

# TEST REPORT

## EN 50549-10

**October 2022**

**Requirements for generating plants to be connected in parallel with distribution networks - Part 10: Tests for conformity assessment of generating units**

| | |
|---|---|
| | **Danyang Weisheng Electronics Co., Ltd** |
| For the unit(s) | **Cube-5200** |
| Test report no. | **LS2A26011201EGEU01** |
| Date | **2026-04-02** |

ilac-MRA

ACCREDITED
Certificate # 5200.02

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| | |
|---|---|
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| Date of issue.....: | 2026-04-02 |
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| **Applicant's name .....:** | **Danyang Weisheng Electronics Co., Ltd** |
| Address.....: | No. 88, Qiliang North Road, Danyang Development Zone, Zhenjiang City, Jiangsu Province |
| **Test specification .....:** | **EN 50549-10**, October 2022<br>Requirements for generating plants to be connected in parallel with distribution networks - Part 10: Tests for conformity assessment of generating units |
| Grid connection code.....: | **EN 50549-1:2019+A1:2023**<br>Requirements for generating plants to be connected in parallel with distribution networks - Part 1: connection to a LV distribution network - Generating plants up to and including Type B |
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| Test report form(s) originator.....: | Lyns-tci Technology Guangdong Co., Ltd. |
| Master TRF.....: | Dated 2024-01-08 |
| **Test item description.....:** | Device Category: **Inverter**<br>Device Type: **Hybrid Inverter** |
| Trademark .....: | BIENESOL |
| Model / Type reference.....: | **Cube-5200** |
| Technical data .....: | See section 3.1 on p.9 |
| Dates of testing.....: | 2025-08-12 - 2025-12-12 |

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# 1 General information of test report

## 1.1 Important Note

**General disclaimer**

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

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Information on derived or extended models of the range as provided by the applicant (if any) is included in this report for information purposes only. LYNS shall not be liable for any incorrect results due to unclear, incorrect, incomplete, misleading or false information provided by client.

## 1.2 Revision history

| Revision | Date | Editor | Modification / Change | Status |
|---|---|---|---|---|
| LS2A26011201EGEU01 | 2026-04-02 | Pan Pan | Initial report was written | Active |
| Supplementary information:<br>Test results documented in this report are taken from test report no. LS2A25082502EGEU01, issued by Lyns-tci Technology Guangdong Co., Ltd. on 2026-01-11. | | | | |

## 2 General remarks for documentation

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

Throughout this report a ☐ comma ',' / ☒ point '.' is used as decimal separator and a ☐ point '.' / ☒ comma ',' as thousands separator.

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

| | |
|---|---|
| 0.2 | average values over 200 milliseconds |
| 60 | average values over 60 seconds |
| 600 | average values over 10 minutes |
| + | positive sequence component for 3-phase generating unit |
| - | negative sequence component for 3-phase generating unit |
| 0 | zero sequence component for 3-phase generating unit |
| 1 | fundamental component (main frequency) |
| Lx | index of phase x |
| LxLy | phase-to-phase voltages of phase x and phase y |
| s | apparent |
| p | active |
| q | reactive |

**Abbreviations**

| | | |
|---|---|---|
| AC | : | Alternating Current |
| CT | : | Current Transformer |
| DC | : | Direct Current |
| DSO | : | Distribution System Operator |
| EES | : | Electrical Energy Storage |
| EUT | : | Equipment Under Test |
| GUT | : | Generating Unit Under Test |
| LV | : | Low Voltage |
| MP | : | Measurement Point |
| MPP | : | Maximum Power Point |
| MV | : | Medium Voltage |
| PGM | : | Power Generating Module |
| PGU | : | Power Generating Unit |
| POC | : | Point of Connection |
| PWHD | : | Partial Weighted Harmonic Distortion |
| THD | : | Total Harmonic Distortion |
| PWHD | : | Partial Weighted Harmonic Distortion |

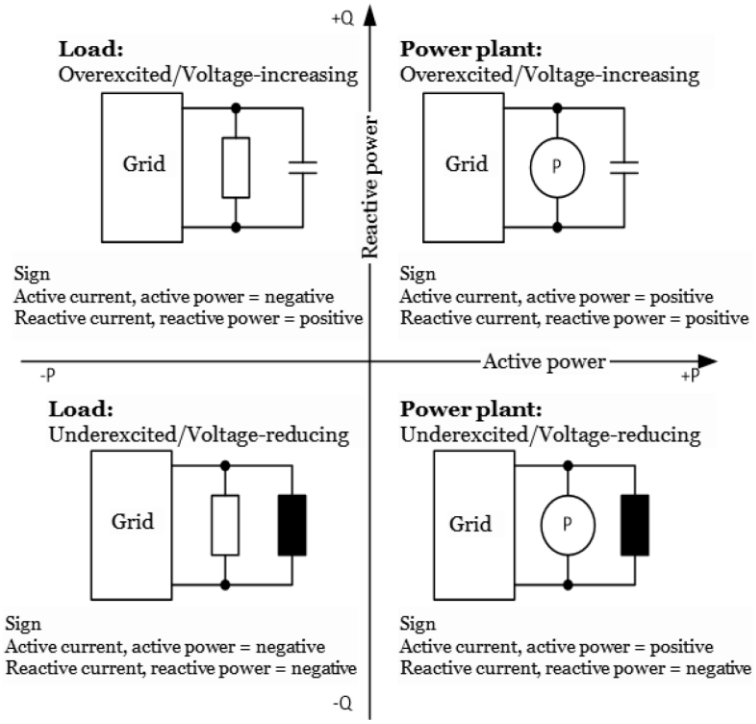
**Symbols**

| | | |
|---|---|---|
| $A_r$ | : | Required accuracy |
| $G_R$ | : | Reset value of the characteristic quantity |
| $G_S$ | : | Setting value of the characteristic quantity (activation threshold) |
| $I_n$ | : | Nominal current, nominal value of generating unit, either as stated by the manufacturer or which shall be calculated from nominal active power $P_n$ and nominal voltage $U_n$ |
| $k_i$ | : | Switching current factor |
| $P_D$ | : | Design active power, maximum AC active power output at an active factor of 0,9 (EN 50549-1:2019) the active factor specified by the DSO or the responsible party for a certain generating plant or generating technology |
| $P_n$ | : | Nominal active power, nominal value of a generating unit's active power, which is stated by the manufacturer |
| $P_M$ | : | Momentary active power, actual AC active power output at a certain instant |
| $P_{max}$ | : | Maximum active power, maximum continuous active power, measured in a 10 min average, which a generating unit or the sum of all the generating units in a generating plant can produce, minus any loads associated solely with facilitating the operation of that generating plant and not fed into the network as specified in the connection agreement or as agreed between the DSO and the generating plant operator |
| $S_{max}$ | : | (Definition acc. EN 50549-1)<br>Maximum apparent power, maximum AC apparent power output, measured in a 10 min average, that the generating unit or the sum of all the generating units in a generating plant is designed to achieve under normal operating conditions |
| $T_{Op}$ | : | Operate time (equals start time plus time delay setting) |
| $T_{Res}$ | : | Reset time |
| $T_{Ov}$ | : | Overshoot time |
| > / >> | : | First / second stage of protection function |
| $\Delta f$ | : | Frequency step |
| $\Delta t$ | : | Time step |
| $\Delta U$ | : | Voltage step |

**Direction definition of P and Q**

in this test report, the regarded system of the voltage and current vectors is the active sign convention system:

- If the inverter feeds to the grid the active power is measured with positive sign.
- If the inverter injects reactive power / current with leading power factor the reactive power / current is marked “leading” or “inductive” (under-excited) or has a negative sign.
- If the inverter injects reactive power / current with lagging power factor the reactive power / current is marked “lagging” or “capacitive” (over-excited) or has a positive sign.



# 3 General product information

| **Factory's name** | **Danyang Weisheng Electronics Co., Ltd** |
|---|---|
| Factory address | No. 88, Qiliang North Road, Danyang Development Zone, Zhenjiang City, Jiangsu Province |

## 3.1 Technical data of the unit(s)

| **Model** | **Cube-5200** |
|---|---|
| Hardware version (tested) | 04BSI-GF3704-2505 |
| Software version (tested) | V1.01 |
| Parameter set (used for testing) | *8* |
| Input Data (PV) | |
| Max. Input Power [W] | 2500 |
| MPPT Voltage Range [V] | 16 - 60 |
| Max. Input Voltage [V] | 60 |
| Max. Input Current [A] | 8*16 |
| Battery Date | |
| Battery Type | LiFePO4 |
| Battery information | 51.2 V, 100 Ah, 5120Wh |
| Battery voltage range [V] | 41.6 - 58.4 |
| Firmware version of the BMS | P16S100A-52447-1.00 |
| Max. Charge/Discharge Current [A] | 62/62 |
| AC Input / Output (On-Grid) | |
| AC Nominal Output Voltage | 220V / 230V / 240V, L+N+PE, 50 Hz * |
| Max.  Output Power [W] | 2500 |
| Max. apparent power [VA] | 2500 |
| Max. Output Current [A] | 11 |
| Max. Input Current [A] | 11 |
| Max. Input Power [W] | 2500 |
| EPS (AC) | |
| AC Nominal Output Voltage | 220V / 230V / 240V, L+N+PE, 50 Hz * |
| Max.  Output Power [W] | 2500 |
| Max. Output Current [A] | 11 |

| | |
|---|---|
| Mass of equipment [kg] | 62 |
| Communication | Wi-Fi / Bluetooth |
| IP Rating | IP65 |
| Protective Class | I |

| | |
|---|---|
| Overvoltage Category | II (DC), III (AC) |

Note:
* All tests are performed at 230V, 50Hz.

**Datasheet of the generating units:**

| Model | Cube-5200 |
|---|---|
| PV Input (PV) | |
| Recommended Module Power (Wp) | 300 - 650 |
| Quantity of PV Module | 1 to 8 |
| Max. PV Input Power (W) | 2500W |
| Startup Voltage @Rated condition (V) | 22 |
| Operating Voltage Range per Input (V) | 16 - 60 |
| Max. Input Voltage per Input (V) | 60 |
| Nominal Input Voltage (V) | 42 |
| Short Circuit Current per Input (A) | 18 |
| Max. Input Current per Input (A) | 16 |
| AC Port (On-grid) | |
| Nominal AC Output power (VA) | 2500 |
| Max. AC Output Power (VA) | 2500 |
| Nominal AC Output Current (A) | 11 |
| Max. AC Output Current (A) | 11 |
| Nominal AC Voltage (V) | 220/230/240<br>L/N/PE |
| Nominal AC Frequency (Hz) | 50 |
| Power Factor | >0.99 default<br>0.8 leading -0.8 lagging |
| THDI | ≤3%@100%<br>Load |
| Nominal AC Output Power (W) | 2500 |
| AC Port (Off-grid) | |
| Max. AC Output Power (VA) | 2500 |
| Nominal AC Output Power (W) | 2500 |
| Nominal AC Output Current (A) | 11 |
| Max. AC Output Current (A) | 11 |

| | |
|---|---|
| Nominal AC Voltage (V) | 220/230/240<br>L/N/PE |
| Nominal AC Frequency (Hz) | 50 |
| Switch Time [ms] | < 20 |
| Efficiency | |
| Peak Inverter Efficiency | 94.5% |
| MPPT Efficiency | 99.9% |
| Battery Charge/Discharge Efficiency | 94%/94% |
| No-load power consumption | < 25W |
| Shut-down and consume electricity | < 1W |
| Battery | |
| Battery Type | $LiFePO_4$ |
| Nominal capacity | 5120Wh |
| Nominal voltage | 51.2V |
| Operation voltage | 41.6V-58.4V |
| Max Charge Current | 62A |
| MAX Discharge Current | 62A |
| Charging temperature | -25-60℃ |
| Discharge template | -25-60℃ |
| Recommend charging method declared by the manufacturer: Charge the battery at constant current 50A until voltage reaches 58.4V, then charge at constant voltage 58.4V till charge current is 5A | |

| | |
|---|---|
| Mechanical Data | |
| Dimensions (WxHxD mm) | 630*380*251 |
| Weight ( kg ) | 62Kg |
| General Data | |
| Communication | Wi-Fi/(Bluetooth) |
| Extra Communication Port | RS485 |
| Display | SOC Light |
| Ingress Protection | IP65 |
| Type of Isolation | Reinforced insulation |
| Cooling | Natural convection |
| Protection Class | I |
| Over-voltage Category | PV II<br>AC III |
| Operating Ambient Temperature Range | -25 ~ 60℃ |
| Max. Operating Altitude [m] | 2000 |
| Relative Humidity | 0-95%, Non condensing |

*Supports a maximum grid-connected output of 2500W

## 3.2 P-Q characteristic of the generating unit(s)

(Manufacturer's Data) see *Annex 3 – Capability curve of the PGU(s)*

## 3.3 Description of the differences of the models within the product series

The units of the series are identical hardware platform.

The implemented control and firmware are identical in all units. There is no difference regarding AC behaviour between the PGU-types apart from the power rating deviation and current limitation of each unit.

### Statement of Differences

We, Danyang Weisheng Electronics Co., Ltd., declare that for the product models Cube-5200, Cube-5200-800 under this certification, their software and hardware are completely identical to those of the product models Cube-AIO-M, Cube-AIO-M-800. The other differences are as follows:

1:The appearance of the products is inconsistent

2: The battery changes from a stacked type to a built - in type;

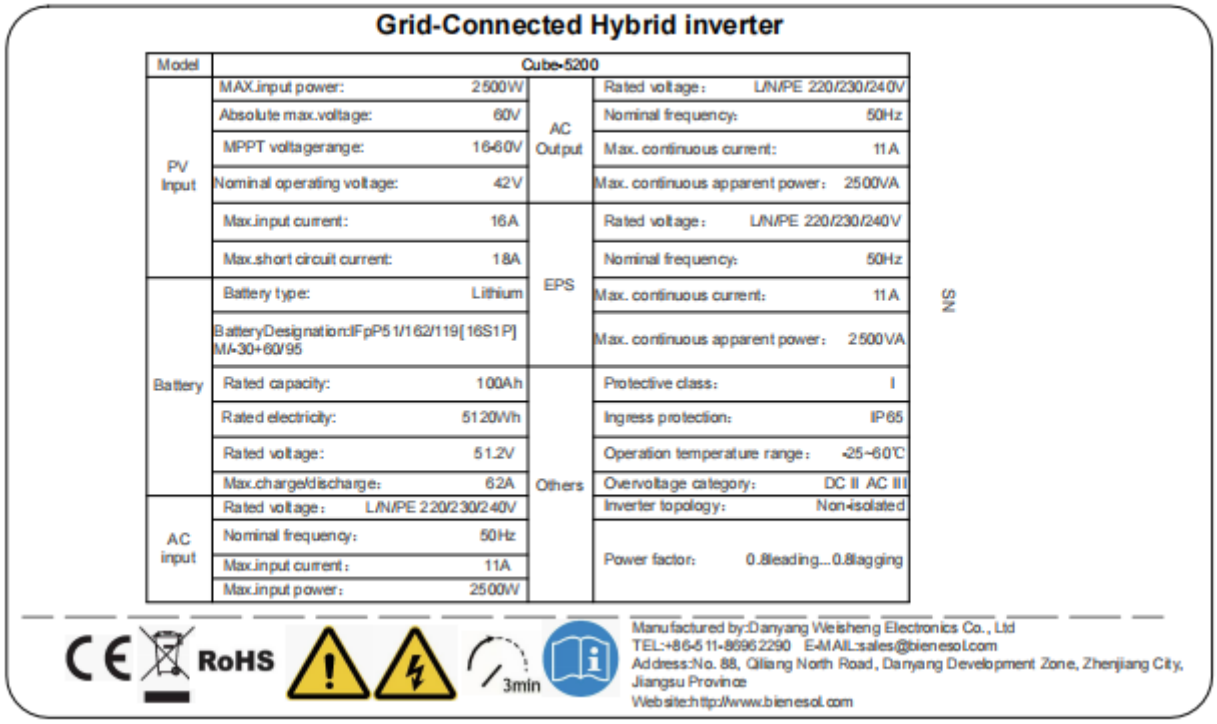
3: Replacement of WiFi module

4: The cell capacity is replaced with 100Ah.

| model | Cube-AIO-M/Cube-AIO-800 | Cube-5200-800/Cube-5200 |
|---|---|---|
| MPPT number | 4 | 8 |
| Weight | 17.5KG | 62.5KG |
| Rated Capacity | 52Ah（16S1P） | 100Ah（16S1P） |
| Appearance | Stacked | Integrated |
| Cell | IFP28148115A-52Ah | PF160-100A |
| WiFi | Suzhou New Raymond IoT Technology Co., Ltd. 2.4G WiFi | Shenzhen Nengkong Cloud Technology Co., Ltd. 2.4G WiFi |

We guarantee that the above information provided is accurate, true and legal. Otherwise, our company will bear all legal liabilities and expenses arising from providing false information.

## 3.4 Copy of marking plate



**Grid-Connected Hybrid inverter**

| Model | Cube-5200 | | | |
|---|---|---|---|---|
| PV Input | MAX.input power: | 2500W | AC Output | Rated voltage: L/N/PE 220/230/240V |
| | Absolute max.voltage: | 60V | | Nominal frequency: 50Hz |
| | MPPT voltagerange: | 16-60V | | Max. continuous current: 11A |
| | Nominal operating voltage: | 42V | | Max. continuous apparent power: 2500VA |
| | Max.input current: | 16A | EPS | Rated voltage: L/N/PE 220/230/240V |
| | Max.short circuit current: | 18A | | Nominal frequency: 50Hz |
| Battery | Battery type: | Lithium | | Max. continuous current: 11A |
| | BatteryDesignation:IFpP51/162/119[16S1P] M/-30+60/95 | | | Max. continuous apparent power: 2500VA |
| | Rated capacity: | 100Ah | Others | Protective class: I |
| | Rated electricity: | 5120Wh | | Ingress protection: IP65 |
| | Rated voltage: | 51.2V | | Operation temperature range: -25~60℃ |
| | Max.charge/discharge: | 62A | | Overvoltage category: DC II AC III |
| AC input | Rated voltage: L/N/PE 220/230/240V | | | Inverter topology: Non-isolated |
| | Nominal frequency: 50Hz | | | Power factor: 0.8leading...0.8lagging |
| | Max.input current: 11A | | | |
| | Max.input power: 2500W | | | |

SN

RoHS 3min

Manufactured by:Danyang Weisheng Electronics Co., Ltd
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Website:http://www.bienesol.com

Note:

The marking plates shown above may be only a draft. The use of certification marks on products must be approved by the respective NCBs to which these marks belong.

The marking plate is attached to the side surface or the back of the enclosure and is visible after installation.

## 3.5 Description of the power circuit

The low voltage control circuit is controlled by the main control MCU1, and the high voltage control circuit is controlled by the main control MCU2. Among them, the low-voltage circuits are mainly PV boost circuits, battery charging and discharging circuits, and LLC primary side low-voltage circuits. The high-voltage circuits are mainly LLC secondary side high-voltage circuits and INV circuits.

The MCU1 simultaneously detects the DC voltage and current corresponding to the low-voltage circuit, DC-side insulation impedance, NTC, etc., for voltage boost circuit control and solar power tracking. MCU2 also detects the DC voltage and current corresponding to the high-voltage circuit, AC voltage, AC current, DC components, etc., for LLC circuit control and INV circuit grid-connected and off-grid control. In addition, as an external monitoring system, the MCU1 is responsible for generating statistical data and performing the monitoring function.

RLY1 is inverter to grid RLY, RLY2 is Inverter to load RLY. when grid state, RLY1 is on and inverter can charge discharge from grid. When off grid state, RLY2 is on and inverter can supply power to load.

In the event of a fault, the master and slave DSP coordinate to trigger protection, and if necessary, the secondary side is disconnected by a relay or isolation transformer to ensure basic insulation between PV/battery and the grid.

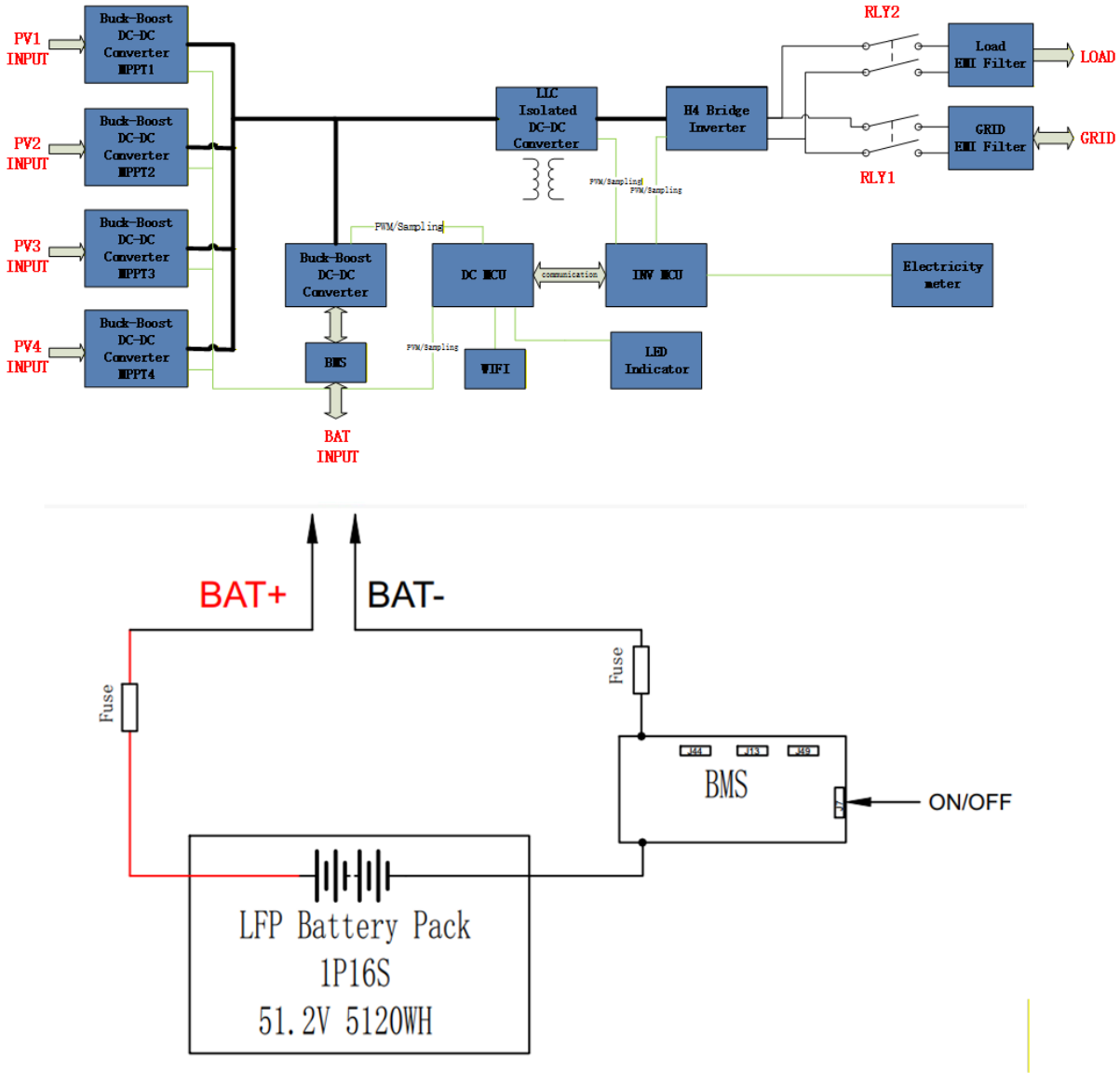



**Figure 1 – Block diagram**

# 4 General remarks for testing

## 4.1 Energy Conversion Technology

| Photovoltaic * | Fuel Cells | Hydro | Wind | Electricity Storage devices | Other |
|---|---|---|---|---|---|
| ☒ | ☐ | ☐ | ☐ | ☒ | --- |

Note:

* Connection scenario:

☐ Photovoltaic Power Park Module connected to the DNO's Distribution Network via an Inverter

☒ Hybrid converter:

Photovoltaic Power Park Module with DC coupled storage unit connected to the DNO's Distribution Network via an Inverter

In this case the Registered Capacity is based on the Inverter rating. The storage unit has no compliance effect, compliance based on the inverter.

## 4.2 PGM categories

The PGUs considered in this test report are:

☒ Type A

☐ Type B

generating module(s).

## 4.3 Scope of measurements

The type tests documented in this test report are intended to demonstrate that the generating unit(s) considered herein meet(s) the following technical requirements for grid connection:

☒ **EN 50549-1:2019+A1:2023**: Requirements for generating plants to be connected in parallel with distribution networks - Part 1: connection to a LV distribution network - Generating plants up to and including Type B

☐ **EN 50549-2:2019+A1:2023**: Requirements for generating plants to be connected in parallel with distribution networks - Part 2: Connection to a MV distribution network - Generating plants up to and including Type B

Date of receipt of test items ..... : 2025-08-12

Date(s) of performance of tests ..... : 2025-08-12 - 2025-12-12

| Clause(s) / subclause(s) of EN 50549-1:2019 or EN 50549-2:2019 | Applicable Clause(s) / subclause(s) of EN 50549-10:2022 | Section in this test report | Tests completed |
|---|---|---|---|
| 4.4.2 Operating frequency range | 5.2.1 Frequency operating range | 6.1.1 | ☒ |
| 4.4.3 Minimal requirement for active power delivery at underfrequency | 5.2.1 Frequency operating range | 6.1.1 | ☒ |
| 4.4.4 Continuous operating voltage range | 5.2.2 Voltage operating range | 6.1.2 | ☒ |
| 4.5.2 Rate of change of frequency (ROCOF) immunity | 5.3.1 Immunity to disturbances - Rate of change of frequency (ROCOF) | 6.2.1 | ☒ |

| Clause(s) / subclause(s) of EN 50549-1:2019 or EN 50549-2:2019 | Applicable Clause(s) / subclause(s) of EN 50549-10:2022 | Section in this test report | Tests completed |
|---|---|---|---|
| 4.5.3.2 Generating plant with non-synchronous generating technology | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | ☒ |
| 4.5.3.3 Generating plant with synchronous generating technology | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | --- | ☐ |
| 4.5.4 Over-voltage ride through (OVRT) | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | ☒ |
| 4.5.5 Phase jump immunity | 5.3.2 Phase jump | 6.2.2 | ☒ |
| 4.6.1 Power response to overfrequency | 5.4 Active response to frequency deviation | 6.3.1 | ☒ |
| 4.6.2 Power response to underfrequency | 5.4 Active response to frequency deviation | 6.3.2 | ☒ |
| 4.7.2.2 Voltage support by reactive power, Capabilities | 5.5.1 Power capabilities assessment | 6.4.1 | ☒ |
| 4.7.2.3 Voltage support by reactive power, Control modes | 5.5.2 Voltage support by reactive power - test to determine the reactive power control modes | 6.4.2 | ☒ |
| 4.7.2.3.2 Set point control modes | 5.5.2.3 Verification procedure for Set point control | 6.4.2.1 | ☒ |
| 4.7.2.3.3 Voltage related control modes | 5.5.2.4 Verification procedure for voltage related control modes for reactive power | 6.4.2.2 | ☒ |
| 4.7.2.3.4 Power related control mode | 5.5.2.5 Verification procedure for power related control modes for reactive power | 6.4.2.3 | ☒ |
| 4.7.3 Voltage related active power reduction | 5.6 Voltage related active power reduction - P(U) | 6.5 | ☒ |
| only EN 50549-2:2019 4.7.4.2.1.1 Voltage support during faults and voltage steps – General | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | ☐ |
| only EN 50549-2:2019 4.7.4.2.1.2 Voltage support during faults and voltage steps - Optional Modes | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | ☐ |
| 4.7.4.2.2 Zero current mode for converter connected generating technology | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | ☒ |
| 4.8 EMC and power quality | 5.7 EMC and power quality | 6.6 | ☒ |
| only EN 50549-1:2019 4.9.3 Requirements on voltage and frequency protection | 5.8.3 Verification procedure for generating plants to be connected to a LV distribution network with Interface protection as internal device<br>or<br>5.8.4 Verification procedure for generating plants to be connected to a LV distribution network with Interface protection as dedicated device | 6.7 | ☒ |
| only EN 50549-2:2019, 4.9.3. Requirements on voltage and frequency protection | 5.8.5 Verification procedure for generating plants to be connected to a MV distribution network | --- | ☐ |
| 4.9.4 Means to detect island situation | 5.8.6 Islanding detection | 6.7.4 | ☒ |
| 4.10.2 Automatic reconnection after tripping | 5.9.3 Automatic reconnection after tripping | 6.8.1 | ☒ |

| Clause(s) / subclause(s) of EN 50549-1:2019 or EN 50549-2:2019 | Applicable Clause(s) / subclause(s) of EN 50549-10:2022 | Section in this test report | Tests completed |
|---|---|---|---|
| 4.10.3 Starting to generate electrical power | 5.9.4 Starting to generate electrical power | 6.8.2 | ☒ |
| 4.11.1 Ceasing active power | 5.10 Active power reduction on set point | 6.9 | ☒ |
| 4.11.2 Reduction of active power on set point | 5.10 Active power reduction on set point | 6.9 | ☒ |
| 4.12 Remote information exchange | 5.11 Remote information exchange | --- | ☐ |
| only EN 50549-1:2019, 4.13 single fault tolerance of interface protection system and interface switch | 5.12 Requirements regarding single fault tolerance of interface protection system and interface switch | 6.11 | ☒ |
| --- | 5.13 Model definition and model validation for generating units of synchronous generating technology | 6.12 | ☐ |

### 4.3.1 Definition of the boundary of the EUT

| | Clause / subclause of EN 50549-10:2022 | Description |
|---|---|---|
| ☐ | 4.2.1 | Test on complete generating unit |
| ☒ | 4.2.2 | Test on the electrical generation system * |
| ☐ | 4.2.3 | Test on the nacelle of a wind turbine |
| ☐ | 4.2.4 | Test on the primary energy converter |
| ☐ | 4.2.5 | Test at limited power |
| ☐ | 4.2.6 | Test on stopped generating unit |
| ☐ | 4.2.7 | Test on an independent component |
| ☐ | 4.2.8 | Simulated input test |
| ☐ | 4.2.9 | Test by changing a control parameter |
| ☐ | 4.2.10 | Field measurements |
| ☐ | 4.2.11 | Test by calculation and numerical simulation for generating units of synchronous generating technology |
| ☐ | 4.2.12 | Test of the real generating unit control unit in a simulated environment (“Controller-Hardware-in-the-loop” (HIL) test) |
| ☐ | 4.2.13 | Evaluation by inspection and test of dependent components |

Note:

* Tests were performed on a EUT limited to the *electrical generation system* with an alternative energy source emulating the behaviour of that primary source:

☒ The nominal frequency of the output stage of the EUT corresponds to the nominal frequency of the distribution network.

☒ The generating units considered in this test report are designed for connection to the LV distribution network, the voltage level at the output stage of the EUT is in line with the voltage of the LV distribution network.

☐ The generating units considered in this test report are designed for connection to the MV distribution network, the voltage level at the output stage of the EUT corresponds to

☐ the voltage of the MV distribution network.

☐ the rated output voltage of the inverter, which requires a transformer in the final installation.

☒ The primary energy converter is replaced by an alternative energy source emulating the behaviour of that primary source.

☒ a DC source is used to emulate the characteristics of a PV array

☒ a bi-directional DC source is used to emulate the characteristics of the battery

(Note:
This is acceptable as the behaviour of the primary source can be emulated sufficiently accurately by the alternative energy source used. This does not impact the results of the assessed requirement. )

☒ includes all auxiliary equipment of the electrical generation system.

The boundary of the EUT as defined as descripted above (for more details see Figure 2, Figure 3 ).

### 4.3.2 Selecting the EUT to cover the entire product family

- **Definition of EUT**
  This report defines the EUT using guidelines from the following document:
  *EG HCF: Harmonization of Equipment Certificate Acceptance at European Level and Product Family Grouping* (V 1.0, dated 16/03/23)

  ☐ Based on the tests done on the smallest and biggest representative units of the family*

  ☒ Based on a range dependent on the tested unit's nominal active power; this can be defined as in Germany (Pgen/√10 < Pgentestate < Pgen x 2)

  **Cube-5200** which provides the highest current / power was selected as the **EUT.**

- Technical justification for transferability of measurement results:
  see section 3.3 on p.14.

### 4.3.3 General information on EUT

All tests were performed on the EUT **Cube-5200** equipped with the following hardware/software:

- Hardware Version: 04BSI-GF3704-2505
- Software Version: V1.01

### 4.3.4 Parameter set

In this report following parameter set(s) is/are considered:

☒ Single parameter set: " *8* "

☐ Test for one specific setting

☒ Test for multiple settings (setting range verification)

☐ Multiple parameter sets: ---

☐ Test for one specific setting

☐ Test for multiple settings (setting range verification)

For details on the parameter set and the configurability of the associated parameters, see Annex 1

## 4.4 Reference values

Reference values for the p.u. or percentage calculations:

| | **Cube-5200** |
|---|---|
| Nominal active power [1] $P_n$ [W] | 2500 |
| Nominal voltage (phase-to-neutral), $U_n$ [V] | 230 |
| Nominal frequency, $f_n$ [Hz] | 50 |
| Nominal current, $I_n$ [2] [A] | 11 |

## 4.5 Measurement setup

Tests documented in this test report were performed using the following test configuration:

☐ Measurements in the field on real grid

☐ Test bench tests on real grid

☒ Test bench tests on an AC grid simulator

Operating mode of the EUT during the measurement

☒ MPP-Tracking operation mode

☒ Fixed voltage control operation mode

The PGU is connected on the DC-side to a DC-simulator and on the AC-side to an AC-grid simulator. The AC-grid simulator is operated with nominal conditions of $U_n$ = 230 (phase-to-neutral) and $f_n$ = 50 Hz unless stated otherwise by the applied test requirement.

[1] Definition according to EN 50549-10:2022, section 3.1.3.1.

[2] Definition according to EN 50549-10:2022, section 3.1.3.2.

The measurement setups are shown in Figure 2 and Figure 3. The specific test and measurement devices are stated in section 4.6.

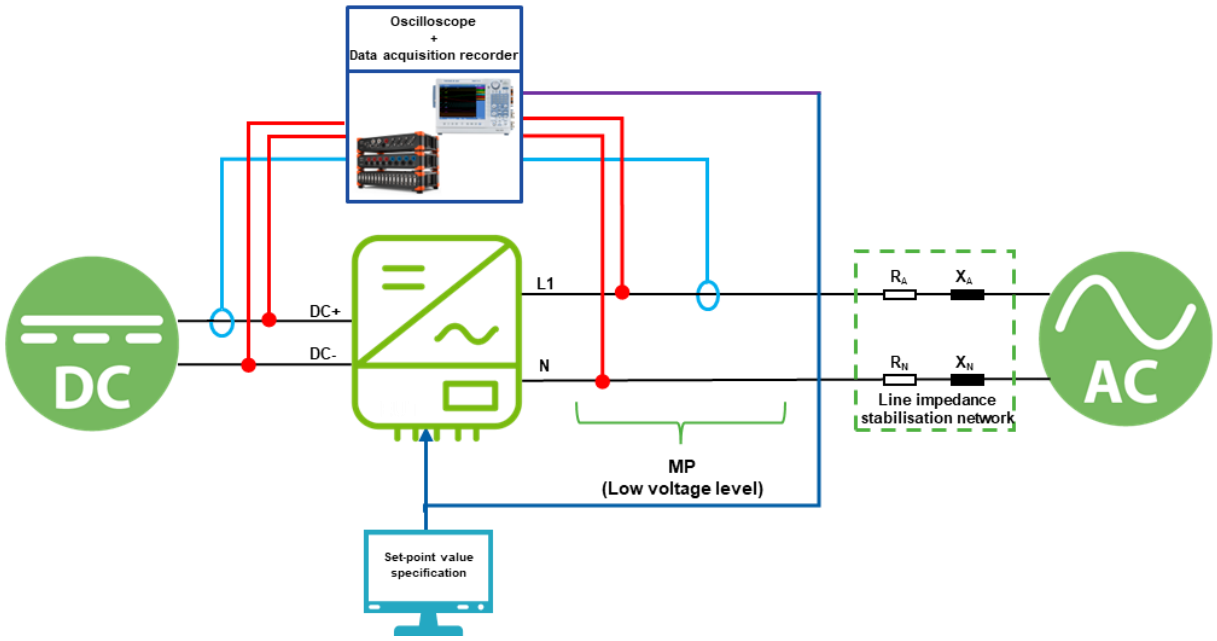



**Figure 2 – Measurement setup used for tests except Loss of Mains and Short Circuit test**

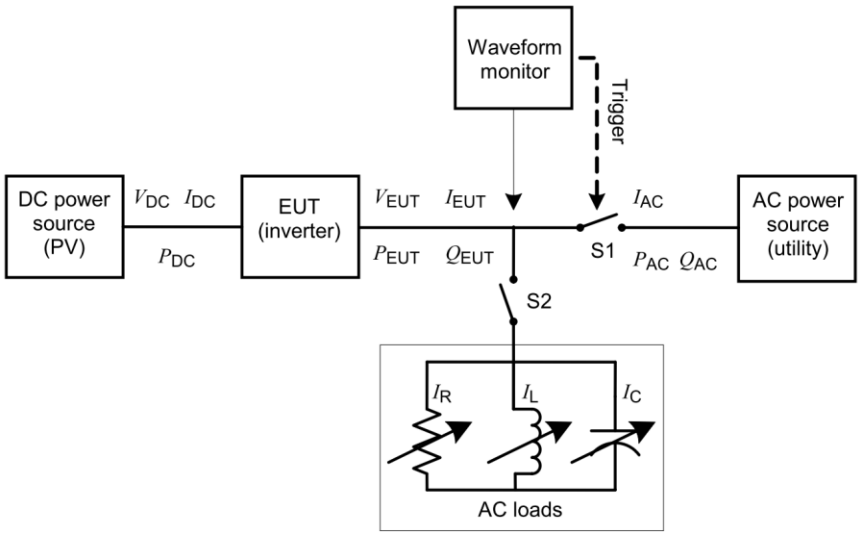



**Figure 3 – Test circuit for Loss of Mains according to *IEC 62116:2014***

## 4.6 Measurement equipment

| Equipment | Internal No. | Manufacturer | Type | Serial No. | Next Calibration |
|---|---|---|---|---|---|
| DC power supply | HC-ENG-043 | KEWELL | S7000-21K-2000-0040 | 6018888221003326 | Monitored by Power Analyzer |
| AC source | HC-ENG-030 | KEWELL | KAC-45-345-33 | 6018888220300485 | |
| RLC Load | HC-ENG-005 | Qunling Energy Resources | ACLT-3803H | 93H006289 | |
| Oscilloscope | -- | Tektronix | MDO3014 | C044522 | 2026-08-28 |
| Power analyser | HC-ENG-029 | DEWETRON | TRION-1820-POWER | ACLT-3803H | 2026-03-20 |
| Current sensor | HC-ENG-029-001 | SIGNALTEC | CT 400 | 1221300587 | 2026-03-20 |
| | HC-ENG-029-002 | SIGNALTEC | CT 400 | 1221300588 | 2026-03-20 |
| | HC-ENG-029-003 | SIGNALTEC | CT 400 | 1221300595 | 2026-03-20 |
| | HC-ENG-029-004 | SIGNALTEC | CT 400 | 1221300596 | 2026-03-20 |
| Humidity & Temperature recorder | HC-ENG-002 | Jiangsu Jingchuang Electric Co., Ltd. | GSP-8A | CMA215000031 | 2026-03-23 |

Note:

All measurement equipment was used within the calibration period. Copy of calibration certificates are available at the laboratory for reference.

## 4.7 Sampling rates of measurement equipment and data acquisition

| Test item | Voltages and currents signals A) | Set points and reference signals B) | Other signals (e.g. wind speed, rotational speed, battery state of charge etc.) C) | Sampling rates used for testing (for all signals A), B) & C)) |
|---|---|---|---|---|
| 5.1 Power specification of the generating unit | ≥ 3 kHz | ≥ 3 kHz | ≥ 1 kHz | 10 kHz |
| 5.2 Normal operating range | ≥ 3 kHz | ≥ 3 kHz | ≥ 1 kHz | 10 kHz |
| 5.3 Immunity to disturbances | ≥ 10 kHz | N/A | ≥ 1 kHz | 10 kHz |
| 5.4 Active response to frequency deviation | ≥ 3 kHz | N/A | ≥ 1 kHz | 10 kHz |
| 5.5 Power specification and response to voltage variations | ≥ 3 kHz | ≥ 3 kHz | ≥ 1 kHz | 10 kHz |
| 5.7 EMC and power quality | | | | |
| 5.7.2.2 Verification procedure for harmonics, interharmonics and higher frequencies up to 9 kHz | ≥ 20 kHz | N/A | ≥ 1 kHz | 50 kHz |
| 5.7.2.3 Verification procedure for flicker and rapid voltage changes | ≥ 3 kHz | N/A | ≥ 1 kHz | 10 kHz |
| 5.7.2.4 Verification procedure for DC injection | ≥ 3 kHz | N/A | ≥ 1 kHz | 10 kHz |

| Test item | Voltages and currents signals A) | Set points and reference signals B) | Other signals (e.g. wind speed, rotational speed, battery state of charge etc.) C) | Sampling rates used for testing (for all signals A), B) & C)) |
|---|---|---|---|---|
| 5.8 Interface protection | ≥ 10 kHz (≥ 1 kHz for voltage protection tests) | N/A | ≥ 1 kHz | 10 kHz |
| 5.9 Connection and starting | ≥ 3 kHz | N/A | ≥ 1 kHz | 10 kHz |
| 5.10 Active power reduction on set point | ≥ 3 kHz | ≥ 3 kHz | ≥ 1 kHz | 10 kHz |
| 5.11 Remote information exchange | N/A | N/A | N/A | --- |
| 5.12 Requirements regarding single fault tolerance of interface protection system and interface switch | N/A | N/A | N/A | --- |
| 5.13 Model definition and model validation for generating units of synchronous generating technology | N/A | N/A | N/A | --- |

## 4.8 Measurement uncertainties

| Value | Required measurement uncertainty (k = 2) (excluding the contribution of voltage and current transducers) | Maximum uncertainty (k = 2) measurement equipment used for testing (contribution of voltage and current transducers has been taken into account) |
|---|---|---|
| Voltage (fundamental) | ≤ 0.5% of $U_n$ | ±0.06% |
| Current (fundamental) | ≤ 0.5% of $I_n$ | ±0.14 |
| Harmonic currents up to 9 kHz | | |
| ≥ 0,1% of $I_n$ | ≤ 30% of measured value | ±0.66 |
| < 0,1% of $I_n$ | ≤ 0.03% of $I_n$ | ±0.016% |
| Set point signals | ≤ 0.5% of nominal value | ±0.18% of nominal value |
| Flicker | ≤ 5.8% referenced to $P_{st}$ = 1 | ±1.7% |
| Interface protection (test signals) | voltage ≤ 0.1% of $U_n$<br>frequency ≤ 0.01% of $f_n$ | Voltage: ±0.05% of $U_n$<br>frequency: ±0.006% of $f_n$ |
| pole wheel angle | ≤4°electrical | --- |

## 4.9 Test environment conditions

| **Applicable Clause(s) / subclause(s) of EN 50549-10:2022** | **Test date** | Tamb during test [°C] | Humidity during test [%rH] | Air pressure [hPA] |
|---|---|---|---|---|
| 5.2.1 Frequency operating range | 2025-08-12 | 26 | 70 | 965 |
| 5.2.2 Voltage operating range | 2025-08-15 | 26 | 70 | 965 |
| 5.3.1 Immunity to disturbances - Rate of change of frequency (ROCOF) | 2025-08-19 | 26 | 71 | 966 |
| 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 2025-08-22 | 26 | 70 | 965 |

| Applicable Clause(s) / subclause(s) of EN 50549-10:2022 | Test date | Tamb during test [°C] | Humidity during test [%rH] | Air pressure [hPA] |
|---|---|---|---|---|
| 5.4 Active response to frequency deviation | 2025-08-23 | 25 | 72 | 964 |
| 5.5.1 Power capabilities assessment | 2025-09-14 | 26 | 70 | 965 |
| 5.5.2 Voltage support by reactive power - test to determine the reactive power control modes | 2025-09-25 | 26 | 70 | 965 |
| 5.5.2.3 Verification procedure for Set point control | 2025-10-06 | 25 | 71 | 965 |
| 5.5.2.5 Verification procedure for power related control modes for reactive power | 2025-10-18 | 26 | 70 | 966 |
| 5.8.3 Verification procedure for generating plants to be connected to a LV distribution network with Interface protection as internal device<br>or<br>5.8.4 Verification procedure for generating plants to be connected to a LV distribution network with Interface protection as dedicated device | 2025-10-30 | 27 | 70 | 965 |
| 5.8.5 Verification procedure for generating plants to be connected to a MV distribution network | -- | -- | -- | -- |
| 5.8.6 Islanding detection | 2025-11-11 | 26 | 70 | 965 |
| 5.9.3 Automatic reconnection after tripping | 2025-11-22 | 25 | 71 | 963 |
| 5.9.4 Starting to generate electrical power | 2025-12-03 | 26 | 70 | 965 |
| 5.10 Active power reduction on set point | 2025-12-12 | 27 | 72 | 966 |
| 5.11 Remote information exchange | --- | --- | --- | --- |
| 5.12 Requirements regarding<br>single fault tolerance of interface protection system and interface switch | --- | --- | --- | --- |
| 5.13 Model definition and model validation for generating units of synchronous generating technology | --- | --- | --- | --- |

# 5 Assessment overview

**Possible test case verdicts:**

Test item does meet the requirement.....: P (Pass)

Test item does not meet the requirement....: F (Fail)

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

Test case is not rated .....: N/R

Reference to declaration documents.....: R/D

**Note:**

Conformity statement are decided in accordance with ILAC-G8:09/2019 *Binary Statement for Simple Acceptance Rule*, unless otherwise normatively specified. or contractually agreed.

For the ***transferability*** of test results from the EUT to other units within the product family, refer to section 4.3.2.

| Clause(s) / subclause(s) of EN 50549-1:2019 or EN 50549-2:2019 | Applicable Clause(s) / subclause(s) of EN 50549-10:2022 | Section in this test report | Remark | Verdict |
|---|---|---|---|---|
| 4.4.2 Operating frequency range | 5.2.1 Frequency operating range | 6.1.1 | --- | P |
| 4.4.3 Minimal requirement for active power delivery at underfrequency | 5.2.1 Frequency operating range | 6.1.1 | --- | P |
| 4.4.4 Continuous operating voltage range | 5.2.2 Voltage operating range | 6.1.2 | --- | P |
| 4.5.2 Rate of change of frequency (ROCOF) immunity | 5.3.1 Immunity to disturbances - Rate of change of frequency (ROCOF) | 6.2.1 | --- | P |
| 4.5.3.2 Generating plant with non-synchronous generating technology | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | --- | P |
| 4.5.3.3 Generating plant with synchronous generating technology | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | --- | --- | N/A |
| 4.5.4 Over-voltage ride through (OVRT) | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | --- | P |
| 4.5.5 Phase jump immunity | 5.3.2 Phase jump | 6.2.2 | --- | P |
| 4.6.1 Power response to overfrequency | 5.4 Active response to frequency deviation | 6.3.1 | --- | P |
| 4.6.2 Power response to underfrequency | 5.4 Active response to frequency deviation | 6.3.2 | --- | P |
| 4.7.2.2 Voltage support by reactive power, Capabilities | 5.5.1 Power capabilities assessment | 6.4.1 | --- | P |
| 4.7.2.3 Voltage support by reactive power, Control modes | 5.5.2 Voltage support by reactive power - test to determine the reactive power control modes | 6.4.2 | --- | P |
| 4.7.2.3.2 Set point control modes | 5.5.2.3 Verification procedure for Set point control | 6.4.2.1 | --- | P |
| 4.7.2.3.3 Voltage related control modes | 5.5.2.4 Verification procedure for voltage related control modes for reactive power | 6.4.2.2 | --- | P |
| 4.7.2.3.4 Power related control mode | 5.5.2.5 Verification procedure for power related control modes for reactive power | 6.4.2.3 | --- | P |

| Clause(s) / subclause(s) of EN 50549-1:2019 or EN 50549-2:2019 | Applicable Clause(s) / subclause(s) of EN 50549-10:2022 | Section in this test report | Remark | Verdict |
|---|---|---|---|---|
| 4.7.3 Voltage related active power reduction | 5.6 Voltage related active power reduction - P(U) | 6.5 | --- | P |
| only EN 50549-2:2019 4.7.4.2.1.1 Voltage support during faults and voltage steps – General | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | --- | N/A |
| only EN 50549-2:2019 4.7.4.2.1.2 Voltage support during faults and voltage steps - Optional Modes | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | --- | N/A |
| 4.7.4.2.2 Zero current mode for converter connected generating technology | 5.3.3 Immunity to disturbances - Fault ride through, over-voltage (OVRT) and under-voltage (UVRT) | 6.2.3 | --- | P |
| 4.8 EMC and power quality | 5.7 EMC and power quality | 6.6 | --- | P |
| only EN 50549-1:2019 4.9.3 Requirements on voltage and frequency protection | 5.8.3 Verification procedure for generating plants to be connected to a LV distribution network with Interface protection as internal device<br>or<br>5.8.4 Verification procedure for generating plants to be connected to a LV distribution network with Interface protection as dedicated device | 6.7 | --- | P |
| only EN 50549-2:2019, 4.9.3. Requirements on voltage and frequency protection | 5.8.5 Verification procedure for generating plants to be connected to a MV distribution network | --- | --- | N/A |
| 4.9.4 Means to detect island situation | 5.8.6 Islanding detection | 6.7.4 | --- | P |
| 4.10.2 Automatic reconnection after tripping | 5.9.3 Automatic reconnection after tripping | 6.8.1 | --- | P |
| 4.10.3 Starting to generate electrical power | 5.9.4 Starting to generate electrical power | 6.8.2 | --- | P |
| 4.11.1 Ceasing active power | 5.10 Active power reduction on set point | 6.9 | --- | P |
| 4.11.2 Reduction of active power on set point | 5.10 Active power reduction on set point | 6.9 | --- | P |
| 4.12 Remote information exchange | 5.11 Remote information exchange | --- | --- | N/A |
| only EN 50549-1:2019, 4.13 single fault tolerance of interface protection system and interface switch | 5.12 Requirements regarding<br>single fault tolerance of interface protection system and interface switch | 6.11 | --- | P |
| --- | 5.13 Model definition and model validation for generating units of synchronous generating technology | 6.12 | --- | N/A |

# 6 Measurement results

## 6.1 Normal operating range

### 6.1.1 Frequency operating range

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.2.1.3, EN 50549-10 |

| | |
|---|---|
| Active Power level | 100%$P_{max}$ |
| Active factor | 1.000 |
| LFSM-O control function | disable |
| Voltage and frequency protection | deactivated |

**Acceptance criteria**

- the generating unit does not trip and operates at frequencies stated in section 5.2.1.3, EN 50549-10 or
- the generating unit does not trip and operates at an exceeding frequency range as stated by the manufacturer or responsible party or a specific grid code.
- When evaluating the underfrequency condition the generating unit is allowed to decrease its power output by up to 10%$P_{max}$ per Hertz starting from 49,5 Hz according to characteristic described in EN 50549-1:2019 and EN 50549-2:2019, 4.4.3, Figure 5 or to a more stringent power reduction characteristic defined by the manufacturer or responsible party or a specific grid code.

**Manufacturer's data**

(Regarding the nominal voltage/frequency of the EUT, please refer to section 4.4.)

The unit can be continuously operated within the voltage/frequency range:

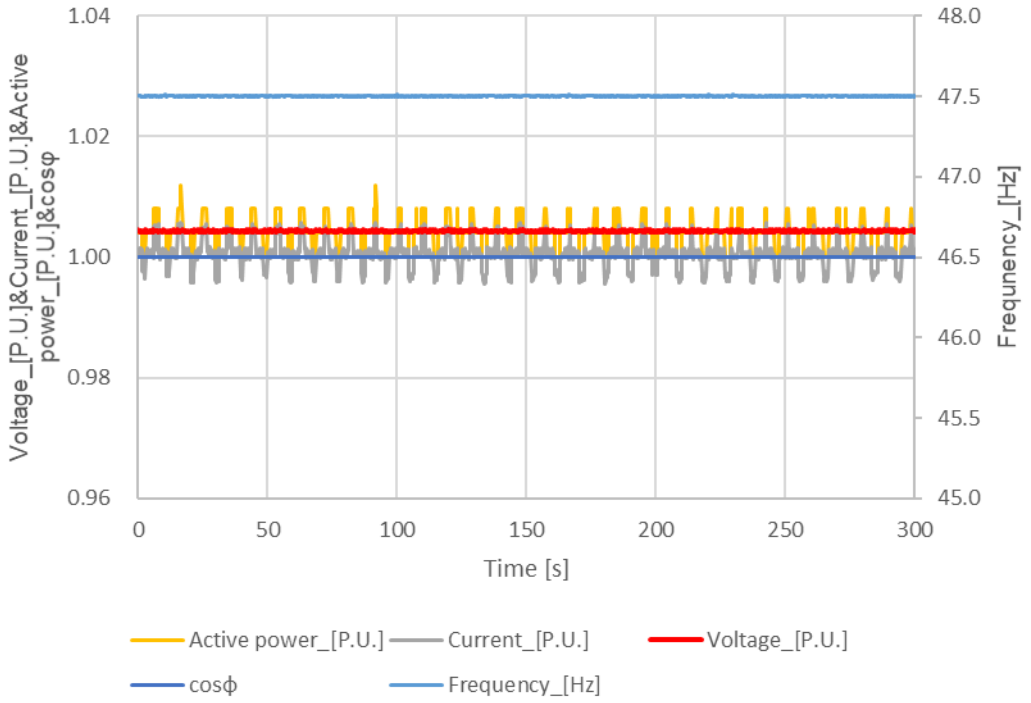
- 85%$U_n$ ~ 110%$U_n$
- 47.5Hz ~ 51.5Hz (requirements according to table 1, EN 50549-1 can be met)

The operating range of voltage and frequency can also be limited using the protection functions.

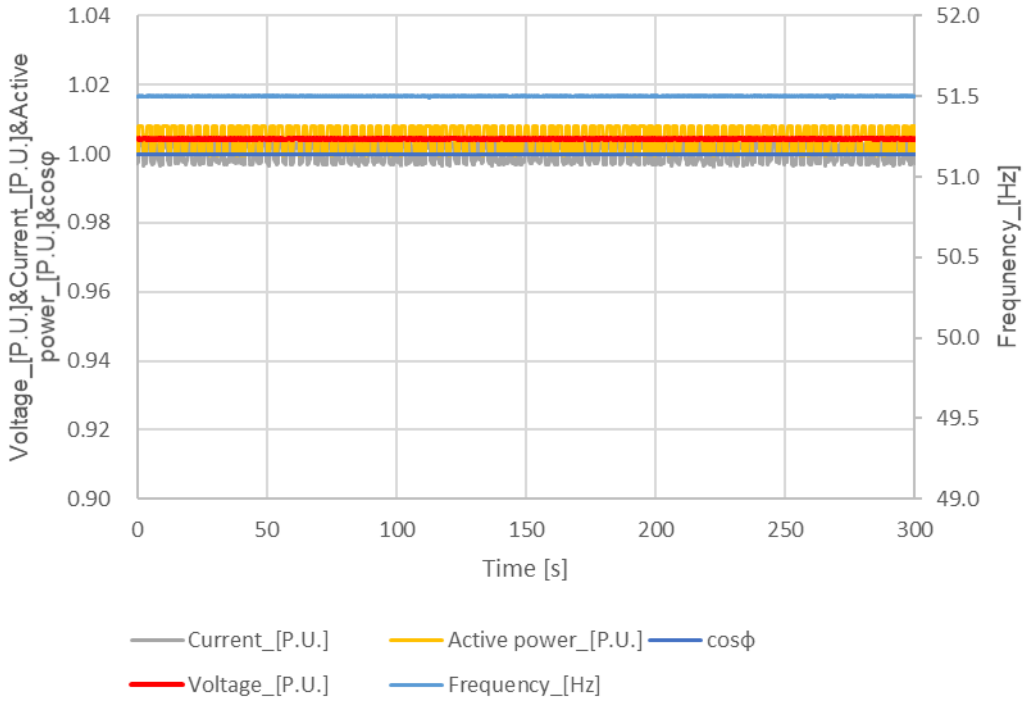
**Test results**

| Test no. | U [%] | f [Hz] | $P_{meas}$ [%$P_{max}$] | Active factor [-] | Duration of recording [min] | EUT tripped during test? | |
|---|---|---|---|---|---|---|---|
| 1 | 100 | 47.50 | 100.4 | 0.999 | ≥ 5 min | ☐ Yes | ☒ No |
| 2 | 100 | 51.50 | 100.5 | 0.999 | ≥ 5 min | ☐ Yes | ☒ No |
| 3 | 100 | 47.00 | 99.8 | 0.999 | ≥ 20 s | ☐ Yes | ☒ No |
| 4 | 100 | 51.89 | 100.5 | 0.999 | ≥ 5 min | ☐ Yes | ☒ No |

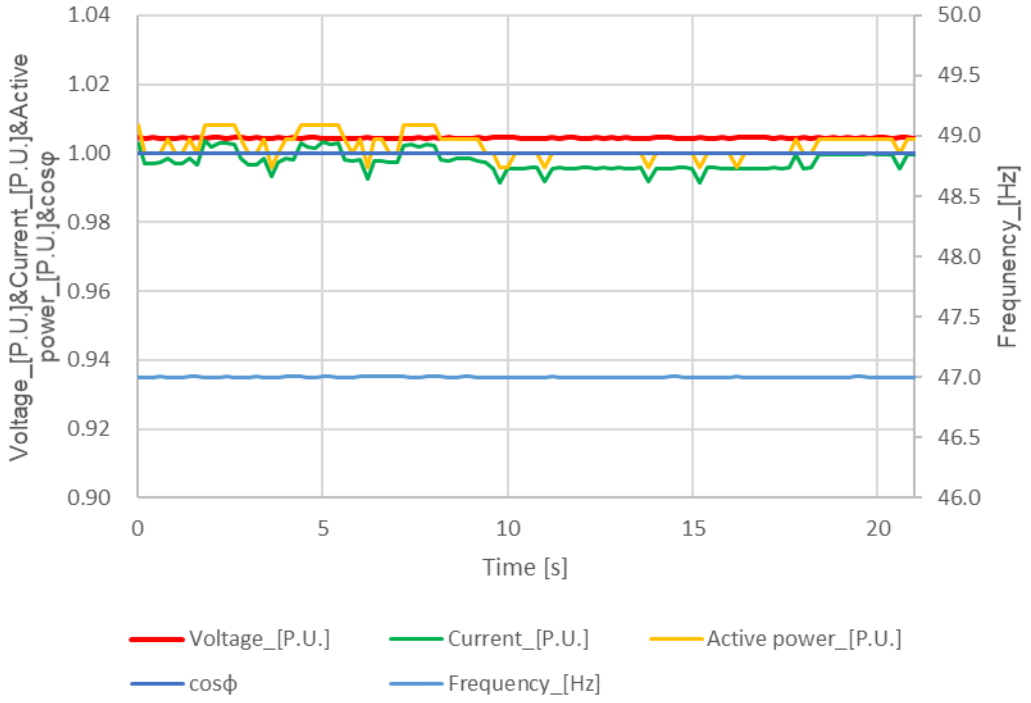
**Test 1**


1.04
1.02
1.00
0.98
0.96
48.0
47.5
47.0
46.5
46.0
45.5
45.0
0
50
100
150
200
250
300
Time [s]
Voltage_[P.U.]&Current_[P.U.]&Active power_[P.U.]&cosφ
Frequency_[Hz]
Active power_[P.U.]
Current_[P.U.]
Voltage_[P.U.]
cosϕ
Frequency_[Hz]

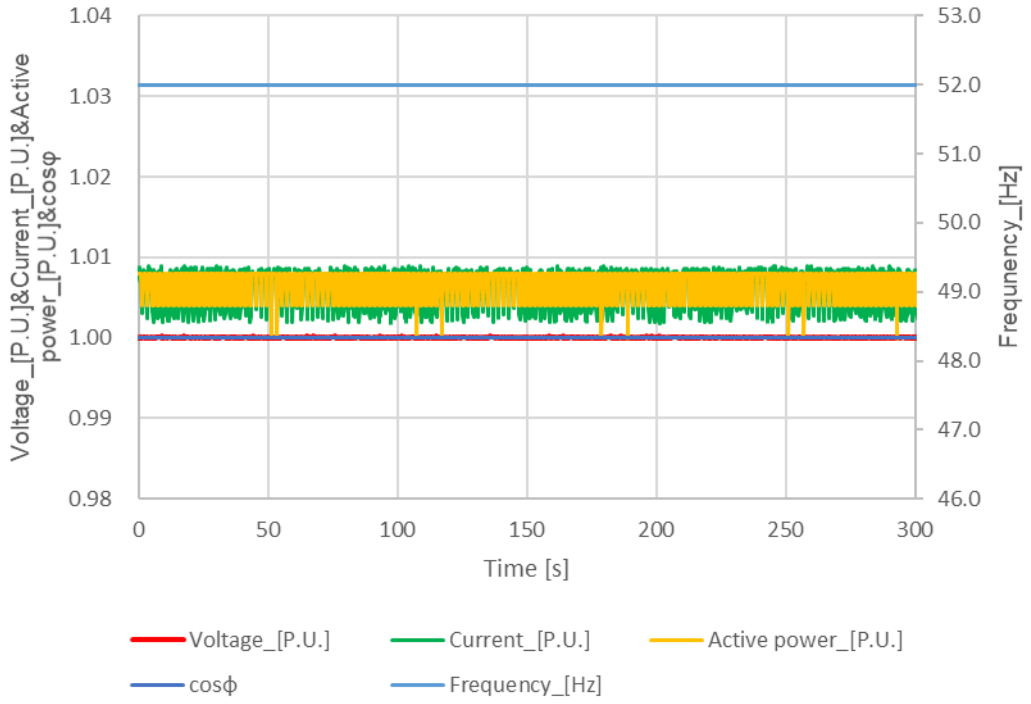
**Test 2**


1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
52.0
51.5
51.0
50.5
50.0
49.5
49.0
0
50
100
150
200
250
300
Time [s]
Voltage_[P.U.]&Current_[P.U.]&Active power_[P.U.]&cosφ
Frequency_[Hz]
Current_[P.U.]
Active power_[P.U.]
cosϕ
Voltage_[P.U.]
Frequency_[Hz]

**Test 3**


1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
50.0
49.5
49.0
48.5
48.0
47.5
47.0
46.5
46.0
0
5
10
15
20
Time [s]
Voltage_[P.U.]&Current_[P.U.]&Active power_[P.U.]&cosφ
Frequency_[Hz]
Voltage_[P.U.]
Current_[P.U.]
Active power_[P.U.]
cosϕ
Frequency_[Hz]

**Test 4**


1.04
1.03
1.02
1.01
1.00
0.99
0.98
53.0
52.0
51.0
50.0
49.0
48.0
47.0
46.0
0
50
100
150
200
250
300
Time [s]
Voltage_[P.U.]&Current_[P.U.]&Active power_[P.U.]&cosφ
Frequency_[Hz]
Voltage_[P.U.]
Current_[P.U.]
Active power_[P.U.]
cosϕ
Frequency_[Hz]

### 6.1.2 Voltage operating range

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.2.2.3, EN 50549-10 |

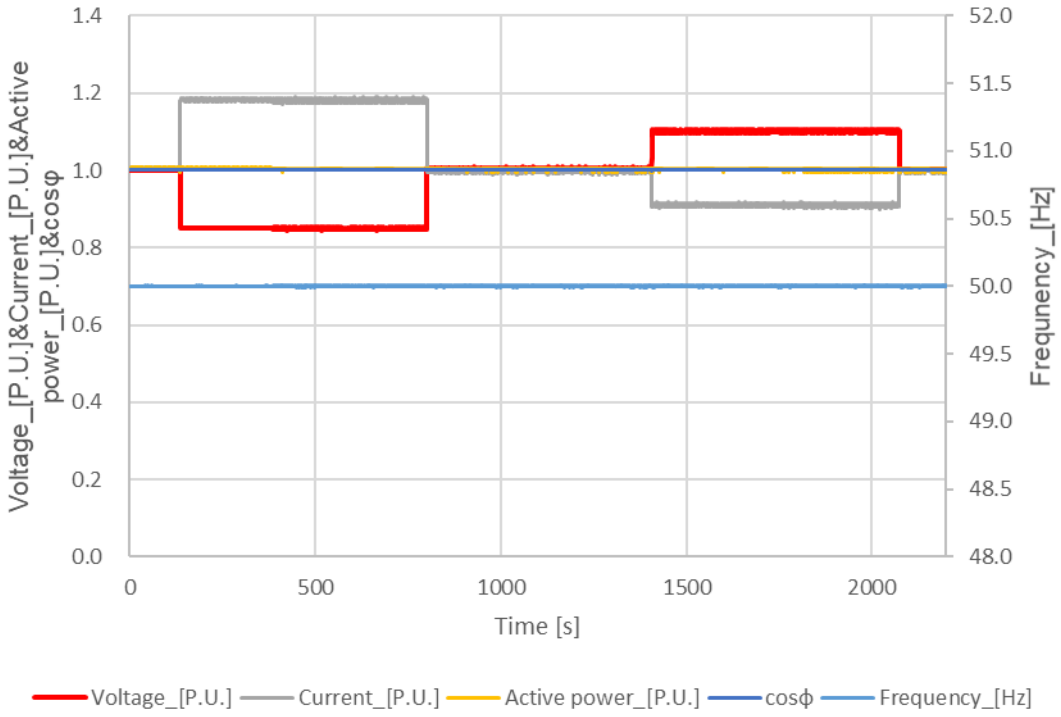
| | |
|---|---|
| Active Power level | 100%$P_{max}$ |
| Active factor | 1.000 |
| LFSM-O control function | disable |
| Voltage and frequency protection | deactivated |

| Acceptance criteria |
|---|
| The requirement is considered passed when the generating unit is able to remain in operation and does not disconnect from the system during the test and if the documentation provided shows that the generating unit is expected to run within its operational limits (e.g. temperature on the components does not exceed insulation thermal classes). |

| Manufacturer's data |
|---|
| (Regarding the nominal voltage/frequency of the EUT, please refer to section 4.4.)<br>The unit can be continuously operated within the voltage/frequency range:<br>- 85%$U_n$ ~ 110%$U_n$<br>- 47.5Hz ~ 51.5Hz (requirements according to table 1, EN 50549-1 can be met)<br>The operating range of voltage and frequency can also be limited using the protection functions. |

**Test results**

| Test seq. | $U_{L-L}$ [%] | $U_{L-N}$ [%] | f [Hz] | $P_{meas}$ [%$P_{max}$] | Active factor [-] | Duration of recording [min] | EUT tripped during test? | |
|---|---|---|---|---|---|---|---|---|
| 1 | 100.0 | 100.0 | 50.00 | 100.63 | 0.999 | ≥ 1 min | ☐ Yes | ☒ No |
| 2 | 85.0 | 85.0 | 50.00 | 100.34 | 0.999 | ≥ 10 min | ☐ Yes | ☒ No |
| 3 | 100.4 | 100.4 | 50.00 | 100.16 | 0.999 | ≥ 5 min | ☐ Yes | ☒ No |
| 4 | 110.1 | 110.1 | 50.00 | 100.15 | 0.999 | ≥ 10 min | ☐ Yes | ☒ No |
| 5 | 100.4 | 100.4 | 50.00 | 100.15 | 0.999 | ≥ 1 min | ☐ Yes | ☒ No |




## 6.2 Immunity to disturbances

### 6.2.1 Rate of change of frequency (ROCOF)

| **Verdict** | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| **Test conditions** | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.3.1.3, EN 50549-10 |

| | |
|---|---|
| Active Power level | 100%$P_n$ |
| Active factor | 1.000 |
| ROCOF protection | disable |
| Vector shift protection | not available |
| LFSM-O control function | disable |
| Voltage and frequency protection | set to values not interfering to the tests |

| **Acceptance criteria** |
|---|
| The generating unit operates or unit component remains in operation without disconnection from the grid (no trip). |

| **Test results** | | | | |
|---|---|---|---|---|
| ☒ ≥ 2 Hz/s | | ☐ specified by the responsible party: ≥ _ Hz/s | | |
| Test seq. | Step | f [Hz] | ROCOF value [Hz/s] | EUT tripped during test? |
| 1 | T0 | 50.0 | --- | ☐ Yes ☒ No |

| | | | | | |
|---|---|---|---|---|---|
| | ↓ | | 2 | ☐ Yes | ☒ No |
| 2 | T1 | 51.0 | --- | ☐ Yes | ☒ No |
| | ↓ | | 2 | ☐ Yes | ☒ No |
| 3 | T2 | 51.0 | --- | ☐ Yes | ☒ No |
| | ↓ | | 2 | ☐ Yes | ☒ No |
| 4 | T3 | 49.0 | --- | ☐ Yes | ☒ No |
| | ↓ | | 2 | ☐ Yes | ☒ No |
| 5 | T4 | 49.0 | --- | ☐ Yes | ☒ No |
| | ↓ | | 2 | ☐ Yes | ☒ No |
| 6 | T5 | 50.0 | --- | ☐ Yes | ☒ No |




### 6.2.2 Phase jump

| **Verdict** | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| **Test conditions** | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.3.2.3, EN 50549-10 |

| | |
|---|---|
| Active Power level | 100%$P_n$ |
| Active factor | 1.000 |
| ROCOF protection | disable |
| Vector shift protection | disable |
| LFSM-O control function | disable |
| Voltage and frequency protection | deactivated |

| **Acceptance criteria** |
|---|

- The phase jump ride through capability 1 as declared by the manufacturer or as requested by the responsible party or a specific grid code is confirmed.
- The active power and reactive power recovery response times and settling times as declared by the manufacturer or as requested by the responsible party or a specific grid code are confirmed. (section 4.5.5 EN 50549-1: after the phase jump, 90 % of pre-fault power or available power whichever is the smallest shall be resumed as fast as possible, but at the latest within 3 s in case of synchronous generating technologies and within 1 s in case of non-synchronous generating technologies.)
- The withstand without damage capability as declared by the manufacturer or as requested by the responsible party or a specific grid code is confirmed.

