TEST REPORT

TECHNICAL REGULATION 3.3.1

FOR ELECTRICAL ENERGY STORAGE FACILITIES

Report reference number .... :	**PVDK200917N006-7**
Date of issue .... :	2021-01-25
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Testing laboratory name .... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
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Accreditation .... :	ilac-MRA; A2LA ACCREDITED Certificate # 2951.01
Applicant's name .... :	**Shenzhen SOFARSOLAR Co., Ltd.**
Address .... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard... :	TECHNICAL REGULATION 3.3.1: 2019-12
Test Report Form No. .... :	TR 3.3.1 VER.0
TRF Originator .... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF .... :	Dated 2020-08-22
Test item description..................... :	**Hybrid inverter**
Trademark.. :	SOFAR SOLAR
Model / Type .... :	HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP, HYD 5500-EP, HYD 6000-EP

Ratings ....:	**HYD 3000-EP**	**HYD 3680-EP**	**HYD 4000-EP**
Full load MPP DC voltage range [V] :	160-520V	180-520V	200-520V
Input DC voltage range[V]................:	90-600V		
Input DC current [A] ....:	Max. 13A/13A		
Output AC voltage [V] ....:	L/N/PE, 230Vac, 50Hz		
Output AC current [A].......................:	15,0	16,0	20,0
Output power [W] ....:	3000	3680	4000
Max. output power [VA]....................:	3300	3680	4400
Output DC voltage range [V]............: [Battery charge]………………………:	42-58V		
Input/Output DC current [A]..............: [Battery charge/discharge] …………:	Max. 75A	Max. 80A	Max. 85A
Charge and discharge power[W] .....:	Max. 3750	Max. 4000	Max. 4250
Output AC voltage [V] ....:	L/N/PE, 230Vac, 50Hz		
Max. Input/Output AC current [A].....: [Battery charge/discharge mode] …:	13,6	16,0	18,2
Max. Input/Output AC power [VA]....: [Battery charge/discharge mode] …:	3000	3680	4000
Ratings ....:	**HYD 4600-EP**	**HYD 5000-EP**	**HYD 5500-EP**
Full load MPP DC voltage range [V] :	230-520V	250-520V	250-520V7
Input DC voltage range[V]................:	90-600V		
Input DC current [A] ....:	Max. 13A/13A		
Output AC voltage [V] ....:	L/N/PE, 230Vac, 50Hz		
Output AC current [A].......................:	20,9	21,7	25,0
Output power [W] ....:	4600	5000	5000
Max. output power [VA]....................:	4600	5000	5500
Output DC voltage range [V]............: [Battery charge]………………………:	42-58V		
Input/Output DC current [A]..............: [Battery charge/discharge] …………:	Max. 100A		
Charge and discharge power[W] .....:	Max. 5000		
Output AC voltage [V] ....:	L/N/PE, 230Vac, 50Hz		
Max. Input/Output AC current [A].....: [Battery charge/discharge mode] …:	20,9	22,7	22,7
Max. Input/Output AC power [VA]....: [Battery charge/discharge mode] …:	4600	5000	5000

Ratings:	**HYD 6000-EP**
Full load MPP DC voltage range [V] :	300-520V
Input DC voltage range[V]:	90-600V
Input DC current [A]:	Max. 13A/13A
Output AC voltage [V]:	L/N/PE, 230Vac, 50Hz
Output AC current [A]:	27,3
Output power [W]:	6000
Max. output power [VA]:	6000
Output DC voltage range [V]: [Battery charge]:	42-58V
Input/Output DC current [A]: [Battery charge/discharge]:	Max. 100A
Charge and discharge power[W]:	Max. 5000
Output AC voltage [V]:	L/N/PE, 230Vac, 50Hz
Max. Input/Output AC current [A]: [Battery charge/discharge mode]:	22,7
Max. Input/Output AC power [VA]: [Battery charge/discharge mode]:	5000

Testing Location .... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**	
Address .... :	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China	
Tested by (name and signature) .... :	Lukes Lin	
Approved by (name and signature) .... :	James Huang	
Manufacturer's name .... :	**Shenzhen SOFARSOLAR Co., Ltd.**	
Manufacturer address .... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China	
Factory's name .... :	**Dongguan SOFAR SOLAR Co.,Ltd.**	
Factory address	1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City, Guangdong, China.	

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2021-01-25	Lukes Lin	Initial report was written	0
Supplementary information:			

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] ....:	Approx. 21,5kg

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 ....:	2020-09-17
Date(s) of performance of test ....:	2020-09-17 to 2021-01-25

General remarks:

The test result presented in this report relate only to the object(s) tested. This report shall not be reproduced in part or in full without the written approval of the issuing testing laboratory.

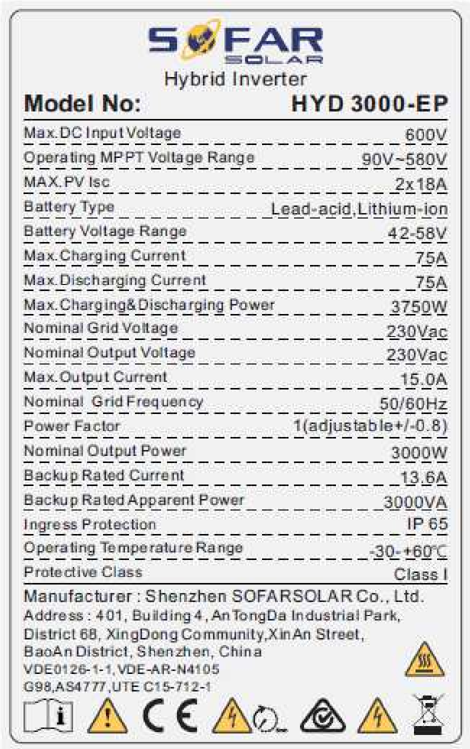
"(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

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

This Test Report consists of the following documents:

1. Test Report
2. Annex No. 1 – Pictures of the unit
3. Annex No. 2 – Test equipment list

Copy of marking plate



SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 3000-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	75A
Max.Discharging Current	75A
Max.Charging&Discharging Power	3750W
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	15.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3000W
Backup Rated Current	13.6A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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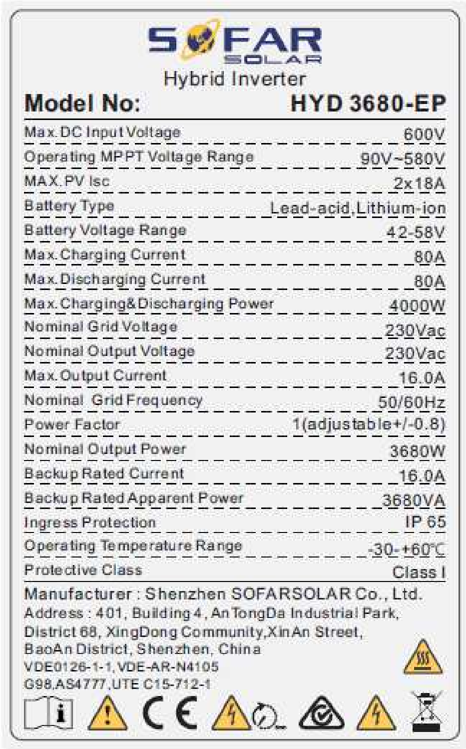

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 3680-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	80A
Max.Discharging Current	80A
Max.Charging&Discharging Power	4000W
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	16.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3680W
Backup Rated Current	16.0A
Backup Rated Apparent Power	3680VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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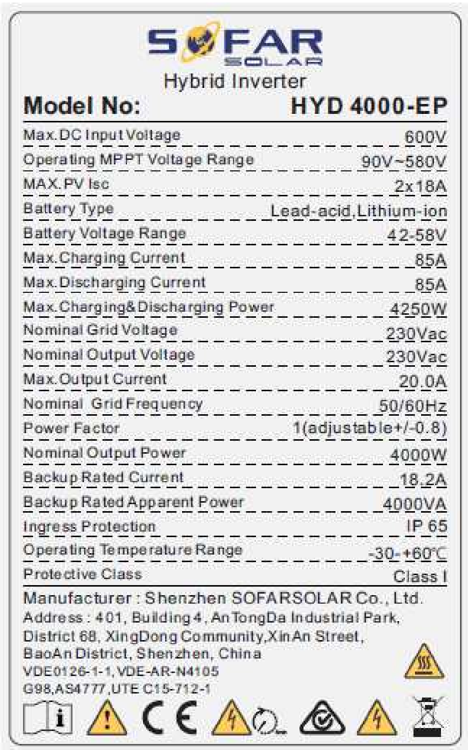

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 4000-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	85A
Max.Discharging Current	85A
Max.Charging&Discharging Power	4250W
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	20.0A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	4000W
Backup Rated Current	18.2A
Backup Rated Apparent Power	4000VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

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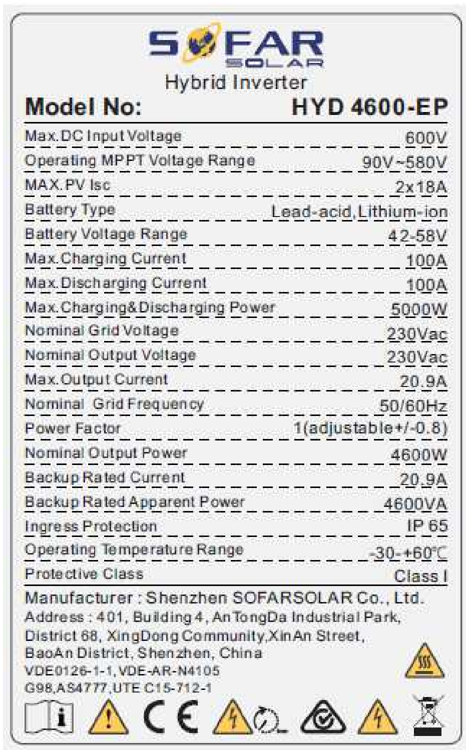

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 4600-EP
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V~580V
MAX.PV Isc	2x18A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	100A
Max.Discharging Current	100A
Max.Charging&Discharging Power	5000W
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	20.9A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	4600W
Backup Rated Current	20.9A
Backup Rated Apparent Power	4600VA
Ingress Protection	IP 65
Operating Temperature Range	-30-+60℃
Protective Class	Class I

Manufacturer : Shenzhen SOFARSOLAR Co., Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
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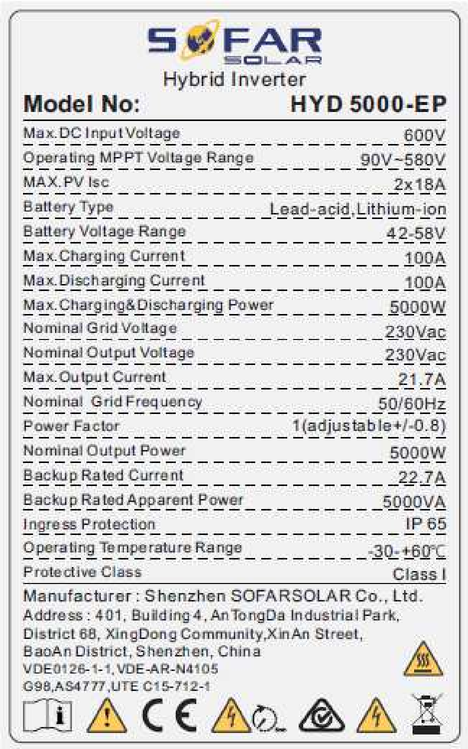

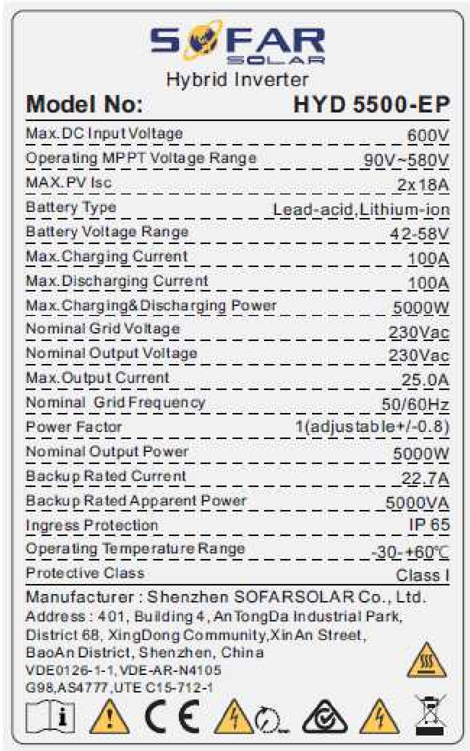

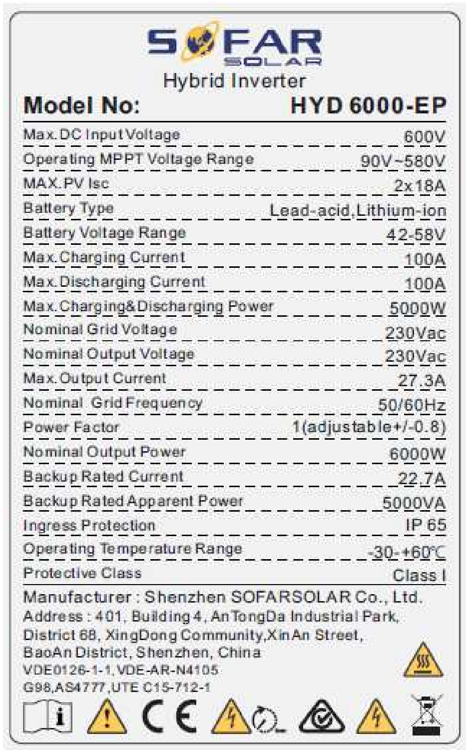

General product information:

The inverter converts DC voltage, generated by photovoltaic modules, into AC voltage.
The units are single-phases hybrid-inverter.
Rate of change of frequency (RoCoF) detection was used for LOM protection.

Description of the power circuit (Figure 1):

The charging current to batteries from PV array and grid, battery management unit is integrated in External Energy storage.

The Solar converter is a single-phase type, only one machine is allowed on each line conductor and power capacity is allowed to less than 11,08kW while is parallel to power generation system

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

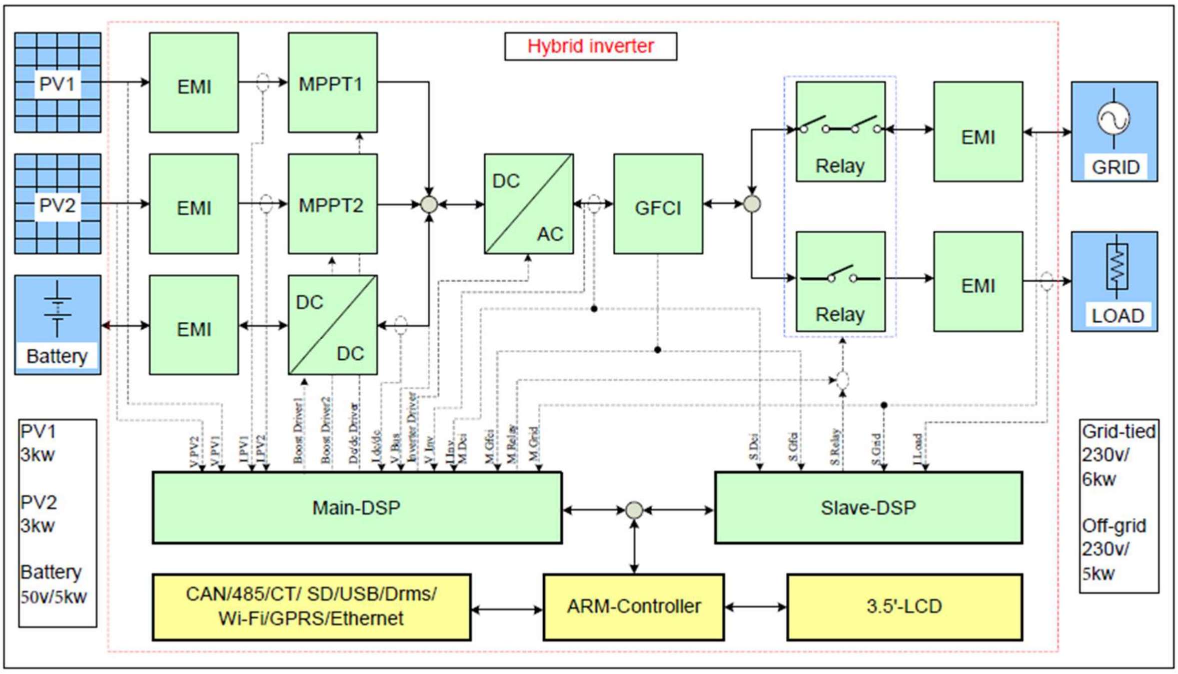

Figure 1 – Block diagram

The internal control is redundant built. It consists of Main DSP(U4) and slave DSP(U43).

The Main DSP(U4) can control the relays, measures voltage, and frequency, AC current with injected DC, insulation resistance and residual current, In addition it tests the array insulation resistance and the RCMU circuit before each start up.

The slave DSP(U43) is using for controlling the relays, measuring the voltage , frequency, inject a dc AC current, the residual current, and communicating with the master DSP(U4). And if the communicating with the master DSP, the slave DSP will disconnect the relays.

