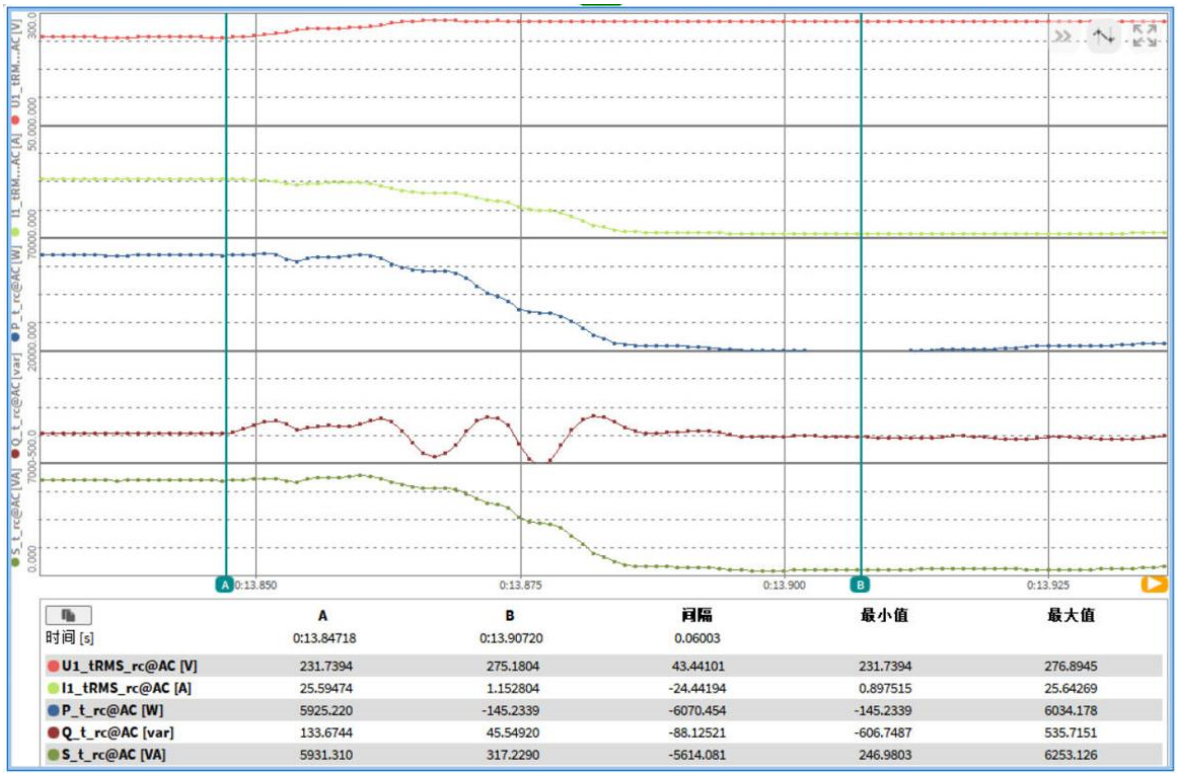
时间 [s]	A 00:10:09.3774652	B 00:10:10.1511796	间隔 0.7737144	最小值	最大值
U1_tRMS_rc@AC [V]	286.9534	232.2183	-54.73511	228.8823	286.9534
I1_tRMS_rc@AC [A]	1.494330	24.49262	22.99829	1.288243	24.50359
P_t_rc@AC [W]	245.9493	5680.067	5434.118	195.9385	5682.639
Q_t_rc@AC [var]	47.86591	189.3432	141.4773	-251.7177	202.1881
S_t_rc@AC [VA]	428.8030	5687.634	5258.831	295.6648	5689.692

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load graph of HFRT tests

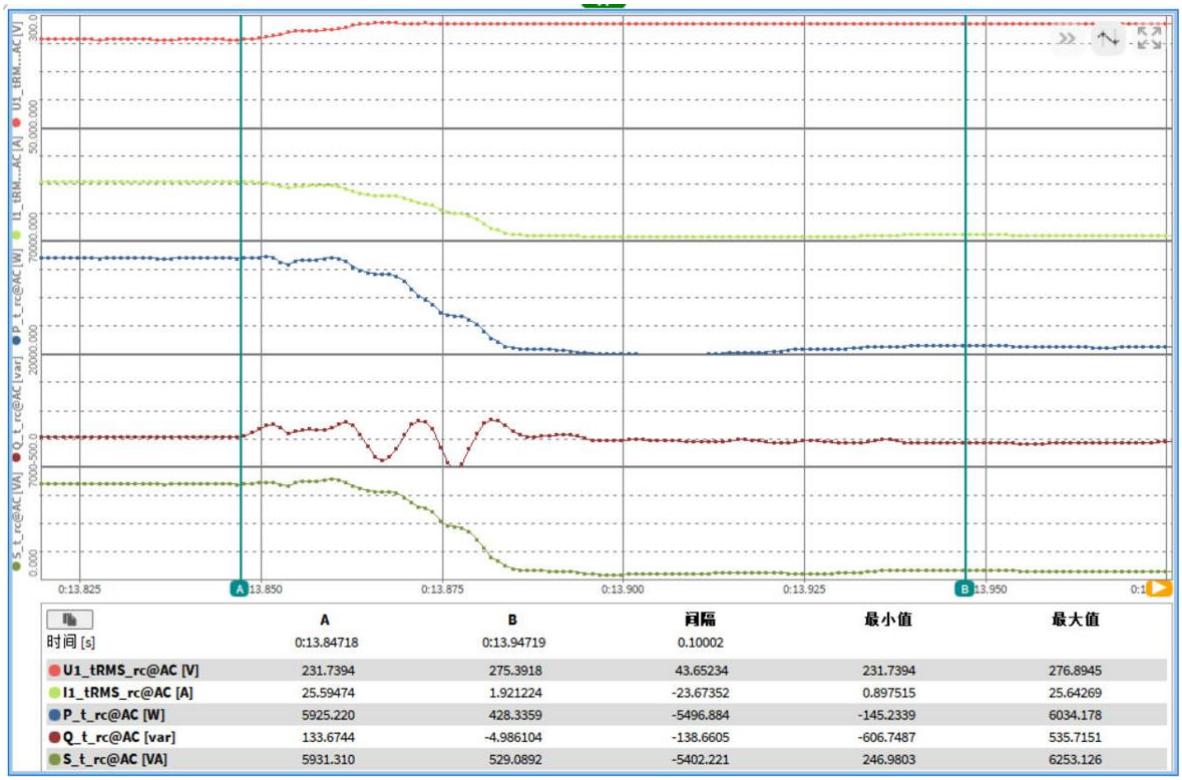
load Test: OV2(symmetrical; V/Vnom = 1,20; duration = 5000ms)

0~60ms



时间 [s]	A 0:13.84718	B 0:13.90720	间隔 0.06003	最小值	最大值
U1_tRMS_rc@AC [V]	231.7394	275.1804	43.44101	231.7394	276.8945
I1_tRMS_rc@AC [A]	25.59474	1.152804	-24.44194	0.897515	25.64269
P_t_rc@AC [W]	5925.220	-145.2339	-6070.454	-145.2339	6034.178
Q_t_rc@AC [var]	133.6744	45.54920	-88.12521	-606.7487	535.7151
S_t_rc@AC [VA]	5931.310	317.2290	-5614.081	246.9803	6253.126

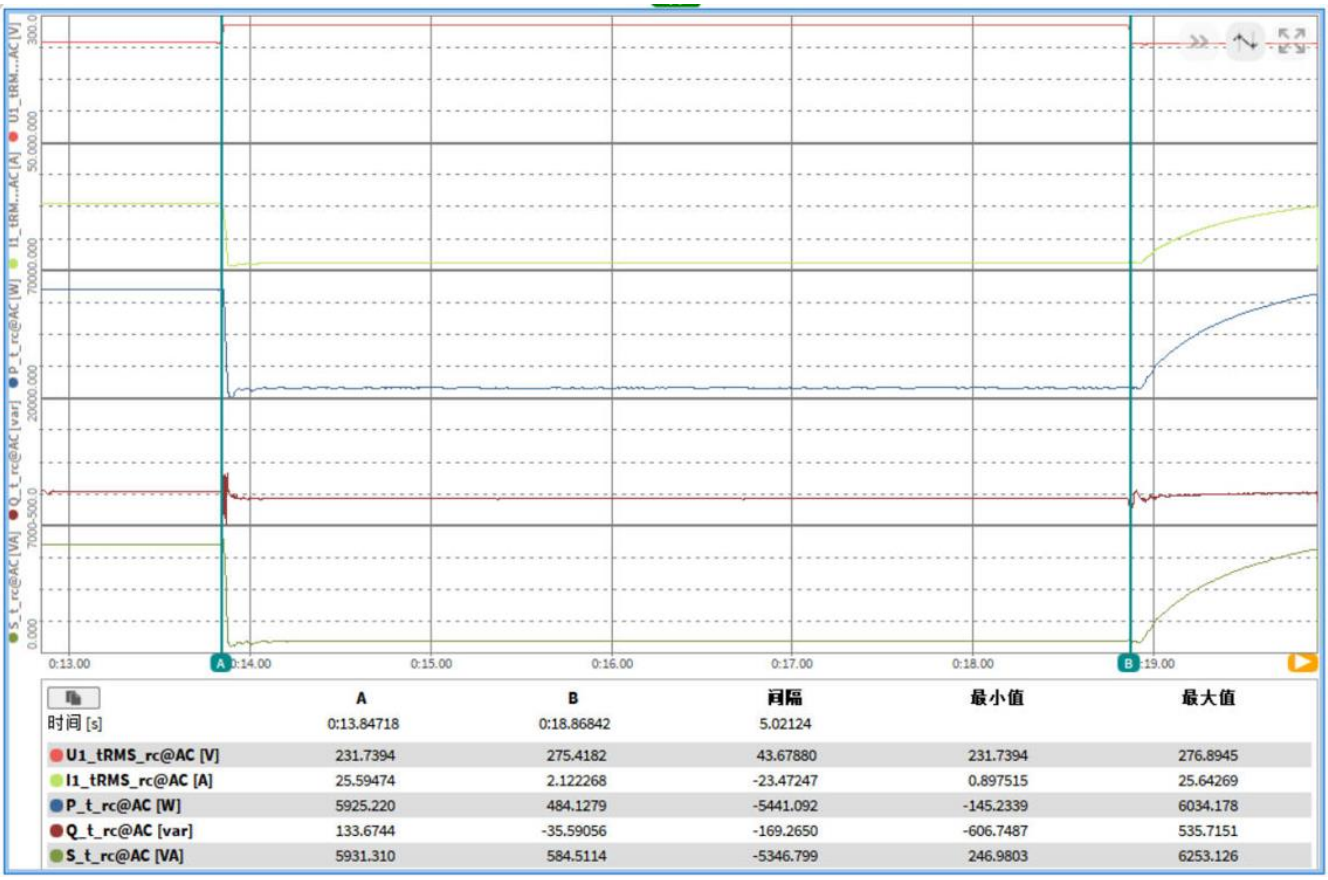
0~100ms



时间 [s]	A 0:13.84718	B 0:13.94719	间隔 0.10002	最小值	最大值
U1_tRMS_rc@AC [V]	231.7394	275.3918	43.65234	231.7394	276.8945
I1_tRMS_rc@AC [A]	25.59474	1.921224	-23.67352	0.897515	25.64269
P_t_rc@AC [W]	5925.220	428.3359	-5496.884	-145.2339	6034.178
Q_t_rc@AC [var]	133.6744	-4.986104	-138.6605	-606.7487	535.7151
S_t_rc@AC [VA]	5931.310	529.0892	-5402.221	246.9803	6253.126

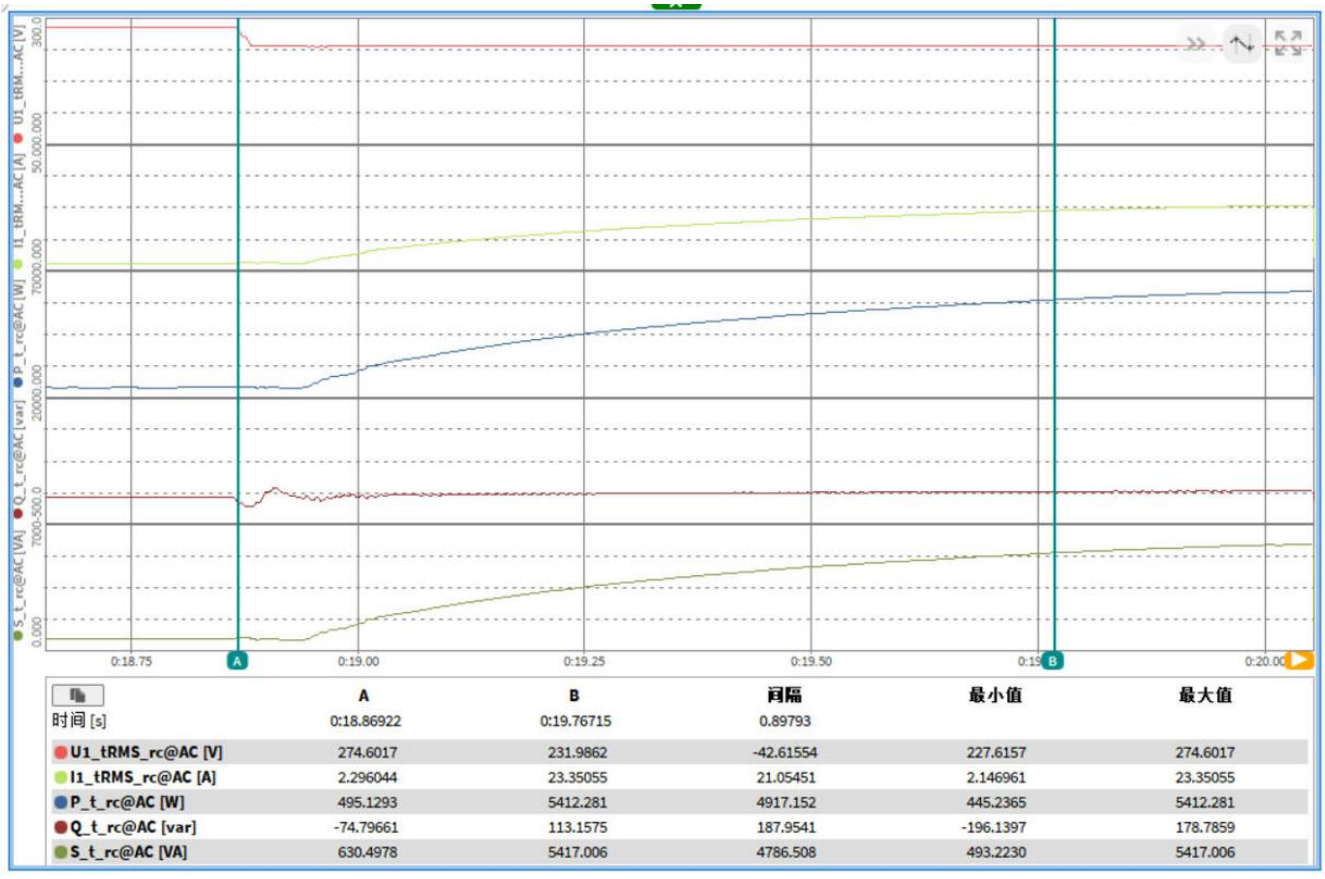
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Duration time



	A	B	间隔	最小值	最大值
时间 [s]	0:13.84718	0:18.86842	5.02124		
U1_tRMS_rc@AC [V]	231.7394	275.4182	43.67880	231.7394	276.8945
I1_tRMS_rc@AC [A]	25.59474	2.122268	-23.47247	0.897515	25.64269
P_t_rc@AC [W]	5925.220	484.1279	-5441.092	-145.2339	6034.178
Q_t_rc@AC [var]	133.6744	-35.59056	-169.2650	-606.7487	535.7151
S_t_rc@AC [VA]	5931.310	584.5114	-5346.799	246.9803	6253.126

Recovery time of active power



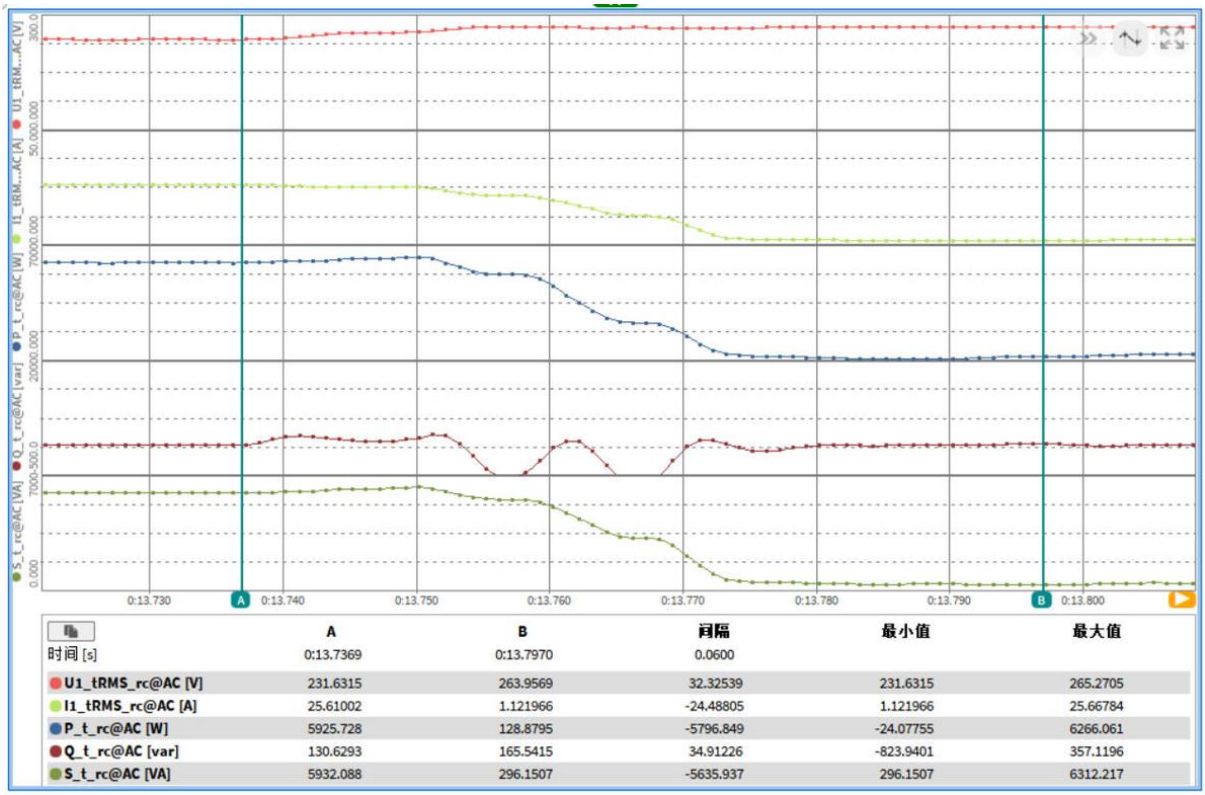
	A	B	间隔	最小值	最大值
时间 [s]	0:18.86922	0:19.76715	0.89793		
U1_tRMS_rc@AC [V]	274.6017	231.9862	-42.61554	227.6157	274.6017
I1_tRMS_rc@AC [A]	2.296044	23.35055	21.05451	2.146961	23.35055
P_t_rc@AC [W]	495.1293	5412.281	4917.152	445.2365	5412.281
Q_t_rc@AC [var]	-74.79661	113.1575	187.9541	-196.1397	178.7859
S_t_rc@AC [VA]	630.4978	5417.006	4786.508	493.2230	5417.006

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load graph of HFRT tests

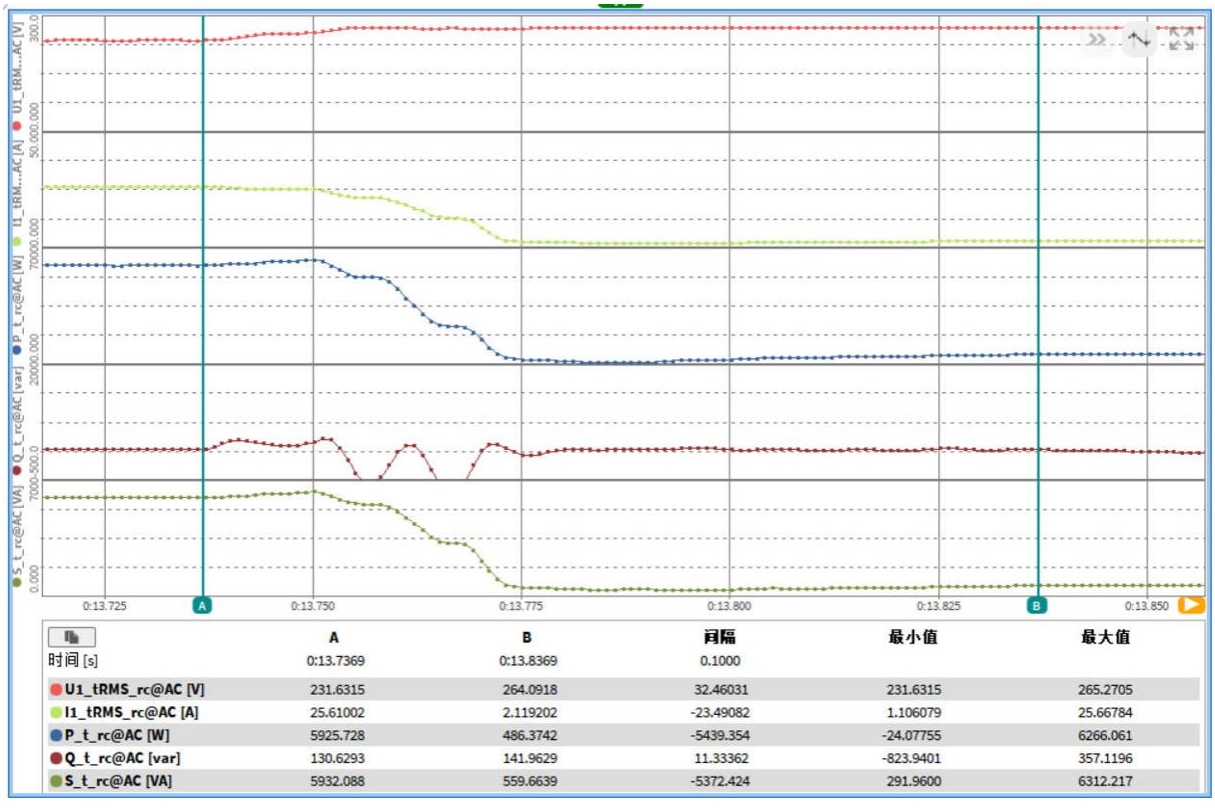
load Test: OV3(symmetrical; V/Vnom = 1,15; duration = 60000ms)

0~60ms



	A	B	间隔	最小值	最大值
时间 [s]	0:13.7369	0:13.7970	0.0600		
U1_tRMS_rc@AC [V]	231.6315	263.9569	32.32539	231.6315	265.2705
I1_tRMS_rc@AC [A]	25.61002	1.121966	-24.48805	1.121966	25.66784
P_t_rc@AC [W]	5925.728	128.8795	-5796.849	-24.07755	6266.061
Q_t_rc@AC [var]	130.6293	165.5415	34.91226	-823.9401	357.1196
S_t_rc@AC [VA]	5932.088	296.1507	-5635.937	296.1507	6312.217

0~100ms



	A	B	间隔	最小值	最大值
时间 [s]	0:13.7369	0:13.8369	0.1000		
U1_tRMS_rc@AC [V]	231.6315	264.0918	32.46031	231.6315	265.2705
I1_tRMS_rc@AC [A]	25.61002	2.119202	-23.49082	1.106079	25.66784
P_t_rc@AC [W]	5925.728	486.3742	-5439.354	-24.07755	6266.061
Q_t_rc@AC [var]	130.6293	141.9629	11.33362	-823.9401	357.1196
S_t_rc@AC [VA]	5932.088	559.6639	-5372.424	291.9600	6312.217

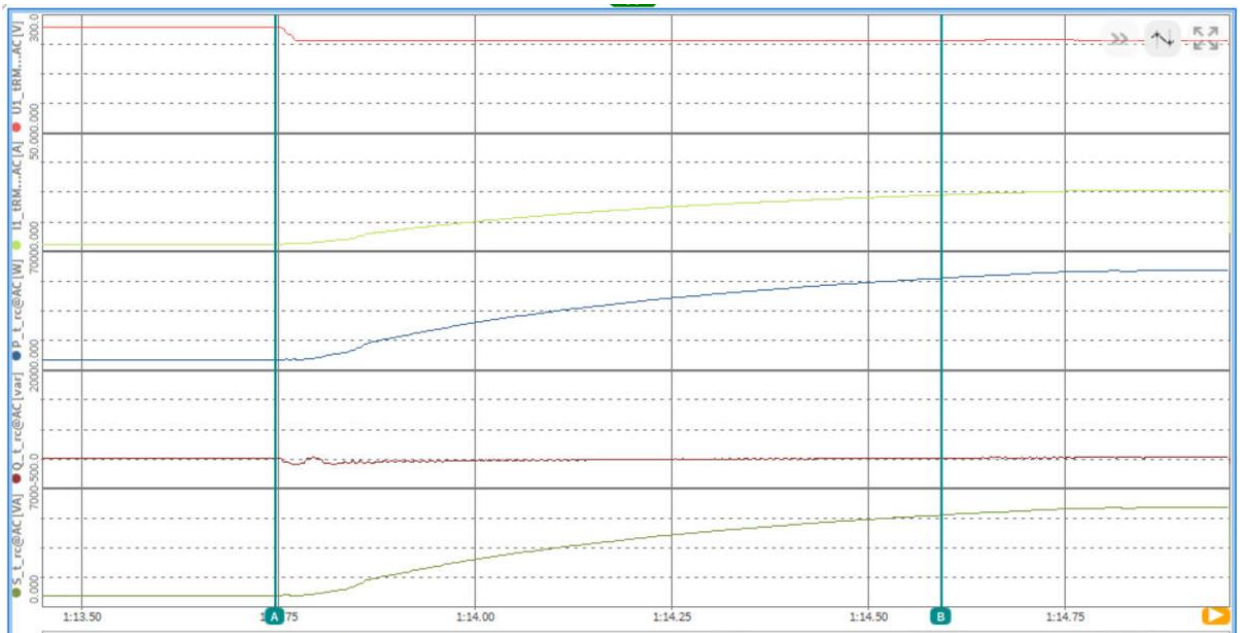
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Duration time



	A	B	间隔	最小值	最大值
时间 [s]	0:13.7341	1:13.7573	1:00.0232		
U1_tRMS_rc@AC [V]	232.4951	264.1557	31.66060	231.6315	265.2705
I1_tRMS_rc@AC [A]	25.69784	2.242975	-23.45486	1.106079	25.69784
P_t_rc@AC [W]	5968.255	517.9715	-5450.284	-24.07755	6266.061
Q_t_rc@AC [var]	128.3531	104.9805	-23.37262	-823.9401	357.1196
S_t_rc@AC [VA]	5974.621	592.4945	-5382.126	291.9600	6312.217

Recovery time of active power



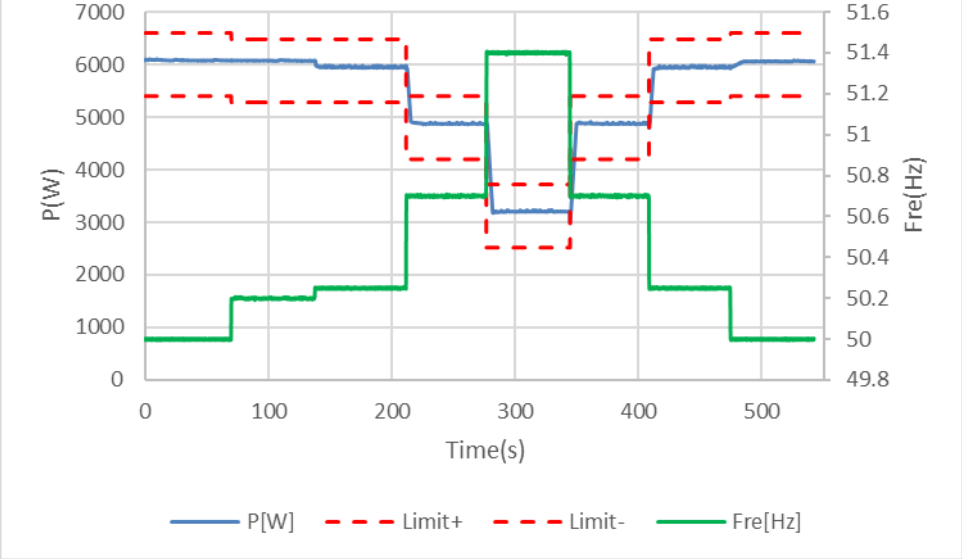
	A	B	间隔	最小值	最大值
时间 [s]	1:13.7470	1:14.5932	0.8462		
U1_tRMS_rc@AC [V]	264.1567	232.0409	-32.11577	229.5425	264.1573
I1_tRMS_rc@AC [A]	2.242254	23.34700	21.10474	2.240570	23.34700
P_t_rc@AC [W]	517.9182	5410.510	4892.592	517.3696	5410.510
Q_t_rc@AC [var]	104.5347	105.4592	0.924446	-37.37868	137.5761
S_t_rc@AC [VA]	592.3063	5417.458	4825.152	566.8362	5417.458

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EN 50549-1:2019: Active response to frequency deviation			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.6.1	Power response to over-frequency	VDE V 0124-100:2020-06, clause 5.4.5	**P**
4.6.2	Power response to under-frequency	VDE V 0124-100:2020-06, clause 5.4.6	**N/A**

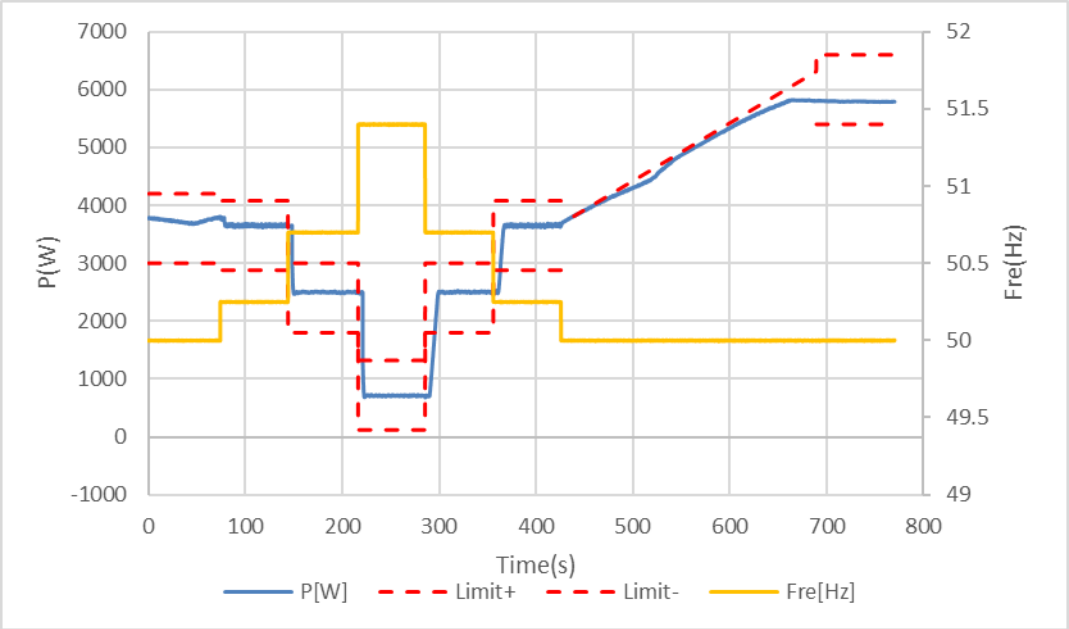
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4.6.1 Power response to over-frequency							P
Test : HESP4860S100-H							
Test:							
1-min mean value [Hz]:	a) 50,00	b) 50,25	c) 50,70	d) 51,40	e) 50,70	f) 50,25	g) 50,00
1. Measurement a) to g): Active power output =100% P_{Emax} s=5% (40% P_{ref} / Hz), threshold frequency for start/return: 50,2Hz							
Frequency [Hz]:	50,00	50,25	50,70	51,40	50,70	50,25	50,00
P_M [W]:	N/A	5880	4800	3120	4800	5880	N/A
P_{E60} [W]:	6082,50	5953,53	4877,41	3211,09	4876,78	5956,69	6058,18
$\Delta P_{E60}/P_M$ [%]:	N/A	1,23	1,29	1,52	1,28	1,28	N/A
Test:							
1-min mean value [Hz]:	a) 50,00	b) 50,30	c) 50,70	d) 51,40	e) 50,70	f) 50,30	g) 50,00
2. Measurement a) to g): Active power output 60% after freezing = 100% P_{Emax} s=5% (40% P_{ref} / Hz), threshold frequency for start/return: 50,2Hz							
Frequency [Hz]:	50,00	50,25	50,70	51,40	50,70	50,25	50,00
P_M [W]:	N/A	3480	2400	720	2400	3480	N/A
P_{E60} [W]:	3737,43	3658,48	2469,95	714,23	2469,74	3516,62	5095,50
$\Delta P_{E60}/P_M$ [%]:	N/A	2,97	1,17	-0,10	1,16	0,61	N/A
Limit $\Delta P/P_{1min}$:	± 10 % of P_{Emax}						
Graph of Measurement 1.: Active power output > 80% P_{Emax}							

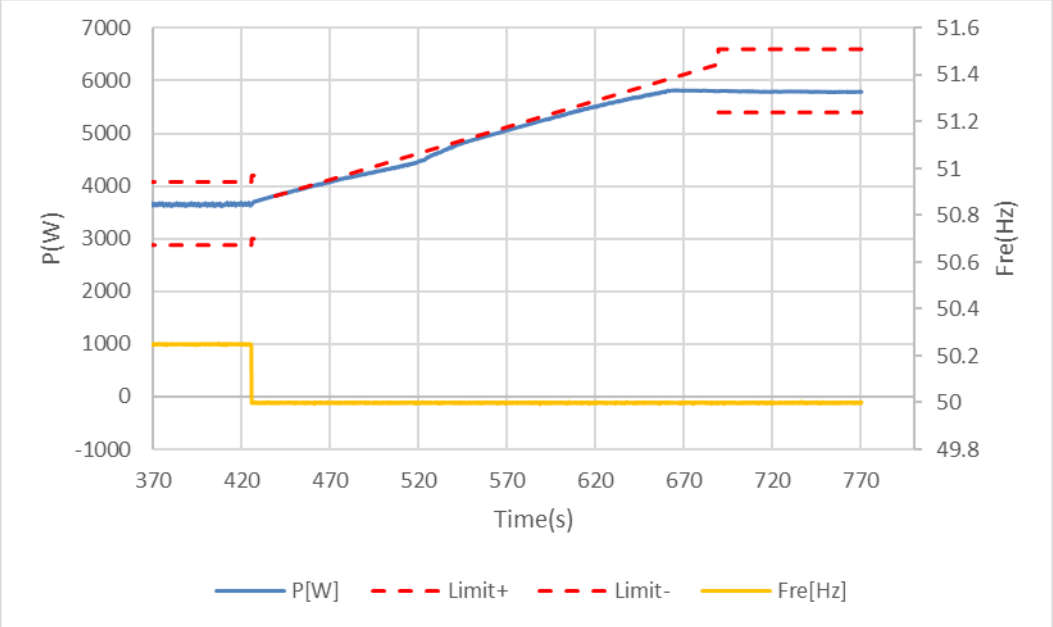


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Graph of Measurement 2.:Active power output 40% and 60% after freezing > 80% P_n



Graph of power gradient:



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Test:
The test is conducted for two powers. First, the test must start at a power =100% P_{Emax} ("Measurement 1"), and in a second test, for a power 60% P_{Emax} ("Measurement 2"). In the second test, after freezing of the P_M, the available active power output must be increased to a value =100% P_{Emax}, and after the network frequency of 50,2 Hz is fallen below, the rise of the active power gradient must be recorded.

