TEST REPORT

DIN VDE V 0124-100

Test requirements for generation units to be connected and operated parallel with the low voltage distribution networks

Report No,..... :	**BWDO-ESH-P24070520**
Date of issue ..... :	2024-07-21
Total number of pages ..... :	224
Testing laboratory name..... :	**Bureau Veritas Consumer Products Services Germany GmbH**
Address..... :	Businesspark A96 86842 Türkheim Germany
Accreditation ..... :	ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12024-03-00
Applicant's name ..... :	**Marstek energy Co., Ltd.**
Address..... :	1-4F, BLDG#9, 1/F, BLDG#5, West Industrial Park, South of the Intersection of Ma'anshan Tunnel and Zhangshe Avenue, Xiangxi High-tech Zone, Hunan Province, China
Test specification	
Standard ..... :	VDE AR-N 4105:2018-11 DIN VDE V 0124-100:2020-06
Certificate ..... :	**Certificate of compliance**
Template number standard ..... :	TRF_VDE0124-100_16
Master TRF originator..... :	Bureau Veritas Consumer Products Services Germany GmbH
Test item description..... :	**Balcony All-in-One ESS**
Trademark..... :	MARSTEK
Model / Type ..... :	**MST-HIE2.5-1000, MST-HIE2.5-0800, MST-HIE2.5-0600, MST-HIE5-1000, MST-HIE5-0800, MST-HIE5-0600**

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Ratings..... :	**MST-HIE2.5-0600 MST-HIE5-0600**	**MST-HIE2.5-0800 MST-HIE5-0800**	**MST-HIE2.5-1000 MST-HIE5-1000**
Max. input voltage [V] ..... :	60		
Max. input DC current [A]..... :	14,5*4		
Rated battery voltage [V]..... :	51,2		
Output AC voltage ..... :	L/N/PE, 230Va.c., 50/60Hz		
Output AC current [A]..... :	2,61	3,48	4,35
Initial short-circuit AC current $I_{k''}$[A] ..... :	5,46		
Max. output power [VA]..... :	600	800	1000

Testing Location..... :	**LCIE China Company Limited**
Address..... :	Building 4, No, 518, Xinzhuan Road, Caohejing, Songjiang High-Tech Park, Shanghai, P,R, China (201612)
Tested by (name, function and signature)..... :	Joell Qin
Approved by (name, function and signature)..... :	Robin Wu
Manufacturer's name..... :	**Marstek energy Co., Ltd.**
Manufacturer address..... :	1-4F, BLDG#9, 1/F, BLDG#5, West Industrial Park, South of the Intersection of Ma'anshan Tunnel and Zhangshe Avenue, Xiangxi High-tech Zone, Hunan Province, China
Factory's name……..:	**Hunan Planck Esstechnology Co., Ltd.**
Factory address……...:	Building 12, West Industrial Park, South of intersection of Maanshan Tunnel and Zhangshe Avenue, Xiangxi High-tech Zone, Hunan Province

Document History

Date	Internal reference	Modification / Change / Status	Revision
2024-07-21	Joell Qin	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]..... :	38,2 kg for MST-HIE2.5-1000, MST-HIE2.5-0800, MST-HIE2.5-0600, 59,5 kg for MST-HIE5-1000, MST-HIE5-0800, MST-HIE5-0600

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 ..... :	2024-04-29
Date(s) of performance of test..... :	2024-04-29 to 2024-05-21

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 VDE-AR-N 4105 / DIN VDE V 0124-100,

All information in this test report limited to the type label, warning markings, trademark, block diagram, manual and datasheets are provided by the customer,

Conformity statements are decided in accordance with IEC GUIDE 115:2021 Procedure 2 (accuracy method), unless otherwise normatively specified or contractually agreed, The measurement result is considered as "pass" according to the requirement if it is within the prescribed limit or exactly on the limit,

"(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,

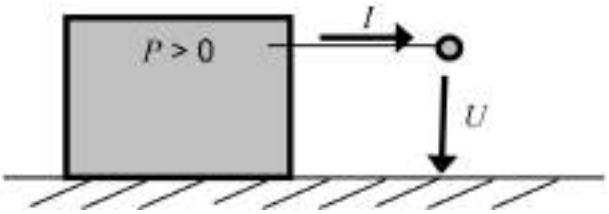
- "P_{rE}" for the rated active power:

  $P_{rE} = U_n \times I_r \times \cos \varphi$ (single-Phase); $P_{rE} = \sqrt{3}\ U_n \times I_r \times \cos \varphi$ (three-Phase)
- "P_{ref}" for the momentary power
- "ΔP_{E60}" in [%] = $(P_{Setpoint} - P_{E60}) / P_{rE}$
- "ΔQ_{E60}" in [%] = $(Q_{expected} - Q_{E60}) / P_{Emax}$
- "$_{E0,2}$" 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

Active and reactive power:

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

- if the inverter feeds to the grid the active power is measured with positive sign,



For the representation in quadrants, a power circle is chosen whose representation is compatible with mathematical representations of trigonometry and complex numbers (see Figure 2), Angles are counted positively counter-clockwise as in mathematics, The phase angle is defined as the angle from the current pointer to the voltage pointer, The current pointer is always in the real axis; the position of the voltage pointer corresponds to the apparent power and the phase angle,

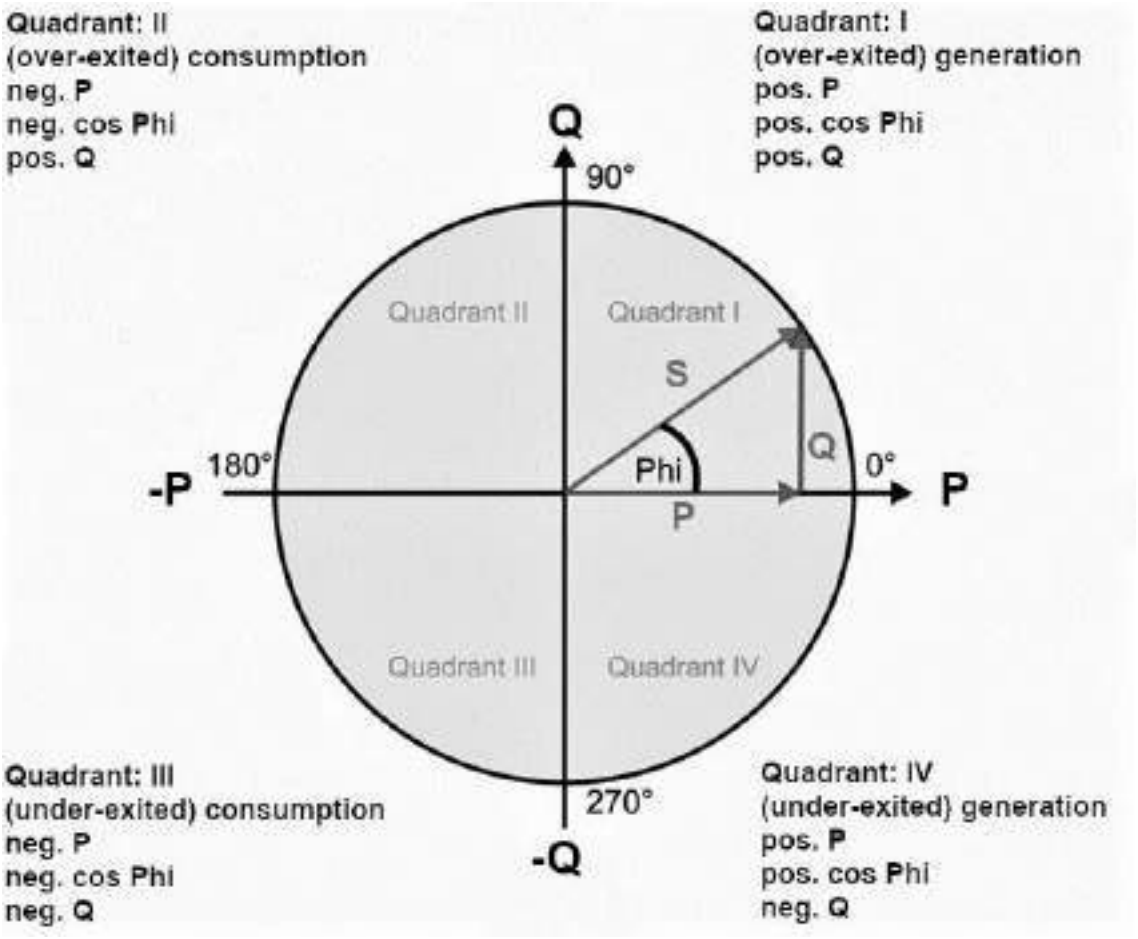
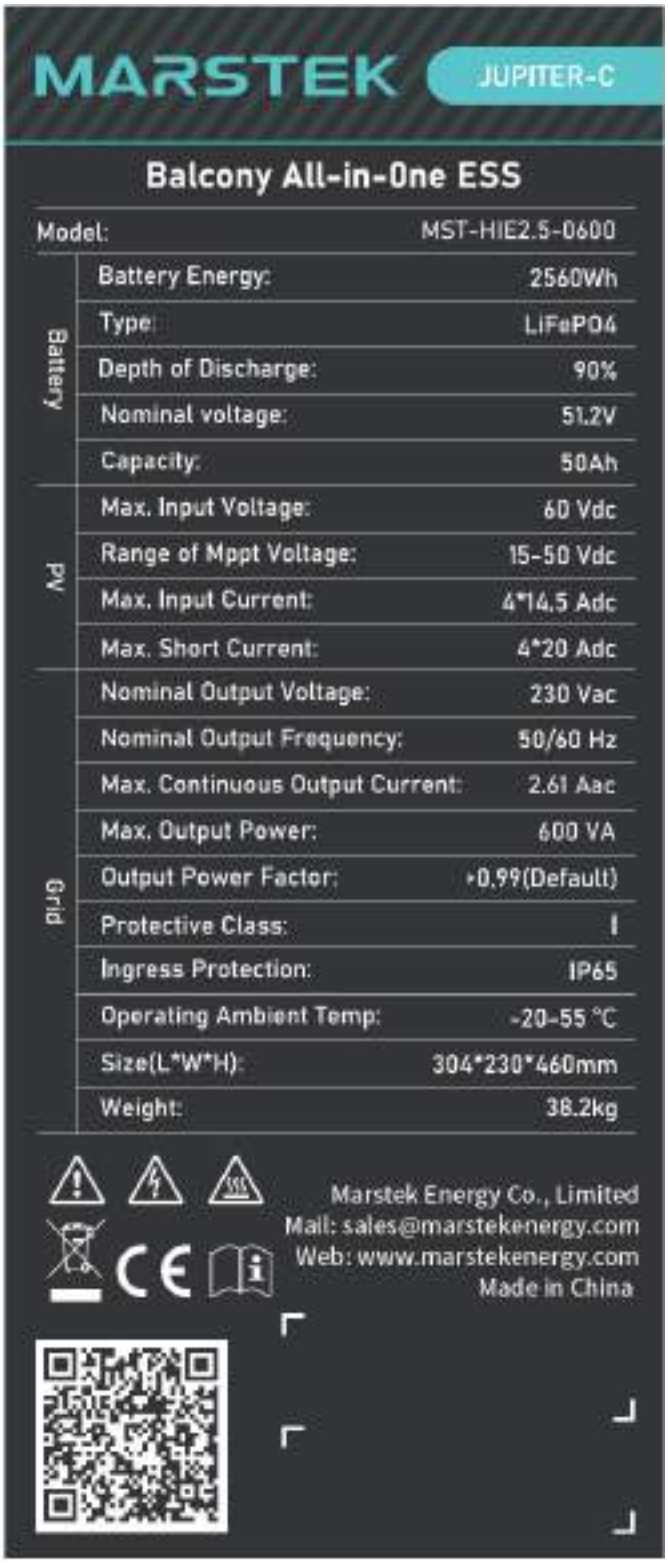


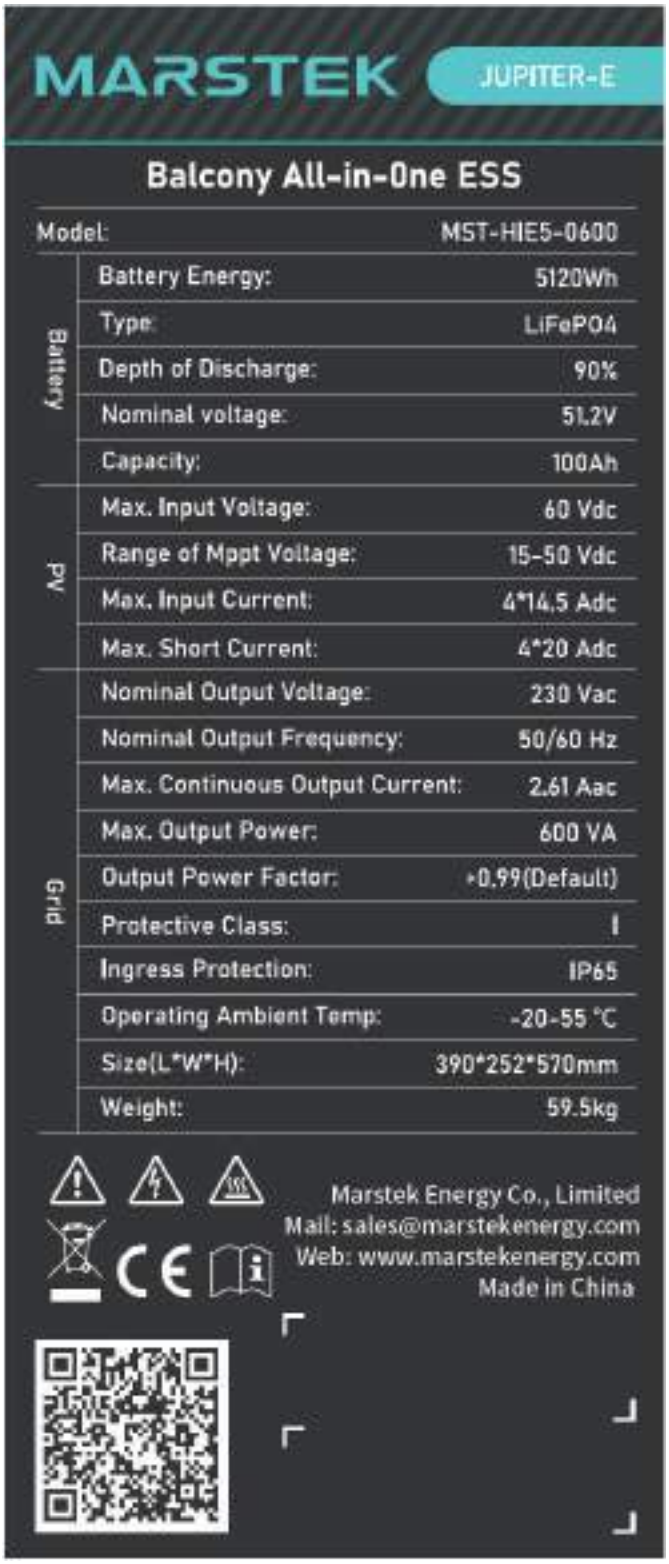
Figure 2

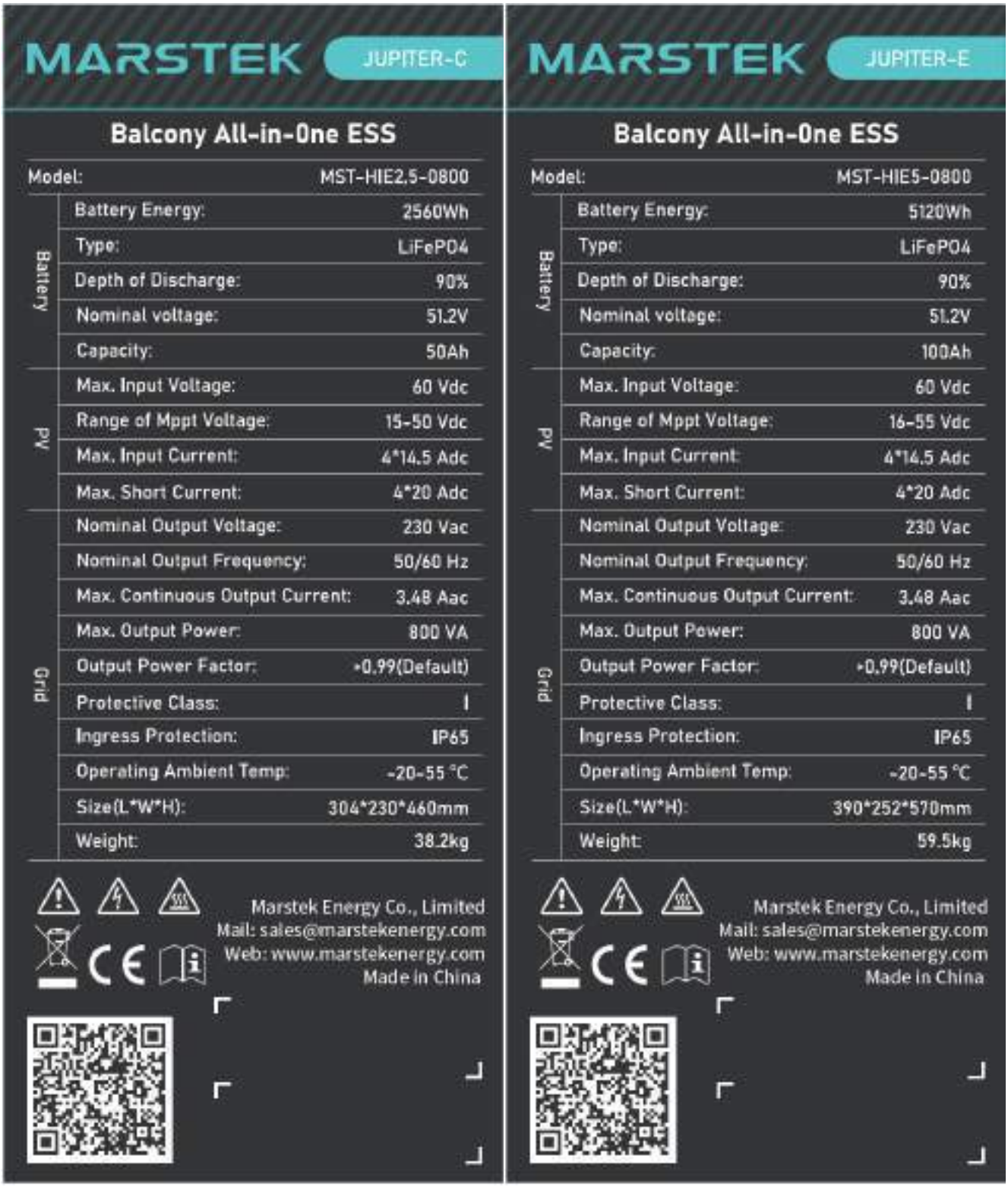
The different operating states can be represented in quadrants I to quadrant IV, The quadrants are named in a counter-clockwise direction,

This Test Report consists of the following documents:

Copy of marking plate







MARSTEK JUPITER-C

Balcony All-in-One ESS

Model:		MST-HIE2.5-0800
Battery	Battery Energy:	2560Wh
	Type:	LiFePO4
	Depth of Discharge:	90%
	Nominal voltage:	51.2V
	Capacity:	50Ah
PV	Max. Input Voltage:	60 Vdc
	Range of Mppt Voltage:	15-50 Vdc
	Max. Input Current:	4*14.5 Adc
	Max. Short Current:	4*20 Adc
Grid	Nominal Output Voltage:	230 Vac
	Nominal Output Frequency:	50/60 Hz
	Max. Continuous Output Current:	3.48 Aac
	Max. Output Power:	800 VA
	Output Power Factor:	>0.99(Default)
	Protective Class:	I
	Ingress Protection:	IP65
	Operating Ambient Temp:	-20-55 °C
	Size(L*W*H):	304*230*460mm
	Weight:	38.2kg

Marstek Energy Co., Limited
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Made in China

MARSTEK JUPITER-E

Balcony All-in-One ESS

Model:		MST-HIE5-0800
Battery	Battery Energy:	5120Wh
	Type:	LiFePO4
	Depth of Discharge:	90%
	Nominal voltage:	51.2V
	Capacity:	100Ah
PV	Max. Input Voltage:	60 Vdc
	Range of Mppt Voltage:	16-55 Vdc
	Max. Input Current:	4*14.5 Adc
	Max. Short Current:	4*20 Adc
Grid	Nominal Output Voltage:	230 Vac
	Nominal Output Frequency:	50/60 Hz
	Max. Continuous Output Current:	3.48 Aac
	Max. Output Power:	800 VA
	Output Power Factor:	>0.99(Default)
	Protective Class:	I
	Ingress Protection:	IP65
	Operating Ambient Temp:	-20-55 °C
	Size(L*W*H):	390*252*570mm
	Weight:	59.5kg

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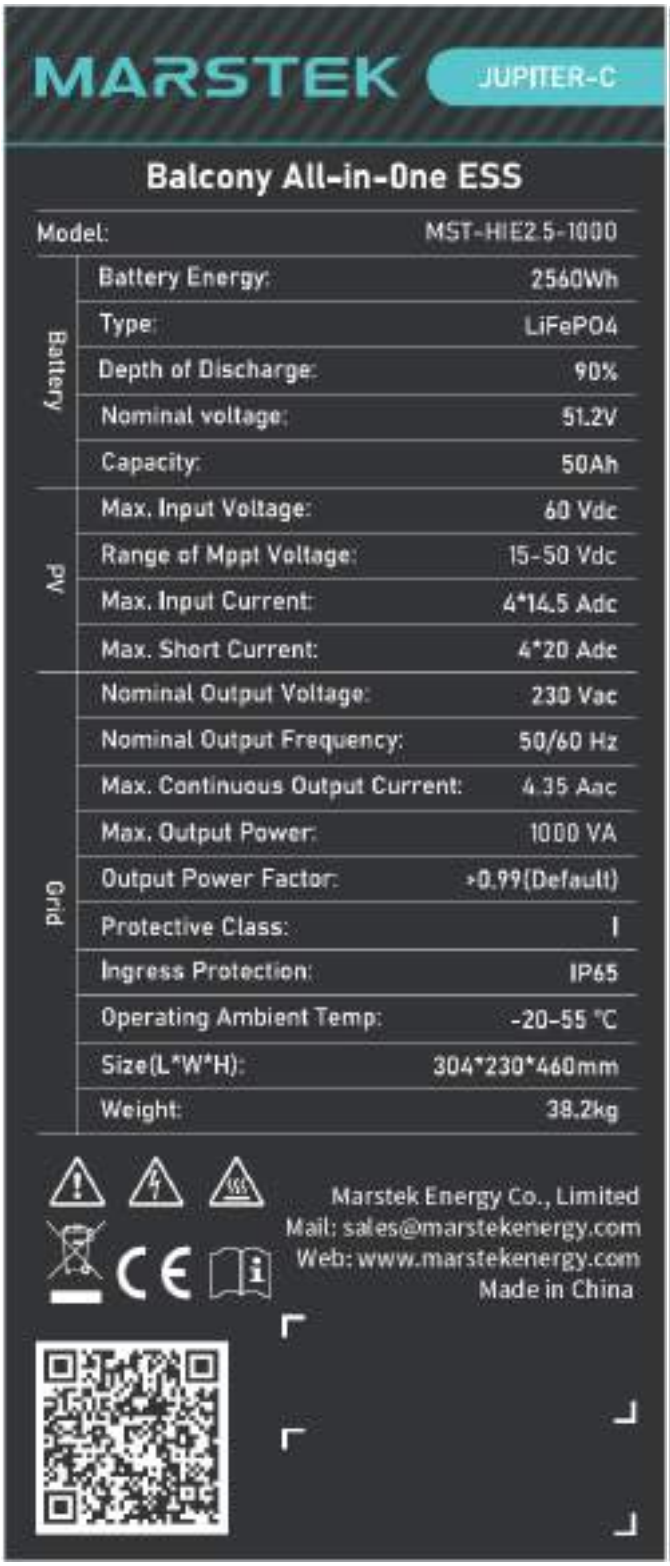
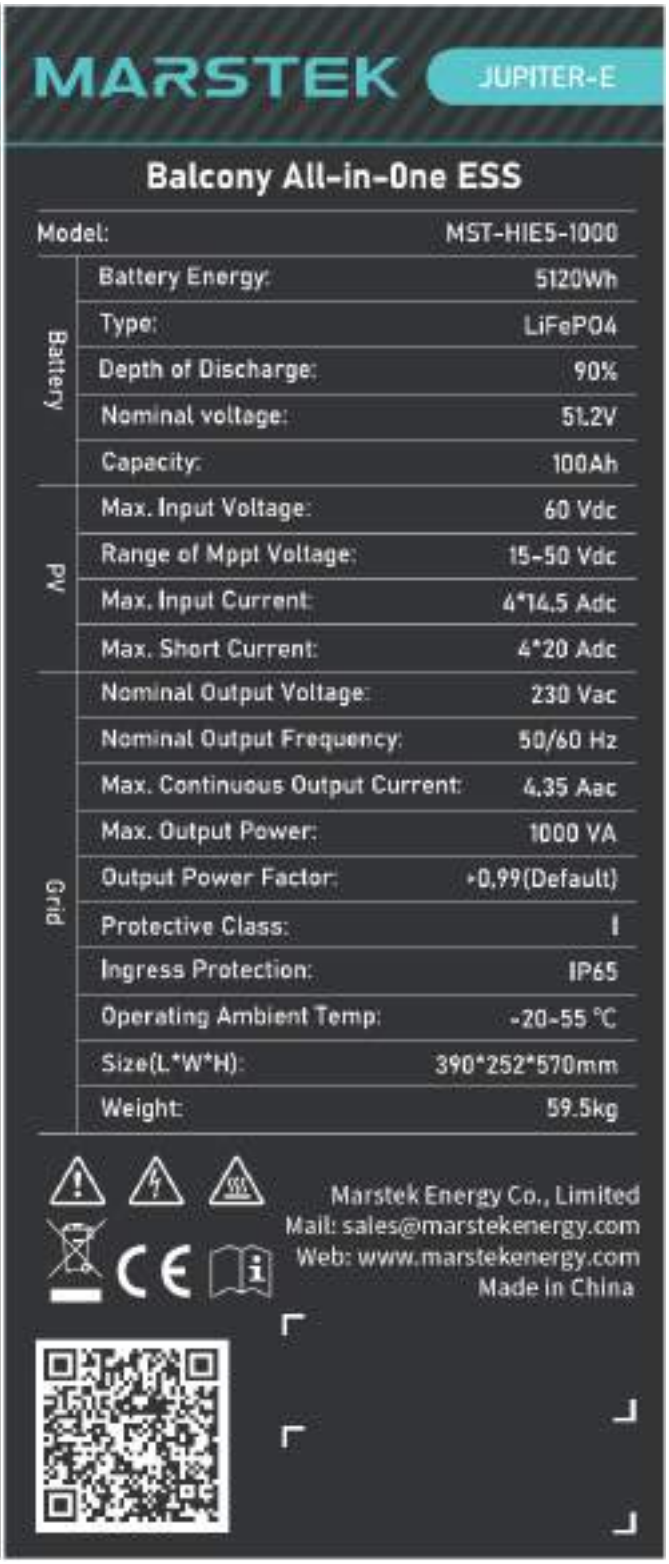
Made in China



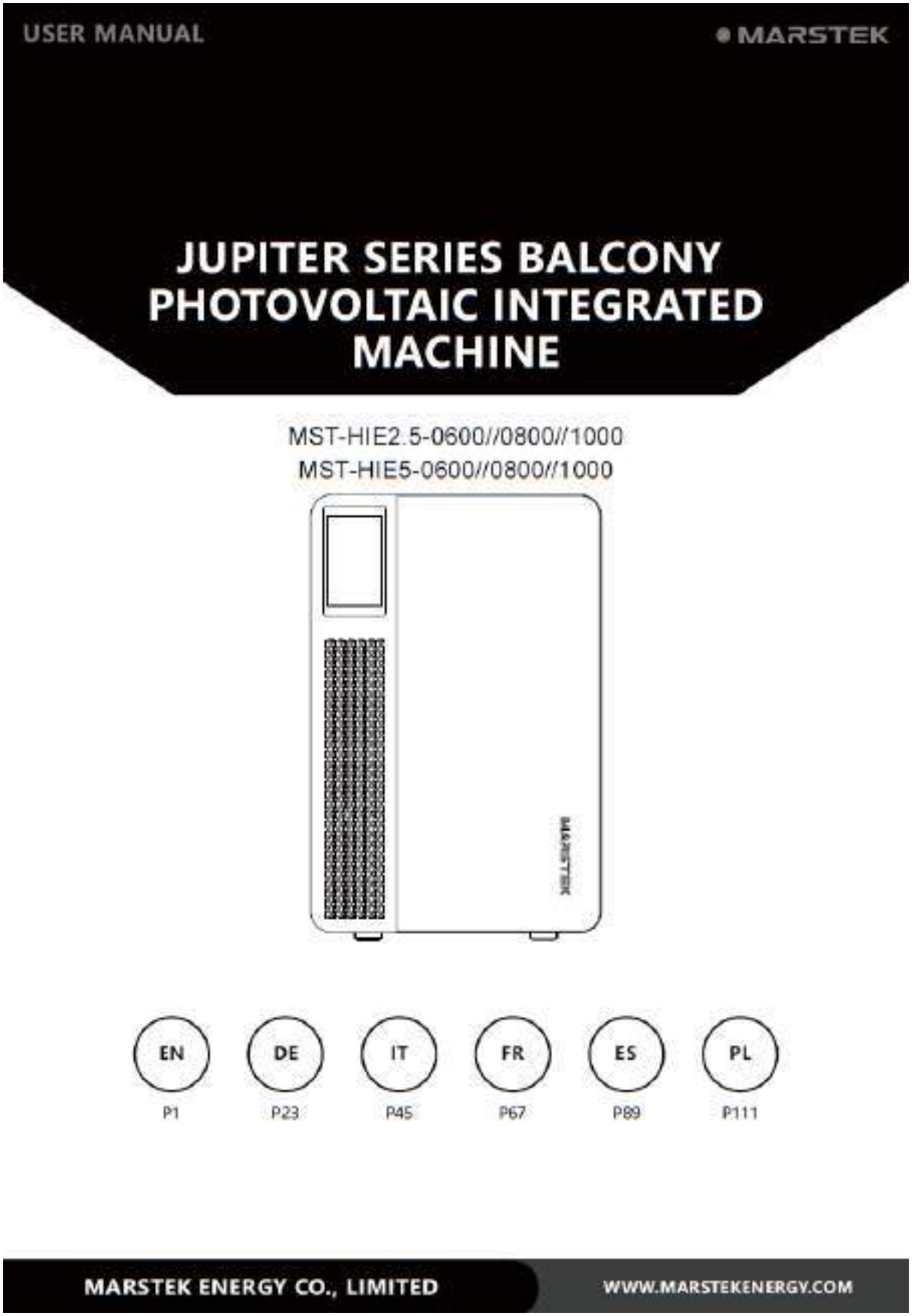


Note:

Example of marking plate

General product information

Datasheet Manufacturer example:



6. Technical Specifications

Specification Type	MST-HIE2.5-0600	MST-HIE2.5-0800	MST-HIE2.5-1000
DC Input			
Max. Input Voltage		60V	
PV Typical Input Power		400W-670W+	
Range of Input Operating Voltage		15-50V	
Max. Input Current		14.5A×4	
Max. Short Current		20A	
MPPT No.		4	
MPPT Efficiency		99.8%	
Max. inverter feedback current		0	
AC Output			
Max. Output Power	600W	800W	1000W
Nominal Output Voltage(AC)		230V	
Output Voltage Range		180-275V	
Nominal Output Frequency & Range		50Hz/45~55Hz 60Hz/55~65Hz	
Max. Continuous Output Current(AC)	2.61A	3.48A	4.35A
Max. Overcurrent		10A	
MaxFault Current		24A	
Current (In rush)		2A	
Max. Efficiency		96.5%	
Output Power Factor		>0.99 (Default)	
THDi		<3%	
General Parameter			
Ingress Protection		IP65	
Over Voltage category		PV:Ⅱ, Mains:Ⅲ	
Inverter Topology		Isolated	
Operating Ambient Temp.		-20~+55℃	
Relative humidity		≤95%RH	
Cooling Strategy		Natural Convection	
Protective Class		I	
Standard		VDE 4105/0124,TOR R25,EN50549-10,CE10-21,PETREE,PN-EN 50549-1/-2	
Supported Communication Interface		WIFI	
Size	304mm×230mm×460mm(JUPITER-C)	390mm×252mm×570mm(JUPITER-E)	

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Weight	38.2kg(JUPITER-C)	59.5kg(JUPITER-E)
Monitoring Platform	Power Zero	
Maintenance	10 Year	
Pollution Degree	Outdoor PD:III Indoor PD:II	
Max operation Altitude	2000m	
Battery Parameter		
Rated Voltage	51.2V	
Battery Energy	2560Wh(JUPITER-C)	5120Wh(JUPITER-E)
Life Cycle (Times)	>6000(25°C)	
Battery Type	LiFePO4	
DoD	90%	
Capacity	50Ah(JUPITER-C)	100Ah(JUPITER-E)

* Note 1: Rated voltage/frequency range can be changed according to the requirements of local power department.

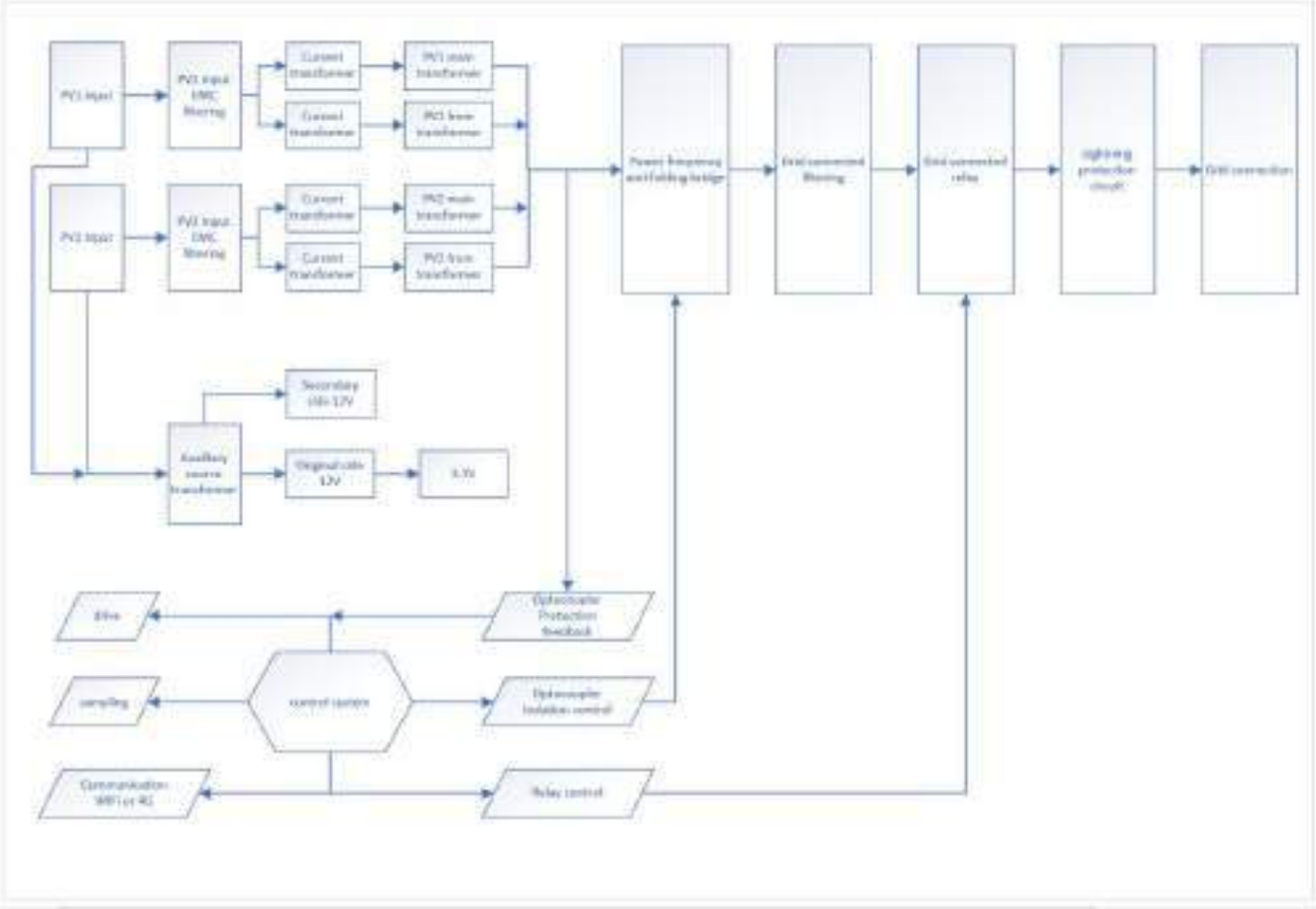
* Note 2: Please refer to local electrical regulations to determine the number of the balcony photovoltaic integrated machine that can be connected to each branch.

Block diagram of the utility interactive inverter

Description of the power circuit:

The internal control is redundant built, It consists of master controller(U15) and slave controller(U17), the master controller(U15) can control relays, measures voltage, frequency, AC current with injected DC, insulation resistance and residual current, The slave controller (U17) can control the relays, measures the voltage and frequency, Both controllers communicate with each other, The voltage and frequency measurement is achieved with resistors in serial which are connected directly to line and neutral, Both controllers get these signals and calculate the data.

The unit provides one dual contact relay in L and N, The relay is tested before each start up, In addition the power bridge can be stopped by both controllers.



Differences of the models in the series

Description example:

<u>All Identically</u>

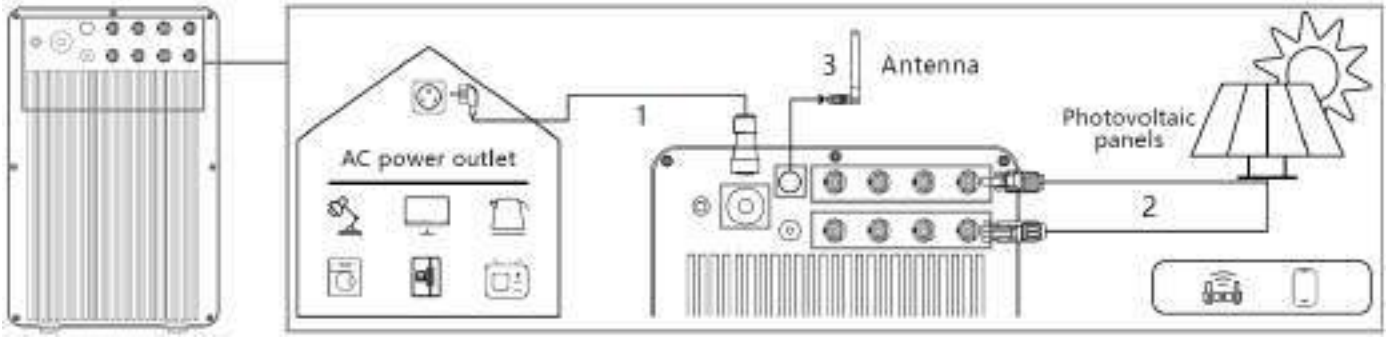
The PGUs MST-HIE2.5-1000, MST-HIE2.5-0800, MST-HIE2.5-0600, MST-HIE5-1000, MST-HIE5-0800, MST-HIE5-0600 use the same hardware platform. The ‘2,5’ models have the half battery energy and capacity of the ‘5’ models.

The PGUs use the same control unit, control system and software,

Therefore testing of the PGU MST-HIE2.5-1000 is applicable for the PGUs MST-HIE2.5-0800 and MST-HIE2.5-0600, MST-HIE5-1000, MST-HIE5-0800, MST-HIE5-0600.

The product was tested on
The products with serial number HMMI1000W20241200001, HMMI0800W20241200001 and HMMI0600W20241200001 were tested on. Hardware: V3.0 Software: V1.0.1 Note: The tests were performed with firmware version 1.0.1. Changes in the firmware version on position 1.0.X have no effect on the required electrical properties. "X" could be any number (or sign) higher (newer) than the tested version. All tests were performed on EUT MST-HIE2.5-1000 and are valid for the whole series.

Description of the remote control in a typical installation



Test Results

DIN VDE V 0124-100		
Clause	**Requirement – Test**	**Verdict**
5,2	Evidence of permissible network perturbations	**P**
5,3	Evidence of symmetry behaviour of inverters	**P**
5,4	Evidence of the behaviour of the generating unit on the network	**P**
5,5	NS-protection	**P**
5,6	Connecting conditions and synchronization	**P**
5,7	Evidence of $P_{AV,E}$-Control	**P**
5,8	Evidence dynamic grid support	**P**
5,9	Test of Ancillary Unit	**N/A**

DIN VDE V 0124-100		
Clause	**Requirement – Test**	**Verdict**
5,2	**Evidence of permissible network perturbations**	
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 a)	Test Harmonics DIN EN 61000-3-2 (≤ 16 A per Phase)	**P**
5,2,4,1 a)	Test Harmonics DIN EN 61000-3-12 (≥ 16 A and ≤ 75 A per Phase)	**N/A**
5,2,4,1 b)	Test Harmonics and interharmonics DIN EN 61000-4-7 (≥ 75 A per Phase)	**P**
5,2,5	Commutation	**N/A**
5,2,6	Feed in of DC current	**P**

5,2,1	General	P

The electrical installations of the customer system shall be planned, constructed and operated so that reactions to the network operator's network and to the systems of other customers are permanently reduced to a permissible minimum, Should interfering reactions on the network operator's network occur nonetheless, the customer shall apply measures to his system that are to be coordinated with the network operator, The network operator is entitled to disconnect the power generation system concerned from the network until the deficiencies are corrected,

System perturbations are defined as:

- Rapid voltage changes
- Flicker
- Harmonics, interharmonics and higher frequencies (up to 9 kHz)

5,2,2	Rapid voltage changes	P

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

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

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

Note: For PV-plants the inverter is the generator

- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

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

Test conditions:

Frequency: 50 Hz ±0,5%

THD of the voltage supply: ≤ 3 %

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

Test: MST-HIE2.5-1000

Switch-on for any capacity (10% PEmax)

Phase	L1			L2			L3		
Single period effective values of the current [A]	0,172	0,177	0,180	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,3	227,2	227,1	NA	NA	NA	NA	NA	NA
k_i value [1]	0,038	0,039	0,040	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,040			NA			NA		

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

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

Switch-on for nominal capacity

Phase	L1			L2			L3		
Single period effective values of the current [A]	0,173	0,175	0,173	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,2	227,1	227,1	NA	NA	NA	NA	NA	NA
k_i value [1]	0,038	0,038	0,038	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,038			NA			NA		

5,2,2	Rapid voltage changes	P

Switch-off for nominal capacity

Phase	L1			L2			L3		
Single period effective values of the current [A]	0,950	1,950	3,353	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,2	227,3	227,5	NA	NA	NA	NA	NA	NA
k_i value [1]	0,209	0,429	0,737	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,737			NA			NA		

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	4,55
Highest k_{imax} value for all switching operations [1]	0,737

Note:

Limits:

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

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

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

(I_a = starting current)

5,2,2	Rapid voltage changes	P

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

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

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

Note: For PV-plants the inverter is the generator

- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

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

Test conditions:

Frequency: 50 Hz ±0,5%

THD of the voltage supply: ≤ 3 %

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

Test: MST-HIE2.5-0800

Switch-on for any capacity (10% PEmax)

Phase	L1			L2			L3		
Single period effective values of the current [A]	0,175	0,172	0,173	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,0	227,0	227,1	NA	NA	NA	NA	NA	NA
k_i value [1]	0,048	0,047	0,048	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,048			NA			NA		

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

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

Switch-on for nominal capacity

Phase	L1			L2			L3		
Single period effective values of the current [A]	0,175	0,173	0,169	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,1	227,2	227,2	NA	NA	NA	NA	NA	NA
k_i value [1]	0,048	0,048	0,046	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,048			NA			NA		

5,2,2	Rapid voltage changes	P

Switch-off for nominal capacity

Phase	L1			L2			L3		
Single period effective values of the current [A]	1,335	0,879	1,558	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,1	227,0	227,0	NA	NA	NA	NA	NA	NA
k_i value [1]	0,367	0,241	0,428	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,428			NA			NA		

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	3,64
Highest k_{imax} value for all switching operations [1]	0,428

Note:

Limits:

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

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

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

(I_a = starting current)

5,2,2	Rapid voltage changes	P

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

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

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

Note: For PV-plants the inverter is the generator

- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)

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

Test conditions:

Frequency: 50 Hz ±0,5%

THD of the voltage supply: ≤ 3 %

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

Test: MST-HIE2.5-0600

Switch-on for any capacity (10% PEmax)

Phase	L1			L2			L3		
Single period effective values of the current [A]	0,171	0,171	0,066	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,2	227,1	227,3	NA	NA	NA	NA	NA	NA
k_i value [1]	0,063	0,063	0,024	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,063			NA			NA		

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

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

Switch-on for nominal capacity

Phase	L1			L2			L3		
Single period effective values of the current [A]	0,171	0,172	0,176	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,3	227,3	227,3	NA	NA	NA	NA	NA	NA
k_i value [1]	0,063	0,063	0,064	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,064			NA			NA		

5,2,2	Rapid voltage changes	P

Switch-off for nominal capacity

Phase	L1			L2			L3		
Single period effective values of the current [A]	1,152	1,141	0,911	NA	NA	NA	NA	NA	NA
Single period effective values of the voltage [V]	227,3	227,3	227,4	NA	NA	NA	NA	NA	NA
k_i value [1]	0,422	0,418	0,334	NA	NA	NA	NA	NA	NA
k_{imax} value [1]	0,422			NA			NA		

Grid Frequency [Hz]	50
Grid voltage [V]	230
Rated current I_r [A]	2,73
Highest k_{imax} value for all switching operations [1]	0,422

Note:

Limits:

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

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

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

(I_a = starting current)

5,2,3	**Flicker** 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 flicker must be verified as followed:

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

Test conditions:

Voltage: 86% U_n to 109% U_n

Frequency: 50 Hz ±0,5%

THD of the voltage supply: ≤ 3 %

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

Test:

MST-HIE2.5-1000

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

Grid impedance DIN EN 61000-3-3 (VDE 0838-3) [Ω]:	R_A = 0,24Ω jX_A = 0,15Ω / R_N = 0,16Ω jX_N = 0,10Ω (Rn and jXn only for single-phase units used!)
Output voltage of the impedance network [V]	230 V

Flicker to:	Result:		
	P_{lt}	P_{st}	dc%
DIN EN 61000-3-3	0,017	0,019	0,031

Assessment criterion:

Long-term flicker strength Plt to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 must be ≤ 0,5,

Determination of the flicker coefficient:

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

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

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

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

Grid impedance angle ψ_k	32°
Flicker coefficient c(ψ_k)	1,932

Assessment criterion:

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

Note:

5,2,4,1 a)	Test Harmonics DIN EN 61000-3-2 (≤16 A per Phase)	P

MST-HIE2.5-1000

Phase	L1	L2	L3
Power Level	100%	100%	100%
AC Power [W]	1008,1	N/A	N/A
AC Voltage [V]	229,9	N/A	N/A
AC Current [A]	4,39	N/A	N/A
Frequency [Hz]	50,00	N/A	N/A
THD [%][50]	1,92	N/A	N/A

Harmonic	Current Magnitude (A)	% of Funda-mental	Current Magnitude (A)	% of Funda-mental	Current Magnitude (A)	% of Funda-mental	Harmonic Current Limits (A)
1st	4,385	-	N/A	N/A	N/A	N/A	--
2nd	0,007	0,170	N/A	N/A	N/A	N/A	1,080
3rd	0,028	0,636	N/A	N/A	N/A	N/A	2,300
4th	0,004	0,084	N/A	N/A	N/A	N/A	0,430
5th	0,023	0,534	N/A	N/A	N/A	N/A	1,140
6th	0,002	0,044	N/A	N/A	N/A	N/A	0,300
7th	0,016	0,365	N/A	N/A	N/A	N/A	0,770
8th	0,001	0,033	N/A	N/A	N/A	N/A	0,263
9th	0,016	0,377	N/A	N/A	N/A	N/A	0,400
10th	0,001	0,028	N/A	N/A	N/A	N/A	0,184
11th	0,013	0,297	N/A	N/A	N/A	N/A	0,330
12th	0,001	0,027	N/A	N/A	N/A	N/A	0,153
13th	0,011	0,253	N/A	N/A	N/A	N/A	0,210
14th	0,001	0,016	N/A	N/A	N/A	N/A	0,131
15th	0,016	0,357	N/A	N/A	N/A	N/A	0,150
16th	0,000	0,011	N/A	N/A	N/A	N/A	0,115
17th	0,019	0,435	N/A	N/A	N/A	N/A	0,132
18th	0,001	0,018	N/A	N/A	N/A	N/A	0,102
19th	0,020	0,465	N/A	N/A	N/A	N/A	0,188
20th	0,001	0,012	N/A	N/A	N/A	N/A	0,092
21th	0,021	0,481	N/A	N/A	N/A	N/A	0,107
22th	0,000	0,007	N/A	N/A	N/A	N/A	0,084
23th	0,020	0,465	N/A	N/A	N/A	N/A	0,098
24th	0,001	0,012	N/A	N/A	N/A	N/A	0,077
25th	0,017	0,399	N/A	N/A	N/A	N/A	0,090
26th	0,001	0,013	N/A	N/A	N/A	N/A	0,071
27th	0,017	0,387	N/A	N/A	N/A	N/A	0,080
28th	0,001	0,024	N/A	N/A	N/A	N/A	0,066
29th	0,018	0,417	N/A	N/A	N/A	N/A	0,078
30th	0,001	0,012	N/A	N/A	N/A	N/A	0,061
31th	0,019	0,441	N/A	N/A	N/A	N/A	0,073

5,2,4,1 a)	Test Harmonics DIN EN 61000-3-2 (≤16 A per Phase)						P
MST-HIE2.5-1000							
32th	0,000	0,010	N/A	N/A	N/A	N/A	0,057
33th	0,019	0,443	N/A	N/A	N/A	N/A	0,068
34th	0,000	0,008	N/A	N/A	N/A	N/A	0,054
35th	0,018	0,418	N/A	N/A	N/A	N/A	0,064
36th	0,000	0,011	N/A	N/A	N/A	N/A	0,051
37th	0,016	0,368	N/A	N/A	N/A	N/A	0,061
38th	0,001	0,013	N/A	N/A	N/A	N/A	0,048
39th	0,014	0,312	N/A	N/A	N/A	N/A	0,058
40th	0,000	0,011	N/A	N/A	N/A	N/A	0,046
41th	0,012	0,266	N/A	N/A	N/A	N/A	N/A
42th	0,001	0,014	N/A	N/A	N/A	N/A	N/A
43th	0,011	0,251	N/A	N/A	N/A	N/A	N/A
44th	0,001	0,018	N/A	N/A	N/A	N/A	N/A
45th	0,009	0,217	N/A	N/A	N/A	N/A	N/A
46th	0,001	0,018	N/A	N/A	N/A	N/A	N/A
47th	0,006	0,145	N/A	N/A	N/A	N/A	N/A
48th	0,001	0,013	N/A	N/A	N/A	N/A	N/A
49th	0,004	0,082	N/A	N/A	N/A	N/A	N/A
50th	0,001	0,012	N/A	N/A	N/A	N/A	N/A

Impedance [Ω]	
Line	$R_A = 0,24\ jX_A = 0,15$
Neutral	$R_N = 0,16\ jX_N = 0,10$

Note:

5.2.4.1 b)	Test Harmonics DIN EN 61000-4-7											P
MST-HIE2.5-1000												
Harmonics												
P/ P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
Order	I_h [%]											
1	4,038	10,916	20,550	30,221	40,301	50,666	60,762	70,903	81,150	91,083	100,795	100,795
2	0,027	0,008	0,025	0,031	0,045	0,055	0,084	0,094	0,117	0,151	0,168	0,170
3	0,039	0,192	0,082	0,299	0,223	0,197	0,349	0,482	0,460	0,457	0,632	0,636
4	0,006	0,019	0,005	0,007	0,014	0,026	0,035	0,037	0,054	0,059	0,083	0,084
5	0,022	0,141	0,049	0,218	0,136	0,079	0,219	0,391	0,352	0,390	0,531	0,534
6	0,010	0,006	0,004	0,023	0,014	0,019	0,017	0,022	0,035	0,046	0,043	0,044
7	0,031	0,078	0,090	0,216	0,173	0,170	0,173	0,098	0,262	0,334	0,369	0,365
8	0,013	0,004	0,007	0,005	0,010	0,018	0,020	0,015	0,019	0,025	0,032	0,033
9	0,014	0,037	0,052	0,084	0,095	0,096	0,083	0,071	0,120	0,249	0,375	0,377
10	0,011	0,006	0,011	0,015	0,019	0,020	0,008	0,011	0,015	0,023	0,028	0,028
11	0,015	0,026	0,016	0,035	0,048	0,060	0,089	0,175	0,173	0,182	0,296	0,297
12	0,010	0,006	0,005	0,008	0,005	0,015	0,013	0,010	0,011	0,024	0,028	0,027
13	0,013	0,028	0,029	0,032	0,073	0,111	0,215	0,115	0,250	0,252	0,255	0,253
14	0,008	0,003	0,006	0,007	0,010	0,015	0,013	0,008	0,013	0,015	0,015	0,016
15	0,013	0,027	0,039	0,058	0,089	0,135	0,130	0,279	0,270	0,337	0,358	0,357
16	0,009	0,003	0,004	0,005	0,006	0,006	0,010	0,011	0,020	0,007	0,011	0,011
17	0,015	0,006	0,063	0,051	0,123	0,135	0,291	0,351	0,393	0,383	0,436	0,435
18	0,009	0,003	0,006	0,007	0,014	0,012	0,008	0,011	0,010	0,016	0,018	0,018
19	0,015	0,046	0,088	0,045	0,146	0,160	0,151	0,253	0,433	0,458	0,467	0,465
20	0,009	0,003	0,007	0,004	0,009	0,008	0,007	0,009	0,013	0,010	0,010	0,012
21	0,012	0,055	0,086	0,088	0,153	0,206	0,330	0,344	0,342	0,458	0,486	0,481
22	0,009	0,004	0,005	0,004	0,008	0,010	0,009	0,012	0,010	0,013	0,007	0,007
23	0,013	0,051	0,079	0,141	0,151	0,233	0,234	0,323	0,353	0,378	0,464	0,465
24	0,009	0,003	0,006	0,005	0,009	0,012	0,018	0,009	0,019	0,012	0,012	0,012
25	0,015	0,054	0,091	0,161	0,187	0,223	0,373	0,325	0,387	0,355	0,401	0,399
26	0,007	0,005	0,004	0,004	0,008	0,010	0,012	0,008	0,012	0,014	0,013	0,013
27	0,011	0,054	0,113	0,191	0,232	0,224	0,246	0,412	0,367	0,392	0,388	0,387
28	0,009	0,002	0,006	0,010	0,011	0,007	0,014	0,019	0,012	0,016	0,023	0,024
29	0,019	0,081	0,118	0,199	0,240	0,256	0,313	0,318	0,404	0,404	0,416	0,417
30	0,011	0,004	0,007	0,012	0,010	0,008	0,010	0,009	0,014	0,017	0,012	0,012
31	0,017	0,086	0,114	0,178	0,225	0,285	0,235	0,303	0,413	0,414	0,440	0,441
32	0,011	0,003	0,004	0,004	0,008	0,010	0,009	0,007	0,013	0,010	0,010	0,010
33	0,018	0,095	0,121	0,182	0,238	0,278	0,331	0,313	0,327	0,422	0,442	0,443
34	0,010	0,003	0,005	0,011	0,011	0,006	0,012	0,010	0,014	0,009	0,008	0,008
35	0,029	0,085	0,123	0,197	0,234	0,250	0,275	0,263	0,311	0,368	0,418	0,418
36	0,010	0,006	0,006	0,008	0,009	0,007	0,014	0,007	0,010	0,009	0,010	0,011
37	0,024	0,068	0,104	0,182	0,201	0,240	0,290	0,326	0,314	0,309	0,369	0,368
38	0,009	0,004	0,003	0,006	0,010	0,005	0,013	0,011	0,014	0,008	0,013	0,013
39	0,021	0,071	0,096	0,175	0,176	0,247	0,230	0,300	0,264	0,307	0,315	0,312
40	0,010	0,004	0,003	0,006	0,007	0,016	0,014	0,015	0,012	0,014	0,010	0,011
41	0,026	0,069	0,090	0,169	0,173	0,216	0,223	0,210	0,244	0,288	0,267	0,266
42	0,014	0,011	0,012	0,012	0,009	0,021	0,016	0,018	0,015	0,021	0,014	0,014
43	0,020	0,064	0,077	0,142	0,163	0,158	0,182	0,188	0,212	0,227	0,250	0,251

5.2.4.1 b)	Test Harmonics DIN EN 61000-4-7											P
MST-HIE2.5-1000												
Harmonics												
P/ P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
44	0,021	0,013	0,010	0,005	0,007	0,015	0,015	0,017	0,016	0,020	0,019	0,018
45	0,014	0,048	0,064	0,108	0,125	0,116	0,148	0,094	0,107	0,167	0,216	0,217
46	0,015	0,004	0,003	0,004	0,006	0,019	0,017	0,018	0,015	0,013	0,018	0,018
47	0,016	0,033	0,048	0,087	0,092	0,104	0,102	0,083	0,065	0,109	0,143	0,145
48	0,013	0,004	0,006	0,007	0,006	0,027	0,013	0,014	0,015	0,010	0,013	0,013
49	0,016	0,021	0,036	0,065	0,076	0,090	0,023	0,084	0,052	0,021	0,082	0,082
50	0,015	0,015	0,012	0,011	0,012	0,029	0,011	0,012	0,015	0,013	0,013	0,012

5.2.4.1 b)	Interharmonics											P
MST-HIE2.5-1000												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [Hz]	I_h [%]											
75	0,015	0,014	0,011	0,014	0,016	0,019	0,021	0,046	0,057	0,028	0,039	0,039
125	0,013	0,008	0,009	0,012	0,014	0,018	0,019	0,022	0,028	0,026	0,029	0,029
175	0,015	0,011	0,012	0,013	0,015	0,018	0,021	0,022	0,027	0,025	0,027	0,027
225	0,013	0,008	0,008	0,010	0,012	0,016	0,016	0,021	0,024	0,021	0,025	0,025
275	0,015	0,009	0,011	0,012	0,013	0,016	0,015	0,020	0,024	0,021	0,025	0,025
325	0,013	0,007	0,009	0,011	0,012	0,016	0,015	0,019	0,021	0,021	0,023	0,023
375	0,014	0,007	0,010	0,011	0,012	0,014	0,018	0,020	0,023	0,019	0,023	0,023
425	0,013	0,008	0,009	0,009	0,013	0,015	0,016	0,018	0,021	0,020	0,021	0,021
475	0,014	0,008	0,009	0,011	0,011	0,014	0,017	0,019	0,021	0,021	0,022	0,022
525	0,014	0,008	0,008	0,011	0,012	0,015	0,017	0,020	0,022	0,021	0,021	0,021
575	0,013	0,007	0,009	0,011	0,012	0,015	0,017	0,020	0,020	0,023	0,022	0,022
625	0,013	0,008	0,009	0,010	0,011	0,014	0,016	0,019	0,022	0,020	0,023	0,023
675	0,013	0,009	0,009	0,011	0,014	0,014	0,015	0,019	0,019	0,021	0,021	0,021
725	0,013	0,007	0,009	0,010	0,011	0,014	0,018	0,020	0,019	0,021	0,024	0,024
775	0,013	0,007	0,009	0,010	0,011	0,015	0,018	0,017	0,019	0,020	0,023	0,023
825	0,014	0,008	0,009	0,010	0,013	0,014	0,017	0,021	0,019	0,021	0,023	0,023
875	0,014	0,007	0,008	0,011	0,012	0,014	0,013	0,016	0,018	0,016	0,022	0,022
925	0,013	0,008	0,009	0,011	0,012	0,015	0,015	0,018	0,020	0,020	0,023	0,023
975	0,013	0,008	0,010	0,012	0,014	0,015	0,014	0,016	0,021	0,020	0,023	0,023
1025	0,013	0,007	0,010	0,010	0,012	0,013	0,016	0,017	0,020	0,019	0,021	0,021
1075	0,013	0,007	0,009	0,011	0,010	0,015	0,013	0,017	0,018	0,018	0,020	0,020
1125	0,014	0,007	0,008	0,010	0,011	0,014	0,013	0,017	0,019	0,019	0,022	0,022
1175	0,014	0,007	0,009	0,010	0,010	0,014	0,013	0,017	0,018	0,019	0,023	0,023
1225	0,013	0,008	0,009	0,011	0,012	0,013	0,013	0,017	0,019	0,018	0,023	0,023
1275	0,013	0,007	0,008	0,011	0,011	0,013	0,014	0,016	0,018	0,022	0,025	0,025
1325	0,013	0,008	0,009	0,011	0,012	0,013	0,014	0,016	0,018	0,017	0,020	0,020
1375	0,014	0,008	0,008	0,010	0,011	0,012	0,013	0,017	0,020	0,024	0,025	0,025
1425	0,014	0,008	0,009	0,009	0,011	0,014	0,014	0,015	0,019	0,018	0,022	0,022
1475	0,014	0,007	0,009	0,011	0,012	0,013	0,014	0,018	0,018	0,023	0,029	0,029
1525	0,014	0,008	0,009	0,011	0,012	0,014	0,013	0,016	0,020	0,020	0,021	0,021
1575	0,014	0,009	0,009	0,012	0,012	0,014	0,013	0,016	0,021	0,025	0,032	0,032
1625	0,015	0,009	0,008	0,009	0,012	0,014	0,015	0,017	0,019	0,020	0,022	0,022
1675	0,014	0,008	0,009	0,012	0,013	0,014	0,015	0,018	0,021	0,025	0,032	0,032
1725	0,015	0,009	0,009	0,012	0,011	0,014	0,014	0,018	0,019	0,019	0,020	0,020
1775	0,015	0,009	0,009	0,011	0,012	0,015	0,014	0,019	0,022	0,026	0,029	0,029
1825	0,015	0,008	0,009	0,010	0,012	0,015	0,014	0,018	0,020	0,019	0,023	0,023
1875	0,015	0,010	0,010	0,012	0,014	0,016	0,015	0,022	0,021	0,025	0,027	0,027
1925	0,015	0,009	0,009	0,010	0,012	0,015	0,015	0,018	0,018	0,020	0,025	0,025
1975	0,015	0,008	0,011	0,011	0,018	0,017	0,018	0,025	0,021	0,023	0,025	0,025

5.2.4.1 b)	Higher Frequencies											P
MST-HIE2.5-1000												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [kHz]	I_h [%]											
2,1	0,052	0,097	0,122	0,223	0,239	0,271	0,291	0,287	0,327	0,370	0,371	0,371
2,3	0,045	0,062	0,083	0,142	0,158	0,163	0,185	0,135	0,134	0,206	0,266	0,266
2,5	0,046	0,036	0,052	0,081	0,092	0,118	0,056	0,096	0,079	0,086	0,142	0,142
2,7	0,068	0,042	0,042	0,050	0,071	0,060	0,060	0,119	0,125	0,135	0,264	0,264
2,9	0,072	0,083	0,083	0,139	0,148	0,131	0,156	0,194	0,329	0,265	0,272	0,272
3,1	0,077	0,091	0,112	0,179	0,207	0,229	0,243	0,286	0,351	0,420	0,336	0,336
3,3	0,077	0,072	0,103	0,193	0,231	0,273	0,322	0,388	0,345	0,426	0,488	0,488
3,5	0,075	0,111	0,161	0,282	0,321	0,348	0,419	0,350	0,449	0,407	0,535	0,535
3,7	0,085	0,099	0,152	0,311	0,297	0,374	0,366	0,408	0,397	0,463	0,496	0,496
3,9	0,135	0,194	0,340	0,535	0,600	0,763	0,798	0,909	0,915	1,014	1,036	1,036
4,1	0,188	0,148	0,164	0,331	0,262	0,443	0,394	0,392	0,452	0,451	0,476	0,476
4,3	0,214	0,157	0,205	0,339	0,305	0,344	0,352	0,357	0,468	0,519	0,551	0,551
4,5	0,261	0,213	0,242	0,354	0,276	0,342	0,357	0,371	0,468	0,496	0,565	0,565
4,7	0,244	0,181	0,215	0,357	0,303	0,361	0,375	0,461	0,423	0,520	0,517	0,517
4,9	0,186	0,150	0,211	0,326	0,337	0,407	0,450	0,434	0,515	0,435	0,462	0,462
5,1	0,142	0,098	0,174	0,323	0,302	0,385	0,364	0,395	0,530	0,336	0,533	0,533
5,3	0,092	0,097	0,170	0,314	0,308	0,325	0,353	0,364	0,286	0,443	0,352	0,352
5,5	0,071	0,070	0,101	0,202	0,206	0,229	0,250	0,232	0,296	0,315	0,245	0,245
5,7	0,061	0,056	0,080	0,137	0,148	0,185	0,188	0,195	0,209	0,189	0,247	0,247
5,9	0,046	0,046	0,047	0,068	0,084	0,088	0,118	0,115	0,094	0,124	0,157	0,157
6,1	0,038	0,039	0,038	0,036	0,059	0,073	0,054	0,054	0,062	0,100	0,074	0,074
6,3	0,037	0,033	0,032	0,038	0,050	0,053	0,040	0,044	0,051	0,075	0,061	0,061
6,5	0,033	0,023	0,028	0,060	0,052	0,053	0,056	0,063	0,081	0,090	0,080	0,080
6,7	0,029	0,023	0,035	0,062	0,060	0,069	0,055	0,080	0,073	0,067	0,109	0,109
6,9	0,027	0,026	0,028	0,065	0,051	0,067	0,066	0,062	0,075	0,079	0,073	0,073
7,1	0,029	0,026	0,032	0,067	0,049	0,054	0,076	0,066	0,077	0,073	0,060	0,060
7,3	0,025	0,025	0,028	0,044	0,031	0,048	0,046	0,056	0,049	0,057	0,078	0,078
7,5	0,022	0,020	0,021	0,028	0,027	0,031	0,046	0,043	0,038	0,049	0,064	0,064
7,7	0,019	0,020	0,017	0,017	0,020	0,029	0,034	0,041	0,037	0,035	0,037	0,037
7,9	0,018	0,018	0,017	0,017	0,017	0,020	0,022	0,026	0,027	0,025	0,024	0,024
8,1	0,017	0,013	0,013	0,019	0,018	0,017	0,024	0,020	0,024	0,024	0,021	0,021
8,3	0,015	0,012	0,012	0,018	0,017	0,019	0,021	0,019	0,018	0,020	0,020	0,020
8,5	0,014	0,011	0,012	0,016	0,016	0,018	0,018	0,026	0,023	0,028	0,023	0,023
8,7	0,013	0,011	0,011	0,015	0,014	0,017	0,021	0,025	0,026	0,027	0,023	0,023
8,9	0,012	0,011	0,011	0,013	0,013	0,019	0,025	0,023	0,020	0,018	0,029	0,029
Impedance [Ω]												
					Line	$R_A = 0,24$ j$X_A = 0,15$						
					Neutral	$R_N = 0,16$ j$X_N = 0,10$						

Note:

The normalization current is 4,35 A.

The harmonics, interharmonics and higher frequencies are maximum values of all three phases.

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.

5.2.4.1 b)	Test Harmonics DIN EN 61000-4-7											P
MST-HIE2.5-0800												
Harmonics												
P/ P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
Order	I_h [%]											
1	5,105	11,193	20,649	30,565	40,017	50,269	60,274	70,305	80,568	90,424	100,620	100,620
2	0,020	0,023	0,025	0,028	0,045	0,065	0,074	0,102	0,115	0,133	0,149	0,149
3	0,067	0,319	0,182	0,122	0,282	0,209	0,238	0,245	0,574	0,709	0,671	0,671
4	0,007	0,012	0,006	0,040	0,011	0,018	0,035	0,031	0,052	0,069	0,070	0,070
5	0,016	0,191	0,122	0,052	0,241	0,171	0,083	0,154	0,508	0,490	0,443	0,443
6	0,004	0,008	0,019	0,008	0,021	0,019	0,013	0,023	0,025	0,037	0,049	0,049
7	0,021	0,111	0,152	0,116	0,285	0,240	0,220	0,142	0,253	0,164	0,313	0,313
8	0,003	0,008	0,017	0,005	0,013	0,013	0,020	0,014	0,023	0,034	0,038	0,038
9	0,013	0,045	0,063	0,069	0,120	0,126	0,113	0,103	0,150	0,089	0,133	0,133
10	0,003	0,006	0,004	0,016	0,015	0,025	0,014	0,018	0,012	0,026	0,033	0,033
11	0,013	0,061	0,019	0,035	0,038	0,051	0,071	0,095	0,085	0,235	0,215	0,215
12	0,004	0,007	0,004	0,010	0,009	0,009	0,012	0,021	0,016	0,015	0,023	0,023
13	0,013	0,077	0,016	0,055	0,041	0,086	0,134	0,173	0,165	0,168	0,307	0,307
14	0,003	0,004	0,007	0,007	0,013	0,015	0,009	0,011	0,010	0,014	0,021	0,021
15	0,012	0,051	0,031	0,070	0,074	0,107	0,169	0,244	0,382	0,338	0,317	0,317
16	0,004	0,004	0,008	0,005	0,006	0,008	0,007	0,010	0,013	0,013	0,025	0,025
17	0,005	0,015	0,047	0,074	0,089	0,144	0,181	0,235	0,224	0,460	0,479	0,479
18	0,002	0,004	0,006	0,005	0,009	0,016	0,009	0,013	0,019	0,014	0,024	0,024
19	0,008	0,039	0,033	0,082	0,083	0,178	0,238	0,261	0,385	0,300	0,509	0,509
20	0,003	0,004	0,007	0,006	0,007	0,010	0,009	0,015	0,011	0,012	0,016	0,016
21	0,008	0,028	0,042	0,114	0,114	0,174	0,284	0,319	0,271	0,373	0,390	0,390
22	0,003	0,005	0,004	0,007	0,008	0,009	0,011	0,017	0,017	0,018	0,010	0,010
23	0,010	0,033	0,089	0,132	0,178	0,183	0,280	0,355	0,410	0,427	0,421	0,421
24	0,003	0,004	0,006	0,008	0,007	0,009	0,008	0,010	0,009	0,013	0,026	0,026
25	0,008	0,046	0,100	0,120	0,205	0,229	0,261	0,350	0,446	0,409	0,466	0,466
26	0,006	0,006	0,007	0,006	0,006	0,010	0,009	0,013	0,015	0,011	0,017	0,017
27	0,006	0,074	0,113	0,132	0,225	0,281	0,274	0,316	0,381	0,531	0,445	0,445
28	0,003	0,004	0,005	0,007	0,009	0,012	0,017	0,022	0,020	0,020	0,021	0,021
29	0,018	0,096	0,133	0,163	0,258	0,286	0,323	0,314	0,436	0,472	0,507	0,507
30	0,003	0,006	0,005	0,008	0,014	0,011	0,014	0,021	0,019	0,018	0,025	0,025
31	0,020	0,080	0,128	0,182	0,244	0,283	0,347	0,352	0,300	0,391	0,504	0,504
32	0,006	0,004	0,004	0,004	0,005	0,010	0,010	0,012	0,015	0,018	0,016	0,016
33	0,021	0,083	0,124	0,178	0,228	0,299	0,327	0,381	0,411	0,426	0,392	0,392
34	0,004	0,004	0,004	0,005	0,007	0,011	0,013	0,015	0,019	0,018	0,024	0,024
35	0,035	0,104	0,127	0,173	0,233	0,297	0,300	0,351	0,364	0,348	0,380	0,380
36	0,004	0,007	0,006	0,008	0,007	0,012	0,012	0,017	0,015	0,020	0,015	0,015
37	0,024	0,101	0,127	0,162	0,240	0,251	0,287	0,295	0,355	0,360	0,376	0,376
38	0,006	0,005	0,005	0,004	0,005	0,011	0,012	0,016	0,018	0,020	0,013	0,013
39	0,016	0,097	0,128	0,173	0,236	0,233	0,262	0,247	0,328	0,366	0,309	0,309
40	0,003	0,003	0,005	0,009	0,007	0,013	0,013	0,019	0,020	0,032	0,016	0,016
41	0,018	0,077	0,119	0,149	0,224	0,229	0,210	0,235	0,192	0,230	0,312	0,312
42	0,008	0,015	0,014	0,019	0,016	0,020	0,012	0,021	0,010	0,025	0,016	0,016
43	0,011	0,056	0,103	0,100	0,197	0,206	0,166	0,221	0,255	0,209	0,288	0,288

5.2.4.1 b)	Test Harmonics DIN EN 61000-4-7											P
MST-HIE2.5-0800												
Harmonics												
P/ P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
44	0,017	0,019	0,014	0,012	0,008	0,012	0,006	0,015	0,009	0,020	0,013	0,013
45	0,005	0,066	0,077	0,087	0,147	0,159	0,148	0,166	0,161	0,169	0,162	0,162
46	0,006	0,007	0,005	0,004	0,008	0,009	0,009	0,015	0,013	0,022	0,013	0,013
47	0,010	0,065	0,056	0,082	0,092	0,118	0,138	0,097	0,165	0,101	0,109	0,109
48	0,003	0,006	0,007	0,011	0,014	0,016	0,013	0,021	0,013	0,020	0,019	0,019
49	0,012	0,043	0,037	0,063	0,081	0,094	0,098	0,066	0,084	0,128	0,082	0,082
50	0,014	0,018	0,018	0,019	0,015	0,015	0,013	0,018	0,014	0,014	0,017	0,017

5.2.4.1 b)	Interharmonics											P
MST-HIE2.5-0800												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [Hz]	I_h [%]											
75	0,012	0,014	0,016	0,016	0,023	0,022	0,033	0,025	0,027	0,054	0,048	0,048
125	0,009	0,011	0,012	0,013	0,015	0,018	0,021	0,020	0,026	0,029	0,029	0,029
175	0,011	0,013	0,014	0,013	0,017	0,021	0,021	0,024	0,024	0,029	0,030	0,030
225	0,009	0,010	0,011	0,012	0,013	0,016	0,019	0,019	0,022	0,025	0,027	0,027
275	0,011	0,010	0,012	0,013	0,016	0,017	0,019	0,019	0,021	0,029	0,028	0,028
325	0,009	0,009	0,011	0,011	0,014	0,016	0,018	0,020	0,022	0,021	0,024	0,024
375	0,011	0,011	0,012	0,013	0,014	0,017	0,018	0,020	0,023	0,024	0,027	0,027
425	0,008	0,009	0,010	0,011	0,013	0,016	0,018	0,018	0,022	0,021	0,025	0,025
475	0,010	0,010	0,010	0,012	0,013	0,016	0,018	0,018	0,021	0,026	0,025	0,025
525	0,009	0,009	0,010	0,011	0,013	0,015	0,017	0,018	0,023	0,021	0,025	0,025
575	0,009	0,009	0,011	0,011	0,015	0,014	0,018	0,016	0,023	0,025	0,024	0,024
625	0,009	0,010	0,010	0,012	0,013	0,015	0,016	0,020	0,023	0,023	0,025	0,025
675	0,009	0,011	0,011	0,012	0,014	0,017	0,018	0,017	0,022	0,021	0,023	0,023
725	0,009	0,009	0,011	0,011	0,013	0,016	0,016	0,018	0,025	0,024	0,025	0,025
775	0,009	0,009	0,010	0,011	0,013	0,016	0,017	0,018	0,022	0,021	0,022	0,022
825	0,009	0,012	0,010	0,011	0,014	0,016	0,016	0,019	0,025	0,022	0,025	0,025
875	0,009	0,009	0,011	0,011	0,014	0,013	0,016	0,020	0,023	0,022	0,021	0,021
925	0,009	0,010	0,011	0,012	0,013	0,015	0,016	0,018	0,024	0,022	0,024	0,024
975	0,009	0,010	0,010	0,013	0,014	0,014	0,017	0,019	0,023	0,020	0,022	0,022
1025	0,009	0,011	0,011	0,012	0,014	0,015	0,017	0,017	0,021	0,025	0,023	0,023
1075	0,009	0,009	0,010	0,012	0,015	0,017	0,017	0,019	0,021	0,021	0,021	0,021
1125	0,009	0,010	0,011	0,012	0,014	0,013	0,016	0,017	0,021	0,022	0,023	0,023
1175	0,009	0,011	0,011	0,012	0,013	0,015	0,017	0,017	0,018	0,020	0,021	0,021
1225	0,009	0,011	0,011	0,013	0,014	0,014	0,015	0,016	0,019	0,021	0,022	0,022
1275	0,009	0,010	0,011	0,012	0,014	0,016	0,017	0,017	0,018	0,019	0,022	0,022
1325	0,009	0,010	0,011	0,012	0,014	0,015	0,016	0,016	0,019	0,022	0,021	0,021
1375	0,009	0,010	0,010	0,011	0,013	0,017	0,017	0,016	0,018	0,024	0,023	0,023
1425	0,009	0,010	0,011	0,012	0,013	0,015	0,016	0,016	0,019	0,023	0,023	0,023
1475	0,010	0,010	0,010	0,012	0,013	0,017	0,017	0,016	0,017	0,022	0,024	0,024
1525	0,010	0,009	0,010	0,012	0,014	0,015	0,017	0,018	0,018	0,022	0,023	0,023
1575	0,009	0,010	0,011	0,011	0,014	0,015	0,017	0,018	0,018	0,021	0,023	0,023
1625	0,009	0,009	0,011	0,012	0,014	0,016	0,017	0,016	0,018	0,020	0,023	0,023
1675	0,009	0,010	0,011	0,012	0,014	0,017	0,018	0,019	0,019	0,020	0,026	0,026
1725	0,009	0,010	0,010	0,011	0,014	0,016	0,017	0,018	0,019	0,018	0,024	0,024
1775	0,009	0,009	0,010	0,012	0,014	0,015	0,019	0,018	0,019	0,021	0,025	0,025
1825	0,009	0,010	0,010	0,012	0,013	0,015	0,017	0,017	0,018	0,022	0,025	0,025
1875	0,009	0,009	0,011	0,012	0,016	0,018	0,018	0,020	0,020	0,024	0,025	0,025
1925	0,009	0,010	0,011	0,011	0,014	0,016	0,018	0,019	0,020	0,022	0,026	0,026
1975	0,009	0,010	0,013	0,015	0,017	0,019	0,019	0,019	0,022	0,020	0,024	0,024

5.2.4.1 b)	Higher Frequencies											P
MST-HIE2.5-0800												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [kHz]	I_h [%]											
2,1	0,035	0,100	0,160	0,183	0,301	0,311	0,271	0,327	0,323	0,316	0,428	0,428
2,3	0,024	0,096	0,099	0,124	0,178	0,203	0,208	0,200	0,237	0,205	0,203	0,203
2,5	0,032	0,056	0,059	0,081	0,107	0,119	0,116	0,100	0,111	0,147	0,104	0,104
2,7	0,051	0,058	0,052	0,043	0,054	0,078	0,065	0,082	0,141	0,154	0,124	0,124
2,9	0,048	0,066	0,092	0,110	0,139	0,177	0,173	0,219	0,222	0,298	0,310	0,310
3,1	0,056	0,090	0,127	0,154	0,219	0,258	0,283	0,259	0,345	0,361	0,381	0,381
3,3	0,066	0,071	0,122	0,148	0,277	0,282	0,329	0,402	0,375	0,473	0,477	0,477
3,5	0,051	0,124	0,154	0,229	0,312	0,409	0,418	0,430	0,488	0,481	0,599	0,599
3,7	0,060	0,121	0,199	0,239	0,393	0,377	0,419	0,452	0,535	0,505	0,523	0,523
3,9	0,137	0,229	0,384	0,531	0,701	0,783	0,917	0,966	1,027	1,140	1,191	1,191
4,1	0,173	0,238	0,248	0,294	0,405	0,395	0,437	0,498	0,480	0,488	0,625	0,625
4,3	0,175	0,280	0,250	0,297	0,398	0,401	0,365	0,503	0,427	0,468	0,492	0,492
4,5	0,237	0,365	0,288	0,331	0,434	0,365	0,360	0,433	0,548	0,436	0,565	0,565
4,7	0,197	0,293	0,271	0,377	0,428	0,394	0,473	0,463	0,502	0,549	0,534	0,534
4,9	0,151	0,215	0,260	0,342	0,418	0,493	0,470	0,391	0,459	0,626	0,552	0,552
5,1	0,102	0,170	0,217	0,338	0,380	0,417	0,551	0,482	0,484	0,464	0,641	0,641
5,3	0,084	0,223	0,202	0,223	0,361	0,397	0,371	0,376	0,405	0,445	0,379	0,379
5,5	0,081	0,167	0,139	0,183	0,268	0,241	0,320	0,340	0,402	0,315	0,366	0,366
5,7	0,062	0,121	0,111	0,125	0,172	0,183	0,174	0,211	0,198	0,178	0,286	0,286
5,9	0,050	0,070	0,075	0,092	0,110	0,078	0,120	0,129	0,094	0,139	0,111	0,111
6,1	0,042	0,043	0,053	0,057	0,060	0,065	0,073	0,091	0,065	0,089	0,093	0,093
6,3	0,036	0,039	0,041	0,034	0,044	0,041	0,052	0,062	0,074	0,063	0,063	0,063
6,5	0,031	0,037	0,036	0,049	0,057	0,045	0,080	0,060	0,060	0,075	0,101	0,101
6,7	0,025	0,042	0,044	0,054	0,080	0,063	0,082	0,088	0,089	0,104	0,085	0,085
6,9	0,024	0,041	0,044	0,053	0,070	0,049	0,077	0,081	0,093	0,081	0,084	0,084
7,1	0,023	0,035	0,048	0,052	0,079	0,057	0,074	0,076	0,071	0,075	0,104	0,104
7,3	0,021	0,030	0,043	0,037	0,069	0,049	0,053	0,068	0,066	0,067	0,068	0,068
7,5	0,019	0,024	0,034	0,030	0,046	0,048	0,046	0,041	0,039	0,037	0,054	0,054
7,7	0,021	0,023	0,025	0,021	0,030	0,036	0,026	0,035	0,035	0,031	0,054	0,054
7,9	0,018	0,019	0,019	0,018	0,021	0,032	0,025	0,025	0,029	0,033	0,031	0,031
8,1	0,014	0,015	0,016	0,017	0,024	0,021	0,022	0,024	0,024	0,024	0,024	0,024
8,3	0,013	0,015	0,019	0,016	0,029	0,018	0,020	0,024	0,021	0,025	0,023	0,023
8,5	0,012	0,014	0,017	0,018	0,026	0,018	0,026	0,028	0,024	0,029	0,029	0,029
8,7	0,011	0,013	0,016	0,018	0,021	0,018	0,022	0,023	0,024	0,030	0,033	0,033
8,9	0,010	0,012	0,015	0,017	0,019	0,024	0,019	0,026	0,020	0,021	0,026	0,026
Impedance [Ω]												
Line						$R_A = 0,24$ j$X_A = 0,15$						
Neutral						$R_N = 0,16$ j$X_N = 0,10$						

Note:

The normalization current is 3,48 A.