The unit provides two relays in series on Line and Neutral conductors. When single-fault applied to one relay, alarm an error code in display panel, another redundant relay provides basic insulation maintained between the PV array and the mains. All the relays are tested before start up. Both controllers Main DSP(U4), Slave DSP(U43) can open the relays.

Differences of the models:

The models HYD 3000-EP, HYD 3680-EP, HYD 4000-EP, HYD 4600-EP, HYD 5000-EP, HYD 5500-EP and HYD 6000-EP are completely identical and output power derated by software, except for the following table.

	HYD 3000-EP	HYD 3680-EP	HYD 4000-EP	HYD 4600-EP	HYD 5000-EP	HYD 5500-EP	HYD 6000-EP
R332, R334, R336	(NC, 0Ω, NC)			(0Ω, NC, 0Ω)			
Bus capacitance	6pcs			8pcs			
INV inductor	1,035mH			0,75mH			
R123, R132	(499Ω, 499Ω)			(1.5kΩ, 1.5kΩ)			

The product was tested on:

Hardware version: V001

Software version: V02000

General remarks:

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"(see appended table)" refers to a table appended to the report.

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

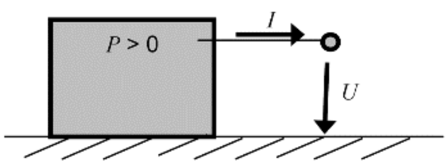
The following suffixes are used for variables in tables and figures:

- "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.

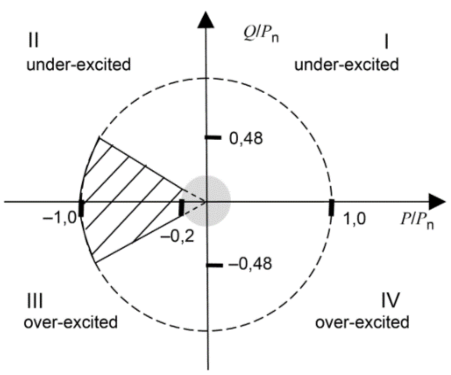


Figure 2

TECHNICAL REGULATION 3.3.1		
Clause	**Test requirement (According to Appendix 1)**	**Result**
4	**Voltage and frequency**	**P**
5	**Power quality**	**P**
6	**Control**	**P**
7	**Protection**	**P**

TECHNICAL REGULATION 3.3.1: Voltage and frequency		
Clause	**Test requirement**	**Result**
4.3	**Normal operating range**	**P**
4.3.1	**Automatic connection and gradient for active power**	**P**
4.3.2	**Normal operating range, distribution system connection, category A**	**P**
4.3.3	**Normal operating range, distribution system connection, categories B, C and D**	**P**
4.3.4	**Normal operating range, transmission system connection**	**N/A**
4.4	**Abnormal operating conditions**	**P**
4.4.1	**Phase jumps**	**P**
4.4.2	**ROCOF**	**P**
4.4.3	**Normal operation after voltage dips**	**N/A**
4.4.4	**Tolerance of voltage dips, distribution system**	**N/A**
4.4.5	**Tolerance of voltage dips, transmission system**	**N/A**

4.3.2 Normal operating range, distribution system connection, category A 4.4.1 Phase jumps		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 S_n; cosφ = 1
- Test 2: U = 195,5 V; f = 48,5 Hz; P = 1,00 S_n; cosφ = 1
- Test 3: U = 253,0 V; f = 51,5 Hz; P = 1,00 S_n; cosφ = 1
- Test 4: U = 230,0 V; f = 50,0 Hz; Voltage Phase jumps Change +20 degrees P = 1,00 S_n; cosφ = 1

Test result:

Test sequence	Voltage [V]	Frequency [Hz]	Output power [kW]	Cos φ
Test1	195,36	47,50	5,949	0,9939
Test2	195,41	48,50	5,948	0,9977
Test3	253,72	51,50	6,032	0,9972
Test4	230,83	50,00	6,017	0,9995

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, equal to the maximum power that can be supplied on reaching the maximum output current limit (P ≥ 0,85 S_n).

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

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

4.3.1 Automatic connection and gradient for active 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(DK1) :		49,8
	Min. frequency for connected to grid(DK2) :		49,9
	Max. frequency for connected to grid(DK1) :		50,2
	Max. frequency for connected to grid(DK2) :		50,1
	Observation time (≥180s) :		180

Test:		
	Voltage conditons	
a) Start up for voltage range	<89% Un for twice of observation time	>110% Un for twice of observation time
Connection:	No connection	No connection
Limit	No connection allowed	
b) In voltage range at start-up	≥90% Un within twice setting observation time	≤110% Un within twice setting observation time
Reconnection time [s]	185 s	186 s
Limit:	Connected after setting observation time (≥180s)	
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: 20%P_{Emax}/min.	
c) In voltage range after voltage failture	≥89% Un for twice of setting observation time	≤110% Un for twice of setting observation time
Reconnection time [s]	185 s	184 s
Limit:	Reconnection after setting observation time (≥180s)	
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: 20%P_{Emax}/min.For recorded gradient see diagram below.	

	Frequency conditions	
FSM band for DK1		
d) Start up for frequency range	<49,80 Hz for twice of setting observation time	>50,20 Hz for twice of setting observation time
Connection:	No connection	No connection
Limit	No connection allowed	
e) In frequency range at start-up	≥49,80 Hz within twice of setting observation time	≤50,20 Hz within twice of setting observation time
Reconnection time [s]	186 s	185 s
Limit:	Connected after setting delay time(≥180s)	
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: 20%P_{Emax}/min.	
f) In frequency range after frequency failture	≥49,80 Hz for twice of setting observation time	≤50,20 Hz for twice of setting observation time
Reconnection time [s]	185 s	184 s
Limit:	Reconnection after setting observation time (≥180s)	
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: 20%P_{Emax}/min. tion is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	

	Frequency conditions	
FSM band for DK2		
d) Start up for frequency range	<49,90 Hz for twice of setting observation time	>50,10 Hz for twice of setting observation time
Connection:	No connection	No connection
Limit	No connection allowed	
e) In frequency range at start-up	≥49,90 Hz within twice of setting observation time	≤50,10 Hz within twice of setting observation time
Reconnection time [s]	185 s	185 s
Limit:	Connected after setting delay time(≥180s)	
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: 20%P_{Emax}/min.	
f) In frequency range after frequency failture	≥49,90 Hz for twice of setting observation time	≤50,10 Hz for twice of setting observation time
Reconnection time [s]	185 s	184 s
Limit:	Reconnection after setting observation time (≥180s)	
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: 20%P_{Emax}/min. tion is delayed by a randomised value between 1 min and 10 min. For recorded gradient see diagram below.	

Test:

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.

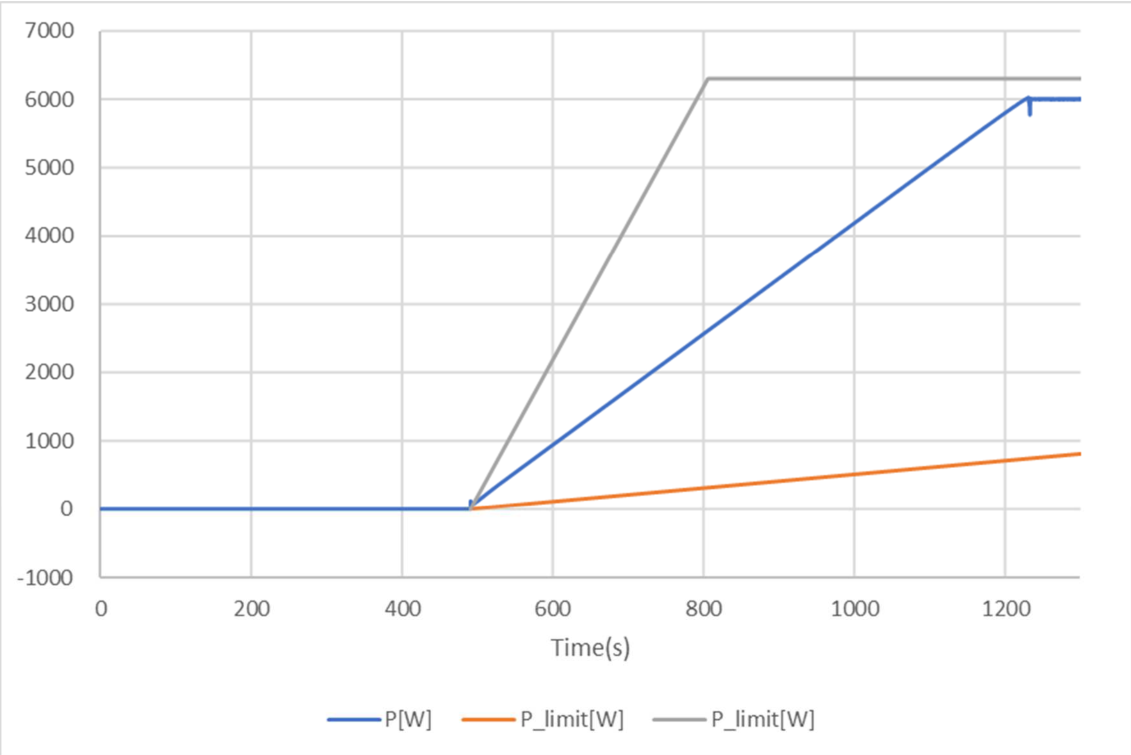
The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

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

Graph of the gradual power supply :



4.4.2	Rate of change of frequency (ROCOF) immunity			P

	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.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

TECHNICAL REGULATION 3.3.1: Power quality		
Clause	**Test requirement**	**Result**
5.1	**Power quality, energy storage facilities categories A, B and T, connected to the distribution system**	**P**
5.1.1	**Threshold values**	**P**
5.1.2	**Division of responsibilities**	**P**
5.1.3	**Measuring method**	**P**
5.2	**Power quality, energy storage facilities categories C, D and T, connected to the distribution system**	**N/A**
5.2.1	**Threshold values**	**N/A**
5.2.2	**Division of responsibilities**	**N/A**
5.2.3	**Measuring method**	**N/A**
5.3	**Power quality, energy storage facilities connected to the transmission system**	**N/A**

5.1.1.1 DC content				P
Test result: HYD 3000-EP				
Protection limit	**Tested at four power levels limit 0,5% of $I_{AC;nom}$ (65mA)**			
Output power	~20%	~50%	75%	~100%
Abs. Max. Test Value:L1 [mA]	25,1	24,0	23,5	15,3
Abs. Ave. Test Value:L1 [mA]	14,0	12,8	10,7	0,6
Test result: HYD 6000-EP				
Protection limit	**Tested at four power levels limit 0,5% of $I_{AC;nom}$ (130mA)**			
Output power	~20%	~50%	75%	~100%
Abs. Max. Test Value:L1 [mA]	23,8	22,5	23,5	36,8
Abs. Ave. Test Value:L1 [mA]	12,6	11,0	9,6	5,1

Note:

Test method and setting value refer Annex D.3.10 of EN 50438:2013.

The tests had been performed on the HYD 6000-EP and HYD 3000-EPis valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP and HYD 3680-EP, since it is identical in hardware and software construction except output power derated by software.

Diagram of permanent dc-injection of HYD 3000-EP

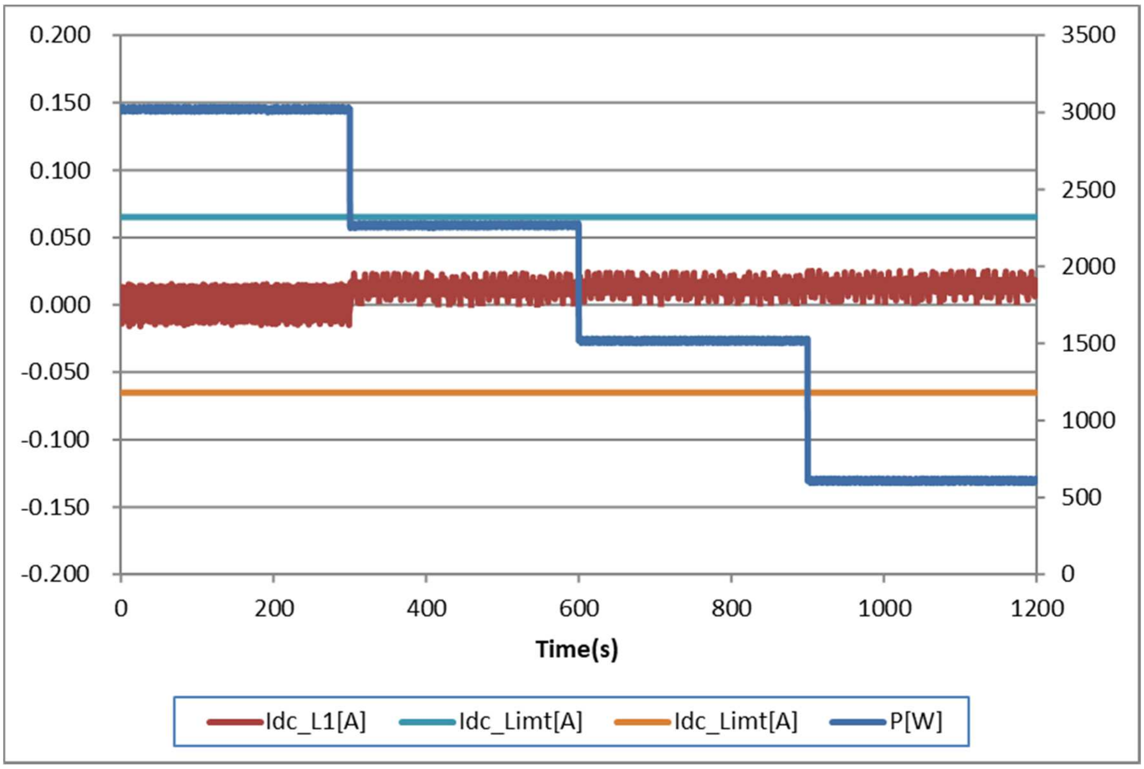
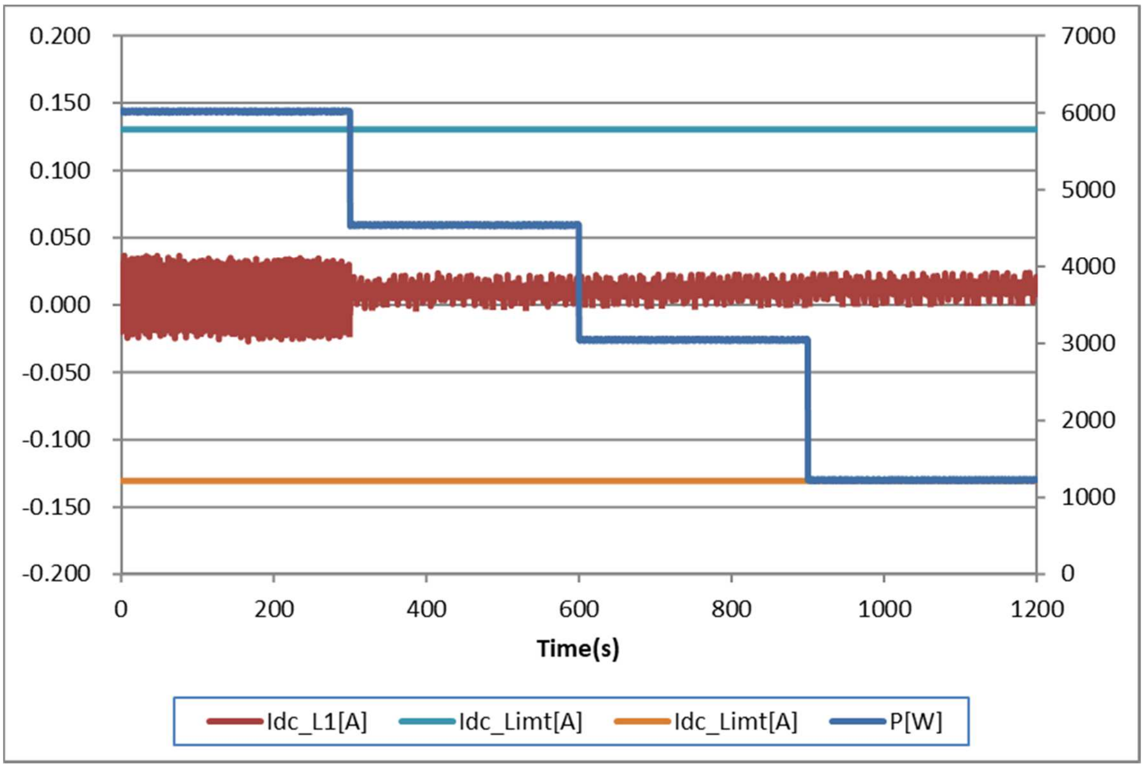


Diagram of permanent dc-injection of HYD 6000-EP



5.1.1.3	Rapid voltage changes Switching operation (Refer IEC 61400-21)				P
Test result: HYD 6000-EP					
Max. number of switching operations, N_{10}	10				
Max. number of switching operations, N_{120}	120				
Case of switching operation	Cut-in at 9%P_{Emax}				
Grid impedance angle, ψ_k	30°	50°	70°	85°	
Flicker step factor, $k_f(\psi_k)$	0,056	0,036	0,030	0,028	
Voltage change factor, $k_u(\psi_k)$	0,334	0,338	0,349	0,347	
Maximum inrush current factor k_{imax}	0,014				
Case of switching operation	Cut-in at 100%P_{Emax}				
Grid impedance angle, ψ_k	30°	50°	70°	85°	
Flicker step factor, $k_f(\psi_k)$	0,230	0,151	0,125	0,119	
Voltage change factor, $k_u(\psi_k)$	2,965	2,984	2,928	2,858	
Maximum inrush current factor k_{imax}	0,014				
Case of switching operation	Service disconnection at rated power				
Grid impedance angle, ψ_k	30°	50°	70°	85°	
Flicker step factor, $k_f(\psi_k)$	0,093	0,061	0,051	0,045	
Voltage change factor, $k_u(\psi_k)$	2,424	2,507	2,592	2,441	
Maximum inrush current factor k_{imax}	0,079				
Worst case over all switching operations, k_{imax}	0,079				

Note:

$S_{k,fic}/S_n$ in the fictitious grid was set to:20.

