TESTING FOR THE VERIFICATION OF COMPLIANCE OF ECOFLOW STREAM ULTRA / ECOFLOW STREAM PRO / ECOFLOW STREAM AC PRO WITH :
VDE-AR-N 4105:2018-11 + CORRECTION 1: 2020-10: GENERATORS CONNECTED TO THE LOW-VOLTAGE DISTRIBUTION NETWORK – TECHNICAL REQUIREMENTS FOR THE CONNECTION TO AND PARALLEL OPERATION WITH LOW-VOLTAGE DISTRIBUTION NETWORKS

Test Report Number ....:	**SUEE250300007051**
Type ....:	**EcoFlow STREAM Ultra / EcoFlow STREAM Pro / EcoFlow STREAM AC Pro**
Trademark..:	**EF ꓱCOFLOW or ꓱCOFLOW**
Tested Model ....:	**EF-EA-HD-U2K-800**
Variant Models ....:	EF-EA-HD-U2K-600, EF-EA-HD-P2K-800, EF-EA-HD-P2K-600, EF-EA-AC-P2K-800, EF-EA-AC-P2K-600

APPLICANT

Name ....:	**EcoFlow Inc.**
Address ....:	RM 401, Plant #1, Runheng Industrial Zone, Fuyuanyi Road, Zhancheng Community, Fuhai Street, Bao'an District, Shenzhen City, Guangdong Province, P.R. China

TESTING LABORATORY

Name..:	**SGS-CSTC Standards Technical Services Co., Ltd. Suzhou Branch**
Address ....:	1/F., Building 12, Xinxing Industry Park, No.78, Xinglin Street, Suzhou Industrial Park, Suzhou, Jiangsu, China
Conducted (tested) by ....:	Jojo Shao (Project Engineer)
Reviewed & Approved by............................:	Colin Chen (Technical Reviewer)
Date of issue ....:	2025/04/09
Number of pages ....:	102
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Total Number of pages ....:	111

TRF No. EEC_ VDE-AR-N 4105 B

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Data Provided By The Client:
The following data has been provided by the applicant:

1. Any information regarding technical characteristics of the equipment (ratings, operation modes, software and hardware versions, dimensions and weight).
2. Equipment operation & construction information (manuals, electrical diagrams, information about components, operation procedures).
3. Documental information (brand and models names, address or other information about applicant, company or manufacturer).
4. Other information remarked within this report.

Test Report Historical Revision:

Test Report Version	Date	Resume
SUEE250300007051	2025/04/09	First issuance

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1 SCOPE

SGS-CSTC Standards Technical Services Co., Ltd. Suzhou Branch has been contracted by EcoFlow Inc. in order to perform the testing according to:

- VDE-AR-N 4105:2018-11: "Generators connected to the low-voltage distribution network - Technical requirements for the connection to and parallel operation with low-voltage distribution networks" and including "Correction 1:2020-10".

As Test procedure, the following Standard has been used for some of the applicable tests of the Standard above:

- VDE V 0124-100:2020-06: Grid integration of generator plants Low-voltage – Test requirements for generation units, intended for connection and parallel operation on the low-voltage grid.

2 GENERAL INFORMATION

2.1 Testing Period and Climatic Conditions

The necessary testing has been performed between February 10th and March 13th of 2025.

All the tests and checks have been performed at climatic conditions:

Temperature	25 ± 5 ºC
Relative Humidity	50 ± 10 %
Pressure	96 ± 10 kPa

2.2 Equipment Under Testing

Apparatus type ....: EcoFlow STREAM Ultra / EcoFlow STREAM Pro / EcoFlow STREAM AC Pro

Installation ....: Fixed installation

Manufacturer ....: **EcoFlow Inc.**

Trademark ....: EcoFLOW or ECOFLOW

Model / Type reference ....: EF-EA-HD-U2K-800

Serial Number ....: BK11ZEBB2H350030, produced in Huizhou Sunwoda Energy Technology Co., Ltd. (for all clauses expect section 4.1.2)
BK12ZEBB2H3D0099, produced in Shenzhen Highpower Technology Co., Ltd. (for section 4.1.2)

Software Version ....: 1.0.0.117

Rated Characteristics ....: Refer to page 8.

Date of manufacturing: 2025

Input ....: DC

Output .... AC, L/N/PE

Class of protection against electric shock...: Class I

Degree of protection against moisture ....: IP65

Type of connection to the main supply ....: Single – Fixed installation

Cooling group ....: Natural Convection

Modular ....: No

Internal Transformer ....: Yes

Copy of marking plate (representative):

EcoFlow STREAM Ultra
EF

Model	EF-EA-HD-U2K-800

PV terminal

Max.PV Input Voltage	60V⎓
Max.PV Input Current	14A⎓
Max. Isc. PV	20A⎓
Max MPPT Input Power	2000W(500W per MPPT)
Operation Voltage Range	15V-60V⎓

Grid terminal

AC Output Power	800W
AC Rated Output Current	3.48A
AC Rated Output/Input	230V~, 50Hz
Max. AC Input Power	2300W
Max. AC Input Current	10A
Power Factor	1(-0.8~+0.8)

AC outlet

Max. AC Output Power	1200W
Max. AC Output Apparent Power	1200VA
AC Rated Output/Input	230V~, 50Hz
AC Rated Output Current	5.22A
Max. AC Output Current(Bypass Mode)	10A
Max. AC Input Powe	800W
Max. AC Input Current	3.48A
Max. AC Input Apparent Power	800VA
Power Factor	1(-0.8~+0.8)

Parallel terminal

Max. AC Output Power	2300W
Max. AC Output Apparent Power	2300VA
AC Rated Output/Input	230V~, 50Hz
Max Output/Input Current	10A
Max. AC Input Power	2300W
Max. AC Input Apparent Power	2300VA
Power Factor	1(-0.8~+0.8)

General parameters

Protection Class	Class I
Battery Rated Voltage	19.2V⎓
Operation Temperature Range	-20°C-55°C
Enclosure IP Degree	IP65
Isolated Method(solar)	Isolated Transformer
Rated Energy	1920Wh
Overvoltage Category	PV: II, AC: III
Weight	23.1Kg
Size	284*255*458mm
WiFi protocol, Frequency band	802.11 b/g/n, 2.4GHz

Modell	EF-EA-HD-U2K-800

PV-Klemme

Max. PV-Eingangsspannung	60 V⎓
Max. PV-Eingangsstrom	14 A⎓
Max. Isc. PV	20 A⎓
Max. MPPT-Eingangsleistung	2 000 W (500 W pro MPPT)
Betriebsspannungsbereich	15-60 V⎓

Netzanschluss

AC-Ausgangsleistung	800 W
AC-Nennausgangsstrom	3,48 A
AC-Nennausgang/-eingang	230 V~, 50 Hz
Max. AC-Eingangsleistung	2 300 W
Max. AC-Eingangsstrom	10 A
Leistungsfaktor	1 (-0,8-+0,8)

AC-Ausgang

Max. AC-Ausgangsleistung	1 200 W
Max-. AC-Ausgangs-Scheinleistung	1 200 VA
AC-Nennausgang/-eingang	230 V~, 50 Hz
AC-Nennausgangsstrom	5,22 A
Max. AC-Ausgangsstrom(Bypass-Modus)	10 A
Max. AC-Eingangsleistung	800 W
Max. AC-Eingangsstrom	3,48 A
Max. AC-Eingangs-Scheinleistung	800 VA
Leistungsfaktor	1 (-0,8-+0,8)

Parallelanschluss

Max. AC-Ausgangsleistung	2 300 W
Max-. AC-Ausgangs-Scheinleistung	2 300 VA
AC-Nennausgang/-eingang	230 V~, 50 Hz
Maximaler Ausgangs-/Eingangsstrom	10 A
Max. AC-Eingangsleistung	2 300 W
Max. AC-Eingangs-Scheinleistung	2 300 VA
Leistungsfaktor	1 (-0,8-+0,8)

Allgemeine Parameter

Schutzklasse	Klasse I
Batterie-Nennspannung	19,2 V⎓
Betriebstemperaturbereich	-20 °C-55 °C
IP-Schutzart des Gehäuses	IP65
Isolierte Methode (Solar)	Isolierter Transformator
Nennenergie	1920 Wh
Überspannungskategorie:	PV: II, AC: III
Gewicht	23.1Kg
Größe	284*255*458mm
WLAN-Protokoll, Frequenzband	802,11 b/g/n, 2,4 GHz

Manufacturer: EcoFlow Inc.
Address: RM 401, Plant #1, Runheng Industrial Zone,Fuyuanyi
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Note:
1.   The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2.   Label is attached on the side surface of enclosure and visible after installation.
3.   Labels of other models are as the same with **EF-EA-HD-U2K-800**'s except for the parameters of rating.

Equipment Under Testing:

– **EF-EA-HD-U2K-800**

Variant models:

– EF-EA-HD-U2K-600,
– EF-EA-HD-P2K-800,
– EF-EA-HD-P2K-600,
– EF-EA-AC-P2K-800,
– EF-EA-AC-P2K-600

The variant models have been included in this test report without tests because the following features don´t change regarding to the tested model:

- Same connection system, software version and hardware topology.
- Same control algorithm.
- Output power within $1/\sqrt{10}$ and 2 times of the rated output power of the EUT or Modular inverters.
- Same Firmware Version.

EcoFlow STREAM Ultra, EcoFlow STREAM Pro and EcoFlow STREAM AC Pro are the same except EcoFlow STREAM Ultra has four PV input ports, EcoFlow STREAM Pro has three PV input ports while EcoFlow STREAM AC pro has no PV input port.

EcoFlow STREAM UItra (with four PV input ports): EF-EA-HD-U2K-600, EF-EA-HID-U2K-800 are identical only grid power is different.

EcoFlow STREAM Pro (with three PV input ports): EF-EA-HD-P2K-600, EF-EA-HD-P2K-800 are identical only grid power is different.

EcoFlow STREAM AC Pro (with no PV input port): EF-EA-AC-P2K-600, EF-EA-AC-P2K-800 are identical only grid power is different.

The results obtained apply only to the particular sample tested that is the subject of the present test report.

The most unfavorable result values of the verifications and tests performed are contained herein.

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

Following table shows the full ratings of all the models referenced in this report, marked in **bold letters** is the one subjected to testing:

Rating specifications of EcoFlow STREAM Ultra / EcoFlow STREAM Pro / EcoFlow STREAM AC Pro						
Model	**EF-EA-HD-U2K-800**	EF-EA-HD-U2K-600	EF-EA-HD-P2K-800	EF-EA-HD-P2K-600	EF-EA-AC-P2K-800	EF-EA-AC-P2K-600
PV Terminal:						
Max. PV Input Voltage (V)	60				/	
Max. PV Input Current (A)	14				/	
Max. Isc PV (A)	20				/	
Max. MPPT Input Power (W)	2000		1500		/	
Number of MPP trackers	4		3		/	
Operation Voltage Range (V)	15 - 60				/	
Battery Info:						
Rated Voltage (V)	19.2					
Rated Capacity (kWh)	1.92					
Cell Chemistry	$LiFePO_4$					
Grid Terminal:						
Rated Output Voltage (V)	230, L/N/PE					
Rated Output Power (W)	800	600	800	600	800	600
Rated Output Current (A)	3.48	2.61	3.48	2.61	3.48	2.61
Rated Frequency (Hz)	50					
Power factor (adjustable)	-0.8 ~ +0.8					
Max. Input Power (W)	2300					
Max. Input Current (A)	10					
Parallet Terminal:						
Max. Input / Output Power (W)	2300					
Max. Input / Output Current (A)	10					
Rated Output Voltage (V)	230, L/N/PE					
Power factor (adjustable)	-0.8 ~ +0.8					
Others:						
Ingress protection (IP)	IP65					
Protective class	Class I					
Operating / Storage Temperature (°C)	-20°C to +55°C, with derating above 35°C					
Cooling Method	National Convection					
Inverter Isolation	Isolated					
Overvoltage category	II (DC), III (AC)					
Dimensions (W*D*H)	283*248*459 mm					
Weight (kg)	23.1		23.0			
Operating Altitude (m)	≤ 4000					
Topology	Transformer					

2.3 Manufacturer And Factory Information

Manufacturer:

Name ....: **EcoFlow Inc.**

Address ....: RM 401, Plant #1, Runheng Industrial Zone, Fuyuanyi Road, Zhancheng Community, Fuhai Street, Bao'an District, Shenzhen City, Guangdong Province, P.R. China

Factory 1:

Name ....: **Huizhou Sunwoda Energy Technology Co., Ltd.**

Address ....: Floor 2 of Building C, Floor 7 and Floor 15 of Building B, Sunwoda Electronic Factory, Tangjia Community, Fenghuang Street, Guangming District, Shenzhen, China

Factory 2:

Name ....: **Shenzhen Highpower Technology Co., Ltd.**

Address ....: Building A7&A6, No. 68 Xinxia Road, Pinghu Street, Longgang District, Shenzhen City, Guangdong Province, P.R.China

2.4 Reference Values

The values presented in the following table have been used for calculation of referenced values (p.u.; %) through the report.

Reference Values (EF-EA-HD-U2K-800)	
Rated power, **Pn** (**P$_{rE}$**) in VA	800
Max. apparent power, **Smax** (**S$_{Amax}$ | S$_{Emax}$**) in VA	800
Rated wind speed (only WT), **vn** in m/s	N/A
Rated current, **In** in A	3.48
Max. current, **Imax** in A	3.48
Rated output voltage, (phase to neutral) **Un** in Vac	230
Note: In this report p.u. values are calculated as follows: -For Active & Reactive Power p.u values are reference to **Pn** -For Currents p.u values, the reference is always **In** -For Voltages p.u values, the reference is always **Un=230V$_{L-N}$**	

2.5 Test Equipment List

From	No.	Equipment Name	Trademark / Model No.	Equipment No.	Calibration Period
SGS	1	Power analyzer	DEWETRON/TRIONet	SUZE600301	2024/07/24 to 2025/08/23
	2	Power analyzer	ZLG/PA6004H-P0004-2159	SUZE600303	2024/10/15 to 2025/10/14
	3	Current Clamp	HIOKI/CT6873	SUZE600807	2024/07/24 to 2025/07/23
	4	Current Clamp	HIOKI/CT6873	SUZE600808	2024/07/24 to 2025/07/23
	5	Temperature & Humidity meter	testo/175-H1	SUZE601701	2024/03/29 to 2025/03/28
	6	True RMS Multimeter	Fluke/175C	SUZE600601	2024/03/28 to 2025/03/27

Note: Voltage direct measurement through power analyzer. No voltage probes were used. All measurement equipment was used inside their corresponding calibration period. Copy of all calibration certificates are available at the laboratory for reference.

2.6 Measurement Uncertainty

Associated uncertainties through measurements showed in this this report are the maximum allowable uncertainties.

Magnitude	Uncertainty
Voltage measurement	±1.5 %
Current measurement	±2.0 %
Frequency measurement	±0.2 %
Time measurement	±0.2 %
Power measurement	±2.5 %
Phase Angle	±1º
Cosφ	±0.01
Note1: Measurement uncertainties showed in this table are maximum allowable uncertainties. The measurement uncertainties associated with other parameters measured during the tests are in the laboratory at disposal of the petitioner. Note2: Where the standard requires lower uncertainties that those in this table. Most restrictive uncertainty has been considered.	

2.7   Test Set Up of The Different Standard

Below is the simplified construction of the test set up.
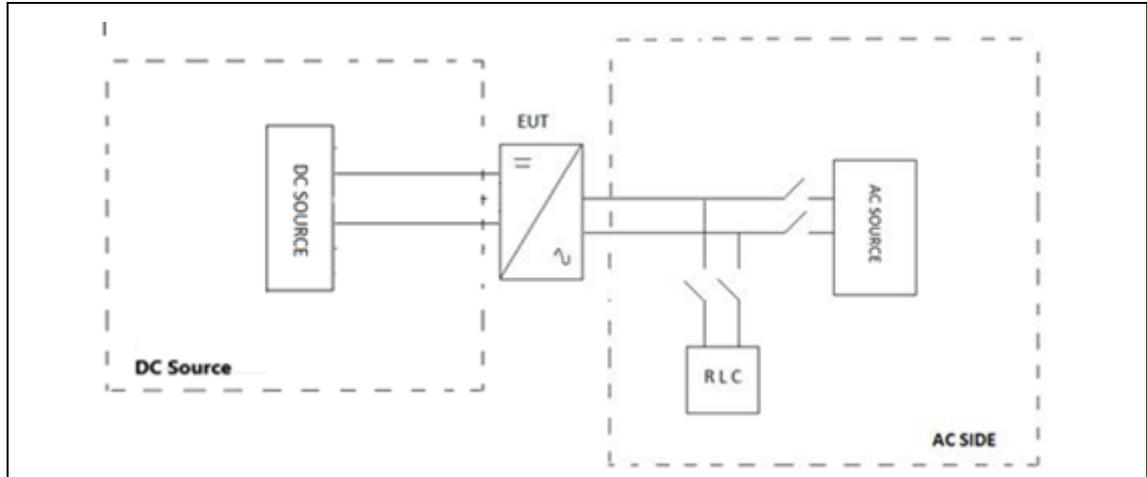
Different equipment has been used to take measures as it shows in chapter 2.5. Current and voltage clamps have been connected to the inverter input / output for all the tests.

All the tests described in the following pages have used this specified test setup.

The test bench used includes:

EQUIPMENT	TRADEMARK / MODEL	RATED CHARACTERISTICS	SN.
AC source	WAGO/ WLPA-330150kVA-D-W	0-600 Vac; 0-208 A 150 kVA max. 45-65 Hz	SUZE600101
DC source	EA/ PSI 11500-60	1500 V, 60 A max.	SUZE600201
RLC load	KAIXIANG/ AC400V-450.99kVA-RLC	450 kW, 450 kVAR	SUZE660101

Test Conditions		
Condition	**Value**	**Comments**
Point of measurement	EUT Output (Low Voltage)	Equipment enounced in section 2.5 of this report has been used in the point of measurement
Short circuit ratio at the measurement point (S_k /Sn)	The value of SEmax/Skv used for the analysis has been 20.	
If the PGU is connected directly to the medium-voltage grid and a step-up transformer is installed between the PGU and the grid (which is not part of the PGU), a standard transformer must be used, the rated apparent power of which corresponds at least to the rated apparent power of the PGU being evaluated.	Connect to LV grid only	
MV Tansformer: Short circuit Power	--	Not applicable measured in Low voltage side
MV Tansformer: Network impedance Phase Angle	--	Not applicable measured in Low voltage side
MV Transformer : Service voltage Uc	--	Not applicable measured in Low voltage side
LV Isolation transformer : Nominal Power (kVA)	--	Transformer
LV Isolation transformer : Short circuit voltage U_k (%)	--	Transformer
LV Isolation transformer : Tap possition	--	Transformer
MV Side: Additional impedance	--	Not applicable measured in Low voltage side
LV Side: Additional impedance	R_A = 0.24 W; X_A = j 0.15 W at 50 Hz; R_N = 0.16 W; X_N = j 0.10 W at 50 Hz.	
The THDSU of the voltage which includes all integer harmonics up to the 50th order must be smaller than 5%. It is measured as the 10-minute mean at the PGU terminals while the PGU is not generating any power.	See section 4.1.3. of this report	
The voltage, measured as a 10-minute mean at the PGU terminals, must lie within a range of ±10% of the rated voltage	-0.105%	
The voltage unbalance, measured as a 10-minute mean	--	Single Phase

Test Conditions		
Condition	**Value**	**Comments**
at the PGU terminals, must be less than 2%.		
The grid frequency, measured as a 0.2 second mean, must lie within a range of ±1% of the rated frequency around the rated frequency. The rate of change of the grid frequency, measured as a 0.2 second mean, must be smaller than 0.2% of the rated frequency per 0.2 seconds.	Tested Max. Value 50.003Hz Tested Min. Value 50.002Hz Tested Avg. Value 50.002Hz	
Note 1: These test conditions have been used in all the test performed in Sections 4 of this report. Note 2: See also the test bench information table in this section		

2.8 Definitions

In	Nominal Current	P	Power
p.u	Per unit	I	Current
Pn	Nominal Power	M	Change for real power
Sn	Apparent Power	N	Change for reactive power
PGU	Power Generation Unit	F	Frequency
Pst	Short-term flicker strength	Q_f	Quality factor
Plt	Long-term flicker strength	NS	Network and System
$C_{\Psi K}$	Flicker coefficient for continuous operation	Un	Nominal Voltage
S_r	Apparent Power Rated	PWHD	Partial weight harmonic distortion
S_k	Short-circuit Apparent Power	THD	Total harmonic distortion
K_{imax}	Maximum switching current factor	Z_{test}	Test circuit impedance at which the emission test
Z_{ref}	The reference impedance	EUT	Equipment under test
P_{rE}	rated active power	S_{rE}	rated apparent power
S_{Amax}	maximum apparent power of a power generation system	S_{Emax}	maximum apparent power of a power generation unit
P_{Amax}	maximum active power of the power generation system	P_{Emax}	maximum active power of the power generation unit
P_{mom}	instantaneous active power	$P_{AV, E}$	agreed active power of a connection for feed-in

3 RESUME OF TEST RESULTS

INTERPRETATION KEYS

Test object does meet the requirement... : **P**   Pass

Test object does not meet the requirement .... : **F**   Fails

Test case does not apply to the test object...................................... : **N/A**   Not applicable

To make a reference to a table or an annex. .... : See additional sheet

To indicate that the test has not been performed .... : **N/P**   Not performed

TEST REPORT SECTION	VDE V 0124-100:2020-06 CLAUSE	STANDARD REQUIREMENTS		RESULT
		VDE-AR-N 4105:2018-11		
		CLAUSE	TEST	
4.1	**5.2**	**5.4**	**Network connection**	**-**
4.1.1	5.2.2	--	Rapid Voltage Changes	P
4.1.2	5.2.3	--	Flickers	P
4.1.3	5.2.4	--	Harmonics and interharmonics	P
4.1.4	5.2.5	--	Commutation notches	P
4.1.5	5.2.6	--	Direct current feed	P
4.2		**5.5**	**Connection criteria**	P
4.2.1		5.5.2	$P_{AV, E}$ monitoring (feed-in limitation)	P
4.3	**5.3**	**5.6**	**Verification of the symmetry behaviour of converters**	**N/A**
4.3.1	5.3.2	--	Calculation of asymmetry of three-phase converters	N/A
4.3.2	5.3.3	--	Symmetrical operation with a symmetry device	N/A
--	**5.4**	**5.7**	**Behaviour of the power generation system at the network**	**N/A**
4.4	--	5.7.1	General (Normal frequency operating range)	P
4.5	--	5.7.1	General (RoCoF)	P
4.6.1	5.4.8.2	5.7.2.2	Reactive power supply at ΣS_{Emax}	P
4.6.2	--	5.7.2.3	Reactive power supply smaller than P_{Emax}	P
4.7.1	5.4.8.4	5.7.2.4 a) / 5.7.2.5	Reactive power voltage characteristic curve Q(U) / Requirements for reactive power methods of type 2 systems (inverters only) and type 1 systems	N/A
4.7.2	5.4.8.3	5.7.2.4 b) / 5.7.2.5	Displacement factor/active power characteristic curve cos φ (P) / Requirements for reactive power methods of type 2 systems (inverters only) and type 1 systems	P
4.7.3	--	5.7.2.4 c) / 5.7.2.5	Displacement factor cos φ / Requirements for reactive power methods of type 2 systems (inverters only) and type 1 systems	P
4.8	5.8	5.7.3	Dynamic network stability	N/A
4.9.1	5.4.3.4	5.7.4.1	Active power output – General (P gradient)	P
4.9.2	--	5.7.4.1	Active power output – General (Ceasing of P)	P
4.9.3	5.4.3.3	5.7.4.2.2	Active power steps	P

4.9.4.1	5.4.5	5.7.4.2.3	Active power adjustment as a function of grid frequency (Overfrequency, storage)	P
4.9.4.2	5.4.7	5.7.4.2.3	Active power adjustment as a function of grid frequency (Underfrequency, storage)	P
4.9.5	--	5.7.4.4	Voltage-dependent active power reduction	P
4.10	--	5.7.5	Short circuit contribution	P
--	**5.5**	**6.5**	**Protection devices and protection settings**	**P**
4.11	5.5.7	6.5.2	Protective functions	P
4.12	5.5.10	6.5.3	Islanding detection	P
4.13	**5.6**	**8.3**	**Connection conditions and synchronisation**	**P**

Note:
Decision Rule of Statements of conformity evaluated according to Guidelines ILAC G8:09/2019 and IEC 115:2023 (4.3.3 / 4.4) & ISO/IEC Guide 98-4 (8.3.12).
Decision Rules used: Binary Statement for Simple Acceptance (Guard Band with respect to the limit w=0).
Specific Risk: Probability of False Accept or Reject lower than 50 %, (PFA / PFR < 50 %)
Measurement uncertainty is not applied when statements of conformity is the simple acceptance.
For more information see ILAC G8/09 & 115 Guidelines.

No deviation from standards

Conclusion: From the test results on the submitted sample, we conclude that it complies with the requirements of the standard.

4   TEST RESULTS

4.1   SYSTEM PERTURBATIONS

System perturbations have been measured with tests procedures from chapter 5.2 of the VDE V 0124-100:2020-06 standard to verify requirements specified in form E.5 of VDE AR-N 4105:2018-11.

4.1.1   Rapid Voltage Changes

The point 5.2.2 of VDE V 0124-100:2020-06 refers to the standard DIN EN 61000-3-2 for the verification of the rapid voltage changes in equipment with a nominal current less than 16 A.

Test results offered have a reference grid impedance Z_{ref} of **32°**.

		d_c (%)	d_{max} (%)	T_{max} (ms)
Limits set under DIN EN 61000-3-2		3.3	4.0	500
100% Pn	Measured values at test impedance	0.314	0.513	0
66% Pn	Measured values at test impedance	0.298	0.426	0
33% Pn	Measured values at test impedance	0.306	0.501	0

Graphics of the results are same with the flickers, refer to the section paragraph 4.1.2 of this report.

4.1.2 Flickers

The Flickers test has been performed according to the paragraph 5.4.3 of VDE-AR-N 4105:2018-11 and the paragraph 5.2.3 of VDE V 0124-100:2020-06. It has been taken the EN 61000-3-3 as reference standard due to the output current ≤ 16 A of the inverter. In addition of the requirements of this reference standard, VDE-AR-N 4105: 2011 requires a Plt value less or equal to 0.5.

In table below are offered the values measured [1]:

[1] This section is tested by EUT which SN is BK12ZEBB2H3D0099.

	Limit	33% Pn	66% Pn	100% Pn
Pst	≤ 1	0.138	0.137	0.135
Plt	≤ 0.5	0.132	0.132	0.134
dc [%]	≤ 3.30	0.314	0.298	0.303
dmax [%]	4	0.513	0.426	0.501

As it can be seen in the next screenshots, this test has 12 steps and each step for 10min. The values took of Pst, Plt, dc and dmax are the most unfavorable of the 12 steps.

According to the standard, the flicker coefficient $c\Psi k$ must be determined for the impedance angle 32°. The flicker coefficient is determined on the basis of the previously measured P_{st} values in accordance with the following formula:

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

Whereby the following applies:

P_{st} Short-term flicker value measured on the network substitute element;
S_k Short circuit power of the network substitute element (during determination of the corresponding P_{st} values).

The default analog values for the power analyzer used are as follows:

$S_k / Pn = 20$

These tests are only based on a 32° network impedance angle.

Z_{test} impedance test (Test method refer to IEC 61000-3-2):

R_A = 0.24 W; X_A = j 0.15 W at 50 Hz;
R_N = 0.16 W; X_N = j 0.10 W at 50 Hz.

The impedance test Z_{test} is the same that the reference impedance Z_{ref}.

It has also been calculated the flicker coefficient in function of different network impedance phase angles. These calculations are offered in the table below

Network impedance phase angle, Ψk	32°
Average active power	Flicker coefficient, C (Ψk, P)
P = 33%Pn	2.76
P = 66% Pn	2.74
P = 100% Pn	2.70

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33 %Pn

Phase A

	Flicker Mode	Range Over		SCL ▪ Line Filter ▪		CH: 1 **2**
	Flicker	U1 U2 U3 U4 U5 U6 U7 / I1 I2 I3 I4 I5 I6 I7		AVG ▪ Freq Filter ▪		4 5 6

Count ▬▬▬▬▬▬▬▬▬▬ 12/12   Complete
Interval ▬ 00:00s/10:00s
Element 2
Volt Range 300 V/50Hz   Element2 Judgement   Pass
Un (U2) 229.950V   Total Judgement   Pass
Freq (U2) 49.995Hz   (Element2)
Dmin 0.25%

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.301	Pass	0.457	Pass	0.0	Pass	0.114	Pass		
2	0.301	Pass	0.489	Pass	0.0	Pass	0.129	Pass		
3	0.313	Pass	0.484	Pass	0.0	Pass	0.138	Pass		
4	0.313	Pass	0.500	Pass	0.0	Pass	0.133	Pass		
5	0.309	Pass	0.505	Pass	0.0	Pass	0.132	Pass		
6	0.312	Pass	0.505	Pass	0.0	Pass	0.134	Pass		
7	0.312	Pass	0.508	Pass	0.0	Pass	0.132	Pass		
8	0.313	Pass	0.513	Pass	0.0	Pass	0.133	Pass		
9	0.310	Pass	0.507	Pass	0.0	Pass	0.133	Pass		
10	0.313	Pass	0.511	Pass	0.0	Pass	0.134	Pass		
11	0.314	Pass	0.505	Pass	0.0	Pass	0.133	Pass		
12	0.314	Pass	0.512	Pass	0.0	Pass	0.135	Pass		
Result		Pass		Pass		Pass		Pass	0.132	Pass

Element 1: U1 600 V / I1 50 mV / Sync Src: U1 / Integral: Reset
Element 2: U2 300 V / I2 10 mA / Sync Src: U2 / Integral: Reset
Element 3: U3 300 V / I3 50 mV / Sync Src: U2 / Integral: Reset
Element 4: U4 300 V / I4 50 mV / Sync Src: U2 / Integral: Reset
Element 5: U5 600 V / I5 50 mV / Sync Src: U1 / Integral: Reset
Element 6: U6 15 V / I6 50 mV / Sync Src: U1 / Integral: Reset

66 %Pn

	Flicker Mode	Range Over		SCL ▪ Line Filter ▪	PA_00001.png	CH: 1 **2**
	Flicker	U1 U2 U3 U4 U5 U6 U7 / I1 I2 I3 I4 I5 I6 I7		AVG ▪ Freq Filter ▪		4 5 6

Count ▬▬▬▬▬▬▬▬▬▬ 12/12   Complete
Interval ▬ 00:00s/10:00s
Element 2
Volt Range 300 V/50Hz   Element2 Judgement   Pass
Un (U2) 229.950V   Total Judgement   Pass
Freq (U2) 49.995Hz   (Element2)
Dmin 0.25%

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500 3.30%		1.00		0.65 N:12	
No. 1	0.216	Pass	0.394	Pass	0.0	Pass	0.114	Pass		
2	0.220	Pass	0.411	Pass	0.0	Pass	0.128	Pass		
3	0.298	Pass	0.424	Pass	0.0	Pass	0.137	Pass		
4	0.219	Pass	0.426	Pass	0.0	Pass	0.132	Pass		
5	0.215	Pass	0.416	Pass	0.0	Pass	0.131	Pass		
6	0.217	Pass	0.421	Pass	0.0	Pass	0.134	Pass		
7	0.216	Pass	0.419	Pass	0.0	Pass	0.132	Pass		
8	0.216	Pass	0.416	Pass	0.0	Pass	0.133	Pass		
9	0.217	Pass	0.417	Pass	0.0	Pass	0.133	Pass		
10	0.219	Pass	0.419	Pass	0.0	Pass	0.133	Pass		
11	0.216	Pass	0.425	Pass	0.0	Pass	0.133	Pass		
12	0.216	Pass	0.416	Pass	0.0	Pass	0.134	Pass		
Result		Pass		Pass		Pass		Pass	0.132	Pass

Element 1: U1 600 V / I1 50 mV / Sync Src: U1 / Integral: Reset
Element 2: U2 300 V / I2 10 mA / Sync Src: U2 / Integral: Reset
Element 3: U3 300 V / I3 50 mV / Sync Src: U2 / Integral: Reset
Element 4: U4 300 V / I4 50 mV / Sync Src: U2 / Integral: Reset
Element 5: U5 600 V / I5 50 mV / Sync Src: U1 / Integral: Reset
Element 6: U6 15 V / I6 50 mV / Sync Src: U1 / Integral: Reset

100 %Pn

Flicker Mode
Flicker

Range Over
U1 U2 U3 U4 U5 U6 U7
I1 I2 I3 I4 I5 I6 I7

SCL Line Filter
AVG Freq Filter

CH: 1 2
4 5 6

Count   12/12   Complete
Interval   00:00s/10:00s
Element   2
Volt Range   300 V/50Hz   Element2   Judgement   Pass
Un (U2)   230.260V   Total   Judgement   Pass
Freq (U2)   49.994Hz   (Element2)
Dmin   0.25%

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		500		1.00		0.65	
					3.30%				N:12	
No. 1	0.217	Pass	0.450	Pass	0.0	Pass	0.134	Pass		
2	0.303	Pass	0.488	Pass	0.0	Pass	0.133	Pass		
3	0.213	Pass	0.447	Pass	0.0	Pass	0.132	Pass		
4	0.214	Pass	0.453	Pass	0.0	Pass	0.134	Pass		
5	0.215	Pass	0.447	Pass	0.0	Pass	0.135	Pass		
6	0.306	Pass	0.501	Pass	0.0	Pass	0.133	Pass		
7	0.216	Pass	0.453	Pass	0.0	Pass	0.134	Pass		
8	0.215	Pass	0.460	Pass	0.0	Pass	0.134	Pass		
9	0.216	Pass	0.445	Pass	0.0	Pass	0.134	Pass		
10	0.215	Pass	0.450	Pass	0.0	Pass	0.134	Pass		
11	0.215	Pass	0.450	Pass	0.0	Pass	0.134	Pass		
12	0.301	Pass	0.489	Pass	0.0	Pass	0.134	Pass		
Result		Pass		Pass		Pass		Pass	0.134	Pass

Element 1
U1   600 V
I1   50 mV
Sync Src: U1
Integral: Reset

Element 2
U2   300 V
I2   10 mA
Sync Src: U2
Integral: Reset

Element 3
U3   300 V
I3   50 mV
Sync Src: U2
Integral: Reset

Element 4
U4   300 V
I4   50 mV
Sync Src: U2
Integral: Reset

Element 5
U5   600 V
I5   50 mV
Sync Src: U1
Integral: Reset

Element 6
U6   15 V
I6   50 mV
Sync Src: U1
Integral: Reset

4.1.3   Harmonics And Interharmonics

The current harmonics, interharmonics and supraharmonics have been measured according to chapter 5.2.4 of VDE V 0124-100:2020-06, at the required power values.

4.1.3.1   Harmonics

Standard VDE-AR-N 4100:2019-04 has been taken as reference for harmonic limits and calculations.

The reactive power setpoint is 0 VAr, the harmonics have been measured 10 minutes average values of line current, at least three records consisting of 3-phase measurements.

They have been verified limits at different power levels, from 0%Pn to 100% Pn, in 10%Pn steps.

The arithmetic average is formed over the 10 minutes record for each harmonic, interharmonic and higher frequency component of the current.

Standard EN 61000-3-2 has been taken as reference for harmonic limits.
Values measured for current harmonics, total harmonic distortion (THD) up to the 40th harmonic and Partial Weighted Harmonic Distortion (PWHD) from the 12th to the 40th harmonic is offered in the following table and graphs:

P (%Pₙ)	0	10	20	30	40	50	60	70	80	90	100	Limit
Nr. / Order	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)	I(A)
2	0.006	0.005	0.005	0.029	0.040	0.041	0.045	0.042	0.039	0.039	0.046	1.080
3	0.051	0.051	0.059	0.065	0.056	0.062	0.071	0.071	0.067	0.063	0.063	2.300
4	0.005	0.004	0.009	0.024	0.020	0.014	0.018	0.014	0.012	0.010	0.016	0.430
5	0.036	0.035	0.037	0.026	0.010	0.009	0.016	0.026	0.032	0.034	0.033	1.140
6	0.004	0.004	0.005	0.007	0.006	0.008	0.004	0.007	0.008	0.007	0.004	0.300
7	0.049	0.046	0.046	0.062	0.064	0.041	0.031	0.025	0.041	0.062	0.075	0.770
8	0.003	0.003	0.003	0.003	0.007	0.003	0.007	0.003	0.005	0.008	0.011	0.230
9	0.032	0.030	0.027	0.020	0.034	0.043	0.032	0.033	0.029	0.025	0.037	0.400
10	0.002	0.002	0.003	0.002	0.002	0.006	0.004	0.003	0.005	0.005	0.004	0.184
11	0.016	0.015	0.017	0.018	0.010	0.022	0.029	0.025	0.027	0.028	0.025	0.330
12	0.004	0.004	0.004	0.004	0.003	0.002	0.006	0.003	0.006	0.002	0.004	0.153
13	0.007	0.007	0.009	0.010	0.013	0.008	0.016	0.021	0.024	0.026	0.028	0.210
14	0.002	0.002	0.002	0.002	0.005	0.002	0.004	0.004	0.004	0.007	0.004	0.131
15	0.003	0.005	0.006	0.007	0.010	0.010	0.008	0.016	0.015	0.023	0.021	0.150
16	0.002	0.002	0.002	0.003	0.002	0.002	0.004	0.005	0.007	0.003	0.005	0.115
17	0.003	0.003	0.004	0.005	0.007	0.009	0.012	0.006	0.013	0.013	0.017	0.132
18	0.002	0.002	0.003	0.003	0.004	0.005	0.005	0.004	0.005	0.002	0.006	0.102
19	0.003	0.003	0.004	0.004	0.005	0.003	0.006	0.006	0.006	0.011	0.007	0.118
20	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.005	0.003	0.003	0.005	0.092
21	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.006	0.004	0.006	0.009	0.107
22	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.002	0.004	0.003	0.084
23	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.006	0.003	0.005	0.098
24	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.005	0.002	0.002	0.077
25	0.004	0.003	0.003	0.003	0.004	0.005	0.004	0.004	0.007	0.003	0.009	0.090
26	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.003	0.004	0.004	0.071
27	0.002	0.002	0.002	0.003	0.003	0.004	0.007	0.007	0.009	0.006	0.007	0.083
28	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.003	0.004	0.003	0.004	0.066
29	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.005	0.078
30	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.004	0.061
31	0.003	0.003	0.004	0.004	0.003	0.004	0.005	0.006	0.006	0.007	0.007	0.073
32	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.058
33	0.004	0.004	0.004	0.003	0.003	0.004	0.004	0.005	0.006	0.003	0.010	0.068
34	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.003	0.054
35	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.004	0.003	0.064
36	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.051
37	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.006	0.003	0.061
38	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.004	0.048
39	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005	0.006	0.005	0.006	0.058
40	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.002	0.003	0.003	0.046
THC (%)	2.572	2.510	2.658	3.083	3.065	2.963	3.097	3.071	3.176	3.433	3.821	--
PWHC (%)	3.118	3.115	3.156	3.260	3.502	3.679	3.927	4.313	4.753	5.154	5.620	--

Current Harmonics
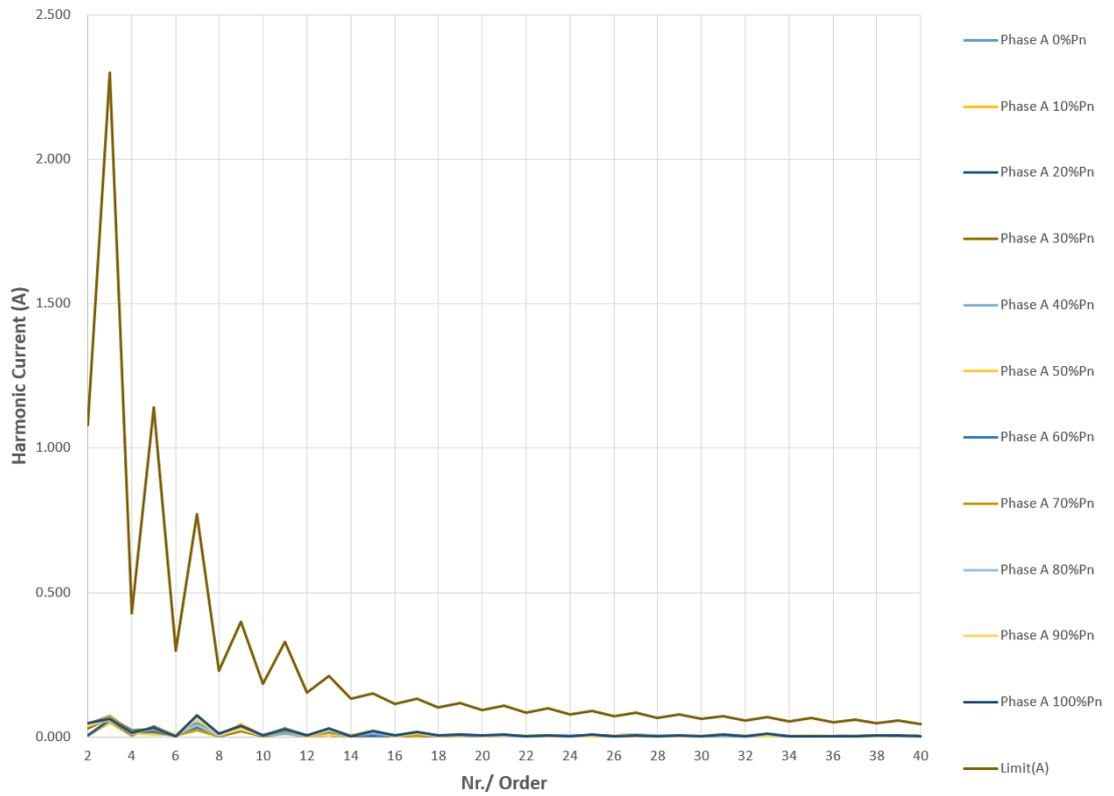
Total Harmonic Current Distortion
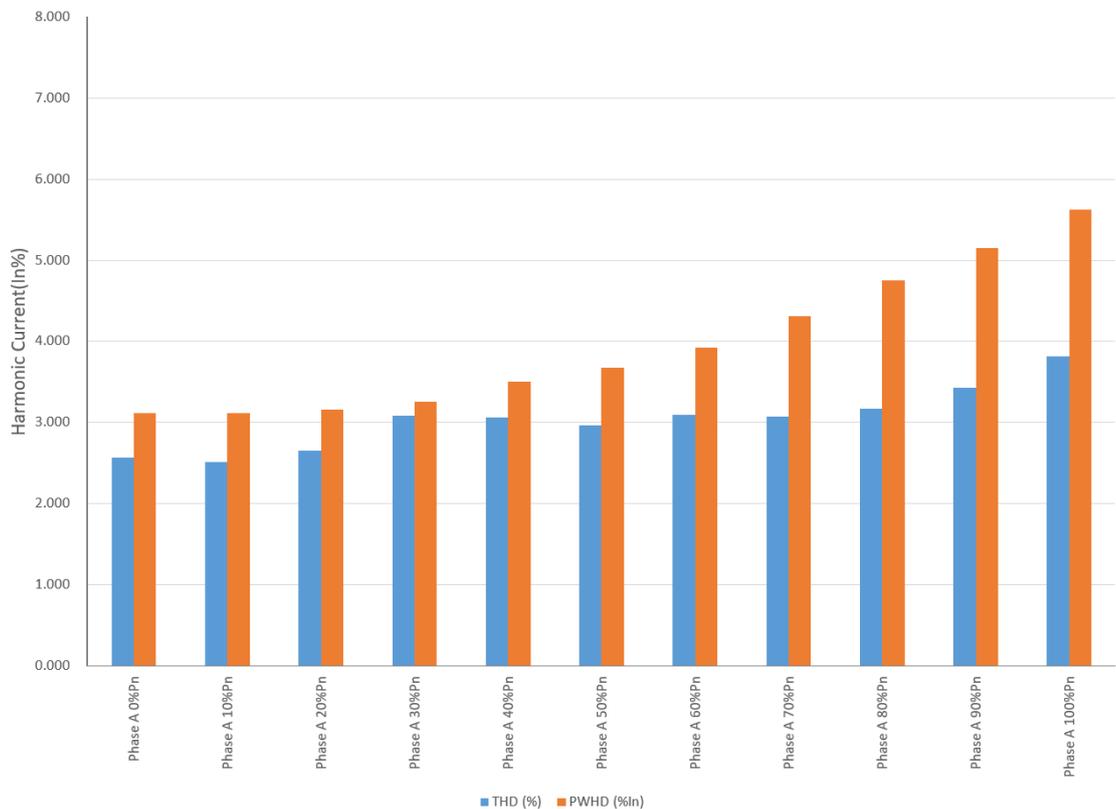
4.1.3.2 Interharmonics

This test is not applicable according to paragraph 5.2.4 of standard VDE V 0124-100:2020-06, which states that inverters >75 A will have to perform current interharmonics test.