The harmonics, interharmonics and higher frequencies are maximum values of all three phases.

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.

5.2.4.1 b)	Test Harmonics DIN EN 61000-4-7											P
MST-HIE2.5-0600												
Harmonics												
P/ P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
Order	I_h [%]											
1	6,638	11,935	21,056	30,863	40,873	50,495	60,226	70,595	80,726	90,920	101,112	101,112
2	0,028	0,030	0,011	0,033	0,034	0,048	0,063	0,085	0,091	0,110	0,129	0,129
3	0,086	0,444	0,202	0,232	0,085	0,372	0,444	0,352	0,308	0,412	0,510	0,510
4	0,010	0,020	0,037	0,009	0,056	0,015	0,025	0,024	0,043	0,036	0,050	0,050
5	0,018	0,208	0,228	0,138	0,024	0,365	0,256	0,190	0,110	0,147	0,317	0,317
6	0,006	0,008	0,014	0,005	0,012	0,041	0,012	0,020	0,021	0,032	0,023	0,023
7	0,037	0,099	0,200	0,194	0,118	0,400	0,353	0,309	0,291	0,226	0,228	0,228
8	0,003	0,005	0,006	0,027	0,008	0,011	0,031	0,016	0,023	0,026	0,028	0,028
9	0,015	0,102	0,072	0,090	0,081	0,124	0,167	0,143	0,155	0,157	0,112	0,112
10	0,006	0,006	0,007	0,011	0,022	0,019	0,010	0,019	0,012	0,029	0,010	0,010
11	0,017	0,169	0,035	0,023	0,040	0,067	0,059	0,082	0,089	0,106	0,115	0,115
12	0,005	0,005	0,009	0,006	0,011	0,017	0,027	0,011	0,008	0,023	0,020	0,020
13	0,018	0,120	0,025	0,032	0,070	0,068	0,075	0,135	0,176	0,221	0,313	0,313
14	0,004	0,006	0,008	0,007	0,008	0,022	0,017	0,030	0,007	0,013	0,013	0,013
15	0,012	0,035	0,024	0,052	0,104	0,095	0,111	0,160	0,224	0,290	0,290	0,290
16	0,007	0,006	0,004	0,007	0,006	0,009	0,013	0,018	0,015	0,017	0,011	0,011
17	0,005	0,030	0,014	0,088	0,119	0,078	0,176	0,212	0,240	0,273	0,452	0,452
18	0,004	0,005	0,009	0,008	0,006	0,008	0,013	0,013	0,030	0,018	0,008	0,008
19	0,011	0,055	0,033	0,106	0,165	0,052	0,194	0,281	0,319	0,292	0,321	0,321
20	0,004	0,005	0,011	0,011	0,005	0,011	0,010	0,011	0,011	0,022	0,012	0,012
21	0,009	0,030	0,062	0,094	0,203	0,140	0,183	0,290	0,381	0,375	0,527	0,527
22	0,006	0,005	0,005	0,005	0,011	0,008	0,009	0,014	0,023	0,022	0,020	0,020
23	0,015	0,064	0,118	0,117	0,188	0,218	0,232	0,282	0,385	0,441	0,427	0,427
24	0,004	0,003	0,005	0,008	0,013	0,008	0,014	0,014	0,017	0,012	0,026	0,026
25	0,005	0,064	0,116	0,152	0,171	0,266	0,309	0,315	0,357	0,434	0,598	0,598
26	0,007	0,009	0,008	0,008	0,009	0,008	0,017	0,015	0,016	0,014	0,014	0,014
27	0,011	0,048	0,118	0,171	0,180	0,313	0,336	0,390	0,378	0,403	0,417	0,417
28	0,005	0,005	0,006	0,009	0,011	0,014	0,013	0,017	0,017	0,014	0,022	0,022
29	0,026	0,095	0,133	0,174	0,214	0,318	0,350	0,413	0,435	0,423	0,517	0,517
30	0,006	0,007	0,009	0,010	0,013	0,011	0,011	0,022	0,018	0,010	0,016	0,016
31	0,018	0,126	0,127	0,185	0,235	0,298	0,368	0,398	0,462	0,471	0,396	0,396
32	0,007	0,009	0,005	0,005	0,006	0,009	0,008	0,013	0,012	0,014	0,017	0,017
33	0,032	0,128	0,167	0,195	0,225	0,303	0,375	0,403	0,434	0,494	0,584	0,584
34	0,005	0,005	0,007	0,004	0,009	0,010	0,012	0,015	0,015	0,011	0,013	0,013
35	0,053	0,123	0,176	0,175	0,213	0,322	0,317	0,405	0,393	0,457	0,445	0,445
36	0,007	0,012	0,010	0,009	0,011	0,008	0,015	0,014	0,010	0,013	0,013	0,013
37	0,035	0,120	0,153	0,150	0,200	0,309	0,295	0,360	0,385	0,404	0,523	0,523
38	0,011	0,012	0,005	0,005	0,006	0,007	0,010	0,013	0,012	0,012	0,013	0,013
39	0,025	0,136	0,145	0,170	0,216	0,323	0,324	0,289	0,384	0,404	0,309	0,309
40	0,004	0,006	0,005	0,005	0,011	0,013	0,012	0,011	0,011	0,018	0,018	0,018
41	0,027	0,120	0,117	0,164	0,179	0,309	0,307	0,254	0,313	0,382	0,384	0,384
42	0,013	0,019	0,017	0,018	0,023	0,024	0,020	0,013	0,009	0,031	0,030	0,030
43	0,009	0,082	0,099	0,118	0,108	0,237	0,246	0,261	0,223	0,302	0,224	0,224

5.2.4.1 b)	Test Harmonics DIN EN 61000-4-7											P
MST-HIE2.5-0600												
Harmonics												
P/ P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
44	0,022	0,027	0,019	0,020	0,020	0,018	0,017	0,010	0,011	0,021	0,013	0,013
45	0,006	0,097	0,100	0,102	0,093	0,173	0,215	0,236	0,184	0,200	0,304	0,304
46	0,006	0,009	0,009	0,008	0,008	0,015	0,014	0,011	0,014	0,024	0,018	0,018
47	0,018	0,106	0,087	0,091	0,083	0,148	0,176	0,158	0,170	0,124	0,090	0,090
48	0,005	0,009	0,007	0,012	0,017	0,022	0,021	0,010	0,017	0,033	0,019	0,019
49	0,013	0,077	0,069	0,045	0,063	0,107	0,098	0,102	0,123	0,095	0,119	0,119
50	0,022	0,024	0,025	0,022	0,026	0,030	0,023	0,014	0,019	0,034	0,018	0,018

5.2.4.1 b)	Interharmonics											P
MST-HIE2.5-0600												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [Hz]	I_h [%]											
75	0,017	0,016	0,022	0,018	0,021	0,032	0,029	0,030	0,028	0,037	0,052	0,052
125	0,013	0,014	0,015	0,016	0,020	0,023	0,026	0,025	0,022	0,030	0,031	0,031
175	0,017	0,016	0,018	0,017	0,020	0,023	0,024	0,028	0,024	0,030	0,032	0,032
225	0,012	0,014	0,014	0,014	0,016	0,019	0,021	0,020	0,021	0,024	0,025	0,025
275	0,014	0,015	0,016	0,017	0,018	0,021	0,021	0,021	0,021	0,025	0,030	0,030
325	0,013	0,013	0,013	0,014	0,015	0,019	0,020	0,022	0,020	0,022	0,026	0,026
375	0,013	0,016	0,015	0,015	0,016	0,021	0,020	0,021	0,019	0,026	0,025	0,025
425	0,011	0,013	0,013	0,014	0,015	0,019	0,018	0,019	0,020	0,027	0,026	0,026
475	0,013	0,013	0,014	0,015	0,015	0,019	0,020	0,021	0,021	0,024	0,024	0,024
525	0,011	0,012	0,013	0,013	0,014	0,020	0,018	0,020	0,021	0,025	0,026	0,026
575	0,013	0,013	0,015	0,014	0,015	0,019	0,020	0,021	0,022	0,024	0,026	0,026
625	0,012	0,013	0,015	0,014	0,015	0,018	0,018	0,018	0,020	0,022	0,026	0,026
675	0,012	0,012	0,013	0,015	0,015	0,018	0,019	0,020	0,021	0,025	0,025	0,025
725	0,011	0,013	0,013	0,014	0,014	0,018	0,018	0,020	0,020	0,022	0,027	0,027
775	0,013	0,013	0,013	0,014	0,016	0,017	0,020	0,019	0,021	0,026	0,024	0,024
825	0,013	0,013	0,014	0,015	0,016	0,018	0,019	0,018	0,019	0,024	0,026	0,026
875	0,012	0,014	0,013	0,014	0,015	0,017	0,021	0,021	0,018	0,023	0,028	0,028
925	0,013	0,013	0,014	0,016	0,013	0,018	0,019	0,019	0,020	0,028	0,029	0,029
975	0,011	0,013	0,014	0,015	0,016	0,018	0,017	0,020	0,021	0,026	0,026	0,026
1025	0,012	0,015	0,015	0,014	0,016	0,017	0,019	0,020	0,020	0,026	0,026	0,026
1075	0,012	0,014	0,014	0,015	0,016	0,018	0,020	0,019	0,022	0,021	0,026	0,026
1125	0,012	0,014	0,013	0,015	0,016	0,017	0,020	0,019	0,021	0,022	0,025	0,025
1175	0,011	0,014	0,014	0,014	0,016	0,017	0,018	0,019	0,020	0,021	0,023	0,023
1225	0,012	0,014	0,014	0,015	0,018	0,019	0,019	0,018	0,019	0,020	0,024	0,024
1275	0,012	0,013	0,014	0,015	0,016	0,018	0,018	0,021	0,021	0,020	0,025	0,025
1325	0,011	0,014	0,014	0,016	0,020	0,018	0,020	0,017	0,019	0,022	0,023	0,023
1375	0,012	0,013	0,015	0,014	0,016	0,019	0,021	0,019	0,020	0,023	0,023	0,023
1425	0,012	0,014	0,015	0,014	0,018	0,018	0,019	0,018	0,020	0,024	0,025	0,025
1475	0,012	0,013	0,014	0,015	0,016	0,019	0,019	0,020	0,022	0,021	0,024	0,024
1525	0,013	0,014	0,015	0,016	0,015	0,017	0,020	0,018	0,021	0,023	0,023	0,023
1575	0,011	0,013	0,015	0,015	0,016	0,019	0,020	0,022	0,019	0,023	0,024	0,024
1625	0,013	0,013	0,015	0,015	0,016	0,018	0,019	0,018	0,021	0,023	0,026	0,026
1675	0,012	0,014	0,015	0,014	0,016	0,019	0,018	0,018	0,020	0,020	0,027	0,027
1725	0,012	0,014	0,016	0,014	0,015	0,018	0,021	0,019	0,020	0,023	0,025	0,025
1775	0,013	0,014	0,014	0,015	0,017	0,019	0,019	0,021	0,022	0,023	0,026	0,026
1825	0,014	0,012	0,014	0,014	0,017	0,018	0,021	0,019	0,020	0,022	0,026	0,026
1875	0,015	0,013	0,016	0,015	0,016	0,020	0,021	0,023	0,022	0,027	0,028	0,028
1925	0,013	0,015	0,015	0,015	0,017	0,018	0,020	0,020	0,023	0,022	0,025	0,025
1975	0,012	0,013	0,016	0,018	0,020	0,022	0,025	0,025	0,027	0,027	0,030	0,030

5.2.4.1 b)	Higher Frequencies											P
MST-HIE2.5-0600												
P/P_{rE} [%]	5	10	20	30	40	50	60	70	80	90	100	Max
f [kHz]	I_h [%]											
2,1	0,047	0,152	0,159	0,207	0,214	0,393	0,396	0,368	0,387	0,492	0,451	0,451
2,3	0,034	0,147	0,137	0,142	0,131	0,234	0,283	0,288	0,256	0,245	0,326	0,326
2,5	0,044	0,098	0,088	0,064	0,084	0,141	0,118	0,137	0,144	0,147	0,147	0,147
2,7	0,073	0,111	0,065	0,070	0,056	0,089	0,069	0,124	0,094	0,115	0,162	0,162
2,9	0,068	0,093	0,107	0,117	0,138	0,213	0,187	0,277	0,257	0,302	0,372	0,372
3,1	0,074	0,112	0,148	0,146	0,216	0,281	0,256	0,328	0,404	0,379	0,452	0,452
3,3	0,087	0,129	0,160	0,197	0,210	0,322	0,415	0,402	0,453	0,532	0,498	0,498
3,5	0,068	0,188	0,193	0,227	0,284	0,476	0,458	0,534	0,563	0,538	0,659	0,659
3,7	0,086	0,300	0,216	0,230	0,278	0,529	0,481	0,570	0,562	0,642	0,601	0,601
3,9	0,189	0,367	0,399	0,529	0,677	0,885	0,958	1,038	1,166	1,279	1,285	1,285
4,1	0,231	0,434	0,280	0,349	0,351	0,583	0,586	0,471	0,520	0,753	0,573	0,573
4,3	0,212	0,363	0,319	0,329	0,322	0,596	0,534	0,458	0,518	0,613	0,625	0,625
4,5	0,258	0,474	0,414	0,332	0,360	0,612	0,448	0,478	0,445	0,553	0,643	0,643
4,7	0,214	0,513	0,376	0,340	0,438	0,601	0,502	0,655	0,610	0,581	0,641	0,641
4,9	0,176	0,364	0,309	0,290	0,347	0,616	0,585	0,589	0,655	0,723	0,775	0,775
5,1	0,130	0,284	0,253	0,264	0,386	0,576	0,524	0,630	0,755	0,733	0,661	0,661
5,3	0,101	0,247	0,251	0,274	0,316	0,483	0,448	0,489	0,476	0,503	0,577	0,577
5,5	0,090	0,186	0,162	0,184	0,229	0,345	0,316	0,386	0,400	0,439	0,379	0,379
5,7	0,069	0,122	0,117	0,158	0,141	0,248	0,265	0,218	0,221	0,248	0,291	0,291
5,9	0,071	0,080	0,085	0,089	0,080	0,148	0,133	0,131	0,155	0,169	0,163	0,163
6,1	0,072	0,066	0,077	0,062	0,065	0,087	0,098	0,084	0,101	0,085	0,103	0,103
6,3	0,056	0,053	0,070	0,053	0,054	0,064	0,064	0,064	0,083	0,061	0,072	0,072
6,5	0,043	0,055	0,053	0,048	0,066	0,092	0,068	0,080	0,108	0,083	0,098	0,098
6,7	0,034	0,049	0,043	0,051	0,069	0,107	0,075	0,078	0,118	0,109	0,107	0,107
6,9	0,032	0,052	0,037	0,053	0,057	0,115	0,091	0,106	0,086	0,106	0,110	0,110
7,1	0,027	0,042	0,034	0,050	0,058	0,115	0,085	0,074	0,090	0,113	0,122	0,122
7,3	0,027	0,041	0,034	0,043	0,043	0,074	0,074	0,065	0,067	0,076	0,075	0,075
7,5	0,025	0,029	0,032	0,040	0,038	0,052	0,055	0,049	0,052	0,068	0,072	0,072
7,7	0,022	0,025	0,033	0,034	0,027	0,035	0,048	0,046	0,033	0,051	0,057	0,057
7,9	0,020	0,020	0,026	0,026	0,025	0,032	0,036	0,036	0,027	0,034	0,039	0,039
8,1	0,019	0,020	0,022	0,023	0,026	0,034	0,029	0,030	0,030	0,034	0,035	0,035
8,3	0,018	0,020	0,019	0,020	0,020	0,028	0,030	0,027	0,028	0,036	0,031	0,031
8,5	0,017	0,018	0,018	0,019	0,020	0,030	0,028	0,021	0,029	0,030	0,026	0,026
8,7	0,015	0,017	0,017	0,020	0,019	0,027	0,034	0,027	0,027	0,032	0,032	0,032
8,9	0,014	0,016	0,016	0,021	0,017	0,024	0,034	0,024	0,022	0,027	0,038	0,038
Impedance [Ω]												
					Line	$R_A = 0,24$ j$X_A = 0,15$						
					Neutral	$R_N = 0,16$ j$X_N = 0,10$						

Note:

The normalization current is 2,61 A.

The harmonics, interharmonics and higher frequencies are maximum values of all three phases.

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.

5,2,6	Feed in of DC current	P

Test:

Phase1

Power Level [% of VA_r]	30% S_{Emax} to 40% S_{Emax}	60% S_{Emax} to 70% S_{Emax}	>95% S_{Emax}
AC Power [VA]	346,2	649,8	1042,8
AC Voltage [V]	230,2	230,2	230,2
AC Current [A]	1,507	2,823	4,529
DC Current in AC [A]	0,008	0,013	0,015
DC Current in AC [% of I_r]	0,176	0,286	0,330

Test:

The inverter must be used in the adjustment range Test 1, Test 2 and Test 3, Each test point shall be held for min 5 minutes and I_{AC}, U_{AC}, $I_{dc\ in\ AC}$ of each phase has to be recorded, Measurement of $I_{dc\ in\ AC}$ must be done according to VDE AR-N 4100:2020-06 based on DIN EN 61000-4-7 (VDE-0847-4-7) over 10 fundamental periods,

Assessment criterion:

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

DIN VDE V 0124-100		
Clause	**Requirement – Test**	**Verdict**
5,4	**Evidence of the behaviour of the generating unit on the network**	
5,4,1	General	**P**
5,4,2	Measurement of the active and reactive power range	**P**
5,4,3,2 **5,4,3,3**	Measurement of setting accuracy	**P**
5,4,3,4	Measurement of the power gradient	**P**
5,4,3,5	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	Static voltage stability / reactive power supply	**P**
5,4,8,2	Tests of the Reactive power / cos φ setting accuracy	**P**
	The regulating and control behaviour of the reactive power	**P**
5,4,8,3	Test of the displacement factor/active power characteristic curve cos φ (P)	**P**
	Test 1) for conducted PGUs - Accuracy (characteristic)	**N/A**
	Test 2) for conducted PGUs - dynamics	**N/A**
	Test 3) supply-dependent PGUs - Accuracy (characteristic curve)	**P**
	Test 4) supply-dependent PGUs - Dynamic	**P**
5,4,8,4,1	Test of the accuracy of the Q(U) regulation	**N/A**
5,4,8,4,2	Test of the dynamics of the Q(U) regulation	**N/A**

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 S_{Emax} and P_{Emax})	**P**
Test Condition:	The measurements were performed in the testing laboratory at the grid-simulator, Test voltage between 0,9 Un and 1,09 Un with ±2% Un until the test Test frequency: 50,0 Hz ± 0,5%	
Note: If an examination is required for any other requirements, these apply to this test,		

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 4105:2018-11, 5,7,2,2 are met and to determine the values for S_{Emax} and P_{Emax})	**P**

Test:

MST-HIE2.5-1000

600 s mean value	U [V]	$P_{Emax600\ c)}$ [W]	$S_{Emax600\ c)}$ [VA]	cos $\varphi_{Emax600}$ [1]
0,90 U_n at 100% P_{Emax}				
cos φ = 1	206,96	1000,90	1001,15	0,9997
cos φ max, over-excited	206,96	945,94	996,75	0,9490
0,95 U_n at 100% P_{Emax}				
cos φ max, under-excited	218,46	954,68	1004,37	0,9504
1,0 U_n at 100% P_{Emax}				
cos φ = 1	229,96	998,91	999,32	0,9997
cos φ max, under-excited	229,96	953,54	1003,59	0,9501
cos φ max, over-excited	229,96	948,02	998,31	0,9496
1,05 U_n at 100% P_{Emax}				
cos φ max, over-excited	241,46	943,66	992,90	0,9504
1,09 U_n at 100% P_{Emax}				
cos φ = 1	250,66	999,13	999,57	0,9996
cos φ max, under-excited	250,66	954,76	1005,76	0,9493

$S_{Emax600}$ and $P_{Emax\ 600}$	
$S_{Emax600}$= max ($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$) [VA]	1005,76
$P_{Emax\ 600}$= max ($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$) [W]	1000,90

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 4105:2018-11, 5,7,2,2 are met and to determine the values for S_{Emax} and P_{Emax})	**P**

Test:

MST-HIE2.5-0800

600 s mean value	U [V]	$P_{Emax600\ c)}$ [W]	$S_{Emax600\ c)}$ [VA]	cos $\varphi_{Emax600}$ [1]
0,90 U_n at 100% P_{Emax}				
cos φ = 1	206,95	795,55	795,80	0,9997
cos φ max, over-excited	206,96	752,13	793,38	0,9480
0,95 U_n at 100% P_{Emax}				
cos φ max, under-excited	218,46	760,14	799,13	0,9513
1,0 U_n at 100% P_{Emax}				
cos φ = 1	229,97	795,37	795,74	0,9996
cos φ max, under-excited	229,97	749,72	789,92	0,9491
cos φ max, over-excited	229,97	760,21	799,47	0,9509
1,05 U_n at 100% P_{Emax}				
cos φ max, over-excited	241,47	745,10	784,93	0,9492
1,09 U_n at 100% P_{Emax}				
cos φ = 1	250,66	793,47	793,86	0,9995
cos φ max, under-excited	250,66	761,65	801,89	0,9498

$S_{Emax600}$ and $P_{Emax\ 600}$

$S_{Emax600}$= max ($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$) [VA]	801,89
$P_{Emax\ 600}$= max ($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$) [W]	795,55

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 4105:2018-11, 5,7,2,2 are met and to determine the values for S_{Emax} and P_{Emax})	**P**

Test:

MST-HIE2.5-0600

600 s mean value	U [V]	$P_{Emax600\ c)}$ [W]	$S_{Emax600\ c)}$ [VA]	cos $\varphi_{Emax600}$ [1]
0,90 U_n at 100% P_{Emax}				
cos φ = 1	206,97	595,21	595,56	0,9996
cos φ max, over-excited	206,97	559,18	590,78	0,9464
0,95 U_n at 100% P_{Emax}				
cos φ max, under-excited	218,47	573,30	601,28	0,9535
1,0 U_n at 100% P_{Emax}				
cos φ = 1	229,96	594,12	594,43	0,9993
cos φ max, under-excited	229,97	560,84	591,57	0,9480
cos φ max, over-excited	229,97	570,62	599,17	0,9523
1,05 U_n at 100% P_{Emax}				
cos φ max, over-excited	241,46	558,59	588,68	0,9489
1,09 U_n at 100% P_{Emax}				
cos φ = 1	250,66	594,36	594,81	0,9992
cos φ max, under-excited	250,66	570,62	599,92	0,9512

$S_{Emax600}$ and $P_{Emax\ 600}$

$S_{Emax600}$= max ($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$) [VA]	601,28
$P_{Emax\ 600}$= max ($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$) [W]	595,21

5,4,3 **5,4,3,2** **5,4,3,3**	**Measurement of setting accuracy**	**P**

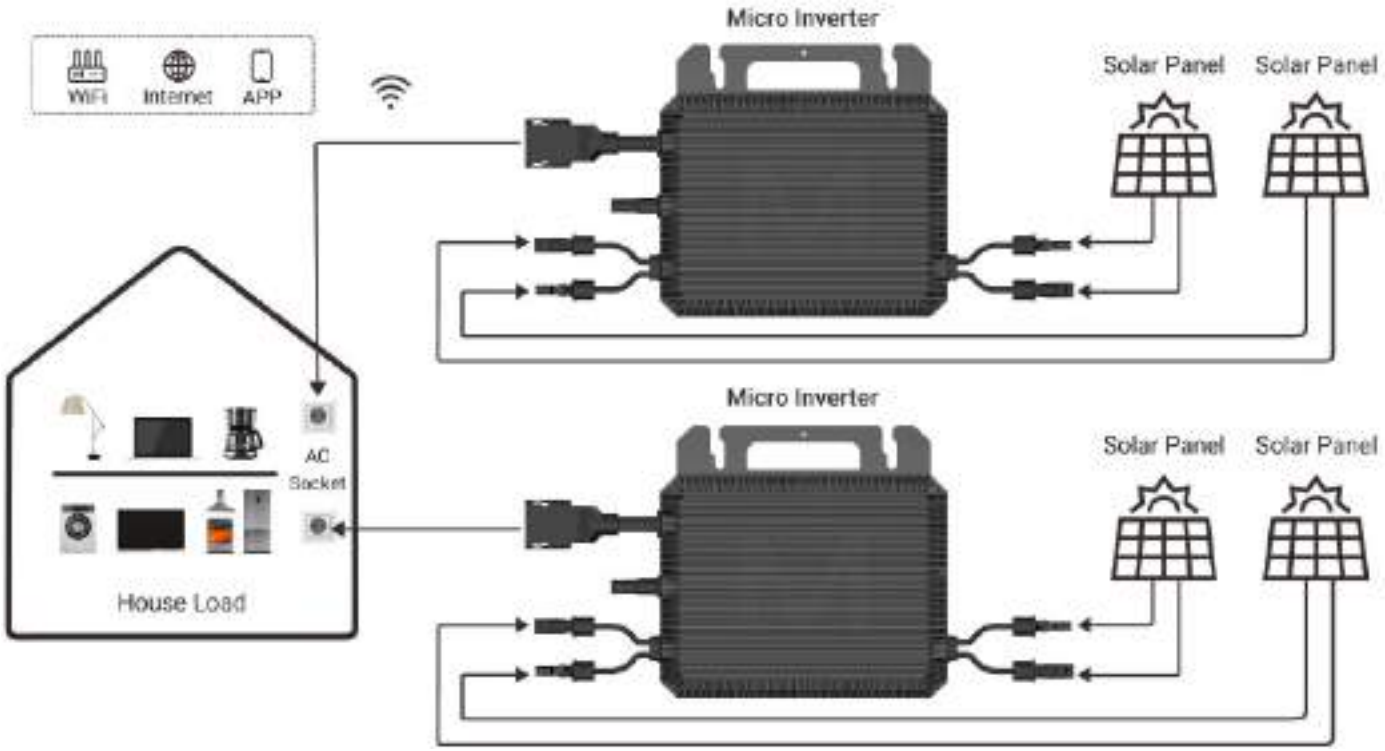
Test:

1-min mean value P/P_{rE} [%]	100	90	80	70	60	50	40	30	20	10
$P_{Setpoint}$ [W]	1000	900	800	700	600	500	400	300	200	100
P_{E60} [W]	1002	907	804	710	604	509	403	309	206	101
ΔP_{E60} [%]	0,2	0,7	0,4	1,0	0,4	0,9	0,3	0,9	0,6	0,1

Limit

ΔP_{E60} in %	≤ ±5% of P_{rE}	P

Graph of the setting accuracy:



Test:

The setpoint signal must be reduced from 100% to 10% P_{rE}:

For adjustable PGUs in increments of 10% P_{rE} 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,

Assessment criterion:

a) for adjustable PGUs:

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

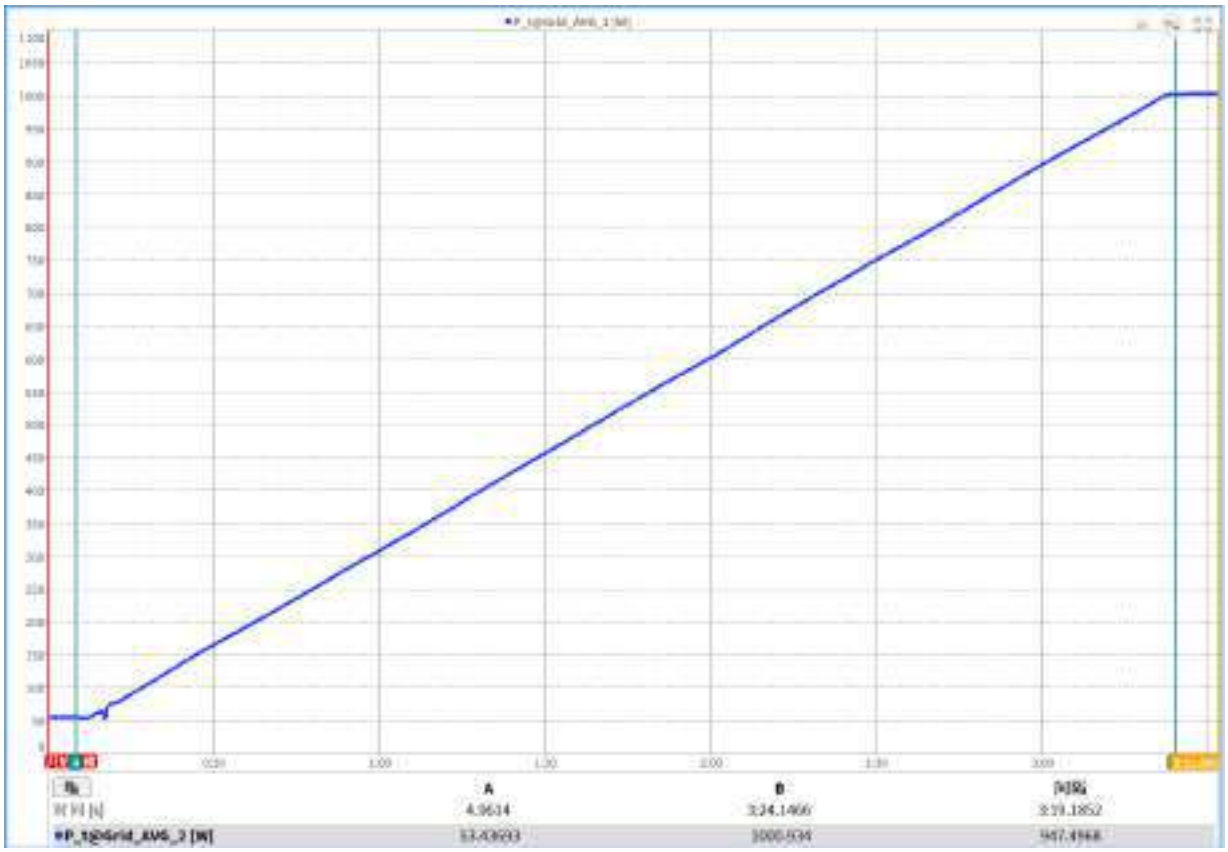
Note:

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

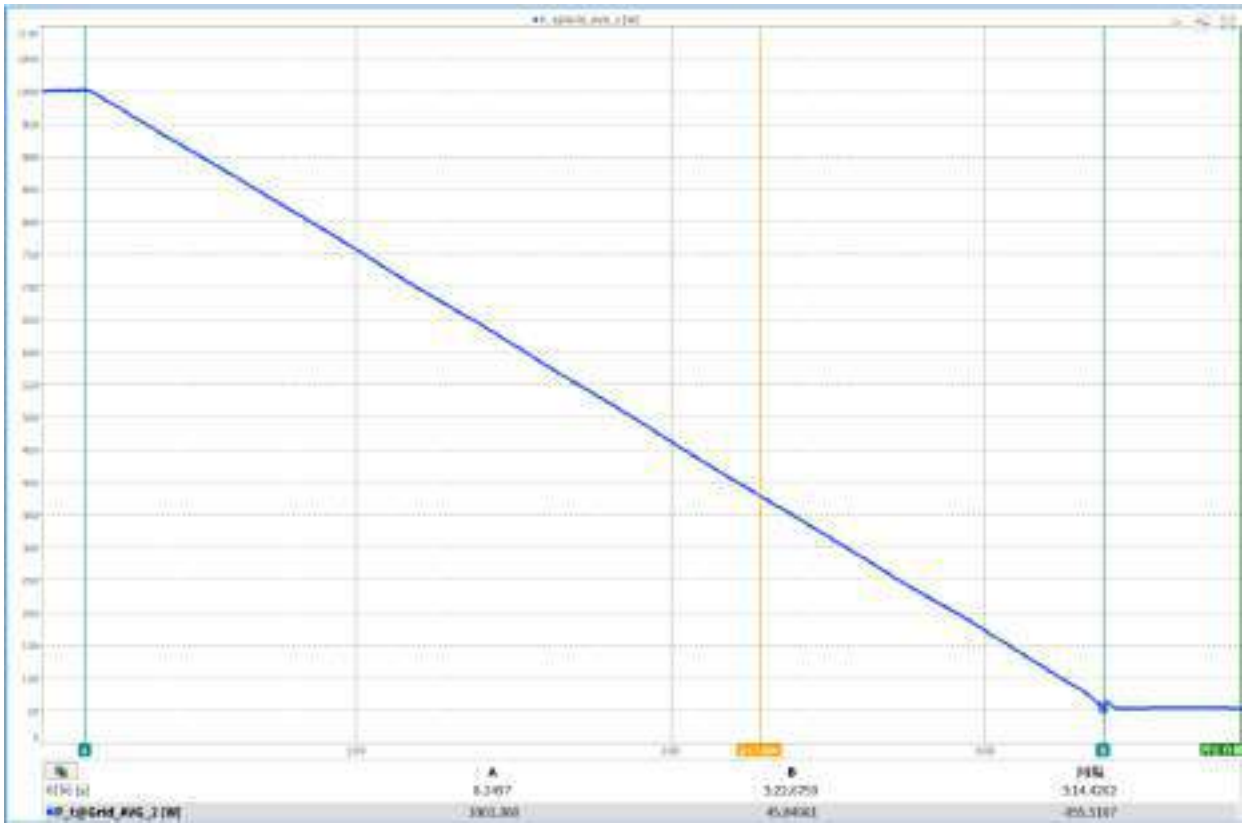
5,4,3,4	Measurement of the power gradient	P

Test:

Graph of the gradient <5% to 100% P_{rE}



Graph of the gradient 100% to <5% P_{rE}



Test:

The measurement of the power gradient takes place :

- Via a setpoint change from 100% to 5% of the rated effective power P_{rE} at time t_0, If the technical performance is >5%, this should be specified,

- Via a setpoint change from 5% to 100% of the rated effective power P_{rE} at time t_0, Is the technical Performance >5%, this should be specified,

Assessment criterion:

for adjustable PGUs:

- no network disconnection

- the active power value does not exceed the setpoint by more than 5% P_{rE}

- the power gradient determined according 5,4,3,4 not be less than 0,33% P_{rE}/s and not more than 0,66% P_{rE}/s, The first gradient is to be created 30 s after the setpoint jump has been set,

The formation of gradients is ended 30 s before the static 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,

5,4,3,5	Measurement priority interfaces / energy management system	P

Test:

a) The lowest setpoint is always given priority
b) the setpoint at the interface programmed for the NSM is never exceeded

		$P/P_{rE\ Setpoint}$	$P/P_{rE\ Measured}$
Test 1	Interface NSM (Digital inputs)	0,7	0,71
	Interface low Priority Modbus, TCP IP etc, (Software)	0,9	
Test 2	Interface NSM (Digital inputs)	0,9	0,50
	Interface low Priority Modbus, TCP IP etc, (Software)	0,5	

Note:

a) Software to set setpoint at the interface with low priority is Modbus etc, The interface NSM (Digital Inputs) have always priority,
b) The setpoint at the interface programmed for the NSM is never exceeded,

Assessment criterion:

for measurements 5,4,3,5 either

a) the lowest setpoint is always given priority

or

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

- When the logical interface (input port) was tested, the active power feed-in of the PGU was completely terminated within a maximum of 5 s after the change in status of the logical signal,

5,4,4	**Active power feed-in for PGUs at overfrequency** (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)	**P**

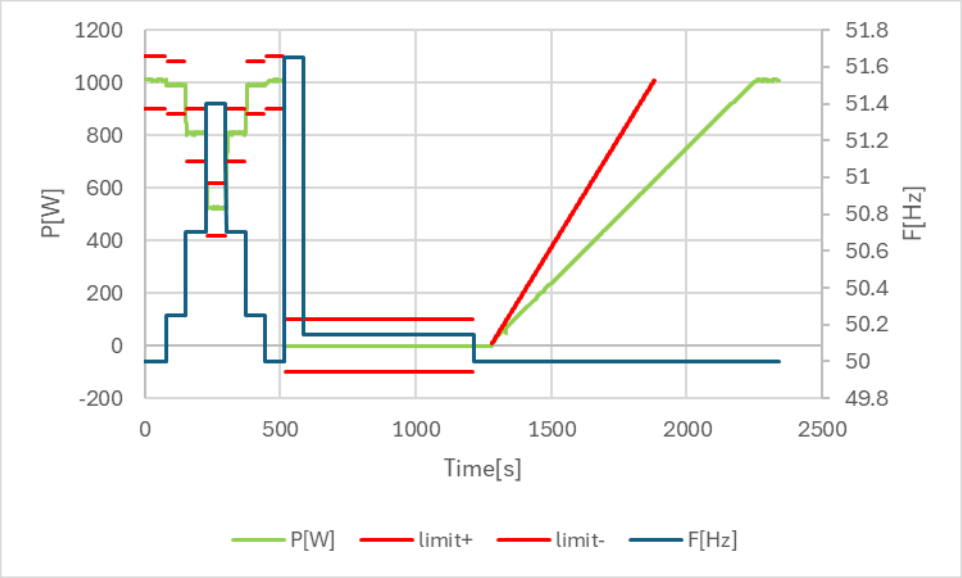
Test cycle for adjustable PGUs:										
Test 1:										
1-min mean value:	50,00	50,25	50,70	51,40	50,70	50,25	50,00	51,65	50,15	50,00
Expected active power output [% of P_{Emax}]	100	98	80	52	80	98	100	0	0	100
Measurement: 100% P_{Emax}; start frequency 50,20Hz; droop setting s = 5% (40% P_{ref}/Hz)										
Frequency [Hz]	50,00	50,25	50,70	51,40	50,70	50,25	50,00	51,65	50,15	50,00
$P_{setpoint}$ [W]	1000	980	800	520	800	980	1000	0	0	1000
P_{E60} [W]	1011	992	809	525	809	991	1009	0,42	0,19	1009
ΔP_{E60} [%]	1,10	1,20	0,90	0,50	0,90	1,10	0,90	0,04	0,02	0,90
Available DC-power [%]	100									

Test 2:							
1-min mean value:	50,00	50,40	50,70	51,40	50,70	50,40	50,00
Expected active power output [% of P_{Emax}]	60	60	58	51	58	60 – 100*	100
Measurement: 60% P_{Emax}; start frequency 50,50Hz; droop setting s = 12% (16,67% P_{ref}/Hz)							
Frequency [Hz]	50,00	50,40	50,70	51,40	50,70	50,40	50,00
$P_{setpoint}$ [W]	600	600	580	510	580	1000	1000
P_{E60} [W]	607	607	586	515	586	1009	1008
ΔP_{E60} [%]	0,70	0,70	0,60	0,50	0,60	0,90	0,80
Available DC-power [%]	60		100				

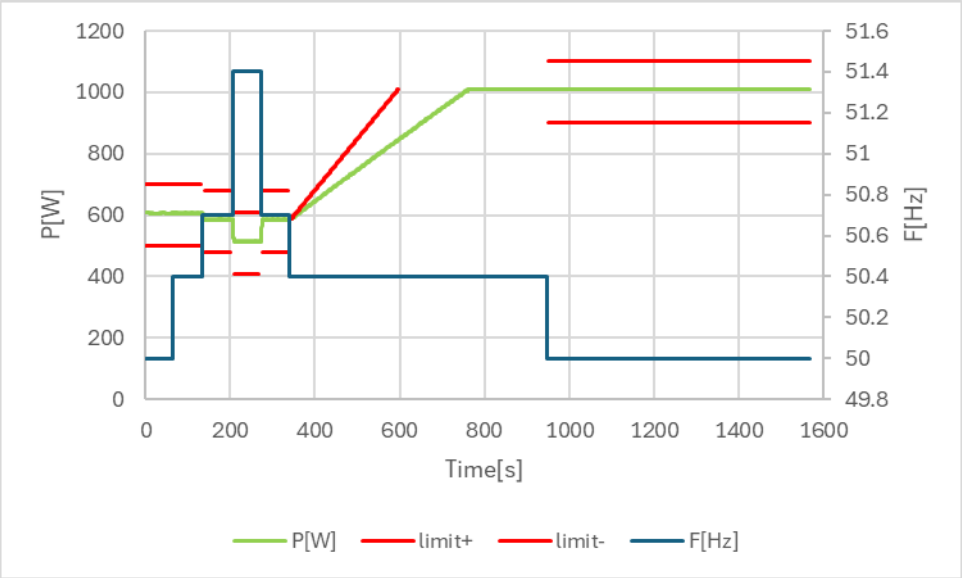
Limit		
ΔP_{E60} in %	≤ ±10% of P_{Emax}	P

5,4,4	**Active power feed-in for PGUś at overfrequency** (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)	**P**

Graph Test 1@ 100% P_{Emax}

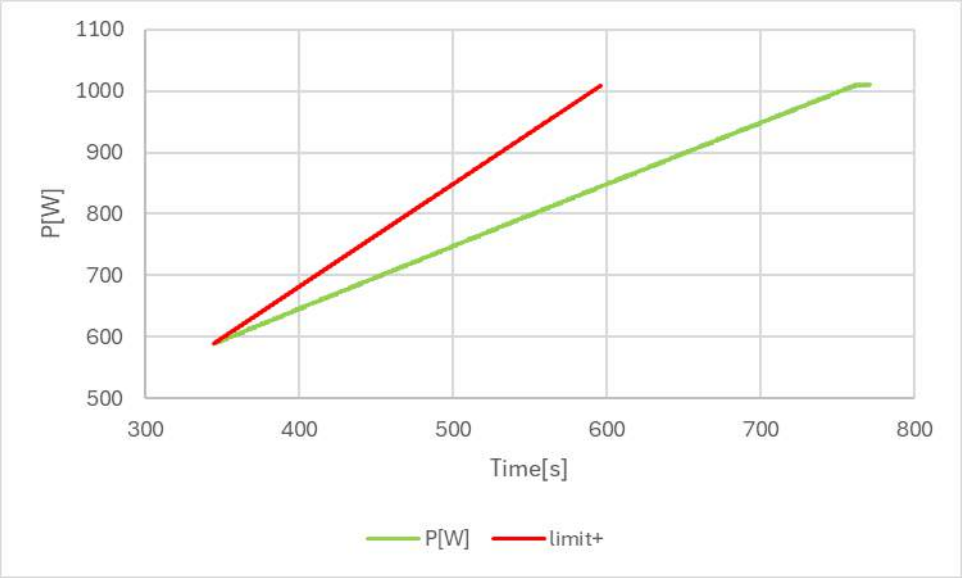


Gradient Test 1



5,4,4	**Active power feed-in for PGUś at overfrequency** (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)	**P**

Graph Test2 @ 60% P_{Emax}



5,4,4	**Active power feed-in for PGUś at overfrequency** (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)	**P**

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},

In the measurement points h) and i) shall no active power be given,

- 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 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 PGU, 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 proofed by a manufacturer's declaration,

d) for linear generators with S_{Emax} ≤ 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:

*At this point, a gradient is run from 60% to 100%, so an exact value cannot be determined

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**

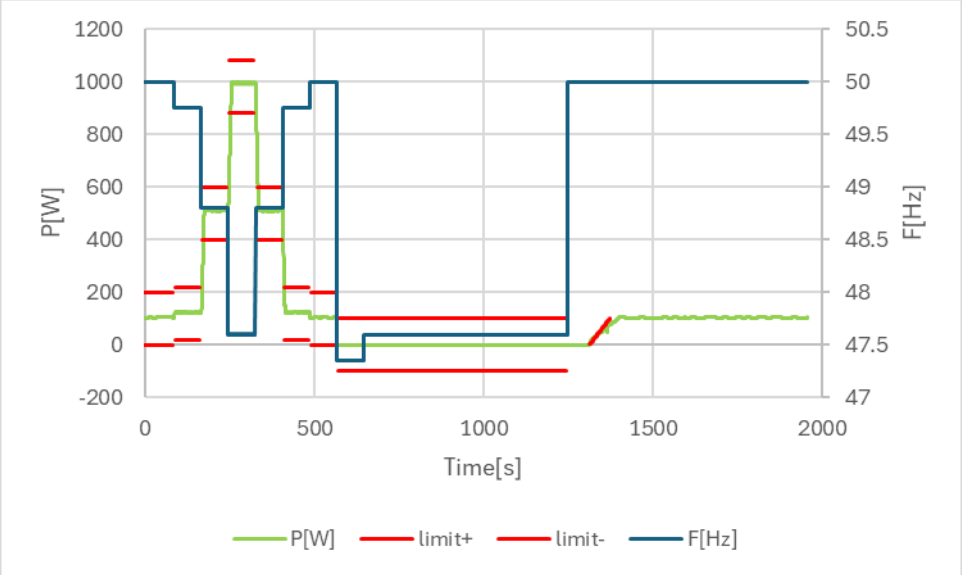
Test cycle for adjustable PGUs:										
Test 1:										
1-min mean value:	50,00	49,75	48,80	47,60	48,80	49,75	50,00	47,35	47,60	50,00
Expected active power output [% of P_{Emax}]:	10	12	50	98	50	12	10	0	0	10
Measurement: 10% P_{Emax}; start frequency 49,80Hz; droop setting s = 5% (40% P_{ref}/Hz)										
Frequency [Hz]:	50,00	49,75	48,80	47,60	48,80	49,75	50,00	47,35	47,60	50,00
$P_{setpoint}$ [W]:	100	120	500	980	500	120	100	0	0	100
P_{E60} [W]:	102,2	122,2	509,6	996,6	508,6	122,7	103,6	0	0	103,2
ΔP_{E60} [%]	0,22	0,22	0,96	1,66	0,86	0,27	0,36	0	0	0,32
Available DC-power [%]:	10%									

Test 2:							
1-min mean value:	50,00	49,75	49,20	48,80	49,20	49,85	50,00
Expected active power output [% of P_{Emax}]:	60	62	84	100	84	60	60
Measurement: 60% P_{Emax}; start frequency 49,80Hz; droop setting s = 5% (40% P_{ref}/Hz)							
Frequency [Hz]:	50,00	49,75	49,20	48,80	49,20	49,85	50,00
$P_{setpoint}$ [W]:	600	620	840	1000	840	600	600
P_{E60} [W]:	603,6	622,6	848,5	1008,7	848,2	603,5	605,9
ΔP_{E60} [%]	0,36	0,26	0,85	0,87	0,82	0,35	0,59
Available DC-power [%]:	60%						

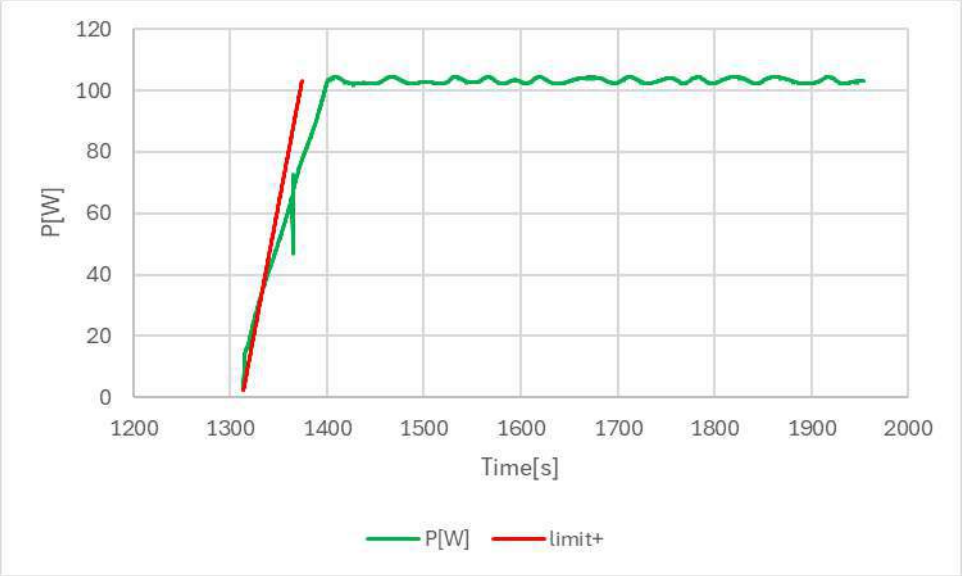
Limit:		
ΔP_{E60} in %	≤ ±10% of P_{Emax}	P

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**

Graph Test 1@ 100% P_{Emax}

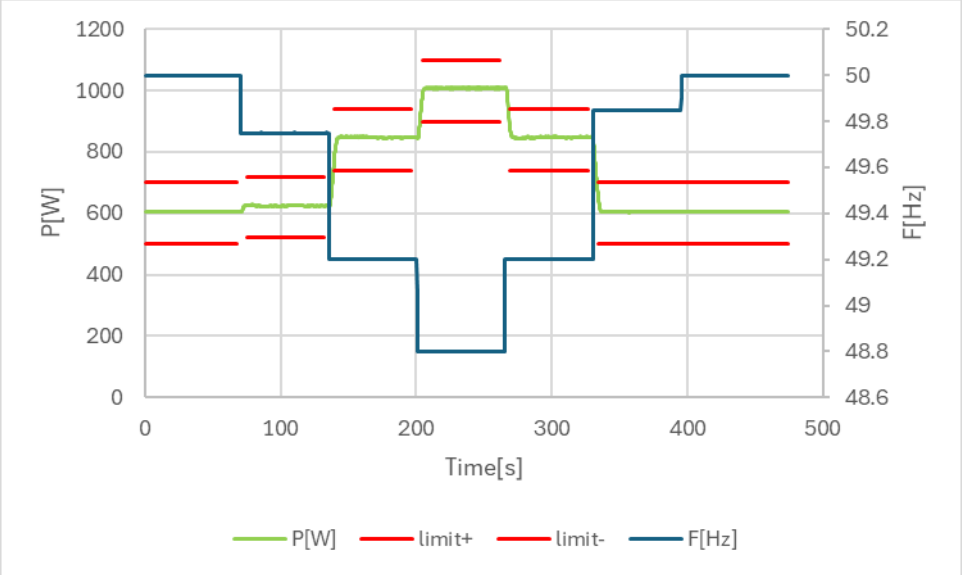


Gradient Test 1



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**

Graph Test2 @ 60% P_{Emax}



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**

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 PGU, 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 proofed 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 resynchronization/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:

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 PGU in normal operation,	
5,4,8,2	**Tests of the Reactive power / cos φ setting accuracy**	**P**

Test: MST-HIE2.5-1000

60 s mean value	0,9 U_n		U_n		1,1 U_n	
Active power	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}
cos φ 0,95 over-excited						
U [V]	207,0	207,0	230,0	230,0	253,0	253,0
P_{E60} [W]	480,0	954,1	478,8	953,9	478,8	955,3
Q_{E60} [VAr]	151,2	312,0	153,4	315,1	158,0	319,2
S_{E60} [VA]	503,2	1003,8	502,8	1004,6	504,2	1007,2
cos $\varphi_{E60\ over\text{-}excited}$	0,9538	0,9505	0,9523	0,9495	0,9496	0,9484
$Q_{expected}$ [VA]	+164,3	+312,2	+164,3	+312,2	+164,3	+312,2
ΔQ_{E60} [%]	-1,31	-0,02	-1,09	0,29	-0,63	0,70
cos φ 0,95 under-excited						
U [V]	207,0	207,0	230,0	230,0	253,0	253,0
P_{E60} [W]	467,5	945,0	467,4	944,4	466,9	945,3
Q_{E60} [VAr]	-163,3	-314,7	-160,7	-313,0	-158,0	-310,8
S_{E60} [VA]	495,2	996,0	494,2	994,9	492,9	995,1
cos $\varphi_{E60\ under\text{-}excited}$	0,9440	0,9488	0,9457	0,9492	0,9473	0,9500
$Q_{expected}$ [VA]	-164,3	-312,2	-164,3	-312,2	-164,3	-312,2
ΔQ_{E60} [%]	0,10	-0,25	0,36	-0,08	0,63	0,14
cos φ 0,98 over-excited						
U [V]	207,0	207,0	230,0	230,0	253,0	253,0
P_{E60} [W]	491,3	982,5	492,2	983,1	491,1	982,7
Q_{E60} [Var]	94,7	198,8	99,6	202,8	104,3	205,7
S_{E60} [VA]	500,4	1002,4	502,2	1003,8	502,0	1004,0
cos $\varphi_{E60\ over\text{-}excited}$	0,9819	0,9801	0,9801	0,9794	0,9782	0,9788
$Q_{expected}$ [VA]	+101,5	+198,9	+101,5	+198,9	+101,5	+198,9
ΔQ_{E60} [%]	-0,68	-0,01	-0,19	0,39	0,28	0,68

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 PGU in normal operation,	
5,4,8,2	**Tests of the Reactive power / cos φ setting accuracy**	**P**

Test: MST-HIE2.5-1000

60 s mean value	0,9 U_n		U_n		1,1 U_n	
Active power	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}
cos φ 0,98 under-excited						
U [V]	207,0	207,0	230,0	230,0	253,0	253,0
P_{E60} [W]	484,4	976,2	485,0	976,5	484,9	976,9
Q_{E60} [Var]	-107,0	-201,5	-106,8	-199,3	-103,1	-197,6
S_{E60} [VA]	496,1	996,8	496,6	996,6	495,8	996,7
cos $\varphi_{E60\ under\text{-}excited}$	0,9765	0,9794	0,9766	0,9798	0,9781	0,9801
$Q_{expected}$ [VA]	-101,5	-198,9	-101,5	-198,9	-101,5	-198,9
ΔQ_{E60} [%]	-0,55	-0,26	-0,53	-0,04	-0,16	0,13

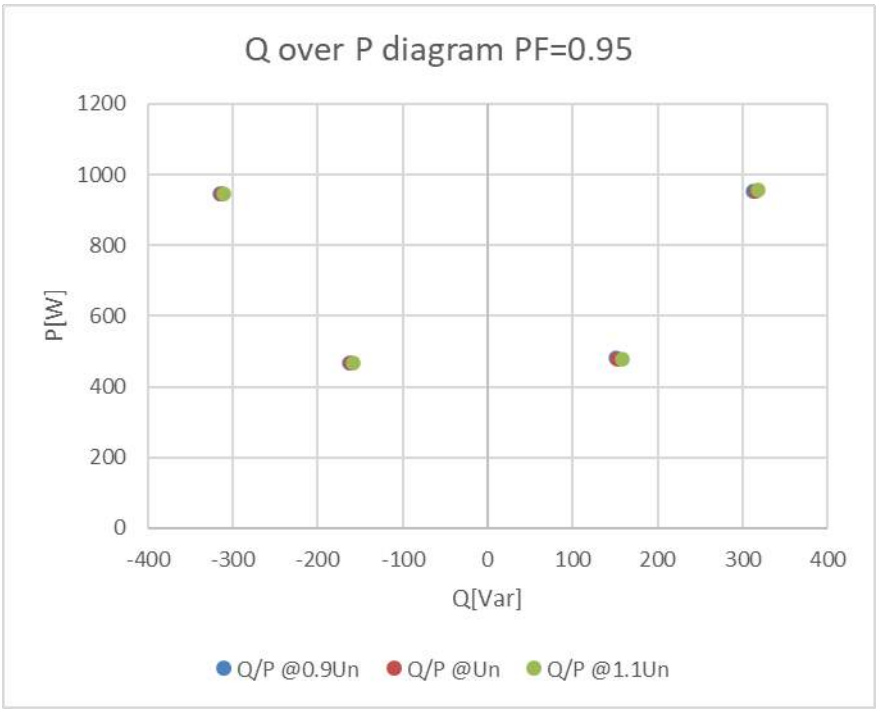
Limit		
cos φ_{E60}	cos φ = 0,94 to 0,96 I and cos φ = 0,94 to 0,96 (i) cos φ = 0,97 to 0,99 I and cos φ = 0,97 to 0,99 (i)	P
cos φ settling steps	≤ 0,01	P
ΔQ_{E60} in %	≤ ±4% P_{Emax}	P

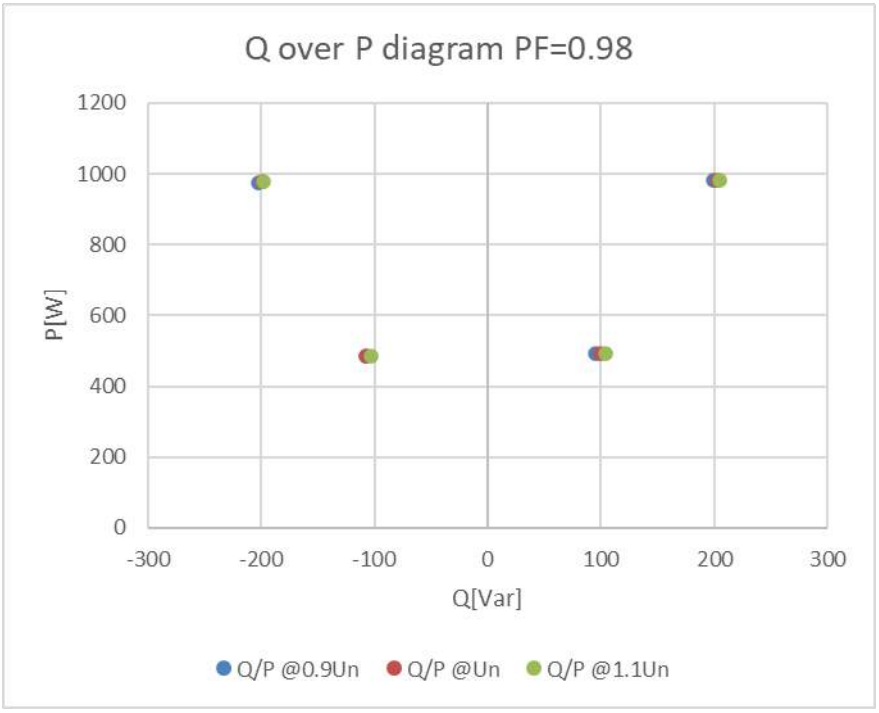
5,4,8	**Static voltage stability / reactive power supply** The test serves as verification of the reactive power mode according to VD-AR-N 4105: 2018-11, 5,7,2 of the PGU in normal operation,	
5,4,8,2	**Tests of the Reactive power / cos φ setting accuracy**	**P**

Test: MST-HIE2.5-1000

60 s mean value	0,9 U_n		U_n		1,1 U_n	
Active power	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}

Graph: Q/P diagram





Test:

applies for PGUs Type 2 - only inverter $\Sigma S_{Emax} \leq 4{,}6$ kVA

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 PGU in normal operation,	
5,4,8,2	**Tests of the Reactive power / cos φ setting accuracy**	**P**

Test: MST-HIE2.5-1000

60 s mean value	0,9 U_n		U_n		1,1 U_n	
Active power	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}	40 – 60% P_{Emax}	S_{Emax}

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 0,98 over-excited and φ 0,98 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 $\Sigma S_{Emax} \geq 4{,}6$ 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 $\Sigma S_{Emax} > 4{,}6$ 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 0,98 over-excited and φ 0,98 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 $S_{Emax,}$ The test is performed only at U_n,

Assessment criterion:

applies for PGUs Type 2 - only inverter $\Sigma S_{Emax} \leq 4{,}6$ kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0,95 and one time at 0,98 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 $\Sigma S_{Emax} \geq 4{,}6$ 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 $\Sigma S_{Emax} \leq 4{,}6$ kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0,95 and one time at 0,98 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 $\Sigma S_{Emax} \geq 4{,}6$ kVA

The Q setpoint is calculated by using the required cos φ setpoint one time at 0,95 and one time at 0,98 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 under excited ±0,02 ,

Note:

	The regulating and control behavior of the reactive power	P

The regulating or control behaviour of the reactive power is based on the PT-1 behaviour shown in Figure 10, Each reactive power value, which results from the control behaviour specified by the network operator, can be set between 6s and 60s (for Type 1 between 10 s and 60 s), The signal runtime includes the detection of the mains voltage or the active and reactive power,

Step response with the tolerances relevant for the evaluation

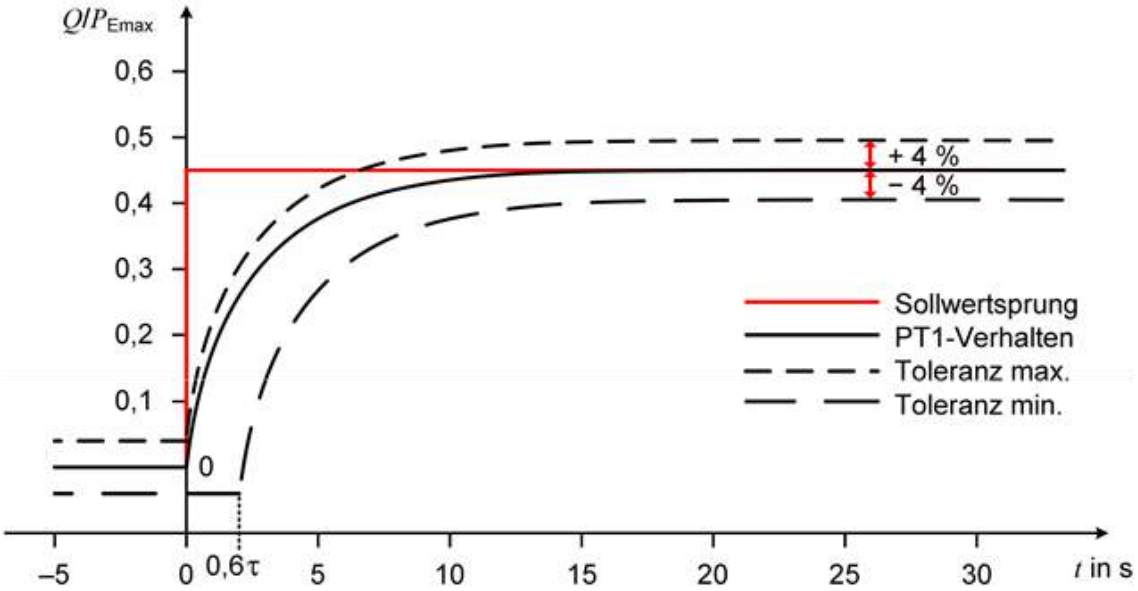


Figure 10 - Illustration at 3 tau = 10 s

Comment:

The regulation and control behaviour according to PT-1 is implemented and checked for all reactive power control modes,

5,4,8,3	**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)

Test: MST-HIE2.5-1000

Measurement: 20-100% P_{Emax}

P_{Emax}/P [%]	20	30	40	50	60	70	80	90	100
U [V]	230,0	230,0	230,0	230,0	230,0	230,0	230,0	230,0	230,0
P_{E30} [W]	193,7	291,7	390,7	488,5	574,8	666,0	753,3	837,3	924,3
P_{E30} of P_{Emax} [%]	19,4	29,2	39,1	48,9	57,5	66,6	75,3	83,7	92,4
Q_{E30} [VAr]	16,3	18,0	19,0	19,8	-84,8	-137,0	-190,5	-246,0	-305,1
cos φ_{E30}	0,9965	0,9981	0,9988	0,9992	0,9893	0,9795	0,9695	0,9595	0,9496
cos $\varphi_{setpoint}$ of P_{E30}	1,0000	1,0000	1,0000	1,0000	0,9900	0,9800	0,9700	0,9600	0,9500

Measurement: 100-20% P_{Emax}

P_{Emax}/P [%]	100	90	80	70	60	50	40	30	20
U [V]	230,0	230,0	230,0	230,0	230,0	230,0	230,0	230,0	230,0
P_{E30} [W]	919,4	839,0	752,5	666,0	575,7	488,6	390,0	291,4	194,7
P_{E30} of P_{Emax} [%]	91,9	83,9	75,2	66,6	57,6	48,9	39,0	29,1	19,5
Q_{E30} [VAr]	-303,5	-245,2	-190,0	-137,2	-84,2	19,2	19,4	17,6	17,2
cos φ_{E30}	0,9496	0,9599	0,9696	0,9794	0,9895	0,9992	0,9988	0,9982	0,9961
cos $\varphi_{setpoint}$ of P_{E30}	0,9500	0,9600	0,9700	0,9800	0,9900	1,0000	1,0000	1,0000	1,0000

Limit

ΔQ_{E30} in %	≤ ±4,0% relative to P_{Emax}	P

5,4,8,3	**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: MST-HIE2.5-1000

Test d): supply-dependent PGUs - Dynamic

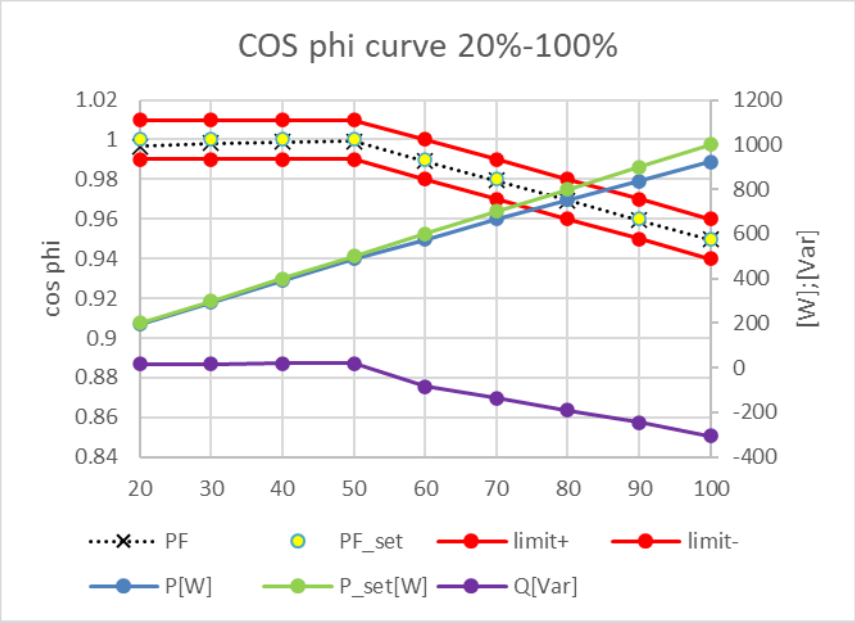
P_{Emax}/P_n [%]	100	40	100	75
U [V]	229,9	229,9	229,9	229,9
P_{E30} [W]	947,9	401,6	946,8	745,9
P_{E30} of P_{Emax} [%]	94,79	40,16	94,68	74,59
Q_{E30} [VAr]	-305,2	18,65	-311,1	-180,5
$Q_{expected}$	-312,2	0	-312,2	-170,9
ΔQ_{E30} [%]	-30,52	1,87	-31,11	-18,27
cos φ_{E30}	0,9519	0,9989	0,9499	0,9719
cos $\varphi_{setpoint}$ of P_{E30}	0,9500	1,0000	0,9500	0,9750

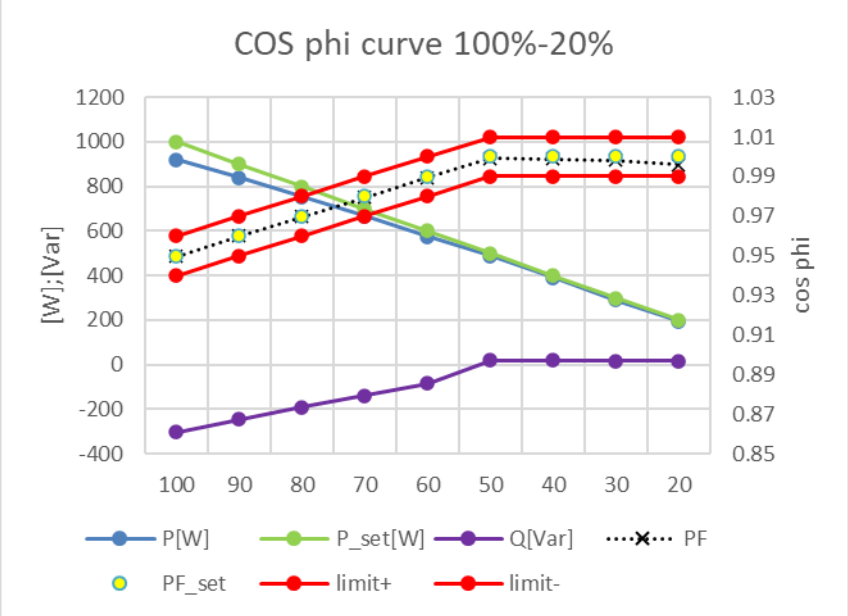
Limit

ΔQ_{E30} in %	≤ ± 4,0% relative to P_{Emax}	P

5,4,8,3	**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**

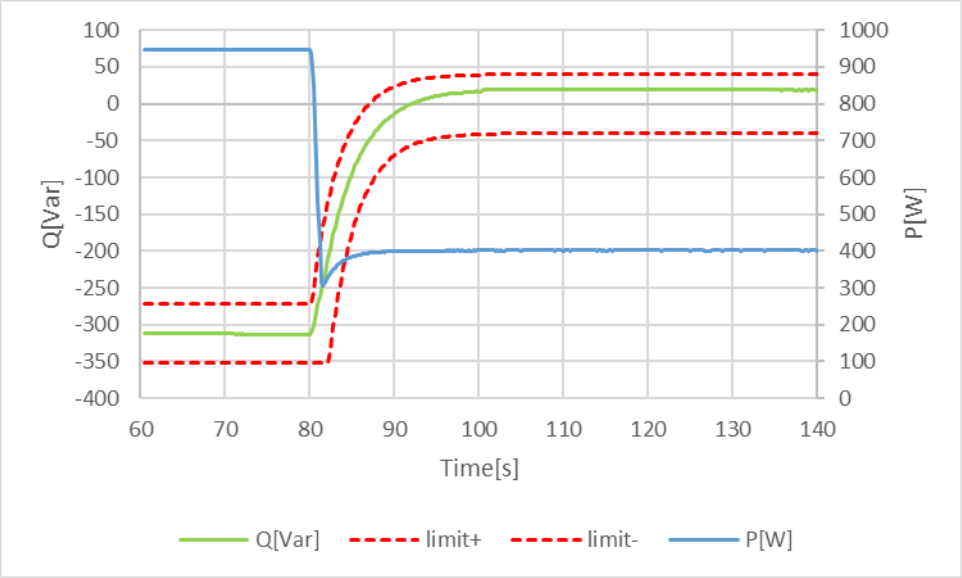
Graph of Test c)

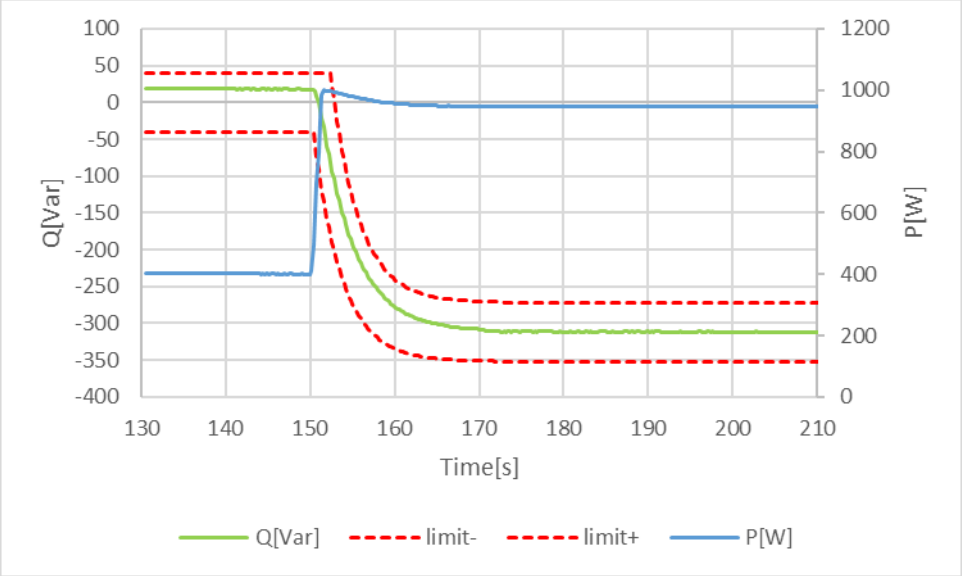




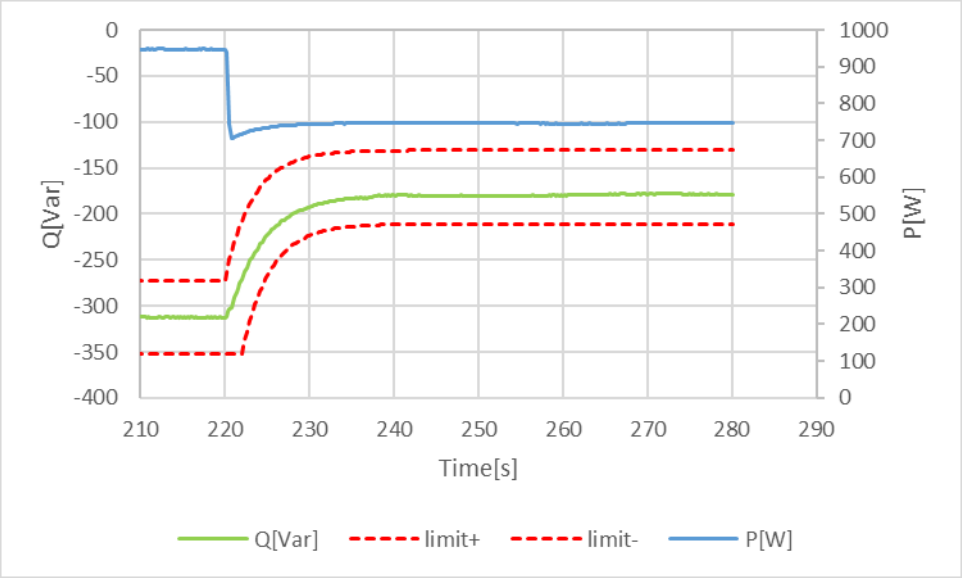
5,4,8,3	**Test of the displacement factor/active power characteristic curve cos φ (P)** The test serves as verification of the standard cos φ (P) curve according to VDE-AR-N 4105:2018-11, 5,7,2,4,	**P**

Graph of Test d)





5,4,8,3	**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**



Assessment criterion:

Test 5,4,8,3 (2) is considered to have been passed if the PGU meets the requirements for the performance gradient in VDE AR-N 4105: 2018-11, 5,7,4,2,

Test 5,4,8,3 (4) is passed if the step response of the reactive power in test steps c) and e) shows PT-1 behaviour according to VDE-AR-N 4105: 2018-11, 5,7,2,5 and for test step d) optionally the power gradient lies between the limits defined in VDE AR-N 4105: 2018-11, 5,7,4,1 or the step response of the reactive power also has PT-1 behaviour according to VDE-AR-N 4105: 2018-11, 5,7,2,5,

DIN VDE 0124-100		
Clause	**Requirement – Test**	**Verdict**
5,5	**Testing of NS protection**	
5,5,2	NS protection	**P**
5,5,2,1	Functional safety	**P**
5,5,3	Central NS-protection	**N/A**
5,5,4	Integrated NS-protection	**P**
5,5,6	Interface switch	**P**
5,5,6,2	Central interface switch	**N/A**
5,5,6,3	Integrated interface switch	**P**
5,5,7,2	Check of setting values	**P**
5,5,7,3	Wiring check	**P**
5,5,7,4	Voltage and frequency control	**P**
5,5,7,4,1	Voltage and frequency control – Single Phase	**P**
	Voltage and frequency control – Multi Phase (Phase to N)	**N/A**
	Voltage and frequency control – Multi Phase (Phase to Phase)	**N/A**
	Voltage and frequency control – Measuring the rise-in voltage protection as a running 10-minute mean value	**P**
	Voltage and frequency control – Frequency measurement	**P**
5,5,7,5	Reporting of NS protection	**P**
5,5,9	Constructional characteristics of NS protection	**P**
5,5,10,1	General	**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 (PGU output = 100%)	**P**
	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (PGUT output = 66%)	**P**
	Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (PGU output = 33%)	**P**

5,5,2	NS protection	P

The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6,1),

5,5,2,1	Functional safety	P

Componen t No.	Fault	test voltage (V)		Test time	fuse No.	fuse current (A)		Result
		AC	DC		(AC)	AC	DC	
Relay K1 L to N	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0,07A	PVA:45V/0,025A PVB:45V/0,025A	Unit shut down, LED light display red, no damage, no hazard, no fire
Transformer T4 （Pin 1 to pin 2）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0,07A	PVA:45V/0,025A PVB:45V/0,026A	Unit shut down, LED light display red, no damage, no hazard, no fire
Transformer T4 （Pin 3 to pin 4）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0,07A	PVA:45V/0,05A PVB:45,94V/3,1A	Unit shut down, LED light display red, no damage, no hazard, no fire
Transformer T8 （Pin 1 to pin 2）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/3,6A	PVA:45V/0,05A PVB: 45V/1,5A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
Transformer T8 （Pin 3 to pin 4）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	10min	FU1 FU2	230V/0A	PVA:45V/0,05A PVB:0,97V/19,92A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
MOS Q11 （Pin 2 to pin 3）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,025A PVB:45V/0,025A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
D2 （Pin 1 to pin 2）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,034A PVB:45V/0,034A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
D8 （Pin 1 to pin 2）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,034A PVB:45V/0,034A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
PV MOS Q3 （Pin 1,2,3 to pin5,6,7,8）	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	10min	FU1 FU2	230V/0A	PVA:45V/0,05A PVB:0,84V/20A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
Bus capacitor C10	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	10min	FU1 FU2	230V/0A	PVA:45V/0,05A PVB:0,84V/20A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
X capacitor C50	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	0V/0A	PVA:45V/0,034A PVB:45V/0,034A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
Y capacitor C57	Short circuit	230V/5A	PVA:45V/20A	2min	FU1 FU2	230V/4,35A	PVA:37,55V/14,58A PVB:37,55V/14,	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire

			PVB:45V/20A				58A	
PV array insulation resistance monitoring, R115	open circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/4,35A	PVA:37,55V/14,58A PVB:37,55V/14,58A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R2	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/3,74A	PVA:37,55V/14,58A PVB:38V/10,3A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R2	open circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0,07A	PVA:45V/0,025A PVB:45V/0,025A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R99	open circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,034A PVB:45V/0,034A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R99	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,034A PVB:45V/0,034A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R135	open circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/2A	PVA:45V/0,034A PVB:45V/0,7A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R135	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	10min	FU1 FU2	230V/0,18A	PVA:50V/0,06A PVB:50V/0,05A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R95	open circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,025A PVB:45V/0,025A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R95	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/4,42A	PVA:37,55V/14,58A PVB:37,55V/14,58A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R102	open circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,025A PVB:45V/0,025A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R102	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/4A	PVA:45V/10A PVB:45V/10A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R13、R14	open circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,025A PVB:45V/0,025A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
R13、R14	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/4,42A	PVA:37,55V/14,58A PVB:37,55V/14,58A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
Optocoupler	Short circuit	230V/5A	PVA:45V/20	2min	FU1	230V/0	PVA:45V/0,034A	Unit shut down, LED light

U5			A PVB:45V/20A		FU2	A	PVB:45V/0,034A	display red, no damage to enclosure, no hazard, no fire
Optocoupler U8	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0A	PVA:45V/0,034A PVB:45V/0,034A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire
Output L to N	Short circuit	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	0V/73A	PVA:45V/0,025A PVB:45V/0,025A	After the power grid simulator is powered on, self-protection, the indicator light flashes red, no damage, no danger
PV+ to PV- J7,J6	Reverse	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/0,07A	PVA:45V/0,05A PVB:1,52V/20A	Input power-on voltage is directly pulled down, input 31W, maximum current, no start, no danger
Output L to N	Reverse	230V/5A	PVA:45V/20A PVB:45V/20A	2min	FU1 FU2	230V/4,42A	PVA:37,55V/14,58A PVB:37,55V/14,58A	Unit shut down, LED light display red, no damage to enclosure, no hazard, no fire

Note:

The errors in the control circuit simulate that the safety is even ensured during a single fault,

Assessment criterion:

The NS protection must send a shutdown command to the coupling switch,

If the error is detected, the device is switched off within 10 s after error detection,

If the auxiliary voltage fails with the central NS protection or if the control fails with the integrated NS protection, the switch-off command must be given immediately,

5,5,4	**Integrated NS protection**	**P**
The integrated NS protection is tested in 5,5,7 and in connection with the examination of the entire NS protection chain and switch,		
Note: For test results see 5,5,2,1 Functional safety,		

5,5,6,3	**Integrated interface switch**	**P**
5,5,6,3,1	**Test (functional chain integrated NS-protection and integrated interface switch)**	**P**
Following monitoring options of an interface switch are valid (a) or (b) or (c):		
(a) Use of a interface switch in which a control voltage must be constantly applied when switched on and which switches off automatically when this voltage is not present, The operational switch-on and switch-off processes is monitored		
The disconnection of the control voltage leads to the instantaneous disconnection of the interface switch,		N/A
A simulated defect during the closing and opening of the interface switch leads to an instantaneous shutdown of the PGU, A restart is not possible,		N/A
A simulated defect of the interface switch after the NS protection as operated leads to an instantaneous shutdown of the PGU, A restart is not possible,		N/A
The switch-off time of the whole reaction chain is within 0,2s,		N/A
(b) The interface switch is switched on and off at least once a day by the NS protection and the proper functioning of the coupling switch is monitored,		
A simulated defect of the interface switch during the daily test leads to an instantaneous shutdown of the PGU, A restart is not possible,		N/A
A simulated defect of the interface switch after the NS protection has operated leads to an instantaneous shutdown of the PGU, A restart is not possible,		N/A
A function for daily switching on and off is available and explained by a manufacturer's declaration,		N/A
(c) Use of the integrated coupling switch and the integrated NA protection for PV and battery converters according to DIN EN 62109 (VDE 0126-14-1),		
The integrated interface switch and NS protection is comply with DIN EN 62109 (VDE 0126-14-1), See IEC 62109-2 test report BWDO-ESH-P24011134-2,		P
Note: See test results 5,5,2,1 functional safety,		
The inverter has a galvanic separating break device, The interface switch is short-circuit proof for the maximum short-circuit current of the power generation unit,		
Max, initial short-circuit current of the PGU (power generation unit)	= 5,46 A, 230 Vac	
Max, switching current relay	= 10 A, 250 Vac	
Relay type used	HF30F/12-2HSTF	

Datasheet of the relay (interface protection relay / Interface switch):

产品规格书 Specification

四川宏发电声有限公司

Sichuan Hongfa Electroacoustic Co.,Ltd.