The test refer IEC 61400-21.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP, HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

5.1.1.4	**Flicker**					**P**
Test result:						
Test conditions:	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker as per EN 61000-3-3 and/or EN 61000-3-11.					
Test:						
Value	P_{st}	P_{lt} 2 hours	d(t) 500ms	d_c	d_{max}	
Limit	1,0	0,65	3,3%	3,3%	4%	
Test value	See below					

inverter <16A (HYD 3000-EP)

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.034	Pass	0.228	Pass	0.0	Pass	0.174	Pass		
2	0.034	Pass	0.219	Pass	0.0	Pass	0.174	Pass		
3	0.037	Pass	0.223	Pass	0.0	Pass	0.173	Pass		
4	0.036	Pass	0.223	Pass	0.0	Pass	0.173	Pass		
5	0.033	Pass	0.226	Pass	0.0	Pass	0.174	Pass		
6	0.036	Pass	0.226	Pass	0.0	Pass	0.174	Pass		
7	0.037	Pass	0.223	Pass	0.0	Pass	0.174	Pass		
8	0.038	Pass	0.221	Pass	0.0	Pass	0.174	Pass		
9	0.035	Pass	0.228	Pass	0.0	Pass	0.176	Pass		
10	0.041	Pass	0.233	Pass	0.0	Pass	0.176	Pass		
11	0.036	Pass	0.241	Pass	0.0	Pass	0.176	Pass		
12	0.037	Pass	0.235	Pass	0.0	Pass	0.176	Pass		
Result		Pass		Pass		Pass		Pass	0.175	Pass

Inverter >16A (HYD 6000-EP)

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.046	Pass	0.217	Pass	0.0	Pass	0.164	Pass		
2	0.044	Pass	0.218	Pass	0.0	Pass	0.164	Pass		
3	0.044	Pass	0.227	Pass	0.0	Pass	0.164	Pass		
4	0.052	Pass	0.229	Pass	0.0	Pass	0.165	Pass		
5	0.051	Pass	0.224	Pass	0.0	Pass	0.166	Pass		
6	0.053	Pass	0.231	Pass	0.0	Pass	0.166	Pass		
7	0.040	Pass	0.226	Pass	0.0	Pass	0.165	Pass		
8	0.036	Pass	0.225	Pass	0.0	Pass	0.166	Pass		
9	0.046	Pass	0.233	Pass	0.0	Pass	0.166	Pass		
10	0.051	Pass	0.225	Pass	0.0	Pass	0.167	Pass		
11	0.047	Pass	0.229	Pass	0.0	Pass	0.168	Pass		
12	0.034	Pass	0.233	Pass	0.0	Pass	0.167	Pass		
Result		Pass		Pass		Pass		Pass	0.166	Pass

Note:
*The stationary deviance of dc% is more relevant than the dynamic deviance of dmax at starting and stopping,

Mains Impedance according EN61000-3-11:

Rmax = 0,24Ω; jXmax= 0,15Ω @50Hz (|Zmax| = 0,283/0,4717Ω) for single phase inverter use also

R_n = 0,16Ω; jX_n= 0,1Ω.

Calculation of the maximum permissible grid impedance at the point of common coupling based on dc:

$Z_{max} = Z_{ref} * 3{,}3\% / d_c(P_n)$.

The tests should be based on the limits of the EN 61000-3-3 for less than 16A and on EN 61000-3-11 for more than 16A.

The tests had been performed on the HYD 6000-EP and HYD 3000-EPis valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP and HYD 3680-EP, since it is identical in hardware and software construction except output power derated by software.

5.1.1.5 Harmonic current emission (EN 61000-3-2)	P

Test result: HYD 3000-EP

Watts [KW]	3,022
Vrms [V]	230,41
Arms [A]	13,13
Frequency [Hz]	50
THD50* (100% output power)	1,446

Harmonic order n	Current Magnitude [A] at 100% rated output power	% of Fundamental	Phase	Harmonic Current Limits [A]
1st	13,126	99,947	Single Phase	--
2nd	0,004	0,029	Single Phase	1,080
3rd	0,162	1,235	Single Phase	2,300
4th	0,002	0,012	Single Phase	0,430
5th	0,077	0,583	Single Phase	1,140
6th	0,002	0,015	Single Phase	0,300
7th	0,039	0,300	Single Phase	0,770
8th	0,001	0,011	Single Phase	0,230
9th	0,021	0,160	Single Phase	0,400
10th	0,001	0,010	Single Phase	0,184
11th	0,010	0,079	Single Phase	0,330
12th	0,001	0,009	Single Phase	0,153
13th	0,007	0,055	Single Phase	0,210
14th	0,001	0,008	Single Phase	0,131
15th	0,006	0,048	Single Phase	0,150
16th	0,001	0,007	Single Phase	0,115
17th	0,009	0,065	Single Phase	0,132
18th	0,001	0,007	Single Phase	0,102
19th	0,009	0,072	Single Phase	0,118
20th	0,001	0,007	Single Phase	0,092
21th	0,011	0,080	Single Phase	0,107
22th	0,001	0,006	Single Phase	0,084
23th	0,011	0,087	Single Phase	0,098
24th	0,001	0,006	Single Phase	0,077
25th	0,011	0,085	Single Phase	0,090
26th	0,001	0,005	Single Phase	0,071
27th	0,011	0,087	Single Phase	0,083
28th	0,001	0,005	Single Phase	0,066
29th	0,011	0,082	Single Phase	0,078
30th	0,001	0,006	Single Phase	0,061
31th	0,011	0,082	Single Phase	0,073
32th	0,001	0,005	Single Phase	0,058
33th	0,011	0,081	Single Phase	0,068
34th	0,001	0,006	Single Phase	0,054
35th	0,010	0,075	Single Phase	0,064
36th	0,001	0,006	Single Phase	0,051
37th	0,010	0,075	Single Phase	0,061
38th	0,001	0,006	Single Phase	0,048
39th	0,010	0,076	Single Phase	0,058
40th	0,001	0,005	Single Phase	0,046

Note: The tests should be based on the limits of the EN 61000-3-2 for less than 16A.

5.1.1.5 Harmonic current emission (EN 61000-3-12)	P

Test result: HYD 6000-EP

Watts [KW]	6,034
Vrms [V]	230,70
Arms [A]	26,17
Frequency [Hz]	50
THD50* (100% output power)	0,965

Harmonic order n	Current Magnitude [A] at 100% rated output power	% of Fundamental	Phase	Harmonic Current Limits [%]
1st	26,157	99,961	Single Phase	--
2nd	0,007	0,026	Single Phase	8,000
3rd	0,207	0,792	Single Phase	21,600
4th	0,002	0,007	Single Phase	4,000
5th	0,109	0,417	Single Phase	10,700
6th	0,003	0,013	Single Phase	2,667
7th	0,067	0,255	Single Phase	7,200
8th	0,003	0,012	Single Phase	2,000
9th	0,042	0,159	Single Phase	3,800
10th	0,003	0,012	Single Phase	1,600
11th	0,020	0,077	Single Phase	3,100
12th	0,003	0,010	Single Phase	1,333
13th	0,012	0,044	Single Phase	2,000
14th	0,002	0,009	Single Phase	8,000
15th	0,013	0,050	Single Phase	N/A
16th	0,002	0,008	Single Phase	N/A
17th	0,017	0,065	Single Phase	N/A
18th	0,002	0,007	Single Phase	N/A
19th	0,017	0,064	Single Phase	N/A
20th	0,001	0,005	Single Phase	N/A
21th	0,015	0,059	Single Phase	N/A
22th	0,001	0,005	Single Phase	N/A
23th	0,013	0,049	Single Phase	N/A
24th	0,001	0,005	Single Phase	N/A
25th	0,011	0,044	Single Phase	N/A
26th	0,001	0,004	Single Phase	N/A
27th	0,012	0,044	Single Phase	N/A
28th	0,001	0,006	Single Phase	N/A
29th	0,010	0,040	Single Phase	N/A
30th	0,001	0,005	Single Phase	N/A
31th	0,010	0,039	Single Phase	N/A
32th	0,001	0,004	Single Phase	N/A
33th	0,009	0,036	Single Phase	N/A
34th	0,001	0,004	Single Phase	N/A
35th	0,008	0,029	Single Phase	N/A
36th	0,001	0,005	Single Phase	N/A
37th	0,007	0,027	Single Phase	N/A
38th	0,001	0,005	Single Phase	N/A
39th	0,007	0,028	Single Phase	N/A
40th	0,001	0,004	Single Phase	N/A

Note: The tests should be based on the limits of the EN 61000-3-12 for more than 16A.

5.1.1.6 Interharmonics 5.1.1.7 Disturbances in the 2-9kHz interval	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 result: HYD 3000-EP

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	2,970	10,467	20,579	30,726	40,816	50,853	60,856	70,786	80,677	90,505	100,260
2	0,018	0,025	0,024	0,018	0,019	0,019	0,018	0,016	0,015	0,017	0,044
3	0,476	0,608	0,618	0,625	0,635	0,638	0,640	0,645	0,651	0,692	0,809
4	0,016	0,011	0,011	0,009	0,009	0,010	0,011	0,011	0,013	0,012	0,015
5	0,273	0,303	0,299	0,294	0,292	0,291	0,287	0,277	0,270	0,305	0,399
6	0,012	0,008	0,009	0,007	0,007	0,008	0,008	0,008	0,007	0,013	0,021
7	0,180	0,168	0,155	0,154	0,150	0,148	0,139	0,132	0,128	0,168	0,242
8	0,008	0,008	0,008	0,007	0,007	0,008	0,008	0,008	0,007	0,009	0,010
9	0,110	0,099	0,093	0,090	0,085	0,079	0,074	0,072	0,074	0,114	0,158
10	0,007	0,008	0,008	0,007	0,007	0,007	0,008	0,008	0,007	0,011	0,012
11	0,076	0,066	0,061	0,050	0,044	0,039	0,039	0,049	0,063	0,077	0,076
12	0,007	0,007	0,007	0,006	0,007	0,007	0,007	0,007	0,008	0,010	0,012
13	0,064	0,055	0,044	0,030	0,027	0,029	0,038	0,056	0,074	0,069	0,047
14	0,007	0,006	0,007	0,006	0,006	0,007	0,007	0,007	0,008	0,010	0,010
15	0,052	0,051	0,035	0,027	0,023	0,029	0,047	0,065	0,082	0,070	0,059
16	0,006	0,006	0,006	0,006	0,006	0,006	0,007	0,007	0,007	0,011	0,008
17	0,057	0,053	0,036	0,028	0,026	0,040	0,058	0,074	0,089	0,077	0,076
18	0,006	0,005	0,006	0,005	0,006	0,006	0,006	0,006	0,006	0,011	0,009
19	0,057	0,053	0,034	0,027	0,032	0,046	0,061	0,076	0,087	0,079	0,074
20	0,006	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,006	0,010	0,008
21	0,062	0,055	0,035	0,029	0,035	0,050	0,066	0,079	0,088	0,081	0,069
22	0,006	0,005	0,005	0,005	0,005	0,005	0,005	0,006	0,006	0,009	0,008
23	0,065	0,055	0,035	0,031	0,039	0,055	0,068	0,078	0,084	0,077	0,058
24	0,006	0,005	0,005	0,004	0,005	0,005	0,006	0,006	0,007	0,009	0,008
25	0,067	0,053	0,033	0,032	0,039	0,055	0,065	0,074	0,079	0,072	0,054
26	0,006	0,004	0,004	0,004	0,004	0,005	0,005	0,006	0,006	0,007	0,007
27	0,066	0,053	0,035	0,035	0,043	0,057	0,067	0,076	0,079	0,069	0,053
28	0,006	0,005	0,004	0,004	0,005	0,005	0,006	0,006	0,006	0,008	0,008
29	0,064	0,048	0,031	0,033	0,041	0,054	0,066	0,072	0,073	0,062	0,049
30	0,006	0,004	0,004	0,004	0,005	0,005	0,005	0,006	0,006	0,007	0,007
31	0,060	0,048	0,032	0,033	0,042	0,056	0,065	0,070	0,070	0,060	0,048
32	0,006	0,005	0,004	0,004	0,005	0,005	0,005	0,005	0,006	0,007	0,007
33	0,059	0,044	0,031	0,033	0,041	0,055	0,064	0,068	0,068	0,058	0,045
34	0,007	0,005	0,004	0,004	0,005	0,005	0,006	0,006	0,006	0,008	0,007
35	0,050	0,040	0,028	0,030	0,040	0,054	0,062	0,065	0,063	0,053	0,037
36	0,007	0,005	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,008	0,008
37	0,049	0,037	0,026	0,029	0,038	0,052	0,061	0,064	0,062	0,051	0,035

38	0,008	0,005	0,005	0,005	0,005	0,005	0,005	0,006	0,006	0,007	0,007
39	0,047	0,040	0,028	0,030	0,040	0,055	0,062	0,063	0,061	0,050	0,036
40	0,008	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,007	0,008

Interharmonics											
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100	Limit
f [Hz]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]
75	0,050	0,066	0,068	0,041	0,041	0,042	0,043	0,044	0,043	0,043	0,058	0,40
125	0,025	0,023	0,022	0,015	0,015	0,017	0,017	0,015	0,015	0,014	0,018	0,60
175	0,024	0,014	0,015	0,012	0,011	0,012	0,013	0,012	0,011	0,011	0,014	0,43
225	0,019	0,013	0,014	0,011	0,011	0,011	0,012	0,011	0,011	0,011	0,012	0,33
275	0,018	0,011	0,013	0,011	0,011	0,011	0,012	0,012	0,011	0,011	0,012	0,27
325	0,017	0,012	0,013	0,011	0,012	0,012	0,012	0,012	0,012	0,012	0,013	0,23
375	0,012	0,012	0,013	0,011	0,012	0,012	0,013	0,012	0,012	0,012	0,013	0,20
425	0,011	0,012	0,013	0,012	0,012	0,012	0,013	0,012	0,012	0,013	0,013	0,18
475	0,010	0,011	0,012	0,011	0,012	0,012	0,013	0,013	0,013	0,013	0,013	0,16
525	0,010	0,011	0,011	0,011	0,011	0,012	0,013	0,013	0,012	0,013	0,013	0,14
575	0,010	0,010	0,011	0,011	0,011	0,012	0,012	0,012	0,013	0,013	0,013	0,13
625	0,010	0,010	0,010	0,010	0,011	0,011	0,012	0,012	0,012	0,013	0,013	0,12
675	0,010	0,009	0,010	0,010	0,010	0,011	0,012	0,012	0,013	0,013	0,013	0,11
725	0,010	0,009	0,009	0,009	0,010	0,011	0,011	0,012	0,012	0,013	0,013	0,10
775	0,010	0,009	0,009	0,009	0,010	0,010	0,011	0,012	0,012	0,013	0,013	0,10
825	0,010	0,008	0,008	0,009	0,009	0,010	0,011	0,011	0,012	0,013	0,013	0,09
875	0,009	0,008	0,008	0,008	0,009	0,010	0,011	0,011	0,012	0,012	0,013	0,09
925	0,009	0,008	0,008	0,008	0,009	0,009	0,010	0,011	0,011	0,012	0,013	0,08
975	0,012	0,010	0,010	0,010	0,011	0,012	0,012	0,013	0,014	0,014	0,015	0,08
1025	0,009	0,007	0,007	0,007	0,008	0,009	0,009	0,010	0,011	0,012	0,012	0,07
1075	0,013	0,010	0,010	0,011	0,011	0,012	0,012	0,013	0,014	0,015	0,017	0,07
1125	0,009	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,011	0,012	0,013	0,07
1175	0,009	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,011	0,012	0,013	0,06
1225	0,009	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,011	0,012	0,013	0,06
1275	0,009	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,011	0,012	0,013	0,06
1325	0,009	0,007	0,007	0,007	0,007	0,008	0,009	0,009	0,010	0,012	0,013	0,06
1375	0,009	0,007	0,007	0,007	0,007	0,008	0,009	0,009	0,010	0,012	0,013	0,05
1425	0,009	0,007	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,012	0,013	0,05
1475	0,009	0,007	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,011	0,013	0,05
1525	0,009	0,007	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,011	0,012	0,05
1575	0,009	0,007	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,011	0,013	0,05
1625	0,009	0,007	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,011	0,012	0,05
1675	0,010	0,008	0,007	0,007	0,008	0,008	0,009	0,009	0,010	0,011	0,013	0,04
1725	0,009	0,007	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,011	0,012	0,04
1775	0,011	0,008	0,008	0,008	0,008	0,008	0,009	0,009	0,010	0,011	0,012	0,04
1825	0,010	0,007	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,010	0,012	0,04
1875	0,010	0,008	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,011	0,011	0,04
1925	0,010	0,008	0,007	0,007	0,007	0,008	0,008	0,009	0,010	0,010	0,011	0,04
1975	0,011	0,008	0,008	0,007	0,007	0,008	0,008	0,009	0,010	0,011	0,012	0,04