4.1.3.3 Higher Frequency

This test is not applicable according to paragraph 5.2.4 of standard VDE V 0124-100:2020-06, which states that inverters >75 A will have to perform current higher frequencies (between 2 kHz and 9 kHz) test.

4.1.4 Commutation Notches

The point 5.2.5 of VDE V 0124-100:2020-06 requires verification of the commutation voltage dips in line-commutated inverters.

The equipment shall be operated in three operation points, and three 100ms oscillograms from each operation point shall be measured to check the commutation dips.

Limits and success criteria are specified in VDE-AR-N 4100:2019-04, section 5.4.

Most unfavorable test results for each operation point are presented in the following table:

Operating point	P measured ($\%P_{Emax}$)	V measured (V)	$\hat{U}_n$ (V)	ΔU_{com} (V)	d_{com} limit (%)	d_{com} measured (%)
$25\%P_{Emax}<P<35\%P_{Emax}$	29.8	325.3	230.1	0.1		0.0
$65\%P_{Emax}<P<75\%P_{Emax}$	69.4	325.3	230.1	0.1	5.0	0.0
$90\%P_{Emax}<P$	99.6	325.3	230.1	0.1		0.0

Commutation notches test ($25\%P_{Emax}<P<35\%P_{Emax}$)

	A	B	间隔	最小值	最大值
时间 [s]	4.167101	6.876870	2.709769		
AI 2/I3@TRIONet3_1149	-0.161409	0.136137	0.297546	-0.465632	0.336409
AI 2/U3@TRIONet3_1149	258.4870	-295.4719	-553.9589	-324.8861	325.3298

d_{com} = ((|+325.3| / 1.414) - 230) / 230 * 100% = 0.0%
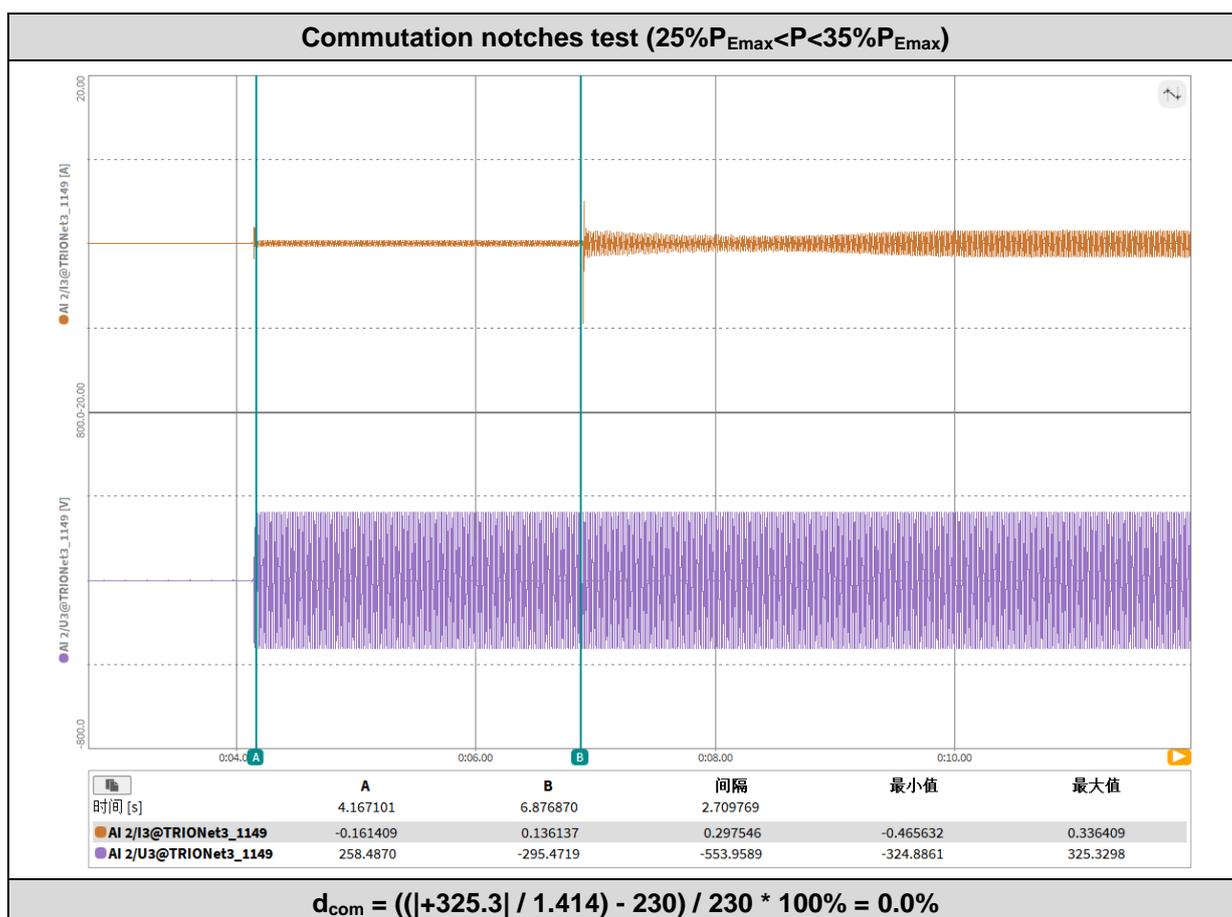
Commutation notches test (65%P$_{Emax}$<P<75%P$_{Emax}$)

时间 [s]	A	B	间隔	最小值	最大值
	0:25.46187	0:28.19518	2.73331		
AI 2/I3@TRIONet3_1149	-0.271440	-0.033379	0.238061	-0.442743	0.336528
AI 2/U3@TRIONet3_1149	58.67648	-320.2772	-378.9537	-324.8820	325.2762
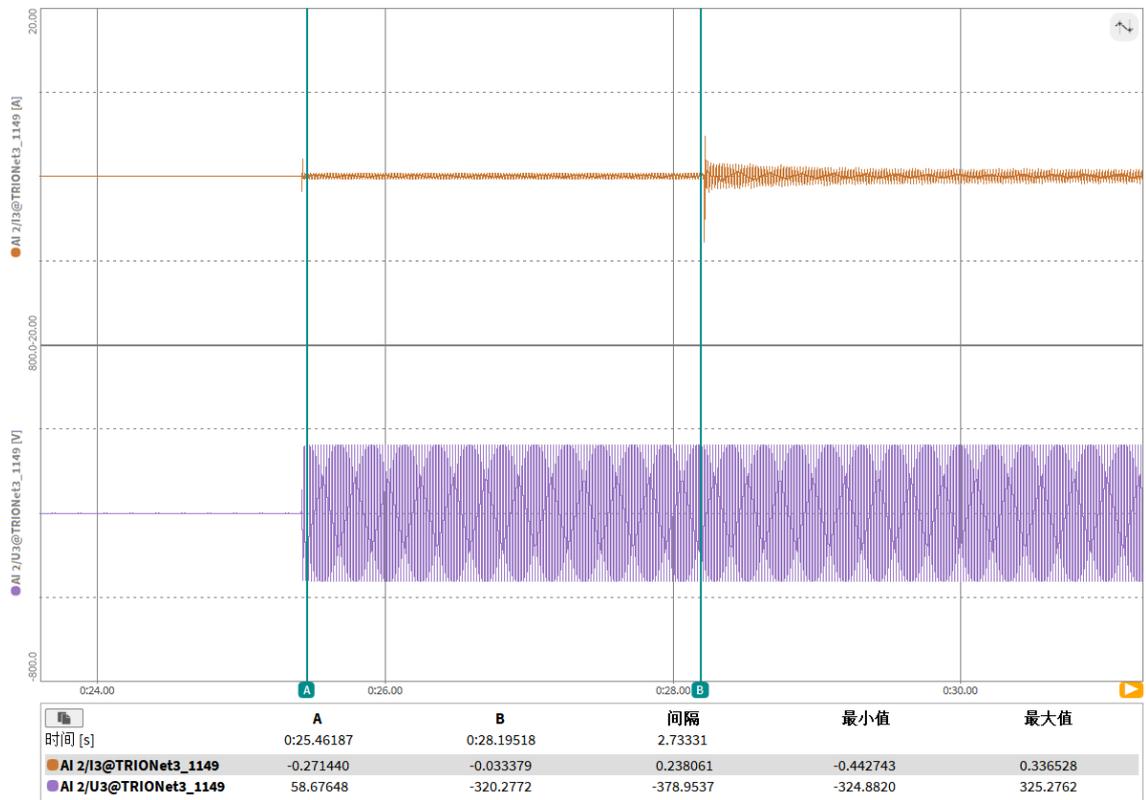
d$_{com}$ = ((|+325.3| / 1.414) - 230) / 230 * 100% = 0.0%

Commutation notches test (90%P$_{Emax}$<P)

时间 [s]	A	B	间隔	最小值	最大值
	0:11.803794	0:15.930937	4.127142		
AI 2/I3@TRIONet3_1149	-0.130177	0.103712	0.233889	-0.320196	0.336051
AI 2/U3@TRIONet3_1149	290.5853	-309.9432	-600.5285	-324.8236	325.2807
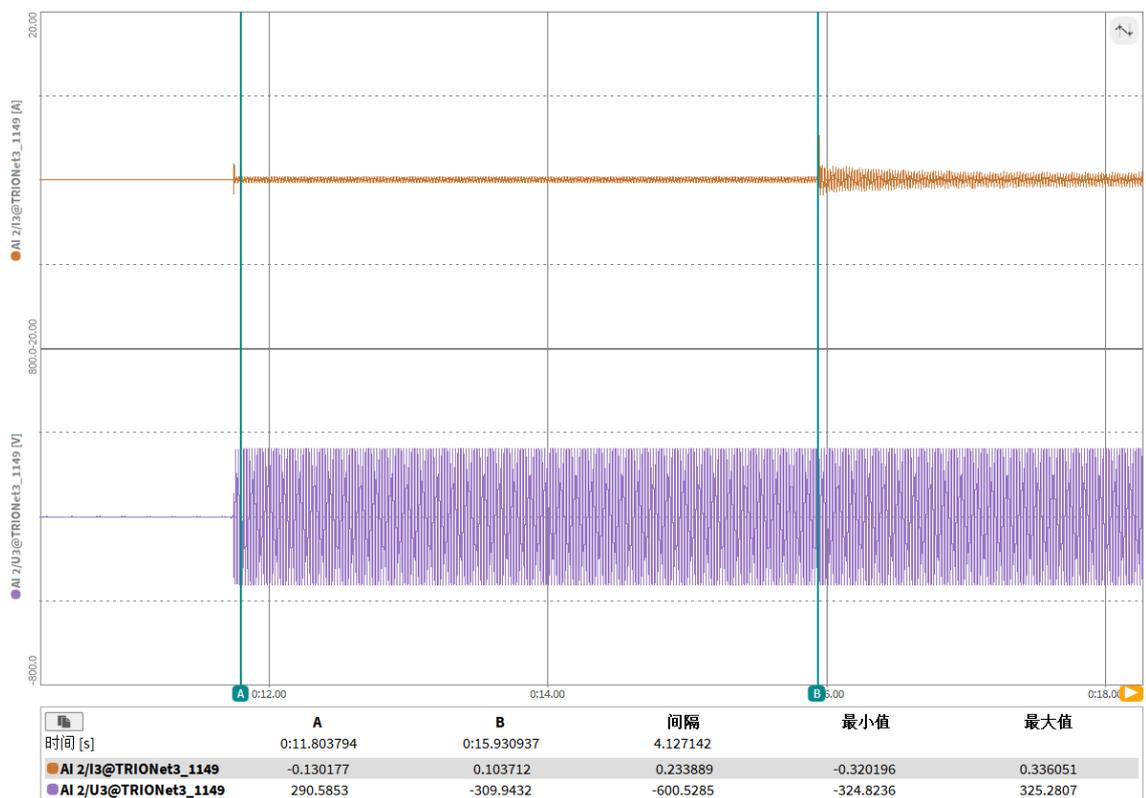
d$_{com}$ = ((|+325.3| / 1.414) - 230) / 230 * 100% = 0.0%

4.1.5 DC Current Injection

The point 5.2.6 of VDE V 0124-100:2020-06 refers to the standard DIN EN 61000-4-7 for the verification of the DC current feed into the low-voltage grid.

The equipment shall be operated in the following points at the following active power levels:

−	30.0% P_{Emax} <P <40.0% P_{Emax}
−	60.0% P_{Emax} <P <70.0% P_{Emax}
−	P >95.0% P_{Emax}

The network or network simulator used for the tests shall meet the following conditions:

−	U = U_n ± 5.0%
−	f = 50.00 ± 0.20 Hz
−	Voltage THD <2.5%
−	DC component of the voltage <0.1%

Limits given in VDE-AR-N 4100:2019-04 for direct current feed in are 0.5% of the rated current, or 20 mA, whichever is higher.

Operating point	P measured (p.u)	U measured (p.u.)	F measured (Hz)	Idc limit (mA)	Idc measured (mA)
30%P_{Emax}<P<40%P_{Emax}	0.329	1.002	49.99		19
60%P_{Emax} <P<70%P_{emax}	0.656	1.002	49.99	20	12
P>95% P_{Emax}	0.991	1.002	49.99		11

Results Chart
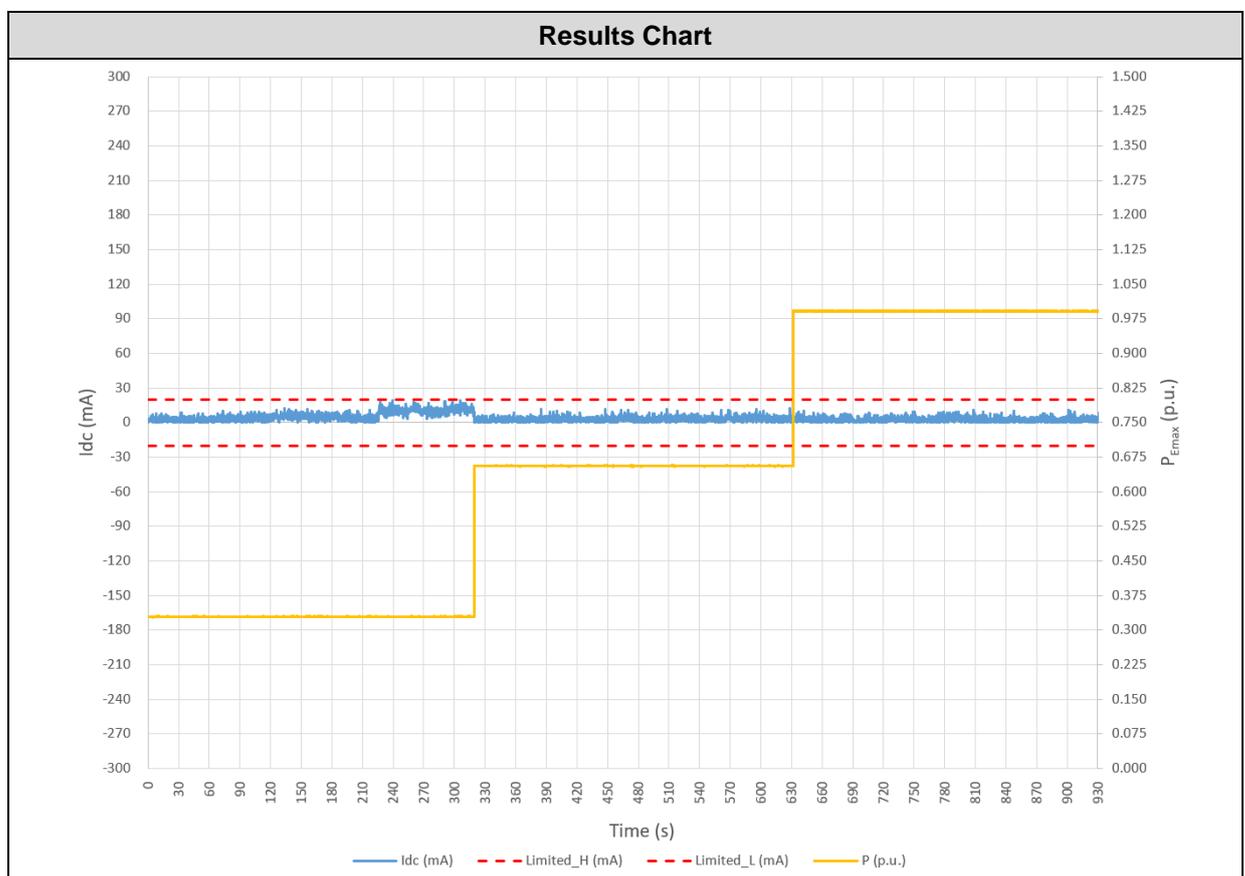
4.2 CONNECTION CRITERIA

4.2.1 $P_{AV, E}$ monitoring (feed-in limitation)

The test serves to prove the requirements of VDE-AR-N 4105: 2018 - 11, 5.5.2. The P AV, E-monitoring may, but does not have to be, integrated into the PGU. If the $P_{AV,E}$-monitoring is not as a unit built, but distributed over several devices, the entire impact chain is analogous to the examination of NA protection including the communicative Check coupling.
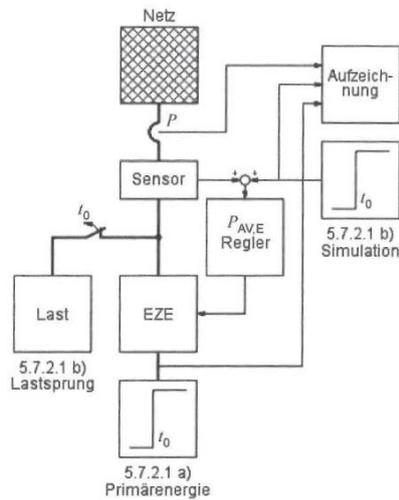
Bild 8 – Skizze des Prüfaufbaus zur Prüfung der Regeldynamik
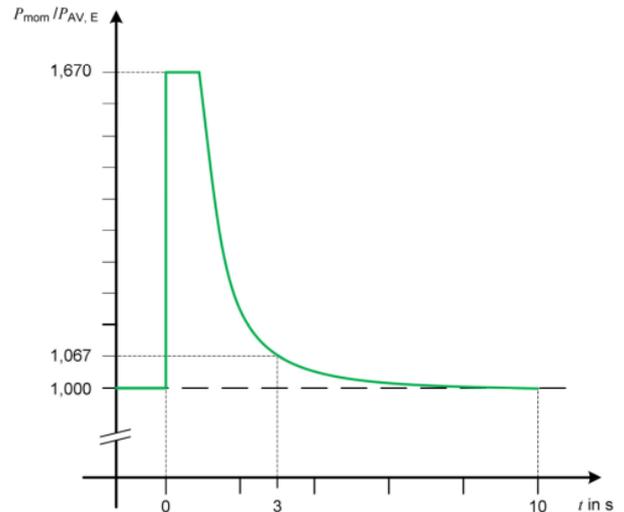
Bild 1 – Wirkleistungs-Grenzkurve für Erzeugungsanlagen

The PGU with any necessary additional components is installed according to the manufacturer's instructions and parameterized so that the feed limitation $P_{AV,E}$ is activated at ≥ 60% P_{rE}. The power jump can be simulated either by a jump in the primary energy supply or by the fall of a load become:

a) Primary energy supply jump: The primary energy supply is adjusted so that the PGU supplies the power $P_{AV,E}$ = 60% P_{rE} with a tolerance of -2%. At the time t0, the primary energy supply is to be suddenly increased so that the PGU can provide the rated output.

b) Loss of load: The PGU is operated at nominal power. Via a load which is to be connected symmetrically to all feeding phases parallel to the PGU, the power at the grid connection point is set to $P_{AV, E}$ with a tolerance of -2%. At time t0, the load is switched off. The elimination of the load can also be simulated by an appropriate offset on the power measurement signal.

The closed loop must not be disconnected. Here, the sum of the effective active values of all 3 phases at the grid connection point must be recorded for at least 15s from the power jump.

Test a): Primary energy supply jump				
P_{SUM} before energy jump [W]	P_{SUM} after energy jump [W]	P_{DC} before energy jump [W]	Available P_{DC} after energy jump [W]	Settling time [s]
781	458	781	461	4.00
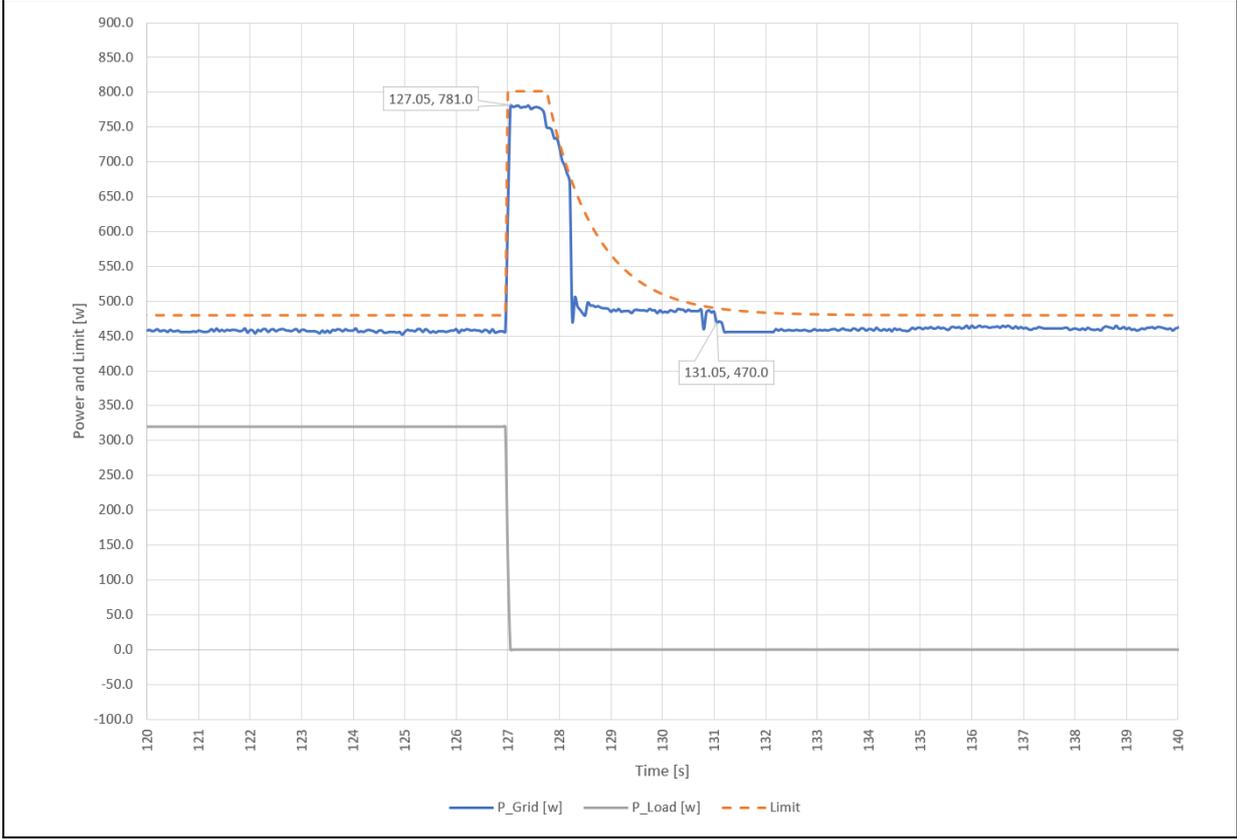
4.3 THREE-PHASE INVERTER SYSTEMS

This chapter has been done taking into consideration requirements from chapter 5.6 and information of Annex A.4 of the VDE AR-N 4105:2018-11 standard. Chapter 5.3 of the VDE V 0124-100:2020-06 has been used as a testing procedure.

4.3.1 Calculation Of Asymmetry Of Three-Phase Converters

This test is not applicable according to the section 5.3.2 of the standard VDE V 0124-100:2020-06 due to this testing is only applied to three-phase converters.

4.3.2 Symmetrical Operation With A Symmetry Device

This test is not applicable according to the section 5.3.3 of the standard VDE V 0124-100:2020-06 due to this testing is only applied to EZE and storage operating with a symmetry device.

4.4 NORMAL FREQUENCY OPERATING RANGE

According to the paragraph 5.7.1 of the VDE-AR-N 4105:2018-11, in the frequency range of 47.5 Hz to 51.5 Hz, power generation systems shall be capable of network parallel operation in compliance with the time-related minimum requirements given in Table 1.

Table 1 – Frequency/time ranges for the proper operation of power generation systems

Frequency range	Operating period
47,5 Hz to 49,0 Hz	≥ 30 min
49,0 Hz to 51,0 Hz	unlimited
51,0 Hz to 51,5 Hz	≥ 30 min

Test results are offered in the following tables and graphs:

Test no.	Voltage setpoint (%Un)	Voltage measured (%Un)	Frequency setpoint (Hz)	Frequency measured (Hz)	Min. time required (min)	Time measured (min)	Active power measured (%Pn)	Disconnection
1	100.0	100.1	47.50	47.49	≥30	66.0	101.2	☐ Yes ☒ No
2	100.0	100.1	50.00	49.99	Unlimited	9.0	100.2	☐ Yes ☒ No
3	100.0	100.1	51.50	51.49	≥30	72.0	100.1	☐ Yes ☒ No

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Test 1 (V = 100%Un and F = 47.5 Hz)

Test 2 (V = 100%Un and F = 50.0 Hz)

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
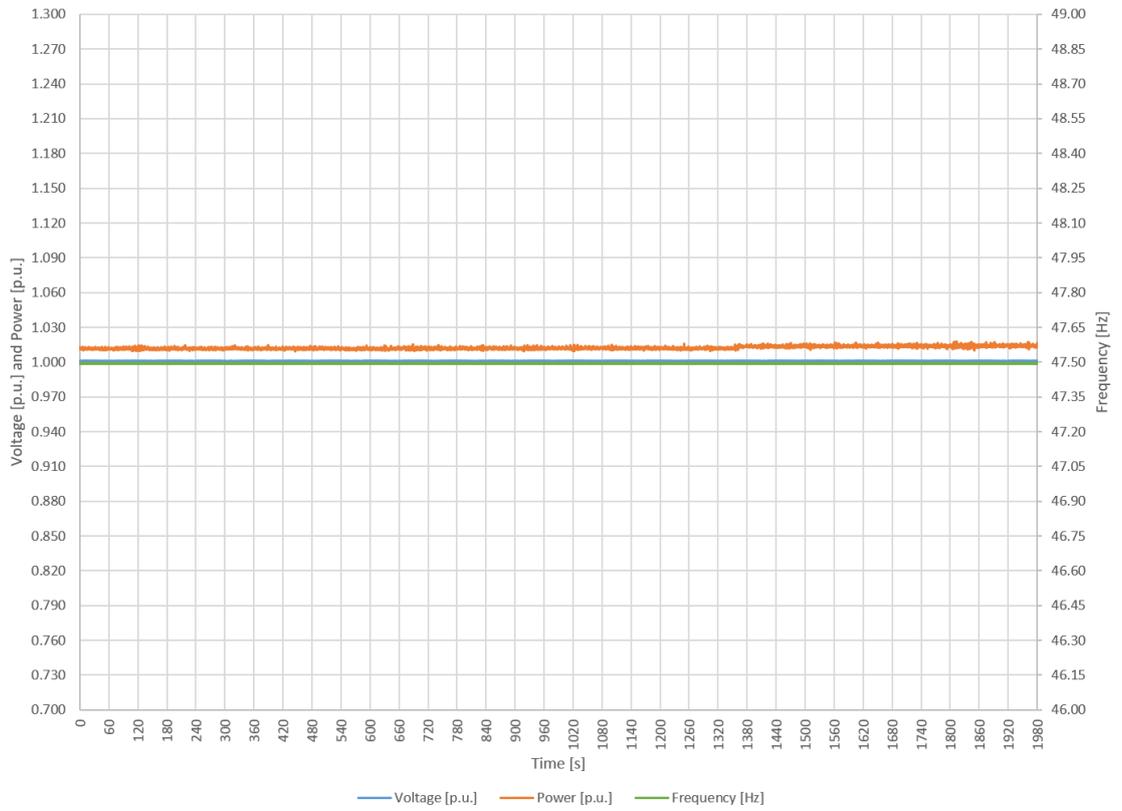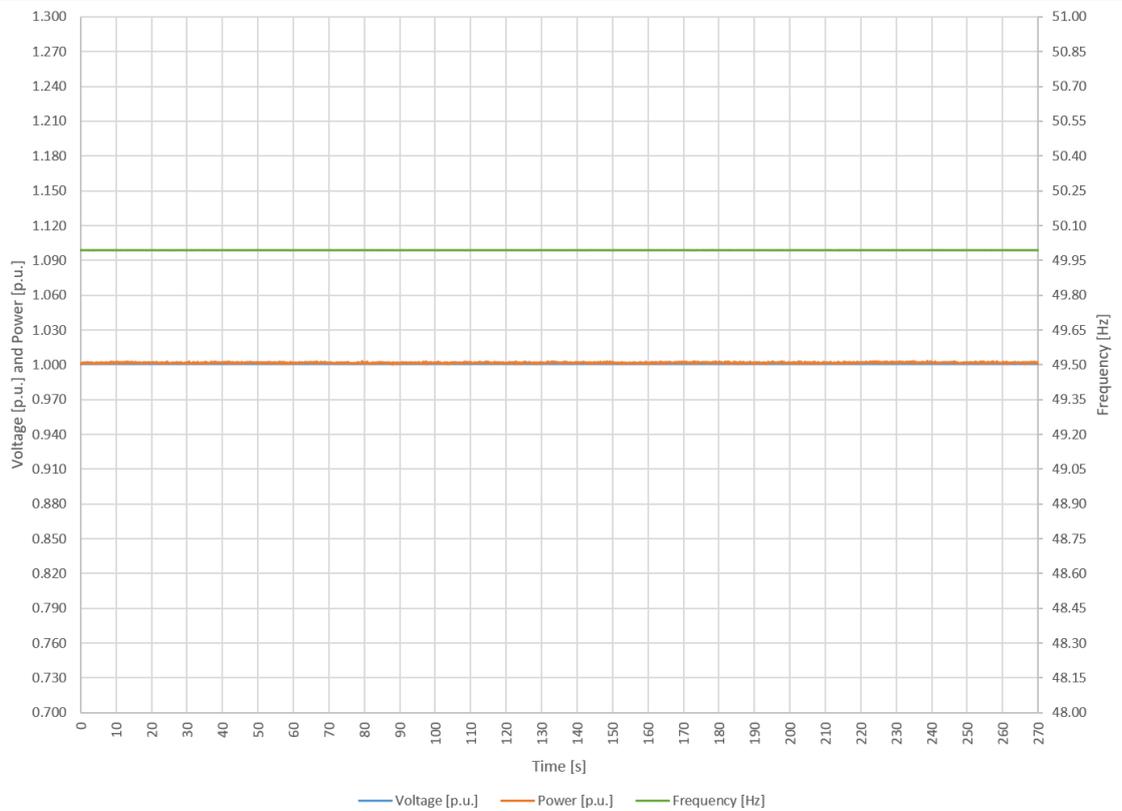
Test 3 (V = 100%Un and F = 51.5 Hz)
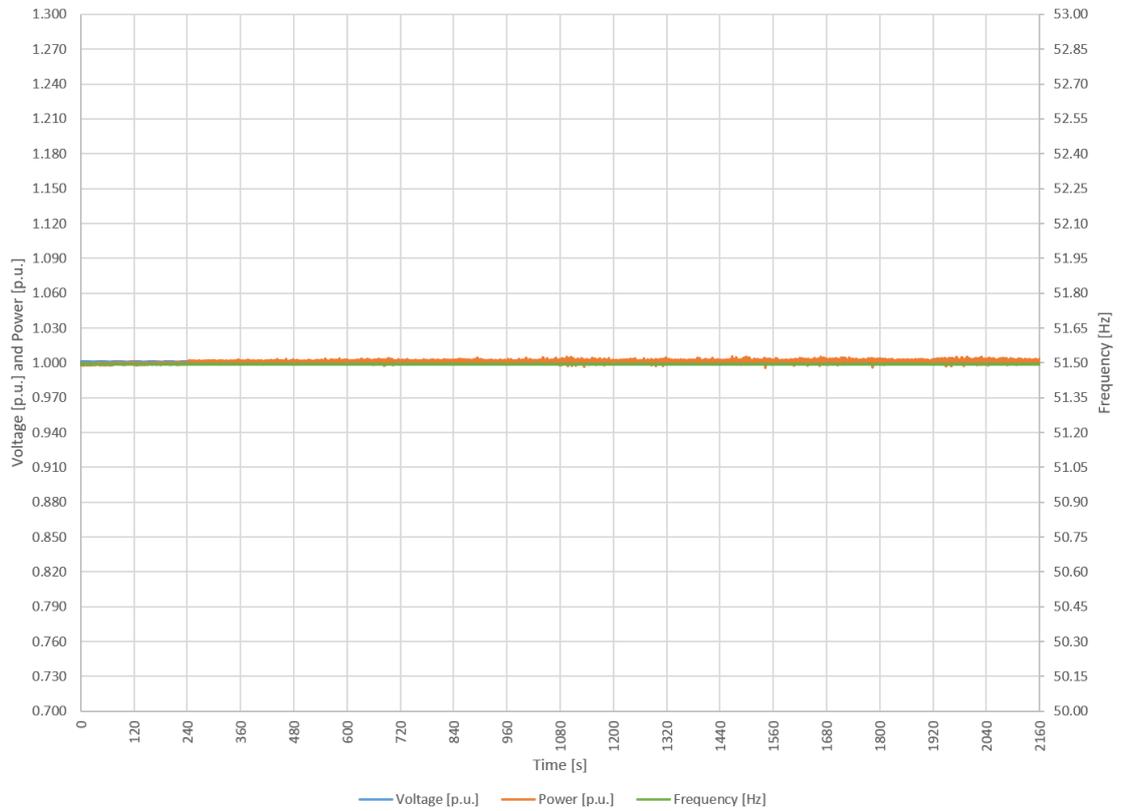
4.5 RoCoF

This test has been done according to chapter 5.7.1 of the VDE AR-N 4105:2018-11 standard to verify that the EUT does not disconnect when submitted to frequency jumps.

For verification of this requirement, different tests have been done regarding different frequency jumps and different mobile time windows in the range 47.5 Hz – 51.5 Hz, at 100 %Pn:

- ± 2 Hz/s for a mobile time window of 0.5 s
- ± 1.5 Hz/s for a mobile time window of 1 s
- ± 1.25 Hz/s for a mobile time window of 2 s

Test results are offered in the following tables and graphs:

Test 1: ± 2 Hz/s					
	Start frequency (Hz)	**Change desired (Hz/s)**	**Final Value (Hz)**	**Ramp (Hz/s)**	**Disconnection**
Positive frequency drift	49.00	+2.00	51.00	+2.50	☒ NO ☐ YES
Negative frequency drift	50.99	-2.00	48.99	-2.50	☒ NO ☐ YES

Test 2: ± 1.5 Hz/s					
	Start frequency (Hz)	**Change desired (Hz/s)**	**Final Value (Hz)**	**Ramp (Hz/s)**	**Disconnection**
Positive frequency drift	49.24	+1.50	50.74	+1.67	☒ NO ☐ YES
Negative frequency drift	50.74	-1.50	49.24	-1.67	☒ NO ☐ YES

Test 3: ± 1.25 Hz/s					
	Start frequency (Hz)	**Change desired (Hz/s)**	**Final Value (Hz)**	**Ramp (Hz/s)**	**Disconnection**
Positive frequency drift	48.74	+1.25	51.24	+1.36	☒ NO ☐ YES
Negative frequency drift	51.24	-1.25	48.74	-1.36	☒ NO ☐ YES

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Test 1 (+2 Hz/s) - Positive frequency drift
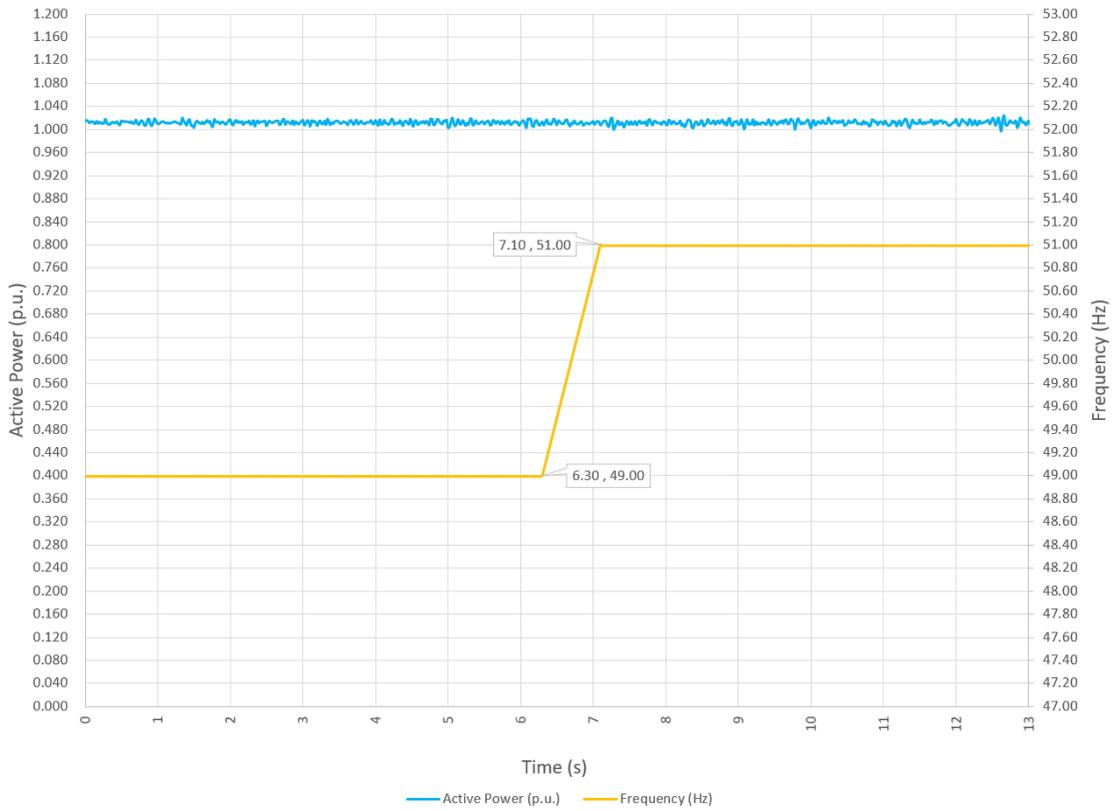
Time of change measured: 800 ms

Test 1 (-2 Hz/s) - Negative frequency drift

Time of change measured: 800 ms

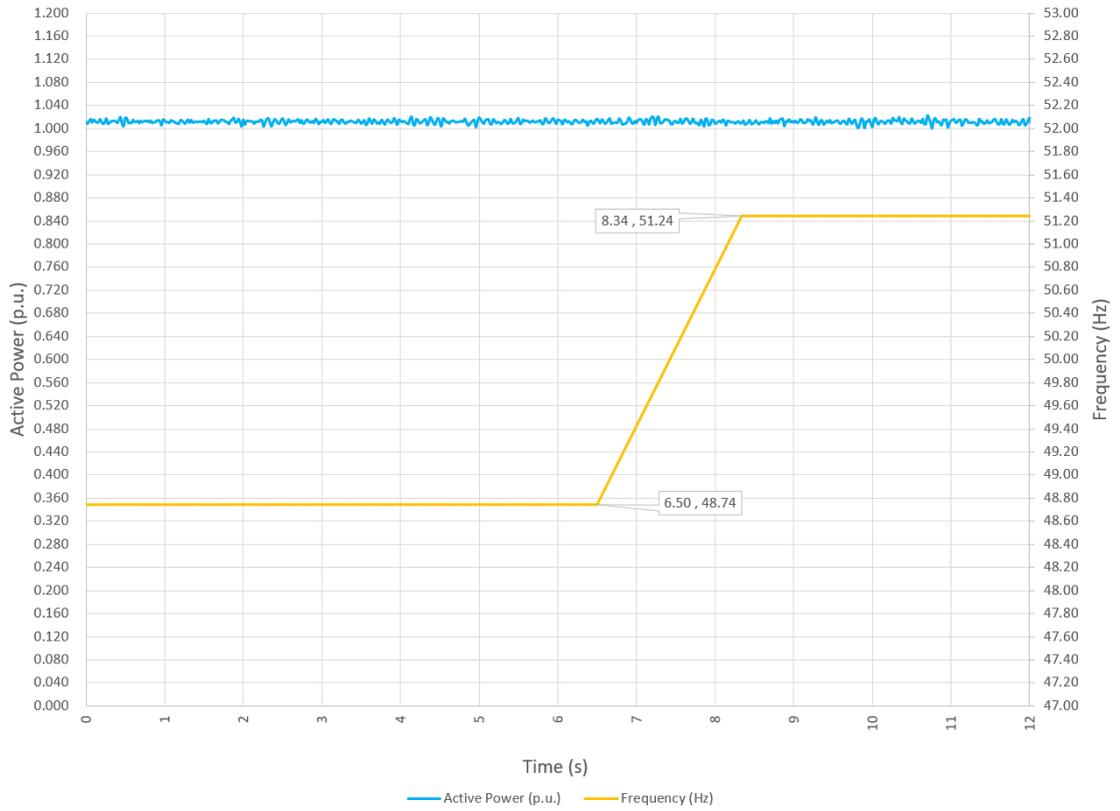VDE-AR-N 4105:2018-11 + Correction 1:2020-10
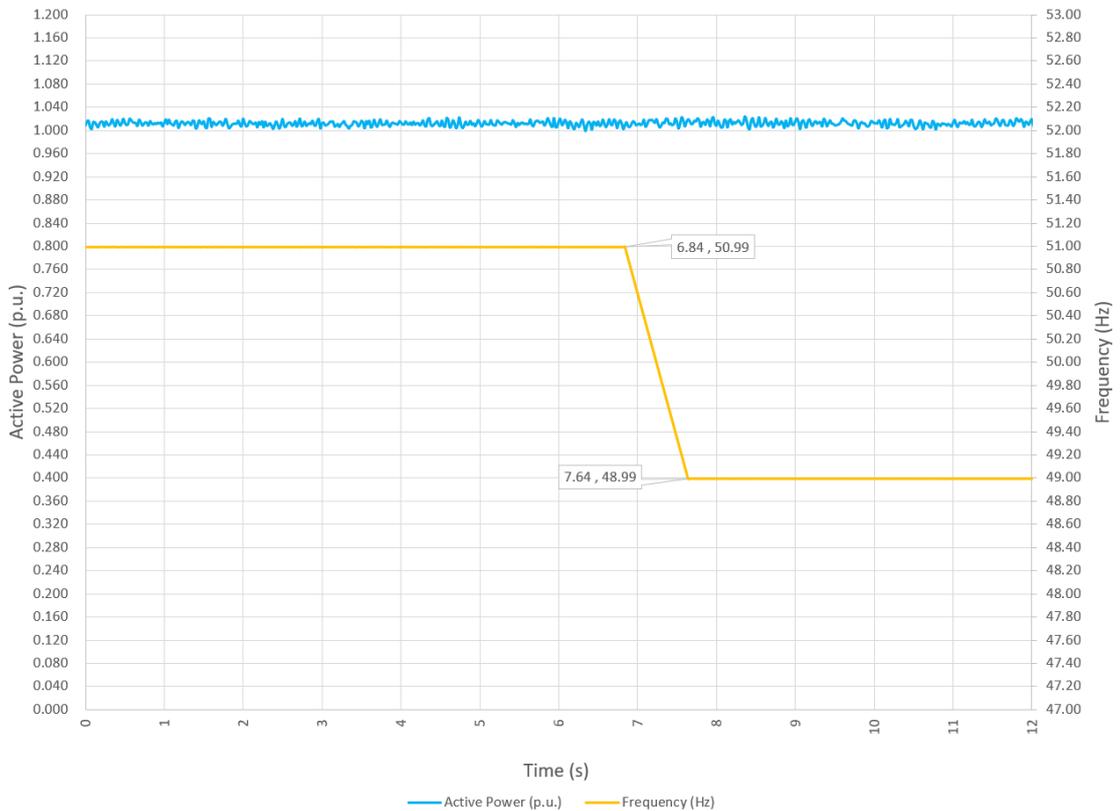
Test 2 (+1.5 Hz/s) - Positive frequency drift
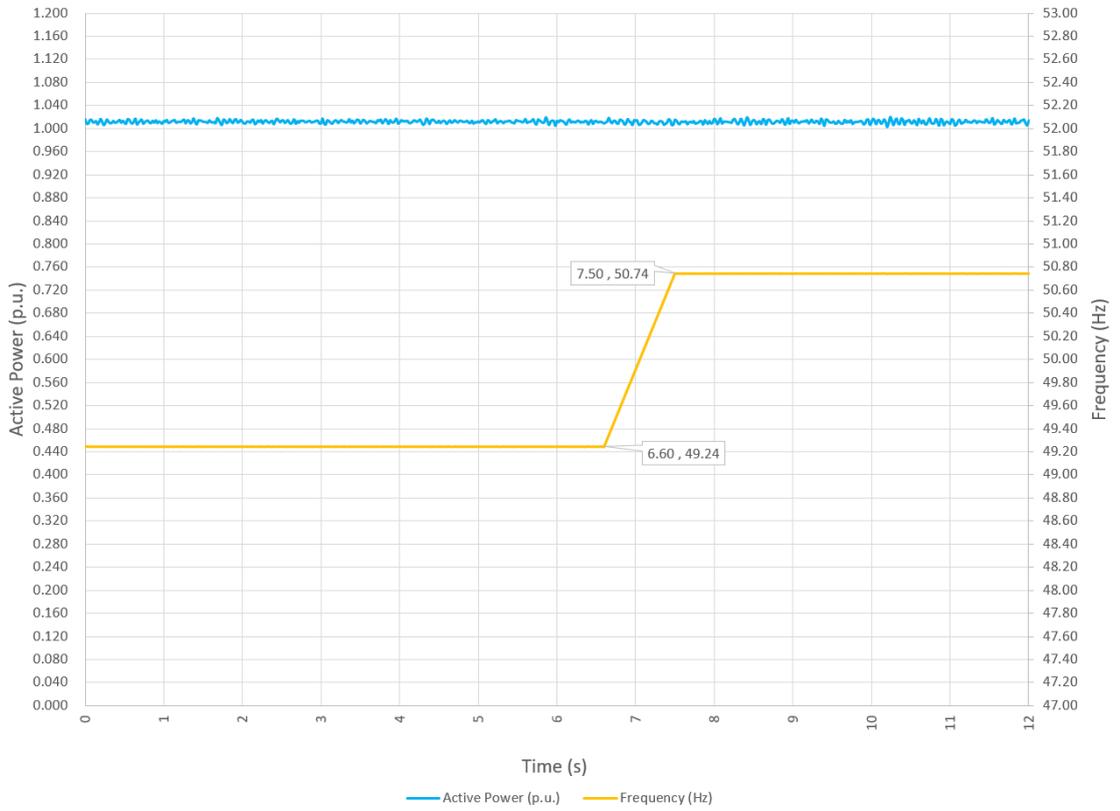
Time of change measured: 900 ms
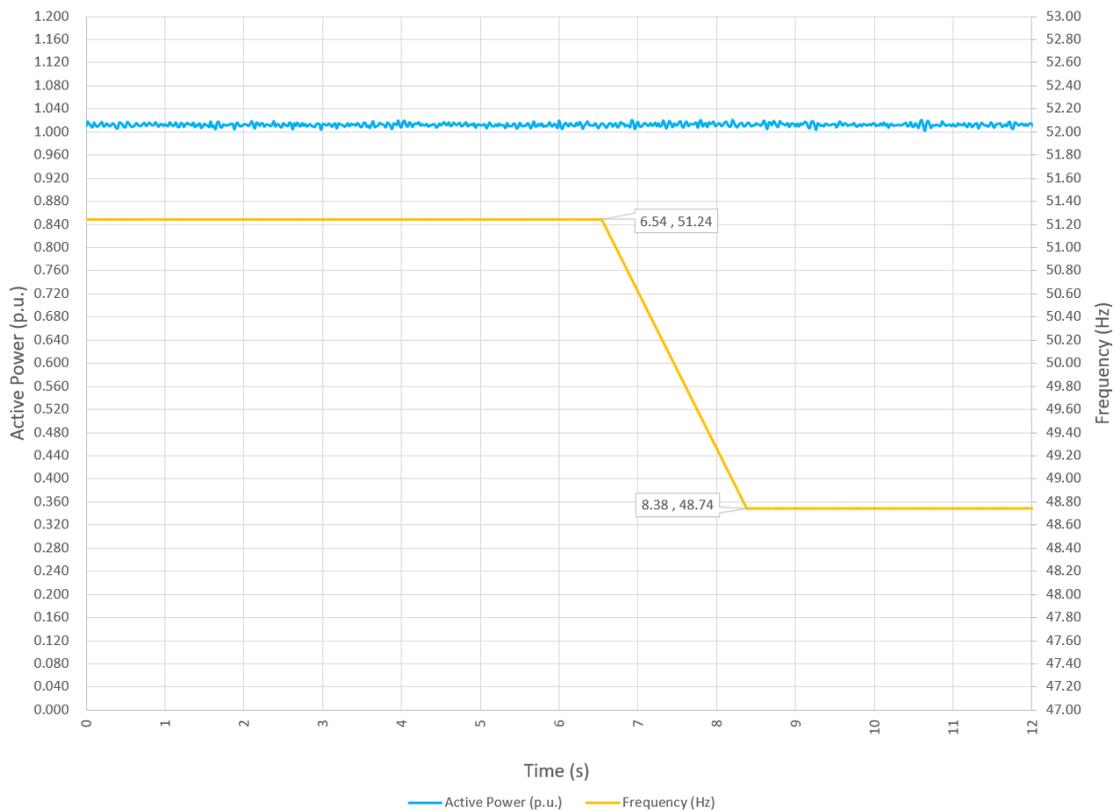
Test 2 (-1.5 Hz/s) - Negative frequency drift

Time of change measured: 900 ms

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Test 3 (+1.25 Hz/s) - Positive frequency drift

Time of change measured: 1840 ms

Test 3 (-1.25 Hz/s) - Negative frequency drift

Time of change measured: 1840 ms

4.6 REACTIVE POWER SUPPLY

4.6.1 Reactive Power Supply At ΣS_{Emax}

This test has been measured according to chapter 5.4.8.2 of VDE V 0124-100:2020-06 to verify requirements from chapter 5.7.2.2 of the VDE AR-N 4105:2018-11 standard. The aim of the test is to verify the following $\cos\varphi(U)$ characteristic and verify the maximum reactive power capacity of the EUT:
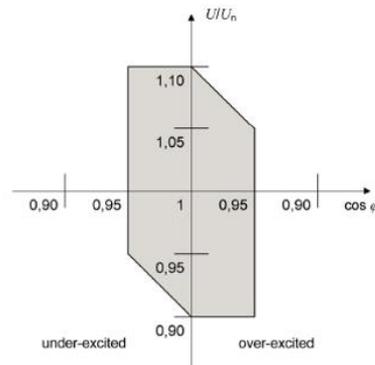
Figure 2 – Requirements for power generation units regarding the reactive power supply at the generator terminals ($\sum S_{Emax} \leq 4,6\,kVA$)

For this test, 60s average measurements of the following operation points shall be taken at a voltage of 0.900 p.u., 1.000 p.u. and 1.100 p.u., with a 0.020 U p.u. accuracy:

FOR INVERTERS WITH ΣS_{Emax} < 4.6 KVA
• cos φ = 0.950 (Underexcited and overexcited) and cos φ = 0.980 (Underexcited and overexcited), at an active power value between 40% P_{Emax} and 60% P_{Emax} and at S_{Emax}.