**Manufacturer's data**

- Capability 1, phase jump ride through:
  - $\delta_1 = 60°$
- Capability 2, withstand without damage:
  - $\delta_{2.1} = 90°$, $\delta_{2.2} = 180°$

**Test results**

Note:

Prior to testing, the EUT shall be operated at nominal voltage, a power level greater than $0.9P_n$, with a unit power factor (cos = 1) for at least 5 min, or the time required for the internal temperature stabilization, whichever is longer. The phase jump shall then be simulated using the Grid Simulator according to the requirements of "Capability 1" and "Capability 2".

**Capability 1**

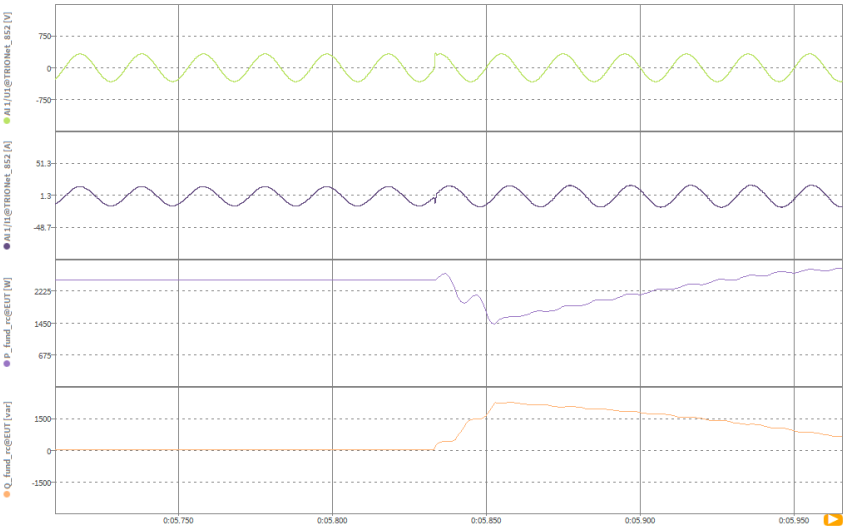
| Test no. | Type of phase jump | P-Recovery response time [s] | P-Recovery settling time [s] | Q-Recovery response time [s] | Q-Recovery settling time [s] |
|---|---|---|---|---|---|
| 1 | $+\delta_1$ at voltage zero crossing (0°) | 0.089 | 0.089 | 0.178 | 0.178 |
| 2 | $+\delta_1$ at the top of the sinewave (+90°) | 0.747 | 0.747 | 0.042 | 0.042 |
| 3 | $-\delta_1$ at voltage zero crossing (0°) | 0.670 | 0.760 | 0.047 | 0.047 |
| 4 | $-\delta_1$ at the top of the sinewave (+90°) | 0.091 | 0.091 | 0.722 | 0.722 |

**Capability 2**

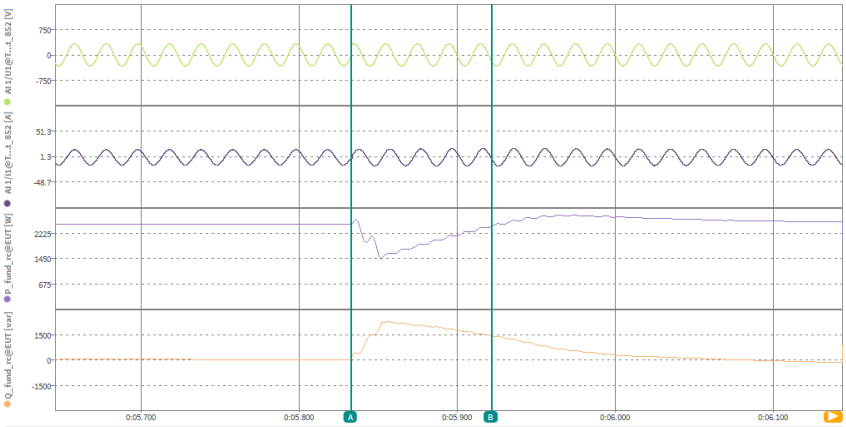
| Test no. | Type of phase jump | Description of behaviours of the EUT after phase jump |
|---|---|---|
| 5 | $+\delta_{2.1}$ at voltage zero crossing (0°) | EUT no tripped after phase jump.<br>EUT can be operated normally. |
| 6 | $+\delta_{2.1}$ at the top of the sinewave (+90°) | EUT no tripped after phase jump.<br>EUT can be operated normally. |
| 7 | $+\delta_{2.2}$ at voltage zero crossing (0°) | EUT tripped after phase jump but caused no damage.<br>EUT can be operated normally after the restart. |
| 8 | $+\delta_{2.2}$ at the top of the sinewave (+90°) | EUT tripped after phase jump but caused no damage.<br>EUT can be operated normally after the restart. |

## Test 1

+$\delta_1$ at voltage zero crossing (0°)

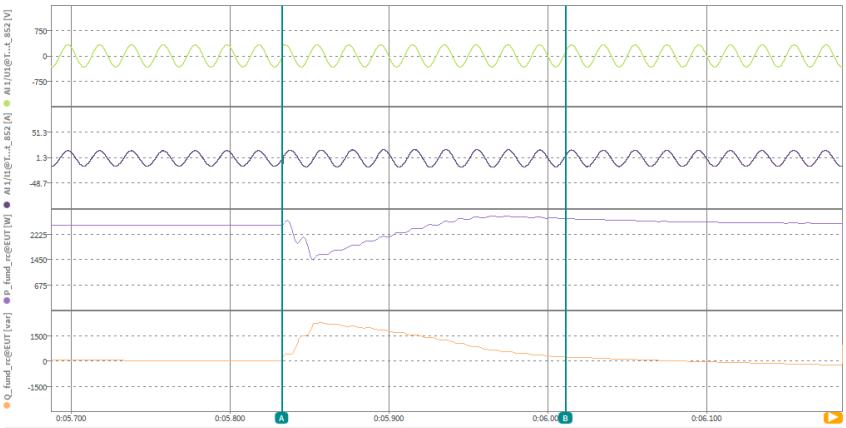



P settling time




| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.8329276 | 5.9217870 | 0.0888594 |
| AI 1/U1@TRIONet_852 [V] | -38.99265 | -169.2588 | -130.2662 |
| AI 1/I1@TRIONet_852 [A] | -2.265309 | -1.476740 | 0.788569 |
| P_fund_rc@EUT [W] | 2484.828 | 2384.909 | -99.91943 |
| Q_fund_rc@EUT [var] | -12.67979 | 1447.342 | 1460.021 |

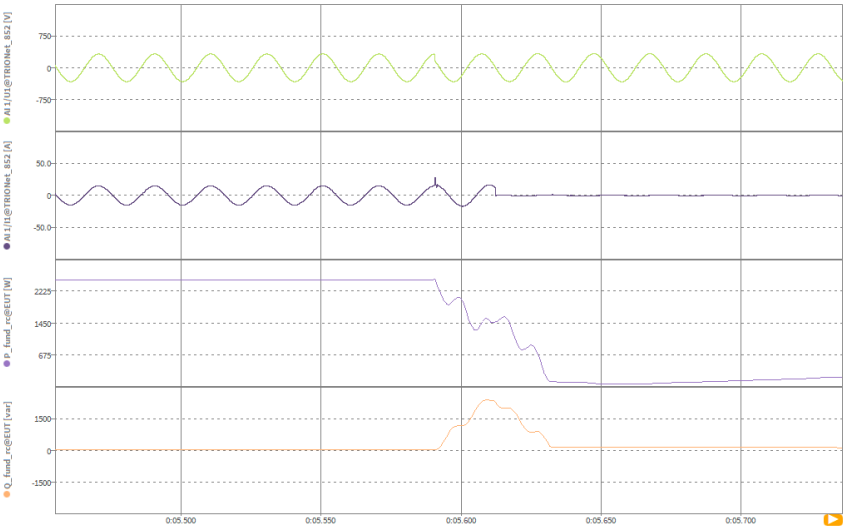
Q settling time



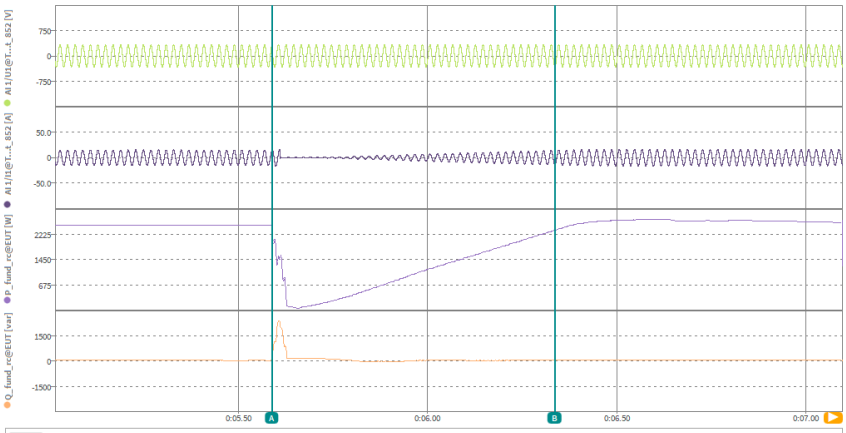

| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.8329276 | 6.0113515 | 0.1784239 |
| AI 1/U1@TRIONet_852 [V] | -38.99265 | 136.0250 | 175.0176 |
| AI 1/I1@TRIONet_852 [A] | -2.265309 | 4.940893 | 7.206202 |
| P_fund_rc@EUT [W] | 2484.828 | 2692.076 | 207.2483 |
| Q_fund_rc@EUT [var] | -12.67979 | 202.1410 | 214.8208 |

## Test 2

+$\delta_1$ at the top of the sinewave (+90°)

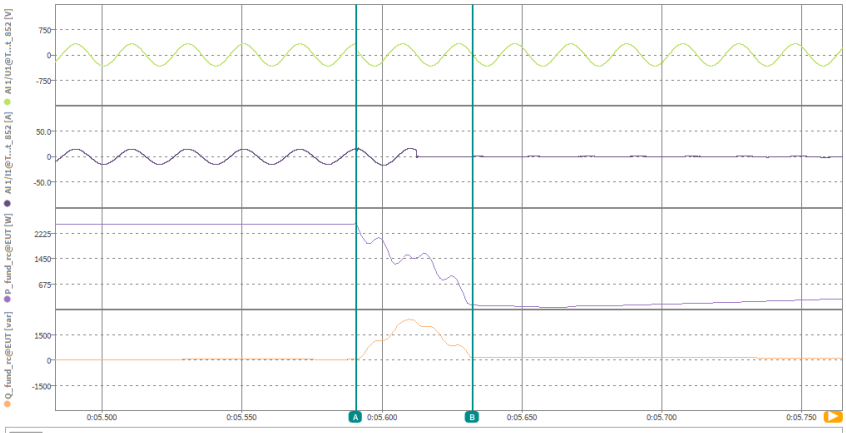



P settling time




| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.5907291 | 6.3373871 | 0.7466580 |
| AI 1/U1@TRIONet_852 [V] | 235.4751 | -327.1744 | -562.6495 |
| AI 1/I1@TRIONet_852 [A] | 24.01498 | -14.78944 | -38.80441 |
| P_fund_rc@EUT [W] | 2483.606 | 2322.317 | -161.2896 |
| Q_fund_rc@EUT [var] | 1.771967 | 29.72680 | 27.95483 |

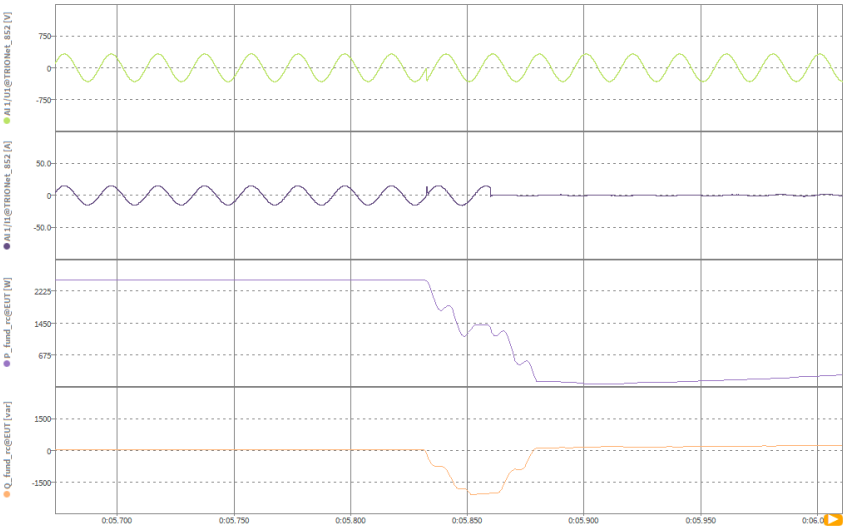
Q settling time



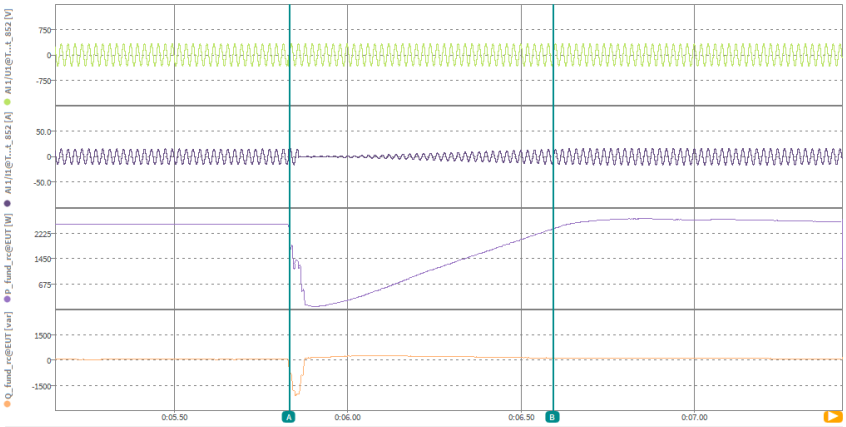

| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.5907291 | 5.6323535 | 0.0416244 |
| AI 1/U1@TRIONet_852 [V] | 235.4751 | 11.15394 | -224.3211 |
| AI 1/I1@TRIONet_852 [A] | 24.01498 | 0.486637 | -23.52834 |
| P_fund_rc@EUT [W] | 2483.606 | 1.865142 | -2481.741 |
| Q_fund_rc@EUT [var] | 1.771967 | 148.2687 | 146.4967 |

## Test 3

-$\delta_1$ at voltage zero crossing (0°)

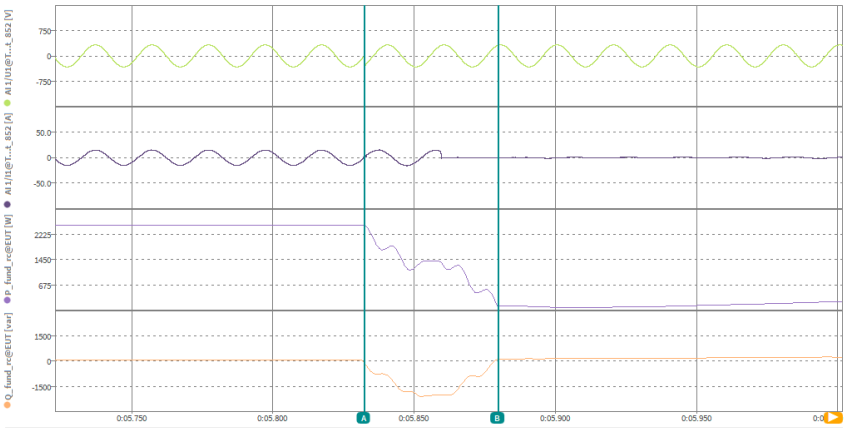


P settling time



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.8322979 | 6.5926103 | 0.7603124 |
| AI 1/U1@TRIONet_852 [V] | -25.36273 | -275.2953 | -249.9325 |
| AI 1/I1@TRIONet_852 [A] | -1.567935 | -12.12869 | -10.56075 |
| P_fund_rc@EUT [W] | 2488.347 | 2337.532 | -150.8154 |
| Q_fund_rc@EUT [var] | 17.37173 | 80.48442 | 63.11270 |

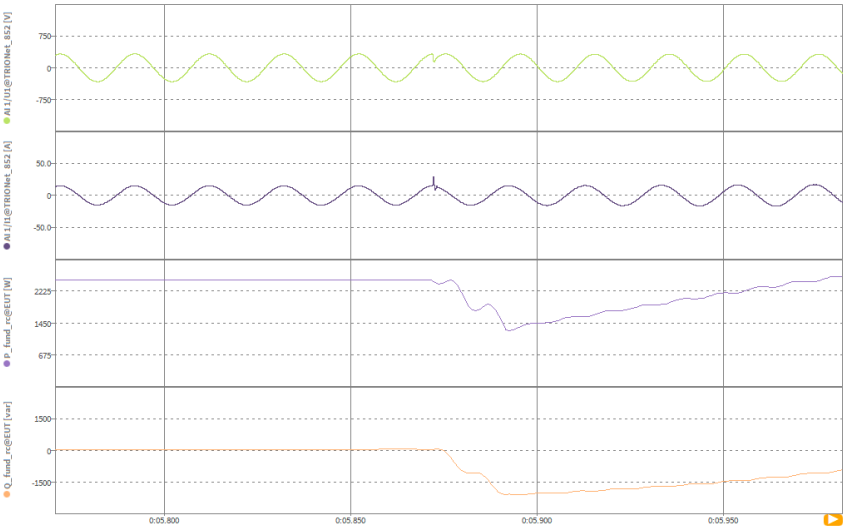
Q settling time



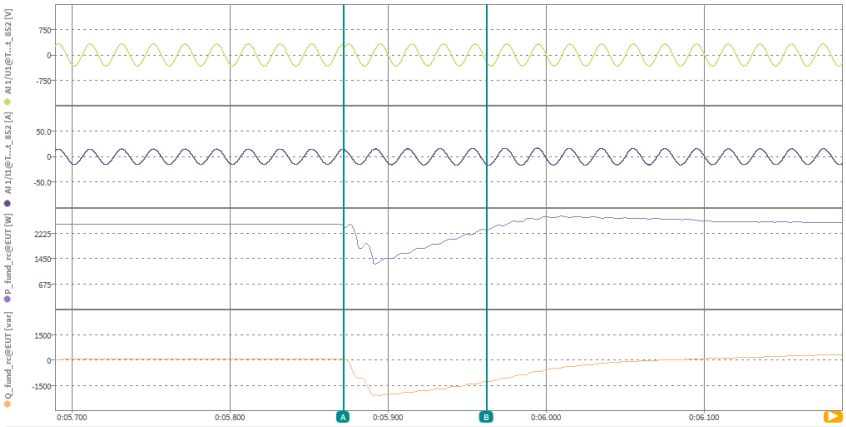
| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.8322979 | 5.8797154 | 0.0474175 |
| AI 1/U1@TRIONet_852 [V] | -25.36273 | 309.0673 | 334.4300 |
| AI 1/I1@TRIONet_852 [A] | -1.567935 | -0.423526 | 1.144409 |
| P_fund_rc@EUT [W] | 2488.347 | 149.1748 | -2339.172 |
| Q_fund_rc@EUT [var] | 17.37173 | 25.00366 | 7.631939 |

## Test 4

-$\delta_1$ at the top of the sinewave (+90°)

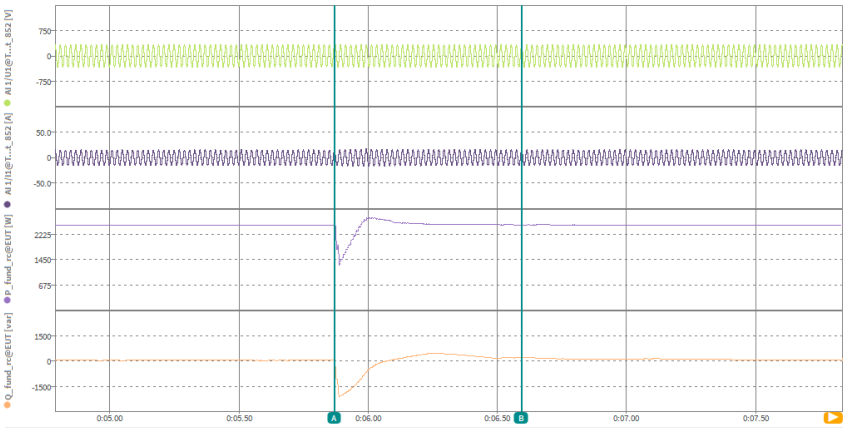



P settling time




| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.8720919 | 5.9626960 | 0.0906041 |
| AI 1/U1@TRIONet_852 [V] | 321.2135 | -198.9973 | -520.2108 |
| AI 1/I1@TRIONet_852 [A] | 16.20796 | -15.57443 | -31.78239 |
| P_fund_rc@EUT [W] | 2489.636 | 2317.049 | -172.5864 |
| Q_fund_rc@EUT [var] | 18.49048 | -1300.117 | -1318.607 |

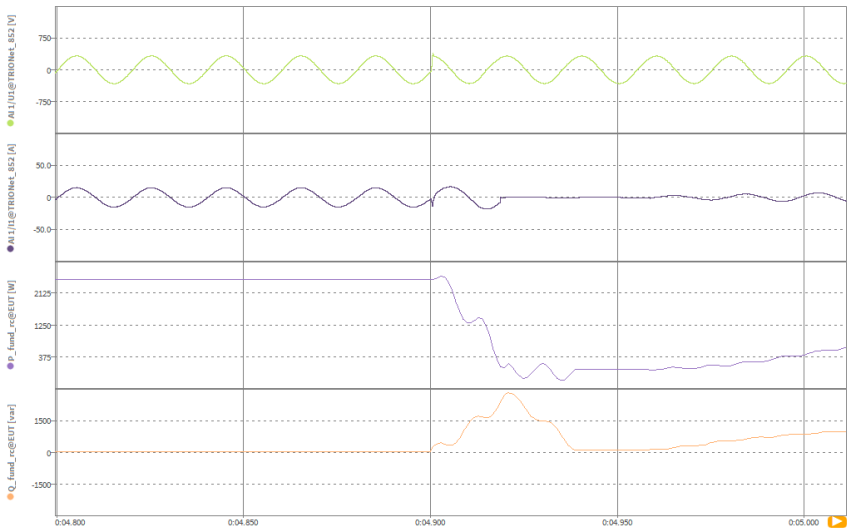
Q settling time

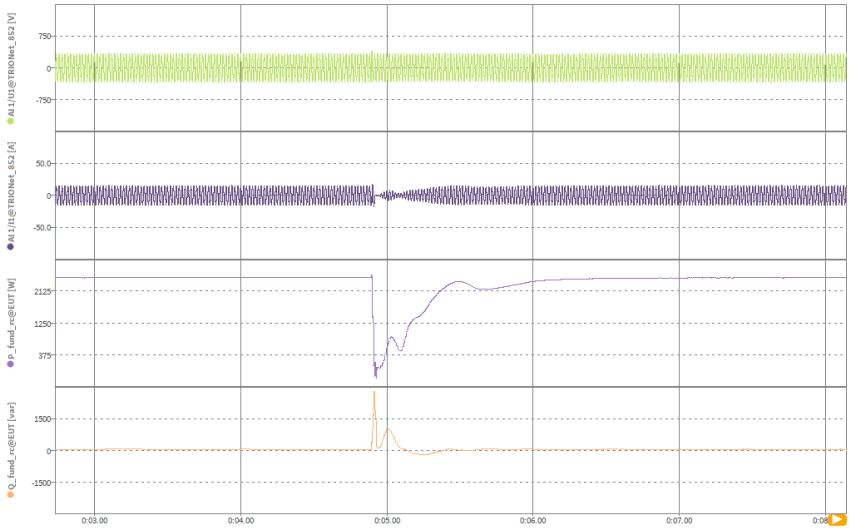



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 5.8720919 | 6.5941785 | 0.7220866 |
| AI 1/U1@TRIONet_852 [V] | 321.2135 | 293.9372 | -27.27628 |
| AI 1/I1@TRIONet_852 [A] | 16.20796 | 13.41131 | -2.796650 |
| P_fund_rc@EUT [W] | 2489.636 | 2494.819 | 5.183594 |
| Q_fund_rc@EUT [var] | 18.49048 | 172.8555 | 154.3651 |

## Test 5

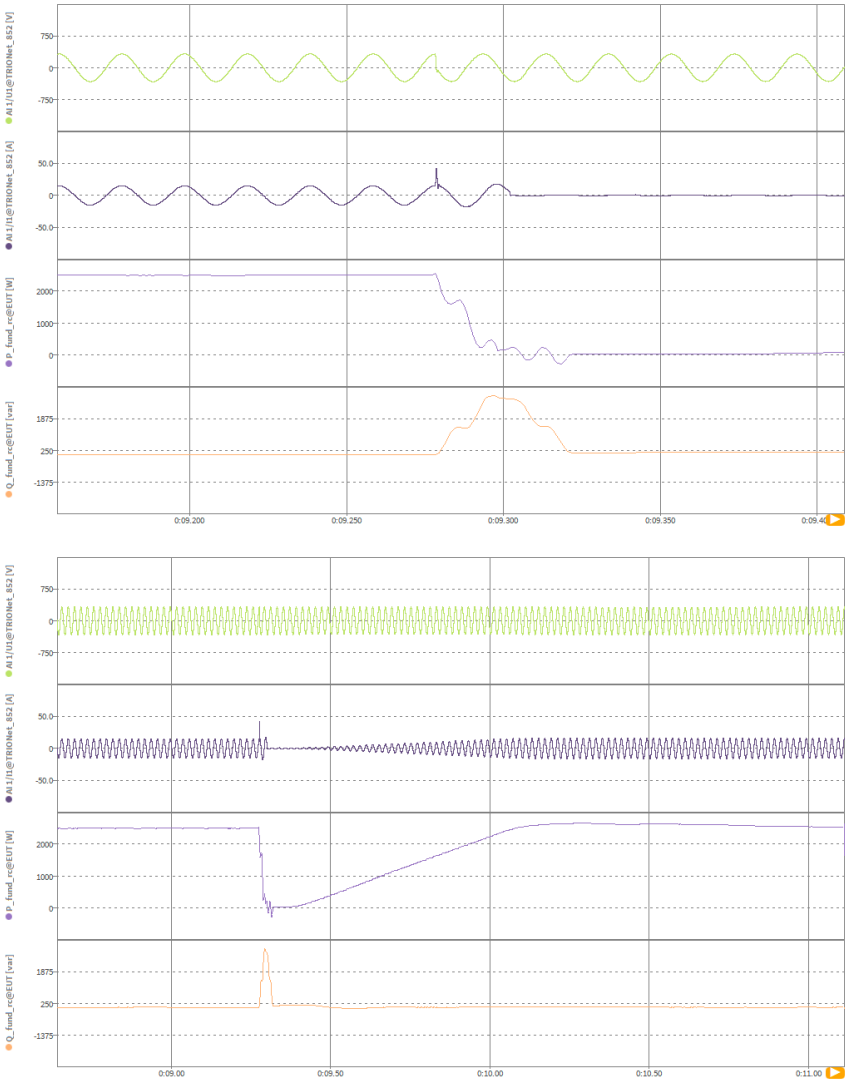
$+\delta_{2.1}$ at voltage zero crossing (0°)



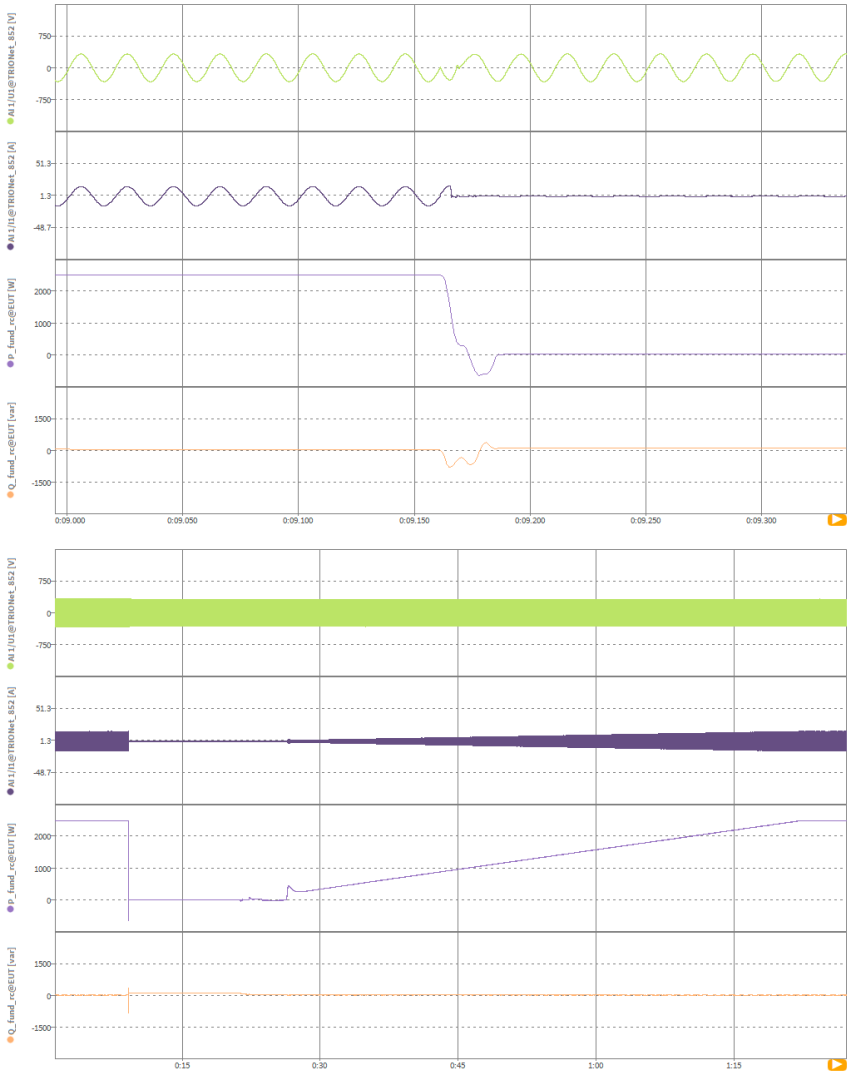
## Test 6

+$\delta_{2.1}$ at the top of the sinewave (+90°)



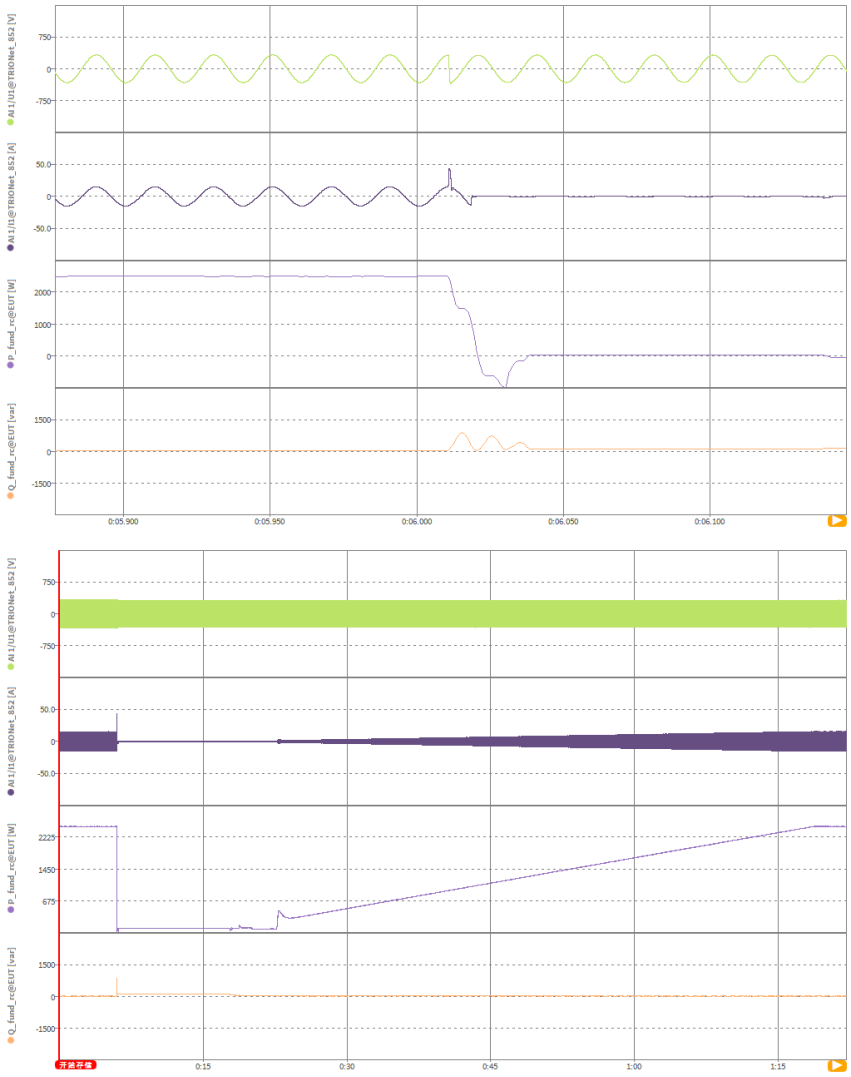
**Test 7**

$+\delta_{2.2}$ at voltage zero crossing (0°)



## Test 8

$+\delta_{2.2}$ at the top of the sinewave (+90°)



### 6.2.3 Fault ride through, over-voltage (OVRT) and under-voltage (UVRT)

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22<br>Note: The line impedances depicted in *Figure 2* primarily represent the impedance of the connection cable.<br>(As the FRT mode tested in this report is "zero current mode", the generating unit has a negligible impact on the voltage magnitude during grid fault. Therefore, this test setup is adequate for the test requirements.)<br>Nominal apparent power of the test setup $S_n$ [kVA]: 2.5<br>Grid impedance $R_A$ [mΩ]: 0.675<br>Grid reactance $X_A$ [mΩ]: 2.312<br>X/R: 3.43 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.3.3.3, EN 50549-10 |

| | |
|---|---|
| Operating mode of the EUT | ☐ MPP-Tracking operation mode<br>☒ Fixed voltage control operation mode |
| Active Power level | See table *Test cases* below |
| Reactive Power setpoint | See table *Test cases* below |
| Voltage protection | deactivated |
| Active islanding detection | disable |

| | |
|---|---|
| Voltage support mode provide by the PGU(s) | ☒ No voltage support during faults (*zero current mode only*)<br>☐ Voltage support during faults<br>☐ Zero current mode (*in addition to voltage support mode*)<br>☐ Active power priority<br>☐ Reactive current limitation |

Voltage ride through capability according to:

☒ EN 50549-1: ☒ most stringent ☐ default requirement

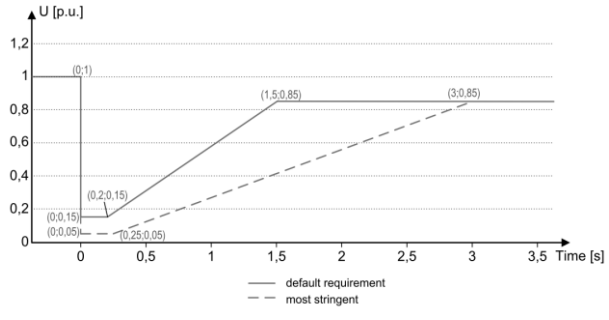



Figure 6 — Under-voltage ride through capability for non-synchronous generating technology

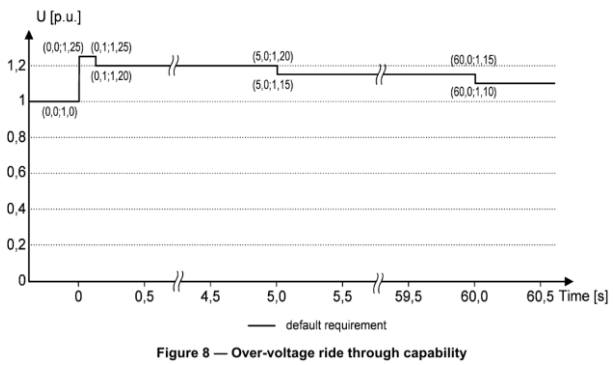



Figure 8 — Over-voltage ride through capability

$U_{min}$ = 0.05; $U_{UVRC}$ = 0.95, $U_{max}$ = 1.25, $U_{OVRC}$ = 0.25

☐ EN 50549-2 ☐ most stringent ☐ default requirement

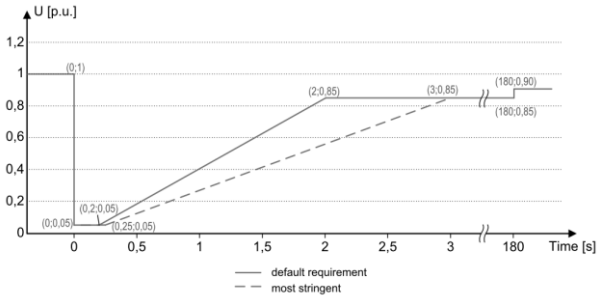



**Figure 6 — Under-voltage ride through capability for non-synchronous generating technology**

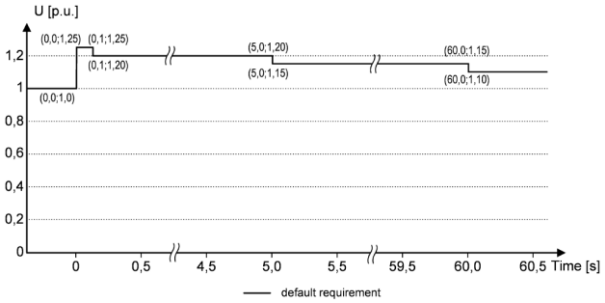



**Figure 8 — Over-voltage ride through capability**

$U_{min}$ = 0.05; $U_{UVRC}$ = 0.95, $U_{max}$ = 1.25, $U_{OVRC}$ = 0.25

**Acceptance criteria**

- The conducted tests verify the specified capability curve of the manufacturer.
- No trip occurred.
- Conducted tests represent the specified capability in duration and depth of voltage dips.
- The specified capability curve of the manufacturer does not show any “may disconnect” areas above (test case UVRT) or below (test case OVRT) the voltage time characteristic as specified by the DSO or applied grid code.
- The active power recovery time after fault is equal or less the time specified by the DSO or applied grid code.

☒ Assessment criteria of zero current mode for non-synchronous generating technology

- All criteria of section 5.3.3.6, EN 50549-10 apply (see above)
- The conducted tests verify the activation threshold with an accuracy of 5 % of nominal voltage.
- The EUT reduced its current as fast as technically feasible below 10 % of rated current. A response time below 30 ms and a settling time below 60 ms is considered sufficient. In case of longer response and/or settling times, justification shall be provided. Delays resulting from the calculation of the phasor and the symmetrical components, typically 20 ms, shall be considered in the evaluation of the controlled short circuit current.
- The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

Note: Parameters cannot be modified.

☐ Assessment criteria of controlled short circuit current contribution for non-synchronous generating technology

- The tests and the selection of voltage levels and fault duration have been conducted according to section 5.3.3.3, EN 50549-10. All requirements of section 5.3.3.6, EN 50549-10 (see above) apply.
- The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).
- The conducted tests verify the activation beyond the insensitivity range with an accuracy of 5 % of nominal voltage.
- The conducted tests verify the provision of controlled short circuit current with:
  - Accuracy for positive and negative sequence current as required of the applicable grid code, or according to Figure 17 of EN 50549-2:2019.
  - Dynamic of response and settling time as required of the applicable grid code. In case of EN 50549-2:2019: 30 ms response time, 60 ms settling time for both fault inception and fault clearance. Delays resulting from the calculation of the phasor and the symmetrical components, typically 20 ms, shall be considered in the evaluation of the controlled short circuit current.

| Test | Voltage dip U/Un (p.u.) | VRT fault type | Fault duration (t2-t1) (ms) | P/Pn (p.u.) | Q/Pn (p.u.) | Test No. | |
|---|---|---|---|---|---|---|---|
| | | | | | | Test1 | Test2 |
| 1 | 0.05 | VD1 | ≥ 250 | 0.98 to 1.02 | 0 to ± 0.1 | 1.1 | 1.1 |
| | | | | 0.1 to 0.5 | | 1.2 | 1.2 |
| | | VD6 | | 0.98 to 1.02 | | 1.3 | 1.3 |
| | | | | 0.1 to 0.5 | | 1.4 | 1.4 |
| 2 | 0.24 | VD2 | ≥ 910 | 0.98 to 1.02 | 0 to ± 0.1 | 2.1 | 2.1 |
| | | | | 0.1 to 0.5 | | 2.2 | 2.2 |
| | | VD7 | | 0.98 to 1.02 | | 2.3 | 2.3 |
| | | | | 0.1 to 0.5 | | 2.4 | 2.4 |
| 3 | 0.52 | VD3 | ≥ 1870 | 0.98 to 1.02 | 0 to ± 0.1 | 3.1 | 3.1 |
| | | | | 0.1 to 0.5 | | 3.2 | 3.2 |
| | | VD8 | | 0.98 to 1.02 | | 3.3 | 3.3 |
| | | | | 0.1 to 0.5 | | 3.4 | 3.4 |
| 4 | 0.76 | VD4 | ≥ 2690 | 0.98 to 1.02 | 0 to ± 0.1 | 4.1 | 4.1 |
| | | | | 0.1 to 0.5 | | 4.2 | 4.2 |
| | | VD9 | | 0.98 to 1.02 | | 4.3 | 4.3 |
| | | | | 0.1 to 0.5 | | 4.4 | 4.4 |
| 5 | 0.90 | VD5 | ≥ 6000 | 0.98 to 1.02 | 0 to ± 0.1 | 5.1 | 5.1 |
| | | | | 0.1 to 0.5 | | 5.2 | 5.2 |
| | | VD10 | | 0.98 to 1.02 | | 5.3 | 5.3 |
| | | | | 0.1 to 0.5 | | 5.4 | 5.4 |
| 6 | 1.15 | VS2.2 | ≥ 60000 | 0.98 to 1.02 | 0 to ± 0.1 | 6.1 | 6.1 |
| | | | | 0.1 to 0.5 | | 6.2 | 6.2 |
| | | VS4.2 | | 0.98 to 1.02 | | 6.3 | 6.3 |
| | | | | 0.1 to 0.5 | | 6.4 | 6.4 |
| 7 | 1.20 | VS2.1 | ≥ 5000 | 0.98 to 1.02 | 0 to ± 0.1 | 7.1 | 7.1 |
| | | | | 0.1 to 0.5 | | 7.2 | 7.2 |
| | | VS4.1 | | 0.98 to 1.02 | | 7.3 | 7.3 |
| | | | | 0.1 to 0.5 | | 7.4 | 7.4 |
| 8 | 1.25 | VS1 | ≥ 100 | 0.98 to 1.02 | 0 to ± 0.1 | 8.1 | 8.1 |
| | | | | 0.1 to 0.5 | | 8.2 | 8.2 |
| | | VS3 | | 0.98 to 1.02 | | 8.3 | 8.3 |
| | | | | 0.1 to 0.5 | | 8.4 | 8.4 |

| FRT fault type A and D | Test equipment (AC grid simulator) | Test sample |
|---|---|---|
| Connection terminal | U | L1 |
| | V | L2 |
| | W | L3 (L for single phase) |

| | $U/U_n$ (MV side) | Phase-earth voltages (LV side) | | | Phase angles | | |
|---|---|---|---|---|---|---|---|
| | | $U_1 / U_{1,n}$ | $U_2 / U_{2,n}$ | $U_3 / U_{3,n}$ | $\varphi_{U1}$ | $\varphi_{U2}$ | $\varphi_{U3}$ |
| VD6 | 0.05 ± 0.05 | 0.05 ± 0.05 | 0.87 ± 0.05 | 0.87 ± 0.05 | 0° | 268° | 92° |
| | 0.15 ± 0.05 | 0.15 ± 0.05 | 0.87 ± 0.05 | 0.87 ± 0.05 | 0° | 265° | 95° |
| VD7 | 0.25 ± 0.05 | 0.25 ± 0.05 | 0.88 ± 0.05 | 0.88 ± 0.05 | 0° | 262° | 98° |
| | 0.30 ± 0.05 | 0.25 ± 0.05 | 0.88 ± 0.05 | 0.88 ± 0.05 | 0° | 260° | 100° |
| VD8 | 0.50 ± 0.05 | 0.50 ± 0.05 | 0.90 ± 0.05 | 0.90 ± 0.05 | 0° | 254° | 106° |
| | 0.55 ± 0.05 | 0.55 ± 0.05 | 0.91 ± 0.05 | 0.91 ± 0.05 | 0° | 252° | 108° |
| VD9 | 0.75 ± 0.05 | 0.75 ± 0.05 | 0.94 ± 0.05 | 0.94 ± 0.05 | 0° | 247° | 113° |
| | 0.80 ± 0.05 | 0.80 ± 0.05 | 0.95 ± 0.05 | 0.95 ± 0.05 | 0° | 245° | 115° |
| VD10 | 0.90 ± 0.05 | 0.90 ± 0.05 | 0.98 ± 0.05 | 0.98 ± 0.05 | 0° | 243° | 117° |
| VS3 | 1.25 ± 0.05 | 1.25 ± 0.05 | 1.07 ± 0.05 | 1.07 ± 0.05 | 0° | 234° | 126° |
| VS4.1 | 1.20 ± 0.05 | 1.20 ± 0.05 | 1.05 ± 0.05 | 1.05 ± 0.05 | 0° | 235° | 125° |
| VS4.2 | 1.15 ± 0.05 | 1.15 ± 0.05 | 1.04 ± 0.05 | 1.04 ± 0.05 | 0° | 236° | 124° |
| normal conditions | 1 | 1 | 1 | 1 | 0° | 240° | 120° |

**Note:**
The test method refers to EN 50549-1:2019

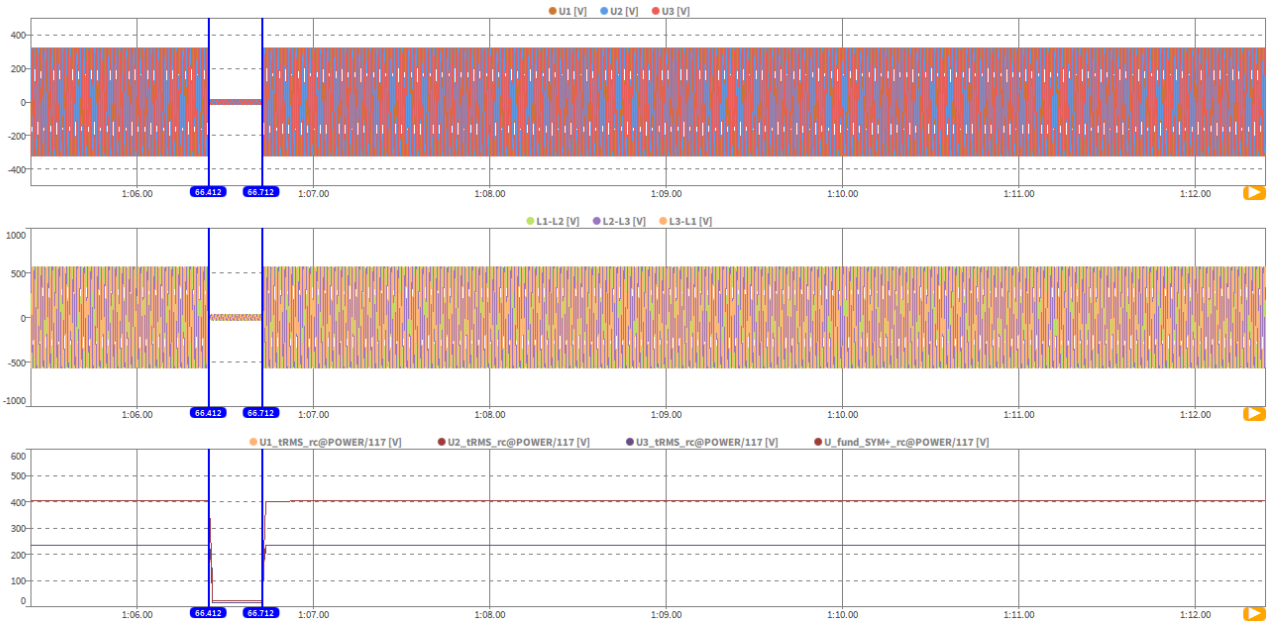
☒ Additional specifications for test of inverters with specified DC input voltage range:

DC voltage input range of PGU: 43.2-57.6 V

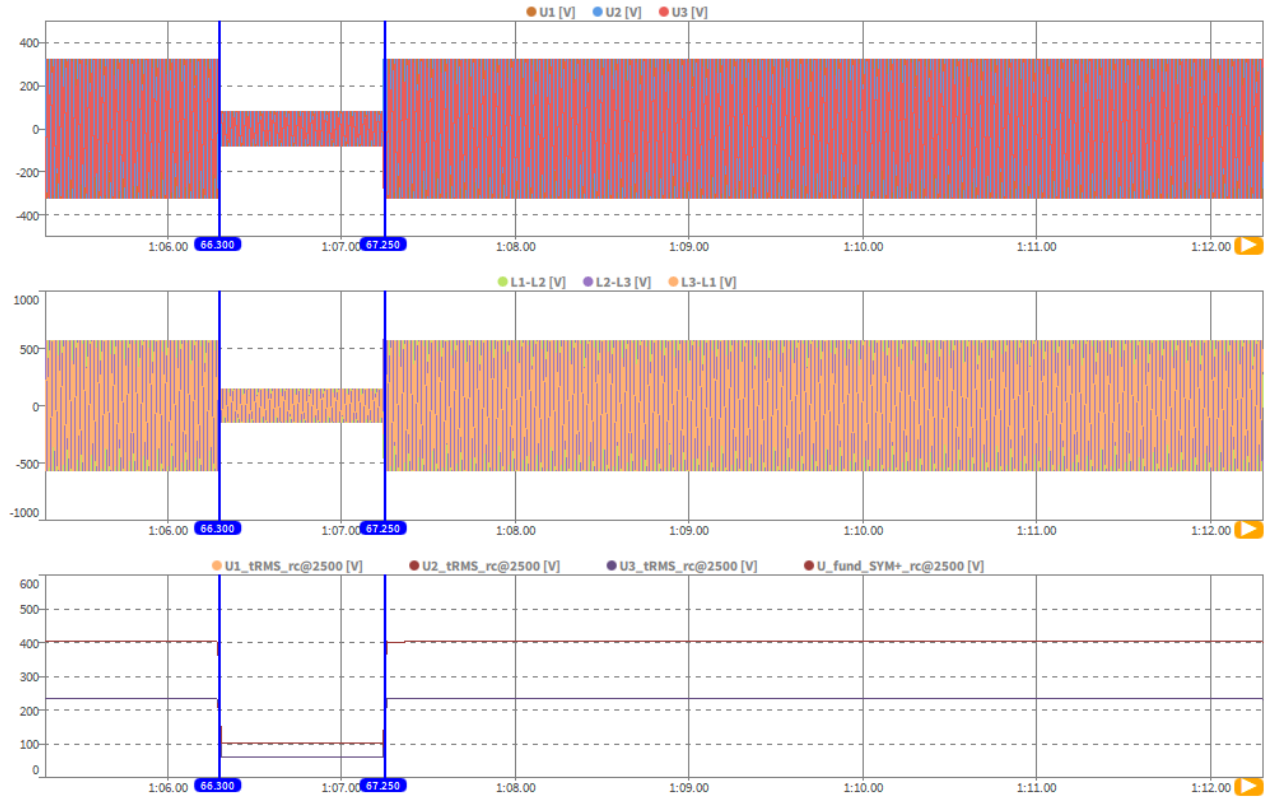
- One test near the minimum DC input voltage, between 0% – 20% of the voltage range: $U_{testmin}$ = 43.2-46.1 V
- One test near the maximum DC input voltage, between 80% – 100% of the voltage range: $U_{testmax}$ =54.7-57.6 V