电话 Tel：(86)-838-7136686
传真 Fax：(86)-838-7136676
网址 Web site:www.hongfa.com

产品规格书

Specification

文件编号 File No.：

顾客 Customer: _____

顾客产品名称 Customer Product Name: _____

顾客零件号 Customer Part No.: _____

宏发产品名称 Hongfa Product Name: 继电器 RELAY

宏发产品型号 Hongfa Product Part No.: HF30F/12-2HSTF

发布日期 Release Date: 2023 年 2 月 28 日

生产工厂 Production Plant: 四川宏发电声有限公司 Sichuan Hongfa Electroacoustic Co., Ltd.

版本 Version: a 更改单号 Number of Modification: _____

宏发审批签字 Signature by Hongfa			顾客确认 Customer Approval
拟制 Make	审核 Check	批准 Approved	负责人 By:
			日期 Date:

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- 1 - 保存期限:长期 保存部门:技术系统

产品规格书 Relay Specification

顾客 Customer:_____

1 品种 Type Model

1.1 种类 Type: 电磁继电器 Electromagnetic Relay

1.2 型号 Part NO.: HF30F/12-2HSTF

1.3 外形尺寸 Outline dimensions : 20.5 mm×12.7 mm×15.7 mm

1.4 触点形式 Contact Form: 两组常开 2 Form A

1.5 触点材料 Contact Material: AgSnO$_2$

2 安全认证 Safety Approval

认证机构 Certification Agency	认证号 File No.
UL/CUL	E133481
VDE	40055993
CQC	CQC21002317491

上述认证号代表该产品取得相关认证，但具体认证内容请以我公司提交的认证证书为准。
The above certificate No. is just a license No. Please refer to the certificates we supplied for detail information.

3 线圈额定参数 Coil Rating

at 23 ℃

额定电压 Rated Voltage Vd.c.	动作电压(1) Operate Voltage Vd.c.	释放电压(1) Release Voltage Vd.c.	允许最大线圈电压(2) Max Allowable Coil Voltage Vd.c.	线圈电阻 Coil Resistance Ω	线圈功耗 Coil Power W 大约 Approx.
12	≤9	≥0.6	15.6*	360×(1±10%)	0.4

备注：(1) 上述值为初始值。
(2) 允许最大线圈电压是指继电器线圈在短时间内能够承受的最大电压值。
Note: (1) The data shown above are initial values
(2) Maximun allowable coil voltage refers to the maximun voltage which relay coil could endure in a short period of time.

4 触点参数 Contact Parameters

4.1 触点额定负载 Contact Rating:10 A, 250 Va.c

4.2 最大切换电流 Max Switching Current: 10 A

4.3 最大切换电压 Max Switching Voltage: 250 Va.c.

4.4 最小适用负载 Min Applicable Load: 6 V, 1 A

5 性能 Performance

5.1 接触电阻 Contact Resistance: 100 mΩ max (at 6 Vd.c. 1A)。 (四端法 Four Probe Method)

5.2 动作时间 Operate Time: ≤ 10 ms 。

5.3 释放时间 Release Time: ≤ 5 ms 。

5.4 耐久性 Endurance

5.4.1 电耐久性 Electrical Endurance

结构型式 Version	触点材料 Contact Material	触点负载 Contact Rating	环境温度 Ambient Temperature	通断比 Ratio ON: OFF	电耐久性 Electrical Endurance
2H 型 Type 2H	$AgSnO_2$	阻性负载 Resistive load 10 A 250 Va.c	85℃	1s:9s	5×10^4次(ops)
2H 型 Type 2H	$AgSnO_2$	阻性负载 Resistive load 10 A 250 Va.c	室温	1s:9s	1×10^5(ops)

严酷等级 B:六次瞬时失效或两次连续瞬时失效判定为失效。

5.4.2 机械耐久性 Mechanical Endurance

结构型式 Version	触点负载 Contact Rating	环境温度 Ambient Temperature	通断比 Ratio ON: OFF	机械耐久性 Mechanical Endurance
2H 型 Type 2H	无负载 No load	常温 Room Temperature	0.1s: 0.1s	1×10^6次(ops)

5.5 介质耐压 Dielectric Strength (漏电流 Leakage Current: ≤1 mA)

5.5.1 断开触点电路的各引出端之间 Between terminals of each opened contact circuit: 1000 Va.c. (50/60 Hz 1 min) 。

5.5.2 所有线圈引出端与所有触点电路引出端之间 Between all coil terminals and all contact circuit terminals: 4000 Va.c. (50/60 Hz 1 min) 。

5.5.3 各独立的触点电路的引出端之间 Between terminals of separate contact circuits: 2500 Va.c. (50/60 Hz 1 min) 。

5.6 绝缘电阻 Insulation Resistance

5.6.1 断开触点电路的各引出端之间 Between terminals of each opened contact circuit: 1000 MΩ (500 Vd.c.) 。

5.6.2 所有线圈引出端与所有触点电路引出端之间 Between all coil terminals and all contact circuit terminals: 1000 MΩ (500 Vd.c.) 。

5.7 线圈温升 Coil Temperature Rise: 70 K max

以 110%额定电压激励，触点负载 10 A 250 Va.c.，环境温度：85 ℃。

Applied voltage of coil 110% rated voltage, Carry current of contact

5,5,7,2	**Check of setting values**	**P**
5,5,7,2,1	**Test**	**P**
Inverter name		
Setting values:		

PGU type	Description	Parameter name	Set value in p,u,	Set value L-N	Set value L-L *2)
	nominal voltage	U_n	1	230,0 V	400,0 V
	Nominal frequency	f_n	1	50,0 Hz	50,0 Hz
a) name set of parameter (Parameter setup name in manual or software)					
Stirling generators, fuel cells, coupled directly or via a converter Synchronous and asynchronous generators with $P_n \leq 50$ kW	Excitation threshold U>>	AU>>	1,15	264,5 V	460,0 V
	Delay time U>>	tU>>	-	0,100 s	0,100 s
	Excitation threshold U>	AU>	1,10	253,0 V	440,0 V
	Delay time U> * 1)	tU>	-	0,100 s *1)	0,100 s *1)
	Excitation threshold U<	AU<	0,8	184,0 V	320,0 V
	Delay time U<	tU<	-	0,100 s	0,100 s
	Excitation threshold U<<	AU<<	deactivated	-	-
	Delay time U<<	tU<<	deactivated	-	-
	Excitation threshold f>	Af>	1,03	51,5 Hz	51,5 Hz
	Delay time f>	tf>	-	0,100 s	0,100 s
	Excitation threshold f<	Af<	0,95	47,5 Hz	47,5 Hz
	Delay time f<	tf<	-	0,100 s	0,100 s
b) name set of parameter (Parameter setup name in manual or software)					
directly coupled synchronous and asynchronous generators with $P_n > 50$ kW	Excitation threshold U>>	AU>>	1,25	287,5 V	500,0 V
	Delay time U>>	tU>>	-	0,100 s	0,100 s
	Excitation threshold U>	AU>	1,10	253,0 V	440,0 V
	Delay time U> * 1)	tU>	-	0,100 s *1)	0,100 s *1)
	Excitation threshold U<	AU<	0,8	184,0 V	320,0 V
	Delay time U<	tU<	-	1,0 s	1,0 s
	Excitation threshold U<<	AU<<	0,45	103,5 V	180,0 V
	Delay time U<<	tU<<	-	0,300 s	0,300 s
	Excitation threshold f>	Af>	1,03	51,5 Hz	51,5 Hz
	Delay time f>	tf>	-	0,100 s	0,100 s
	Excitation threshold f<	Af<	0,95	47,5 Hz	47,5 Hz
	Delay time f<	tf<	-	0,100 s	0,100 s
c) name set of parameter (Parameter setup name in manual or software)					
Inverter	Excitation threshold U>>	AU>>	1,25	287,5 V	500,0 V
	Delay time U>>	tU>>	-	0,100 s	0,100 s
	Excitation threshold U>	AU>	1,10	253,0 V	440,0 V
	Delay time U> * 1)	tU>	-	0,100 s *1)	0,100 s *1)
	Excitation threshold U<	AU<	0,8	184,0 V	320,0 V
	Delay time U<	tU<	-	3,0 s	3,0 s
	Excitation threshold U<<	AU<<	0,45	103,5 V	180,0 V
	Delay time U<<	tU<<	-	0,300 s	0,300 s

	Excitation threshold f>	Af>	1,03	51,5 Hz	51,5 Hz
	Delay time f>	tf>	-	0,100 s	0,100 s
	Excitation threshold f<	Af<	0,95	47,5 Hz	47,5 Hz
	Delay time f<	tf<	-	0,100 s	0,100 s

*1) 10-min mean value

*2) testing of external NS-protection

Factory settings correspond to the values in Table 36	Yes
There are no factory settings, The information on the setting values in the instructions manual correspond to those in Table 36,	No
External NS protection: settings and delay times are password protected settable	N/A
External NS protection: It is possible to read the setting values without a tool	N/A
Integrated NS protection: the setting values are visible via a data interface or display	Yes
The limit values for U> can be set between 110% and 115% and, in the case of directly coupled synchronous and asynchronous generators with P_{rE} >50kW, the time delay for U< and U<< can be set, All other limit values are protected against unauthorized access,	Yes

Assessment criterion:

The exam is passed if the following points are met:

The factory setting values correspond

a) With integrated NA protection of VDE-AR-N 4105: 2018-11, 6,5,2 Table 2 (see also Table 36),
b) With central NA protection, either the factory settings of VDE-AR-N 4105: 2018-11, 6,5,2, Table 2 (see also Table 36) or these values can be set,

- In the event of an operator input, the test object only goes into operation after settings have been selected,

The setting values that can be changed according to 4105: 2018-11, 6,5,1 and 6,5,2 can be set within the specified limits and are protected against unauthorized access,

The setting values that cannot be changed according to VDE-AR-N 4105: 2018-11, 6,5,1 and 6,5,2 cannot be changed or are protected from unauthorized access by an additional separate protection system

5,5,7,3	**Wiring check**			**P**
5,5,7,3,1	**Test**			**P**
Setting values:				
U L1-E	219,4 V	0°	50,0 Hz	
U L2-E	N/A	-120°	50,0 Hz	
U L3-E	N/A	120°	50,00 Hz	
Measured values:				
U L1-E	219,7 V	0°	50,0 Hz	
U L2-E	N/A	-120°	50,0 Hz	
U L3-E	N/A	120°	50,0 Hz	
Evaluation criterion				
This test is not assessed, If a phase shift is found, it must be corrected and the test repeated				

5,5,7,4	**Voltage and frequency control**	**P**
5,5,7,4,1	**Voltage and frequency control – Single Phase**	**P**

Integrated NS protection single phase ≤ 30 kVA

Operating time of the monitoring device:

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L1 to N:	**Under voltage 1 (4,2):**	**Over voltage 1 (1,2):**
Ramp [start V to stop V]	>188,6 → <179,4	<282,9 → >292,1
Step size [V]	<1,15	<1,15
Step length [s]	>3,200	>0,400
Limit [V]	184,0 ± 1% U_n	287,5 ± 1% U_n
Measurement [V]	183,2	288,4

L1 to N:	**Under voltage 1 (5,2):**	**Over voltage 1 (2,2):**
Jump [start V to stop V]	>200,1 → <179,4	<282,9 → >292,1
Step size [V]	>9,2	>9,2
Step length [s]	>3,200	>0,400
Limit [s]	3,000 ±0,100	0,100 ±0,100
Measurement [s]	3,042	0,147

L1 to N:	**Under voltage 2 (6,2):**
Ramp [start V to stop V]:	>108,1 → <98,9
Step size [V]	<1,15
Step length [s]	>0,500
Limit [V]:	103,5 ± 1% U_n
Measurement [V:]	102,9

L1 to N:	**Under voltage 2 (7,2):**
Jump [start V to stop V]:	>108,1 → <98,9
Step size [V]	>9,2
Step length [s]	>0,500
Limit [s]:	0,300 ±0,100
Measurement [s]:	0,368

Note:

The disconnection time includes disconnect time + operate time of the integrated relay, Therefore limit is give with +0,1 s according to Table 2 set values of the NS-protection according to VDE AR-N 4105:2018,

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

5,5,7,4	**Voltage and frequency control**	**P**
5,5,7,4,1	**Voltage and frequency control – Measuring the rise-in voltage protection as a running 10-minute mean value**	**P**

MST-HIE2.5-1000	
L-N:	**Over voltage 10-minute mean value (3,1):**
Ramp [start V to stop V]	230,0 → 257,6
Step size [V]	27,6
Step length [s]	>600,2
Limit for disconnection [s]	450 – 550
Measurement [s]	487,63
L-N:	**Over voltage 10-minute mean value (3,2):**
Ramp [start V to stop V]	230,0 → >248,4
Step size [V]	18,4
Step length [s]	>600,2
Limit for reconnection [s]	no disconnection (also after 600 s)
Measurement [s]	no disconnection
L-N:	**Over voltage 10-minute mean value (3,3):**
Ramp [start V to stop V]	243,8 → >262,2
Step size [V]	18,4
Step length [s]	>600,2
Limit for disconnection[s]	225 – 375
Measurement [s]	296,74
Note:	

5,5,7,4	**Voltage and frequency control**	**P**
5,5,7,4,1	**Voltage and frequency control – Frequency measurement**	**P**

Operating time of the monitoring device:

MST-HIE2.5-1000

	Under frequency (10,1):	**Over frequency (8,1):**
Ramp [start Hz to stop Hz]	47,60 → 47,40	51,40 → 51,60
Step size [Hz]	<0,025	<0,025
Step length [s]	>0,4	>0,4
Limit [Hz]	47,50 ± 1% f_n	51,50 ± 1% f_n
Measurement [Hz]	47,49	51,50
	Under frequency (11,1):	**Over frequency (9,1):**
Jump [start Hz to stop Hz]	47,60 → 47,40	51,40 → 51,60
Step size [Hz]	>0,2	>0,2
Step length [s]	>0,4	>0,4
Limit [s]	0,100 ±0,100	0,100 ±0,100
Disconnection time [s]	0,156	0,139

Note:

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

5,5,7,5	Reporting NS protection	P

The last 5 dated failure reports on the NS protection can be read, An interruption in the supply voltage of ≤ 3 s does not result in any loss of failure reports,

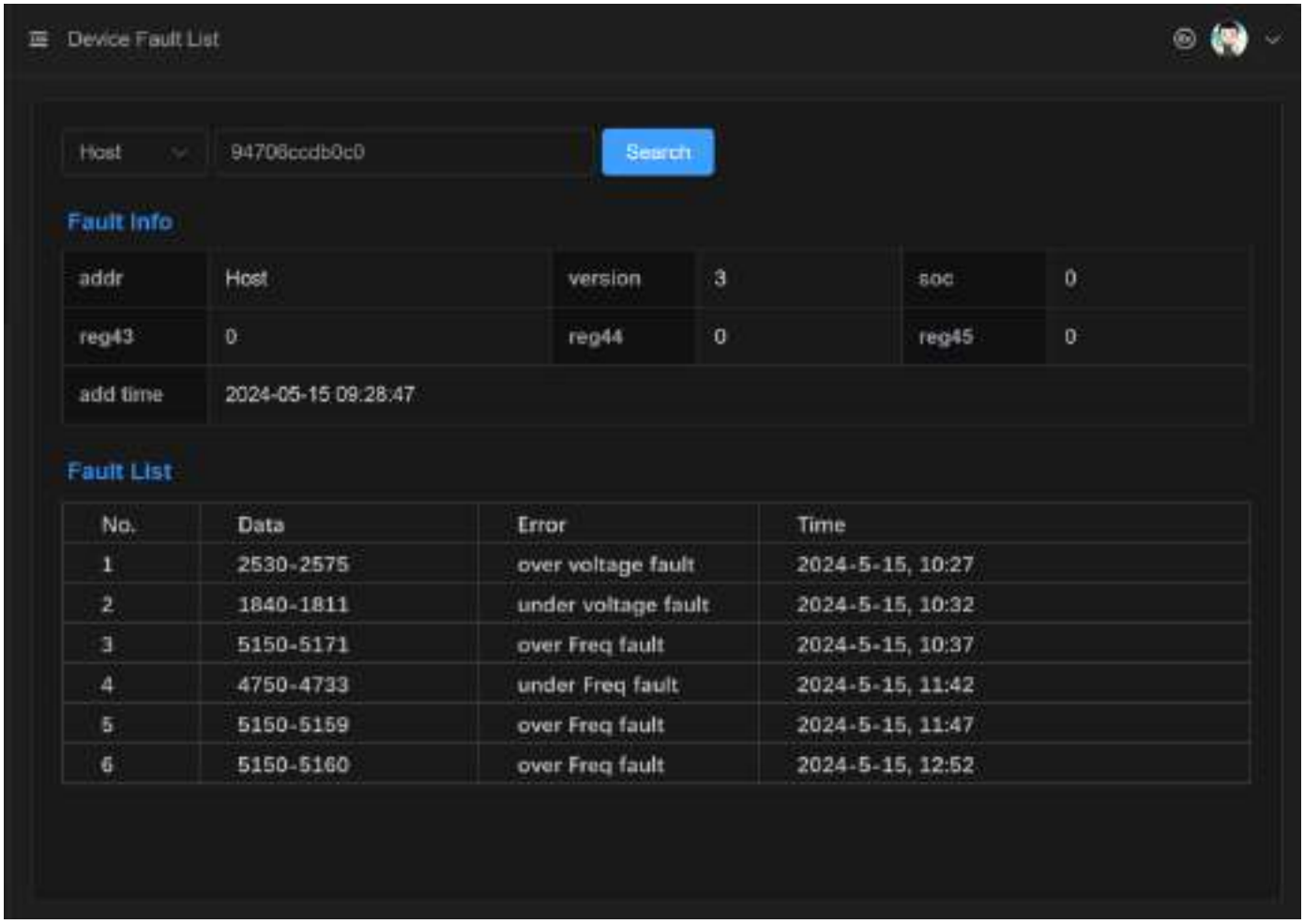
Central NS protection:

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,

Picture of 5 last dated failure:



Assessment criterion:

At least the last 5 error messages including time stamps that were recorded before the voltage interruption and at least 5 error messages including time stamps that were recorded after the voltage interruption must be documented,

5,5,9	**Constructional characteristics of NS protection**	**P**
5,5,9,1	**General**	**P**
These tests serve to demonstrate the requirements of VDE-AR-N 4105: 2018-11, 6,5,2,		
5,5,9,2	**Test**	**P**
Type of NS protection: Internal		
NS-protection is sealed or a password protection is used (or both)		P
adjustability of U> and the time delays for U< and U<< is given		P
All other protective functions are either permanently protected or protected from unauthorized access by additional, separate protection (example password)		P

5,5,10	**Islanding detection**	**P**
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 by means of the three-phase voltage monitoring (possible only for power generation systems without inverters or for single-phase power generation units with inverters), (see 5,5,7,4 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°,		
5,5,10,1	**General**	**P**
These tests serve as proof of the requirements of VDE-AR-N 4105: 2018-11, 6,5,3, The maximum switch-off time is 9 s,		

5,5,10,2	Passive Islanding detection	P
The passive procedure is implemented by the voltage increase and voltage decrease protection of the NS protection,		
Note: A passive procedure is possible with the help of three-phase voltage monitoring (only for generating units without converter or for single-phase generating units with converter) The three-phase voltage monitoring is also permissible with the structural integration of several single-phase generating units that feed into different external conductors, as long as the currents of these generating units are regulated independently of each other so that any phase positions can be set,		

5,5,10,3	**Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (PGU output = 100%)**	**P**

Test conditions	Frequency: 50,00 Hz ± 1% f_n U_n = 230,0 V ± 1% U_n Distortion factor of chokes ≤ 2%
Disconnection limit	2 s (IEC 62116)

MST-HIE2.5-1000

No	P_{PGU} [1)] [% of PGU 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_{PGU} [W per phase]	V_{DC} [V]	Q_f [1]	Run on Time [s]	Re-marks[5)]
					L1	L2	L3					
1	100	100	0	0	-	-	-	1000	49	1,01	353	BL
4	100	100	-5	-5	-	-	-	1000	49	1,03	81	IB
5	100	100	-5	0	-	-	-	1000	49	1,06	213	IB
6	100	100	-5	+5	-	-	-	1000	49	1,09	100	IB
7	100	100	0	-5	-	-	-	1000	49	0,98	81	IB
8	100	100	0	+5	-	-	-	1000	49	1,03	81	IB
9	100	100	+5	-5	-	-	-	1000	49	0,94	105	IB
10	100	100	+5	0	-	-	-	1000	49	0,96	184	IB
11	100	100	+5	+5	-	-	-	1000	49	0,99	119	IB

Parameter at 0% per phase	L= 168,47 mH	R= 52,9 Ω	C= 60,20 µF

5,5,10,3	**Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (PGU output = 100%)**	**P**

Note:

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

1) P_{PGU}: PGU output power

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

3) Q_{AC}: Reactive power flow at S1 in Figure 1, Positive means power from PGU 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:

PGU output power P_{PGU} = Maximum 6)

PGU input voltage 6) ≥ 75% of rated input voltage range

6) Maximum PGU output power condition should be achieved using the maximum allowable input power, Actual output power may exceed nominal rated output,

7) Based on PGU 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 × PGU maximum system voltage (i,e,, maximum allowable array open circuit voltage), In any case, the PGU should not be operated outside of its allowable input voltage range,

5,5,10,3	**Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (PGU output = 50 % – 66 %)**	**P**

Test conditions	Frequency: 50,00 Hz ± 1% f_n U_n = 230,0 V ± 1% U_n Distortion factor of chokes ≤ 2%
Disconnection limit	2 s (IEC 62116)

No	P_{PGU} [1] [% of PGU 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_{PGU} [W per phase]	V_{DC} [V]	Q_f [1]	Run on Time [s]	Re-marks [5]
					L1	L2	L3					
12	66	66	0	-5	-	-	-	600	38	0,98	88	IB
13	66	66	0	-4	-	-	-	600	38	0,99	104	IB
14	66	66	0	-3	-	-	-	600	38	0,99	100	IB
15	66	66	0	-2	-	-	-	600	38	1,00	130	IB
16	66	66	0	-1	-	-	-	600	38	1,01	172	IB
2	66	66	0	0	-	-	-	600	38	1,01	211	BL
17	66	66	0	1	-	-	-	600	38	1,02	141	IB
18	66	66	0	2	-	-	-	600	38	1,02	139	IB
19	66	66	0	3	-	-	-	600	38	1,03	109	IB
20	66	66	0	4	-	-	-	600	38	1,04	115	IB
21	66	66	0	5	-	-	-	600	38	1,04	99	IB

Parameter at 0% per phase	L= 280,79 mH	R= 88,17 Ω	C= 36,12 µF

Note:

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

[1] P_{PGU}: PGU output power

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

[3] Q_{AC}: Reactive power flow at S1 in Figure 1, Positive means power from PGU 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:

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

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

[6] Based on PGU 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 × PGU maximum system voltage (i,e,, maximum allowable array open circuit voltage), In any case, the PGU should not be operated outside of its allowable input voltage range,

5,5,10	Islanding protection according Table 7 – Load imbalance (reactive load) for test condition C (PGU output = 25 % – 33 %)	P

Test conditions	Frequency: 50,00 Hz ± 1% f_n U_n = 230,0 V ± 1% U_n Distortion factor of chokes ≤ 2%
Disconnection limit	2s (IEC 62116)

No	P_{PGU} [1] [% of PGU 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_{PGU} [W per phase]	V_{DC} [V]	Q_f [1]	Run on Time [s]	Re-marks [5]
					L1	L2	L3					
22	33	33	0	-5	-	-	-	300	24	0,98	122	IB
23	33	33	0	-4	-	-	-	300	24	0,99	131	IB
24	33	33	0	-3	-	-	-	300	24	1,00	156	IB
25	33	33	0	-2	-	-	-	300	24	1,00	146	IB
26	33	33	0	-1	-	-	-	300	24	1,00	196	IB
3	33	33	0	0	-	-	-	300	24	1,00	203	BL
27	33	33	0	1	-	-	-	300	24	1,01	200	IB
28	33	33	0	2	-	-	-	300	24	1,01	189	IB
29	33	33	0	3	-	-	-	300	24	1,02	200	IB
30	33	33	0	4	-	-	-	300	24	1,03	146	IB
31	33	33	0	5	-	-	-	300	24	1,03	138	IB

Parameter at 0% per phase	L= 561,57 mH	R= 176,33 Ω	C= 18,06 µF

Note:

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

[1] P_{PGU}: PGU output power

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

[3] Q_{AC}: Reactive power flow at S1 in Figure 1, Positive means power from PGU 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:

PGU output power P_{PGU} = 25 % – 33 % [6] of maximum

PGU input voltage [7] < 20 % of rated input voltage range

[6] Or minimum allowable PGU output level if greater than 33 %,

[7] Based on PGU 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 × PGU maximum system voltage (i,e,, maximum allowable array open circuit voltage), In any case, the PGU should not be operated outside of its allowable input voltage range,

DIN VDE 0124-100		
Clause	**Requirement – Test**	**Verdict**
5,6	**Testing of connecting conditions and synchronisation**	
5,6,1	General	**P**
5,6,2	Connecting conditions and synchronisation	**P**

5,6	**Testing of connecting conditions and synchronisation**	**P**
5,6,1	**General**	**P**
These tests serve to demonstrate the requirements of VDE-AR-N 4105: 2018-11, 8,3		

5,6,2,	Connecting conditions and synchronisation		P
Test:			
	f_{ist}	**Reset time:**	**Limit:**
Connecting conditions for frequencies:			
a)	< 47,45 Hz	No reconnection	No resetting allowed
	Switch to:		
b)	≥ 47,55 Hz	67,02	≥ 60 s
c)	> 50,15 Hz	No reconnection	No resetting allowed
	Switch to:		
d)	≤ 50,05 Hz	67,44	≥ 60 s
Connecting conditions for voltages:			
e)	84% U_n	No reconnection	No resetting allowed
	Switch to:		
f)	≥ 86% U_n	67,25	≥ 60 s
g)	111% U_n	No reconnection	No resetting allowed
	Switch to:		
h)	≤ 109% U_n	67,06	≥ 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 / 50,0 Hz to 200 V / 47,0 Hz resulted in a 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 ((80% U_n ≤ U ≤110% U_n) and (47,50 Hz ≤ f ≤ 50,10 Hz)) at the earliest after 60 s after voltage and frequency has remained within the tolerance ranges,

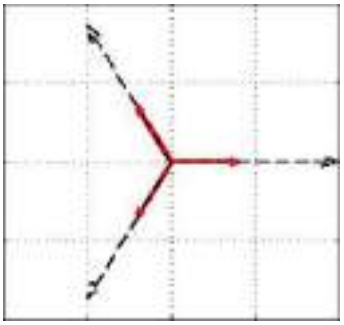
5,7	Evidence of $P_{AV,E}$ –Control	
Clause	**Requirement – Test**	**Verdict**
5,7,1	General	**P**
5,7,2,1	Test control dynamic	**P**
5,7,2,2	Test disconnection function	**N/A**

5,8	Evidence dynamic grid support	
Clause	**Requirement – Test**	**Verdict**
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	Evidence dynamic grid support	
Clause	**Requirement – Test**	**Verdict**
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**

5.8.1	General	

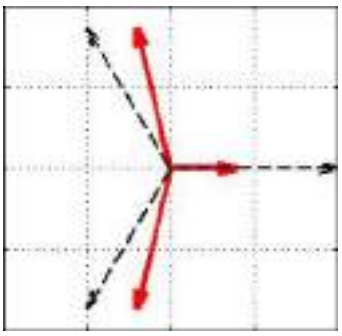
FRT test for three-phase symmetrical (Test ref no. x.1.x)



Typ-A

LVRT test for two-phase asymmetrical fault (Test ref no. 1.2.x to 5.2.x)

Test No.	V/V_{nom}	Phase-to-earth voltages			Phase angles		
		$u_1/u_{1,nom}$	$u_2/u_{2,nom}$	$u_3/u_{3,nom}$	φ_{u1}	φ_{u2}	φ_{u3}
1.2.x	0,1-0,15	0,1-0,15	0,87 ±0 ,05	0,87 ±0 ,05	0°	-94°	94°
2.2.x	0,20-0,25	0,20-0,25	0,87 ±0 ,05	0,87 ±0 ,05	0°	-97°	97°
3.2.x	0,50 ±0 ,05	0,50 ±0 ,05	0,90 ±0 ,05	0,90 ± 0,05	0°	-106°	106°
4.2.x	0,75 ±0 ,05	0,75 ±0 ,05	0,94 ±0 ,05	0,94 ±0 ,05	0°	-113°	113°
5.2.x	0,92 ±0 ,05	0,92 ±0 ,05	0,98 ±0 ,05	0,98 ±0 ,05	0°	-118°	118°
Normal condition	1	1	1	1	0°	-120°	120°



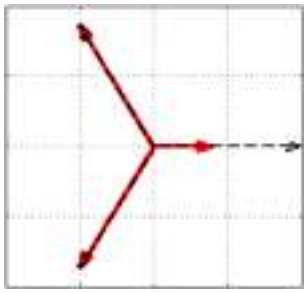
Typ-D

5.8.1	General	

FRT test for two-phase asymmetrical fault (Test ref no. 6.2.x to 7.2.x)

Test No.	V/V_{nom}	Phase-to-earth voltages			Phase angles		
		$u_1/u_{1,nom}$	$u_2/u_{2,nom}$	$u_3/u_{3,nom}$	φ_{u1}	φ_{u2}	φ_{u3}
6.2.x	1,25-1,30	1,25-1,30	1,25-1,30	1,00 ±0 ,05	0°	-120°	120°
7.2.x	1,20 ±0 ,05	1,20 ±0 ,05	1,20 ±0 ,05	1,00 ±0 ,05	0°	-120°	120°
Normal condition	1	1	1	1	0°	-120°	120°

FRT test for two-phase asymmetrical fault (Test ref no. x.3.x)



Typ-B

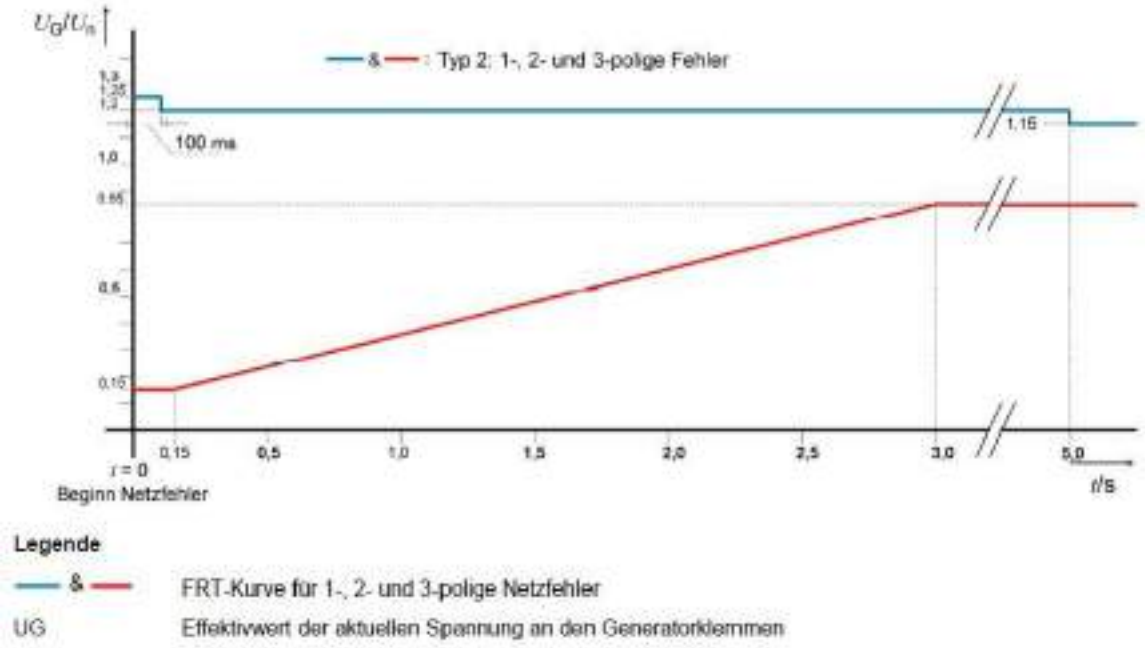


Bild 12 – Fault-Ride-Through-Grenzkurve für den Spannungsverlauf an den Generatorklemmen für eine Erzeugungseinheit vom Typ 2 und für Speicher

Figure 12 - Fault ride-through limit curve for the voltage curve at the generator terminals for a **type 2** generation unit and for storage

5.8.3	Testing of the dynamic grid support	P
	For PGUs Type 2 and storage systems	P
	1 and 3-phase systems	

Test	Voltage dip to (U_n / p.u.)	Dip type	duration (s)	P set point (P_{rE} / p.u.)	Q set point (Q / p.u.)	Comment	Test ref. No.	R recovery response time [s]
1	0,15 to 0,25	A	for 0,15 ≥0,150 / for 0,25 ≥0,500	1	0 to ±0,1	Symmetric	1.1	0,442
				0,2 to 0,6			1.2	0,242
		D1		1		Asymmetric (ph-2ph + Dy5-Trafo)	1.3	0,506
				0,2 to 0,6			1.4	0,282
		D2		1			1.5	0,500
2	0,50 to 0,60	A	for 0,50 ≥1,5 / for 0,60 ≥2,000	1	Max. over excited	Symmetric	2.1	0,423
				0,2 to 0,6			2.2	0,242
		D1		1		Asymmetric (ph-2ph + Dy5-Trafo)	2.3	0,520
				0,2 to 0,6			2.4	0,451
3	0,50 to 0,60	A	for 0,50 ≥1,500 / for 0,60 ≥2,000	1	Max. under excited	Symmetric	3.1	0,466
				0,2 to 0,6			3.2	0,298
		D1		1		Asymmetric (ph-2ph + Dy5-Trafo)	3.3	0,496
				0,2 to 0,6			3.4	0,398
4	0,85 to 0,90	A	≥60,000	1	0 to ±0,1	Symmetric	4.1	N/A
				0,2 to 0,6			4.2	N/A
		D1		1		Asymmetric (ph-2ph + Dy5-Trafo)	4.3	N/A
				0,2 to 0,6			4.4	N/A
5	1,20 to 1,25	A	≥0,100	1	0 to ±0,1	Symmetric	5.1	0,435
				0,2 to 0,6			5.2	0,309
		D1		1		Asymmetric (ph-2ph + Dy5-Trafo)	5.3	N/A
				0,2 to 0,6			5.4	N/A
		D2		1			5.5	0,434
6	1,15 to 1,20	A	≥5,000	1	0 to ±0,1	Symmetric	6.1	0,499
				0,2 to 0,6			6.2	0,501
		D1		1		Asymmetric (ph-2ph + Dy5-Trafo)	6.3	N/A
				0,2 to 0,6			6.4	N/A
7	1,10 to 1,15	A	≥60,000	1	0 to ±0,1	Symmetric	7.1	N/A
				0,2 to 0,6			7.2	N/A
		D1		1		Asymmetric (ph-2ph + Dy5-Trafo)	7.3	N/A
				0,2 to 0,6			7.4	N/A

5.8.3	Testing of the dynamic grid support	P

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.

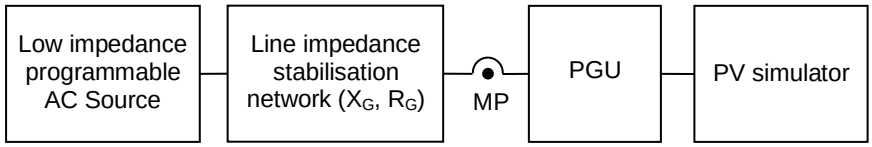
Behaviour during the network error:

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.

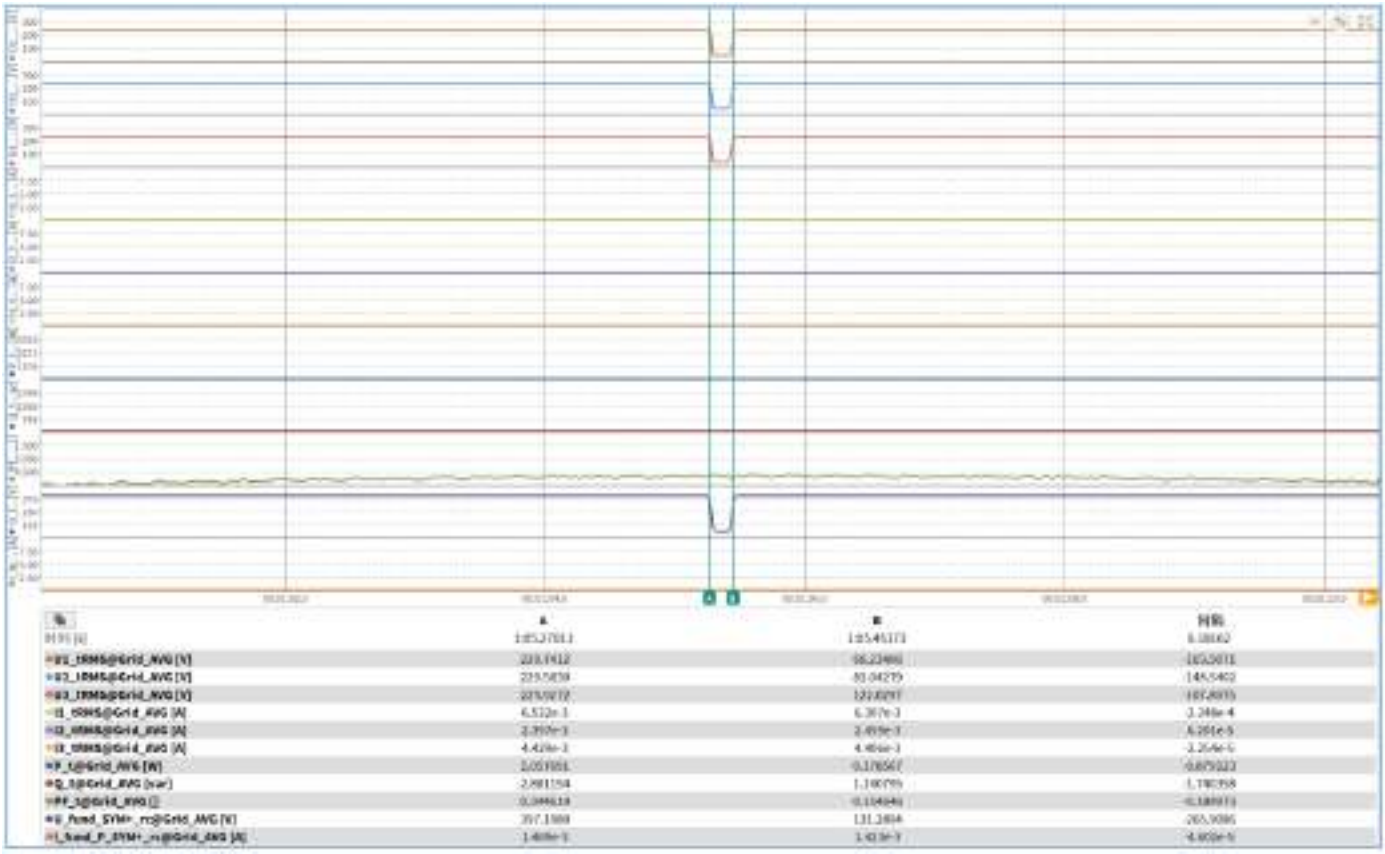
- Type 2 units and storage systems are not allowed to inject either active or reactive current during a line voltage at the PGUs terminals below 0,8 Un and above 1,15 Un. This requirement is met if, in the event of a under-/ under voltage dip, the injected current of the generating unit and / or the storage systems does not exceed 20% of the rated current Ir and no more than 10% Ir after 0,06 s after the occurrence of this under-/ under voltage dip in any phase.

Behaviour after the end of the error:

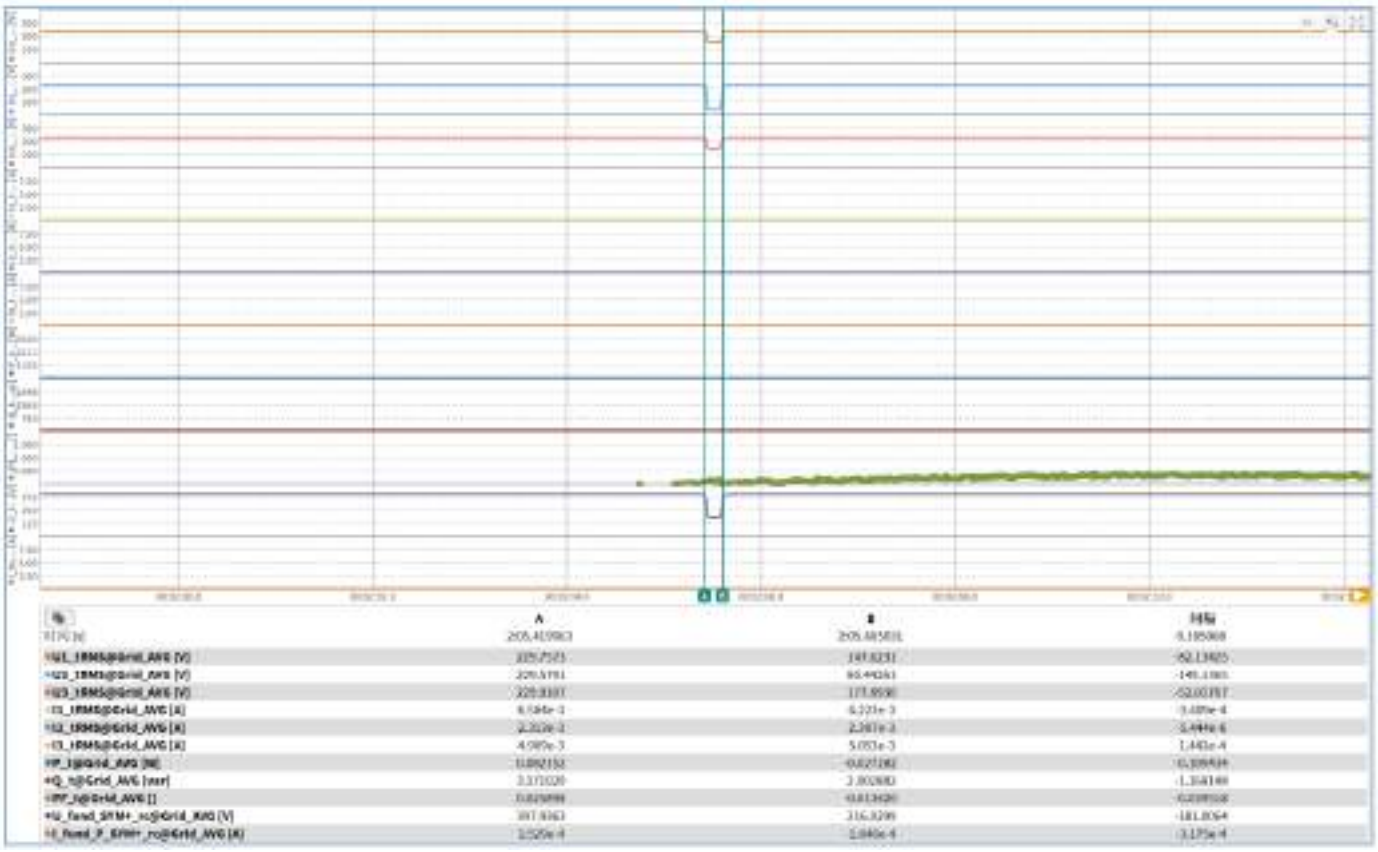
- Not disconnection of the PGU within 60s after the end of the fault.
- Type 2 units and storage systems: Reaction time of active power up to 1 s, Reaction time of reactive power according to PT-1 behaviour with 3 tau = 10 s in accordance with VDE-AR-N 4105: 2018-11, 5.7.2.5

Test setup	
Grid simulator (grid conditions varied)	☒
Test bench	☐
Identifier of test setup	See Annex 2 – Test equipment list
Schematic of test setup:  	Note on test setup: Instead of an LVRT test bench a low-voltage AC simulator was used.
Note: Evaluation of data measured at MP. Used sample rate: 10 kHz	
Grid parameters at MP1	
Nominal voltage PCC // U_G [V]	230 V (P-N) / 400 V (P-P)
Nominal apparent power of test setup // S_n [kVA]	30
Short-circuit power of the test setup // S_{sc} [kVA]	≥ 3x$S_{n,PGU}$
Grid reactance X_G [Ω]	0,39
Grid impedance R_G [Ω]	0,15

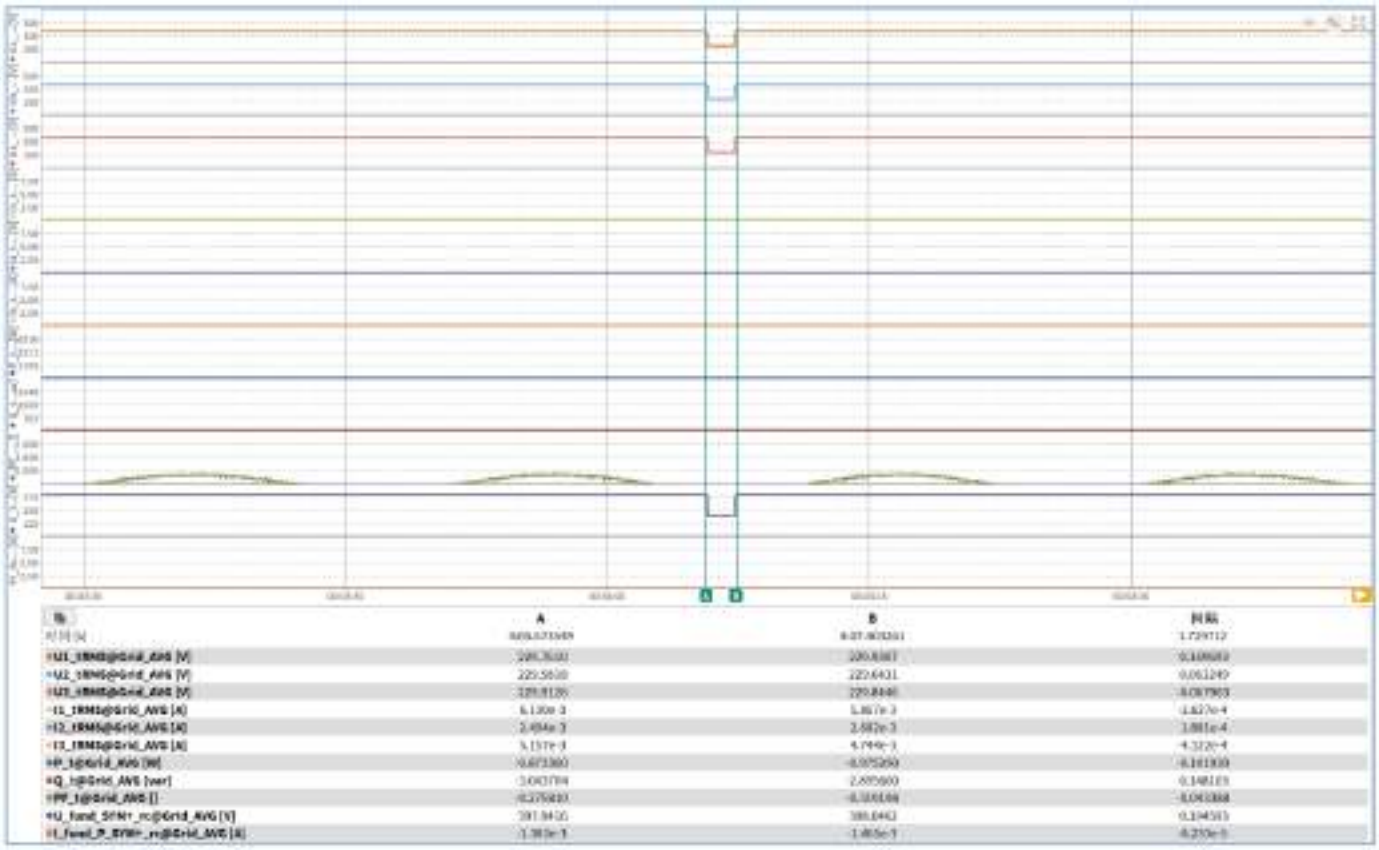
5.8.3	For PGUs Type 2 and storage systems – no load	P
	1.1	



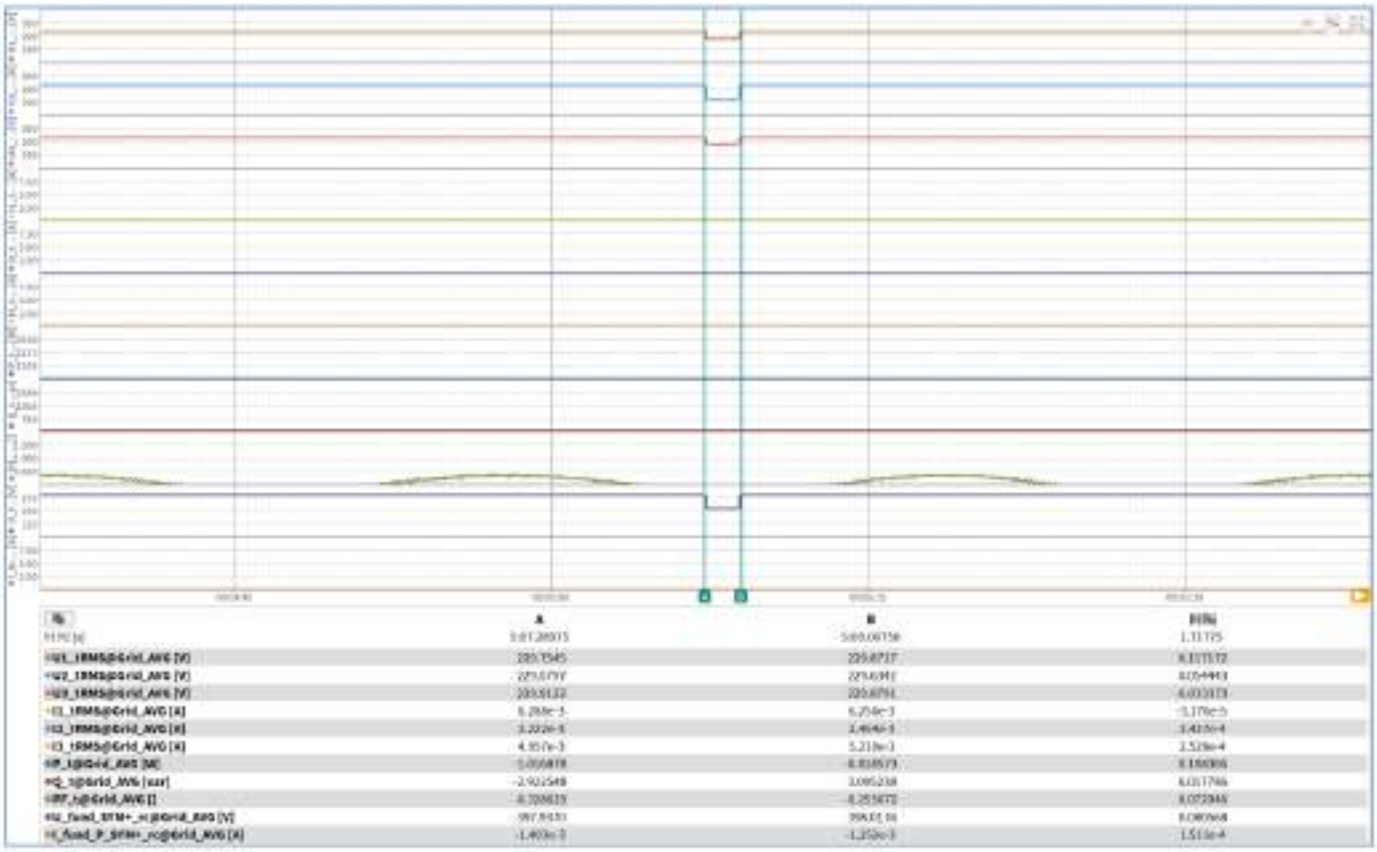
5.8.3	For PGUs Type 2 and storage systems – no load	P
	1.3	



5.8.3	For PGUs Type 2 and storage systems – no load	P
	2.1	

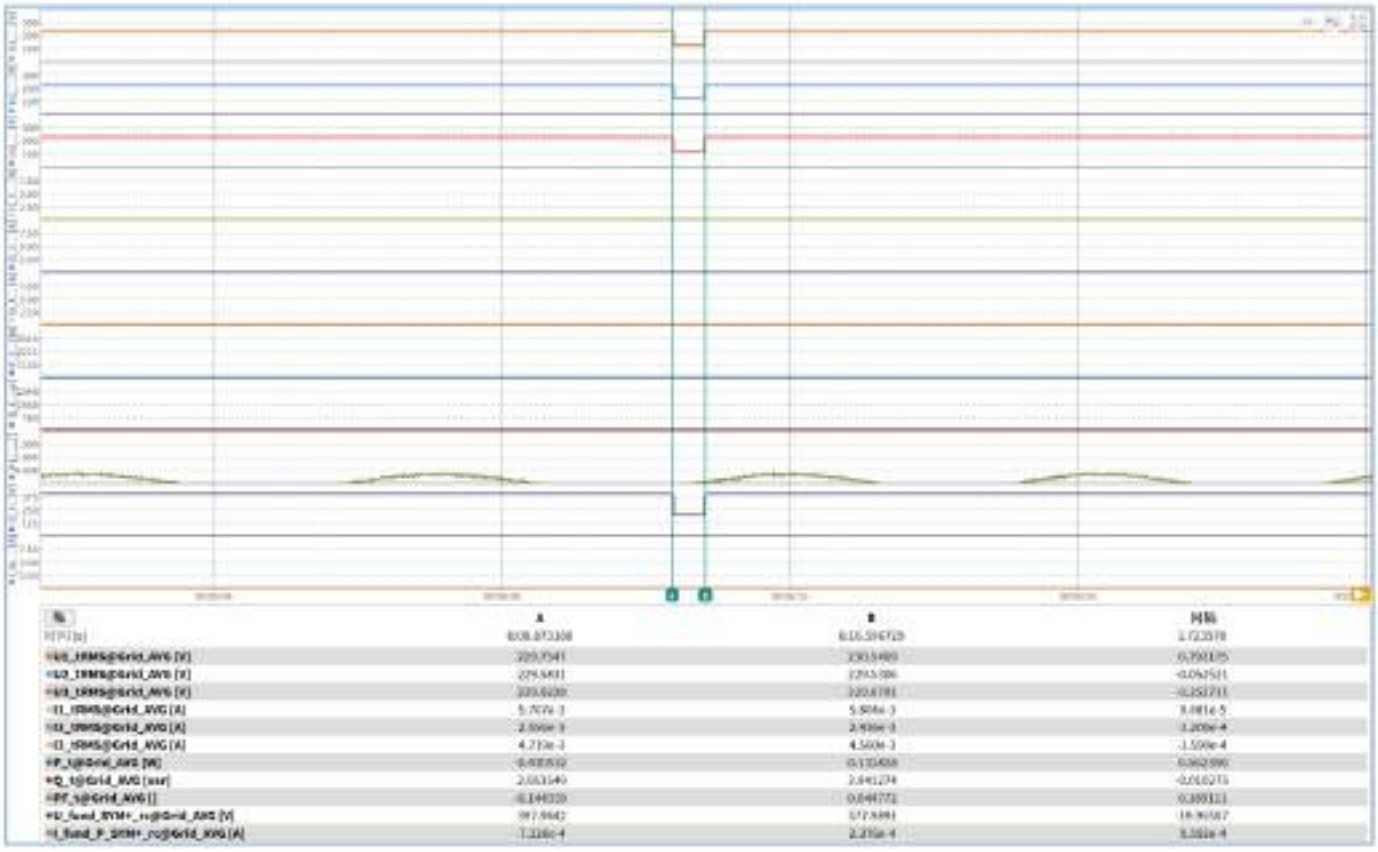


5.8.3	For PGUs Type 2 and storage systems – no load	P
	2.3	

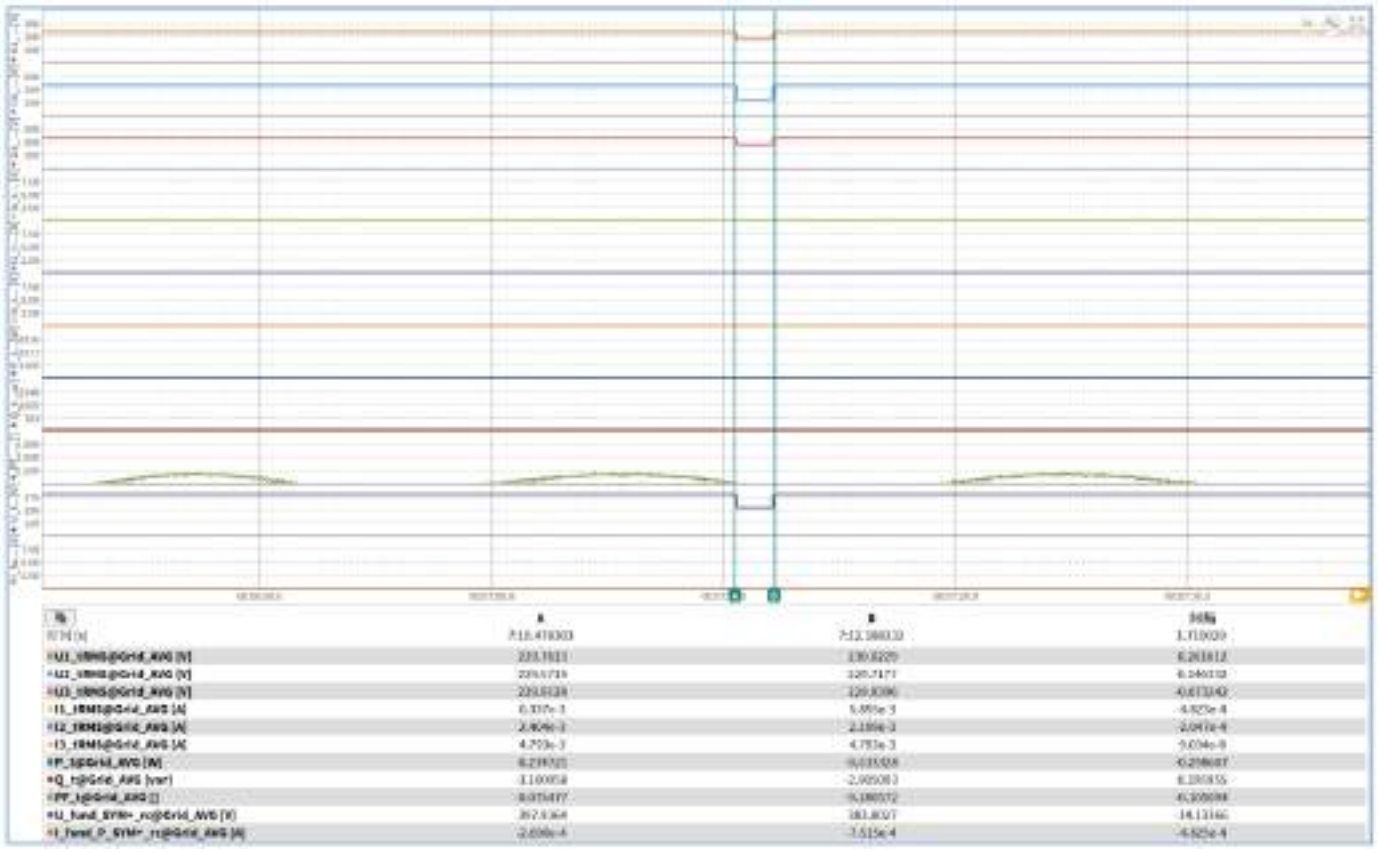


5.8.3	For PGUs Type 2 and storage systems – no load	P

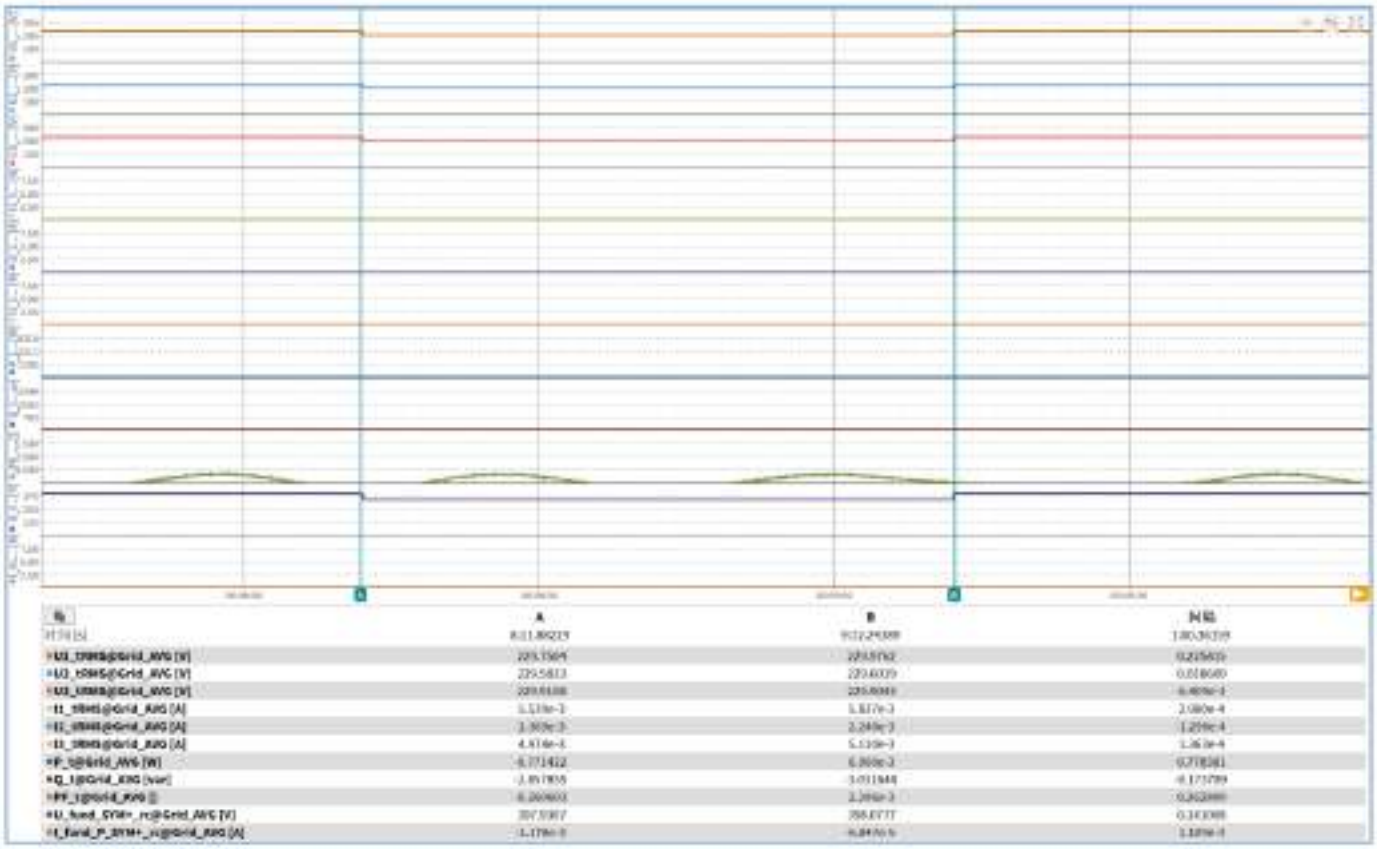
3.1



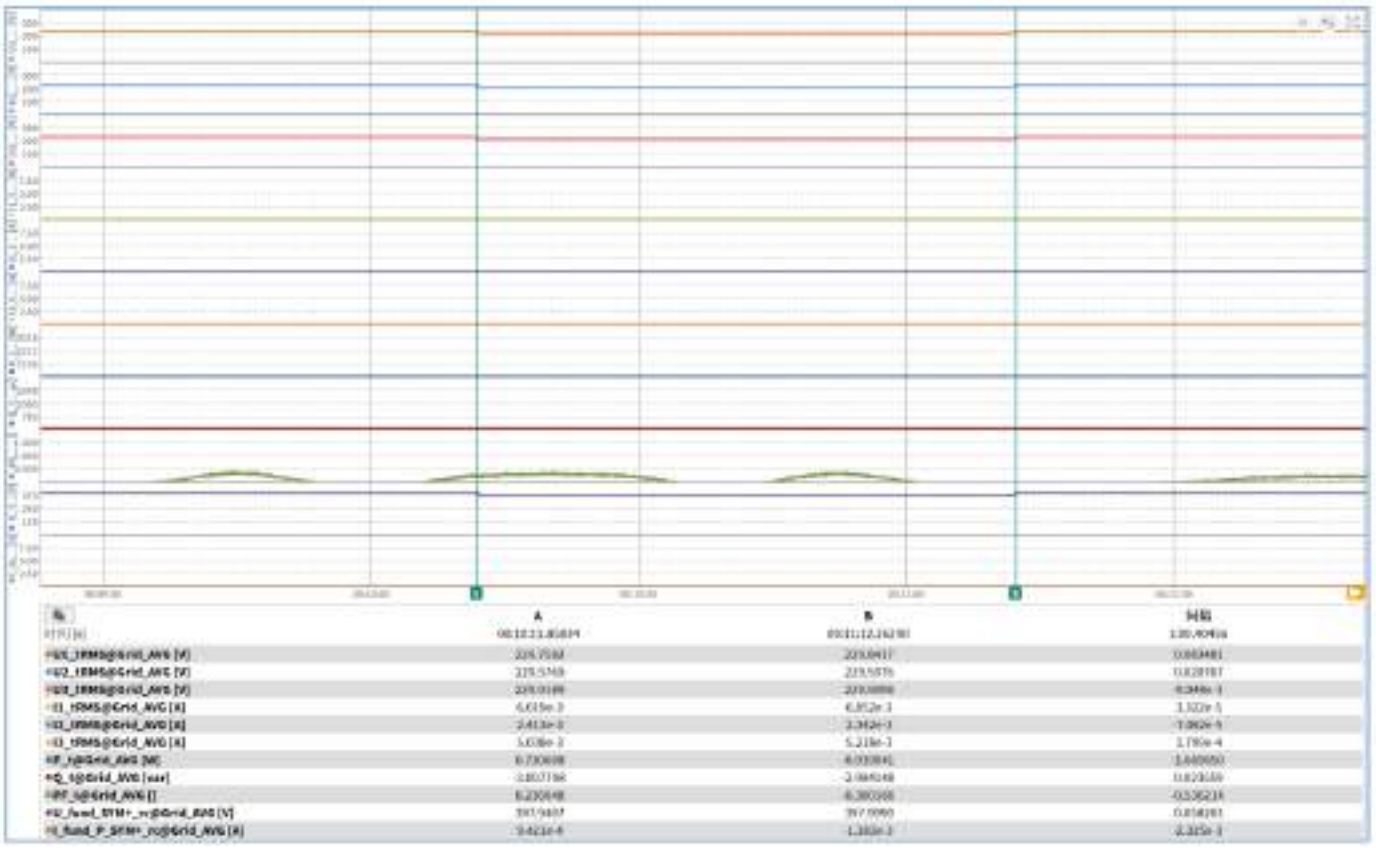
5.8.3	For PGUs Type 2 and storage systems – no load	P
	3.3	



5.8.3	For PGUs Type 2 and storage systems – no load	P
	4.1	

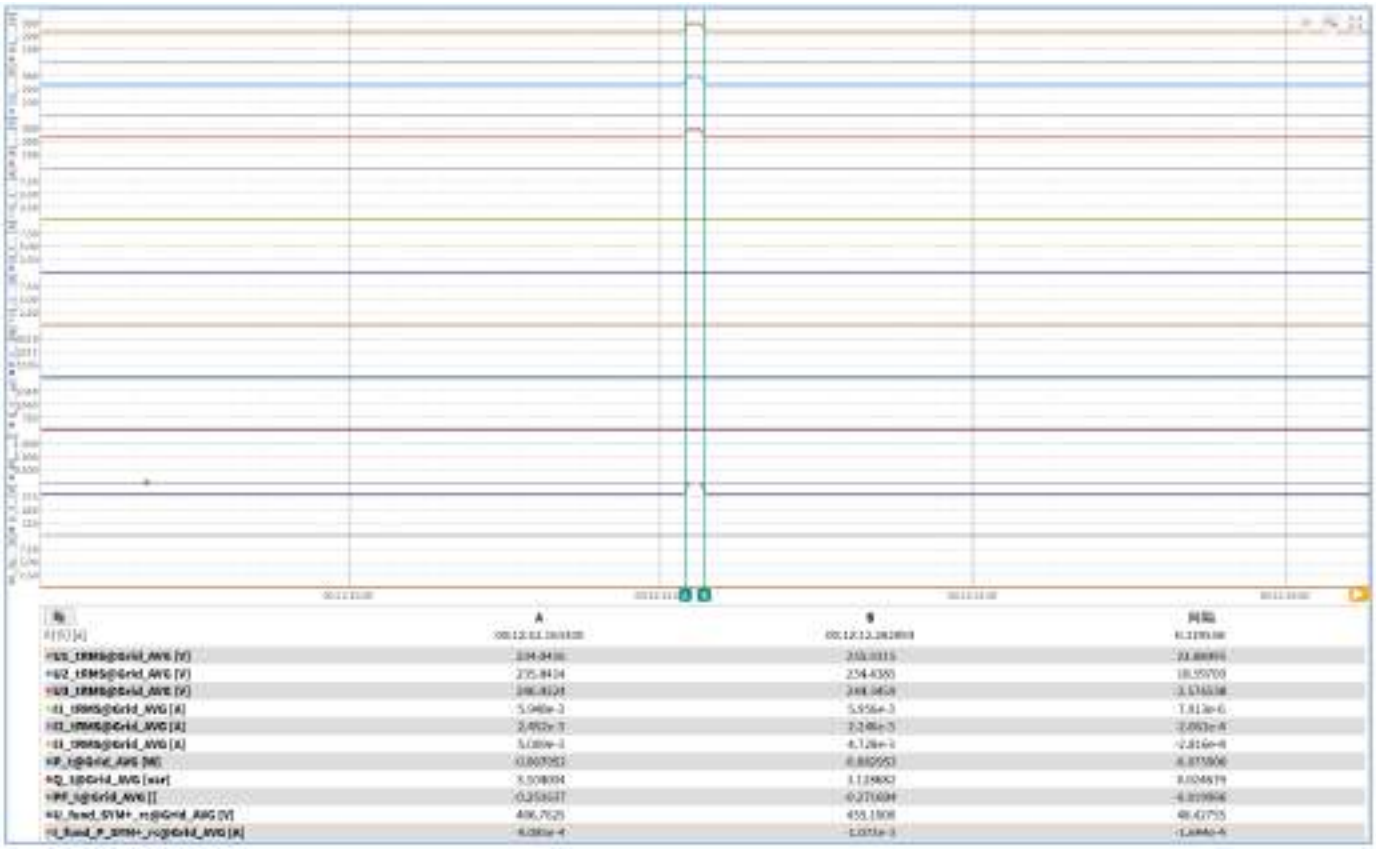


5.8.3	For PGUs Type 2 and storage systems – no load	P
	4.3	



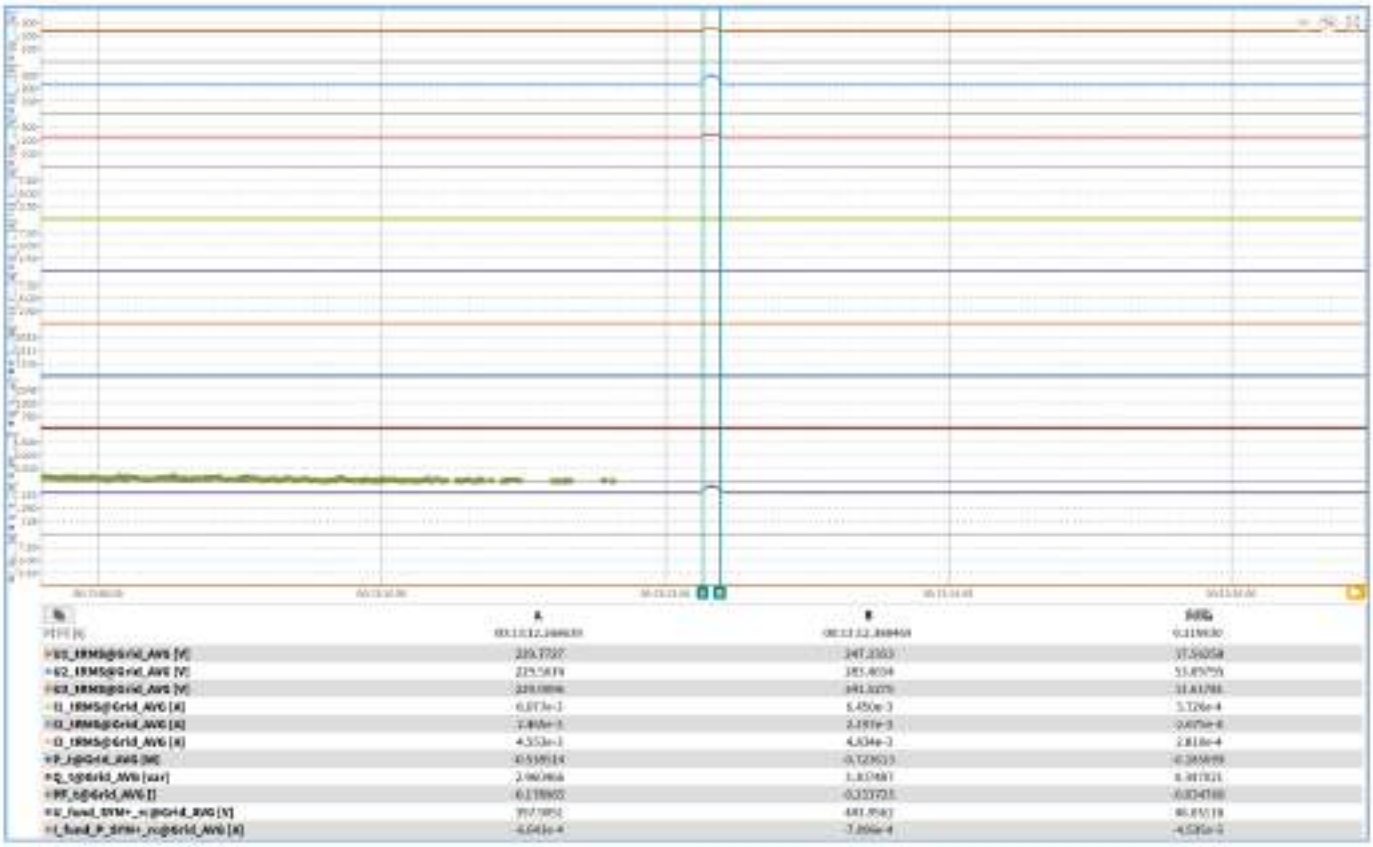
5.8.3	For PGUs Type 2 and storage systems – no load	P

5.1



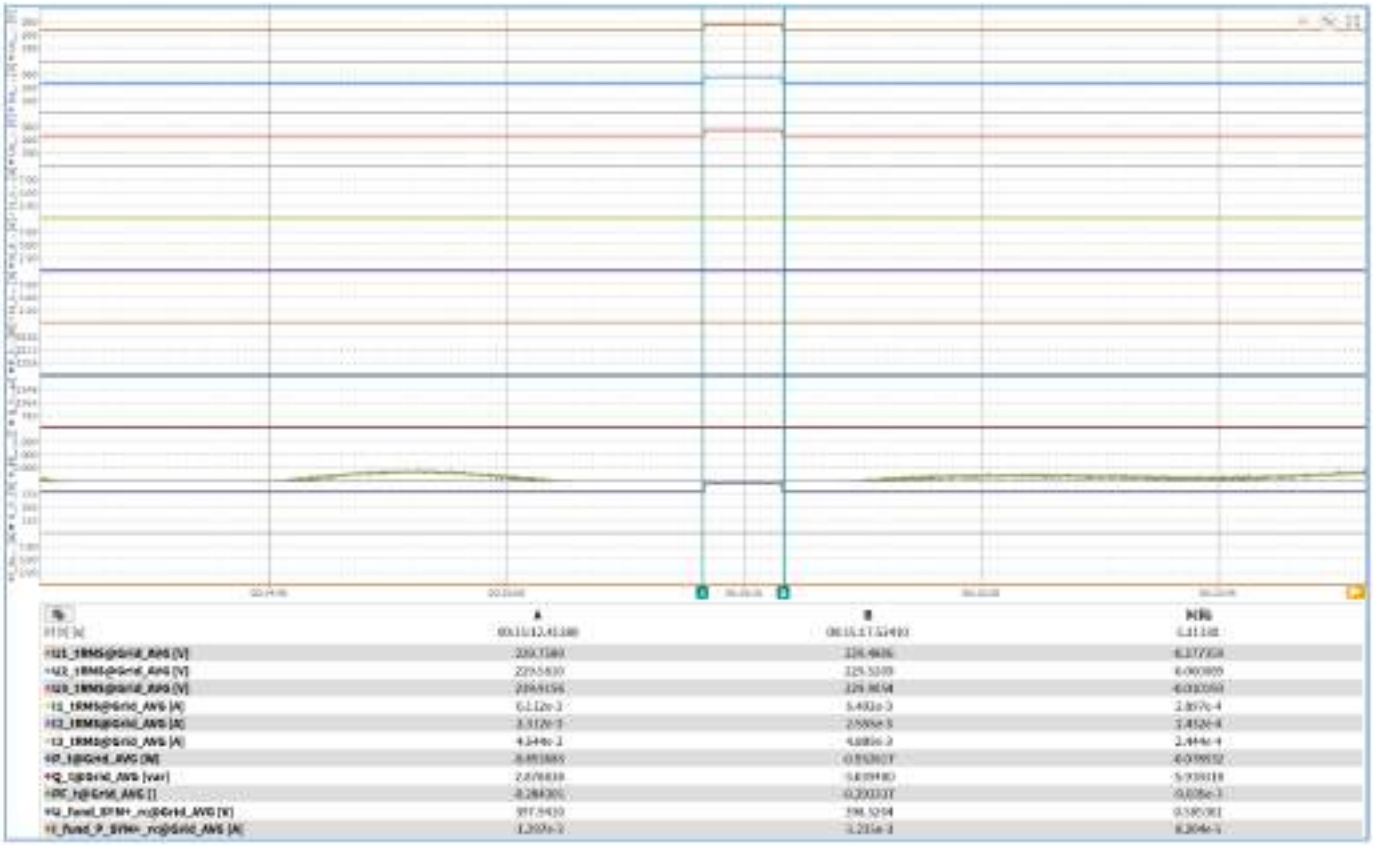
5.8.3	For PGUs Type 2 and storage systems – no load	P