Cos φ shall be configurable in steps of at least 0.01.

Measured average Q values tolerances are ±0.040 of P_{Emax} of the Q setpoint for each cos φ.

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Test results are offered in the following tables and graphs:

Step	U setpoint (p.u.)	U meas. (p.u.)	P meas. (p.u.)	S meas. (p.u.)	Q Desired (p.u.)	Q meas. (p.u.)	Q Deviation (p.u.) (±0.040 of P_{Emax})	PF setpoint	PF meas.	time meas. (s)
40%P_{Emax} <P setpoint <60P_{Emax}										
Test 1 (cos phi setpoint = 0.950 inductive)										
1	0.900	0.901	0.494	0.516	+0.164	+0.147	-0.017	0.950	0.959	120.8
2	1.000	1.001	0.502	0.526	+0.164	+0.158	-0.006	0.950	0.954	119.6
3	1.100	1.100	0.505	0.533	+0.164	+0.171	+0.007	0.950	0.948	118.8
Test 2 (cos phi setpoint = 0.950 capacitive)										
1	0.900	0.901	0.495	0.522	-0.164	-0.157	+0.007	0.950	0.949	136.4
2	1.000	1.001	0.502	0.526	-0.164	-0.147	+0.017	0.950	0.955	119.6
3	1.100	1.100	0.506	0.528	-0.164	-0.136	+0.028	0.950	0.960	103.2
Test 3 (cos phi setpoint = 0.980 inductive)										
1	0.900	0.901	0.495	0.501	+0.102	+0.078	-0.024	0.980	0.988	121.2
2	1.000	1.001	0.502	0.510	+0.102	+0.090	-0.012	0.980	0.984	119.4
3	1.100	1.100	0.505	0.516	+0.102	+0.104	+0.002	0.980	0.980	118.2
Test 4 (cos phi setpoint = 0.980 capacitive)										
1	0.900	0.901	0.494	0.503	-0.102	-0.082	+0.020	0.980	0.982	136.2
2	1.000	1.001	0.501	0.509	-0.102	-0.073	+0.029	0.980	0.985	119.8
3	1.100	1.100	0.505	0.512	-0.102	-0.064	+0.038	0.980	0.987	103.2

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S set point = S_{Emax}									
Test 1 (cos phi setpoint = 0.950 inductive)									
Step	U setpoint (p.u.)	U meas. (p.u.)	P meas. (p.u.)	S meas. (p.u.)	Q Desired (p.u.)	Q meas. (p.u.)	Q Deviation (p.u.) (±0.040 of P_{Emax})	PF setpoint	PF meas.	time meas. (s)
1	0.900	0.901	0.854	0.899	+0.281	+0.281	0.000	0.950	0.950	130.2
2	1.000	1.001	0.955	1.002	+0.312	+0.303	-0.009	0.950	0.953	122.4
3	1.100	1.101	0.959	1.004	+0.312	+0.299	-0.013	0.950	0.955	107.0
Test 2 (cos phi setpoint = 0.950 capacitive)									
Step	U setpoint (p.u.)	U meas. (p.u.)	P meas. (p.u.)	S meas. (p.u.)	Q Desired (p.u.)	Q meas. (p.u.)	Q Deviation (p.u.) (±0.040 of P_{Emax})	PF setpoint	PF meas.	time meas. (s)
1	0.900	0.901	0.864	0.905	-0.281	-0.263	+0.018	0.950	0.955	123.0
2	1.000	1.001	0.954	1.002	-0.312	-0.303	+0.009	0.950	0.952	123.6
3	1.100	1.101	0.956	1.007	-0.312	-0.308	+0.004	0.950	0.950	113.0
Test 3 (cos phi setpoint = 0.980 inductive)									
Step	U setpoint (p.u.)	U meas. (p.u.)	P meas. (p.u.)	S meas. (p.u.)	Q Desired (p.u.)	Q meas. (p.u.)	Q Deviation (p.u.) (±0.040 of P_{Emax})	PF setpoint	PF meas.	time meas. (s)
1	0.900	0.901	0.885	0.901	+0.179	+0.167	-0.012	0.980	0.983	122.8
2	1.000	1.001	0.986	1.002	+0.199	+0.177	-0.022	0.980	0.984	124.0
3	1.100	1.101	0.986	1.000	+0.199	+0.169	-0.030	0.980	0.986	112.8
Test 4 (cos phi setpoint = 0.980 capacitive)									
Step	U setpoint (p.u.)	U meas. (p.u.)	P meas. (p.u.)	S meas. (p.u.)	Q Desired (p.u.)	Q meas. (p.u.)	Q Deviation (p.u.) (±0.040 of P_{Emax})	PF setpoint	PF meas.	time meas. (s)
1	0.900	0.901	0.886	0.901	-0.179	-0.163	+0.016	0.980	0.982	129.0
2	1.000	1.001	0.984	1.003	-0.199	-0.187	+0.012	0.980	0.981	122.2
3	1.100	1.101	0.986	1.004	-0.199	-0.176	+0.023	0.980	0.982	108.4

40%P$_{Emax}$ <P setpoint <60P$_{Emax}$
Test 1 (cos phi setpoint = 0.950 inductive)
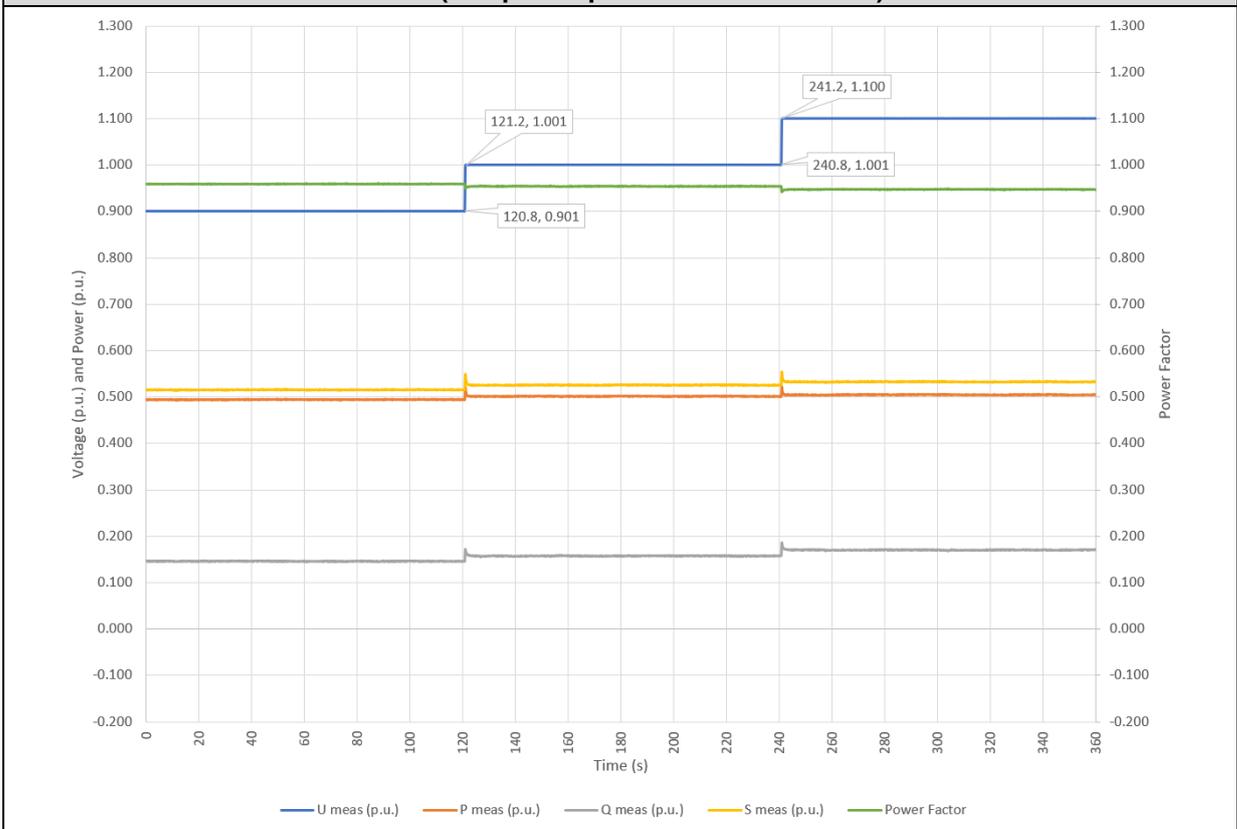
40%P$_{Emax}$ <P setpoint <60P$_{Emax}$
Test 2 (cos phi setpoint = 0.950 capacitive)
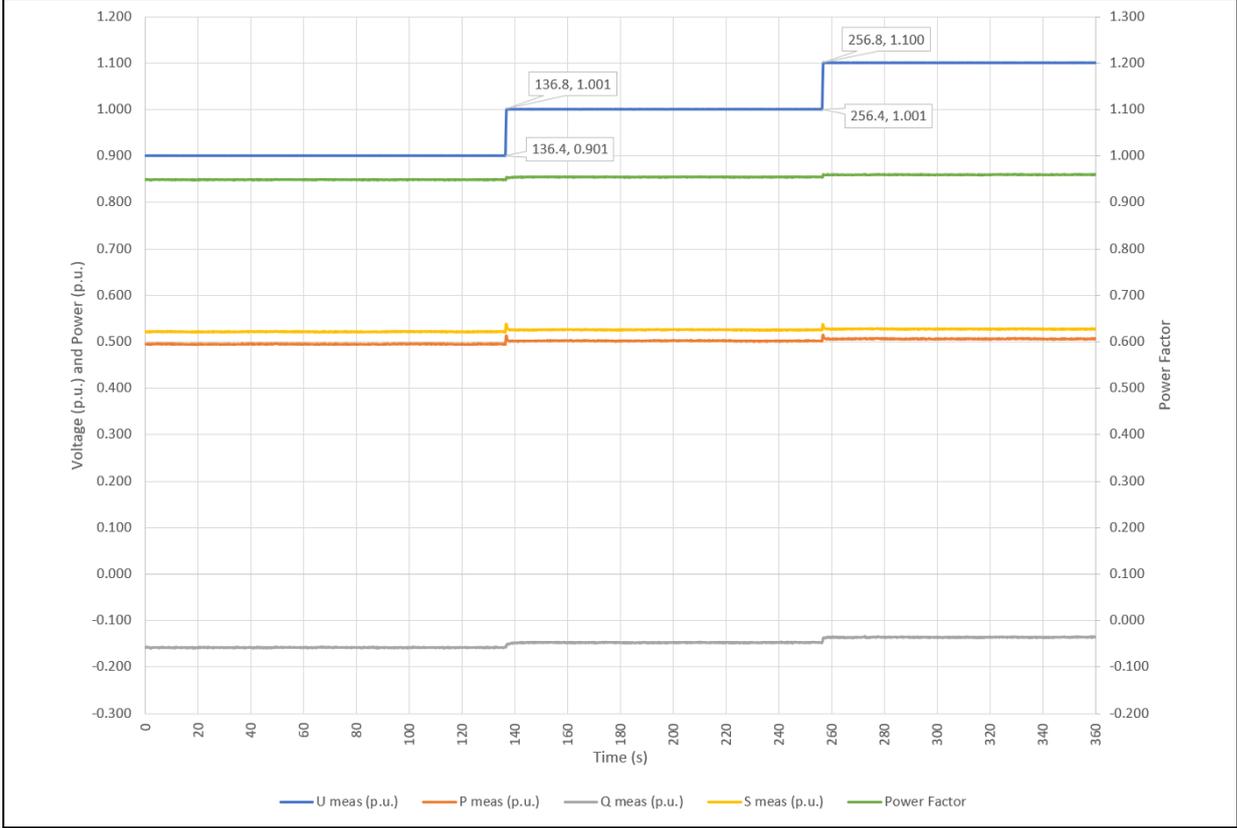
40%P_{Emax} <P setpoint <60P_{Emax}
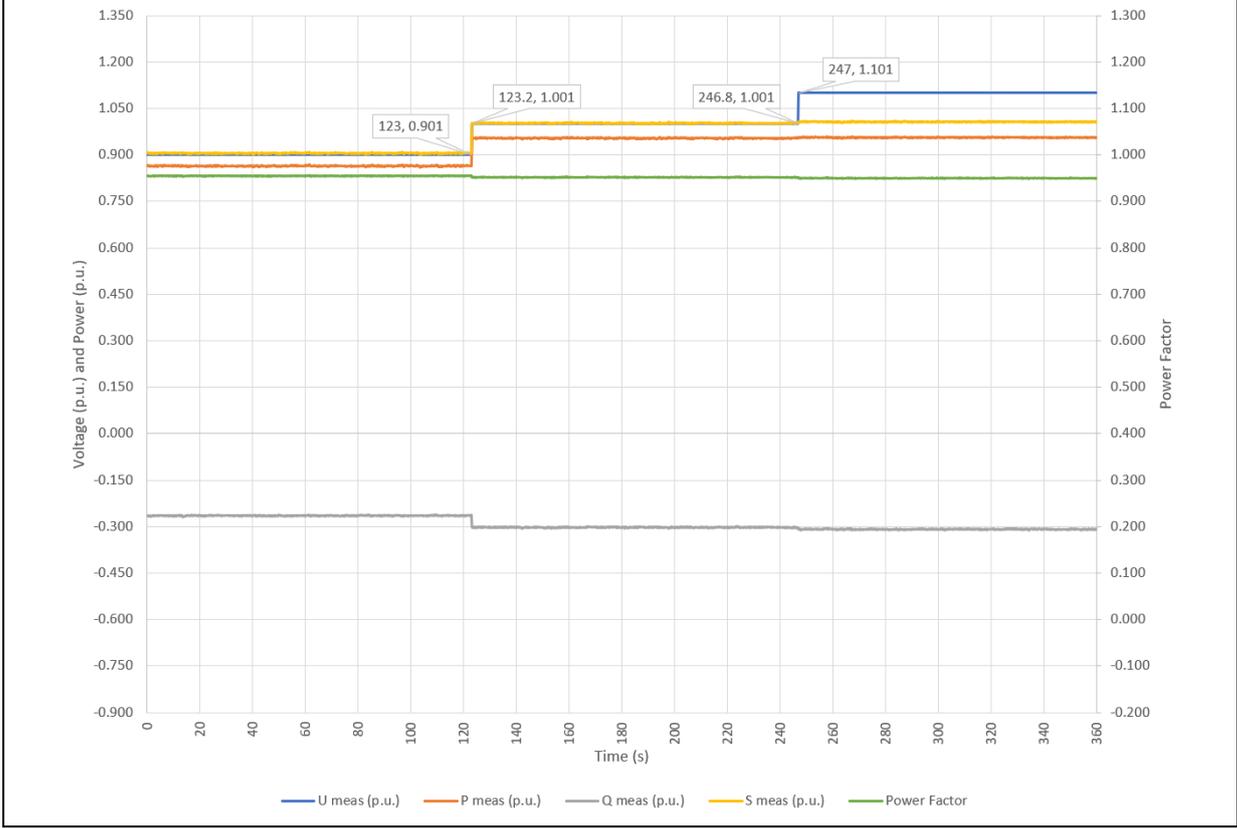### Test 3 (cos phi setpoint = 0.980 inductive)
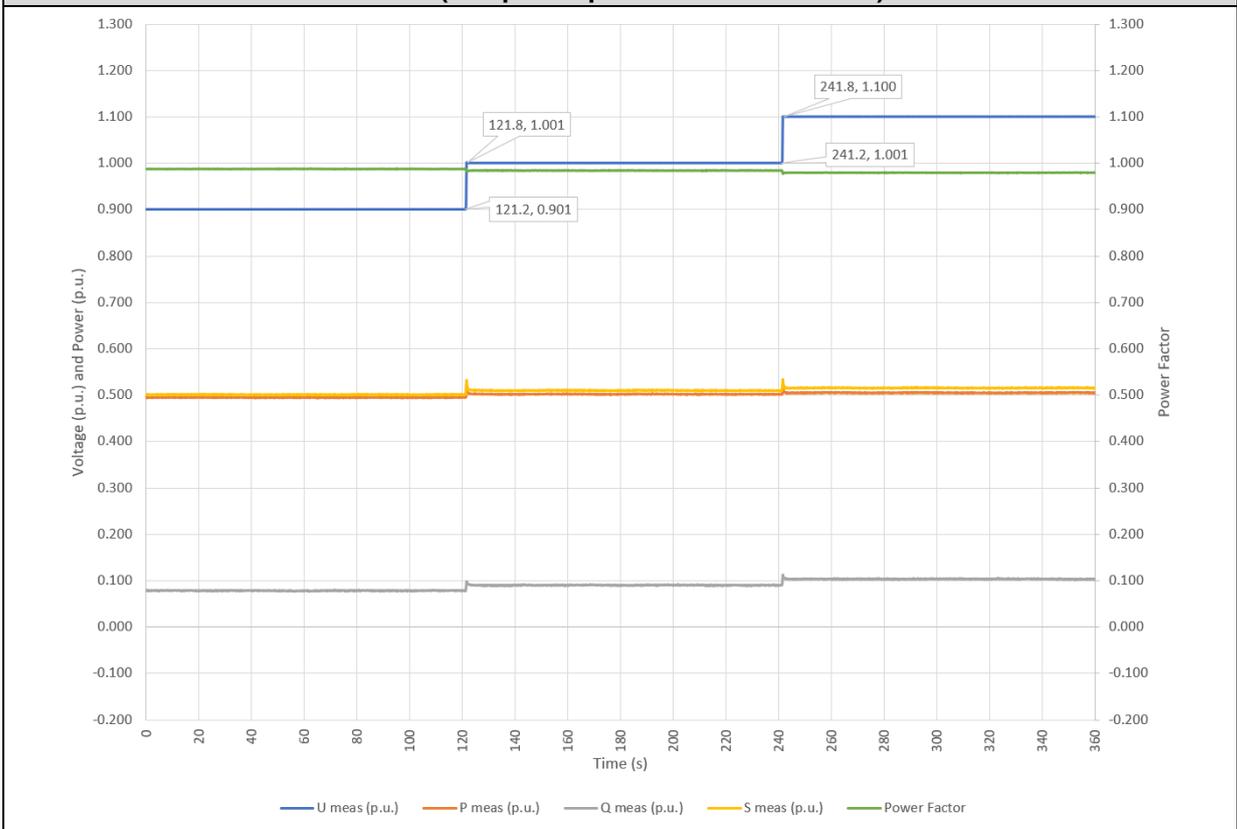
40%P_{Emax} <P setpoint <60P_{Emax}
Test 4 (cos phi setpoint = 0.980 capacitive)
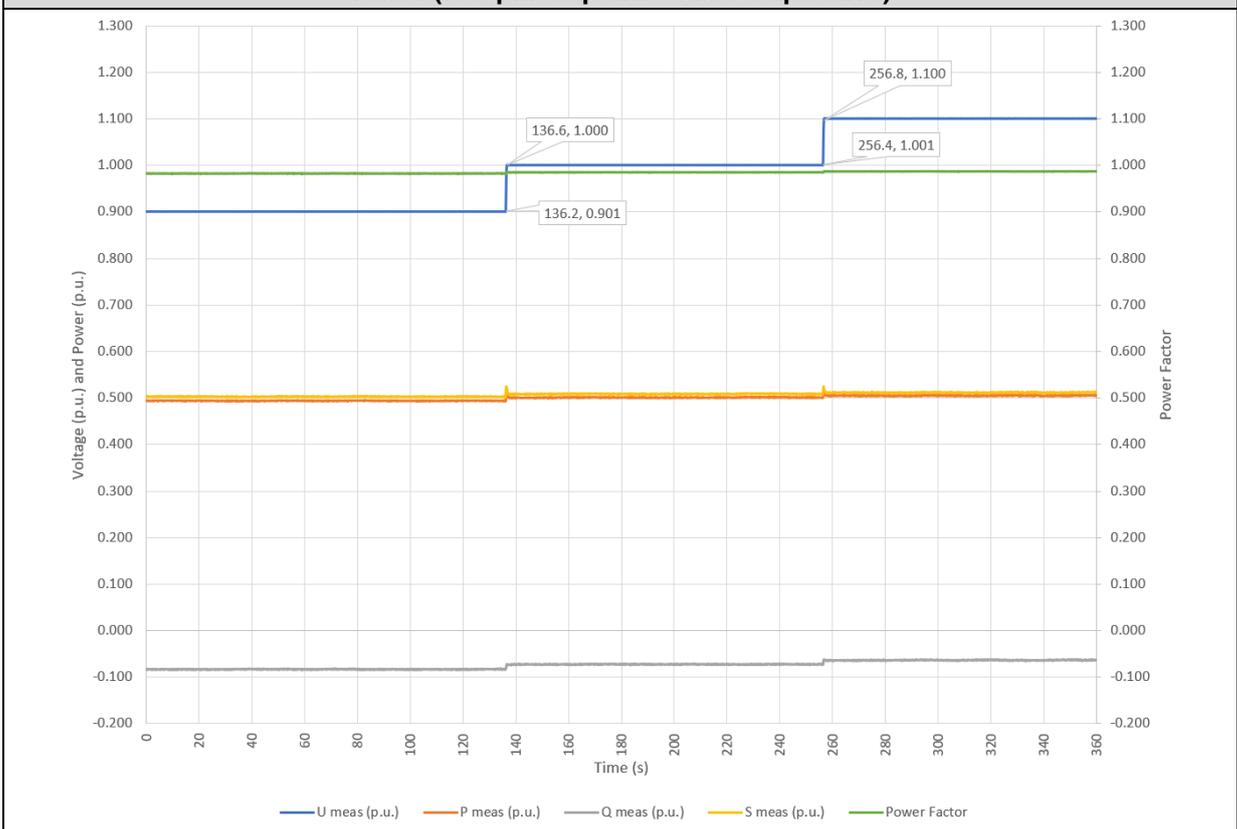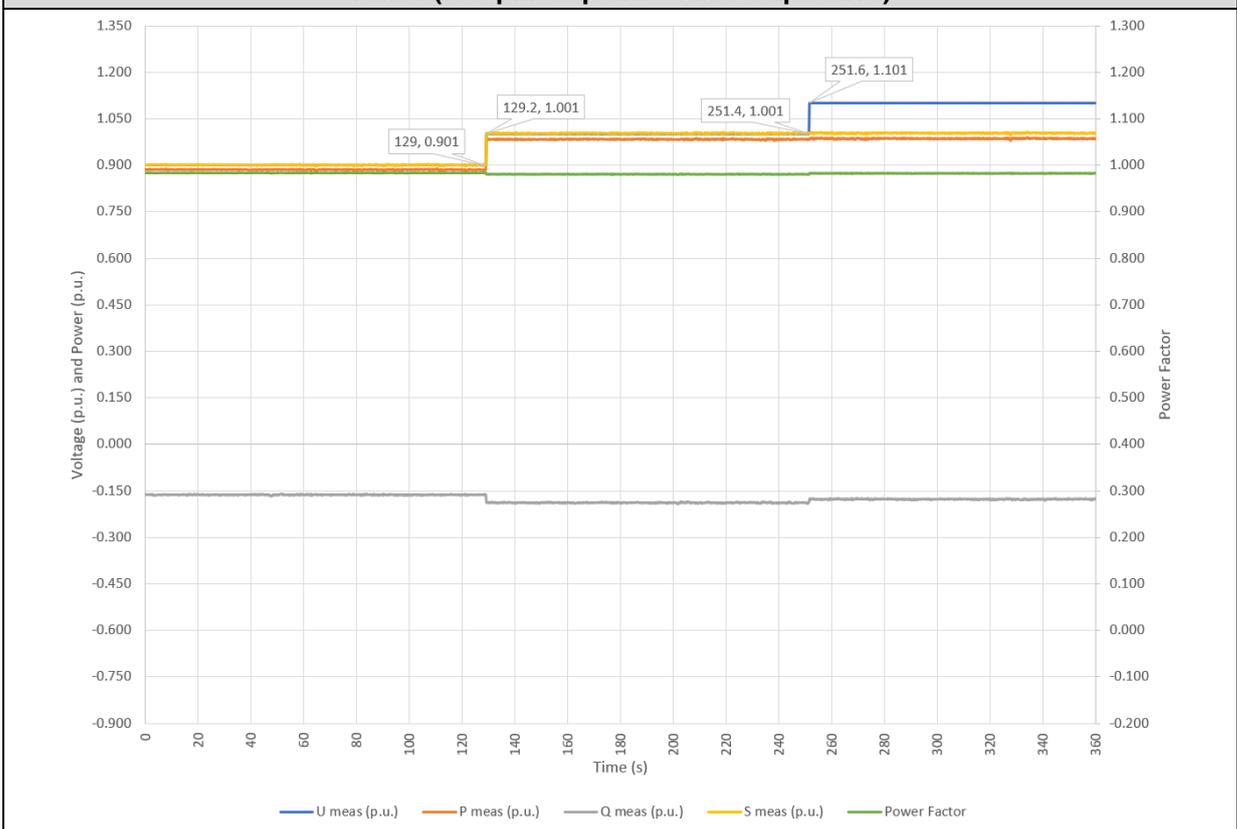
S set point = S$_{Emax}$
Test 1 (cos phi setpoint = 0.950 inductive)
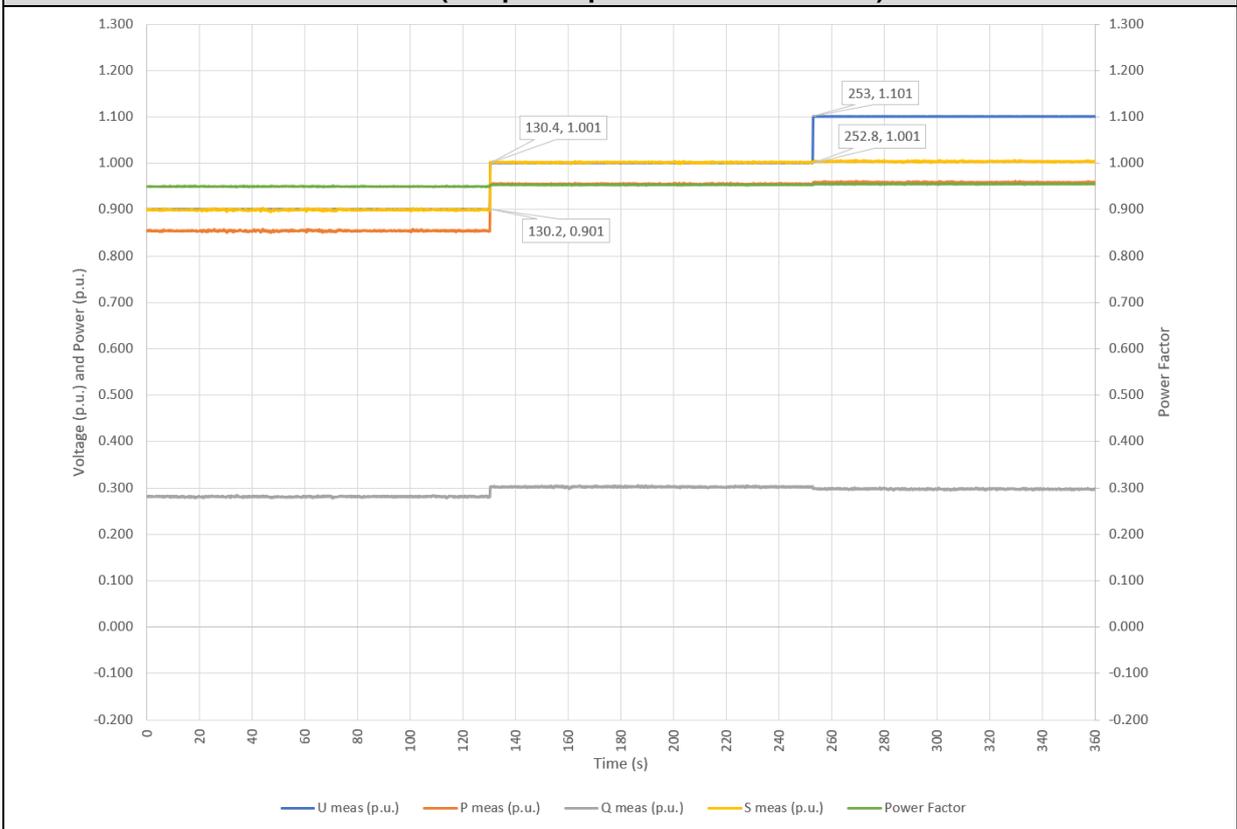
S set point = S$_{Emax}$
Test 2 (cos phi setpoint = 0.950 capacitive)

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S set point = S$_{Emax}$
Test 3 (cos phi setpoint = 0.980 inductive)
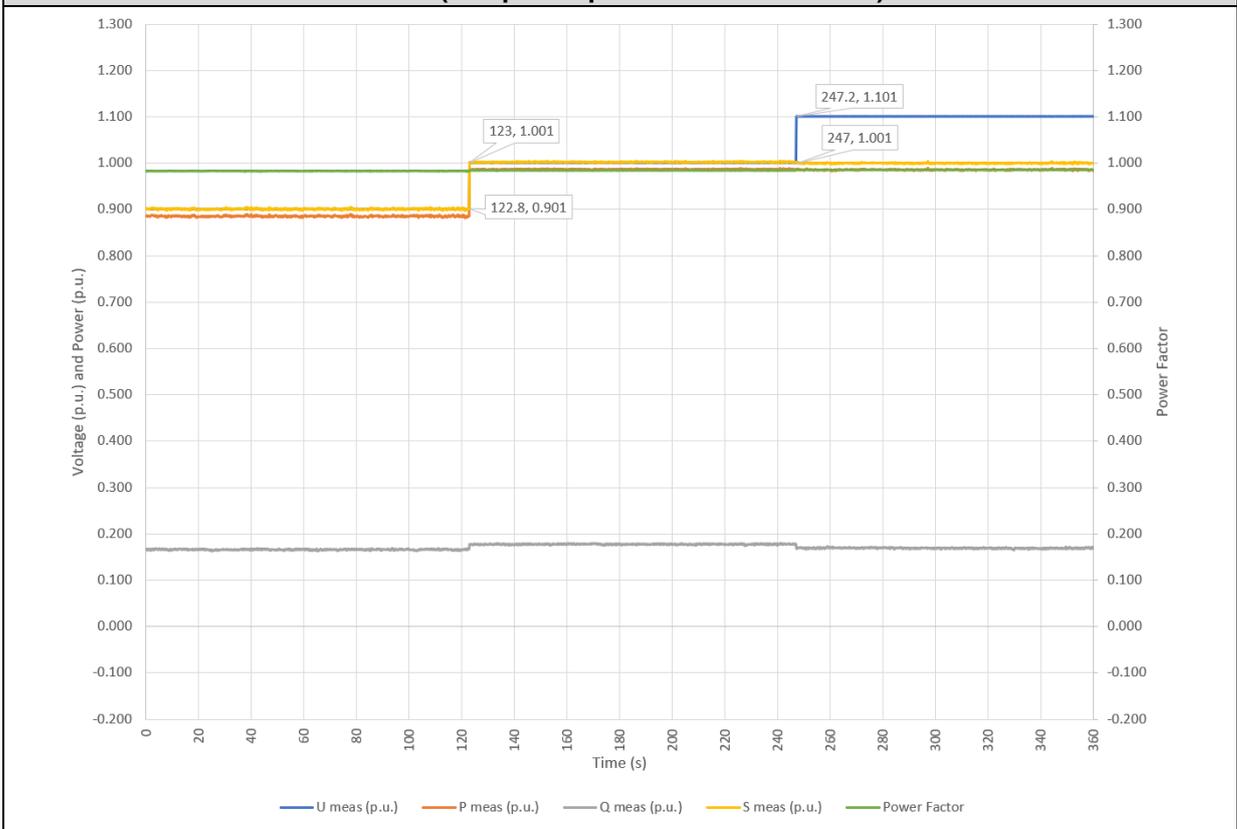
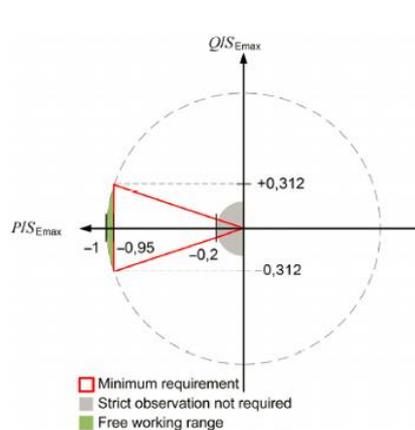## S set point = S$_{Emax}$
### Test 4 (cos phi setpoint = 0.980 capacitive)

4.6.2 Reactive Power Supply Smaller Than P_{Emax}

This test has been done to verify requirements from chapter 5.7.2.3 of the VDE AR-N 4105:2018-11 standard. The aim of the test is to verify the following P/Q characteristic:

Figure 5 – P/Q diagram for type 2 $\sum S_{Emax} \leq 4,6\ kVA$ and type 1, stirling generator, fuel cell $\sum S_{Emax} > 4,6\ kVA$ at the generator terminals in the passive sign convention system
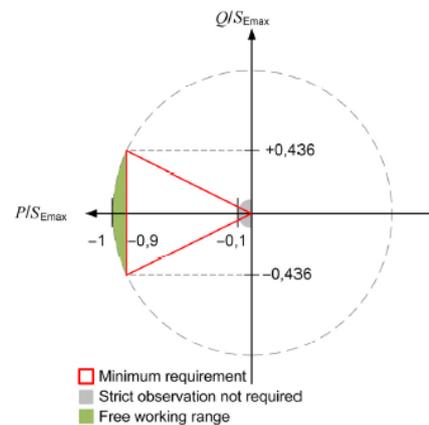
Figure 6 – P/Q diagram for type 2 (inverters only) $\sum S_{Emax} > 4,6\ kVA$ at the generator terminals in the passive sign convention system

Within the range of $0 \leq P_{mom}/P_{Emax} < 0.100 / 0.200$ (or the agreed minimum technical power) the power generation unit shall not exceed the reactive power value at the generator terminals of 10 % of the active power value P_{Emax} (reactive power supply and consumption respectively).

Within the free working range, a reduction of the active power to the benefit of the reactive power is permitted.

The following tests have been done:

- Test 1: Power factor of 0.950 over-excited measuring steps of 5%P_n
- Test 2: Power factor of 0.950 under-excited measuring steps of 5%P_n
- Test 3: Power factor of 1.000 measuring steps of 5%P_n
- Test 4: Power factor of 0.950 over-excited with 20%P_n, 50%P_n and 90%P_n setpoints
- Test 5: Power factor of 0.950 under-excited with 20%P_n, 50%P_n and 90%P_n setpoints

Tests 1, 2 and 3 have been performed to confirm that the equipment complies with the minimum capabilities. Tests 4 and 5 have been performed to check the dynamics of the reactive power provision.