Higher Frequencies												
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100	Limit
f [kHz]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]
2,1	0,064	0,052	0,037	0,040	0,055	0,073	0,084	0,085	0,079	0,064	0,046	0,2
2,3	0,062	0,049	0,035	0,038	0,054	0,074	0,084	0,084	0,078	0,061	0,042	0,2
2,5	0,072	0,061	0,049	0,049	0,062	0,078	0,085	0,083	0,079	0,064	0,051	0,2
2,7	0,065	0,052	0,038	0,041	0,057	0,074	0,080	0,078	0,071	0,056	0,037	0,2
2,9	0,060	0,050	0,036	0,038	0,054	0,070	0,076	0,071	0,063	0,048	0,034	0,2
3,1	0,058	0,048	0,038	0,040	0,056	0,069	0,073	0,069	0,062	0,048	0,034	0,2
3,3	0,051	0,044	0,034	0,036	0,048	0,060	0,064	0,060	0,053	0,041	0,030	0,2
3,5	0,046	0,041	0,033	0,035	0,045	0,053	0,055	0,051	0,044	0,035	0,027	0,2
3,7	0,043	0,039	0,033	0,035	0,044	0,050	0,052	0,049	0,043	0,034	0,028	0,2
3,9	0,037	0,033	0,029	0,032	0,038	0,043	0,044	0,042	0,037	0,031	0,026	0,2
4,1	0,031	0,027	0,024	0,026	0,032	0,036	0,038	0,036	0,032	0,027	0,023	0,2
4,3	0,027	0,023	0,021	0,023	0,026	0,029	0,031	0,030	0,027	0,023	0,021	0,2
4,5	0,023	0,021	0,019	0,020	0,022	0,025	0,026	0,025	0,023	0,022	0,021	0,2
4,7	0,036	0,035	0,033	0,033	0,033	0,034	0,035	0,035	0,034	0,033	0,033	0,2
4,9	0,035	0,033	0,032	0,032	0,032	0,033	0,033	0,033	0,033	0,032	0,032	0,2
5,1	0,016	0,015	0,014	0,015	0,016	0,018	0,019	0,018	0,017	0,016	0,016	0,2
5,3	0,015	0,014	0,013	0,014	0,015	0,016	0,016	0,016	0,015	0,015	0,014	0,2
5,5	0,014	0,013	0,013	0,013	0,014	0,014	0,015	0,014	0,014	0,014	0,014	0,2
5,7	0,019	0,019	0,018	0,018	0,018	0,018	0,018	0,018	0,018	0,018	0,019	0,2
5,9	0,018	0,018	0,017	0,017	0,016	0,016	0,017	0,017	0,017	0,017	0,018	0,2
6,1	0,011	0,010	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,012	0,012	0,2
6,3	0,010	0,010	0,010	0,009	0,009	0,009	0,010	0,011	0,011	0,011	0,011	0,2
6,5	0,010	0,010	0,010	0,009	0,009	0,009	0,010	0,011	0,011	0,011	0,011	0,2
6,7	0,010	0,010	0,009	0,009	0,009	0,009	0,010	0,010	0,011	0,011	0,011	0,2
6,9	0,011	0,011	0,010	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,012	0,2
7,1	0,010	0,010	0,009	0,009	0,008	0,008	0,009	0,010	0,010	0,010	0,010	0,2
7,3	0,010	0,009	0,009	0,009	0,008	0,008	0,009	0,010	0,010	0,010	0,010	0,2
7,5	0,010	0,010	0,009	0,009	0,008	0,008	0,009	0,010	0,010	0,010	0,010	0,2
7,7	0,009	0,009	0,009	0,008	0,008	0,008	0,009	0,009	0,010	0,010	0,010	0,2
7,9	0,009	0,009	0,009	0,008	0,008	0,008	0,008	0,009	0,009	0,009	0,010	0,2
8,1	0,009	0,008	0,008	0,007	0,007	0,007	0,008	0,008	0,009	0,009	0,009	0,2
8,3	0,008	0,008	0,008	0,007	0,007	0,007	0,008	0,008	0,009	0,009	0,009	0,2
8,5	0,008	0,008	0,008	0,007	0,007	0,007	0,008	0,008	0,009	0,009	0,009	0,2
8,7	0,008	0,008	0,007	0,007	0,007	0,007	0,008	0,008	0,008	0,008	0,008	0,2
8,9	0,007	0,007	0,007	0,006	0,006	0,007	0,007	0,007	0,008	0,008	0,008	0,2

HYD 6000-EP											
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	2,965	10,447	20,528	30,625	40,691	50,691	60,672	70,560	80,425	90,206	99,926
2	0,017	0,017	0,018	0,017	0,017	0,017	0,020	0,017	0,019	0,016	0,045
3	0,477	0,613	0,619	0,624	0,633	0,638	0,639	0,644	0,650	0,690	0,804
4	0,016	0,008	0,008	0,008	0,008	0,009	0,011	0,009	0,010	0,015	0,013
5	0,275	0,302	0,297	0,293	0,291	0,291	0,287	0,278	0,269	0,302	0,394
6	0,011	0,007	0,007	0,007	0,007	0,007	0,008	0,008	0,007	0,013	0,021
7	0,180	0,168	0,155	0,154	0,151	0,149	0,141	0,134	0,128	0,165	0,237
8	0,008	0,007	0,007	0,007	0,007	0,007	0,007	0,007	0,008	0,009	0,011
9	0,111	0,099	0,092	0,090	0,086	0,080	0,075	0,072	0,074	0,111	0,154
10	0,008	0,007	0,007	0,007	0,007	0,007	0,008	0,008	0,007	0,009	0,012
11	0,076	0,066	0,062	0,050	0,044	0,040	0,040	0,049	0,062	0,076	0,076
12	0,007	0,007	0,006	0,007	0,007	0,007	0,007	0,007	0,007	0,010	0,012
13	0,064	0,055	0,044	0,030	0,028	0,029	0,038	0,054	0,073	0,069	0,047
14	0,007	0,006	0,006	0,006	0,006	0,006	0,007	0,007	0,007	0,010	0,010
15	0,052	0,052	0,035	0,027	0,023	0,029	0,047	0,064	0,081	0,070	0,059
16	0,006	0,005	0,005	0,006	0,006	0,006	0,007	0,007	0,007	0,010	0,008
17	0,057	0,054	0,036	0,028	0,026	0,039	0,057	0,073	0,088	0,077	0,075
18	0,006	0,005	0,005	0,006	0,006	0,006	0,006	0,006	0,007	0,009	0,008
19	0,058	0,053	0,035	0,027	0,031	0,045	0,060	0,075	0,087	0,078	0,074
20	0,006	0,005	0,005	0,005	0,005	0,005	0,006	0,006	0,007	0,008	0,007
21	0,063	0,055	0,035	0,030	0,035	0,049	0,066	0,078	0,088	0,081	0,069
22	0,006	0,005	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,008	0,008
23	0,065	0,056	0,035	0,032	0,038	0,055	0,068	0,077	0,084	0,076	0,059
24	0,006	0,005	0,004	0,004	0,005	0,005	0,005	0,006	0,006	0,008	0,007
25	0,067	0,054	0,034	0,032	0,039	0,055	0,065	0,074	0,080	0,071	0,055
26	0,006	0,004	0,004	0,004	0,004	0,005	0,005	0,005	0,006	0,007	0,007
27	0,067	0,053	0,035	0,035	0,043	0,057	0,068	0,076	0,079	0,069	0,054
28	0,006	0,005	0,004	0,004	0,005	0,005	0,006	0,006	0,006	0,007	0,008
29	0,065	0,048	0,031	0,032	0,041	0,054	0,065	0,072	0,073	0,062	0,050
30	0,006	0,004	0,004	0,004	0,004	0,005	0,005	0,006	0,006	0,007	0,007
31	0,061	0,047	0,032	0,034	0,042	0,055	0,065	0,069	0,070	0,060	0,048
32	0,007	0,005	0,004	0,004	0,005	0,005	0,005	0,005	0,006	0,007	0,007
33	0,059	0,044	0,031	0,033	0,041	0,055	0,064	0,068	0,068	0,058	0,046
34	0,007	0,004	0,004	0,004	0,005	0,005	0,005	0,006	0,006	0,007	0,007
35	0,051	0,040	0,028	0,030	0,040	0,053	0,062	0,065	0,063	0,053	0,037
36	0,008	0,006	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,008	0,008
37	0,049	0,038	0,026	0,029	0,038	0,052	0,061	0,063	0,062	0,051	0,035
38	0,008	0,005	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,007	0,007
39	0,046	0,040	0,029	0,030	0,040	0,054	0,062	0,064	0,062	0,051	0,036
40	0,009	0,007	0,006	0,005	0,006	0,006	0,006	0,006	0,006	0,007	0,008

Interharmonics												
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100	Limit
f [Hz]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]
75	0,004	0,004	0,004	0,004	0,004	0,004	0,005	0,004	0,006	0,005	0,005	0,40
125	0,003	0,003	0,003	0,003	0,003	0,004	0,004	0,005	0,004	0,006	0,007	0,60
175	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,002	0,003	0,003	0,43
225	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,002	0,003	0,003	0,33
275	0,002	0,002	0,003	0,004	0,005	0,006	0,006	0,006	0,006	0,006	0,007	0,27
325	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,23
375	0,002	0,002	0,002	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,004	0,20
425	0,005	0,006	0,007	0,012	0,007	0,006	0,018	0,005	0,008	0,009	0,011	0,18
475	0,004	0,004	0,005	0,004	0,005	0,005	0,004	0,005	0,005	0,005	0,004	0,16
525	0,004	0,003	0,004	0,003	0,006	0,009	0,005	0,009	0,009	0,010	0,012	0,14
575	0,003	0,003	0,003	0,003	0,004	0,004	0,003	0,005	0,004	0,004	0,004	0,13
625	0,004	0,005	0,006	0,006	0,006	0,005	0,006	0,005	0,005	0,005	0,004	0,12
675	0,003	0,003	0,003	0,004	0,005	0,006	0,004	0,006	0,006	0,006	0,006	0,11
725	0,002	0,002	0,002	0,002	0,003	0,004	0,003	0,005	0,005	0,006	0,006	0,10
775	0,002	0,002	0,003	0,003	0,003	0,004	0,003	0,005	0,006	0,007	0,007	0,10
825	0,004	0,013	0,016	0,016	0,016	0,011	0,019	0,019	0,025	0,029	0,033	0,09
875	0,002	0,002	0,002	0,002	0,003	0,003	0,003	0,003	0,004	0,004	0,005	0,09
925	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,003	0,003	0,003	0,08
975	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,003	0,08
1025	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,07
1075	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,07
1125	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,07
1175	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,06
1225	0,002	0,002	0,002	0,003	0,002	0,002	0,002	0,002	0,003	0,003	0,004	0,06
1275	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,06
1325	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,06
1375	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,05
1425	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,003	0,003	0,004	0,05
1475	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,05
1525	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,05
1575	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,003	0,003	0,003	0,05
1625	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,05
1675	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,04
1725	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,04
1775	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,04
1825	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,04
1875	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,04
1925	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,04
1975	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,04

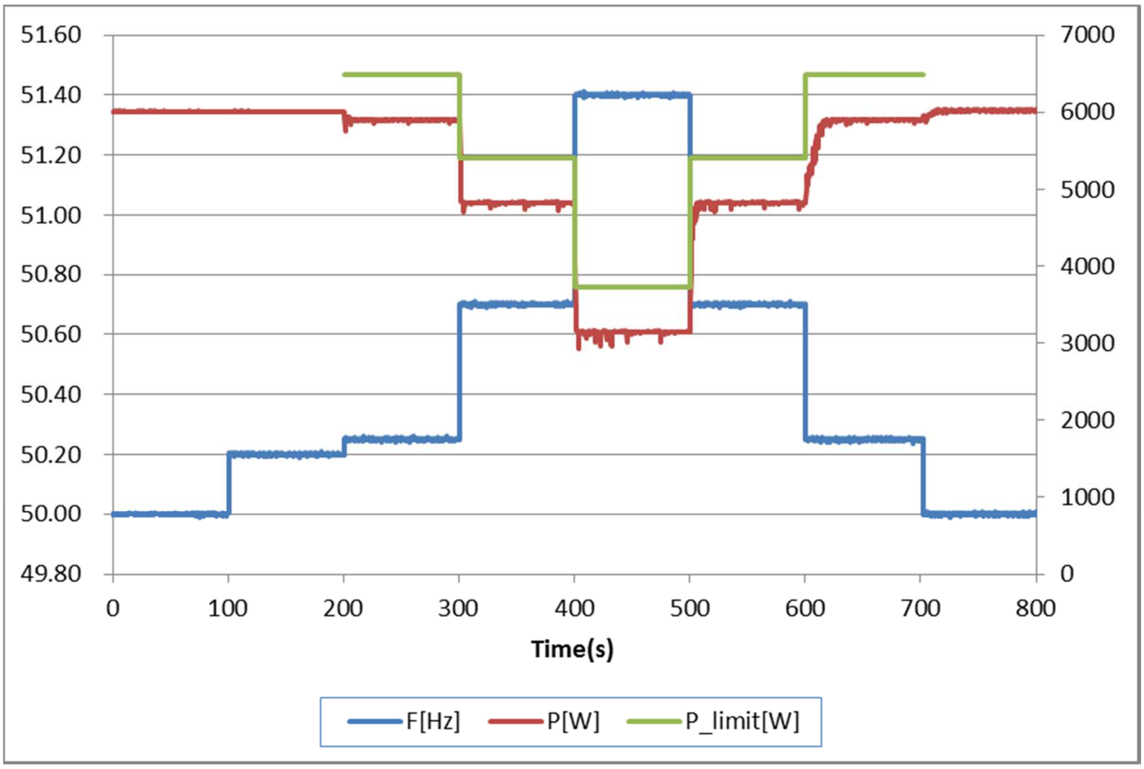
Higher Frequencies (HYD 5KTL-3PH)												
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100	Limit
f [kHz]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]	I [%In]
2,1	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,2
2,3	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,2
2,5	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,2
2,7	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,2
2,9	0,004	0,006	0,008	0,007	0,006	0,005	0,006	0,005	0,006	0,006	0,006	0,2
3,1	0,004	0,006	0,006	0,005	0,005	0,004	0,005	0,005	0,005	0,005	0,005	0,2
3,3	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,004	0,2
3,5	0,004	0,004	0,005	0,005	0,004	0,004	0,005	0,004	0,005	0,005	0,005	0,2
3,7	0,004	0,005	0,006	0,005	0,005	0,004	0,005	0,005	0,005	0,005	0,005	0,2
3,9	0,004	0,005	0,004	0,004	0,004	0,004	0,004	0,004	0,005	0,005	0,005	0,2
4,1	0,004	0,005	0,005	0,005	0,005	0,004	0,005	0,004	0,005	0,005	0,006	0,2
4,3	0,004	0,005	0,006	0,007	0,005	0,005	0,006	0,005	0,006	0,007	0,007	0,2
4,5	0,005	0,006	0,009	0,009	0,007	0,005	0,007	0,006	0,007	0,007	0,007	0,2
4,7	0,004	0,006	0,007	0,008	0,007	0,005	0,005	0,005	0,006	0,006	0,006	0,2
4,9	0,004	0,004	0,004	0,004	0,004	0,004	0,005	0,004	0,005	0,005	0,005	0,2
5,1	0,004	0,006	0,005	0,006	0,005	0,004	0,005	0,004	0,005	0,005	0,005	0,2
5,3	0,006	0,011	0,016	0,014	0,008	0,006	0,010	0,006	0,010	0,010	0,010	0,2
5,5	0,004	0,005	0,005	0,005	0,004	0,004	0,005	0,004	0,005	0,005	0,005	0,2
5,7	0,006	0,014	0,012	0,016	0,010	0,006	0,010	0,007	0,010	0,010	0,009	0,2
5,9	0,004	0,012	0,010	0,011	0,008	0,005	0,007	0,006	0,008	0,008	0,009	0,2
6,1	0,004	0,004	0,005	0,005	0,004	0,004	0,005	0,005	0,005	0,005	0,005	0,2
6,3	0,004	0,005	0,005	0,006	0,006	0,005	0,005	0,005	0,005	0,005	0,005	0,2
6,5	0,004	0,004	0,005	0,005	0,004	0,004	0,005	0,004	0,005	0,005	0,005	0,2
6,7	0,004	0,004	0,004	0,005	0,004	0,004	0,005	0,005	0,005	0,005	0,005	0,2
6,9	0,004	0,004	0,004	0,005	0,004	0,004	0,005	0,005	0,005	0,005	0,005	0,2
7,1	0,005	0,006	0,007	0,009	0,006	0,005	0,008	0,005	0,007	0,008	0,008	0,2
7,3	0,005	0,006	0,008	0,010	0,006	0,005	0,008	0,005	0,008	0,009	0,009	0,2
7,5	0,004	0,005	0,007	0,008	0,006	0,005	0,007	0,005	0,008	0,008	0,008	0,2
7,7	0,004	0,005	0,005	0,008	0,006	0,005	0,010	0,006	0,011	0,012	0,014	0,2
7,9	0,004	0,005	0,006	0,009	0,007	0,005	0,011	0,006	0,013	0,015	0,016	0,2
8,1	0,004	0,004	0,006	0,008	0,006	0,005	0,011	0,006	0,012	0,014	0,016	0,2
8,3	0,004	0,005	0,005	0,007	0,007	0,005	0,008	0,006	0,010	0,011	0,012	0,2
8,5	0,004	0,005	0,006	0,009	0,011	0,005	0,010	0,010	0,014	0,016	0,017	0,2
8,7	0,004	0,006	0,007	0,010	0,012	0,006	0,008	0,012	0,014	0,015	0,016	0,2
8,9	0,005	0,008	0,013	0,015	0,014	0,008	0,011	0,014	0,017	0,018	0,018	0,2

Note:
The normalization current is 27,3A for HYD 6000-EP.
The tests had been performed on the HYD 6000-EP and HYD 3000-EPis valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP and HYD 3680-EP, since it is identical in hardware and software construction except output power derated by software.