Point g) must be held until the micro-generator is again feeding in with the active power output available.

Assessment criterion:
For f = 50,2 Hz, the value of the P_M active power currently being generated is "frozen".

a) For adjustable micro-generators when:
- 1) the active power reduces between measuring points b) and f) given above with the set gradient P_M per Hz for a increasing frequency (or rises for a frequency decreasing again).
- 2) the maximum active power gradient occurring in point is less than the configured maximum active power per minute
- 3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from P_{Emax} by more than ± 10%.
- 4) the settling time is equal or below 2 s with an intentional delay set to zero

b) For partly adjustable micro-generators
- 1) when they behave as in a) within their adjustment range, and
- 2) when, outside the adjustable range, the power fed in on leaving the adjustment range remains constant until shutdown. Shutdown must be no later than at 51,5 Hz.

Note:
The test method refer to clause 5.4.5 of VDE V 0124-100:2020-06

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EN 50549-1:2019: Power response to voltage variations and voltage changes			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.7.2.2	Capabilities	--	**P**
4.7.2.3.2	Setpoint control modes (Q setpoint mode or Cos φ setpoint mode)	FGW TG3, Revision 25, clause 4.2.2	**P**
4.7.2.3.3	Voltage related control modes (Q (U) controls)	FGW TG3, Revision 25, clause 4.2.5	**P**
4.7.2.3.4	Power related Control mode (cos φ (P) controls)	VDE V 0124-100:2020-06, clause 5.4.8.3	**P**
4.7.3	Voltage related active power reduction (P(U) controls)	CEI 0-21:2019-04, Annex B.1.3.1	**P**

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4.7.2.2 4.7.2.3.2	Capabilities Fix control modes (Q setpoint mode)	P

HESP4860S100-H

Inductive reactive power absorbation

Power-BIN [%]	Active power [W]	Reactive power [Var]	Power factor (cos φ)	Voltage [V]
0 – 10	593,90	2935,13	0,1984	230,5
10 – 20	1197,60	2925,48	0,3787	230,4
20– 30	1802,08	2923,78	0,5247	230,8
30 – 40	2408,85	2921,80	0,6361	231,1
40 – 50	2955,38	2930,50	0,7101	231,3
50 – 60	3563,38	2947,03	0,7706	231,2
60 – 70	4167,78	2936,65	0,8175	231,2
70 – 80	4774,50	2929,03	0,8524	231,4
80 – 90	5382,45	2933,15	0,8781	231,5
90 – 100	5990,20	2949,80	0,8971	231,7

Capacitive reactive power supply

Power-BIN [%]	Active power [W]	Reactive power [Var]	Power factor (cos φ)	Voltage [V]
0 – 10	580,62	-2951,58	0,1930	230,1
10 – 20	1188,33	-2939,53	0,3747	230,3
20– 30	1796,83	-2934,90	0,5221	230,5
30 – 40	2346,00	-2931,78	0,6247	230,7
40 – 50	2953,13	-2931,43	0,7097	230,8
50 – 60	3564,55	-2929,93	0,7725	231,1
60 – 70	4177,20	-2930,93	0,8186	231,2
70 – 80	4788,45	-2933,30	0,8527	231,4
80 – 90	5401,93	-2936,78	0,8786	231,3
90 – 100	6016,95	-2941,28	0,8984	231,5

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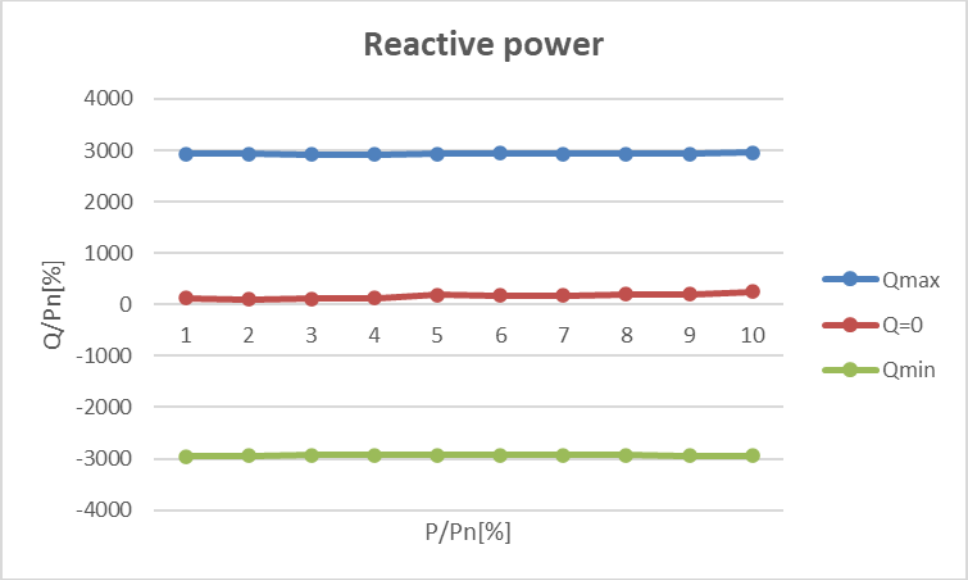
Reactive power supply with set point Q = 0				
Power-BIN [%]	**Active power [W]**	**Reactive power [Var]**	**Power factor (cos φ)**	**Voltage [V]**
0 – 10	671,41	119,42	0,9844	230,5
10 – 20	1218,25	100,60	0,9966	230,5
20– 30	1813,42	114,90	0,9980	230,6
30 – 40	2407,67	124,51	0,9986	230,6
40 – 50	3000,72	185,52	0,9981	230,6
50 – 60	3599,25	172,31	0,9988	230,6
60 – 70	4196,09	181,22	0,9991	230,6
70 – 80	4794,16	198,35	0,9991	230,7
80 – 90	5455,33	202,67	0,9993	230,7
90 – 100	6015,18	247,54	0,9991	230,6

Note:

The reactive power must be 48,43% or more at the 10 levels.

The inverter was power derated of 10% of the nominal output power.

Diagram of the reactive power provision dependencies



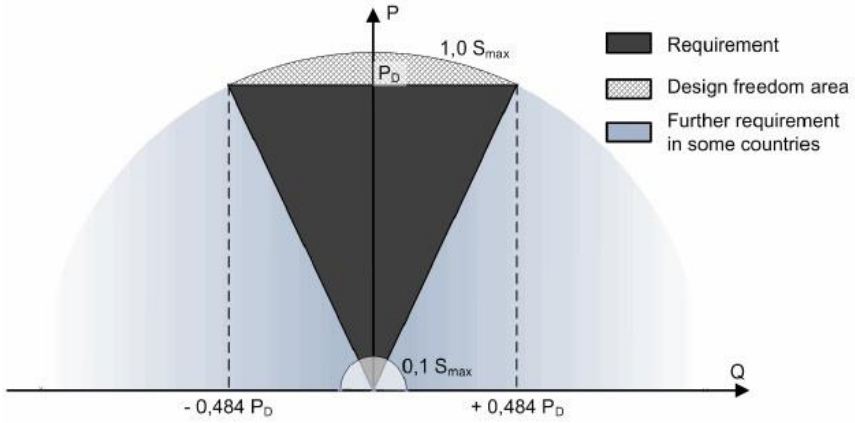
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Assessment criterion:

The power factor resulting in each of the measurement points between 10 % and 90 % of the nominal power is equal or lower than 0,90 both in over excited and under excited operation.

The settling time shall be less than one minute.

Reactive power capability shall be provided with an accuracy of ± 2 % Smax above 10%Smax, and reactive power is less than 10%Smax while S is less than 10%Smax.



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4.7.2.2 4.7.2.3.2	Capabilities Fix control modes (PF setpoint mode)	P

HESP4860S100-H

Inductive reactive power absorbation cos φ = 0,9

Power-BIN [%]	Active power [W]	Reactive power [Var]	Power factor (cos φ)	Voltage [V]
0 – 10	429,33	260,48	0,8549	230,5
10 – 20	1034,37	555,69	0,8809	230,4
20– 30	1587,84	763,43	0,9012	230,4
30 – 40	2189,37	1094,36	0,8945	230,4
40 – 50	2783,24	1369,42	0,8973	230,5
50 – 60	3381,08	1629,23	0,9009	230,5
60 – 70	3970,91	1946,11	0,8979	230,6
70 – 80	4568,23	2234,17	0,8983	230,6
80 – 90	5163,98	2523,61	0,8984	230,7
90 – 100	5478,29	2641,65	0,9007	230,6

Capacitive reactive power supply cos φ = -0,9

Power-BIN [%]	Active power [W]	Reactive power [Var]	Power factor (cos φ)	Voltage [V]
0 – 10	456,37	-270,97	0,8598	230,5
10 – 20	1035,48	-581,74	0,8718	230,4
20– 30	1654,55	-827,93	0,8943	230,4
30 – 40	2271,55	-1140,02	0,8938	230,4
40 – 50	2716,70	-1283,15	0,9042	230,5
50 – 60	3345,24	-1580,91	0,9041	230,5
60 – 70	3975,93	-1883,04	0,9037	230,5
70 – 80	4604,27	-2187,41	0,9032	230,5
80 – 90	5233,10	-2494,08	0,9027	230,6
90 – 100	5727,81	-2747,09	0,9017	230,6

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Reactive power supply with set point cos φ = 1				
Power-BIN [%]	**Active power [W]**	**Reactive power [Var]**	**Power factor (cos φ)**	**Voltage [V]**
0 – 10	386,75	54,65	0,9901	230,5
10 – 20	1051,69	150,89	0,9899	230,4
20– 30	1607,35	129,68	0,9967	230,4
30 – 40	2213,97	173,57	0,9969	230,4
40 – 50	2829,07	86,80	0,9995	230,5
50 – 60	3436,06	129,48	0,9993	230,5
60 – 70	4043,66	169,79	0,9991	230,6
70 – 80	4656,05	149,96	0,9995	230,6
80 – 90	5266,77	190,95	0,9993	230,6
90 – 100	5865,30	236,68	0,9992	230,6

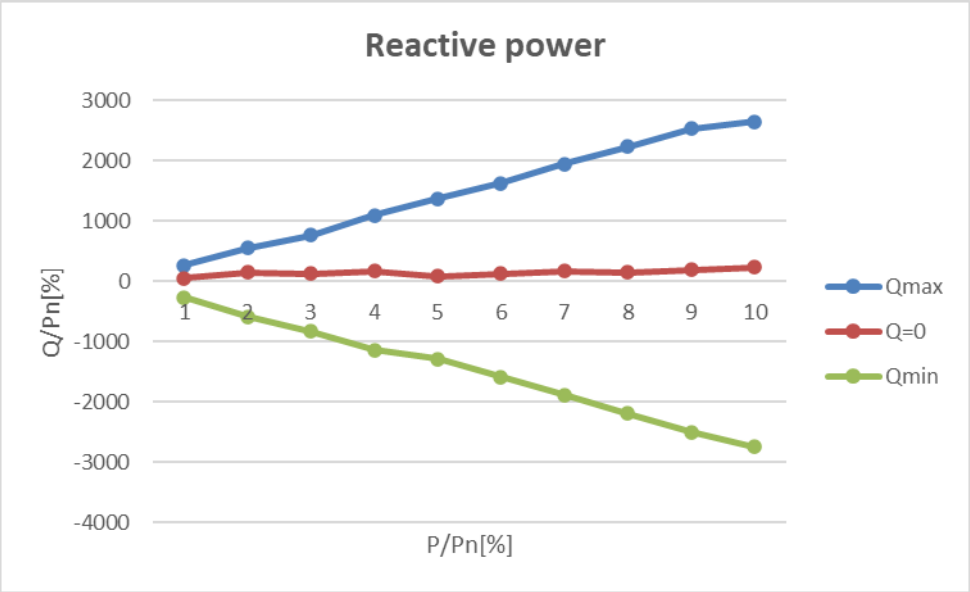
Note

a) 1 min-average-values were calculated using measurements at the basic frequency in a period of 200 ms.

b) For each of the 10 active power levels, at least 3 under excited and 3 over excited reactive power levels were recorded.

c) 1 min-average-values were calculated using voltage measurements at the basic frequency in a period of 200 ms

Diagram of the reactive power provision dependencies



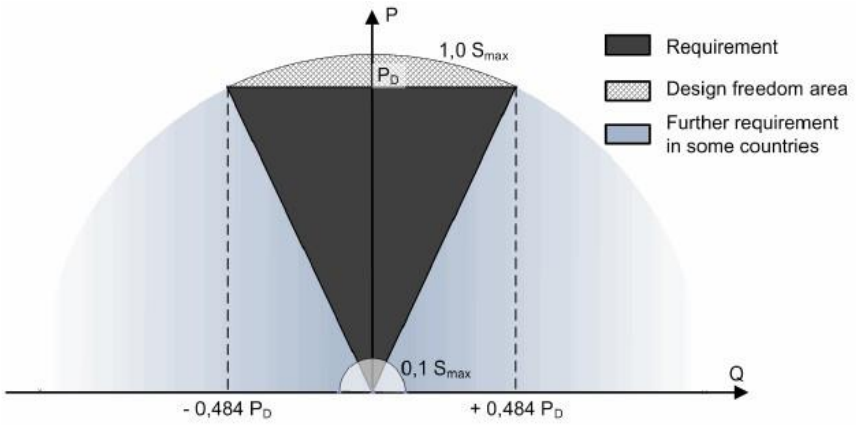
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Assessment criterion:

The power factor resulting in each of the measurement points between 10 % and 90 % of the nominal power is equal or lower than 0,90 both in over excited and under excited operation.

The settling time shall be less than one minute.

Reactive power capability shall be provided with an accuracy of ± 2 % Smax above 10%Smax, and reactive power is less than 10%Smax while S is less than 10%Smax.



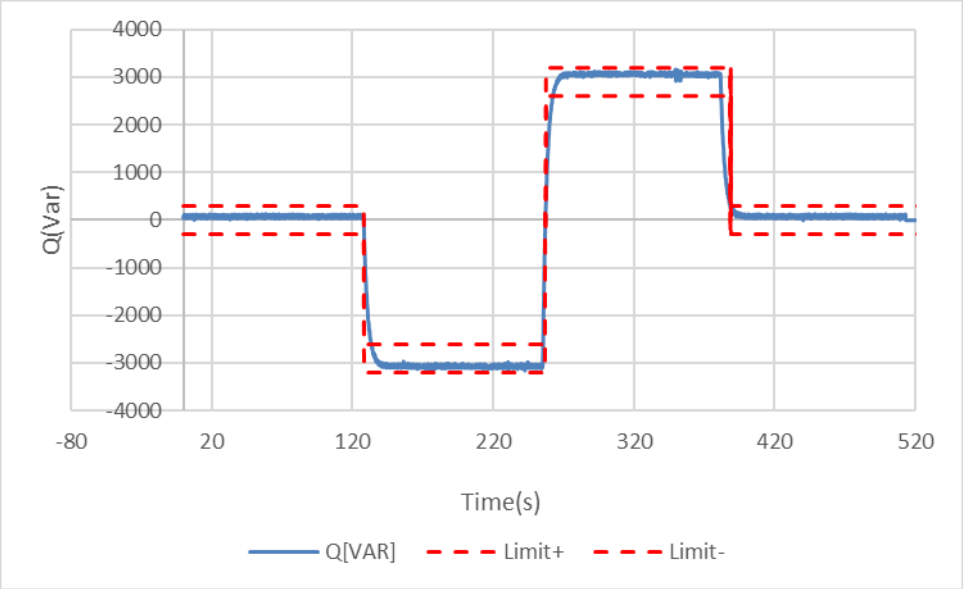
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4.7.2.2	Capabilities Q Response time	P

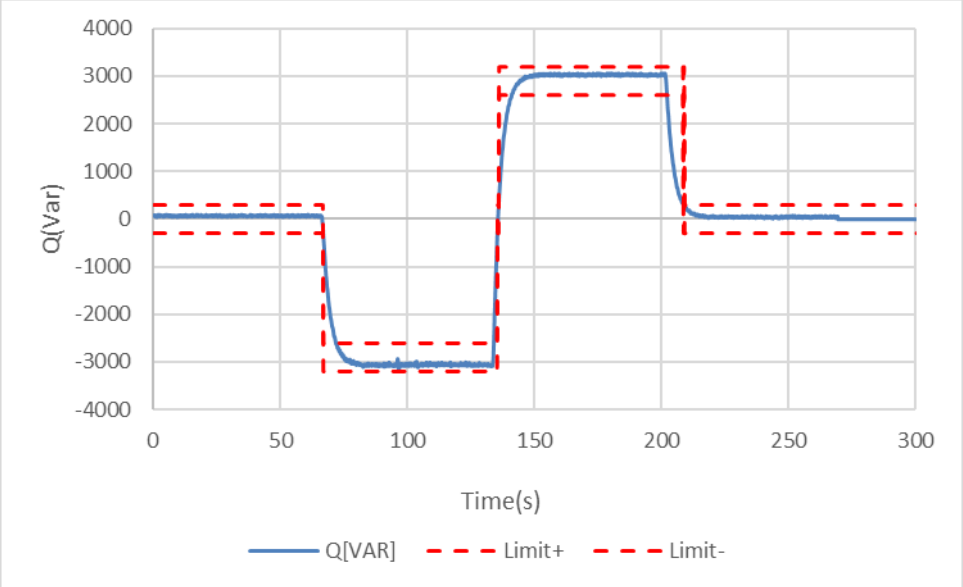
Test result: Reaction time

No.	Steps	Time [s]	Result:
1.	Reaction time Q=0 to Qmin (100% test)	8,6	P
2.	Reaction time Qmin to Qmax (100% test)	9,8	P
3.	Reaction time Qmax to Q=0 (100% test)	8,8	P
4.	Reaction time Q=0 to Qmin (50% test)	8,8	P
5.	Reaction time Qmin to Qmax (50% test)	9,6	P
6.	Reaction time Qmax to Q=0 (50% test)	9,0	P

Graph: 100%

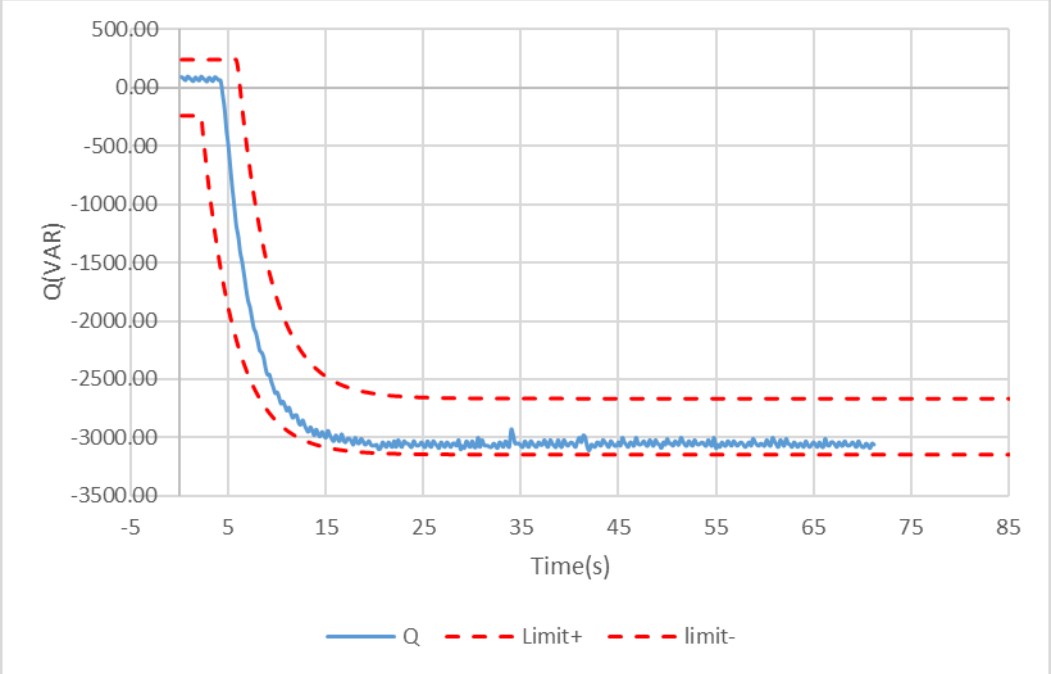


Graph: 50%

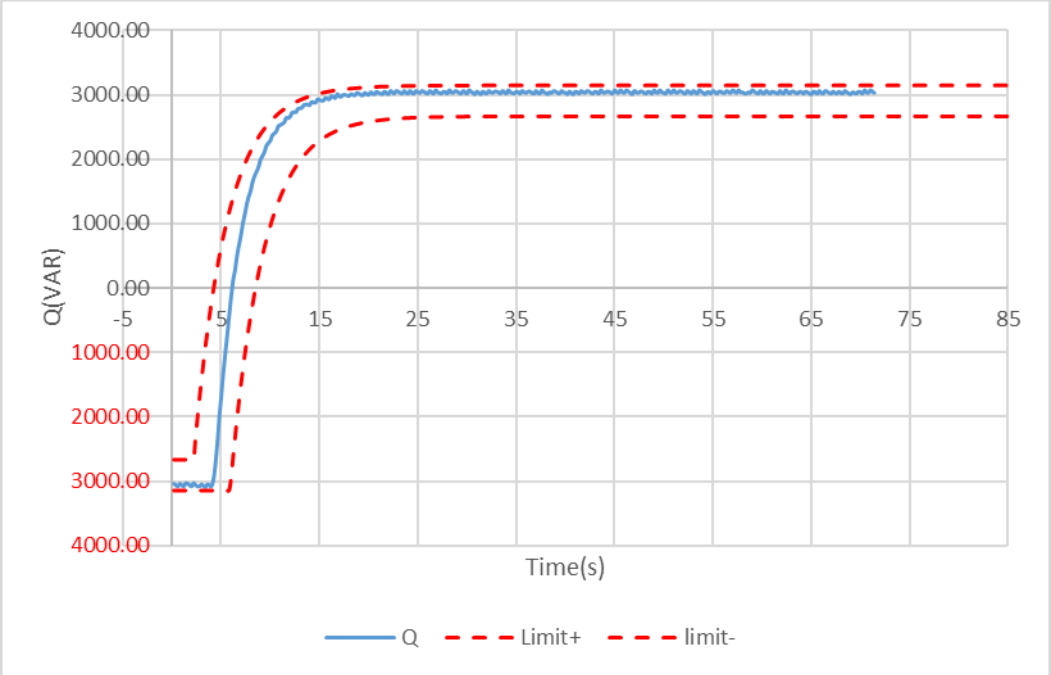


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Graph: Q=0 to Qmin

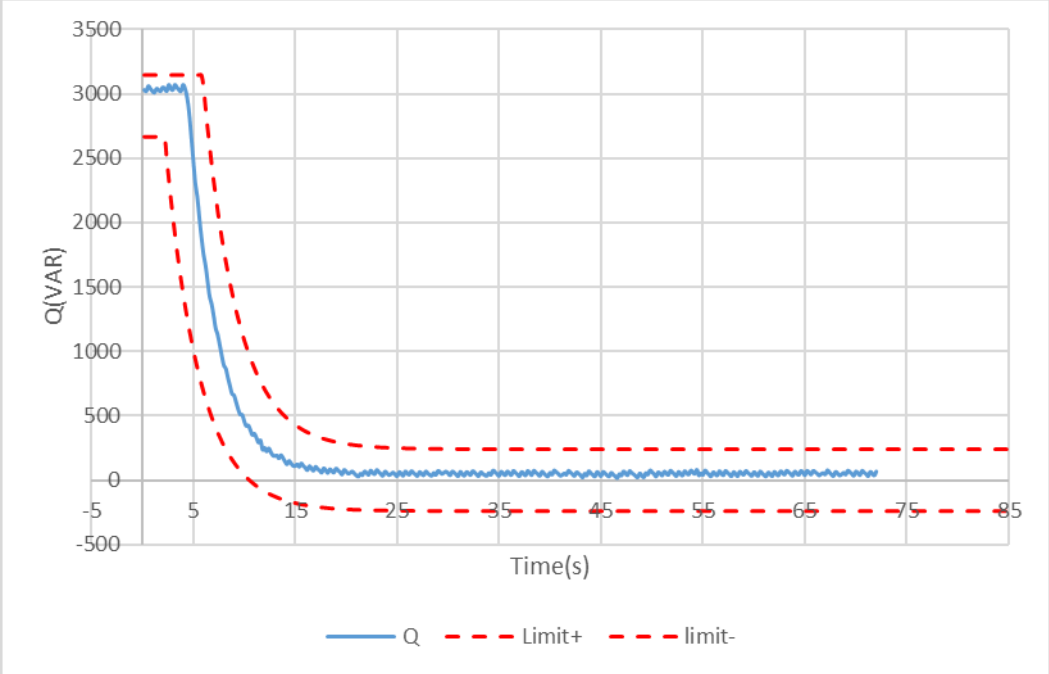


Graph: Qmin to Qmax



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Graph: Qmax to Q=0



Note:

Two test should be performed. At 50%P_n and 100%P_n

- $\Delta Q \leq \pm 5\% S_n$
- Max response time 10s

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4.7.2.2 4.7.2.3.3	Capabilities Voltage related control modes (Q (U) controls)	P

Qmin reactive power in accordance to standard characteristic curve Q = f(V)

P/Pn	Vac [V] Set point	P/Pn [%]	Vac [V] measured	Q [Var] measured	Q [Var] expected	ΔQ [%]
< 20%	1,07Vn	18,85	246,55	94,02	≈0(<±2.5%Pn)	1,57
< 20%	1,09Vn	18,76	250,73	96,43	≈0(<±2.5%Pn)	1,61
< 20%-30%	1,09Vn	25,39	250,90	-1416,72	-0,5 Qmin	-1,25
40%	1,09Vn	39,90	250,80	-1404,94	-0,5 Qmin	-1,65
50%	1,09Vn	50,05	250,89	-1411,05	-0,5 Qmin	-1,44
60%	1,09Vn	59,38	250,97	-1417,48	-0,5 Qmin	-1,22
70%	1,09Vn	69,62	250,89	-1425,50	-0,5 Qmin	-0,94
80%	1,09Vn	79,63	250,79	-1434,99	-0,5 Qmin	-0,62
90%	1,09Vn	89,46	250,82	-1454,63	-0,5 Qmin	0,06
100%	1,09Vn	97,61	250,99	-1471,11	-0,5 Qmin	0,63
*100%	1,1 Vn	91,17	253,27	-2800,93	-Qmin	-3,61
100%-10%	1,1 Vn	74,44	253,52	-2867,29	-Qmin	-1,33
≤5%	1,1 Vn	4,88	253,23	110,15	≈0(<±2.5%Pn)	1,84

Qmax reactive power in accordance to standard characteristic curve Q = f(V)

P/Pn	Vac [V] Set point	P/Pn [%]	Vac [V] measured	Q [Var] measured	Q [Var] expected	ΔQ [%]
< 20%	0,93Vn	19,09	214,10	94,23	≈0(<±2,5%Pn)	1,57
< 20%	0,91Vn	19,13	209,49	90,47	≈0(<±2,5%Pn)	1,51
< 20%-30%	0,91Vn	25,19	209,56	1377,17	0,5 Qmax	-2,61
40%	0,91Vn	39,92	209,42	1388,87	0,5 Qmax	-2,20
50%	0,91Vn	49,69	209,62	1396,44	0,5 Qmax	-1,94
60%	0,91Vn	59,18	209,57	1406,62	0,5 Qmax	-1,59
70%	0,91Vn	69,11	209,48	1417,84	0,5 Qmax	-1,21
80%	0,91Vn	79,23	209,60	1431,05	0,5 Qmax	-0,75
90%	0,91Vn	88,93	209,56	1450,19	0,5 Qmax	-0,09
100%	0,91Vn	96,74	209,65	1465,34	0,5 Qmax	0,43
*100%	0,90Vn	84,43	207,71	3024,64	Qmax	4,09
100%-10%	0,90Vn	56,87	207,66	3020,92	Qmax	3,96
≤5%	0,90Vn	4,44	207,47	87,30	≈0(<±2,5%Pn)	1,46

Note: * means Pn can't be reached because of the output current limit

Plog in/out: 5%Pn - Vlog in: 94% Un / 106% Un

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4.7.2.2 **4.7.2.3.3**	**Capabilities** **Voltage related control modes (Q (U) controls)**	**P**

The output power was reduced by 10%

The dynamic accuracy shall be in accordance with Figure 15 with a maximum tolerance of +/- 5% of PD plus a time delay of up to 3 seconds deviating from an ideal first order filter response.

Assessment criterion:

The test method was performed like the Q(U) clause B1.2.6 of CEI0-21 but with different voltage points and log in and log values for P

The value measured for each set point to the set value is $\Delta Q \leq \pm 5$ %PD

Note:

The above test data is according to the four set points: V_{1s}=1,07 Un ; V_{2s}=1,10 Un ; V_{1i}=0,93 Un and V_{2i}=0,90 Un , these set points are adjustable for Poland.

