TEST REPORT

TOR Generator
Connection and parallel operation of Type A power generation systems and small-scale generation systems
OVE-Guideline R 25
Test requirements for generator units to be connected to and operated in parallel with low-voltage distribution networks

Report Number.............................: 6134610.50
Date of issue ....: 2023-01-05
Total number of pages..................: 243 pages

Testing Laboratory ....: DEKRA Testing and Certification (Suzhou) Co., Ltd.
Address ....: No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China

Applicant's name ....: AKKU SYS Akkumu|ator - und Batterietechnik Nord GmbH
Address...: Verbindungsweg 23, 25469, Halstenbek, Germany

Test specification:
Standard.......................................: TOR Erzeuger Type A Version 1.2:2022-04-11
OVE-Richtlinie R 25:2020-03-01
Test procedure.............................: Type test
Non-standard test method………..: N/A

Test Report Form No. ....: TOR Erzeuger_V1.1
Test Report Form(s) Originator....: DEKRA Testing and Certification (Suzhou) Co., Ltd.
Master TRF....................................: Dated 2022-05

Test item description....................: Hybrid Inverter
Trade Mark ....: AK a-tronix
Manufacturer.................................: AKKU SYS Akkumu|ator - und Batterietechnik Nord GmbH
Verbindungsweg 23, 25469, Halstenbek, Germany
Model/Type reference ....: Hybridpower 4kW 3ph, Hybridpower 5kW 3ph, Hybridpower 6kW 3ph, Hybridpower 8kW 3ph, Hybridpower 10kW 3PH, Hybridpower 12kW 3ph

Ratings .... :	Operating temperature range: - 30°C to + 60°C Protective class: I Ingress protection rating: IP65 Power factor range (adjustable): 0.8 leading…0.8 lagging Overvoltage category: III(Mains), II(DC) Operating altitude: 3000m Inverter topology: Non-isolated Hybridpower 4kW 3ph: PV input: Max 1000 Vdc, MPPT voltage range: 150-850 Vdc, Max 13A/13 A, Isc PV: 18 A/18 A Battery: Voltage Range 140-750 Vdc, Max charge and discharge current: 25 A, Battery type: Li-Ion AC output: 3/N/PE 230/400 Vac , 50 Hz, Rated Active Power 4000 W, Max. Apparent Power 4400 VA, Max 6.7 A Hybridpower 5kW 3ph: PV input: Max 1000 Vdc, MPPT voltage range: 150-850 Vdc, Max 13A/13 A, Isc PV: 18 A/18 A Battery: Voltage Range 140-750 Vdc, Max charge and discharge current: 25 A, Battery type: Li-Ion AC output: 3/N/PE 230/400 Vac , 50 Hz, Rated Active Power 5000 W, Max. Apparent Power 5500 VA, Max 8.3 A Hybridpower 6kW 3ph: PV input: Max 1000 Vdc, MPPT voltage range: 200-850 Vdc, Max 13A/13 A, Isc PV: 18 A/18 A Battery: Voltage Range 140-750 Vdc, Max charge and discharge current: 25 A, Battery type: Li-Ion AC output: 3/N/PE 230/400 Vac , 50 Hz, Rated Active Power 6000 W, Max. Apparent Power 6600 VA, Max 10.0 A Hybridpower 8kW 3ph: PV input: Max 1000 Vdc, MPPT voltage range: 200-850 Vdc, Max 13A/13 A, Isc PV: 18 A/18 A Battery: Voltage Range 140-750 Vdc, Max charge and discharge current: 25 A, Battery type: Li-Ion AC output: 3/N/PE 230/400 Vac , 50 Hz, Rated Active Power 8000 W, Max. Apparent Power 8800 VA, Max 13.3 A Hybridpower 10kW 3ph: PV input: Max 1000 Vdc, MPPT voltage range: 200-850 Vdc, Max 13A/13 A, Isc PV: 18 A/18 A Battery: Voltage Range 140-750 Vdc, Max charge and discharge current: 25 A, Battery type: Li-Ion AC output: 3/N/PE 230/400 Vac , 50 Hz, Rated Active Power 10000 W, Max. Apparent Power 11000 VA, Max 16.5 A Hybridpower 12kW 3ph: PV input: Max 1000 Vdc, MPPT voltage range: 200-850 Vdc, Max 13A/13 A, Isc PV: 18 A/18 A Battery: Voltage Range 140-750 Vdc, Max charge and discharge current: 25 A, Battery type: Li-Ion AC output: 3/N/PE 230/400 Vac , 50 Hz, Rated Active Power 12000 W, Max. Apparent Power 13200 VA, Max 20.0 A

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):		
☒ **Testing Laboratory:**	DEKRA Testing and Certification (Suzhou) Co., Ltd.	
Testing location/ address .... :	No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China	
Tested by (name, function, signature) .... :	Janey Qian (ENG)	Janey Qian
Approved by (name, function, signature) .. :	Jason Guo (REW)	Jason Guo
☐ ~~**Testing procedure: CTF Stage 1:**~~		
~~**Testing location/ address .... :**~~		
~~**Tested by (name, function, signature) .... :**~~		
~~**Approved by (name, function, signature) .. :**~~		
☐ ~~**Testing procedure: CTF Stage 2:**~~		
~~**Testing location/ address .... :**~~		
~~**Tested by (name + signature).................... :**~~		
~~**Witnessed by (name, function, signature) . :**~~		
~~**Approved by (name, function, signature) .. :**~~		
☐ ~~**Testing procedure: CTF Stage 3:**~~		
☐ ~~**Testing procedure: CTF Stage 4:**~~		
~~**Testing location/ address .... :**~~		
~~**Tested by (name, function, signature) .... :**~~		
~~**Witnessed by (name, function, signature) . :**~~		
~~**Approved by (name, function, signature) .. :**~~		
~~**Supervised by (name, function, signature) :**~~		

List of Attachments (including a total number of pages in each attachment):

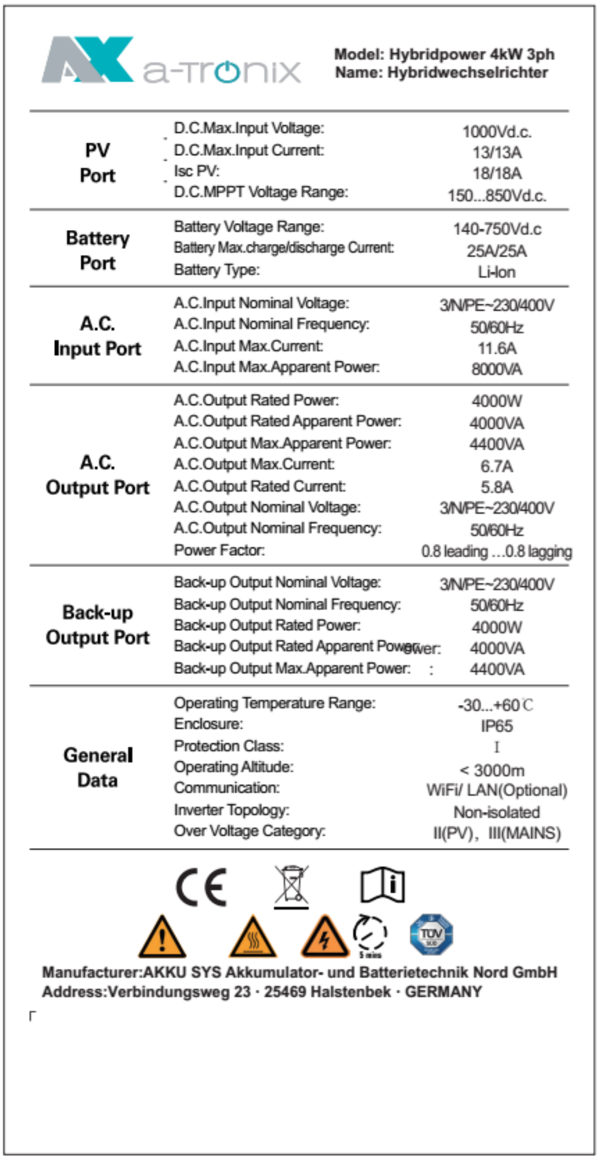
Appendix: Pictures (13 pages)

Summary of testing:

Tests performed (name of test and test clause):	**Testing location:**
Report 6142730.50A Full applicable clauses test according to standards: TOR Erzeuger Type A Version 1.2:2022-04-11 OVE-Richtlinie R 25:2020-03-01 **Report 6134610.50A** No testing	DEKRA Testing and Certification (Suzhou) Co., Ltd. No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China

Copy of marking plate:

Rating label

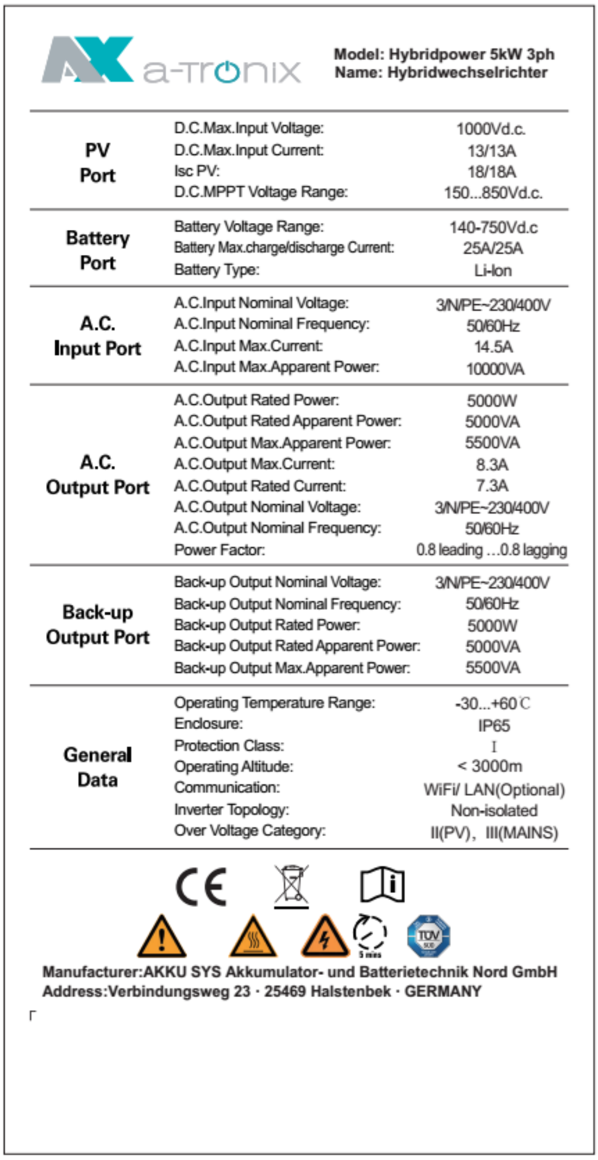


a-TrONIX

Model: Hybridpower 4kW 3ph
Name: Hybridwechselrichter

PV Port	D.C.Max.Input Voltage:	1000Vd.c.
	D.C.Max.Input Current:	13/13A
	Isc PV:	18/18A
	D.C.MPPT Voltage Range:	150...850Vd.c.
Battery Port	Battery Voltage Range:	140-750Vd.c
	Battery Max.charge/discharge Current:	25A/25A
	Battery Type:	Li-Ion
A.C. Input Port	A.C.Input Nominal Voltage:	3/N/PE~230/400V
	A.C.Input Nominal Frequency:	50/60Hz
	A.C.Input Max.Current:	11.6A
	A.C.Input Max.Apparent Power:	8000VA
A.C. Output Port	A.C.Output Rated Power:	4000W
	A.C.Output Rated Apparent Power:	4000VA
	A.C.Output Max.Apparent Power:	4400VA
	A.C.Output Max.Current:	6.7A
	A.C.Output Rated Current:	5.8A
	A.C.Output Nominal Voltage:	3/N/PE~230/400V
	A.C.Output Nominal Frequency:	50/60Hz
	Power Factor:	0.8 leading ...0.8 lagging
Back-up Output Port	Back-up Output Nominal Voltage:	3/N/PE~230/400V
	Back-up Output Nominal Frequency:	50/60Hz
	Back-up Output Rated Power:	4000W
	Back-up Output Rated Apparent Power:	4000VA
	Back-up Output Max.Apparent Power: :	4400VA
General Data	Operating Temperature Range:	-30...+60℃
	Enclosure:	IP65
	Protection Class:	I
	Operating Altitude:	< 3000m
	Communication:	WiFi/ LAN(Optional)
	Inverter Topology:	Non-isolated
	Over Voltage Category:	II(PV)，III(MAINS)

Manufacturer:AKKU SYS Akkumulator- und Batterietechnik Nord GmbH
Address:Verbindungsweg 23 · 25469 Halstenbek · GERMANY

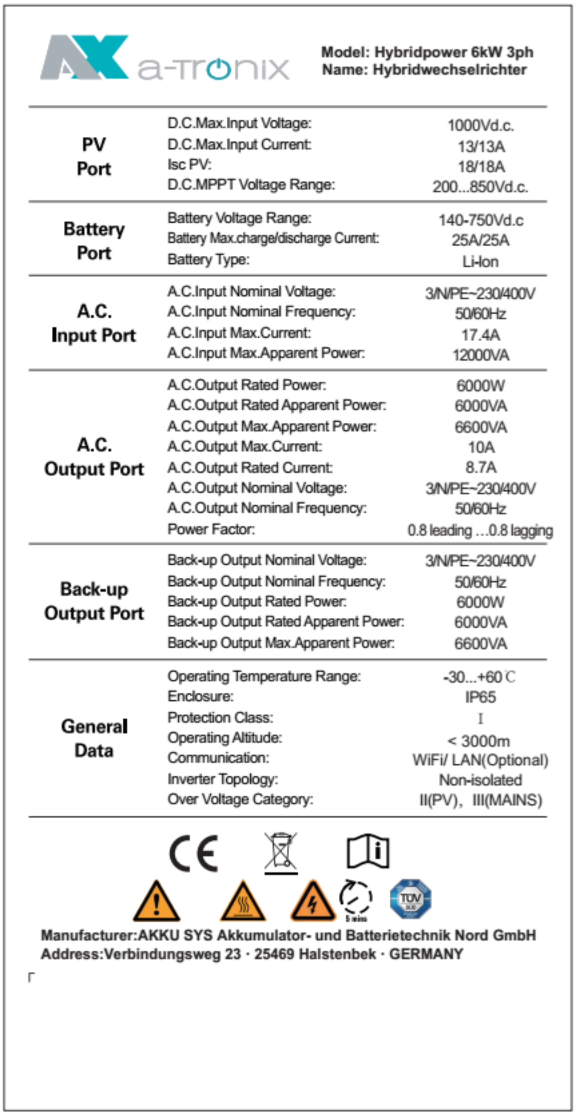


a-TrONIX

Model: Hybridpower 5kW 3ph
Name: Hybridwechselrichter

PV Port	D.C.Max.Input Voltage:	1000Vd.c.
	D.C.Max.Input Current:	13/13A
	Isc PV:	18/18A
	D.C.MPPT Voltage Range:	150...850Vd.c.
Battery Port	Battery Voltage Range:	140-750Vd.c
	Battery Max.charge/discharge Current:	25A/25A
	Battery Type:	Li-Ion
A.C. Input Port	A.C.Input Nominal Voltage:	3/N/PE~230/400V
	A.C.Input Nominal Frequency:	50/60Hz
	A.C.Input Max.Current:	14.5A
	A.C.Input Max.Apparent Power:	10000VA
A.C. Output Port	A.C.Output Rated Power:	5000W
	A.C.Output Rated Apparent Power:	5000VA
	A.C.Output Max.Apparent Power:	5500VA
	A.C.Output Max.Current:	8.3A
	A.C.Output Rated Current:	7.3A
	A.C.Output Nominal Voltage:	3/N/PE~230/400V
	A.C.Output Nominal Frequency:	50/60Hz
	Power Factor:	0.8 leading ...0.8 lagging
Back-up Output Port	Back-up Output Nominal Voltage:	3/N/PE~230/400V
	Back-up Output Nominal Frequency:	50/60Hz
	Back-up Output Rated Power:	5000W
	Back-up Output Rated Apparent Power:	5000VA
	Back-up Output Max.Apparent Power:	5500VA
General Data	Operating Temperature Range:	-30...+60℃
	Enclosure:	IP65
	Protection Class:	I
	Operating Altitude:	< 3000m
	Communication:	WiFi/ LAN(Optional)
	Inverter Topology:	Non-isolated
	Over Voltage Category:	II(PV)，III(MAINS)

Manufacturer:AKKU SYS Akkumulator- und Batterietechnik Nord GmbH
Address:Verbindungsweg 23 · 25469 Halstenbek · GERMANY



a-TrOnix

Model: Hybridpower 6kW 3ph
Name: Hybridwechselrichter

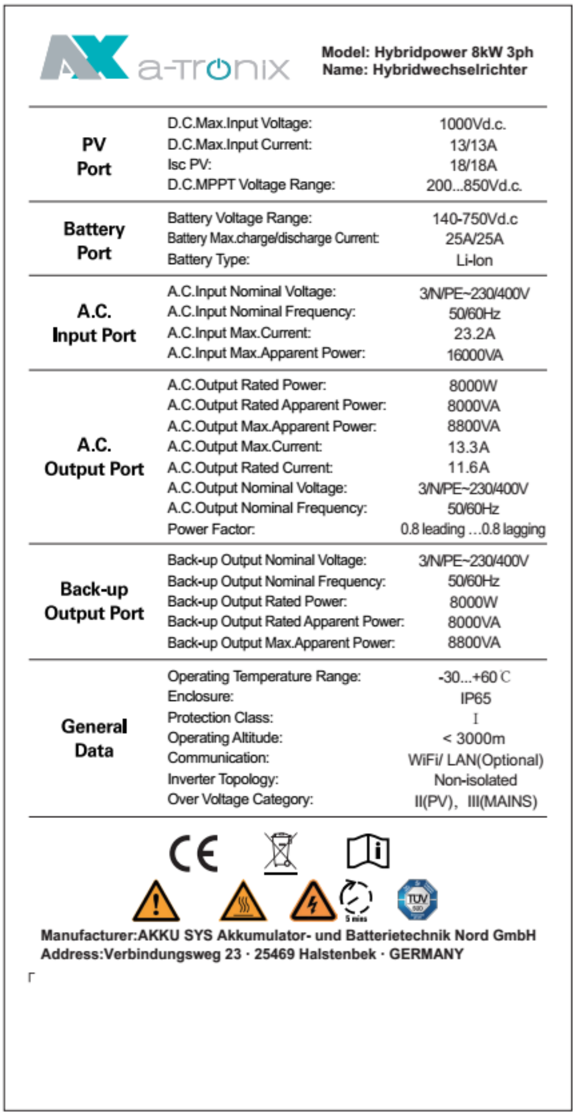
PV Port	D.C.Max.Input Voltage:	1000Vd.c.
	D.C.Max.Input Current:	13/13A
	Isc PV:	18/18A
	D.C.MPPT Voltage Range:	200...850Vd.c.
Battery Port	Battery Voltage Range:	140-750Vd.c
	Battery Max.charge/discharge Current:	25A/25A
	Battery Type:	Li-Ion
A.C. Input Port	A.C.Input Nominal Voltage:	3/N/PE~230/400V
	A.C.Input Nominal Frequency:	50/60Hz
	A.C.Input Max.Current:	17.4A
	A.C.Input Max.Apparent Power:	12000VA
A.C. Output Port	A.C.Output Rated Power:	6000W
	A.C.Output Rated Apparent Power:	6000VA
	A.C.Output Max.Apparent Power:	6600VA
	A.C.Output Max.Current:	10A
	A.C.Output Rated Current:	8.7A
	A.C.Output Nominal Voltage:	3/N/PE~230/400V
	A.C.Output Nominal Frequency:	50/60Hz
	Power Factor:	0.8 leading ...0.8 lagging
Back-up Output Port	Back-up Output Nominal Voltage:	3/N/PE~230/400V
	Back-up Output Nominal Frequency:	50/60Hz
	Back-up Output Rated Power:	6000W
	Back-up Output Rated Apparent Power:	6000VA
	Back-up Output Max.Apparent Power:	6600VA
General Data	Operating Temperature Range:	-30...+60℃
	Enclosure:	IP65
	Protection Class:	I
	Operating Altitude:	< 3000m
	Communication:	WiFi/ LAN(Optional)
	Inverter Topology:	Non-isolated
	Over Voltage Category:	II(PV)，III(MAINS)

CE

5 mins

TÜV SÜD

Manufacturer:AKKU SYS Akkumulator- und Batterietechnik Nord GmbH
Address:Verbindungsweg 23 · 25469 Halstenbek · GERMANY



a-TrOnix

Model: Hybridpower 8kW 3ph
Name: Hybridwechselrichter

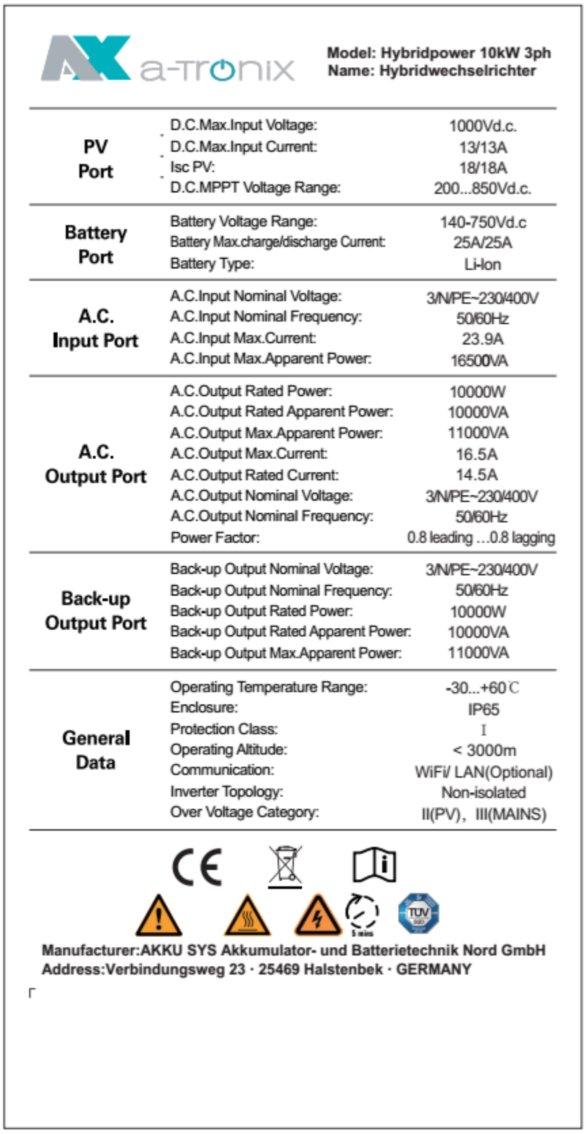
PV Port	D.C.Max.Input Voltage:	1000Vd.c.
	D.C.Max.Input Current:	13/13A
	Isc PV:	18/18A
	D.C.MPPT Voltage Range:	200...850Vd.c.
Battery Port	Battery Voltage Range:	140-750Vd.c
	Battery Max.charge/discharge Current:	25A/25A
	Battery Type:	Li-Ion
A.C. Input Port	A.C.Input Nominal Voltage:	3/N/PE~230/400V
	A.C.Input Nominal Frequency:	50/60Hz
	A.C.Input Max.Current:	23.2A
	A.C.Input Max.Apparent Power:	16000VA
A.C. Output Port	A.C.Output Rated Power:	8000W
	A.C.Output Rated Apparent Power:	8000VA
	A.C.Output Max.Apparent Power:	8800VA
	A.C.Output Max.Current:	13.3A
	A.C.Output Rated Current:	11.6A
	A.C.Output Nominal Voltage:	3/N/PE~230/400V
	A.C.Output Nominal Frequency:	50/60Hz
	Power Factor:	0.8 leading ...0.8 lagging
Back-up Output Port	Back-up Output Nominal Voltage:	3/N/PE~230/400V
	Back-up Output Nominal Frequency:	50/60Hz
	Back-up Output Rated Power:	8000W
	Back-up Output Rated Apparent Power:	8000VA
	Back-up Output Max.Apparent Power:	8800VA
General Data	Operating Temperature Range:	-30...+60℃
	Enclosure:	IP65
	Protection Class:	I
	Operating Altitude:	< 3000m
	Communication:	WiFi/ LAN(Optional)
	Inverter Topology:	Non-isolated
	Over Voltage Category:	II(PV)，III(MAINS)

CE

5 mins

TÜV SÜD

Manufacturer:AKKU SYS Akkumulator- und Batterietechnik Nord GmbH
Address:Verbindungsweg 23 · 25469 Halstenbek · GERMANY



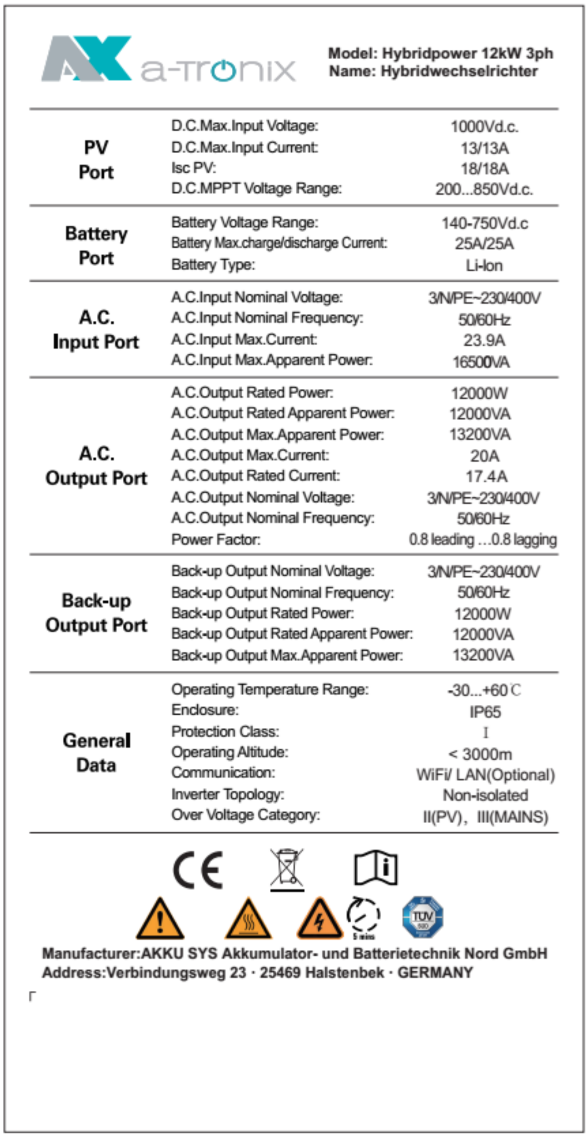
a-TrONIX

Model: Hybridpower 10kW 3ph
Name: Hybridwechselrichter

PV Port	D.C.Max.Input Voltage:	1000Vd.c.
	D.C.Max.Input Current:	13/13A
	Isc PV:	18/18A
	D.C.MPPT Voltage Range:	200...850Vd.c.
Battery Port	Battery Voltage Range:	140-750Vd.c
	Battery Max.charge/discharge Current:	25A/25A
	Battery Type:	Li-Ion
A.C. Input Port	A.C.Input Nominal Voltage:	3/N/PE~230/400V
	A.C.Input Nominal Frequency:	50/60Hz
	A.C.Input Max.Current:	23.9A
	A.C.Input Max.Apparent Power:	16500VA
A.C. Output Port	A.C.Output Rated Power:	10000W
	A.C.Output Rated Apparent Power:	10000VA
	A.C.Output Max.Apparent Power:	11000VA
	A.C.Output Max.Current:	16.5A
	A.C.Output Rated Current:	14.5A
	A.C.Output Nominal Voltage:	3/N/PE~230/400V
	A.C.Output Nominal Frequency:	50/60Hz
	Power Factor:	0.8 leading ...0.8 lagging
Back-up Output Port	Back-up Output Nominal Voltage:	3/N/PE~230/400V
	Back-up Output Nominal Frequency:	50/60Hz
	Back-up Output Rated Power:	10000W
	Back-up Output Rated Apparent Power:	10000VA
	Back-up Output Max.Apparent Power:	11000VA
General Data	Operating Temperature Range:	-30...+60℃
	Enclosure:	IP65
	Protection Class:	I
	Operating Altitude:	< 3000m
	Communication:	WiFi/ LAN(Optional)
	Inverter Topology:	Non-isolated
	Over Voltage Category:	II(PV)， III(MAINS)

CE

Manufacturer:AKKU SYS Akkumulator- und Batterietechnik Nord GmbH
Address:Verbindungsweg 23 · 25469 Halstenbek · GERMANY



a-TrONIX

Model: Hybridpower 12kW 3ph
Name: Hybridwechselrichter

PV Port	D.C.Max.Input Voltage:	1000Vd.c.
	D.C.Max.Input Current:	13/13A
	Isc PV:	18/18A
	D.C.MPPT Voltage Range:	200...850Vd.c.
Battery Port	Battery Voltage Range:	140-750Vd.c
	Battery Max.charge/discharge Current:	25A/25A
	Battery Type:	Li-Ion
A.C. Input Port	A.C.Input Nominal Voltage:	3/N/PE~230/400V
	A.C.Input Nominal Frequency:	50/60Hz
	A.C.Input Max.Current:	23.9A
	A.C.Input Max.Apparent Power:	16500VA
A.C. Output Port	A.C.Output Rated Power:	12000W
	A.C.Output Rated Apparent Power:	12000VA
	A.C.Output Max.Apparent Power:	13200VA
	A.C.Output Max.Current:	20A
	A.C.Output Rated Current:	17.4A
	A.C.Output Nominal Voltage:	3/N/PE~230/400V
	A.C.Output Nominal Frequency:	50/60Hz
	Power Factor:	0.8 leading ...0.8 lagging
Back-up Output Port	Back-up Output Nominal Voltage:	3/N/PE~230/400V
	Back-up Output Nominal Frequency:	50/60Hz
	Back-up Output Rated Power:	12000W
	Back-up Output Rated Apparent Power:	12000VA
	Back-up Output Max.Apparent Power:	13200VA
General Data	Operating Temperature Range:	-30...+60℃
	Enclosure:	IP65
	Protection Class:	I
	Operating Altitude:	< 3000m
	Communication:	WiFi/ LAN(Optional)
	Inverter Topology:	Non-isolated
	Over Voltage Category:	II(PV)， III(MAINS)

CE

Manufacturer:AKKU SYS Akkumulator- und Batterietechnik Nord GmbH
Address:Verbindungsweg 23 · 25469 Halstenbek · GERMANY

Remark:

According to customer's requirement and Austria low-voltage distribution networks code, these models were only evaluated under the grid frequency of 50 Hz.

Test item particulars.. :	
Class of equipment .... :	Class I
Connection to the mains .... :	Permanent connection
IP protection class .... :	IP65
Possible test case verdicts:	
- test case does not apply to the test object .... :	N/A
- test object does meet the requirement..................... :	P (Pass)
- test object does not meet the requirement .... :	F (Fail)
- this clause is information reference for installation... :	Info.
Testing.. :	
Date of receipt of test item(s) .... :	2022-08-03 (samples provided by applicant)
Dates tests performed.. :	2022-08-03 to 2022-11-23

General remarks:

The test results presented in this report relate only to the object tested.

This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
The measurement result is considered in conformance with the requirement if it is within the prescribed limit, it is not necessary to account the uncertainty associated with the measurement result.

This report is only for reference and is not used for legal proof function in China market.

The information provided by the customer in this report may affect the validity of the results, the test lab is not responsible for it.

"(See Enclosure #)" refers to additional information appended to the report.

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

In case of doubt the German version standard will be valid.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

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

- "P_N" for the nominal active power.
  $P_n = U_n \times I_n \times \cos \varphi_n$ (single-Phase); $P_n = \sqrt{3}\, U_n \times I_n \times \cos \varphi_n$ (three-Phase).
- "_E0.2" for gliding average values over 200 milliseconds.
- "_E30" for gliding average values over 30 seconds.
- "_E60" for gliding average values over 60 seconds.
- "_E600" for gliding average values over 10 minutes.

Acronyms:

EZE (Erzeugungseinheit): Power Generating Unit - PGU
EZA (Erzeugungsanlage): Power Generating System - PGS

Name and address of factory (ies)

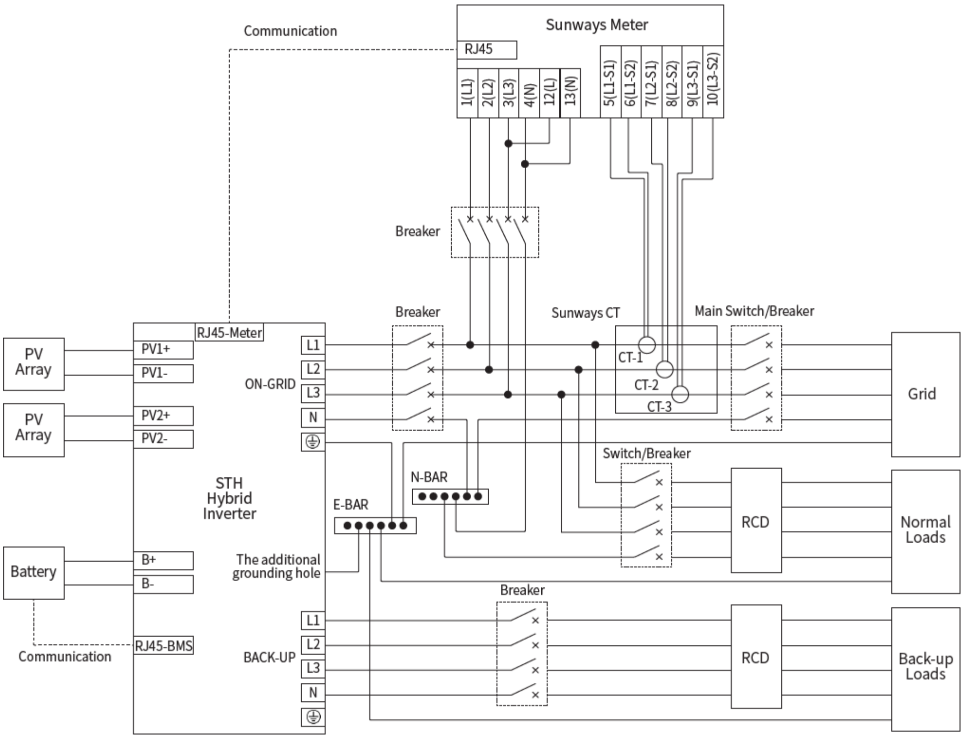
Ningbo Sunways Technologies Co., Ltd.

No. 1, Second Road, Green Industrial Zone, Chongshou Town 315334 Cixi, Ningbo, Zhejiang, P.R. China

General product information:

These devices are Hybrid inverters (bi-directional converter) designed to work with PV panels up to 1000Vd.c. and Li-ion batteries up to 750Vd.c.. It is responsible for converting the direct current generated by photovoltaic panels and batteries into three-phase 400V, 50 Hz alternative current for feeding into the electrical power distribution grid or the backup load. The Hybrid inverter can operate when it is connected to the electrical power distribution line and as a stand-alone unit or in case of AC grid disruption (standalone mode only for equipment with Back-up output port).

Block Diagram:



Model difference:

Hybridpower 12kW 3ph: basic model.

Hybridpower 4kW 3ph, Hybridpower 5kW 3ph, Hybridpower 6kW 3ph, Hybridpower 8kW 3ph, Hybridpower 10kW 3ph same family product,

technical similar as basic model, except for model name and some electrical parameters about current and power.

The product was tested on:

Firmware/software version: V1.05

Hardware version: V1.00

Unless otherwise specified, all the tests were performed on model Hybridpower 12kW 3ph and also applicable for all other models stated in this report.

Amendment 1 report 6134610.50A:

The report 6134610.50A was based on the report 6142730.50A issued by DEKRA Testing and Certification (Suzhou) Co., Ltd., issued on 2021-12-22. It was issued due to below modifications:

1. Applicant’s and Manufacturer’s name was changed from Ningbo Sunways Technologies Co., Ltd. to AKKU SYS Akkumu|ator - und Batterietechnik Nord GmbH, updated address accordingly;
2. Trade name was changed from Sunways to AKKU, updated marking;
3. Change the model name see page 2;
4. Update the photos of the sample enclosure with the new manufacturer's logo.

After technical review, no tests were considered necessary; see the “summary of testing”.

<table>
<tr><th colspan="3">Default country settings of Austria:</th></tr>
<tr><td colspan="3">Default settings for the grid decoupling protection:</td></tr>
<tr><td>Parameter</td><td>Default setting value</td><td>Default settings time</td></tr>
<tr><td>Overvoltage protection U>> (stage 2)</td><td>1.15 U_n (264.5V)</td><td>0.1 s</td></tr>
<tr><td>Overvoltage protection U> (stage 1) *</td><td>1.11 U_n (255.3V)</td><td>0.1 s</td></tr>
<tr><td>Undervoltage U< (stage 1)</td><td>0.80 U_n (184.0V)</td><td>1.5 s</td></tr>
<tr><td>Undervoltage U<< (stage 2)</td><td>0.25 U_n (57.5V)</td><td>0.5 s</td></tr>
<tr><td>Over frequency f></td><td>51.5 Hz</td><td>0.1 s</td></tr>
<tr><td>Under frequency f<</td><td>47.5 Hz</td><td>0.1 s</td></tr>
<tr><td>Loss of mains according EN 62116 (LoM)</td><td colspan="2">2 s</td></tr>
<tr><td colspan="3">Default settings for the reconnection conditions:</td></tr>
<tr><td>Connection setting value for overvoltage</td><td colspan="2">1.09 U_n (250.7V)</td></tr>
<tr><td>Connection setting value or undervoltage</td><td colspan="2">0.85 U_n (195.5V)</td></tr>
<tr><td>Connection setting value for overfrequency</td><td colspan="2">50.1 Hz</td></tr>
<tr><td>Connection setting value for underfrequency</td><td colspan="2">47.5 Hz</td></tr>
<tr><td>Waiting time for automatic connection</td><td colspan="2">60 s</td></tr>
<tr><td>Waiting time for reconnection after the decoupling protection has been tripped</td><td colspan="2">300 s</td></tr>
<tr><td>Active power gradient after tripped</td><td colspan="2">10% P_{max} / minute</td></tr>
<tr><td colspan="3">Reactive power control:</td></tr>
<tr><td>a) Fixed displacement factor cos φ</td><td colspan="2">Cos φ = 1</td></tr>
<tr><td>b) Displacement factor / active power characteristic curve cos φ (P)</td><td colspan="2">
<table>
<tr><td>Set point</td><td>P_1</td><td>P_2</td><td>P_3</td></tr>
<tr><td>P/P_n</td><td>0</td><td>50% P_{max}</td><td>100% P_{max}</td></tr>
<tr><td>cos φ</td><td>1</td><td>1</td><td>$0.9_{underexcited}$</td></tr>
</table>
</td></tr>
<tr><td>c) Reactive power voltage characteristic curve Q (U)</td><td colspan="2">
<table>
<tr><td>Set point</td><td>U_1</td><td>U_2</td><td>U_3</td><td>U_4</td></tr>
<tr><td>U/U_n</td><td>0.92</td><td>0.96</td><td>1.05</td><td>1.08</td></tr>
<tr><td>Q/P_{max}</td><td>0.436</td><td>0</td><td>0</td><td>-0.436</td></tr>
<tr><td>cos φ</td><td>cos $φ_{min}$</td><td>1</td><td>1</td><td>-cos $φ_{min}$</td></tr>
</table>
</td></tr>
<tr><td>Q(U) control PT1 behaviour time constant</td><td colspan="2">5 s (setting 3 s for OVE-Richtlinie R 25 clause 5.3.10 testing)</td></tr>
<tr><td>d) Fixed reactive power Q</td><td colspan="2">Q = 0</td></tr>
<tr><td colspan="3">Active power reduction at overfrequency (LFSM-O):</td></tr>
<tr><td>Start of power reduction from frequency</td><td colspan="2">50.2 Hz</td></tr>
<tr><td>End of power reduction at frequency</td><td colspan="2">51.5 Hz</td></tr>
<tr><td>Droop</td><td colspan="2">5% (corresponds to 40% P_M / Hz)</td></tr>
<tr><td colspan="3">P(U) control:</td></tr>
<tr><td>P(U) control Interpolation point (start voltage / power)</td><td colspan="2">
<table>
<tr><td>Set point</td><td>U_1</td><td>U_2</td></tr>
<tr><td>U/U_n</td><td>1.10</td><td>1.12</td></tr>
<tr><td>Power</td><td>100%P_n</td><td>0%P_n</td></tr>
</table>
</td></tr>
<tr><td>P(U) control PT1 behaviour time constant</td><td colspan="2">5 s</td></tr>
<tr><td colspan="3">Standard settings for the FRT capability:</td></tr>
<tr><td>FRT voltage dips interpolation point (voltage / time)</td><td colspan="2">
<table>
<tr><td>Set point</td><td>U_1</td><td>U_2</td><td>U_3</td><td>U_4</td><td>U_5</td></tr>
<tr><td>U/U_n</td><td>0.15</td><td>0.30</td><td>0.50</td><td>0.75</td><td>0.81</td></tr>
<tr><td>Time (ms)</td><td>200</td><td>350</td><td>900</td><td>1500</td><td>1500</td></tr>
</table>
</td></tr>
</table>

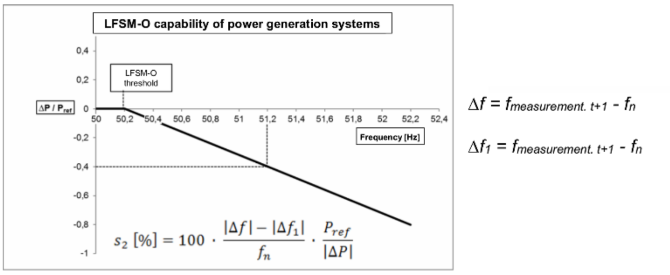
<table>
<tr><td>Zero current lock-in voltage during voltage dips</td><td>< 0.8 U_n</td></tr>
<tr><td colspan="2">Remark:
The stated voltages are ‘true r.m.s.’ or fundamental component -values.
* Over-voltage – stage 1: 10-min-value corresponding to ÖNORM EN 50160.
The calculation of the 10 min value shall comply with the 10 min aggregation of EN 61000-4-30, class S. The function shall be based on the calculation of the square root of the arithmetic mean of the squared input values over 10 min. In deviation from EN 61000-4-30, a moving window shall be used. The calculation of a new 10-min value at least every 3 s is sufficient, which is then to be compared with the trip value.</td></tr>
</table>

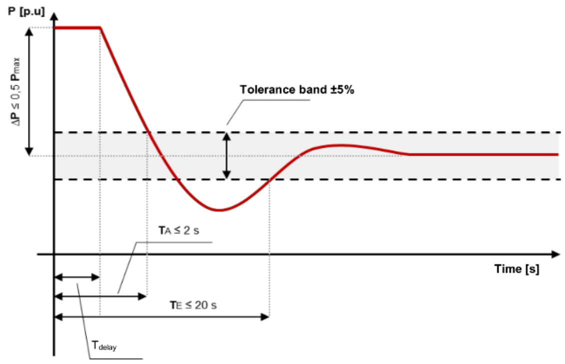
Clause	Requirement - Test	Result - Remark	Verdict
4	**GRID CONNECTION PROCEDURE AND RELEVANT DOCUMENTS**		-
4.1	**Determination of the maximum capacity of the power generation system**		-
4.2	**Grid connection application**		-
4.3	**Connection assessment and concept**		-
4.4	**Grid connection contract**		-
5	**GRID BEHAVIOUR OF THE POWER GENERATION SYSTEM**		P
5.1	**Frequency stability requirements**		P
	Power generation systems must meet the following requirements for frequency stability:		P
5.1.1	Frequency ranges		P
	a) power generation systems must be able to maintain grid connection and operation within the frequency ranges and time periods shown in Table 1;	(See appended table)	P

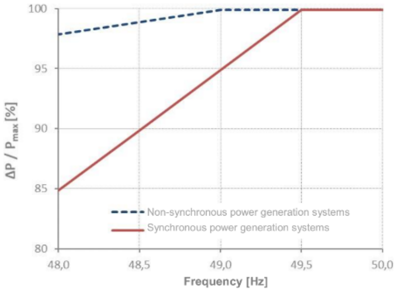
Frequency range	Minimum period
47.5 Hz – 48.5 Hz	60 minutes
48.5 Hz – 49.0 Hz	90 minutes
49.0 Hz – 51.0 Hz	unlimited
51.0 Hz – 51.5 Hz	30 minutes

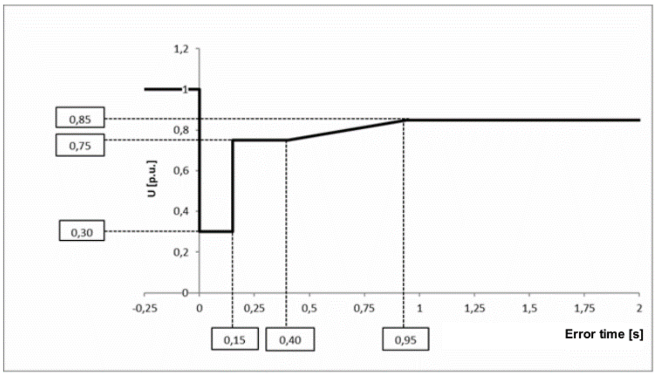
Table *1: Minimum periods in which a power generation system must be able to operate under deviations from the nominal frequency without disconnection from the grid.*

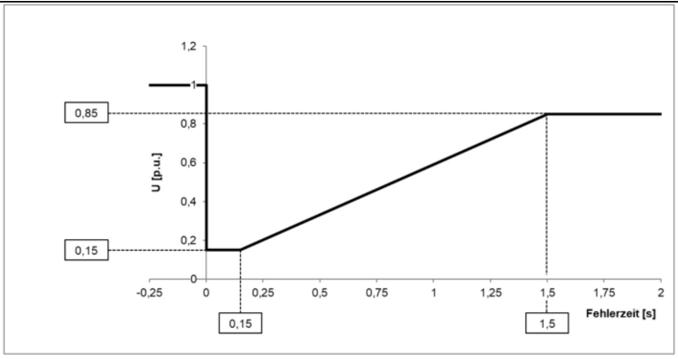
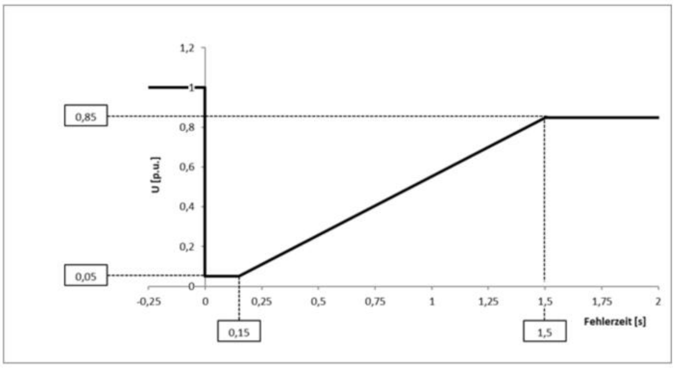
Clause	Requirement - Test	Result - Remark	Verdict
	b) the relevant grid operator can agree in coordination with the relevant TSO and grid user upon wider frequency ranges, longer minimum operating periods or specific requirements regarding combined frequency and voltage deviations in order to ensure the best possible use of the technical capacities of a power generation system, if this is necessary to maintain or restore system security;		P
	c) the grid user may not, without good reason, refuse to give consent for the use of broader frequency ranges or longer minimum operating periods subject to the economic and technical feasibility.		P
	Exceptions are only permitted in agreement with the grid operator. The frequency with which a power generation unit is to be disconnected from the grid must be agreed upon with the grid operator.		P
5.1.2	Frequency gradients		P
	Power generation systems must be able to maintain the connection to the grid and the operation at frequency gradients up to 2 Hz/s, unless the disconnection from the grid was caused by a triggering of the grid failure protection (generator protection or grid decoupling protection) as a result of the frequency gradient.	(See appended table)	P

Clause	Requirement - Test	Result - Remark	Verdict
	A frequency gradient triggered protection function is generally not provided in chapter 6.3 “Protection devices and grid decoupling protection”. Under certain circumstances, the relevant grid operator can require that a frequency gradient triggered protection function be provided.		P
	The parametrisation of the grid failure protection (generator protection or grid decoupling protection) with the frequency gradient is determined by the relevant grid operator in coordination with the relevant TSO.		P
5.1.3	Active power reduction with overfrequency (LFSM-O)		P
	The following provisions apply to the limited frequency sensitive mode – overfrequency (LFSM-O): For non-synchronous power generation systems with converters and grid connection point in the low-voltage network, LFSM-O must be activated by default. Power generation systems with a grid connection point in the low-voltage network, which are technologically not compliant with the regulations for the limited frequency sensitive mode at overfrequency (LFSM-O), must be able to disconnect from the grid in the frequency range between 50.2 Hz and 51.5 Hz. The setting value of the trip frequency is specified by the relevant grid operator (scaling). Grid operators must publish this scaling in a suitable manner.	(See appended table)	P
	 $s_2\,[\%] = 100 \cdot \frac{\lvert\Delta f\rvert - \lvert\Delta f_1\rvert}{f_n} \cdot \frac{P_{ref}}{\lvert\Delta P\rvert}$ $\Delta f = f_{measurement.\ t+1} - f_n$ $\Delta f_1 = f_{measurement.\ t+1} - f_n$ *Figure 1: Ability of power generation systems for frequency-dependent adjustment of the active power in LFSM-O mode* *P_{ref} is the reference active power that corresponds to the maximum capacity P_{max} in the case of synchronous power generation systems and the actual active power output at the time t when the frequency threshold value is reached in the case of non-synchronous power generation systems; ΔP is the change in the active power output of the power generation system at the time t+1 against t; f_n is the nominal frequency (50 Hz) of the grid; Δf is the frequency deviation in the grid at the time t+1 in Hz; Δf_1 is the frequency deviation in the grid at the time t in Hz and s_2 is the statics of the LFSM-O mode in %.*		P
	At overfrequency where *Δf* is above *Δf_1*, the power generation system must reduce the active power output depending on the statics *s_2*. The frequency threshold for the start of LFSM-O mode must be freely adjustable from 50.2 Hz to 50.5 Hz. The statics *s_2* for the LFSM-O mode must be freely adjustable from 2% to 12%. Unless otherwise specified by the grid operator for the LFSM-O mode, a frequency threshold of 50.2 Hz and a statics of 5% must be used - see figure 1.		P

Clause	Requirement - Test	Result - Remark	Verdict
	The resolution of the frequency measurement must be ≤ 10 mHz. The tolerance band about the stationary end value of the control variable in LFSM-O mode is ± 5% of the nominal power of the power generation system.		P
	The power generation system must be able to activate the frequency-dependent adjustment of the active power output after an initial time delay (T_{delay}) that is as short as possible. If this time delay is more than two seconds, the grid user must justify the delay by presenting technical evidence to the relevant TSO. Any parametrisable artificial delay time must be deactivated or set to 0 s.		P
	The power generation system must be able to continue operating at this minimum control value when the minimum capacity for regular operation is reached.		P
	The power generation system must be able to operate stably in LFSM-O mode. If LFSM-O mode is activated, the LFSM-O setpoint has priority over all other setpoints for active power output.		P
	For synchronous power generation systems (including pumped storage power plants), the control times (response and settling times) in LFSM-O mode must be coordinated with the grid operator subject to the technical capacities of the power generation system.	The grid-connected PV inverters under test were not synchronous power generation systems.	N/A
	For non-synchronous power generation systems, the following control times (response and settling times) are recommended in LFSM-O mode: $T_A \leq 2$ s for an active power reduction of 50 % of P_{max} $T_E \leq 20$ s $T_{delay} << T_A$  *Figure 2: Example of response and settling times of non-synchronous power generation systems in LFSM-O mode* *T_A is the response time between the erratic occurrence of a control deviation and the first time the tolerance band about the stationary end value of the control variable is reached in s; the response time also includes the time when the control deviation is recognised; TE is the settling time in s that is required until the control variable remains permanently within the tolerance band about the stationary end value, T_{delay} is the delay time in s.*		P
5.1.4	Active power output according to the setpoint		P
	The power generation system must be able to deliver a constant active power output according to its setpoint regardless of frequency changes, unless the change in power output is due to one of the modes described in chapter 5.1 “Frequency stability requirements” or due to insufficiently available primary energy.		P
5.1.5	Reduction in the maximum active power output with decreasing frequency		P

TOR Erzeuger			
Clause	Requirement - Test	Result - Remark	Verdict
	For synchronous power generation systems, the permissible reduction in the maximum active power output $\Delta P/P_{max}$ with decreasing frequency is: – up to 49.5 Hz: 0%; – below 49.5 Hz: Reduction by 10% of the maximum capacity at 50 Hz per Hz frequency drop.	The grid-connected PV inverters under test were not synchronous power generation systems.	N/A
	For non-synchronous power generation systems, the permissible reduction in the maximum active power output $\Delta P/P_{max}$ with decreasing frequency is: – up to 49.0 Hz: 0%; – below 49.0 Hz: Reduction by 2% of the maximum capacity at 50 Hz per Hz frequency drop.		P
	Technology-dependent deviations from the required values must be agreed upon with the relevant grid operator in the grid connection contract.  *Figure 3: Permissible reduction in the maximum active power output with decreasing frequency* *$\Delta P/P_{max}$ is the dimensionless ratio of the change in the active power output ΔP to the maximum capacity P_{max}.*		P
5.1.6	Active power increase with underfrequency (LFSM-U)		N/A
	There are no requirements for power generation systems in this regard.		N/A
5.1.7	Frequency sensitive mode (FSM)		N/A
	There are no requirements for power generation systems in this regard.		N/A
5.1.8	Provision of synthetic oscillating weight		N/A
	There are no requirements for power generation systems in this regard.		N/A
5.2	**Requirements regarding robustness and dynamic grid support**		P
5.2.1	FRT (fault ride through) capability of power generation systems		P
	The requirements for FRT capability apply to both symmetrical and asymmetrical faults in the grid.		P
	Power generation systems must be able to maintain a connection to the grid and stable operation if there are faults in the power grid in the form of faults that can be controlled according to the concept (in the transmission or distribution system).		P
	This capability corresponds to a voltage-time profile at the grid connection point, which is established for fault conditions. The voltage-time profile shows the lower limit of the actual course of the line-to-line voltages at the grid voltage level during a fault as a function of the time before, during and after the fault.		P

Clause	Requirement - Test	Result - Remark	Verdict
	For synchronous power generation systems with a grid connection point in the low-voltage network, the voltage-time profile is a reference value. They should be able to maintain connection to the grid and stable operation during a fault in accordance with the manufacturer's instructions.	The grid-connected PV inverters under test were not synchronous power generation systems	N/A
	Power generation systems must be designed to run through several consecutive faults. If the thermal design limits are exceeded due to several consecutive faults, the power generation system may disconnect from the grid.		P
	The protection systems and settings for internal electrical faults must not endanger the FRT capability; without prejudice to this, the undervoltage protection (either FRT capability or specified minimum voltage) must be determined by the grid user as broadly as possible subject to the capacities of the power generation system, provided the relevant grid operator does not prescribe any narrower limits for the settings in accordance with chapter 6.3 “Protection systems and settings”. The grid user must justify the settings according to this principle.		P
	The following diagrams show the lower limit value of a voltage-time profile of the voltage U at the grid connection point on the y-axis as the ratio of its actual value to its reference value 1 p.u. before, during and after the fault. The time t after the start of the fault is plotted in seconds on the x-axis.		P
	The following FRT profile applies to synchronous power generation systems:  *Figure 4: FRT profile of synchronous power generation systems*	The grid-connected PV inverters under test were not synchronous power generation systems.	N/A
	The following FRT profile applies to non-synchronous power generation systems:		P

Clause	Requirement - Test	Result - Remark	Verdict
	 *Figure 5: FRT profile of non-synchronous power generation systems with grid connection point at LV level*	The grid-connected PV inverters under test were connected to LV distribution network.	P
	 *Figure 6: FRT profile of non-synchronous power generation systems with grid connection point at MV level*	The grid-connected PV inverters under test were connected to LV distribution network.	N/A
5.2.2	Active and reactive current feed during and after grid faults		P
5.2.2.1	Behaviour in the event of a fault		P
	In the event of faults that require FRT capability, non-synchronous power generation systems with a grid connection point in the low-voltage network must be able to withstand voltage dips with a residual voltage U < 0.8 Un, without disconnecting from the grid and without electricity being fed into the grid of the grid operator (limited dynamic grid support)		P
	In coordination with the relevant grid operator and its express consent, non-synchronous power generation systems with a grid connection point in the low-voltage network, which are able to maintain a defined operating point in the event of faults that require FRT capability, can maintain the active and reactive current feed with deviation from the above specification or the active and reactive power feed with the highest possible accuracy.		P
	In the event of faults that require FRT capability, non-synchronous power generation systems connected to the medium-voltage network must be able to support the grid voltage by feeding in a reactive current. The reactive current feed must also be possible in the event of asymmetrical faults.	The grid-connected PV inverters under test were connected to LV distribution network.	N/A
	The relevant grid operator shall specify in the grid connection contract how reactive power must be fed in or whether no power should be fed into the grid of the grid operator (limited dynamic grid support).	It's depended on relevant grid operator.	Info.

Clause	Requirement - Test	Result - Remark	Verdict
	If the relevant grid operator requires dynamic reactive current support, the following requirements must be observed: Non-synchronous power generation systems connected to the medium-voltage network must provide dynamic reactive current support in the event of symmetrical and asymmetrical faults under the following conditions: – If there is an erratic change in voltage or if a voltage at the grid connection point is > 1.1 p.u. or < 0.9 p.u., non-synchronous power generation systems must support the voltage by increasing or decreasing an additional reactive current $\Delta i_{B1.2}$ in the positive and negative sequences; – The additional reactive current $\Delta i_{B1.2}$ is proportional to the voltage deviation $\Delta u_{1.2}$ and a gain factor k, which is specified by the relevant grid operator subject to the essential impedances between the power generation unit(s) of the non-synchronous power generation system and the grid connection point. Unless otherwise specified by the relevant grid operator for the gain factor k, a value k = 2 should be selected. *The consumer counting arrow system is used for the following formula.* $\Delta i_{B1} = k * \Delta u_1$ $\Delta i_{B2} = k * \Delta u_2$ Δi_{B1}...*additional reactive current in the positive sequence* Δi_{B2}...*additional reactive current in the negative sequence* Δu_1... *change in the positive sequence voltage* Δu_2... *change in the negative sequence voltage* *k* gain factor ($2 \le k \le 6$), adjustable in steps of 0.5 (except power generation systems with directly coupled asynchronous generators in the event of asymmetrical faults); After the fault has ended, the transition from dynamic reactive current support to static voltage stability takes place. The transition should be continuous and not abrupt.	The grid-connected PV inverters under test were connected to LV distribution network.	N/A
	Non-synchronous power generation systems must be able to feed in a reactive current of at least the level of the rated current. Continuous dynamic grid support is also permissible as part of the aforementioned requirements, which is permanent and parallel to the stationary voltage stability regardless of the fulfilment of the criteria for the start and end of the fault.	The grid-connected PV inverters under test were connected to LV distribution network.	N/A
5.2.2.2	Resumption of power output after fault finding		P
	The following applies to non-synchronous power generation systems with a grid connection point in the low-voltage network: If the grid voltage is within the permissible voltage range after fault finding and the active current has been reduced during the grid fault, power generation systems must be able to increase the active current to the pre-fault value as quickly as technically possible. The response time may be a maximum of 1 s; for rotating machines a maximum of 6 s.		P

<table>
<tr><th colspan="4">TOR Erzeuger</th></tr>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>The following applies to all other power generation systems: If the grid voltage is within the permissible voltage range after fault finding and the active power output has been reduced during the grid fault, power generation systems must be able to increase the active power output to the pre-fault value as quickly as technically possible.</td><td></td><td>P</td></tr>
<tr><td></td><td>The reactive power provision of the power generation system follows the set procedure for reactive power provision in terms of time response.</td><td></td><td>P</td></tr>
<tr><td>5.3</td><td colspan="2">Static voltage range requirements</td><td>P</td></tr>
<tr><td>5.3.1</td><td>Voltage ranges</td><td></td><td>P</td></tr>
<tr><td></td><td>Without prejudice to the FRT capability, a power generation system must be able to maintain connection to the grid and operation during the periods specified in the following tables and within the grid voltage ranges listed in same tables, which are specified as voltage in relation to the reference value 1 p.u.:
<table>
<tr><th>Voltage range</th><th>Minimum period</th></tr>
<tr><td>0.85 p.u. – 0.9 p.u.</td><td>60 minutes</td></tr>
<tr><td>0.9 p.u. – 1.1 p.u.</td><td>unlimited</td></tr>
<tr><td>1.1 p.u. – 1.12 p.u.</td><td>10 minutes</td></tr>
</table>
<i>Table 2: Minimum periods in which a power generation system with a grid connection point at the LV level must be able to operate without disconnection from the grid if the voltage deviates from reference value 1 p.u.</i></td><td></td><td>P</td></tr>
<tr><td></td><td>
<table>
<tr><th>Voltage range</th><th>Minimum period</th></tr>
<tr><td>0.85 p.u. – 0.9 p.u.</td><td>180 seconds</td></tr>
<tr><td>0.9 p.u. – 1.1 p.u.</td><td>unlimited</td></tr>
</table>
<i>Table 3: Minimum periods in which a power generation system with a grid connection point at the MV level must be able to operate without disconnection from the grid if the voltage deviates from reference value 1 p.u.</i></td><td>The grid-connected PV inverters under test were connected to LV distribution network.</td><td>N/A</td></tr>
<tr><td>5.3.2</td><td>Disconnection of the power generation system from the grid</td><td></td><td>P</td></tr>
<tr><td></td><td>With regard to voltage stability, power generation systems must be able to automatically disconnect from the grid when the voltage at the grid connection point reaches values specified by the relevant grid operator in coordination with the relevant TSO, as described in chapter 6.3.3 “Setting values for the grid decoupling protection”.</td><td></td><td>P</td></tr>
<tr><td>5.3.3</td><td>Reactive power capacity</td><td></td><td>P</td></tr>
<tr><td></td><td>The requirements for reactive power capacity apply at the grid connection point at the LV level at the terminals of the generator/converter. At the grid connection point at the MV level, the requirements for the reactive power capacity at the grid connection point shall apply.</td><td>The grid-connected PV inverters under test were connected to LV distribution network.</td><td>P</td></tr>
<tr><td></td><td>The power generation system must be able to be operated in the required reactive power ranges under normal stationary operating conditions regardless of the number of feeding phases.</td><td></td><td>P</td></tr>
</table>

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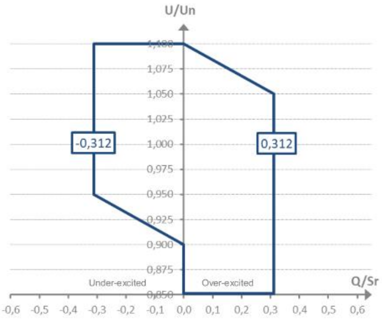
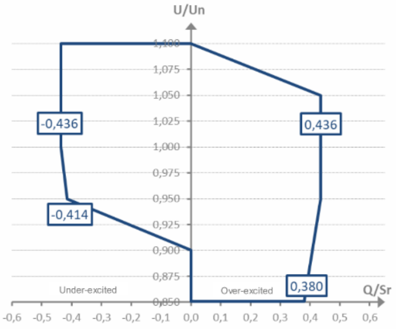
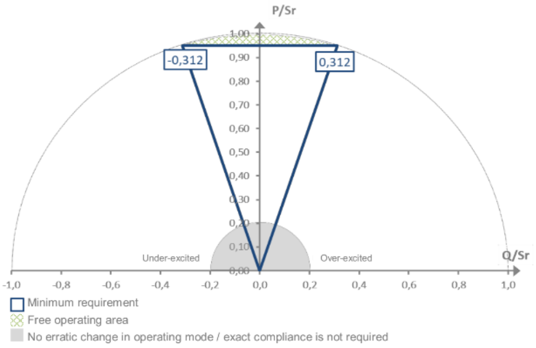
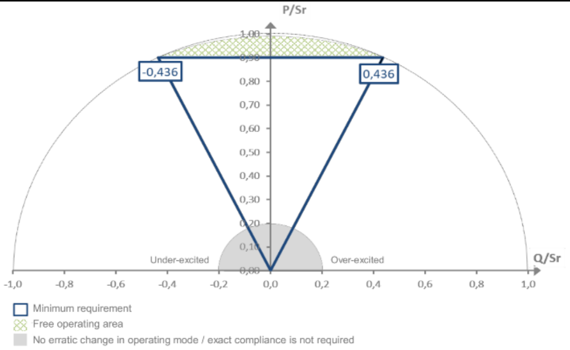
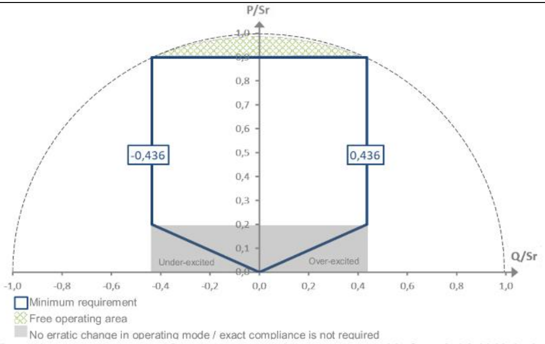
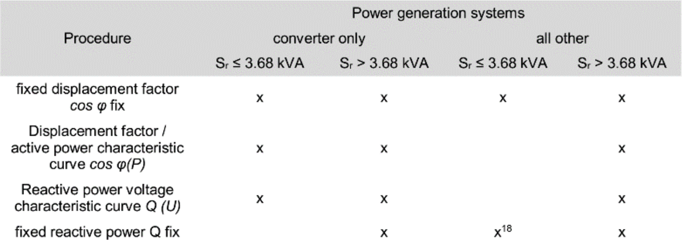
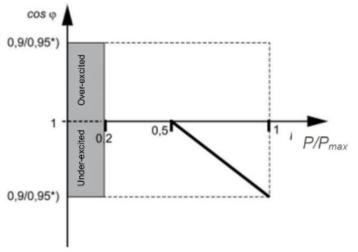
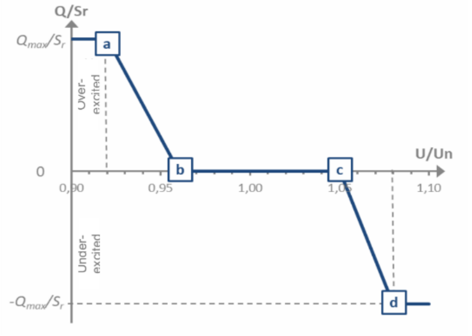
Clause	Requirement - Test	Result - Remark	Verdict
	The reactive power of the power generation system must be able to follow a procedure for the reactive power provision specified by the relevant grid operator in accordance with chapter 5.3.4 within the required reactive power ranges.		P
	The generator reference-arrow system (GRAS) is used for the following graphics.		P
5.3.3.1	Reactive power capacity at nominal apparent power or maximum capacity		N/A
	 *Figure 7: Reactive power range of power generation systems with S_r ≤3.68 kVA (without converter [16]) at nominal apparent power*	Single-phase inverter with $S_r > 3.68$ kVA.	N/A
	 *Figure 8: Reactive power range of power generation systems at nominal apparent power (except power generation systems with S_r ≤3.68 kVA without converter)*		P
	Power generation systems (except power generation systems with $S_r \leq 3.68$ kVA without converter) must be able to cover a displacement factor of cos φ = 0.9 underexcited to cos φ = 0.9 overexcited ($Q_{max} = \pm 0.436$ S_r) at nominal apparent power Sr. In the operational ranges $Q/P_{max} > 0$ and U/p.u. < 0.85 (overexcited operation and undervoltage) or $Q/P_{max} < 0$ and U/p.u > 1.1 (underexcited operation and overvoltage), the power generation system should still be able to provide voltage support.		P
5.3.3.2	Reactive power capacity below the nominal apparent power or maximum capacity		P

Clause	Requirement - Test	Result - Remark	Verdict
	 *Figure 9: Reactive power range of power generation systems with S_r ≤3.68 kVA (without converter) below the nominal apparent power*	The output power of grid-connected PV inverters under test more than 3.68 kVA.	N/A
	 *Figure 10: Reactive power range of power generation systems with S_r ≤3.68 kVA (only converter) below the nominal apparent power*	The output power of grid-connected PV inverters under test more than 3.68 kVA.	N/A
	 *Figure 11: Reactive power range of power generation systems with S_r > 3.68 kVA below the nominal apparent power* *P is the active power of the power generation system in W; Q is the reactive power of the power generation system in var and S_r is the nominal apparent power of the power generation system in VA.*		P
	For power generation systems with Sr > 3.68 kVA without converter, there is the possibility of a further limitation of the reactive power range below the nominal apparent power if value ranges (e.g. below the minimum excitation limit) cannot be reached due to the limits in the PQ diagram of the generator. These inadmissible operating ranges are omitted from the reactive power range according to figure 11. However, the basic design of the generator must always be based on the displacement factor according to chapter 5.3.3.1.		N/A
	In the operational range P < 0.2 S_r, the reactive power behaviour of the power generation system must not change abruptly; exact compliance with the specification is not required in this operational range (grey area in the figure).		P

Clause	Requirement - Test	Result - Remark	Verdict
	If a minimum displacement factor cos φ can be set in this operational range for power generation systems with converters and S_r > 3.68 kVA, cos φ = 0.4 should be selected.		P
	For power generation systems that can be operated stably for an unlimited period of time only above a minimum active power, 0.2 P_{max} is to be replaced by this minimum power for stable operation.		P
5.3.3.3	Reactive power compensation		N/A
	Power generation systems with grid connection point at MV level		N/A
	The relevant grid operator can request that additional reactive power be provided if the grid connection point is neither at the terminals of the grid transformer at the MV level nor at the terminals of the converter (generator) if there is no grid transformer. This additional reactive power must cover the reactive power requirement of the MV line or the MV cable between the terminals of the power transformer of the power generation system or, if there is no power transformer, between the terminals of the converter (generator) and the grid connection point and must be provided by the grid user.	The grid-connected PV inverters under test were connected to LV distribution network.	N/A
	Power generation systems with compensation requirement		N/A
	Power generation systems that have a reactive power requirement (e.g. asynchronous generators) that should not be covered by the distribution system require a device for reactive power compensation (e.g. capacitors). The type, power and circuit of the reactive power compensation system as well as the type of control and the degree of compensation (see TOR main section D1) must be coordinated with the grid operator.		N/A
	Compensation capacitors must not be connected before the generator or must be switched off at the same time. It should be noted that when the power generation system is disconnected from the distribution system, the generator may be self-excited by the compensation capacitors in certain circumstances, which must be avoided by a suitable circuit.		N/A
	If the power generation system has a heavily fluctuating reactive power requirement, the reactive power compensation must be adjusted accordingly. Overcompensation without specification by the grid operator must be avoid-ed. Additional measures (e.g. choking of compensation capacitors) may be necessary to avoid resonances and inadmissible repercussions on the grid operator's audio frequency ripple control systems. The type and scope of such measures are specified in the TOR main section D3.		N/A
5.3.4	Procedure for reactive power provision		P

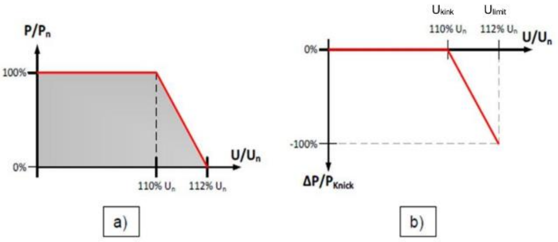
<table>
<tr><th colspan="4">TOR Erzeuger</th></tr>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>The reactive power of the power generation system must, within its reactive power ranges in accordance with chapter 5.3.3, automatically adjust to the specific fixed value or the specific characteristic curve determined by the relevant grid operator as part of the procedure for providing reactive power.</td><td></td><td>P</td></tr>
<tr><td></td><td>For power generation systems, one of the following procedures for providing reactive power is specified by the grid operator:</td><td></td><td>P</td></tr>
<tr><td></td><td>
<table>
<tr><th rowspan="3">Procedure</th><th colspan="4">Power generation systems</th></tr>
<tr><th colspan="2">converter only</th><th colspan="2">all other</th></tr>
<tr><th>$S_r \leq 3.68$ kVA</th><th>$S_r > 3.68$ kVA</th><th>$S_r \leq 3.68$ kVA</th><th>$S_r > 3.68$ kVA</th></tr>
<tr><td>fixed displacement factor *cos φ* fix</td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>Displacement factor / active power characteristic curve *cos φ(P)*</td><td>x</td><td>x</td><td></td><td>x</td></tr>
<tr><td>Reactive power voltage characteristic curve *Q (U)*</td><td>x</td><td>x</td><td></td><td>x</td></tr>
<tr><td>fixed reactive power Q fix</td><td></td><td>x</td><td>x[18]</td><td>x</td></tr>
</table>
Table 4: Intended procedures for providing reactive power for power generation systems</td><td></td><td>P</td></tr>
<tr><td></td><td>A procedure for providing reactive power is specified in the grid connection contract. In justified cases, a different procedure may also be specified by the relevant grid operator at a later point in time. This change must be implemented by the grid user within 12 months.</td><td></td><td>P</td></tr>
<tr><td></td><td>The default setting without the grid operator's specification is a fixed displacement factor cos φ = 1 and a fixed reactive power Q fix = 0.</td><td></td><td>P</td></tr>
<tr><td>5.3.4.1</td><td>Default characteristic curve for the procedure for providing reactive power cos φ (P) in the low-voltage network</td><td>(See appended table)</td><td>P</td></tr>
<tr><td></td><td>The cos φ (P) control should be deactivated by default.</td><td></td><td>P</td></tr>
<tr><td></td><td>

*) depending on the required Q capability
Figure 12: Displacement factor / active power characteristic curve cos φ(P) in the low-voltage network
cos φ is the displacement factor of the power generation system; P is the active power of the power generation system in W; P_{max} is the maximum capacity of the power generation system in W; S_{max} is the maximum apparent power of the power generation system in VA.</td><td></td><td></td></tr>
<tr><td>5.3.4.2</td><td>Default characteristic curve for the procedure for providing reactive power Q(U) in the low-voltage network</td><td></td><td>P</td></tr>
</table>

<table>
<tr><th colspan="4">TOR Erzeuger</th></tr>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>

<i>Figure 13: Reactive power / voltage characteristic curve Q(U) in the low-voltage network</i>
<i>Q is the reactive power of the power generation system in var; Q_{max} is the maximum reactive power in the overexcited range;</i>
<i>$-Q_{max}$ is the maximum reactive power in the underexcited range; S_r is the nominal apparent power of the power generation system in VA; U is the operating voltage and U_n is the nominal voltage.</i></td><td>(See appended table)</td><td>P</td></tr>
<tr><td></td><td>The following default setting of the four interpolation points is recommended:

<table>
<tr><th>Interpolation point</th><th>U/U_n</th><th colspan="2">Q/S_r</th></tr>
<tr><td>a</td><td>0.92 U_n</td><td>Q_{max}/S_r</td><td>$\cos \varphi_{min}$ overexcited</td></tr>
<tr><td>b</td><td>0.96 U_n</td><td>0</td><td>$\cos \varphi = 1$</td></tr>
<tr><td>c</td><td>1.05 U_n</td><td>0</td><td>$\cos \varphi = 1$</td></tr>
<tr><td>d</td><td>1.08 U_n</td><td>$-Q_{max}/S_r$</td><td>$\cos \varphi_{min}$ underexcited</td></tr>
</table>
<i>Table 5: Interpolation points of the reactive power / voltage characteristic curve Q(U) in the low-voltage network</i></td><td></td><td>P</td></tr>
<tr><td></td><td>As part of the procedure for the reactive power control Q(U), the interpolation points (minimum 4) of the Q(U) characteristic curve must be freely parametrisable in the reactive power and the voltage in the range according to chapter 5.3.3.1 (step size ≤ 1% U_n). Unless each phase is regulated individually, the highest phase voltage must be regulated symmetrically. The same reference-arrow system must apply to P and Q during setup.</td><td></td><td>P</td></tr>
<tr><td></td><td>The dynamics of the Q(U) control corresponds to a filter of the first order (PT1 element) with a configurable time constant between 3 s and 60 s, whereby a time constant of 5 s must be set by default. At least 95% of a new setpoint must be reached within the triple time constant.</td><td></td><td>P</td></tr>
<tr><td></td><td>The Q(U) control must be activated after a setpoint jump after an initial time delay that is as short as possible (maximum 1 s). Any parametrisable artificial delay time must be deactivated or set to 0 s.</td><td></td><td>P</td></tr>
<tr><td>5.3.5</td><td>Voltage control of synchronous power generation systems</td><td></td><td>N/A</td></tr>
<tr><td>5.3.6</td><td>Voltage-regulated active power reduction</td><td></td><td>P</td></tr>
<tr><td></td><td>In order to comply with the upper limit value of the voltage according to ÖVE/ÖNORM EN 50160, the grid operator of power generation systems with a grid connection point in the low voltage network may require a voltage-regulated active power reduction</td><td></td><td>P</td></tr>
<tr><td></td><td>The application and specifications for the P(U) control are agreed upon in the grid connection contract. The P(U) controls integrated in the inverter must be used.</td><td></td><td>P</td></tr>
<tr><td></td><td>The grid user can choose between two procedures for voltage-regulated active power reduction:</td><td></td><td>P</td></tr>
</table>

Clause	Requirement - Test	Result - Remark	Verdict
	a) For the P(U) active power operating range, the maximum permissible active power output is limited according to figure 14 (a) depending on the voltage. If the U_{kink} voltage is exceeded, the permissible maximum value of 100% of the rated active power is linearly reduced to 0 at U_{limit}		P
	b) The voltage-regulated active power reduction is implemented by a P(U) characteristic curve. If the U_{kink} voltage is exceeded, the feed-in power is reduced linearly by ΔP based on the current feed-in power P_{kink} (active power at the time when U_{kink} is exceeded) according to figure 14 (b).		P
	 *Figure 14: Default settings of the P(U) control* *P is the active power of the power generation system in W; P_n is the nominal active power of the power generation system in W; U is the operating voltage in V; U_n is the nominal voltage of the grid in V; U_{kink} is the operating voltage in V at which the P(U) control starts; U_{limit} is the operating voltage in V at which the active power should have been completely reduced; ΔP is the change in active power in W; Pkink is the active power at the time when U_{kink} is exceeded in W.*		P
	For power generation systems with converters and grid connection point at low voltage level, the P(U) control should be active by default and configured according to figure 14 point a).		P
	The dynamics of the P(U) control corresponds to a filter of the first order (PT1 element) with a configurable time constant between 3 s and 60 s, whereby a time constant of 5 s must be set by default. 95% of a new setpoint must be reached within the triple time constant.		P
	The P(U) control must be activated after a setpoint jump after an initial time delay that is as short as possible (maximum 3 s). Any parametrisable artificial delay time must be deactivated or set to 0 s.		P
	Unless otherwise agreed between the grid operator and the grid user, the measurement point for the implementation of these requirements is the generator terminal or connection point of the inverter.		P
	The setting values U_{kink} and U_{limit} can also be set differently in agreement with the grid operator, in particular to account for the execution of the energy dissipation in the grid user's system. The regulation must not cause vibrations or jumps in the output power.		P
	Power generation systems that can only be operated above a minimum output (e.g. internal combustion engines) must reduce the active power only up to this minimum output according to procedure a) or b).		N/A
5.4	**Grid management and system protection requirements**		P
5.4.1	Active power specification of the grid operator		P

Clause	Requirement - Test	Result - Remark	Verdict
	The power generation system must have a telecontrol interface (input port), which enables to terminate the active power output within 5 seconds after the corresponding instructions have been received.		P
	The grid operator shall not intervene in the control of the power generation system. It is only responsible for the signalling - see also chapter 6.2.1 “Remote control or telecontrol interface”. The active power output may be changed according to the technical capacities of the power generation system under the sole responsibility of the system operator.		P
	The relevant grid operator is entitled to temporarily specify or limit the active power up to shut down in the following (technical) cases: – to avert an immediate, even suspected danger to people or property; – if this is necessary due to compliance with official orders, requirements, etc.; – where the provision of network services is prevented due to force majeure or other circumstances beyond control of the grid operator; – where measures are taken by transmission system operators in accordance with the TOR system protection plan to avoid major disruptions and mitigate their effects; – in the event of an impending or already occurring system collapse; – when performing maintenance work on the grid.		P
	These measures including the rationale shall be duly documented by the grid operator in a suitable form (e.g. entry in the logbook) and the system operators concerned shall be provided information upon request.		P
5.4.2	Simulation models and simulation parameters		N/A
	There are no requirements for power generation systems in this regard		N/A
5.4.3	System protection		N/A
	Power generation systems with a grid connection point at MV level must comply with the specifications of the national system protection plan in accordance with Article 11 ER-VO or TOR system protection plan.		N/A
5.5	**Synchronisation and grid recovery requirements**		P
5.5.1	Synchronisation devices		P
	Power generation systems must be equipped with a synchronisation device.		P
	Power generation systems must be able to be synchronised within the frequency ranges specified in Table 1.		P

Clause	Requirement - Test	Result - Remark	Verdict
	Power generation systems (with the exception of asynchronous generators) or off-grid networks with systems of grid users with integrated power generation systems which are not switched on without voltage may only be connected to the grid via synchronisation devices or only after a check has been carried out to ensure frequency synchronism and voltage equality between the grid and systems of grid users.		P
	For off-grid power generation systems (including electrical energy storage devices), asynchronous restarting must be prevented after grid failure and voltage recovery.		P
	If grid decoupling protection and synchronisation devices are implemented in a common device, faulty synchronisation must be prevented (e.g. by means of a test switch) when feeding in analogue test quantities for the protection test.		P
	For inverters with built-in grid synchronisation, the built-in frequency and voltage equalisation replaces a synchronisation device implemented in a separate device.		P
	The settings of the synchronisation devices must be adapted to the operating conditions of the grid and are specified by the grid operator.		P
5.5.2	Connection conditions		P
	The following conditions apply to the (automatic) grid connection after an unintentional disconnection, both due to the faulty operation of a power generation system and due to a grid disturbance.		P
	It must be possible to connect power generation systems automatically to the grid. The grid connection may only be made if the following conditions are met: – U/p.u. ≥ 0.85 and U/p.u. ≤ 1.09; and – grid frequency between 47.5 Hz and 50.10 Hz; and – there is no triggering criterion of the grid decoupling protection. The waiting time must always be adjustable between 0 and 300 seconds. If the grid operator does not specify a different waiting time, a waiting time of 60 seconds is recommended.		P
	After automatic connection to the grid in the event of faulty operation, the active power delivered to the grid must not exceed the gradient of 10% P_{max} per minute. In order to reach the minimum performance level for stable operation, the grid user and the relevant grid operator may agree to different gradients in accordance with Chapter 5.4.1 “Active power specification by the grid operator”.		P
	The following default settings are recommended for non-synchronous power generation systems with inverters and grid connection point at the low voltage level:		P
	– Waiting time for automatic or operation-related connection: 60 s – Waiting time for connection after the decoupling protection has been tripped: 300 s		P

TOR Erzeuger			
Clause	Requirement - Test	Result - Remark	Verdict
	10% P_{max} per minute is recommended as the setting for the maximum gradient of the active power increase in case of a reconnection after a tripping of the decoupling protection. As a rule, non-self-excited asynchronous generators may only be switched on in the range from 95% to 105% of their synchronous speed. If the maximum permissible voltage drop is exceeded when connecting, appropriate measures for current limitation must be provided (see TOR part D2).		P
	When a power generation system is connected to the grid or when compensation devices are switched on or off, the grid of the relevant grid operator must not be influenced in an non-permitted way (see TOR Part D2).		N/A
	As a rule, non-self-excited asynchronous generators may only be switched on in the range from 95% to 105% of their synchronous speed. If the maximum permissible voltage drop is exceeded when connecting, appropriate measures for current limitation must be provided (see TOR part D2).	Not asynchronous generators.	N/A
5.5.3	Black start capability		N/A
	There are no requirements for power generation systems in this regard.		N/A
5.5.4	Island operation capability		N/A
	There are no requirements for power generation systems in this regard.		N/A
5.5.5	Fast resynchronisation		N/A
	There are no requirements for power generation systems in this regard.		N/A
5.6	**Requirements regarding data exchange**		N/A
	There are no requirements regarding the transmission of real-time data, unavailability data and schedules to the relevant grid operators.		N/A
6	**DESIGN OF THE SYSTEM AND PROTECTION**		P
6.1	**Primary technology**		P
6.1.1	Connection system and symmetry		P
	The connection system is the physical connection between the system of a grid user and the grid system *(network side)*. It begins at the *technically suitable connection point (network access point)* and ends at the property line agreed in the grid connection contract. The grid operator is responsible for the operationally ready construction, modification and extension of the connection system; the grid user is responsible for the parts of the system located after the property line.	The grid operator and the plant owner are responsible for this.	N/A
	Power generation systems, including any electrical energy storage devices, must be designed as symmetrical three-phase systems, permanently connected to the grid and equipped with an appropriate switching and decoupling point.		P
	Supply via a touch-proof plug connection is permissible if the system as a whole is expressly approved for such use.		P

Clause	Requirement - Test	Result - Remark	Verdict
	As an exception, power generation systems can also be connected to the distribution grid in single phase, taking into account a maximum resulting unsymmetrical power of 3.68 kVA. A maximum of 3 x 3.68 kVA single-phase (distributed over the three outer conductors) can therefore be connected.		N/A
	If a symmetrical supply of the power generation units into the individual outer conductors of the three-phase grid is ensured by a communicative coupling between single-phase power generation units, the power generation system is to be regarded as a symmetrical three phase power supply.		N/A
	When using DC-coupled systems (electrical energy storage devices together with DC generation system connected to the same inverter), up to three single-phase inverters with a maximum of 3.68 kVA each may also be connected to the three-phase outer conductors.		N/A
	When using AC-coupled systems (electrical energy storage devices including AC converter and generation system connected on the AC side), the following case distinction applies to avoid inadmissible asymmetries in the grid:		P
	– Case 1: Single-phase supply, single-phase storage Since storage systems are generally used to maximise internal consumption, it is currently assumed that the storage systems do not feed back into the grid. In this case, to achieve minimum asymmetry, the generation system and the inverter of the electrical energy storage device must be connected to the same phase.	Three-phase hybrid inverter.	N/A
	– Case 2: Single-phase supply, three-phase storage or vice versa The apparent power of a single-phase connected inverter, an electrical energy storage device or a single-phase connected power generation unit may be 3.68 kVA and a maximum of 3 single-phase devices divided between the three phases may be connected.	Three-phase hybrid inverter.	N/A
	– Case 3: Three-phase supply, three-phase storage. The permissible degree of asymmetry according to TOR D2 of the AC-coupled system is limited with a value of k_u = 0.7%.	Three-phase hybrid inverter.	P
6.1.2	Switching point		N/A
	For reasons of operational management and personal safety, a switching point with isolating function and load switching capacity must be available to the grid operator at all times. It serves to comply with the five safety rules according to ÖVE/ÖNORM EN 50110-1 and can be identical with the decoupling point.	The grid operator and the plant owner are responsible for this.	N/A
	In low-voltage grids, the switching point can be omitted if the inverters are equipped with an automatic disconnection point in accordance with ÖVE Guideline R 25, and the grid-effective rated power of the grid user at the grid connection point does not exceed 30 kVA		N/A
6.1.3	Decoupling point		P

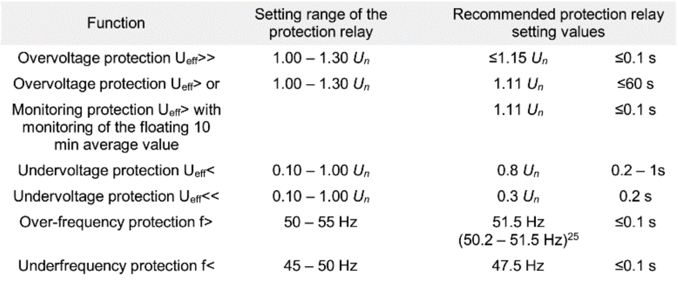
Clause	Requirement - Test	Result - Remark	Verdict
	The decoupling point ensures that the power generation system is disconnected from the grid. The switching device of the decoupling point (decoupling switch) is actuated by the protection device (decoupling protection) and trips automatically if one of the protection functions of the protection device responds.		P
	The decoupling point must be determined in agreement with the grid operator and can be provided on the high or low-voltage side. The switching device of the decoupling device must be able to be triggered electrically instantaneously and provide all-pole galvanic isolation.		P
	If isolated operation is not planned, the decentralised switching devices of the individual power generation units (generator circuit breaker, integrated switching devices of the automatic disconnection point) can be used as decoupling points.		P
	In off-grid power generation systems with a grid connection point in the low-voltage grid, a four-pole disconnection may be necessary and may be required by the grid operator. In this case, the safety regulations for the separation and earthing of a PEN conductor must be observed in particular.		P
	The switching device of the decoupling point must have a minimum load switching capacity and be designed for the maximum short-circuit power to be disconnected.		P
	If fuses are used for short-circuit protection, the switching capacity of the switching device must be rated at least in accordance with the operating range of the upstream fuse. However, the switching device must be suitable for switching on the power generation system and for switching off the maximum possible generation capacity.		N/A
	It must be possible to check the function of the switching devices of the decoupling point. This check can be omitted for automatic disconnection points according to chapter 6.3.1.		P
6.1.4	Neutral point treatment		P
6.1.4.1	Grid connection in the low-voltage grid		P
	Asynchronous generators are generally operated in delta connection. The neutral point must be operated isolated in a star connection.	Not asynchronous generators	N/A
	Synchronous power generation systems can be operated with isolated neutral point. In the case of synchronous power generation systems whose neutral point is connected to the PEN conductor of the grid, this may only be done directly if the harmonics current occurring via the neutral point is less than approx. 20% of the rated current of the generator. Higher currents may require the installation of a neutral point choke or other measures.	Not synchronous Power generation systems	N/A
6.1.4.2	Grid connection in the medium-voltage grid	Not connected to the medium-voltage grid.	N/A
	The devices for earthing the neutral point on the grid side of power transformers must comply with the specifications of the relevant grid operator.		N/A
6.2	**Secondary technology**		P

TOR Erzeuger			
Clause	Requirement - Test	Result - Remark	Verdict
6.2.1	Remote control or telecontrol interface		P
	The telecontrol interface for active power cut-off in accordance with chapter 5.4.1 and for any reactive power specification in accordance with chapter 5.3.4 must be implemented in the form of potential-free contacts, if provided for by the relevant grid operator in the grid connection contract, which are made available to the grid operator on the telecontrol device (e.g. radio ripple control receiver, gateway). Any requirements for the devices for the transmission of real-time data according to chapter 5.6 are agreed between the relevant grid operator and grid user.		P
6.2.2	Backup systems for communication		N/A
	There are no requirements for power generation systems in this regard		N/A
6.2.3	Control systems and settings		P
	For non-synchronous power generation systems with inverters and grid connection point at low voltage level, it must be ensured that the settings described in this part of the TOR cannot be changed by the grid user and that they are protected against unauthorised changes. Software updates must not lead to a change in settings. This can be achieved, for example, by appropriate password protection of the settings. The password must not be given to the user.		P
	If the actual set values deviate from the recommended default settings, this should be indicated on the device or shown on the display or when the settings are read out (e.g. via an interface).		P
6.2.4	Measuring instruments		N/A
	The RfG Regulation does not contain any requirements in this regard for power generation systems.		N/A
6.3	**Protection devices and grid decoupling protection**		P
	The relevant grid operator must define the systems and settings necessary to protect the grid, taking into account the characteristics of the power generation systems. The protection systems required for the power generation system and the grid and the settings relevant to the power generation system are coordinated and agreed between the relevant grid operator and the grid user. The protection systems and settings for internal electrical faults must not jeopardise the required performance of a power generation system.		P
	The electrical protection of the power generation system has priority over operational regulations, whereby the safety of the grid, the health and safety of employees and the public and the limitation of any damage to the power generation system must be considered.		P

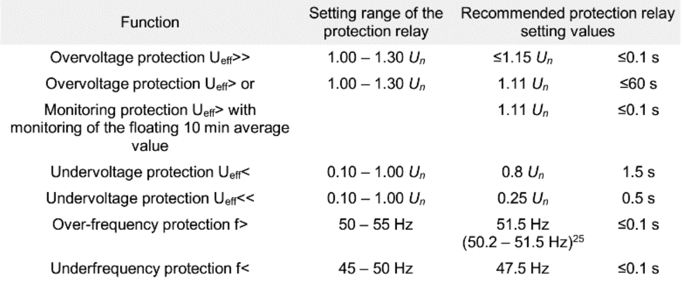
Clause	Requirement - Test	Result - Remark	Verdict
	Taking into account the previous paragraph, the settings of the protection devices must be selected in such a way that they support the grid operation and ensure that grid faults must always be disconnected first from the grid protection devices selectively to the smallest possible extent. Power generation units may only be switched off as the last objects in the event of a grid fault and only in case of danger (end time schedule).		P
	In principle, the selection, scope and functions of the electrical protection devices of power generation units (generator protection) are solely at the discretion and responsibility of the system operator. When making the selection, the selectivity and compatibility with the grid protection devices must be taken into account.		P
	Significant changes in the operating conditions must be met by a timely review and adaptation of the protection concept.		P
6.3.1	General information on the grid coupling protection		P
	The provisions of this chapter do not refer to the protection measures for the power generation system or power generation units (generator protection), but exclusively to the protection functions of the grid decoupling protection.		P
	The protection device actuates the central or the decentralised decoupling switch if one of the protection functions in the protection device trips in the event of faulty operating states.		P
	In principle, a central protection device must be provided as separate electrical equipment.		N/A
	Up to a grid-effective rated power of a maximum of 30 kVA per grid connection point of a grid user in the low-voltage grid, automatic disconnection points in accordance with ÖVE Guideline R 25 can also be used. The method used to protect against decoupling is left to the system operator.		P
	The basic mode of operation of the protection devices and the interlocking devices is shown in the functional examples in Appendix A2.		P
	Tripping of the decoupling point by the protection devices need only be effective if the power generation system is operated in parallel with the grid.		P
	The individual protection functions of the protection device can be implemented in individual devices or in a joint device.		P
	The protection functions can be implemented either in a hardware separate from the system control or in a common hardware. This also applies to equipment for connection control and connection release. If the protection functions are performed separately from the system control, the trip contacts of the protection devices must be wired directly to the switching device of the decoupling point.		P

TOR Erzeuger			
Clause	Requirement - Test	Result - Remark	Verdict
	A shunt opening release of the switching device of the decoupling point must not be operated with or dependent on the grid voltage or the generator voltage. Undervoltage releases in closed circuit, which are operated with the grid voltage or the generator voltage, may be used. Failure of the auxiliary voltage or the response of the self-monitoring of the protection device must lead to tripping of the decoupling switch. This requirement applies equally to independent protection devices and to combined devices in which protection functions and control functions are implemented in a common hardware.		P
	It must be possible to check the protection functions by setting analogue values (current, voltage). This check can be omitted for automatic disconnection points according to chapter 6.3.1.		P
	The grid operator can seal the protection devices or protect them in another way against unwanted changes or have them protected in another way (e.g. code word protection).		P
	Additional protection and safety regulations for power generation systems, which represent a switchable supply alternative to the general power supply, are contained in ÖVE-EN 1 part 4 Section 53 or OVE E 8101-5-551 or OVE E 8101-7-717 and OVE guideline R 20. Compliance with the criteria regarding the quality of supply for island operation in the system of the grid user is the responsibility of the system operator.		P
	Replacement power supply systems which can feed into a grid-supplied consumer system and which are not equipped for grid parallel operation must be equipped with an interlocked changeover device (changeover with interruption).		P
	Power generation systems for purely island operation (e.g. power generation systems in the systems of the grid user without grid connection or replacement power supply systems) are not subject to these conditions.		P
6.3.2	Protective functions of the protection device for the decoupling point		P
6.3.2.1	Voltage protection functions.		P
	The voltage protection functions must meet the accuracy of ≤ 1% in the range from 45 Hz to 55 Hz and be three-phase with adjustable tripping delay. (For exception, see Table 8: Setting values for the decoupling protection of inverters with automatic disconnection point).		P
	In medium-voltage grids with insulated or inductively earthed neutral point, the voltages between the outer conductors are monitored; in low-voltage grids, the voltages of the outer conductors are monitored against the neutral conductor.		P
	The response values must be adjustable in steps of ≤ 0.5% U_n. The time delay must be adjustable at least in the range from 0 s to approx. 180 s with a step of 0.05 s.		P

TOR Erzeuger			
Clause	Requirement - Test	Result - Remark	Verdict
	The use of multi-stage relays offers the advantage of a better adaptation of the tripping values to the grid conditions. – Undervoltage protection U< or U<< The undervoltage protection trips when one of the three measuring elements detects that the voltage has fallen below the set threshold, i.e. the measuring elements are logically OR-linked. The disengaging ratio must be adjustable in the range from 1.01 U_n to 1.05 U_n. – Overvoltage protection U> or U>> The overvoltage protection is activated when one of the three measuring elements detects that the set threshold value has been exceeded, i.e. the measuring elements are logically OR-linked. The disengaging ratio must be adjustable in the range from 0.95 U_n to 0.99 U_n.		P
6.3.2.2	Frequency protection functions		P
	The frequency protection must be independent of voltage at least in the range from 0.7 U_n to 1.3 U_n. The measuring time must be shorter than 100 ms; any time delay must be able to be set to “undelayed”. The response values must be adjustable with a step of ≤ 0.2 Hz and the measuring accuracy must be ≤ 50 mHz. The frequency protection functions can be single-phase or three-phase. In isolated and compensated networks only phase-to-phase voltages are to be evaluated. – Under-frequency protection f< – Over-frequency protection f>		P
6.3.2.3	Reactive power undervoltage protection (Q+ & U<)		N/A
	This point applies only to power generation systems connected to the grid at MV level.	Not connected to MV network	N/A
	The reactive power undervoltage protection (Q+ & U<) disconnects the power generation system from the grid after 0.5 s if the voltage at the grid connection point is < 0.85 U_n or U_c and if the power generation system simultaneously absorbs reactive power from the grid of the grid operator. Always use the phase-to-phase voltages for voltage measurement. The trips of the three measuring elements are logically AND-linked.		N/A
	The protection monitors the system-compatible behaviour of the power generation system after a fault in the grid. Power generation systems that hinder the restoration of the grid voltage by absorbing inductive reactive power from the distribution grid or by insufficient voltage support are disconnected from the grid before the end time of the grid protection devices is reached.		N/A
6.3.2.4	Earth fault protection (U_e>)		P
	The grid operator can require an earth fault detection in order to be able to disconnect the power generation system from the grid in the event of an earth fault or to prevent it from being connected. Setting ranges: 0 to 70% voltage shift in a time range from 0 to 180 s		P

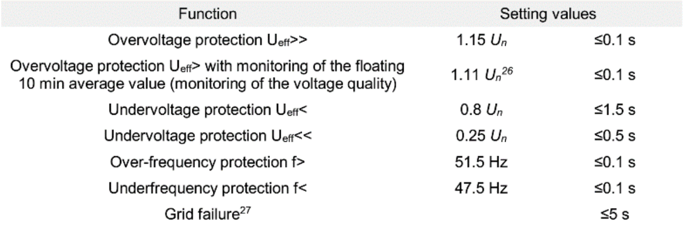
<table>
<tr><th colspan="4">TOR Erzeuger</th></tr>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td>6.3.2.5</td><td>In some cases, the use of additional protection functions may be necessary to ensure the decoupling function or for secure grid operation.</td><td></td><td>P</td></tr>
<tr><td>6.3.3</td><td>Setting values for the grid decoupling protection</td><td></td><td>P</td></tr>
<tr><td></td><td>Within the framework of the overall protection concept, the grid operator determines the setting values for the grid decoupling protection and can, if necessary, make modifications to achieve the protection goals. In principle, this is done in coordination with the operator of the power generation system and in consideration of its technical possibilities.</td><td></td><td>P</td></tr>
<tr><td></td><td>The setting values of the voltage protection functions must be referred to the nominal voltage U_n (for low voltage) or to the agreed supply voltage U_c (for medium and high voltage).</td><td></td><td>P</td></tr>
<tr><td></td><td>If a synchronous power generation system or a non-synchronous power generation system which is not operated with restricted dynamic grid support is connected to a grid which is operated with an automatic restart (ARS) in an upstream grid, the tripping threshold and tripping time of the grid decoupling protection must be measured in such a way that in the event of an arc fault on this line the arc can extinguish in the remaining voltage-free pause and a sufficiently long deionisation time is given.</td><td></td><td>N/A</td></tr>
<tr><td></td><td>If complete dynamic grid support or activated LV FRT (Low Voltage Fault Ride Through) is required, longer setting times for the undervoltage protection may be required than those specified in the following tables.</td><td></td><td>P</td></tr>
<tr><td></td><td>A total tripping time of the individual protection functions, including the intrinsic time of the switching device in the decoupling point of maximum 0.2 s must be achievable</td><td></td><td>P</td></tr>
<tr><td>6.3.3.1</td><td>Setting values for the grid decoupling protection in the low-voltage grid</td><td></td><td>P</td></tr>
<tr><td></td><td>The following setting values are recommended as the basic setting of the grid decoupling protection for synchronous power generation systems:

<table>
<tr><th>Function</th><th>Setting range of the protection relay</th><th colspan="2">Recommended protection relay setting values</th></tr>
<tr><td>Overvoltage protection $U_{eff}>>$</td><td>1.00 – 1.30 U_n</td><td>≤1.15 U_n</td><td>≤0.1 s</td></tr>
<tr><td>Overvoltage protection $U_{eff}>$ or</td><td>1.00 – 1.30 U_n</td><td>1.11 U_n</td><td>≤60 s</td></tr>
<tr><td>Monitoring protection $U_{eff}>$ with monitoring of the floating 10 min average value</td><td></td><td>1.11 U_n</td><td>≤0.1 s</td></tr>
<tr><td>Undervoltage protection $U_{eff}<$</td><td>0.10 – 1.00 U_n</td><td>0.8 U_n</td><td>0.2 – 1s</td></tr>
<tr><td>Undervoltage protection $U_{eff}<<$</td><td>0.10 – 1.00 U_n</td><td>0.3 U_n</td><td>0.2 s</td></tr>
<tr><td>Over-frequency protection f></td><td>50 – 55 Hz</td><td>51.5 Hz
(50.2 – 51.5 Hz)[25]</td><td>≤0.1 s</td></tr>
<tr><td>Underfrequency protection f<</td><td>45 – 50 Hz</td><td>47.5 Hz</td><td>≤0.1 s</td></tr>
</table>
Table 6: Setting values for the grid decoupling protection of synchronous power generation systems in the low-voltage grid</td><td></td><td>N/A</td></tr>
</table>

<table>
<tr><td></td><td>The following setting values are recommended as basic settings of the grid decoupling protection for non-synchronous systems:



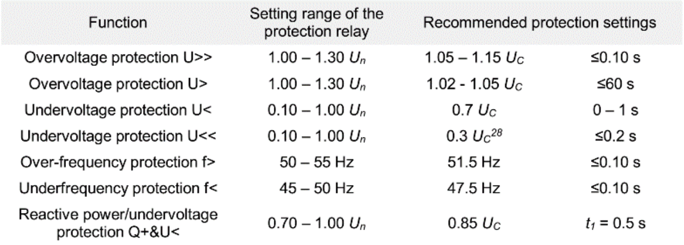
<table>
<tr><th>Function</th><th>Setting range of the protection relay</th><th colspan="2">Recommended protection relay setting values</th></tr>
<tr><td>Overvoltage protection U_{eff}>></td><td>1.00 – 1.30 U_n</td><td>≤1.15 U_n</td><td>≤0.1 s</td></tr>
<tr><td>Overvoltage protection U_{eff}> or</td><td>1.00 – 1.30 U_n</td><td>1.11 U_n</td><td>≤60 s</td></tr>
<tr><td>Monitoring protection U_{eff}> with monitoring of the floating 10 min average value</td><td></td><td>1.11 U_n</td><td>≤0.1 s</td></tr>
<tr><td>Undervoltage protection U_{eff}<</td><td>0.10 – 1.00 U_n</td><td>0.8 U_n</td><td>1.5 s</td></tr>
<tr><td>Undervoltage protection U_{eff}<<</td><td>0.10 – 1.00 U_n</td><td>0.25 U_n</td><td>0.5 s</td></tr>
<tr><td>Over-frequency protection f></td><td>50 – 55 Hz</td><td>51.5 Hz
(50.2 – 51.5 Hz)[25]</td><td>≤0.1 s</td></tr>
<tr><td>Underfrequency protection f<</td><td>45 – 50 Hz</td><td>47.5 Hz</td><td>≤0.1 s</td></tr>
</table>

Table 7: Setting values for the grid decoupling protection of non-synchronous power generation systems in the low-voltage grid</td><td></td><td>N/A</td></tr>
<tr><td></td><td>If inverters with limited dynamic grid support according to 5.2.2.1 are used with an automatic disconnection point according to chapter 6.3.1, it must be ensured that they can be switched off under the grid conditions specified in Table 8.



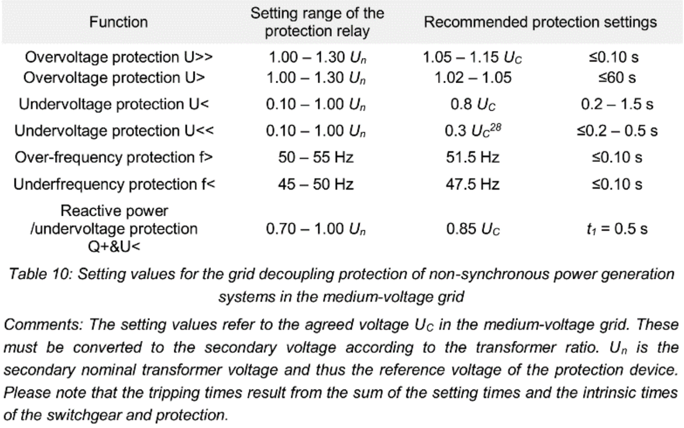
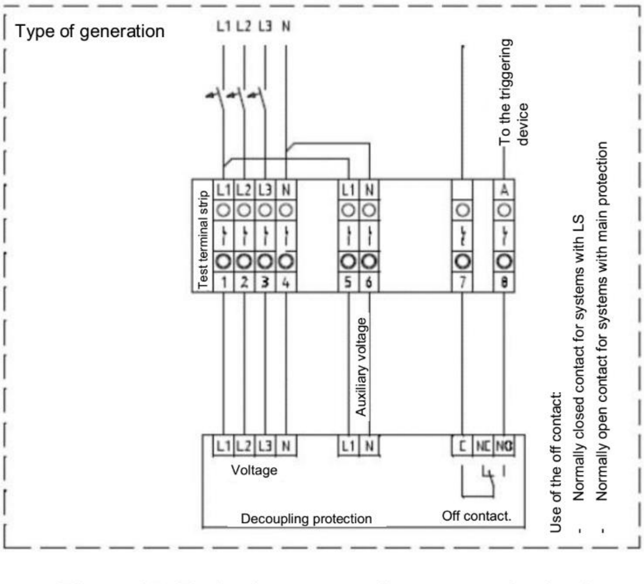
<table>
<tr><th>Function</th><th colspan="2">Setting values</th></tr>
<tr><td>Overvoltage protection U_{eff}>></td><td>1.15 U_n</td><td>≤0.1 s</td></tr>
<tr><td>Overvoltage protection U_{eff}> with monitoring of the floating 10 min average value (monitoring of the voltage quality)</td><td>1.11 U_n[26]</td><td>≤0.1 s</td></tr>
<tr><td>Undervoltage protection U_{eff}<</td><td>0.8 U_n</td><td>≤1.5 s</td></tr>
<tr><td>Undervoltage protection U_{eff}<<</td><td>0.25 U_n</td><td>≤0.5 s</td></tr>
<tr><td>Over-frequency protection f></td><td>51.5 Hz</td><td>≤0.1 s</td></tr>
<tr><td>Underfrequency protection f<</td><td>47.5 Hz</td><td>≤0.1 s</td></tr>
<tr><td>Grid failure[27]</td><td></td><td>≤5 s</td></tr>
</table>

Table 8: Setting values for the decoupling protection of inverters with automatic disconnection point</td><td></td><td>P</td></tr>
<tr><td>6.3.3.2</td><td>Setting values for grid decoupling protection in the medium-voltage grid</td><td>Not connected to the medium-voltage grid.</td><td>N/A</td></tr>
<tr><td></td><td>The following setting values are recommended as the basic setting of the grid decoupling protection for synchronous power generation systems:



<table>
<tr><th>Function</th><th>Setting range of the protection relay</th><th colspan="2">Recommended protection settings</th></tr>
<tr><td>Overvoltage protection U>></td><td>1.00 – 1.30 U_n</td><td>1.05 – 1.15 U_C</td><td>≤0.10 s</td></tr>
<tr><td>Overvoltage protection U></td><td>1.00 – 1.30 U_n</td><td>1.02 - 1.05 U_C</td><td>≤60 s</td></tr>
<tr><td>Undervoltage protection U<</td><td>0.10 – 1.00 U_n</td><td>0.7 U_C</td><td>0 – 1 s</td></tr>
<tr><td>Undervoltage protection U<<</td><td>0.10 – 1.00 U_n</td><td>0.3 U_C[28]</td><td>≤0.2 s</td></tr>
<tr><td>Over-frequency protection f></td><td>50 – 55 Hz</td><td>51.5 Hz</td><td>≤0.10 s</td></tr>
<tr><td>Underfrequency protection f<</td><td>45 – 50 Hz</td><td>47.5 Hz</td><td>≤0.10 s</td></tr>
<tr><td>Reactive power/undervoltage protection Q+&U<</td><td>0.70 – 1.00 U_n</td><td>0.85 U_C</td><td>t_1 = 0.5 s</td></tr>
</table>

Table 9: Setting values for the grid decoupling protection of synchronous power generation systems in the medium-voltage grid</td><td></td><td>N/A</td></tr>
</table>

<table>
<tr><td></td><td>The following setting values are recommended as the basic setting of the grid decoupling protection for non-synchronous power generation systems:
<table>
<tr><th>Function</th><th>Setting range of the protection relay</th><th colspan="2">Recommended protection settings</th></tr>
<tr><td>Overvoltage protection U>></td><td>1.00 – 1.30 U_n</td><td>1.05 – 1.15 U_C</td><td>≤0.10 s</td></tr>
<tr><td>Overvoltage protection U></td><td>1.00 – 1.30 U_n</td><td>1.02 – 1.05</td><td>≤60 s</td></tr>
<tr><td>Undervoltage protection U<</td><td>0.10 – 1.00 U_n</td><td>0.8 U_C</td><td>0.2 – 1.5 s</td></tr>
<tr><td>Undervoltage protection U<<</td><td>0.10 – 1.00 U_n</td><td>0.3 U_C[28]</td><td>≤0.2 – 0.5 s</td></tr>
<tr><td>Over-frequency protection f></td><td>50 – 55 Hz</td><td>51.5 Hz</td><td>≤0.10 s</td></tr>
<tr><td>Underfrequency protection f<</td><td>45 – 50 Hz</td><td>47.5 Hz</td><td>≤0.10 s</td></tr>
<tr><td>Reactive power /undervoltage protection Q+&U<</td><td>0.70 – 1.00 U_n</td><td>0.85 U_C</td><td>t_1 = 0.5 s</td></tr>
</table>
<i>Table 10: Setting values for the grid decoupling protection of non-synchronous power generation systems in the medium-voltage grid</i>
<i>Comments: The setting values refer to the agreed voltage U_C in the medium-voltage grid. These must be converted to the secondary voltage according to the transformer ratio. U_n is the secondary nominal transformer voltage and thus the reference voltage of the protection device. Please note that the tripping times result from the sum of the setting times and the intrinsic times of the switchgear and protection.</i></td><td></td><td>N/A</td></tr>
<tr><td>6.3.4</td><td>Test terminal strip</td><td></td><td>P</td></tr>
<tr><td></td><td>To carry out the functional test of the protection devices, a terminal strip with longitudinal separation and test sockets must be provided as an interface, which must be installed at an easily accessible location. The measuring inputs of the protection devices, the auxiliary voltages and the releases for the section switch must be routed via this terminal strip (see Figure 15).</td><td></td><td>P</td></tr>
<tr><td></td><td>The test terminal strip can be omitted for systems with automatic disconnection point according to chapter 6.3.1.