5.3

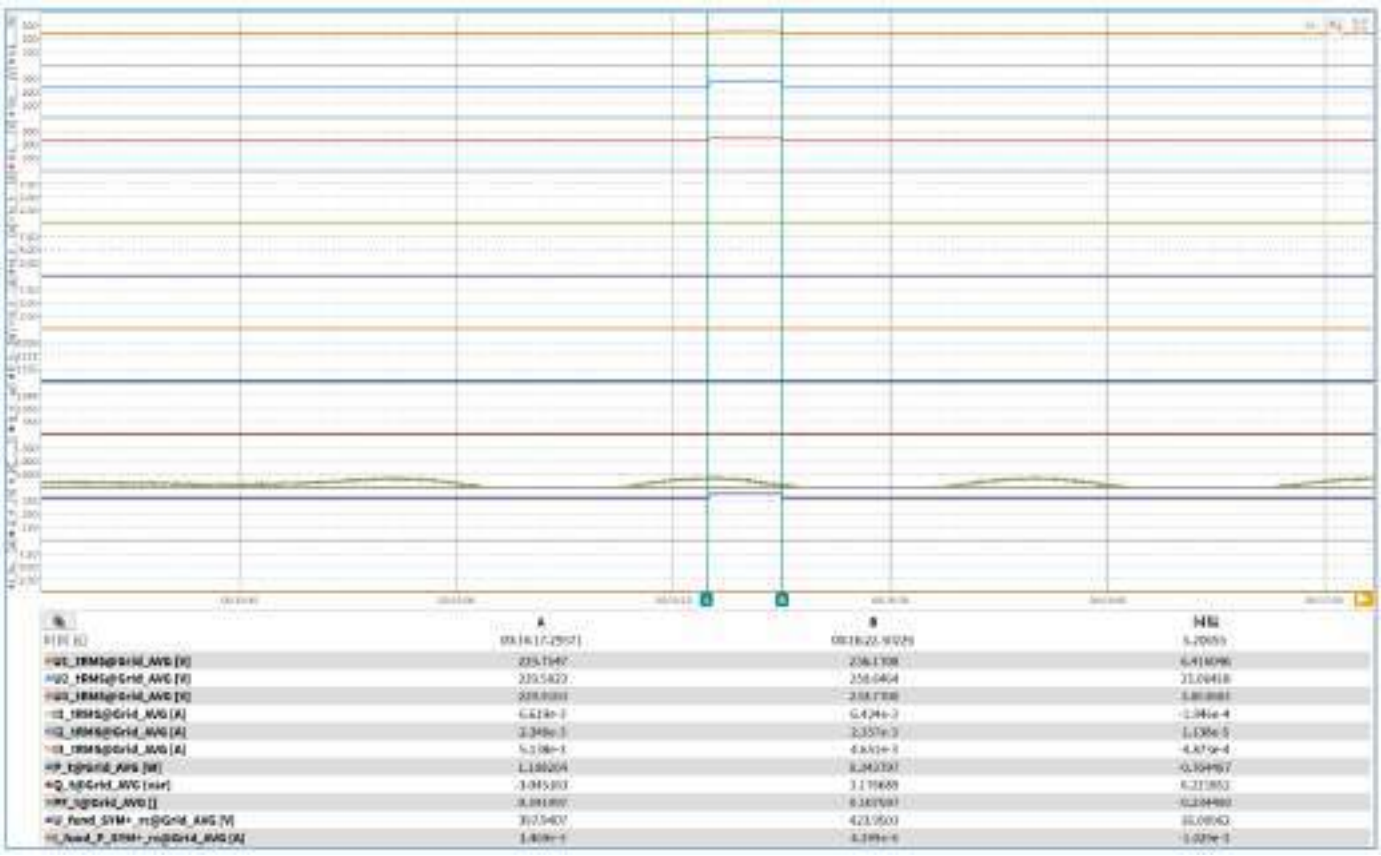


5.8.3	For PGUs Type 2 and storage systems – no load	P

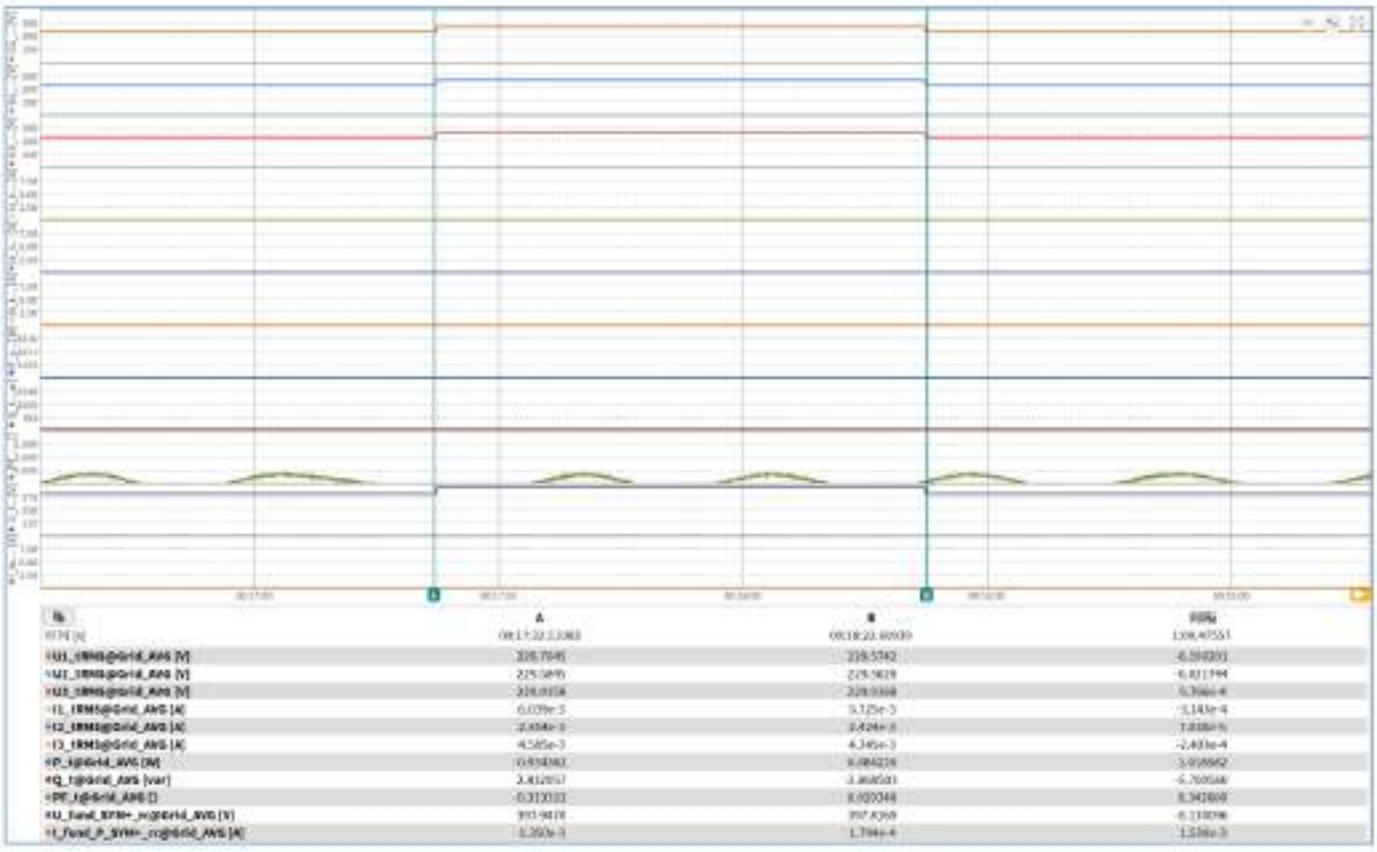
6.1



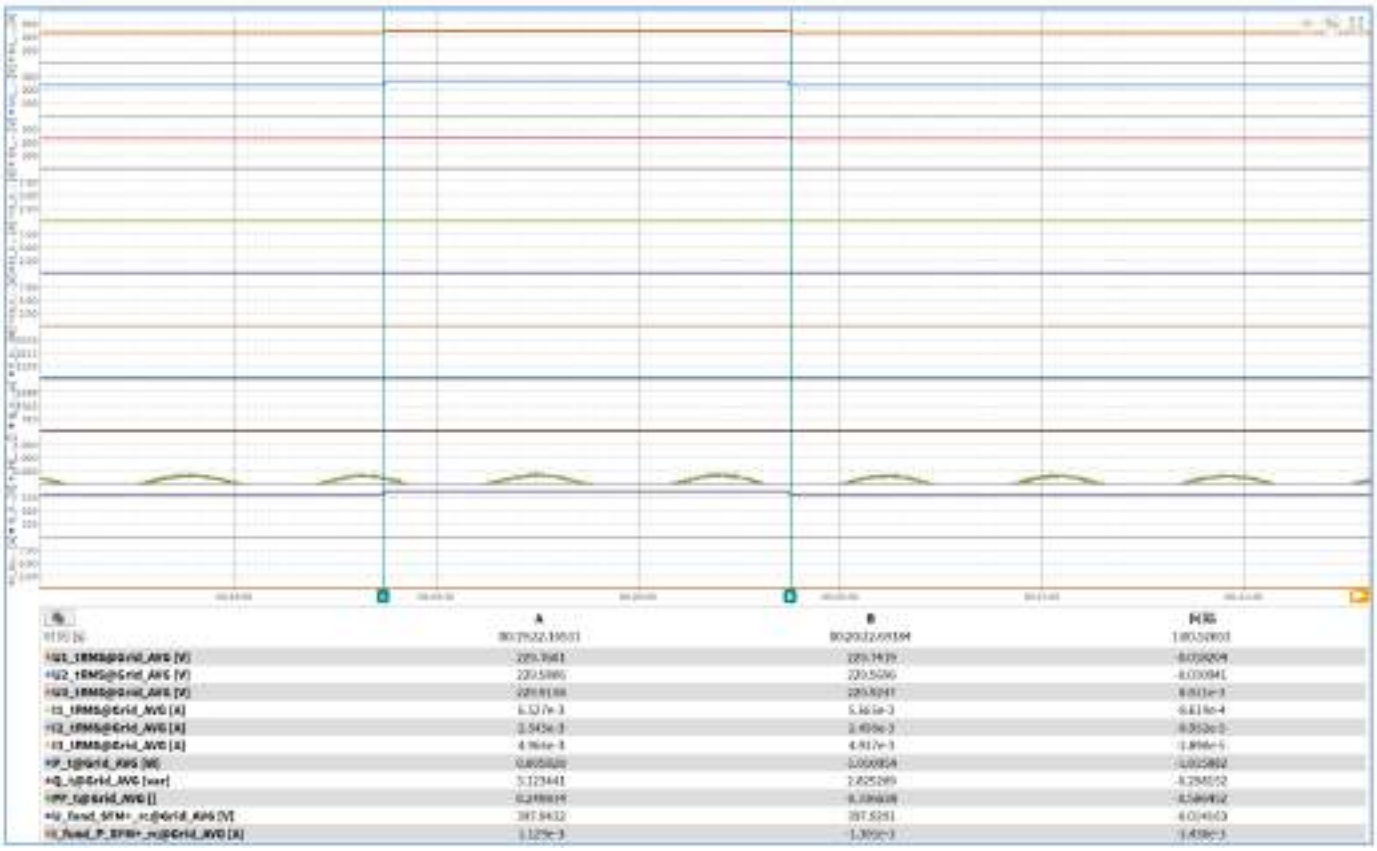
5.8.3	For PGUs Type 2 and storage systems – no load	P
	6.3	



5.8.3	For PGUs Type 2 and storage systems – no load	P
	7.1	



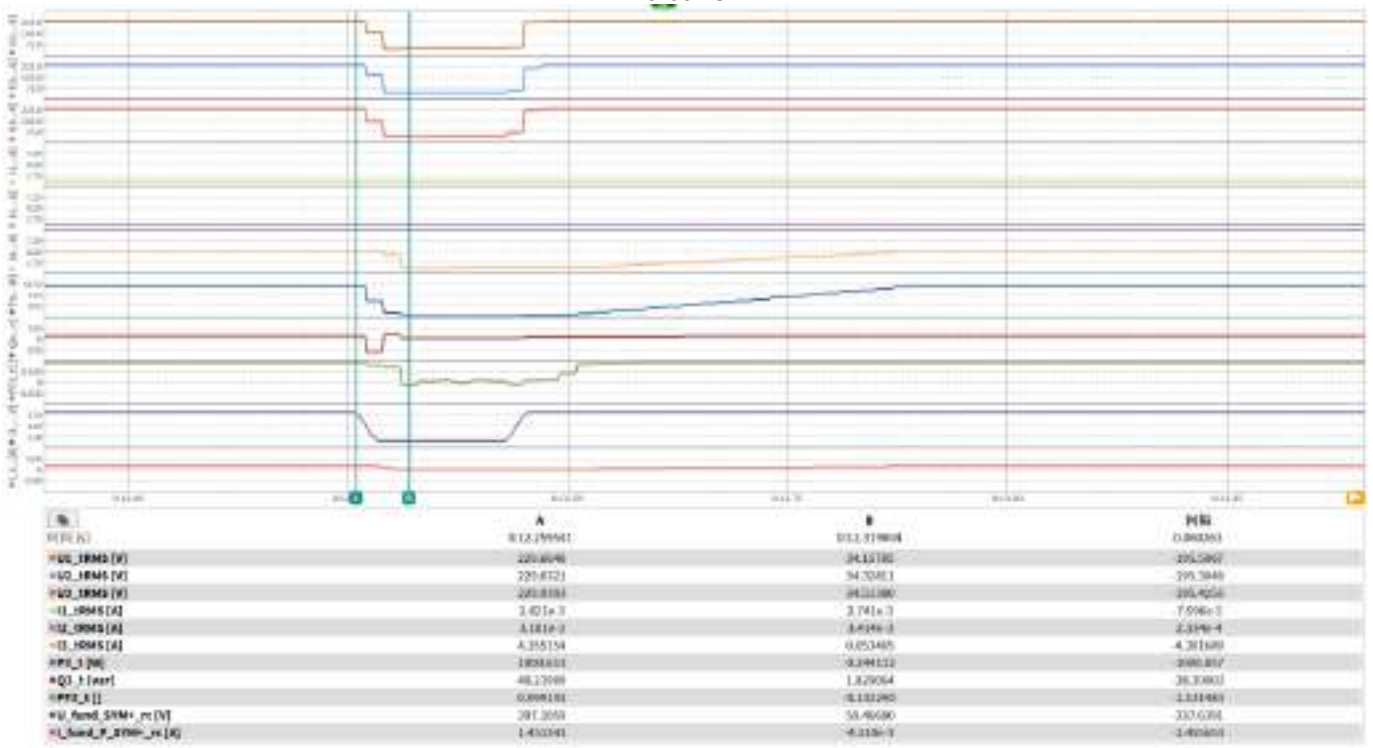
5.8.3	For PGUs Type 2 and storage systems – no load	P
	7.3	



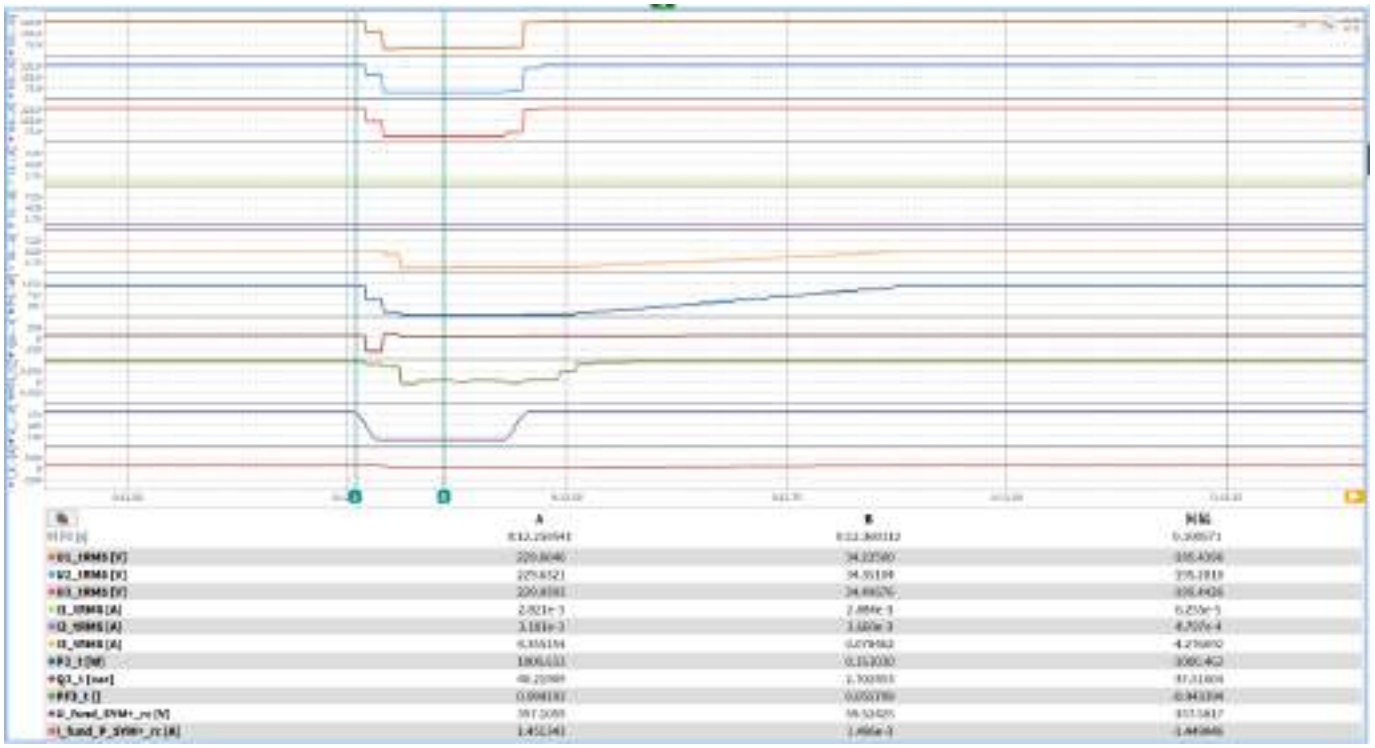
Load tests 1.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.1
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0.15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	180
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,850
	10		Positive sequence			0,850
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,001
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,001
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,001
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,040
	16		Total	t_1-10 s to t_1	[p.u.]	0,040
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9992
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,150
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,012
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,018
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,998
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,970
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,970
	30	Response time active power	Positive sequence	-	[s]	0,442
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,046
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,046
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

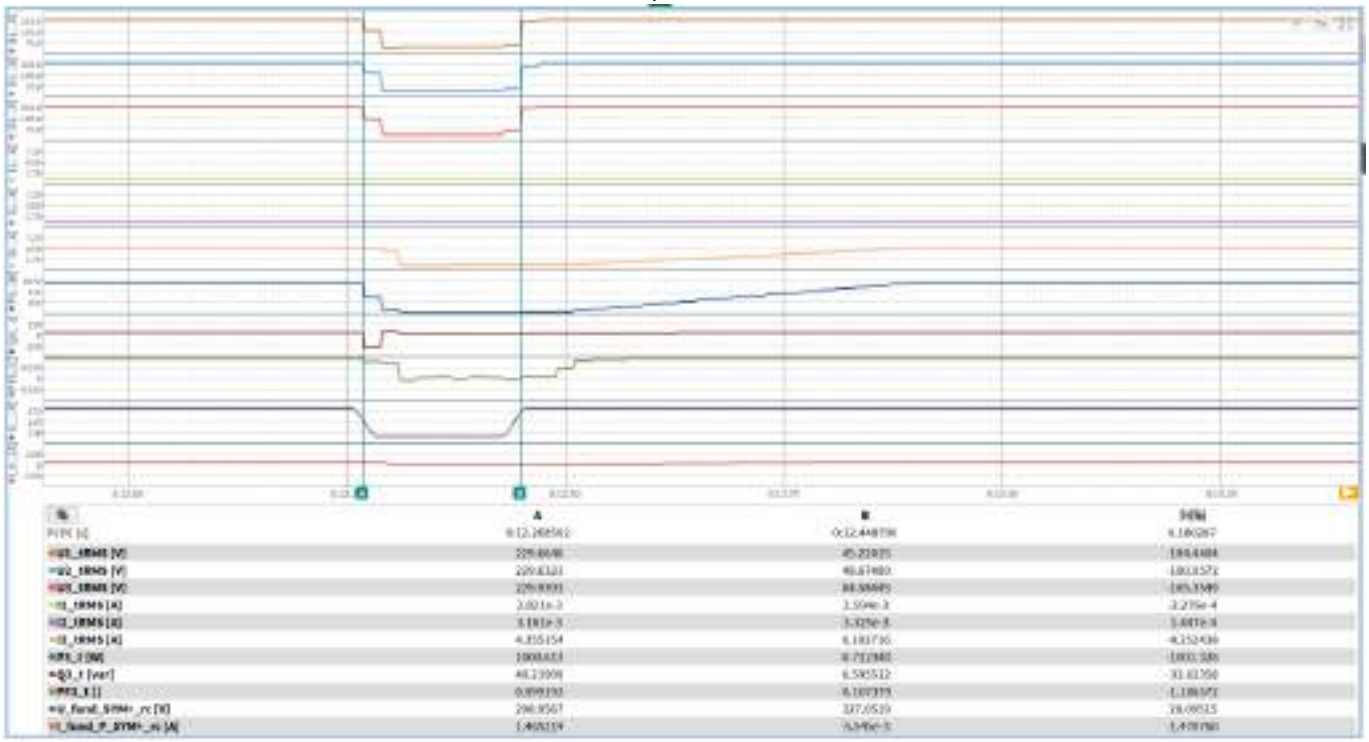
0-60ms



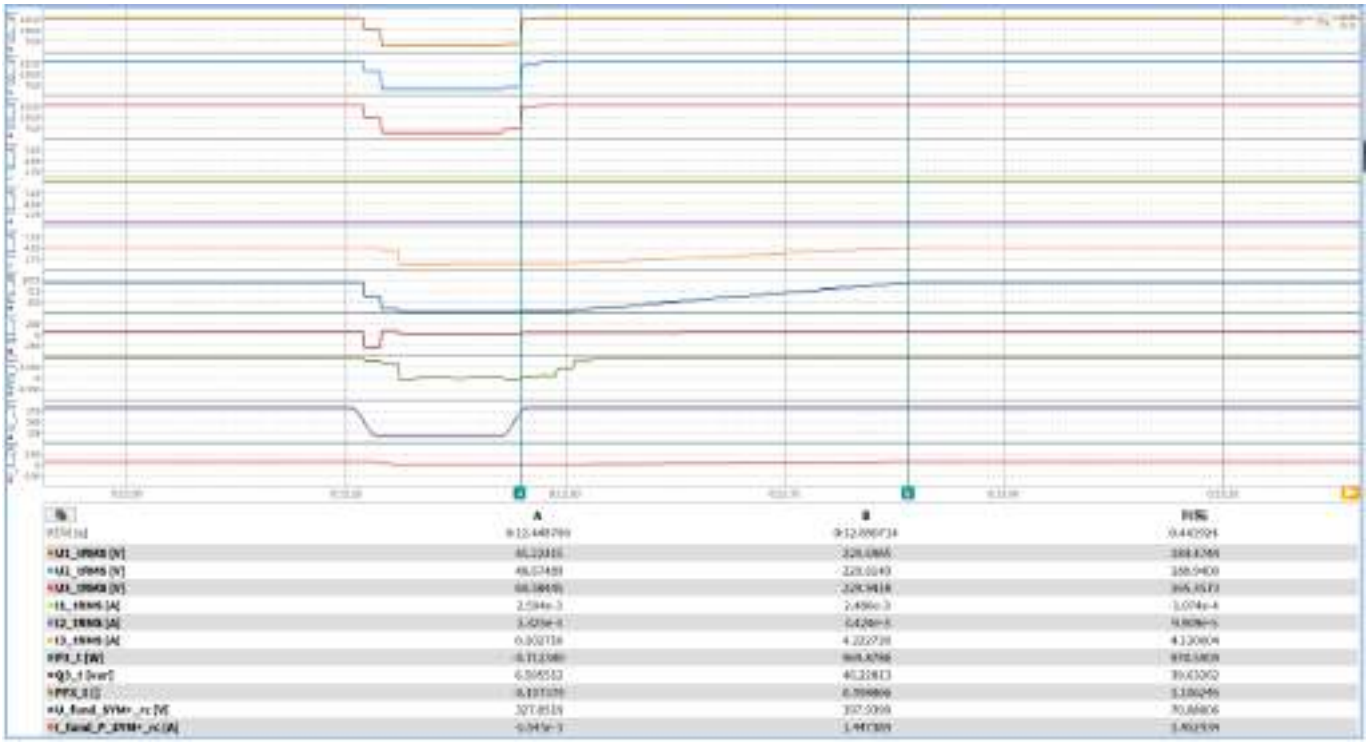
0-100ms



Drop duration



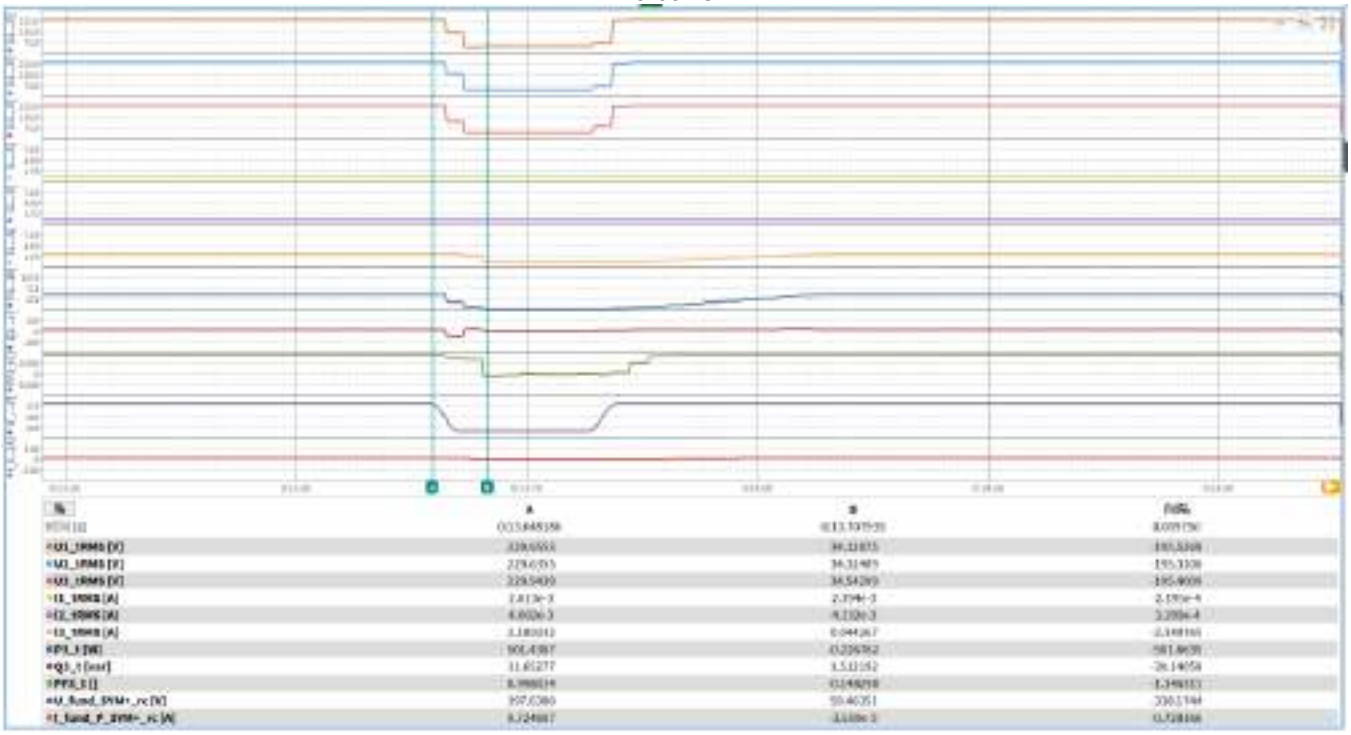
Recover time



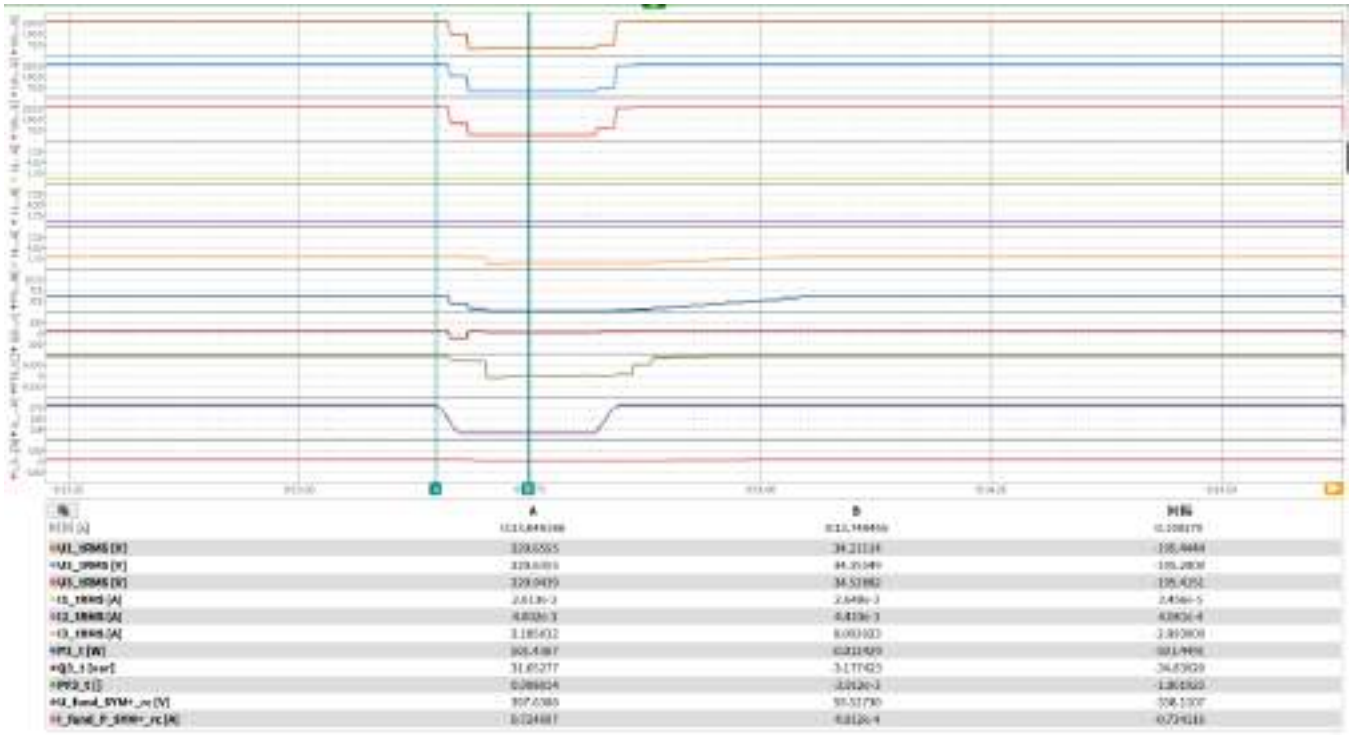
Load tests 1.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.2
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0.15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	180
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,850
	10		Positive sequence			0,850
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,502
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,501
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,501
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,032
	16		Total	t_1-10 s to t_1	[p.u.]	0,032
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9980
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,150
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,011
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,021
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,998
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,468
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,468
	30	Response time active power	Positive sequence	-	[s]	0,242
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,039
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,039
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

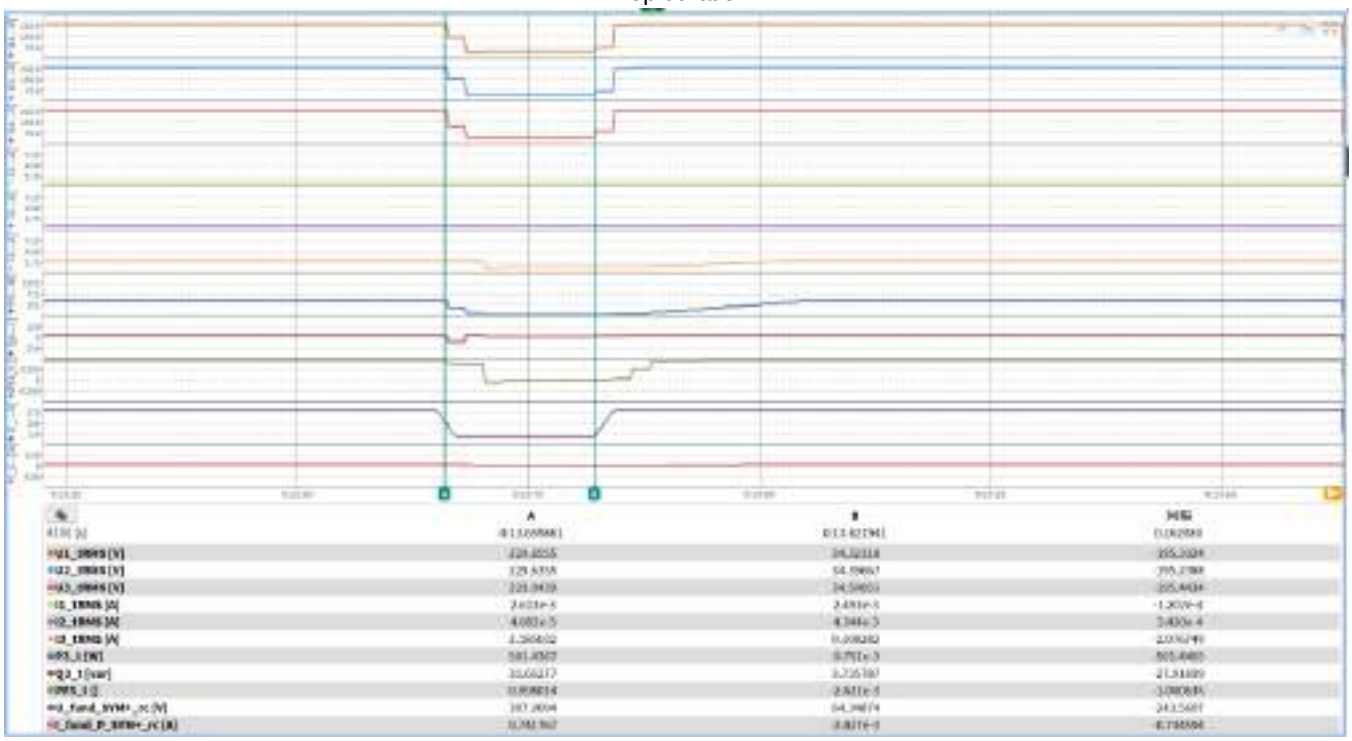
0-60ms



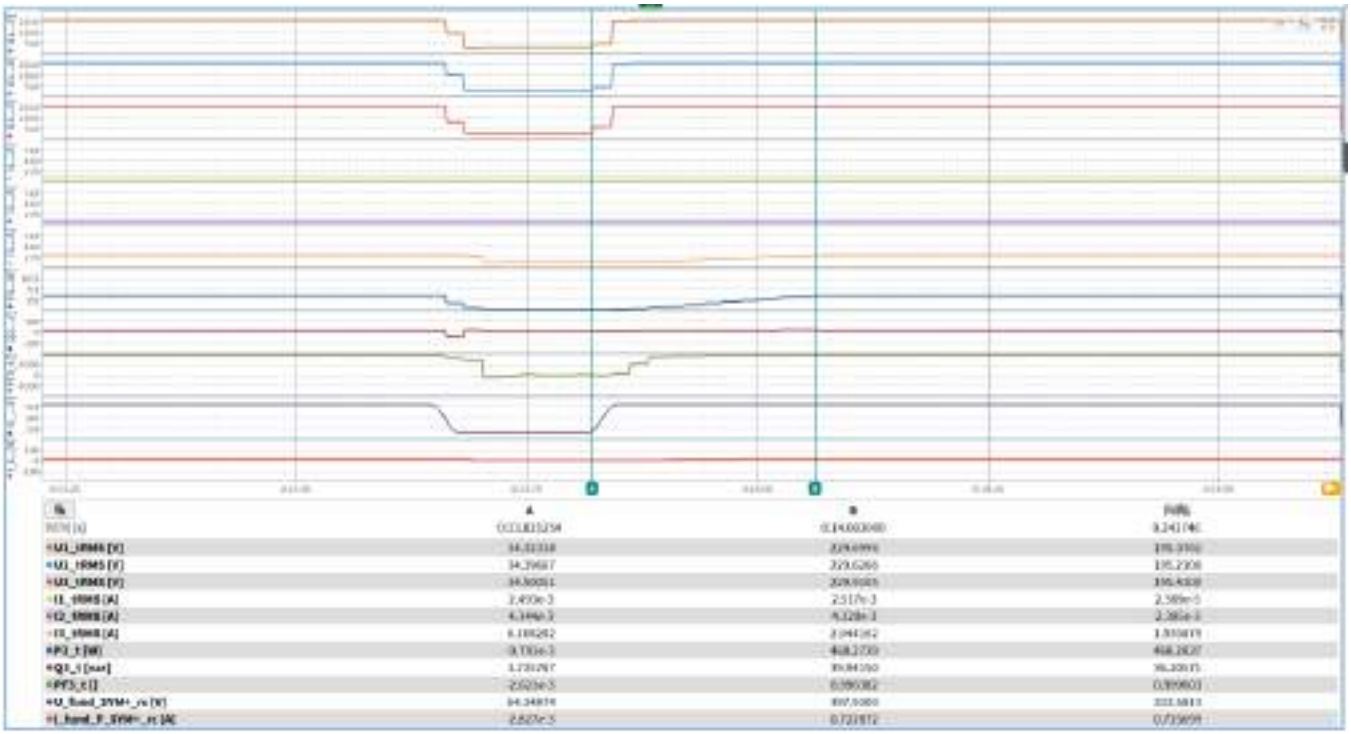
0-100ms



Drop duration



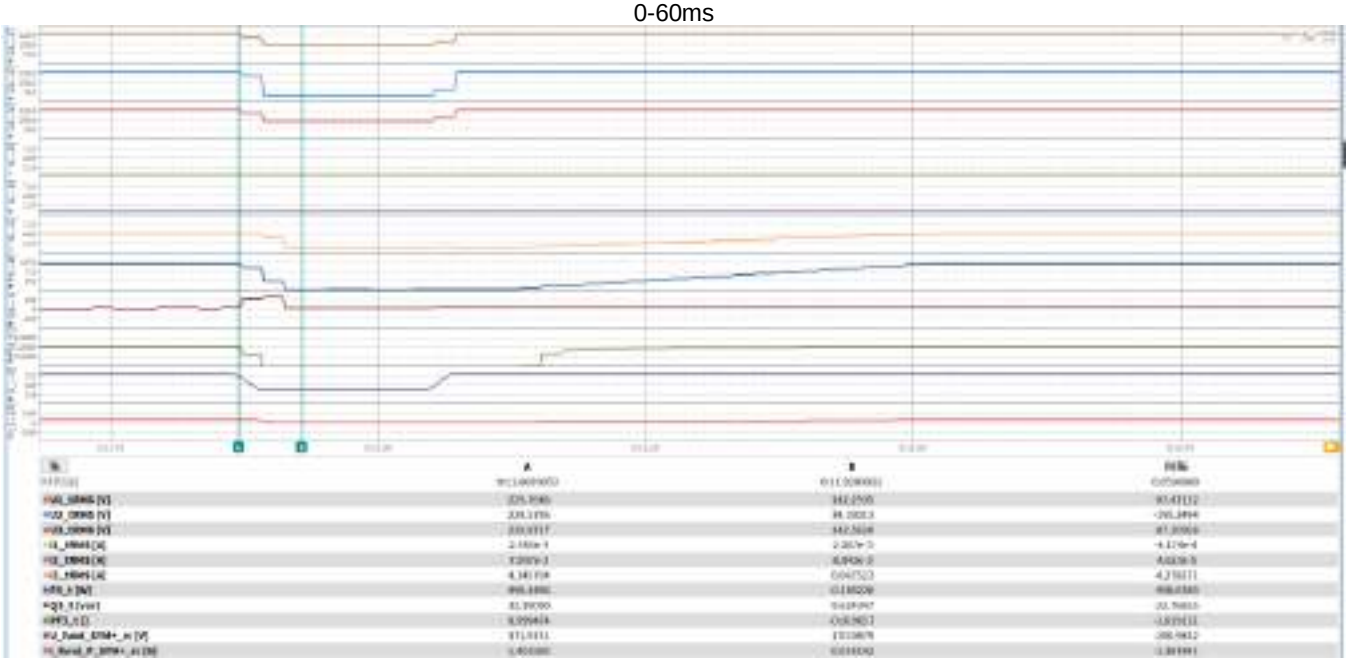
Recover time



Load tests 1.3

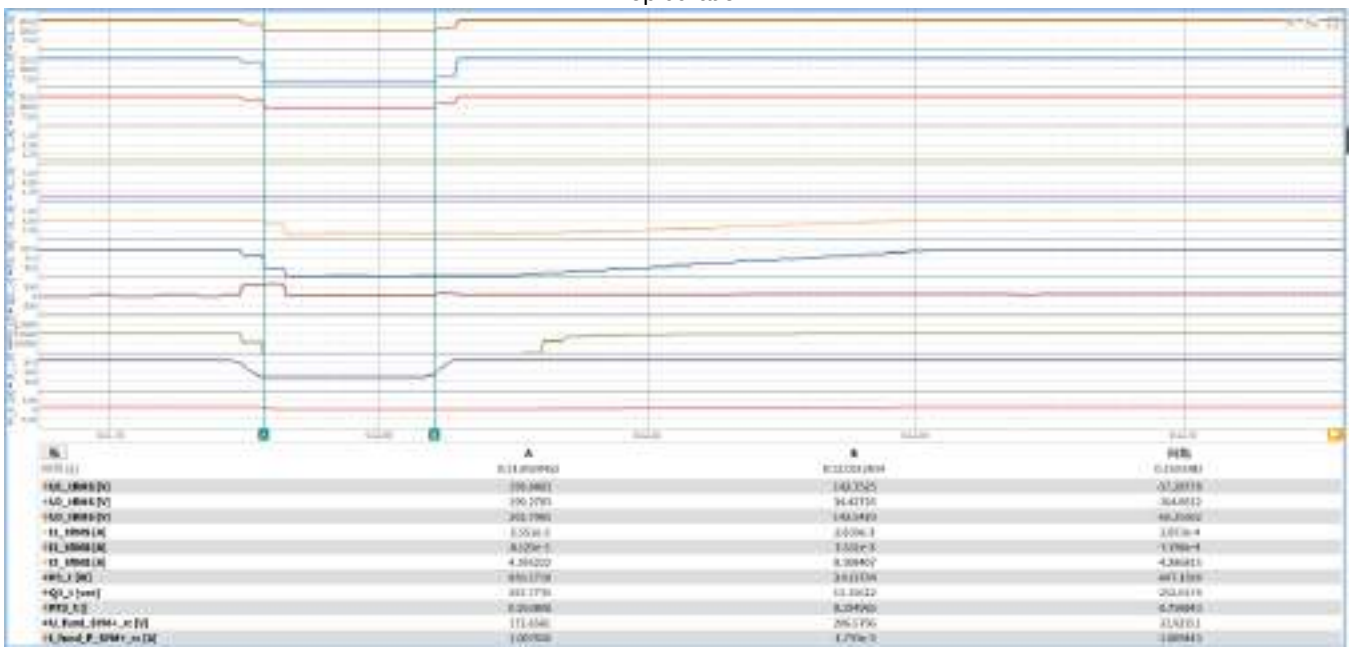
	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.3
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0.15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	159
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,380
	10		Positive sequence			0,380
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,999
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,998
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,998
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,032
	16		Total	t_1-10 s to t_1	[p.u.]	0,032
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9995
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,620
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,015
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,024
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,999
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,999
	30	Response time active power	Positive sequence	-	[s]	0,506
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,040
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,040
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

0-60ms

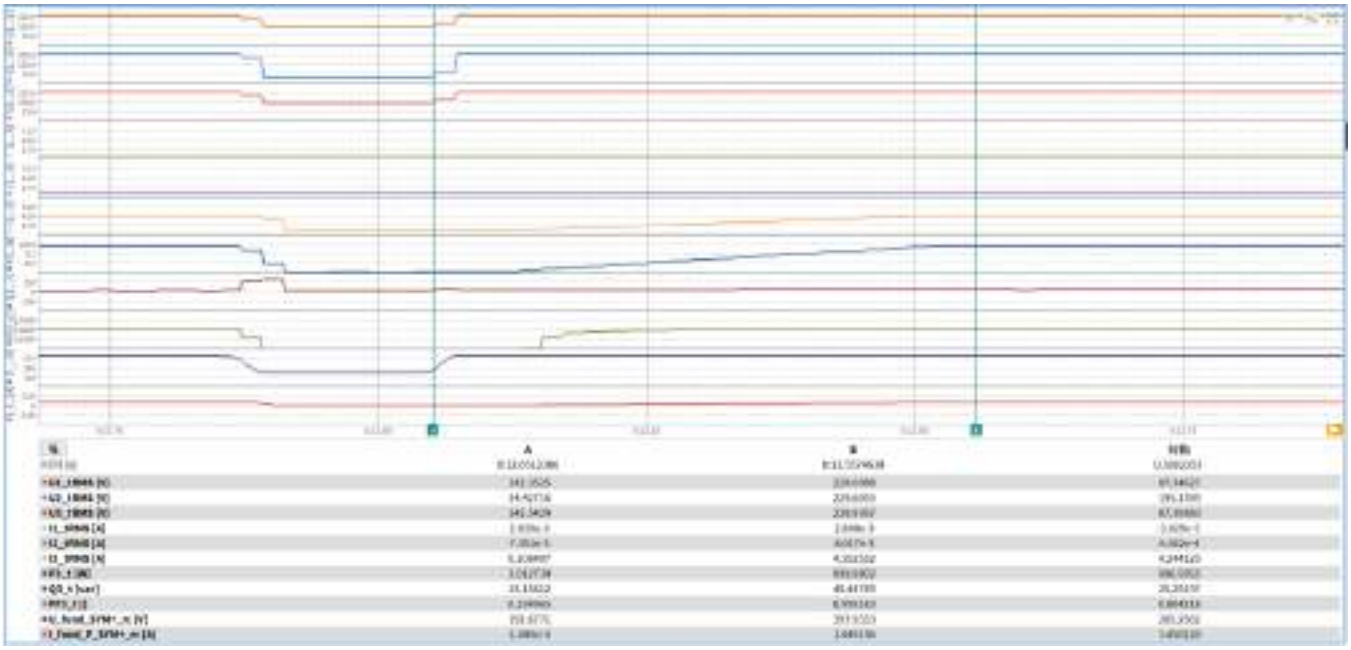


0-100ms

Drop duration



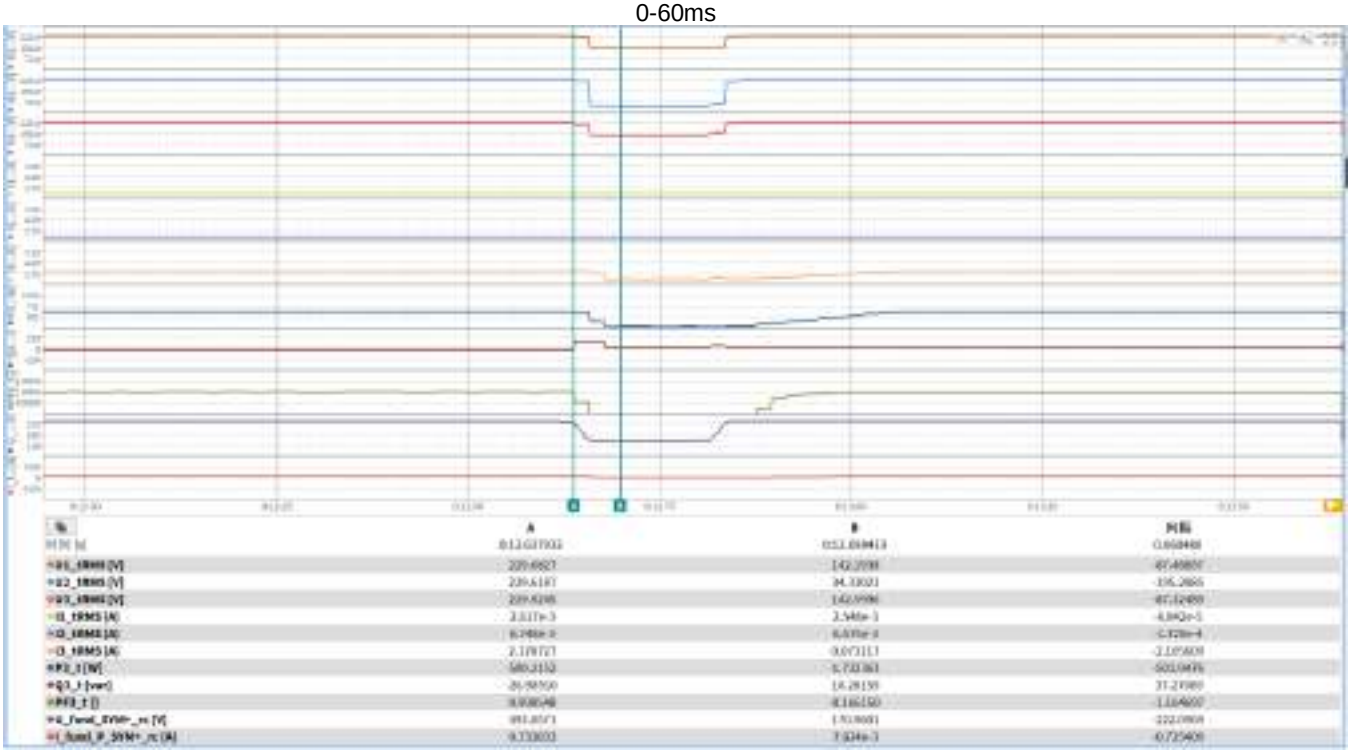
Recover time



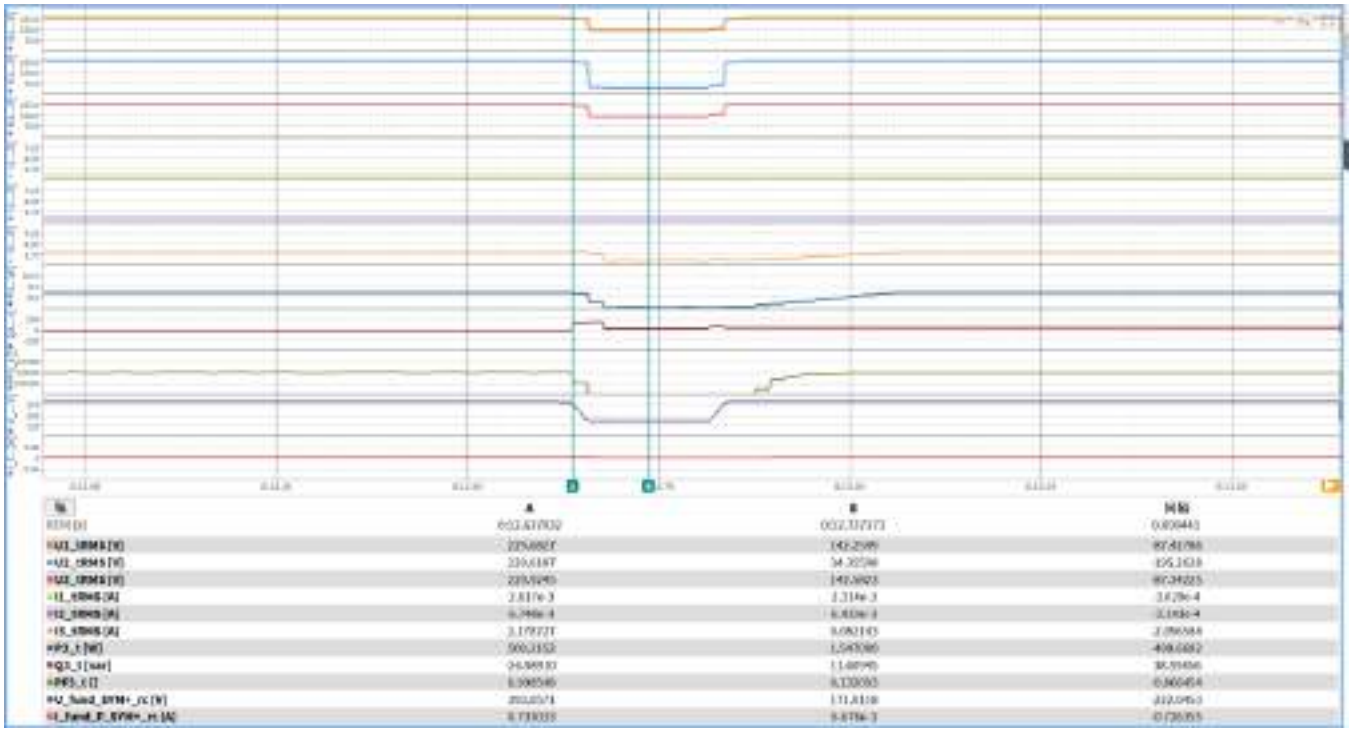
Load tests 1.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.4
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	175
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,380
	10		Positive sequence			0,380
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,501
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,500
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,500
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,027
	16		Total	t_1-10 s to t_1	[p.u.]	-0,027
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9985
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,620
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,017
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,018
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,499
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,499
	30	Response time active power	Positive sequence	-	[s]	0,282
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,033
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,033
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

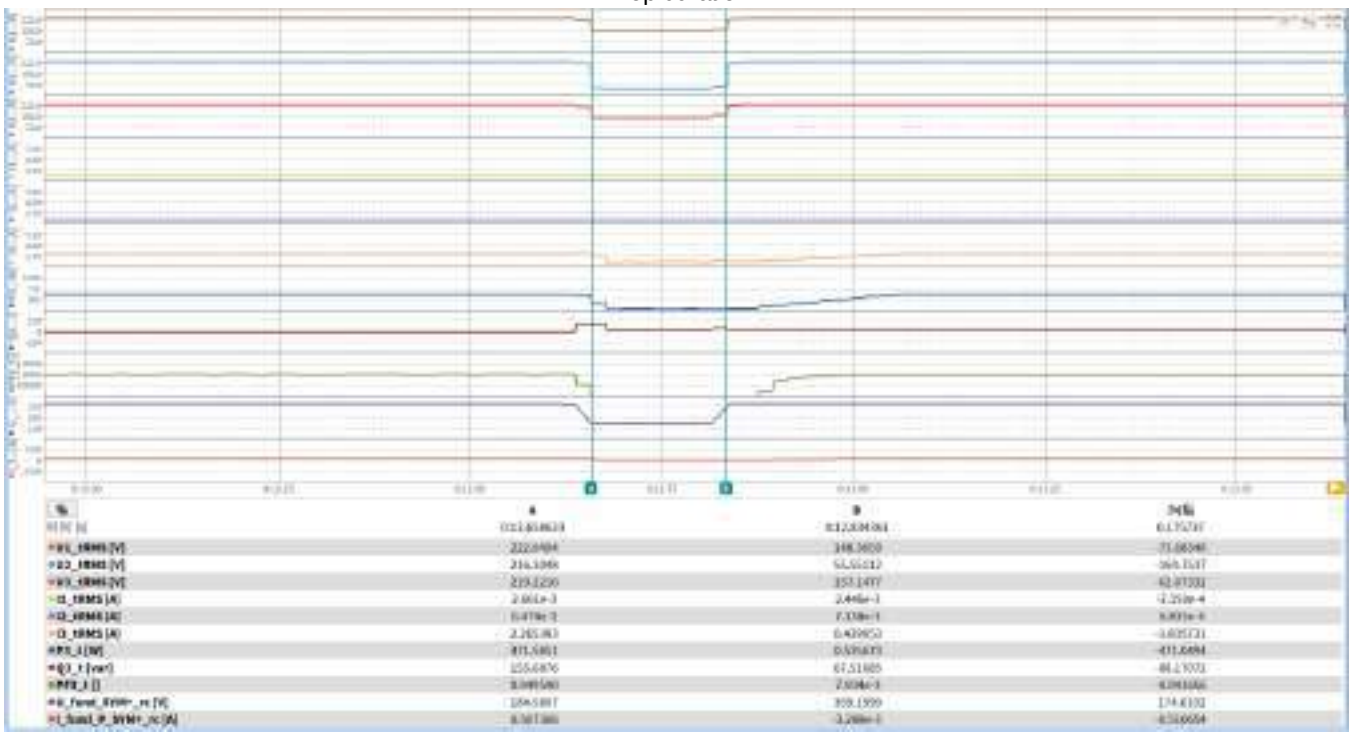
0-60ms



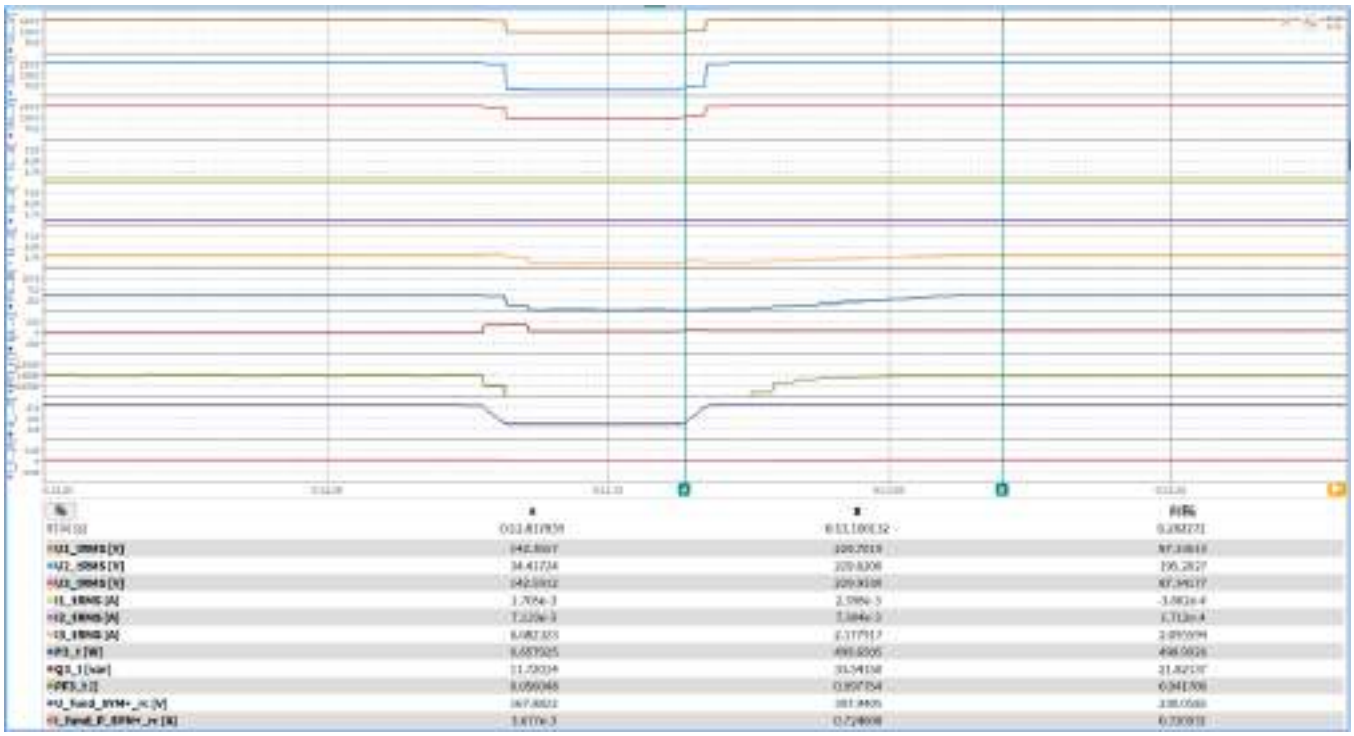
0-100ms



Drop duration



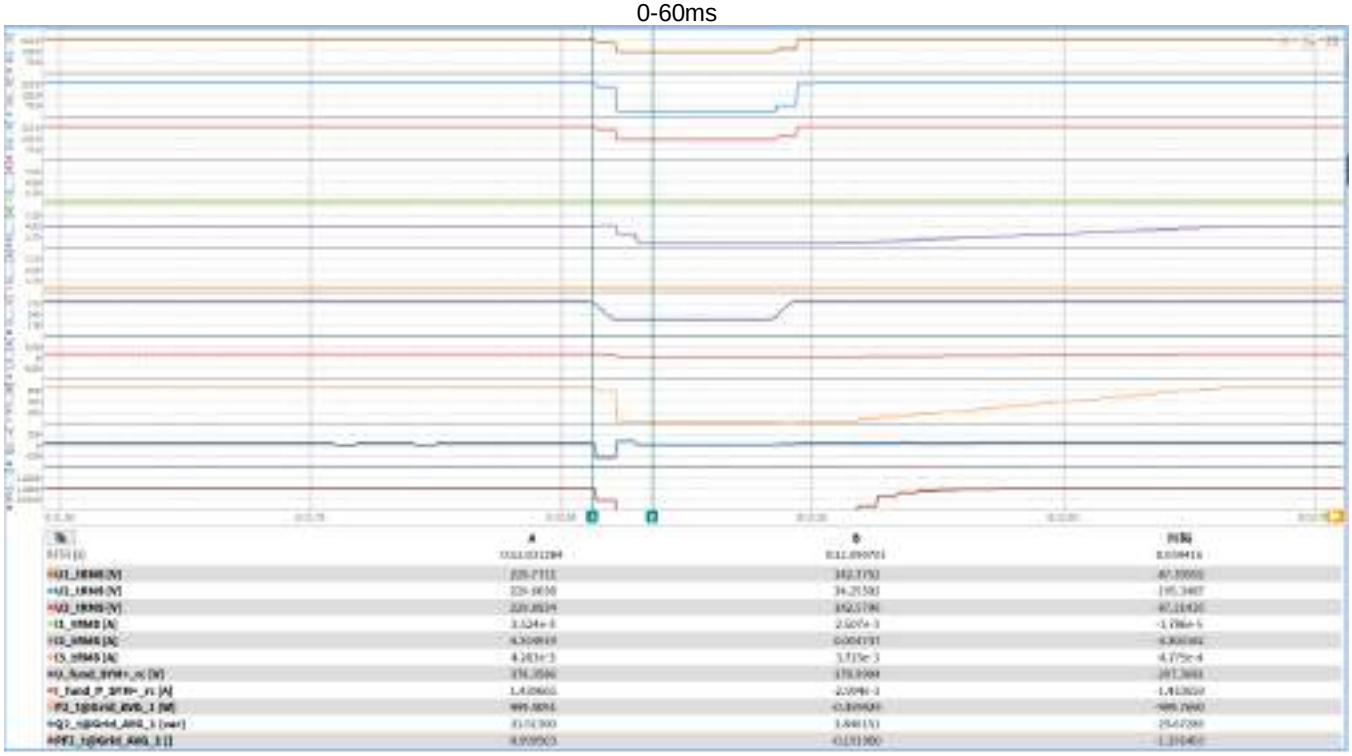
Recover time



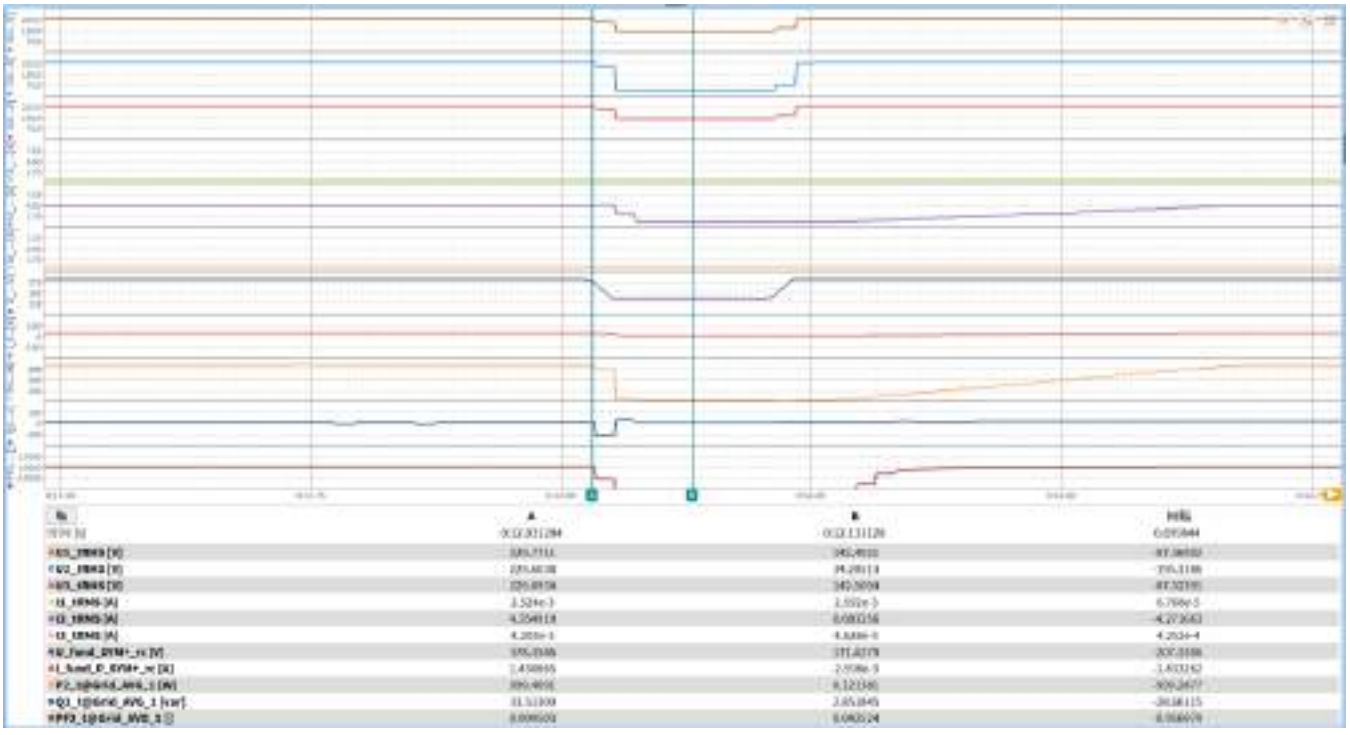
Load tests 1.5

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	1.5
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D2
	4	Drop depth setpoint	Phase	–	[p.u]	0,15
	5	Drop duration setpoint	Total	–	[ms]	150
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	159
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,851
	10		Positive sequence			0,851
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,001
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,999
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,999
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,032
	16		Total	t_1-10 s to t_1	[p.u.]	0,032
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9995
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,149
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	0,012
	21		Phase 3	t_1+60 ms	[p.u.]	N/A
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	0,018
	24		Phase 3	t_1 +100 ms	[p.u.]	N/A
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,997
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,997
	30	Response time active power	Positive sequence	-	[s]	0,500
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,038
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,038
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

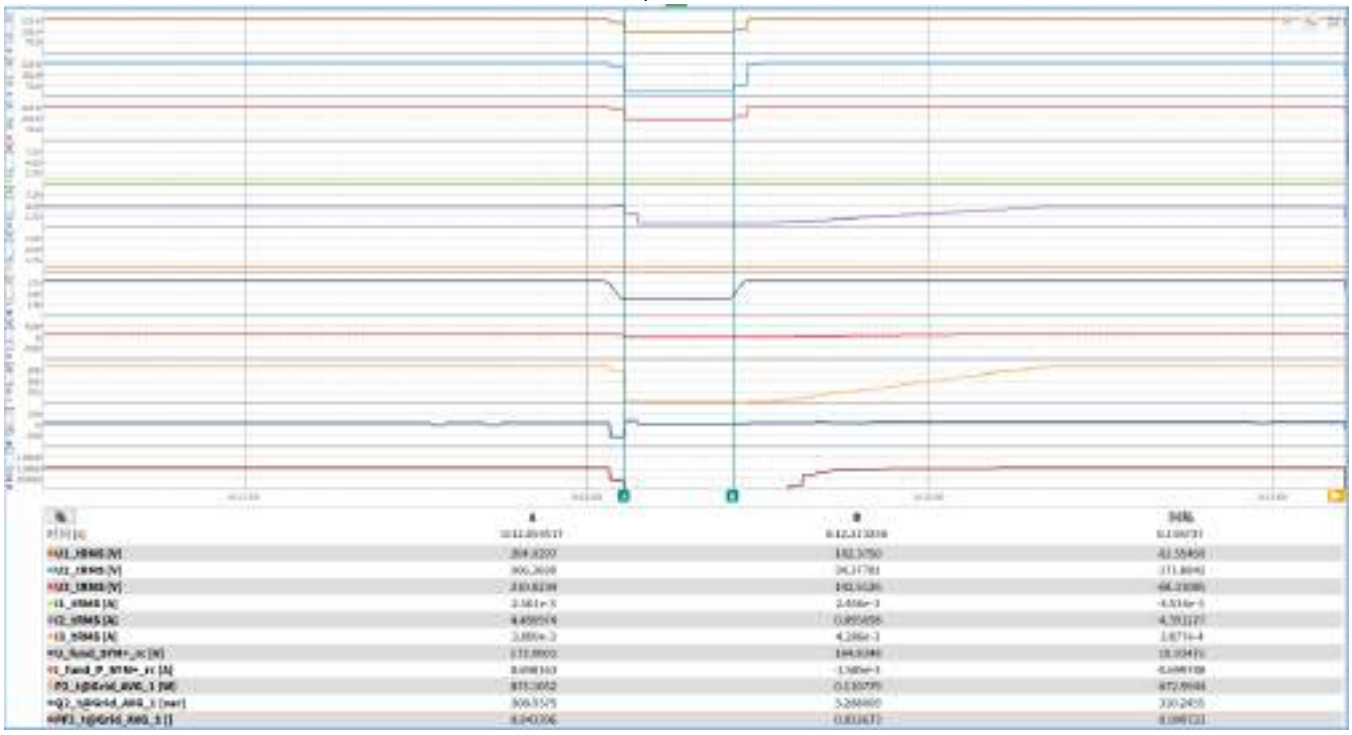
0-60ms



0-100ms



Drop duration

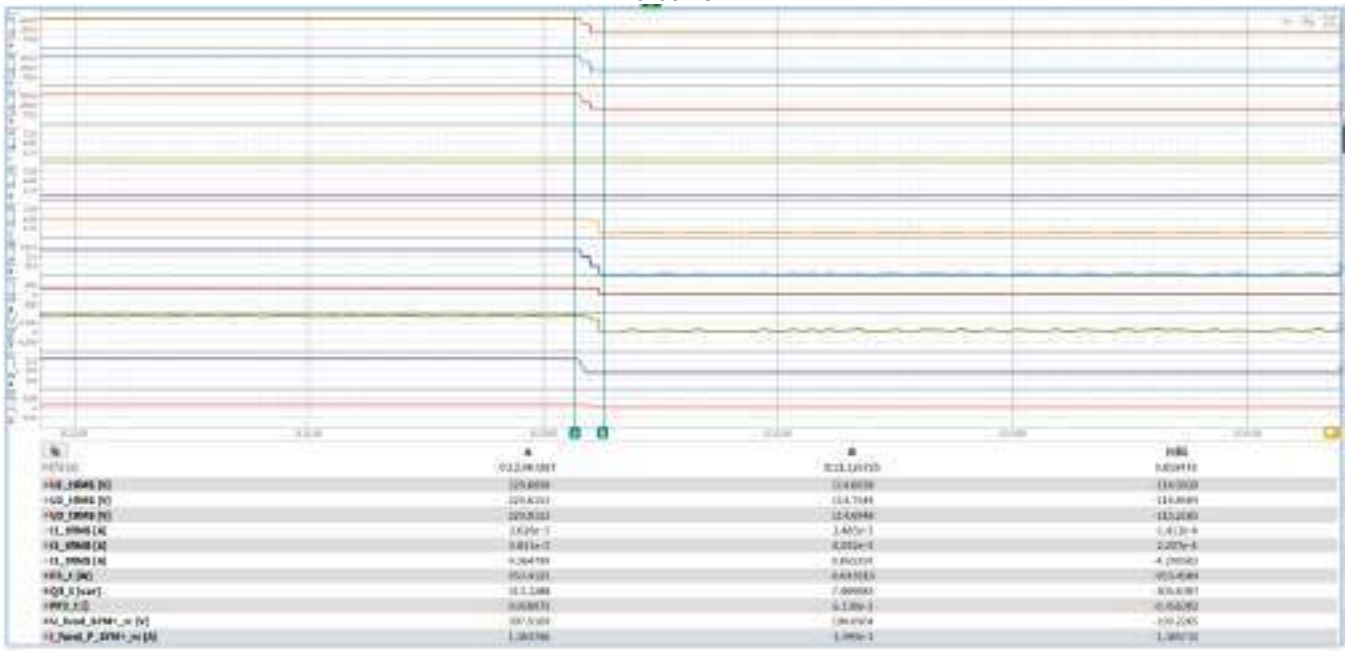


Recover time

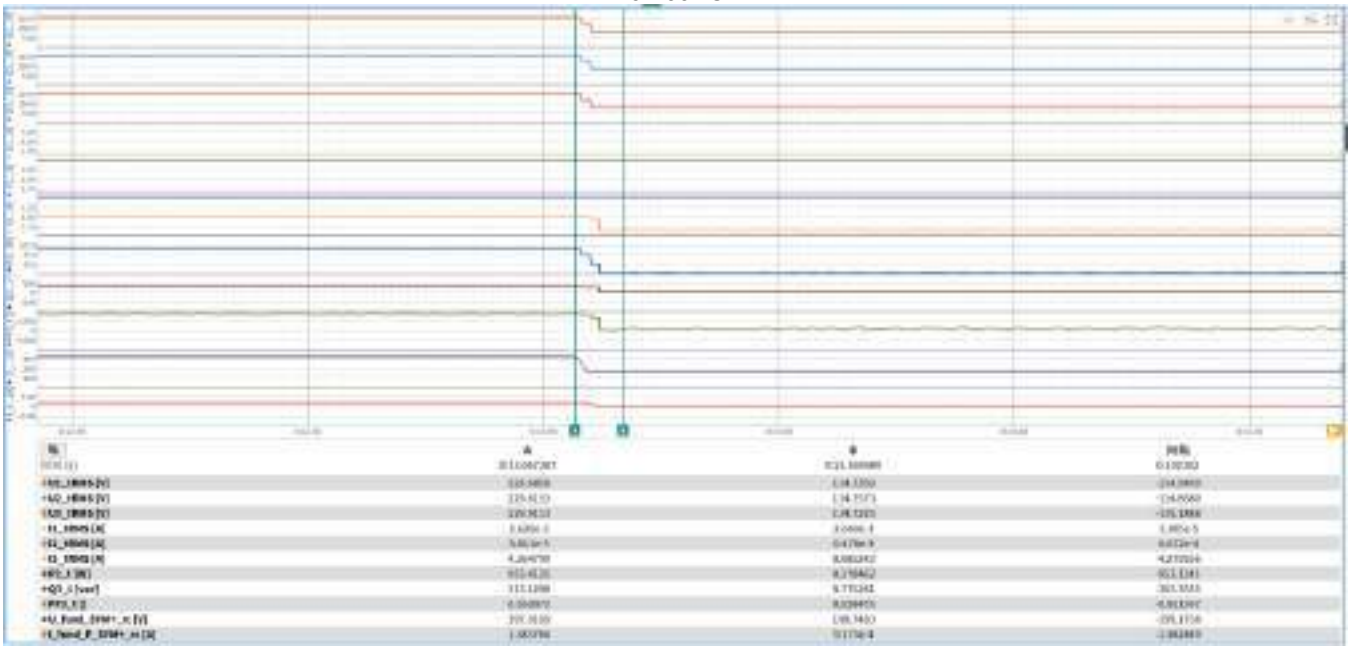
Load tests 2.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.1
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0,50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1732
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,501
	10		Positive sequence			0,501
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,999
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,003
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,003
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,313
	16		Total	t_1-10 s to t_1	[p.u.]	0,313
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9501
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,499
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,015
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,020
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,971
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,971
	30	Response time active power	Positive sequence	-	[s]	0,423
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,291
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,291
	33	Response time reactive power	Positive sequence	–	[s]	9,981
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