## Test results

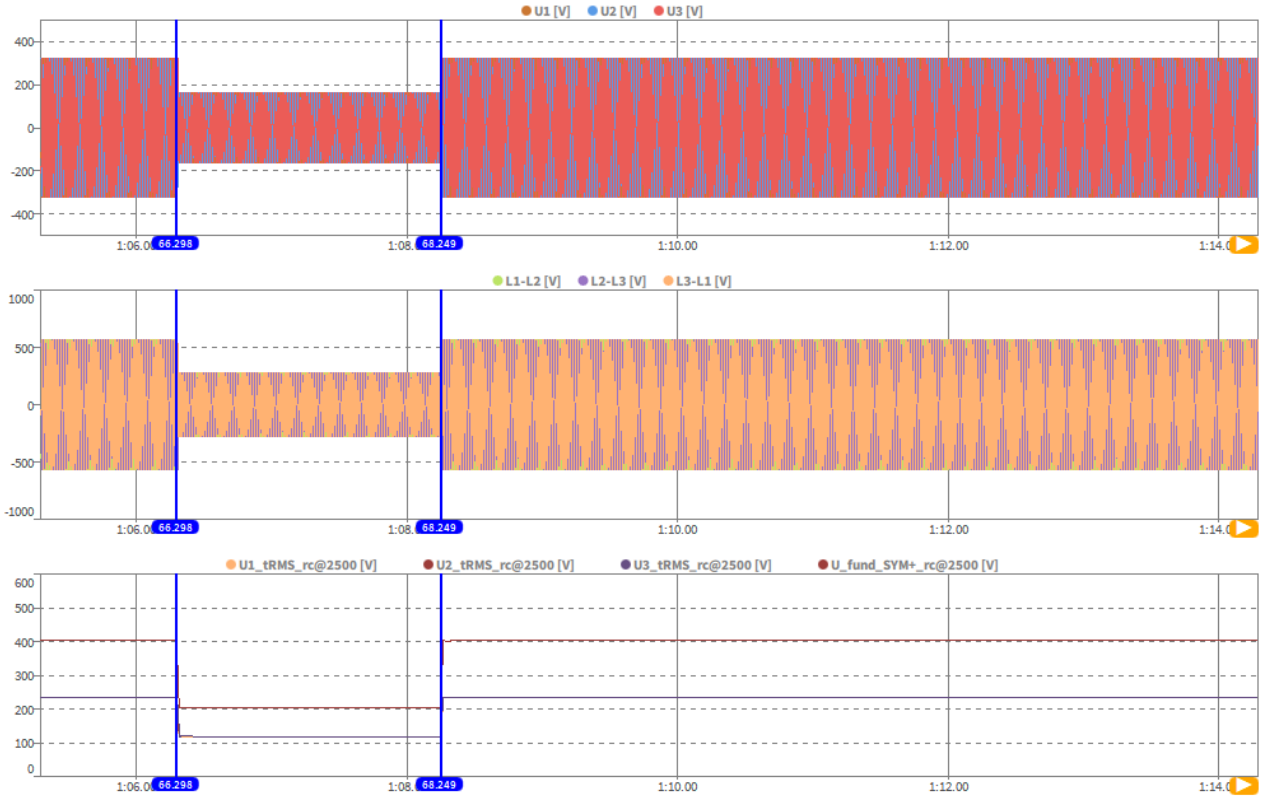
### No load VD1



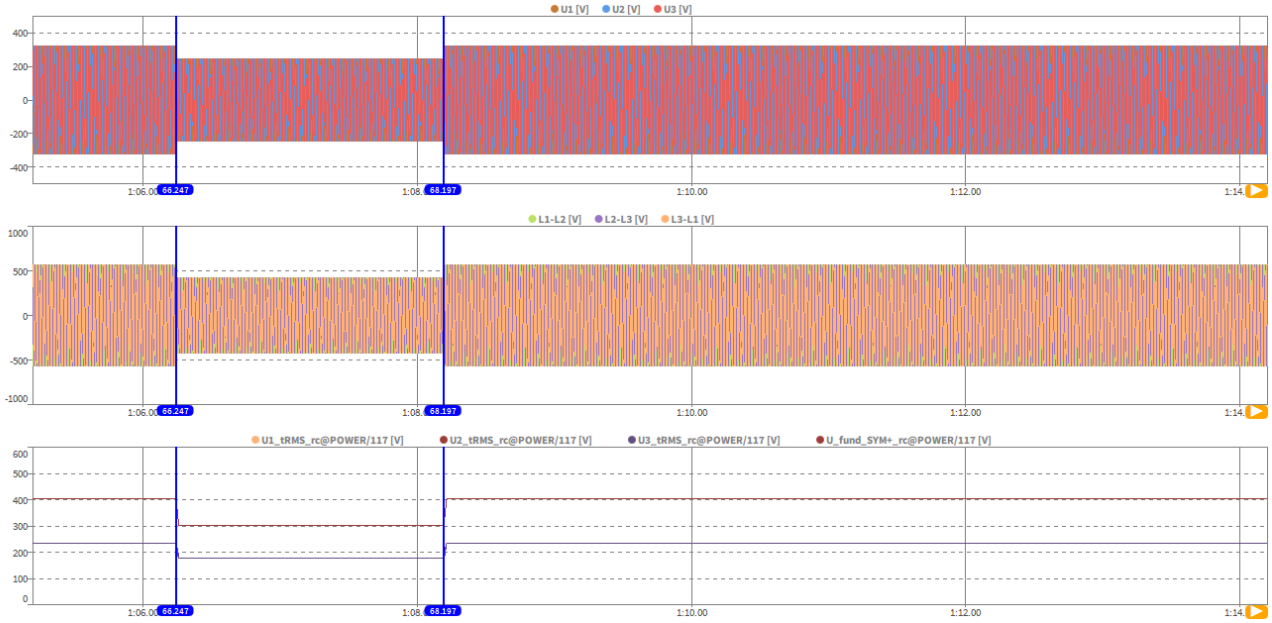

### No load VD2



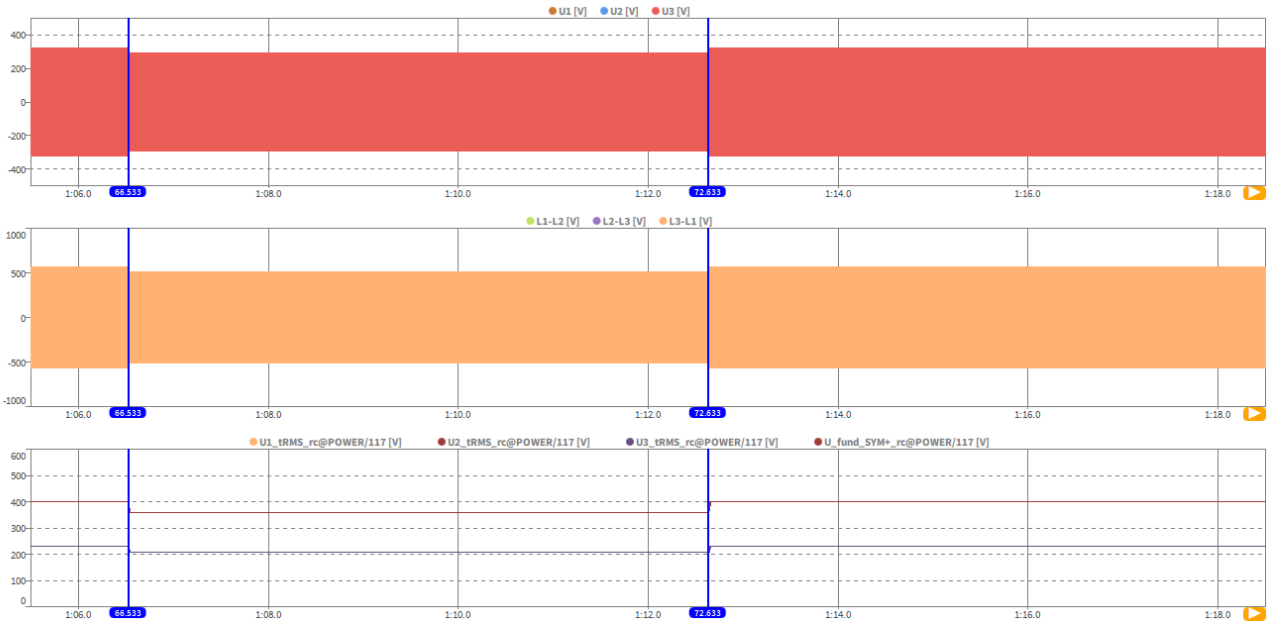
## No load VD3



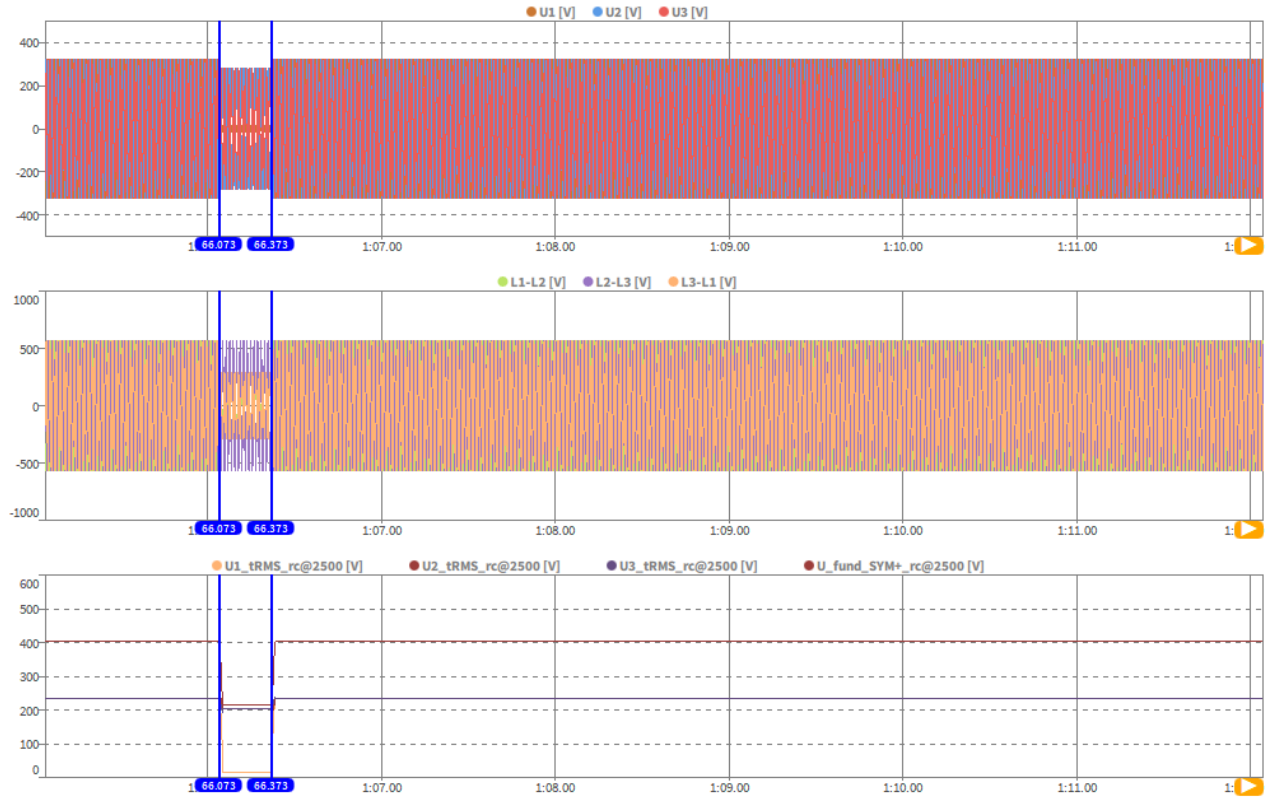

## No load VD4



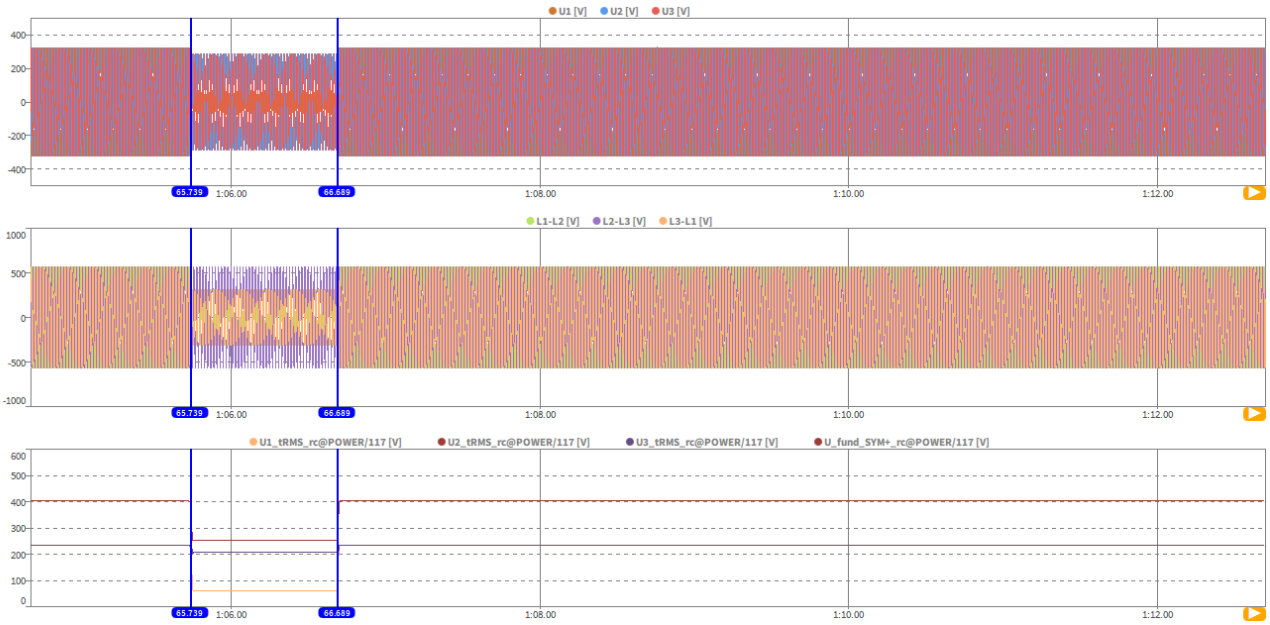
## No load VD5



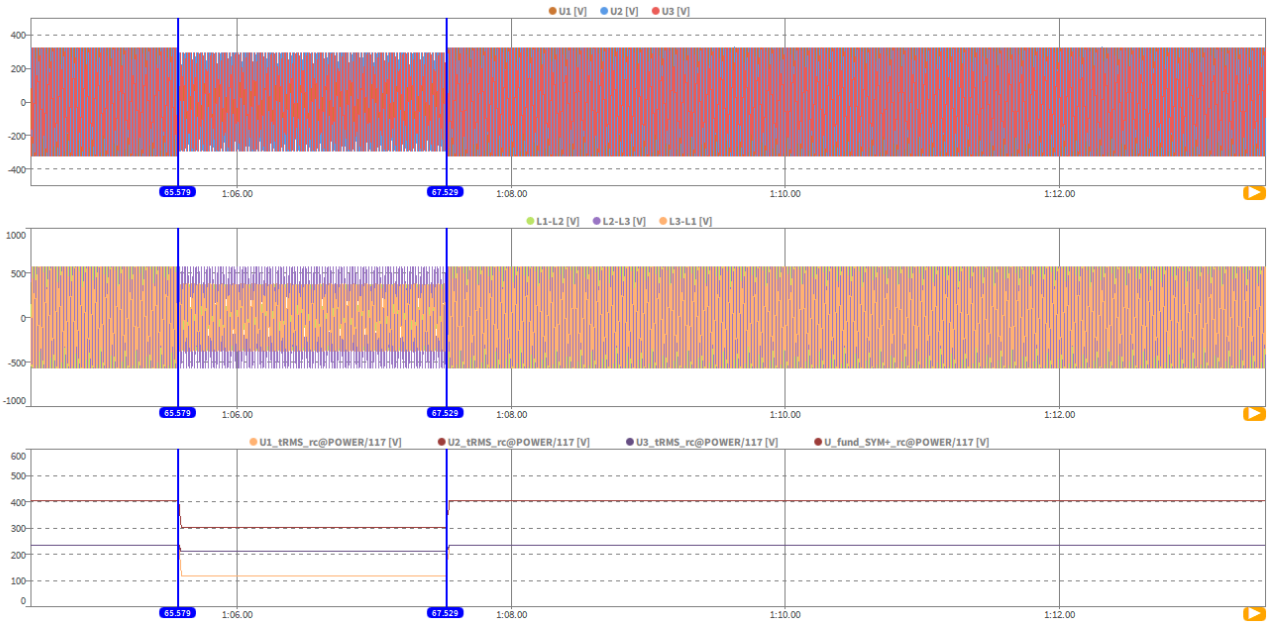

## No load VD6



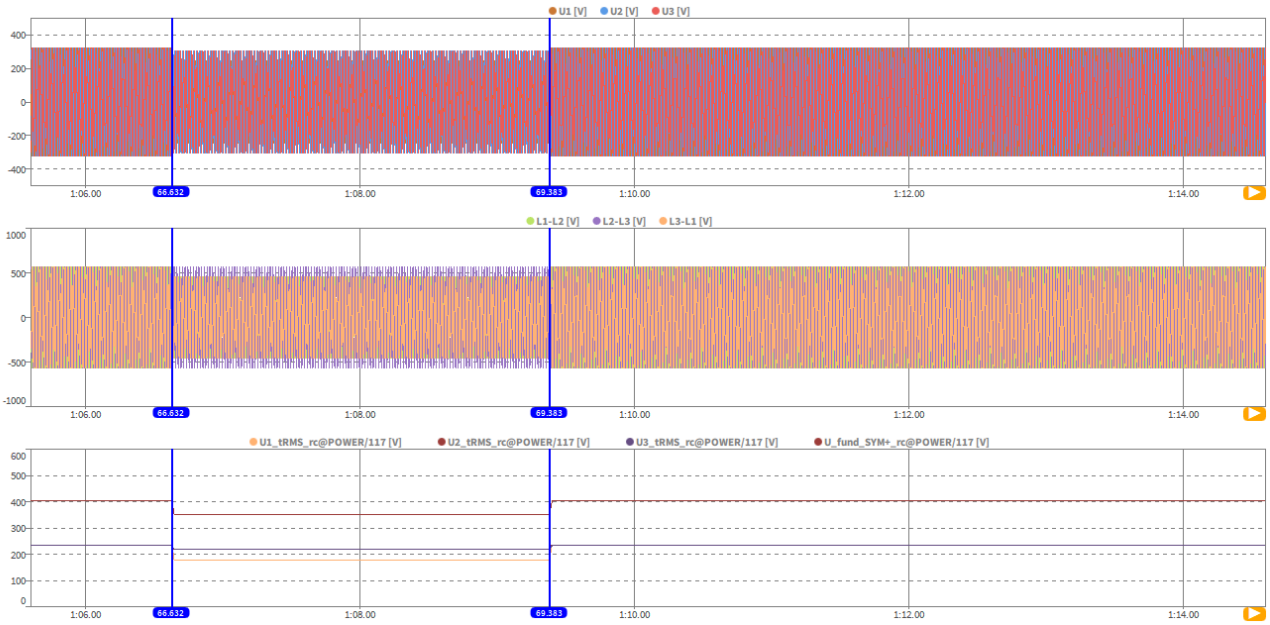
## No load VD7



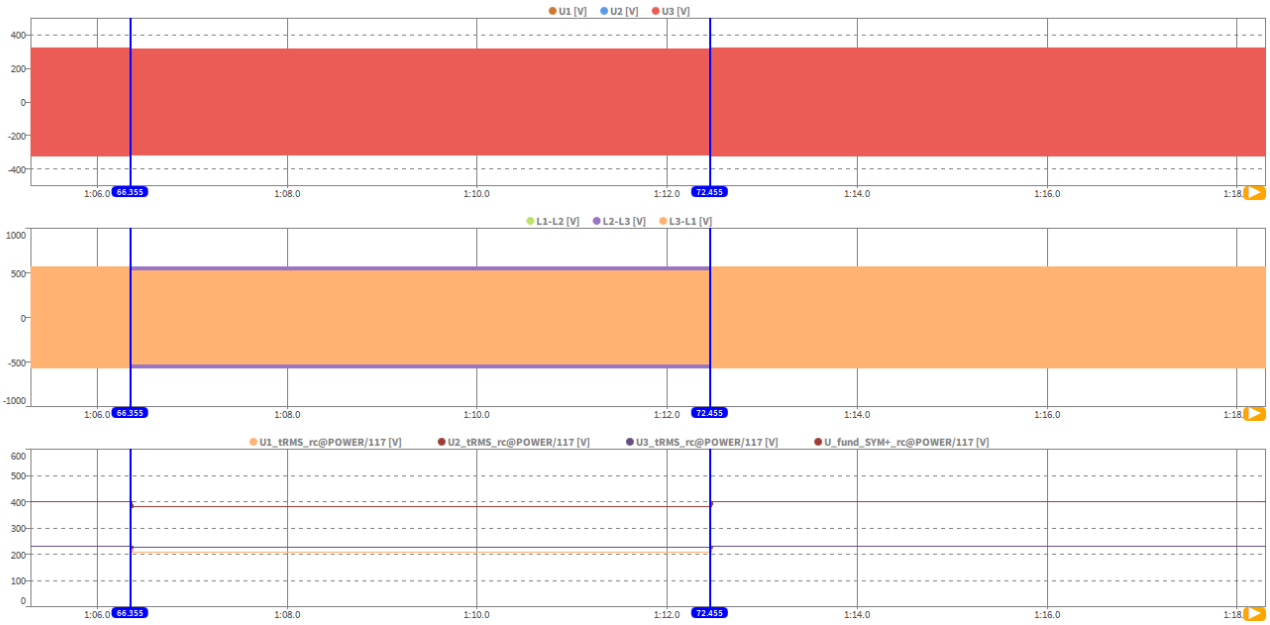

## No load VD8



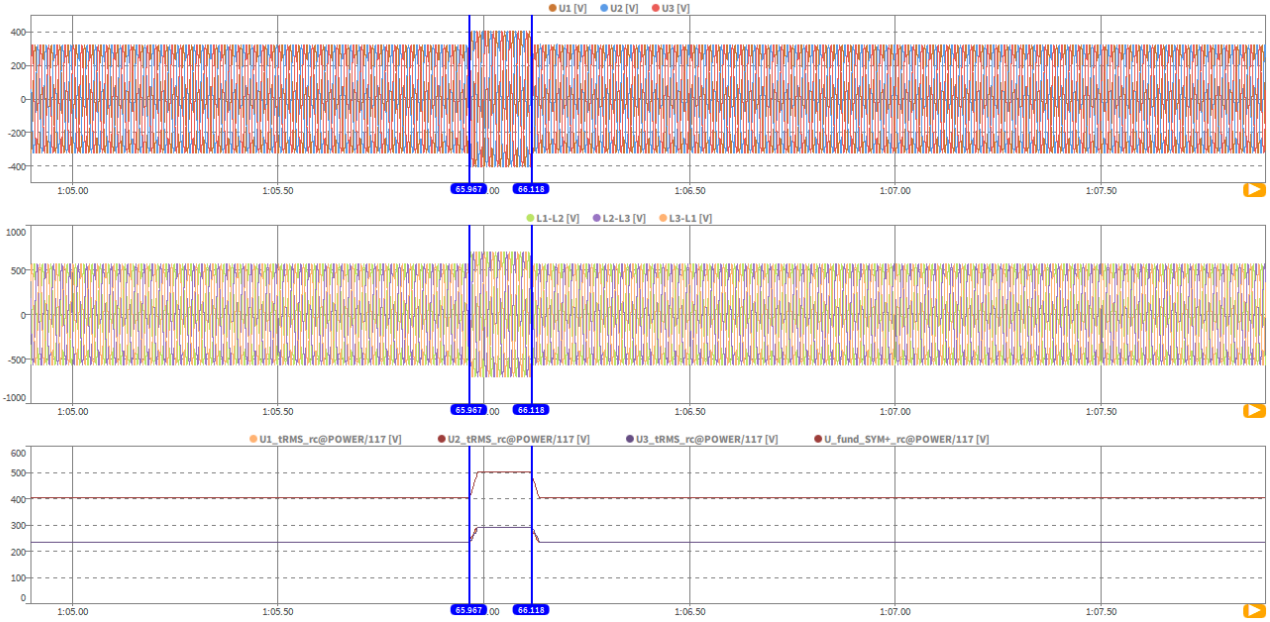
## No load VD9



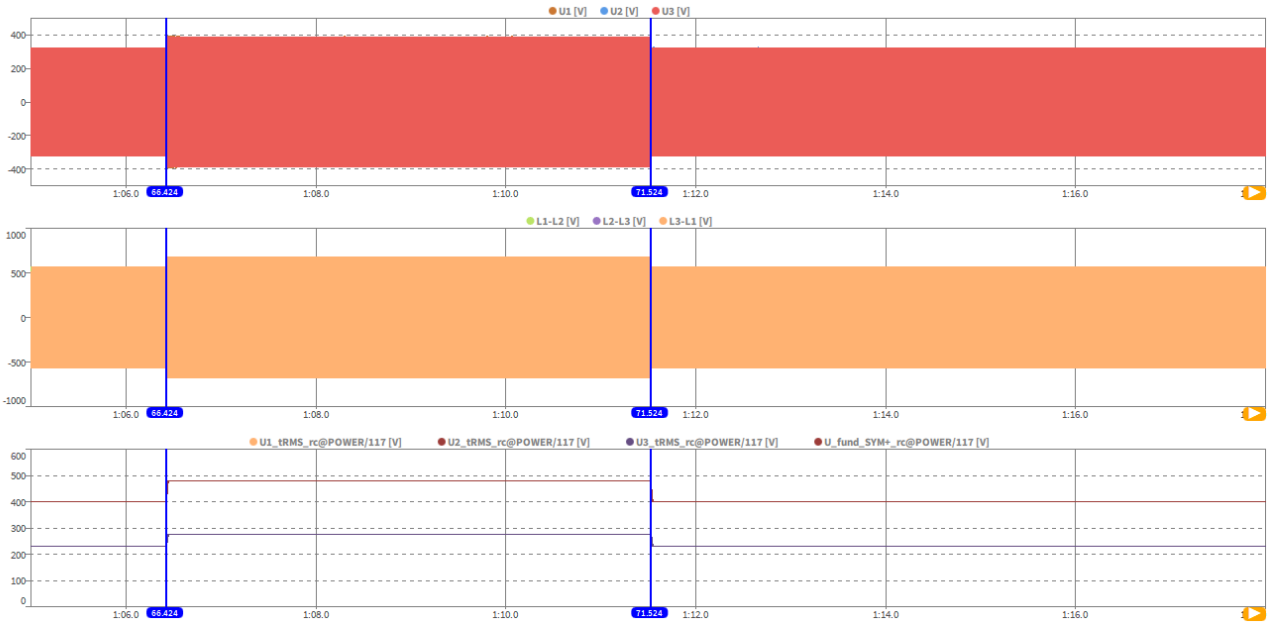

## No load VD10



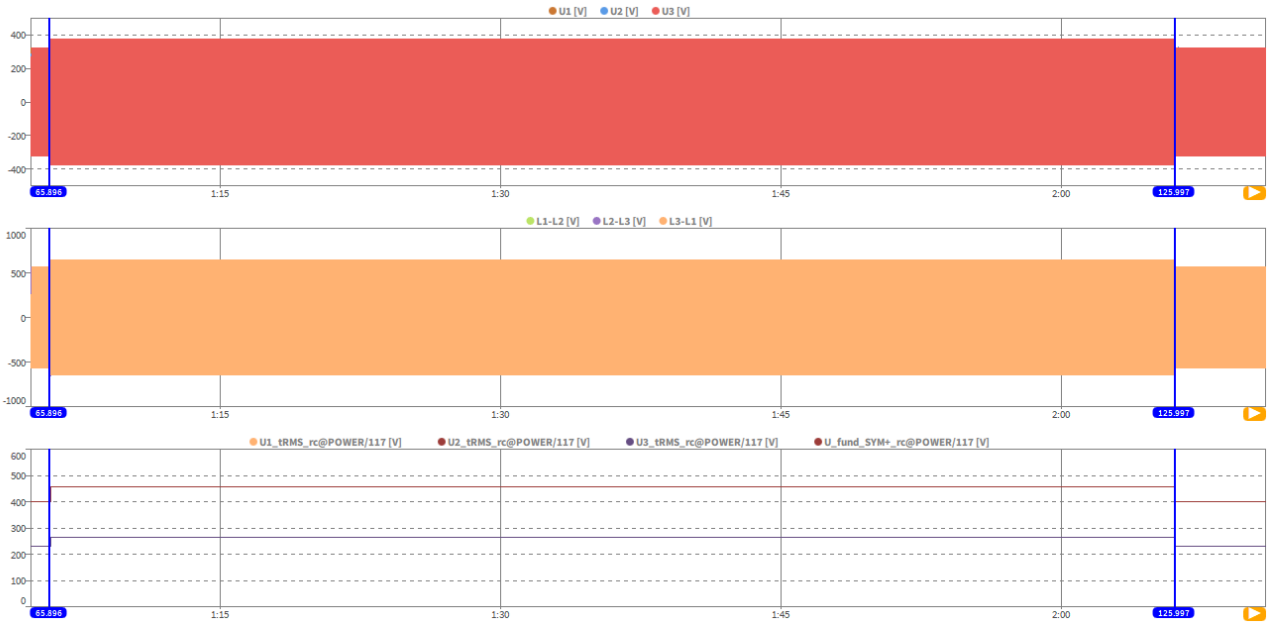
## No load VS1



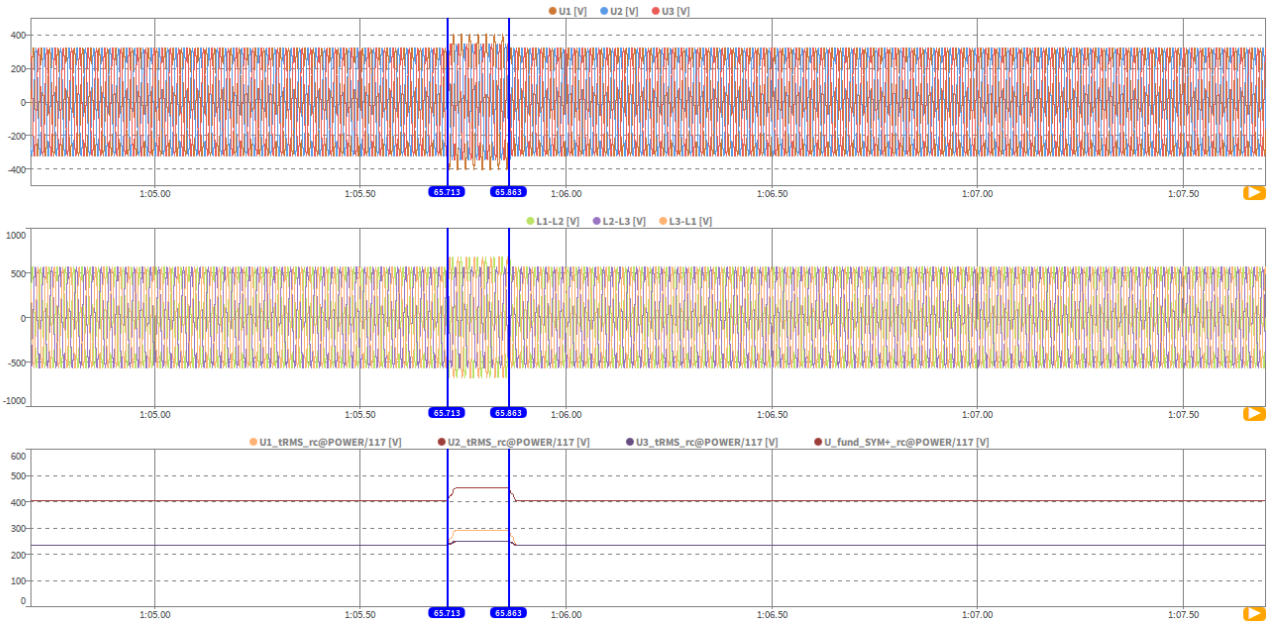

## No load VS2.1



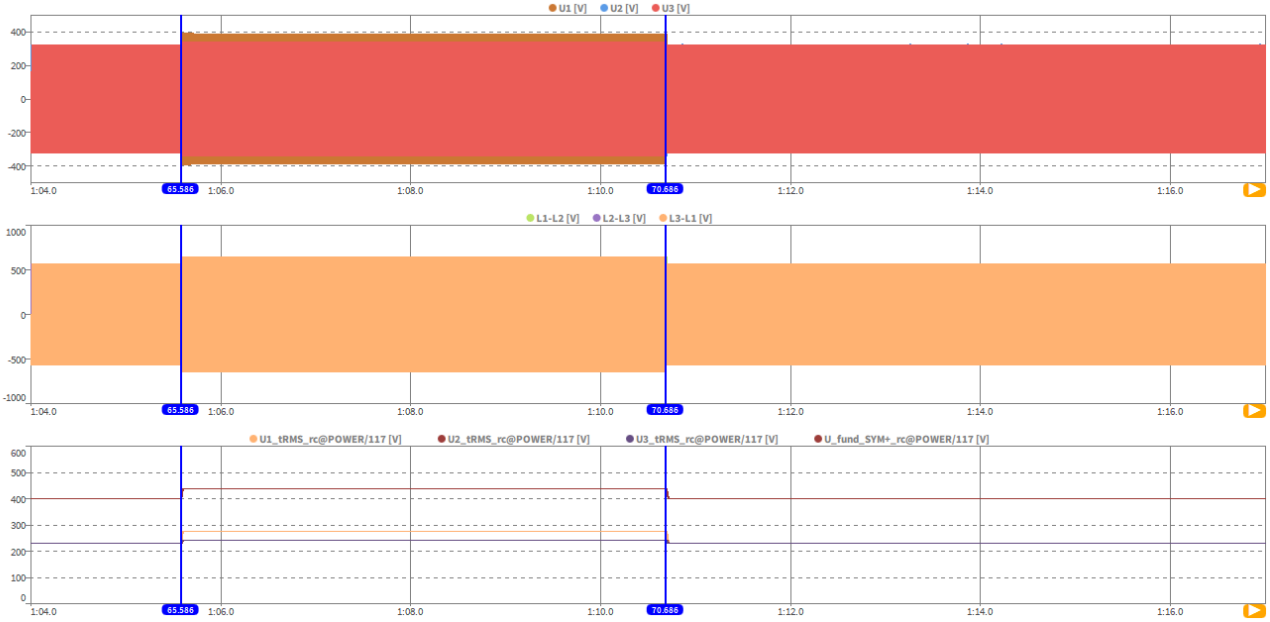
## No load VS2.2



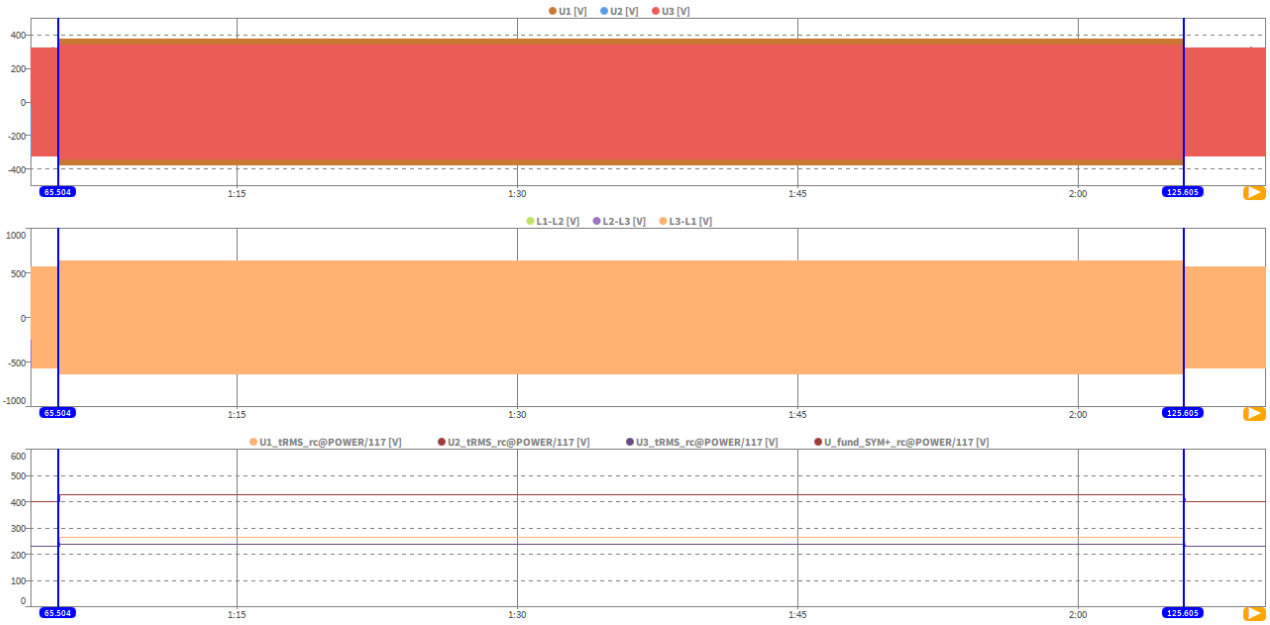

## No load VS3



## No load VS4.1

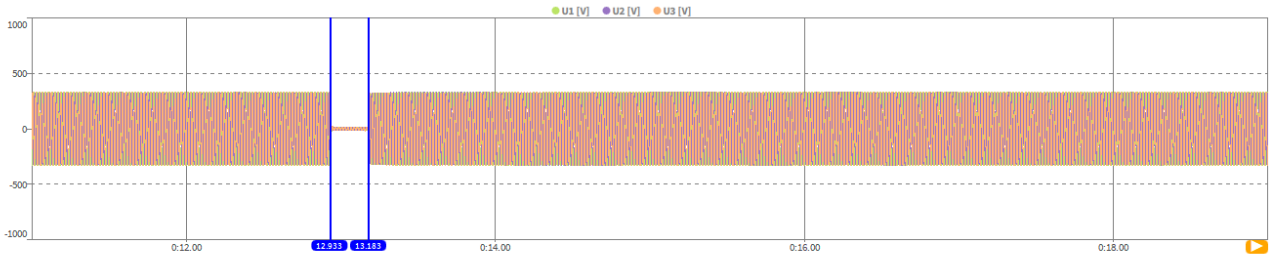


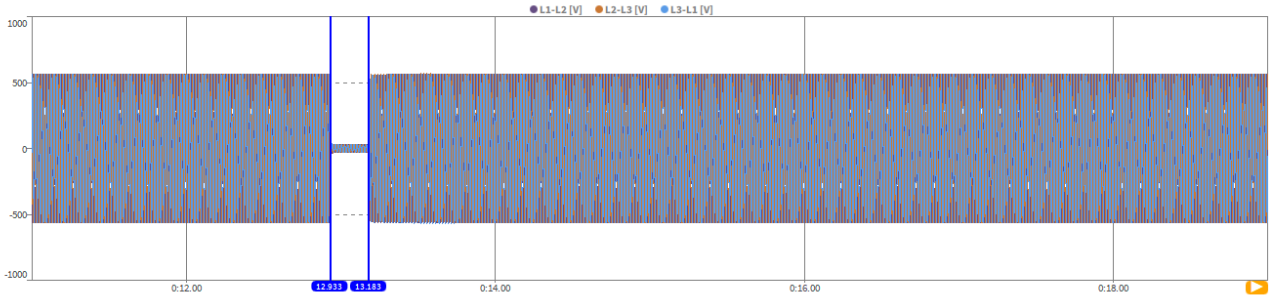

## No load VS4.2

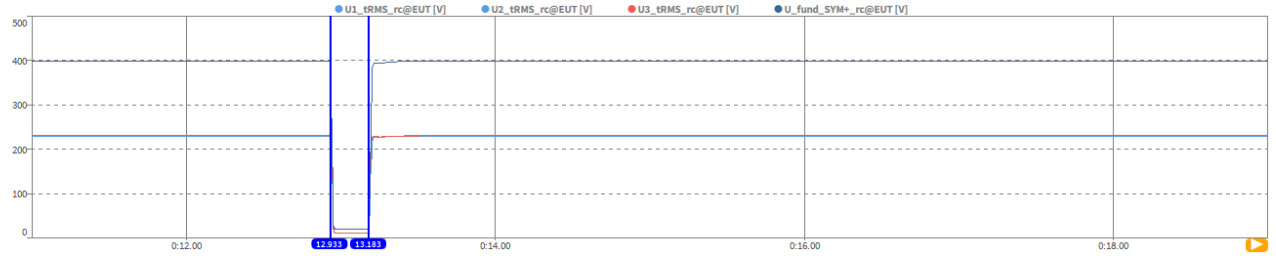


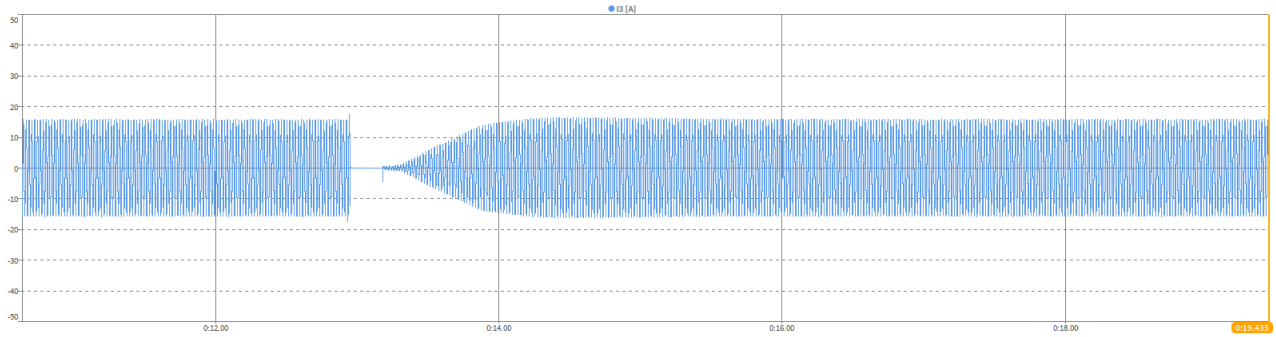
## 1.1

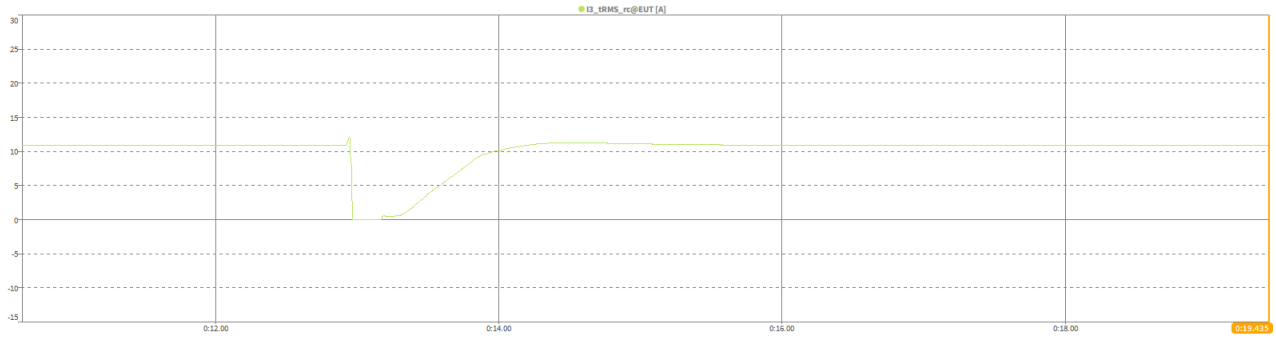
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 1.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:06:21 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.05 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 250 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 12933 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 13183 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 250 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.050 | 0.050 | 0.051 |
| | 10 | | Positive sequence | | [p.u.] | 0.050 | 0.050 | 0.050 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.002 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.004 |
| | 14 | | Positive sequence | | | -- | -- | 1.004 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.018 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.050 | 0.050 | 0.051 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.076 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.076 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.000 |
| | 22 | | Positive sequence | | | -- | -- | 0.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.003 |
| | 25 | | Positive sequence | | | -- | -- | 1.003 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.755 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.018 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

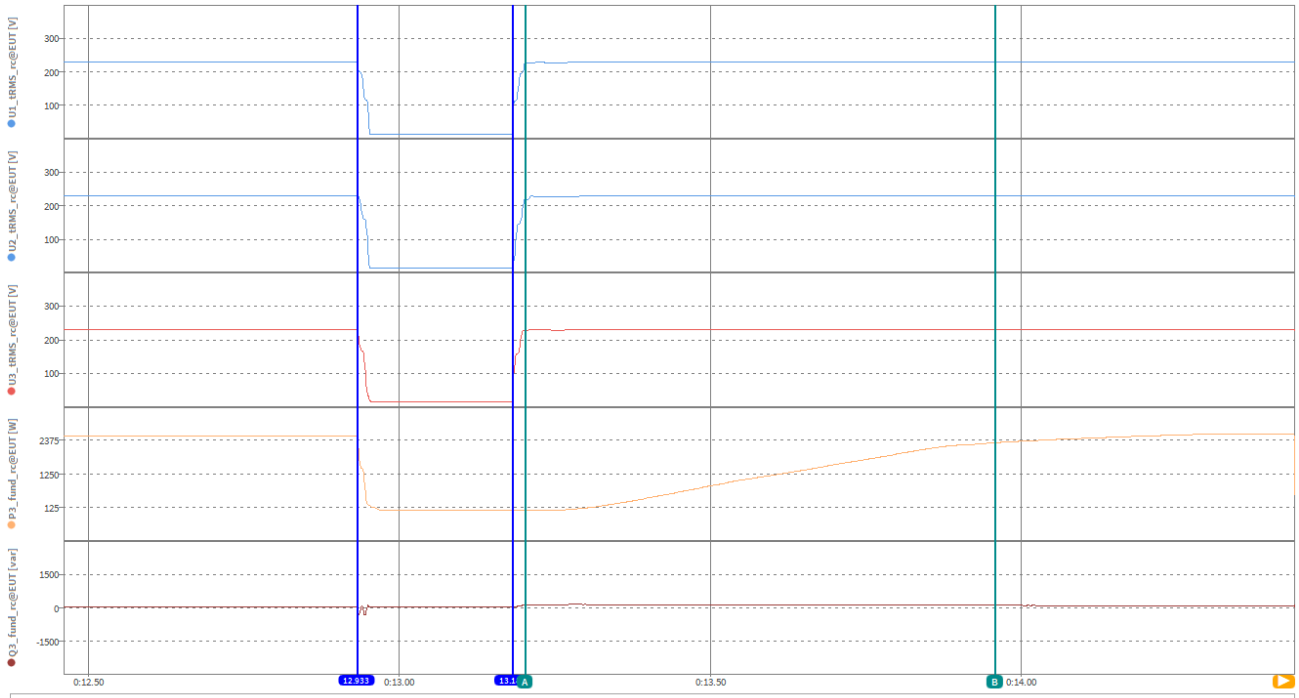

U1 [V]
U2 [V]
U3 [V]
1000
500
0
-500
-1000
0:12.00
12.933
13.183
0:14.00
0:16.00
0:18.00


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
0:12.00
12.933
13.183
0:14.00
0:16.00
0:18.00


U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
500
400
300
200
100
0
0:12.00
12.933
13.183
0:14.00
0:16.00
0:18.00


I3 [A]
50
40
30
20
10
0
-10
-20
-30
-40
-50
0:12.00
0:14.00
0:16.00
0:18.00
0:19.435

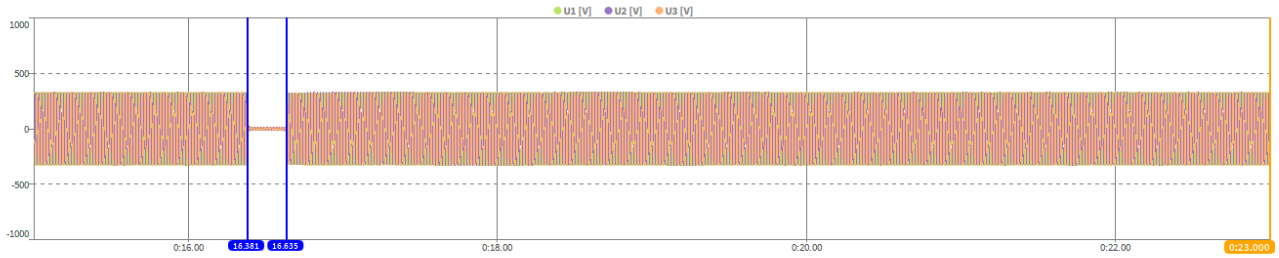

I3_tRMS_rc@EUT [A]
30
25
20
15
10
5
0
-5
-10
-15
0:12.00
0:14.00
0:16.00
0:18.00
0:19.435

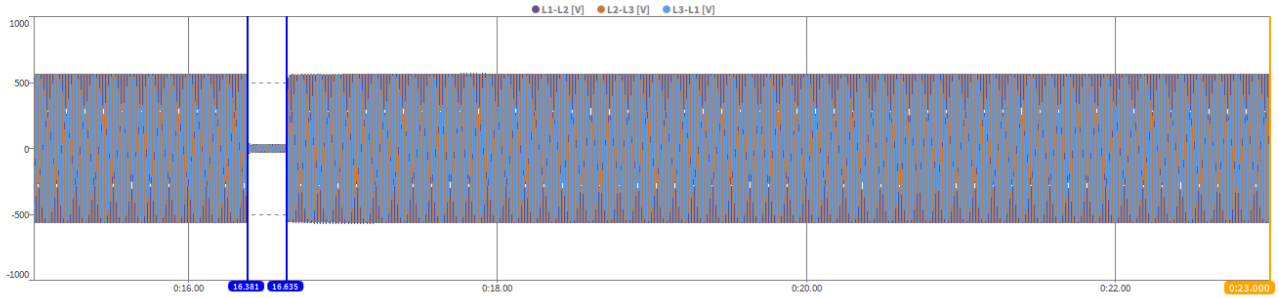


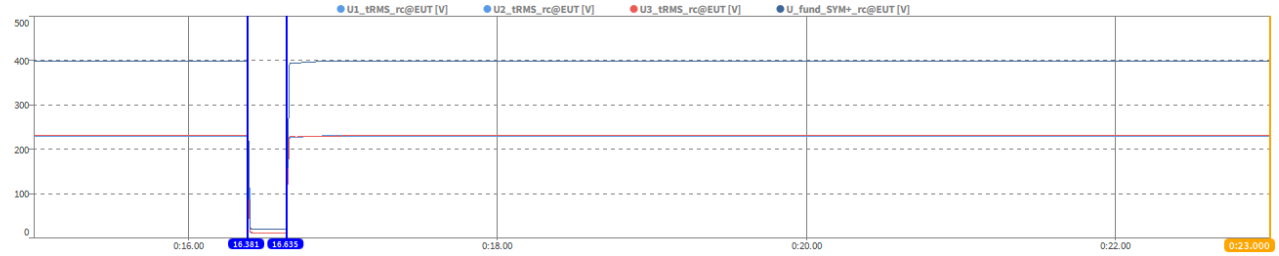

| | A | B | Delta |
|---|---|---|---|
| Time [s] | 0:13.203000 | 0:13.958134 | 0.755134 |
| U1_tRMS_rc@EUT [V] | 210.8013 | 230.3725 | 19.57120 |
| U2_tRMS_rc@EUT [V] | 211.9420 | 229.2805 | 17.33842 |
| U3_tRMS_rc@EUT [V] | 225.3519 | 230.3932 | 5.041306 |
| P3_fund_rc@EUT [W] | 0.543638 | 2277.132 | 2276.588 |
| Q3_fund_rc@EUT [var] | 94.56271 | 71.63760 | -22.92511 |

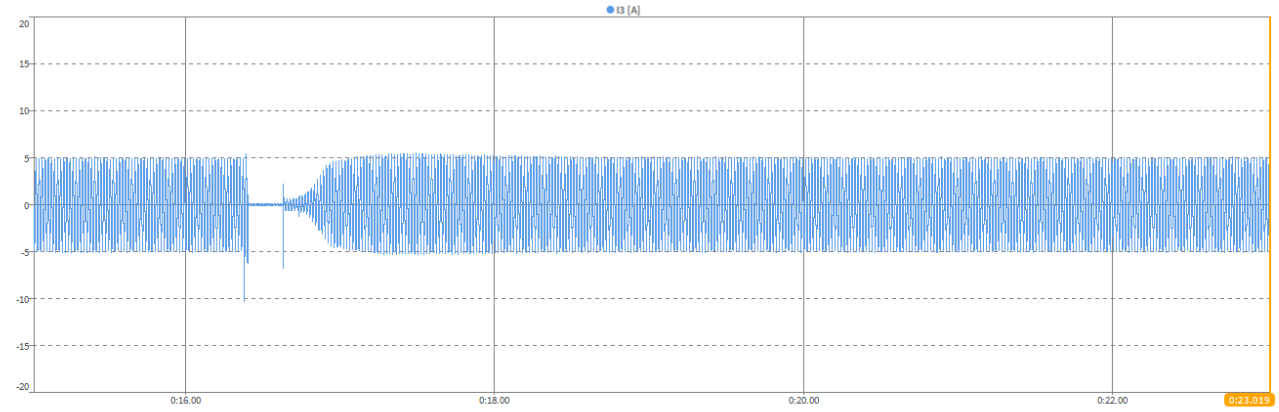
## 1.2

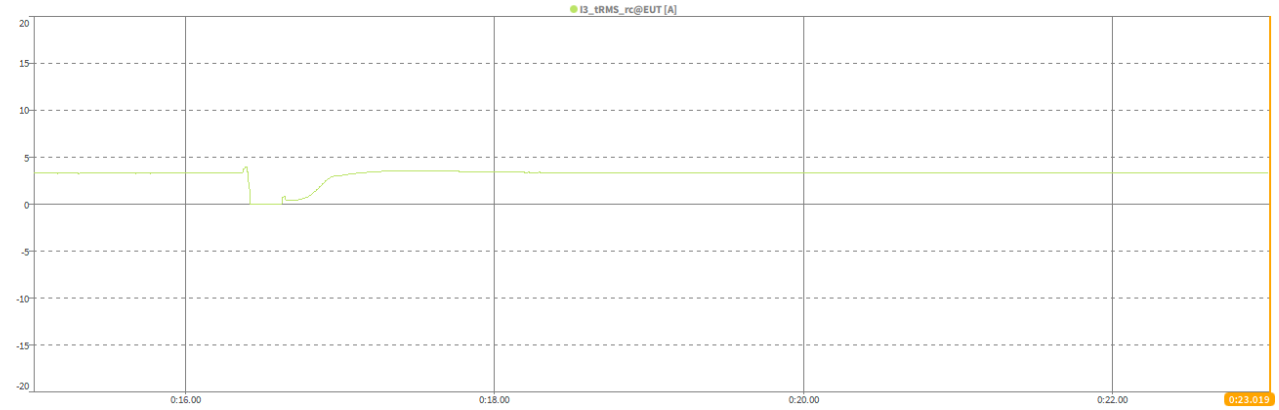
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 1.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:11:15 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.05 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 250 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 16381 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 16635 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 254 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.050 | 0.050 | 0.050 |
| | 10 | | Positive sequence | | [p.u.] | 0.050 | 0.050 | 0.050 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.303 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.303 |
| | 14 | | Positive sequence | | | -- | -- | 0.303 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.017 |
| | 16 | | Positive sequence | | | -- | -- | 0.007 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.050 | 0.050 | 0.050 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.021 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.021 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.000 |
| | 22 | | Positive sequence | | | -- | -- | 0.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.304 |
| | 25 | | Positive sequence | | | -- | -- | 0.304 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.317 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.016 |
| | 28 | | Positive sequence | | | -- | -- | 0.006 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

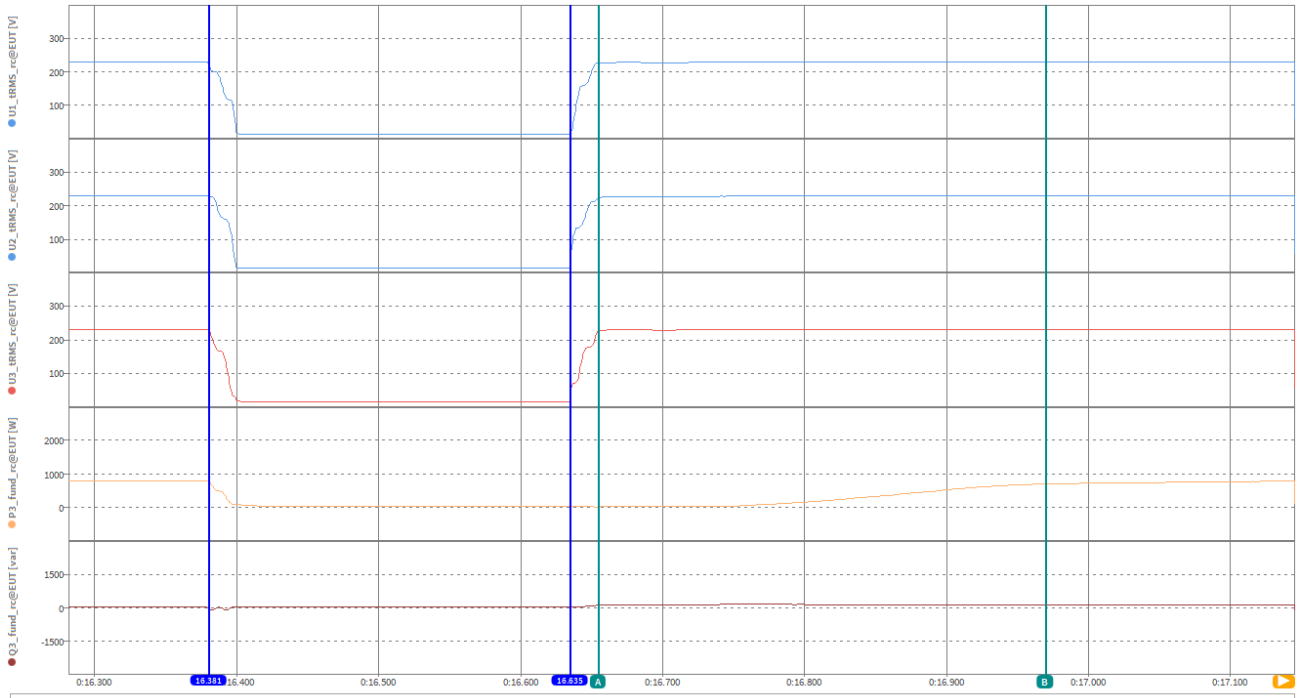

U1 [V]
U2 [V]
U3 [V]
1000
500
0
-500
-1000
0:16.00
16.381
16.835
0:18.00
0:20.00
0:22.00
0:23.000


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
0:16.00
16.381
16.835
0:18.00
0:20.00
0:22.00
0:23.000


U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
500
400
300
200
100
0
0:16.00
16.381
16.835
0:18.00
0:20.00
0:22.00
0:23.000


I3 [A]
20
15
10
5
0
-5
-10
-15
-20
0:16.00
0:18.00
0:20.00
0:22.00
0:23.019

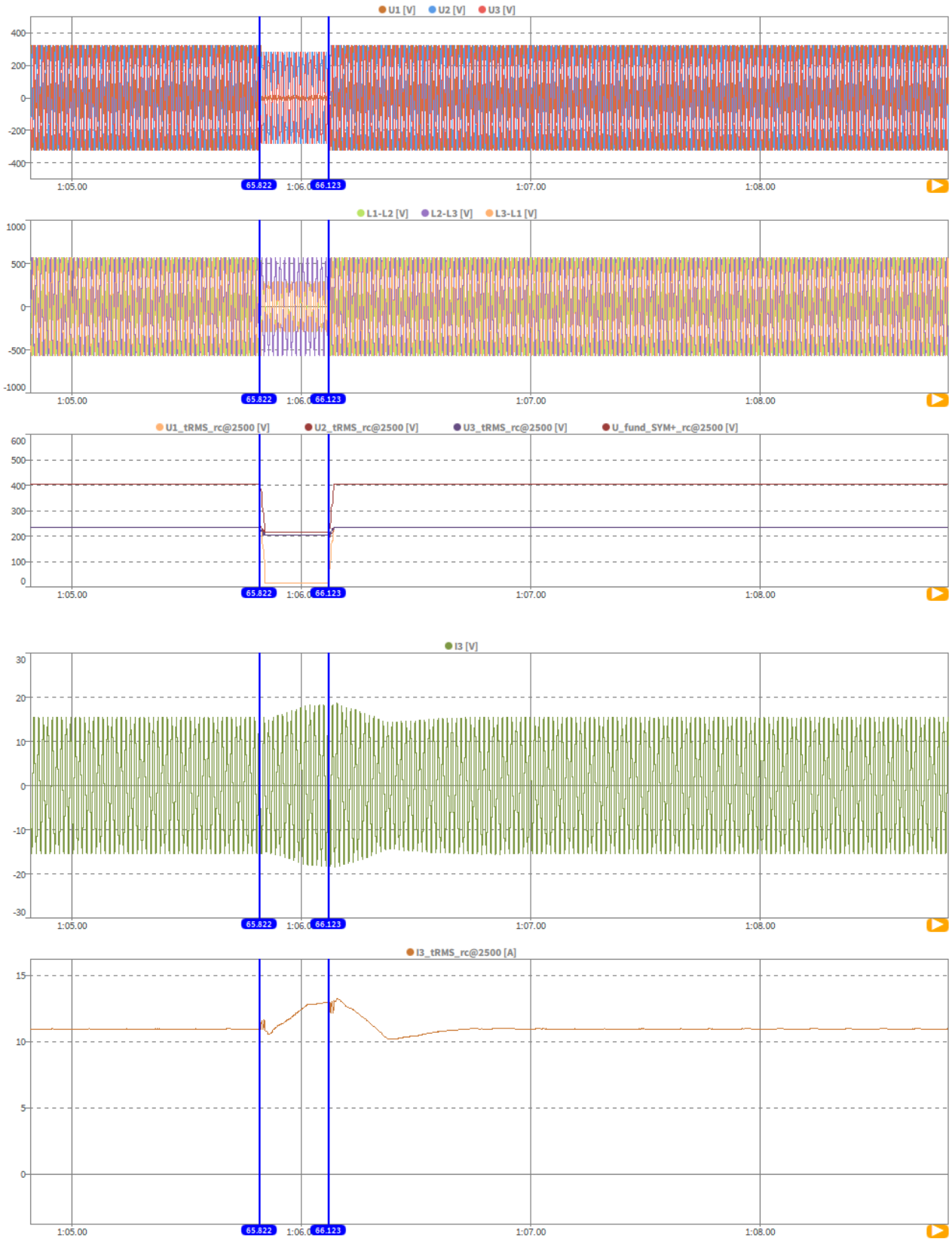

I3_tRMS_rc@EUT [A]
20
15
10
5
0
-5
-10
-15
-20
0:16.00
0:18.00
0:20.00
0:22.00
0:23.019

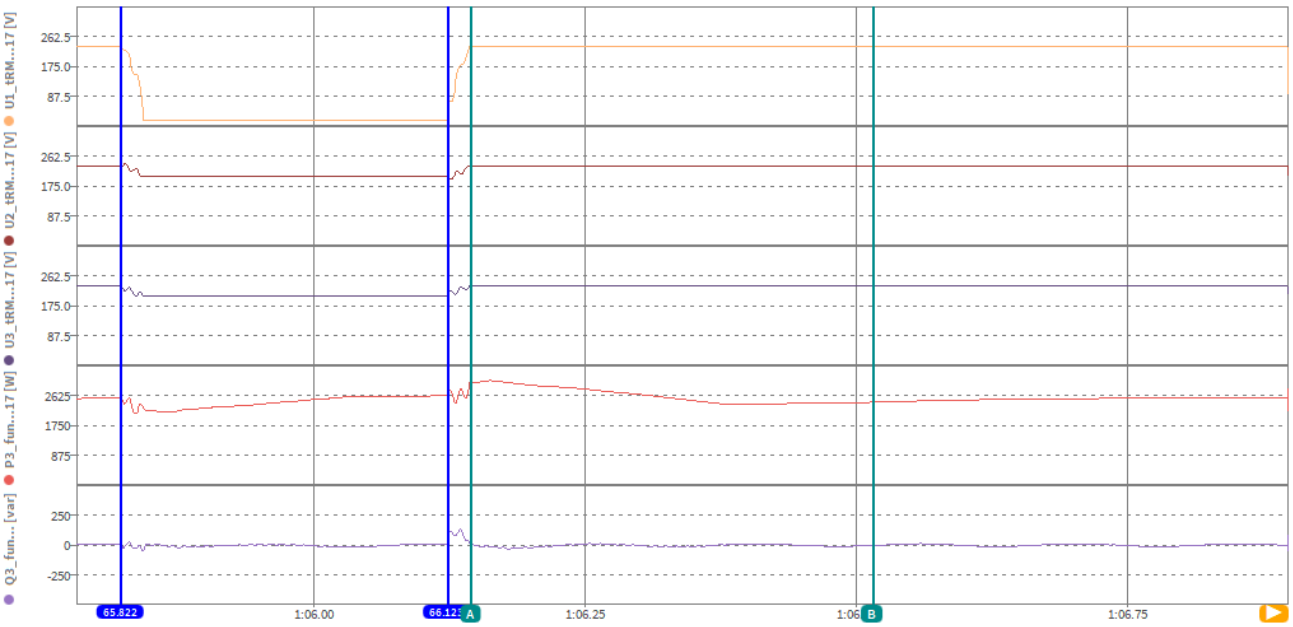



| | A | B | Delta |
|---|---|---|---|
| Time [s] | 0:16.655000 | 0:16.969694 | 0.314694 |
| U1_tRMS_rc@EUT [V] | 224.8634 | 230.4775 | 5.614059 |
| U2_tRMS_rc@EUT [V] | 213.7153 | 229.2863 | 15.57103 |
| U3_tRMS_rc@EUT [V] | 212.3302 | 230.1286 | 17.79832 |
| P3_fund_rc@EUT [W] | -24.63774 | 676.6082 | 701.2459 |
| Q3_fund_rc@EUT [var] | 69.86856 | 97.45628 | 27.58772 |

## 1.3

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 1.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 14:35:12 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.05 | 0.87 | 0.87 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 250 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65822 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 66123 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 301 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.050 | 0.870 | 0.870 |
| | 10 | | Positive sequence | | [p.u.] | 0.529 | 0.529 | 0.529 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.002 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.002 |
| | 14 | | Positive sequence | | | -- | -- | 1.002 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.014 |
| | 16 | | Positive sequence | | | -- | -- | 0.005 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.050 | 0.870 | 0.870 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.976 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 1.026 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.987 |
| | 22 | | Positive sequence | | | -- | -- | 0.987 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.001 |
| | 25 | | Positive sequence | | | -- | -- | 1.001 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.369 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.014 |
| | 28 | | Positive sequence | | | -- | -- | 0.004 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

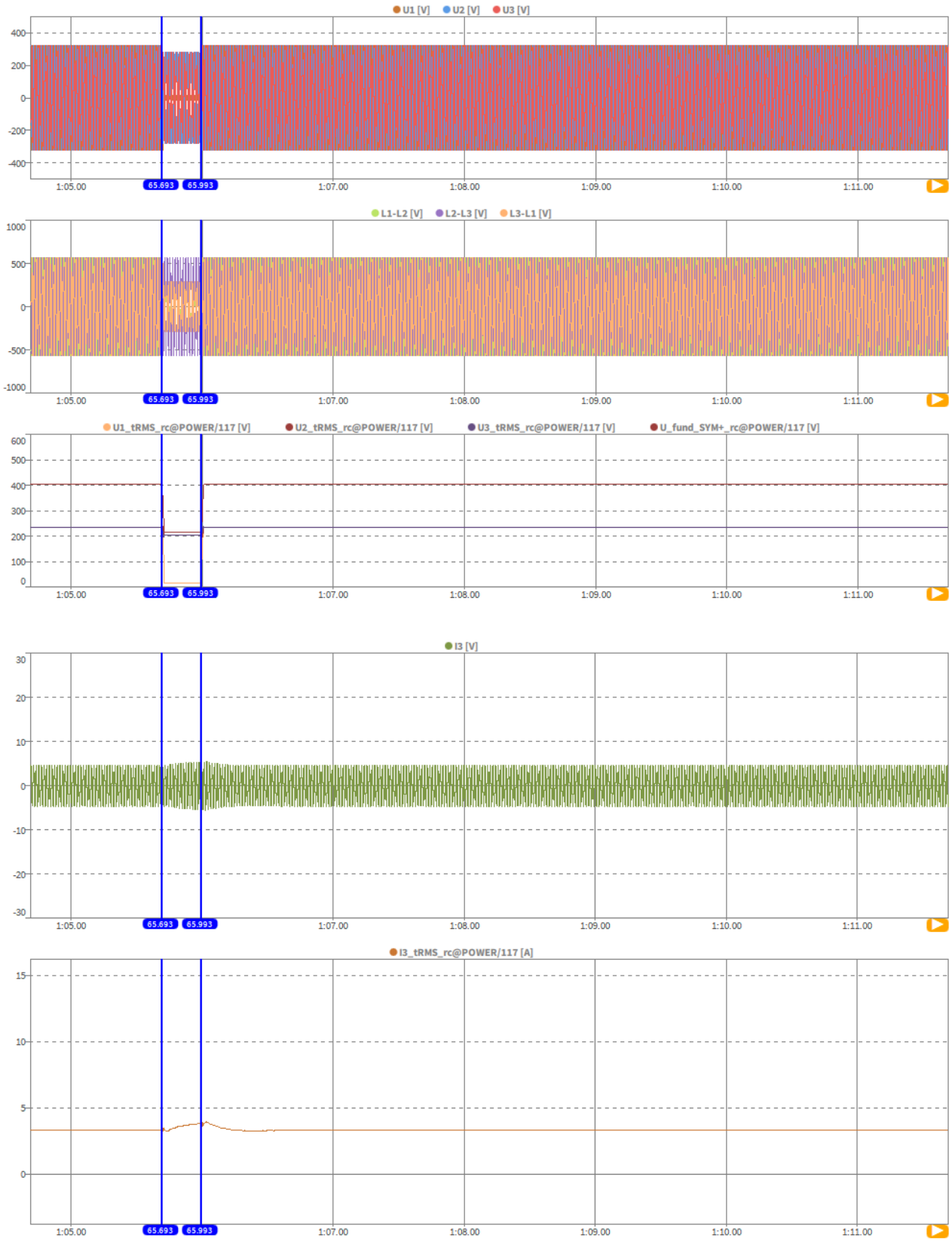

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
1:05.00
65.822
1:06.
66.123
1:07.00
1:08.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
1:05.00
65.822
1:06.
66.123
1:07.00
1:08.00
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
1:05.00
65.822
1:06.
66.123
1:07.00
1:08.00
I3 [V]
30
20
10
0
-10
-20
-30
1:05.00
65.822
1:06.
66.123
1:07.00
1:08.00
I3_tRMS_rc@2500 [A]
15
10
5
0
1:05.00
65.822
1:06.
66.123
1:07.00
1:08.00

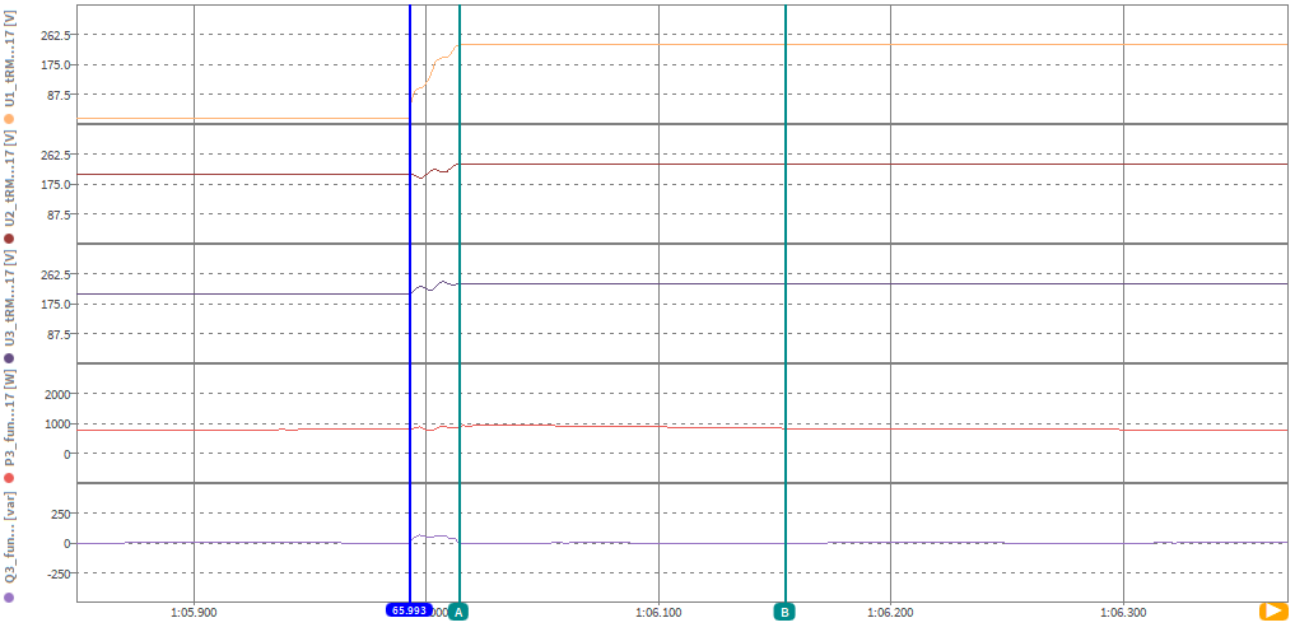



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:06.1453103 | 1:06.5149388 | 0.3696286 |
| U1_tRMS_rc@POWER/117 [V] | 229.9326 | 229.9914 | 0.058823 |
| U2_tRMS_rc@POWER/117 [V] | 230.0294 | 230.0072 | -0.022171 |
| U3_tRMS_rc@POWER/117 [V] | 229.9842 | 229.9743 | -9.918e-3 |
| P3_fund_rc@POWER/117 [W] | 2934.892 | 2391.643 | -543.2493 |
| Q3_fund_rc@POWER/117 [var] | 18.39268 | -16.25185 | -34.64453 |

## 1.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 1.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 14:24:21 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.05 | 0.87 | 0.87 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 250 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65693 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 65993 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 300 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.050 | 0.870 | 0.870 |
| | 10 | | Positive sequence | | [p.u.] | 0.529 | 0.529 | 0.529 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 3.058 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.298 |
| | 14 | | Positive sequence | | | -- | -- | 0.298 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.009 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.050 | 0.870 | 0.870 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.298 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.309 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.289 |
| | 22 | | Positive sequence | | | -- | -- | 0.289 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.301 |
| | 25 | | Positive sequence | | | -- | -- | 0.301 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.140 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.008 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

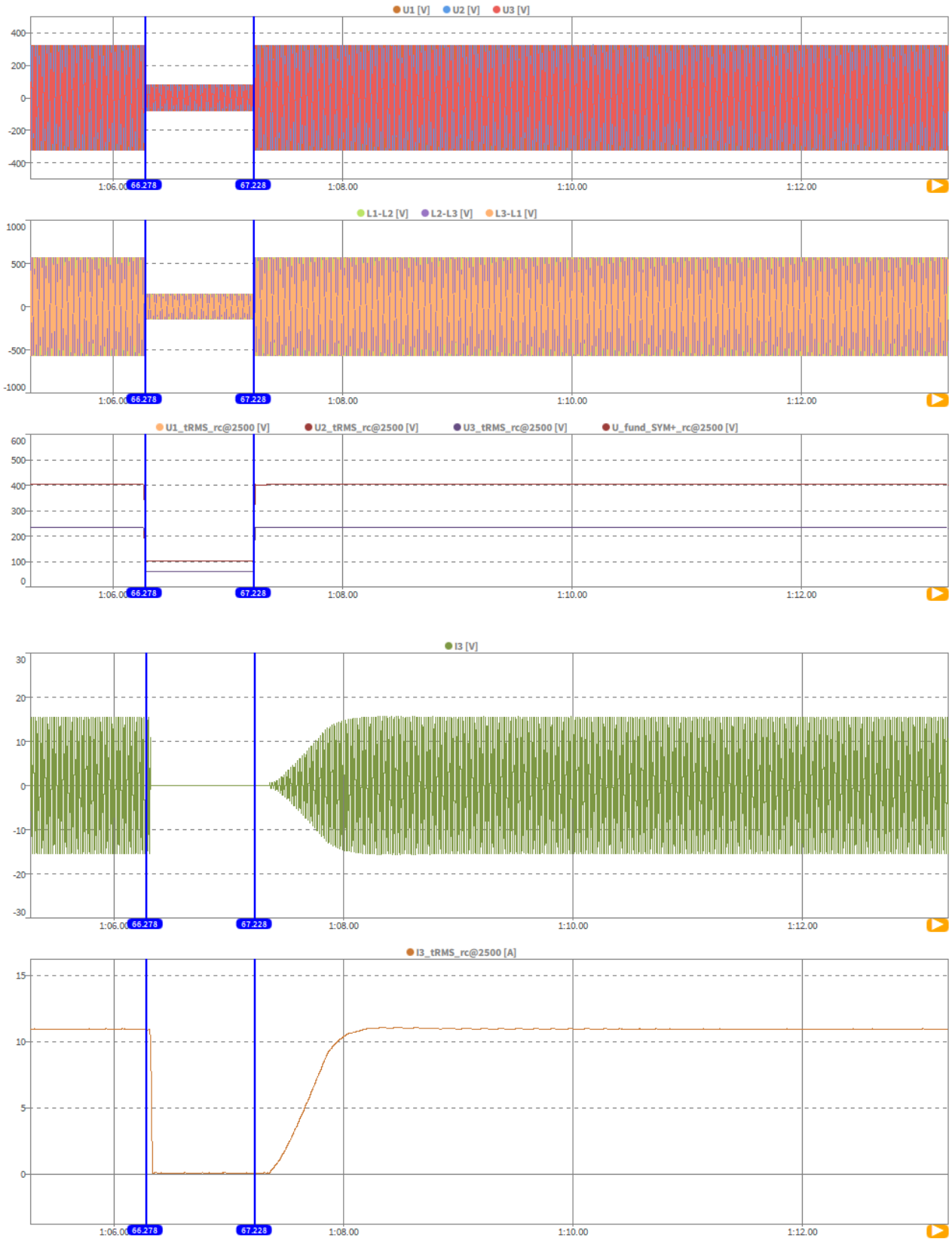

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
1:05.00
65.693
65.993
1:07.00
1:08.00
1:09.00
1:10.00
1:11.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