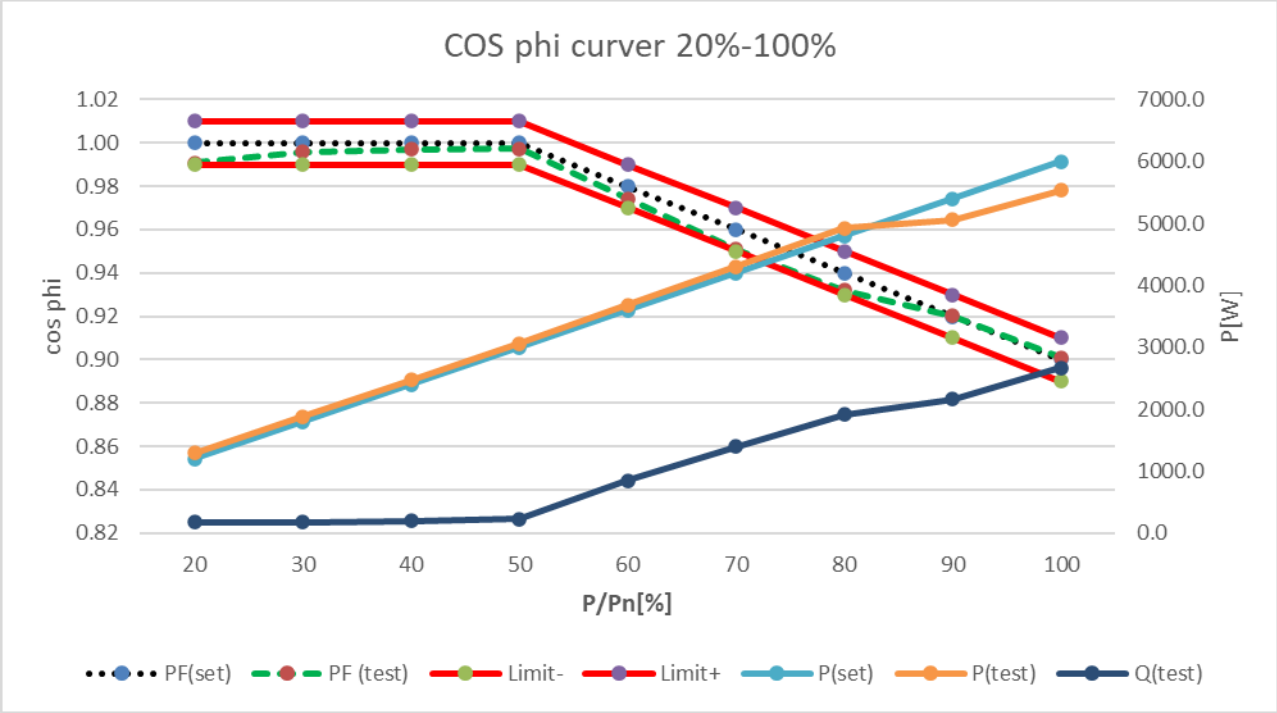
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4.7.2.2 Capabilities **4.7.2.3.4 Power related Control mode (cos φ (P) controls)**										**P**
Test a): HESP4860S100-H										
P / P_{Emax} [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}									
U [V]:	N/A	230,1	230,1	230,2	230,2	230,3	230,3	230,4	230,3	230,4
P_{E30} [W]:	N/A	1288,4	1879,0	2467,4	3063,4	3686,2	4301,7	4920,5	5061,7	5537,9
P_{E30} of P_{Emax} [%]:	N/A	21,47	31,32	41,12	51,06	61,44	71,69	82,01	84,36	92,30
Q_{E30} [Var]:	N/A	177,01	174,7	190,3	222,3	851,4	1400,3	1915,0	2157,6	2664,6
cos φ_{E30}:	N/A	0,9907	0,9957	0,9970	0,9974	0,9743	0,9509	0,9319	0,9203	0,9011
cos $\varphi_{setpoint}$ of P_{E30}:	N/A	1,0000	1,0000	1,0000	1,0000	0,9800	0,9600	0,9400	0,9200	0,9000
Limit cos φ_{E30}:	cos $\varphi_{setpoint}$ ± 0,01									
Test b): HESP4860S100-H										
P / P_{Emax} [%]	100	90	80	70	60	50	40	30	20	10
30 s mean value	100% to 20% P_{Emax}									
U [V]:	230,4	230,4	230,3	230,3	230,3	230,3	230,2	230,2	230,1	N/A
P_{E30} [W]:	5536,3	5534,9	4911,8	4291,5	3676,2	3054,0	2458,3	1872,6	1283,1	N/A
P_{E30} of P_{Emax} [%]:	92,27	92,25	81,86	71,53	61,27	50,90	40,97	31,21	21,38	N/A
Q_{E30} [Var]:	2663,9	2445,8	1719,1	1397,6	851,3	218,4	188,5	185,6	175,5	N/A
cos φ_{E30}:	0,9011	0,9147	0,9439	0,9509	0,9742	0,9974	0,9971	0,9963	0,9908	N/A
cos $\varphi_{setpoint}$ of P_{E30}:	0,9000	0,9200	0,9400	0,9600	0,9800	1,0000	1,0000	1,0000	1,0000	N/A
Limit cos φ_{E30}:	cos $\varphi_{setpoint}$ ± 0,01									

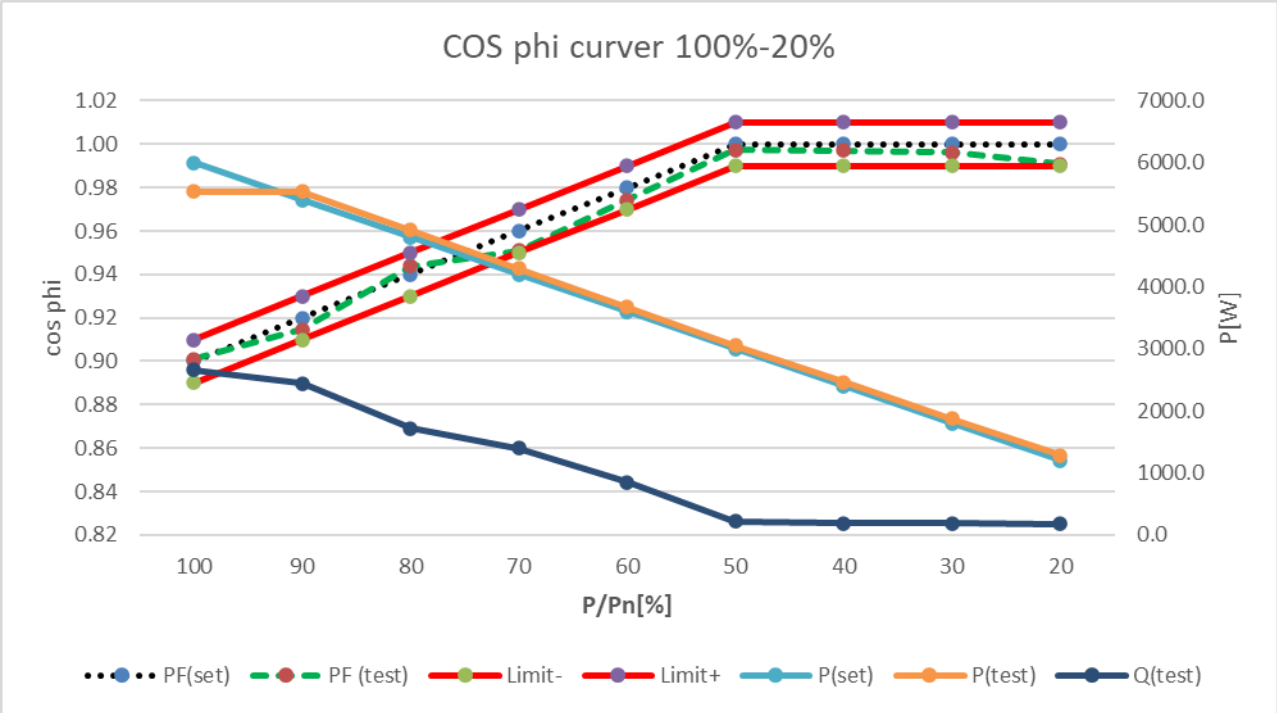
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Test: HESP4860S100-H

Graph of cos φ(P): Test a)



Graph of cos φ(P): Test b)

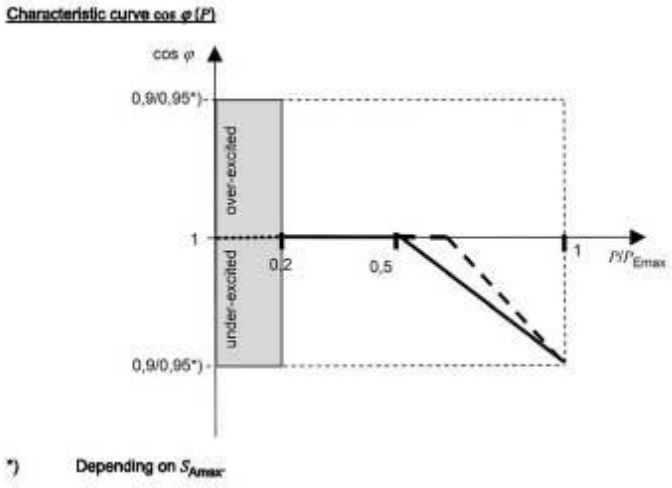


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Test:

Test 1: Using the standard characteristic curve increases the active power from 20% P_{Emax} in increments of 10% P_{Emax} to P_{Emax}. The test is carried out in reverse.

Test 2: Using the standard characteristic curve increases the active power from 20% P_{Emax} to 50% P_{Emax} and to P_{Emax}. The test is carried out in reverse. After the PGU has settled, the end value reached is determined as a 30 s mean value.



Assessment criterion:

Test 1: cos φ accuracy cos φ (±0,01)

Test 2: cos φ accuracy cos φ (±0,02)

For the test to be passed, the cos φ setpoint from the active power must be measured at the terminals of the PGU within a settling time of 10 s.

Note:

The test method refer to clause 5.4.8.3 of VDE V 0124-100:2020-06

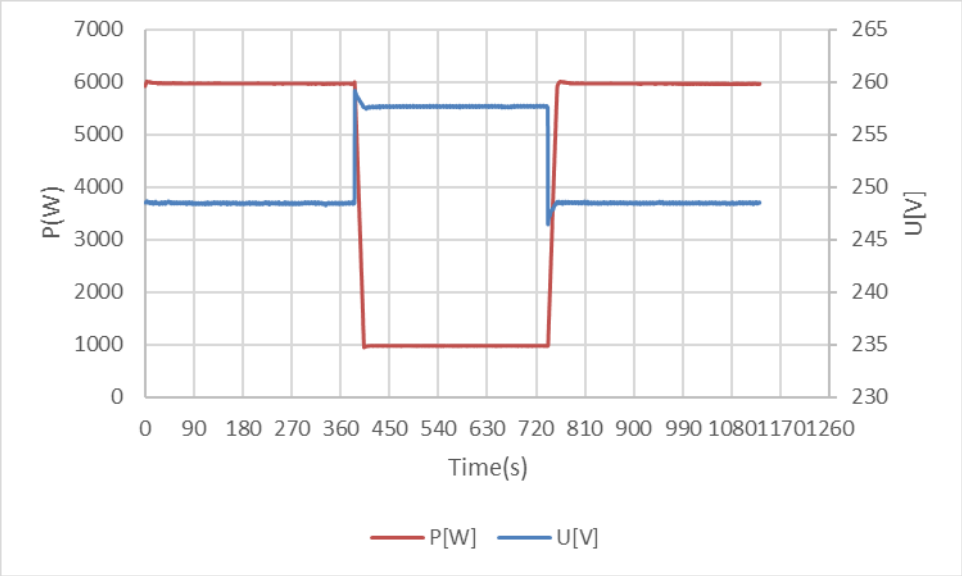
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4.7.3 Voltage related active power reduction (P(U) function)	P

Model: **HESP4860S100-H**

Test result:

	a) threshold -2%U_n (108%U_n)	b) threshold +2%U_n (112%U_n)	c) threshold-2% U_n (108% U_n)
Active power P [W]	5979,2	974,1	5967,9
Vac [V] measured	248,50	257,66	248,47



Note:

Test method refer CEI 0-21:2019-04, Annex B.1.3.1.

a) Set the voltage to 2% Un lower than the activation threshold stated by the manufacturer.

b) Set the voltage back to 2% Un lower than the activation threshold. Check that the active power will return to the value consistent with the power available from the primary source or simulated.

c) Within 5 min from the moment of application of voltage of 2% of declared by the manufacturer activation threshold (compatibly with the capacity of the energy storage system) it is shown that, in the case of storage systems connected to converters unidirectional, the active power supplied by the inverter has been reduced to a value not higher than 20% PSMAX * (20% * PNINV, in the case of integrated EESS), while in the case of use of bidirectional converters, is passed to the EESS absorb, consistent with the constraints data from its own capacity, an active power at least equal to 80% * PCMAX ; it also verifies that the device signals the ongoing power reduction (by recording mode in the test report);

In order to avoid disconnection due to overvoltage protection (see 4.9.2.3 and 4.9.2.4), generating plants/units are allowed to reduce active power output as a function of this rising voltage. The final implemented logic can be chosen by the manufacturer. Nevertheless, this logic shall not cause steps or oscillations in the output power. (Default 3s (=33%P_{EMAX} /second at 100%P_{EMAX} change)

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EN 50549-1:2019: Power quality			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.8	EMC and power quality	--	**P**
	Harmonic current emission	EN 61000-3-2, EN 61000-3-12	**P**
	Harmonic current emission	IEC 61000-4-7	**P**
	Switching operations	IEC 61400-21	**P**
	Voltage fluctuation and flicker	EN 61000-3-3, EN 61000-3-11	**P**
	Flicker and voltage fluctuations	IEC 61400-21	**N/A**
	DC injection	EN 50438, Annex D.3.10	**P**
	Immunity to voltage dips and short interruptions	G99-1_4:2019	**P**
	Unbalance	VDE0124-100(2020-06)	**P**

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4.8	EMC and power quality Harmonic current emission DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)	P

HESP4860S100-H

Phase L

Power Level	100%
AC Power [W]	6000,20
AC Voltage [V]	230,51
AC Current [A]	26,04
Frequency [Hz]	50,00
THD [%]	3,073

Harmonic	Current Magnitude (A)	% of Funda-mental	Harmonic Current Limits (A)
1st	26,041	99,814	-
2nd	0,208	0,799	8,00
3rd	0,552	2,114	N/A
4th	0,123	0,471	4,00
5th	0,125	0,481	10,70
6th	0,074	0,283	2,67
7th	0,065	0,249	7,20
8th	0,039	0,150	2,00
9th	0,202	0,775	N/A
10th	0,031	0,119	1,60
11th	0,251	0,960	3,10
12th	0,013	0,052	1,33
13th	0,275	1,055	2,00
14th	0,015	0,059	N/A
15th	0,171	0,656	N/A
16th	0,012	0,045	N/A
17th	0,117	0,449	N/A
18th	0,012	0,046	N/A
19th	0,071	0,272	N/A
20th	0,009	0,034	N/A
21th	0,076	0,292	N/A
22th	0,009	0,033	N/A
23th	0,061	0,235	N/A
24th	0,011	0,043	N/A
25th	0,059	0,225	N/A
26th	0,007	0,025	N/A
27th	0,046	0,174	N/A
28th	0,004	0,015	N/A
29th	0,042	0,161	N/A
30th	0,004	0,015	N/A
31th	0,036	0,137	N/A
32th	0,007	0,027	N/A
33th	0,033	0,125	N/A
34th	0,006	0,024	N/A
35th	0,026	0,101	N/A
36th	0,005	0,018	N/A
37th	0,022	0,086	N/A
38th	0,004	0,014	N/A
39th	0,019	0,075	N/A
40th	0,003	0,011	N/A
41th	0,017	0,064	N/A
42th	0,003	0,010	N/A
43th	0,015	0,059	N/A
44th	0,003	0,012	N/A
45th	0,014	0,052	N/A
46th	0,004	0,014	N/A

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4.8	EMC and power quality Harmonic current emission DIN EN 61000-3-12 (≥16 A and ≤75 A per Phase)		P
HESP4860S100-H			
47th	0,013	0,051	N/A
48th	0,004	0,015	N/A
49th	0,012	0,047	N/A
50th	0,003	0,011	N/A
Impedance [Ω] Line Neutral		R_A = 0,15 jX_A= 0,15 R_N = 0,01 jX_N= 0,01	
Note:			

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4.8	EMC and power quality Harmonic current emission (EN 61000-4-7)	P

The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.

Test: HESP4860S100-H

Harmonics

P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	4,730	10,392	20,284	30,713	40,453	50,558	60,481	70,365	79,321	89,349	99,304
2	0,035	0,074	0,145	0,222	0,291	0,362	0,425	0,496	0,553	0,617	0,693
3	0,115	0,239	0,466	0,701	0,926	1,148	1,363	1,580	1,769	1,970	2,158
4	0,013	0,026	0,052	0,078	0,102	0,127	0,151	0,175	0,195	0,217	0,241
5	0,039	0,077	0,153	0,230	0,303	0,376	0,452	0,526	0,589	0,661	0,739
6	0,005	0,013	0,025	0,037	0,049	0,060	0,072	0,083	0,093	0,103	0,114
7	0,025	0,051	0,099	0,151	0,201	0,251	0,297	0,347	0,394	0,449	0,498
8	0,003	0,007	0,014	0,021	0,027	0,034	0,040	0,047	0,051	0,058	0,063
9	0,015	0,031	0,061	0,091	0,120	0,149	0,180	0,210	0,236	0,264	0,297
10	0,002	0,004	0,008	0,012	0,015	0,019	0,023	0,026	0,030	0,034	0,037
11	0,019	0,039	0,074	0,113	0,150	0,187	0,223	0,259	0,293	0,331	0,366
12	0,001	0,003	0,005	0,008	0,010	0,013	0,015	0,017	0,019	0,022	0,024
13	0,015	0,031	0,060	0,091	0,121	0,150	0,178	0,208	0,235	0,266	0,293
14	0,001	0,002	0,004	0,006	0,007	0,009	0,011	0,012	0,013	0,016	0,017
15	0,016	0,032	0,062	0,094	0,124	0,154	0,186	0,216	0,243	0,274	0,307
16	0,001	0,003	0,005	0,008	0,010	0,013	0,015	0,017	0,019	0,021	0,023
17	0,019	0,038	0,074	0,113	0,149	0,186	0,221	0,257	0,292	0,331	0,367
18	0,001	0,002	0,004	0,006	0,008	0,010	0,012	0,013	0,015	0,016	0,018
19	0,018	0,037	0,073	0,111	0,147	0,183	0,220	0,256	0,289	0,326	0,364
20	0,002	0,004	0,007	0,011	0,014	0,018	0,021	0,024	0,027	0,028	0,032
21	0,022	0,046	0,089	0,135	0,178	0,222	0,266	0,308	0,348	0,394	0,438
22	0,002	0,003	0,006	0,009	0,012	0,015	0,018	0,020	0,023	0,026	0,028
23	0,020	0,043	0,083	0,126	0,166	0,208	0,249	0,289	0,327	0,370	0,411
24	0,002	0,003	0,006	0,009	0,012	0,015	0,018	0,021	0,023	0,027	0,031
25	0,021	0,045	0,087	0,133	0,175	0,219	0,262	0,304	0,343	0,386	0,431
26	0,002	0,003	0,006	0,009	0,012	0,015	0,018	0,020	0,023	0,026	0,029
27	0,018	0,038	0,074	0,112	0,149	0,186	0,222	0,258	0,291	0,329	0,366
28	0,002	0,004	0,008	0,012	0,016	0,020	0,024	0,027	0,030	0,034	0,038
29	0,017	0,035	0,068	0,103	0,137	0,170	0,204	0,236	0,266	0,301	0,334
30	0,002	0,003	0,007	0,010	0,014	0,017	0,020	0,023	0,027	0,030	0,034
31	0,013	0,028	0,055	0,084	0,110	0,139	0,165	0,192	0,216	0,245	0,272
32	0,002	0,003	0,006	0,009	0,012	0,015	0,018	0,021	0,024	0,027	0,030
33	0,012	0,024	0,047	0,072	0,095	0,117	0,140	0,163	0,184	0,207	0,230
34	0,002	0,004	0,008	0,012	0,016	0,020	0,025	0,028	0,032	0,036	0,040
35	0,009	0,019	0,038	0,057	0,075	0,094	0,112	0,130	0,147	0,167	0,185
36	0,002	0,003	0,007	0,011	0,014	0,017	0,020	0,024	0,028	0,031	0,034
37	0,008	0,017	0,032	0,049	0,065	0,081	0,097	0,112	0,126	0,143	0,158
38	0,001	0,003	0,005	0,008	0,011	0,014	0,016	0,019	0,022	0,024	0,027
39	0,007	0,014	0,027	0,041	0,055	0,068	0,081	0,094	0,106	0,120	0,134
40	0,001	0,002	0,004	0,007	0,009	0,012	0,014	0,016	0,019	0,022	0,025
41	0,006	0,012	0,023	0,035	0,047	0,058	0,070	0,081	0,091	0,103	0,114
42	0,001	0,002	0,004	0,006	0,008	0,010	0,012	0,014	0,017	0,019	0,020
43	0,005	0,010	0,019	0,028	0,038	0,047	0,056	0,065	0,075	0,083	0,093
44	0,001	0,002	0,004	0,006	0,008	0,010	0,012	0,015	0,017	0,021	0,023
45	0,004	0,008	0,016	0,024	0,032	0,039	0,047	0,055	0,061	0,069	0,077
46	0,001	0,002	0,004	0,005	0,007	0,009	0,011	0,013	0,016	0,019	0,021
47	0,004	0,007	0,014	0,022	0,029	0,035	0,042	0,050	0,057	0,063	0,070

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48	0,001	0,002	0,004	0,006	0,007	0,009	0,012	0,014	0,017	0,019	0,022
49	0,003	0,006	0,012	0,018	0,023	0,029	0,035	0,041	0,046	0,052	0,058
50	0,001	0,002	0,004	0,005	0,007	0,009	0,011	0,014	0,016	0,019	0,021
Note:											

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Test: HESP4860S100-H											
Interharmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
75	0,025	0,027	0,028	0,027	0,025	0,026	0,024	0,024	0,020	0,020	0,021
125	0,030	0,030	0,030	0,029	0,028	0,028	0,030	0,029	0,027	0,027	0,028
175	0,017	0,018	0,019	0,017	0,015	0,015	0,016	0,015	0,017	0,015	0,013
225	0,028	0,029	0,029	0,028	0,027	0,026	0,026	0,026	0,028	0,027	0,026
275	0,014	0,019	0,016	0,016	0,015	0,014	0,013	0,013	0,015	0,014	0,011
325	0,014	0,018	0,014	0,018	0,015	0,013	0,012	0,013	0,013	0,014	0,011
375	0,016	0,016	0,014	0,018	0,017	0,017	0,014	0,014	0,013	0,015	0,012
425	0,014	0,014	0,012	0,015	0,017	0,018	0,013	0,014	0,013	0,014	0,011
475	0,016	0,014	0,012	0,014	0,016	0,018	0,017	0,018	0,014	0,014	0,013
525	0,017	0,012	0,011	0,013	0,013	0,015	0,019	0,018	0,016	0,014	0,013
575	0,017	0,013	0,012	0,013	0,013	0,014	0,016	0,015	0,019	0,016	0,014
625	0,015	0,013	0,013	0,013	0,013	0,014	0,015	0,015	0,019	0,017	0,015
675	0,015	0,014	0,013	0,014	0,013	0,014	0,015	0,015	0,017	0,017	0,015
725	0,015	0,014	0,014	0,014	0,014	0,014	0,014	0,015	0,016	0,018	0,016
775	0,016	0,015	0,015	0,015	0,015	0,015	0,015	0,016	0,016	0,018	0,017
825	0,016	0,016	0,015	0,015	0,015	0,015	0,015	0,016	0,016	0,018	0,017
875	0,017	0,017	0,017	0,017	0,017	0,017	0,017	0,018	0,018	0,018	0,020
925	0,017	0,017	0,017	0,017	0,016	0,017	0,017	0,017	0,017	0,018	0,020
975	0,018	0,018	0,018	0,018	0,018	0,018	0,018	0,019	0,019	0,019	0,021
1025	0,018	0,018	0,018	0,018	0,018	0,018	0,018	0,019	0,019	0,019	0,021
1075	0,019	0,019	0,019	0,019	0,019	0,019	0,019	0,020	0,020	0,020	0,022
1125	0,019	0,019	0,019	0,019	0,018	0,018	0,019	0,019	0,020	0,020	0,021
1175	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,021	0,021	0,021	0,022
1225	0,020	0,020	0,020	0,019	0,019	0,020	0,020	0,020	0,020	0,021	0,022
1275	0,020	0,021	0,021	0,021	0,020	0,020	0,021	0,021	0,022	0,022	0,023
1325	0,020	0,021	0,020	0,020	0,020	0,021	0,021	0,021	0,022	0,022	0,023
1375	0,020	0,020	0,020	0,020	0,019	0,020	0,020	0,021	0,021	0,022	0,023
1425	0,021	0,021	0,021	0,020	0,020	0,021	0,021	0,022	0,022	0,023	0,023
1475	0,019	0,020	0,019	0,020	0,020	0,020	0,020	0,021	0,021	0,022	0,023
1525	0,021	0,022	0,021	0,021	0,021	0,022	0,022	0,022	0,023	0,023	0,024
1575	0,019	0,020	0,019	0,019	0,019	0,020	0,020	0,021	0,021	0,021	0,022
1625	0,021	0,022	0,022	0,022	0,022	0,022	0,022	0,023	0,024	0,024	0,025
1675	0,019	0,019	0,019	0,019	0,019	0,019	0,020	0,021	0,021	0,022	0,023
1725	0,022	0,022	0,022	0,022	0,022	0,022	0,023	0,023	0,024	0,025	0,025
1775	0,020	0,020	0,020	0,019	0,020	0,019	0,020	0,021	0,022	0,023	0,023
1825	0,022	0,023	0,022	0,022	0,023	0,022	0,023	0,024	0,024	0,025	0,026
1875	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,022	0,023	0,023	0,024
1925	0,023	0,023	0,022	0,022	0,022	0,023	0,023	0,024	0,025	0,026	0,026
1975	0,020	0,020	0,020	0,020	0,020	0,020	0,021	0,022	0,023	0,024	0,024
Note:											

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Test: HESP4860S100-H											
Higher Frequencies											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2,1	0,080	0,081	0,056	0,038	0,038	0,047	0,059	0,074	0,087	0,090	0,091
2,3	0,072	0,072	0,053	0,036	0,035	0,044	0,054	0,069	0,079	0,079	0,074
2,5	0,062	0,062	0,046	0,035	0,036	0,046	0,055	0,068	0,078	0,077	0,068
2,7	0,062	0,061	0,049	0,038	0,041	0,048	0,057	0,070	0,077	0,075	0,064
2,9	0,062	0,061	0,051	0,045	0,046	0,051	0,058	0,069	0,076	0,073	0,061
3,1	0,058	0,058	0,053	0,049	0,049	0,053	0,057	0,065	0,072	0,071	0,059
3,3	0,060	0,060	0,058	0,053	0,052	0,056	0,059	0,064	0,070	0,068	0,056
3,5	0,061	0,061	0,062	0,056	0,055	0,061	0,062	0,066	0,068	0,064	0,051
3,7	0,061	0,061	0,063	0,061	0,061	0,066	0,066	0,067	0,069	0,064	0,050
3,9	0,061	0,061	0,066	0,067	0,064	0,066	0,068	0,066	0,064	0,060	0,047
4,1	0,061	0,060	0,067	0,067	0,064	0,071	0,067	0,064	0,061	0,057	0,045
4,3	0,058	0,057	0,064	0,066	0,066	0,067	0,065	0,063	0,060	0,056	0,044
4,5	0,055	0,054	0,062	0,065	0,069	0,064	0,061	0,062	0,059	0,057	0,046
4,7	0,057	0,056	0,064	0,070	0,072	0,076	0,077	0,080	0,084	0,086	0,087
4,9	0,051	0,050	0,055	0,059	0,059	0,062	0,061	0,062	0,066	0,063	0,058
5,1	0,048	0,047	0,052	0,068	0,058	0,062	0,059	0,056	0,065	0,060	0,062
5,3	0,047	0,047	0,053	0,053	0,054	0,057	0,057	0,056	0,066	0,059	0,065
5,5	0,041	0,045	0,052	0,051	0,051	0,051	0,053	0,051	0,056	0,053	0,059
5,7	0,038	0,041	0,051	0,046	0,050	0,052	0,052	0,050	0,049	0,047	0,052
5,9	0,035	0,037	0,046	0,039	0,041	0,043	0,045	0,045	0,045	0,044	0,047
6,1	0,035	0,038	0,038	0,038	0,037	0,039	0,040	0,039	0,040	0,040	0,041
6,3	0,032	0,036	0,034	0,038	0,031	0,033	0,035	0,035	0,036	0,036	0,037
6,5	0,029	0,034	0,031	0,038	0,029	0,031	0,032	0,033	0,033	0,034	0,034
6,7	0,030	0,035	0,028	0,039	0,028	0,030	0,031	0,031	0,032	0,033	0,033
6,9	0,026	0,036	0,028	0,035	0,028	0,029	0,030	0,031	0,031	0,032	0,032
7,1	0,026	0,032	0,025	0,030	0,025	0,026	0,028	0,030	0,032	0,032	0,033
7,3	0,034	0,026	0,024	0,027	0,024	0,025	0,028	0,030	0,031	0,031	0,030
7,5	0,022	0,024	0,023	0,025	0,024	0,023	0,024	0,026	0,027	0,028	0,028
7,7	0,023	0,023	0,024	0,024	0,022	0,022	0,024	0,024	0,025	0,025	0,025
7,9	0,022	0,019	0,021	0,022	0,023	0,022	0,022	0,023	0,024	0,025	0,024
8,1	0,023	0,019	0,021	0,021	0,022	0,022	0,022	0,022	0,022	0,022	0,022
8,3	0,022	0,017	0,020	0,020	0,022	0,022	0,021	0,021	0,023	0,023	0,023
8,5	0,021	0,017	0,019	0,018	0,021	0,021	0,020	0,021	0,022	0,022	0,022
8,7	0,019	0,016	0,018	0,018	0,023	0,020	0,020	0,021	0,022	0,022	0,022
8,9	0,017	0,016	0,018	0,018	0,026	0,020	0,020	0,019	0,021	0,021	0,021
Note:											

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4.8	EMC and power quality Harmonic current emission (EN 61000-4-7)	P

The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.