<i>Figure 15: Typical structure of a test terminal strip</i></td><td></td><td>P</td></tr>
<tr><td>7</td><td colspan="2">OPERATING PERMIT PROCEDURE</td><td>Info.</td></tr>
</table>

TOR Erzeuger			
Clause	Requirement - Test	Result - Remark	Verdict
	The (future) grid user must demonstrate to the relevant grid operator that they meet the requirements set out in chapter 5 “Behaviour of the power generation system in the grid” and chapter 6 “Execution of the system and protection” as well as the project-specific requirements stipulated in the grid connection contract and runs through the operating permit procedures for the connection described for each power generation system.		Info.
	The commissioning and the first parallel operation of the power generation system within the scope of the operating permit procedure may only be carried out in coordination with the relevant grid operator.	The grid operator and the plant owner are responsible for this.	Info.
	The basic procedure for the operating permit procedure is described in Annex A4. The relevant grid operator must declare and publish the details of the operating permit procedure. The operating permit procedure for the connection of each new power generation system includes the submission of an installation document. The grid user must ensure that the required details are entered in an installation document provided by the relevant grid operator and submitted to the latter.		Info.
	The installation document contains general data, technical data and proof of the conformity of the power generation system according to chapter 8.1. The template for an installation document is given in Annex A5.		Info.
	A separate installation document must be provided for each power generation system within the overall power generation installation. If several identical power generation systems/units have been installed in the course of an overall project, the submission of a single installation document is sufficient.		Info.
	The relevant grid operator must ensure that the required information can be provided by third parties on behalf of the grid user.		Info.
	After the acceptance of the complete and appropriate installation document for power generation systems, the relevant grid operator must grant the grid user the operating permit.		Info.
	The grid user must ensure that the relevant grid operator is notified of the permanent decommissioning of a power generation system. The relevant system operator must ensure that third parties, including aggregators, can make such notification.		Info.
8	**CONFORMITY**		P
8.1	**Proof of conformity**		P
	The grid user must provide proof of the conformity of the power generation system within the framework of the operating permit procedure by submitting the following documents: – Test report of the grid decoupling protection or the protection device of an authorised person/company (except systems with automatic disconnection point and corresponding test report). – Confirmation of contractually compliant installation by the system constructor and the grid user;		P

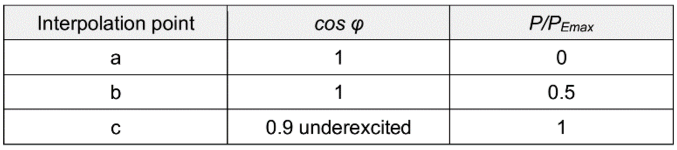
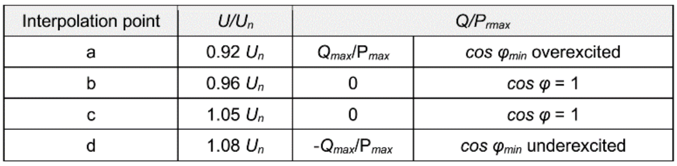
Clause	Requirement - Test	Result - Remark	Verdict
	At the request of the relevant grid operator, the grid user must also provide one or more of the following documents as part of the operating permit procedure: – CE declarations of conformity for devices or electrical equipment (depending on the applicability e.g. according to EN 61000-3-2 and EN 61000-3-3 or EN 61000-3-11 and EN 61000-3-12); – Test reports of a qualified person/company for automatic disconnection points in power generation systems with a grid connection point at LV level according to ÖVE regulation R 25, or – Test reports of a test centre accredited according to ÖVE/ÖNORM EN ISO/IEC 17025 for this specialist area for converter-based power generation systems with grid connection point at LV level in accordance with test standard ÖVE Guideline R 25, which also includes documentation of or a manufacturer's parameterisation manual with the country settings “Austria” (see *Appendix A3*) has been confirmed, or – Test reports of a test centre accredited according to ÖVE/ÖNORM EN ISO/IEC 17025 for this specialist area for converter-based power generation systems with grid connection point at LV level according to VDE-AR-N 4105 or DIN VDE V 0124-100, provided that the system installer or a qualified electrician confirms that a setup with the country settings “Austria” - see *Appendix A3* - was carried out under consideration of deviating specific grid operator specifications; – Confirmation by the system installer or a qualified electrician for power generation systems with converters and grid connection point at LV level that a setup with the country settings “Austria” - see *Appendix A3* - was carried out taking into account deviating specific grid operator requirements.		P
	Instead of carrying out the relevant checks, tests and simulations (in whole or in part), grid users can demonstrate compliance with the relevant requirement by means of equipment certificates issued by an authorised certification body. In this case, the equipment certificates must be submitted to the relevant grid operator.		P

Clause	Requirement - Test	Result - Remark	Verdict
	The grid operator reserves the right to be present when the following points are checked: – Separation function of the switching point and control of accessibility; – Protective devices of the decoupling point by specification of analogue test variables and creation of a test report with response values and tripping times; – Triggering of the decoupling switching device by the grid decoupling protection; – Switching on and off as well as functional testing of any compensation devices; – Compliance with the limits of the system perturbations; – Compliance with the connection conditions; – Reactive power and voltage regulation; – Where appropriate, relevant operational measuring equipment.		P
	The test report of the test of the protection functions of the grid decoupling protection device must include at least the following checks: – The trip and disengaging values of the protection functions by feeding in of analogue test variables; – The trip times of the protection functions; – The tripping of the switching device of the decoupling point by the protection functions.		P
	When using an automatic disconnection point according to chapter 6.3.1 the inspection must be carried out according to the instructions of the testing institute or the manufacturer.		P
	The relevant grid operator must publicly disclose how the responsibilities for compliance testing and simulation are shared between the grid user and the grid operator.		P
8.2	***Conformance testing and conformance simulations***		N/A
8.2.1	Responsibility of the grid user		N/A
	The grid user must ensure that each power generation system complies with the requirements set out in this part of the TOR throughout its lifetime.	Responsibility of the grid user.	N/A
	To this end, the grid user must regularly (in workplaces in accordance with the required intervals of periodic inspections in accordance with ESV 2012; otherwise, however, at least every 5 years) draw up the information specified in Annex A8 and provide this information and documents to the relevant grid operator on request.		N/A
	The grid user may use equipment certificates issued in accordance with regulation (EC) No.765/2008 here.		N/A
	The grid user must inform the relevant grid operator of any planned change to the technical capabilities of a power generation system that could affect the fulfilment of the requirements under this part of the TOR before initiating such a change.		N/A
	The grid user must inform the relevant grid operator of any malfunction or breakdown of a power generation system affecting compliance with the requirements of this part of the TOR immediately upon its occurrence.		N/A

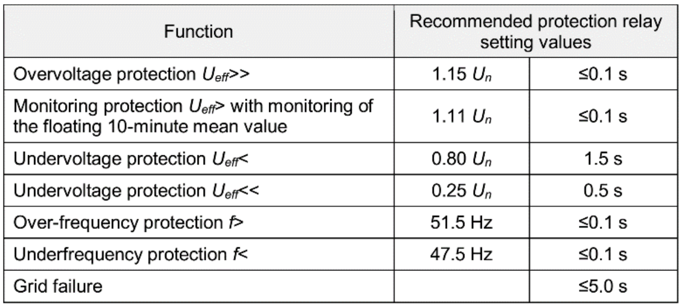
Clause	Requirement - Test	Result - Remark	Verdict
8.2.2	Tasks of the relevant grid operator		N/A
	The relevant grid operator must publicly disclose how the responsibilities for monitoring compliance are divided between the grid user and the grid operator.		N/A
	The relevant grid operator must verify throughout the lifetime of the overall power generation installation that a power generation system complies with the requirements under this part of the TOR. The grid user must be informed of the result of this check.		N/A
	In individual cases and after reasonable advance notice, the grid operator is also entitled to carry out on-site inspections, in particular of the grid decoupling protection.		N/A
	If the grid user regularly creates the information and documents listed in chapter 8.2.1 and presents it to the grid operator on request, it is assumed that the obligation according to Art. 41 (1) RfG regulation has been fulfilled.		N/A
	The relevant grid operator may rely on equipment certificates issued by an authorised certification body for this test.		N/A
9	**OPERATION**		N/A
9.1	**General**		N/A
	The operation of electrical systems according to ÖVE/ÖNORM EN 50110-1 includes all activities that are necessary for the electrical system to function. This includes switching, control, monitoring and maintenance as well as electrical and non-electrical work.		N/A
	When operating the connection system, the provisions and guidelines of the grid operator must be observed in addition to the applicable statutory and official regulations, in particular for switching operations and work at the grid connection point.	The grid operator and the plant owner are responsible for this.	N/A
	For example, a contract to be concluded between the operator of the power generation system and the grid operator should include the following points: – Definition of property lines and, if applicable, limits of the area of responsibility (e.g. area of availability, operational management area, access authorisations) between grid operator and grid operator must be defined, – Designation of a system operator with overall responsibility for the safe operation of the electrical system according to ÖVE/ÖNORM EN 50110-1, – Type and manner of the functionality of the grid decoupling protection and the decoupling switching devices (e.g. repeat tests), type and manner of document tests, – Supplementary agreements on the exchange of information, – Procedure for work necessary for operation and planned shutdowns in the grid, – The operator of a power generation system must name at least one person authorised to carry out switching operations at the switching point		N/A
9.2	**Access to the connection system**		N/A

TOR Erzeuger			
Clause	Requirement - Test	Result - Remark	Verdict
	The relevant grid operator must be granted access to the switching point, to the grid operator’s facilities (e.g. metering equipment) and to the parts of the connection system within their area of responsibility after consultation with the system operator.		N/A
9.3	**Operation on site**		N/A
	For power generation systems with a grid connection point at MV level		N/A
	The grid operator orders the switching operations for the system components within their exclusive area of disposal (switching instructions). If switching devices are located in the joint area of authority of the grid operator and system operator, the grid operator and system operator or their representatives coordinate the switching operations in these switching fields and determine who orders the switching operation in each specific case. The switching operations for the other parts of the system are ordered by the system operator or their representative. Operating actions are only carried out by order of the person authorised to dispose of the system (grid operator and/or system operator). Operation may only be carried out by qualified electricians or persons trained in electrical engineering.		N/A
9.4	**Maintenance**		N/A
	The grid user is responsible for the proper maintenance of the power generation system and its operating equipment.	Grid user is responsible for this.	N/A
	The system operator must carry out the corresponding system checks at regular intervals in accordance with the legal requirements and regulations. In particular, the system operator must have the protection and decoupling devices tested by a person authorised to do so and must make the corresponding test results available to the grid operator free of charge on request.		N/A
	When using automatic disconnection points according to chapter 6.3.1 the inspection must be carried out in accordance with the instructions of the testing institute or the manufacturer.		N/A
	The system operator must agree with the grid operator on releases in the grid operator’s area of authority in good time.		N/A
9.5	**Operation during maintenance or grid disturbances**		N/A
	In the event of planned shutdowns of grid equipment by the grid operator as well as in case of maintenance-related changes in the switching status, it may be necessary to temporarily disconnect the power generation system from the grid or to reduce its output. Such work is to be carried out with reasonable advance notice.		N/A

Clause	Requirement - Test	Result - Remark	Verdict
	The grid operator is entitled to disconnect the power generation system from the grid in case of immediate danger and in case of malfunction. Due to the fact that the voltage can return at any time in the event of an interruption in the grid supply, the grid must be considered as permanently live. Usually, the grid operator does provide notification before reconnecting the grid.	The grid operator and the plant owner are responsible for this.	N/A
10	**Metering**		N/A
10.1	**General**		N/A
	All tasks in connection with metering and data provision must be performed by the grid operator in compliance with the statutory provisions, in particular the ElWOG 2010 and the Measurement and Verification Act 1950 (MEG) as amended, the General Terms and Conditions of the relevant grid operator, TOR Part F “Metering and metering transmission” and other market rules, in particular chapter 6 “Metering, data formats and standardised load profiles”, according to transparent, objective and non-discriminatory criteria.		N/A
10.2	**Equipment for metering and measurement**		N/A
	The equipment for metering and measurement must be designed according to the requirements of the relevant grid operator.		N/A
	The class accuracy of the transformer cores or transformer windings for metering must correspond to the class accuracy of the metering devices required in TOR part F. At each metering/measurement point, the grid operators generally measure active and reactive energy in each direction (supply and consumption) as well as active and reactive power. The standard applied by the grid operator must be observed when carrying out the setup for metering/measurement and transfer of the relevant data.		N/A
Annex	**In the event of contradictions in content between the main part of this TOR (points 0 to *10*) and the annexes (Annex A1 to A8) the content of the main part takes precedence over the annexes. This only applies insofar as the respective content of the annexes has not been declared binding by law or regulation**		
A1.	**Applicability and scope of data exchange**		Info.
	This annex will be supplemented following the publication of the SOGL Data Exchange V		Info.
A2.	**Functional examples of Grid decoupling protection**		Info.
A3.	**Setting values for inverters on low-voltage distribution networks**		P
	The uniform specification of setting values for converter-based power generation systems for connection and parallel operation with low-voltage distribution networks aims to increase planning reliability on the part of manufacturers, installers of electrical systems and the relevant grid operators. In particular, this is intended to prevent incorrect settings and the associated possible impairment of the operational security of the grids.		P

<table>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>The default values described in this annex are a collection of guide values that can be summarised as part of a set of settings in the inverter. All parameters must be individually adjustable. Before the initial commissioning of the system, the parameters deviating from the default setting must be set accordingly according to the specifications of the grid operator.</td><td></td><td>P</td></tr>
<tr><td></td><td>If the actual set values deviate from the recommended default setting, this should be indicated on the device or shown on the display or when reading out the settings (e.g. via an interface).</td><td></td><td>P</td></tr>
<tr><td></td><td>Reactive power range of inverters</td><td></td><td>P</td></tr>
<tr><td></td><td>The reactive power of the inverter must be freely adjustable within the reactive power range according to 5.3.3.2 and follow a control strategy specified by the relevant grid operator. If a minimum cos φ can be set on the inverter for the operating range $P < 0.2\ S_r$, cos φ = 0.4 must be selected.</td><td></td><td>P</td></tr>
<tr><td></td><td>According to point 5.3.4, for power generation systems with converters, one of the following procedures for reactive power supply is specified by the grid operator:
1a. Fixed displacement factor cos φ fix;
1b. Displacement factor/active power characteristic curve cos φ (P);
1c. Reactive power voltage characteristic curve Q (U);
1d. Fixed reactive power Q fix
As a default setting without any specification by the grid operator, a fixed displacement factor of cos φ = 1 or a fixed reactive power of Q = 0 should be set.</td><td></td><td>P</td></tr>
<tr><td>1a.</td><td colspan="2">Fixed displacement factor cos φ fix</td><td>P</td></tr>
<tr><td></td><td>The default parameter is cos φ = 1.</td><td></td><td>P</td></tr>
<tr><td>1b.</td><td colspan="2">Displacement factor/active power characteristic curve cos φ (P)</td><td>P</td></tr>
<tr><td></td><td>For cos φ (P)-control, the following standard values are recommended for setting the interpolation points of the characteristic curve:

<table>
<tr><th>Interpolation point</th><th>cos φ</th><th>P/P_{Emax}</th></tr>
<tr><td>a</td><td>1</td><td>0</td></tr>
<tr><td>b</td><td>1</td><td>0.5</td></tr>
<tr><td>c</td><td>0.9 underexcited</td><td>1</td></tr>
</table></td><td></td><td>P</td></tr>
<tr><td>1c.</td><td colspan="2">Reactive power voltage characteristic curve Q (U)</td><td>P</td></tr>
<tr><td></td><td>For Q(U)-control, the following standard values are recommended for setting the interpolation points of the characteristic curve.

<table>
<tr><th>Interpolation point</th><th>U/U_n</th><th colspan="2">Q/P_{rmax}</th></tr>
<tr><td>a</td><td>$0.92\ U_n$</td><td>Q_{max}/P_{max}</td><td>$\cos \varphi_{min}$ overexcited</td></tr>
<tr><td>b</td><td>$0.96\ U_n$</td><td>0</td><td>$\cos \varphi = 1$</td></tr>
<tr><td>c</td><td>$1.05\ U_n$</td><td>0</td><td>$\cos \varphi = 1$</td></tr>
<tr><td>d</td><td>$1.08\ U_n$</td><td>$-Q_{max}/P_{max}$</td><td>$\cos \varphi_{min}$ underexcited</td></tr>
</table></td><td></td><td>P</td></tr>
</table>

<table>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>A value of 5 s (corresponding to the time constant of a first-order filter (PT1 behaviour)) must be set as the setting for the dynamics of the Q(U)-control. Within the triple time constant, 95 % of a new target value must be reached.</td><td></td><td>P</td></tr>
<tr><td></td><td>The Q(U) control must be activated after a setpoint jump after an initial time delay that is as short as possible (maximum 1 s). Any artificial delay time that can be parameterised must be deactivated or set to 0 s.
Note:
The time constant of Q(U)-control must be adjustable independently of the time constants of other control functions (e.g. P(U)-control).</td><td></td><td>P</td></tr>
<tr><td>1d.</td><td colspan="2">Fixed reactive power Q fix</td><td>P</td></tr>
<tr><td></td><td>A fixed reactive power of Q = 0 is recommended as the standard parameter</td><td></td><td>P</td></tr>
<tr><td>2.</td><td colspan="2">Standard settings for active power control</td><td>P</td></tr>
<tr><td>2a.</td><td colspan="2">Active power reduction at over-frequency LFSM-O</td><td>P</td></tr>
<tr><td></td><td>The active power reduction at over-frequency (LFSM-O) according to point 5.1.3 must be activated for inverters by default.
The following default values must be set for the LFSM-O control.
<table>
<tr><td>Start of power reduction from</td><td>50.2 Hz</td></tr>
<tr><td>Statics s_2</td><td>5% (corresponds to 40% PM/Hz)</td></tr>
</table>
The dynamics of the LFSM-O control must be set so that a response time of <2 s is achieved. Any additional delay time that can be set must be deactivated or set to 0 s.</td><td></td><td>P</td></tr>
<tr><td>2b.</td><td colspan="2">Voltage controlled active power control P(U)</td><td>P</td></tr>
<tr><td></td><td>The voltage-regulated active power control<i>(P(U)-control)</i> according to point 5.3.6 should be standardly active for inverters at delivery.
<table>
<tr><th>For <i>P(U)-control</i>, the following standard values apply for setting the interpolation points of the characteristic curve:</th><th>U/U_n</th><th>P/P_n</th></tr>
<tr><td>Interpolation point a</td><td>110% U_n</td><td>100%</td></tr>
<tr><td>Interpolation point b</td><td>112% U_n</td><td>0%</td></tr>
</table>
The dynamics of the <i>P(U)-control</i> corresponds to a first-order filter (PT1 behaviour), with a configurable time constant between 3s and 60s, whereby a time constant of 5s must be set as default. 95% of a new setpoint must be reached within the triple time constant.
The <i>P(U)</i> control must be activated after a setpoint jump after an initial time delay that is as short as possible (maximum 3 s). Any artificial delay time that can be parameterised must be deactivated or set to 0 s.</td><td></td><td>P</td></tr>
<tr><td></td><td>Note: The dynamics of the time constant of P(U)-control must be adjustable independently of other control functions (e.g. Q(U)-control).</td><td></td><td>P</td></tr>
<tr><td>3.</td><td colspan="2">Standard settings for the FRT capability</td><td>P</td></tr>
<tr><td></td><td>With regard to their FRT capability, inverters should be set so that voltage dips with a residual voltage U < 0.8 Un are passed through without feeding in a current (limited dynamic grid support according to point 5.2.2.1).</td><td></td><td>P</td></tr>
</table>

Clause	Requirement - Test	Result - Remark	Verdict
4.	**Default settings for the connection conditions**		P
	For connection to the grid according to point 5.5.2, the following setting values (connection conditions) are recommended: – U ≥ 0.85 p.u. and U ≤ 1.09 p.u.; and – Grid frequency >47.5 Hz and <50.10 Hz; The following values are recommended as settings for the minimum waiting time – For automatic or operation-related connection: 60 s – In the event of connection after a tripping of the decoupling protection: 300 s A gradient of 10 % P_{max} per minute is recommended as the setting for the maximum gradient of the active power increase in case of a reconnection after a tripping of the decoupling protection.		P
5.	**Default settings for the grid decoupling protection**		P
	The following setting values are recommended as basic settings of the grid decoupling protection for non-synchronous systems in the low-voltage grid: 		P

Function	Recommended protection relay setting values	
Overvoltage protection U_{eff}>>	1.15 U_n	≤0.1 s
Monitoring protection U_{eff}> with monitoring of the floating 10-minute mean value	1.11 U_n	≤0.1 s
Undervoltage protection U_{eff}<	0.80 U_n	1.5 s
Undervoltage protection U_{eff}<<	0.25 U_n	0.5 s
Over-frequency protection *f*>	51.5 Hz	≤0.1 s
Underfrequency protection *f*<	47.5 Hz	≤0.1 s
Grid failure		≤5.0 s

	Password protection for setting values		P
	For the settings described in this annex, it must be ensured that they cannot be modified by the user and that they are protected against unauthorised changes. Software updates must not lead to a change in settings. This can be achieved, for example, by appropriate password protection of the settings. The password must not be given to the user.		P
A4.	**Basic procedure for the operating permit procedure**		Info.
A5.	**Templates for installation or verification documents**		Info.
A6.	**Description of the conformity tests and simulations**		N/A
A7.	**Technical characteristics and parameters for simulation models**		N/A
A8.	**Information and documentation on conformity monitoring**		Info.
	Recurrent inspections must be carried out in accordance with or based on § 7 (3) (1) ESV 2012 (at least checking the function of residual current protection devices).		Info.

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Clause	Requirement - Test	Result - Remark	Verdict
5	**TESTING**		P
	All tests must be carried out with the setup of the country setting Austria or a setting according to a manufacturer's parameterization guide for Austria.	Default country settings of Austria see General product information part.	P
5.1	**Testing the network perturbations**		P
	This section serves to demonstrate the requirements of TOR D2.		P
5.1.1	General		P
	Network interference in the sense of this guideline are: – Rapid voltage changes; – Flicker; – Harmonics, harmonics and higher frequencies up to 9 kHz. For systems that feed from a DC voltage source via an inverter (e.g. PV systems, battery storage systems), the tests in accordance with Section 5.1 may only be carried out on the inverter and the system controller. To do this, it must be ensured that the selection of the DC voltage source does not affect the specific system properties	(See appended table)	P
5.1.2	Fast voltage changes		P
5.1.2.1	Target		P
	These tests serve to demonstrate the requirements of TOR D2, Section 9.2.3. The following operating cases (if applicable) must be checked: – Switch on at power <10% P_n, or minimum possible power; – Switching on at nominal active power; – Switching operations when switching between generator stages (if applicable); – Switch off at nominal active power (no emergency shutdown, but operational shutdown).	(See appended table)	P
5.1.2.2	Test method		P
	The following tests must be carried out in the four cases mentioned above: – Measurements of the time profiles for currents and phase-neutral voltages, three measurements each; – Determine the one-period effective values of the current and the voltage.		P
5.1.2.3	Evaluation method		P
	The switching current factor k_i must be calculated for each switching operation according to the following equation: $k_i = \frac{I_{max}}{I_n}$ I_{max}: largest current measured during the switching process (eg pull-in or switch-on current or the largest operational switch-off current); I_n: Rated current		P

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Clause	Requirement - Test	Result - Remark	Verdict
	For the k_{imax} value, the maximum value is determined from three measurements per switching operation.		P
5.1.2.4	Documentation		P
	At least it should be noted: a) measuring devices used; b) Frequency; c) Single-period RMS values of current and voltage; d) all k_i-values; e) e) k_{imax}-value.	(See appended table)	P
5.1.3	Flicker		P
5.1.3.1	General		P
	These tests serve to demonstrate the requirements of TOR D2, Section 9.2.4. The aim of the test is to determine the flicker coefficient $c_{\Psi k}$.		P
5.1.3.2	Testing		P
	Compliance with the limit values specified in TOR D2, Section 9.2.4 must be demonstrated in accordance with ÖVE / ÖNORM EN 61000-3-3 or ÖVE / ÖNORM EN 61000-3-11 or in accordance with ÖVE / ÖNORM EN 61400-21.		P
	The flicker coefficient $c_{\Psi k}$ must be specified in accordance with the requirements of the test standard used. The network impedance or the network impedance angle result from the measurement method. These must be stated in the test report.		P
	The flicker coefficient $c_{\Psi k}$ is determined for continuous continuous operation without disruptions. The flicker coefficient is to be normalized to the nominal active power. The short circuit power S_k is to be related to a symmetrical short circuit of the test source for three-phase test objects, in the case of single-phase test objects to the single-phase short circuit power.		P
	For controllable EZE with nominal currents> 75 A, at least 12 measurements of 10 minutes each must be carried out. One measurement each within the 9 performance intervals [0%, 10%], [10%, 20%] to [80%, 90%] related to P_n and three measurements in the interval from 90% P_n to P_n. One measurement consists of determining the short-term flicker strength P_{st} as a 3-phase (phase L1, L2 and L3). For non-controllable EZE, a tuple must be determined for the adjustable working points and P_n.	The tested PV inverter may be used in EZA with nominal currents> 75 A.	P
	Alternatively, P_{lt} may be determined for each of the above measurements according to ÖVE / ÖNORM EN 61000-4-15		P
5.1.3.3	Evaluation method		P
	The maximum for all P_{st} should be selected as the value for the long-term flicker strength P_{lt}.		P

Clause	Requirement - Test	Result - Remark	Verdict
	The flicker coefficient $c_{\psi k}$ is determined on the basis of the previously measured P_{st} values according to the following formula: $c_{\psi k} = P_{st} \cdot \left(\frac{S_k}{P_n}\right)$ It is P_{st} Short-term flicker measured on the network replacement element; S_k Short-circuit power of the network replacement element (during the determination of the corresponding P_{st} values).		P
5.1.3.4	Documentation	(See appended table)	P
	It should be noted: – measuring devices used; – Output voltage of the network simulation; – Reference impedance; – Single-period RMS values of current and voltage; – the largest $C_{\psi k}$ - value determined; – P_{st}, P_{lt}.		P
5.1.4	Harmonics and interharmonics		P
5.1.4.1	General		P
	These tests serve to demonstrate the requirements of TOR D2, Section 9.2.5.		P
	The aim of the test is to determine the harmonic and intermediate harmonic currents and the higher-frequency harmonic currents between 2 kHz and 9 kHz (for generating units in systems larger than 75 A).		P
5.1.4.2	Tests		P
	Compliance with the limit values for harmonic currents must be demonstrated as follows: – with rated currents of the EZE ≤ 16 A per conductor according to ÖVE / ÖNORM EN 61000-3-2; – with rated currents of the EZE> 16 A and ≤ 75 A per conductor according to ÖVE / ÖNORM EN 61000-3-12. – for nominal currents of the EZE> 75 A and for EZE, which are intended for EZA with nominal currents>75 A according to ÖVE / ÖNORM EN 61000-4-7: 2010, Appendix A. The measurement of the higher-frequency harmonic currents between 2 kHz and 9 kHz must be in accordance with ÖVE / ÖNORM EN 61000-4-7: 2010, Appendix B.	(See appended table)	P
	The measurement according to ÖVE / ÖNORM EN 61000-4-7 may be carried out on a test voltage source of any impedance.		P
	The harmonic currents or currents of the interharmonics are determined for each 10% active power bin. The center points of the bins are to be chosen close to 0% P_n, 10% P_n, 20% P_n to 100% P_n of the EZE. If it is not possible to approach the aforementioned active power values due to the design, the possible active power values must be approached and measured.		P

Clause	Requirement - Test	Result - Remark	Verdict
	ÖVE / ÖNORM EN 61000-3-12 applies to the measuring method. According to ÖVE / ÖNORM EN 61000-4-7, the time window is ten cycles of the basic frequency. A suitable observation period should be selected in accordance with ÖVE / ÖNORM EN 61000-3-12.		P
5.1.4.3	Evaluation method		P
	The evaluation takes place: – with rated currents of the EZE ≤ 16 A per phase according to ÖVE / ÖNORM EN 61000-3-2; – with rated currents of the EZE> 16 A and ≤75 A per phase according to ÖVE / ÖNORM EN 61000-3-12; – for rated currents of the EZE> 75 A and for EZE, which are intended for EZA with rated currents> 75 A according to ÖVE / ÖNORM EN 61000-4-7: 2010, Appendix B; – Every harmonic, intermediate harmonic and every component of higher frequencies of the current is to be arithmetically averaged over the duration of the observation for each active power bin.		P
5.1.4.4	Documentation	(See appended table)	P
	At least it should be noted: a) measuring devices used; b) for measurements on EZE> 75 A as well as for EZE, which are intended for EZA with nominal currents>75 A additionally: – the reference impedance; – for each active power bin: the values of the individual current components and the total harmonic distortion in tables as percentages of I_n; – for each active power bin: the values of the individual current components for each phase of the harmonic sub-group according to ÖVE / ÖNORM EN 61000-4-7, the intermediate harmonic group according to ÖVE / ÖNORM EN 61000-4-7, the frequency bands in the range above the 40th harmonic up to 9 kHz according to ÖVE / ÖNORM EN 61000-4-7: 2010, Appendix B.		P
5.2	**Testing the symmetry behaviour of three-phase inverters**		P
5.2.1	General		P
	This section serves to demonstrate the requirements of the TOR generator, section 6.1.1.		P
	These tests do not apply to rotating generators that are directly connected to the distribution network. For all converter-linked systems, only the converter has to be checked.	Three-phase inverter.	P
5.2.2	Tests		P
	In the test laboratory, the test must be carried out under symmetrical voltage conditions at nominal voltage and with a symmetrical mains impedance.		P
	At least 5 measurements at nominal active power and 5 measurements at 50% of nominal active power must be carried out over a period of 1 minute each.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	These measurements must be carried out with the following reactive power specification: – cos φ = 1, – maximally underexcited, and – maximally overexcited.		P
	The following tests must also be carried out for communicatively coupled inverters:	Not communicatively coupled inverters.	N/A
	a) Failure of individual inverters The failure of the inverters is to be simulated at time t_0. At t_0 + 1 minute, the 1-minute mean value of the apparent power must be formed. The following measurements are to be carried out: – Maximum value measurement in the event of an inverter failure; – Measurements with an inverter failure at 100% nominal active power, cos φ = 1; Maximum value measurement in case of failure of two inverters in different phases: – Measurements with failure of two inverters in different phases at 100% nominal active power, cos φ = 1.		N/A
	b) Performance loss of individual inverters The inverters are to be operated with nominal active power and cos φ = 1. On the DC side of the inverters in one phase, the power must be reduced suddenly so that on the AC side, the power value in one phase drops by at least 3.68 kVA + 10%. The drop in power of the inverters must be simulated at time t_0. At t_0 + 1 minute, the 1-minute mean value of the apparent power must be formed. During the measurements, it must be ensured that the DC source does not limit the performance of the inverters. The measurement must be carried out five times. NOTE 5 The power-limited inverters of one phase can be replaced by a corresponding simulation of the communication device.		N/A
5.2.3	Evaluation method		P
	The asymmetry for an operating point, characterized by power and cos φ, must be calculated		P
	For each of the 5 measurements (1-minute averages) at the respective operating point, the maximum difference between the apparent powers of the three phases is determined. The maximum value is again determined from these 5 values. This maximum value is to be given for the following operating points: a) 100 % P_n ± 5 % P_n cos φ = 1; b) 100 % P_n ± 5 % P_n cos φ = maximally underexcited; c) 100 % P_n ± 5 % P_n cos φ = maximally overexcited; d) 50 % P_n ± 5% P_n cos φ = 1; e) 50 % P_n ± 5% P_n cos φ = maximally underexcited; f) 50 % P_n ± 5% P_n cos φ = maximally overexcited.		P
	For communicatively coupled inverters, the maximum asymmetry values from the individual measurements must also be determined.		N/A

Clause	Requirement - Test	Result - Remark	Verdict
	The test is passed if the maximum value from the above measurements a) to f) is that in the TOR generator, section 6.1.1. does not exceed the specified limit.		P
5.2.4	Documentation		P
	At least it should be noted: – all determined 1-minute averages, – the maximum values from the above measurements, – for communicatively coupled inverters: the maximum values of the 1-minute average values determined during the measurements.		P
5.3	**Test the behaviour of the generating unit on the network**		P
5.3.1	General		P
	Section 5.3 is used to demonstrate the requirements of the TOR generator, Section 5		P
5.3.2	Measurement of active and reactive power working area ("PQ diagram")		P
	These tests serve to demonstrate the adjustable reactive power range in accordance with the requirements of the TOR generators, Section 5.3.3.		P
5.3.2.1	Tests		P
	All tests must be carried out at the specified voltages.		P
	The EZE is operated in all possible of the following operating points, each operating point being held for at least 60 s after the settling process has subsided. During the partial measurements a) to c) below, the primary energy source must not limit the output.		P
	The measurements a) to c) are to be carried out at U_n, 0.86 U_n and 1.09 U_n. a) With cos φ = 1, the maximum active power possible at this operating point is set. b) At Q = 43.6% S_n underexcited operation, the maximum active power possible at this operating point is set. c) At Q = 43.6% S_n overexcited operation, the maximum active power possible at this operating point is set. d) With Q = 43.6% S_n underexcited operation, the active power is set to 20% to 30% of the active power determined under a). e) With Q = 43.6% S_n overexcited operation, the active power is set to 20% to 30% of the active power determined under a). f) At Q = 43.6% S_n underexcited operation, the active power is set to 10% to 20% of the active power determined under a). g) At Q = 43.6% S_n overexcited operation, the active power is set to 10% to 20% of the active power determined under a). h) With Q = 43.6% S_n underexcited operation, the active power is set to 0% to 10% of the active power determined under a). i) At Q = 43.6% S_n overexcited operation, the active power is set to 0% to 10% of the active power determined under a).	(See appended table)	P

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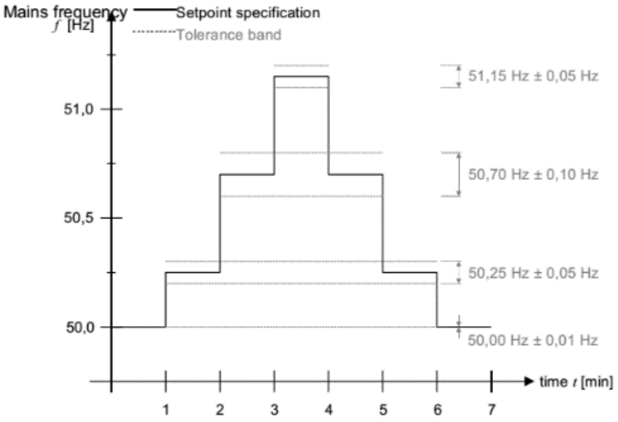
Clause	Requirement - Test	Result - Remark	Verdict
5.3.2.2	Evaluation method		P
	The 1-minute mean value of the active, apparent and reactive power as well as the associated voltage and cos φ value are determined from the measured values for each of the operating points.		P
	The tests are passed if the active and reactive power range corresponds to the requirements according to the TOR generator, section 5.3.3, depending on the respective power or the type of generating plant (converter based or without converter).		P
5.3.2.3	Documentation	(See appended table)	P
	At least it should be noted: – for all measured values from a) to i) for P and S with the associated voltage and cos φ values or reactive power values;		P
5.3.3	End of active power feed-in after OFF command via telecontrol interface (input port)		P
	These tests serve to demonstrate the requirements of the TOR generator, Section 5.4.1.		P
5.3.3.1	Tests		P
	For this test, the EZE is operated with an active power of at least 20% P_n.		P
	The command to terminate the active power feed-in is then given via the provided interface (input port) and the time until the actual termination of the active power feed-in is measured.		P
5.3.3.2	Evaluation method		P
	The test is passed if the EZE ends the active power feed within 5 s. The criterion is an active power feed-in<5% P_n. NOTE A separation of the EZE from the grid is permissible but not mandatory.		P
5.3.3.3	Documentation	(See appended table)	P
	The interface used and the time course of the active power feed-in must be documented.		P
5.3.4	Active power reduction at overfrequency		P
	These tests serve to demonstrate the active power reduction of the EZE at overfrequency according to the TOR generator, section 5.1.3. as well as the proof of the active power gradient after reconnection according to TOR generator, section 5.5.2		P
5.3.4.1	Tests		P
	The tests to prove the frequency-dependent active power feed-in of the EZE are to be carried out on a network simulator.		P
	Alternatively, the tests may be over a) an adjustment of the input signals on the control of the EZE, or b) the limit values (setpoints) are adjusted within the control of the EZE if the manufacturer declares the full functionality of the EZE control and feed at all required operating frequencies (47.5 Hz to 51.5 Hz).		P

Clause	Requirement - Test	Result - Remark	Verdict
	The following measuring points a) to g) must be approached (see Figure 3): a) 50,00 Hz ± 0,01 Hz; b) 50,25 Hz ± 0,05 Hz; c) 50,70 Hz ± 0,10 Hz; d) 51,15 Hz ± 0,05 Hz; e) 50,70 Hz ± 0,10 Hz; f) 50,25 Hz ± 0,05 Hz; g) 50,00 Hz ± 0,01 Hz; h) 51,65 Hz ± 0,05 Hz; i) 50,15 Hz + 0,01 Hz; j) 50,00 Hz ± 0,01 Hz.	(See appended table)	P
	The same frequency deviations must result from the application of the alternative test procedure by adjusting the limit values.  **Figure 3 - Testing active power feed-in at overfrequency (steps a) to g))** NOTE The steps between points a) to j) may also be carried out with a frequency ramp of 1 Hz / s.		P
5.3.4.1.1	Test sequence for controllable or limited controllable EZE		P
	At f = 50.2 Hz, the value of the currently generated active power P_M is "frozen".		P
	The test is carried out for two services. On the one hand, the test must start with a power > 80% P_n and in a second test with a power between 40% P_n and 60% P_n. In the second test, after freezing the P_M, the available active power output (depending on the primary energy supply, heat output, gas quality, etc.) has to be increased to a value > 80% P_n and after falling below the mains frequency of 50.2 Hz, the increase in the active power gradient has to be recorded.	(See appended table)	P
	Point g) must be held until the EZE feeds in again with the available active power output (depending on the primary energy supply, heat output, gas quality, etc.). The power gradient (dP/dt) of the EZE must be continuously determined during this period. To determine the power gradient, a moving 1-minute average of the active power is calculated, the 1-minute average having to be recalculated from the previous data at least every second.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	The active power gradient is calculated from the 1-minute mean values from the difference between the 1- minute mean value at time t_1 and time t_1 + 1 minute as follows: (ΔP/1 min) = ($P_t = t_1$ + 1 min - $P_t = t_1$)/1 min Here t_1 is the time from the start of the active power feed-in of the EZE after reconnection until the end of the power limitation. With step control, the averaging starts at t_1 - 1 minute. The frequency applied to the EZE and the active power must be recorded. The active power output available during the test must be demonstrated.		P
5.3.4.1.2	Test sequence for all EZE (adjustable, conditional and non-adjustable EZE)		P
	Following tests a) to g), the following tests must be carried out for all EZE: – Start frequency h) and hold it until the EZE has switched off. If the EZE is only designed for use with an external automatic disconnection point and there is therefore no shutdown, a triggering of the external automatic disconnection point for the unit must be simulated for the measurement of the active power gradient after switching on again. In this case the frequency i) may be skipped. – Start frequency i) and hold it for at least 7 minutes, then – Start frequency j) and keep it at least until the active power settles.		P
5.3.4.2	Evaluation method		P
	a) for controllable EZE, if – between the aforementioned measuring points b) and f) the active power is reduced with a gradient of 40% of P_M (droop of 5%) per Hz with increasing frequency or increases with decreasing frequency, and – the maximum active power gradient occurring in points g) and j) is less than 10% of the maximum active power P_n per minute, and – the active power value of the target value determined by the gradient characteristic does not deviate by more than +5% P_n.		P
	b) for conditionally adjustable EZE, if – they behave within their control range as in point a), and – outside the controllable range, the power fed in when leaving the control range remains constant until it is switched off, – the connection time in point j) corresponds to the manufacturer's information on the random generator;		N/A
	c) for non-regulated EZE, if – a shutdown between 50.2 Hz and 51.5 Hz takes place within 1 s; – the connection time in point j) corresponds to the manufacturer's information on the random generator.		N/A
5.3.4.3	Documentation	(See appended table)	P

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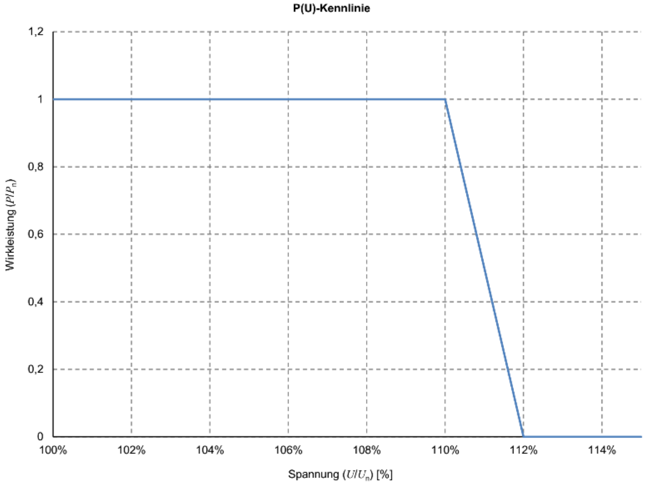
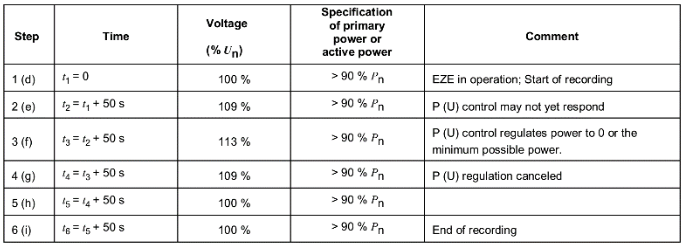
Clause	Requirement - Test	Result - Remark	Verdict
	At least it must be documented: – Variation of the network frequency over time; – Primary energy supply, heat emission, gas quality, etc.); – the measured active power over time; – the maximum gradient.		P
5.3.5	Frequency-dependent active power reduction (active power at underfrequency)		P
	These tests serve to demonstrate the behaviour of the EZE at underfrequency according to the TOR generator, section 5.1.5.		P
5.3.5.1	Tests		P
	The EZE is to be operated with an active power output > 80% P_n. The measurements are carried out at the following operating points: a) Nominal frequency ± 0,01 Hz; b) Nominal frequency - 0.5 Hz for synchronous EZE, nominal frequency - 1 Hz for non-synchronous EZE; c) a point between nominal frequency - 2.4 Hz to - 2.5 Hz. Operating points b) and c) must be kept for at least 1 minute.	(See appended table)	P
5.3.5.2	Evaluation method		P
	For synchronous EZE: – The test is passed if the EZE does not reduce the power when the mains frequency changes from operating point a) to b) and the power drops by a maximum of 10% P_n per Hz from operating point b) to c).		N/A
	For non-synchronous EZE: – The test is passed if the EZE does not reduce the power when the mains frequency changes from operating point a) to b) and the power drops by a maximum of 2% P_n per Hz from operating point b) to c).		P
5.3.5.3	Documentation	(See appended table)	P
	At least it must be documented: – Variation of the network frequency over time; – the measured active power over time.		P
5.3.6	Voltage-controlled active power limitation P (U)		P
	These tests from section 5.3.6. serve as proof of the active power reduction in the event of overvoltage according to TOR generator, section 5.3.6		P

Clause	Requirement - Test	Result - Remark	Verdict
	Overvoltage protection U_{eff} > may be deactivated when testing the voltage-dependent control functions. A fixed cos φ = 1 must be set as the reactive power specification.  **Bild 4 – Standardkennlinie für P(U) gemäß TOR Erzeuger, Abbildung 14 a)**		P
	A fixed cos φ = 1 must be set as the reactive power specification		P
5.3.6.1	Tests		P
	The tests to prove the active power reduction in the event of overvoltage of the EZE are to be carried out on a network simulator.		P
	Depending on the type of EZE (single or three-phase), the changes in voltage must be carried out simultaneously or symmetrically on all phases.		P
5.3.6.1.1	Test sequence for the static behaviour of the P (U) control		P
	The accuracy of the P (U) control is checked by slowly increasing the mains voltage, starting from a voltage value below the response threshold of 110% U_n.		P

Clause	Requirement - Test	Result - Remark	Verdict
	The test must be carried out according to the following procedure. a) Setting the mains voltage to *U*n; b) Switching on the EZE; c) Setting the primary energy to P_n (or setting the power setpoint of the EZE to 100% P_n). The criterion is a power P> 90% P_n; d) Start of recording (U, I, P, Q) as 200 ms averages; e) Increase the mains voltage at the terminals of the EZE to 109% U_n, whereby a waiting time of at least 30 s must be observed to achieve a steady state; f) Measurement of U, I, P, Q for 30 s; g) Increase the voltage in steps of 1% U_n, with a waiting time of at least 30 s between the steps for reaching a steady state; h) Measurement of U, I, P, Q for at least 30 s; i) Repetition of g) and h) until a tension of 113% is reached; j) Lowering the voltage in steps of 1% Un, with a waiting time of at least 30 s between the steps for achieving a steady state; k) Measurement of U, I, P, Q for 30 s; l) Repetition of j) and k) until a voltage of 109% U_n is reached; m) Setting the voltage to 100% U_n; n) End of recording (U, I, P, Q); o) Switch off the EZE.	(See appended table)	P
5.3.6.1.2	Test sequence for the dynamic behaviour of the P (U) control		P
	The dynamic behaviour of the P (U) control is checked by a sudden increase in the mains voltage, starting from a voltage value below the response threshold of 110% U_n.		P
	The test must be carried out according to the following procedure. a) Setting the mains voltage to *U*n; b) Switching on the EZE; c) Setting the primary energy to P_n (or setting the power setpoint of the EZE to 100% P_n). The criterion is a power P> 90% P_n; d) Start recording (U, I, P, Q) as 200 ms averages; e) Sudden increase in voltage to 109% U_n, measurement of U, I, P, Q for a period of at least 10 times the time constant of the P (U) control; f) Sudden increase in voltage to 110% + 3% U_n, measurement of U, I, P, Q for a period of at least 10 times the time constant of the P (U) control; g) Sudden lowering of the voltage to 109% U_n, measurement of U, I, P, Q for a period of at least 10 times the time constant of the P (U) control; h) Sudden lowering of the voltage to 100% U_n, measurement of U, I, P, Q for a period of at least 10 times the time constant of the P (U) control; i) Setting the voltage to 100% U_n; j) End of recording (U, I, P, Q); k) Switch off the EZE	(See appended table)	P

<table>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>

Table 1 - Test procedure for the dynamic behavior of the P (U) control

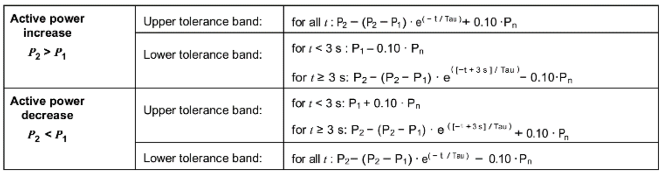


<table>
<tr><th>Step</th><th>Time</th><th>Voltage
(% U_n)</th><th>Specification of primary power or active power</th><th>Comment</th></tr>
<tr><td>1 (d)</td><td>$t_1 = 0$</td><td>100 %</td><td>> 90 % P_n</td><td>EZE in operation; Start of recording</td></tr>
<tr><td>2 (e)</td><td>$t_2 = t_1 + 50$ s</td><td>109 %</td><td>> 90 % P_n</td><td>P (U) control may not yet respond</td></tr>
<tr><td>3 (f)</td><td>$t_3 = t_2 + 50$ s</td><td>113 %</td><td>> 90 % P_n</td><td>P (U) control regulates power to 0 or the minimum possible power.</td></tr>
<tr><td>4 (g)</td><td>$t_4 = t_3 + 50$ s</td><td>109 %</td><td>> 90 % P_n</td><td>P (U) regulation canceled</td></tr>
<tr><td>5 (h)</td><td>$t_5 = t_4 + 50$ s</td><td>100 %</td><td>> 90 % P_n</td><td></td></tr>
<tr><td>6 (i)</td><td>$t_6 = t_5 + 50$ s</td><td>100 %</td><td>> 90 % P_n</td><td>End of recording</td></tr>
</table>

</td><td></td><td>P</td></tr>
<tr><td>5.3.6.2</td><td>Evaluation method</td><td></td><td>P</td></tr>
<tr><td></td><td>The static-state behaviour test has been passed, if
– the active power values measured according to 5.3.6.2.1 (30 s mean values) in stationary operation are within the tolerance band of ± 10% P_n and ± 1% U_n of the specified P (U) characteristic.</td><td></td><td>P</td></tr>
<tr><td></td><td>The dynamic behaviour test is passed if the determined time profile of the active power during the measurement according to 5.3.6.2.2 is within the entire measurement duration within the tolerance bands that result from the behaviour of an equivalent PT1 element (1st order filter). Permissible tolerances are ± 10% P_n for the active power values and +3 seconds for the time.</td><td></td><td>P</td></tr>
<tr><td></td><td>

The tolerance bands are calculated according to Table 2
– There are no discontinuities in the characteristic curve, fluctuations in power or a shutdown of the EZE;
– It is possible to limit the active power to a power of <10% P_n or to the minimum power specified by the manufacturer.

Table 2 - Calculation of the tolerance bands for evaluating the dynamic behavior of the P (U) control in the event of a setpoint jump from an active power P_1 to an active power P_2



<table>
<tr><td rowspan="2">Active power increase
$P_2 > P_1$</td><td>Upper tolerance band:</td><td>for all t : $P_2 - (P_2 - P_1) \cdot e^{(-t/Tau)} + 0.10 \cdot P_n$</td></tr>
<tr><td>Lower tolerance band:</td><td>for $t < 3$ s : $P_1 - 0.10 \cdot P_n$
for $t \geq 3$ s: $P_2 - (P_2 - P_1) \cdot e^{([-t+3s]/Tau)} - 0.10 \cdot P_n$</td></tr>
<tr><td rowspan="2">Active power decrease
$P_2 < P_1$</td><td>Upper tolerance band:</td><td>for $t < 3$ s: $P_1 + 0.10 \cdot P_n$
for $t \geq 3$ s: $P_2 - (P_2 - P_1) \cdot e^{([-t+3s]/Tau)} + 0.10 \cdot P_n$</td></tr>
<tr><td>Lower tolerance band:</td><td>for all t : $P_2 - (P_2 - P_1) \cdot e^{(-t/Tau)} - 0.10 \cdot P_n$</td></tr>
</table>

</td><td></td><td>P</td></tr>
<tr><td>5.3.6.3</td><td>Documentation</td><td>(See appended table)</td><td>P</td></tr>
<tr><td></td><td>– Examination of the static-steady-state behaviour: Tabular representation of the mains voltage and active power (30 s mean values) as well as the determined tolerance limits;
– Checking the dynamic behaviour: Graphical representation of the measured mains voltage and active power (200 ms mean values) as well as the calculated tolerance bands for the active power over time.</td><td></td><td>P</td></tr>
<tr><td>5.3.7</td><td>Reactive power control according to setpoint "cos φ fixed"</td><td></td><td>P</td></tr>
<tr><td></td><td>These tests serve to demonstrate the reactive power control strategy "cos φ fixed" according to the TOR generator, section 5.3.4.</td><td></td><td>P</td></tr>
<tr><td>5.3.7.1</td><td>Tests</td><td></td><td>P</td></tr>
<tr><td></td><td>The EZE is operated in all possible of the following operating points, with a data set with 30 s averaging having to be recorded for each operating point after the settling process of the active power has subsided.</td><td></td><td>P</td></tr>
</table>

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Clause	Requirement - Test	Result - Remark	Verdict
	During the following partial measurements a) to b), the primary energy source must not limit the output. The measurements a) to b) must be carried out at 0.91 U_n, U_n and 1.09 U_n.		P
	For each of the measurements at different voltages, a different value between 40% P_n and 60% P_n must be approached.		P
	The cos φ to be set must be determined in accordance with the TOR generator, Section 5.3.3.2. a) At a minimum cos φ overexcitation occurs with an active power value – between 40% P_n and 60% P_n, and – measured at S_n. b) With minimal cos φ underexcitation with an active power value – between 40% P_n and 60% P_n, and – measured at S_n.	(See appended table)	P
5.7.3.2	Evaluation method		P
	The test is passed if all cos φ values (30 s mean) do not deviate from the specification by more than ± 0.01.		P
	In the case of EZE with generators directly connected to the grid, which cannot regulate reactive power due to the principle, such as asynchronous generators, and therefore use non-controllable fixed capacitances, the tolerance band increases from 0.01 to 0.02. This device type is only evaluated at U_n.		P
5.3.7.3	Documentation		P
	At least it must be documented: – Tabular representation of all measuring points from 5.3.7.2 a) or b) for P, Q, U, cos φ values as a 30 s mean value; – graphic representation of all measuring points from 5.3.7.2 a) and b) for P, Q, U, cos φ as 30 s mean; Pass / fail for the adjustable cos φ range and possibly restrictions for the use of the EZE in EZA with higher performance.	(See appended table)	P
5.3.8	Reactive power control "cos φ (P)"		P
	These tests serve to demonstrate the reactive power control "cos φ (P)" according to the TOR generator, section 5.3.4.1		P
5.3.8.1	Tests		P
	To check the standard characteristic curve for cos φ (P) shown in TOR generator, Figure 12, the change in reactive power must be checked in accordance with the level of the active power feed-in. For this purpose, the active power range must be traversed three times from 20% P_n to the maximum active power feed-in and vice versa.		P

Clause	Requirement - Test	Result - Remark	Verdict
	a) The active power range is traversed once in steps of 10% P_n to demonstrate the level of the displacement factor. b) The active power range is run through twice in the steps 20% P_n, 50% P_n, 90% P_n to prove the amount of the displacement factor and to demonstrate the settling time.		P
	The active power jumps must be carried out at the highest rate of change, limited by the generator power of the EZE. The measurement data are recorded as 200 ms average. The active power steps are to be approached with an accuracy of ± 5% P_n		P
5.3.8.2	Evaluation method		P
	To pass the test 5.3.8.1 a), the stationary final value of the cos φ must be within the limit deviation of ± 0.01 cos φ around the cos φ setpoint resulting from the active power. The final value is determined as a 30 s average.		P
	To pass the test 5.3.8.1 b), the cos φ setpoint resulting from the active power must be set at the terminals of the EZE within a settling time of 10 s. The measurement of the settling time begins when the active power enters the band for the first time by ± 1% of the final value reached. The final value reached is determined as a 30 s average. The settling time ends with the last entry of the cos φ value in the tolerance band of ± 0.02 cos φ around the setpoint calculated from the final value of the active power.		P
	If cos φ noise is superimposed due to island grid detection and the tolerance band ± 0.02 cos φ is violated by the setpoint after settling due to this noise, then this interference can be neglected by island grid detection. The behaviour of the island grid detection in the steady state without a jump in active power with the same temporal resolution is to be shown as proof of this negligibility.		P
5.3.8.3	Documentation	(See appended table)	P
	For each change in active power, the following is to be stated in a table: – Final value of active power; – Setpoint of cos φ; – Settling time; – Assessment of compliance with the tolerance band.		P
5.3.9	Reactive power control according to setpoint "Q fix"		P
	These tests serve to demonstrate the reactive power control strategy "Q fix" according to the TOR generator, clause 5.3.4. According to the TOR generator, these measurements are only required for EZE for operation in EZA with a S_r higher than the threshold value defined in the TOR generator.		P
5.3.9.1	Tests		P
	The EZE is operated in all possible of the following operating points, with a data set with 30 s averaging having to be recorded for each operating point after the settling process of the active power has subsided.		P

Clause	Requirement - Test	Result - Remark	Verdict
	During the following partial measurements a) and b), the primary energy source must not limit the output.		P
	Measurements a) and b) must be carried out at 0.91 U_n, U_n and 1.09 U_n.		P
	For each of the measurements at different voltages, a different value between 40% P_n and 60% P_n must be approached.		P
	The maximum value to be set for Q overexcited or underexcited must be defined in accordance with TOR generator, section 5.3.3.2. a) At maximum Q, overexcitation occurs at an active power value – between 40% P n and 60% P_n, and – measured at S_n. b) At maximum Q, under-excitation occurs at an active power value – between 40% P_n and 60% P_n, and – measured at S_n.		P
5.3.9.2	Evaluation method		P
	The test is passed if all Q values (30 s average) do not deviate from the specification by more than ± 4% S_n.		P
	In the case of EZE with generators directly connected to the grid, which cannot regulate reactive power due to the principle, such as asynchronous generators, and therefore use non-controllable fixed capacities, the tolerance band extends from ± 4% P_n to ± 10% P_n. This device type is only used at U_n rated.		N/A
5.3.9.3	Documentation	(See appended table)	P
	At least it should be noted: – Tabular representation of all measuring points from 5.3.9.1 a) or b) for P, Q, U, as a 30 s mean value; – graphical representation of all measuring points from 5.3.9.1 a) and b) for P, Q, U, as 30 s mean. Pass/fail for the adjustable Q range and possibly restrictions for the use of the EZE in EZA with higher performance		P
5.3.10	Voltage-controlled control functions (reactive power control Q (U) and active power control P (U))		P
	These tests serve to demonstrate the reactive power control strategy Q (U) and active power control strategy P(U) according to the TOR generator, Section 5.3.4.2 and Section 5.3.6.		P
	To check the behaviour of the Q (U) control, the time constant or the response time of the Q (U) control must be defined according to a first-order filter (PT1 element) with a time constant Tau of 3 s (deviating from the standard setup). Overvoltage protection U_{eff} > may be deactivated when testing the voltage-dependent control functions	The setting value of a time constant Tau of 3 s for Q (U) control and Tau of 5 s for P (U) control when performed this test. (See appended table)	P
5.3.10.1	Tests		P
	The tests to prove the voltage-controlled regulation are to be carried out on a network simulator.		P

Clause	Requirement - Test	Result - Remark	Verdict
	The tests are to be carried out at nominal power and at a power of 20% of the nominal power of the EZE. With only partially controllable EZE, the minimum possible output can be set instead of 20% P_n.		P
	For generating plants with P_{min} <20% P_n, an additional test between P_{min} and 20% P_n is required. P_{min} is the minimum possible power of the EZE in feed-in operation.		P
	Depending on the type of EZE (single or three-phase), the changes in voltage must be carried out simultaneously or symmetrically on all phases.		P
5.3.10.1.1	Test procedure for static-stationary behaviour		P
	The accuracy of the regulations is checked by slowly varying the mains voltage based on the nominal voltage. In addition, the accuracy is checked by varying the active power. a) Mains voltage to U_n; b) Switching on the EZE; c) Specification of primary energy at P_n (or setting power setpoint EUT at 100% Pn), criterion $P > 90\ \%\ P_n$; d) Start recording (U, I, P, Q), 200 ms averages; e) Increase the voltage in steps of 1% U_n, with a waiting time of at least 30 s between the steps for reaching a steady state; f) Measurement of U, I, P, Q for 30 s; g) Repetition of e) and f) up to 113% U_n; h) Lowering the voltage in steps of 1% U_n, with a waiting time of at least 30 s between the steps for achieving a steady state; i) Measurement of U, I, P, Q for at least 30 s; j) Repetition of h) and i) up to 85% U_n; k) Increase the voltage in steps of 1% U_n, with a waiting time of at least 30 s between the steps for reaching a steady state; l) Measurement of U, I, P, Q for 30 s; m) Repetition of k) and l) until nominal voltage (U_n) is reached; n) Repeat steps e) to m) with primary energy at 20% Pn (or setting power setpoint EUT at 20% P_n). With only partially controllable EZE, the minimum possible output can be set instead of 20% P_n	(See appended table)	P

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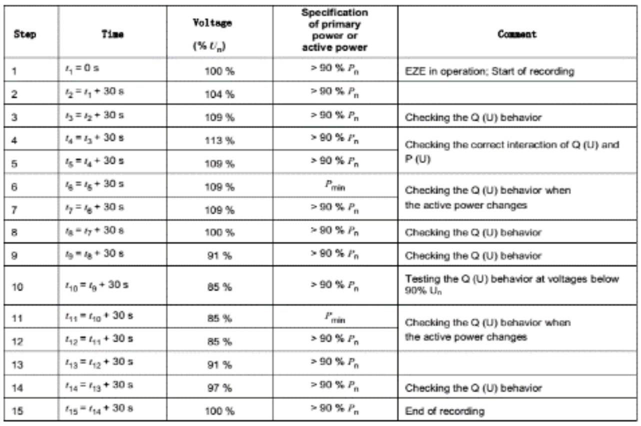
Clause	Requirement - Test	Result - Remark	Verdict
	The following measurements o) to z) only for EZE with a minimum active power < 20% P_n. o) Setting the voltage to 91% Un and active power to P_{min}, with a waiting time of at least 30 s to reach a steady state; p) Measurement of U, I, P, Q for at least 30 s; q) Increase the active power in steps of 5% P_n, with a waiting time of at least 30 s between the steps to achieve a steady state; r) Measurement of U, I, P, Q for at least 30 s; s) Repetition of q) and r) until at least 20% P_n is reached; t) Reduction of the active power in steps of 5% P_n, with a waiting time of at least 30 s between the steps for achieving a steady state; u) Measurement of U, I, P, Q for at least 30 s; v) Repetition of t) and u) until the minimum active power P_{min} is reached; w) Setting the voltage to 109% U_n, while waiting for at least 30 s to reach a steady state; x) Repetition of steps p) to v); y) End of recording (U, I, P, Q), 200 ms averages; z) Switch off EUT.	(See appended table)	P
5.3.10.1.2	Test procedure for dynamic behaviour		P

	The dynamic behaviour of the controls is checked by abruptly varying the mains voltage based on the nominal voltage. a) Mains voltage on U_n; b) Switch on EUT; c) Primary energy at P_n (or setting power setpoint EUT to > 90% P_n); d) Start recording (U, I, P, Q), 200 ms averages; e) Increase the voltage to 104% U_n, measure U, I, P, Q for at least 30 s; f) Increase the voltage to 109% U_n, measure U, I, P, Q for at least 30 s; g) Increase the voltage to 113% U_n, measure U, I, P, Q for at least 30 s; h) Lowering the voltage to 109% U_n, measuring U, I, P, Q for at least 30 s; i) Lowering the primary power to P_{min}; j) Wait until performance is achieved; Measurement of U, I, P, Q for at least 30 s; k) Increasing primary energy to P_n (or setting power setpoint EUT to> 90% P_n); l) After reaching the power, measure U, I, P, Q for at least 30 s; m) Lowering the voltage to U_n, measuring U, I, P, Q for at least 30 s; n) Lowering the voltage to 91% U_n, measuring U, I, P, Q for at least 30 s; o) Lowering the voltage to the minimum mains voltage 85% U_n. Measurement of U, I, P, Q for at least 30 s; p) Lowering the primary power to P_{min}; q) Wait until performance is achieved; Measurement of U, I, P, Q for at least 30 s; r) Setting the primary energy to P_n (or setting the power setpoint EUT to> 90% P_n). Wait until performance is achieved; s) Increase the voltage to 91% U_n, measure U, I, P, Q for at least 30 s; t) Increase the voltage to 97% U_n, measure U, I, P, Q for at least 30 s; u) Increasing the voltage to U_n; v) End of recording	(See appended table)	P
	Table 4 - Test procedure for dynamic behavior of the Q (U) control 		P

Step	Time	Voltage (% U_n)	Specification of primary power or active power	Comment
1	$t_1 = 0$ s	100 %	> 90 % P_n	EZE in operation; Start of recording
2	$t_2 = t_1 + 30$ s	104 %	> 90 % P_n	
3	$t_3 = t_2 + 30$ s	109 %	> 90 % P_n	Checking the Q (U) behavior
4	$t_4 = t_3 + 30$ s	113 %	> 90 % P_n	Checking the correct interaction of Q (U) and P (U)
5	$t_5 = t_4 + 30$ s	109 %	> 90 % P_n	
6	$t_6 = t_5 + 30$ s	109 %	P_{min}	Checking the Q (U) behavior when the active power changes
7	$t_7 = t_6 + 30$ s	109 %	> 90 % P_n	
8	$t_8 = t_7 + 30$ s	100 %	> 90 % P_n	Checking the Q (U) behavior
9	$t_9 = t_8 + 30$ s	91 %	> 90 % P_n	Checking the Q (U) behavior
10	$t_{10} = t_9 + 30$ s	85 %	> 90 % P_n	Testing the Q (U) behavior at voltages below 90% U_n
11	$t_{11} = t_{10} + 30$ s	85 %	P_{min}	Checking the Q (U) behavior when the active power changes
12	$t_{12} = t_{11} + 30$ s	85 %	> 90 % P_n	
13	$t_{13} = t_{12} + 30$ s	91 %	> 90 % P_n	
14	$t_{14} = t_{13} + 30$ s	97 %	> 90 % P_n	Checking the Q (U) behavior
15	$t_{15} = t_{14} + 30$ s	100 %	> 90 % P_n	End of recording

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Clause	Requirement - Test	Result - Remark	Verdict
5.3.10.2	Evaluation method		P
	The examination of inpatient behaviour is passed if – the 30 s mean values of the reactive power values measured in stationary operation measured according to 5.3.10.1.1 are within the tolerance band of ± 4% S_n and ± 1% U_n of the set Q (U) characteristic. – in the power range P_{min} to 20% P_n the time course of the reactive power is steady and at P=0 the reactive power approaches 0. Compliance with the tolerance band of ± 4% S_n is not required in this active power range.		P
	The dynamic behaviour test is passed if – the time curve of the reactive power during the measurement according to 5.3.10.1.2 for powers greater than 20% P_n is within the tolerance bands that result from the behaviour of an equivalent PT1 element (1st order filter). Permissible tolerances for the reactive power values are ± 4% S_n and for the time + 1 second.		P
	The tolerance bands are calculated according to Table 6. – There are no discontinuities in the characteristic curve, no persistent vibrations (after the end of the transient process after 5 Tau) of the reactive power and no disconnections of the EZE occur; – At the transition to active powers <20% P_n there are no sudden changes in reactive power. With changes in active power between 0% and 20% P_n, the reactive power must behave continuously.		P
	When assessing the setpoint jump from step 3 to step 4, the active power must be assessed according to the tolerance bands in Figure 18. The accuracy of the reactive power does not have to meet a tolerance band for active powers below 20% S_n. Check whether the course is steady and does not jump. If P = 0, the reactive power must go to zero.		P
5.3.10.3	Documentation	(See appended table)	P
	At least it must be documented: – Setting values of the P (U) and Q (U) characteristics and time constants or setting times; – Calculated tolerance bands for active and reactive power over time; – Examination of the static-steady-state behaviour: Tabular representation of the measured grid voltage, active and reactive power (30 s mean values) as well as the calculated tolerance limits; – Checking the dynamic behaviour: Graphical representation of the measured grid voltage, active and reactive power (200 ms mean values) as well as the calculated tolerance bands for the reactive power over time.		P
5.3.11	Protection of the settings as requested by the TOR generator		P

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Clause	Requirement - Test	Result - Remark	Verdict
	This section serves as evidence of the requirements in TOR generators, section 6.2.3. These requirements only apply to inverters.		P
5.3.11.1	The test has been passed if: – in the above mentioned measuring points 5.4.5.1 a) to g) and j) the expected active power output, after swinging, with a deviation of ≤ ±10% P_{Emax}. Deviations caused by the maximum discharge power being small P_{Emax} are permitted. In the measuring points h) and i) no action power may be output. – the initial time delay is T_V of the frequency-dependent adjustment of the active power output of ≤ 2 s, – the start-up time of the adjustment of the active power output is a maximum of 1 s and – the settling time of the adjustment of the active power output is not more than 20s and – the switching time in j) is at least 60 s and the power is then increased with a gradient of 10% P_{Emax} / min.		P
5.3.11.2	Evaluation method		P
	The test is passed if the corresponding parameters or settings cannot be changed by the user or by means of aids accessible by the user.		P
	The test is passed if the parameters or settings are not changed by software updates.		P
5.3.11.3	Documentation	(See appended table)	P
	The type of documentation for the protection of the corresponding parameters or settings must be documented.		P
5.4	**Testing the automatic activation point**		P
	A separate activation point must be tested together with a suitable generator. It must be ensured that the switch-off signal is not generated by the generator, but by the activation point		P
	The measurements may be carried out with the exception of testing the entire impact chain with the EZE switched off.		P
	With the help of the network simulator, a symmetrical three-phase network with nominal frequency and nominal voltage is simulated. Single-phase measurements are allowed for single-phase EZE		P
	The measurement is carried out on a network simulator: – At central isolating points, the switching output for the connection of a tie switch is monitored. – An integrated, automatically acting disconnection point in EZE <30 kVA can usually be checked in normal operation. Operation at nominal active power is not necessary. The opening of the internal tie switches is monitored.		P

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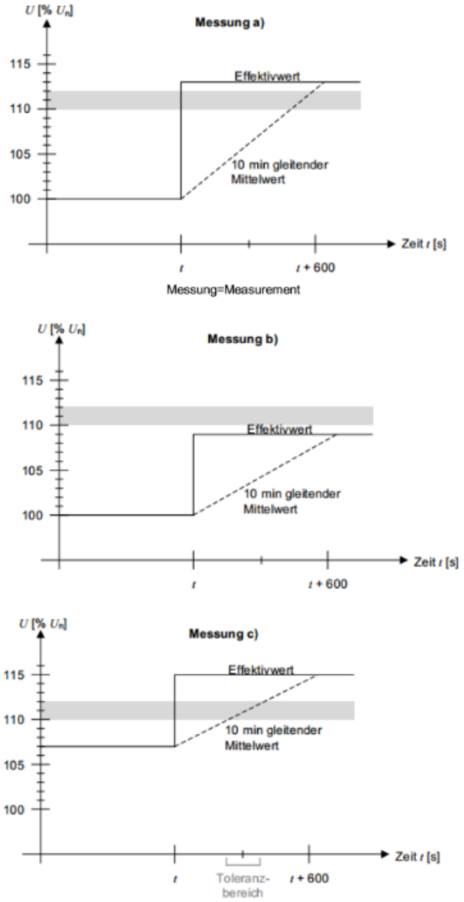
Clause	Requirement - Test	Result - Remark	Verdict
	An integrated automatic activation point in EZE may not be checked during normal operation. If testing is carried out with the EZE switched off, the release signal for the protection of the tie switch must be made available for the measurement. The release signal of the automatic activation point is monitored. When assessing the switch-off time, the own times of the tie switch and the control must be taken into account.		P
5.4.2	Voltage protection devices		P
	To check the voltage monitoring, the automatic disconnection point must be operated via an AC voltage source with variable amplitude at nominal AC voltage and any power.		P
5.4.1.1	Tests		P
5.4.1.1.1	Testing the overvoltage protection U_{eff} >> and the undervoltage protection U_{eff} < and U_{eff} <<		P
	a) For the measurement of the phase-phase voltages, the phase angle must be adjusted so that one phase-phase voltage reaches the limit value, whereby the phase-neutral conductor voltages for the overvoltage test to 110% U_n and for undervoltage to 90% U_n be set.		P
	b) To measure the phase-neutral voltage, one phase-neutral voltage must be changed, whereby the other two phase-neutral voltages are kept at the nominal voltage. This test must be carried out individually for each phase.		P
	Proceed as follows for the test: – By slowly reducing or increasing the mains voltage up to the limits set in accordance with the TOR generator, Section 6.3.3.1, the voltages that result in the automatic disconnection point being switched off are determined. The undervoltage protection U_{eff} < may be deactivated for testing the undervoltage protection U_{eff} <<. – By suddenly changing the mains voltage to the set value according to the TOR generator, section 6.3.3.1 + 3% U_n for overvoltage or -3% U_n for undervoltage, the time until the automatic disconnection point is switched off is determined. The specified tripping delay must be observed in the event of voltage jumps in which the set trigger values for the overvoltage are exceeded by a maximum of 3% of the nominal voltage U_n or the undervoltage is not exceeded by more than 3% of the nominal voltage U_n.	(See appended table)	P
	All tests for the detection of the switch-off values and switch-off times must be carried out three times.		P
5.4.1.1.2	Testing the overvoltage protection U_{eff} > with monitoring of the moving 10-minute average. (monitoring of the voltage quality)		P
	To avoid triggering the overvoltage protection U_{eff} >>, deactivate it when carrying out the tests.		P

Clause	Requirement - Test	Result - Remark	Verdict
	The voltage surge protection U> is tested as follows: a) The voltage is set to 100% U_n and maintained for 600 s. The voltage is then set to 113% U_n. It must be switched off within 600 s. b) The voltage is set to U_n for 600 s, then to 109% U_n for 600 s. It must not be switched off. c) The voltage is set to 107% U_n and maintained for 600 s. Then the voltage is set to 115% U_n. It must be switched off within 300 s.	(See appended table)	P
	The test is carried out on any phase neutral voltage  **Figure 22 - Testing the voltage increase protection as a sliding 10-minute average measurement a), b), c)**		P
5.4.1.2	Evaluation method		P
	The test of overvoltage protection U_{eff} >> and under-voltage protection U_{eff} < and U_{eff} << is considered passed if the determined voltages that lead to a shutdown are within a tolerance band of ± 1% U_n around the setting values and if the determined tripping delay is within ± 100 ms of the set trigger delay.		P
	The test of overvoltage protection U_{eff} > is considered passed if the conditions specified in 5.4.1.1.2 a) to c) are met.		P
5.4.1.3	Documentation	(See appended table)	P

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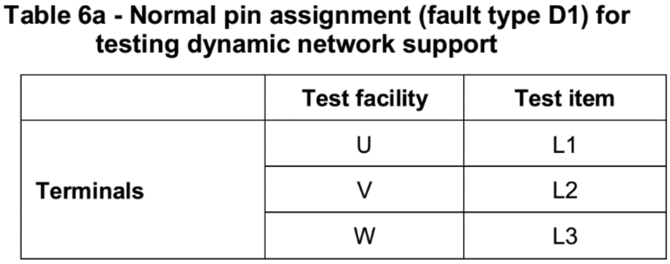
Clause	Requirement - Test	Result - Remark	Verdict
	At least it must be documented: – Settings of the activation point (setting values, tripping delays); – Measured trigger values and trigger times for each individual test; – Deviations between setting and trigger values.		P
5.4.2	Frequency protection devices		P
5.4.2.1	Tests		P
	To check the frequency monitoring, the automatic disconnection point must be operated at any power via an AC voltage source with variable amplitude and frequency.		P
	The tripping frequencies and the tripping times of the frequency monitoring are determined by reducing or increasing the mains frequency with a rate of change of 1 Hz/s up to the setting values defined in accordance with TOR generator, Section 6.3.3.1.		P
	All tests for the detection of the switch-off values and switch-off times must be carried out three times.		P
5.4.2.2	Evaluation method		P
	The entire test is considered to have been passed if the values for frequencies and the switch-off times measured in each individual test are within the limits specified in TOR generators, Section 6.3.3.1. The deviations between the setting and trigger values may be those in TOR generator, section 6.3.2. Do not exceed the specified tolerance.		P
5.4.2.3	Documentation	(See appended table)	P
	At least it must be documented: – Settings of the activation point (setting values, tripping delays); – Measured trigger values and trigger times for each individual test; – Deviations between setting and trigger values.		P
5.4.3	Detection of unwanted island operation		P
	Detection of undesired island operation must be demonstrated in accordance with the procedure defined in ÖVE / ÖNORM EN 62116.	(See appended table)	P
5.5	**Testing the connection conditions and synchronization**		P
	This section serves to demonstrate the requirements of the TOR generator, section 5.5.2		P
5.5.1	Tests		P

Clause	Requirement - Test	Result - Remark	Verdict
	The connection and synchronization are carried out or monitored by at least one suitable device. This device can be implemented in the control of the EZE or in the automatic activation point (integrated or external) and is according to the TOR generator, section 5.5.2. set and check as follows: a) The manufacturer must provide the test laboratory with documentation on the functions implemented in the component. b) If the EZE is not switched on, the test is carried out by changing the set nominal frequency and nominal voltage in the control. Alternatively, other methods such as a network simulator or a test bench test may be used for the verification.		P
	Test procedure: a) $f_{ist} < 47,45$ Hz: no reconnection allowed; b) Change on $f_{ist} \geq 47,55$ Hz: reconnection possible; c) $f_{ist} > 50,15$ Hz: no reconnection allowed; d) Change on $f_{ist} \leq 50,05$ Hz: reconnection possible; e) $U_{ist} < 84\ \%\ U_n$: no reconnection allowed; f) $U_{ist} \geq 86\ \%\ U_n$: reconnection possible; g) $U_{ist} > 110\ \%\ U_n$: no reconnection allowed; h) $U_{ist} \leq 108\ \%\ U_n$: reconnection possible. The switch-on time must be specified by the manufacturer.	(See appended table)	P
5.5.2	Evaluation method		P
	The test is passed if the EZE or the automatic activation point can only be activated within the tolerance bands according to the TOR generator, Section 5.5.2 and after the voltage and frequency have remained within the tolerance bands after 300 s at the earliest.		P
5.5.3	Documentation	(See appended table)	P
	It must at least be documented: – Settings of the EZE or the activation point for the connection conditions (setting values, times); – Measured threshold values and activation times for reactivation for each individual test.		P
5.6	**Testing of robustness and dynamic network support**		P
5.6.1	General		P
	These tests serve to demonstrate the requirements of the requirements regarding robustness and dynamic network support according to TOR generators, Section 5.2.		P
	The aim of these tests is to determine whether the test specimen is able to ride through voltage dips undamaged and to behave accordingly. The device under test can be a generation unit (EZE) or a storage system.		P
	The test item includes: – The control system and the auxiliary units including the self-supply installed in the EZE – The generator (synchronous or asynchronous generator) or the converter – Synchronous and asynchronous generators, which are coupled directly or via converters		P

<table>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>Passing through several consecutive network faults is not the subject of the test. The tests listed below can, however, be repeated for any sequence of network faults with a fixed or variable pause time in order to test the passage of multiple network faults.</td><td></td><td>P</td></tr>
<tr><td>5.6.2</td><td>Method</td><td></td><td>P</td></tr>
<tr><td></td><td>The device under test is connected to a network with a downstream test facility (or a network simulator with a downstream network simulation). This test facility must be able to simulate the corresponding voltage drop (s) as described in the following procedure on the test object side.</td><td></td><td>P</td></tr>
<tr><td></td><td>The correct parameterization of the test equipment in order to obtain the respective voltage dips/-according to Table 8 and Table 9, must be checked for each test by an idle test (each separately symmetrical, asymmetrical).
The value to be set in each case for voltage dips is the resultant smallest conductor-neutral conductor voltage, based on the nominal value.</td><td></td><td>P</td></tr>
<tr><td></td><td>The tests are to be started at a voltage in the range of U_n ± 5% U_n.</td><td></td><td>P</td></tr>
<tr><td></td><td>The reference points for the dynamic network support of the EZE or the storage system are the network-side connection terminals of the device under test.</td><td></td><td>P</td></tr>
<tr><td></td><td>It must be tested at full load (P_n ± 2% P_n) and in the partial load range from 0.2 P_n to 0.6 P_n. The reference value is the measured active power as a 10 s mean value immediately before the voltage dip/surge.</td><td></td><td>P</td></tr>
<tr><td></td><td>Tests 1 to 3 from Table 8 and Tests 1 to 7 from Table 9 must be carried out both symmetrically (fault type A) and asymmetrically (according to fault pattern D) (according to Bollen, see Appendix A)</td><td></td><td>P</td></tr>
<tr><td></td><td>The FRT tests are carried out with normal pin assignment according to Table 6a. In addition, in the case of the asymmetrical tests, the deepest voltage dips at full load must be tested again with a cyclically exchanged pin assignment according to Table 6b</td><td></td><td>P</td></tr>
<tr><td></td><td>Single-phase EZE are connected to terminals W and N for fault type D1. For fault type D2, the connection is made at terminals V and N.</td><td></td><td>P</td></tr>
<tr><td></td><td>
Table 6a - Normal pin assignment (fault type D1) for testing dynamic network support
<table>
<tr><th></th><th>Test facility</th><th>Test item</th></tr>
<tr><td>Terminals</td><td>U</td><td>L1</td></tr>
<tr><td></td><td>V</td><td>L2</td></tr>
<tr><td></td><td>W</td><td>L3</td></tr>
</table></td><td></td><td>P</td></tr>
</table>

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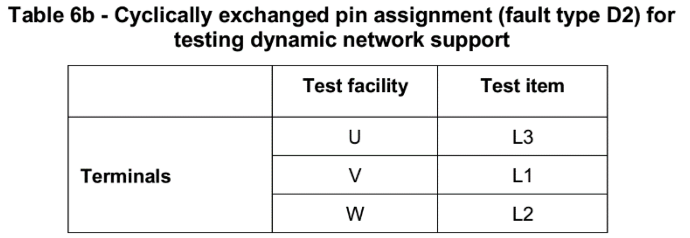
Clause	Requirement - Test	Result - Remark	Verdict
			P

Table 6b - Cyclically exchanged pin assignment (fault type D2) for testing dynamic network support

	Test facility	Test item
Terminals	U	L3
	V	L1
	W	L2

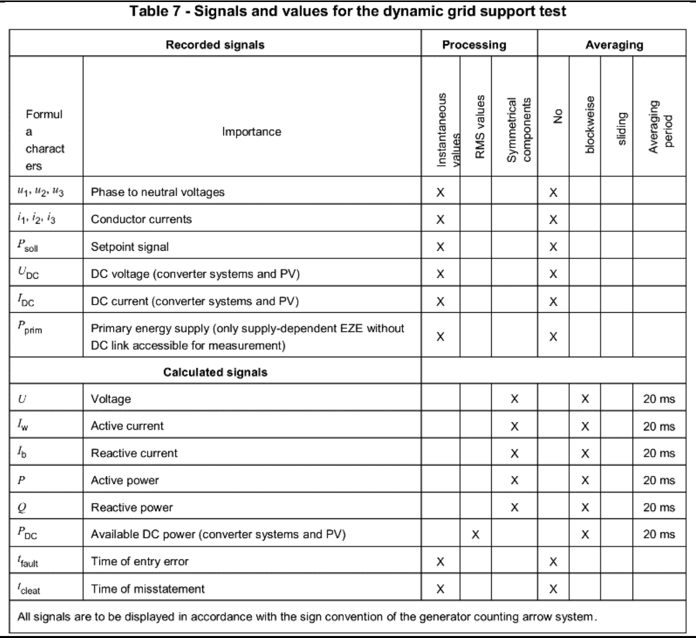
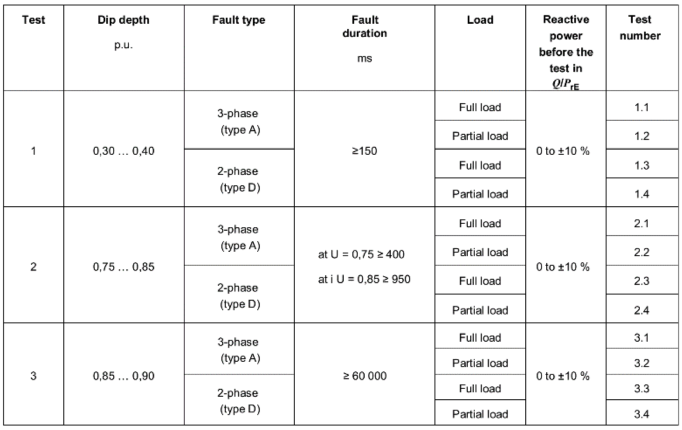
Clause	Requirement - Test	Result - Remark	Verdict
	The recording must start at least 10 s before the fault occurs. After an fault explanation (voltage in the range 0.85 $U_n \leq U \leq 1,1\ U_n$), the recording must continue for at least another 60 s.		P
	In the case of two successive test runs per test, the network fault must be run through completely so that the test is passed.		P
	There is no normative requirement for a direct temporal relationship between test and test repetition if the accredited test laboratory ensures and confirms that the EZE between test and test repetition has not been changed in either hardware or software.		P
5.6.3	Tests		P
			P

Table 7 - Signals and values for the dynamic grid support test

Recorded signals		Processing			Averaging			
Formula characters	Importance	Instantaneous values	RMS values	Symmetrical components	No	blockweise	sliding	Averaging period
u_1, u_2, u_3	Phase to neutral voltages	X			X			
i_1, i_2, i_3	Conductor currents	X			X			
P_{soll}	Setpoint signal	X			X			
U_{DC}	DC voltage (converter systems and PV)	X			X			
I_{DC}	DC current (converter systems and PV)	X			X			
P_{prim}	Primary energy supply (only supply-dependent EZE without DC link accessible for measurement)	X			X			
Calculated signals								
U	Voltage			X		X		20 ms
I_w	Active current			X		X		20 ms
I_b	Reactive current			X		X		20 ms
P	Active power			X		X		20 ms
Q	Reactive power			X		X		20 ms
P_{DC}	Available DC power (converter systems and PV)		X			X		20 ms
t_{fault}	Time of entry error	X			X			
t_{cleat}	Time of misstatement	X			X			
All signals are to be displayed in accordance with the sign convention of the generator counting arrow system.								

Clause	Requirement - Test	Result - Remark	Verdict
	The following tests must be carried out for synchronous EZE and asynchronous generators:	Not synchronous generator.	N/A

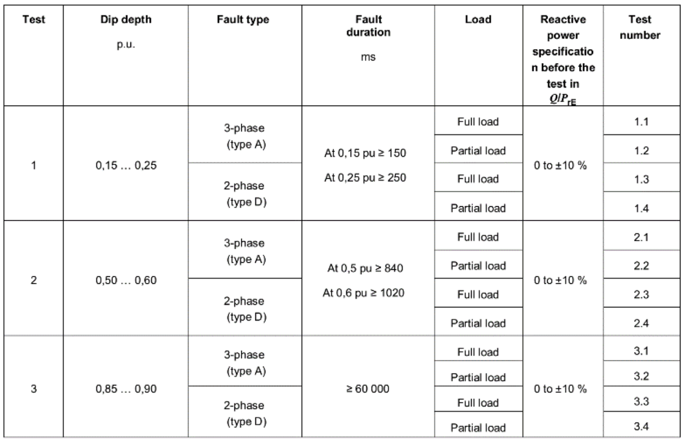
Table 8 - Tests of dynamic network support for synchronous EZE



Test	Dip depth p.u.	Fault type	Fault duration ms	Load	Reactive power before the test in Q/P_{rE}	Test number
1	0,30 … 0,40	3-phase (type A)	≥150	Full load	0 to ±10 %	1.1
				Partial load		1.2
		2-phase (type D)		Full load		1.3
				Partial load		1.4
2	0,75 … 0,85	3-phase (type A)	at U = 0,75 ≥ 400 at i U = 0,85 ≥ 950	Full load	0 to ±10 %	2.1
				Partial load		2.2
		2-phase (type D)		Full load		2.3
				Partial load		2.4
3	0,85 … 0,90	3-phase (type A)	≥ 60 000	Full load	0 to ±10 %	3.1
				Partial load		3.2
		2-phase (type D)		Full load		3.3
				Partial load		3.4

Clause	Requirement - Test	Result - Remark	Verdict
	The following tests must be carried out for non-synchronous EZE:	(See appended table)	P

Table 9 - Tests of dynamic network support for non-synchronous EZE



Test	Dip depth p.u.	Fault type	Fault duration ms	Load	Reactive power specification before the test in Q/P_{rE}	Test number
1	0,15 … 0,25	3-phase (type A)	At 0,15 pu ≥ 150 At 0,25 pu ≥ 250	Full load	0 to ±10 %	1.1
				Partial load		1.2
		2-phase (type D)		Full load		1.3
				Partial load		1.4
2	0,50 … 0,60	3-phase (type A)	At 0,5 pu ≥ 840 At 0,6 pu ≥ 1020	Full load	0 to ±10 %	2.1
				Partial load		2.2
		2-phase (type D)		Full load		2.3
				Partial load		2.4
3	0,85 … 0,90	3-phase (type A)	≥ 60 000	Full load	0 to ±10 %	3.1
				Partial load		3.2
		2-phase (type D)		Full load		3.3
				Partial load		3.4

Clause	Requirement - Test	Result - Remark	Verdict
5.6.4	Evaluation criteria		P
	Behaviour during the network fault		P
	– No separation of the EZE from the grid during the break-in. If the EZE disconnects from the network, the time of the disconnection must be documented. – Non-synchronous units and memories must not feed in either an active or a reactive current during a network fault and a voltage at the terminals of the EZE below 0.8 U_n. This requirement is met if, in the event of a voltage dip or the fed-in current of the generating unit and / or the memory 60 ms after the occurrence of this voltage dip/rise, in no phase conductor 20% of the rated current I_r and after 100 ms no more than 10% I_r exceeds.		P
	Behaviour after the end of the fault		P
	– No separation of the EZE within 60 s after the end of the fault; – Synchronous units: Rise time of the active power maximum 6 s; – Non-synchronous units and memory: Rise time of the active power maximum 1 s	Rise time of the active power less than 1 s.	P

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Clause	Requirement - Test	Result - Remark	Verdict
5.6.5	Documentation	(See appended table)	P
	Necessary information: – Calculation method for the rms values, power and displacement factor; – Description of the measurement technology, test equipment and the device under test. The description of the test facility must describe the complete operating principle, especially with a view to the correct consideration of the network-side interactions; – Voltage level at which the grid fault is generated; – Short-circuit power of the test facility at the generator terminals; – If changes have been made to the device under test to ensure its functionality during the test, these must be clearly described; – Measuring point of the recorded currents and voltages; – NA protection settings; – Relevant FRT parameters of the EZE or the storage system (for synchronous units, for example AVR setting).		P
	Diagram:		P
	For each of the tests, the following diagrams are shown as time courses from t_1 - 1 s (one second before the fault occurs) to t_2 + 6 s (six seconds after the fault has been explained), possibly zoomed:		P
	No load tests: – Phase-phase voltages and phase-neutral voltages (signal curves); – RMS full-period values of phase-neutral voltages with a recalculation rate of at least 1 / ms.		P
	Tests with the device under test: – Phase-phase voltages and phase-neutral voltages (signal curves); – Line currents (waveforms); – RMS full-period values of phase-neutral voltages with a recalculation rate of at least 1 / ms; – Full-period RMS values of the line currents with a recalculation rate of at least 1 / ms (if necessary, additionally divided into active and reactive components; – Active power and reactive power in the co-system with a recalculation rate of at least 1 / ms; – Voltage and current in the co-system with a recalculation rate of at least 1 / ms		P

Clause	Requirement - Test	Result - Remark	Verdict
	The following must be stated for each of the tests:		P

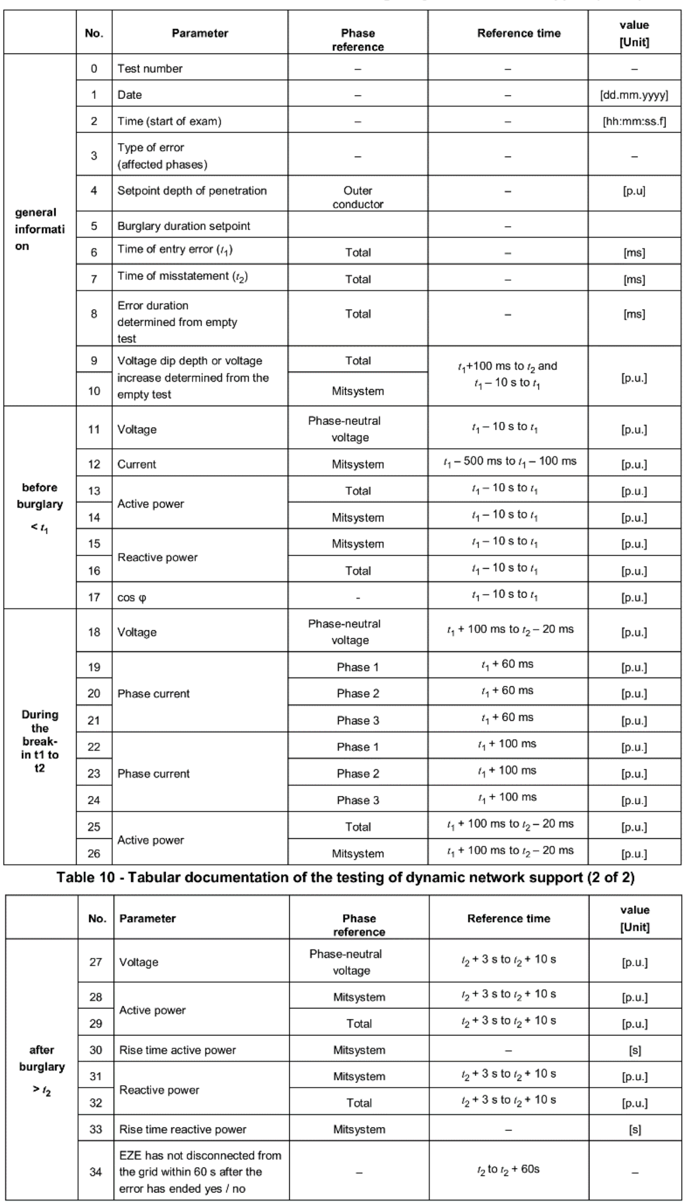


Table 10 - Tabular documentation of the testing of dynamic network support (1 of 2)

	No.	Parameter	Phase reference	Reference time	value [Unit]
general information	0	Test number	–	–	–
	1	Date	–	–	[dd.mm.yyyy]
	2	Time (start of exam)	–	–	[hh:mm:ss.f]
	3	Type of error (affected phases)	–	–	–
	4	Setpoint depth of penetration	Outer conductor	–	[p.u]
	5	Burglary duration setpoint		–	
	6	Time of entry error (t_1)	Total	–	[ms]
	7	Time of misstatement (t_2)	Total	–	[ms]
	8	Error duration determined from empty test	Total	–	[ms]
	9	Voltage dip depth or voltage increase determined from the empty test	Total	t_1+100 ms to t_2 and t_1 – 10 s to t_1	[p.u.]
	10		Mitsystem		
before burglary < t_1	11	Voltage	Phase-neutral voltage	t_1 – 10 s to t_1	[p.u.]
	12	Current	Mitsystem	t_1 – 500 ms to t_1 – 100 ms	[p.u.]
	13	Active power	Total	t_1 – 10 s to t_1	[p.u.]
	14		Mitsystem	t_1 – 10 s to t_1	[p.u.]
	15	Reactive power	Mitsystem	t_1 – 10 s to t_1	[p.u.]
	16		Total	t_1 – 10 s to t_1	[p.u.]
	17	cos φ	-	t_1 – 10 s to t_1	[p.u.]
During the break-in t1 to t2	18	Voltage	Phase-neutral voltage	t_1 + 100 ms to t_2 – 20 ms	[p.u.]
	19	Phase current	Phase 1	t_1 + 60 ms	[p.u.]
	20		Phase 2	t_1 + 60 ms	[p.u.]
	21		Phase 3	t_1 + 60 ms	[p.u.]
	22	Phase current	Phase 1	t_1 + 100 ms	[p.u.]
	23		Phase 2	t_1 + 100 ms	[p.u.]
	24		Phase 3	t_1 + 100 ms	[p.u.]
	25	Active power	Total	t_1 + 100 ms to t_2 – 20 ms	[p.u.]
	26		Mitsystem	t_1 + 100 ms to t_2 – 20 ms	[p.u.]

Table 10 - Tabular documentation of the testing of dynamic network support (2 of 2)

	No.	Parameter	Phase reference	Reference time	value [Unit]
after burglary > t_2	27	Voltage	Phase-neutral voltage	t_2 + 3 s to t_2 + 10 s	[p.u.]
	28	Active power	Mitsystem	t_2 + 3 s to t_2 + 10 s	[p.u.]
	29		Total	t_2 + 3 s to t_2 + 10 s	[p.u.]
	30	Rise time active power	Mitsystem	–	[s]
	31	Reactive power	Mitsystem	t_2 + 3 s to t_2 + 10 s	[p.u.]
	32		Total	t_2 + 3 s to t_2 + 10 s	[p.u.]
	33	Rise time reactive power	Mitsystem	–	[s]
	34	EZE has not disconnected from the grid within 60 s after the error has ended yes / no	–	t_2 to t_2 + 60s	–

Clause	Requirement - Test	Result - Remark	Verdict
5.7	**Testing of auxiliary units**		N/A
5.7.1	General		N/A
	Auxiliary units that have not been tested in the FRT tests in accordance with Section 5.8 can be checked using the procedure described here.		N/A
5.7.2	Tests		N/A

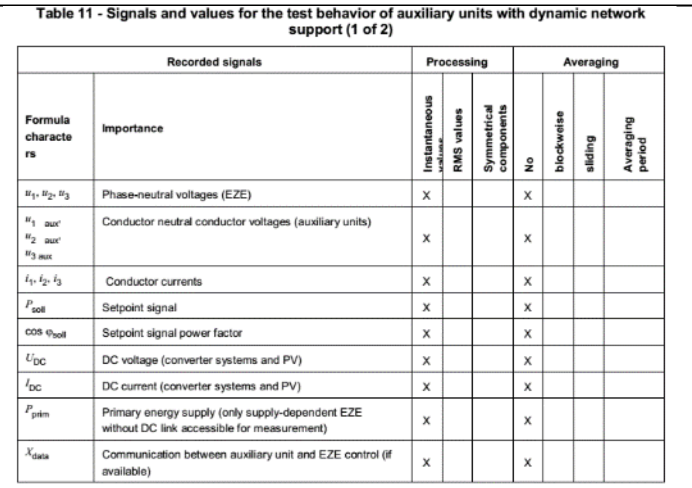
Clause	Requirement - Test	Result - Remark	Verdict
			N/A

Table 11 - Signals and values for the test behavior of auxiliary units with dynamic network support (1 of 2)

Recorded signals		Processing			Averaging			
Formula characters	Importance	Instantaneous values	RMS values	Symmetrical components	No	blockwise	sliding	Averaging period
u_1, u_2, u_3	Phase-neutral voltages (EZE)	X			X			
$u_{1\,\mathrm{aux}}$, $u_{2\,\mathrm{aux}}$, $u_{3\,\mathrm{aux}}$	Conductor neutral conductor voltages (auxiliary units)	X			X			
i_1, i_2, i_3	Conductor currents	X			X			
P_{soll}	Setpoint signal	X			X			
$\cos \varphi_{\mathrm{soll}}$	Setpoint signal power factor	X			X			
U_{DC}	DC voltage (converter systems and PV)	X			X			
I_{DC}	DC current (converter systems and PV)	X			X			
P_{prim}	Primary energy supply (only supply-dependent EZE without DC link accessible for measurement)	X			X			
X_{data}	Communication between auxiliary unit and EZE control (if available)	X			X			

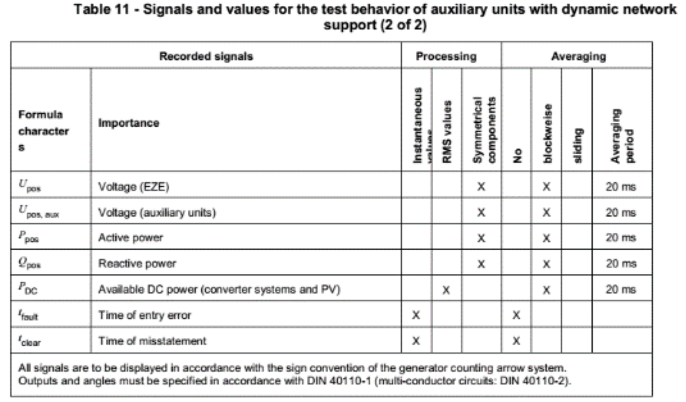
Clause	Requirement - Test	Result - Remark	Verdict
			N/A

Table 11 - Signals and values for the test behavior of auxiliary units with dynamic network support (2 of 2)

Recorded signals		Processing			Averaging			
Formula characters	Importance	Instantaneous values	RMS values	Symmetrical components	No	blockwise	sliding	Averaging period
U_{pos}	Voltage (EZE)			X		X		20 ms
$U_{\mathrm{pos,\,aux}}$	Voltage (auxiliary units)			X		X		20 ms
P_{pos}	Active power			X		X		20 ms
Q_{pos}	Reactive power			X		X		20 ms
P_{DC}	Available DC power (converter systems and PV)		X			X		20 ms
t_{fault}	Time of entry error	X			X			
t_{clear}	Time of misstatement	X			X			
All signals are to be displayed in accordance with the sign convention of the generator counting arrow system. Outputs and angles must be specified in accordance with DIN 40110-1 (multi-conductor circuits: DIN 40110-2).								

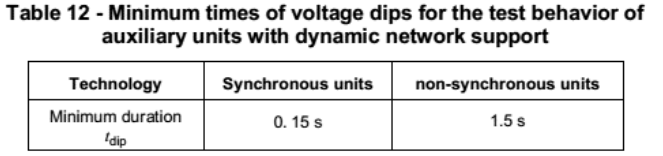
Clause	Requirement - Test	Result - Remark	Verdict
	The generating unit is operated at nominal power during the test. To test the auxiliary units, the supply voltage of the auxiliary units to be tested and their control are dropped to a residual voltage of not more than 50% of the nominal voltage for a minimum period of time according to Table 12. 		N/A

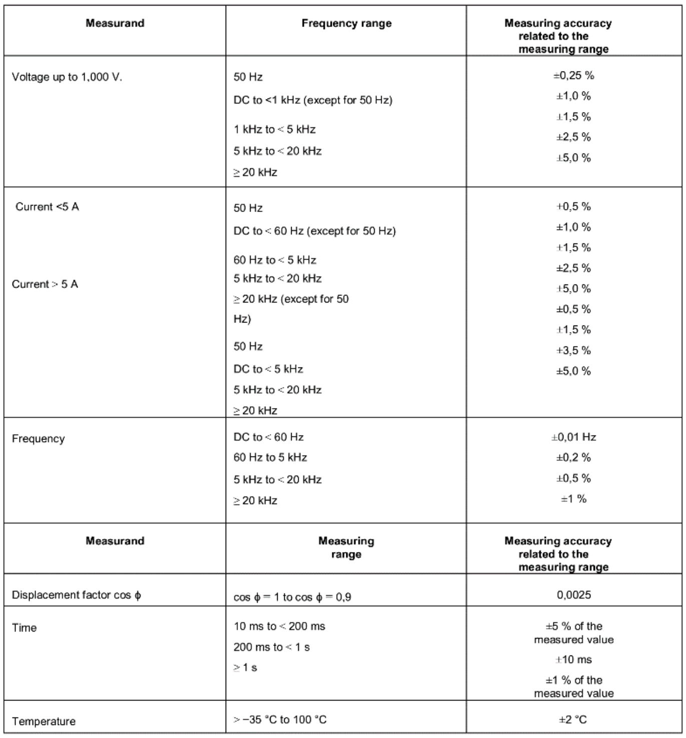
Table 12 - Minimum times of voltage dips for the test behavior of auxiliary units with dynamic network support

Technology	Synchronous units	non-synchronous units
Minimum duration t_{dip}	0. 15 s	1.5 s

Clause	Requirement - Test	Result - Remark	Verdict
	The currents and voltages at the EZE terminals and the voltages at the auxiliary units must be recorded for the entire duration of the test. The recording starts 10 s before the voltage drop and ends 10 minutes after the voltage returns.		N/A
	Alternatively, an auxiliary unit can be tested independently of an EZE. For this purpose, the auxiliary unit must be operated at full load according to its specifications or under those operating conditions that correspond to full load operation in the associated EZE. The operating conditions used are to be documented in the test report. Instead of the currents and voltages at the EZE terminals, suitable signals are to be recorded, by which the successful continued operation of the auxiliary unit can be verified.		N/A

Clause	Requirement - Test	Result - Remark	Verdict
	If communication with the EZE controller is provided (eg status monitoring), it may be necessary to ensure by recording the appropriate signals that the auxiliary unit does not generate any fault states within the measurement period that could lead to the shutdown of the EZE.		N/A
5.7.3	Evaluation criteria		N/A
	The following applies: The drop in the supply voltage of the auxiliary units and their control must not result in the generation unit being disconnected from the grid. Proof is provided if the generation unit has not been disconnected from the grid within 10 minutes after the voltage returns.		N/A
5.7.4	Documentation of the tests	(See appended table)	N/A
	For the entire duration of the test up to 10 minutes after voltage recovery, the voltage, active and reactive power of the EZE in the co-system sizes as well as the voltages on the auxiliary units are to be shown as diagrams.		N/A
APPENDIX A	**TEST BENCH REQUIREMENTS**		P
A.1	**Measuring accuracy of the measuring devices**		P
	The measuring devices used should have at least the following measuring accuracies (see table A.1):		P

Table A.1 - Minimum measurement accuracies



Measurand	**Frequency range**	**Measuring accuracy related to the measuring range**
Voltage up to 1,000 V.	50 Hz DC to <1 kHz (except for 50 Hz) 1 kHz to < 5 kHz 5 kHz to < 20 kHz ≥ 20 kHz	±0,25 % ±1,0 % ±1,5 % ±2,5 % ±5,0 %
Current <5 A Current > 5 A	50 Hz DC to < 60 Hz (except for 50 Hz) 60 Hz to < 5 kHz 5 kHz to < 20 kHz ≥ 20 kHz (except for 50 Hz) 50 Hz DC to < 5 kHz 5 kHz to < 20 kHz ≥ 20 kHz	+0,5 % ±1,0 % ±1,5 % ±2,5 % ±5,0 % ±0,5 % ±1,5 % +3,5 % ±5,0 %
Frequency	DC to < 60 Hz 60 Hz to 5 kHz 5 kHz to < 20 kHz ≥ 20 kHz	±0,01 Hz ±0,2 % ±0,5 % ±1 %
Measurand	**Measuring range**	**Measuring accuracy related to the measuring range**
Displacement factor cos ϕ	cos ϕ = 1 to cos ϕ = 0,9	0,0025
Time	10 ms to < 200 ms 200 ms to < 1 s ≥ 1 s	±5 % of the measured value ±10 ms ±1 % of the measured value
Temperature	> −35 °C to 100 °C	±2 °C

Clause	Requirement - Test	Result - Remark	Verdict
	The accuracies for measurements not equal to 50 Hz should be based on the requirements of the referenced standards. The selected measuring range should not exceed 150% of the nominal value of the signal to be measured.		P
A.2	**Quality of the test bench**		P

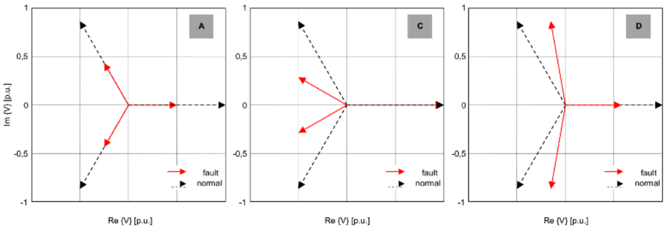
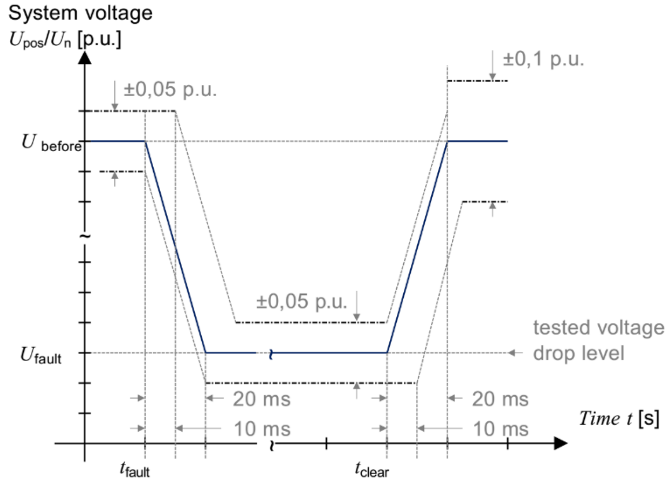
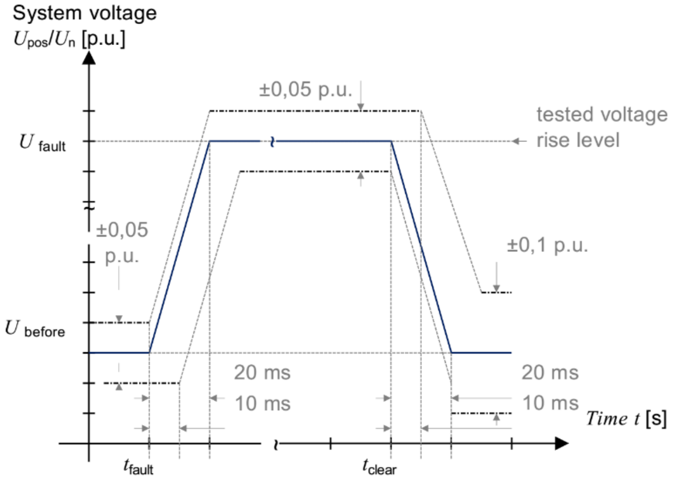
<table>
<tr><th colspan="4">OVE-Richtlinie R 25</th></tr>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td>A.2.1</td><td>General requirements</td><td></td><td>P</td></tr>
<tr><td></td><td>The voltage on the test bench should be between 86% U_n and 109% U_n during the tests, unless a test requires otherwise.</td><td></td><td>P</td></tr>
<tr><td></td><td>The frequency on the test bench should be 50 Hz ± 0.5% during the tests, unless otherwise required during a test.</td><td></td><td>P</td></tr>
<tr><td></td><td>The voltage on the test bench should have a maximum total harmonic distortion of 3% (THD according to ÖVE / ÖNORM EN 61000-3-2).</td><td></td><td>P</td></tr>
<tr><td></td><td>The nominal current of the EZE should not increase the voltage on the test bench by more than 3%</td><td></td><td>P</td></tr>
<tr><td>A.2.2</td><td>Test bench requirements for FRT tests</td><td></td><td>P</td></tr>
<tr><td></td><td>The voltage drops and voltage increases should meet the following requirements:
– The effective grid impedance from the EZE perspective (with voltage divider principle: with the series impedance switched on) must meet the following criteria:
– Short-circuit power at the EZE before and after the fault must be between 10 S_n and 30 S_n;
– R/X 0.3 - 3 (for the impedances used in the test facility).
– The test facility and, if applicable, the network simulator must be able to carry the maximum current of the test object in the generator as well as in the motor area. The energy consumption must be designed for the occurring surge short-circuit current i_P (according to OVE EN 60909-0). i_P of the DUT types is very different. Guide values are:
  – for converter-coupled systems approx. 2.2 I_r;
  – for directly coupled asynchronous or synchronous machines approx. 7 I_r.
– In the case of symmetrical and asymmetrical voltage dips and voltage increases, taking into account the switching group effect, the fault forms A and D according to Figure A.1 with the phase angles of the voltages according to Table A.2 must be observed. The representations show conductor-neutral conductor voltages.


