TEST REPORT

VDE-AR-N 4105

Generators connected to the low-voltage distribution network – Technical requirements for the connection to and parallel operation with low-voltage distribution networks

Report reference number .... :	**PVDE200320N031**
Date of issue .... ……...:	2020-07-31
Total number of pages........... ……...:	152
Testing laboratory name .... :	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**
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Accreditation .... :	
Applicant's name .... :	**Shenzhen SOFAR SOLAR Co., Ltd.**
Address .... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard .... :	VDE-AR-N 4105:2018-11 (tested according to DIN VDE V 0124-100:2020-06)
Test Report Form No. .... :	TEST REPORT VDE-AR-N 4105 VER.0
TRF Originator .... :	Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Master TRF .... :	Dated 2019-11-06
Test item description..................... :	**Hybrid inverter**
Trademark....................................... :	

Model / Type .... :	HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 15KTL-3PH, HYD 20KTL-3PH		
Ratings .... :	**HYD 5KTL-3PH**	**HYD 6KTL-3PH**	**HYD 8KTL-3PH**
Full load MPP DC voltage range [V]	250-850V	320-850V	360-850V
DC voltage range [V]........................ :	180-960		
DC input voltage [V] .... :	1000V Max		
Input DC current [A] .... :	Max 12,5A * 2		
Output AC voltage [V] .... :	3/N/PE, 380/400Vac, 50/60Hz		
Output AC current [A]....................... :	Max. 8,0	Max. 10,0	Max. 13,0
Output power [kVA].......................... :	5,5	6,6	8,8
Intput DC voltage range [V]…………: [Battery charging]……………………:	180-800V		
Intput DC current range [V]…………: [Battery charging]……………………:	Max 25,0A		
Output DC current range [V]…………: [Battery discharg]……………………:	Max 25,0A		
Charging and discharge power [kVA].:	Max.5,5	Max.6,6	Max.8,8
Output AC voltage [V]………………...:	3/N/PE, 380/400Vac, 50/60Hz		
Output AC current [A]………………...:	Max. 8,0	Max. 10,0	Max. 13,0
Output power [kVA]	Max.5,5	Max.6,6	Max.8,8
Ratings .... :	**HYD 10KTL-3PH**	**HYD 15KTL-3PH**	**HYD 20KTL-3PH**
Full load MPP DC voltage range [V]	220-850V	350-850V	450-850V
DC voltage range [V]........................ :	180-960V		
DC input voltage [V] .... :	1000V Max		
Input DC current [A] .... :	Max 25,0A * 2		
Output AC voltage [V] .... :	3/N/PE, 380/400Vac, 50/60Hz		
Output AC current [A]....................... :	Max. 16,0	Max. 24,0	Max. 32
Output power [kVA].......................... :	Max.11,0	Max.16,5	Max. 22,0
Intput DC voltage range [V]…………: [Battery charging]……………………:	180-800V		
Intput DC current range [V]…………: [Battery charging]……………………:	Max 25,0A * 2		
Output DC current range [V]…………: [Battery discharg]……………………:	Max 25,0A * 2		

Charging and discharge power [kVA].:	11,0	16,5	22,0
Output AC voltage [V]………………...:	3/N/PE, 380/400Vac, 50/60Hz		
Output AC current [A]………………...:	Max. 16,0	Max. 24,0	Max. 32
Output power [kVA]	Max. 11,0	Max.16,5	Max.22,0

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 SOFAR SOLAR 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
2020-07-31	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. 33kg for HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, Approx. 37kg for HYD 10KTL-3PH, HYD 15KTL-3PH, HYD 20KTL-3PH

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............... :	2020-03-21
Date(s) of performance of test......... :	2020-03-21 to 2020-07-30

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 DIN VDE V 0124-100. This report shall not be reproduced, except in full, without the written approval of the applicant.

”(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
    5.2. Evidence of permissible network perturbations
    5.3. Evidence of symmetry behavior of inverters
    5.4. Evidence of the behavior of the generating unit on the network
    5.5. NS-protection
    5.6 Connecting conditions and synchronization
    5.7 Evidence of $P_{AV,E}$-Control (not implemented till yet in test plan)
    5.8 Evidence dynamic grid support
2. Pictures of the unit – Annex No. 1
3. Test equipment list – Annex No. 2

Copy of marking plate

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 5KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	12.5/12.5A
Max.PV Isc	15/15A
Battery Type	Li-Ion
Battery Voltage Range	180~800V
Battery Max. Charging Current	25A
Battery Max. Discharging Current	25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	8A
Max. Power Output to Grid	5500VA
Max. Current from Grid	15A
Max. Power from Grid	10000VA
Back-up Max. Output Current	8A
Back-up Max. Output Power	5500VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	Class I
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II

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

SAA VDE0126-1-1,VDE-AR-N4105
G98,G99,EN50438,AS4777,UTE C15-712-1

SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 6KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	12.5/12.5A
Max.PV Isc	15/15A
Battery Type	Li-Ion
Battery Voltage Range	180~800V
Battery Max. Charging Current	25A
Battery Max. Discharging Current	25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	10A
Max. Power Output to Grid	6600VA
Max. Current from Grid	17A
Max. Power from Grid	12000VA
Back-up Max. Output Current	10A
Back-up Max. Output Power	6600VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	Class I
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II

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

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SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 8KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	12.5/12.5A
Max.PV Isc	15/15A
Battery Type	Li-Ion
Battery Voltage Range	180~800V
Battery Max. Charging Current	25A
Battery Max. Discharging Current	25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	13A
Max. Power Output to Grid	8800VA
Max. Current from Grid	24A
Max. Power from Grid	16000VA
Back-up Max. Output Current	13A
Back-up Max. Output Power	8800VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	Class I
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II

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

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SOFAR SOLAR
Hybrid Inverter

Model No:	HYD 10KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	25/25A
Max.PV Isc	30/30A
Battery Type	Li-Ion
Battery Voltage Range	180~800V
Battery Max. Charging Current	25/25A
Battery Max. Discharging Current	25/25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	16A
Max. Power Output to Grid	11000VA
Max. Current from Grid	29A
Max. Power from Grid	20000VA
Back-up Max. Output Current	16A
Back-up Max. Output Power	11000VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	Class I
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II

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

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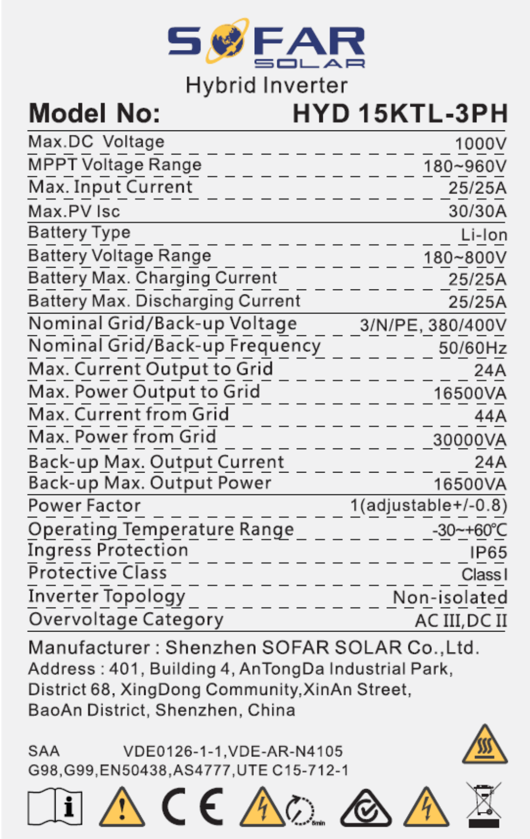

SOFAR SOLAR

Hybrid Inverter

Model No:	HYD 15KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	25/25A
Max.PV Isc	30/30A
Battery Type	Li-Ion
Battery Voltage Range	180~800V
Battery Max. Charging Current	25/25A
Battery Max. Discharging Current	25/25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	24A
Max. Power Output to Grid	16500VA
Max. Current from Grid	44A
Max. Power from Grid	30000VA
Back-up Max. Output Current	24A
Back-up Max. Output Power	16500VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	Class I
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II

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

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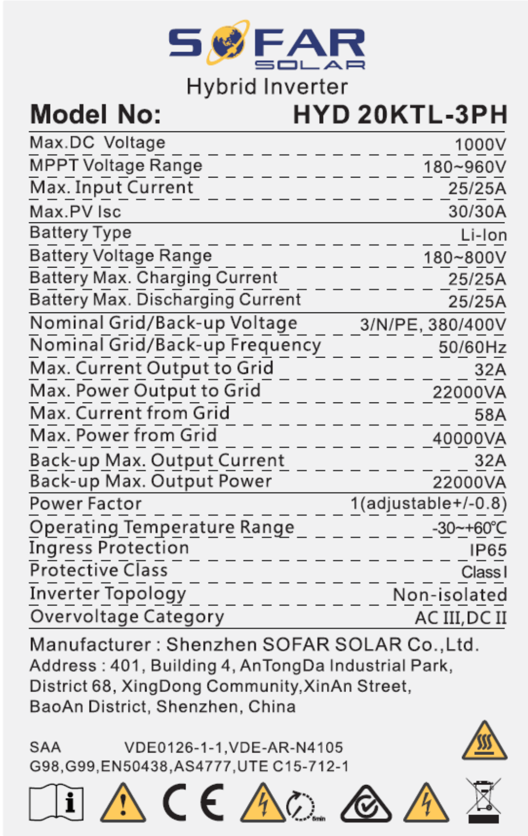

SOFAR SOLAR

Hybrid Inverter

Model No:	HYD 20KTL-3PH
Max.DC Voltage	1000V
MPPT Voltage Range	180~960V
Max. Input Current	25/25A
Max.PV Isc	30/30A
Battery Type	Li-Ion
Battery Voltage Range	180~800V
Battery Max. Charging Current	25/25A
Battery Max. Discharging Current	25/25A
Nominal Grid/Back-up Voltage	3/N/PE, 380/400V
Nominal Grid/Back-up Frequency	50/60Hz
Max. Current Output to Grid	32A
Max. Power Output to Grid	22000VA
Max. Current from Grid	58A
Max. Power from Grid	40000VA
Back-up Max. Output Current	32A
Back-up Max. Output Power	22000VA
Power Factor	1(adjustable+/-0.8)
Operating Temperature Range	-30~+60℃
Ingress Protection	IP65
Protective Class	Class I
Inverter Topology	Non-isolated
Overvoltage Category	AC III,DC II

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

SAA VDE0126-1-1,VDE-AR-N4105
G98,G99,EN50438,AS4777,UTE C15-712-1

General product information: The inverter converts DC voltage, generated by photovoltaic modules, into AC voltage. The units are three-phases inverter. Rate of change of frequency (RoCoF) detection was used for LOM protection. The unit do not have the PAV,E monitoring function.

Description of the power circuit (Figure 1):

The hybrid inverter coverters DC voltage, generated by photovoltaic modules and batteries, into AC voltage.

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

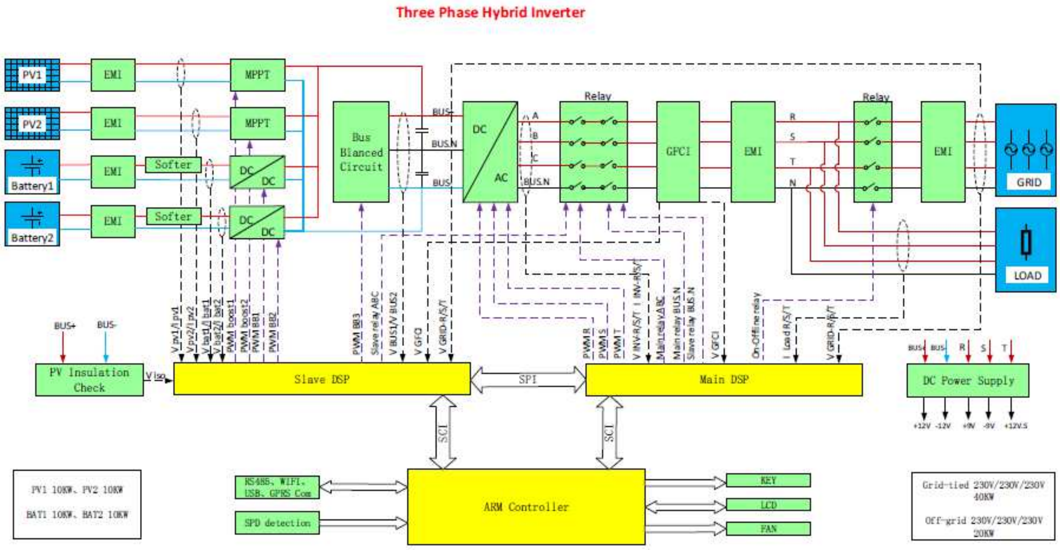

Figure 1 – Block diagram

The internal control is redundant built. It consists of master DSP(U37) and slave DSP(U39).

The master DSP (U37) control the relays by switch signals, measures PV voltage, PV current,Bus voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground, in addition it tests the array insulation resistance and the RMCU circuit before each start up.

The slave DSP (U39) is measures the grid voltage, grid frequency and residual current , also can switch off the relays independently, and communicate with master DSP (U39).

The current is measured by a current sensor. The AC current signal and the injectied DC current signal are sent to the Main DSP(U37). The Mian DSP(U37) tests and calibrates before each start upp all current sensors.

The unit provides two relays in series in all output 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 DPSs can open the relays.

Models difference:
1. Model HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 15KTL-3PH, HYD 20KTL-3PH are completely identical and output power derated by software, except for the following table.

Models	HYD 5KTL-3PH	HYD 6KTL-3PH	HYD 8KTL-3PH	HYD 10KTL-3PH	HYD 15KTL-3PH	HYD 20KTL-3PH
Inverter induction	0,876mH		1,12mH		1,5mH	
BOOST induction	0,915mH			1,8mH		
Cooling system	Without external fans			With external fans		

The product was tested on:
Hardware Version: V1.0
Software Version: V2.00 e superiore

Description of the remote control in a typical installation:

Following information show inverter’s interface to connect WIFI,GPRS and RS485 accessory:

WIFI/GPRS:

The system connects to a WIFI module monitors over an WIFI port,the WIFI module implements communication with Cloud server thtough wireless network to monitor PV inverter’s data status.

RS485:

Connects the TX+ and TX- of the inverter to the TX+ and TX- of RS485 transfor USB adapter, and connect the USB port of adater to computer, as shown in mode (1) .

RS485 wires are connected in parallel between inverters, refer to section 4.5 of this manual for wire connection methods. Connects the TX+ and TX- of the inverter to the TX+ and TX- of RS485 transfor USB adapter, and connect the USB port of adater to computer, the device number should be less than 10 pieces, as shown in mode (2).

RS485 communication mode (1)

RS485 communication mode (2)

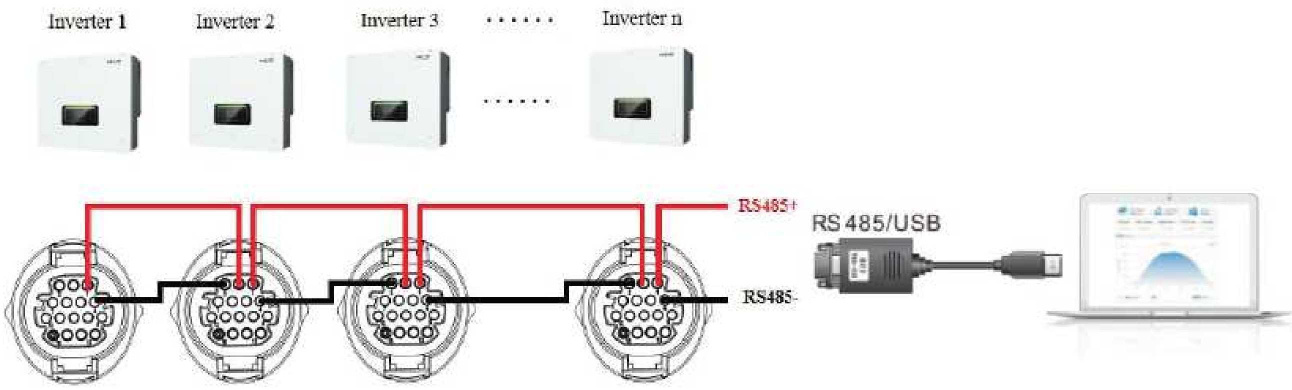

Figure 2 – Scheme of an installation

Description of the connection to the ripple control receiver:

N/A

General remarks:

The test results presented in this report relate only to the object(s) tested.
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"(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.

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)
- "_E0,2" for gliding average values over 200 milliseconds
- "_E60" for gliding average values over 60 seconds.
- "_E600" for gliding average values over 10 minutes.
- "(c)" for over-excited
- "(i)" for under-excited

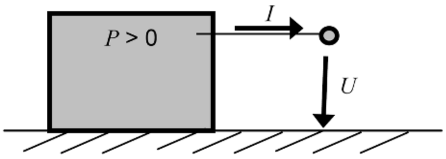
Acronyms:

PGU: power generating unit

PGS: power generating system

The regarded system of the voltage and current vectors is the load view (Figure 3):

- 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.

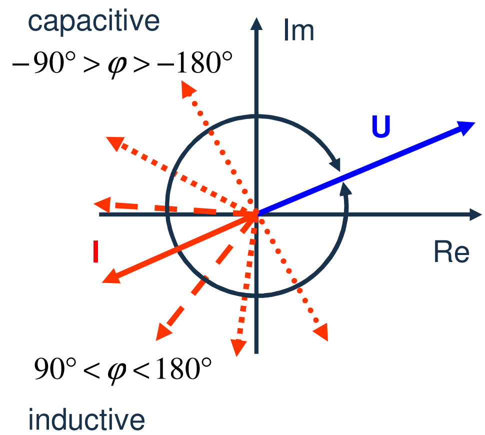


Figure 3

5 Prüfungen DIN VDE V 0124-100:2020-06		
Clause	**Test**	**Result**
5.2	Evidence of permissible network perturbations	**P**
5.3	Evidence of symmetry behavior of inverters	**P**
5.4	Evidence of the behavior of the generating unit on the network	**P**
5.5	NS-protection	**P**
5.6	Connecting conditions and synchronization	**P**
5.8	Evidence dynamic grid support	**P**
5.9	Test of Ancillary Unit (not implemented till yet in test plan)	**N/A**

5.2	**Evidence of permissible network perturbations DIN VDE V 0124-100:2020-06**	
Clause	**Test**	**Result**
5.2.1	General	**P**
5.2.2	Rapid voltage changes	**P**
5.2.3	Flicker	**P**
5.2.4	Harmonics and interharmonics	**P**
5.2.4.1	Test: 61000-3-3 / 61000-3-12	**P**
5.2.4.1	Test: 61000-4-7	**P**
5.2.5	Commutation “only for line-commutated inverter”	**N/A**
5.2.6	Feed in of DC current “only for inverter”	**P**

5.2.1 **General** These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4 are met.	**P**

Network reactions in the sense of this document according to VDE-AR-N 4100: 2019-04, 5.4 are:

- fast voltage changes;
- flicker;
- Harmonics, interharmonics and super-harmonics (higher frequencies from 2 kHz to 9 kHz);
- Commutation “necessary only for mains-controlled inverter”
- Feed in of direct current “necessary only for inverter”

Note:

5.2.2 Rapid voltage changes These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4.2 are met.	**P**

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

The following three cases must be tested to VDE-AR-N 4105, Annex F.3 (where applicable).

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

Test conditions:
Frequency: 50 Hz ± 0,5%
THD of the voltage supply: ≤ 3 %
Voltage rise of the PGU at 100 P_{Emax} %: ≤ 3 %

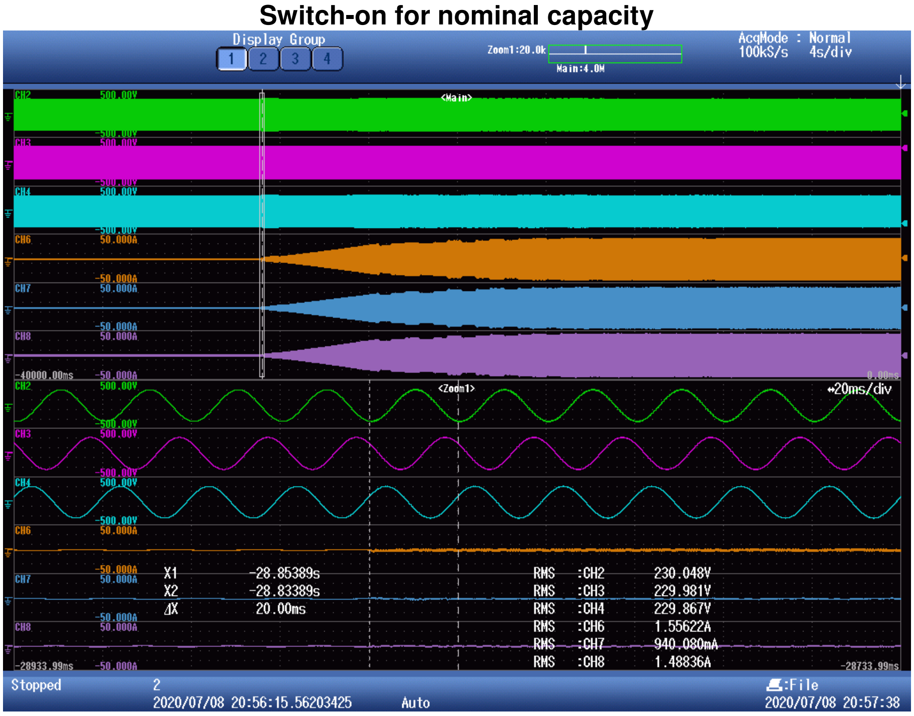
L1 phase			
Switch-on for any capacity (10% P_{Emax})			
Single period effective values of the current [A]	1,038	1,816	1,486
Single period effective values of the voltage [V]	229,9	230,1	230,1
k_i value	0,032	0,057	0,046
k_{imax} value	0,057		
Unfavourable case when switching the generator step			
Single period effective values of the current [A]	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A
k_i value	N/A	N/A	N/A
k_{imax} value	N/A		
Switch-on for nominal capacity			
Single period effective values of the current [A]	1,160	1,556	1,057
Single period effective values of the voltage [V]	230,0	230,0	229,9
k_i value	0,036	0,049	0,033
k_{imax} value	0,049		
L2 phase			
Switch-on for any capacity (10% P_{Emax})			
Single period effective values of the current [A]	0,628	0,878	0,943
Single period effective values of the voltage [V]	229,9	230,1	230,1
k_i value	0,020	0,027	0,029
k_{imax} value	0,029		
Unfavourable case when switching the generator step			

Single period effective values of the current [A]	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A
k_i value	N/A	N/A	N/A
k_{imax} value	N/A		
Switch-on for nominal capacity			
Single period effective values of the current [A]	0,942	0,940	0,976
Single period effective values of the voltage [V]	229,8	229,9	229,9
k_i value	0,029	0,029	0,031
k_{imax} value	0,031		
L3 phase			
Switch-on for any capacity (10% P_{Emax})			
Single period effective values of the current [A]	0,907	1,067	0,996
Single period effective values of the voltage [V]	229,9	229,9	229,9
k_i value	0,028	0,033	0,031
k_{imax} value	0,033		
Unfavourable case when switching the generator step			
Single period effective values of the current [A]	N/A	N/A	N/A
Single period effective values of the voltage [V]	N/A	N/A	N/A
k_i value	N/A	N/A	N/A
k_{imax} value	N/A		
Switch-on for nominal capacity			
Single period effective values of the current [A]	1,363	1,488	1,459
Single period effective values of the voltage [V]	229,9	229,9	229,9
k_i value	0,043	0,047	0,046
k_{imax} value	0,047		
Highest k_{imax} value for all switching operations			
0,057			

Note:
The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

Switch-on for any capacity (10% P_{Emax})

Switch-on for nominal capacity



5.2.3 Flicker

These tests are designed to provide evidence that the requirements of VDE-AR-N 4100:2109-04 are met.

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)
- For PGUs and PSUs intended for PGSs with nominal currents > 75 A, the measurements must be conducted as in 5.2.3.2.

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 %

Flicker für Bemessungsströme >75A (bei SCR = 20)

Method: Measurement was carried out according to the procedure in IEC 61400-21.

HYD 5KTL-3PH				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	5,331	3,479	2,836	2,675
Short-term flicker, P_{st}	0,157	0,102	0,083	0,079
HYD 20KTL-3PH				
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	4,149	2,327	1,907	1,794
Short-term flicker, P_{st}	0,127	0,083	0,068	0,064

Note:

The table entries are worst case values.

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

The test had been performed on the model HYD 20KTL-3PH and HYD 5KTL-3PH the test results are valid for the HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

5.2.4 Harmonics and interharmonics These tests are designed to provide evidence that the requirements of VDE-AR-N 4100:2109-04 are met.	**P**

Adherence to the thresholds for harmonic currents must be verified as followed:

- For nominal currents ≤ 16 A per conductor to DIN EN 61000-3-2 (VDE 0838-2)
- For nominal currents > 16 A and ≤ 75 A per conductor to DIN EN 61000-3-12 (VDE 0838-12)
- For PGUs intended for PGSs with nominal currents > 75 A, the measurements must be conducted as in 5.1.4.2.

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 %

5.2.4.1 Tests								P
Maximum permissible harmonic current as per EN 61000-3-2 Class A								
Harmonics	2nd	3rd	5th	7th	9th	11th	13th	15 th ≤ n ≤ 39 th
Limit	1,08A	2,3A	1,14A	0,77A	0,4A	0,33A	0,21A	0,15 * (15/n)
Test value	See below							

HYD 5KTL-3PH: L1phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	7.2830			2	0.0135	1.0800	98.7
3	0.0190	2.3000	99.2	4	0.0167	0.4300	96.1
5	0.0705	1.1400	93.8	6	0.0158	0.3000	94.7
7	0.0333	0.7700	95.7	8	0.0136	0.2300	94.1
9	0.0248	0.4000	93.8	10	0.0108	0.1840	94.1
11	0.0613	0.3300	81.4	12	0.0088	0.1533	94.3
13	0.0461	0.2100	78.1	14	0.0079	0.1314	94.0
15	0.0241	0.1500	84.0	16	0.0077	0.1150	93.3
17	0.0260	0.1324	80.3	18	0.0066	0.1022	93.6
19	0.0741	0.1184	37.4	20	0.0058	0.0920	93.7
21	0.0175	0.1071	83.7	22	0.0058	0.0836	93.0
23	0.0188	0.0978	80.8	24	0.0055	0.0767	92.9
25	0.0476	0.0900	47.1	26	0.0083	0.0708	88.3
27	0.0124	0.0833	85.1	28	0.0055	0.0657	91.7
29	0.0158	0.0776	79.6	30	0.0050	0.0613	91.9
31	0.0129	0.0726	82.2	32	0.0048	0.0575	91.6
33	0.0171	0.0682	75.0	34	0.0050	0.0541	90.7
35	0.0234	0.0643	63.6	36	0.0056	0.0511	89.0
37	0.0126	0.0608	79.3	38	0.0054	0.0484	88.9
39	0.0221	0.0577	61.6	40	0.0049	0.0460	89.3

HYD 5KTL-3PH: L2 phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	7.3058			2	0.0167	1.6200	99.0
3	0.0220	3.4500	99.4	4	0.0199	0.6450	96.9
5	0.0744	1.7100	95.6	6	0.0194	0.4500	95.7
7	0.0412	1.1550	96.4	8	0.0157	0.3450	95.4
9	0.0270	0.6000	95.5	10	0.0122	0.2760	95.6
11	0.0636	0.4950	87.2	12	0.0104	0.2300	95.5
13	0.0504	0.3150	84.0	14	0.0092	0.1971	95.3
15	0.0260	0.2250	88.4	16	0.0085	0.1725	95.1
17	0.0273	0.1985	86.2	18	0.0079	0.1533	94.9
19	0.0763	0.1776	57.0	20	0.0066	0.1380	95.2
21	0.0197	0.1607	87.8	22	0.0067	0.1255	94.6
23	0.0224	0.1467	84.8	24	0.0069	0.1150	94.0
25	0.0488	0.1350	63.9	26	0.0092	0.1062	91.4
27	0.0151	0.1250	87.9	28	0.0071	0.0986	92.8
29	0.0175	0.1164	85.0	30	0.0058	0.0920	93.7
31	0.0185	0.1089	83.0	32	0.0055	0.0862	93.6
33	0.0206	0.1023	79.9	34	0.0057	0.0812	93.0
35	0.0262	0.0964	72.8	36	0.0070	0.0767	90.9
37	0.0155	0.0912	83.0	38	0.0065	0.0726	91.1
39	0.0235	0.0865	72.8	40	0.0055	0.0690	92.0

HYD 5KTL-3PH: L3 phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	7.3204			2	0.0106	1.0800	99.0
3	0.0165	2.3000	99.3	4	0.0205	0.4300	95.2
5	0.0602	1.1400	94.7	6	0.0176	0.3000	94.1
7	0.0393	0.7700	94.9	8	0.0153	0.2300	93.4
9	0.0138	0.4000	96.6	10	0.0114	0.1840	93.8
11	0.0499	0.3300	84.9	12	0.0095	0.1533	93.8
13	0.0380	0.2100	81.9	14	0.0081	0.1314	93.9
15	0.0078	0.1500	94.8	16	0.0084	0.1150	92.7
17	0.0218	0.1324	83.5	18	0.0064	0.1022	93.7
19	0.0694	0.1184	41.4	20	0.0060	0.0920	93.5
21	0.0073	0.1071	93.2	22	0.0061	0.0836	92.7
23	0.0215	0.0978	78.1	24	0.0055	0.0767	92.8
25	0.0415	0.0900	53.8	26	0.0064	0.0708	90.9
27	0.0072	0.0833	91.4	28	0.0055	0.0657	91.7
29	0.0111	0.0776	85.7	30	0.0051	0.0613	91.7
31	0.0109	0.0726	85.0	32	0.0056	0.0575	90.2
33	0.0137	0.0682	79.9	34	0.0056	0.0541	89.6
35	0.0129	0.0643	79.9	36	0.0057	0.0511	88.9
37	0.0186	0.0608	69.4	38	0.0049	0.0484	89.8
39	0.0099	0.0577	82.8	40	0.0050	0.0460	89.1

HYD 10KTL-3PH: L1 phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	14.4818			2	0.0122	1.0800	98.9
3	0.0147	2.3000	99.4	4	0.0135	0.4300	96.9
5	0.0615	1.1400	94.6	6	0.0144	0.3000	95.2
7	0.0312	0.7700	95.9	8	0.0119	0.2300	94.8
9	0.0179	0.4000	95.5	10	0.0095	0.1840	94.8
11	0.0467	0.3300	85.8	12	0.0076	0.1533	95.1
13	0.0304	0.2100	85.5	14	0.0069	0.1314	94.8
15	0.0187	0.1500	87.6	16	0.0067	0.1150	94.2
17	0.0321	0.1324	75.8	18	0.0056	0.1022	94.5
19	0.0490	0.1184	58.6	20	0.0054	0.0920	94.2
21	0.0152	0.1071	85.8	22	0.0054	0.0836	93.5
23	0.0165	0.0978	83.1	24	0.0048	0.0767	93.7
25	0.0472	0.0900	47.6	26	0.0076	0.0708	89.2
27	0.0101	0.0833	87.9	28	0.0049	0.0657	92.6
29	0.0183	0.0776	76.4	30	0.0046	0.0613	92.6
31	0.0322	0.0726	55.6	32	0.0049	0.0575	91.5
33	0.0133	0.0682	80.5	34	0.0049	0.0541	90.9
35	0.0315	0.0643	50.9	36	0.0054	0.0511	89.5
37	0.0231	0.0608	61.9	38	0.0051	0.0484	89.4
39	0.0316	0.0577	45.2	40	0.0055	0.0460	88.1

HYD 10KTL-3PH: L2 phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	14.5013			2	0.0169	1.6200	99.0
3	0.0179	3.4500	99.5	4	0.0174	0.6450	97.3
5	0.0640	1.7100	96.3	6	0.0184	0.4500	95.9
7	0.0359	1.1550	96.9	8	0.0159	0.3450	95.4
9	0.0203	0.6000	96.6	10	0.0111	0.2760	96.0
11	0.0497	0.4950	90.0	12	0.0089	0.2300	96.1
13	0.0336	0.3150	89.3	14	0.0081	0.1971	95.9
15	0.0203	0.2250	91.0	16	0.0077	0.1725	95.5
17	0.0342	0.1985	82.8	18	0.0066	0.1533	95.7
19	0.0514	0.1776	71.0	20	0.0065	0.1380	95.3
21	0.0165	0.1607	89.7	22	0.0063	0.1255	94.9
23	0.0182	0.1467	87.6	24	0.0056	0.1150	95.1
25	0.0485	0.1350	64.1	26	0.0088	0.1062	91.7
27	0.0119	0.1250	90.4	28	0.0055	0.0986	94.4
29	0.0207	0.1164	82.2	30	0.0053	0.0920	94.3
31	0.0349	0.1089	68.0	32	0.0057	0.0862	93.4
33	0.0148	0.1023	85.6	34	0.0057	0.0812	93.0
35	0.0340	0.0964	64.7	36	0.0064	0.0767	91.7
37	0.0261	0.0912	71.4	38	0.0058	0.0726	92.0
39	0.0338	0.0865	60.9	40	0.0065	0.0690	90.5

HYD 10KTL-3PH: L3 phase

Order	Measure[A]	Limit[A]	Margin[%]	Order	Measure[A]	Limit[A]	Margin[%]
1	14.5102			2	0.0104	1.0800	99.0
3	0.0148	2.3000	99.4	4	0.0153	0.4300	96.4
5	0.0558	1.1400	95.1	6	0.0158	0.3000	94.7
7	0.0368	0.7700	95.2	8	0.0131	0.2300	94.3
9	0.0121	0.4000	97.0	10	0.0093	0.1840	94.9
11	0.0414	0.3300	87.5	12	0.0075	0.1533	95.1
13	0.0245	0.2100	88.4	14	0.0069	0.1314	94.8
15	0.0083	0.1500	94.5	16	0.0060	0.1150	94.7
17	0.0294	0.1324	77.8	18	0.0056	0.1022	94.5
19	0.0447	0.1184	62.2	20	0.0053	0.0920	94.3
21	0.0076	0.1071	92.9	22	0.0050	0.0836	94.1
23	0.0140	0.0978	85.6	24	0.0048	0.0767	93.7
25	0.0419	0.0900	53.4	26	0.0056	0.0708	92.0
27	0.0074	0.0833	91.2	28	0.0048	0.0657	92.7
29	0.0178	0.0776	77.1	30	0.0045	0.0613	92.6
31	0.0259	0.0726	64.3	32	0.0046	0.0575	92.0
33	0.0091	0.0682	86.6	34	0.0046	0.0541	91.5
35	0.0232	0.0643	63.9	36	0.0049	0.0511	90.3
37	0.0247	0.0608	59.4	38	0.0049	0.0484	89.9
39	0.0218	0.0577	62.3	40	0.0054	0.0460	88.4

Note:
The tests should be based on the limits of the EN61000-3-2 for Less than 16A.
Covered by EMC Report 13.7.6.8

Maximum permissible harmonic current as per EN 61000-3-12

Harmonic	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Limit [%] 3phasig	8,00	N/A	4,00	10,70	2,67	7,20	2,00	N/A	1,60	3,10	1,33	2,00
Test value [%]	See below											

	THD	PWHD
Limit [%] 3-phase	13	22
Test value [%]	See below	

HYD 20KTL-3PH: L1 phase

Order	Measure[%]	Limit[%]	Margin[%]
2	0.0678	12.0000	99.4
3	0.0753	32.9700	99.8
4	0.0533	6.0000	99.1
5	0.2213	16.9800	98.7
6	0.0923	4.0000	97.7
7	0.1253	10.9875	98.9
8	0.0617	3.0000	97.9
9	0.0858	5.7375	98.5
10	0.0511	2.4000	97.9
11	0.1657	4.7400	96.5
12	0.0518	2.0000	97.4
13	0.1225	3.0900	96.0
THD	0.5514	35.2125	98.4
PWHD	1.9783	35.2125	94.4

HYD 20KTL-3PH: L2 phase

Order	Measure[%]	Limit[%]	Margin[%]
2	0.0754	12.0000	99.4
3	0.0718	32.9700	99.8
4	0.0686	6.0000	98.9
5	0.1850	16.9800	98.9
6	0.1283	4.0000	96.8
7	0.1434	10.9875	98.7
8	0.0792	3.0000	97.4
9	0.0655	5.7375	98.9
10	0.0529	2.4000	97.8
11	0.1255	4.7400	97.4
12	0.0542	2.0000	97.3
13	0.1023	3.0900	96.7
THD	0.4948	35.2125	98.6
PWHD	1.6966	35.2125	95.2

HYD 20KTL-3PH: L3 phase

Order	Measure[%]	Limit[%]	Margin[%]
2	0.0620	12.0000	99.5
3	0.1059	32.9700	99.7
4	0.0721	6.0000	98.8
5	0.2161	16.9800	98.7
6	0.1867	4.0000	95.3
7	0.1360	10.9875	98.8
8	0.0869	3.0000	97.1
9	0.1037	5.7375	98.2
10	0.0631	2.4000	97.4
11	0.1585	4.7400	96.7
12	0.0775	2.0000	96.1
13	0.1366	3.0900	95.6
THD	0.5988	35.2125	98.3
PWHD	2.0039	35.2125	94.3

Note:

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

The test had been performed on the model HYD 20KTL-3PH, HYD 10KTL-3PH and HYD 5KTL-3PH the test results are valid for the HYD 6KTL-3PH, HYD 8KTL-3PH, and HYD 15KTL-3PH since it is identical in hardware and just power derated by software

5.2.4.2 Additional measurements for PGUs intended for PGSs with nominal currents > 75 A	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.

HYD 5KTL-3PH

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	2,214	9,427	19,473	29,632	39,781	49,953	60,130	70,276	80,405	90,599	100,688
2	0,181	0,276	0,253	0,231	0,219	0,168	0,154	0,180	0,177	0,137	0,155
3	0,102	0,199	0,258	0,201	0,148	0,146	0,188	0,196	0,234	0,234	0,221
4	0,113	0,294	0,255	0,215	0,187	0,129	0,113	0,127	0,124	0,101	0,116
5	0,567	1,248	1,233	0,663	0,512	0,627	0,765	0,840	0,833	0,848	0,840
6	0,082	0,187	0,163	0,150	0,141	0,113	0,121	0,135	0,132	0,110	0,125
7	0,794	0,896	1,245	0,829	0,434	0,209	0,225	0,370	0,384	0,265	0,340
8	0,190	0,240	0,184	0,158	0,126	0,089	0,099	0,107	0,119	0,103	0,109
9	0,098	0,160	0,202	0,240	0,230	0,192	0,216	0,257	0,235	0,238	0,214
10	0,136	0,217	0,143	0,152	0,122	0,097	0,104	0,103	0,100	0,086	0,095
11	0,596	0,884	0,831	1,518	1,216	0,550	0,318	0,463	0,608	0,719	0,755
12	0,085	0,145	0,125	0,122	0,109	0,079	0,080	0,083	0,074	0,076	0,075
13	0,398	0,584	0,845	0,848	0,534	0,428	0,542	0,693	0,707	0,664	0,577
14	0,327	0,307	0,140	0,116	0,107	0,085	0,081	0,086	0,076	0,068	0,072
15	0,097	0,113	0,189	0,123	0,103	0,129	0,126	0,136	0,186	0,206	0,186
16	0,239	0,200	0,202	0,098	0,094	0,080	0,075	0,074	0,074	0,074	0,068
17	0,304	0,284	0,826	0,613	0,917	0,967	0,652	0,521	0,292	0,136	0,294
18	0,062	0,126	0,118	0,090	0,083	0,057	0,060	0,056	0,053	0,052	0,048
19	0,564	0,512	0,835	0,825	1,080	0,588	0,298	0,460	0,707	0,913	0,988
20	0,258	0,352	0,125	0,079	0,082	0,073	0,058	0,060	0,055	0,049	0,054
21	0,068	0,086	0,105	0,111	0,085	0,102	0,131	0,112	0,109	0,120	0,133
22	0,115	0,162	0,104	0,119	0,061	0,068	0,073	0,063	0,057	0,051	0,053
23	0,451	0,202	0,394	0,583	0,773	0,522	0,405	0,349	0,252	0,243	0,289
24	0,050	0,097	0,083	0,071	0,059	0,050	0,045	0,044	0,040	0,041	0,037
25	0,326	0,258	0,225	0,665	0,704	0,742	0,505	0,377	0,320	0,466	0,592
26	0,252	0,228	0,072	0,130	0,083	0,063	0,044	0,049	0,051	0,043	0,039
27	0,055	0,087	0,069	0,076	0,075	0,064	0,049	0,067	0,069	0,070	0,076
28	0,149	0,195	0,134	0,106	0,059	0,039	0,037	0,043	0,044	0,040	0,042
29	0,331	0,256	0,559	0,500	0,173	0,679	0,578	0,236	0,142	0,156	0,178
30	0,060	0,100	0,093	0,062	0,050	0,037	0,037	0,039	0,034	0,035	0,037
31	0,234	0,157	0,356	0,395	0,167	0,528	0,387	0,236	0,214	0,220	0,159
32	0,323	0,162	0,147	0,135	0,093	0,097	0,075	0,058	0,051	0,046	0,036
33	0,058	0,093	0,088	0,101	0,082	0,089	0,077	0,083	0,095	0,110	0,090
34	0,251	0,205	0,161	0,122	0,061	0,051	0,052	0,051	0,040	0,046	0,042
35	0,126	0,191	0,175	0,233	0,230	0,203	0,203	0,410	0,392	0,296	0,189
36	0,065	0,111	0,097	0,055	0,056	0,040	0,048	0,045	0,037	0,037	0,041
37	0,164	0,164	0,120	0,290	0,166	0,207	0,235	0,372	0,242	0,096	0,196
38	0,143	0,289	0,132	0,067	0,055	0,051	0,054	0,045	0,039	0,040	0,036
39	0,067	0,068	0,048	0,043	0,075	0,109	0,105	0,077	0,089	0,108	0,125
40	0,340	0,315	0,261	0,142	0,104	0,067	0,065	0,046	0,038	0,040	0,036

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	0,055	0,352	0,319	0,311	0,322	0,203	0,195	0,296	0,309	0,193	0,256
125	0,061	0,163	0,135	0,136	0,138	0,099	0,099	0,111	0,121	0,093	0,112
175	0,065	0,163	0,140	0,142	0,141	0,111	0,111	0,124	0,129	0,113	0,128
225	0,070	0,338	0,284	0,243	0,187	0,130	0,132	0,147	0,148	0,132	0,147
275	0,079	0,369	0,301	0,259	0,199	0,139	0,139	0,152	0,157	0,145	0,155
325	0,074	0,325	0,271	0,244	0,212	0,145	0,145	0,161	0,162	0,143	0,154
375	0,077	0,360	0,299	0,231	0,179	0,126	0,131	0,160	0,173	0,145	0,157
425	0,068	0,169	0,138	0,140	0,132	0,111	0,115	0,119	0,121	0,116	0,117
475	0,060	0,142	0,117	0,124	0,119	0,099	0,104	0,107	0,103	0,099	0,101
525	0,059	0,275	0,233	0,177	0,150	0,103	0,096	0,101	0,093	0,087	0,089
575	0,062	0,289	0,235	0,194	0,171	0,103	0,088	0,095	0,083	0,078	0,083
625	0,052	0,211	0,212	0,157	0,140	0,093	0,082	0,089	0,080	0,072	0,077
675	0,053	0,215	0,230	0,162	0,153	0,097	0,078	0,082	0,074	0,064	0,070
725	0,045	0,112	0,103	0,088	0,088	0,073	0,065	0,065	0,064	0,060	0,061
775	0,042	0,096	0,090	0,082	0,081	0,067	0,059	0,061	0,062	0,059	0,058
825	0,041	0,176	0,170	0,135	0,115	0,069	0,056	0,063	0,066	0,058	0,059
875	0,042	0,160	0,183	0,130	0,109	0,072	0,059	0,065	0,059	0,056	0,053
925	0,042	0,142	0,150	0,131	0,104	0,067	0,056	0,060	0,057	0,053	0,053
975	0,039	0,137	0,154	0,121	0,096	0,063	0,055	0,057	0,051	0,045	0,048
1025	0,040	0,077	0,077	0,071	0,073	0,055	0,053	0,053	0,048	0,044	0,050
1075	0,034	0,074	0,061	0,064	0,058	0,060	0,051	0,048	0,044	0,049	0,050
1125	0,035	0,112	0,113	0,100	0,089	0,060	0,058	0,056	0,055	0,043	0,048
1175	0,035	0,101	0,115	0,106	0,083	0,055	0,050	0,053	0,049	0,042	0,043
1225	0,047	0,101	0,118	0,115	0,100	0,075	0,068	0,062	0,057	0,046	0,041
1275	0,035	0,089	0,108	0,097	0,077	0,053	0,041	0,043	0,042	0,040	0,043
1325	0,040	0,062	0,063	0,058	0,052	0,046	0,042	0,044	0,044	0,042	0,041
1375	0,032	0,057	0,053	0,052	0,046	0,040	0,036	0,038	0,039	0,037	0,036
1425	0,039	0,086	0,096	0,085	0,069	0,051	0,045	0,047	0,046	0,042	0,043
1475	0,032	0,078	0,096	0,081	0,067	0,044	0,039	0,045	0,044	0,037	0,038
1525	0,031	0,076	0,088	0,075	0,062	0,043	0,040	0,042	0,043	0,038	0,040
1575	0,032	0,073	0,089	0,071	0,057	0,042	0,042	0,046	0,042	0,036	0,039
1625	0,031	0,058	0,050	0,043	0,039	0,037	0,038	0,038	0,037	0,036	0,035
1675	0,031	0,056	0,045	0,040	0,038	0,036	0,038	0,038	0,038	0,036	0,036
1725	0,032	0,074	0,058	0,050	0,044	0,038	0,040	0,040	0,039	0,036	0,036
1775	0,033	0,069	0,056	0,050	0,046	0,037	0,038	0,041	0,040	0,035	0,036
1825	0,033	0,065	0,055	0,053	0,045	0,039	0,039	0,038	0,039	0,036	0,036
1875	0,034	0,066	0,057	0,052	0,046	0,036	0,039	0,040	0,039	0,034	0,034
1925	0,037	0,060	0,042	0,039	0,038	0,036	0,037	0,037	0,037	0,035	0,035
1975	0,036	0,059	0,043	0,040	0,038	0,035	0,037	0,037	0,036	0,035	0,035

Higher Frequencies											
P/Pn [%]	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	0,433	0,320	0,373	0,389	0,444	0,432	0,485	0,650	0,608	0,466	0,369
2,3	0,358	0,358	0,400	0,403	0,442	0,331	0,335	0,280	0,386	0,359	0,326
2,5	0,485	0,383	0,417	0,365	0,342	0,346	0,316	0,414	0,360	0,265	0,280
2,7	0,347	0,341	0,389	0,420	0,427	0,462	0,382	0,313	0,396	0,297	0,273
2,9	0,298	0,320	0,298	0,248	0,368	0,220	0,323	0,254	0,334	0,351	0,254
3,1	0,360	0,280	0,334	0,317	0,297	0,257	0,262	0,236	0,331	0,335	0,246
3,3	0,283	0,283	0,305	0,336	0,288	0,318	0,402	0,329	0,327	0,402	0,327
3,5	0,169	0,217	0,248	0,239	0,238	0,270	0,234	0,286	0,245	0,268	0,281
3,7	0,149	0,171	0,194	0,197	0,195	0,198	0,227	0,209	0,215	0,211	0,207
3,9	0,103	0,114	0,123	0,124	0,127	0,135	0,136	0,149	0,142	0,141	0,142
4,1	0,077	0,090	0,096	0,096	0,100	0,098	0,100	0,103	0,106	0,103	0,104
4,3	0,067	0,076	0,081	0,082	0,083	0,081	0,083	0,086	0,084	0,087	0,087
4,5	0,059	0,064	0,068	0,069	0,070	0,070	0,072	0,071	0,074	0,073	0,074
4,7	0,107	0,113	0,117	0,119	0,120	0,121	0,121	0,122	0,122	0,122	0,123
4,9	0,049	0,052	0,054	0,054	0,055	0,055	0,054	0,056	0,056	0,057	0,057
5,1	0,047	0,049	0,050	0,051	0,051	0,051	0,052	0,052	0,053	0,053	0,053
5,3	0,042	0,044	0,045	0,045	0,045	0,046	0,046	0,046	0,047	0,047	0,047
5,5	0,040	0,042	0,042	0,042	0,042	0,042	0,043	0,043	0,043	0,044	0,044
5,7	0,041	0,042	0,042	0,042	0,043	0,043	0,043	0,043	0,044	0,044	0,044
5,9	0,036	0,038	0,038	0,037	0,038	0,037	0,038	0,038	0,039	0,039	0,039
6,1	0,047	0,048	0,048	0,048	0,048	0,048	0,048	0,049	0,049	0,049	0,049
6,3	0,035	0,035	0,035	0,035	0,035	0,035	0,035	0,036	0,036	0,036	0,037
6,5	0,033	0,034	0,034	0,033	0,034	0,034	0,034	0,034	0,035	0,035	0,035
6,7	0,033	0,034	0,033	0,033	0,033	0,033	0,033	0,034	0,035	0,034	0,035
6,9	0,031	0,033	0,033	0,032	0,033	0,033	0,034	0,034	0,034	0,033	0,035
7,1	0,054	0,055	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,055
7,3	0,031	0,032	0,031	0,032	0,032	0,032	0,032	0,032	0,033	0,033	0,033
7,5	0,030	0,031	0,030	0,030	0,031	0,031	0,031	0,031	0,031	0,033	0,032
7,7	0,029	0,030	0,029	0,029	0,029	0,030	0,029	0,029	0,029	0,031	0,030
7,9	0,028	0,030	0,029	0,029	0,029	0,030	0,029	0,029	0,029	0,030	0,030
8,1	0,028	0,030	0,029	0,029	0,029	0,030	0,030	0,030	0,030	0,032	0,030
8,3	0,036	0,038	0,037	0,038	0,038	0,037	0,038	0,038	0,038	0,038	0,039
8,5	0,036	0,039	0,038	0,037	0,037	0,037	0,037	0,038	0,037	0,038	0,038
8,7	0,025	0,027	0,026	0,026	0,026	0,027	0,027	0,027	0,027	0,028	0,028
8,9	0,025	0,027	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,027	0,027

HYD 6KTL-3PH										
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	1,763	9,277	19,363	29,502	39,672	49,832	59,981	70,113	80,243	90,297	100,460
2	0,118	0,195	0,204	0,174	0,151	0,115	0,112	0,114	0,113	0,144	0,113
3	0,079	0,161	0,190	0,124	0,118	0,140	0,150	0,195	0,178	0,178	0,164
4	0,084	0,216	0,191	0,152	0,114	0,092	0,089	0,087	0,085	0,102	0,082
5	0,497	1,011	0,850	0,461	0,476	0,617	0,688	0,697	0,709	0,708	0,690
6	0,050	0,162	0,138	0,127	0,099	0,097	0,094	0,095	0,091	0,111	0,089
7	0,772	0,823	0,890	0,498	0,208	0,203	0,234	0,215	0,216	0,321	0,260
8	0,101	0,169	0,134	0,110	0,082	0,079	0,089	0,092	0,086	0,093	0,078
9	0,068	0,142	0,165	0,176	0,161	0,170	0,206	0,197	0,185	0,164	0,157
10	0,092	0,158	0,128	0,106	0,088	0,085	0,080	0,076	0,071	0,078	0,070
11	0,475	0,702	1,032	1,163	0,575	0,251	0,401	0,548	0,617	0,647	0,617
12	0,055	0,140	0,121	0,086	0,064	0,061	0,063	0,061	0,059	0,061	0,054
13	0,537	0,580	0,788	0,578	0,375	0,428	0,580	0,590	0,520	0,450	0,413
14	0,161	0,263	0,094	0,101	0,078	0,067	0,068	0,061	0,058	0,059	0,053
15	0,081	0,109	0,161	0,063	0,105	0,099	0,117	0,168	0,164	0,138	0,132
16	0,199	0,164	0,119	0,069	0,070	0,065	0,059	0,063	0,058	0,055	0,050
17	0,388	0,385	0,471	0,697	0,870	0,603	0,405	0,149	0,186	0,326	0,338
18	0,050	0,120	0,083	0,079	0,054	0,045	0,044	0,042	0,040	0,042	0,038
19	0,554	0,328	0,362	0,923	0,609	0,203	0,421	0,661	0,823	0,784	0,705
20	0,272	0,330	0,090	0,069	0,071	0,048	0,044	0,044	0,040	0,043	0,040
21	0,071	0,094	0,061	0,104	0,071	0,115	0,089	0,096	0,099	0,110	0,108
22	0,212	0,148	0,073	0,072	0,064	0,062	0,049	0,046	0,036	0,042	0,034
23	0,468	0,389	0,697	0,419	0,458	0,401	0,268	0,164	0,260	0,189	0,194
24	0,062	0,119	0,080	0,071	0,063	0,052	0,049	0,047	0,044	0,053	0,059
25	0,355	0,237	0,501	0,303	0,665	0,460	0,303	0,297	0,445	0,543	0,508
26	0,206	0,249	0,094	0,079	0,051	0,034	0,038	0,039	0,034	0,031	0,032
27	0,037	0,075	0,059	0,068	0,065	0,044	0,054	0,054	0,059	0,070	0,063
28	0,210	0,188	0,104	0,080	0,037	0,030	0,034	0,034	0,032	0,037	0,027
29	0,145	0,233	0,322	0,365	0,487	0,445	0,146	0,103	0,149	0,143	0,213
30	0,035	0,088	0,057	0,041	0,032	0,033	0,031	0,030	0,028	0,032	0,028
31	0,238	0,249	0,257	0,348	0,398	0,355	0,166	0,181	0,185	0,175	0,154
32	0,124	0,192	0,125	0,084	0,080	0,064	0,046	0,043	0,036	0,028	0,030
33	0,046	0,061	0,056	0,045	0,074	0,060	0,071	0,090	0,085	0,072	0,090
34	0,207	0,201	0,108	0,078	0,053	0,049	0,041	0,037	0,036	0,035	0,033
35	0,107	0,137	0,118	0,154	0,213	0,171	0,365	0,301	0,194	0,114	0,177
36	0,037	0,072	0,057	0,048	0,033	0,042	0,035	0,033	0,030	0,033	0,028
37	0,070	0,166	0,249	0,175	0,196	0,207	0,313	0,129	0,108	0,243	0,328
38	0,303	0,315	0,082	0,064	0,044	0,051	0,037	0,028	0,032	0,033	0,027
39	0,049	0,044	0,050	0,069	0,076	0,093	0,066	0,079	0,096	0,106	0,112
40	0,313	0,314	0,165	0,110	0,056	0,051	0,035	0,032	0,032	0,030	0,028