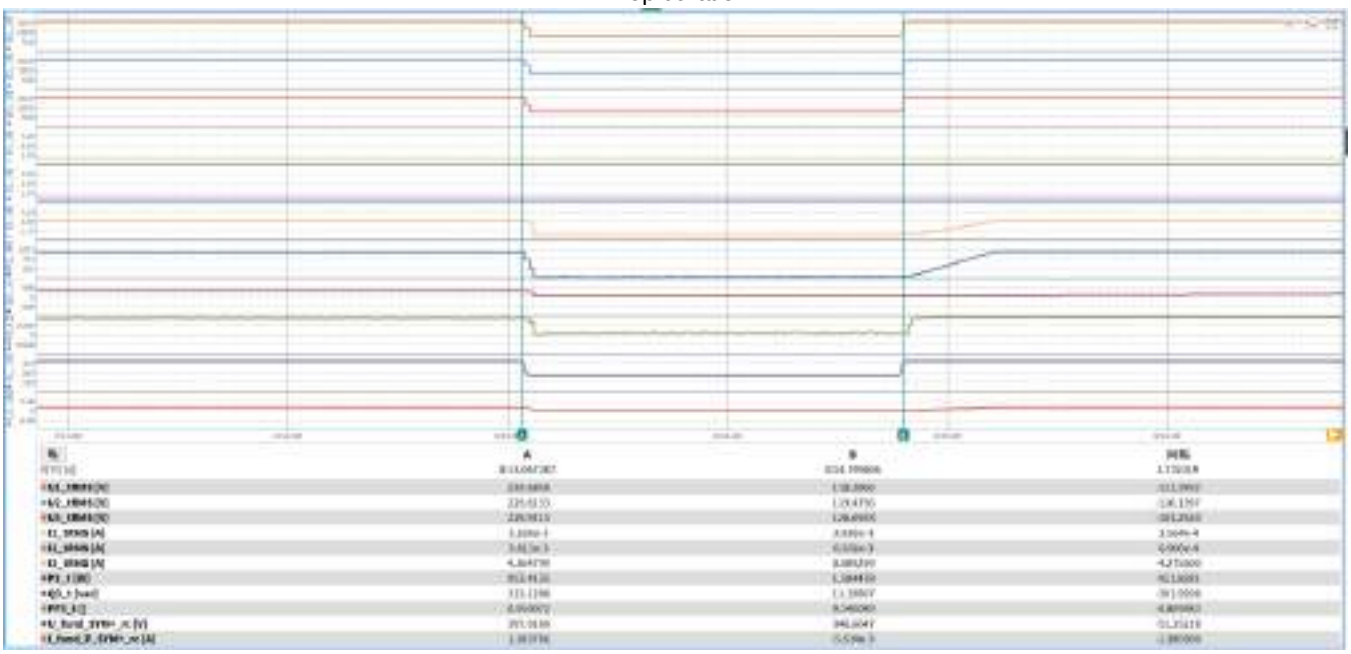
0-60ms



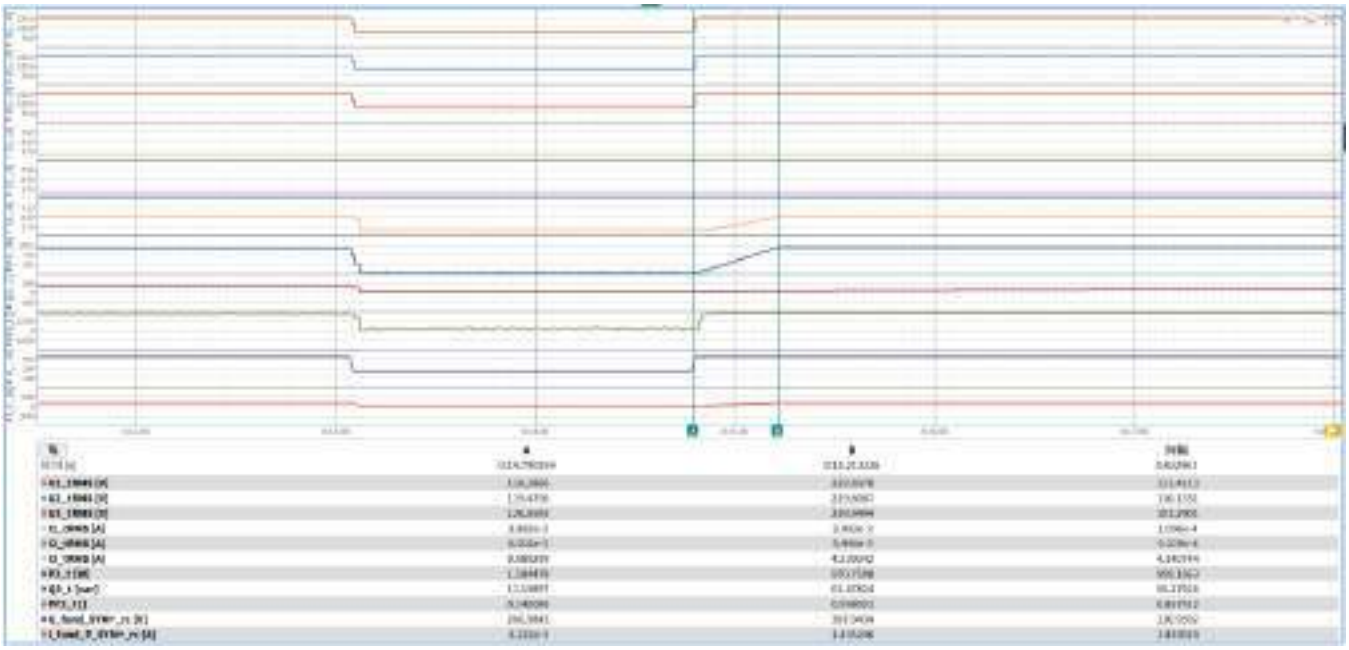
0-100ms

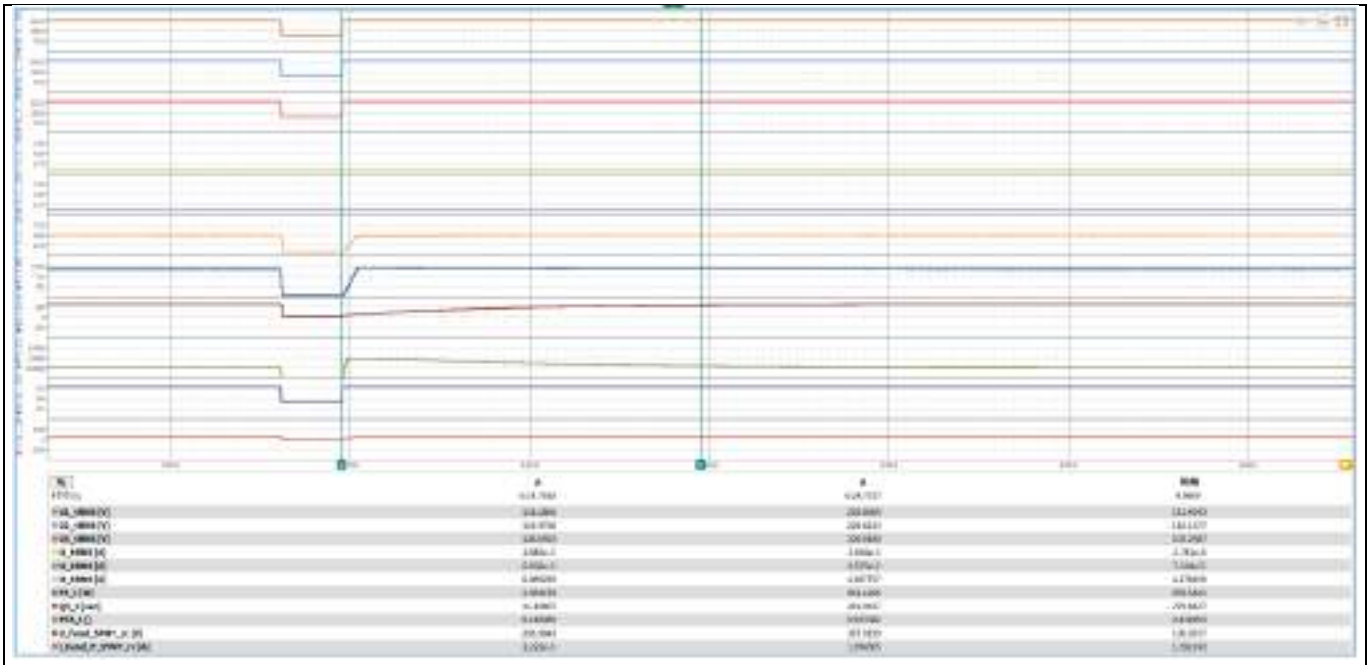


Drop duration



Recover time

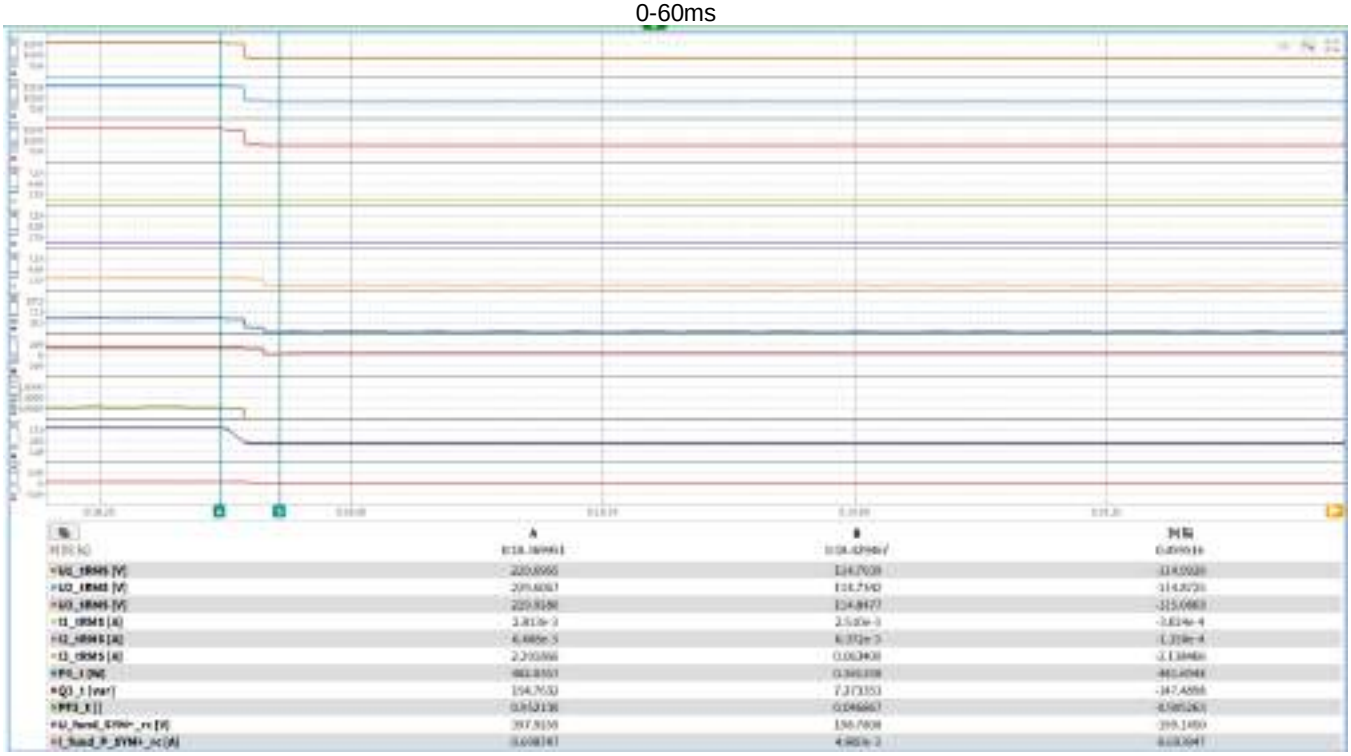




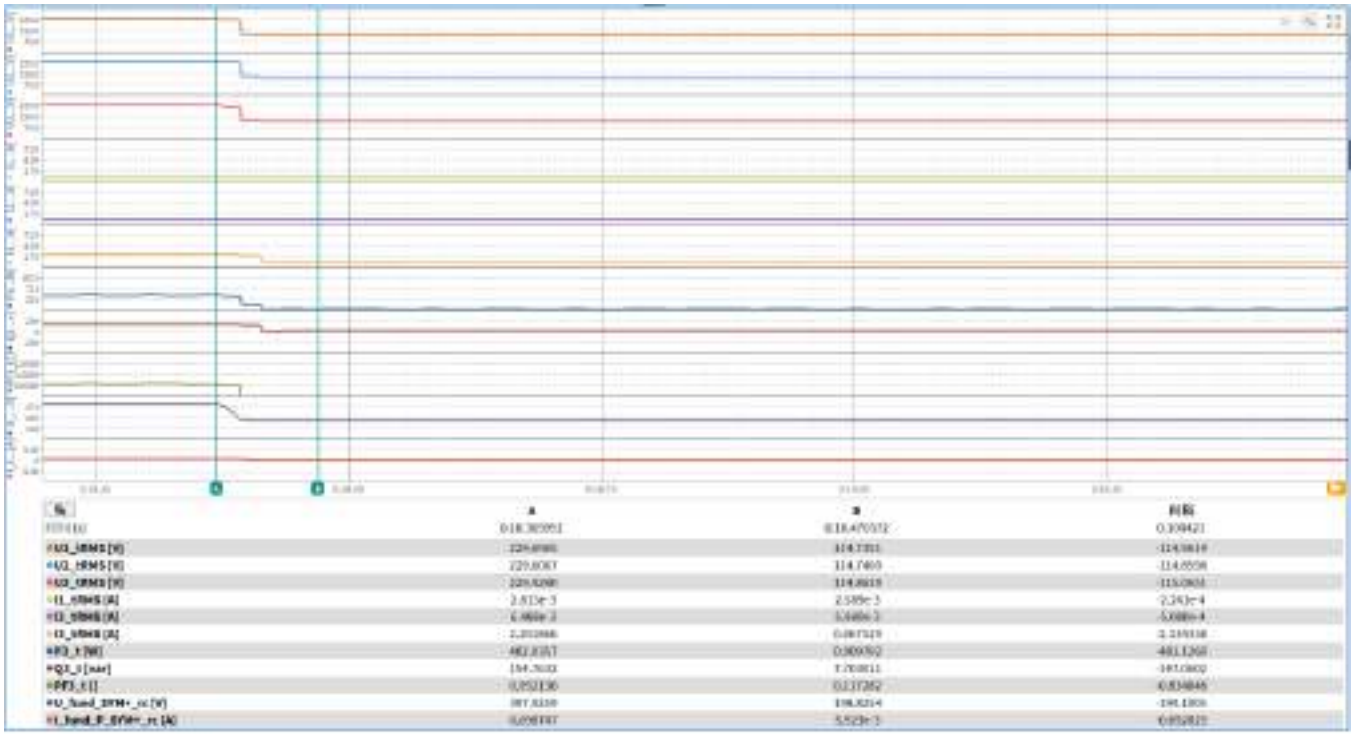
Load tests 2.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.2
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0,50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1719
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,501
	10		Positive sequence			0,501
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,506
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,482
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,482
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,154
	16		Total	t_1-10 s to t_1	[p.u.]	0,154
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9521
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,499
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,016
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,017
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,469
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,469
	30	Response time active power	Positive sequence	-	[s]	0,242
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,143
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,143
	33	Response time reactive power	Positive sequence	–	[s]	9,985
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

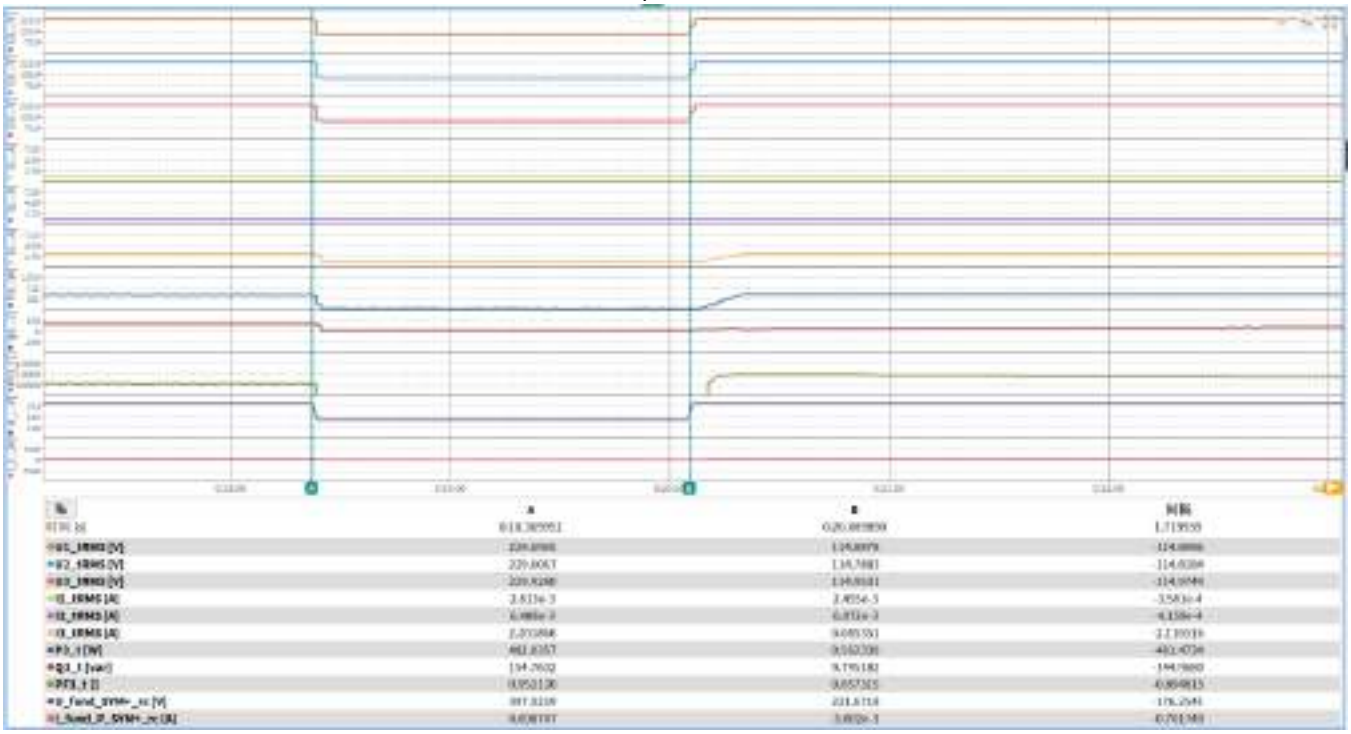
0-60ms



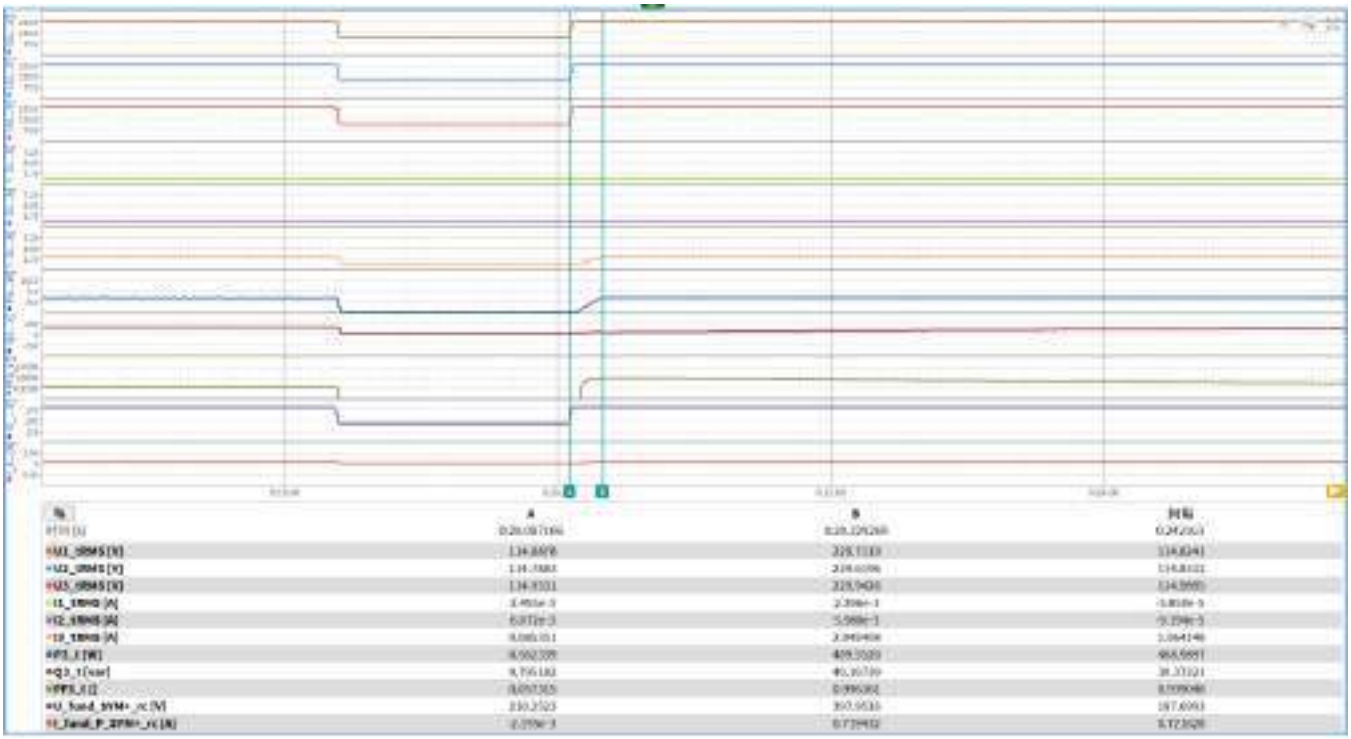
0-100ms

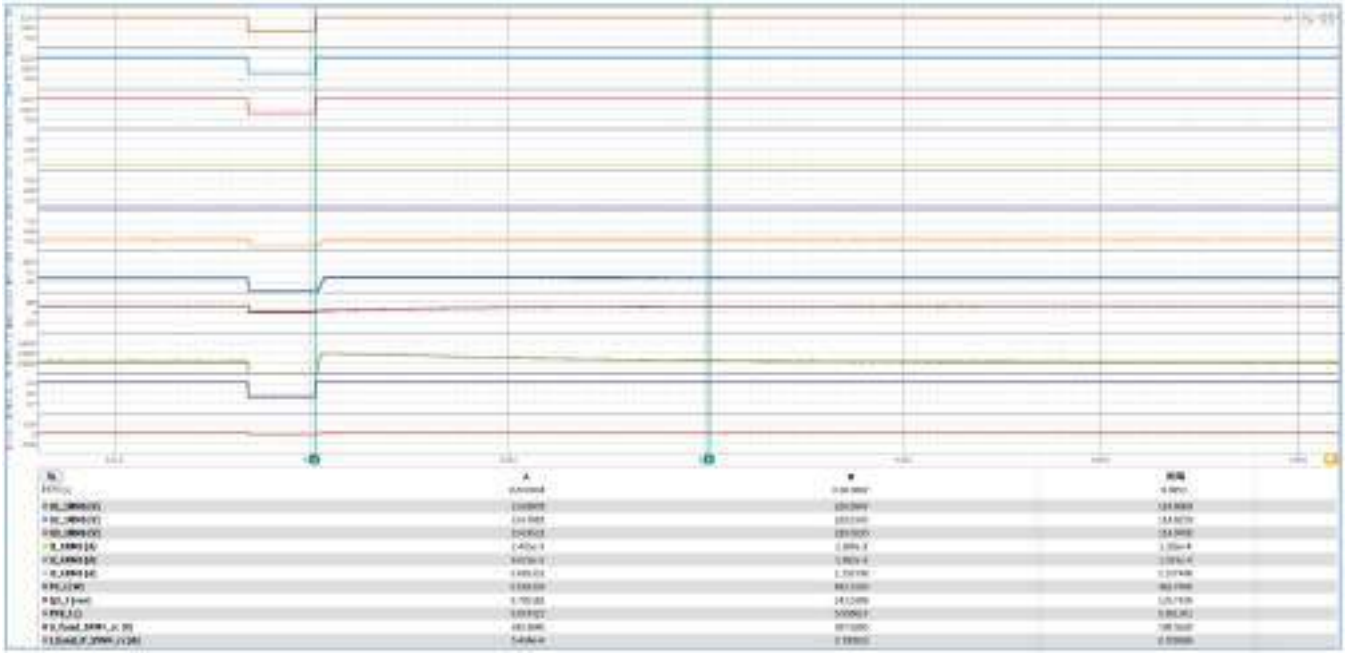


Drop duration



Recover time

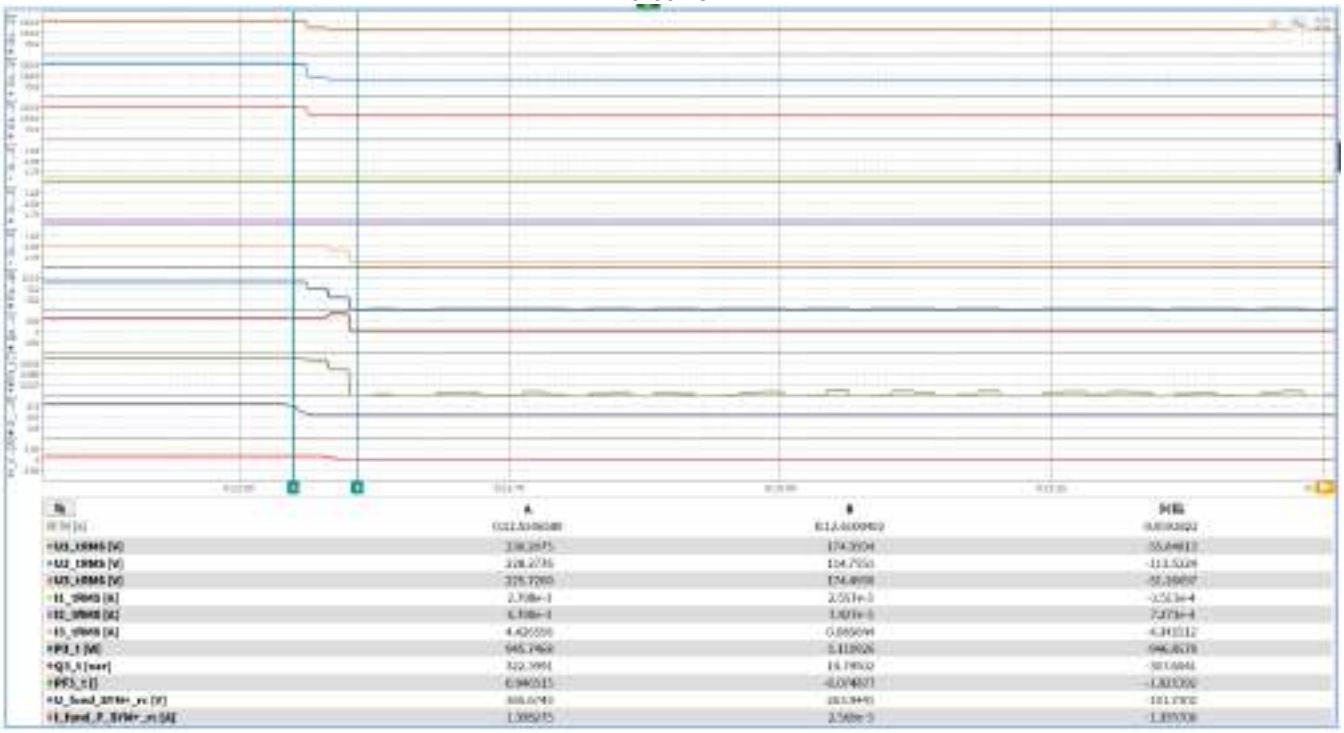




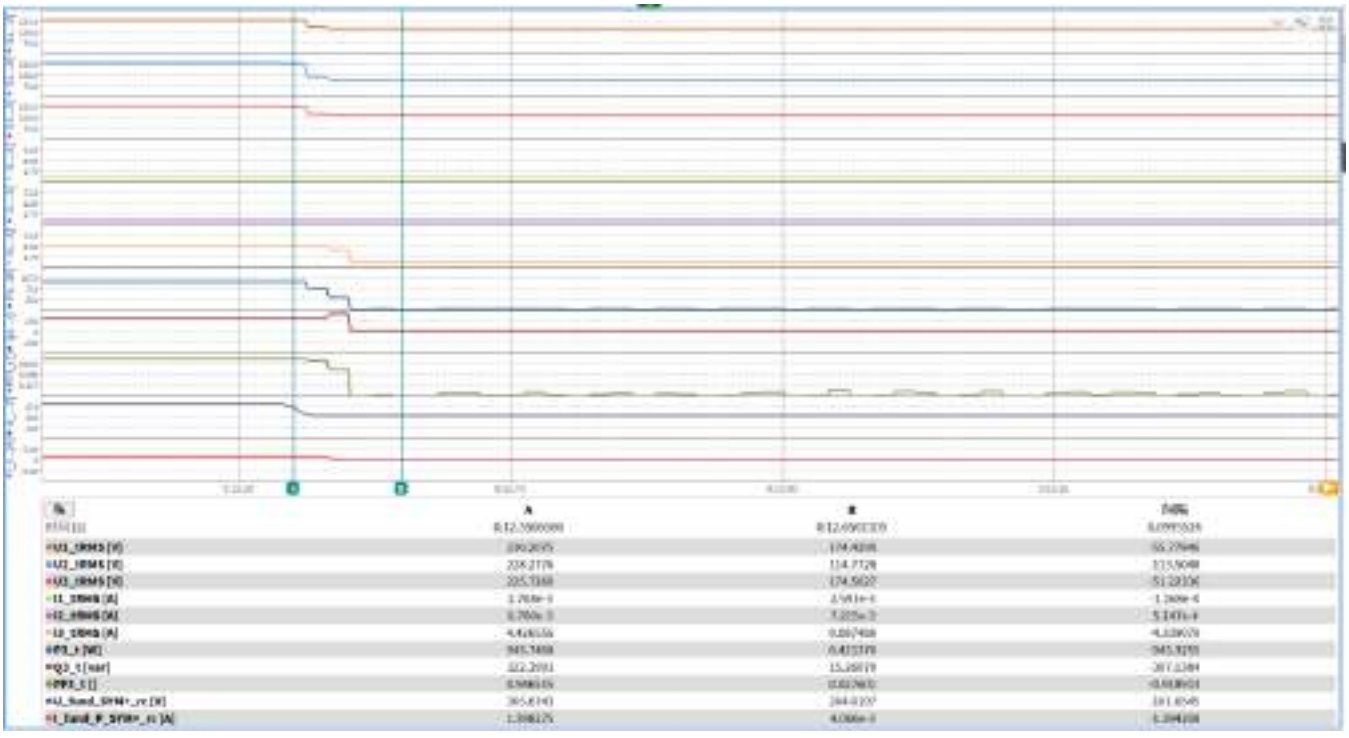
Load tests 2.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.3
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0.50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1576
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,242
	10		Positive sequence			0,242
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,981
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,017
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,946
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,946
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,322
	16		Total	t_1-10 s to t_1	[p.u.]	0,322
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9465
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,758
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,020
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,020
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,000
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,000
	30	Response time active power	Positive sequence	-	[s]	0,520
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,290
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,290
	33	Response time reactive power	Positive sequence	–	[s]	9,996
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

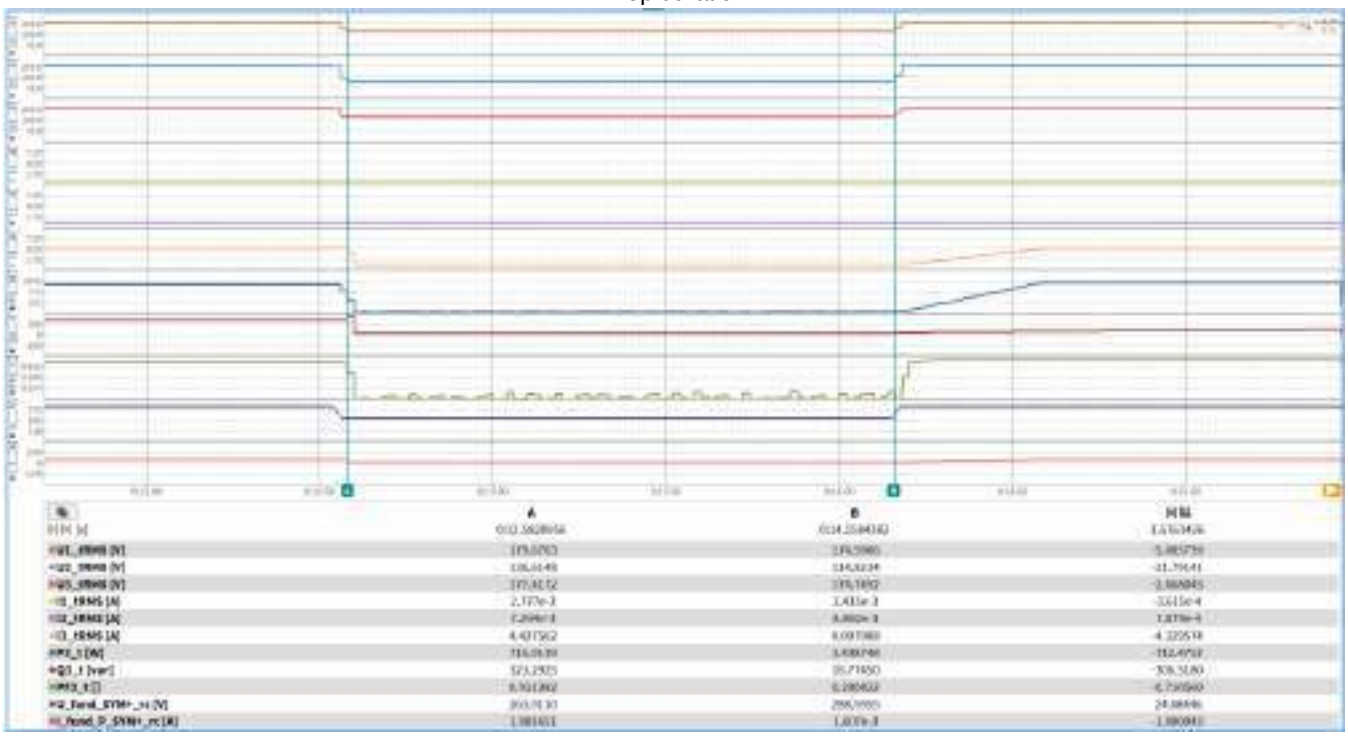
0-60ms



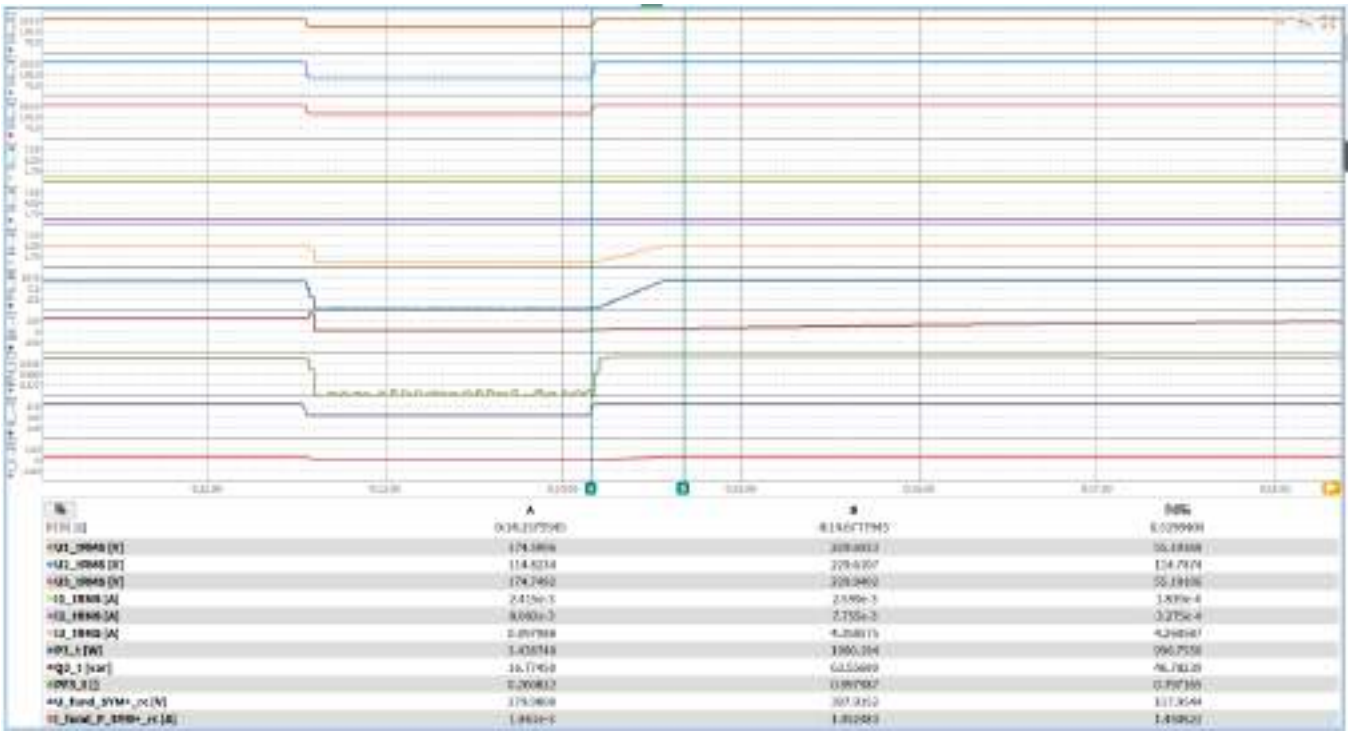
0-100ms

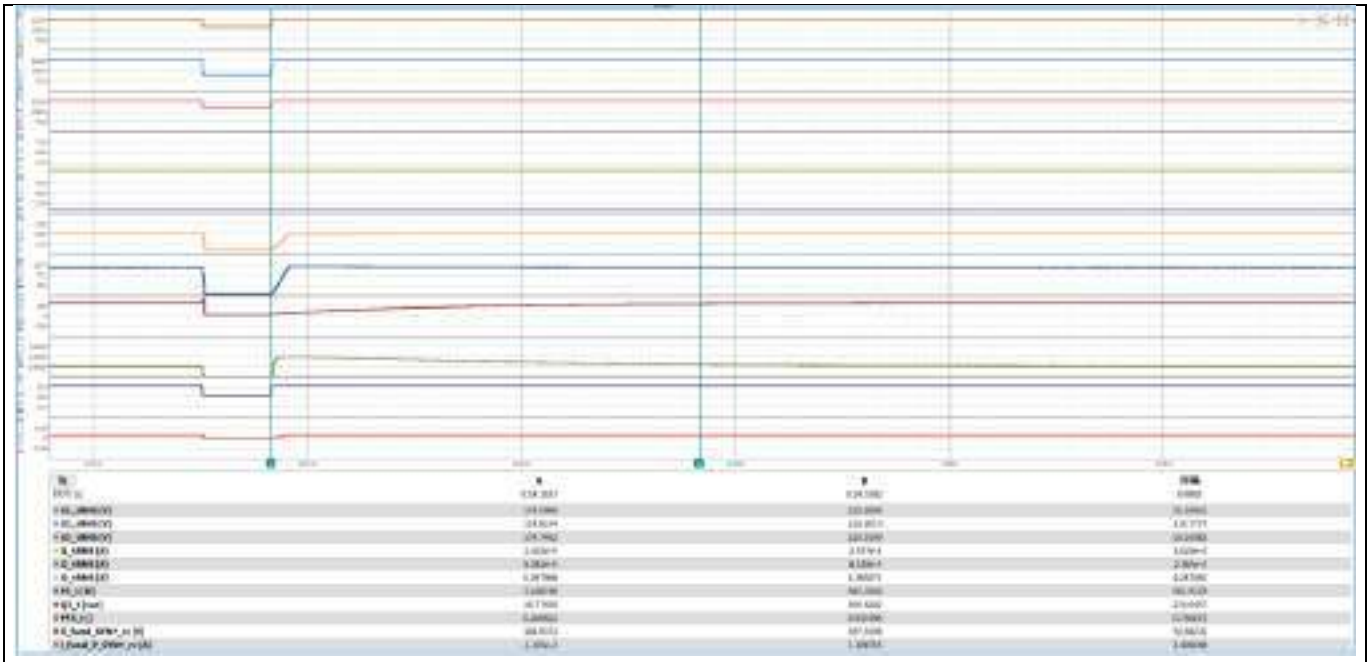


Drop duration



Recover time

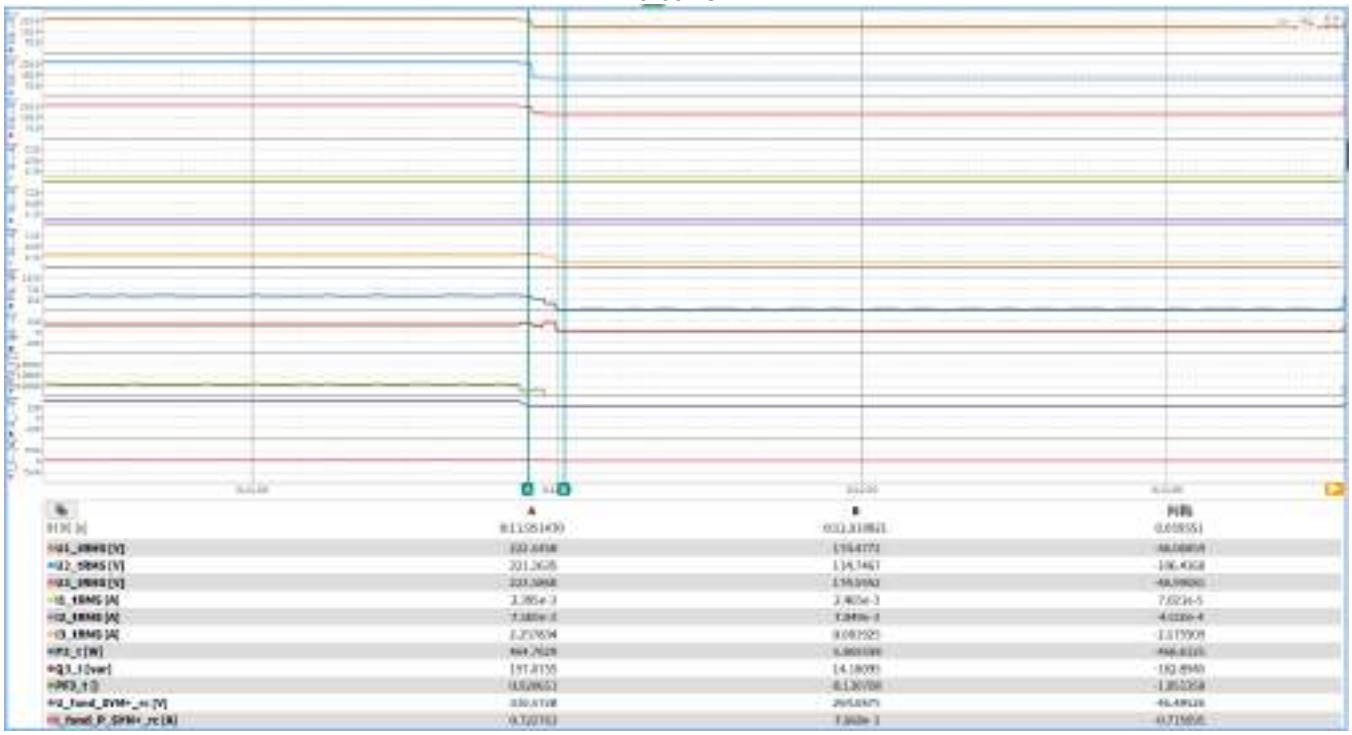




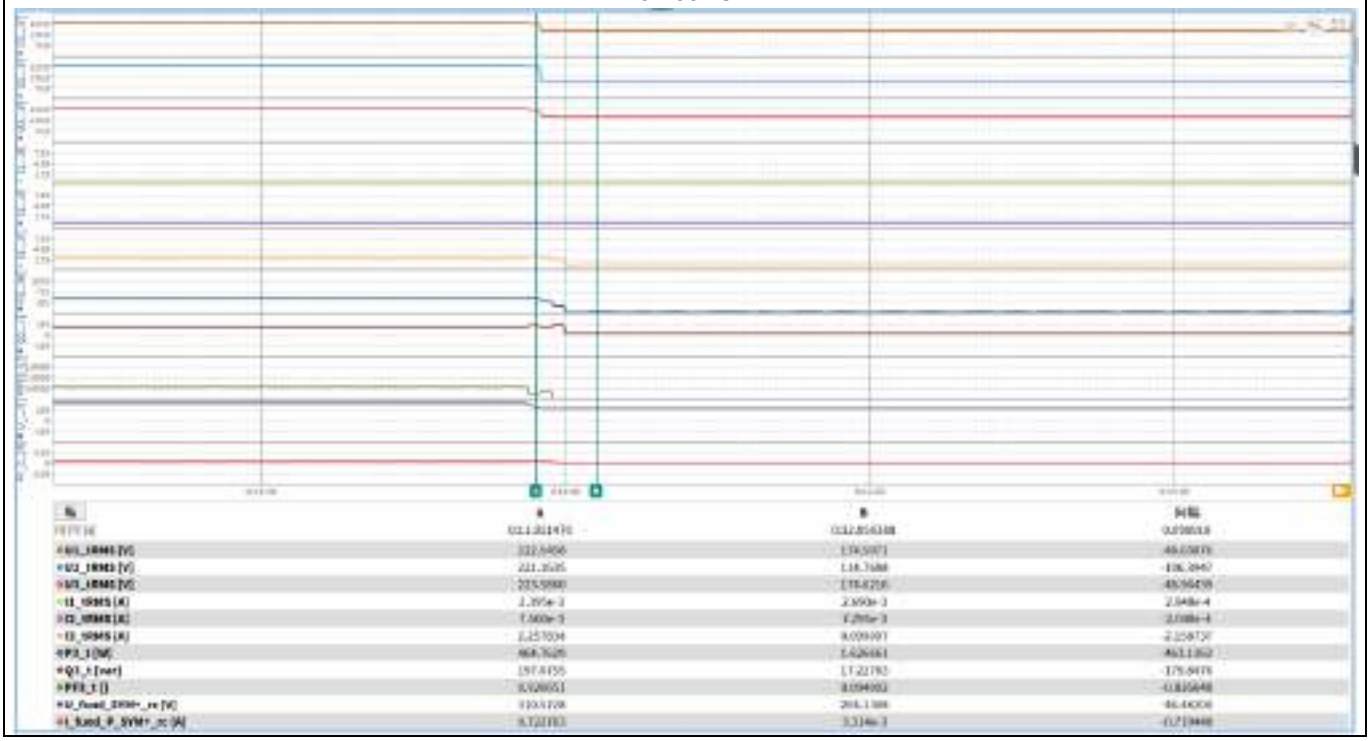
Load tests 2.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	2.4
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0.50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1596
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,241
	10		Positive sequence			0,241
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,970
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,519
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,465
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,465
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,197
	16		Total	t_1-10 s to t_1	[p.u.]	0,197
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9206
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,759
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,019
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,023
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,000
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,498
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,498
	30	Response time active power	Positive sequence	-	[s]	0,451
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,144
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,144
	33	Response time reactive power	Positive sequence	–	[s]	9,999
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

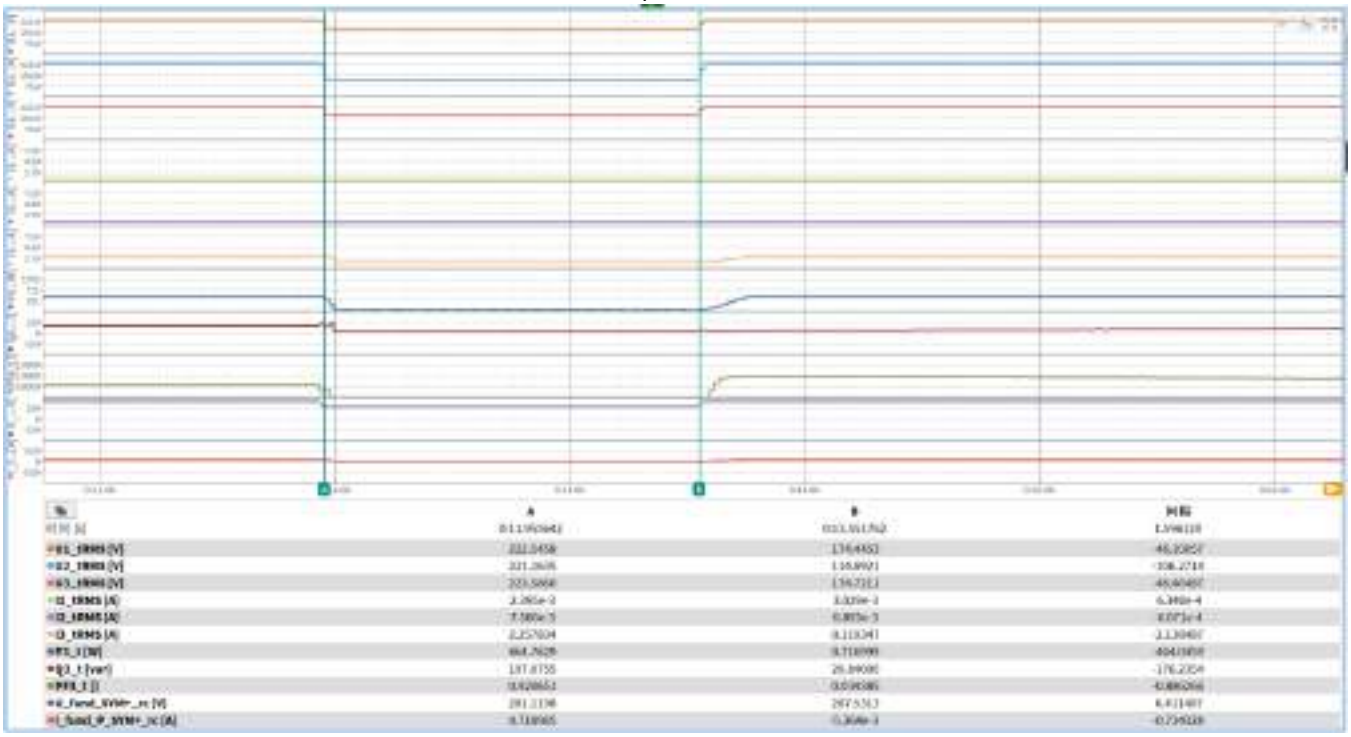
0-60ms



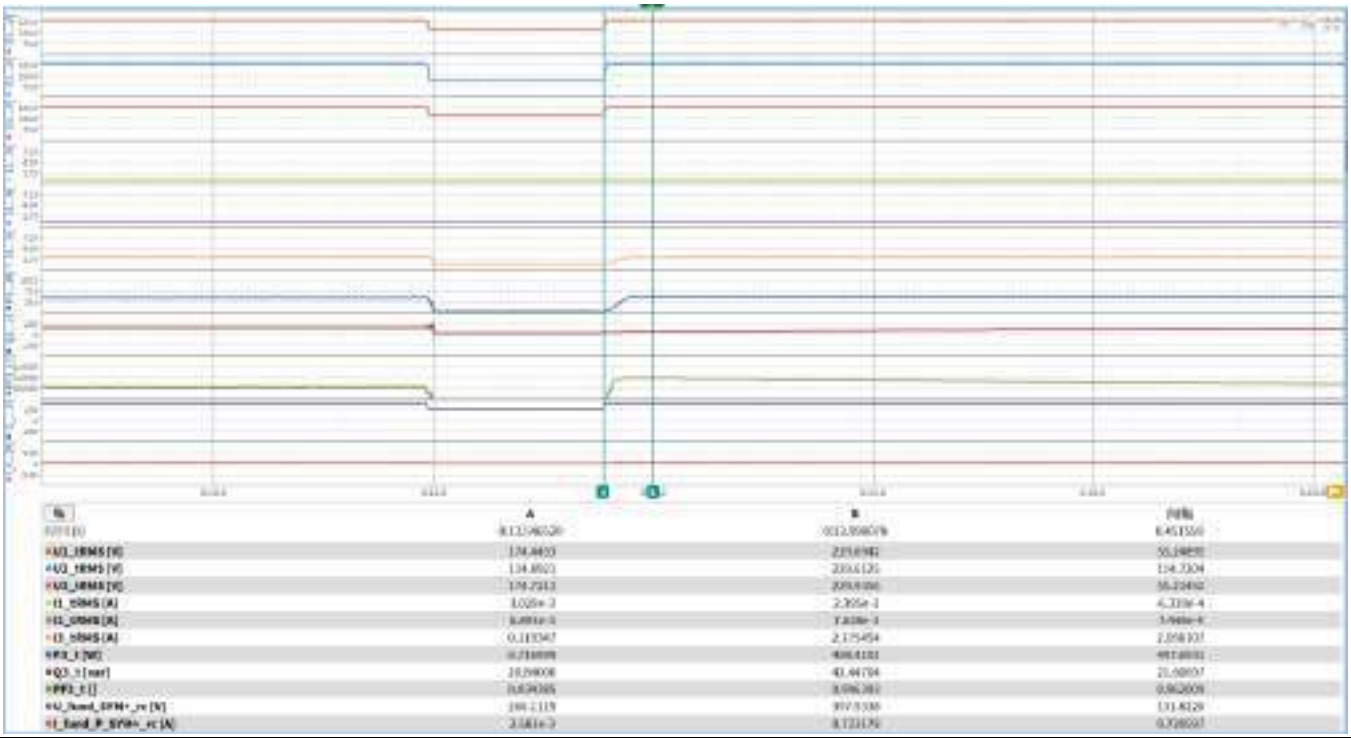
0-100ms

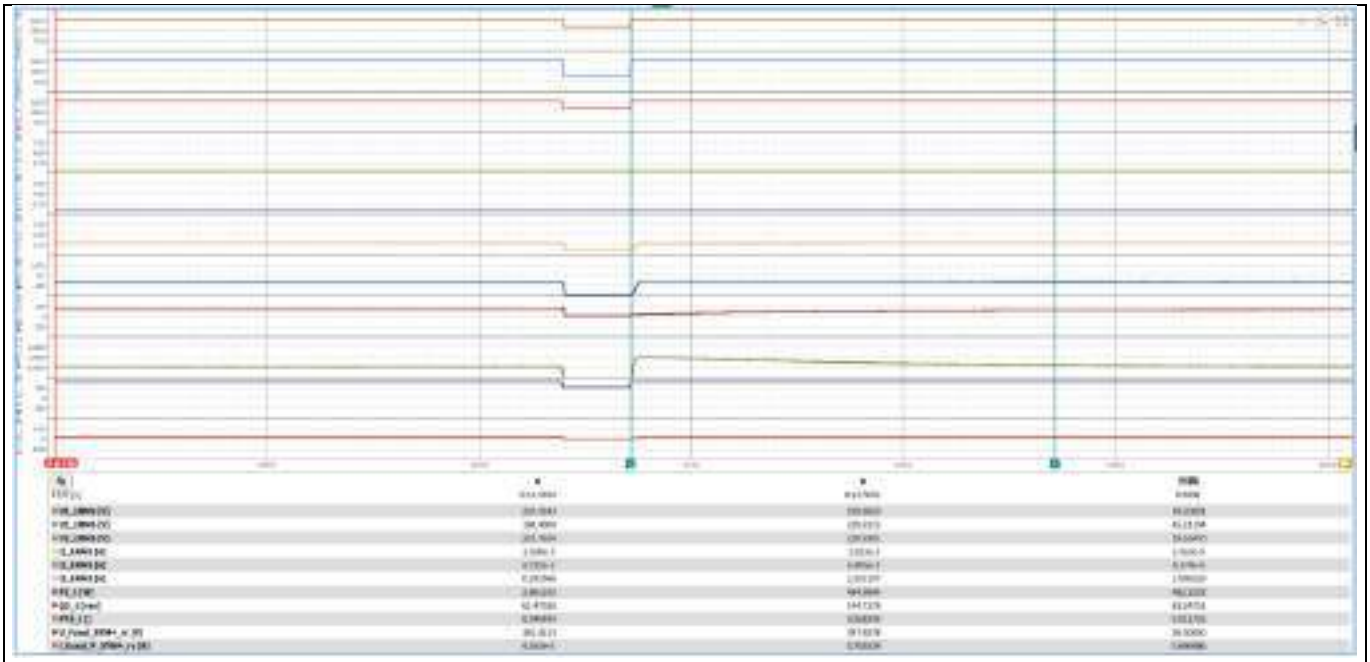


Drop duration



Recover time

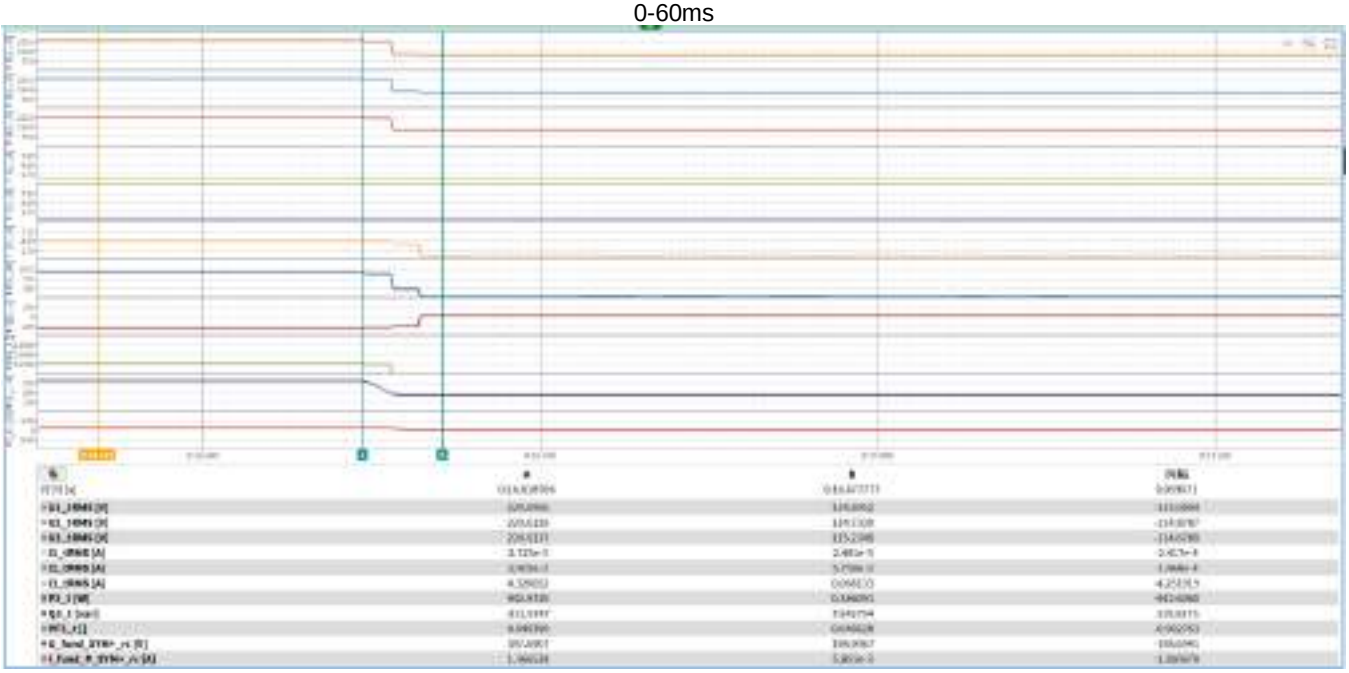




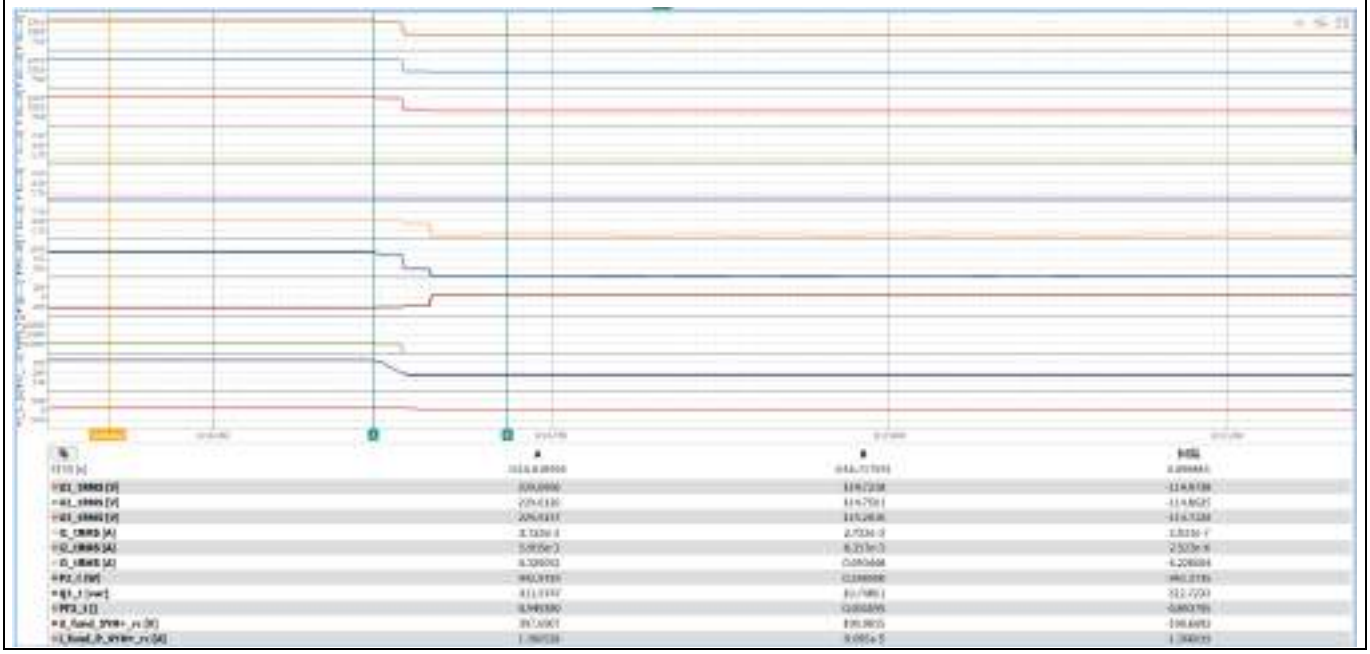
Load tests 3.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.1
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0,50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1713
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,499
	10		Positive sequence			0,499
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,993
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,943
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,943
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,312
	16		Total	t_1-10 s to t_1	[p.u.]	-0,312
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9494
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,501
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,016
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,021
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,001
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,001
	30	Response time active power	Positive sequence	-	[s]	0,466
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,283
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,283
	33	Response time reactive power	Positive sequence	–	[s]	9,99
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

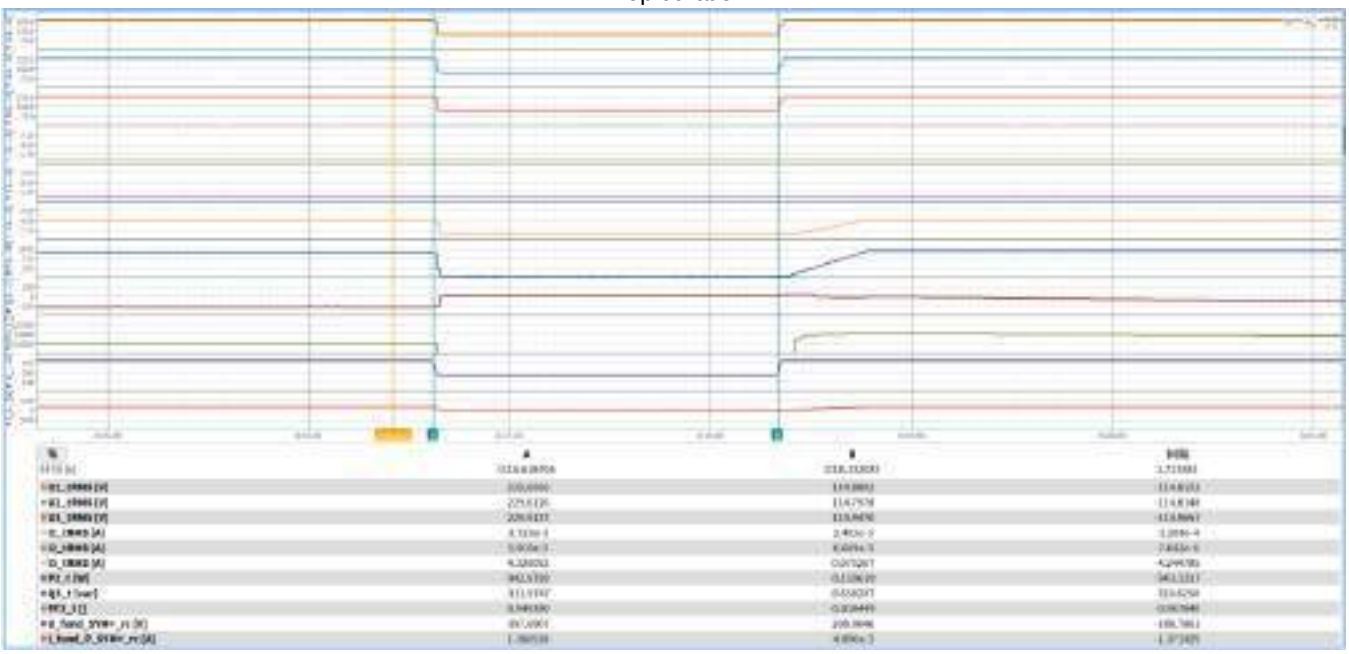
0-60ms



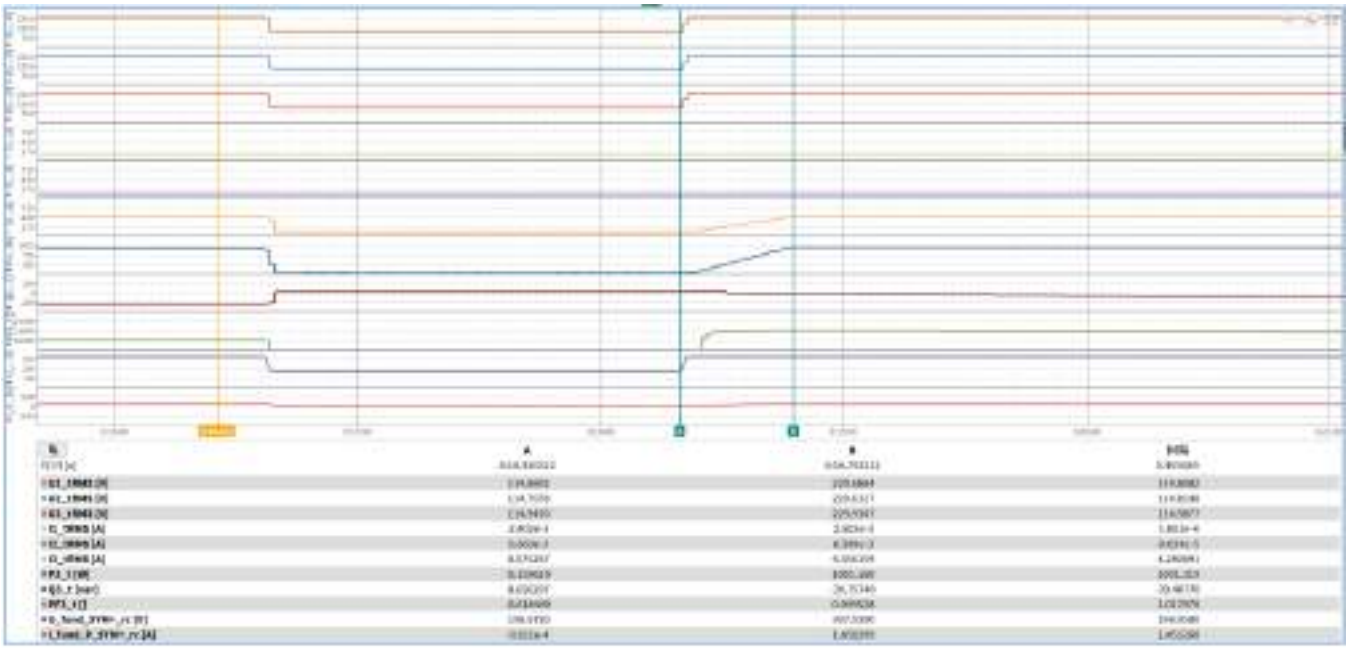
0-100ms

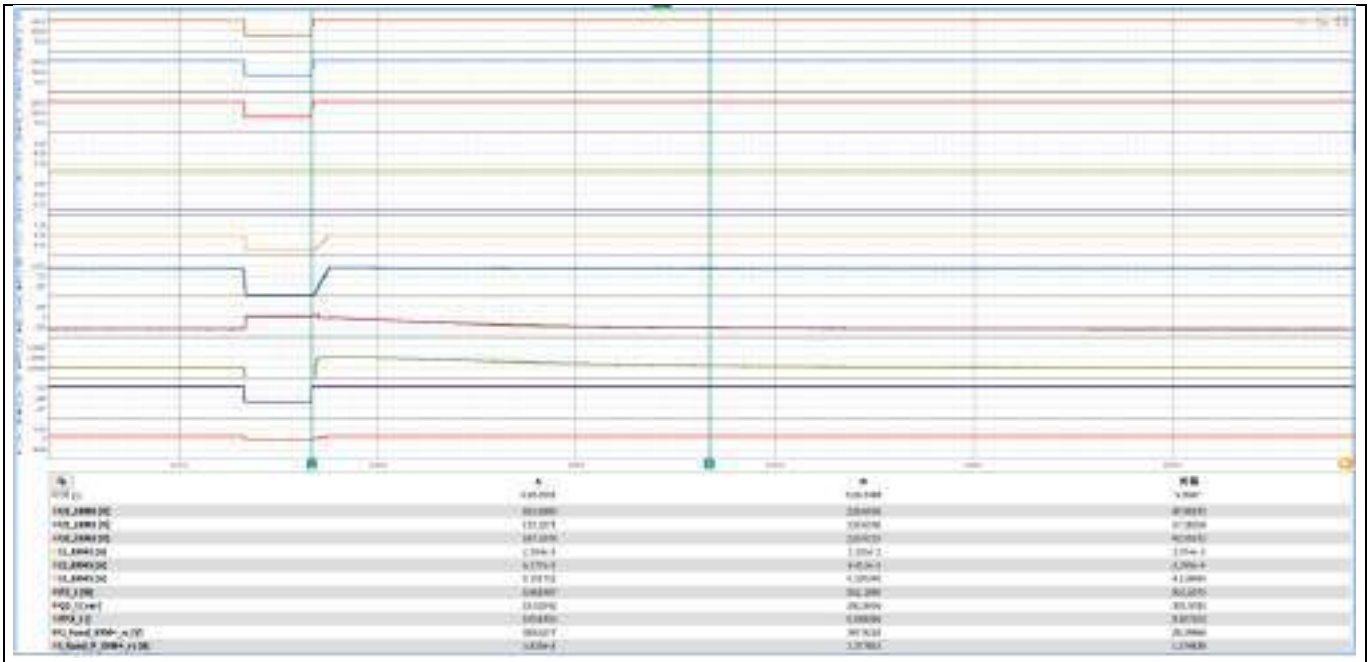


Drop duration



Recover time

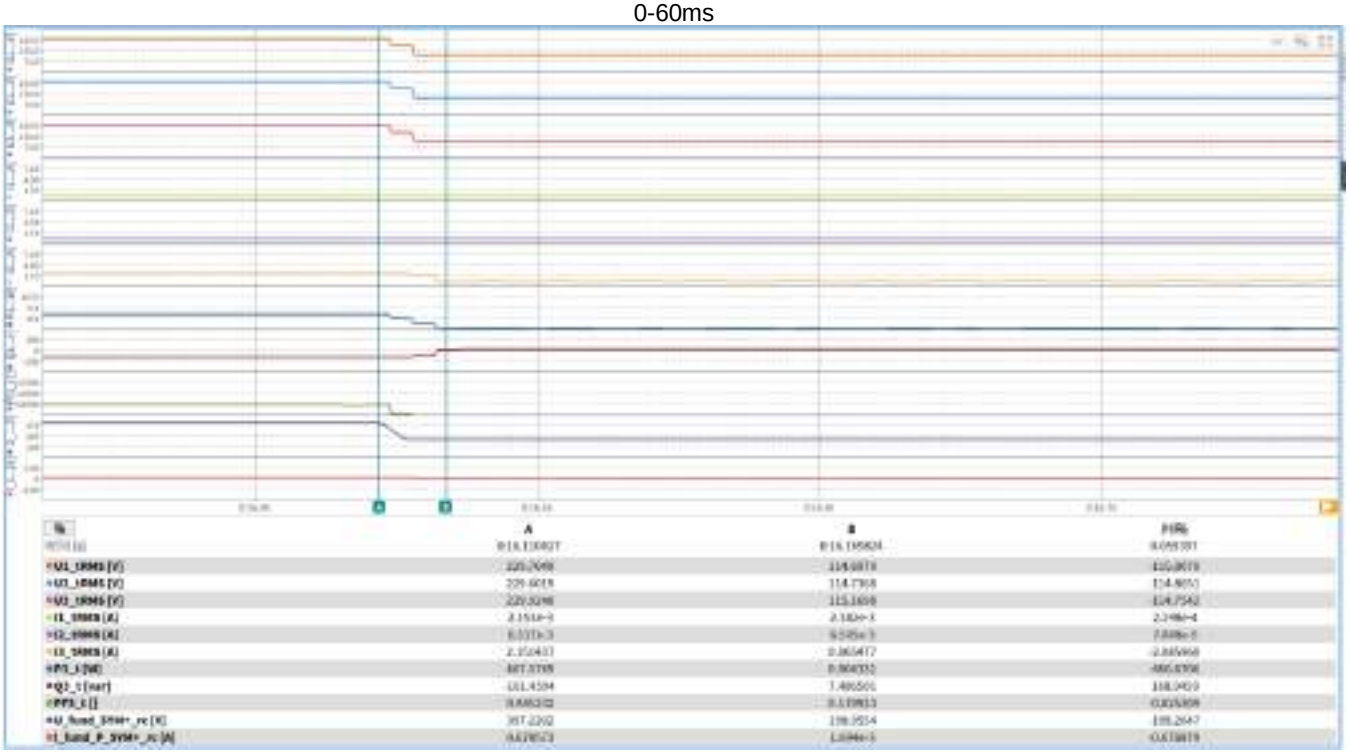




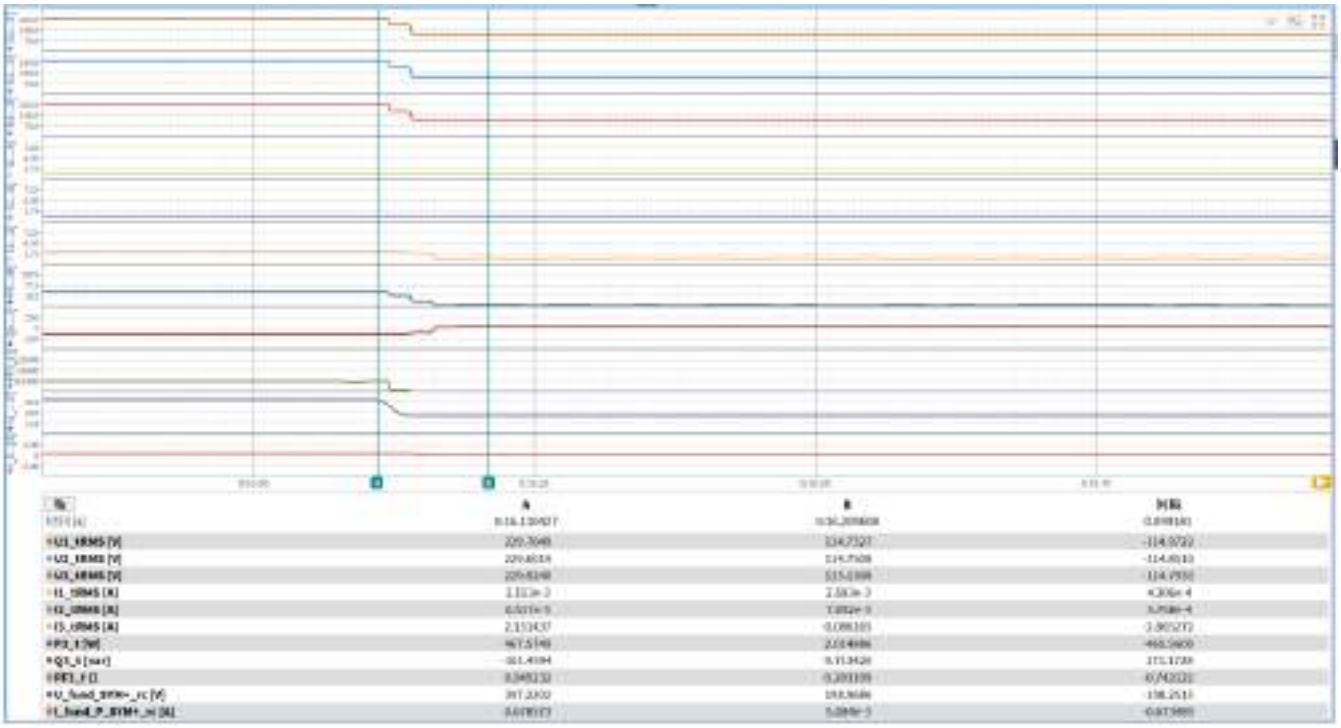
Load tests 3.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.2
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0,50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1727
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,500
	10		Positive sequence			0,500
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,494
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,468
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,468
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,161
	16		Total	t_1-10 s to t_1	[p.u.]	-0,161
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9452
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,500
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,016
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,020
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,002
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,002
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,500
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,500
	30	Response time active power	Positive sequence	-	[s]	0,298
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,148
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,148
	33	Response time reactive power	Positive sequence	–	[s]	9,988
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