Figure A.1 - Fault types "A", "C" and "D" after [M. H. J. Bollen "Understanding Power Quality Problems"]
Table A.2 – Fault type for FRT tests on type 2 EZE and storage when carried out on electronic network simulators
<table>
<tr><th>Test No.</th><th>L1</th><th>L2</th><th>L3</th><th>Type</th><th>Comment</th></tr>
<tr><td>–</td><td>1,00 > –150,0 °</td><td>1,00 > 90,0 °</td><td>1,00 > –30,0 °</td><td>A</td><td>Initial state</td></tr>
<tr><td>1.3, 1.4</td><td>0,62 > –173,3 °</td><td>0,15 > 90,0 °</td><td>0,62 > –6,9 °</td><td>D 1</td><td rowspan="3">LV FRT</td></tr>
<tr><td>2.3, 2.4</td><td>0,76 > –161,1 °</td><td>0,50 > 90,0 °</td><td>0,76 > –19,1 °</td><td>D 1</td></tr>
<tr><td>3.3, 3.4</td><td>0,93 > –152,8 °</td><td>0,85 > 89,9 °</td><td>0,93 > –27,4 °</td><td>D 1</td></tr>
</table>
</td><td></td><td>P</td></tr>
</table>

OVE-Richtlinie R 25			
Clause	Requirement - Test	Result - Remark	Verdict
	– The slope of the voltage must correspond to that of a circuit breaker in the event of an fault and an fault explanation. The LV FRT should change the instantaneous voltage from 90% to 10% of the pre-fault voltage within a period of max. 4 ms. – As part of the no load tests, the requirements for the curve shape of the test voltage must be checked. The test voltage must be within the range shown in Figure A.2 for voltage drop tests or in Figure A.3 tolerances shown for overvoltage tests.  **Figure A.2 - Tolerances for voltage dips [Positive-sequence calculation according to OVE EN IEC 61400-21-1]**  **Figure A.3 - Tolerances for voltage rise [Positive-sequence calculation according to OVE EN IEC 61400-21-1]**		P

OVE-Richtlinie R 25			
Clause	Requirement - Test	Result - Remark	Verdict
	– The occurrence of the fault must be independent of the phase position. – It must be ensured that the test facility does not cause any interruptions or discontinuities in voltage and current during the tests. (Saturation and intrinsic effects that may occur due to the transformer-based test facility must be documented as part of the empty tests)		P
APPENDIX B	**NOTES ON THE DELTA CHECK FOR VDE-AR-N 4105: 2018**		P
	In the TOR generator, an examination based on VDE-AR-N 4105 is permitted under clause 8 conformity footnote 31.	Not based on VDE-AR-N 4105, all applicable clause of TOR generator and OVE regulation R 25 was performed.	N/A
	Since the requirements of the TOR generators differ significantly from those specified in VDE-AR-N 4105: 2018, additional tests are required to assess whether the requirements of the TOR generators have been met.		N/A
	The following additional points must be checked in detail:		P
	– General - Check the parameterization according to the TOR generator, Appendix A3 Setting values for inverters on low-voltage distribution networks. After selecting the country setting Austria (if available) or the setting according to a manufacturer's parameterization guide for Austria, a visual inspection must be carried out to determine whether the set values match the setting values specified in the TOR generator, Appendix A3.	Not based on VDE-AR-N 4105, all applicable clause of TOR generator and OVE regulation R 25 was performed.	P
	– 5.3.2 Measurement of active and reactive power work area		P
	– 5.3.6 Voltage-controlled active power limitation P (U)		P
	– 5.3.9 Reactive power control according to setpoint Q fixed.		P
	– 5.3.10 Live control functions		P
	– 5.3.11 Protection of the settings according to the requirements of the TOR generators		P

Summary of Test

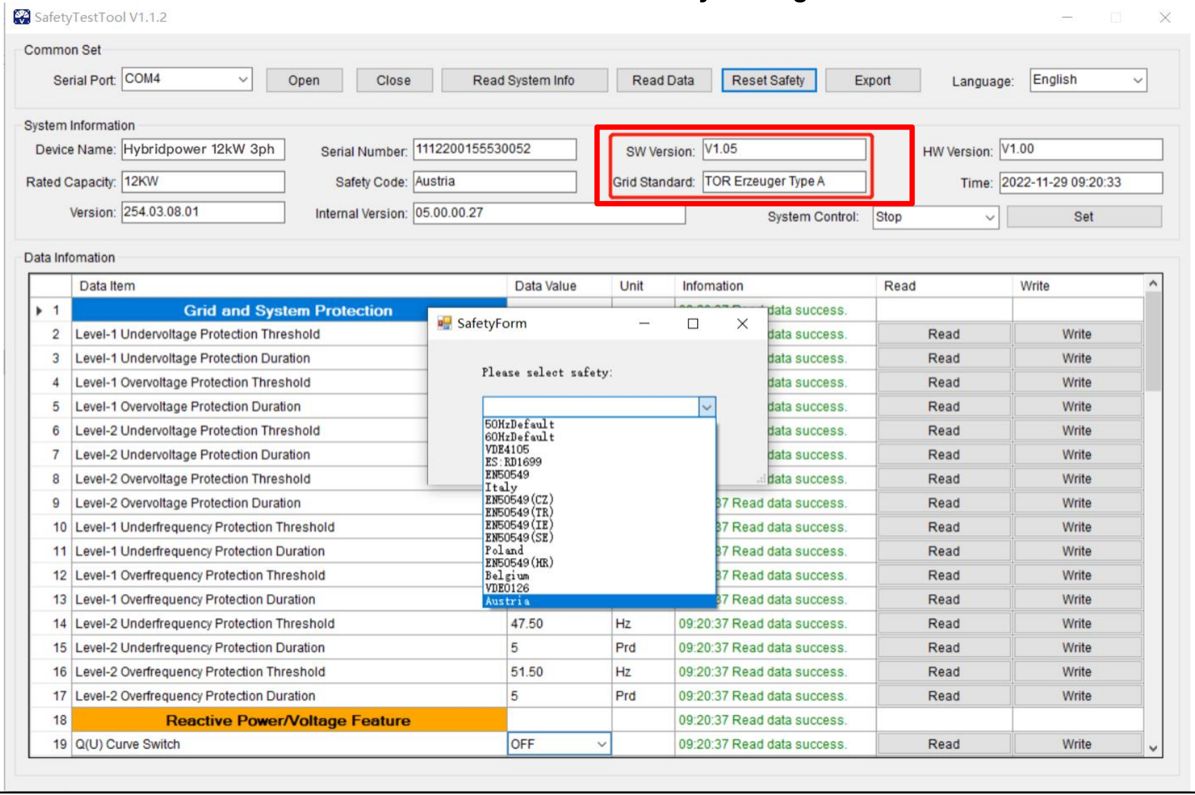
Clause	Test Item	Summary (P/F/N/Retest)
(5.1.1 & 5.3.1)	Frequency range & Voltage range operating measurement	P
5.1.2	Rapid voltage changes	P
5.1.3	Flicker	P
5.1.4	Harmonics and Interharmonics	P
5.2 (6.1.1)	Testing the symmetry behaviour of three-phase inverters	P
5.3 (5)	Test the behaviour of the generating unit on the network	P
5.3.2 (5.3.3)	Measurement of active and reactive power working area (PQ diagram)	P
5.3.3 (5.4.1)	Ceasing of power feed-in after remote control (input port)	P
5.3.4 (5.1.3 & 5.5.2)	Active power reduction at overfrequency	P
5.3.5 (5.1.5)	Active power reduction at underfrequency	P
5.3.6 (5.3.6)	Voltage related active power reduction (P(U) control)	P
5.3.6.1.1 (5.3.6)	Test sequence for the static behaviour of the P (U) control	P
5.3.6.1.2 (5.3.6)	Test sequence for the dynamic behaviour of the P (U) control	P
5.3.7 (5.3.4)	Reactive power control according to setpoint fixed cos φ	P
5.3.8 (5.3.4.1)	Power related control mode – cos φ (P)	P
5.3.9 (5.3.4)	Setpoint control modes – fixed Q	P
5.3.10 (5.3.4.2 & 5.3.6)	Voltage-control functions (reactive power control Q (U) and active power control P (U))	P
5.3.10.1.1 (5.3.4.2 & 5.3.6)	Test procedure for static behaviour	P
5.3.10.1.2 (5.3.4.2 & 5.3.6)	Test procedure for dynamic behaviour	P
5.3.11 (6.2.3)	Protection of the settings as requested by the TOR generator	P
5.4.1.1.1 (6.1.2 & 6.3.3.1)	Testing the overvoltage protection U_{eff} >> and the undervoltage protection U_{eff} < and U_{eff} <<	P
5.4.1.1.2 (6.1.2)	Testing the overvoltage protection U_{eff} > with monitoring of the moving 10-minute average	P
5.4.2 (6.1.2 & 6.3.3.1)	Frequency protection devices	P
5.4.3	Detection of island operation	P
5.5 (5.5.2)	Testing the connection conditions and synchronization	P
5.6 (5.2)	Proof of dynamic network support	P
5.7	Tests on auxiliary devices	N/A

Note:
The clause no. in this table and below appended table including two standards of OVE-Richtlinie R 25:2020-03-01 and TOR Erzeuger:2022-04-11. For example clause 5.2 (6.1.1), the clause 5.2 before the parenthesis is representing for OVE-Richtlinie R 25:2020-03-01 and 6.1.1 in the parenthesis is representing for TOR Erzeuger:2022-04-11.

Documentation of Austria country setting:

OVE-Richtlinie R 25			
Clause	Requirement - Test	Result - Remark	Verdict

Screenshot of the selection of Austria country setting in PC Software tool:



Serial Port: COM4
Language: English

System Information
Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.05
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:20:33
Version: 254.03.08.01
Internal Version: 05.00.00.27
System Control: Stop

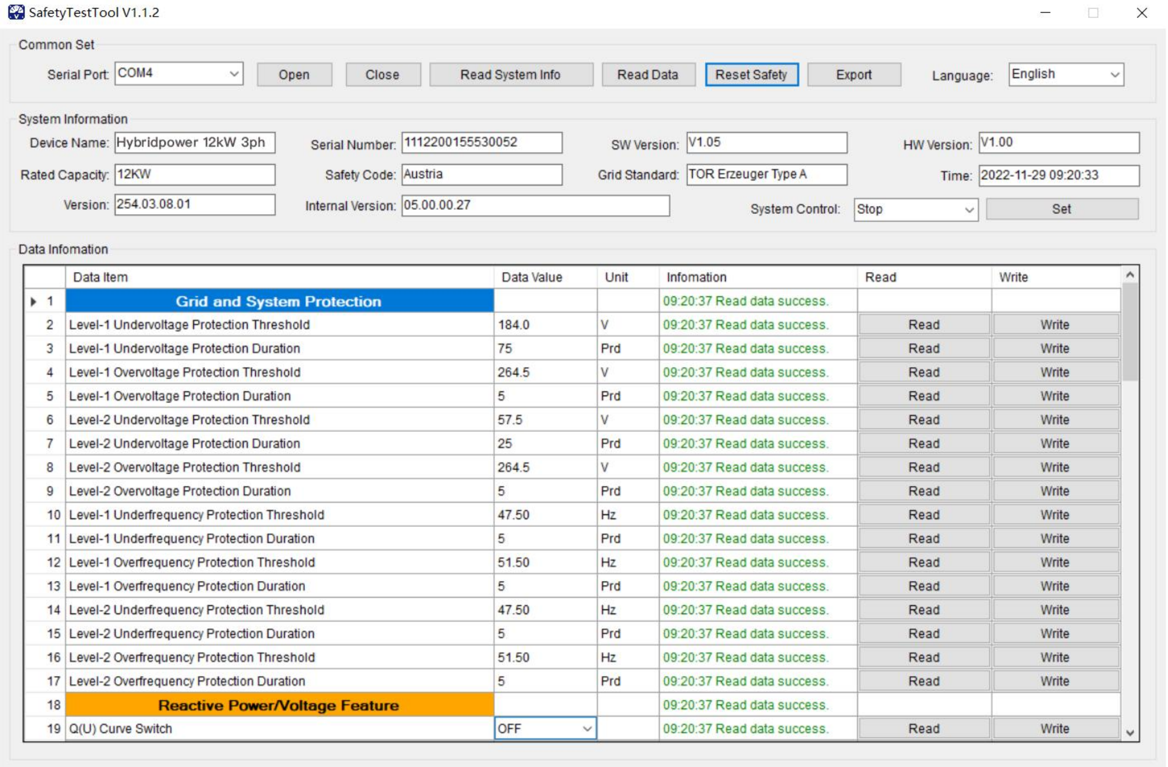
Please select safety:

- 50HzDefault
- 60HzDefault
- VDE4105
- ES:RD1699
- EN50549
- Italy
- EN50549(CZ)
- EN50549(TR)
- EN50549(IE)
- EN50549(SE)
- Poland
- EN50549(HR)
- Belgium
- VDE0126
- Austria

Data Infomation

	Data Item	Data Value	Unit	Infomation	Read	Write
1	Grid and System Protection			data success.		
2	Level-1 Undervoltage Protection Threshold			data success.	Read	Write
3	Level-1 Undervoltage Protection Duration			data success.	Read	Write
4	Level-1 Overvoltage Protection Threshold			data success.	Read	Write
5	Level-1 Overvoltage Protection Duration			data success.	Read	Write
6	Level-2 Undervoltage Protection Threshold			data success.	Read	Write
7	Level-2 Undervoltage Protection Duration			data success.	Read	Write
8	Level-2 Overvoltage Protection Threshold			data success.	Read	Write
9	Level-2 Overvoltage Protection Duration			7 Read data success.	Read	Write
10	Level-1 Underfrequency Protection Threshold			7 Read data success.	Read	Write
11	Level-1 Underfrequency Protection Duration			7 Read data success.	Read	Write
12	Level-1 Overfrequency Protection Threshold			7 Read data success.	Read	Write
13	Level-1 Overfrequency Protection Duration			7 Read data success.	Read	Write
14	Level-2 Underfrequency Protection Threshold	47.50	Hz	09:20:37 Read data success.	Read	Write
15	Level-2 Underfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
16	Level-2 Overfrequency Protection Threshold	51.50	Hz	09:20:37 Read data success.	Read	Write
17	Level-2 Overfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
18	Reactive Power/Voltage Feature			09:20:37 Read data success.		
19	Q(U) Curve Switch	OFF		09:20:37 Read data success.	Read	Write

Screenshot of the parameterization interface setting about Austria grid-relevant parameters for standard TOR Erzeuger Type A in PC Software tool:

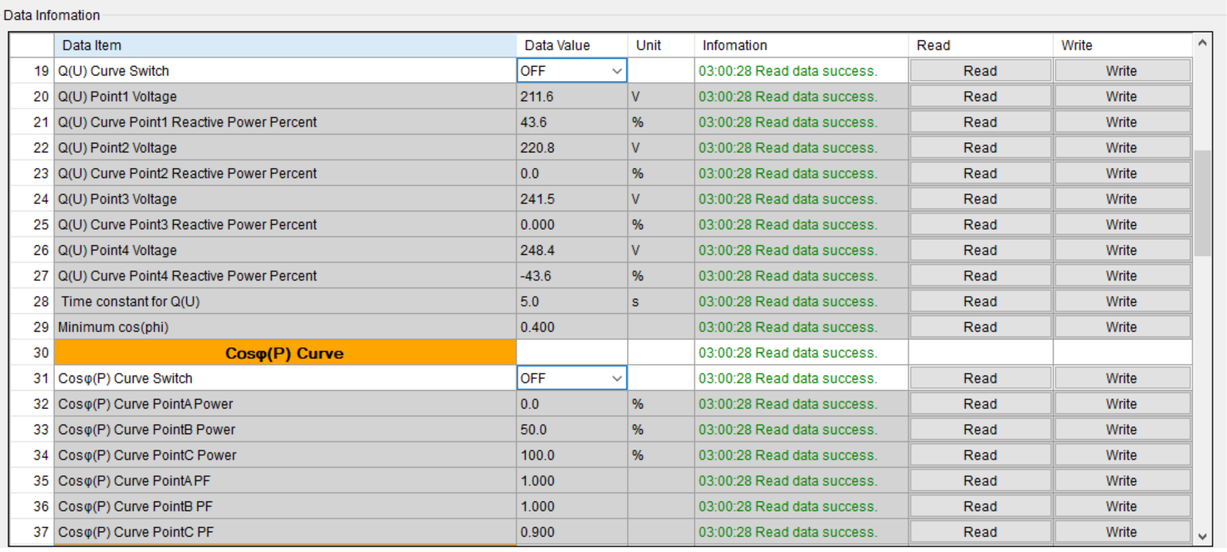


Serial Port: COM4
Language: English

System Information
Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.05
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:20:33
Version: 254.03.08.01
Internal Version: 05.00.00.27
System Control: Stop

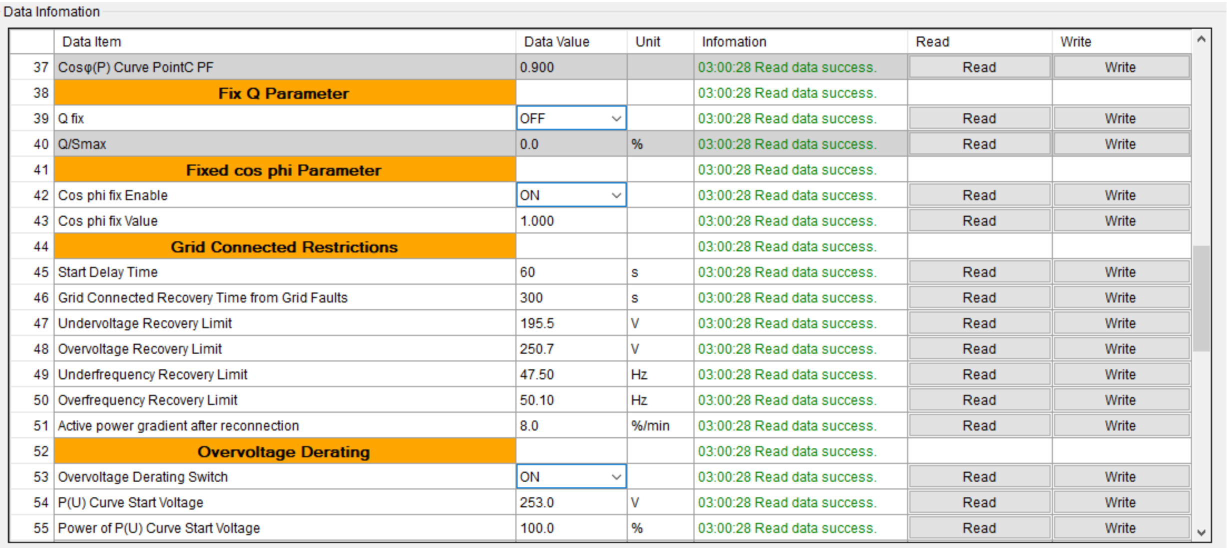
Data Infomation

	Data Item	Data Value	Unit	Infomation	Read	Write
1	Grid and System Protection			09:20:37 Read data success.		
2	Level-1 Undervoltage Protection Threshold	184.0	V	09:20:37 Read data success.	Read	Write
3	Level-1 Undervoltage Protection Duration	75	Prd	09:20:37 Read data success.	Read	Write
4	Level-1 Overvoltage Protection Threshold	264.5	V	09:20:37 Read data success.	Read	Write
5	Level-1 Overvoltage Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
6	Level-2 Undervoltage Protection Threshold	57.5	V	09:20:37 Read data success.	Read	Write
7	Level-2 Undervoltage Protection Duration	25	Prd	09:20:37 Read data success.	Read	Write
8	Level-2 Overvoltage Protection Threshold	264.5	V	09:20:37 Read data success.	Read	Write
9	Level-2 Overvoltage Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
10	Level-1 Underfrequency Protection Threshold	47.50	Hz	09:20:37 Read data success.	Read	Write
11	Level-1 Underfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
12	Level-1 Overfrequency Protection Threshold	51.50	Hz	09:20:37 Read data success.	Read	Write
13	Level-1 Overfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
14	Level-2 Underfrequency Protection Threshold	47.50	Hz	09:20:37 Read data success.	Read	Write
15	Level-2 Underfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
16	Level-2 Overfrequency Protection Threshold	51.50	Hz	09:20:37 Read data success.	Read	Write
17	Level-2 Overfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
18	Reactive Power/Voltage Feature			09:20:37 Read data success.		
19	Q(U) Curve Switch	OFF		09:20:37 Read data success.	Read	Write



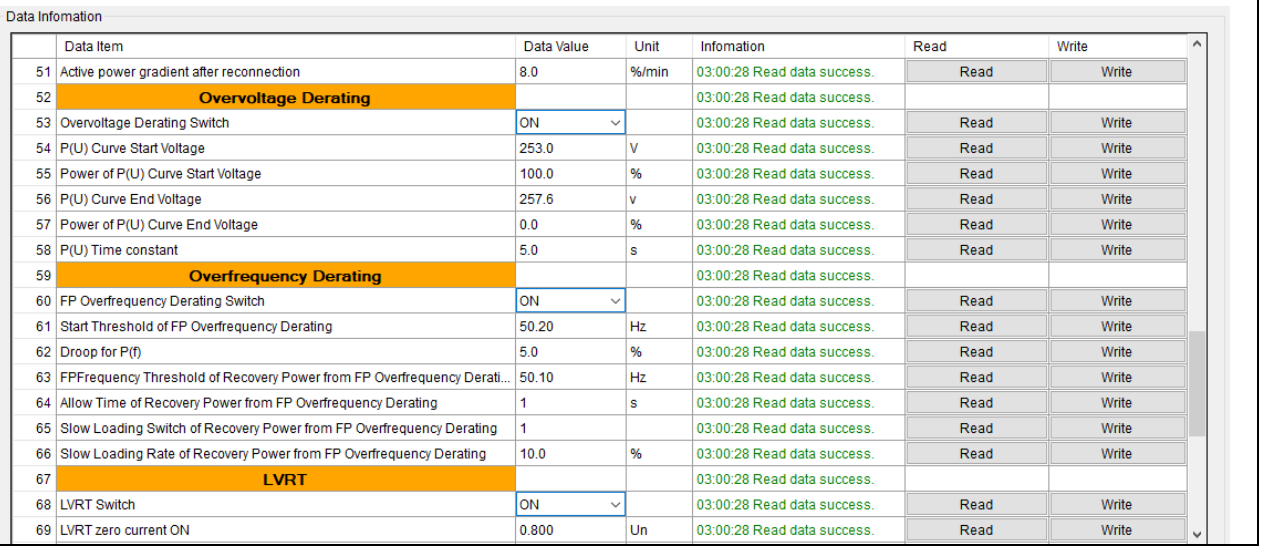
Data Infomation

	Data Item	Data Value	Unit	Infomation	Read	Write
19	Q(U) Curve Switch	OFF		03:00:28 Read data success.	Read	Write
20	Q(U) Point1 Voltage	211.6	V	03:00:28 Read data success.	Read	Write
21	Q(U) Curve Point1 Reactive Power Percent	43.6	%	03:00:28 Read data success.	Read	Write
22	Q(U) Point2 Voltage	220.8	V	03:00:28 Read data success.	Read	Write
23	Q(U) Curve Point2 Reactive Power Percent	0.0	%	03:00:28 Read data success.	Read	Write
24	Q(U) Point3 Voltage	241.5	V	03:00:28 Read data success.	Read	Write
25	Q(U) Curve Point3 Reactive Power Percent	0.000	%	03:00:28 Read data success.	Read	Write
26	Q(U) Point4 Voltage	248.4	V	03:00:28 Read data success.	Read	Write
27	Q(U) Curve Point4 Reactive Power Percent	-43.6	%	03:00:28 Read data success.	Read	Write
28	Time constant for Q(U)	5.0	s	03:00:28 Read data success.	Read	Write
29	Minimum cos(phi)	0.400		03:00:28 Read data success.	Read	Write
30	**Cosφ(P) Curve**			03:00:28 Read data success.		
31	Cosφ(P) Curve Switch	OFF		03:00:28 Read data success.	Read	Write
32	Cosφ(P) Curve PointA Power	0.0	%	03:00:28 Read data success.	Read	Write
33	Cosφ(P) Curve PointB Power	50.0	%	03:00:28 Read data success.	Read	Write
34	Cosφ(P) Curve PointC Power	100.0	%	03:00:28 Read data success.	Read	Write
35	Cosφ(P) Curve PointA PF	1.000		03:00:28 Read data success.	Read	Write
36	Cosφ(P) Curve PointB PF	1.000		03:00:28 Read data success.	Read	Write
37	Cosφ(P) Curve PointC PF	0.900		03:00:28 Read data success.	Read	Write



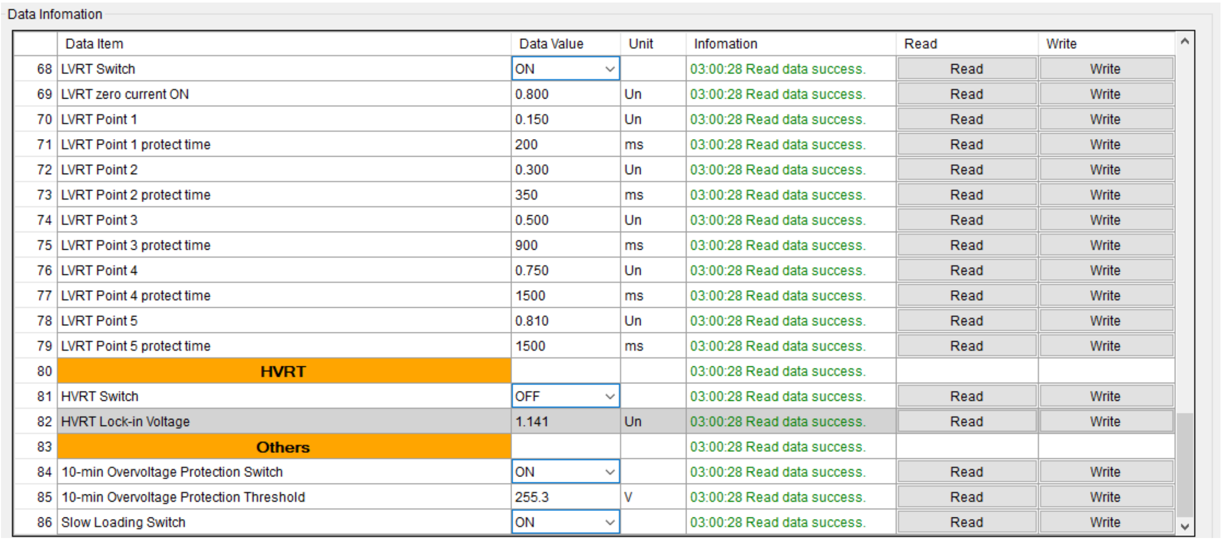
Data Infomation

	Data Item	Data Value	Unit	Infomation	Read	Write
37	Cosφ(P) Curve PointC PF	0.900		03:00:28 Read data success.	Read	Write
38	**Fix Q Parameter**			03:00:28 Read data success.		
39	Q fix	OFF		03:00:28 Read data success.	Read	Write
40	Q/Smax	0.0	%	03:00:28 Read data success.	Read	Write
41	**Fixed cos phi Parameter**			03:00:28 Read data success.		
42	Cos phi fix Enable	ON		03:00:28 Read data success.	Read	Write
43	Cos phi fix Value	1.000		03:00:28 Read data success.	Read	Write
44	**Grid Connected Restrictions**			03:00:28 Read data success.		
45	Start Delay Time	60	s	03:00:28 Read data success.	Read	Write
46	Grid Connected Recovery Time from Grid Faults	300	s	03:00:28 Read data success.	Read	Write
47	Undervoltage Recovery Limit	195.5	V	03:00:28 Read data success.	Read	Write
48	Overvoltage Recovery Limit	250.7	V	03:00:28 Read data success.	Read	Write
49	Underfrequency Recovery Limit	47.50	Hz	03:00:28 Read data success.	Read	Write
50	Overfrequency Recovery Limit	50.10	Hz	03:00:28 Read data success.	Read	Write
51	Active power gradient after reconnection	8.0	%/min	03:00:28 Read data success.	Read	Write
52	**Overvoltage Derating**			03:00:28 Read data success.		
53	Overvoltage Derating Switch	ON		03:00:28 Read data success.	Read	Write
54	P(U) Curve Start Voltage	253.0	V	03:00:28 Read data success.	Read	Write
55	Power of P(U) Curve Start Voltage	100.0	%	03:00:28 Read data success.	Read	Write



Data Infomation

	Data Item	Data Value	Unit	Infomation	Read	Write
51	Active power gradient after reconnection	8.0	%/min	03:00:28 Read data success.	Read	Write
52	**Overvoltage Derating**			03:00:28 Read data success.		
53	Overvoltage Derating Switch	ON		03:00:28 Read data success.	Read	Write
54	P(U) Curve Start Voltage	253.0	V	03:00:28 Read data success.	Read	Write
55	Power of P(U) Curve Start Voltage	100.0	%	03:00:28 Read data success.	Read	Write
56	P(U) Curve End Voltage	257.6	v	03:00:28 Read data success.	Read	Write
57	Power of P(U) Curve End Voltage	0.0	%	03:00:28 Read data success.	Read	Write
58	P(U) Time constant	5.0	s	03:00:28 Read data success.	Read	Write
59	**Overfrequency Derating**			03:00:28 Read data success.		
60	FP Overfrequency Derating Switch	ON		03:00:28 Read data success.	Read	Write
61	Start Threshold of FP Overfrequency Derating	50.20	Hz	03:00:28 Read data success.	Read	Write
62	Droop for P(f)	5.0	%	03:00:28 Read data success.	Read	Write
63	FPFrequency Threshold of Recovery Power from FP Overfrequency Derati...	50.10	Hz	03:00:28 Read data success.	Read	Write
64	Allow Time of Recovery Power from FP Overfrequency Derating	1	s	03:00:28 Read data success.	Read	Write
65	Slow Loading Switch of Recovery Power from FP Overfrequency Derating	1		03:00:28 Read data success.	Read	Write
66	Slow Loading Rate of Recovery Power from FP Overfrequency Derating	10.0	%	03:00:28 Read data success.	Read	Write
67	**LVRT**			03:00:28 Read data success.		
68	LVRT Switch	ON		03:00:28 Read data success.	Read	Write
69	LVRT zero current ON	0.800	Un	03:00:28 Read data success.	Read	Write



Data Infomation

	Data Item	Data Value	Unit	Infomation	Read	Write
68	LVRT Switch	ON		03:00:28 Read data success.	Read	Write
69	LVRT zero current ON	0.800	Un	03:00:28 Read data success.	Read	Write
70	LVRT Point 1	0.150	Un	03:00:28 Read data success.	Read	Write
71	LVRT Point 1 protect time	200	ms	03:00:28 Read data success.	Read	Write
72	LVRT Point 2	0.300	Un	03:00:28 Read data success.	Read	Write
73	LVRT Point 2 protect time	350	ms	03:00:28 Read data success.	Read	Write
74	LVRT Point 3	0.500	Un	03:00:28 Read data success.	Read	Write
75	LVRT Point 3 protect time	900	ms	03:00:28 Read data success.	Read	Write
76	LVRT Point 4	0.750	Un	03:00:28 Read data success.	Read	Write
77	LVRT Point 4 protect time	1500	ms	03:00:28 Read data success.	Read	Write
78	LVRT Point 5	0.810	Un	03:00:28 Read data success.	Read	Write
79	LVRT Point 5 protect time	1500	ms	03:00:28 Read data success.	Read	Write
80	**HVRT**			03:00:28 Read data success.		
81	HVRT Switch	OFF		03:00:28 Read data success.	Read	Write
82	HVRT Lock-in Voltage	1.141	Un	03:00:28 Read data success.	Read	Write
83	**Others**			03:00:28 Read data success.		
84	10-min Overvoltage Protection Switch	ON		03:00:28 Read data success.	Read	Write
85	10-min Overvoltage Protection Threshold	255.3	V	03:00:28 Read data success.	Read	Write
86	Slow Loading Switch	ON		03:00:28 Read data success.	Read	Write

Note:
The selection of Austria country setting can only be completed in the factory or authorised person, the user cannot change the country setting.

(5.1.1 & 5.3.1)	**TABLE: Frequency range &Voltage range operating measurement**				**P**
Model	Hybridpower 12kW 3ph				
Test condition	P=100%S_n @ PF=1				
Test sequence	Setting Value	Frequency [Hz]	Voltage [V]	Output power [W]	Time period Required
Test 1	85% U_n / 47.5 Hz	47.50	195.67	11692.30	> 60 min
Test 2	85% U_n / 48.5 Hz	48.50	195.66	11685.54	> 90 min
Test 3	110% U_n / 51.0 Hz	51.00	253.14	11932.21	> 90 min
Test 4	110% U_n / 51.5 Hz	51.50	253.24	11916.46	> 30 min
Test 5	112% U_n / 50.0 Hz	50.00	257.76	11916.49	> 10 min

Note:

Respecting the legal framework, it is possible that longer time periods are required by the responsible party in some synchronous areas.

If the voltage is lower than U_n, the active power may be reduced below the rated value due to the output current limit of the inverter.

The testing values refer to EN 50549-1, the settings of the interface protection were disable when performing this test.

5.1.2	**TABLE: Rapid voltage changes – Phase A**					**P**
Model	Hybridpower 12kW 3ph					
Test cases:	Switching on without specification (10% rated output power)			Most unfavourable case when switching the generator (10% → 100% rated output power)		
Cos φ setting	Cos φ=1.00	Cos φ = max.over-excited	Cos φ= max.under-excited	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited
Single period effective values of the voltage [V]	229.7	229.3	228.9	229.3	230.6	230.9
Single period effective values of the current [A]	1.189	1.837	2.042	1.975	2.821	1.893
k_i	0.068	0.106	0.117	0.114	0.162	0.109
Test cases:	Switching on at rated power			Switch off at rated power		
Cos φ setting	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited
Single period effective values of the voltage [V]	229.3	229.6	229.4	228.0	226.2	230.5
Single period effective values of the current [A]	1.328	1.641	1.763	1.471	1.508	2.005
k_i	0.076	0.094	0.101	0.085	0.087	0.115
k_{imax}	0.162					
Test conditions: Frequency: 50 Hz ± 0.5% THD of the voltage supply: ≤ 3% Voltage rise of the PGU at 100% P_{Emax}: ≤ 3%						
Note: Power generation units with inverters (such as photovoltaic systems) and storage units with inverters shall only be connected with k_{imax} ≤ 1.2.						

5.1.2	**TABLE: Rapid voltage changes – Phase B**					**P**
Model	Hybridpower 12kW 3ph					
Test cases:	Switching on without specification (10% rated output power)			Most unfavourable case when switching the generator (10% → 100% rated output power)		
Cos φ setting	Cos φ=1.00	Cos φ = max.over-excited	Cos φ= max.under-excited	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited
Single period effective values of the voltage [V]	228.8	229.0	229.0	229.3	229.1	228.5
Single period effective values of the current [A]	1.189	1.837	2.042	1.975	2.821	1.893
k_i	0.068	0.106	0.117	0.114	0.162	0.109
Test cases:	Switching on at rated power			Switch off at rated power		
Cos φ setting	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited
Single period effective values of the voltage [V]	228.8	229.2	228.9	228.0	224.4	231.5
Single period effective values of the current [A]	1.328	1.641	1.763	1.471	1.508	2.005
k_i	0.076	0.094	0.101	0.085	0.087	0.115
k_{imax}	0.162					
Test conditions: Frequency: 50 Hz ± 0.5% THD of the voltage supply: ≤ 3% Voltage rise of the PGU at 100% P_{Emax}: ≤ 3%						
Note: Power generation units with inverters (such as photovoltaic systems) and storage units with inverters shall only be connected with k_{imax} ≤ 1.2.						

5.1.2	**TABLE: Rapid voltage changes – Phase C**					**P**
Model	Hybridpower 12kW 3ph					
Test cases:	Switching on without specification (10% rated output power)			Most unfavourable case when switching the generator (10% → 100% rated output power)		
Cos φ setting	Cos φ=1.00	Cos φ = max.over-excited	Cos φ= max.under-excited	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited
Single period effective values of the voltage [V]	230.3	230.4	230.3	230.0	231.4	230.6
Single period effective values of the current [A]	1.923	1.348	1.357	1.922	2.525	2.226
k_i	0.111	0.077	0.078	0.110	0.145	0.128
Test cases:	Switching on at rated power			Switch off at rated power		
Cos φ setting	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited	Cos φ=1.00	Cos φ= max.over-excited	Cos φ= max.under-excited
Single period effective values of the voltage [V]	230.5	230.3	230.3	229.3	226.6	231.4
Single period effective values of the current [A]	1.227	1.026	1.772	1.245	2.088	1.306
k_i	0.071	0.059	0.102	0.072	0.120	0.075
k_{imax}	0.145					
Test conditions: Frequency: 50 Hz ± 0.5% THD of the voltage supply: ≤ 3% Voltage rise of the PGU at 100% P_{Emax}: ≤ 3%						
Note: Power generation units with inverters (such as photovoltaic systems) and storage units with inverters shall only be connected with $k_{imax} \leq 1.2$.						

5.1.3	**TABLE: Flicker**				**P**
Model	Hybridpower 12kW 3ph				
a) Flicker must be demonstrated in accordance with ÖVE / ÖNORM EN 61000-3-3 or ÖVE / ÖNORM EN 61000-3-11 or in accordance with ÖVE / ÖNORM EN 61400-21.					
Parameter:	dc%	d_{max}	d(t)	P_{st}	*P_{lt}
Limit:	3.3%	4.00%	500 ms	1.00	0.65
~~DIN EN 61000-3-3 (≤ 16 A)~~					
~~Phase A~~	--	--	--	--	--
~~Phase B~~	--	--	--	--	--
~~Phase C~~	--	--	--	--	--
DIN EN 61000-3-11 (> 16 A and ≤ 75 A)					
Phase A	0.032	0.089	0	0.029	0.028
Phase B	0.003	0.181	0	0.036	0.036
Phase C	0.014	0.081	0	0.026	0.024
Note: The maximum for all P_{st} values must be selected as the value for long-term flicker value $P_{lt.}$					

b) Flicker to DIN EN 61400-21 (VDE 0127-21) (or FGW TR3)				
10% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.012	0.010	0.006	0.004
Phase B	0.012	0.009	0.006	0.004
Phase C	0.012	0.009	0.006	0.004
Flicker coefficient $c(\psi_k)$				
Phase A	0.561	0.467	0.280	0.187
Phase B	0.561	0.421	0.280	0.187
Phase C	0.561	0.421	0.280	0.187
20% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.012	0.010	0.006	0.004
Phase B	0.012	0.009	0.006	0.004
Phase C	0.012	0.009	0.006	0.004
Flicker coefficient $c(\psi_k)$				
Phase A	0.561	0.467	0.280	0.187
Phase B	0.561	0.421	0.280	0.187
Phase C	0.561	0.421	0.280	0.187
30% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.012	0.009	0.006	0.004
Phase B	0.011	0.009	0.006	0.004
Phase C	0.011	0.009	0.005	0.004
Flicker coefficient $c(\psi_k)$				
Phase A	0.561	0.421	0.280	0.187
Phase B	0.514	0.421	0.280	0.187
Phase C	0.514	0.421	0.234	0.187
40% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.010	0.008	0.005	0.003
Phase B	0.010	0.007	0.005	0.003
Phase C	0.010	0.007	0.005	0.003

Flicker coefficient c(ψ_k)				
Phase A	0.467	0.374	0.234	0.140
Phase B	0.467	0.327	0.234	0.140
Phase C	0.467	0.327	0.234	0.140
50% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.008	0.006	0.004	0.003
Phase B	0.008	0.006	0.004	0.003
Phase C	0.008	0.006	0.004	0.003
Flicker coefficient c(ψ_k)				
Phase A	0.374	0.280	0.187	0.140
Phase B	0.374	0.280	0.187	0.140
Phase C	0.374	0.280	0.187	0.140
60% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.008	0.007	0.004	0.003
Phase B	0.008	0.007	0.004	0.003
Phase C	0.009	0.007	0.005	0.003
Flicker coefficient c(ψ_k)				
Phase A	0.374	0.327	0.187	0.140
Phase B	0.374	0.327	0.187	0.140
Phase C	0.421	0.327	0.234	0.140
70% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.008	0.007	0.005	0.003
Phase B	0.008	0.006	0.004	0.003
Phase C	0.008	0.007	0.004	0.003
Flicker coefficient c(ψ_k)				
Phase A	0.374	0.327	0.234	0.140
Phase B	0.374	0.280	0.187	0.140
Phase C	0.374	0.327	0.187	0.140
80% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				

Phase A	0.009	0.007	0.005	0.003
Phase B	0.008	0.006	0.004	0.003
Phase C	0.008	0.006	0.004	0.003
Flicker coefficient $c(\psi_k)$				
Phase A	0.421	0.327	0.234	0.140
Phase B	0.374	0.280	0.187	0.140
Phase C	0.374	0.280	0.187	0.140
90% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.011	0.009	0.006	0.004
Phase B	0.011	0.009	0.006	0.004
Phase C	0.011	0.009	0.005	0.004
Flicker coefficient $c(\psi_k)$				
Phase A	0.514	0.421	0.280	0.187
Phase B	0.514	0.421	0.280	0.187
Phase C	0.514	0.421	0.234	0.187
100% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.011	0.009	0.006	0.004
Phase B	0.011	0.009	0.006	0.004
Phase C	0.011	0.009	0.005	0.004
Flicker coefficient $c(\psi_k)$				
Phase A	0.514	0.421	0.280	0.187
Phase B	0.514	0.421	0.280	0.187
Phase C	0.514	0.421	0.234	0.187
100% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.014	0.013	0.011	0.011
Phase B	0.014	0.013	0.011	0.011
Phase C	0.014	0.012	0.011	0.011
Flicker coefficient $c(\psi_k)$				
Phase A	0.654	0.607	0.514	0.514
Phase B	0.654	0.607	0.514	0.514
Phase C	0.654	0.561	0.514	0.514

100% P_n				
Grid impedance angle ψ_k	30°	50°	70°	85°
Short-term flicker P_{st}				
Phase A	0.010	0.008	0.005	0.004
Phase B	0.010	0.008	0.005	0.004
Phase C	0.010	0.007	0.005	0.004
Flicker coefficient $c(\psi_k)$				
Phase A	0.467	0.374	0.234	0.187
Phase B	0.467	0.374	0.234	0.187
Phase C	0.467	0.327	0.234	0.187

Remark:

The tested PV inverter may be used in EZA with nominal currents> 75 A.

5.1.3.2 Testing:

For controllable EZE with nominal currents> 75 A, at least 12 measurements of 10 minutes each must be carried out. One measurement each within the 9 performance intervals [0%, 10%], [10%, 20%] to [80%, 90%] related to P_n and three measurements in the interval from 90% P_n to P_n. One measurement consists of determining the short-term flicker strength P_{st} as a 3-tuple (phases L1, L2 and L3). For non-controllable EZE, a tuple must be determined for the adjustable working points and P_n.

Alternatively, P_{lt} may be determined for each of the above measurements according to ÖVE / ÖNORM EN 61000-4-15.

5.1.3.3 Assessment criterion:
The maximum for all P_{st} should be selected as the value for the long-term flicker strength P_{lt}.
Determination of the flicker coefficient:

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

Where
P_{st} is the short-term flicker value measured at the grid substitute element;
S_k is the short-circuit power of the network standby element (during the determination of the appropriate P_{st} values).

Test conditions:

$Z_{test} = Z_{ref}$:
$Z_A = R_A + X_A = 0.24\ \Omega + j\ 0.15\ \Omega$
$Z_N = R_N + X_N = 0.16\ \Omega + j\ 0.10\ \Omega$
Voltage: 86% U_n to 109% U_n
Frequency: 50 Hz ± 0.5%
THD of the voltage supply: ≤ 3%
Voltage rise of the PGU at 100% P_{Emax}: ≤ 3%

5.1.4	**TABLE: Harmonics and Interharmonics** **a) Generation units and storage (single devices) with a rated current ≤ 75 A**	**P**
Model	Hybridpower 12kW 3ph	

~~Maximum permissible harmonic current as per EN 61000-3-2 Class A~~

~~Harmonics~~	~~2nd~~	~~3rd~~	~~5th~~	~~7th~~	~~9th~~	~~11th~~	~~13th~~	~~15 th ≤ n ≤ 39 th~~
~~Limit [A]~~	~~1,08~~	~~2,30~~	~~1,14~~	~~0,77~~	~~0,4~~	~~0,33~~	~~0,21~~	~~0,15 * (15/n)~~
~~Test value [A]~~	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note:
The tests should be based on the limits of the EN61000-3-2 for less than 16 A.

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

Harmonic	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Limit [%] 3-phase	N/A	8.00	N/A	4.00	10.7	2.67	7.20	2.00	N/A	1.60	3.10	1.33	2.00
~~Limit [%] single phase~~	N/A	~~8.00~~	~~21.6~~	~~4.00~~	~~10.7~~	~~2.67~~	~~7.20~~	~~2.00~~	~~3.80~~	~~1.60~~	~~3.10~~	~~1.33~~	~~2.00~~
Test value L1 Phase [A]	17.363	0.159	0.073	0.102	0.276	0.019	0.179	0.018	0.021	0.033	0.135	0.009	0.075
Test value L2 Phase [A]	17.522	0.109	0.031	0.098	0.287	0.016	0.173	0.007	0.019	0.036	0.120	0.013	0.084
Test value L3 Phase [A]	17.478	0.093	0.034	0.086	0.303	0.006	0.191	0.014	0.010	0.022	0.118	0.005	0.083
Test value L1 Phase [%]	N/A	0.914	0.420	0.586	1.591	0.108	1.032	0.106	0.121	0.192	0.775	0.051	0.435
Test value L2 Phase [%]	N/A	0.622	0.175	0.559	1.640	0.093	0.987	0.041	0.109	0.203	0.686	0.076	0.481
Test value L3 Phase [%]	N/A	0.531	0.196	0.492	1.734	0.034	1.092	0.080	0.059	0.124	0.677	0.031	0.477

	THC	PWHC
Three-phase limit [%]	13	22
~~Single-phase limit [%]~~	~~23~~	~~23~~
Test value - L1 phase [%]	2.533	3.665
Test value - L2 phase [%]	2.400	3.655
Test value - L3 phase [%]	2.457	3.562

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

5.1.4	**TABLE: Additional Measurements for PGU provided for PGS having Nominal Currents >75 A**										**P**
Model	Hybridpower 12kW 3ph										
Harmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2	0.141	0.332	0.245	0.244	0.250	0.218	0.231	0.257	0.324	0.442	0.579
3	0.119	0.300	0.335	0.335	0.352	0.347	0.342	0.361	0.358	0.359	0.389
4	0.061	0.155	0.098	0.107	0.108	0.123	0.187	0.254	0.370	0.491	0.603
5	0.253	0.426	0.861	1.036	1.143	1.244	1.314	1.290	1.327	1.393	1.492
6	0.083	0.076	0.097	0.097	0.116	0.121	0.126	0.130	0.135	0.132	0.148
7	0.281	0.306	0.449	0.625	0.698	0.709	0.776	0.842	0.879	0.873	0.883
8	0.040	0.111	0.132	0.150	0.158	0.165	0.148	0.133	0.119	0.111	0.098
9	0.064	0.048	0.090	0.113	0.114	0.106	0.114	0.109	0.093	0.090	0.087
10	0.031	0.082	0.108	0.125	0.135	0.164	0.176	0.197	0.212	0.227	0.252
11	0.124	0.086	0.173	0.335	0.452	0.515	0.560	0.564	0.584	0.613	0.662
12	0.028	0.028	0.037	0.055	0.062	0.070	0.074	0.076	0.068	0.076	0.076
13	0.136	0.173	0.107	0.211	0.292	0.342	0.372	0.390	0.414	0.399	0.387
14	0.034	0.033	0.040	0.047	0.048	0.050	0.055	0.051	0.050	0.051	0.057
15	0.029	0.020	0.040	0.043	0.044	0.054	0.057	0.058	0.056	0.053	0.063
16	0.020	0.032	0.039	0.049	0.046	0.049	0.054	0.059	0.060	0.066	0.067
17	0.145	0.152	0.091	0.139	0.181	0.229	0.258	0.264	0.292	0.294	0.293
18	0.016	0.025	0.028	0.029	0.020	0.024	0.023	0.026	0.024	0.025	0.024
19	0.055	0.088	0.086	0.125	0.130	0.169	0.214	0.246	0.299	0.313	0.325
20	0.025	0.022	0.019	0.020	0.016	0.019	0.019	0.018	0.023	0.023	0.028
21	0.015	0.019	0.035	0.020	0.026	0.038	0.046	0.054	0.051	0.052	0.053
22	0.021	0.016	0.012	0.012	0.015	0.015	0.014	0.018	0.021	0.026	0.035
23	0.033	0.013	0.090	0.108	0.059	0.103	0.147	0.189	0.247	0.268	0.284
24	0.012	0.015	0.016	0.019	0.025	0.024	0.026	0.028	0.027	0.036	0.039
25	0.041	0.052	0.087	0.114	0.080	0.068	0.093	0.106	0.152	0.157	0.159
26	0.013	0.018	0.025	0.021	0.027	0.033	0.031	0.034	0.032	0.033	0.038
27	0.026	0.017	0.032	0.018	0.029	0.035	0.042	0.045	0.043	0.042	0.050
28	0.014	0.015	0.020	0.021	0.032	0.034	0.035	0.037	0.040	0.043	0.046
29	0.062	0.098	0.105	0.117	0.071	0.046	0.067	0.083	0.126	0.129	0.129
30	0.012	0.008	0.010	0.011	0.023	0.031	0.032	0.033	0.025	0.025	0.021
31	0.051	0.087	0.080	0.098	0.176	0.141	0.122	0.145	0.182	0.192	0.196
32	0.010	0.012	0.015	0.011	0.020	0.026	0.024	0.020	0.019	0.017	0.020

33	0.020	0.019	0.030	0.051	0.052	0.023	0.028	0.029	0.021	0.021	0.024
34	0.010	0.009	0.008	0.012	0.014	0.024	0.036	0.021	0.013	0.013	0.013
35	0.018	0.038	0.062	0.123	0.200	0.144	0.126	0.153	0.152	0.153	0.152
36	0.010	0.009	0.008	0.010	0.020	0.020	0.018	0.040	0.026	0.022	0.022
37	0.028	0.019	0.035	0.051	0.059	0.072	0.105	0.287	0.282	0.147	0.116
38	0.011	0.011	0.012	0.010	0.007	0.010	0.034	0.038	0.079	0.036	0.031
39	0.011	0.012	0.011	0.012	0.012	0.011	0.018	0.047	0.043	0.036	0.042
40	0.009	0.012	0.011	0.012	0.012	0.012	0.016	0.037	0.033	0.051	0.038
Note: The nominal current is 17.4 A. The stated harmonics are max values of three phases.											

5.1.4	**TABLE: Additional Measurements for PGU provided for PGS having Nominal Currents >75A**										**P**
Model	Hybridpower 12kW 3ph										
Interharmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
75	0.054	0.628	0.340	0.469	0.702	0.625	0.766	0.797	0.939	1.018	1.146
125	0.056	0.389	0.242	0.307	0.363	0.312	0.341	0.338	0.365	0.411	0.418
175	0.050	0.228	0.157	0.192	0.223	0.202	0.224	0.226	0.249	0.278	0.308
225	0.041	0.169	0.128	0.168	0.201	0.185	0.206	0.218	0.225	0.237	0.269
275	0.035	0.136	0.112	0.148	0.176	0.158	0.176	0.188	0.188	0.202	0.236
325	0.031	0.103	0.087	0.119	0.147	0.129	0.145	0.145	0.165	0.174	0.184
375	0.027	0.077	0.066	0.092	0.110	0.105	0.119	0.125	0.140	0.150	0.159
425	0.026	0.066	0.059	0.074	0.087	0.081	0.087	0.090	0.100	0.109	0.116
475	0.024	0.056	0.053	0.066	0.079	0.076	0.082	0.084	0.088	0.098	0.103
525	0.022	0.049	0.045	0.060	0.081	0.082	0.090	0.095	0.095	0.104	0.118
575	0.021	0.046	0.040	0.056	0.076	0.079	0.086	0.094	0.089	0.097	0.108
625	0.020	0.042	0.037	0.047	0.069	0.069	0.079	0.080	0.089	0.088	0.090
675	0.019	0.039	0.038	0.040	0.055	0.060	0.068	0.074	0.081	0.082	0.081
725	0.018	0.036	0.035	0.038	0.048	0.045	0.049	0.050	0.057	0.055	0.058
775	0.017	0.035	0.033	0.038	0.044	0.042	0.044	0.048	0.050	0.050	0.051
825	0.016	0.035	0.029	0.035	0.046	0.049	0.055	0.062	0.065	0.065	0.072
875	0.015	0.037	0.027	0.032	0.044	0.050	0.057	0.065	0.059	0.065	0.070
925	0.014	0.031	0.023	0.028	0.039	0.040	0.053	0.055	0.060	0.060	0.063
975	0.013	0.026	0.020	0.024	0.032	0.036	0.045	0.052	0.054	0.060	0.060
1025	0.013	0.021	0.018	0.022	0.029	0.027	0.033	0.033	0.036	0.040	0.042

1075	0.012	0.020	0.018	0.021	0.028	0.025	0.030	0.032	0.034	0.040	0.041
1125	0.012	0.020	0.017	0.020	0.028	0.031	0.037	0.042	0.050	0.055	0.059
1175	0.011	0.020	0.017	0.021	0.029	0.032	0.038	0.045	0.048	0.056	0.057
1225	0.011	0.021	0.016	0.021	0.028	0.029	0.037	0.042	0.048	0.050	0.054
1275	0.010	0.020	0.016	0.020	0.026	0.028	0.034	0.040	0.044	0.048	0.051
1325	0.011	0.018	0.016	0.019	0.025	0.026	0.030	0.031	0.035	0.035	0.038
1375	0.011	0.018	0.016	0.019	0.024	0.026	0.028	0.030	0.033	0.033	0.036
1425	0.011	0.017	0.017	0.018	0.024	0.027	0.032	0.035	0.042	0.044	0.046
1475	0.011	0.018	0.016	0.020	0.026	0.028	0.032	0.037	0.041	0.045	0.044
1525	0.012	0.016	0.014	0.021	0.030	0.027	0.033	0.036	0.042	0.041	0.043
1575	0.012	0.016	0.016	0.017	0.034	0.029	0.032	0.038	0.039	0.043	0.043
1625	0.012	0.015	0.017	0.019	0.025	0.039	0.033	0.032	0.031	0.030	0.032
1675	0.012	0.016	0.015	0.020	0.023	0.033	0.039	0.031	0.030	0.031	0.031
1725	0.013	0.016	0.016	0.023	0.030	0.029	0.052	0.040	0.043	0.040	0.043
1775	0.013	0.015	0.014	0.018	0.037	0.033	0.039	0.060	0.048	0.047	0.048
1825	0.013	0.015	0.015	0.017	0.026	0.041	0.038	0.078	0.067	0.055	0.054
1875	0.015	0.015	0.014	0.014	0.018	0.029	0.043	0.047	0.080	0.058	0.051
1925	0.016	0.016	0.018	0.017	0.015	0.020	0.052	0.050	0.088	0.067	0.058
1975	0.017	0.017	0.020	0.018	0.016	0.016	0.029	0.062	0.059	0.092	0.068
Note: The nominal current is 17.4 A. The stated harmonics are max values of three phases.											

5.1.4	**TABLE: Additional Measurements for PGU provided for PGS having Nominal Currents >75A**										**P**
Model	Hybridpower 12kW 3ph										
Higher Frequencies											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2.1	0.044	0.038	0.039	0.062	0.077	0.072	0.108	0.304	0.332	0.279	0.493
2.3	0.041	0.038	0.035	0.043	0.050	0.044	0.049	0.057	0.096	0.204	0.480
2.5	0.036	0.036	0.036	0.040	0.046	0.045	0.047	0.056	0.053	0.067	0.110
2.7	0.039	0.030	0.039	0.033	0.039	0.040	0.044	0.050	0.052	0.068	0.107
2.9	0.041	0.035	0.037	0.040	0.042	0.041	0.044	0.045	0.053	0.055	0.065
3.1	0.048	0.044	0.044	0.049	0.049	0.049	0.051	0.057	0.052	0.055	0.052
3.3	0.061	0.057	0.057	0.060	0.062	0.059	0.065	0.071	0.078	0.084	0.094
3.5	0.061	0.059	0.061	0.065	0.067	0.067	0.072	0.083	0.090	0.096	0.109
3.7	0.064	0.072	0.086	0.095	0.104	0.110	0.129	0.152	0.180	0.212	0.249

3.9	0.053	0.054	0.056	0.059	0.061	0.063	0.068	0.075	0.080	0.083	0.088
4.1	0.046	0.048	0.052	0.055	0.057	0.060	0.064	0.068	0.070	0.072	0.073
4.3	0.038	0.040	0.043	0.045	0.048	0.050	0.053	0.056	0.058	0.060	0.061
4.5	0.029	0.030	0.031	0.033	0.034	0.036	0.037	0.040	0.041	0.042	0.042
4.7	0.030	0.030	0.031	0.032	0.033	0.034	0.034	0.035	0.036	0.036	0.036
4.9	0.018	0.019	0.019	0.020	0.021	0.021	0.022	0.023	0.023	0.023	0.024
5.1	0.016	0.016	0.016	0.017	0.017	0.018	0.018	0.019	0.019	0.019	0.020
5.3	0.013	0.014	0.014	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.016
5.5	0.011	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.014	0.014
5.7	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.012	0.012
5.9	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009
6.1	0.007	0.008	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
6.3	0.005	0.006	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
6.5	0.004	0.005	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
6.7	0.003	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
6.9	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
7.1	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
7.3	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
7.5	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
7.7	0.001	0.002	0.001	0.002	0.002	0.001	0.002	0.001	0.002	0.002	0.002
7.9	0.001	0.002	0.001	0.002	0.002	0.001	0.002	0.001	0.001	0.002	0.002
8.1	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002
8.3	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002
8.5	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
8.7	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
8.9	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Note:
The nominal current is 17.4 A.
The stated harmonics are max values of three phases.

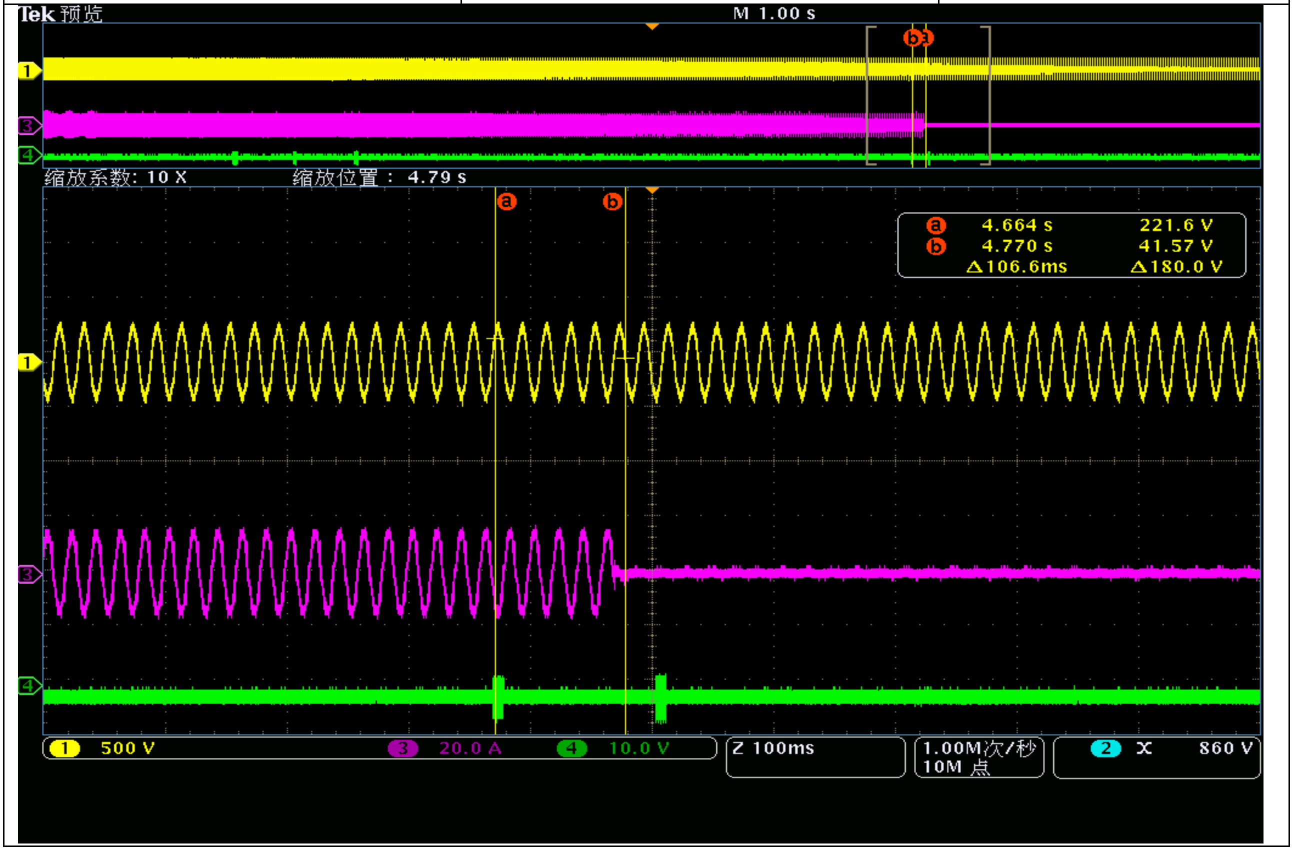
5.2 (6.1.1)	**TABLE: Testing the symmetry behavior of three-phase inverters**				**P**
Model	Hybridpower 12kW 3ph				
Measurement No.	1	2	3	4	5
a) 100% nominal power±5% P_{Emax}, $\cos \varphi = 1$					
S_{E60} [VA]: L1	3982.12	4001.39	3999.38	3997.43	4000.54
S_{E60} [VA]: L2	3977.68	3992.65	3981.64	3991.8	3998.08
S_{E60} [VA]: L3	3983.91	4004.3	3999.61	4005.91	3998.69
S_{E60} [VA]: |L1 - L2|	4.44	8.74	17.74	5.63	2.46
S_{E60} [VA]: |L2 - L3|	6.23	11.65	17.97	14.11	0.61
S_{E60} [VA]: |L3 - L1|	1.79	2.91	0.23	8.48	1.85
$\cos \varphi_{E60}$ max.:	0.999				
Max. Asymmetry [VA]:	17.97				
b) 100% nominal power±5% P_{Emax}, $\cos \varphi$ = maximum under-excited (i)					
S_{E60} [kVA]: L1	4385.02	4376.72	4399.97	4371.11	4356.44
S_{E60} [VA]: L2	4360.78	4360.71	4390.13	4355.94	4346.48
S_{E60} [VA]: L3	4374.33	4368.35	4384.1	4362.78	4357.38
S_{E60} [VA]: |L1 - L2|	24.24	16.01	9.84	15.17	9.96
S_{E60} [VA]: |L2 - L3|	13.55	7.64	6.03	6.84	10.9
S_{E60} [VA]: |L3 - L1|	10.69	8.37	15.87	8.33	0.94
$\cos \varphi_{E60}$ max.:	$0.807_{\text{under-excited}}$				
Max. Asymmetry [VA]:	24.24				
c) 100% nominal power±5% P_{Emax}, $\cos \varphi$ = maximum over-excited (c)					
S_{E60} [VA]: L1	4373.78	4388.27	4373.52	4359.17	4392.01
S_{E60} [VA]: L2	4384.14	4391.98	4364.89	4366.92	4409.83
S_{E60} [VA]: L3	4379.23	4387.14	4373.54	4371.86	4412.09
S_{E60} [VA]: |L1 - L2|	10.36	3.71	8.63	7.75	17.82
S_{E60} [VA]: |L2 - L3|	4.91	4.84	8.65	4.94	2.26
S_{E60} [VA]: |L3 - L1|	5.45	1.13	0.02	12.69	20.08
$\cos \varphi_{E60}$ max.:	$0.806_{\text{over-excited}}$				
Max. Asymmetry [VA]:	20.08				
Measurement No.	1	2	3	4	5
d) 50% nominal power±5% P_{Emax}, $\cos \varphi = 1$;					
S_{E60} [VA]: L1	2003.21	1995.83	1999.25	2001.05	1997.11
S_{E60} [VA]: L2	2008.17	2002.1	2005.44	1995.97	2003.68
S_{E60} [VA]: L3	2012.43	2010.86	2018.41	2018.67	2011.31
S_{E60} [VA]: |L1 - L2|	4.96	6.27	6.19	5.08	6.57

S_{E60} [VA]: |L2 - L3|	4.26	8.76	12.97	22.7	7.63
S_{E60} [VA]: |L3 - L1|	9.22	15.03	19.16	17.62	14.2
cos φ_{E60} max.:	0.999				
Max. Asymmetry [VA]:	22.7				
e) 50% nominal power±5% P_{Emax}, cos φ = maximum under-excited (i)					
S_{E60} [VA]: L1	2490.68	2482.54	2492.88	2490.7	2477.89
S_{E60} [VA]: L2	2480.04	2472.5	2461.54	2478.85	2477.82
S_{E60} [VA]: L3	2488.28	2489.94	2486.8	2492.13	2479.67
S_{E60} [VA]: |L1 - L2|	10.64	10.04	31.34	11.85	0.07
S_{E60} [VA]: |L2 - L3|	8.24	17.44	25.26	13.28	1.85
S_{E60} [VA]: |L3 - L1|	2.4	7.4	6.08	1.43	1.78
cos φ_{E60} max.:	$0.807_{\text{under-excited}}$				
Max. Asymmetry [VA]:	31.34				
f) 50% nominal power±5% P_{Emax}, cos φ = maximum over-excited (c)					
S_{E60} [VA]: L1	2486.00	2491.60	2488.32	2482.45	2472.74
S_{E60} [VA]: L2	2495.88	2496.66	2500.73	2490.53	2486.79
S_{E60} [VA]: L3	2508.52	2497.8	2511.89	2502.86	2491.78
S_{E60} [VA]: |L1 - L2|	9.88	5.06	12.41	8.08	14.05
S_{E60} [VA]: |L2 - L3|	12.64	1.14	11.16	12.33	4.99
S_{E60} [VA]: |L3 - L1|	22.52	6.20	23.57	20.41	19.04
cos φ_{E60} max.:	$0.804_{\text{over-excited}}$				
Max. Asymmetry [VA]:	23.57				
Limit [VA]:	≤ 5% S_{Emax} and 4,6 kVA				
Note: The test is passed when the maximum value of preceding measurements a) to f) does not exceed the 5% *S*Emax value and 4.6 kVA.					

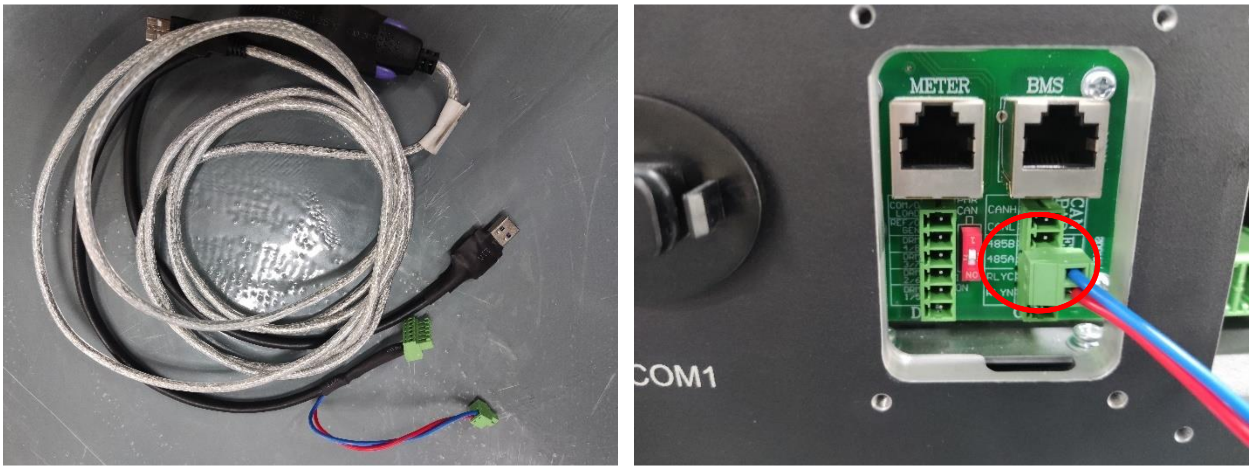
5.3.2 (5.3.3)	**TABLE: Measurement of active and reactive power working area (PQ diagram)**					**P**
Model	Hybridpower 12kW 3ph					
Measurement carried out at 0.86 U_n						
Q set-point (%Sn)	P set-point (%Pn)	Active power (W)	Apparent power (VA)	Q measured (Var)	Voltage (Vac)	Measured cos φ
a) 0	100%	11875.69	11877.45	-196.85	198.01	1.000
b) 43.6% (c)	Max possible	10622.00	11850.06	-5253.11	197.96	0.896
c) 43.6% (i)	Max possible	10535.47	11794.42	5301.65	198.02	0.893
d) 43.6% (c)	20%-30%	2900.15	5970.01	-5218.23	197.97	0.486
e) 43.6% (i)	20%-30%	2916.33	6024.62	5271.70	197.90	0.484
f) 43.6% (c)	10%-20%	1678.28	5549.92	-5290.04	197.86	0.302
g) 43.6% (i)	10%-20%	1696.35	5460.40	5190.17	197.93	0.311
h) 43.6% (c)	0-10%	829.47	5321.16	-5255.97	197.88	0.156
i) 43.6% (i)	0-10%	842.80	5301.00	5233.22	197.87	0.159
Measurement carried out at U_n						
Q set-point (%Sn)	P set-point (%Pn)	Active power (W)	Apparent power (VA)	Q measured (Var)	Voltage (Vac)	Measured cos φ
a) 0	100%	11985.62	11985.73	-8.24	230.21	1.000
b) 43.6% (c)	Max possible	11836.57	12959.43	-5275.79	230.17	0.913
c) 43.6% (i)	Max possible	11767.17	12882.10	5241.73	230.24	0.913
d) 43.6% (c)	20%-30%	3205.24	6127.44	-5222.24	230.12	0.523
e) 43.6% (i)	20%-30%	3213.91	6164.20	5260.04	230.11	0.521
f) 43.6% (c)	10%-20%	1711.12	5545.06	-5274.44	230.10	0.308
g) 43.6% (i)	10%-20%	1692.32	5498.30	5231.38	230.07	0.309
h) 43.6% (c)	0-10%	859.41	5306.12	-5236.06	230.09	0.160
i) 43.6% (i)	0-10%	841.05	5259.08	5191.39	230.03	0.162
Measurement carried out at 1.09 U_n						
Q set-point (%Sn)	P set-point (%Pn)	Active power (W)	Apparent power (VA)	Q measured (Var)	Voltage (Vac)	Measured cos φ
a) 0	100%	11924.99	11925.14	-4.9	250.83	0.999
b) 43.6% (c)	Max possible	11856.42	12958.16	-5228.30	250.78	0.915
c) 43.6% (i)	Max possible	11889.67	13014.23	5291.81	250.80	0.914
d) 43.6% (c)	20%-30%	2901.75	6007.45	-5260.15	250.71	0.483
e) 43.6% (i)	20%-30%	2918.16	6004.43	5247.61	250.71	0.486
f) 43.6% (c)	10%-20%	1688.40	5503.57	-5238.18	250.68	0.307
g) 43.6% (i)	10%-20%	1709.69	5504.27	5232.00	250.69	0.311
h) 43.6% (c)	0-10%	836.97	5287.72	-5221.05	250.61	0.158
i) 43.6% (i)	0-10%	856.51	5338.98	5269.82	250.69	0.160
Note:						

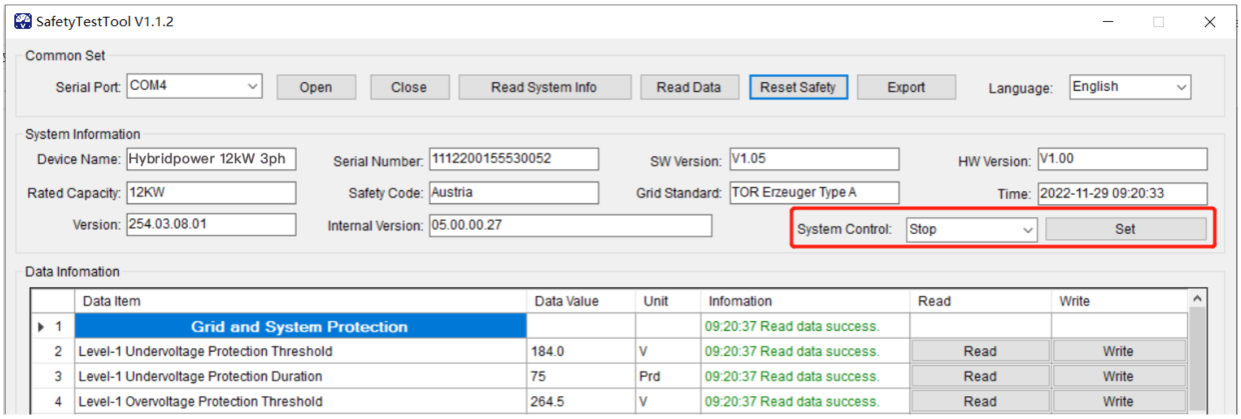
5.3.3 (5.4.1)	**TABLE: Ceasing of power feed-in after remote control**	**P**
Model	Hybridpower 12kW 3ph	
Reducing the active power from 100% P_n to 0		

Measured max power [kW]	Ceasing time [s]	Limit [s]
12	0.107	5



The interface of RS485 was used for communication with PC software tool to perform remote control:





Serial Port: COM4

Language: English

Device Name: Hybridpower 12kW 3ph

Serial Number: 1112200155530052

SW Version: V1.05

HW Version: V1.00

Rated Capacity: 12KW

Safety Code: Austria

Grid Standard: TOR Erzeuger Type A

Time: 2022-11-29 09:20:33

Version: 254.03.08.01

Internal Version: 05.00.00.27

System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
1	Grid and System Protection			09:20:37 Read data success.		
2	Level-1 Undervoltage Protection Threshold	184.0	V	09:20:37 Read data success.	Read	Write
3	Level-1 Undervoltage Protection Duration	75	Prd	09:20:37 Read data success.	Read	Write
4	Level-1 Overvoltage Protection Threshold	264.5	V	09:20:37 Read data success.	Read	Write

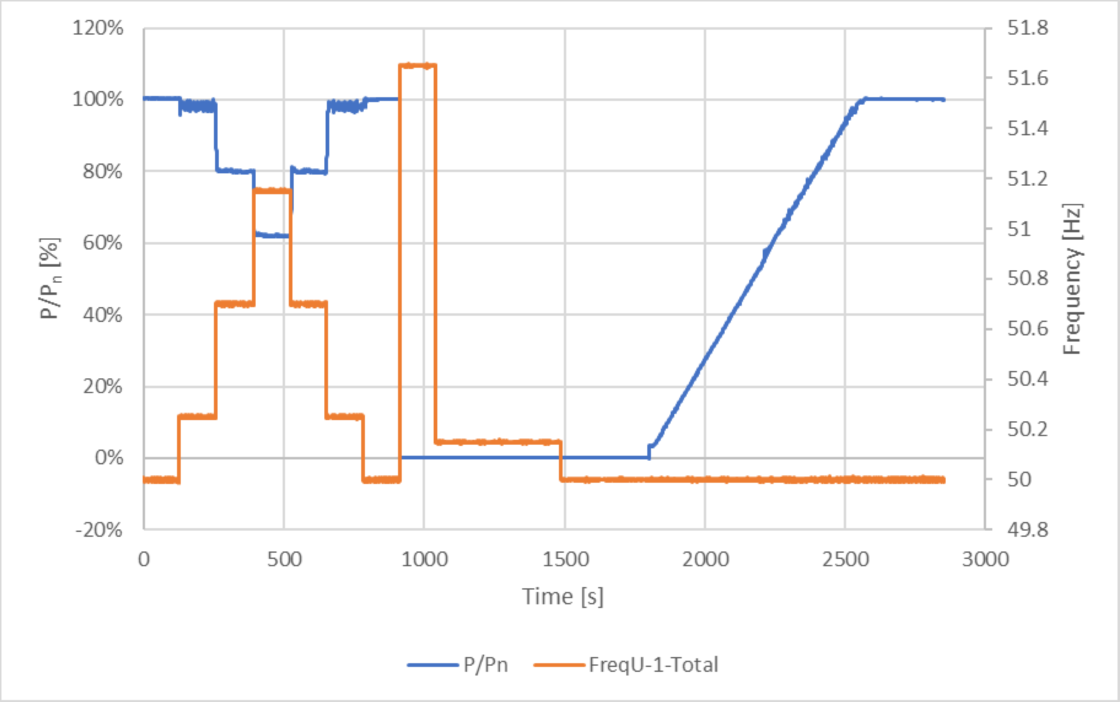
5.3.4 (5.1.3 & 5.5.2)	**TABLE: Active power supply of PGU at over-frequency**							**P**
Model	Hybridpower 12kW 3ph							
Test No. 1:								
Power output:		100% P_n						
Starting frequency f_1:		50.2Hz						
Deactivation threshold f_{stop}:		50.2Hz (Deactivated)						
Droop:		5% (40%P_{ref} / Hz)						
Test condition		Measurement						Limit $\Delta P/P_n$
f (Hz)	Target P/P_n	f (Hz)	P/P_n	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	$\Delta P/P_n$	
a) 50	100%	50.00	100.34%	--	--	--	0.34%	± 5%
b) 50.25	98%	50.25	98.21%	--	--	--	0.21%	
c) 50.7	80%	50.70	80.03%	--	2.6	--	0.03%	
d) 51.15	62%	51.15	62.09%	--	1.4	--	0.09%	
e) 50.7	80%	50.70	79.97%	--	3.2	--	-0.03%	
f) 50.25	98%	50.25	98.23%	--	5.8	--	0.23%	
g) 50	100%	50.00	100.04%	--	--	--	0.04%	

Test condition	Measurement		Limit
g) 50 to h) 51.65	Disconnection Time (ms):	170 ms	200ms
h) 51.65 to i) 50.15	Reconnection:	7.42 min No reconnection	No reconnection
i) 50.15 to j) 50	Reconnection time (s):	313 s	≥ 300s
	Max. power gradient (%P_n/min):	7.94%	≤10% P_n/min

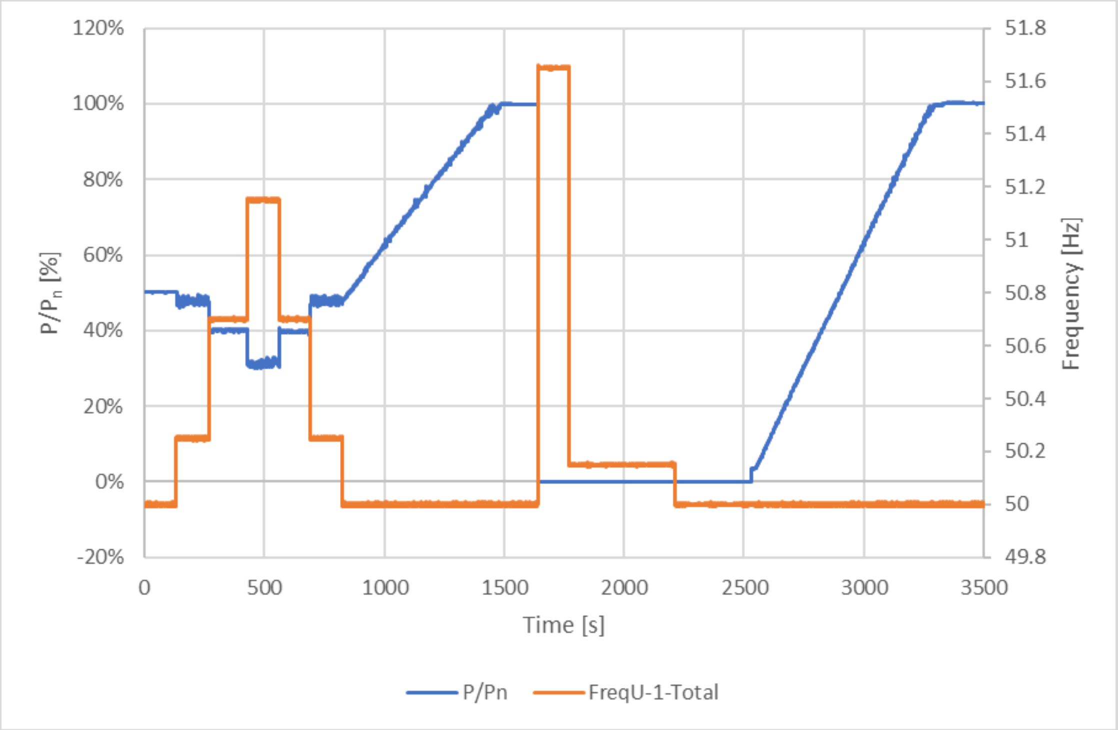
5.3.4 (5.1.3 & 5.5.2)	**TABLE: Active power supply of PGU at over-frequency**							**P**
Model	Hybridpower 12kW 3ph							
Test No. 2:								
Power output:		50% P_n						
Starting frequency f_1:		50.2Hz						
Deactivation threshold f_{stop}:		50.2Hz (Deactivated)						
Droop:		5% (40%P_{ref} / Hz)						
Test condition		Measurement						Limit ΔP/P_n
f (Hz)	Target P/P_n	f (Hz)	P/P_n	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	ΔP/P_n	
a) 50	50%	50.00	50.12%	--	--	--	0.12%	± 5%
b) 50.25	49%	50.25	47.86%	--	--	--	-1.14%	
c) 50.7	40%	50.70	40.09%	--	1.8	--	0.09%	
d) 51.15	31%	51.15	31.21%	--	1.8	--	0.21%	
e) 50.7	40%	50.70	39.76%	--	2.6	--	-0.24%	
f) 50.25	49%	50.25	47.90%	--	7.8	--	-1.10%	
g) 50	100%	50.00	99.77%	--	--	--	-0.23%	

Test condition	Measurement		Limit
g) 50 to h) 51.65	Disconnection Time (ms):	178 ms	200ms
h) 51.65 to i) 50.15	Reconnection:	No reconnection	No reconnection
i) 50.15 to j) 50	Reconnection time (s):	318 s	≥ 300s
	Max. power gradient (%P_n/min):	7.88%	≤10% P_n/min

Test 1: Measurement a) to j): Active power output 100% P_n



Test 2: Measurement a) to j): Active power output 40% P_n and 60% P_n



5.3.5 (5.1.5)	TABLE: Active power reduction at underfrequency	P
Model	Hybridpower 12kW 3ph	

Voltage	U_n=230Vac			
Test sequence	Frequency	Output power(W)	$\Delta P/P_M$ per 1 Hz	Reduction P rate per Hz limits
Test a)	50.0Hz	11991.87	0	0%
Test b)	49.5Hz	11991.12	0	0%
Test c)	47.6Hz	11986.61	0	2% P_n

Test:

The test must be carried out at 100% P_n,
Measurements are carried out at the following operating points:
a) nominal frequency±0.01 Hz;
b) Nominal frequency - 0.5 Hz for synchronous EZE, nominal frequency - 1 Hz for non-synchronous EZE;
c) a point between the nominal frequency -2.4 Hz to -2.5 Hz.

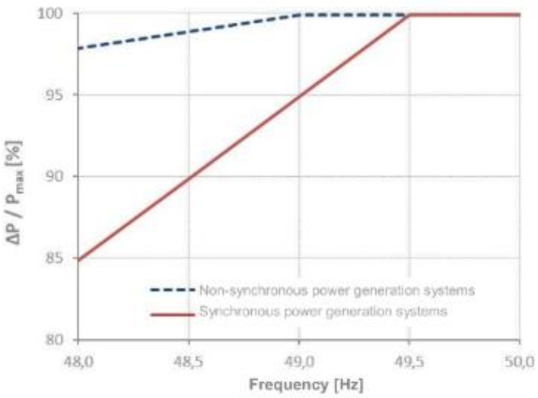
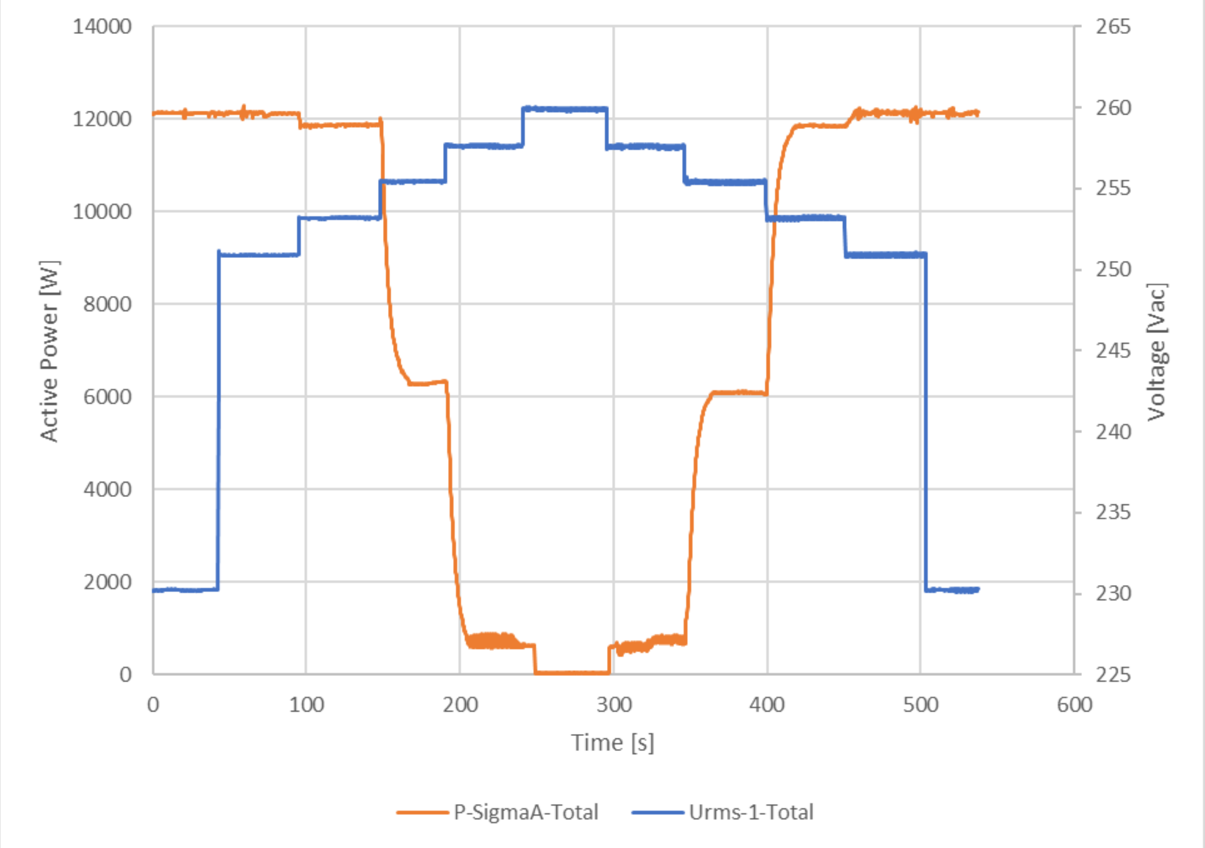


Figure 3: Permissible reduction in the maximum active power output with decreasing frequency

5.3.6.1.1 (5.3.6)	**TABLE: Test sequence for the static behaviour of the P (U) control**	**P**
Model	Hybridpower 12kW 3ph	

P (U) derating threshold set @ 110% U_n

Test voltage (%U_n)	Measured voltage (V)	Measured current (A)	Measured P (W)	Measured Q (Var)	Target P / P_n (%)	Deviation ΔP / P_n (%)
100	230.07	52.72	12123.3	-45.5	100%	1.03%
109	250.76	48.36	12121.0	82.1	100%	1.01%
110	253.06	46.94	11871.8	106.2	100%	-1.07%
111	255.33	24.68	6296.1	96.0	50%	2.47%
112	257.59	2.72	696.9	47.7	0%	5.81%
113	259.89	0.78	37.7	21.5	0%	0.31%
112	257.57	2.61	671.7	37.0	0%	5.60%
111	255.36	23.79	6065.8	99.8	50%	0.55%
110	253.10	46.51	11853.2	123.1	100%	-1.22%
109	250.81	48.32	12111.9	108.1	100%	0.93%
100	230.10	52.71	12123.8	-33.5	100%	1.03%



Note:
The active power values measured according to 5.3.6.1.1 (30 s mean values) in stationary operation are within the tolerance band of ± 10% P_n and ± 1% U_n of the specified P (U) characteristic.

5.3.6.1.2 (5.3.6)	**TABLE: Test sequence for the dynamic behaviour of the P (U) control**	**P**
Model	Hybridpower 12kW 3ph	

Threshold set @ 110% U_n

Test voltage (%U_n)	Measured voltage (V)	Measured P (W)	Response time $T_{95\%}$ (s)	Time constant T_{au} (s)	Target P/P_n
100	230.07	12026.3	--	5	100.0%
109	250.89	11985.7	--	5	100.0%
113	260.11	37.5	14.4	5	0.0%
109	250.89	11988.7	15.0	5	100.0%
100	230.21	11961.3	--	5	100.0%
100	230.07	12026.3	--	5	100.0%

Table 1 - Test procedure for the dynamic behavior of the P (U) control

Step	**Time**	**Voltage (% U_n)**	**Specification of primary power or active power**	**Comment**
1 (d)	$t_1 = 0$	100 %	> 90 % P_n	EZE in operation; Start of recording
2 (e)	$t_2 = t_1 + 50$ s	109 %	> 90 % P_n	P (U) control may not yet respond
3 (f)	$t_3 = t_2 + 50$ s	113 %	> 90 % P_n	P (U) control regulates power to 0 or the minimum possible power.
4 (g)	$t_4 = t_3 + 50$ s	109 %	> 90 % P_n	P (U) regulation canceled
5 (h)	$t_5 = t_4 + 50$ s	100 %	> 90 % P_n	
6 (i)	$t_6 = t_5 + 50$ s	100 %	> 90 % P_n	End of recording

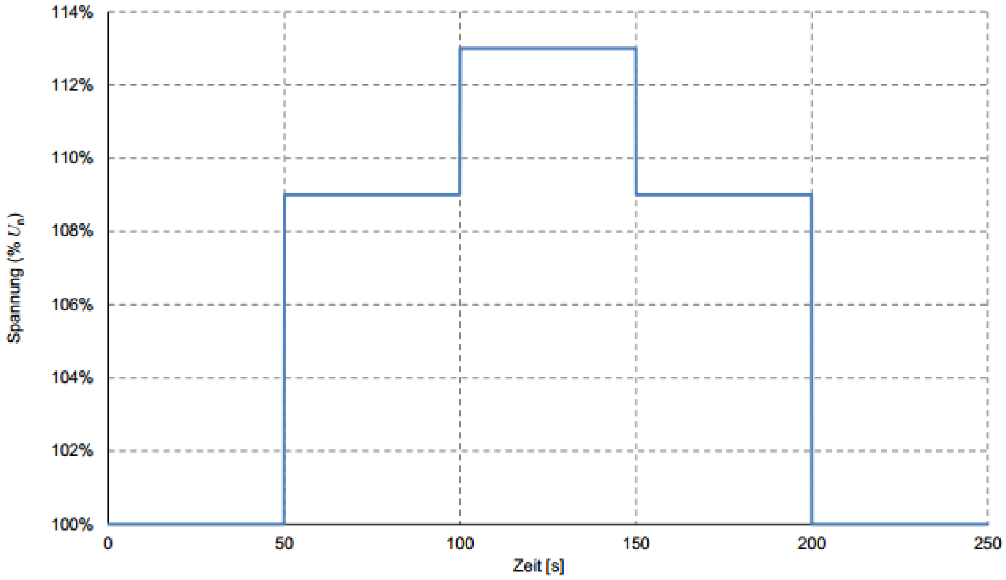


Figure 5 - Exemplary representation of the test sequence for the dynamic behaviour of the P (U) control

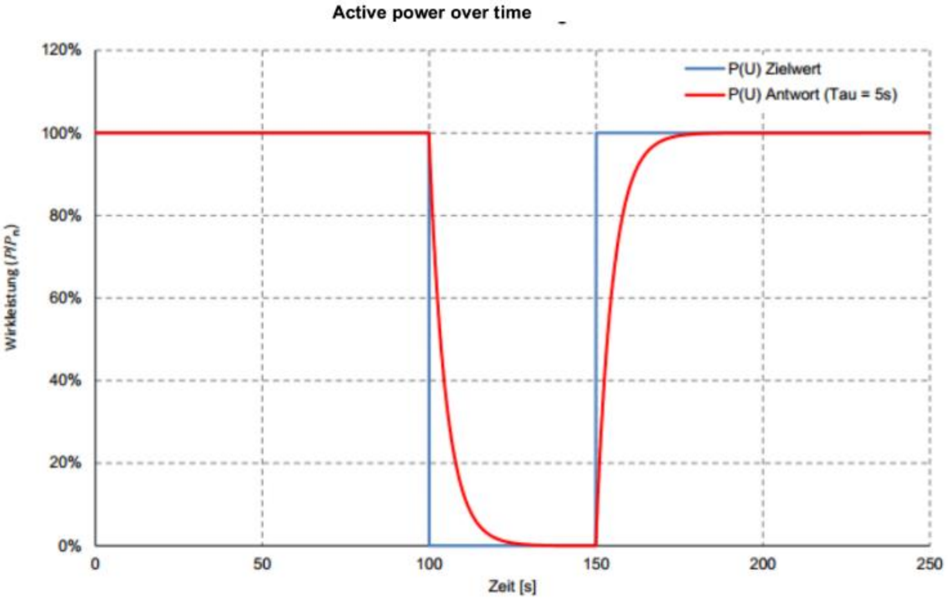


Figure 6 - Exemplary step response in the test sequence for the dynamic behavior of the P (U) control

Table 2 - Calculation of the tolerance bands for evaluating the dynamic behavior of the P (U) control in the event of a setpoint jump from an active power P_1 to an active power P_2

Active power increase $P_2 > P_1$	Upper tolerance band:	for all t : $P_2 - (P_2 - P_1) \cdot e^{(-t/Tau)} + 0.10 \cdot P_n$
	Lower tolerance band:	for $t < 3$ s : $P_1 - 0.10 \cdot P_n$ for $t \geq 3$ s: $P_2 - (P_2 - P_1) \cdot e^{([-t+3\,s]/Tau)} - 0.10 \cdot P_n$
Active power decrease $P_2 < P_1$	Upper tolerance band:	for $t < 3$ s: $P_1 + 0.10 \cdot P_n$ for $t \geq 3$ s: $P_2 - (P_2 - P_1) \cdot e^{([-t+3\,s]/Tau)} + 0.10 \cdot P_n$
	Lower tolerance band:	for all t : $P_2 - (P_2 - P_1) \cdot e^{(-t/Tau)} - 0.10 \cdot P_n$

Figure 7 illustrates the tolerance limits using a setpoint jump in active power from P_1 = 100% P_n to a setpoint value of P_2 = 0% P_n.

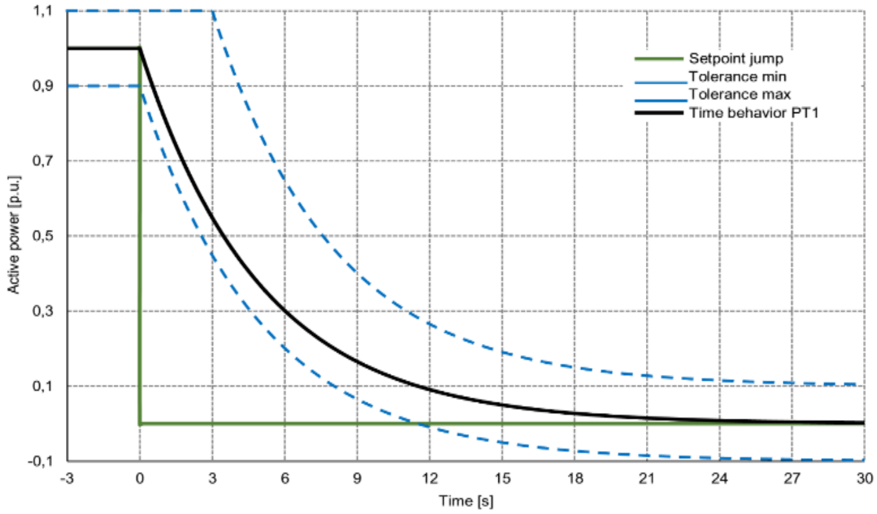
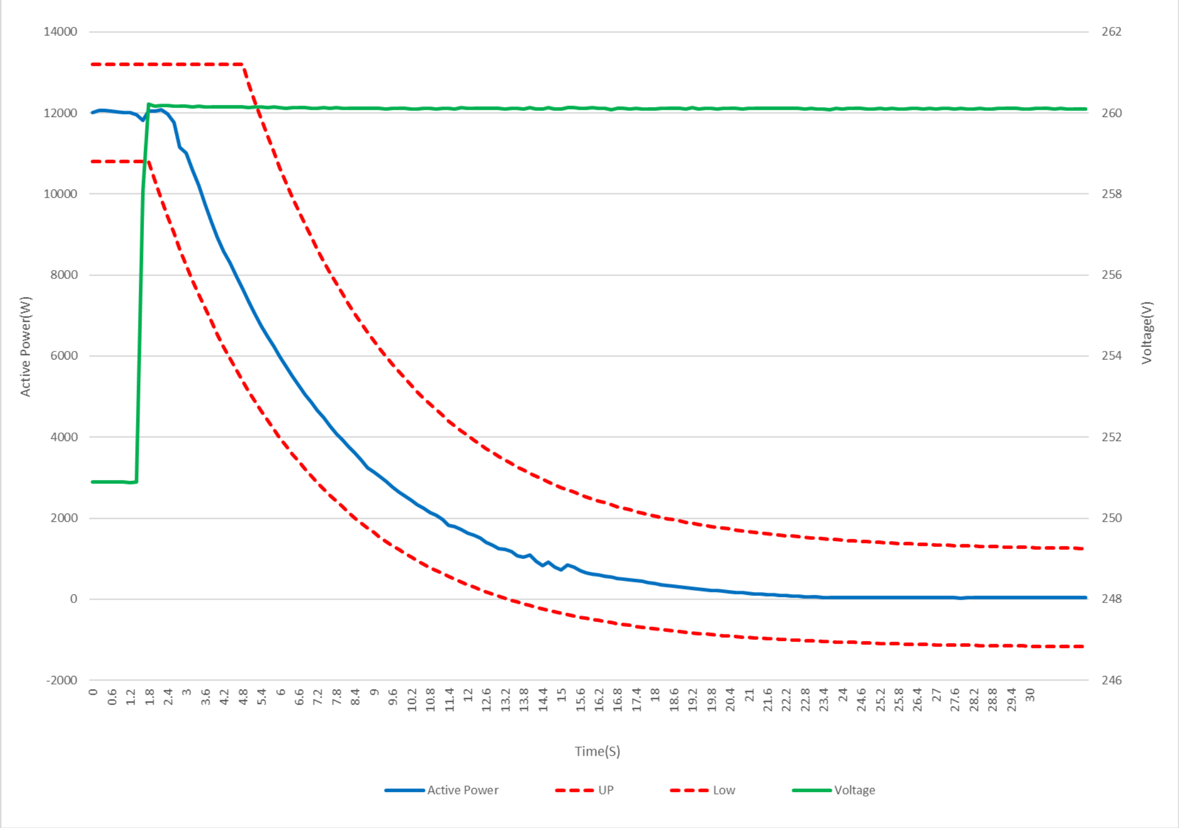
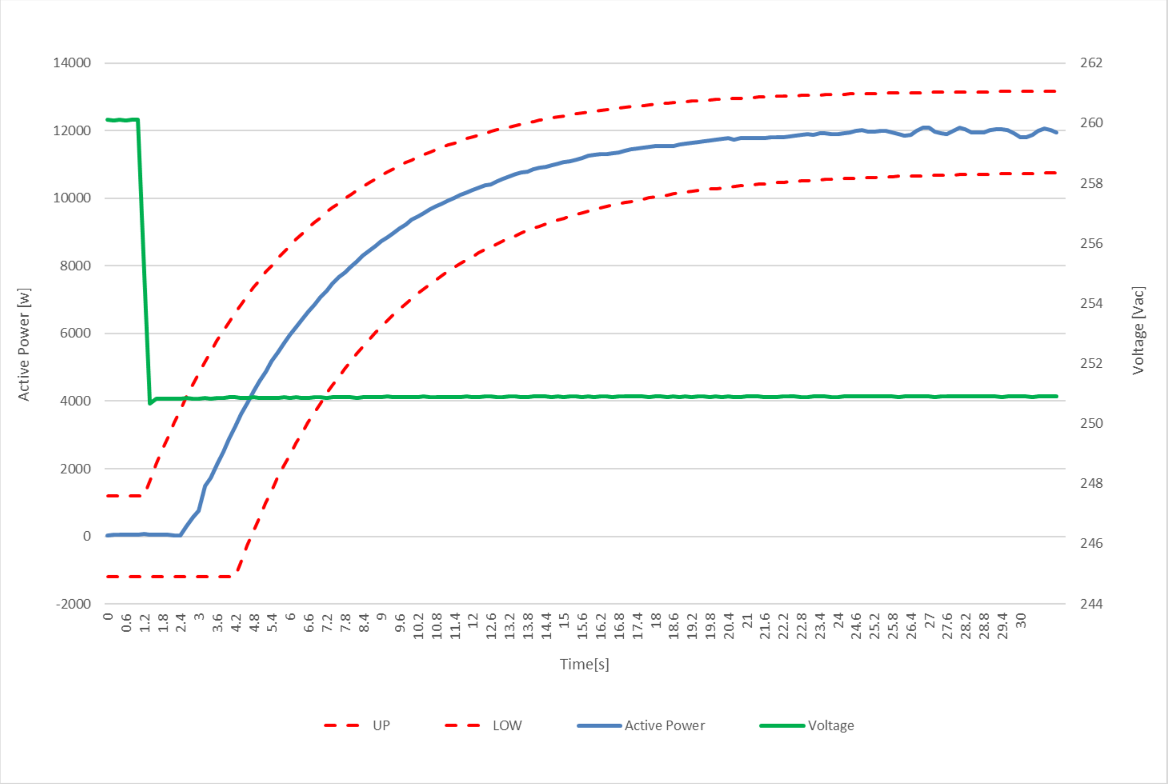


Figure 7 - Exemplary evaluation of the transient response of the P (U) control with permissible tolerances

P (U) control in the event of a setpoint jump from active power 100%P_n to 0:



P (U) control in the event of a setpoint jump from active power 0 to 100%P_n:



5.3.7 (5.3.4)	**TABLE: Reactive power control according to setting fixed cos φ**	**P**
Model	Hybridpower 12kW 3ph	

No.	Test condition			Measurement				Deviation	Limitation
	Cos φ	P	U/U_n [%]	U [V]	P [W]	Q [Var]	Cos φ	∆ Cos φ	∆ Cos φ
a)	0.90 (c)	$50\%P_n$	91%	209.35	6032.45	2873.00	0.903	0.003	0.01
		S_n		209.46	11472.1	5531.42	0.901	0.001	0.01
		$50\%P_n$	100%	230.05	6034.50	2863.54	0.903	0.003	0.01
		S_n		230.15	11646.9	5563.24	0.902	0.002	0.01
		$50\%P_n$	109%	250.77	6033.41	2920.71	0.900	0.000	0.01
		S_n		250.82	11755.0	5547.69	0.904	0.004	0.01
b)	0.90 (i)	$50\%P_n$	91%	209.44	5998.46	-2861.72	0.902	0.002	0.01
		S_n		209.51	11438.6	-5516.30	0.901	0.001	0.01
		$50\%P_n$	100%	230.14	6009.57	-2910.00	0.900	0.000	0.01
		S_n		230.21	11679.5	-5610.99	0.901	0.001	0.01
		$50\%P_n$	109%	250.58	6006.48	-2920.69	0.899	-0.001	0.01
		S_n		250.67	11796.0	-5658.81	0.902	0.002	0.01

Note: The measurement value in above table are 30 s mean values.

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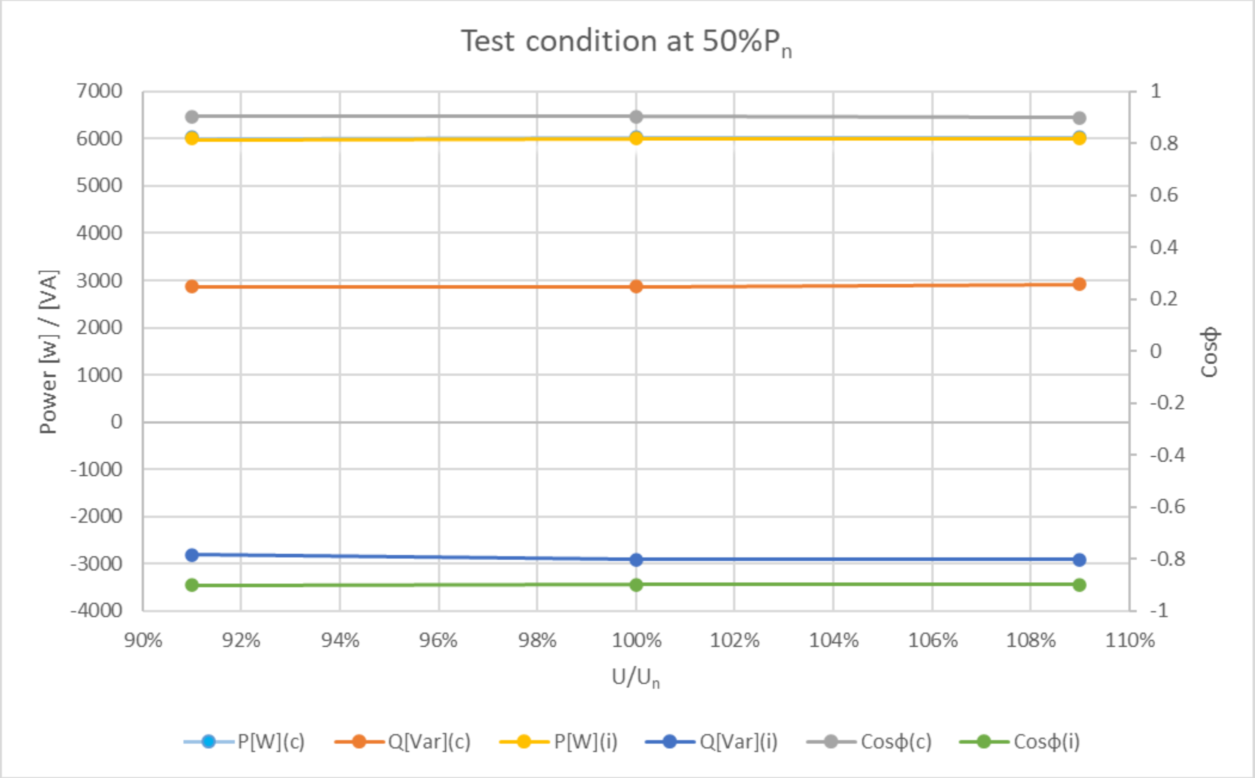
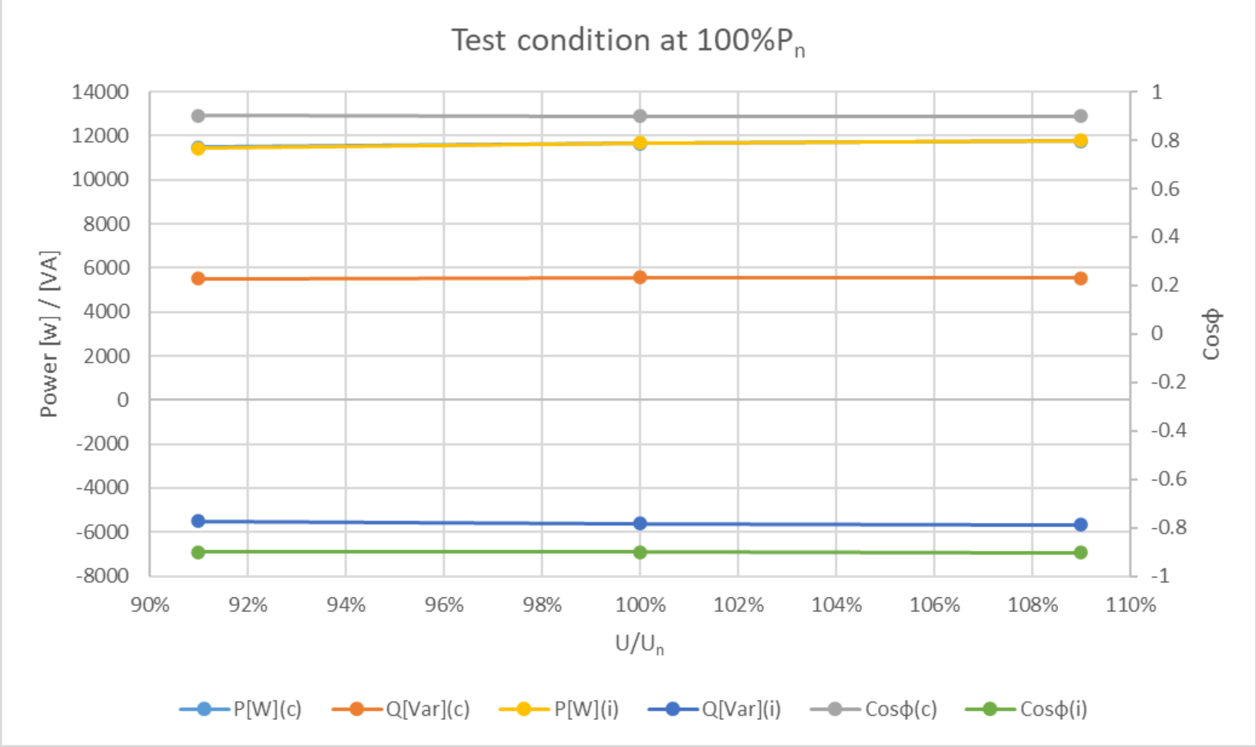
Clause	Requirement - Test	Result - Remark	Verdict

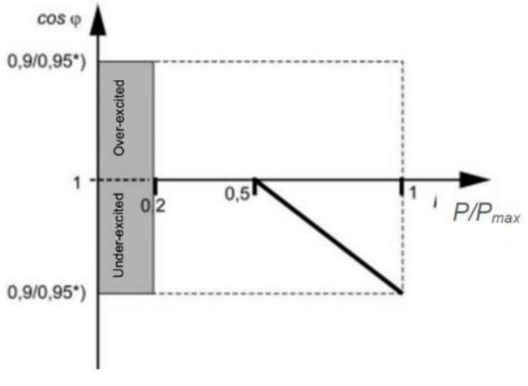




5.3.8 (5.3.4.1) (5.7.5)	**TABLE: Power related control mode – cos φ (P)**									P
Model	Hybridpower 12kW 3ph									
Test a): displacement factor active power characteristic curve cos φ (P)										
30 s mean value	10% → 100% P_{Emax}									
P/P_n [%]	10	20	30	40	50	60	70	80	90	100
U [V]:	230.28	230.30	230.32	230.35	230.37	230.41	230.43	230.48	230.50	230.50
P_{E30} [kW]:	1.22	2.39	3.63	4.84	6.04	7.26	8.47	9.68	10.86	12.03
P_{E30} of P_{Emax} [%]:	10.16	19.95	30.28	40.35	50.38	60.49	70.59	80.71	90.53	100.24
Q_{E30} [kVAr]:	0.274	0.319	0.291	0.330	-0.366	-1.460	-2.433	-3.478	-4.579	-5.796
$\cos\varphi_{E30}$:	0.975	0.991	0.997	0.998	0.998	0.980	0.961	0.941	0.921	0.901
$\cos\varphi_{setpoint}$:	1.00	1.00	1.00	1.00	0.999	0.979	0.959	0.938	0.919	0.90
30 s mean value	100% → 10% P_{Emax}									
P/P_n [%]	100	90	80	70	60	50	40	30	20	10
U [V]:	230.51	230.50	230.48	230.43	230.40	230.37	230.35	230.32	230.30	230.28
P_{E30} [kW]:	12.03	10.88	9.68	8.47	7.26	6.04	4.84	3.63	2.39	1.22
P_{E30} of P_{Emax} [%]:	100.28	90.70	80.69	70.59	60.50	50.36	40.35	30.29	19.96	10.16
Q_{E30} [kVAr]:	-5.798	-4.588	-3.476	-2.433	-1.460	-0.367	0.327	0.291	0.319	0.273
$\cos\varphi_{E30}$:	0.901	0.921	0.941	0.961	0.980	0.998	0.998	0.997	0.991	0.975
$\cos\varphi_{setpoint}$:	0.90	0.919	0.939	0.959	0.979	0.999	1.00	1.00	1.00	1.00
Limit $\cos\varphi_{E30}$:	$\cos\varphi_{setpoint}$ ± 0.01									

Note:

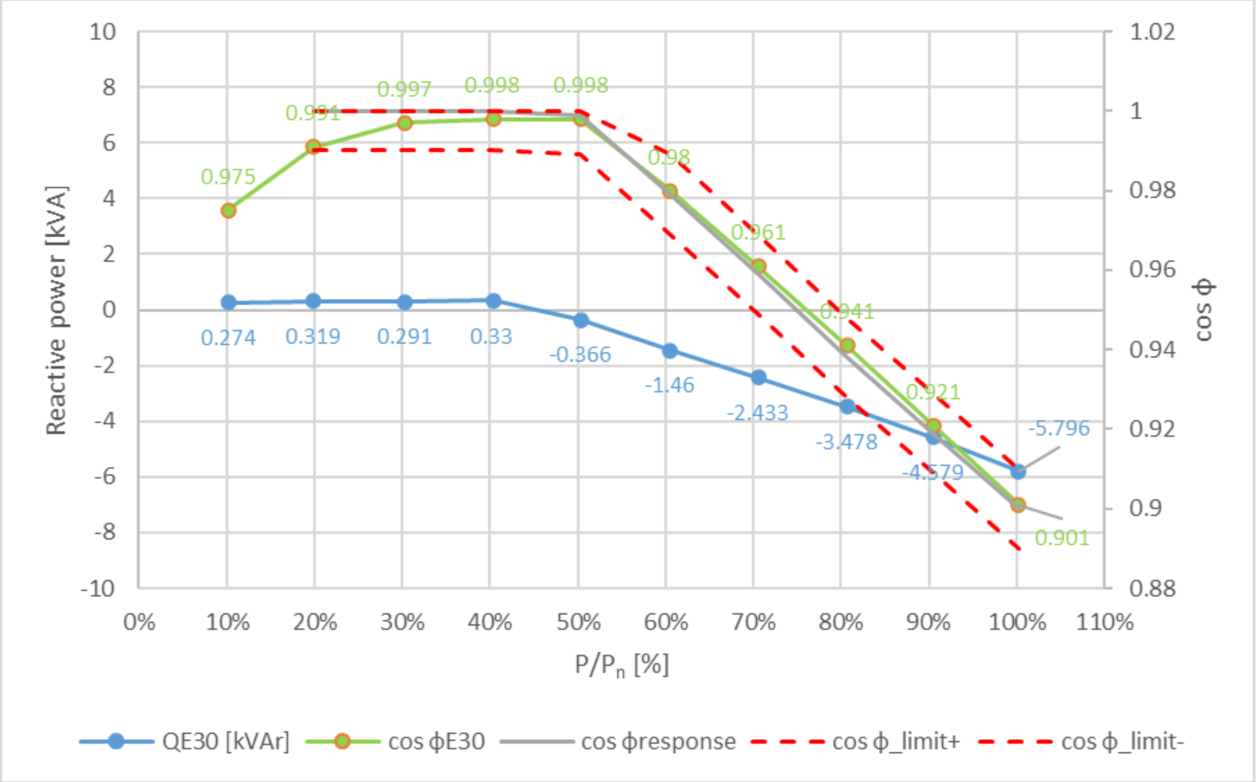
The *cos φ(P) control* should be deactivated by default.