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	0,036	0,253	0,253	0,272	0,197	0,161	0,157	0,172	0,166	0,257	0,171
125	0,045	0,099	0,099	0,107	0,091	0,081	0,080	0,086	0,083	0,107	0,081
175	0,049	0,110	0,110	0,115	0,099	0,093	0,098	0,098	0,098	0,114	0,097
225	0,047	0,224	0,224	0,184	0,115	0,104	0,114	0,114	0,116	0,133	0,117
275	0,047	0,233	0,233	0,188	0,122	0,114	0,123	0,126	0,127	0,140	0,124
325	0,050	0,221	0,221	0,208	0,134	0,116	0,121	0,126	0,125	0,137	0,118
375	0,050	0,231	0,231	0,175	0,118	0,111	0,116	0,124	0,122	0,139	0,118
425	0,050	0,103	0,103	0,105	0,097	0,094	0,095	0,098	0,098	0,100	0,092
475	0,046	0,092	0,092	0,089	0,086	0,084	0,083	0,085	0,085	0,090	0,084
525	0,043	0,175	0,175	0,134	0,097	0,077	0,074	0,074	0,073	0,075	0,074
575	0,040	0,187	0,187	0,147	0,099	0,074	0,071	0,070	0,069	0,071	0,067
625	0,037	0,168	0,168	0,117	0,088	0,068	0,064	0,063	0,062	0,067	0,062
675	0,035	0,166	0,166	0,134	0,097	0,065	0,058	0,056	0,055	0,067	0,060
725	0,033	0,077	0,077	0,069	0,064	0,053	0,052	0,052	0,051	0,054	0,052
775	0,031	0,072	0,072	0,064	0,059	0,048	0,048	0,051	0,050	0,050	0,049
825	0,030	0,132	0,132	0,106	0,066	0,047	0,047	0,051	0,049	0,050	0,049
875	0,029	0,132	0,132	0,100	0,071	0,049	0,047	0,048	0,046	0,048	0,045
925	0,031	0,119	0,119	0,099	0,063	0,046	0,047	0,047	0,045	0,046	0,044
975	0,027	0,109	0,109	0,093	0,058	0,044	0,041	0,040	0,038	0,041	0,040
1025	0,030	0,056	0,056	0,056	0,046	0,044	0,041	0,038	0,038	0,040	0,039
1075	0,025	0,050	0,050	0,050	0,043	0,041	0,037	0,034	0,034	0,037	0,037
1125	0,025	0,090	0,090	0,085	0,056	0,041	0,037	0,035	0,035	0,042	0,038
1175	0,026	0,087	0,087	0,086	0,052	0,041	0,038	0,038	0,037	0,038	0,036
1225	0,029	0,088	0,088	0,080	0,057	0,051	0,054	0,054	0,055	0,049	0,035
1275	0,025	0,084	0,084	0,074	0,049	0,034	0,033	0,034	0,032	0,034	0,033
1325	0,030	0,050	0,050	0,047	0,039	0,035	0,035	0,036	0,035	0,035	0,034
1375	0,025	0,047	0,047	0,041	0,035	0,030	0,032	0,032	0,031	0,032	0,030
1425	0,030	0,080	0,080	0,066	0,047	0,039	0,036	0,036	0,035	0,038	0,037
1475	0,025	0,078	0,078	0,060	0,042	0,034	0,034	0,034	0,032	0,034	0,032
1525	0,025	0,075	0,075	0,057	0,041	0,035	0,032	0,033	0,033	0,037	0,034
1575	0,025	0,069	0,069	0,053	0,039	0,036	0,033	0,032	0,032	0,036	0,035
1625	0,026	0,041	0,041	0,034	0,032	0,032	0,030	0,031	0,031	0,031	0,031
1675	0,026	0,038	0,038	0,033	0,030	0,031	0,031	0,031	0,031	0,032	0,031
1725	0,026	0,046	0,046	0,040	0,032	0,032	0,031	0,031	0,030	0,032	0,031
1775	0,026	0,043	0,043	0,038	0,033	0,032	0,031	0,032	0,030	0,032	0,030
1825	0,026	0,047	0,047	0,040	0,034	0,033	0,030	0,031	0,030	0,032	0,030
1875	0,026	0,044	0,044	0,038	0,033	0,032	0,030	0,030	0,029	0,030	0,030
1925	0,029	0,034	0,034	0,032	0,031	0,030	0,030	0,030	0,030	0,031	0,030
1975	0,028	0,034	0,034	0,031	0,029	0,029	0,029	0,030	0,029	0,030	0,030

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	0,339	0,262	0,403	0,271	0,410	0,404	0,575	0,476	0,339	0,335	0,465
2,3	0,372	0,333	0,293	0,392	0,259	0,293	0,241	0,322	0,273	0,240	0,258
2,5	0,341	0,302	0,289	0,399	0,298	0,261	0,361	0,270	0,218	0,268	0,325
2,7	0,413	0,260	0,325	0,284	0,320	0,328	0,277	0,305	0,204	0,255	0,320
2,9	0,152	0,229	0,239	0,223	0,238	0,231	0,205	0,316	0,242	0,213	0,241
3,1	0,232	0,227	0,256	0,229	0,231	0,235	0,194	0,276	0,249	0,179	0,204
3,3	0,263	0,223	0,248	0,228	0,286	0,326	0,248	0,314	0,317	0,229	0,237
3,5	0,131	0,183	0,209	0,194	0,211	0,191	0,241	0,203	0,235	0,216	0,208
3,7	0,108	0,146	0,161	0,172	0,168	0,184	0,172	0,182	0,170	0,172	0,179
3,9	0,077	0,097	0,105	0,114	0,106	0,115	0,126	0,117	0,117	0,117	0,116
4,1	0,063	0,075	0,080	0,083	0,083	0,086	0,087	0,086	0,087	0,088	0,088
4,3	0,055	0,063	0,066	0,068	0,068	0,068	0,072	0,070	0,073	0,071	0,072
4,5	0,048	0,054	0,056	0,057	0,058	0,060	0,060	0,060	0,062	0,062	0,062
4,7	0,089	0,095	0,098	0,100	0,101	0,101	0,101	0,102	0,102	0,103	0,103
4,9	0,040	0,043	0,044	0,045	0,045	0,046	0,046	0,047	0,047	0,048	0,049
5,1	0,039	0,041	0,042	0,042	0,043	0,043	0,043	0,044	0,044	0,045	0,045
5,3	0,035	0,037	0,037	0,038	0,038	0,038	0,039	0,039	0,039	0,040	0,040
5,5	0,033	0,034	0,035	0,035	0,035	0,036	0,036	0,036	0,037	0,037	0,037
5,7	0,034	0,035	0,035	0,036	0,036	0,036	0,036	0,037	0,037	0,037	0,037
5,9	0,030	0,031	0,031	0,031	0,032	0,032	0,032	0,032	0,033	0,033	0,033
6,1	0,039	0,040	0,040	0,040	0,040	0,040	0,041	0,041	0,041	0,041	0,041
6,3	0,028	0,029	0,029	0,029	0,029	0,030	0,030	0,030	0,031	0,030	0,031
6,5	0,027	0,028	0,028	0,028	0,028	0,028	0,029	0,029	0,029	0,029	0,029
6,7	0,027	0,028	0,027	0,027	0,028	0,028	0,028	0,028	0,029	0,028	0,029
6,9	0,027	0,027	0,027	0,027	0,027	0,028	0,028	0,029	0,028	0,028	0,028
7,1	0,044	0,046	0,045	0,045	0,045	0,045	0,045	0,046	0,046	0,046	0,046
7,3	0,025	0,026	0,026	0,027	0,027	0,027	0,027	0,028	0,027	0,028	0,027
7,5	0,025	0,026	0,025	0,025	0,026	0,026	0,026	0,027	0,026	0,027	0,026
7,7	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,025	0,025	0,025	0,025
7,9	0,023	0,024	0,024	0,024	0,024	0,024	0,025	0,025	0,025	0,025	0,025
8,1	0,023	0,024	0,024	0,024	0,024	0,025	0,025	0,025	0,026	0,025	0,025
8,3	0,031	0,031	0,031	0,031	0,031	0,031	0,031	0,031	0,032	0,032	0,032
8,5	0,031	0,032	0,031	0,031	0,031	0,031	0,031	0,031	0,031	0,032	0,031
8,7	0,021	0,022	0,022	0,022	0,022	0,022	0,022	0,023	0,024	0,023	0,023
8,9	0,020	0,022	0,021	0,022	0,022	0,022	0,022	0,022	0,023	0,022	0,023

Harmonic HYD 8KTL-3PH											
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	1,332	9,351	19,329	29,328	39,363	49,370	59,365	69,337	79,265	89,251	99,193
2	0,089	0,173	0,138	0,124	0,090	0,086	0,084	0,081	0,099	0,082	0,077
3	0,060	0,163	0,117	0,093	0,114	0,132	0,133	0,132	0,115	0,112	0,110
4	0,064	0,185	0,128	0,098	0,070	0,064	0,062	0,061	0,069	0,059	0,057
5	0,368	0,836	0,400	0,365	0,488	0,509	0,531	0,535	0,507	0,498	0,498
6	0,039	0,123	0,097	0,084	0,075	0,069	0,071	0,069	0,072	0,064	0,061
7	0,572	0,799	0,479	0,177	0,153	0,160	0,165	0,183	0,241	0,205	0,196
8	0,078	0,115	0,090	0,064	0,060	0,067	0,064	0,064	0,062	0,055	0,056
9	0,053	0,138	0,141	0,119	0,137	0,146	0,139	0,126	0,108	0,098	0,094
10	0,072	0,089	0,087	0,067	0,064	0,058	0,053	0,055	0,055	0,049	0,046
11	0,359	0,446	0,945	0,468	0,209	0,367	0,462	0,484	0,446	0,402	0,398
12	0,042	0,080	0,071	0,055	0,048	0,046	0,046	0,044	0,041	0,038	0,038
13	0,394	0,448	0,517	0,314	0,355	0,445	0,392	0,340	0,285	0,246	0,244
14	0,125	0,176	0,075	0,063	0,052	0,048	0,043	0,041	0,041	0,038	0,042
15	0,060	0,081	0,064	0,080	0,074	0,115	0,122	0,109	0,093	0,084	0,084
16	0,150	0,135	0,055	0,054	0,046	0,045	0,046	0,042	0,037	0,034	0,030
17	0,287	0,527	0,394	0,660	0,395	0,193	0,127	0,240	0,283	0,265	0,253
18	0,038	0,071	0,054	0,041	0,035	0,031	0,031	0,031	0,029	0,026	0,025
19	0,415	0,314	0,558	0,480	0,194	0,429	0,610	0,593	0,480	0,424	0,433
20	0,206	0,165	0,054	0,055	0,037	0,034	0,031	0,028	0,030	0,028	0,031
21	0,056	0,060	0,077	0,051	0,085	0,065	0,074	0,082	0,082	0,069	0,069
22	0,159	0,078	0,071	0,050	0,044	0,035	0,027	0,029	0,027	0,022	0,020
23	0,351	0,407	0,274	0,357	0,269	0,143	0,183	0,160	0,138	0,143	0,130
24	0,036	0,054	0,051	0,038	0,029	0,029	0,025	0,026	0,035	0,021	0,022
25	0,261	0,240	0,324	0,504	0,299	0,193	0,327	0,397	0,401	0,369	0,362
26	0,146	0,071	0,074	0,042	0,026	0,028	0,028	0,023	0,023	0,023	0,027
27	0,027	0,036	0,046	0,051	0,030	0,043	0,046	0,046	0,054	0,038	0,042
28	0,153	0,099	0,070	0,030	0,021	0,024	0,024	0,023	0,023	0,018	0,017
29	0,117	0,181	0,340	0,344	0,282	0,060	0,109	0,126	0,176	0,223	0,211
30	0,025	0,050	0,034	0,024	0,024	0,025	0,021	0,022	0,023	0,020	0,020
31	0,180	0,122	0,310	0,281	0,220	0,114	0,132	0,100	0,188	0,200	0,184
32	0,112	0,095	0,079	0,057	0,046	0,034	0,029	0,023	0,021	0,020	0,024
33	0,033	0,050	0,050	0,055	0,045	0,061	0,065	0,063	0,064	0,058	0,054
34	0,162	0,139	0,079	0,041	0,036	0,026	0,027	0,026	0,024	0,020	0,018
35	0,080	0,135	0,172	0,164	0,174	0,264	0,157	0,096	0,170	0,243	0,253
36	0,029	0,059	0,031	0,026	0,033	0,026	0,024	0,021	0,022	0,021	0,020
37	0,056	0,121	0,215	0,161	0,186	0,158	0,073	0,196	0,281	0,324	0,316
38	0,231	0,208	0,048	0,036	0,036	0,023	0,021	0,023	0,023	0,019	0,021
39	0,037	0,027	0,033	0,050	0,063	0,055	0,071	0,085	0,079	0,088	0,100
40	0,247	0,231	0,095	0,044	0,036	0,023	0,024	0,021	0,022	0,022	0,022

Interharmonics HYD 8KTL-3PH											
P/Pn [%]	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	0,028	0,212	0,194	0,180	0,122	0,115	0,113	0,112	0,162	0,120	0,115
125	0,035	0,082	0,079	0,077	0,062	0,057	0,057	0,062	0,067	0,056	0,055
175	0,038	0,084	0,083	0,081	0,071	0,070	0,071	0,075	0,074	0,070	0,070
225	0,037	0,187	0,151	0,097	0,082	0,084	0,085	0,089	0,091	0,084	0,084
275	0,038	0,199	0,160	0,104	0,085	0,090	0,093	0,100	0,097	0,093	0,093
325	0,039	0,175	0,155	0,113	0,088	0,090	0,091	0,092	0,094	0,088	0,088
375	0,039	0,200	0,137	0,092	0,081	0,087	0,089	0,088	0,094	0,085	0,086
425	0,042	0,086	0,079	0,074	0,070	0,071	0,071	0,073	0,072	0,070	0,071
475	0,040	0,077	0,070	0,068	0,064	0,061	0,062	0,064	0,063	0,063	0,065
525	0,036	0,160	0,105	0,081	0,059	0,054	0,054	0,054	0,054	0,055	0,056
575	0,033	0,162	0,116	0,085	0,056	0,049	0,048	0,051	0,050	0,049	0,051
625	0,030	0,138	0,093	0,075	0,052	0,045	0,044	0,046	0,048	0,046	0,046
675	0,028	0,154	0,101	0,085	0,048	0,042	0,041	0,042	0,048	0,045	0,044
725	0,026	0,065	0,053	0,052	0,040	0,039	0,037	0,039	0,039	0,038	0,040
775	0,025	0,056	0,047	0,048	0,036	0,037	0,036	0,037	0,036	0,037	0,039
825	0,024	0,103	0,080	0,054	0,034	0,036	0,036	0,035	0,035	0,036	0,037
875	0,023	0,109	0,077	0,058	0,036	0,034	0,034	0,033	0,034	0,034	0,035
925	0,025	0,089	0,075	0,050	0,034	0,034	0,033	0,033	0,032	0,032	0,033
975	0,021	0,099	0,072	0,048	0,034	0,029	0,028	0,029	0,029	0,028	0,029
1025	0,024	0,048	0,045	0,036	0,033	0,029	0,028	0,029	0,029	0,028	0,029
1075	0,020	0,043	0,039	0,034	0,031	0,026	0,025	0,028	0,028	0,026	0,028
1125	0,020	0,072	0,060	0,047	0,030	0,026	0,026	0,028	0,029	0,026	0,027
1175	0,020	0,075	0,067	0,045	0,030	0,027	0,026	0,027	0,027	0,026	0,027
1225	0,038	0,076	0,065	0,059	0,048	0,046	0,046	0,047	0,040	0,048	0,045
1275	0,019	0,066	0,060	0,040	0,031	0,024	0,024	0,023	0,025	0,024	0,024
1325	0,024	0,037	0,036	0,031	0,026	0,028	0,027	0,026	0,026	0,025	0,026
1375	0,019	0,033	0,030	0,027	0,022	0,028	0,023	0,023	0,023	0,022	0,022
1425	0,024	0,055	0,050	0,037	0,027	0,027	0,031	0,028	0,028	0,026	0,026
1475	0,019	0,055	0,048	0,034	0,024	0,025	0,024	0,029	0,025	0,023	0,024
1525	0,021	0,049	0,044	0,032	0,024	0,024	0,024	0,025	0,027	0,024	0,025
1575	0,019	0,051	0,042	0,030	0,026	0,023	0,023	0,024	0,027	0,025	0,026
1625	0,019	0,030	0,025	0,024	0,023	0,022	0,023	0,024	0,023	0,024	0,024
1675	0,020	0,030	0,023	0,023	0,024	0,023	0,023	0,023	0,023	0,024	0,024
1725	0,020	0,037	0,031	0,026	0,025	0,023	0,022	0,023	0,023	0,023	0,024
1775	0,020	0,033	0,030	0,027	0,025	0,023	0,022	0,023	0,023	0,023	0,024
1825	0,021	0,033	0,032	0,027	0,024	0,023	0,022	0,022	0,023	0,022	0,024
1875	0,021	0,032	0,031	0,026	0,024	0,023	0,021	0,022	0,023	0,022	0,023
1925	0,023	0,028	0,024	0,023	0,023	0,022	0,022	0,022	0,023	0,022	0,023
1975	0,022	0,028	0,024	0,023	0,023	0,022	0,021	0,022	0,022	0,022	0,023

Higher Frequencies HYD 8KTL-3PH											
P/Pn [%]	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	0,252	0,229	0,262	0,309	0,360	0,413	0,261	0,297	0,361	0,430	0,426
2,3	0,274	0,264	0,215	0,187	0,193	0,235	0,213	0,175	0,216	0,253	0,281
2,5	0,257	0,266	0,206	0,217	0,233	0,247	0,163	0,223	0,231	0,237	0,216
2,7	0,317	0,262	0,293	0,233	0,193	0,245	0,164	0,183	0,242	0,266	0,268
2,9	0,114	0,187	0,182	0,199	0,152	0,212	0,190	0,131	0,175	0,201	0,207
3,1	0,172	0,202	0,172	0,188	0,166	0,194	0,193	0,130	0,182	0,208	0,233
3,3	0,194	0,187	0,194	0,211	0,261	0,198	0,240	0,168	0,188	0,236	0,266
3,5	0,099	0,144	0,145	0,152	0,159	0,154	0,174	0,163	0,158	0,181	0,206
3,7	0,080	0,116	0,125	0,126	0,131	0,135	0,127	0,127	0,134	0,139	0,142
3,9	0,057	0,077	0,079	0,080	0,085	0,089	0,088	0,086	0,087	0,093	0,096
4,1	0,047	0,058	0,061	0,062	0,063	0,065	0,064	0,065	0,066	0,068	0,069
4,3	0,041	0,049	0,051	0,051	0,052	0,052	0,055	0,053	0,055	0,058	0,059
4,5	0,036	0,042	0,043	0,044	0,044	0,046	0,046	0,046	0,047	0,048	0,050
4,7	0,067	0,072	0,074	0,075	0,076	0,076	0,077	0,077	0,077	0,078	0,078
4,9	0,030	0,033	0,034	0,034	0,035	0,035	0,035	0,036	0,037	0,038	0,038
5,1	0,029	0,031	0,031	0,032	0,033	0,033	0,033	0,034	0,034	0,035	0,036
5,3	0,026	0,028	0,028	0,028	0,029	0,029	0,030	0,030	0,030	0,031	0,032
5,5	0,025	0,026	0,026	0,026	0,027	0,027	0,028	0,028	0,028	0,029	0,029
5,7	0,025	0,026	0,026	0,027	0,027	0,027	0,028	0,028	0,028	0,029	0,029
5,9	0,022	0,023	0,023	0,024	0,024	0,024	0,024	0,025	0,025	0,025	0,026
6,1	0,029	0,030	0,030	0,030	0,030	0,031	0,031	0,031	0,031	0,031	0,031
6,3	0,021	0,022	0,022	0,022	0,022	0,023	0,023	0,023	0,023	0,023	0,024
6,5	0,020	0,021	0,021	0,021	0,021	0,022	0,022	0,022	0,022	0,022	0,023
6,7	0,020	0,021	0,021	0,021	0,021	0,022	0,022	0,021	0,022	0,022	0,022
6,9	0,020	0,021	0,020	0,020	0,021	0,021	0,021	0,021	0,021	0,021	0,022
7,1	0,033	0,034	0,034	0,034	0,034	0,034	0,034	0,034	0,034	0,034	0,035
7,3	0,019	0,020	0,020	0,020	0,020	0,020	0,020	0,021	0,021	0,021	0,021
7,5	0,018	0,019	0,019	0,019	0,020	0,019	0,020	0,020	0,020	0,020	0,021
7,7	0,018	0,018	0,018	0,018	0,018	0,018	0,019	0,019	0,019	0,019	0,019
7,9	0,017	0,018	0,018	0,018	0,018	0,018	0,019	0,019	0,019	0,019	0,019
8,1	0,018	0,018	0,018	0,019	0,018	0,019	0,019	0,019	0,019	0,019	0,019
8,3	0,023	0,023	0,023	0,024	0,024	0,023	0,024	0,024	0,024	0,024	0,024
8,5	0,023	0,023	0,023	0,023	0,023	0,023	0,024	0,024	0,023	0,024	0,024
8,7	0,016	0,016	0,016	0,016	0,017	0,017	0,018	0,018	0,017	0,018	0,018
8,9	0,015	0,016	0,016	0,016	0,016	0,016	0,017	0,017	0,017	0,017	0,017

Harminoc HYD 10KTL-3PH											
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	6,14	10,75	20,72	30,66	40,51	50,66	60,68	70,75	80,75	90,76	100,53
2	0,381	0,365	0,380	0,373	0,373	0,352	0,325	0,315	0,314	0,313	0,310
3	0,293	0,313	0,355	0,388	0,364	0,313	0,318	0,329	0,335	0,340	0,334
4	0,243	0,282	0,295	0,388	0,353	0,346	0,263	0,264	0,267	0,263	0,258
5	0,599	0,483	0,616	0,632	0,616	0,638	0,633	0,656	0,681	0,691	0,714
6	0,235	0,256	0,246	0,242	0,246	0,243	0,239	0,240	0,240	0,239	0,239
7	0,542	0,383	0,370	0,414	0,419	0,405	0,373	0,364	0,356	0,356	0,334
8	0,153	0,144	0,146	0,152	0,147	0,147	0,143	0,146	0,149	0,151	0,152
9	0,111	0,051	0,055	0,059	0,059	0,060	0,063	0,062	0,065	0,075	0,074
10	0,098	0,070	0,083	0,083	0,077	0,077	0,075	0,079	0,080	0,081	0,080
11	0,244	0,217	0,220	0,240	0,275	0,265	0,169	0,126	0,130	0,119	0,105
12	0,127	0,062	0,053	0,049	0,053	0,082	0,071	0,082	0,070	0,080	0,082
13	0,166	0,157	0,143	0,151	0,276	0,291	0,219	0,204	0,219	0,235	0,232
14	0,099	0,065	0,024	0,036	0,031	0,028	0,026	0,026	0,025	0,026	0,027
15	0,141	0,029	0,085	0,080	0,107	0,104	0,101	0,101	0,100	0,097	0,096
16	0,117	0,079	0,019	0,022	0,017	0,015	0,015	0,015	0,015	0,017	0,018
17	0,125	0,054	0,240	0,075	0,227	0,262	0,165	0,149	0,186	0,200	0,204
18	0,085	0,068	0,028	0,021	0,020	0,020	0,016	0,014	0,014	0,017	0,019
19	0,101	0,081	0,231	0,076	0,218	0,251	0,150	0,058	0,041	0,054	0,061
20	0,071	0,042	0,021	0,017	0,018	0,016	0,016	0,015	0,013	0,015	0,017
21	0,078	0,067	0,072	0,105	0,118	0,106	0,098	0,090	0,086	0,077	0,077
22	0,060	0,046	0,020	0,015	0,015	0,013	0,012	0,011	0,010	0,011	0,011
23	0,041	0,050	0,186	0,064	0,204	0,262	0,162	0,050	0,028	0,049	0,068
24	0,057	0,068	0,022	0,015	0,012	0,016	0,019	0,018	0,019	0,019	0,016
25	0,101	0,121	0,151	0,147	0,209	0,235	0,350	0,403	0,401	0,362	0,339
26	0,025	0,057	0,026	0,019	0,021	0,017	0,016	0,026	0,020	0,016	0,011
27	0,117	0,094	0,132	0,186	0,157	0,303	0,432	0,290	0,280	0,244	0,213
28	0,026	0,026	0,012	0,010	0,011	0,016	0,020	0,023	0,018	0,025	0,021
29	0,076	0,107	0,161	0,113	0,211	0,325	0,462	0,496	0,536	0,425	0,418
30	0,028	0,032	0,014	0,010	0,009	0,010	0,011	0,023	0,019	0,020	0,025
31	0,062	0,080	0,104	0,057	0,092	0,082	0,138	0,215	0,287	0,252	0,387
32	0,028	0,015	0,017	0,011	0,010	0,010	0,010	0,011	0,015	0,024	0,032
33	0,076	0,032	0,048	0,027	0,053	0,075	0,060	0,047	0,072	0,099	0,215
34	0,027	0,036	0,014	0,011	0,010	0,010	0,011	0,009	0,009	0,011	0,024
35	0,038	0,064	0,054	0,057	0,087	0,086	0,046	0,103	0,142	0,192	0,253
36	0,038	0,032	0,017	0,014	0,014	0,013	0,014	0,013	0,013	0,014	0,014
37	0,030	0,064	0,029	0,048	0,078	0,106	0,050	0,031	0,027	0,026	0,021
38	0,025	0,016	0,016	0,013	0,012	0,012	0,010	0,012	0,012	0,012	0,014
39	0,024	0,026	0,020	0,023	0,031	0,036	0,035	0,044	0,053	0,057	0,056
40	0,048	0,029	0,014	0,013	0,011	0,011	0,011	0,011	0,011	0,010	0,011

Interharmonics HYD 10KTL-3PH											
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	0,135	0,190	0,250	0,250	0,239	0,137	0,156	0,125	0,126	0,125	0,110
125	0,091	0,134	0,204	0,203	0,190	0,120	0,126	0,112	0,110	0,110	0,099
175	0,068	0,097	0,120	0,136	0,127	0,088	0,082	0,087	0,091	0,089	0,085
225	0,076	0,080	0,083	0,097	0,088	0,080	0,051	0,053	0,054	0,061	0,060
275	0,064	0,057	0,062	0,056	0,059	0,042	0,043	0,046	0,045	0,045	0,045
325	0,056	0,047	0,049	0,042	0,041	0,033	0,032	0,031	0,032	0,035	0,038
375	0,052	0,041	0,037	0,034	0,031	0,024	0,025	0,026	0,026	0,027	0,026
425	0,039	0,034	0,026	0,028	0,027	0,021	0,021	0,022	0,022	0,022	0,022
475	0,034	0,030	0,026	0,023	0,022	0,019	0,021	0,020	0,018	0,018	0,019
525	0,079	0,110	0,042	0,112	0,074	0,017	0,018	0,017	0,017	0,017	0,017
575	0,043	0,033	0,074	0,023	0,023	0,059	0,081	0,051	0,056	0,027	0,020
625	0,036	0,030	0,024	0,021	0,018	0,042	0,020	0,022	0,022	0,023	0,036
675	0,034	0,026	0,020	0,018	0,016	0,015	0,015	0,015	0,014	0,013	0,014
725	0,028	0,020	0,015	0,014	0,014	0,013	0,013	0,013	0,012	0,013	0,013
775	0,023	0,019	0,015	0,014	0,014	0,012	0,012	0,012	0,011	0,012	0,012
825	0,028	0,022	0,018	0,016	0,014	0,011	0,012	0,012	0,011	0,011	0,012
875	0,027	0,019	0,015	0,015	0,013	0,012	0,013	0,012	0,012	0,012	0,012
925	0,026	0,020	0,017	0,016	0,014	0,013	0,013	0,012	0,013	0,014	0,015
975	0,024	0,019	0,014	0,013	0,012	0,011	0,011	0,011	0,010	0,011	0,011
1025	0,023	0,015	0,013	0,013	0,013	0,012	0,013	0,013	0,013	0,013	0,013
1075	0,020	0,017	0,012	0,013	0,014	0,011	0,011	0,011	0,010	0,011	0,011
1125	0,018	0,014	0,016	0,013	0,012	0,011	0,011	0,011	0,011	0,011	0,011
1175	0,017	0,016	0,013	0,012	0,012	0,014	0,014	0,013	0,013	0,012	0,011
1225	0,017	0,016	0,014	0,013	0,012	0,014	0,015	0,013	0,013	0,013	0,014
1275	0,015	0,016	0,014	0,014	0,013	0,012	0,016	0,015	0,013	0,013	0,012
1325	0,017	0,015	0,016	0,016	0,018	0,017	0,017	0,017	0,020	0,018	0,017
1375	0,014	0,012	0,011	0,011	0,013	0,014	0,018	0,014	0,015	0,018	0,015
1425	0,017	0,015	0,015	0,014	0,014	0,016	0,020	0,020	0,019	0,018	0,023
1475	0,015	0,012	0,012	0,011	0,011	0,011	0,016	0,016	0,017	0,017	0,018
1525	0,015	0,013	0,012	0,011	0,010	0,010	0,012	0,016	0,020	0,020	0,021
1575	0,016	0,013	0,012	0,011	0,011	0,010	0,011	0,011	0,015	0,019	0,019
1625	0,016	0,012	0,012	0,011	0,011	0,011	0,011	0,011	0,012	0,016	0,022
1675	0,016	0,013	0,012	0,011	0,012	0,011	0,011	0,011	0,011	0,013	0,017
1725	0,017	0,014	0,014	0,012	0,012	0,012	0,013	0,012	0,012	0,014	0,016
1775	0,021	0,017	0,017	0,016	0,016	0,016	0,017	0,014	0,015	0,017	0,017
1825	0,023	0,021	0,020	0,020	0,020	0,021	0,020	0,019	0,020	0,021	0,021
1875	0,018	0,017	0,016	0,016	0,016	0,017	0,016	0,020	0,020	0,019	0,020
1925	0,018	0,016	0,015	0,015	0,015	0,015	0,015	0,017	0,017	0,016	0,017
1975	0,018	0,015	0,014	0,014	0,014	0,014	0,014	0,014	0,014	0,014	0,014

Higher Frequencies HYD 10KTL-3PH											
P/Pn [%]	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	0,086	0,083	0,065	0,095	0,102	0,137	0,066	0,062	0,074	0,086	0,103
2,3	0,167	0,142	0,140	0,142	0,135	0,140	0,124	0,125	0,132	0,140	0,150
2,5	0,167	0,150	0,151	0,145	0,137	0,134	0,144	0,136	0,131	0,129	0,130
2,7	0,130	0,117	0,145	0,092	0,111	0,091	0,137	0,110	0,109	0,104	0,107
2,9	0,121	0,115	0,121	0,100	0,113	0,099	0,150	0,123	0,128	0,116	0,129
3,1	0,109	0,111	0,120	0,111	0,119	0,116	0,136	0,148	0,147	0,144	0,149
3,3	0,128	0,129	0,134	0,136	0,141	0,144	0,148	0,170	0,184	0,186	0,194
3,5	0,095	0,098	0,102	0,106	0,110	0,113	0,116	0,126	0,137	0,148	0,159
3,7	0,081	0,085	0,091	0,093	0,096	0,098	0,100	0,105	0,110	0,113	0,116
3,9	0,053	0,056	0,059	0,060	0,062	0,064	0,065	0,067	0,071	0,072	0,072
4,1	0,042	0,044	0,046	0,048	0,049	0,050	0,051	0,053	0,054	0,056	0,056
4,3	0,036	0,038	0,039	0,040	0,041	0,041	0,043	0,044	0,045	0,046	0,047
4,5	0,032	0,033	0,034	0,034	0,035	0,036	0,037	0,037	0,038	0,039	0,040
4,7	0,057	0,059	0,060	0,061	0,061	0,061	0,062	0,063	0,063	0,063	0,064
4,9	0,026	0,026	0,027	0,027	0,028	0,029	0,029	0,030	0,030	0,031	0,031
5,1	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029	0,029
5,3	0,022	0,022	0,023	0,023	0,023	0,024	0,024	0,025	0,025	0,026	0,026
5,5	0,021	0,021	0,021	0,021	0,022	0,022	0,023	0,023	0,023	0,024	0,024
5,7	0,021	0,021	0,021	0,021	0,022	0,022	0,023	0,023	0,023	0,024	0,024
5,9	0,018	0,019	0,019	0,019	0,019	0,020	0,020	0,020	0,021	0,021	0,021
6,1	0,024	0,024	0,024	0,024	0,025	0,025	0,025	0,025	0,026	0,026	0,026
6,3	0,017	0,017	0,017	0,017	0,018	0,018	0,019	0,019	0,019	0,019	0,019
6,5	0,017	0,017	0,017	0,017	0,017	0,017	0,018	0,018	0,018	0,019	0,019
6,7	0,016	0,016	0,016	0,017	0,017	0,017	0,018	0,018	0,018	0,018	0,018
6,9	0,016	0,016	0,016	0,016	0,016	0,017	0,017	0,017	0,017	0,018	0,018
7,1	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,028	0,029	0,029
7,3	0,016	0,016	0,016	0,016	0,016	0,016	0,016	0,017	0,017	0,017	0,017
7,5	0,015	0,015	0,015	0,015	0,016	0,016	0,016	0,016	0,016	0,017	0,017
7,7	0,015	0,014	0,014	0,015	0,015	0,015	0,015	0,016	0,016	0,016	0,016
7,9	0,015	0,015	0,015	0,015	0,015	0,015	0,016	0,016	0,016	0,016	0,016
8,1	0,015	0,015	0,015	0,015	0,015	0,015	0,016	0,016	0,016	0,016	0,017
8,3	0,022	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,022	0,021	0,021
8,5	0,019	0,020	0,020	0,021	0,021	0,021	0,021	0,021	0,022	0,022	0,022
8,7	0,014	0,014	0,014	0,014	0,014	0,015	0,015	0,015	0,016	0,016	0,015
8,9	0,014	0,014	0,014	0,014	0,015	0,015	0,015	0,015	0,016	0,016	0,015

Harmonic HYD 15KTL-3PH											
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	5,51	10,40	20,35	30,41	40,42	50,37	60,41	70,30	80,27	90,21	100,10
2	0,263	0,261	0,236	0,243	0,261	0,265	0,270	0,282	0,293	0,310	0,318
3	0,198	0,197	0,195	0,195	0,209	0,208	0,211	0,215	0,215	0,217	0,221
4	0,169	0,184	0,169	0,166	0,173	0,168	0,169	0,170	0,170	0,174	0,173
5	0,493	0,545	0,691	0,668	0,671	0,671	0,671	0,688	0,686	0,704	0,721
6	0,169	0,147	0,141	0,140	0,140	0,143	0,141	0,144	0,145	0,144	0,146
7	0,499	0,313	0,462	0,468	0,462	0,446	0,443	0,415	0,403	0,388	0,375
8	0,125	0,075	0,079	0,077	0,081	0,084	0,083	0,083	0,085	0,085	0,087
9	0,079	0,033	0,027	0,027	0,029	0,030	0,031	0,039	0,035	0,034	0,033
10	0,115	0,051	0,054	0,049	0,050	0,047	0,052	0,048	0,049	0,047	0,049
11	0,265	0,283	0,305	0,330	0,269	0,224	0,202	0,166	0,133	0,119	0,097
12	0,108	0,072	0,023	0,027	0,031	0,036	0,034	0,040	0,039	0,038	0,036
13	0,087	0,394	0,169	0,261	0,245	0,227	0,223	0,196	0,182	0,157	0,158
14	0,117	0,065	0,017	0,014	0,016	0,021	0,024	0,029	0,030	0,029	0,027
15	0,123	0,043	0,030	0,032	0,030	0,029	0,024	0,030	0,027	0,031	0,030
16	0,119	0,081	0,015	0,013	0,017	0,014	0,015	0,019	0,018	0,015	0,015
17	0,250	0,389	0,156	0,199	0,137	0,171	0,162	0,134	0,111	0,098	0,090
18	0,092	0,070	0,019	0,022	0,018	0,020	0,023	0,027	0,026	0,023	0,020
19	0,231	0,331	0,102	0,164	0,095	0,135	0,122	0,087	0,066	0,056	0,049
20	0,055	0,058	0,015	0,016	0,013	0,018	0,018	0,023	0,023	0,021	0,020
21	0,064	0,044	0,024	0,029	0,029	0,028	0,023	0,026	0,023	0,023	0,022
22	0,060	0,056	0,016	0,017	0,011	0,011	0,013	0,017	0,017	0,016	0,015
23	0,153	0,201	0,091	0,150	0,035	0,105	0,084	0,059	0,046	0,050	0,077
24	0,055	0,039	0,017	0,021	0,009	0,016	0,018	0,021	0,021	0,019	0,017
25	0,091	0,153	0,101	0,110	0,041	0,142	0,149	0,128	0,118	0,105	0,094
26	0,046	0,034	0,013	0,015	0,010	0,014	0,015	0,020	0,020	0,018	0,017
27	0,037	0,035	0,022	0,022	0,026	0,031	0,029	0,034	0,027	0,024	0,023
28	0,019	0,016	0,012	0,014	0,009	0,012	0,012	0,015	0,014	0,014	0,013
29	0,061	0,118	0,156	0,084	0,086	0,149	0,149	0,138	0,120	0,111	0,113
30	0,029	0,030	0,011	0,012	0,010	0,015	0,016	0,021	0,021	0,018	0,015
31	0,039	0,124	0,158	0,067	0,179	0,214	0,146	0,057	0,045	0,079	0,096
32	0,036	0,022	0,012	0,009	0,011	0,017	0,014	0,018	0,020	0,019	0,016
33	0,053	0,037	0,017	0,099	0,086	0,065	0,042	0,041	0,046	0,046	0,041
34	0,034	0,011	0,013	0,010	0,009	0,011	0,012	0,015	0,019	0,020	0,018
35	0,101	0,131	0,154	0,112	0,197	0,212	0,160	0,085	0,048	0,080	0,109
36	0,015	0,013	0,012	0,008	0,012	0,015	0,012	0,016	0,020	0,020	0,021
37	0,127	0,116	0,133	0,053	0,100	0,082	0,045	0,042	0,097	0,192	0,332
38	0,018	0,017	0,012	0,008	0,011	0,011	0,010	0,015	0,017	0,017	0,019
39	0,018	0,025	0,024	0,018	0,020	0,024	0,026	0,030	0,028	0,045	0,061
40	0,023	0,025	0,013	0,010	0,008	0,009	0,009	0,011	0,010	0,014	0,018

Interharmonics HYD 15KTL-3PH											
P/Pn [%]	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	0,118	0,135	0,080	0,082	0,109	0,084	0,082	0,081	0,084	0,082	0,074
125	0,067	0,083	0,060	0,062	0,080	0,066	0,062	0,063	0,062	0,062	0,057
175	0,044	0,058	0,041	0,043	0,053	0,049	0,049	0,051	0,051	0,052	0,050
225	0,074	0,065	0,030	0,031	0,036	0,034	0,034	0,036	0,037	0,040	0,039
275	0,054	0,045	0,026	0,026	0,029	0,026	0,026	0,027	0,028	0,031	0,031
325	0,048	0,043	0,022	0,021	0,024	0,022	0,021	0,023	0,023	0,024	0,025
375	0,040	0,036	0,019	0,018	0,020	0,018	0,017	0,018	0,019	0,020	0,020
425	0,032	0,025	0,016	0,015	0,017	0,015	0,015	0,016	0,016	0,017	0,018
475	0,027	0,023	0,014	0,012	0,014	0,013	0,013	0,013	0,014	0,015	0,015
525	0,029	0,030	0,013	0,012	0,013	0,012	0,012	0,013	0,013	0,014	0,014
575	0,030	0,030	0,012	0,011	0,012	0,011	0,011	0,012	0,012	0,012	0,013
625	0,027	0,029	0,012	0,010	0,011	0,010	0,010	0,011	0,011	0,011	0,012
675	0,028	0,029	0,011	0,011	0,011	0,009	0,009	0,010	0,010	0,011	0,011
725	0,022	0,019	0,009	0,010	0,010	0,009	0,009	0,009	0,009	0,010	0,010
775	0,020	0,016	0,010	0,009	0,010	0,008	0,008	0,009	0,009	0,009	0,009
825	0,021	0,024	0,010	0,008	0,009	0,008	0,008	0,009	0,009	0,009	0,009
875	0,021	0,022	0,009	0,008	0,009	0,008	0,009	0,008	0,008	0,009	0,009
925	0,019	0,023	0,010	0,009	0,010	0,010	0,009	0,009	0,009	0,010	0,010
975	0,018	0,020	0,008	0,007	0,008	0,007	0,007	0,008	0,008	0,008	0,008
1025	0,016	0,016	0,009	0,009	0,009	0,009	0,008	0,009	0,009	0,009	0,009
1075	0,014	0,015	0,007	0,007	0,008	0,007	0,007	0,008	0,007	0,008	0,008
1125	0,015	0,015	0,008	0,007	0,007	0,007	0,007	0,008	0,007	0,008	0,008
1175	0,015	0,016	0,008	0,007	0,008	0,007	0,007	0,008	0,008	0,008	0,008
1225	0,013	0,014	0,008	0,007	0,008	0,007	0,007	0,008	0,008	0,008	0,008
1275	0,014	0,014	0,008	0,007	0,008	0,007	0,007	0,008	0,008	0,008	0,008
1325	0,014	0,012	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,010	0,010
1375	0,012	0,009	0,007	0,007	0,007	0,007	0,007	0,008	0,008	0,008	0,008
1425	0,014	0,012	0,009	0,009	0,010	0,010	0,010	0,010	0,010	0,010	0,010
1475	0,012	0,010	0,008	0,007	0,008	0,008	0,008	0,008	0,008	0,008	0,008
1525	0,012	0,009	0,008	0,008	0,008	0,008	0,008	0,008	0,009	0,009	0,009
1575	0,012	0,010	0,008	0,008	0,008	0,009	0,009	0,009	0,009	0,009	0,009
1625	0,012	0,011	0,010	0,008	0,008	0,009	0,010	0,012	0,011	0,012	0,011
1675	0,011	0,009	0,008	0,008	0,009	0,008	0,008	0,009	0,010	0,010	0,010
1725	0,011	0,008	0,008	0,008	0,008	0,009	0,008	0,009	0,010	0,011	0,011
1775	0,011	0,009	0,008	0,008	0,008	0,008	0,009	0,009	0,010	0,010	0,011
1825	0,012	0,009	0,008	0,008	0,008	0,008	0,009	0,010	0,010	0,010	0,012
1875	0,011	0,010	0,008	0,008	0,008	0,008	0,008	0,009	0,010	0,010	0,011
1925	0,012	0,010	0,009	0,009	0,009	0,009	0,009	0,009	0,010	0,011	0,011
1975	0,011	0,010	0,009	0,009	0,009	0,009	0,009	0,009	0,009	0,010	0,012

Higher Frequencies HYD 15KTL-3PH											
P/Pn [%]	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	0,069	0,111	0,129	0,053	0,124	0,095	0,077	0,088	0,133	0,221	0,376
2,3	0,105	0,103	0,110	0,087	0,117	0,098	0,089	0,090	0,103	0,108	0,118
2,5	0,108	0,106	0,119	0,086	0,124	0,110	0,099	0,086	0,081	0,089	0,086
2,7	0,075	0,089	0,143	0,065	0,121	0,107	0,083	0,064	0,073	0,086	0,102
2,9	0,075	0,077	0,089	0,068	0,068	0,090	0,080	0,072	0,080	0,086	0,092
3,1	0,076	0,079	0,081	0,071	0,073	0,106	0,097	0,088	0,086	0,094	0,105
3,3	0,077	0,082	0,082	0,083	0,085	0,112	0,107	0,106	0,108	0,118	0,128
3,5	0,063	0,068	0,072	0,074	0,075	0,085	0,093	0,103	0,111	0,116	0,124
3,7	0,055	0,061	0,065	0,064	0,066	0,071	0,073	0,077	0,079	0,080	0,082
3,9	0,036	0,039	0,043	0,042	0,043	0,045	0,047	0,047	0,047	0,048	0,049
4,1	0,029	0,030	0,032	0,033	0,034	0,035	0,036	0,037	0,038	0,038	0,038
4,3	0,025	0,026	0,027	0,028	0,029	0,029	0,030	0,031	0,031	0,031	0,032
4,5	0,021	0,022	0,023	0,024	0,025	0,025	0,026	0,026	0,026	0,026	0,026
4,7	0,038	0,039	0,040	0,041	0,041	0,041	0,042	0,042	0,042	0,042	0,042
4,9	0,017	0,018	0,018	0,019	0,020	0,020	0,020	0,021	0,021	0,021	0,022
5,1	0,016	0,017	0,017	0,017	0,018	0,019	0,019	0,019	0,020	0,020	0,020
5,3	0,015	0,015	0,015	0,016	0,016	0,017	0,017	0,017	0,017	0,018	0,018
5,5	0,014	0,014	0,014	0,015	0,015	0,015	0,016	0,016	0,016	0,016	0,017
5,7	0,014	0,014	0,014	0,015	0,015	0,015	0,016	0,016	0,016	0,016	0,017
5,9	0,012	0,012	0,013	0,013	0,013	0,014	0,014	0,014	0,014	0,014	0,015
6,1	0,016	0,016	0,016	0,016	0,017	0,017	0,017	0,017	0,017	0,018	0,018
6,3	0,011	0,011	0,012	0,012	0,012	0,012	0,013	0,013	0,013	0,013	0,014
6,5	0,011	0,011	0,011	0,011	0,012	0,012	0,012	0,012	0,012	0,013	0,013
6,7	0,011	0,011	0,011	0,011	0,012	0,012	0,012	0,012	0,012	0,012	0,013
6,9	0,011	0,010	0,011	0,011	0,011	0,011	0,012	0,012	0,012	0,012	0,012
7,1	0,018	0,018	0,018	0,018	0,019	0,019	0,019	0,019	0,019	0,019	0,019
7,3	0,010	0,010	0,010	0,011	0,011	0,011	0,011	0,011	0,011	0,011	0,012
7,5	0,010	0,010	0,010	0,011	0,011	0,011	0,011	0,011	0,011	0,011	0,011
7,7	0,009	0,009	0,010	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,011
7,9	0,009	0,009	0,010	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,011
8,1	0,010	0,010	0,010	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,011
8,3	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,014	0,014	0,014	0,014
8,5	0,012	0,013	0,013	0,013	0,013	0,013	0,013	0,014	0,014	0,014	0,014
8,7	0,009	0,009	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,011	0,010
8,9	0,008	0,009	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,011	0,011

Harmonic HYD 20KTL-3PH											
P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	5,447	10,35	20,31	30,46	40,27	50,25	60,21	70,31	80,18	90,10	100,53
2	0,198	0,178	0,162	0,158	0,163	0,154	0,155	0,155	0,159	0,171	0,310
3	0,191	0,156	0,150	0,158	0,164	0,166	0,168	0,171	0,178	0,189	0,334
4	0,121	0,129	0,129	0,132	0,225	0,134	0,132	0,131	0,129	0,122	0,258
5	0,248	0,469	0,512	0,506	0,505	0,505	0,505	0,516	0,538	0,557	0,714
6	0,138	0,102	0,101	0,100	0,101	0,104	0,105	0,106	0,106	0,113	0,239
7	0,267	0,271	0,368	0,353	0,332	0,314	0,296	0,282	0,264	0,249	0,334
8	0,098	0,062	0,063	0,059	0,063	0,062	0,063	0,064	0,068	0,079	0,152
9	0,024	0,024	0,025	0,026	0,027	0,033	0,036	0,035	0,041	0,057	0,074
10	0,109	0,041	0,037	0,032	0,034	0,031	0,031	0,031	0,026	0,020	0,080
11	0,294	0,266	0,254	0,199	0,162	0,119	0,083	0,065	0,066	0,077	0,105
12	0,078	0,033	0,013	0,015	0,016	0,017	0,019	0,020	0,024	0,034	0,082
13	0,222	0,259	0,188	0,180	0,167	0,149	0,124	0,105	0,105	0,116	0,232
14	0,065	0,020	0,016	0,012	0,014	0,012	0,011	0,012	0,013	0,019	0,027
15	0,069	0,026	0,023	0,024	0,020	0,021	0,023	0,025	0,025	0,022	0,096
16	0,102	0,024	0,012	0,009	0,011	0,008	0,009	0,008	0,009	0,012	0,018
17	0,060	0,283	0,147	0,098	0,130	0,108	0,084	0,070	0,073	0,088	0,204
18	0,088	0,026	0,009	0,008	0,007	0,008	0,009	0,009	0,012	0,015	0,019
19	0,059	0,227	0,129	0,068	0,099	0,072	0,050	0,044	0,054	0,072	0,061
20	0,069	0,021	0,009	0,009	0,009	0,007	0,008	0,007	0,008	0,010	0,017
21	0,061	0,025	0,022	0,022	0,019	0,020	0,019	0,019	0,020	0,020	0,077
22	0,081	0,018	0,008	0,007	0,008	0,006	0,006	0,006	0,007	0,009	0,011
23	0,061	0,112	0,137	0,024	0,078	0,048	0,035	0,047	0,077	0,092	0,068
24	0,060	0,017	0,008	0,006	0,005	0,006	0,007	0,007	0,008	0,009	0,016
25	0,064	0,067	0,121	0,030	0,114	0,102	0,088	0,075	0,076	0,087	0,339
26	0,038	0,017	0,011	0,007	0,007	0,005	0,006	0,006	0,006	0,006	0,011
27	0,038	0,017	0,016	0,019	0,022	0,025	0,022	0,019	0,018	0,016	0,213
28	0,036	0,015	0,009	0,006	0,007	0,006	0,006	0,006	0,006	0,007	0,021
29	0,039	0,013	0,105	0,066	0,116	0,108	0,090	0,083	0,092	0,097	0,418
30	0,019	0,014	0,009	0,007	0,006	0,006	0,007	0,006	0,007	0,007	0,025
31	0,046	0,043	0,065	0,136	0,148	0,070	0,036	0,066	0,084	0,100	0,387
32	0,017	0,016	0,010	0,006	0,009	0,008	0,009	0,007	0,007	0,007	0,032
33	0,033	0,073	0,061	0,065	0,042	0,030	0,035	0,034	0,030	0,027	0,215
34	0,014	0,011	0,009	0,007	0,008	0,008	0,010	0,009	0,009	0,008	0,024
35	0,096	0,060	0,075	0,149	0,149	0,085	0,038	0,069	0,099	0,111	0,253
36	0,009	0,010	0,006	0,005	0,008	0,009	0,009	0,011	0,012	0,011	0,014
37	0,095	0,032	0,043	0,076	0,053	0,024	0,073	0,177	0,305	0,265	0,021
38	0,011	0,013	0,007	0,005	0,005	0,006	0,009	0,009	0,010	0,011	0,014
39	0,018	0,012	0,014	0,016	0,018	0,020	0,021	0,038	0,047	0,043	0,056
40	0,020	0,012	0,008	0,006	0,006	0,006	0,007	0,011	0,014	0,015	0,011

Interharmonics HYD 20KTL-3PH											
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	0,090	0,102	0,065	0,067	0,067	0,067	0,066	0,065	0,066	0,068	0,110
125	0,054	0,071	0,052	0,055	0,057	0,053	0,053	0,052	0,053	0,054	0,099
175	0,042	0,040	0,033	0,036	0,048	0,037	0,039	0,039	0,042	0,044	0,085
225	0,054	0,036	0,023	0,025	0,044	0,027	0,028	0,029	0,031	0,033	0,060
275	0,041	0,031	0,020	0,020	0,022	0,020	0,022	0,023	0,024	0,026	0,045
325	0,036	0,028	0,016	0,015	0,016	0,016	0,017	0,018	0,019	0,021	0,038
375	0,033	0,025	0,013	0,013	0,013	0,013	0,014	0,015	0,016	0,017	0,026
425	0,021	0,016	0,011	0,011	0,012	0,011	0,012	0,012	0,013	0,015	0,022
475	0,019	0,015	0,010	0,009	0,010	0,009	0,010	0,011	0,012	0,013	0,019
525	0,027	0,021	0,009	0,009	0,009	0,009	0,009	0,010	0,011	0,012	0,017
575	0,028	0,019	0,009	0,009	0,008	0,008	0,009	0,009	0,010	0,010	0,020
625	0,021	0,020	0,008	0,008	0,008	0,008	0,008	0,008	0,009	0,010	0,036
675	0,023	0,016	0,008	0,008	0,008	0,007	0,008	0,008	0,008	0,009	0,014
725	0,015	0,011	0,007	0,007	0,007	0,007	0,007	0,007	0,008	0,008	0,013
775	0,013	0,011	0,006	0,006	0,007	0,006	0,007	0,007	0,007	0,008	0,012
825	0,016	0,016	0,007	0,006	0,006	0,006	0,006	0,007	0,007	0,008	0,012
875	0,016	0,014	0,006	0,006	0,006	0,006	0,006	0,006	0,007	0,007	0,012
925	0,014	0,015	0,007	0,007	0,007	0,007	0,007	0,007	0,007	0,008	0,015
975	0,014	0,012	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,007	0,011
1025	0,012	0,010	0,006	0,006	0,006	0,006	0,007	0,007	0,007	0,007	0,013
1075	0,010	0,008	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,006	0,011
1125	0,012	0,011	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,006	0,011
1175	0,012	0,010	0,006	0,005	0,005	0,005	0,006	0,006	0,006	0,006	0,011
1225	0,011	0,009	0,005	0,005	0,005	0,005	0,006	0,006	0,006	0,006	0,014
1275	0,011	0,009	0,006	0,005	0,005	0,006	0,006	0,006	0,006	0,006	0,012
1325	0,011	0,009	0,007	0,007	0,007	0,007	0,007	0,007	0,007	0,008	0,017
1375	0,009	0,007	0,005	0,005	0,006	0,006	0,006	0,006	0,006	0,006	0,015
1425	0,011	0,009	0,007	0,007	0,007	0,007	0,008	0,008	0,008	0,008	0,023
1475	0,008	0,008	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,007	0,018
1525	0,008	0,007	0,006	0,006	0,006	0,006	0,006	0,006	0,007	0,007	0,021
1575	0,008	0,008	0,006	0,006	0,007	0,007	0,007	0,007	0,007	0,007	0,019
1625	0,009	0,009	0,007	0,007	0,007	0,008	0,008	0,009	0,009	0,009	0,022
1675	0,007	0,007	0,006	0,006	0,006	0,006	0,007	0,008	0,007	0,008	0,017
1725	0,007	0,007	0,006	0,006	0,006	0,006	0,007	0,008	0,008	0,008	0,016
1775	0,007	0,007	0,006	0,006	0,006	0,007	0,007	0,008	0,009	0,008	0,017
1825	0,008	0,007	0,006	0,006	0,006	0,007	0,007	0,008	0,010	0,009	0,021
1875	0,008	0,007	0,006	0,006	0,006	0,006	0,007	0,008	0,009	0,010	0,020
1925	0,009	0,008	0,007	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,017
1975	0,008	0,007	0,007	0,007	0,007	0,007	0,007	0,008	0,009	0,010	0,014