Test: HESP4855S100-H

Harmonics

P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	5,442	9,777	20,077	30,058	40,038	50,029	60,028	70,047	79,981	90,043	99,889
2	0,073	0,061	0,075	0,263	0,371	0,351	0,344	0,410	0,416	0,427	0,555
3	1,499	1,678	1,635	1,651	1,713	1,743	1,776	1,859	1,923	1,962	2,079
4	0,015	0,027	0,033	0,136	0,191	0,189	0,195	0,236	0,246	0,245	0,323
5	0,914	0,826	0,909	0,856	0,786	0,755	0,729	0,718	0,713	0,689	0,615
6	0,015	0,015	0,010	0,060	0,087	0,093	0,098	0,119	0,131	0,138	0,182
7	0,671	0,780	0,539	0,686	0,583	0,529	0,486	0,434	0,385	0,391	0,364
8	0,010	0,012	0,025	0,039	0,059	0,056	0,062	0,074	0,075	0,081	0,095
9	0,620	0,506	0,901	0,868	1,102	1,057	1,082	1,060	0,989	0,858	0,796
10	0,016	0,017	0,031	0,046	0,052	0,048	0,045	0,055	0,060	0,063	0,074
11	0,461	0,868	1,025	0,761	1,090	1,127	1,054	1,092	1,108	1,083	0,972
12	0,025	0,017	0,021	0,022	0,028	0,029	0,036	0,025	0,026	0,028	0,022
13	0,338	0,423	0,529	0,565	0,739	0,927	0,903	0,869	0,922	0,991	1,009
14	0,017	0,013	0,024	0,030	0,034	0,034	0,029	0,031	0,037	0,041	0,042
15	0,368	0,455	0,269	0,409	0,447	0,512	0,593	0,553	0,514	0,556	0,601
16	0,011	0,014	0,013	0,014	0,017	0,020	0,018	0,017	0,017	0,019	0,025
17	0,290	0,288	0,285	0,339	0,344	0,396	0,440	0,496	0,464	0,422	0,428
18	0,012	0,017	0,013	0,014	0,012	0,014	0,016	0,015	0,018	0,020	0,026
19	0,234	0,162	0,205	0,220	0,215	0,261	0,275	0,317	0,351	0,327	0,290
20	0,011	0,015	0,014	0,016	0,015	0,018	0,015	0,017	0,018	0,017	0,021
21	0,167	0,139	0,118	0,166	0,200	0,237	0,256	0,265	0,304	0,327	0,324
22	0,009	0,010	0,010	0,010	0,010	0,012	0,011	0,012	0,014	0,015	0,021
23	0,091	0,064	0,053	0,087	0,145	0,149	0,183	0,200	0,204	0,230	0,251
24	0,012	0,012	0,013	0,012	0,014	0,012	0,012	0,016	0,018	0,019	0,028
25	0,052	0,056	0,071	0,079	0,138	0,139	0,169	0,192	0,203	0,205	0,227
26	0,008	0,008	0,010	0,010	0,009	0,010	0,012	0,011	0,012	0,013	0,016
27	0,017	0,061	0,039	0,056	0,103	0,103	0,122	0,143	0,163	0,169	0,171
28	0,009	0,009	0,011	0,010	0,012	0,012	0,013	0,015	0,013	0,012	0,012
29	0,019	0,036	0,026	0,064	0,094	0,093	0,118	0,131	0,146	0,162	0,169
30	0,007	0,008	0,008	0,008	0,009	0,010	0,010	0,012	0,013	0,012	0,012
31	0,046	0,027	0,011	0,044	0,071	0,070	0,090	0,114	0,116	0,131	0,143
32	0,011	0,011	0,011	0,013	0,011	0,012	0,012	0,014	0,014	0,016	0,022
33	0,035	0,018	0,014	0,039	0,059	0,063	0,077	0,103	0,113	0,112	0,126
34	0,010	0,010	0,010	0,010	0,010	0,011	0,010	0,012	0,013	0,014	0,019
35	0,040	0,032	0,021	0,015	0,044	0,052	0,063	0,082	0,099	0,096	0,101
36	0,009	0,009	0,010	0,009	0,008	0,010	0,009	0,010	0,011	0,012	0,015
37	0,025	0,029	0,021	0,011	0,032	0,043	0,057	0,067	0,086	0,091	0,090
38	0,007	0,008	0,007	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,011
39	0,026	0,039	0,023	0,018	0,026	0,039	0,045	0,060	0,070	0,080	0,079
40	0,006	0,008	0,006	0,007	0,007	0,007	0,007	0,008	0,008	0,009	0,010
41	0,024	0,031	0,016	0,015	0,020	0,032	0,038	0,056	0,060	0,067	0,070
42	0,006	0,007	0,006	0,007	0,007	0,007	0,007	0,008	0,008	0,008	0,010
43	0,035	0,030	0,027	0,017	0,021	0,031	0,035	0,050	0,057	0,061	0,065
44	0,006	0,007	0,007	0,008	0,008	0,007	0,008	0,009	0,010	0,010	0,012
45	0,040	0,028	0,029	0,015	0,020	0,028	0,032	0,042	0,051	0,052	0,053
46	0,017	0,017	0,016	0,016	0,014	0,013	0,013	0,013	0,014	0,014	0,015
47	0,043	0,031	0,025	0,014	0,022	0,027	0,030	0,041	0,050	0,051	0,051

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48	0,017	0,018	0,015	0,015	0,014	0,013	0,013	0,013	0,014	0,014	0,015
49	0,043	0,034	0,022	0,017	0,024	0,028	0,029	0,042	0,049	0,050	0,048
50	0,006	0,007	0,007	0,008	0,007	0,007	0,008	0,008	0,009	0,010	0,011
Note:											

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Test: HESP4855S100-H											
Interharmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
75	0,039	0,030	0,038	0,051	0,080	0,095	0,109	0,139	0,164	0,187	0,215
125	0,021	0,017	0,022	0,029	0,041	0,047	0,053	0,066	0,079	0,095	0,115
175	0,011	0,011	0,012	0,013	0,015	0,017	0,018	0,021	0,024	0,026	0,029
225	0,013	0,015	0,014	0,018	0,021	0,022	0,023	0,028	0,031	0,034	0,039
275	0,011	0,012	0,012	0,013	0,014	0,015	0,015	0,017	0,018	0,020	0,021
325	0,012	0,013	0,014	0,016	0,018	0,019	0,020	0,022	0,024	0,025	0,027
375	0,012	0,012	0,012	0,013	0,014	0,014	0,015	0,016	0,016	0,017	0,018
425	0,015	0,015	0,019	0,018	0,022	0,022	0,022	0,024	0,025	0,025	0,025
475	0,017	0,017	0,020	0,023	0,026	0,025	0,025	0,027	0,028	0,027	0,028
525	0,017	0,017	0,023	0,022	0,028	0,030	0,029	0,032	0,034	0,034	0,034
575	0,018	0,018	0,024	0,025	0,031	0,032	0,031	0,033	0,035	0,035	0,036
625	0,017	0,017	0,022	0,023	0,027	0,031	0,031	0,033	0,035	0,036	0,038
675	0,017	0,016	0,021	0,023	0,026	0,030	0,030	0,031	0,033	0,034	0,036
725	0,016	0,016	0,019	0,021	0,022	0,026	0,028	0,029	0,030	0,031	0,033
775	0,016	0,016	0,018	0,020	0,021	0,024	0,026	0,028	0,028	0,028	0,030
825	0,015	0,015	0,018	0,019	0,019	0,022	0,023	0,026	0,026	0,026	0,027
875	0,015	0,015	0,017	0,018	0,018	0,021	0,022	0,025	0,025	0,024	0,025
925	0,015	0,015	0,017	0,018	0,017	0,020	0,021	0,024	0,025	0,025	0,025
975	0,014	0,014	0,015	0,017	0,016	0,018	0,019	0,022	0,023	0,023	0,023
1025	0,014	0,014	0,015	0,015	0,016	0,018	0,019	0,021	0,022	0,023	0,023
1075	0,013	0,013	0,014	0,015	0,015	0,017	0,018	0,019	0,021	0,022	0,022
1125	0,013	0,012	0,013	0,014	0,014	0,016	0,017	0,019	0,020	0,020	0,022
1175	0,012	0,012	0,013	0,013	0,014	0,015	0,017	0,018	0,019	0,020	0,021
1225	0,012	0,012	0,012	0,012	0,013	0,015	0,016	0,018	0,018	0,019	0,020
1275	0,012	0,011	0,012	0,012	0,013	0,014	0,016	0,017	0,018	0,018	0,020
1325	0,012	0,012	0,012	0,013	0,013	0,015	0,016	0,017	0,018	0,019	0,019
1375	0,011	0,011	0,011	0,011	0,012	0,013	0,014	0,016	0,017	0,018	0,018
1425	0,012	0,012	0,011	0,012	0,013	0,014	0,015	0,016	0,017	0,018	0,018
1475	0,011	0,010	0,011	0,011	0,012	0,013	0,014	0,015	0,016	0,017	0,017
1525	0,010	0,010	0,010	0,011	0,011	0,012	0,013	0,015	0,016	0,016	0,017
1575	0,010	0,010	0,010	0,011	0,011	0,012	0,013	0,014	0,015	0,016	0,017
1625	0,010	0,010	0,010	0,011	0,011	0,012	0,013	0,014	0,015	0,015	0,016
1675	0,010	0,010	0,010	0,011	0,011	0,012	0,012	0,014	0,015	0,015	0,016
1725	0,010	0,010	0,010	0,010	0,010	0,011	0,012	0,013	0,014	0,015	0,016
1775	0,010	0,010	0,009	0,010	0,010	0,011	0,012	0,013	0,014	0,015	0,015
1825	0,010	0,009	0,009	0,009	0,010	0,011	0,012	0,013	0,014	0,014	0,015
1875	0,009	0,009	0,009	0,009	0,010	0,011	0,011	0,012	0,013	0,014	0,015
1925	0,009	0,009	0,009	0,009	0,009	0,011	0,011	0,012	0,013	0,014	0,014
1975	0,009	0,009	0,009	0,009	0,009	0,010	0,011	0,012	0,013	0,013	0,014
Note:											

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Test: HESP4855S100-H											
Higher Frequencies											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2,1	0,047	0,048	0,037	0,031	0,036	0,050	0,057	0,080	0,087	0,095	0,100
2,3	0,064	0,050	0,046	0,032	0,039	0,047	0,051	0,065	0,078	0,079	0,081
2,5	0,063	0,058	0,041	0,036	0,043	0,047	0,049	0,066	0,074	0,077	0,075
2,7	0,053	0,061	0,053	0,046	0,044	0,047	0,049	0,063	0,073	0,077	0,074
2,9	0,066	0,068	0,060	0,056	0,047	0,049	0,049	0,063	0,073	0,074	0,075
3,1	0,092	0,089	0,080	0,068	0,053	0,053	0,054	0,064	0,070	0,075	0,070
3,3	0,103	0,112	0,095	0,088	0,061	0,059	0,059	0,064	0,072	0,071	0,067
3,5	0,092	0,112	0,105	0,098	0,070	0,069	0,073	0,080	0,081	0,082	0,098
3,7	0,067	0,086	0,080	0,078	0,067	0,075	0,087	0,103	0,116	0,127	0,171
3,9	0,041	0,050	0,046	0,047	0,048	0,056	0,064	0,075	0,091	0,127	0,206
4,1	0,029	0,031	0,031	0,033	0,038	0,042	0,045	0,049	0,052	0,058	0,080
4,3	0,024	0,024	0,025	0,027	0,031	0,034	0,035	0,037	0,038	0,040	0,041
4,5	0,021	0,021	0,022	0,023	0,026	0,028	0,029	0,029	0,030	0,030	0,031
4,7	0,027	0,026	0,027	0,028	0,030	0,031	0,031	0,031	0,031	0,031	0,032
4,9	0,017	0,017	0,018	0,019	0,020	0,021	0,021	0,021	0,021	0,022	0,022
5,1	0,016	0,016	0,017	0,017	0,018	0,018	0,018	0,019	0,019	0,019	0,019
5,3	0,014	0,015	0,015	0,016	0,016	0,016	0,016	0,016	0,017	0,017	0,017
5,5	0,013	0,014	0,014	0,014	0,014	0,014	0,014	0,015	0,015	0,015	0,016
5,7	0,012	0,013	0,013	0,013	0,013	0,013	0,014	0,014	0,014	0,014	0,015
5,9	0,011	0,012	0,012	0,012	0,012	0,012	0,012	0,013	0,013	0,013	0,013
6,1	0,012	0,013	0,012	0,012	0,013	0,013	0,013	0,013	0,014	0,014	0,014
6,3	0,010	0,011	0,010	0,010	0,011	0,012	0,012	0,012	0,012	0,012	0,012
6,5	0,011	0,011	0,010	0,010	0,011	0,012	0,012	0,012	0,012	0,012	0,012
6,7	0,015	0,010	0,010	0,010	0,012	0,012	0,012	0,012	0,012	0,013	0,013
6,9	0,011	0,010	0,010	0,010	0,011	0,011	0,011	0,011	0,011	0,012	0,012
7,1	0,012	0,012	0,012	0,012	0,013	0,013	0,013	0,013	0,013	0,013	0,013
7,3	0,010	0,009	0,009	0,010	0,011	0,010	0,010	0,010	0,010	0,011	0,011
7,5	0,010	0,009	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,011
7,7	0,009	0,009	0,010	0,010	0,010	0,009	0,010	0,010	0,010	0,010	0,011
7,9	0,009	0,009	0,009	0,010	0,009	0,009	0,009	0,009	0,009	0,010	0,010
8,1	0,009	0,009	0,010	0,010	0,009	0,009	0,010	0,010	0,010	0,010	0,011
8,3	0,010	0,010	0,010	0,011	0,010	0,010	0,011	0,011	0,011	0,011	0,011
8,5	0,009	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,011	0,011	0,011
8,7	0,008	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,010	0,010	0,010
8,9	0,008	0,009	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,010	0,010
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4.8	EMC and power quality Harmonic current emission (EN 61000-4-7)	P

The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.

Test: HESP4850S100-H

Harmonics

P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	5,465	10,131	20,123	30,070	40,054	50,031	60,102	70,049	80,058	90,043	99,976
2	0,155	0,153	0,037	0,222	0,345	0,325	0,330	0,371	0,361	0,386	0,473
3	1,500	1,692	1,646	1,660	1,751	1,793	1,838	1,901	1,959	2,006	2,047
4	0,041	0,077	0,020	0,128	0,183	0,179	0,190	0,219	0,216	0,232	0,285
5	0,916	0,817	0,919	0,863	0,802	0,775	0,754	0,746	0,736	0,724	0,604
6	0,019	0,023	0,023	0,066	0,088	0,090	0,096	0,111	0,115	0,129	0,157
7	0,675	0,811	0,538	0,670	0,569	0,517	0,473	0,424	0,380	0,370	0,374
8	0,013	0,013	0,032	0,050	0,063	0,059	0,064	0,073	0,072	0,078	0,084
9	0,621	0,509	0,870	0,863	1,091	1,040	1,065	1,045	0,978	0,868	0,813
10	0,027	0,060	0,042	0,058	0,056	0,047	0,046	0,051	0,053	0,055	0,061
11	0,462	0,916	1,014	0,755	1,073	1,116	1,038	1,065	1,091	1,093	0,979
12	0,031	0,018	0,032	0,031	0,041	0,034	0,041	0,033	0,038	0,034	0,026
13	0,335	0,444	0,544	0,554	0,733	0,916	0,887	0,847	0,899	0,970	1,006
14	0,032	0,018	0,029	0,038	0,040	0,034	0,028	0,028	0,030	0,031	0,030
15	0,364	0,422	0,261	0,402	0,441	0,504	0,589	0,539	0,500	0,533	0,596
16	0,018	0,034	0,019	0,021	0,019	0,022	0,019	0,017	0,016	0,016	0,019
17	0,288	0,301	0,271	0,333	0,339	0,391	0,431	0,485	0,452	0,410	0,425
18	0,014	0,014	0,018	0,017	0,012	0,013	0,018	0,016	0,019	0,020	0,024
19	0,235	0,141	0,204	0,220	0,214	0,258	0,267	0,308	0,341	0,320	0,286
20	0,016	0,026	0,022	0,023	0,015	0,017	0,015	0,016	0,015	0,014	0,017
21	0,167	0,133	0,127	0,166	0,196	0,232	0,253	0,257	0,296	0,325	0,322
22	0,011	0,016	0,011	0,014	0,009	0,011	0,012	0,012	0,012	0,013	0,017
23	0,090	0,077	0,050	0,088	0,142	0,148	0,183	0,196	0,198	0,225	0,250
24	0,011	0,012	0,013	0,011	0,012	0,011	0,011	0,014	0,016	0,018	0,026
25	0,052	0,058	0,067	0,078	0,135	0,139	0,163	0,188	0,199	0,203	0,224
26	0,011	0,013	0,012	0,011	0,008	0,009	0,011	0,011	0,011	0,011	0,014
27	0,016	0,058	0,039	0,052	0,101	0,101	0,122	0,139	0,160	0,166	0,171
28	0,013	0,012	0,014	0,012	0,013	0,011	0,014	0,015	0,013	0,012	0,012
29	0,018	0,038	0,029	0,065	0,093	0,093	0,116	0,130	0,143	0,160	0,166
30	0,010	0,010	0,009	0,011	0,010	0,010	0,011	0,012	0,012	0,011	0,011
31	0,045	0,025	0,011	0,043	0,070	0,070	0,089	0,112	0,115	0,127	0,142
32	0,011	0,012	0,011	0,011	0,010	0,011	0,011	0,012	0,012	0,015	0,020
33	0,034	0,022	0,013	0,040	0,059	0,063	0,078	0,103	0,111	0,112	0,124
34	0,010	0,012	0,010	0,011	0,009	0,011	0,010	0,011	0,011	0,013	0,018
35	0,040	0,040	0,020	0,016	0,044	0,051	0,063	0,081	0,098	0,095	0,102
36	0,010	0,009	0,012	0,010	0,008	0,009	0,008	0,009	0,010	0,010	0,013
37	0,024	0,031	0,021	0,012	0,032	0,043	0,057	0,068	0,086	0,089	0,087
38	0,008	0,009	0,008	0,009	0,007	0,007	0,007	0,008	0,008	0,009	0,011
39	0,025	0,038	0,026	0,016	0,026	0,039	0,046	0,060	0,069	0,080	0,079
40	0,008	0,009	0,007	0,008	0,007	0,007	0,007	0,008	0,008	0,008	0,009
41	0,024	0,030	0,016	0,013	0,020	0,032	0,040	0,057	0,060	0,066	0,071
42	0,007	0,008	0,008	0,008	0,007	0,007	0,007	0,008	0,008	0,008	0,009
43	0,034	0,032	0,024	0,018	0,022	0,030	0,036	0,050	0,056	0,060	0,063
44	0,007	0,008	0,009	0,009	0,008	0,007	0,008	0,008	0,010	0,010	0,011
45	0,039	0,032	0,028	0,013	0,019	0,028	0,032	0,043	0,051	0,051	0,054
46	0,017	0,017	0,017	0,016	0,014	0,013	0,013	0,013	0,013	0,014	0,015
47	0,043	0,035	0,028	0,014	0,022	0,027	0,031	0,042	0,051	0,051	0,051

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48	0,017	0,017	0,016	0,016	0,014	0,013	0,013	0,013	0,014	0,014	0,015
49	0,043	0,034	0,022	0,015	0,024	0,027	0,030	0,043	0,049	0,050	0,048
50	0,007	0,008	0,008	0,009	0,008	0,007	0,007	0,008	0,009	0,010	0,011
Note:											

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Test: HESP4850S100-H											
Interharmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
75	0,041	0,033	0,041	0,053	0,088	0,106	0,130	0,159	0,180	0,206	0,232
125	0,023	0,020	0,023	0,029	0,044	0,052	0,063	0,077	0,086	0,103	0,124
175	0,012	0,013	0,013	0,014	0,018	0,019	0,021	0,024	0,026	0,029	0,031
225	0,014	0,017	0,014	0,019	0,023	0,024	0,027	0,031	0,034	0,037	0,043
275	0,012	0,013	0,012	0,014	0,015	0,016	0,017	0,019	0,020	0,021	0,023
325	0,014	0,014	0,014	0,016	0,020	0,020	0,022	0,024	0,025	0,028	0,030
375	0,013	0,013	0,013	0,014	0,015	0,015	0,016	0,017	0,017	0,018	0,019
425	0,017	0,017	0,019	0,019	0,024	0,023	0,024	0,026	0,026	0,027	0,028
475	0,018	0,020	0,021	0,023	0,028	0,027	0,027	0,029	0,029	0,030	0,031
525	0,019	0,021	0,023	0,023	0,030	0,032	0,032	0,034	0,035	0,037	0,038
575	0,020	0,021	0,024	0,025	0,032	0,033	0,034	0,036	0,037	0,038	0,040
625	0,019	0,020	0,022	0,024	0,028	0,032	0,033	0,035	0,037	0,039	0,042
675	0,019	0,019	0,022	0,023	0,028	0,031	0,032	0,033	0,035	0,037	0,040
725	0,018	0,019	0,019	0,023	0,023	0,027	0,030	0,031	0,031	0,033	0,037
775	0,018	0,018	0,018	0,021	0,022	0,025	0,028	0,029	0,029	0,030	0,034
825	0,017	0,018	0,018	0,020	0,020	0,023	0,025	0,027	0,027	0,027	0,030
875	0,016	0,017	0,017	0,019	0,019	0,022	0,024	0,026	0,026	0,025	0,028
925	0,017	0,017	0,017	0,019	0,018	0,021	0,023	0,025	0,026	0,026	0,028
975	0,015	0,016	0,016	0,017	0,016	0,019	0,021	0,023	0,024	0,024	0,026
1025	0,016	0,016	0,015	0,016	0,017	0,019	0,020	0,022	0,023	0,024	0,026
1075	0,014	0,015	0,014	0,015	0,015	0,017	0,019	0,020	0,022	0,023	0,025
1125	0,014	0,014	0,013	0,014	0,015	0,016	0,018	0,019	0,020	0,022	0,025
1175	0,014	0,014	0,013	0,014	0,014	0,016	0,018	0,019	0,020	0,021	0,023
1225	0,013	0,013	0,013	0,013	0,014	0,015	0,017	0,018	0,019	0,020	0,022
1275	0,013	0,013	0,012	0,013	0,014	0,015	0,016	0,018	0,019	0,019	0,022
1325	0,014	0,013	0,013	0,013	0,014	0,015	0,017	0,018	0,019	0,020	0,022
1375	0,012	0,012	0,012	0,012	0,013	0,014	0,015	0,017	0,018	0,018	0,020
1425	0,013	0,013	0,012	0,013	0,013	0,014	0,016	0,017	0,018	0,018	0,020
1475	0,012	0,012	0,011	0,011	0,012	0,013	0,014	0,016	0,017	0,017	0,020
1525	0,012	0,012	0,011	0,012	0,012	0,013	0,014	0,015	0,016	0,017	0,019
1575	0,011	0,011	0,010	0,011	0,012	0,012	0,014	0,015	0,016	0,017	0,019
1625	0,011	0,011	0,010	0,011	0,011	0,012	0,013	0,014	0,015	0,016	0,018
1675	0,011	0,011	0,010	0,011	0,011	0,012	0,013	0,014	0,015	0,016	0,018
1725	0,011	0,011	0,010	0,010	0,011	0,012	0,013	0,014	0,015	0,015	0,017
1775	0,011	0,011	0,010	0,010	0,010	0,011	0,013	0,014	0,015	0,015	0,017
1825	0,011	0,011	0,009	0,010	0,010	0,011	0,012	0,013	0,014	0,015	0,017
1875	0,011	0,010	0,009	0,010	0,010	0,011	0,012	0,013	0,014	0,015	0,017
1925	0,011	0,010	0,009	0,009	0,010	0,011	0,012	0,013	0,013	0,014	0,016
1975	0,010	0,010	0,009	0,009	0,010	0,010	0,011	0,012	0,013	0,014	0,016
Note:											

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Test: HESP4850S100-H											
Higher Frequencies											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2,1	0,052	0,054	0,039	0,033	0,040	0,054	0,064	0,088	0,095	0,102	0,109
2,3	0,070	0,059	0,051	0,035	0,041	0,050	0,056	0,072	0,085	0,085	0,089
2,5	0,069	0,062	0,043	0,037	0,046	0,050	0,055	0,073	0,081	0,084	0,082
2,7	0,058	0,067	0,056	0,049	0,050	0,051	0,055	0,070	0,081	0,083	0,082
2,9	0,073	0,078	0,066	0,062	0,053	0,055	0,056	0,071	0,081	0,081	0,082
3,1	0,101	0,096	0,086	0,074	0,059	0,060	0,061	0,071	0,078	0,082	0,077
3,3	0,114	0,121	0,104	0,095	0,069	0,066	0,066	0,071	0,079	0,077	0,074
3,5	0,101	0,127	0,116	0,110	0,079	0,075	0,080	0,085	0,087	0,089	0,112
3,7	0,073	0,098	0,088	0,086	0,074	0,081	0,094	0,109	0,123	0,137	0,197
3,9	0,045	0,056	0,050	0,051	0,052	0,060	0,069	0,081	0,099	0,138	0,235
4,1	0,032	0,035	0,034	0,036	0,041	0,046	0,049	0,052	0,056	0,063	0,089
4,3	0,027	0,027	0,028	0,029	0,034	0,037	0,038	0,040	0,042	0,044	0,046
4,5	0,024	0,023	0,024	0,025	0,029	0,031	0,031	0,032	0,032	0,033	0,034
4,7	0,029	0,029	0,030	0,031	0,033	0,034	0,034	0,034	0,035	0,035	0,035
4,9	0,019	0,019	0,020	0,020	0,022	0,023	0,023	0,023	0,023	0,024	0,024
5,1	0,017	0,017	0,018	0,019	0,020	0,020	0,020	0,020	0,021	0,021	0,021
5,3	0,016	0,016	0,017	0,017	0,017	0,018	0,018	0,018	0,018	0,018	0,019
5,5	0,014	0,015	0,015	0,016	0,016	0,016	0,016	0,016	0,017	0,017	0,017
5,7	0,013	0,015	0,014	0,015	0,014	0,015	0,015	0,015	0,016	0,016	0,016
5,9	0,012	0,013	0,013	0,013	0,013	0,013	0,014	0,014	0,014	0,014	0,015
6,1	0,013	0,014	0,013	0,014	0,014	0,014	0,014	0,015	0,015	0,015	0,015
6,3	0,011	0,012	0,011	0,011	0,012	0,013	0,013	0,013	0,013	0,013	0,013
6,5	0,013	0,012	0,011	0,011	0,012	0,013	0,013	0,013	0,013	0,013	0,014
6,7	0,016	0,012	0,011	0,011	0,013	0,013	0,013	0,013	0,013	0,014	0,014
6,9	0,012	0,011	0,010	0,011	0,013	0,013	0,012	0,012	0,013	0,013	0,013
7,1	0,014	0,013	0,013	0,014	0,015	0,014	0,014	0,014	0,014	0,015	0,015
7,3	0,011	0,010	0,010	0,011	0,012	0,011	0,011	0,011	0,011	0,012	0,012
7,5	0,011	0,010	0,010	0,011	0,011	0,011	0,011	0,011	0,011	0,011	0,012
7,7	0,010	0,010	0,010	0,011	0,011	0,010	0,010	0,010	0,011	0,011	0,012
7,9	0,010	0,010	0,010	0,011	0,010	0,010	0,010	0,010	0,010	0,011	0,011
8,1	0,010	0,010	0,011	0,011	0,010	0,010	0,011	0,011	0,011	0,011	0,012
8,3	0,011	0,011	0,011	0,012	0,011	0,011	0,012	0,012	0,012	0,012	0,012
8,5	0,010	0,011	0,011	0,011	0,011	0,012	0,012	0,012	0,012	0,012	0,012
8,7	0,009	0,010	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,010	0,011
8,9	0,008	0,010	0,009	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,011
Note:											

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4.8	EMC and power quality Harmonic current emission (EN 61000-4-7)	P

The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.

Test: HESP4846S100-H

Harmonics

P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	5,577	10,200	20,091	30,068	40,050	50,138	60,029	70,049	80,039	90,062	99,944
2	0,049	0,030	0,105	0,254	0,392	0,439	0,454	0,461	0,463	0,483	0,484
3	1,784	1,944	1,982	2,001	2,080	2,151	2,178	2,220	2,259	2,317	2,385
4	0,011	0,012	0,046	0,118	0,199	0,232	0,242	0,255	0,266	0,285	0,289
5	1,114	1,056	1,024	1,088	1,017	0,984	0,962	0,942	0,929	0,929	0,935
6	0,015	0,021	0,019	0,041	0,087	0,101	0,117	0,126	0,133	0,147	0,158
7	0,821	0,776	0,686	0,784	0,767	0,688	0,649	0,614	0,576	0,538	0,515
8	0,013	0,013	0,013	0,030	0,055	0,068	0,068	0,075	0,082	0,087	0,091
9	0,707	0,727	1,120	0,645	1,025	1,076	1,014	1,020	1,009	0,954	0,875
10	0,014	0,017	0,024	0,036	0,052	0,054	0,053	0,056	0,057	0,064	0,062
11	0,538	0,879	0,889	0,758	0,952	1,119	1,082	0,995	0,995	1,006	1,000
12	0,025	0,018	0,020	0,020	0,027	0,031	0,027	0,034	0,030	0,029	0,031
13	0,378	0,516	0,468	0,751	0,697	0,864	0,977	0,941	0,869	0,865	0,896
14	0,016	0,012	0,027	0,029	0,037	0,042	0,040	0,038	0,033	0,039	0,045
15	0,439	0,597	0,575	0,572	0,499	0,592	0,625	0,687	0,652	0,587	0,568
16	0,014	0,012	0,016	0,016	0,018	0,020	0,022	0,023	0,020	0,020	0,020
17	0,347	0,354	0,398	0,348	0,414	0,477	0,511	0,536	0,592	0,581	0,531
18	0,017	0,014	0,014	0,017	0,016	0,015	0,017	0,018	0,017	0,019	0,020
19	0,315	0,293	0,198	0,196	0,309	0,307	0,352	0,353	0,375	0,416	0,410
20	0,012	0,012	0,015	0,017	0,017	0,019	0,023	0,018	0,021	0,022	0,020
21	0,229	0,181	0,191	0,178	0,278	0,280	0,328	0,343	0,344	0,366	0,402
22	0,012	0,013	0,013	0,012	0,013	0,013	0,016	0,015	0,015	0,017	0,018
23	0,157	0,123	0,161	0,142	0,196	0,196	0,221	0,250	0,264	0,259	0,272
24	0,016	0,013	0,016	0,018	0,015	0,015	0,016	0,015	0,018	0,022	0,021
25	0,102	0,086	0,095	0,130	0,171	0,190	0,210	0,233	0,252	0,270	0,268
26	0,011	0,011	0,011	0,012	0,012	0,011	0,012	0,014	0,015	0,015	0,015
27	0,042	0,079	0,049	0,070	0,108	0,142	0,151	0,172	0,191	0,208	0,214
28	0,011	0,009	0,010	0,011	0,014	0,014	0,014	0,014	0,018	0,017	0,015
29	0,020	0,062	0,057	0,048	0,096	0,133	0,145	0,168	0,183	0,192	0,212
30	0,009	0,009	0,010	0,010	0,011	0,011	0,012	0,013	0,015	0,016	0,015
31	0,035	0,060	0,028	0,022	0,064	0,107	0,110	0,128	0,151	0,157	0,164
32	0,016	0,013	0,014	0,017	0,016	0,015	0,016	0,015	0,017	0,017	0,018
33	0,030	0,028	0,020	0,032	0,067	0,098	0,099	0,117	0,141	0,155	0,151
34	0,014	0,013	0,013	0,013	0,013	0,013	0,014	0,015	0,016	0,016	0,016
35	0,045	0,032	0,024	0,015	0,056	0,077	0,078	0,096	0,109	0,129	0,133
36	0,012	0,012	0,011	0,011	0,011	0,012	0,013	0,013	0,013	0,015	0,015
37	0,033	0,026	0,024	0,013	0,050	0,066	0,070	0,085	0,097	0,113	0,125
38	0,009	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,011	0,011	0,013
39	0,034	0,043	0,032	0,027	0,040	0,053	0,058	0,067	0,084	0,091	0,103
40	0,009	0,008	0,008	0,008	0,009	0,009	0,009	0,010	0,010	0,011	0,011
41	0,026	0,044	0,023	0,025	0,033	0,043	0,049	0,060	0,077	0,080	0,088
42	0,008	0,009	0,007	0,009	0,009	0,009	0,009	0,010	0,010	0,011	0,011
43	0,033	0,043	0,037	0,028	0,023	0,036	0,044	0,054	0,064	0,076	0,075
44	0,008	0,009	0,008	0,010	0,010	0,010	0,010	0,011	0,011	0,012	0,014
45	0,039	0,039	0,036	0,023	0,018	0,030	0,041	0,046	0,055	0,068	0,067
46	0,022	0,020	0,021	0,021	0,019	0,018	0,017	0,017	0,018	0,019	0,019
47	0,047	0,033	0,030	0,024	0,017	0,030	0,036	0,044	0,056	0,063	0,065

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48	0,022	0,026	0,018	0,019	0,018	0,017	0,017	0,017	0,018	0,018	0,019
49	0,051	0,037	0,031	0,032	0,021	0,030	0,039	0,043	0,055	0,058	0,063
50	0,009	0,010	0,008	0,010	0,010	0,009	0,009	0,010	0,010	0,012	0,013
Note:											