Only red triangle area is Required, with tolerance: ±4% of PEmax
When operated at <20% P_{Emax} (figure 5), or <10% P_{Emax} (figure 6), reactive power <10% P_{Emax}

Note:
1.   The unit can meet the requirements according to Figure 6.
2.   Tests 4 and 5 are not applicable according to the section 5.4.8.3 of the standard VDE V 0124-100:2020-06, due to for guided EZE dynamics: A test of the PT1 behavior of the transition dynamics specified in VDE-AR-N 4105: 2018-11 is not necessarily due to the required limitations of the active power gradient. However, tests have been performed and results are shown below.
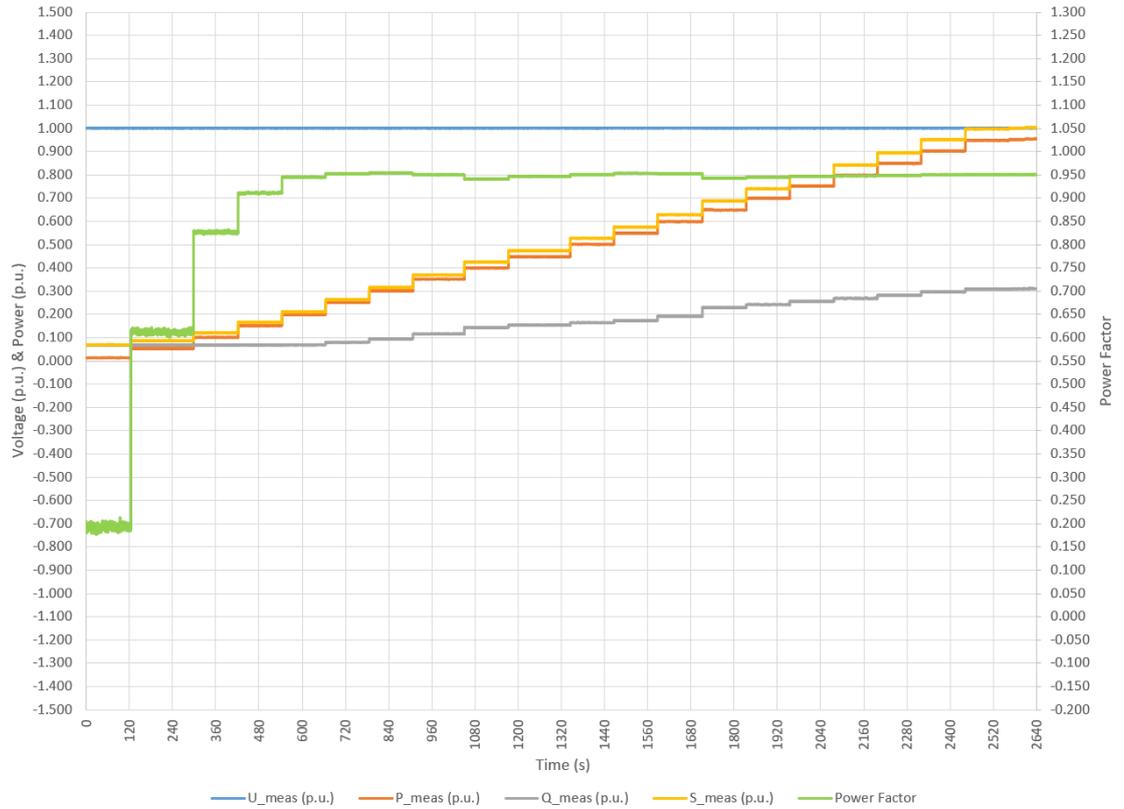
Test results are offered in the following tables and graphs:

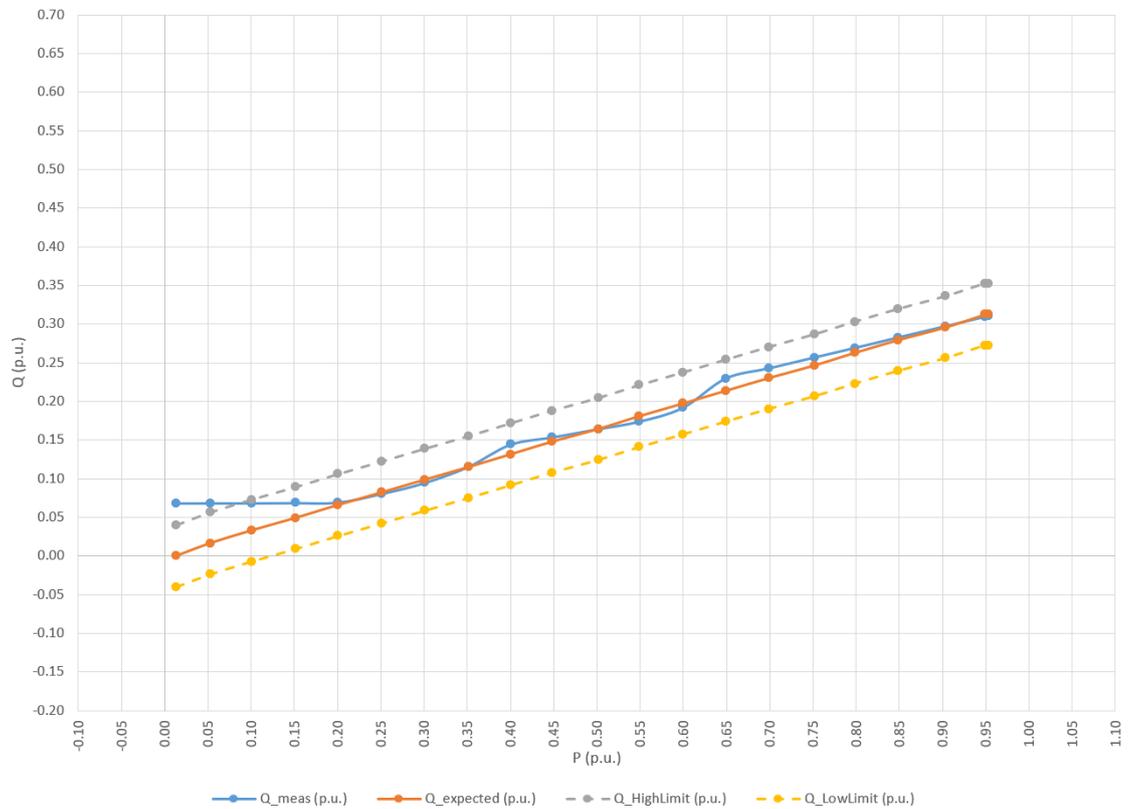#### 4.6.2.1 Test 1 (cos phi setpoint = maximum inductive) (PF=0.95)

Test 1 (cos phi setpoint = maximum inductive) (PF=0.95)
P Setting (% P_{Emax})	U Measured (%Un)	P Measured (% P_{Emax})	Q Measured (% P_{Emax})	S Measured (% P_{Emax})	cos φ Measured	Q Desired (% $P_{Emax.}$)	Δ Q (<=±4% * P_{Emax})
0.0	100.1	1.3	+6.8	7.0	--	0.0	--
5.0	100.1	5.3	+6.8	8.6	--	+1.6	--
10.0	100.1	10.0	+6.8	12.2	--	+3.3	--
15.0	100.1	15.2	+6.9	16.7	--	+4.9	--
20.0	100.1	20.0	+6.9	21.2	0.945	+6.6	+0.3
25.0	100.1	25.1	+8.0	26.4	0.952	+8.2	-0.2
30.0	100.1	30.1	+9.5	31.5	0.954	+9.9	-0.4
35.0	100.1	35.2	+11.6	37.0	0.950	+11.5	+0.1
40.0	100.1	40.0	+14.4	42.5	0.941	+13.1	+1.3
45.0	100.1	44.9	+15.3	47.4	0.946	+14.8	+0.5
50.0	100.1	50.2	+16.4	52.8	0.950	+16.4	0.0
55.0	100.1	54.9	+17.4	57.6	0.953	+18.1	-0.7
60.0	100.1	60.0	+19.2	62.9	0.953	+19.7	-0.5
65.0	100.1	64.9	+22.9	68.8	0.943	+21.4	+1.5
70.0	100.1	69.9	+24.3	74.0	0.945	+23.0	+1.3
75.0	100.1	75.2	+25.7	79.4	0.946	+24.7	+1.0
80.0	100.1	79.9	+26.9	84.3	0.948	+26.3	+0.6
85.0	100.1	84.9	+28.3	89.5	0.949	+27.9	+0.4
90.0	100.1	90.4	+29.7	95.1	0.950	+29.6	+0.1
95.0	100.1	94.9	+30.9	99.8	0.951	+31.2	-0.3
100.0	100.1	95.3	+31.0	100.3	0.951	+31.2 [1]	-0.2

[1] Because of limited by apparent power, the active does not reach to 100%P_{Emax}, when cos φ = 0.95, then the desired reactive power equals to 31.2% P_{Emax}.

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Setting cos φ = 0.950 (in steps of 5 % P_{Emax})

Test 1 PQ Curve

4.6.2.2 Test 2 (cos phi setpoint = maximum capacitive) (PF=0.95)

P Setting (% P$_{Emax}$)	U Measured (p.u.)	P Measured (% P$_{Emax}$)	Q Measured (% P$_{Emax}$)	S Measured (% P$_{Emax}$)	cos φ Measured	Q Desired (% P$_{Emax}$.)	Δ Q (<=±4% *P$_{Emax}$)
0.0	1.001	1.4	+5.7	6.9	--	0.0	--
5.0	1.001	5.2	+4.5	7.8	--	-1.6	--
10.0	1.001	10.4	+2.9	11.4	--	-3.3	--
15.0	1.001	15.1	-2.6	15.8	--	-4.9	--
20.0	1.001	20.1	-4.9	21.1	0.956	-6.6	+1.7
25.0	1.001	25.3	-6.7	26.5	0.955	-8.2	+1.5
30.0	1.001	30.1	-8.0	31.5	0.957	-9.9	+1.9
35.0	1.001	35.3	-10.5	37.1	0.951	-11.5	+1.0
40.0	1.001	40.2	-10.6	41.9	0.959	-13.1	+2.5
45.0	1.001	44.9	-12.6	47.0	0.957	-14.8	+2.2
50.0	1.001	50.0	-14.8	52.4	0.954	-16.4	+1.6
55.0	1.001	55.1	-15.2	57.4	0.959	-18.1	+2.9
60.0	1.001	60.2	-17.2	62.9	0.958	-19.7	+2.5
65.0	1.001	65.3	-19.1	68.3	0.956	-21.4	+2.3
70.0	1.001	70.4	-21.1	73.7	0.955	-23.0	+1.9
75.0	1.001	75.5	-23.1	79.2	0.954	-24.7	+1.6
80.0	1.001	80.1	-24.8	84.0	0.953	-26.3	+1.5
85.0	1.001	85.3	-24.2	88.9	0.960	-27.9	+3.7
90.0	1.001	89.8	-25.8	93.6	0.959	-29.6	+3.8
95.0	1.001	95.3	-27.8	99.5	0.958	-31.2	+3.4
100.0	1.001	96.3	-28.1	100.5	0.958	-31.2 [1]	+3.1

[1] Because of limited by apparent power, the active does not reach to 100%P$_{Emax}$, when cos φ = 0.95, then the desired reactive power equals to 31.2% P$_{Emax}$.

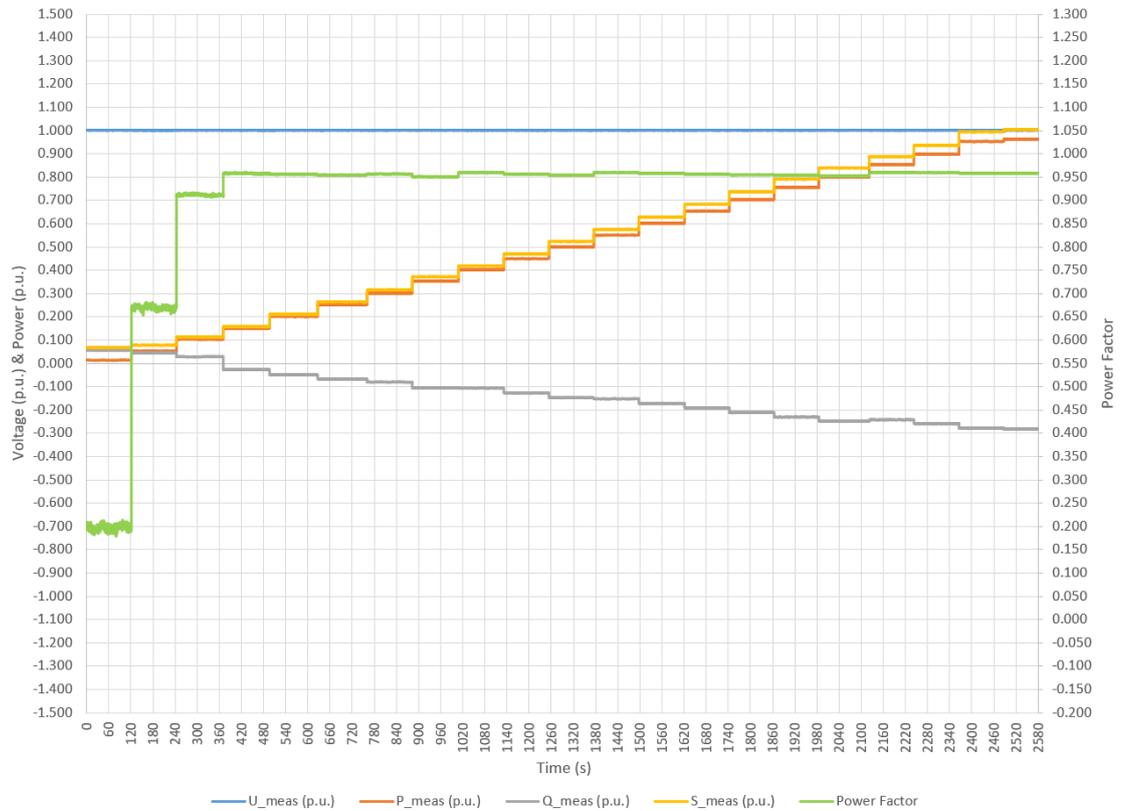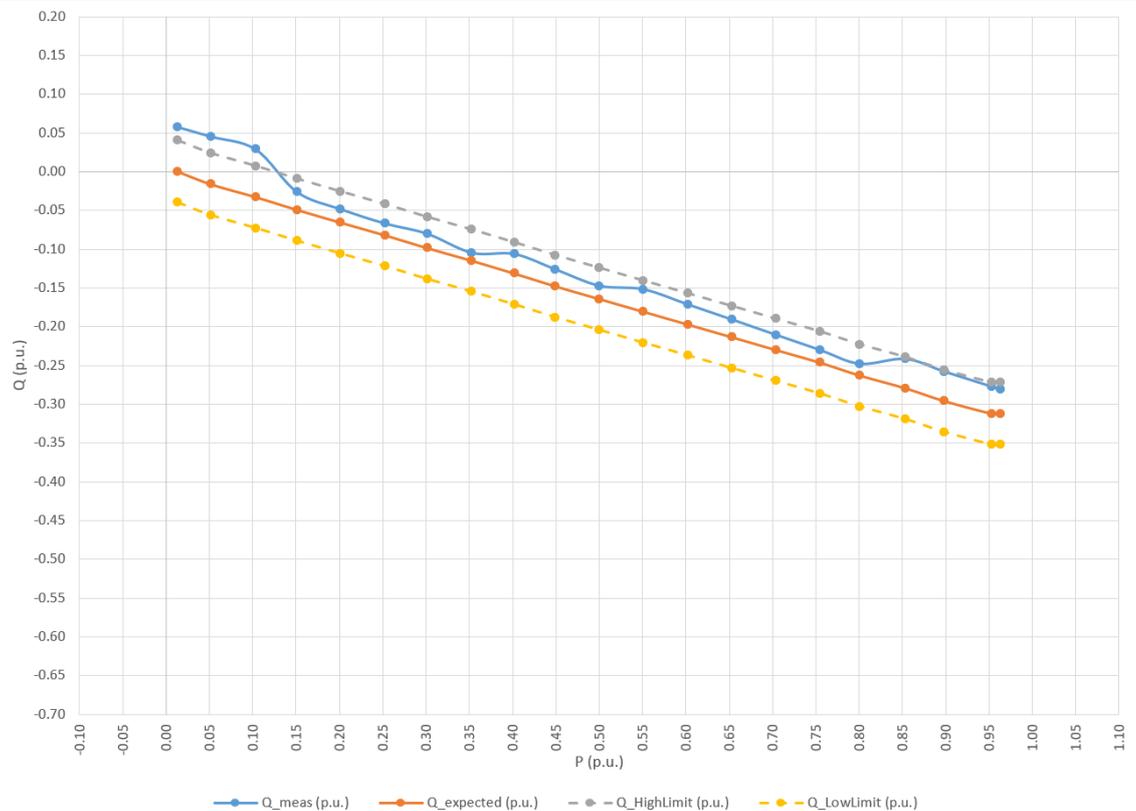## Setting cos φ = 0.950 (in steps of 5 % P$_{Emax}$)

Test 2 PQ Curve

4.6.2.3 Test 3 (cos phi setpoint = 1.000)

Test 3 (cos phi setpoint = 1.000)							
P Setting (% P_{Emax})	U Measured (p.u.)	P Measured (% P_{Emax})	Q Measured (% P_{Emax})	S Measured (% P_{Emax})	cos φ Measured	Q Desired (% $P_{Emax.}$)	Δ Q (<=±4% *P_{Emax})
0.0	1.002	-0.1	-0.1	2.9	--	--	--
5.0	1.002	4.9	-0.1	5.7	--	--	--
10.0	1.002	9.8	0.0	10.2	--	0.0	--
15.0	1.002	14.8	0.0	15.0	--	0.0	--
20.0	1.002	19.7	0.0	19.9	0.990	0.0	0.0
25.0	1.002	24.7	0.0	24.9	0.992	0.0	0.0
30.0	1.002	29.7	0.0	29.9	0.994	0.0	0.0
35.0	1.002	34.7	0.0	34.9	0.995	0.0	0.0
40.0	1.002	39.7	0.0	39.9	0.996	0.0	0.0
45.0	1.002	44.7	+0.1	44.9	0.996	0.0	+0.1
50.0	1.002	49.7	+0.1	49.9	0.997	0.0	+0.1
55.0	1.002	54.7	+0.1	54.8	0.997	0.0	+0.1
60.0	1.002	59.6	+0.2	59.8	0.997	0.0	+0.2
65.0	1.002	64.6	+0.2	64.8	0.998	0.0	+0.2
70.0	1.002	69.5	+0.2	69.7	0.998	0.0	+0.2
75.0	1.002	74.5	+0.3	74.7	0.998	0.0	+0.3
80.0	1.002	79.5	+0.3	79.6	0.998	0.0	+0.3
85.0	1.002	84.4	+0.3	84.5	0.998	0.0	+0.3
90.0	1.002	89.3	+0.4	89.5	0.998	0.0	+0.4
95.0	1.002	94.2	+0.4	94.4	0.999	0.0	+0.4
100.0	1.002	99.1	+0.4	99.3	0.999	0.0	+0.4

Setting cos φ = 1.000 (in steps of 5 % P$_{Emax}$)
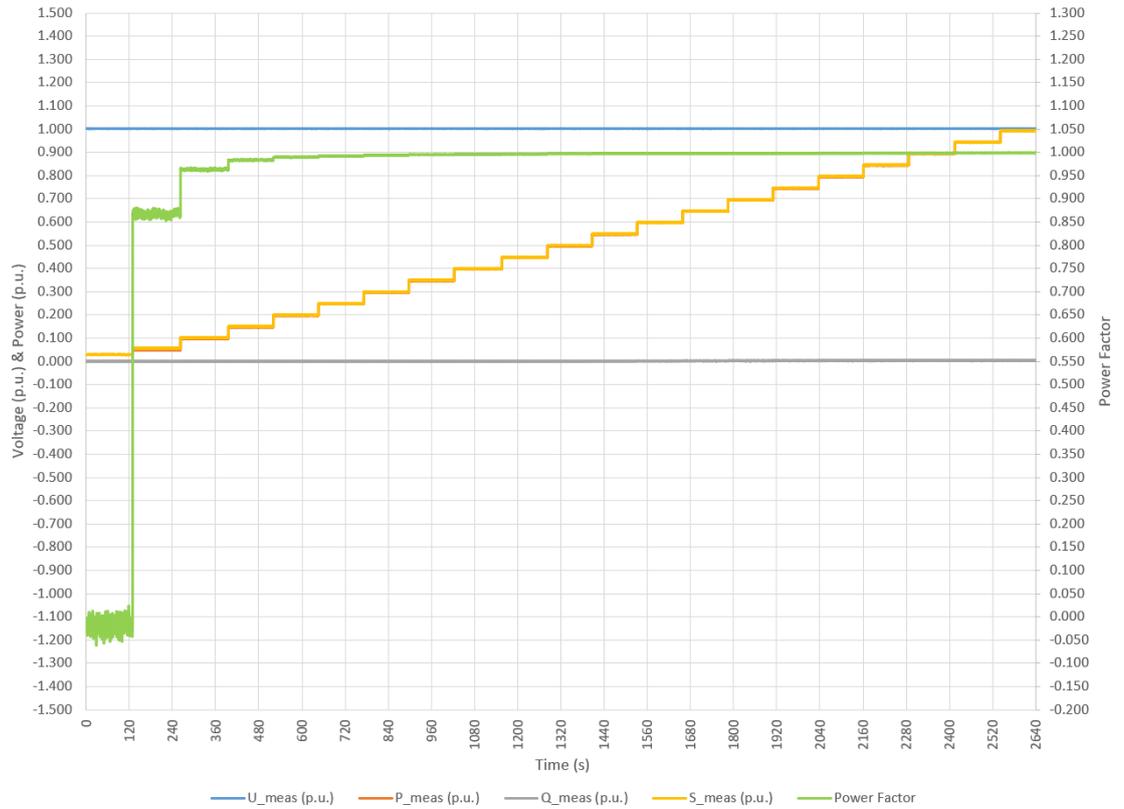
Test 3 PQ Curve
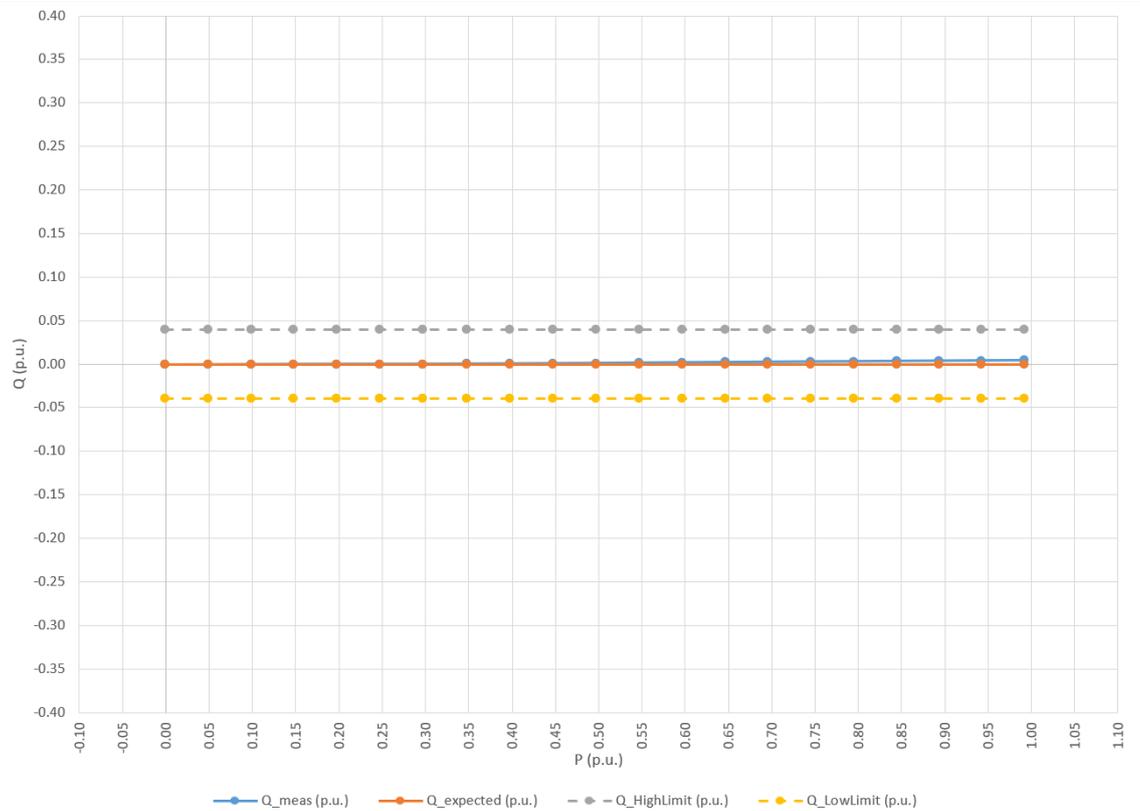
4.7 REACTIVE POWER CONTROL

4.7.1 Reactive Power Voltage Characteristic Q(U)

This test is not applicable according to the section 5.7.2.4 of the standard VDE AR-N 4105:2018-11, due to the Q(U) rule applies only to three-phase power generation units connected to the three-phase current system.

4.7.2 Displacement factor/active power characteristic curve cosφ(P)

This test has been done to verify requirements presented in chapter 5.7.2.4 b) of the VDE AR-N 4105:2018-11. For this test, test procedure from chapter 5.4.8.3 of the VDE V 0124-100:2020-06 has been used.

The aim of the test is to verify the capacity of the EUT of controlling power factor using active power through the following characteristic:
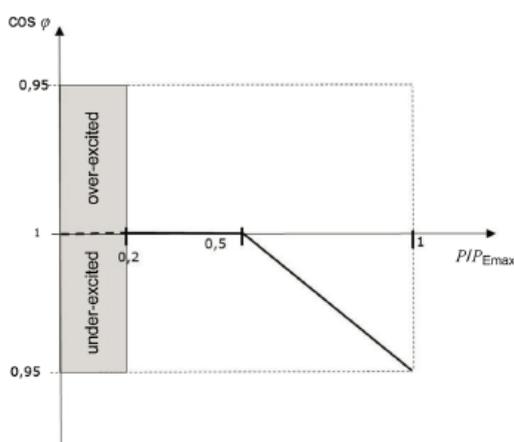
Figure 8 – Characteristic curve for type 2
$\sum S_{Emax} \leq 4,6\,\text{kVA}$ **and type 1, stirling generator, fuel cell** $\sum S_{Emax} > 4,6\,\text{kVA}$
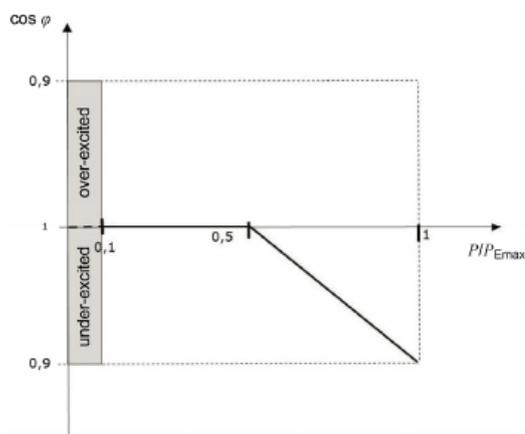
Figure 9 – Standard characteristic curve for type 2 (inverters only)
$\sum S_{Emax} > 4,6\,\text{kVA}$

The test procedure for this characteristic and for guided EUT consists in performing two power steps, one from P ≤ 20% PrE to P = 100% PrE, and then another one from P = 100% PrE to P ≤ 20% PrE, waiting for the stationary values to settle for both steps.

The reactive power control for this characteristic curve method must be assessed with regard to stationary accuracy only. Maximum tolerance for Q is ±0.040 P p.u.

Dynamic accuracy for guided EUT is omitted due to the limitations of the prescribed active power gradients for active power setpoints changes (see section 4.9.1 of this Test Report).
The active power gradient of the steps has to be measured and in compliance with the requirements of chapter 5.7.4.1 of the VDE AR-N 4105:2018-11 standard.

The power gradients shall occur when the P steps are commanded by a third party, such as the grid operator, and in cases of network security management.

In this case, the unit is Type 2 systems and meet the requirements according to Figure 8.

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Test results are offered in the following tables and graphs:

Active Power Setting (% P_{Emax})	Active Power Measured (p.u.)	Reactive Power Measured (p.u.)	Reactive Power Desired (p.u.)	Reactive Power Deviation (p.u.) (<=±0.040 p.u)	cos φ Measured	P gradient measured (%PAmax/s)
P ≤ 0.20	0.196	0.000	0.000	0.000	0.991	--
From 0.2 to 1.00	0.947 [1]	-0.294	-0.312	+0.018	0.954	+0.50
From 1.00 to 0.20	0.196	0.000	0.000	0.000	0.991	-0.50

[1] Limited by apparent power, the active power does not reach to 100%P_{Emax} when cos φ = 0.90.

Result Chart
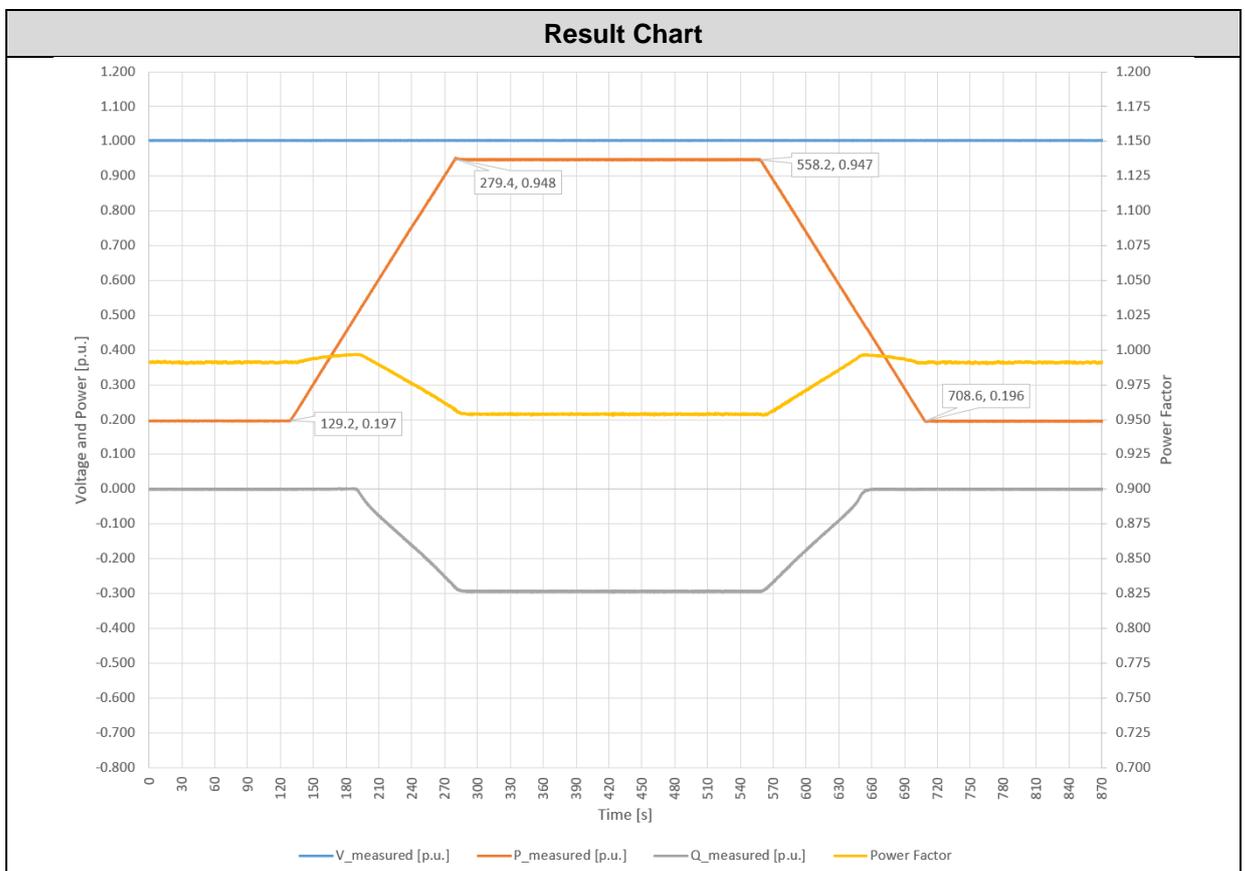
4.7.3 Fixed displacement factor cosφ(P)

This test is used to verify requirements presented in chapter 5.7.2.4 c) of the VDE AR-N 4105:2018-11.

The results obtained for this test can be checked in section 4.6.2 of this Test Report.

4.8 DYNAMIC NETWORK STABILITY

This test requirements are stated in chapter 5.7.3.3 of the VDE AR-N 4105:2018-11 standard, to verify the capacity of the EUT of riding through short-term voltage drops/rises without disconnection.

Throughout the different clauses of the mentioned chapter, all the requirements for grid faults are presented. For this test, the procedure from chapter 5.8 of the VDE V 0124-100:2019-09 is used.

Section 5.8.1 of the test procedure specifies that the following generators are excluded from testing:
- Stirling generators and fuel cells, which in principle cannot provide dynamic grid support.
- Synchronous and non-synchronous generators, which are coupled directly or via a converter, with PrE ≤ 50 kW.

This test is considered not applicable with PrE ≤ 50 kW.

4.9 ACTIVE POWER OUTPUT

4.9.1 Active Power Gradient

This test has been done in order to comply with requirements from chapter 5.7.4.1 of the VDE AR-N 4105:2018-11 standard testing procedure from chapter 5.4.3.4 of the VDE V 0124-100:2020-06 applying the correct limits has been used.

This chapter requires testing an active power step from 100% P_{Amax} to 5% P_{Amax} and another one from 5% P_{Amax} to 100% P_{Amax} for storage units with a power gradient between 0.33%P_{Amax}/s and 0.66%P_{Amax}/s.

Test results are presented in the table and graphs below:

| Test at maximum power gradient		
Active Power step (Setpoint)	**Gradient setting (%P_{Amax}/s)**	**Active power gradient expected (%P_{Amax}/s)**
100.0% to 5.0% P_{Amax}	-0.615	-0.66<P grad <-0.33
5.0% to 100.0% P_{Amax}	+0.614	0.33 <P grad <0.66

Test at minimum power gradient		
Active Power step (Setpoint)	**Gradient setting (%P_{Amax}/s)**	**Active power gradient expected (%P_{Amax}/s)**
100.0% to 5.0% P_{Amax}	-0.333	-0.66<P grad <-0.33
5.0% to 100.0% P_{Amax}	+0.331	0.33 <P grad <0.66

Output power change (100% to 5% to 100% of P_Amax) – 0.66%P_Amax/s
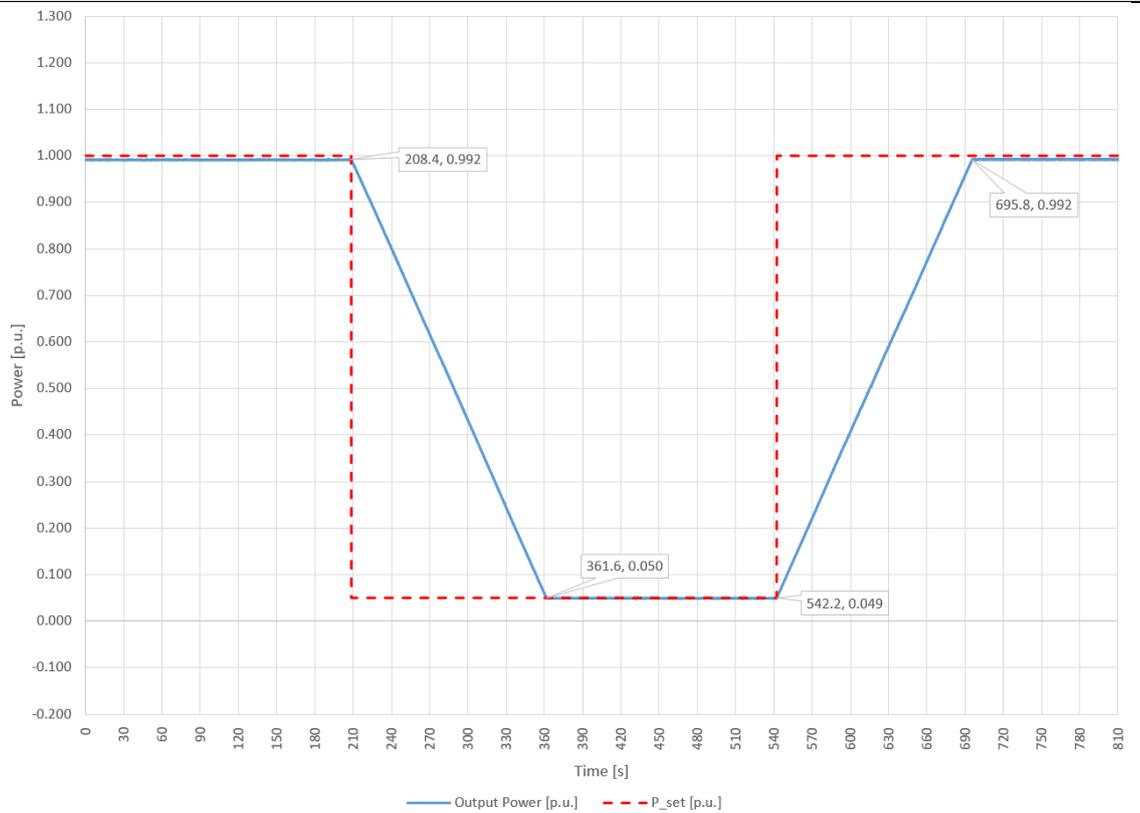
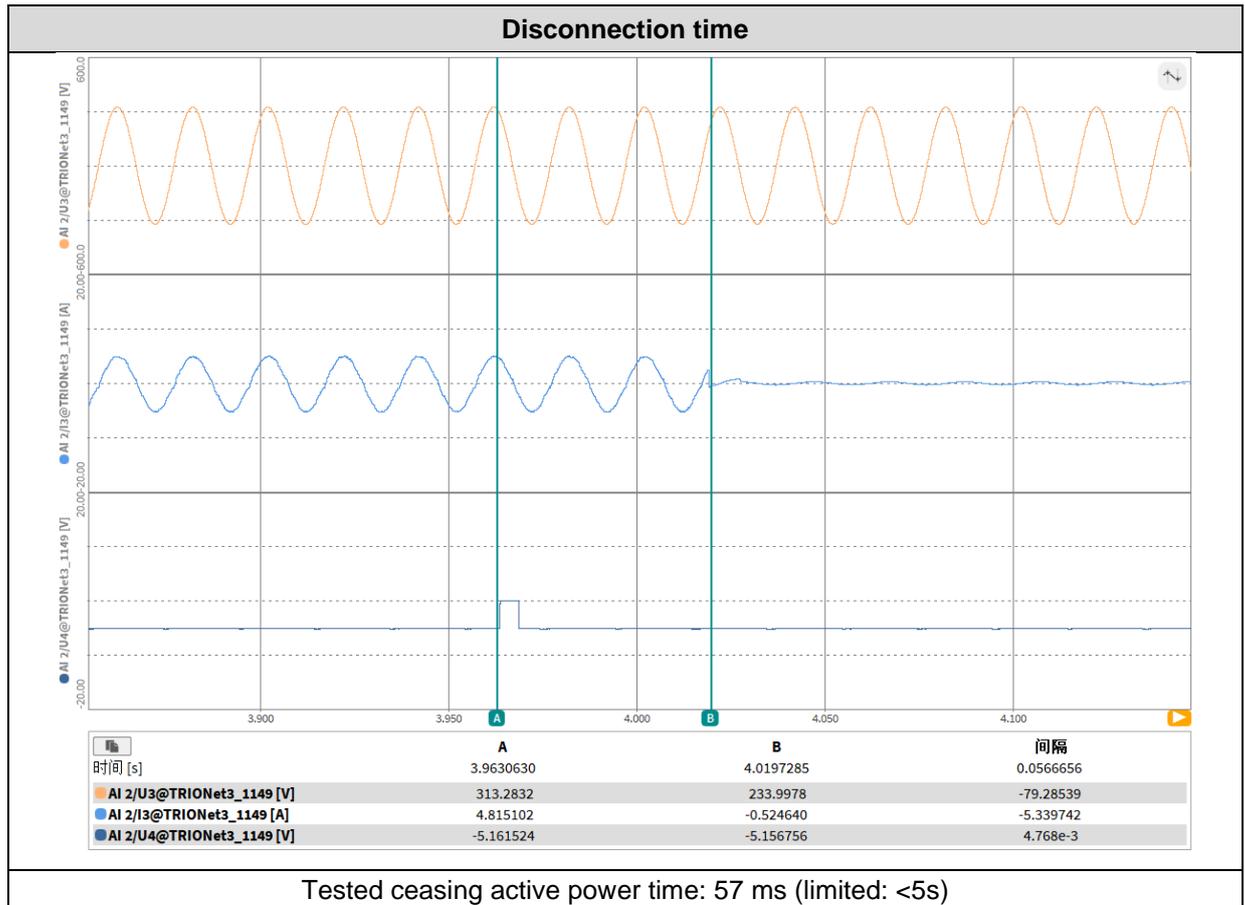## Output power change (100% to 5% to 100% of P_Amax) – 0.33%P_Amax/s
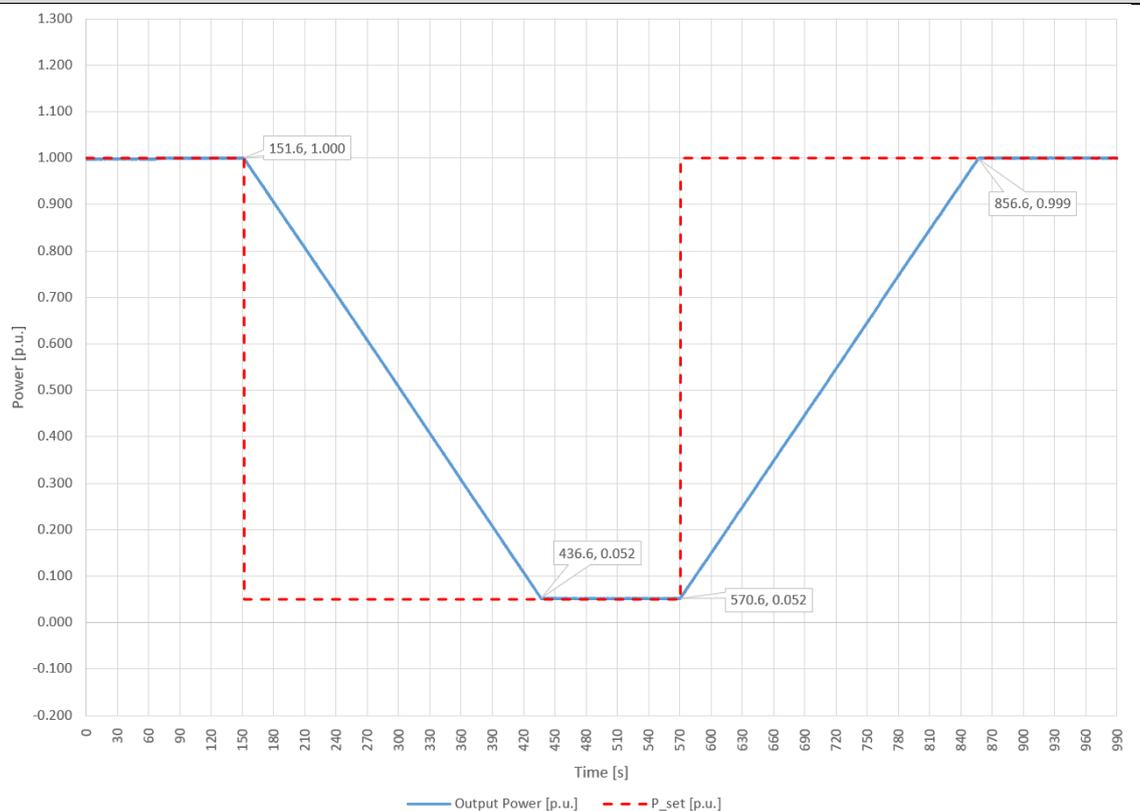
4.9.2 Ceasing Of Active Power By External Signal On Input Port

This test has been done in order to comply with requirements from chapter 5.7.4.1 of the VDE AR-N 4105:2018-11 standard.

Generating units shall be equipped with a logic interface ("CAN (Controller Area Network)") in order to cease active power output within 5 seconds following an instruction from the grid operator being received at the input port, irrespective of the power gradients from point 4.9.1 of this Test Report. Additionally, the interface may be used for network security management.

Test results are graphically shown as below.

Disconnection time

时间 [s]	A	B	间隔
	3.9630630	4.0197285	0.0566656
AI 2/U3@TRIONet3_1149 [V]	313.2832	233.9978	-79.28539
AI 2/I3@TRIONet3_1149 [A]	4.815102	-0.524640	-5.339742
AI 2/U4@TRIONet3_1149 [V]	-5.161524	-5.156756	4.768e-3

Tested ceasing active power time: 57 ms (limited: <5s)

4.9.3 Active Power Steps

This test has been done in order to comply with requirements from chapter 5.7.4.2.2 of the VDE AR-N 4105:2018-11 standard. In order to evaluate this requirement, testing procedure from chapter 5.4.3.3 of the VDE V 0124-100:2020-06 standard has been taken.

Active power will be reduced from 100%Pn to the minimum active power possible in steps of 10% Pn to check that the EUT does not disconnect during those steps.

For each step, wait 1 minute after the change of setpoint to allow the EUT to adjust to the new setpoint. After that, the active power shall be measured as a 1-minute average.

Test results are presented in the following table and graph:

| Active Power step ($\%P_{rE}$)	Setpoint value		Actual value		Deviation (Limit ±5% P_{rE})	
	(kW)	($\%P_{rE}$)	(kW)	($\%P_{rE}$)	(kW)	($\%P_{rE}$)
100.0	0.800	100.0	0.800	100.1	0.000	+0.1
90.0	0.720	90.0	0.719	89.9	-0.001	-0.1
80.0	0.640	80.0	0.638	79.8	-0.002	-0.2
70.0	0.560	70.0	0.557	69.6	-0.003	-0.4
60.0	0.480	60.0	0.475	59.4	-0.005	-0.6
50.0	0.400	50.0	0.393	49.2	-0.007	-0.8
40.0	0.320	40.0	0.311	38.9	-0.009	-1.1
30.0	0.240	30.0	0.229	28.6	-0.011	-1.4
20.0	0.160	20.0	0.147	18.4	-0.013	-1.6
10.0	0.080	10.0	0.065	8.2	-0.015	-1.8
0.0	0.000	0.0	0.011	1.3	+0.011	+1.3

- Values above detailed are obtained as 1-minute mean after 1 minute since the setpoint was adjusted to the required active power step.
- Power change gradient set during testing: 0.50%P_{Amax}/s

Step from 100%P$_{rE}$ to 0%P$_{rE}$
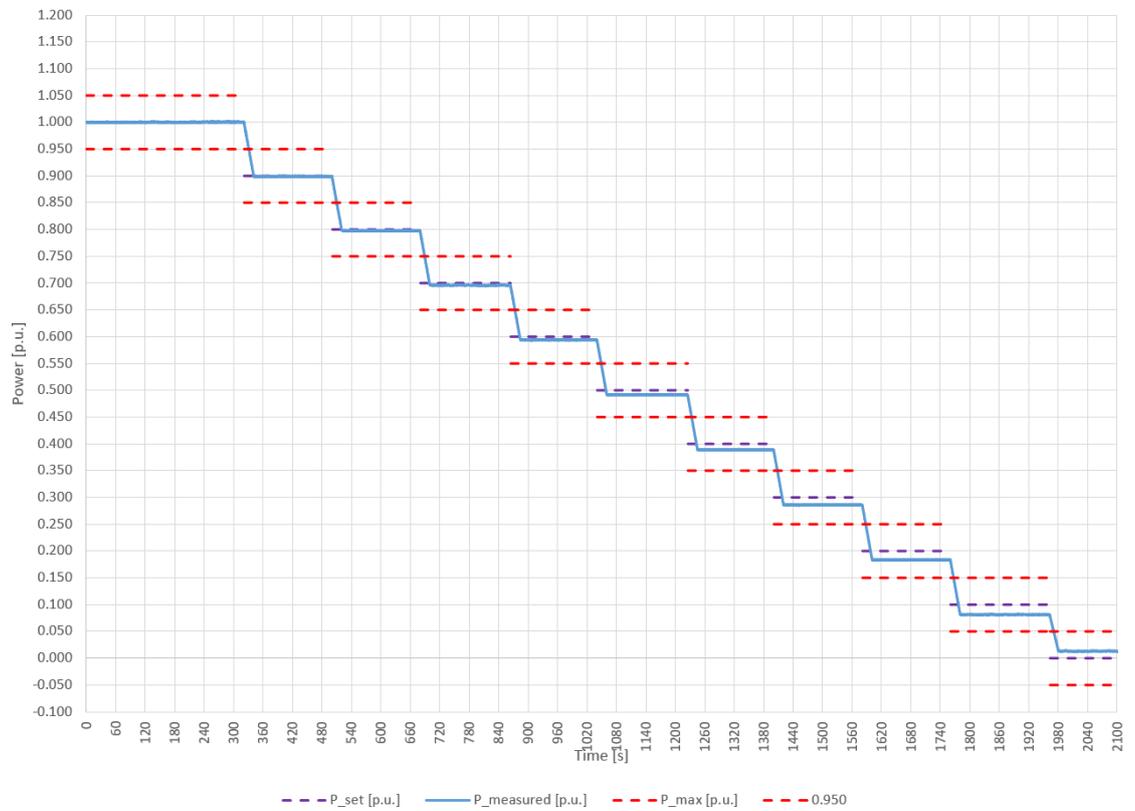
4.9.4   Active Power Adjustment At A Function Of Grid Frequency

The aim of the test is to demonstrate the response of the EUT due to a deviation in grid frequency from rated value in terms of speed (rise/settling time) and the active power gradient.
This test has been performed according to the point 5.7.4.2.3 of the VDE AR-N 4105:2018-11 standard, changing the parameters in the PGU control system.
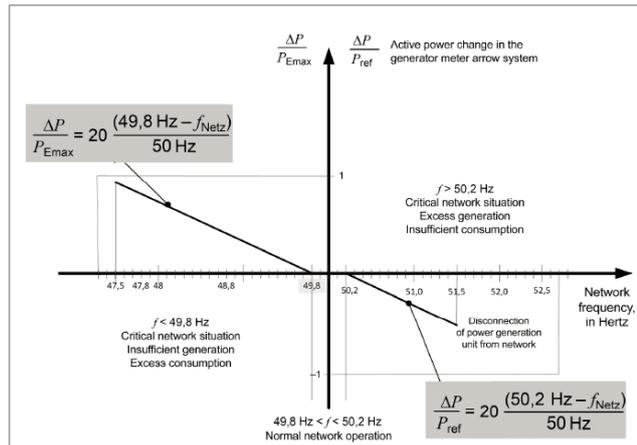
Key

P_{Emax} highest active power of a power generation unit (10 min mean value)

P_{ref} equals P_{Emax} for type 1 power generation units or P_{mom} for type 2 power generation units at the moment when 50,2 Hz is exceeded.