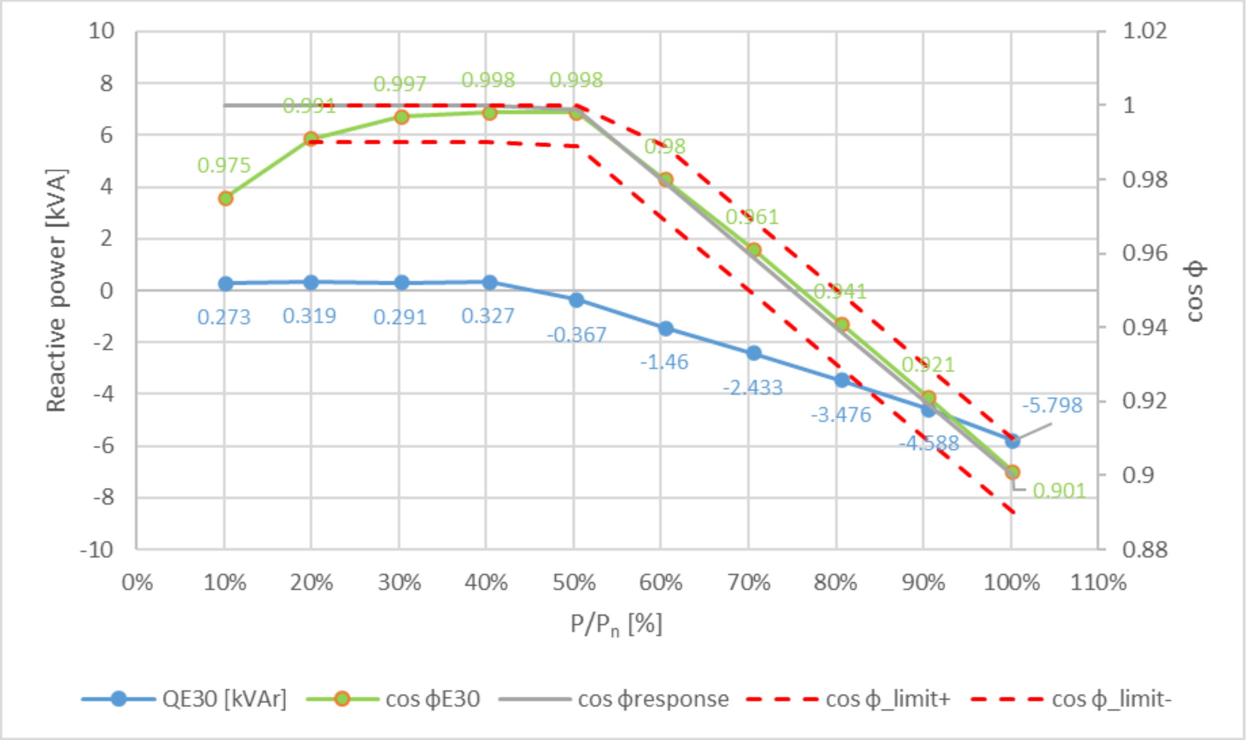
**) depending on the required Q capability*

Figure 12: Displacement factor / active power characteristic curve cos φ(P) in the low-voltage network

Curve cos φ (P)-- 10% → 100% P_{Emax}



Curve cos φ (P)-- 100% → 10% P_{Emax}



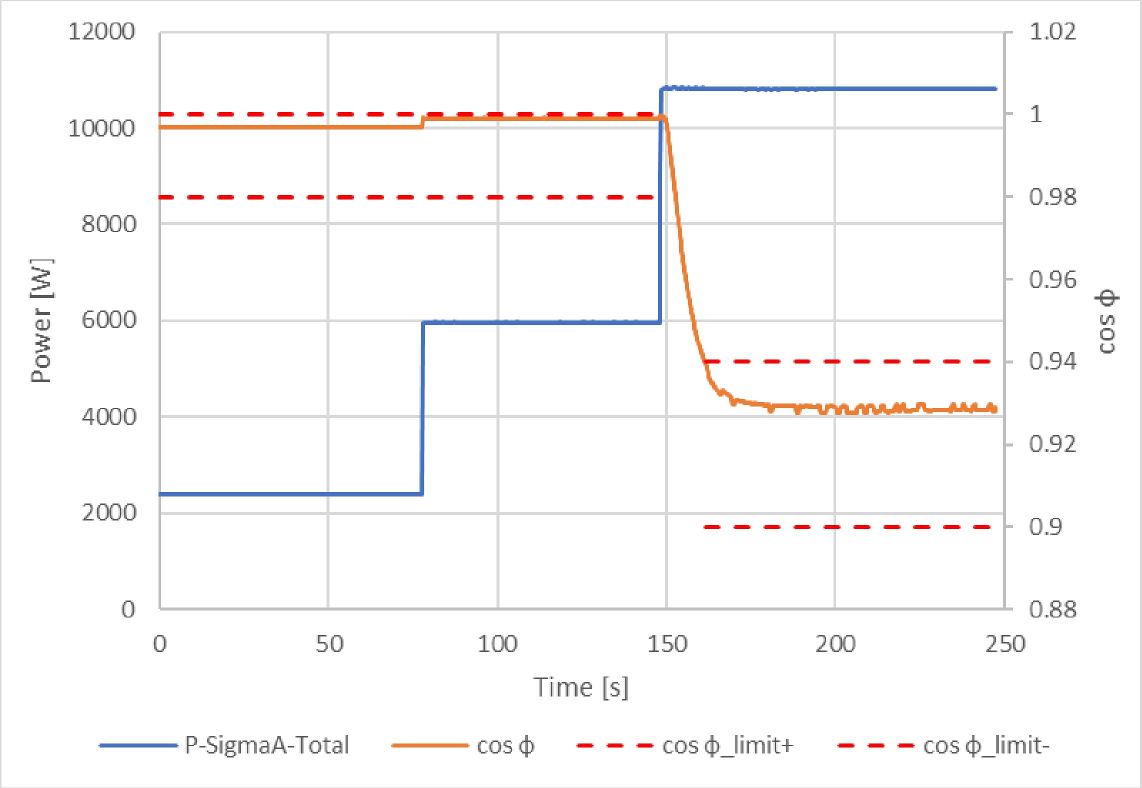
5.3.8 (5.3.4.1) (5.7.5)	**TABLE: Power related control mode – cos φ (P)**			**P**
Model	Hybridpower 12kW 3ph			
Test b): demonstrate the settling time				
30 s mean value	20% → 50% → 90% P_{Emax}			
P/P_n [%]	20	50	90	
U [V]:	230.09	230.11	230.14	
P_{E30} [kW]:	2.43	5.96	10.81	
P_{E30} of P_{Emax} [%]:	20.25	49.67	90.08	
Q_{E30} [kVAr]:	0.191	0.264	-4.31	
cos $φ_{E30}$:	0.997	0.999	0.929	
cos $φ_{setpoint}$:	1.000	1.000	0.920	
ΔT [s]:	20% → 50% P_{Emax}:	1		
	50% → 90% P_{Emax}:	1		
30 s mean value	90% → 50% → 20% P_{Emax}			
P/P_n [%]	90	50	20	
U [V]:	230.11	230.11	230.08	
P_{E30} [kW]:	10.81	5.97	2.43	
P_{E30} of P_{Emax} [%]:	90.08	49.75	20.25	
Q_{E30} [kVAr]:	-4.32	0.278	0.191	
cos $φ_{E30}$:	0.928	0.999	0.997	
cos $φ_{setpoint}$:	0.920	1.000	1.000	
ΔT [s]:	90% → 50% P_{Emax}:	1		
	50% → 20% P_{Emax}:	1		
Limit T_0 [s]:	10			
Limit cos $φ_{E30}$:	cos $φ_{setpoint}$ ± 0.02			

Note:

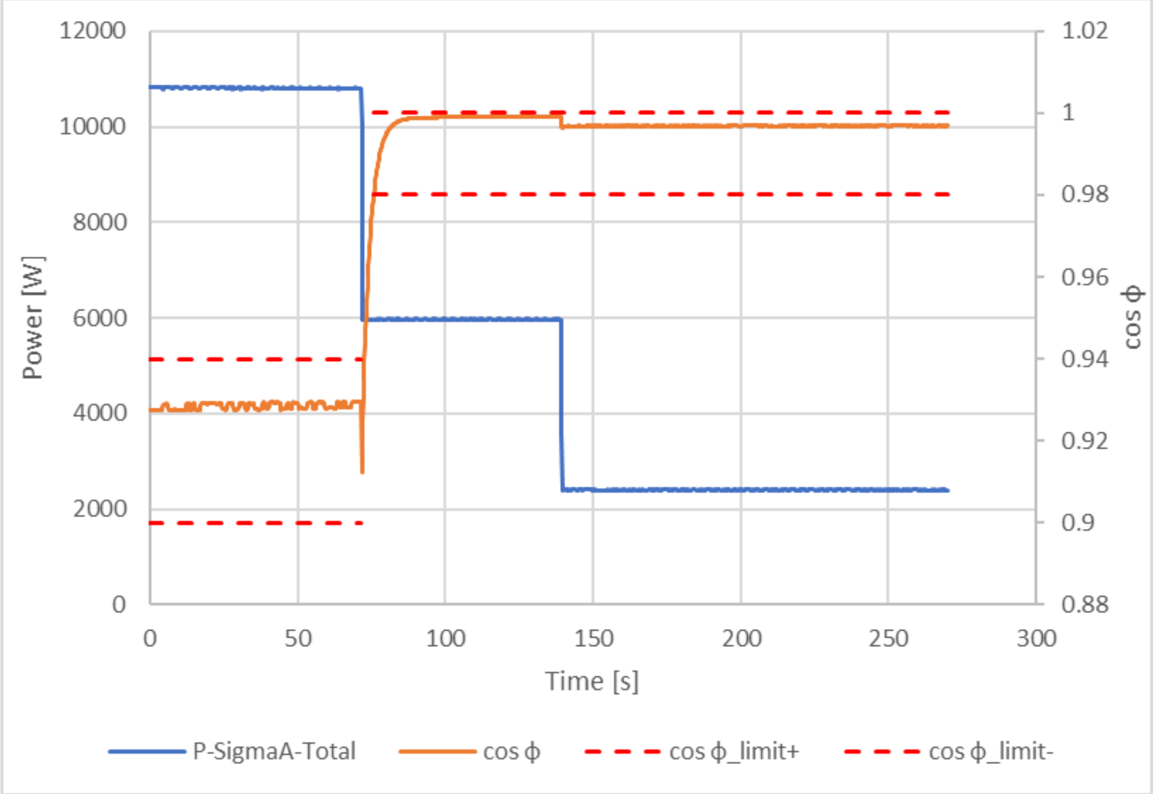
When cos φ noise is superimposed due to island grid detection, and the cos φ tolerance band ±0.02 is violated for the nominal value after transient due to this noise, then this parasitic induction caused by island grid detection can be neglected.

OVE-Richtlinie R 25			
Clause	Requirement - Test	Result - Remark	Verdict

Test b): Demonstrate the settling time 20% → 50% → 90% P_{Emax}



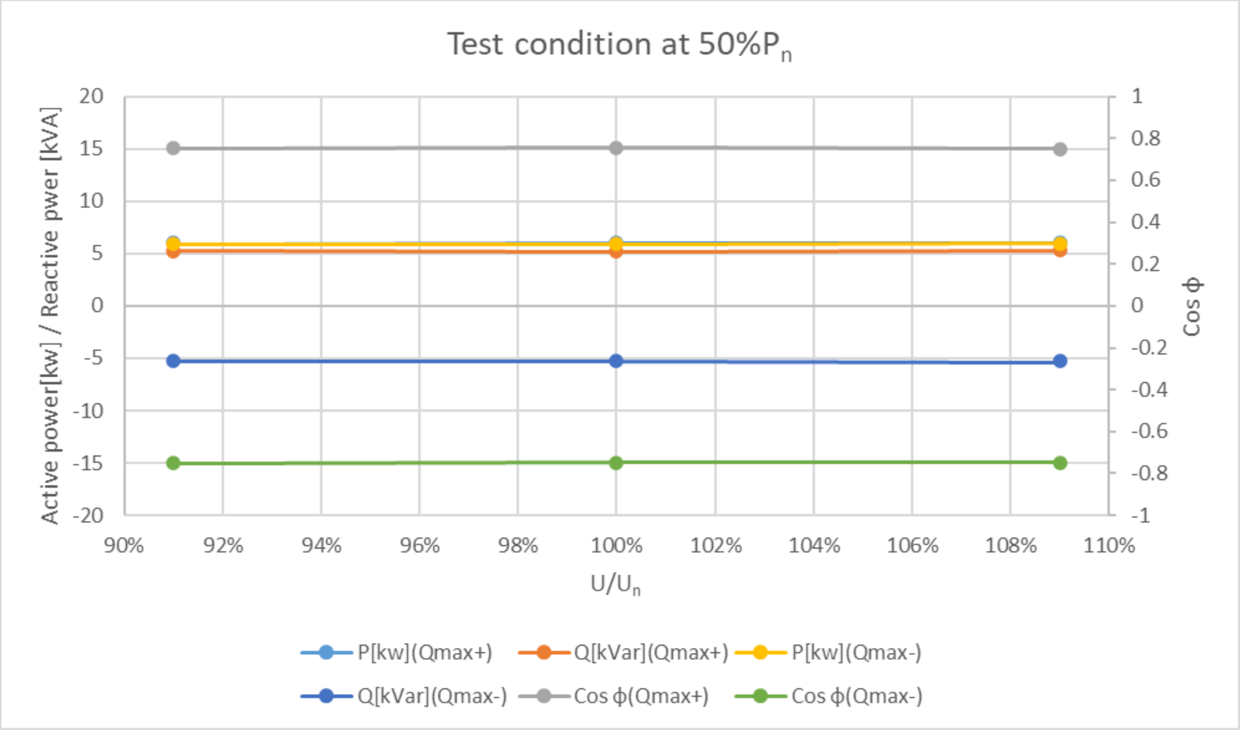
Test b): Demonstrate the settling time 90% → 50% → 20% P_{Emax}

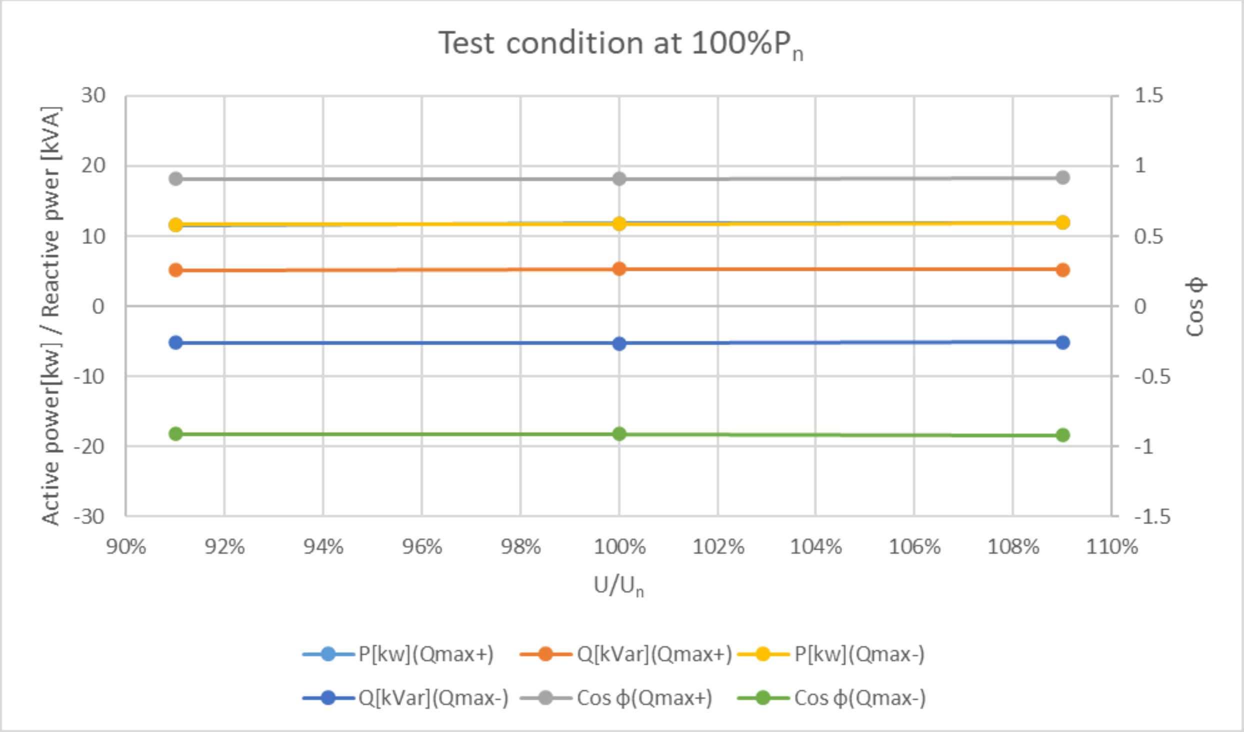


5.3.9 (5.3.4)	**TABLE: Reactive power control according to setting "Fixed Q"**								**P**
Model:	Hybridpower 12kW 3ph								
No.	Test condition			Measurement				Deviation	Limitation
	Q / P_n	P	U/U_n[%]	U [V]	P [kW]	Q [kVar]	Cos φ	Δ Q / S_n [%]	Δ Q / S_n
a)	0.436	50%P_n	91%	209.43	6.01	5.26	0.753	0.22%	≤ ±4%
		S_n		209.52	11.57	5.21	0.912	-0.15%	≤ ±4%
		50%P_n	100%	230.12	6.02	5.21	0.756	-0.22%	≤ ±4%
		S_n		230.24	11.79	5.32	0.912	0.72%	≤ ±4%
		50%P_n	109%	250.91	6.02	5.29	0.751	0.46%	≤ ±4%
		S_n		250.88	11.91	5.23	0.915	0.00%	≤ ±4%
b)	-0.436	50%P_n	91%	209.41	5.96	-5.25	-0.750	-0.14%	≤ ±4%
		S_n		209.48	11.67	-5.21	-0.913	0.20%	≤ ±4%
		50%P_n	100%	230.08	5.96	-5.28	-0.748	-0.41%	≤ ±4%
		S_n		230.17	11.76	-5.27	-0.913	-0.30%	≤ ±4%
		50%P_n	109%	250.79	5.97	-5.29	-0.749	-0.46%	≤ ±4%
		S_n		250.74	11.88	-5.13	-0.918	0.83%	≤ ±4%

Note:
The test is passed if all Q values (30 s average) do not deviate from the specification by more than ± 4% S_n.
In the case of EZE with generators directly connected to the grid, which cannot regulate reactive power due to the principle, such as asynchronous generators, and therefore use non-controllable fixed capacities, the tolerance band extends from ± 4% P_n to ± 10% P_n. This device type is only used at U_n rated.

OVE-Richtlinie R 25			
Clause	Requirement - Test	Result - Remark	Verdict





5.3.10.1.1 (5.3.4.2 & 5.3.6)	**TABLE: Voltage-control functions (reactive power control Q (U) and active power control P (U)) -Test procedure for static behaviour**							**P**
Model	Hybridpower 12kW 3ph							
Test condition		Measurement				Target	Deviation	Limit
U/U_n	P/P_n	U (V)	I (A)	P (W)	Q (Var)	Q/S_n	$\Delta Q/S_n$(%)	$\Delta Q/S_n$
Steps a) to m) with primary energy at 100% P_n (or setting power setpoint EUT at 100% P_n):								
100%	100%	230.22	52.49	12080.1	355.8	0	2.97	≤ ±4%
101%	100%	232.53	51.93	12070.9	357.0	0	2.97	≤ ±4%
102%	100%	234.84	51.67	12127.8	358.3	0	2.99	≤ ±4%
103%	100%	237.14	51.08	12107.3	361.1	0	3.01	≤ ±4%
104%	100%	239.42	50.66	12124.7	364.5	0	3.04	≤ ±4%
105%	100%	241.72	50.11	12106.8	377.8	0	3.15	≤ ±4%
106%	100%	244.01	49.14	11852.0	-1819.5	-14.6%	-0.56	≤ ±4%
107%	100%	246.31	48.20	11281.1	-3696.7	-29.1%	-1.71	≤ ±4%
108%	100%	248.60	47.32	10501.1	-5302.0	-43.6%	-0.58	≤ ±4%
109%	100%	250.90	46.85	10493.2	-5298.2	-43.6%	-0.55	≤ ±4%
110%	100%	253.19	40.84	8859.6	-5323.6	-43.6%	-0.76	≤ ±4%
111%	100%	255.45	24.04	2751.3	-5481.6	-43.6%	-2.08	≤ ±4%
112%	100%	257.75	0.79	-37.9	61.6	0	0.51	≤ ±4%
113%	100%	260.05	0.77	-38.0	60.8	0	0.51	≤ ±4%
112%	100%	257.75	0.77	-37.5	59.9	0	0.50	≤ ±4%
111%	100%	255.46	23.97	2765.9	-5463.4	-43.6%	-1.93	≤ ±4%
110%	100%	253.20	39.72	8528.2	-5329.4	-43.6%	-0.81	≤ ±4%
109%	100%	250.91	46.54	10410.5	-5288.4	-43.6%	-0.47	≤ ±4%
108%	100%	248.61	47.28	10490.2	-5302.0	-43.6%	-0.58	≤ ±4%
107%	100%	246.32	48.17	11266.7	-3717.0	-29.1%	-1.88	≤ ±4%
106%	100%	244.03	49.19	11860.9	-1842.5	-14.6%	-0.75	≤ ±4%
105%	100%	241.73	49.11	11864.9	370.2	0	3.08	≤ ±4%
104%	100%	239.44	49.55	11857.7	356.3	0	2.97	≤ ±4%
103%	100%	237.13	50.02	11855.4	352.5	0	2.94	≤ ±4%
102%	100%	234.83	50.50	11852.7	349.6	0	2.91	≤ ±4%
101%	100%	232.53	50.97	11846.2	346.9	0	2.89	≤ ±4%
100%	100%	230.24	51.46	11843.7	343.3	0	2.86	≤ ±4%
99%	100%	227.94	51.96	11839.1	343.1	0	2.86	≤ ±4%
98%	100%	225.64	52.48	11837.0	342.6	0	2.86	≤ ±4%
97%	100%	223.35	53.01	11835.1	343.0	0	2.86	≤ ±4%
96%	100%	221.05	53.60	11843.1	342.8	0	2.86	≤ ±4%

5.3.10.1.1 (5.3.4.2 & 5.3.6)	**TABLE: Voltage-control functions (reactive power control Q (U) and active power control P (U)) -Test procedure for static behaviour**							**P**
Model	Hybridpower 12kW 3ph							
Test condition		Measurement				Target	Deviation	Limit
U/U_n	P/P_n	U (V)	I (A)	P (W)	Q (Var)	Q/S_n	$\Delta Q/S_n$(%)	$\Delta Q/S_n$
95%	100%	218.75	54.34	11836.0	1097.4	10.9%	-1.76	≤ ±4%
94%	100%	216.46	55.85	11831.5	2481.6	21.8%	-1.12	≤ ±4%
93%	100%	214.16	57.32	11644.4	3885.3	32.7%	-0.32	≤ ±4%
92%	100%	211.87	58.20	11134.5	5296.2	43.6%	0.53	≤ ±4%
91%	100%	209.56	58.82	10991.7	5577.3	43.6%	2.88	≤ ±4%
90%	100%	207.27	59.46	10983.3	5588.6	43.6%	2.97	≤ ±4%
89%	100%	204.97	60.12	10991.8	5570.7	43.6%	2.82	≤ ±4%
88%	100%	202.66	60.68	10967.4	5563.5	43.6%	2.76	≤ ±4%
87%	100%	200.37	61.45	10988.9	5553.2	43.6%	2.68	≤ ±4%
86%	100%	198.08	62.03	10970.2	5534.0	43.6%	2.52	≤ ±4%
85%	100%	195.78	62.75	10969.0	5530.9	43.6%	2.49	≤ ±4%
86%	100%	198.07	62.03	10961.6	5548.5	43.6%	2.64	≤ ±4%
87%	100%	200.37	61.42	10984.5	5546.6	43.6%	2.62	≤ ±4%
88%	100%	202.67	60.74	10983.4	5560.5	43.6%	2.74	≤ ±4%
89%	100%	204.97	60.18	11003.9	5574.9	43.6%	2.86	≤ ±4%
90%	100%	207.27	59.49	10989.3	5592.8	43.6%	3.01	≤ ±4%
91%	100%	209.57	58.91	10999.7	5606.6	43.6%	3.12	≤ ±4%
92%	100%	211.87	58.31	11137.8	5345.6	43.6%	0.95	≤ ±4%
93%	100%	214.17	57.32	11644.6	3884.3	32.7%	-0.33	≤ ±4%
94%	100%	216.47	55.86	11837.3	2470.6	21.8%	-1.21	≤ ±4%
95%	100%	218.76	54.31	11833.5	1069.7	10.9%	-1.99	≤ ±4%
96%	100%	221.05	53.57	11836.1	352.0	0	2.93	≤ ±4%
97%	100%	223.35	53.02	11836.6	352.7	0	2.94	≤ ±4%
98%	100%	225.65	52.51	11844.3	349.5	0	2.91	≤ ±4%
99%	100%	227.95	51.96	11838.6	349.0	0	2.91	≤ ±4%
100%	100%	230.24	51.48	11847.1	346.7	0	2.89	≤ ±4%
Repeat steps e) to m) with primary energy at 20% P_n (or setting power setpoint EUT at 20% P_n):								
100%	20%	230.08	11.22	2574.1	202.1	0	1.68	≤ ±4%
101%	20%	232.38	11.10	2571.9	198.0	0	1.65	≤ ±4%
102%	20%	234.68	10.94	2560.2	197.0	0	1.64	≤ ±4%
103%	20%	236.99	11.09	2620.8	195.3	0	1.63	≤ ±4%
104%	20%	239.30	10.97	2618.1	194.9	0	1.62	≤ ±4%

5.3.10.1.1 (5.3.4.2 & 5.3.6)	**TABLE: Voltage-control functions (reactive power control Q (U) and active power control P (U)) -Test procedure for static behaviour**								**P**
Model	Hybridpower 12kW 3ph								
Test condition		Measurement				Target	Deviation	Limit	
U/U$_n$	P/P$_n$	U (V)	I (A)	P (W)	Q (Var)	Q/S$_n$	ΔQ/S$_n$(%)	ΔQ/S$_n$	
105%	20%	241.60	10.86	2615.8	196.2	0	1.63	≤ ±4%	
106%	20%	243.90	12.52	2602.5	-1596.8	-14.6%	1.29	≤ ±4%	
107%	20%	246.19	17.96	2580.4	-3589.9	-29.1%	-0.82	≤ ±4%	
108%	20%	248.50	24.50	2552.5	-5526.9	-43.6%	-2.46	≤ ±4%	
109%	20%	250.80	24.26	2550.9	-5524.0	-43.6%	-2.43	≤ ±4%	
110%	20%	253.10	24.00	2552.4	-5511.3	-43.6%	-2.33	≤ ±4%	
111%	20%	255.41	23.73	2552.5	-5497.9	-43.6%	-2.22	≤ ±4%	
112%	20%	257.70	0.77	-37.6	-195.1	0	-1.63	≤ ±4%	
113%	20%	260.00	0.77	-37.7	-197.5	0	-1.65	≤ ±4%	
112%	20%	257.71	0.86	-37.4	-219.0	0	-1.82	≤ ±4%	
111%	20%	255.42	23.68	2554.5	-5481.1	-43.6%	-2.08	≤ ±4%	
110%	20%	253.12	23.97	2553.7	-5502.6	-43.6%	-2.25	≤ ±4%	
109%	20%	250.83	24.23	2552.2	-5515.4	-43.6%	-2.36	≤ ±4%	
108%	20%	248.53	24.50	2552.2	-5528.8	-43.6%	-2.47	≤ ±4%	
107%	20%	246.23	18.14	2585.2	-3641.6	-29.1%	-1.25	≤ ±4%	
106%	20%	243.93	12.71	2602.8	-1683.9	-14.6%	0.57	≤ ±4%	
105%	20%	241.64	10.94	2615.8	377.1	0	3.14	≤ ±4%	
104%	20%	239.34	10.99	2618.3	236.6	0	1.97	≤ ±4%	
103%	20%	237.04	11.09	2618.2	221.7	0	1.85	≤ ±4%	
102%	20%	234.73	11.21	2622.9	199.9	0	1.67	≤ ±4%	
101%	20%	232.44	11.33	2622.3	228.5	0	1.90	≤ ±4%	
100%	20%	230.14	11.48	2626.7	290.2	0	2.42	≤ ±4%	
99%	20%	227.84	11.58	2627.4	232.4	0	1.94	≤ ±4%	
98%	20%	225.55	11.69	2628.1	214.7	0	1.79	≤ ±4%	
97%	20%	223.25	11.82	2629.1	217.1	0	1.81	≤ ±4%	
96%	20%	220.95	11.94	2629.0	225.2	0	1.88	≤ ±4%	
95%	20%	218.66	13.35	2627.0	1274.3	10.9%	-0.28	≤ ±4%	
94%	20%	216.36	17.49	2618.2	2731.6	21.8%	0.96	≤ ±4%	
93%	20%	214.07	22.93	2601.6	4162.2	32.7%	1.99	≤ ±4%	
92%	20%	211.77	29.32	2578.1	5649.1	43.6%	3.48	≤ ±4%	
91%	20%	209.47	29.62	2577.1	5644.5	43.6%	3.44	≤ ±4%	
90%	20%	207.17	29.91	2575.1	5635.4	43.6%	3.36	≤ ±4%	

5.3.10.1.1 (5.3.4.2 & 5.3.6)	**TABLE: Voltage-control functions (reactive power control Q (U) and active power control P (U)) -Test procedure for static behaviour**						**P**
Model	Hybridpower 12kW 3ph						
Test condition		Measurement				Target	Deviation	Limit
U/U_n	P/P_n	U (V)	I (A)	P (W)	Q (Var)	Q/S_n	$\Delta Q/S_n$(%)	$\Delta Q/S_n$
89%	20%	204.87	30.19	2573.8	5623.6	43.6%	3.26	≤ ±4%
88%	20%	202.56	30.48	2572.5	5612.8	43.6%	3.17	≤ ±4%
87%	20%	200.27	30.78	2569.1	5602.7	43.6%	3.09	≤ ±4%
86%	20%	197.97	31.08	2569.3	5591.5	43.6%	3.00	≤ ±4%
85%	20%	195.68	31.40	2569.7	5580.9	43.6%	2.91	≤ ±4%
86%	20%	197.97	31.13	2570.5	5601.0	43.6%	3.08	≤ ±4%
87%	20%	200.26	30.82	2571.1	5611.1	43.6%	3.16	≤ ±4%
88%	20%	202.56	30.53	2573.4	5622.4	43.6%	3.25	≤ ±4%
89%	20%	204.86	30.22	2574.4	5629.6	43.6%	3.31	≤ ±4%
90%	20%	207.16	29.93	2575.5	5639.5	43.6%	3.40	≤ ±4%
91%	20%	209.47	29.65	2576.7	5652.0	43.6%	3.50	≤ ±4%
92%	20%	211.76	29.15	2578.4	5608.5	43.6%	3.14	≤ ±4%
93%	20%	214.06	22.89	2599.6	4153.9	32.7%	1.92	≤ ±4%
94%	20%	216.36	17.40	2620.0	2703.2	21.8%	0.73	≤ ±4%
95%	20%	218.65	13.38	2630.6	1277.5	10.9%	-0.25	≤ ±4%
96%	20%	220.95	11.95	2631.0	218.0	0	1.82	≤ ±4%
97%	20%	223.25	11.83	2632.2	213.2	0	1.78	≤ ±4%
98%	20%	225.54	11.69	2629.4	208.90	0	1.74	≤ ±4%
99%	20%	227.84	11.58	2630.4	205.1	0	1.71	≤ ±4%
100%	20%	230.14	11.46	2630.8	199.5	0	1.66	≤ ±4%

The following measurements o) to z) only for EZE with a minimum active power < 20% P_n:								
Test condition		Measurement					Target	Deviation
U/U_n	P/P_n	U (V)	I (A)	P (W)	Q (Var)	$\cos \varphi_{E30}$	Q/S_n	$\Delta Q/S_n$(%)
91%	P_{min}=5%	209.45	6.94	577.8	1334.4	0.397	11.50%	-0.38
91%	10%	209.45	13.83	1149.9	2658.3	0.397	22.90%	-0.75
91%	15%	209.47	21.08	1745.1	4056.5	0.395	34.40%	-0.60
91%	20%	209.48	26.23	2231.8	5020.9	0.406	43.60%	-1.76
91%	15%	209.47	21.07	1742	4056	0.395	34.40%	-0.60
91%	10%	209.45	13.83	1151.5	2658.2	0.397	22.90%	-0.75
91%	P_{min}=5%	209.45	6.96	581.5	1336.4	0.399	11.50%	-0.36
109%	P_{min}=5%	250.86	5.35	584.7	-1337.3	-0.401	-11.50%	0.36

The following measurements o) to z) only for EZE with a minimum active power < 20% P_n:

Test condition		Measurement					Target	Deviation
U/U_n	P/P_n	U (V)	I (A)	P (W)	Q (Var)	cos φ_{E30}	Q/S_n	$\Delta Q/S_n$(%)
109%	10%	250.85	11.93	1155.5	-2659.6	-0.398	-21.80%	-0.36
109%	15%	250.86	18.24	1756	-4025.6	-0.400	-34.40%	0.85
109%	20%	250.86	23.18	2207.6	-5079.2	-0.399	-43.60%	1.27
109%	15%	250.86	18.24	1738.3	-4032.1	-0.396	-34.40%	0.80
109%	10%	250.86	11.78	1143.7	-2622.5	-0.400	-22.90%	1.05
109%	P_{min}=5%	250.86	5.39	582.1	-1320.6	-0.403	-11.50%	0.49
ΔP / P_n Limit		10%						

Note:
The setting value of a time constant Tau of 3 s for Q(U) control and Tau of 5 s for P (U) control when performed this test.
The examination of inpatient behaviour is passed if:
– the 30 s mean values of the reactive power values measured in stationary operation measured according to 5.3.10.1.1 are within the tolerance band of ± 4% S_n and ± 1% U_n of the set Q (U) characteristic.
– in the power range P_{min} to 20% P_n the time course of the reactive power is steady and at P=0 the reactive power approaches 0. Compliance with the tolerance band of ± 4% S_n is not required in this active power range.

To check the behavior of the Q (U) control, the time constant or the response time of the Q (U) control must be defined according to a first-order filter (PT1 element) with a time constant Tau of 3 s (deviating from the standard setup). Overvoltage protection U_{eff}> may be deactivated when testing the voltage-dependent control functions.

Table 3 - Setting values for the Q (U) characteristic according to the TOR generator

Point according to TOR generator, Figure 13	Voltage (U/U_n)	Reactive power (Q/S_n)
a	0.92	43.6 % (overexcited)
b	0.96	0
c	1.05	0
d	1.08	43.6 % (underexcited)

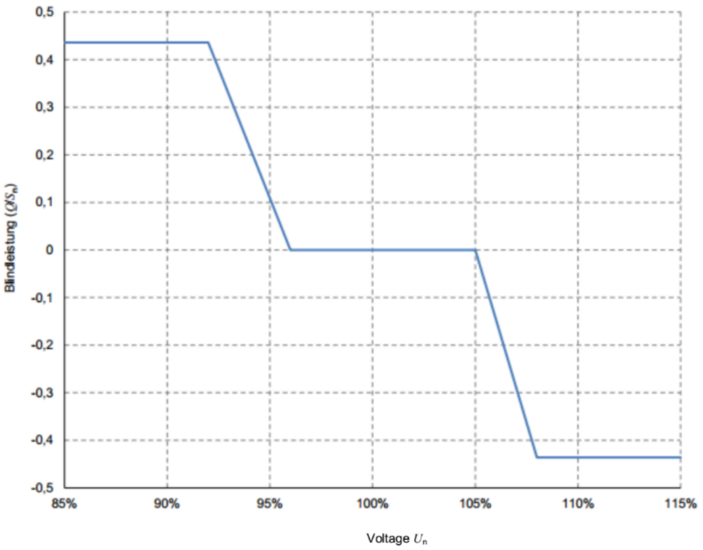
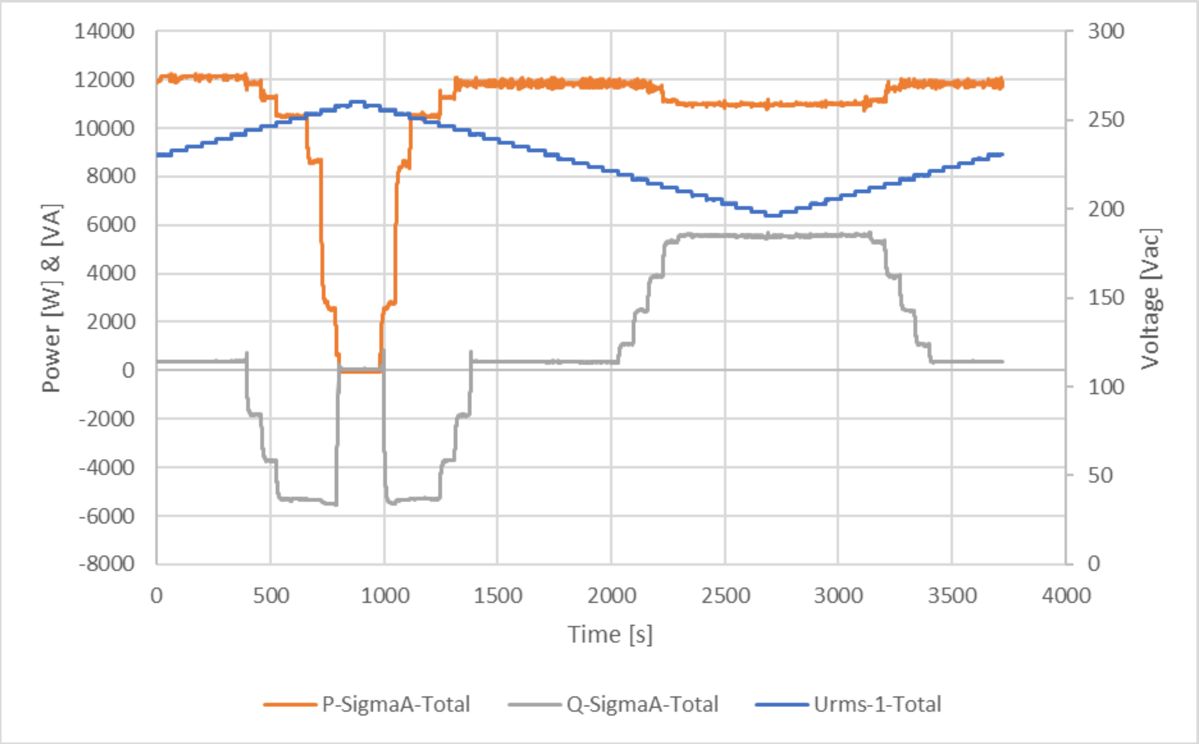


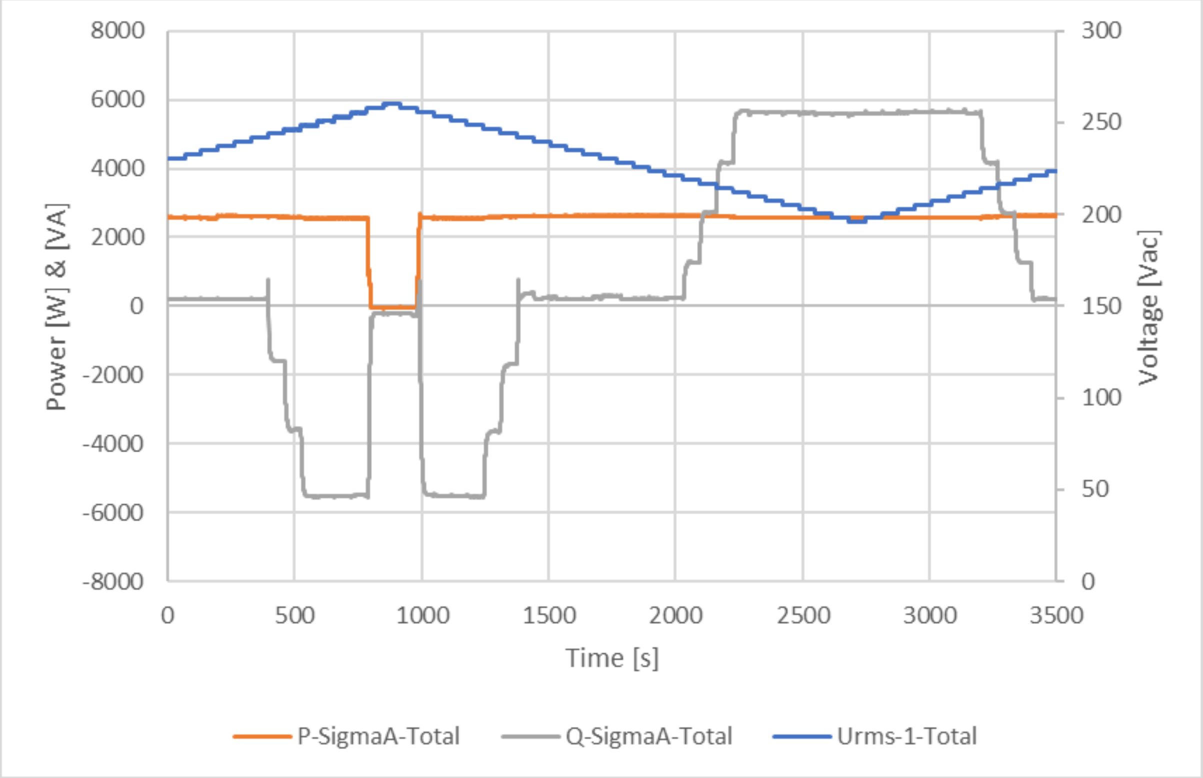
Figure 8 - Q (U) characteristic

Clause	Requirement - Test	Result - Remark	Verdict

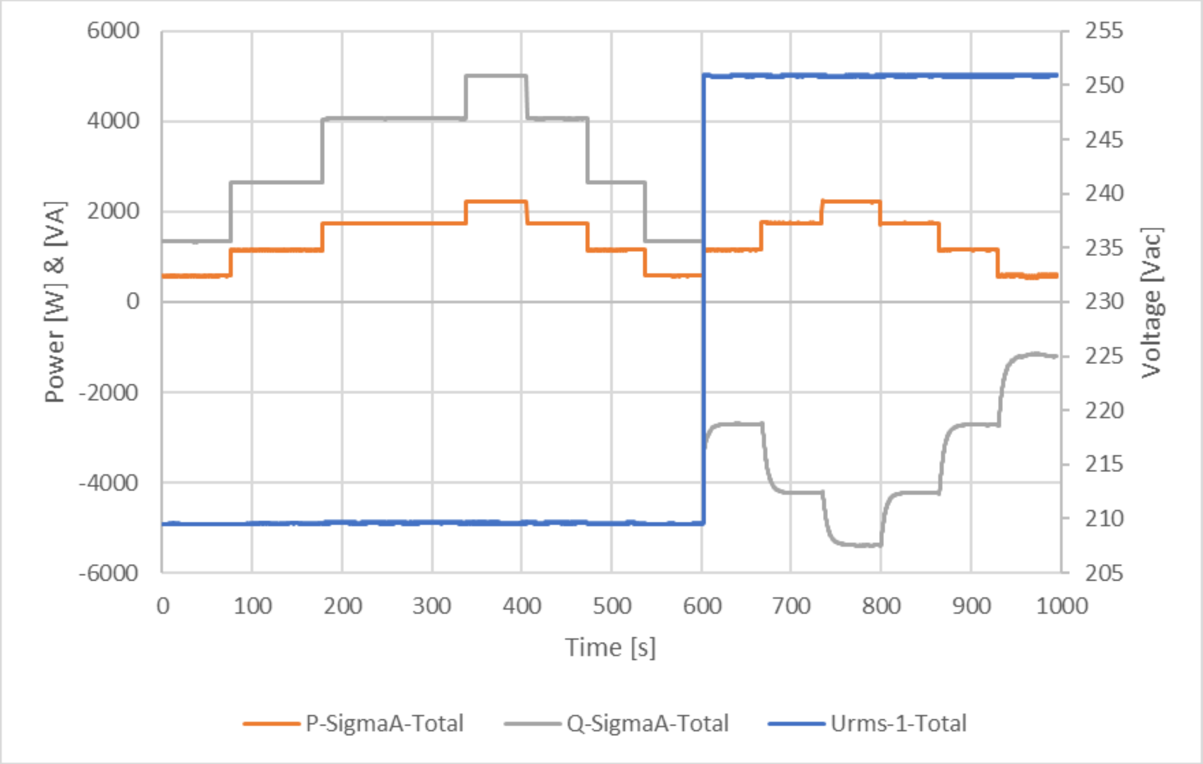
Repeat steps e) to m) with primary energy at 100% P_n (or setting power setpoint EUT at 100% P_n):

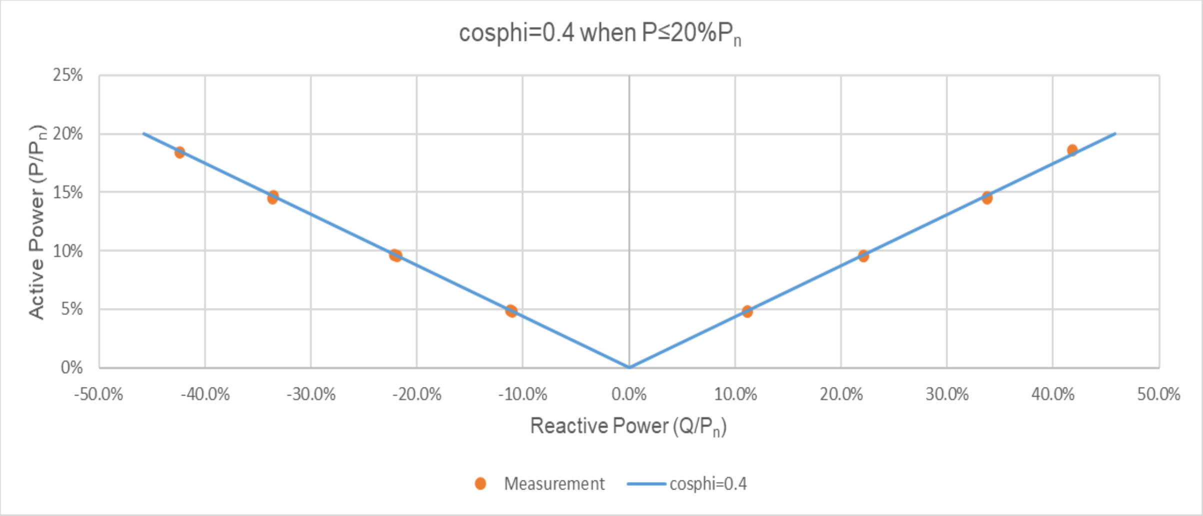


Repeat steps e) to m) with primary energy at 20% P_n (or setting power setpoint EUT at 20% P_n):



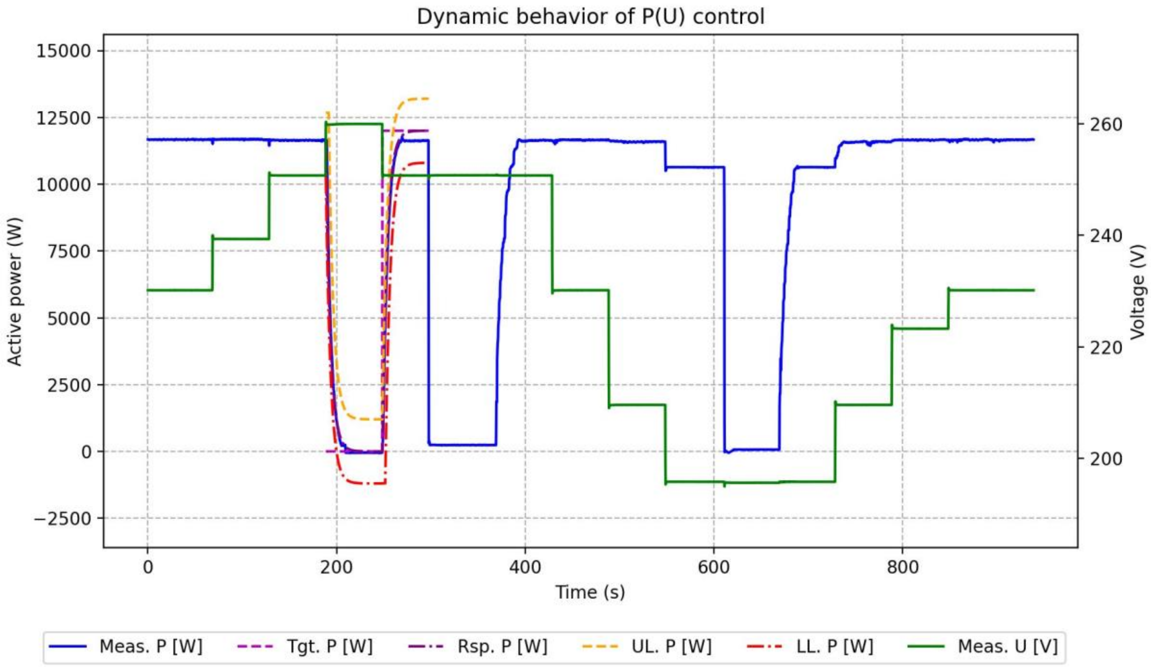
Measurements o) to z) for EZE with a minimum active power < 20% P_n:

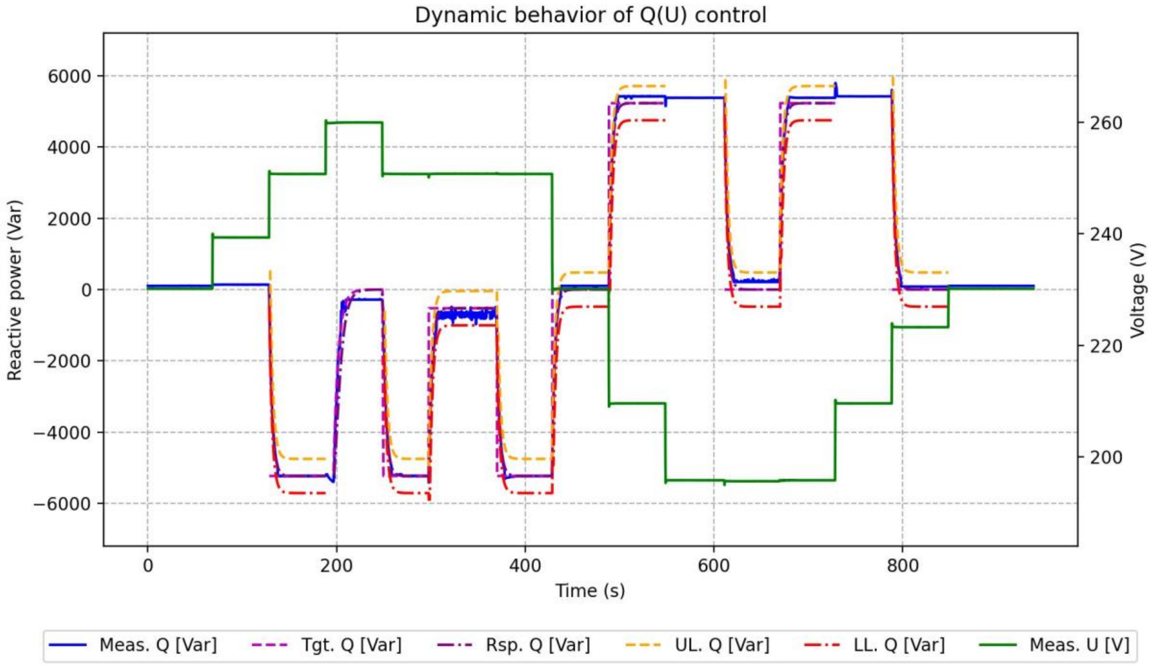


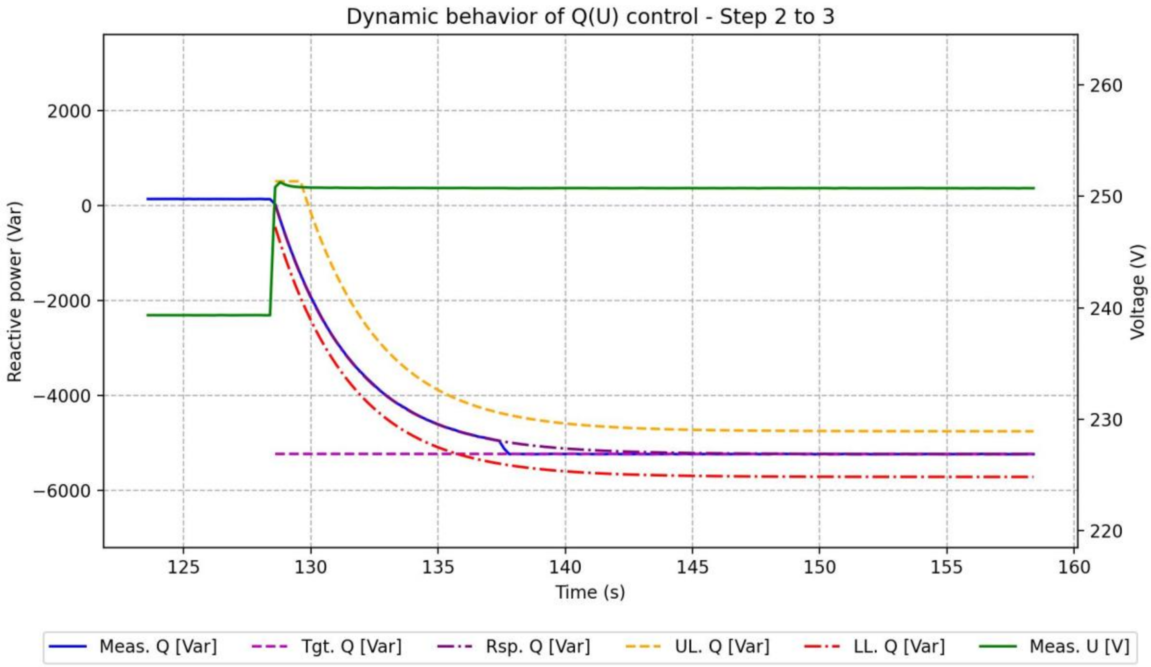


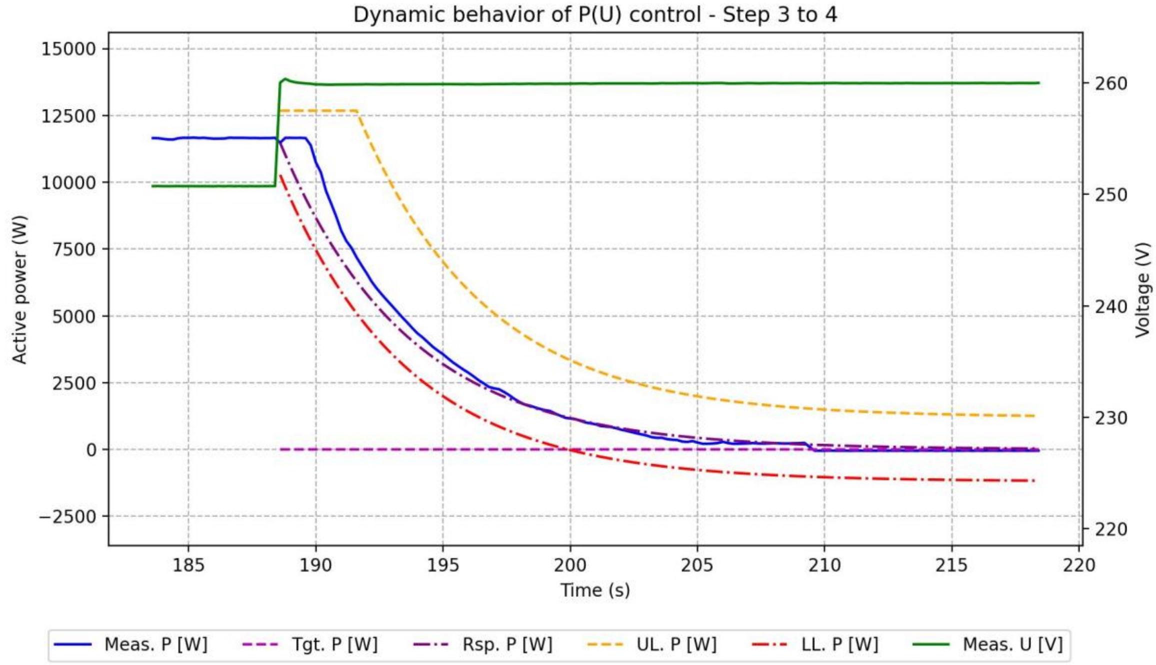
5.3.10.1.2 (5.3.4.2 & 5.3.6)	**TABLE: Voltage-control functions (reactive power control Q (U) and active power control P (U)) -Test procedure for dynamic behaviour**						**P**
Model	Hybridpower 12kW 3ph						
Test condition		Measurement				Dynamic as PT1 behaviour pass?	
U/U_n	P/P_n	U (V)	I (A)	P (W)	Q (Var)	P	Q
1. 100%	100%	230.15	16.94	11679.62	103.69	P	P
2. 104%	100%	239.34	16.30	11687.54	139.77	P	P
3. 109%	100%	250.73	16.99	11640.08	-5232.36	P	P
4. 113%	100%	259.98	0.937	-51.08	-283.93	P	P
5. 109%	100%	250.73	16.97	11621.95	-5229.05	P	P
6. 109%	P_{min}	250.77	1.24	233.83	-642.49	P	P
7. 109%	100%	250.73	16.95	11606.13	-5234.73	P	P
8. 100%	100%	230.13	16.91	11661.86	100.77	P	P
9. 91%	100%	209.58	20.38	11595.50	5424.35	P	P
10. 85%	100%	195.81	20.32	10638.85	5381.67	P	P
11. 85%	P_{min}	195.63	0.773	69.98	211.93	P	P
12. 85%	100%	195.80	20.32	10639.54	5382.75	P	P
13. 91%	100%	209.59	20.41	11610.33	5421.09	P	P
14. 97%	100%	223.26	17.43	11660.54	84.41	P	P
15. 100%	100%	230.15	16.92	11666.31	104.48	P	P

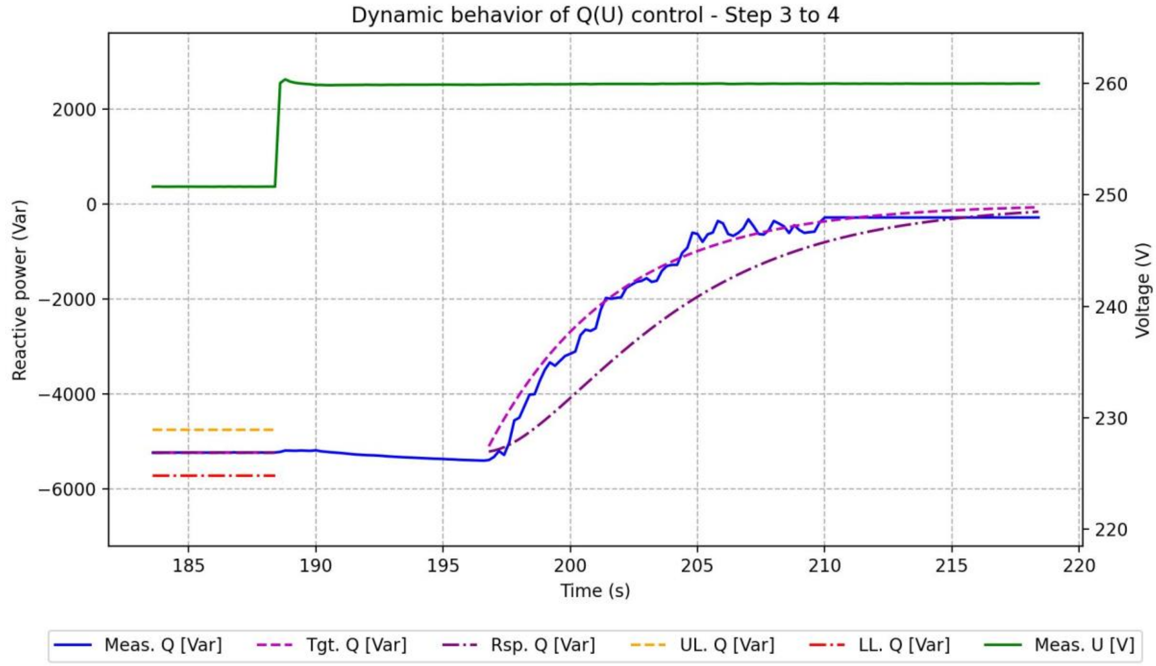
Note:
The setting value of a time constant Tau of 3 s for Q(U) control and Tau of 5 s for P (U) control when performed this test.
The dynamic behaviour test is passed if
– the time curve of the reactive power during the measurement according to 5.3.10.1.2 for powers greater than 20% P_n is within the tolerance bands that result from the behaviour of an equivalent PT1 element (1st order filter). Permissible tolerances for the reactive power values are ± 4% S_n and for the time + 1 second. The tolerance bands are calculated according to Table 6.
– There are no discontinuities in the characteristic curve, no persistent vibrations (after the end of the transient process after 5 Tau) of the reactive power and no disconnections of the EZE occur;
– At the transition to active powers <20% P_n there are no sudden changes in reactive power. With changes in active power between 0% and 20% P_n, the reactive power must behave continuously.

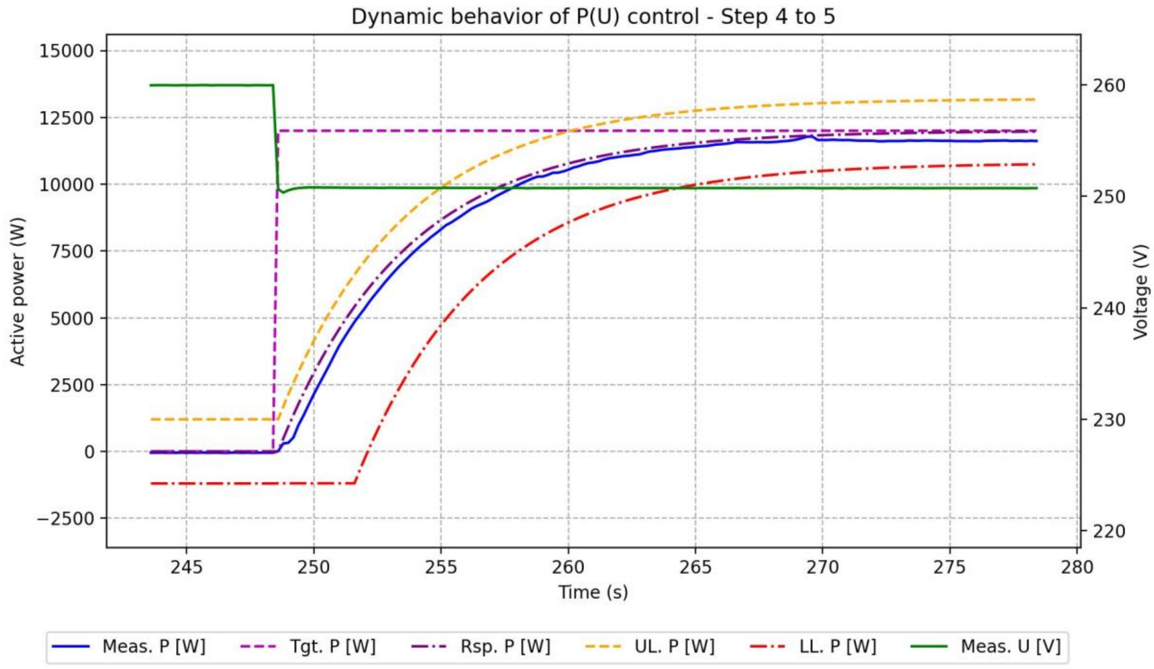

Dynamic behavior of P(U) control
Active power (W)
15000
12500
10000
7500
5000
2500
0
−2500
Voltage (V)
260
240
220
200
0
200
400
600
800
Time (s)
Meas. P [W]
Tgt. P [W]
Rsp. P [W]
UL. P [W]
LL. P [W]
Meas. U [V]


Dynamic behavior of Q(U) control
Reactive power (Var)
6000
4000
2000
0
−2000
−4000
−6000
Voltage (V)
260
240
220
200
0
200
400
600
800
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

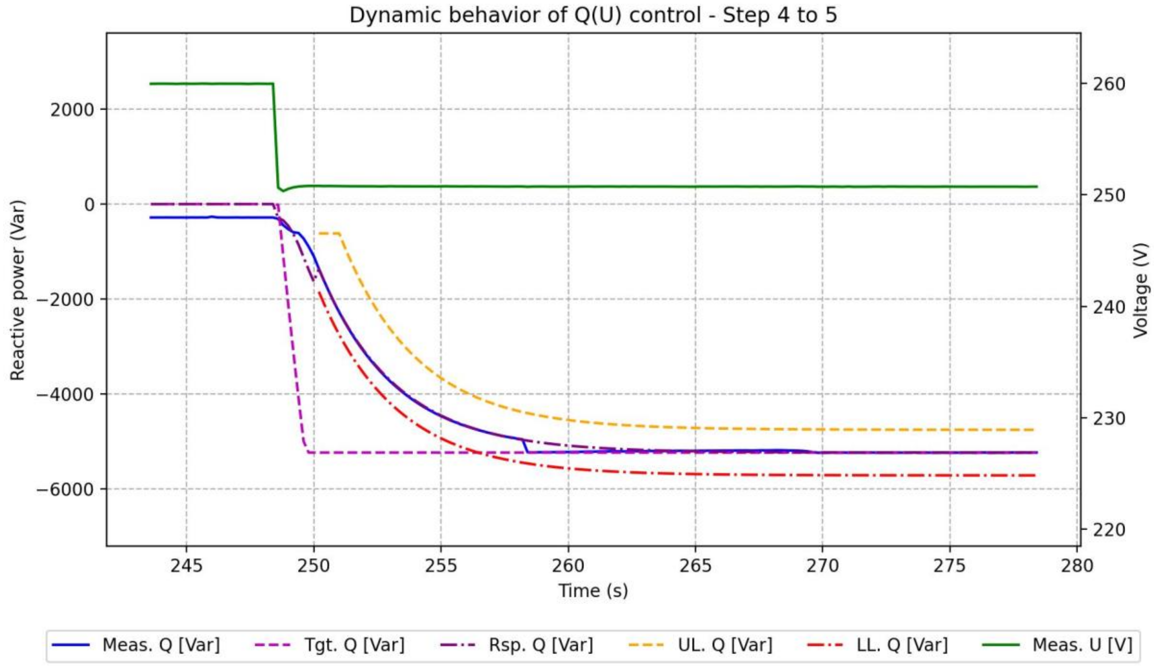

Dynamic behavior of Q(U) control - Step 2 to 3
Reactive power (Var)
2000
0
−2000
−4000
−6000
Voltage (V)
260
250
240
230
220
125
130
135
140
145
150
155
160
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]


Dynamic behavior of P(U) control - Step 3 to 4
Active power (W)
15000
12500
10000
7500
5000
2500
0
−2500
Voltage (V)
260
250
240
230
220
185
190
195
200
205
210
215
220
Time (s)
Meas. P [W]
Tgt. P [W]
Rsp. P [W]
UL. P [W]
LL. P [W]
Meas. U [V]

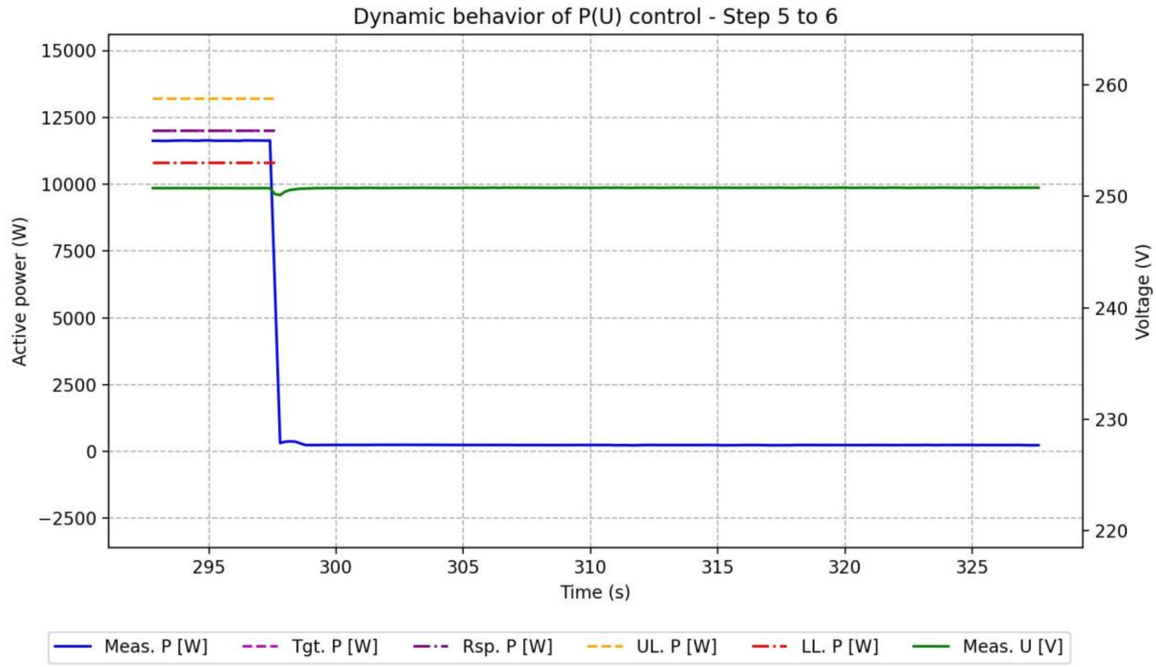

Dynamic behavior of Q(U) control - Step 3 to 4
Reactive power (Var)
2000
0
−2000
−4000
−6000
Voltage (V)
260
250
240
230
220
185
190
195
200
205
210
215
220
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

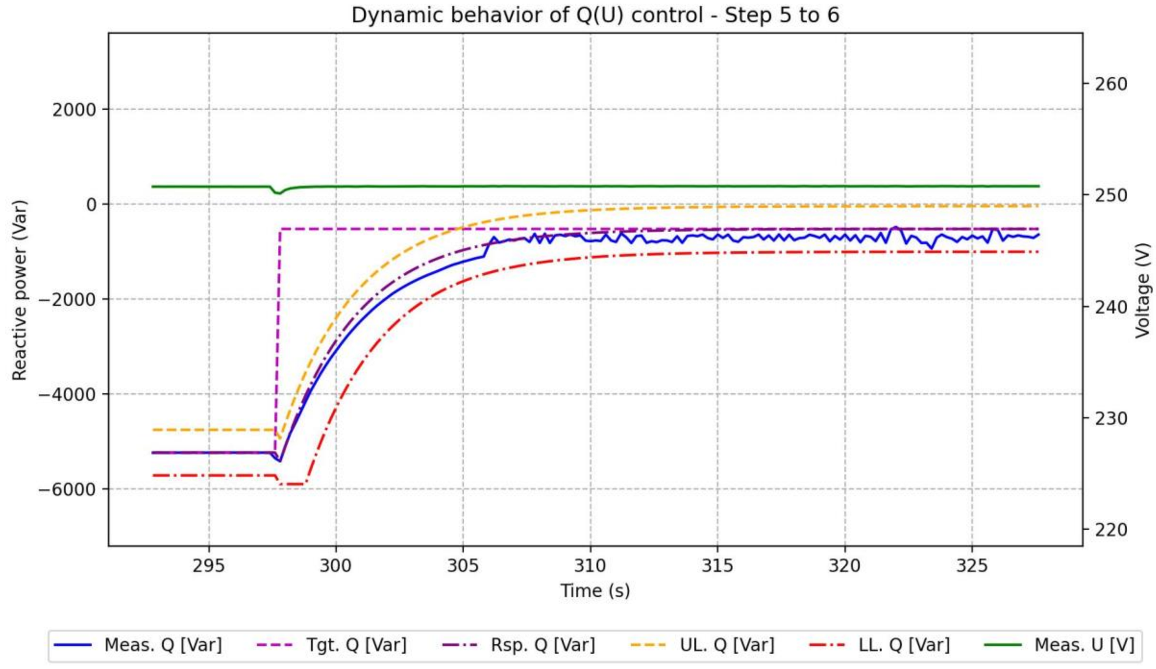


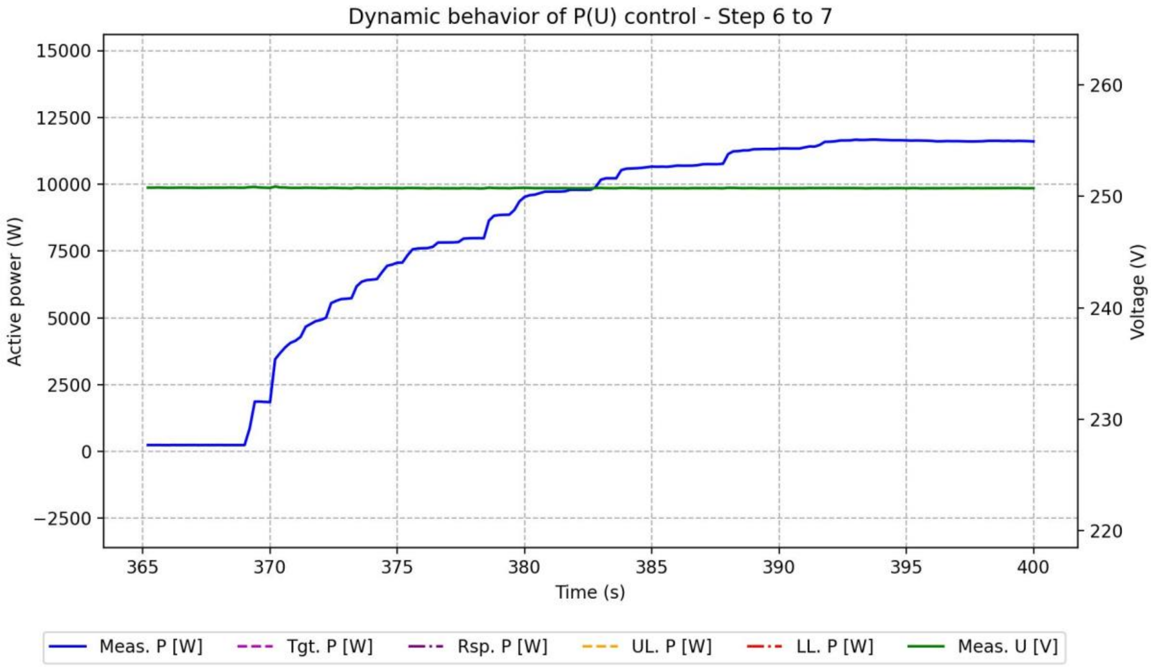
Dynamic behavior of P(U) control - Step 4 to 5
Active power (W)
Voltage (V)
Time (s)
15000
12500
10000
7500
5000
2500
0
−2500
260
250
240
230
220
245
250
255
260
265
270
275
280
Meas. P [W]
Tgt. P [W]
Rsp. P [W]
UL. P [W]
LL. P [W]
Meas. U [V]

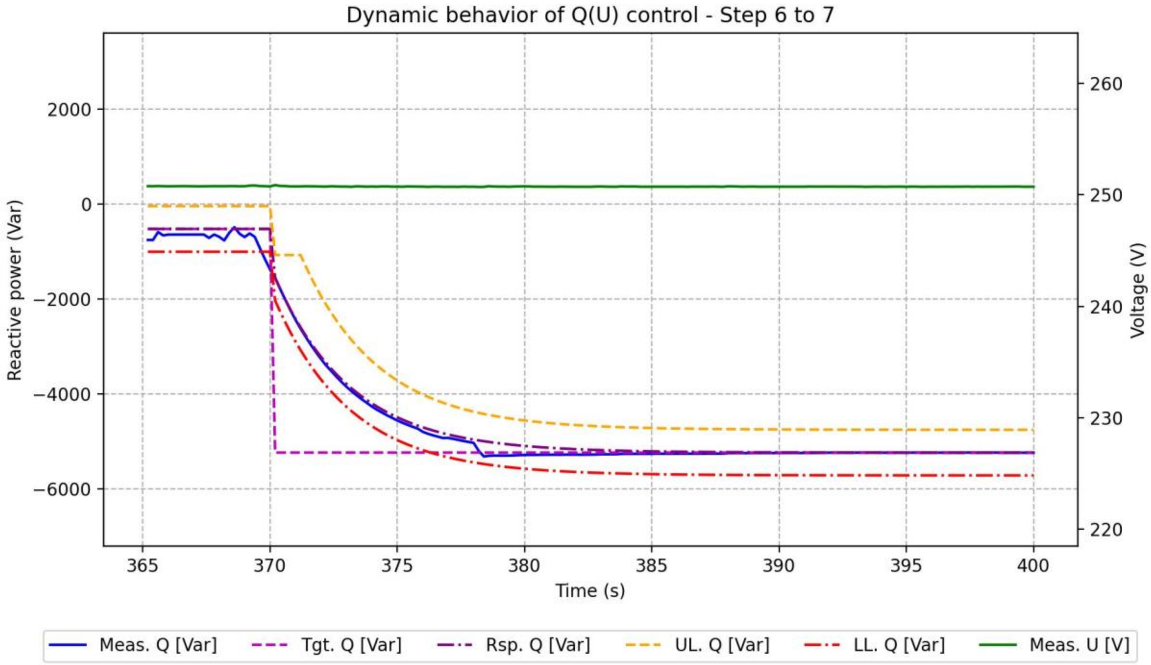


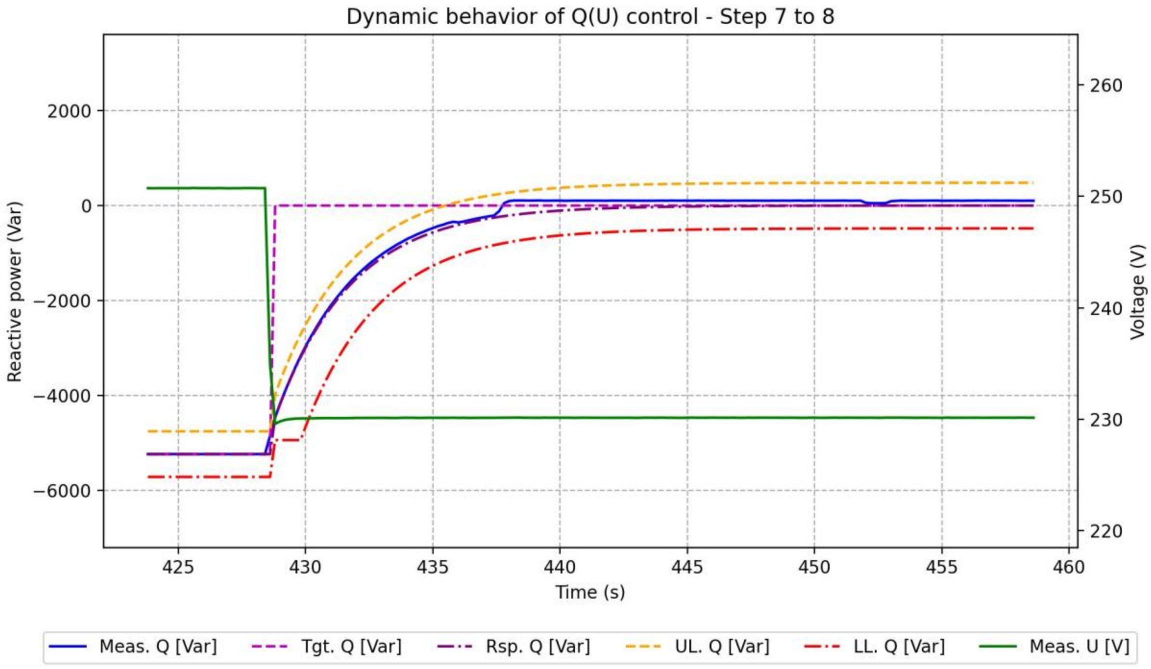
Dynamic behavior of Q(U) control - Step 4 to 5
Reactive power (Var)
Voltage (V)
Time (s)
2000
0
−2000
−4000
−6000
260
250
240
230
220
245
250
255
260
265
270
275
280
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

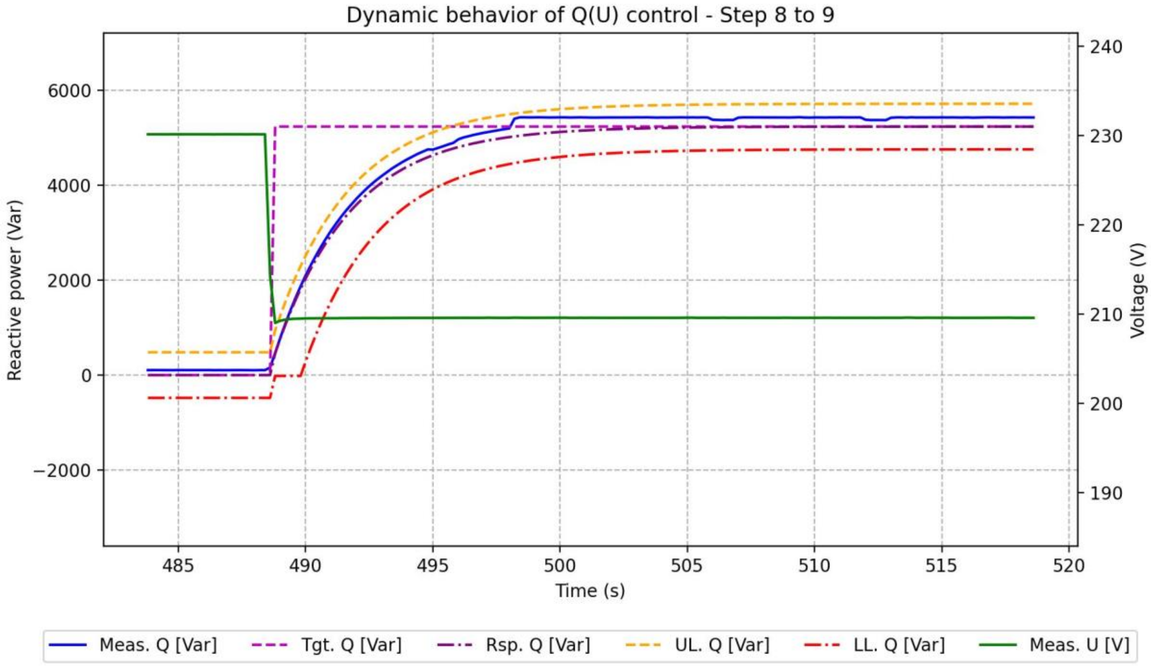

Dynamic behavior of P(U) control - Step 5 to 6
Active power (W)
15000
12500
10000
7500
5000
2500
0
−2500
Voltage (V)
260
250
240
230
220
295
300
305
310
315
320
325
Time (s)
Meas. P [W]
Tgt. P [W]
Rsp. P [W]
UL. P [W]
LL. P [W]
Meas. U [V]

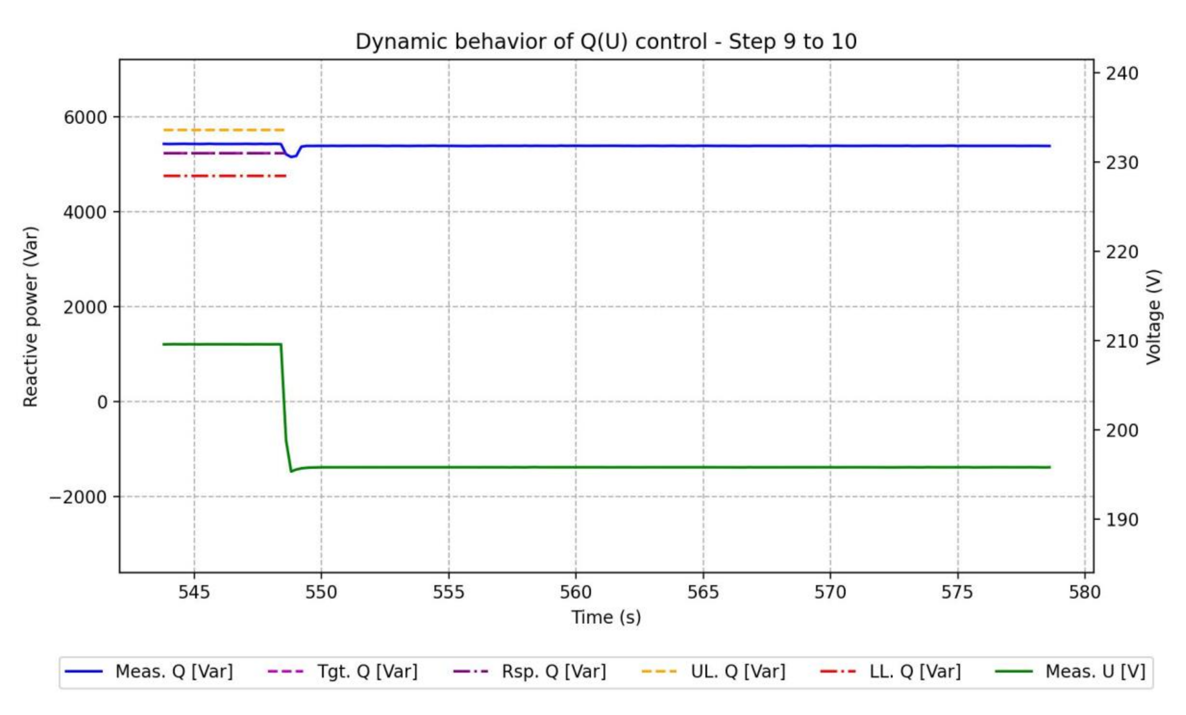

Dynamic behavior of Q(U) control - Step 5 to 6
Reactive power (Var)
2000
0
−2000
−4000
−6000
Voltage (V)
260
250
240
230
220
295
300
305
310
315
320
325
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

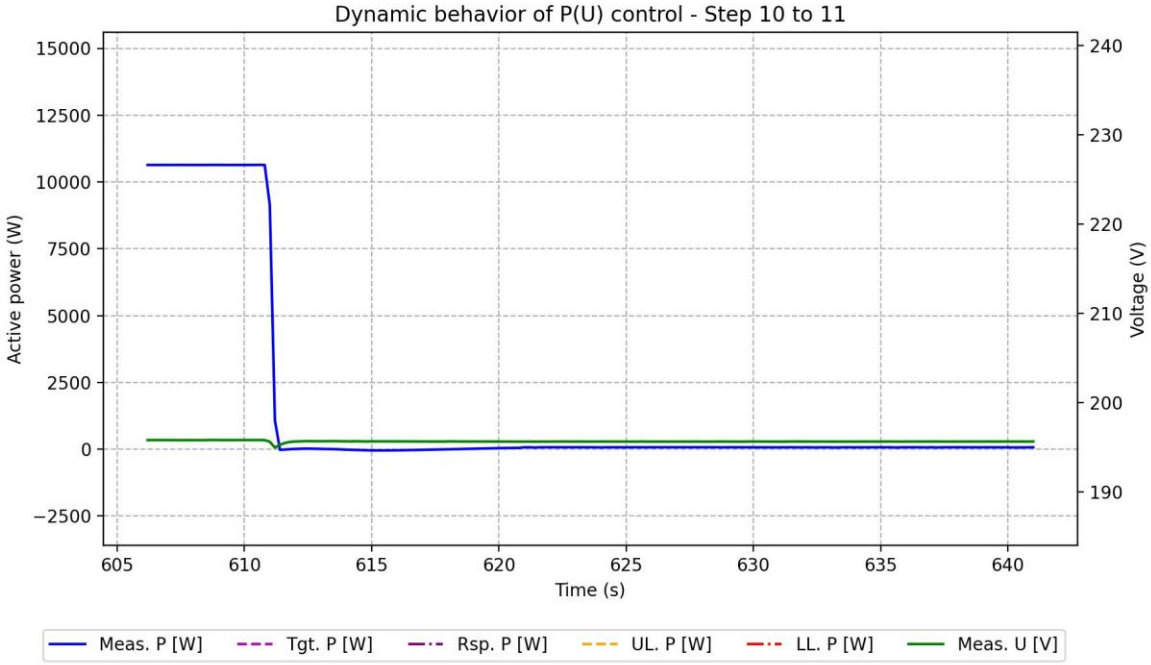

Dynamic behavior of P(U) control - Step 6 to 7
Active power (W)
15000
12500
10000
7500
5000
2500
0
−2500
Voltage (V)
260
250
240
230
220
365
370
375
380
385
390
395
400
Time (s)
Meas. P [W]
Tgt. P [W]
Rsp. P [W]
UL. P [W]
LL. P [W]
Meas. U [V]

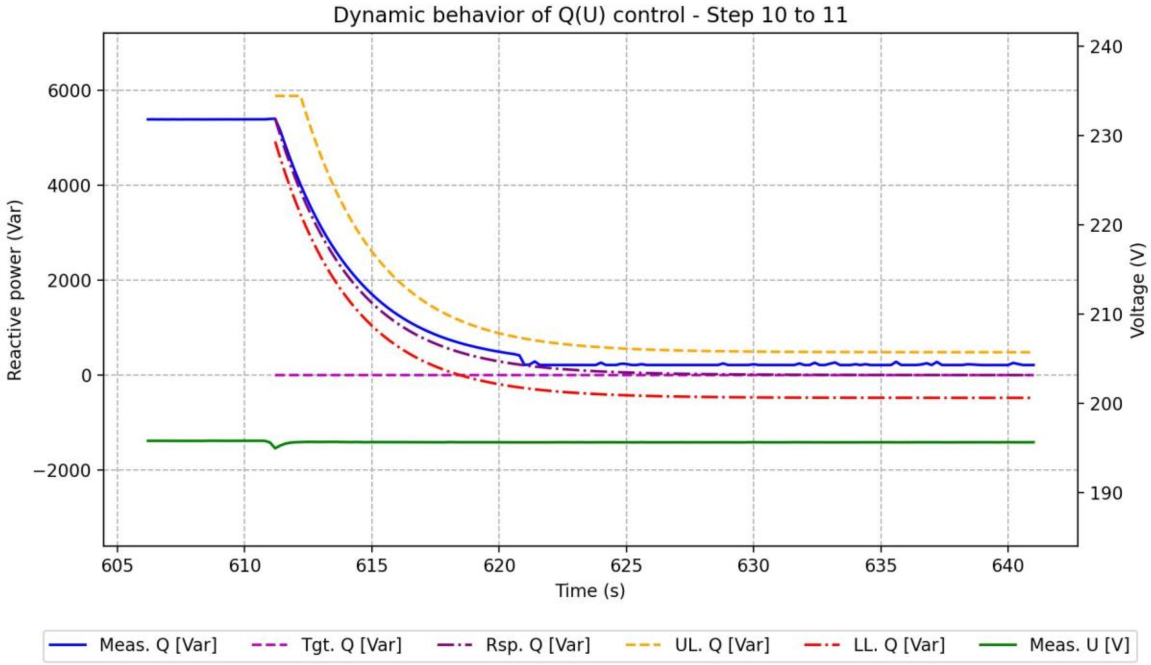

Dynamic behavior of Q(U) control - Step 6 to 7
Reactive power (Var)
2000
0
−2000
−4000
−6000
Voltage (V)
260
250
240
230
220
365
370
375
380
385
390
395
400
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]


Dynamic behavior of Q(U) control - Step 7 to 8
Reactive power (Var)
2000
0
−2000
−4000
−6000
Voltage (V)
260
250
240
230
220
425
430
435
440
445
450
455
460
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

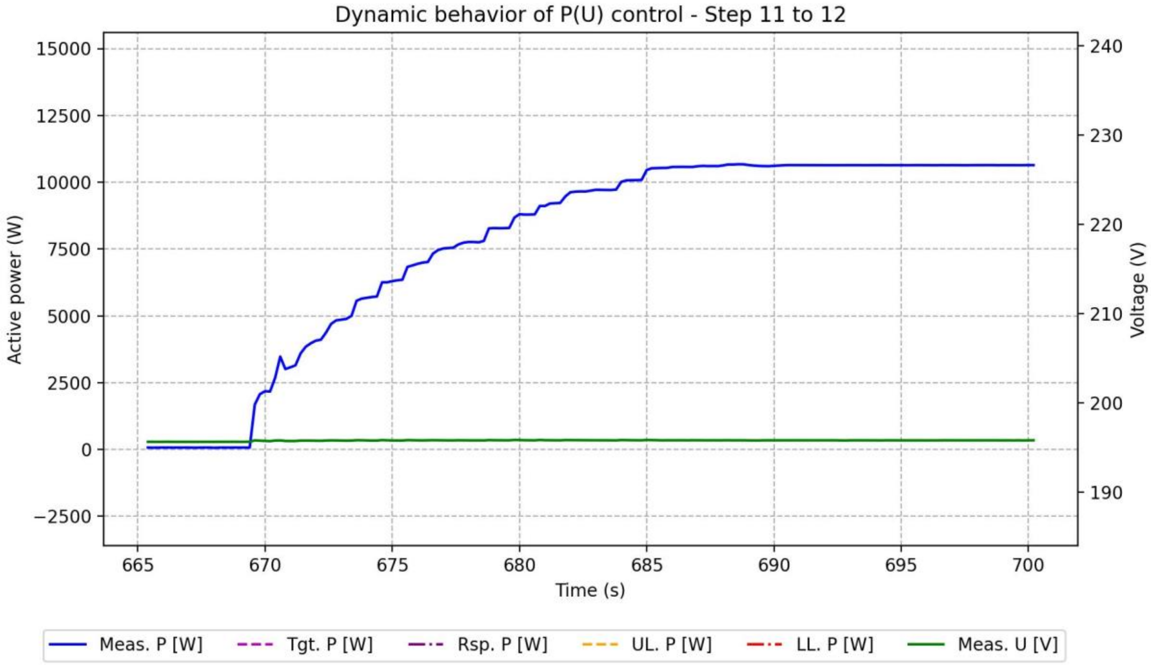

Dynamic behavior of Q(U) control - Step 8 to 9
Reactive power (Var)
6000
4000
2000
0
−2000
Voltage (V)
240
230
220
210
200
190
485
490
495
500
505
510
515
520
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

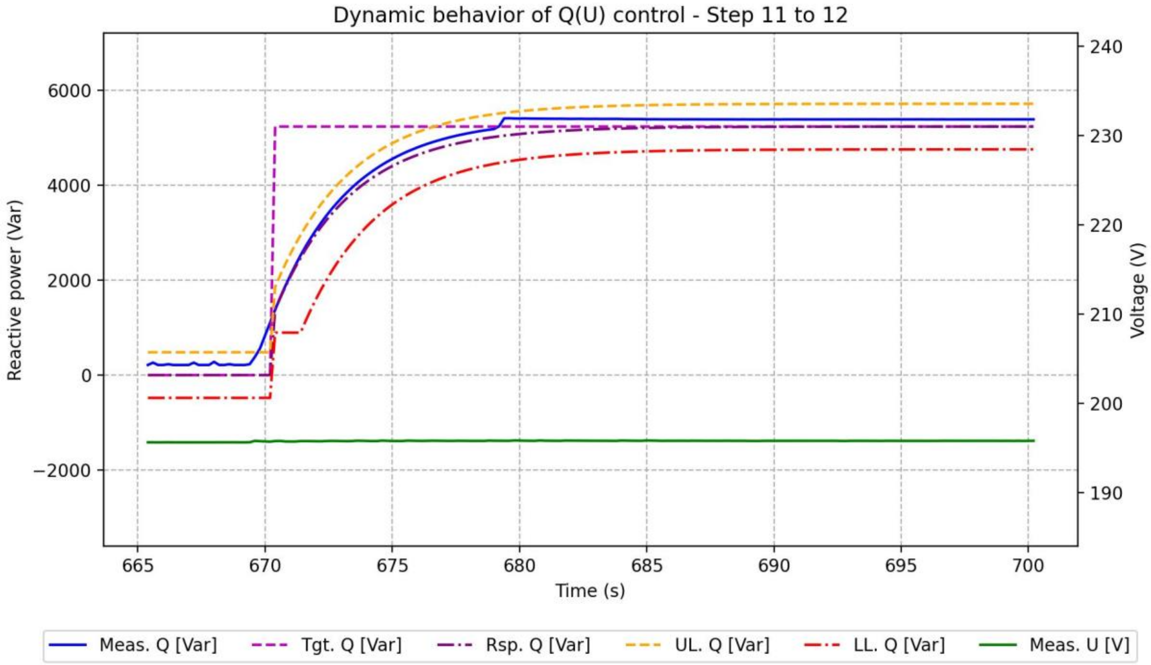

Dynamic behavior of Q(U) control - Step 9 to 10
Reactive power (Var)
6000
4000
2000
0
−2000
Voltage (V)
240
230
220
210
200
190
545
550
555
560
565
570
575
580
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]


Dynamic behavior of P(U) control - Step 10 to 11
Active power (W)
15000
12500
10000
7500
5000
2500
0
−2500
Voltage (V)
240
230
220
210
200
190
605
610
615
620
625
630
635
640
Time (s)
Meas. P [W]
Tgt. P [W]
Rsp. P [W]
UL. P [W]
LL. P [W]
Meas. U [V]

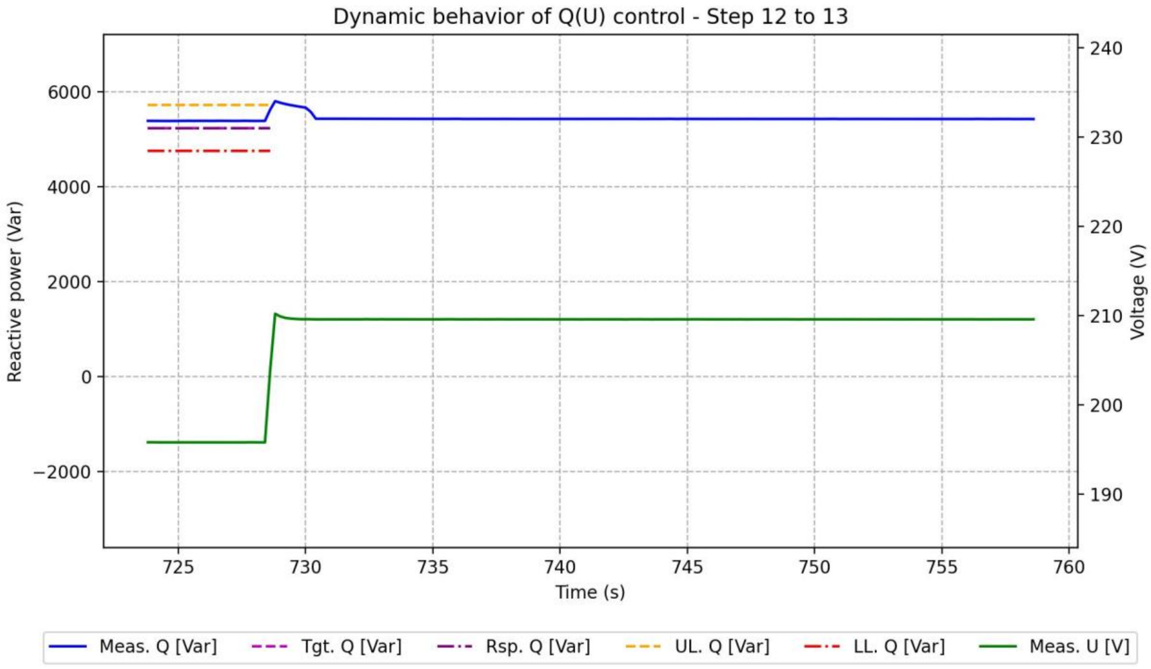

Dynamic behavior of Q(U) control - Step 10 to 11
Reactive power (Var)
6000
4000
2000
0
−2000
Voltage (V)
240
230
220
210
200
190
605
610
615
620
625
630
635
640
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

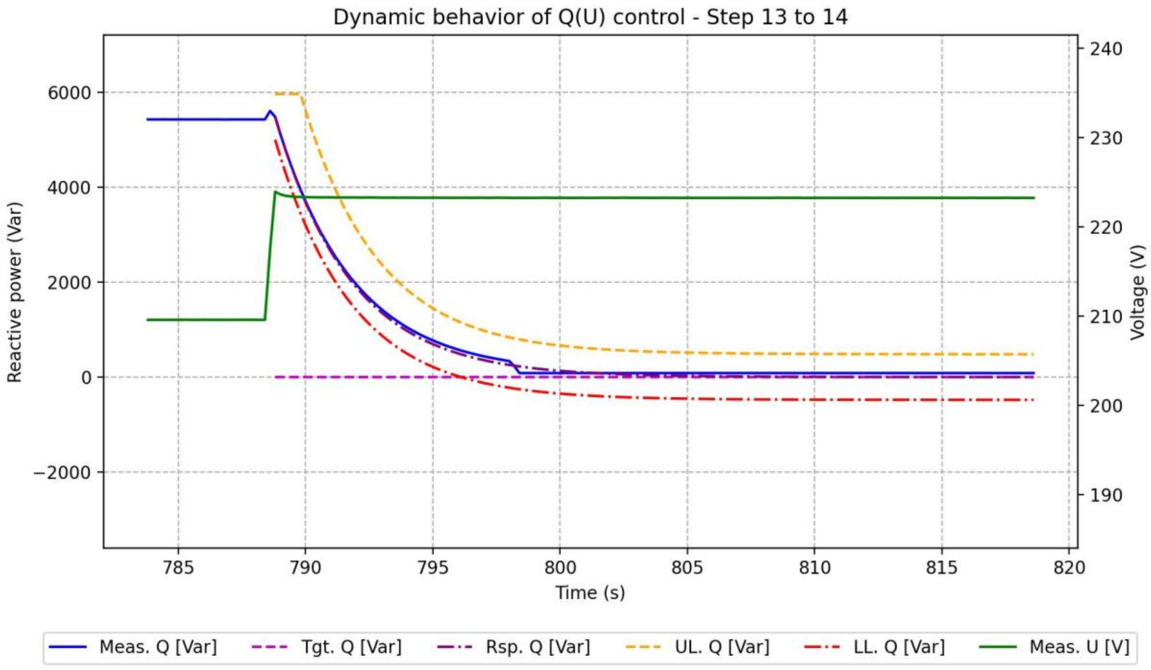
OVE-Richtlinie R 25			
Clause	Requirement - Test	Result - Remark	Verdict

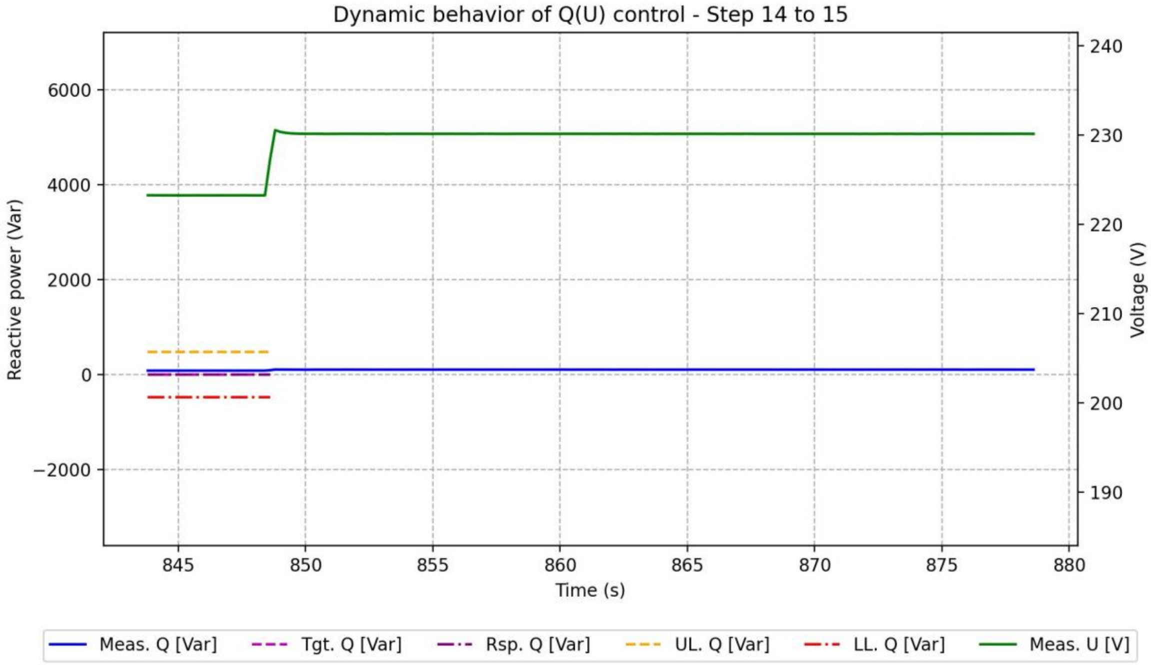




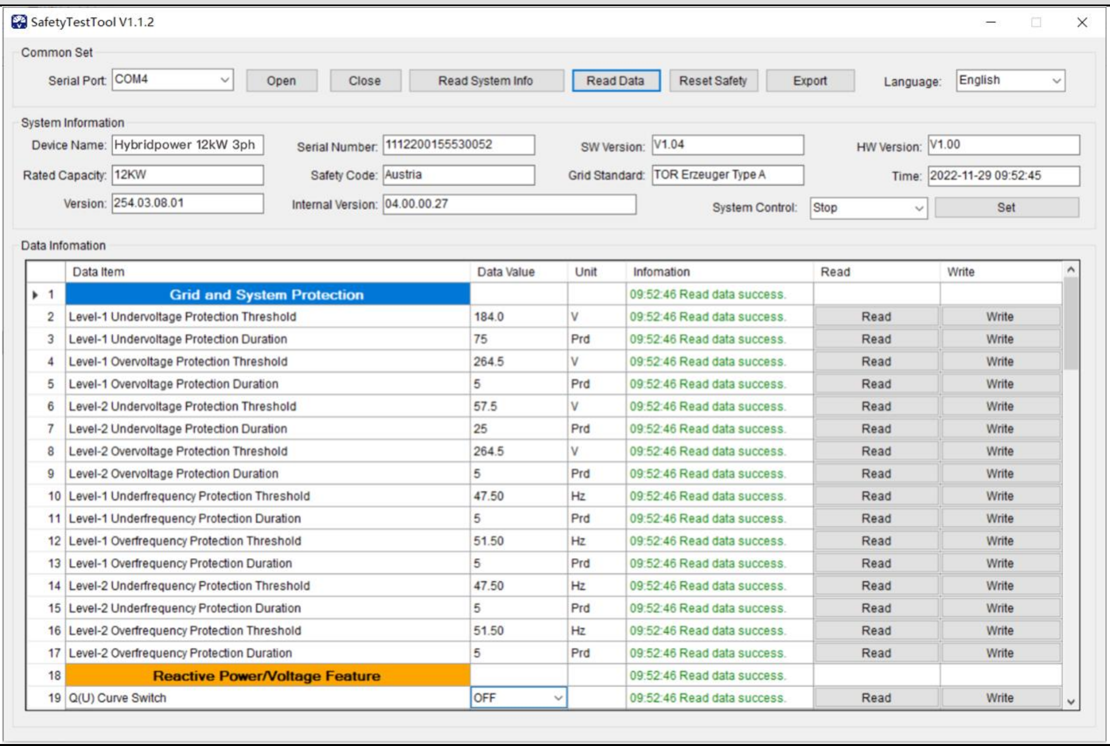
Clause	Requirement - Test	Result - Remark	Verdict






Dynamic behavior of Q(U) control - Step 14 to 15
Reactive power (Var)
6000
4000
2000
0
−2000
Voltage (V)
240
230
220
210
200
190
845
850
855
860
865
870
875
880
Time (s)
Meas. Q [Var]
Tgt. Q [Var]
Rsp. Q [Var]
UL. Q [Var]
LL. Q [Var]
Meas. U [V]

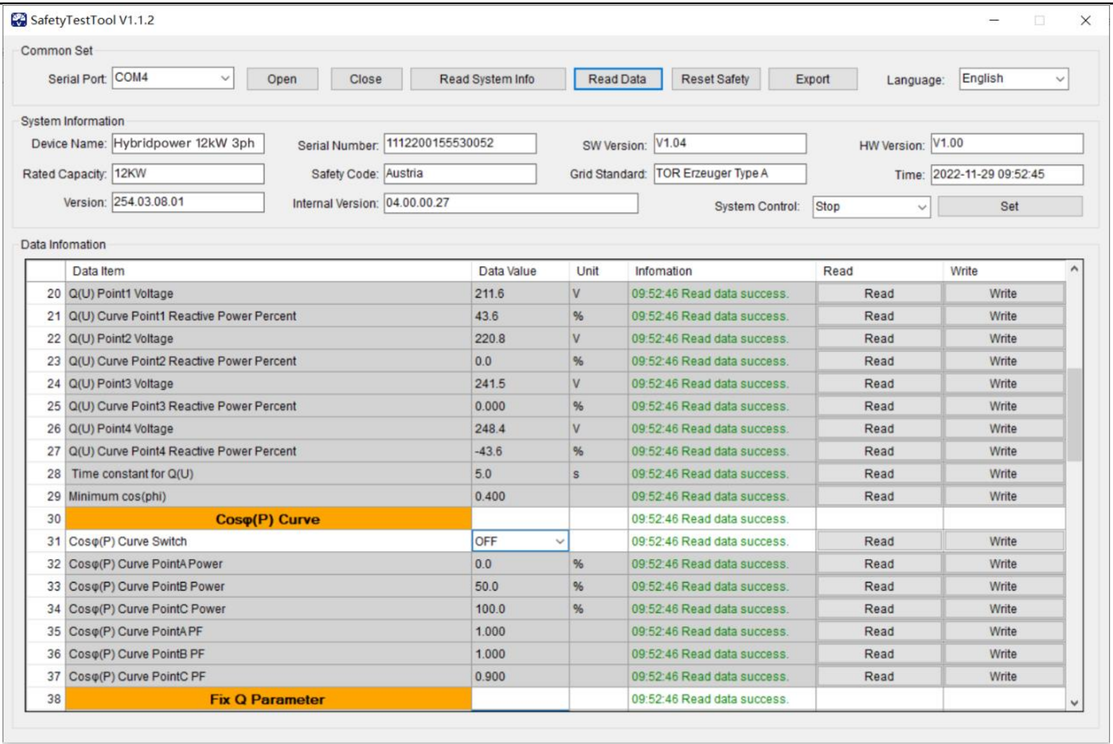
5.3.11 (6.2.3)	**TABLE: Protection of the settings as requested by the TOR generator**	**P**
Model	Hybridpower 12kW 3ph	
The corresponding parameters or settings cannot be changed by the user or by means of aids accessible by the user.		P
The parameters or settings are not changed by software updates.		P
Protection type: Password used.		P
Note: The test is passed if the corresponding parameters or settings cannot be changed by the user or by means of aids accessible by the user. This can be achieved, for example, by using suitable password protection. The password must not be accessible to the user. The test is passed if the parameters or settings are not changed by software updates.		
Parameters List print export from PC software tool about SW Version: **V1.04**		



Serial Port: COM4
Language: English

Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.04
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:52:45
Version: 254.03.08.01
Internal Version: 04.00.00.27
System Control: Stop

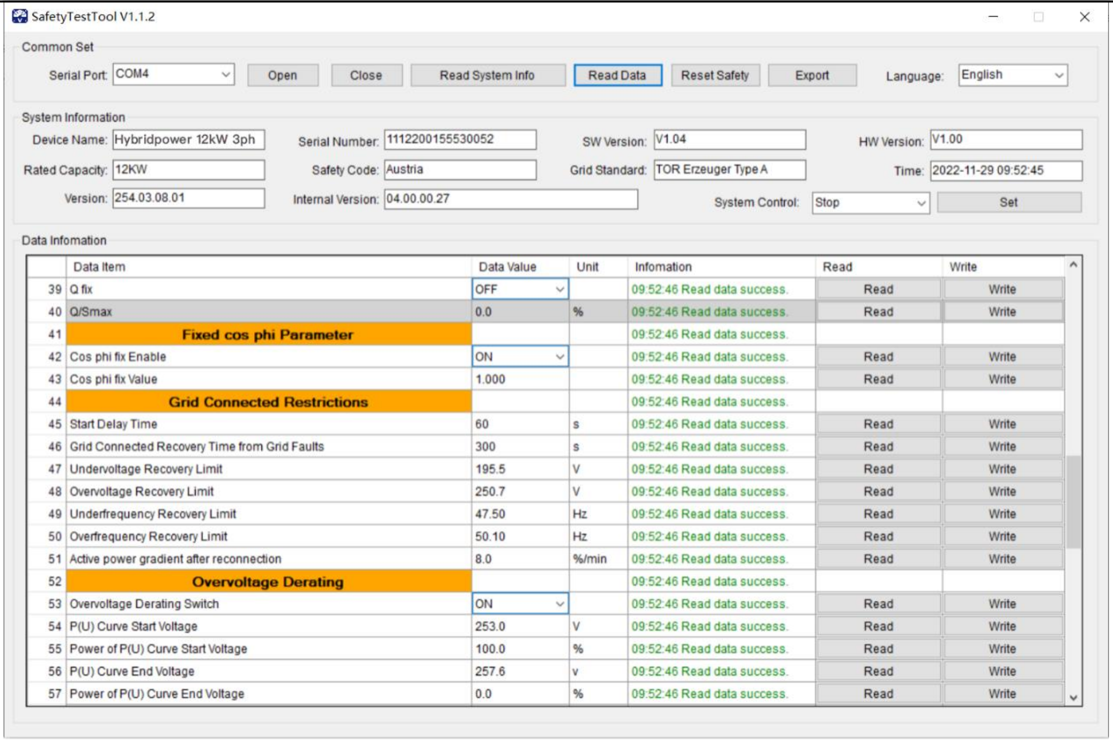
	Data Item	Data Value	Unit	Infomation	Read	Write
1	Grid and System Protection			09:52:46 Read data success.		
2	Level-1 Undervoltage Protection Threshold	184.0	V	09:52:46 Read data success.	Read	Write
3	Level-1 Undervoltage Protection Duration	75	Prd	09:52:46 Read data success.	Read	Write
4	Level-1 Overvoltage Protection Threshold	264.5	V	09:52:46 Read data success.	Read	Write
5	Level-1 Overvoltage Protection Duration	5	Prd	09:52:46 Read data success.	Read	Write
6	Level-2 Undervoltage Protection Threshold	57.5	V	09:52:46 Read data success.	Read	Write
7	Level-2 Undervoltage Protection Duration	25	Prd	09:52:46 Read data success.	Read	Write
8	Level-2 Overvoltage Protection Threshold	264.5	V	09:52:46 Read data success.	Read	Write
9	Level-2 Overvoltage Protection Duration	5	Prd	09:52:46 Read data success.	Read	Write
10	Level-1 Underfrequency Protection Threshold	47.50	Hz	09:52:46 Read data success.	Read	Write
11	Level-1 Underfrequency Protection Duration	5	Prd	09:52:46 Read data success.	Read	Write
12	Level-1 Overfrequency Protection Threshold	51.50	Hz	09:52:46 Read data success.	Read	Write
13	Level-1 Overfrequency Protection Duration	5	Prd	09:52:46 Read data success.	Read	Write
14	Level-2 Underfrequency Protection Threshold	47.50	Hz	09:52:46 Read data success.	Read	Write
15	Level-2 Underfrequency Protection Duration	5	Prd	09:52:46 Read data success.	Read	Write
16	Level-2 Overfrequency Protection Threshold	51.50	Hz	09:52:46 Read data success.	Read	Write
17	Level-2 Overfrequency Protection Duration	5	Prd	09:52:46 Read data success.	Read	Write
18	Reactive Power/Voltage Feature			09:52:46 Read data success.		
19	Q(U) Curve Switch	OFF		09:52:46 Read data success.	Read	Write



Serial Port: COM4
Language: English

Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.04
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:52:45
Version: 254.03.08.01
Internal Version: 04.00.00.27
System Control: Stop

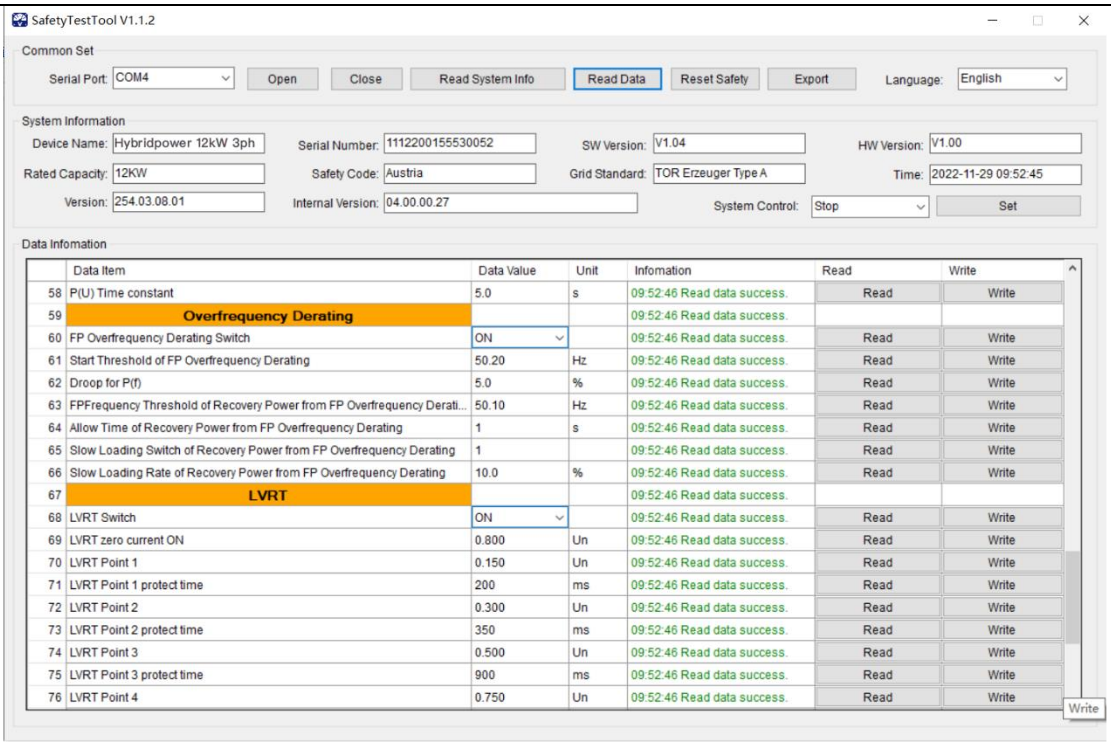
	Data Item	Data Value	Unit	Infomation	Read	Write
20	Q(U) Point1 Voltage	211.6	V	09:52:46 Read data success.	Read	Write
21	Q(U) Curve Point1 Reactive Power Percent	43.6	%	09:52:46 Read data success.	Read	Write
22	Q(U) Point2 Voltage	220.8	V	09:52:46 Read data success.	Read	Write
23	Q(U) Curve Point2 Reactive Power Percent	0.0	%	09:52:46 Read data success.	Read	Write
24	Q(U) Point3 Voltage	241.5	V	09:52:46 Read data success.	Read	Write
25	Q(U) Curve Point3 Reactive Power Percent	0.000	%	09:52:46 Read data success.	Read	Write
26	Q(U) Point4 Voltage	248.4	V	09:52:46 Read data success.	Read	Write
27	Q(U) Curve Point4 Reactive Power Percent	-43.6	%	09:52:46 Read data success.	Read	Write
28	Time constant for Q(U)	5.0	s	09:52:46 Read data success.	Read	Write
29	Minimum cos(phi)	0.400		09:52:46 Read data success.	Read	Write
30	**Cosφ(P) Curve**			09:52:46 Read data success.		
31	Cosφ(P) Curve Switch	OFF		09:52:46 Read data success.	Read	Write
32	Cosφ(P) Curve PointA Power	0.0	%	09:52:46 Read data success.	Read	Write
33	Cosφ(P) Curve PointB Power	50.0	%	09:52:46 Read data success.	Read	Write
34	Cosφ(P) Curve PointC Power	100.0	%	09:52:46 Read data success.	Read	Write
35	Cosφ(P) Curve PointA PF	1.000		09:52:46 Read data success.	Read	Write
36	Cosφ(P) Curve PointB PF	1.000		09:52:46 Read data success.	Read	Write
37	Cosφ(P) Curve PointC PF	0.900		09:52:46 Read data success.	Read	Write
38	**Fix Q Parameter**			09:52:46 Read data success.		