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Test: HESP4846S100-H											
Interharmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
75	0,035	0,034	0,043	0,055	0,065	0,107	0,118	0,135	0,154	0,185	0,215
125	0,021	0,020	0,024	0,031	0,035	0,051	0,058	0,064	0,074	0,087	0,103
175	0,012	0,013	0,013	0,015	0,016	0,019	0,020	0,022	0,024	0,026	0,029
225	0,014	0,014	0,015	0,018	0,020	0,025	0,025	0,027	0,030	0,034	0,037
275	0,012	0,013	0,013	0,014	0,015	0,016	0,017	0,018	0,019	0,020	0,022
325	0,013	0,014	0,015	0,016	0,018	0,020	0,021	0,022	0,023	0,025	0,027
375	0,013	0,014	0,014	0,014	0,015	0,016	0,016	0,016	0,017	0,018	0,018
425	0,015	0,018	0,018	0,018	0,020	0,023	0,022	0,022	0,023	0,025	0,025
475	0,017	0,018	0,020	0,020	0,024	0,026	0,025	0,025	0,026	0,027	0,028
525	0,018	0,019	0,021	0,023	0,025	0,029	0,029	0,029	0,030	0,032	0,033
575	0,019	0,018	0,023	0,024	0,028	0,032	0,031	0,031	0,032	0,034	0,035
625	0,019	0,018	0,022	0,027	0,026	0,031	0,033	0,033	0,033	0,035	0,037
675	0,019	0,017	0,023	0,026	0,027	0,031	0,032	0,033	0,033	0,035	0,036
725	0,018	0,017	0,022	0,026	0,025	0,028	0,030	0,031	0,033	0,034	0,034
775	0,018	0,017	0,022	0,025	0,024	0,027	0,029	0,030	0,031	0,032	0,033
825	0,018	0,017	0,021	0,022	0,023	0,024	0,027	0,028	0,030	0,031	0,031
875	0,018	0,016	0,020	0,022	0,022	0,023	0,026	0,027	0,028	0,030	0,030
925	0,018	0,017	0,020	0,021	0,022	0,023	0,025	0,026	0,028	0,030	0,031
975	0,017	0,016	0,018	0,019	0,020	0,021	0,023	0,024	0,026	0,028	0,028
1025	0,018	0,016	0,018	0,019	0,020	0,020	0,023	0,024	0,025	0,027	0,028
1075	0,017	0,015	0,017	0,018	0,019	0,019	0,022	0,023	0,024	0,025	0,027
1125	0,016	0,014	0,017	0,018	0,018	0,018	0,021	0,022	0,023	0,024	0,025
1175	0,016	0,014	0,016	0,018	0,018	0,018	0,020	0,021	0,022	0,024	0,025
1225	0,016	0,014	0,016	0,017	0,017	0,017	0,019	0,021	0,021	0,023	0,024
1275	0,015	0,014	0,015	0,017	0,017	0,017	0,019	0,020	0,021	0,023	0,024
1325	0,016	0,014	0,016	0,017	0,017	0,018	0,019	0,021	0,022	0,023	0,024
1375	0,015	0,013	0,015	0,016	0,016	0,016	0,018	0,019	0,020	0,022	0,022
1425	0,016	0,014	0,015	0,016	0,016	0,017	0,018	0,019	0,021	0,022	0,022
1475	0,014	0,013	0,014	0,015	0,015	0,016	0,017	0,018	0,019	0,020	0,021
1525	0,014	0,012	0,014	0,014	0,014	0,015	0,016	0,018	0,019	0,020	0,021
1575	0,014	0,012	0,013	0,014	0,014	0,015	0,016	0,017	0,019	0,020	0,021
1625	0,013	0,012	0,013	0,014	0,014	0,015	0,016	0,017	0,018	0,019	0,020
1675	0,013	0,012	0,013	0,014	0,014	0,015	0,015	0,017	0,018	0,019	0,020
1725	0,013	0,012	0,013	0,013	0,013	0,014	0,015	0,016	0,017	0,019	0,019
1775	0,013	0,012	0,013	0,013	0,013	0,014	0,015	0,016	0,017	0,019	0,020
1825	0,013	0,012	0,012	0,013	0,013	0,013	0,015	0,015	0,017	0,018	0,019
1875	0,013	0,012	0,012	0,013	0,013	0,013	0,014	0,015	0,016	0,018	0,019
1925	0,013	0,012	0,012	0,012	0,013	0,013	0,014	0,015	0,016	0,017	0,018
1975	0,013	0,012	0,012	0,012	0,012	0,013	0,014	0,015	0,016	0,017	0,018
Note:											

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Test: HESP4846S100-H											
Higher Frequencies											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2,1	0,051	0,067	0,051	0,047	0,050	0,063	0,072	0,087	0,106	0,116	0,121
2,3	0,070	0,060	0,057	0,047	0,042	0,053	0,064	0,072	0,087	0,101	0,102
2,5	0,079	0,068	0,057	0,056	0,045	0,052	0,063	0,069	0,084	0,091	0,097
2,7	0,069	0,080	0,060	0,060	0,051	0,057	0,065	0,069	0,082	0,093	0,093
2,9	0,073	0,078	0,075	0,068	0,060	0,066	0,070	0,071	0,084	0,092	0,097
3,1	0,106	0,096	0,091	0,094	0,074	0,080	0,077	0,077	0,085	0,094	0,096
3,3	0,135	0,139	0,121	0,116	0,096	0,092	0,087	0,084	0,088	0,095	0,093
3,5	0,139	0,149	0,147	0,137	0,118	0,101	0,097	0,097	0,101	0,106	0,119
3,7	0,104	0,117	0,123	0,116	0,105	0,094	0,101	0,115	0,133	0,158	0,195
3,9	0,059	0,069	0,068	0,063	0,062	0,062	0,069	0,080	0,096	0,127	0,195
4,1	0,037	0,041	0,042	0,041	0,042	0,045	0,049	0,053	0,058	0,064	0,072
4,3	0,029	0,030	0,031	0,031	0,033	0,036	0,039	0,040	0,042	0,043	0,046
4,5	0,025	0,025	0,025	0,026	0,028	0,031	0,033	0,033	0,034	0,036	0,036
4,7	0,032	0,031	0,032	0,033	0,034	0,036	0,037	0,037	0,038	0,038	0,038
4,9	0,020	0,020	0,020	0,022	0,023	0,024	0,025	0,025	0,026	0,026	0,026
5,1	0,019	0,019	0,019	0,020	0,021	0,022	0,023	0,023	0,023	0,023	0,024
5,3	0,018	0,017	0,018	0,019	0,019	0,020	0,021	0,021	0,021	0,021	0,021
5,5	0,016	0,017	0,017	0,018	0,018	0,018	0,019	0,019	0,019	0,019	0,019
5,7	0,015	0,016	0,017	0,017	0,017	0,017	0,017	0,017	0,018	0,018	0,018
5,9	0,014	0,015	0,016	0,015	0,015	0,015	0,015	0,016	0,016	0,016	0,016
6,1	0,015	0,016	0,016	0,015	0,016	0,016	0,016	0,016	0,016	0,017	0,017
6,3	0,012	0,014	0,014	0,013	0,013	0,013	0,014	0,014	0,014	0,015	0,015
6,5	0,014	0,015	0,013	0,012	0,013	0,013	0,014	0,014	0,015	0,015	0,015
6,7	0,018	0,014	0,012	0,012	0,013	0,014	0,014	0,015	0,015	0,015	0,015
6,9	0,013	0,013	0,012	0,012	0,012	0,014	0,014	0,014	0,014	0,014	0,014
7,1	0,015	0,014	0,014	0,014	0,015	0,016	0,016	0,016	0,016	0,016	0,016
7,3	0,011	0,010	0,010	0,011	0,012	0,013	0,013	0,013	0,013	0,013	0,013
7,5	0,012	0,010	0,010	0,011	0,012	0,014	0,013	0,013	0,013	0,013	0,013
7,7	0,011	0,010	0,010	0,011	0,012	0,013	0,012	0,012	0,012	0,012	0,013
7,9	0,011	0,010	0,010	0,011	0,012	0,012	0,012	0,012	0,012	0,012	0,012
8,1	0,012	0,010	0,011	0,012	0,012	0,012	0,012	0,012	0,012	0,012	0,012
8,3	0,012	0,012	0,012	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,013
8,5	0,012	0,012	0,012	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,013
8,7	0,010	0,010	0,011	0,011	0,012	0,012	0,012	0,013	0,013	0,013	0,012
8,9	0,010	0,010	0,011	0,011	0,012	0,012	0,013	0,013	0,013	0,013	0,013
Note:											

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4.8	EMC and power quality Harmonic current emission (EN 61000-4-7)	P

The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.

Test: HESP4840S100-H

Harmonics

P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	5,015	10,030	20,028	30,050	40,065	50,085	60,094	70,117	80,156	90,146	100,165
2	0,044	0,088	0,178	0,263	0,343	0,433	0,530	0,618	0,692	0,784	0,871
3	0,120	0,238	0,487	0,732	0,976	1,215	1,462	1,707	1,951	2,192	2,433
4	0,016	0,031	0,064	0,094	0,122	0,156	0,191	0,216	0,245	0,280	0,312
5	0,052	0,104	0,206	0,310	0,416	0,516	0,619	0,724	0,831	0,933	1,034
6	0,011	0,022	0,044	0,062	0,092	0,108	0,132	0,145	0,186	0,207	0,184
7	0,020	0,039	0,078	0,117	0,155	0,192	0,233	0,272	0,312	0,349	0,388
8	0,004	0,008	0,016	0,023	0,031	0,038	0,047	0,055	0,062	0,069	0,073
9	0,024	0,048	0,096	0,145	0,194	0,244	0,290	0,338	0,387	0,436	0,484
10	0,002	0,004	0,009	0,013	0,018	0,022	0,028	0,031	0,035	0,039	0,044
11	0,027	0,053	0,107	0,160	0,214	0,266	0,320	0,373	0,426	0,480	0,534
12	0,002	0,003	0,006	0,009	0,011	0,015	0,018	0,021	0,023	0,026	0,029
13	0,020	0,039	0,079	0,118	0,157	0,194	0,236	0,275	0,315	0,353	0,391
14	0,001	0,003	0,006	0,009	0,010	0,013	0,016	0,019	0,020	0,024	0,026
15	0,016	0,032	0,064	0,097	0,129	0,163	0,193	0,225	0,257	0,289	0,322
16	0,002	0,003	0,006	0,010	0,012	0,015	0,019	0,024	0,024	0,027	0,032
17	0,018	0,037	0,073	0,110	0,147	0,182	0,220	0,256	0,293	0,328	0,365
18	0,002	0,003	0,006	0,009	0,011	0,014	0,018	0,021	0,022	0,026	0,029
19	0,013	0,027	0,052	0,079	0,105	0,132	0,157	0,184	0,210	0,236	0,261
20	0,002	0,003	0,007	0,010	0,012	0,016	0,020	0,023	0,024	0,028	0,033
21	0,016	0,032	0,064	0,097	0,128	0,161	0,193	0,225	0,257	0,289	0,322
22	0,002	0,003	0,006	0,010	0,012	0,016	0,020	0,023	0,023	0,027	0,032
23	0,012	0,024	0,046	0,070	0,093	0,116	0,139	0,163	0,187	0,209	0,233
24	0,002	0,004	0,007	0,011	0,014	0,018	0,023	0,026	0,029	0,032	0,037
25	0,014	0,027	0,054	0,081	0,108	0,135	0,163	0,189	0,217	0,242	0,270
26	0,002	0,003	0,006	0,009	0,012	0,015	0,019	0,022	0,023	0,027	0,031
27	0,011	0,022	0,043	0,064	0,086	0,107	0,128	0,150	0,171	0,192	0,213
28	0,001	0,003	0,006	0,008	0,010	0,013	0,017	0,020	0,022	0,024	0,028
29	0,012	0,024	0,047	0,071	0,094	0,118	0,141	0,165	0,189	0,212	0,236
30	0,002	0,003	0,006	0,009	0,012	0,015	0,018	0,022	0,023	0,027	0,031
31	0,010	0,019	0,039	0,058	0,078	0,097	0,116	0,136	0,155	0,173	0,193
32	0,002	0,005	0,009	0,013	0,017	0,022	0,027	0,031	0,035	0,039	0,045
33	0,010	0,020	0,040	0,060	0,080	0,100	0,121	0,141	0,161	0,180	0,200
34	0,002	0,005	0,010	0,014	0,018	0,023	0,028	0,033	0,036	0,042	0,047
35	0,009	0,018	0,036	0,054	0,072	0,090	0,107	0,125	0,144	0,161	0,179
36	0,002	0,004	0,008	0,012	0,015	0,019	0,024	0,028	0,030	0,034	0,039
37	0,008	0,017	0,034	0,051	0,067	0,084	0,102	0,119	0,137	0,152	0,171
38	0,002	0,004	0,007	0,011	0,013	0,017	0,021	0,025	0,027	0,031	0,035
39	0,008	0,016	0,033	0,049	0,065	0,082	0,097	0,115	0,130	0,148	0,164
40	0,002	0,003	0,006	0,009	0,012	0,015	0,019	0,022	0,024	0,027	0,031
41	0,008	0,015	0,030	0,046	0,061	0,076	0,092	0,108	0,124	0,138	0,153
42	0,001	0,003	0,006	0,008	0,010	0,013	0,016	0,019	0,020	0,024	0,027
43	0,007	0,014	0,028	0,042	0,056	0,070	0,083	0,098	0,111	0,126	0,141
44	0,001	0,003	0,006	0,008	0,010	0,013	0,017	0,020	0,021	0,024	0,027
45	0,007	0,013	0,026	0,040	0,052	0,065	0,079	0,092	0,104	0,118	0,131
46	0,001	0,003	0,006	0,008	0,011	0,013	0,017	0,019	0,023	0,024	0,027
47	0,006	0,012	0,025	0,037	0,049	0,062	0,074	0,086	0,099	0,112	0,123
48	0,001	0,003	0,006	0,008	0,010	0,012	0,016	0,018	0,020	0,023	0,024

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49	0,005	0,010	0,021	0,032	0,042	0,053	0,064	0,074	0,083	0,095	0,105
50	0,001	0,003	0,006	0,008	0,010	0,013	0,016	0,019	0,021	0,023	0,026
Note:											

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Test: HESP4840S100-H											
Interharmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
75	0,022	0,018	0,023	0,021	0,028	0,027	0,026	0,021	0,021	0,021	0,059
125	0,040	0,038	0,041	0,040	0,042	0,043	0,043	0,040	0,040	0,040	0,037
175	0,019	0,018	0,025	0,024	0,024	0,024	0,025	0,020	0,023	0,022	0,044
225	0,045	0,043	0,046	0,048	0,046	0,046	0,048	0,046	0,048	0,045	0,072
275	0,024	0,023	0,029	0,030	0,027	0,027	0,030	0,027	0,030	0,028	0,052
325	0,017	0,016	0,023	0,023	0,021	0,021	0,025	0,022	0,023	0,023	0,021
375	0,019	0,018	0,024	0,023	0,022	0,023	0,025	0,025	0,023	0,025	0,017
425	0,017	0,016	0,021	0,020	0,021	0,021	0,022	0,024	0,020	0,024	0,017
475	0,018	0,018	0,021	0,021	0,023	0,021	0,023	0,025	0,021	0,024	0,018
525	0,018	0,017	0,021	0,020	0,022	0,019	0,022	0,023	0,021	0,022	0,019
575	0,018	0,018	0,022	0,022	0,021	0,019	0,022	0,022	0,022	0,022	0,022
625	0,020	0,019	0,025	0,025	0,021	0,020	0,025	0,024	0,025	0,023	0,022
675	0,020	0,019	0,025	0,026	0,020	0,020	0,025	0,022	0,025	0,023	0,024
725	0,020	0,020	0,025	0,024	0,020	0,020	0,025	0,024	0,023	0,025	0,024
775	0,021	0,020	0,024	0,022	0,021	0,021	0,024	0,025	0,022	0,026	0,024
825	0,021	0,021	0,023	0,022	0,021	0,021	0,023	0,026	0,022	0,026	0,023
875	0,023	0,023	0,024	0,023	0,023	0,022	0,024	0,028	0,023	0,026	0,024
925	0,022	0,023	0,023	0,023	0,023	0,023	0,023	0,026	0,022	0,025	0,024
975	0,023	0,022	0,023	0,023	0,023	0,023	0,024	0,024	0,023	0,025	0,024
1025	0,022	0,022	0,023	0,022	0,022	0,022	0,023	0,023	0,022	0,023	0,024
1075	0,023	0,022	0,023	0,023	0,023	0,023	0,023	0,023	0,023	0,024	0,025
1125	0,024	0,023	0,024	0,024	0,024	0,023	0,024	0,024	0,024	0,024	0,024
1175	0,023	0,023	0,024	0,024	0,024	0,023	0,024	0,025	0,023	0,024	0,025
1225	0,024	0,024	0,025	0,025	0,024	0,024	0,025	0,025	0,024	0,025	0,024
1275	0,025	0,024	0,024	0,024	0,024	0,024	0,025	0,025	0,025	0,026	0,025
1325	0,024	0,024	0,024	0,024	0,024	0,024	0,025	0,025	0,024	0,025	0,024
1375	0,025	0,025	0,025	0,024	0,024	0,024	0,025	0,025	0,024	0,025	0,025
1425	0,025	0,024	0,024	0,024	0,024	0,025	0,025	0,025	0,024	0,025	0,025
1475	0,025	0,025	0,025	0,024	0,024	0,025	0,025	0,025	0,024	0,025	0,026
1525	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,025	0,026	0,026
1575	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026
1625	0,027	0,027	0,027	0,027	0,026	0,027	0,027	0,027	0,027	0,027	0,026
1675	0,027	0,027	0,027	0,027	0,026	0,027	0,027	0,027	0,027	0,027	0,026
1725	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,027
1775	0,029	0,028	0,029	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,030
1825	0,029	0,029	0,029	0,030	0,029	0,029	0,029	0,029	0,029	0,029	0,028
1875	0,029	0,028	0,027	0,028	0,029	0,028	0,028	0,028	0,028	0,029	0,028
1925	0,031	0,031	0,030	0,031	0,032	0,031	0,031	0,031	0,030	0,030	0,029
1975	0,030	0,030	0,030	0,030	0,030	0,030	0,031	0,030	0,030	0,030	0,028
Note:											

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Test: HESP4840S100-H											
Higher Frequencies											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2,1	0,128	0,128	0,131	0,090	0,073	0,082	0,094	0,102	0,114	0,132	0,149
2,3	0,114	0,114	0,110	0,081	0,063	0,069	0,079	0,085	0,093	0,108	0,122
2,5	0,099	0,099	0,096	0,073	0,065	0,066	0,072	0,081	0,089	0,102	0,114
2,7	0,092	0,093	0,094	0,069	0,065	0,062	0,074	0,083	0,088	0,100	0,112
2,9	0,092	0,090	0,091	0,076	0,067	0,067	0,077	0,087	0,092	0,102	0,113
3,1	0,091	0,089	0,088	0,074	0,077	0,075	0,079	0,087	0,092	0,100	0,109
3,3	0,093	0,092	0,092	0,083	0,086	0,082	0,085	0,090	0,093	0,101	0,108
3,5	0,096	0,095	0,095	0,089	0,090	0,087	0,090	0,095	0,097	0,101	0,108
3,7	0,097	0,096	0,097	0,093	0,094	0,093	0,097	0,100	0,100	0,103	0,107
3,9	0,096	0,095	0,095	0,097	0,102	0,098	0,099	0,100	0,098	0,098	0,101
4,1	0,094	0,093	0,095	0,100	0,103	0,100	0,099	0,100	0,098	0,097	0,097
4,3	0,089	0,089	0,089	0,096	0,101	0,100	0,098	0,099	0,101	0,095	0,092
4,5	0,084	0,084	0,083	0,093	0,100	0,095	0,097	0,100	0,090	0,093	0,086
4,7	0,090	0,091	0,091	0,100	0,111	0,114	0,121	0,118	0,119	0,124	0,127
4,9	0,075	0,077	0,075	0,081	0,090	0,100	0,089	0,090	0,090	0,095	0,093
5,1	0,071	0,071	0,072	0,077	0,088	0,084	0,088	0,090	0,089	0,095	0,091
5,3	0,068	0,067	0,069	0,075	0,092	0,083	0,083	0,083	0,083	0,092	0,091
5,5	0,065	0,063	0,062	0,072	0,074	0,086	0,079	0,074	0,077	0,090	0,083
5,7	0,061	0,058	0,057	0,070	0,064	0,082	0,077	0,076	0,078	0,089	0,081
5,9	0,056	0,050	0,054	0,068	0,057	0,077	0,061	0,063	0,065	0,080	0,074
6,1	0,057	0,050	0,057	0,058	0,052	0,066	0,062	0,059	0,059	0,071	0,066
6,3	0,055	0,046	0,054	0,047	0,046	0,054	0,065	0,051	0,053	0,058	0,057
6,5	0,053	0,042	0,053	0,045	0,043	0,046	0,065	0,051	0,057	0,051	0,054
6,7	0,052	0,043	0,049	0,043	0,039	0,041	0,060	0,065	0,069	0,046	0,055
6,9	0,044	0,037	0,040	0,040	0,040	0,042	0,055	0,065	0,064	0,048	0,048
7,1	0,043	0,053	0,039	0,036	0,035	0,037	0,042	0,059	0,059	0,041	0,045
7,3	0,041	0,034	0,037	0,034	0,034	0,036	0,038	0,046	0,045	0,041	0,046
7,5	0,036	0,032	0,035	0,033	0,034	0,037	0,038	0,036	0,036	0,037	0,040
7,7	0,034	0,032	0,036	0,034	0,034	0,037	0,035	0,034	0,035	0,036	0,038
7,9	0,028	0,028	0,031	0,029	0,031	0,036	0,033	0,034	0,033	0,034	0,036
8,1	0,028	0,029	0,031	0,029	0,030	0,034	0,032	0,033	0,033	0,033	0,034
8,3	0,026	0,028	0,029	0,027	0,029	0,033	0,032	0,031	0,031	0,031	0,033
8,5	0,025	0,029	0,029	0,027	0,028	0,029	0,030	0,029	0,030	0,030	0,031
8,7	0,024	0,029	0,026	0,028	0,028	0,029	0,029	0,029	0,029	0,030	0,031
8,9	0,024	0,029	0,026	0,029	0,028	0,028	0,029	0,029	0,028	0,028	0,030
Note:											

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4.8	**EMC and power quality** **Switching operation (Rapid voltage changes)**	**P**

The purpose of the test is to determine k_i and k_{imax}.

The following three cases must be tested (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity

  Note: For PV-plants the inverter is the generator
- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

If the manufacturer knows more critical cases (e.g. different cos φ parameters) then these additional have to be tested

Test conditions:

Frequency: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Test:

HESP4860S100-H

Switch-on for any capacity (10% PEmax)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	5,051	1,475	1,456	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,3	230,1	231,5	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,194	0,057	0,056	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,194								

Unfavourable case when switching the generator step (not necessary for electronic inverter)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	N/A								

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Switch-on for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	9,721	4,801	12,263	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	229,4	230,6	230,3	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,374	0,185	0,472	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,472								
Switch-off for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	26,438	26,243	26,497	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,2	231,0	230,5	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	1,017	1,009	1,019	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	1,019								

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	26,0
Highest k_{imax} value for all switching operations [1]	1,019

Note:

Limits:

k_{imax} = 1,2 for synchronous generators with fine synchronization, converter; (electronic inverter)

k_{imax} = 4 for asynchronous generators, which are switched on at 95% to 105% of their synchronous speed, if no further details are available regarding the type of current limitation. With regard to short-term compensation processes, the condition mentioned below for very short voltage changes must also be observed.

K_{imax} = 8 for asynchronous generators that are powered up by the network if I_a is unknown.

(I_a = starting current)

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4.8	**EMC and power quality** **Switching operation (Rapid voltage changes)**	**P**

The purpose of the test is to determine k_i and k_{imax}.

The following three cases must be tested (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity
  Note: For PV-plants the inverter is the generator
- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

If the manufacturer knows more critical cases (e.g. different cos φ parameters) then these additional have to be tested

Test conditions:

Frequency: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Test:

HESP4855S100-H

Switch-on for any capacity (10% PEmax)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	1,609	1,464	4,890	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,3	231,3	230,3	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,067	0,061	0,204	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,204								

Unfavourable case when switching the generator step (not necessary for electronic inverter)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	N/A								

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Switch-on for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	1,632	1,754	11,422	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,4	230,7	229,0	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,068	0,073	0,476	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,476								
Switch-off for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	22,019	22,033	22,340	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	231,6	231,3	231,0	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,917	0,918	0,931	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,931								

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	24,0
Highest k_{imax} value for all switching operations [1]	0,931

Note:

Limits:

k_{imax} = 1,2 for synchronous generators with fine synchronization, converter; (electronic inverter)

k_{imax} = 4 for asynchronous generators, which are switched on at 95% to 105% of their synchronous speed, if no further details are available regarding the type of current limitation. With regard to short-term compensation processes, the condition mentioned below for very short voltage changes must also be observed.

K_{imax} = 8 for asynchronous generators that are powered up by the network if I_a is unknown.

(I_a = starting current)

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4.8	**EMC and power quality** **Switching operation (Rapid voltage changes)**	**P**

The purpose of the test is to determine k_i and k_{imax}.

The following three cases must be tested (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity
  Note: For PV-plants the inverter is the generator
- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

If the manufacturer knows more critical cases (e.g. different cos φ parameters) then these additional have to be tested

Test conditions:

Frequency: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Test:

HESP4850S100-H

Switch-on for any capacity (10% PEmax)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	1,609	1,464	4,890	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,3	231,3	230,3	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,067	0,061	0,204	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,204								

Unfavourable case when switching the generator step (not necessary for electronic inverter)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	N/A								

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Switch-on for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	1,632	1,754	11,422	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,4	230,7	229,0	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,068	0,073	0,476	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,476								
Switch-off for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	22,019	22,033	22,340	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	231,6	231,3	231,0	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,917	0,918	0,931	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,931								

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	24,0
Highest k_{imax} value for all switching operations [1]	0,931

Note:

Limits:

k_{imax} = 1,2 for synchronous generators with fine synchronization, converter; (electronic inverter)

k_{imax} = 4 for asynchronous generators, which are switched on at 95% to 105% of their synchronous speed, if no further details are available regarding the type of current limitation. With regard to short-term compensation processes, the condition mentioned below for very short voltage changes must also be observed.

K_{imax} = 8 for asynchronous generators that are powered up by the network if I_a is unknown.

(I_a = starting current)

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4.8	**EMC and power quality** **Switching operation (Rapid voltage changes)**	**P**

The purpose of the test is to determine k_i and k_{imax}.

The following three cases must be tested (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity
  Note: For PV-plants the inverter is the generator
- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

If the manufacturer knows more critical cases (e.g. different cos φ parameters) then these additional have to be tested

Test conditions:

Frequency: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Test:

HESP4846S100-H

Switch-on for any capacity (10% PEmax)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	2,358	2,449	2,380	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,2	230,4	230,1	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,118	0,122	0,119	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,122								

Unfavourable case when switching the generator step (not necessary for electronic inverter)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	N/A								

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Switch-on for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	1,505	1,289	3,111	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,6	231,7	230,0	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,075	0,064	0,156	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,156								
Switch-off for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	20,701	20,796	19,807	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	231,7	230,1	230,5	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	1,035	1,040	0,990	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	1,040								

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	20,0
Highest k_{imax} value for all switching operations [1]	1,040

Note:

Limits:

k_{imax} = 1,2 for synchronous generators with fine synchronization, converter; (electronic inverter)

k_{imax} = 4 for asynchronous generators, which are switched on at 95% to 105% of their synchronous speed, if no further details are available regarding the type of current limitation. With regard to short-term compensation processes, the condition mentioned below for very short voltage changes must also be observed.

K_{imax} = 8 for asynchronous generators that are powered up by the network if I_a is unknown.

(I_a = starting current)

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4.8	**EMC and power quality** **Switching operation (Rapid voltage changes)**	**P**

The purpose of the test is to determine k_i and k_{imax}.

The following three cases must be tested (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity
  Note: For PV-plants the inverter is the generator
- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

If the manufacturer knows more critical cases (e.g. different cos φ parameters) then these additional have to be tested

Test conditions:

Frequency: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

Test:

HESP4840S100-H

Switch-on for any capacity (10% PEmax)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	2,206	2,491	2,642	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	231,0	230,5	230,1	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,127	0,143	0,152	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,152								

Unfavourable case when switching the generator step (not necessary for electronic inverter)

Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	N/A								

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Switch-on for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	3,079	3,177	2,951	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	230,9	230,8	230,8	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,177	0,183	0,170	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	0,183								
Switch-off for nominal capacity(100% PEmax)									
Phase	**L1**			**L2**			**L3**		
Single period effective values of the current [A]	11,656	17,458	18,177	N/A	N/A	N/A	N/A	N/A	N/A
Single period effective values of the voltage [V]	231,0	230,3	230,2	N/A	N/A	N/A	N/A	N/A	N/A
k_i value [1]	0,670	1,003	1,045	N/A	N/A	N/A	N/A	N/A	N/A
k_{imax} value [1]	1,045								

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	17,4
Highest k_{imax} value for all switching operations [1]	1,045

Note:

Limits:

k_{imax} = 1,2 for synchronous generators with fine synchronization, converter; (electronic inverter)

k_{imax} = 4 for asynchronous generators, which are switched on at 95% to 105% of their synchronous speed, if no further details are available regarding the type of current limitation. With regard to short-term compensation processes, the condition mentioned below for very short voltage changes must also be observed.

K_{imax} = 8 for asynchronous generators that are powered up by the network if I_a is unknown.

(I_a = starting current)

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4.8	Voltage fluctuation and flicker	P

Adherence to the thresholds for flicker must be verified as followed:

- For nominal currents ≤ 16 A per conductor to DIN EN 61000-3-3 (VDE 0838-3)
- For nominal currents > 16 A and ≤ 75 A per conductor to DIN EN 61000-3-11 (VDE 0838-11)

Test conditions:

Voltage: 86% U_n to 109% U_n

Frequency: 50 Hz ± 0,5%

THD of the voltage supply: ≤ 3 %

Voltage rise of the PGU at 100% P_{Emax}: ≤ 3 %

Test:

HESP4860S100-H

Flicker to DIN EN 61000-3-11 (VDE 0838-11) for generator units ≤ 75 A

Grid impedance DIN EN 61000-3-11 (VDE 0838-11) [Ω]:	R_A = 0,15Ω jX_A = 0,15Ω
Output voltage of the impedance network [V]	230V

Flicker to:	Result:				
	P_{lt}	P_{st}	dc%	d_{max}%	$d_{(t)}$
DIN EN 61000-3-11	0,16	0,16	0,14	0,26	0

Assessment criterion:

Long-term flicker strength Plt to DIN EN 61000-3-3 (VDE 0838-3) must be ≤ 0,5.

Determination of the flicker coefficient:

$$c_{\psi k} = P_{st} \times (S_k / P_n)$$

where S_k is the short-circuit power of the network standby element (during the determination of the appropriate P_{st} values)

The value for the network standby element must be determined separately with measurements for rated currents > 75 A.