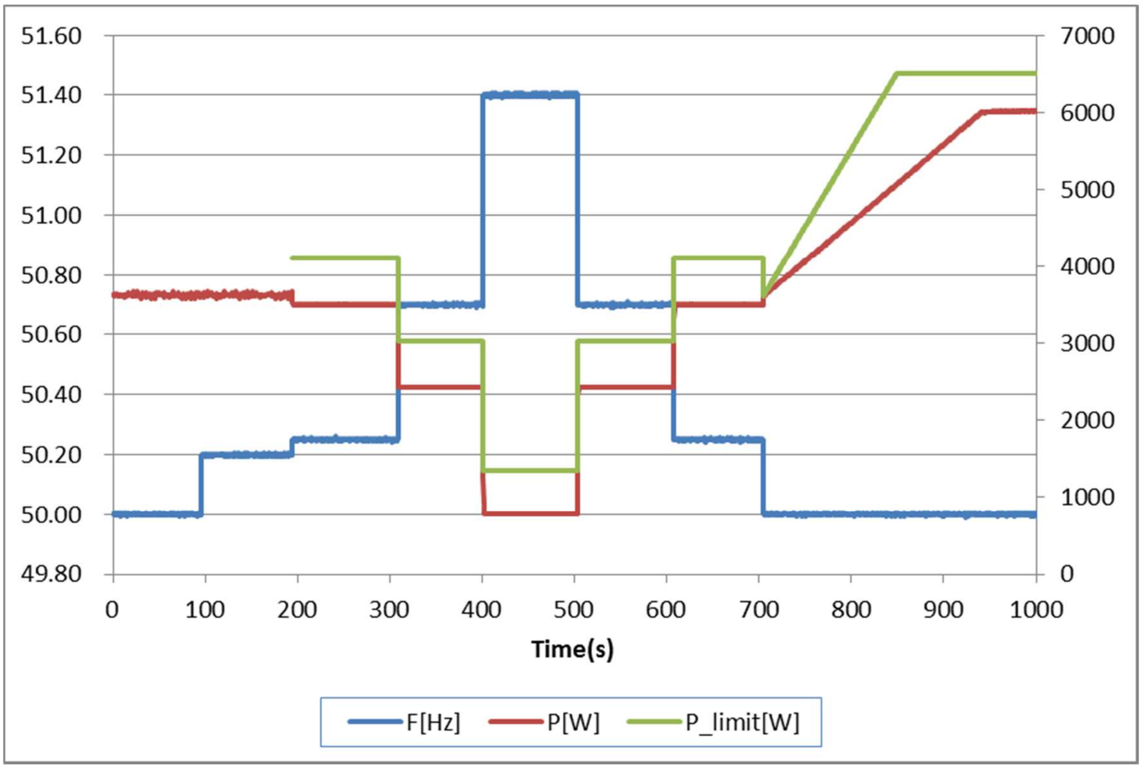
TECHNICAL REGULATION 3.3.1: Control		
Clause	**Test requirement**	**Result**
6.1	**General requirements**	**P**
6.2	**Active power and frequency control functions**	**P**
6.2.1	**Frequency response, LFSM-U and LFSM-O**	**P**
6.2.2	**Frequency settings and frequency response**	**P**
6.2.3	**Frequency control (FSM)**	**N/A**
6.2.4	**Limiter functions – active power control**	**P**
6.3	**Reactive power and voltage control functions**	**P**
6.3.1	**Q control**	**P**
6.3.2	**Power factor control**	**P**
6.3.3	**Voltage control**	**N/A**
6.3.4	**Automatic power factor control**	**P**
6.3.5	**Requirements for reactive power properties of the facility in relation to Pn**	**P**
6.4	**System protection**	**N/A**
6.4.1	**System protection, categories A and B**	**N/A**
6.4.2	**System protection, categories C and D**	**N/A**
6.5	**Order of priority for control functions and protection**	**P**

6.2.2 6.2.2.1	**Frequency settings and frequency response** **LFSM-O, categories A, B, C and D**						**P**
Test result: HYD 6000-EP							
Standard frequency response settings for DK1							
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} Droop=5% (40% P_n / 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 [kW]:	N/A	5,887	4,807	3,127	4,807	5,886	N/A
P_{E60} [kW]:	6,009	5,898	4,826	3,134	4,824	5,899	6,020
$\Delta P_{E60}/P_M$ [%]:	N/A	0,19	0,32	0,11	0,29	0,22	N/A
2. Measurement a) to g): Active power output 60% after freezing = 100% P_{Emax} s=5% (40% P_n / 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 [kW]:	N/A	3,505	2,425	0,745	2,424	3,503	N/A
P_{E60} [kW]:	3,625	3,500	2,430	0,777	2,430	3,500	6,019
$\Delta P_{E60}/P_M$ [%]:	N/A	-0,08	0,09	0,53	0,10	-0,06	N/A
Limit $\Delta P/P_{1min}$:	± 10 % of P_{Emax}						
Standard frequency response settings for DK2							
1-min mean value [Hz]:	a) 50,00	b) 50,55	c) 50,70	d) 51,40	e) 50,70	f) 50,55	g) 50,00
1. Measurement a) to g): Active power output =100% P_{Emax} s=4% (50% P_n / Hz), threshold frequency for start/return: 50,5Hz							
Frequency [Hz]:	50,00	50,55	50,70	51,40	50,70	50,55	50,00
P_M [kW]:	N/A	5,840	5,390	3,290	5,390	5,840	N/A
P_{E60} [kW]:	5,991	5,834	5,388	3,294	5,388	5,834	5,992
$\Delta P_{E60}/P_M$ [%]:	N/A	-0,11	-0,04	0,06	-0,04	-0,10	N/A
2. Measurement a) to g): Active power output 60% after freezing = 100% P_{Emax} s=4% (50% P_n / Hz), threshold frequency for start/return: 50,5Hz							
Frequency [Hz]:	50,00	50,55	50,70	51,40	50,70	50,55	50,00
P_M [kW]:	N/A	3,450	3,000	0,900	3,000	3,450	N/A
P_{E60} [kW]:	3,601	3,461	3,020	0,942	3,019	3,461	5,991
$\Delta P_{E60}/P_M$ [%]:	N/A	0,17	0,34	0,71	0,32	0,18	N/A
Limit $\Delta P/P_{1min}$:	± 10 % of P_{Emax}						

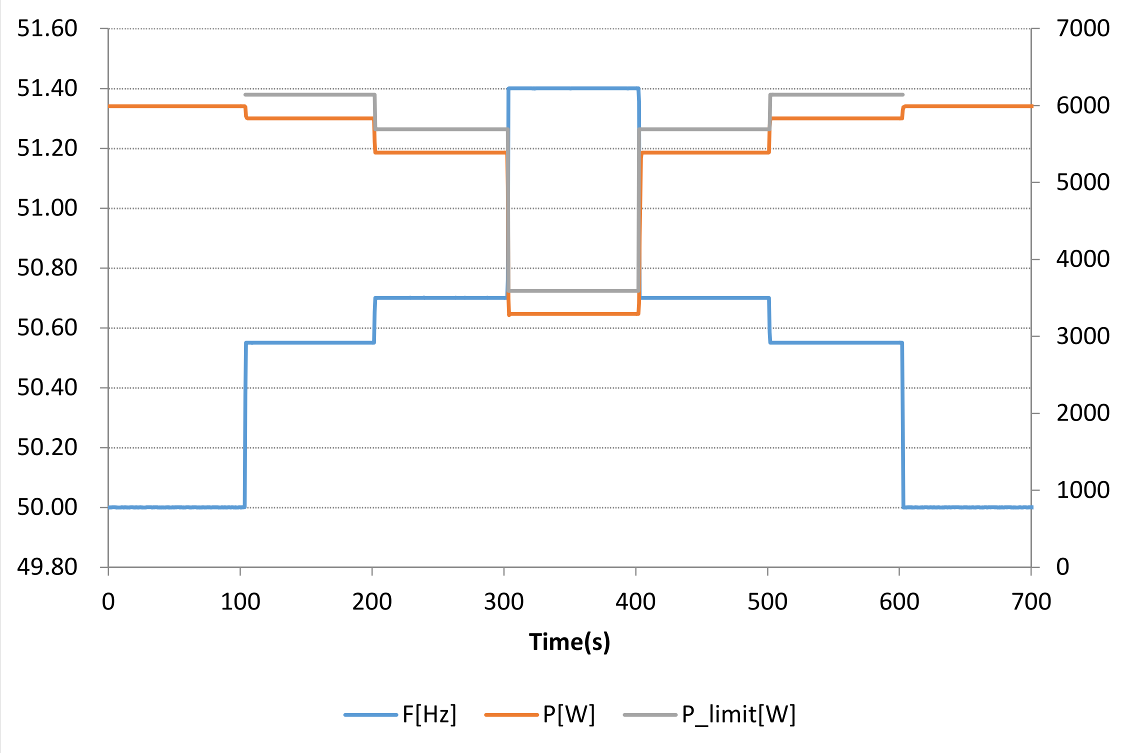
Graph of Measurement 1.of DK1: Active power output > 80% P_{Emax}



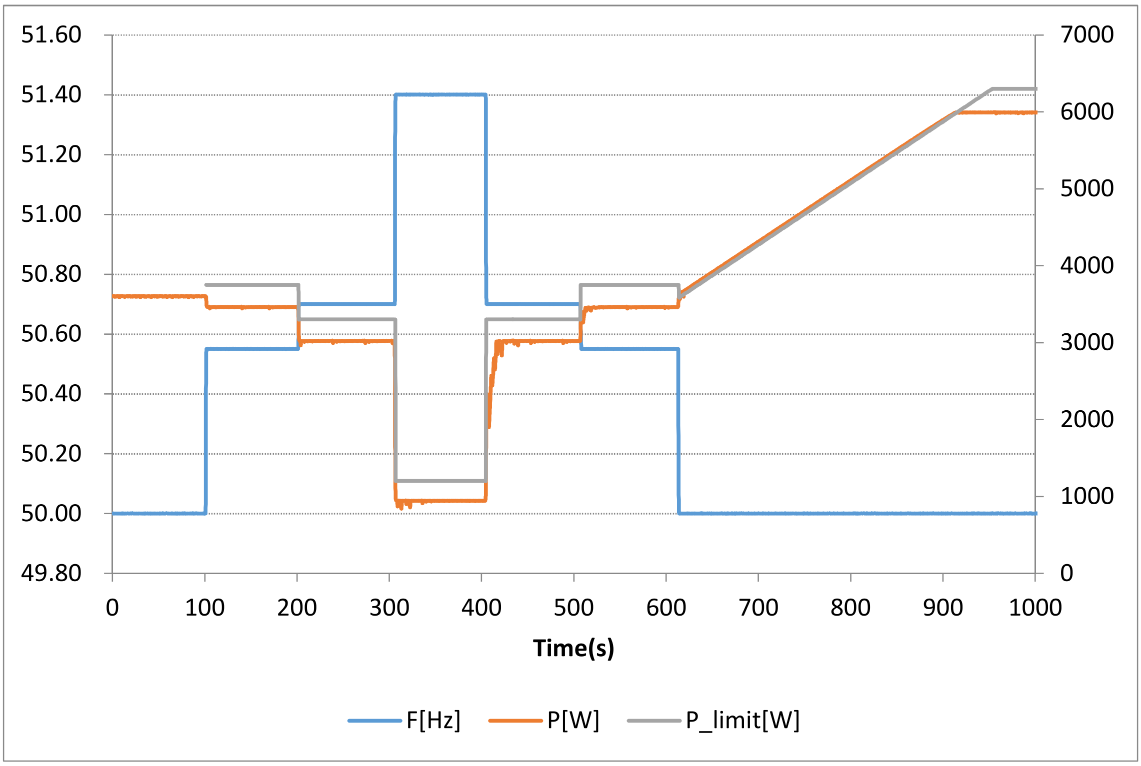
Graph of Measurement 2 of DK1.:Active power output 40% and 60% after freezing > 80% P_n



Graph of Measurement 1.of DK2: Active power output > 80% P_{Emax}



Graph of Measurement 2 of DK2.:Active power output 40% and 60% after freezing > 80% P_n



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 /50,5Hz 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. Max gradient: 20%P_{Emax}/min.
Assessment criterion: If frequency increases to above f_2 (LFSM-O), the droop must be followed, i.e. power flow from the grid increases as frequency increases. If frequency is subsequently stabilised and decreases, the droop must still be followed until system frequency is once again below frequency f_2. a) For adjustable micro-generators when: 1) the active power reduces between measuring points b) and f) given above with the set gradient P_n 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 tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

6.2.4 Limiter functions – active power control			P
Test result:			
Setpoint power bin [% P_{Emax}]	P_{set} [kW]	P_{60} [kW]	Deviation [% P_{Emax}]
100%	6,000	6,001	0,023
90%	5,400	5,465	1,087
80%	4,800	4,858	0,968
70%	4,200	4,253	0,884
60%	3,600	3,648	0,806
50%	3,000	3,050	0,829
40%	2,400	2,445	0,749
30%	1,800	1,845	0,751
20%	1,200	1,246	0,771
10%	0,600	0,647	0,777
3%	0,600	0,638	0,191

	Setpoint power bin [% P_{Emax}]	Deviation [% P_{Emax}]
Max. deviation	90%	1,087
Limit $\Delta P_{E60}/P_{Setpoint}$:	±5% P_{set} or ±0,5% of P_{Emax}, highest	

Test:

The setpoint signal must be reduced from 100% to 10% 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:

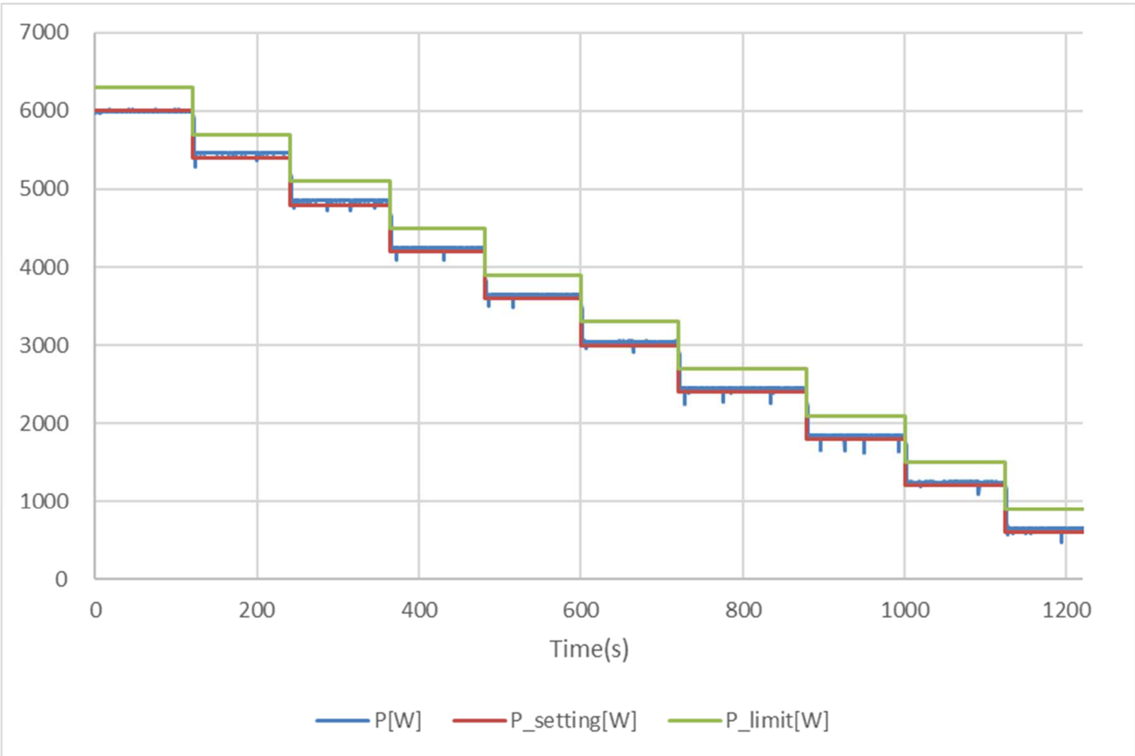
- the active power value does not exceed the setpoint by more than 5% P_{Emax} or
- the setpoint is fallen below within 5 minutes or the PGU has switched off