Higher Frequencies HYD 20KTL-3PH											
P/Pn [%]	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	0,079	0,051	0,031	0,095	0,066	0,059	0,099	0,200	0,346	0,317	0,103
2,3	0,073	0,090	0,073	0,089	0,071	0,066	0,075	0,080	0,104	0,138	0,150
2,5	0,077	0,103	0,080	0,095	0,081	0,066	0,061	0,065	0,071	0,087	0,130
2,7	0,074	0,109	0,091	0,094	0,077	0,053	0,052	0,066	0,079	0,093	0,107
2,9	0,058	0,062	0,058	0,052	0,069	0,055	0,059	0,065	0,070	0,072	0,129
3,1	0,054	0,059	0,059	0,055	0,078	0,071	0,064	0,073	0,085	0,102	0,149
3,3	0,057	0,060	0,069	0,063	0,083	0,080	0,081	0,091	0,103	0,118	0,194
3,5	0,049	0,053	0,058	0,058	0,066	0,075	0,083	0,092	0,103	0,101	0,159
3,7	0,043	0,046	0,048	0,049	0,053	0,056	0,059	0,060	0,063	0,067	0,116
3,9	0,028	0,031	0,031	0,032	0,034	0,035	0,035	0,036	0,037	0,040	0,072
4,1	0,022	0,023	0,024	0,025	0,026	0,027	0,028	0,028	0,029	0,029	0,056
4,3	0,019	0,020	0,021	0,021	0,022	0,023	0,023	0,023	0,024	0,024	0,047
4,5	0,016	0,017	0,018	0,018	0,019	0,019	0,020	0,020	0,020	0,020	0,040
4,7	0,029	0,030	0,030	0,031	0,031	0,031	0,032	0,032	0,032	0,032	0,064
4,9	0,013	0,013	0,014	0,015	0,015	0,015	0,016	0,016	0,016	0,016	0,031
5,1	0,012	0,013	0,013	0,014	0,014	0,014	0,015	0,015	0,015	0,015	0,029
5,3	0,011	0,011	0,012	0,012	0,013	0,013	0,013	0,013	0,014	0,014	0,026
5,5	0,010	0,011	0,011	0,011	0,012	0,012	0,012	0,012	0,013	0,013	0,024
5,7	0,010	0,011	0,011	0,011	0,012	0,012	0,012	0,012	0,013	0,013	0,024
5,9	0,009	0,009	0,010	0,010	0,010	0,010	0,011	0,011	0,011	0,012	0,021
6,1	0,012	0,012	0,012	0,012	0,013	0,013	0,013	0,013	0,014	0,014	0,026
6,3	0,008	0,009	0,009	0,009	0,009	0,010	0,010	0,010	0,011	0,011	0,019
6,5	0,008	0,008	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,011	0,019
6,7	0,008	0,008	0,008	0,009	0,009	0,009	0,009	0,009	0,010	0,010	0,018
6,9	0,008	0,008	0,008	0,008	0,008	0,009	0,099	0,009	0,009	0,010	0,018
7,1	0,014	0,014	0,014	0,014	0,014	0,014	0,075	0,014	0,014	0,015	0,029
7,3	0,008	0,008	0,008	0,008	0,008	0,008	0,061	0,009	0,009	0,009	0,017
7,5	0,007	0,007	0,008	0,008	0,008	0,008	0,052	0,008	0,008	0,009	0,017
7,7	0,007	0,007	0,007	0,008	0,008	0,008	0,059	0,008	0,008	0,009	0,016
7,9	0,007	0,007	0,007	0,007	0,008	0,008	0,064	0,008	0,008	0,009	0,016
8,1	0,007	0,007	0,007	0,008	0,008	0,008	0,081	0,008	0,008	0,008	0,017
8,3	0,010	0,010	0,010	0,010	0,010	0,010	0,083	0,010	0,011	0,011	0,021
8,5	0,009	0,010	0,010	0,010	0,010	0,010	0,059	0,011	0,011	0,011	0,022
8,7	0,007	0,007	0,007	0,007	0,007	0,007	0,035	0,008	0,008	0,008	0,015
8,9	0,006	0,007	0,007	0,007	0,007	0,007	0,028	0,008	0,008	0,008	0,015

Note:
The normalization current is 7,25A for HYD 5KTL-3PH;
The normalization current is 8,69A for HYD 6KTL-3PH;
The normalization current is 11,59A for HYD 8KTL-3PH;
The normalization current is 14,49A for HYD 10KTL-3PH;
The normalization current is 21,74A for HYD 15KTL-3PH;
The normalization current is 28,99A for HYD 20KTL-3PH;
The stated harmonics are maximum values of all 3 phases ,

5.2.6 Feed in of DC current			P
Test result: HYD 20KTL-3PH			
Protection limit	**Tested at four power levels limit 0,5% of $I_{AC;nom}$ (145mA)**		
Output power	30% S_{Emax} to 40% S_{Emax}	60% S_{Emax} to 70% S_{Emax}	>95% S_{Emax}
L1 Max, test value [mA]	30,0	31,0	29,0
L1 Average, test value [mA]	17,3	17,3	17,2
L2 Max, test value [mA]	24,0	20,0	20,0
L2 Average, test value [mA]	13,9	11,8	10,4
L3 Max, test value [mA]	45,0	51,0	49,0
L3 Average, test value [mA]	38,1	37,9	37,3
Test result: HYD 5KTL-3PH			
Protection limit	**Tested at four power levels limit 0,5% of $I_{AC;nom}$ (40mA)**		
Output power	30% S_{Emax} to 40% S_{Emax}	60% S_{Emax} to 70% S_{Emax}	>95% S_{Emax}
L1 Max, test value [mA]	8,0	11,0	12,0
L1 Average, test value [mA]	3,6	3,4	3,2
L2 Max, test value [mA]	6,0	11,0	13,0
L2 Average, test value [mA]	0,6	0,7	0,7
L3 Max, test value [mA]	-10,0	-16,0	-17,0
L3 Average, test value [mA]	-5,8	-6,0	-6,0

Test:

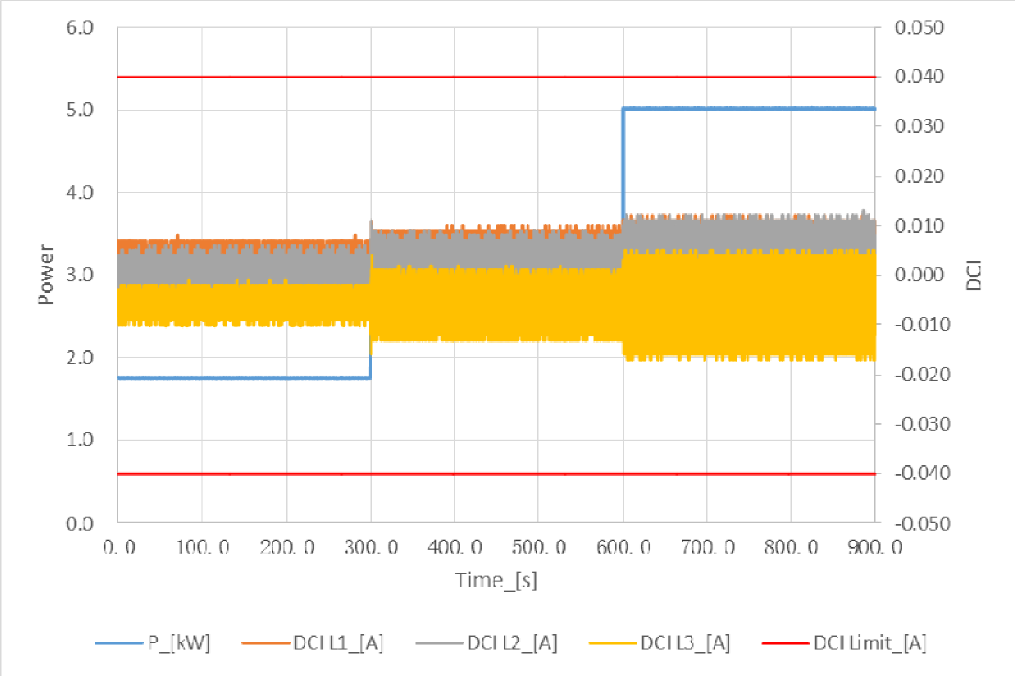
The inverter must be used in the adjustment range Test1, Test2 and Test 3 , Each test point shall be held for min 5 minutes and I_{grid}, U_{grid}, I_{dc} of each phase has to be recorded , Measurement of I_{dc} must be done according to VDE AR-N 4100:2019-04 based on DIN EN 61000-4-7 (VDE-0847-4-7) over 10 fundamental periods ,

Assessment criterion:

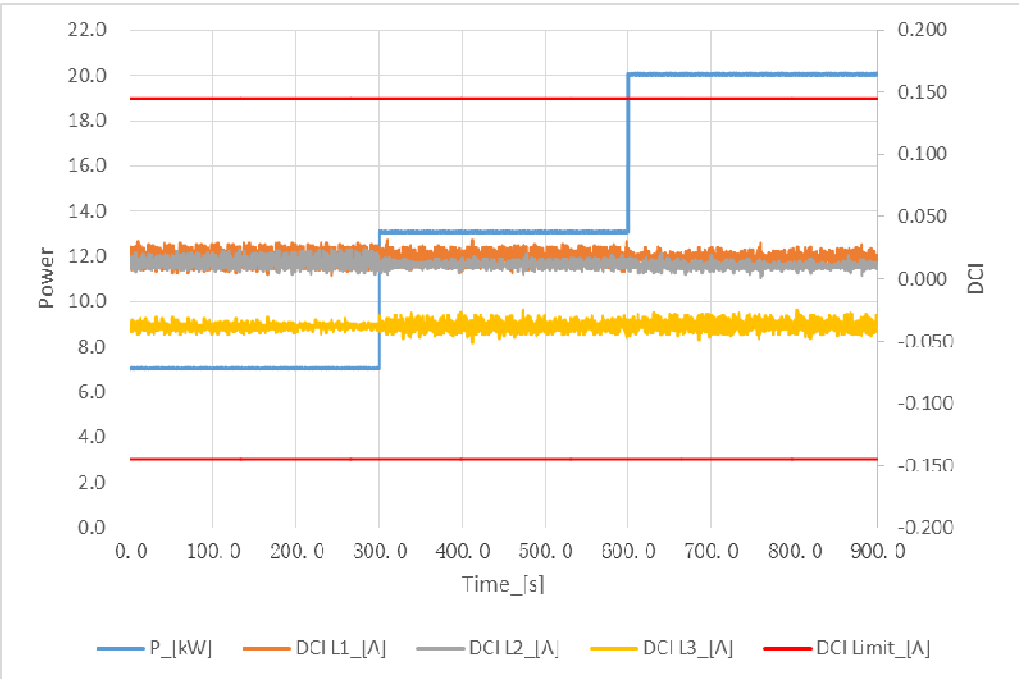
A inverter must not feed more than 0 ,5% of its rated current or a maximum of 20 mA (the higher value is to be selected) as direct current ,

The test had been performed on the model HYD 20KTL-3PH and HYD 5KTL-3PH the test results are valid for the HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

HYD 5KTL-3PH
Diagram of Feed in of DC current



HYD 20KTL-3PH
Diagram of Feed in of DC current



5 ,3 Evidence of symmetry behavior of inverters **DIN VDE V 0124-100:2020-06**		
Clause	**Test**	**Result**
5.3.1	General	**P**
5.3.2.1	Calculation of the asymmetry of three-phase inverters	**P**
5.3.2.2.1	Failure of single inverter modules	**N/A**
5.3.2.2.2	Power drop of single inverter modules	**N/A**
5.3.2.3.2	Symmetrical operation with a symmetry device	**N/A**

5.3.1 General These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5 ,5 are met ,	**P**
These tests serve to prove the requirements according to VDE-AR-N 4100: 2019-04, 5 ,5: These tests are not valid for direct connected rotating machines ,	
Note:	

5.3.2 Test in the test laboratory		**P**
Test Condition:	The measurements were performed in the testing laboratory , at the grid-simulator: U_N = between 86 % Un and 109% Un until the test Frequency: 50 Hz +/- 0,5%	
Note: If an examination is required for any other requirements, these apply to this test ,		

5.3.2.1 Calculation of asymmetry			P
Setting values	cos φ = 1:	1,0	
	cos φ over-excited:	0,9	
	cos φ under-excited:	0,9	

Test:HYD 20KTL-3PH						
1-min mean value	L1	L2	L3	L1 – L2	L2 – L3	L3 – L1
a) cos φ = 1 at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	6,686	6,701	6,697	0,015	0,004	0,011
	6,688	6,701	6,695	0,013	0,006	0,007
	6,689	6,702	6,699	0,013	0,003	0,010
	6,687	6,700	6,698	0,013	0,002	0,011
	6,688	6,700	6,697	0,012	0,003	0,009
cos $φ_{E60}$:	1,000					
max , asymmetry [kVA]:	0,015					
b) maximum under-excited (i) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	6,665	6,672	6,671	0,007	0,001	0,006
	6,664	6,673	6,672	0,009	0,001	0,008
	6,664	6,673	6,672	0,009	0,001	0,008
	6,658	6,665	6,666	0,007	0,001	0,008
	6,653	6,663	6,664	0,010	0,001	0,011
cos $φ_{E60}$:	0,897					
max , asymmetry [kVA]:	0,011					
c) maximum over-excited (c) at 100 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	6,665	6,674	6,671	0,009	0,003	0,006
	6,665	6,674	6,670	0,009	0,004	0,005
	6,665	6,674	6,671	0,009	0,003	0,006
	6,666	6,674	6,671	0,008	0,003	0,005
	6,666	6,674	6,671	0,008	0,003	0,005
cos $φ_{E60}$:	0,903					
max , asymmetry [kVA]:	0,009					
d) cos φ = 1 at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	3,351	3,361	3,358	0,010	0,003	0,007
	3,352	3,361	3,359	0,009	0,002	0,007
	3,352	3,361	3,359	0,009	0,002	0,007
	3,352	3,361	3,359	0,009	0,002	0,007
	3,352	3,361	3,359	0,009	0,002	0,007

cos φ_{E60}:	1,000					
max , asymmetry [kVA]:	0,010					
e) maximum under-excited (i) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	3,341	3,348	3,344	-0,007	0,004	0,003
	3,341	3,348	3,344	-0,007	0,004	0,003
	3,341	3,348	3,344	-0,007	0,004	0,003
	3,342	3,347	3,344	-0,005	0,003	0,002
	3,341	3,347	3,344	-0,006	0,003	0,003
cos φ_{E60}:	0,903					
max , asymmetry [kVA]:	0,007					
f) maximum over-excited (c) at 50 % P_n ± 5 % P_{Emax}						
S_{E60} [kVA]:	3,345	3,353	3,351	-0,008	0,002	0,006
	3,346	3,353	3,352	-0,007	0,001	0,006
	3,346	3,353	3,352	-0,007	0,001	0,006
	3,346	3,353	3,352	-0,007	0,001	0,006
	3,346	3,353	3,352	-0,007	0,001	0,006
cos φ_{E60}:	0,907					
max , asymmetry [kVA]:	0,008					
Limit [kVA]:	≤ 5 % S_{Emax} and 4,6 kVA					

Test:

The maximum absolute difference between the apparent powers of the three phases is determined for each of the five measurements (1-min means) in the respective operating point , The maximum of these five values is again determined ,

Example:

Messung Nr.	1	2	3	4	5
L1	8	7	9	10	9
L2	9	10	10	10	10
L3	10	10	11	8	8
Rechnung					
|L1 - L2|	1	3	1	0	1
|L2 - L3|	1	0	1	2	2
|L3 – L1|	2	3	2	2	1
Unsymmetrie	2	3	2	2	2
max. Unsymmetrie	3				

Assessment criterion:

The test is passed if the maximum value from the above measurements does not exceed 5 % S_{Emax} and 4,6 kVA ,

Note:

The maximum inductive and capacitive values are specified by the manufacturer ,

The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

5.4 Evidence of the characteristics of the power generation unit on the network DIN VDE V 0124-100:2020-06		
Clause	**Test**	**Result**
5.4.1	General	**P**
5.4.2	Measurement of the active power and reactive power range	**P**
5.4.3.2	Measurement of setting accuracy	**P**
5.4.3.3	Measurement of the power gradient	**P**
5.4.3.4	Measurement Priority Interfaces / Energy Management	**P**
5.4.4	Active power feed-in for PGUs at overfrequency	**P**
5.4.5	Active power feed-in of Storage systems for overfrequency	**N/A**
5.4.6	Active power feed-in for PGUs at Underfrequency	**P**
5.4.7	Active power feed-in for storage systems at Underfrequency	**N/A**
5.4.8.1	Tests of the Reactive power / cos φ setting accuracy	**P**
5.4.8.2	Test of the displacement factor/active power characteristic curve cos φ (P)	**P**
5.4.8.3.1	Test of the accuracy of the Q (U) regulation	**P**
5.4.8.3.2	Test of the dynamics of the Q (U) regulation	**P**

5.4.1 General (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11, 5.7.2.2 are met and to determine the values for SEmax and PEmax)		**P**
Test Condition:	The measurements were performed in the testing laboratory , at the grid-simulator: U_N = between 86 % Un and 109% Un until the test Frequency: 50 Hz +/- 0,5%	
Designation for under-excited and over-excited: - "(c)" stands for over-excited , - "(i)" stands for under-excited ,		
Note: If an examination is required for any other requirements, these apply to this test , The RoCoF requirements of the VDE-AR-N 4105:2018-11, 5 ,7 ,1 are not part of the Unit certification ,		

5.4.2 Measurement of the active power and reactive power range (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7.5 are met)		**P**
Setting values	cos φ = 1:	1,00
	cos φ max , over-excited:	0,90
	cos φ max , under-excited:	0,90

Test: HYD 5KTL-3PH

600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,3	218,8	230,3	241,7	250,9
P_{E30} [kW]:	5,045	5,014	5 ,063	5,031	5,068
Q_{E30} [kVar]:	0,100	0,154	0,026	0,142	0,115
S_{E30} [kVA] ,	5,048	5,017	5,068	5,033	5,074
cos $φ_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,6	218,7	230,2	241,7	250,8
P_{E30} [kW]:	4,975	5,036	5 ,049	5,006	5,054
Q_{E30} [kVar]:	-2,384	-2,392	-2,421	-2,360	-2,441
S_{E30} [kVA] ,	5,517	5,575	5,599	5,534	5,613
cos $φ_{E30\text{-over-excited}}$:	0,902	0,903	0,902	0,904	0,900
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,3	218,8	230,3	241,7	251,0
P_{E30} [kW]:	5 ,041	4,993	5,061	5,066	5,019
Q_{E30} [kVar]:	2,480	2,365	2,477	2,469	2,359
S_{E30} [kVA] ,	5,618	5,525	5,635	5,636	5,545
cos $φ_{E30\text{-over-excited}}$:	0,897	0,904	0,898	0,899	0,905

$S_{Emax600}$ and $P_{Emax\ 600}$	
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	5,636 kVA
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	5,068 kW

Test: HYD 6KTL-3PH					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,2	218,8	230,3	241,7	250,7
P_{E30} [kW]:	6,014	6,016	6,037	6,035	6,043
Q_{E30} [kVar]:	0,188	0,186	0,058	0,171	0,074
S_{E30} [kVA] ,	6,018	6,019	6,041	6,037	6,048
cos $φ_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,3	218,6	230,3	241,7	250,8
P_{E30} [kW]:	5,969	6,005	6,011	6,015	6,028
Q_{E30} [kVar]:	-2,846	-2,836	-2,851	-2,842	-2,887
S_{E30} [kVA] ,	6,612	6,641	6,653	6,653	6 ,684
cos $φ_{E30\text{-over-excited}}$:	0,903	0,904	0,904	0,904	0,902
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,2	218,8	230,3	241,6	250,9
P_{E30} [kW]:	6,009	5,990	6,024	6,040	6,024
Q_{E30} [kVar]:	2,970	2,837	2,965	2,963	2,832
S_{E30} [kVA] ,	6,703	6,628	6,714	6,727	6,656
cos $φ_{E30\text{-over-excited}}$:	0,896	0,904	0,897	0,898	0,905
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	6,727 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	6,043 kW				

Test: HYD 8KTL-3PH					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,3	218,8	230,4	241,7	258,9
P_{E30} [kW]:	8,011	8,023	8,042	8,050	8,053
Q_{E30} [kVar]:	0,224	0,250	0,171	0,228	0,216
S_{E30} [kVA] ,	8,014	8,027	8,045	8,053	8,057
cos $φ_{E30\text{-over-excited}}$:	0,999	0,999	0,999	0,999	0,999
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,3	218,6	230,4	241,7	250,8
P_{E30} [kW]:	7,961	7,996	8,006	8,017	8,031
Q_{E30} [kVar]:	-3,706	-3,968	-3,984	-3,788	-3,807
S_{E30} [kVA] ,	8,781	8,926	8,942	8,867	8,888
cos $φ_{E30\text{-over-excited}}$:	0,907	0,896	0,895	0,904	0,904
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,3	218,8	230,5	241,8	250,7
P_{E30} [kW]:	8,000	8,002	8,023	8,012	8,036
Q_{E30} [kVar]:	3,984	3,790	3 ,980	3,954	3,771
S_{E30} [kVA] ,	8,937	8,854	8 ,956	8,935	8,877
cos $φ_{E30\text{-over-excited}}$:	0,895	0,904	0,896	0,897	0,905
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	8,956 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	8,053 kW				

Test: HYD 10KTL-3PH					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,1	218,6	230,4	241,7	250,8
P_{E30} [kW]:	10,000	10,025	10,039	10,057	10,055
Q_{E30} [kVar]:	0,290	0,310	0,246	0,286	0,222
S_{E30} [kVA] ,	10,005	10,030	10,043	10,061	10,058
cos $\varphi_{E30\text{-over-excited}}$:	1,000	1,000	1,000	1,000	1,000
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,4	218,5	230,4	241.7	250,5
P_{E30} [kW]:	9,947	9,881	9,995	10.023	10,025
Q_{E30} [kVar]:	-4,748	-4,944	-4,959	-4.736	-4,999
S_{E30} [kVA] ,	11,022	11,139	11,157	11.085	11,203
cos $\varphi_{E30\text{-over-excited}}$:	0,902	0,896	0,896	0.904	0 ,895
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,1	218,5	230,5	241,5	250,7
P_{E30} [kW]:	9,985	9,983	10,028	10,039	10,046
Q_{E30} [kVar]:	4,708	4,728	4,710	4,704	4,714
S_{E30} [kVA] ,	11,040	11,046	11,079	11,087	11,097
cos $\varphi_{E30\text{-over-excited}}$:	0,904	0,904	0,905	0,906	0,905
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	11,203 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	10,055 kW				

Test: HYD 15KTL-3PH					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,4	218,6	230,8	241.7	250,9
P_{E30} [kW]:	14,982	15,038	15,049	15.089	15,075
Q_{E30} [kVar]:	0,535	0,446	0,378	0.431	0,370
S_{E30} [kVA] ,	14,992	15,045	15,054	15.095	15,080
cos $φ_{E30\text{-over-excited}}$:	0,999	1,000	1,000	1.000	1,000
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,4	218,7	230,68	241,7	250,9
P_{E30} [kW]:	14,923	14,972	14,996	15,040	15,028
Q_{E30} [kVar]:	-7,117	7,402	7,423	-7,105	7,450
S_{E30} [kVA] ,	16,533	16,702	16,733	16,634	16,773
cos $φ_{E30\text{-over-excited}}$:	0,903	0,896	0,896	0,904	0,896
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,3	218,8	230,7	241,8	250,7
P_{E30} [kW]:	14,949	14,993	15,022	15,043	15,075
Q_{E30} [kVar]:	7,093	7,124	7,111	7,104	7,075
S_{E30} [kVA] ,	16,547	16,599	16,620	16,636	16,653
cos $φ_{E30\text{-over-excited}}$:	0,903	0,903	0,904	0,904	0,905
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	16,773 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	15,089 kW				

Test: HYD 20KTL-3PH					
600 s mean value	0,90 ± 0,2 U_n	0,95 ± 0,2 U_n	1,0 ± 0,2 U_n	1,05 ± 0,2 U_n	1,09 ± 0,2 U_n
a) cos φ 1 at 100% P_{Emax}					
U [V]:	207,1	218,8	230,0	241,7	250,9
P_{E30} [kW]:	19,987	20,051	20,086	20,117	20,132
Q_{E30} [kVAr]:	0,565	0,576	0,443	0,573	0,433
S_{E30} [kVA] ,	19,995	20,060	20,091	20,125	20,137
cos $φ_{E30\text{-over-excited}}$:	1,000	1,000	1,000	1,000	1,000
b) maximum under-excited (i) at 100% P_{Emax}					
U [V]:	207,4	218,9	229,8	241,7	250,9
P_{E30} [kW]:	19,907	19,971	19,979	20,052	20,060
Q_{E30} [kVar]:	-9,256	9,853	9,831	-9,472	9,910
S_{E30} [kVA] ,	21,953	22,270	22,267	22,176	22,375
cos $φ_{E30\text{-over-excited}}$:	0,907	0,897	0,897	0,904	0,897
c) maximum over-excited (c) at 100% P_{Emax}					
U [V]:	207,1	218,8	230,1	241,8	250,7
P_{E30} [kW]:	19,928	19,969	20,008	20,075	20,099
Q_{E30} [kVar]:	9,482	9,460	9,504	9,521	9,433
S_{E30} [kVA] ,	22,069	22,096	22,150	22,218	22,203
cos $φ_{E30\text{-over-excited}}$:	0,903	0,904	0,903	0,904	0,905
$S_{Emax600}$ and $P_{Emax\ 600}$					
$S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$)	22,375 kVA				
$P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$)	20,132 kW				

Test:

The PGU is operated in all of the following, possible operating points , Every operating point must be retained for at least 600s after the transient effect has faded , During the measurements, there may be no power limitation by the primary energy source ,

a) For cos φ = 1, the maximum active power possible in this range is set ,

b) For maximum under-excited operation, the maximum active power possible in this operating point is set ,

c) For maximum over-excited operation, the maximum active power possible in this operating point is set ,

Assessment criterion:

$S_{Emax600}$ and $P_{Emax\ 600}$ are determined by the highest value measured ,

$S_{Emax600}$ = max($S_{Emax600a)}$, $S_{Emax600b)}$, $S_{Emax600c)}$)

$P_{Emax600}$ = max($P_{Emax600a)}$, $P_{Emax600b)}$, $P_{Emax600c)}$)

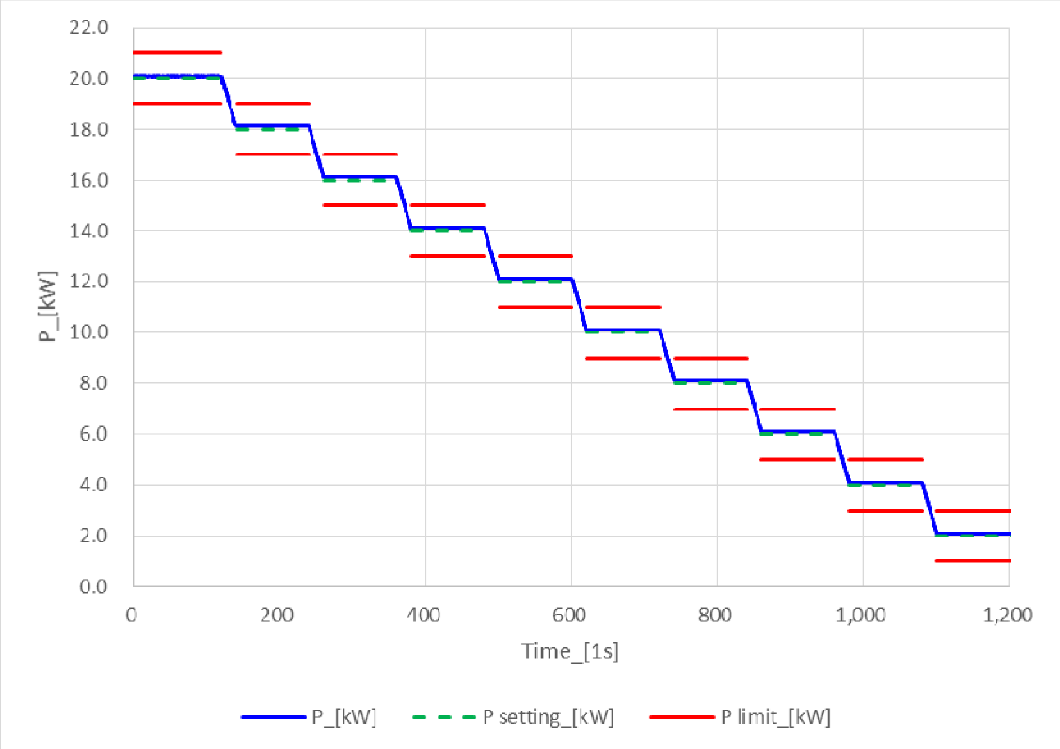
Note:

φ 0,95 (i) and (c): PGU ≤ 4,6 kVA

φ 0,90 (i) and (c): PGU > 4,6 kVA

5.4.3.2 Measurement of setting accuracy	P

Graph of the setting accuracy:



Test:

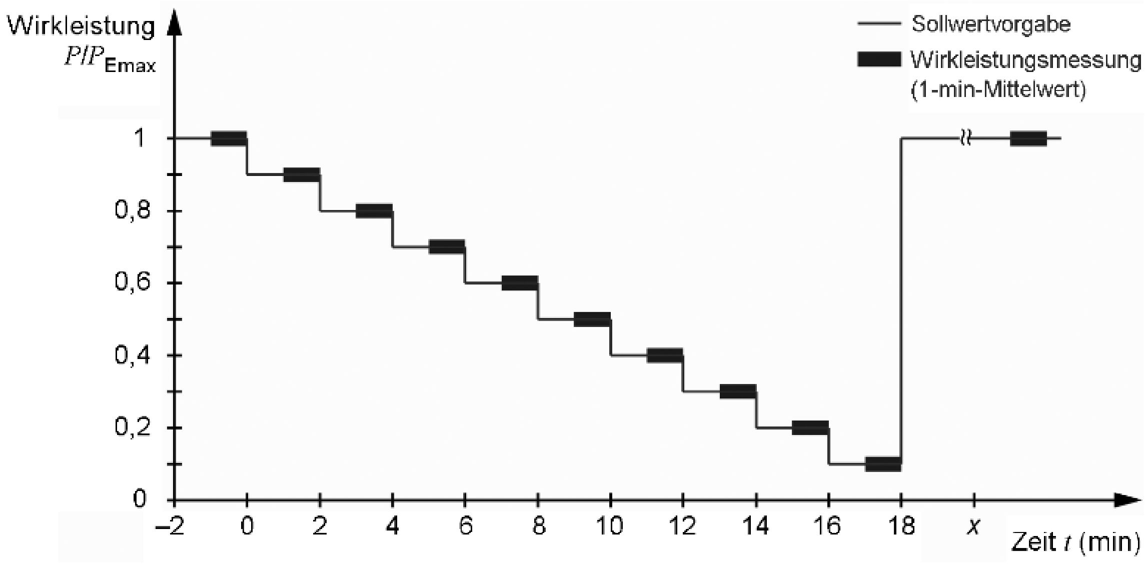
1-min mean value / P_n/P [%]	100	90	80	70	60	50	40	30	20	10
$P_{Setpoint}$[kW]:	20,0	18,0	16,0	14,0	12,0	10,0	8,0	6,0	4,0	2,0
P_{E60} [kW]:	20,084	18,136	16,116	14,110	12,111	10,113	8,107	6,099	4,087	2,075
$\Delta P_{E60}/P_{Setpoint}$ [%]:	0,420	0,680	0,580	0,550	0,555	0,565	0,535	0,495	0,435	0,375
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of P_{Emax}									

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 , 1 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% PEmax
- the power gradient determined according 5 ,4 ,3 ,3 not be less than 0 ,33% PrE/s and not more than 0 ,66% PrE/s ,

Note:

The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

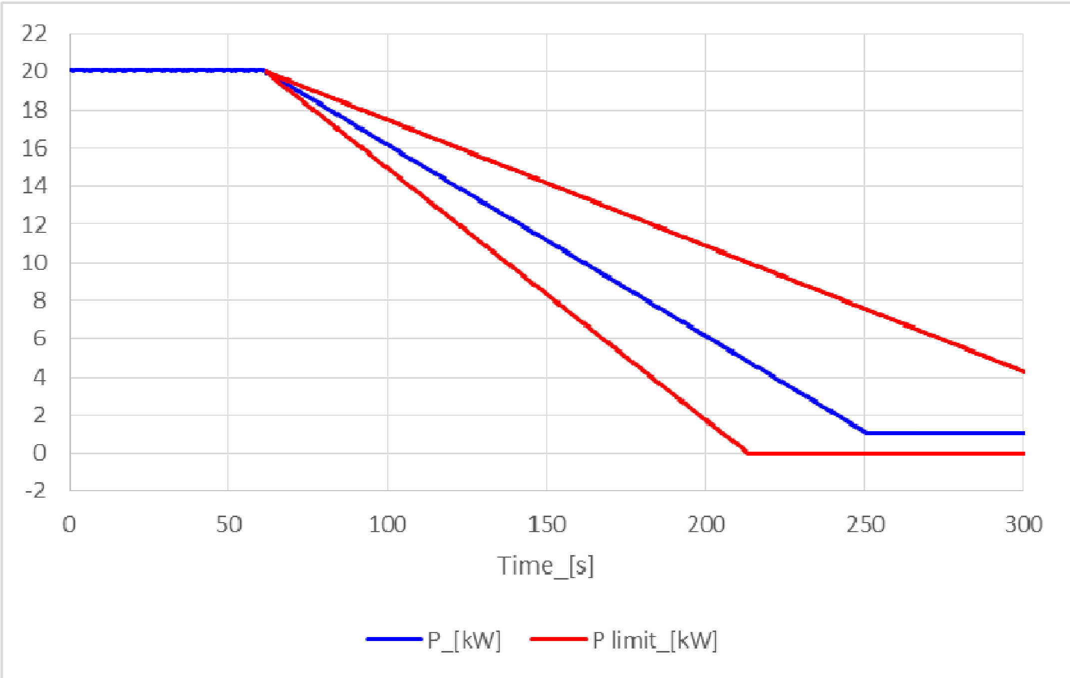
5.4.3.3 Measurement of the power gradient				P
Test:				
$P_{Setpoint}$	100% to 5% P_{Emax}		5% to 100% P_{Emax}	
$P_{Setpoint}$[kW]:	20,000	1,000	1,000	20,000
P_{E60} [kW]:	20,091	1,064	1,064	20,095
$\Delta P_{E60}/P_{Setpoint}$ [%]:	0,455	0,320	0,320	0,475
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of PEmax			
Gradient[P_{rE}/s ,]:	0,058		0,058	
Limit Gradient [P_{rE}/s ,]:	0,33 to 0,66			

Test:
The measurement of the power gradient takes place :
- Via a setpoint change from 100% to 5% of the rated effective power PrE at time t0 , If the technical performance is> 5%, this should be specified ,
- Via a setpoint change from 5% to 100% of the rated effective power PrE at time t0 , Is the technical Performance> 5%, this should be specified

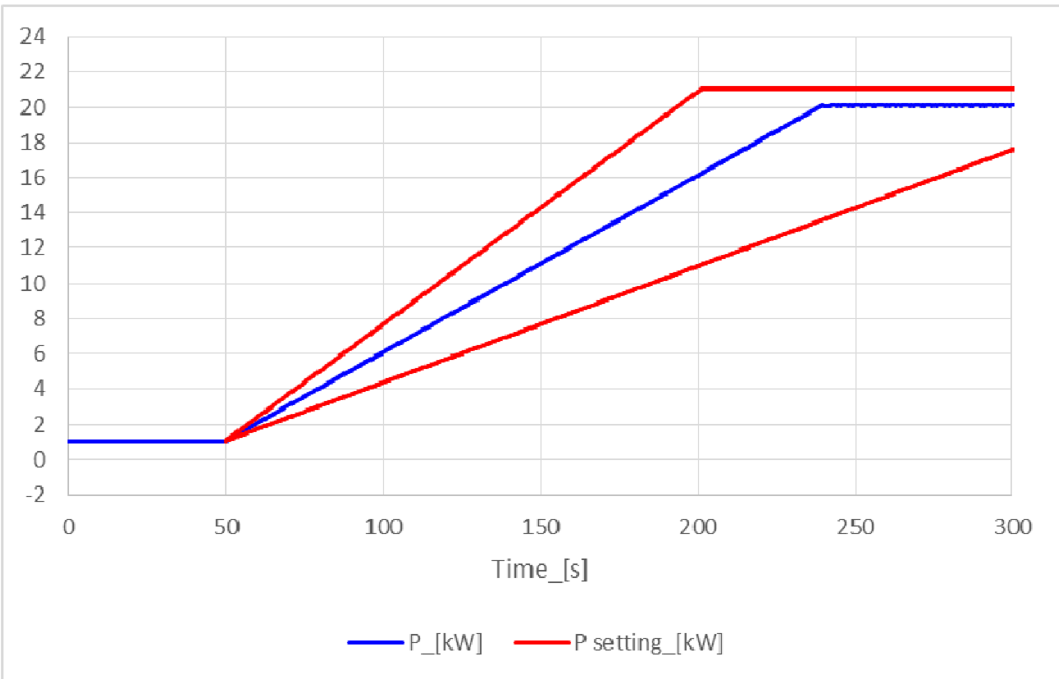
Assessment criterion:
a) for adjustable PGUs:
- no network disconnection
- the active power value does not exceed the setpoint by more than 5% PEmax
- the power gradient determined according 5 ,4 ,3 ,3 not be less than 0 ,33% PrE/s and not more than 0 ,66% PrE/s ,

Note:
The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

Graph of power gradient: 100% to 5% P_{Emax}



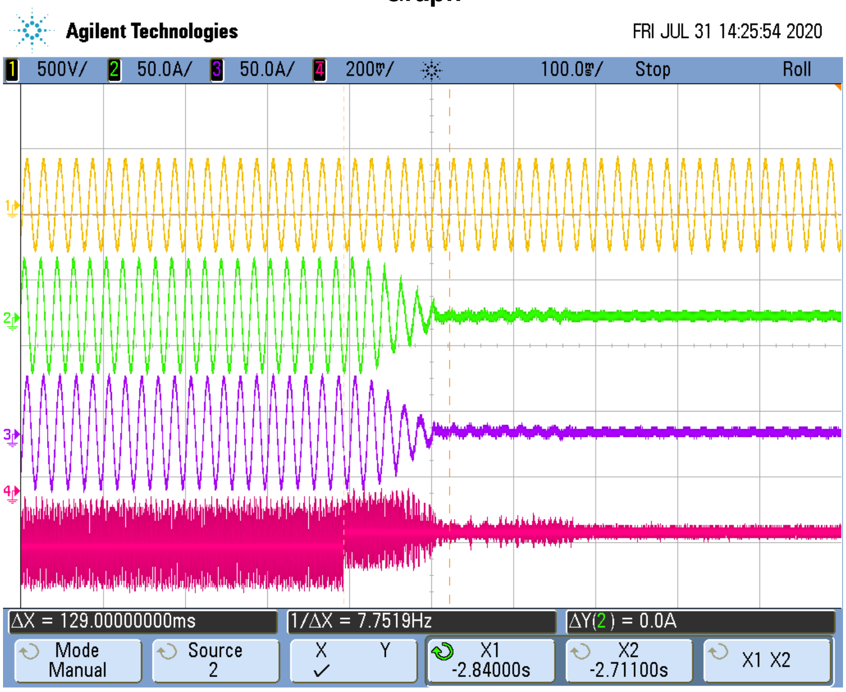
Graph of power gradient: 5% to 100% P_{Emax}



5.4.3.4 Measurement Priority Interfaces / Energy Management				P
Test: Priority of Interfaces				
Interface	1	2	3	4
Test 1: $P_{setting}$ in pu	0,3	0,9	0,6	0,1
Test 2: $P_{setting}$ in pu	0,6	1,0	0,1	0,3
Test 3: $P_{setting}$ in pu	1,0	0,1	0,3	0,6
Test 4: $P_{setting}$ in pu	0,1	0,3	0,6	0,9
Test	Test 1	Test 2	Test 3	Test 4
$P_{Setpoint}$[kW]:	2,000	6,000	12,000	20,000
P_{E60} [kW]:	2,075	6,030	12,017	20,048
$\Delta P_{E60}/P_{Setpoint}$ [%]:	0,375	0,150	0,085	0,240
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 5 % of P_{rE}			

Test: logical interface	
Test	logical interface terminate the active power
Limit [s]:	5
Reaction time of terminate the active power [s]:	0,129

Graph



Test:
test steps:
a) the PGU is operated with no less than 90% PrE;
b) the change of state of the logic signal according to (b) is set.

Assessment criterion:

The tests 5.4.3.2 to 5.4.3.5 are passed if,

- there is no mains disconnection and

- the active power value does not deviate from the target value by more than + 5% P_{rE} and

- the performance gradients determined according to 5.4.3.4 do not fall below 0.33% P_{rE}/s and do not exceed 0.66% P_{rE}/s. The first gradient is to be formed 30 s after the setpoint step has been set.

The formation of gradients is ended 30 s before the stationary end value is reached.

NOTE These times were determined by the maximum or minimum prescribed gradients and with a performance delta of ± 10% P_{rE} around the target value.

- for measurement 5.4.3.5 either

a) the lowest setpoint always has priority or

b) the setpoint at the interface programmed for the NSM is never exceeded.

- when testing the logical interface (input port), the active power feed-in of the PGU was completely terminated within a maximum of 5 s after the change of state of the logical signal.

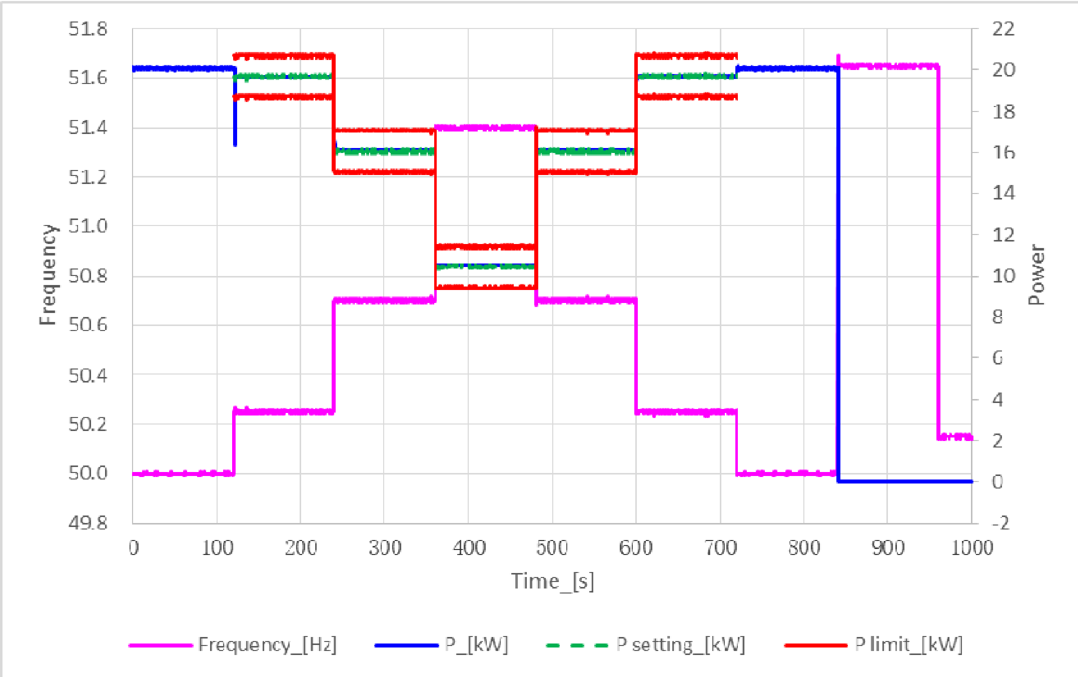
Note:
The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

5.4.4 Active power feed-in for overfrequency (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5 ,7 ,3 ,3 are met)	
5.4.4.1.1 Test cycle for adjustable/conditionally adjustable PGUs	**P**

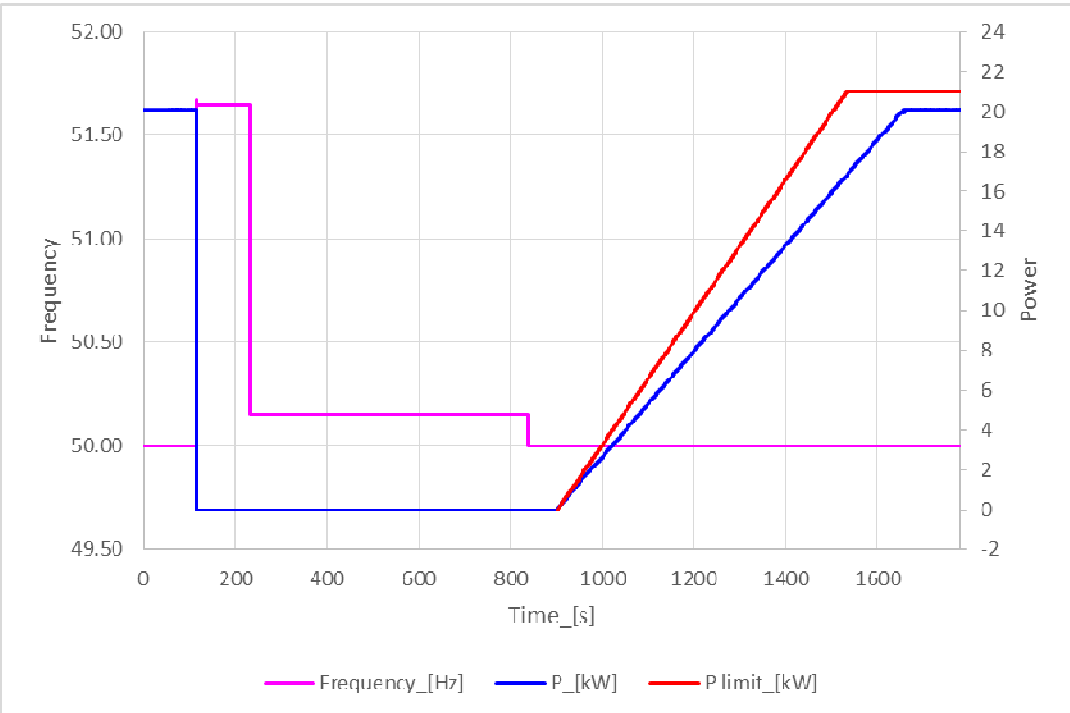
Test 1:										
f [Hz]	a) 50,00	b) 50,25	c) 50,70	d) 51,40	e) 50,70	f) 50,25	g) 50,00	h) 51,65	i) 50,15	j) 50,00
Test 1:										
Frequency [Hz]:	50,00	50,25	50,70	51,40	50,70	50,25	50,00	51,65	50,15	50,00
$P_{setpoint}$ [% P_{Emax}]:	100,00	98,00	80,00	52,00	80,00	98,00	100,00	-0,00	-0,00	100,00
P_{E60} [% P_{Emax}]:	100,45	98,47	80,46	52,50	80,46	98,54	100,43	-0,01	-0,01	100,44
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	0,45	0,47	0,46	0,50	0,46	0,54	0,43	0,01	0,01	0,44

Test 2:							
f [Hz]	a) 50,00	b) 50,40	c) 50,70	d) 51,40	e) 50,70	f) 50,40	g) 50,00
Frequency [Hz]:	50,00	50,40	50,70	51,40	50,70	50,40	50,00
$P_{setpoint}$ [% P_{Emax}]:	60,00	60,00	58,00	51,00	58,00	60,00	100,00
P_{E60} [% P_{Emax}]:	60,50	60,50	57,00	45,50	57,00	60,50	100,50
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	0,50	0,50	-1,00	-5,50	-1,00	0,50	0,50
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 10 % of P_{Emax}						

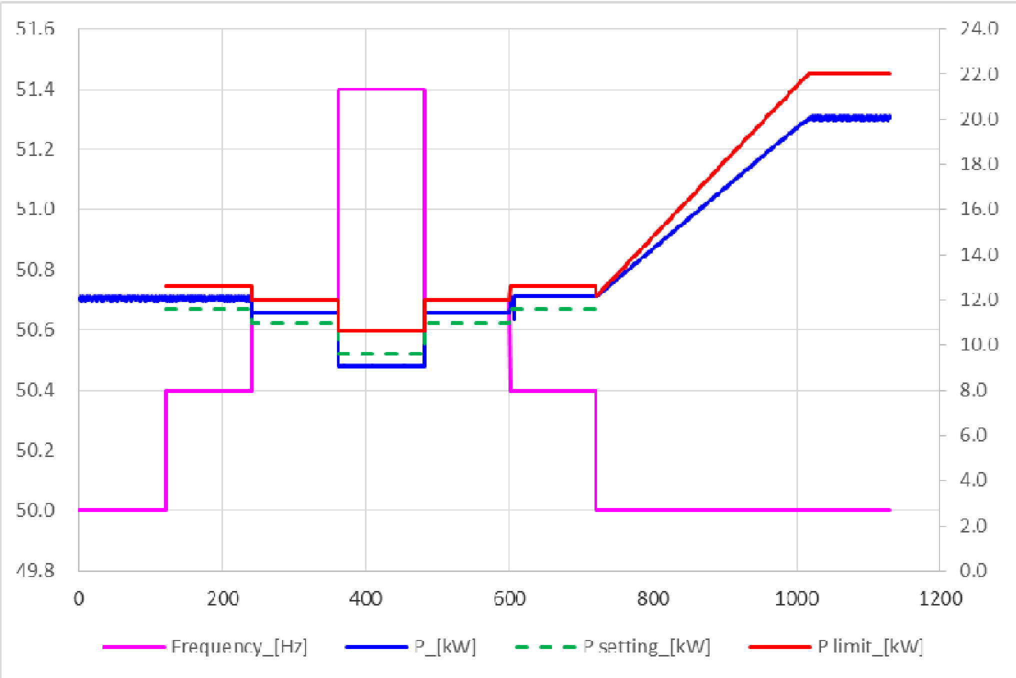
Graph of Test 1:



Graph of Test 1:



Graph of Test 2:



Tests: The test is conducted for two powers.
Test1:
First, the test must start at a power > 100% PEmax ("Measurement 1") Start of the Power reduction at 50,20Hz s =5% (40% Pref/Hz), the rise of the active power gradient must be recorded ,
Test2:
In a second test, for a power 60% PEmax ("Measurement 2") , Start of the Power reduction at 50,50Hz s =12% (16,67% Pref/Hz) , After freezing of the PM, the available active power output must be increased to a value 100% PEmax, and after the network frequency of 50,2 Hz is raised above, the rise of the active power gradient must be recorded ,

Assessment criterion:
The test is regarded as passed:
a) for controllable PGU if:
- The active power reduces between measuring points 5 ,4 ,4 ,1 a) to g) and j), the expected active power output, after settling, adjusts with a deviation ≤ ± 10% PEmax ,
  In the measurement points h) and i) shall no active power be given ,
- The initial time delay TV of the frequency-dependent adaptation of the active power output ≤ 2 s ,
- The response time of the adaptation of the active power output is a maximum of 8 s (type 1 units and type 2 units with rotating machines) or 2 s (all other type 2 units)
- the settling time of the adaptation of the active power output is a maximum time of 30 s (for type 1 units and for type 2 units with rotating machines) or respectively a maximum time of 20 s (for all other generation units type 2) and
- The connection time at point j) is at least 60 s and the power is then increased with a gradient of ≤ 10% PEmax / min ,
- In the case of generating units with combustion engines or gas turbines, if the criteria for response time and settling time are not met, the test shall be passed, even if the adaptation of active power output occurs with a power gradient of at least 66% PEmax per min (corresponding to 1 ,11% PEmax per s) ,

b) for conditionally adjustable PGU, if:
- they behave as described in a) inside their control range and
- outside the control range, the power supplied when leaving the control range remains constant until it is switched off
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

NOTE: The Uniform distribution of the disconnection frequency in maximum increments of 0 ,1 Hz between the end of the control range (at least 50 ,2 Hz) and 51 ,5 Hz shall be proofed by a manufacturer's declaration ,
c) for non-adjustable EZE, if
- a disconnection takes place between 50 ,2 Hz and 51 ,5 Hz;
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

NOTE The Uniform distribution of the disconnection frequency in maximum increments of 0 ,1 Hz between 50 ,2 Hz and 51 ,5 Hz shall be proofen by a manufacturer's declaration ,
d) for linear generators with SEmax ≤ 4 ,6 kVA,
- if they disconnect from the mains at a frequency ≥ 50 ,2 Hz and their maximum upper frequency limit (as specified by the manufacturer), but at the latest when they exceed 51 ,5 Hz ,
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