ΔP power change

f network frequency

Figure 14 – Active power adjustment for type 1 and type 2 power generation units at over-frequency and under-frequency with a static value of 5 % and frequency limit values of 49,8 Hz and 50,2 Hz for starting the adjustment

Frequency measurement accuracy for this test shall be $\leq \pm$ 10mHz

Tests for both over and underfrequency deviations have been done. For both tests, additional requirements shall be taken into consideration presented in the standard.

The initial delay (Tv) of the steps shall be $\leq$ 2s.

During a frequency step, certain conditions that shall be verified:

- After Tv + 0.1*(T$_{an\_90\%}$-Tv), a minimum of 9% of the required power gradient for that step has been reached.
- After T$_{an\_90\%}$, a minimum of 90% of the required power gradient for that step has been reached.
- Settling time shall not exceed 20s with a tolerance band of 10% of the required setpoint.
- After the disconnection, when the frequency has returned to a value that allows a reconnection, a delay of at least 60s must elapse, and power shall be restored via a gradient $\leq$ 10% P$_{Emax}$/min.

(*) T$_{an\_90\%}$ refers to rise time and Tv refers to initial delay.

Static accuracy for active power is $\leq \pm$10% P$_{Emax}$.

4.9.4.1   Over-frequency

Test procedure from chapter 5.4.4 (for inverters) / 5.4.5 (for storage) of the VDE V 0124-100:2020-06 standard establishes two tests for certificating the power droop and the disconnection and reconnection conditions at different parameters:

- **For Inverters**

Regarding active power adjustment at over-frequency, the VDE AR-N 4105:2018-11 standard stablishes that in the frequency range from 50.2/50.5 Hz to 51.5 Hz, active power shall be reduced with a power drop of 2-12%, and that the generation unit shall disconnect if 51.5 Hz is surpassed.
Default values for threshold frequency and droop are 50.2 Hz and 5%, respectively.

− Test 1: P = 100% P_{Emax}, frequency threshold for power droop = 50.2 Hz, droop = 5%, test with disconnection and reconnection
− Test 2: P = 60% P_{Emax}, threshold for power droop = 50.5 Hz, droop = 12%, test without disconnection

Note: The PV input port of inverter was supplied by a PV simulator source with I-V characteristic during the testing.
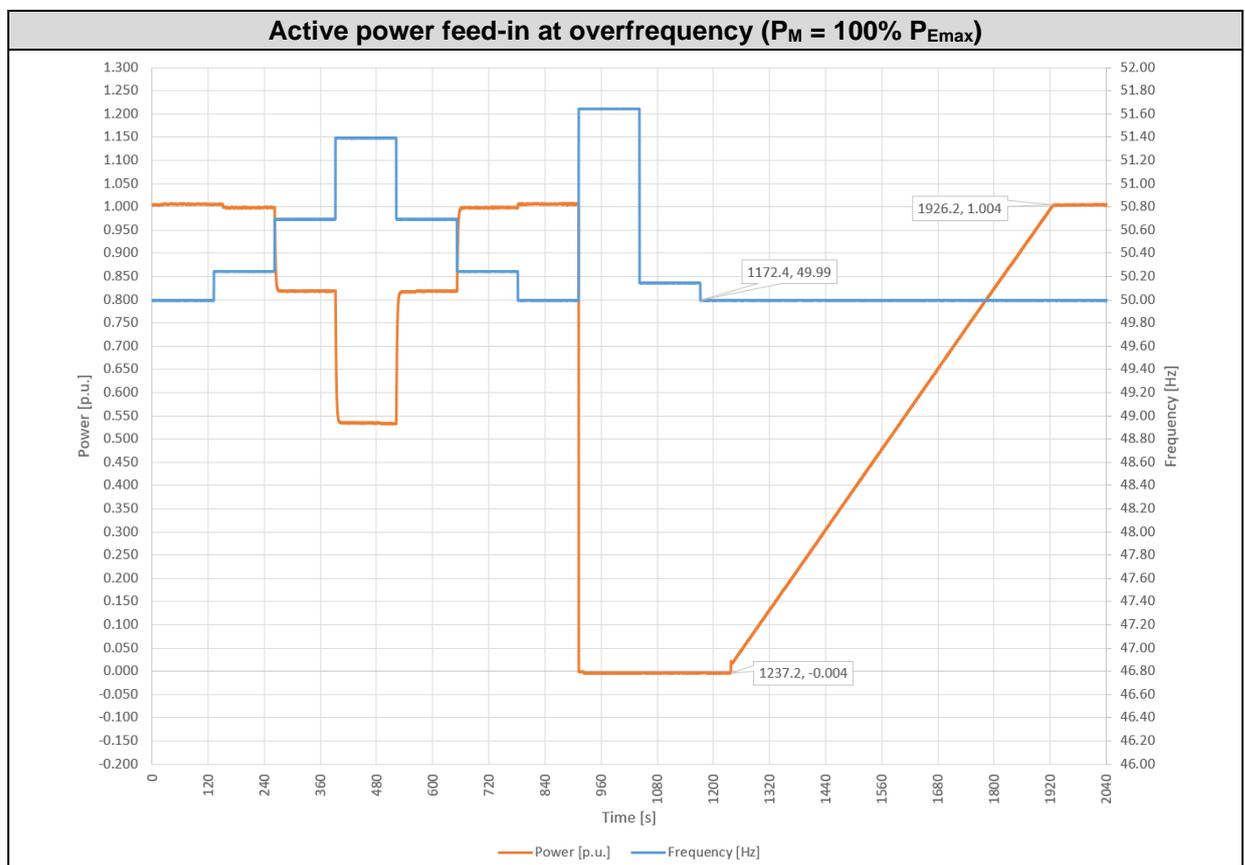
- **For storage unit**

Regarding active power adjustment at over-frequency, the VDE AR-N 4105:2018-11 standard stablishes that in the frequency range from 50.2/50.5Hz to 51.5Hz, active power shall be reduced with a power drop of 5%, and that the storage unit shall disconnect if 51.5 Hz is surpassed.

− Test 3: P = 100% P_{Emax}, frequency threshold for power droop = 50.2 Hz, droop = 5%, test with disconnection and reconnection
− Test 4: P = 60% P_{Emax}, threshold for power droop = 50.5 Hz, droop = 5%, test without disconnection

Note: The battery input port of inverter was supplied by a simulator DC source with battery characteristic during the testing.
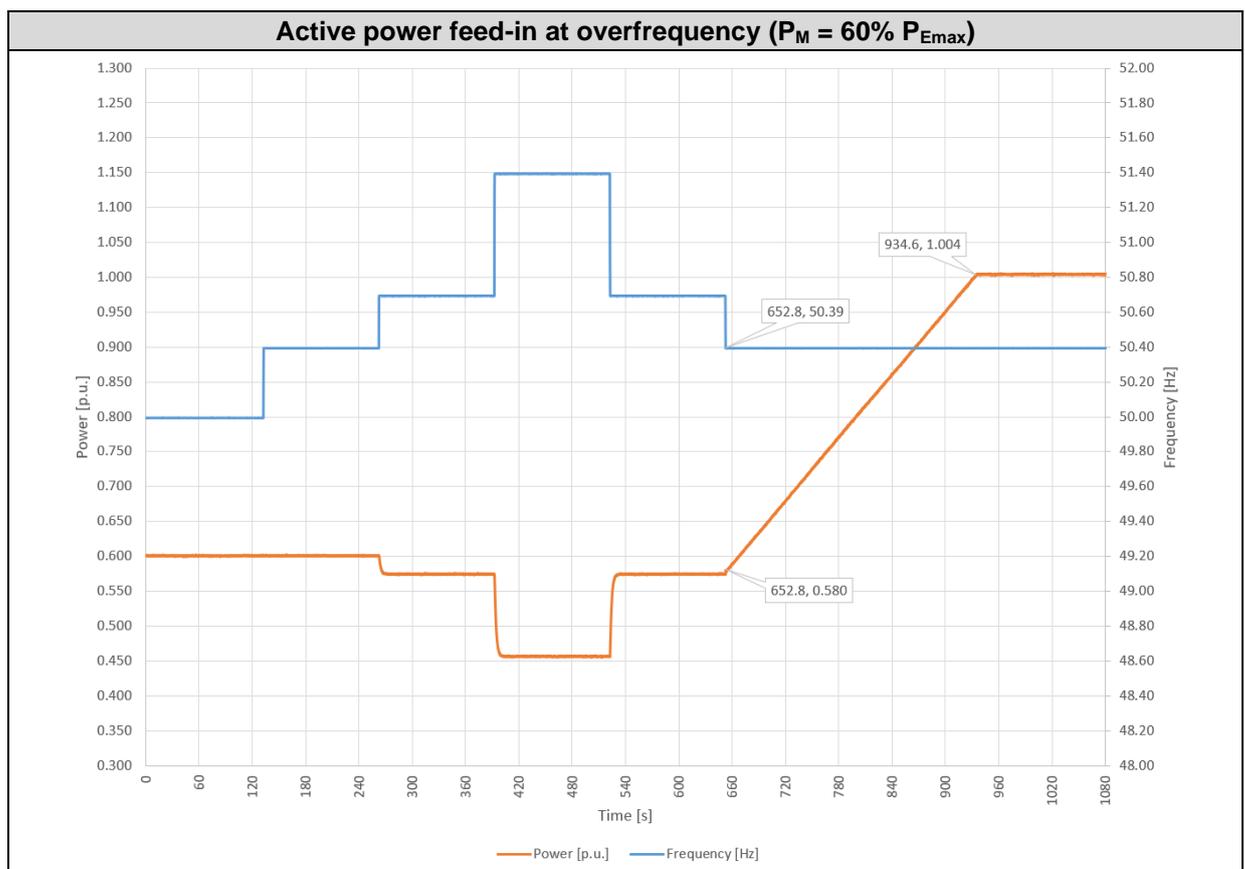
- **Test-1: PV Unit characteristic – Start power (P_M) = 100%P_{Emax}**

	Settings	F_{start} (Hz)	50.2	$s = \dfrac{\Delta f}{f_n} \Big/ \dfrac{\Delta P}{P_{ref}}$	5%
		$F_{disconnect}$ (Hz)	51.5		
	Steps			**P_M = 100% P_{Emax}**	
Step	**Frequency setting (Hz)**	**Active Power expected (%P_{Emax})**	**Frequency measured (Hz)**	**Active power measured (%P_{Emax})**	**Variation measured (%P_{Emax}) (±10%P_{Emax})**
a)	50.00	+100.0	49.99	+100.6	+0.6
b)	50.25	+98.0	50.24	+99.8	+1.8
c)	50.70	+80.0	50.69	+81.8	+1.8
d)	51.40	+52.0	51.39	+53.4	+1.4
e)	50.70	+80.0	50.69	+81.8	+1.8
f)	50.25	+98.0	50.24	+99.8	+1.8
g)	50.00	+100.0	49.99	+100.6	+0.6
h)	51.65	0.0	51.64	-0.4	-0.4
--	Disconnection confirm (Yes or No)		Yes		
i)	50.15	0.0	50.14	-0.4	-0.4
--	Reconnected confirm (Yes or No)		No		
j)	50.00	+100.0	49.99	+100.4	+0.4
	Reconnection Time (s)		64.8		
--	Power gradient limited during step j (<= 10%P_{Emax}/min)				
	Power gradient measured (%P_{Emax} /min)		8.8		

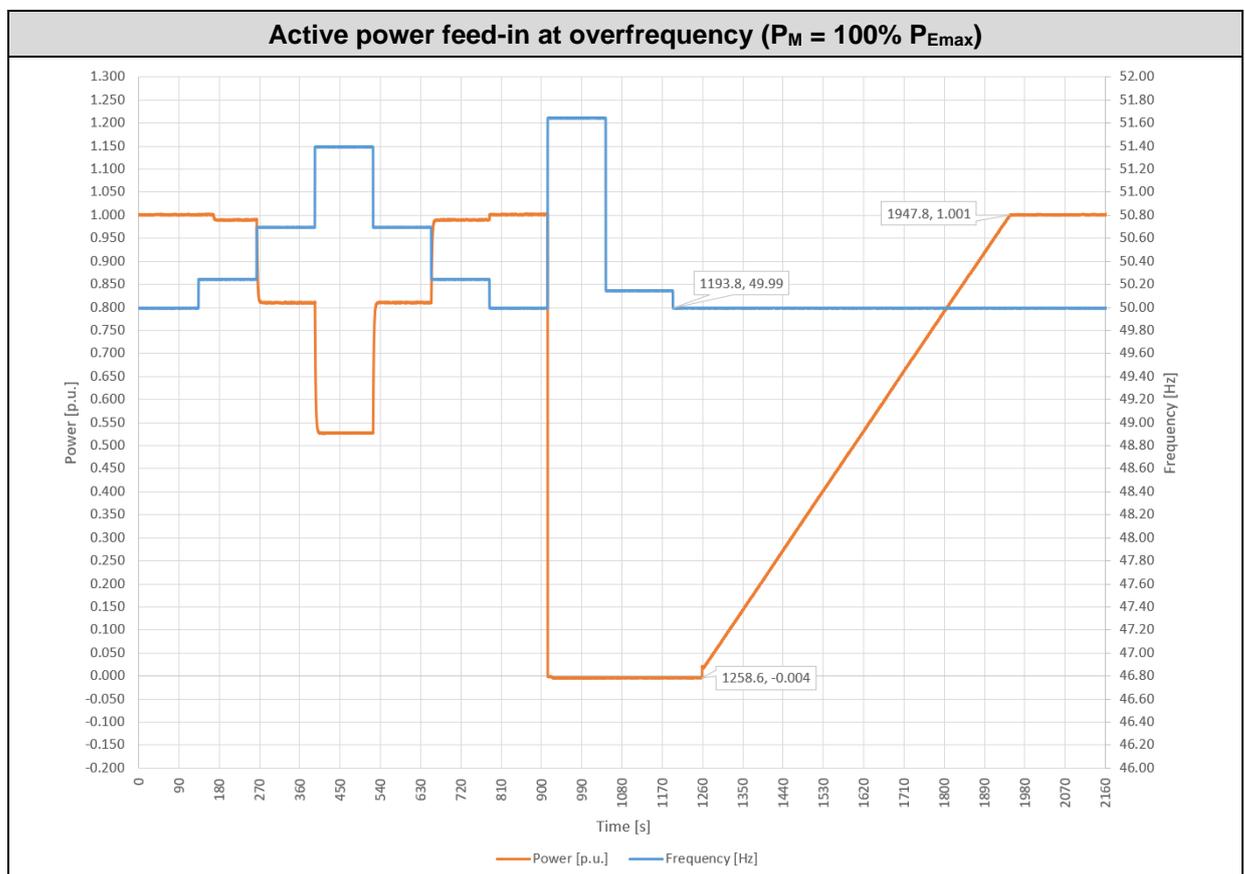Active power feed-in at overfrequency (P_M = 100% P_{Emax})

- **Test-2: PV Unit characteristic – Start power (P_M) = 60%P_{Emax}**

		F_{start} (Hz)	50.5	$s = \dfrac{\Delta f}{f_n} \Big/ \dfrac{\Delta P}{P_{ref}}$	12%
	Settings	**$F_{disconnect}$ (Hz)**	51.5		
		Steps		**P_M = 60% P_{Emax}**	
Step	**Frequency setting (Hz)**	**Active Power expected (%P_{Emax})**	**Frequency measured (Hz)**	**Active power measured (%P_{Emax})**	**Variation measured (%P_{Emax}) (±10%P_{Emax})**
a)	50.00	+60.0	49.99	+60.1	+0.1
b)	50.40	+60.0	50.39	+60.1	+0.1
c)	50.70	+58.0	50.69	+57.5	-0.5
d)	51.40	+51.0	51.39	+45.6	-5.4
e)	50.70	+58.0	50.69	+57.5	-0.5
f)	50.40	+60.0 to +100.0 stable at +100.0	50.39	+100.4	+0.4
--	Power gradient limited during step f (<= 10%P_{Emax}/min)				
	Power gradient measured (%P_{Emax} /min)		9.2		
g)	50.00	+100.0	49.99	+100.4	+0.4

Active power feed-in at overfrequency (P_M = 60% P_{Emax})
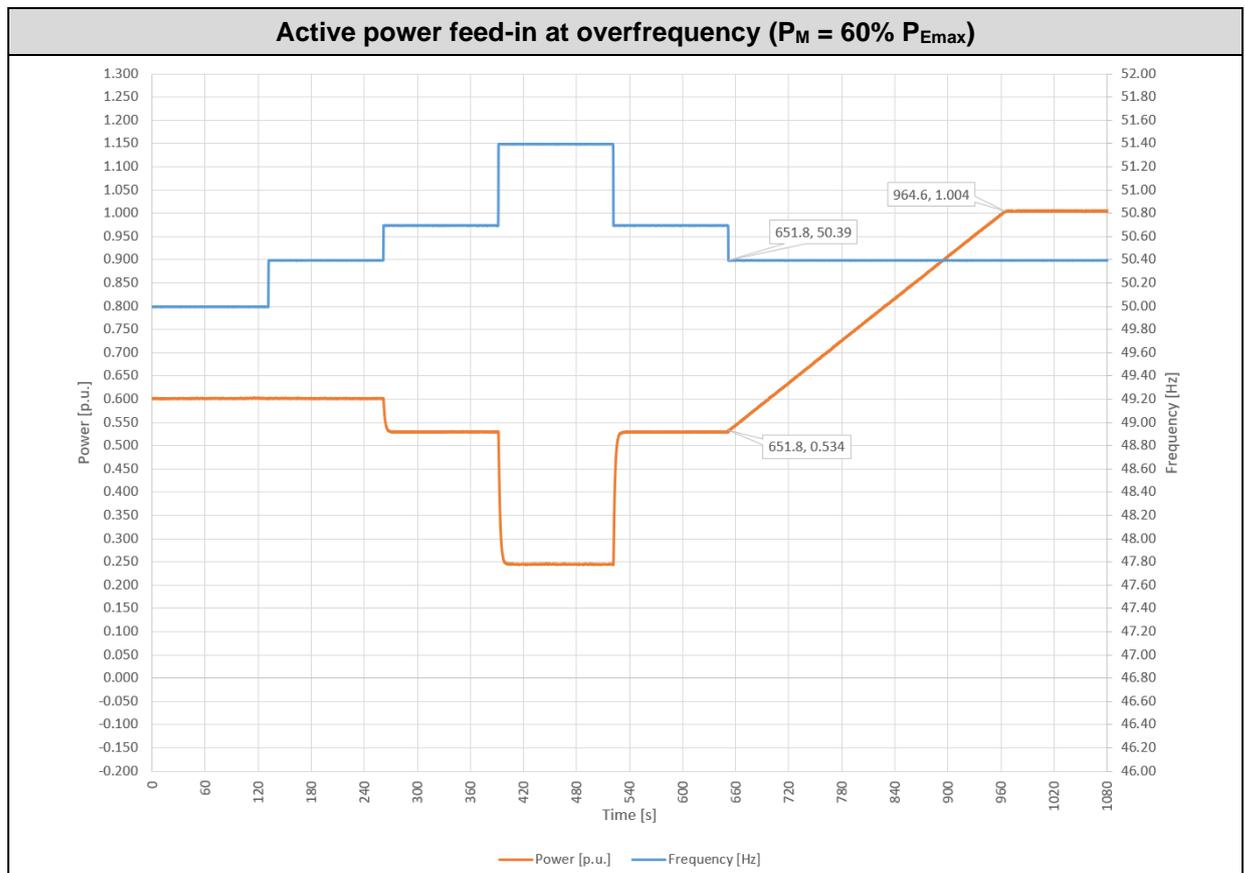
VDE-AR-N 4105:2018-11 + Correction 1:2020-10

- **Test-3: Storage Unit characteristic – Start power (P_M) = 100%P_{Emax}**

Settings		F_{start} (Hz)	50.2	$s = \dfrac{\Delta f}{f_n} \bigg/ \dfrac{\Delta P}{P_{ref}}$	5%
		$F_{disconnect}$ (Hz)	51.5		
Steps				**P_M = 100% P_{Emax}**	
Step	**Frequency setting (Hz)**	**Active Power expected (%P_{Emax})**	**Frequency measured (Hz)**	**Active power measured (%P_{Emax})**	**Variation measured (%P_{Emax})**
a)	50.00	100.0	49.99	+100.1	+0.1
b)	50.25	98.0	50.24	+99.0	+1.0
c)	50.70	80.0	50.69	+81.0	+1.0
d)	51.40	52.0	51.39	+52.7	+0.7
e)	50.70	80.0	50.69	+81.1	+1.1
f)	50.25	98.0	50.24	+99.0	+1.0
g)	50.00	100.0	49.99	+100.2	+0.2
h)	51.65	0.0	51.64	-0.4	-0.4
--	Disconnection confirm (Yes or No)		Yes		
i)	50.15	0.0	50.14	-0.4	-0.4
--	Reconnected confirm (Yes or No)		No		
j)	50.00	100.0	49.99	+100.1	+0.1
	Reconnection Time (s)		64.8		
--	Power gradient limited during step j (<= 10%P_{Emax}/min)				
	Power gradient measured (%P_{Emax} /min)		8.7		

Active power feed-in at overfrequency (P_M = 100% P_{Emax})

Data point labels: 1947.8, 1.001; 1193.8, 49.99; 1258.6, -0.004

Legend: Power [p.u.]   Frequency [Hz]

VDE-AR-N 4105:2018-11 + Correction 1:2020-10

- **Test-4: Storage Unit characteristic – Start power (P_M) = 60%P_{Emax}**

Settings		F_{start} (Hz)	50.5	$s = \dfrac{\Delta f}{f_n} \Big/ \dfrac{\Delta P}{P_{ref}}$	5%
		$F_{disconnect}$ (Hz)	51.5		
Steps				**P_M = 60% P_{Emax}**	
Step	**Frequency setting (Hz)**	**Active Power expected (%P_{Emax})**	**Frequency measured (Hz)**	**Active power measured (%P_{Emax})**	**Variation measured (%P_{Emax}) (±10%P_{Emax})**
a)	50.00	60.0	49.99	+60.2	+0.2
b)	50.40	60.0	50.39	+60.2	+0.2
c)	50.70	52.0	50.69	+53.0	+1.0
d)	51.40	24.0	51.39	+24.5	+0.5
e)	50.70	52.0	50.69	+52.9	+0.9
f)	50.40	60.0 to 100.0 stable at 100.0	50.39	+100.5	+0.5
--	Power gradient limited during step f (<= 10%P_{Emax}/min)				
	Power gradient measured (%P_{Emax} /min)		9.0		
g)	50.00	100.0	49.99	+100.5	+0.5

Active power feed-in at overfrequency (P_M = 60% P_{Emax})

4.9.4.2 Under-frequency

Test procedure from chapter 5.4.6 (for inverters) / 5.4.7 (for storage) of the VDE V 0124-100:2020-06 standard establishes two tests for verification the power droop and the disconnection and reconnection conditions at different parameters:

- **For Inverters**

Regarding active power adjustment at underfrequency, the VDE AR-N 4105:2018-11 standard states that under 49.8 Hz, active power shall be increased with a power gradient of 40%Pref / Hz. If frequency is reduced under 47.5 Hz, the generation unit shall disconnect.

− Test 1: P = 10% P_{Emax}, test with disconnection and reconnection
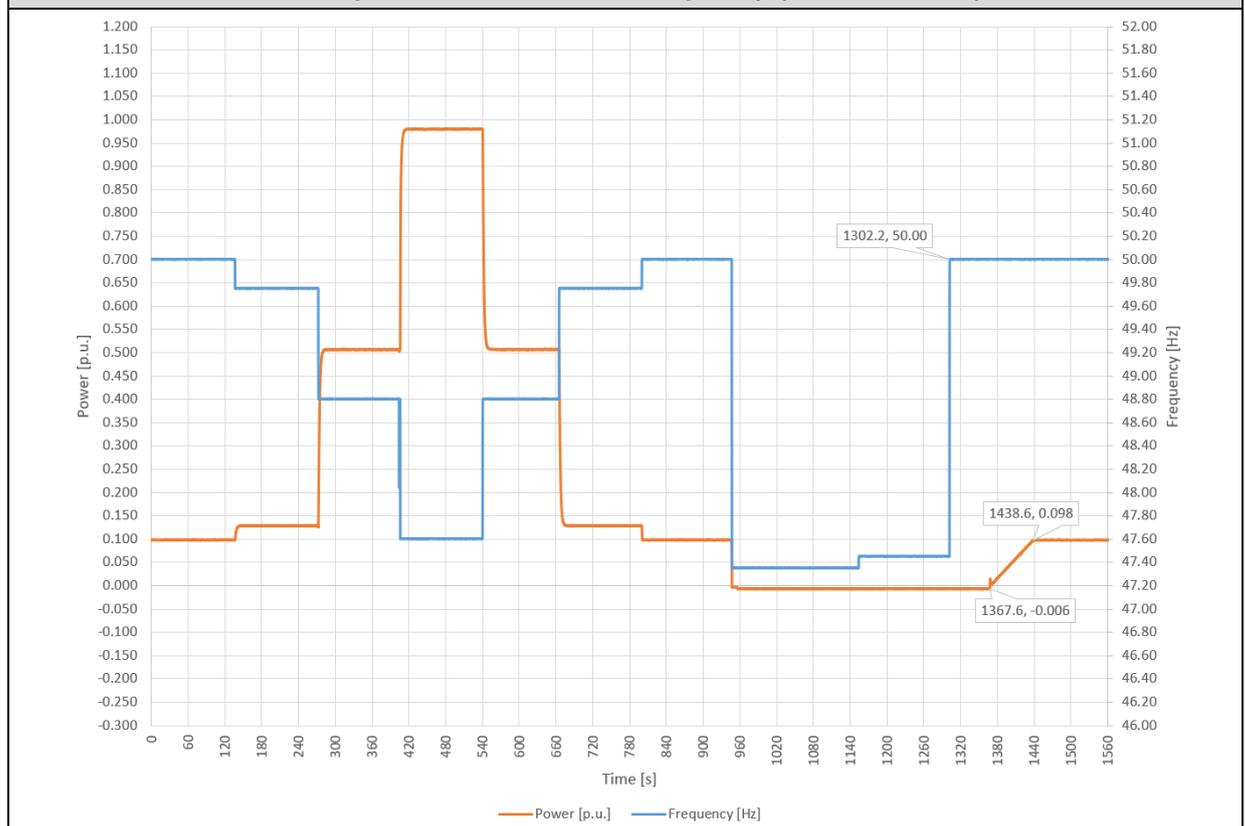− Test 2: P = 60% P_{Emax}, test without disconnection

- **For storage unit**

Regarding active power adjustment at underfrequency, the VDE AR-N 4105:2018-11 standard states that under 49.8 Hz, active power shall be increased with a power gradient of 100%Pref / Hz. If frequency is reduced under 47.5 Hz, the storage unit shall disconnect.

− Test 3: P = -100% P_{Emax}, test with disconnection and reconnection*
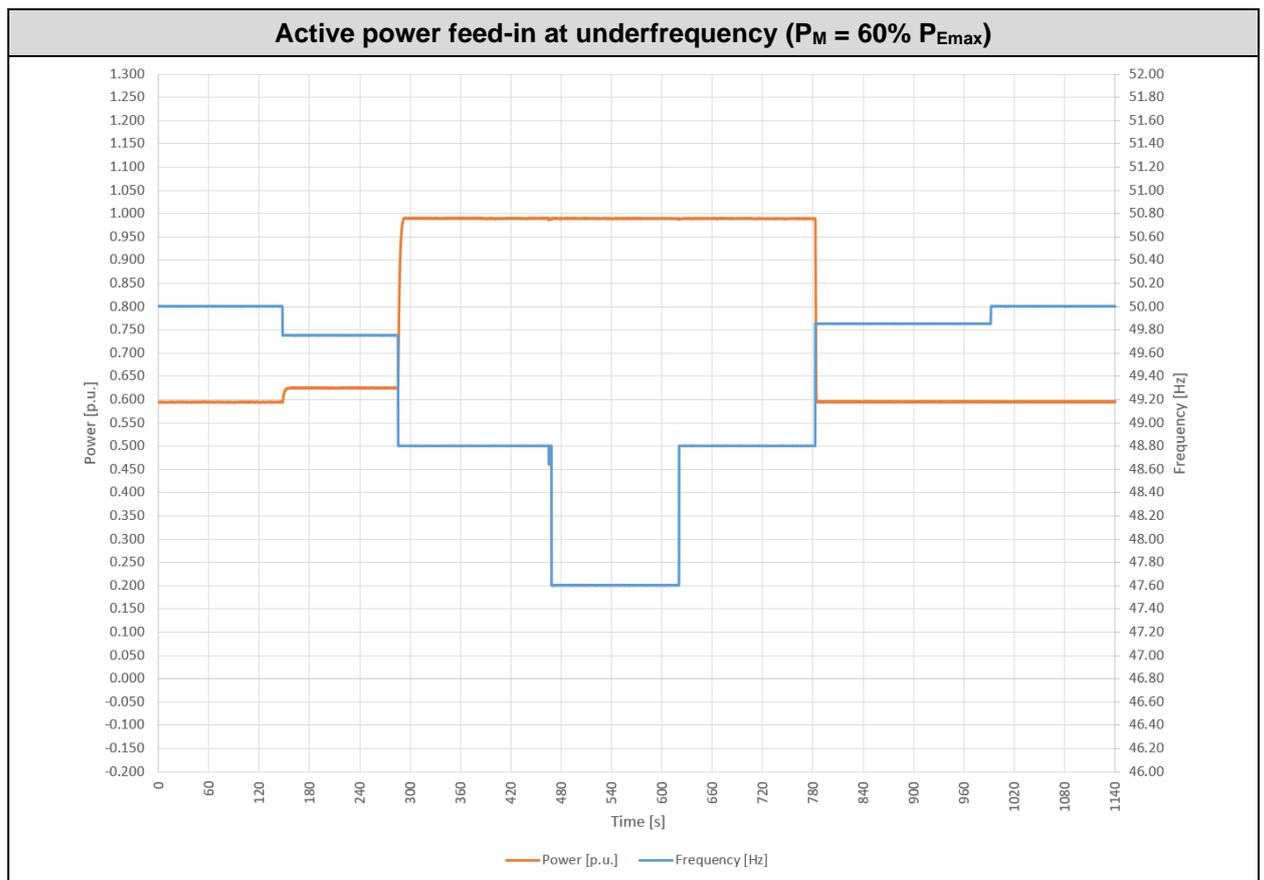− Test 4: P = 10% P_{Emax}, test without disconnection

- **Test-1: PV Unit characteristic – Start power (P_M) = 10%P_{Emax}**

Settings		F_{start} (Hz)	49.8	$s = \dfrac{\Delta f}{f_n} \Big/ \dfrac{\Delta P}{P_{ref}}$	5%
		$F_{disconnect}$ (Hz)	47.5		
Steps				**P_M = 10% P_{Emax}**	
Step	Frequency setting (Hz)	Active Power expected (%P_{Emax})	Frequency measured (Hz)	Active power measured (%P_{Emax})	Variation measured (%P_{Emax}) (±10%P_{Emax})
a)	50.00	+10.0	50.00	+9.8	-0.2
b)	49.75	+12.0	49.75	+12.9	+0.9
c)	48.80	+50.0	48.80	+50.7	+0.7
d)	47.60	+98.0	47.60	+98.0	0.0
e)	48.80	+50.0	48.80	+50.7	+0.7
f)	49.75	+12.0	49.75	+12.9	+0.9
g)	50.00	+10.0	50.00	+9.8	-0.2
h)	47.35	0.0	47.35	-0.6	-0.6
--	Disconnection confirm (Yes or No)		Yes		
i)	47.45	0.0	47.45	-0.6	-0.6
--	Reconnected confirm (Yes or No)		No		
j)	50.00	+10.0	50.00	+9.8	-0.2
--	Reconnection Time (s)		65.4		
	Power gradient limited during step j (<= 10%P_{Emax}/min)				
	Power gradient measured (%P_{Emax} /min)		8.8		

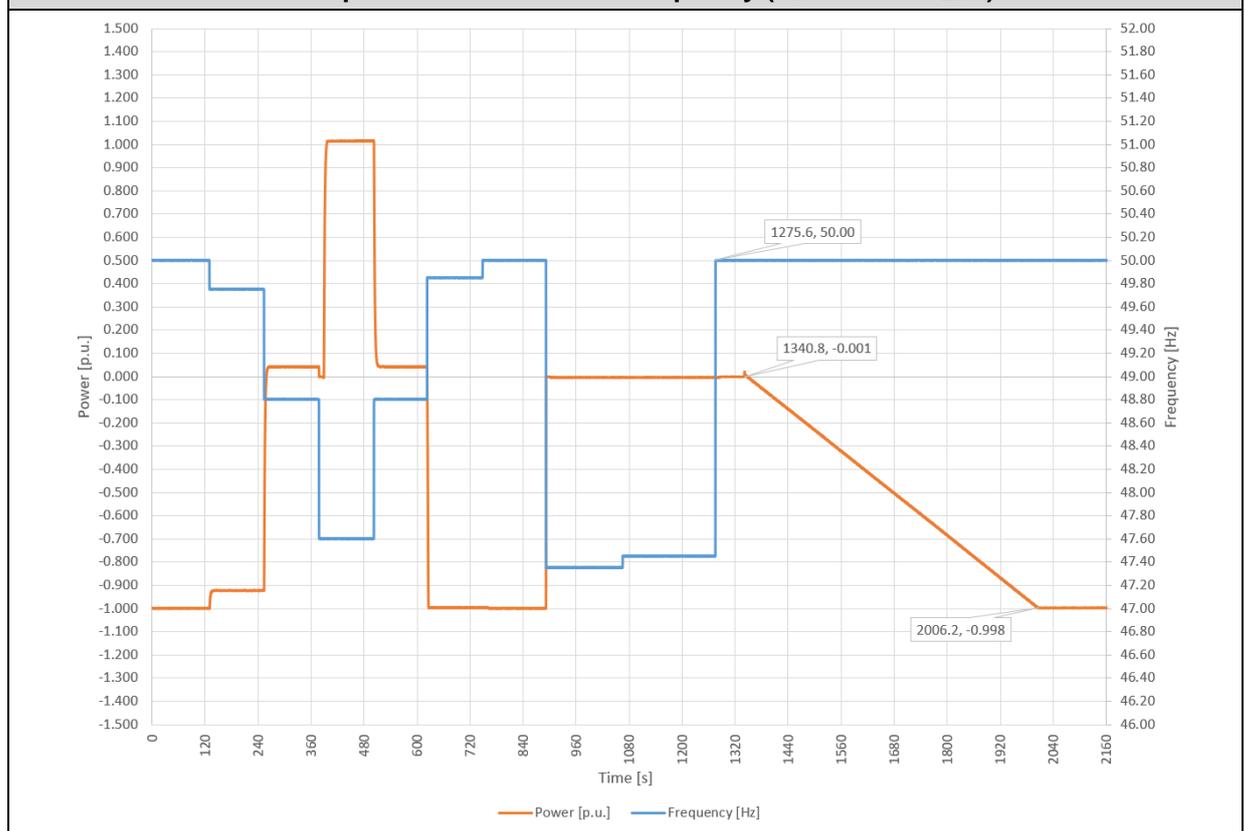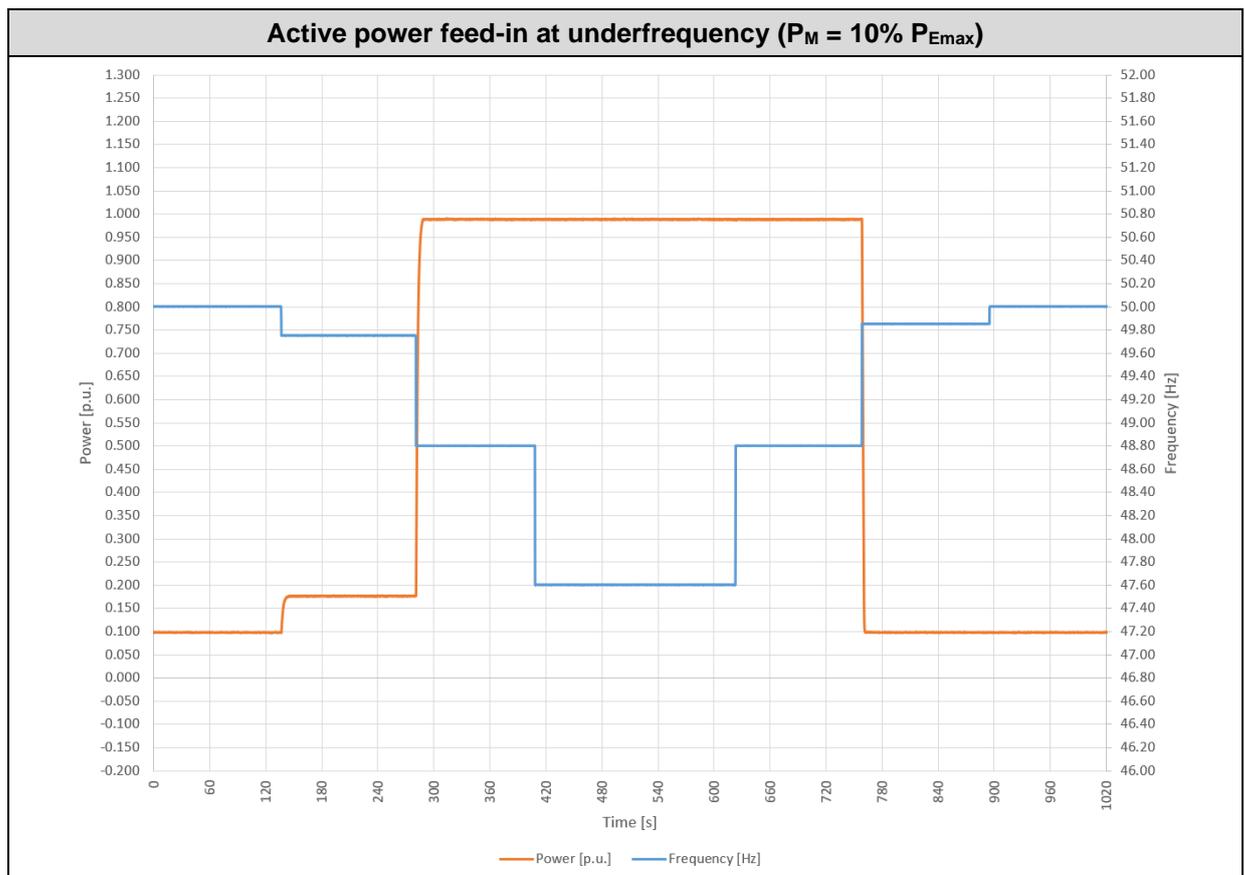**Active power feed-in at underfrequency (P_M = 10% P_{Emax})**

- **Test-2: PV Unit characteristic – Start power (P_M) = 60%P_{Emax}**

Settings		F_{start} **(Hz)**	49.8	$s = \dfrac{\Delta f}{f_n} \Big/ \dfrac{\Delta P}{P_{ref}}$	5%
		$F_{disconnect}$ **(Hz)**	47.5		
Steps				**P_M = 60% P_{Emax}**	
Step	**Frequency setting (Hz)**	**Active Power expected (%P_{Emax})**	**Frequency measured (Hz)**	**Active power measured (%P_{Emax})**	**Variation measured (%P_{Emax}) (±10%P_{Emax})**
a)	50.00	+60.0	50.00	+59.4	-0.6
b)	49.75	+62.0	49.75	+62.5	+0.5
c)	48.80	+100.0	48.80	+98.9	-1.1
d)	47.60	+100.0	47.60	+98.9	-1.1
e)	48.80	+100.0	48.80	+98.9	-1.1
f)	49.85	+60.0	49.85	+59.5	-0.5
g)	50.00	+60.0	50.00	+59.5	-0.5

Active power feed-in at underfrequency (P_M = 60% P_{Emax})

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- **Test-3: Storage Unit characteristic – Start power (P_M) = -100%P_Emax**

Settings		F_{start} (Hz)	49.8	$s = \dfrac{\Delta f}{f_n} \Big/ \dfrac{\Delta P}{P_{ref}}$	2%
		$F_{disconnect}$ (Hz)	47.5		
Steps				**P_M = -100% Pn**	
Step	Frequency setting (Hz)	Active Power expected (%P_Emax)	Frequency measured (Hz)	Active power measured (%P_Emax)	Variation measured (%P_Emax) (±10%P_Emax)
a)	50.00	-100.0	50.00	-99.8	+0.2
b)	49.75	-95.0	49.75	-92.2	+2.8
c)	48.80	0.0	48.80	+4.2	+4.2
d)	47.60	100.0	47.60	+101.5	+1.5
e)	48.80	0.0	48.80	+4.2	+4.2
f)	49.85	-100.0	49.85	-99.7	+0.3
g)	50.00	-100.0	50.00	-99.9	+0.1
h)	47.35	0.0	47.35	-0.4	-0.4
--	Disconnection confirm (Yes or No)		Yes		
i)	47.45	0.0	47.45	-0.4	-0.4
--	Reconnected confirm (Yes or No)		No		
j)	50.00	-100.0	50.00	-99.8	+0.2
	Reconnection Time (s)		65.2		
--	Power gradient limited during step j (<= -10%P_Emax/min)				
	Power gradient measured (%P_Emax /min)		-9.0		

Active power feed-in at underfrequency (P_M = -100% P_Emax)

- **Test-4: Storage Unit characteristic – Start power (P$_M$) = 10%P$_{Emax}$**

Settings		F$_{start}$ (Hz)	49.8	$s = \dfrac{\Delta f}{f_n} \Big/ \dfrac{\Delta P}{P_{ref}}$	2%
		F$_{disconnect}$ (Hz)	47.5		
Steps				**P$_M$ = 10% P$_{Emax}$**	
Step	Frequency setting (Hz)	Active Power expected (%P$_{Emax}$)	Frequency measured (Hz)	Active power measured (%P$_{Emax}$)	Variation measured (%P$_{Emax}$) (±10%P$_{Emax}$)
a)	50.00	+10.0	50.00	+9.8	-0.2
b)	49.75	+15.0	49.75	+17.7	+2.7
c)	48.80	+100.0	48.80	+98.9	-1.1
d)	47.60	+100.0	47.60	+98.9	-1.1
e)	48.80	+100.0	48.80	+98.9	-1.1
f)	49.85	+10.0	49.85	+9.8	-0.2
g)	50.00	+10.0	50.00	+9.8	-0.2

Active power feed-in at underfrequency (P$_M$ = 10% P$_{Emax}$)

4.9.5 Voltage-Dependent Active Power Reduction

This test is not required according to the section 5.7.4.4 of the standard VDE AR-N 4105:2018-11 due to reduce the active power feed-in as a function of the voltage of (a) power generation unit(s) is optional.
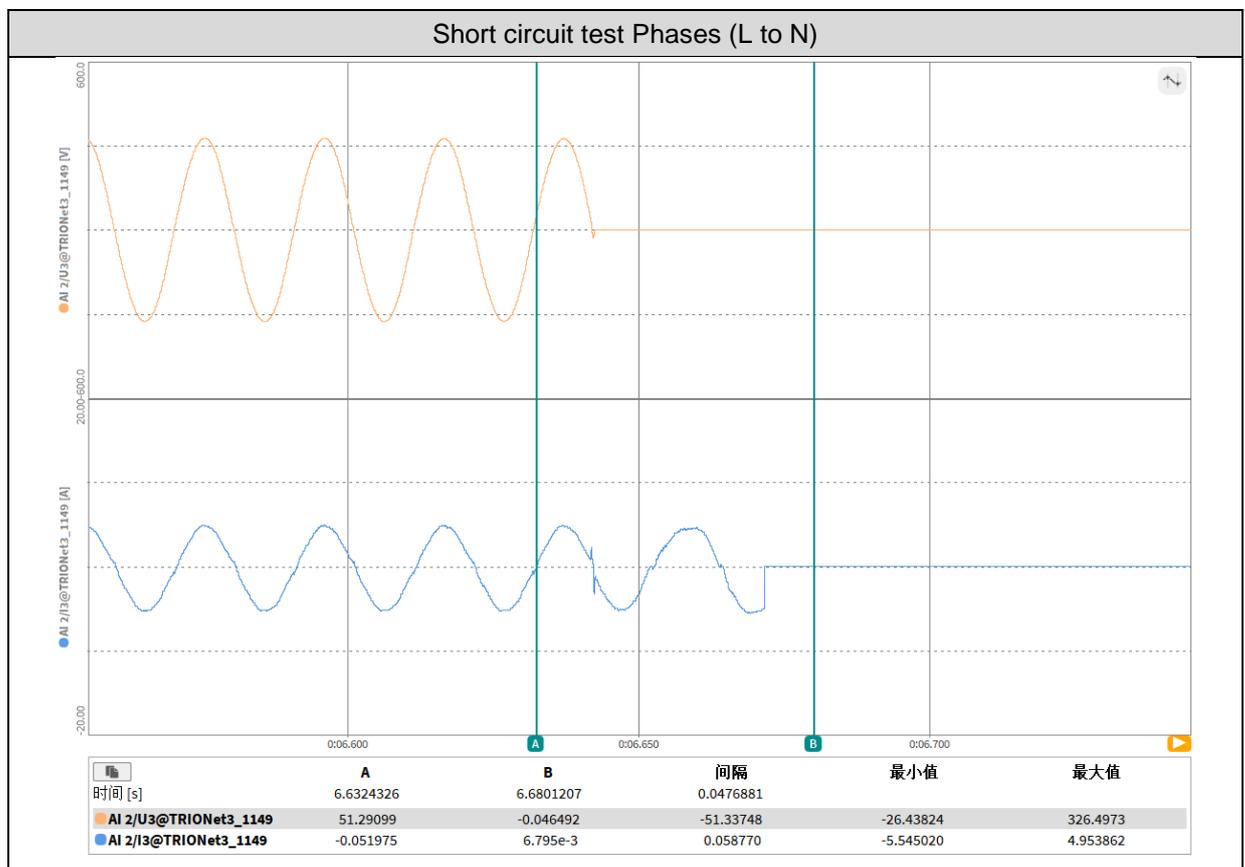
4.10 SHORT-CIRCUIT CONTRIBUTION

According to the paragraph 5.7.5 of the VDE-AR-N 4105:2018-11, due to the operation of a power generation system, the short-circuit current of the low-voltage network is increased by the short-circuit current of the power generation system. Therefore, the short-circuit current of the power generation system to be expected at the network connection point shall be indicated in accordance with 4.2. For the determination of the initial short-circuit AC current contribution IkA of a power generation system, the following roughly estimated values can be assumed:

– for synchronous generators: 8 times the rated current;
– for asynchronous generators: 6 times the rated current;
– for generators and storage units with inverters: the rated current.