Serial Port: COM4
Language: English

Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.04
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:52:45
Version: 254.03.08.01
Internal Version: 04.00.00.27
System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
39	Q fix	OFF		09:52:46 Read data success.	Read	Write
40	Q/Smax	0.0	%	09:52:46 Read data success.	Read	Write
41	**Fixed cos phi Parameter**			09:52:46 Read data success.		
42	Cos phi fix Enable	ON		09:52:46 Read data success.	Read	Write
43	Cos phi fix Value	1.000		09:52:46 Read data success.	Read	Write
44	**Grid Connected Restrictions**			09:52:46 Read data success.		
45	Start Delay Time	60	s	09:52:46 Read data success.	Read	Write
46	Grid Connected Recovery Time from Grid Faults	300	s	09:52:46 Read data success.	Read	Write
47	Undervoltage Recovery Limit	195.5	V	09:52:46 Read data success.	Read	Write
48	Overvoltage Recovery Limit	250.7	V	09:52:46 Read data success.	Read	Write
49	Underfrequency Recovery Limit	47.50	Hz	09:52:46 Read data success.	Read	Write
50	Overfrequency Recovery Limit	50.10	Hz	09:52:46 Read data success.	Read	Write
51	Active power gradient after reconnection	8.0	%/min	09:52:46 Read data success.	Read	Write
52	**Overvoltage Derating**			09:52:46 Read data success.		
53	Overvoltage Derating Switch	ON		09:52:46 Read data success.	Read	Write
54	P(U) Curve Start Voltage	253.0	V	09:52:46 Read data success.	Read	Write
55	Power of P(U) Curve Start Voltage	100.0	%	09:52:46 Read data success.	Read	Write
56	P(U) Curve End Voltage	257.6	v	09:52:46 Read data success.	Read	Write
57	Power of P(U) Curve End Voltage	0.0	%	09:52:46 Read data success.	Read	Write



Serial Port: COM4

Language: English

Device Name: Hybridpower 12kW 3ph

Serial Number: 1112200155530052

SW Version: V1.04

HW Version: V1.00

Rated Capacity: 12KW

Safety Code: Austria

Grid Standard: TOR Erzeuger Type A

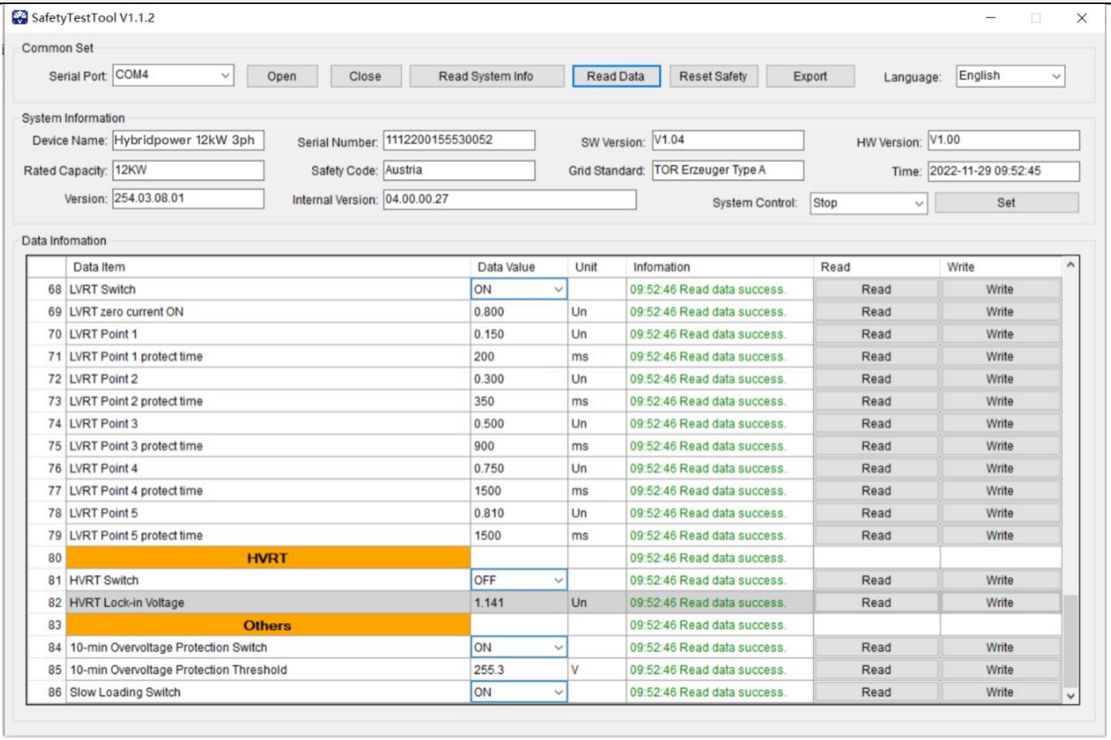
Time: 2022-11-29 09:52:45

Version: 254.03.08.01

Internal Version: 04.00.00.27

System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
58	P(U) Time constant	5.0	s	09:52:46 Read data success.	Read	Write
59	**Overfrequency Derating**			09:52:46 Read data success.		
60	FP Overfrequency Derating Switch	ON		09:52:46 Read data success.	Read	Write
61	Start Threshold of FP Overfrequency Derating	50.20	Hz	09:52:46 Read data success.	Read	Write
62	Droop for P(f)	5.0	%	09:52:46 Read data success.	Read	Write
63	FPFrequency Threshold of Recovery Power from FP Overfrequency Derati...	50.10	Hz	09:52:46 Read data success.	Read	Write
64	Allow Time of Recovery Power from FP Overfrequency Derating	1	s	09:52:46 Read data success.	Read	Write
65	Slow Loading Switch of Recovery Power from FP Overfrequency Derating	1		09:52:46 Read data success.	Read	Write
66	Slow Loading Rate of Recovery Power from FP Overfrequency Derating	10.0	%	09:52:46 Read data success.	Read	Write
67	**LVRT**			09:52:46 Read data success.		
68	LVRT Switch	ON		09:52:46 Read data success.	Read	Write
69	LVRT zero current ON	0.800	Un	09:52:46 Read data success.	Read	Write
70	LVRT Point 1	0.150	Un	09:52:46 Read data success.	Read	Write
71	LVRT Point 1 protect time	200	ms	09:52:46 Read data success.	Read	Write
72	LVRT Point 2	0.300	Un	09:52:46 Read data success.	Read	Write
73	LVRT Point 2 protect time	350	ms	09:52:46 Read data success.	Read	Write
74	LVRT Point 3	0.500	Un	09:52:46 Read data success.	Read	Write
75	LVRT Point 3 protect time	900	ms	09:52:46 Read data success.	Read	Write
76	LVRT Point 4	0.750	Un	09:52:46 Read data success.	Read	Write



Serial Port: COM4

Language: English

Device Name: Hybridpower 12kW 3ph

Serial Number: 1112200155530052

SW Version: V1.04

HW Version: V1.00

Rated Capacity: 12KW

Safety Code: Austria

Grid Standard: TOR Erzeuger Type A

Time: 2022-11-29 09:52:45

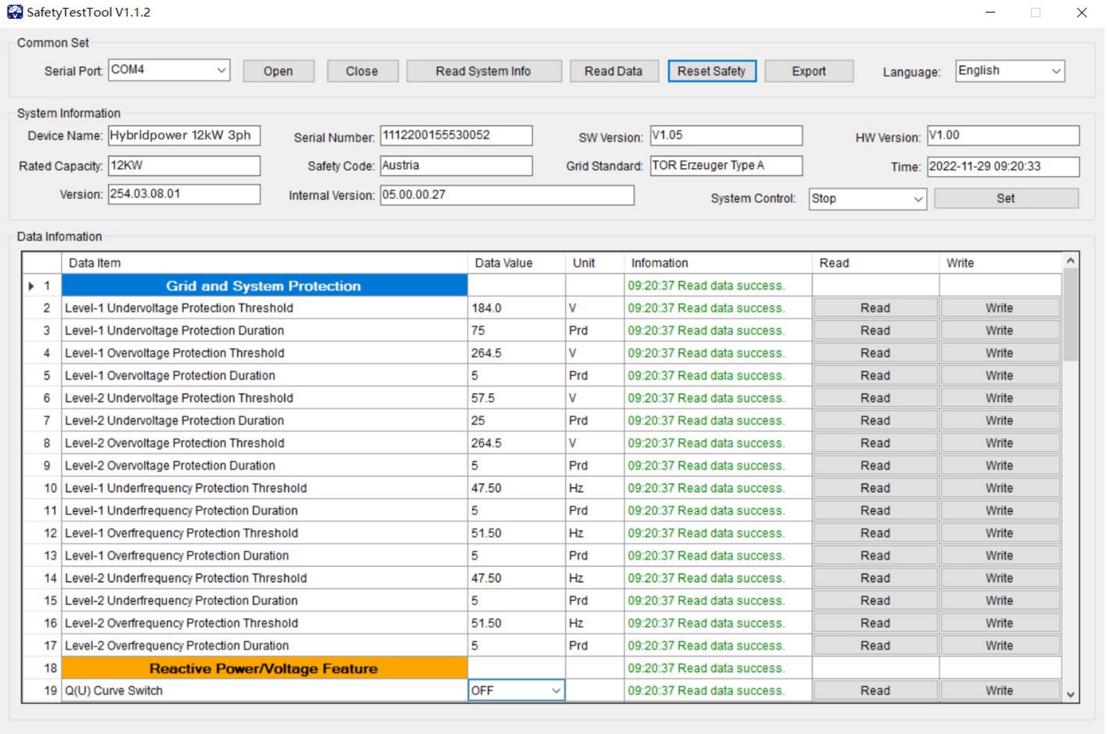
Version: 254.03.08.01

Internal Version: 04.00.00.27

System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
68	LVRT Switch	ON		09:52:46 Read data success.	Read	Write
69	LVRT zero current ON	0.800	Un	09:52:46 Read data success.	Read	Write
70	LVRT Point 1	0.150	Un	09:52:46 Read data success.	Read	Write
71	LVRT Point 1 protect time	200	ms	09:52:46 Read data success.	Read	Write
72	LVRT Point 2	0.300	Un	09:52:46 Read data success.	Read	Write
73	LVRT Point 2 protect time	350	ms	09:52:46 Read data success.	Read	Write
74	LVRT Point 3	0.500	Un	09:52:46 Read data success.	Read	Write
75	LVRT Point 3 protect time	900	ms	09:52:46 Read data success.	Read	Write
76	LVRT Point 4	0.750	Un	09:52:46 Read data success.	Read	Write
77	LVRT Point 4 protect time	1500	ms	09:52:46 Read data success.	Read	Write
78	LVRT Point 5	0.810	Un	09:52:46 Read data success.	Read	Write
79	LVRT Point 5 protect time	1500	ms	09:52:46 Read data success.	Read	Write
80	**HVRT**			09:52:46 Read data success.		
81	HVRT Switch	OFF		09:52:46 Read data success.	Read	Write
82	HVRT Lock-in Voltage	1.141	Un	09:52:46 Read data success.	Read	Write
83	**Others**			09:52:46 Read data success.		
84	10-min Overvoltage Protection Switch	ON		09:52:46 Read data success.	Read	Write
85	10-min Overvoltage Protection Threshold	255.3	V	09:52:46 Read data success.	Read	Write
86	Slow Loading Switch	ON		09:52:46 Read data success.	Read	Write

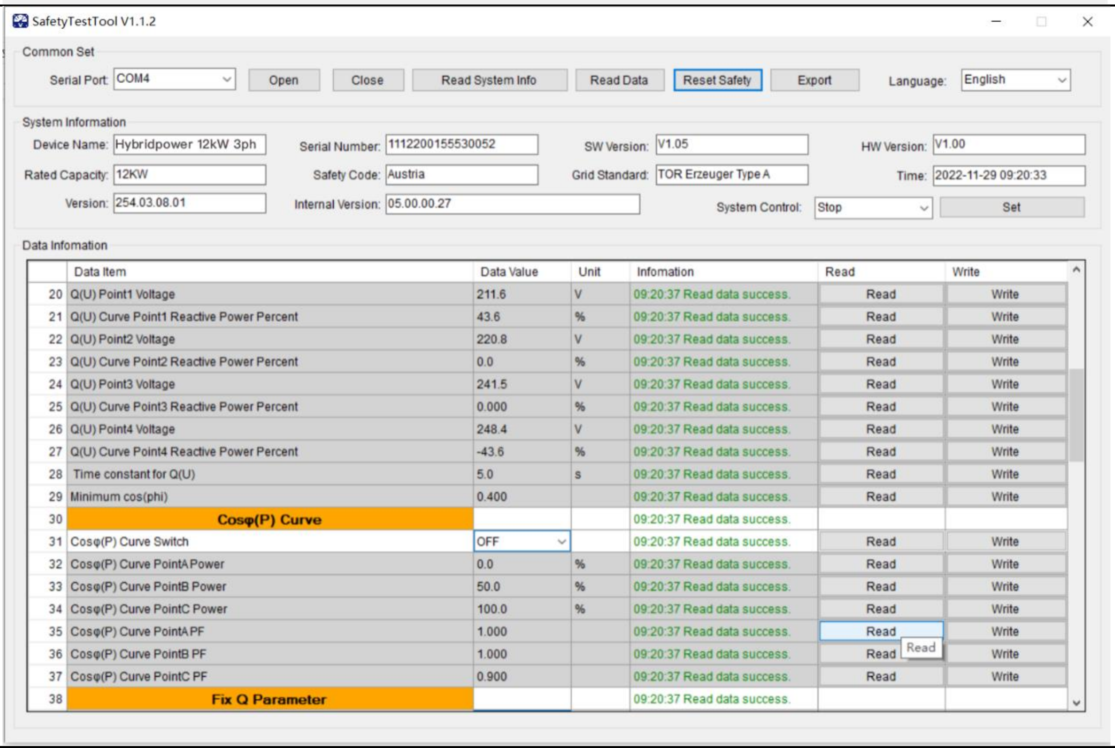
Parameters List print export from PC software tool about SW Version: **V1.05**



Serial Port: COM4
Language: English

Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.05
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:20:33
Version: 254.03.08.01
Internal Version: 05.00.00.27
System Control: Stop

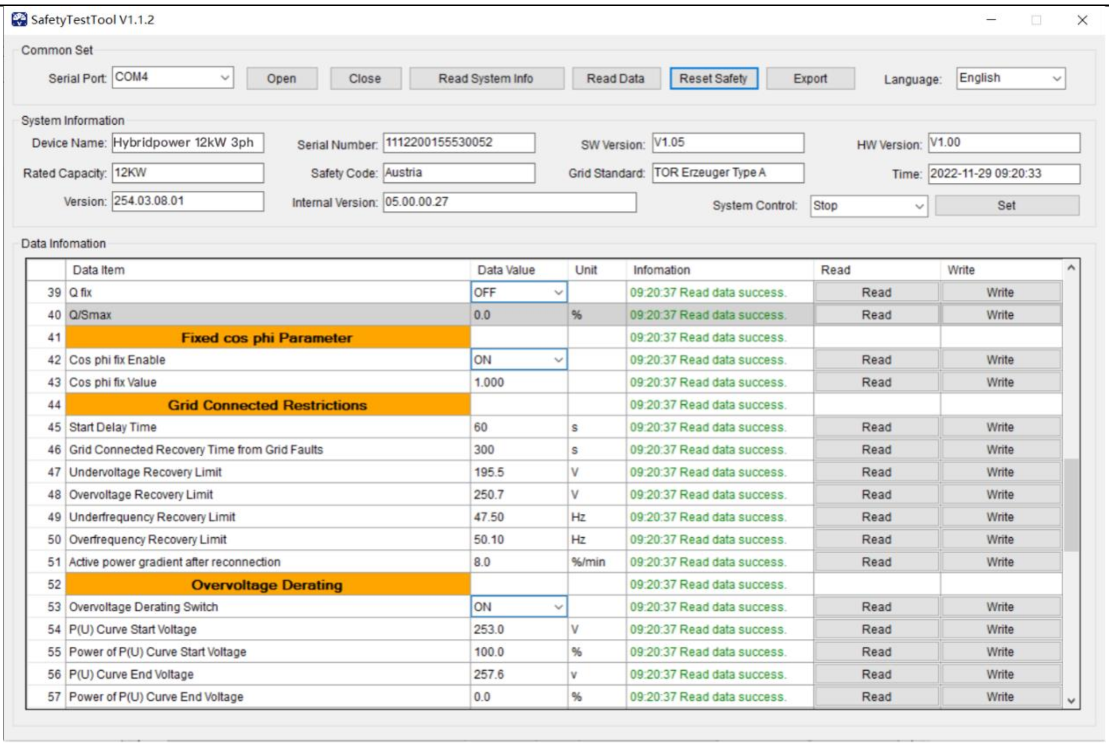
	Data Item	Data Value	Unit	Infomation	Read	Write
1	**Grid and System Protection**			09:20:37 Read data success.		
2	Level-1 Undervoltage Protection Threshold	184.0	V	09:20:37 Read data success.	Read	Write
3	Level-1 Undervoltage Protection Duration	75	Prd	09:20:37 Read data success.	Read	Write
4	Level-1 Overvoltage Protection Threshold	264.5	V	09:20:37 Read data success.	Read	Write
5	Level-1 Overvoltage Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
6	Level-2 Undervoltage Protection Threshold	57.5	V	09:20:37 Read data success.	Read	Write
7	Level-2 Undervoltage Protection Duration	25	Prd	09:20:37 Read data success.	Read	Write
8	Level-2 Overvoltage Protection Threshold	264.5	V	09:20:37 Read data success.	Read	Write
9	Level-2 Overvoltage Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
10	Level-1 Underfrequency Protection Threshold	47.50	Hz	09:20:37 Read data success.	Read	Write
11	Level-1 Underfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
12	Level-1 Overfrequency Protection Threshold	51.50	Hz	09:20:37 Read data success.	Read	Write
13	Level-1 Overfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
14	Level-2 Underfrequency Protection Threshold	47.50	Hz	09:20:37 Read data success.	Read	Write
15	Level-2 Underfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
16	Level-2 Overfrequency Protection Threshold	51.50	Hz	09:20:37 Read data success.	Read	Write
17	Level-2 Overfrequency Protection Duration	5	Prd	09:20:37 Read data success.	Read	Write
18	**Reactive Power/Voltage Feature**			09:20:37 Read data success.		
19	Q(U) Curve Switch	OFF		09:20:37 Read data success.	Read	Write



Serial Port: COM4
Language: English

Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.05
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:20:33
Version: 254.03.08.01
Internal Version: 05.00.00.27
System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
20	Q(U) Point1 Voltage	211.6	V	09:20:37 Read data success.	Read	Write
21	Q(U) Curve Point1 Reactive Power Percent	43.6	%	09:20:37 Read data success.	Read	Write
22	Q(U) Point2 Voltage	220.8	V	09:20:37 Read data success.	Read	Write
23	Q(U) Curve Point2 Reactive Power Percent	0.0	%	09:20:37 Read data success.	Read	Write
24	Q(U) Point3 Voltage	241.5	V	09:20:37 Read data success.	Read	Write
25	Q(U) Curve Point3 Reactive Power Percent	0.000	%	09:20:37 Read data success.	Read	Write
26	Q(U) Point4 Voltage	248.4	V	09:20:37 Read data success.	Read	Write
27	Q(U) Curve Point4 Reactive Power Percent	-43.6	%	09:20:37 Read data success.	Read	Write
28	Time constant for Q(U)	5.0	s	09:20:37 Read data success.	Read	Write
29	Minimum cos(phi)	0.400		09:20:37 Read data success.	Read	Write
30	**Cosφ(P) Curve**			09:20:37 Read data success.		
31	Cosφ(P) Curve Switch	OFF		09:20:37 Read data success.	Read	Write
32	Cosφ(P) Curve PointA Power	0.0	%	09:20:37 Read data success.	Read	Write
33	Cosφ(P) Curve PointB Power	50.0	%	09:20:37 Read data success.	Read	Write
34	Cosφ(P) Curve PointC Power	100.0	%	09:20:37 Read data success.	Read	Write
35	Cosφ(P) Curve PointA PF	1.000		09:20:37 Read data success.	Read	Write
36	Cosφ(P) Curve PointB PF	1.000		09:20:37 Read data success.	Read	Write
37	Cosφ(P) Curve PointC PF	0.900		09:20:37 Read data success.	Read	Write
38	**Fix Q Parameter**			09:20:37 Read data success.		



Serial Port: COM4

Language: English

Device Name: Hybridpower 12kW 3ph

Serial Number: 1112200155530052

SW Version: V1.05

HW Version: V1.00

Rated Capacity: 12KW

Safety Code: Austria

Grid Standard: TOR Erzeuger Type A

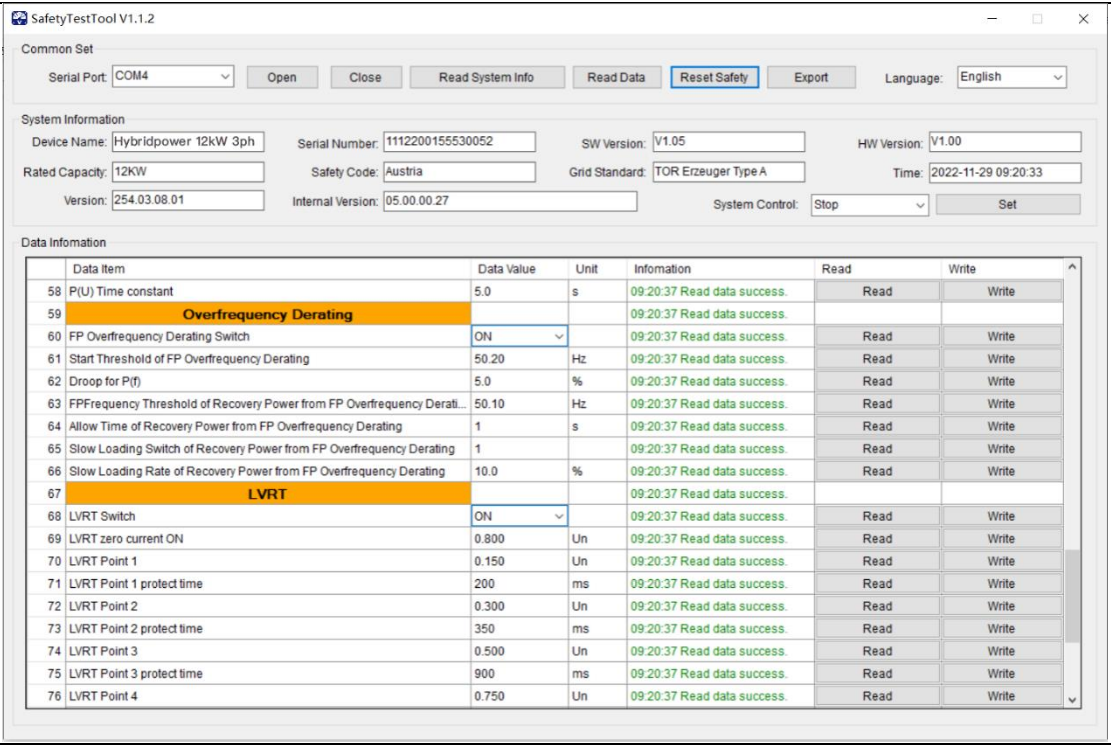
Time: 2022-11-29 09:20:33

Version: 254.03.08.01

Internal Version: 05.00.00.27

System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
39	Q fix	OFF		09:20:37 Read data success.	Read	Write
40	Q/Smax	0.0	%	09:20:37 Read data success.	Read	Write
41	**Fixed cos phi Parameter**			09:20:37 Read data success.		
42	Cos phi fix Enable	ON		09:20:37 Read data success.	Read	Write
43	Cos phi fix Value	1.000		09:20:37 Read data success.	Read	Write
44	**Grid Connected Restrictions**			09:20:37 Read data success.		
45	Start Delay Time	60	s	09:20:37 Read data success.	Read	Write
46	Grid Connected Recovery Time from Grid Faults	300	s	09:20:37 Read data success.	Read	Write
47	Undervoltage Recovery Limit	195.5	V	09:20:37 Read data success.	Read	Write
48	Overvoltage Recovery Limit	250.7	V	09:20:37 Read data success.	Read	Write
49	Underfrequency Recovery Limit	47.50	Hz	09:20:37 Read data success.	Read	Write
50	Overfrequency Recovery Limit	50.10	Hz	09:20:37 Read data success.	Read	Write
51	Active power gradient after reconnection	8.0	%/min	09:20:37 Read data success.	Read	Write
52	**Overvoltage Derating**			09:20:37 Read data success.		
53	Overvoltage Derating Switch	ON		09:20:37 Read data success.	Read	Write
54	P(U) Curve Start Voltage	253.0	V	09:20:37 Read data success.	Read	Write
55	Power of P(U) Curve Start Voltage	100.0	%	09:20:37 Read data success.	Read	Write
56	P(U) Curve End Voltage	257.6	v	09:20:37 Read data success.	Read	Write
57	Power of P(U) Curve End Voltage	0.0	%	09:20:37 Read data success.	Read	Write



Serial Port: COM4

Language: English

Device Name: Hybridpower 12kW 3ph

Serial Number: 1112200155530052

SW Version: V1.05

HW Version: V1.00

Rated Capacity: 12KW

Safety Code: Austria

Grid Standard: TOR Erzeuger Type A

Time: 2022-11-29 09:20:33

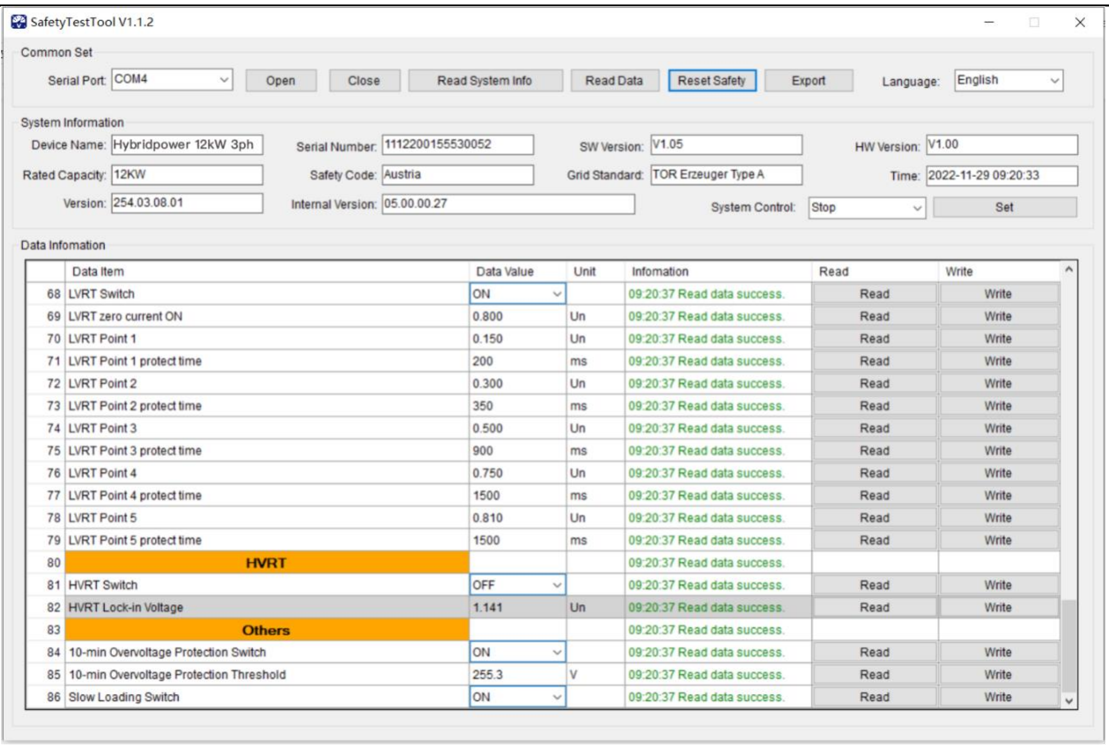
Version: 254.03.08.01

Internal Version: 05.00.00.27

System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
58	P(U) Time constant	5.0	s	09:20:37 Read data success.	Read	Write
59	**Overfrequency Derating**			09:20:37 Read data success.		
60	FP Overfrequency Derating Switch	ON		09:20:37 Read data success.	Read	Write
61	Start Threshold of FP Overfrequency Derating	50.20	Hz	09:20:37 Read data success.	Read	Write
62	Droop for P(f)	5.0	%	09:20:37 Read data success.	Read	Write
63	FPFrequency Threshold of Recovery Power from FP Overfrequency Derati...	50.10	Hz	09:20:37 Read data success.	Read	Write
64	Allow Time of Recovery Power from FP Overfrequency Derating	1	s	09:20:37 Read data success.	Read	Write
65	Slow Loading Switch of Recovery Power from FP Overfrequency Derating	1		09:20:37 Read data success.	Read	Write
66	Slow Loading Rate of Recovery Power from FP Overfrequency Derating	10.0	%	09:20:37 Read data success.	Read	Write
67	**LVRT**			09:20:37 Read data success.		
68	LVRT Switch	ON		09:20:37 Read data success.	Read	Write
69	LVRT zero current ON	0.800	Un	09:20:37 Read data success.	Read	Write
70	LVRT Point 1	0.150	Un	09:20:37 Read data success.	Read	Write
71	LVRT Point 1 protect time	200	ms	09:20:37 Read data success.	Read	Write
72	LVRT Point 2	0.300	Un	09:20:37 Read data success.	Read	Write
73	LVRT Point 2 protect time	350	ms	09:20:37 Read data success.	Read	Write
74	LVRT Point 3	0.500	Un	09:20:37 Read data success.	Read	Write
75	LVRT Point 3 protect time	900	ms	09:20:37 Read data success.	Read	Write
76	LVRT Point 4	0.750	Un	09:20:37 Read data success.	Read	Write

Clause	Requirement - Test	Result - Remark	Verdict



Serial Port: COM4
Language: English

Device Name: Hybridpower 12kW 3ph
Serial Number: 1112200155530052
SW Version: V1.05
HW Version: V1.00
Rated Capacity: 12KW
Safety Code: Austria
Grid Standard: TOR Erzeuger Type A
Time: 2022-11-29 09:20:33
Version: 254.03.08.01
Internal Version: 05.00.00.27
System Control: Stop

	Data Item	Data Value	Unit	Infomation	Read	Write
68	LVRT Switch	ON		09:20:37 Read data success.	Read	Write
69	LVRT zero current ON	0.800	Un	09:20:37 Read data success.	Read	Write
70	LVRT Point 1	0.150	Un	09:20:37 Read data success.	Read	Write
71	LVRT Point 1 protect time	200	ms	09:20:37 Read data success.	Read	Write
72	LVRT Point 2	0.300	Un	09:20:37 Read data success.	Read	Write
73	LVRT Point 2 protect time	350	ms	09:20:37 Read data success.	Read	Write
74	LVRT Point 3	0.500	Un	09:20:37 Read data success.	Read	Write
75	LVRT Point 3 protect time	900	ms	09:20:37 Read data success.	Read	Write
76	LVRT Point 4	0.750	Un	09:20:37 Read data success.	Read	Write
77	LVRT Point 4 protect time	1500	ms	09:20:37 Read data success.	Read	Write
78	LVRT Point 5	0.810	Un	09:20:37 Read data success.	Read	Write
79	LVRT Point 5 protect time	1500	ms	09:20:37 Read data success.	Read	Write
80	**HVRT**			09:20:37 Read data success.		
81	HVRT Switch	OFF		09:20:37 Read data success.	Read	Write
82	HVRT Lock-in Voltage	1.141	Un	09:20:37 Read data success.	Read	Write
83	**Others**			09:20:37 Read data success.		
84	10-min Overvoltage Protection Switch	ON		09:20:37 Read data success.	Read	Write
85	10-min Overvoltage Protection Threshold	255.3	V	09:20:37 Read data success.	Read	Write
86	Slow Loading Switch	ON		09:20:37 Read data success.	Read	Write

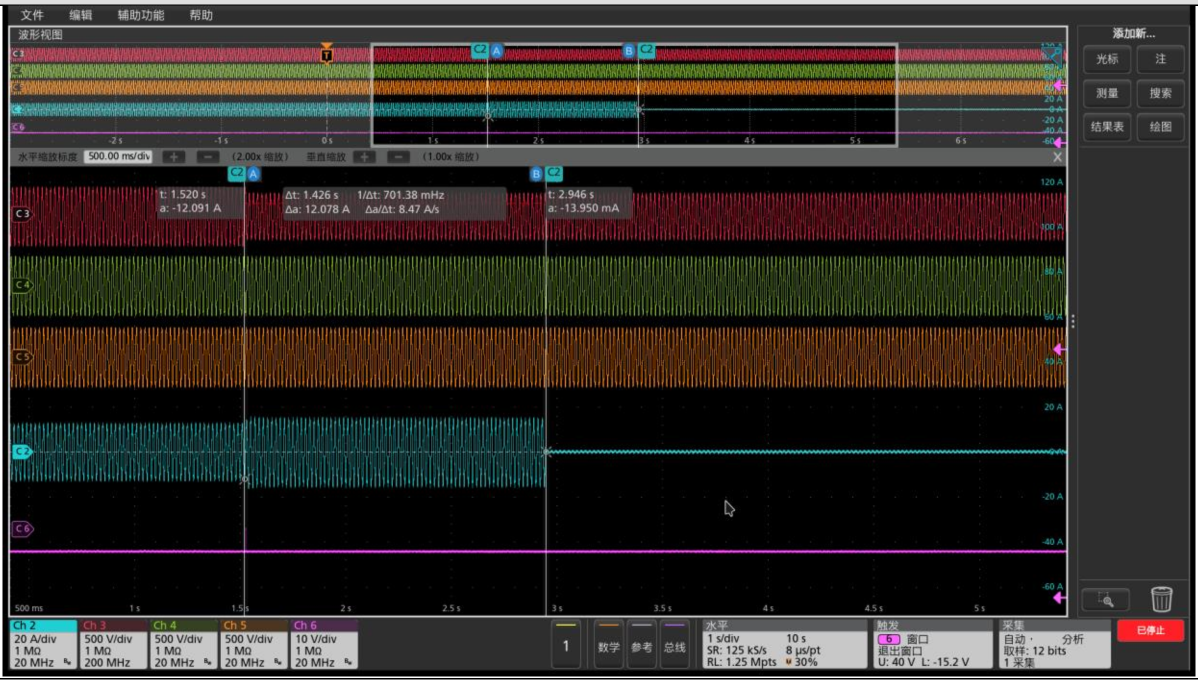
Password used for Parameters and Country settings
 
Note: The selection of Austria parameters and country setting can only be completed in the factory or authorised person by password, the user cannot change the country setting.

5.4.1.1.1 (6.1.2 & 6.3.3.1)	**TABLE: Voltage protection devices**					**P**
Model	Hybridpower 12kW 3ph					
Test condition:	Output level: 50 ± 5% of its rated current output Frequency: 50 Hz					
Phase	Thresholds Limit [V]	Internal setting of thresholds [V]	Measured trip value [V]	Internal setting of disconnection time [s]	Measured disconnection time [s]	Trip Time Limit [s]
L1	0.8 U_n (U_{eff} <)	184	184.8	1.5 s	1.411	1.4 - 1.6
			184.2		1.423	
			184.3		1.426	
	0.25 U_n (U_{eff} <<)	57.5	57.0	0.5 s	0.516	0.4 - 0.6
			57.3		0.514	
			57.2		0.518	
	1.15 U_n (U_{eff} >>)	264.5	264.4	0.1 s	0.095	≤ 0.2
			264.5		0.093	
			264.4		0.086	

Note:
The test of overvoltage protection U_{eff} >> and undervoltage protection U_{eff} <and U_{eff} << is considered passed if the determined voltages that lead to a shutdown are within a tolerance band of ± 1% U_n around the setting values and if the determined tripping delay is within ± 100 ms of the set trigger delay.

The LVRT function is switch on when the voltage protection test is performed.

Voltage protection @ 0.8 U_n – L1 Phase



t: 1.520 s
a: -12.091 A

Δt: 1.426 s 1/Δt: 701.38 mHz
Δa: 12.078 A Δa/Δt: 8.47 A/s

t: 2.946 s
a: -13.950 mA

水平缩放标度 500.00 ms/div (2.00x 缩放) 垂直缩放 (1.00x 缩放)

Ch 2 20 A/div 1 MΩ 20 MHz
Ch 3 500 V/div 1 MΩ 200 MHz
Ch 4 500 V/div 1 MΩ 20 MHz
Ch 5 500 V/div 1 MΩ 20 MHz
Ch 6 10 V/div 1 MΩ 20 MHz

水平 1 s/div 10 s SR: 125 kS/s 8 µs/pt RL: 1.25 Mpts 30%
触发 6 窗口 退出窗口 U: 40 V L: -15.2 V
采集 自动 分析 取样: 12 bits 1 采集

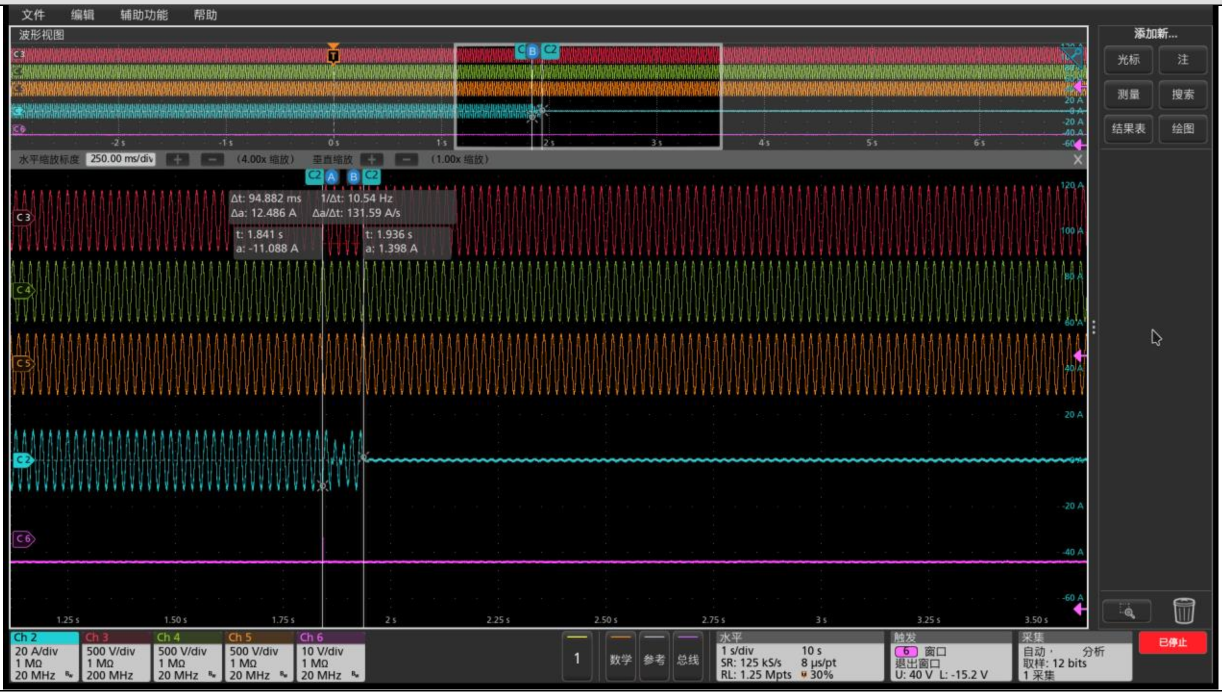
Voltage protection @ 0.25 U_n – L1 Phase

t: 21.602 s
Δt: 518.221 ms
1/Δt: 1.93 Hz
t: 22.120 s

Meas 1 RMS μ': 175.5 V
Meas 2 RMS μ': 229.2 V
Meas 3 RMS μ': 230.6 V
Meas 5 Maximum μ': 17.00 A
Meas 6 Minimum μ': -9.271 A
Meas 7 AC RMS μ': 5.646 A
Meas 8 Frequency μ': 10.58 kHz Low amplitude

Ch 1 500 V/div 1 MΩ 350 MHz
Ch 2 500 V/div 1 MΩ 350 MHz
Ch 3 500 V/div 1 MΩ 350 MHz
Ch 4 19 A/div 1 MΩ 20 MHz
水平 4 s/div 40 s SR: 31.25 kS/s 32 μs/pt RL: 1.25 Mpts 0%
触发 -2.76 kV
采集 自动 分析 取样: 12 bits 1 采集
已停止 14 Nov 2022 5:28:00 PM

Voltage protection @ 1.15 U_n – L1 Phase



Δt: 94.882 ms 1/Δt: 10.54 Hz
Δa: 12.486 A Δa/Δt: 131.59 A/s
t: 1.841 s a: -11.088 A
t: 1.936 s a: 1.398 A

Ch 2 20 A/div 1 MΩ 20 MHz
Ch 3 500 V/div 1 MΩ 200 MHz
Ch 4 500 V/div 1 MΩ 20 MHz
Ch 5 500 V/div 1 MΩ 20 MHz
Ch 6 10 V/div 1 MΩ 20 MHz
水平 1 s/div 10 s SR: 125 kS/s 8 μs/pt RL: 1.25 Mpts 30%
触发 6 窗口 退出窗口 U: 40 V L: -15.2 V
采集 自动 分析 取样: 12 bits 1 采集
已停止

5.4.1.1.1 (6.1.2 & 6.3.3.1)	**TABLE: Voltage protection devices**					**P**
Model	Hybridpower 12kW 3ph					
Test condition:	Output level: 50 ± 5% of its rated current output Frequency: 50 Hz					
Phase	Thresholds Limit [V]	Internal setting of thresholds [V]	Measured trip value [V]	Internal setting of disconnection time [s]	Measured disconnection time [s]	Trip Time Limit [s]
L2	0.8 U_n (U_{eff} <)	184	184.1	1.5 s	1.417	1.4 - 1.6
			184.3		1.408	
			184.1		1.429	
	0.25 U_n (U_{eff} <<)	57.5	57.5	0.5 s	0.517	0.4 - 0.6
			57.3		0.516	
			57.3		0.510	
	1.15 U_n (U_{eff} >>)	264.5	263.9	0.1 s	0.086	≤ 0.2
			263.6		0.092	
			264.0		0.088	

Note:
The test of overvoltage protection U_{eff} >> and undervoltage protection U_{eff} <and U_{eff} << is considered passed if the determined voltages that lead to a shutdown are within a tolerance band of ± 1% U_n around the setting values and if the determined tripping delay is within ± 100 ms of the set trigger delay.

The LVRT function is switch on when the voltage protection test is performed.

Voltage protection @ 0.8 U_n – L2 Phase


t: 2.150 s
a: 7.871 A

Δt: 1.429 s 1/Δt: 699.93 mHz
Δa: 7.552 A Δa/Δt: 5.29 A/s

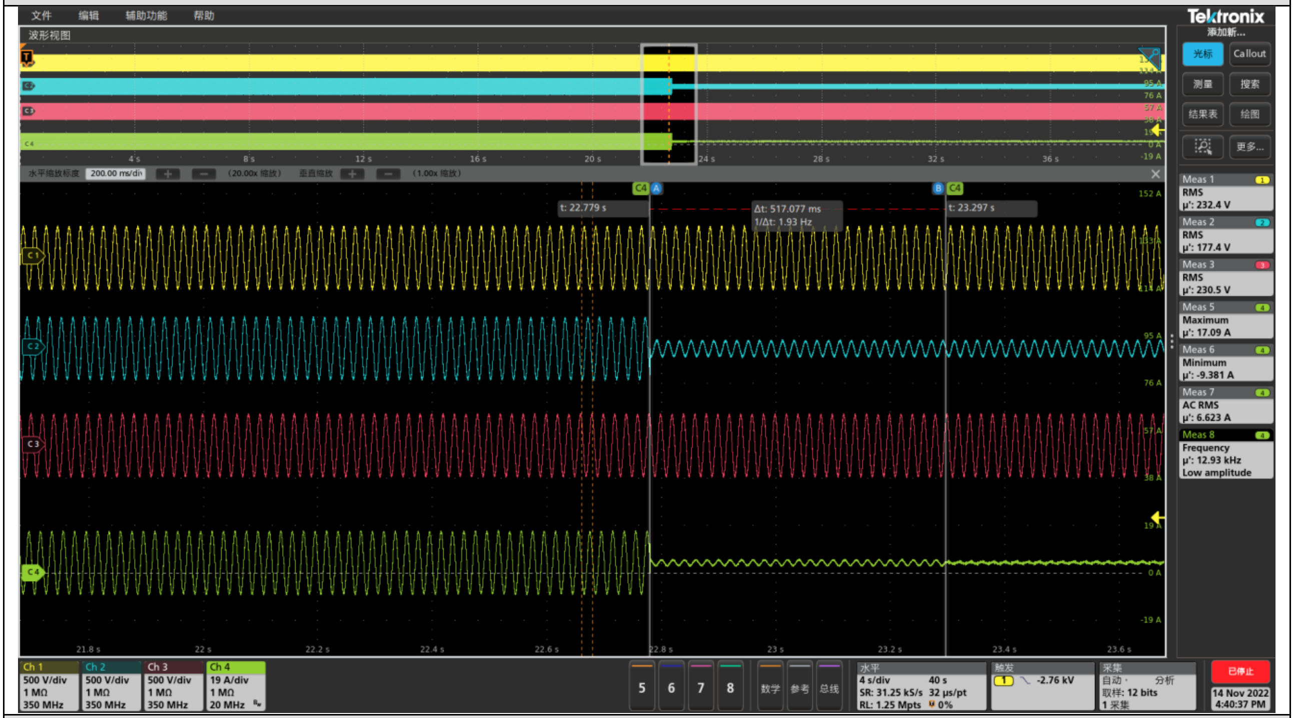
t: 3.578 s
a: 319.315 mA

水平缩放标度 500.00 ms/div （2.00x 缩放） 垂直缩放 （1.00x 缩放）

Ch 2 20 A/div 1 MΩ 20 MHz
Ch 3 500 V/div 1 MΩ 200 MHz
Ch 4 500 V/div 1 MΩ 20 MHz
Ch 5 500 V/div 1 MΩ 20 MHz
Ch 6 10 V/div 1 MΩ 20 MHz

水平 1 s/div 10 s SR: 125 kS/s 8 µs/pt RL: 1.25 Mpts 30%
触发 6 窗口 退出窗口 U: 40 V L: -15.2 V
采集 自动 · 分析 取样: 12 bits 1 采集

Voltage protection @ 0.25 U_n – L2 Phase



t: 22.779 s
Δt: 517.077 ms
1/Δt: 1.93 Hz
t: 23.297 s

Meas 1
RMS
μ': 232.4 V

Meas 2
RMS
μ': 177.4 V

Meas 3
RMS
μ': 230.5 V

Meas 5
Maximum
μ': 17.09 A

Meas 6
Minimum
μ': -9.381 A

Meas 7
AC RMS
μ': 6.623 A

Meas 8
Frequency
μ': 12.93 kHz
Low amplitude

Ch 1
500 V/div
1 MΩ
350 MHz

Ch 2
500 V/div
1 MΩ
350 MHz

Ch 3
500 V/div
1 MΩ
350 MHz

Ch 4
19 A/div
1 MΩ
20 MHz

水平
4 s/div 40 s
SR: 31.25 kS/s 32 μs/pt
RL: 1.25 Mpts 0%

触发
1 -2.76 kV

采集
自动 · 分析
取样: 12 bits
1 采集

14 Nov 2022
4:40:37 PM

Voltage protection @ 1.15 U_n – L2 Phase

Δt: 91.941 ms 1/Δt: 10.88 Hz
Δa: 8.618 A Δa/Δt: 93.74 A/s
t: 1.717 s
a: 8.386 A
t: 1.809 s
a: -231.672 mA

Ch 2
20 A/div
1 MΩ
20 MHz

Ch 3
500 V/div
1 MΩ
200 MHz

Ch 4
500 V/div
1 MΩ
20 MHz

Ch 5
500 V/div
1 MΩ
20 MHz

Ch 6
10 V/div
1 MΩ
20 MHz

水平
1 s/div 10 s
SR: 125 kS/s 8 μs/pt
RL: 1.25 Mpts 30%

触发
6 窗口
退出窗口
U: 40 V L: -15.2 V

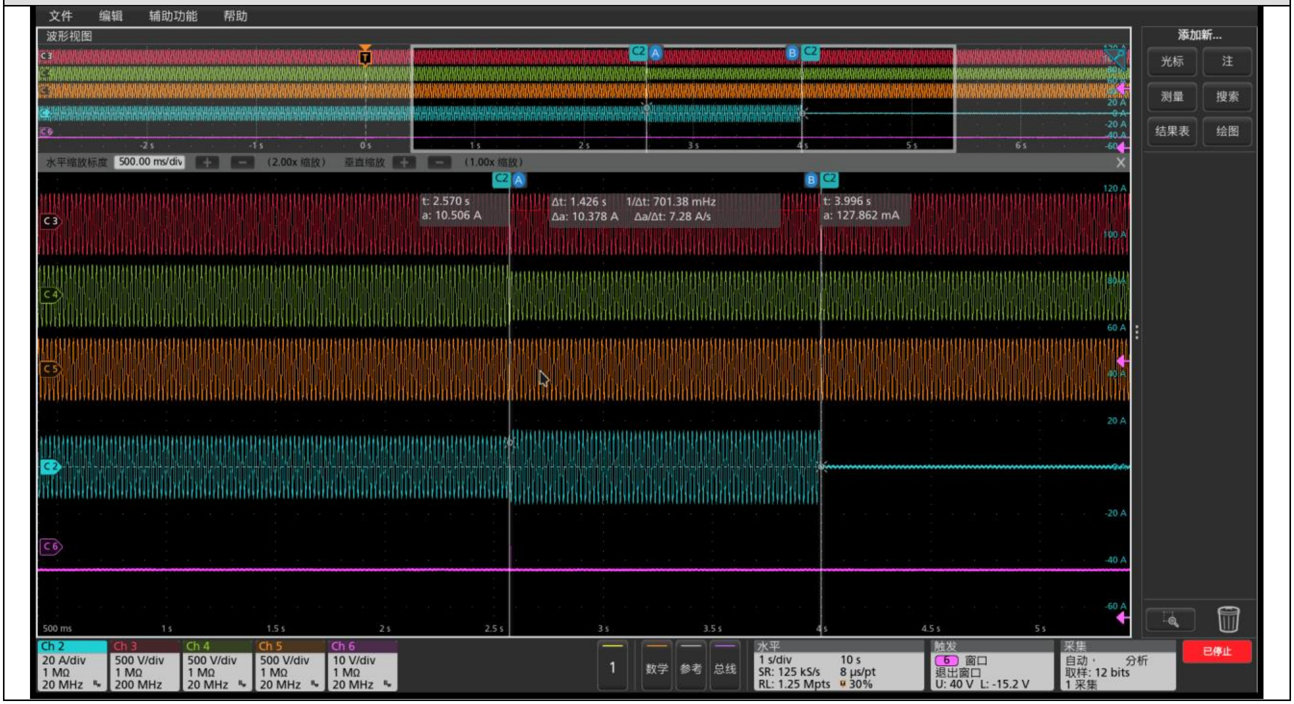
采集
自动 · 分析
取样: 12 bits
1 采集

5.4.1.1.1 (6.1.2 & 6.3.3.1)	**TABLE: Voltage protection devices**					**P**
Model	Hybridpower 12kW 3ph					
Test condition:	Output level: 50 ± 5% of its rated current output Frequency: 50 Hz					
Phase	Thresholds Limit [V]	Internal setting of thresholds [V]	Measured trip value [V]	Internal setting of disconnection time [s]	Measured disconnection time [s]	Trip Time Limit [s]
L3	0.8 U_n (U_{eff} <)	184	184.3	1.5 s	1.423	1.4 - 1.6
			184.1		1.426	
			184.3		1.435	
	0.25 U_n (U_{eff} <<)	57.5	56.3	0.5 s	0.509	0.4 - 0.6
			55.9		0.519	
			55.8		0.512	
	1.15 U_n (U_{eff} >>)	264.5	264.9	0.1 s	0.082	≤ 0.2
			264.9		0.086	
			265.0		0.074	

Note:
The test of overvoltage protection U_{eff} >> and undervoltage protection U_{eff} <and U_{eff} << is considered passed if the determined voltages that lead to a shutdown are within a tolerance band of ± 1% U_n around the setting values and if the determined tripping delay is within ± 100 ms of the set trigger delay.

The LVRT function is switch on when the voltage protection test is performed.

Voltage protection @ 0.8 U_n – L3 Phase



t: 2.570 s
a: 10.506 A

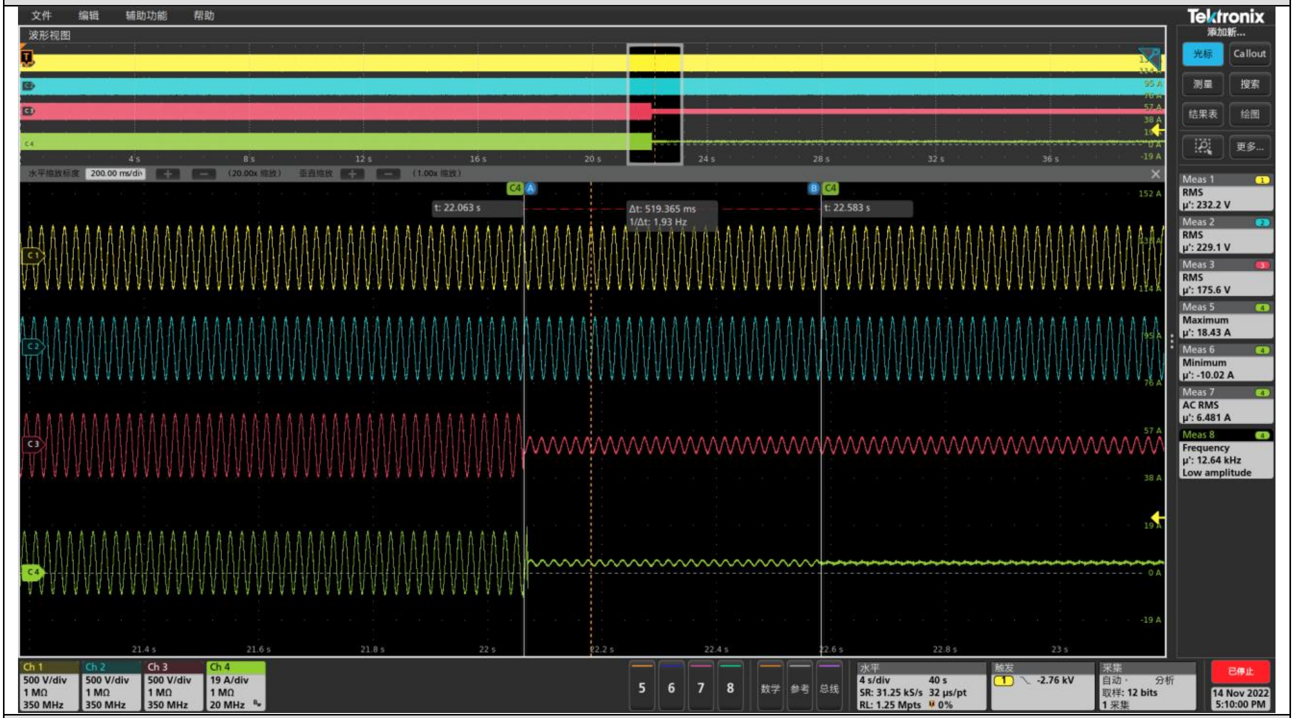
Δt: 1.426 s 1/Δt: 701.38 mHz
Δa: 10.378 A Δa/Δt: 7.28 A/s

t: 3.996 s
a: 127.862 mA

Ch 2: 20 A/div, 1 MΩ, 20 MHz
Ch 3: 500 V/div, 1 MΩ, 200 MHz
Ch 4: 500 V/div, 1 MΩ, 20 MHz
Ch 5: 500 V/div, 1 MΩ, 20 MHz
Ch 6: 10 V/div, 1 MΩ, 20 MHz

水平: 1 s/div 10 s, SR: 125 kS/s 8 μs/pt, RL: 1.25 Mpts 30%
触发: 6 窗口, 退出窗口, U: 40 V L: -15.2 V
采集: 自动 · 分析, 取样: 12 bits, 1 采集

Voltage protection @ 0.25 U_n – L3 Phase



t: 22.063 s

Δt: 519.365 ms
1/Δt: 1.93 Hz

t: 22.583 s

Meas 1
RMS
μ': 232.2 V

Meas 2
RMS
μ': 229.1 V

Meas 3
RMS
μ': 175.6 V

Meas 5
Maximum
μ': 18.43 A

Meas 6
Minimum
μ': -10.02 A

Meas 7
AC RMS
μ': 6.481 A

Meas 8
Frequency
μ': 12.64 kHz
Low amplitude

Ch 1
500 V/div
1 MΩ
350 MHz

Ch 2
500 V/div
1 MΩ
350 MHz

Ch 3
500 V/div
1 MΩ
350 MHz

Ch 4
19 A/div
1 MΩ
20 MHz

水平
4 s/div 40 s
SR: 31.25 kS/s 32 μs/pt
RL: 1.25 Mpts 0%

触发
1 -2.76 kV

采集
自动， 分析
取样: 12 bits
1 采集

14 Nov 2022
5:10:00 PM

Voltage protection @ 1.15 U_n – L3 Phase

Δt: 86.059 ms 1/Δt: 11.62 Hz
Δa: 1.479 A Δa/Δt: 17.19 A/s

t: 5.207 s
a: 1.730 A

t: 5.293 s
a: 250.457 mA

Ch 2
20 A/div
1 MΩ
20 MHz

Ch 3
500 V/div
1 MΩ
200 MHz

Ch 4
500 V/div
1 MΩ
20 MHz

Ch 5
500 V/div
1 MΩ
20 MHz

Ch 6
10 V/div
1 MΩ
20 MHz

水平
1 s/div 10 s
SR: 125 kS/s 8 μs/pt
RL: 1.25 Mpts 30%

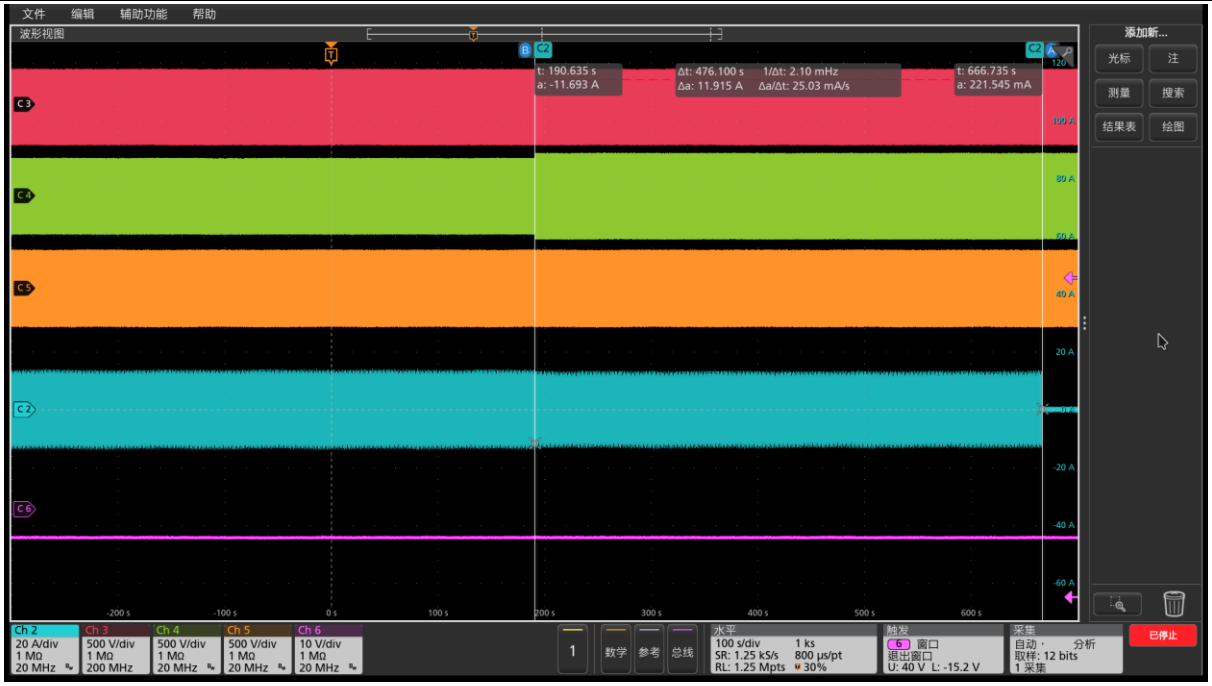
触发
6 窗口
退出窗口
U: 40 V L: -15.2 V

采集
自动， 分析
取样: 12 bits
1 采集

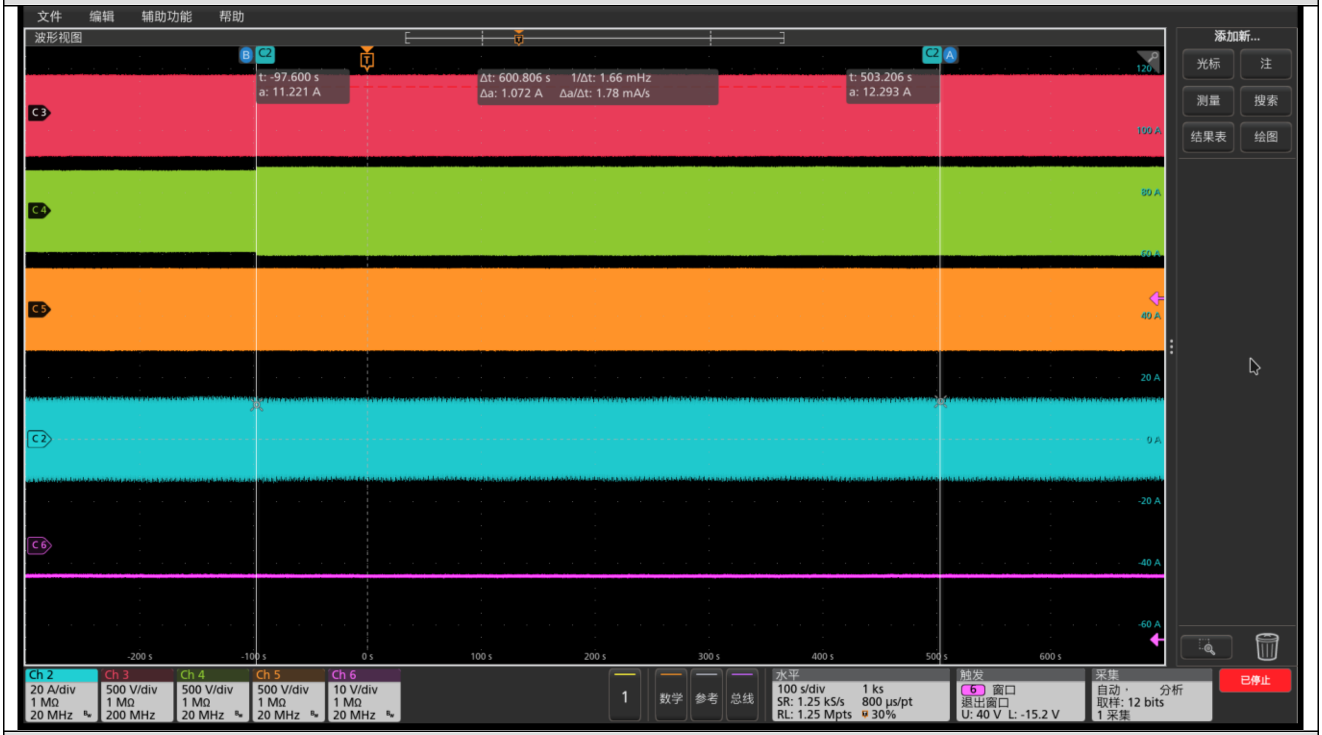
5.4.1.1.2 (6.1.2 & 6.3.3.1)	**TABLE: Testing the overvoltage protection U_{eff} > with monitoring of the moving 10-minute average**		P
Model	Hybridpower 12kW 3ph		
Test condition:		Disconnection time (s):	Limit:
a)	The voltage is set to 100% U_n and held for 600 s. Thereafter the voltage is set to 113% U_n. Disconnection must take place within 600 s.		
	Phase 1	469.0	≤ 600 s
	Phase 2	463.8	
	Phase 3	476.1	
b)	The voltage is set to U_n for 600 s and then to 109% U_n for 600 s. No disconnection should take place.		
	Phase 1	No disconnection	Disconnection should not take place.
	Phase 2	No disconnection	
	Phase 3	No disconnection	
c)	The voltage is set to 107% U_n and held for 600 s. Thereafter the voltage is set to 115% U_n. Disconnection must take place within 300 s or about 50% of the disconnection time measured in point a).*		
	Phase 1	276.0	The disconnection time should be about 50% of the value measured in a).
	Phase 2	283.1	
	Phase 3	292.5	

Note:
The switch-off time for test c) can vary due to limit deviations in the voltage measurement accuracy. A switch-off time between 225 s and 375 s after the voltage jump at time t is within the permitted limit deviation (± 1% U_n) (see OVE-guideline R 25 Figure 22, measurement c).

Test: a) 100 % U_n to 113%U_n



Test: b) 100% U_n to 109%U_n



t: -97.600 s
a: 11.221 A

Δt: 600.806 s 1/Δt: 1.66 mHz
Δa: 1.072 A Δa/Δt: 1.78 mA/s

t: 503.206 s
a: 12.293 A

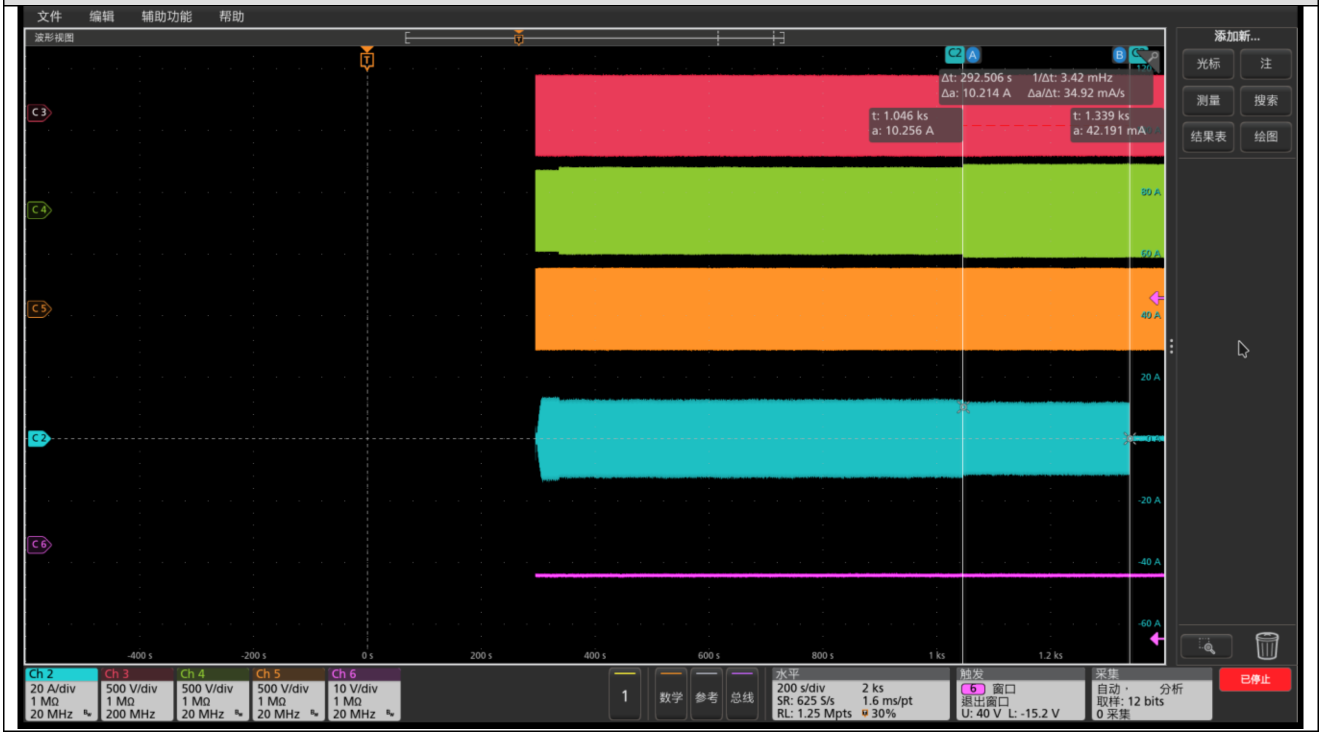
Ch 2	Ch 3	Ch 4	Ch 5	Ch 6
20 A/div 1 MΩ 20 MHz	500 V/div 1 MΩ 200 MHz	500 V/div 1 MΩ 20 MHz	500 V/div 1 MΩ 20 MHz	10 V/div 1 MΩ 20 MHz

水平
100 s/div 1 ks
SR: 1.25 kS/s 800 µs/pt
RL: 1.25 Mpts 30%

触发
6 窗口
退出窗口
U: 40 V L: -15.2 V

采集
自动 · 分析
取样: 12 bits
1 采集

Test: c) 107%U_n to 115%U_n



Δt: 292.506 s 1/Δt: 3.42 mHz
Δa: 10.214 A Δa/Δt: 34.92 mA/s

t: 1.046 ks
a: 10.256 A

t: 1.339 ks
a: 42.191 mA

Ch 2	Ch 3	Ch 4	Ch 5	Ch 6
20 A/div 1 MΩ 20 MHz	500 V/div 1 MΩ 200 MHz	500 V/div 1 MΩ 20 MHz	500 V/div 1 MΩ 20 MHz	10 V/div 1 MΩ 20 MHz

水平
200 s/div 2 ks
SR: 625 S/s 1.6 ms/pt
RL: 1.25 Mpts 30%

触发
6 窗口
退出窗口
U: 40 V L: -15.2 V

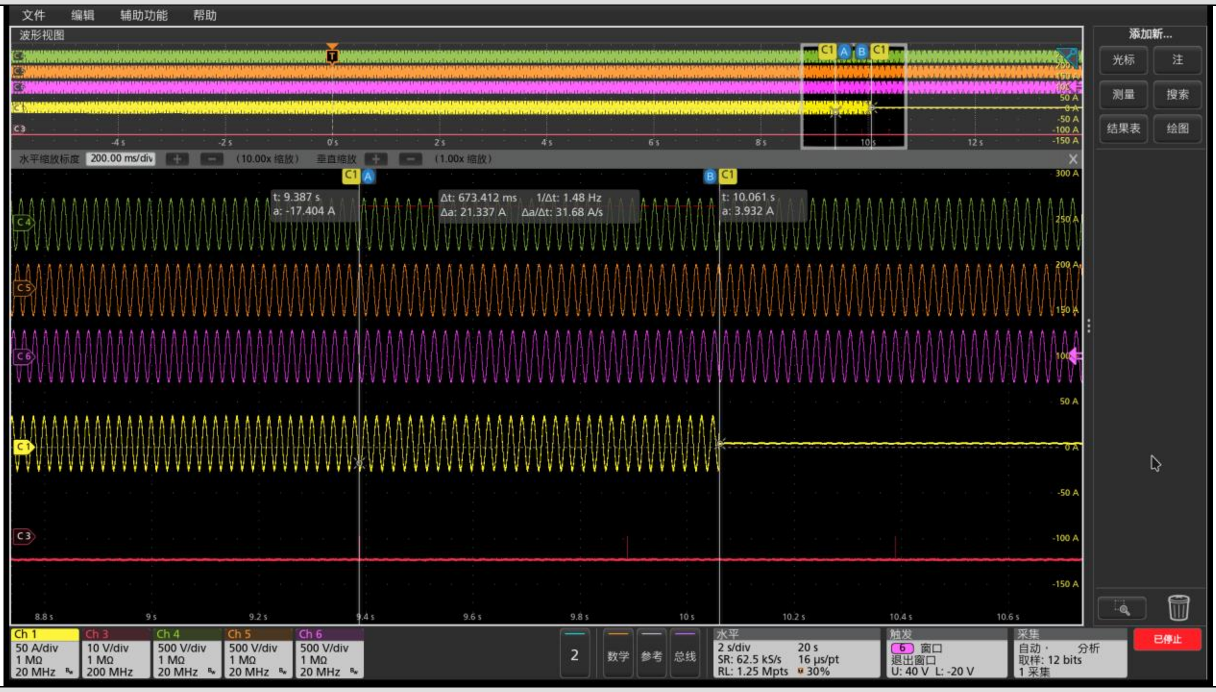
采集
自动 · 分析
取样: 12 bits
0 采集

5.4.2 (6.1.2 & 6.3.3.1)	**TABLE: Frequency protection devices**					**P**
Model	Hybridpower 12kW 3ph					
Setting trip value [Hz]	Frequency step	Test voltage [V]	Measured trip value [Hz]	Internal setting of disconnection time [s]	Measured disconnection time [ms]	Trip Time Limit [ms]
47.50	48.0 Hz to 47.0 Hz	0.85 U_n	47.5	100	173	≤200
		U_n	47.5		163	
		1.10 U_n	47.5		179	
51.50	51.0 Hz to 52.0 Hz	0.85 U_n	51.5	100	161	≤200
		U_n	51.5		170	
		1.10 U_n	51.5		159	

Note:

The tripping frequencies and the tripping times of the frequency monitoring are determined by reducing or increasing the mains frequency with a rate of change of 1 Hz/s up to the setting values defined in accordance with TOR generator, Section 6.3.3.1.
The trip value was determined manually by reducing the frequency in 10mHz steps. When the trip value is known (e.g. 47.5 Hz), the ac-source is programmed to run from e.g. 48.0Hz to 47.0Hz with 1Hz / s. The disconnection time is calculated by the measured time minus the 500ms from 48.0Hz to 47.5Hz.

0.85 U_n & 47.50 Hz



t: 9.387 s
a: -17.404 A

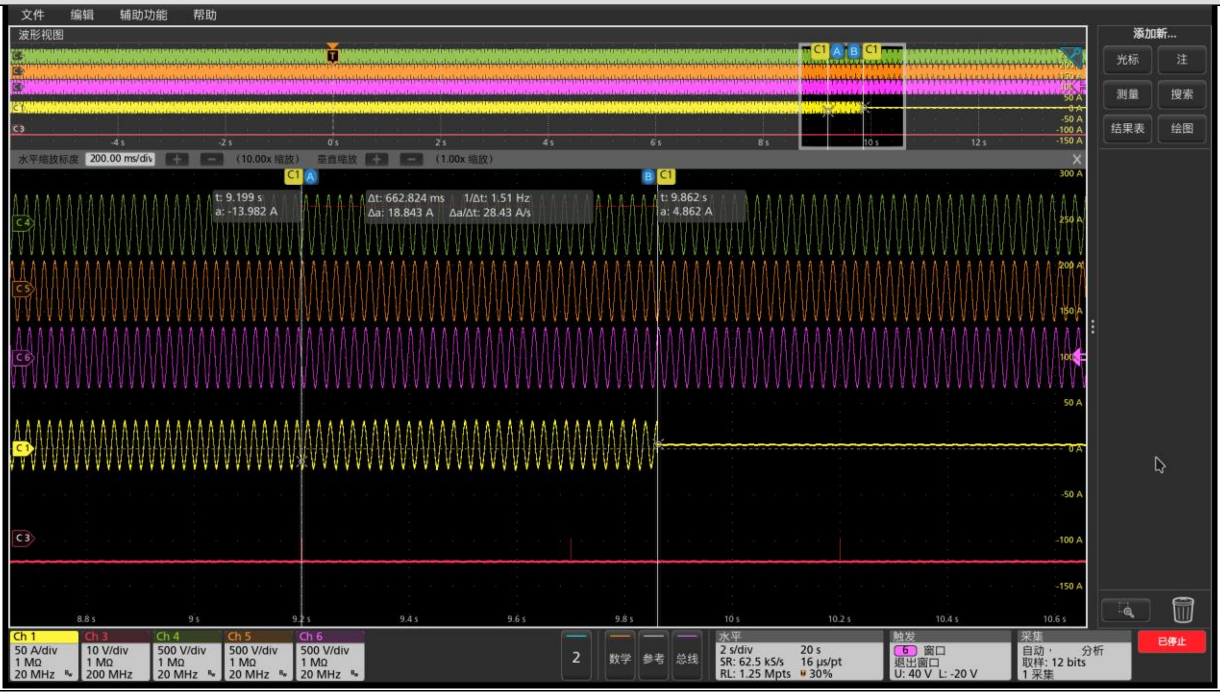
Δt: 673.412 ms 1/Δt: 1.48 Hz
Δa: 21.337 A Δa/Δt: 31.68 A/s

t: 10.061 s
a: 3.932 A

Ch 1: 50 A/div, 1 MΩ, 20 MHz
Ch 3: 10 V/div, 1 MΩ, 200 MHz
Ch 4: 500 V/div, 1 MΩ, 20 MHz
Ch 5: 500 V/div, 1 MΩ, 20 MHz
Ch 6: 500 V/div, 1 MΩ, 20 MHz

水平: 2 s/div 20 s, SR: 62.5 kS/s 16 µs/pt, RL: 1.25 Mpts 30%
触发: 6 窗口, 退出窗口, U: 40 V L: -20 V
采集: 自动 · 分析, 取样: 12 bits, 1 采集

U_n & 47.50 Hz



t: 9.199 s
a: -13.982 A

Δt: 662.824 ms 1/Δt: 1.51 Hz
Δa: 18.843 A Δa/Δt: 28.43 A/s

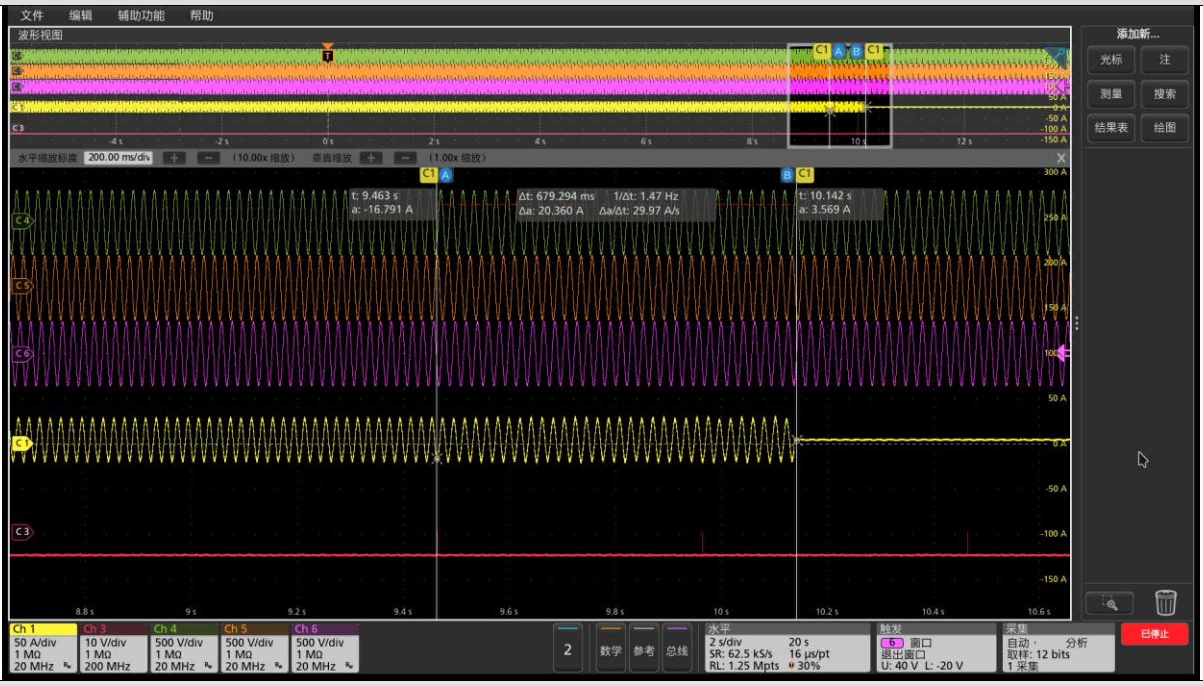
t: 9.862 s
a: 4.862 A

Ch 1: 50 A/div, 1 MΩ, 20 MHz
Ch 3: 10 V/div, 1 MΩ, 200 MHz
Ch 4: 500 V/div, 1 MΩ, 20 MHz
Ch 5: 500 V/div, 1 MΩ, 20 MHz
Ch 6: 500 V/div, 1 MΩ, 20 MHz

水平: 2 s/div 20 s, SR: 62.5 kS/s 16 µs/pt, RL: 1.25 Mpts 30%
触发: 6 窗口, 退出窗口, U: 40 V L: -20 V
采集: 自动 · 分析, 取样: 12 bits, 1 采集

Clause	Requirement - Test	Result - Remark	Verdict

1.10 U_n & 47.50 Hz



t: 9.463 s
a: -16.791 A

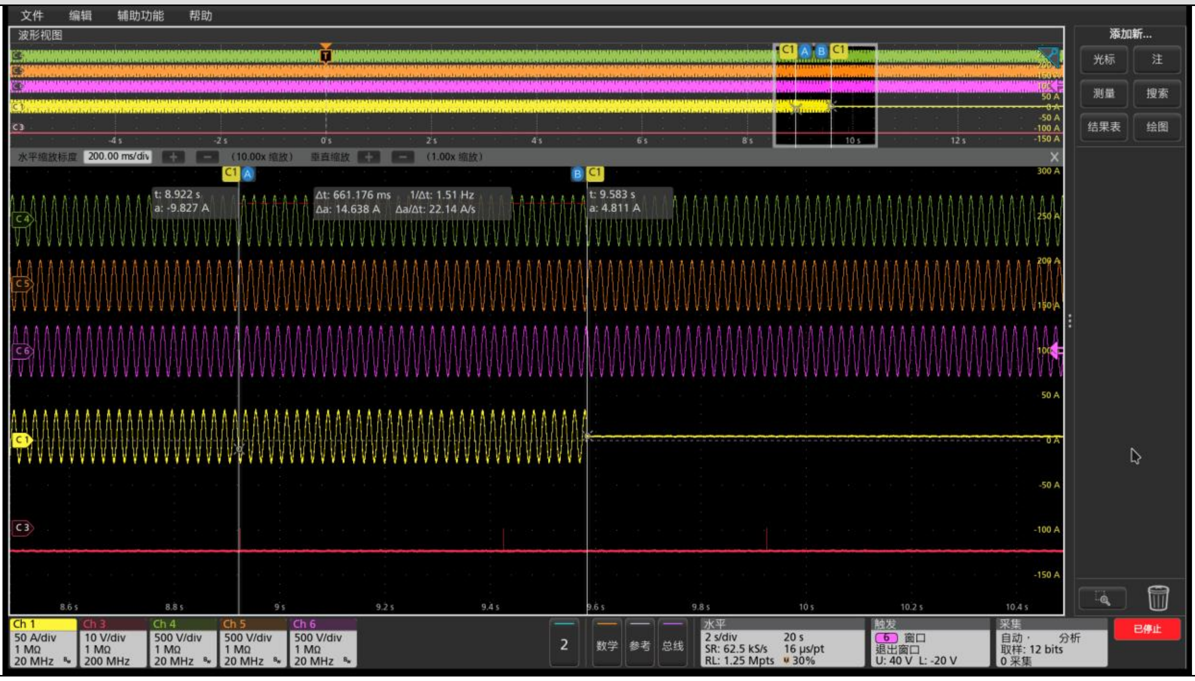
Δt: 679.294 ms 1/Δt: 1.47 Hz
Δa: 20.360 A Δa/Δt: 29.97 A/s

t: 10.142 s
a: 3.569 A

Ch 1: 50 A/div, 1 MΩ, 20 MHz
Ch 3: 10 V/div, 1 MΩ, 200 MHz
Ch 4: 500 V/div, 1 MΩ, 20 MHz
Ch 5: 500 V/div, 1 MΩ, 20 MHz
Ch 6: 500 V/div, 1 MΩ, 20 MHz

水平: 2 s/div 20 s, SR: 62.5 kS/s 16 µs/pt, RL: 1.25 Mpts 30%
触发: 6 窗口, 退出窗口, U: 40 V L: -20 V
采集: 自动， 分析, 取样: 12 bits, 1 采集

0.85 U_n & 51.50 Hz



t: 8.922 s
a: -9.827 A

Δt: 661.176 ms 1/Δt: 1.51 Hz
Δa: 14.638 A Δa/Δt: 22.14 A/s

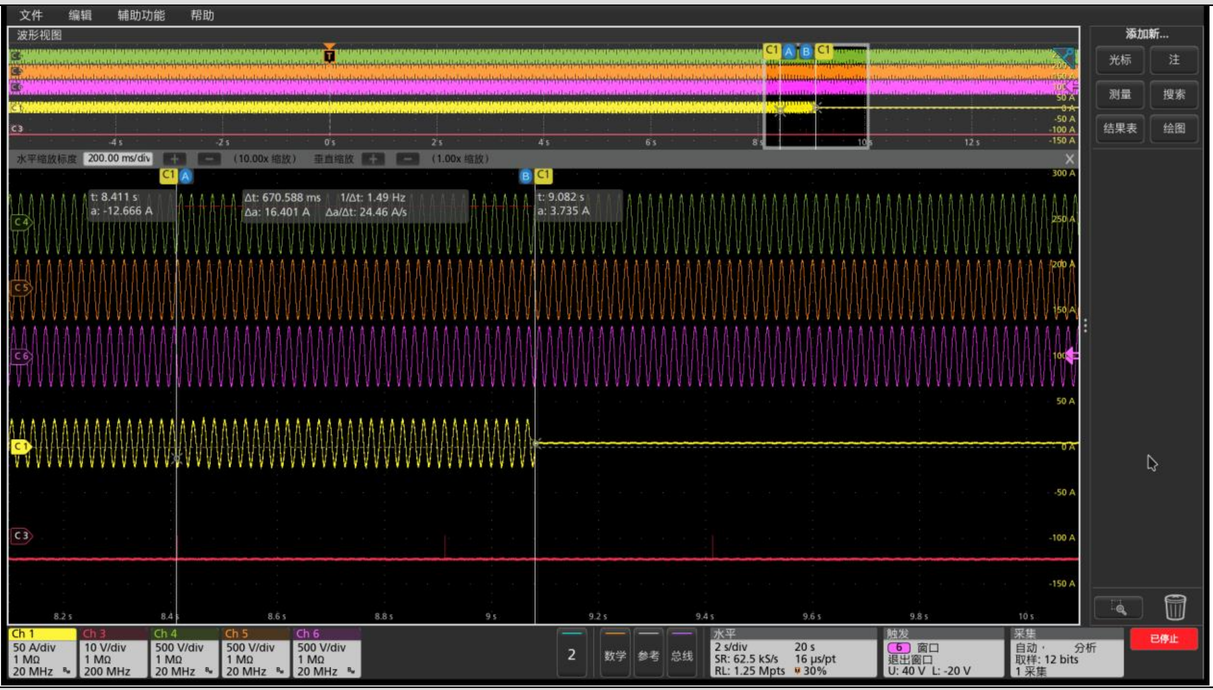
t: 9.583 s
a: 4.811 A

Ch 1: 50 A/div, 1 MΩ, 20 MHz
Ch 3: 10 V/div, 1 MΩ, 200 MHz
Ch 4: 500 V/div, 1 MΩ, 20 MHz
Ch 5: 500 V/div, 1 MΩ, 20 MHz
Ch 6: 500 V/div, 1 MΩ, 20 MHz

水平: 2 s/div 20 s, SR: 62.5 kS/s 16 µs/pt, RL: 1.25 Mpts 30%
触发: 6 窗口, 退出窗口, U: 40 V L: -20 V
采集: 自动， 分析, 取样: 12 bits, 0 采集

OVE-Richtlinie R 25			
Clause	Requirement - Test	Result - Remark	Verdict

U_n & 51.50 Hz



200.00 ms/div （10.00x 缩放） （1.00x 缩放）

t: 8.411 s
a: -12.666 A

Δt: 670.588 ms 1/Δt: 1.49 Hz
Δa: 16.401 A Δa/Δt: 24.46 A/s

t: 9.082 s
a: 3.735 A

Ch 1: 50 A/div, 1 MΩ, 20 MHz
Ch 3: 10 V/div, 1 MΩ, 200 MHz
Ch 4: 500 V/div, 1 MΩ, 20 MHz
Ch 5: 500 V/div, 1 MΩ, 20 MHz
Ch 6: 500 V/div, 1 MΩ, 20 MHz

水平: 2 s/div 20 s, SR: 62.5 kS/s 16 µs/pt, RL: 1.25 Mpts 30%

触发: 6 窗口, 退出窗口, U: 40 V L: -20 V

采集: 自动 分析, 取样: 12 bits, 1 采集

1.10 U_n & 51.50 Hz

200.00 ms/div （10.00x 缩放） （1.00x 缩放）

t: 9.069 s
a: -13.746 A

Δt: 659.294 ms 1/Δt: 1.52 Hz
Δa: 18.062 A Δa/Δt: 27.40 A/s

t: 9.728 s
a: 4.316 A

Ch 1: 50 A/div, 1 MΩ, 20 MHz
Ch 3: 10 V/div, 1 MΩ, 200 MHz
Ch 4: 500 V/div, 1 MΩ, 20 MHz
Ch 5: 500 V/div, 1 MΩ, 20 MHz
Ch 6: 500 V/div, 1 MΩ, 20 MHz

水平: 2 s/div 20 s, SR: 62.5 kS/s 16 µs/pt, RL: 1.25 Mpts 30%

触发: 6 窗口, 退出窗口, U: 40 V L: -20 V

采集: 自动 分析, 取样: 12 bits, 1 采集

5.4.3	**TABLE: Detection of island operation** **In accordance with EN 62116 - test condition A (EUT output = 100%)**	**P**
Model	Hybridpower 12kW 3ph	
Disconnection limit:	2 s	

No	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{ac} b) (% of nominal)	Q_{ac} c) (% of nominal)	Run on Time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC}	Remarks d)
1	100	100	0	0	159	12	0.98	650	Test A at BL
2	100	100	0	- 5	83	12	1.01	650	Test A at IB
3	100	100	0	+ 5	127	12	1.04	650	Test A at IB
4	100	100	- 5	- 5	64	12	1.04	650	Test A at IB
5	100	100	- 5	0	68	12	0.97	650	Test A at IB
6	100	100	- 5	+ 5	76	12	1.00	650	Test A at IB
7	100	100	+ 5	- 5	93.6	12	0.99	650	Test A at IB
8	100	100	+ 5	0	46.4	12	0.97	650	Test A at IB
9	100	100	+ 5	+ 5	88	12	0.98	650	Test A at IB
10	100	100	- 5	- 10	79.6	12	1.00	650	Test A at IB
11	100	100	- 5	+ 10	112.8	12	1.03	650	Test A at IB
12	100	100	0	- 10	75	12	1.03	650	Test A at IB
13	100	100	0	+ 10	142	12	0.97	650	Test A at IB
14	100	100	+ 5	- 10	87	12	1.03	650	Test A at IB
15	100	100	+ 5	+ 10	137	12	0.98	650	Test A at IB
16	100	100	- 10	- 10	77.8	12	0.98	650	Test A at IB
17	100	100	- 10	- 5	65.8	12	0.95	650	Test A at IB
18	100	100	- 10	0	108.2	12	0.97	650	Test A at IB
19	100	100	- 10	+ 5	78.6	12	0.99	650	Test A at IB
20	100	100	- 10	+10	70.2	12	1.02	650	Test A at IB
21	100	100	+ 10	- 10	136.2	12	1.02	650	Test A at IB
22	100	100	+ 10	- 5	79.8	12	0.99	650	Test A at IB
23	100	100	+ 10	0	44	12	0.96	650	Test A at IB
24	100	100	+ 10	+ 5	134	12	0.99	650	Test A at IB
25	100	100	+ 10	+ 10	50	12	1.02	650	Test A at IB

5.4.3	**TABLE: Detection of island operation** **In accordance with EN 62116 - test condition B (EUT output = 50 % – 66 %)**	**P**
Model	Hybridpower 12kW 3ph	
Disconnection limit:	2 s	

No	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{ac} b) (% of nominal)	Q_{ac} c) (% of nominal)	Run on Time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC}	Remarks d)
1	66	66	0	- 5	74	7.92	1.01	450V	Test B at IB
2	66	66	0	- 4	116	7.92	0.97	450V	Test B at IB
3	66	66	0	- 3	119	7.92	0.99	450V	Test B at IB
4	66	66	0	- 2	130	7.92	0.98	450V	Test B at IB
5	66	66	0	- 1	147	7.92	1.02	450V	Test B at IB
6	66	66	0	0	176	7.92	1.01	450V	Test B at BL
7	66	66	0	+ 1	175	7.92	1.03	450V	Test B at IB
8	66	66	0	+ 2	138	7.92	1.02	450V	Test B at IB
9	66	66	0	+ 3	123	7.92	1.05	450V	Test B at IB
10	66	66	0	+ 4	117	7.92	1.00	450V	Test B at IB
11	66	66	0	+ 5	89	7.92	1.02	450V	Test B at IB

5.4.3	**TABLE: Detection of island operation In accordance with EN 62116 - test condition C (EUT output = 25 %-33 %)**	**P**
Model	Hybridpower 12kW 3ph	
Disconnection limit:	2 s	

No	P_{EUT} [a] (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{ac} [b] (% of nominal)	Q_{ac} [c] (% of nominal)	Run on Time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC}	Remarks[d]
1	33	33	0	- 5	47	3.96	1.02	200V	Test C at IB
2	33	33	0	- 4	59	3.96	0.99	200V	Test C at IB
3	33	33	0	- 3	67	3.96	0.96	200V	Test C at IB
4	33	33	0	- 2	71	3.96	1.00	200V	Test C at IB
5	33	33	0	- 1	71	3.96	0.96	200V	Test C at IB
6	33	33	0	0	142	3.96	1.00	200V	Test C at BL
7	33	33	0	+ 1	97	3.96	0.96	200V	Test C at IB
8	33	33	0	+ 2	49	3.96	0.97	200V	Test C at IB
9	33	33	0	+ 3	47	3.96	0.98	200V	Test C at IB
10	33	33	0	+ 4	45	3.96	0.99	200V	Test C at IB
11	33	33	0	+ 5	43	3.96	1.00	200V	Test C at IB

Note:

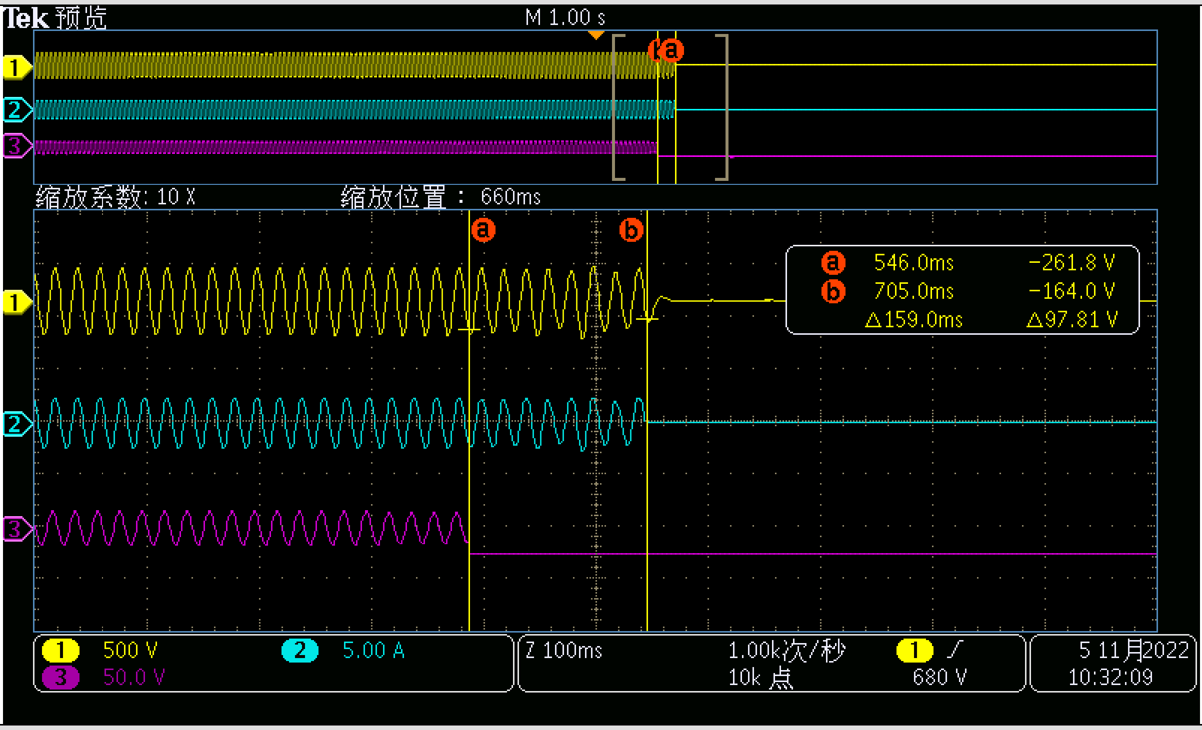
[a] P_{EUT}: EUT output power

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

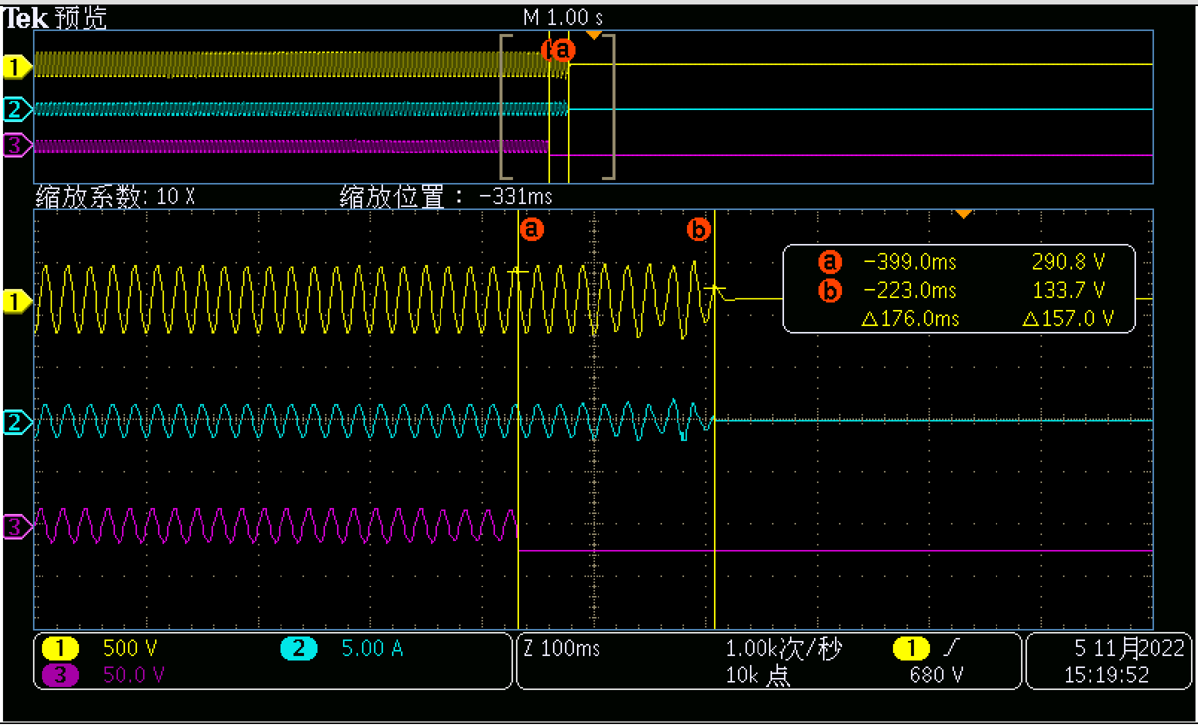
[c] Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

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

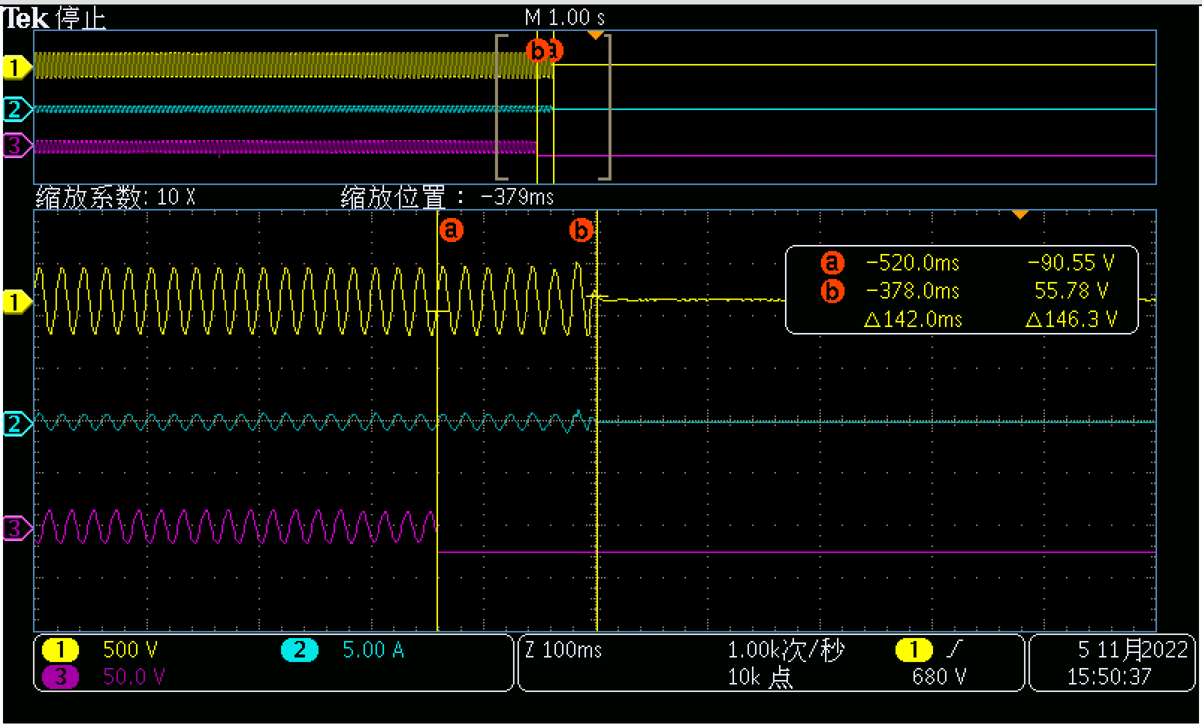
Graph of disconnection at P_{AC} 0 and Q_{AC} 0 reactive load and 100% nominal power



Graph of disconnection at P_{AC} 0 and Q_{AC} 0 reactive load and 66% nominal power



Graph of disconnection at P_{AC} 0 and Q_{AC} 0 reactive load and 33% nominal power



5.5 (5.5.2)	**TABLE: Testing the connection conditions and synchronization**	**P**
Model	Hybridpower 12kW 3ph	
Setting values:	Setting $T_{reconnection}$ [s]:	300
	Setting f < for connected to grid [Hz]:	47.5
	Setting f > for connected to grid [Hz]:	50.1
	Setting V < for connected to grid [V]:	195.5
	Setting V > for connected to grid [V]:	250.7

Test: automatic reconnection after tripping

	Test condition	Reconnection time [s]:	Limit [s]:
Connecting conditions for frequencies:			
a)	<47.45 Hz	No connection	No resetting allowed
	Switch to:		
b)	≥47.55 Hz	325	≥ 300 s
	Power gradient after connection	9.9%	≤10% P_{max} per minute
c)	> 50.15 Hz	No connection	No resetting allowed
	Switch to:		
d)	≤50.05 Hz	322	≥ 300 s
	Power gradient after connection	9.9%	≤ 10% P_{max} per minute
Connecting conditions for voltages:			
e)	< 84%	No connection	No resetting allowed
	Switch to:		
f)	≥86%	324	≥ 300 s
	Power gradient after connection	9.9%	≤ 10% P_{max} per minute
g)	>110 %	No connection	No resetting allowed
	Switch to:		
h)	≤109%	324	≥ 300 s
	Power gradient after connection	9.9%	≤ 10% P_{max} per minute

Note:

Power gradient after reconnection must ≤ 10%P_{max} per minute.

The test is passed if the EZE or the automatic activation point can only be activated within the tolerance bands according to the TOR generator, Section 5.5.2 and after the voltage and frequency have remained within the tolerance bands after 300 s at the earliest.