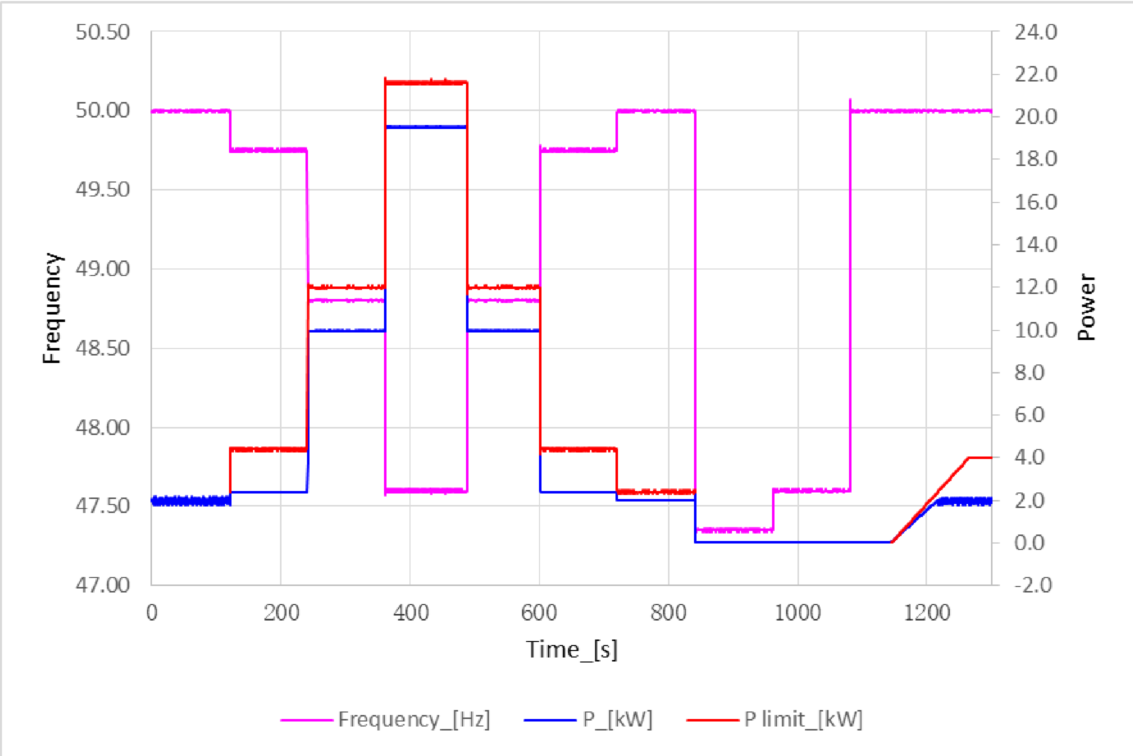
Subsequently no more resynchronisation/active power feed-in is permitted, also while the frequency 5 ,4 ,4 ,1 i) is maintained (i ,e no running on the characteristic curve as previously tested in a) at g) ,

Note: The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

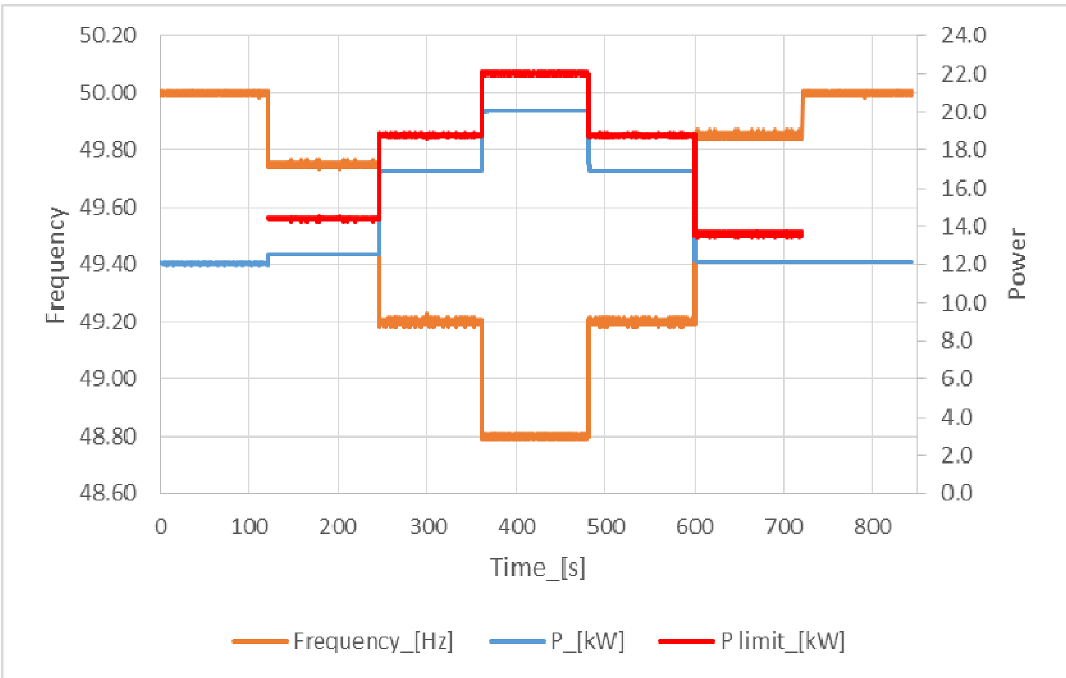
5.4.6 Active power feed-in for PGUs at Underfrequency (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11 5 ,7 ,4 ,3 , and VDE-AR-N 4105:2018-11 8 ,3 ,1 , are met) (not for DC-coupled Storage systems)										**P**
Test:										
f [Hz]	a) 50,00	b) 49,75	c) 48,80	d) 47,60	e) 48,80	f) 49,85	g) 50,00	h) 47,35	i) 47,60	j) 50,00
Test 1:										
Frequency [Hz]:	50,00	49,75	48,80	47,60	48,80	49,85	50,00	47,35	47,60	50,00
$P_{setpoint}$ [% P_{Emax}]:	10,00	12,00	50,00	98,00	50,00	12,00	10,00	0,00	0,00	10,00
P_{E60} [% P_{Emax}]:	9,84	11,81	49,83	97,61	49,83	11,81	10,02	-0,01	-0,01	9,85
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	0,16	0,19	0,18	0,39	0,18	0,19	-0,02	0,01	0,01	0,15

Test 2:							
f [Hz]	a) 50,00	b) 49,75	c) 49,20	d) 48,80	e) 49,20	f) 49,85	g) 50,00
Frequency [Hz]:	50,00	49,75	49,20	48,80	49,20	49,85	50,00
$P_{setpoint}$ [% P_{Emax}]:	60,00	62,00	84,00	100,00	84,00	60,00	60,00
P_{E60} [% P_{Emax}]:	60,40	62,50	84,50	100,35	84,50	60,75	60,75
$\Delta P_{E60}/P_{Setpoint}$ [% P_{Emax}]:	0,40	0,50	0,50	0,35	0,50	0,75	0,75
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 10 % of P_{Emax}						

Graph of Test 1:



Graph of Test 2:



Tests:
The test is conducted for two powers ,
In both tests, the following measuring points a) to j) must be approached with an accuracy of ± 10 mHz , The measuring points a) to h) and j) are to be approached for at least 60 s or until the maximum power is reached after a shutdown , The measuring point i) must be started for at least 10 min , The specified initial active power must be maintained with a tolerance of ± 5% PEmax , The deviation must be taken into account during the evaluation ,
Start of the increase of active power at 49,8Hz s =5% (40% Pref/Hz), the rise of the active power gradient must be recorded ,
Test1:
First, the test must start at a power > 10% PEmax ("Measurement 1")
Note: Testing is only valid for adjustable PGUs
Test2:
First, the test must start at a power > 60% PEmax ("Measurement 2")
Note: If the technical minimum line is above 60% PEmax, this must be taken into account accordingly , In the case of non-controllable EZE, this test is omitted ,

Assessment criterion:
The test is regarded as passed:
a) for controllable PGU if:
- The active power reduces between measuring points 5 ,4 ,4 ,1 a) to g) and j), the expected active power output, after settling, adjusts with a deviation ≤ ± 10% P_{Emax} , Deviations according to VDE-AR-N 4105: 2018-11, 5 ,7 ,4 ,3, Figure 13 and due to the technical restrictions described are permissible , In the measuring points h) and i) no active power may be delivered,
- The initial time delay T_V of the frequency-dependent adaptation of the active power output ≤ 2 s ,
- The response time of the adaptation of the active power output is a maximum of 8 s (type 1 units and type 2 units with rotating machines) or 2 s (all other type 2 units)
- the settling time of the adaptation of the active power output is a maximum time of 30 s (for type 1 units and for type 2 units with rotating machines) or respectively a maximum time of 20 s (for all other generation units type 2) and
- The connection time at point j) is at least 60 s and the power is then increased with a gradient of ≤ 10% P_{Emax} / min ,
- In the case of generating units with combustion engines or gas turbines, if the criteria for response time and settling time are not met, the test shall be passed, even if the adaptation of active power output occurs with a power gradient of at least 66% P_{Emax} per min (corresponding to 1 ,11% P_{Emax} per s) ,

b) for conditionally adjustable PGU, if:
- they behave as descripted in a) inside their control range and
- no disconnection takes place between 49,8 Hz and 47,5 Hz;
- the connection time in j) corresponds to the manufacturer's information on the random number generator;

NOTE: The Uniform distribution of the disconnection frequency in maximum increments of 0 ,1 Hz between the end of the control range (at least 50 ,2 Hz) and 51 ,5 Hz shall be proofed by a manufacturer's declaration ,

c) for non-adjustable EZE, if
- no disconnection takes place between 49,8 Hz and 47,5 Hz;
- the connection time in j) corresponds to the manufacturer's information on the random number generator;

NOTE The Uniform distribution of the disconnection frequency in maximum increments of 0 ,1 Hz between 50 ,2 Hz and 51 ,5 Hz shall be proofen by a manufacturer's declaration ,

d) for linear generators with S_{Emax} ≤ 4 ,6 kVA,
- if they disconnect from the mains at a frequency ≤ 49,8 Hz and their maximum upper frequency limit (as specified by the manufacturer), but at the latest when they exceed 47 ,5 Hz ,

the connection time in j) corresponds to the manufacturer's information on the random number generator;

Subsequently no more resynchronisation/active power feed-in is permitted, also while the frequency 5 ,4 ,4 ,1 i) is maintained (i ,e no running on the characteristic curve as previously tested in a) at g) ,

Note: The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

5.4.8 Static voltage stability / reactive power supply

The test serves as verification of the reactive power mode according to VD-AR-N 4105:2018-11, 5.7.2 of the EZE in normal operation ,

The PGU has:
applies for PGUs Type 2 - only inverter $\Sigma S_{Emax} \geq 4,6$ kVA

5.4.8.1 Tests of the Reactive power / cos φ setting accuracy — P

Setting values	cos φ over-excited:	0,90
	cos φ under-excited:	0,90

Test: HYD 20KTL-3PH

30 s mean value	$0,90U_n$		U_n		$1,1\ U_n$	
	S_{Emax}	40 – 60 $\%P_{Emax}$	S_{Emax}	40 – 60 $\%P_{Emax}$	S_{Emax}	40 – 60 $\%P_{Emax}$
cos φ (1)						
U [V]:	207,4	207,4	231,0	230,4	253,2	253,5
P_{E30} [kW]:	19,986	10,031	20,084	10,070	20,127	10,083
Q_{E30} [kVar]:	0,572	0,300	0,445	0,250	0,441	0,271
S_{E30} [kVA] ,	19,994	10,035	20,089	10,074	20,132	10,087
cos φ_{E30}:	1,000	1,000	1,000	1,000	1,000	1,000
$Q_{setpoint}$ [kVar]:	0,000	0,000	0,00	0,000	0,000	0,000
$\Delta Q/P_{Emax}$[%]	2,860	1,500	2,225	1,250	2,205	1,355
cos φ (c)						
U [V]:	207,3	207,3	230,0	230,5	253,4	253,4
P_{E30} [kW]:	19,931	10,015	20,008	10,058	20,063	10,075
Q_{E30} [kVar]:	9,485	4,724	9,504	4,725	9,514	4,711
S_{E30} [kVA] ,	22,073	11,073	22,151	11,113	22,205	11,122
cos $\varphi_{E30\text{-over-excited}}$:	0,903	0,904	0,903	0,905	0,904	0,906
$Q_{setpoint}$ [kVar]:	9,621	4,827	9,655	4,844	9,679	4,848
$\Delta Q/P_{Emax}$[%]	2,728	2,052	3,028	2,381	3,299	2,739
cos φ (i)						
U [V]:	207,4	207,2	230,3	230,4	253,3	253,3
P_{E30} [kW]:	19,900	9,999	19,978	10,041	20,029	10,058
Q_{E30} [kVar]:	-9,668	-4,672	-9,837	-4,717	-9,882	-4,743
S_{E30} [kVA] ,	22,124	11,037	22,269	11,093	22,335	11,120
cos $\varphi_{E30\text{-under-excited}}$:	0,899	0,906	0,897	0,905	0,897	0,904
$Q_{setpoint}$ [kVar]:	-9,644	-4,811	-9,707	-4,835	-9,736	-4,847
$\Delta Q/P_{Emax}$[%]	0.487	-2.778	2.603	-2.367	2.928	-2.082
Limit ΔQ:	$\pm 4\%\ P_{Emax}$					

Test: HYD 5KTL-3PH						
30 s mean value	$0{,}90U_n$		U_n		$1{,}1\ U_n$	
	S_{Emax}	40 – 60 %P_{Emax}	S_{Emax}	40 – 60 %P_{Emax}	S_{Emax}	40 – 60 %P_{Emax}
cos φ (1)						
U [V]:	207,5	207,3	230,9	230,5	253,2	253,5
P_{E30} [kW]:	4,983	2,506	5,013	2,516	5,029	2,520
Q_{E30} [kVar]:	0,037	0,079	0,034	0,079	0,020	0,083
S_{E30} [kVA] ,	4,987	2,507	5,015	2,517	5,031	2,521
cos $φ_{E30}$:	0,999	0,999	1,000	1,000	1,000	0,999
$Q_{setpoint}$ [kVar]:	0,000	0,000	0,000	0,000	0,000	0,000
ΔQ/P_{Emax}[%]	0,740	1,580	0,680	1,580	0,400	1,660
cos φ (c)						
U [V]:	207,5	207,1	230,9	230,5	253,3	253,5
P_{E30} [kW]:	4,968	2,501	4,999	2,513	5,008	2,513
Q_{E30} [kVAr]:	2,364	1,239	2,367	1,240	2,360	1,232
S_{E30} [kVA] ,	5,502	2,792	5,532	2,802	5,536	2,798
cos $φ_{E30\text{-over-excited}}$:	0,903	0,896	0,904	0,897	0,905	0,898
$Q_{setpoint}$ [kVar]:	2,398	1,217	2,411	1,221	2,413	1,220
ΔQ/P_{Emax}[%]	0,685	-0,440	0,887	-0,373	1,062	-0,248
cos φ (i)						
U [V]:	207,4	207,2	230,8	230,4	253,2	253,4
P_{E30} [kW]:	4,959	2,498	4,993	2,508	5,010	2,510
Q_{E30} [kVar]:	-2,438	-1,178	-2,350	-1,194	-2,361	-1,199
S_{E30} [kVA] ,	5,526	2,761	5,519	2,778	5,539	2,781
cos $φ_{E30\text{-under-excited}}$:	0,897	0,904	0,905	0,903	0,905	0,902
$Q_{setpoint}$ [kVar]:	-2,409	-1,203	-2,406	-1,211	-2,414	-1,212
ΔQ/P_{Emax}[%]	0,585	-0,510	-1,114	-0,338	-1,068	0,264
Limit ΔQ:	± 4% P_{Emax}					

Test:

applies for PGUs Type 2 - only inverter ΣS_{Emax} ≤ 4,6 kVA

a)and b) For cos φ 0,95 over-excited and φ 0,95 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax} and a second time,
for cos φ 0,975 over-excited and φ 0,975 under-excited, the active power will be measured at a value between 40% P_{Emax} and 60% and S_{Emax}

applies for PGUs Type 2 - only inverter ΣS_{Emax} ≥ 4,6 kVA

c) and d) For cos φ 0,90 over-excited and φ 0,90 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax} and a second time,
for cos φ 0,95 over-excited and φ 0,95 under-excited, the active power will be measured at a value between 40% P_{Emax} and 60% and S_{Emax}

applies PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells $\Sigma S_{Emax} \leq 4{,}6$ kVA

e) without specification of the cos φ the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax} ,

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells $\Sigma S_{Emax} \geq 4{,}6$ kVA

f) and g) For cos φ 0,95 over-excited and cos φ 0,95 under-excited, the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax} and a second time,

for cos φ 0,975 over-excited and φ 0,975 under-excited, the active power will be measured at a value between 40% P_{Emax} and 60% and S_{Emax}

applies for PGUs Type 2 Asynchronous generators:

h) without specification of the cos φ the active power will be measured at value between 40% P_{Emax} and 60% and S_{Emax}

Assessment criterion:

applies for PGUs Type 2 - only inverter ΣSEmax ≤ 4 ,6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0 ,95 and one time at 0,975 and the measured apparent power of the fundamental , The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point ± 4% P_{Emax} overexcited and for b) in the range of Q set point ± 4% P_{Emax} under-excited , In addition, a setting of the cos φ must be possible within a step size of at least 0 ,01 ,

applies for PGUs Type 2 - only inverter ΣSEmax ≥ 4 ,6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0 ,90 and one time at 0,95 and the measured apparent power of the fundamental , The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point ± 4% P_{Emax} overexcited and for c) in the range of Q set point ± 4% P_{Emax} under-excited , In addition, a setting of the cos φ must be possible within a step size of at least 0 ,01 ,

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells ΣSEmax ≤ 4 ,6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0 ,95 and one time at 0,975 and the measured apparent power of the fundamental , The test is passed if all the Q 60 s mean values of the fundamental from e) are in the range Q maximal overexcited till Q minimal under-excited ,

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells ΣSEmax ≥ 4 ,6 kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0 ,95 and one time at 0,975 and the measured apparent power of the fundamental , The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point ± 4% P_{Emax} overexcited and for f) in the range of Q set point ± 4% P_{Emax} under-excited , In addition, a setting of the cos φ must be possible within a step size of at least 0 ,01 ,

applies for PGUs Type 1 Asynchronous generators:

The test is passed if the cos φ Q 60 s mean values of h) is in the range cos φ = 0,95 underexcited ±0,02 ,

Note:

The test had been performed on the model HYD 20KTL-3PH and HYD 5KTL-3PH the test results are valid for the HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

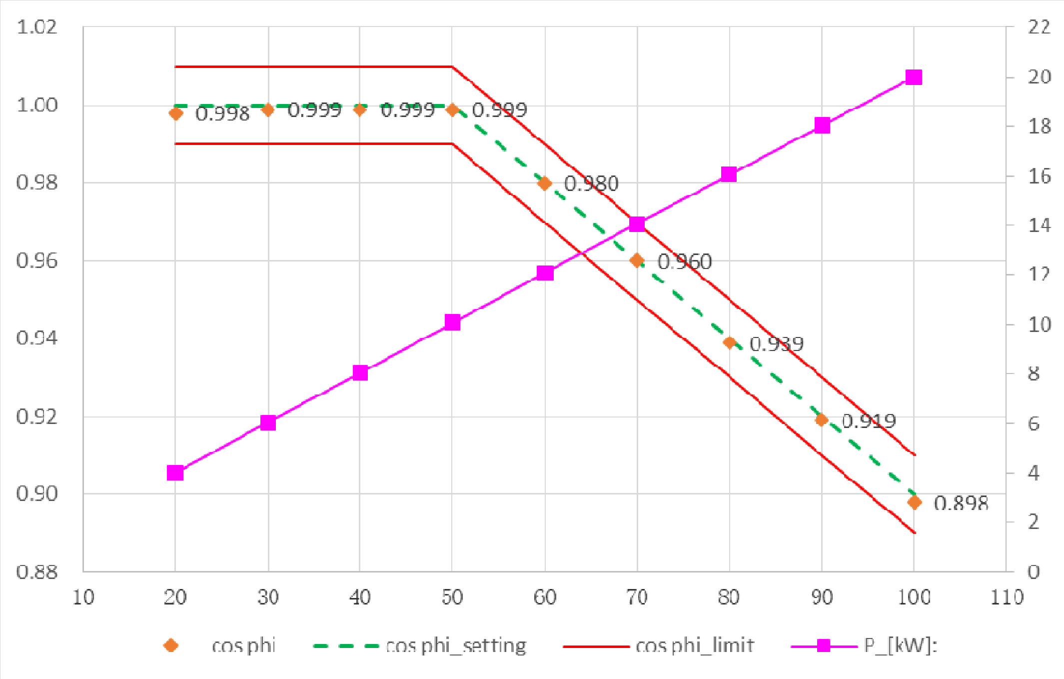
5.4.8.2 Test of the displacement factor/active power characteristic curve cos φ (P) The test serves as verification of the standard cos φ (P) curve according to VDE-AR-N 4105:2018-11, 5.7.2.4.	P

Test c): supply-dependent PGUs - Accuracy (characteristic curve): HYD 20KTL-3PH										
P_{Emax}/P [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}									
U [V]:	--	230,2	230,3	230,4	230,5	230,4	230,6	230,7	230,7	230,8
P_{E30} [kW]:	--	4,004	6,029	8,053	10,069	12,072	14,069	16,057	18,037	20,008
P_{E30} of P_{Emax} [%]:	--	20,02	30,15	40,27	50,35	60,36	70,35	80,29	90,19	100,04
Q_{E30} [kVar]:	--	-0,004	0,001	0,007	-0,002	-2,449	-4,120	-5,866	-7,745	-9,775
S_{E30} [kVA] ,	--	4,012	6,035	8,058	10,075	12,318	14,660	17,096	19,630	22,269
cos $φ_{E30}$:	--	0,998	0,999	0,999	0,999	0,980	0,960	0,939	0,919	0,898
cos $φ_{setpoint}$ of P_{E30}:	--	1,000	1,000	1,000	1,000	0,980	0,960	0,940	0,920	0,900
$Q_{setpoint}$ [kVar]:	--	0,000	0,000	0,000	0,000	-2,451	-4,105	-5,833	-7,693	-9,707
ΔQ/P_{Emax}[%]	--	-0,020	0,005	0,035	-0,010	0,010	-0,075	-0,165	-0,260	-0,340
Limit ΔQ:	± 4% P_{Emax}									
P_{Emax}/P [%]	100	90	80	70	60	50	40	30	20	10
30 s mean value	100% to 20% P_{Emax}									
U [V]:	230,8	230,8	230,7	230,6	230,5	230,5	230,3	230,2	230,1	--
P_{E30} [kW]:	20,007	18,035	16,054	14,066	12,070	10,068	8,051	6,028	4,004	--
P_{E30} of P_{Emax} [%]:	100,04	90,18	80,27	70,33	60,35	50,34	40,26	30,14	20,02	--
Q_{E30} [kVar]:	-9,775	-7,741	-5,863	-4,116	-2,445	0,002	0,019	0,010	0,000	--
S_{E30} [kVA] ,	22,268	19,627	17,092	14,657	12,315	10,073	8,057	6,034	4,011	--
cos $φ_{E30}$:	0,898	0,919	0,939	0,960	0,980	0,999	0,999	0,999	0,998	--
cos $φ_{setpoint}$ of P_{E30}:	0,900	0,920	0,940	0,960	0,980	1,000	1,000	1,000	1,000	--
$Q_{setpoint}$ [kVar]:	-9,706	-7,692	-5,831	-4,104	-2,451	0,000	0,000	0,000	0,000	--
ΔQ/P_{Emax}[%]	-0,345	-0,245	-0,160	-0,060	0,030	0,010	0,095	0,050	0,000	--
Limit ΔQ:	± 4% P_{Emax}									

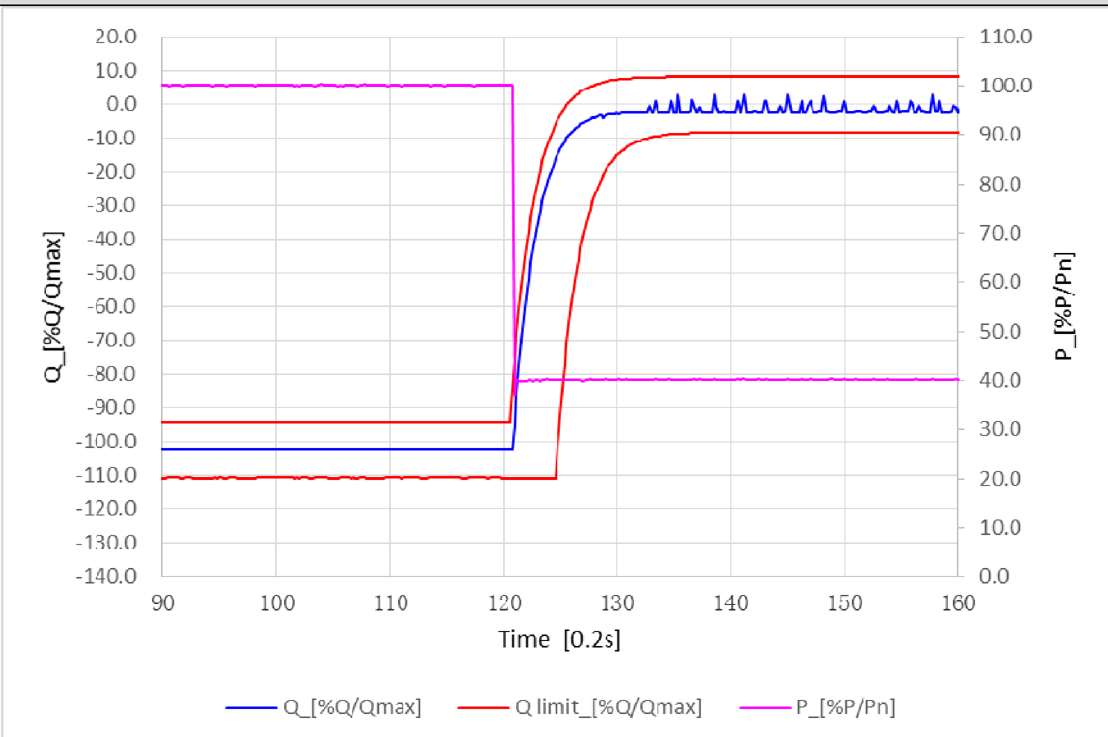
Test d): supply-dependent PGUs - Dynamic: HYD 20KTL-3PH				
P_{Emax}/P_n [%]	100	40	100	75
30 s mean value	100% to 40% to 100% to 75% P_{Emax}			
U [V]:	230,7	230,4	230,7	230,6
P_{E30} [kW]:	20,008	8,048	20,010	15,040
P_{E30} of P_{Emax} [%]:	100,04	40,24	100,05	75,20
Q_{E30} [kVar]:	-9,919	-0,164	-9,920	-5,103
S_{E30} [kVA] ,	22,332	8,051	22,334	15,882

cos φ_{E30}:	0,896	1,000	0,896	0,947
cos $\varphi_{setpoint}$ of P_{E30}:	0,900	1,000	0,900	0,950
$Q_{setpoint}$ [kVar]:	-9,917	0,000	-9,918	-5,102
$\Delta Q/P_{Emax}$[%]	-0,012	-0,820	-0,012	-0,006
Limit ΔQ:	± 4% P_{Emax}			

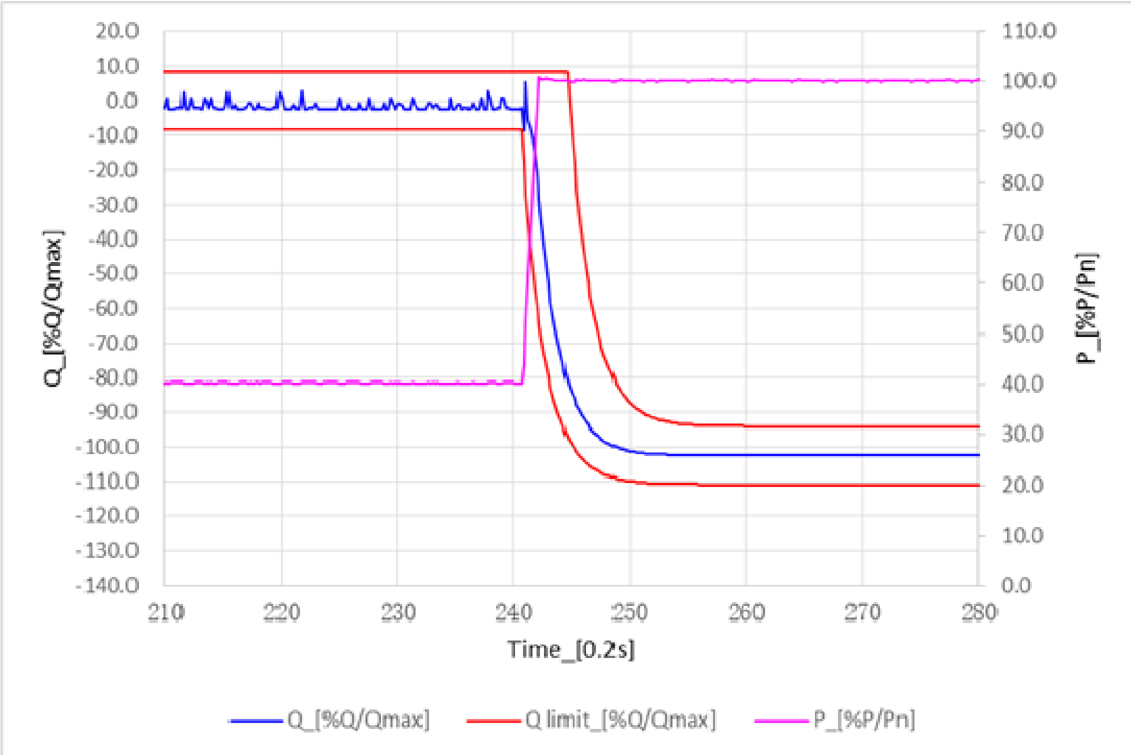
Graph of cos φ(P): Test c)



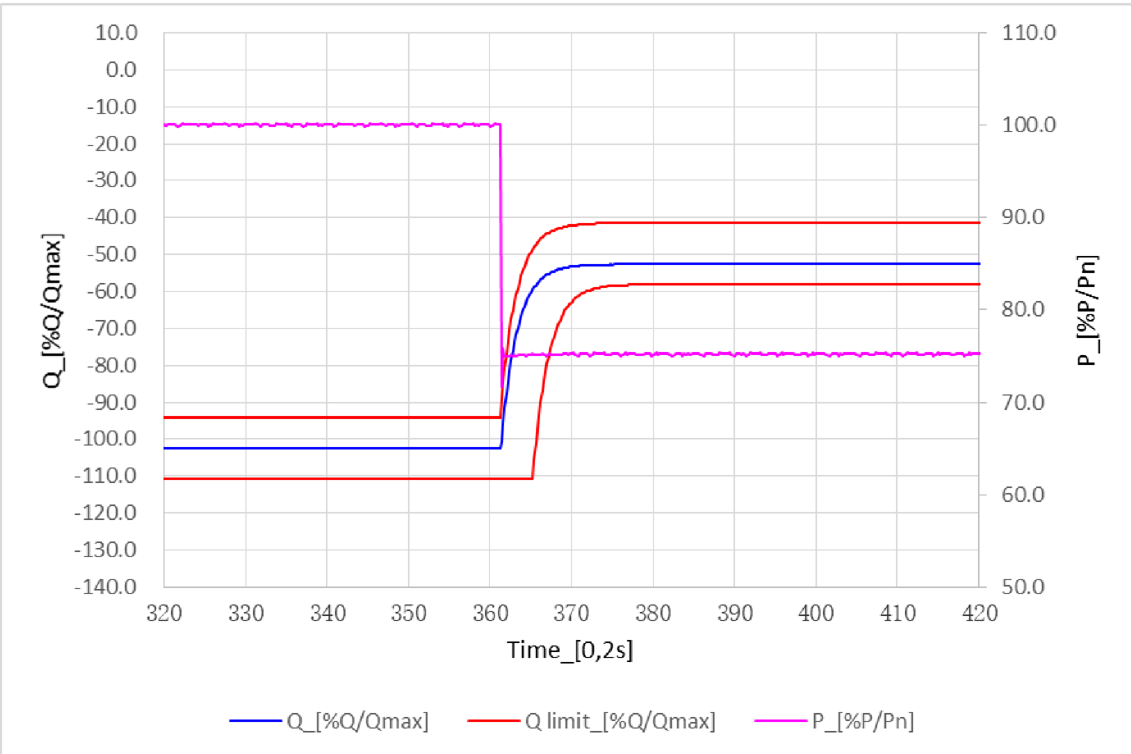
Graph of Test d): 100% to 40% P_{Emax}



Graph of Test d): 40% to 100% P_{Emax}



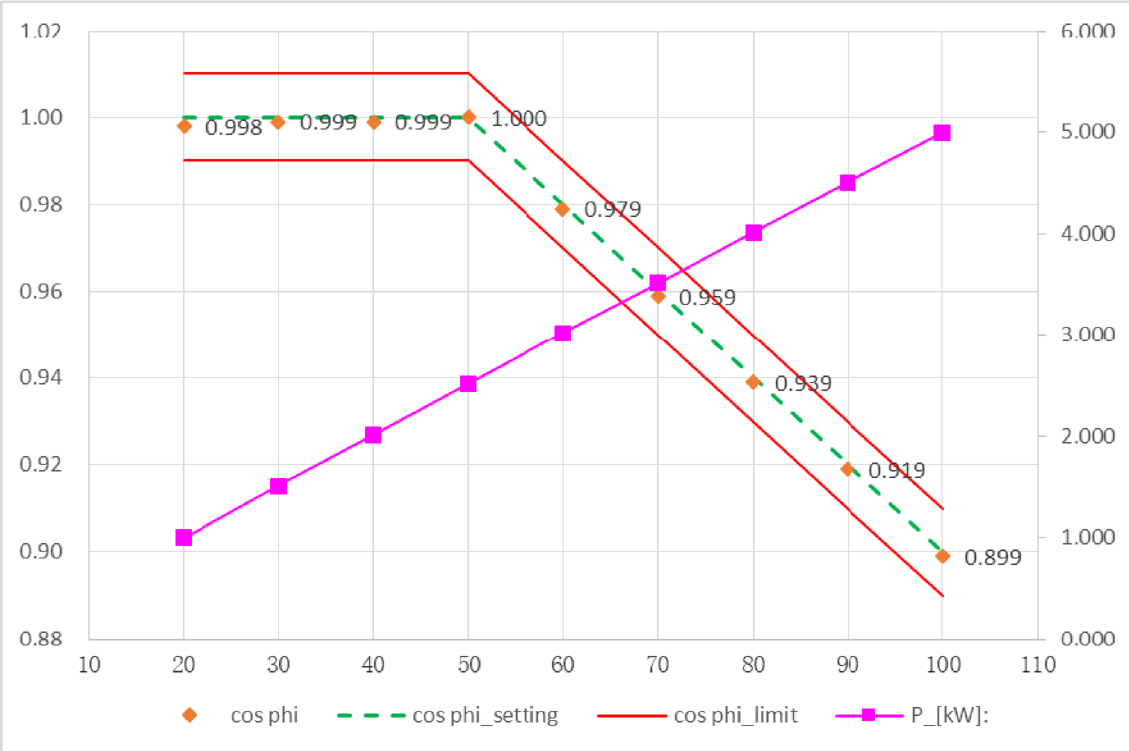
Graph of Test d): 100% to 75% P_{Emax}



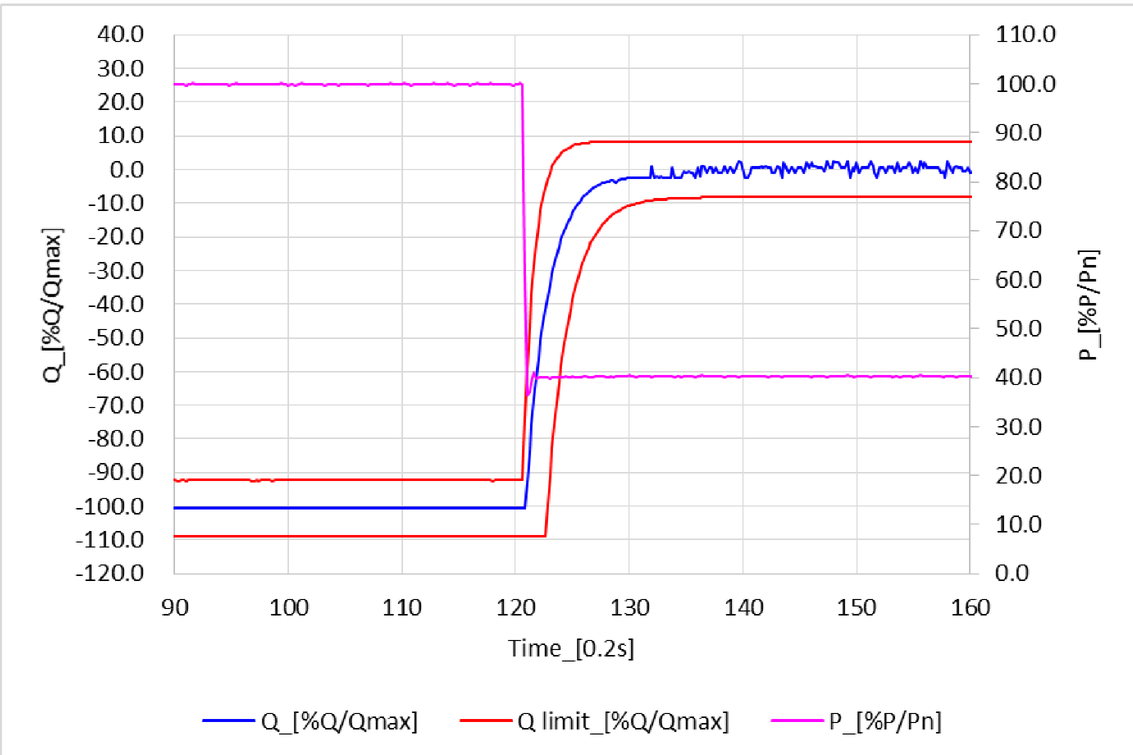
Test c): supply-dependent PGUs - Accuracy (characteristic curve): HYD 5KTL-3PH										
P_{Emax}/P [%]	10	20	30	40	50	60	70	80	90	100
30 s mean value	20% to 100% P_{Emax}									
U [V]:	--	230,3	230,4	230,4	230,5	230,5	230,6	230,6	230,7	230,9
P_{E30} [kW]:	--	0,999	1,506	2,012	2,516	3,017	3,514	4,011	4,504	4,994
P_{E30} of P_{Emax} [%]:	--	19,98	30,12	40,24	50,32	60,34	70,28	80,22	90,08	99,88
Q_{E30} [kVar]:	--	-0,011	-0,003	0,000	-0,001	-0,621	-1,037	-1,471	-1,936	-2,436
S_{E30} [kVA] ,	--	1,001	1,507	2,013	2,518	3,080	3,664	4,272	4,902	5,556
cos φ_{E30}:	--	0,998	0,999	0,999	1,000	0,979	0,959	0,939	0,919	0,899
cos $\varphi_{setpoint}$ of P_{E30}:	--	1,000	1,000	1,000	1,000	0,980	0,960	0,940	0,920	0,900
$Q_{setpoint}$ [kVar]:	--	0,000	0,000	0,000	0,000	-0,613	-1,025	-1,456	-1,919	-2,419
$\Delta Q/P_{Emax}$[%]	--	0,011	0,003	0,000	0,001	-0,160	-0,240	-0,300	-0,340	-0,340
Limit ΔQ:	± 4% P_{Emax}									
P_{Emax}/P [%]	100	90	80	70	60	50	40	30	20	10
30 s mean value	100% to 20% P_{Emax}									
U [V]:	230,8	230,8	230,8	230,7	230,6	230,5	230,5	230,4	230,3	--
P_{E30} [kW]:	4,993	4,993	4,502	4,009	3,514	3,016	2,516	2,012	0,999	--
P_{E30} of P_{Emax} [%]:	99,86	99,86	90,04	80,18	70,28	60,32	50,32	40,24	19,98	--
Q_{E30} [kVar]:	-2,436	-2,436	-1,934	-1,470	-1,036	-0,620	0,000	0,000	-0,011	--
S_{E30} [kVA] ,	5,556	5,555	4,900	4,270	3,663	3,079	2,517	2,013	1,001	--
cos φ_{E30}:	0,899	0,899	0,919	0,939	0,959	0,979	1,000	0,999	0,998	--
cos $\varphi_{setpoint}$ of P_{E30}:	0,900	0,920	0,940	0,960	0,980	1,000	1,000	1,000	1,000	--
$Q_{setpoint}$ [kVar]:	-2,418	-2,127	-1,634	-1,169	-0,714	0,000	0,000	0,000	0,000	--
$\Delta Q/P_{Emax}$[%]	-0,360	-6,180	-6,000	-6,020	-6,440	0,000	0,000	0,000	0,011	--
Limit ΔQ:	± 4% P_{Emax}									

Test d): supply-dependent PGUs - Dynamic: HYD 5KTL-3PH				
P_{Emax}/P_n [%]	100	40	100	75
30 s mean value	100% to 40% to 100% to 75% P_{Emax}			
U [V]:	230,8	230,5	230,7	230,8
P_{E30} [kW]:	4,996	2,012	4,995	3,758
P_{E30} of P_{Emax} [%]:	99,92	40,24	99,90	75,16
Q_{E30} [kVar]:	-2,438	0,008	-2,435	-1,239
S_{E30} [kVA] ,	5,559	2,012	5,557	3,957
cos φ_{E30}:	0,899	1,000	0,899	0,950
cos $\varphi_{setpoint}$ of P_{E30}:	0,90	1,00	0,90	0,95
$Q_{setpoint}$ [kVar]:	-2,435	0,000	-2,434	-1,236
$\Delta Q/P_{Emax}$[%]	-0,069	0,160	-0,026	-0,069
Limit ΔQ:	± 4% P_{Emax}			

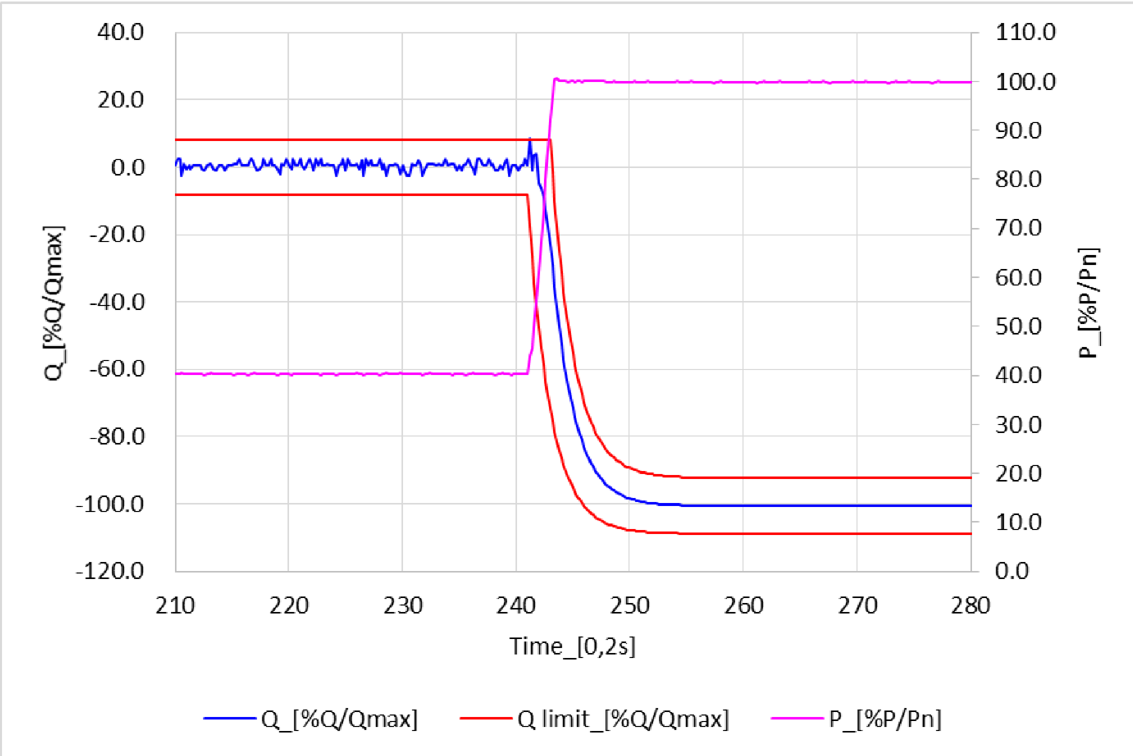
Graph of cos φ(P): Test c)



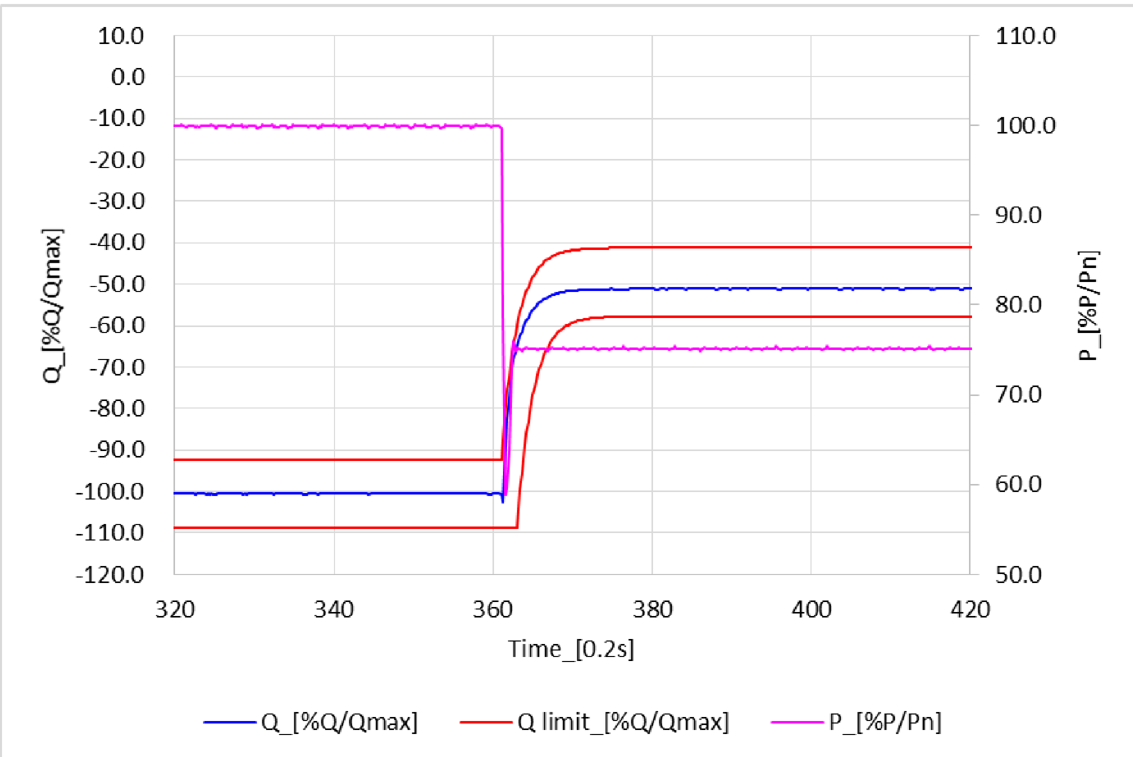
Graph of Test d): 100% to 40% P_{Emax}



Graph of Test d): 40% to 100% P_{Emax}



Graph of Test d): 100% to 75% P_{Emax}



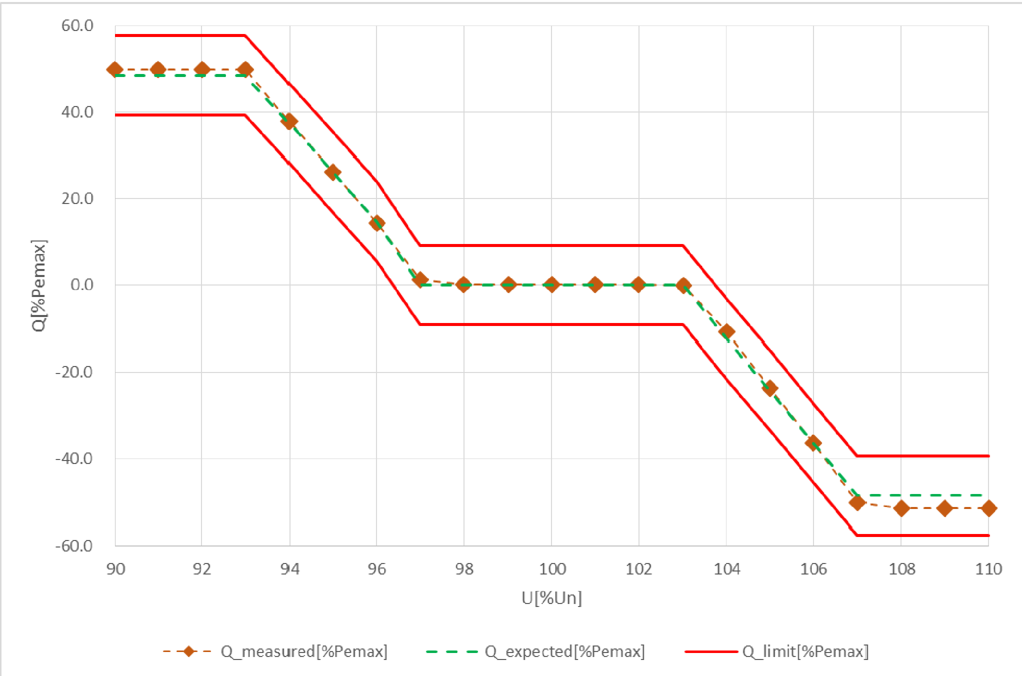
Assessment criterion: Test 5.4.8.2 a) and c) are passed if the maximum deviation between the reactive power setpoint (calculated from the characteristic) and the reactive power actual value at the generator terminals for all calculated reactive power values is a maximum of ± 4.0% relative to P_{Emax}. Test 5.4.8.2 (b) is regarded as passed if the PGU demonstrably complies with the performance gradient requirements of VDE-AR-N 4105: 2018-11 in Section 5.7.4.2. Test 5.4.8.2 d) is passed if the step response of the reactive power in the test steps c) and e) exhibits the PT1 behavior according to VDE-AR-N 4105: 2018-11 Section 5.7.2.5 and for test step d) the power gradient between the Limits of VDE-AR-N 4105: 2018-11 Section 5.7.4.2.
Note: The test had been performed on the model HYD 20KTL-3PH and HYD 5KTL-3PH the test results are valid for the HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

5.4.8.3 Test the reactive power-voltage characteristic Q (U) The validation of the Q (U) regulation according to VDE-AR-N 4105: 2018-05, 5.7.2.4 is divided into two partial tests, so that on the one hand the accuracy and on the other hand the dynamics of the Q (U) control is checked. For all inverter-coupled systems, only the inverter must be tested.	**P**
5.4.8.3.1 Test of the reactive power-voltage characteristic Q (U): HYD 20KTL-3PH	**P**

Vac [% U_n] Set point	Vac_L1 [V] measured	Vac_L2 [V] measured	Vac_L3 [V] measured	P [kW] measured	Q [kVar] measured	Q [kVar] expected	ΔQ [% P_{Emax}]
100	230,9	230,9	231,0	20,083	0,033	0,000	0,165
99	227,6	227,6	227,7	20,074	0,030	0,000	0,150
98	225,3	225,3	225,4	20,067	0,030	0,000	0,150
97	223,0	223,0	223,1	20,061	0,227	0,000	1,135
96	220,7	220,7	220,8	20,052	2,867	2,963	-0,482
95	218,4	218,5	218,5	20,025	5,251	5,204	0,233
94	216,1	216,2	216,3	19,981	7,572	7,445	0,633
93	213,8	213,9	214,0	19,944	9,953	9,686	1,333
92	211,6	211,6	211,7	19,936	9,957	9,686	1,353
91	209,3	209,3	209,4	19,926	9,959	9,686	1,363
90	207,0	207,0	207,1	19,917	9,951	9,686	1,323
91	209,3	209,3	209,4	19,926	9,960	9,686	1,368
92	211,5	211,6	211,7	19,934	9,955	9,686	1,343
93	213,9	213,9	214,0	19,943	9,946	9,686	1,298
94	216,2	216,2	216,3	19,980	7,569	7,445	0,618
95	218,4	218,5	218,6	20,028	5,233	5,204	0,143
96	220,7	220,8	220,8	20,053	2,883	2,963	-0,402
97	223,0	223,0	223,1	20,063	0,249	0,000	1,245
98	225,3	225,3	225,4	20,070	0,035	0,000	0,175
99	227,6	227,6	227,7	20,077	0,035	0,000	0,175
100	230,4	230,4	230,5	20,084	0,033	0,000	0,165
101	232,2	232,2	232,3	20,088	0,034	0,000	0,170
102	234,5	234,5	234,6	20,094	0,015	0,000	0,075
103	236,7	236,8	236,8	20,100	0,010	0,000	0,050
104	239,0	239,1	239,1	20,100	-2,133	-2,456	1,617
105	241,3	241,4	241,4	20,091	-4,720	-4,866	0,732
106	243,5	243,6	243,7	20,075	-7,285	-7,276	-0,043
107	246,0	246,0	246,1	20,047	-10,043	-9,686	-1,783
108	248,4	248,4	248,5	19,963	-10,272	-9,686	-2,928
109	250,8	250,8	250,9	19,962	-10,272	-9,686	-2,928
110	253,1	253,1	253,2	19,961	-10,272	-9,686	-2,928

109	250,8	250,8	250,9	19,963	-10,273	-9,686	-2,933
108	248,6	248,5	248,6	19,963	-10,271	-9,686	-2,923
107	246,2	246,2	246,3	19,965	-10,272	-9,686	-2,928
106	243,8	243,9	243,9	20,072	-7,561	-7,445	-0,578
105	241,6	241,7	241,7	20,090	-5,056	-5,204	0,742
104	239,3	239,4	239,4	20,100	-2,465	-2,963	2,492
103	237,0	237,0	237,1	20,101	0,112	0,000	0,560
102	234,8	234,8	235,0	20,096	0,127	0,000	0,635
101	232,3	232,3	232,4	20,090	0,118	0,000	0,590
100	230,3	230,4	230,5	20,084	0,136	0,000	0,680
Limit ΔQ:	± 4% P_{Emax}						

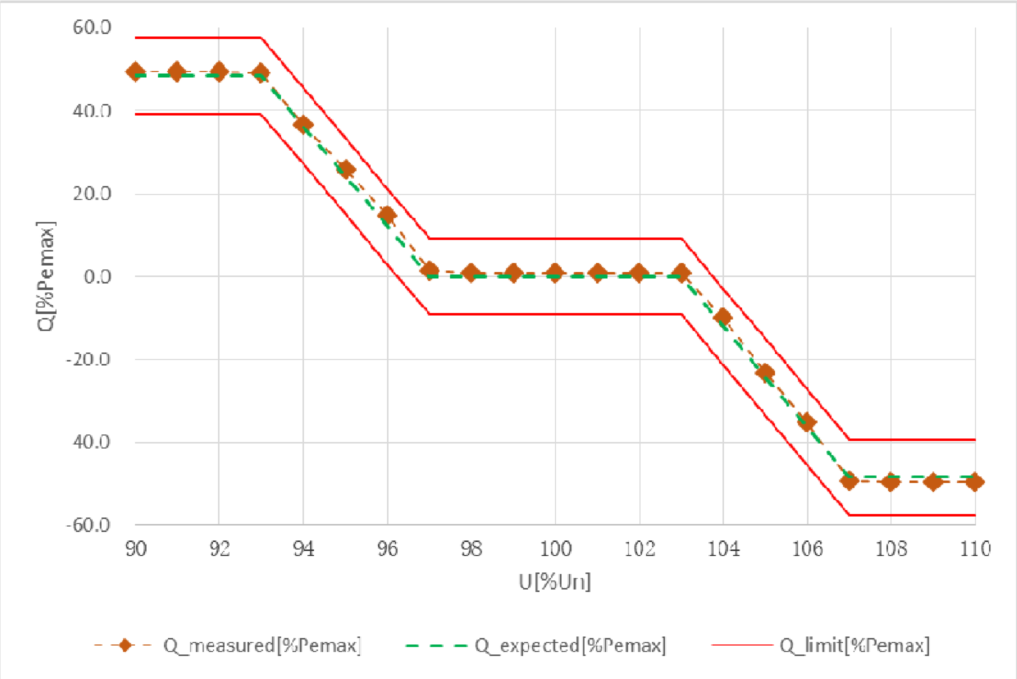
Graph of characteristic Q (U):