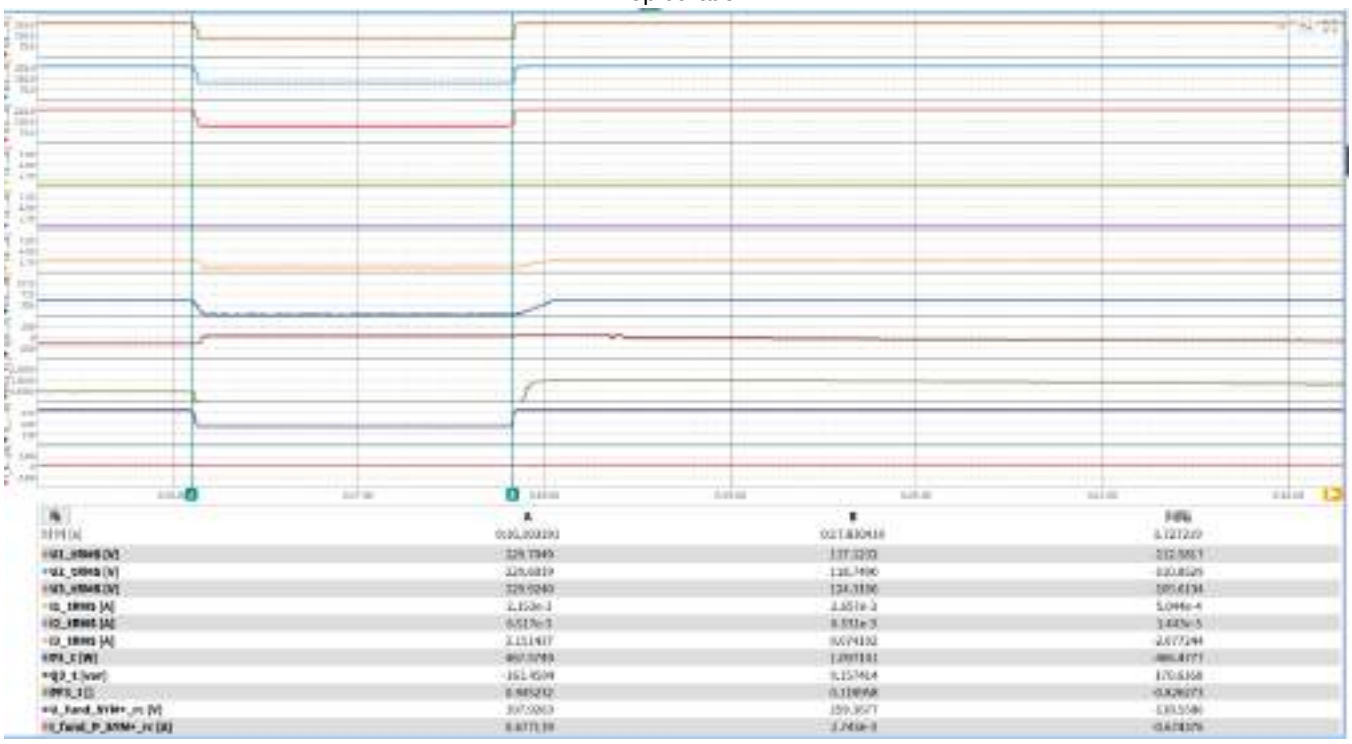
0-60ms



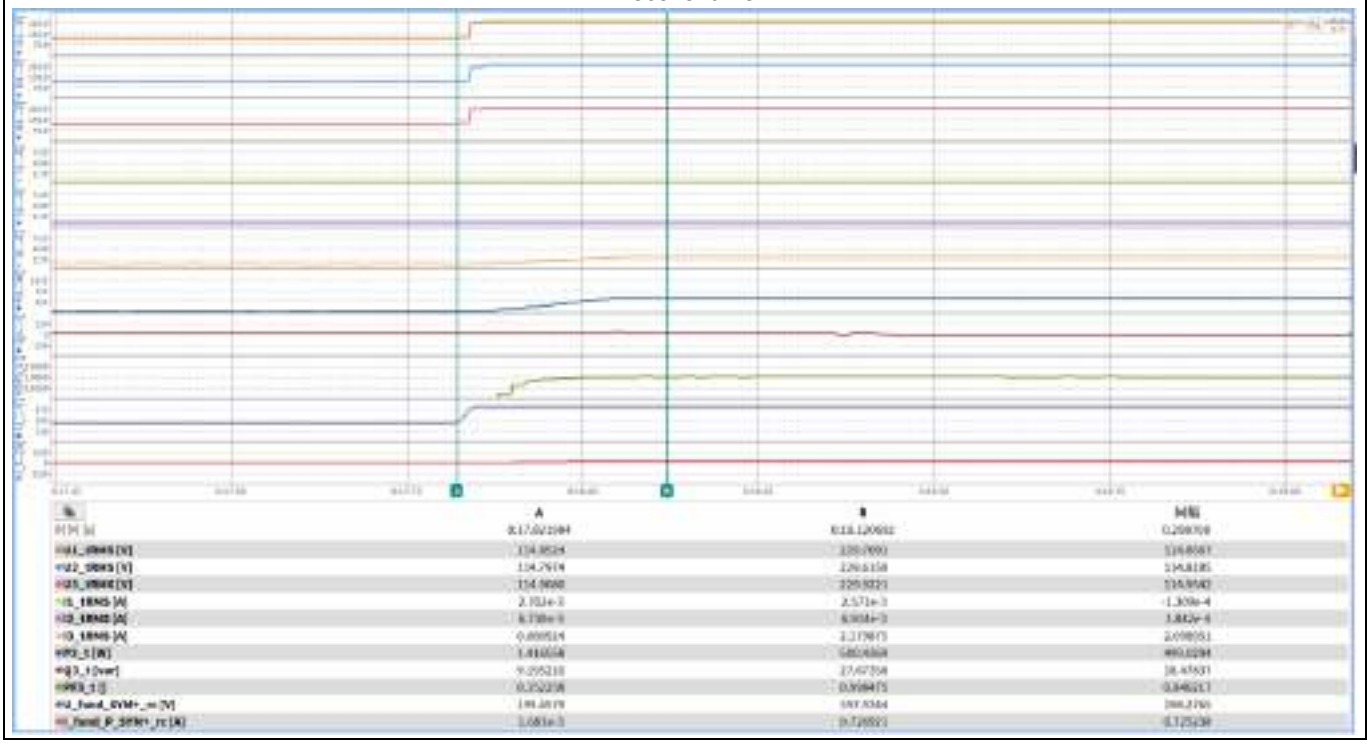
0-100ms

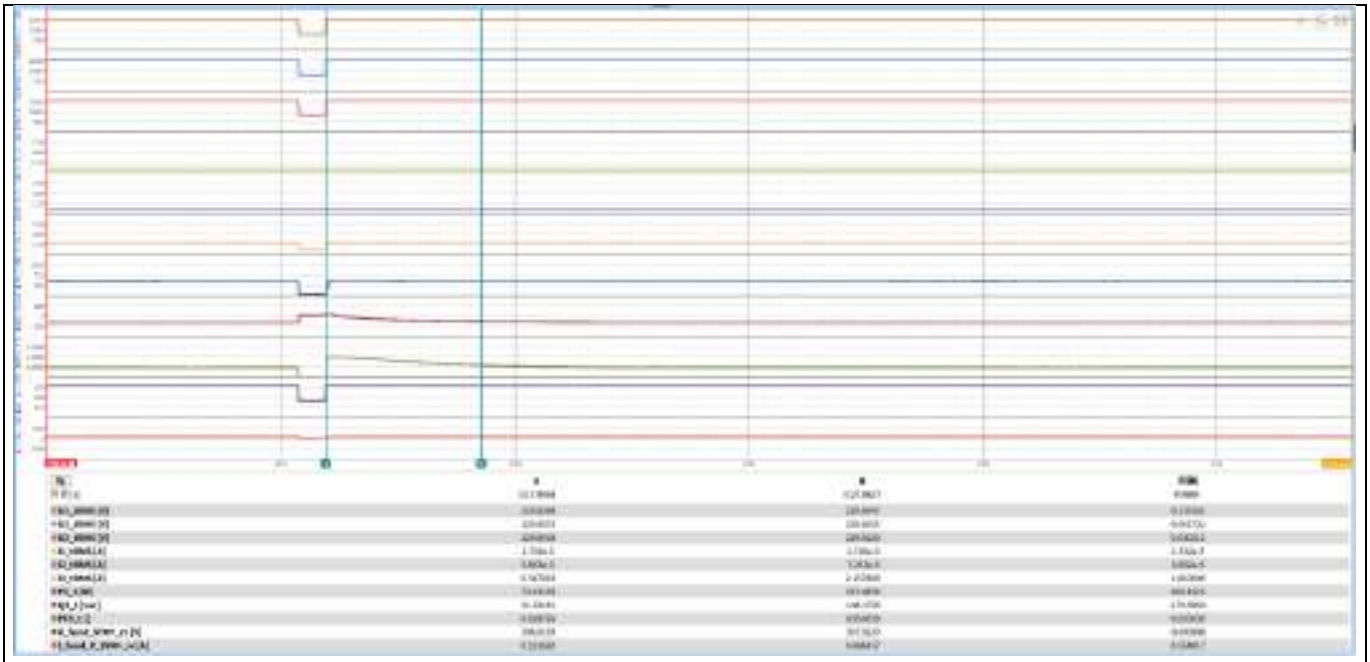


Drop duration



Recover time

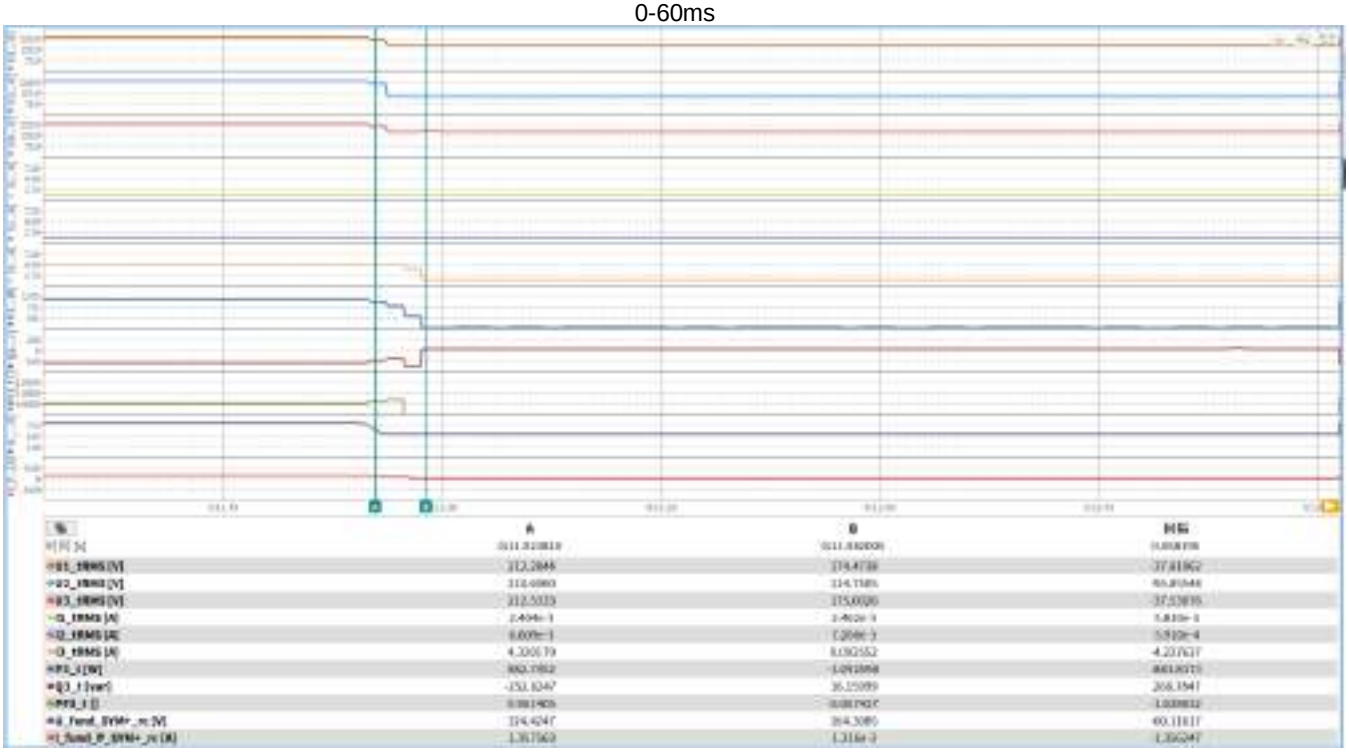




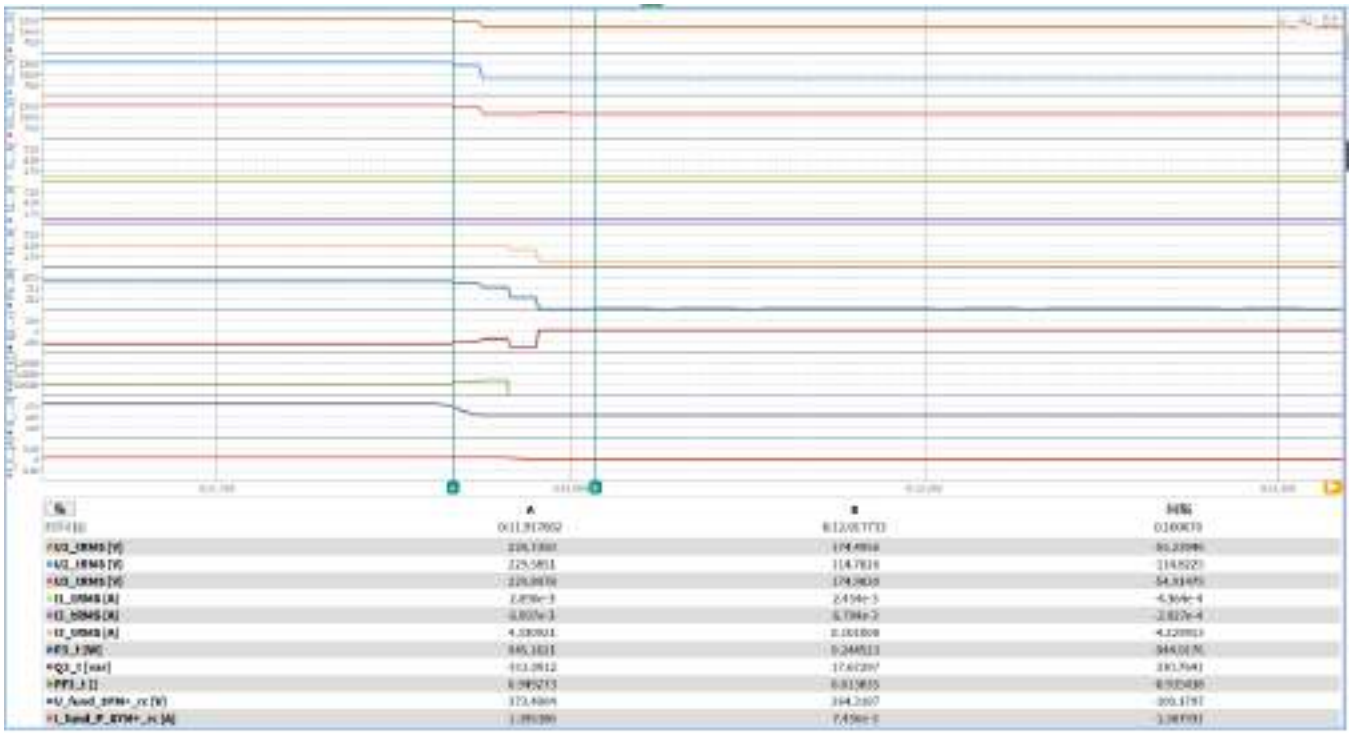
Load tests 3.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.3
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0.50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1578
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,239
	10		Positive sequence			0,239
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,922
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,993
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,883
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,883
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,253
	16		Total	t_1-10 s to t_1	[p.u.]	-0,253
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9614
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,761
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,021
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,023
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,0
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,0
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,001
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,001
	30	Response time active power	Positive sequence	-	[s]	0,496
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,282
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,282
	33	Response time reactive power	Positive sequence	–	[s]	9,994
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

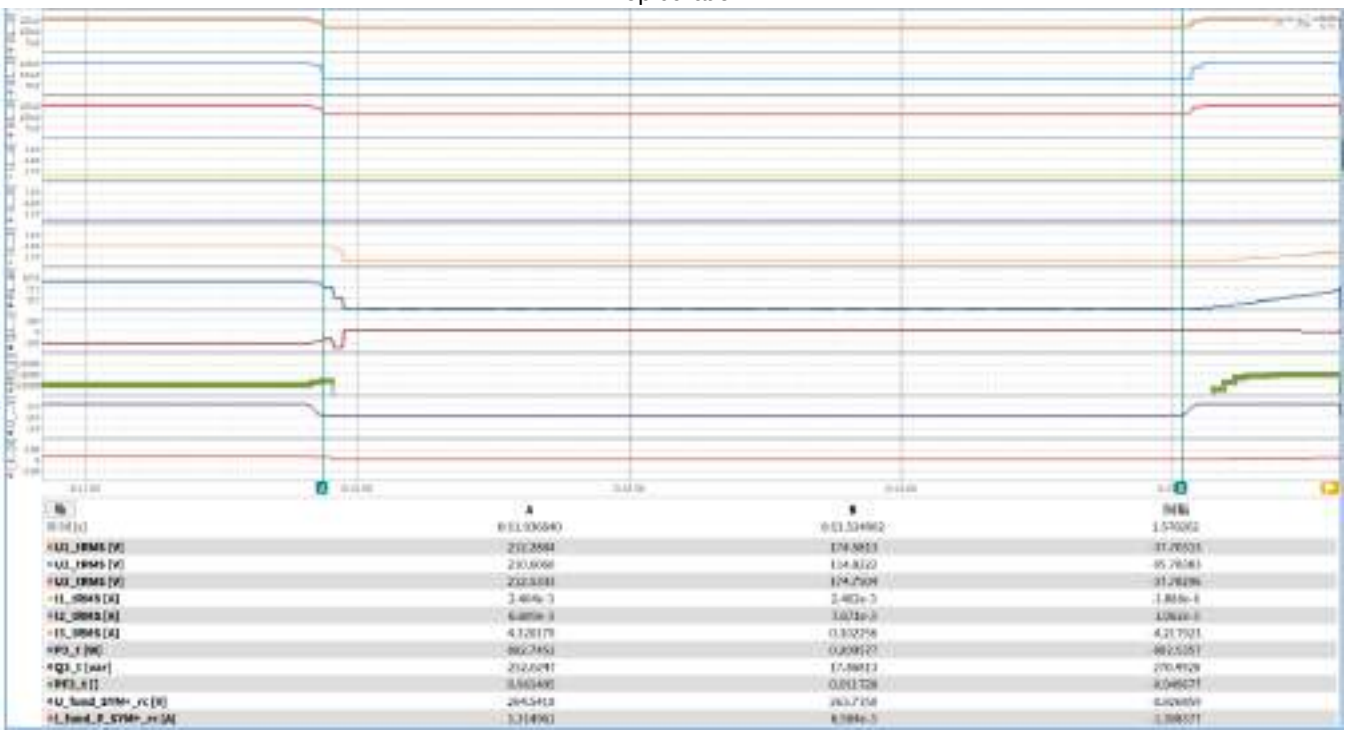
0-60ms



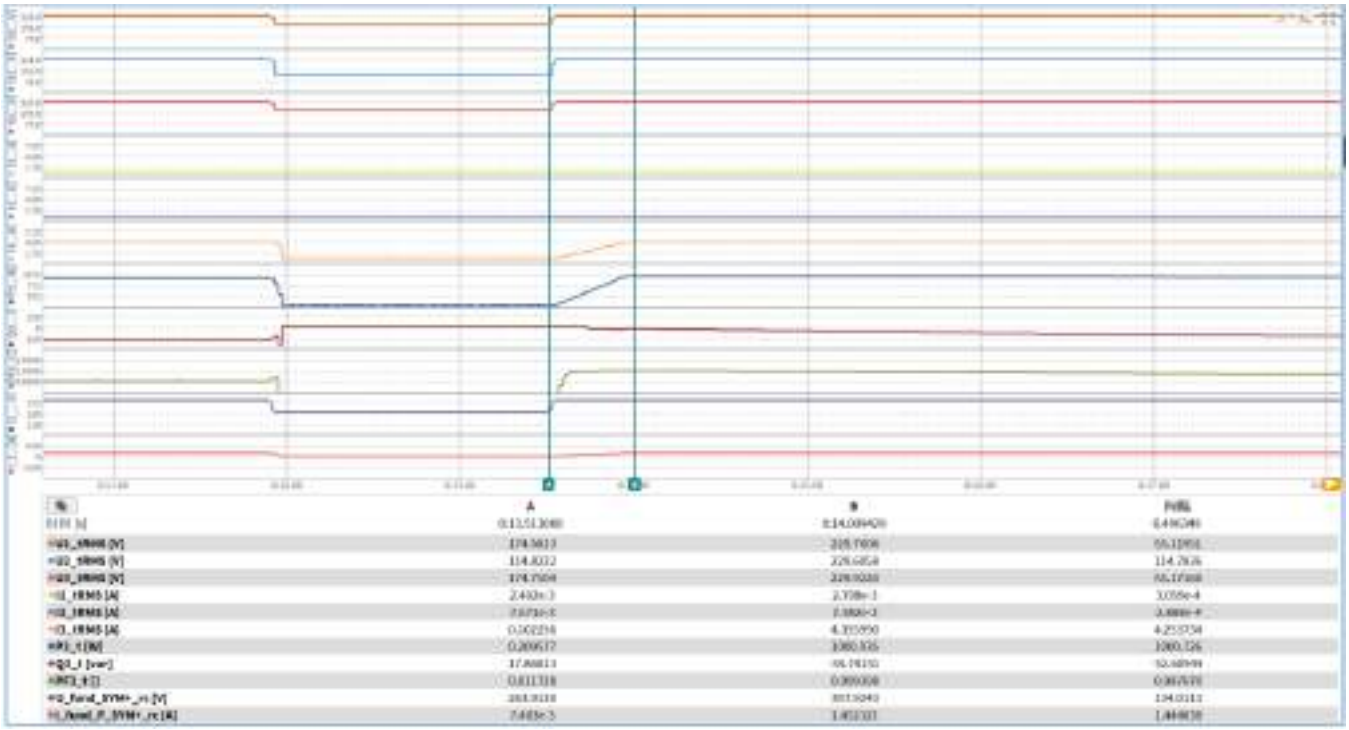
0-100ms

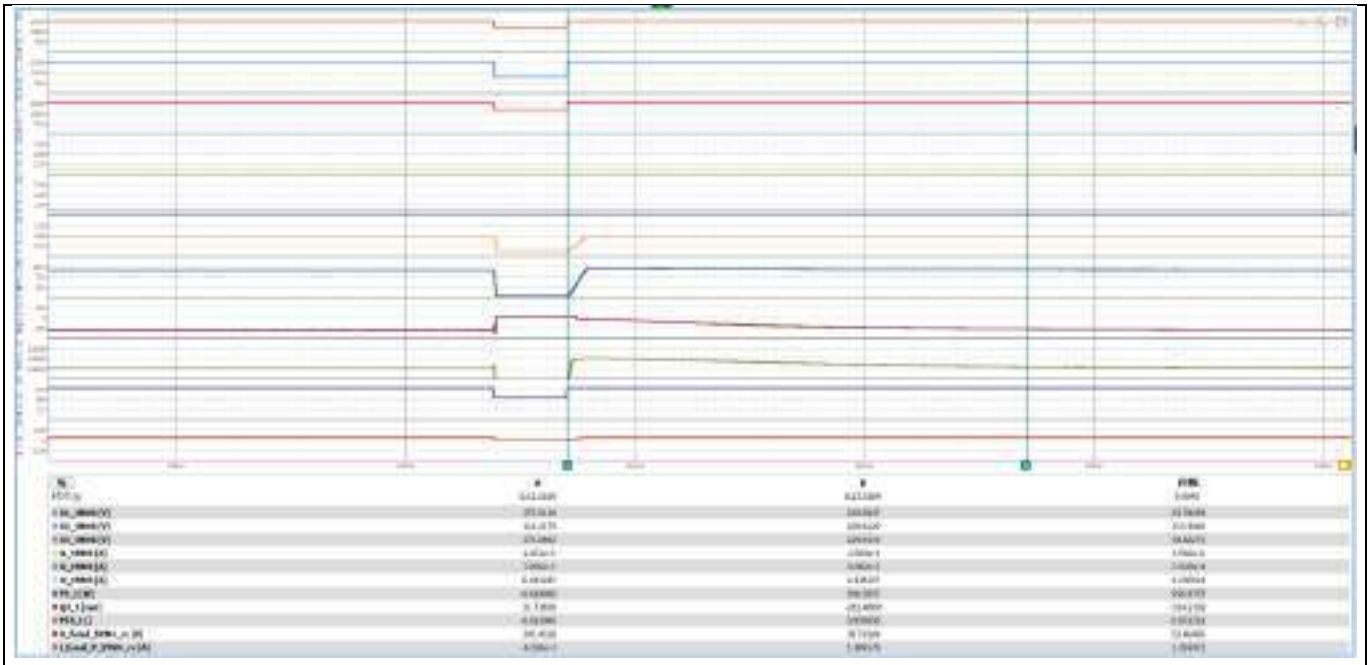


Drop duration



Recover time

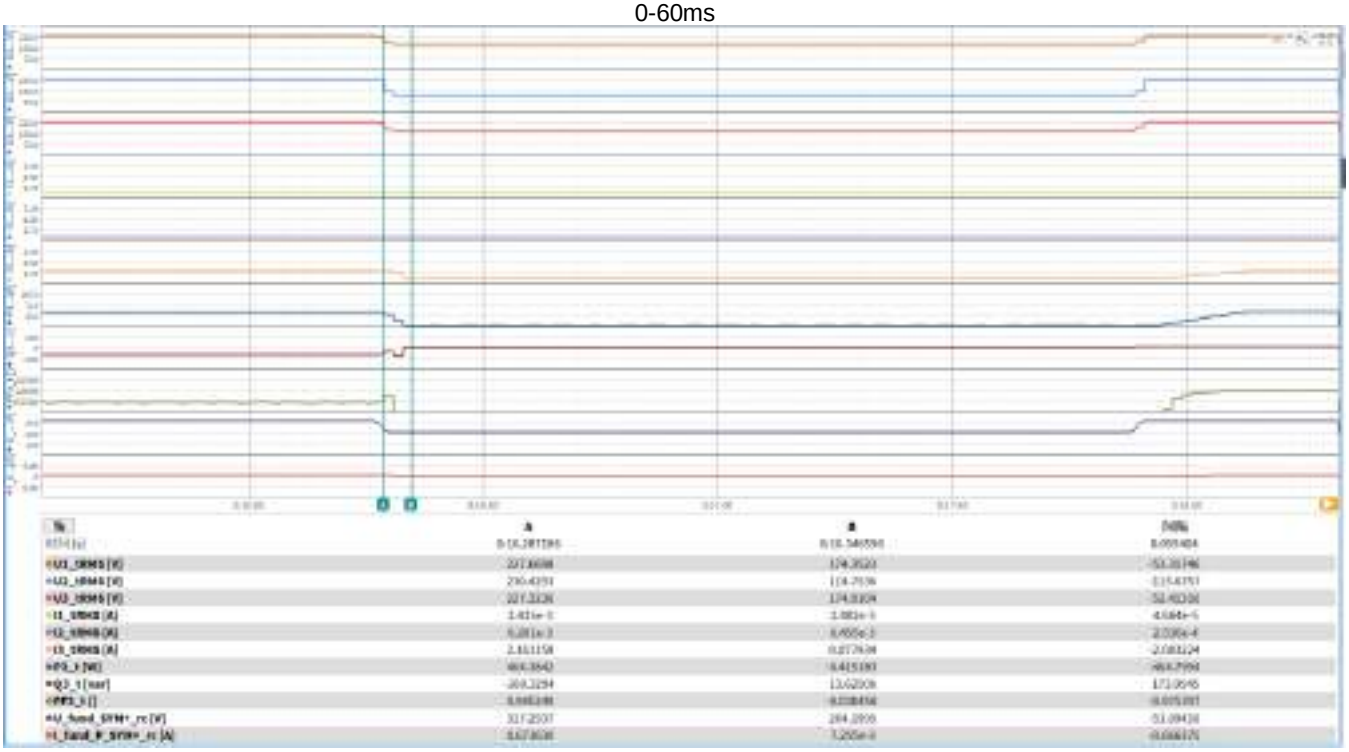




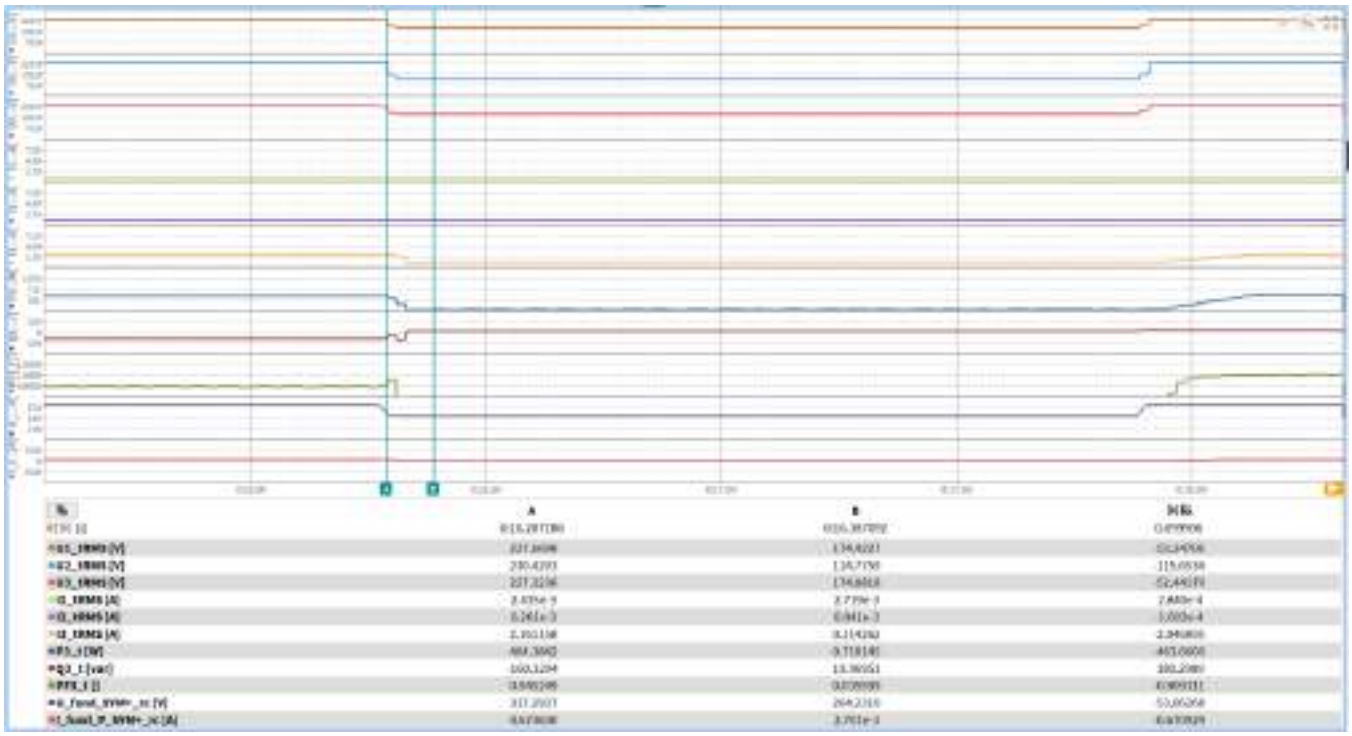
Load tests 3.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	3.4
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0,50
	5	Drop duration setpoint	Total	–	[ms]	1500
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	1577
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,240
	10		Positive sequence			0,240
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,987
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,497
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,464
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,464
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,160
	16		Total	t_1-10 s to t_1	[p.u.]	-0,160
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9452
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,760
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,018
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,026
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,0
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,0
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	30	Response time active power	Positive sequence	-	[s]	0,398
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,147
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,147
	33	Response time reactive power	Positive sequence	–	[s]	9,949
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

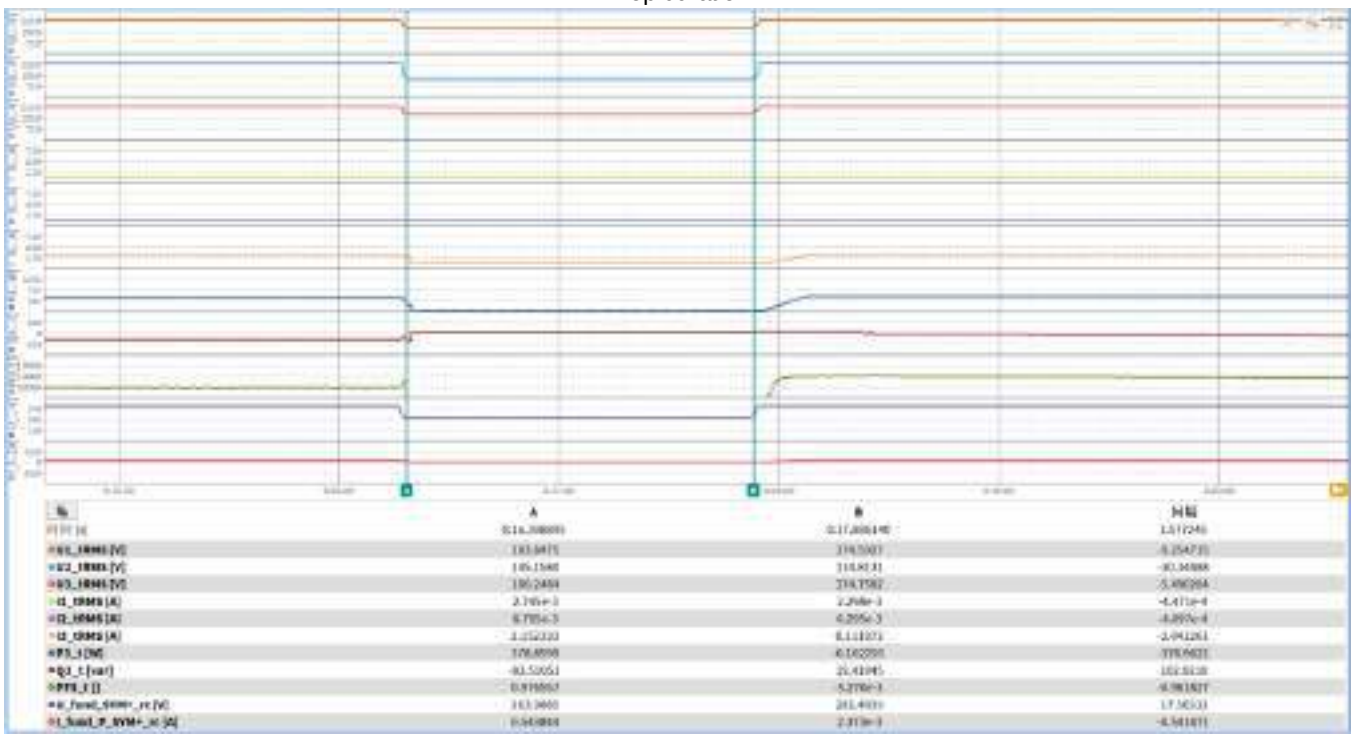
0-60ms



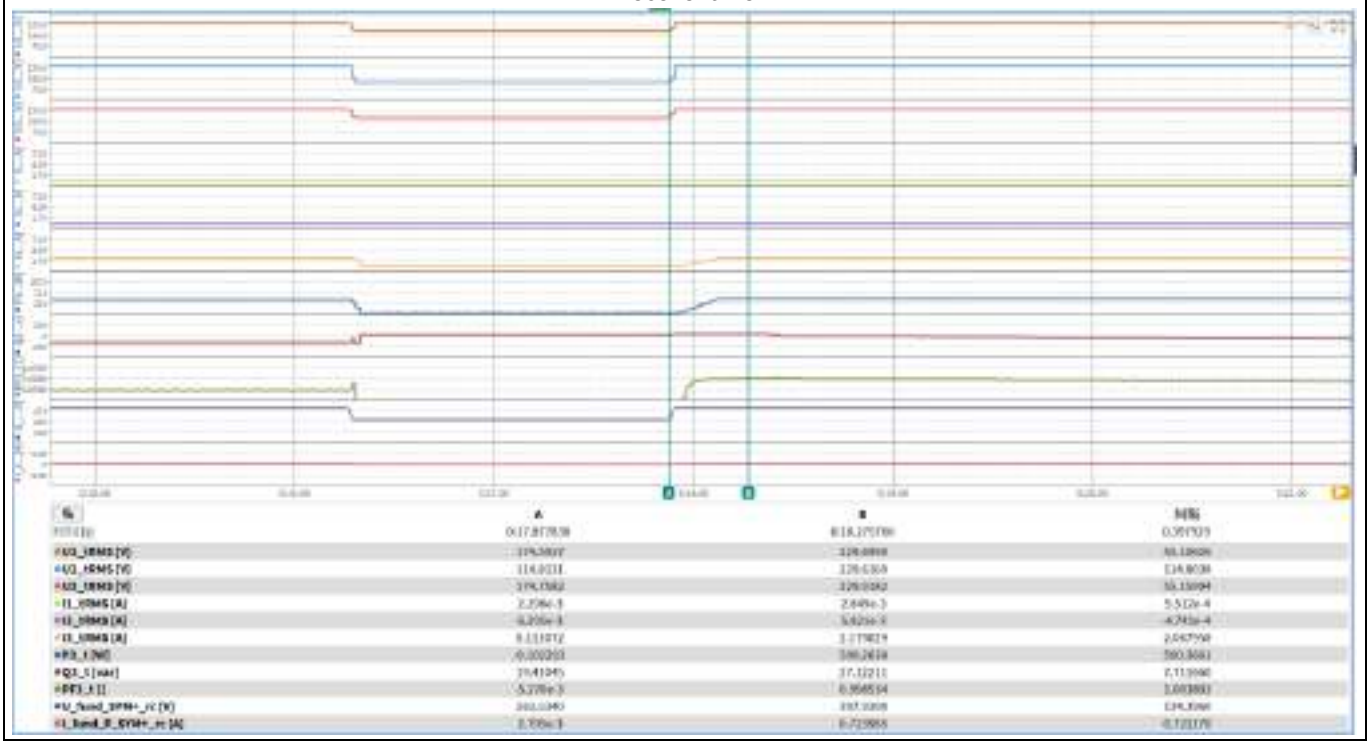
0-100ms

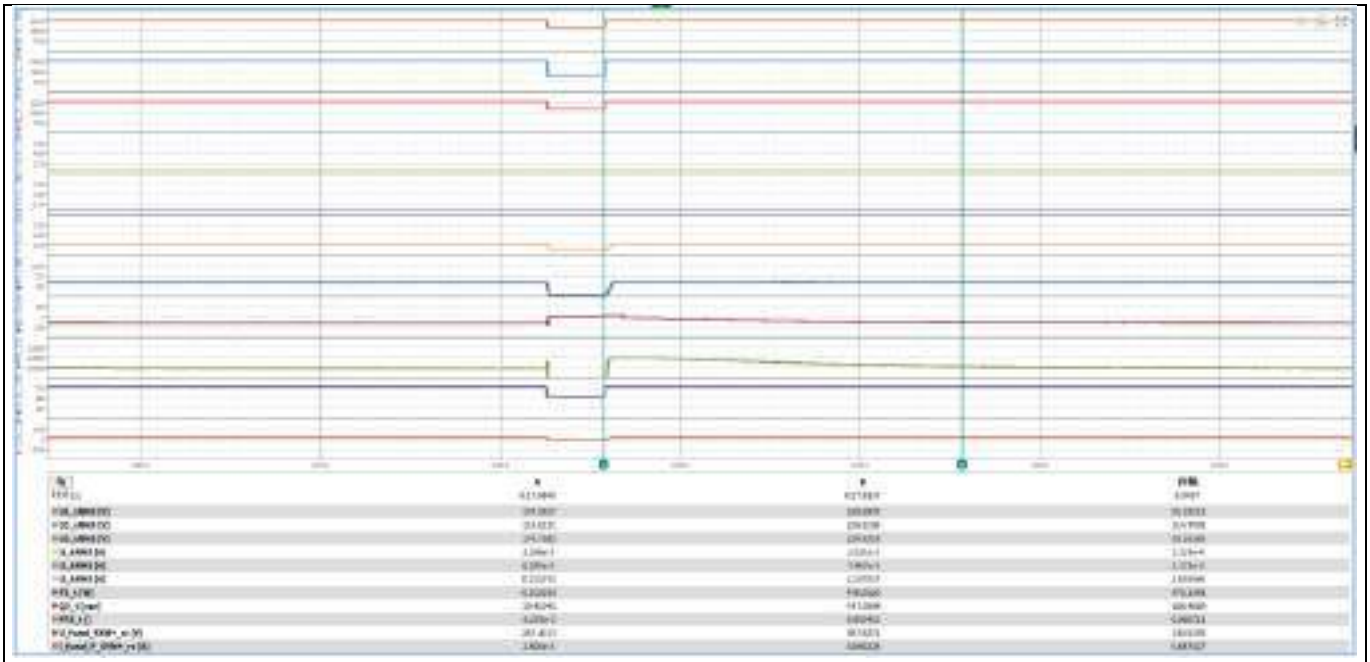


Drop duration



Recover time

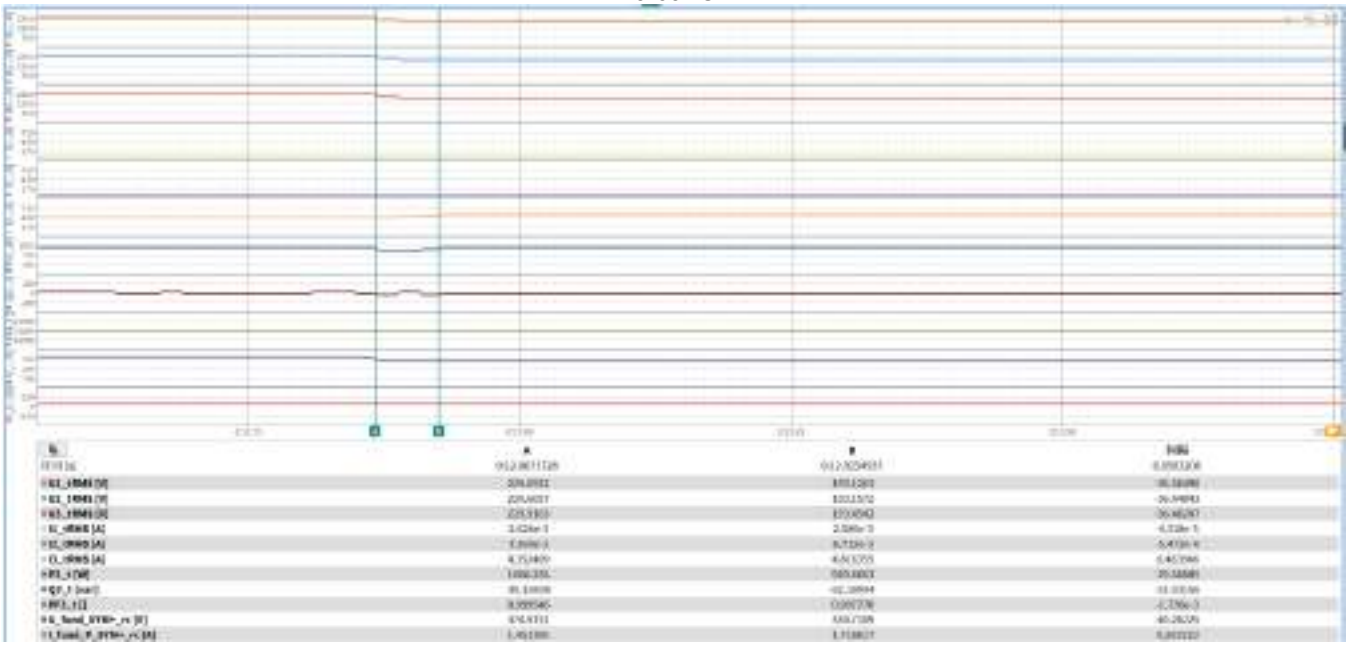




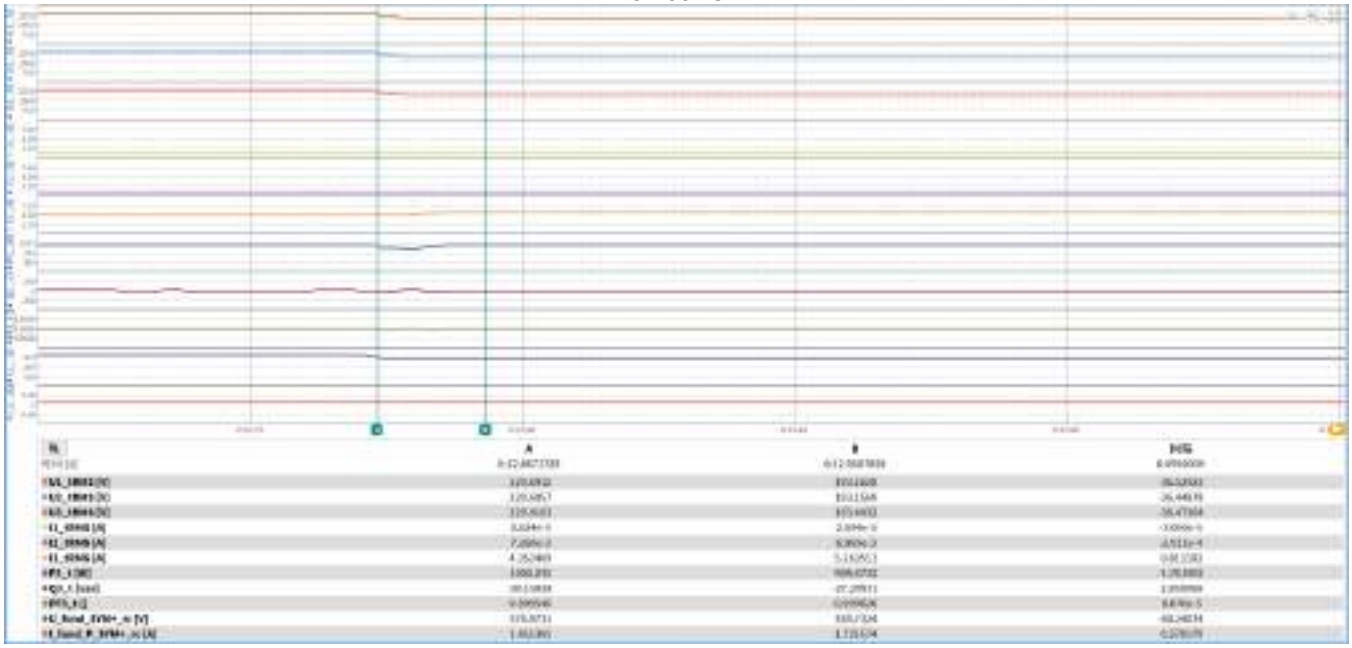
Load tests 4.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	4.1
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	61007
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,259
	10		Positive sequence			0,259
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,001
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,000
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,000
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,030
	16		Total	t_1-10 s to t_1	[p.u.]	-0,030
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9995
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,841
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	1,107
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	1,186
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,998
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,998
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,998
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,998
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,032
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,032
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

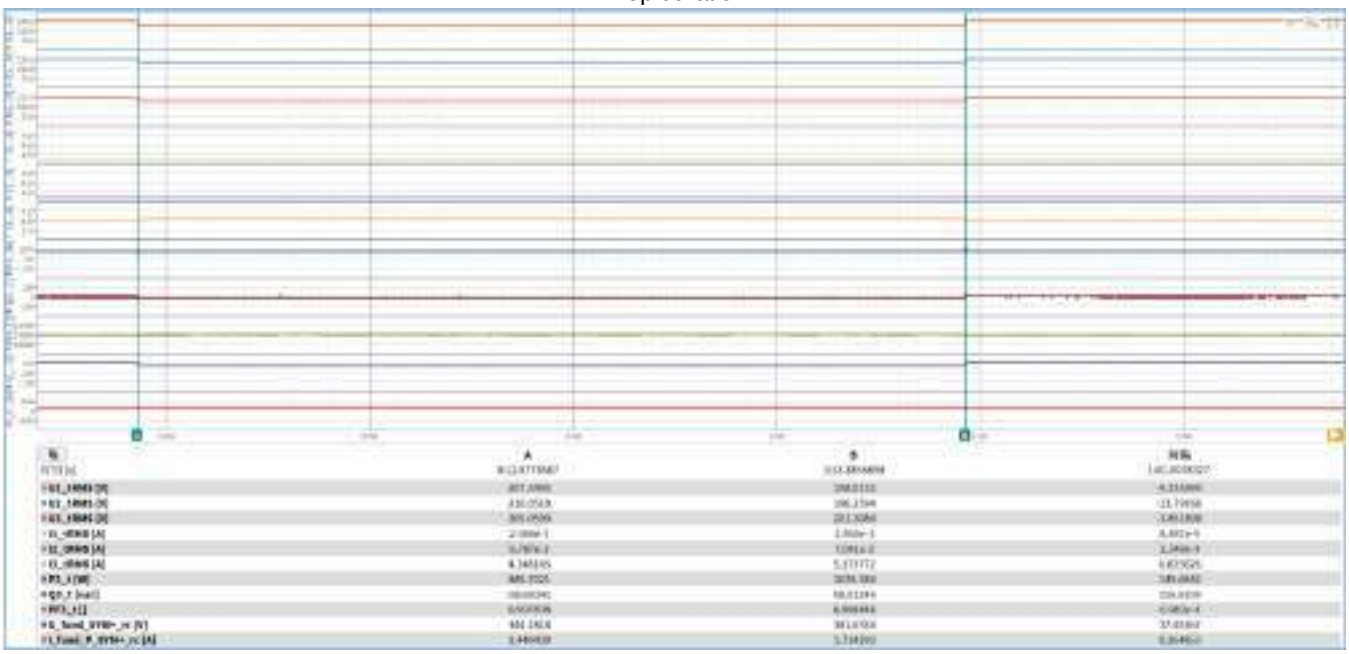
0-60ms



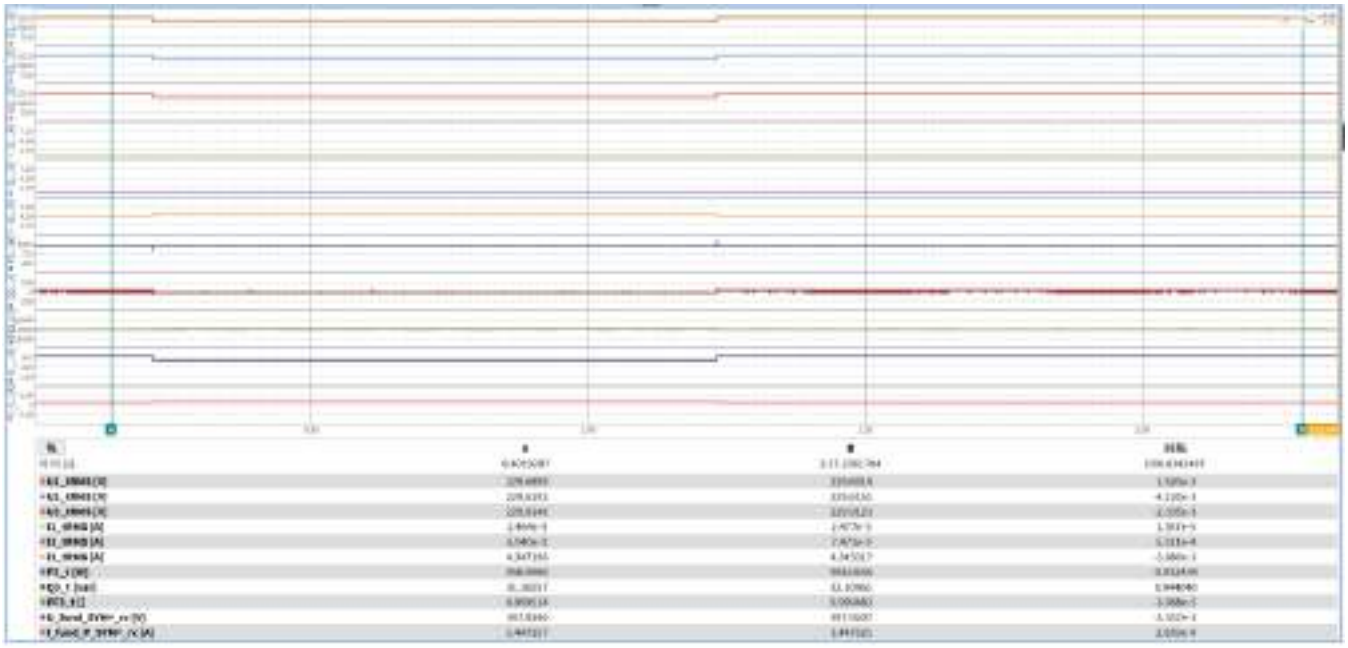
0-100ms



Drop duration



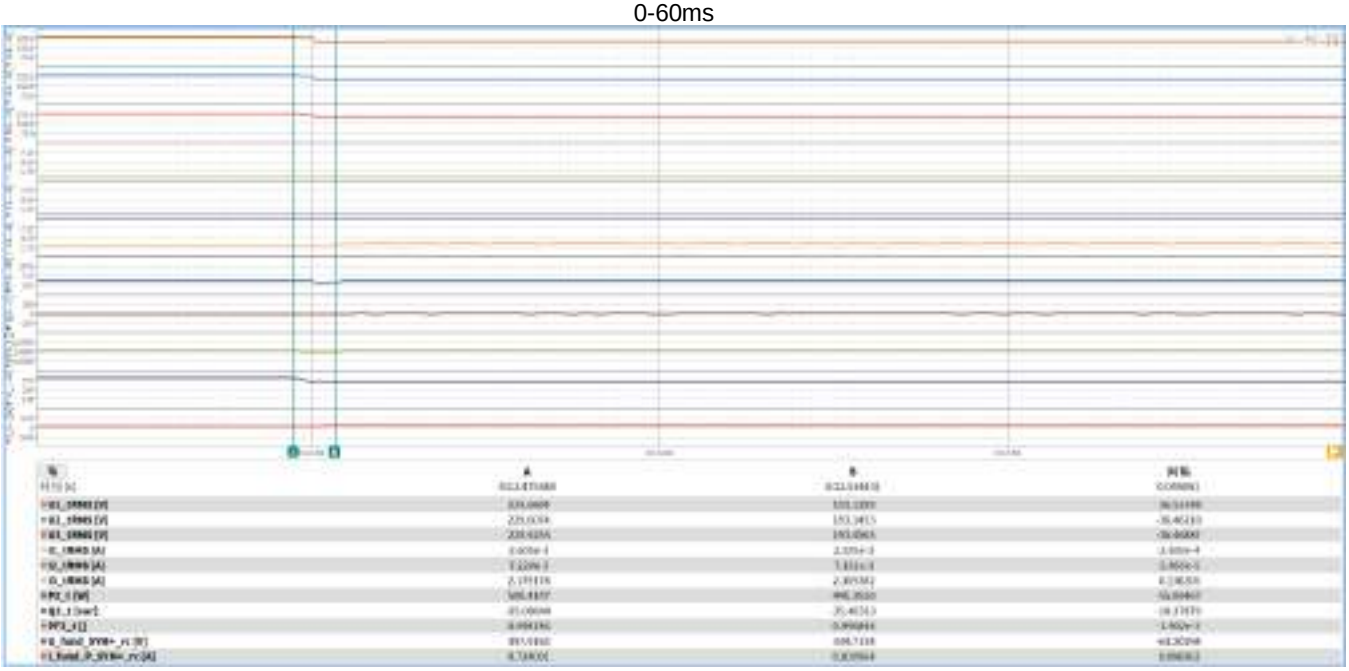
Recover time



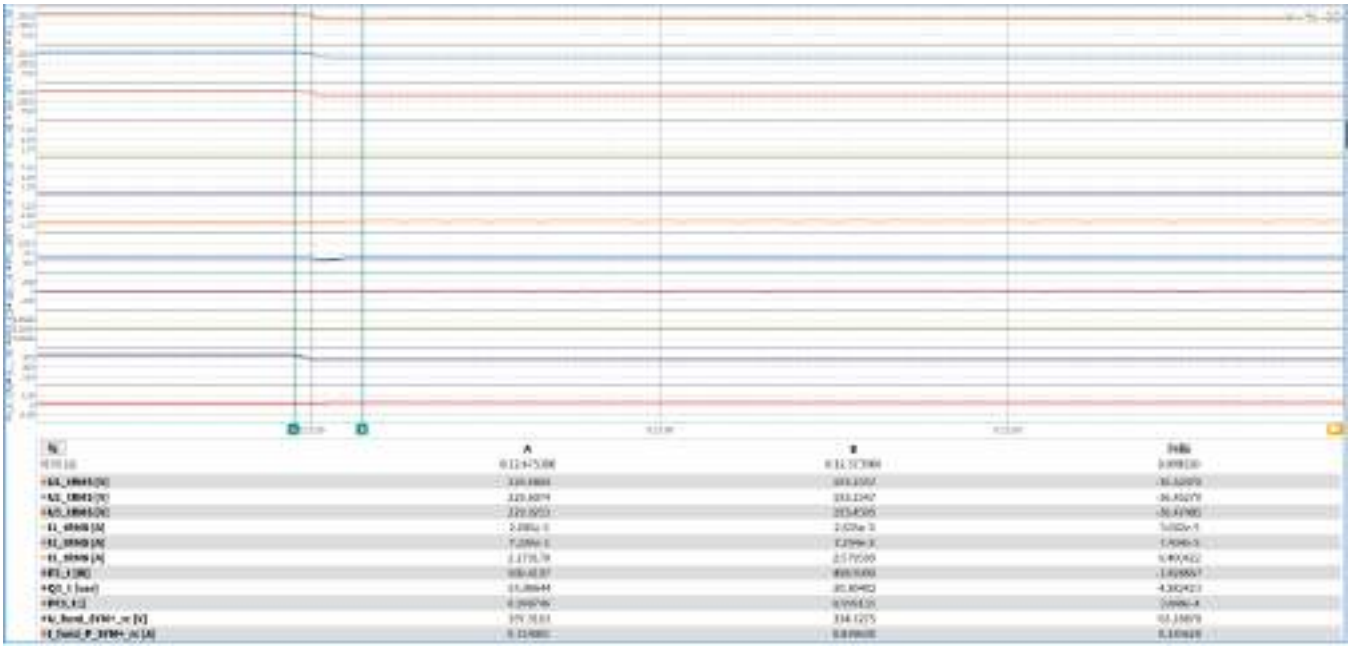
Load tests 4.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	4.2
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	61041
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,259
	10		Positive sequence			0,259
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,501
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,500
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,500
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,025
	16		Total	t_1-10 s to t_1	[p.u.]	-0,025
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9987
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,841
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,531
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,593
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,498
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,498
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,026
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,026
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

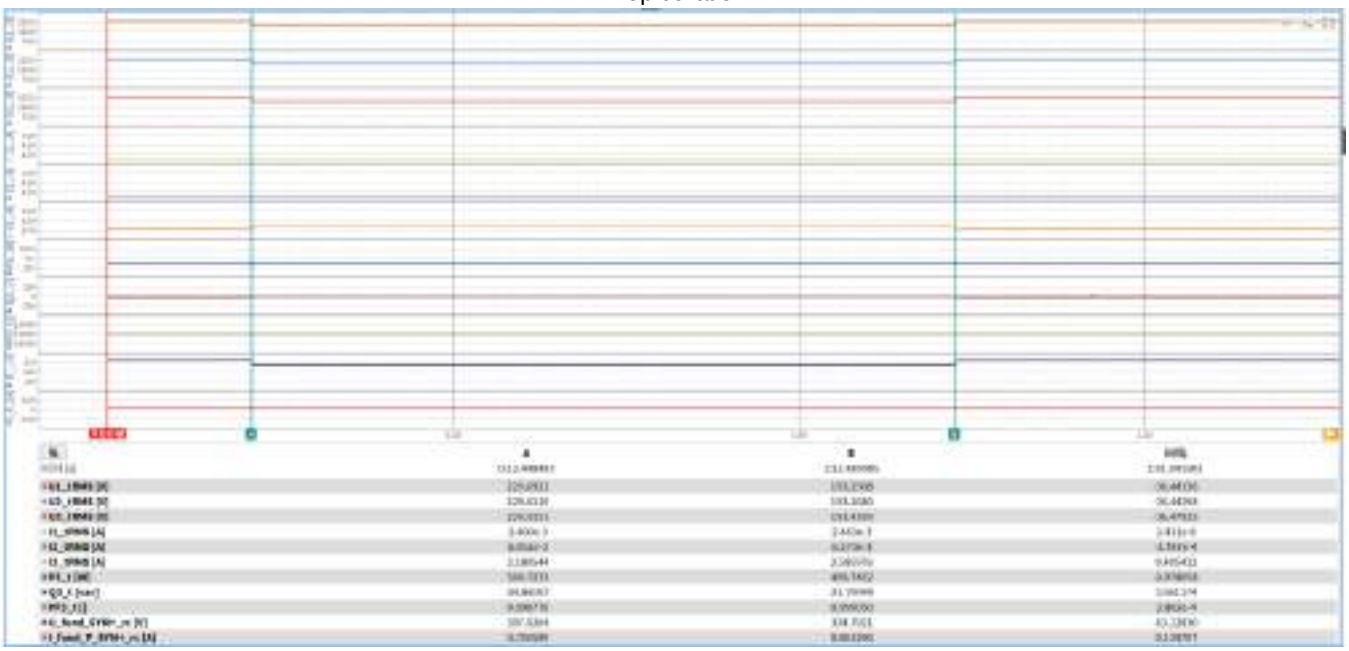
0-60ms



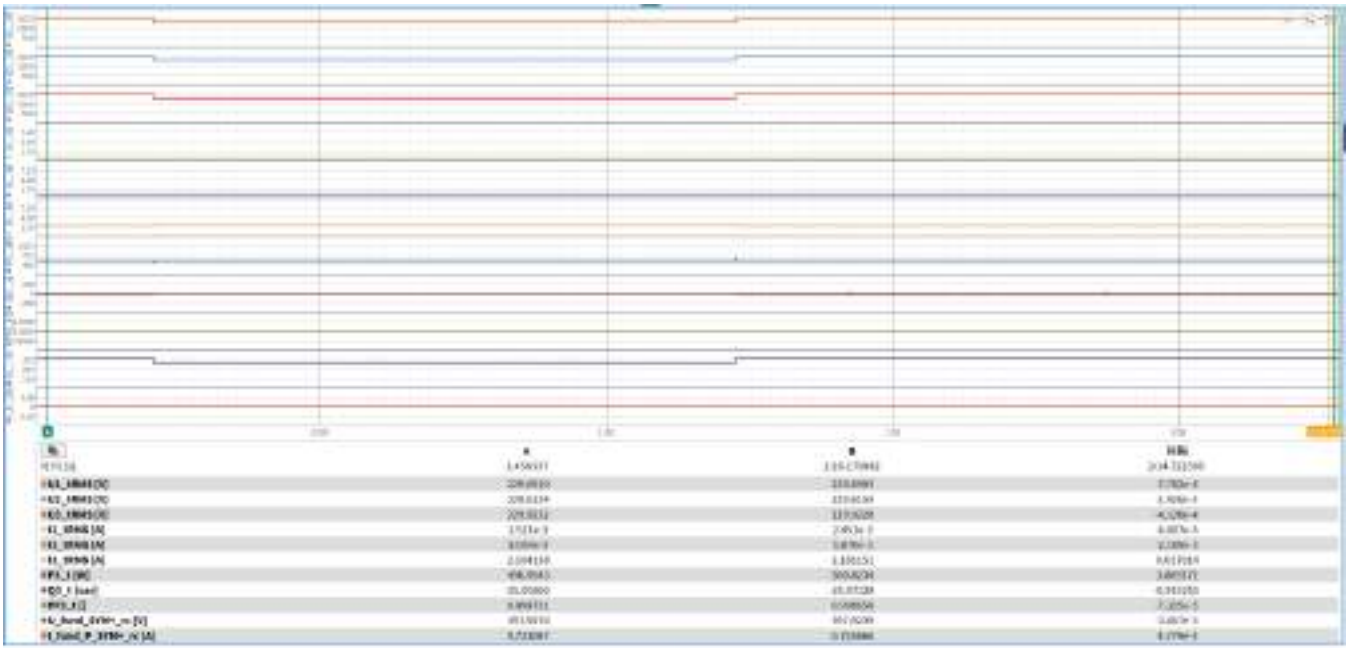
0-100ms



Drop duration



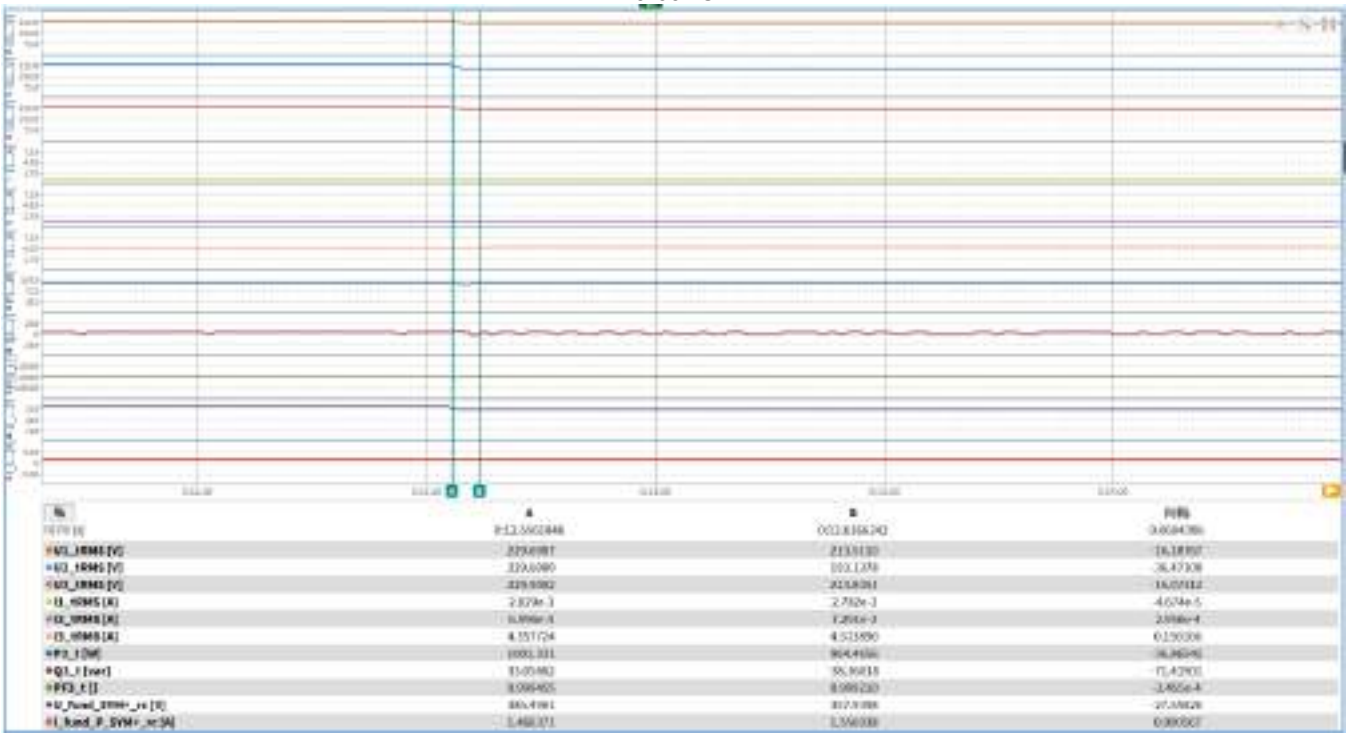
Recover time



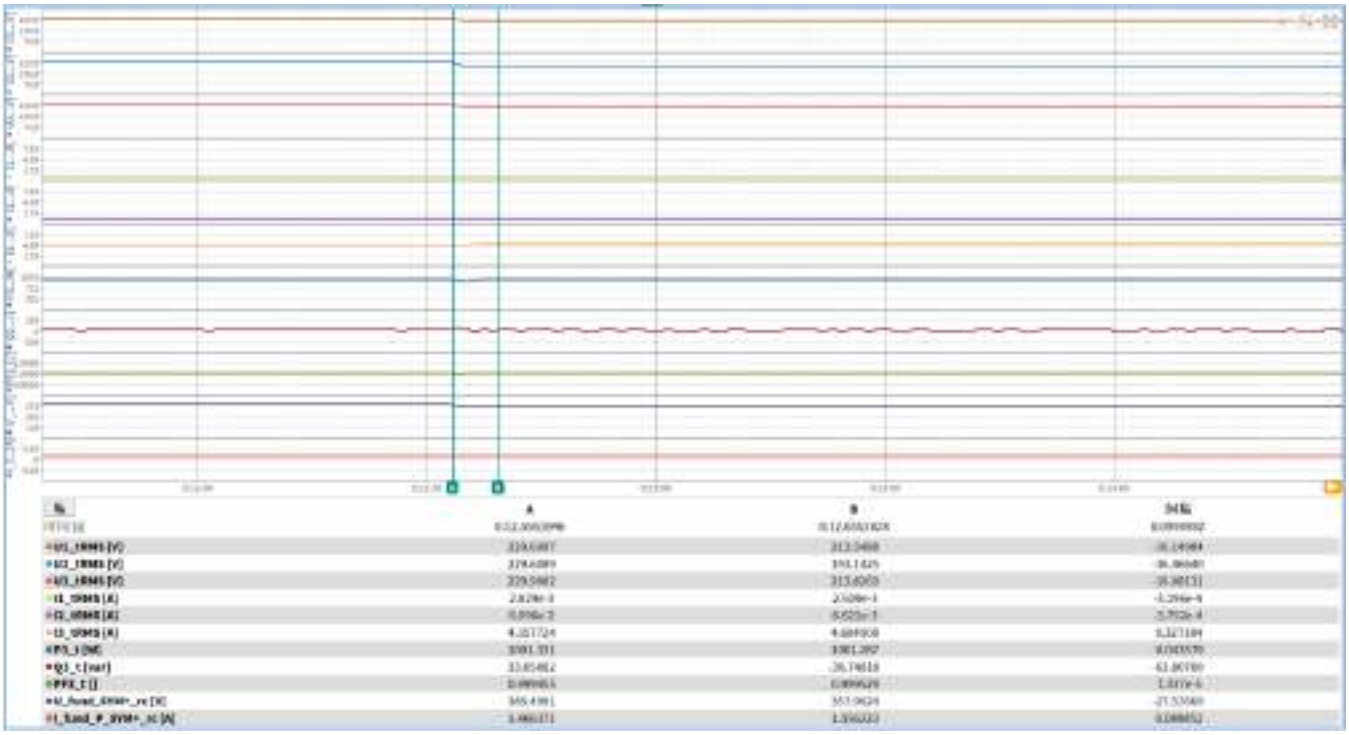
Load tests 4.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	4.3
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	60678
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,070
	10		Positive sequence			0,070
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,002
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,001
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,001
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,033
	16		Total	t_1-10 s to t_1	[p.u.]	0,033
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9995
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,930
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	1,038
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	1,077
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	1,001
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	1,001
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,001
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,001
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,033
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,033
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

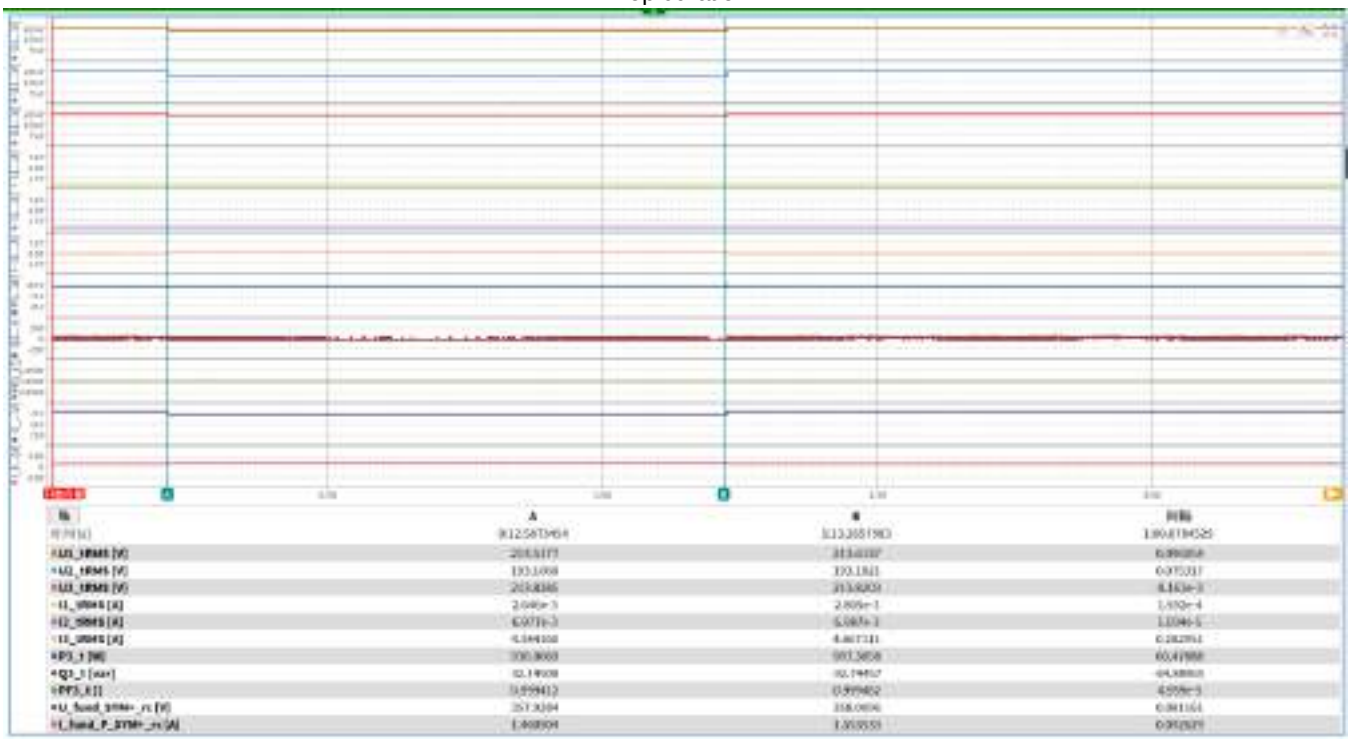
0-60ms



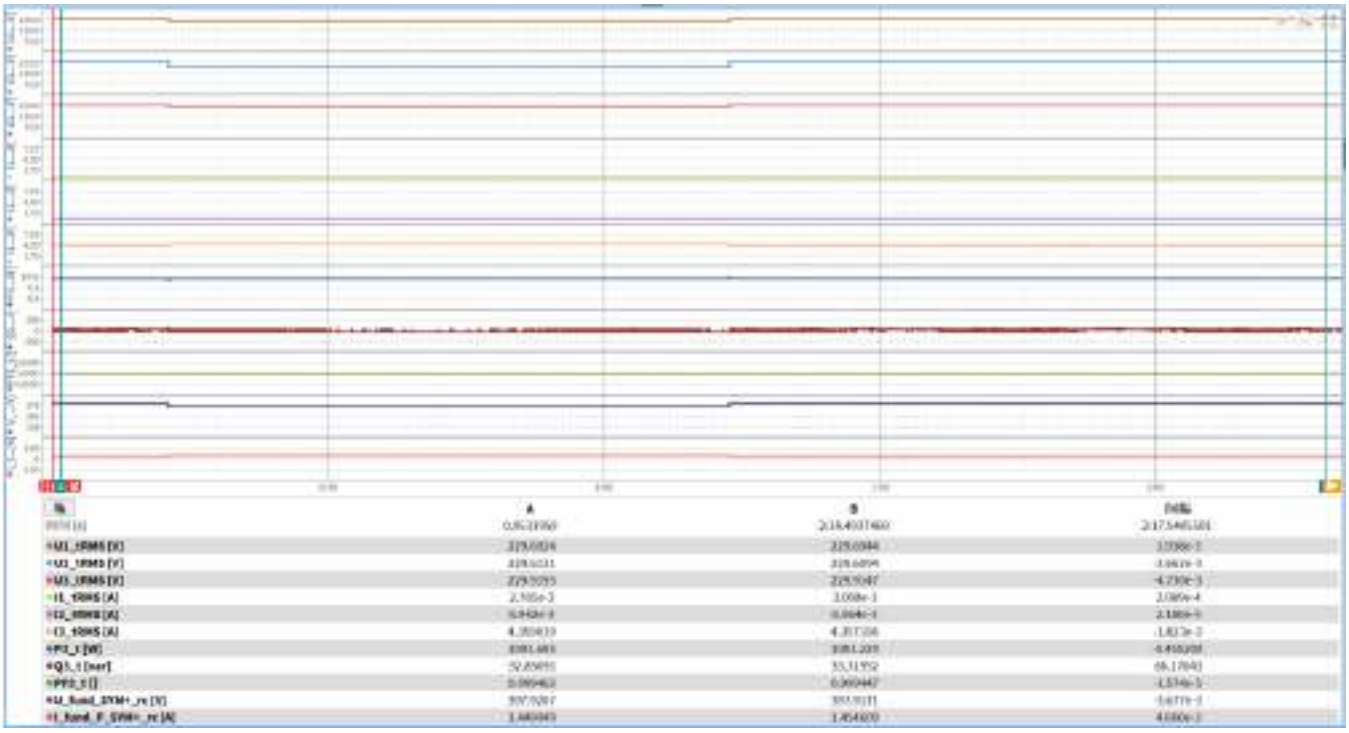
0-100ms



Drop duration



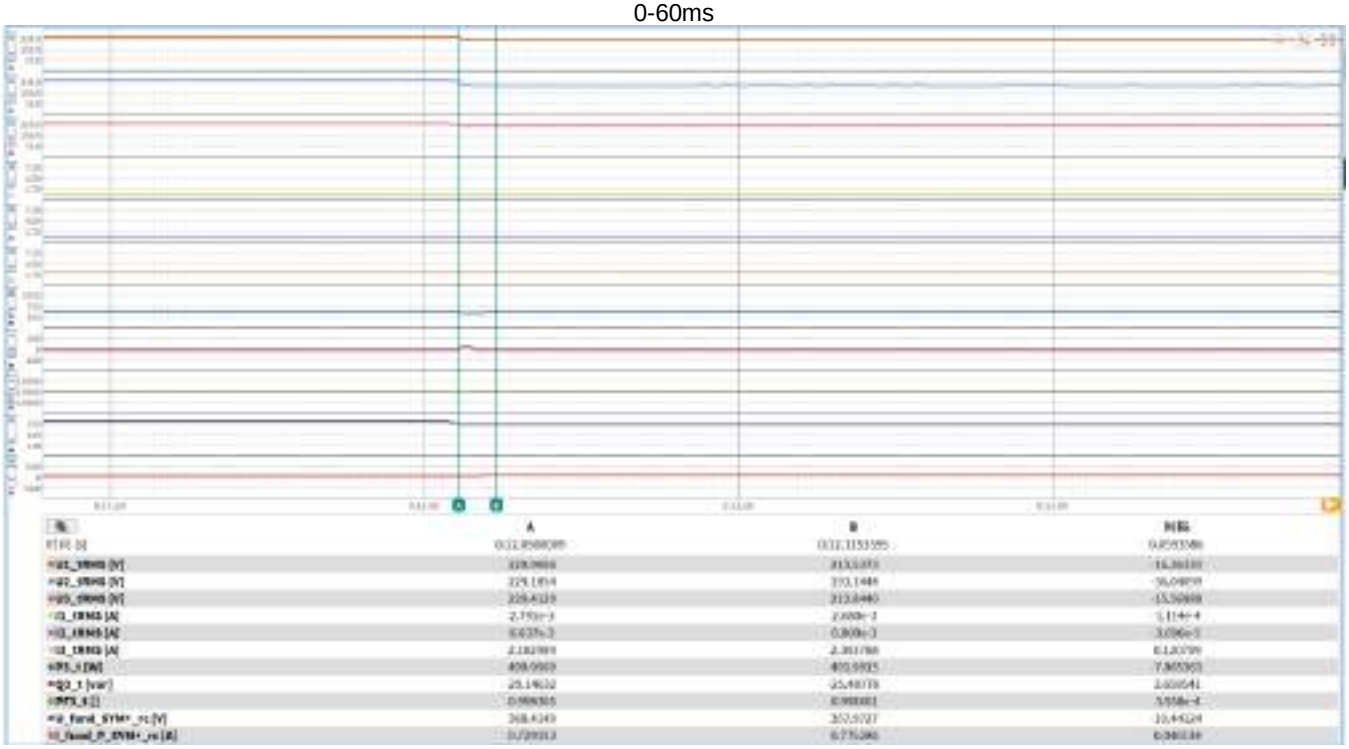
Recover time



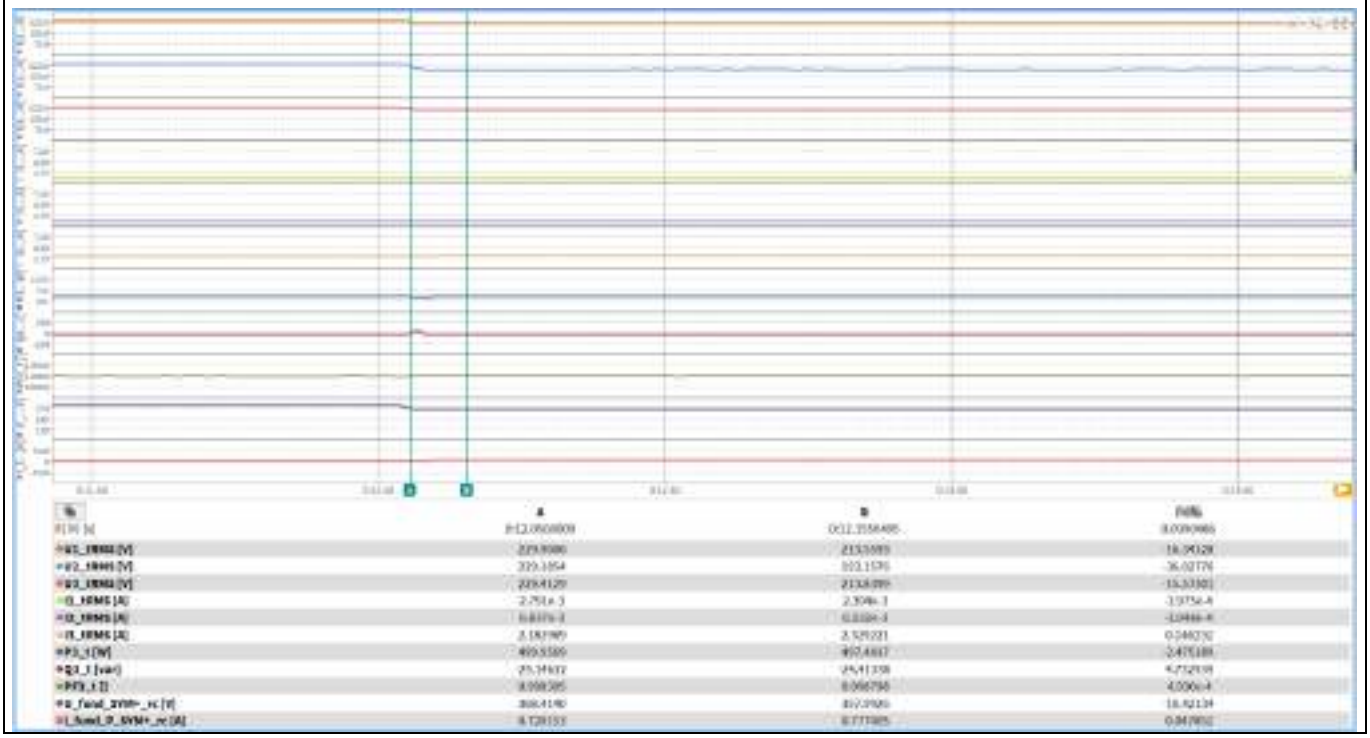
Load tests 4.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	4.4
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	0,85
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	60915
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,070
	10		Positive sequence			0,070
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,502
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,500
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,500
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,029
	16		Total	t_1-10 s to t_1	[p.u.]	-0,029
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9983
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	0,930
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,530
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,535
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,497
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,497
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,500
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,500
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,028
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,028
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