5.6 (5.2)	**TABLE: Proof of dynamic network support**	**P**
Model	Hybridpower 12kW 3ph	

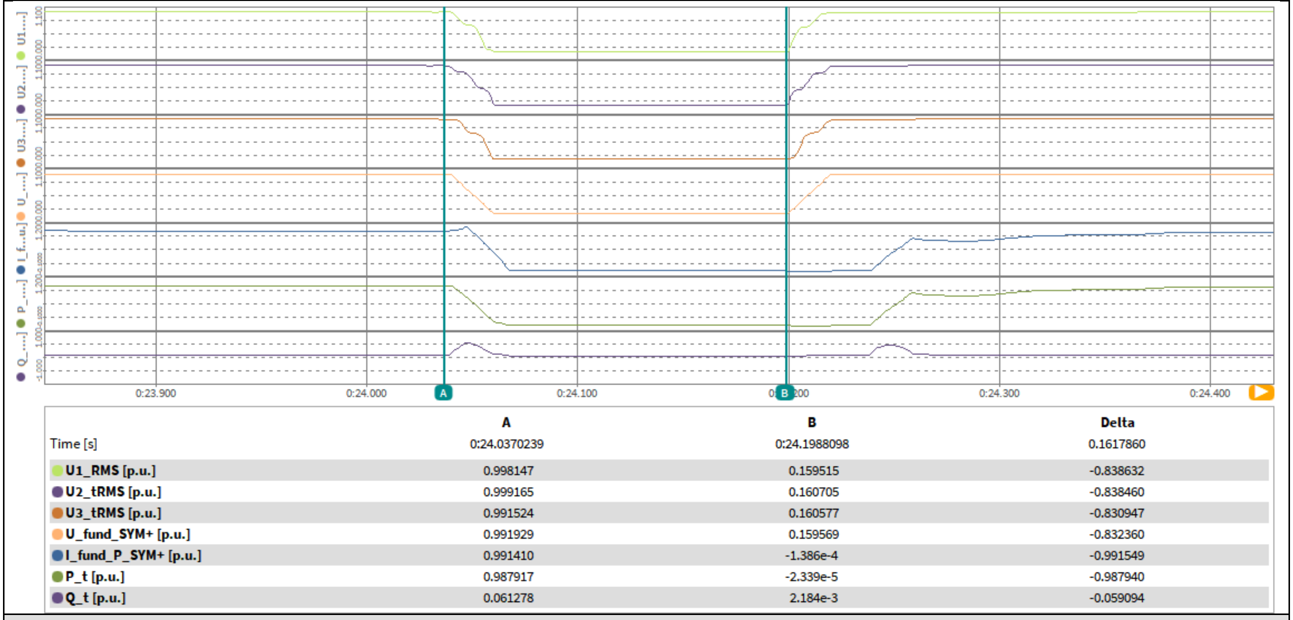
Test number	U/U_n [p.u.] / [ms]	Fault type	Output power level P set point [%P_n]	Average remaining voltage [pos.]	Measured fault duration [ms]	Percent of current after fault 60 ms [%I_r]	Percent of current after fault 100 ms [%I_r]	Duration of restoring network [ms]
1.0A	0.15 / 160	A	$P = 0$	34.85	251	N/A	N/A	N/A
1.1			$P = P_n \pm 2\% P_n$	36.84	161	0.008	0.008	516
1.2			$P = 0.2 P_n$ to $0.6 P_n$	34.77	253	0.124	0.124	808
1.0D1		D1	$P = 0$	143.7	263	N/A	N/A	N/A
1.3			$P = P_n \pm 2\% P_n$	141.6	262	0.431	0.427	821
1.4			$P = 0.2 P_n$ to $0.6 P_n$	141.7	255	0.504	0.430	835
2.0A	0.50 / 860	A	$P = 0$	114.8	1014	N/A	N/A	N/A
2.1			$P = P_n \pm 2\% P_n$	116.9	1011	0.350	0.354	884
2.2			$P = 0.2 P_n$ to $0.6 P_n$	114.3	1002	0.343	0.351	676
2.0D1		D1	$P = 0$	174.4	989	N/A	N/A	N/A
2.3			$P = P_n \pm 2\% P_n$	174.7	1002	0.531	0.527	706
2.4			$P = 0.2 P_n$ to $0.6 P_n$	173.2	1009	0.527	0.529	790
3.0A	0.85 / 60000	A	$P = 0$	197.4	61000	N/A	N/A	N/A
3.1			$P = P_n \pm 2\% P_n$	198.9	60960	113.25	113.21	N/A
3.2			$P = 0.2 P_n$ to $0.6 P_n$	198.0	61020	45.54	45.52	N/A
3.0D1		D1	$P = 0$	213.3	61000	N/A	N/A	N/A
3.3			$P = P_n \pm 2\% P_n$	214.7	61080	106.25	106.30	N/A
3.4			$P = 0.2 P_n$ to $0.6 P_n$	213.5	61020	42.80	42.64	N/A

Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	1.1
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	15:13:58
	3	Fault type (phase)	--	--	--	3-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.15
	5	Setting dip duration	160	--	ms	161
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	161
	8	Fault duration in empty load test	Total	--	ms	162
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.836
	10		Pos.			0.836
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	0.996
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0
	13	Active power	Total	t_1-10s to t_1	p.u.	0.985
	14		Pos.			0.985
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.061
	16		Pos.			0.061
	17	Cosφ	--	t_1-10s to t_1	--	0.998
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.159
	19	Line current	Phase 1	t_1+60ms	p.u.	0.014
	20		Phase 2			0.013
	21		Phase 3			0.013
	22	Line current	Phase 1	t_1+100ms	p.u.	0.014
	23		Phase 2			0.013
	24		Phase 3			0.013
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			0
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	0.997
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.986
	29		Pos.			0.986
	30	Active power rising time	Pos.	--	s	0.516
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.061
	32		Pos.			0.061
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 1.0A
Depth of fault: 0.15 p.u., three-phase SC (type A), 0% load (No load test)

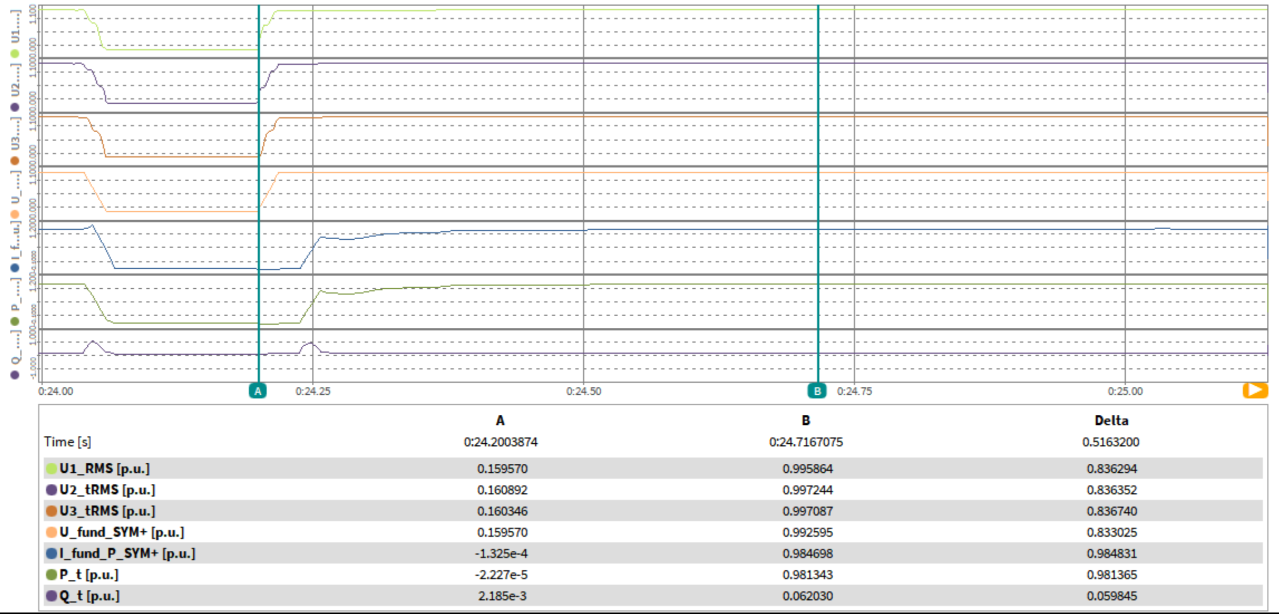
	A	B	Delta
Time [s]	0:24.0370239	0:24.1988098	0.1617860
U1_RMS [p.u.]	0.998147	0.159515	-0.838632
U2_tRMS [p.u.]	0.999165	0.160705	-0.838460
U3_tRMS [p.u.]	0.991524	0.160577	-0.830947
U_fund_SYM+ [p.u.]	0.991929	0.159569	-0.832360

Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, fault time



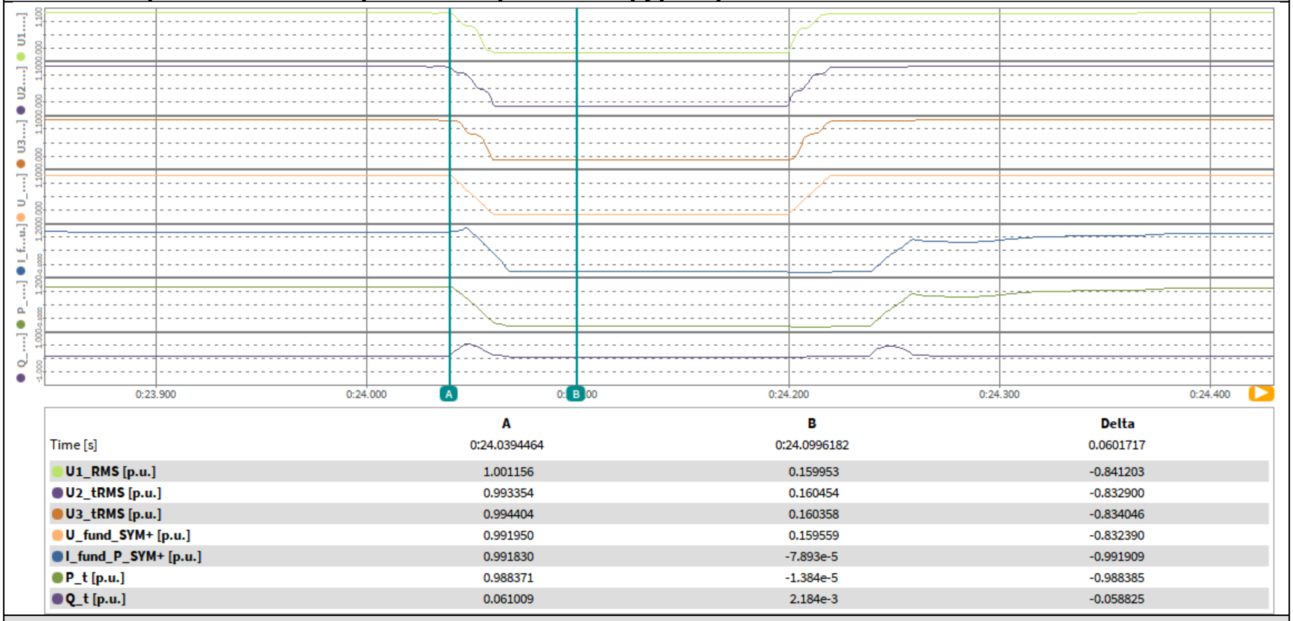
	A	B	Delta
Time [s]	0:24.0370239	0:24.1988098	0.1617860
● U1_RMS [p.u.]	0.998147	0.159515	-0.838632
● U2_tRMS [p.u.]	0.999165	0.160705	-0.838460
● U3_tRMS [p.u.]	0.991524	0.160577	-0.830947
● U_fund_SYM+ [p.u.]	0.991929	0.159569	-0.832360
● I_fund_P_SYM+ [p.u.]	0.991410	-1.386e-4	-0.991549
● P_t [p.u.]	0.987917	-2.339e-5	-0.987940
● Q_t [p.u.]	0.061278	2.184e-3	-0.059094

Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, restoring time



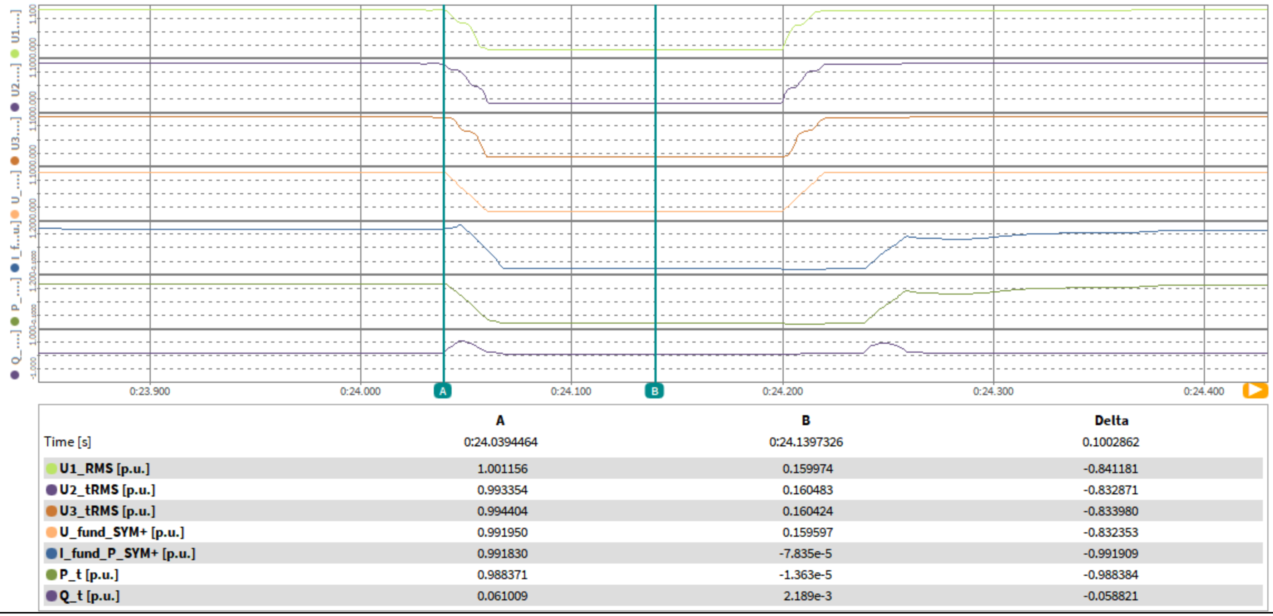
	A	B	Delta
Time [s]	0:24.2003874	0:24.7167075	0.5163200
● U1_RMS [p.u.]	0.159570	0.995864	0.836294
● U2_tRMS [p.u.]	0.160892	0.997244	0.836352
● U3_tRMS [p.u.]	0.160346	0.997087	0.836740
● U_fund_SYM+ [p.u.]	0.159570	0.992595	0.833025
● I_fund_P_SYM+ [p.u.]	-1.325e-4	0.984698	0.984831
● P_t [p.u.]	-2.227e-5	0.981343	0.981365
● Q_t [p.u.]	2.185e-3	0.062030	0.059845

Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, current after fault 60ms



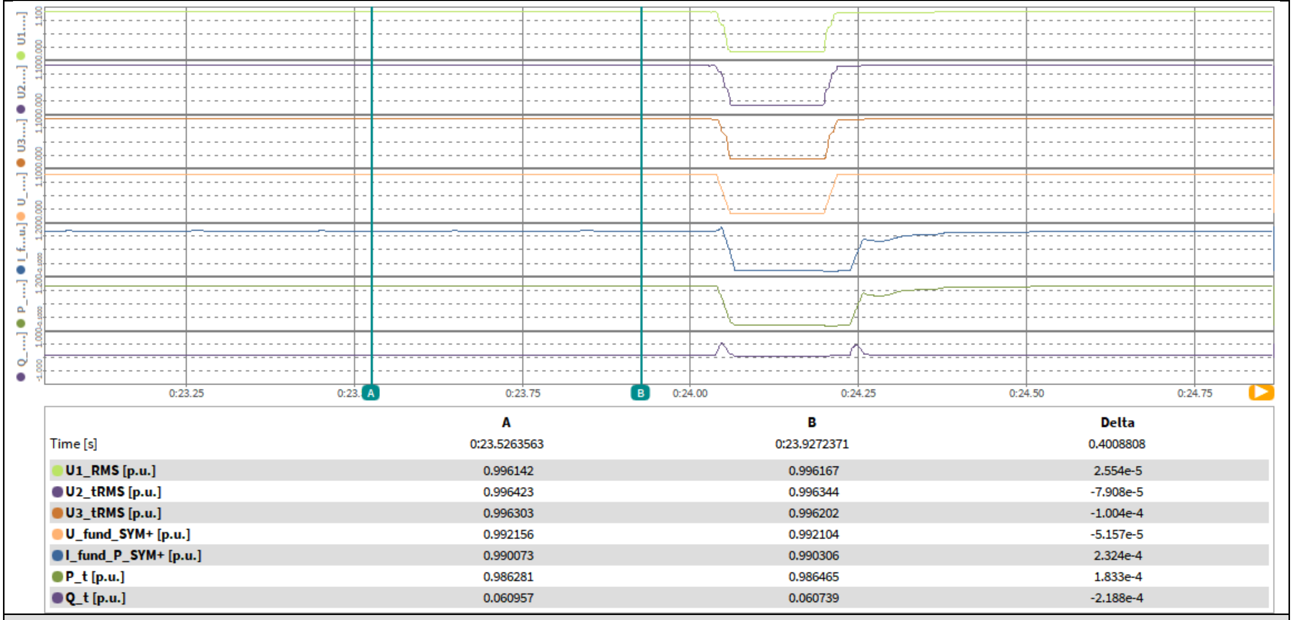
	A	B	Delta
Time [s]	0:24.0394464	0:24.0996182	0.0601717
● U1_RMS [p.u.]	1.001156	0.159953	-0.841203
● U2_tRMS [p.u.]	0.993354	0.160454	-0.832900
● U3_tRMS [p.u.]	0.994404	0.160358	-0.834046
● U_fund_SYM+ [p.u.]	0.991950	0.159559	-0.832390
● I_fund_P_SYM+ [p.u.]	0.991830	-7.893e-5	-0.991909
● P_t [p.u.]	0.988371	-1.384e-5	-0.988385
● Q_t [p.u.]	0.061009	2.184e-3	-0.058825

Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, current after fault 100ms



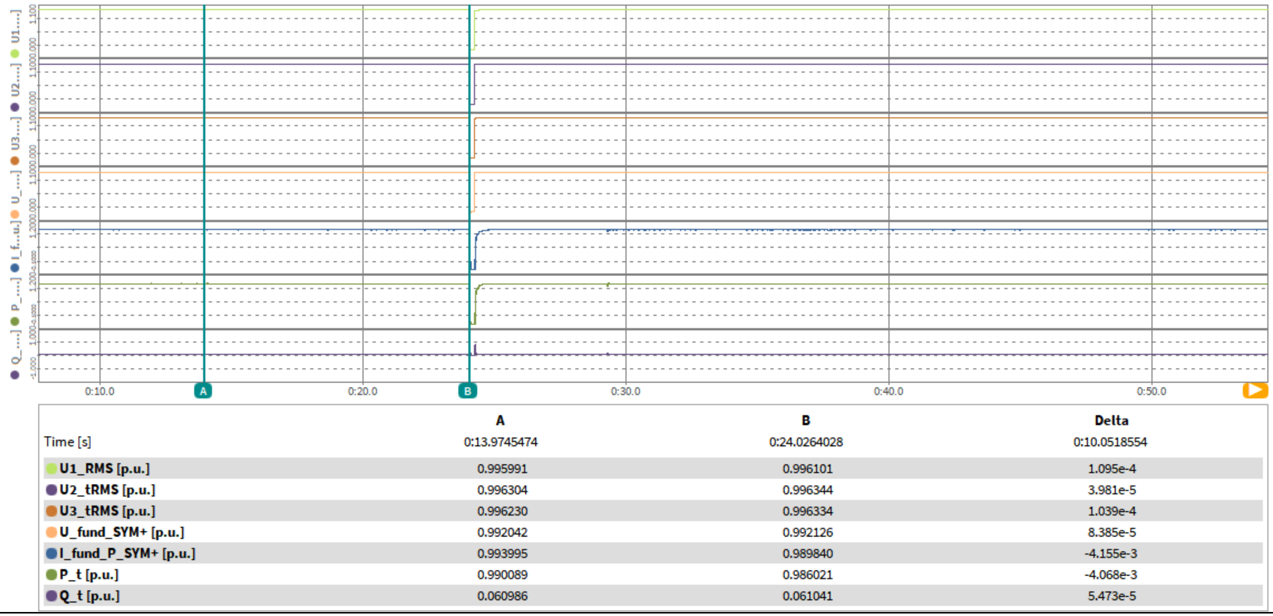
	A	B	Delta
Time [s]	0:24.0394464	0:24.1397326	0.1002862
● U1_RMS [p.u.]	1.001156	0.159974	-0.841181
● U2_tRMS [p.u.]	0.993354	0.160483	-0.832871
● U3_tRMS [p.u.]	0.994404	0.160424	-0.833980
● U_fund_SYM+ [p.u.]	0.991950	0.159597	-0.832353
● I_fund_P_SYM+ [p.u.]	0.991830	-7.835e-5	-0.991909
● P_t [p.u.]	0.988371	-1.363e-5	-0.988384
● Q_t [p.u.]	0.061009	2.189e-3	-0.058821

Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, t_1-500ms to t_1-100ms



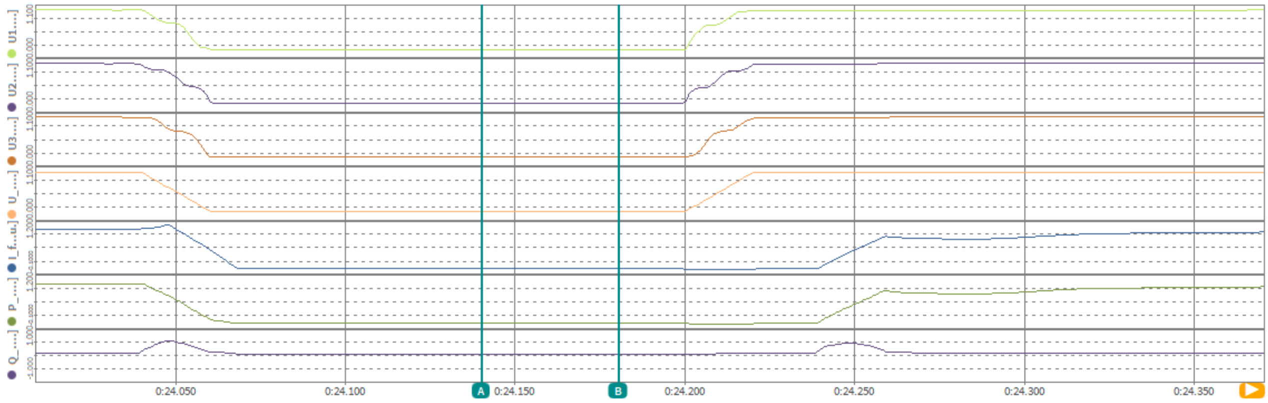
	A	B	Delta
Time [s]	0:23.5263563	0:23.9272371	0.4008808
U1_RMS [p.u.]	0.996142	0.996167	2.554e-5
U2_tRMS [p.u.]	0.996423	0.996344	-7.908e-5
U3_tRMS [p.u.]	0.996303	0.996202	-1.004e-4
U_fund_SYM+ [p.u.]	0.992156	0.992104	-5.157e-5
I_fund_P_SYM+ [p.u.]	0.990073	0.990306	2.324e-4
P_t [p.u.]	0.986281	0.986465	1.833e-4
Q_t [p.u.]	0.060957	0.060739	-2.188e-4

Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, t_1-10s to t_1



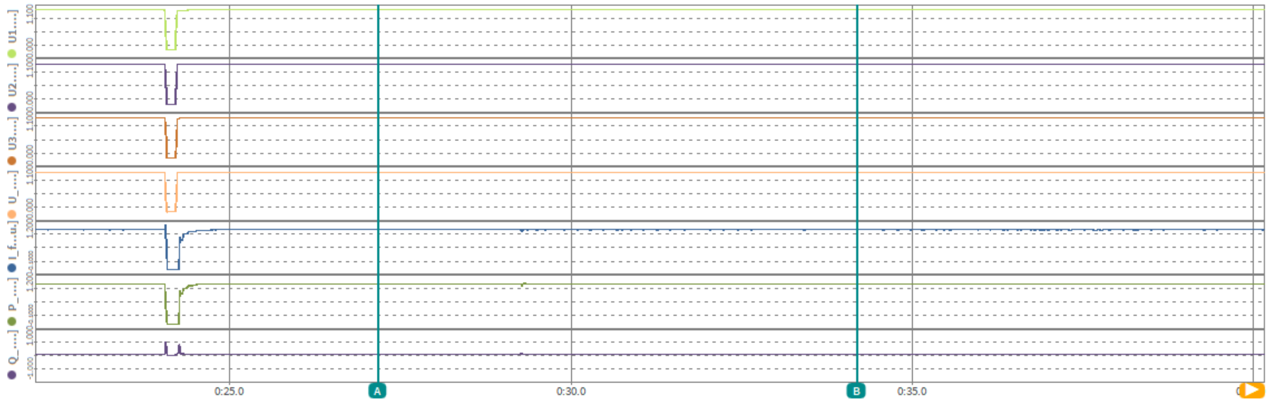
	A	B	Delta
Time [s]	0:13.9745474	0:24.0264028	0:10.0518554
U1_RMS [p.u.]	0.995991	0.996101	1.095e-4
U2_tRMS [p.u.]	0.996304	0.996344	3.981e-5
U3_tRMS [p.u.]	0.996230	0.996334	1.039e-4
U_fund_SYM+ [p.u.]	0.992042	0.992126	8.385e-5
I_fund_P_SYM+ [p.u.]	0.993995	0.989840	-4.155e-3
P_t [p.u.]	0.990089	0.986021	-4.068e-3
Q_t [p.u.]	0.060986	0.061041	5.473e-5

Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:24.1402531	0:24.1805647	0.0403115
● U1_RMS [p.u.]	0.159969	0.160231	2.622e-4
● U2_tRMS [p.u.]	0.160473	0.160108	-3.653e-4
● U3_tRMS [p.u.]	0.160422	0.160477	5.540e-5
● U_fund_SYM+ [p.u.]	0.159591	0.159569	-2.143e-5
● I_fund_P_SYM+ [p.u.]	-7.819e-5	-8.775e-5	-9.559e-6
● P_t [p.u.]	-1.362e-5	-1.510e-5	-1.481e-6
● Q_t [p.u.]	2.188e-3	2.192e-3	3.894e-6

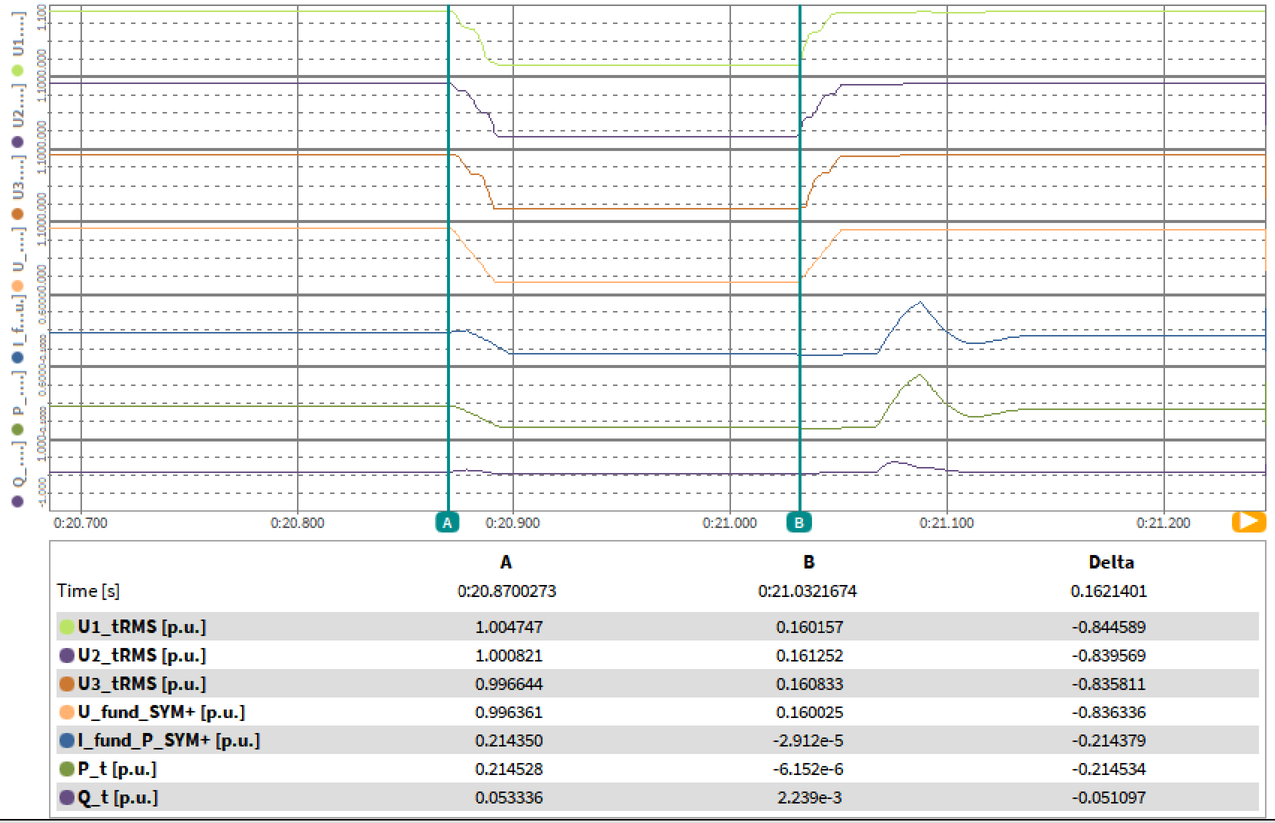
Test 1.1
Depth of fault: 0.15 p.u., three-phase SC (type A), 100% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	0:27.1815102	0:34.1934474	7.0119372
● U1_RMS [p.u.]	0.996081	0.996072	-8.426e-6
● U2_tRMS [p.u.]	0.996226	0.996202	-2.422e-5
● U3_tRMS [p.u.]	0.996372	0.996292	-8.041e-5
● U_fund_SYM+ [p.u.]	0.992092	0.992053	-3.929e-5
● I_fund_P_SYM+ [p.u.]	0.990363	0.986514	-3.849e-3
● P_t [p.u.]	0.986510	0.982645	-3.865e-3
● Q_t [p.u.]	0.062644	0.061269	-1.375e-3

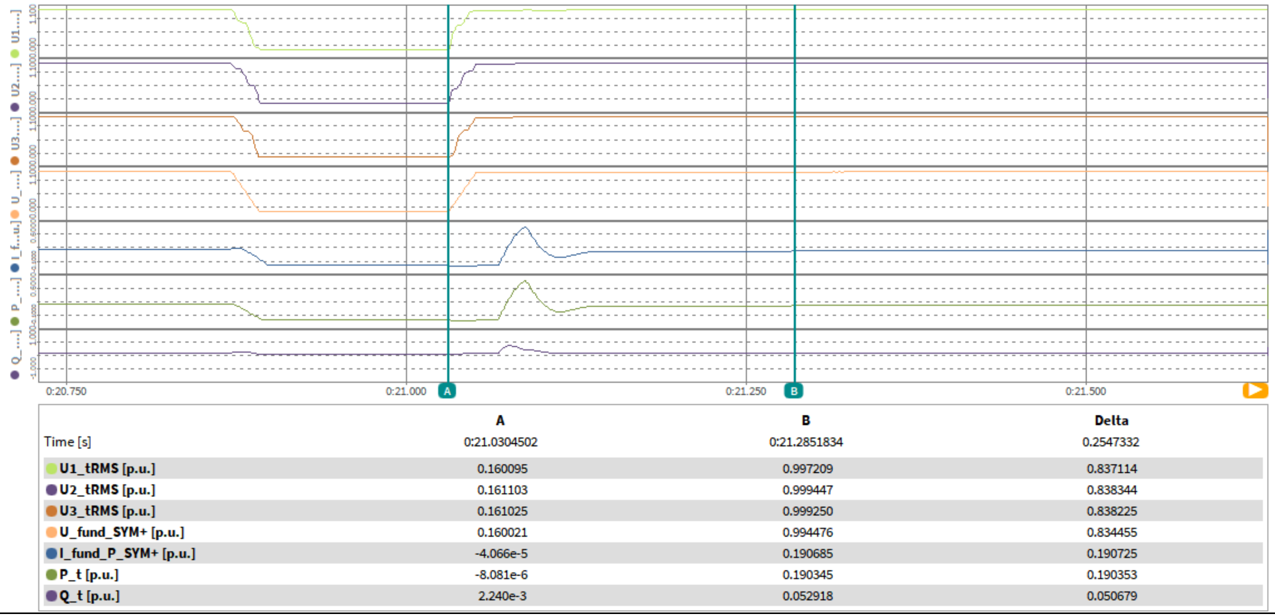
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	1.2
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:07:30
	3	Fault type (phase)	--	--	--	3-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.15
	5	Setting dip duration	160	--	ms	162
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	162
	8	Fault duration in empty load test	Total	--	ms	162
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.840
	10		Pos.			0.836
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.001
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0
	13	Active power	Total	t_1-10s to t_1	p.u.	0.216
	14		Pos.			0.216
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.053
	16		Pos.			0.053
	17	Cosφ	--	t_1-10s to t_1	--	0.970
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.160
	19	Line current	Phase 1	t_1+60ms	p.u.	0.015
	20		Phase 2			0.014
	21		Phase 3			0.013
	22	Line current	Phase 1	t_1+100ms	p.u.	0.015
	23		Phase 2			0.014
	24		Phase 3			0.013
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			--
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.001
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.214
	29		Pos.			0.214
	30	Active power rising time	Pos.	--	s	0.255
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.054
	32		Pos.			0.054
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 1.2
Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, fault time



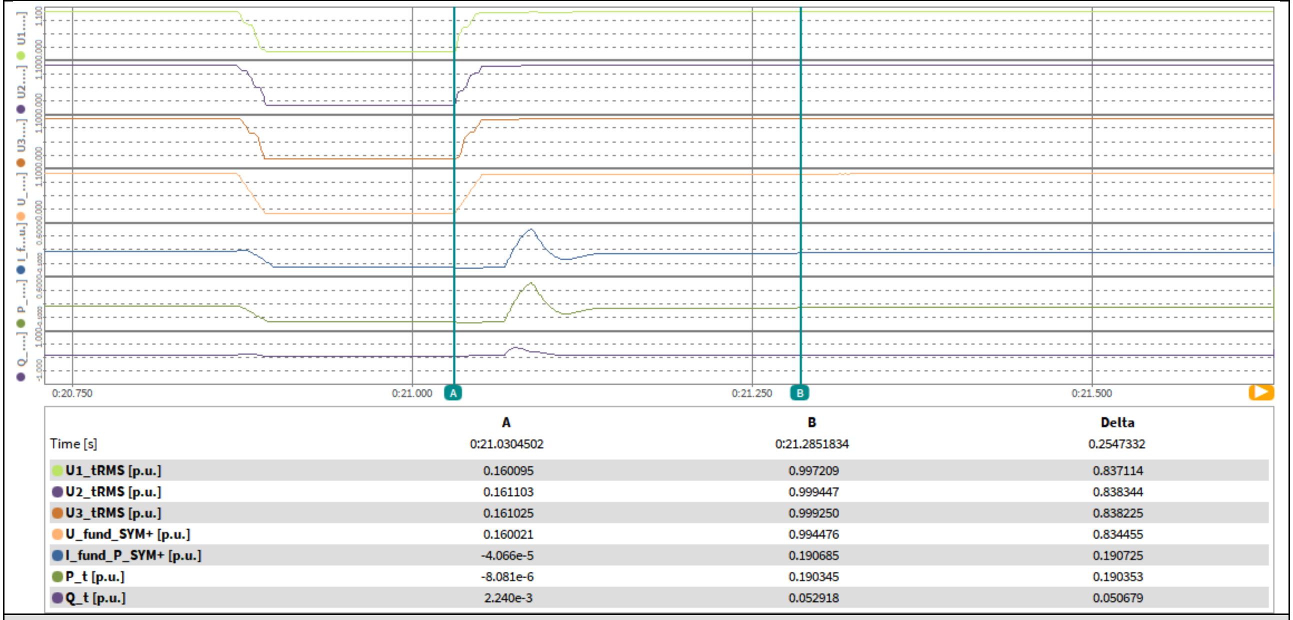
	A	B	Delta
Time [s]	0:20.8700273	0:21.0321674	0.1621401
U1_tRMS [p.u.]	1.004747	0.160157	-0.844589
U2_tRMS [p.u.]	1.000821	0.161252	-0.839569
U3_tRMS [p.u.]	0.996644	0.160833	-0.835811
U_fund_SYM+ [p.u.]	0.996361	0.160025	-0.836336
I_fund_P_SYM+ [p.u.]	0.214350	-2.912e-5	-0.214379
P_t [p.u.]	0.214528	-6.152e-6	-0.214534
Q_t [p.u.]	0.053336	2.239e-3	-0.051097

Test 1.2
Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, restoring time



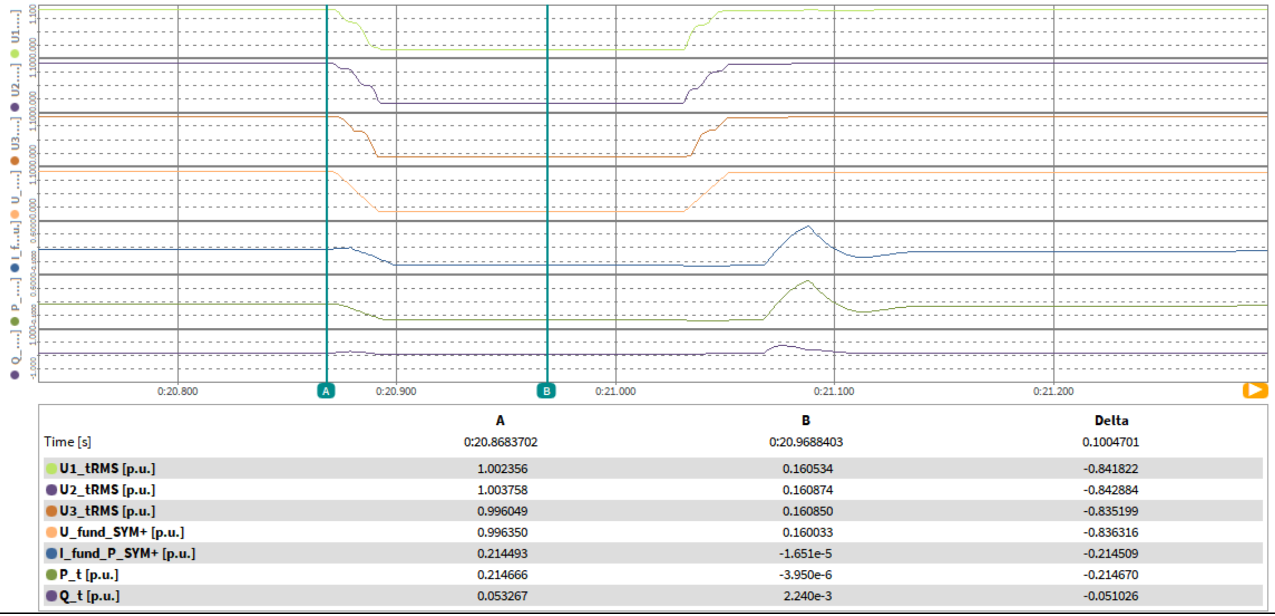
	A	B	Delta
Time [s]	0:21.0304502	0:21.2851834	0.2547332
U1_tRMS [p.u.]	0.160095	0.997209	0.837114
U2_tRMS [p.u.]	0.161103	0.999447	0.838344
U3_tRMS [p.u.]	0.161025	0.999250	0.838225
U_fund_SYM+ [p.u.]	0.160021	0.994476	0.834455
I_fund_P_SYM+ [p.u.]	-4.066e-5	0.190685	0.190725
P_t [p.u.]	-8.081e-6	0.190345	0.190353
Q_t [p.u.]	2.240e-3	0.052918	0.050679

Test 1.2
Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, current after fault 60ms



	A	B	Delta
Time [s]	0:21.0304502	0:21.2851834	0.2547332
● **U1_tRMS [p.u.]**	0.160095	0.997209	0.837114
● **U2_tRMS [p.u.]**	0.161103	0.999447	0.838344
● **U3_tRMS [p.u.]**	0.161025	0.999250	0.838225
● **U_fund_SYM+ [p.u.]**	0.160021	0.994476	0.834455
● **I_fund_P_SYM+ [p.u.]**	-4.066e-5	0.190685	0.190725
● **P_t [p.u.]**	-8.081e-6	0.190345	0.190353
● **Q_t [p.u.]**	2.240e-3	0.052918	0.050679

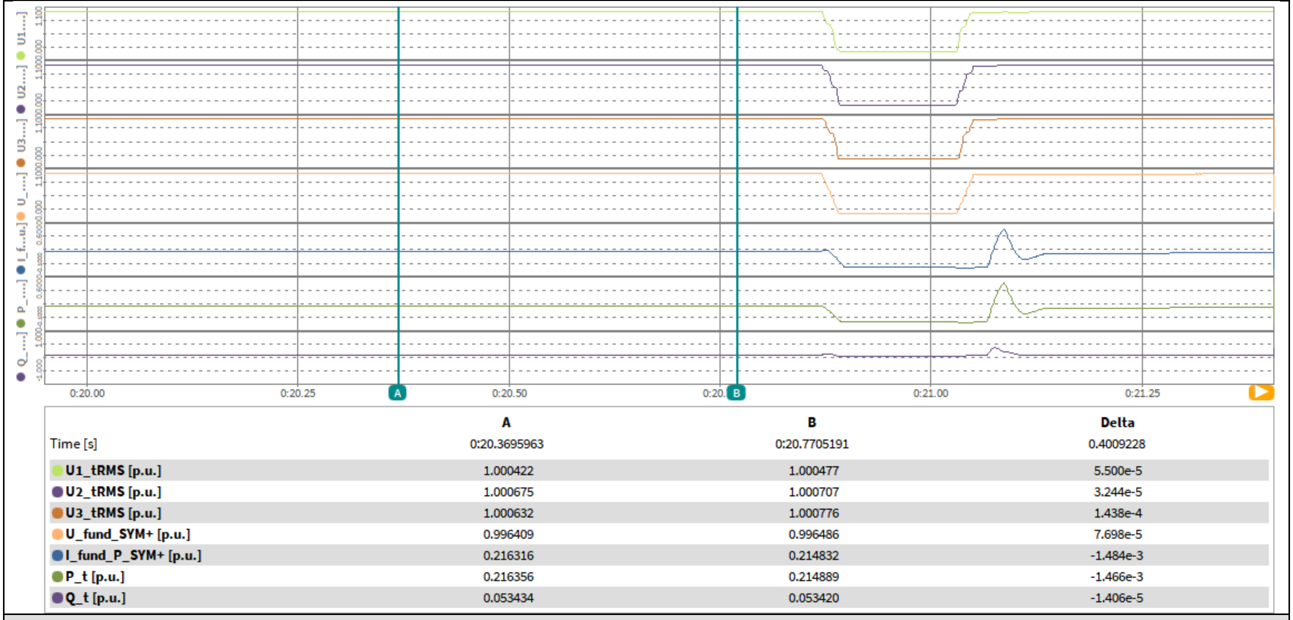
Test 1.2
Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, current after fault 100ms



	A	B	Delta
Time [s]	0:20.8683702	0:20.9688403	0.1004701
● **U1_tRMS [p.u.]**	1.002356	0.160534	-0.841822
● **U2_tRMS [p.u.]**	1.003758	0.160874	-0.842884
● **U3_tRMS [p.u.]**	0.996049	0.160850	-0.835199
● **U_fund_SYM+ [p.u.]**	0.996350	0.160033	-0.836316
● **I_fund_P_SYM+ [p.u.]**	0.214493	-1.651e-5	-0.214509
● **P_t [p.u.]**	0.214666	-3.950e-6	-0.214670
● **Q_t [p.u.]**	0.053267	2.240e-3	-0.051026

Test 1.2

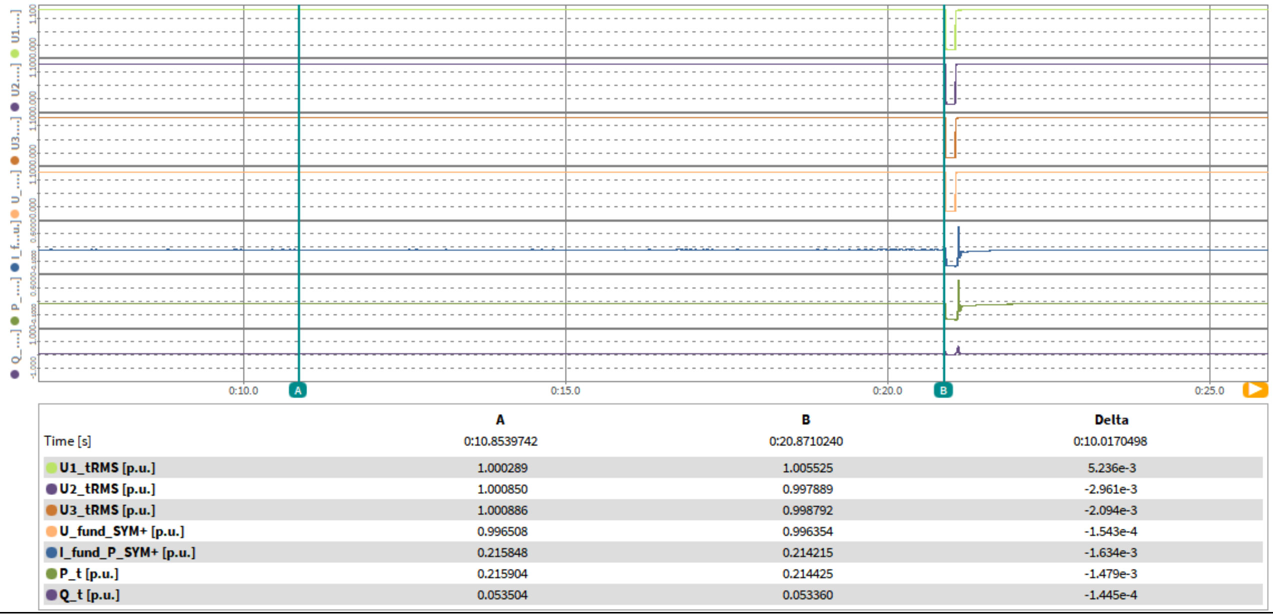
Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, t_1-500ms to t_1-100ms



	A	B	Delta
Time [s]	0:20.3695963	0:20.7705191	0.4009228
● **U1_tRMS [p.u.]**	1.000422	1.000477	5.500e-5
● **U2_tRMS [p.u.]**	1.000675	1.000707	3.244e-5
● **U3_tRMS [p.u.]**	1.000632	1.000776	1.438e-4
● **U_fund_SYM+ [p.u.]**	0.996409	0.996486	7.698e-5
● **I_fund_P_SYM+ [p.u.]**	0.216316	0.214832	-1.484e-3
● **P_t [p.u.]**	0.216356	0.214889	-1.466e-3
● **Q_t [p.u.]**	0.053434	0.053420	-1.406e-5

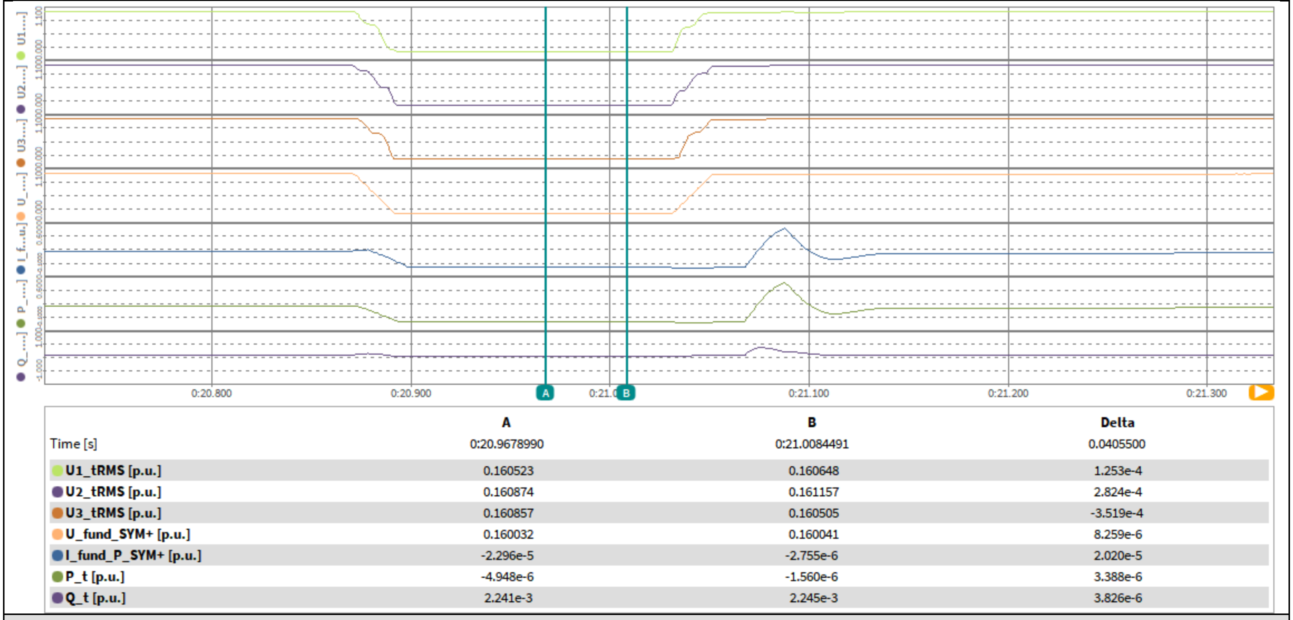
Test 1.2

Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, t_1-10s to t_1



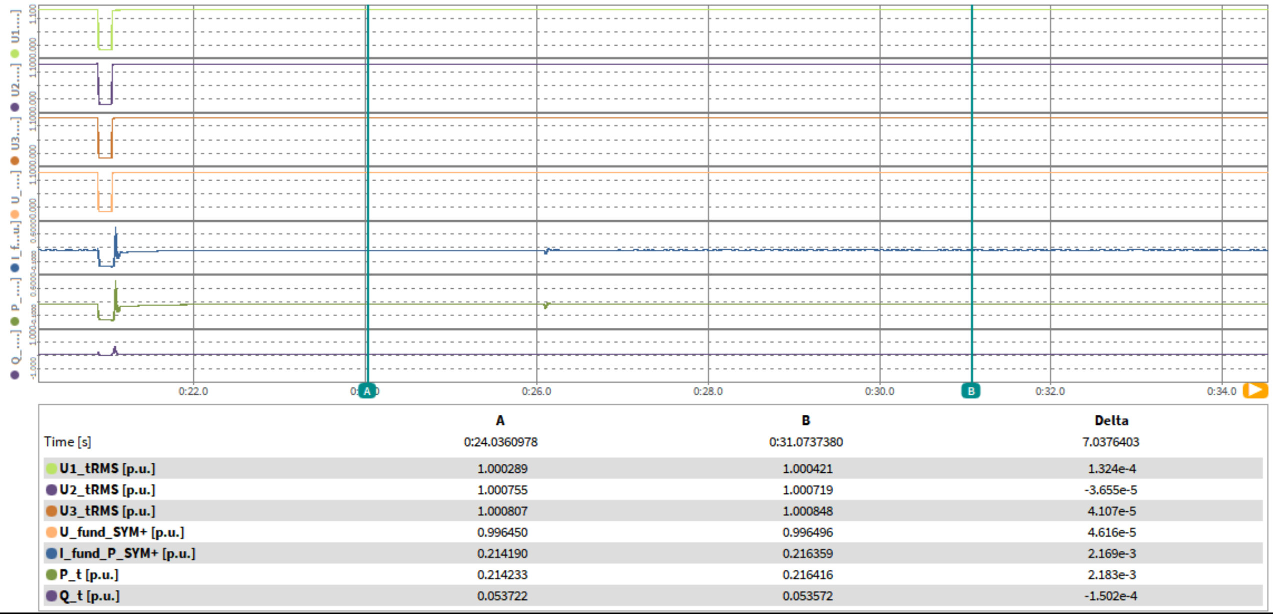
	A	B	Delta
Time [s]	0:10.8539742	0:20.8710240	0:10.0170498
● **U1_tRMS [p.u.]**	1.000289	1.005525	5.236e-3
● **U2_tRMS [p.u.]**	1.000850	0.997889	-2.961e-3
● **U3_tRMS [p.u.]**	1.000886	0.998792	-2.094e-3
● **U_fund_SYM+ [p.u.]**	0.996508	0.996354	-1.543e-4
● **I_fund_P_SYM+ [p.u.]**	0.215848	0.214215	-1.634e-3
● **P_t [p.u.]**	0.215904	0.214425	-1.479e-3
● **Q_t [p.u.]**	0.053504	0.053360	-1.445e-4

Test 1.2
Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:20.9678990	0:21.0084491	0.0405500
● **U1_tRMS [p.u.]**	0.160523	0.160648	1.253e-4
● **U2_tRMS [p.u.]**	0.160874	0.161157	2.824e-4
● **U3_tRMS [p.u.]**	0.160857	0.160505	-3.519e-4
● **U_fund_SYM+ [p.u.]**	0.160032	0.160041	8.259e-6
● **I_fund_P_SYM+ [p.u.]**	-2.296e-5	-2.755e-6	2.020e-5
● **P_t [p.u.]**	-4.948e-6	-1.560e-6	3.388e-6
● **Q_t [p.u.]**	2.241e-3	2.245e-3	3.826e-6

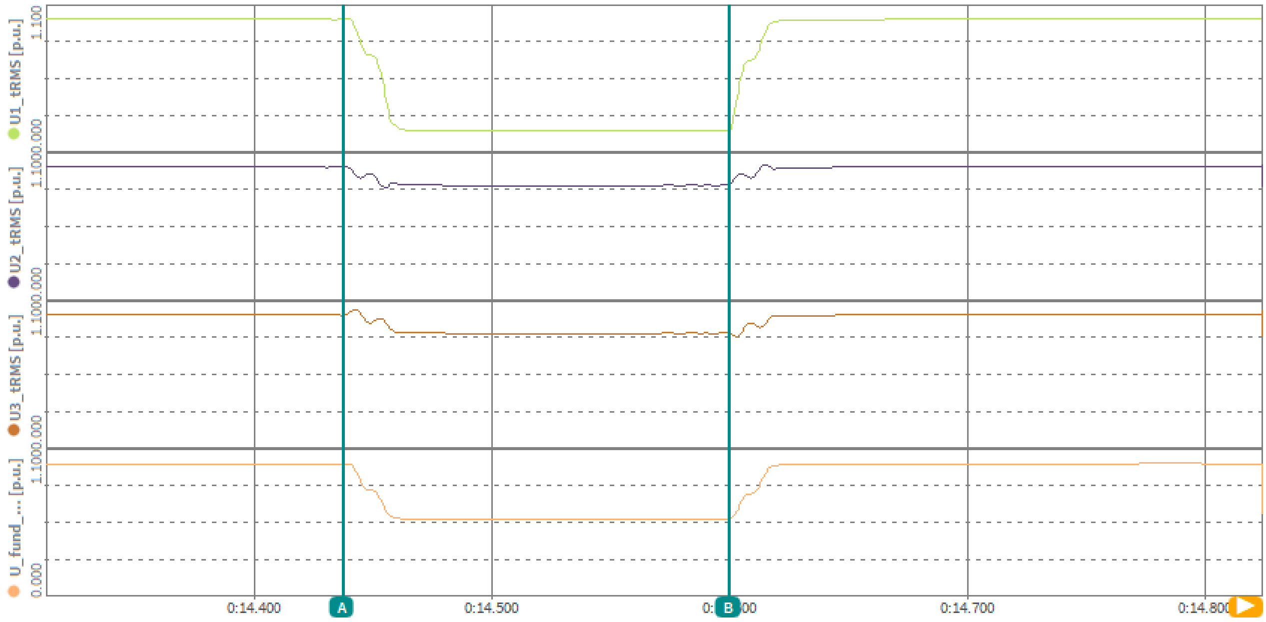
Test 1.2
Depth of fault: 0.15 p.u., three-phase SC (type A), 20% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	0:24.0360978	0:31.0737380	7.0376403
● **U1_tRMS [p.u.]**	1.000289	1.000421	1.324e-4
● **U2_tRMS [p.u.]**	1.000755	1.000719	-3.655e-5
● **U3_tRMS [p.u.]**	1.000807	1.000848	4.107e-5
● **U_fund_SYM+ [p.u.]**	0.996450	0.996496	4.616e-5
● **I_fund_P_SYM+ [p.u.]**	0.214190	0.216359	2.169e-3
● **P_t [p.u.]**	0.214233	0.216416	2.183e-3
● **Q_t [p.u.]**	0.053722	0.053572	-1.502e-4

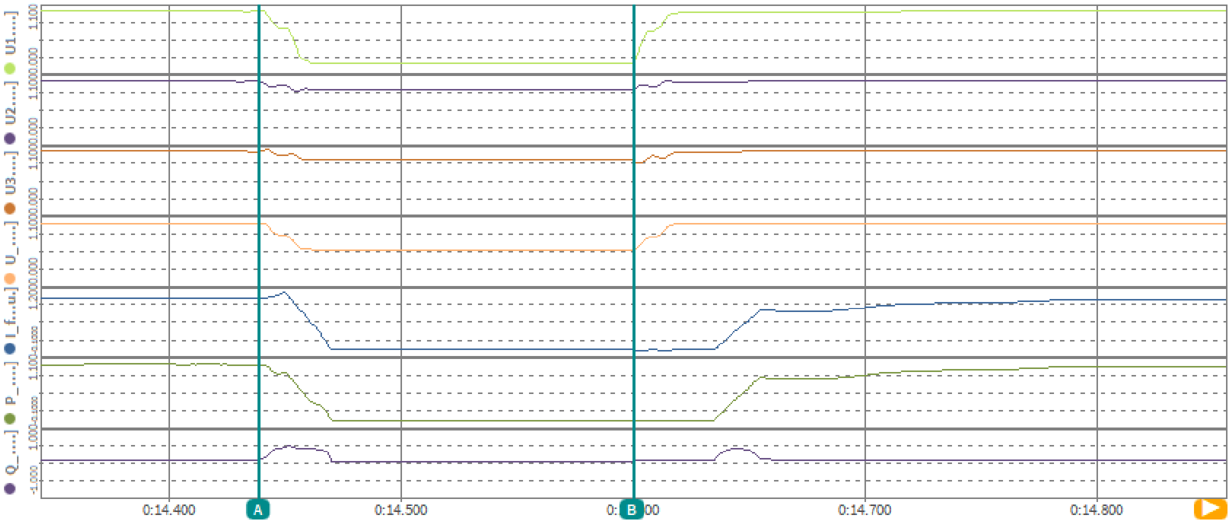
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	1.3
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:46:22
	3	Fault type (phase)	--	--	--	2-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.62
	5	Setting dip duration	250	--	ms	161
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	161
	8	Fault duration in empty load test	Total	--	ms	162
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.371
	10		Pos.			0.423
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	0.997
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0
	13	Active power	Total	t_1-10s to t_1	p.u.	0.982
	14		Pos.			0.982
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.060
	16		Pos.			0.059
	17	Cosφ	--	t_1-10s to t_1	--	0.998
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.625
	19	Line current	Phase 1	t_1+60ms	p.u.	0.015
	20		Phase 2			0.067
	21		Phase 3			0.065
	22	Line current	Phase 1	t_1+100ms	p.u.	0.015
	23		Phase 2			0.067
	24		Phase 3			0.065
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			0
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	0.996
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.982
	29		Pos.			0.982
	30	Active power rising time	Pos.	--	s	0.317
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.060
	32		Pos.			0.059
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 1.0D1
Depth of fault: 0.15 p.u., two-phase SC (type D1), 0% load (No load test)



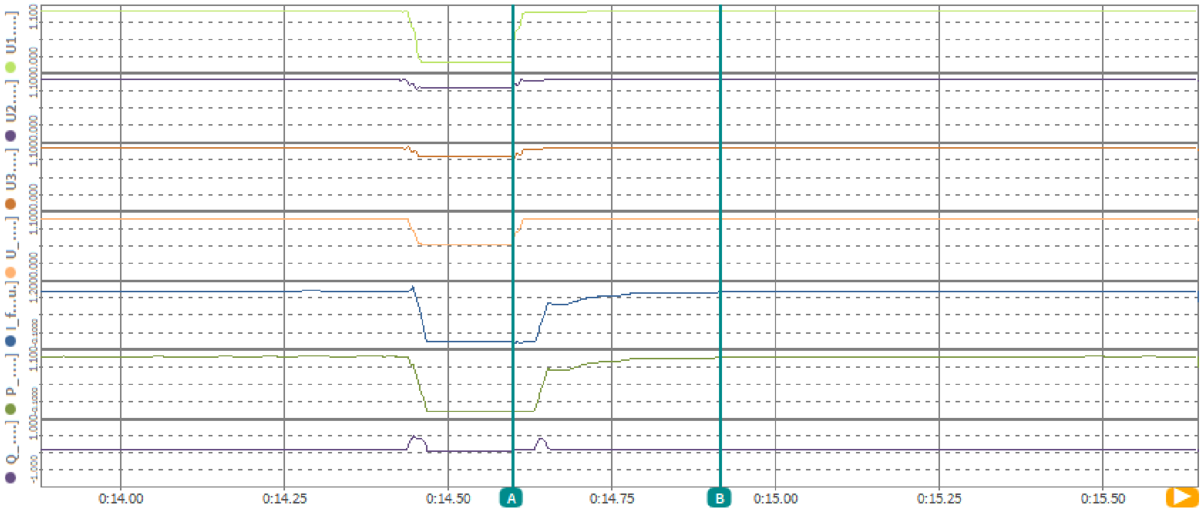
	A	B	Delta
Time [s]	0:14.437150	0:14.599577	0.162427
● **U1_tRMS [p.u.]**	0.996284	0.160074	-0.836210
● **U2_tRMS [p.u.]**	1.000455	0.860225	-0.140230
● **U3_tRMS [p.u.]**	0.992019	0.860658	-0.131361
● **U_fund_SYM+ [p.u.]**	0.991961	0.570645	-0.421316

Test 1.3
Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, fault time



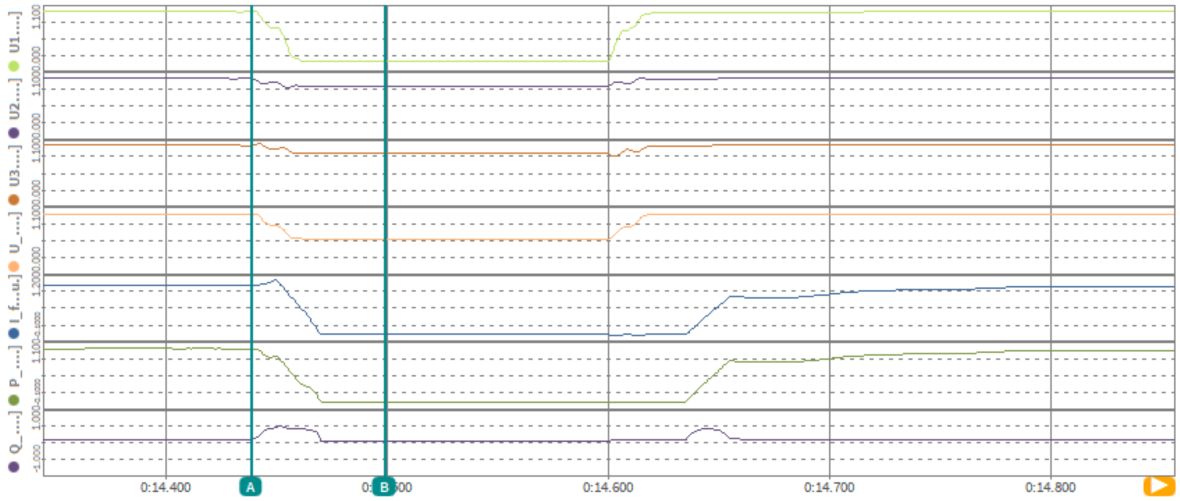
	A	B	Delta
Time [s]	0:14.4390050	0:14.6001361	0.1611310
● **U1_tRMS [p.u.]**	1.000958	0.160055	-0.840903
● **U2_tRMS [p.u.]**	0.994928	0.860560	-0.134368
● **U3_tRMS [p.u.]**	0.992846	0.860601	-0.132245
● **U_fund_SYM+ [p.u.]**	0.991960	0.570723	-0.421237
● **I_fund_P_SYM+ [p.u.]**	0.987643	-1.294e-4	-0.987772
● **P_t [p.u.]**	0.984038	-4.449e-5	-0.984083
● **Q_t [p.u.]**	0.059667	0.038784	-0.020883

Test 1.3
Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, restoring time



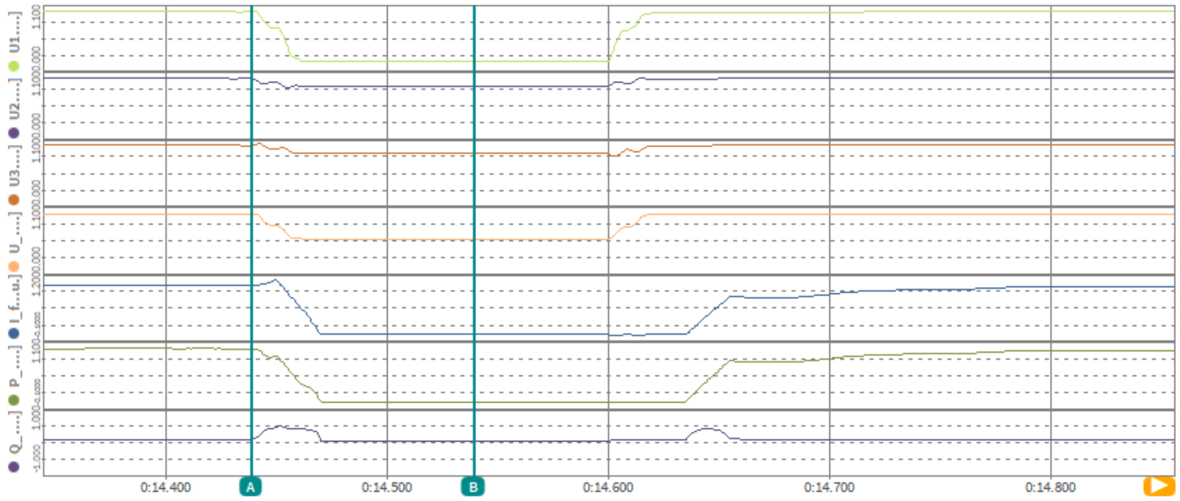
	A	B	Delta
Time [s]	0:14.5991457	0:14.9166236	0.3174779
● **U1_tRMS [p.u.]**	0.160074	0.995737	0.835664
● **U2_tRMS [p.u.]**	0.860225	0.998060	0.137835
● **U3_tRMS [p.u.]**	0.860658	0.997968	0.137310
● **U_fund_SYM+ [p.u.]**	0.570645	0.993116	0.422472
● **I_fund_P_SYM+ [p.u.]**	-2.335e-4	0.966809	0.967043
● **P_t [p.u.]**	-1.481e-4	0.964027	0.964175
● **Q_t [p.u.]**	0.038701	0.060110	0.021408

Test 1.3
Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, current after fault 60ms



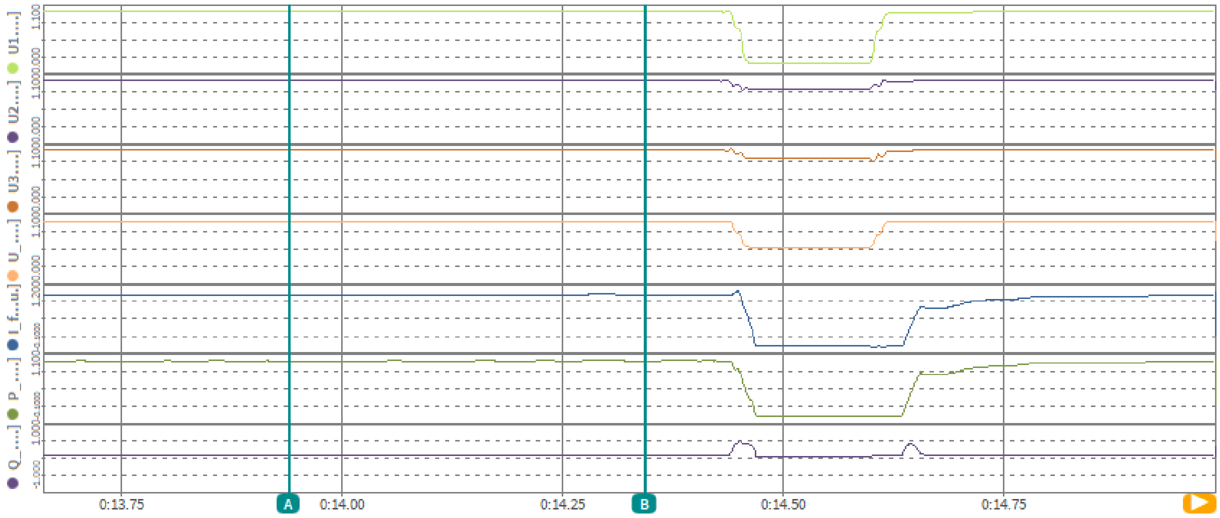
	A	B	Delta
Time [s]	0:14.4390050	0:14.4992001	0.0601951
● **U1_tRMS [p.u.]**	1.000958	0.160472	-0.840486
● **U2_tRMS [p.u.]**	0.994928	0.856403	-0.138525
● **U3_tRMS [p.u.]**	0.992846	0.856599	-0.136247
● **U_fund_SYM+ [p.u.]**	0.991960	0.568427	-0.423533
● **I_fund_P_SYM+ [p.u.]**	0.987643	-4.355e-4	-0.988078
● **P_t [p.u.]**	0.984038	-3.385e-4	-0.984377
● **Q_t [p.u.]**	0.059667	0.038461	-0.021206

Test 1.3
Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, current after fault 100ms



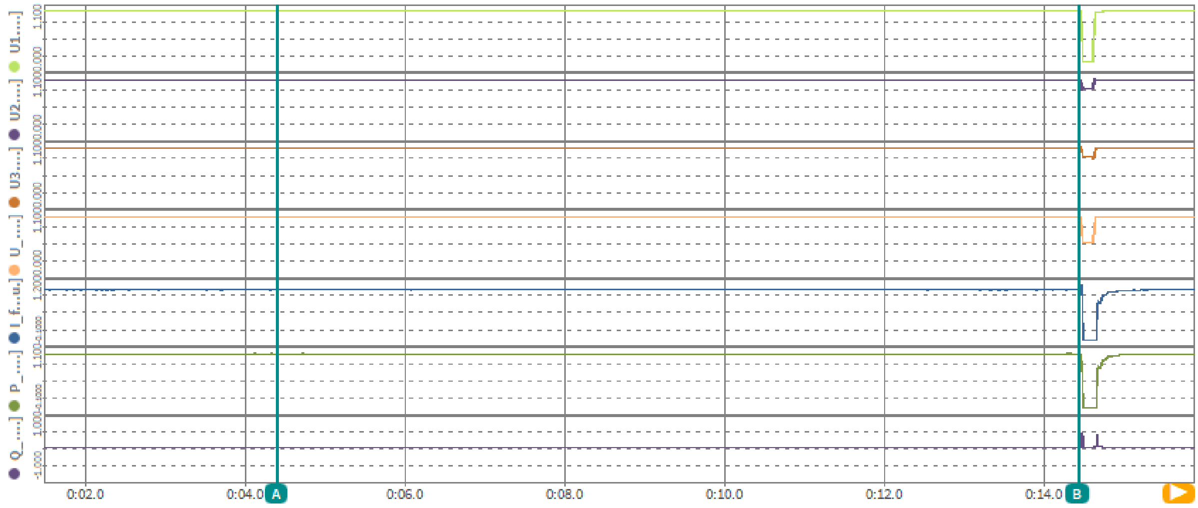
	A	B	Delta
Time [s]	0:14.4390050	0:14.5394298	0.1004247
● **U1_tRMS [p.u.]**	1.000958	0.160488	-0.840470
● **U2_tRMS [p.u.]**	0.994928	0.856594	-0.138334
● **U3_tRMS [p.u.]**	0.992846	0.856935	-0.135911
● **U_fund_SYM+ [p.u.]**	0.991960	0.568558	-0.423402
● **I_fund_P_SYM+ [p.u.]**	0.987643	-4.758e-4	-0.988119
● **P_t [p.u.]**	0.984038	-3.841e-4	-0.984422
● **Q_t [p.u.]**	0.059667	0.038481	-0.021186

Test 1.3
Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, t_1-500ms to t_1-100ms



	A	B	Delta
Time [s]	0:13.9408834	0:14.3435914	0.4027080
● **U1_tRMS [p.u.]**	0.996123	0.995977	-1.461e-4
● **U2_tRMS [p.u.]**	0.996206	0.996294	8.843e-5
● **U3_tRMS [p.u.]**	0.996305	0.996407	1.021e-4
● **U_fund_SYM+ [p.u.]**	0.992076	0.992092	1.556e-5
● **I_fund_P_SYM+ [p.u.]**	0.987586	0.986940	-6.463e-4
● **P_t [p.u.]**	0.983729	0.983097	-6.318e-4
● **Q_t [p.u.]**	0.059315	0.059858	5.429e-4

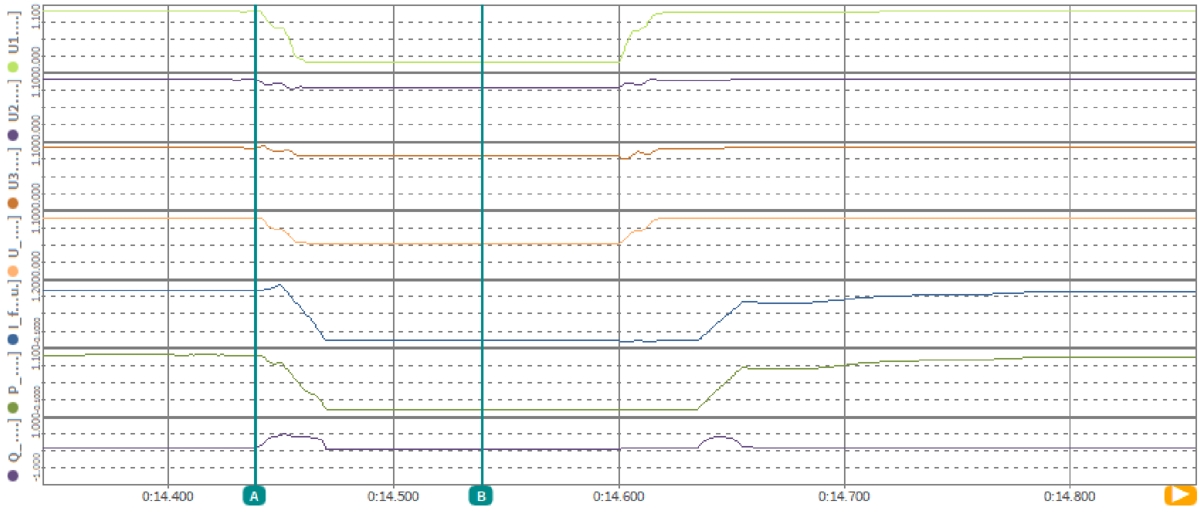
Test 1.3
Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, t_1-10s to t_1



	A	B	Delta
Time [s]	4.4071480	0:14.4176009	0:10.0104528
● **U1_tRMS [p.u.]**	0.996261	0.996049	-2.112e-4
● **U2_tRMS [p.u.]**	0.996366	0.996324	-4.140e-5
● **U3_tRMS [p.u.]**	0.996306	0.996310	4.180e-6
● **U_fund_SYM+ [p.u.]**	0.992173	0.992094	-7.874e-5
● **I_fund_P_SYM+ [p.u.]**	0.988703	0.989177	4.732e-4
● **P_t [p.u.]**	0.984940	0.985326	3.861e-4
● **Q_t [p.u.]**	0.059590	0.059854	2.638e-4

Test 1.3

Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:14.4390050	0:14.5394298	0.1004247
● **U1_tRMS [p.u.]**	1.000958	0.160488	-0.840470
● **U2_tRMS [p.u.]**	0.994928	0.856594	-0.138334
● **U3_tRMS [p.u.]**	0.992846	0.856935	-0.135911
● **U_fund_SYM+ [p.u.]**	0.991960	0.568558	-0.423402
● **I_fund_P_SYM+ [p.u.]**	0.987643	-4.758e-4	-0.988119
● **P_t [p.u.]**	0.984038	-3.841e-4	-0.984422
● **Q_t [p.u.]**	0.059667	0.038481	-0.021186

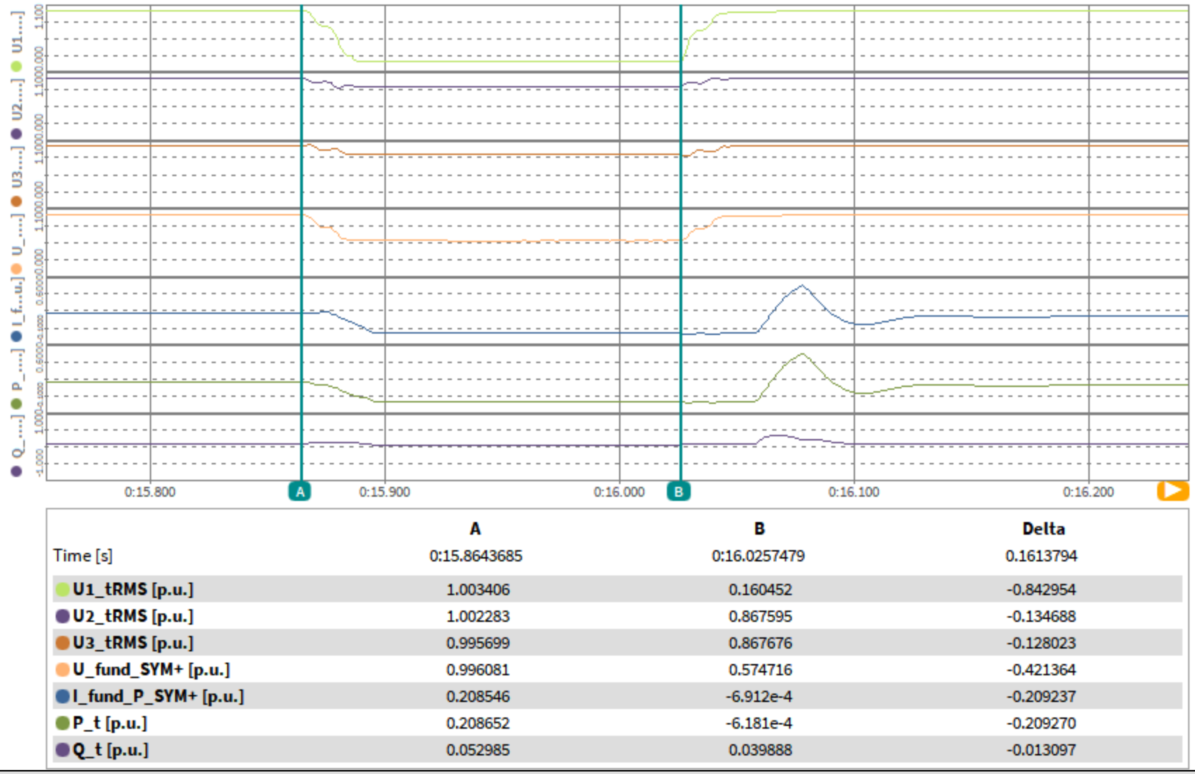
Test 1.3

Depth of fault: 0.15 p.u., three-phase SC (type D1), 100% load, t_2+3s to t_2+10s

	A	B	Delta
Time [s]	0:17.5878607	0:24.5984227	7.0105620
● **U1_tRMS [p.u.]**	0.996120	0.996210	8.996e-5
● **U2_tRMS [p.u.]**	0.996313	0.996332	1.937e-5
● **U3_tRMS [p.u.]**	0.996261	0.996324	6.303e-5
● **U_fund_SYM+ [p.u.]**	0.992096	0.992154	5.882e-5
● **I_fund_P_SYM+ [p.u.]**	0.986401	0.985304	-1.098e-3
● **P_t [p.u.]**	0.982562	0.981535	-1.027e-3
● **Q_t [p.u.]**	0.060139	0.060021	-1.182e-4

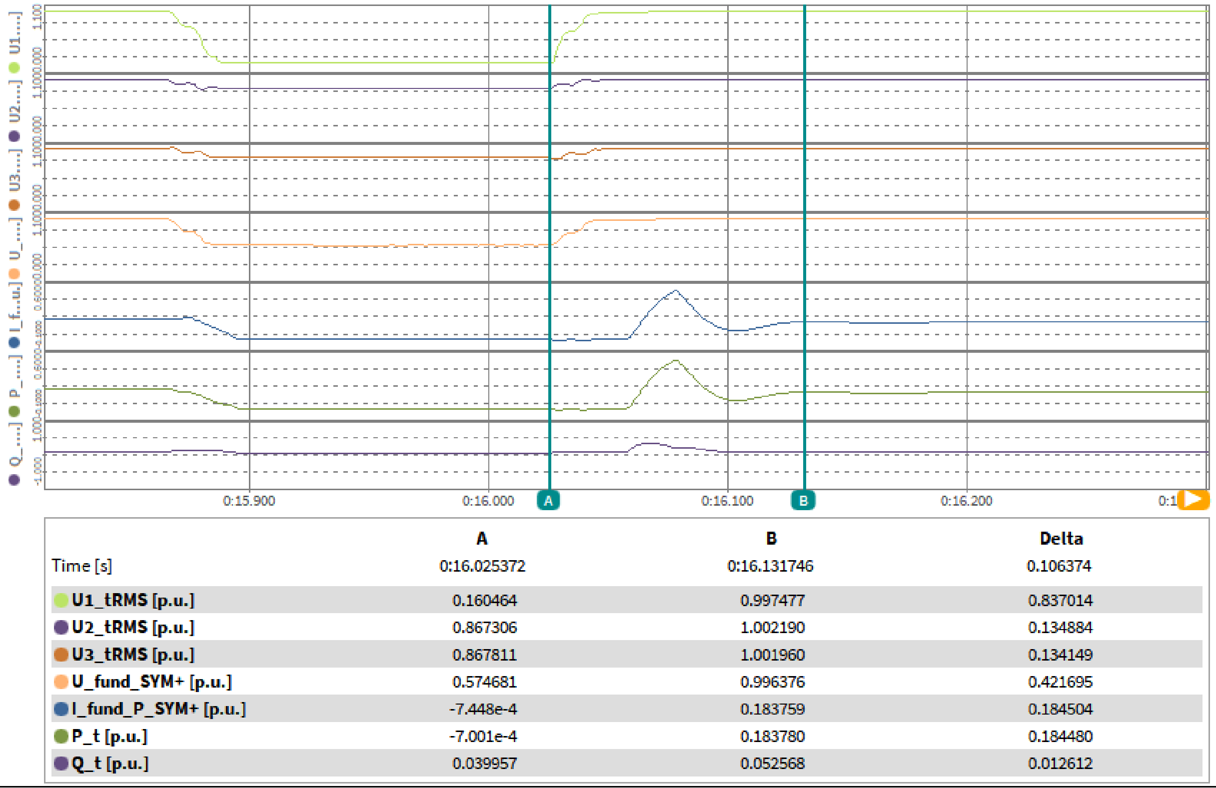
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	1.4
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:39:10
	3	Fault type (phase)	--	--	--	2-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.62
	5	Setting dip duration	160	--	ms	161
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	161
	8	Fault duration in empty load test	Total	--	ms	162
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.630
	10		Pos.			--
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.000
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	--
	13	Active power	Total	t_1-10s to t_1	p.u.	0.209
	14		Pos.			0.209
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.053
	16		Pos.			0.006
	17	Cosφ	--	t_1-10s to t_1	--	0.969
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.630
	19	Line current	Phase 1	t_1+60ms	p.u.	0.015
	20		Phase 2			0.068
	21		Phase 3			0.067
	22	Line current	Phase 1	t_1+100ms	p.u.	0.015
	23		Phase 2			0.068
	24		Phase 3			0.067
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			0
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.001
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.205
	29		Pos.			0.205
	30	Active power rising time	Pos.	--	s	0.106
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.053
	32		Pos.			0.006
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 1.4
Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, fault time



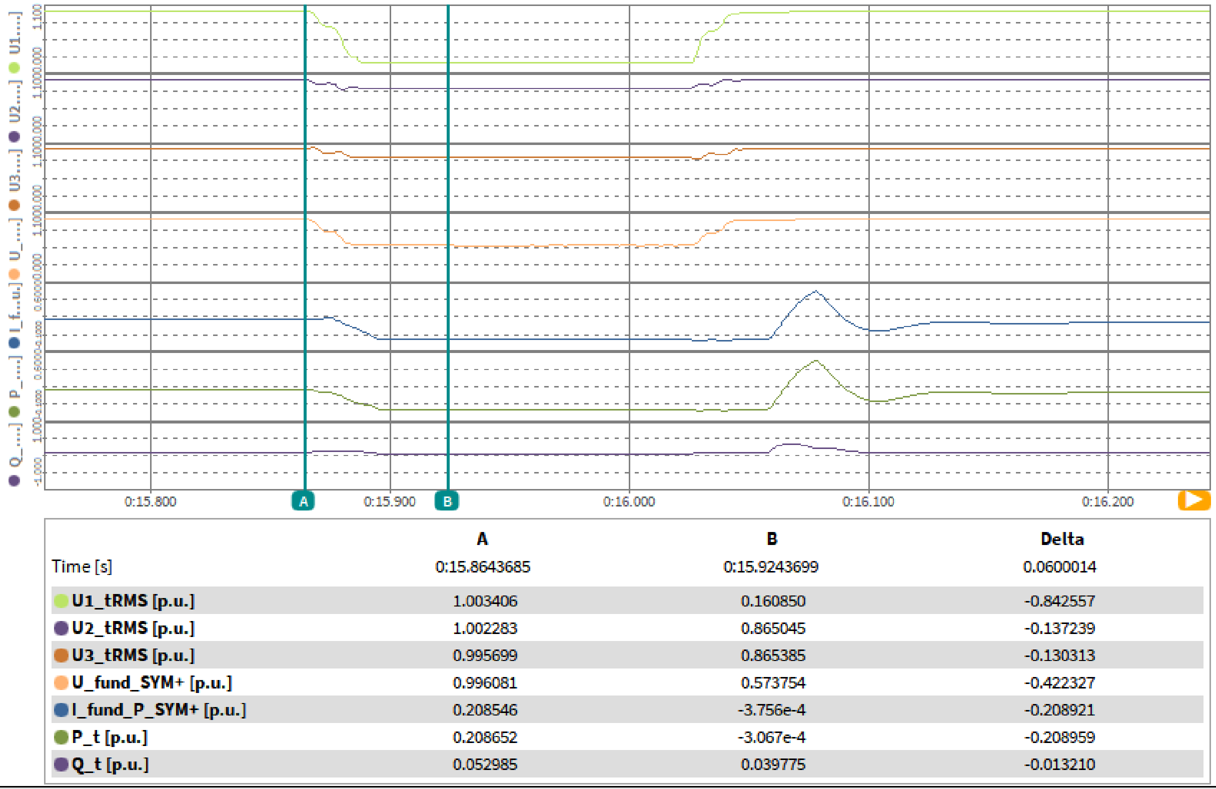
	A	B	Delta
Time [s]	0:15.8643685	0:16.0257479	0.1613794
● **U1_tRMS [p.u.]**	1.003406	0.160452	-0.842954
● **U2_tRMS [p.u.]**	1.002283	0.867595	-0.134688
● **U3_tRMS [p.u.]**	0.995699	0.867676	-0.128023
● **U_fund_SYM+ [p.u.]**	0.996081	0.574716	-0.421364
● **I_fund_P_SYM+ [p.u.]**	0.208546	-6.912e-4	-0.209237
● **P_t [p.u.]**	0.208652	-6.181e-4	-0.209270
● **Q_t [p.u.]**	0.052985	0.039888	-0.013097

Test 1.4
Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, restoring time



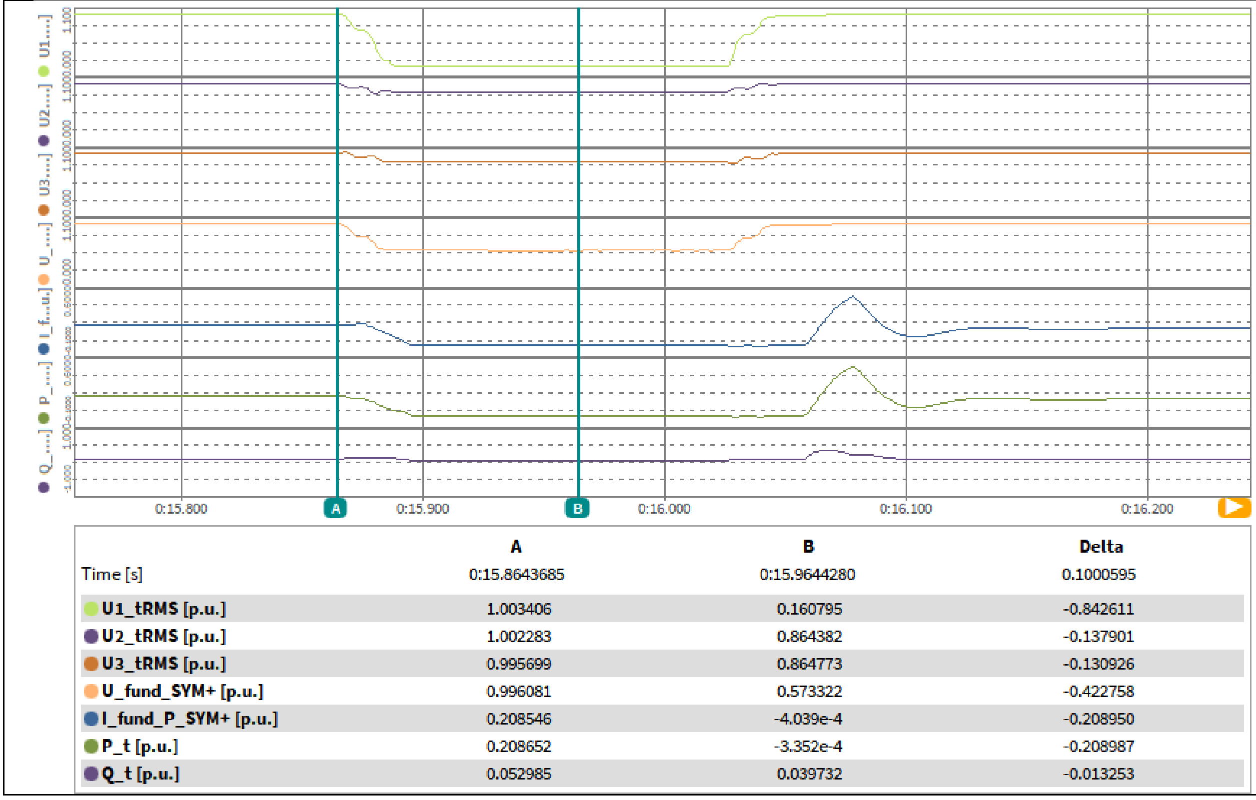
	A	B	Delta
Time [s]	0:16.025372	0:16.131746	0.106374
● **U1_tRMS [p.u.]**	0.160464	0.997477	0.837014
● **U2_tRMS [p.u.]**	0.867306	1.002190	0.134884
● **U3_tRMS [p.u.]**	0.867811	1.001960	0.134149
● **U_fund_SYM+ [p.u.]**	0.574681	0.996376	0.421695
● **I_fund_P_SYM+ [p.u.]**	-7.448e-4	0.183759	0.184504
● **P_t [p.u.]**	-7.001e-4	0.183780	0.184480
● **Q_t [p.u.]**	0.039957	0.052568	0.012612

Test 1.4
Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, current after fault 60ms



	A	B	Delta
Time [s]	0:15.8643685	0:15.9243699	0.0600014
● **U1_tRMS [p.u.]**	1.003406	0.160850	-0.842557
● **U2_tRMS [p.u.]**	1.002283	0.865045	-0.137239
● **U3_tRMS [p.u.]**	0.995699	0.865385	-0.130313
● **U_fund_SYM+ [p.u.]**	0.996081	0.573754	-0.422327
● **I_fund_P_SYM+ [p.u.]**	0.208546	-3.756e-4	-0.208921
● **P_t [p.u.]**	0.208652	-3.067e-4	-0.208959
● **Q_t [p.u.]**	0.052985	0.039775	-0.013210

Test 1.4
Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, current after fault 100ms



	A	B	Delta
Time [s]	0:15.8643685	0:15.9644280	0.1000595
● **U1_tRMS [p.u.]**	1.003406	0.160795	-0.842611
● **U2_tRMS [p.u.]**	1.002283	0.864382	-0.137901
● **U3_tRMS [p.u.]**	0.995699	0.864773	-0.130926
● **U_fund_SYM+ [p.u.]**	0.996081	0.573322	-0.422758
● **I_fund_P_SYM+ [p.u.]**	0.208546	-4.039e-4	-0.208950
● **P_t [p.u.]**	0.208652	-3.352e-4	-0.208987
● **Q_t [p.u.]**	0.052985	0.039732	-0.013253

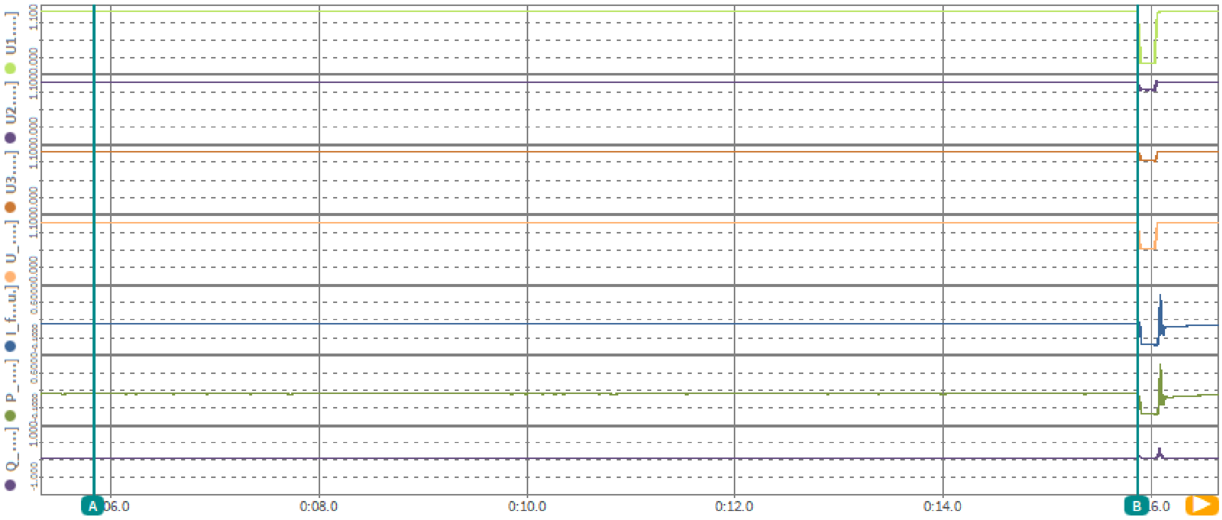
Test 1.4

Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, t_1-500ms to t_1-100ms

	A	B	Delta
Time [s]	0:15.362590	0:15.762684	0.400094
● **U1_tRMS [p.u.]**	1.000298	1.000302	4.246e-6
● **U2_tRMS [p.u.]**	1.000756	1.000682	-7.444e-5
● **U3_tRMS [p.u.]**	1.000633	1.000594	-3.947e-5
● **U_fund_SYM+ [p.u.]**	0.996395	0.996359	-3.639e-5
● **I_fund_P_SYM+ [p.u.]**	0.208789	0.209058	2.685e-4
● **P_t [p.u.]**	0.208829	0.209087	2.583e-4
● **Q_t [p.u.]**	0.052854	0.052837	-1.696e-5

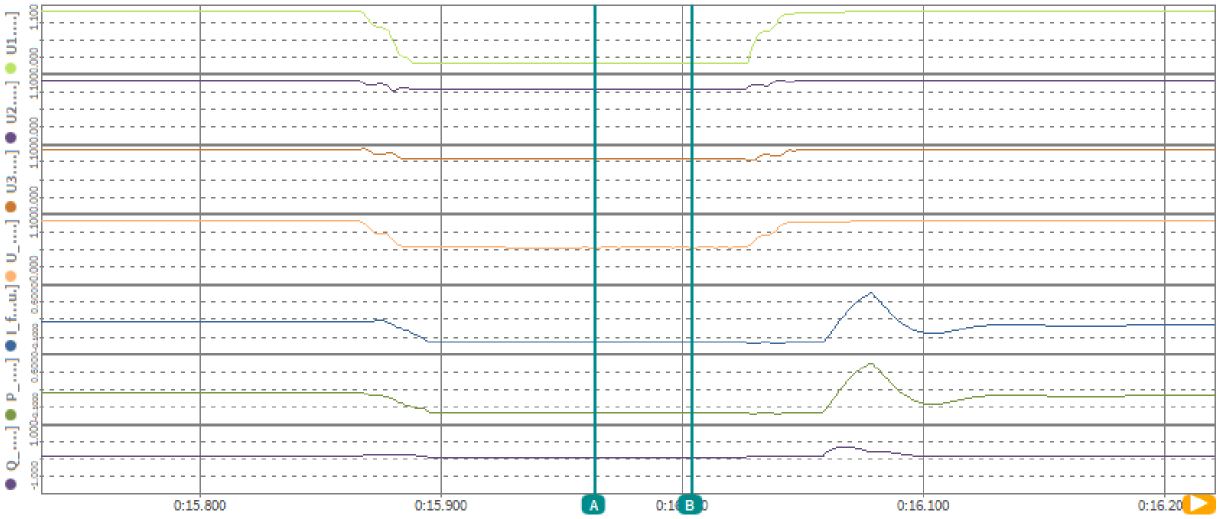
Test 1.4

Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, t_1-10s to t_1



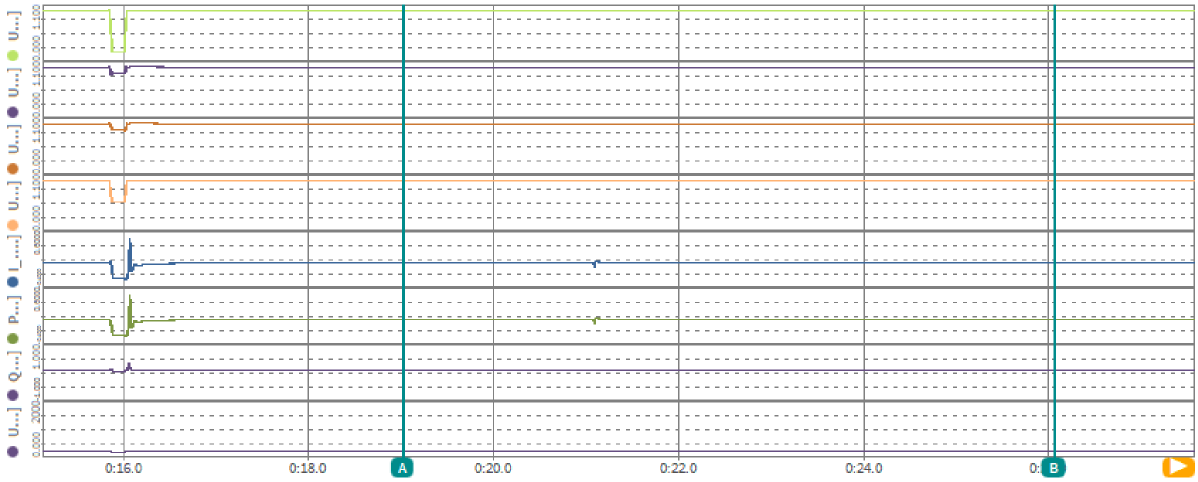
	A	B	Delta
Time [s]	5.848282	0:15.864216	0:10.015934
● **U1_tRMS [p.u.]**	1.000311	1.003406	3.095e-3
● **U2_tRMS [p.u.]**	1.000685	1.002283	1.598e-3
● **U3_tRMS [p.u.]**	1.000741	0.995699	-5.042e-3
● **U_fund_SYM+ [p.u.]**	0.996414	0.996081	-3.329e-4
● **I_fund_P_SYM+ [p.u.]**	0.209404	0.208546	-8.580e-4
● **P_t [p.u.]**	0.209444	0.208652	-7.917e-4
● **Q_t [p.u.]**	0.052784	0.052985	2.010e-4

Test 1.4
Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:15.963509	0:16.003598	0.040089
● **U1_tRMS [p.u.]**	0.160777	0.160894	1.174e-4
● **U2_tRMS [p.u.]**	0.864390	0.865442	1.052e-3
● **U3_tRMS [p.u.]**	0.864770	0.865057	2.871e-4
● **U_fund_SYM+ [p.u.]**	0.573343	0.573771	4.281e-4
● **I_fund_P_SYM+ [p.u.]**	-3.979e-4	-4.284e-4	-3.054e-5
● **P_t [p.u.]**	-3.320e-4	-3.593e-4	-2.736e-5
● **Q_t [p.u.]**	0.039735	0.039867	1.323e-4

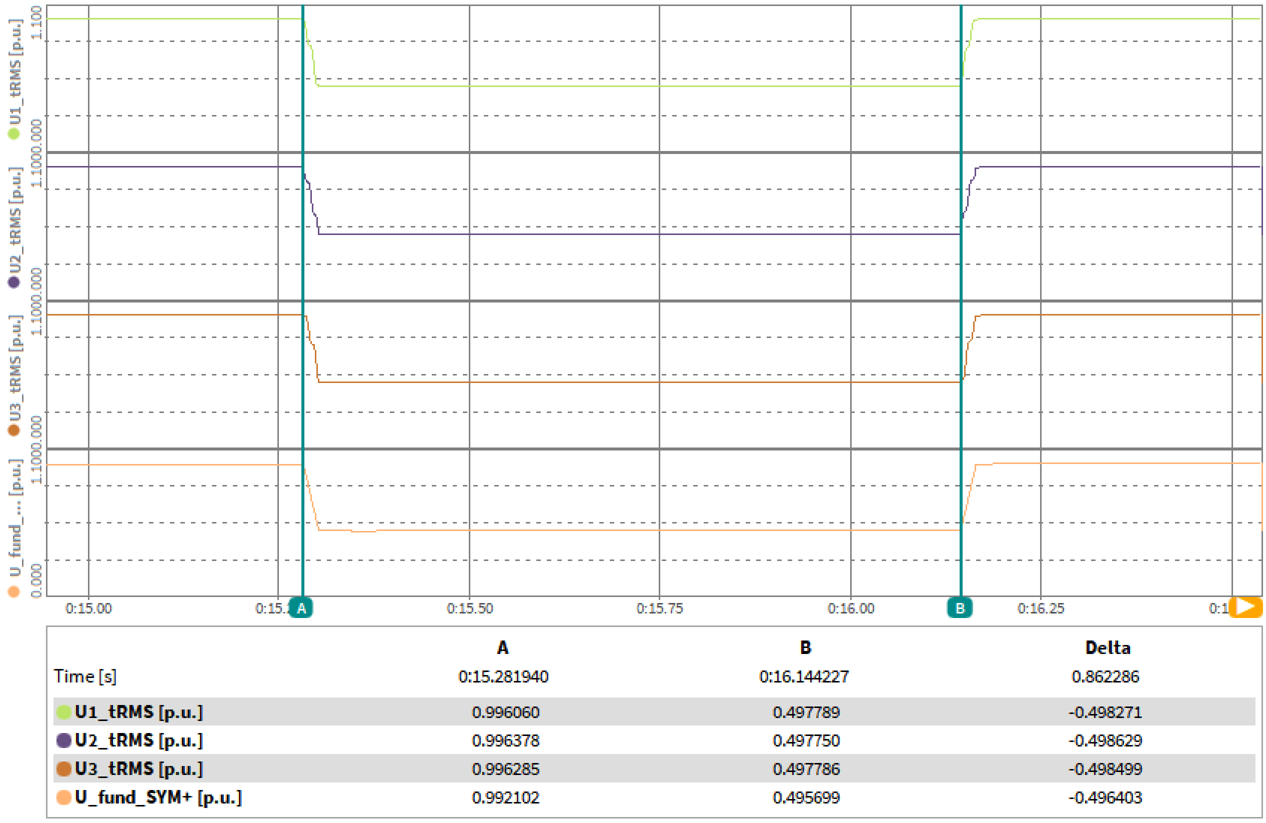
Test 1.4
Depth of fault: 0.15 p.u., three-phase SC (type D1), 20% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	0:19.0278839	0:26.0559015	7.0280176
● **U1_tRMS [p.u.]**	1.000397	1.000439	4.173e-5
● **U2_tRMS [p.u.]**	1.000645	1.000669	2.355e-5
● **U3_tRMS [p.u.]**	1.000705	1.000506	-1.996e-4
● **U_fund_SYM+ [p.u.]**	0.996418	0.996373	-4.494e-5
● **I_fund_P_SYM+ [p.u.]**	0.209674	0.204669	-5.005e-3
● **P_t [p.u.]**	0.209717	0.204700	-5.017e-3
● **Q_t [p.u.]**	0.052565	0.052650	8.539e-5
● **U_tRMS@POWER/0 [V]**	230.1354	230.1210	-0.014450

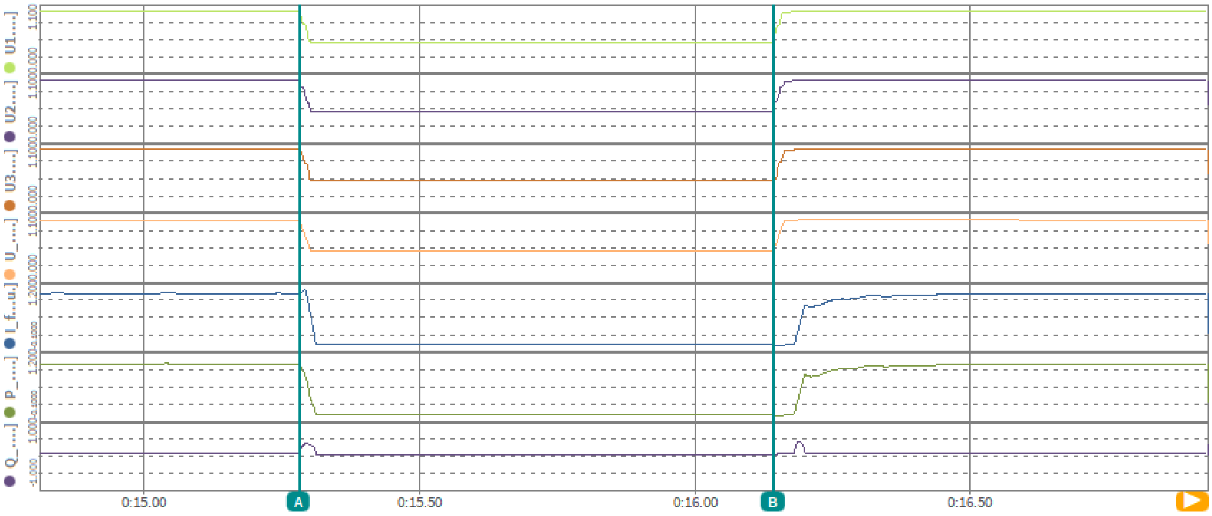
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	2.1
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	15:24:45
	3	Fault type (phase)	--	--	--	3-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.5
	5	Setting dip duration	860	--	ms	861
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	861
	8	Fault duration in empty load test	Total	--	ms	862
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.498
	10		Pos.			0.496
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.00
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	--
	13	Active power	Total	t_1-10s to t_1	p.u.	0.986
	14		Pos.			0.986
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.061
	16		Pos.			0.011
	17	Cosφ	--	t_1-10s to t_1	--	0.998
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0491
	19	Line current	Phase 1	t_1+60ms	p.u.	0.043
	20		Phase 2			0.040
	21		Phase 3			0.040
	22	Line current	Phase 1	t_1+100ms	p.u.	0.043
	23		Phase 2			0.040
	24		Phase 3			0.040
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			0
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	0.996
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.987
	29		Pos.			0.987
	30	Active power rising time	Pos.	--	s	0.306
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.061
	32		Pos.			0.007
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 2.0A
Depth of fault: 0.50 p.u., three-phase SC (type A), 0% load



	A	B	Delta
Time [s]	0:15.281940	0:16.144227	0.862286
● **U1_tRMS [p.u.]**	0.996060	0.497789	-0.498271
● **U2_tRMS [p.u.]**	0.996378	0.497750	-0.498629
● **U3_tRMS [p.u.]**	0.996285	0.497786	-0.498499
● **U_fund_SYM+ [p.u.]**	0.992102	0.495699	-0.496403

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, fault time

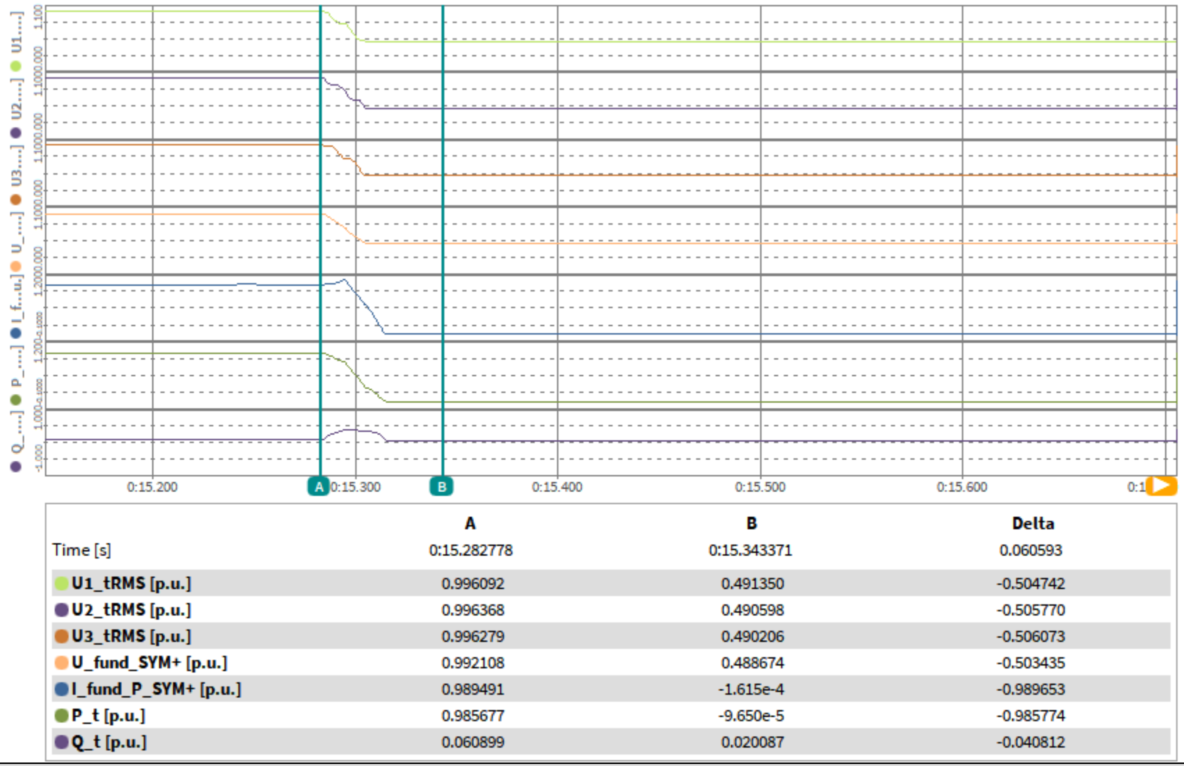


	A	B	Delta
Time [s]	0:15.282778	0:16.144048	0.861270
● **U1_tRMS [p.u.]**	0.996092	0.497789	-0.498303
● **U2_tRMS [p.u.]**	0.996368	0.497750	-0.498618
● **U3_tRMS [p.u.]**	0.996279	0.497786	-0.498493
● **U_fund_SYM+ [p.u.]**	0.992108	0.495699	-0.496410
● **I_fund_P_SYM+ [p.u.]**	0.989491	-5.287e-4	-0.990020
● **P_t [p.u.]**	0.985677	-2.812e-4	-0.985959
● **Q_t [p.u.]**	0.060899	0.020631	-0.040268

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, restoring time

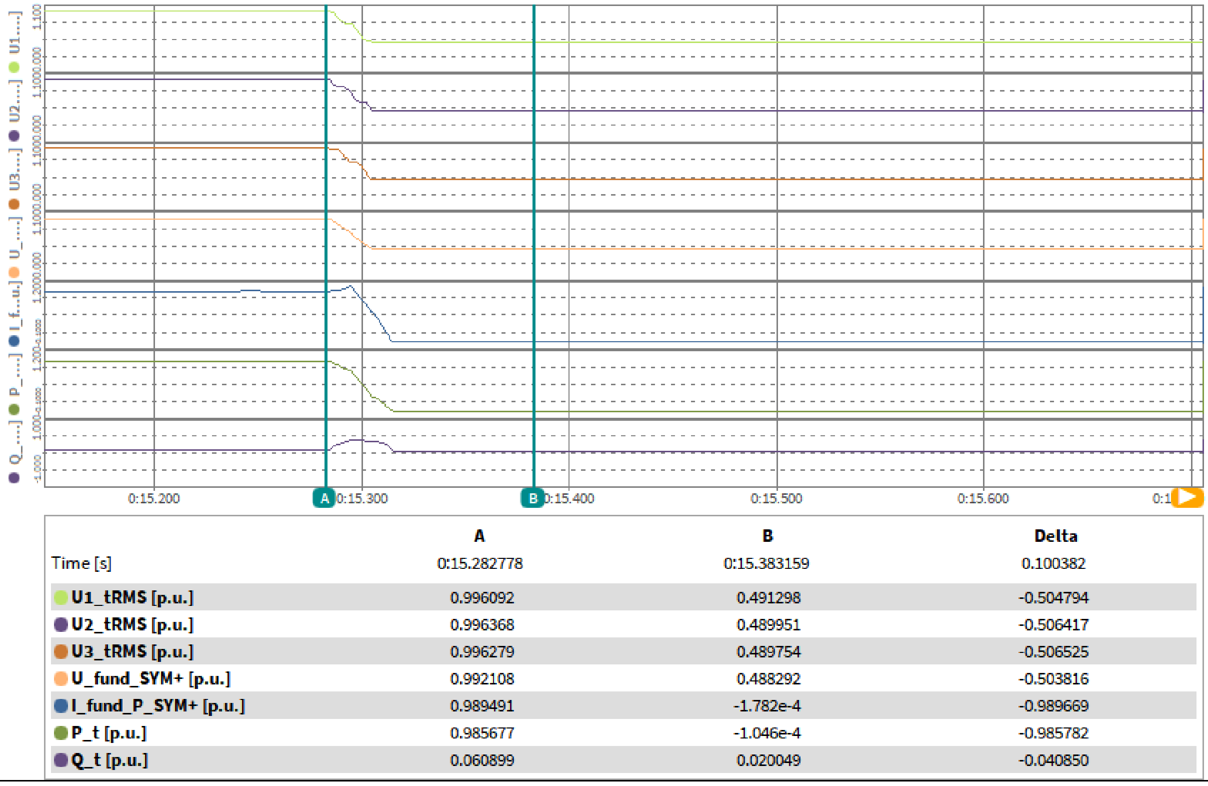
	A	B	Delta
Time [s]	0:16.143422	0:16.449411	0.305989
● **U1_tRMS [p.u.]**	0.497776	1.000224	0.502448
● **U2_tRMS [p.u.]**	0.497776	1.000268	0.502492
● **U3_tRMS [p.u.]**	0.497757	1.000493	0.502736
● **U_fund_SYM+ [p.u.]**	0.495694	0.996176	0.500483
● **I_fund_P_SYM+ [p.u.]**	-5.317e-4	0.972185	0.972717
● **P_t [p.u.]**	-2.826e-4	0.972358	0.972641
● **Q_t [p.u.]**	0.020631	0.060819	0.040188

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, current after fault 60ms



	A	B	Delta
Time [s]	0:15.282778	0:15.343371	0.060593
● **U1_tRMS [p.u.]**	0.996092	0.491350	-0.504742
● **U2_tRMS [p.u.]**	0.996368	0.490598	-0.505770
● **U3_tRMS [p.u.]**	0.996279	0.490206	-0.506073
● **U_fund_SYM+ [p.u.]**	0.992108	0.488674	-0.503435
● **I_fund_P_SYM+ [p.u.]**	0.989491	-1.615e-4	-0.989653
● **P_t [p.u.]**	0.985677	-9.650e-5	-0.985774
● **Q_t [p.u.]**	0.060899	0.020087	-0.040812