5.4.8.3.1	Test of the reactive power-voltage characteristic Q (U): HYD 5KTL-3PH						P
Vac [% U_n] Set point	Vac_L1 [V] measured	Vac_L2 [V] measured	Vac_L3 [V] measured	P [kW] measured	Q [kVar] measured	Q [kVar] expected	ΔQ [% P_{Emax}]
100	230,7	230,8	230,8	5,023	0,042	0,000	0,210
99	227,8	227,8	227,8	5,021	0,042	0,000	0,210
98	225,3	225,4	225,4	5,019	0,042	0,000	0,210
97	223,1	223,1	223,2	5,018	0,061	0,000	0,305
96	220,8	220,8	220,9	5,015	0,743	0,604	0,697
95	218,6	218,6	218,7	5,011	1,303	1,210	0,467
94	216,3	216,3	216,4	5,004	1,888	1,816	0,362
93	213,8	213,8	213,9	4,987	2,462	2,422	0,202
92	211,8	211,9	211,9	4,984	2,472	2,422	0,252
91	209,1	209,2	209,2	4,982	2,473	2,422	0,257
90	206,9	207,0	207,0	4,979	2,474	2,422	0,262
91	209,1	209,2	209,2	4,981	2,473	2,422	0,257
92	211,9	211,9	211,9	4,984	2,472	2,422	0,252
93	213,8	213,9	213,9	4,987	2,462	2,422	0,202
94	216,3	216,3	216,4	4,996	1,839	1,816	0,117
95	218,6	218,7	218,7	5,011	1,299	1,210	0,447
96	220,8	220,8	220,9	5,015	0,742	0,604	0,692
97	223,1	223,1	223,2	5,018	0,067	0,000	0,335
98	225,3	225,4	225,5	5,019	0,041	0,000	0,205
99	227,8	227,8	227,8	5,021	0,042	0,000	0,210
100	230,7	230,8	230,9	5,023	0,041	0,000	0,205
101	232,3	232,4	232,4	5,024	0,041	0,000	0,205
102	234,5	234,6	234,6	5,026	0,040	0,000	0,200
103	236,9	237,0	237,0	5,027	0,040	0,000	0,200
104	239,2	239,3	239,3	5,028	-0,494	-0,604	0,548
105	241,7	241,7	241,8	5,026	-1,162	-1,210	0,238
106	243,9	243,9	244,0	5,022	-1,759	-1,816	0,283
107	246,5	246,5	246,6	5,015	-2,468	-2,422	-0,232
108	248,7	248,7	248,8	5,016	-2,474	-2,422	-0,262
109	250,8	250,9	251,0	5,017	-2,474	-2,422	-0,262
110	253,6	253,7	253,7	5,017	-2,475	-2,422	-0,267
109	250,9	250,9	251,0	5,017	-2,475	-2,422	-0,267
108	248,7	248,7	248,8	5,016	-2,473	-2,422	-0,257
107	246,4	246,5	246,6	5,015	-2,467	-2,422	-0,227
106	243,9	243,9	244,0	5,022	-1,760	-1,816	0,278

105	241,7	241,7	241,8	5,026	-1,160	-1,210	0,248
104	239,2	239,3	239,3	5,028	-0,490	-0,604	0,568
103	236,9	237,0	237,0	5,028	0,040	0,000	0,200
102	234,6	234,6	234,6	5,026	0,041	0,000	0,205
101	232,3	232,4	232,4	5,024	0,042	0,000	0,210
100	230,7	230,8	230,8	5,023	0,041	0,000	0,205
Limit ∆Q:	± 4% P_{Emax}						

Graph of characteristic Q (U):



Note:
The test had been performed on the model HYD 20KTL-3PH and HYD 5KTL-3PH the test results are valid for the HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

Test:

The verification of the accuracy of the Q (U) control of the reactive power-voltage characteristic Un shown in VDE-AR-N 4105: 2018-11, 5 ,7 ,2 ,4, Figure 7 is effected by a slow variation of the line voltage U_n in the range 90% U_n to 110% U_n , Depending on the type of EZE (single- or three-phase), the voltage changes must be carried out simultaneously or symmetrically on all phases ,

a) In order to check the stationary accuracy, the permissible voltage range shall be passed through within steps, with a step size of 1% U_n, but not greater than 2% U_n ,

1. Pass the voltage range from 100% U_n down to the under voltage range to 90% U_n ,
2. Pass the voltage range from 90% U_n up to the over voltage range to 110% U_n ,
3. Pass the voltage range from 110% U_n down to the Nominal Voltage U_n ,

The procedure is analogous to Figure 3 in Section 5 ,4 ,3 ,2 ,

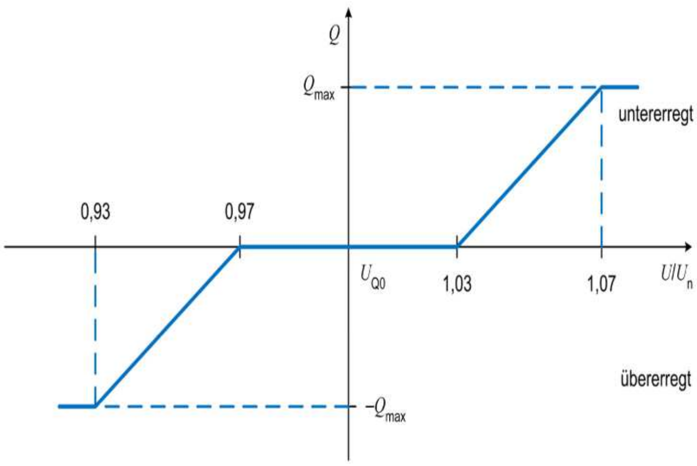


Bild 7 – Standard-Q(U)-Kennlinie

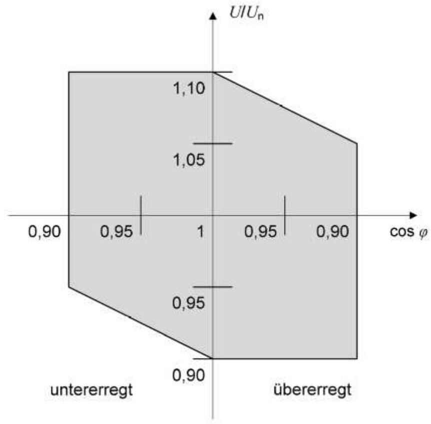


Bild 3 – Anforderungen an Erzeugungseinheiten bezüglich der Blindleistungsbereitstellung an den Generatorklemmen
($\sum S_{Emax} > 4{,}6$ kVA)

The voltages are to be set with a maximum deviation of 0 ,25% U_n ,

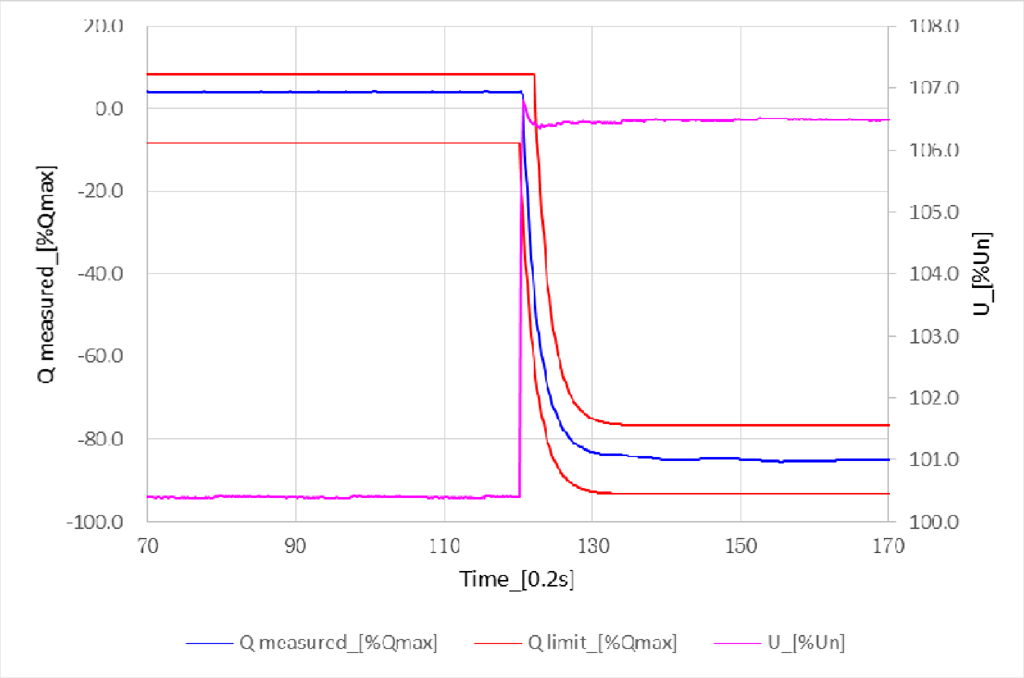
Assessment criterion:

In order to pass the Q (U) accuracy test, the measured stationary value pairs U_{PGU} and Q_{PGU}, under taking account to the correct sign in the consumer metering system, must be within VDE-AR-N 4105: 2018-11, in 5 ,7 ,2 ,4, Figure 7 Q (U) shown characteristic , The stationary value pairs U_{PGU} and Q_{PGU} are determined by averaging over 30 seconds at the end of the respective measuring section analogously to Chapter 5 ,4 ,3 ,2 , The permissible deviations are with the maximum measuring error of the voltage of 1% U_n stated in VDE-AR-N 4105: 2018-11 and a setting accuracy of 4% P_{EMax} at

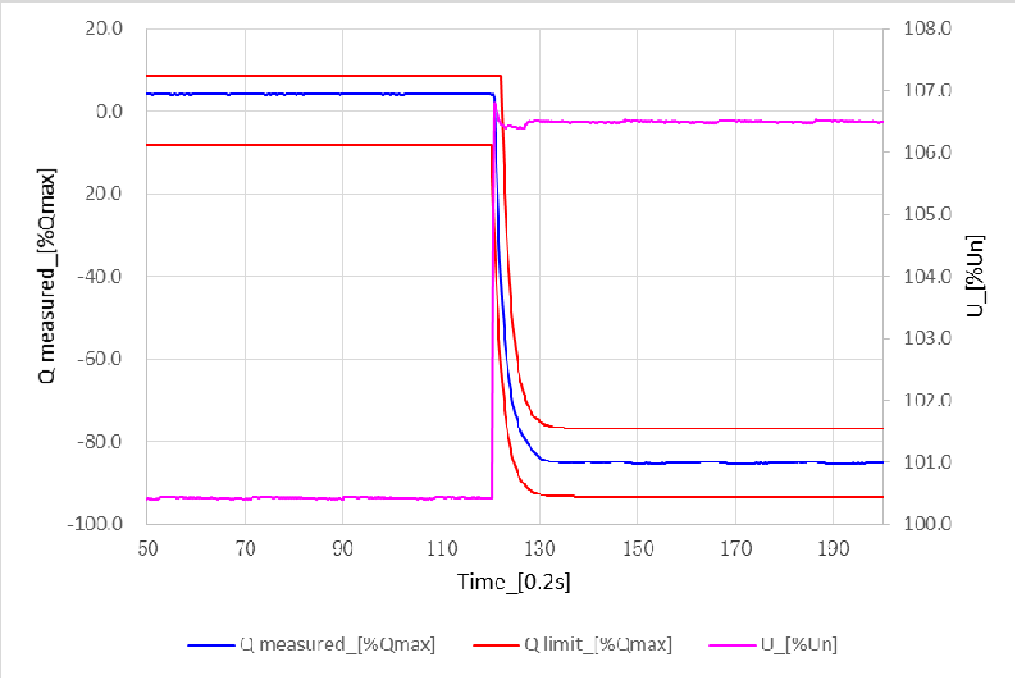
$$Q_{EZE,tol} = \pm(\,0.01 \cdot \mathrm{U_{N,Y}} \cdot \mathrm{k_{QU}} + 0.04 \cdot P_{EMax}) = \pm 0{,}25 \cdot P_{EMax} \cdot (\sin(\arccos(\varphi_{min})) + 0.16).$$

5.4.8.3.2 Test of the dynamics of the Q (U) regulation			P
Test: HYD 20KTL-3PH			
Voltage jump Vac [% U_n]	Q [kVar] measured	Q [%Qmax] measured	T=3τmeasured
100 to 106,4	-8,294	-85,633	7,4 s
	-8,244	-85,110	7,4 s
	-8,308	-85,771	7,4 s
100 to 93,6	8,208	84,743	7,4 s
	8,234	85,012	7,4 s
	8,273	85,413	7,4 s

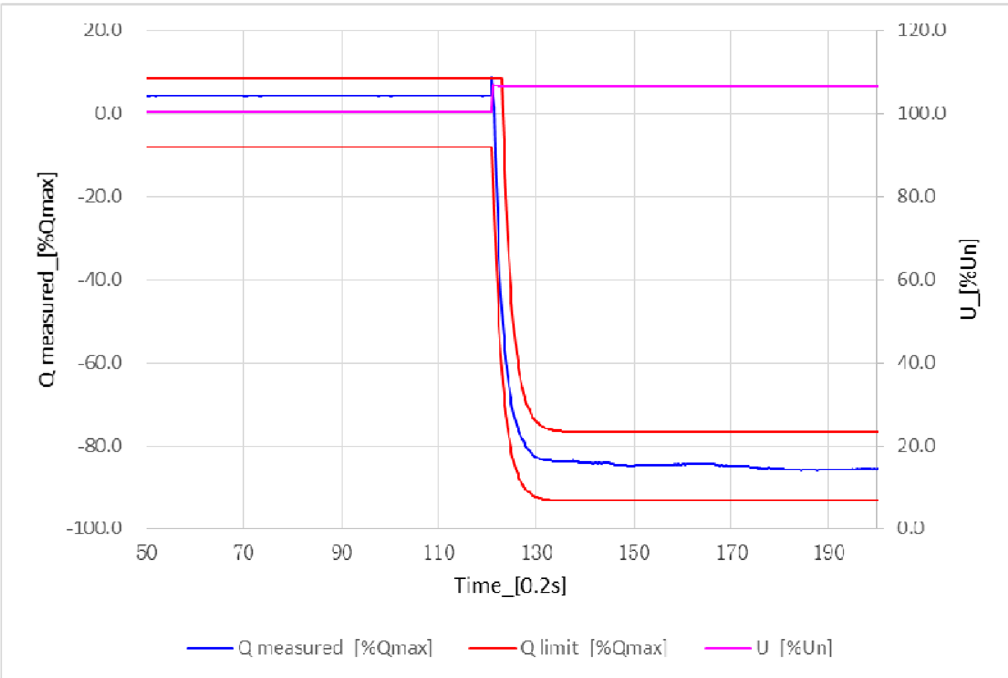
Graph of 100% U_n to 106,4% U_n: Test 1



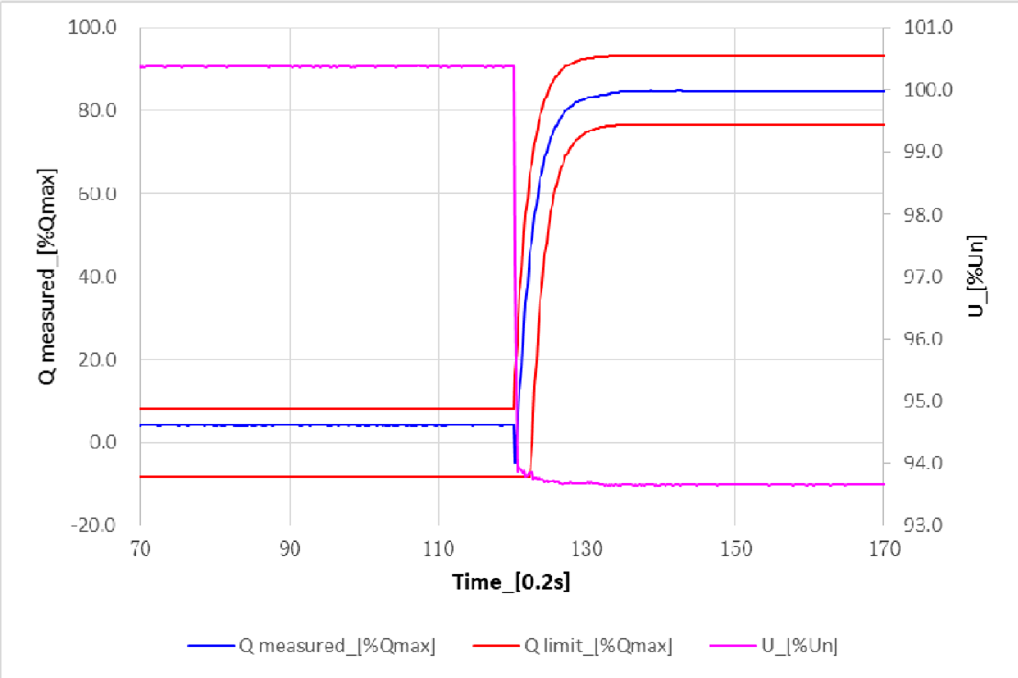
Graph of 100% U_n to 106,4% U_n: Test 2



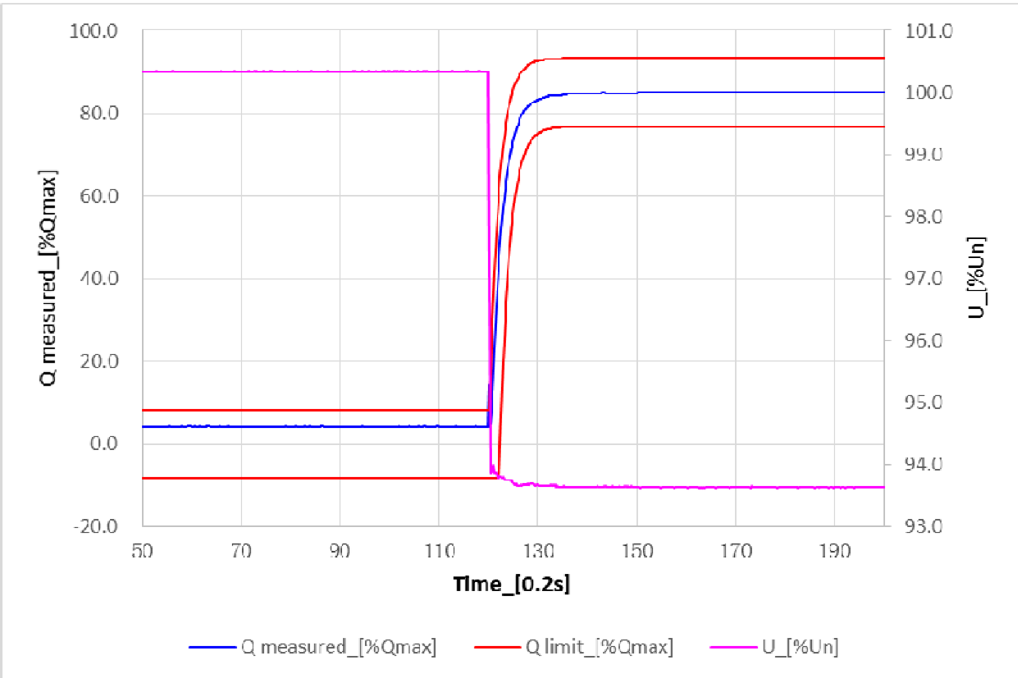
Graph of 100% U_n to 106,4% U_n: Test 3



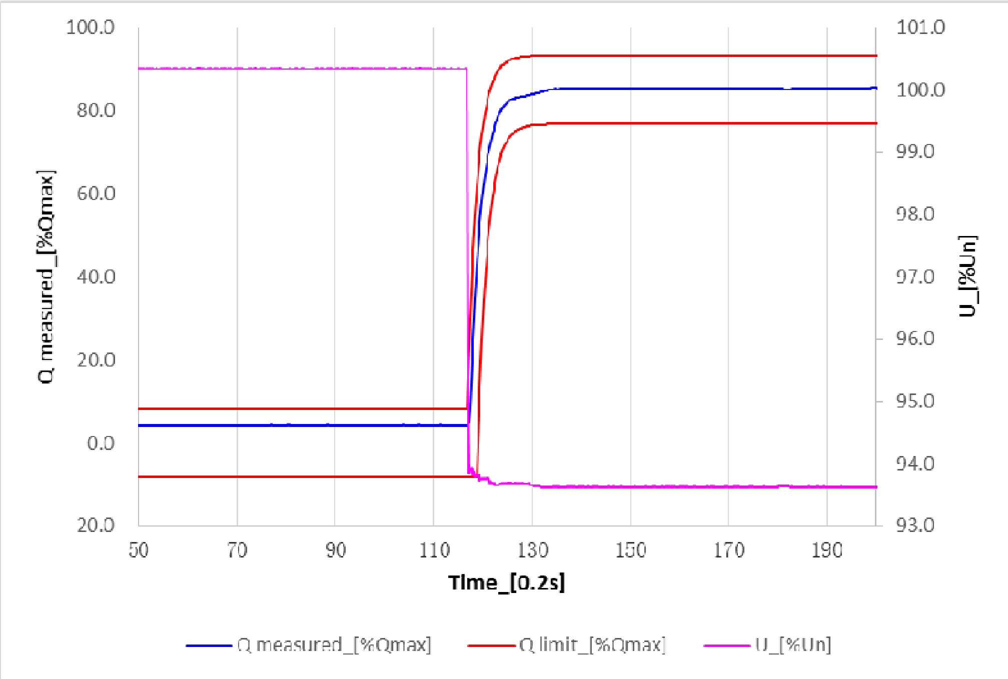
Graph of 100% U_n to 93,6% U_n: Test 1



Graph of 100% U_n to 93,6% U_n: Test 2



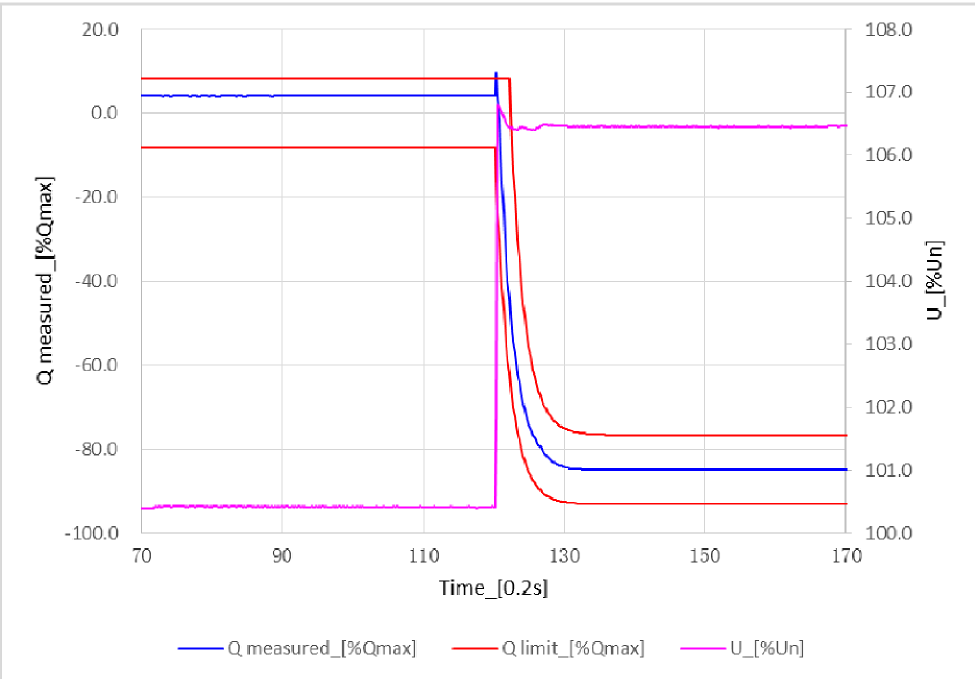
Graph of 100% U_n to 93,6% U_n: Test 3



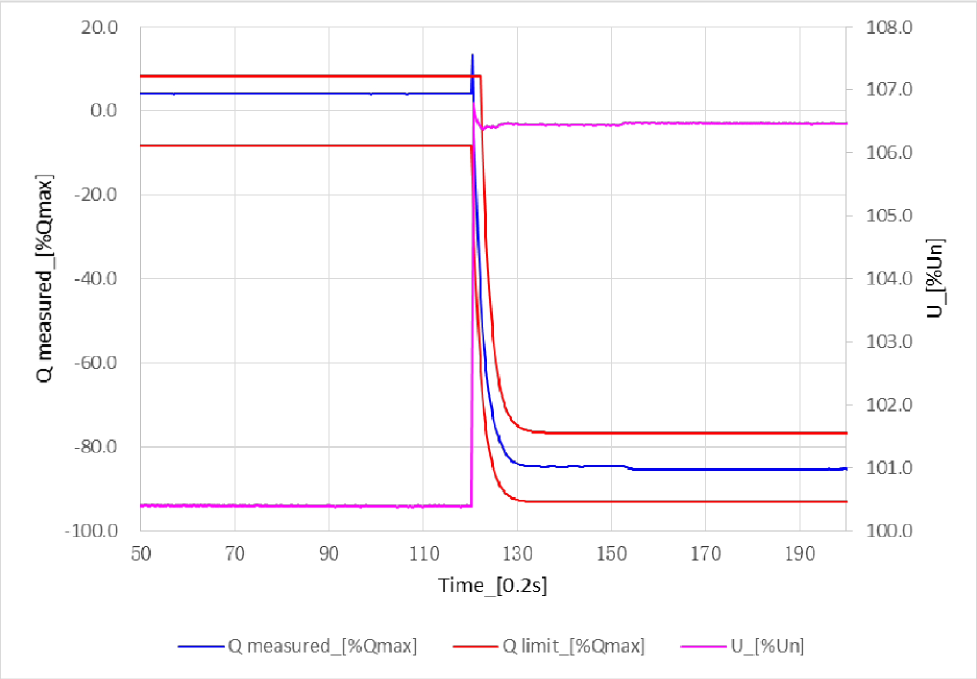
5.4.8.3.2	Test of the dynamics of the Q (U) regulation		P
HYD 5KTL-3PH			
Voltage jump Vac [% U_n]	Q [kVar] measured	Q [%Qmax] measured	T=3τmeasured
100 to 106,4	-2,086	-86,136	7,0 s
	-2,069	-85,442	7,0 s
	-2,079	-85,846	7,0 s
100 to 93,6	2,044	84,418	9,4 s
	2,055	84,876	9,4 s
	2,036	84,096	9,4 s

Note:
The test had been performed on the model HYD 20KTL-3PH and HYD 5KTL-3PH the test results are valid for the HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

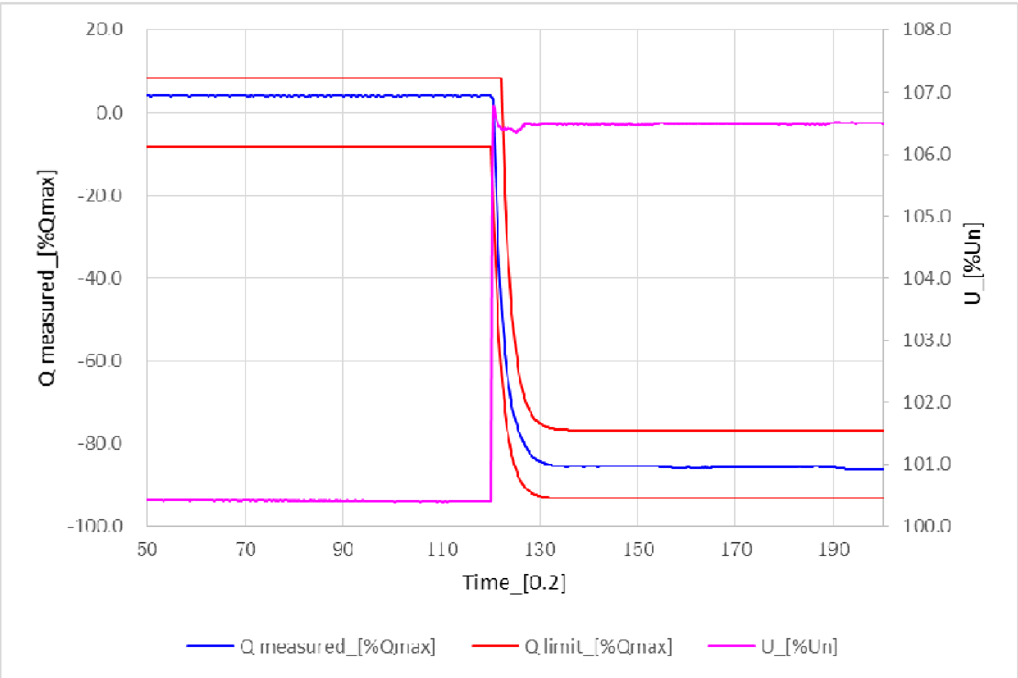
Graph of 100% U_n to 106,4% U_n: Test 1



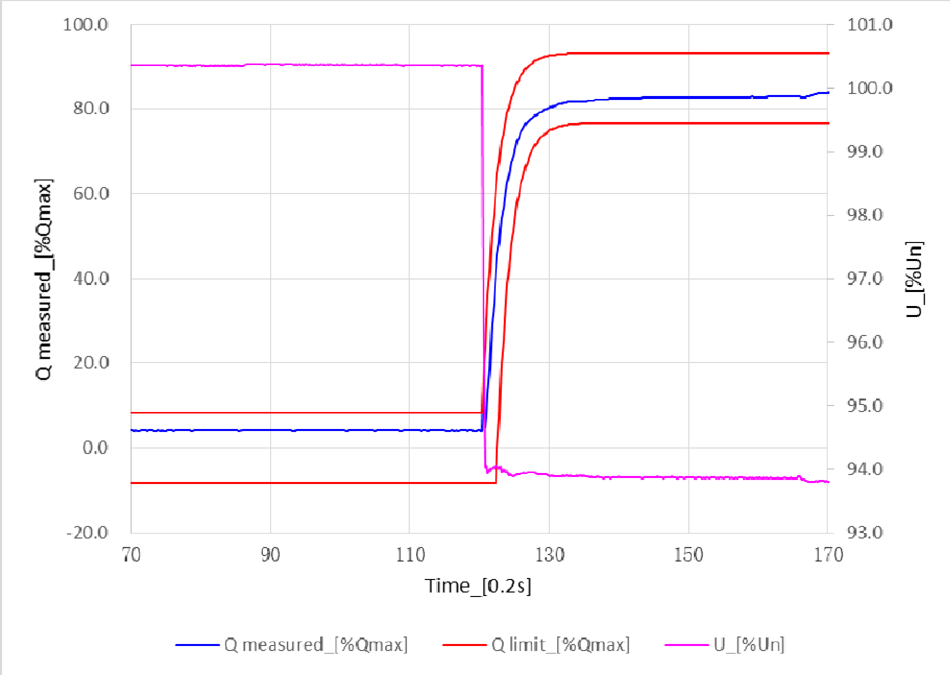
Graph of 100% U_n to 106,4% U_n: Test 2



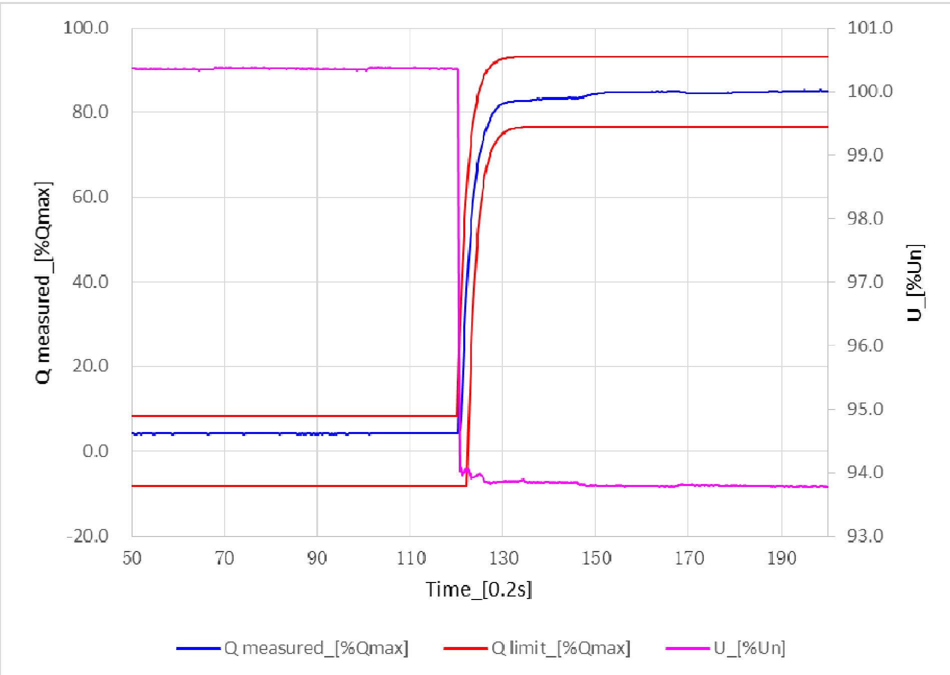
Graph of 100% U_n to 106,4% U_n: Test 3



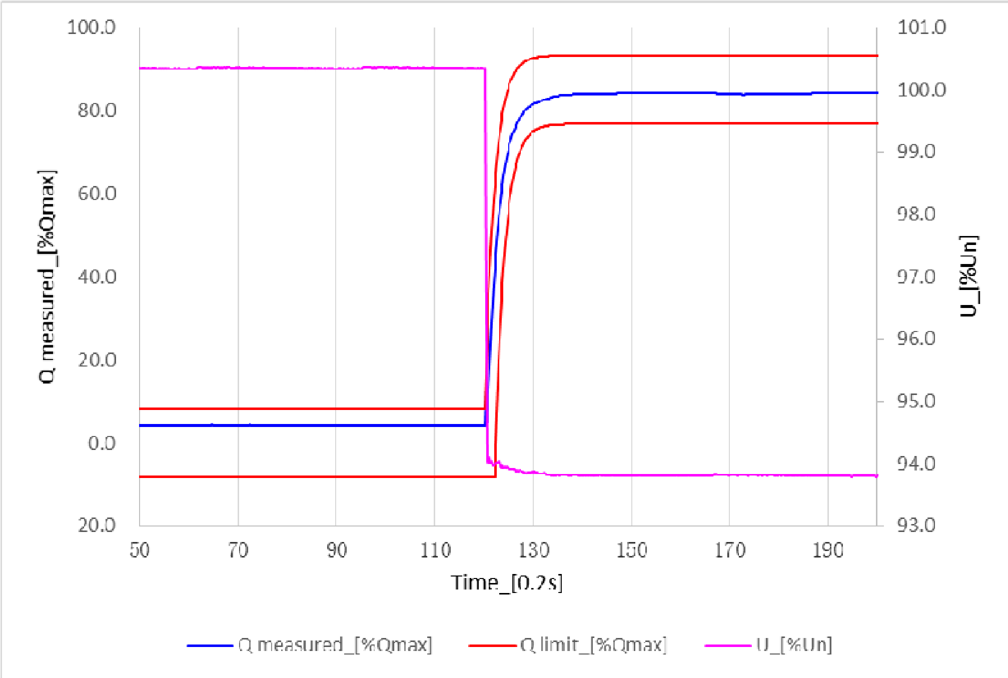
Graph of 100% U_n to 93,6% U_n: Test 1



Graph of 100% U_n to 93,6% U_n: Test 2



Graph of 100% U_n to 93,6% U_n: Test 3



5.5 Testing of NS protection DIN VDE V 0124-100:2020-06		
Clause	**Test**	**Result**
5.5.1	General	**P**
5.5.2.1	Functional safety	**P**
5.5.4	Integrated NS-protection	**P**
5.5.6	Section switch	**P**
5.5.6.2	Central section switch	**N/A**
5.5.6.3	Integrated section switch	**P**
5.5.7.2	Voltage control Single Phase	**N/A**
5.5.7.2	Voltage control Multi Phase (Phase to N)	**P**
5.5.7.2	Voltage control Multi Phase (Phase to Phase)	**N/A**
5.5.7.2.1.3	Measuring the rise-in voltage protection as a running 10-minute mean value	**P**
5.5.7.2.1.9	Frequency measurement	**P**
5.5.8	Reporting of NS protection	**P**
5.5.9	Constructional characteristics of NS protection	**P**
5.5.10.2	Passive Islanding Protection	**N/A**
5.5.10.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	**P**
5.5.10.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 66%)	**P**
5.5.10.3	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (EUT ouput = 33%)	**P**

5.5.2.1 Functional safety								P
Component No.	Fault	Test condition: AC	Test condition: DC	Test time	Fuse no.	Fault condition AC	Fault condition DC	Result
Relay defect RL1 pin4-pin3	Short before start up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate Relay fault,error code"ID41"(RelayFail). Do not connect to AC mainsn. No damage,no hazards.
Relay defect RL2 pin4-pin3	Short before start up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate Relay fault,error code"ID41"(RelayFail). Do not connect to AC mainsn. No damage,no hazards.
Relay defect RL3 pin4-pin3	Short before start up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate Relay fault,error code"ID41"(RelayFail). Do not connect to AC mainsn. No damage,no hazards.
Relay defect RL4 pin4-pin3	Short before start up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate Relay fault,error code"ID41"(RelayFail). Do not connect to AC mainsn. No damage,no hazards.
Relay defect RL5 pin4-pin3	Short before start up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate Relay fault,error code"ID41"(RelayFail). Do not connect to AC mainsn. No damage,no hazards.
Relay defect RL6 pin4-pin3	Short before start up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate Relay fault,error code"ID41"(RelayFail). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R137	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code"ID02"(GridUVP). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R 140	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code"ID01"(GridOVP). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R157	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code"ID02"(GridUVP). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R 159	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code"ID01"(GridOVP). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R152	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code"ID02"(GridUVP). Do not connect to AC mainsn. No damage,no hazards.

Grid voltage monitoring R 155	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code“ID01”(GridOVP). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R147	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code“ID02”(GridUVP). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R 149	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid. error code“ID01”(GridOVP). Do not connect to AC mainsn. No damage,no hazards.
RCMU detect defect R 8	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate GFCI fault,error code”ID21”(GFCIDeviceFault(DC) , ID22”(GFCIDeviceFault(AC).Do not connect to AC mainsn.No damage,no hazards.
RCMU detect defect C171	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate GFCI fault, error code”ID21”(GFCIDeviceFault(DC) , “ID22”(GFCIDeviceFault(AC). Do not connect to AC mainsn. No damage,no hazards.
RCMU detect defect R 246	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate GFCI fault,error code”ID21”(GFCIDeviceFault(DC) , “ID22”(GFCIDeviceFault(AC). Do not connect to AC mainsn. No damage,no hazards.
RCMU detect defect R 244	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate GFCI fault,error code”ID29”(ConsistentFault_GFCI,The GFCI sampling value between the master DSP and slave DSP is not consistent). Do not connect to AC mainsn. No damage,no hazards.
RCMU detect defect R 249	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate GFCI fault,error code”ID29”(ConsistentFault_GFCI, The GFCI sampling value between the master DSP and slave DSP is not consistent). Do not connect to AC mainsn. No damage,no hazards.
RCMU detect defect C551	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate GFCI fault,error code”ID29”(ConsistentFault_GFCI, The GFCI sampling value between the master DSP and slave DSP is not consistent). Do not connect to AC mainsn. No damage,no hazards.
RCMU detect defect R 920	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate GFCI fault,error code”ID29”(ConsistentFault_GFCI, The GFCI sampling value between the master DSP and slave DSP is not consistent). Do not connect to AC mainsn. No damage,no hazards.

Current sensor defect C10	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate DCI fault,error code“ID18”(HwADFaultDCI). Do not connect to AC mainsn. No damage,no hazards.
Current sensor defect C 51	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate DCI fault,error code“ID18”(HwADFaultDCI). Do not connect to AC mainsn. No damage,no hazards.
Current sensor defect C102	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate DCI fault,error code“ID18”(HwADFaultDCI). Do not connect to AC mainsn. No damage,no hazards.
Current sensor defect R 57	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid current fault,error code“ID17”(HwADFaultIGrid). Do not connect to AC mainsn. No damage,no hazards.
Current sensor defect R 166	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate DCI fault,error code“ID18”(HwADFaultDCI). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R109	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 16,0A	850V 25,0A/ 25,0A	No fault. no damage.Offline –DCV is wrong.
Grid voltage monitoring R109	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 16,0A	850V 25,0A/ 25,0A	No fault.no damage. Offline –DCV is wrong.
Grid voltage monitoring R203	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code ”ID19”(HwADFaultVGrid(DC)), ”ID20”(HwADFaultVGrid(AC)). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R240	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code ”ID19”(HwADFaultVGrid(DC)), ”ID20”(HwADFaultVGrid(AC)). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring C541	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code”ID20”(HwADFaultVGrid(AC)). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring C539	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code”ID20”(HwADFaultVGrid(AC)). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring C540	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code”ID20”(HwADFaultVGrid(AC)). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R904	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code”ID19”(HwADFaultVGrid(DC)). Do not connect to AC mainsn. No damage,no hazards.
Grid voltage monitoring R905	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code“ID19”(HwADFaultVGrid(DC)). Do not connect to AC mainsn. No damage,no hazards.

Grid voltage monitoring R906	Open	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate Grid voltage fault,error code"ID19"(HwADFaultVGrid(DC)). Do not connect to AC mainsn. No damage,no hazards.
ISO detect defect R 132	Short before start-up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate ISO fault,error code"ID42"(PvIsoFault). Do not connect to AC mainsn. No damage,no hazards.
ISO detect defect R 77	Short before start-up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate ISO fault,error code"ID42"(PvIsoFault). Do not connect to AC mainsn. No damage,no hazards.
ISO detect defect R 125	Short before start-up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate ISO fault,error code"ID42"(PvIsoFault). Do not connect to AC mainsn. No damage,no hazards.
ISO detect defect R 136	Short before start-up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate ISO fault,error code"ID42"(PvIsoFault). Do not connect to AC mainsn. Q14 damage,no hazards.
ISO detect defect C705	Short before start-up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate ISO fault,error code"ID42"(PvIsoFault). Do not connect to AC mainsn. No damage,no hazards.
ISO detect defect C630	Short before start-up	230V 0,05A	850V 0,10A	10min.	--	230V 0,05A	850V 0,10A	Indicate ISO fault,error code"ID42"(PvIsoFault). Do not connect to AC mainsn. No damage,no hazards.
DSP communication defect R481	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate SCI fault,error code"ID154"(SciCommLose(AC)). Do not connect to AC mainsn. Q26 damage,no hazards.
DSP communication defect R484	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Indicate SCI fault,error code"ID153"(SciCommLose(DC)). Do not connect to AC mainsn. Q25 damage,no hazards.
Loss of control C287	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid,no error code. Do not connect to AC mainsn. No damage.No hazards.
Loss of control C277	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid,error code"ID33,ID34,ID153,ID154"(Spi CommLose DC/AC, SciCommLose DC/AC). Do not connect to AC mainsn. No damage.No hazards.
Loss of control C548	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid,error code"ID33,ID34,ID153,ID154"(Spi CommLose DC/AC, SciCommLose DC/AC). Do not connect to AC mainsn. No damage.No hazards.

Loss of control C679	Short	230V 16,0A	850V 25,0A/ 25,0A	10min.	--	230V 0,05A	850V 0,10A	Output a.c. relays operated, disconnected with grid,error code"ID33,ID34,ID153,ID154"(SpiCommLose DC/AC, SciCommLose DC/AC). Do not connect to AC mainsn. No damage.No hazards.

Note:

The errors in the control circuit simulate that the safety is even ensured during a single fault ,
s-c: short circuit; o-c: open circuit
* Before start-up ,

The test data is referred to test report no. 20TH0332-CEI0-21-1 issued on July 20, 2020.

The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

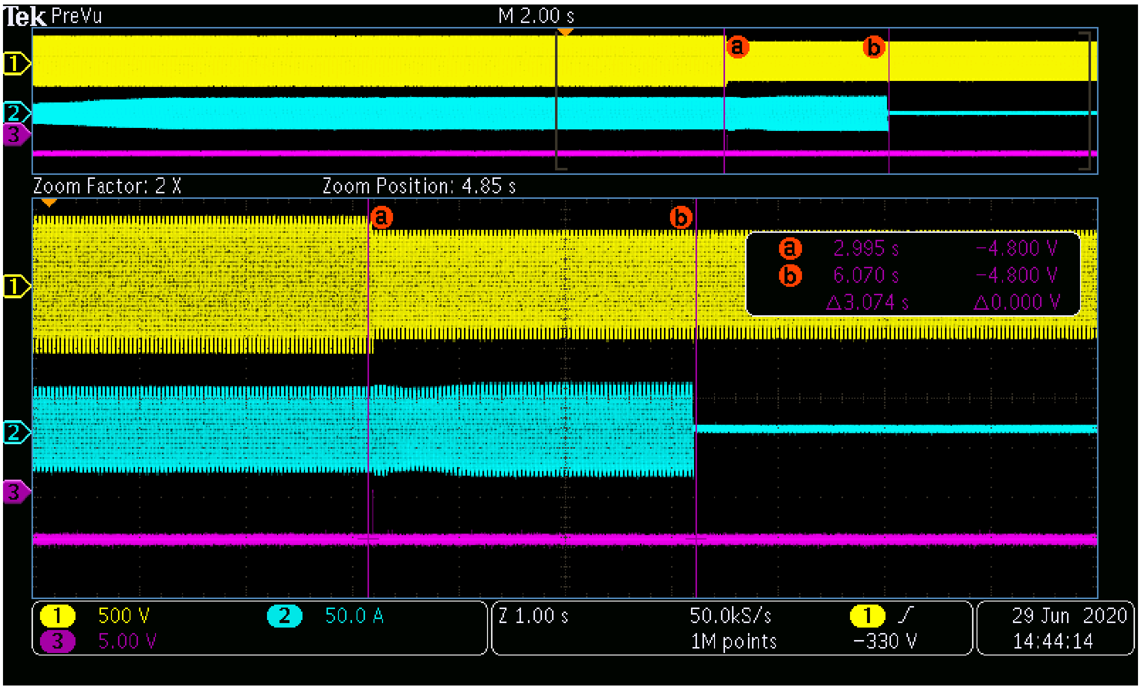
5.5.7.2 Voltage control						P
Integrated NS protection multi phase ≤30kVA (phase to neutral)						
Setting values of the NS protection:	Setting U< [V]:	184,0				
	Setting U>>[V]:	287,5				
	Setting $T_{disconnection}$ [ms]	/				
Operating time of the monitoring device:						
L1 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 294,5 V		
Limit [V]:	184,0 V			287,5 V		
Measurement [V:]	184,5	184,5	184,4	287,4	287,5	287,5
Limit [ms]:	≤ 3100 ms			≤ 200 ms		
Disconnection time [ms]:	3048,0	3048,0	3074,0	87,2	96,0	93,0
	Under voltage 2:					
Step [V to V]:	230,0 V to 96,6 V					
Limit [V]:	103,5 V					
Measurement [V:]	103,6	103,9	103,6			
Limit [ms]:	≤ 400 ms					
Disconnection time [ms]:	344,1	328,0	334,0			
L2 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 294,5 V		
Limit [V]:	184,0 V			287,5 V		
Measurement [V:]	184,4	184,5	184,5	287,4	287,3	287,6
Limit [ms]:	≤ 3100 ms			≤ 200 ms		
Disconnection time [ms]:	3038,0	3058,0	3074,0	94,4	93,2	96,0
	Under voltage 2:					
Step [V to V]:	230,0 V to 96,6 V					
Limit [V]:	103,5 V					
Measurement [V:]	103,1	103,2	103,1			
Limit [ms]:	≤ 400 ms					
Disconnection time [ms]:	352,1	336,0	340,0			

L3 to N:						
	Under voltage 1:			**Over voltage 1:**		
Step [V to V]:	230,0 V to 177,1 V			230,0 V to 294,5 V		
Limit [V]:	184,0 V			287,5 V		
Measurement [V:]	184,4	184,6	184,3	286,7	287,2	286,9
Limit [ms]:	≤ 3100 ms			≤ 200 ms		
Disconnection time [ms]:	3084,0	3058,0	3048,0	94,8	99,6	91,0
	Under voltage 2:					
Step [V to V]:	230,0 V to 96,6 V					
Limit [V]:	103,5 V					
Measurement [V:]	103,9	103,8	102,8			
Limit [ms]:	≤ 400 ms					
Disconnection time [ms]:	334,1	346,0	344,0			

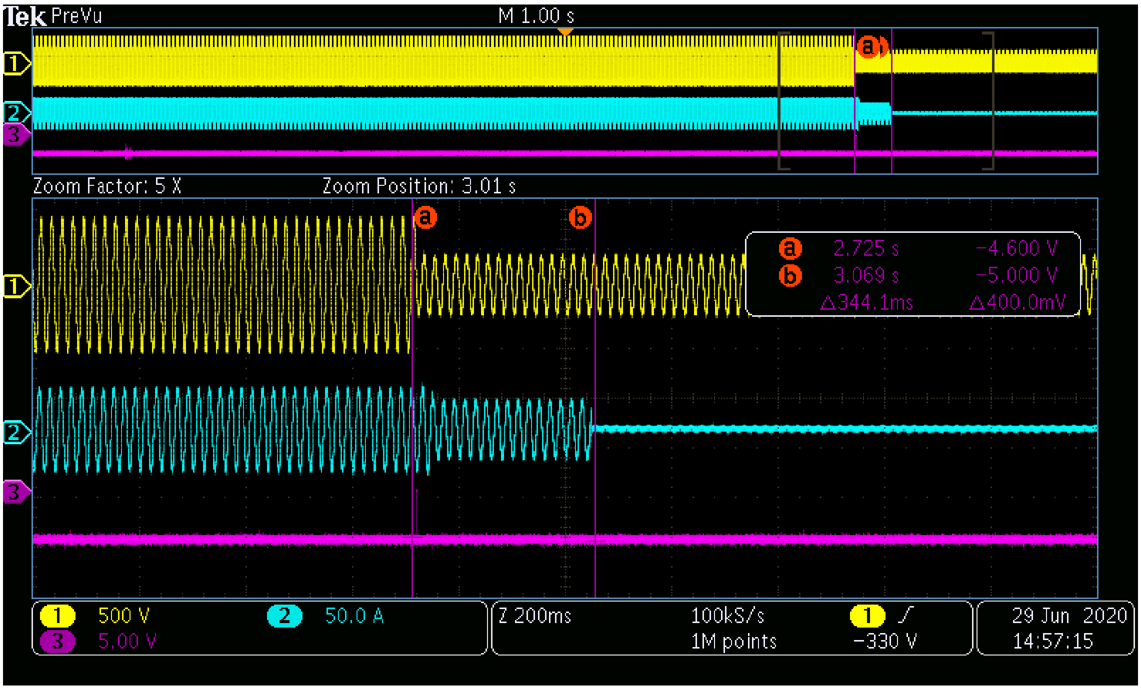
Note:
The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1% of U_n ,
The disconnection time includes disconnect time + operate time of the integrated relay , Therefore limit is give with +100ms according to Table 2 set values of the NS-protection according to VDE AR-N 4105:2018 ,

The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

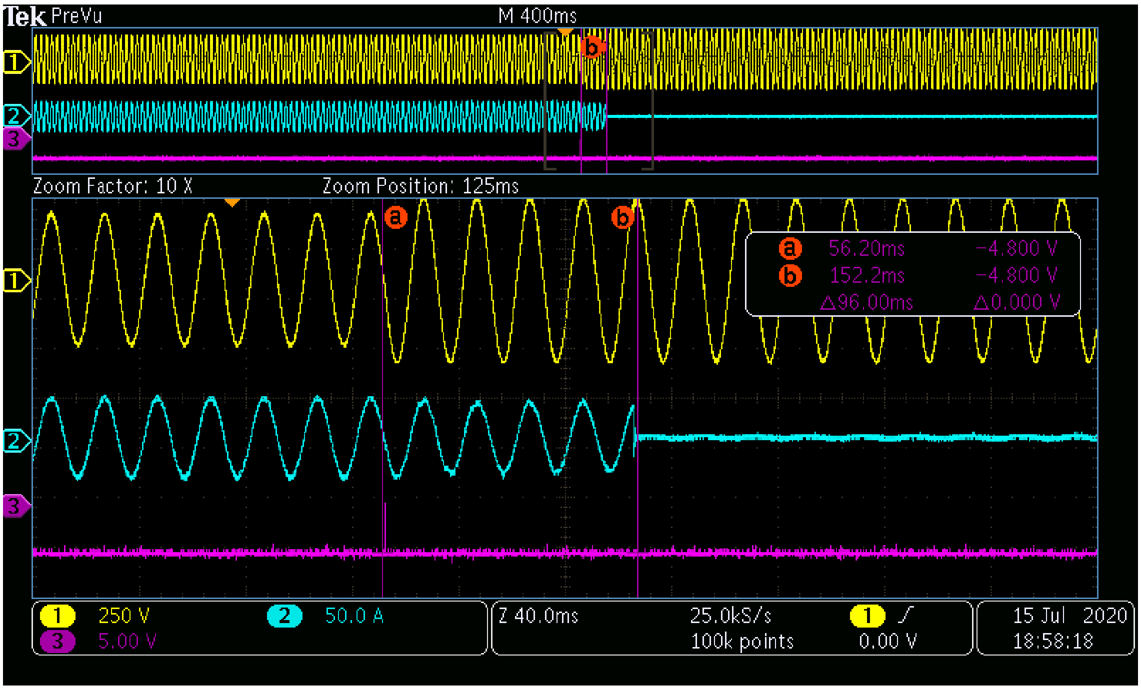
Under voltage 1 L1 to N:



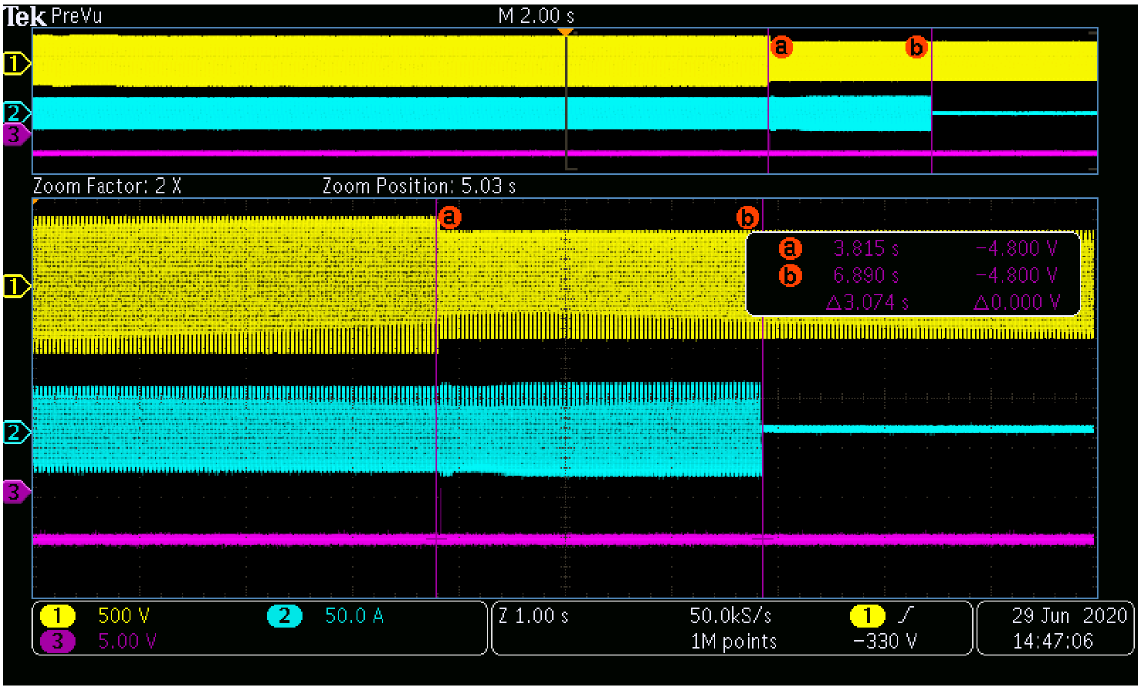
Under voltage 2 L1 to N:



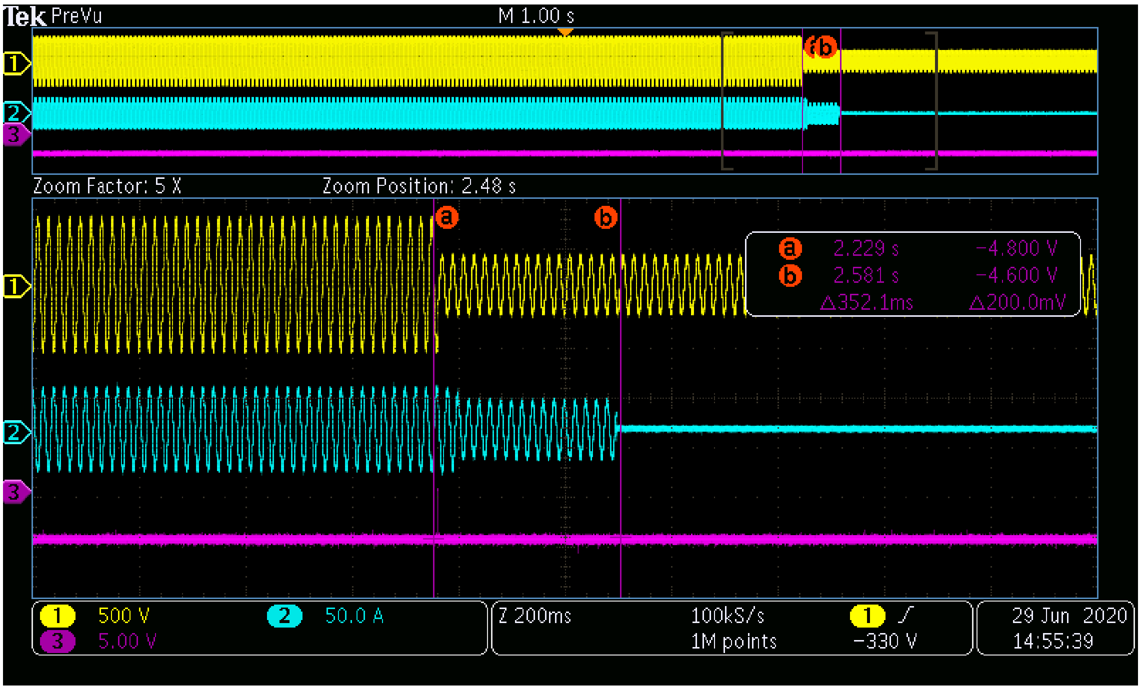
Over voltage L1 to N:



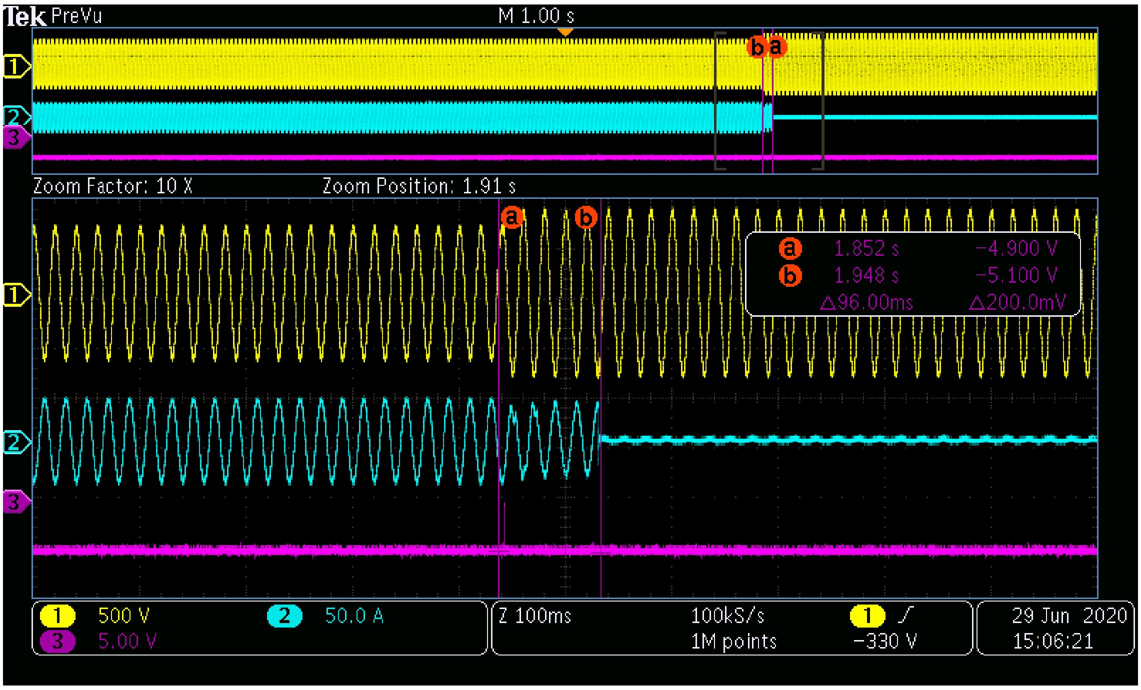
Under voltage 1 L2 to N



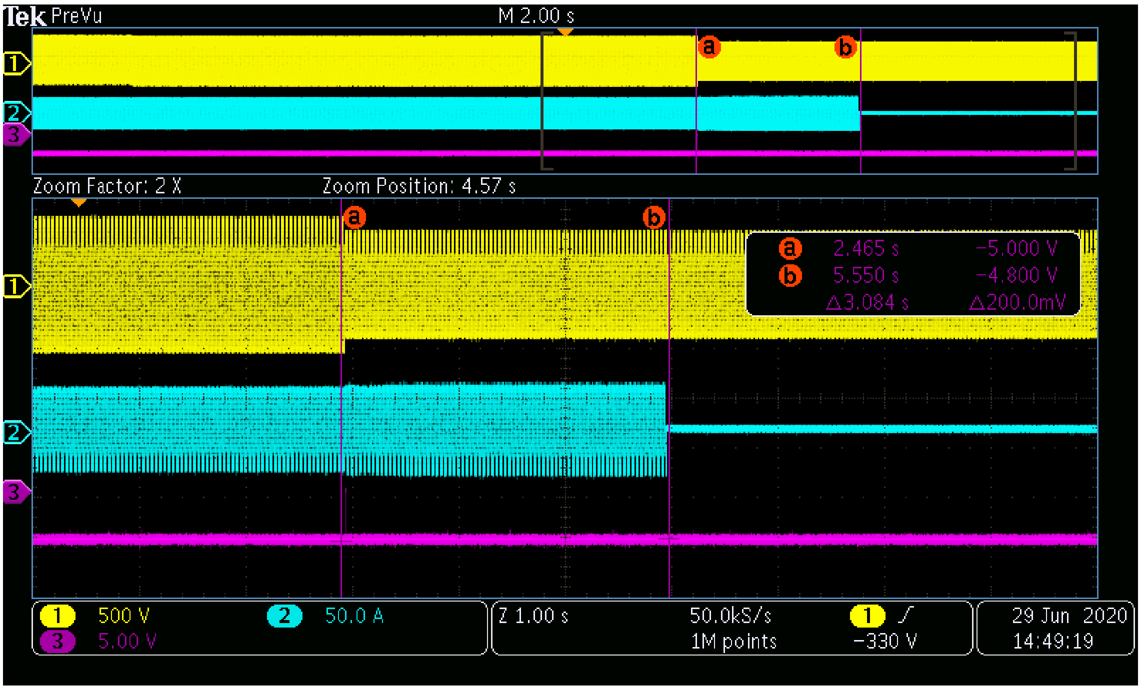
Under voltage 2 L2 to N



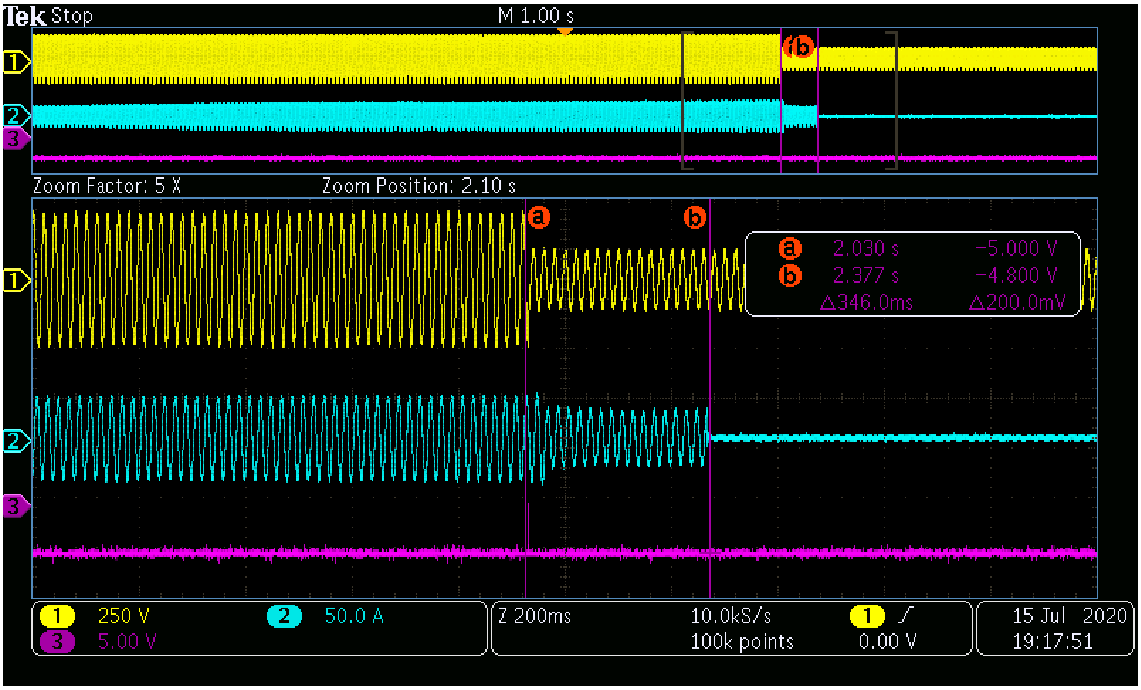
Over voltage L2 to N:



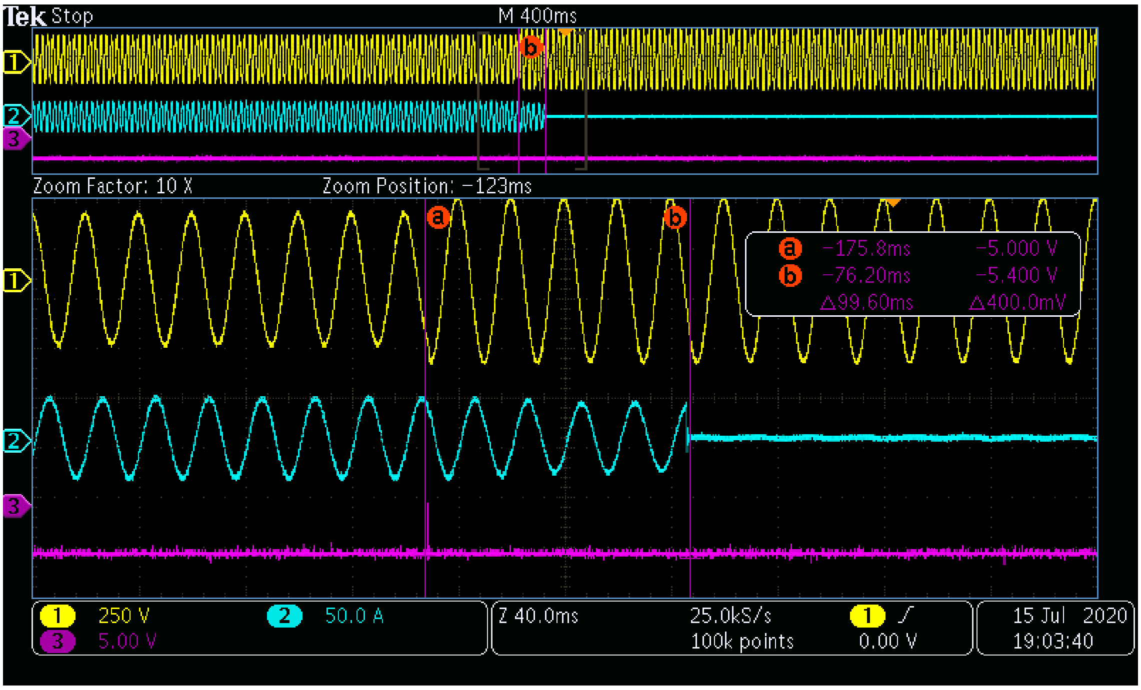
Under voltage 1 L3 to N:



Under voltage 2 L3 to N:



Over voltage L3 to N:



5.5.7.2.1.3 Measuring the rise-in voltage protection as a running 10-minute mean value			P
Test:			
		Disconnection time:	Limit:
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:	496 s	600 s
	Phase 2:	489 s	
	Phase 3:	469 s	
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:	No disconnection	
	Phase 3:	No disconnection	
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:	302 s	300 s
	Phase 2:	287 s	
	Phase 3:	268 s	

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 10 minute running mean value ,

Assessment criterion:

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

Limit values:

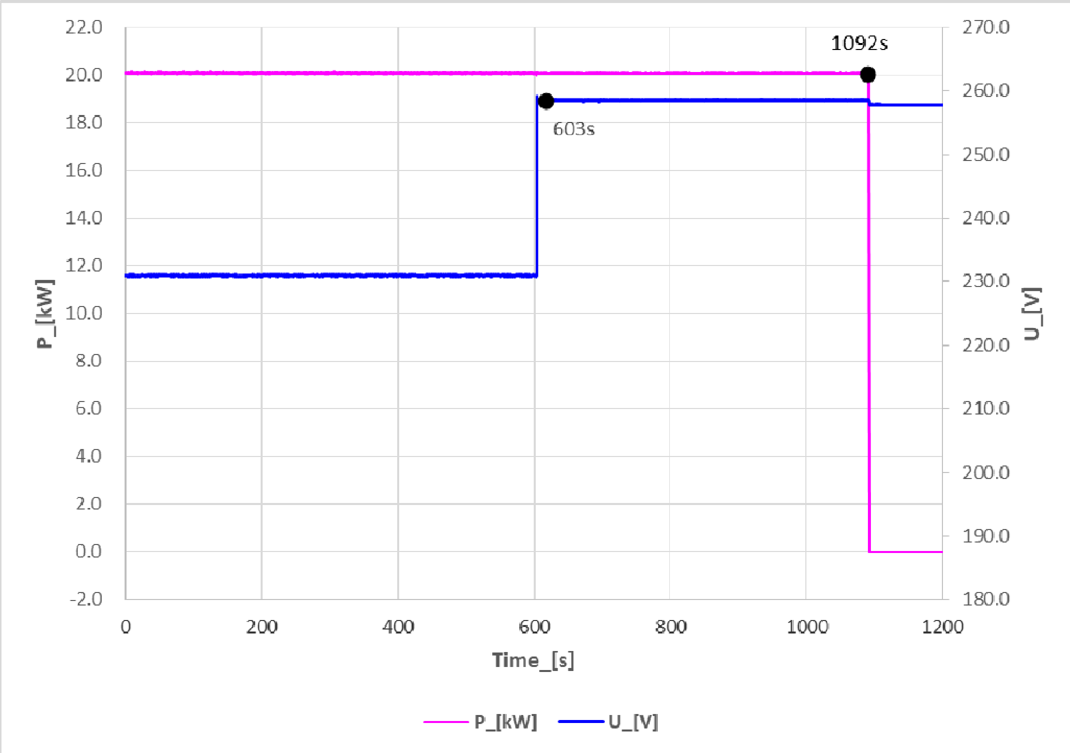
Rise-in voltage protection U>1,1 U_n after a max. 600 s, the switch off after 200 ms ,

Note:

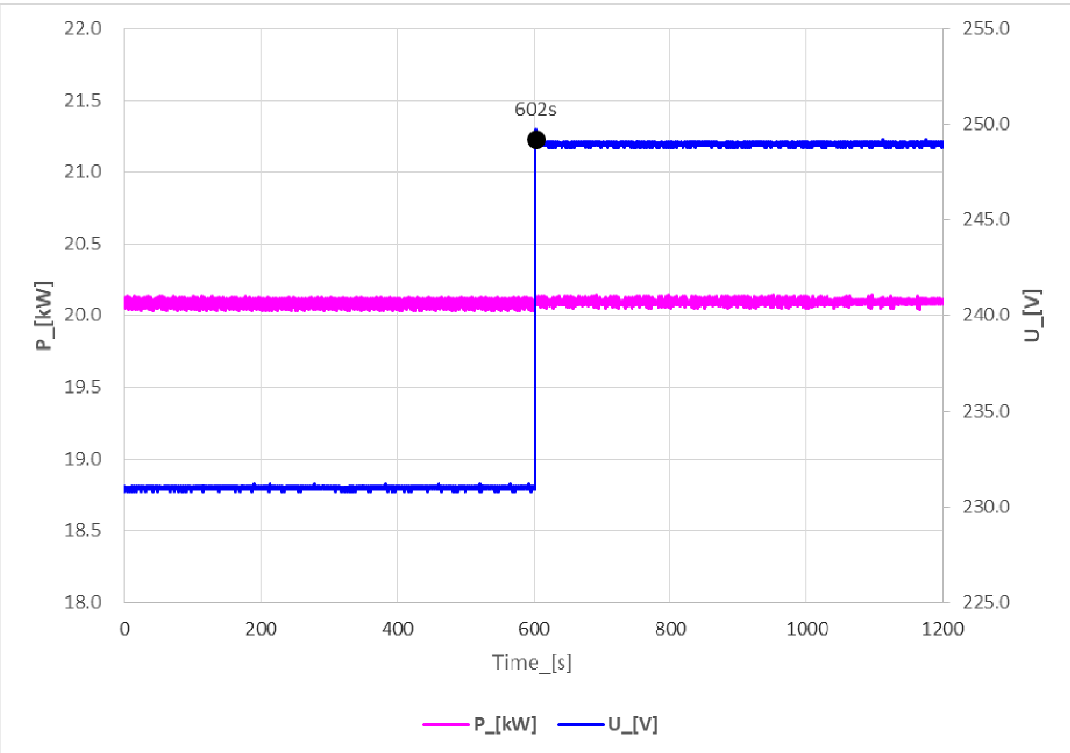
If only one integrated NS protection is used for the power generation systems ≤30kVA, the value of the rise-in voltage protection U> of 1,1 U_n may not be changed ,

The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

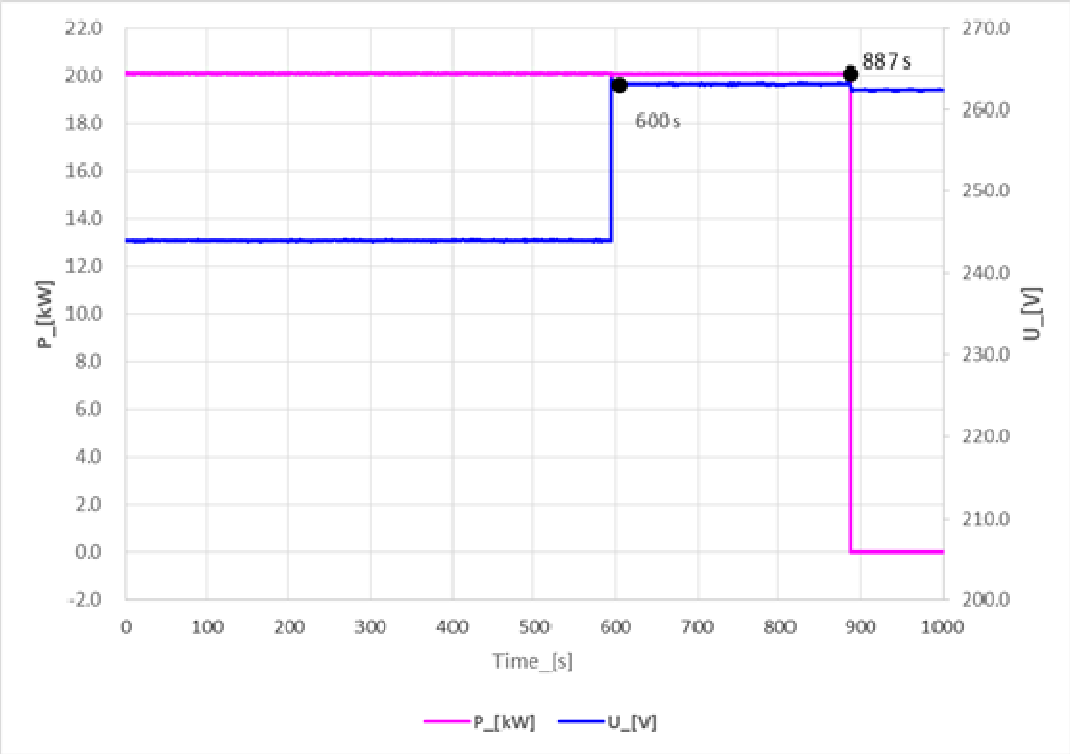
Graph of test a) Voltage set to 112 % Uₙ:



Graph of test b) Voltage set to 108 % Uₙ:



Graph of test c) Voltage set to 106 % U_n, thereafter 114% U_n:



5.5.7.2.1.9 Frequency measurement						P
Setting values of the NS protection:	Setting f< [Hz]:		47,50			
	Setting f>[Hz]:		51,50			
	Setting $T_{disconnection}$ [ms]		/			
Operating time of the monitoring device						
	Under frequency:			**Over frequency:**		
Jump [Hz to Hz]:	47,70 Hz -> 47,30 Hz			51,30 Hz -> 51,70 Hz		
Limit [Hz]:	47,50 Hz			51,50 Hz		
Measurement [Hz]:	47,50	47,50	47,50	51,50	51,50	51,50
Limit [ms]:	≤ 200 ms			≤ 200 ms		
Disconnection time [ms]:	94,3	92,3	92,7	99,0	96,7	91,9

Test:
Testing of the frequency over protection f> and of the under frequency protection f <.

a) The frequency must be set to f_n 50.0 Hz and kept. A jump to 51.3 Hz must be performed and held for 60 sec. Afterwards, a jump to 51.7 Hz must be performed and held.
b) The frequency must be set to f_n 50.0 Hz and kept. A jump to 47.7 Hz must be performed and held for 60 sec. Afterwards, a jump to 47,3 Hz must be performed and held.

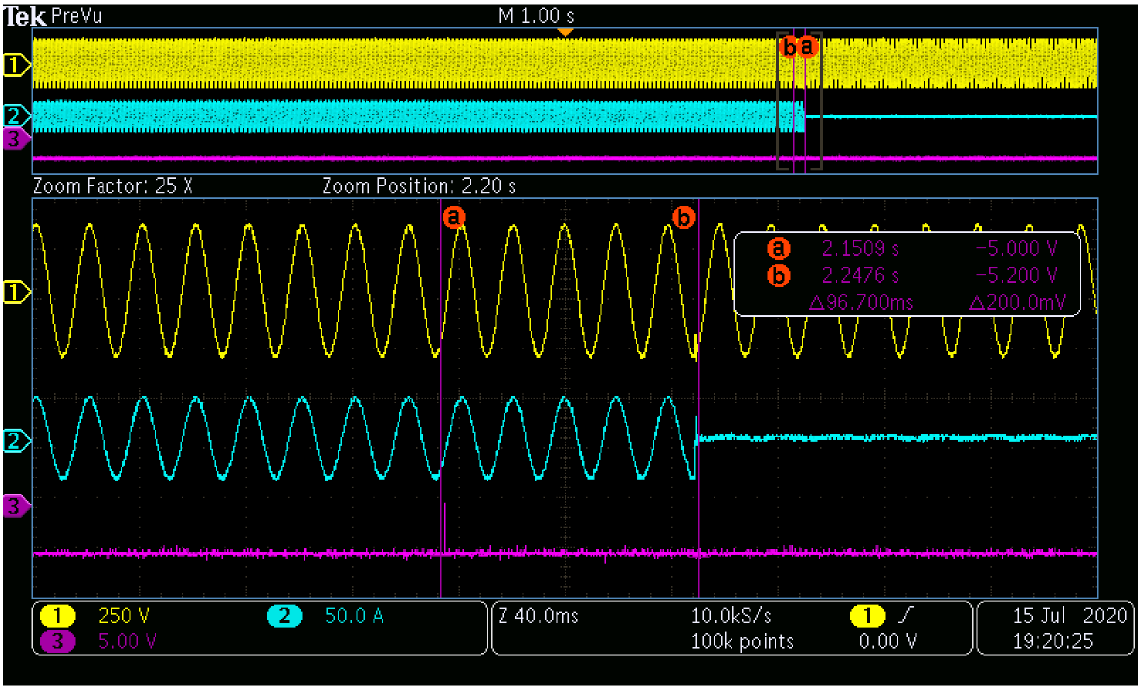
Assessment criteria:
The Test is passed if

a) after the jump to 51.3 Hz no shutdown has taken place and after the jump to 51.7 Hz, a shutdown within 200ms is done.
b) after the jump to 47.7 Hz no shutdown has taken place and after the jump to 47.3 Hz, a shutdown within 200ms is done

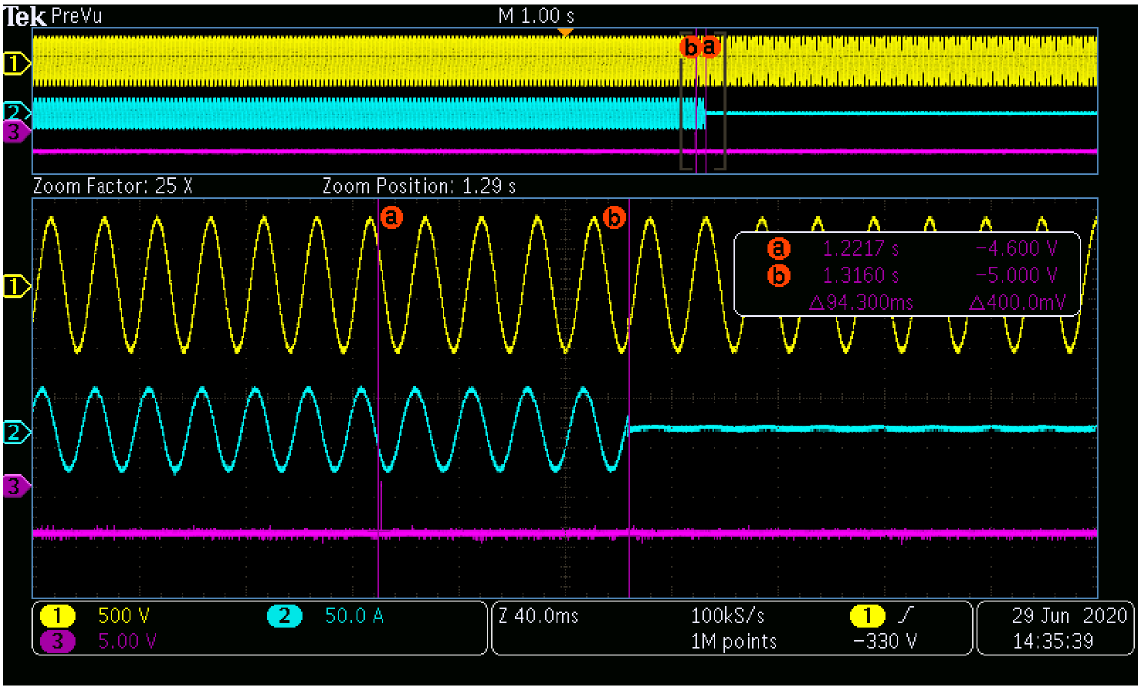
Note:
The setting value and the trip value of the frequency may not vary by more than ±0.1 % f_n ,

The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

Under frequency:



Over frequency:



5.5.8 Reporting NS protection	P
The last 5 dated failure reports on the NS protection can be read , An interruption in the supply voltage of ≤ 3s does not result in any loss of failure reports. Central NS protection: It is possible to read the setting values and the failure reports of the NS protection independently of the operational state and without any additional aids. Integrated NS protection: It is possible to read out the values of the NS protection via the data interface, if the values are not directly readable.	
Note:	

5.5.10 Islanding detection (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6 ,5 ,3 are met)
For power generation systems, islanding detection must be carried out using one of the following processes: a) active method, e ,g , by means of frequency – shift process (oscillating circuit) b) passive method with the help of the three-phase voltage control (only possible for power generation systems without converters or for single-phase generation units with converters) , (see 5 ,4 ,5 ,3 3-phase voltage control) With the passive process, it is important to provide evidence that the power generation unit can be set not equal to 120° ,

5.5.10.3 Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)	P

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]	Remarks5)
1	100	100	0	0	0,156	6,630	738	1,000	544	BL
8	100	100	-5	-5	1,559	6,630	738	1,026	404	IB
9	100	100	-5	0	1,597	6,630	738	1,053	436	IB
10	100	100	-5	+5	1,559	6,630	738	1,079	410	IB
13	100	100	0	-5	0,192	6,630	738	0,975	482	IB
14	100	100	0	+5	0,192	6,630	738	1,025	510	IB
17	100	100	+5	-5	1,632	6,630	738	0,929	412	IB
18	100	100	+5	0	1,597	6,630	738	0,953	442	IB
19	100	100	+5	+5	1,632	6,630	738	0,976	414	IB

Parameter at 0% per phase	L= 25,40 mH	R= 7,98 Ω	C= 398,94 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:

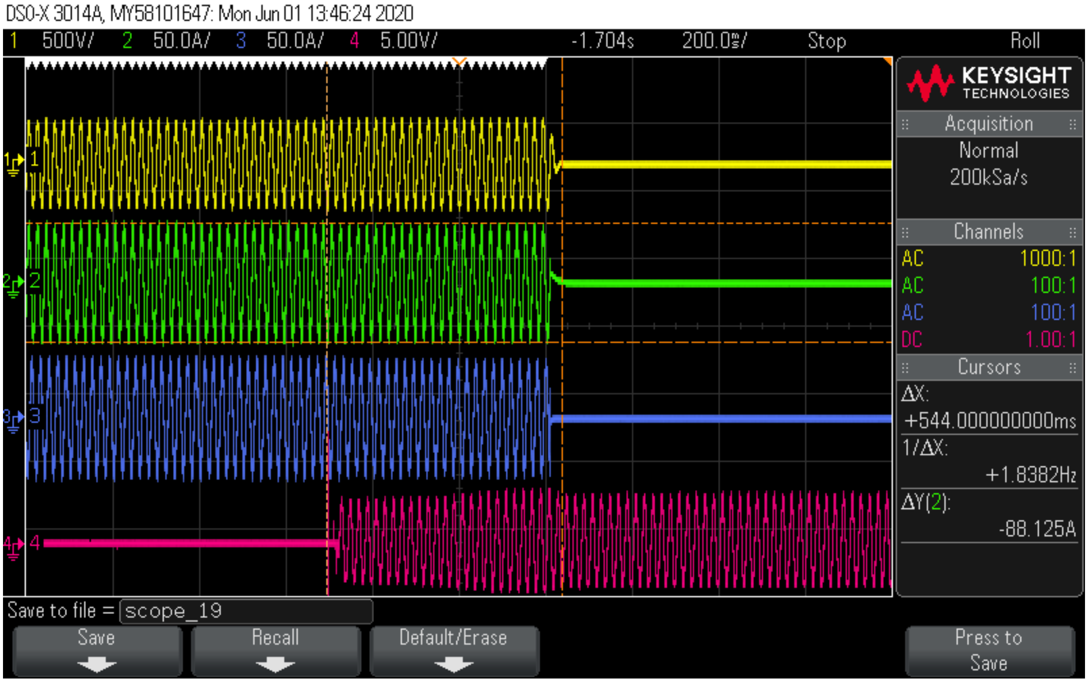
EUT output power P_{EUT} = Maximum 6)

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 test had been performed on the model SE 30KTL-D3 the test results are valid for the SE 28KTL-D3, SE 25KTL-D3, SE 22KTL-D3, SE 20KTL-D3 and SE 17KTL-D3 since it is identical in hardware and just power derated by software.

Scope pictures of the disconnection time
Disconnection at No, 1


5.5.10.3 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)	P

Test :

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]	Remarks5)
1	66	66	0	-5	0,147	4,385	490	0,974	418	IB
2	66	66	0	-4	0,138	4,385	490	0,979	430	IB
3	66	66	0	-3	0,131	4,385	490	0,984	444	IB
4	66	66	0	-2	0,126	4,385	490	0,989	446	IB
5	66	66	0	-1	0,123	4,385	490	0,994	462	IB
6	66	66	0	0	0,122	4,385	490	0,999	496	BL
7	66	66	0	+1	0,123	4,385	490	1,004	490	IB
8	66	66	0	+2	0,125	4,385	490	1,009	468	IB
9	66	66	0	+3	0,130	4,385	490	1,014	458	IB
10	66	66	0	+4	0,136	4,385	490	1,019	452	IB
11	66	66	0	+5	0,145	4,385	490	1,024	404	IB

Parameter at 0% per phase	L= 38,44 mH	R= 12,06 Ω	C= 263,59 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,

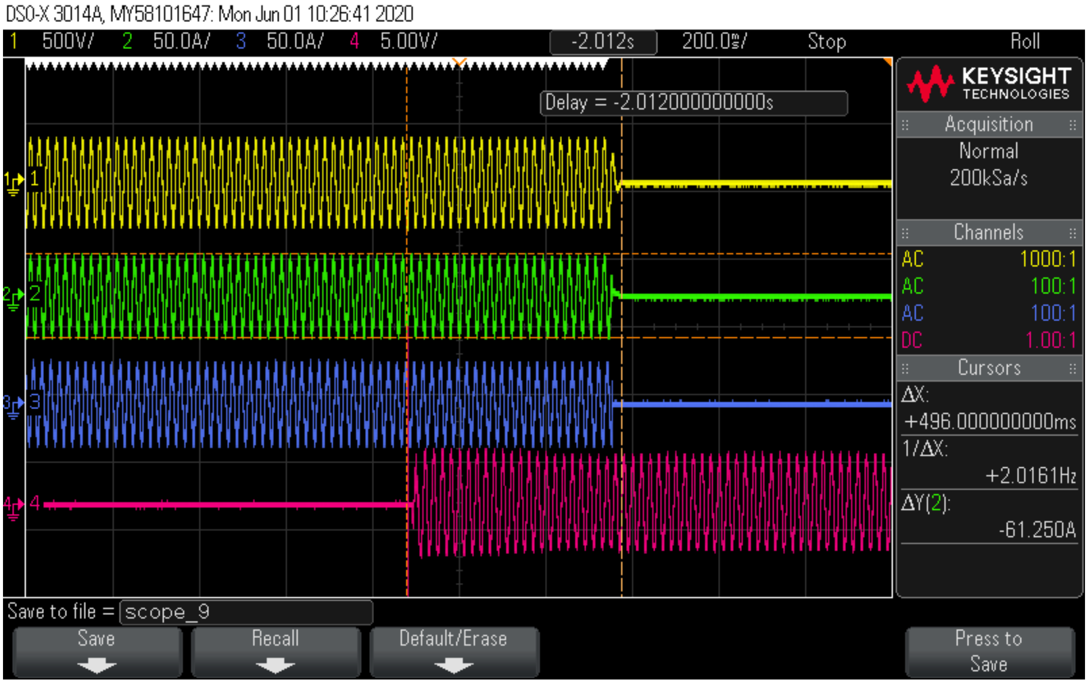
Condition B:

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,

Scope pictures of the disconnection time
Disconnection at No, 6



5.5.10.3 Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (EUT output = 25 % – 33 %)	P

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} [W per phase]	V_{DC} [V]	Q_f	Run on Time [ms]	Remarks5)
1	33	33	0	-5	0,195	2,205	242	0,974	380	IB
2	33	33	0	-4	0,191	2,205	242	0,979	442	IB
3	33	33	0	-3	0,187	2,205	242	0,984	448	IB
4	33	33	0	-2	0,185	2,205	242	0,989	466	IB
5	33	33	0	-1	0,183	2,205	242	0,994	482	IB
6	33	33	0	0	0,183	2,205	242	0,999	518	BL
7	33	33	0	+1	0,183	2,205	242	1,004	508	IB
8	33	33	0	+2	0,185	2,205	242	1,009	444	IB
9	33	33	0	+3	0,187	2,205	242	1,014	424	IB
10	33	33	0	+4	0,191	2,205	242	1,019	422	IB
11	33	33	0	+5	0,195	2,205	242	1,024	396	IB

Parameter at 0% per phase	L= 76,44 mH	R= 23,99 Ω	C= 132,55 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:

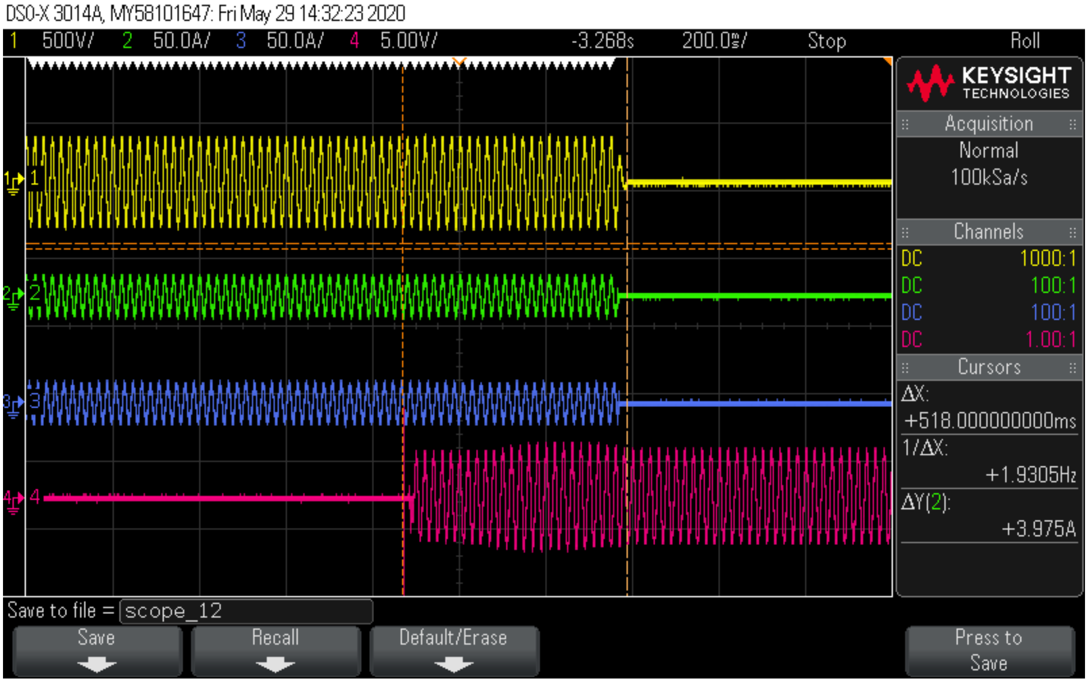
EUT output power P_{EUT} = 25 % – 33 % 6) of maximum

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 ,

Scope pictures of the disconnection time
Disconnection at No, 6



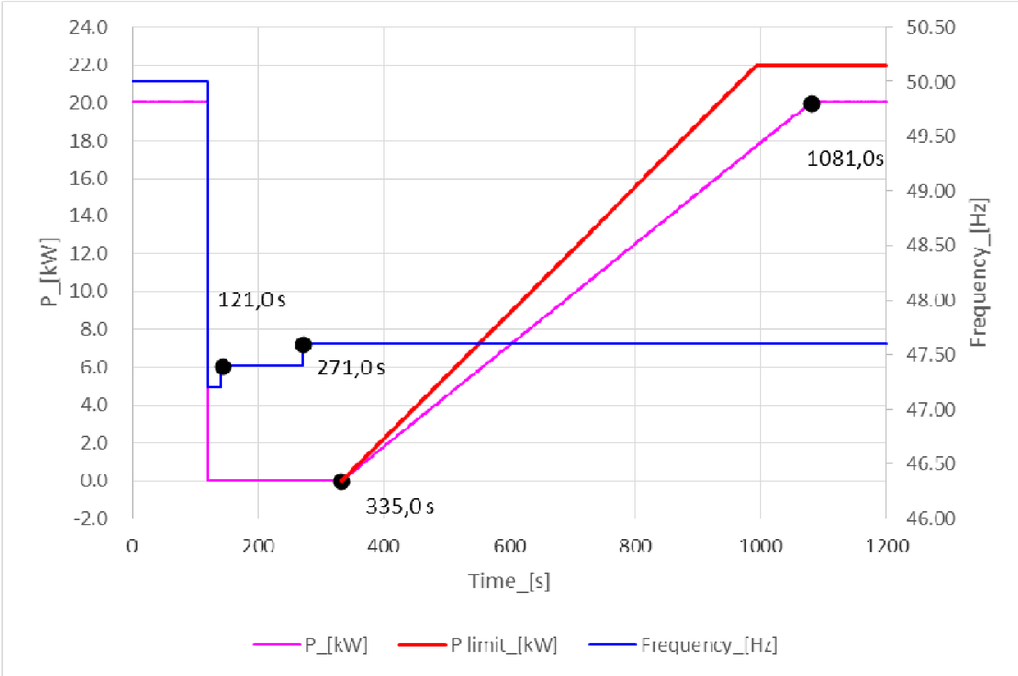
5.6 Connecting conditions and synchronization DIN VDE V 0124-100:2020-06		
Clause	**Test**	**Result**
5.6.1	General	**P**
5.6.2	Test	**P**

5.6	**Connecting conditions and synchronisation** (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 8.3.1 are met)		P
Setting values of the NS protection:	Setting $T_{reconnection\ 60s}$ [s]:	60	
	Setting f< [Hz]:	47,5	
	Setting f> [Hz]:	51,5	
	Setting V< [V]:	184,0	
	Setting V>> [V]:	264,5	

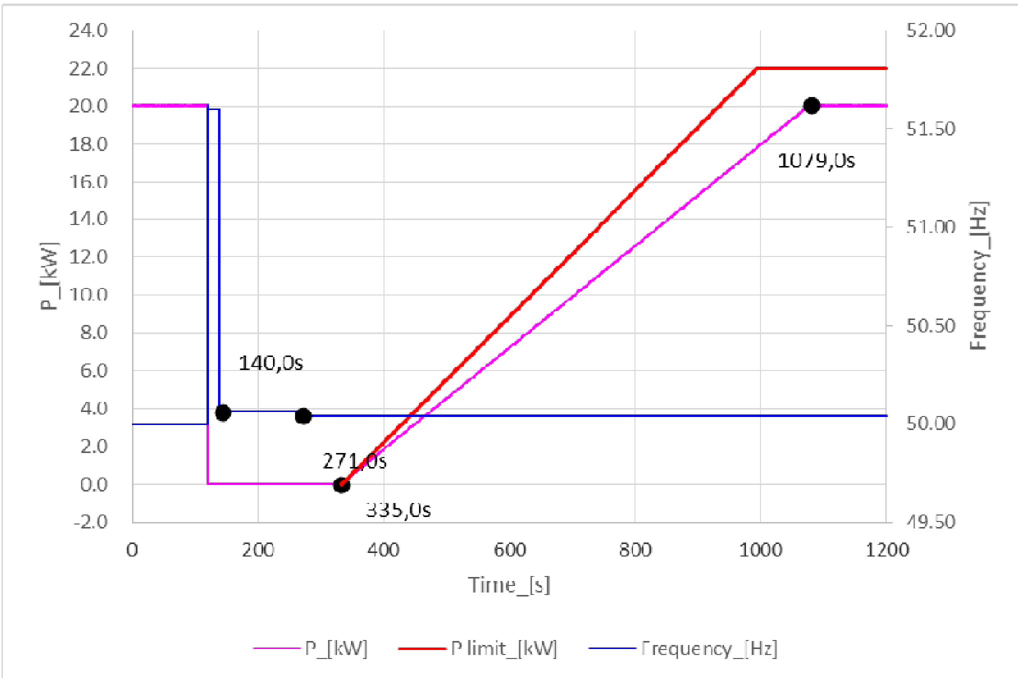
Test:			
	f_{ist}	**Reset time:**	**Limit:**
Connecting conditions for frequencies:			
a)	47,45 Hz	No reconnected ,	No resetting allowed
	Switch to:		
b)	≥ 47,55 Hz	64,0 s	≥ 60 s
c)	50,06 Hz	No reconnected ,	No resetting allowed
	Switch to:		
d)	≥ 50,0 Hz	127 s	≥ 60 s
Connecting conditions for voltages: L1 phase			
e)	84%	No reconnected ,	No resetting allowed
	Switch to:		
f)	≥ 86%	64,0 s	≥ 60 s
g)	111 %	No reconnected ,	No resetting allowed
	Switch to:		
h)	≤ 109%	64,0 s	≥ 60 s
Connecting conditions for voltages: L2 phase			
e)	84%	No reconnected ,	No resetting allowed
	Switch to:		
f)	≥ 86%	64,0 s	≥ 60 s
g)	111 %	No reconnected ,	No resetting allowed
	Switch to:		
h)	≤ 109%	63,0 s	≥ 60 s
Connecting conditions for voltages: L3 phase			
e)	84%	No reconnected ,	No resetting allowed
	Switch to:		
f)	≥ 86%	64,0 s	≥ 60 s
g)	111 %	No reconnected ,	No resetting allowed
	Switch to:		
h)	≤ 109%	64,0 s	≥ 60 s

Test: see points a) to h) for the test process , The measurement was carried out with a programmable AC source , e ,g , connecting conditions for frequencies: Point a) and b) , The AC source was programmed in such a way that the first step of 230 V / 50 Hz to 200 V / 47,0 Hz resulted in a faulty disconnection , Thereafter the voltage and frequency for 100 s is set to 215 V / 47,45 Hz , Switching on again is not permitted , After a lapse of 100 s the voltage is set to 230 V / 47,55 Hz , Setting again after 60 s is permitted ,
Assessment criterion: After actuating the NS protection it should be checked that the system can only be switched within the tolerance ranges ((85% $U_n \leq U \leq$ 110% U_n) and (47,5 Hz ≤ f ≤ 50,05Hz)) at the earliest after 60 s after voltage and frequency has remained within the tolerance ranges ,
Note: The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

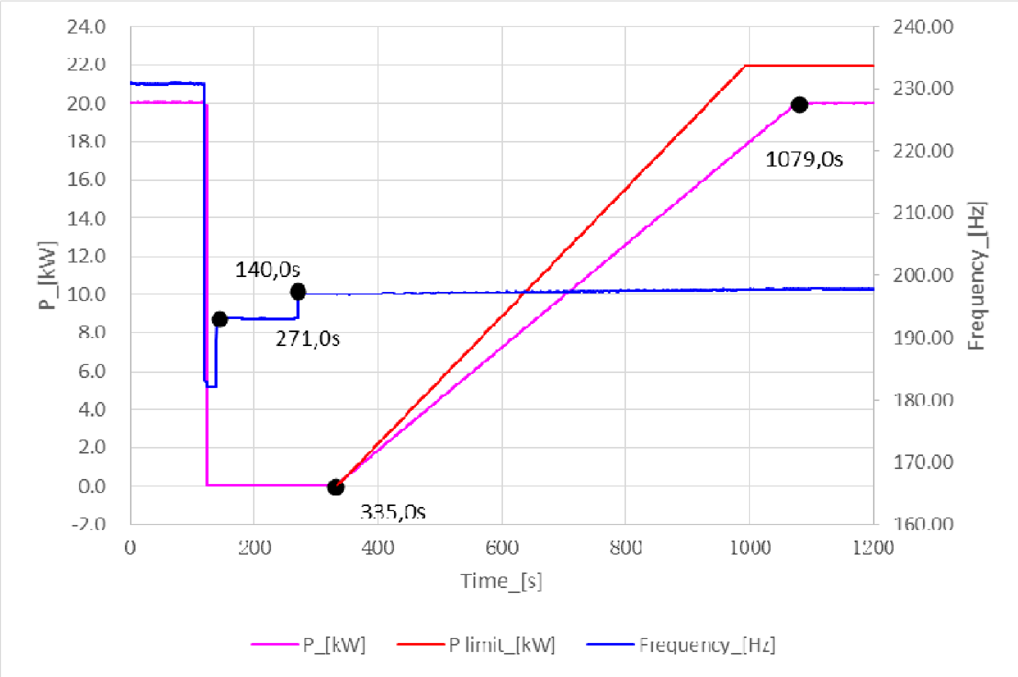
a) 47,50 Hz to b) ≥ 47,55 Hz:



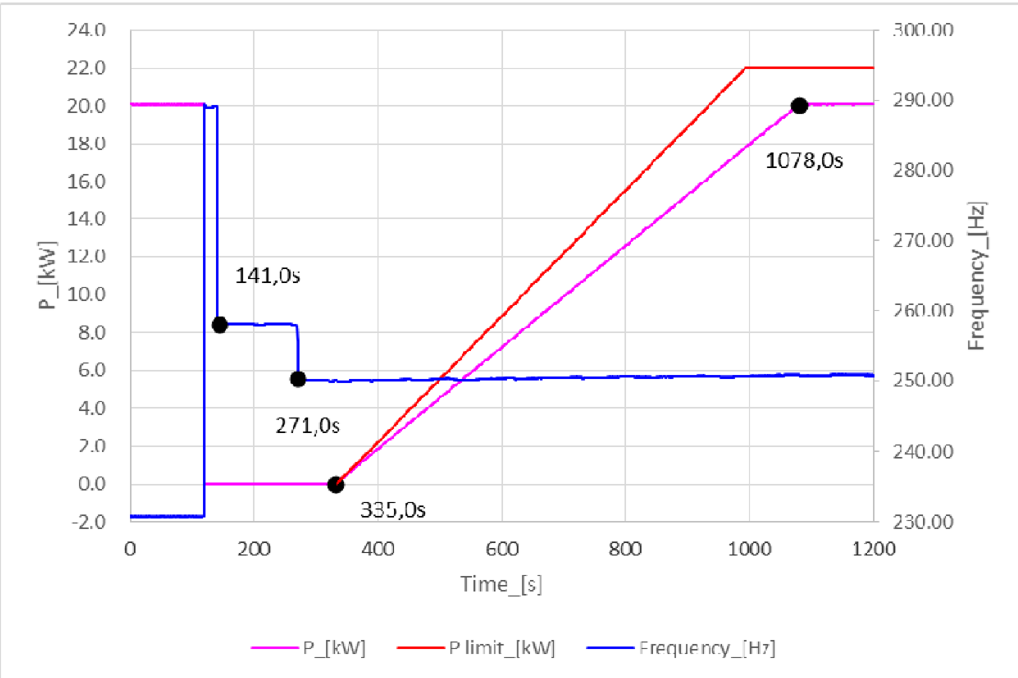
c) 50,10 Hz to d) ≤ 50,00 Hz:



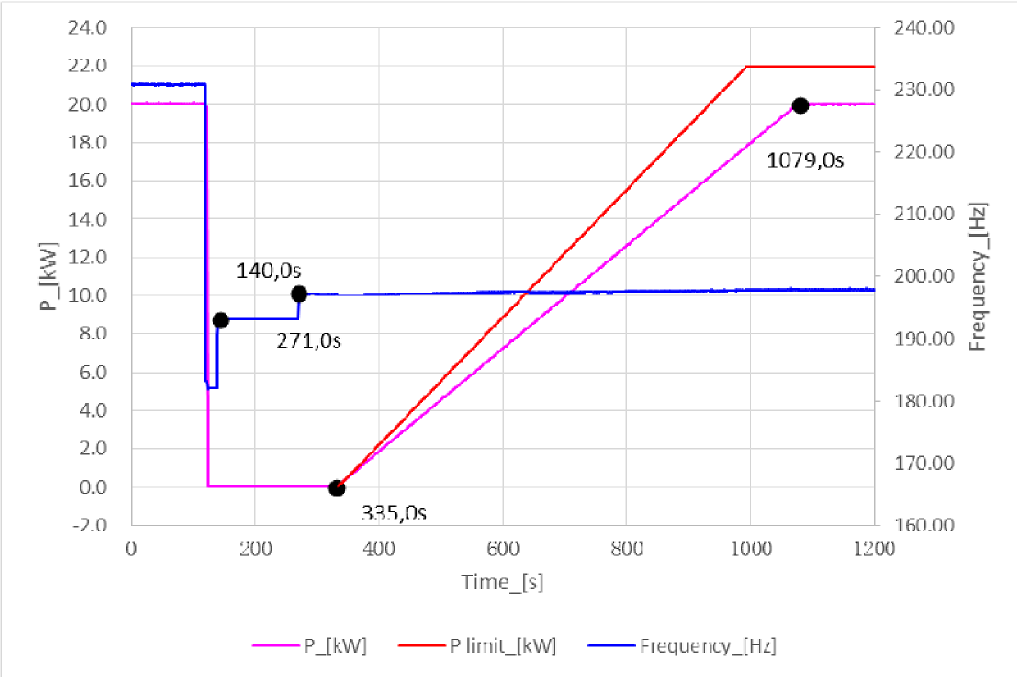
e) 84 % U_n to f) ≥ 86 % U_n: L1 phase



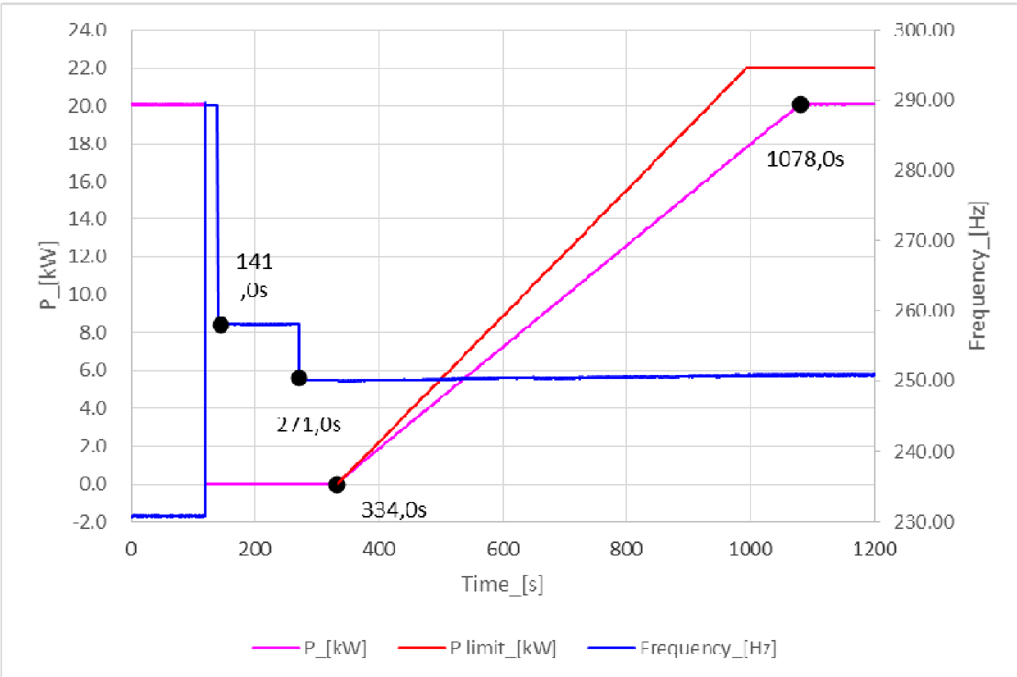
g) 111 % U_n to h) ≤ 109 % U_n: L1 phase



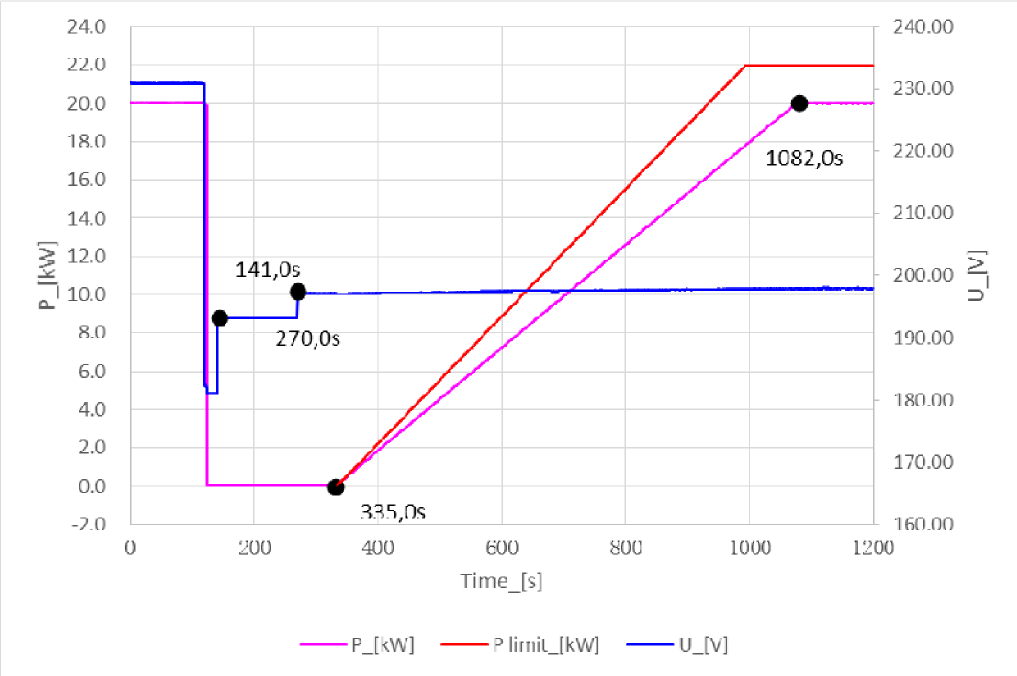
e) 84 % U_n to f) ≥ 86 % U_n: L2 phase



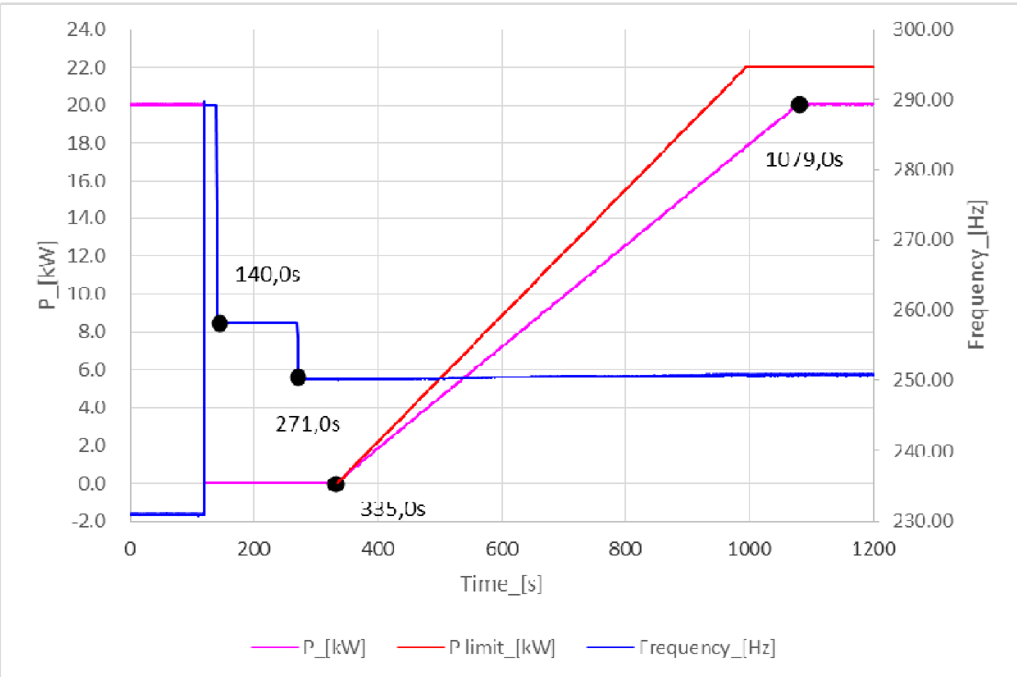
g) 111 % U_n to h) ≤ 109 % U_n: L2 phase



e) 84 % U_n to f) ≥ 86 % U_n: L3 phase

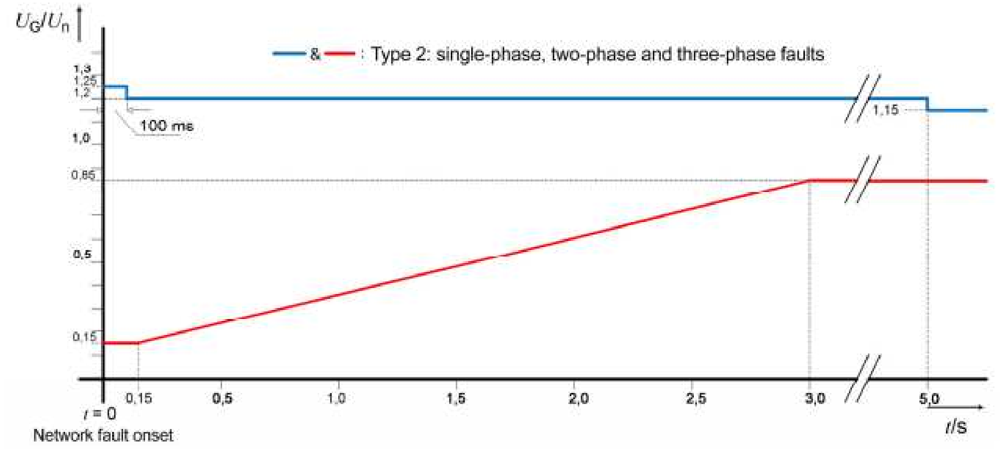


g) 111 % U_n to h) ≤ 109 % U_n: L3 phase



5.8 Evidence dynamic grid support DIN VDE V 0124-100:2020-06		
Clause	**Test**	**Result**
5.8.1	General	**P**
5.8.3	Testing of the dynamic grid support PGU Type 1	**N/A**
5.8.3	Testing of the dynamic grid support PGU Type 2	**P**

5.8.3 Testing of the dynamic grid support	P
For PGUs Type 2 and storage systems	
General:	



Key

& FRT curve for single-phase, two-phase and three-phase network faults

UG r.m.s. value of the actual voltage at the generator terminals

Test	Voltage dip to (U_n / p ,u ,)	Dip type	duration (ms) (2)*	P set point (P_{rE} / p ,u ,)	Q set point (Q / p ,u ,)	Comment	Test ref , No ,	Result
1	0,15 to 0,25	A	for 0,15 ≥ 150 / for 0,25 ≥ 500	1	0 to ± 0,1	Symetric	1 ,1	P
				0,2 to 0,6			1 ,2	P
		D1		1		Asymetric (ph-2-ph + Dy5-Trafo)	1 ,3	P
				0,2 to 0,6			1 ,4	P
		D2		1			1 ,5	P
2	0,50 to 0,60	A	for 0,50 ≥ 1500 / for 0,60 ≥ 2000	1	Max , over exceeded	Symetric	2 ,1	P
				0,2 to 0,6			2 ,2	P
		D1		1		Asymetric (ph-2-ph + Dy5-Trafo)	2 ,3	P
				0,2 to 0,6			2 ,4	P
3	0,50 to 0,60	A	for 0,50 ≥ 1500 / for 0,60 ≥ 2000	1	Max , under exceeded	Symetric	3 ,1	P
				0,2 to 0,6			3 ,2	P
		D1		1		Asymetric (ph-2-ph + Dy5-Trafo)	3 ,3	P
				0,2 to 0,6			3 ,4	P
4	0,85 to 0,90	A	≥ 60000	1	0 to ± 0,1	Symetric	4 ,1	P
				0,2 to 0,6			4 ,2	P
		D1		1		Asymetric (ph-2-ph + Dy5-Trafo)	4 ,3	P
				0,2 to 0,6			4 ,4	P
5	1,20 to 1,25	A	≥ 100	1	0 to ± 0,1	Symetric	5 ,1	P
				0,2 to 0,6			5 ,2	P
		D1		1		Asymetric (ph-2-ph + Dy5-Trafo)	5 ,3	P
				0,2 to 0,6			5 ,4	P
		D2		1			5 ,5	P

6	1,15 to 1,20	A	≥ 5000	1	0 to ± 0,1	Symetric	6 ,1	P
				0,2 to 0,6			6 ,2	P
		D1		1		Asymetric (ph-2-ph + Dy5-Trafo)	6 ,5	P
				0,2 to 0,6			6 ,6	P
7	1,10 to 1,15	A	≥ 60000	1	0 to ± 0,1	Symetric	7 ,1	P
				0,2 to 0,6			7 ,2	P
		D1		1		Asymetric (ph-2-ph + Dy5-Trafo)	7 ,5	P
				0,2 to 0,6			7 ,6	P

Graph of FRT test one				
Test result:				
List of tests	**Residual amplitude of phase-to-phase voltage [p ,u , U_n]**	**Duration limit [ms]**	**Duration [ms]**	**Result**
P_{Emax} in %	20% ±5%			
1 ,A ,1- Symmetrical	0,15	150 ± 20	151	Pass
1 ,D1 ,1- Asymmetrical	0,15	150 ± 20	258	Pass
2 ,A ,1- Symmetrical	0,50	1500 ± 20	1516	Pass
2 ,D1 ,1- Asymmetrical	0,50	1500 ± 20	1512	Pass
3 ,A ,1- Symmetrical	0,50	1500 ± 20	1512	Pass
3 ,D1 ,1- Asymmetrical	0,50	1500 ± 20	1512	Pass
4 ,A ,1- Symmetrical	0,85	60000 ± 20	60000	Pass
4 ,D1 ,1- Asymmetrical	0,85	60000 ± 20	60000	Pass
5 ,A ,1- Symmetrical	1,25	100 ± 20	100	Pass
5 ,D1 ,1- Asymmetrical	1,25	100 ± 20	100	Pass
6 ,A ,1- Symmetrical	1,20	5000 ± 20	5000	Pass
6 ,D1 ,1- Asymmetrical	1,20	5000 ± 20	5008	Pass
7 ,A ,1- Symmetrical	1,15	60000 ± 20	60000	Pass
7 ,D1 ,1- Asymmetrical	1,15	60000 ± 20	60000	Pass
P_{Emax} in %	100% ±5%			
1 ,A ,1- Symmetrical	0,15	150 ± 20	159	Pass
1 ,D1 ,1- Asymmetrical	0,15	150 ± 20	258	Pass
1 ,D1 ,2- Asymmetrical	0,15	150 ± 20	257	Pass
2 ,A ,1- Symmetrical	0,50	1500 ± 20	1516	Pass
2 ,D1 ,1- Asymmetrical	0,50	1500 ± 20	1517	Pass
3 ,A ,1- Symmetrical	0,50	1500 ± 20	1503	Pass
3 ,D1 ,1- Asymmetrical	0,50	1500 ± 20	1512	Pass
4 ,A ,1- Symmetrical	0,85	60000 ± 20	60000	Pass
4 ,D1 ,1- Asymmetrical	0,85	60000 ± 20	60000	Pass
5 ,A ,1- Symmetrical	1,25	100 ± 20	102	Pass
5 ,D1 ,1- Asymmetrical	1,25	100 ± 20	102	Pass
5 ,D1 ,2- Asymmetrical	1,25	100 ± 20	100	Pass
6 ,A ,1- Symmetrical	1,20	5000 ± 20	5000	Pass
6 ,D1 ,1- Asymmetrical	1,20	5000 ± 20	5008	Pass
7 ,A ,1- Symmetrical	1,15	60000 ± 20	60000	Pass

7 ,D1 ,1- Asymmetrical	1,15	60000 ± 20	60000	Pass

Test conditions:

Voltage simulator fall and rise time: < 20ms

Used sample rate: 10 kHz

Note:

At lease The recording must begin at least 10 s before the error occurs , After a faulty declaration (Voltage in the range 0,85 $U_n \leq U \leq 1{,}1\ U_n$), the recording must continue for at least another 60 s ,

Behavior during the network error:
No disconnection of the PGU during the voltage drops the grid , If the PGU disconnects from the grid, the time of disconnection must be documented ,

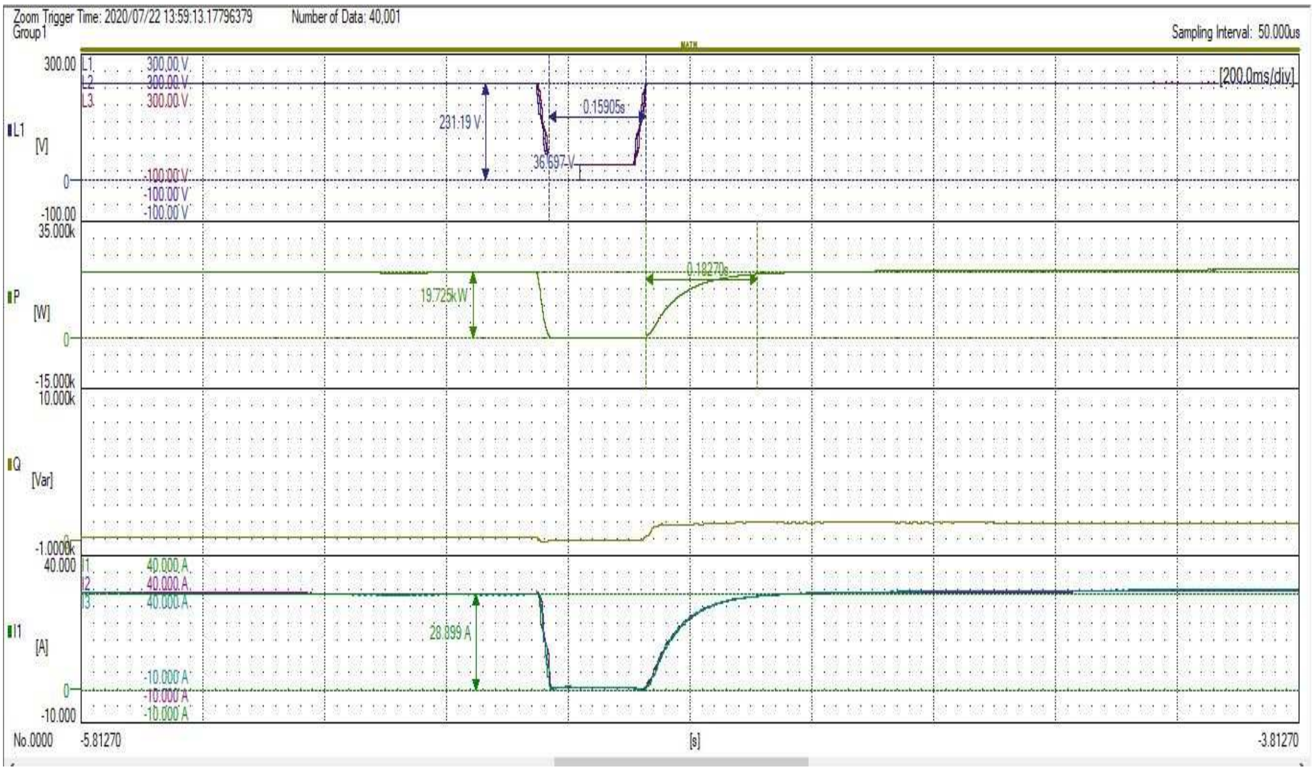
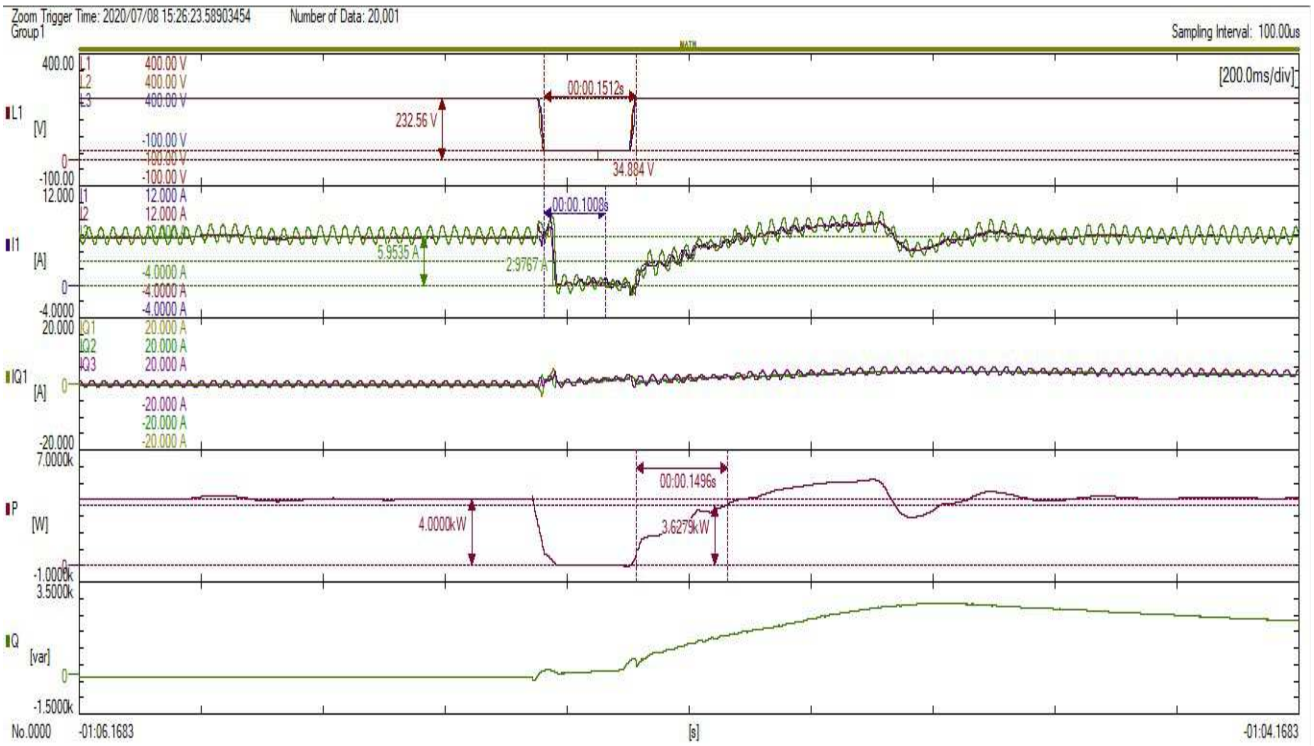
- Type 1 units have to support the line voltage during a line fault principle by supplying a suitable active and reactive current , It is not permitted that the increase in the voltage due to the reactive current supply cause the overvoltage limit curve (cf , VDE-AR-N 4105:2018-11) to be exceeded during a network fault and / or after a network fault ,
- Asynchronous generators must remain connected to the grid during the tests shown and principle, may supply an active and reactive current ,
- Type 2 units and storage systems are not allowed to inject neither active or reactive current during a line voltage at the PGUs terminals below 0 ,8 Un and above 1 ,15 Un , This requirement is met if, in the event of a under-/ under voltage dip, the injected current of the generating unit and / or the storage systems does not exceed 20% of the rated current Ir and no more than 10% Ir after 60 ms after the occurrence of this under-/ under voltage dip in any phase ,

Behavior after the end of the error:

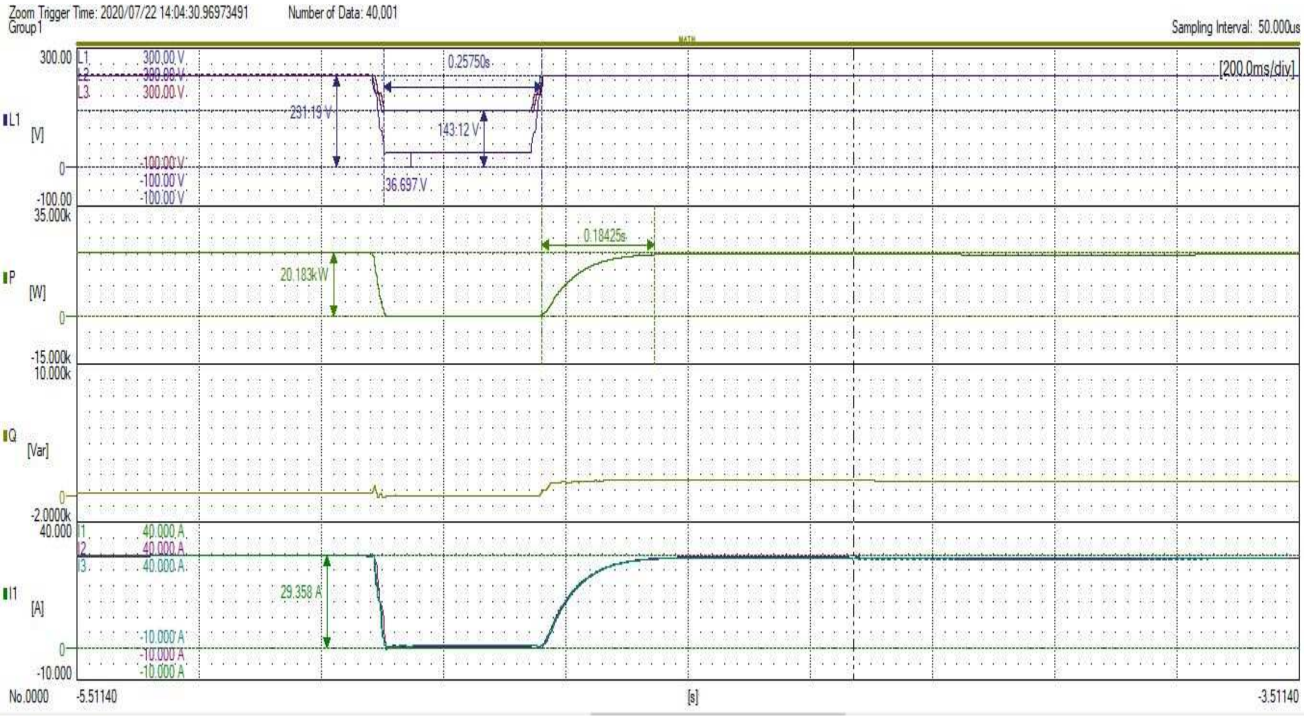
- Not disconnection of the PGU within 60 s after the end of the fault ,
- Type 1 units and asynchronous machines: Reaction time of active power maximum 6 s, Reaction time of reactive power as fast as possible ,

Type 2 units and storage systems: Reaction time of active power up to 1 s, Reaction time of reactive power according to PT1 behavior with 3 tau = 10 s in accordance with VDE-AR-N 4105: 2018-11, 5.7.2.5

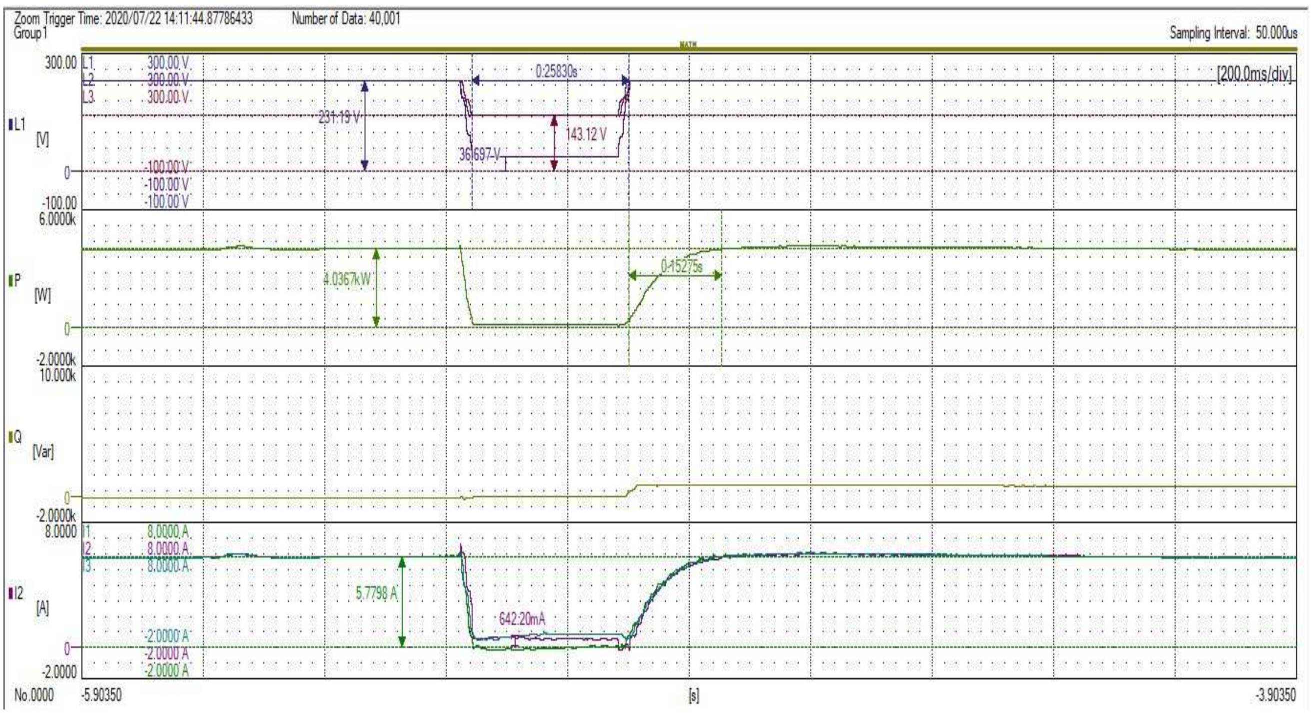
The test had been performed on the model HYD 20KTL-3PH the test results are valid for the HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH and HYD 15KTL-3PH since it is identical in hardware and just power derated by software.

Test 1 ,A ,1-Symmetrical fault (U/U_{nom} =0,15); P = 100% P_n

Test 1 ,A ,2-Symmetrical fault (U/U_{nom} =0,15); P = 20%P_n


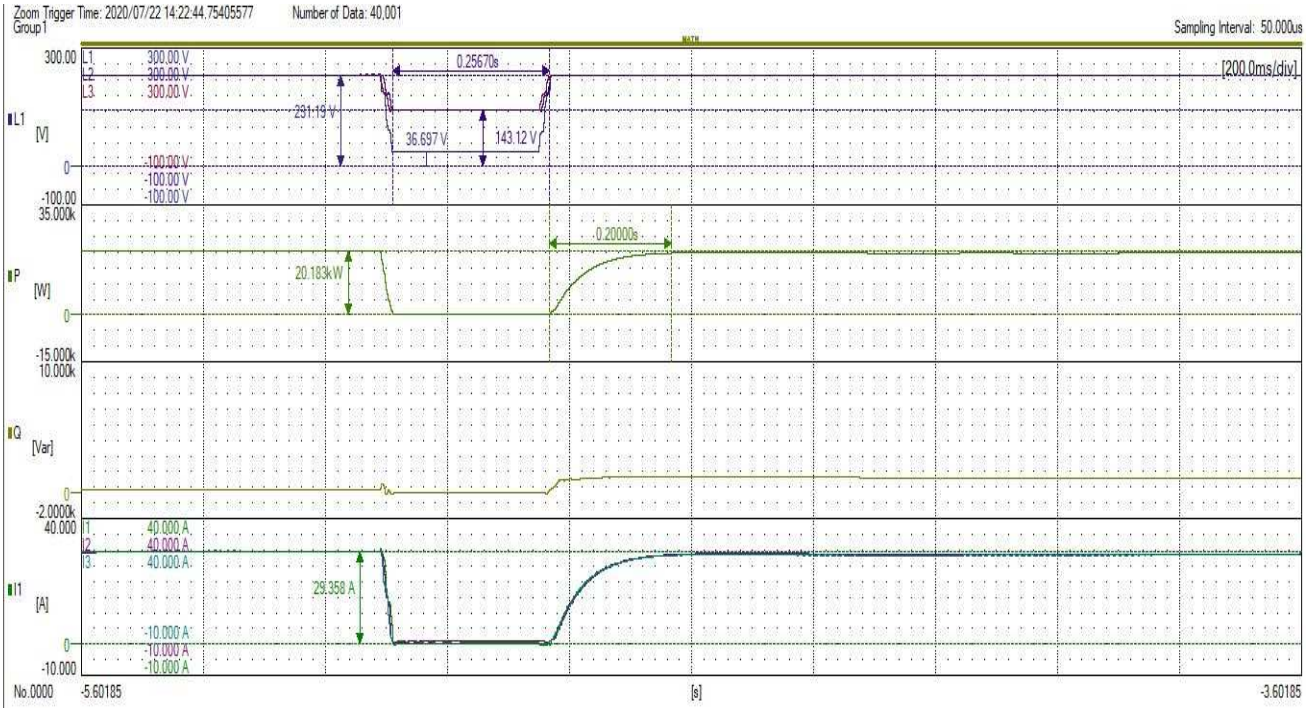
Test 1 ,D1 ,1-Asymmetrical fault (U/U_{nom} =0,15); P = 100% P_n



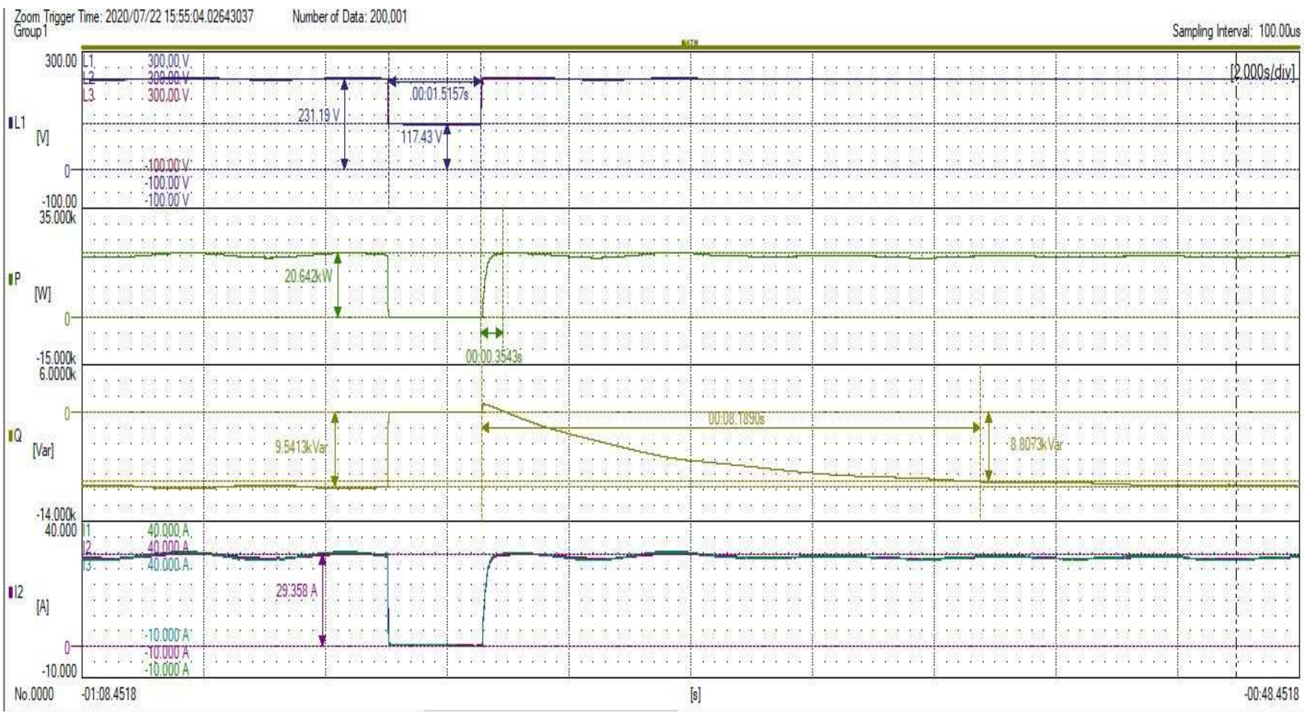
Test 1 ,D1 ,2-Asymmetrical fault (U/U_{nom} =0,15); P = 20%P_n



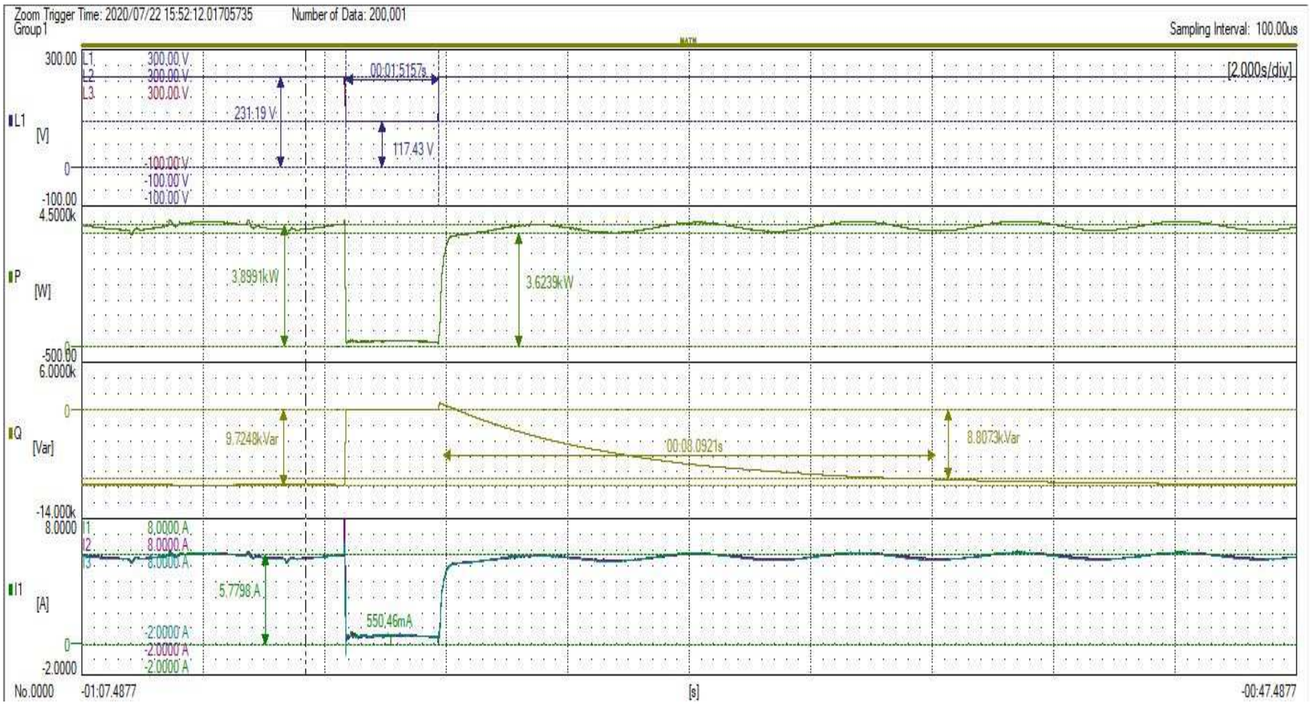
Test 1 ,D2 ,1-Asymmetrical fault (U/U_{nom} =0,15); P = 100%P_n



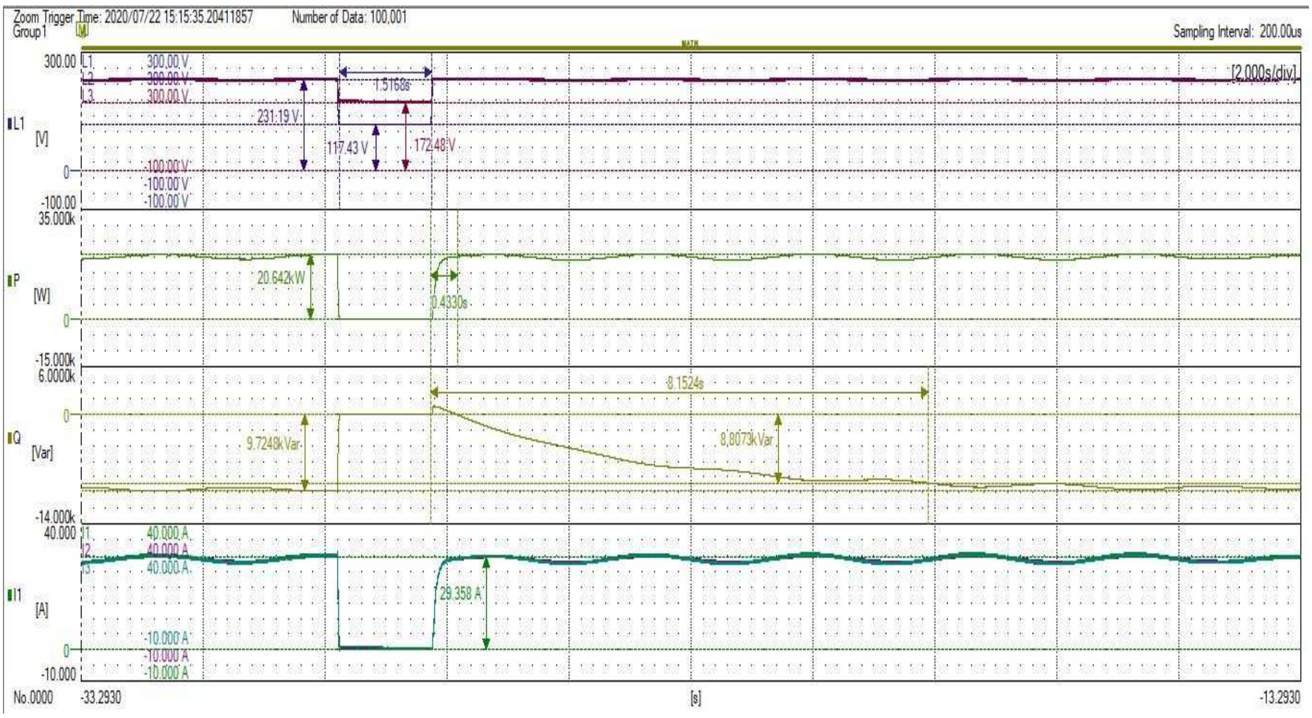
Test 2 ,A ,1-Symmetrical fault (U/U_{nom} =0,50); P =100% P_n

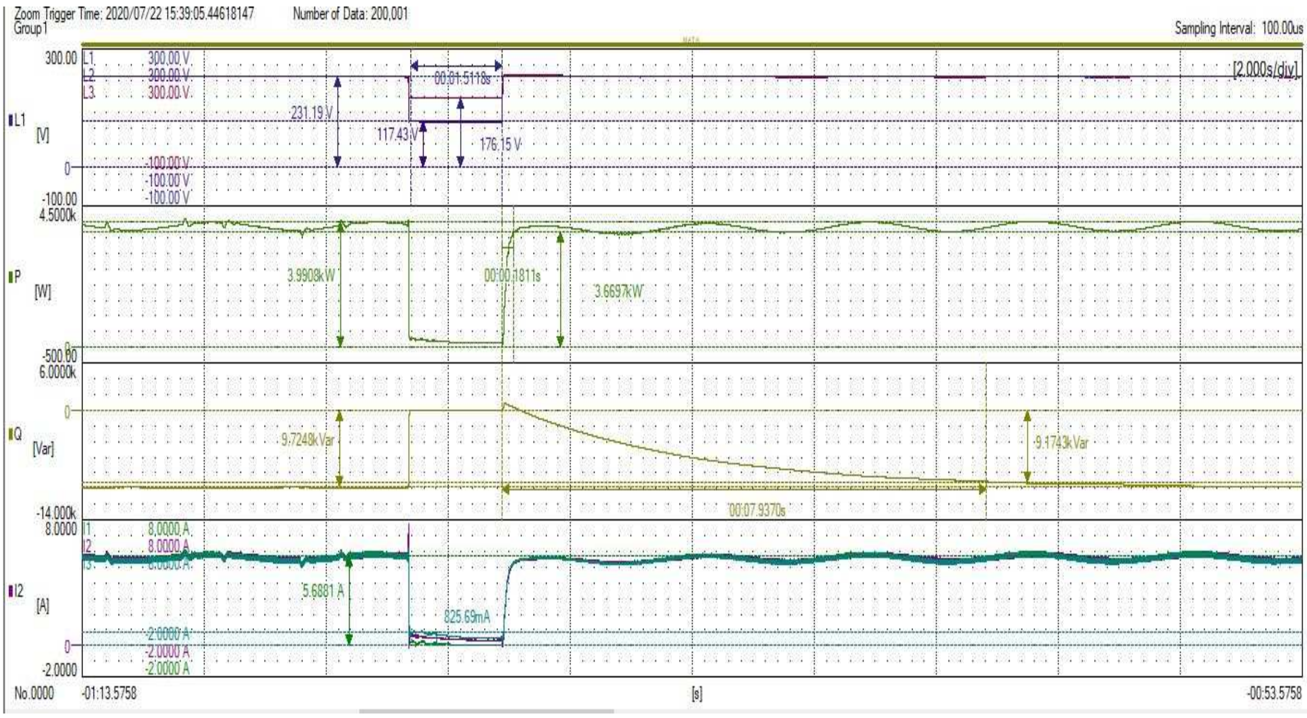
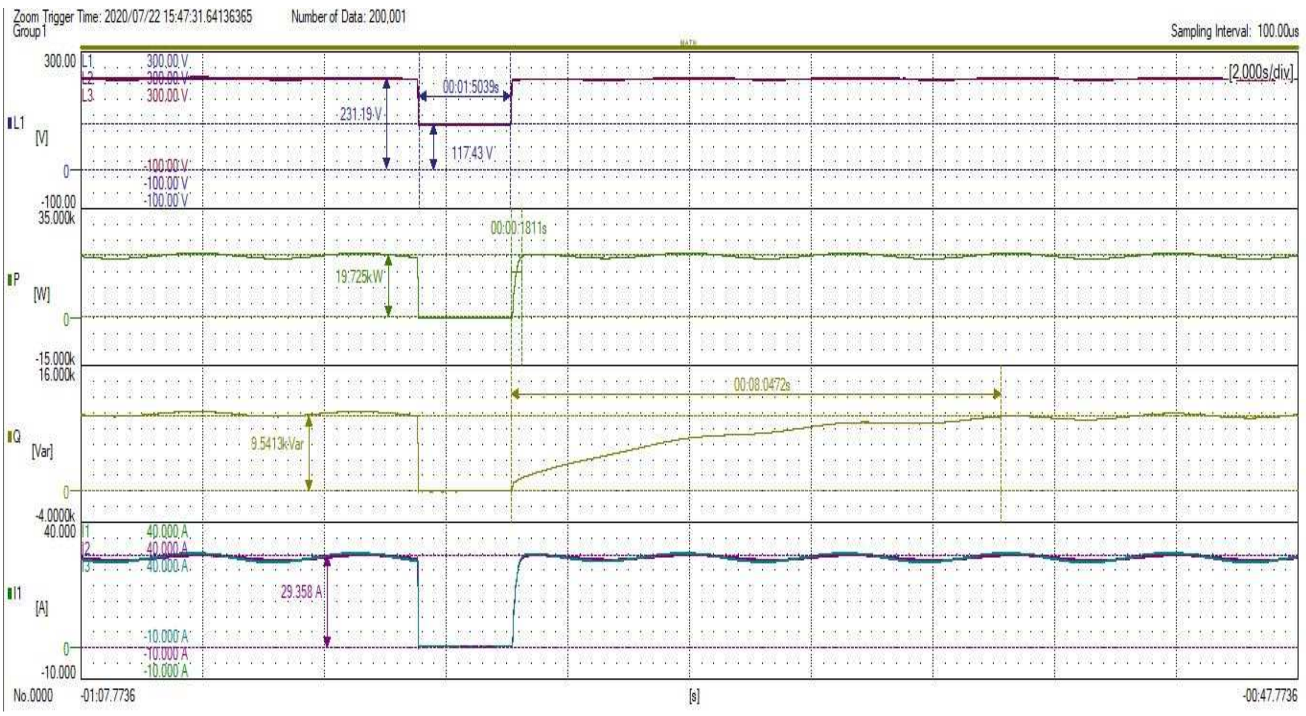


Test 2 , A ,2-Symmetrical fault (U/U_{nom} =0,50); P = 20% P_n

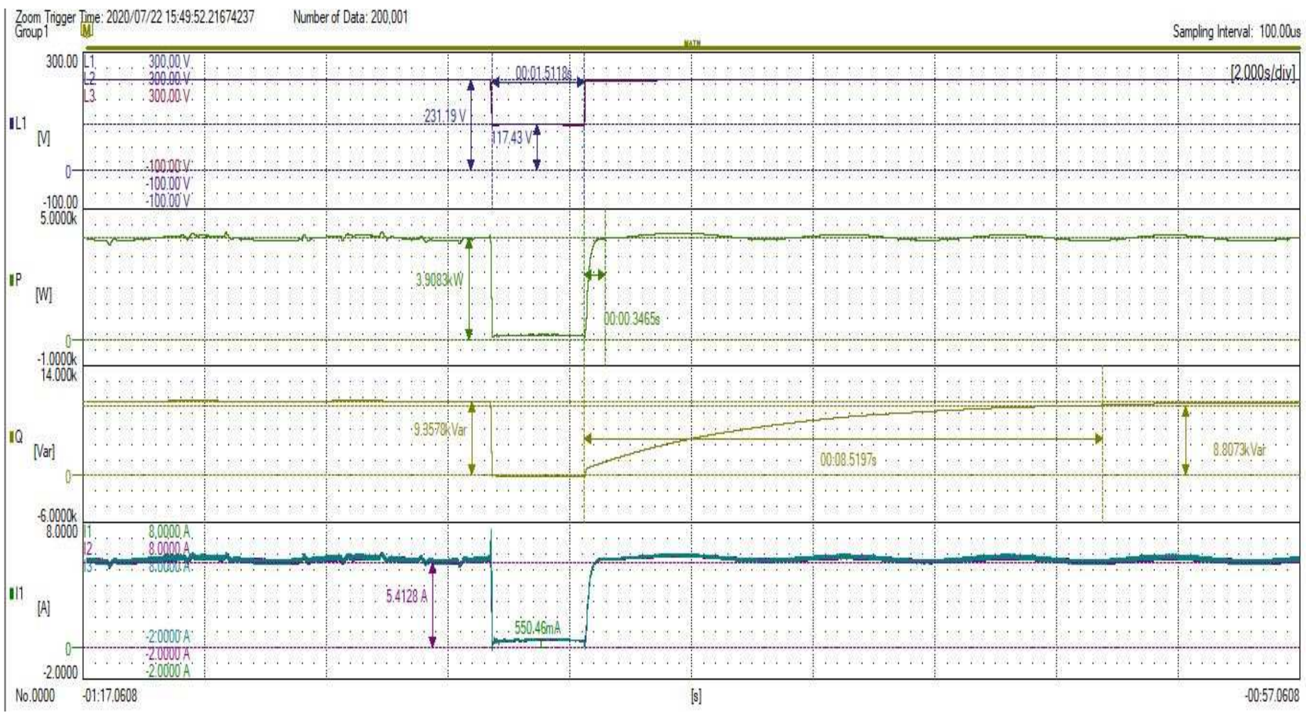


Test 2 ,D1 ,1-Asymmetrical fault (U/U_{nom} =0,50); P = 100% P_n

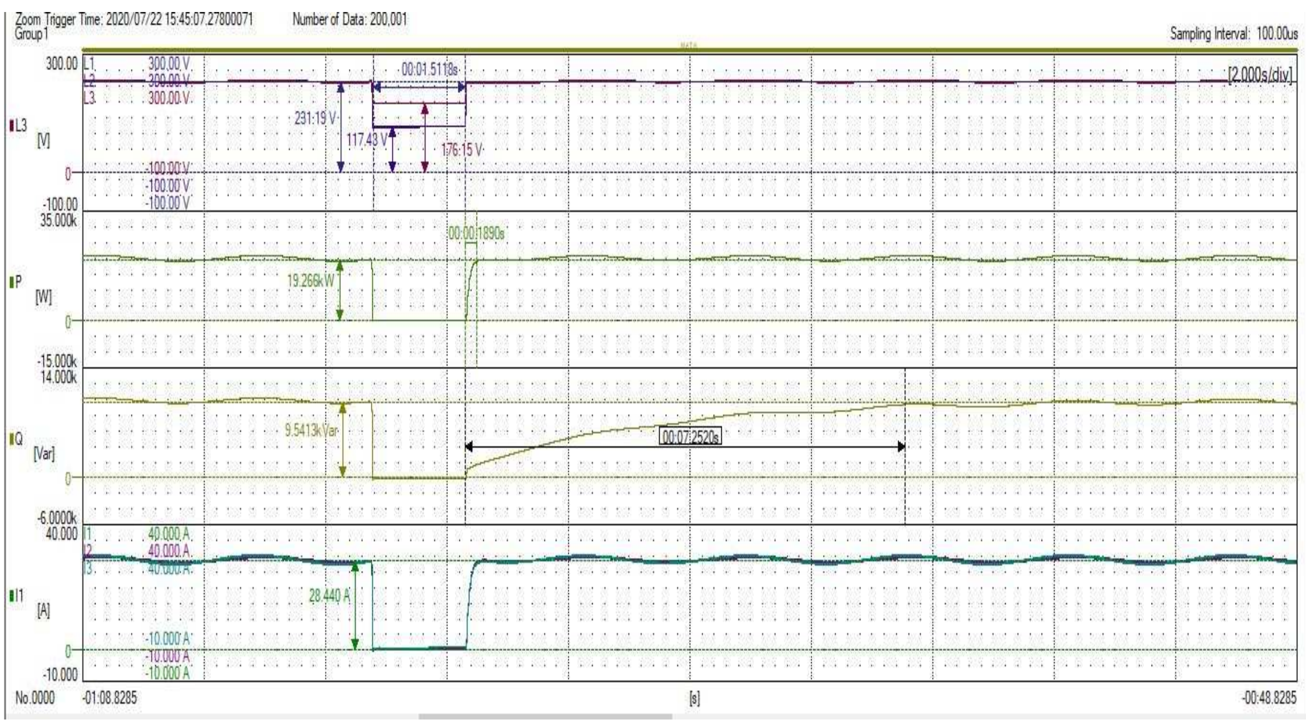


Test 2 ,D1 ,2-Asymmetrical fault (U/U$_{nom}$ =0,50); P = 20% P$_n$

Test 3 ,A ,1-Symmetrical fault (U/U$_{nom}$ =0,50); P =100% P$_n$


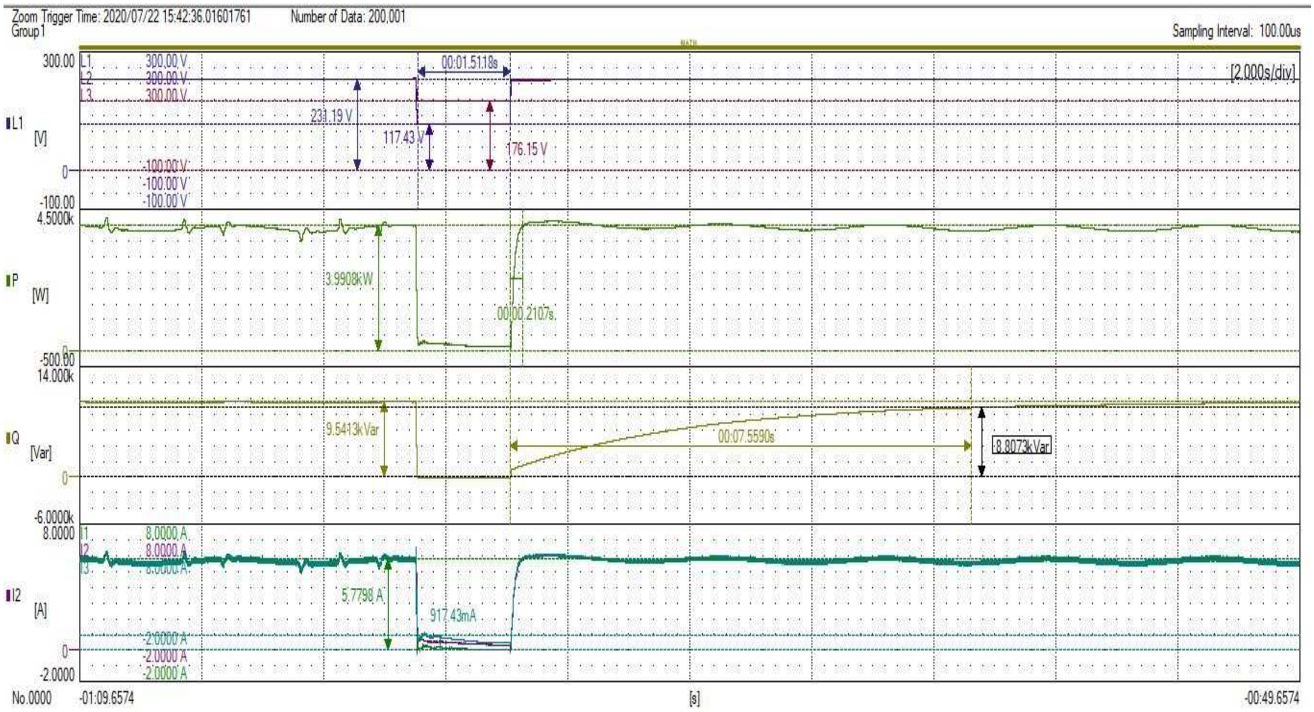
Test 3 , A ,2-Symmetrical fault (U/U_{nom} =0,50); P = 20% P_n