If the power generation system causes a short-circuit current increase in the network operator's network in excess of the rated value, then connection owner and network operator shall agree upon appropriate measures limiting the short-circuit current from the power generation system accordingly.

Short circuit current	
Short Circuit Applied	Isc Max (A)
Phases (L to N)	3.9

Short circuit test Phases (L to N)

时间 [s]	A	B	间隔	最小值	最大值
	6.6324326	6.6801207	0.0476881		
AI 2/U3@TRIONet3_1149	51.29099	-0.046492	-51.33748	-26.43824	326.4973
AI 2/I3@TRIONet3_1149	-0.051975	6.795e-3	0.058770	-5.545020	4.953862

4.11 PROTECTION SETTING

As indicated in VDE-AR-N 4105:2018-11, section 6 (Construction of the power generation system/network and system protection (NS protection)), the requirements for the network and system protection differ depending on the maximum apparent power ($SA\max^{\Sigma\,S_{Amax}}$) of the generating and storage units connected to the same network connection point.

- For installations with $SA\max^{\Sigma\,S_{Amax}}$ ≤ 30kVA, the NS protection can either be
  - a central NS protection at the central meter panel or decentralized in a sub-distribution; or
  - integrated NS protection

  The equipment covered by this Test Report are all below this limit and both of these options can be chosen.

- For installations with $SA\max^{\Sigma\,S_{Amax}}$ >30kVA, the NS protection must be accomplished by a central NS protection device at the central meter panel.

  In the case of the equipment covered by this Test Report, this will happen when several units are connected to the same network connection point.

In any case, the NS protection shall meet that a single fault shall not lead to a loss of the protective function (single fault tolerance).
All the tests in this section have been performed without an additional relay connected, to check the internal protection of the equipment.
This test has been done according to requirements presented in chapter 6.5 of the VDE AR-N 4105:2018-11 standard.

Testing procedure from chapter 5.5.7 of the VDE V 0124-100:2020-06 has been used for determining the trip value and the trip time as follows:

For U>>, U<and U<<tests:

−   For testing the accuracy of threshold: Starting from a voltage level 2.0% U_n below or above the trip value of the protection function to be tested, the voltage is increased or decreased in steps of 0.5% U_n or less for at least the trip time stated in the protection function to be tested + 200ms (taking into account the maximum 100ms delay for the NS + interface switch), and the voltage at which the EUT trips is to be recorded

−   For testing the accuracy of the trip time: Starting from a voltage value 2.0% U_n below or above the expected trip value, the voltage shall be increased in a single step to a value 2.0% U_n above or below that value. The time taken from the start of the step until the EUT trips is recorded as the trip time.

For the U>tests (tests number 3.1, 3.2 and 3.3) the procedure is the following:

−   For test 3.1: Starting from U_n, a single step to 112.0% U_n is performed. The expected behaviour is tripping of the EUT between 450.0s and 550.0s from the start of the step. Each step shall be maintained for at least 600.2s

−   For test 3.2: Starting from 100.0% U_n, a single step to 108.0% U_n is performed. The expected behaviour of the EUT is no-tripping. Each step shall be maintained for at least 600.2s

−   For test 3.3: Starting from 106.0% U_n, a single step to 114.0% U_n is performed. The expected behaviour is tripping of the EUT between 225.0s and 375.0s from the start of the step. Each step shall be maintained for at least 600.2s

For over/underfrequency tests:

− For testing the accuracy of threshold: Starting from a voltage level 0.10 Hz below or above the trip value of the protection function to be tested, the voltage is increased or decreased in steps of 0.05% f_n or less for at least the trip time stated in the protection function to be tested + 200ms (taking into account the maximum 100ms delay for the NS + interface switch), and the voltage at which the EUT trips is to be recorded

− For testing the accuracy of the trip time: Starting from a voltage value 0.10 Hz below or above the expected trip value, the voltage shall be increased in a single step to a value 0.10 Hz above or below that value. The time taken from the start of the step until the EUT trips is recorded as the trip time.

The permissible tolerance for the trip value tests is 1.0% Un for voltage tests and 1.0% fn for the frequency tests.

The trip time tests results shall be within the requirements of Table 2 from chapter 6.5.2 of VDE-AR-N 4105: 2018-11.

Protective function	Setting values for protection relays[a]					
	Stirling generators, fuel cells		Directly coupled synchronous and asynchronous generators with $P_n > 50$ kW		Inverter(s)	
	Synchronous and asynchronous generators with $P_n \leq 50$ kW coupled directly or via inverters					
Rise-in-voltage protection $U \gg$	$1{,}15\ U_n$	≤ 100 ms	$1{,}25\ U_n$	≤ 100 ms	$1{,}25\ U_n$	≤ 100 ms
Rise-in-voltage protection $U >$	$1{,}10\ U_n$[b]	≤ 100 ms	$1{,}10\ U_n$[b]	≤ 100 ms	$1{,}10\ U_n$[b]	≤ 100 ms
Voltage drop protection $U <$	$0{,}8\ U_n$[c]	≤ 100 ms	$0{,}8\ U_n$	$1{,}0$ s[d]	$0{,}8\ U_n$	$3{,}0$ s
Voltage drop protection $U <$	Not applicable		$0{,}45\ U_n$	300 ms[d]	$0{,}45\ U_n$	300 ms
Frequency decrease protection $f <$	47,5 Hz	≤ 100 ms	47,5 Hz	≤ 100 ms	47,5 Hz	≤ 100 ms
Frequency increase protection $f >$	51,5 Hz	≤ 100 ms	51,5 Hz	≤ 100 ms	51,5 Hz	≤ 100 ms

[a] The duration set-point "< 100 ms" for the protection relay setting value is based on the assumption that the maximum response time for NS protection + interface switch is also 100 ms. This results in a maximum "total disconnection time" of 200 ms. If the response time of the components is < 100 ms (e. g. 50 ms), then this allows for a longer period during which to perform the measurements and the evaluation of the protective function (e. g. up to 150 ms). This would then result in a protection relay setting value higher than "< 100 ms", i. e. "< 150 ms". However, in that case, only the 100 ms shall be visualised as the setting value at the NS protection. Nevertheless, the disconnection time of 200 ms shall in no case be exceeded.

[b] It shall be ensured, that the voltage 1,10 U_n is not exceeded at the network connection point. If compliance with this requirement is ensured by a central NS protection, then it is permissible to set the rise-in-voltage protection at the decentralised power generation unit/system to a value of up to 1,15 U_n. In that case, the system installer should consider any potential effects on the customer installation. Combination of central NS protection ($U >$: 1,1 U_n) and integrated NS protection ($U >$: 1,1 U_n to 1,15 U_n) is recommended, if the voltage drop in the house installation cannot be neglected. This is typically the case with longer connection lines.

[c] For the protection of the power generation unit, disconnection may also be realised by means of an additional self-protection setting value (e. g. 0,83 U_n) before the setting value of 0,8 U_n is reached.

[d] Where the medium-voltage network of the network operator upstream of the power generation system is operated with automatic reclosing (AWE, de: automatische Wiedereinschaltung), the following protective settings are recommended: $U \ll$-Relay: 0,45 U_{NS}, undelayed (i. e. shortest possible time delay) and $U <$-Relay: 0,8 U_{NS}, 300 ms. The requirement is specified by the network operator.
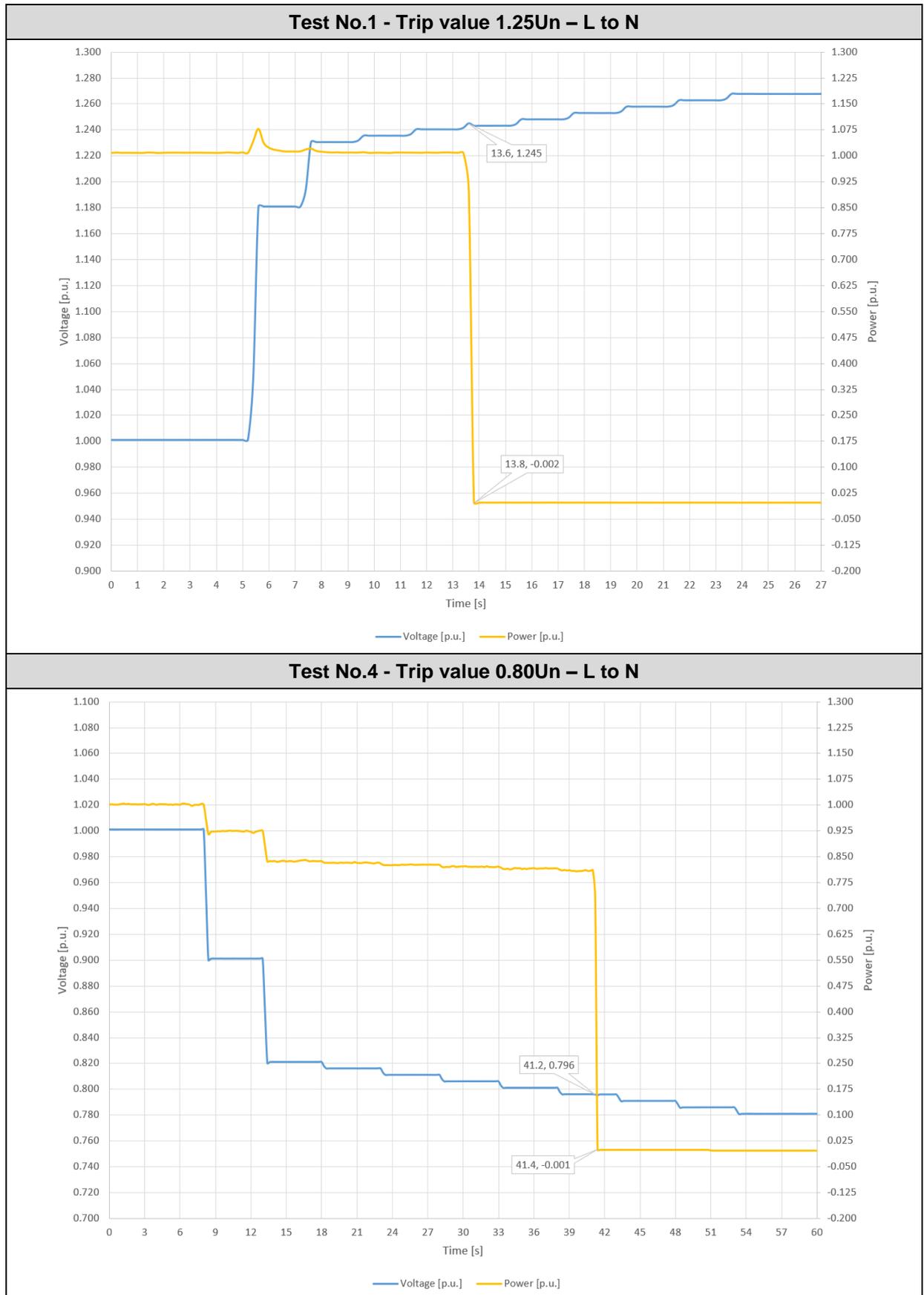
Results are presented in the following tables:

Test No.	Protective function	Ramp or leap	Use on	Start value (p.u.)	End value (p.u.)	Step height ΔU (p.u.)	Step duration Δt	Expected trip value (p.u.)	Measured trip value (p.u.)	Disconnection
1.2	U>>	Ramp	L to N	<1.230	>1.270	<0.005	>400 ms	1.250	1.254	☒ Yes ☐ No
4.2	U<	Ramp	L to N	>0.820	<0.780	<0.005	>3.2 s	0.800	0.796	☒ Yes ☐ No
6.2	V<<	Ramp	L to N	>0.470	<0.430	<0.005	>500 ms	0.450	0.448	☒ Yes ☐ No

Test No.	Protective function	Ramp or leap	Use on	Start value (p.u.)	End value (p.u.)	Step height ΔU (p.u.)	Step duration Δt	Expected trip time	Measured trip time	Disconnection
2.2	U>>	Leap	L to N	<1.230	>1.270	>0.040	>400 ms	≤ 100 ms	64 ms	☒ Yes ☐ No
3.1	U>	Leap	L to N	1.000	1.120	0.120	>600.2 s	450~550 s	498.9 s	☒ Yes ☐ No
3.2	U>	Leap	L to N	1.000	1.080	0.080	>600.2 s	No Trip	No Trip	--
3.3	U>	Leap	L to N	1.060	1.140	0.080	>600.2 s	225~375 s	265.9 s	☒ Yes ☐ No
5.2	U<	Leap	L to N	>0.870	<0.780	>0.040	>3.2 s	3.0~3.1s	3.075 s	☒ Yes ☐ No
7.2	U<<	Leap	L to N	>0.470	<0.430	>0.040	>500 ms	>300 ms	311 ms	☒ Yes ☐ No

Test No.	Protective function	Ramp or leap	Use on	Start value (Hz)	End value (Hz)	Step height Δf (Hz)	Step duration Δt	Expected trip value (Hz)	Measured trip value (Hz)	Disconnection
8.1	f>	Ramp	L to N	<51.40	>51.60	<0.025	>400 ms	51.50	51.49	☒ Yes ☐ No
10.1	f<	Ramp	L to N	>47.60	<47.40	<0.025	>500 ms	47.50	47.49	☒ Yes ☐ No

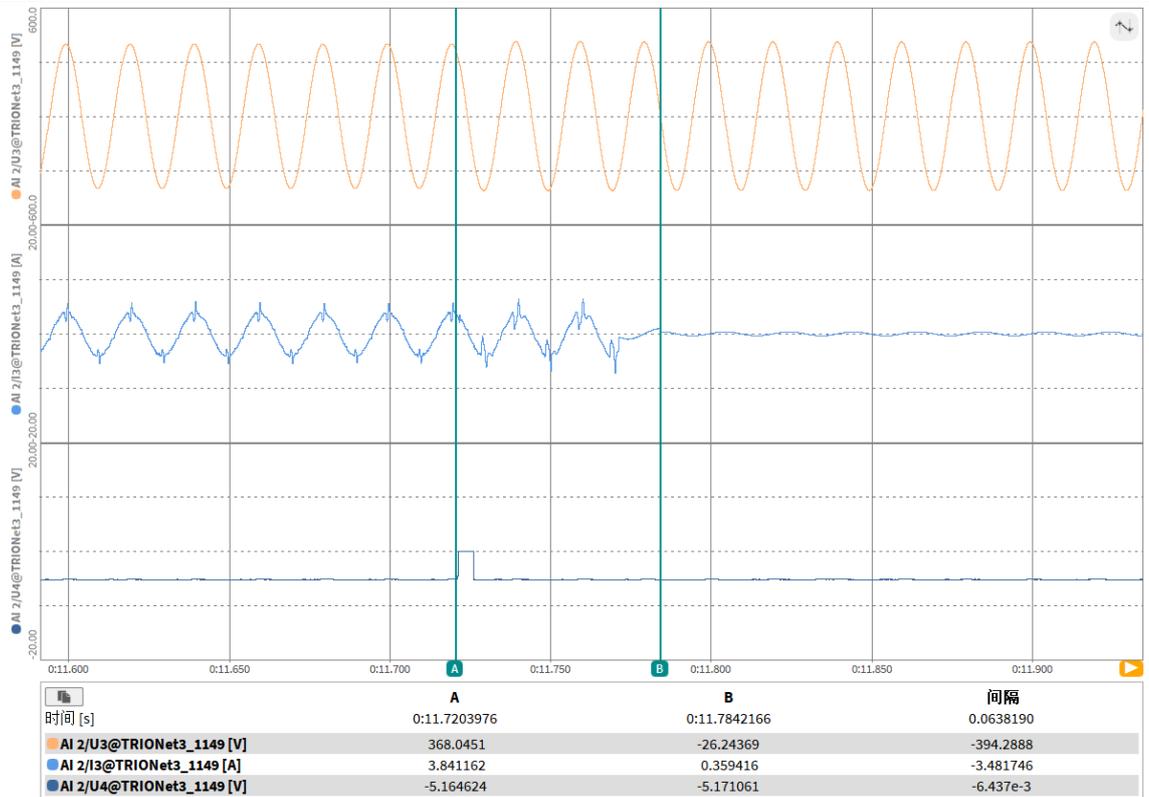| Test No.	Protective function	Ramp or leap	Use on	Start value (Hz)	End value (Hz)	Step height Δf (Hz)	Step duration Δt	Expected trip time	Measured trip time	Disconnection
9.1	f>	Leap	L to N	<51.40	>51.60	>0.2	>400 ms	≤ 100 ms	58 ms	☒ Yes ☐ No
11.1	f<	Leap	L to N	>47.60	<47.40	<0.2	>400 ms	≤ 100 ms	95 ms	☒ Yes ☐ No

In the picture below are offered graphically the results of the test.
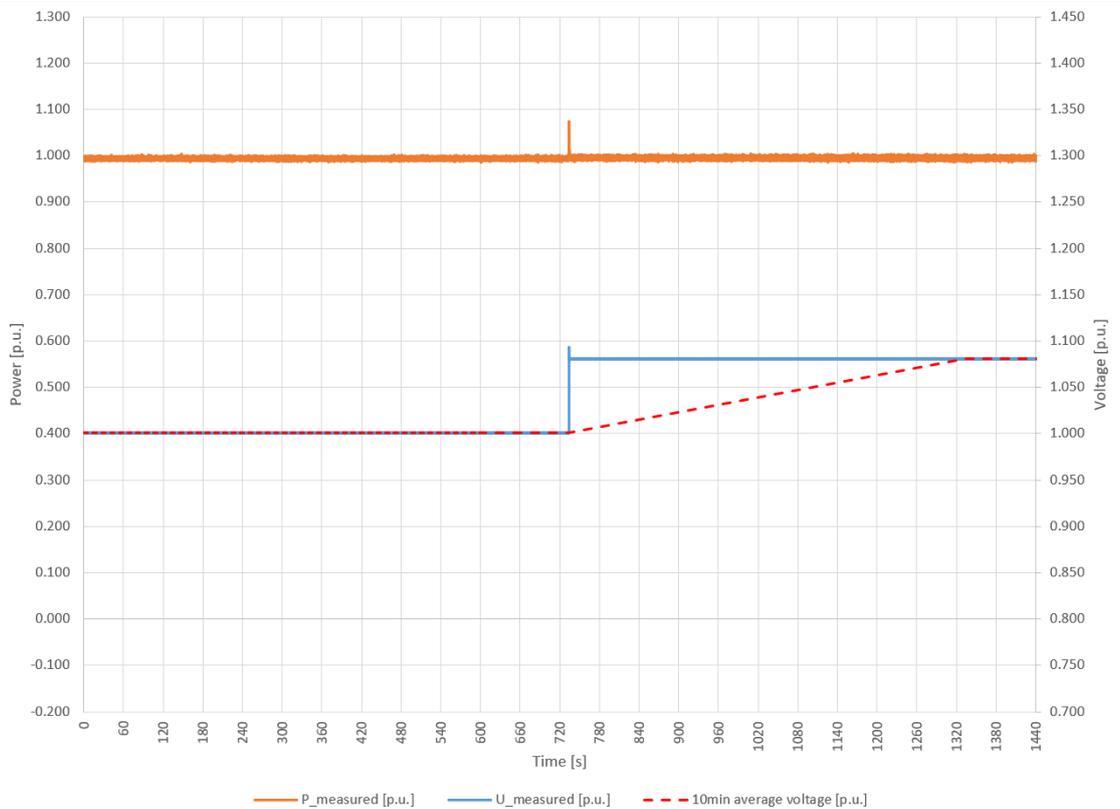

Test No.1 - Trip value 1.25Un – L to N

13.6, 1.245

13.8, -0.002

Test No.4 - Trip value 0.80Un – L to N

41.2, 0.796

41.4, -0.001

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Test No.6 - Trip value 0.45Un – L to N
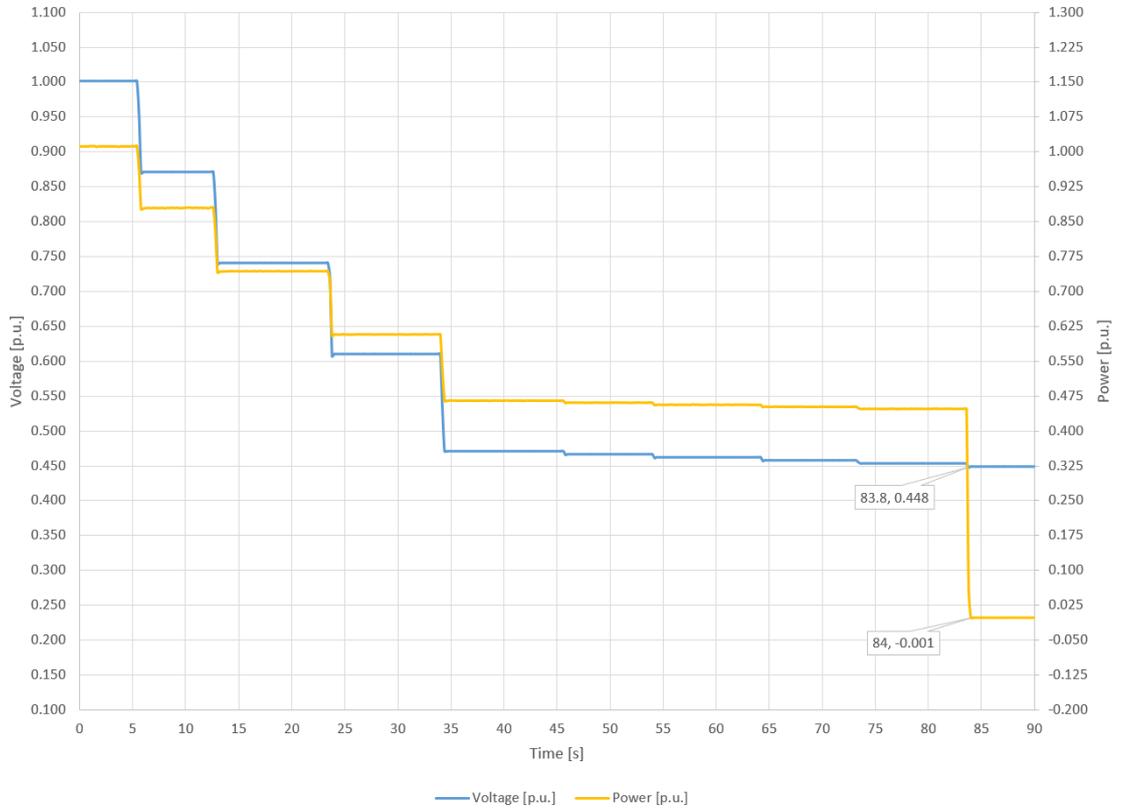
Test No.2 - Trip time 1.25Un – L to N

时间 [s]	A	B	间隔
	0:11.7203976	0:11.7842166	0.0638190
AI 2/U3@TRIONet3_1149 [V]	368.0451	-26.24369	-394.2888
AI 2/I3@TRIONet3_1149 [A]	3.841162	0.359416	-3.481746
AI 2/U4@TRIONet3_1149 [V]	-5.164624	-5.171061	-6.437e-3

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Test No.3.1 - Trip value - 1.10Un of L-N

727.34, 1.121

1226.26, -0.003

P_measured [p.u.]   U_measured [p.u.]   - - - 10min average voltage [p.u.]
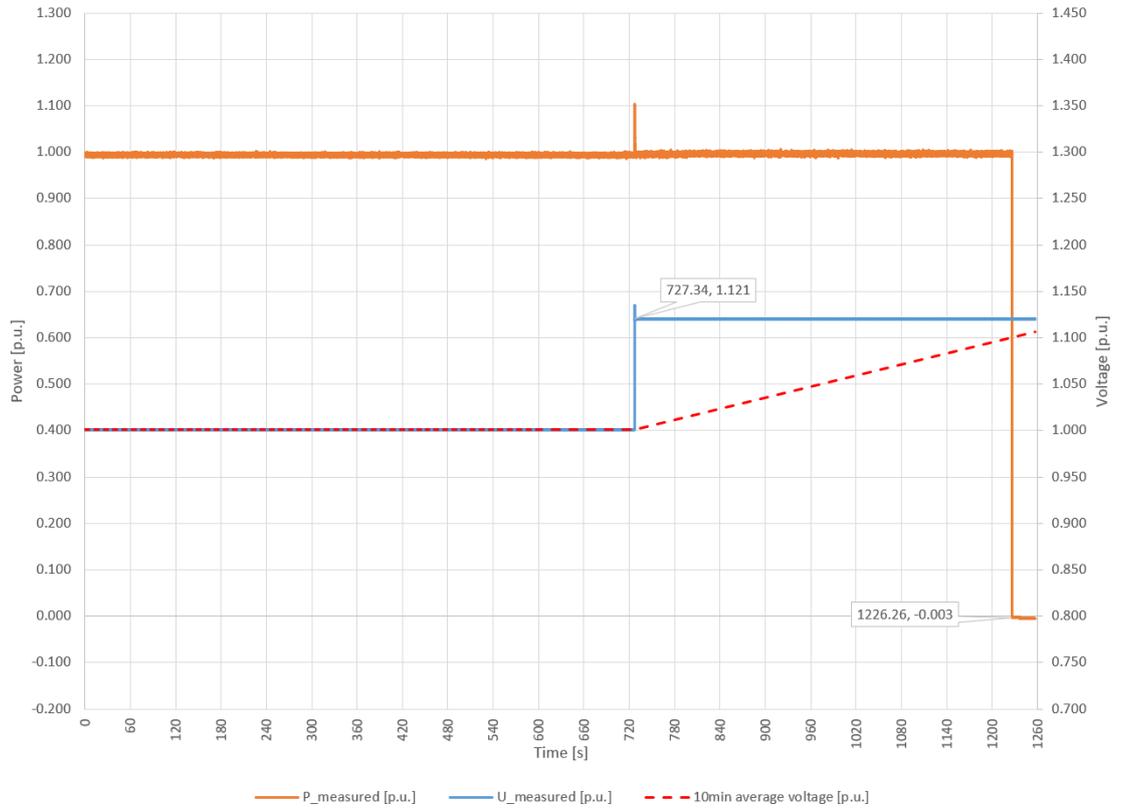
Test No.3.2 - Trip value - 1.10Un of L-N

P_measured [p.u.]   U_measured [p.u.]   - - - 10min average voltage [p.u.]

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Test No.3.3 - Trip time - 1.10Un of L-N

Legend: P_measured [p.u.] | U_measured [p.u.] | 10min average voltage [p.u.]

Annotations on chart: 653.44, 1.141 ; 919.36, -0.002
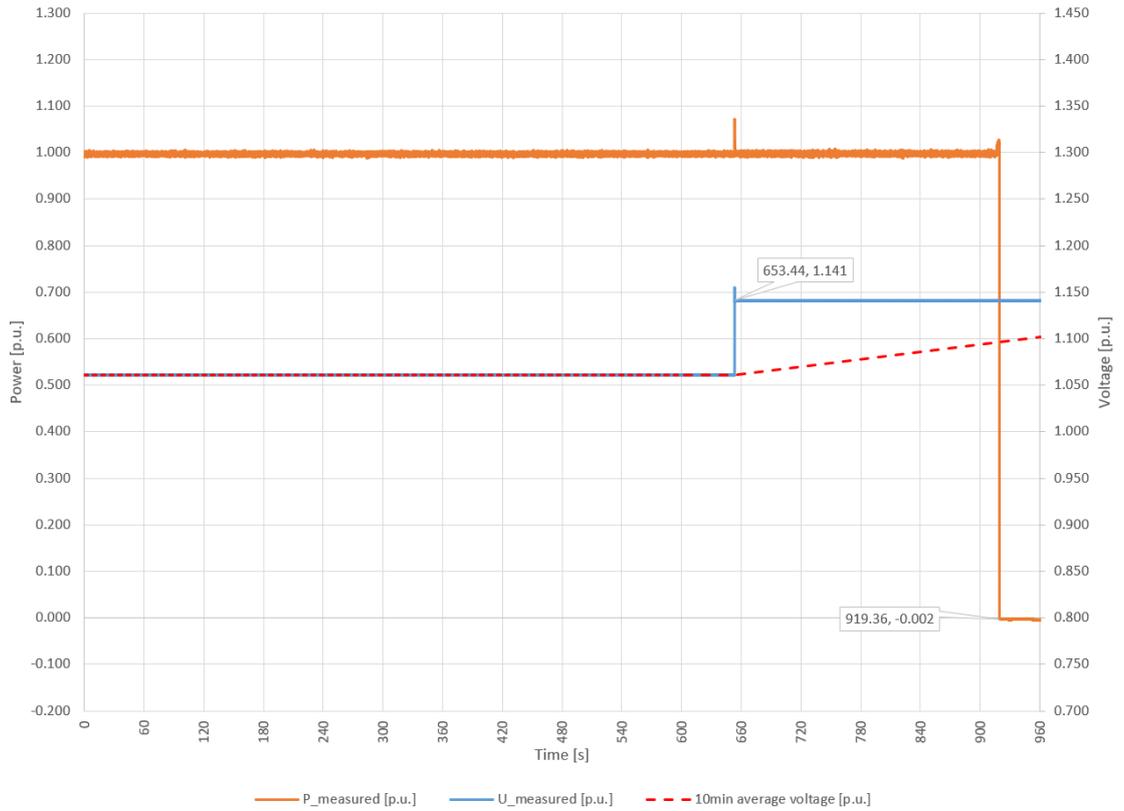
Test No.5 - Trip time 0.80Un – L to N

时间 [s]	A	B	间隔
	0:20.882590	0:23.957624	3.075034
AI 2/U3@TRIONet3_1149 [V]	200.1813	-156.3215	-356.5028
AI 2/I3@TRIONet3_1149 [A]	3.654599	-2.515435	-6.170035
AI 2/U4@TRIONet3_1149 [V]	-5.124092	-5.124092	0.000000
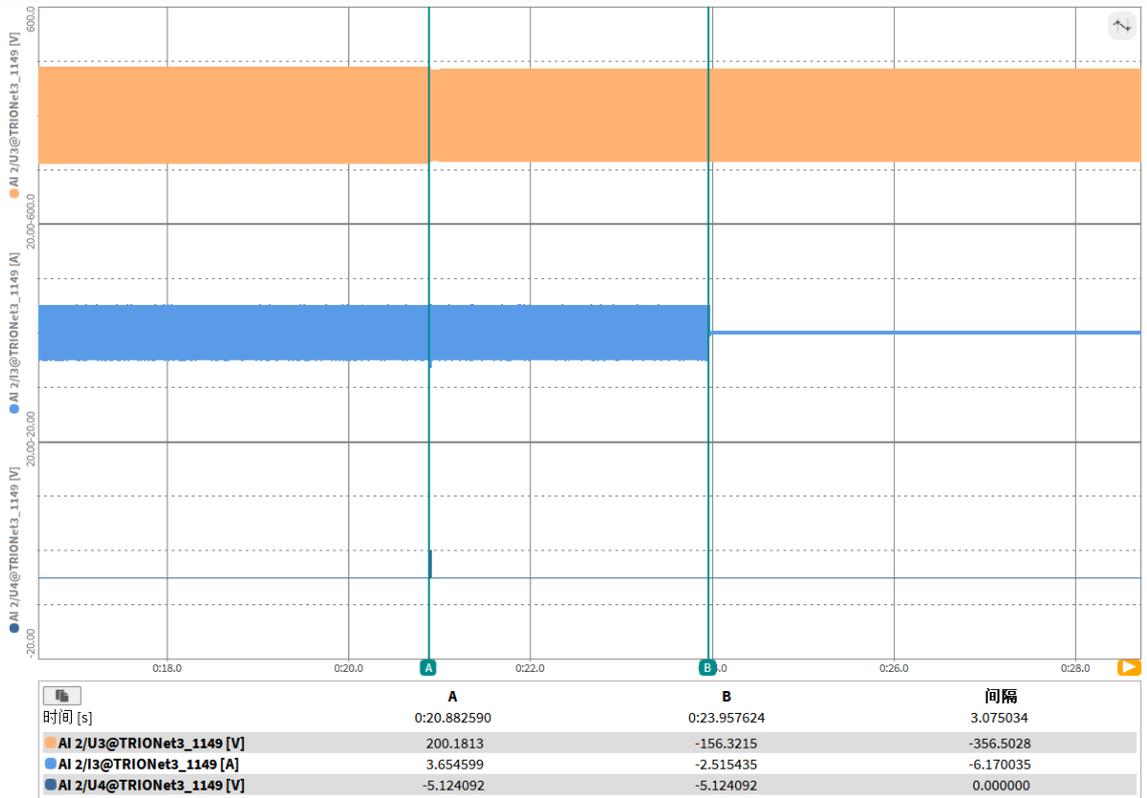
Test No.7 - Trip time 0.45Un – L to N

时间 [s]	A	B	间隔
	0:38.014554	0:38.325601	0.311047
AI 2/U3@TRIONet3_1149 [V]	18.96978	29.40750	10.43773
AI 2/I3@TRIONet3_1149 [A]	0.576139	-0.373602	-0.949740
AI 2/U4@TRIONet3_1149 [V]	-5.132675	-5.126000	6.676e-3
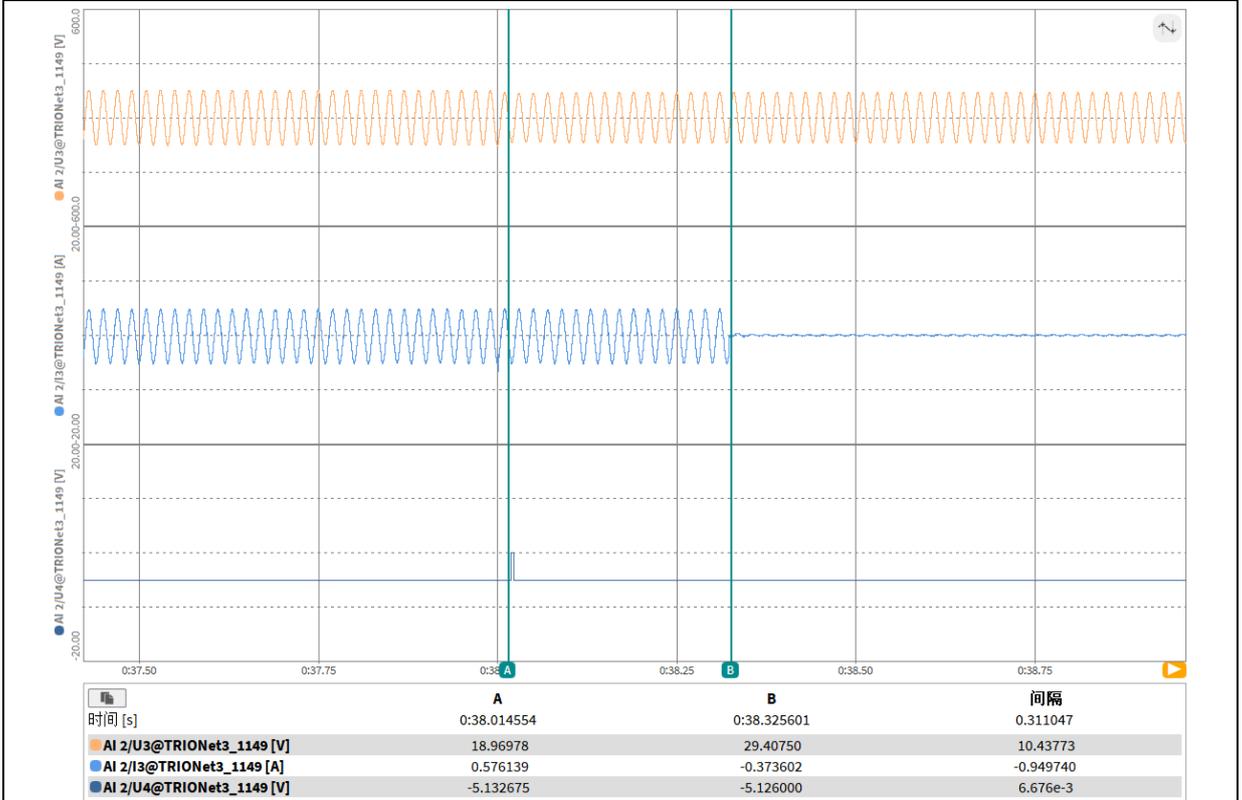
Test No.8 - Trip value 51.5Hz - L to N

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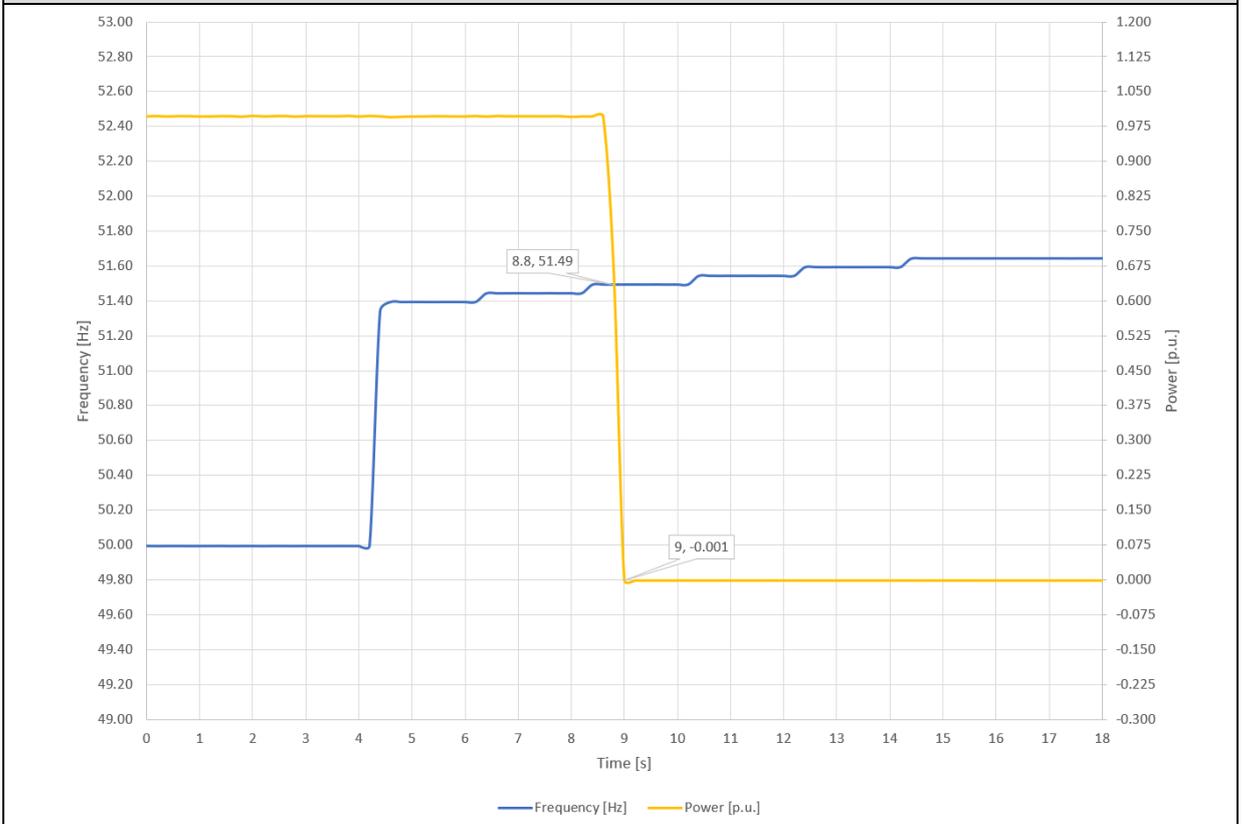
Test No.9 - Trip time 51.5Hz - L to N

时间 [s]	A	B	间隔
	0:11.3770987	0:11.4353505	0.0582518
AI 2/U3@TRIONet3_1149 [V]	302.2335	295.6972	-6.536246
AI 2/I3@TRIONet3_1149 [A]	4.642844	0.303268	-4.339576
AI 2/U4@TRIONet3_1149 [V]	-5.155564	-5.147219	8.345e-3
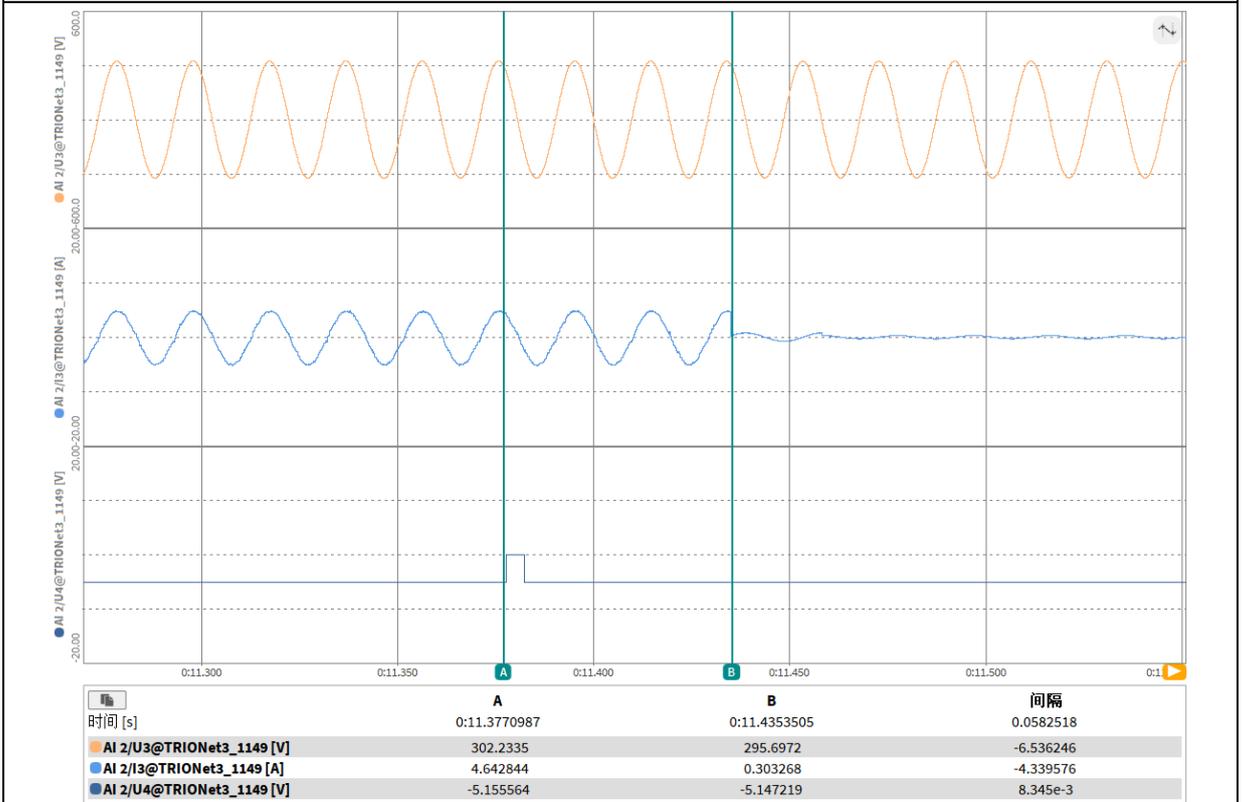
Test No.10 - Trip value 47.5Hz - L to N