Flicker for rated currents ≤75A to DIN EN 61000-3-11 (VDE 0838-11)

Grid impedance angle ψk	45°
Flicker coefficient c(ψk)	3.2

Assessment criterion:

Long-term flicker strength: P_{lt}≤0,5

Note:

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4.8	EMC and power quality DC-Injection	P

Test: HESP4860S100-H

Protection limit		Tested at four power levels limit 0,5% of $I_{AC;nom}$ (0,130A)			
Output power	**Phase**	~20%	~50%	75%	~100%
Average. test value [A]	**L1**	0,0303	0,0275	0,0460	0,0254
	L2	N/A	N/A	N/A	N/A
	L3	N/A	N/A	N/A	N/A

Test: HESP4855S100-H

Protection limit		Tested at four power levels limit 0,5% of $I_{AC;nom}$ (0,120A)			
Output power	**Phase**	~20%	~50%	75%	~100%
Average. test value [A]	**L1**	0,0086	0,0096	0,0135	0,0130
	L2	N/A	N/A	N/A	N/A
	L3	N/A	N/A	N/A	N/A

Test: HESP4850S100-H

Protection limit		Tested at four power levels limit 0,5% of $I_{AC;nom}$ (0,120A)			
Output power	**Phase**	~20%	~50%	75%	~100%
Average. test value [A]	**L1**	0,0086	0,0096	0,0135	0,0130
	L2	N/A	N/A	N/A	N/A
	L3	N/A	N/A	N/A	N/A

Test: HESP4846S100-H

Protection limit		Tested at four power levels limit 0,5% of $I_{AC;nom}$ (0,100A)			
Output power	**Phase**	~20%	~50%	75%	~100%
Average. test value [A]	**L1**	0,0145	0,0082	0,0110	0,0119
	L2	N/A	N/A	N/A	N/A
	L3	N/A	N/A	N/A	N/A

Test: HESP4840S100-H

Protection limit		Tested at four power levels limit 0,5% of $I_{AC;nom}$ (0,087A)			
Output power	**Phase**	~20%	~50%	75%	~100%
Average. test value [A]	**L1**	0,0082	0,0362	0,0111	0,0514
	L2	N/A	N/A	N/A	N/A
	L3	N/A	N/A	N/A	N/A

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Diagram of permanent dc-injection –HESP4860S100-H

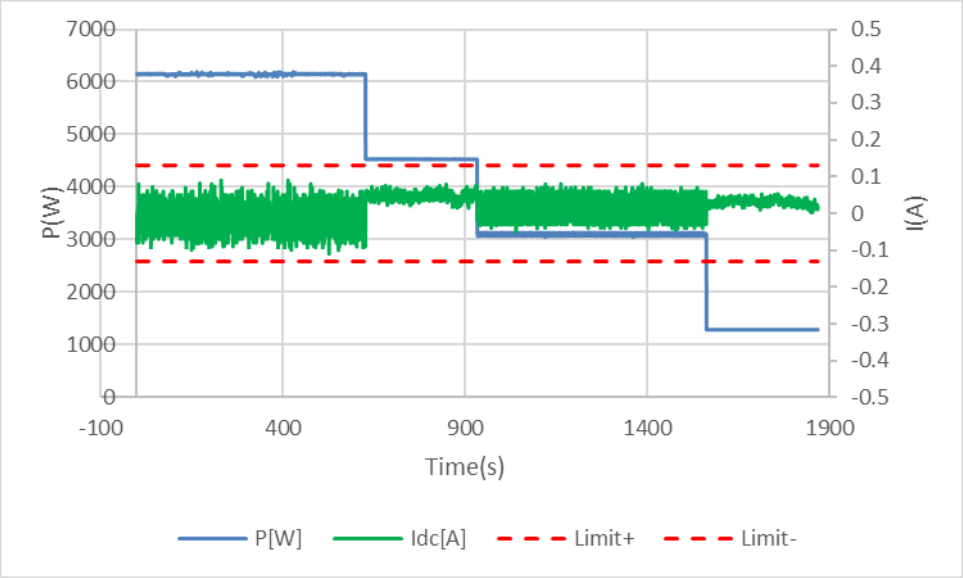


Diagram of permanent dc-injection –HESP4855S100-H

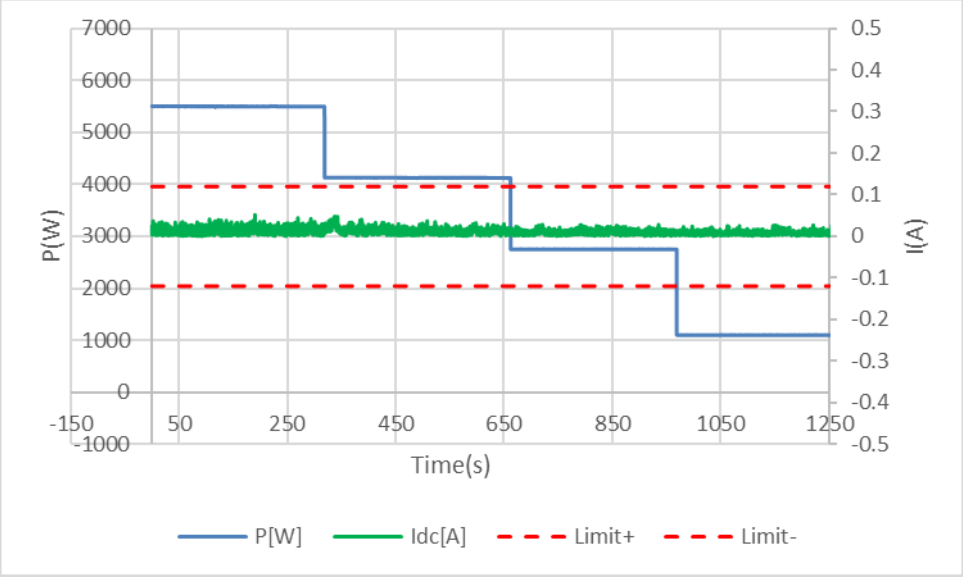


Diagram of permanent dc-injection –HESP4850S100-H

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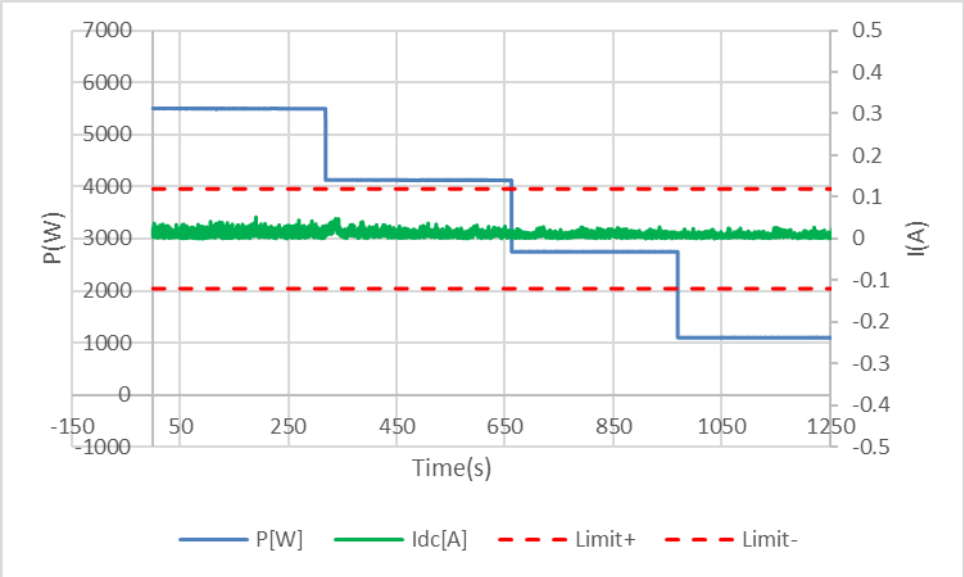


Diagram of permanent dc-injection –HESP4846S100-H

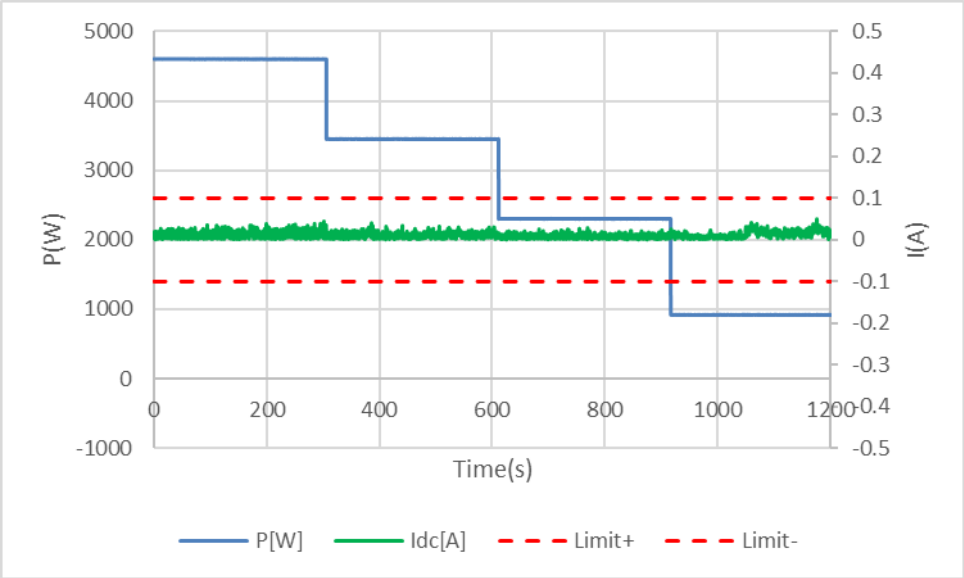
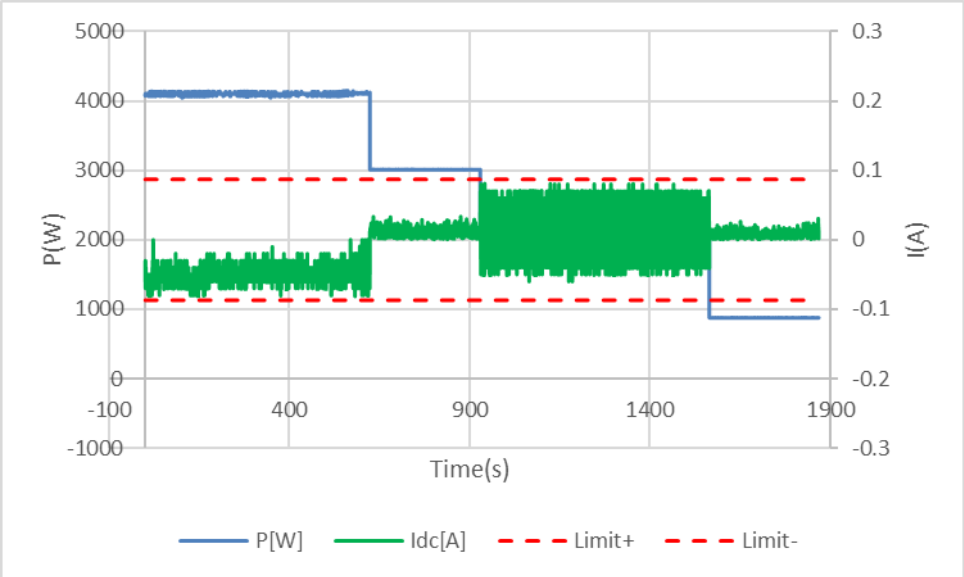


Diagram of permanent dc-injection –HESP4840S100-H

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4.8	Immunity to voltage dips and short interruptions				P
For machines with electro-magnetic output			For Inverter output		
Phase-L1					
Peak Short Circuit current	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	ip	N/A	20ms	26,56 V	0,242 A
Initial Value of aperiodic current	A	N/A	100ms	N/A	N/A
Initial symmetrical short-circuit current*	Ik	N/A	250ms	N/A	N/A
Decaying (aperiodic) component of short circuit current*	iDC	N/A	500ms	N/A	N/A
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	10,1 ms	In seconds
Phase-L2					
Peak Short Circuit current	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	ip	N/A	20ms	N/A	N/A
Initial Value of aperiodic current	A	N/A	100ms	N/A	N/A
Initial symmetrical short-circuit current*	Ik	N/A	250ms	N/A	N/A
Decaying (aperiodic) component of short circuit current*	iDC	N/A	500ms	N/A	N/A
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	N/A	In seconds
Phase-L3					
Peak Short Circuit current	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	ip	N/A	20ms	N/A	N/A
Initial Value of aperiodic current	A	N/A	100ms	N/A	N/A
Initial symmetrical short-circuit current*	Ik	N/A	250ms	N/A	N/A
Decaying (aperiodic) component of short circuit current*	iDC	N/A	500ms	N/A	N/A
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	N/A	In seconds

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EN 50549-1:2019: Interface protection			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.9.3	Requirements on voltage and frequency protection	CEI 0-21:2019-04, Annex A.3.1 to A.3.4	**P**
4.9.3.2	Undervoltage protection	EN 50438, Annex D.2.3	**P**
4.9.3.3	Overvoltage protection	EN 50438, Annex D.2.3	**P**
4.9.3.4	Overvoltage 10 min mean protection	EN 50438, clause 4.6.2	**P**
4.9.3.5	Underfrequency protection	EN 50438, Annex D.2.4	**P**
4.9.3.6	Overfrequency protection	EN 50438, Annex D.2.4	**P**
4.9.4.2	Means to detect island situation	IEC 62116:2014	**P**

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4.9.3	Requirements on voltage and frequency protection Checklist	P

Several points to check		
Clause 4.9.3.1 to 4.9.3.6	All thresholds must be adjustable	P

Voltage values						
Threshold	Stage 1 [27 <]			Stage 2 [27 <<]		
	Operate voltage	Operate time		Operate voltage	Operate time	
Range	0,2-1,0 U_n	0,1-100s		0,2-1,0 U_n	0,1-5s	
Steps	0,01 U_n	0,1 s		0,01 U_n	0,05s	
Threshold	Stage 1 [59 >]		Stage 2 [59 >>]		Overvoltage 10 min mean protection	
	Operate voltage	Operate time	Operate voltage	Operate time	Operate voltage	Operate time
Range	1,0-1,2 U_n	0,1-100s	1,0-1,3 U_n	0,1-5s	1,0-1,15 U_n	3s not adjustable
Steps	0,01 U_n	0,1s	0,01 U_n	0,05s	0,01 U_n	--

Frequency values				
Threshold	Stage 1 [81 <]		Stage 2 [81 <<]	
	Operate frequency	Operate time	Operate frequency	Operate time
Range	47,0-50,0Hz	0,1-100s	47,0-50,0Hz	0,1-5s
Steps	0,1 Hz	0,1 s	0,1 Hz	0,05s
Threshold	Stage 1 [81 >]		Stage 2 [81 >>]	
	Operate frequency	Operate time	Operate frequency	Operate time
Range	50,0-52,0Hz	0,1-100s	50,0-52,0Hz	0,1-5s
Steps	0,1 Hz	0,1 s	0,1 Hz	0,05s
4.9.2.6	Insensitive against 40ms frequency transients, so that the unit will not trip			P

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4.9.3 4.9.3.1	Requirements on voltage and frequency protection General (Interface protection: Over/under voltage) (Setting value refer EN 50438)	P

Test conditions	Output power: 6kW Frequency: 50+/-0,2Hz

HESP4860S100-H

Phase-L

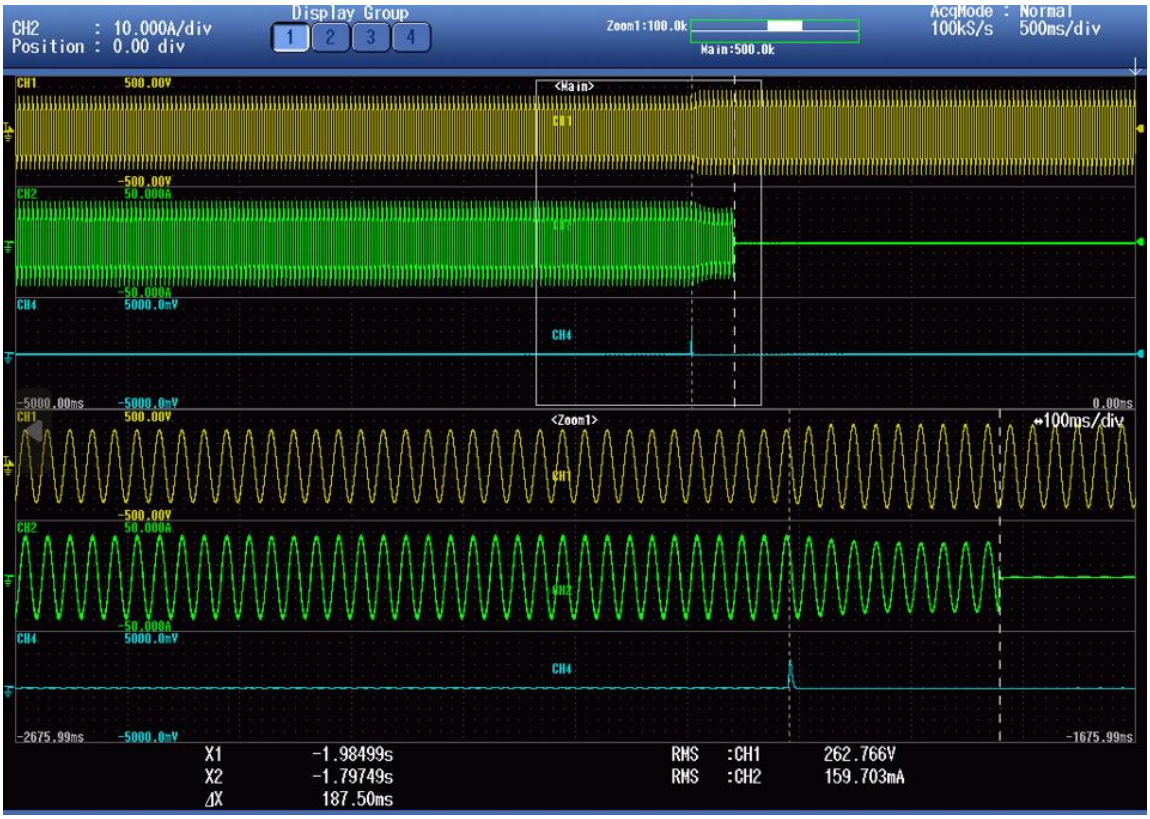
Limit [V]	Trip value [V]	Voltage step [V]	Disconnection time [s]	Limit [s]
115% of U_n = 264,5	264,7	230 to 269	0,186	0,1 ≤ t ≤ 0,2
	264,1	230 to 269	0,172	
	264,5	230 to 269	0,186	
	264,1	230 to 269	0,174	
	264,9	230 to 269	0,188	
85% of U_n = 195,5	194,2	230 to 190	1,384	1,2 ≤ t ≤ 1,5
	193,8	230 to 190	1,384	
	193,4	230 to 190	1,392	
	193,9	230 to 190	1,381	
	194,0	230 to 190	1,389	

Note:

The trip values were evaluated by varying the applied voltage from U_n down to $U_{th\text{-}low}$ - 2% of U_n in steps of 0,5% of U_n for under-voltage testing as well as from U_n up to $U_{th\text{-}high}$ + 2% of U_n in steps of 0,5% of U_n for over-voltage testing. Lower and upper threshold voltage shall not fall or rise below or above 2,3V of the trip value itself. The disconnection time was measured by application of a negative voltage step from U_n to the operate value -5% of U_n as well as positive voltage step from U_n to the operate value +5% of U_n.

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Scope pictures of the disconnection time
Over-voltage



Scope pictures of the disconnection time
Under-voltage



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4.9.3 Requirements on voltage and frequency protection **4.9.3.1 General** **(Maximum voltage 10 min mean protection according to EN 50160)** **(Setting value refer EN 50438 for default settings)**		**P**

Setting values of the protection:	Trip value Setting [V]	253
	Setting $T_{disconnection\ trip\ value}$ [s]	600
	Setting $T_{disconnection}$ [ms]	200

Test: HESP4860S100-H

		Disconnection time [s]	Limit [s]
a)	The voltage is set to 100% U_n and held for 600 s. Thereafter the voltage is set to 112% U_n. Disconnection must take place within 600 s.		
	Phase 1:	487,8	≤ 600 s
	Phase 2:	N/A	
	Phase 3:	N/A	
b)	The voltage is set to U_n for 600 s and then to 108% U_n for 600 s. No disconnection should take place.		
	Phase 1:	No Disconnection	Disconnection should not take place.
	Phase 2:	N/A	
	Phase 3:	N/A	
c)	The voltage is set to 106 % U_n and held for 600 s. Thereafter the voltage is set to 114 % U_n. The disconnection should last for half the period as in Point a)*		
	Phase 1:	279,6	The disconnection time should be about 50 % of the value measured in a). *
	Phase 2:	N/A	
	Phase 3:	N/A	

Test:

a) This test serves as proof of the measurement accuracy and the maximum set time.

b) This test serves as proof of the measurement accuracy.

c) This test serves as proof of the correct formation of the 1 minute running mean value.

Assessment criterion:

The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1 % of U_N.

Limit values:

Rise-in voltage protection 1,1 U_N after a max. 600 s, the switch off after 200 ms.

Note:

If only one integrated protection is used for the power generation systems, the value of the rise-in voltage protection of 1,1 U_N may not be changed.

*If the setting value is set to 600 s, then the disconnection time can be in the range between 225 s and 375 s.

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4.9.3 4.9.3.1	Requirements on voltage and frequency protection General (Interface protection: Over/under frequency) (Setting value refer EN 50438)				P
Test conditions	Output power: 6kW U_n = 230Vac				
	Under-frequency		**Over-frequency**		
Parameter	**Frequency**	**Time**	**Frequency**	**Time**	
Limit	47,50 Hz	0,3 ≤ t ≤ 0,5 s	52,00 Hz	0,3 ≤ t ≤ 0,5 s	
Trip value [Hz]	47,50		52,02		
	47,49		52,02		
	47,50		52,02		
	47,50		52,02		
	47,49		52,02		
Disconnection time [s]	50,00 Hz to 47,40 Hz	0,440	50,00 Hz to 52,10 Hz	0,422	
		0,421		0,420	
		0,416		0,423	
		0,415		0,412	
		0,425		0,411	

Note:

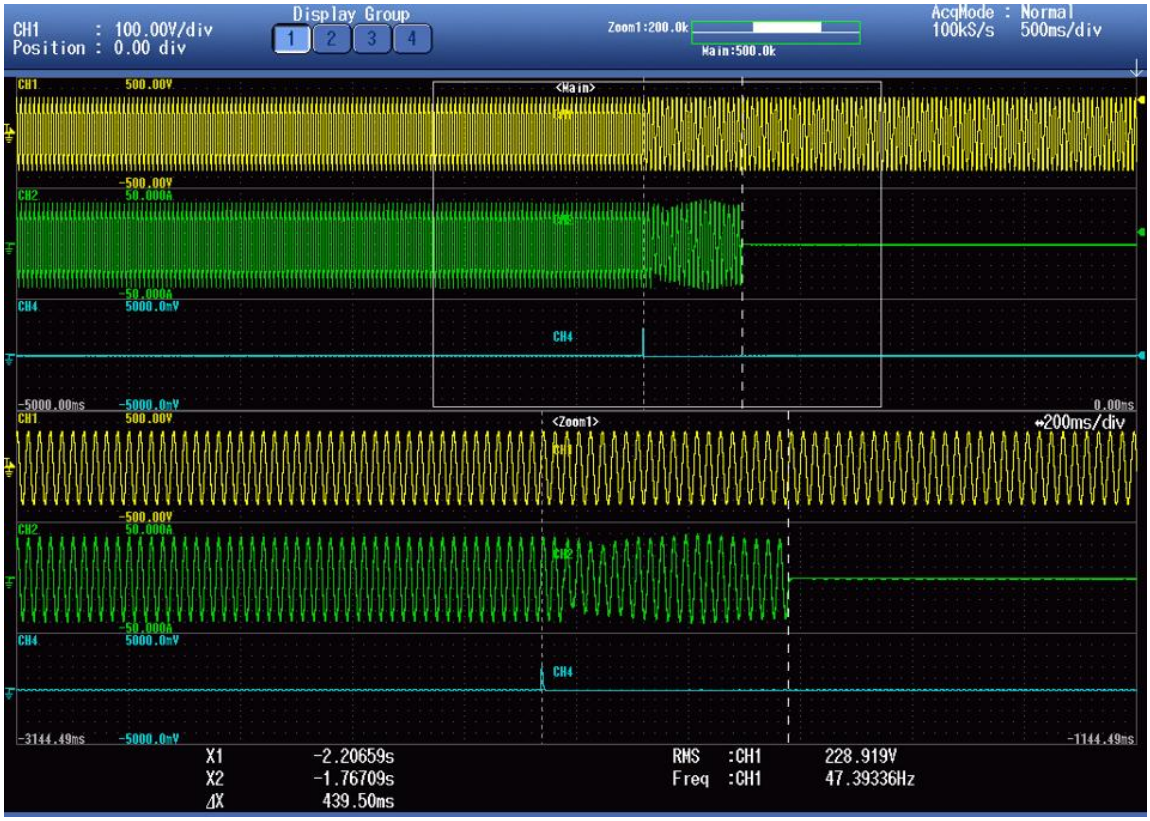
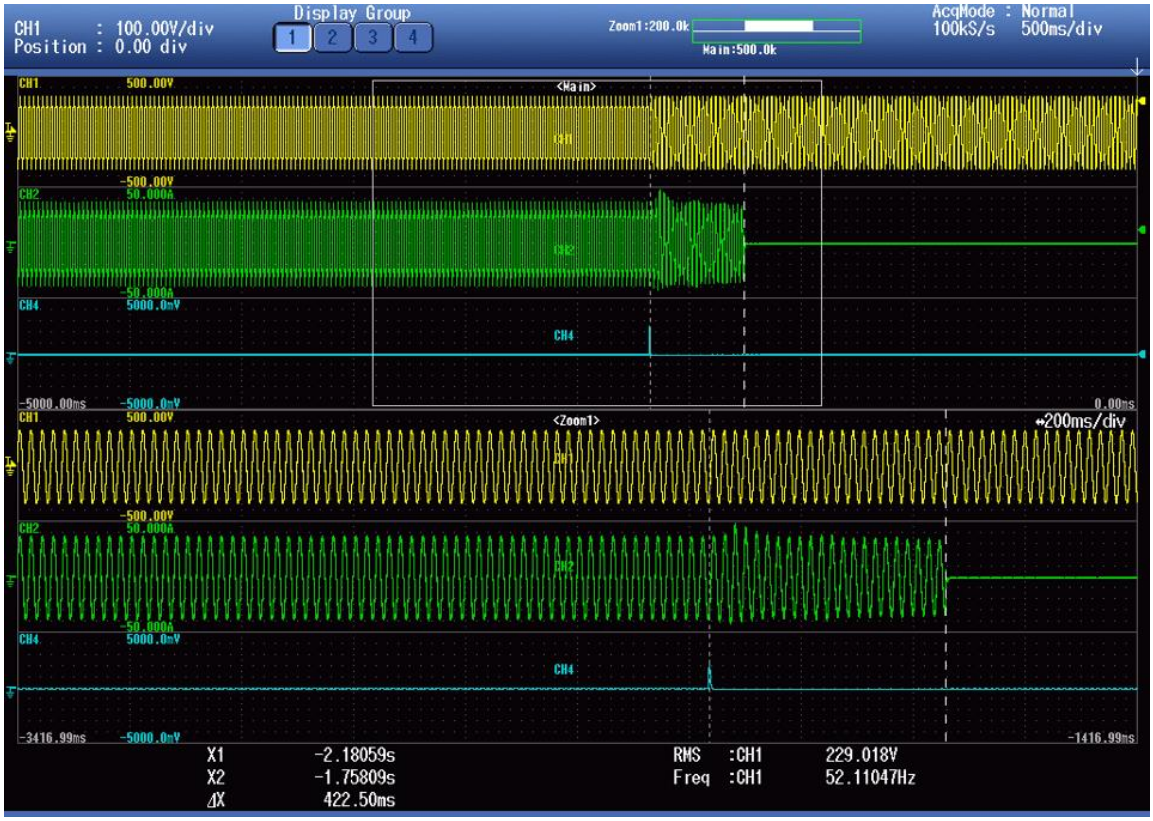
For under-frequency testing the applied frequency is varied from f_n down to $f_{th\text{-}low}$ -0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time. The operate value is the value of the applied frequency at switch the protection function trips and shall be within $f_{th\text{-}low}$ ± 0,05 Hz.

For over-frequency testing the applied frequency is varied from f_n up to $f_{th\text{-}high}$ + 0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time. The operate value is the value of the applied frequency at which the protection function trips and shall be within $f_{th\text{-}high}$ ± 0,05 Hz.

The disconnection time was measured by applying a negative or positive frequency ramp from f_n to the operate value -0,1 Hz or +0,1 Hz, e.g. from 50 Hz to 47,4 Hz. The time elapsed between the application of the frequency ramp and the opening of the interface switch was calculated by the measured time minus the 2500 ms from 50,0 Hz to 47,5 Hz.

The oscilloscope pictures below show the measured worst case disconnection times.

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Scope pictures of the disconnection time
Under-frequency

Over-frequency


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4.9.4.2 Loss of Mains (LoM) detection

Test circuit and parameters

Parameter	Symbol	Units
EUT DC Input		
DC voltage	V_{DC}	V
DC Current	I_{DC}	A
DC Power	P_{DC}	W
EUT AC ouput		
AC voltage	V_{EUT}	V
AC current	I_{EUT}	A
Real power	P_{EUT}	W
Reactive power	Q_{EUT}	VAr
Test Load		
Resistive load current	I_R	A
Inductive load current	I_L	A
Capacitive load current	I_C	A
AC (utility) power source		
Utility real power	P_{AC}	W
Utility reactive power	Q_{AC}	VAr
Utility current	I_{AC}	A

Block diagram test circuit IEC 62116:2014

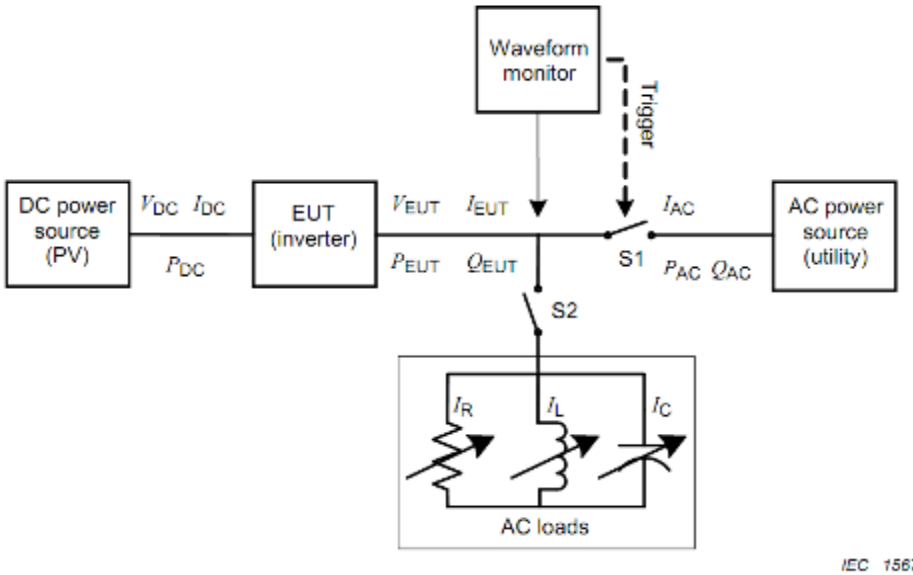


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

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Load imbalance (real, reactive load) for test condition A (EUT output = 100%)	**P**

Test : HESP4860S100-H

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality = 1
Disconnection limit	2s (IEC 62116)

No	P_{EUT} [1] [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) [1]	P_{AC} [2] [% of nominal]	Q_{AC} [3] [% of nominal]	I_{AC} [4] [A]	P_{EUT} [kW]	V_{DC} [V]	Q_f	Run on Time [s]	Remarks [5]
1	100	100	0	0	0.170	6	386	1,00	1,369	BL
2	100	100	-5	-5	--	6	386	1,02	0,909	IB
3	100	100	-5	0	--	6	386	1,05	0,827	IB
4	100	100	-5	+5	--	6	386	1,08	0,452	IB
5	100	100	0	-5	--	6	386	0,97	0,966	IB
6	100	100	0	+5	--	6	386	1,02	1,055	IB
7	100	100	+5	-5	--	6	386	0,93	0,431	IB
8	100	100	+5	0	--	6	386	0,95	0,803	IB
9	100	100	+5	+5	--	6	386	0,97	0,928	IB

Parameter at 0% per phase	L= 28,08 mH	R= 8,82 Ω	C= 361,22 µF

Note:

RLC is adjusted to min. +/-1% of the inverter rated output power

[1] P_{EUT}: EUT output power

[2] P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

[3] Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

[4] Fundamental of I_{AC} when RLC is adjusted

[5] BL: Balance condition, IB: Imbalance condition.

Condition A:

EUT output power P_{EUT} = Maximum [6]

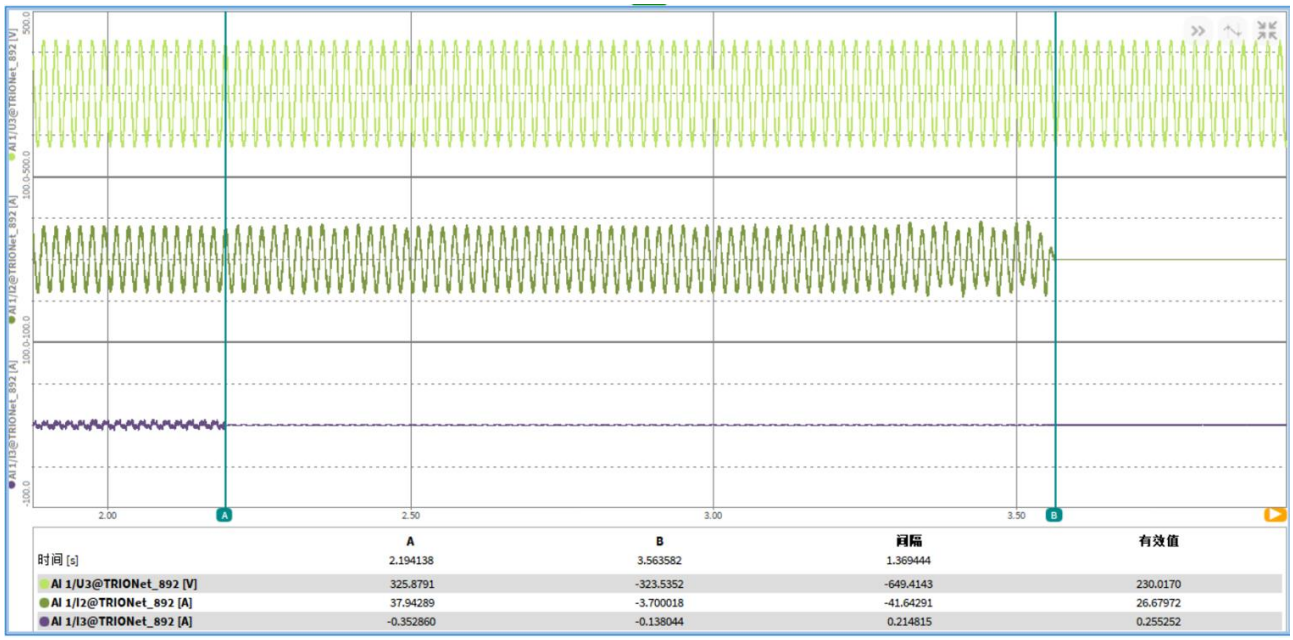
EUT input voltage [6] = >75% of rated input voltage range

[6] Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.