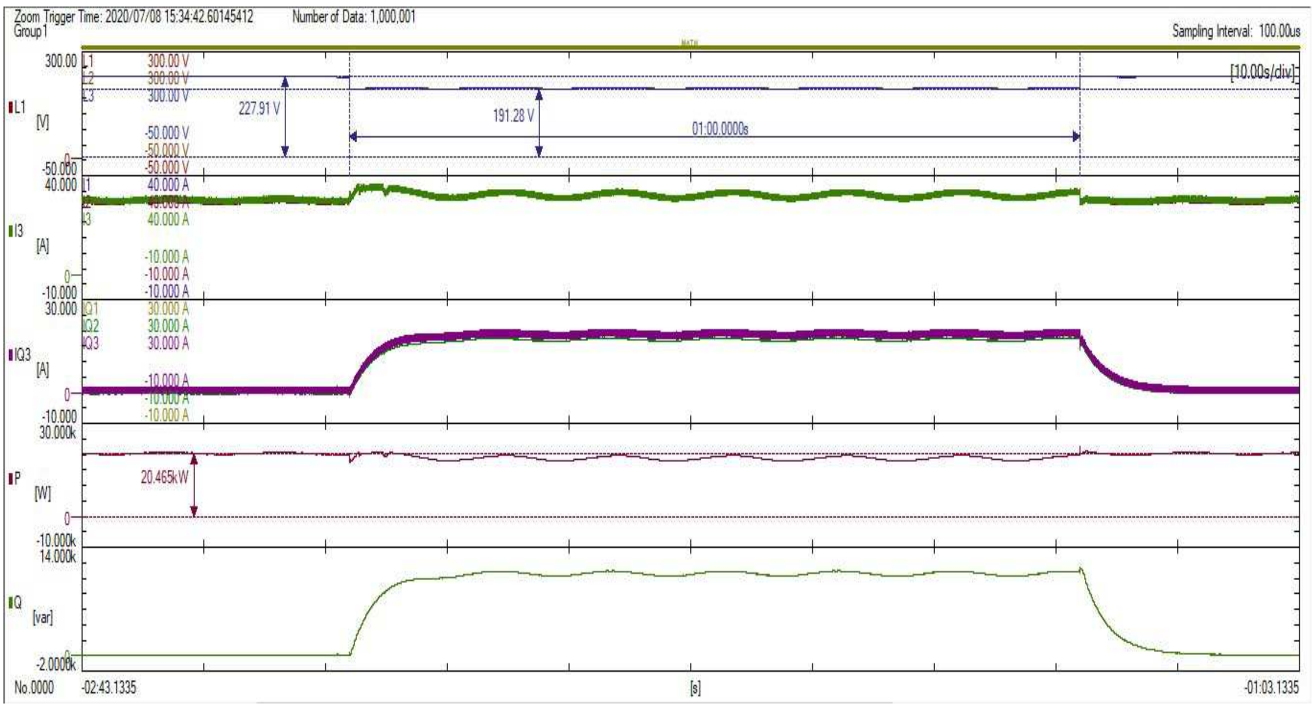
Test 3 ,D1 ,1-Asymmetrical fault (U/U_{nom} =0,50; P = 100% P_n

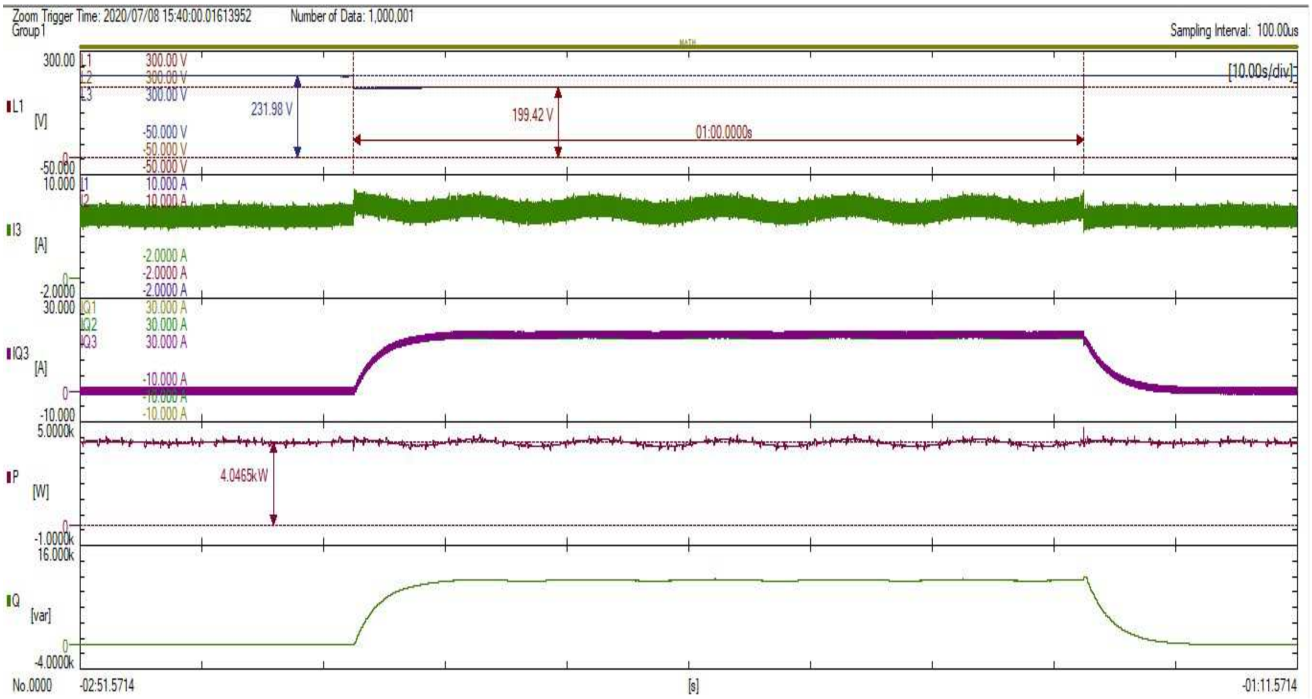
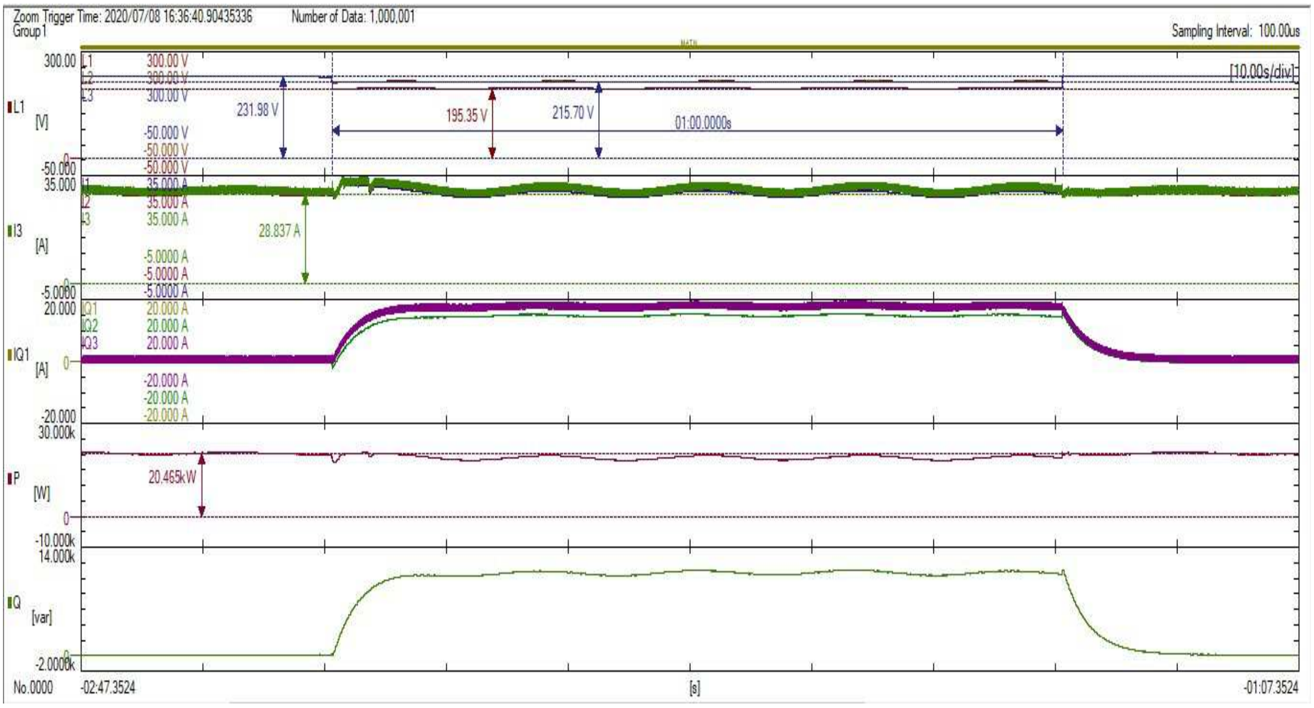


Test 3 ,D ,2-Asymmetrical fault (U/U_{nom} =0,50); P = 20% P_n

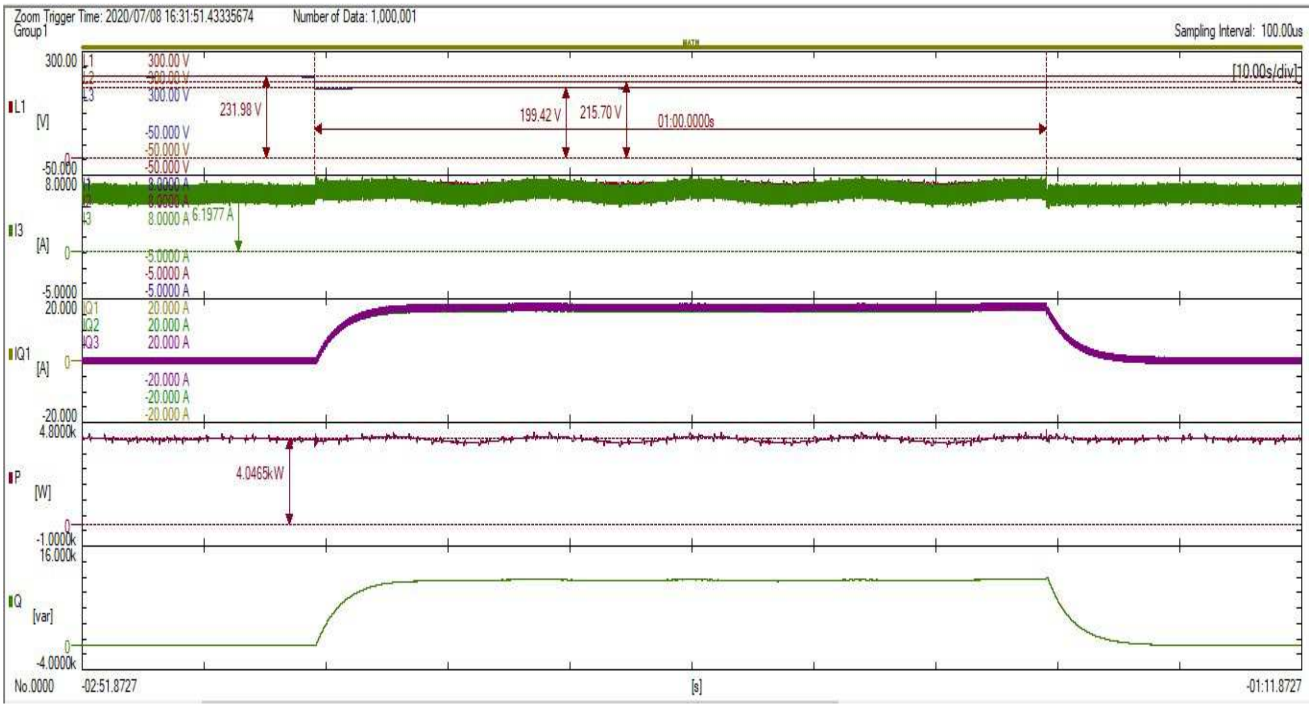


Test 4 ,A ,1-Symmetrical fault (U/U_{nom} =0,85); P =100% P_n

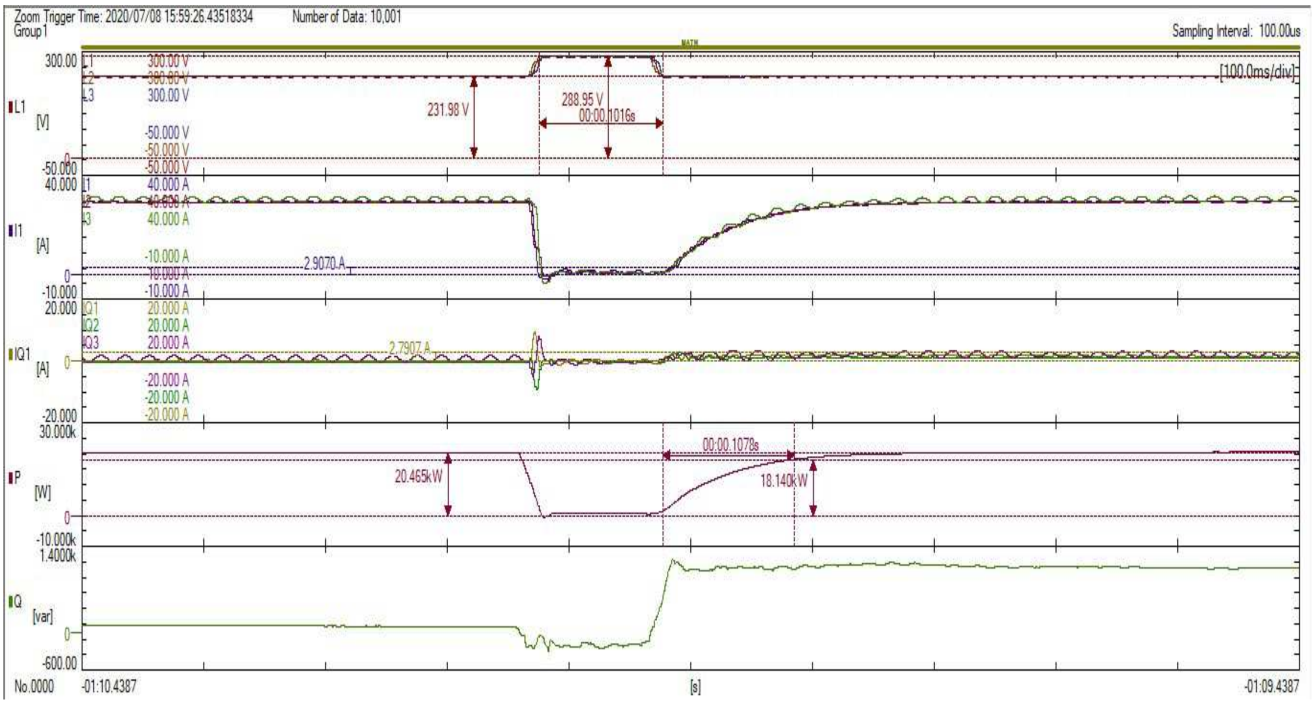


Test 4 , A ,2-Symmetrical fault (U/U_{nom} =0,85); P = 20% P_n

Test 4 ,D1 ,1-Asymmetrical fault (U/U_{nom} =0,85); P = 100% P_n


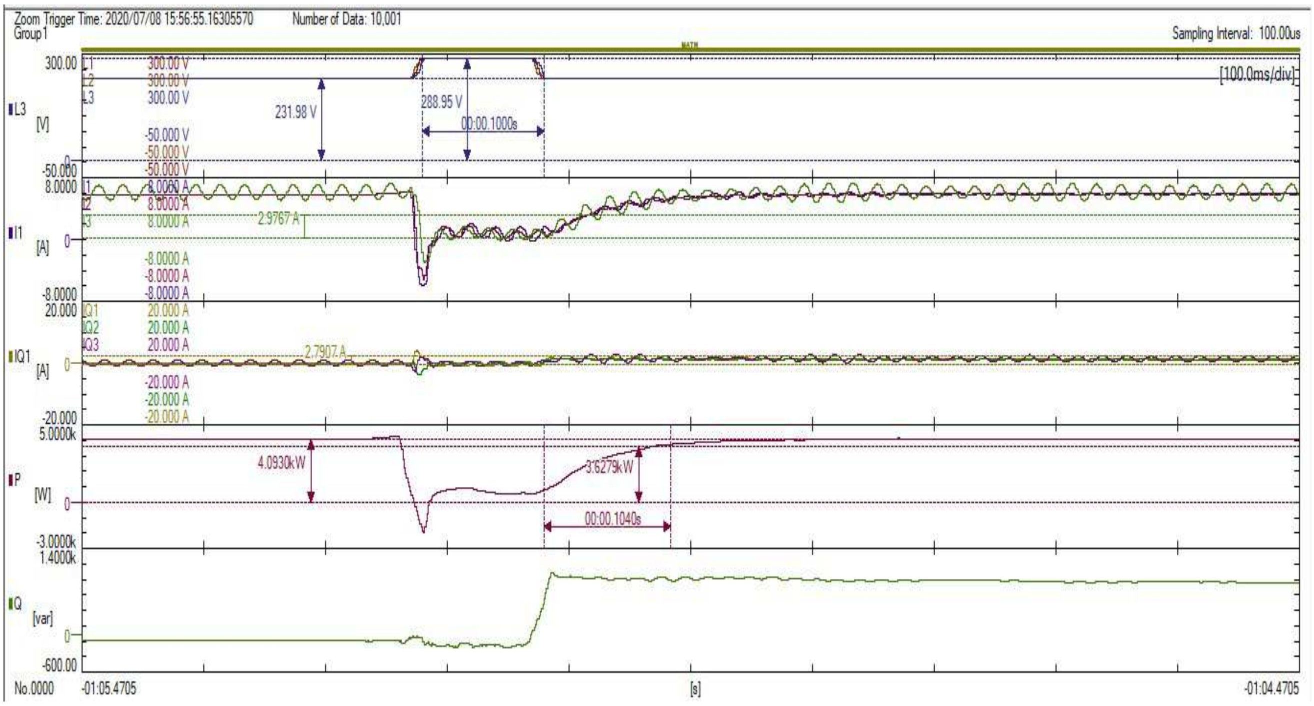
Test 4 ,D1 ,2-Asymmetrical fault (U/U_{nom} =0,85); P = 20% P_n



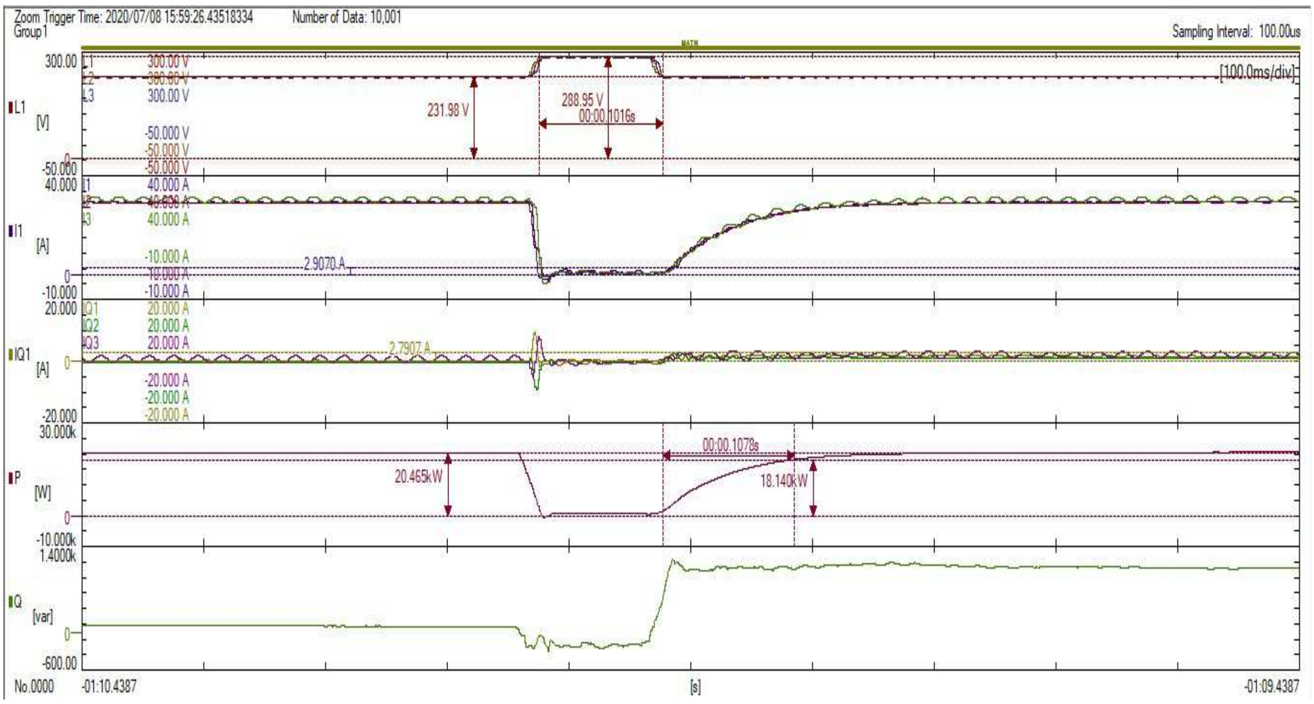
Test 5 ,A ,1-Symmetrical fault (U/U_{nom} =1,25); P =100% P_n

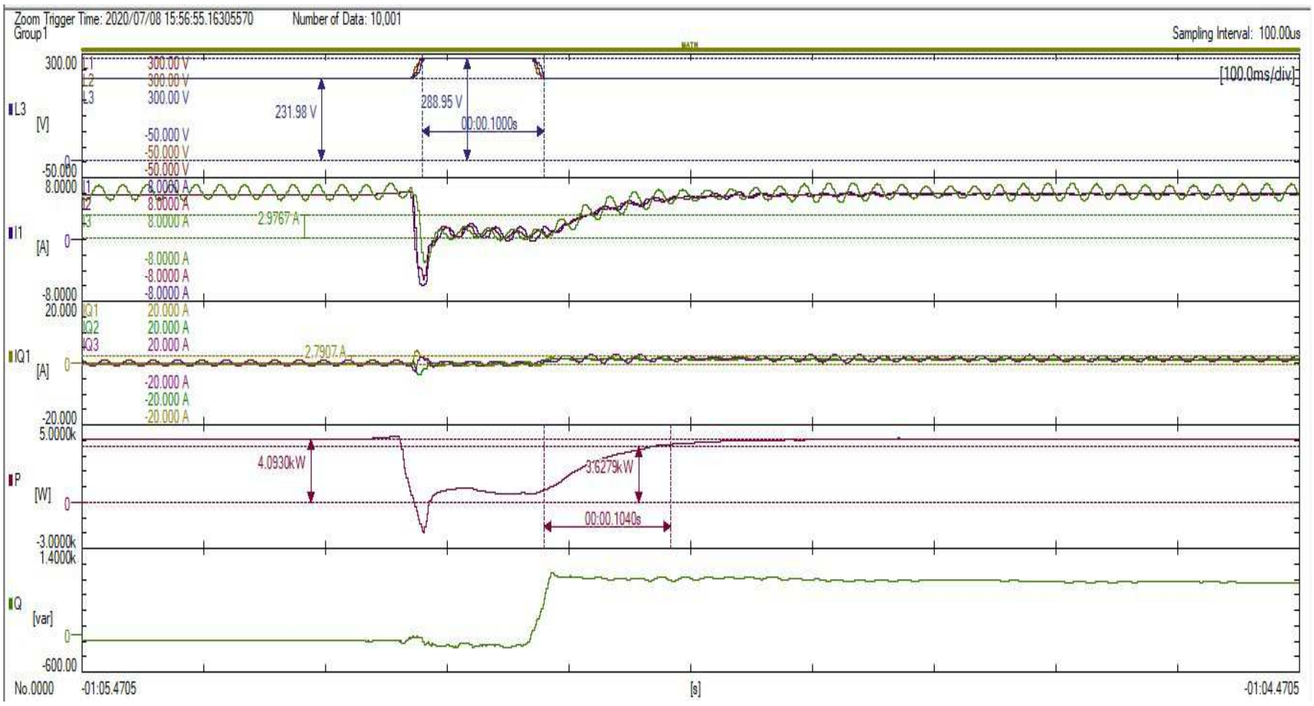
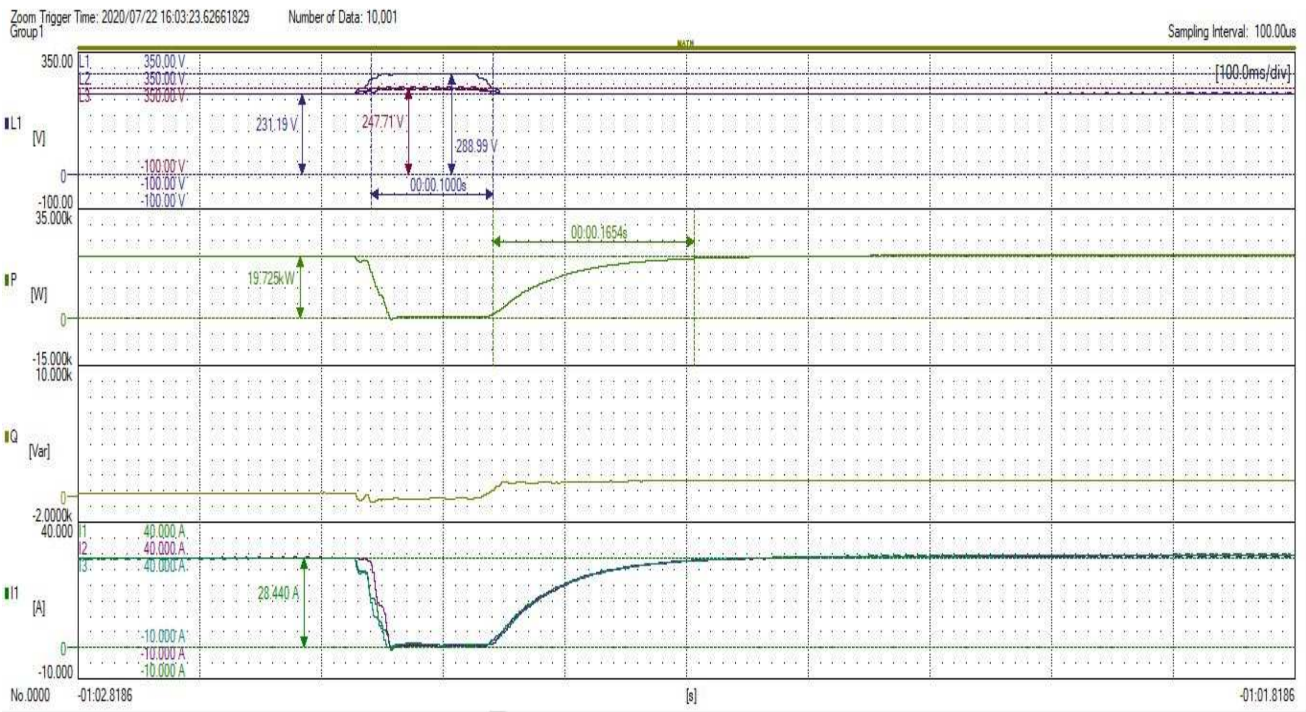


Test 5 , A ,2-Symmetrical fault (U/U_{nom} =1,25); P = 20% P_n

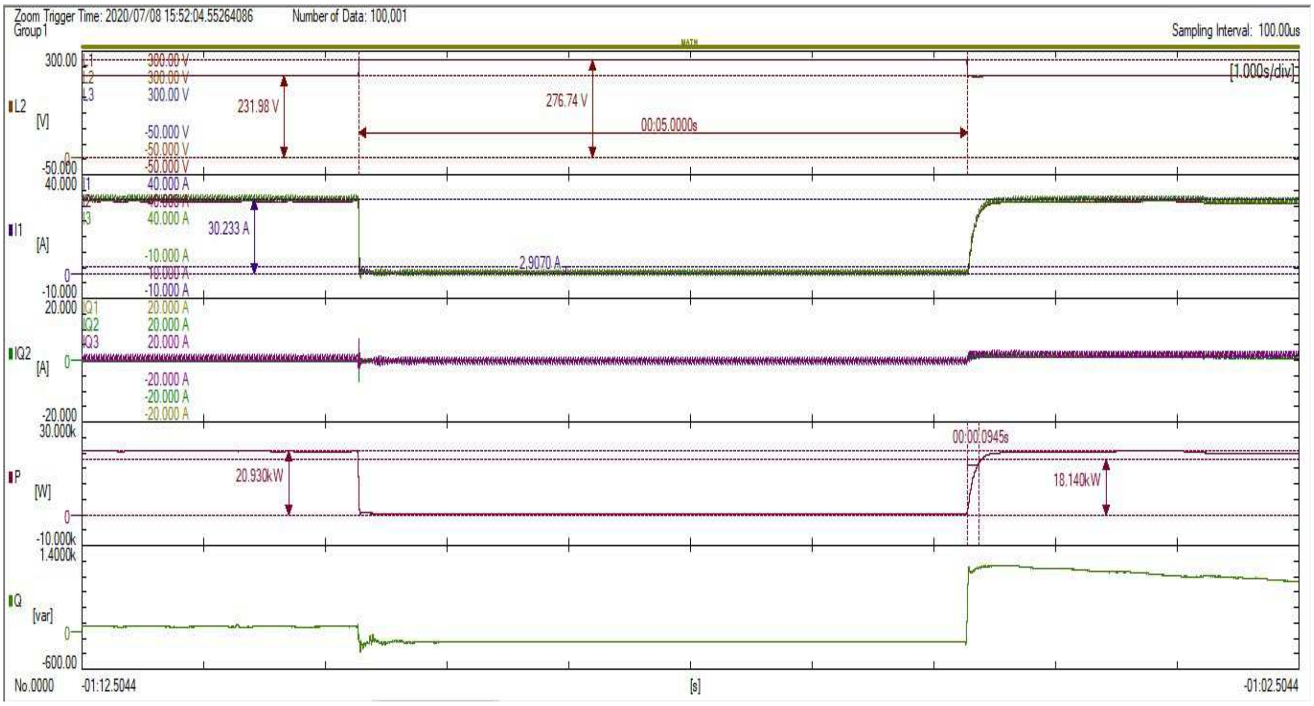


Test 5 ,D1 ,1-Asymmetrical fault (U/U_{nom} =1,25); P = 100% P_n

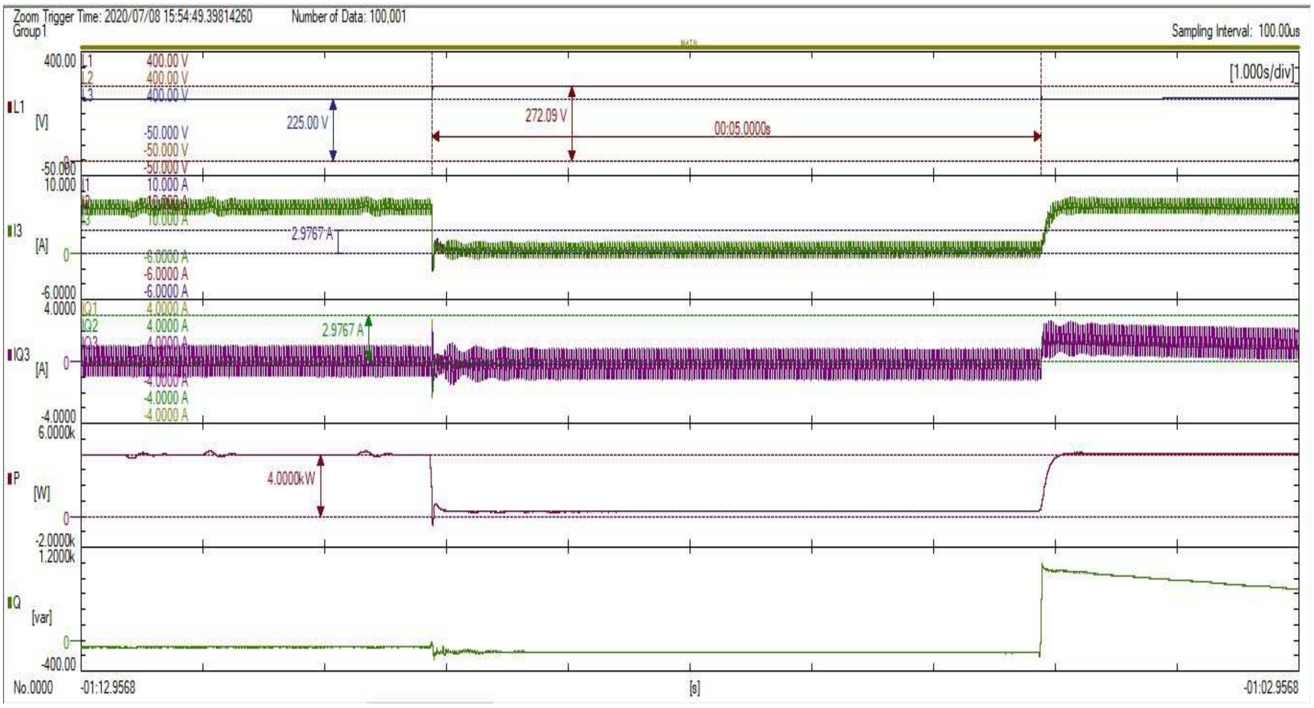


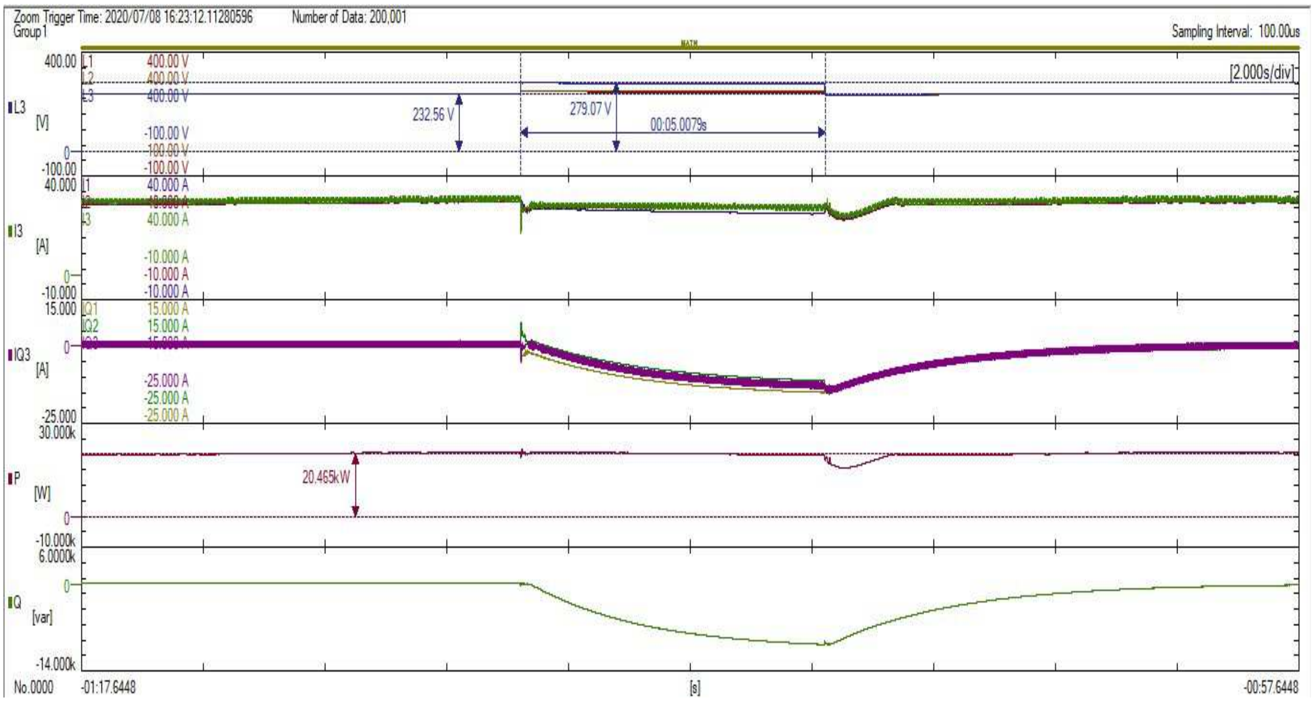
Test 5 ,D1 ,2-Asymmetrical fault (U/U_{nom} =1,25); P = 20% P_n

Test 5 ,D2 ,1-Asymmetrical fault (U/Unom =1,25); P = 100% Pn


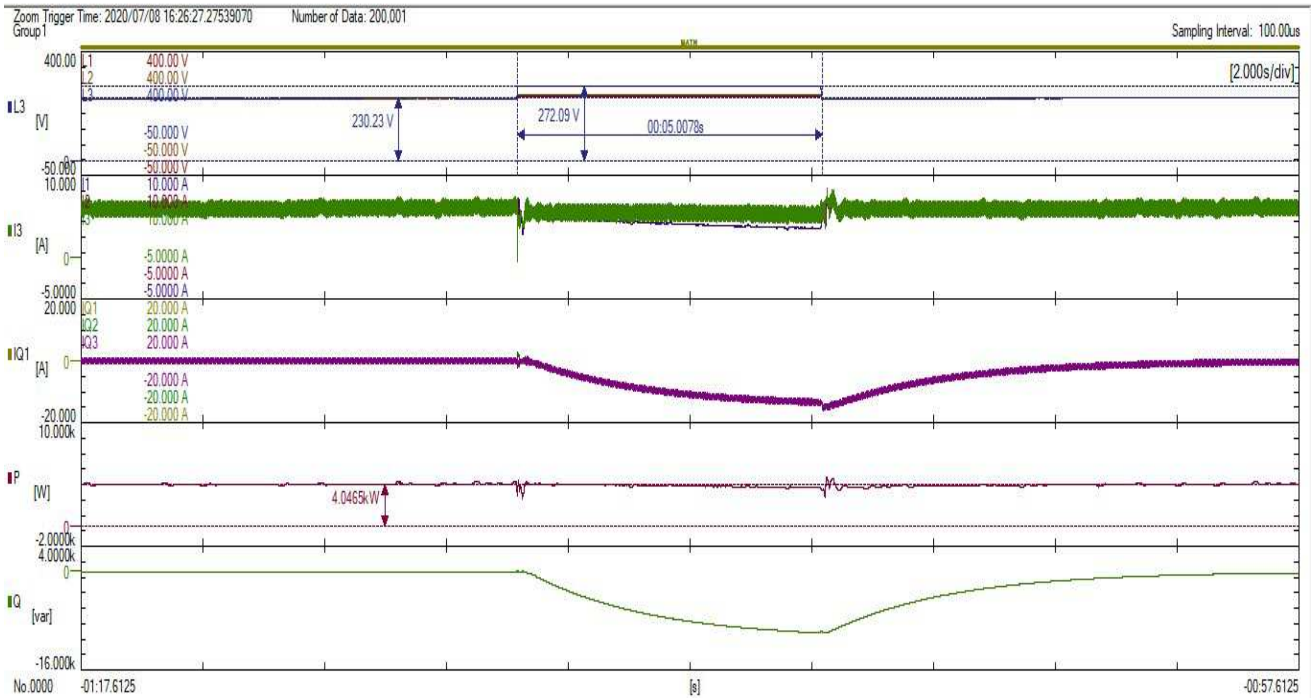
Test 6 ,A ,1-Symmetrical fault (U/U_{nom} =1,20); P =100% P_n



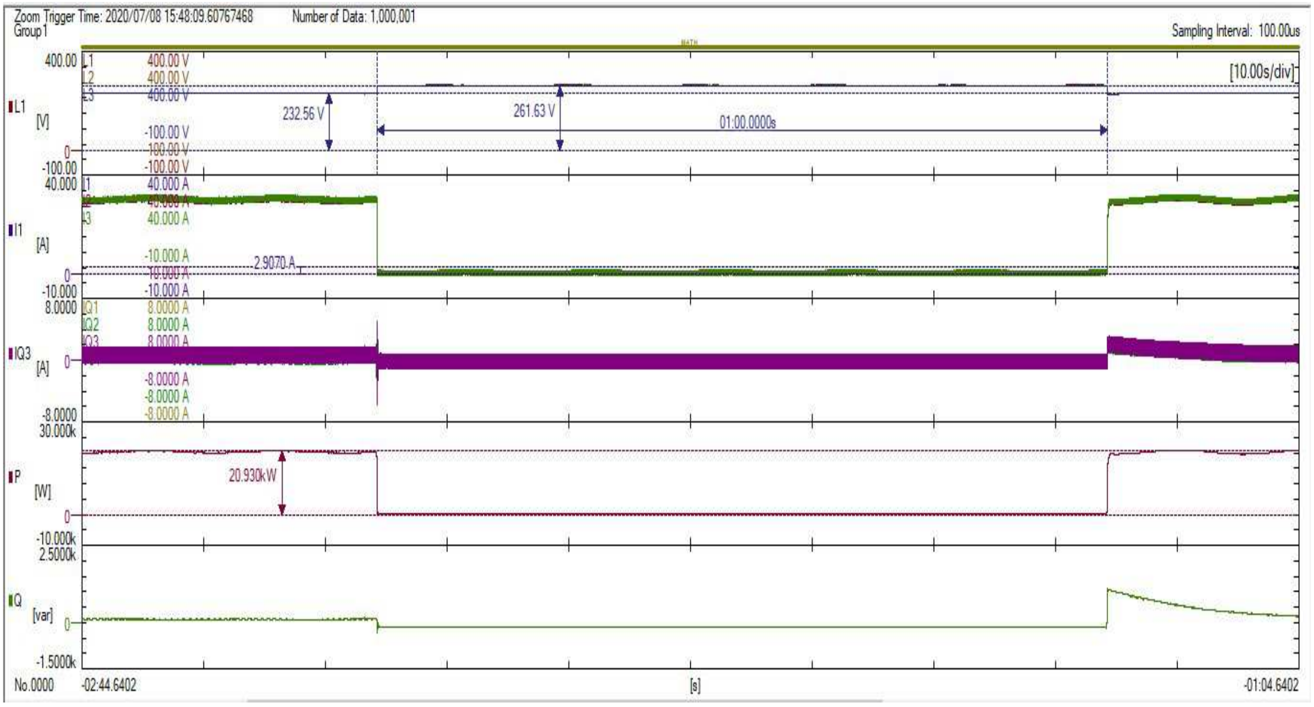
Test 6 , A ,2-Symmetrical fault (U/U_{nom} =1,20); P = 20% P_n



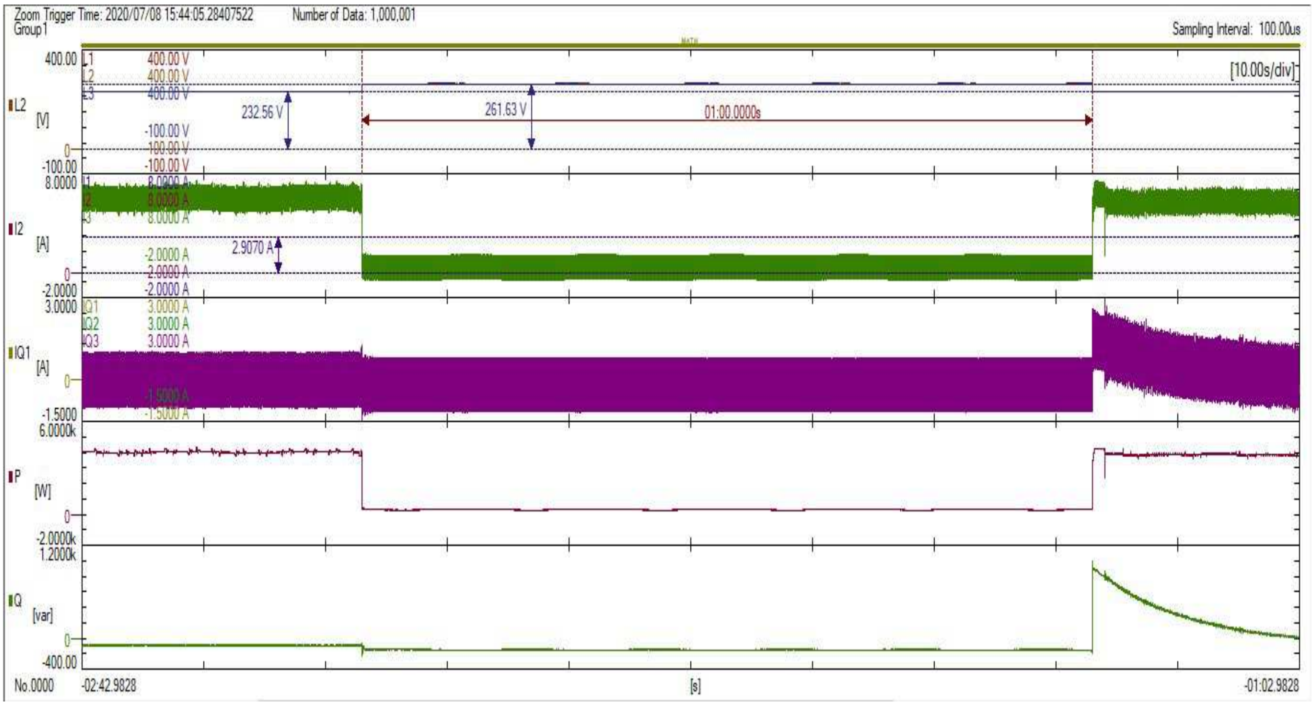
Test 6 ,D1 ,1-Asymmetrical fault (U/U_{nom} =1,20); P = 100% P_n


Test 6 ,D1 ,2-Asymmetrical fault (U/U_{nom} =1,20); P = 20% P_n


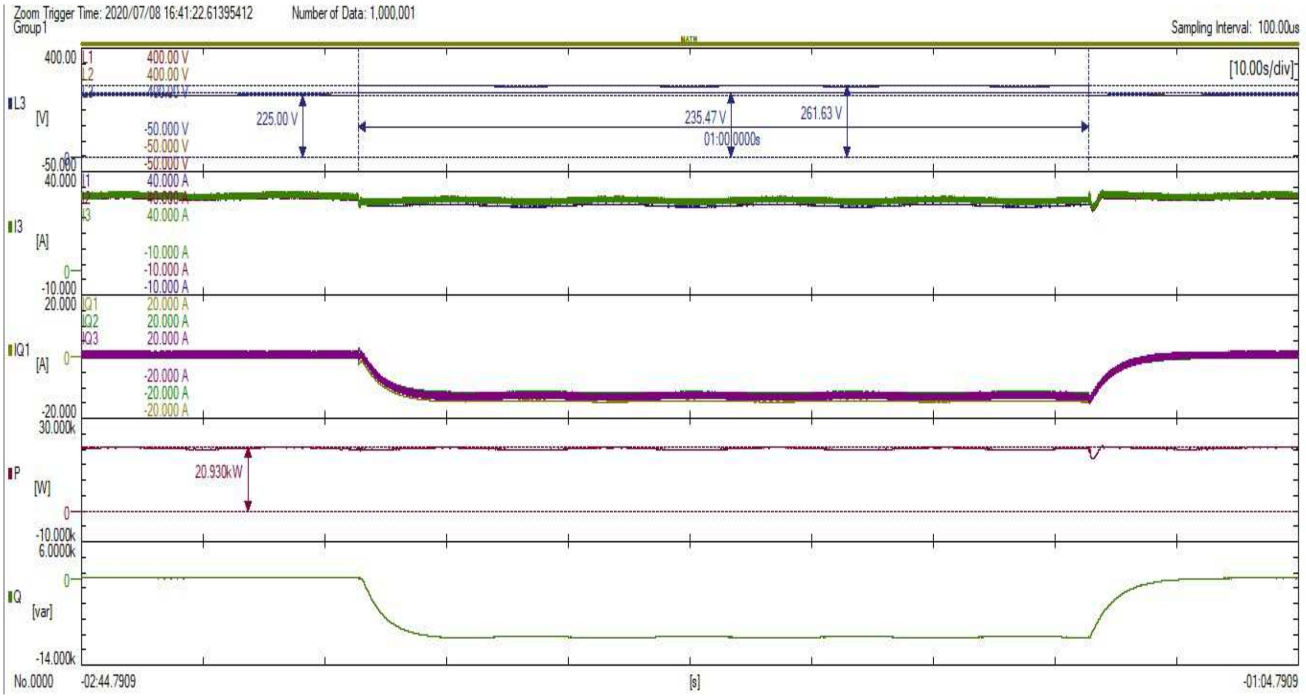
Test 7 ,A ,1-Symmetrical fault (U/U_{nom} =1,15); P =100% P_n



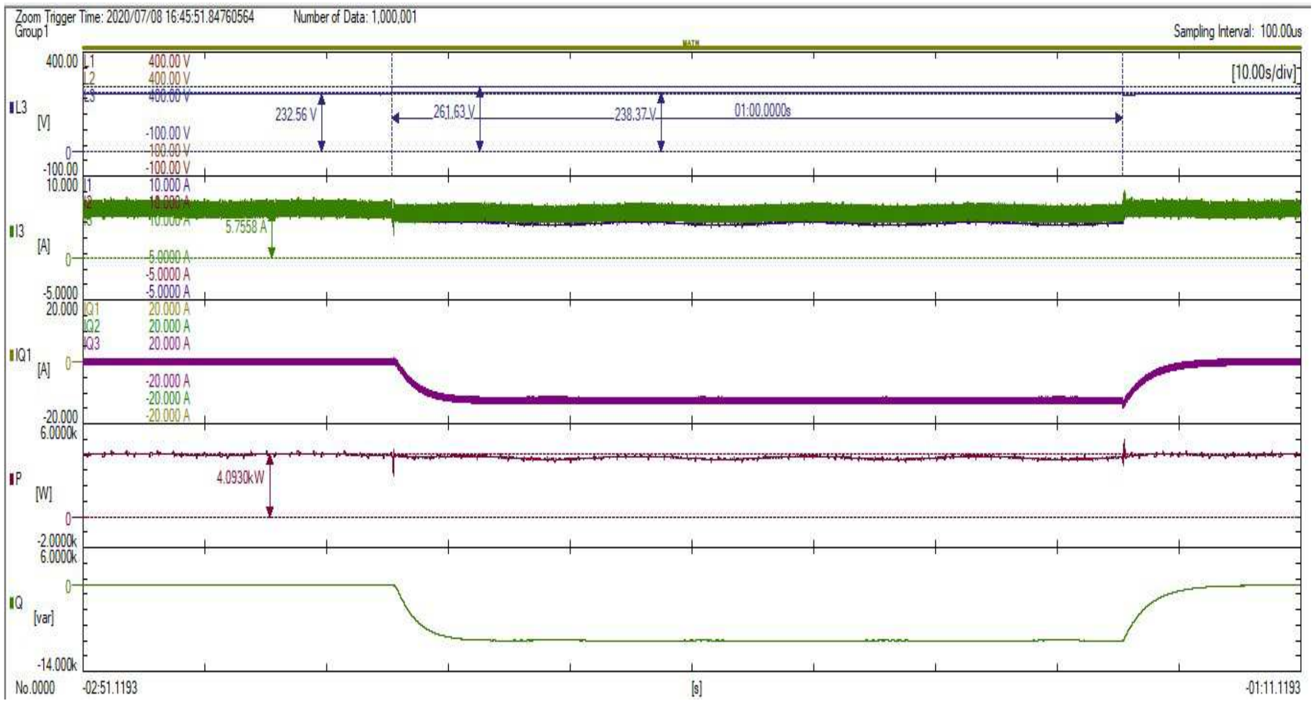
Test 7 , A ,2-Symmetrical fault (U/U_{nom} =1,15); P = 20% P_n



Test 7 ,D1 ,1-Asymmetrical fault (U/U$_{nom}$ =1,15); P = 100% P$_n$



Test 7 ,D1 ,2-Asymmetrical fault (U/U$_{nom}$ =1,15); P = 20% P$_n$



Annex No. 1

Pictures of the unit

The full pictures refer to PHOTO DOCUMENT

Project No.: 200320N031

Date: 20200731

Front enclosure-view (HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 15KTL-3PH, HYD 20KTL-3PH)

Bottom enclosure-view (HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 15KTL-3PH, HYD 20KTL-3PH)


Rear enclosure-view

Bottom enclosure-view (HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH, HYD 10KTL-3PH, HYD 15KTL-3PH, HYD 20KTL-3PH)

Annex No. 2

Test Equipment list

Date(s) of performance test: 2020-03-21 to 2020-07-30

Equipment	Internal No ,	Manufacturer	Type	Serial No ,	Last Calibration
Power Analyzer	A4080002DG	YOKOGAWA	WT3000	91M210852	Sep. 12, 2019
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyzer
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 24, 2019
Oscilloscope probel	A1490008DG	YOKOGAWA	701901	//	Sep. 20, 2019
	A1490009DG	YOKOGAWA	701901	//	Sep. 20, 2019
	A1490010DG	YOKOGAWA	701901	//	Sep. 20, 2019
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 12, 2019
	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 12, 2019
	A1060009DG	YOKOGAWA	CT200	1130700019	Sep. 12, 2019