Note:

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

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Graph of active power on set point



6.3.1 Q control 6.3.3.1 Q control, categories A, B, C and D 6.3.5 Requirements for reactive power properties of the facility in relation to Pn 6.3.5.2 Reactive power, category B				P
Test result: HYD 6000-EP				
Inducitive reactive power supply				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	DC power [kW]
10%	0,556	-2,943	0,1858	0,627
20%	1,178	-2,889	0,3774	1,242
30%	1,792	-2,885	0,5277	1,856
40%	2,405	-2,893	0,6393	2,471
50%	3,011	-2,906	0,7196	3,083
60%	3,615	-2,924	0,7776	3,696
70%	4,215	-2,913	0,8227	4,306
80%	4,812	-2,905	0,8561	4,917
90%	5,403	-2,934	0,8788	5,524
100%	5,696	-2,892	0,8917	5,827
Capacitive reactive power supply				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	DC power [kW]
10%	0,565	2,885	0,1921	0,626
20%	1,184	2,920	0,3757	1,242
30%	1,798	2,938	0,5220	1,856
40%	2,410	2,946	0,6331	2,471
50%	3,017	2,918	0,7188	3,083
60%	3,622	2,920	0,7785	3,696
70%	4,220	2,922	0,8222	4,306
80%	4,817	2,925	0,8548	4,916
90%	5,408	2,933	0,8790	5,523
100%	5,703	2,899	0,8914	5,832
Cos phi=1 no reactive power supply				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	DC power [kW]
10%	0,611	0,116	0,9824	0,630
20%	1,224	0,094	0,9970	1,248
30%	1,833	0,073	0,9992	1,865
40%	2,437	0,053	0,9997	2,479
50%	3,039	0,033	0,9999	3,094
60%	3,641	-0,053	0,9999	3,710
70%	4,236	-0,077	0,9998	4,323
80%	4,829	-0,105	0,9998	4,935

90%	5,418	-0,135	0,9997	5,545
100%	6,002	-0,165	0,9996	6,154

Assessment criterion:

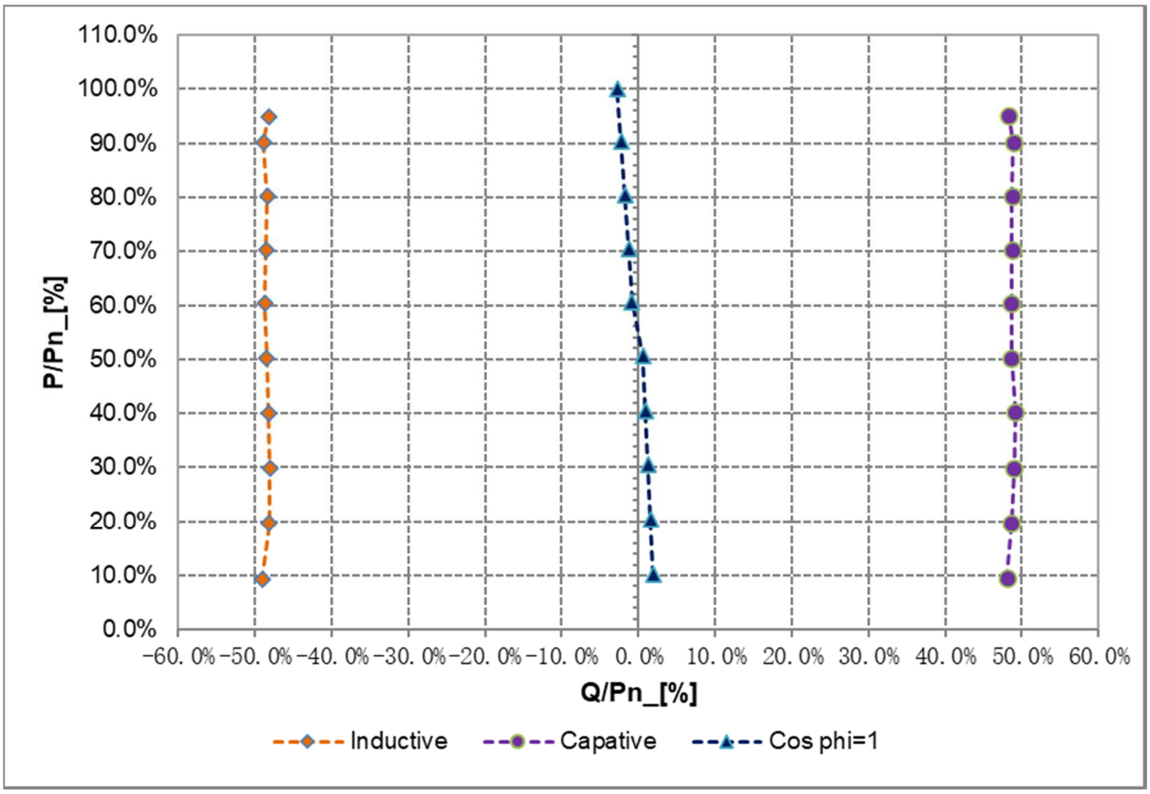
The power factor resulting in each of the measurement points between 20 % and 90 % of the nominal power is equal to or lower than 0,90 both in over excited and under excited operation,

The test method refer to clause CEI0-21 / EN 50438:2013, Annex D,3,4,2,1,

Generating plants must meet the reactive power requirement regardless of the number of feeding phases under normal steady-state operating conditions in the voltage tolerance band +10%U_n and -15%U_n.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Diagram



6.3.2 Voltage control 6.3.2.1 Power factor control, categories A, B, C and D 6.3.5 Requirements for reactive power properties of the facility in relation to Pn 6.3.5.1 Reactive power, category A				P
Test result: HYD 6000-EP				
PF = 0,9 / Inducitive reactive power supply				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	DC power [kW]
10%	0,613	-0,293	0,9024	0,634
20%	1,223	-0,592	0,9002	1,252
30%	1,829	-0,888	0,8995	1,867
40%	2,433	-1,203	0,8964	2,484
50%	3,033	-1,459	0,9011	3,098
60%	3,629	-1,784	0,8974	3,713
70%	4,221	-2,052	0,8994	4,324
80%	4,809	-2,373	0,8967	4,936
90%	5,391	-2,622	0,8993	5,542
100%	5,419	-2,636	0,8993	5,575
PF = 0,9 / Capacitive reactive power supply				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	DC power [kW]
10%	0,615	0,286	0,9065	0,634
20%	1,226	0,591	0,9007	1,252
30%	1,833	0,879	0,9017	1,868
40%	2,437	1,199	0,8973	2,484
50%	3,037	1,463	0,9009	3,098
60%	3,635	1,727	0,9032	3,713
70%	4,226	2,037	0,9008	4,324
80%	4,814	2,359	0,8980	4,935
90%	5,395	2,662	0,8968	5,541
100%	5,423	2,672	0,8971	5,574

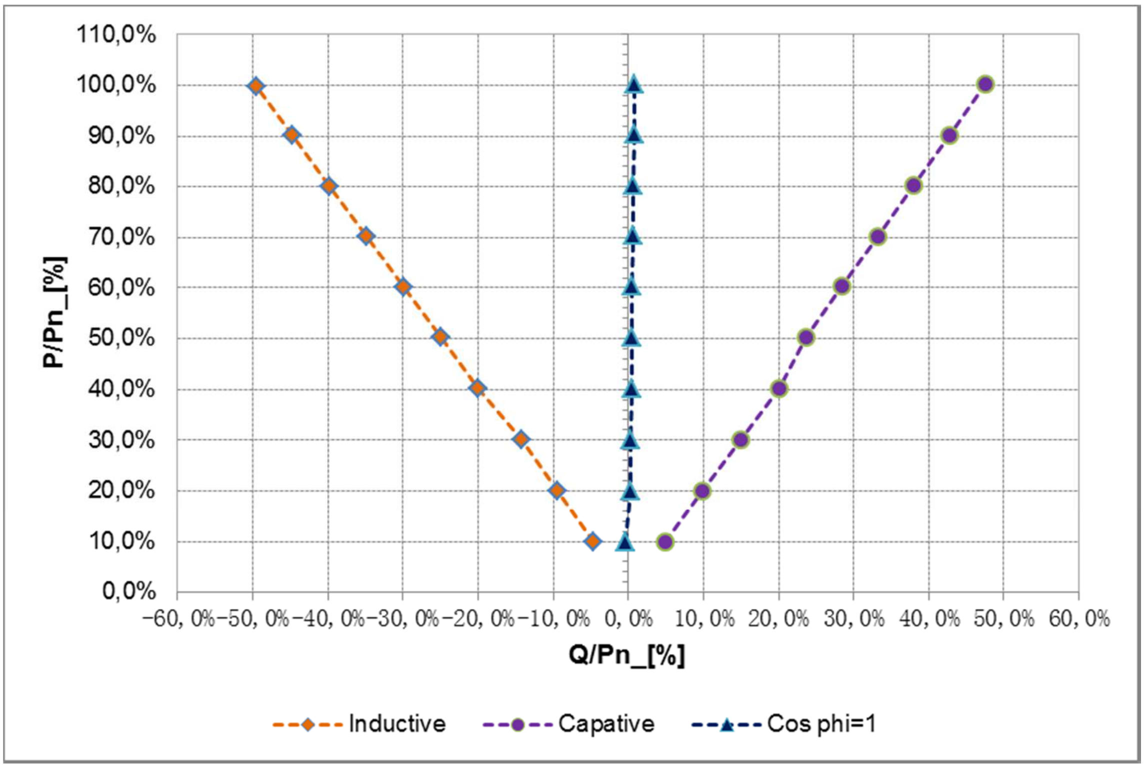
Cos phi=1 no reactive power supply				
Rating power [%]	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	DC power [kW]
10%	0,611	0,116	0,9824	0,630
20%	1,224	0,094	0,9970	1,248
30%	1,833	0,073	0,9992	1,865
40%	2,437	0,053	0,9997	2,479
50%	3,039	0,033	0,9999	3,094
60%	3,641	-0,053	0,9999	3,710
70%	4,236	-0,077	0,9998	4,323
80%	4,829	-0,105	0,9998	4,935
90%	5,418	-0,135	0,9997	5,545
100%	6,002	-0,165	0,9996	6,154

Assessment criterion:

For the control function, the accuracy of a completed or continuous control operation, including accuracy at the set point, must not deviate by more than 1% of the power factor set point over a period of 0,01 minute. The energy storage facility must be able to set a power factor set point with a resolution of 0,01.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Diagram



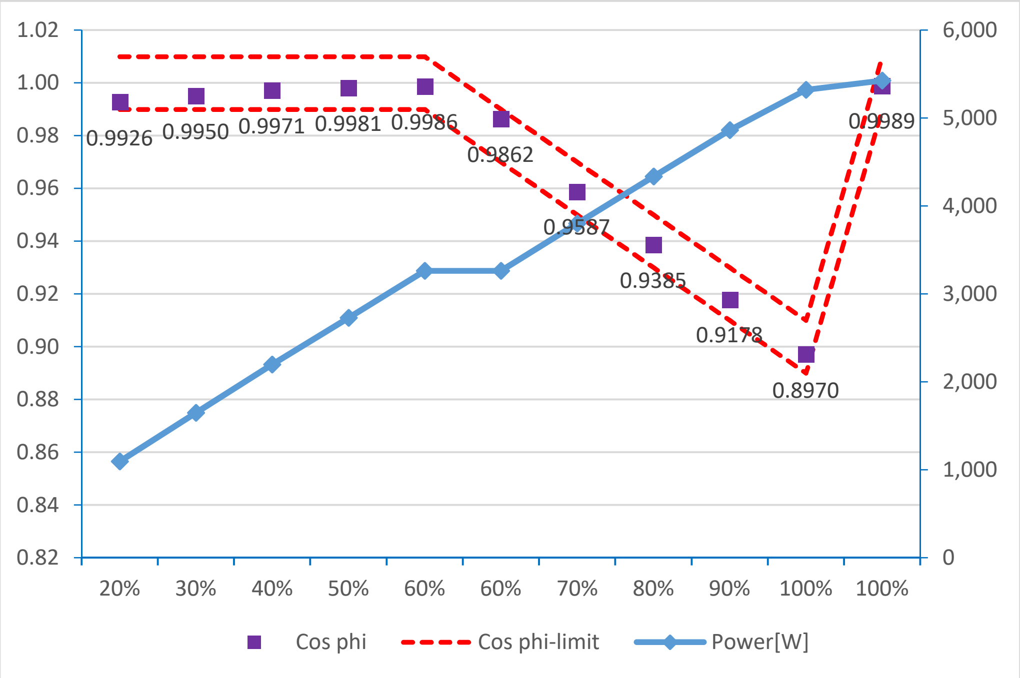
6.3.4 Automatic power factor control
6.3.4.1 Automatic power factor control, categories A and B

P

Test result: HYD 6000-EP

Inductive reactive power absorbation

Power-BIN	Active power P[kW]	Reactive power Q[kVar]	cosφ measured	cosφ expected	Δ cosφ
20%	1,096	0,167	0,9926	1,00	0,007
30%	1,648	0,166	0,9950	1,00	0,005
40%	2,198	0,167	0,9971	1,00	0,003
50%	2,728	0,169	0,9981	1,00	0,002
60%	3,264	-0,547	0,9862	0,98	-0,006
70%	3,801	-1,127	0,9587	0,96	0,001
80%	4,334	-1,595	0,9385	0,94	0,002
90%	4,863	-2,104	0,9178	0,92	0,002
100%	5,320	-2,622	0,8970	0,90	0,003



Note:
The activation level for the function is normally 105% of rated voltage, and the deactivation level is normally 100% of rated voltage. The activation/deactivation level must be adjustable via set points.
The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

6.5	Order of priority for control functions and protection	P

Functions	The order of priority
Protective functions, see section 7	1
Frequency response, see section 6.2.1	2
Frequency control, see section 6.2.3	3
Limiter functions, see section 6.2.4	4

Note:

The order of priority is as follows:
1. Protective functions, see section 7
2. Frequency response, see section 6.2.1
3. Frequency control, see section 6.2.3
4. Limiter functions, see section 6.2.4.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

TECHNICAL REGULATION 3.3.1: Protection		
Clause	**Test requirement**	**Result**
7.1	**Introduction**	**P**
7.2	**Protective setting requirements**	**P**
7.2.1	**Protective functions, category A**	**P**
7.2.2	**Protective functions, category B**	**N/A**
7.2.3	**Protective functions, category C and D**	**N/A**
7.2.4	**Protective functions, transmission system connections**	**N/A**

7.2.1	Protective functions, category A	P

Several points to check

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

Note:

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

7.2.1	Protective functions, category A(Overvoltage and undervoltage)				P
Test conditions			Frequency: 50+/-0,2Hz		
Phase	**Limit [V]**	**Trip value [V]**	**Voltage step [V]**	**Disconnection time [s]**	**Limit [s]**
L1	110% of Un = 253,0 (stage 1)	253,51	230,0 to 258,0	60,0	60s ≤ t ≤ 60,1s
		253,58	230,0 to 258,0	60,0	
		253,51	230,0 to 258,0	60,1	
		253,50	230,0 to 258,0	60,1	
		253,51	230,0 to 258,0	60,1	
	115% of Un = 264,5 (stage 2)	264,5	230,0 to 268,0	0,220	0,2s ≤ t ≤ 0,3s
		264,5	230,0 to 268,0	0,228	
		264,4	230,0 to 268,0	0,222	
		264,4	230,0 to 268,0	0,224	
		264,6	230,0 to 268,0	0,236	
	85% of Un = 195,5 (stage 1)	195,3	230,0 to 192,0	50,0	50s ≤ t ≤ 50,1s
		195,5	230,0 to 192,0	50,0	
		193,4	230,0 to 192,0	50,0	
		193,4	230,0 to 192,0	50,0	
		193,5	230,0 to 192,0	50,0	
	80% of U_n = 184 (stage 2)	183,3	230,0 to 180,0	0,240	0,2s ≤ t ≤ 0,3s
		183,3	230,0 to 180,0	0,232	
		183,2	230,0 to 180,0	0,228	
		183,2	230,0 to 180,0	0,226	
		183,3	230,0 to 180,0	0,226	