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
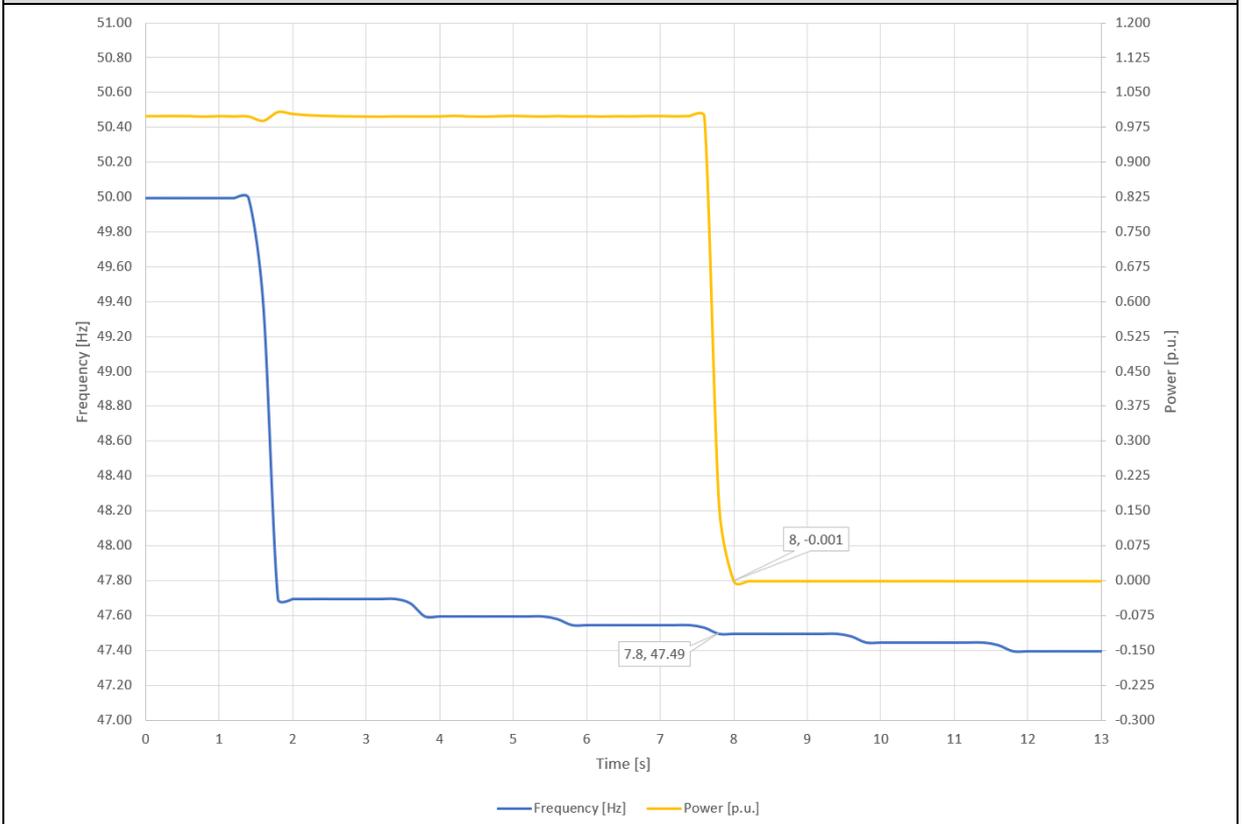
Test No.11 - Trip time 47.5Hz - L to N

时间 [s]	A	B	间隔
	0:12.1077382	0:12.2027787	0.0950405
■ AI 2/U3@TRIONet3_1149 [V]	316.5984	-314.3108	-630.9092
■ AI 2/I3@TRIONet3_1149 [A]	4.778505	-0.160813	-4.939318
■ AI 2/U4@TRIONet3_1149 [V]	-5.160809	-5.159617	1.192e-3
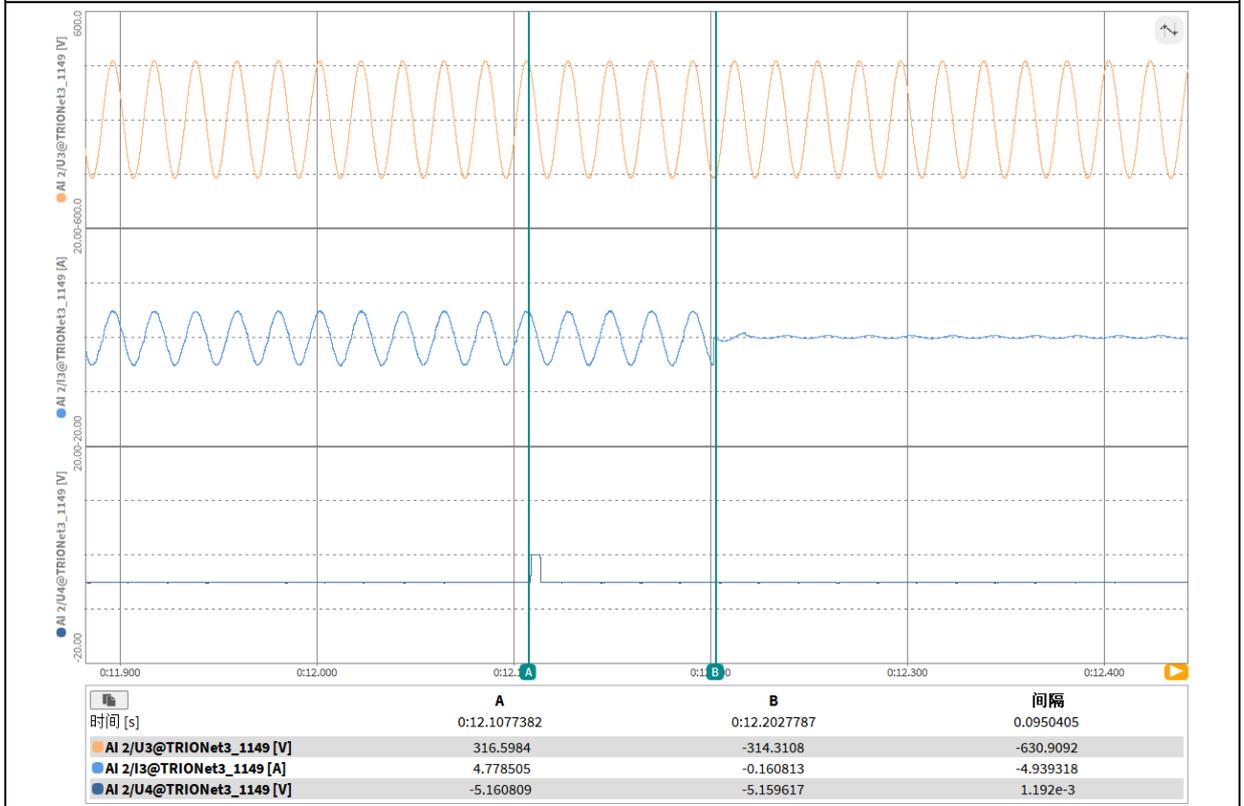
4.12 ISLANDING DETECTION

According to the paragraph 6.5.3 of the VDE-AR-N 4105:2018-11 and the paragraph 5.5.10 of the VDE V 0124-100:2020-06 (refer to DIN EN 62116), detection of an island network and disconnection of the power generation system by means of the interface switch shall be completed within 5 s.
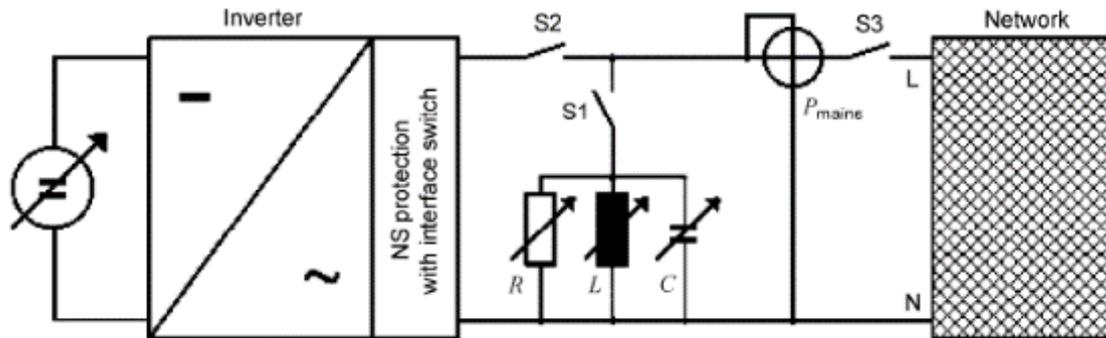
All the tests and checks have been performed in accordance with the reference Standard as specified previously. The used quality factor of resonant load was Qf=1.
There are required three different tests:
- Test A is at full power
- Test B is at 50%Pn to 66%Pn
- Test C is at 20%Pn to 33%Pn

Test results are shown as below table:

No.	P_{EUT} (% of EUT rating)	Reactive load (% of normal)	P_{AC}	Q_{AC}	Run-on time (ms)	P_{EUT} (kW)	Q_{EUT} (kVar) (Cap.)	Q_{EUT} (kVar) (Ind.)	Actual Q_f	Which load is selected to be adjusted (R or L)
Table: tested condition and run-on time
Test Condition A
1	100	100	-5	5	85	0.761	0.806	0.837	1.05	R/L
2	100	100	-5	0	166	0.761	0.806	0.797	1.02	R
3	100	100	-5	-5	126	0.761	0.806	0.757	1.00	R/L
4	100	100	0	5	91	0.801	0.806	0.837	1.00	L
5	100	100	0	0	176	0.801	0.806	0.797	0.97	--
6	100	100	0	-5	123	0.801	0.806	0.757	0.95	L
7	100	100	5	5	86	0.841	0.806	0.837	0.95	R/L
8	100	100	5	0	159	0.841	0.806	0.797	0.93	R
9	100	100	5	-5	143	0.841	0.806	0.757	0.90	R/L
Test Condition B
10	66	66	0	-5	174	0.528	0.529	0.502	1.01	L
11	66	66	0	-4	182	0.528	0.529	0.507	0.99	L
12	66	66	0	-3	107	0.528	0.529	0.512	0.99	L
13	66	66	0	-2	79	0.528	0.529	0.517	1.00	L
14	66	66	0	-1	88	0.528	0.529	0.523	1.00	L
15	66	66	0	0	88	0.528	0.529	0.528	1.01	--
16	66	66	0	1	77	0.528	0.529	0.533	1.01	L
17	66	66	0	2	82	0.528	0.529	0.539	1.02	L
18	66	66	0	3	74	0.528	0.529	0.544	1.02	L
19	66	66	0	4	363	0.528	0.529	0.549	1.03	L
20	66	66	0	5	62	0.528	0.529	0.554	1.03	L
Test Condition C
21	33	33	0	-5	80	0.264	0.265	0.251	0.98	L
22	33	33	0	-4	81	0.264	0.265	0.253	0.96	L
23	33	33	0	-3	77	0.264	0.265	0.256	0.96	L
24	33	33	0	-2	256	0.264	0.265	0.259	0.97	L
25	33	33	0	-1	243	0.264	0.265	0.261	0.97	L
26	33	33	0	0	225	0.264	0.265	0.264	0.98	--
27	33	33	0	1	93	0.264	0.265	0.267	0.98	L
28	33	33	0	2	70	0.264	0.265	0.269	0.99	L
29	33	33	0	3	67	0.264	0.265	0.272	0.99	L
30	33	33	0	4	71	0.264	0.265	0.275	1.00	L
31	33	33	0	5	64	0.264	0.265	0.277	1.00	L

Remark:
For test condition A:
If any of the recorded run-on times are longer than the one recorded for the rated balance condition, then the non-shaded parameter combinations also require testing.
For test condition B and C:
If run-on times are still increasing at the 95 % or 105 % points, additional 1 % increments is taken until run-on times begin decreasing.

Test results are graphically shown as below.

Test Condition A

Test Condition B

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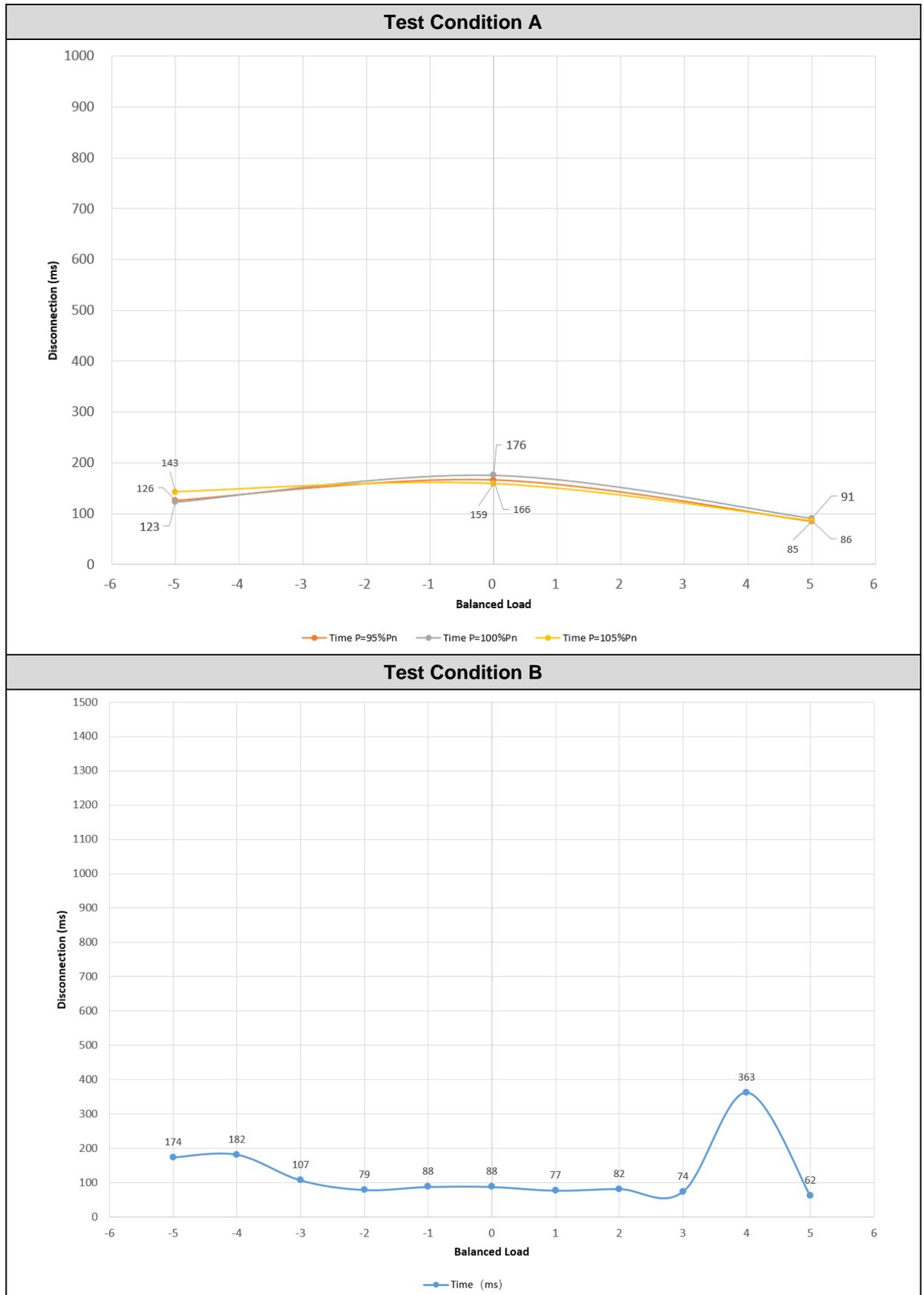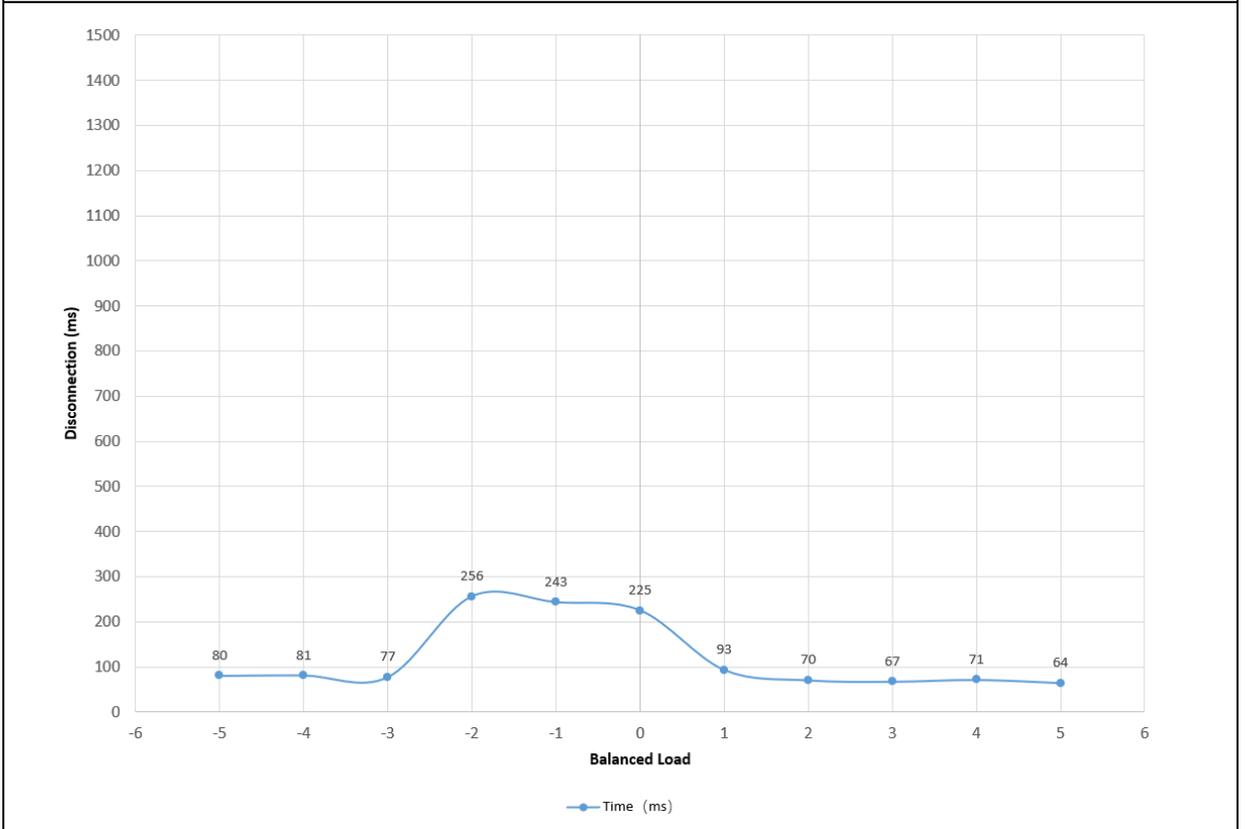
Test Condition C

4.13 CONNECTION CONDITIONS AND SYNCHRONIZATION

The power generation system shall be connected to the network only if both voltage and frequency are within the tolerance range according to the 8.3.1 of VDE-AR-N 4105:2018-11 and the sections 5.6 of VDE V 0124-100:2020-06.

In the pictures below are offered the tests performed. The inverter has to be reconnected after a delay time of 60 seconds once voltage and frequency are within the range specified. It is also shown that the active power doesn't exceed the gradient of 10 % of the active power per minute.

Each step shall be maintained for at least 120s or until the power has recovered completely.

The results are offered in the table and graphs below:

Test item	Measured Value	Reconnection (Yes or No?)	Reconnection Time (s) (>60 s)	Measured gradient (%P_{Amax}/min)
U_{ist} <84% U_n	83.1% Un	⊠ NO ☐ YES	--	--
U_{ist} ≥ 86% U_n	87.1% Un	☐ NO ⊠ YES	65.0	8.7
U_{ist} >111% U_n	112.0%Un	⊠ NO ☐ YES	--	--
U_{ist} ≤ 109% U_n	108.1%Un	☐ NO ⊠ YES	64.8	8.8
f_{ist} <47.45 Hz	47.44 Hz	⊠ NO ☐ YES	--	--
f_{ist} ≥ 47.55 Hz	47.56 Hz	☐ NO ⊠ YES	107.4	8.8
f_{ist} >50.15 Hz	50.15 Hz	⊠ NO ☐ YES	--	--
f_{ist} ≤ 50.05 Hz	49.99 Hz	☐ NO ⊠ YES	65.0	8.8

VDE-AR-N 4105:2018-11 + Correction 1:2020-10

In the picture below are offered waveforms and graphically the results of the test.
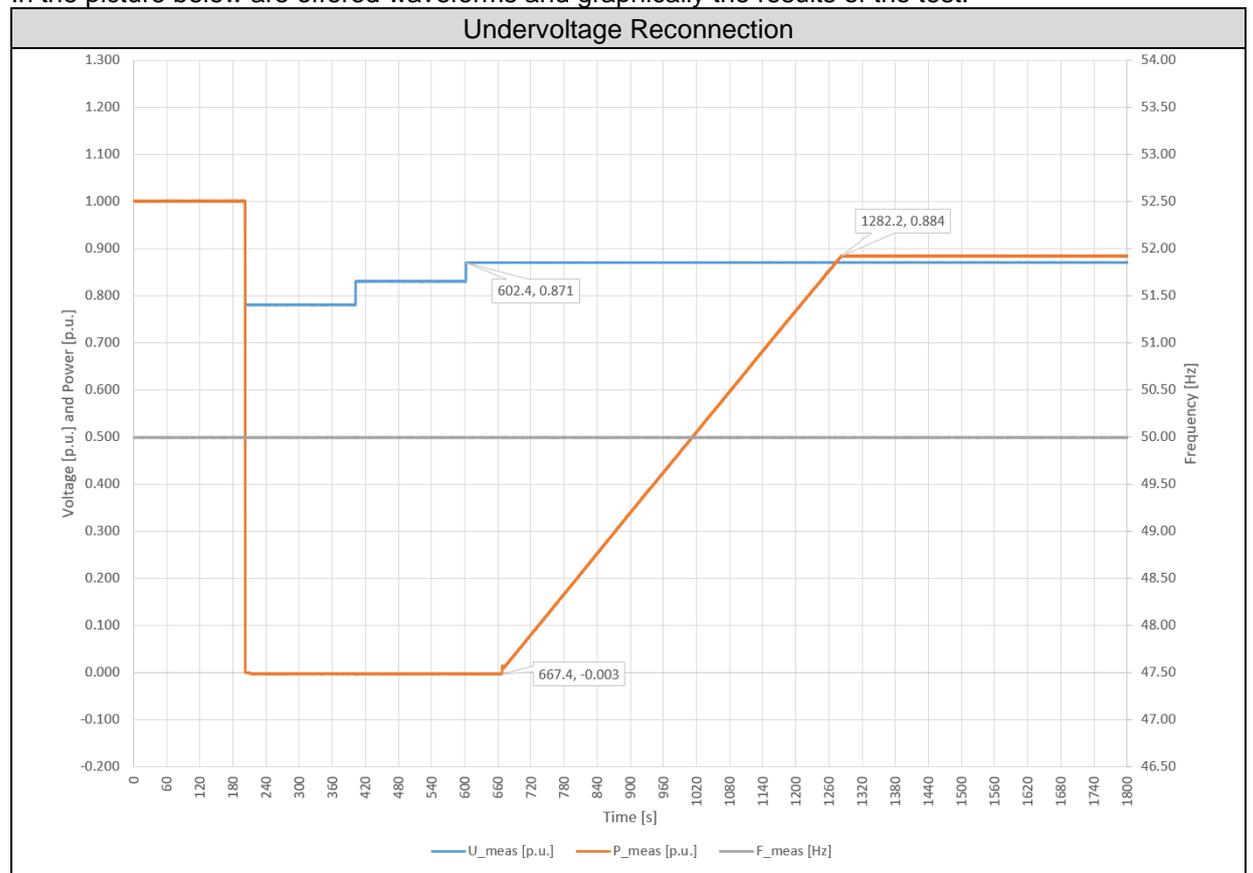
Undervoltage Reconnection

| Reconnection delay time limit: >60 s | Reconnection time measured: 65.0 s |

Overvoltage Reconnection

| Reconnection delay time limit: >60 s | Reconnection time measured: 64.8 s |

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
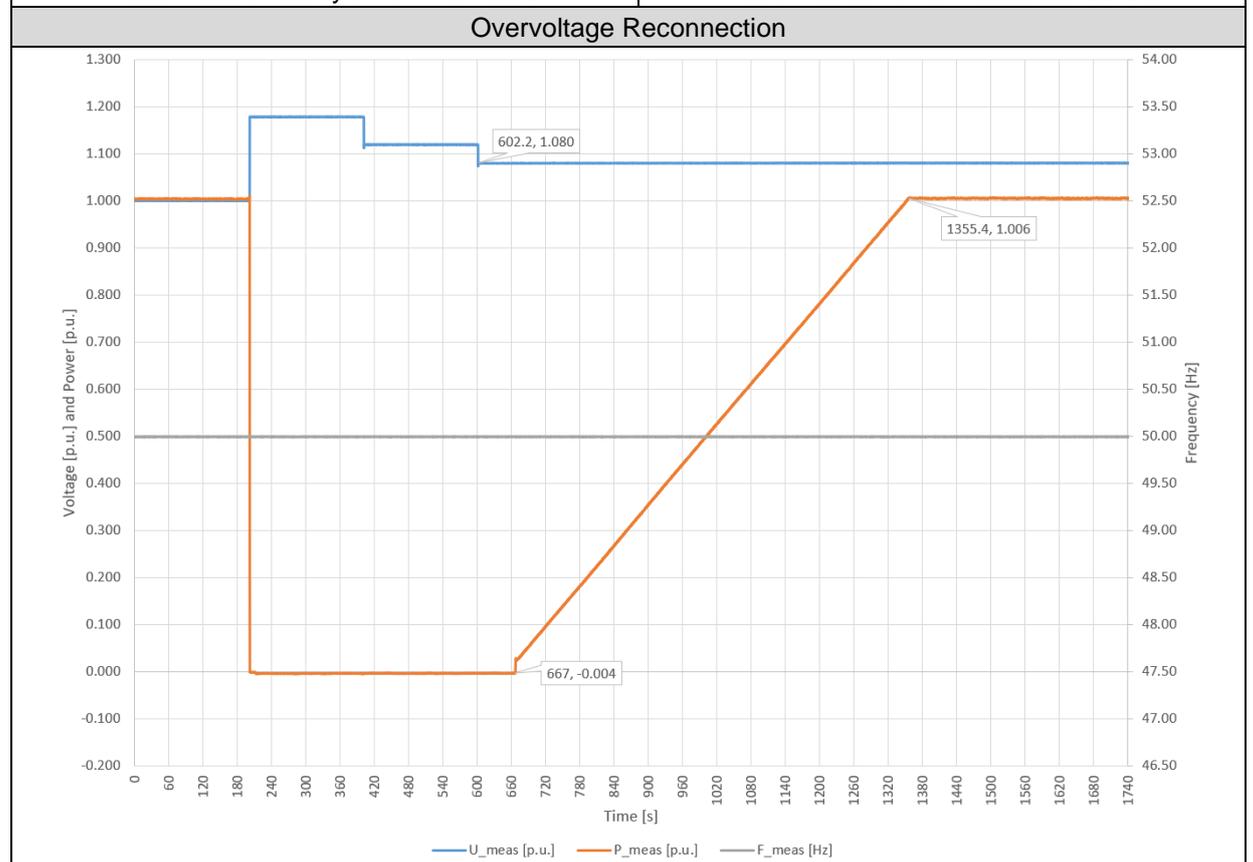
Underfrequency Reconnection
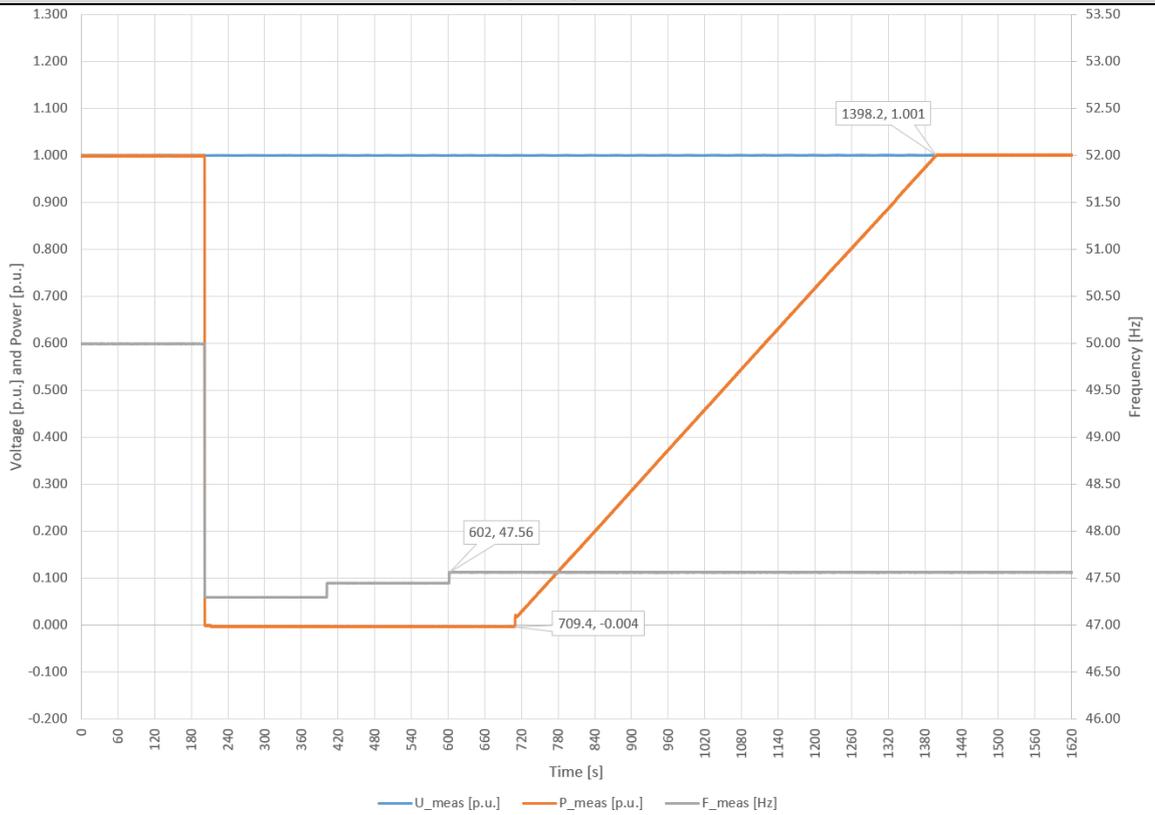
Reconnection delay time limit: >60 s	Reconnection time measured: 107.4 s

Overfrequency Reconnection
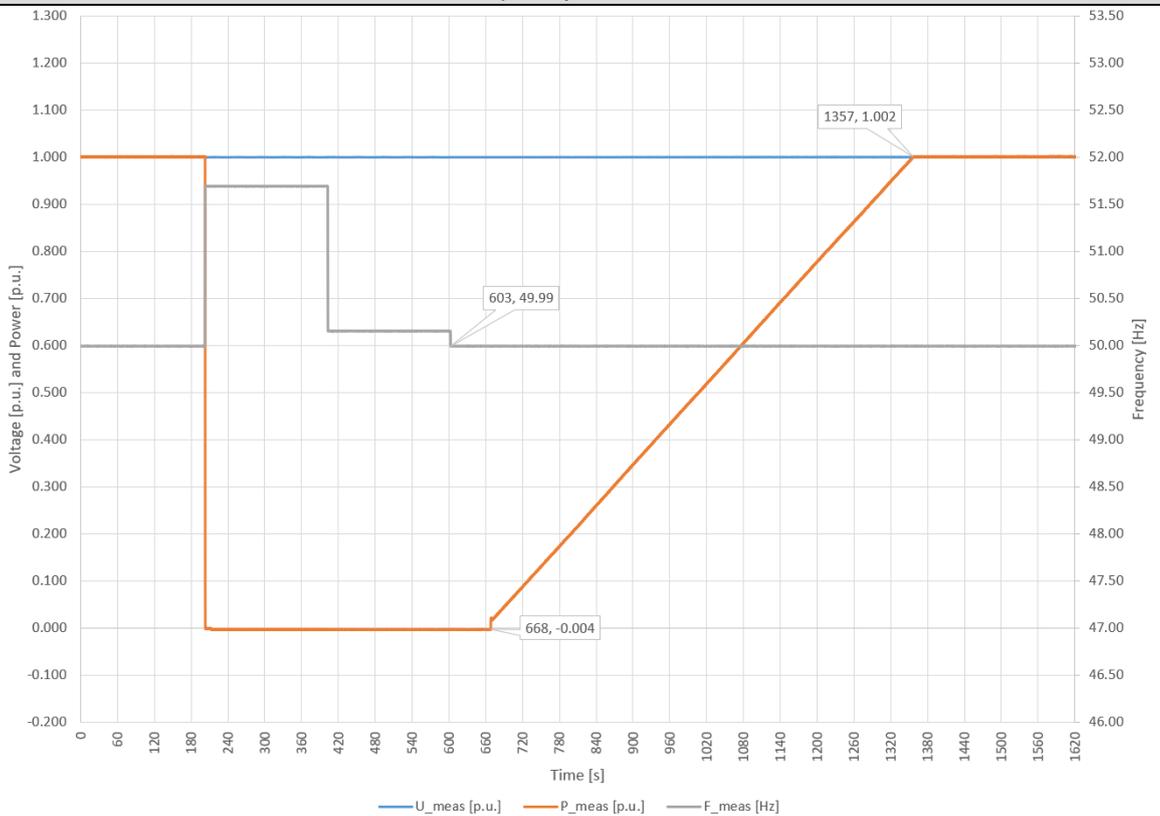
Reconnection delay time limit: >60 s	Reconnection time measured: 65.0 s

5 PICTURES

Front view
Back view

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
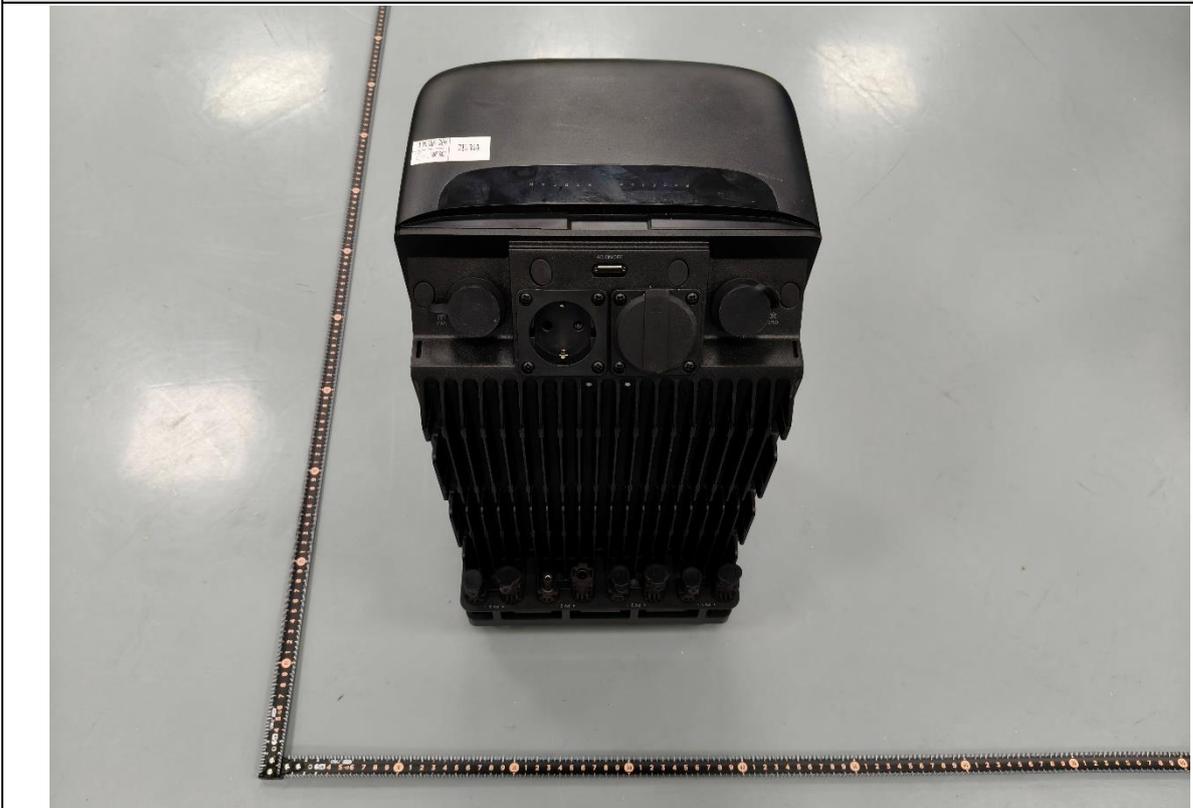
Left view
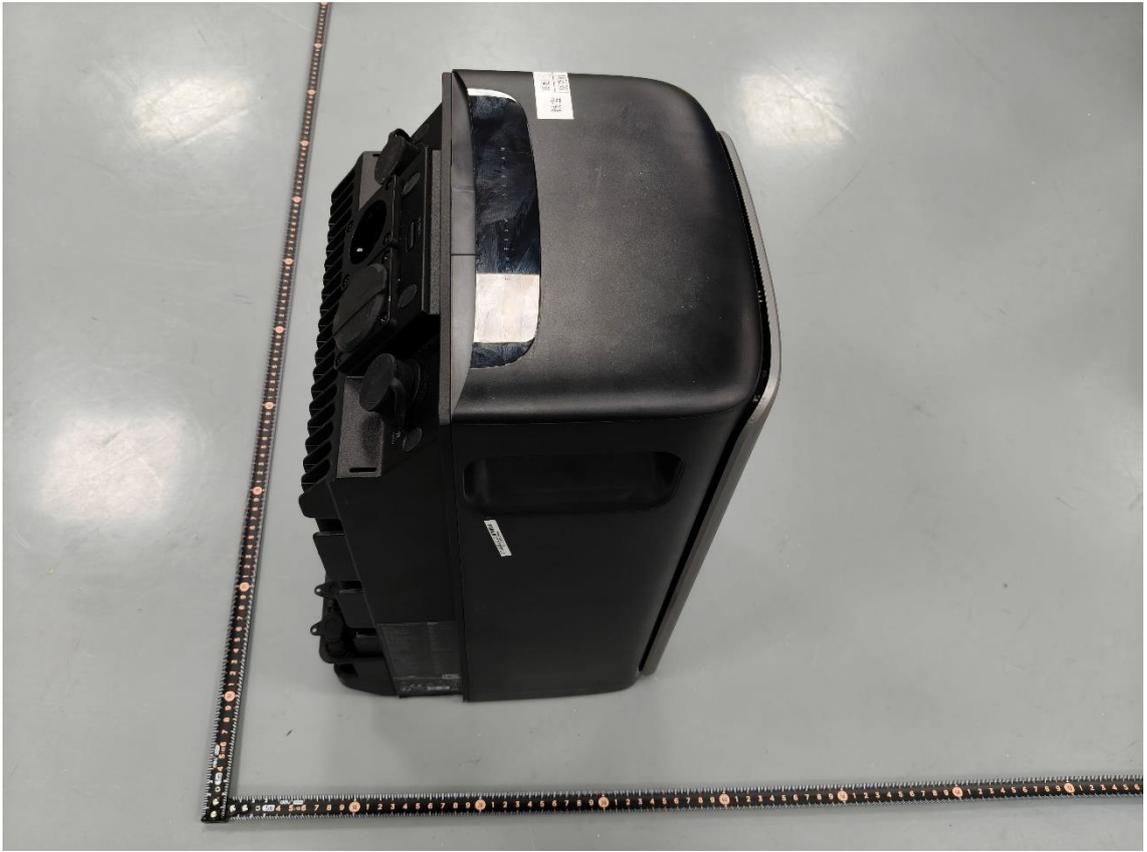
Right view