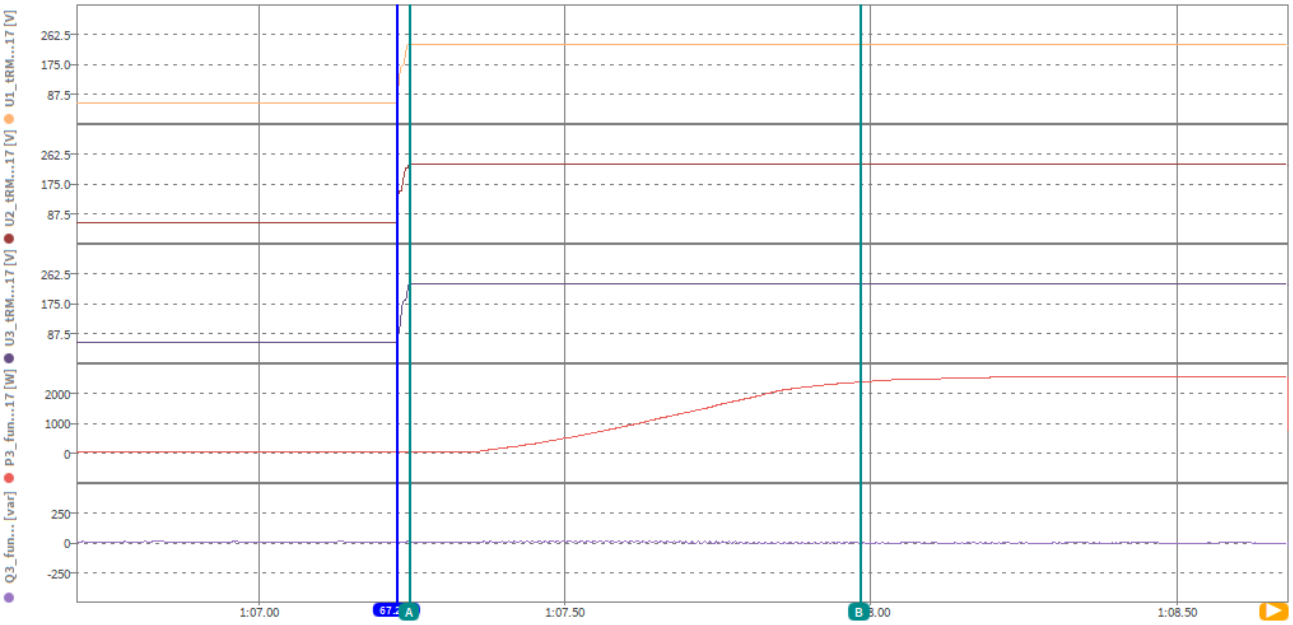



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:06.0144001 | 1:06.1545963 | 0.1401962 |
| U1_tRMS_rc@POWER/117 [V] | 226.5798 | 229.9437 | 3.363922 |
| U2_tRMS_rc@POWER/117 [V] | 229.6322 | 229.9933 | 0.361099 |
| U3_tRMS_rc@POWER/117 [V] | 229.2342 | 229.9639 | 0.729675 |
| P3_fund_rc@POWER/117 [W] | 817.9961 | 784.5888 | -33.40729 |
| Q3_fund_rc@POWER/117 [var] | 21.55161 | -13.93068 | -35.48229 |

## 2.1

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 2.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 10:37:33 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.25 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 910 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66278 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 67228 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 950 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.250 | 0.250 | 0.250 |
| | 10 | | Positive sequence | | [p.u.] | 0.250 | 0.250 | 0.250 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.001 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.999 |
| | 14 | | Positive sequence | | | -- | -- | 0.999 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.011 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.250 | 0.250 | 0.250 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.007 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.003 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.000 |
| | 22 | | Positive sequence | | | -- | -- | 0.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.004 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.001 |
| | 25 | | Positive sequence | | | -- | -- | 1.001 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.734 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.012 |
| | 28 | | Positive sequence | | | -- | -- | 0.006 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

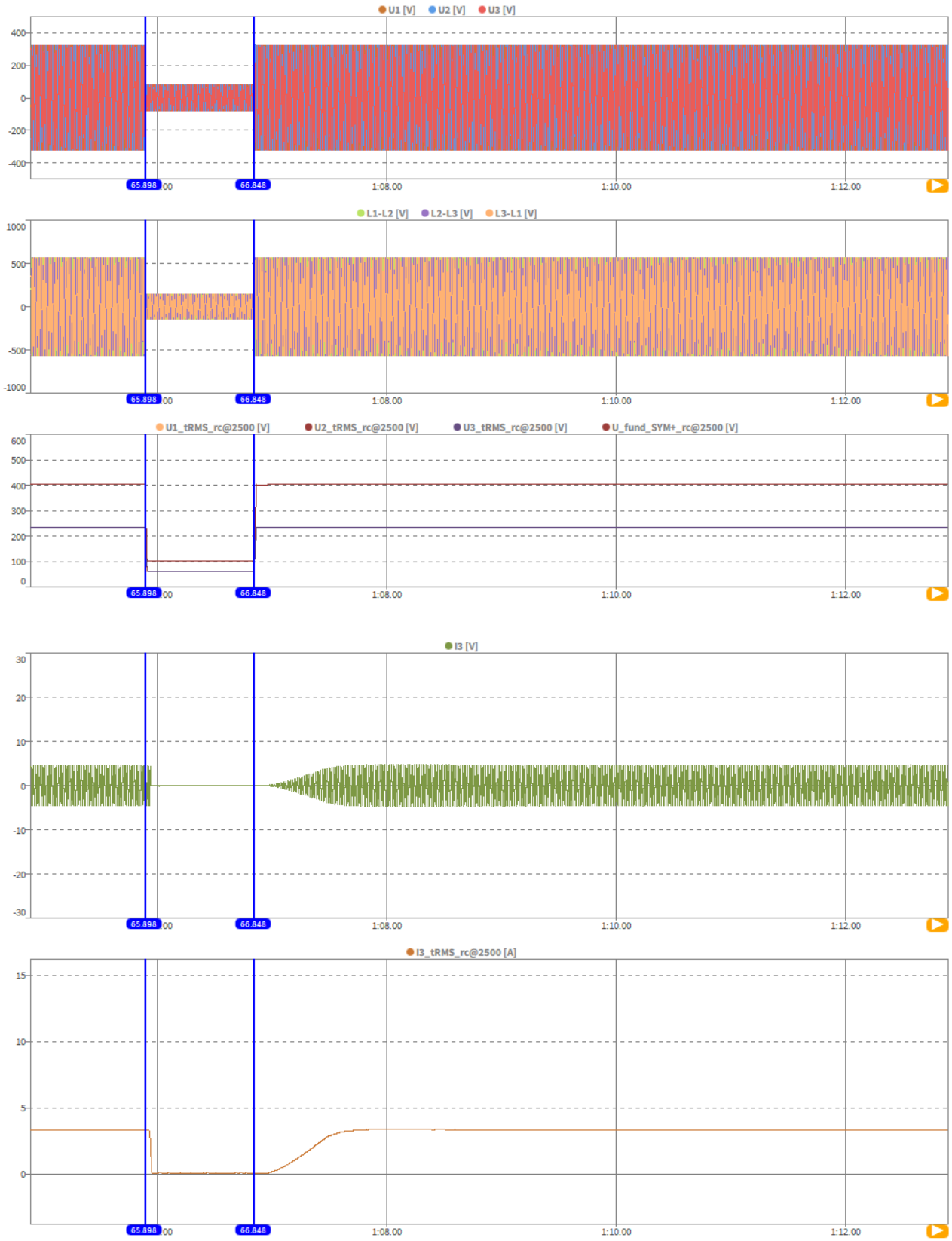

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
1:06.00
66.278
67.228
1:08.00
1:10.00
1:12.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@2500 [A]
15
10
5
0

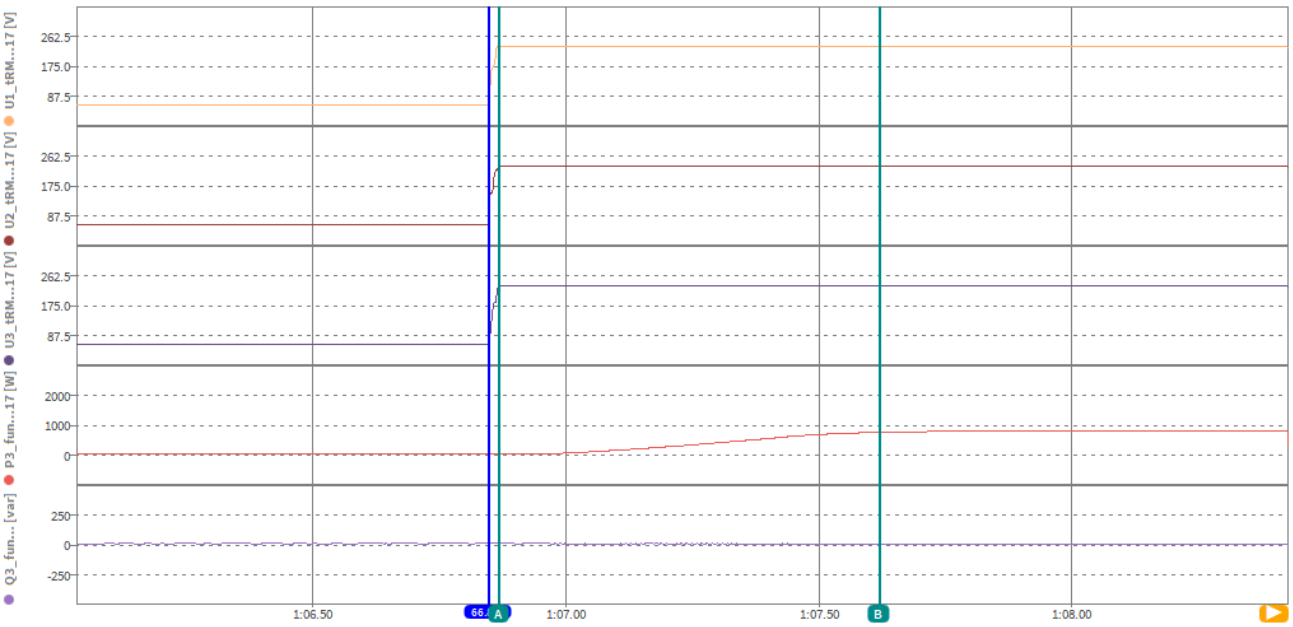



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:07.24790449 | 1:07.98268723 | 0.73478274 |
| U1_tRMS_rc@POWER/117 [V] | 229.8538 | 229.9981 | 0.144287 |
| U2_tRMS_rc@POWER/117 [V] | 222.8461 | 230.0080 | 7.161911 |
| U3_tRMS_rc@POWER/117 [V] | 220.7649 | 229.9779 | 9.212997 |
| P3_fund_rc@POWER/117 [W] | 4.758785 | 2340.929 | 2336.170 |
| Q3_fund_rc@POWER/117 [var] | 0.169433 | -8.469046 | -8.638478 |

## 2.2

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 2.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 10:42:32 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.25 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 910 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65898 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 66848 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 950 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.250 | 0.250 | 0.250 |
| | 10 | | Positive sequence | | [p.u.] | 0.250 | 0.250 | 0.250 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.298 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.301 |
| | 14 | | Positive sequence | | | -- | -- | 0.301 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.005 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.250 | 0.250 | 0.250 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.082 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.003 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.001 |
| | 22 | | Positive sequence | | | -- | -- | 0.001 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.300 |
| | 25 | | Positive sequence | | | -- | -- | 0.300 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.750 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.003 |
| | 28 | | Positive sequence | | | -- | -- | 0.001 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

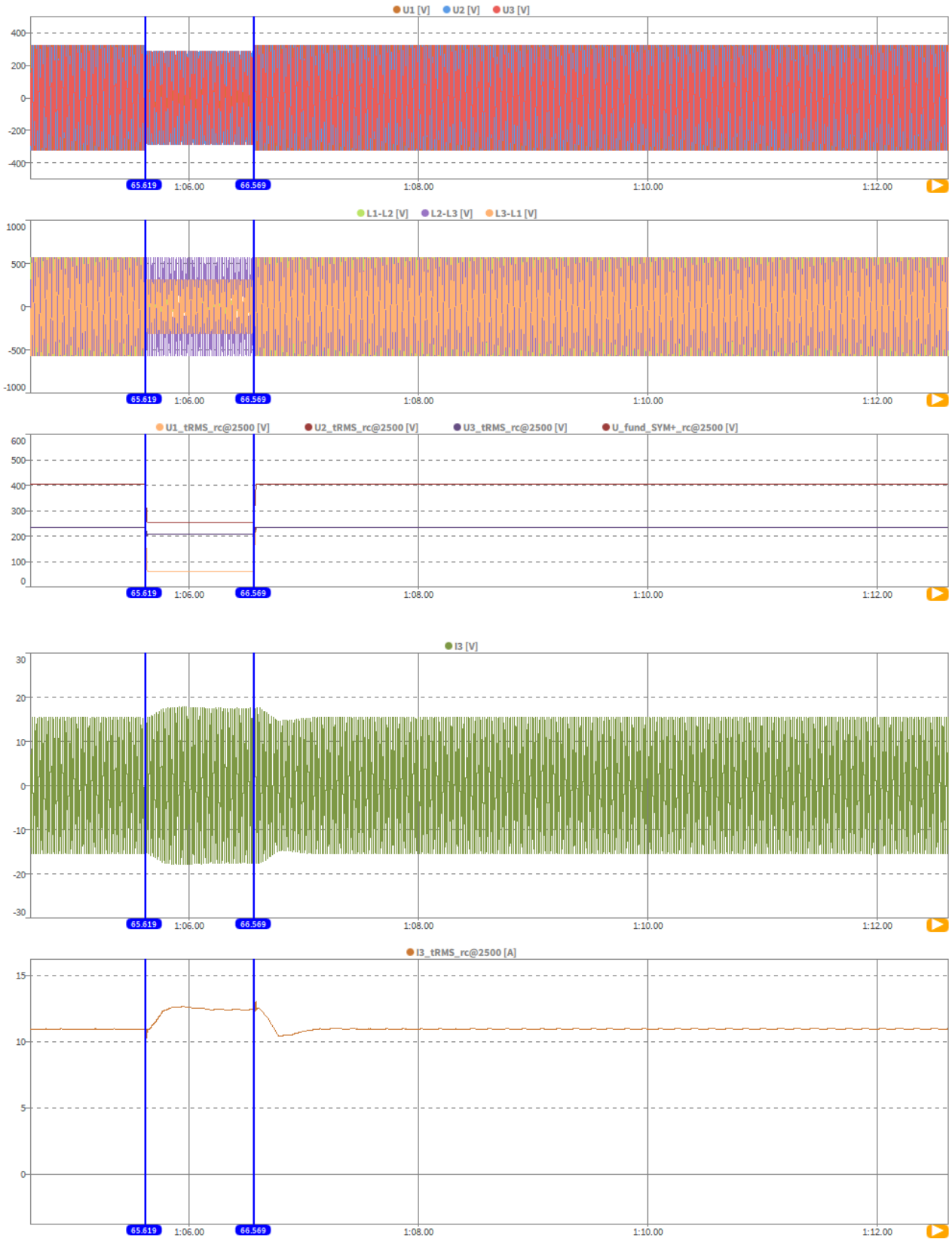

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
65.898
66.848
1:08.00
1:10.00
1:12.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@2500 [A]
15
10
5
0

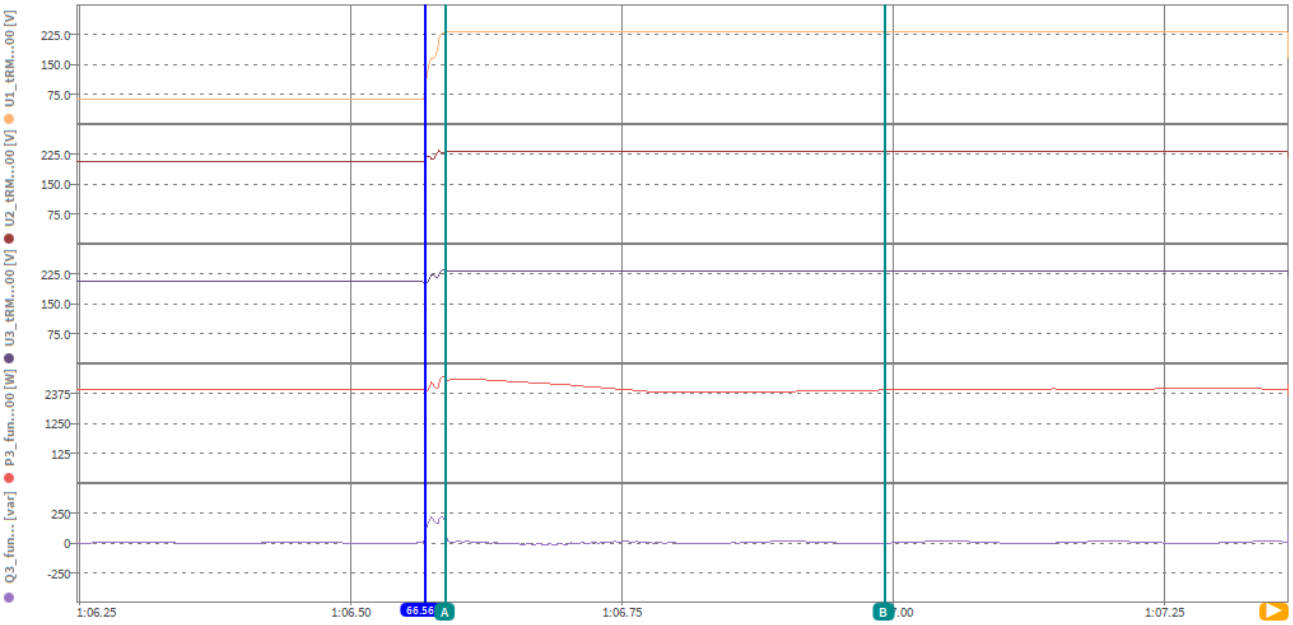



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:06.86925810 | 1:07.61971280 | 0.75045471 |
| U1_tRMS_rc@POWER/117 [V] | 230.0723 | 230.0005 | -0.071732 |
| U2_tRMS_rc@POWER/117 [V] | 229.9112 | 230.0036 | 0.092422 |
| U3_tRMS_rc@POWER/117 [V] | 229.8594 | 229.9822 | 0.122864 |
| P3_fund_rc@POWER/117 [W] | -5.371814 | 716.9568 | 722.3287 |
| Q3_fund_rc@POWER/117 [var] | 0.187067 | -2.826556 | -3.013623 |

## 2.3

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 2.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 14:39:52 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.25 | 0.88 | 0.88 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 910 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65619 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 66569 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 950 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.250 | 0.880 | 0.880 |
| | 10 | | Positive sequence | | [p.u.] | 0.627 | 0.627 | 0.627 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.001 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.001 |
| | 14 | | Positive sequence | | | -- | -- | 1.001 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.014 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.250 | 0.880 | 0.880 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 1.012 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 1.041 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.002 |
| | 22 | | Positive sequence | | | -- | -- | 1.002 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.003 |
| | 25 | | Positive sequence | | | -- | -- | 1.003 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.404 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.013 |
| | 28 | | Positive sequence | | | -- | -- | 0.004 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |


U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
65.619
1:06.00
66.569
1:08.00
1:10.00
1:12.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@2500 [A]
15
10
5
0

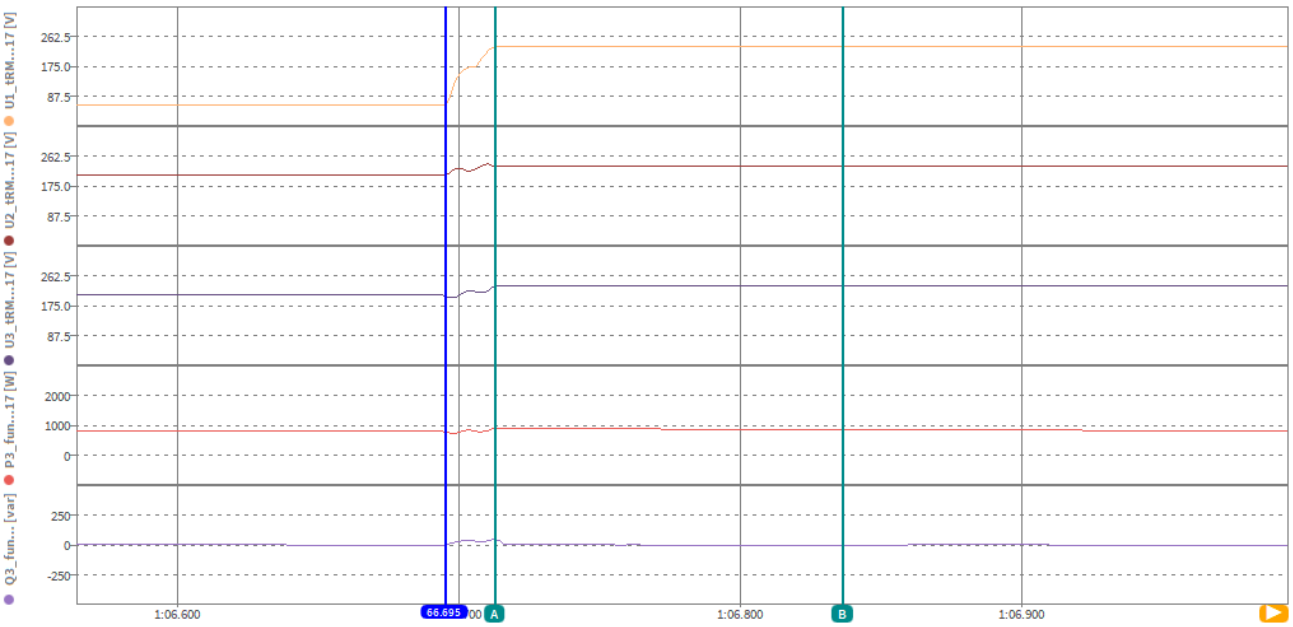



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:06.587968 | 1:06.992544 | 0.404576 |
| U1_tRMS_rc@2500 [V] | 226.0780 | 229.9951 | 3.917114 |
| U2_tRMS_rc@2500 [V] | 224.3527 | 230.0093 | 5.656570 |
| U3_tRMS_rc@2500 [V] | 234.1667 | 229.9808 | -4.185974 |
| P3_fund_rc@2500 [W] | 2997.740 | 2461.408 | -536.3311 |
| Q3_fund_rc@2500 [var] | 208.2432 | -12.01392 | -220.2571 |

## 2.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 2.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 14:46:03 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.25 | 0.88 | 0.88 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 910 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65746 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 66695 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 949 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.250 | 0.880 | 0.880 |
| | 10 | | Positive sequence | | [p.u.] | 0.627 | 0.627 | 0.627 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.299 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.298 |
| | 14 | | Positive sequence | | | -- | -- | 0.298 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.009 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.250 | 0.880 | 0.880 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.299 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.306 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.294 |
| | 22 | | Positive sequence | | | -- | -- | 0.294 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.301 |
| | 25 | | Positive sequence | | | -- | -- | 0.301 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.184 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.009 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

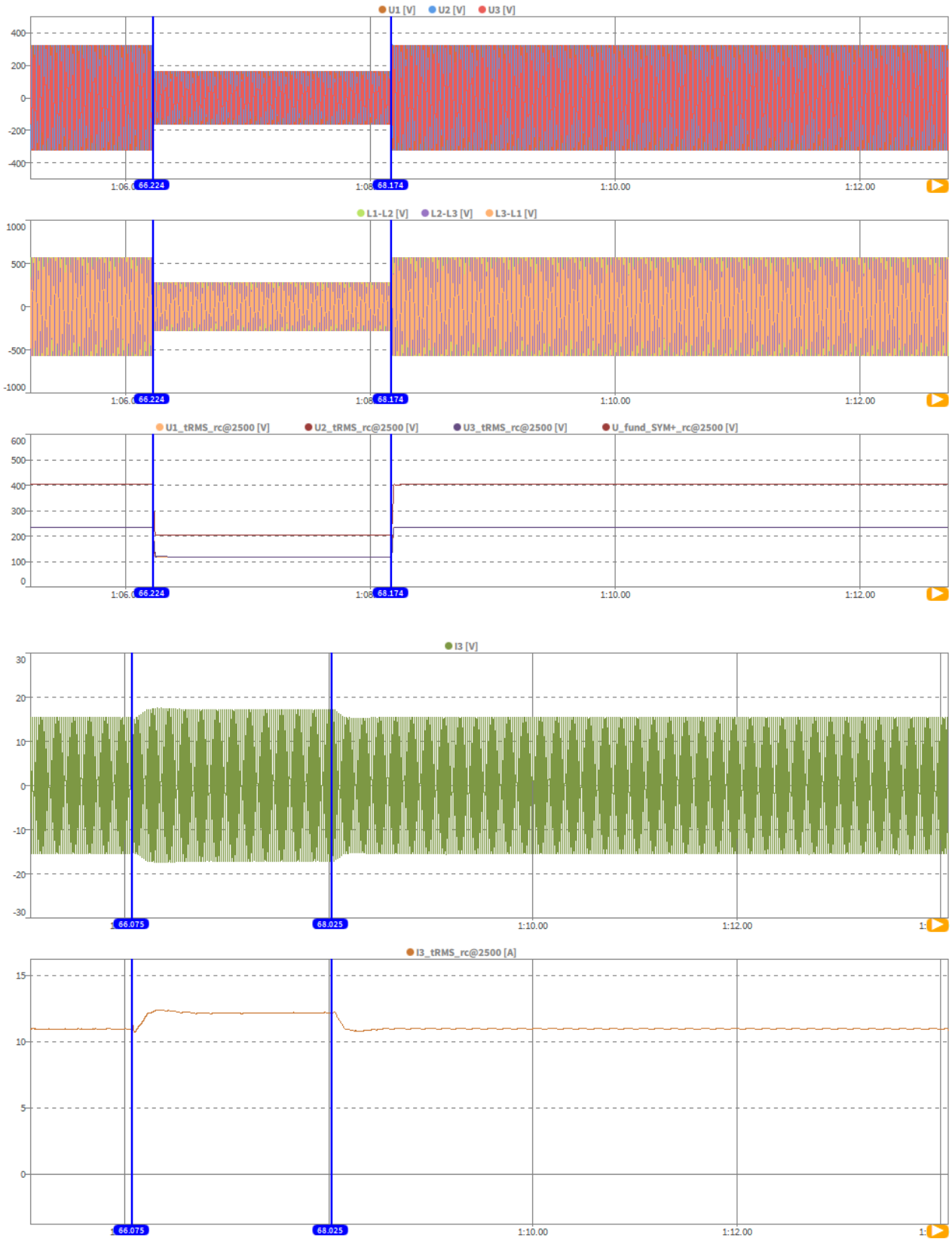

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
65.746
1:06.00
66.695
1:08.00
1:10.00
1:12.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@2500 [A]
15
10
5
0

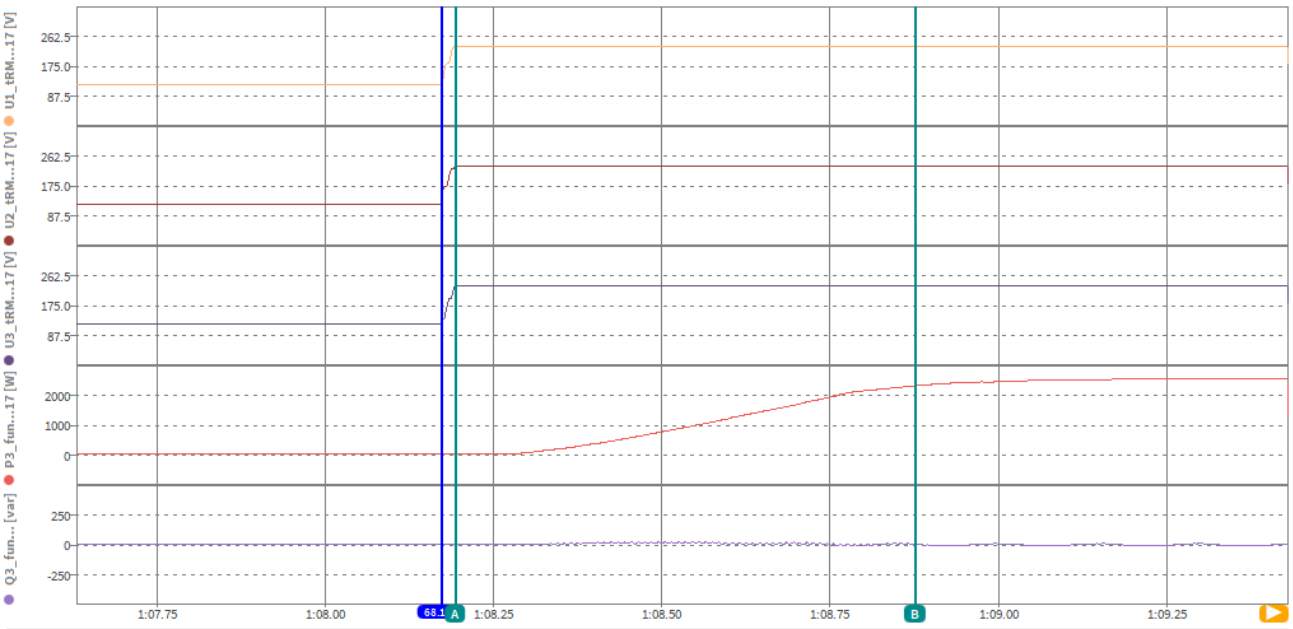



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:06.7129139 | 1:06.8364766 | 0.1235627 |
| U1_tRMS_rc@POWER/117 [V] | 226.7435 | 229.9244 | 3.180939 |
| U2_tRMS_rc@POWER/117 [V] | 233.6391 | 229.9901 | -3.648987 |
| U3_tRMS_rc@POWER/117 [V] | 225.1676 | 229.9632 | 4.795624 |
| P3_fund_rc@POWER/117 [W] | 856.9166 | 812.4184 | -44.49823 |
| Q3_fund_rc@POWER/117 [var] | 33.98110 | -14.48420 | -48.46530 |

## 3.1

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 3.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 10:59:15 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.50 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 1870 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66224 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 68174 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 1950 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.500 | 0.500 | 0.500 |
| | 10 | | Positive sequence | | [p.u.] | 0.500 | 0.500 | 0.500 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.000 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.000 |
| | 14 | | Positive sequence | | | -- | -- | 1.000 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.011 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.500 | 0.500 | 0.500 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.002 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.002 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.001 |
| | 22 | | Positive sequence | | | -- | -- | 0.001 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.000 |
| | 25 | | Positive sequence | | | -- | -- | 1.000 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.682 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.011 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

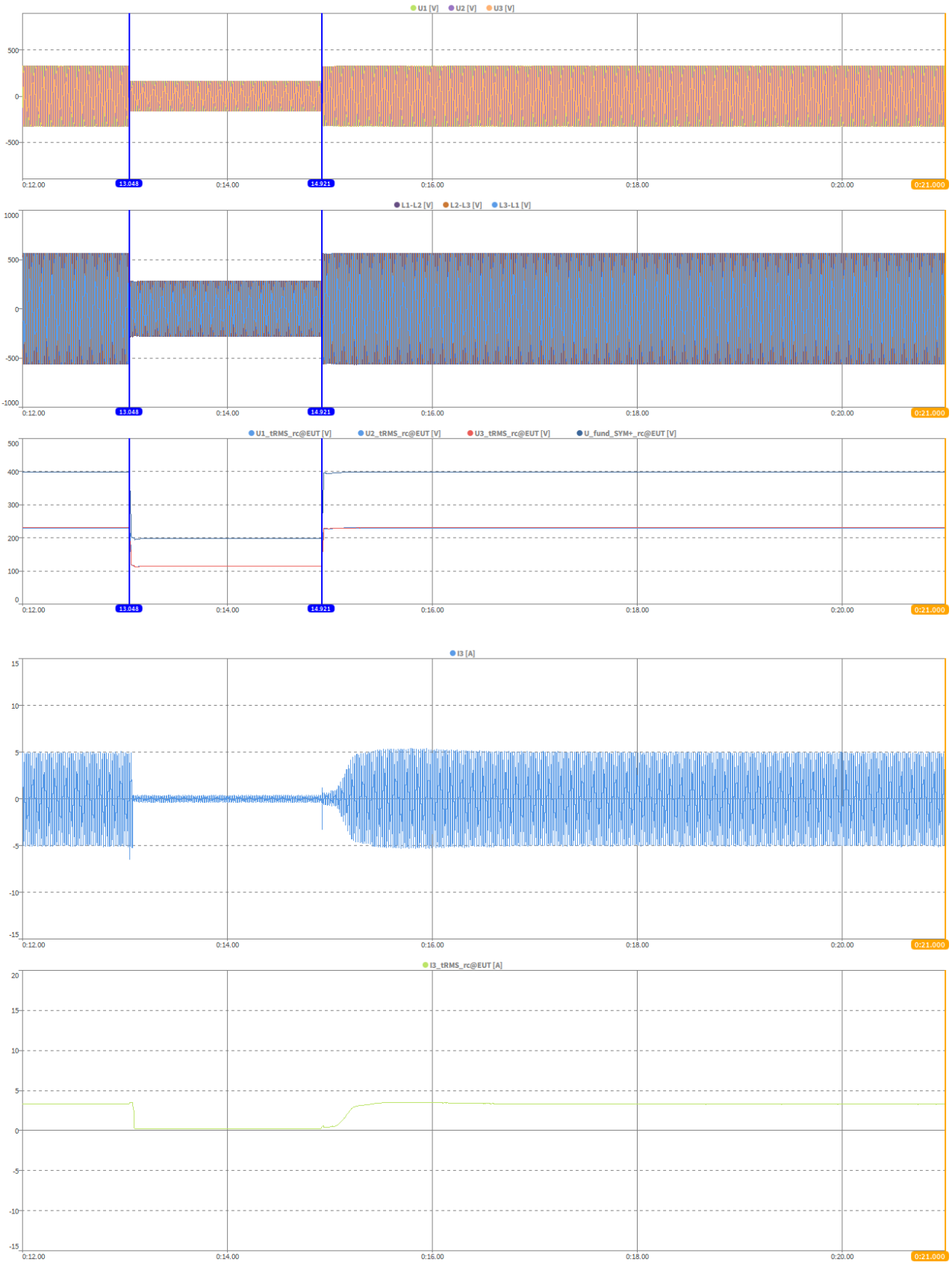

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.224
68.174
1:10.00
1:12.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
66.075
68.025
I3_tRMS_rc@2500 [A]
15
10
5
0

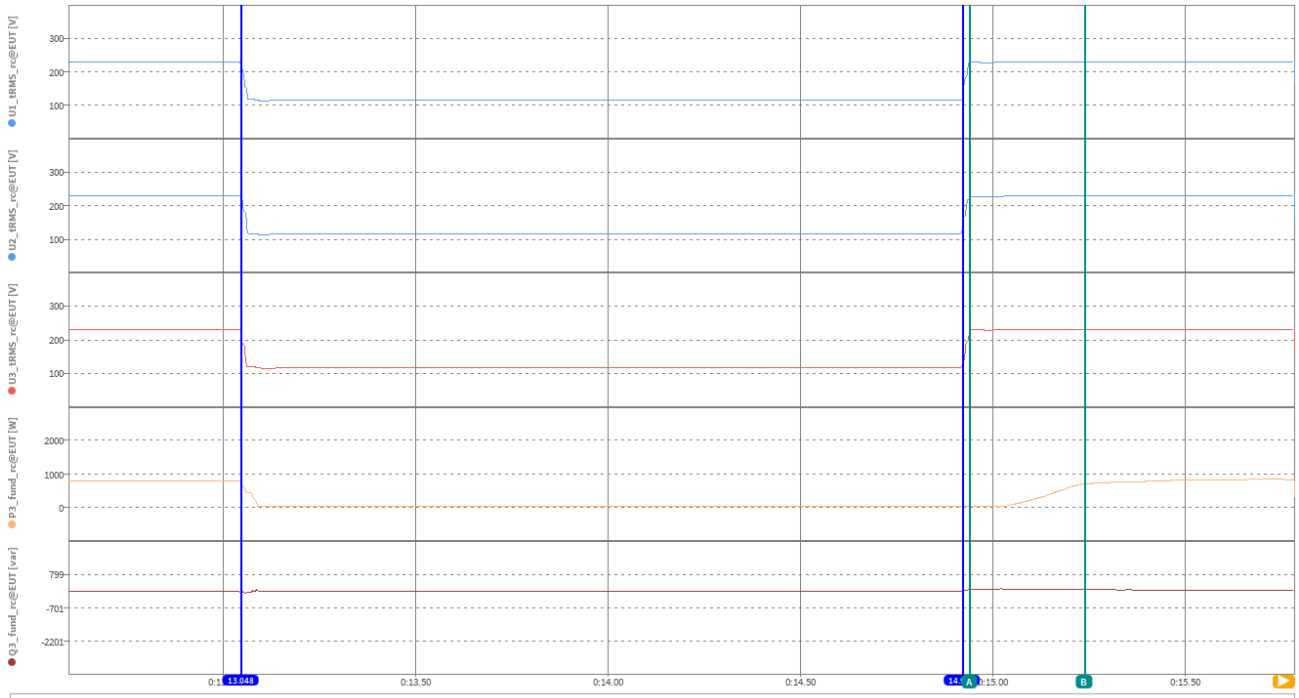



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:08.1948951 | 1:08.8772744 | 0.6823793 |
| U1_tRMS_rc@POWER/117 [V] | 230.0560 | 229.9979 | -0.058136 |
| U2_tRMS_rc@POWER/117 [V] | 227.2946 | 230.0042 | 2.709625 |
| U3_tRMS_rc@POWER/117 [V] | 227.0510 | 229.9808 | 2.929810 |
| P3_fund_rc@POWER/117 [W] | -2.828437 | 2287.860 | 2290.688 |
| Q3_fund_rc@POWER/117 [var] | -4.227639 | -0.944499 | 3.283140 |

## 3.2

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 3.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:24:21 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.50 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 1870 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 13048 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 14921 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 1873 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.499 | 0.498 | 0.501 |
| | 10 | | Positive sequence | | [p.u.] | 0.499 | 0.499 | 0.499 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.303 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.303 |
| | 14 | | Positive sequence | | | -- | -- | 0.303 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.016 |
| | 16 | | Positive sequence | | | -- | -- | 0.006 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.499 | 0.498 | 0.501 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.020 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.020 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.000 |
| | 22 | | Positive sequence | | | -- | -- | 0.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.302 |
| | 25 | | Positive sequence | | | -- | -- | 0.302 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.298 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.016 |
| | 28 | | Positive sequence | | | -- | -- | 0.006 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

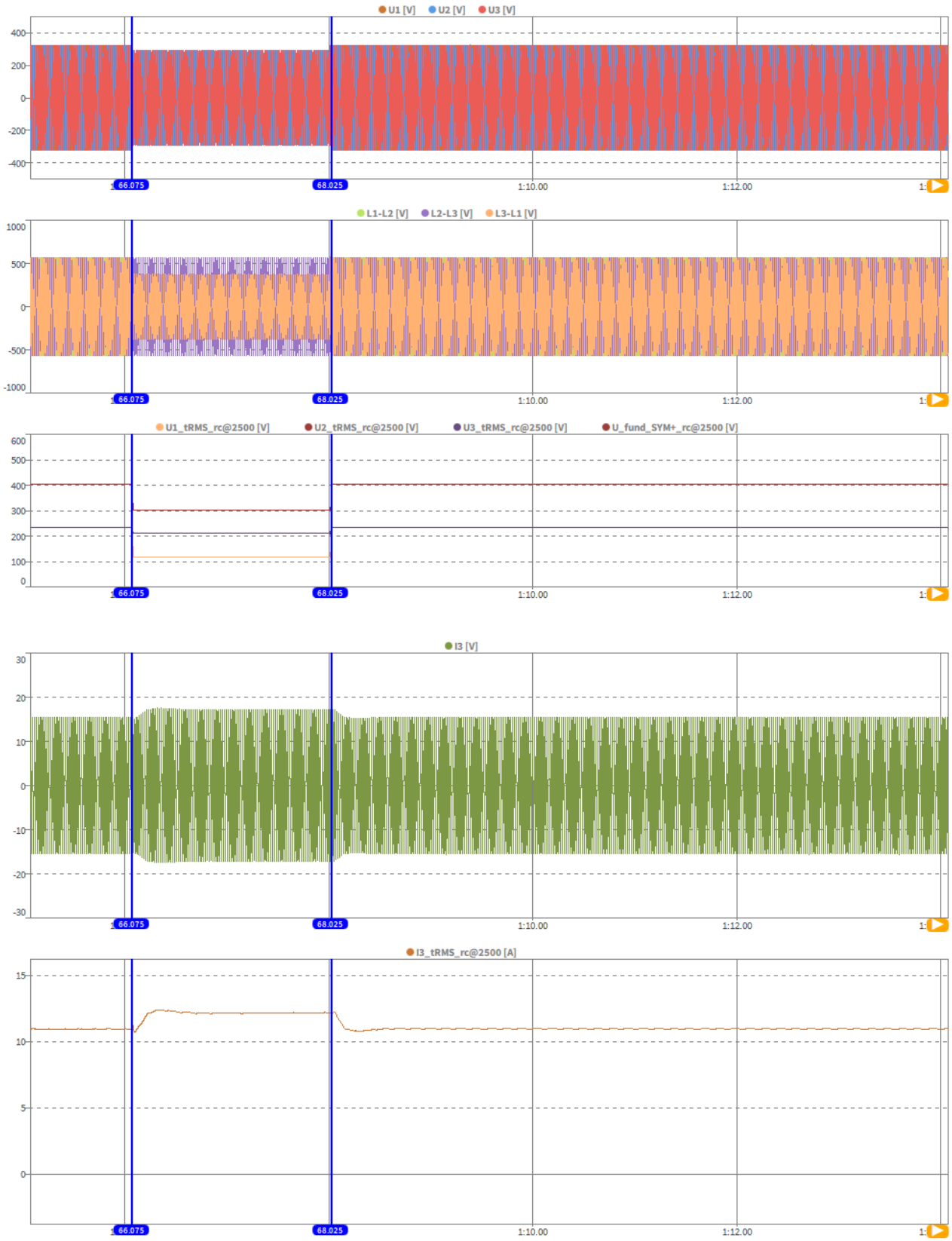

U1 [V]
U2 [V]
U3 [V]
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
I3 [A]
I3_tRMS_rc@EUT [A]
0:12.00
0:14.00
0:16.00
0:18.00
0:20.00
0:21.000
13.048
14.921

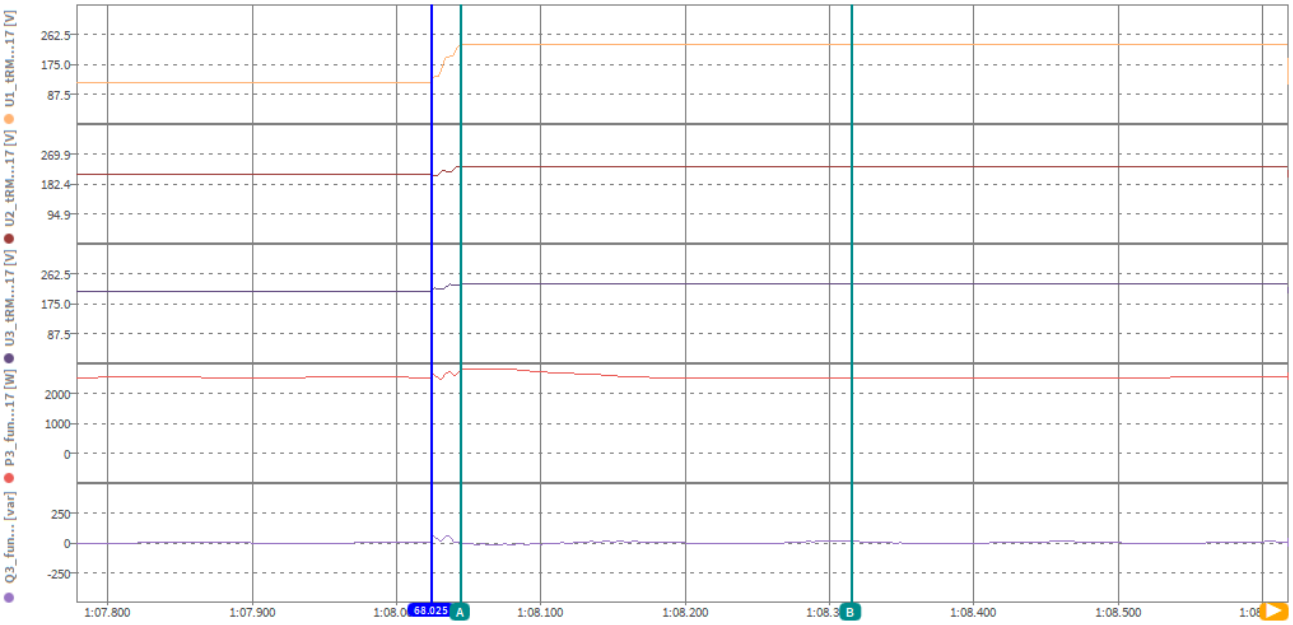



| | A | B | Delta |
|---|---|---|---|
| Time [s] | 0:14.941000 | 0:15.238868 | 0.297868 |
| U1_tRMS_rc@EUT [V] | 228.2509 | 230.3883 | 2.137421 |
| U2_tRMS_rc@EUT [V] | 220.9388 | 229.2485 | 8.309662 |
| U3_tRMS_rc@EUT [V] | 218.3406 | 230.0888 | 11.74812 |
| P3_fund_rc@EUT [W] | -13.45396 | 672.0361 | 685.4901 |
| Q3_fund_rc@EUT [var] | 84.08933 | 76.76717 | -7.322159 |

## 3.3

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 3.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:28:39 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.50 | 0.90 | 0.90 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 1870 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66075 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 68025 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 1950 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.500 | 0.900 | 0.900 |
| | 10 | | Positive sequence | | [p.u.] | 0.749 | 0.749 | 0.749 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.001 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.001 |
| | 14 | | Positive sequence | | | -- | -- | 1.001 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.013 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.500 | 0.900 | 0.900 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.989 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 1.026 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.002 |
| | 22 | | Positive sequence | | | -- | -- | 1.002 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.003 |
| | 25 | | Positive sequence | | | -- | -- | 1.003 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.270 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.013 |
| | 28 | | Positive sequence | | | -- | -- | 0.004 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

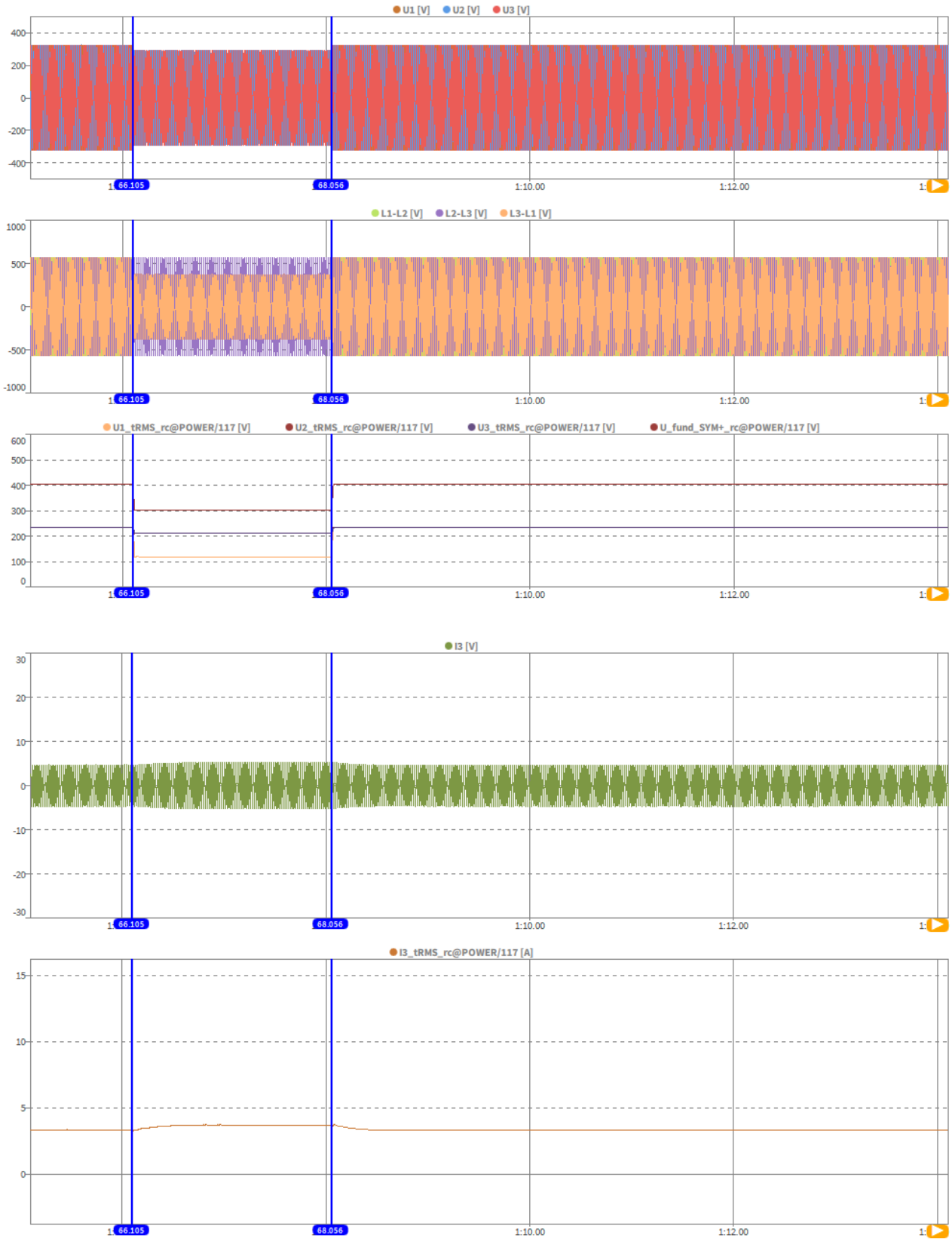

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.075
68.025
1:10.00
1:12.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
66.075
68.025
1:10.00
1:12.00
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
66.075
68.025
1:10.00
1:12.00
I3 [V]
30
20
10
0
-10
-20
-30
66.075
68.025
1:10.00
1:12.00
I3_tRMS_rc@2500 [A]
15
10
5
0
66.075
68.025
1:10.00
1:12.00

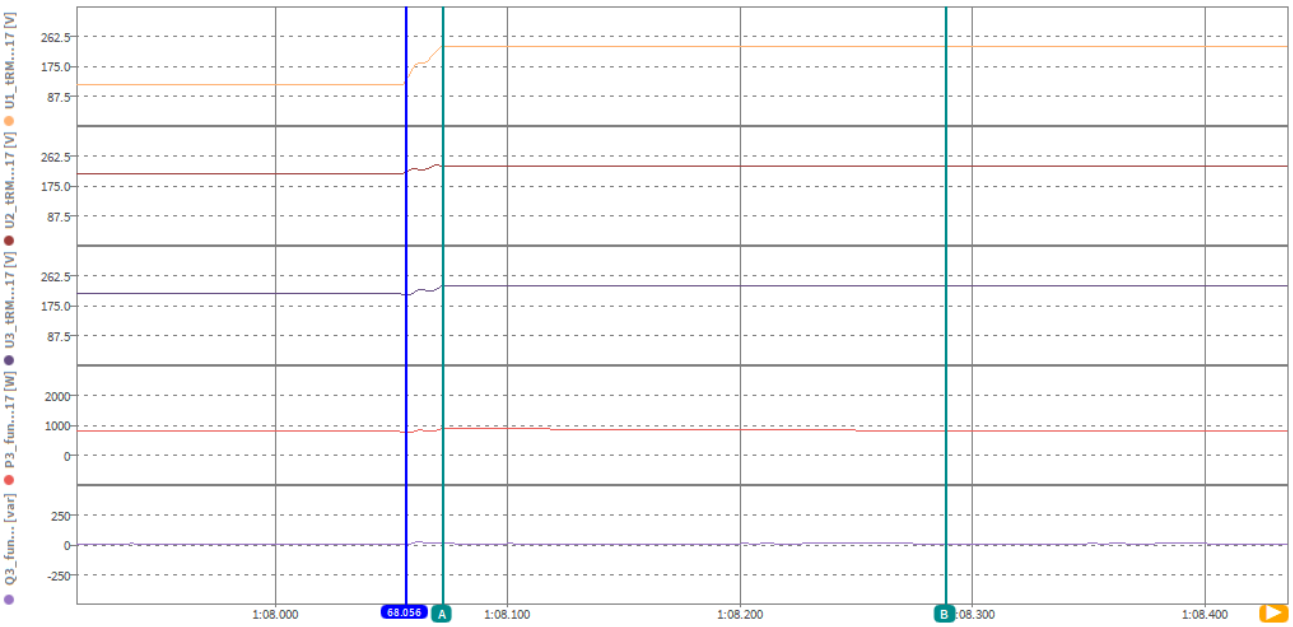



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:08.0446646 | 1:08.3151021 | 0.2704375 |
| U1_tRMS_rc@POWER/117 [V] | 224.2928 | 229.9978 | 5.705002 |
| U2_tRMS_rc@POWER/117 [V] | 229.6630 | 230.0065 | 0.343430 |
| U3_tRMS_rc@POWER/117 [V] | 227.6091 | 229.9766 | 2.367447 |
| P3_fund_rc@POWER/117 [W] | 2679.556 | 2466.860 | -212.6953 |
| Q3_fund_rc@POWER/117 [var] | 2.134064 | 0.852040 | -1.282023 |

## 3.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 3.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:36:30 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.50 | 0.90 | 0.90 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 1870 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66105 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 68056 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 1951 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.500 | 0.900 | 0.900 |
| | 10 | | Positive sequence | | [p.u.] | 0.749 | 0.749 | 0.749 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.302 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.302 |
| | 14 | | Positive sequence | | | -- | -- | 0.302 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.006 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.500 | 0.900 | 0.900 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.302 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.308 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.299 |
| | 22 | | Positive sequence | | | -- | -- | 0.299 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.298 |
| | 25 | | Positive sequence | | | -- | -- | 0.298 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.216 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.006 |
| | 28 | | Positive sequence | | | -- | -- | 0.001 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

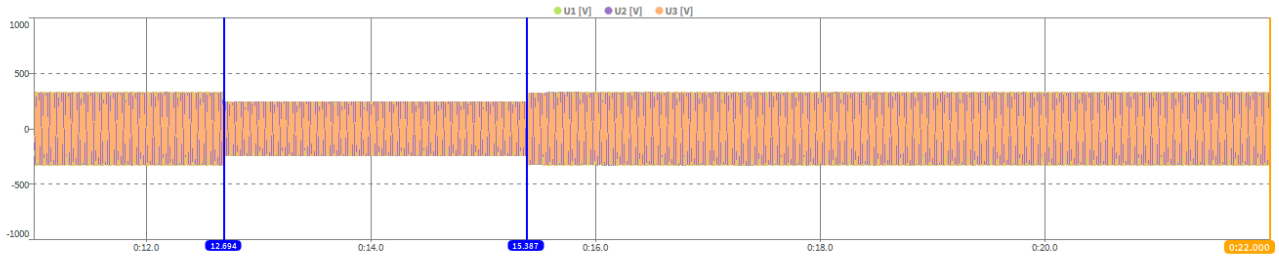

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.105
68.056
1:10.00
1:12.00
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

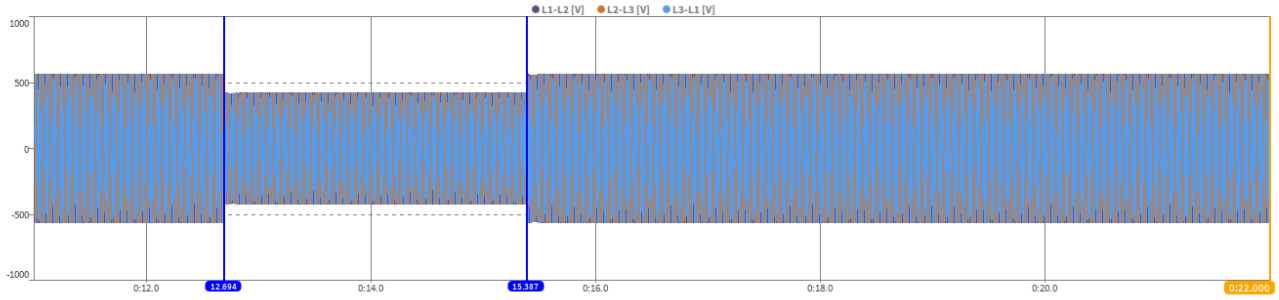


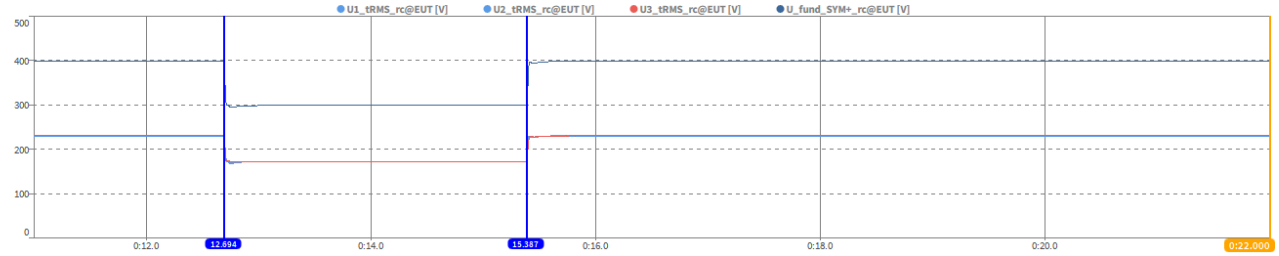

| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:08.0720705 | 1:08.2884564 | 0.2163859 |
| U1_tRMS_rc@POWER/117 [V] | 225.7262 | 229.9809 | 4.254684 |
| U2_tRMS_rc@POWER/117 [V] | 232.9860 | 230.0044 | -2.981644 |
| U3_tRMS_rc@POWER/117 [V] | 224.7198 | 229.9756 | 5.255737 |
| P3_fund_rc@POWER/117 [W] | 823.3414 | 777.9794 | -45.36200 |
| Q3_fund_rc@POWER/117 [var] | 10.42610 | -3.030687 | -13.45678 |

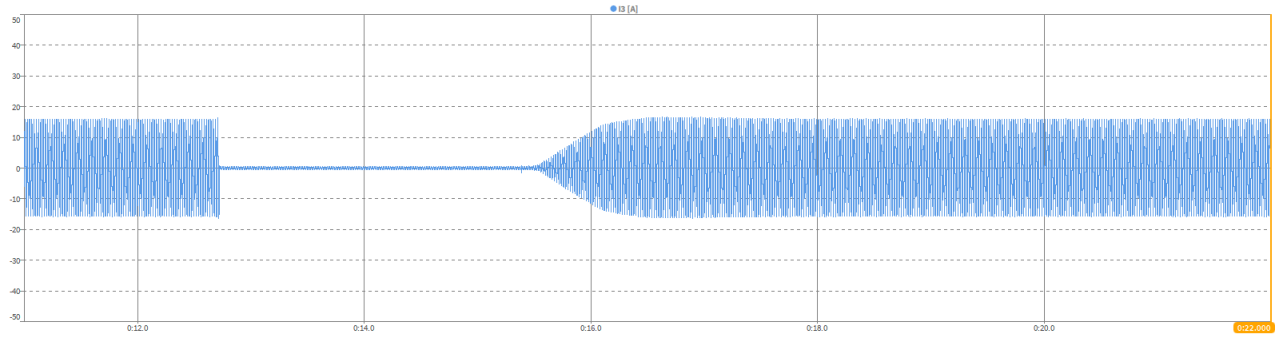
## 4.1

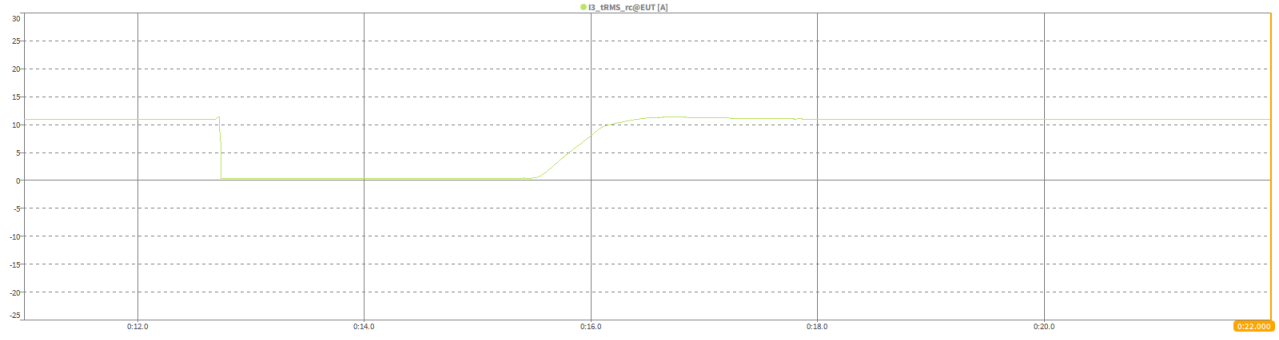
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 4.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:44:36 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.75 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 2690 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 12694 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 15387 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 2693 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.750 | 0.747 | 0.751 |
| | 10 | | Positive sequence | | [p.u.] | 0.749 | 0.749 | 0.749 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.008 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.011 |
| | 14 | | Positive sequence | | | -- | -- | 1.011 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.018 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.750 | 0.747 | 0.751 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.028 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.028 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.001 |
| | 22 | | Positive sequence | | | -- | -- | 0.001 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.011 |
| | 25 | | Positive sequence | | | -- | -- | 1.011 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.787 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.018 |
| | 28 | | Positive sequence | | | -- | -- | 0.004 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

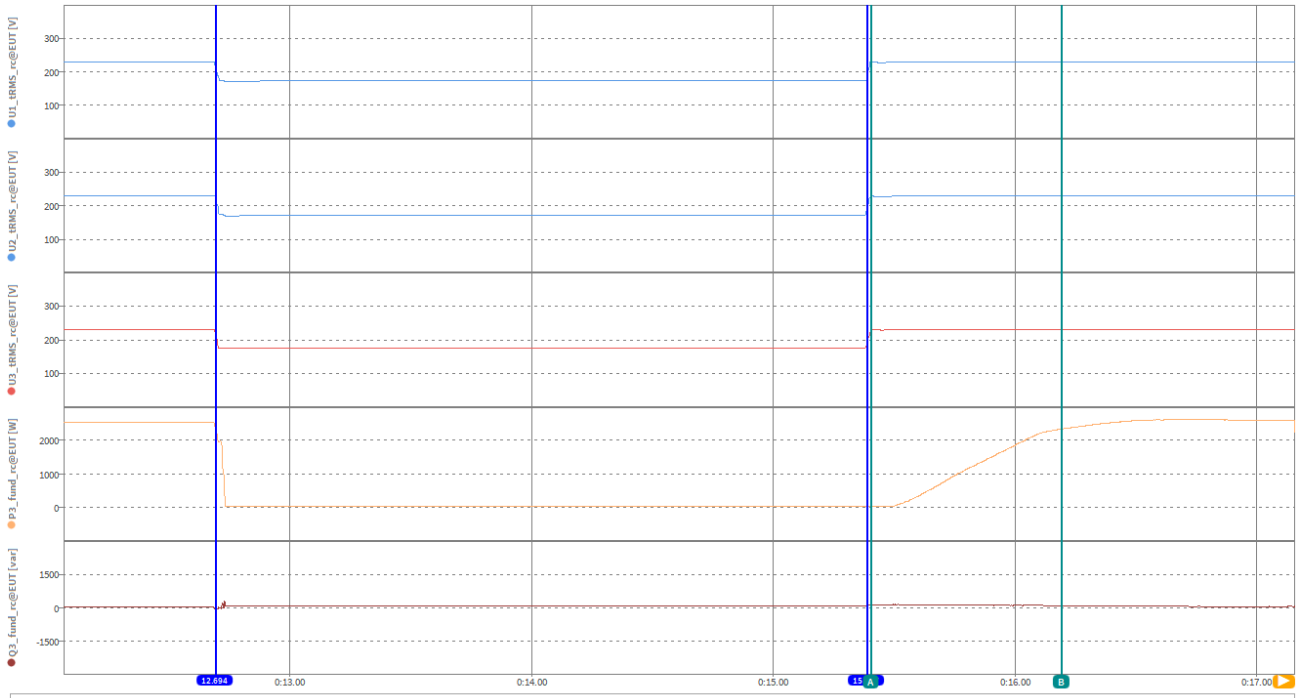

U1 [V]
U2 [V]
U3 [V]
1000
500
0
-500
-1000
0:12.0
12.894
0:14.0
15.387
0:16.0
0:18.0
0:20.0
0:22.000


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
0:12.0
12.894
0:14.0
15.387
0:16.0
0:18.0
0:20.0
0:22.000


U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
500
400
300
200
100
0
0:12.0
12.894
0:14.0
15.387
0:16.0
0:18.0
0:20.0
0:22.000


I3 [A]
50
40
30
20
10
0
-10
-20
-30
-40
-50
0:12.0
0:14.0
0:16.0
0:18.0
0:20.0
0:22.000

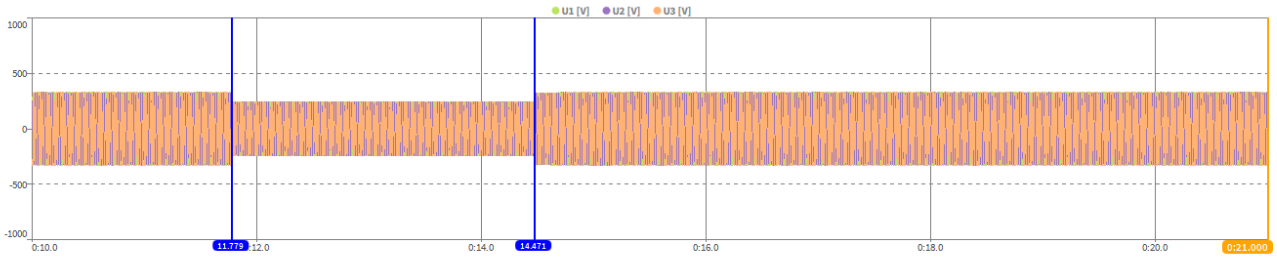

I3_tRMS_rc@EUT [A]
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
0:12.0
0:14.0
0:16.0
0:18.0
0:20.0
0:22.000