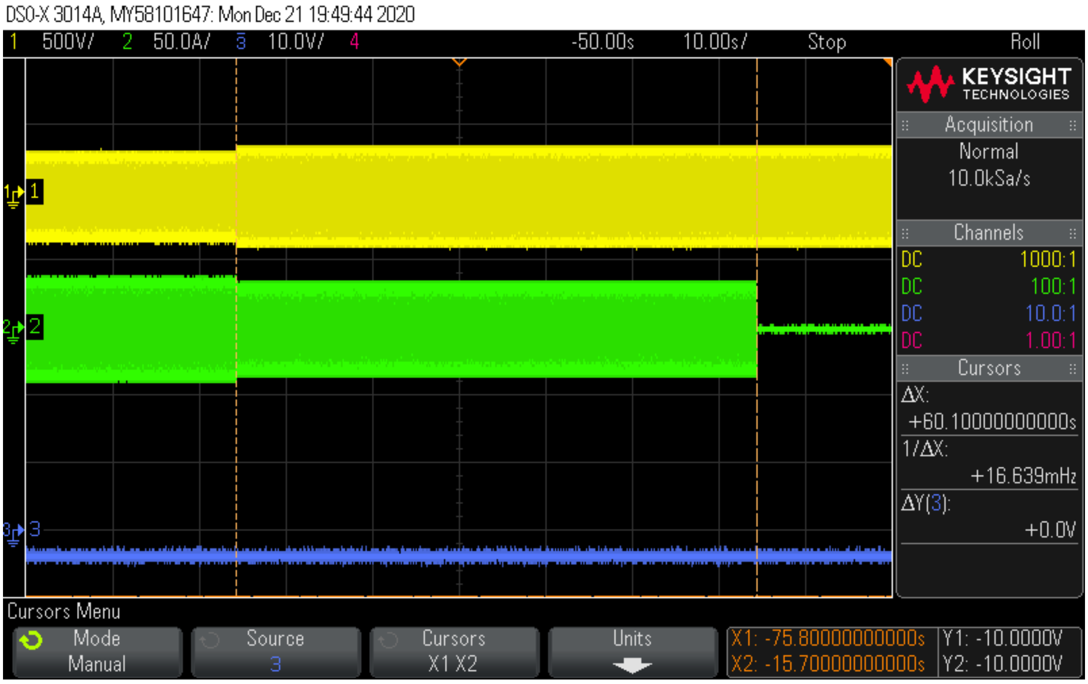
Note:

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

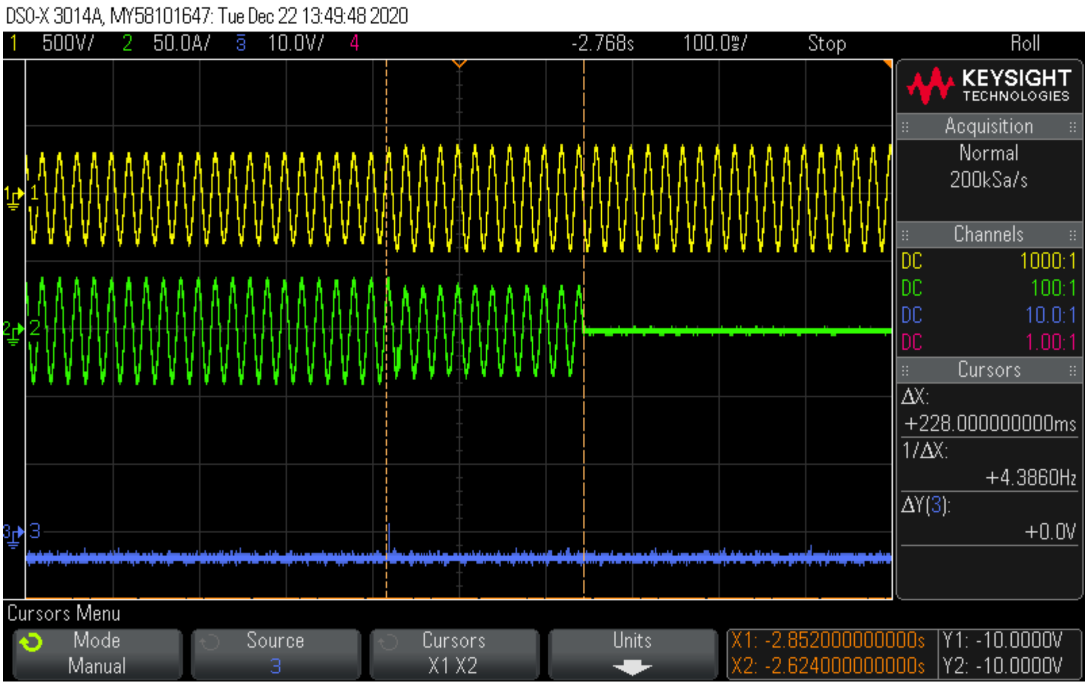
The disconnection time includes disconnect time + operate time of the integrated relay , Therefore limit is give with +100ms according to Table 23 recommended values.

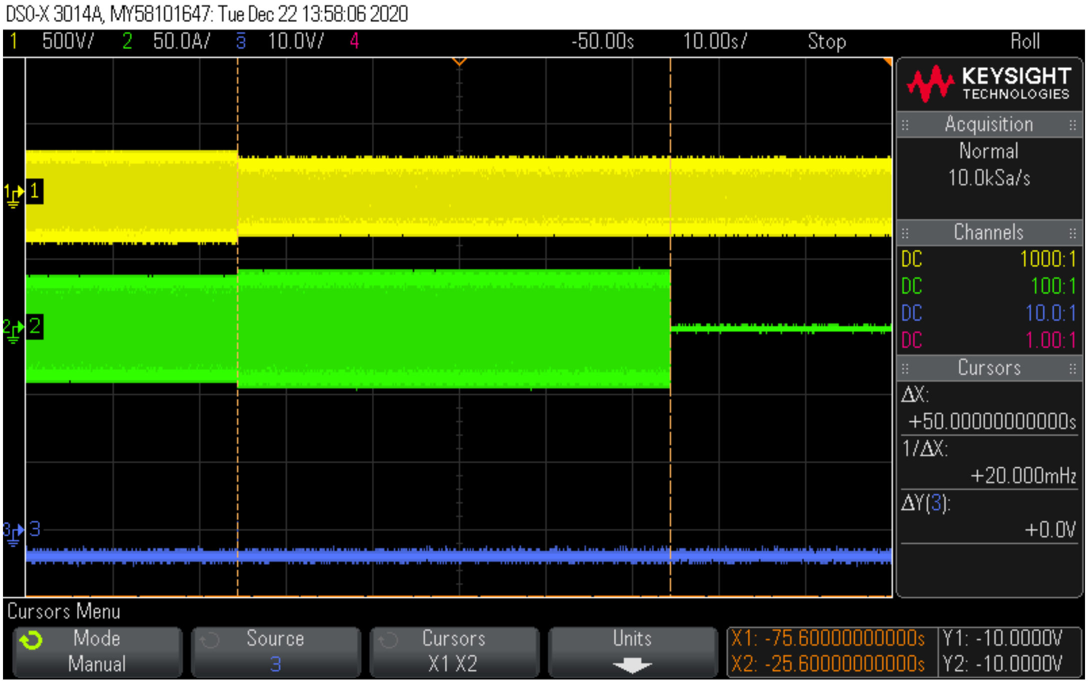
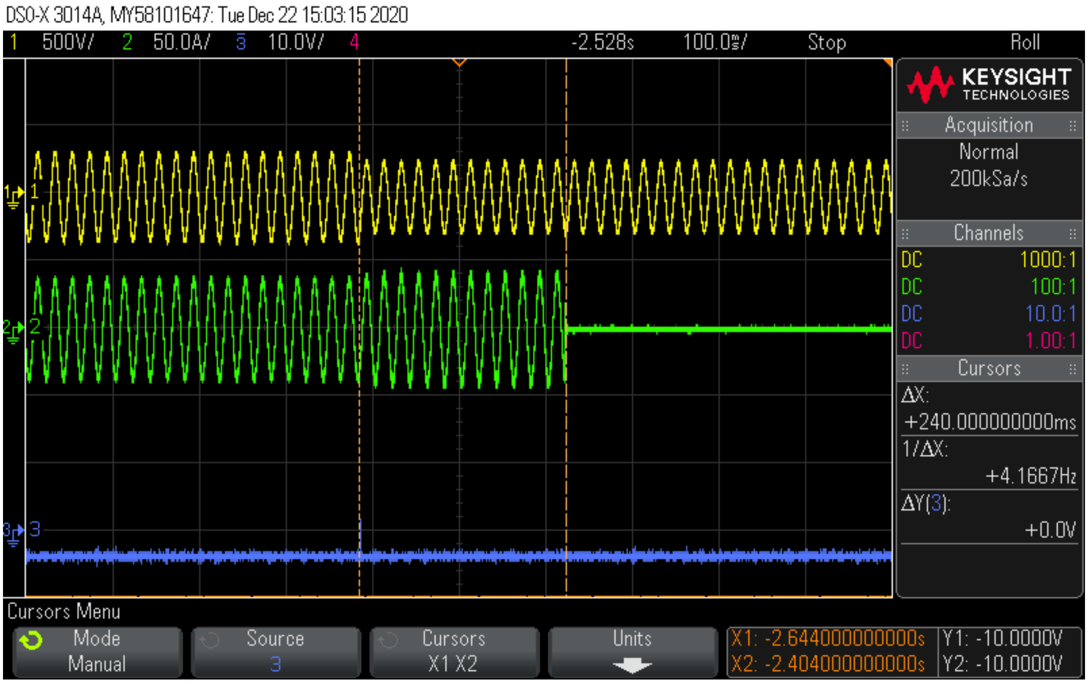
The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Scope pictures of the disconnection time
Over-voltage - Stage 1 (L1 phase)



Over-voltage - Stage 2 (L1 phase)



Under-voltage - Stage 1 (L1 phase)

Under-voltage - Stage 2 (L1 phase)


7.2.1	Protective functions, category A(Overfrequency and underfrequency)				P
Test conditions	U_n = 230Vac				
	Under-frequency		**Over-frequency**		
Parameter	**Under-Frequency**	**Time**	**Over-Frequency**	**Time**	
Limit	47,50 Hz	0,2≤ t ≤ 0,3 s	51,50 Hz	0,2≤ t ≤ 0,3 s	
Trip value [Hz]	47,49		51,50		
	47,49		51,50		
	47,49		51,50		
	47,49		51,50		
	47,49		51,50		
Disconnection time [s]	50,00 Hz to 47,40 Hz	0,229	50,00 Hz to 51,60 Hz	0,225	
		0,249		0,226	
		0,230		0,225	
		0,233		0,227	
		0,231		0,225	

Note:

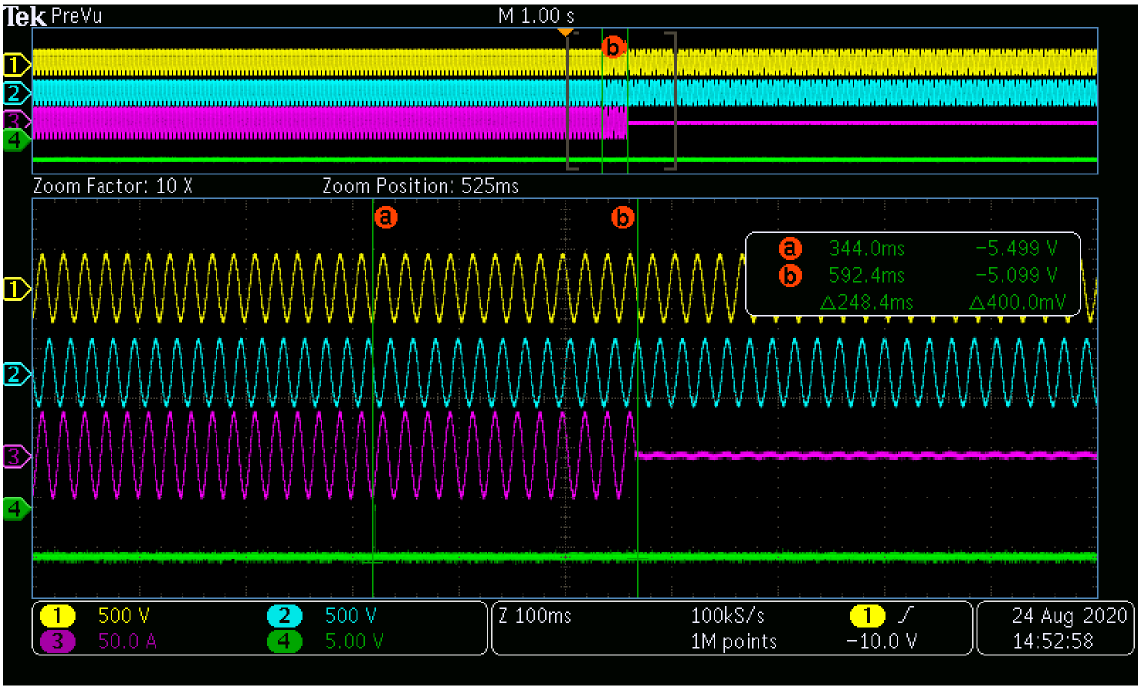
The setting value and the trip value of the frequency may not vary by more than ±0 ,1 % f_n ,

The disconnection time includes disconnect time + operate time of the integrated relay , Therefore limit is give with +100ms according to Table 23 and 24 recommended values.

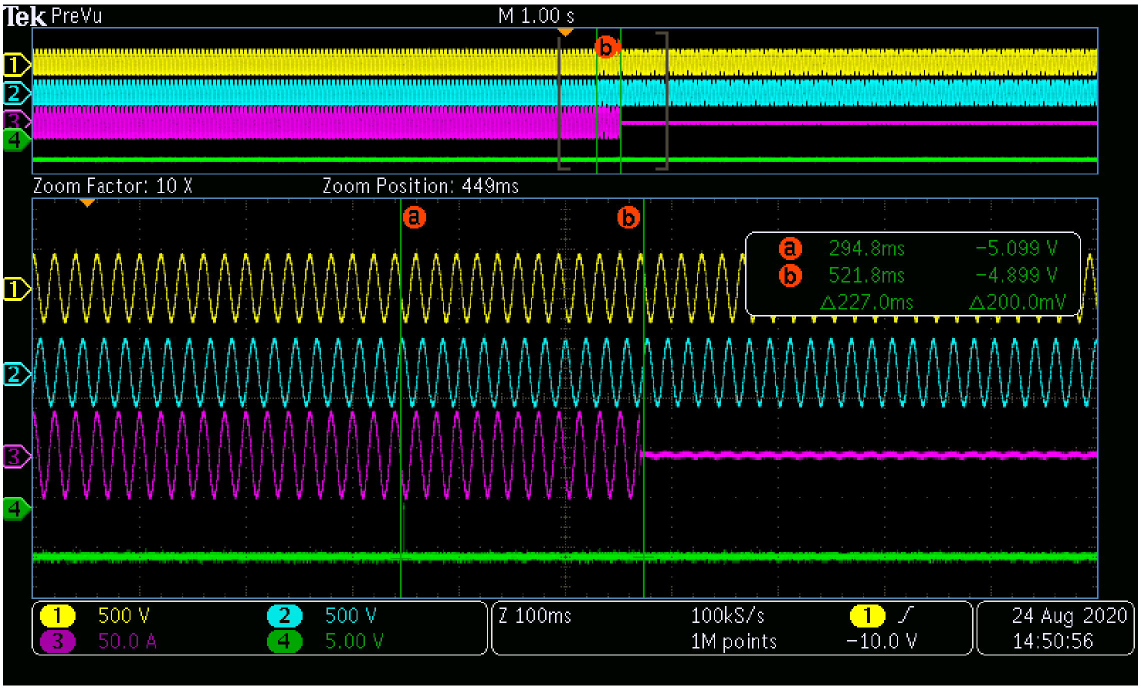
The oscilloscope pictures below show the measured worst case disconnection times.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Scope pictures of the disconnection time
Under-frequency



Over-frequency



7.2 Protective setting requirements

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

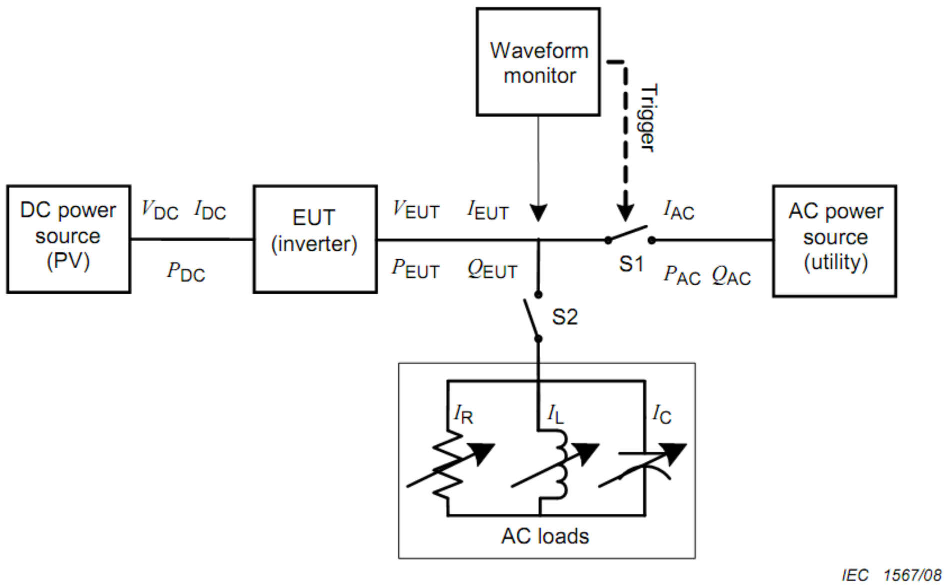


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

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

Test : HYD 6000-EP

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 per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks 5)
1	100	100	0	0	0,126	6,000	462	1,001	225	BL
2	100	100	-5	-5	1,397	6,000	462	1,027	208	IB
3	100	100	-5	0	1,430	6,000	462	1,054	216	IB
4	100	100	-5	+5	1,395	6,000	462	1,080	206	IB
5	100	100	0	-5	0,157	6,000	462	0,976	207	IB
6	100	100	0	+5	0,160	6,000	462	1,026	210	IB
7	100	100	+5	-5	1,460	6,000	462	0,929	148	IB
8	100	100	+5	0	1,430	6,000	462	0,953	208	IB
9	100	100	+5	+5	1,463	6,000	462	0,977	200	IB