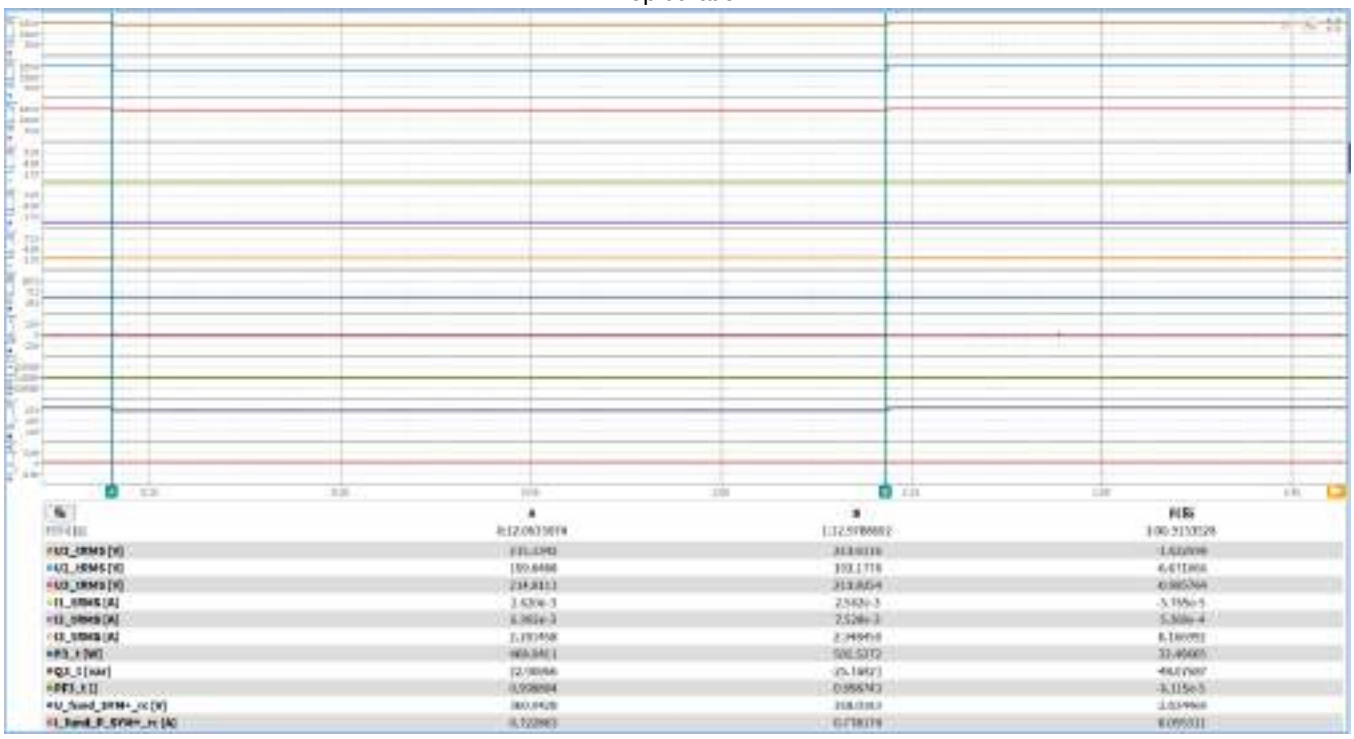
0-60ms



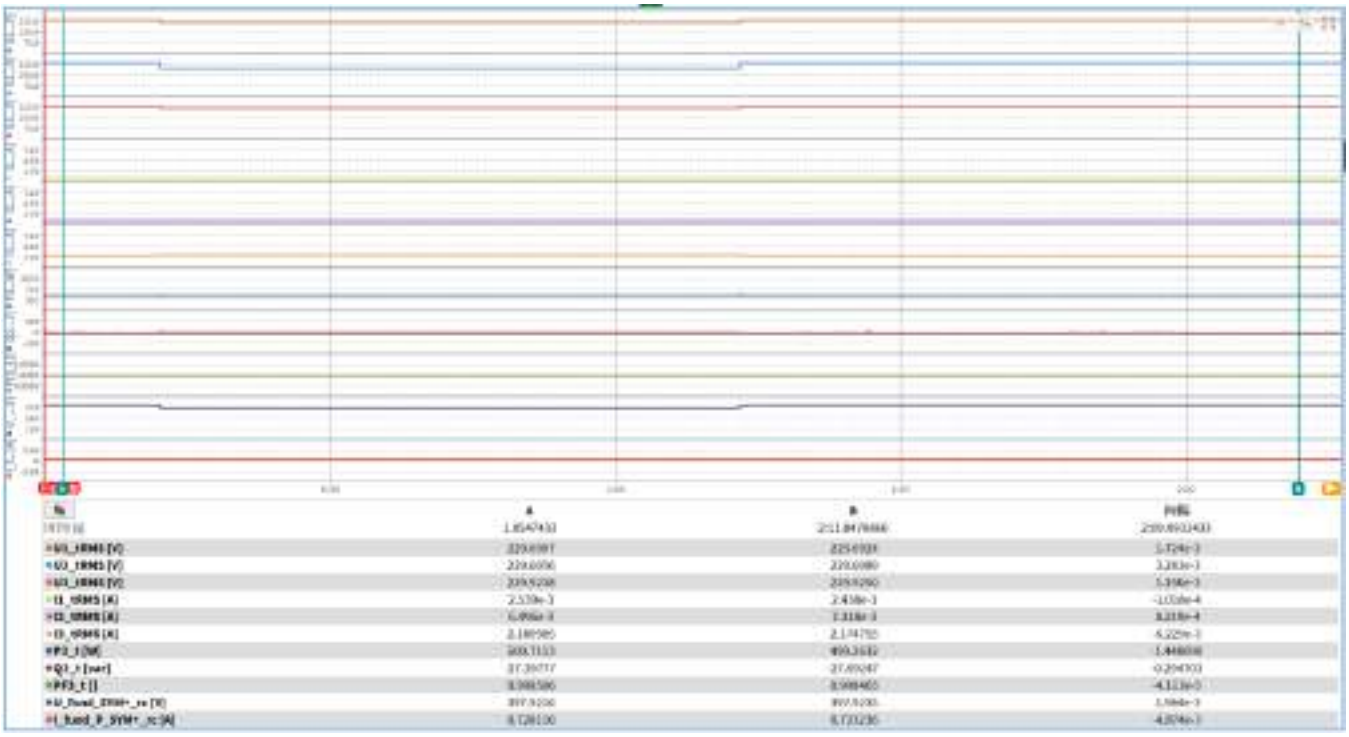
0-100ms



Drop duration



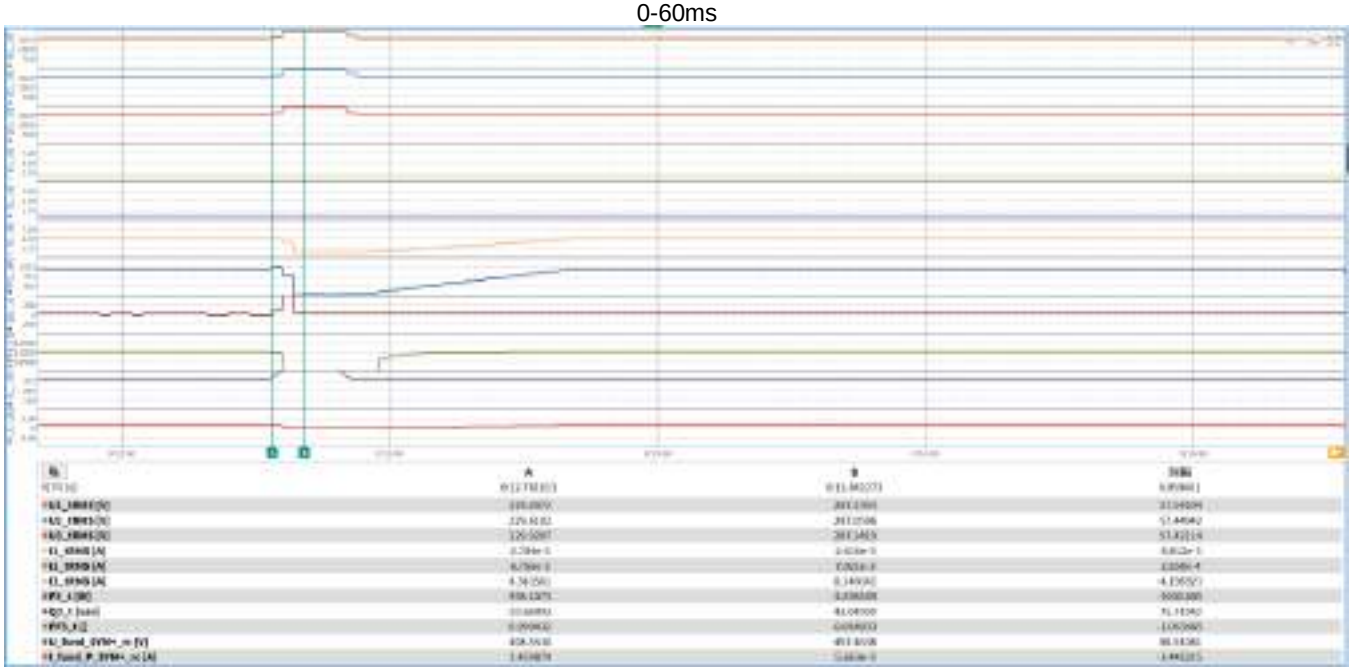
Recover time



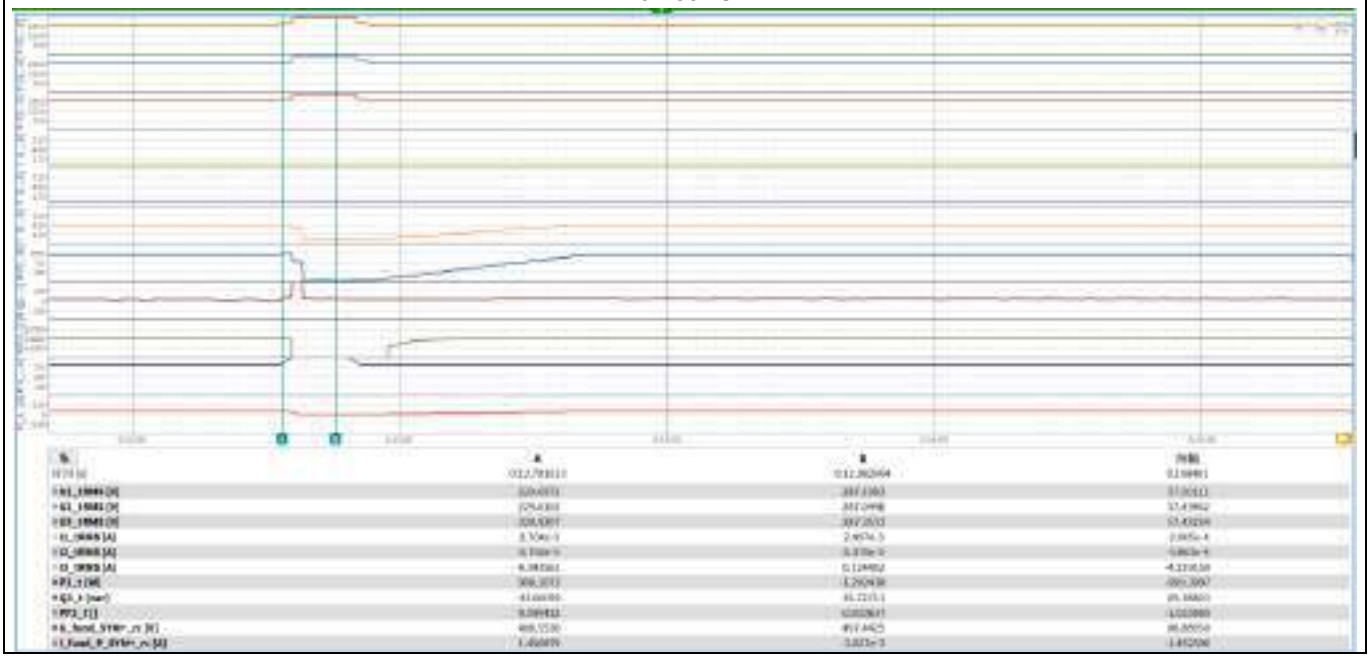
Load tests 5.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	5.1
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	1,25
	5	Drop duration setpoint	Total	–	[ms]	100
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	117
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,249
	10		Positive sequence			0,249
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,998
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,998
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,988
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,034
	16		Total	t_1-10 s to t_1	[p.u.]	-0,034
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9994
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,249
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,034
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,029
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,001
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,001
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	1,003
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,002
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,002
	30	Response time active power	Positive sequence	-	[s]	0,435
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,039
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,039
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

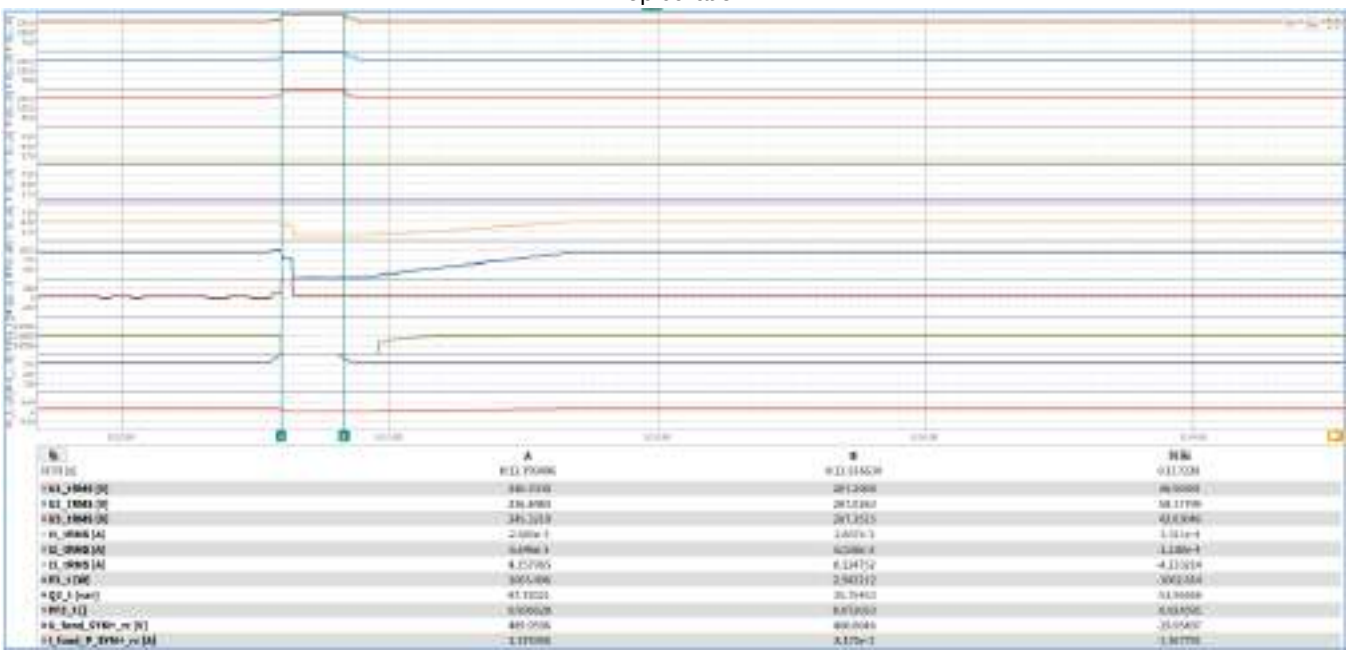
0-60ms



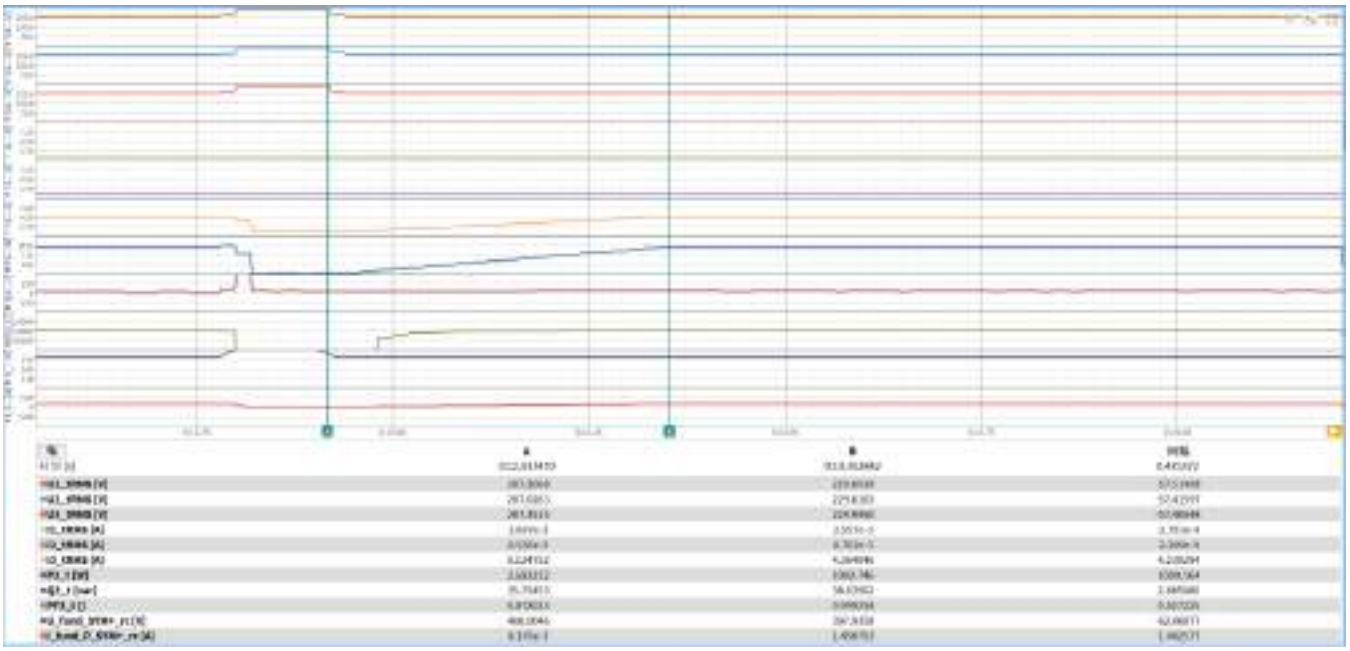
0-100ms



Drop duration



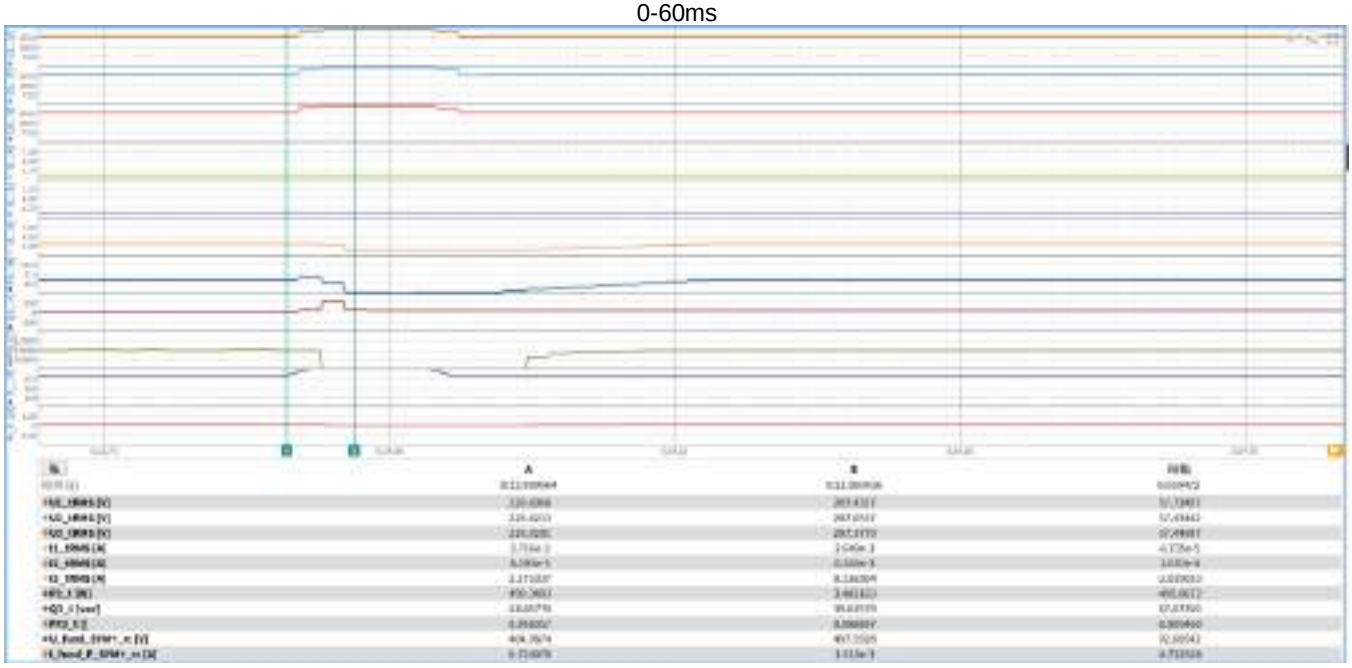
Recover time



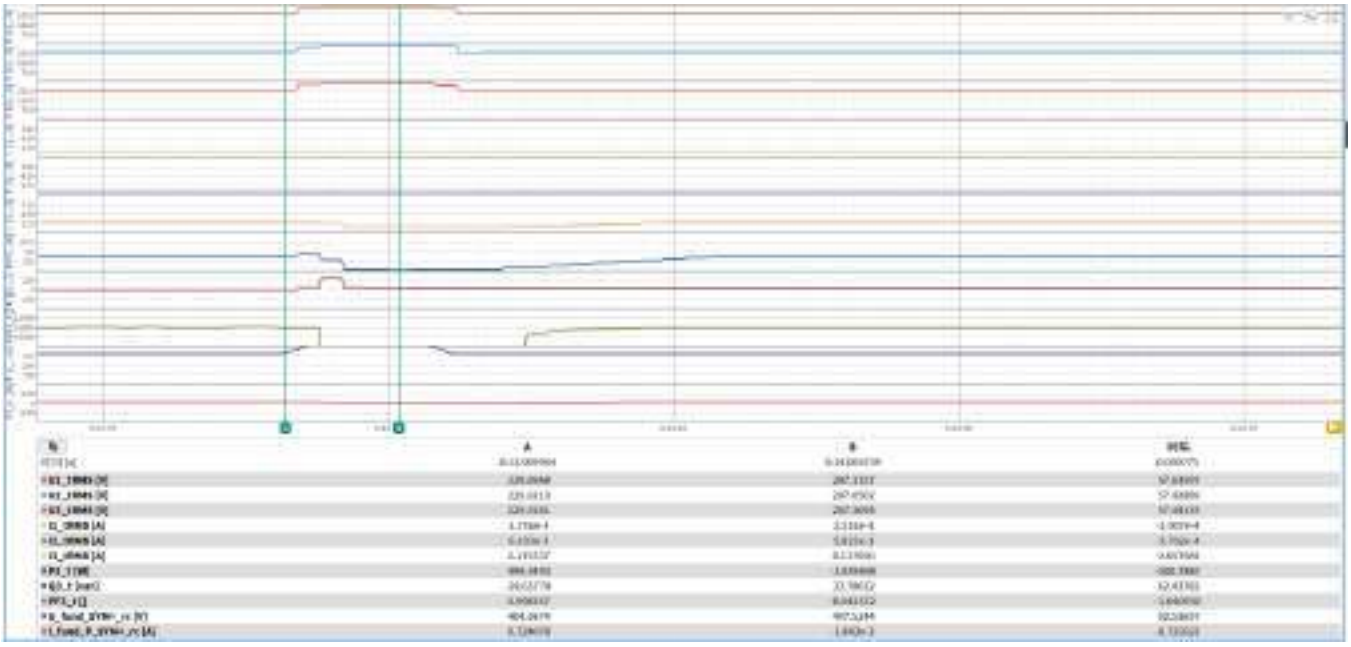
Load tests 5.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	5.2
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	1,25
	5	Drop duration setpoint	Total	–	[ms]	100
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	119
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,250
	10		Positive sequence			0,250
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,998
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,500
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,499
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,499
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,029
	16		Total	t_1-10 s to t_1	[p.u.]	-0,029
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9984
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,250
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,031
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,027
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,001
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,001
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,500
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,500
	30	Response time active power	Positive sequence	-	[s]	0,309
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,032
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,032
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

0-60ms

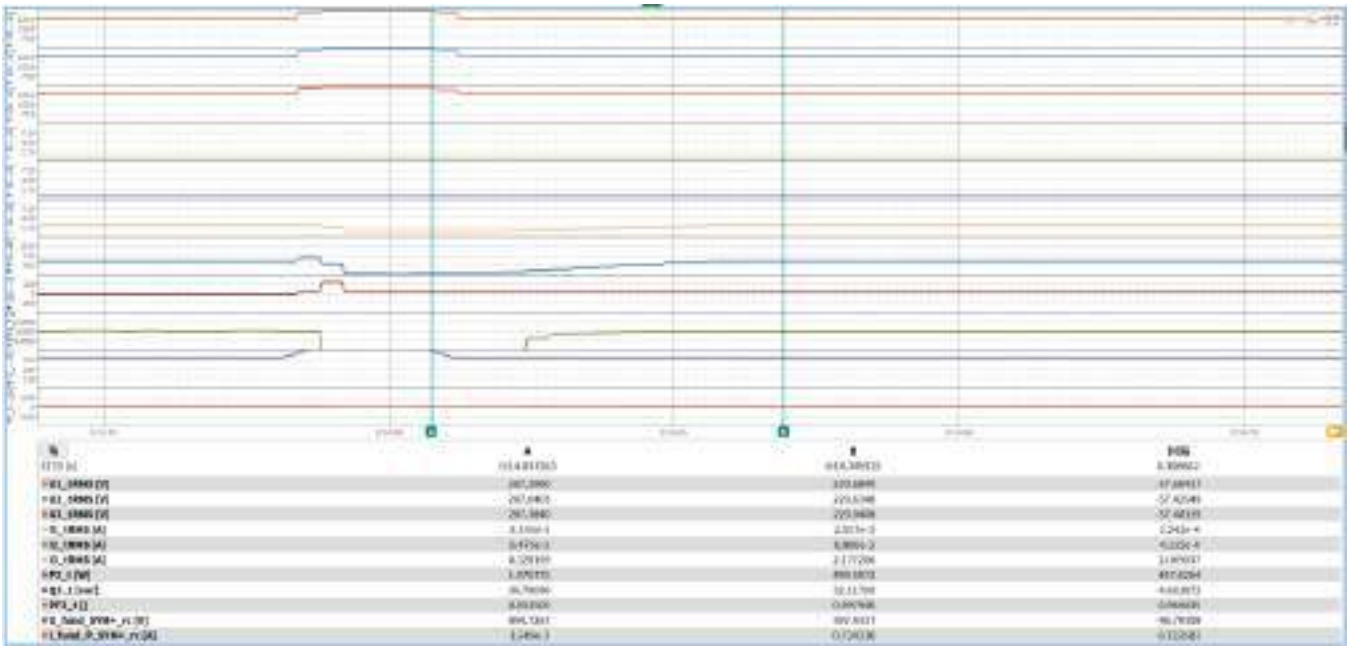


0-100ms



Drop duration

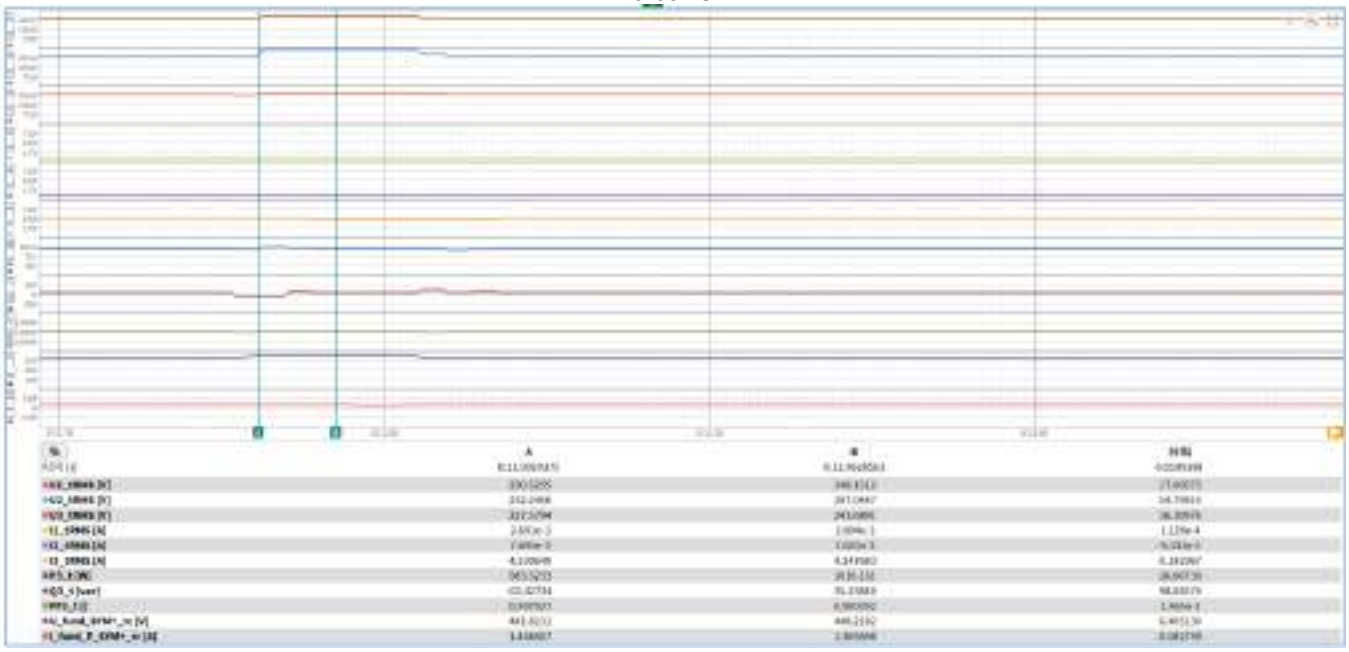
Recover time



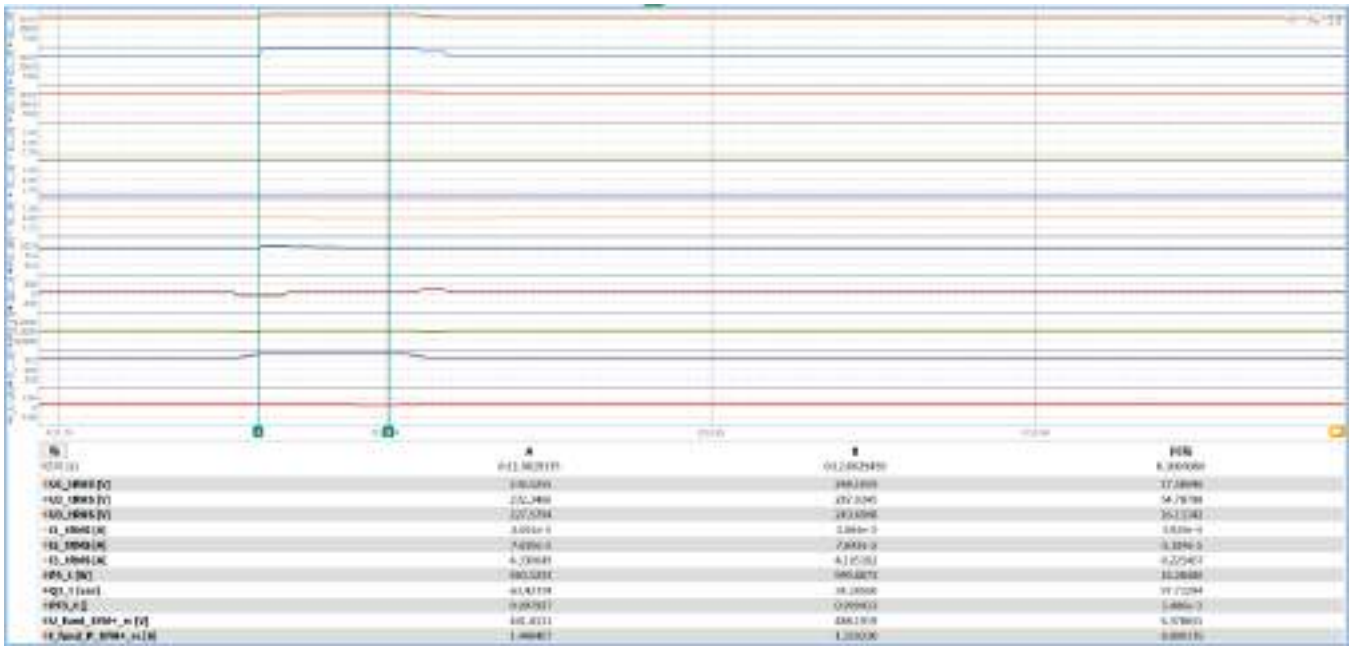
Load tests 5.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	5.3
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	1,25
	5	Drop duration setpoint	Total	–	[ms]	100
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	118
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,060
	10		Positive sequence			0,060
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,997
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,995
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,983
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,983
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,063
	16		Total	t_1-10 s to t_1	[p.u.]	-0,063
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9979
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,060
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,953
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,951
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,999
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,999
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,000
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,000
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,033
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,033
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

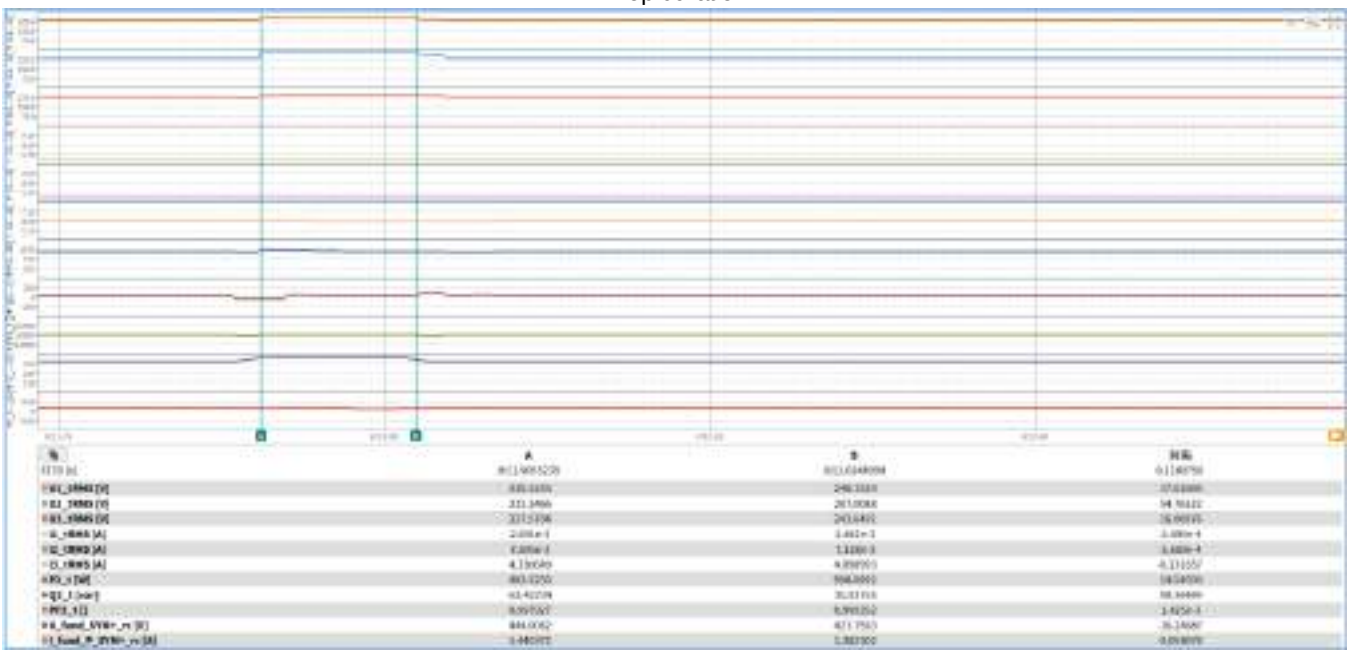
0-60ms



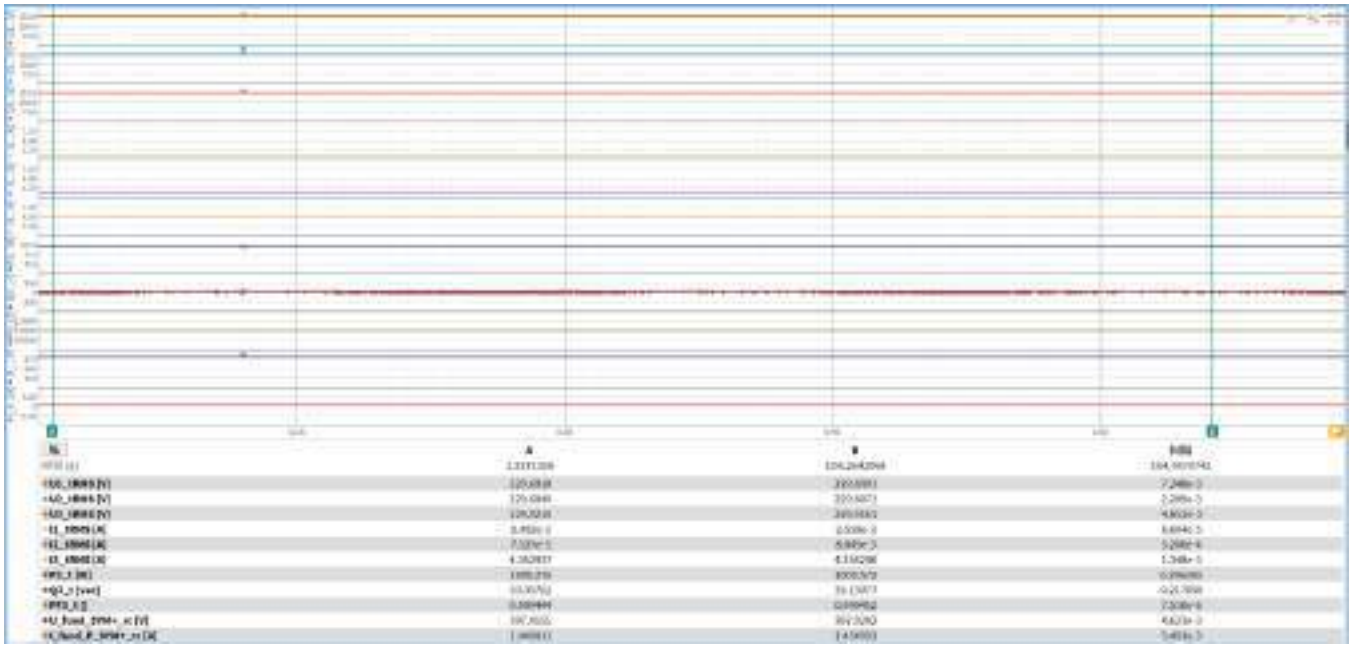
0-100ms



Drop duration



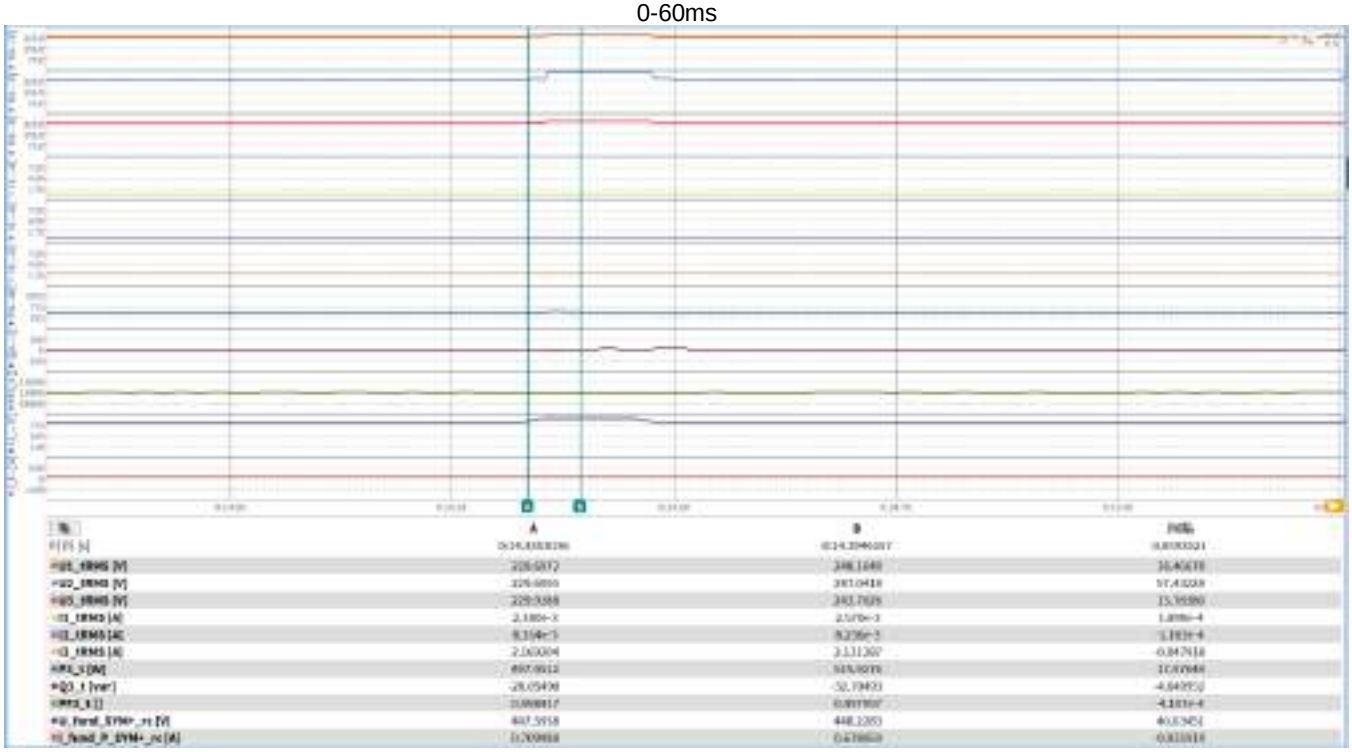
Recover time



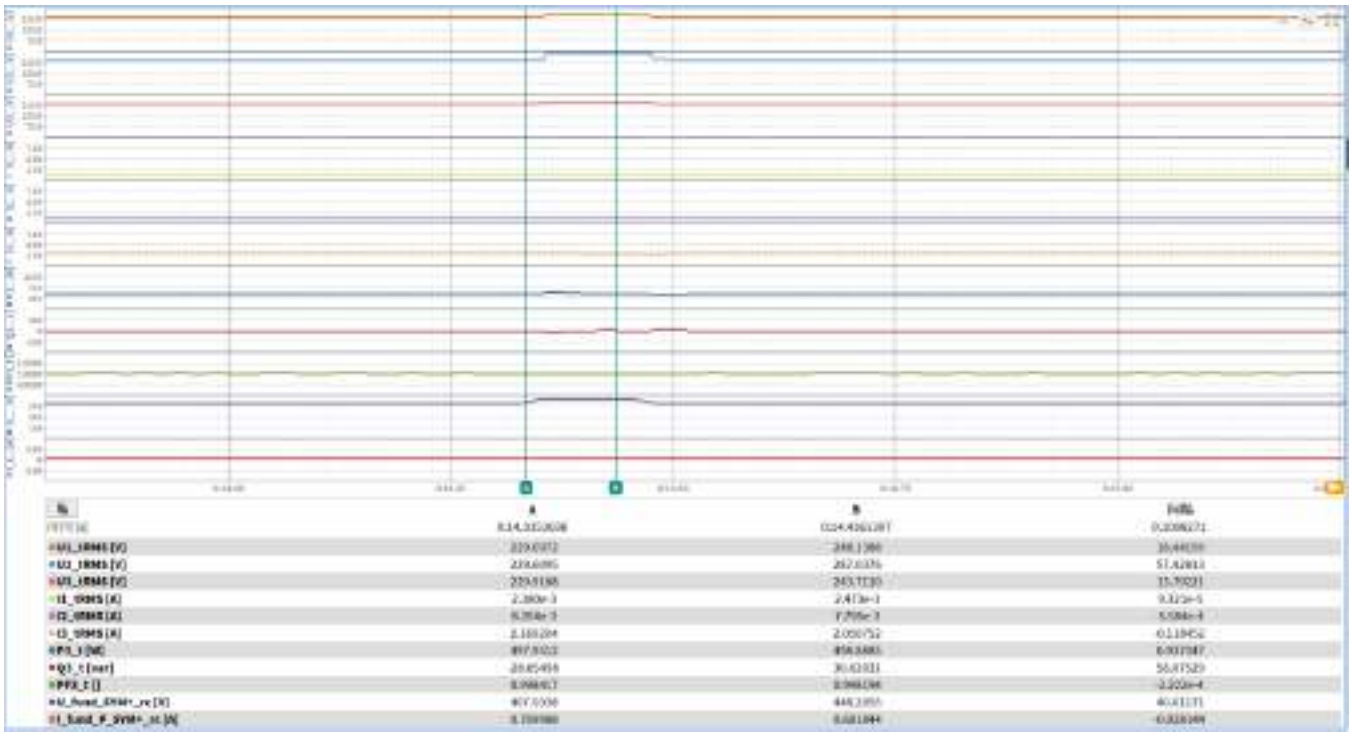
Load tests 5.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	5.4
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	1,25
	5	Drop duration setpoint	Total	–	[ms]	100
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	116
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,060
	10		Positive sequence			0,060
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,998
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,499
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,498
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,498
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,028
	16		Total	t_1-10 s to t_1	[p.u.]	-0,028
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9984
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,060
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,487
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,471
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,499
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,499
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,998
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,502
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,502
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

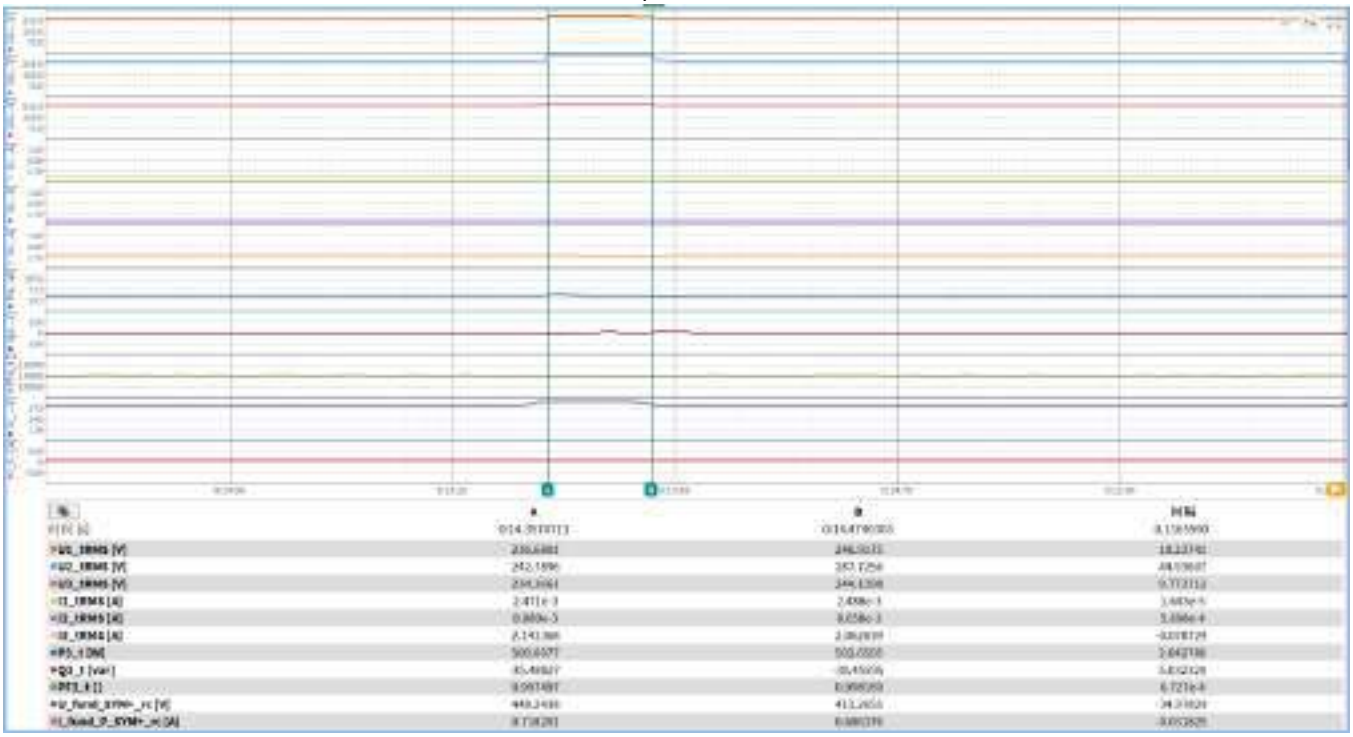
0-60ms



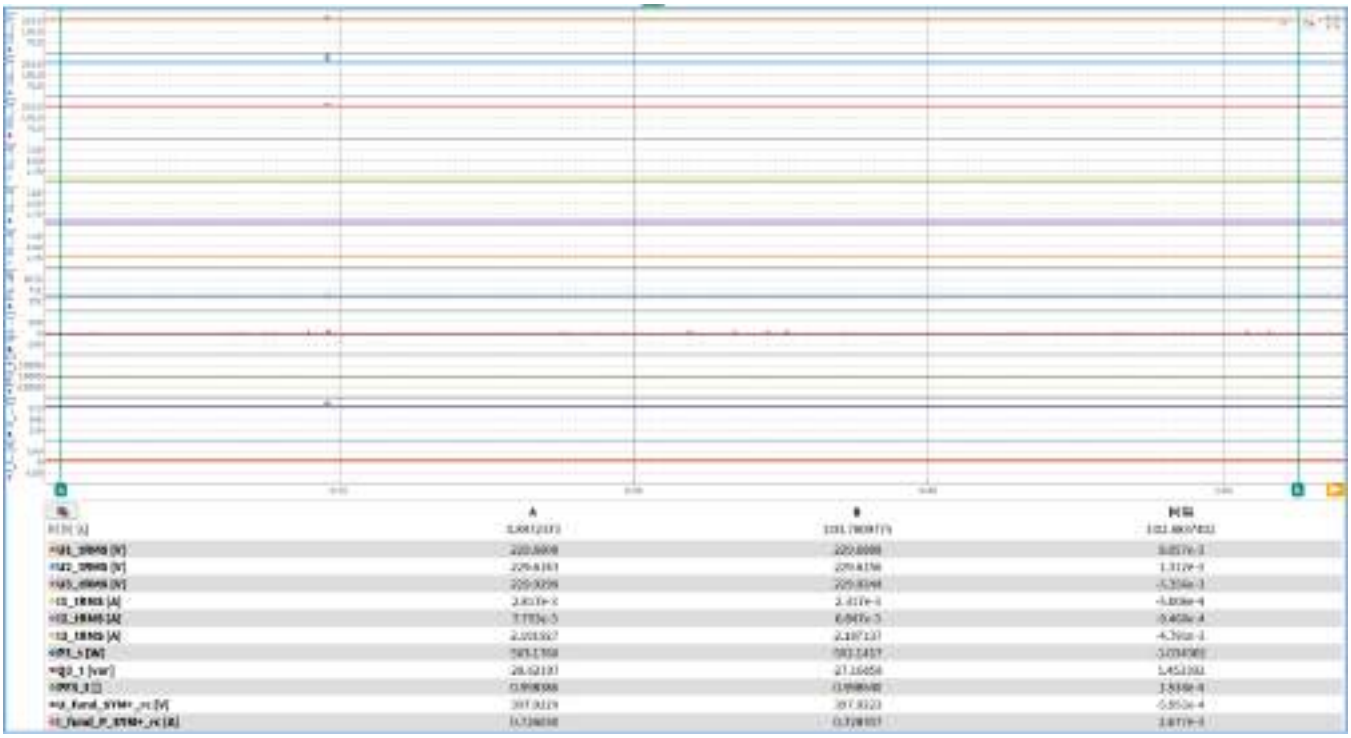
0-100ms



Drop duration



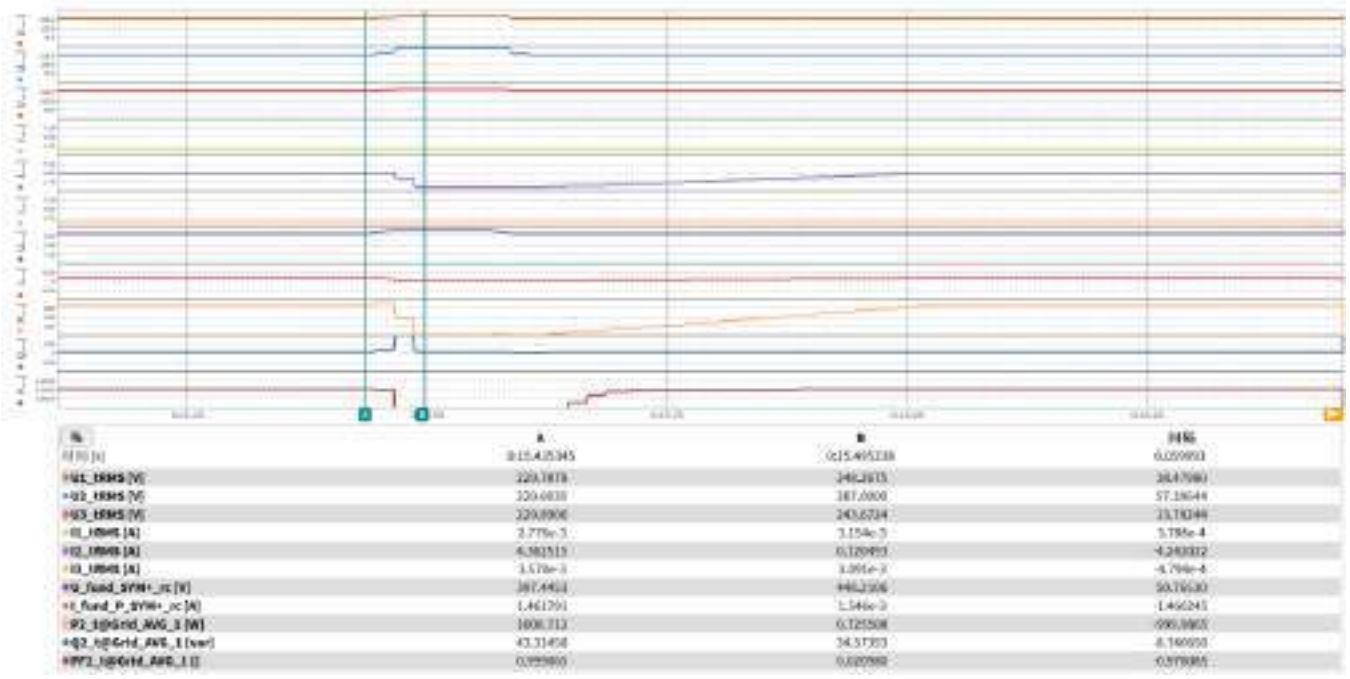
Recover time



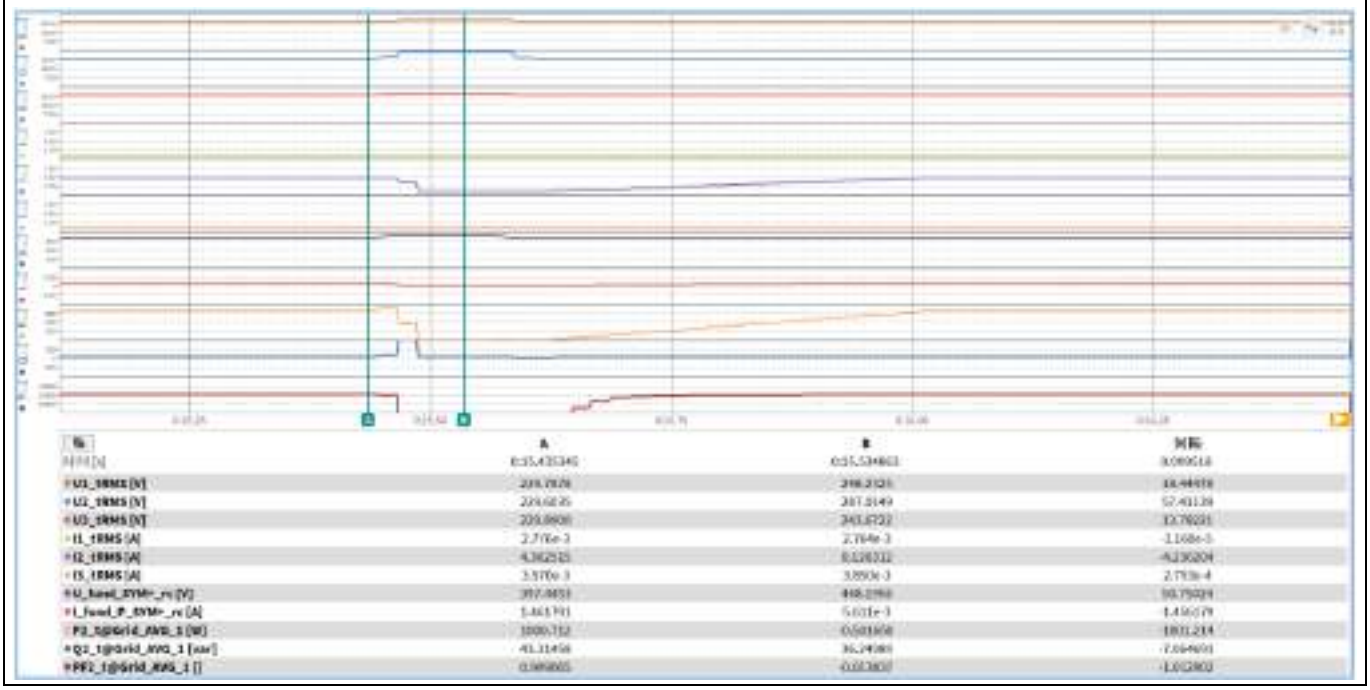
Load tests 5.5

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	5.5
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D2
	4	Drop depth setpoint	Phase	–	[p.u]	1,25
	5	Drop duration setpoint	Total	–	[ms]	100
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	114
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,248
	10		Positive sequence			0,248
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,002
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,000
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,000
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,043
	16		Total	t_1-10 s to t_1	[p.u.]	0,043
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9991
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,248
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	0,028
	21		Phase 3	t_1+60 ms	[p.u.]	N/A
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	0,029
	24		Phase 3	t_1 +100 ms	[p.u.]	N/A
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,0
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,0
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,398
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,398
	30	Response time active power	Positive sequence	-	[s]	0,434
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,044
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,044
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

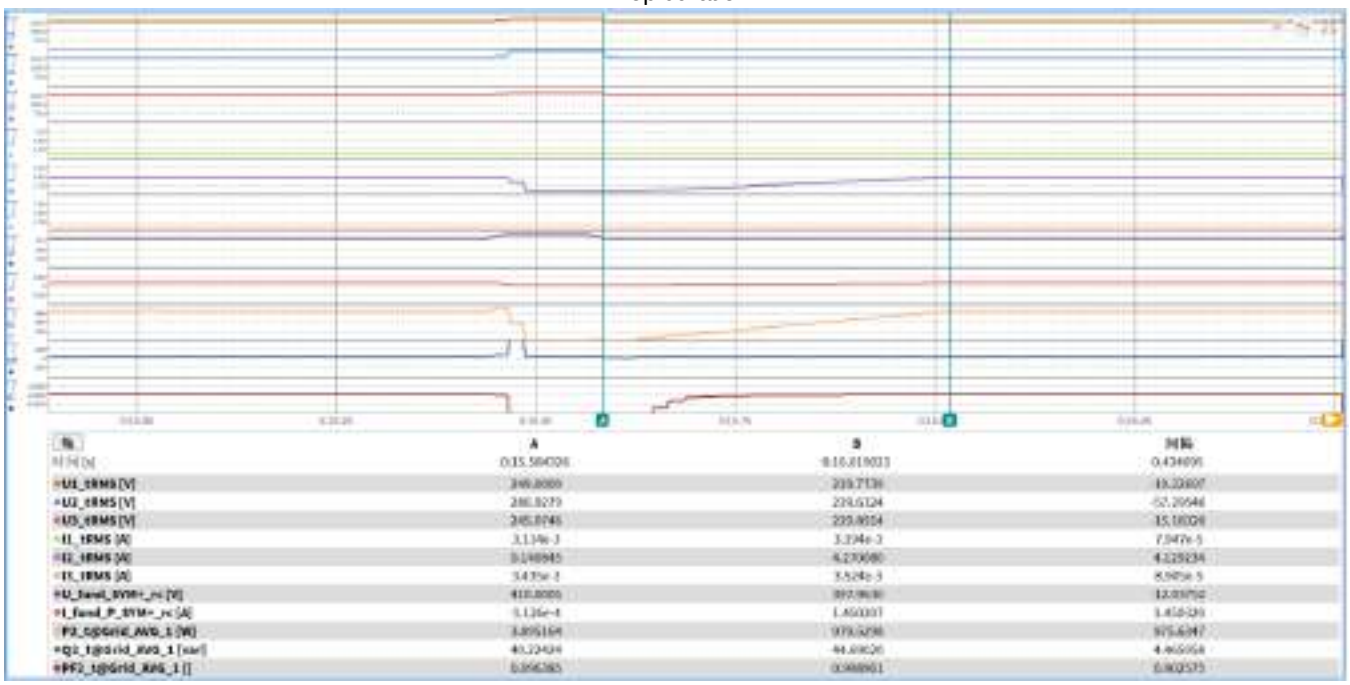
0-60ms



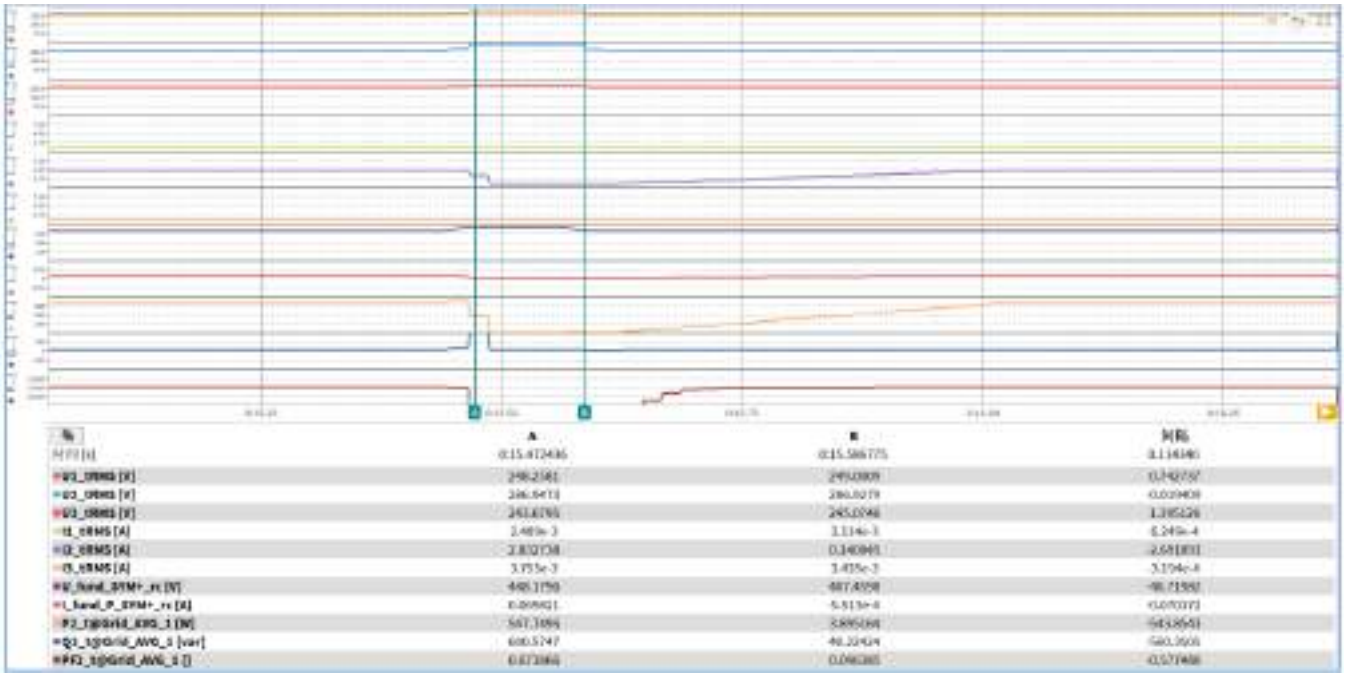
0-100ms



Drop duration



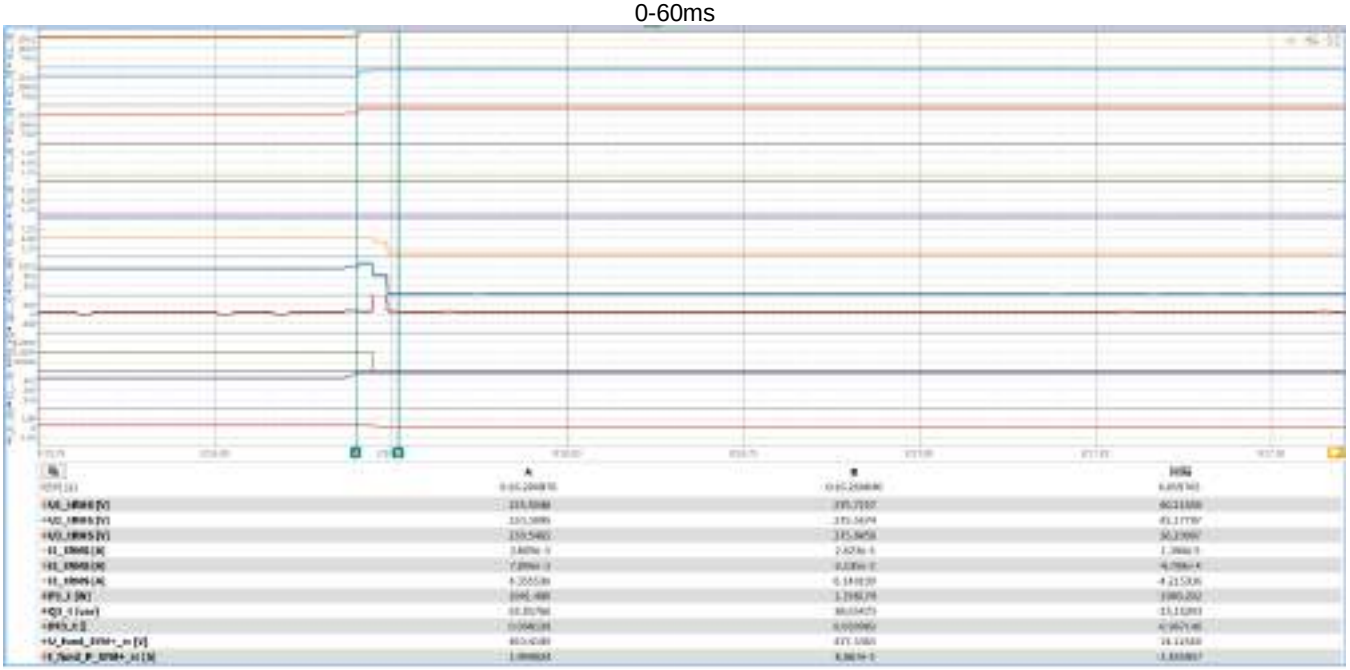
Recover time



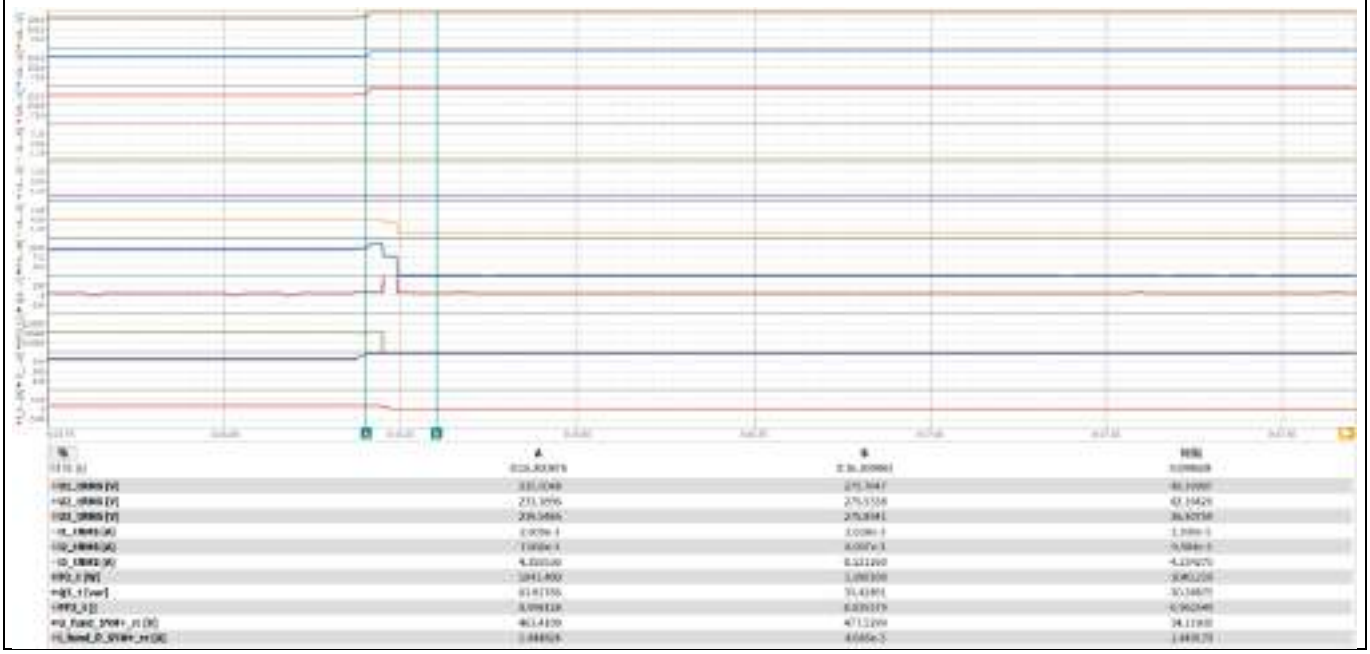
Load tests 6.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	6.1
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	1,20
	5	Drop duration setpoint	Total	–	[ms]	5000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	5192
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,200
	10		Positive sequence			0,200
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	1,039
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,002
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,041
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,041
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,064
	16		Total	t_1-10 s to t_1	[p.u.]	0,064
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9981
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,200
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,032
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,028
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,001
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,001
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,002
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,002
	30	Response time active power	Positive sequence	-	[s]	0,499
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,039
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,039
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

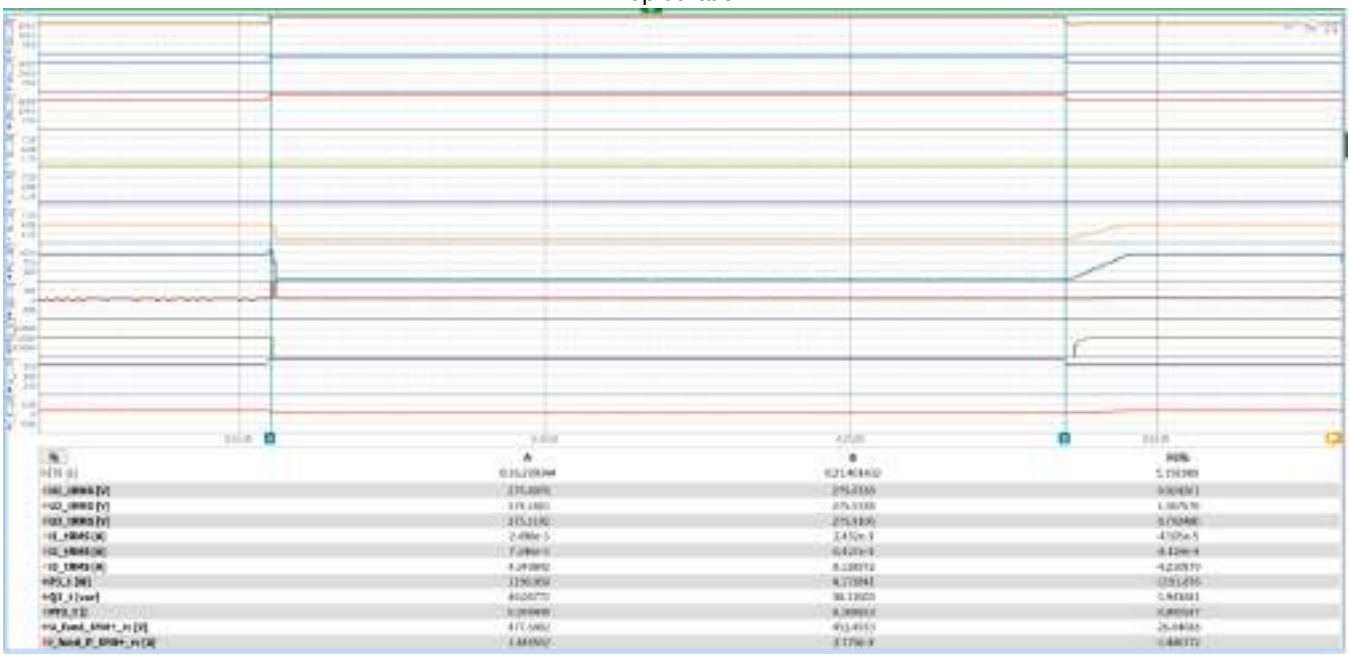
0-60ms



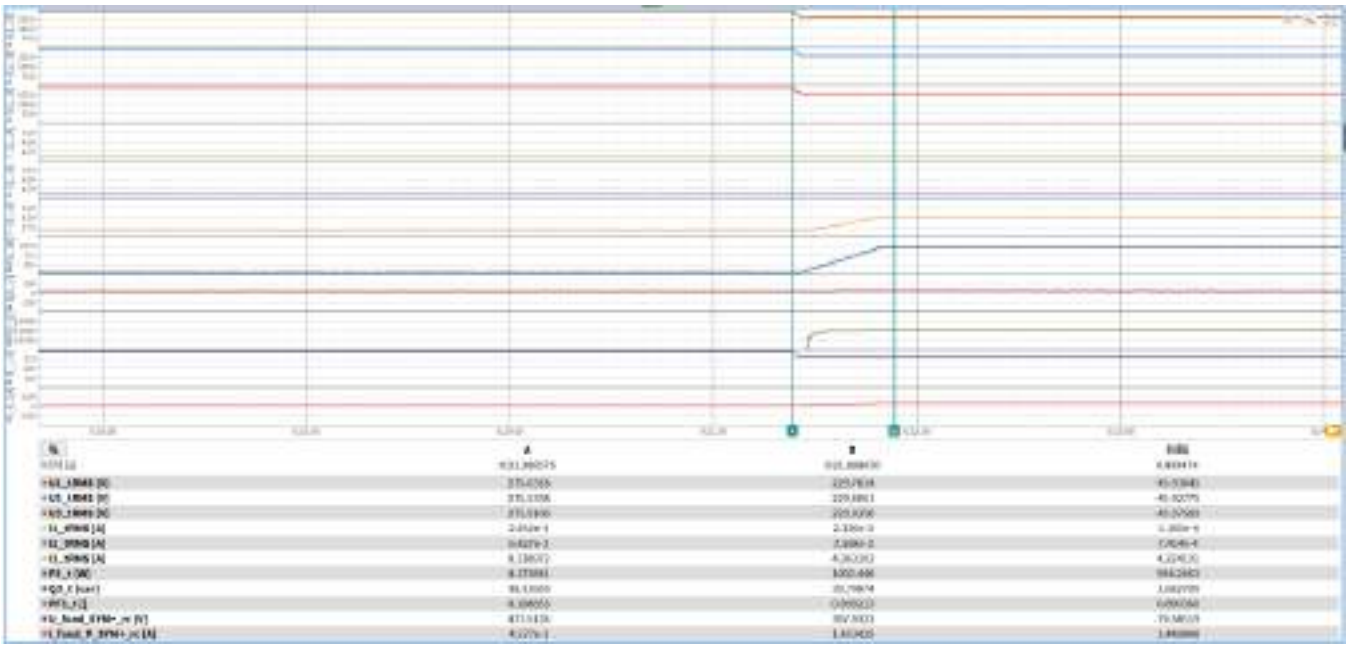
0-100ms



Drop duration



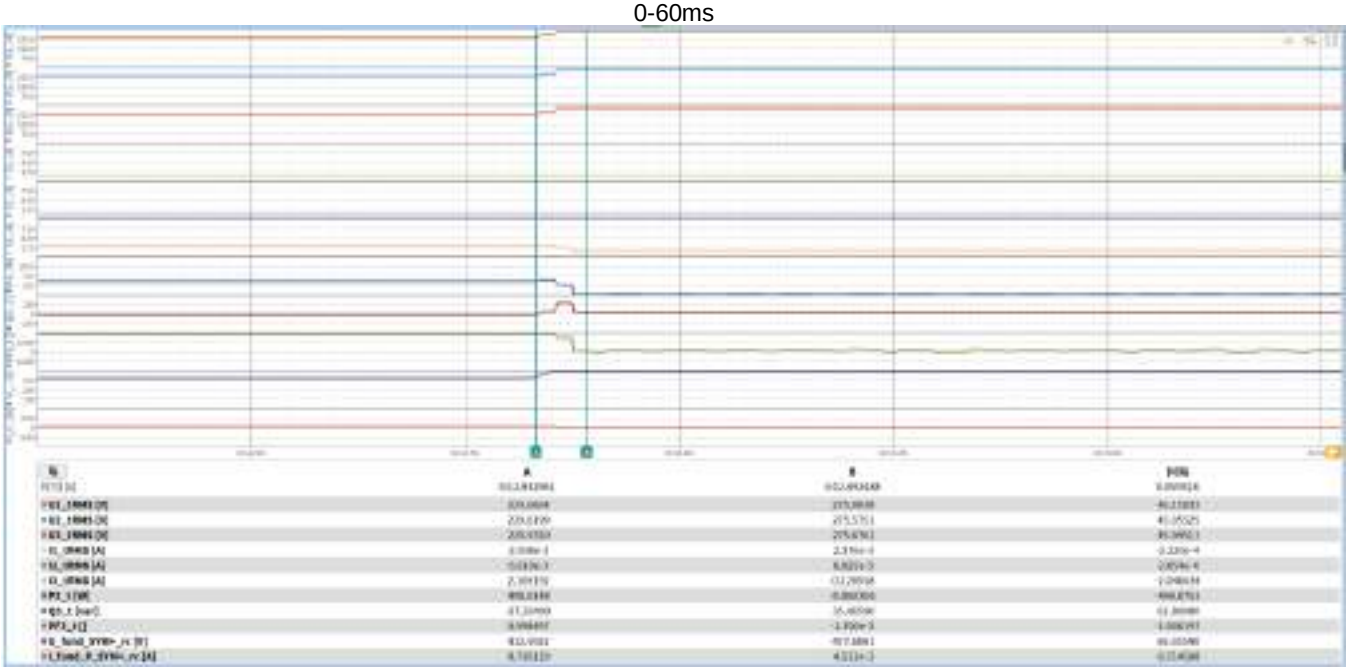
Recover time



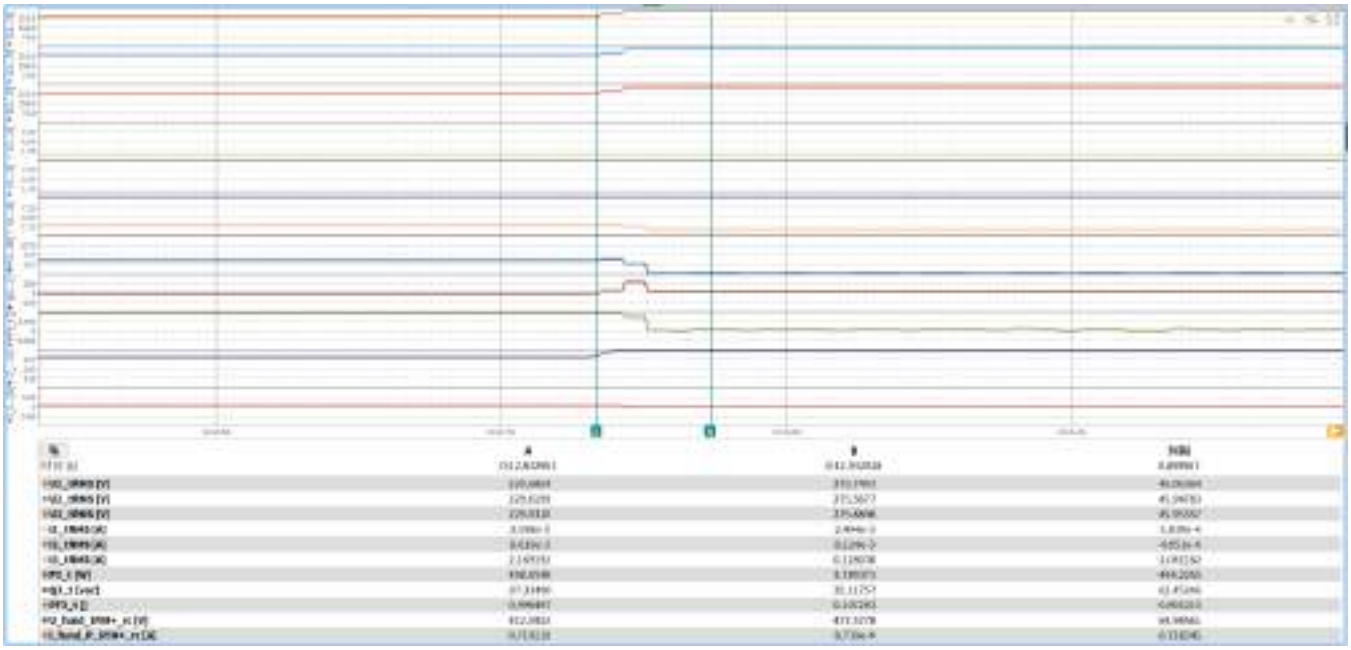
Load tests 6.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	6.2
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	1,20
	5	Drop duration setpoint	Total	–	[ms]	5000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	5207
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,199
	10		Positive sequence			0,199
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,499
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,498
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,498
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,027
	16		Total	t_1-10 s to t_1	[p.u.]	-0,027
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9985
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,199
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,029
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,029
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,003
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,003
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,499
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,499
	30	Response time active power	Positive sequence	-	[s]	0,501
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,031
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,031
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