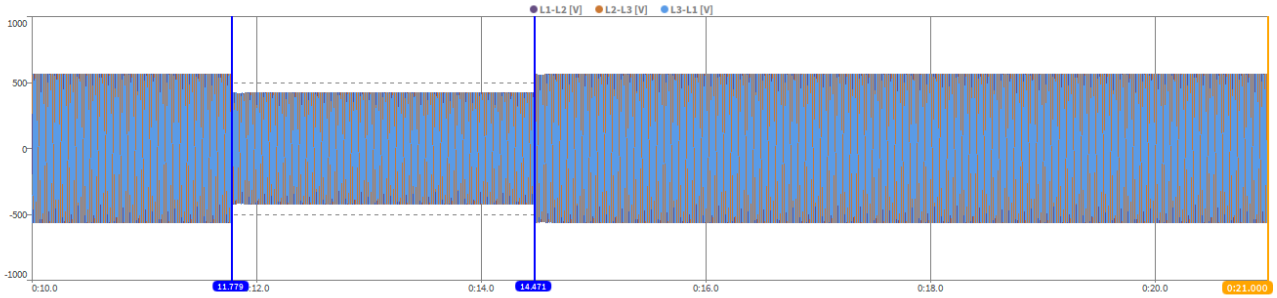


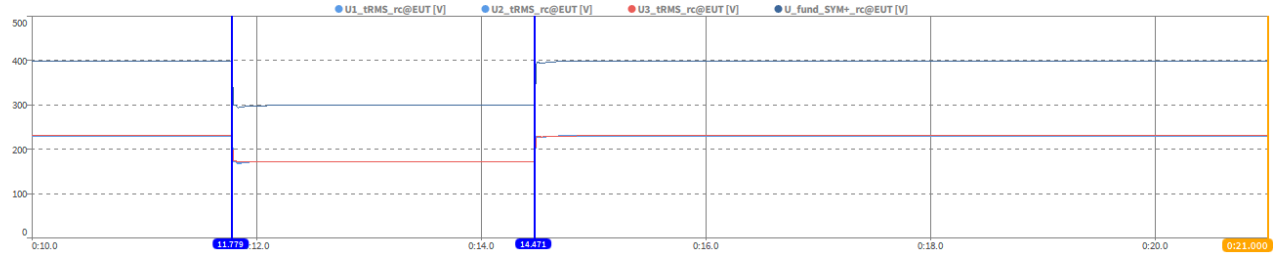

| | A | B | Delta |
|---|---|---|---|
| Time [s] | 0:15.40700 | 0:16.19446 | 0.78746 |
| U1_tRMS_rc@EUT [V] | 229.4817 | 230.4547 | 0.972992 |
| U2_tRMS_rc@EUT [V] | 225.0339 | 229.2852 | 4.251266 |
| U3_tRMS_rc@EUT [V] | 224.9599 | 230.4482 | 5.488235 |
| P3_fund_rc@EUT [W] | -10.69833 | 2328.502 | 2339.200 |
| Q3_fund_rc@EUT [var] | 88.13474 | 59.48136 | -28.65338 |

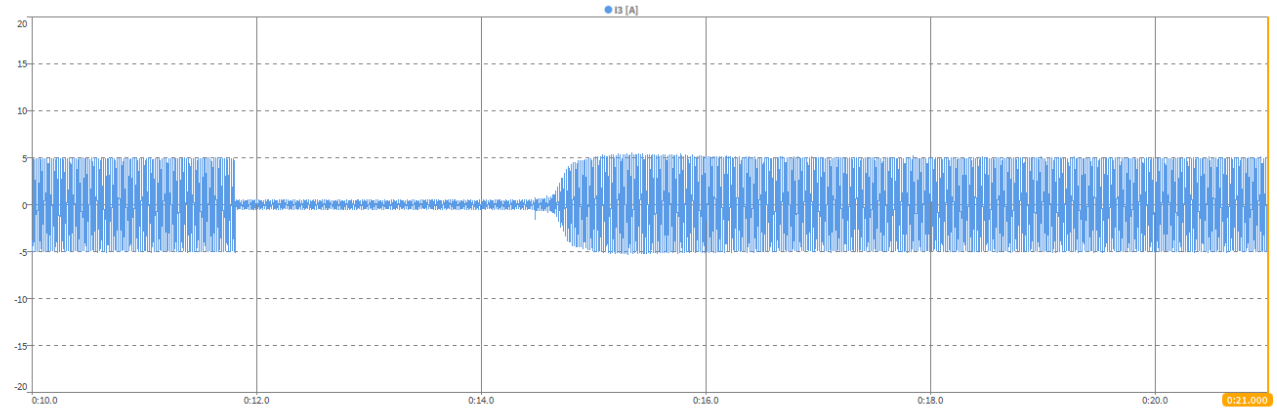
## 4.2

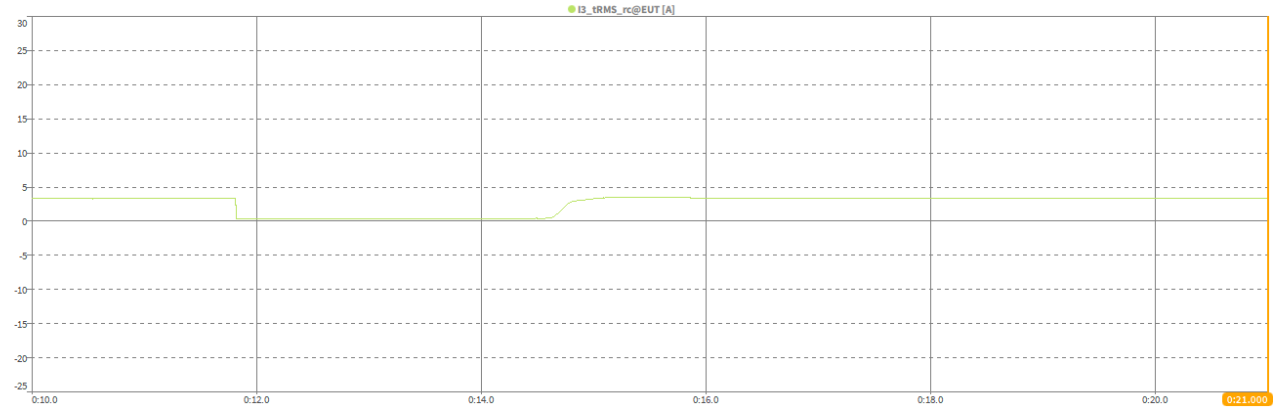
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 4.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:42:25 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.75 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 2690 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 11779 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 14471 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 2692 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.749 | 0.750 | 0.752 |
| | 10 | | Positive sequence | | [p.u.] | 0.750 | 0.750 | 0.750 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.304 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.304 |
| | 14 | | Positive sequence | | | -- | -- | 0.304 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.016 |
| | 16 | | Positive sequence | | | -- | -- | 0.005 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.750 | 0.747 | 0.751 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.028 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.028 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.000 |
| | 22 | | Positive sequence | | | -- | -- | 0.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.305 |
| | 25 | | Positive sequence | | | -- | -- | 0.305 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.383 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.016 |
| | 28 | | Positive sequence | | | -- | -- | 0.005 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

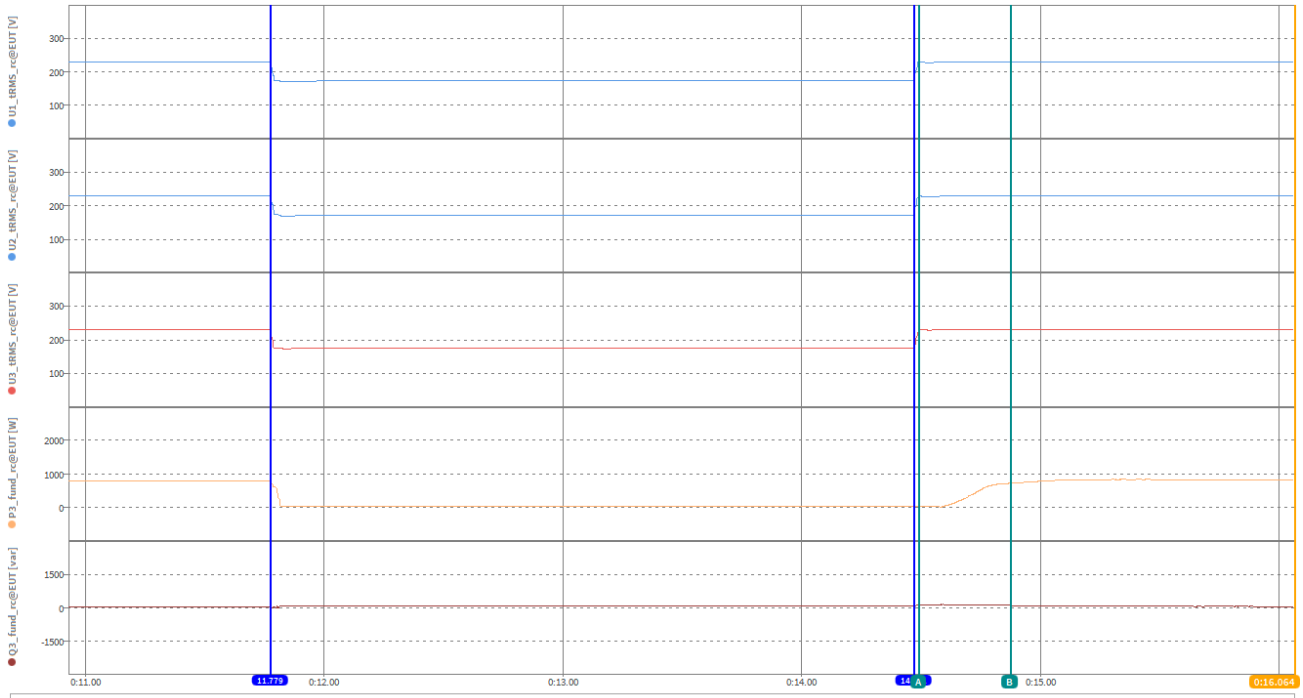

U1 [V]
U2 [V]
U3 [V]
1000
500
0
-500
-1000
0:10.0
11.779
12.0
0:14.0
14.471
0:16.0
0:18.0
0:20.0
0:21.000


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
0:10.0
11.779
12.0
0:14.0
14.471
0:16.0
0:18.0
0:20.0
0:21.000


U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
500
400
300
200
100
0
0:10.0
11.779
12.0
0:14.0
14.471
0:16.0
0:18.0
0:20.0
0:21.000


I3 [A]
20
15
10
5
0
-5
-10
-15
-20
0:10.0
0:12.0
0:14.0
0:16.0
0:18.0
0:20.0
0:21.000

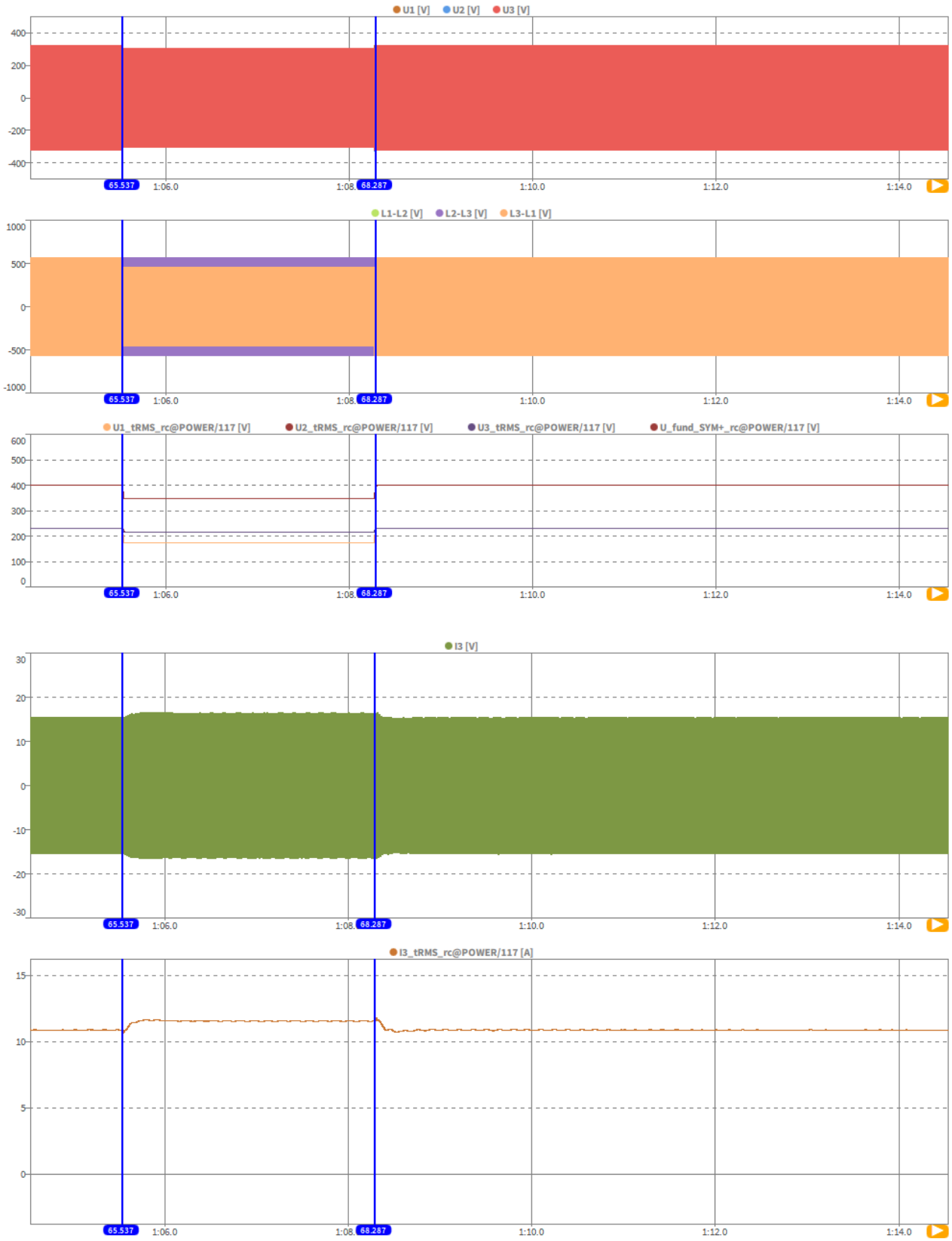

I3_tRMS_rc@EUT [A]
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
0:10.0
0:12.0
0:14.0
0:16.0
0:18.0
0:20.0
0:21.000

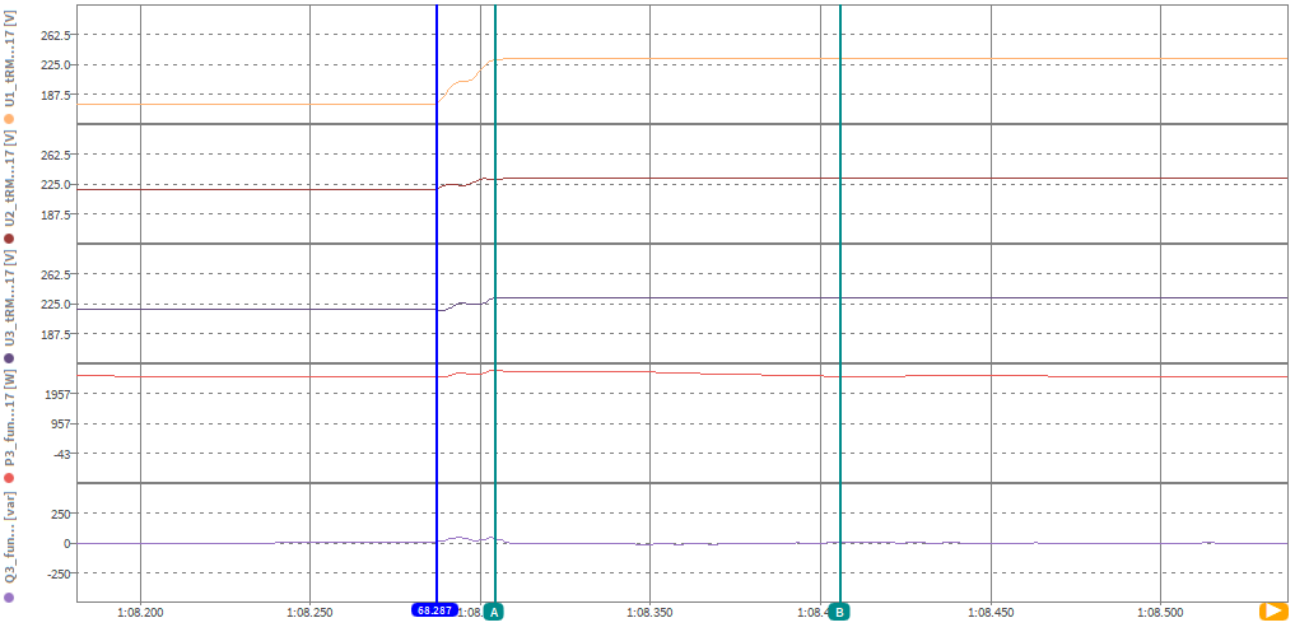



| | A | B | Delta |
|---|---|---|---|
| Time [s] | 0:14.49100 | 0:14.87350 | 0.38250 |
| U1_tRMS_rc@EUT [V] | 225.8596 | 230.4855 | 4.625885 |
| U2_tRMS_rc@EUT [V] | 222.9229 | 229.3593 | 6.436432 |
| U3_tRMS_rc@EUT [V] | 214.6328 | 230.2105 | 15.57764 |
| P3_fund_rc@EUT [W] | -5.684299 | 693.7345 | 699.4188 |
| Q3_fund_rc@EUT [var] | 82.04125 | 67.69373 | -14.34752 |

## 4.3

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 4.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:46:47 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.75 | 0.94 | 0.94 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 2690 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65537 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 68287 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 2750 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.750 | 0.940 | 0.940 |
| | 10 | | Positive sequence | | [p.u.] | 0.872 | 0.872 | 0.872 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.001 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.000 |
| | 14 | | Positive sequence | | | -- | -- | 1.000 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.013 |
| | 16 | | Positive sequence | | | -- | -- | 0.006 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.750 | 0.940 | 0.940 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 1.009 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 1.038 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.000 |
| | 22 | | Positive sequence | | | -- | -- | 1.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.000 |
| | 25 | | Positive sequence | | | -- | -- | 1.000 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.101 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.013 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

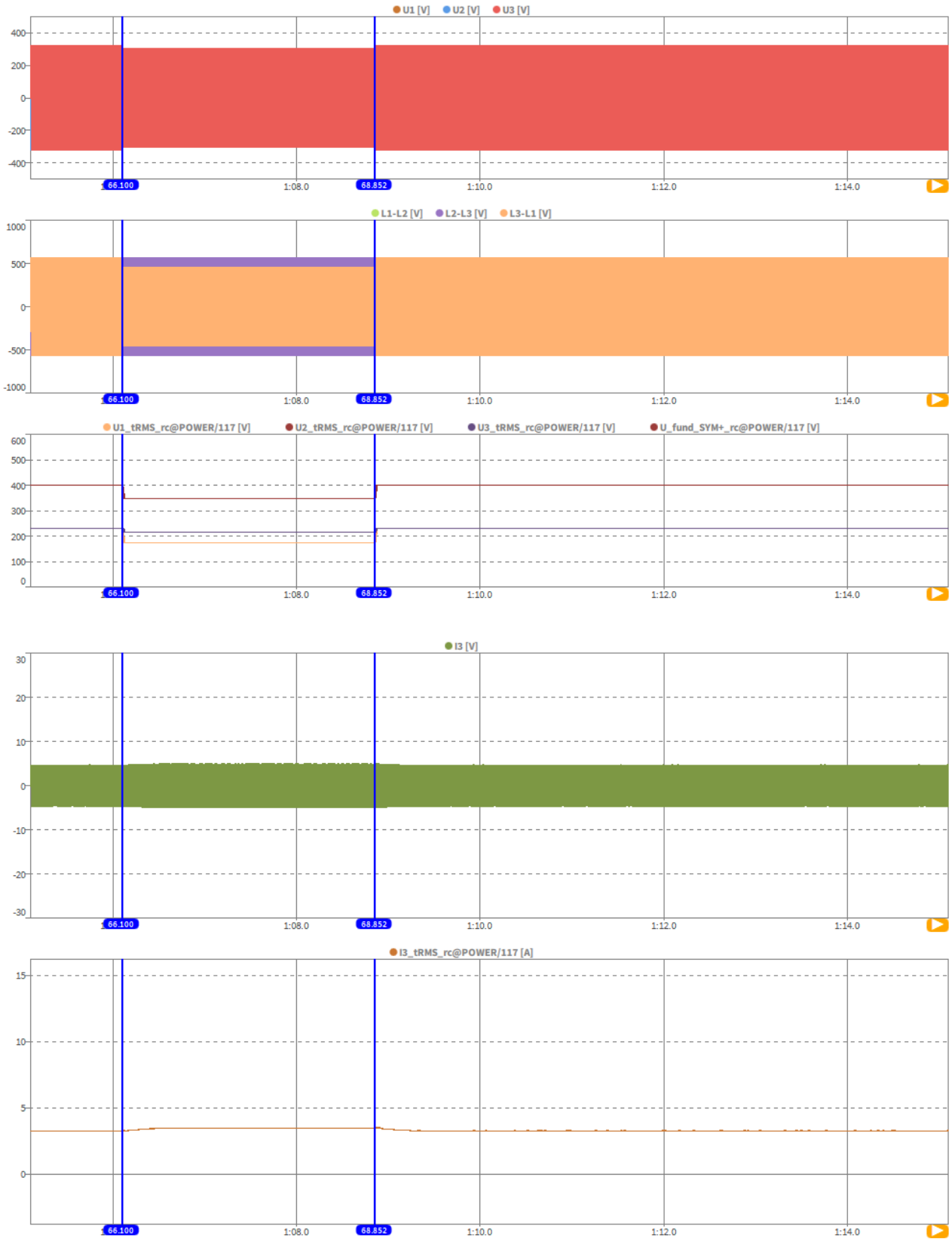

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
65.537
1:06.0
1:08.
68.287
1:10.0
1:12.0
1:14.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

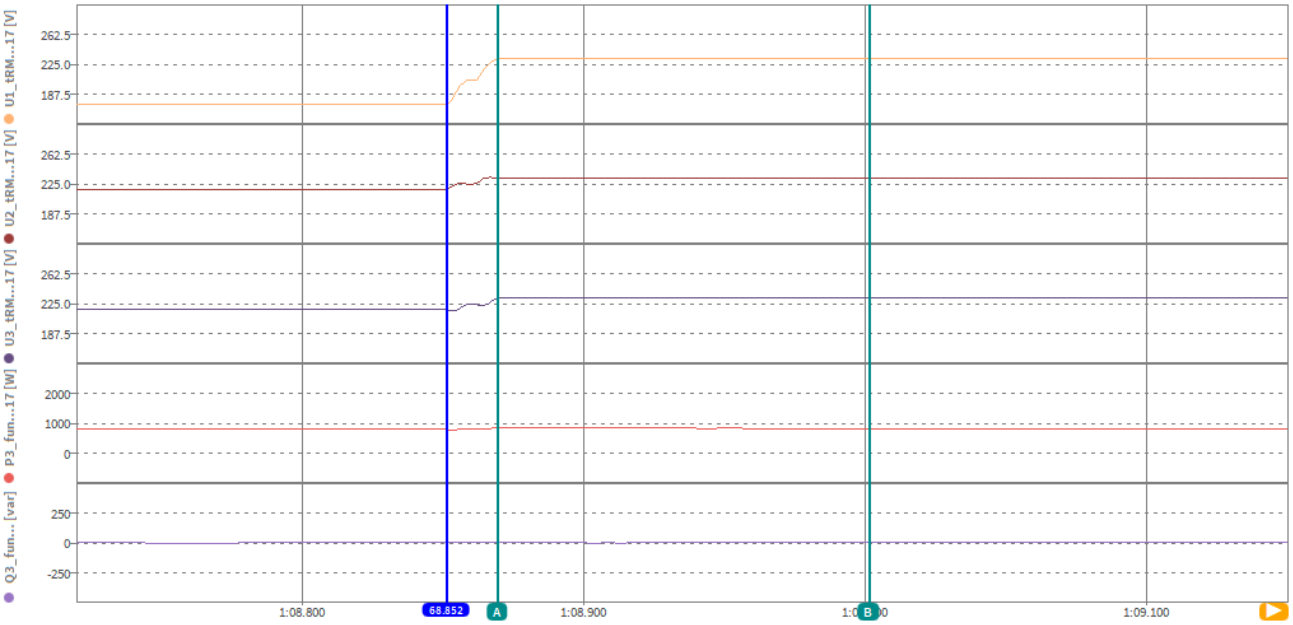



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:08.30424144 | 1:08.40571508 | 0.10147364 |
| U1_tRMS_rc@POWER/117 [V] | 228.7966 | 229.9927 | 1.196167 |
| U2_tRMS_rc@POWER/117 [V] | 229.0410 | 229.9967 | 0.955765 |
| U3_tRMS_rc@POWER/117 [V] | 230.2145 | 229.9683 | -0.246201 |
| P3_fund_rc@POWER/117 [W] | 2716.384 | 2501.712 | -214.6716 |
| Q3_fund_rc@POWER/117 [var] | 32.98995 | -8.129791 | -41.11974 |

## 4.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 4.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:39:34 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.75 | 0.94 | 0.94 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 2690 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66100 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 68852 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 2752 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.750 | 0.940 | 0.940 |
| | 10 | | Positive sequence | | [p.u.] | 0.872 | 0.872 | 0.872 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.301 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.301 |
| | 14 | | Positive sequence | | | -- | -- | 0.301 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.007 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.750 | 0.940 | 0.940 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.301 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.306 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.300 |
| | 22 | | Positive sequence | | | -- | -- | 0.300 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.301 |
| | 25 | | Positive sequence | | | -- | -- | 0.301 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.131 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.007 |
| | 28 | | Positive sequence | | | -- | -- | 0.002 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

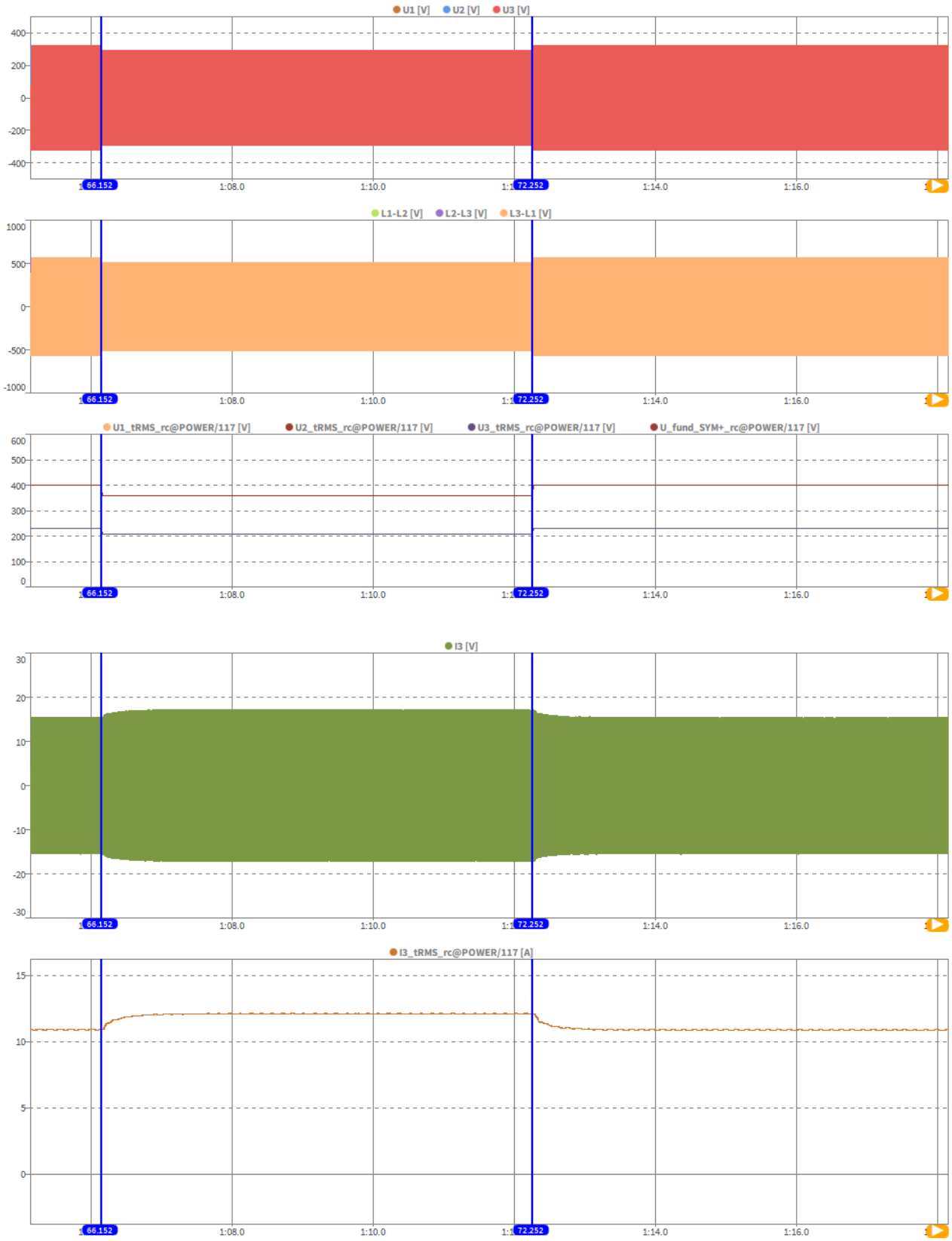

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.100
1:08.0
68.852
1:10.0
1:12.0
1:14.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

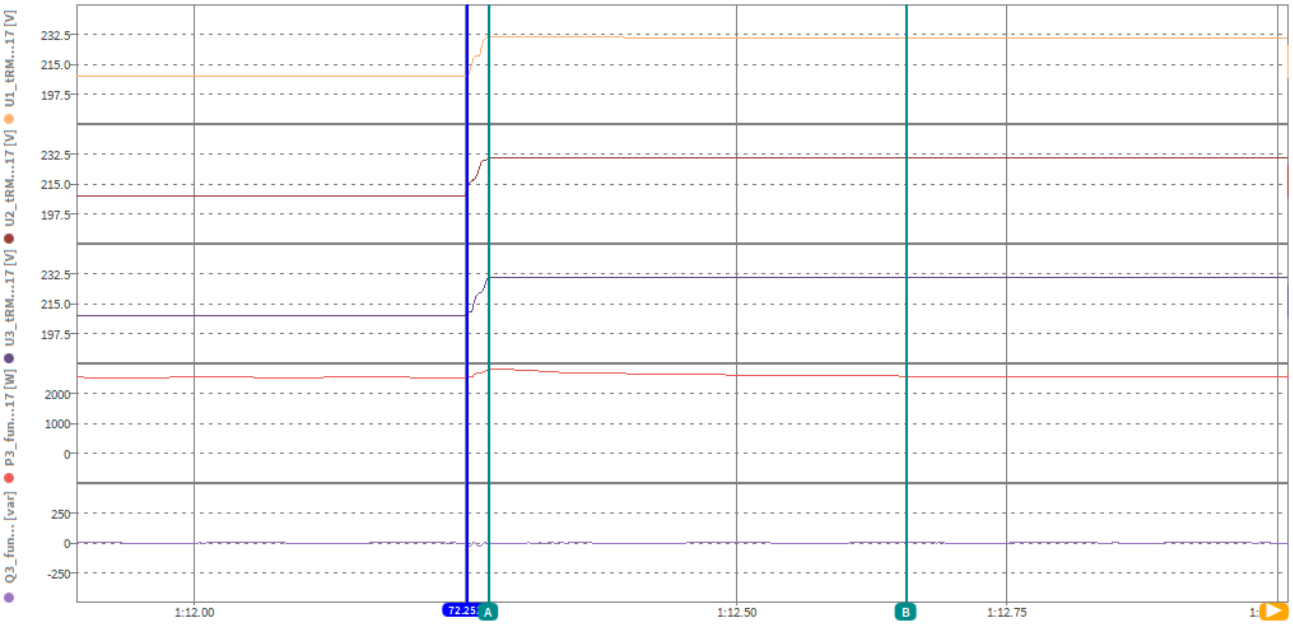



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:08.8697481 | 1:09.0016354 | 0.1318874 |
| U1_tRMS_rc@POWER/117 [V] | 229.3757 | 229.9864 | 0.610672 |
| U2_tRMS_rc@POWER/117 [V] | 230.7560 | 229.9965 | -0.759476 |
| U3_tRMS_rc@POWER/117 [V] | 228.8533 | 229.9792 | 1.125931 |
| P3_fund_rc@POWER/117 [W] | 805.3397 | 780.9505 | -24.38922 |
| Q3_fund_rc@POWER/117 [var] | -3.953234 | -8.565486 | -4.612252 |

## 5.1

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 5.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:31:47 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.90 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 6000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66152 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 72252 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 6100 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.900 | 0.900 | 0.900 |
| | 10 | | Positive sequence | | [p.u.] | 0.900 | 0.900 | 0.900 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.002 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.997 |
| | 14 | | Positive sequence | | | -- | -- | 0.997 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.012 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.900 | 0.900 | 0.900 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 1.026 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 1.048 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.000 |
| | 22 | | Positive sequence | | | -- | -- | 1.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.001 |
| | 25 | | Positive sequence | | | -- | -- | 1.001 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.385 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.012 |
| | 28 | | Positive sequence | | | -- | -- | 0.004 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

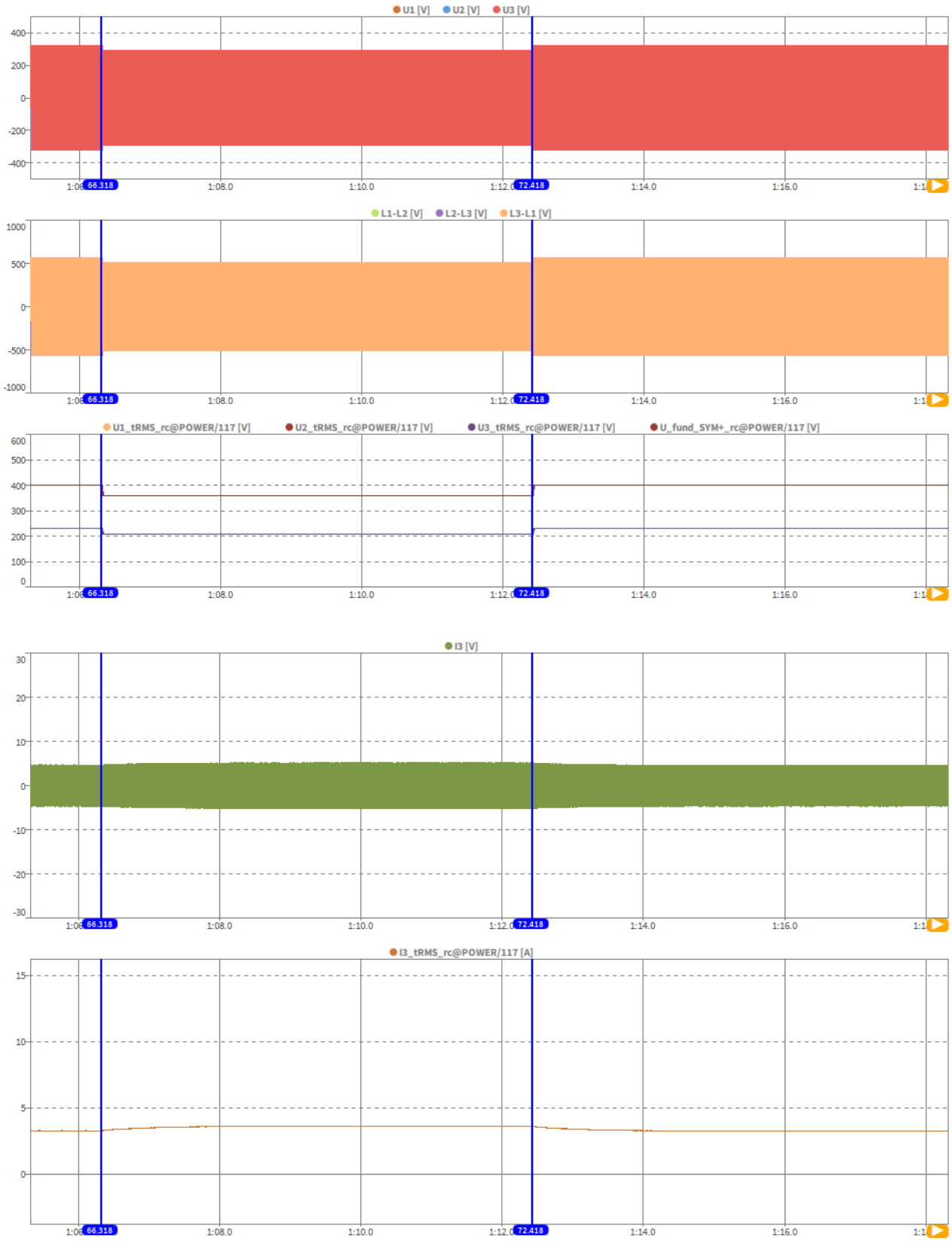

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.152
1:08.0
1:10.0
72.252
1:14.0
1:16.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

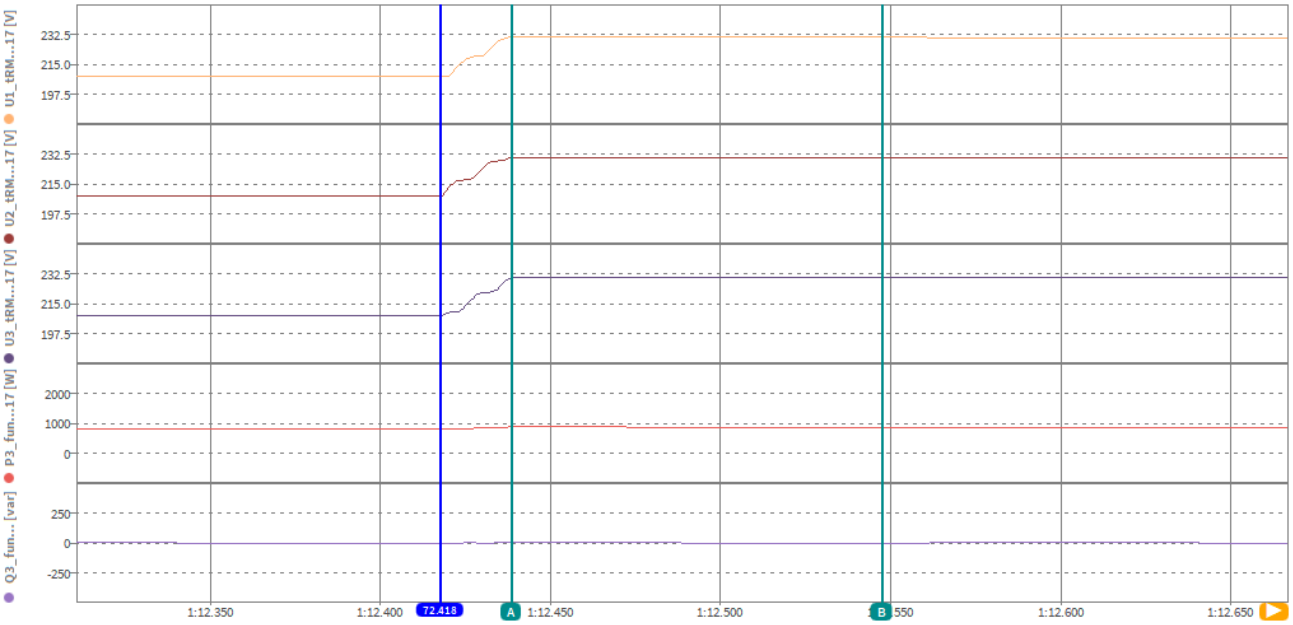



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:12.2725653 | 1:12.6572473 | 0.3846820 |
| U1_tRMS_rc@POWER/117 [V] | 230.1486 | 230.0019 | -0.146744 |
| U2_tRMS_rc@POWER/117 [V] | 230.0022 | 230.0079 | 5.692e-3 |
| U3_tRMS_rc@POWER/117 [V] | 229.9858 | 229.9810 | -4.761e-3 |
| P3_fund_rc@POWER/117 [W] | 2785.511 | 2546.554 | -238.9568 |
| Q3_fund_rc@POWER/117 [var] | -11.12067 | -8.285613 | 2.835053 |

## 5.2

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 5.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:27:25 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.90 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 6000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66318 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 72418 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 6100 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.900 | 0.900 | 0.900 |
| | 10 | | Positive sequence | | [p.u.] | 0.900 | 0.900 | 0.900 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.302 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.298 |
| | 14 | | Positive sequence | | | -- | -- | 0.298 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.004 |
| | 16 | | Positive sequence | | | -- | -- | 0.002 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.900 | 0.900 | 0.900 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.305 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.307 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.298 |
| | 22 | | Positive sequence | | | -- | -- | 0.298 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.298 |
| | 25 | | Positive sequence | | | -- | -- | 0.298 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.108 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.006 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

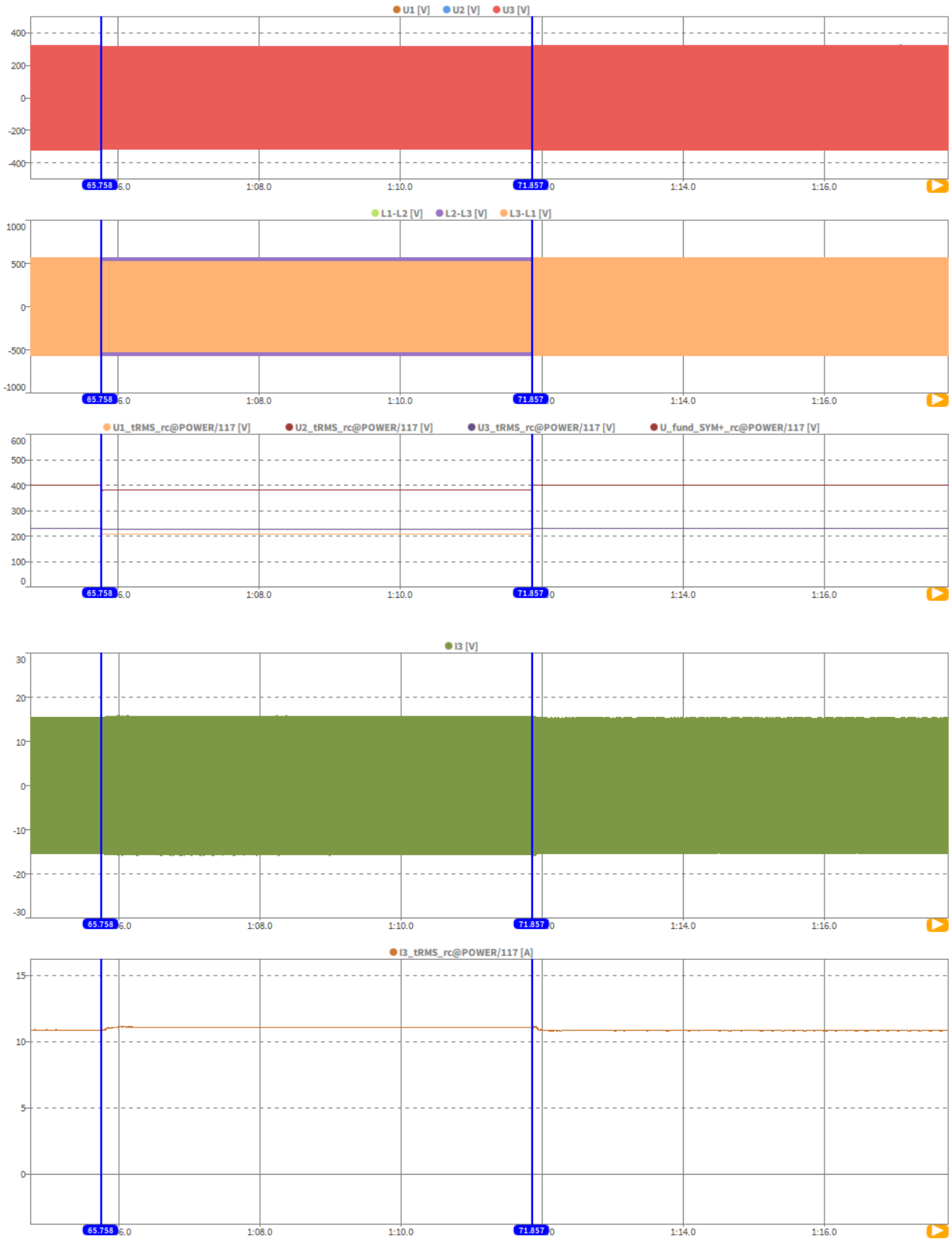

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.318
72.418
1:08.0
1:10.0
1:14.0
1:16.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

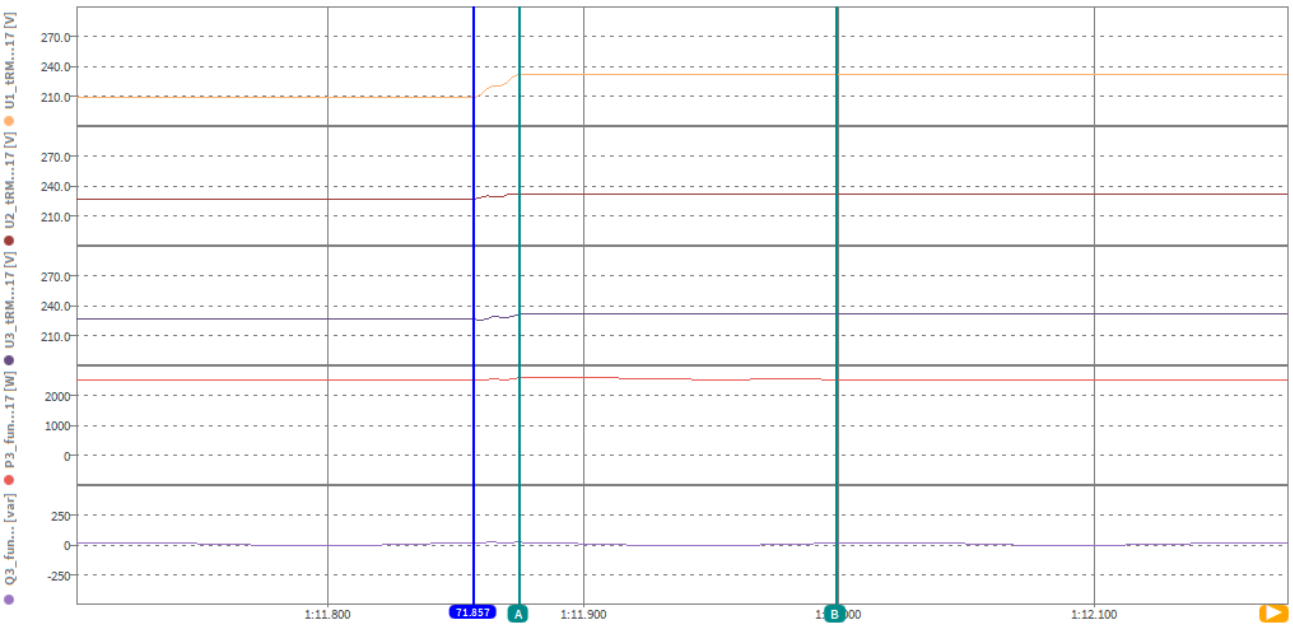



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:12.4387289 | 1:12.5474903 | 0.1087614 |
| U1_tRMS_rc@POWER/117 [V] | 230.1432 | 230.0611 | -0.082077 |
| U2_tRMS_rc@POWER/117 [V] | 229.3622 | 229.9936 | 0.631424 |
| U3_tRMS_rc@POWER/117 [V] | 229.2374 | 229.9633 | 0.725983 |
| P3_fund_rc@POWER/117 [W] | 832.7598 | 815.3904 | -17.36945 |
| Q3_fund_rc@POWER/117 [var] | -4.798260 | -12.90197 | -8.103713 |

## 5.3

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 5.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:24:17 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.90 | 0.98 | 0.98 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 6000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65758 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 71857 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 6099 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.900 | 0.980 | 0.980 |
| | 10 | | Positive sequence | | [p.u.] | 0.952 | 0.952 | 0.952 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.003 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.003 |
| | 14 | | Positive sequence | | | -- | -- | 1.003 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.013 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.900 | 0.980 | 0.980 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.997 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 1.006 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.000 |
| | 22 | | Positive sequence | | | -- | -- | 1.000 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.998 |
| | 25 | | Positive sequence | | | -- | -- | 0.998 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.124 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.013 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

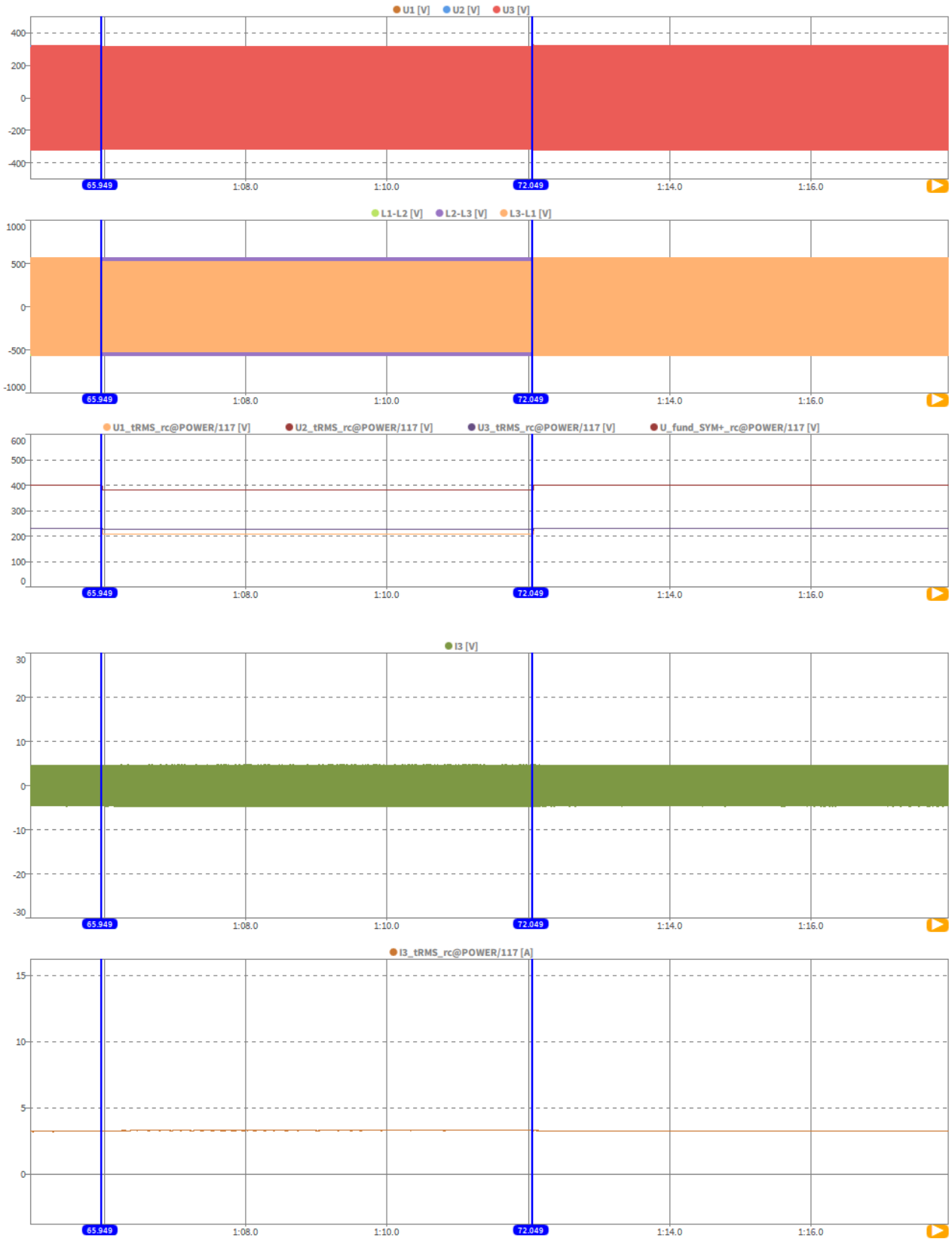

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
65.758
1:08.0
1:10.0
71.857
1:14.0
1:16.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

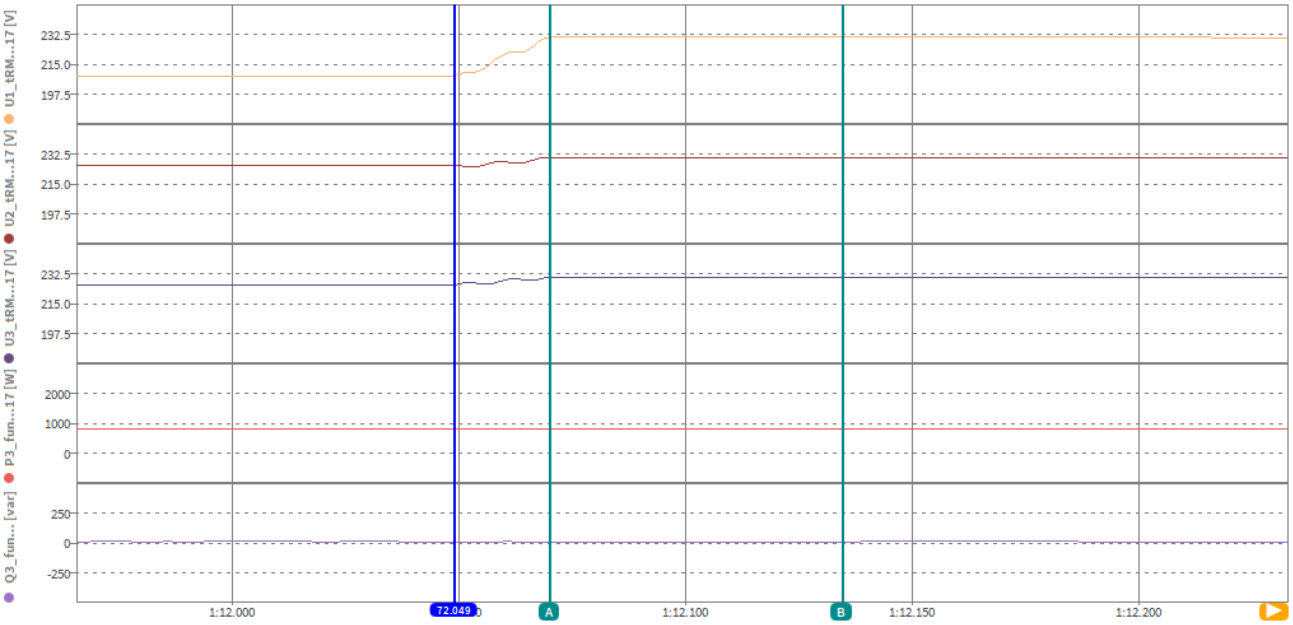



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:11.8748837 | 1:11.9988041 | 0.1239204 |
| U1_tRMS_rc@POWER/117 [V] | 229.7878 | 230.0802 | 0.292404 |
| U2_tRMS_rc@POWER/117 [V] | 230.5446 | 230.0006 | -0.544022 |
| U3_tRMS_rc@POWER/117 [V] | 229.6032 | 229.9834 | 0.380173 |
| P3_fund_rc@POWER/117 [W] | 2552.821 | 2503.323 | -49.49707 |
| Q3_fund_rc@POWER/117 [var] | 13.18086 | 4.347608 | -8.833248 |

## 5.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 5.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:16:02 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 0.90 | 0.98 | 0.98 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 6000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65949 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 72049 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 6100 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 0.900 | 0.980 | 0.980 |
| | 10 | | Positive sequence | | [p.u.] | 0.952 | 0.952 | 0.952 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.298 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.298 |
| | 14 | | Positive sequence | | | -- | -- | 0.298 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.006 |
| | 16 | | Positive sequence | | | -- | -- | 0.002 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 0.900 | 0.980 | 0.980 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.297 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.298 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.298 |
| | 22 | | Positive sequence | | | -- | -- | 0.298 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.300 |
| | 25 | | Positive sequence | | | -- | -- | 0.300 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.064 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.005 |
| | 28 | | Positive sequence | | | -- | -- | 0.001 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

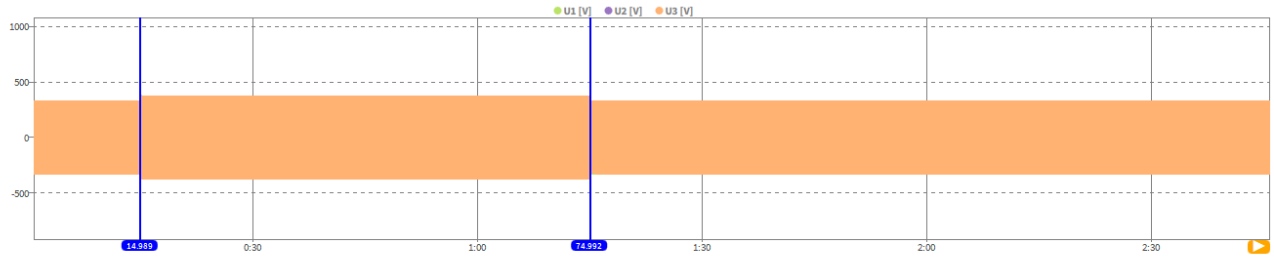

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
65.949
1:08.0
1:10.0
72.049
1:14.0
1:16.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

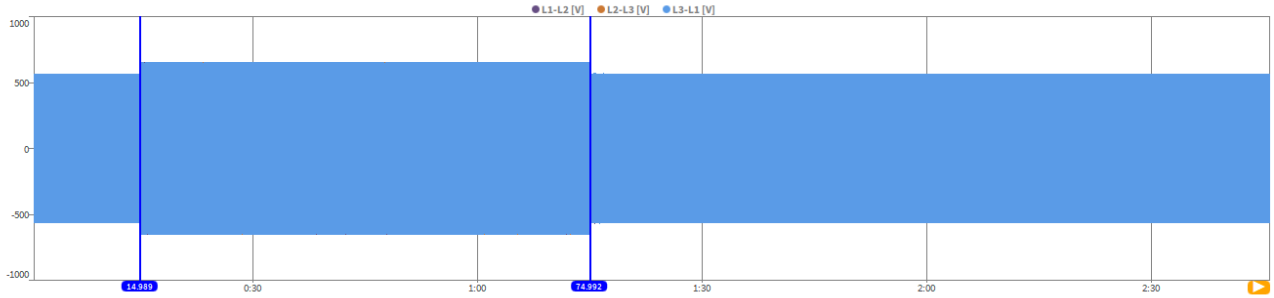


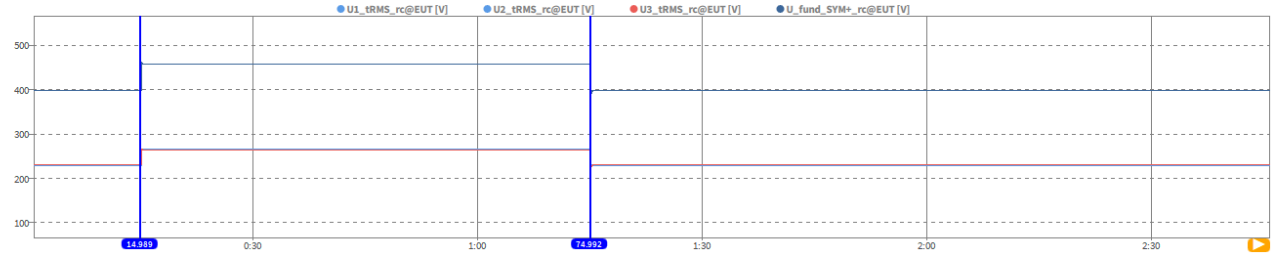

| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:12.07010053 | 1:12.13457469 | 0.06447416 |
| U1_tRMS_rc@POWER/117 [V] | 230.1507 | 230.1282 | -0.022507 |
| U2_tRMS_rc@POWER/117 [V] | 230.0115 | 229.9958 | -0.015701 |
| U3_tRMS_rc@POWER/117 [V] | 229.9796 | 229.9829 | 3.296e-3 |
| P3_fund_rc@POWER/117 [W] | 761.9740 | 756.4218 | -5.552185 |
| Q3_fund_rc@POWER/117 [var] | -4.762259 | -0.414977 | 4.347282 |

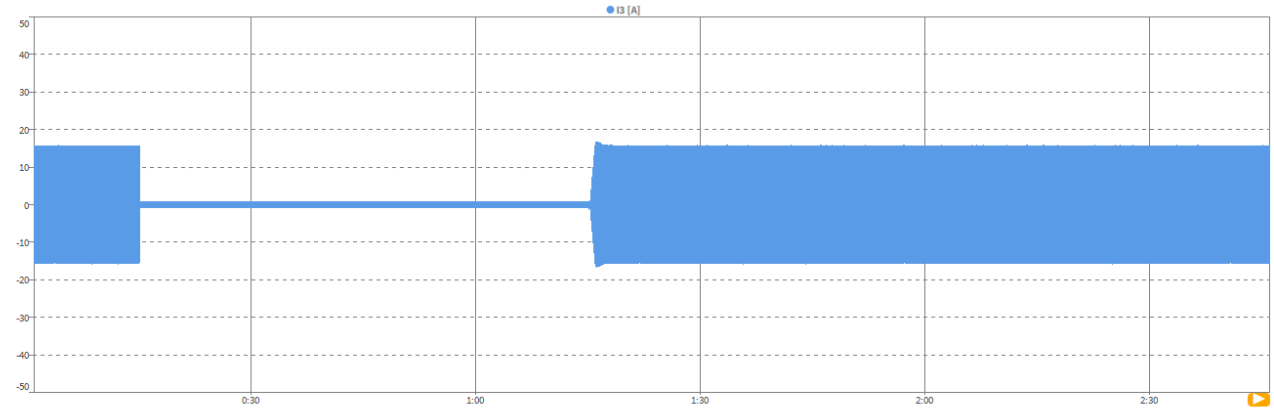
## 6.1

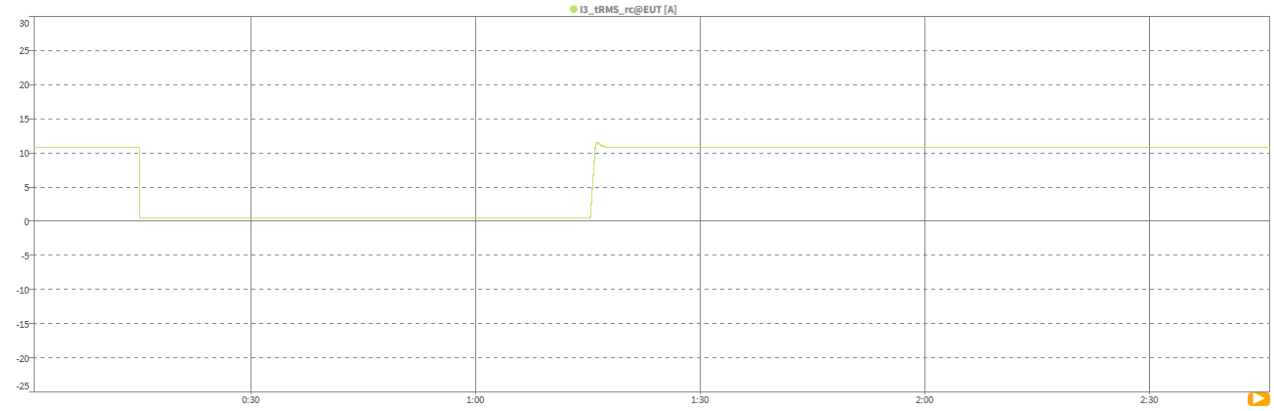
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 6.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 17:35:38 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.15 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 60000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 14989 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 74992 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 60003 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.154 | 1.148 | 1.151 |
| | 10 | | Positive sequence | | [p.u.] | 1.148 | 1.148 | 1.148 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.991 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.994 |
| | 14 | | Positive sequence | | | -- | -- | 0.994 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.017 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.154 | 1.148 | 1.151 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.045 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.045 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.001 |
| | 22 | | Positive sequence | | | -- | -- | 0.001 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.995 |
| | 25 | | Positive sequence | | | -- | -- | 0.995 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.778 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.017 |
| | 28 | | Positive sequence | | | -- | -- | 0.004 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

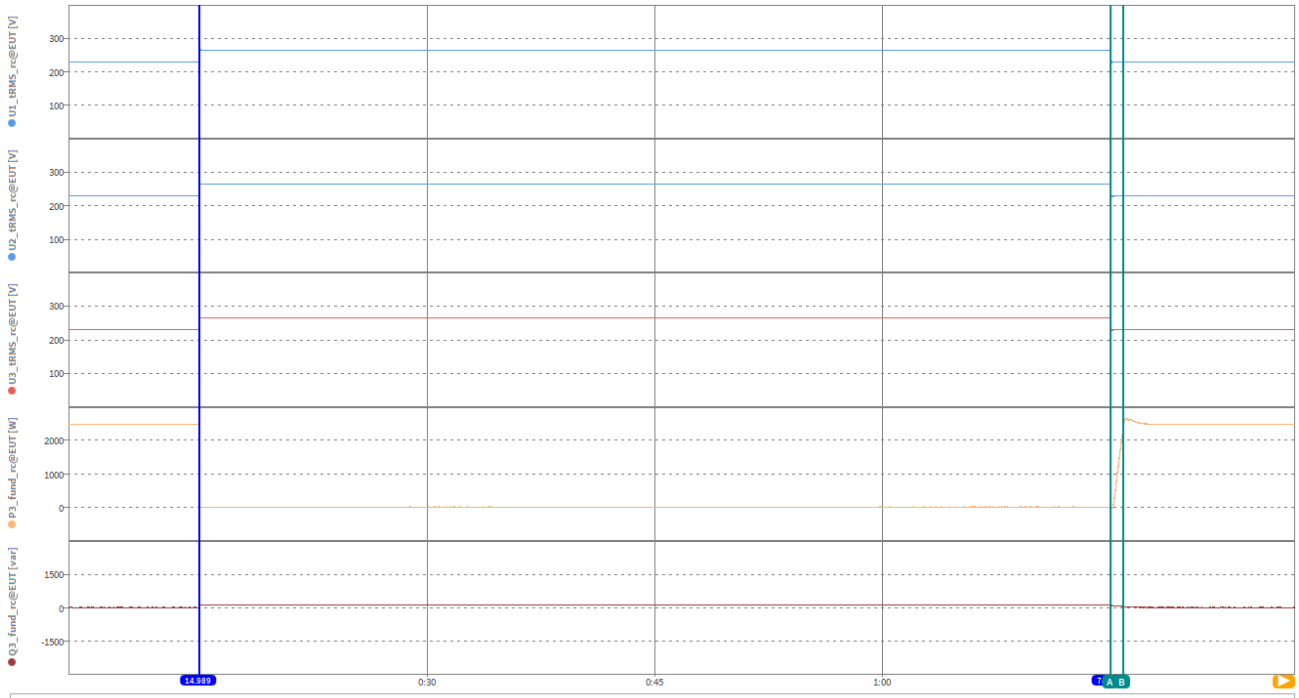

U1 [V]
U2 [V]
U3 [V]
1000
500
0
-500
14.989
74.992
0:30
1:00
1:30
2:00
2:30


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
14.989
74.992
0:30
1:00
1:30
2:00
2:30