[7] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 75 % of range =X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

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Scope pictures of the disconnection time
Disconnection at No. 1



	A	B	间隔	有效值
时间 [s]	2.194138	3.563582	1.369444	
AI 1/U3@TRIONet_892 [V]	325.8791	-323.5352	-649.4143	230.0170
AI 1/I2@TRIONet_892 [A]	37.94289	-3.700018	-41.64291	26.67972
AI 1/I3@TRIONet_892 [A]	-0.352860	-0.138044	0.214815	0.255252

Note:
Yellow: Output voltage signal
Green: Output current signal
Purple: Trigger signal

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Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	**P**

Test : HESP4860S100-H

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	2s (IEC 62116)

No	P_{EUT} [1] [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) [1]	P_{AC} [2] [% of nominal]	Q_{AC} [3] [% of nominal]	I_{AC} [4] [A]	P_{EUT} [kW]	V_{DC} [V]	Q_f	Run on Time [s]	Remarks [5]
1	66	66	0	-5	--	3,97	289	0,97	0,112	IB
2	66	66	0	-4	--	3,97	289	0,97	0,128	IB
3	66	66	0	-3	--	3,97	289	0,98	0,132	IB
4	66	66	0	-2	--	3,97	289	0,98	0,147	IB
5	66	66	0	-1	--	3,97	289	0,99	0,194	IB
6	66	66	0	0	0,242	3,97	289	0,99	0,301	BL
7	66	66	0	+1	--	3,97	289	0,99	0,162	IB
8	66	66	0	+2	--	3,97	289	1,00	0,158	IB
9	66	66	0	+3	--	3,97	289	1,00	0,127	IB
10	66	66	0	+4	--	3,97	289	1,01	0,129	IB
11	66	66	0	+5	--	3,97	289	1,01	0,115	IB

Parameter at 0% per phase	L=	28,08	mH	R=	8,82	Ω	C=	361,22	µF

Note:

RLC is adjusted to min. +/-1% of the inverter rated output power

[1] P_{EUT}: EUT output power

[2] P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

[3] Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

[4] Fundamental of I_{AC} when RLC is adjusted

[5] BL: Balance condition, IB: Imbalance condition.

Condition B:

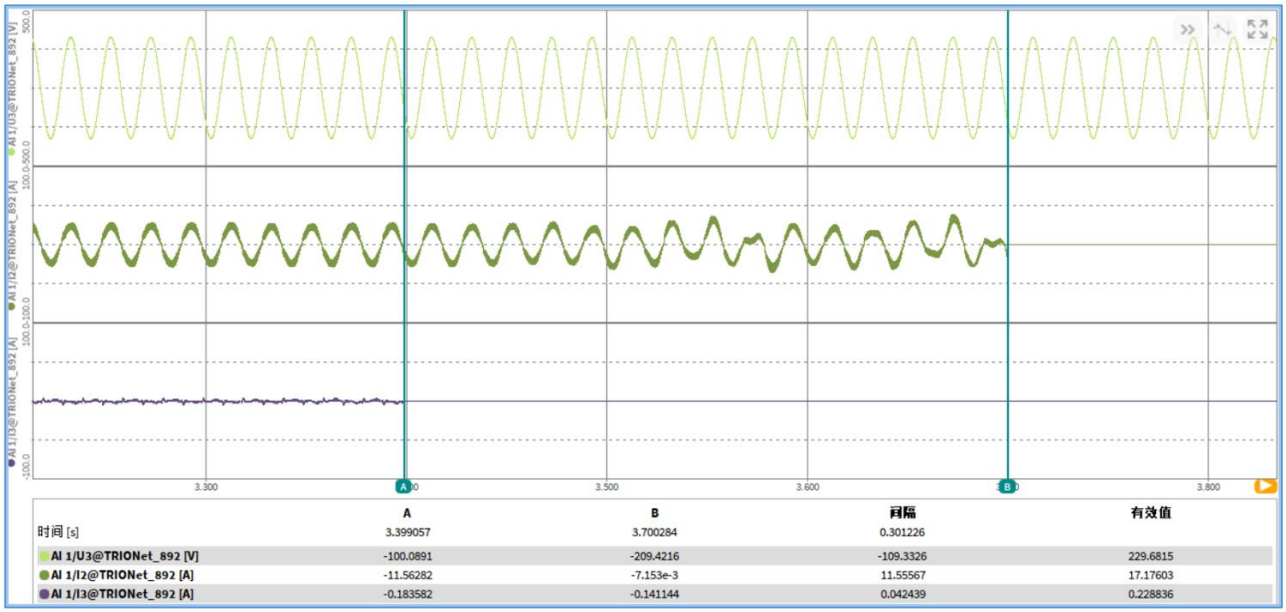
EUT output power P_{EUT} = 50 % – 66 % of maximum

EUT input voltage [6] = 50 % of rated input voltage range, ±10 %

[6] Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 50 % of range =X + 0,5 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

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Scope pictures of the disconnection time
Disconnection at No. 6



	A	B	间隔	有效值
时间 [s]	3.399057	3.700284	0.301226	
AI 1/U3@TRIONet_892 [V]	-100.0891	-209.4216	-109.3326	229.6815
AI 1/I2@TRIONet_892 [A]	-11.56282	-7.153e-3	11.55567	17.17603
AI 1/I3@TRIONet_892 [A]	-0.183582	-0.141144	0.042439	0.228836

Note:
Yellow: Output voltage signal
Green: Output current signal
Purple: Trigger signal

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Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %)	**P**

Test : HESP4860S100-H

Test conditions	Frequency: 50+/-0,1Hz U_N=230+/-3Vac Distortion factor of chokes < 2% Quality =1
Disconnection limit	2s (IEC 62116)

No	P_{EUT} 1) [% of EUT rating]	Reactive load [% of Q_L in 6.1.d) 1)	P_{AC} 2) [% of nominal]	Q_{AC} 3) [% of nominal]	I_{AC} 4) [A]	P_{EUT} [kW]	V_{DC} [V]	Q_f	Run on Time [s]	Remarks 5)
1	33	33	0	-5	--	1,98	177	0,97	0,093	IB
2	33	33	0	-4	--	1,98	177	0,98	0,115	IB
3	33	33	0	-3	--	1,98	177	0,98	0,114	IB
4	33	33	0	-2	--	1,98	177	0,99	0,124	IB
5	33	33	0	-1	--	1,98	177	0,99	0,157	IB
6	33	33	0	0	0,245	1,98	177	1,00	0,211	BL
7	33	33	0	+1	--	1,98	177	1,00	0,139	IB
8	33	33	0	+2	--	1,98	177	1,01	0,119	IB
9	33	33	0	+3	--	1,98	177	1,01	0,116	IB
10	33	33	0	+4	--	1,98	177	1,02	0,113	IB
11	33	33	0	+5	--	1,98	177	1,02	0,100	IB

Parameter at 0% per phase	L= 28,08 mH	R= 8,82 Ω	C= 361,22 µF

Note:

RLC is adjusted to min. +/-1% of the inverter rated output power

1) P_{EUT}: EUT output power

2) P_{AC}: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

4) Fundamental of I_{AC} when RLC is adjusted

5) BL: Balance condition, IB: Imbalance condition.

Condition B:

EUT output power P_{EUT} = 25 % – 33 % 6) of maximum

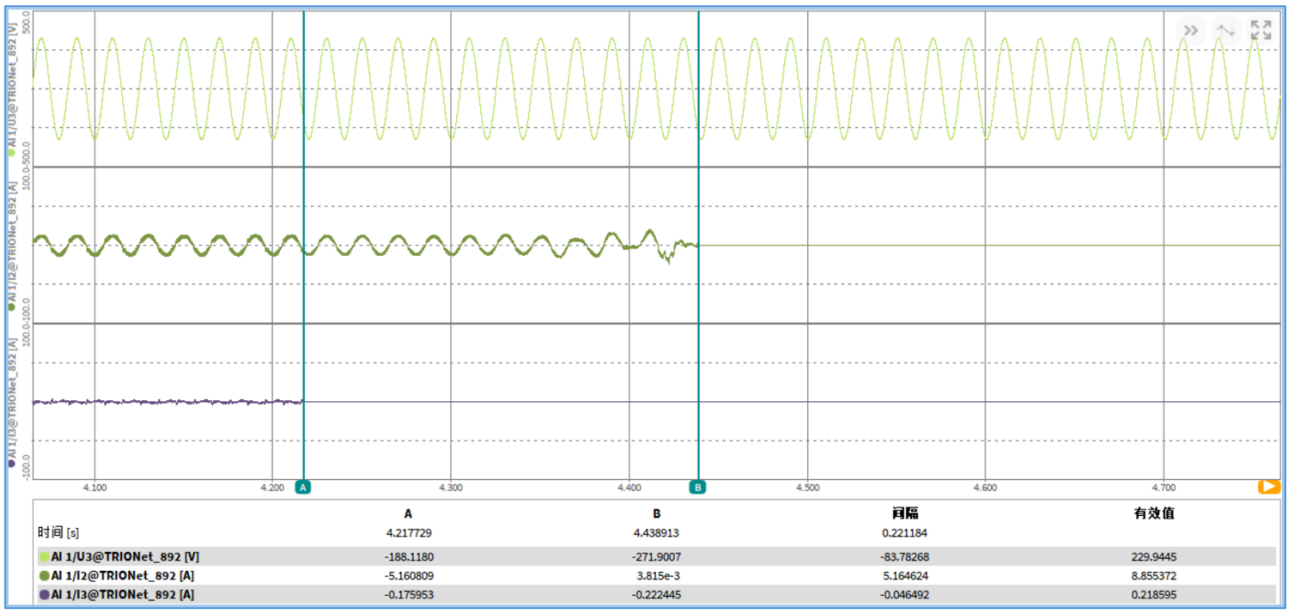
EUT input voltage 7) = <20 % of rated input voltage range

6) Or minimum allowable EUT output level if greater than 33 %.

7) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 20 % of range =X + 0,2 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range..

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Scope pictures of the disconnection time
Disconnection at No. 6



	A	B	间隔	有效值
时间 [s]	4.217729	4.438913	0.221184	
AI 1/U3@TRIONet_892 [V]	-188.1180	-271.9007	-83.78268	229.9445
AI 1/I2@TRIONet_892 [A]	-5.160809	3.815e-3	5.164624	8.855372
AI 1/I3@TRIONet_892 [A]	-0.175953	-0.222445	-0.046492	0.218595

Note:
Yellow: Output voltage signal
Green: Output current signal
Purple: Trigger signal

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EN 50549-1:2019: Connection and starting to generate electrical power			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.10.2	Automatic reconnection after trippin	EN 50438, Annex D.3.6	**P**
4.10.3	Starting to generate electrical power	EN 50438, Annex D.3.6	**P**

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4.10 Connection and starting to generate electrical power **4.10.2 Automatic reconnection after tripping** **4.10.3 Starting to generate electrical power**		**P**
Setting value	Min. voltage for connected to grid :	195,5
	Max. voltage for connected to grid :	253
	Min. Frequency for connected to grid :	49,5
	Max. voltage for connected to grid :	50,1
	Observation time (≥60s) :	60

Test:

	Voltage conditons	
a) Start up for voltage range	<84% Un for twice of observation time	>111% Un for twice of observation time
Connection:	No connection	No connection
Limit	No connection allowed	
b) In voltage range at start-up	≥84% Un within twice setting observation time	≤111% Un within twice setting observation time
Reconnection time [s]	64,3	67,2
Limit:	Connected after setting observation time (≥60s)	
Gradient:	The maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: 10%PEmax/min. For recorded gradient see diagram below.	
c) In voltage range after voltage failture	≥84% Un for twice of setting observation time	≤111% Un for twice of setting observation time
Reconnection time [s]	300,5	301,1
Limit:	Reconnection after setting observation time (≥60s)	
Gradient:	For adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: 10%P_{Emax}/min. For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	

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	Frequency conditions	
d) Start up for frequency range	<49,00 Hz for twice of setting observation time	>50,05 Hz for twice of setting observation time
Connection:	No connection	No connection
Limit	No connection allowed	
e) In frequency range at start-up	≥49,00 Hz within twice of setting observation time	≤50,05 Hz within twice of setting observation time
Reconnection time [s]	65,6	70,0
Limit:	Connected after setting delay time(≥60s)	
Gradient:	The maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: 10%P_{Emax}/min.. For recorded gradient see diagram below.	
f) In frequency range after frequency failture	≥49,00 Hz for twice of setting observation time	≤50,05 Hz for twice of setting observation time
Reconnection time [s]	302,8	305,0
Limit:	Reconnection after setting observation time (≥60s)	
Gradient:	For adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute Max gradient: 10%P_{Emax}/min. For non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	

Test:

Test condition b) and c): voltage within the limits of 85% to 110%U_n.

Test condition e): frequency within the limits of 49,5Hz to 50,1Hz.

Test condition f): frequency within the limits of 49,5Hz to 50,1Hz.

In order to avoid continuous starting and disengaging operations of the interface protection relay, the disengaging value of frequency and voltage functions shall be above 2 % deviating from the operate value.

Assessment criterion:

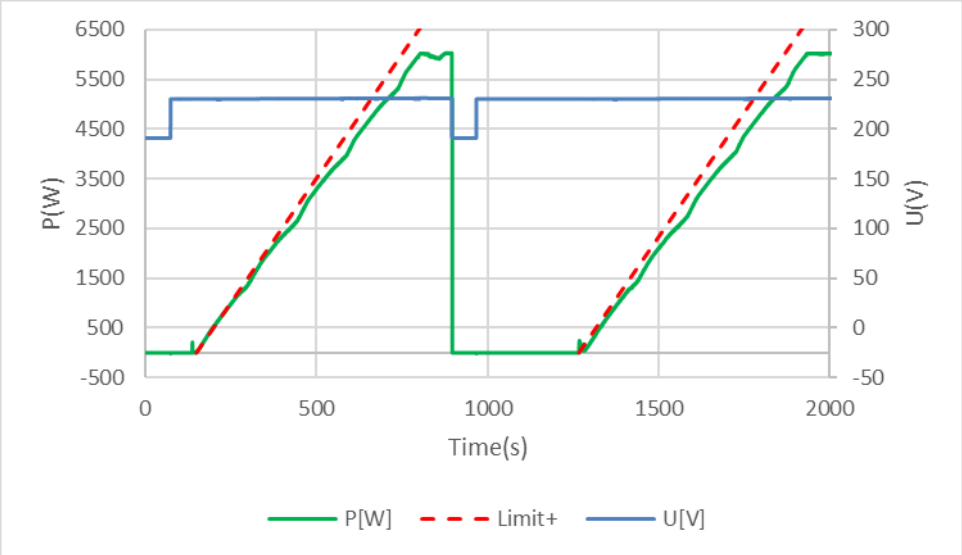
a) the micro generator connects respectively starts generating electrical power only in the permitted range of voltage and frequency and

b) for adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute and

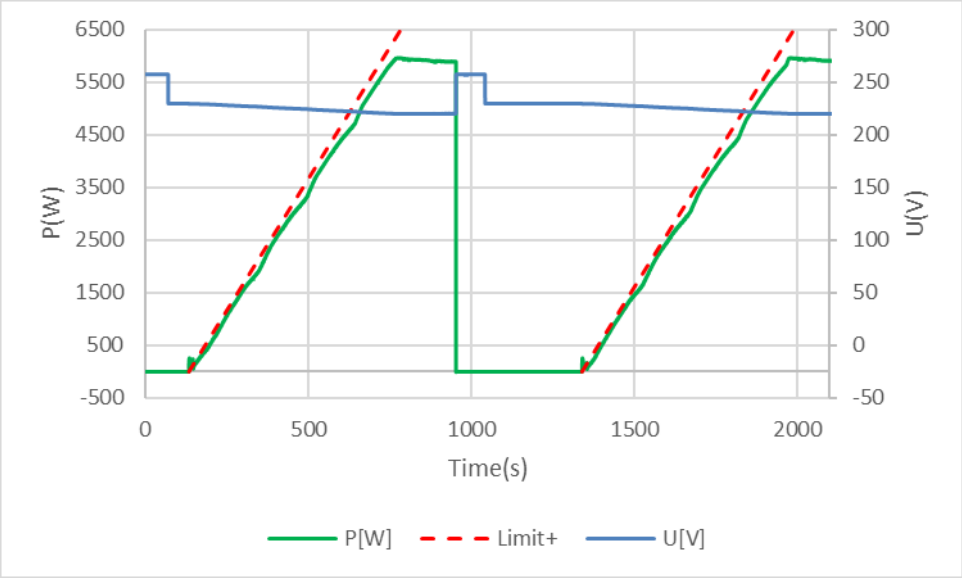
c) for non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min.

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Graph of the gradual power supply : Test b) for ≥ 84% U_n

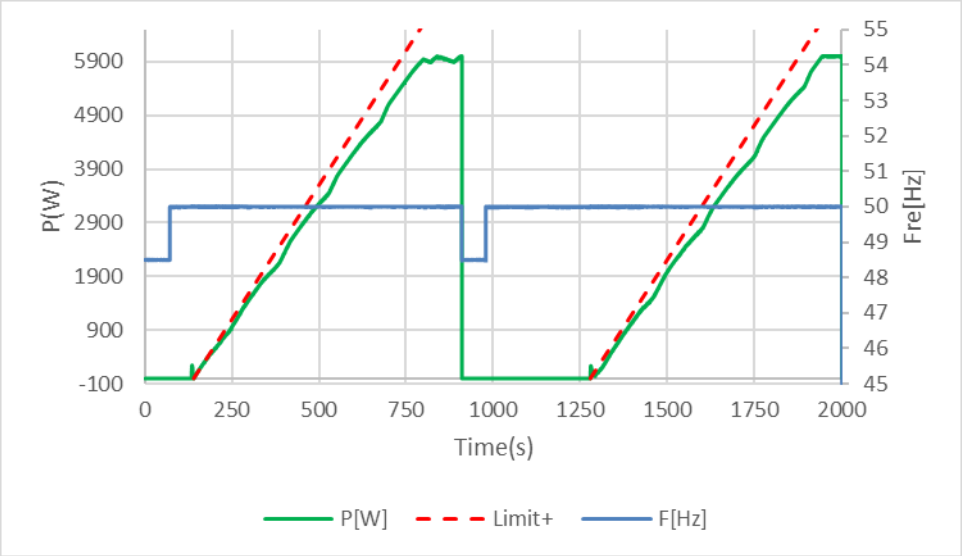


Graph of the gradual power supply : Test b) for ≤ 111% U_n

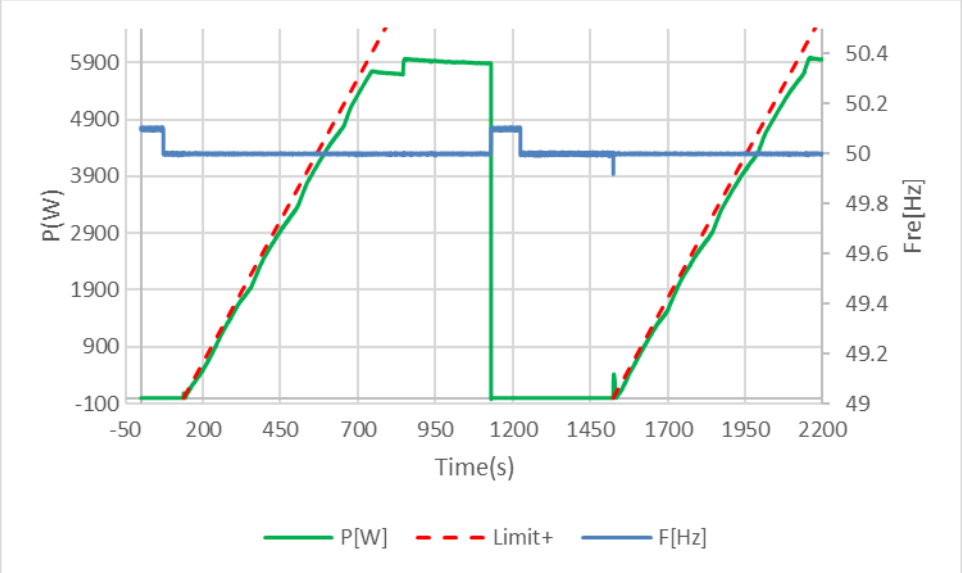


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Graph of the gradual power supply : Test e) for ≥ 49,00Hz



Graph of the gradual power supply : Test e) for ≤ 50,05Hz



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EN 50549-1:2019: Ceasing and reduction of active power on set point			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.11.1	Ceasing active power	CEI 0-21:2019-04, Annex A.4.3.3.2	**P**
4.11.2	Reduction of active power on a set point	FGW TG3, Revision 25, clause 4.1.2	**P**

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4.11.1 Ceasing active power	P

Operating time of the monitoring device	
Test:	Remote tripping signal for the external disconnection
Limit [s]:	5
Reaction time of the tripping value [ms]:	12,75



Note:

The test method refer to Annex A.4.3.2 of CEI 0-21:2019-04.
Generating plants shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port. If required by the DSO, this includes remote operation.

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4.11.2 Reduction of active power on set point			P
Test: HESP4860S100-H			
Setpoint power bin [%P_{Emax}]	P_{set} [W]	P_{60} [W]	Deviation [%P_{Emax}]
100%	6000	5979,851	-0,34
90%	5400	5375,675	-0,41
80%	4800	4776,073	-0,40
70%	4200	4181,954	-0,30
60%	3600	3481,423	-1,98
50%	3000	2994,578	-0,09
40%	2400	2402,72	0,05
30%	1800	1812,052	0,20
20%	1200	1217,778	0,30
10%	600	597,133	-0,05
0%	0	199,661	3,33

	Setpoint power bin [%P_{Emax}]	Deviation [%P_{Emax}]
Max. deviation	0%	3,33
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of P_{Emax}	

Test:

The setpoint signal must be reduced from 100% to 0% P_{Emax}:

a) for adjustable PGUs in increments of 10% P_{Emax}. 1 minute must elapse after every change to the setpoint setting so that the PGU can settle at the new setpoint. Then the active power of the PGU must be measured as a 1-min mean value.

b) For all other PGUs, in line with their adjustable steps. 5 minutes must elapse after the setpoint setting is changed so that the PGU can settle at the new setpoint. Then the active power of the PGU must be measured as a 1-min mean value.

Assessment criterion:

a) for adjustable PGUs:

- no network disconnection
- the active power value does not exceed the setpoint by more than 5% P_{Emax}
- the setting time determined this way is ≤ 1min

b) For all other PGUs:

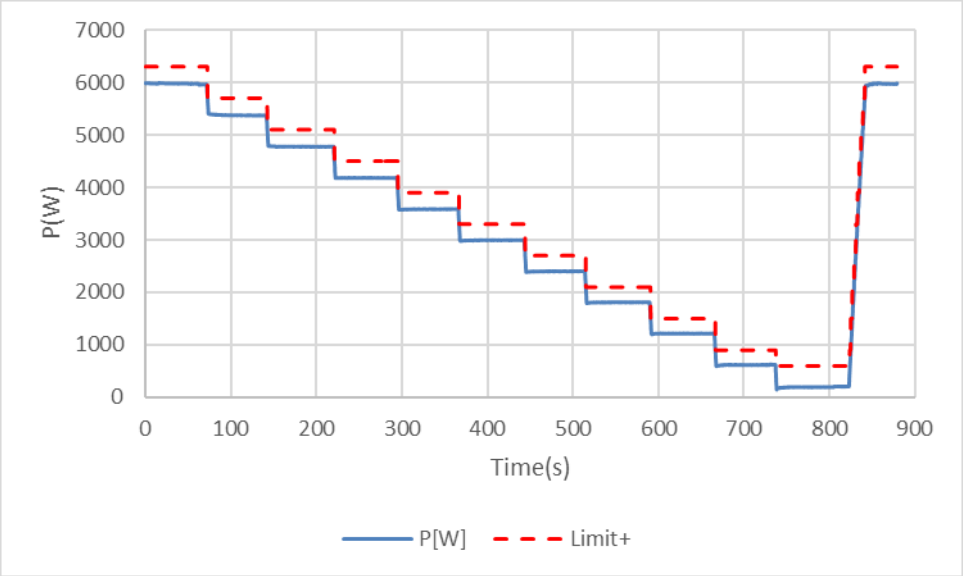
- the active power value does not exceed the setpoint by more than 5% P_{Emax} or
- the setpoint is fallen below within 5 minutes or the PGU has switched off

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Note:

The setting time is ≤ 1min. See below “Graph of the setting accuracy”.

Graph of active power on set point



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EN 50549-1:2019			
Clause	**Test requirement**	**Test procedure according standard**	**Result**
4.13	Requirements regarding single fault tolerance of interface protection system and interface switch	VDE V 0124-100:2020-06, clause 5.5.2	**P**

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4.13	Requirements regarding single fault tolerance of interface protection system and interface switch							P
Component No.	Fault	test voltage (V)		Test time	fuse No. (AC)	fuse current (A)		Result
		AC	DC			AC	DC	
Model: HESP4860S100-H								
U50 Pin 5-4 SC.	CPU1 Failure -Reset	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	EUT Shut down, No output power. No damage, No fire, No hazard
U51 Pin11-12 SC.	CPU2 Failure -Power	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	EUT Shut down, No output power. No damage, No fire, No hazard
U50 Pin 17-Pin22 SC.	AC voltage measure1	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down error message: AC Volt High. No damage, no hazard, no fire.
U50 Pin 16-Pin22 SC.	AC current measure	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down. error message: AC over current. No damage, no hazard, no fire.
U01 Pin 30-Pin22 SC.	PV voltage measure1	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down. Error massage: PV Volt High. No damage, no hazard, no fire.
U50 Pin 28-Pin22 SC.	Battery current measure	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down. Error massage: BAT Volt High. No damage, no hazard, no fire.
U50 Pin 14-Pin22 SC.	Load voltage detection	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down. Error massage: LOAD Volt High. No damage, no hazard, no fire.
U50 Pin 15-Pin22 SC.	Load current detection	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down. error message: LOAD over current. No damage, no hazard, no fire.
U50 Pin 15-Pin22 SC.	Temperature sampling	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down. error message: TEM error . No damage, no hazard, no fire.
U21 Pin 4-Pin8 SC.	Auxiliary auxiliary power port。	PV:450Vdc BAT:50Vdc AC:230Vac		1s	--	--	--	Unit shut down. No damage, no hazard, no fire.
Q12 SC.	Power transistor	PV:450Vdc BAT:50Vdc AC:230Vac		1sec	--	--	--	Unit shut down. error message: Bus Volt Low. No damage, no hazard, no fire.

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T2 Pin 4- 5 SC.	Transformer short circuit tests	PV:450Vdc BAT:50Vdc AC:230Vac	1h	--	--	--	Unit shut down. KF22 T2 damage, no hazard, no fire.
T2 Pin 7- 6 SC.		PV:450Vdc BAT:50Vdc AC:230Vac	1h	--	--	--	Unit shut down. KF22 T2 damage, no hazard, no fire.
T2 Pin 8- 9 SC.		PV:450Vdc BAT:50Vdc AC:230Vac	1h	--	--	--	Unit shut down. KF22 T2 damage, no hazard, no fire.
T2 Pin 9- 10 SC.		PV:450Vdc BAT:50Vdc AC:230Vac	1h	--	--	--	Unit shut down. KF22 T2 damage, no hazard, no fire.
Q48 Control terminal is connected to Power; SC.	power tube Boost	PV:450Vdc BAT:50Vdc AC:230Vac	1sec	--	--	--	Unit shut down. Error massage: PV Cur High Q60 damage, no hazard, no fire.
AC output	Output short circuit	PV:450Vdc BAT:50Vdc AC:230Vac	1sec	--	--	--	Unit shut down, error message: AC Cur High No damage, no hazard, no fire.
AC output	output overload 105% Load	PV:450Vdc BAT:50Vdc AC:230Vac	5min	--	--	--	Unit normal operation No damage ,no hazard ,no fire
Two DC source supply	Back feed current test for equipment with more than one source of supply	PV:450Vdc BAT:50Vdc AC:230Vac	2Hours	--	--	--	0A 0V
Fan1	Cooling system failure	PV:450Vdc BAT:50Vdc AC:230Vac	2Hours	--	--	--	Unit derating operation. No damage ,no hazard ,no fire
	Reverse d.c. connections	PV:450Vdc BAT:50Vdc AC:230Vac	3hours	--	--	--	Unit normal operation, output power reduce no damage, no hazard, no fire.
	Cooling system failure – Blanketing test	PV:450Vdc BAT:50Vdc AC:230Vac	3hours	--	--	--	Unit derating operation. No damage, no hazard, no fire.

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RLY 3	Short circuit	PV:450Vdc BAT:50Vdc AC:230Vac	10min	--	--	--	Unit shut down. error message:RlyShort No damage, no hazard, no fire.
GFCI monitoring R217	Short circuit	PV:450Vdc BAT:50Vdc AC:230Vac	10min	--	--	--	Unit shut down. error message:GFCI Fail No damage, no hazard, no fire.
Main CPU, U50	Open circuit R302	PV:450Vdc BAT:50Vdc AC:230Vac	10min	--	--	--	Unit shut down No damage, no hazard, no fire.
Slave CPU, U51	Open circuit R302	PV:450Vdc BAT:50Vdc AC:230Vac	10min	--	--	--	Unit shut down No damage, no hazard, no fire.

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Annex No. 1

Parameter table

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Scope of assessment and results

The following functionalities for type A in the list below have been assessed based on the rules for the use of equipment certificates for power park modules (PPMs), as specified in chapter 7 and 9 of the PTPiREE.