Parameter at 0% per phase	L= 28,40 mH	R= 8,82 Ω	C= 361,39 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:

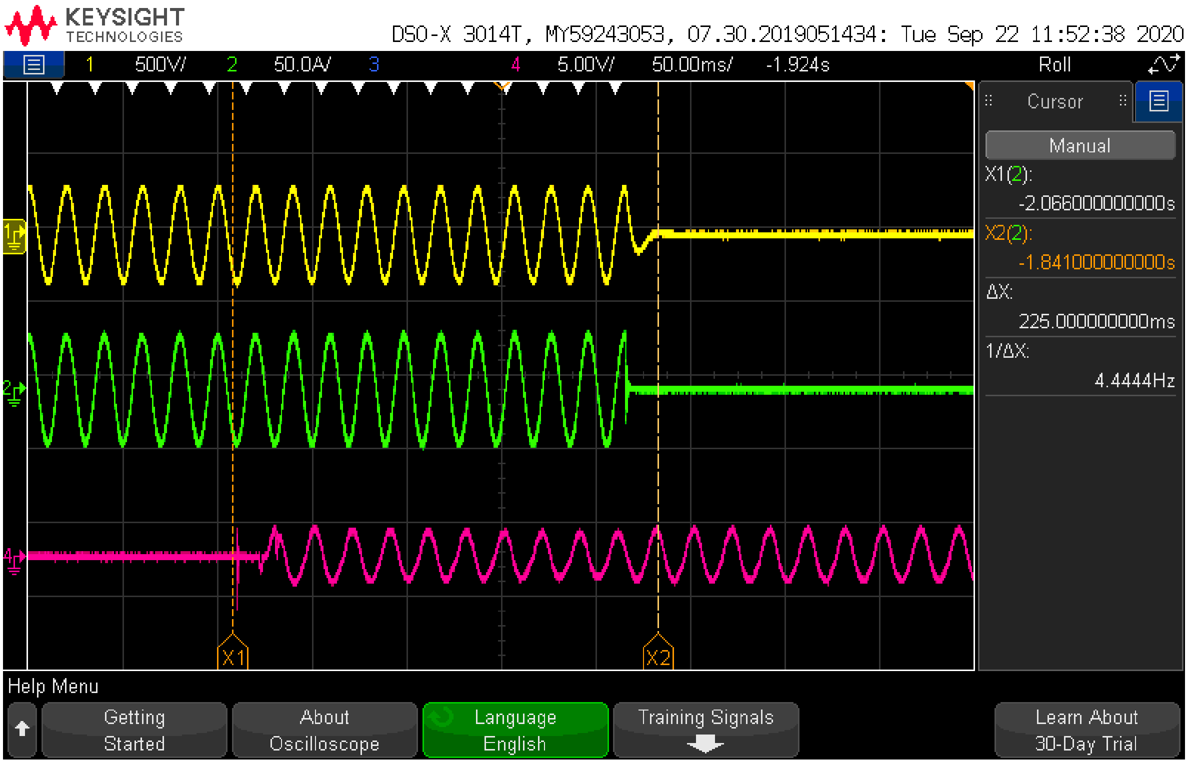
EUT output power P_{EUT} = Maximum 6)

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.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Scope pictures of the disconnection time
Disconnection at No. 1


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

Test : HYD 6000-EP

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 per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks [5]
1	66	66	0	-5	0,138	3,745	390	1,015	149	IB
2	66	66	0	-4	0,130	3,745	390	1,020	222	IB
3	66	66	0	-3	0,124	3,745	390	1,026	200	IB
4	66	66	0	-2	0,120	3,745	390	1,031	199	IB
5	66	66	0	-1	0,117	3,745	390	1,036	201	IB
6	66	66	0	0	0,116	3,745	390	1,041	232	BL
7	66	66	0	+1	0,117	3,745	390	1,047	217	IB
8	66	66	0	+2	0,120	3,745	390	1,052	203	IB
9	66	66	0	+3	0,124	3,745	390	1,057	213	IB
10	66	66	0	+4	0,130	3,745	390	1,062	215	IB
11	66	66	0	+5	0,138	3,745	390	1,067	154	IB

Parameter at 0% per phase	L= 43,19 mH	R= 14,13 Ω	C=234,58μF

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.

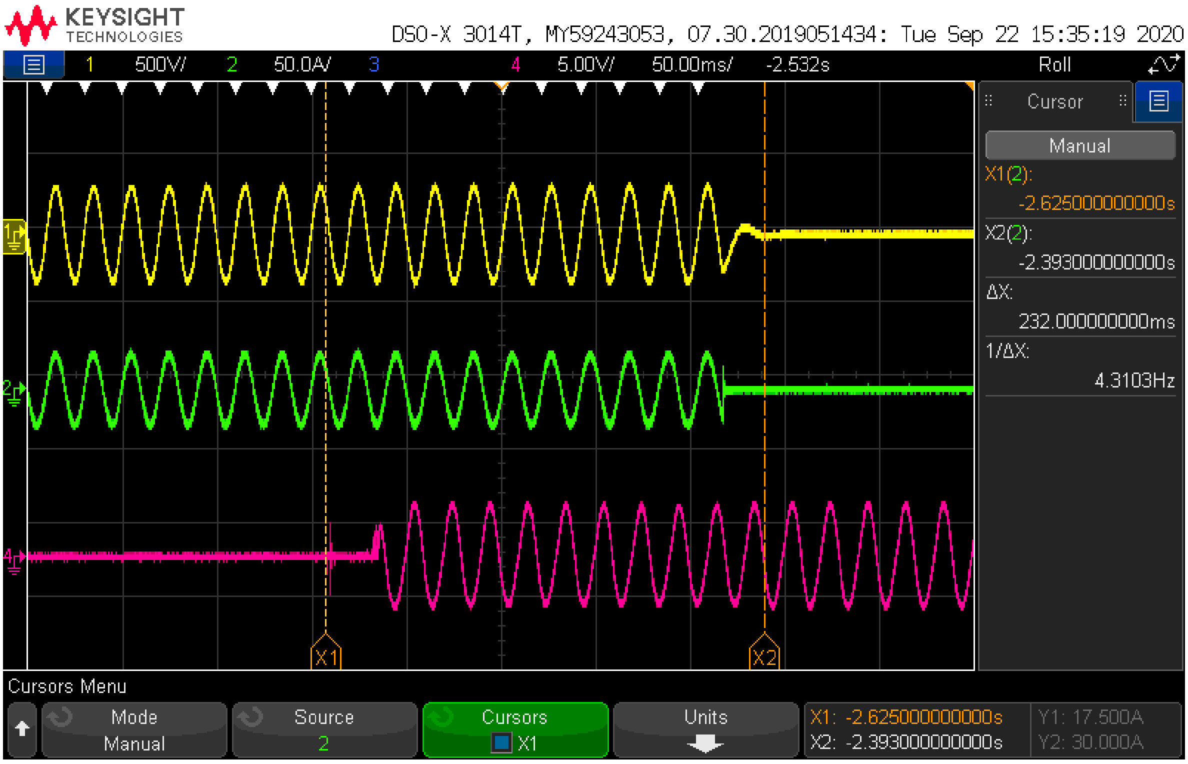
Condition B:

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.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Scope pictures of the disconnection time
Disconnection at No. 6


Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %)										P
Test : HYD 6000-EP										
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 per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks [5)]
1	33	33	0	-5	0,971	1,855	318	0,998	114	IB
2	33	33	0	-4	0,967	1,855	318	1,004	195	IB
3	33	33	0	-3	0,964	1,855	318	1,009	130	IB
4	33	33	0	-2	0,962	1,855	318	1,014	216	IB
5	33	33	0	-1	0,960	1,855	318	1,019	209	IB
6	33	33	0	0	0,960	1,855	318	1,024	221	BL
7	33	33	0	+1	0,960	1,855	318	1,029	214	IB
8	33	33	0	+2	0,962	1,855	318	1,034	211	IB
9	33	33	0	+3	0,964	1,855	318	1,040	138	IB
10	33	33	0	+4	0,967	1,855	318	1,045	195	IB
11	33	33	0	+5	0,971	1,855	318	1,050	129	IB
Parameter at 0% per phase			L= 88,65 mH			R= 28,52 Ω			C= 114,30 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

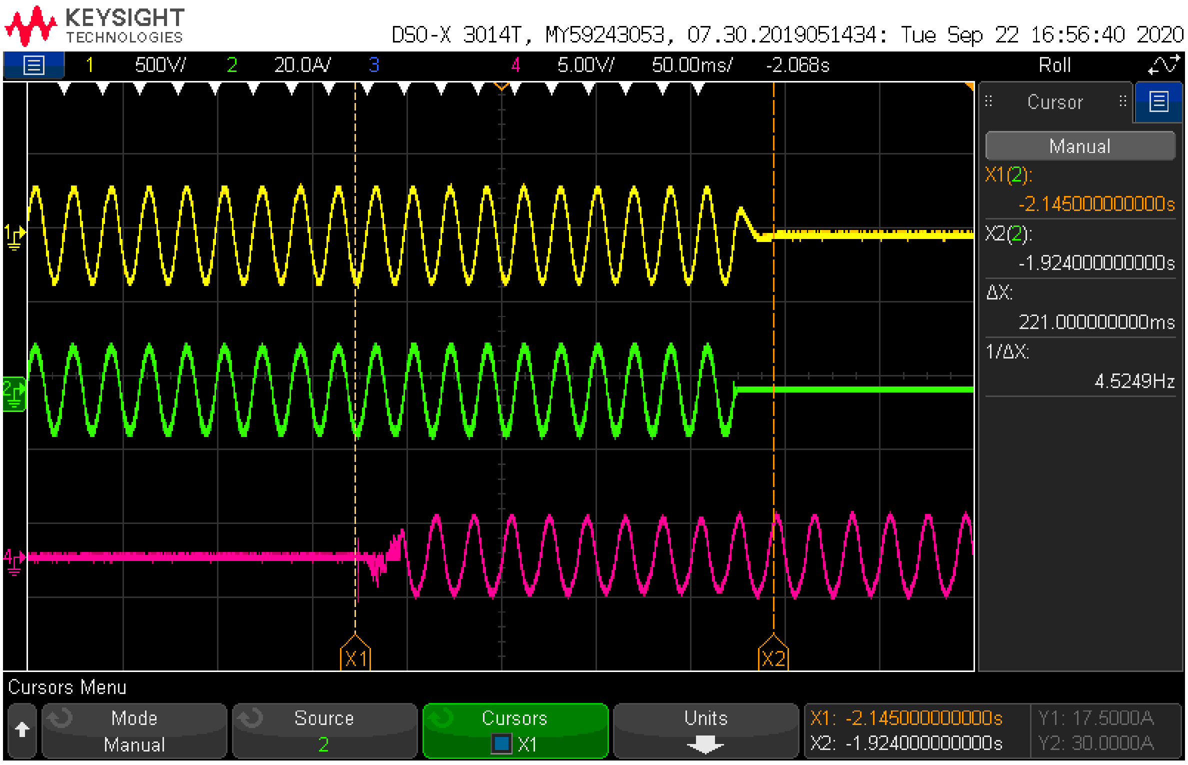
EUT input voltage [7)] = <20 % of rated input voltage range

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.

The tests had been performed on the HYD 6000-EP is valid for the HYD 5500-EP, HYD 5000-EP, HYD 4600-EP , HYD 4000-EP, HYD 3680-EP and HYD 3000-EP, since it is identical in hardware and software construction except output power derated by software.

Scope pictures of the disconnection time
Disconnection at No. 6


Annex 1

Pictures of the unit

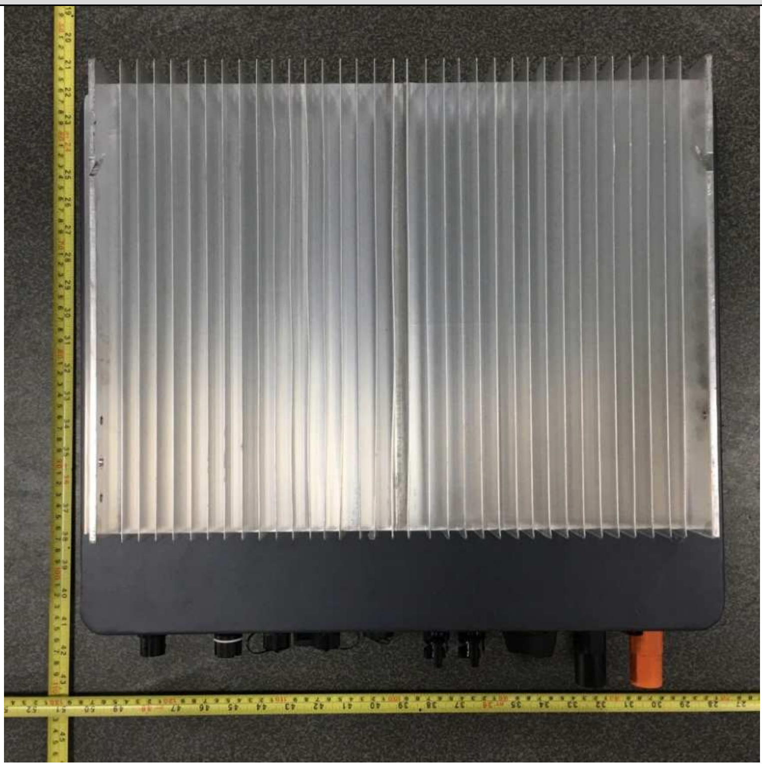
The full pictures refer to PHOTO DOCUMENT

Project No.: 200917N016

Date: 20210112

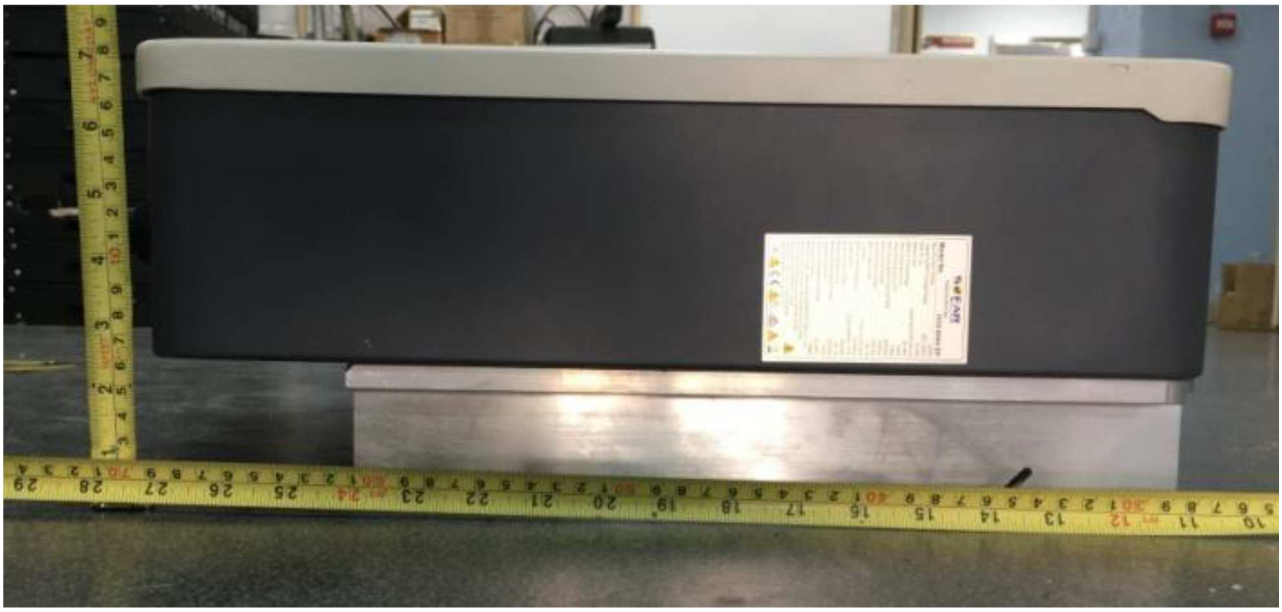
Enclosure front view

Enclosure rear view



Enclosure bottom view

Enclosure side view



Annex No. 2

Test Equipment list

Test Local: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Dates of performer test: 2020-09-17 to 2021-01-25

Equipment	Internal No.	Manufacturer	Type	Serial No.	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Jun. 17, 2020
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 23, 2020
Four Channel Digital Phosphor Oscilloscope	A4089003DG	Tektronix	DPO4104B	C010624	Mar. 06, 2020
	//	KEYSIGHT	DSOX3014T	MY59243036	Jan. 05, 2021
Oscilloscope probel	A1490009DG	YOKOGAWA	701901	//	Sep. 03, 2020
	A1490010DG	YOKOGAWA	701901	//	Sep. 03, 2020
	A1490011DG	YOKOGAWA	701901	//	Sep. 03, 2020
Current transducer	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 03, 2020
	A1060009DG	YOKOGAWA	CT200	1130700019	Sep. 03, 2020
	A1060009DG	YOKOGAWA	CT200	1130700019	Sep. 03, 2020