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, current after fault 100ms



	A	B	Delta
Time [s]	0:15.282778	0:15.383159	0.100382
● **U1_tRMS [p.u.]**	0.996092	0.491298	-0.504794
● **U2_tRMS [p.u.]**	0.996368	0.489951	-0.506417
● **U3_tRMS [p.u.]**	0.996279	0.489754	-0.506525
● **U_fund_SYM+ [p.u.]**	0.992108	0.488292	-0.503816
● **I_fund_P_SYM+ [p.u.]**	0.989491	-1.782e-4	-0.989669
● **P_t [p.u.]**	0.985677	-1.046e-4	-0.985782
● **Q_t [p.u.]**	0.060899	0.020049	-0.040850

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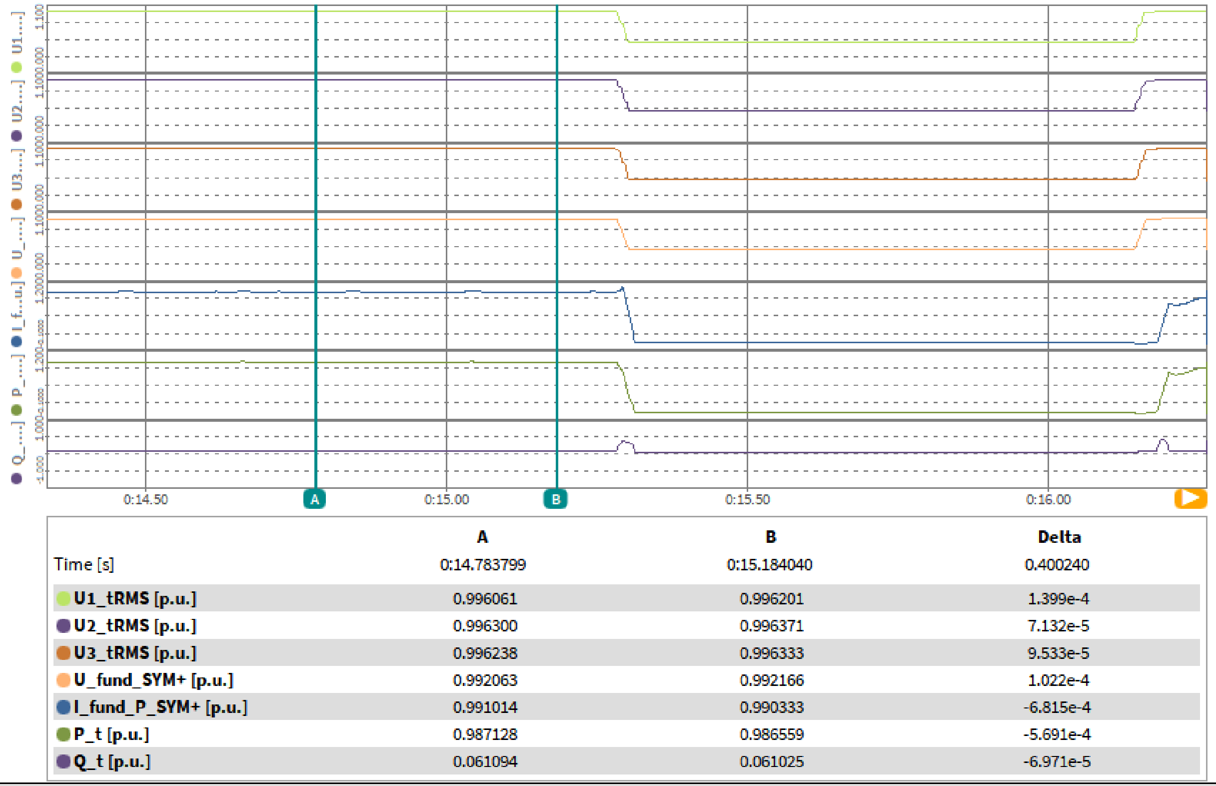
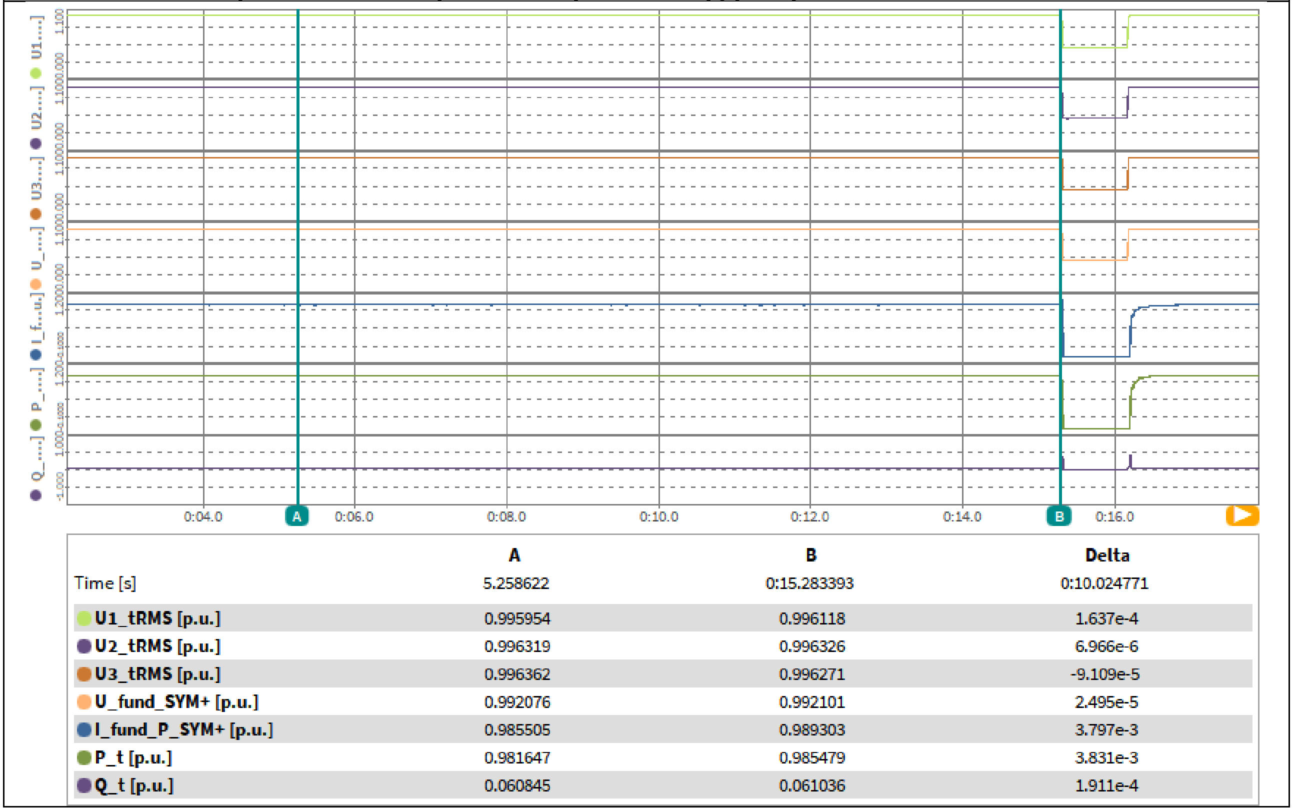
Clause	Requirement - Test	Result - Remark	Verdict

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, t$_1$-500ms to t$_1$-100ms



	A	B	Delta
Time [s]	0:14.783799	0:15.184040	0.400240
● U1_tRMS [p.u.]	0.996061	0.996201	1.399e-4
● U2_tRMS [p.u.]	0.996300	0.996371	7.132e-5
● U3_tRMS [p.u.]	0.996238	0.996333	9.533e-5
● U_fund_SYM+ [p.u.]	0.992063	0.992166	1.022e-4
● I_fund_P_SYM+ [p.u.]	0.991014	0.990333	-6.815e-4
● P_t [p.u.]	0.987128	0.986559	-5.691e-4
● Q_t [p.u.]	0.061094	0.061025	-6.971e-5

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, t$_1$-10s to t$_1$



	A	B	Delta
Time [s]	5.258622	0:15.283393	0:10.024771
● U1_tRMS [p.u.]	0.995954	0.996118	1.637e-4
● U2_tRMS [p.u.]	0.996319	0.996326	6.966e-6
● U3_tRMS [p.u.]	0.996362	0.996271	-9.109e-5
● U_fund_SYM+ [p.u.]	0.992076	0.992101	2.495e-5
● I_fund_P_SYM+ [p.u.]	0.985505	0.989303	3.797e-3
● P_t [p.u.]	0.981647	0.985479	3.831e-3
● Q_t [p.u.]	0.060845	0.061036	1.911e-4

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, t_1+100ms to t_2-20ms

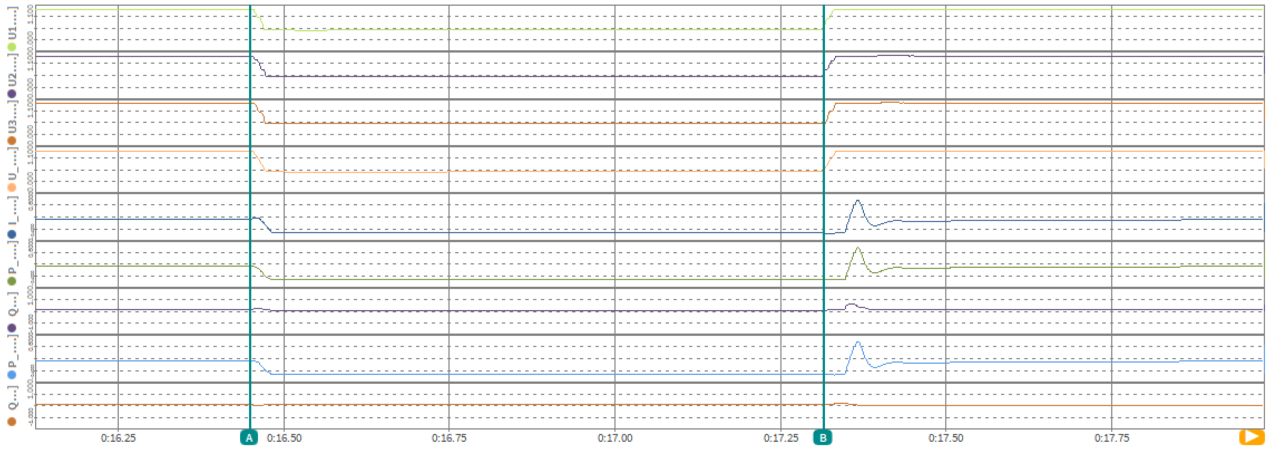
	A	B	Delta
Time [s]	0:15.385911	0:16.125763	0.739853
● **U1_tRMS [p.u.]**	0.491317	0.497747	6.430e-3
● **U2_tRMS [p.u.]**	0.489995	0.497702	7.707e-3
● **U3_tRMS [p.u.]**	0.489859	0.497703	7.844e-3
● **U_fund_SYM+ [p.u.]**	0.488347	0.495641	7.294e-3
● **I_fund_P_SYM+ [p.u.]**	-1.825e-4	-5.452e-4	-3.627e-4
● **P_t [p.u.]**	-1.068e-4	-2.888e-4	-1.820e-4
● **Q_t [p.u.]**	0.020054	0.020631	5.773e-4

Test 2.1
Depth of fault: 0.5 p.u., three-phase SC (type A), 100% load, t_2+3s to t_2+10s

	A	B	Delta
Time [s]	0:19.115682	0:26.171097	7.055415
● **U1_tRMS [p.u.]**	0.996264	0.996175	-8.983e-5
● **U2_tRMS [p.u.]**	0.996271	0.996348	7.696e-5
● **U3_tRMS [p.u.]**	0.996363	0.996425	6.157e-5
● **U_fund_SYM+ [p.u.]**	0.992165	0.992182	1.762e-5
● **I_fund_P_SYM+ [p.u.]**	0.991258	0.987464	-3.794e-3
● **P_t [p.u.]**	0.987471	0.983715	-3.756e-3
● **Q_t [p.u.]**	0.061070	0.060813	-2.566e-4

Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	2.2
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	15:39:34
	3	Fault type (phase)	--	--	--	3-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.5
	5	Setting dip duration	860	--	ms	865
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	865
	8	Fault duration in empty load test	Total	--	ms	862
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.500
	10		Pos.			0.498
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.001
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0.210
	13	Active power	Total	t_1-10s to t_1	p.u.	0.210
	14		Pos.			0.210
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.053
	16		Pos.			0.007
	17	Cosφ	--	t_1-10s to t_1	--	0.970
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.497
	19	Line current	Phase 1	t_1+60ms	p.u.	0.044
	20		Phase 2			0.041
	21		Phase 3			0.041
	22	Line current	Phase 1	t_1+100ms	p.u.	0.044
	23		Phase 2			0.041
	24		Phase 3			0.041
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			0
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.00
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.40
	29		Pos.			--
	30	Active power rising time	Pos.	--	s	0.201
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.03
	32		Pos.			--
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, fault time

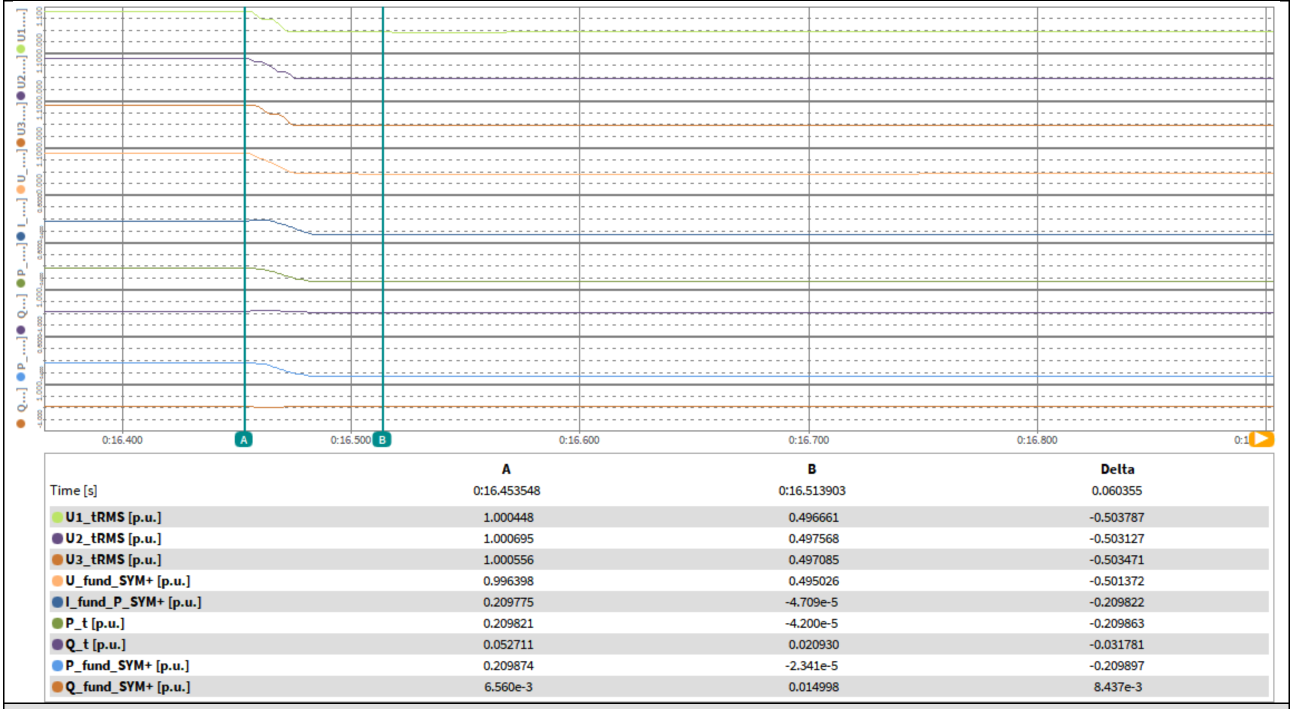


	A	B	Delta
Time [s]	0:16.449576	0:17.314947	0.865371
● **U1_tRMS [p.u.]**	1.000337	0.500236	-0.500101
● **U2_tRMS [p.u.]**	1.000693	0.500322	-0.500371
● **U3_tRMS [p.u.]**	1.000621	0.500426	-0.500195
● **U_fund_SYM+ [p.u.]**	0.996382	0.498238	-0.498144
● **I_fund_P_SYM+ [p.u.]**	0.209664	-4.640e-4	-0.210128
● **P_t [p.u.]**	0.209703	-2.513e-4	-0.209955
● **Q_t [p.u.]**	0.052674	0.021179	-0.031495
● **P_fund_SYM+ [p.u.]**	0.209760	-2.321e-4	-0.209992
● **Q_fund_SYM+ [p.u.]**	6.582e-3	0.015224	8.642e-3

Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, restoring time

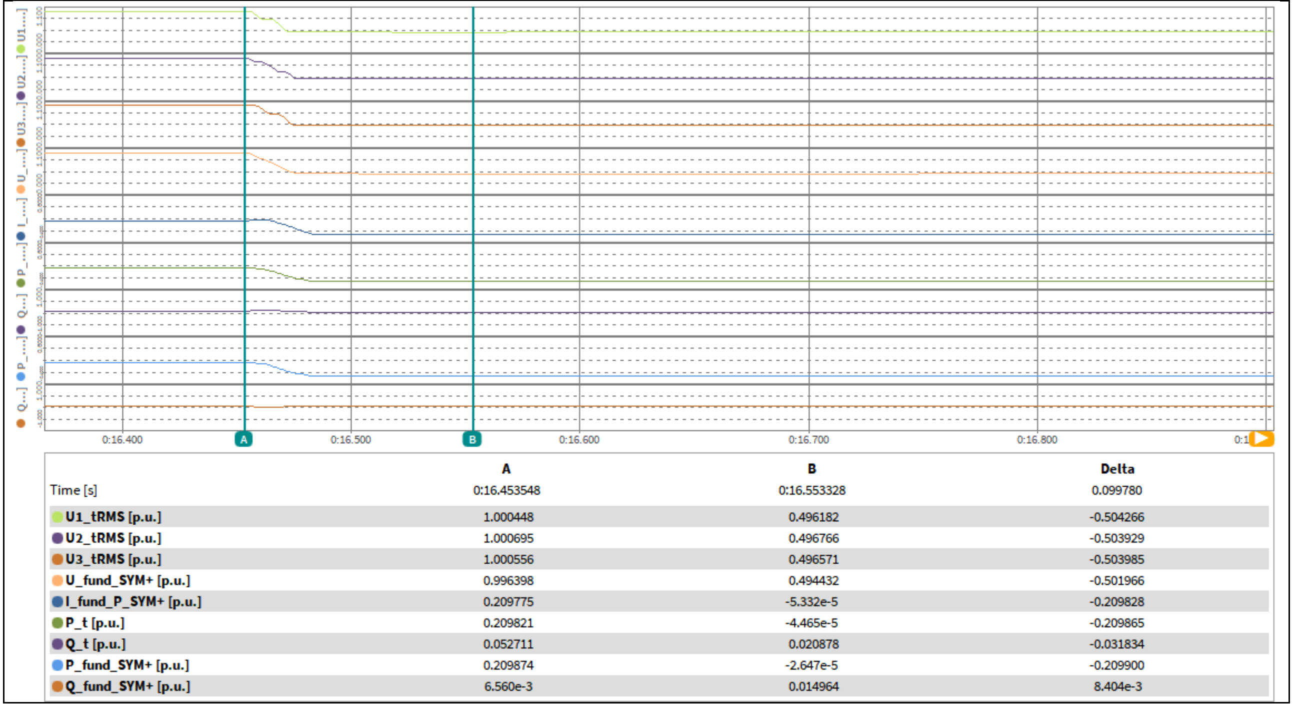
	A	B	Delta
Time [s]	0:17.315715	0:17.516785	0.201070
● **U1_tRMS [p.u.]**	0.500691	1.001968	0.501277
● **U2_tRMS [p.u.]**	0.502007	1.004996	0.502989
● **U3_tRMS [p.u.]**	0.501021	1.004900	0.503878
● **U_fund_SYM+ [p.u.]**	0.499073	0.999776	0.500703
● **I_fund_P_SYM+ [p.u.]**	-1.820e-3	0.182792	0.184611
● **P_t [p.u.]**	-1.038e-3	0.183441	0.184479
● **Q_t [p.u.]**	0.022133	0.052019	0.029886
● **P_fund_SYM+ [p.u.]**	-9.118e-4	0.183498	0.184410
● **Q_fund_SYM+ [p.u.]**	0.015286	-4.051e-3	-0.019338

Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, current after fault 60ms



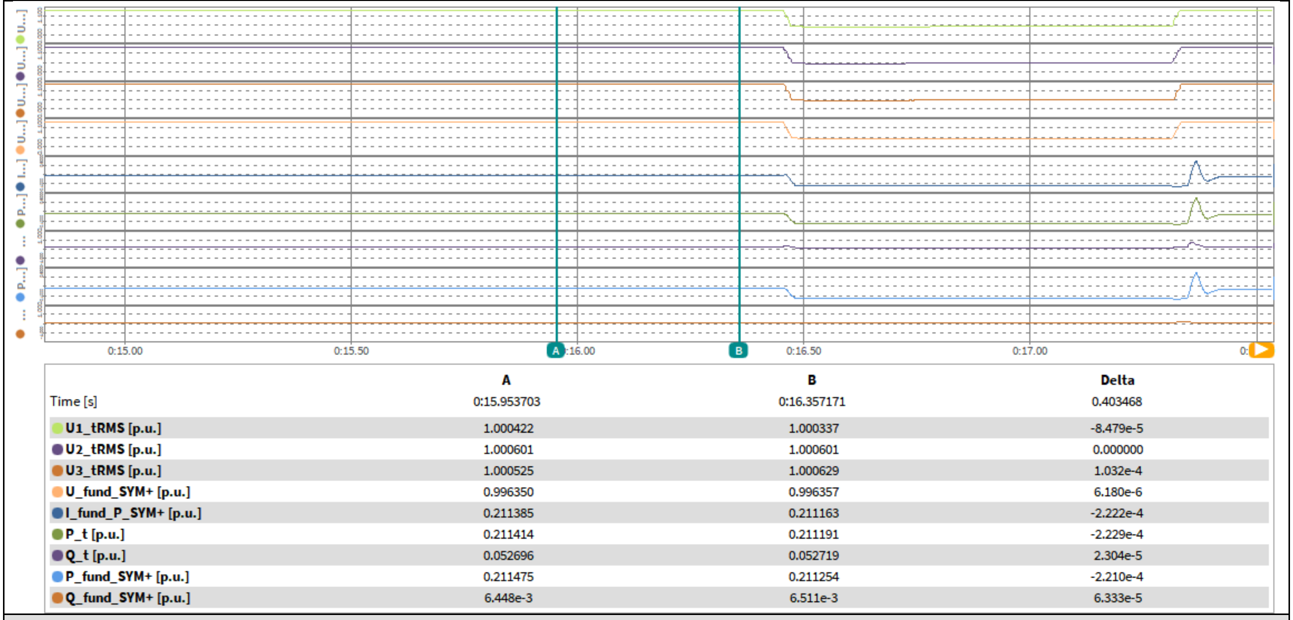
	A	B	Delta
Time [s]	0:16.453548	0:16.513903	0.060355
● **U1_tRMS [p.u.]**	1.000448	0.496661	-0.503787
● **U2_tRMS [p.u.]**	1.000695	0.497568	-0.503127
● **U3_tRMS [p.u.]**	1.000556	0.497085	-0.503471
● **U_fund_SYM+ [p.u.]**	0.996398	0.495026	-0.501372
● **I_fund_P_SYM+ [p.u.]**	0.209775	-4.709e-5	-0.209822
● **P_t [p.u.]**	0.209821	-4.200e-5	-0.209863
● **Q_t [p.u.]**	0.052711	0.020930	-0.031781
● **P_fund_SYM+ [p.u.]**	0.209874	-2.341e-5	-0.209897
● **Q_fund_SYM+ [p.u.]**	6.560e-3	0.014998	8.437e-3

Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, current after fault 100ms



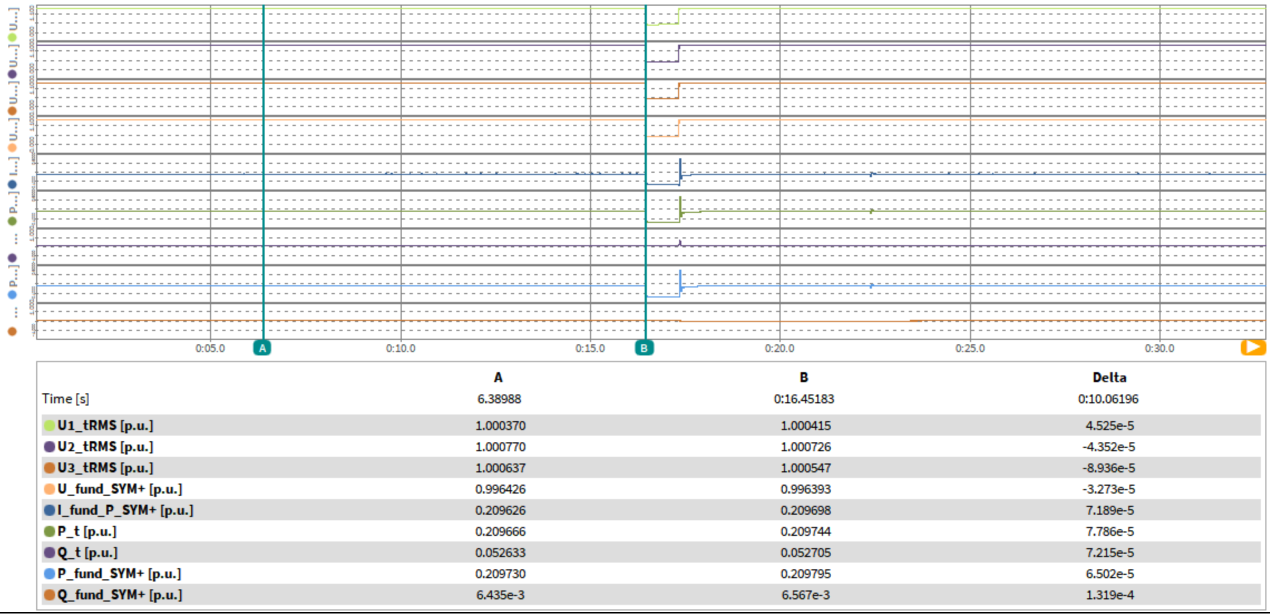
	A	B	Delta
Time [s]	0:16.453548	0:16.553328	0.099780
● **U1_tRMS [p.u.]**	1.000448	0.496182	-0.504266
● **U2_tRMS [p.u.]**	1.000695	0.496766	-0.503929
● **U3_tRMS [p.u.]**	1.000556	0.496571	-0.503985
● **U_fund_SYM+ [p.u.]**	0.996398	0.494432	-0.501966
● **I_fund_P_SYM+ [p.u.]**	0.209775	-5.332e-5	-0.209828
● **P_t [p.u.]**	0.209821	-4.465e-5	-0.209865
● **Q_t [p.u.]**	0.052711	0.020878	-0.031834
● **P_fund_SYM+ [p.u.]**	0.209874	-2.647e-5	-0.209900
● **Q_fund_SYM+ [p.u.]**	6.560e-3	0.014964	8.404e-3

Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, t_1-500ms to t_1-100ms



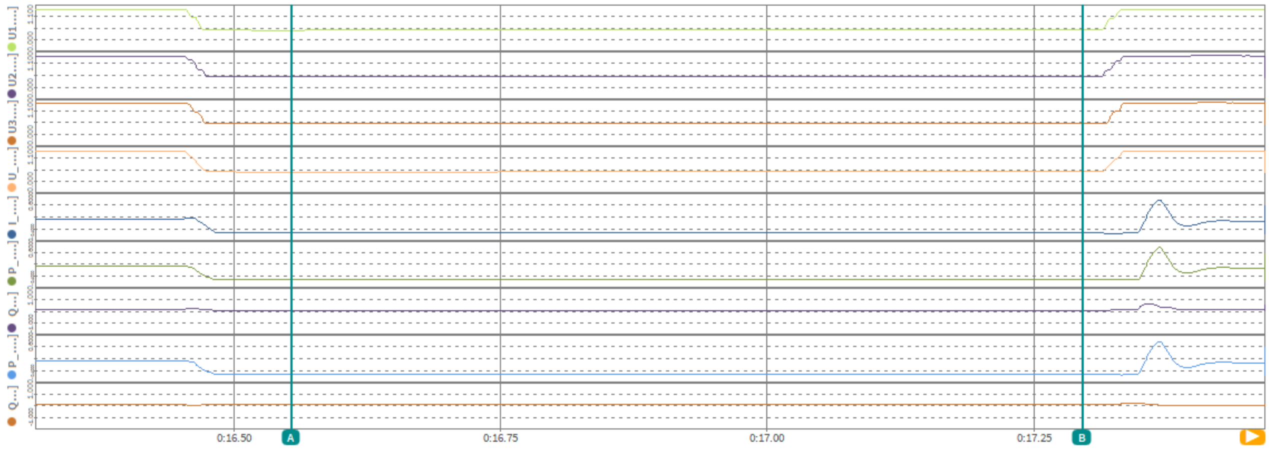
	A	B	Delta
Time [s]	0:15.953703	0:16.357171	0.403468
U1_tRMS [p.u.]	1.000422	1.000337	-8.479e-5
U2_tRMS [p.u.]	1.000601	1.000601	0.000000
U3_tRMS [p.u.]	1.000525	1.000629	1.032e-4
U_fund_SYM+ [p.u.]	0.996350	0.996357	6.180e-6
I_fund_P_SYM+ [p.u.]	0.211385	0.211163	-2.222e-4
P_t [p.u.]	0.211414	0.211191	-2.229e-4
Q_t [p.u.]	0.052696	0.052719	2.304e-5
P_fund_SYM+ [p.u.]	0.211475	0.211254	-2.210e-4
Q_fund_SYM+ [p.u.]	6.448e-3	6.511e-3	6.333e-5

Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, t_1-10s to t_1



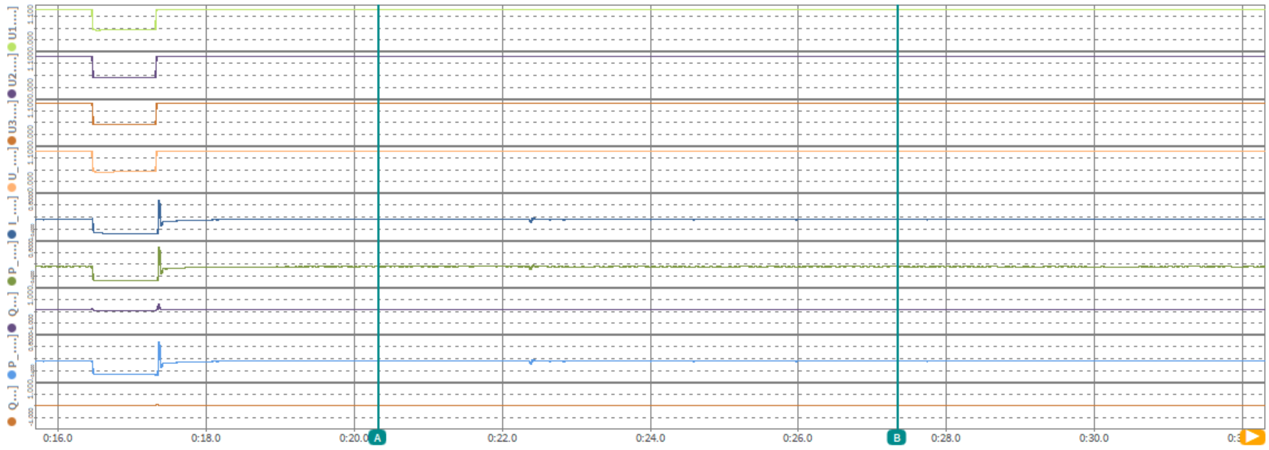
	A	B	Delta
Time [s]	6.38988	0:16.45183	0:10.06196
U1_tRMS [p.u.]	1.000370	1.000415	4.525e-5
U2_tRMS [p.u.]	1.000770	1.000726	-4.352e-5
U3_tRMS [p.u.]	1.000637	1.000547	-8.936e-5
U_fund_SYM+ [p.u.]	0.996426	0.996393	-3.273e-5
I_fund_P_SYM+ [p.u.]	0.209626	0.209698	7.189e-5
P_t [p.u.]	0.209666	0.209744	7.786e-5
Q_t [p.u.]	0.052633	0.052705	7.215e-5
P_fund_SYM+ [p.u.]	0.209730	0.209795	6.502e-5
Q_fund_SYM+ [p.u.]	6.435e-3	6.567e-3	1.319e-4

Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:16.554788	0:17.295207	0.740419
● **U1_tRMS [p.u.]**	0.496194	0.500139	3.945e-3
● **U2_tRMS [p.u.]**	0.496728	0.500347	3.619e-3
● **U3_tRMS [p.u.]**	0.496611	0.500336	3.725e-3
● **U_fund_SYM+ [p.u.]**	0.494436	0.498183	3.746e-3
● **I_fund_P_SYM+ [p.u.]**	-5.532e-5	-4.666e-4	-4.113e-4
● **P_t [p.u.]**	-4.560e-5	-2.521e-4	-2.065e-4
● **Q_t [p.u.]**	0.020876	0.021167	2.913e-4
● **P_fund_SYM+ [p.u.]**	-2.747e-5	-2.334e-4	-2.059e-4
● **Q_fund_SYM+ [p.u.]**	0.014963	0.015214	2.512e-4

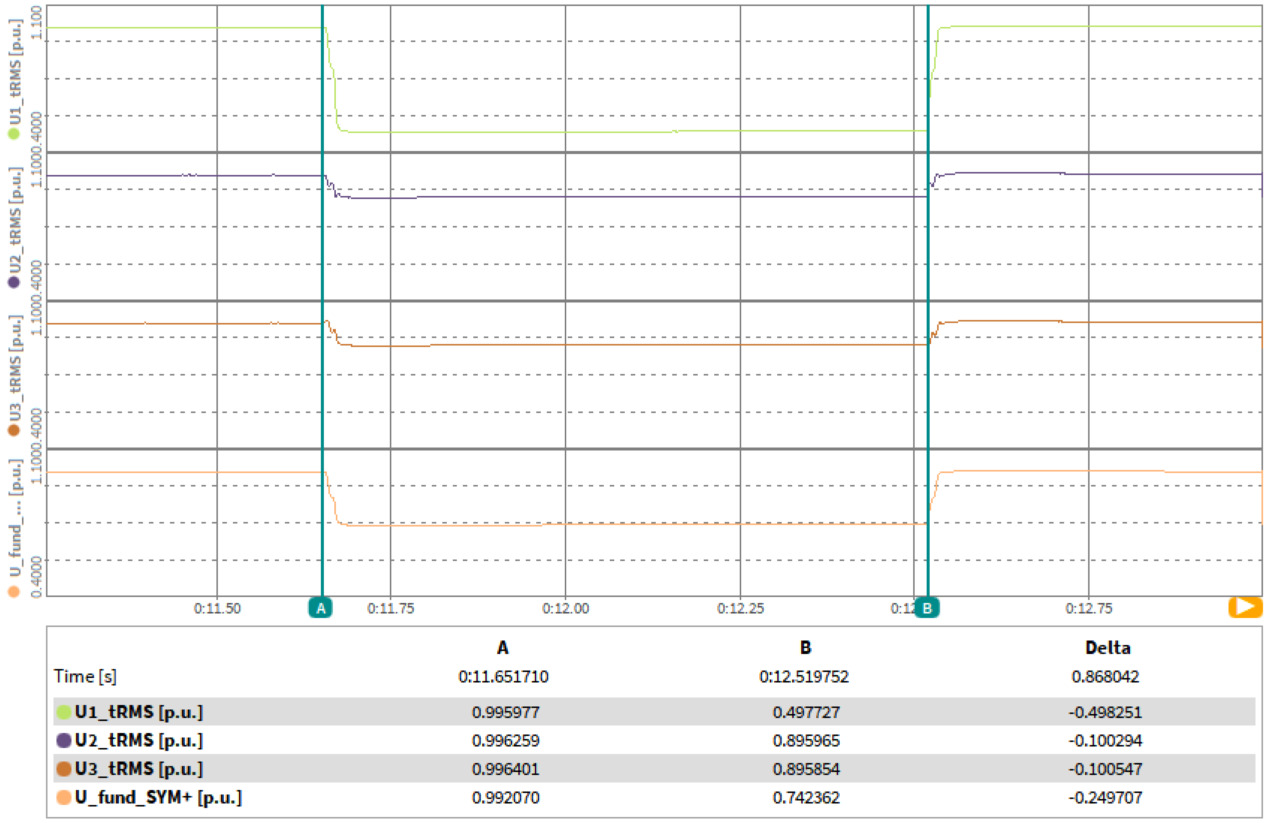
Test 2.2
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	0:20.326705	0:27.338232	7.011527
● **U1_tRMS [p.u.]**	1.000287	1.000303	1.552e-5
● **U2_tRMS [p.u.]**	1.000564	1.000520	-4.352e-5
● **U3_tRMS [p.u.]**	1.000632	1.000653	2.130e-5
● **U_fund_SYM+ [p.u.]**	0.996328	0.996326	-1.221e-6
● **I_fund_P_SYM+ [p.u.]**	0.209940	0.209912	-2.799e-5
● **P_t [p.u.]**	0.209969	0.209935	-3.310e-5
● **Q_t [p.u.]**	0.052243	0.052489	2.459e-4
● **P_fund_SYM+ [p.u.]**	0.210024	0.209996	-2.826e-5
● **Q_fund_SYM+ [p.u.]**	8.593e-4	5.107e-3	4.248e-3

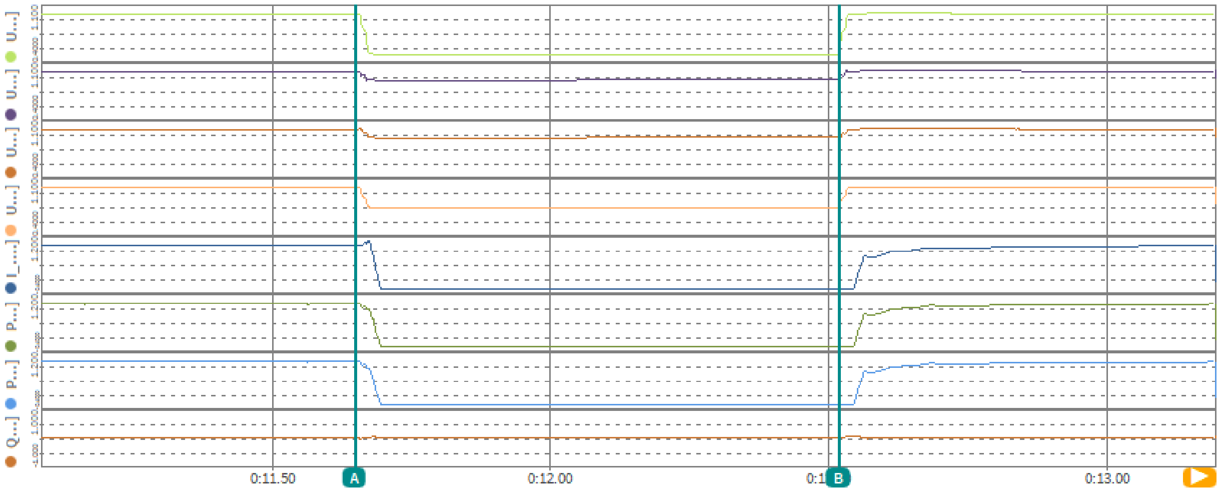
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	2.3
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:39:34
	3	Fault type (phase)	--	--	--	3-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.5
	5	Setting dip duration	860	--	ms	867
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	867
	8	Fault duration in empty load test	Total	--	ms	868
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.233
	10		Pos.			0.250
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	0.997
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0.990
	13	Active power	Total	t_1-10s to t_1	p.u.	0.986
	14		Pos.			0.986
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.060
	16		Pos.			0.009
	17	Cosφ	--	t_1-10s to t_1	--	0.998
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.763
	19	Line current	Phase 1	t_1+60ms	p.u.	0.042
	20		Phase 2			0.070
	21		Phase 3			0.068
	22	Line current	Phase 1	t_1+100ms	p.u.	0.042
	23		Phase 2			0.070
	24		Phase 3			0.068
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			0
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	0.996
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.985
	29		Pos.			0.985
	30	Active power rising time	Pos.	--	s	0.152
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.060
	32		Pos.			0.011
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 2.0D1
Depth of fault: 0.50 p.u., two-phase SC (type D1), 0% load



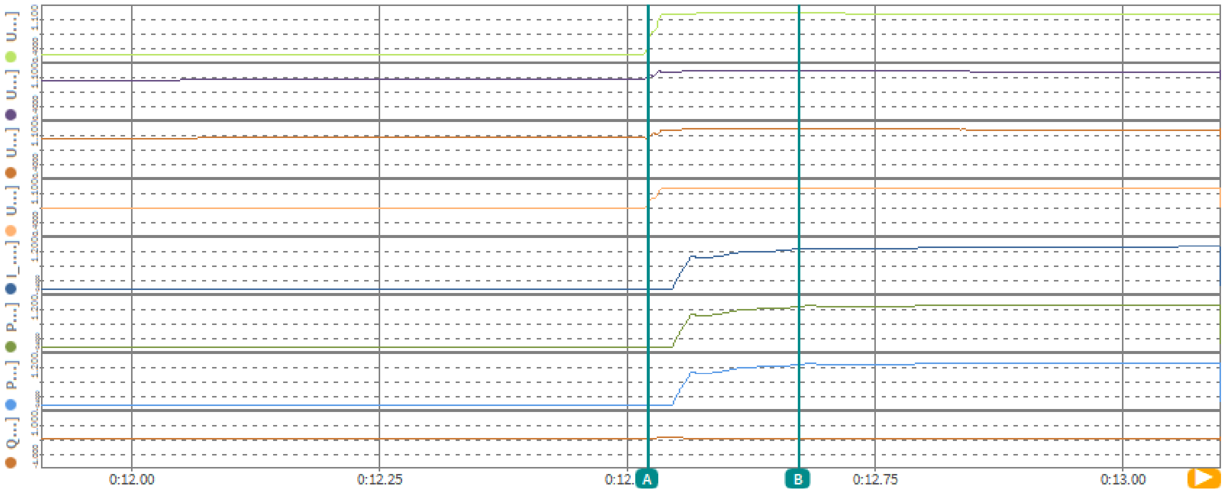
	A	B	Delta
Time [s]	0:11.651710	0:12.519752	0.868042
● **U1_tRMS [p.u.]**	0.995977	0.497727	-0.498251
● **U2_tRMS [p.u.]**	0.996259	0.895965	-0.100294
● **U3_tRMS [p.u.]**	0.996401	0.895854	-0.100547
● **U_fund_SYM+ [p.u.]**	0.992070	0.742362	-0.249707

Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, fault time



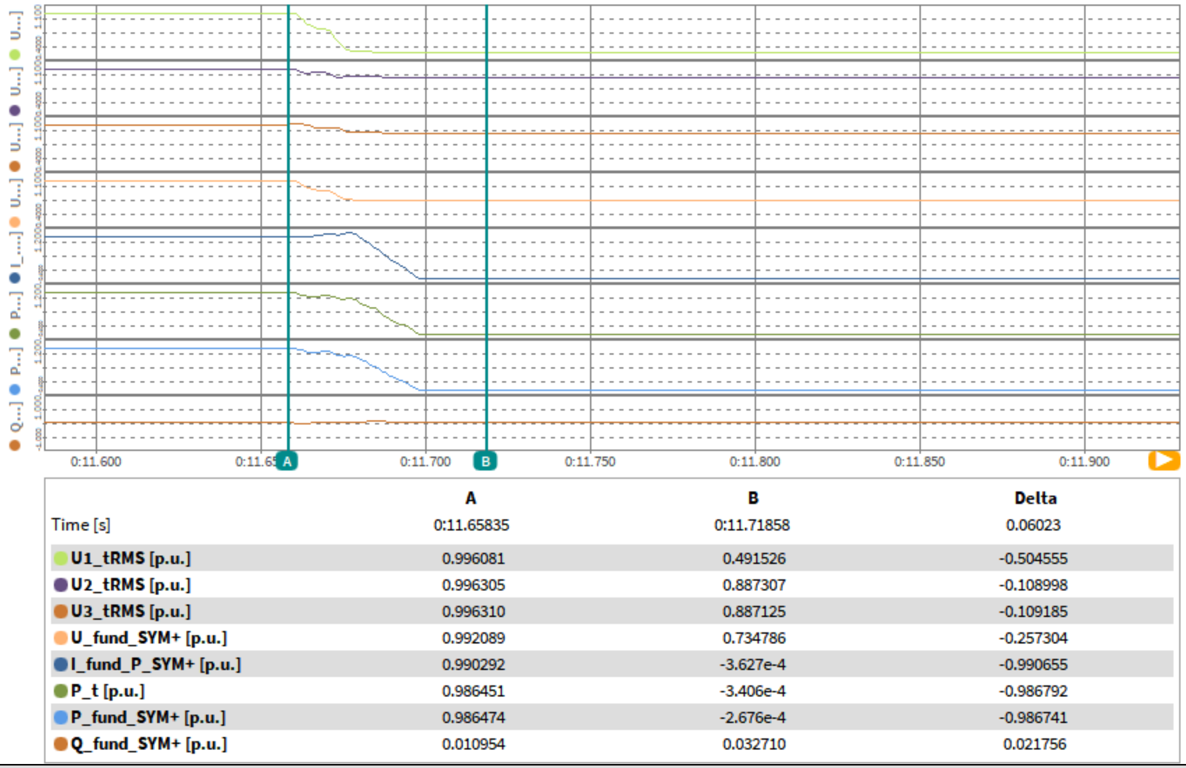
	A	B	Delta
Time [s]	0:11.65054	0:12.51847	0.86793
● **U1_tRMS [p.u.]**	0.996057	0.497733	-0.498324
● **U2_tRMS [p.u.]**	0.996240	0.895983	-0.100257
● **U3_tRMS [p.u.]**	0.996344	0.895985	-0.100359
● **U_fund_SYM+ [p.u.]**	0.992076	0.742390	-0.249686
● **I_fund_P_SYM+ [p.u.]**	0.989560	-3.924e-4	-0.989952
● **P_t [p.u.]**	0.985692	-3.706e-4	-0.986062
● **P_fund_SYM+ [p.u.]**	0.985731	-2.925e-4	-0.986024
● **Q_fund_SYM+ [p.u.]**	0.011100	0.033405	0.022304

Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, restoring time



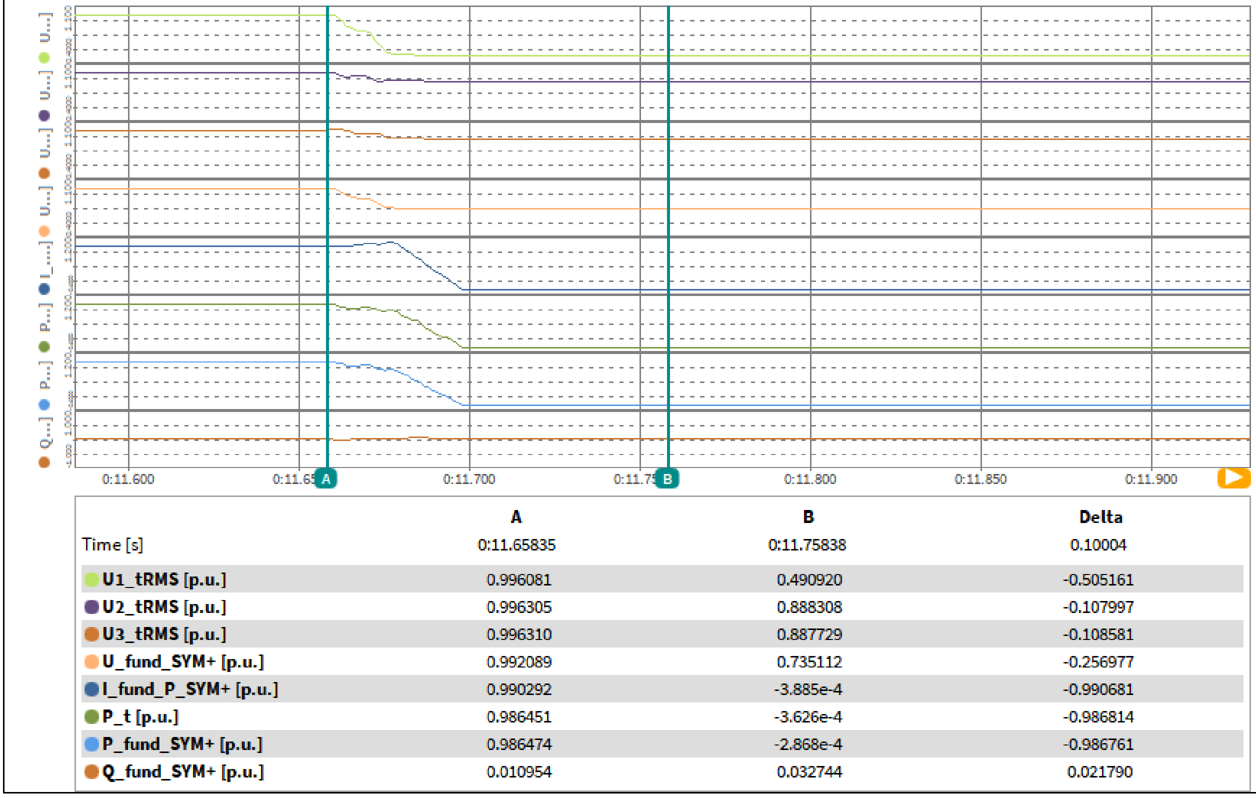
	A	B	Delta
Time [s]	0:12.52117	0:12.67320	0.15203
● **U1_tRMS [p.u.]**	0.507276	1.002267	0.494991
● **U2_tRMS [p.u.]**	0.904668	1.004662	0.099994
● **U3_tRMS [p.u.]**	0.887706	1.004552	0.116846
● **U_fund_SYM+ [p.u.]**	0.745345	0.999659	0.254314
● **I_fund_P_SYM+ [p.u.]**	-2.566e-3	0.928438	0.931004
● **P_t [p.u.]**	-2.064e-3	0.931853	0.933917
● **P_fund_SYM+ [p.u.]**	-1.920e-3	0.931915	0.933835
● **Q_fund_SYM+ [p.u.]**	0.035451	0.010056	-0.025395

Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, current after fault 60ms



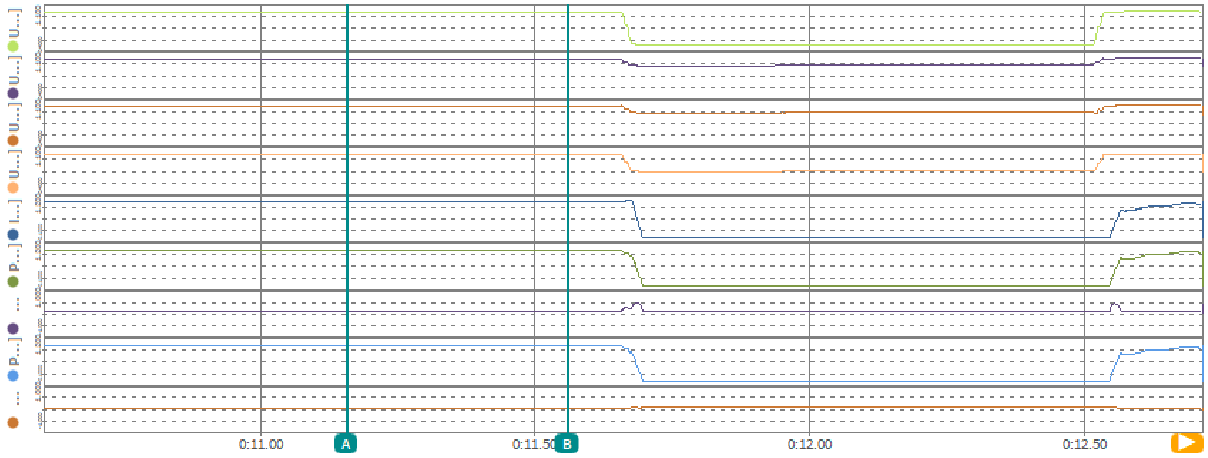
	A	B	Delta
Time [s]	0:11.65835	0:11.71858	0.06023
● **U1_tRMS [p.u.]**	0.996081	0.491526	-0.504555
● **U2_tRMS [p.u.]**	0.996305	0.887307	-0.108998
● **U3_tRMS [p.u.]**	0.996310	0.887125	-0.109185
● **U_fund_SYM+ [p.u.]**	0.992089	0.734786	-0.257304
● **I_fund_P_SYM+ [p.u.]**	0.990292	-3.627e-4	-0.990655
● **P_t [p.u.]**	0.986451	-3.406e-4	-0.986792
● **P_fund_SYM+ [p.u.]**	0.986474	-2.676e-4	-0.986741
● **Q_fund_SYM+ [p.u.]**	0.010954	0.032710	0.021756

Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, current after fault 100ms



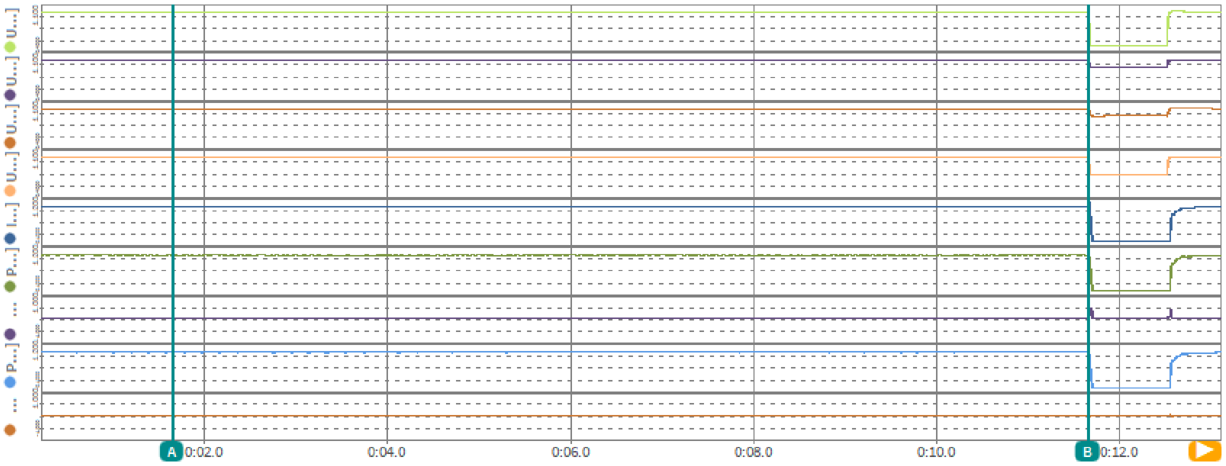
	A	B	Delta
Time [s]	0:11.65835	0:11.75838	0.10004
● **U1_tRMS [p.u.]**	0.996081	0.490920	-0.505161
● **U2_tRMS [p.u.]**	0.996305	0.888308	-0.107997
● **U3_tRMS [p.u.]**	0.996310	0.887729	-0.108581
● **U_fund_SYM+ [p.u.]**	0.992089	0.735112	-0.256977
● **I_fund_P_SYM+ [p.u.]**	0.990292	-3.885e-4	-0.990681
● **P_t [p.u.]**	0.986451	-3.626e-4	-0.986814
● **P_fund_SYM+ [p.u.]**	0.986474	-2.868e-4	-0.986761
● **Q_fund_SYM+ [p.u.]**	0.010954	0.032744	0.021790

Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, t_1-500ms to t_1-100ms



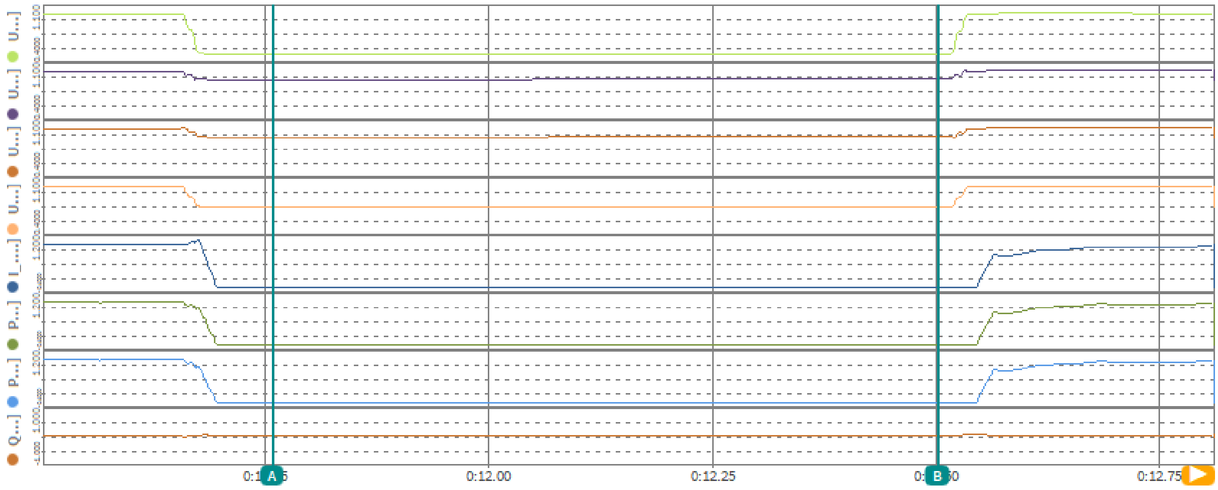
	A	B	Delta
Time [s]	0:11.15851	0:11.55990	0.40139
● **U1_tRMS [p.u.]**	0.996294	0.996087	-2.071e-4
● **U2_tRMS [p.u.]**	0.996331	0.996193	-1.381e-4
● **U3_tRMS [p.u.]**	0.996303	0.996371	6.774e-5
● **U_fund_SYM+ [p.u.]**	0.992173	0.992081	-9.209e-5
● **I_fund_P_SYM+ [p.u.]**	0.989884	0.987910	-1.974e-3
● **P_t [p.u.]**	0.986110	0.984049	-2.061e-3
● **Q_t [p.u.]**	0.060502	0.060149	-3.538e-4
● **P_fund_SYM+ [p.u.]**	0.986151	0.984093	-2.058e-3
● **Q_fund_SYM+ [p.u.]**	8.984e-3	0.011048	2.064e-3

Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, t_1-10s to t_1



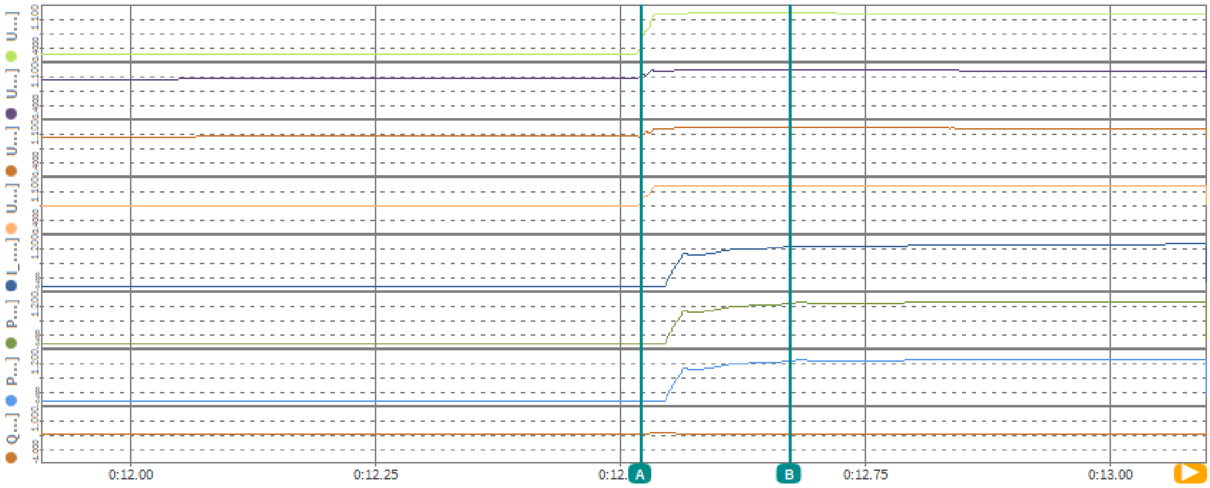
	A	B	Delta
Time [s]	1.65824	0:11.65824	0:10.00000
● **U1_tRMS [p.u.]**	0.996144	0.996081	-6.376e-5
● **U2_tRMS [p.u.]**	0.996144	0.996305	1.617e-4
● **U3_tRMS [p.u.]**	0.996274	0.996310	3.569e-5
● **U_fund_SYM+ [p.u.]**	0.992050	0.992089	3.906e-5
● **I_fund_P_SYM+ [p.u.]**	0.987162	0.990292	3.130e-3
● **P_t [p.u.]**	0.983284	0.986451	3.167e-3
● **Q_t [p.u.]**	0.059929	0.060422	4.923e-4
● **P_fund_SYM+ [p.u.]**	0.983317	0.986474	3.156e-3
● **Q_fund_SYM+ [p.u.]**	0.011091	0.010954	-1.370e-4

Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:11.75944	0:12.50231	0.74288
● **U1_tRMS [p.u.]**	0.490926	0.497649	6.723e-3
● **U2_tRMS [p.u.]**	0.888347	0.895963	7.615e-3
● **U3_tRMS [p.u.]**	0.887798	0.896064	8.266e-3
● **U_fund_SYM+ [p.u.]**	0.735146	0.742478	7.332e-3
● **I_fund_P_SYM+ [p.u.]**	-3.956e-4	-3.996e-4	-4.033e-6
● **P_t [p.u.]**	-3.691e-4	-3.755e-4	-6.396e-6
● **P_fund_SYM+ [p.u.]**	-2.920e-4	-2.979e-4	-5.919e-6
● **Q_fund_SYM+ [p.u.]**	0.032746	0.033407	6.609e-4

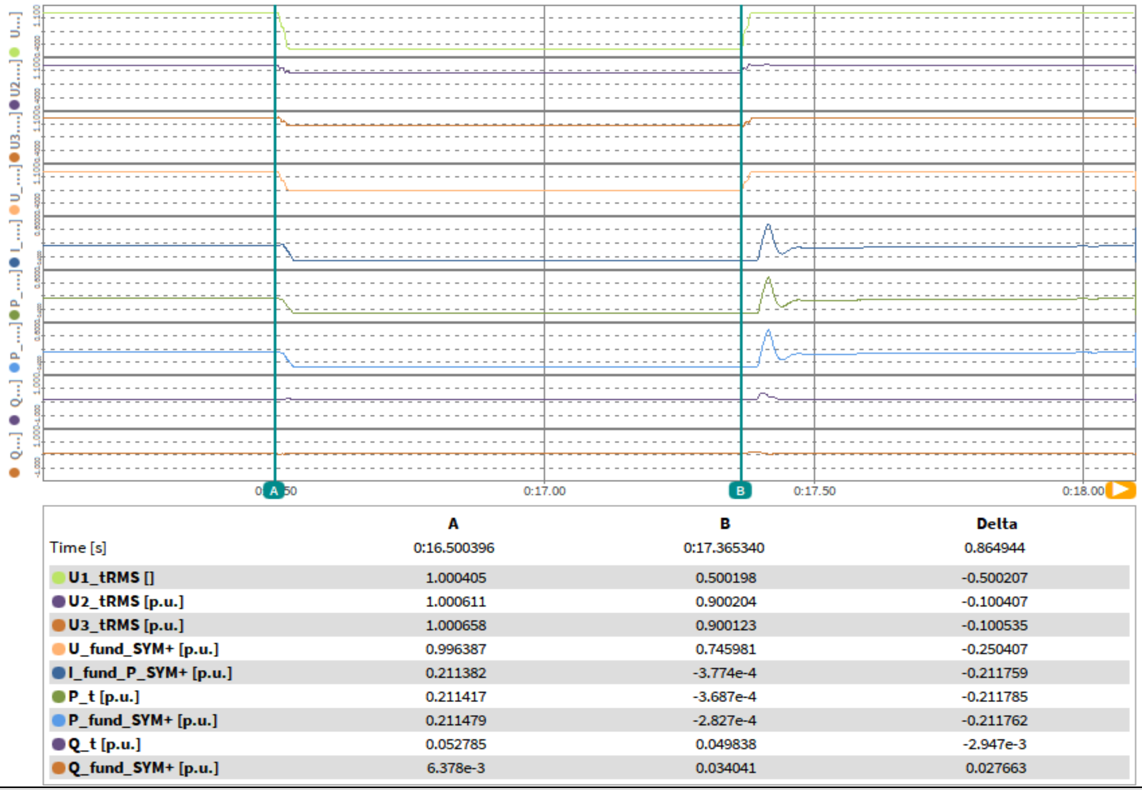
Test 2.3
Depth of fault: 0.5 p.u., three-phase SC (type D1), 100% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	0:12.52117	0:12.67320	0.15203
● **U1_tRMS [p.u.]**	0.507276	1.002267	0.494991
● **U2_tRMS [p.u.]**	0.904668	1.004662	0.099994
● **U3_tRMS [p.u.]**	0.887706	1.004552	0.116846
● **U_fund_SYM+ [p.u.]**	0.745345	0.999659	0.254314
● **I_fund_P_SYM+ [p.u.]**	-2.566e-3	0.928438	0.931004
● **P_t [p.u.]**	-2.064e-3	0.931853	0.933917
● **P_fund_SYM+ [p.u.]**	-1.920e-3	0.931915	0.933835
● **Q_fund_SYM+ [p.u.]**	0.035451	0.010056	-0.025395

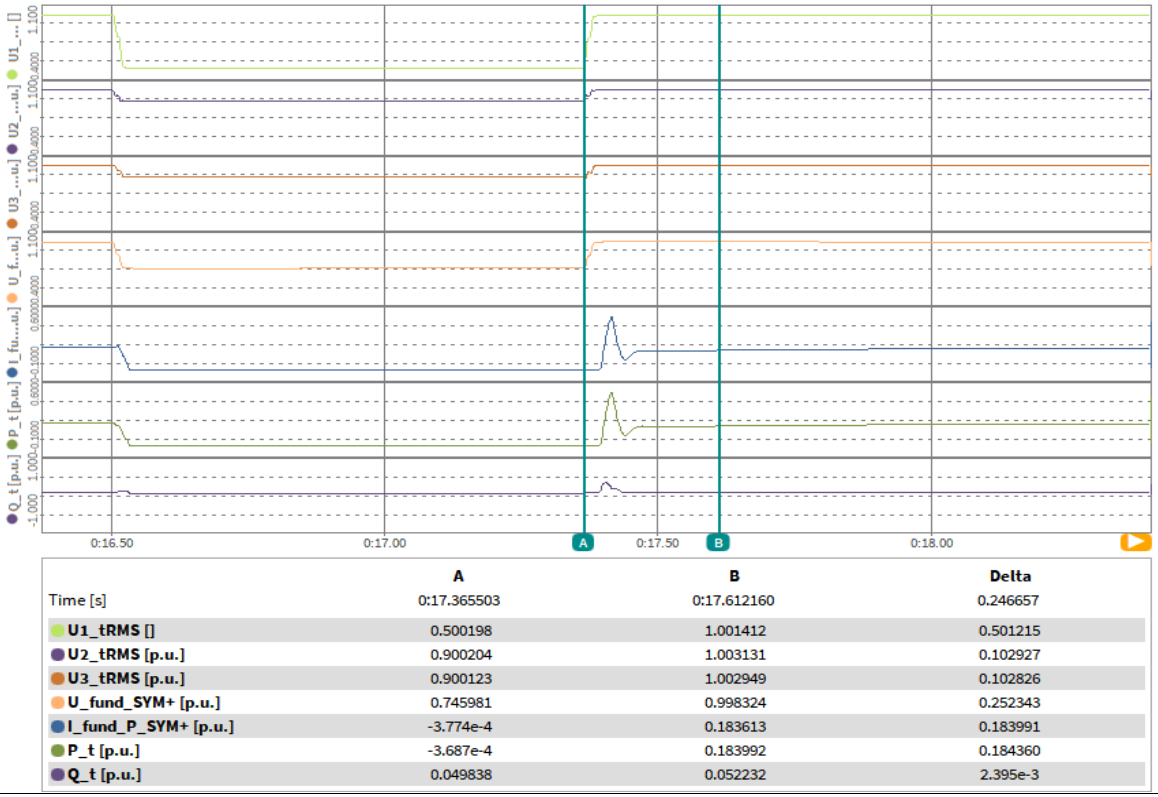
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	2.4
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:24:40
	3	Fault type (phase)	--	--	--	2-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.50
	5	Setting dip duration	860	--	ms	865
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	865
	8	Fault duration in empty load test	Total	--	ms	868
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.234
	10		Pos.			0.250
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.001
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0.211
	13	Active power	Total	t_1-10s to t_1	p.u.	0.211
	14		Pos.			0.211
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.052
	16		Pos.			0.006
	17	Cosφ	--	t_1-10s to t_1	--	0.970
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.767
	19	Line current	Phase 1	t_1+60ms	p.u.	0.044
	20		Phase 2			0.071
	21		Phase 3			0.069
	22	Line current	Phase 1	t_1+100ms	p.u.	0.044
	23		Phase 2			0.071
	24		Phase 3			0.069
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0
	26		Pos.			--
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.001
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.208
	29		Pos.			0.208
	30	Active power rising time	Pos.	--	s	0.247
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.053
	32		Pos.			0.006
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type D1), 20% load, fault time



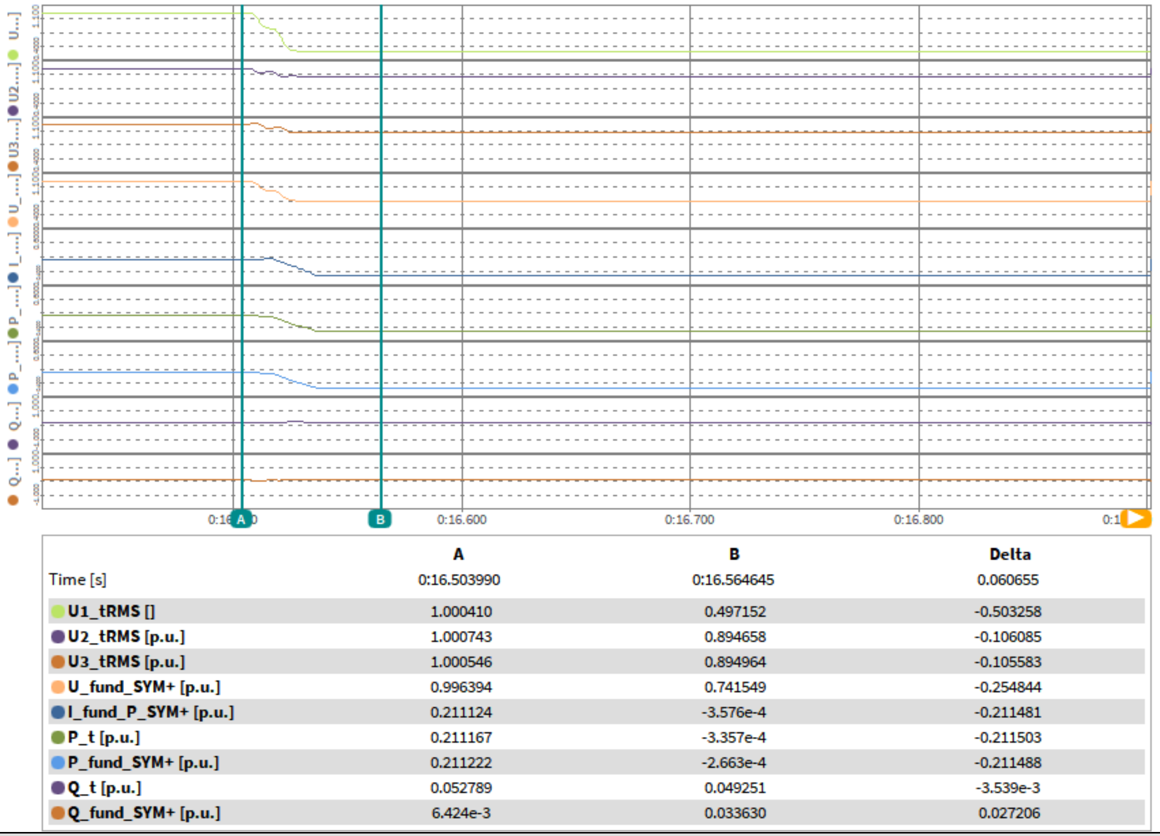
	A	B	Delta
Time [s]	0:16.500396	0:17.365340	0.864944
● **U1_tRMS []**	1.000405	0.500198	-0.500207
● **U2_tRMS [p.u.]**	1.000611	0.900204	-0.100407
● **U3_tRMS [p.u.]**	1.000658	0.900123	-0.100535
● **U_fund_SYM+ [p.u.]**	0.996387	0.745981	-0.250407
● **I_fund_P_SYM+ [p.u.]**	0.211382	-3.774e-4	-0.211759
● **P_t [p.u.]**	0.211417	-3.687e-4	-0.211785
● **P_fund_SYM+ [p.u.]**	0.211479	-2.827e-4	-0.211762
● **Q_t [p.u.]**	0.052785	0.049838	-2.947e-3
● **Q_fund_SYM+ [p.u.]**	6.378e-3	0.034041	0.027663

Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type D1), 20% load, restoring time



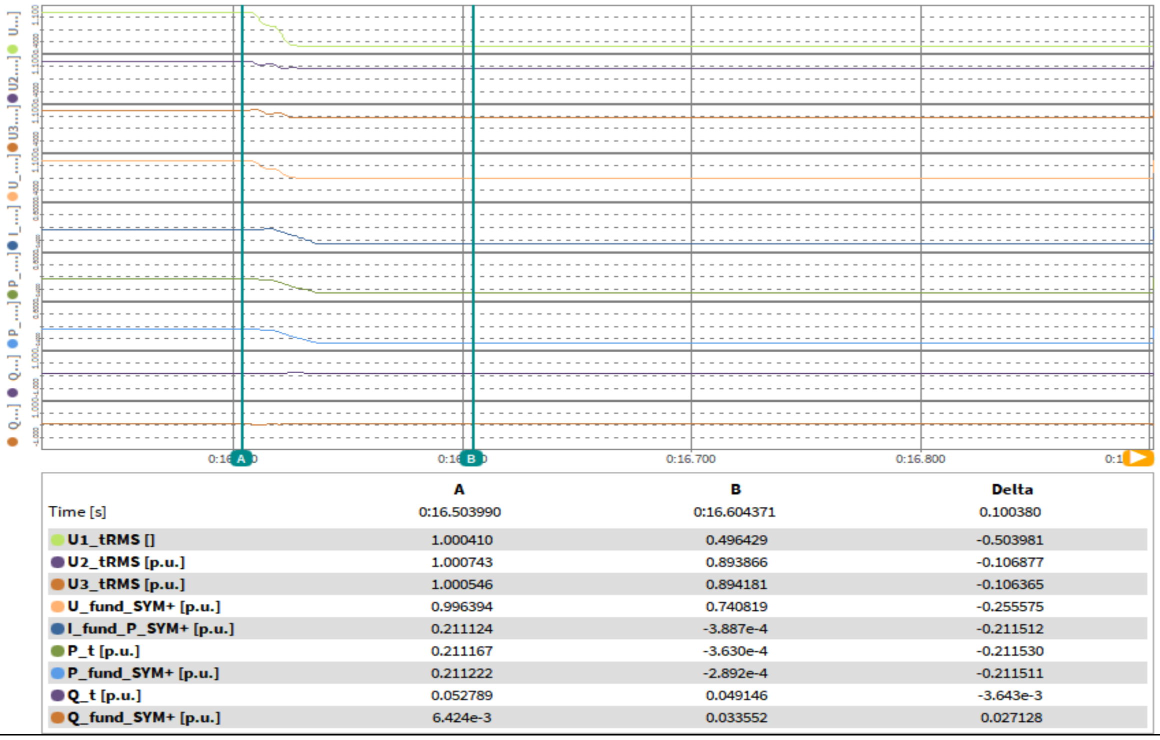
	A	B	Delta
Time [s]	0:17.365503	0:17.612160	0.246657
● **U1_tRMS []**	0.500198	1.001412	0.501215
● **U2_tRMS [p.u.]**	0.900204	1.003131	0.102927
● **U3_tRMS [p.u.]**	0.900123	1.002949	0.102826
● **U_fund_SYM+ [p.u.]**	0.745981	0.998324	0.252343
● **I_fund_P_SYM+ [p.u.]**	-3.774e-4	0.183613	0.183991
● **P_t [p.u.]**	-3.687e-4	0.183992	0.184360
● **Q_t [p.u.]**	0.049838	0.052232	2.395e-3

Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type A), 20% load, current after fault 60ms



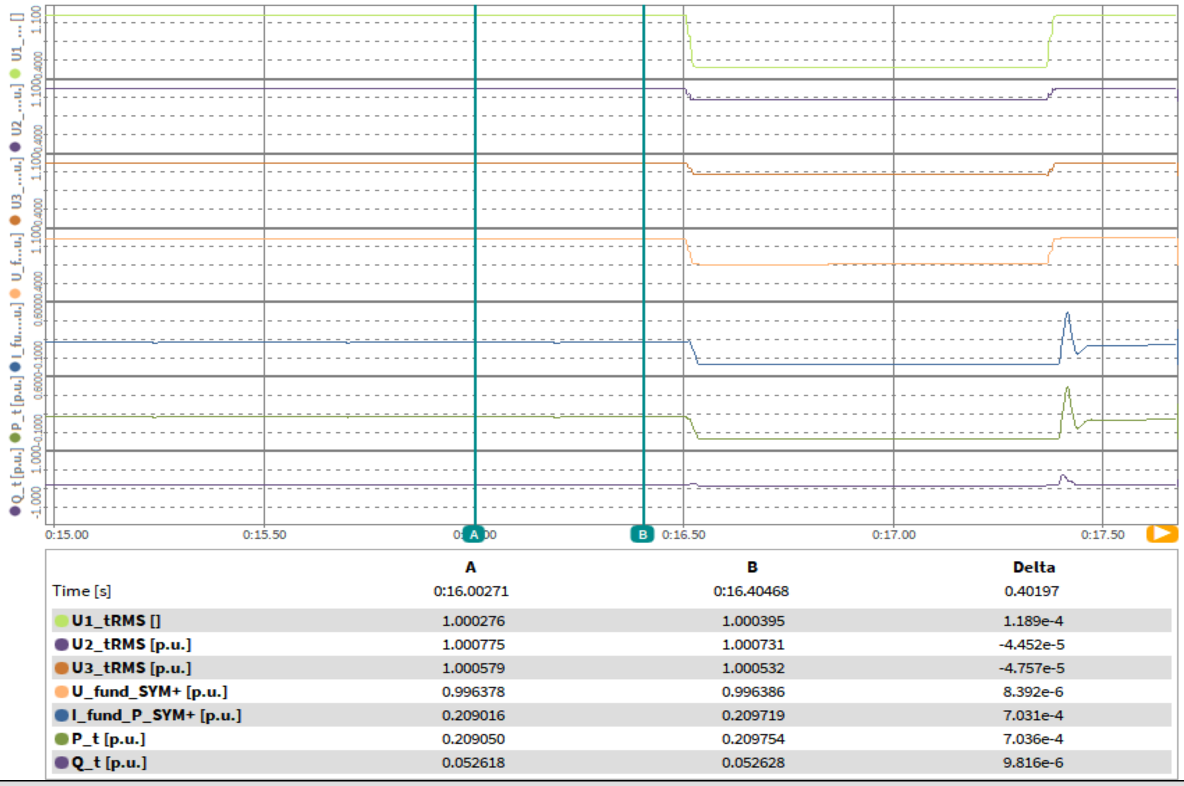
	A	B	Delta
Time [s]	0:16.503990	0:16.564645	0.060655
● U1_tRMS []	1.000410	0.497152	-0.503258
● U2_tRMS [p.u.]	1.000743	0.894658	-0.106085
● U3_tRMS [p.u.]	1.000546	0.894964	-0.105583
● U_fund_SYM+ [p.u.]	0.996394	0.741549	-0.254844
● I_fund_P_SYM+ [p.u.]	0.211124	-3.576e-4	-0.211481
● P_t [p.u.]	0.211167	-3.357e-4	-0.211503
● P_fund_SYM+ [p.u.]	0.211222	-2.663e-4	-0.211488
● Q_t [p.u.]	0.052789	0.049251	-3.539e-3
● Q_fund_SYM+ [p.u.]	6.424e-3	0.033630	0.027206

Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type D1), 20% load, current after fault 100ms



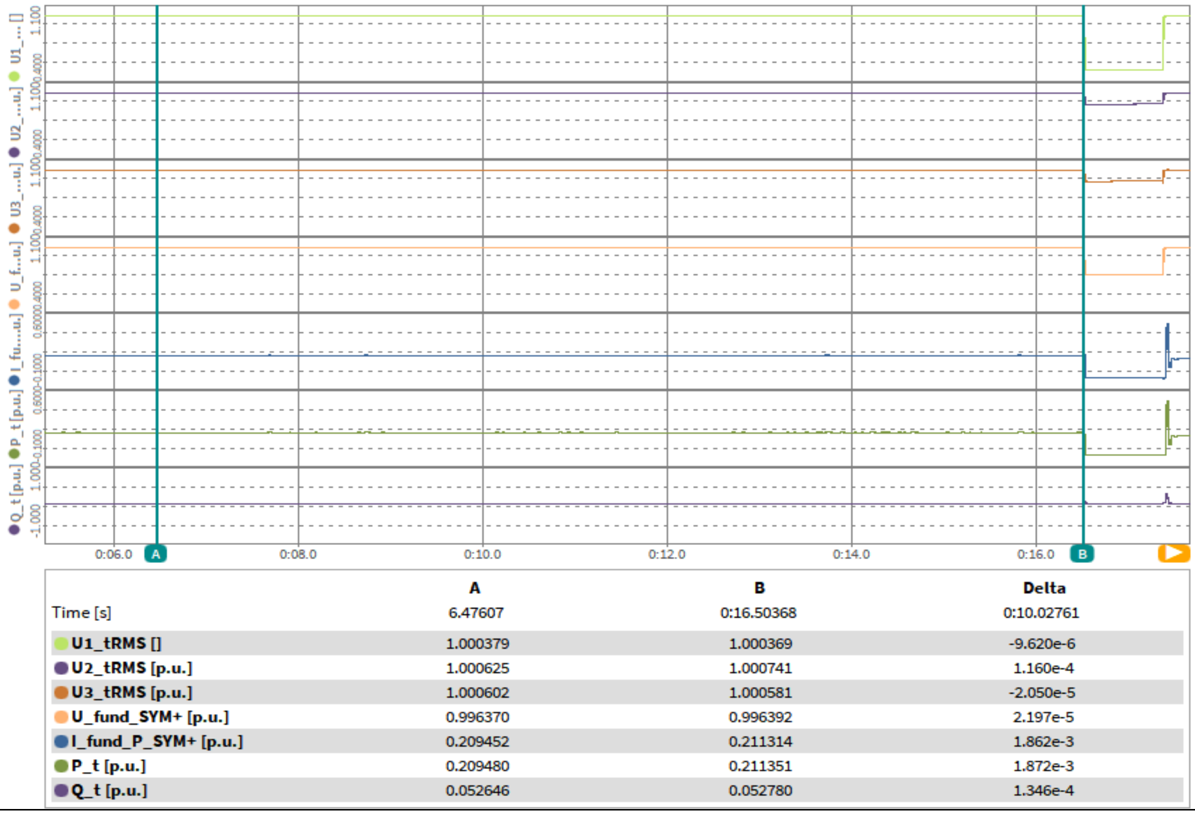
	A	B	Delta
Time [s]	0:16.503990	0:16.604371	0.100380
● U1_tRMS []	1.000410	0.496429	-0.503981
● U2_tRMS [p.u.]	1.000743	0.893866	-0.106877
● U3_tRMS [p.u.]	1.000546	0.894181	-0.106365
● U_fund_SYM+ [p.u.]	0.996394	0.740819	-0.255575
● I_fund_P_SYM+ [p.u.]	0.211124	-3.887e-4	-0.211512
● P_t [p.u.]	0.211167	-3.630e-4	-0.211530
● P_fund_SYM+ [p.u.]	0.211222	-2.892e-4	-0.211511
● Q_t [p.u.]	0.052789	0.049146	-3.643e-3
● Q_fund_SYM+ [p.u.]	6.424e-3	0.033552	0.027128

Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type D1), 20% load, t_1-500ms to t_1-100ms



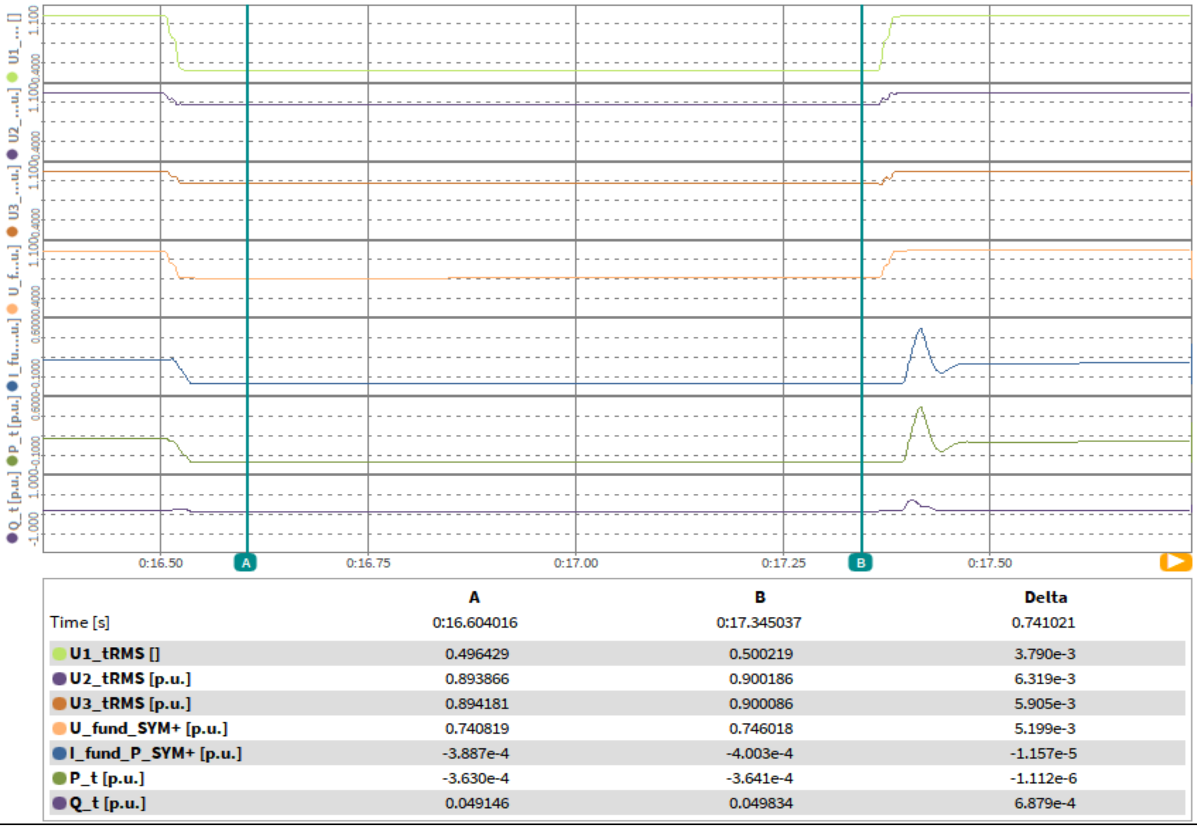
	A	B	Delta
Time [s]	0:16.00271	0:16.40468	0.40197
● **U1_tRMS []**	1.000276	1.000395	1.189e-4
● **U2_tRMS [p.u.]**	1.000775	1.000731	-4.452e-5
● **U3_tRMS [p.u.]**	1.000579	1.000532	-4.757e-5
● **U_fund_SYM+ [p.u.]**	0.996378	0.996386	8.392e-6
● **I_fund_P_SYM+ [p.u.]**	0.209016	0.209719	7.031e-4
● **P_t [p.u.]**	0.209050	0.209754	7.036e-4
● **Q_t [p.u.]**	0.052618	0.052628	9.816e-6

Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type D1), 20% load, t_1-10s to t_1



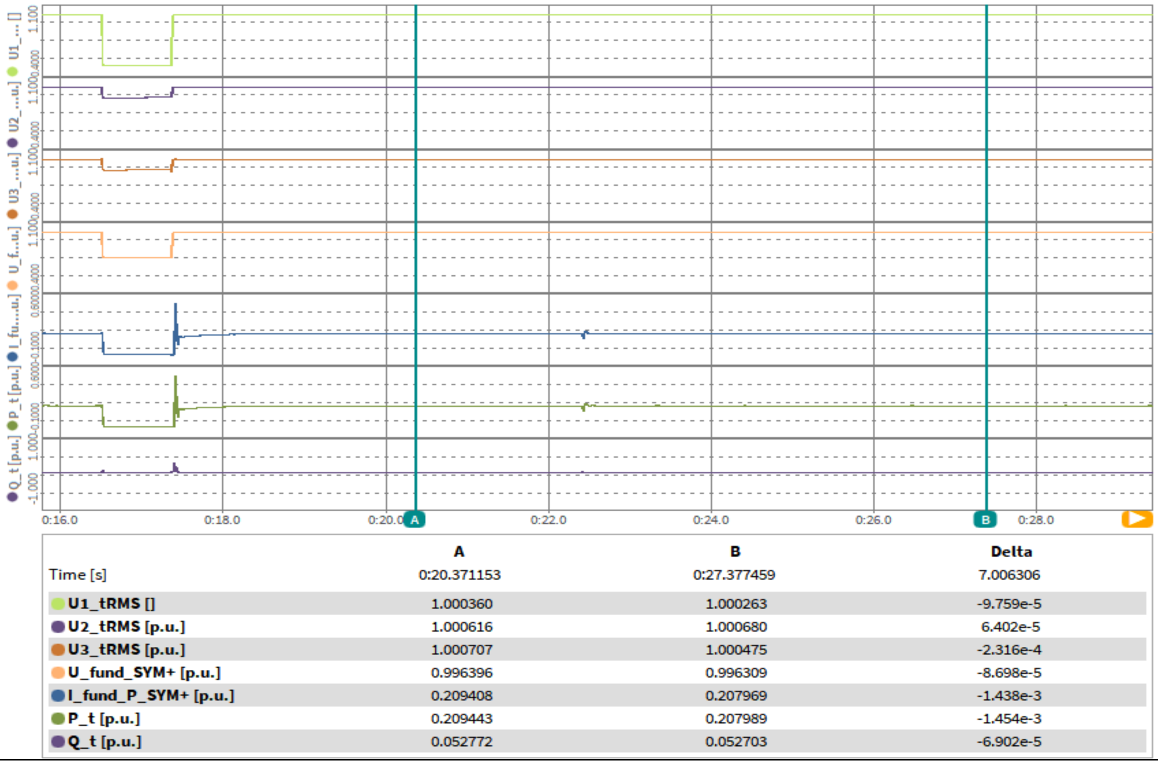
	A	B	Delta
Time [s]	6.47607	0:16.50368	0:10.02761
● **U1_tRMS []**	1.000379	1.000369	-9.620e-6
● **U2_tRMS [p.u.]**	1.000625	1.000741	1.160e-4
● **U3_tRMS [p.u.]**	1.000602	1.000581	-2.050e-5
● **U_fund_SYM+ [p.u.]**	0.996370	0.996392	2.197e-5
● **I_fund_P_SYM+ [p.u.]**	0.209452	0.211314	1.862e-3
● **P_t [p.u.]**	0.209480	0.211351	1.872e-3
● **Q_t [p.u.]**	0.052646	0.052780	1.346e-4

Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type D1), 20% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:16.604016	0:17.345037	0.741021
● **U1_tRMS []**	0.496429	0.500219	3.790e-3
● **U2_tRMS [p.u.]**	0.893866	0.900186	6.319e-3
● **U3_tRMS [p.u.]**	0.894181	0.900086	5.905e-3
● **U_fund_SYM+ [p.u.]**	0.740819	0.746018	5.199e-3
● **I_fund_P_SYM+ [p.u.]**	-3.887e-4	-4.003e-4	-1.157e-5
● **P_t [p.u.]**	-3.630e-4	-3.641e-4	-1.112e-6
● **Q_t [p.u.]**	0.049146	0.049834	6.879e-4

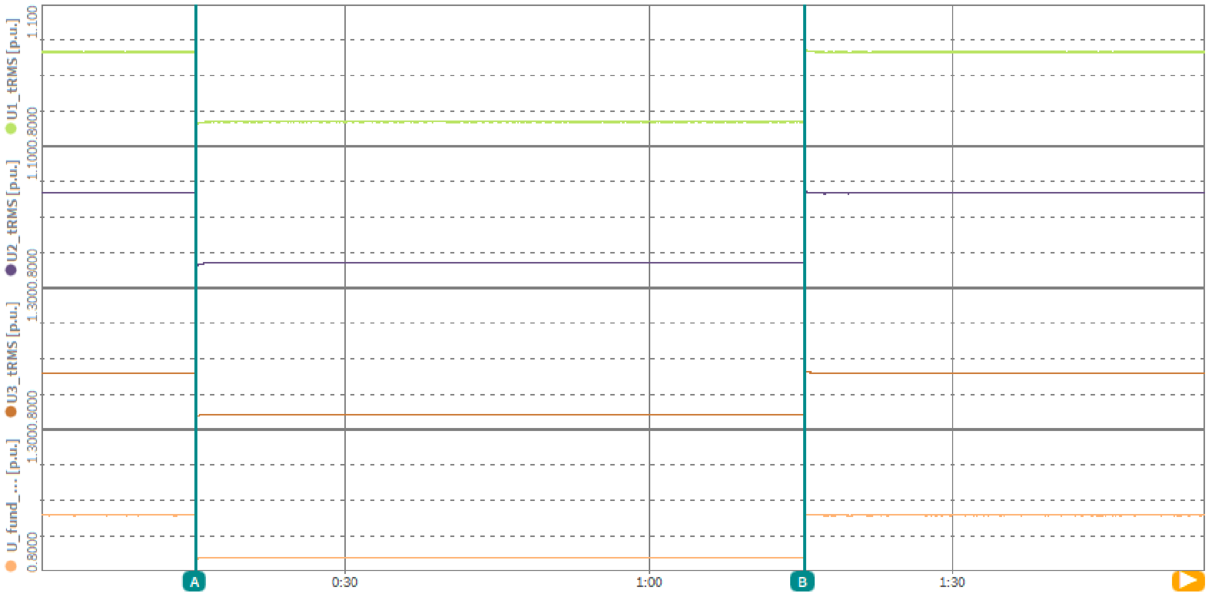
Test 2.4
Depth of fault: 0.5 p.u., three-phase SC (type D1), 20% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	0:20.371153	0:27.377459	7.006306
● **U1_tRMS []**	1.000360	1.000263	-9.759e-5
● **U2_tRMS [p.u.]**	1.000616	1.000680	6.402e-5
● **U3_tRMS [p.u.]**	1.000707	1.000475	-2.316e-4
● **U_fund_SYM+ [p.u.]**	0.996396	0.996309	-8.698e-5
● **I_fund_P_SYM+ [p.u.]**	0.209408	0.207969	-1.438e-3
● **P_t [p.u.]**	0.209443	0.207989	-1.454e-3
● **Q_t [p.u.]**	0.052772	0.052703	-6.902e-5

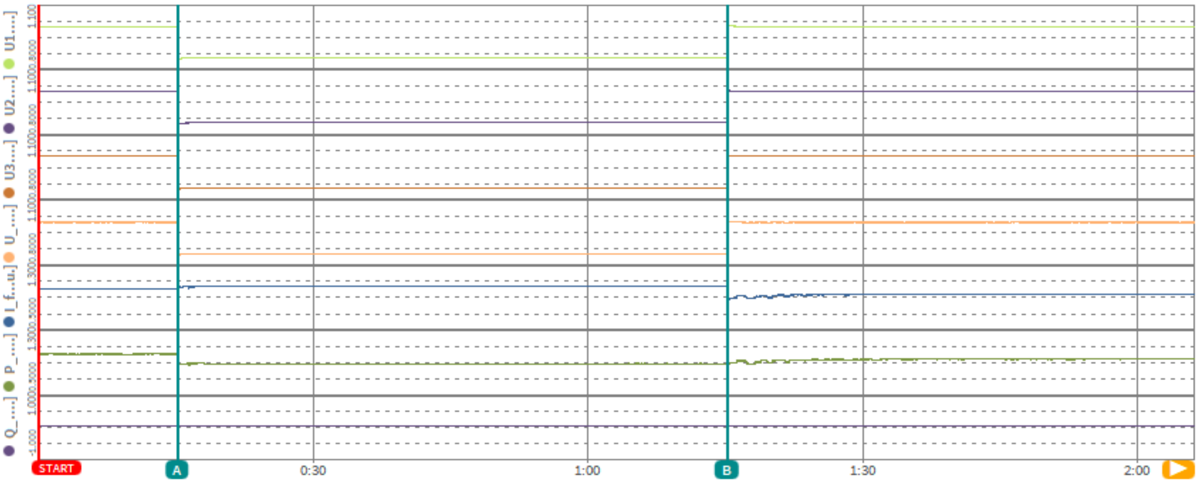
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	3.1
	1	Date	--	--	yyyy.mm.dd	2022.9.20
	2	Time (start of test)	--	--	hh:mm:ss.f	14:43:13
	3	Fault type (phase)	--	--	--	3-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.85
	5	Setting dip duration	60000	--	ms	60003
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	60003
	8	Fault duration in empty load test	Total	--	ms	60009
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.15
	10		Pos.			0.15
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.000
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	1.005
	13	Active power	Total	t_1-10s to t_1	p.u.	1.005
	14		Pos.			1.005
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.063
	16		Pos.			0.012
	17	Cosφ	--	t_1-10s to t_1	--	0.998
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.85
	19	Line current	Phase 1	t_1+60ms	p.u.	1.030
	20		Phase 2			1.033
	21		Phase 3			1.029
	22	Line current	Phase 1	t_1+100ms	p.u.	1.030
	23		Phase 2			1.033
	24		Phase 3			1.029
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0.884
	26		Pos.			0.884
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.00
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.933
	29		Pos.			0.933
	30	Active power rising time	Pos.	--	s	--
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.061
	32		Pos.			0.010
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 3.0A
Depth of fault: 0.85 p.u., three-phase SC (type A), 0% load



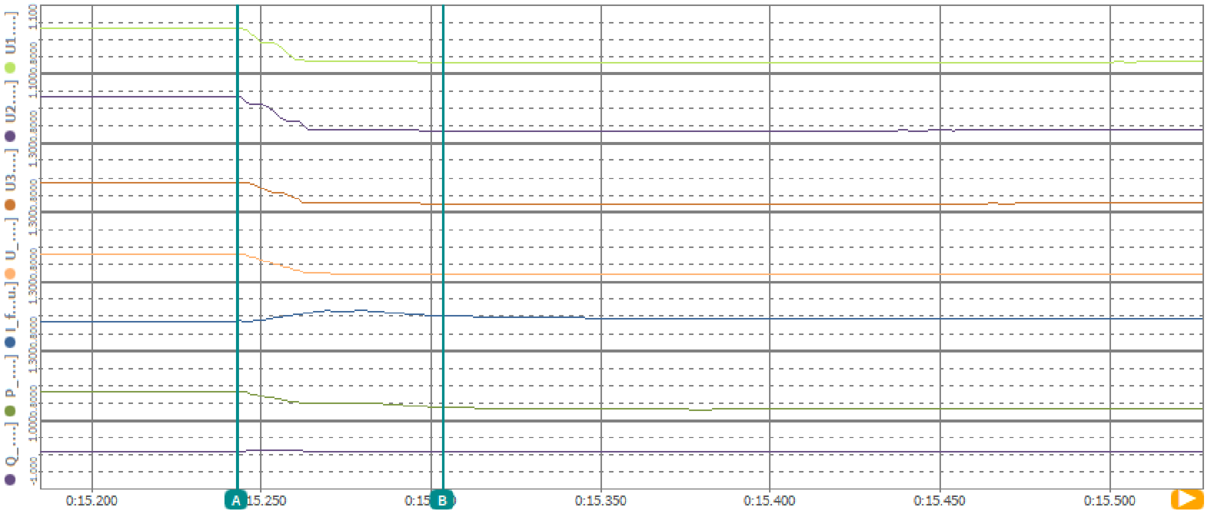
	A	B	Delta
Time [s]	0:15.23596	1:15.24515	1:00.00920
● **U1_tRMS [p.u.]**	1.000545	0.850587	-0.149958
● **U2_tRMS [p.u.]**	1.000795	0.850876	-0.149919
● **U3_tRMS [p.u.]**	1.000829	0.850872	-0.149956
● **U_fund_SYM+ [p.u.]**	0.996567	0.847244	-0.149322

Test 3.1
Depth of fault: 0.85 p.u., three-phase SC (type A), 100% load, fault time



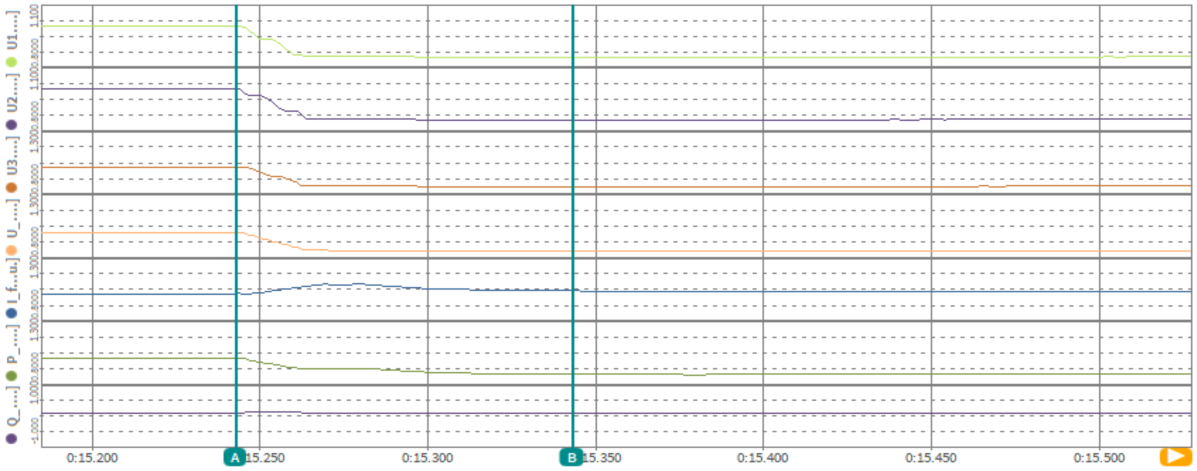
	A	B	Delta
Time [s]	0:15.23956	1:15.24298	1:00.00342
● **U1_tRMS [p.u.]**	1.000515	0.850640	-0.149875
● **U2_tRMS [p.u.]**	1.000920	0.850848	-0.150073
● **U3_tRMS [p.u.]**	1.000709	0.850852	-0.149856
● **U_fund_SYM+ [p.u.]**	0.996558	0.847245	-0.149312
● **I_fund_P_SYM+ [p.u.]**	1.004752	1.039410	0.034658
● **P_t [p.u.]**	1.005347	0.884288	-0.121059
● **Q_t [p.u.]**	0.062939	0.048699	-0.014240

Test 3.1
Depth of fault: 0.85 p.u., three-phase SC (type A), 100% load, current after fault 60ms



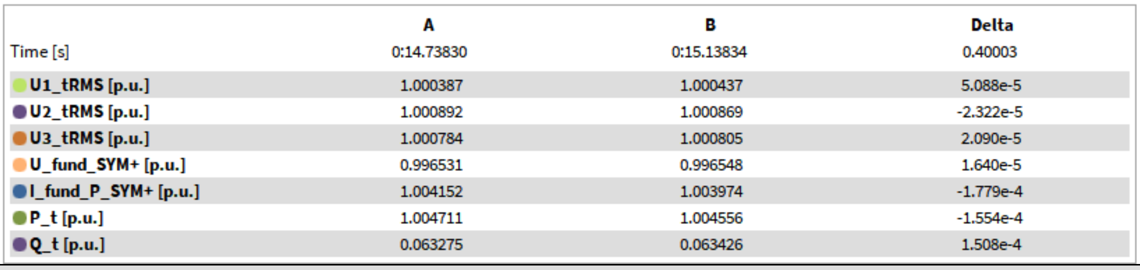
	A	B	Delta
Time [s]	0:15.24307	0:15.30367	0.06060
● **U1_tRMS [p.u.]**	1.000589	0.846771	-0.153818
● **U2_tRMS [p.u.]**	1.000832	0.847350	-0.153482
● **U3_tRMS [p.u.]**	1.000712	0.846800	-0.153913
● **U_fund_SYM+ [p.u.]**	0.996555	0.843452	-0.153103
● **I_fund_P_SYM+ [p.u.]**	1.004999	1.042433	0.037435
● **P_t [p.u.]**	1.005593	0.882879	-0.122713
● **Q_t [p.u.]**	0.063009	0.051590	-0.011419

Test 3.1
Depth of fault: 0.85 p.u., three-phase SC (type A), 100% load, current after fault 100ms



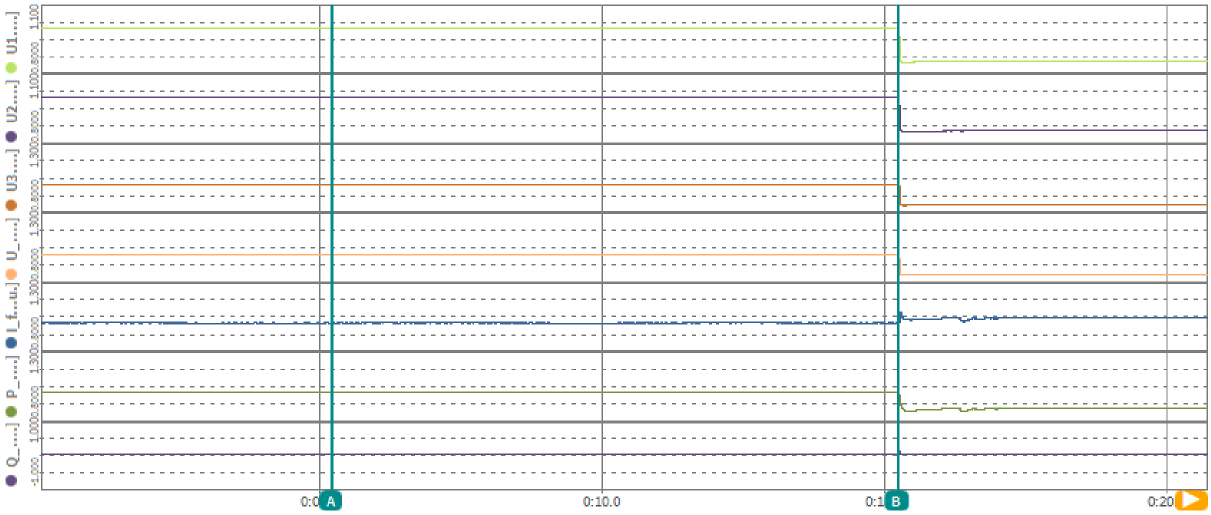
	A	B	Delta
Time [s]	0:15.24307	0:15.34323	0.10016
● **U1_tRMS [p.u.]**	1.000589	0.846122	-0.154468
● **U2_tRMS [p.u.]**	1.000832	0.846616	-0.154216
● **U3_tRMS [p.u.]**	1.000712	0.846333	-0.154379
● **U_fund_SYM+ [p.u.]**	0.996555	0.842839	-0.153716
● **I_fund_P_SYM+ [p.u.]**	1.004999	1.029609	0.024610
● **P_t [p.u.]**	1.005593	0.871411	-0.134182
● **Q_t [p.u.]**	0.063009	0.047190	-0.015819

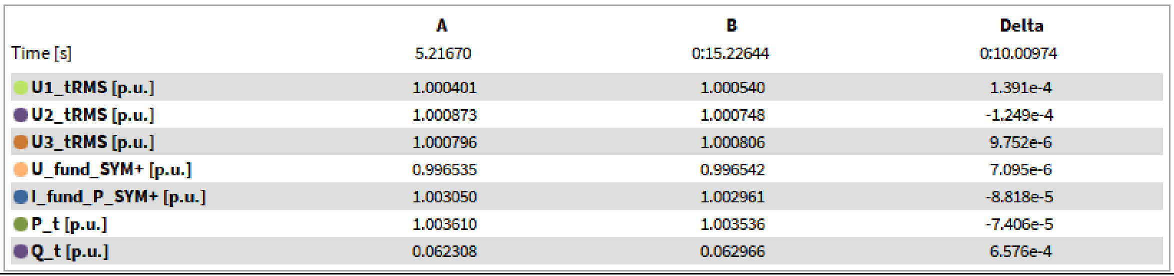
Test 3.1
Depth of fault: 0.85 p.u., three-phase SC (type A), 100% load, t_1-500ms to t_1-100ms



	A	B	Delta
Time [s]	0:14.73830	0:15.13834	0.40003
● **U1_tRMS [p.u.]**	1.000387	1.000437	5.088e-5
● **U2_tRMS [p.u.]**	1.000892	1.000869	-2.322e-5
● **U3_tRMS [p.u.]**	1.000784	1.000805	2.090e-5
● **U_fund_SYM+ [p.u.]**	0.996531	0.996548	1.640e-5
● **I_fund_P_SYM+ [p.u.]**	1.004152	1.003974	-1.779e-4
● **P_t [p.u.]**	1.004711	1.004556	-1.554e-4
● **Q_t [p.u.]**	0.063275	0.063426	1.508e-4

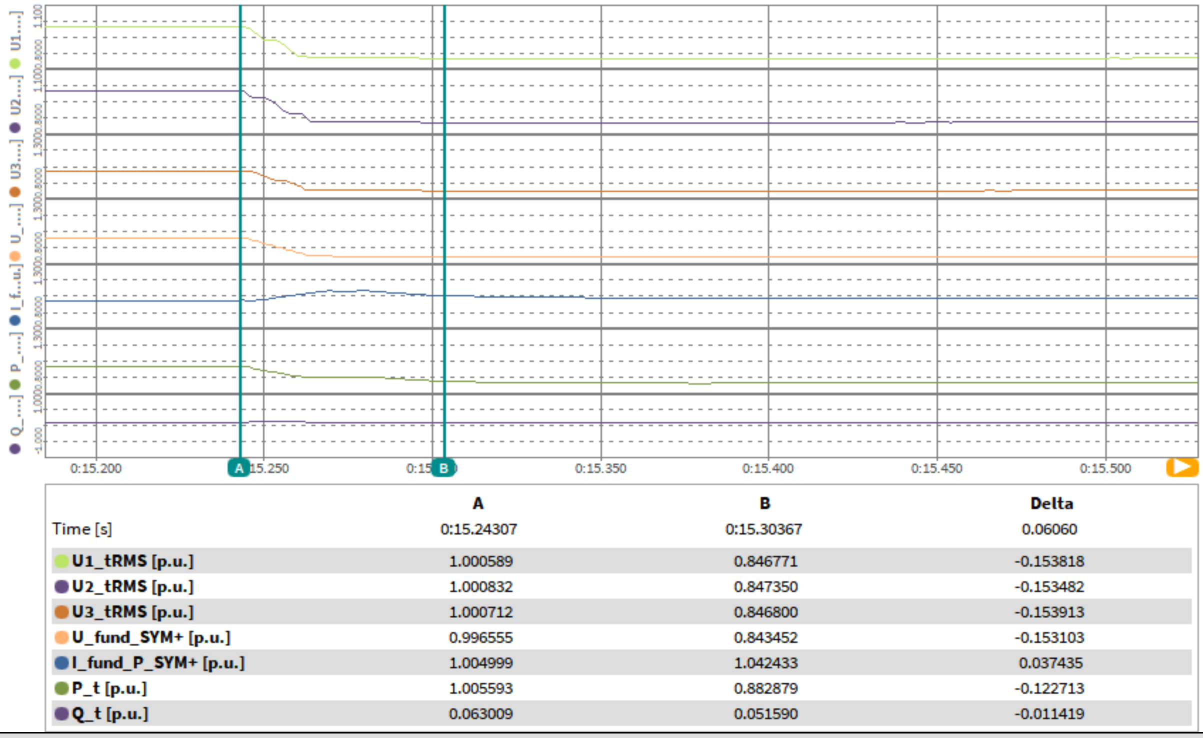
Test 3.1
Depth of fault: 0.85 p.u., three-phase SC (type A), 100% load, t_1-10s to t_1