Note:

NC RFG = Commission Regulation (EU) 2016/631 of 14 April 2016 (NC RFG 2016-04-27)

PSE = Commission Regulation (EU) 2016/631 of 14 April 2016 approved by the Decision of the President of the Energy Regulatory Office DRE.WOSE.7128.550. 2.2018.ZJ of January 2, 2019 (PSE 2018-12-18)

Clause EN 50549-1	Ref	Parameter	Micro generator setting range	Default setting used for Poland
4.3.2 Interface switch	n.a.	Single fault tolerance for interface switch	yes | no	yes
4.4.2 Operating frequency range "PSE Article 13.1(a)(i)" Type A "NC RFG Article 13.1(a)" Type A"	A,B	47,0 – 47,5 Hz Duration	0 – 20 s	0s
	A,B	47,5 – 48,5 Hz Duration	30 – 90 min	≥30 min
	A,B	48,5 – 49,0 Hz Duration	30 – 90 min	≥30 min
	A,B	49,0 – 51,0 Hz Duration	not configurable	unlimited
	A,B	51,0 – 51,5 Hz Duration	30 – 90 min	≥30 min
	A,B	51, 5 – 52 Hz Duration	0 – 15 min	0 s
4.4.3 Minimal requirement for active power delivery at under frequency "PSE Article 13.4" Type A "NC RFG Article 13.4" Type A	A,B	Reduction threshold	49 Hz – 49,5 Hz	Electronic inverter no power reduction take place
	A,B	Maximum reduction rate	2 – 10 % P_M/Hz	≤ 2 %
4.4.4 Continuous operating voltage range	n.a.	Upper limit	100 – 110 %	1,15 U_n
	n.a.	Lower limit	90 – 100 %	0,85 U_n
4.5.2 Rate of change of frequency (ROCOF) immunity "PSE Article 13.1(b)" Type A "NC RFG Article 13.1(b)" Type A	A,B	ROCOF withstand capability (defined with a sliding measurement window of 500 ms) non-synchronous generating technology: synchronous generating technology:	0 – 10 Hz/s	max. ≥2,5 Hz/s
4.6.1 Power response to over frequency (LFSM-O) "PSE Article 13.2(a)(b)(f)" Type A "NC RFG Article 13.2" Type A	A,B	Threshold frequency f_1	50,2 Hz – 52 Hz	50,2 Hz
	A,B	Droop	2 % – 12 %	5 %
	A,B	Power reference	P_M | P_{max}	P_{max}
	n.a.	Intentional delay	0 – 2 s	0 s
	n.a.	Deactivation threshold fstop	50,0 Hz – f_1	deactivated
	n.a.	Deactivation time t_{stop}	0 – 600 s	N/A
	A	Acceptance of staged disconnection	yes | no	No

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4.6.2 Power response to under frequency (LFSM-U)	n.a.	Threshold frequency f_1	49,8 Hz – 46 Hz	N/A
	n.a.	Droop	2 – 12 %	N/A
	n.a.	Power reference	P_M | P_{max}	N/A
	n.a.	Intentional delay	0 – 2 s	N/A
4.7.2.2 Capabilities	B	Active factor range overexcited	0,9 – 1	0,9
	B	Active factor range underexcited	0,9 – 1	0,9
4.7.2.3 Control modes "IRiESD: Reactive power control requirements"	n.a.	Enabled control mode	Q setp. Q(U) cos φ setp. cos φ (P)	activated deactivated activated deactivated
4.7.2.3.2 Set point control modes	n.a.	Q setpoint and excitation	0 – 48 % P_D	0
	n.a.	cos φ setpoint and excitation	1 – 0,9	1
4.7.2.3.3 Voltage related control modes	n.a.	Characteristic curve	Q(U) P(U)	Q(U) (three phase inverter Type A) 0,5…0,0 1,06…0,0 1,08…0,436 1,2…0,436 P(U) deactivated
	n.a.	Time constant	3 s – 60 s	10 s
	n.a.	Min cos φ	0,0 – 1	0,9
	n.a.	Lock in power	0 % – 20 %	deactivated
	n.a.	Lock out power	0 % – 20 %	deactivated
4.7.2.3.4 Power related control mode	n.a.	Characteristic curve	cos φ (P)	deactivated
4.7.4.2.2 Zero current mode for converter connected generating technology	n.a.	Enabling	enable | disable	disabled
	n.a	Static voltage range overvoltage	1,0 U_n – 1,2 U_n	N/A
	n.a	Static voltage range undervoltage	0,2 U_n – 1,0 U_n	N/A

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4.9.2 Requirements on voltage and frequency protection "IRiESD (Instrukcja Ruchu i Eksploatacji Sieci Dystrybucyjnej, 9.1.3 Wymagania w zakresie wyposażenia mikroinstalacji w układ zabezpieczeń)"	n.a	Threshold for protection as dedicated device [in A or kW, kVA]	8 A	Internal safety device
	B	Undervoltage threshold stage 1	0,2 U_n – 1 U_n	0,85 U_n
	B	Undervoltage operate time stage 1	0,1 s – 100 s	1,2 s
	B	Undervoltage threshold stage 2	0,2 U_n – 1 U_n	N/A
	B	Undervoltage operate time stage 2	0,1 s – 100 s	N/A
	B	Overvoltage threshold stage 1	1,0 U_n – 2,0 U_n	1,15 U_n
	B	Overvoltage operate time stage 1	0,1 s – 100 s	0,1 s
	B	Overvoltage threshold stage 2	1,0 U_n – 2,0 U_n	N/A
	B	Overvoltage operate time stage 2	0,1 s – 100 s	N/A
	B	Overvoltage threshold 10 min mean protection[a]	1,0 U_n – 2,0 U_n	1,1 U_n
	B	Overvoltage operate time 10 min mean protection[a]	0,04 – 10 s	10 min (update every 3 s)
	B	Underfrequency threshold stage 1	44,0 Hz – 50,0 Hz	47,5 Hz
	B	Underfrequency operate time stage 1	0,1 s – 100 s	0,3 s
	B	Underfrequency threshold stage 2	44,0 Hz – 50,0 Hz	N/A
	B	Underfrequency operate time stage 2	0,1 s – 1000 s	N/A
	B	Overfrequency threshold stage 1	50,0 Hz – 66,0 Hz	52,0 Hz
	B	Overfrequency operate time stage 1	0,1 s – 1000 s	0,3 s
	B	Overfrequency threshold stage 2	50,0 Hz – 66,0 Hz	N/A
	B	Overfrequency operate time stage 2	0,1 s – 1000 s	N/A
	B	Loss of mains according EN 62116 (LoM)	0-6000s	ROCOF 2,5 Hz/s (0,5 s) aktive 2 s (5 s)
4.10.2 Automatic reconnection after tripping "PSE Article 13.7" Type A "NC RFG Article 13.7" Type A	B	Lower frequency	47,0 Hz – 50,0 Hz	49,00 Hz
	B	Upper frequency	50,0 Hz – 52,0 Hz	50,05 Hz
	B	Lower voltage	0,5 U_n – 1,0 U_n	0,85 U_n
	B	Upper voltage	1,0 U_n – 1,2 U_n	1,10 U_n
	B	Observation time	10 s – 600 s	60 s
	B	Active power increase gradient	1 % – 10000 %/min	9 %/min
4.10.3 Starting to generate electrical power "PSE Article 13.7" Type A "NC RFG Article 13.7" Type A	A,B	Lower frequency	47,0 Hz – 50,0 Hz	49,00 Hz
	A,B	Upper frequency	50,0 Hz – 52,0 Hz	50,05 Hz
	A,B	Lower voltage	0,5 U_n – 1,0 U_n	0,85 U_n
	A,B	Upper voltage	1,0 U_n – 1,2 U_n	1,10 U_n
	A,B	Observation time	10 s – 600 s	60 s
	A,B	Active power increase gradient	1 % – 10000 %/min	9 %/min
4.11.1 Ceasing active power "PSE Article 13.6, Type A	A,B	Remote operation of the logic interface	yes | no	yes Modbus signal via RS485 can be used to change or cease active power output. For RS485.

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"NC RfG Article 13.6" Type A "IRiESD: Requirements for equipping micro-installations with active power regulation"				
4.11.2 Reduction of active power on set point "PSE Article 13.6 Type A "NC RFG Article 13.6" Type A "IRiESD (Instrukcja Ruchu i Eksploatacji Sieci Dystrybucyjnej, 9.1.2. Wymagania w zakresie wyposazenia mikroinstalacji w regulacje mocy czynnej)"	B	Remote operation NOTE: If yes further definition is provided by the DSO	yes | no	yes Modbus signal via RS485 can be used to change or cease active power output. For RS485.
4.12 Remote information exchange	B	Remote information exchange required NOTE: If yes further definition is provided by the DSO.	yes | no	no

Attention:

[a] Overvoltage degree - 1: 10 min - the average value corresponds to the EN 50160 standard.

The default interface setting is used according to the TNC (Distribution Network Operation and Maintenance Manual).

Standard EN 50549-1: 2019, PN-EN 50549-1 based on

- **Commission Regulation** (EU) 2016/631 of 14 April 2016 establishing a network code on the requirements for connecting generating units to the network (Journal of Laws UE L 112/1 of 27.4.2016), requirements for power generating modules of type A (NC RFG 2016-04-27)

- **General Application Requirements** resulting from the **Commission Regulation** (EU) 2016/631 of April 14, 2016 establishing a network code on the requirements for connecting generating units to the grid (NC RfG) - approved by the Decision of the President of the Energy Regulatory Office DRE.WOSE.7128.550. 2.2018.ZJ of 2 January 2019 (PSE 2018-12-18).

The interface protection settings are password protected and can be adjusted within the above-mentioned range.

If the above-mentioned generating units are used with an external protection device, the protection settings of the inverters must be adjusted in accordance with the manufacturer's declaration.

Any modifications affecting the tests must be indicated by the manufacturer / supplier of the product to ensure that the product meets all requirements.

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Scope and functionality assessment based on the rules for the application of equipment certificates for Power Park Modules (PPMs), as set out in Chapters 7 and 9 of PTPiREE document 2021-04 /B/.

NC RfG = Commission Regulation (EU) 2016/631 of 14 April 2016.

PSE 2018 = Commission Regulation (EU) 2016/631 of 14 April 2016 approved by decision of the President of the Energy Regulatory Office DRE.WOSE.7128.550.2.2018.ZJ of 2 January 2019. (PSE 2018-12-18)

Parameter	NC RfG	WOS	Typ A	Typ B	Typ C	Typ D	Ocena (**)
Operating range	13.1 a)	13.1 a), i	x				Pass
Withstand to rate of change of frequency (ROCOF) df/dt	13.1 b)	13.1 b)	x				Pass
Remote cessation of active power generation	13.6	13.6	x		N/A	N/A	Pass
Remote control of active power	14.2	14.2 b)	N/A		N/A	N/A	N/A
Generation module operating mode, in which the generated active power decreases in response to an increase in the system frequency above a certain value (LFSM-O)	13.2 (*)	13.2 a), b), f)	x				Pass
Generation module operation mode, in which the generated active power increases as a result of the system frequency falling below a certain value (LFSM-U)	15.2 c)	15.2 c), i	N/A	N/A			N/A
Ability to withstand voltage dips for connections below 110 kV	14.3	14.3 a), i, b)	N/A				N/A
Ability to withstand voltage dips for connections above 110 kV	16.3	16.3 a), i, c)	N/A	N/A	N/A		N/A
Introduction of fast fault current, symmetrical and asymmetrical disturbances	20.2 b), c) 21.3 e)	20.2 b), c) 21.3 e)	N/A				N/A
Non-interference recovery of active power	20.3	20.3 a)	N/A				N/A

(*) Paragraph 13.2.(b) only applies to Type A PPMs in accordance with NC RfG.

(**) The “Pass” mark only applies to Power Park Modules (PPMs) of a type that is clearly indicated on the first page of the Certificate of Conformity (Equipment intended for operation with a generating unit of the type).

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Annex No. 2

Datasheet of the relay

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Datasheet of the relay:

HF36F SUBMINIATURE INTERMEDIATE POWER RELAY

c UL us
File No.:E134517

File No.:R50356442

CQC
File No.:CQC18002199981
CQC16002159838



Features

- 10A switching capability
- TV-5 125VAC approved by UL standard (only for 1 Form A)
- Plastic sealed and flux proofed types available
- 1 Form A and 1 Form C configurations

RoHS compliant

CONTACT DATA

Contact arrangement	1A ,1C
Contact resistance 1)	100mΩ max.(at 1A 6VDC)
Contact material	$AgSnO_2$, AgCdO
Contact rating	10A 250VAC 10A 30VDC TV-5 125VAC
Max. switching voltage	250VAC / 30VDC
Max. switching current	10A
Max. switching power	2500VA / 300W
Mechanical endurance	1 x 10^7 OPS
Electrical endurance	5 x 10^4OPS (10A 250VAC, Resistive load, Room temp., 1s on 9s off)

Notes: 1) The data shown above are initial values.

CHARACTERISTICS

Insulation resistance		1000MΩ (at 500VDC)
Dielectric strength	Between coil & contacts	NO: 4000VAC 1min NC: 3000VAC 1min
	Between open contacts	1000VAC 1min
Operate time (at rated. volt.)		15ms max.
Release time (at rated. volt.)		5ms max.
Humidity		5% to 85% RH
Ambient temperature		-40˚C to 70˚C
Shock resistance	Functional	196m/s²
	Destructive	980m/s²
Vibration resistance		10Hz to 55Hz 1.5mm DA
Termination		PCB
Unit weight		Approx.12g
Construction		Plastic sealed, Flux proofed

Notes: 1) The data shown above are initial values.
2) Please find coil temperature curve in the characteristic curves below.
3) UL insulation system: Class A.

COIL

Coil power	Standard: Approx. 530mW; Sensitive: Approx. 250mW

COIL DATA at 23˚C

Standard type

Nominal Voltage VDC	Pick-up Voltage VDC max.1)	Drop-out Voltage VDC min.1)	Max. Voltage VDC *2)	Coil Resistance Ω
5	3.75	0.25	6.5	47 x (1±10%)
6	4.50	0.30	7.8	68 x (1±10%)
9	6.75	0.45	11.7	155 x (1±10%)
12	9.00	0.60	15.6	270 x (1±10%)
18	13.5	0.90	23.4	620 x (1±10%)
24	18.0	1.20	31.2	1080 x (1±10%)
48	36.0	2.40	62.4	4400 x (1±10%)

Sensitive type (Only for 1 Form A)

Nominal Voltage VDC	Pick-up Voltage VDC max.1)	Drop-out Voltage VDC min.1)	Max. Voltage VDC *2)	Coil Resistance Ω
5	3.75	0.25	6.5	100 x (1±10%)
6	4.50	0.30	7.8	145 x (1±10%)
9	6.75	0.45	11.7	325 x (1±10%)
12	9.00	0.60	15.6	575 x (1±10%)
18	13.5	0.90	23.4	1300 x (1±10%)
24	18.0	1.20	31.2	2310 x (1±10%)

Notes: 1) The data shown above are initial values.
2)*Maximum voltage refers to the maximum voltage which relay coil could endure in a short period of time.

SAFETY APPROVAL RATINGS

UL/CUL	1 Form C	10A 250VAC 10A 30VDC
	1 Form A	10A 250VAC 10A 30VDC TV-5 125VAC
TÜV		10A 250VAC COSØ =1 10A 30VDC L/R=0

Notes: 1) All values unspecified are at room temperature.
2) Only typical loads are listed above. Other load specifications can be available upon request.

HONGFA RELAY
ISO9001, IATF16949 , ISO14001, ISO45001, IECQ QC 080000 CERTIFIED 2023 Rev. 1.00

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HF32FA SUBMINIATURE INTERMEDIATE POWER RELAY

c UL us
File No.:E134517

File No.:40006182

File No.:CQC17002175721



Features

- 5A switching capability
- Creepage/clearance distance>8mm
- 5kV dielectric strength (between coil and contacts)
- 1 Form A meets VDE 0700, 0631 reinforce insulation
- 1 Form C meets VDE 0631 reinforce insulation
- UL insulation system: Class F
- Product in accordance to IEC 60335-1 available

RoHS compliant

CONTACT DATA

Contact arrangement	1A, 1C	
Contact resistance 1)	70mΩ max.(at 1A 6VDC)	
Contact material	AgNi	
Contact rating (Res. Load)	1A	1C
	Standard/Sensitive	Standard
	5A 250VAC 5A 30VDC	3A 250VAC 3A 30VDC
Max. switching voltage	250VAC / 30VDC	
Max. switching current	5A	
Max. switching power	1250VA / 150W	
Mechanical endurance	1 x 10^6 OPS	
Electrical endurance	H type: 1 x 10^5 OPS (5A 250VAC, Resistive load, Room temp., 1.5s on 1.5s off) Z type: 1 x 10^5 OPS (NO/NC, 3A 250VAC, Resistive load, Room temp., 1.5s on 1.5s off)	

Notes: 1) The data shown above are initial values.

CHARACTERISTICS

Insulation resistance		1000MΩ (at 500VDC)
Dielectric strength	Between coil & contacts	5000VAC 1min
	Between open contacts	1000VAC 1min
Operate time (at rated. volt.)		8ms max.
Release time (at rated. volt.)		4ms max.
Humidity		5% to 85% RH
Ambient temperature		-40°C to 85°C
Shock resistance*	Functional	98m/s²
	Destructive	980m/s²
Vibration resistance*	NO	10Hz to 55 Hz 1.65mm DA
	NC	10Hz to 55 Hz 0.6mm DA
Termination		PCB
Unit weight		Approx.4.6g
Construction		Plastic sealed, Flux proofed

Notes: 1) *Index is not in relay length direction.
2) The data shown above are initial values.
3) Please find coil temperature curve in the characteristic curves below.

COIL

Coil power	Sensitive: Approx. 200mW; Standard: Approx. 450mW

COIL DATA at 23°C

Standard type

Nominal Voltage VDC	Pick-up Voltage VDC max.1)	Drop-out Voltage VDC min.1)	Max. Voltage VDC2)	Coil Resistance Ω
3	2.25	0.15	3.9	20 x (1±10%)
5	3.75	0.25	6.5	55 x (1±10%)
6	4.50	0.30	7.8	80 x (1±10%)
9	6.75	0.45	11.7	180 x (1±10%)
12	9.00	0.60	15.6	320 x (1±10%)
18	13.5	0.90	23.4	720 x (1±10%)
24	18.0	1.20	31.2	1280 x (1±10%)
48 2)	36.0	2.40	62.4	5120 x (1±10%)

Sensitive type (Only for 1 Form A)

Nominal Voltage VDC	Pick-up Voltage VDC max.1)	Drop-out Voltage VDC min.1)	Max. Voltage VDC2)	Coil Resistance Ω
3	2.25	0.15	5.1	45 x (1±10%)
5	3.75	0.25	8.5	125 x (1±10%)
6	4.50	0.30	10.2	180 x (1±10%)
9	6.75	0.45	15.3	400 x (1±10%)
12	9.00	0.60	20.4	720 x (1±10%)
18	13.5	0.90	30.6	1600 x (1±10%)
24	18.0	1.20	40.8	2800 x (1±10%)

Notes: 1) The data shown above are initial values.
2) Maximum voltage refers to the maximum voltage which relay coil could endure in a short period of time.
3) For products with rated voltage ⩾ 48V, measures should be taken to prevent coil overvoltage in order to protect coil in test and application (eg. Connect diodes in parallel).

SAFETY APPROVAL RATINGS

UL/CUL	1 Form A	5A 250VAC 5A 30VDC 1/8HP 125VAC/250VAC TV-2 C300
	1 Form C	3A 250VAC 3A 30VDC
VDE		5A 250VAC at 85°C 2A 250VAC cosø=0.5 at 85°C 1 Form A, Sensitive: 3A 400VAC at 85°C

Notes: 1) All values unspecified are at room temperature.
2) Only typical loads are listed above. Other load specifications can be available upon request.

HONGFA RELAY
ISO9001, ISO/TS16949 , ISO14001, OHSAS18001, IECQ QC 080000 CERTIFIED 2020 Rev. 1.00

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HF165FD-G MINIATURE HIGH POWER RELAY

c UL us
File No.: E134517

VDE
File No.: 40043143

CQC
File No.: CQC15002130956



Features

- 40A switching capability
- Breakdown voltage (between contact and coil): 4kV
- Creepage distance: 5.5mm(high voltage)
- Plastic sealed and flux proofed types available
- Product in accordance to IEC 60335-1 available
- UL insulation system: Class F

CONTACT DATA

Contact arrangement	1A
Contact resistance 1)	100mΩ max. (at 1A 6VDC)
Contact material	$AgSnO_2$
Contact rating (Res. load)	40A 277VAC
Max. switching voltage	277VAC
Max. switching current	40A
Max. continuous current 2)	30A
Max. switching power	11080VA
Mechanical endurance	1 x 10^7OPS
Electrical endurance 3)	1 x 10^4OPS (NO: 40A 277VAC, Resistive load, Room temp., 1s on 9s off, Flux proofed)

Notes: 1) The data shown above are initial values.
2) Long time current-carrying under 40A condition is prohibited
3) For plastic sealed type, the venting-hole should be opened in electrical endurance test.

CHARACTERISTICS

Insulation resistance		1000MΩ (at 500VDC)
Dielectric strength	Between open contacts	1500VAC 1min
	Between coil & contacts	2500VAC 1min(Standard) 4000VAC 1min(V Type)
Surge voltage		6kV (1.2/50μs)
Operate time (at nomi. volt.)		15ms max.
Release time (at nomi. volt.)		10ms max.
Shock resistance	Functional	98m/s²
	Destructive	980m/s²
Vibration resistance		10Hz to 55Hz 1.5mm DA
Humidity		5% to 85% RH
Ambient temperature		-40°C to 85°C
Termination		PCB
Unit weight		Approx. 25g
Construction		Plastic sealed Flux proofed

Notes: 1) The data shown above are initial values.
2) Avoid close arrangement and installation of relays and relays, relays and other heating components

COIL

Coil power	Approx. 900mW

COIL DATA at 23°C

Nominal Voltage VDC	Pick-up Voltage VDC max 1)	Drop-out Voltage VDC min 1)	Max. Voltage VDC 2)	Coil Resistance Ω
5	3.75	0.5	6.5	27 x (1±10%)
6	4.50	0.6	7.8	40 x (1±10%)
9	6.75	0.9	11.7	97 x (1±10%)
12	9.00	1.2	15.6	155 x (1±10%)
15	11.25	1.5	19.5	256 x (1±10%)
18	13.50	1.8	23.4	380 x (1±10%)
24	18.00	2.4	31.2	660 x (1±10%)
48 3)	36.00	4.8	62.4	2560 x (1±10%)
70 3)	52.50	7.0	91.0	5500 x (1±10%)
110 3)	82.50	11.0	143.0	13450 x (1±10%)

Notes: 1) The data shown above are initial values.
2) Maximum voltage refers to the maximum voltage which relay coil could endure in a short period of time.
3) For products with rated voltage ⩾ 48V, measures should be taken to prevent coil overvoltage in order to protect coil in test and application (eg. Connect diodes in parallel).

SAFETY APPROVAL RATINGS

UL/CUL	NO	40A 277VAC 40°C 30A 277VAC 85°C 2HP 240VAC/1HP 120VAC 40°C 96LRA, 30FLA 40°C TV-8 125VAC 40°C
VDE	NO	40A 250VAC

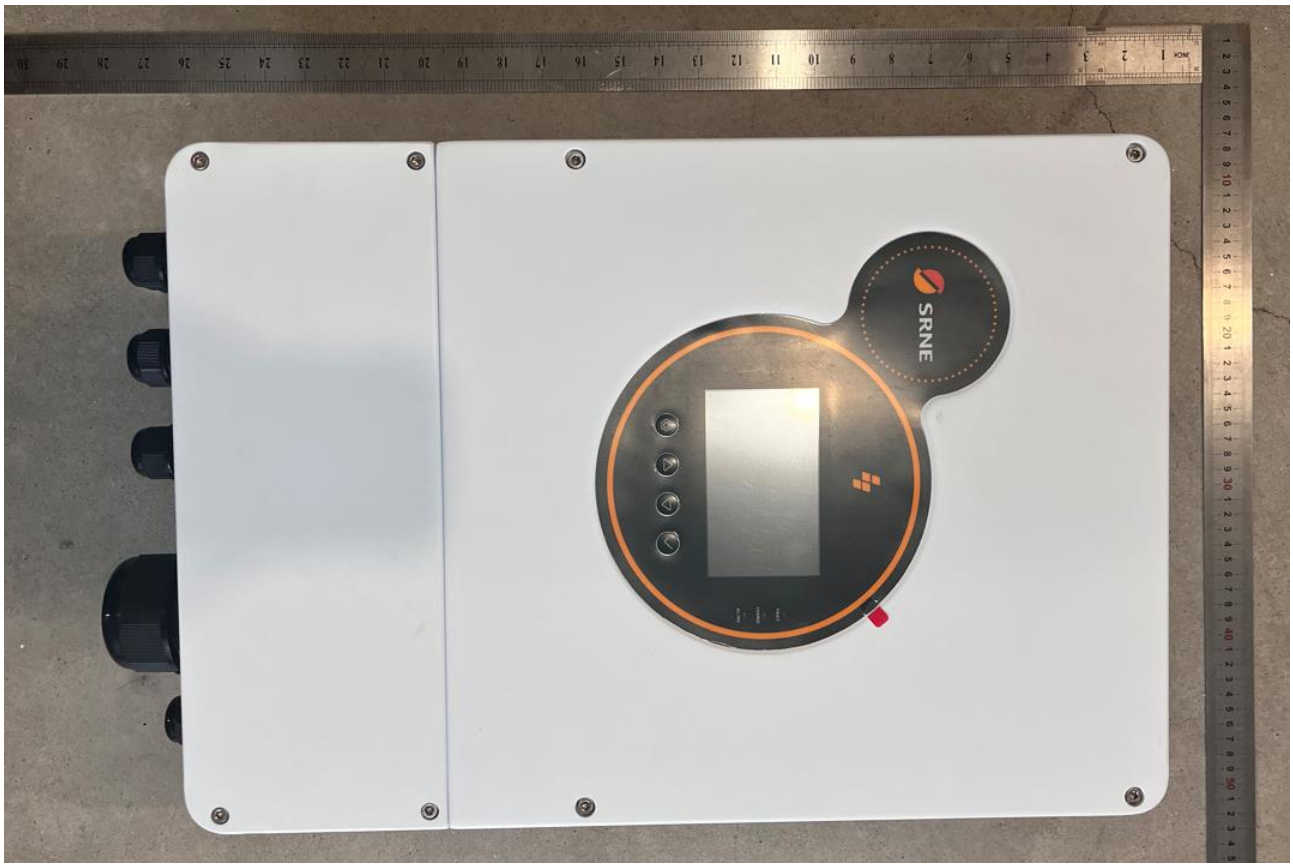
Notes: 1) All values unspecified are at room temperature.
2) Only typical loads are listed above. Other load specifications can be available upon request.

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Annex No. 3

Pictures of the unit

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Front enclosure view for all models



Back enclosure view for all models

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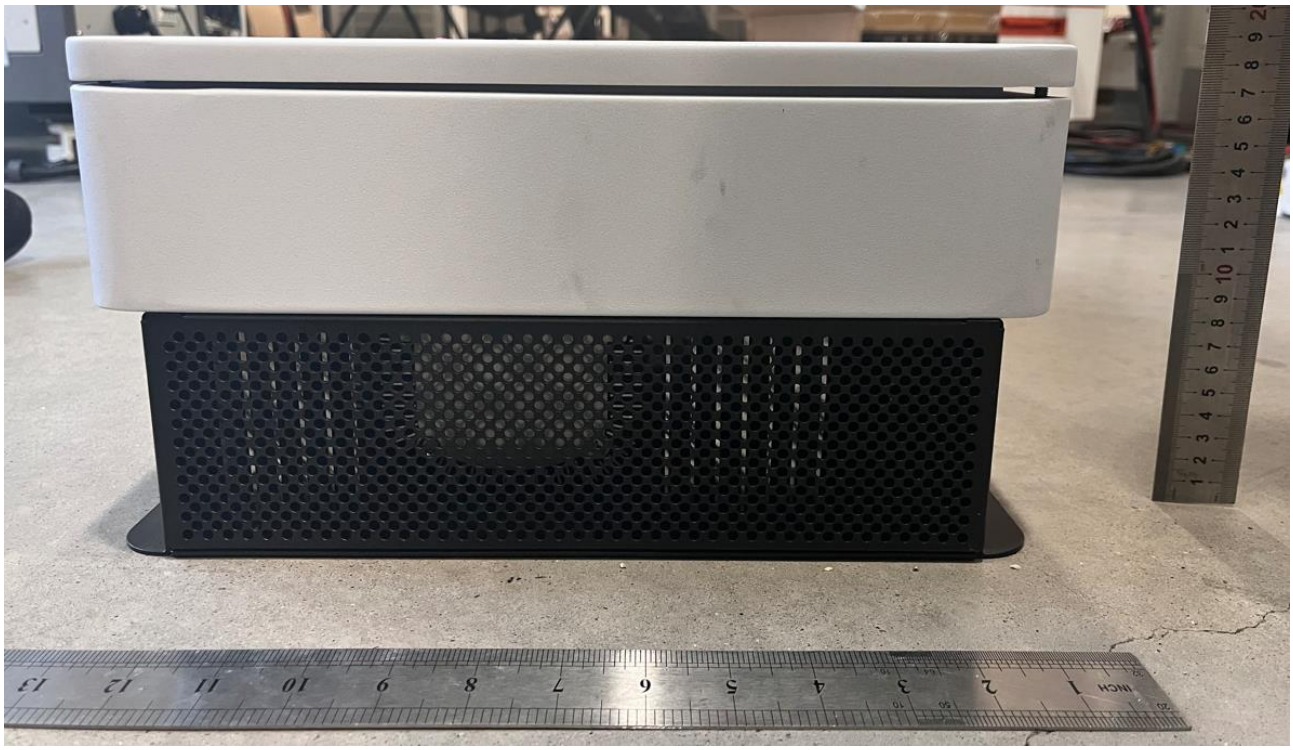


Left enclosure view for all models



Right enclosure view for all models

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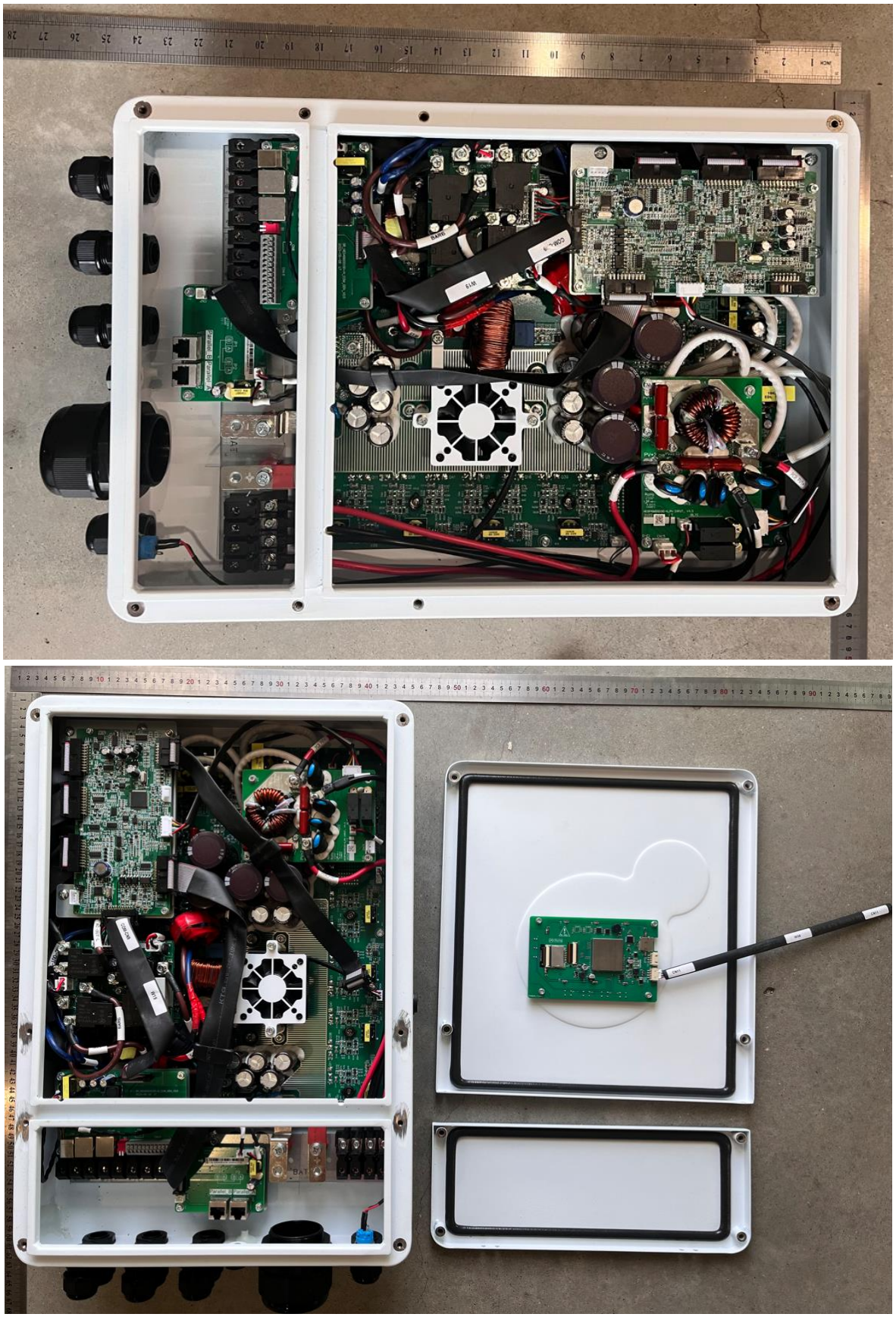


Top enclosure view for all models



Bottom enclosure view for all models

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Internal view for all models

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Annex No. 4

Test Equipment list

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No.	Equipment	Internal No.	Type	Manufacturer	Last Calibration	Due Date
1	Oscilloscope	A4089036SH	DL850	YOKOGAWA	08/Jun/22	07/Jun/23
					29/May/23	28/May/24
2	Voltage probe	A4089026SH	P5200A	Tektronix	21/Dec/22	20/Dec/23
					19/Dec/23	18/Dec/24
3	Current probe	A4089037SH	960 30	YOKOGAWA	29/Aug/22	28/Aug/23
					24/Aug/23	23/Aug/24
4	Current probe	A4089038SH	960 30	YOKOGAWA	29/Aug/22	28/Aug/23
					24/Aug/23	23/Aug/24
5	Current probe	A4089039SH	960 30	YOKOGAWA	29/Aug/22	28/Aug/23
					24/Aug/23	23/Aug/24
6	AC power supply	A7040071SH	61512	Chroma	Monitored by Power Analyzer	
7	AC power supply	A7040077SH	MX-30	AMETEK		
8	Programmable DC source	A7040058SH	62150H-1000S	Chroma		
9	Programmable DC source	A7040059SH	62150H-1000S	Chroma		
10	Programmable DC source	A7040069SH	62150H-1000S	Chroma		
11	Programmable DC source	A7040074SH	62150H-1000S	Chroma		
12	Programmable DC source	A7040075SH	62150H-1000S	Chroma		
13	Programmable DC source	A7040076SH	62150H-1000S	Chroma		
14	Programmable DC source	A7040070SH	62150H-1000S	Chroma		
15	Power Analyzer	A1240096SH	WT3000	YOKOGAWA	29/Aug/22	28/Aug/23
					24/Aug/23	23/Aug/24
16	Power Analyzer	A1240097SH	WT3000	YOKOGAWA	08/Jun/22	07/Jun/23
					29/May/23	28/May/24
17	Temperature & humidity meter	B4200046SH	polyma	W302M2A	20/Dec/22	19/Dec/23
					18/Dec/23	17/Dec/24
18	Temperature & humidity meter	B4200078SH	314	center	07/Jun/22	06/Jun/23
					03/Jun/23	02/Jun/24
19	Power Analyzer	A1240132SH	DEWE2-A4	DEWETRON	08/Jun/22	07/Jun/23
					29/May/23	28/May/24

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END OF TEST REPORT

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