Top view
Bottom view

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
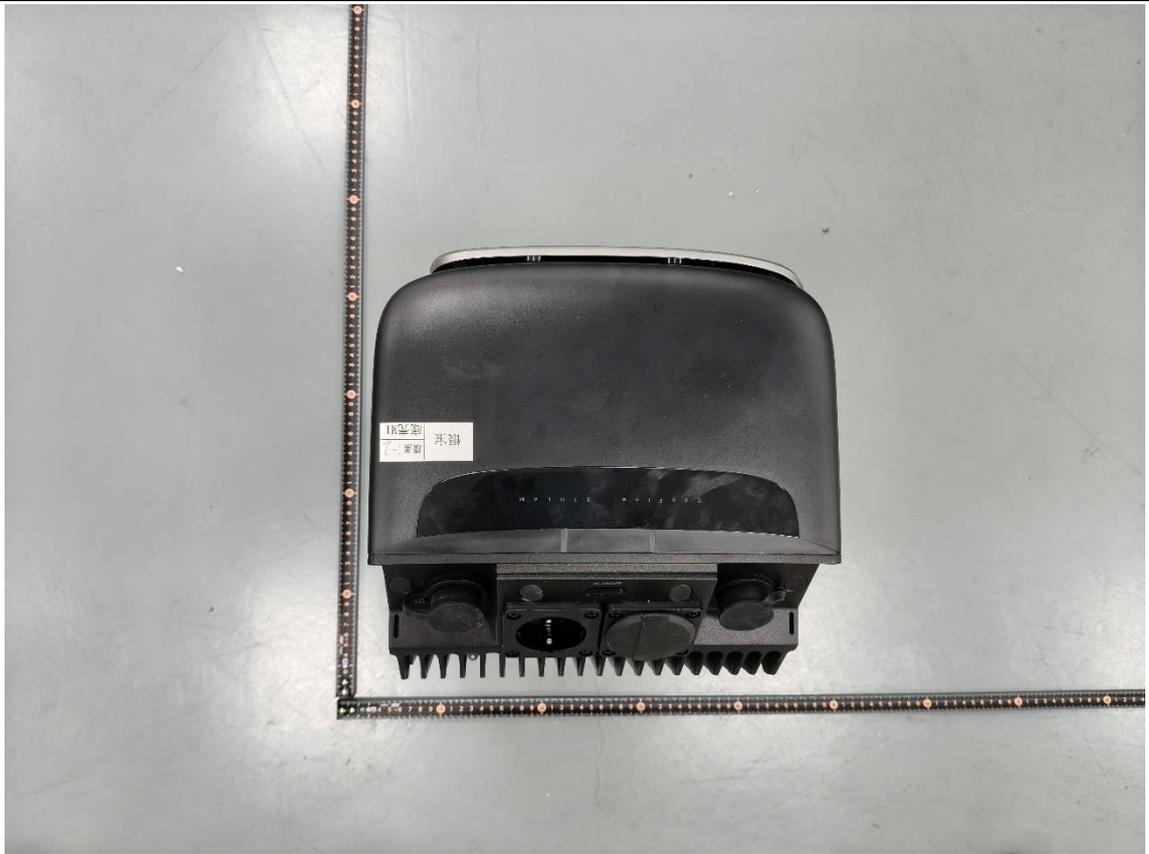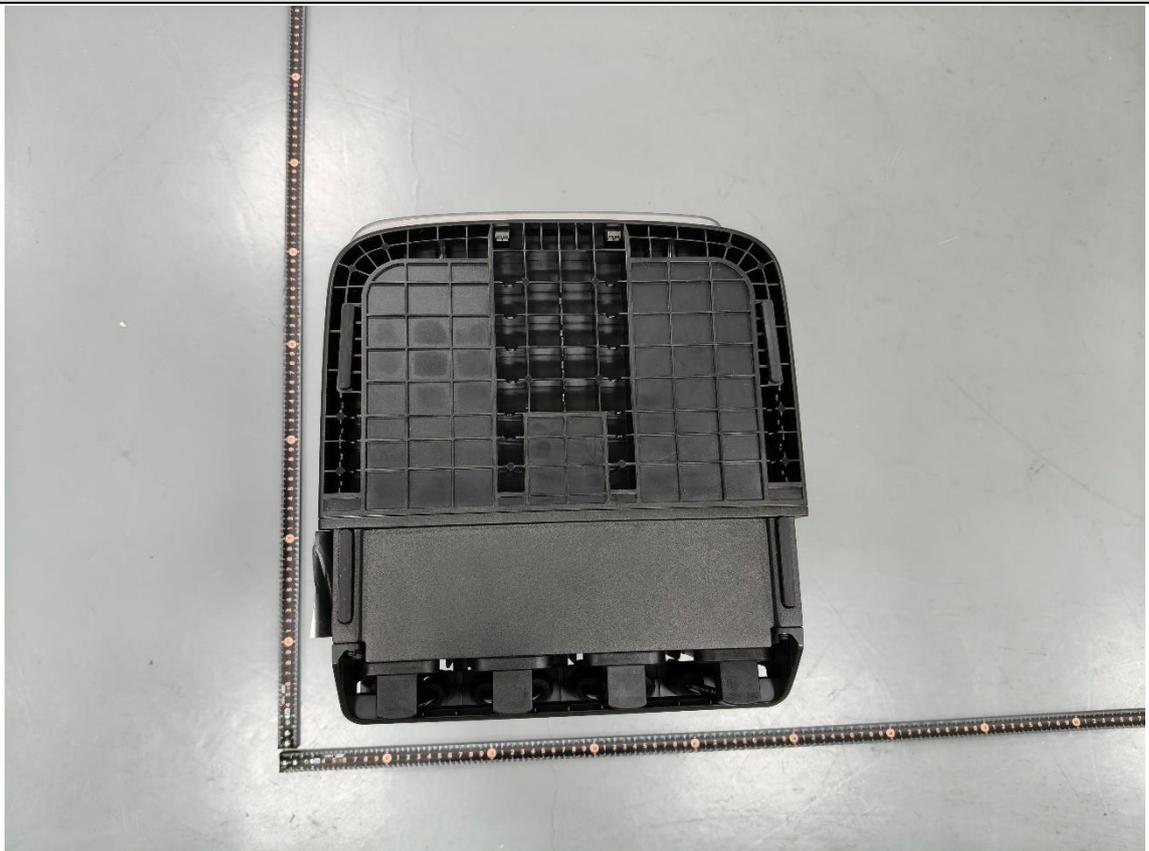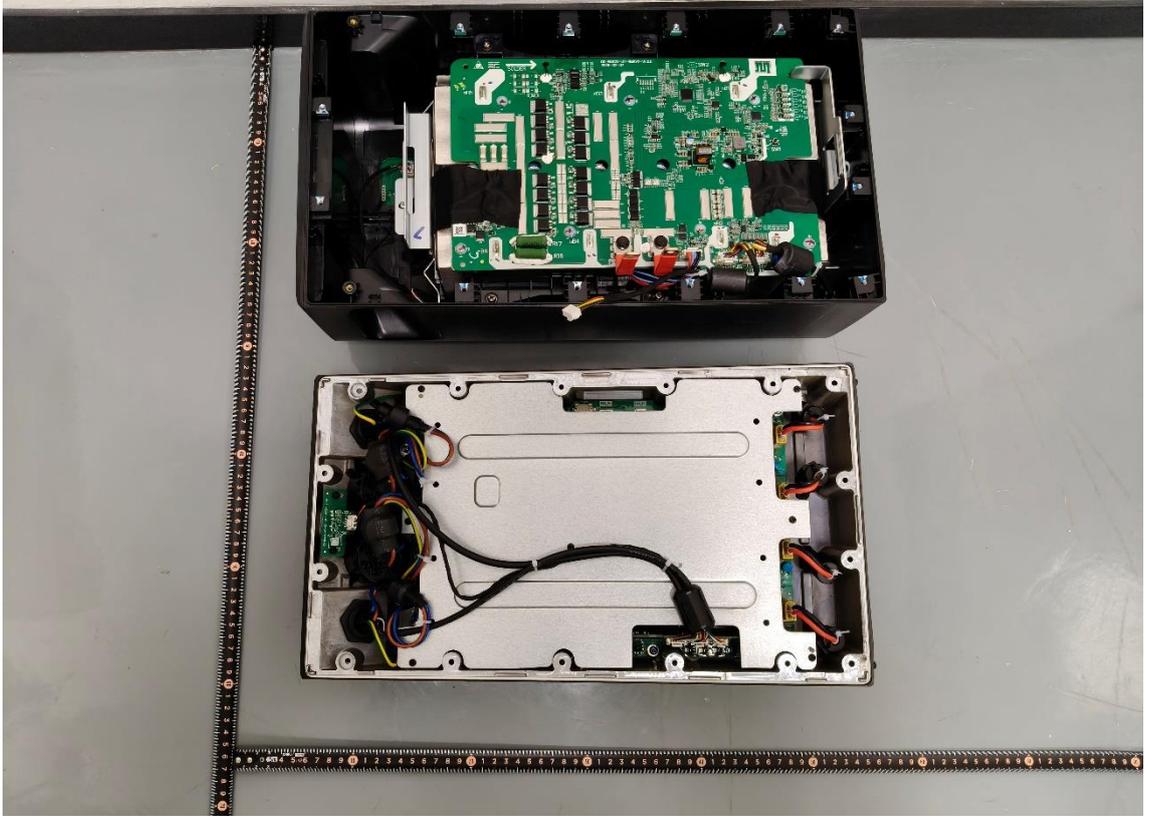
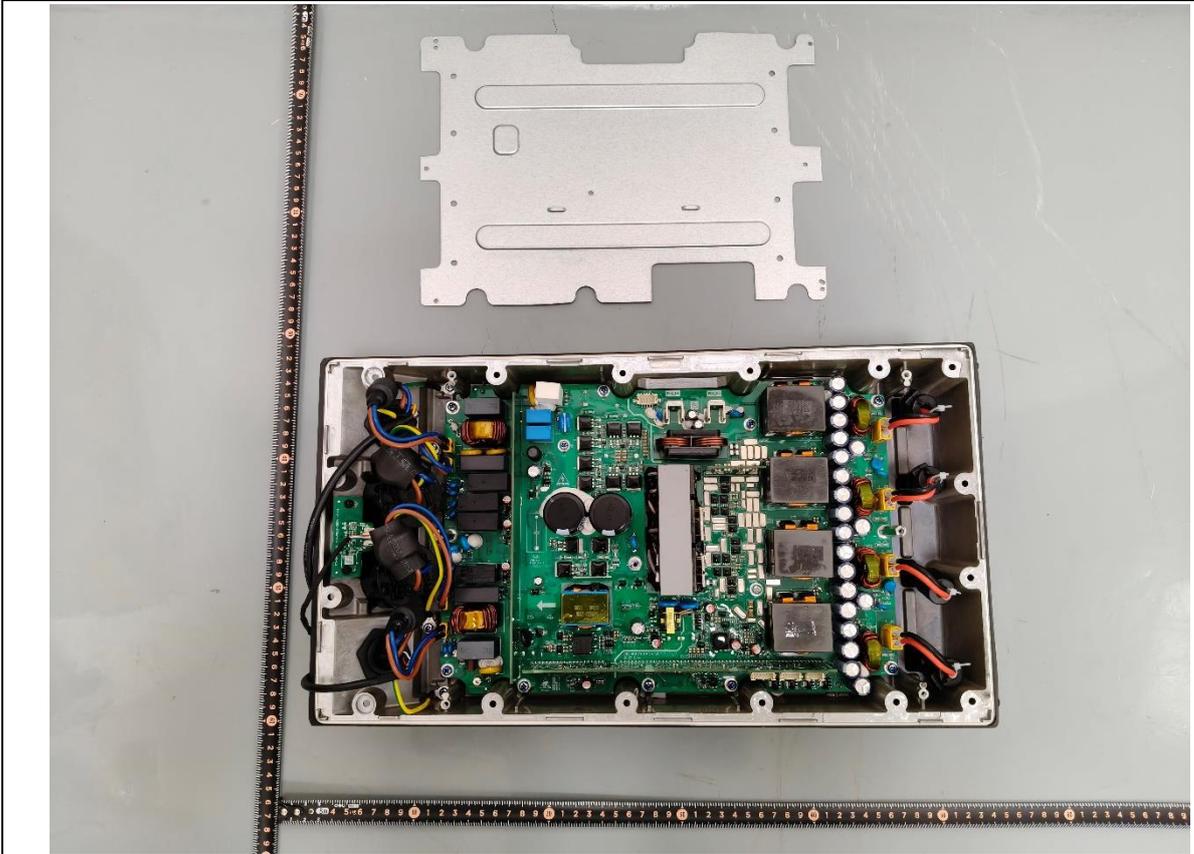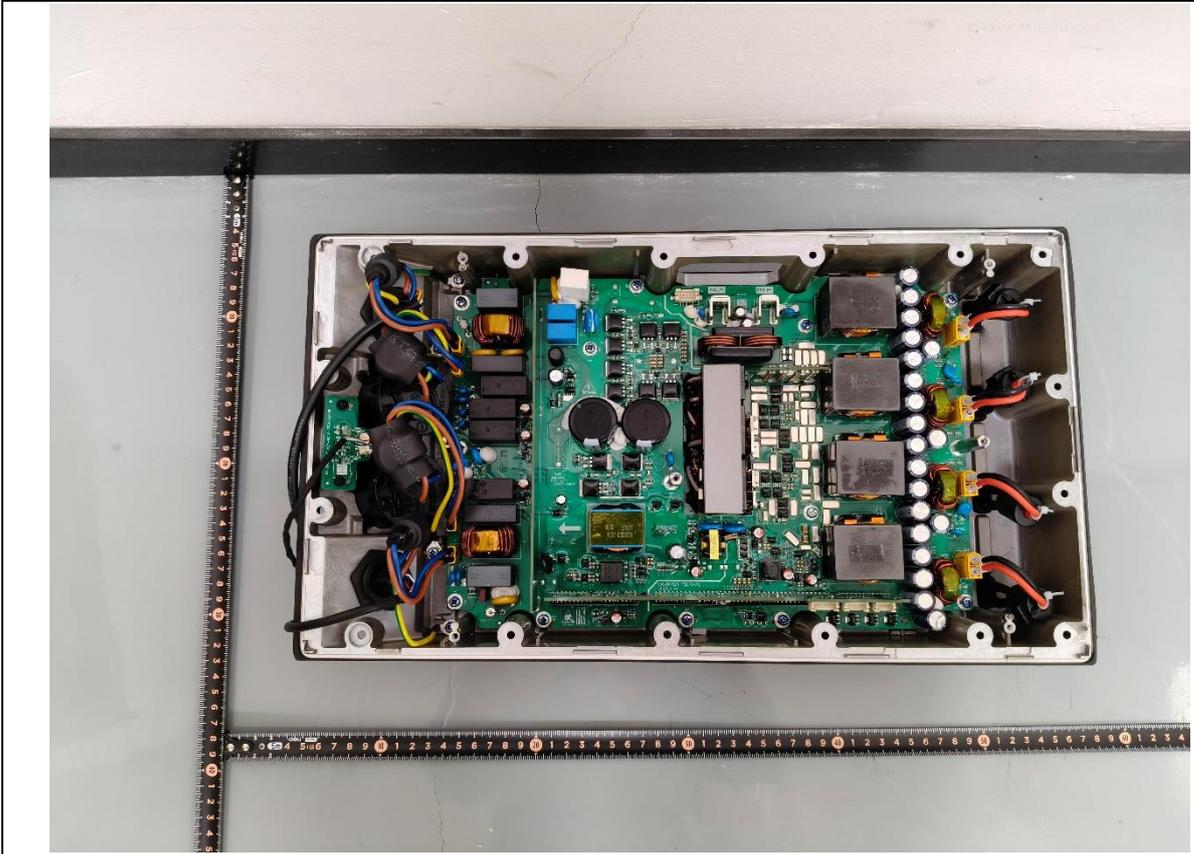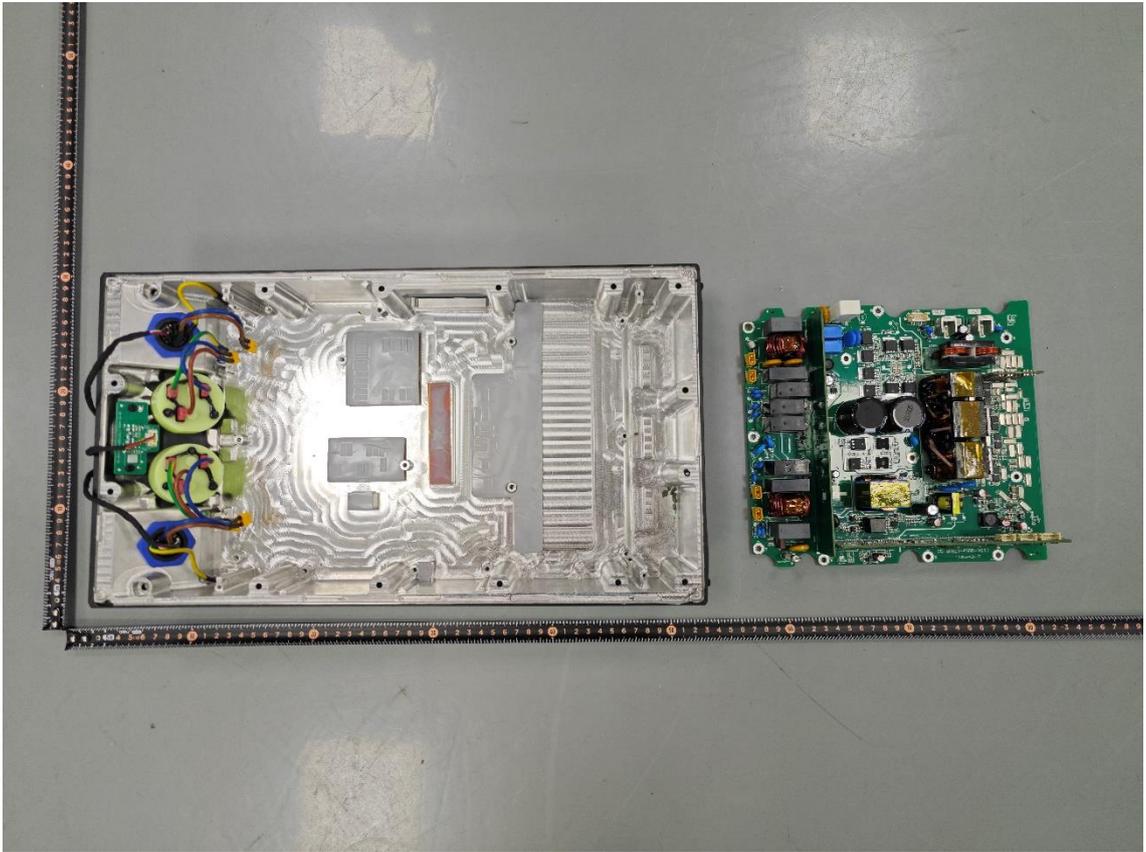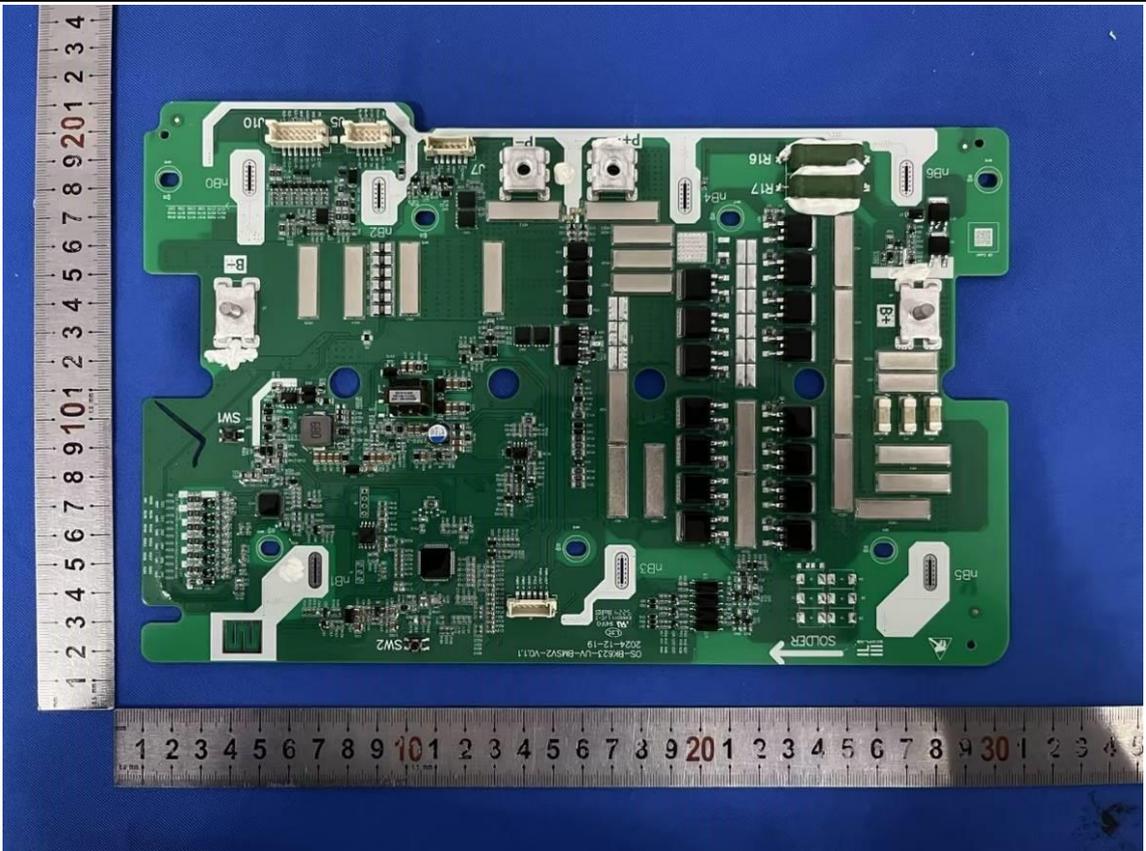| **Internal view 1** |
|:-------------------:|
| |
| **Internal view 2** |
| |
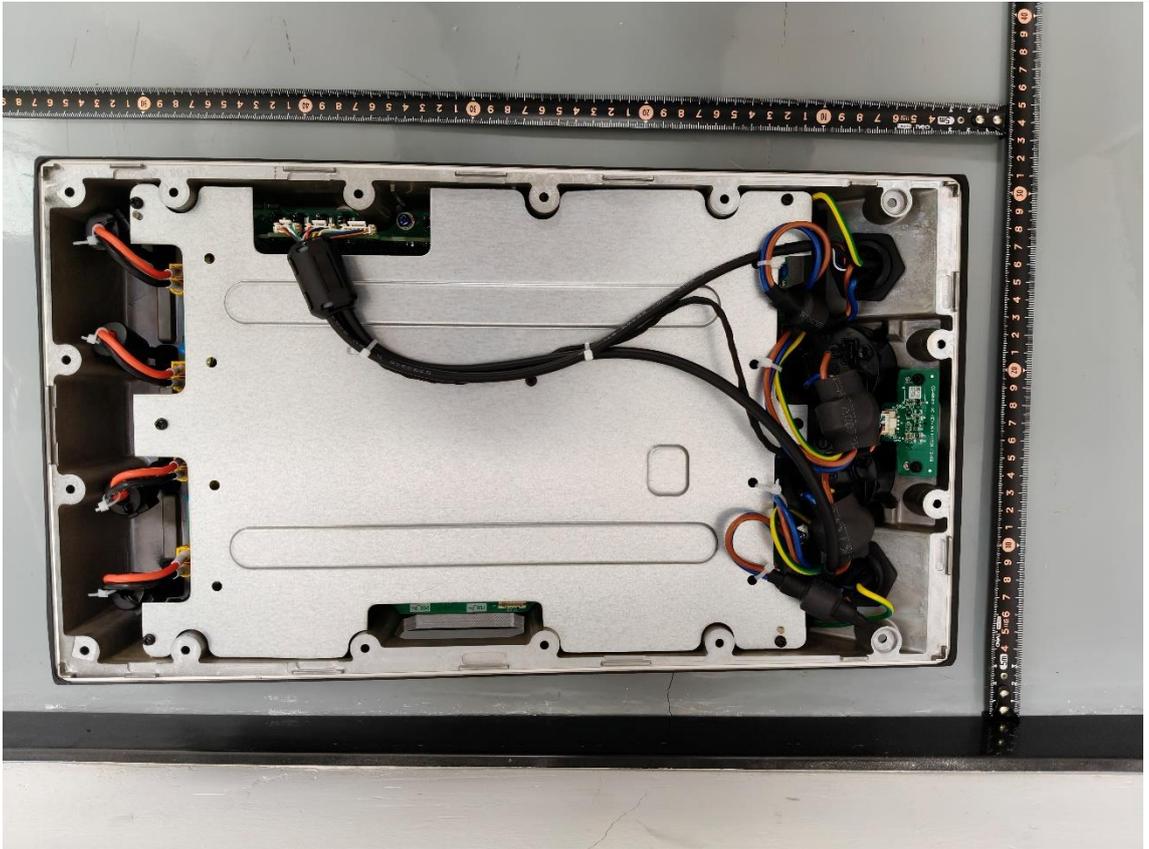
Internal view 3

Internal view 4

Internal view 5

BMS front View

BMS bottom View

PSDR front View

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
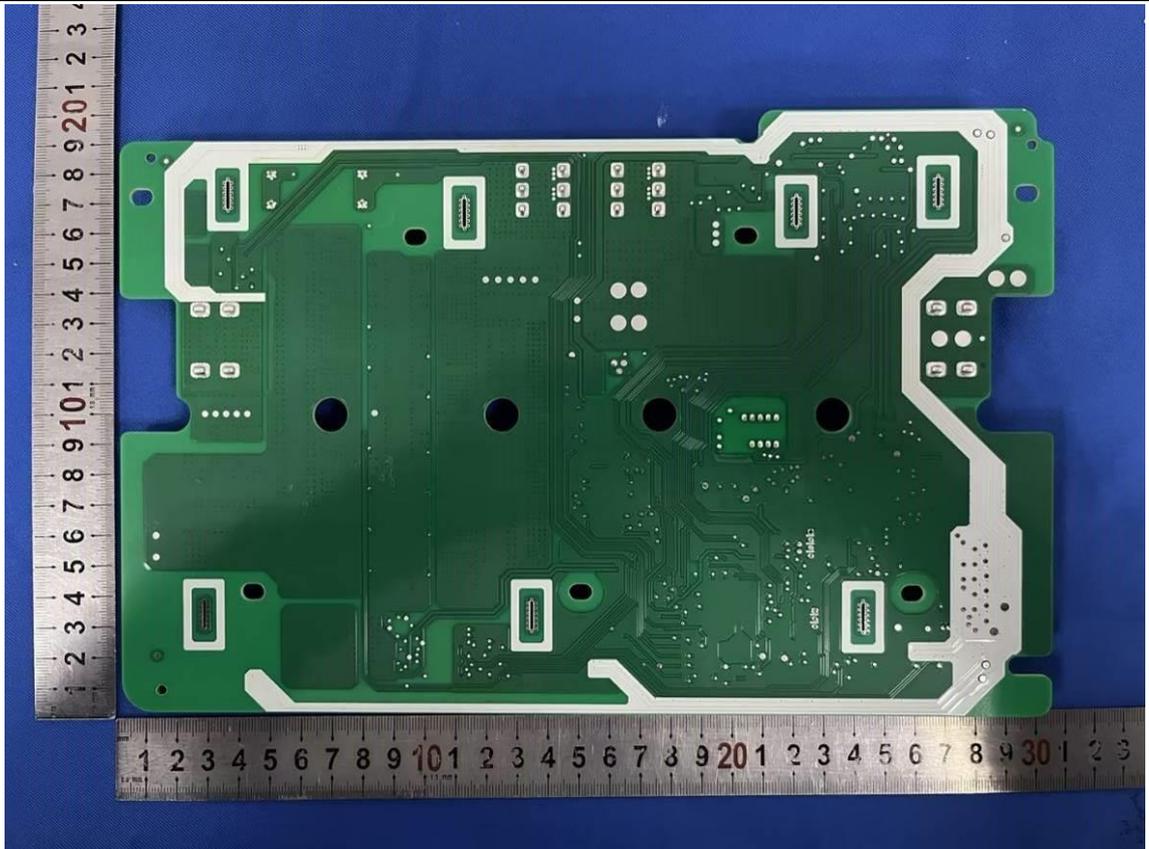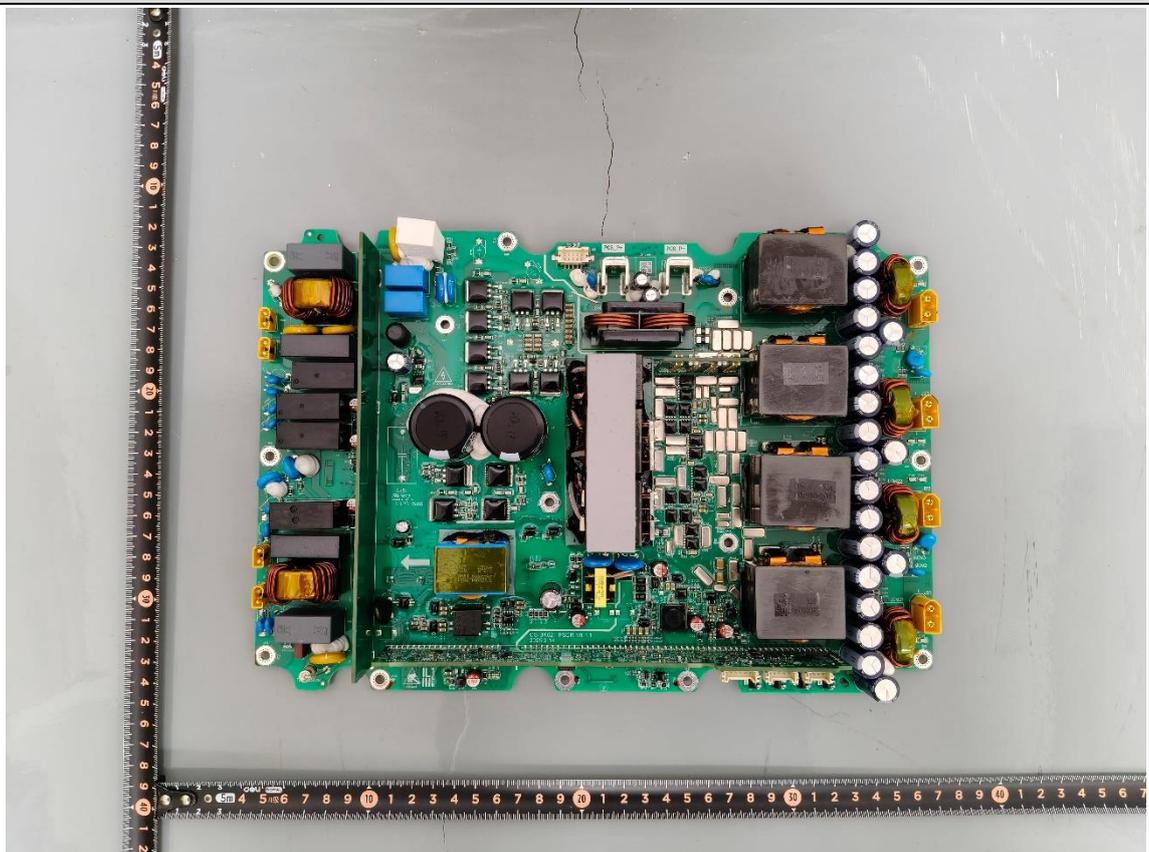
PSDR bottom View

MCU front View

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
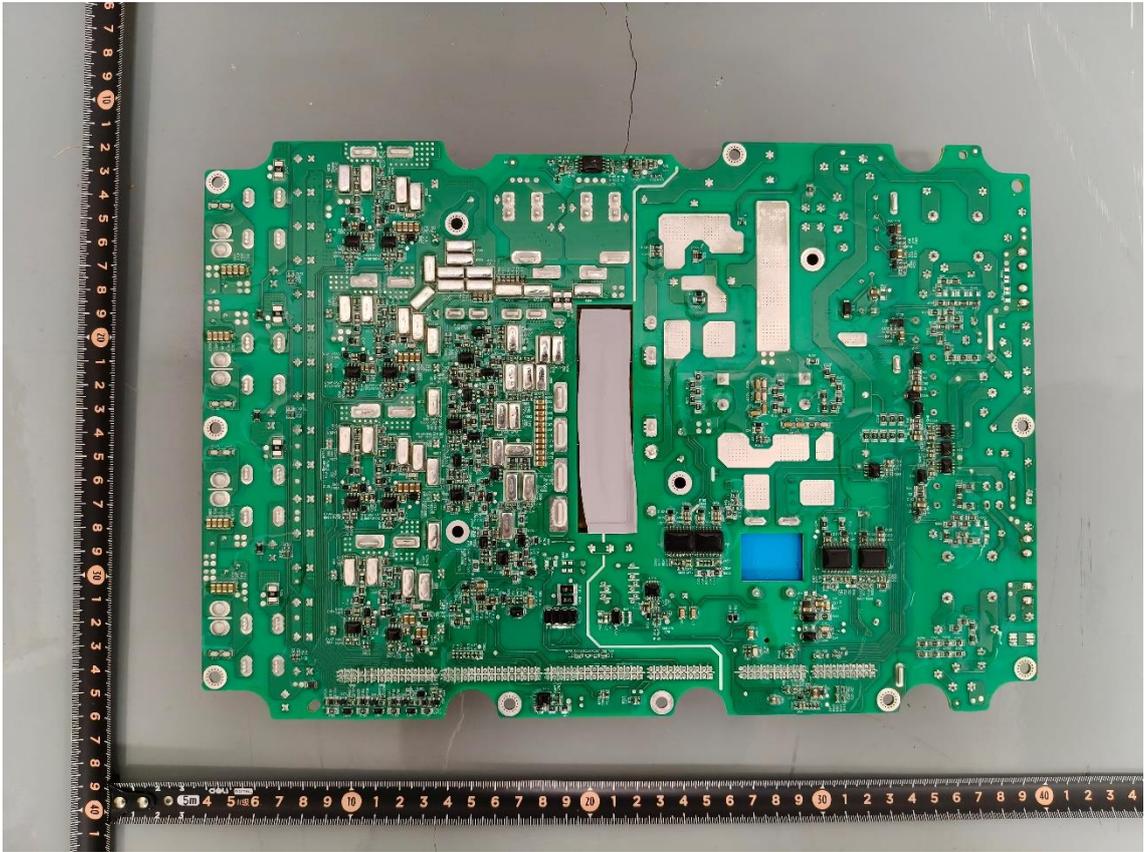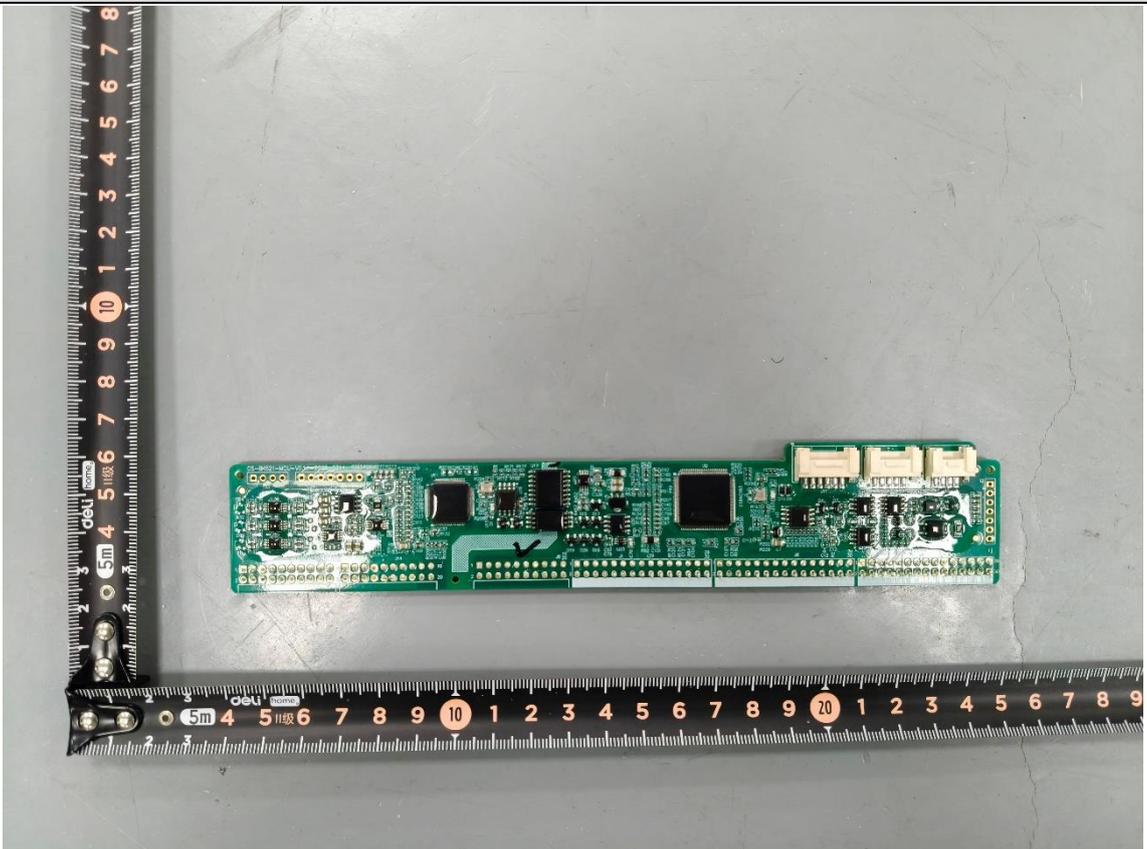
MCU bottom View
Serial Number 1

VDE-AR-N 4105:2018-11 + Correction 1:2020-10
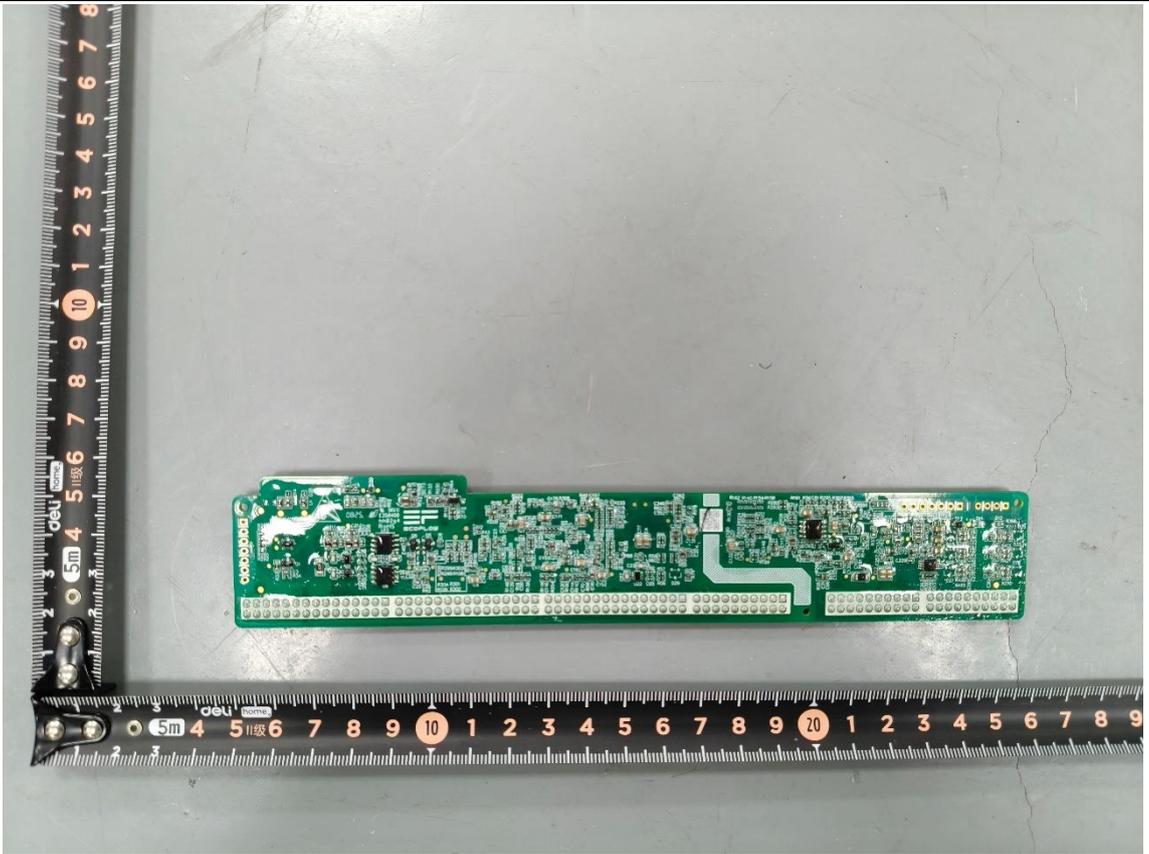
Serial Number 2

Hardware version

OS-BK621-PSDR-V0.1.2
2025.2.21

Software version

| 1 | ›ug | pack | 1.0.0.117(1.0.0.117) 3/26 版本发布 | ☑ | 导出 添加 作为pack 模板 |

6 ELECTRICAL SCHEME

Electrical Scheme of EUT

1:
PIN1: TX
PIN2: RX
PIN3: Vcc_5V
PIN4: Gnd
PIN5: Reset

2:
PIN1: KEY_ONOFF
PIN2: LEDIO6
PIN3: VDD5V
PIN4: AGND

3:
PIN1: LEDIO1
PIN2: LEDIO2
PIN3: LEDIO3
PIN4: LEDIO4
PIN5: LEDIO5
PIN6: LEDIO6
PIN7: KEY_ONOFF
PIN8: VDD5V
PIN9: AGND
PIN10: Vcc_5V
PIN11: Gnd
PIN12: TX
PIN13: RX
PIN14: Reset

4:
PIN1: Vcc_5V
PIN2: Gnd
PIN3: TX
PIN4: RX
PIN5: Reset
PIN6: BMSTX
PIN7: BMSRX
PIN8: Vcc_12V
PIN9: P-

5/6:
PIN1: CANH
PIN2: CANL
PIN3: In-place signal
PIN4: In-place signal
PIN5: Fault
PIN6: Gnd

7:
PIN1: KEY_OUT
PIN2: Gnd
PIN3: Vcc
PIN4: LED_KEY

7 CE DECLARATION

Declaration of CE-LVD

SGS

VERIFICATION OF COMPLIANCE

No.:	LVD GZES2502002628PV
Applicant:	EcoFlow Inc. Room 401, Plant #1, Runheng Industrial Zone, Fuyuanyi Road, Zhancheng Community, Fuhai Street, Bao'an, Shenzhen, Guangdong, China
Manufacturer:	EcoFlow Inc. Room 401, Plant #1, Runheng Industrial Zone, Fuyuanyi Road, Zhancheng Community, Fuhai Street, Bao'an, Shenzhen, Guangdong, China
Product Name:	EcoFlow STREAM Ultra / EcoFlow STREAM Pro
Product Description:	Inverter used in PV system
Model No.:	EF-EA-HD-U2K-800, EF-EA-HD-P2K-800, EF-EA-HD-U2K-600, EF-EA-HD-P2K-600
Trade Mark:	ECOFLOW or ECOFLOW
Rating:	See page 2
Protection against Electric Shock:	Class I
Degree of Protection:	IP65
Additional Information:	Software version: 1.0.0.117 Hardware version: V0.1.2

Sufficient samples of the product have been tested and found to be in conformity with

Test Standard:	EN 62109-1:2010 EN 62109-2:2011
as shown in the Test Report Number(s):	GZES250200262801 GZES250200262802

This Verification of Compliance has been granted to the applicant based on the results of tests, performed by Laboratory of SGS-CSTC Standards Technical Services Co., Ltd. on sample of the above-mentioned product in accordance with the provisions of the relevant harmonized standards under the Low Voltage Directive 2014/35/EU. The CE marking can be affixed, under the responsibility of the manufacturer, after completion of an EC Declaration of Conformity and compliance with all relevant EC Directives. The affixing of the CE marking presumes in addition that the conditions in annexes III and IV of the Directive are fulfilled.

David Guo
Technical Manager
SGS-CSTC Standards Technical Services Co., Ltd.

2025-04-09

SGS

VERIFICATION OF COMPLIANCE

No.: CQES2502000148BA

Applicant: EcoFlow Inc.
Room 401, Plant #1, Runheng Industrial Zone, Fuyuanyi Road, Zhancheng Community, Fuhai Street, Bao'an District, Shenzhen, Guangdong, China

Manufacturer: Same as applicant

Product Name: EcoFlow STREAM AC Pro

Model No.: EF-EA-AC-P2K-800, EF-EA-AC-P2K-600

Trade Mark: ECOFLOW

Rating: See page 2 for details

Protection against Electric Shock: Class I

Sufficient samples of the product have been tested and found to be in conformity with

Test Standard: EN IEC 62477-1: 2023

Test Report Number(s): CQES250200014801

This Verification of Compliance has been granted to the applicant based on the results of tests, performed by Laboratory of SGS-CEC New Energy Technology (Chongqing) Co., Ltd. on sample of the above-mentioned product in accordance with the provisions of the relevant specific standards.

Ruby Yan
Technical Manager
SGS-CEC New Energy Technology (Chongqing) Co., Ltd.

2025-04-03

SGS-CEC New Energy Technology (Chongqing) Co., Ltd.
Building 13 & 14, No. 1839, Ranjun Road, Shuangfu Street, Jiangjin District, Chongqing, 402260 CHINA
www.sgsgroup.com.cn
Member of the SGS Group (SGS SA)

CQBR-VOC-F05 A/2   2024-03-25
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Certification of CE-EMC

CERTIFICATE OF COMPLIANCE

NTEK 北测®

CERTIFICATE OF CE RED COMPLIANCE

According to **Radio Equipment Directive 2014/53/EU**

Ref. No.: S25021305102

Product:	EcoFlow STREAM Ultra, EcoFlow STREAM Pro
Trade Mark:	EF ECOFLOW, ECOFLOW
Applicant:	EcoFlow Inc.
Address:	RM 401, Plant #1, Runheng Industrial Zone, Fuyuanyi Road, Zhancheng Community, Fuhai Street,Bao'anDistrict, ShenzhenCity,Guangdong Province, P.R.China
Manufacturer :	EcoFlow Inc.
Address:	RM 401, Plant #1, Runheng Industrial Zone, Fuyuanyi Road, Zhancheng Community, Fuhai Street,Bao'anDistrict, ShenzhenCity,Guangdong Province, P.R.China
Model:	EF-EA-HD-U2K-1200, EF-EA-HD-U2K-600,EF-EA-HD-U2K-800, EF-EA-HD-P2K-1200,EF-EA-HD-P2K-800, EF-EA-HD-P2K-600, EF-EA-HD-M2K-800

The test sample of product has passed the test according to requirements of the following standards:

Standard(s):Refer to attachment   Test report(s) No.: Refer to attachment

Based on the voluntary assessment of the product sample and technical file, we confirm that the above-mentioned product meets the requirements of the EU directive.
The CE mark can be used for the above product labeling, under the responsibility of the manufacturer or the importer, after completion of an EU declaration of conformity and compliance with all relevant EU directives.

Approved by/Date: _____ Mar. 07, 2025
          Department Manager

Shenzhen NTEK Testing Technology Co., Ltd.
Address: No. 24 Xinfa East Road, Xiangshan Community, Xinqiao Street, Baoan District, Shenzhen, Guangdong, People's Republic of China
Tel. 0755-23200050 Http://www.ntek.org.cn

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CERTIFICATE OF COMPLIANCE

NTEK 北测®

CERTIFICATE OF CE RED COMPLIANCE

According to **Radio Equipment Directive 2014/53/EU**

Ref. No.: **S25021305102**

Attachment:

Standard(s):		Test report(s) No.:
Article 3.1a)	EN IEC 62311:2020	S25021305102001
Article 3.1b)	ETSI EN 301 489-1 V2.2.3 (2019-11)	S25022800701001
	ETSI EN 301 489-17 V3.2.4 (2020-09)	
	EN 62920:2017+A1:2021	S25021305101001
	EN IEC 61000-6-1:2019	
	EN IEC 61000-6-2:2019	
	EN IEC 61000-6-3:2021	
	EN IEC 61000-6-4:2019	
	EN IEC 61000-3-2:2019+A1:2021	
	EN 61000-3-3:2013+A2:2021	
Article 3.2	ETSI EN 300 328 V2.2.2 (2019-07)	S25021305102002
		S25021305102003

Shenzhen NTEK Testing Technology Co., Ltd.
Address: No. 24 Xinfa East Road, Xiangshan Community, Xinqiao Street, Baoan District, Shenzhen, Guangdong, People's Republic of China
Tel. 0755-23200050 Http://www.ntek.org.cn

NTEK

--END OF REPORT---