U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
500
400
300
200
100
14.989
74.992
0:30
1:00
1:30
2:00
2:30


I3 [A]
50
40
30
20
10
0
-10
-20
-30
-40
-50
0:30
1:00
1:30
2:00
2:30

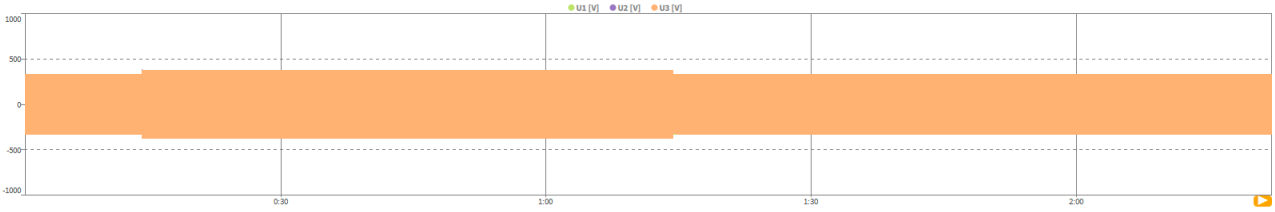

I3_tRMS_rc@EUT [A]
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
0:30
1:00
1:30
2:00
2:30

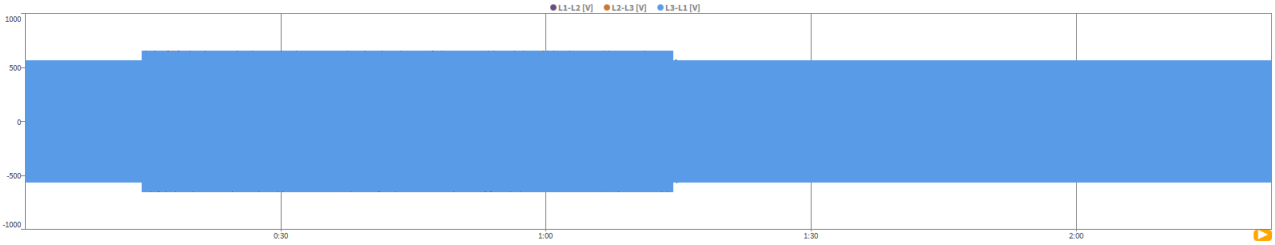


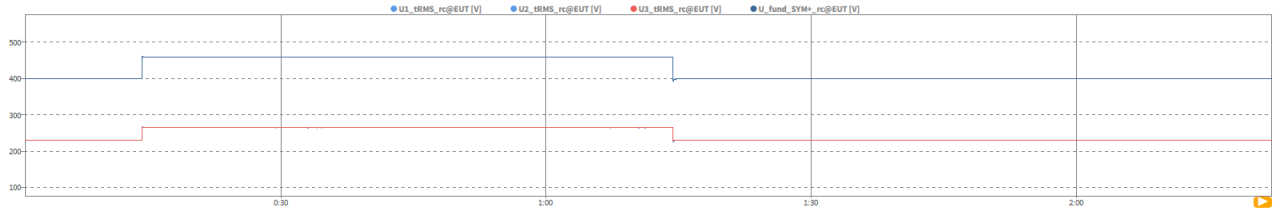

| | A | B | Delta |
|---|---|---|---|
| Time [s] | 1:15.0120 | 1:15.7895 | 0.7775 |
| U1_tRMS_rc@EUT [V] | 236.2305 | 230.5171 | -5.713379 |
| U2_tRMS_rc@EUT [V] | 233.3821 | 229.3139 | -4.068222 |
| U3_tRMS_rc@EUT [V] | 243.1334 | 230.3880 | -12.74544 |
| P3_fund_rc@EUT [W] | 3.579363 | 2324.271 | 2320.692 |
| Q3_fund_rc@EUT [var] | 105.7810 | 60.62902 | -45.15197 |

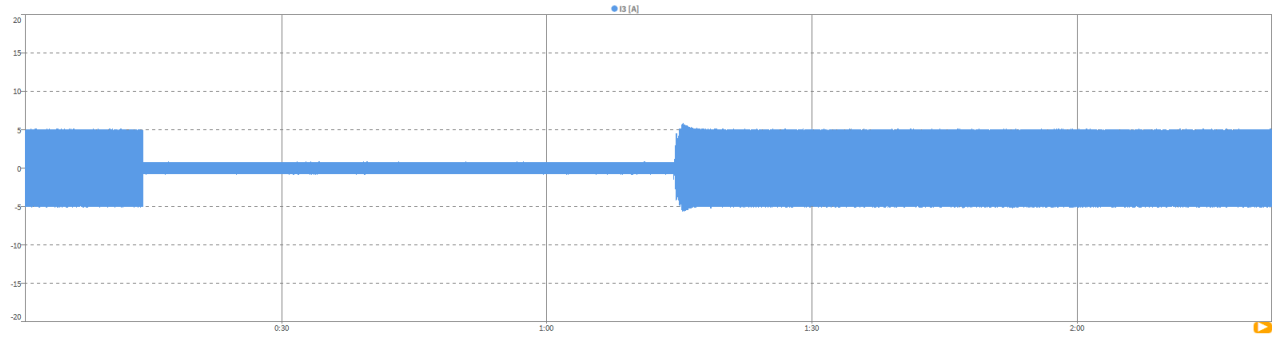
## 6.2

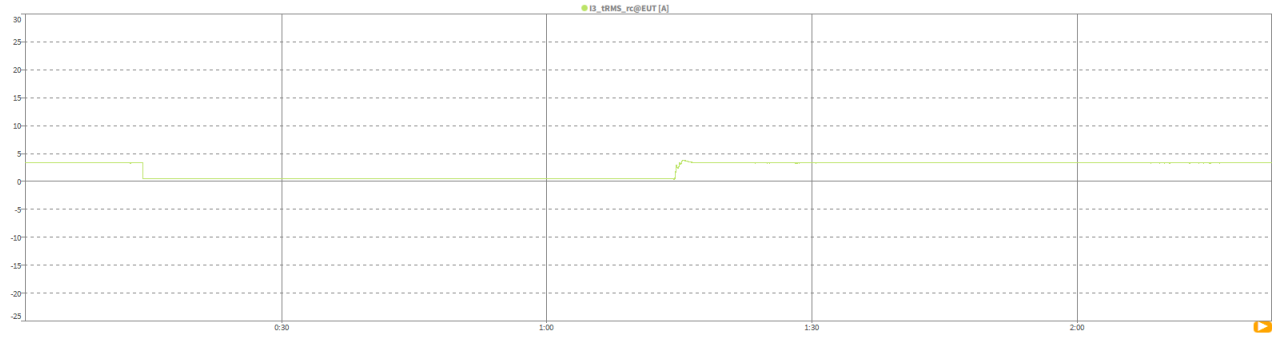
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 6.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:39:29 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.15 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 60000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 14264 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 74270 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 60006 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.154 | 1.148 | 1.151 |
| | 10 | | Positive sequence | | [p.u.] | 1.151 | 1.151 | 1.151 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.304 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.305 |
| | 14 | | Positive sequence | | | -- | -- | 0.305 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.016 |
| | 16 | | Positive sequence | | | -- | -- | 0.006 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.154 | 1.148 | 1.151 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.044 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.044 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.001 |
| | 22 | | Positive sequence | | | -- | -- | 0.001 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.305 |
| | 25 | | Positive sequence | | | -- | -- | 0.305 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.834 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.016 |
| | 28 | | Positive sequence | | | -- | -- | 0.005 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

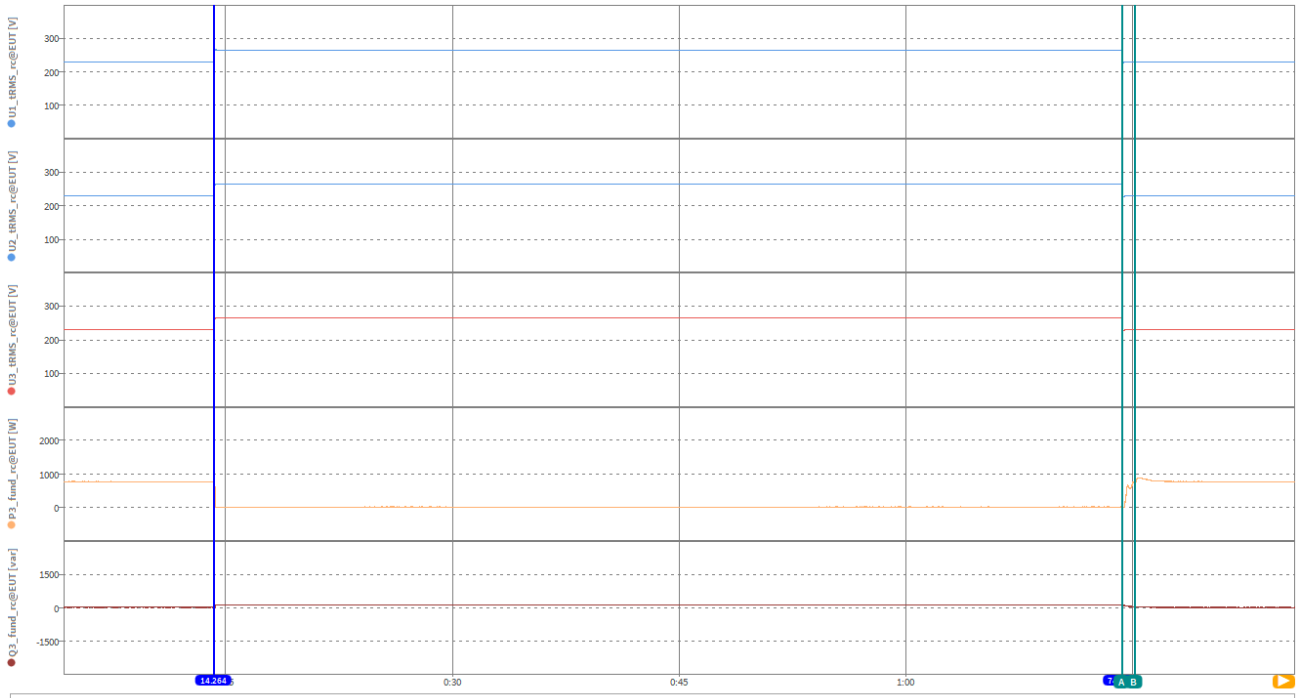

U1 [V]
U2 [V]
U3 [V]
1000
500
0
-500
-1000
0:30
1:00
1:30
2:00


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
0:30
1:00
1:30
2:00


U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
500
400
300
200
100
0:30
1:00
1:30
2:00


I3 [A]
20
15
10
5
0
-5
-10
-15
-20
0:30
1:00
1:30
2:00

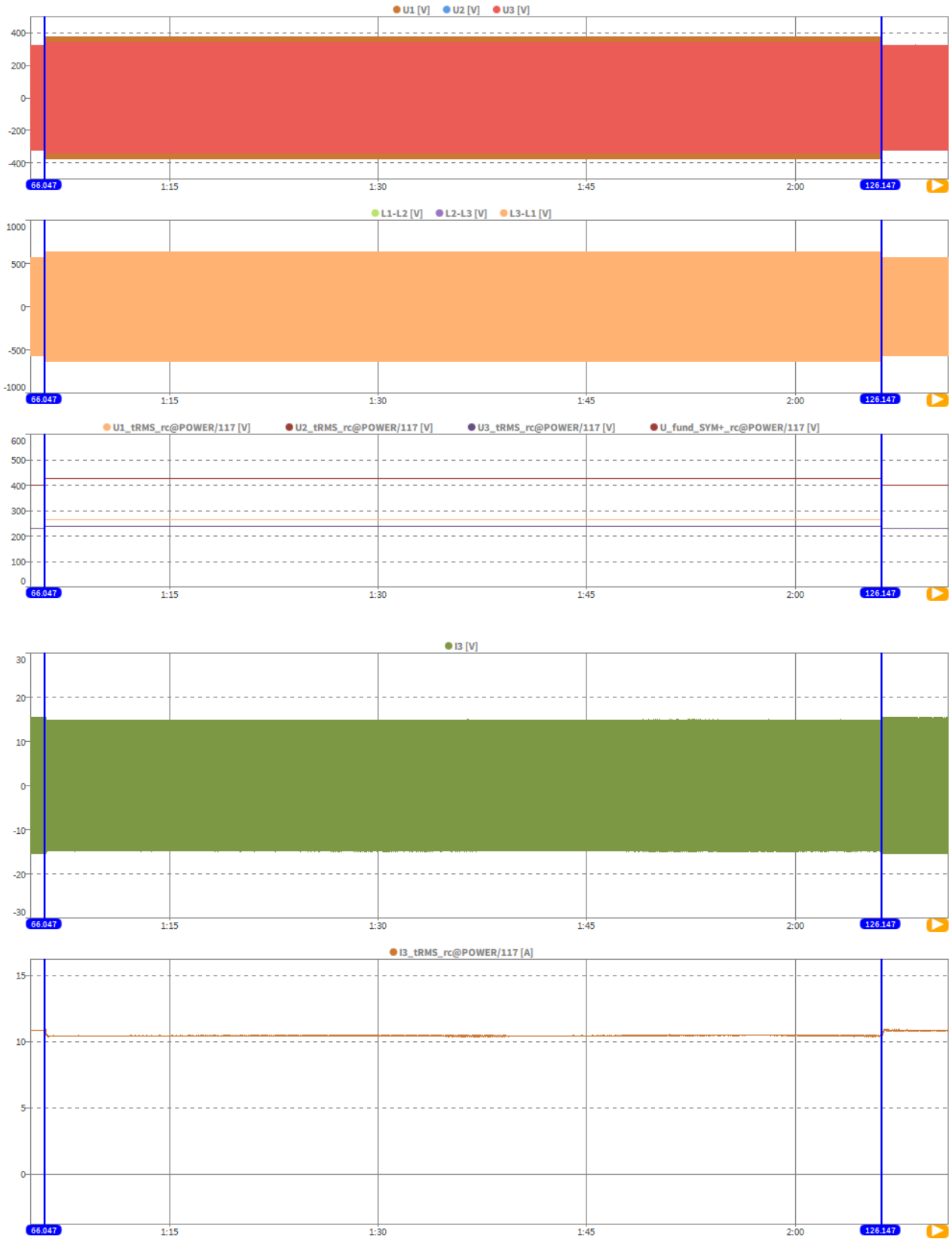

I3_tRMS_rc@EUT [A]
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
0:30
1:00
1:30
2:00

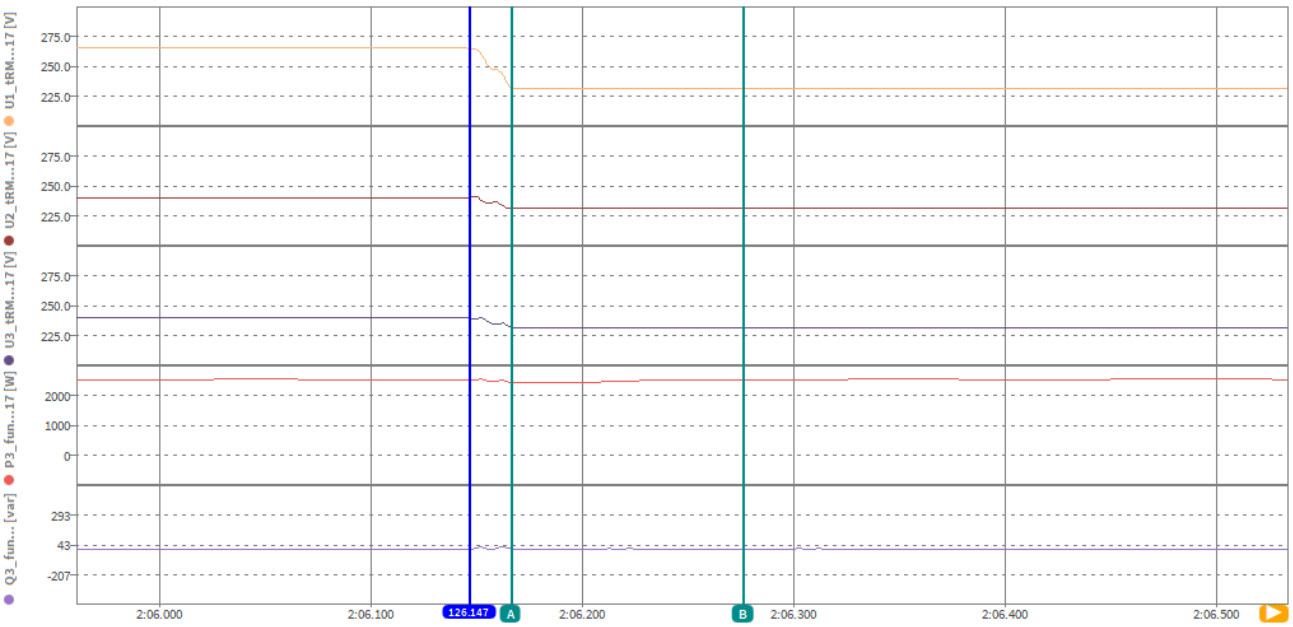



| | A | B | Delta |
|---|---|---|---|
| Time [s] | 1:14.2900 | 1:15.1243 | 0.8343 |
| U1_tRMS_rc@EUT [V] | 230.9691 | 230.4570 | -0.512100 |
| U2_tRMS_rc@EUT [V] | 231.2457 | 229.3382 | -1.907471 |
| U3_tRMS_rc@EUT [V] | 232.8216 | 230.2453 | -2.576233 |
| P3_fund_rc@EUT [W] | 6.378707 | 711.3748 | 704.9961 |
| Q3_fund_rc@EUT [var] | 99.50056 | 36.01693 | -63.48363 |

## 6.3

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 6.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 15:52:23 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.15 | 1.04 | 1.04 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 60000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66047 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 126147 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 60100 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.150 | 1.040 | 1.040 |
| | 10 | | Positive sequence | | [p.u.] | 1.075 | 1.075 | 1.075 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.001 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.001 |
| | 14 | | Positive sequence | | | -- | -- | 1.001 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.013 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.150 | 1.040 | 1.040 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 1.000 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.997 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.030 |
| | 22 | | Positive sequence | | | -- | -- | 1.030 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.997 |
| | 25 | | Positive sequence | | | -- | -- | 0.997 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.110 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.014 |
| | 28 | | Positive sequence | | | -- | -- | 0.005 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

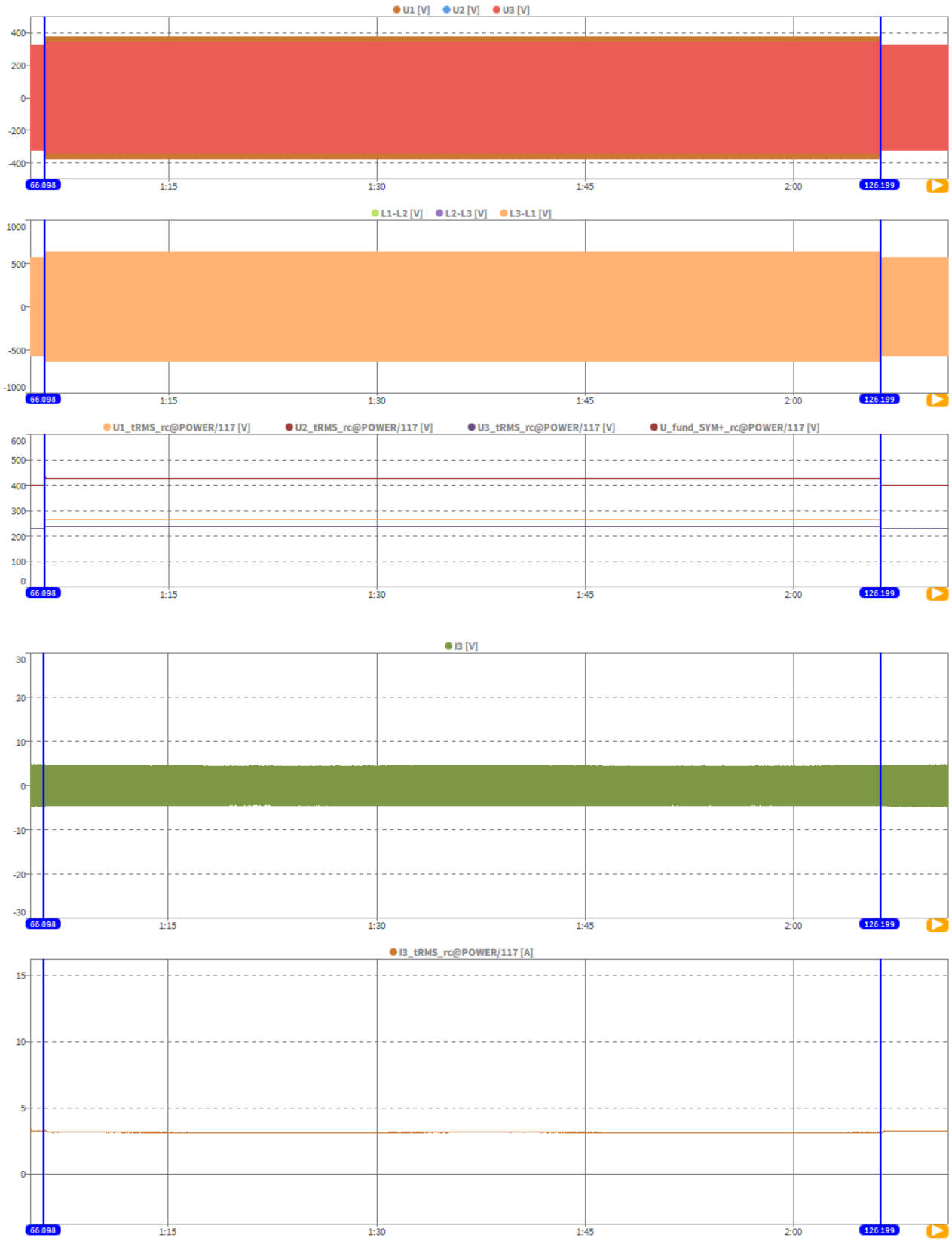

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.047
1:15
1:30
1:45
2:00
126.147
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
5

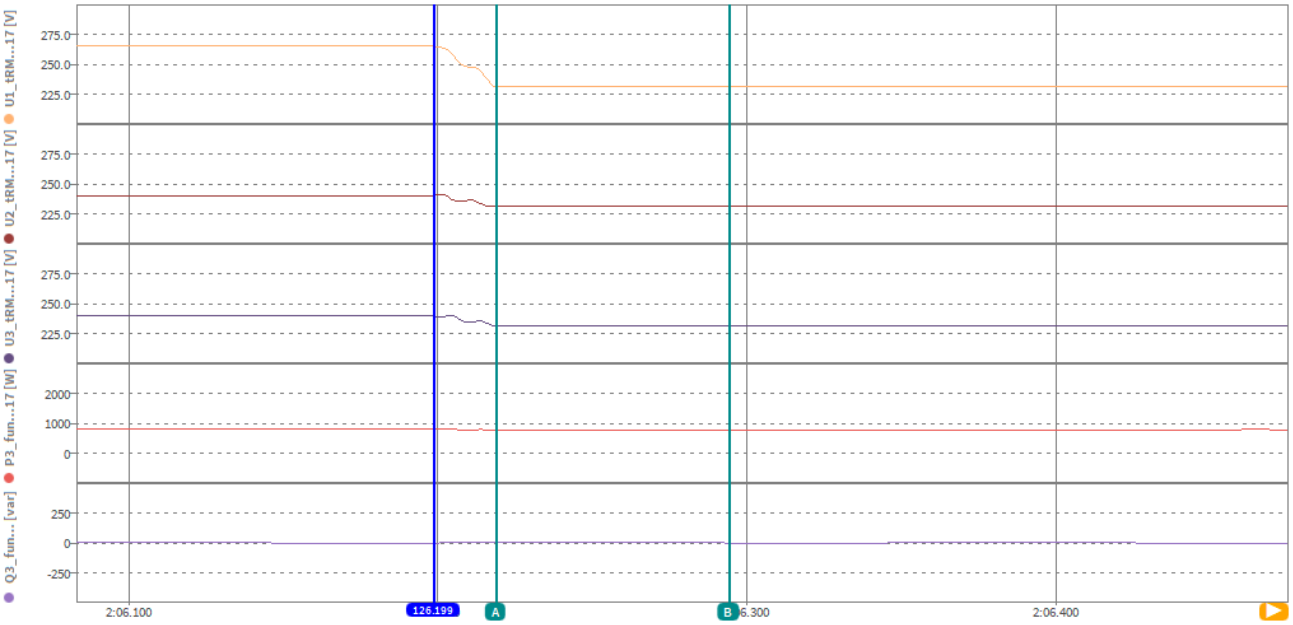



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 2:06.1665 | 2:06.2764 | 0.1099 |
| U1_tRMS_rc@POWER/117 [V] | 234.0109 | 229.8458 | -4.165115 |
| U2_tRMS_rc@POWER/117 [V] | 230.0947 | 230.0166 | -0.078125 |
| U3_tRMS_rc@POWER/117 [V] | 232.1736 | 229.9822 | -2.191360 |
| P3_fund_rc@POWER/117 [W] | 2438.918 | 2468.803 | 29.88501 |
| Q3_fund_rc@POWER/117 [var] | 5.256660 | -2.246864 | -7.503524 |

## 6.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 6.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 16:01:23 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.15 | 1.04 | 1.04 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 60000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66098 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 126199 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 60101 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.150 | 1.040 | 1.040 |
| | 10 | | Positive sequence | | [p.u.] | 1.075 | 1.075 | 1.075 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.300 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.300 |
| | 14 | | Positive sequence | | | -- | -- | 0.300 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.006 |
| | 16 | | Positive sequence | | | -- | -- | 0.004 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.994 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.150 | 1.040 | 1.040 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.303 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.299 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.300 |
| | 22 | | Positive sequence | | | -- | -- | 0.300 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.301 |
| | 25 | | Positive sequence | | | -- | -- | 0.301 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.075 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.007 |
| | 28 | | Positive sequence | | | -- | -- | 0.004 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

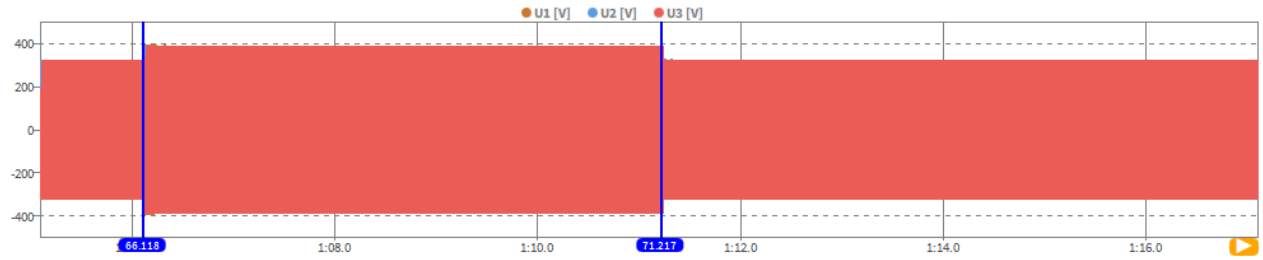

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.098
1:15
1:30
1:45
2:00
126.199
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

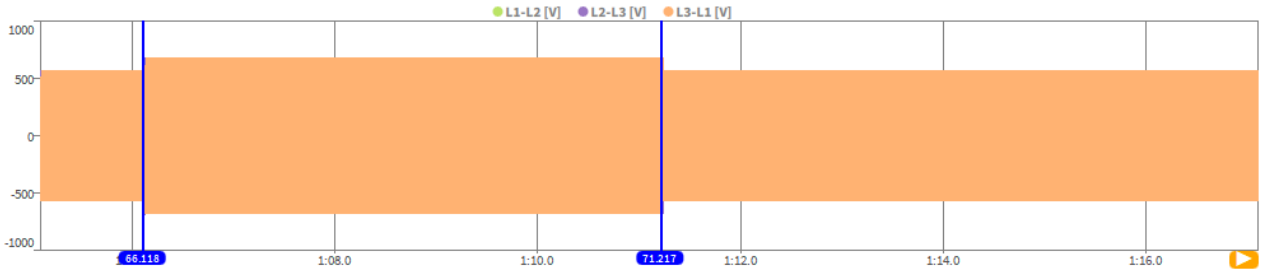


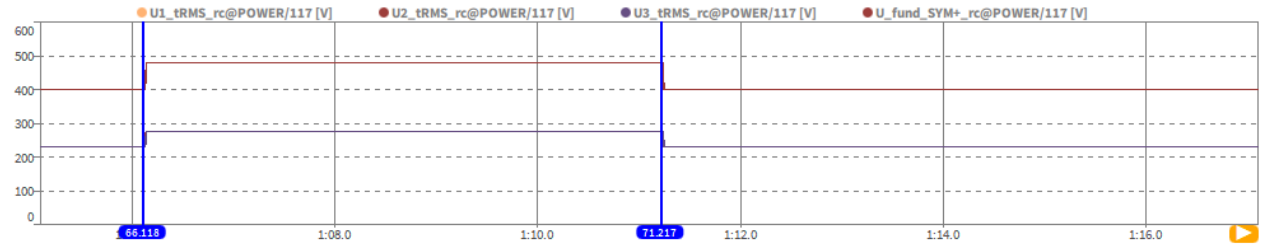

| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 2:06.2189296 | 2:06.2941916 | 0.0752620 |
| U1_tRMS_rc@POWER/117 [V] | 232.1778 | 229.9329 | -2.244827 |
| U2_tRMS_rc@POWER/117 [V] | 229.8154 | 230.0252 | 0.209763 |
| U3_tRMS_rc@POWER/117 [V] | 231.3486 | 229.9785 | -1.370087 |
| P3_fund_rc@POWER/117 [W] | 727.5322 | 731.9045 | 4.372314 |
| Q3_fund_rc@POWER/117 [var] | -9.109614 | -10.91420 | -1.804582 |

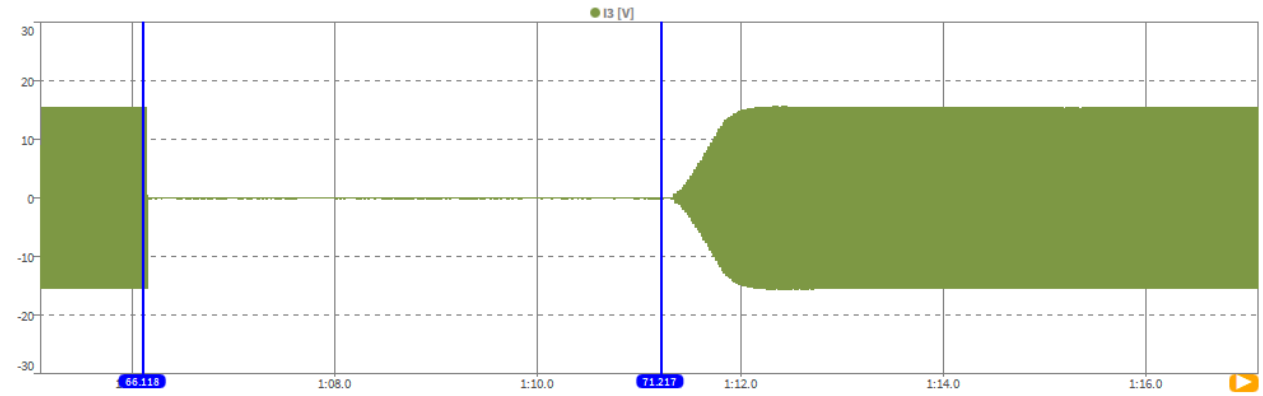
## 7.1

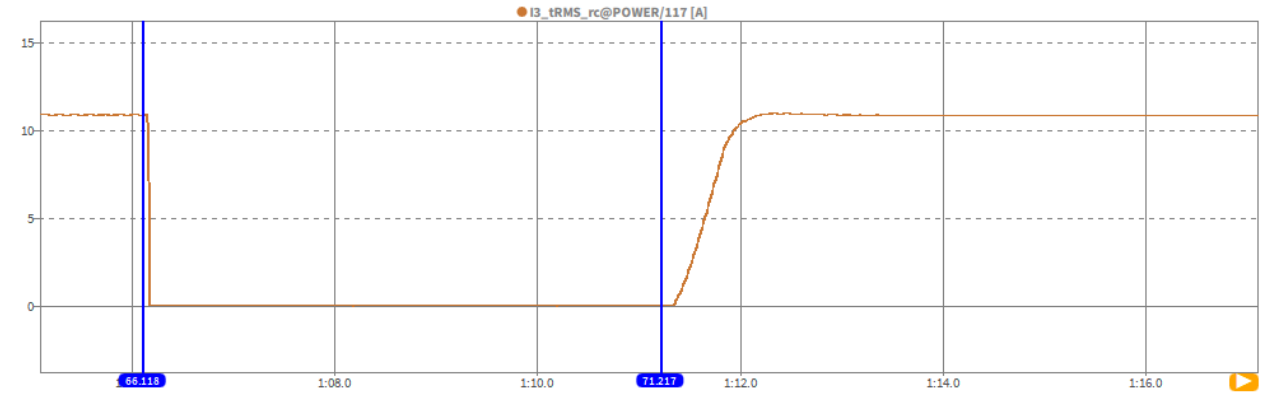
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 7.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 12:00:58 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.20 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 5000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66118 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 71217 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 5099 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.200 | 1.200 | 1.199 |
| | 10 | | Positive sequence | | [p.u.] | 1.200 | 1.200 | 1.200 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.003 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.003 |
| | 14 | | Positive sequence | | | -- | -- | 1.003 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.012 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.200 | 1.200 | 1.199 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.005 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.006 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.001 |
| | 22 | | Positive sequence | | | -- | -- | 0.001 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.999 |
| | 25 | | Positive sequence | | | -- | -- | 0.999 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.671 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.012 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

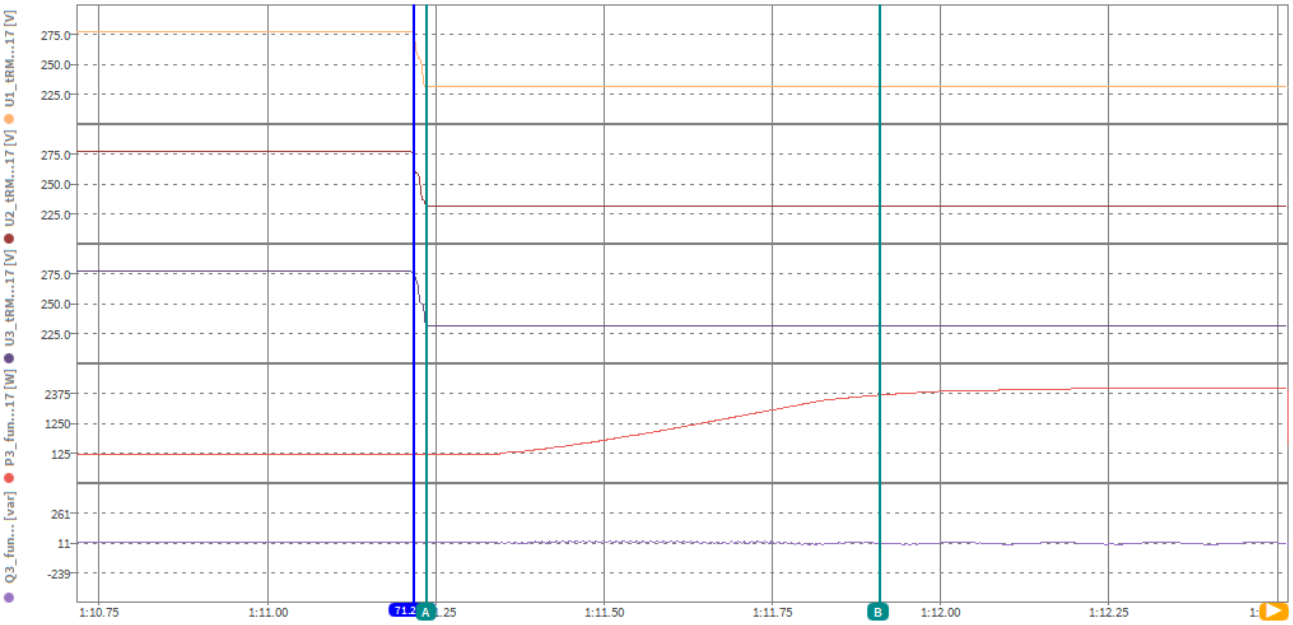

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.118
1:08.0
1:10.0
71.217
1:12.0
1:14.0
1:16.0


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
66.118
1:08.0
1:10.0
71.217
1:12.0
1:14.0
1:16.0


U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
66.118
1:08.0
1:10.0
71.217
1:12.0
1:14.0
1:16.0


I3 [V]
30
20
10
0
-10
-20
-30
66.118
1:08.0
1:10.0
71.217
1:12.0
1:14.0
1:16.0

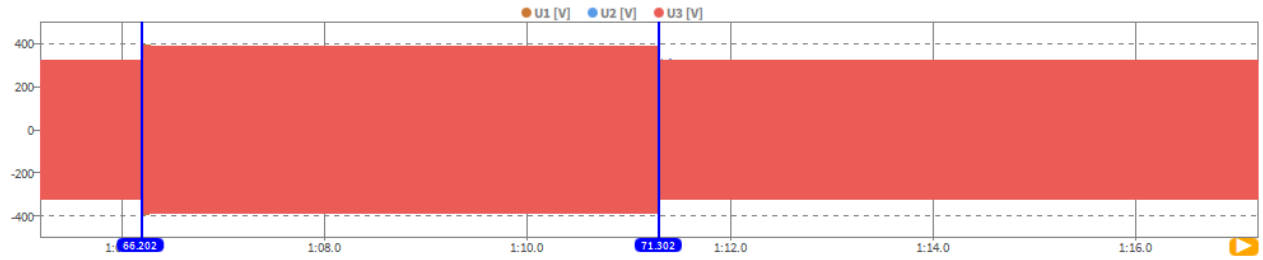

I3_tRMS_rc@POWER/117 [A]
15
10
5
0
66.118
1:08.0
1:10.0
71.217
1:12.0
1:14.0
1:16.0

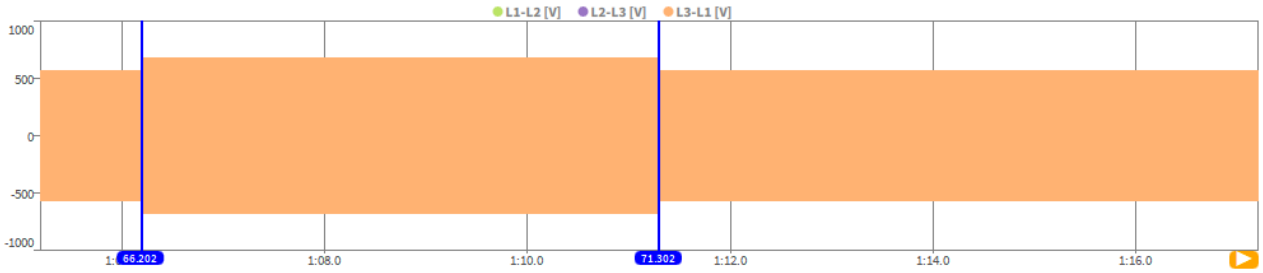


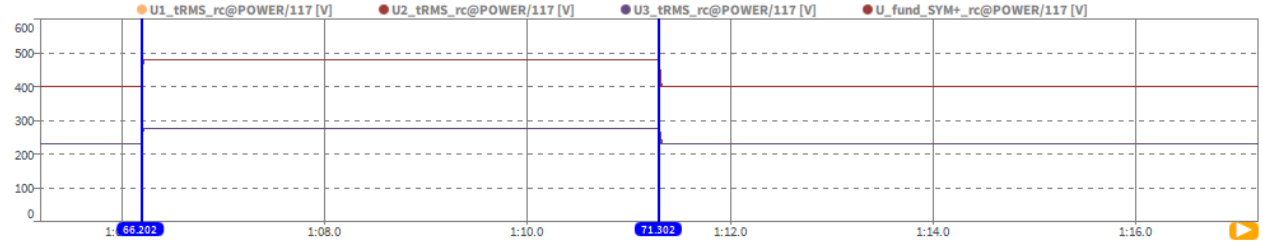

| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:11.2376315 | 1:11.9084715 | 0.6708400 |
| U1_tRMS_rc@POWER/117 [V] | 229.8852 | 230.0014 | 0.116196 |
| U2_tRMS_rc@POWER/117 [V] | 232.4678 | 230.0049 | -2.462967 |
| U3_tRMS_rc@POWER/117 [V] | 233.1513 | 229.9834 | -3.167847 |
| P3_fund_rc@POWER/117 [W] | 1.984934 | 2272.032 | 2270.048 |
| Q3_fund_rc@POWER/117 [var] | 3.637551 | -2.297878 | -5.935429 |

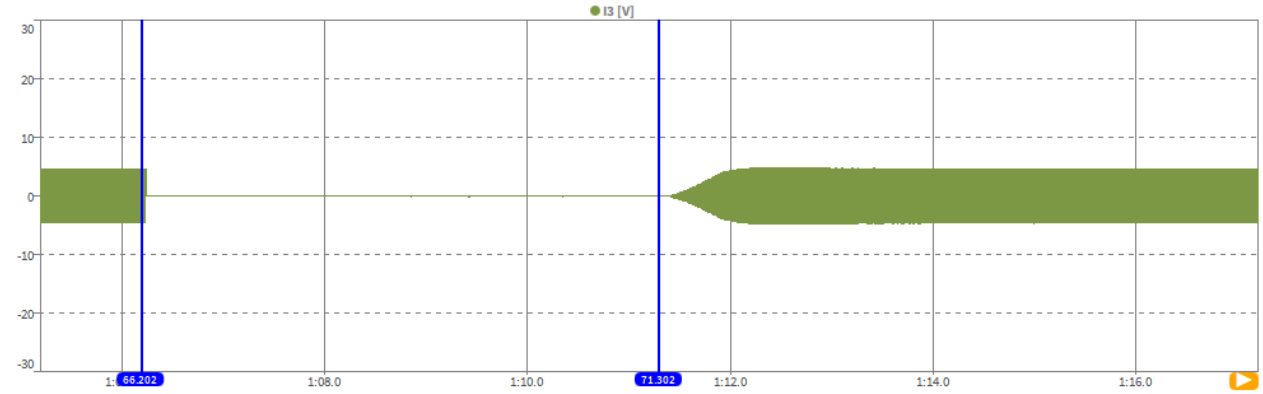
## 7.2

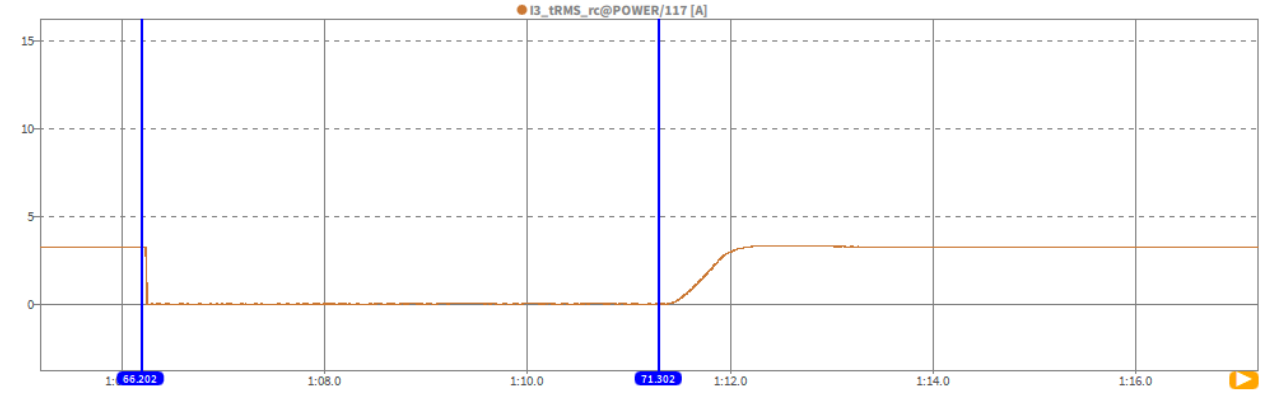
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 7.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:56:45 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.20 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 5000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66202 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 71302 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 5100 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.200 | 1.200 | 1.200 |
| | 10 | | Positive sequence | | [p.u.] | 1.197 | 1.197 | 1.197 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.298 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.298 |
| | 14 | | Positive sequence | | | -- | -- | 0.298 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.005 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.994 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.200 | 1.200 | 1.200 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.060 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.070 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.002 |
| | 22 | | Positive sequence | | | -- | -- | 0.002 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.298 |
| | 25 | | Positive sequence | | | -- | -- | 0.298 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.795 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.005 |
| | 28 | | Positive sequence | | | -- | -- | 0.001 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

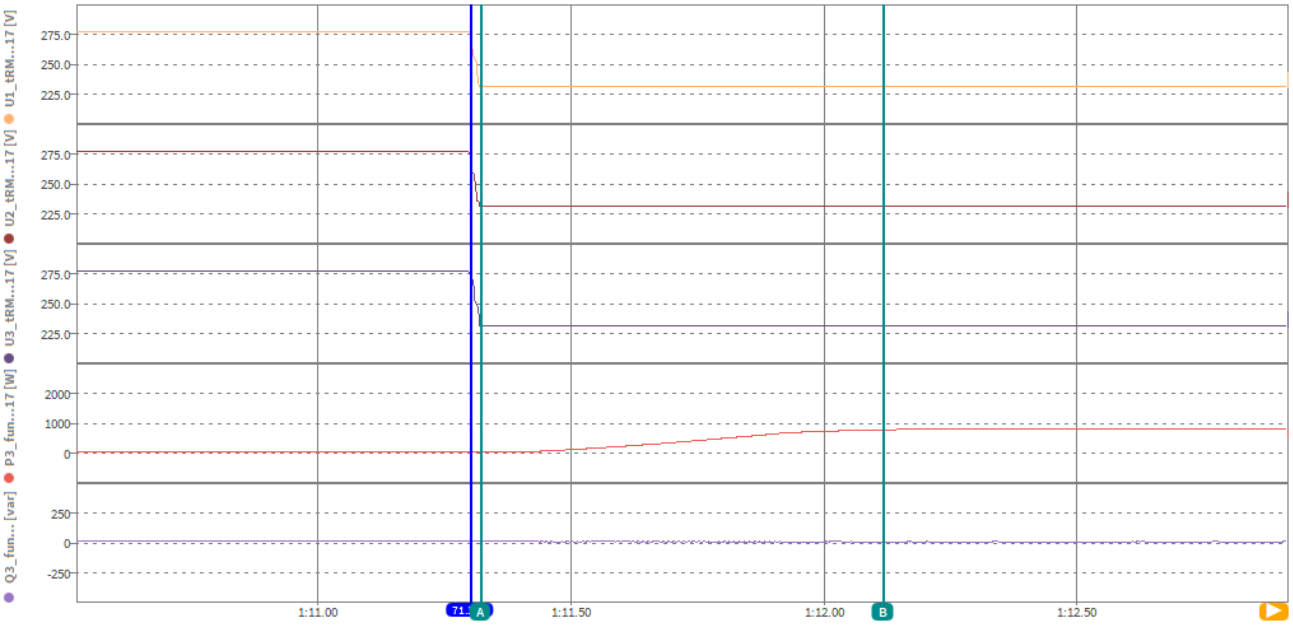

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
1:06.202
1:08.0
1:10.0
1:10.302
1:12.0
1:14.0
1:16.0


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
1:06.202
1:08.0
1:10.0
1:10.302
1:12.0
1:14.0
1:16.0


U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
1:06.202
1:08.0
1:10.0
1:10.302
1:12.0
1:14.0
1:16.0


I3 [V]
30
20
10
0
-10
-20
-30
1:06.202
1:08.0
1:10.0
1:10.302
1:12.0
1:14.0
1:16.0

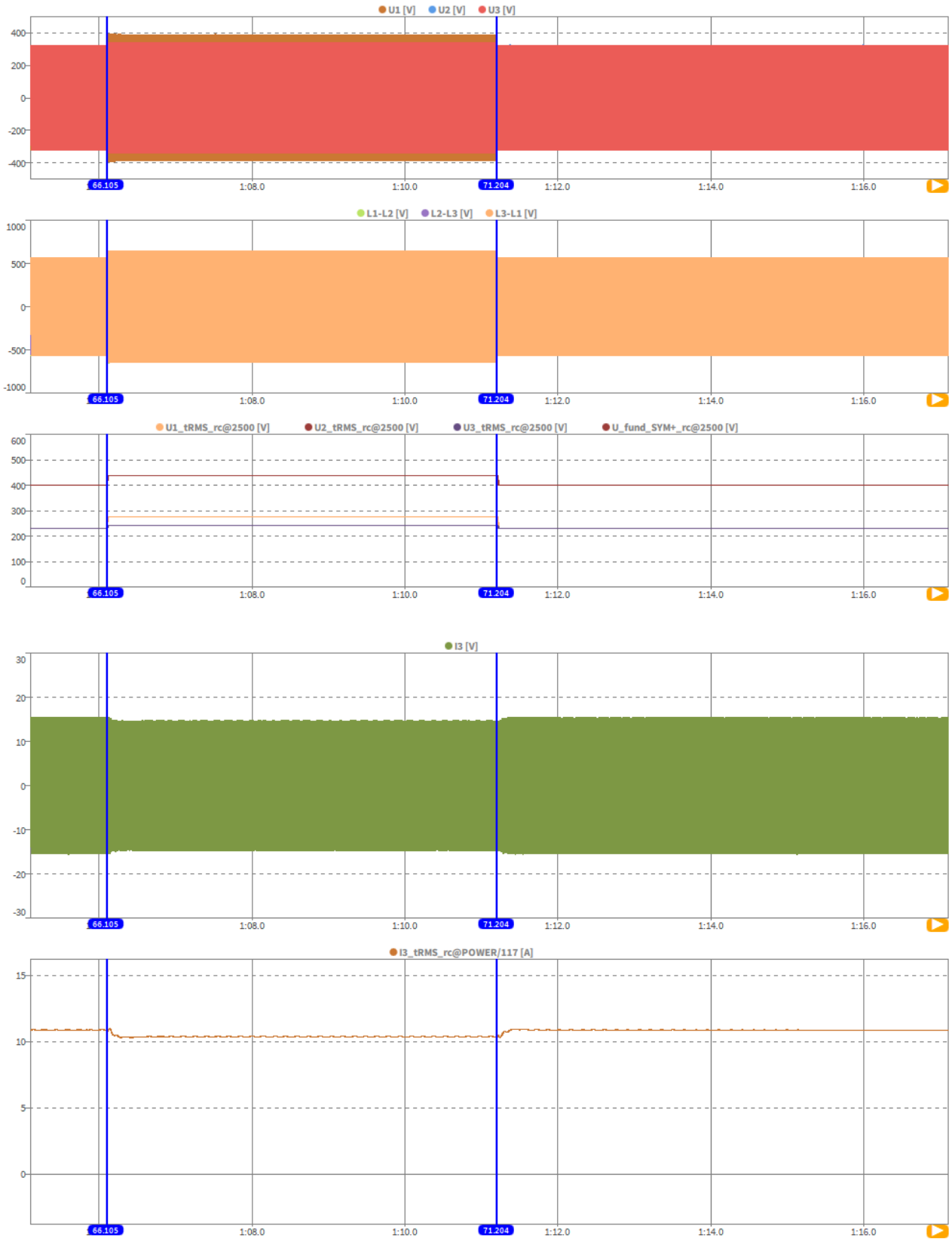

I3_tRMS_rc@POWER/117 [A]
15
10
5
0
1:06.202
1:08.0
1:10.0
1:10.302
1:12.0
1:14.0
1:16.0

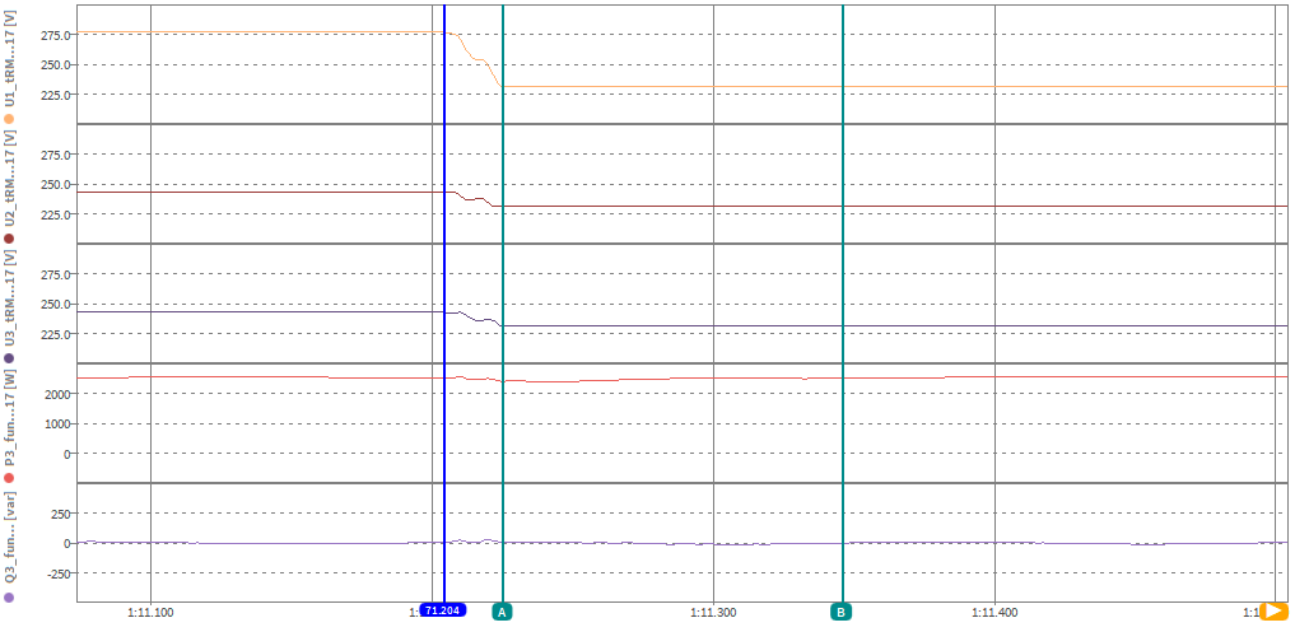



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:11.3223008 | 1:12.1172946 | 0.7949938 |
| U1_tRMS_rc@POWER/117 [V] | 230.1624 | 229.9999 | -0.162476 |
| U2_tRMS_rc@POWER/117 [V] | 233.5844 | 230.0085 | -3.575897 |
| U3_tRMS_rc@POWER/117 [V] | 236.1706 | 229.9852 | -6.185379 |
| P3_fund_rc@POWER/117 [W] | -4.547863 | 736.7382 | 741.2861 |
| Q3_fund_rc@POWER/117 [var] | 2.841636 | -2.870855 | -5.712491 |

## 7.3

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 7.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 16:13:51 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.20 | 1.05 | 1.05 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 5000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66105 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 71204 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 5099 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.200 | 1.050 | 1.050 |
| | 10 | | Positive sequence | | [p.u.] | 1.093 | 1.093 | 1.093 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 1.001 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.000 |
| | 14 | | Positive sequence | | | -- | -- | 1.000 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.014 |
| | 16 | | Positive sequence | | | -- | -- | 0.006 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.200 | 1.050 | 1.050 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.997 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.970 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.003 |
| | 22 | | Positive sequence | | | -- | -- | 1.003 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.999 |
| | 25 | | Positive sequence | | | -- | -- | 0.999 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.120 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.015 |
| | 28 | | Positive sequence | | | -- | -- | 0.006 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

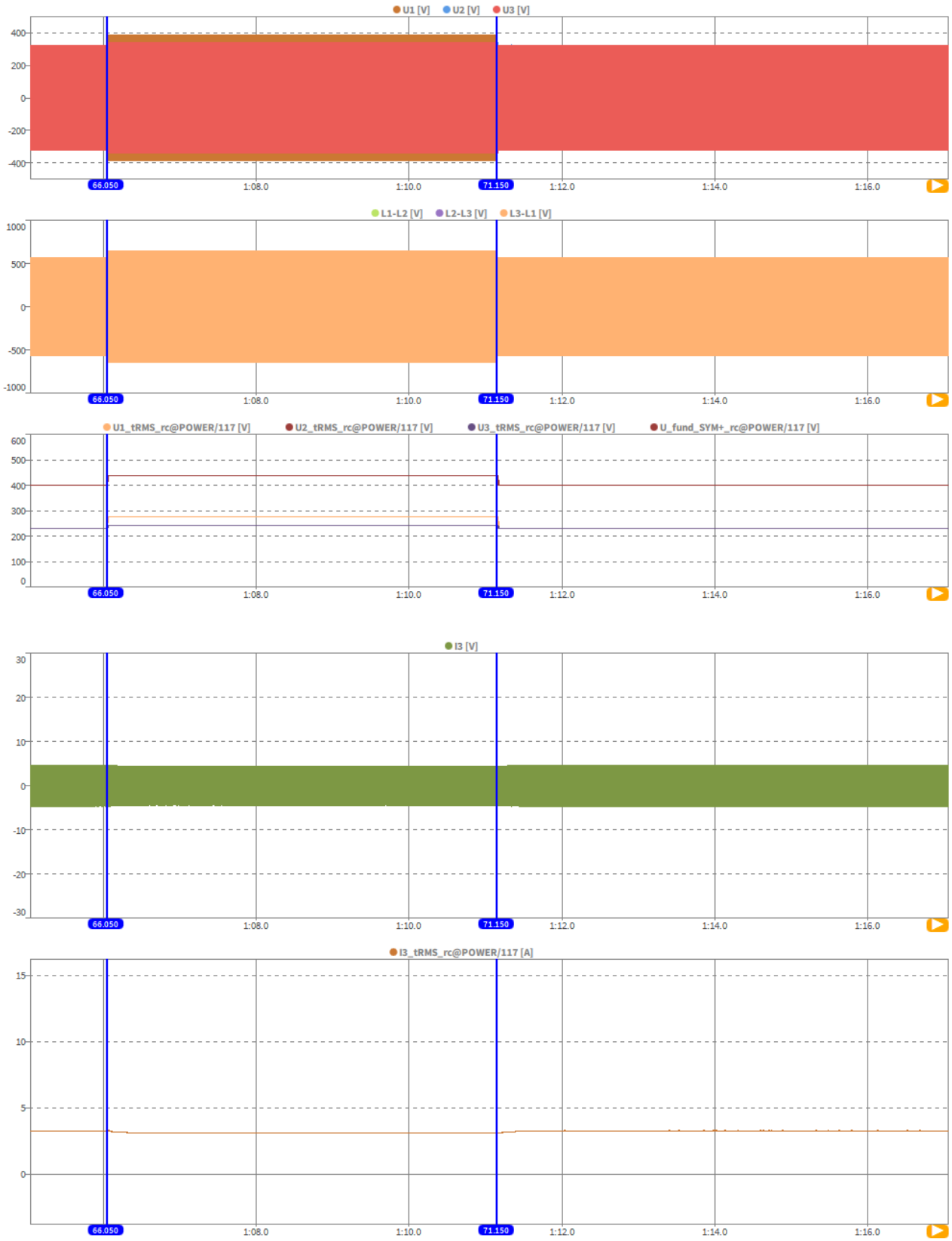

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.105
1:08.0
1:10.0
71.204
1:12.0
1:14.0
1:16.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@2500 [V]
U2_tRMS_rc@2500 [V]
U3_tRMS_rc@2500 [V]
U_fund_SYM+_rc@2500 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

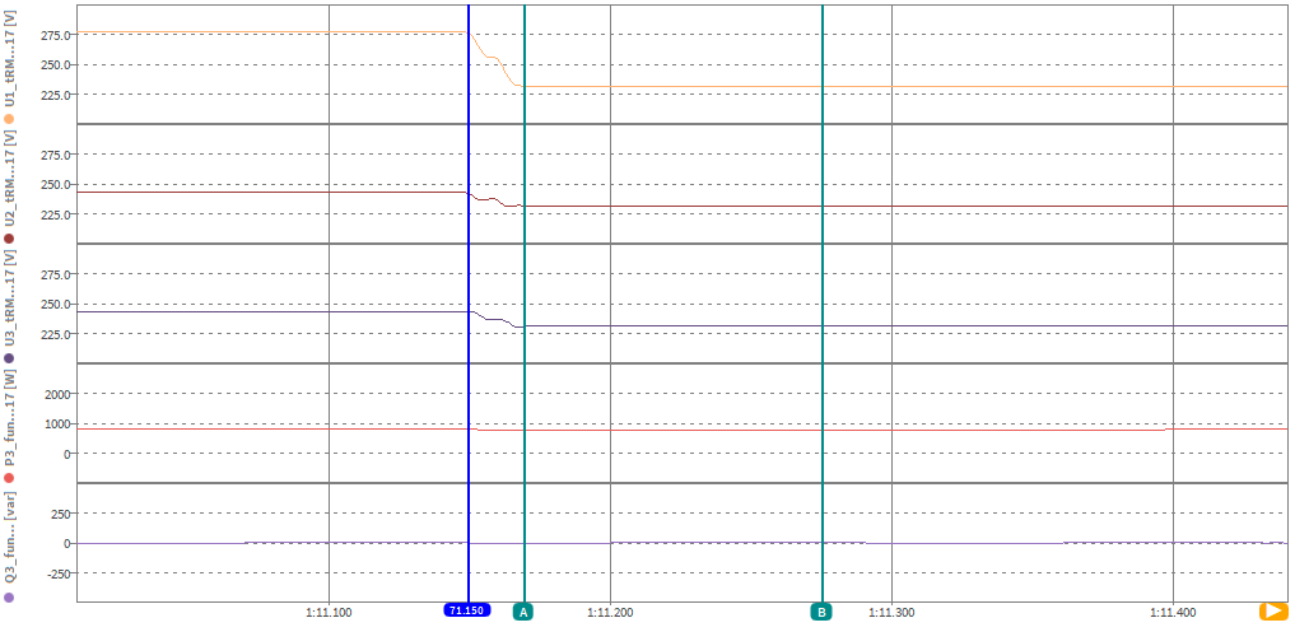



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:11.2254926 | 1:11.3458989 | 0.1204063 |
| U1_tRMS_rc@POWER/117 [V] | 230.6550 | 229.9288 | -0.726166 |
| U2_tRMS_rc@POWER/117 [V] | 229.8031 | 230.0220 | 0.218857 |
| U3_tRMS_rc@POWER/117 [V] | 230.5505 | 229.9799 | -0.570602 |
| P3_fund_rc@POWER/117 [W] | 2382.874 | 2467.240 | 84.36548 |
| Q3_fund_rc@POWER/117 [var] | -3.250147 | -12.38843 | -9.138282 |

## 7.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 7.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 16:06:54 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.20 | 1.05 | 1.05 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 5000 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66050 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 71150 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 5100 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.200 | 1.050 | 1.050 |
| | 10 | | Positive sequence | | [p.u.] | 1.094 | 1.094 | 1.094 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.298 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.298 |
| | 14 | | Positive sequence | | | -- | -- | 0.298 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.009 |
| | 16 | | Positive sequence | | | -- | -- | 0.003 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.200 | 1.050 | 1.050 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.299 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.295 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.301 |
| | 22 | | Positive sequence | | | -- | -- | 0.301 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.302 |
| | 25 | | Positive sequence | | | -- | -- | 0.302 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.106 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.010 |
| | 28 | | Positive sequence | | | -- | -- | 0.002 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