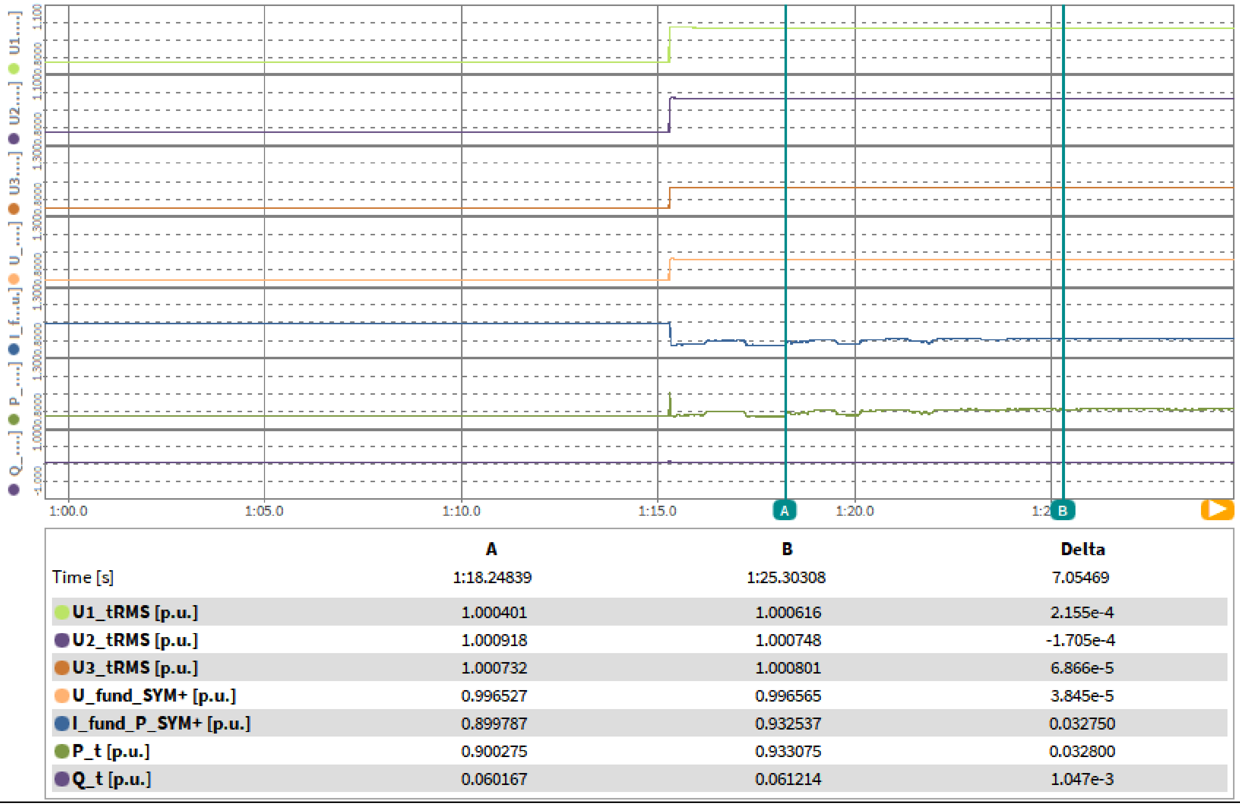
	A	B	Delta
Time [s]	5.21670	0:15.22644	0:10.00974
● **U1_tRMS [p.u.]**	1.000401	1.000540	1.391e-4
● **U2_tRMS [p.u.]**	1.000873	1.000748	-1.249e-4
● **U3_tRMS [p.u.]**	1.000796	1.000806	9.752e-6
● **U_fund_SYM+ [p.u.]**	0.996535	0.996542	7.095e-6
● **I_fund_P_SYM+ [p.u.]**	1.003050	1.002961	-8.818e-5
● **P_t [p.u.]**	1.003610	1.003536	-7.406e-5
● **Q_t [p.u.]**	0.062308	0.062966	6.576e-4

Test 3.1
Depth of fault: 0.85 p.u., three-phase SC (type A), 100% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:15.24307	0:15.30367	0.06060
U1_tRMS [p.u.]	1.000589	0.846771	-0.153818
U2_tRMS [p.u.]	1.000832	0.847350	-0.153482
U3_tRMS [p.u.]	1.000712	0.846800	-0.153913
U_fund_SYM+ [p.u.]	0.996555	0.843452	-0.153103
I_fund_P_SYM+ [p.u.]	1.004999	1.042433	0.037435
P_t [p.u.]	1.005593	0.882879	-0.122713
Q_t [p.u.]	0.063009	0.051590	-0.011419

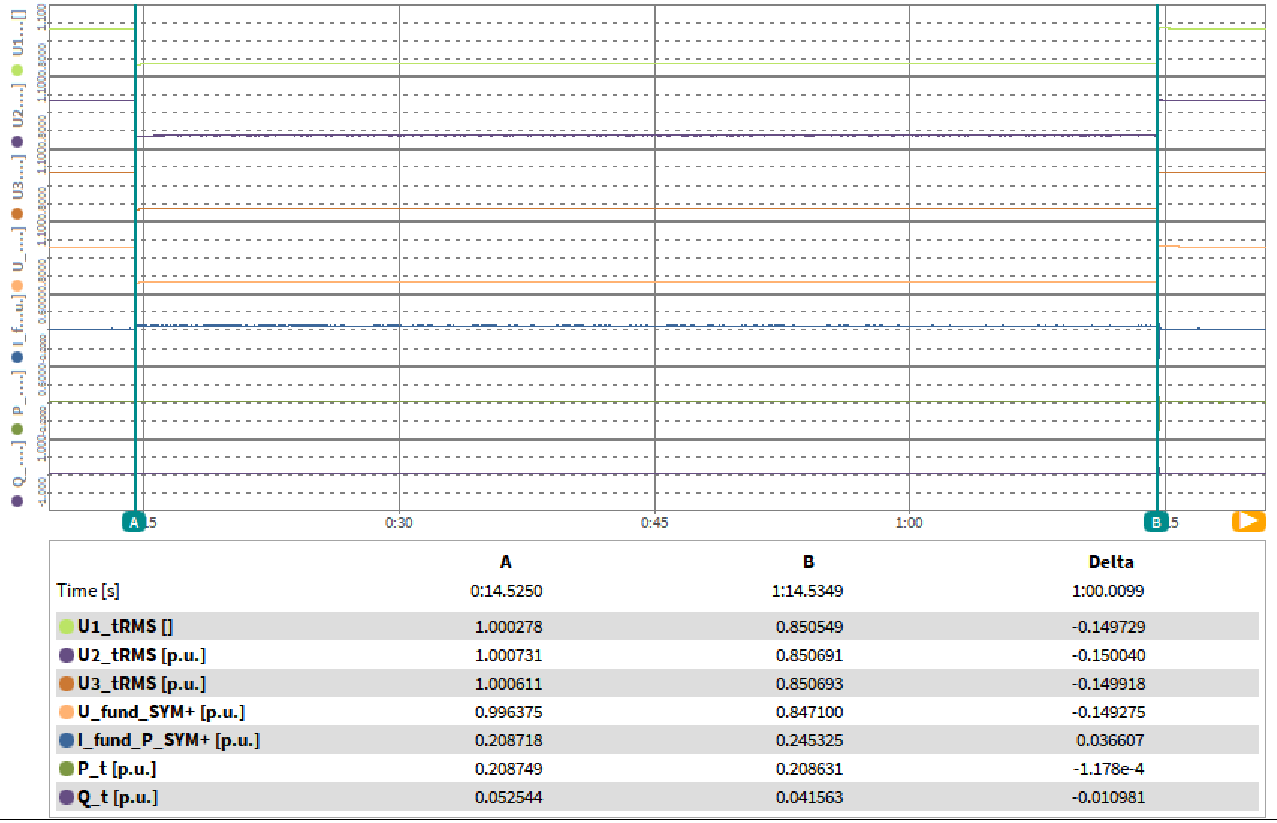
Test 3.1
Depth of fault: 0.85 p.u., three-phase SC (type A), 100% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	1:18.24839	1:25.30308	7.05469
U1_tRMS [p.u.]	1.000401	1.000616	2.155e-4
U2_tRMS [p.u.]	1.000918	1.000748	-1.705e-4
U3_tRMS [p.u.]	1.000732	1.000801	6.866e-5
U_fund_SYM+ [p.u.]	0.996527	0.996565	3.845e-5
I_fund_P_SYM+ [p.u.]	0.899787	0.932537	0.032750
P_t [p.u.]	0.900275	0.933075	0.032800
Q_t [p.u.]	0.060167	0.061214	1.047e-3

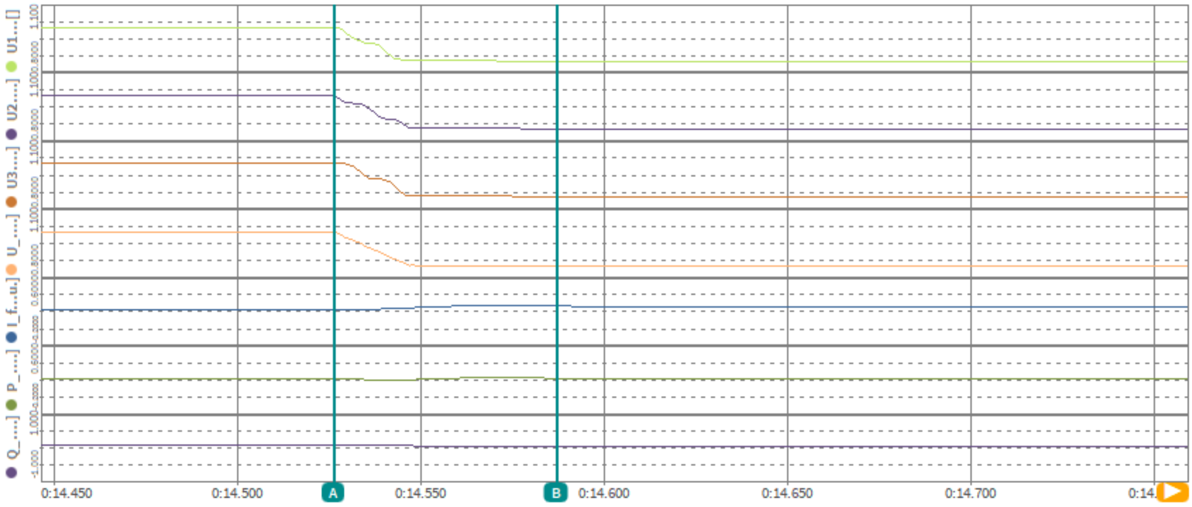
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	3.2
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:13:54
	3	Fault type (phase)	--	--	--	3-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.85
	5	Setting dip duration	60000	--	ms	60009
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	60009
	8	Fault duration in empty load test	Total	--	ms	60009
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.150
	10		Pos.			0.149
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.001
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0.209
	13	Active power	Total	t_1-10s to t_1	p.u.	0.209
	14		Pos.			0.209
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.052
	16		Pos.			0.012
	17	Cosφ	--	t_1-10s to t_1	--	0.970
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.851
	19	Line current	Phase 1	t_1+60ms	p.u.	0.260
	20		Phase 2			0.260
	21		Phase 3			0.256
	22	Line current	Phase 1	t_1+100ms	p.u.	0.249
	23		Phase 2			0.250
	24		Phase 3			0.246
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0.244
	26		Pos.			0.244
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.00
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.209
	29		Pos.			0.209
	30	Active power rising time	Pos.	--	s	--
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.052
	32		Pos.			0.012
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 3.2
Depth of fault: 0.85 p.u., three-phase SC (type A), 20% load, fault time



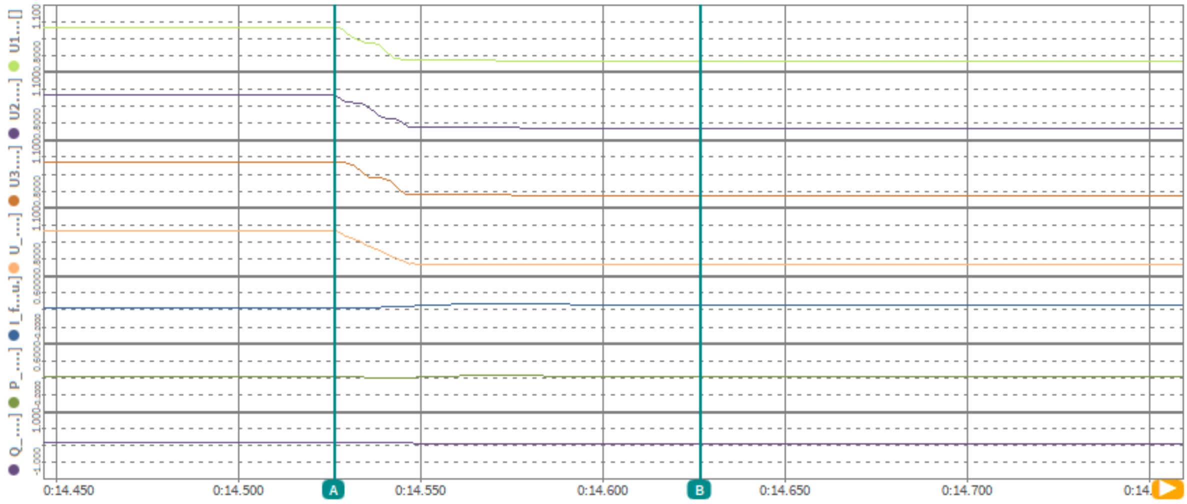
	A	B	Delta
Time [s]	0:14.5250	1:14.5349	1:00.0099
● **U1_tRMS []**	1.000278	0.850549	-0.149729
● **U2_tRMS [p.u.]**	1.000731	0.850691	-0.150040
● **U3_tRMS [p.u.]**	1.000611	0.850693	-0.149918
● **U_fund_SYM+ [p.u.]**	0.996375	0.847100	-0.149275
● **I_fund_P_SYM+ [p.u.]**	0.208718	0.245325	0.036607
● **P_t [p.u.]**	0.208749	0.208631	-1.178e-4
● **Q_t [p.u.]**	0.052544	0.041563	-0.010981

Test 3.2
Depth of fault: 0.85 p.u., three-phase SC (type A), 20% load, current after fault 60ms



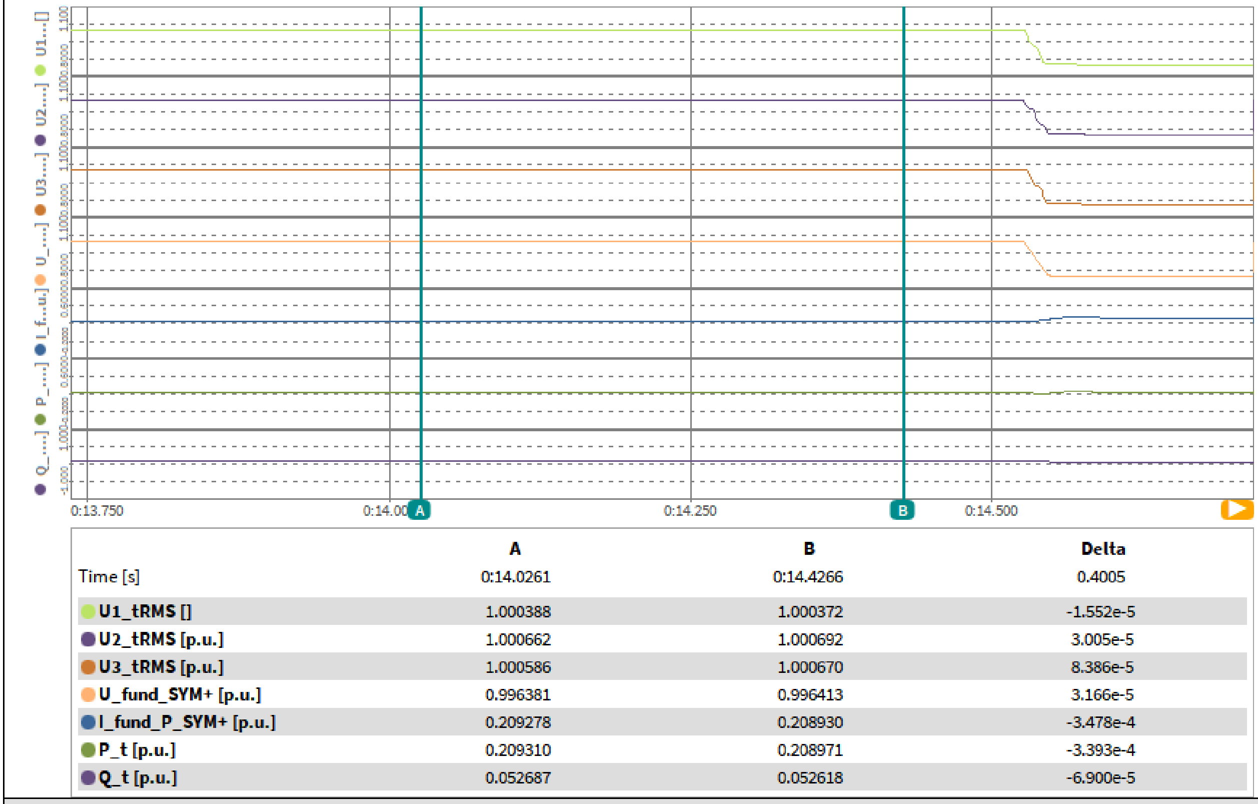
	A	B	Delta
Time [s]	0:14.5265	0:14.5871	0.0606
● **U1_tRMS []**	1.000306	0.846076	-0.154230
● **U2_tRMS [p.u.]**	1.000668	0.846870	-0.153798
● **U3_tRMS [p.u.]**	1.000655	0.846495	-0.154160
● **U_fund_SYM+ [p.u.]**	0.996378	0.842951	-0.153427
● **I_fund_P_SYM+ [p.u.]**	0.208773	0.254581	0.045808
● **P_t [p.u.]**	0.208804	0.215433	6.629e-3
● **Q_t [p.u.]**	0.052537	0.040304	-0.012233

Test 3.2
Depth of fault: 0.85 p.u., three-phase SC (type A), 20% load, current after fault 100ms



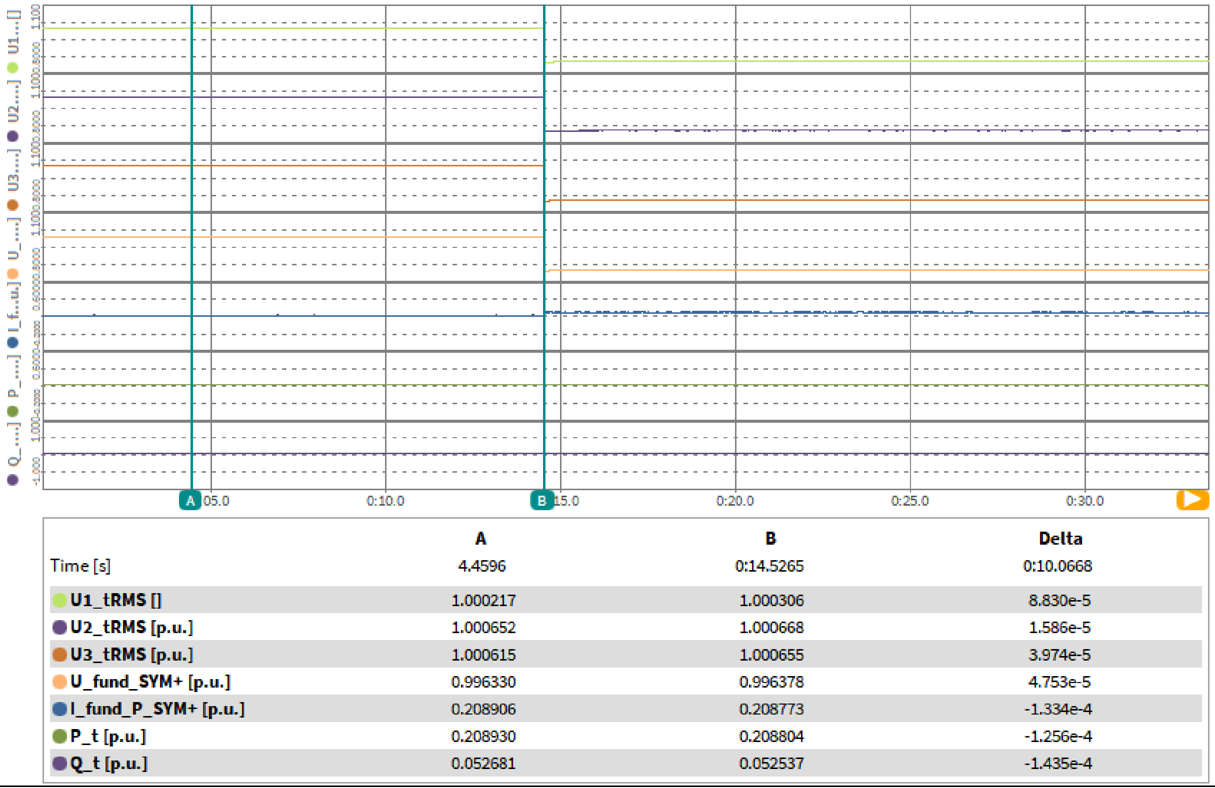
	A	B	Delta
Time [s]	0:14.5265	0:14.6267	0.1002
● **U1_tRMS []**	1.000306	0.845617	-0.154689
● **U2_tRMS [p.u.]**	1.000668	0.846164	-0.154504
● **U3_tRMS [p.u.]**	1.000655	0.846083	-0.154571
● **U_fund_SYM+ [p.u.]**	0.996378	0.842429	-0.153949
● **I_fund_P_SYM+ [p.u.]**	0.208773	0.243659	0.034886
● **P_t [p.u.]**	0.208804	0.206064	-2.740e-3
● **Q_t [p.u.]**	0.052537	0.039581	-0.012955

Test 3.2
Depth of fault: 0.85 p.u., three-phase SC (type A), 20% load, t_1-500ms to t_1-100ms



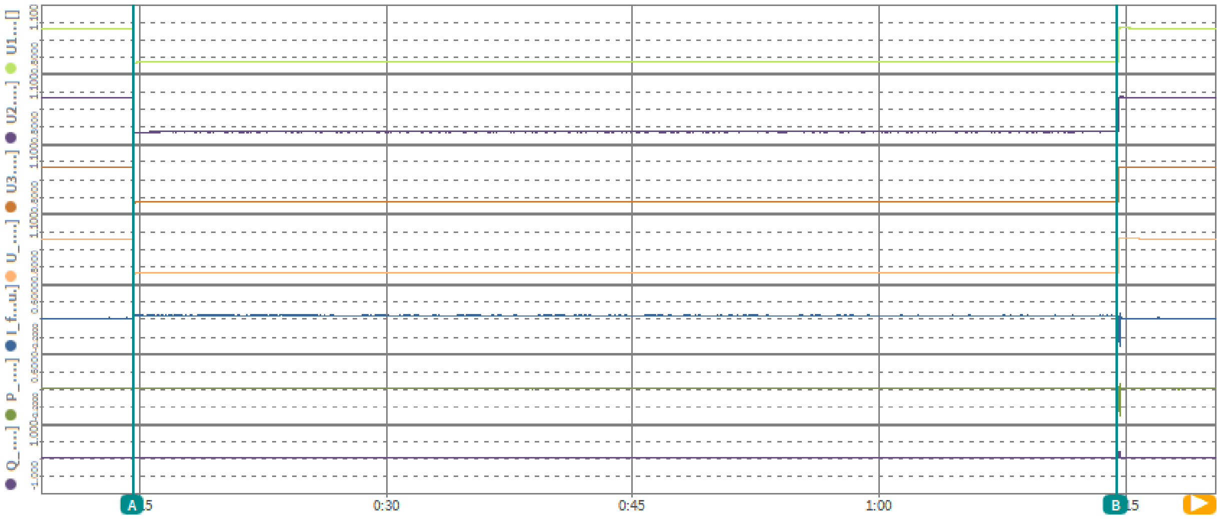
	A	B	Delta
Time [s]	0:14.0261	0:14.4266	0.4005
● U1_tRMS []	1.000388	1.000372	-1.552e-5
● U2_tRMS [p.u.]	1.000662	1.000692	3.005e-5
● U3_tRMS [p.u.]	1.000586	1.000670	8.386e-5
● U_fund_SYM+ [p.u.]	0.996381	0.996413	3.166e-5
● I_fund_P_SYM+ [p.u.]	0.209278	0.208930	-3.478e-4
● P_t [p.u.]	0.209310	0.208971	-3.393e-4
● Q_t [p.u.]	0.052687	0.052618	-6.900e-5

Test 3.2
Depth of fault: 0.85 p.u., three-phase SC (type A), 20% load, t_1-10s to t_1



	A	B	Delta
Time [s]	4.4596	0:14.5265	0:10.0668
● U1_tRMS []	1.000217	1.000306	8.830e-5
● U2_tRMS [p.u.]	1.000652	1.000668	1.586e-5
● U3_tRMS [p.u.]	1.000615	1.000655	3.974e-5
● U_fund_SYM+ [p.u.]	0.996330	0.996378	4.753e-5
● I_fund_P_SYM+ [p.u.]	0.208906	0.208773	-1.334e-4
● P_t [p.u.]	0.208930	0.208804	-1.256e-4
● Q_t [p.u.]	0.052681	0.052537	-1.435e-4

Test 3.2
Depth of fault: 0.85 p.u., three-phase SC (type A), 20% load, t_1+100ms to t_2-20ms



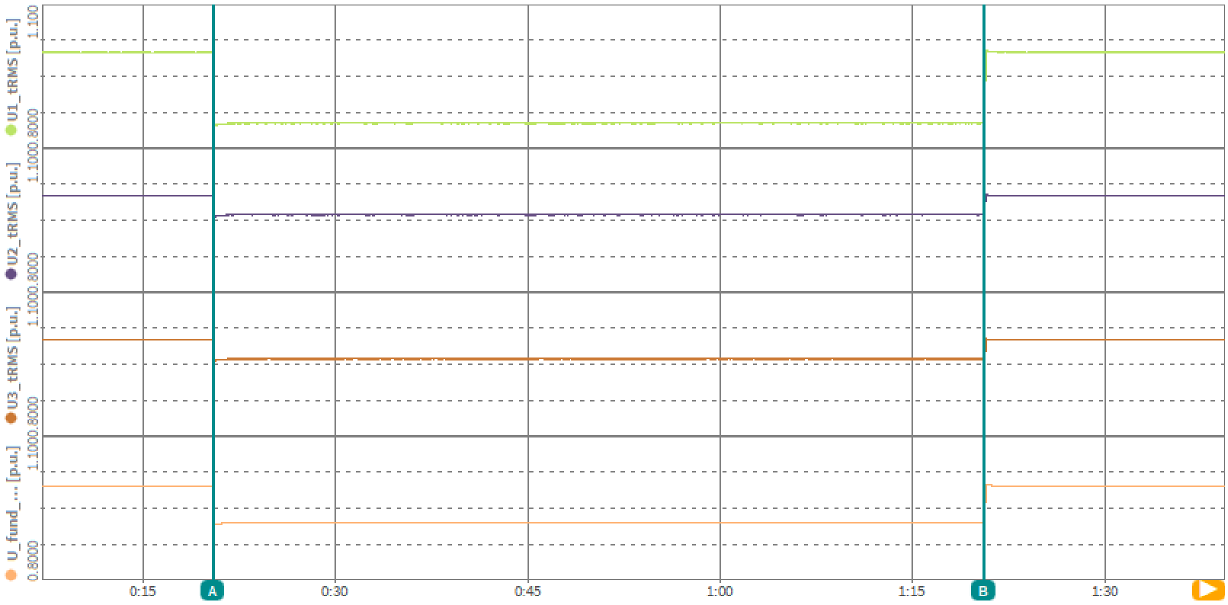
	A	B	Delta
Time [s]	0:14.6243	1:14.4358	0:59.8114
● **U1_tRMS []**	0.845587	0.850486	4.899e-3
● **U2_tRMS [p.u.]**	0.846198	0.850675	4.478e-3
● **U3_tRMS [p.u.]**	0.846015	0.850664	4.648e-3
● **U_fund_SYM+ [p.u.]**	0.842407	0.847064	4.656e-3
● **I_fund_P_SYM+ [p.u.]**	0.243532	0.245310	1.778e-3
● **P_t [p.u.]**	0.205951	0.208607	2.655e-3
● **Q_t [p.u.]**	0.039615	0.041644	2.029e-3

Test 3.2
Depth of fault: 0.85 p.u., three-phase SC (type A), 20% load, t_2+3s to t_2+10s

	A	B	Delta
Time [s]	1:17.5014	1:24.5015	7.0001
● **U1_tRMS []**	1.000245	1.000224	-2.130e-5
● **U2_tRMS [p.u.]**	1.000684	1.000730	4.531e-5
● **U3_tRMS [p.u.]**	1.000480	1.000541	6.090e-5
● **U_fund_SYM+ [p.u.]**	0.996305	0.996333	2.800e-5
● **I_fund_P_SYM+ [p.u.]**	0.208599	0.208751	1.520e-4
● **P_t [p.u.]**	0.208619	0.208776	1.566e-4
● **Q_t [p.u.]**	0.052028	0.052475	4.473e-4

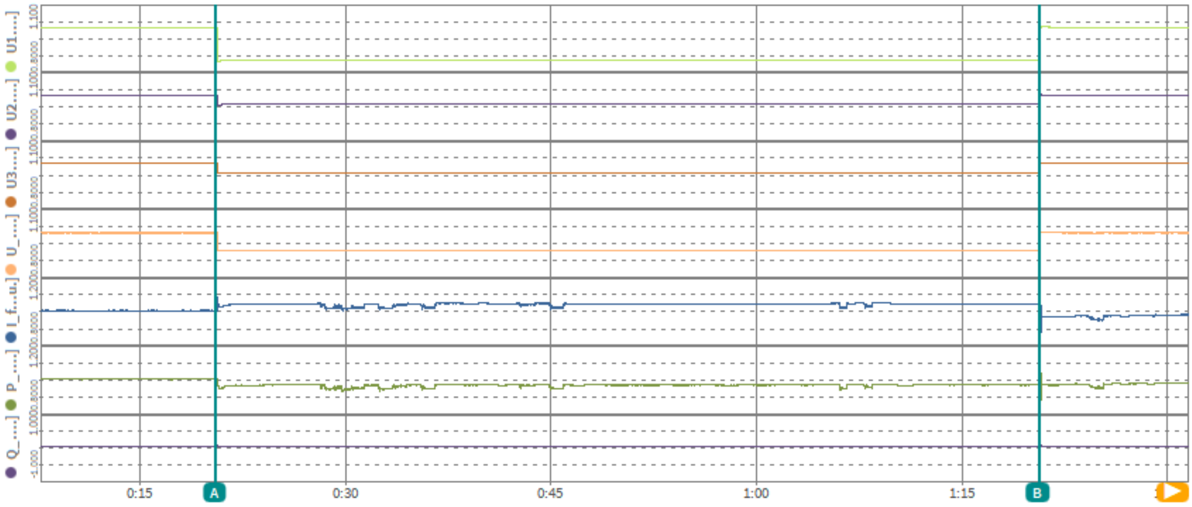
Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	3.3
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:51:04
	3	Fault type (phase)	--	--	--	2-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.93
	5	Setting dip duration	60000	--	ms	60009
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	60009
	8	Fault duration in empty load test	Total	--	ms	60003
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.077
	10		Pos.			0.078
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.001
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	1.005
	13	Active power	Total	t_1-10s to t_1	p.u.	1.005
	14		Pos.			1.005
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.062
	16		Pos.			0.012
	17	Cosφ	--	t_1-10s to t_1	--	0.998
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.919
	19	Line current	Phase 1	t_1+60ms	p.u.	1.046
	20		Phase 2			1.059
	21		Phase 3			1.059
	22	Line current	Phase 1	t_1+100ms	p.u.	1.036
	23		Phase 2			1.046
	24		Phase 3			1.043
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0.99
	26		Pos.			--
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.001
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.977
	29		Pos.			0.977
	30	Active power rising time	Pos.	--	s	--
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.061
	32		Pos.			0.011
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

Test 3.3D1
Depth of fault: 0.85 p.u., two-phase SC (type D1), 0% load



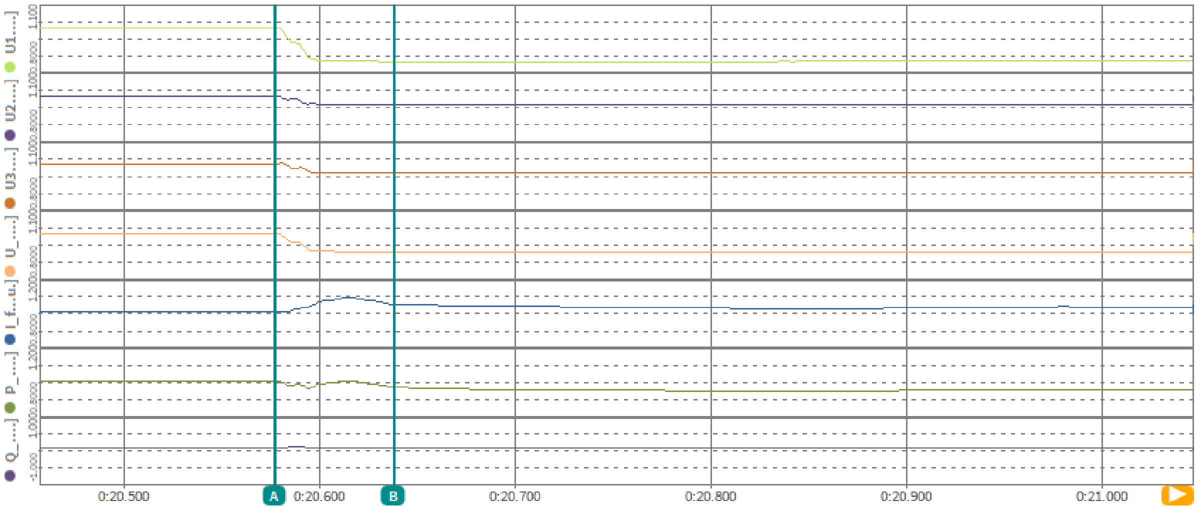
	A	B	Delta
Time [s]	0:20.56072	1:20.58731	1:00.02659
● **U1_tRMS [p.u.]**	1.000422	0.850725	-0.149697
● **U2_tRMS [p.u.]**	1.000720	0.960852	-0.039867
● **U3_tRMS [p.u.]**	1.000765	0.960676	-0.040089
● **U_fund_SYM+ [p.u.]**	0.996481	0.918724	-0.077758

Test 3.3
Depth of fault: 0.85 p.u., three-phase SC (type D1), 100% load, fault time



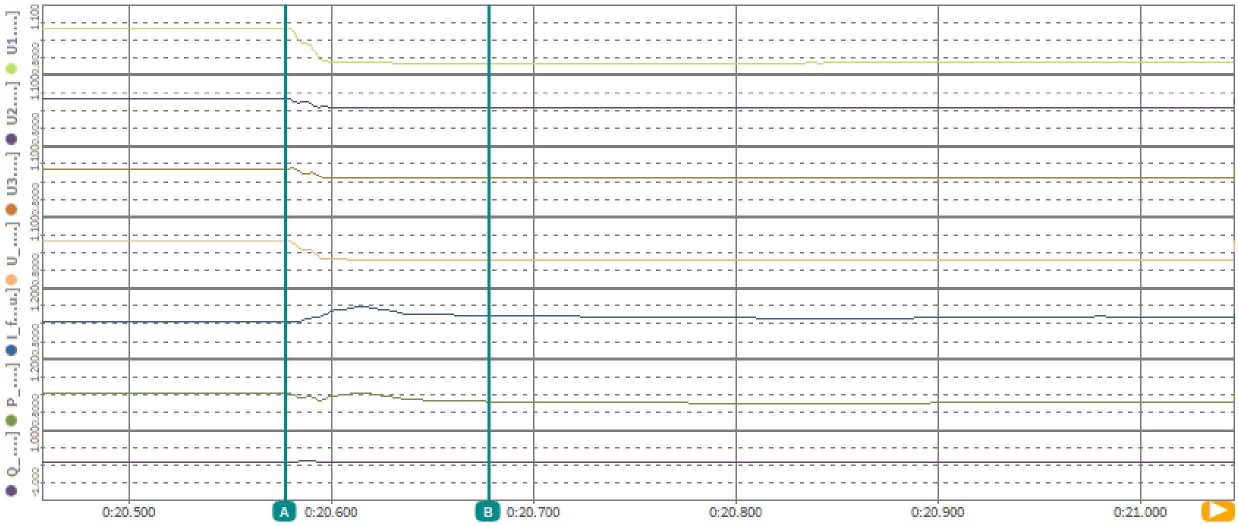
	A	B	Delta
Time [s]	0:20.5778	1:20.5867	1:00.0089
● **U1_tRMS [p.u.]**	1.000490	0.850725	-0.149765
● **U2_tRMS [p.u.]**	1.000874	0.960852	-0.040021
● **U3_tRMS [p.u.]**	1.000715	0.960676	-0.040039
● **U_fund_SYM+ [p.u.]**	0.996538	0.918724	-0.077815
● **I_fund_P_SYM+ [p.u.]**	1.004710	1.046244	0.041533
● **P_t [p.u.]**	1.005296	0.968456	-0.036840
● **Q_t [p.u.]**	0.061682	0.054807	-6.874e-3

Test 3.3
Depth of fault: 0.85 p.u., three-phase SC (type D1), 100% load, current after fault 60ms



	A	B	Delta
Time [s]	0:20.5778	0:20.6383	0.0605
● **U1_tRMS [p.u.]**	1.000490	0.846820	-0.153670
● **U2_tRMS [p.u.]**	1.000874	0.957982	-0.042891
● **U3_tRMS [p.u.]**	1.000715	0.957692	-0.043023
● **U_fund_SYM+ [p.u.]**	0.996538	0.915497	-0.081041
● **I_fund_P_SYM+ [p.u.]**	1.004710	1.050783	0.046073
● **P_t [p.u.]**	1.005296	0.969732	-0.035564
● **Q_t [p.u.]**	0.061682	0.060319	-1.362e-3

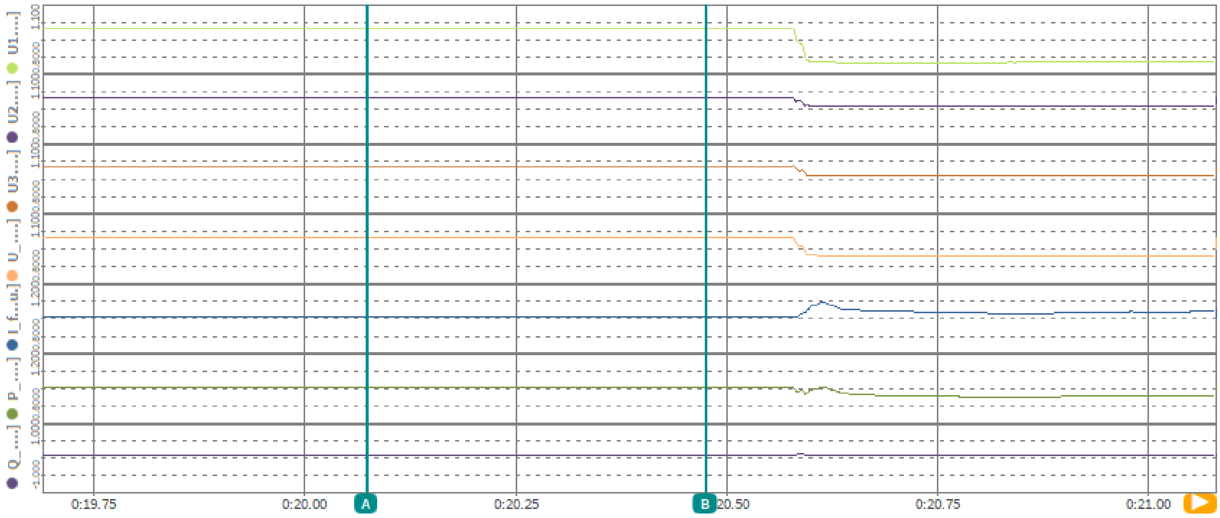
Test 3.3
Depth of fault: 0.85 p.u., three-phase SC (type D1), 100% load, current after fault 100ms



	A	B	Delta
Time [s]	0:20.5778	0:20.6782	0.1004
● **U1_tRMS [p.u.]**	1.000490	0.846196	-0.154294
● **U2_tRMS [p.u.]**	1.000874	0.957500	-0.043373
● **U3_tRMS [p.u.]**	1.000715	0.957422	-0.043293
● **U_fund_SYM+ [p.u.]**	0.996538	0.915046	-0.081492
● **I_fund_P_SYM+ [p.u.]**	1.004710	1.038473	0.033763
● **P_t [p.u.]**	1.005296	0.957341	-0.047955
● **Q_t [p.u.]**	0.061682	0.054070	-7.612e-3

Test 3.3

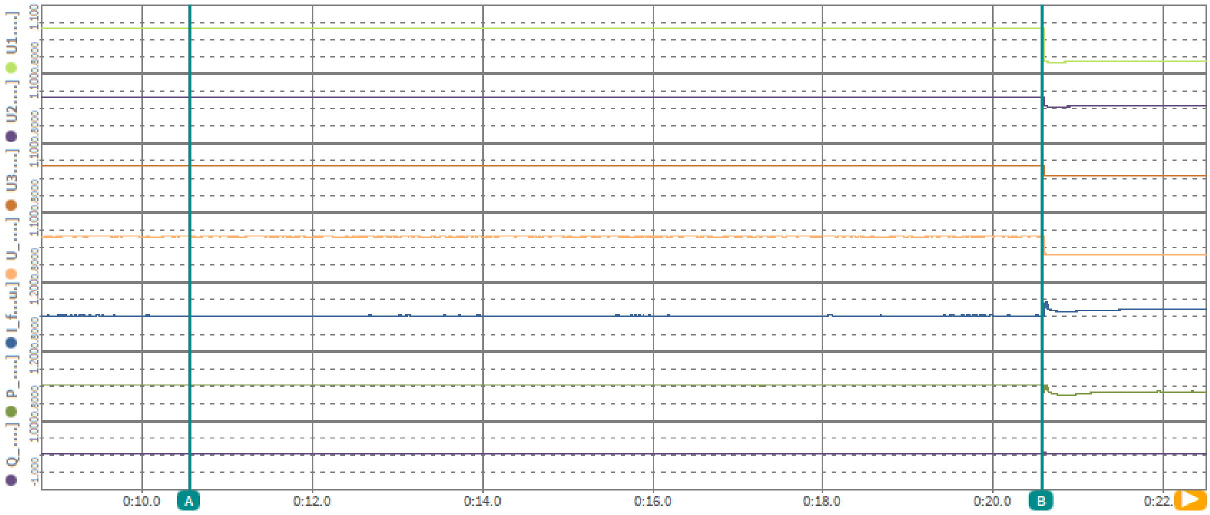
Depth of fault: 0.85 p.u., three-phase SC (type D1), 100% load, t_1-500ms to t_1-100ms



	A	B	Delta
Time [s]	0:20.0741	0:20.4754	0.4013
● **U1_tRMS [p.u.]**	1.000458	1.000479	2.083e-5
● **U2_tRMS [p.u.]**	1.000885	1.000932	4.704e-5
● **U3_tRMS [p.u.]**	1.000798	1.000807	9.155e-6
● **U_fund_SYM+ [p.u.]**	0.996560	0.996585	2.510e-5
● **I_fund_P_SYM+ [p.u.]**	1.005172	1.003549	-1.623e-3
● **P_t [p.u.]**	1.005773	1.004175	-1.598e-3
● **Q_t [p.u.]**	0.062217	0.062615	3.980e-4

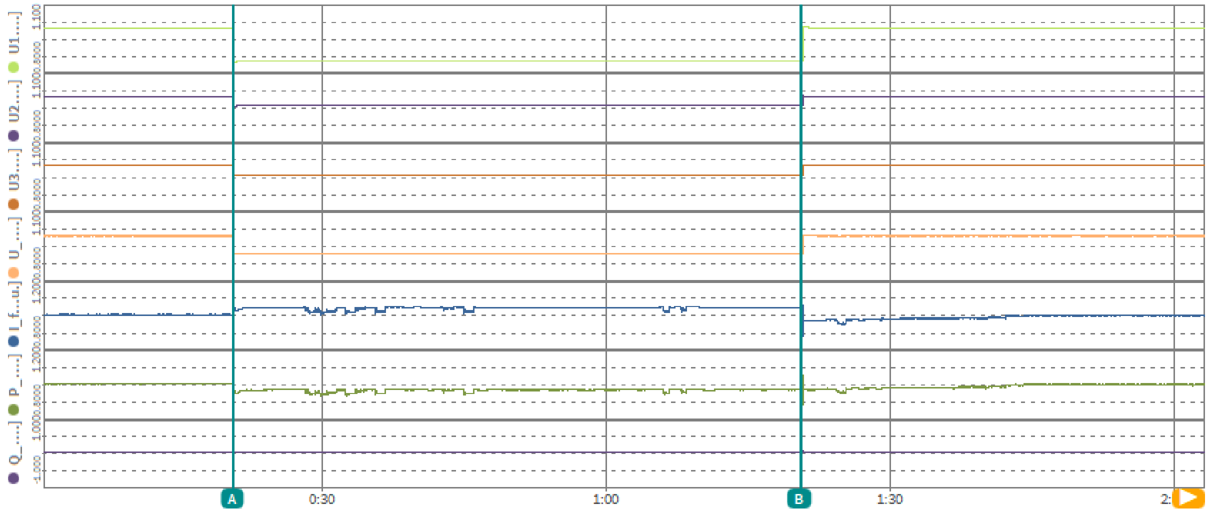
Test 3.3

Depth of fault: 0.85 p.u., three-phase SC (type D1), 100% load, t_1-10s to t_1



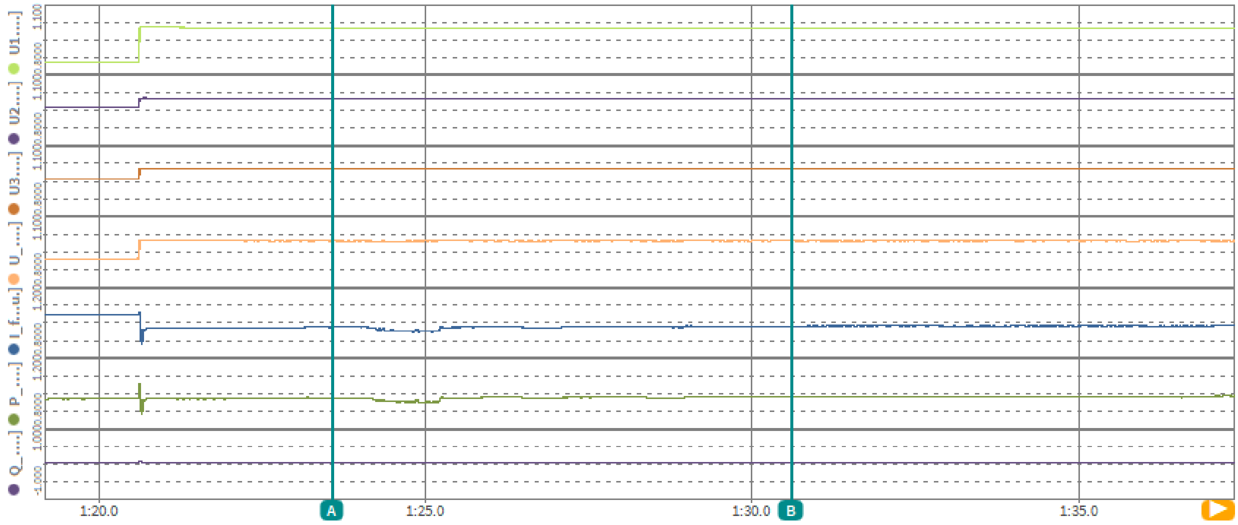
	A	B	Delta
Time [s]	0:10.5635	0:20.5754	0:10.0118
● **U1_tRMS [p.u.]**	1.000384	1.000377	-7.430e-6
● **U2_tRMS [p.u.]**	1.000895	1.000940	4.578e-5
● **U3_tRMS [p.u.]**	1.000685	1.000724	3.888e-5
● **U_fund_SYM+ [p.u.]**	0.996500	0.996525	2.563e-5
● **I_fund_P_SYM+ [p.u.]**	1.001931	1.004882	2.951e-3
● **P_t [p.u.]**	1.002469	1.005452	2.984e-3
● **Q_t [p.u.]**	0.061761	0.061518	-2.427e-4

Test 3.3
Depth of fault: 0.85 p.u., three-phase SC (type D1), 100% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:20.6782	1:20.5276	0:59.8495
● **U1_tRMS [p.u.]**	0.846196	0.850647	4.452e-3
● **U2_tRMS [p.u.]**	0.957500	0.960777	3.276e-3
● **U3_tRMS [p.u.]**	0.957422	0.960770	3.348e-3
● **U_fund_SYM+ [p.u.]**	0.915046	0.918714	3.667e-3
● **I_fund_P_SYM+ [p.u.]**	1.038473	1.045738	7.264e-3
● **P_t [p.u.]**	0.957341	0.967969	0.010628
● **Q_t [p.u.]**	0.054070	0.055230	1.160e-3

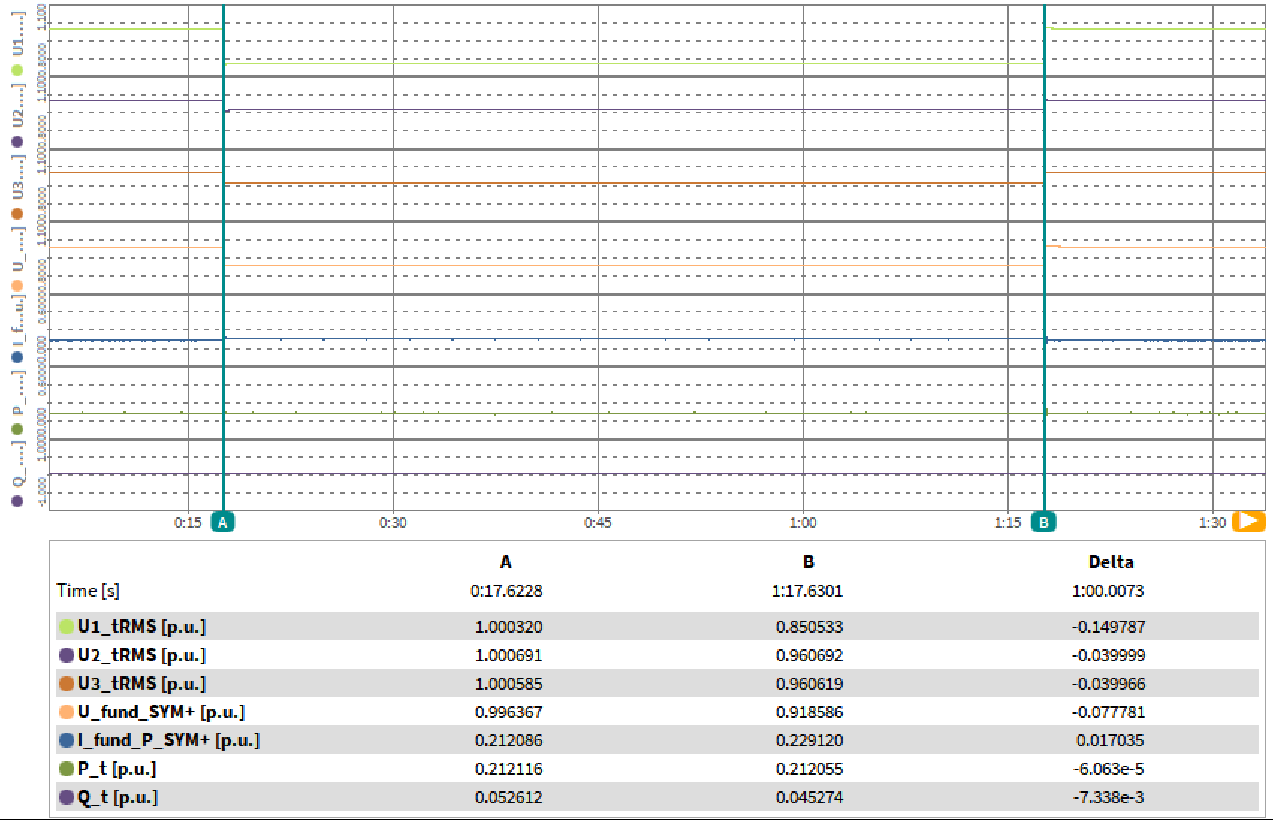
Test 3.3
Depth of fault: 0.85 p.u., three-phase SC (type D1), 100% load, t_2+3s to t_2+10s



	A	B	Delta
Time [s]	1:23.582914	1:30.603693	7.020779
● **U1_tRMS [p.u.]**	1.000462	1.000519	5.652e-5
● **U2_tRMS [p.u.]**	1.000859	1.000810	-4.949e-5
● **U3_tRMS [p.u.]**	1.000709	1.000748	3.908e-5
● **U_fund_SYM+ [p.u.]**	0.996521	0.996536	1.587e-5
● **I_fund_P_SYM+ [p.u.]**	0.973508	0.976329	2.821e-3
● **P_t [p.u.]**	0.974032	0.976890	2.858e-3
● **Q_t [p.u.]**	0.062040	0.061407	-6.327e-4

Item	No.	Parameter	Phase reference	Time reference	Unit	Measured value
General information	0	Test number	--	--	--	3.4
	1	Date	--	--	yyyy.mm.dd	2022.11.08
	2	Time (start of test)	--	--	hh:mm:ss.f	16:47:12
	3	Fault type (phase)	--	--	--	2-phase fault
	4	Setting voltage depth	Line to line	--	p.u.	0.93
	5	Setting dip duration	60000	--	ms	60007
	6	Point of fault entry	Total	--	ms	0
	7	Point of fault clearance	Total	--	ms	60007
	8	Fault duration in empty load test	Total	--	ms	60002
	9	Voltage depth/height in empty load test	Total	t_1+100ms to t_2 and t_1-10s to t_1	p.u.	0.077
	10		Pos.			0.078
Before the dip < t_1	11	Voltage	Line to neutral	t_1-10s to t_1	p.u.	1.000
	12	Current	Pos.	t_1-500ms to t_1 -100ms	p.u.	0.212
	13	Active power	Total	t_1-10s to t_1	p.u.	0.212
	14		Pos.			0.212
	15	Reactive power	Total	t_1-10s to t_1	p.u.	0.053
	16		Pos.			0.006
	17	Cosφ	--	t_1-10s to t_1	--	0.970
During the dip t_1 to t_2	18	Voltage	Line to neutral	t_1+100ms to t_2 -20ms	p.u.	0.919
	19	Line current	Phase 1	t_1+60ms	p.u.	0.232
	20		Phase 2			0.238
	21		Phase 3			0.238
	22	Line current	Phase 1	t_1+100ms	p.u.	0.228
	23		Phase 2			0.233
	24		Phase 3			0.233
	25	Active power	Total	t_1+100ms to t_2 -20ms	p.u.	0.209
	26		Pos.			0.208
After the dip > t_2	27	Voltage	Line to neutral	t_2+3s to t_2+10s	p.u.	1.00
	28	Active power	Total	t_2+3s to t_2+10s	p.u.	0.210
	29		Pos.			0.210
	30	Active power rising time	Pos.	--	s	--
	31	Reactive power	Total	t_2+3s to t_2+10s	p.u.	0.053
	32		Pos.			0.006
	33	Reactive power rising time	Pos.	--	s	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t_2 to t_2+60s	Yes / No	Yes

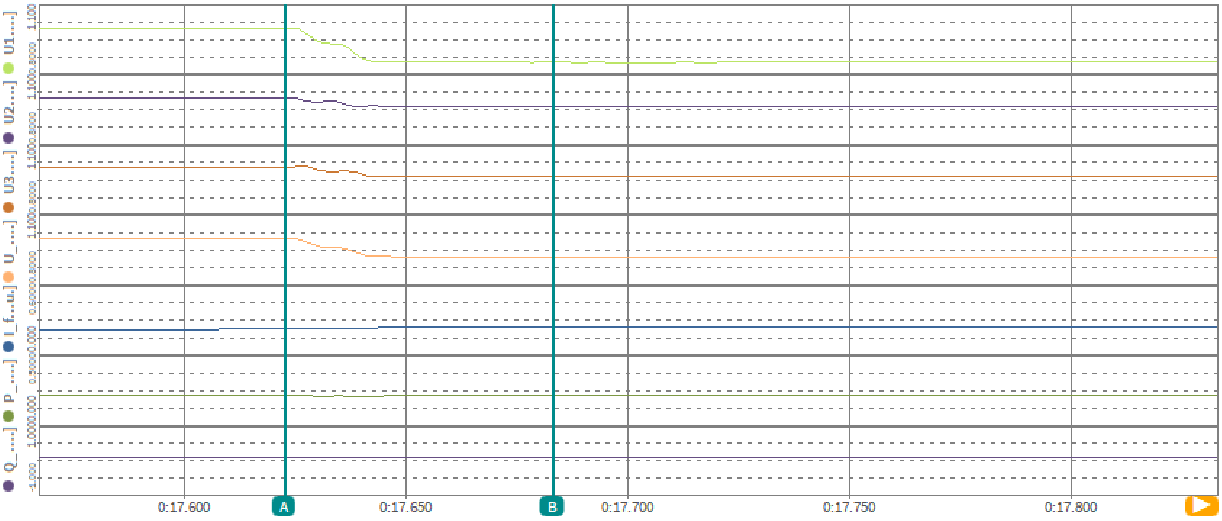
Test 3.4
Depth of fault: 0.85 p.u., three-phase SC (type D1), 20% load, fault time



	A	B	Delta
Time [s]	0:17.6228	1:17.6301	1:00.0073
● **U1_tRMS [p.u.]**	1.000320	0.850533	-0.149787
● **U2_tRMS [p.u.]**	1.000691	0.960692	-0.039999
● **U3_tRMS [p.u.]**	1.000585	0.960619	-0.039966
● **U_fund_SYM+ [p.u.]**	0.996367	0.918586	-0.077781
● **I_fund_P_SYM+ [p.u.]**	0.212086	0.229120	0.017035
● **P_t [p.u.]**	0.212116	0.212055	-6.063e-5
● **Q_t [p.u.]**	0.052612	0.045274	-7.338e-3

Test 3.4

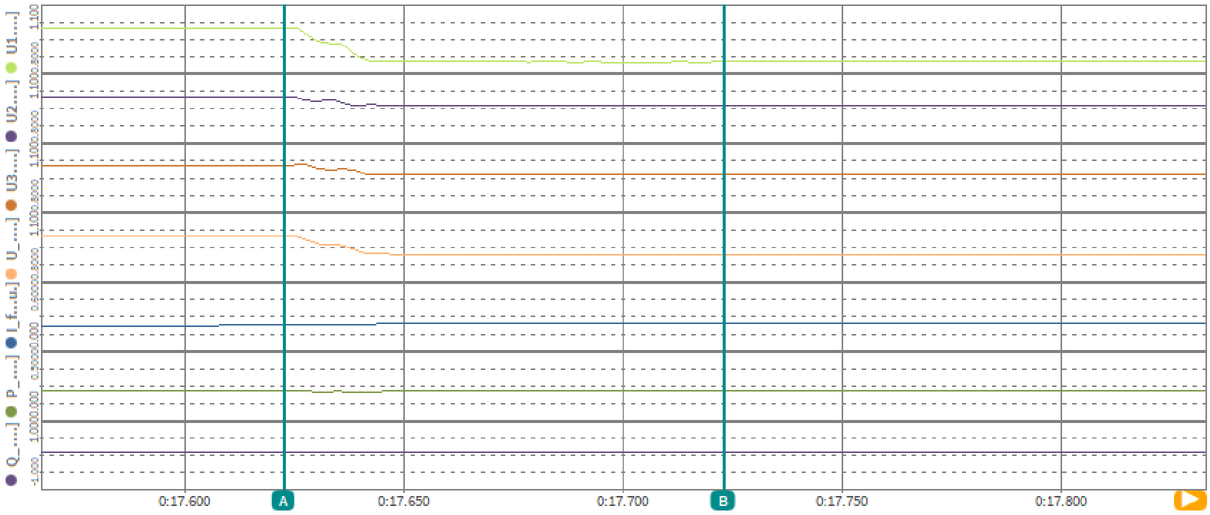
Depth of fault: 0.85 p.u., three-phase SC (type D1), 20% load, current after fault 60ms



	A	B	Delta
Time [s]	0:17.6228	0:17.6832	0.0604
● **U1_tRMS [p.u.]**	1.000320	0.847975	-0.152346
● **U2_tRMS [p.u.]**	1.000691	0.957130	-0.043561
● **U3_tRMS [p.u.]**	1.000585	0.957117	-0.043468
● **U_fund_SYM+ [p.u.]**	0.996367	0.915389	-0.080979
● **I_fund_P_SYM+ [p.u.]**	0.212086	0.230332	0.018247
● **P_t [p.u.]**	0.212116	0.212519	4.036e-4
● **Q_t [p.u.]**	0.052612	0.045509	-7.103e-3

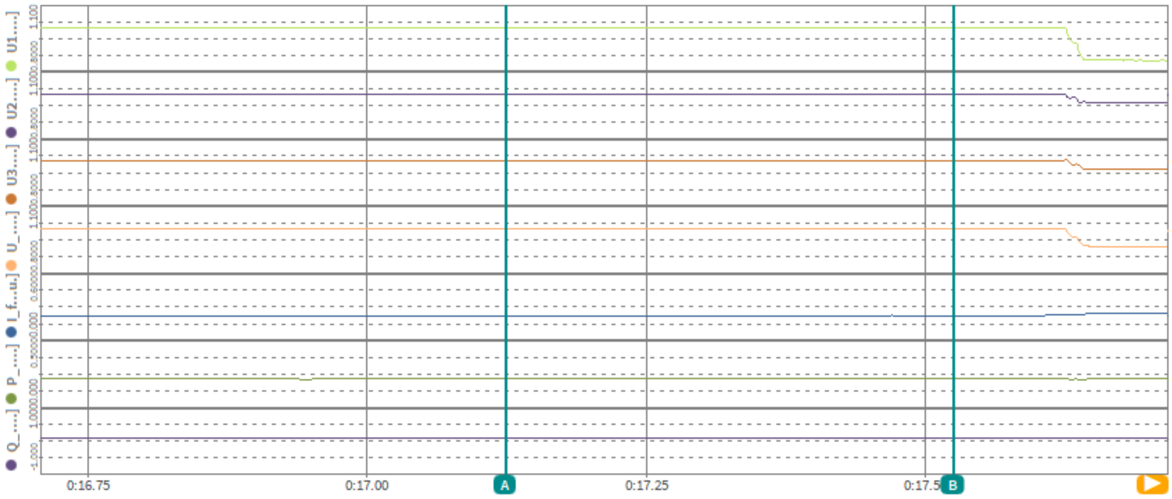
Test 3.4

Depth of fault: 0.85 p.u., three-phase SC (type D1), 20% load, current after fault 100ms



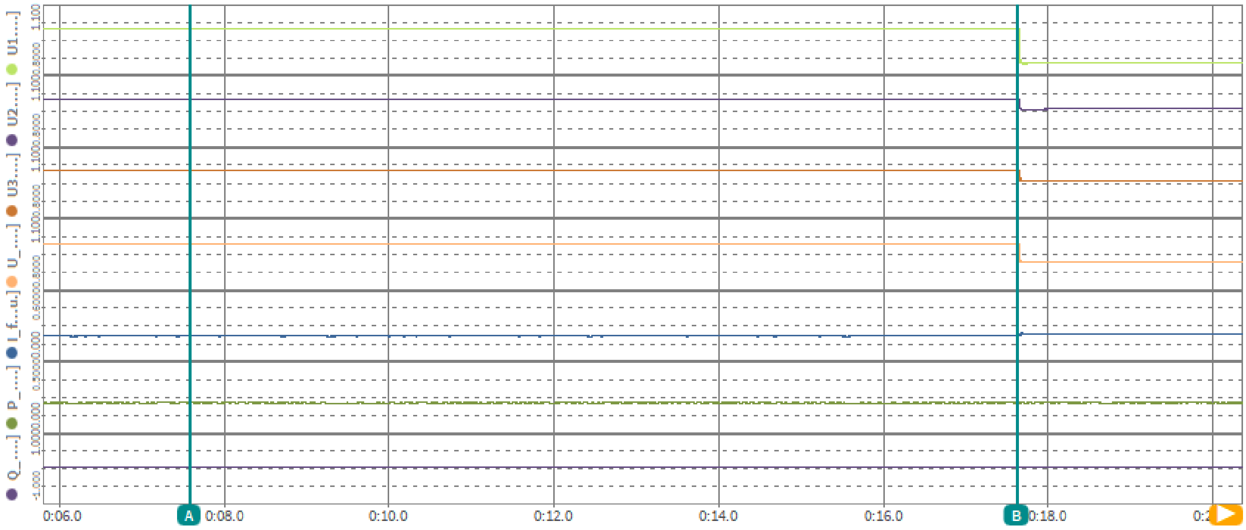
	A	B	Delta
Time [s]	0:17.6228	0:17.7231	0.1003
● **U1_tRMS [p.u.]**	1.000320	0.847927	-0.152393
● **U2_tRMS [p.u.]**	1.000691	0.957272	-0.043419
● **U3_tRMS [p.u.]**	1.000585	0.957223	-0.043362
● **U_fund_SYM+ [p.u.]**	0.996367	0.915454	-0.080914
● **I_fund_P_SYM+ [p.u.]**	0.212086	0.225793	0.013707
● **P_t [p.u.]**	0.212116	0.208233	-3.883e-3
● **Q_t [p.u.]**	0.052612	0.044969	-7.642e-3

Test 3.4
Depth of fault: 0.85 p.u., three-phase SC (type D1), 20% load, t_1-500ms to t_1-100ms



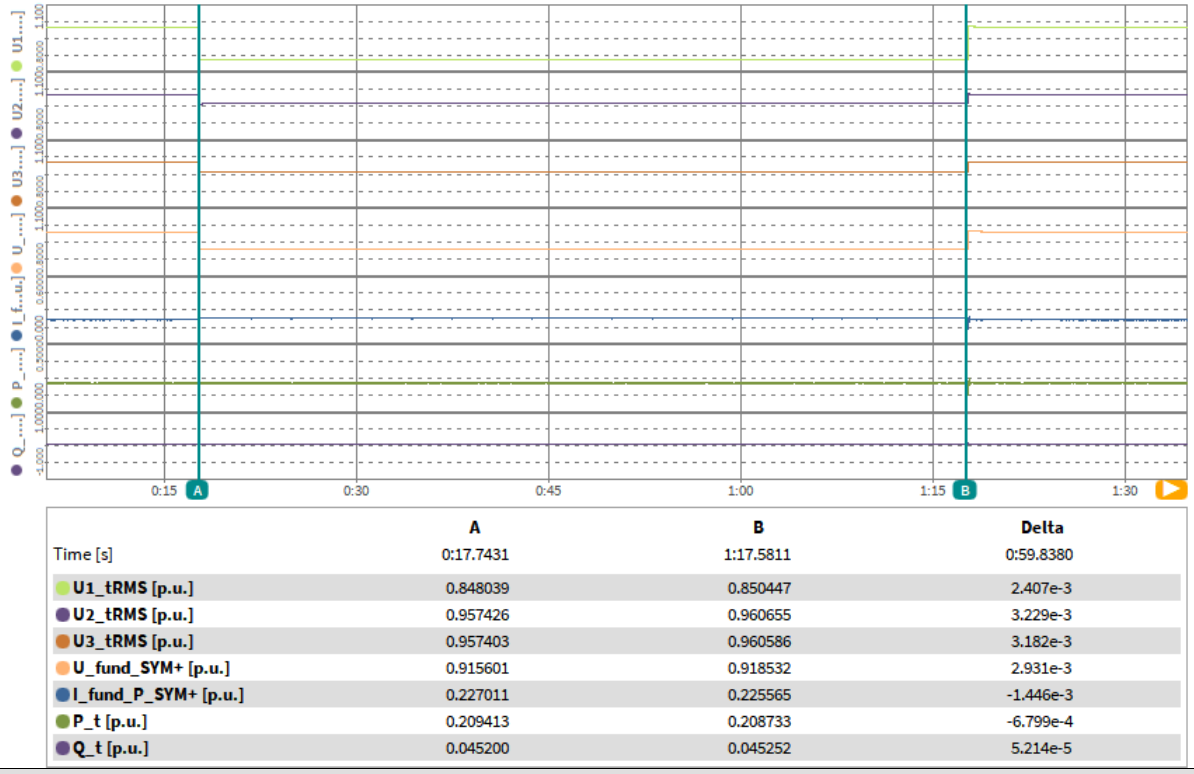
	A	B	Delta
Time [s]	0:17.1244	0:17.5249	0.4004
● **U1_tRMS [p.u.]**	1.000432	1.000362	-7.039e-5
● **U2_tRMS [p.u.]**	1.000620	1.000545	-7.563e-5
● **U3_tRMS [p.u.]**	1.000542	1.000564	2.216e-5
● **U_fund_SYM+ [p.u.]**	0.996367	0.996326	-4.013e-5
● **I_fund_P_SYM+ [p.u.]**	0.209279	0.209206	-7.326e-5
● **P_t [p.u.]**	0.209306	0.209225	-8.169e-5
● **Q_t [p.u.]**	0.052679	0.052595	-8.407e-5

Test 3.4
Depth of fault: 0.85 p.u., three-phase SC (type D1), 20% load, t_1-10s to t_1



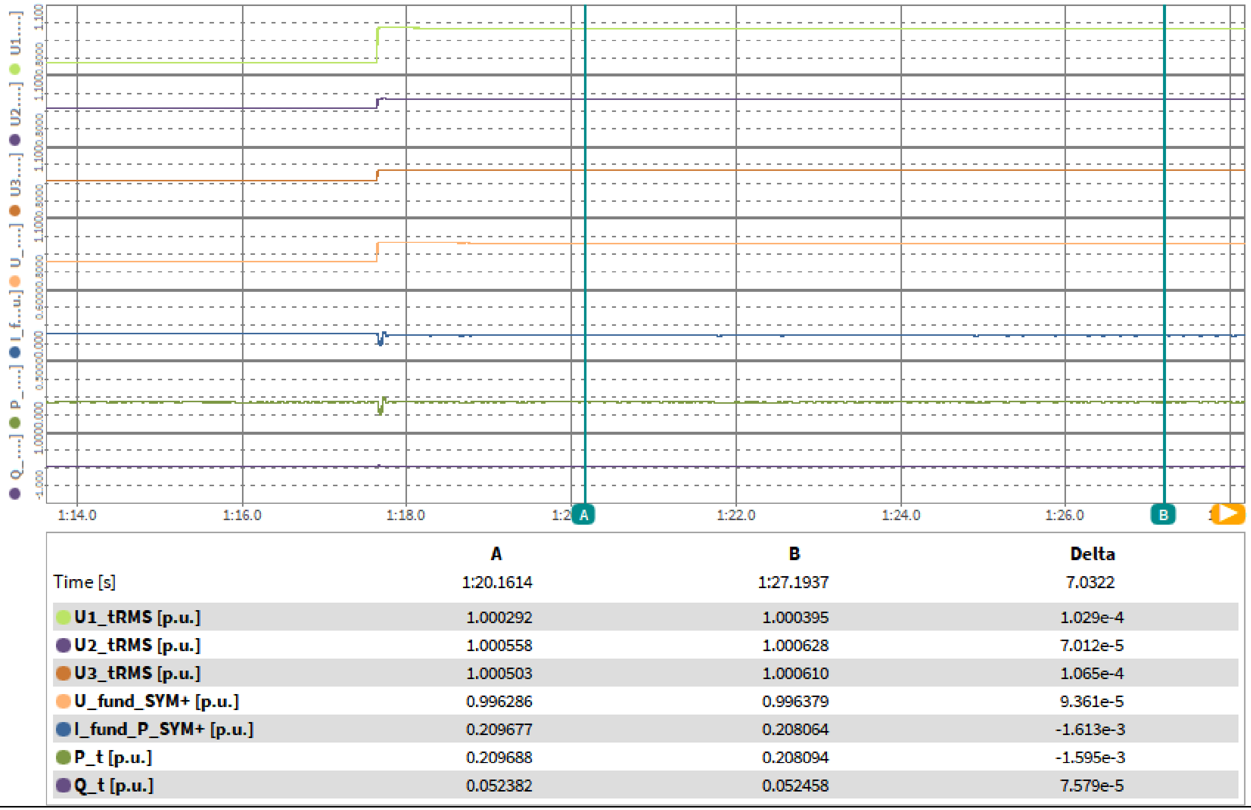
	A	B	Delta
Time [s]	7.5922	0:17.6216	0:10.0293
● **U1_tRMS [p.u.]**	1.000348	1.000291	-5.725e-5
● **U2_tRMS [p.u.]**	1.000618	1.000723	1.044e-4
● **U3_tRMS [p.u.]**	1.000547	1.000596	4.949e-5
● **U_fund_SYM+ [p.u.]**	0.996338	0.996372	3.349e-5
● **I_fund_P_SYM+ [p.u.]**	0.209484	0.212129	2.645e-3
● **P_t [p.u.]**	0.209504	0.212159	2.655e-3
● **Q_t [p.u.]**	0.052845	0.052619	-2.261e-4

Test 3.4
Depth of fault: 0.85 p.u., three-phase SC (type D1), 20% load, t_1+100ms to t_2-20ms



	A	B	Delta
Time [s]	0:17.7431	1:17.5811	0:59.8380
● **U1_tRMS [p.u.]**	0.848039	0.850447	2.407e-3
● **U2_tRMS [p.u.]**	0.957426	0.960655	3.229e-3
● **U3_tRMS [p.u.]**	0.957403	0.960586	3.182e-3
● **U_fund_SYM+ [p.u.]**	0.915601	0.918532	2.931e-3
● **I_fund_P_SYM+ [p.u.]**	0.227011	0.225565	-1.446e-3
● **P_t [p.u.]**	0.209413	0.208733	-6.799e-4
● **Q_t [p.u.]**	0.045200	0.045252	5.214e-5

Test 3.4
Depth of fault: 0.85 p.u., three-phase SC (type D1), 20% load, t_2+3s to t_2+10s



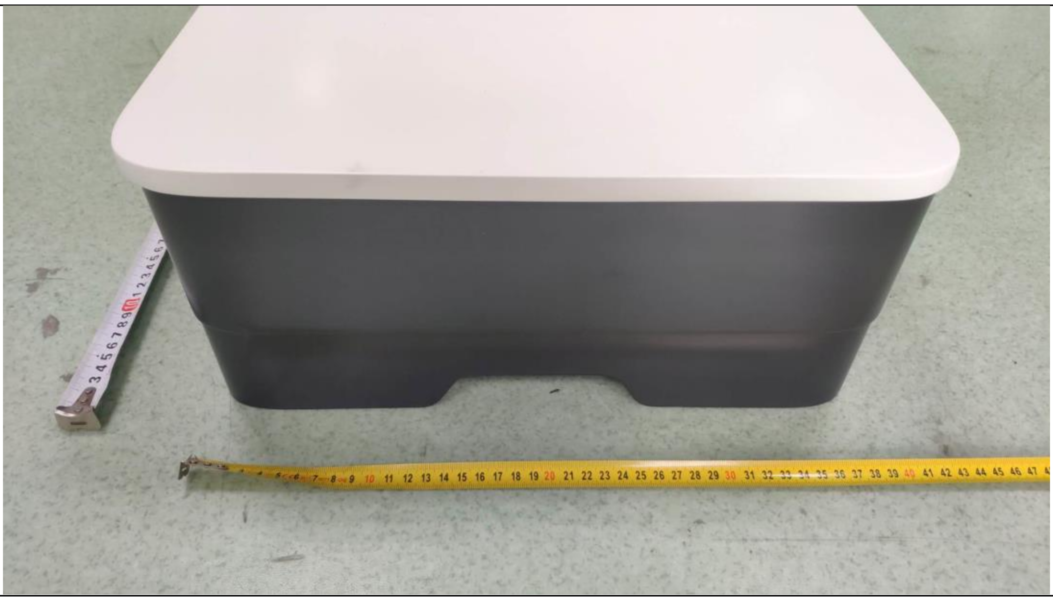
	A	B	Delta
Time [s]	1:20.1614	1:27.1937	7.0322
● **U1_tRMS [p.u.]**	1.000292	1.000395	1.029e-4
● **U2_tRMS [p.u.]**	1.000558	1.000628	7.012e-5
● **U3_tRMS [p.u.]**	1.000503	1.000610	1.065e-4
● **U_fund_SYM+ [p.u.]**	0.996286	0.996379	9.361e-5
● **I_fund_P_SYM+ [p.u.]**	0.209677	0.208064	-1.613e-3
● **P_t [p.u.]**	0.209688	0.208094	-1.595e-3
● **Q_t [p.u.]**	0.052382	0.052458	7.579e-5

Appendix: Photos

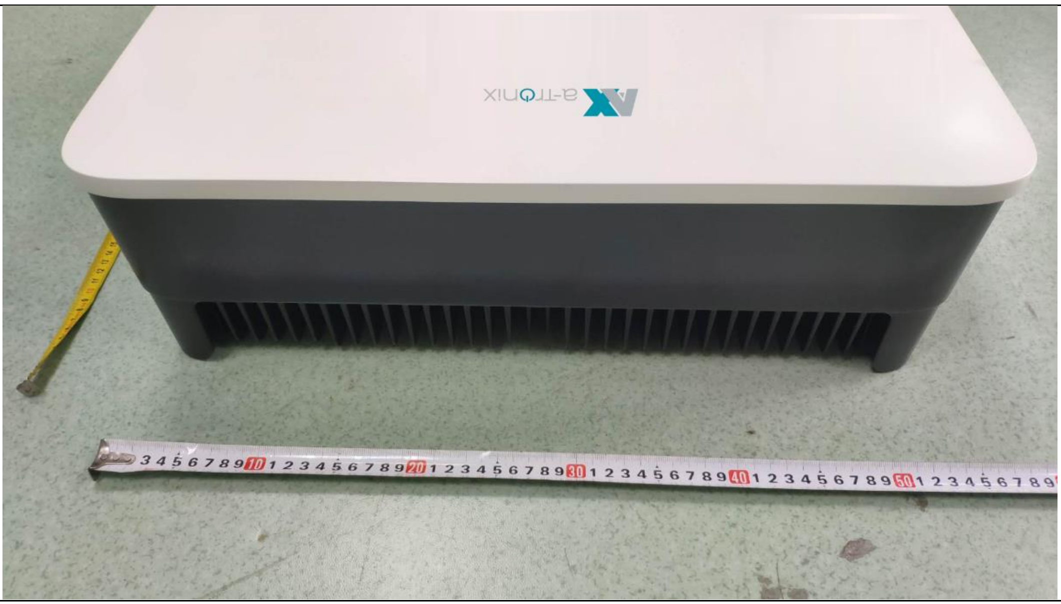
Enclosure – Front View

Enclosure – Rear View of all model


Enclosure – Side view (Right)

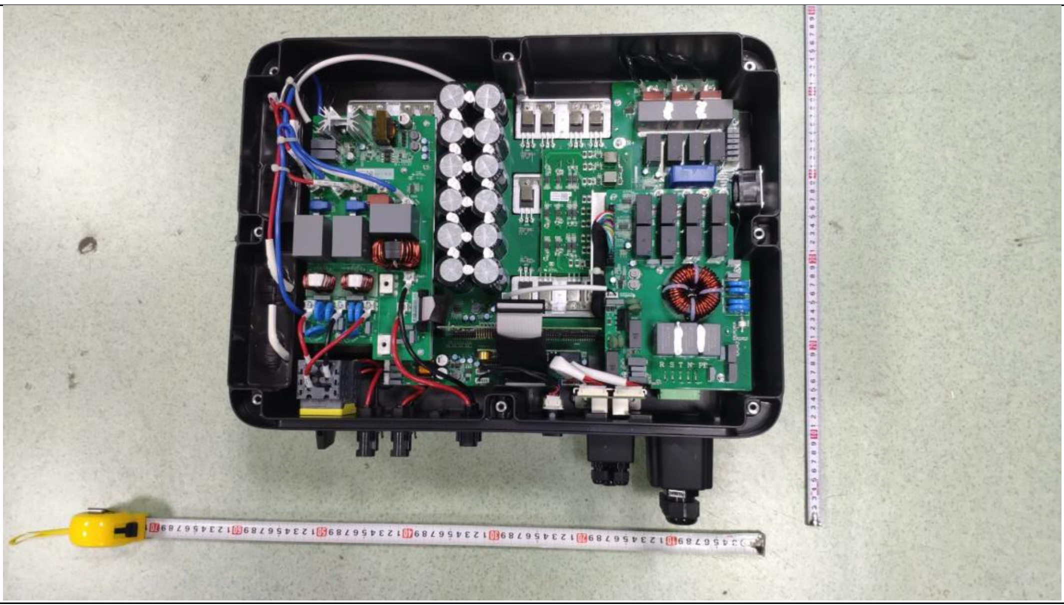
Enclosure – Side view (Left)


Enclosure – Side view (DC and AC connect terminal)

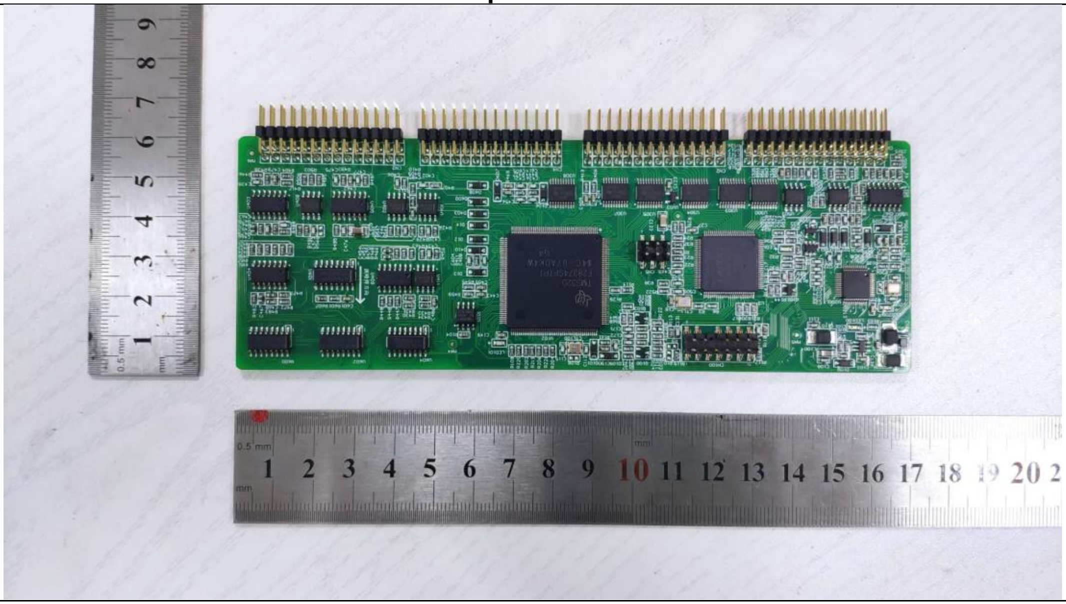
Enclosure – Top view


cover view

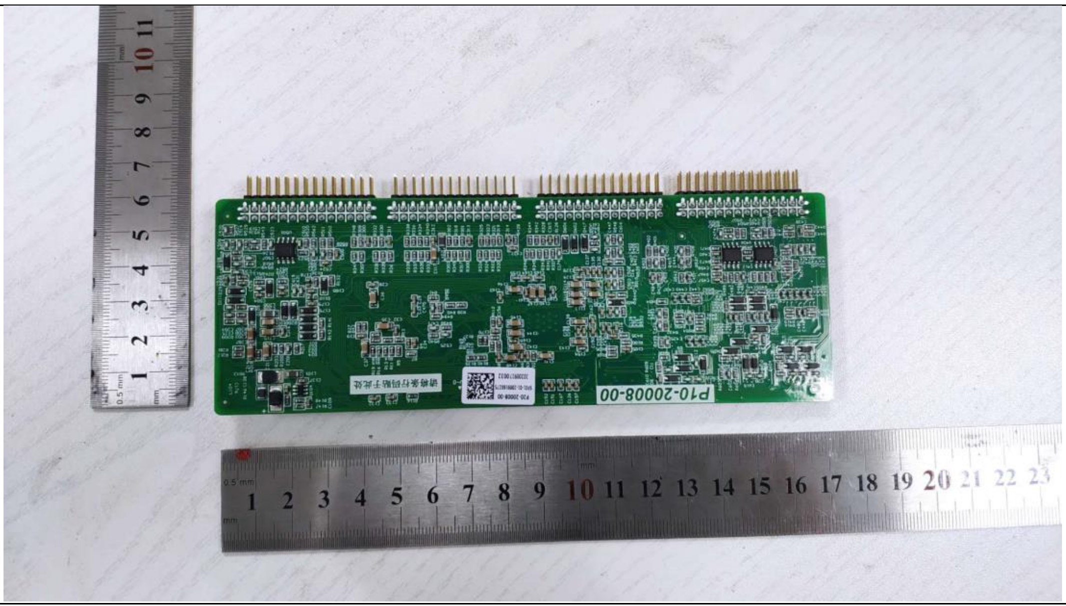
Internal view

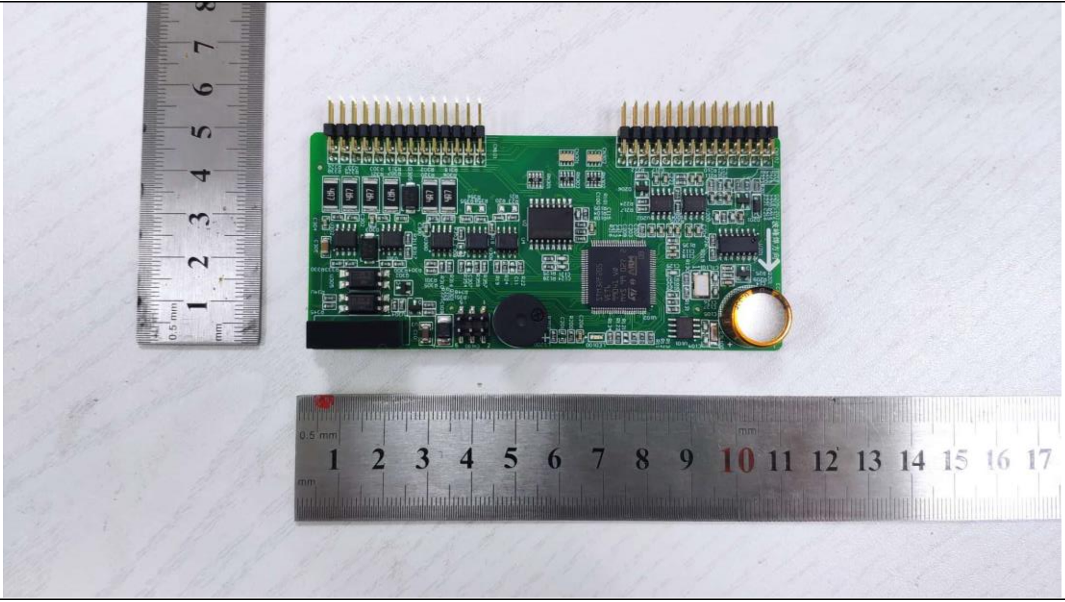


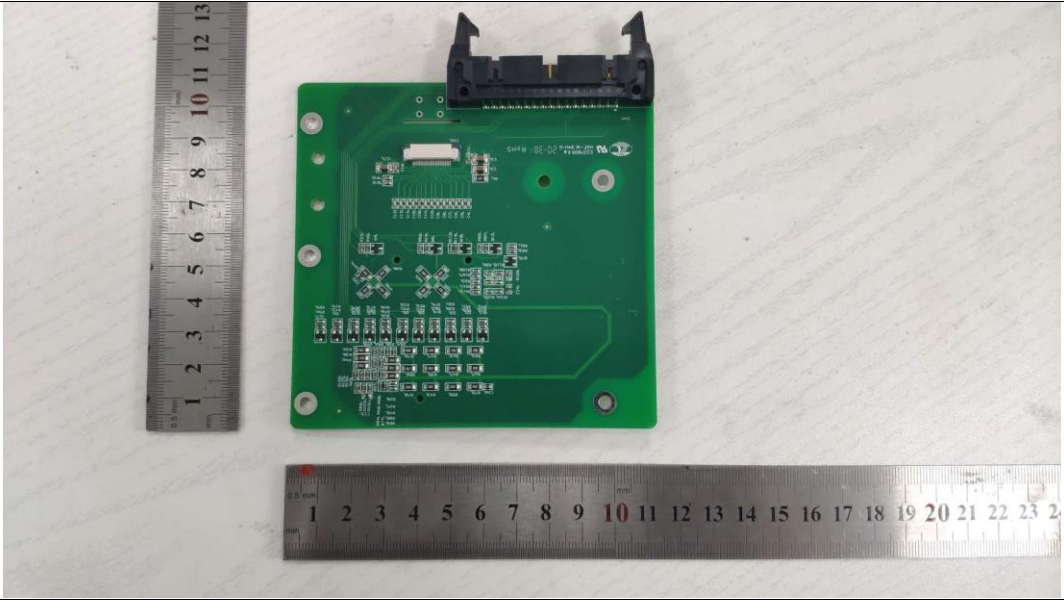
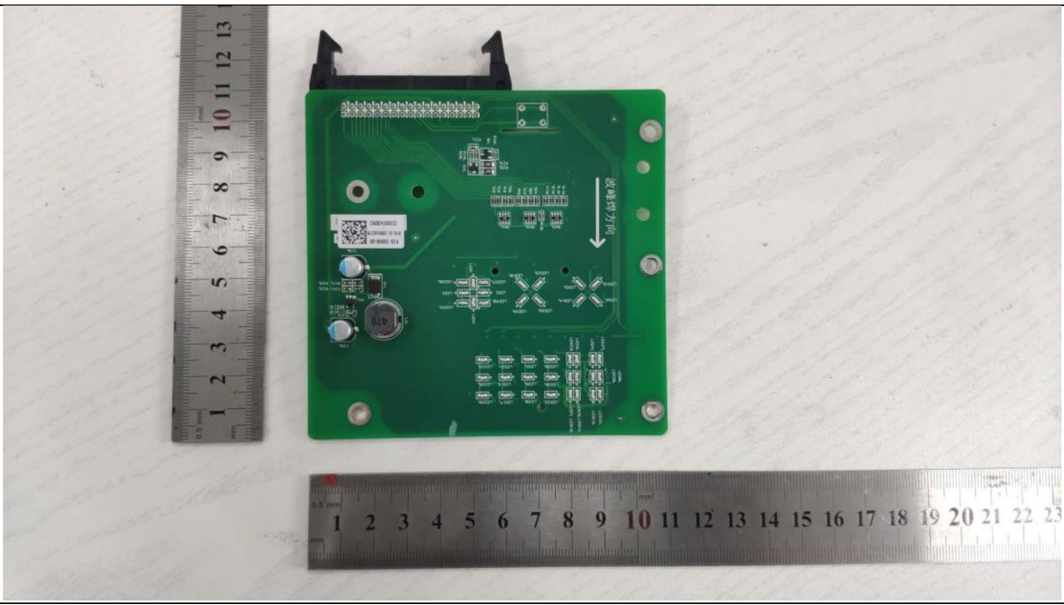
General Control board
Component Side



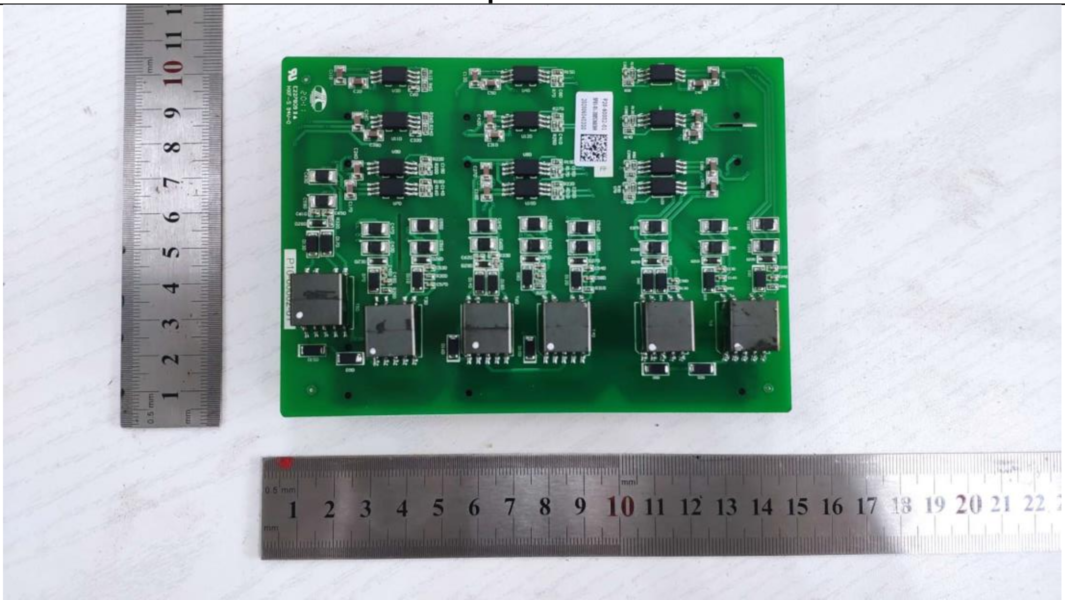
General Control board
Solder Side



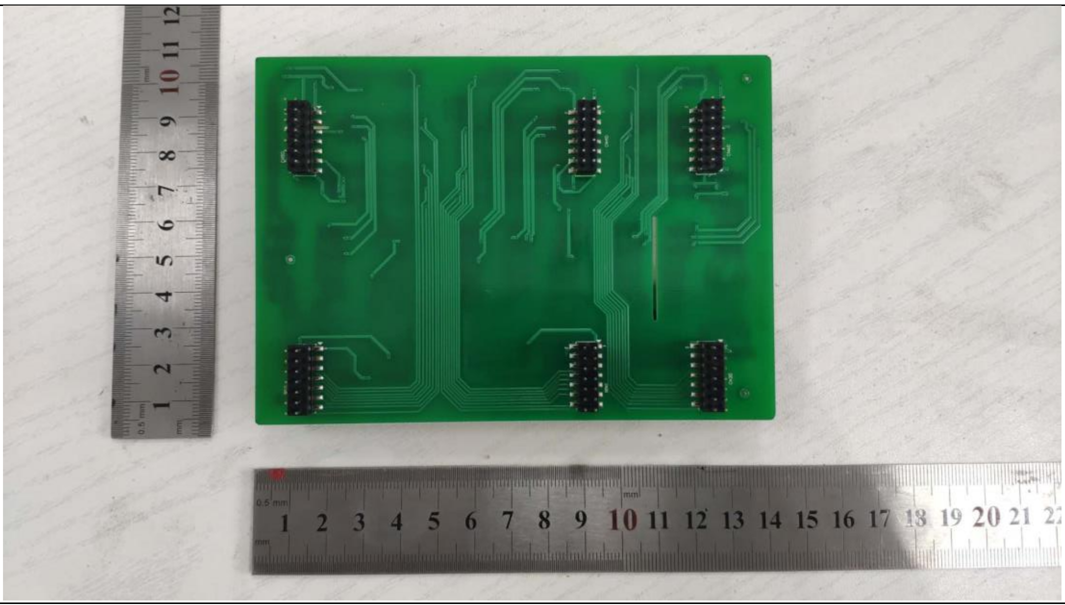
General Control board Component Side

General Control board Solder Side

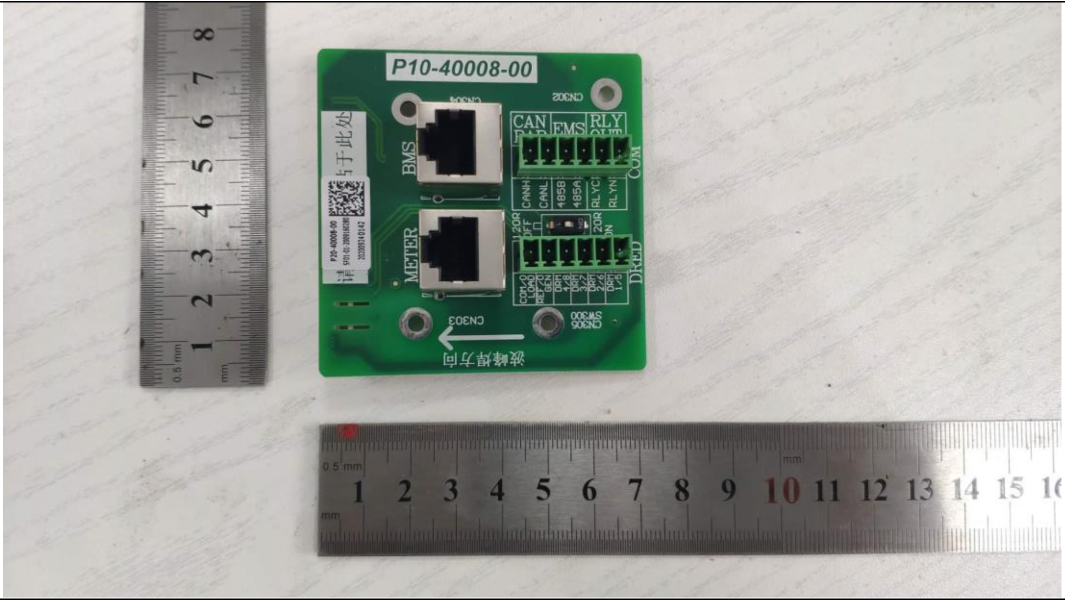
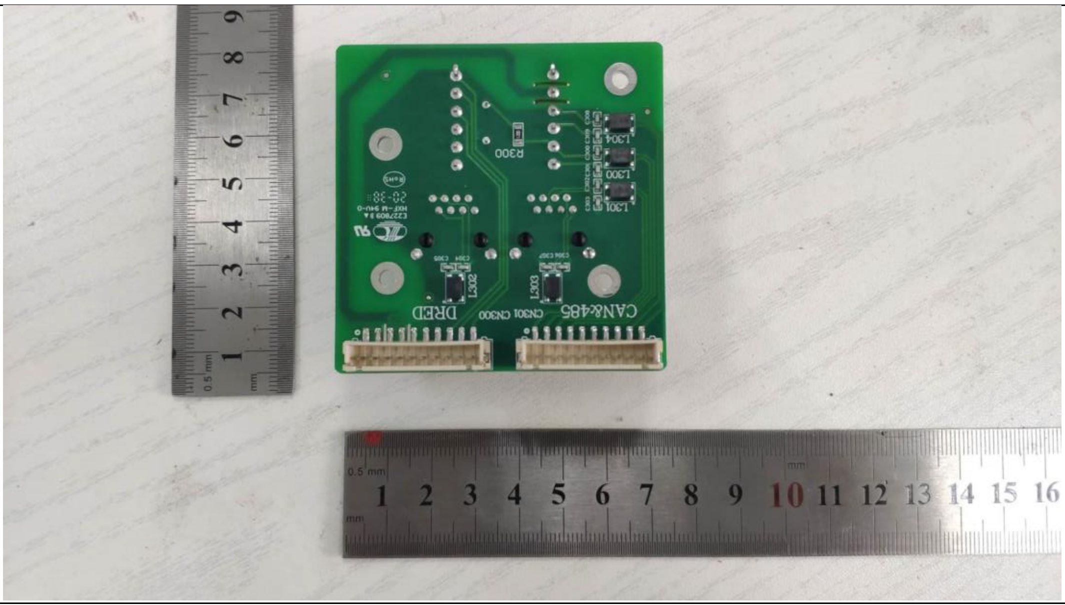

LCD board **Component Side**

LCD board **Solder Side**


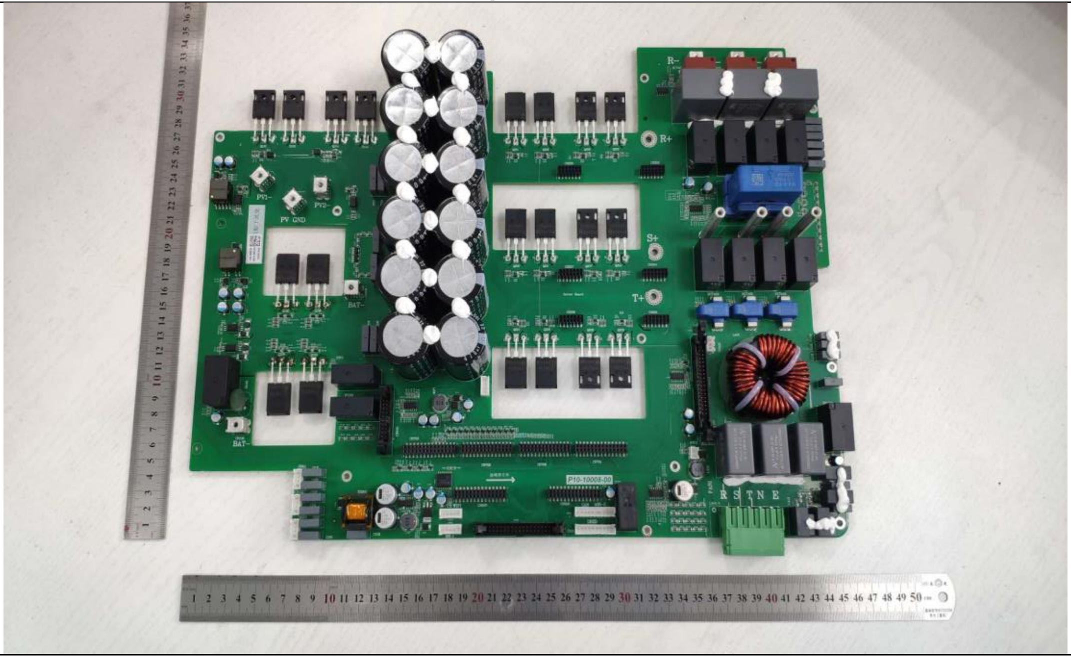
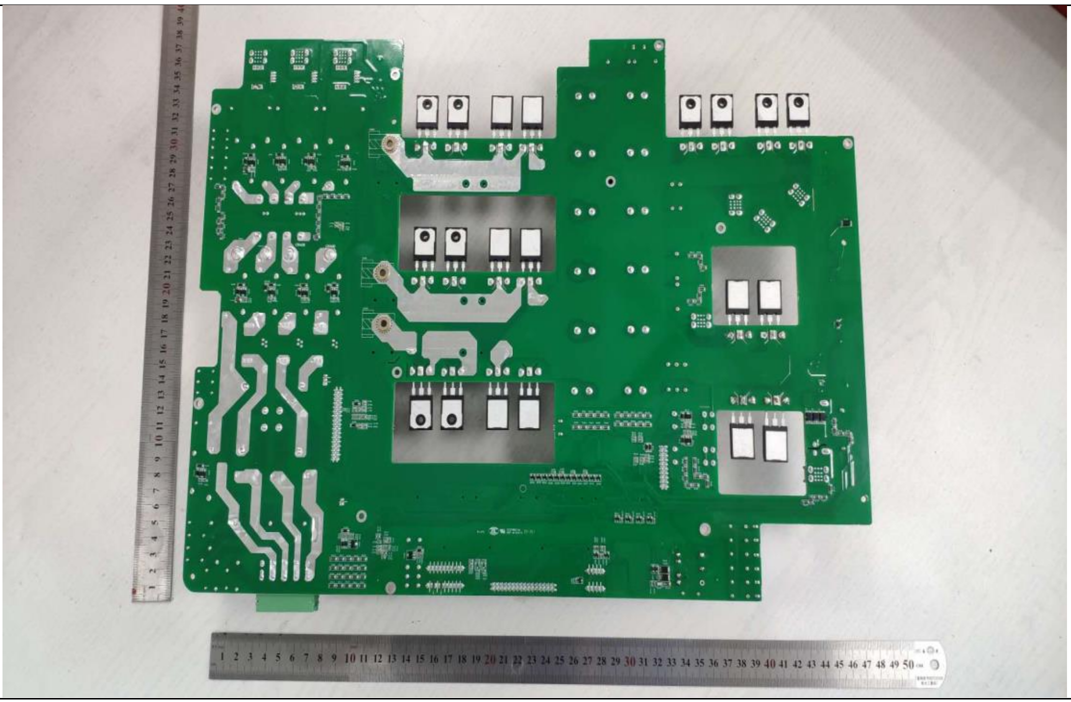
Driver board
Component Side

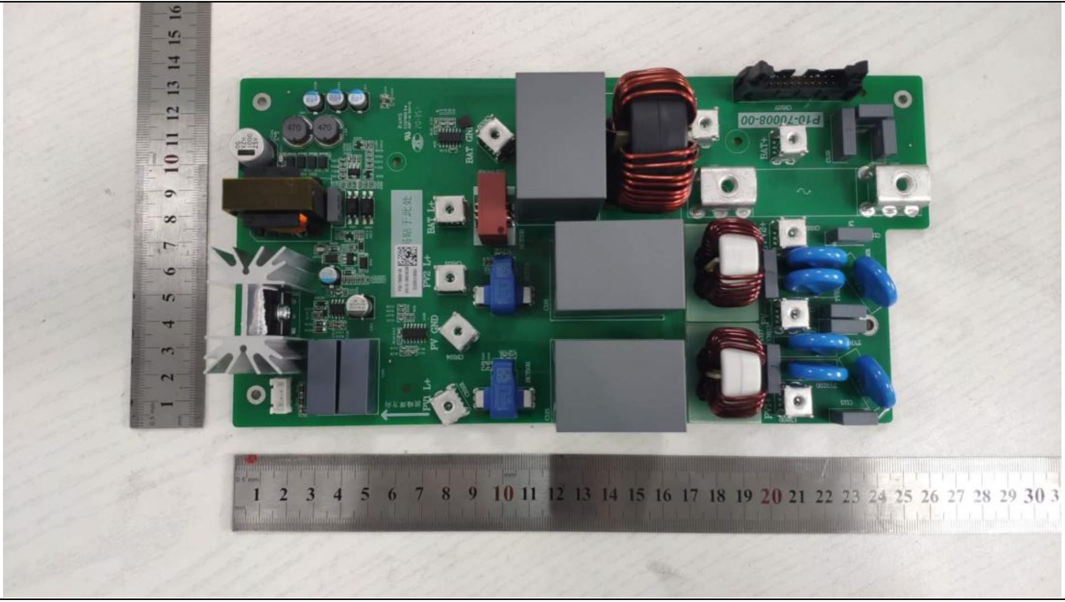
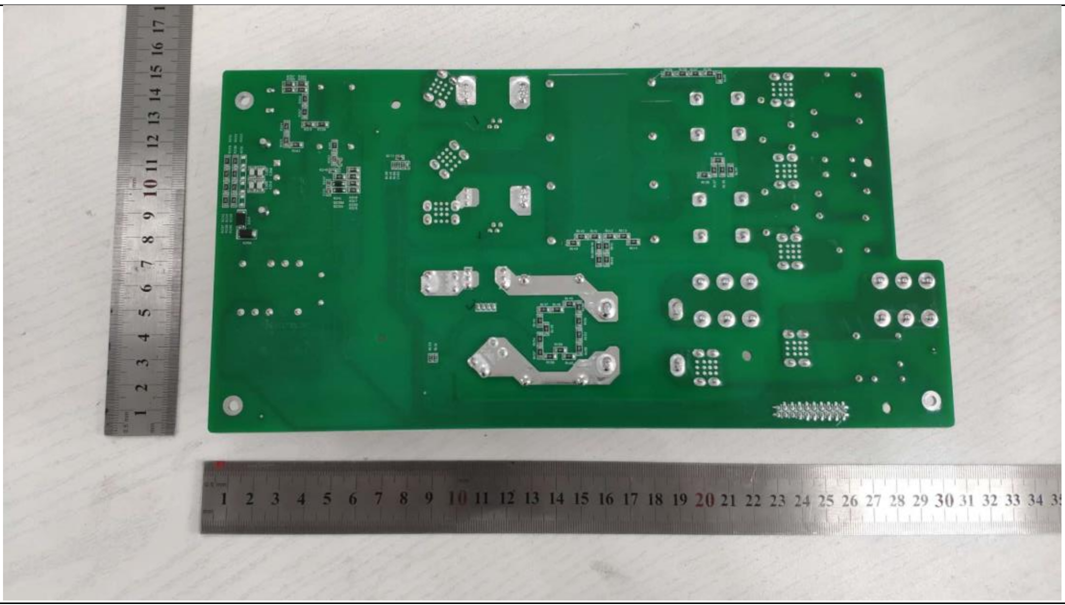


Driver board
Solder Side

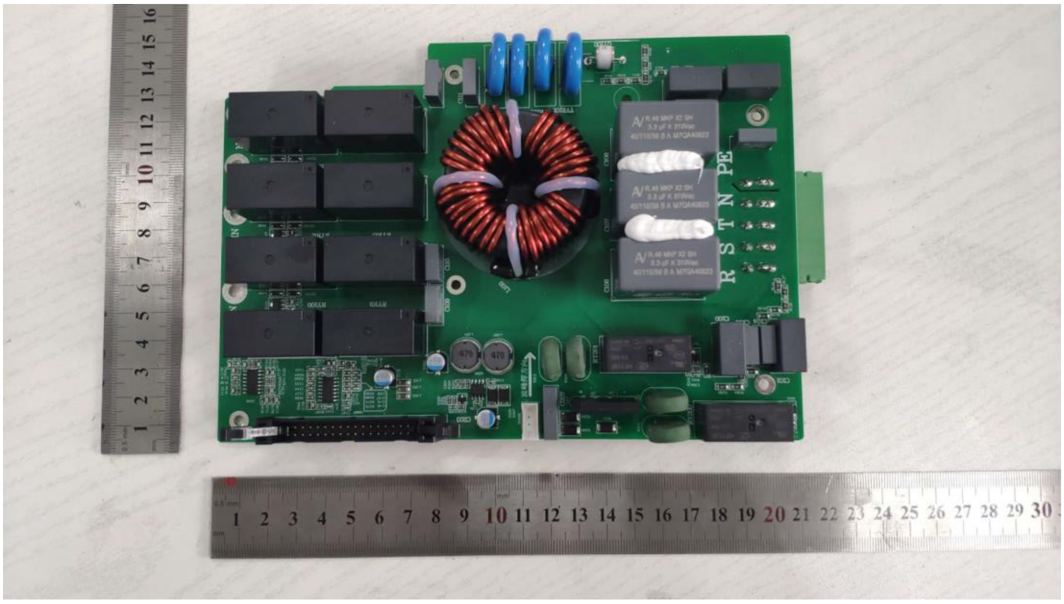


Communication board **Component Side**

Communication board **Solder Side**


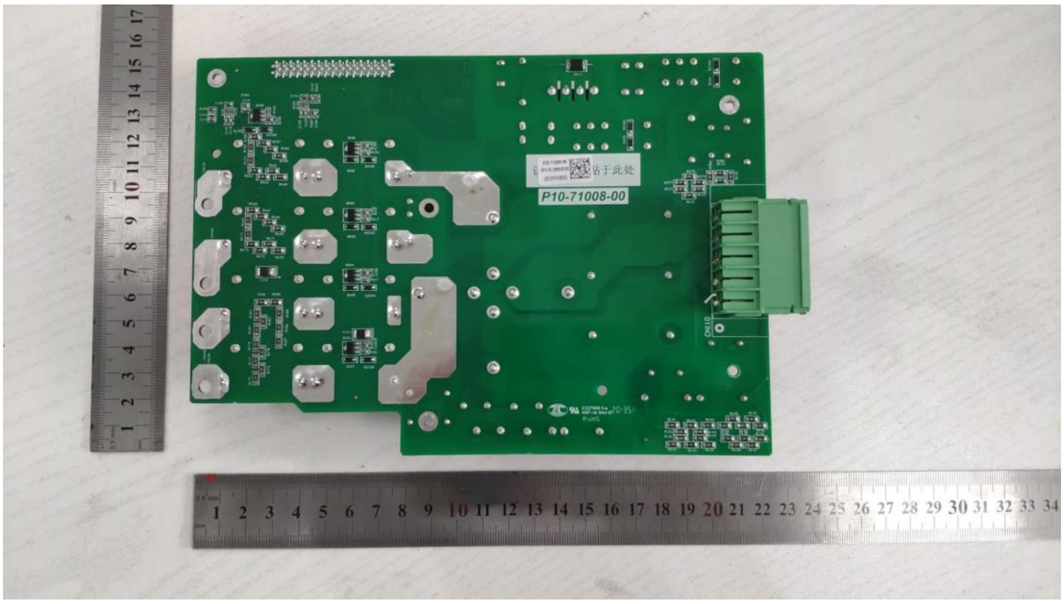
The main power board **Component Side**

The main power board **Solder Side**


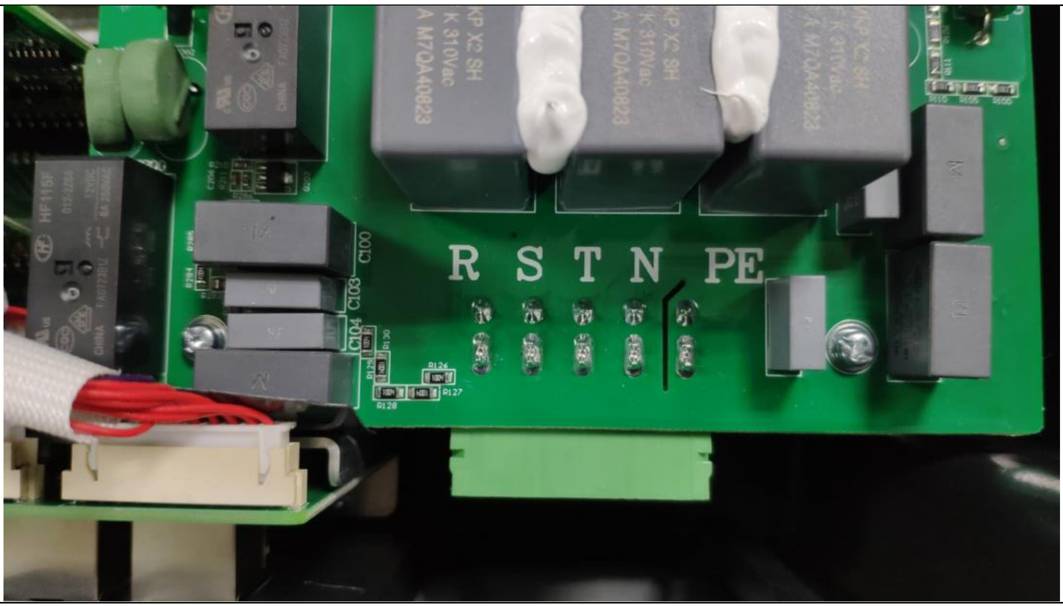
PV input interface board Component Side

PV input interface board Solder Side


PV input interface board
Component Side



PV input interface board
Solder Side



Internal earthing

External earthing


--- End of test report---