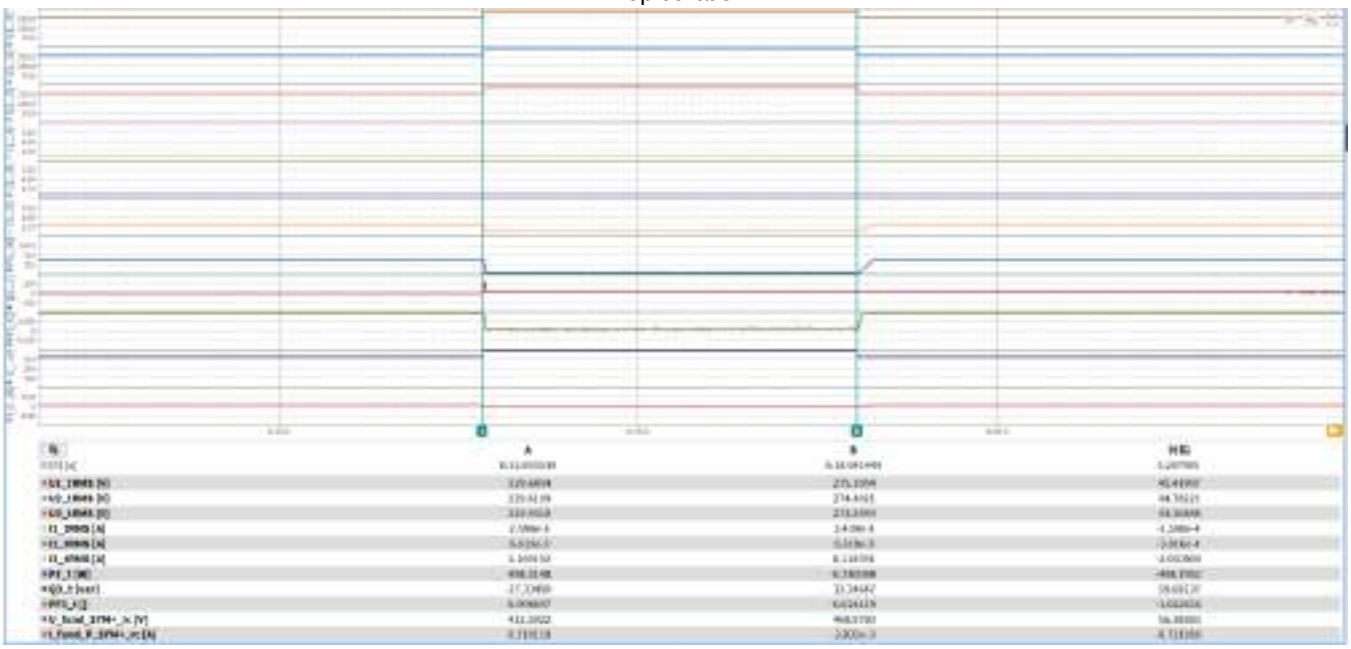
0-60ms



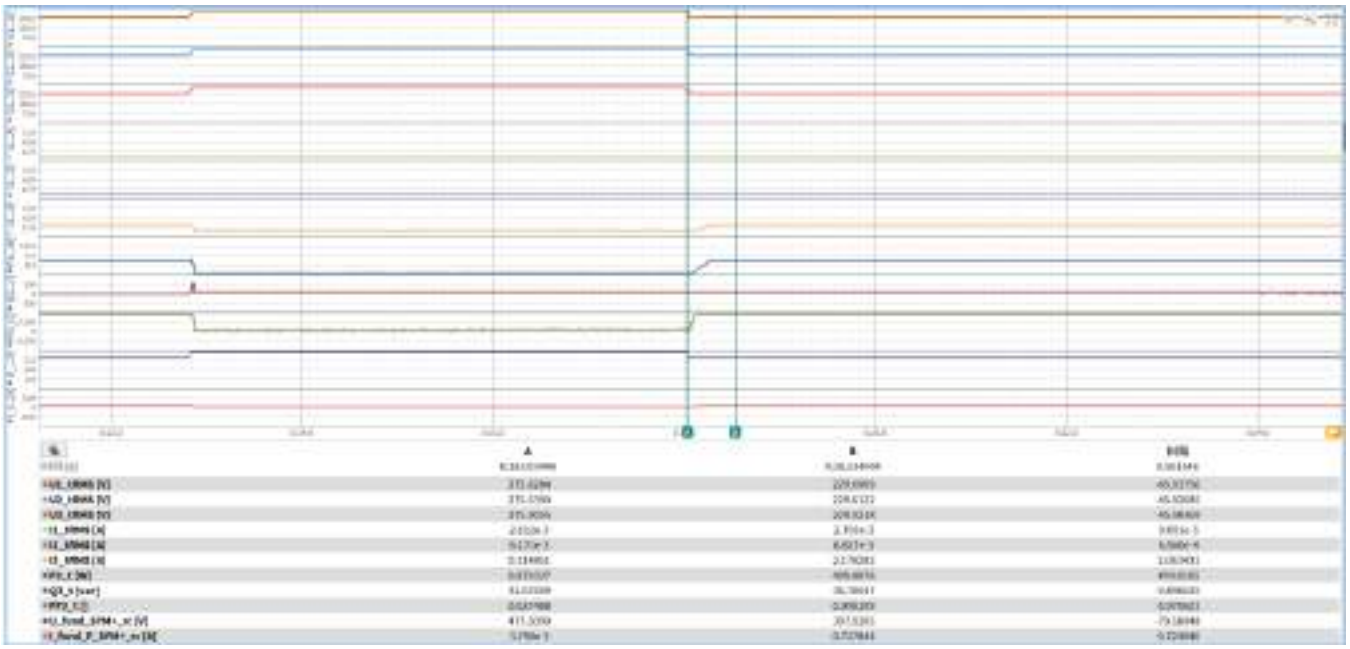
0-100ms



Drop duration



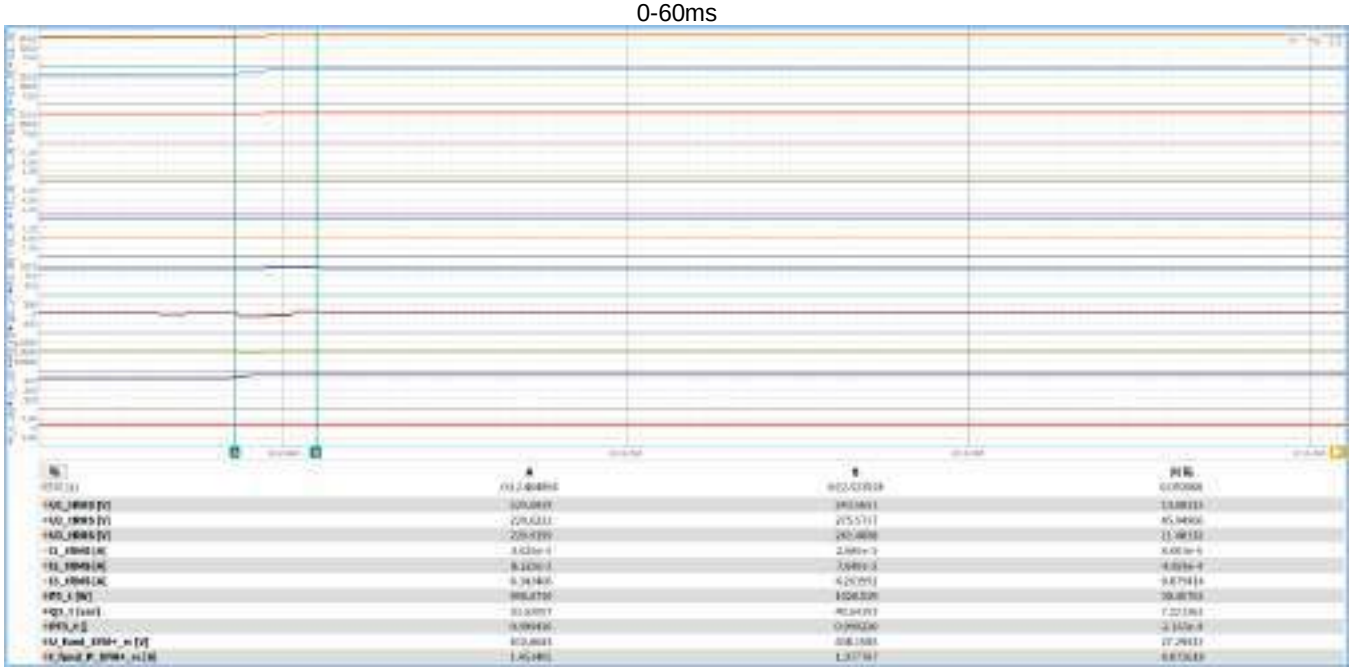
Recover time



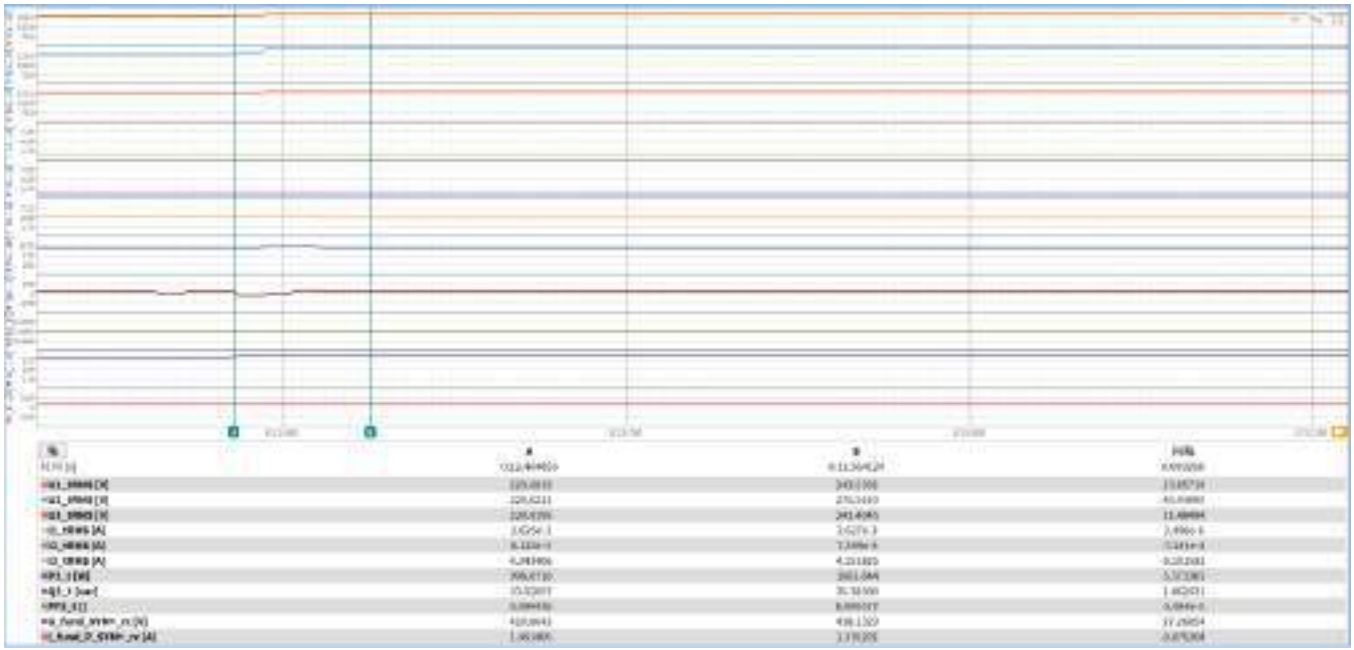
Load tests 6.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	6.3
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	1,20
	5	Drop duration setpoint	Total	–	[ms]	5000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	5176
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,050
	10		Positive sequence			0,050
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,998
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,998
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,998
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,033
	16		Total	t_1-10 s to t_1	[p.u.]	0,033
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9994
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,050
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,980
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,954
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	1,002
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	1,002
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,002
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,002
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,035
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,035
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

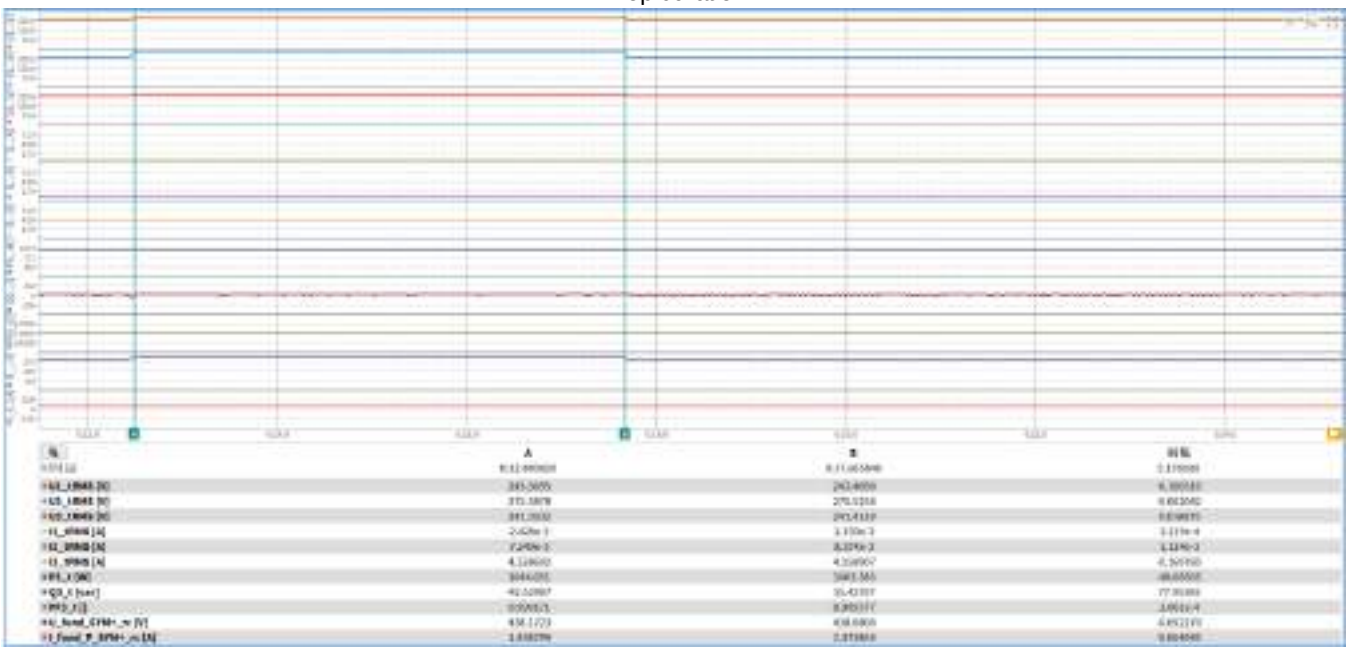
0-60ms



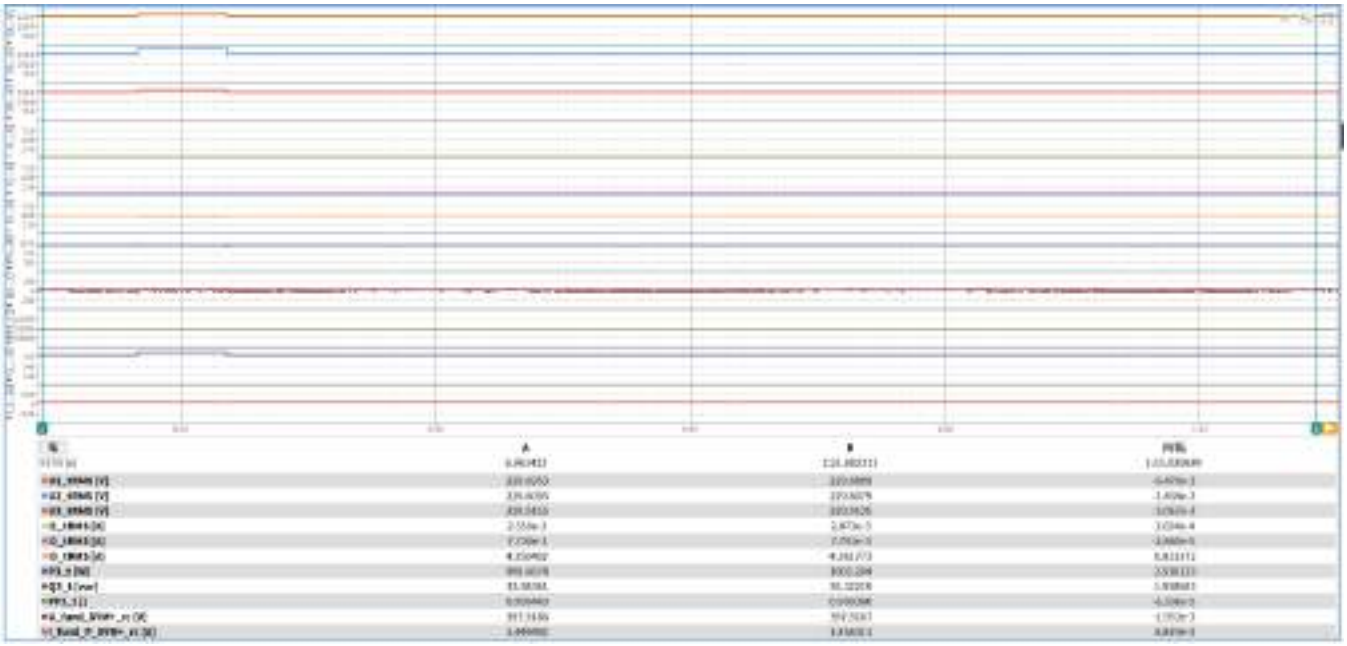
0-100ms



Drop duration



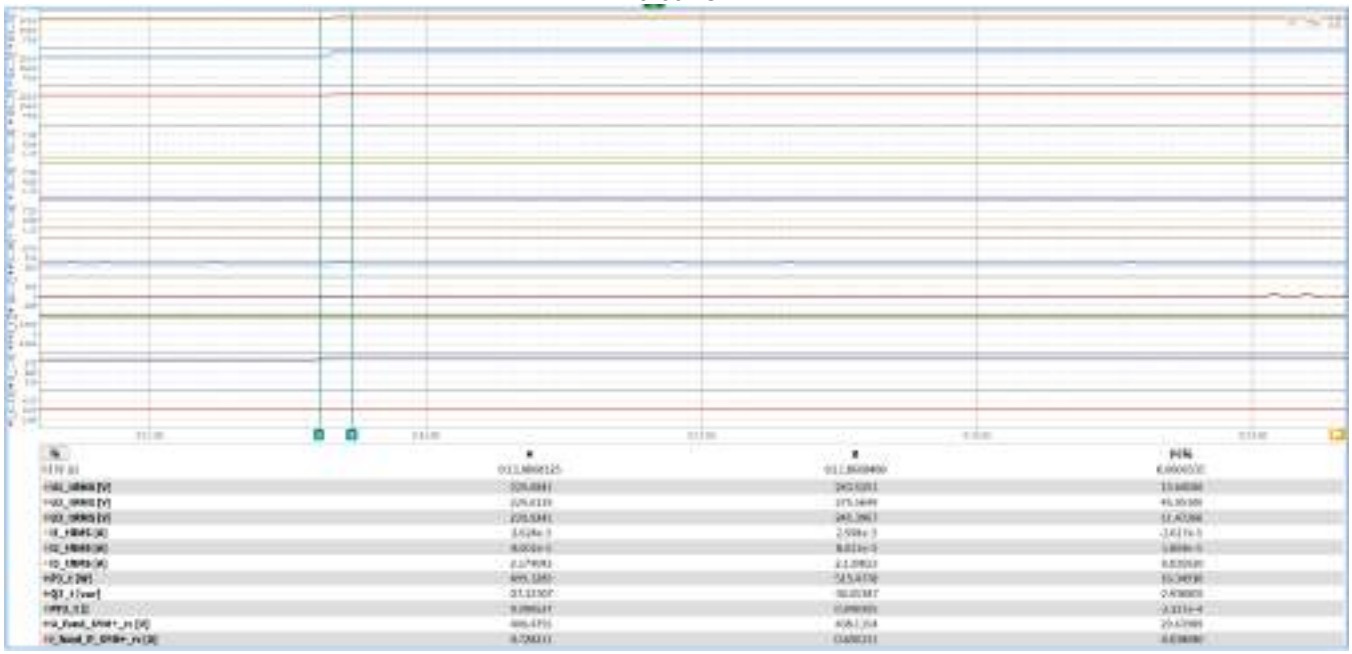
Recover time



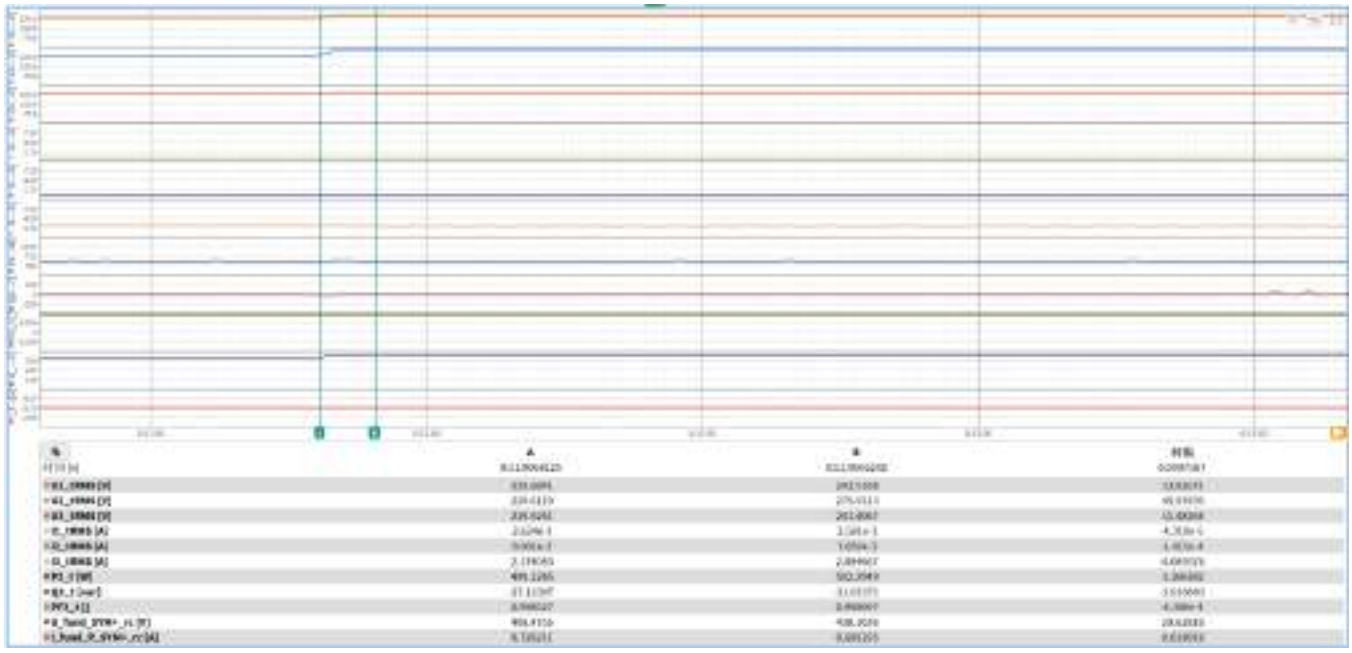
Load tests 6.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	6.4
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	1,20
	5	Drop duration setpoint	Total	–	[ms]	5000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	5192
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,050
	10		Positive sequence			0,050
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	0,500
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,499
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,499
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,027
	16		Total	t_1-10 s to t_1	[p.u.]	-0,027
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9985
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,050
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,492
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,479
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,502
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,502
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

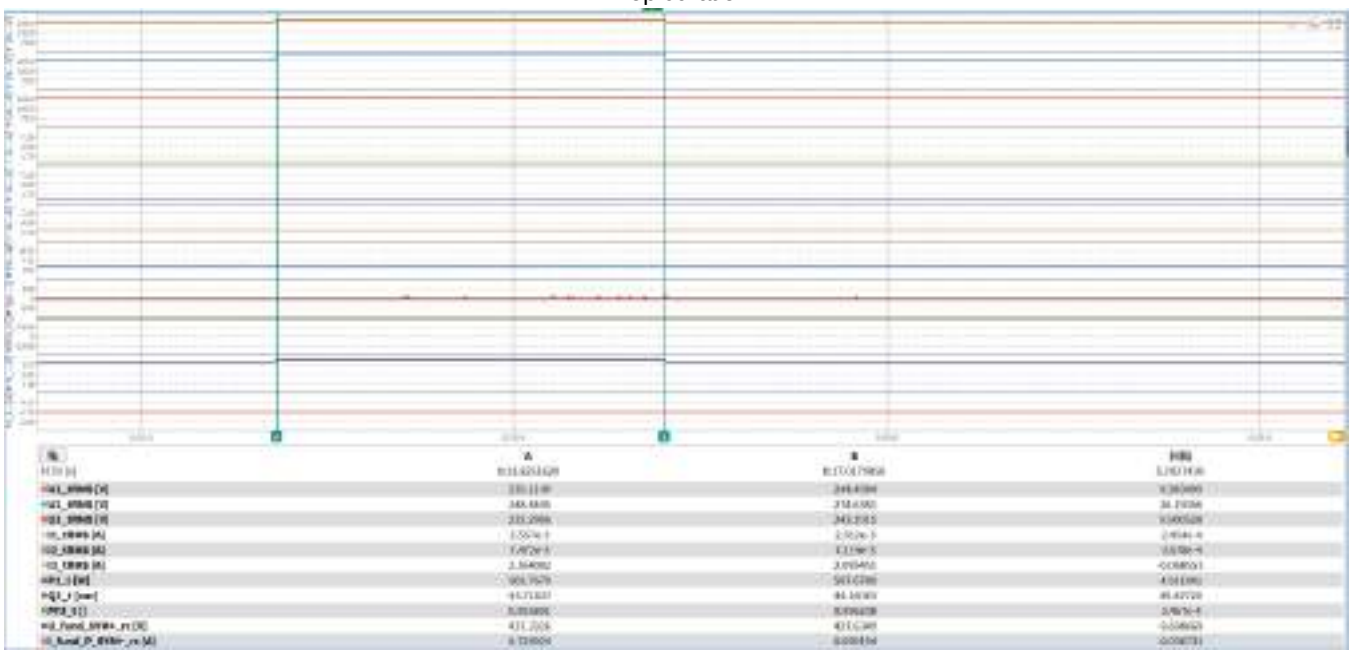
0-60ms



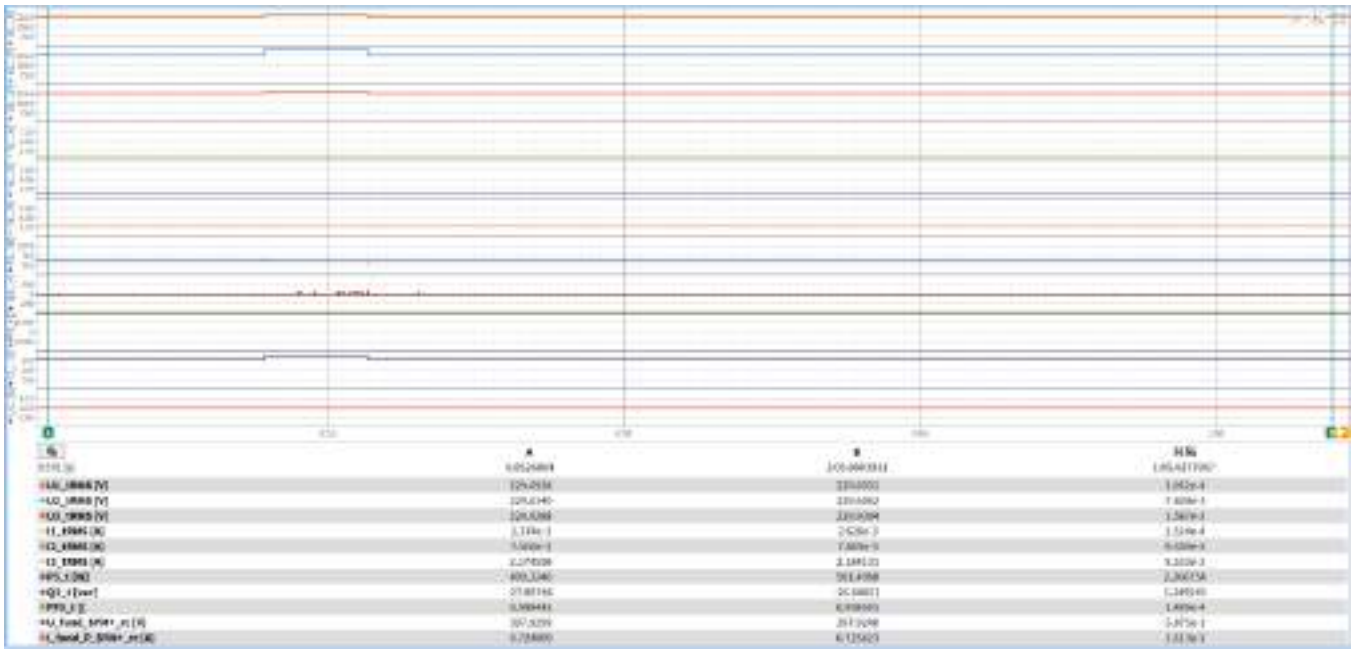
0-100ms



Drop duration



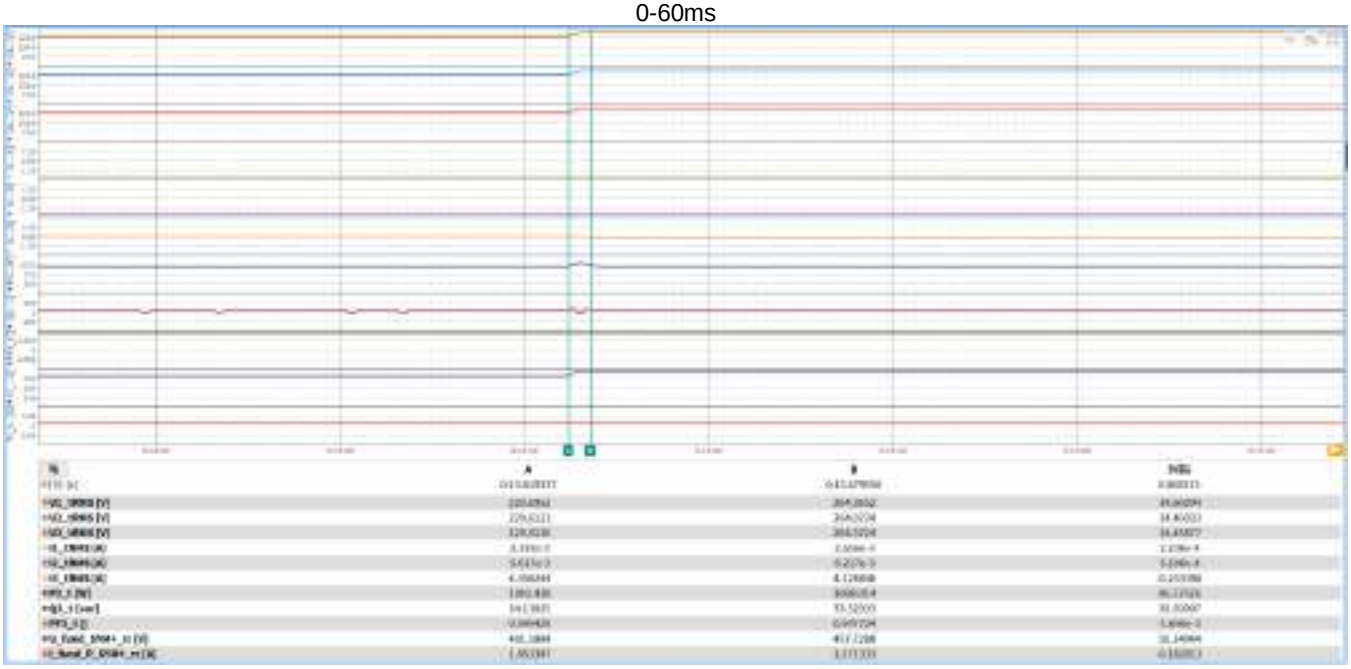
Recover time



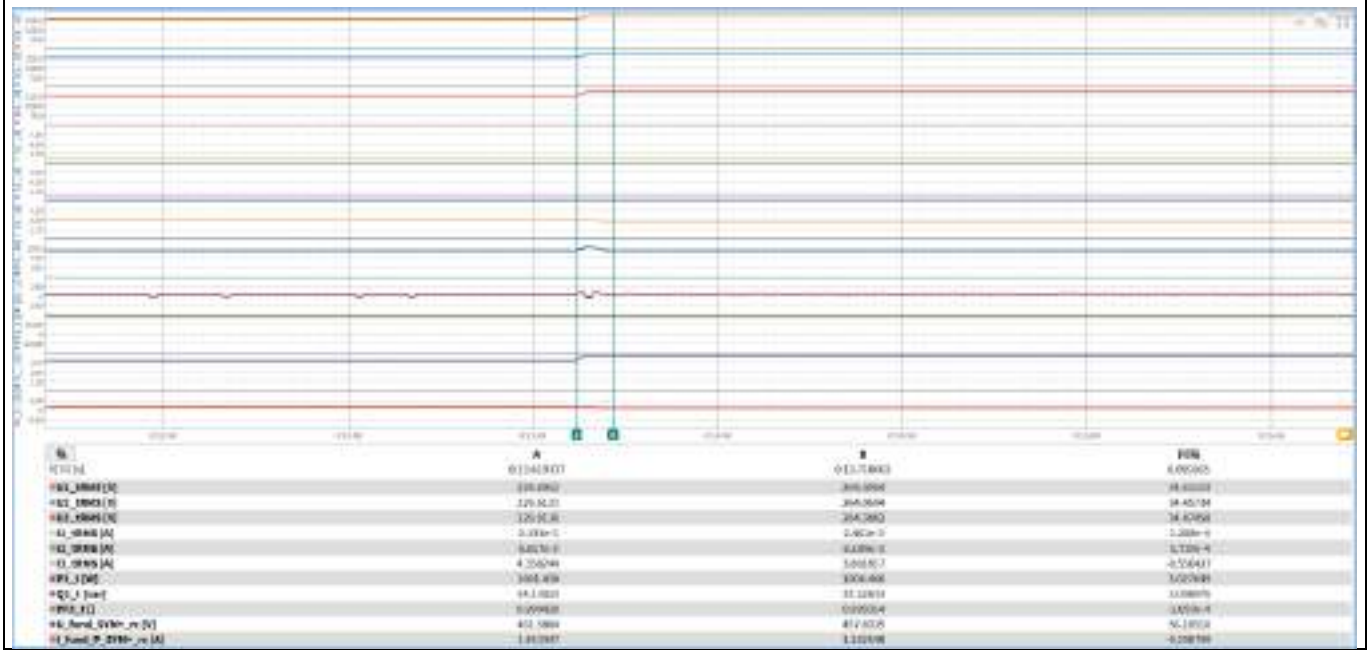
Load tests 7.1

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	7.1
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	1,15
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	61057
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,149
	10		Positive sequence			0,149
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,002
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,001
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,001
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	0,034
	16		Total	t_1-10 s to t_1	[p.u.]	0,034
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9994
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,149
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,948
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,874
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	1,004
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	1,004
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	1,000
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	1,000
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,033
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,033
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

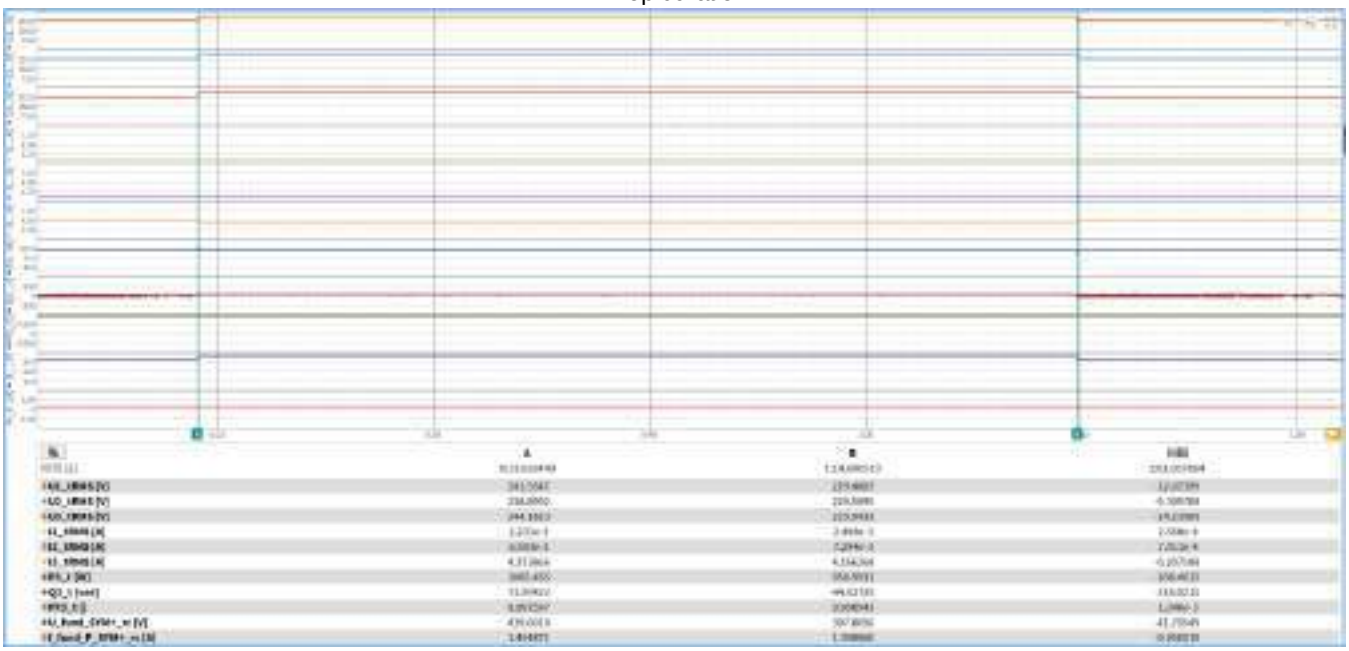
0-60ms



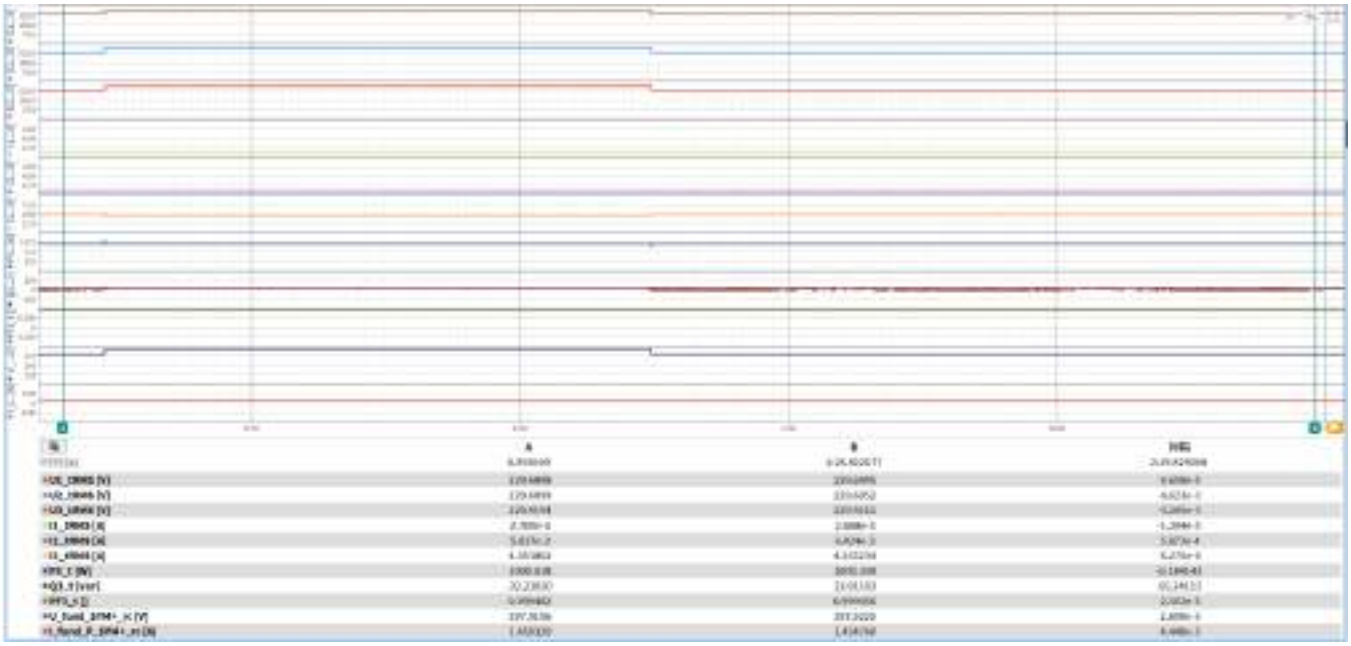
0-100ms



Drop duration



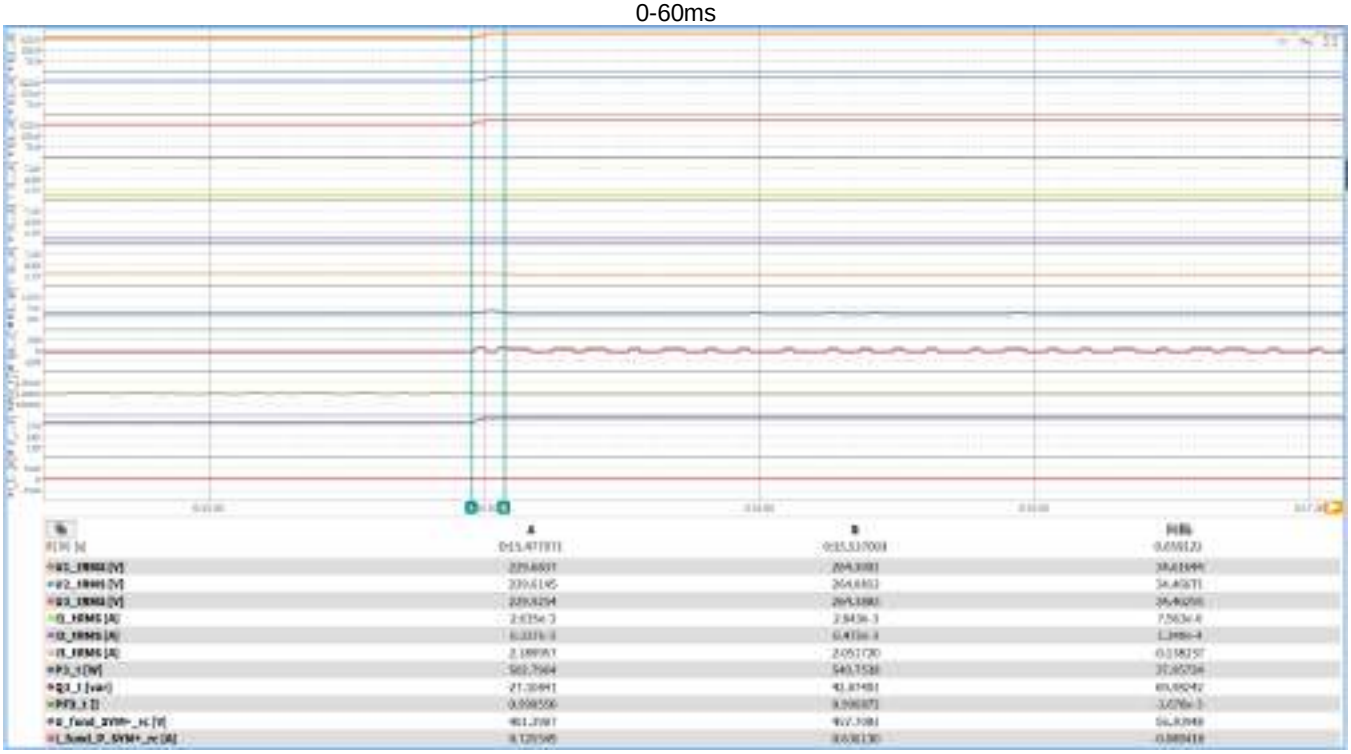
Recover time



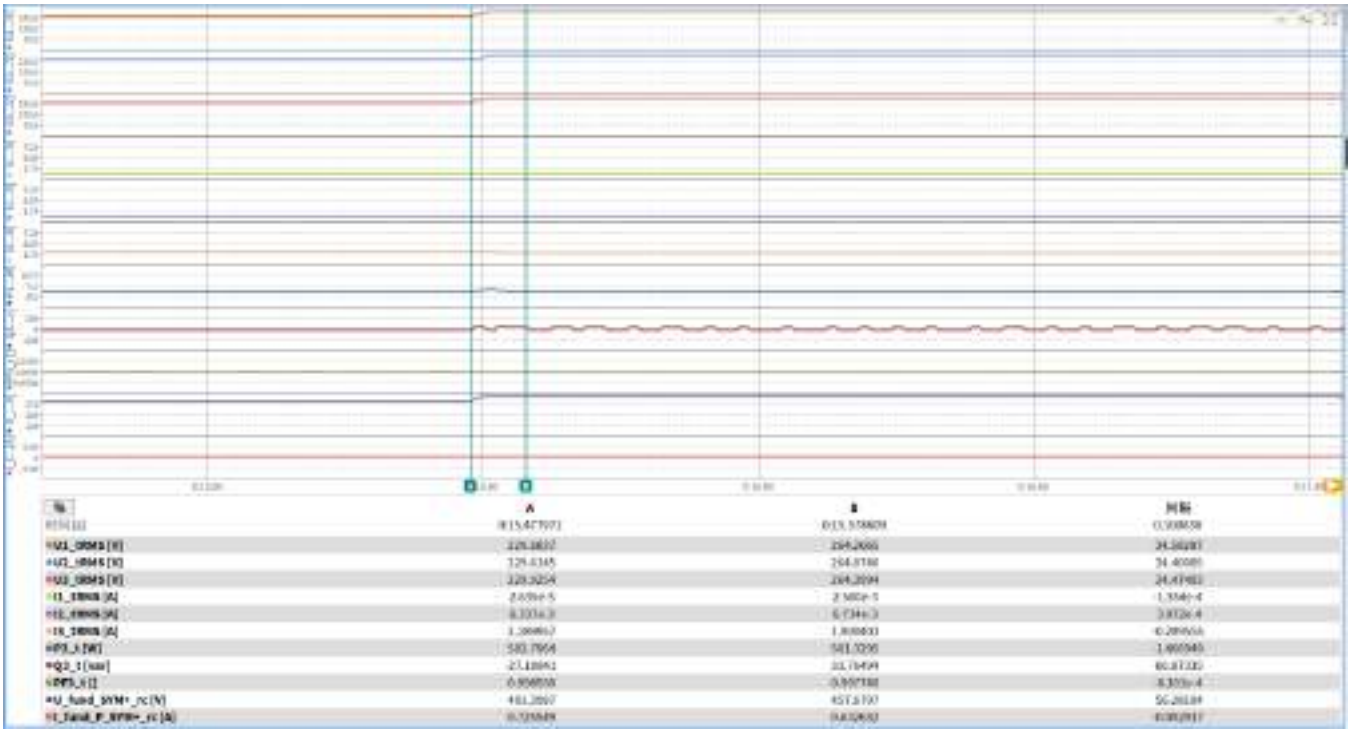
Load tests 7.2

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	7.2
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	A
	4	Drop depth setpoint	Phase	–	[p.u]	1,15
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	61015
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,149
	10		Positive sequence			0,149
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,003
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,502
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,502
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,027
	16		Total	t_1-10 s to t_1	[p.u.]	-0,027
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9986
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,149
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,471
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,436
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,501
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,501
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,502
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,502
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

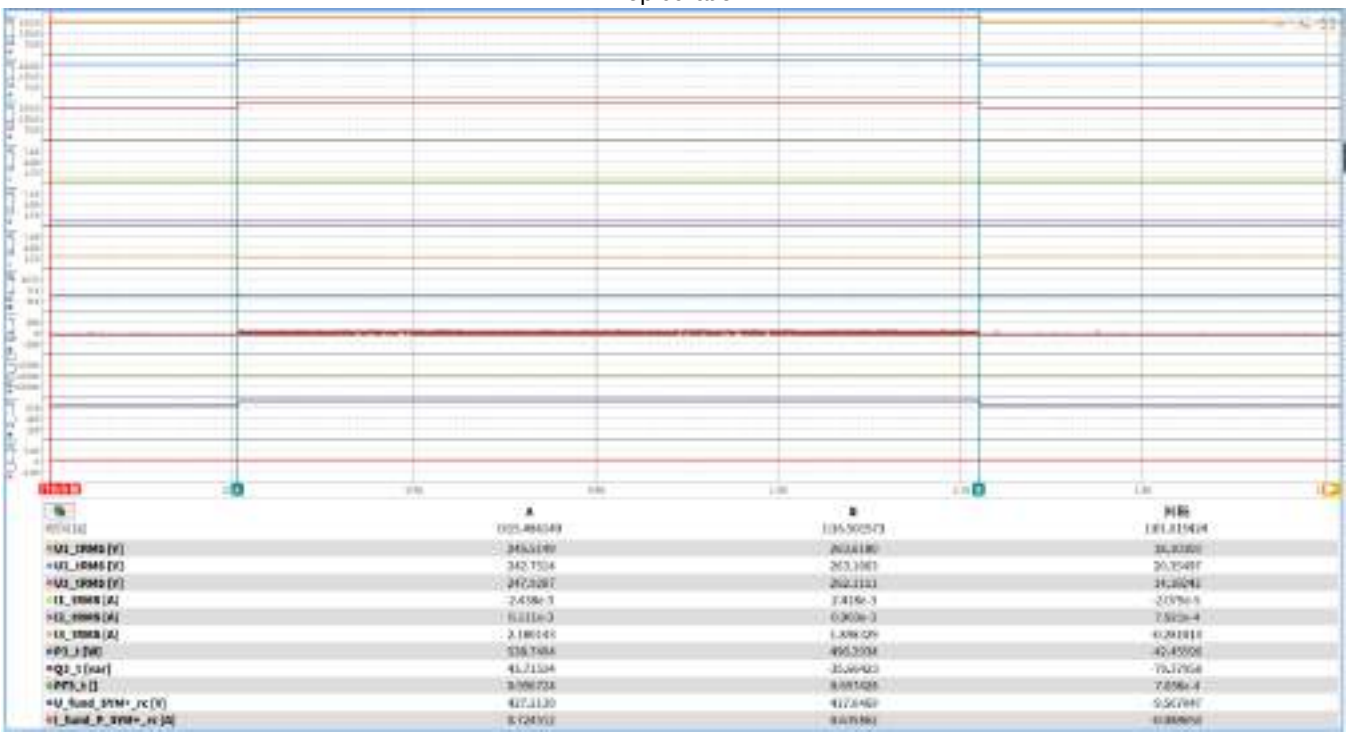
0-60ms



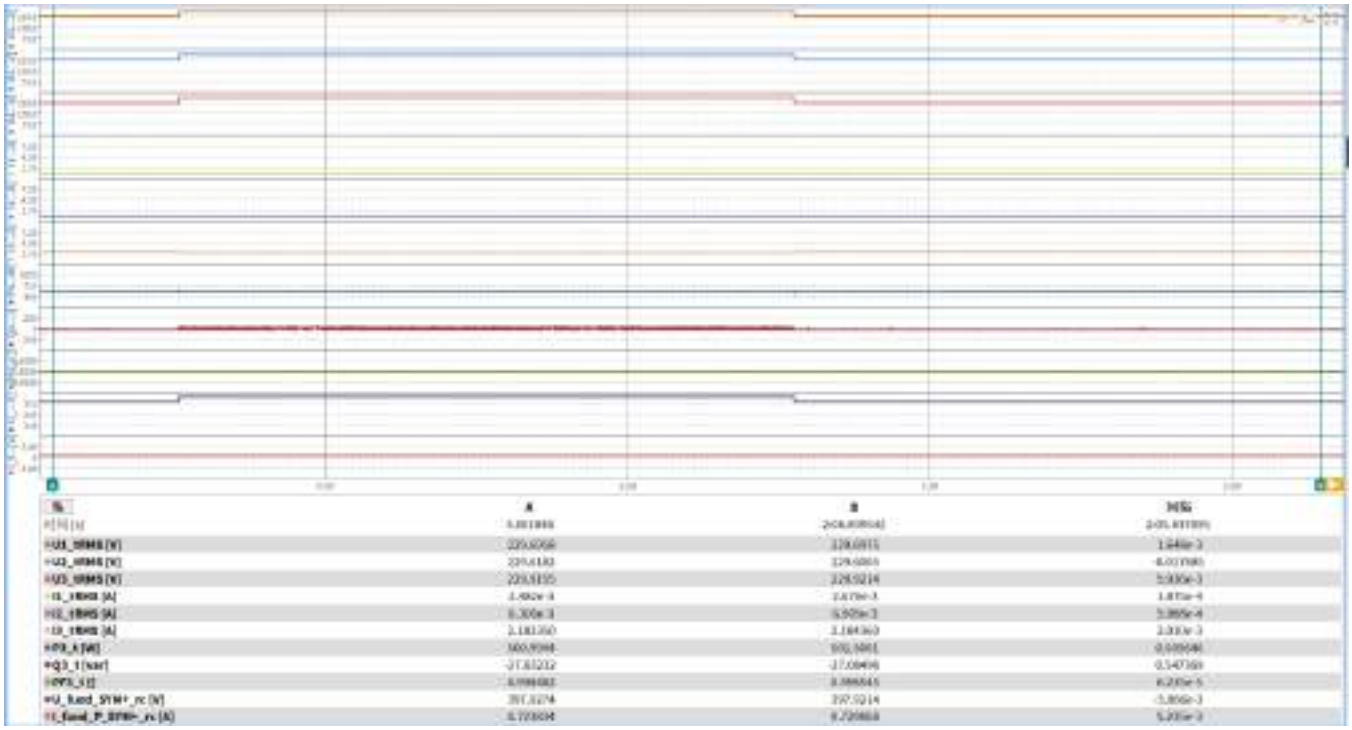
0-100ms



Drop duration



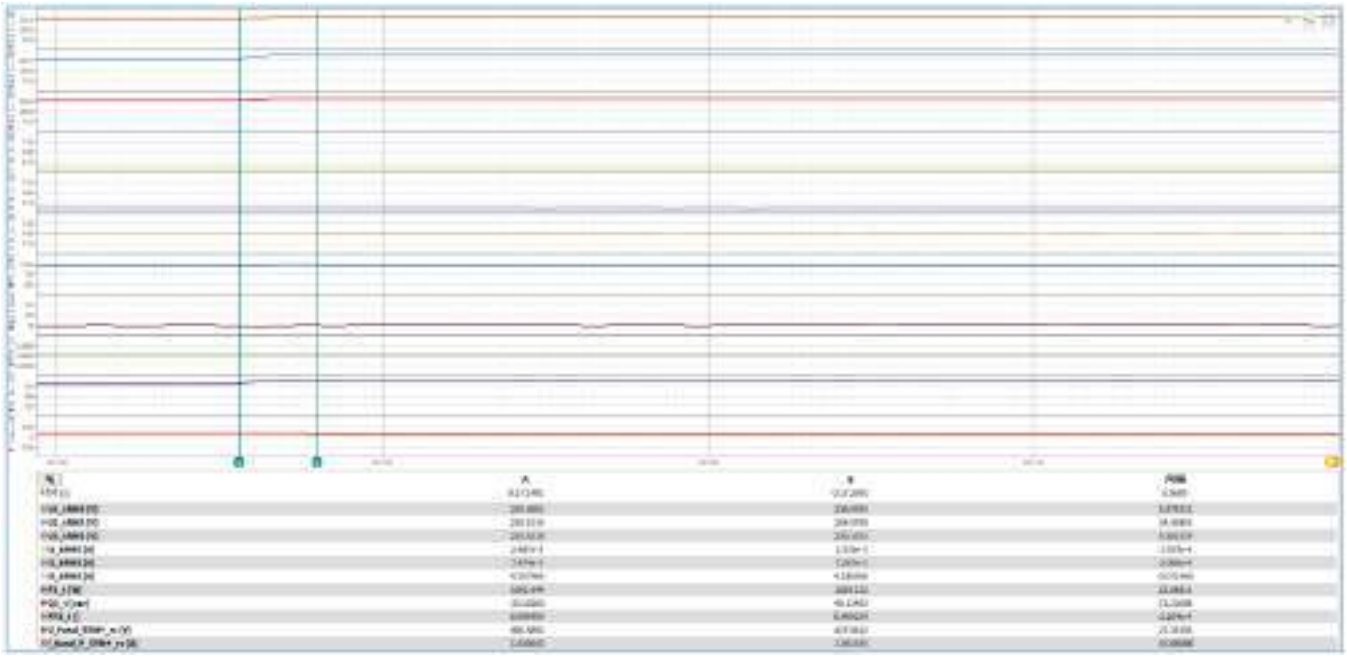
Recover time



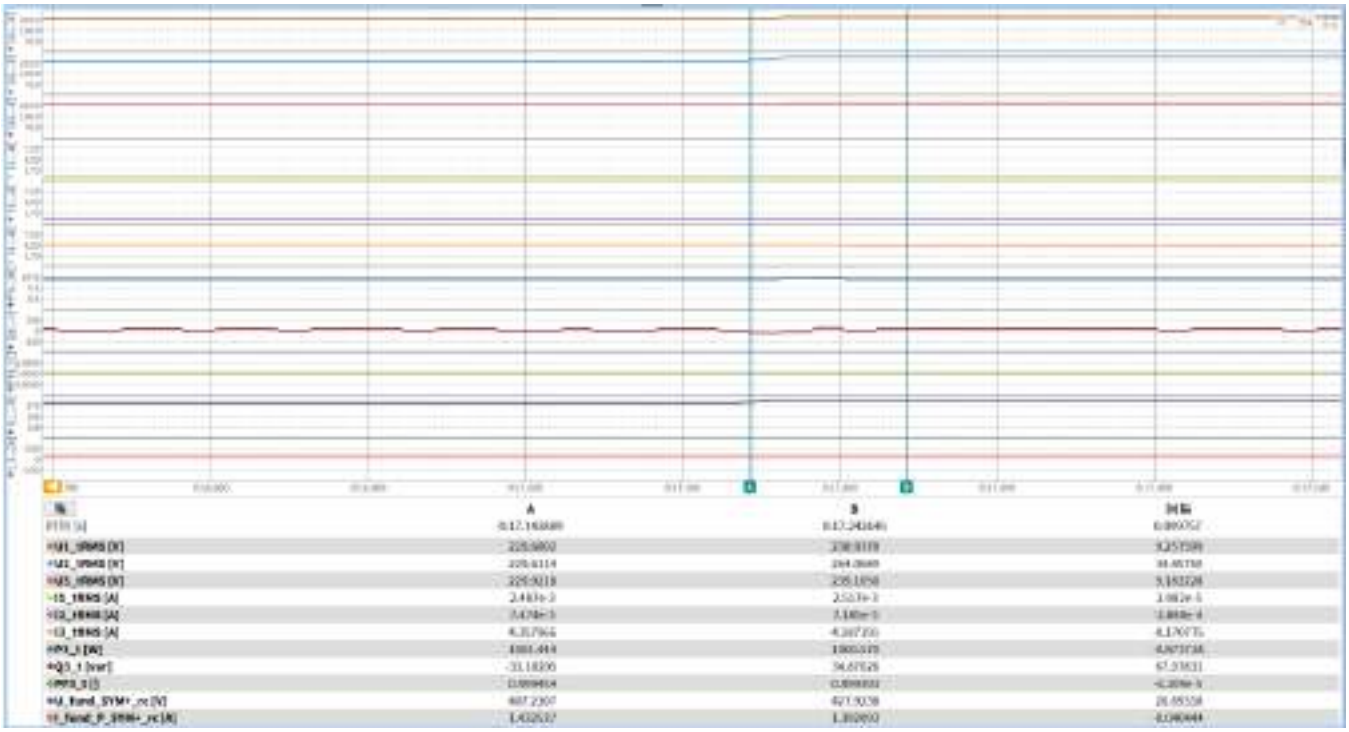
Load tests 7.3

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	7.3
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	1,15
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	60904
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,039
	10		Positive sequence			0,039
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,001
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	1,001
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	1,001
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,033
	16		Total	t_1-10 s to t_1	[p.u.]	-0,033
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9995
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,039
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,985
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,973
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	1,001
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	1,001
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,999
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,999
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	0,033
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	0,033
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didnt disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

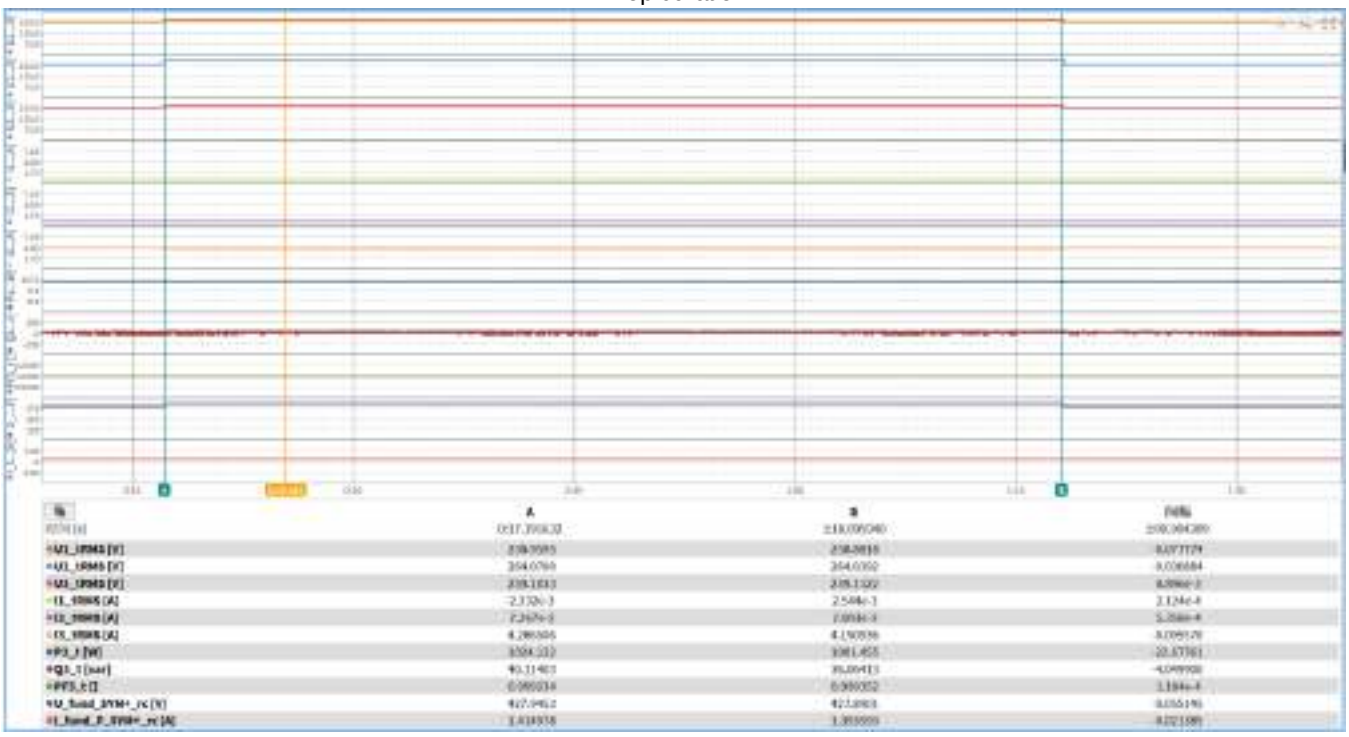
0-60ms



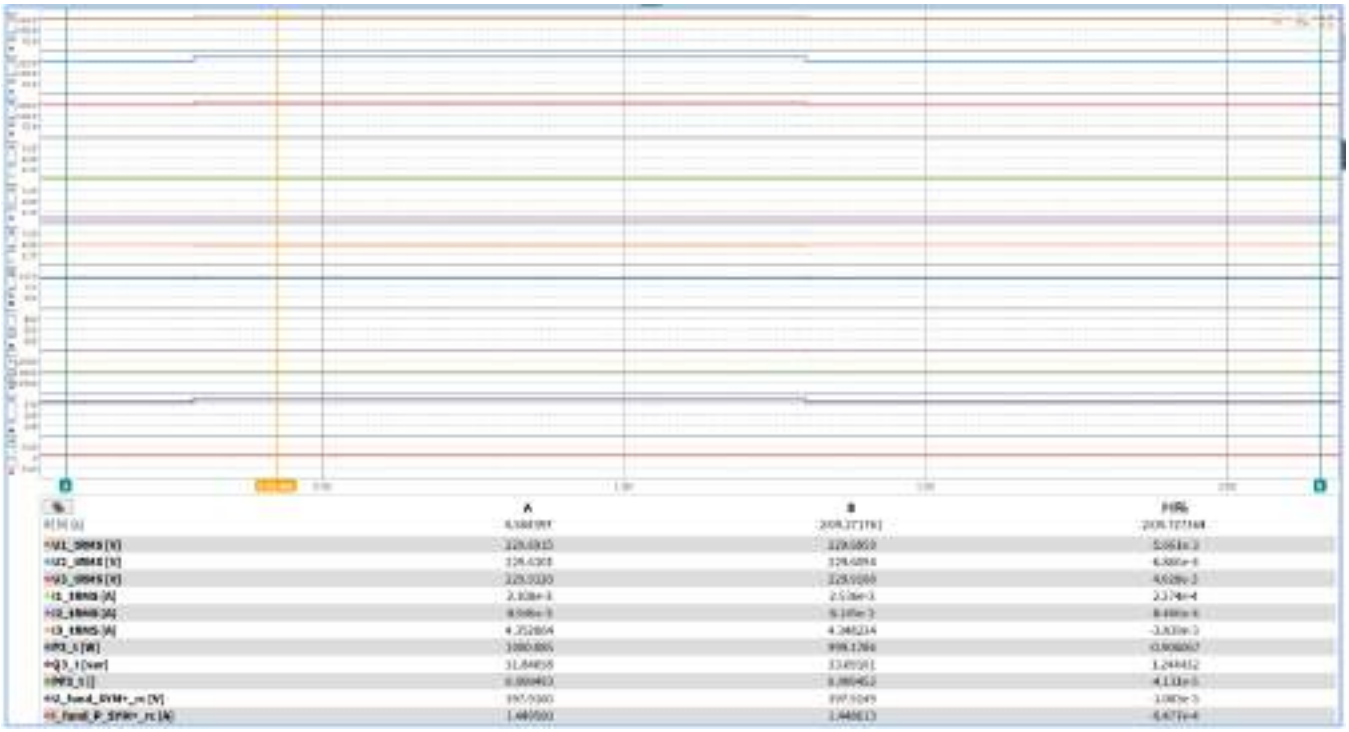
0-100ms



Drop duration



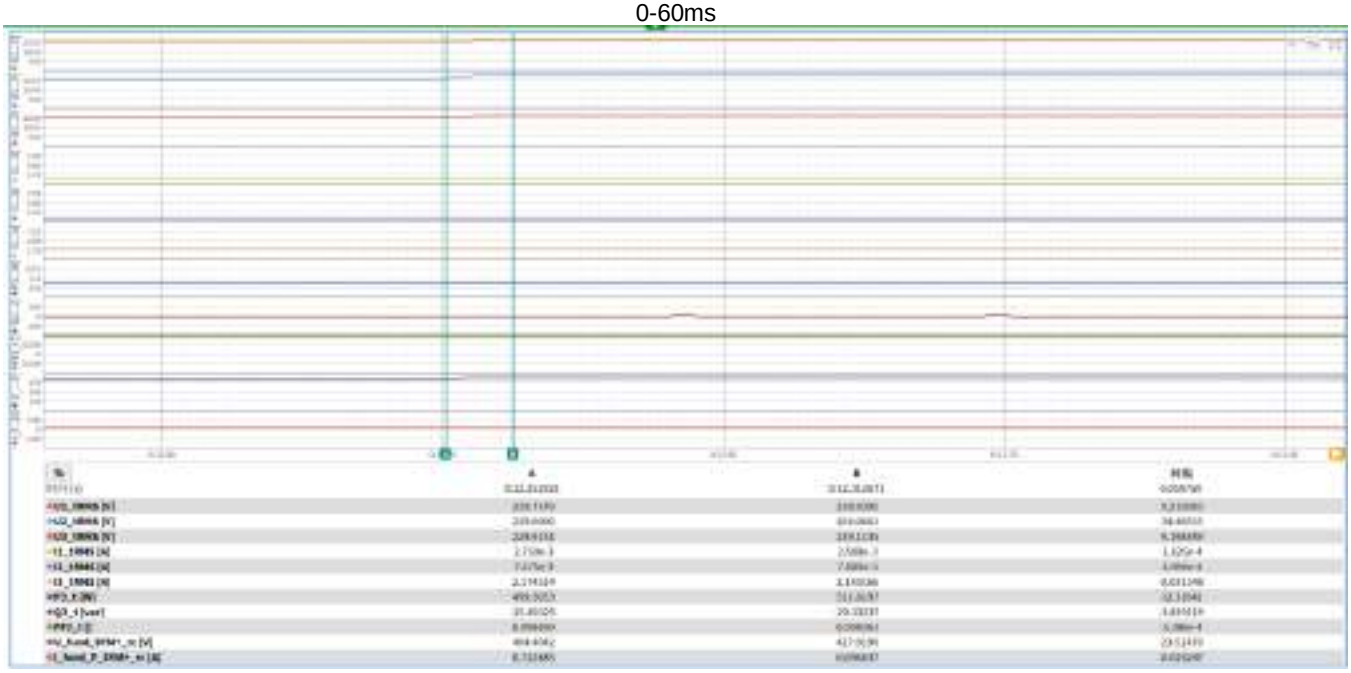
Recover time



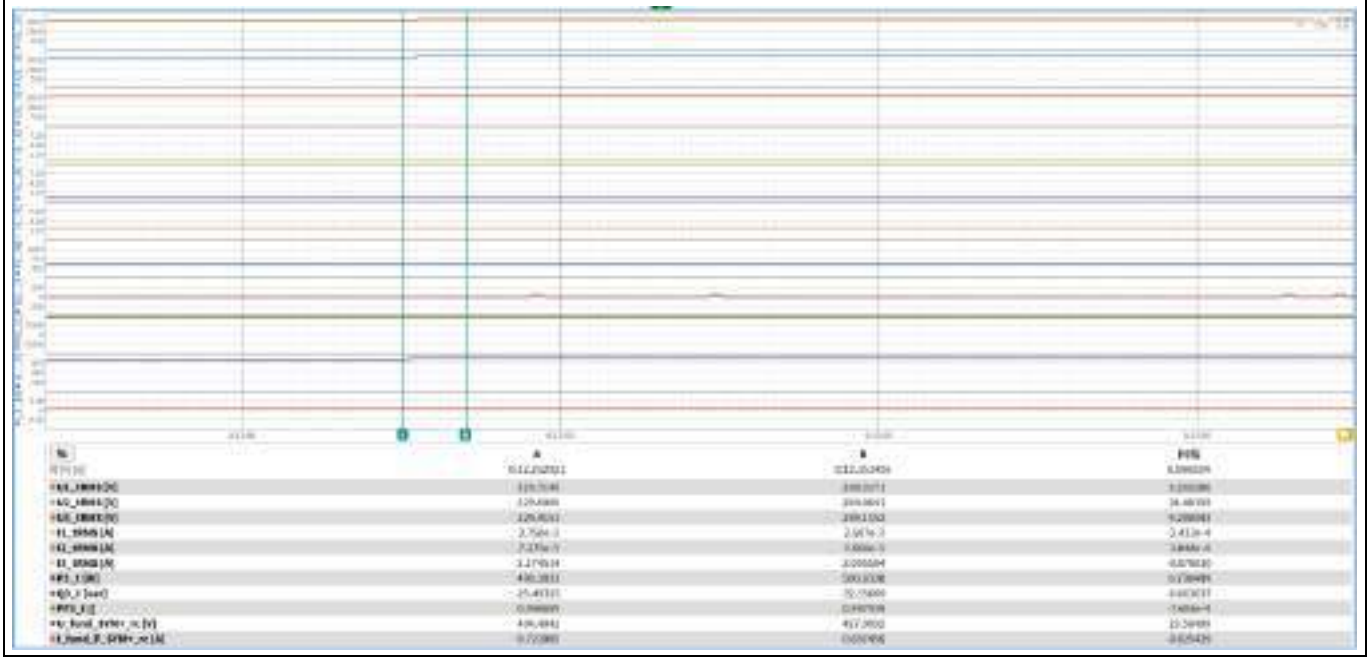
Load tests 7.4

	No.	Parameter	Phase reference	Reference time	Value (unit)	Value
General information	0	Test no.	–	–	–	7.4
	1	Date	–	–	[dd.mm.yyyy]	18.05.2024
	2	Time (Start of test)	–	–	[hh:mm:ss.f]	-
	3	Type of fault (number of affected phases)	–	–	–	D1
	4	Drop depth setpoint	Phase	–	[p.u]	1,15
	5	Drop duration setpoint	Total	–	[ms]	60000
	6	Fault occurrence (*t*1)	Total	–	[ms]	-
	7	Fault clearance (*t*2)	Total	–	[ms]	-
	8	Fault duration determined from test	Total	–	[ms]	61016
	9	Measeured value of voltage drop / increase	Total	t_1+100ms to $t_2$and t_1-10 s to t_1	[p.u.]	0,040
	10		Positive sequence			0,040
Before t_1	11	Voltage	Phase to Neutral	t_1-10s to t_1	[p.u.]	0,999
	12	Current	Positive sequence	t_1-500 ms to t_1-100 ms	[p.u.]	1,002
	13	Active power	Total	t_1-10 s to t_1	[p.u.]	0,499
	14		Positive sequence	t_1-10 s to t_1	[p.u.]	0,499
	15	Reactive power	Positive sequence	t_1-10 s to t_1	[p.u.]	-0,025
	16		Total	t_1-10 s to t_1	[p.u.]	-0,025
	17	cos φ	-	t_1-10 s to t_1	[p.u.]	0,9987
t_1 till t_2	18	Voltage	Phase to Neutral	t_1+100 ms to t_2-20 ms	[p.u.]	1,040
	19	Phase current	Phase 1	t_1+60 ms	[p.u.]	N/A
	20		Phase 2	t_1+60 ms	[p.u.]	N/A
	21		Phase 3	t_1+60 ms	[p.u.]	0,493
	22	Phase current	Phase 1	t_1 +100 ms	[p.u.]	N/A
	23		Phase 2	t_1 +100 ms	[p.u.]	N/A
	24		Phase 3	t_1 +100 ms	[p.u.]	0,482
	25	Active power	Total	t_1+100 ms to t_2-20 ms	[p.u.]	0,500
	26		Positive sequence	t_1+100 ms to t_2-20 ms	[p.u.]	0,500
After t_2	27	Voltage	Phase to Neutral	t_2+3 s to t_2+10 s	[p.u.]	0,999
	28	Active power	Positive sequence	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	29		Total	t_2+3 s to *t*2+10 s	[p.u.]	0,501
	30	Response time active power	Positive sequence	-	[s]	N/A
	31	Reactive power	Positive sequence	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	32		Total	t_2+3 s to t_2+10 s	[p.u.]	-0,027
	33	Response time reactive power	Positive sequence	–	[s]	N/A
	34	EZE didn't disconnect from grid within 60s after fault ended yes/no?	–	t_2 to t_2+60s	–	Yes

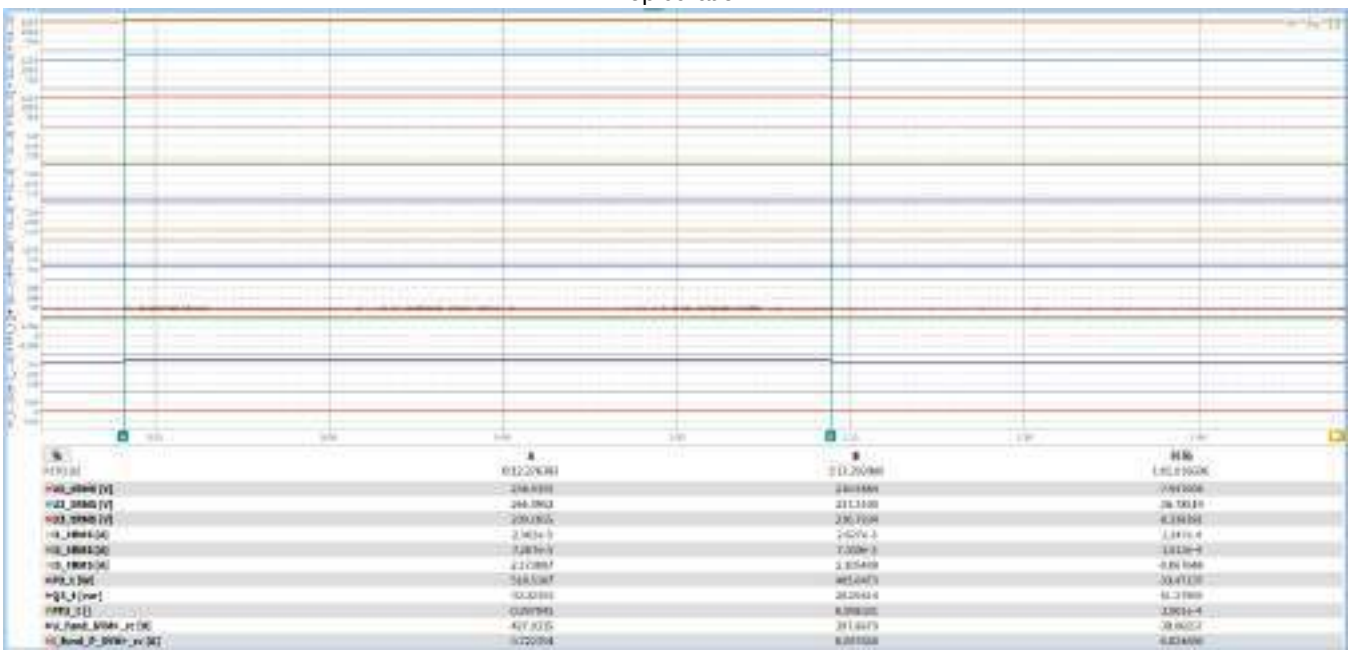
0-60ms



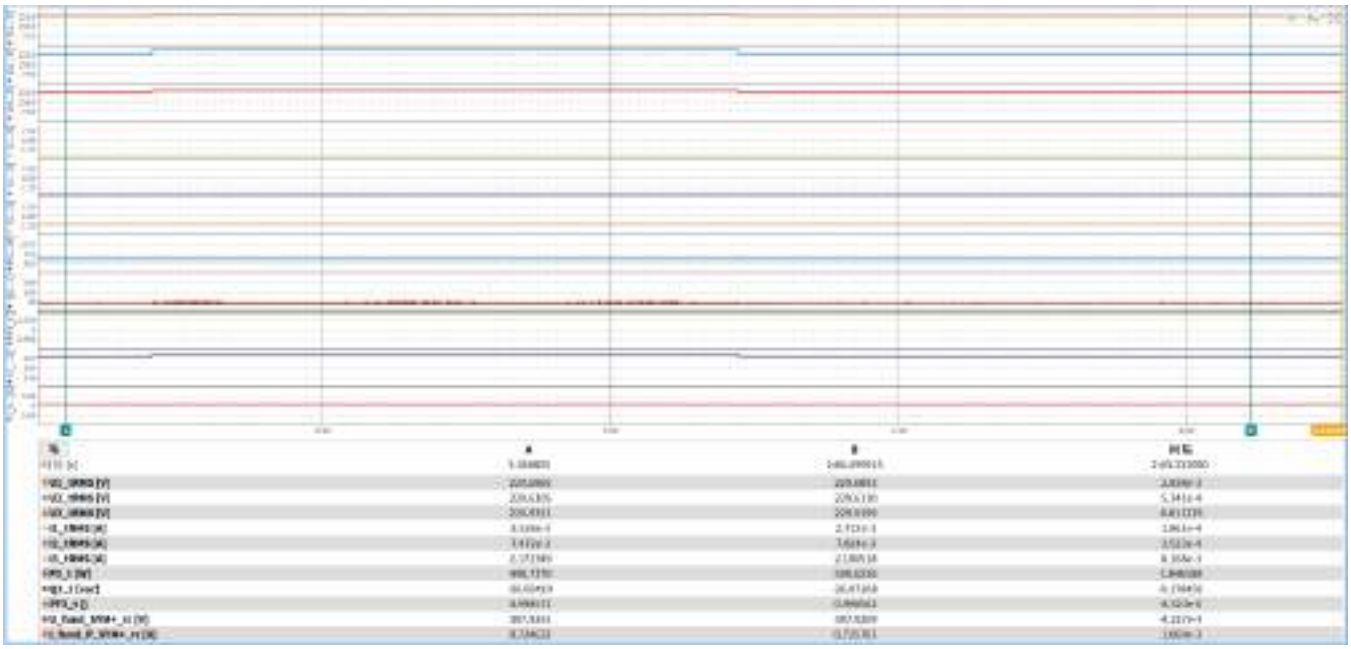
0-100ms



Drop duration



Recover time



Annex No, 1
Pictures of the unit

Enclosure front

Enclosure back

Enclosure bottom side

Enclosure left side

Enclosure right side

Annex No, 2
Test Equipment list

Testing Location: **LCIE China Company Limited**

Building 4, No, 518, Xinzhuan Road, Caohejing, Songjiang High-Tech Park, Shanghai, P,R, China (201612)

Date(s) of performance test: 2024-04-29 to 2024-05-21

No.	Equipment	Internal No.	Type	Manufacturer	Last Calibration	Due Date
1	Oscilloscope	A4089036SH	DL850	YOKOGAWA	29/May/23	28/May/24
2	Voltage probe	A4089026SH	P5200A	Tektronix	21/Dec/22	20/Dec/23
3	Current probe	A4089037SH	960 30	YOKOGAWA	24/Aug/23	23/Aug/24
4	Current probe	A4089038SH	960 30	YOKOGAWA	24/Aug/23	23/Aug/24
5	Current probe	A4089039SH	960 30	YOKOGAWA	24/Aug/23	23/Aug/24
6	AC power supply	A7040071SH	61512	Chroma	Monitored by Power Analyzer	
7	AC power supply	A7040077SH	MX-30	AMETEK		
8	Programmable DC source	A7040058SH	62150H-1000S	Chroma		
9	Programmable DC source	A7040059SH	62150H-1000S	Chroma		
10	Programmable DC source	A7040069SH	62150H-1000S	Chroma		
11	Programmable DC source	A7040074SH	62150H-1000S	Chroma		
12	Programmable DC source	A7040075SH	62150H-1000S	Chroma		
13	Programmable DC source	A7040076SH	62150H-1000S	Chroma		
14	Programmable DC source	A7040070SH	62150H-1000S	Chroma		
15	Power Analyzer	A1240096SH	WT3000	YOKOGAWA	24/Aug/23	23/Aug/24
16	Power Analyzer	A1240097SH	WT3000	YOKOGAWA	29/May/23	28/May/24
17	temperature & humidity meter	B4200079SH	314	center	31/May/23	30/May/24
18	Power Analyzer	A1240132SH	DEWE2-A4	DEWETRON	29/May/23	28/May/24

End of Test Report