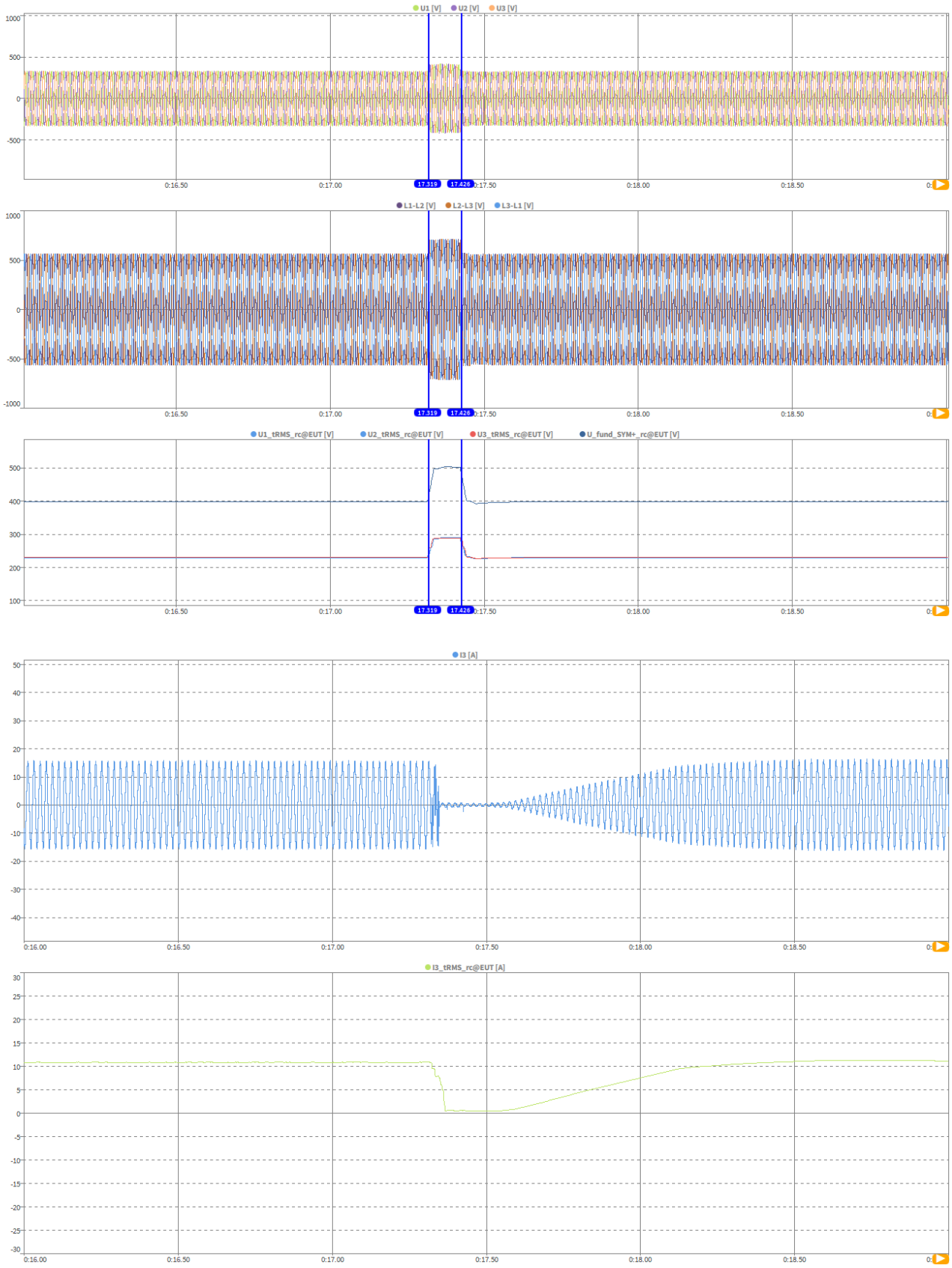

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
66.050
1:08.0
1:10.0
71.150
1:12.0
1:14.0
1:16.0
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
I3 [V]
30
20
10
0
-10
-20
-30
I3_tRMS_rc@POWER/117 [A]
15
10
5
0

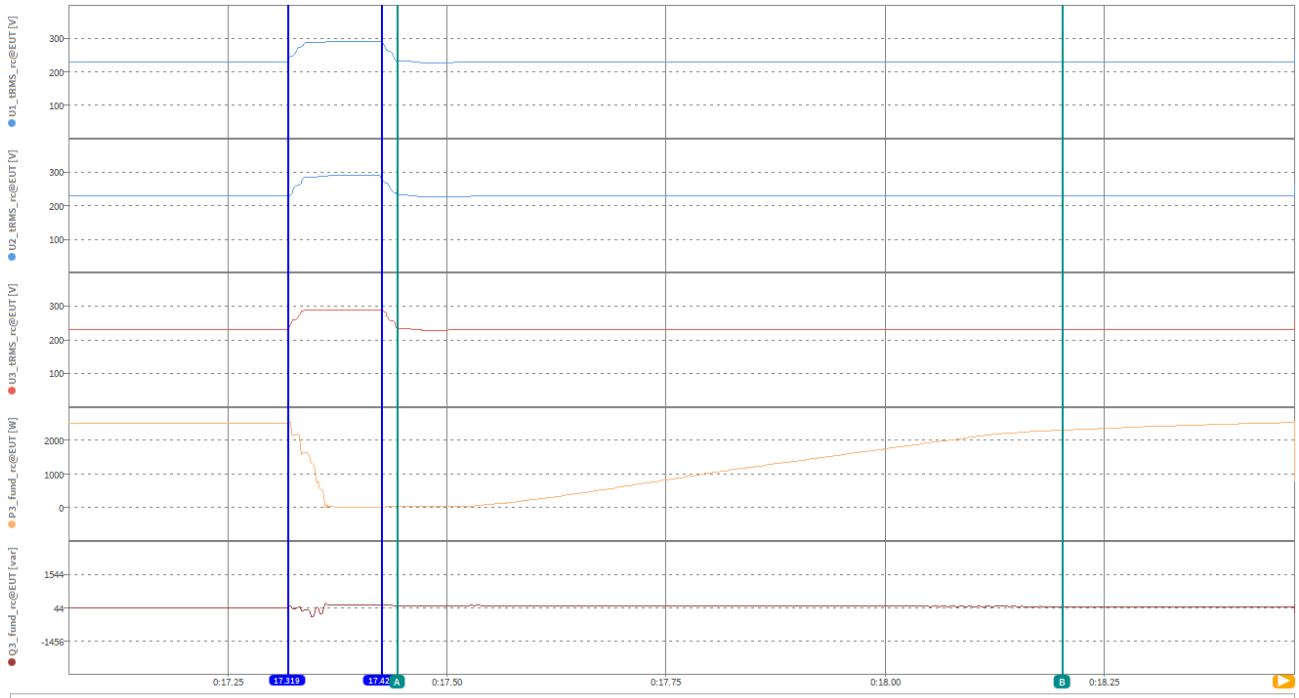



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:11.1692879 | 1:11.2752418 | 0.1059539 |
| U1_tRMS_rc@POWER/117 [V] | 230.8333 | 229.9693 | -0.863922 |
| U2_tRMS_rc@POWER/117 [V] | 230.9613 | 230.0234 | -0.937851 |
| U3_tRMS_rc@POWER/117 [V] | 229.1660 | 229.9879 | 0.821884 |
| P3_fund_rc@POWER/117 [W] | 710.2694 | 729.9191 | 19.64966 |
| Q3_fund_rc@POWER/117 [var] | -18.24031 | -9.225105 | 9.015207 |

## 8.1

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 8.1 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:40:46 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.25 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 100 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 17319 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 17426 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 107 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.262 | 1.249 | 1.247 |
| | 10 | | Positive sequence | | [p.u.] | 1.251 | 1.251 | 1.251 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.998 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 1.001 |
| | 14 | | Positive sequence | | | -- | -- | 1.001 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.018 |
| | 16 | | Positive sequence | | | -- | -- | 0.001 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.262 | 1.249 | 1.247 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.048 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.049 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.008 |
| | 22 | | Positive sequence | | | -- | -- | 0.007 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.002 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.001 |
| | 25 | | Positive sequence | | | -- | -- | 1.001 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.758 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.017 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

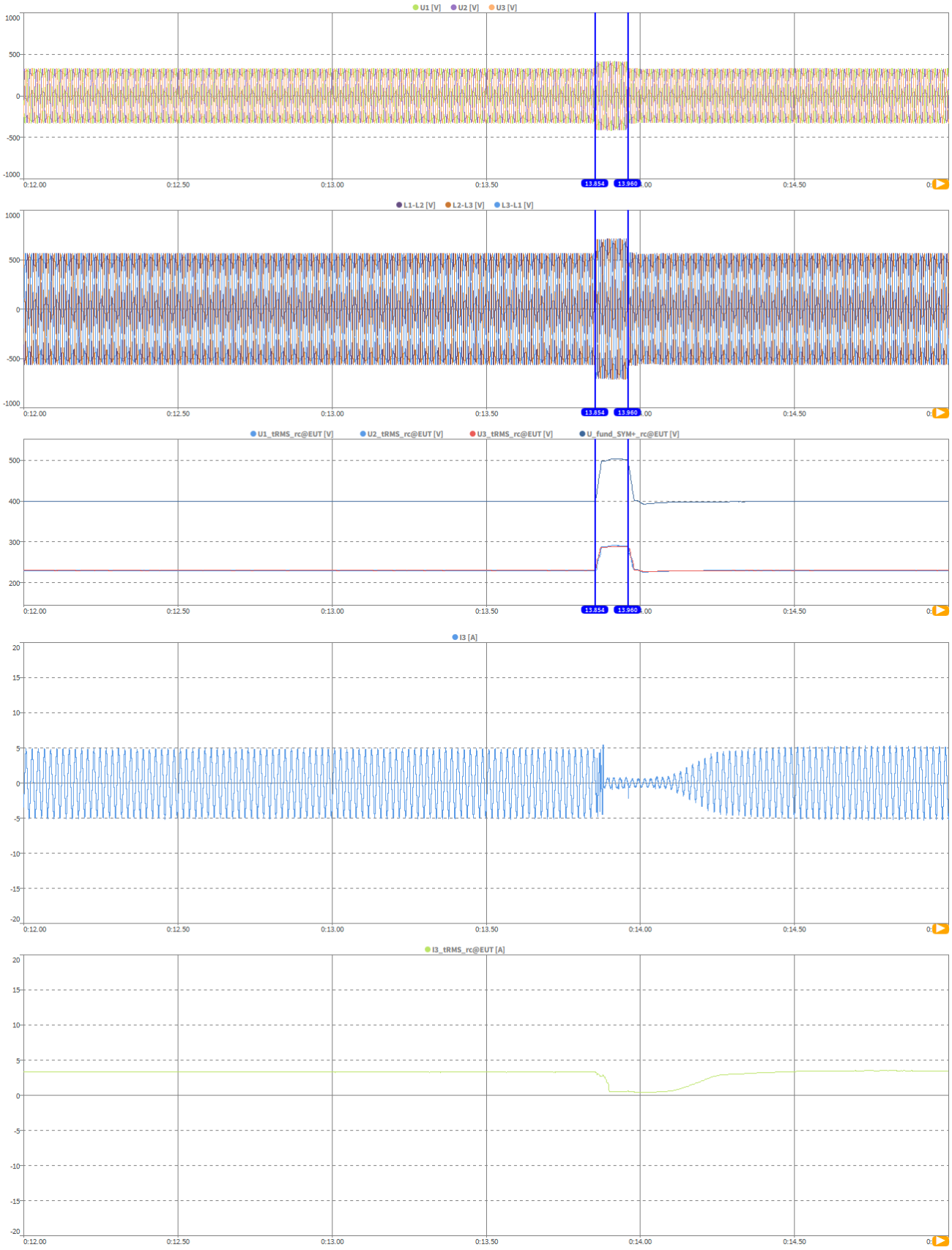

U1 [V]
U2 [V]
U3 [V]
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
I3 [A]
I3_tRMS_rc@EUT [A]

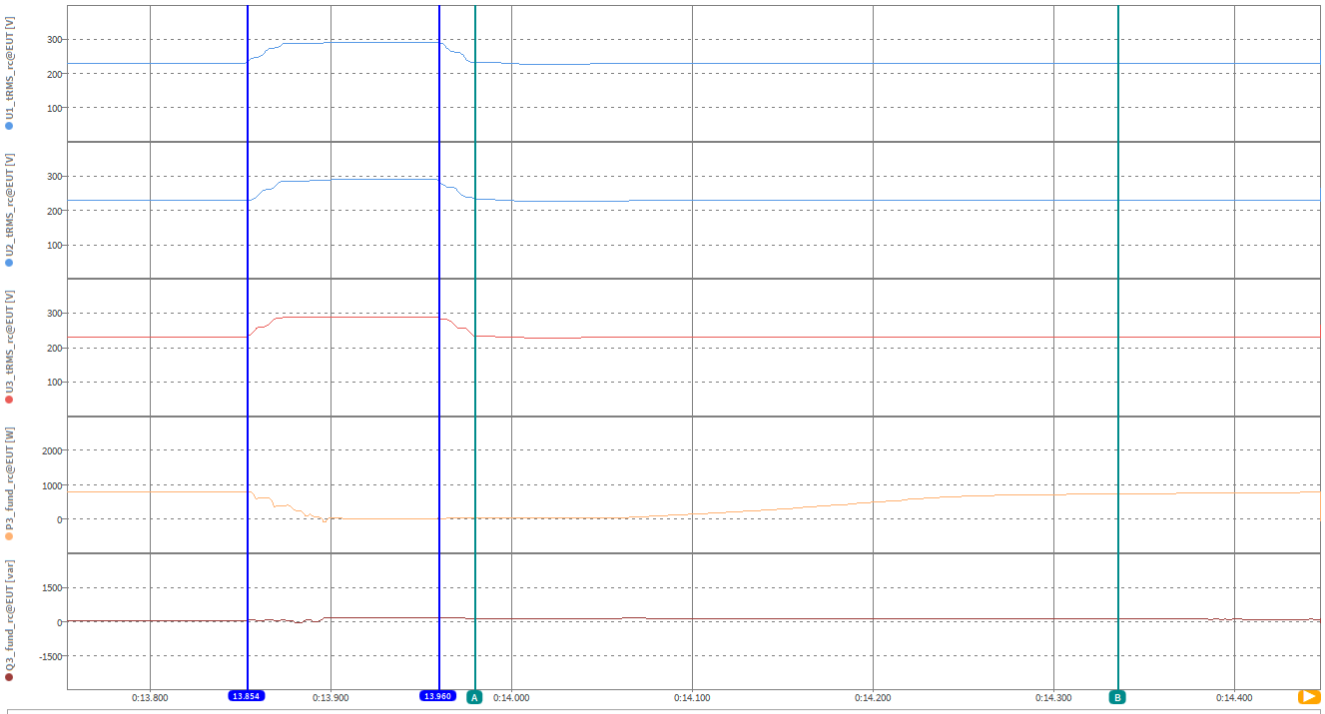



| | A | B | Delta |
|---|---|---|---|
| Time [s] | 0:17.444184 | 0:18.202673 | 0.758488 |
| U1_tRMS_rc@EUT [V] | 232.7364 | 230.4533 | -2.283066 |
| U2_tRMS_rc@EUT [V] | 236.8463 | 229.3047 | -7.541595 |
| U3_tRMS_rc@EUT [V] | 239.5990 | 230.3818 | -9.217133 |
| P3_fund_rc@EUT [W] | 4.138786 | 2292.428 | 2288.290 |
| Q3_fund_rc@EUT [var] | 101.9955 | 57.67598 | -44.31952 |

## 8.2

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 8.2 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 04.09.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 11:36:43 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Symmetrical three-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.25 | | |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 100 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 13854 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 13960 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 106 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.262 | 1.260 | 1.253 |
| | 10 | | Positive sequence | | [p.u.] | 1.258 | 1.258 | 1.258 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.302 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.303 |
| | 14 | | Positive sequence | | | -- | -- | 0.303 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.016 |
| | 16 | | Positive sequence | | | -- | -- | 0.006 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.262 | 1.260 | 1.253 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.049 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.050 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.007 |
| | 22 | | Positive sequence | | | -- | -- | 0.007 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.002 | 0.997 | 1.001 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.302 |
| | 25 | | Positive sequence | | | -- | -- | 0.302 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.355 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.016 |
| | 28 | | Positive sequence | | | -- | -- | 0.005 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

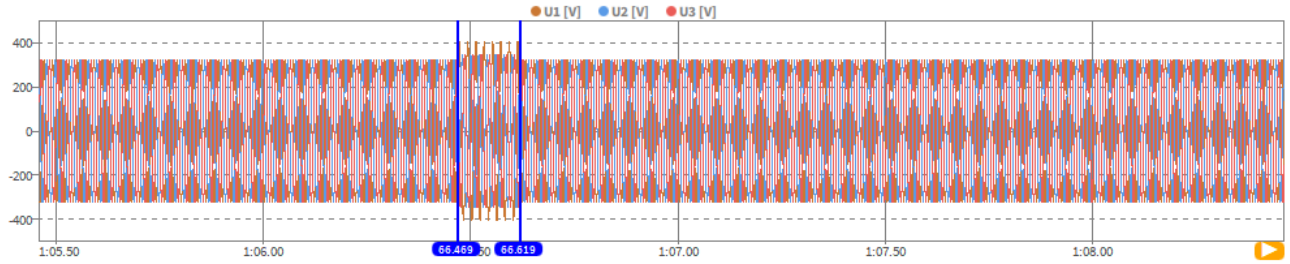

U1 [V]
U2 [V]
U3 [V]
L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
U1_tRMS_rc@EUT [V]
U2_tRMS_rc@EUT [V]
U3_tRMS_rc@EUT [V]
U_fund_SYM+_rc@EUT [V]
I3 [A]
I3_tRMS_rc@EUT [A]

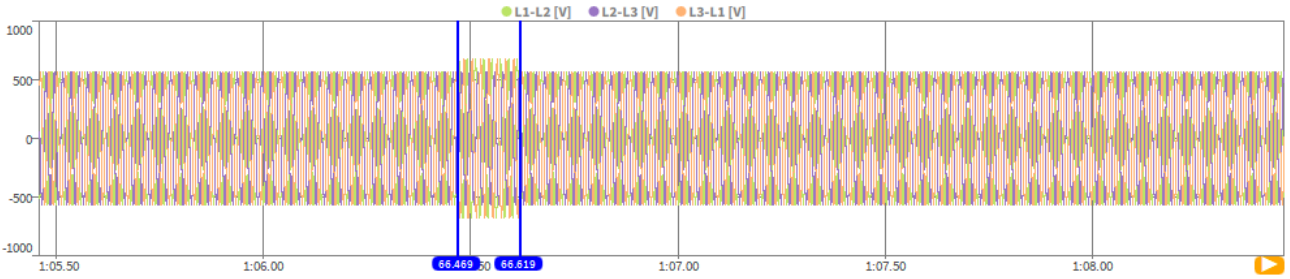


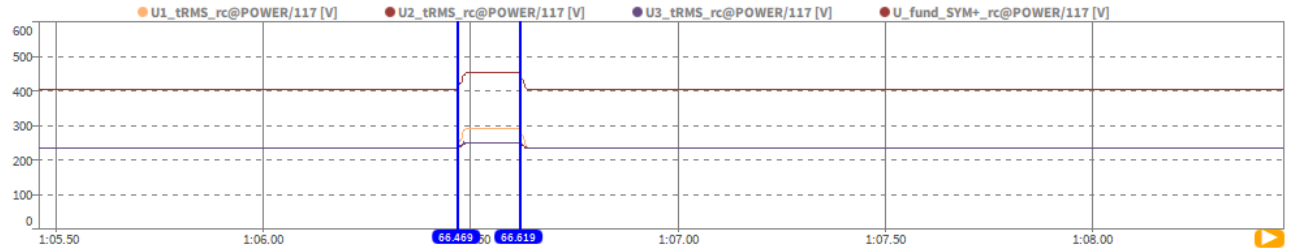

| | A | B | Delta |
|---|---|---|---|
| Time [s] | 0:13.98000000 | 0:14.33547247 | 0.35547247 |
| U1_tRMS_rc@EUT [V] | 232.1627 | 230.3964 | -1.766357 |
| U2_tRMS_rc@EUT [V] | 231.6963 | 229.2587 | -2.437576 |
| U3_tRMS_rc@EUT [V] | 231.0984 | 230.1751 | -0.923325 |
| P3_fund_rc@EUT [W] | 0.051487 | 700.9340 | 700.8825 |
| Q3_fund_rc@EUT [var] | 95.39172 | 67.78666 | -27.60506 |

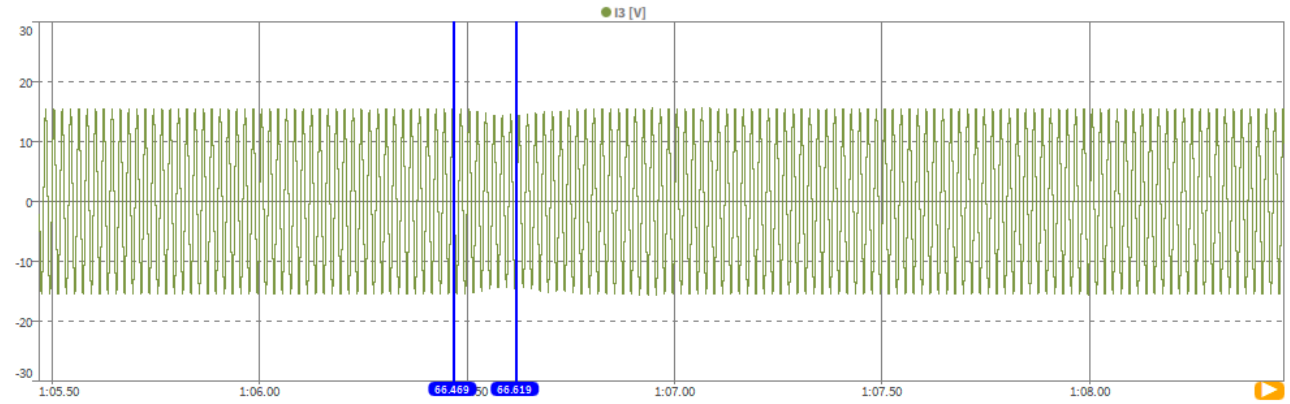
## 8.3

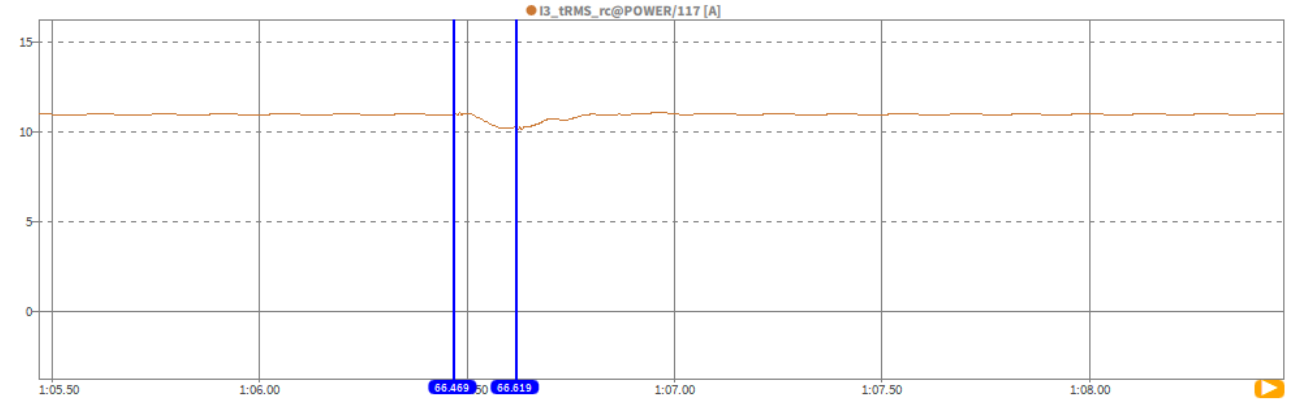
| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 8.3 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 16:17:54 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.25 | 1.07 | 1.07 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 100 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 66469 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 66619 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 150 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.250 | 1.070 | 1.070 |
| | 10 | | Positive sequence | | [p.u.] | 1.126 | 1.126 | 1.126 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.999 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.999 |
| | 14 | | Positive sequence | | | -- | -- | 0.999 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.013 |
| | 16 | | Positive sequence | | | -- | -- | 0.006 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.250 | 1.070 | 1.070 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.999 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.967 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 1.001 |
| | 22 | | Positive sequence | | | -- | -- | 1.001 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 1.002 |
| | 25 | | Positive sequence | | | -- | -- | 1.002 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.121 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.013 |
| | 28 | | Positive sequence | | | -- | -- | 0.003 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |

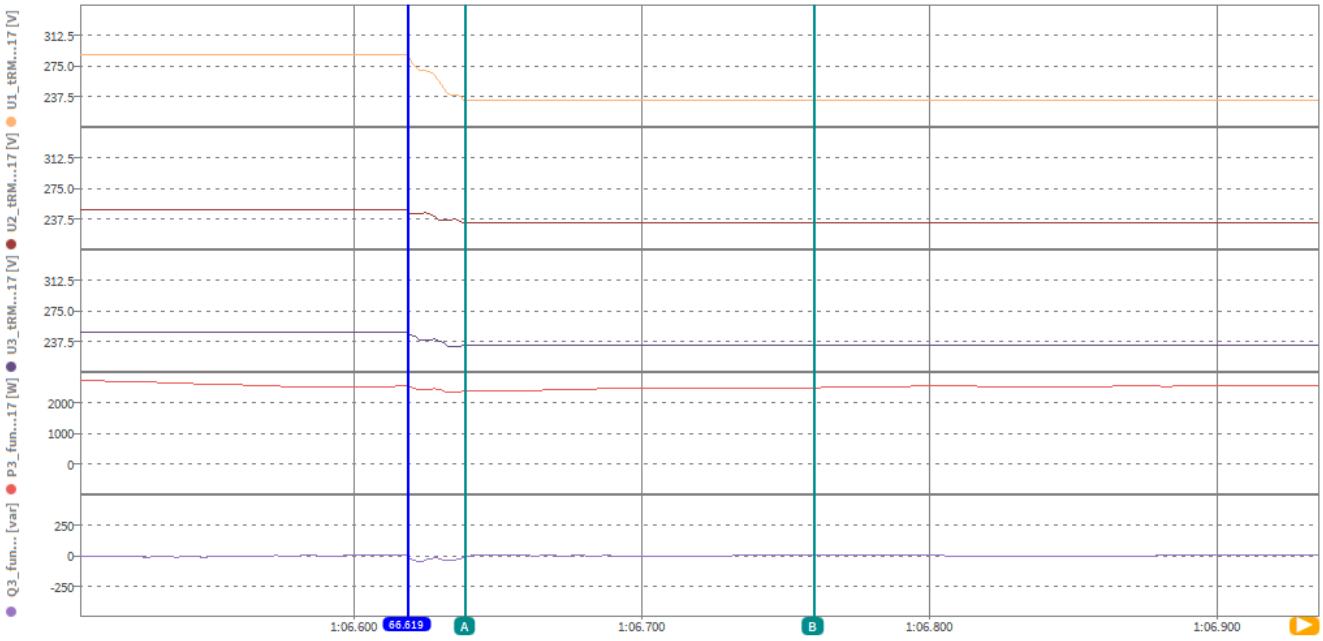

U1 [V]
U2 [V]
U3 [V]
400
200
0
-200
-400
1:05.50
1:06.00
66.469
66.619
1:07.00
1:07.50
1:08.00


L1-L2 [V]
L2-L3 [V]
L3-L1 [V]
1000
500
0
-500
-1000
1:05.50
1:06.00
66.469
66.619
1:07.00
1:07.50
1:08.00


U1_tRMS_rc@POWER/117 [V]
U2_tRMS_rc@POWER/117 [V]
U3_tRMS_rc@POWER/117 [V]
U_fund_SYM+_rc@POWER/117 [V]
600
500
400
300
200
100
0
1:05.50
1:06.00
66.469
66.619
1:07.00
1:07.50
1:08.00


I3 [V]
30
20
10
0
-10
-20
-30
1:05.50
1:06.00
66.469
66.619
1:07.00
1:07.50
1:08.00

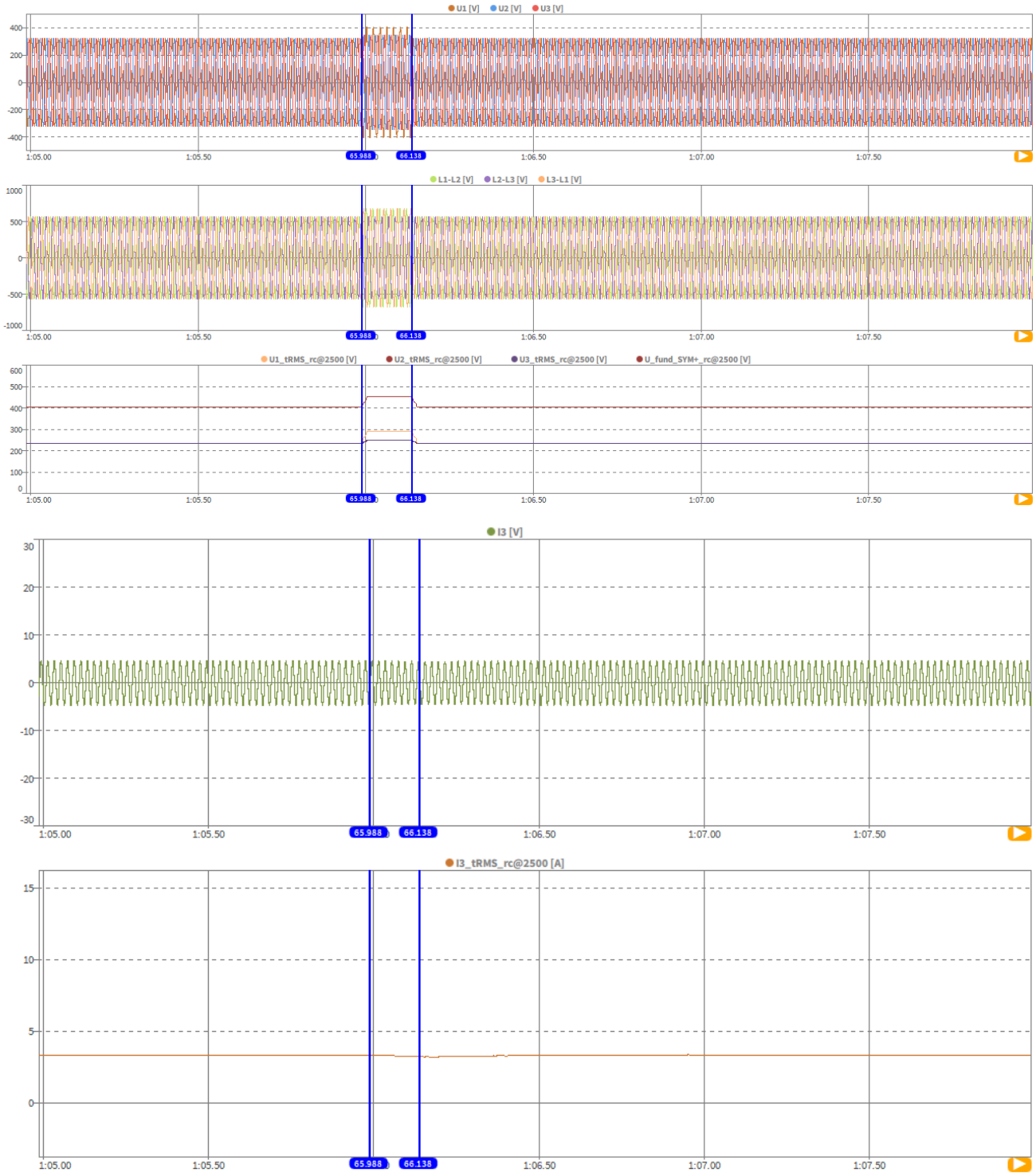

I3_tRMS_rc@POWER/117 [A]
15
10
5
0
1:05.50
1:06.00
66.469
66.619
1:07.00
1:07.50
1:08.00

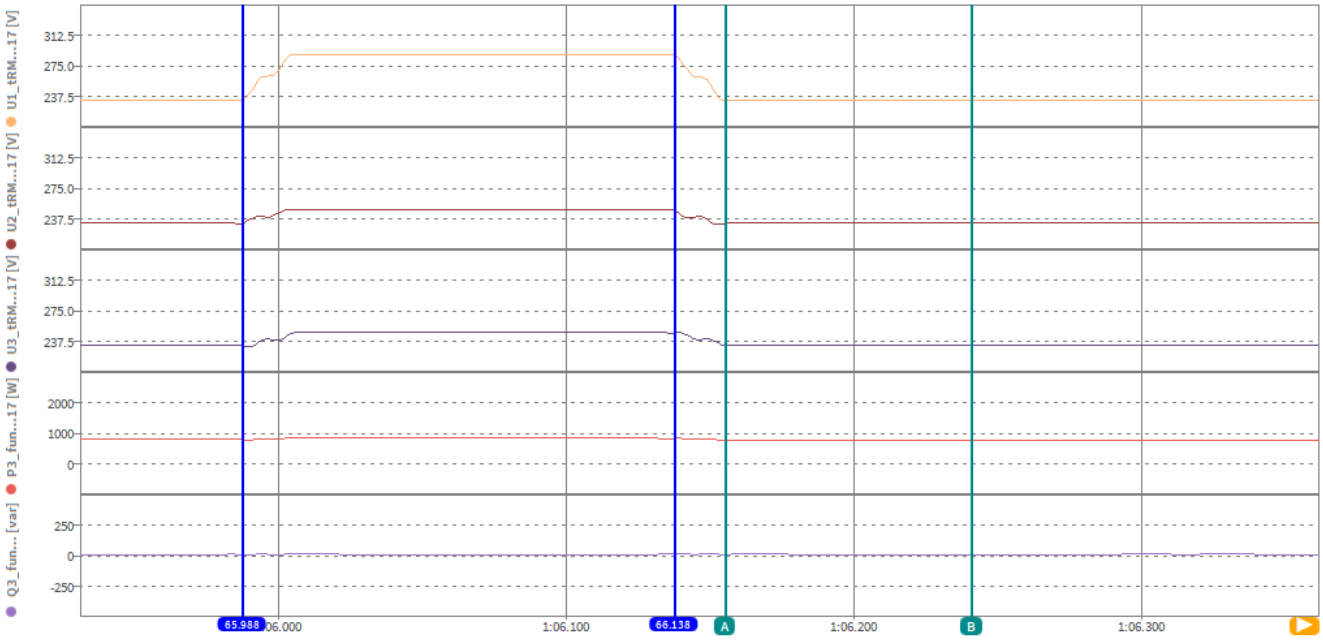



| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:06.6387267 | 1:06.7596873 | 0.1209606 |
| U1_tRMS_rc@POWER/117 [V] | 234.7063 | 229.9660 | -4.740295 |
| U2_tRMS_rc@POWER/117 [V] | 232.5080 | 230.0177 | -2.490341 |
| U3_tRMS_rc@POWER/117 [V] | 229.9132 | 229.9913 | 0.078125 |
| P3_fund_rc@POWER/117 [W] | 2346.509 | 2458.847 | 112.3379 |
| Q3_fund_rc@POWER/117 [var] | -30.11782 | -3.428427 | 26.68939 |

## 8.4

| | No. | Parameter | Phase reference | Reference time | Value [unit] | Measurement results | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Phase 1 | Phase 2 | Phase 3 |
| General information | 0 | Test no. | -- | -- | -- | 8.4 | | |
| | 1 | Date | -- | -- | [dd.mm.yyyy] | 26.08.2025 | | |
| | 2 | Time (start of test) | -- | -- | [hh:mm:ss.f] | 16:24:21 | | |
| | 3 | Type of fault (number of affected phases) | -- | -- | -- | Asymmetric two-phase fault | | |
| | 4 | Drop depth setpoint | Phase | -- | [p.u.] | 1.25 | 1.07 | 1.07 |
| | 5 | Drop duration setpoint | Total | -- | [ms] | 100 | | |
| | 6 | Fault occurrence (t1) | Total | -- | [ms] | 65988 | | |
| | 7 | Fault clearance (t2) | Total | -- | [ms] | 66138 | | |
| | 8 | Fault duration determined from no-load test | Total | -- | [ms] | 150 | | |
| | 9 | Voltage drop / increase determined from no-load test | Total | t1+100ms to t2 and t1-10s to t1 | [p.u.] | 1.250 | 1.070 | 1.070 |
| | 10 | | Positive sequence | | [p.u.] | 1.126 | 1.126 | 1.126 |
| Before voltage dip < t1 | 11 | Voltage | Phase to Neutral | t1-10s to t1 | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 12 | Current | Positive sequence | t1-500ms to t1-100ms | [p.u.] | -- | -- | 0.301 |
| | 13 | Active power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.301 |
| | 14 | | Positive sequence | | | -- | -- | 0.301 |
| | 15 | Reactive power | Total | t1-10s to t1 | [p.u.] | -- | -- | 0.007 |
| | 16 | | Positive sequence | | | -- | -- | 0.001 |
| | 17 | Cosφ | Total | t1-10s to t1 | -- | -- | -- | 0.999 |
| During voltage dip t1 to t2 | 18 | Voltage | Phase to Neutral | t1+100ms to t2-20ms | [p.u.] | 1.250 | 1.070 | 1.070 |
| | 19 | Phase current | Phase to Neutral | t1+50ms | [p.u.] | -- | -- | 0.301 |
| | 20 | Phase current | Phase to Neutral | t1+80ms | [p.u.] | -- | -- | 0.300 |
| | 21 | Active power | Total | t1+100ms to t2-20ms | [p.u.] | -- | -- | 0.315 |
| | 22 | | Positive sequence | | | -- | -- | 0.315 |
| After valtage dip > t2 | 23 | Voltage | Phase to Neutral | t2+3s to t2+10s | [p.u.] | 1.000 | 1.000 | 1.000 |
| | 24 | Active power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.301 |
| | 25 | | Positive sequence | | | -- | -- | 0.301 |
| | 26 | Response time active power | Positive sequence | -- | [s] | -- | -- | 0.086 |
| | 27 | Reactive power | Total | t2+3s to t2+10s | [p.u.] | -- | -- | 0.008 |
| | 28 | | Positive sequence | | | -- | -- | 0.002 |
| | 29 | Reactive power rising time | Positive sequence | -- | [s] | -- | -- | -- |
| | 30 | PGU has not disconnected from the grid within 60 s after the end of the fault: yes / no | -- | t2 to t2+60s | [Yes / No] | -- | -- | Yes |


U1 [V] U2 [V] U3 [V]
L1-L2 [V] L2-L3 [V] L3-L1 [V]
U1_tRMS_rc@2500 [V] U2_tRMS_rc@2500 [V] U3_tRMS_rc@2500 [V] U_fund_SYM+_rc@2500 [V]
I3 [V]
I3_tRMS_rc@2500 [A]
1:05.00
1:05.50
1:06.50
1:07.00
1:07.50
65.988
66.138




| | A | B | 间隔 |
|---|---|---|---|
| 时间 [s] | 1:06.15546005 | 1:06.24120035 | 0.08574030 |
| U1_tRMS_rc@POWER/117 [V] | 231.2527 | 230.0239 | -1.228806 |
| U2_tRMS_rc@POWER/117 [V] | 229.3828 | 230.0248 | 0.641937 |
| U3_tRMS_rc@POWER/117 [V] | 231.2678 | 229.9811 | -1.286758 |
| P3_fund_rc@POWER/117 [W] | 726.3185 | 735.9850 | 9.666565 |
| Q3_fund_rc@POWER/117 [var] | -1.062818 | -4.316204 | -3.253385 |

## 6.3 Active response to frequency deviation

### 6.3.1 Power response to over-frequencies

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | Test setup n.1 according to section 5.4.2.1, EN 50549-10. See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.4.3, EN 50549-10 |

| | |
|---|---|
| Operating mode of the EUT | ☐ MPP-Tracking operation mode<br>☒ Fixed voltage control operation mode |
| Active Power level | See table *Test cases* below |
| Active factor | 1.000 |
| ROCOF protection | disable |
| Voltage protection | set to values not interfering to the tests |
| Other LFSM-O-relevant parameter settings | See table *Test cases* below and *Annex 1 – Parameter list* |

**Acceptance criteria**

- for each frequency point, the deviation between the expected and the measured value of active power falls within the required tolerance, e.g. ±10%$P_n$, evaluated with a 1 min average value;
- the dead time of the EUT is less than required value, e.g. 2 s, in test scenarios with a configured intentional delay of zero;
- the dead time of the EUT is less than required value, e.g. 2 s, and the accuracy of the configured intentional delay shall be ± 250 ms in test scenarios with a configured intentional delay other than zero;
- the intentional delay acts only for the activation of the function;
- the step response time is less than required value, e.g. 30 s;
- for the procedure for setting (a) or the setting for a specific grid code with power level at start of the test in partial load, the ramp of active power after deactivation of the active power frequency response does not exceed the required value, e.g. 10%$P_n$/min;
- in case of active power response to over-frequency with configured deactivation threshold, if the ramp of active power after deactivation of the active power frequency response does not exceed the required value, e.g. 10%$P_n$/min;
- an EES in charging mode during over frequency does not reduce charging power within required tolerance, e.g. 10% and if declared by the manufacturer, an EES in charging mode does increase the charging power according to the configured droop (see par. 4.6.1 of EN 50549-1:2019 and EN 50549-2:2019).
- randomized disconnection documentation complies to the requirement of EN 50549-1:2019 or EN 50549-2:2019, if this option is used;
- the settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

**Manufacturer's data**

The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software.

**Test cases**

Technology of the PGUs:

☐ T1: Synchronous generating technology: $P_{ref} = P_{max}$

☒ T2: Systems with energy storage: $P_{ref} = P_{max}$

☐ T3: Other non-synchronous generating technology: $P_{ref} = P_M$

Note:

**T2**: mainly refers to AC-coupled Energy Storage Systems (EES).

- For DC-coupled storage integrated into the DC side of a generating unit, if they are not capable of charging from AC, they shall be considered according to **T3**. In this case, the units, upon reaching zero power, shall remain at zero power and shall not switch into charging mode.
- For DC-coupled storage integrated into the DC side of a generating unit, if they are capable of charging from AC, they shall be considered according to **T2**.

LFSM-O control strategy

☒ Figure 9, EN 50549-1 or EN 50549-2: suffix „-F9“

☒ Figure 10, EN 50549-1 or EN 50549-2: suffix „-F10“

Note:

The two LFSM-O control modes can be switched via parameters Ena[1,2] (see also *Annex 1 – Parameter list*)

| | Setting (a) | Setting (b) | Setting (c) |
|---|---|---|---|
| frequency threshold $f_{th}$ [Hz] | 50.2 | 50.5 | 50.2 |
| droop [%] | 5 | 2 | 12 |
| power level at start of test [%$P_n$] | 100 / 50 / -50 | 60 | 40 |
| Intentional delay [s] | 0 | 0 | 2 |
| Configured deactivation threshold and time $f_{stop}$ [Hz] / $t_{stop}$ [s] | N/A | 50.5 / 1 | 50.05 / 600 |

T3-F9-Test 1: Setting (a), power level at start of test: 100%$P_n$
T3-F9-Test 2: Setting (a), power level at start of test: 50%$P_n$
T3-F10-Test 3: Setting (b), power level at start of test: 60%$P_n$
T3-F10-Test 4: Setting (c), power level at start of test: 40%$P_n$
T2-F9-Test 1: Setting (a), power level at start of test: 100%$P_{max}$
T2-F9-Test 2: Setting (a), power level at start of test: 50%$P_{max}$
T2-F9-Test 3: Setting (a), power level at start of test: -50%$P_{max}$
T2-F10-Test 4: Setting (b), power level at start of test: 60%$P_{max}$
T2-F10-Test 5: Setting (c), power level at start of test: 40%$P_{max}$

**Test results**

Note:

The frequency points/sequence acc. Table 7 and Figure 11, EN 50549-10 were modified to the frequency steps specified in the result tables below.

**T3-F9-Test 1**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | --- | --- | --- | --- | --- |
| 2 | 50.10 | --- | --- | --- | --- | --- |
| 3 | 50.80 | --- | 76.0% | --- | --- | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 51.40 | --- | 52.0% | --- | --- | ≤ 10 |
| 5 | 52.00 | --- | 28.0% | --- | --- | |
| 6 | 51.40 | --- | 52.0% | --- | --- | |
| 7 | 50.80 | --- | 76.0% | --- | --- | |
| 8 | 50.10 | --- | --- | --- | --- | --- |
| 9 | 50.00 | --- | --- | --- | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | --- | --- | --- | --- | < 2 | < 1 | --- |
| 3 → 4 | --- | --- | --- | --- | < 2 | | |
| 4 → 5 | --- | --- | --- | --- | | | |
| 5 → 6 | --- | --- | --- | --- | | | |
| 6 → 7 | --- | --- | --- | --- | | | |
| 7 → 8 | --- | --- | --- | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:

* The Dead time for frequency step 1 → 2 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T3-F9-Test 2**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | --- | --- | --- | --- | --- |
| 2 | 50.10 | --- | --- | --- | --- | --- |
| 3 | 50.80 | --- | 38.0% | --- | --- | ≤ 10 |
| 4 | 51.40 | --- | 26.0% | --- | --- | |
| 5 | 52.00 | --- | 14.0% | --- | --- | |
| 6 | 51.40 | --- | 26.0% | --- | --- | |
| 7 | 50.80 | --- | 38.0% | --- | --- | |
| 8 | 50.10 | --- | --- | --- | --- | --- |
| 9 | 50.00 | --- | --- | --- | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | --- | --- | --- | --- | < 2 | < 1 | --- |
| 3 → 4 | --- | --- | --- | --- | < 2 | | |
| 4 → 5 | --- | --- | --- | --- | | | |
| 5 → 6 | --- | --- | --- | --- | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 → 7 | --- | --- | --- | --- | | | |
| 7 → 8 | --- | --- | --- | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:
* The Dead time for frequency step 1 → 2 refers to the **intentional delay** for the activation of the function;
The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T3-F10-Test 3**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | --- | --- | --- | --- | --- |
| 2 | 50.25 | --- | --- | --- | --- | --- |
| 3 | 51.00 | --- | 30.0% | --- | --- | ≤ 10 |
| 4 | 51.50 | --- | 0.0% | --- | --- | |
| 5 | 52.00 | --- | 0.0% | --- | --- | |
| 6 | 51.50 | --- | 0.0% | --- | --- | |
| 7 | 51.00 | --- | 0.0% | --- | --- | |
| 8 | 50.25 | --- | --- | --- | --- | --- |
| 9 | 50.00 | --- | --- | --- | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Deactivation time [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | --- | --- | --- | --- | --- | < 2 | < 1 | --- |
| 3 → 4 | --- | --- | --- | --- | --- | < 2 | | |
| 4 → 5 | --- | --- | --- | --- | --- | --- | --- | |
| 5 → 6 | --- | --- | --- | --- | --- | --- | --- | |
| 6 → 7 | --- | --- | --- | --- | --- | | | |
| 7 → 8 | --- | --- | --- | --- | --- | | | ≤ 10 |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- | --- |

Note:
* The Dead time for frequency step 1 → 2 refers to the **intentional delay** for the activation of the function;
The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T3-F10-Test 4**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | --- | --- | --- | --- | --- |
| 2 | 50.10 | --- | --- | --- | --- | --- |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 50.80 | --- | 36.0% | --- | --- | ≤ 10 |
| 4 | 51.40 | --- | 32.0% | --- | --- | |
| 5 | 52.00 | --- | 28.0% | --- | --- | |
| 6 | 51.40 | --- | 28.0% | --- | --- | |
| 7 | 50.80 | --- | 28.0% | --- | --- | |
| 8 | 50.10 | --- | --- | --- | --- | --- |
| 9 | 50.00 | --- | --- | --- | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Deactivation time [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | --- | --- | --- | --- | --- | 1.75 ~ 2 | < 1 | |
| 3 → 4 | --- | --- | --- | --- | --- | < 2 | | |
| 4 → 5 | --- | --- | --- | --- | --- | | | |
| 5 → 6 | --- | --- | --- | --- | --- | --- | --- | |
| 6 → 7 | --- | --- | --- | --- | --- | | | |
| 7 → 8 | --- | --- | --- | --- | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | | | ≤ 10 |

Note:

* The Dead time for frequency step 2 → 3 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T2-F9-Test 1**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_{max}$ [%] | Measured value $P/P_{max}$ [%] | Deviation $\Delta P/P_{max}$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_{max}\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | --- | 100.29% | --- | --- |
| 2 | 50.10 | 50.10 | --- | 100.28% | --- | --- |
| 3 | 50.80 | 50.80 | 76.0% | 77.17% | 1.17% | ≤ 10 |
| 4 | 51.40 | 51.40 | 52.0% | 52.86% | 0.86% | |
| 5 | 52.00 | 52.00 | 28.0% | 28.44% | 0.44% | |
| 6 | 51.40 | 51.40 | 52.0% | 52.88% | 0.88% | |
| 7 | 50.80 | 50.80 | 76.0% | 77.17% | 1.17% | |
| 8 | 50.10 | 50.10 | --- | 100.12% | --- | --- |
| 9 | 50.00 | 50.00 | --- | 100.29% | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_{max}$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_{max}$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.2 | 0.6 | 0.6 | --- | < 2 | < 1 | --- |
| 3 → 4 | 0.2 | 0.6 | 0.6 | --- | < 2 | | |
| 4 → 5 | 0.2 | 0.6 | 0.6 | --- | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 → 6 | 0.2 | 0.4 | 0.4 | --- | | | |
| 6 → 7 | 0.2 | 0.2 | 0.2 | --- | | | |
| 7 → 8 | 0.2 | 0.4 | 0.4 | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:

* The Dead time for frequency step 1 → 2 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T2-F9-Test 2**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_{max}$ [%] | Measured value $P/P_{max}$ [%] | Deviation $\Delta P/P_{max}$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_{max}\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | --- | 50.08% | --- | --- |
| 2 | 50.10 | 50.10 | --- | 50.10% | --- | --- |
| 3 | 50.80 | 50.80 | 26.0% | 27.03% | 1.03% | ≤ 10 |
| 4 | 51.40 | 51.40 | 2.0% | 2.61% | 0.61% | |
| 5 | 52.00 | 52.00 | -22.0% | -22.07% | 0.07% | |
| 6 | 51.40 | 51.40 | 2.0% | 2.66% | 0.66% | |
| 7 | 50.80 | 50.80 | 26.0% | 27.06% | 1.06% | |
| 8 | 50.10 | 50.10 | --- | 100.31% | --- | --- |
| 9 | 50.00 | 50.00 | --- | 100.20% | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_{max}$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_{max}$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.2 | 0.4 | 0.4 | --- | < 2 | < 1 | --- |
| 3 → 4 | 0.2 | 0.4 | 0.4 | --- | < 2 | | |
| 4 → 5 | 0.2 | 0.4 | 0.4 | --- | | | |
| 5 → 6 | 0.2 | 0.4 | 0.4 | --- | | | |
| 6 → 7 | 0.2 | 0.2 | 0.2 | --- | | | |
| 7 → 8 | --- | --- | --- | --- | --- | --- | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:

* The Dead time for frequency step 1 → 2 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T2-F9-Test 3**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_{max}$ [%] | Measured value $P/P_{max}$ [%] | Deviation $\Delta P/P_{max}$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_{max}\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | --- | -51.33% | --- | --- |
| 2 | 50.10 | 50.10 | --- | -51.36% | --- | --- |
| 3 | 50.80 | 50.80 | -74.0% | -73.44% | 0.56% | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 51.40 | 51.40 | -98.0% | -97.80% | 0.20% | ≤ 10 |
| 5 | 52.00 | 52.00 | -100.0% | -101.38% | 1.38% | |
| 6 | 51.40 | 51.40 | -98.0% | -97.80% | 0.20% | |
| 7 | 50.80 | 50.80 | -74.0% | -73.43% | 0.57% | |
| 8 | 50.10 | 50.10 | --- | -51.29% | --- | --- |
| 9 | 50.00 | 50.00 | --- | -51.36% | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_{max}$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_{max}$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.4 | 0.6 | 0.6 | --- | < 2 | < 1 | --- |
| 3 → 4 | 0.2 | 0.6 | 0.6 | --- | < 2 | | |
| 4 → 5 | 0.2 | 0.2 | 0.2 | --- | | | |
| 5 → 6 | 0.2 | 0.2 | 0.2 | --- | | | |
| 6 → 7 | 0.2 | 0.6 | 0.6 | --- | | | |
| 7 → 8 | 0.2 | 0.6 | 0.6 | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:

* The Dead time for frequency step 1 → 2 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T2-F10-Test 4**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_{max}$ [%] | Measured value $P/P_{max}$ [%] | Deviation $\Delta P/P_{max}$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_{max}\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | --- | 60.38% | --- | --- |
| 2 | 50.20 | 50.20 | --- | 60.33% | --- | --- |
| 3 | 51.00 | 51.00 | 10.0% | 10.46% | 0.46% | ≤ 10 |
| 4 | 51.50 | 51.50 | -40.0% | -38.23% | 1.77% | |
| 5 | 52.00 | 52.00 | -90.0% | -87.76% | 2.24% | |
| 6 | 51.50 | 51.50 | -90.0% | -88.08% | 1.92% | |
| 7 | 51.00 | 51.00 | -90.0% | -88.05% | 1.95% | |
| 8 | 50.20 | 50.20 | --- | 59.46% | --- | --- |
| 9 | 50.00 | 50.00 | --- | 60.32% | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Deactivation time [s] | Ramp of active power after deactivation LFSM-O [$P_{max}$/min] | Limit | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_{max}$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.2 | 0.2 | 0.2 | --- | --- | < 2 | < 1 | --- |
| 3 → 4 | 0.2 | 0.2 | 0.2 | --- | --- | < 2 | | |
| 4 → 5 | 0.2 | 0.2 | 0.2 | --- | --- | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 → 6 | --- | --- | --- | --- | --- | --- | --- | |
| 6 → 7 | --- | --- | --- | --- | --- | --- | --- | |
| 7 → 8 | --- | --- | --- | --- | 8.57% | | | ≤ 10 |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- | --- |

Note:

* The Dead time for frequency step 1 → 2 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**T2-F10-Test 5**

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_{max}$ [%] | Measured value $P/P_{max}$ [%] | Deviation $\Delta P/P_{max}$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_{max}\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | --- | 40.00% | -- | --- |
| 2 | 50.10 | 50.10 | --- | 40.00% | -- | --- |
| 3 | 50.80 | 50.80 | 30.0% | 30.04% | 0.04% | |
| 4 | 51.40 | 51.40 | 20.0% | 19.83% | 0.17% | |
| 5 | 52.00 | 52.00 | 10.0% | 9.65% | 0.35% | ≤ 10 |
| 6 | 51.40 | 51.40 | 10.0% | 9.65% | 0.35% | |
| 7 | 50.80 | 50.80 | 10.0% | 9.65% | 0.35% | |
| 8 | 50.10 | 50.10 | --- | 9.65% | -- | --- |
| 9 | 50.00 | 50.00 | --- | 39.97% | -- | --- |

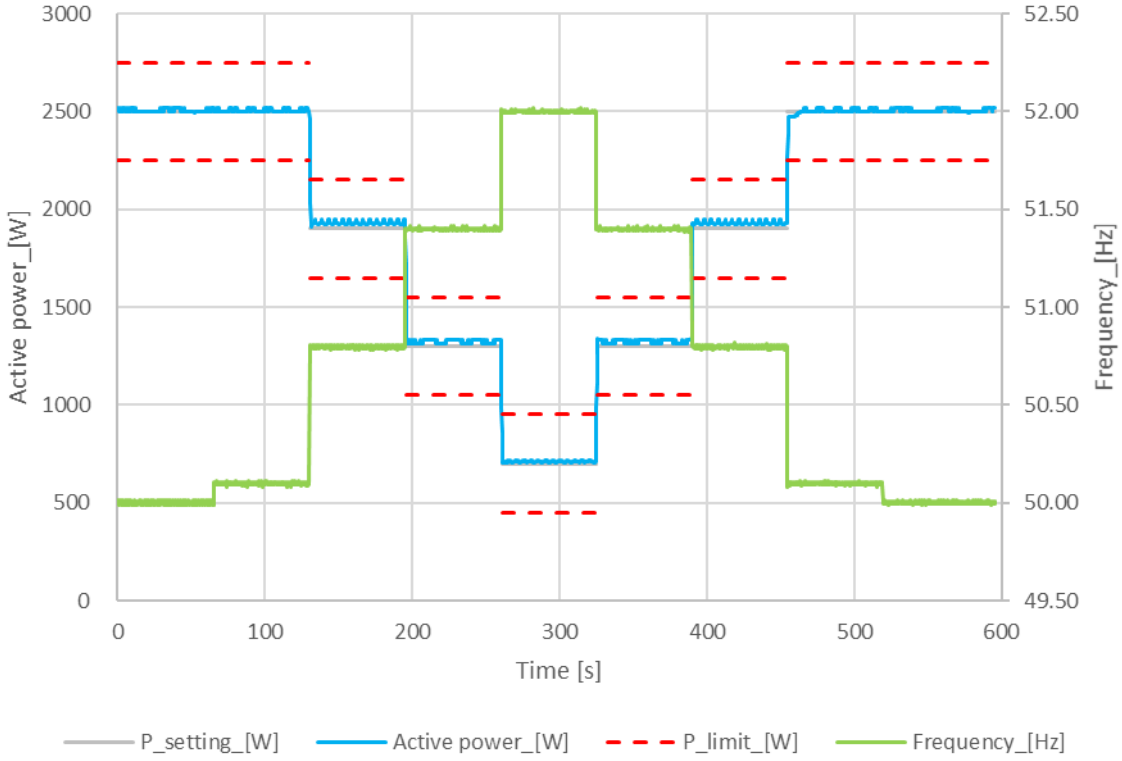
| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Deactivation time [s] | Ramp of active power after deactivation LFSM-O [$P_{max}$/min] | Limit | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_{max}$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- | |
| 2 → 3 | 1.8 | 0.2 | 0.2 | --- | --- | 1.75 ~ 2 | | |
| 3 → 4 | 0.2 | 0.2 | 0.2 | --- | --- | < 2 | < 1 | --- |
| 4 → 5 | 0.2 | 0.2 | 0.2 | --- | --- | | | |
| 5 → 6 | --- | --- | --- | --- | --- | | | |
| 6 → 7 | --- | --- | --- | --- | --- | --- | --- | |
| 7 → 8 | --- | --- | --- | --- | --- | | | |
| 8 → 9 | --- | --- | --- | 611.4 | 9.92% | | | ≤ 10 |

Note:

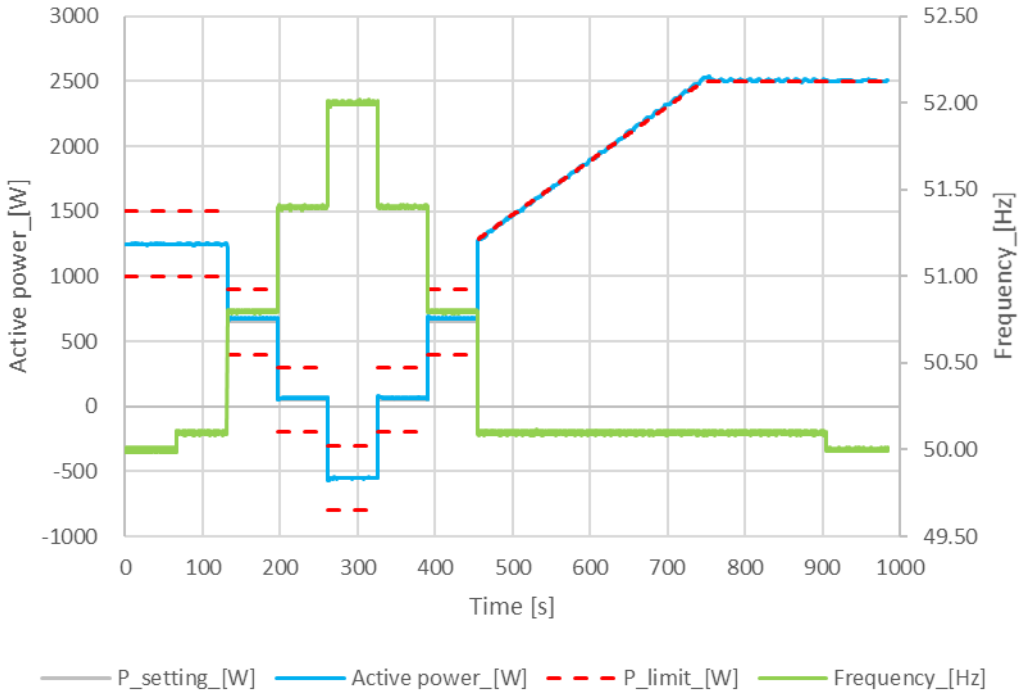
* The Dead time for frequency step 2 → 3 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

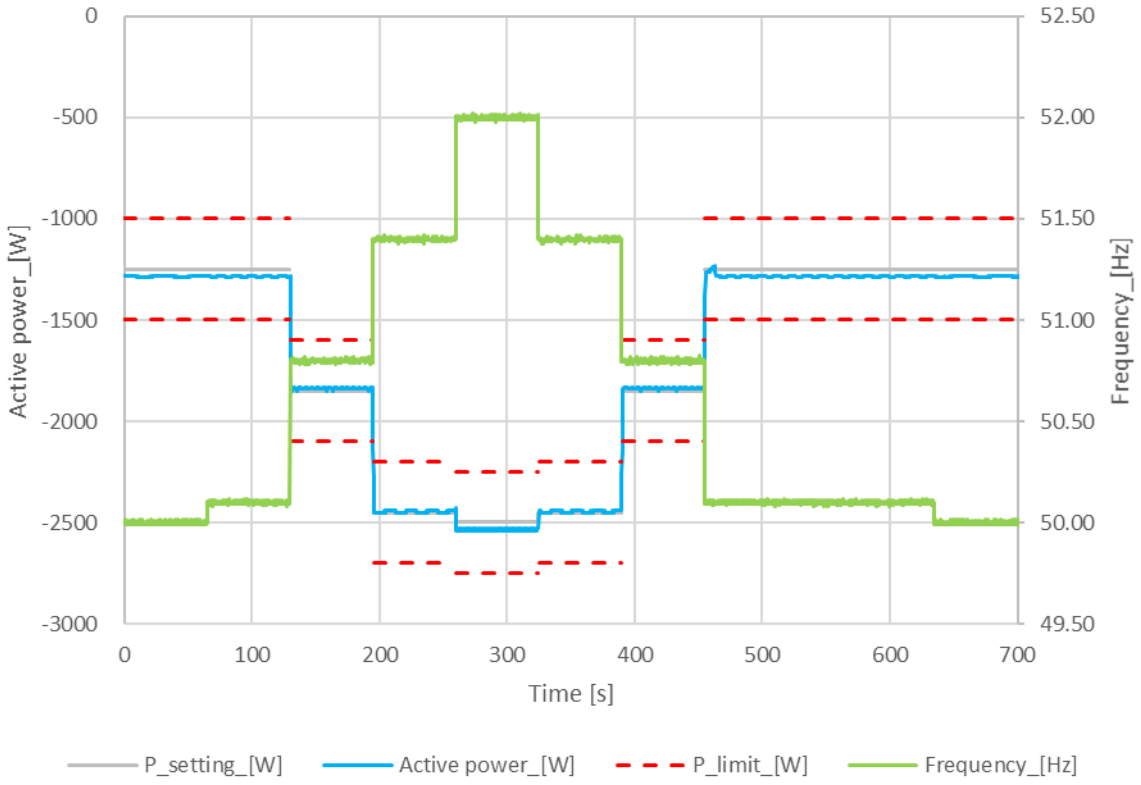
**T2-F9-Test 1**



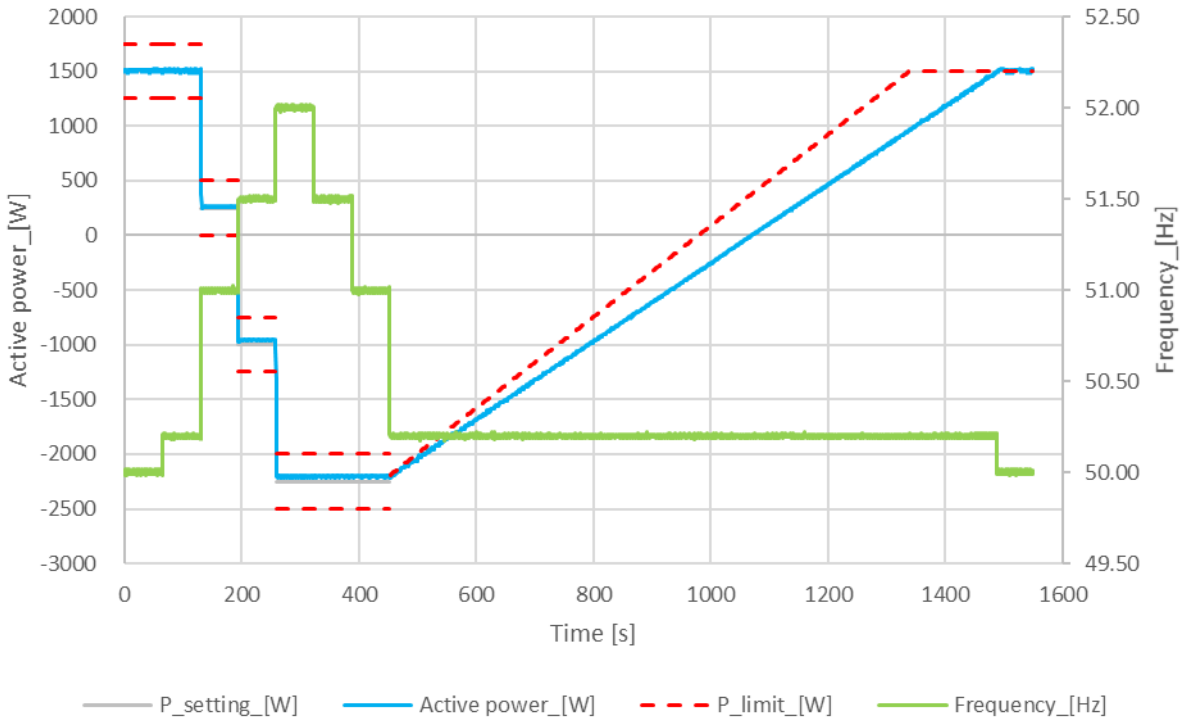

**T2-F9-Test 2**



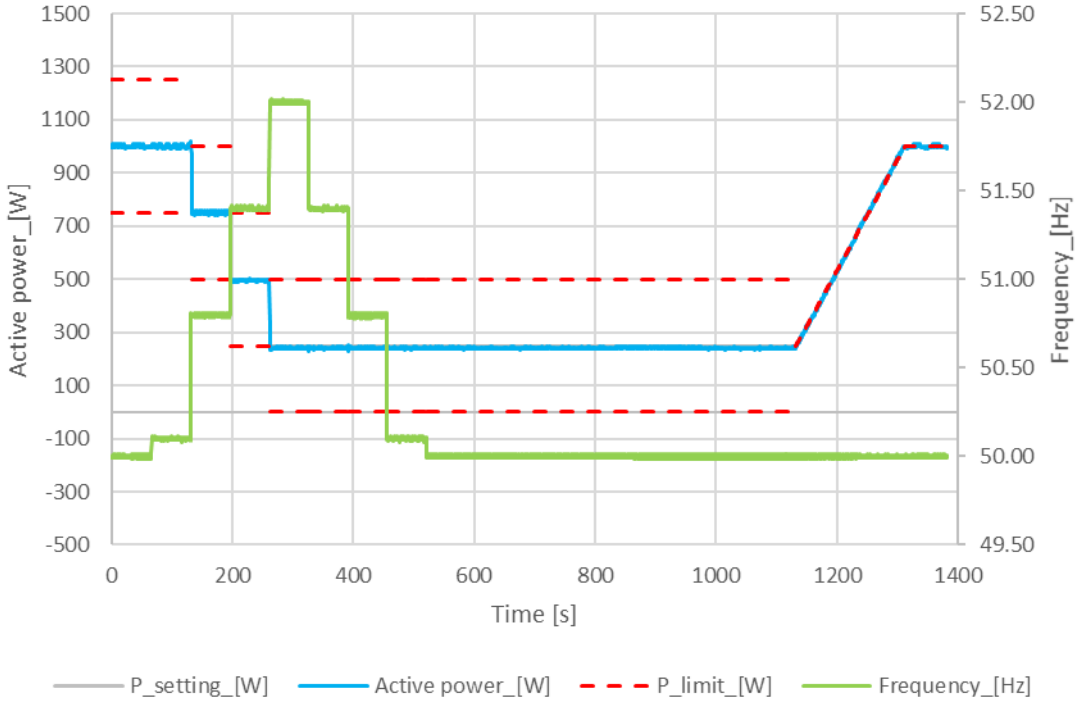
**T2-F9-Test 3**




**T2-F10-Test 4**



**T2-F10-Test 5**


1500
1300
1100
900
700
500
300
100
-100
-300
-500
Active power_[W]
52.50
52.00
51.50
51.00
50.50
50.00
49.50
Frequency_[Hz]
0
200
400
600
800
1000
1200
1400
Time [s]
P_setting_[W]
Active power_[W]
P_limit_[W]
Frequency_[Hz]

### 6.3.2 Power response to under-frequency

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | Test setup n.1 according to section 5.4.2.1, EN 50549-10.<br>See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.4.3, EN 50549-10 |

| | |
|---|---|
| Operating mode of the EUT | ☐ MPP-Tracking operation mode<br>☒ Fixed voltage control operation mode |
| Active Power level | See table *Test cases* below |
| Active factor | 1.000 |
| ROCOF protection | disable |
| Voltage protection | set to values not interfering to the tests |
| Other LFSM-U-relevant parameter settings | See table *Test cases* below and *Annex 1 – Parameter list* |

**Acceptance criteria**

- for each frequency point, the deviation between the expected and the measured value of active power falls within the required tolerance, e.g. ±10%$P_n$, evaluated with a 1 min average value;
- the dead time of the EUT is less than required value, e.g. 2 s, in test scenarios with a configured intentional delay of zero;
- the dead time of the EUT is less than required value, e.g. 2 s, and the accuracy of the configured intentional delay shall be ± 250 ms in test scenarios with a configured intentional delay other than zero;
- the intentional delay acts only for the activation of the function;
- the step response time is less than required value, e.g. 30 s;
- for the procedure for setting (a) or the setting for a specific grid code with power level at start of the test in partial load, the ramp of active power after deactivation of the active power frequency response does not exceed the required value, e.g. 10%$P_n$/min;
- in case of active power response to over-frequency with configured deactivation threshold, if the ramp of active power after deactivation of the active power frequency response does not exceed the required value, e.g. 10%$P_n$/min;
- an EES in charging mode during over frequency does not reduce charging power within required tolerance, e.g. 10% and if declared by the manufacturer, an EES in charging mode does increase the charging power according to the configured droop (see par. 4.6.1 of EN 50549-1:2019 and EN 50549-2:2019).
- randomized disconnection documentation complies to the requirement of EN 50549-1:2019 or EN 50549-2:2019, if this option is used;
- the settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

**Manufacturer's data**

The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software.

## Test cases

Technology of the PGUs:

☐ Synchronous generating technology: $P_{ref} = P_{max}$

☒ Systems with energy storage: $P_{ref} = P_{max}$

☐ Other non-synchronous generating technology: $P_{ref} = P_{max}$

Note:

For DC-coupled storage integrated into the DC side of a generating unit, if they are capable of charging from AC, they shall be considered according to *Systems with energy storage*.

| | Setting (a) | Setting (b) | Setting (c) |
|---|---|---|---|
| frequency threshold $f_{th}$ [Hz] | 49.8 | 49.5 | 49.8 |
| droop [%] | 5 | 2 | 12 |
| power level at start of test [%$P_n$] | -50 / 0 | 0 | 50 |
| Intentional delay [s] | 0 | 0 | 2 |
| Configured deactivation threshold | --- | --- | --- |

Test 1: Setting (a), power level at start of test: 0%$P_{max}$

Test 2: Setting (a), power level at start of test: -50%$P_{max}$

Test 3: Setting (b), power level at start of test: 0%$P_{max}$

Test 4: Setting (c), power level at start of test: 50%$P_{max}$

## Test results

Note:

The frequency points/sequence acc. Table 10 were modified to the frequency steps specified in the result tables below.

**Test 1** (Systems with energy storage) - Setting (a)-0%$P_{max}$

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | 0.00 | 0.03 | --- | --- |
| 2 | 49.90 | 49.90 | 0.00 | 0.03 | --- | --- |
| 3 | 49.00 | 49.00 | 32.00 | 33.35 | 1.35 | ≤ 10 |
| 4 | 48.00 | 48.00 | 72.00 | 74.26 | 2.26 | |
| 5 | 46.00 | 46.00 | 100.00 | 101.83 | 1.83 | |
| 6 | 48.00 | 48.00 | 72.00 | 74.25 | 2.25 | |
| 7 | 49.00 | 49.00 | 32.00 | 33.33 | 1.33 | |
| 8 | 49.90 | 49.90 | 0.00 | 0.00 | --- | --- |
| 9 | 50.00 | 50.00 | 0.00 | 0.03 | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.2 | 1.4 | 1.4 | --- | < 2 | < 30 | --- |
| 3 → 4 | 0.2 | 0.4 | 0.4 | --- | < 2 | | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 → 5 | 0.2 | 0.2 | 0.2 | --- | | | |
| 5 → 6 | 0.2 | 0.4 | 0.4 | --- | | | |
| 6 → 7 | 0.2 | 0.6 | 0.6 | --- | | | |
| 7 → 8 | 0.2 | 0.6 | 0.6 | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:
* The Dead time for frequency step 2 → 3 refers to the **intentional delay** for the activation of the function;
The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**Test 2** (Systems with energy storage) - Setting (a)-(-50%)$P_{max}$

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | -50.00 | -50.17 | --- | --- |
| 2 | 49.90 | 49.90 | -50.00 | -50.19 | --- | --- |
| 3 | 49.00 | 49.00 | -18.00 | -16.74 | 1.26 | ≤ 10 |
| 4 | 48.00 | 48.00 | 22.00 | 24.16 | 2.16 | |
| 5 | 46.00 | 46.00 | 100.00 | 100.01 | 0.01 | |
| 6 | 48.00 | 48.00 | 22.00 | 24.17 | 2.17 | |
| 7 | 49.00 | 49.00 | -18.00 | -16.74 | 1.26 | |
| 8 | 49.90 | 49.90 | -50.00 | -50.20 | --- | --- |
| 9 | 50.00 | 50.00 | -50.00 | -50.18 | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.2 | 1.8 | 1.8 | --- | < 2 | < 30 | --- |
| 3 → 4 | 0.2 | 1.0 | 1.0 | --- | < 2 | | |
| 4 → 5 | 0.2 | 1.6 | 1.6 | --- | | | |
| 5 → 6 | 0.2 | 2.2 | 2.2 | --- | | | |
| 6 → 7 | 0.2 | 0.6 | 0.6 | --- | | | |
| 7 → 8 | 0.2 | 0.6 | 0.6 | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:
* The Dead time for frequency step 2 → 3 refers to the **intentional delay** for the activation of the function;
The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**Test 3** (Systems with energy storage) - Setting (b)-0%$P_{max}$

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value - Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | 0.00 | -0.06 | --- | --- |
| 2 | 49.80 | 49.80 | 0.00 | -0.05 | --- | --- |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 49.20 | 49.20 | 30.00 | 32.18 | 2.18 | ≤ 10 |
| 4 | 48.80 | 48.80 | 70.00 | 73.15 | 3.15 | |
| 5 | 46.00 | 46.00 | 100.00 | 100.96 | 0.96 | |
| 6 | 48.80 | 48.80 | 70.00 | 73.19 | 3.19 | |
| 7 | 49.20 | 49.20 | 30.00 | 32.16 | 2.16 | |
| 8 | 49.80 | 49.80 | 0.00 | -0.07 | --- | --- |
| 9 | 50.00 | 50.00 | 0.00 | -0.05 | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.2 | 1.6 | 1.6 | --- | < 2 | < 30 | --- |
| 3 → 4 | 0.2 | 1.0 | 1.0 | --- | < 2 | | |
| 4 → 5 | 0.2 | 0.2 | 0.2 | --- | | | |
| 5 → 6 | 0.2 | 0.8 | 0.8 | --- | | | |
| 6 → 7 | 0.2 | 1.2 | 1.2 | --- | | | |
| 7 → 8 | 0.2 | 0.8 | 0.8 | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:

* The Dead time for frequency step 2 → 3 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

**Test 4** (Systems with energy storage） - Setting (c)-50%$P_{max}$

| Frequency step | Simulated frequency [Hz] | Measured frequency [Hz] | P-Setpoint $P_{set}/P_n$ [%] | Measured value $P/P_n$ [%] | Deviation $\Delta P/P_n$ [%] (Measured value – Set point) | Limit $\lvert\Delta P/P_n\rvert$ [%] |
|---|---|---|---|---|---|---|
| 1 | 50.00 | 50.00 | 50.00 | 50.03 | --- | --- |
| 2 | 49.90 | 49.90 | 50.00 | 50.04 | --- | --- |
| 3 | 49.00 | 49.00 | 63.00 | 63.81 | 0.81 | ≤ 10 |
| 4 | 47.50 | 47.50 | 88.00 | 89.73 | 1.73 | |
| 5 | 46.00 | 46.00 | 100.00 | 100.93 | 0.93 | |
| 6 | 47.50 | 47.50 | 88.00 | 89.71 | 1.71 | |
| 7 | 49.00 | 49.00 | 63.00 | 64.16 | 1.16 | |
| 8 | 49.90 | 49.90 | 50.00 | 50.06 | --- | --- |
| 9 | 50.00 | 50.00 | 50.00 | 50.03 | --- | --- |

| Frequency step | $T_d$ [s] * | $T_{sr}$ [s] | $T_s$ [s] | Ramp of active power after deactivation LFSM-O [$P_n$/min] | Limit | | |
|---|---|---|---|---|---|---|---|
| | | | | | $T_d$ [s] | $T_{sr}$ [s] | Ramp of active power after deactivation LFSM-O [%$P_n$/min] |
| 1 → 2 | --- | --- | --- | --- | --- | --- | --- |
| 2 → 3 | 0.4 | 1.2 | 1.2 | --- | < 2 | < 30 | --- |
| 3 → 4 | 0.2 | 0.4 | 0.4 | --- | < 2 | | |
| 4 → 5 | 0.2 | 0.2 | 0.2 | --- | | | |

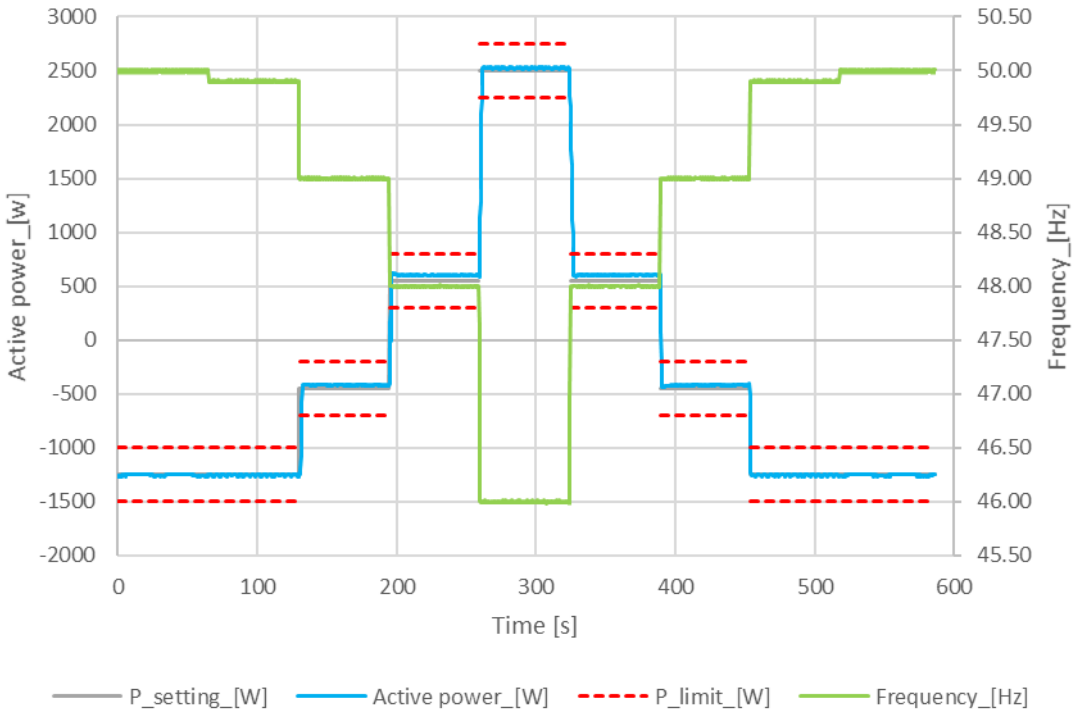
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 → 6 | 0.2 | 0.2 | 0.2 | --- | | | |
| 6 → 7 | 0.2 | 0.4 | 0.4 | --- | | | |
| 7 → 8 | 0.2 | 0.2 | 0.2 | --- | | | |
| 8 → 9 | --- | --- | --- | --- | --- | --- | --- |

Note:

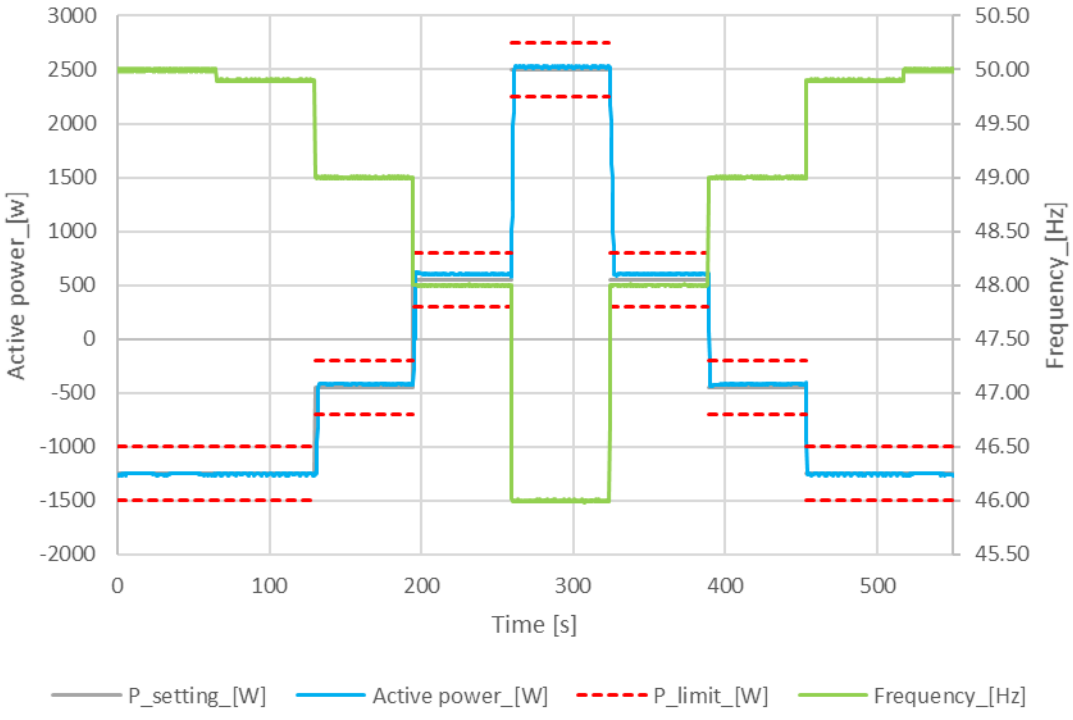
* The Dead time for frequency step 2 → 3 refers to the **intentional delay** for the activation of the function;

The Dead time for other frequency steps refers to the intrinsic dead time of the LFSM control algorithm for response to frequency changes.

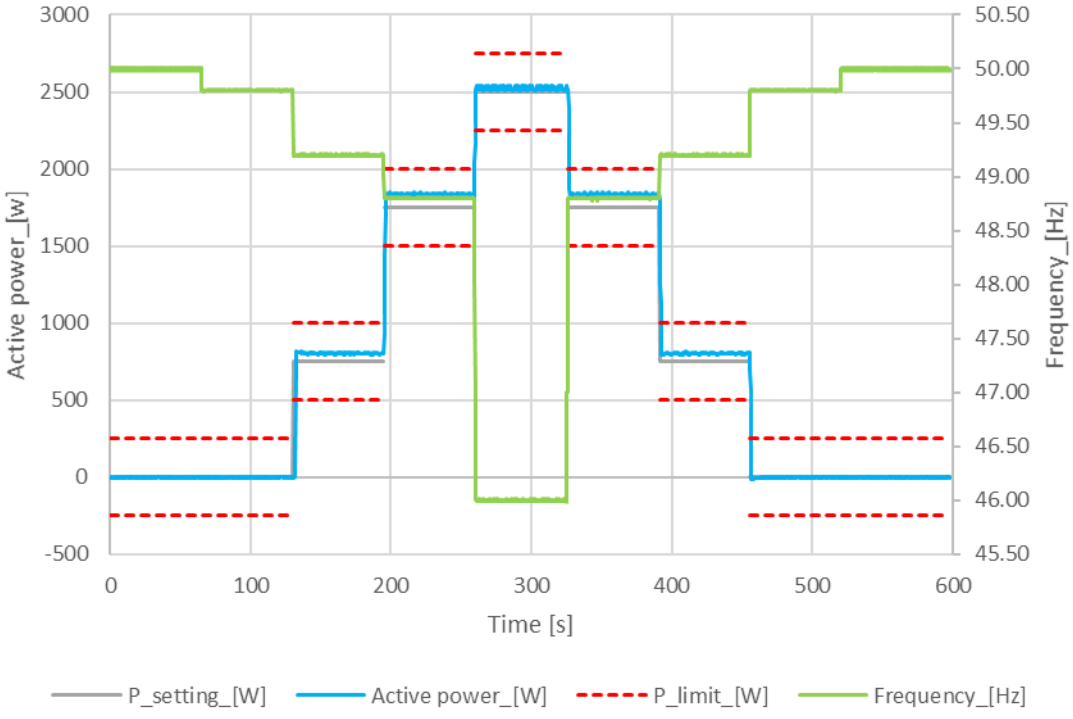
**Test 1**



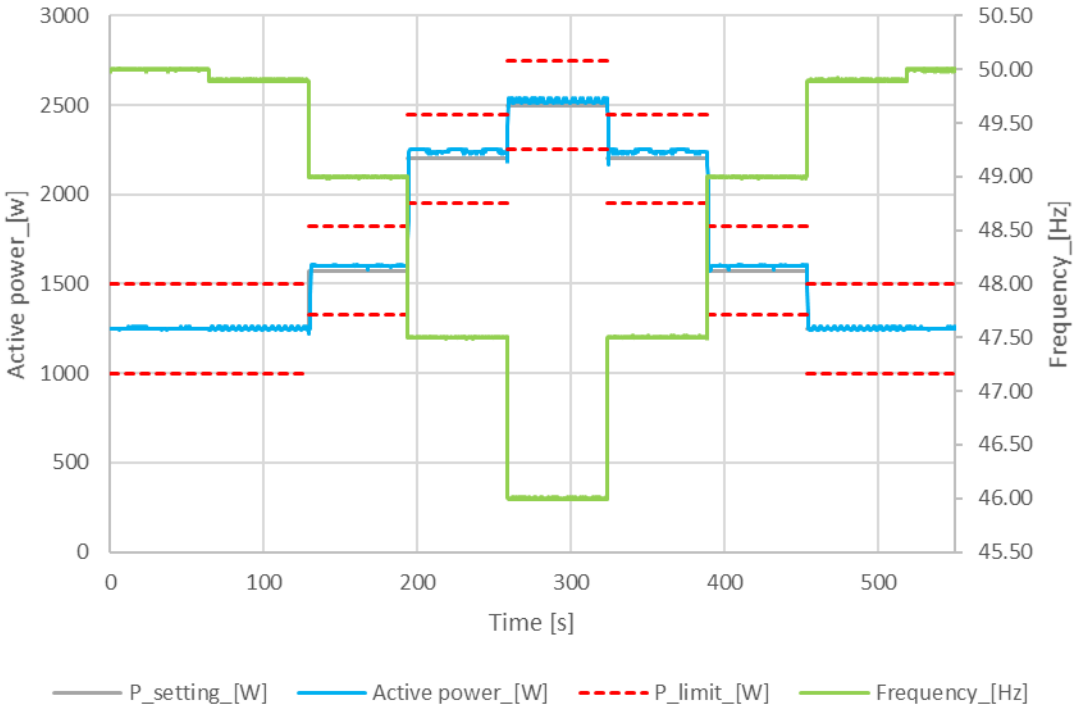
**Test 2**


Active power_[w]
Frequency_[Hz]
Time [s]
P_setting_[W]
Active power_[W]
P_limit_[W]
Frequency_[Hz]

**Test 3**


Active power_[w]
Frequency_[Hz]
Time [s]
P_setting_[W]
Active power_[W]
P_limit_[W]
Frequency_[Hz]

**Test 4**


3000
2500
2000
1500
1000
500
0
Active power_[w]
50.50
50.00
49.50
49.00
48.50
48.00
47.50
47.00
46.50
46.00
45.50
Frequency_[Hz]
0
100
200
300
400
500
Time [s]
P_setting_[W]
Active power_[W]
P_limit_[W]
Frequency_[Hz]

## 6.4 Power specification and response to voltage variations

### 6.4.1 Power capabilities assessment - voltage support by reactive power

#### 6.4.1.1 Determine the power capability at nominal voltage

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.5.1.3 & 5.5.1.6, EN 50549-10 |

| Acceptance criteria |
|---|
| The generating unit is able to meet the reactive power value of the capability curve in overexcited and underexcited condition as declared by the manufacturer. In particular the values are reached and maintained for the specified time. |

**Manufacturer's data**

Th PGU(s) are designed for the P-Q capability acc.:

☐ EN 50549-1:

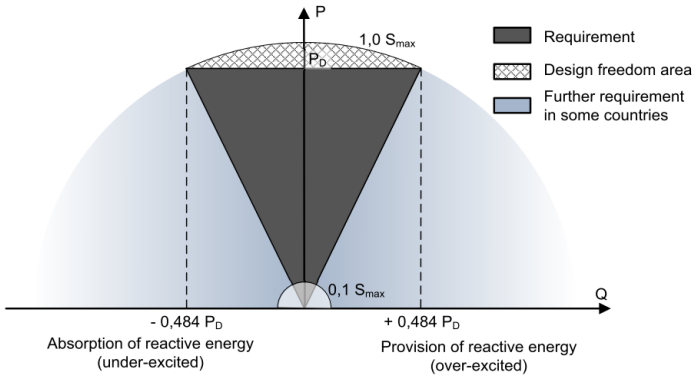



**Figure 12 — Reactive power capability at nominal voltage**

☐ EN 50549-2 ☐ Stringent Requirement ☐ default requirement

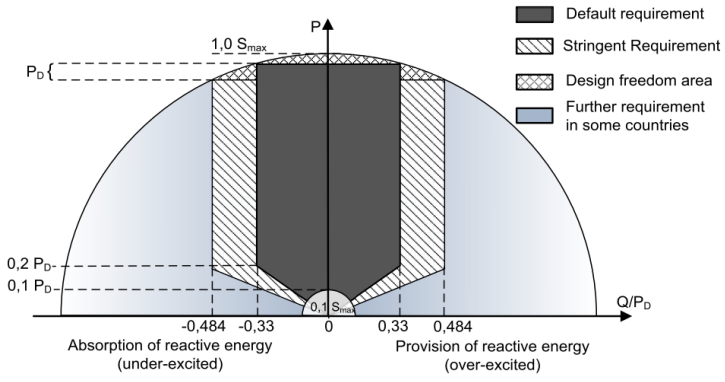



**Figure 12 — Reactive power capability at nominal voltage**

☒ According to manufactuer' data

See *Annex 3 – Capability curve of the PGU(s)*.

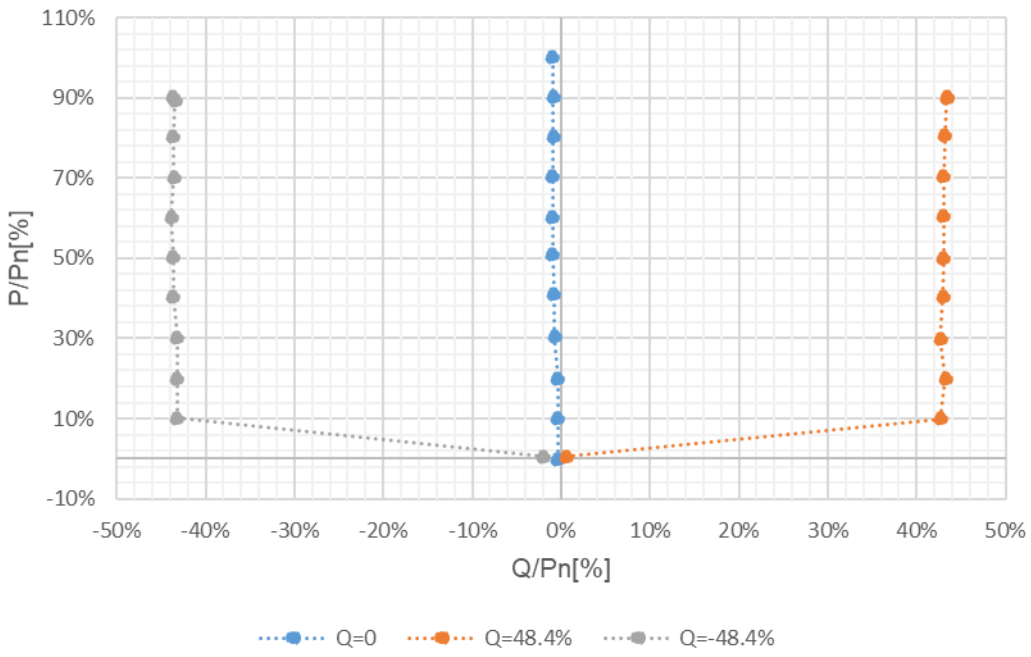
## Test results

| Active power level P/$P_n$ [%] | Q = 0 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $P_{60}$ | | $Q_{60}$ | | $S_{60}$ | | cosφ$_{60}$ [-] | $U_{60}$[V] | |
| | [W] | [p.u. based $P_n$] | [Var] | [p.u. based $P_n$] | [VA] | [p.u. based $P_n$] | | [V] | [p.u. based $U_n$] |
| 0 | -5 | 0.00 | -9 | 0.00 | 10 | 0.00 | -0.485 | 230.41 | 1.00 |
| 10 | 251 | 0.10 | -9 | 0.00 | 251 | 0.10 | 0.999 | 230.41 | 1.00 |
| 20 | 501 | 0.20 | -10 | 0.00 | 501 | 0.20 | 0.999 | 230.41 | 1.00 |
| 30 | 759 | 0.30 | -19 | -0.01 | 759 | 0.30 | 0.999 | 230.61 | 1.00 |
| 40 | 1029 | 0.41 | -21 | -0.01 | 1029 | 0.41 | 0.999 | 230.61 | 1.00 |
| 50 | 1269 | 0.51 | -24 | -0.01 | 1269 | 0.51 | 0.999 | 230.41 | 1.00 |
| 60 | 1501 | 0.60 | -23 | -0.01 | 1501 | 0.60 | 0.999 | 230.41 | 1.00 |
| 70 | 1758 | 0.70 | -24 | -0.01 | 1758 | 0.70 | 0.999 | 230.41 | 1.00 |
| 80 | 2006 | 0.80 | -23 | -0.01 | 2006 | 0.80 | 0.999 | 230.41 | 1.00 |
| 90 | 2254 | 0.90 | -23 | -0.01 | 2254 | 0.90 | 0.999 | 230.41 | 1.00 |
| 100 | 2505 | 1.00 | -24 | -0.01 | 2505 | 1.00 | 0.999 | 230.41 | 1.00 |

| Active power level P/$P_n$ [%] | Underexcited | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $P_{60}$ | | $Q_{60}$ | | $S_{60}$ | | cosφ$_{60}$ [-] | $U_{60}$[V] | |
| | [W] | [p.u. based $P_n$] | [Var] | [p.u. based $P_n$] | [VA] | [p.u. based $P_n$] | | [V] | [p.u. based $U_n$] |
| 0 | 11 | 0.00 | -48 | -0.02 | 50 | 0.02 | -0.224 | 230.41 | 1.00 |
| 10 | 252 | 0.10 | -1080 | -0.43 | 1110 | 0.44 | -0.226 | 230.41 | 1.00 |
| 20 | 499 | 0.20 | -1081 | -0.43 | 1191 | 0.48 | -0.419 | 230.60 | 1.00 |
| 30 | 755 | 0.30 | -1081 | -0.43 | 1319 | 0.53 | -0.573 | 230.41 | 1.00 |
| 40 | 1010 | 0.40 | -1091 | -0.44 | 1486 | 0.59 | -0.679 | 230.41 | 1.00 |
| 50 | 1260 | 0.50 | -1091 | -0.44 | 1666 | 0.67 | -0.756 | 230.41 | 1.00 |
| 60 | 1505 | 0.60 | -1096 | -0.44 | 1861 | 0.74 | -0.808 | 230.42 | 1.00 |
| 70 | 1750 | 0.70 | -1090 | -0.44 | 2060 | 0.82 | -0.849 | 230.41 | 1.00 |
| 80 | 2010 | 0.80 | -1090 | -0.44 | 2286 | 0.91 | -0.879 | 230.41 | 1.00 |
| 90 | 2230 | 0.89 | -1085 | -0.43 | 2480 | 0.99 | -0.899 | 230.41 | 1.00 |
| 100 | 2258 | 0.90 | -1091 | -0.44 | 2508 | 1.00 | -0.900 | 230.41 | 1.00 |

| Active power level P/$P_n$ [%] | Overexcited | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $P_{60}$ | | $Q_{60}$ | | $S_{60}$ | | cosφ$_{60}$ [-] | $U_{60}$[V] | |
| | [W] | [p.u. based $P_n$] | [Var] | [p.u. based $P_n$] | [VA] | [p.u. based $P_n$] | | [V] | [p.u. based $U_n$] |
| 0 | 12 | 0.00 | 14 | 0.01 | 19 | 0.01 | 0.634 | 230.19 | 1.00 |
| 10 | 250 | 0.10 | 1066 | 0.43 | 1095 | 0.44 | 0.228 | 230.19 | 1.00 |
| 20 | 501 | 0.20 | 1082 | 0.43 | 1192 | 0.48 | 0.420 | 230.40 | 1.00 |
| 30 | 742 | 0.30 | 1066 | 0.43 | 1298 | 0.52 | 0.572 | 230.40 | 1.00 |
| 40 | 1007 | 0.40 | 1074 | 0.43 | 1472 | 0.59 | 0.683 | 230.19 | 1.00 |
| 50 | 1251 | 0.50 | 1076 | 0.43 | 1648 | 0.66 | 0.758 | 230.19 | 1.00 |
| 60 | 1512 | 0.60 | 1076 | 0.43 | 1854 | 0.74 | 0.815 | 230.19 | 1.00 |
| 70 | 1760 | 0.70 | 1076 | 0.43 | 2061 | 0.82 | 0.853 | 230.19 | 1.00 |
| 80 | 2014 | 0.81 | 1080 | 0.43 | 2284 | 0.91 | 0.881 | 230.19 | 1.00 |
| 90 | 2249 | 0.90 | 1084 | 0.43 | 2496 | 1.00 | 0.901 | 230.18 | 1.00 |
| 100 | 2254 | 0.90 | 1086 | 0.43 | 2501 | 1.00 | 0.901 | 230.19 | 1.00 |

| | |
|---|---|
| $P_{max,\ 600}$ = max ($P_{max,\ 600,\ underexcited}$, $P_{max,\ 600,\ Q=0}$, $P_{max,\ 600,\ overexcited}$) [W] | 2510 |
| $P_{max,\ 60}$ = max ($P_{max,\ 60,\ underexcited}$, $P_{max,\ 60,\ Q=0}$, $P_{max,\ 60,\ overexcited}$) [W] | 2510 |
| $P_{max,\ 0.2}$ = max ($P_{max,\ 0.2,\ underexcited}$, $P_{max,\ 0.2,\ Q=0}$, $P_{max,\ 0.2,\ overexcited}$) [W] | 2500 |
| $S_{max,\ 600}$ = max ($S_{max,\ 600,\ underexcited}$, $S_{max,\ 600,\ Q=0}$, $S_{max,\ 600,\ overexcited}$) [VA] | 2510 |
| $S_{max,\ 60}$ = max ($S_{max,\ 60,\ underexcited}$, $S_{max,\ 60,\ Q=0}$, $S_{max,\ 60,\ overexcited}$) [VA] | 2510 |
| $S_{max,\ 0.2}$ = max ($S_{max,\ 0.2,\ underexcited}$, $S_{max,\ 0.2,\ Q=0}$, $S_{max,\ 0.2,\ overexcited}$) [VA] | 2500 |
| $Q_{max,\ over,\ 600}$ = max ($Q_{max,\ 600,\ overexcited}$) [var] | 1100 |
| $Q_{max,\ over,\ 60}$ = max ($Q_{max,\ 60,\ overexcited}$) [var] | 1100 |
| $Q_{max,\ over,\ 0.2}$ = max ($Q_{max,\ 0.2,\ overexcited}$) [var] | 1090 |
| $Q_{max,\ under,\ 600}$ = max ($Q_{max,\ 600,\ underexcited}$) [var] | -1100 |
| $Q_{max,\ under,\ 60}$ = max ($Q_{max,\ 60,\ underexcited}$) [var] | -1100 |
| $Q_{max,\ under,\ 0.2}$ = max ($Q_{max,\ 0.2,\ underexcited}$) [var] | -1100 |




### 6.4.1.2 Determine the power capability considering voltage range

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |

| Acceptance criteria |
|---|
| The U-Q diagram provides all the information to evaluate the performance of the generating unit considering active power, reactive power and associated voltage level. The U-Q diagram shall be equal or exceed U-Q requirements. |

| Manufacturer's data |
|---|
| See *Annex 3 – Capability curve of the PGU(s)*. |

| Test results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Voltage level $U/U_n$ [%] | $Q = Q_{max, under}$ | | | | | | | | |
| | $P_{60}$ | | $Q_{60}$ | | $S_{60}$ | | $\cos\varphi_{60}$ [-] | $U_{+, 60}$[V] | |
| | [W] | [p.u. based $P_n$] | [Var] | [p.u. based $P_n$] | [VA] | [p.u. based $P_n$] | | [V] | [p.u. based $U_n$] |
| 85 | 2251 | 0.90 | -1101 | -0.44 | 2506 | 1.00 | 0.898 | 195.4 | 0.85 |
| 90 | 2248 | 0.90 | -1098 | -0.44 | 2503 | 1.00 | 0.899 | 206.8 | 0.90 |
| 95 | 2246 | 0.90 | -1095 | -0.44 | 2498 | 1.00 | 0.899 | 218.2 | 0.95 |
| 100 | 2244 | 0.90 | -1092 | -0.44 | 2495 | 1.00 | 0.899 | 229.7 | 1.00 |
| 105 | 2240 | 0.90 | -1090 | -0.44 | 2491 | 1.00 | 0.899 | 241.1 | 1.05 |
| 110 | 2237 | 0.89 | -1088 | -0.44 | 2487 | 0.99 | 0.899 | 252.6 | 1.10 |
| | $Q = Q_{max, over}$ | | | | | | | | |
| 85 | 2262 | 0.90 | 1071 | 0.43 | 2503 | 1.00 | 0.904 | 195.8 | 0.85 |
| 90 | 2257 | 0.90 | 1071 | 0.43 | 2499 | 1.00 | 0.903 | 207.2 | 0.90 |
| 95 | 2257 | 0.90 | 1072 | 0.43 | 2499 | 1.00 | 0.903 | 218.6 | 0.95 |
| 100 | 2254 | 0.90 | 1074 | 0.43 | 2498 | 1.00 | 0.903 | 230.0 | 1.00 |
| 105 | 2256 | 0.90 | 1077 | 0.43 | 2499 | 1.00 | 0.902 | 241.5 | 1.05 |
| 110 | 2257 | 0.90 | 1080 | 0.43 | 2502 | 1.00 | 0.902 | 252.9 | 1.10 |

### 6.4.2 Determine the reactive power control modes

#### 6.4.2.1 Q-Set point control

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |

| | |
|---|---|
| The interface used to provide reactive power set points | Using specialized software tool *at_**Modbus Poll**_tool* through the RS485 interface. |
| Reactive power set points | Parameter: Var (see *Annex 1 – Parameter list*) |

**Acceptance criteria**

Reactive power set point control accuracy (static reactive power value) is better than 2 % Smax. In case of cos φ set points, the reactive power accuracy applies for the reactive power set value derived from the cos φ set point and the active power during the measurement.

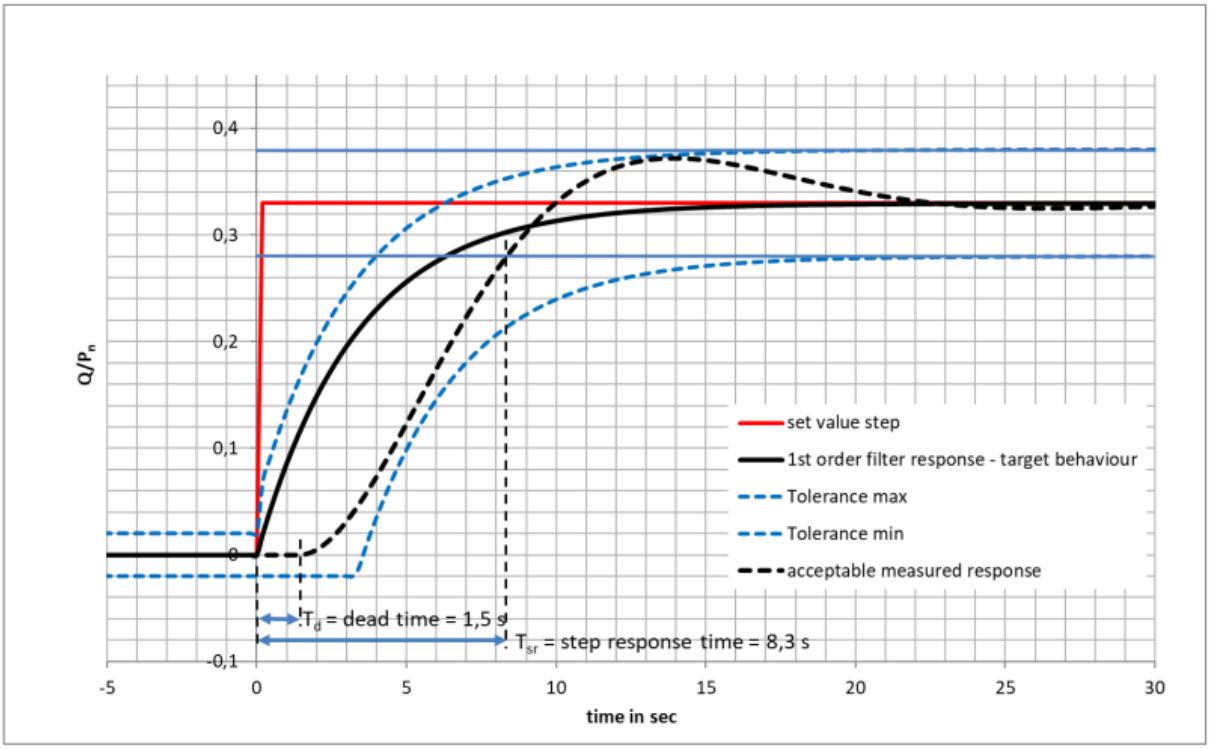


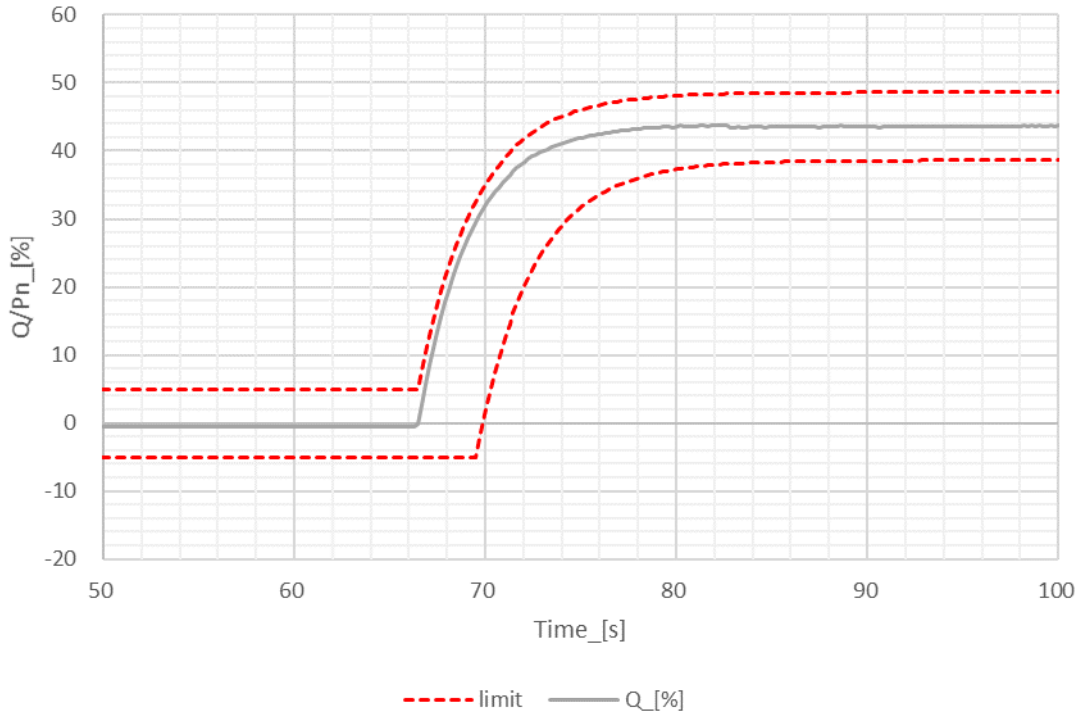

**Figure 32 — Example graphical representation of step response behaviour for a step from Q = 0 to Q = 0,33 % $P_n$ with a time constant configured to a value equal to 3,33 s (settling time $3 \times \tau = 10s$).**

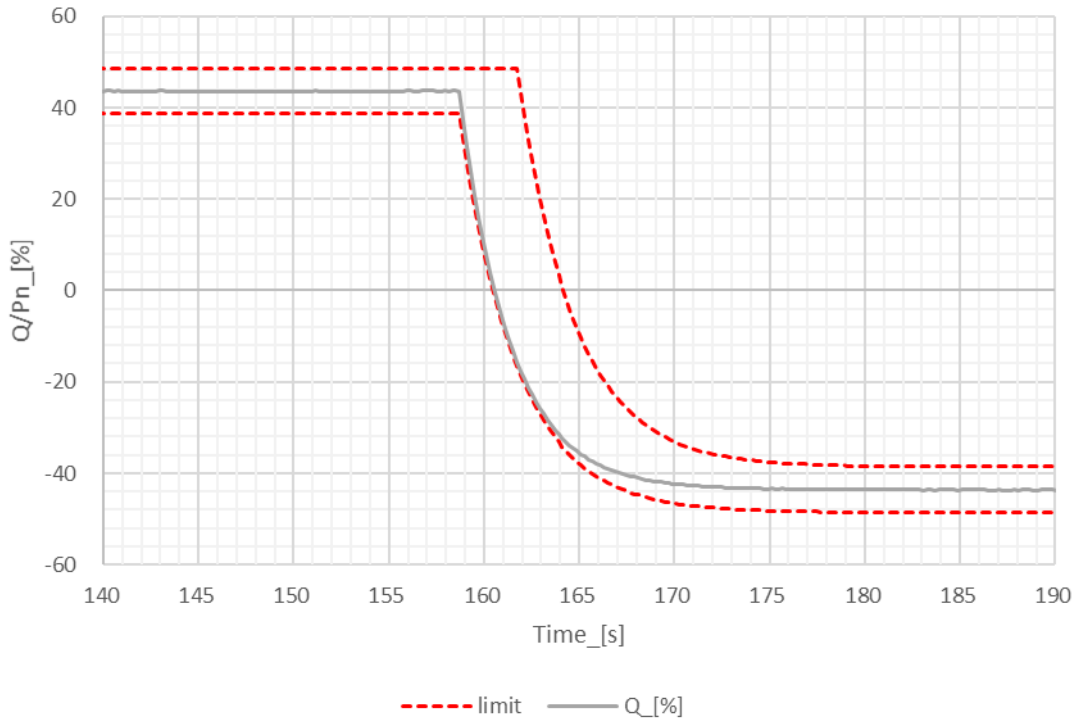
**Manufacturer's data**

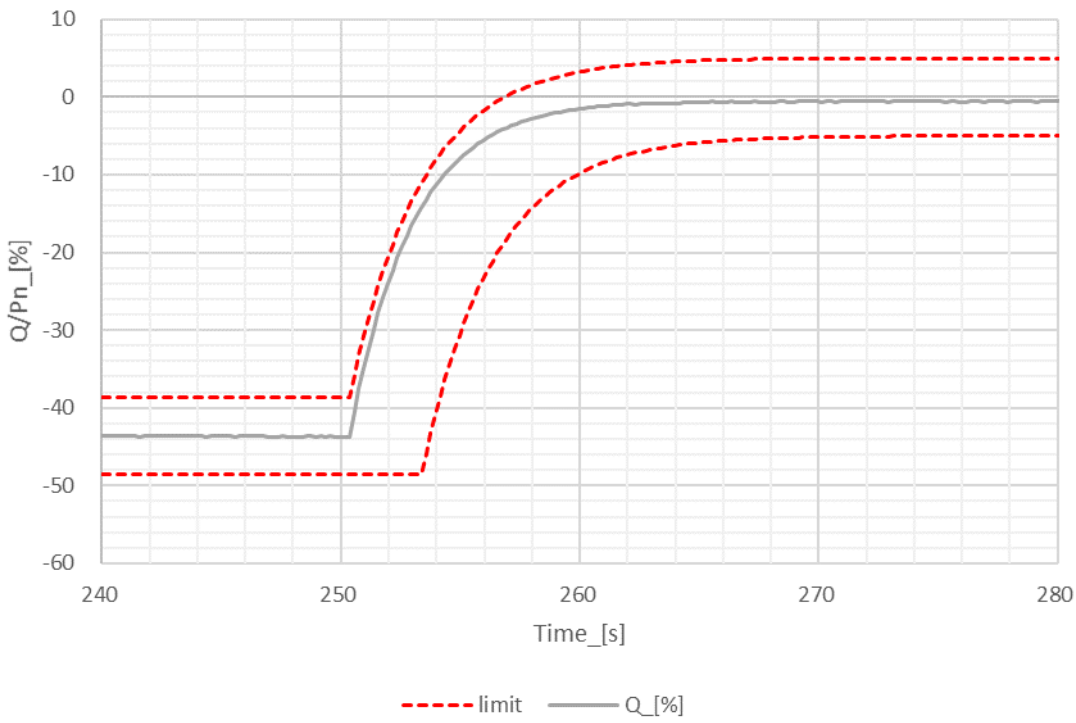
See *Annex 3 – Capability curve of the PGU(s)*.

| Reactive power step Q/Pn (pu) | Voltage | Set point value | | Measured value (1-min average) | | Deviation (Measured value - Set point) | |
|---|---|---|---|---|---|---|---|
| | [V] | [Var] | [p.u. based $P_n$] | [Var] | [p.u. based $P_n$] | [Var] | [p.u. based $P_n$] |
| Q = 0 | 230.0 | 0 | 0.000 | -12 | -0.005 | -12 | -0.005 |
| Q = 0.5$Q_{max,over}$ | 230.0 | 545 | 0.218 | 524 | 0.210 | -21 | -0.008 |
| Q = 0.5$Q_{max,under}$ | 230.0 | -545 | -0.218 | -549 | -0.219 | -4 | -0.001 |

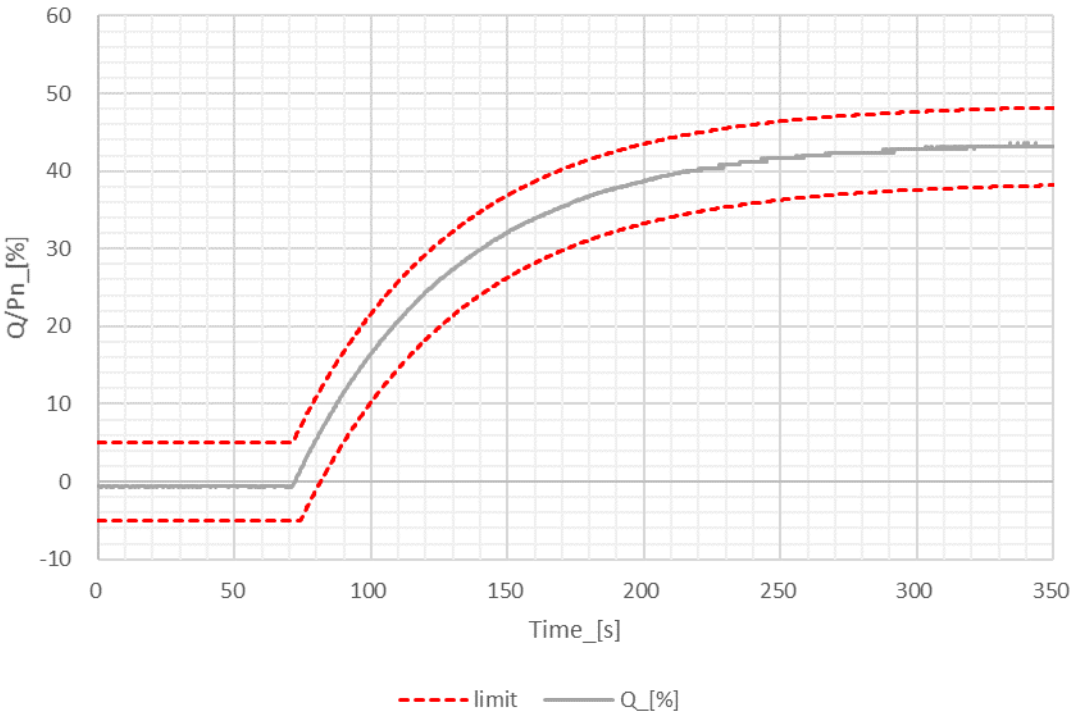
| **Tau=3s** | | | |
|---|---|---|---|
| Reactive power set point step p.u. | Generating unit response time setting [s] | Measured response behaviour [s] | |
| | | dead time | response time / settling time |
| Q = 0 ➔ Q = Qmax over | 9 | 0.2 | 5.8 |
| Q = Qmax over ➔ Q = Qmax under | 9 | 0.2 | 7.8 |
| Q = Qmax under ➔ Q = 0 | 9 | 0.2 | 6.0 |

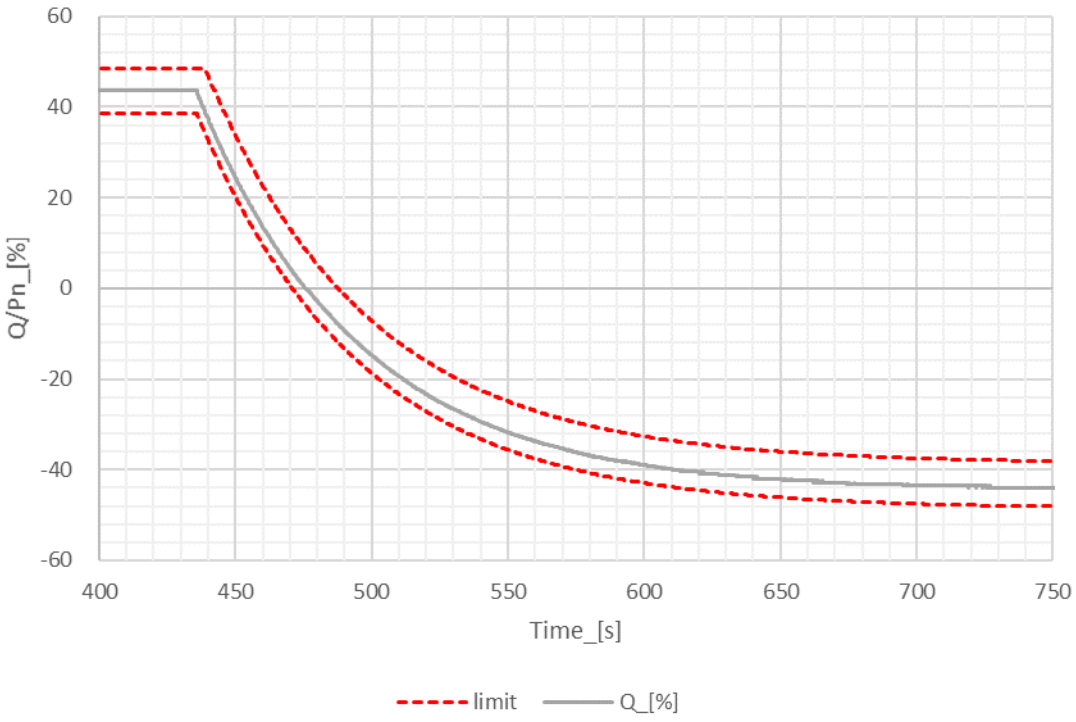


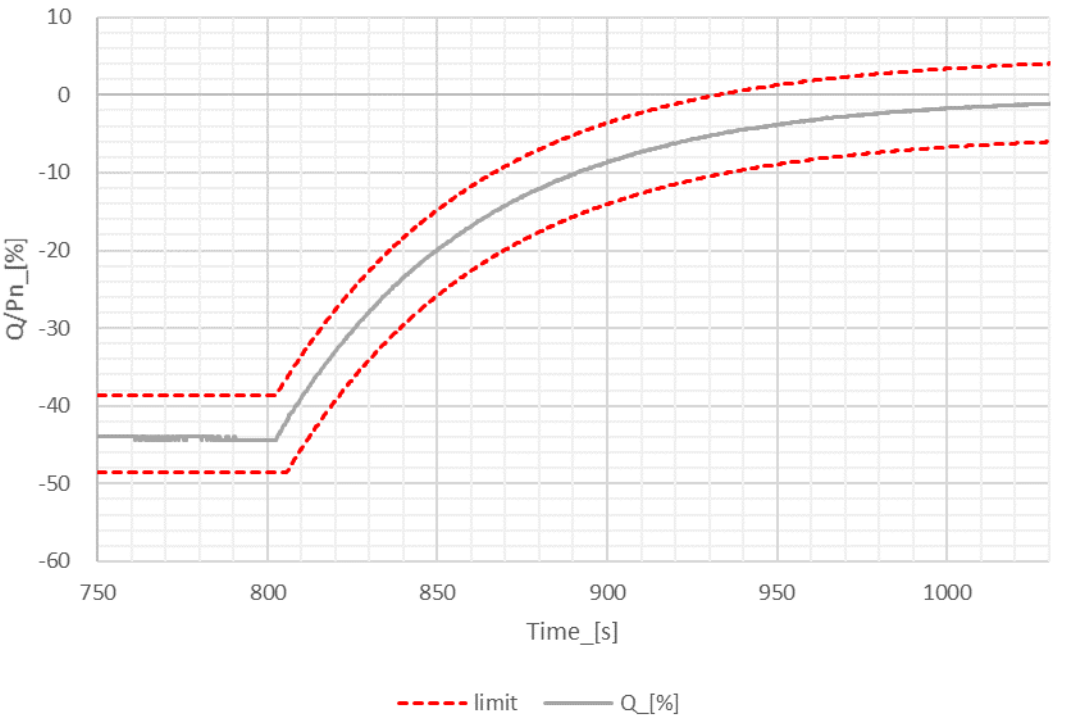

60
40
20
0
-20
-40
-60
Q/Pn_[%]
140
145
150
155
160
165
170
175
180
185
190
Time_[s]
limit
Q_[%]


10
0
-10
-20
-30
-40
-50
-60
Q/Pn_[%]
240
250
260
270
280
Time_[s]
limit
Q_[%]

| Tau=60s | | | |
|---|---|---|---|
| Reactive power set point step p.u. | Generating unit response time setting [s] | Measured response behaviour [s] | |
| | | dead time | response time / settling time |
| Q = 0 ➔ Q = Qmax over | 180 | 0.2 | 127.6 |
| Q = Qmax over ➔ Q = Qmax under | 180 | 0.2 | 160.0 |
| Q = Qmax under ➔ Q = 0 | 180 | 0.2 | 130.8 |






### 6.4.2.2 Voltage related control mode for reactive power Q(U)

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |

| **Acceptance criteria** |
|---|
| -The test of the accuracy of the Q(U) control under quasi-stationary conditions shall be considered passed if: The measured 30-s averages of the reactive power (positive sequence components) during steady-state conditions are within a tolerance band of + 2 % Smax and + 1 % Un of the set Q(U) characteristic including correct behaviour related to Lock-in/Lock-out and min cos p.<br>- The test of the dynamic behaviour of the Q(U) control shall be considered passed if:<br>1. the time response of the reactive power during the measurement is within the tolerance band resulting from the behaviour of an equivalent first order filter element and the configured time constant tau. Accepted tolerances are ± 5 % Pn for the reactive power values and 3 s for the time delay deviating from an ideal first order filter response. The tolerance bands can be calculated according to Table 14 (see also Figure 32).<br>2. No discontinuities in the characteristic curve are detected and no oscillations of the reactive power after the end of the transient period of 5 τ as configured and no disconnection of the EUT occur.<br>3. Correct functioning of lock-in and lock-out thresholds if activated: Q(U) is disabled for power levels below the lock-out setting and enabled again if the active power is above lock-in threshold.<br>4. Correct functioning of minimum active factor if activated: The reactive power value is reduced for small active power to maintain the configured minimum active factor. The accuracy requirement for the active factor set point applies.<br>5. The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal). |

| **Manufacturer's data** |
|---|
| See *Annex 3 – Capability curve of the PGU(s)*. |

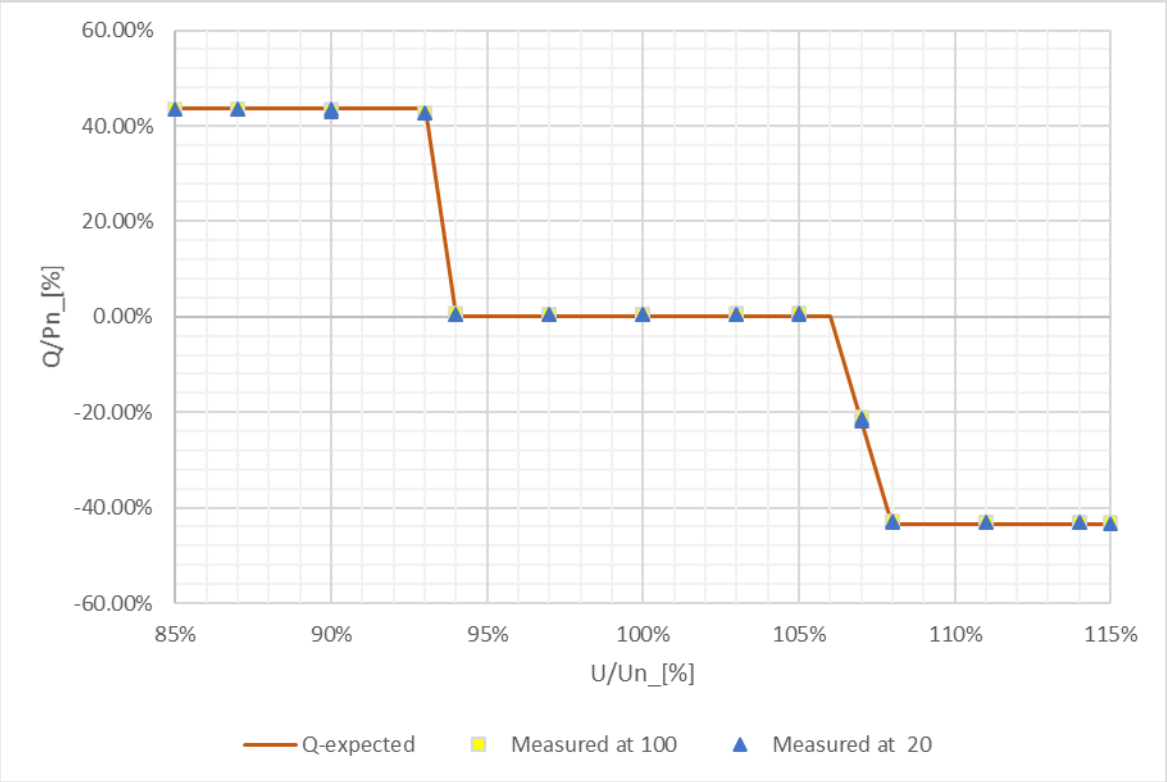
TABLE: Test procedure for steady-state behaviour

Test procedure for accuracy-**Setting (a)**

| Q(U) curve settings: | Set points | X1 | X2 | X3 | X4 |
|---|---|---|---|---|---|
| | U/Un | 93% | 94% | 106% | 108% |
| | Q/Qmax | 100% | 0 | 0 | -100% |

| Test Conditions | | Measurements | | | Target value | Δ | Δ Limits | |
|---|---|---|---|---|---|---|---|---|
| U/Un | P/Pn | Q/Pn | U/Un | Cosφ | Q/Pn | ΔQ/ Smax* | ΔQ/ Smax | Cosφ |
| 100% | 100% | 0.51% | 100.0% | 0.999 | 0.00% | 0.51% | ≤ ±2 Smax% | ≥0.4 |
| 103% | 100% | 0.66% | 103.0% | 0.999 | 0.00% | 0.66% | | |
| 105% | 100% | 0.78% | 105.2% | 0.999 | 0.00% | 0.78% | | |
| 107% | 100% | -21.13% | 106.9% | 0.978 | -21.80% | 0.67% | | |
| 108% | 100% | -42.95% | 107.9% | 0.903 | -43.60% | 0.65% | | |
| 111% | 100% | -43.03% | 111.0% | 0.902 | -43.60% | 0.57% | | |
| 114% | 100% | -43.16% | 114.3% | 0.902 | -43.60% | 0.44% | | |
| 115% | 100% | -43.20% | 114.9% | 0.902 | -43.60% | 0.40% | | |
| 114% | 100% | -43.13% | 113.8% | 0.902 | -43.60% | 0.47% | | |
| 111% | 100% | -43.10% | 111.0% | 0.902 | -43.60% | 0.50% | | |
| 108% | 100% | -42.78% | 107.9% | 0.903 | -43.60% | 0.82% | | |
| 107% | 100% | -21.80% | 106.9% | 0.977 | -21.80% | 0.00% | | |
| 105% | 100% | 0.62% | 105.2% | 0.999 | 0.00% | 0.62% | | |
| 103% | 100% | 0.49% | 103.0% | 0.999 | 0.00% | 0.49% | | |
| 100% | 100% | 0.42% | 100.0% | 0.999 | 0.00% | 0.42% | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 97% | 100% | 0.43% | 97.0% | 0.999 | 0.00% | 0.43% | | |
| 94% | 100% | 0.52% | 94.0% | 0.999 | 0.00% | 0.52% | | |
| 93% | 100% | 42.70% | 93.1% | 0.904 | 43.60% | 0.90% | | |
| 90% | 100% | 43.43% | 90.1% | 0.901 | 43.60% | 0.17% | | |
| 87% | 100% | 43.41% | 87.1% | 0.901 | 43.60% | 0.19% | | |
| 85% | 100% | 43.42% | 85.1% | 0.901 | 43.60% | 0.18% | | |
| 87% | 100% | 43.41% | 87.1% | 0.901 | 43.60% | 0.19% | | |
| 90% | 100% | 43.15% | 90.1% | 0.902 | 43.60% | 0.45% | | |
| 93% | 100% | 42.73% | 93.1% | 0.903 | 43.60% | 0.87% | | |
| 94% | 100% | 0.66% | 94.0% | 0.999 | 0.00% | 0.66% | | |
| 97% | 100% | 0.52% | 97.0% | 0.999 | 0.00% | 0.52% | | |
| 100% | 100% | 0.50% | 100.0% | 0.999 | 0.00% | 0.50% | | |
| 100% | 20% | 0.45% | 100.0% | 0.999 | 0.00% | 0.45% | | |
| 103% | 20% | 0.60% | 103.0% | 0.999 | 0.00% | 0.60% | | |
| 105% | 20% | 0.71% | 105.2% | 0.999 | 0.00% | 0.71% | | |
| 107% | 20% | -21.19% | 107.0% | 0.683 | -21.80% | 0.61% | | |
| 108% | 20% | -43.00% | 108.1% | 0.419 | -43.60% | 0.60% | | |
| 111% | 20% | -43.06% | 111.1% | 0.418 | -43.60% | 0.54% | | |
| 114% | 20% | -43.19% | 114.0% | 0.417 | -43.60% | 0.41% | | |
| 115% | 20% | -43.25% | 115.0% | 0.416 | -43.60% | 0.35% | | |
| 114% | 20% | -43.20% | 114.0% | 0.416 | -43.60% | 0.40% | | |
| 111% | 20% | -43.16% | 111.1% | 0.417 | -43.60% | 0.44% | | |
| 108% | 20% | -42.88% | 108.1% | 0.420 | -43.60% | 0.72% | | |
| 107% | 20% | -21.86% | 107.0% | 0.671 | -21.80% | 0.06% | | |
| 105% | 20% | 0.55% | 105.4% | 0.999 | 0.00% | 0.55% | | |
| 103% | 20% | 0.44% | 103.2% | 0.999 | 0.00% | 0.44% | | |
| 100% | 20% | 0.36% | 100.2% | 0.999 | 0.00% | 0.36% | | |
| 97% | 20% | 0.38% | 97.1% | 0.999 | 0.00% | 0.38% | | |
| 94% | 20% | 0.46% | 94.1% | 0.999 | 0.00% | 0.46% | | |
| 93% | 20% | 42.64% | 93.3% | 0.424 | 43.60% | 0.96% | | |
| 90% | 20% | 43.39% | 90.2% | 0.418 | 43.60% | 0.21% | | |
| 87% | 20% | 43.38% | 87.2% | 0.418 | 43.60% | 0.22% | | |
| 85% | 20% | 43.39% | 85.2% | 0.419 | 43.60% | 0.21% | | |
| 87% | 20% | 43.37% | 87.2% | 0.418 | 43.60% | 0.23% | | |
| 90% | 20% | 43.08% | 90.2% | 0.420 | 43.60% | 0.52% | | |
| 93% | 20% | 42.67% | 93.3% | 0.424 | 43.60% | 0.93% | | |
| 94% | 20% | 0.61% | 94.1% | 0.999 | 0.00% | 0.61% | | |
| 97% | 20% | 0.46% | 97.0% | 0.999 | 0.00% | 0.46% | | |
| 100% | 20% | 0.44% | 100.0% | 0.999 | 0.00% | 0.44% | | |



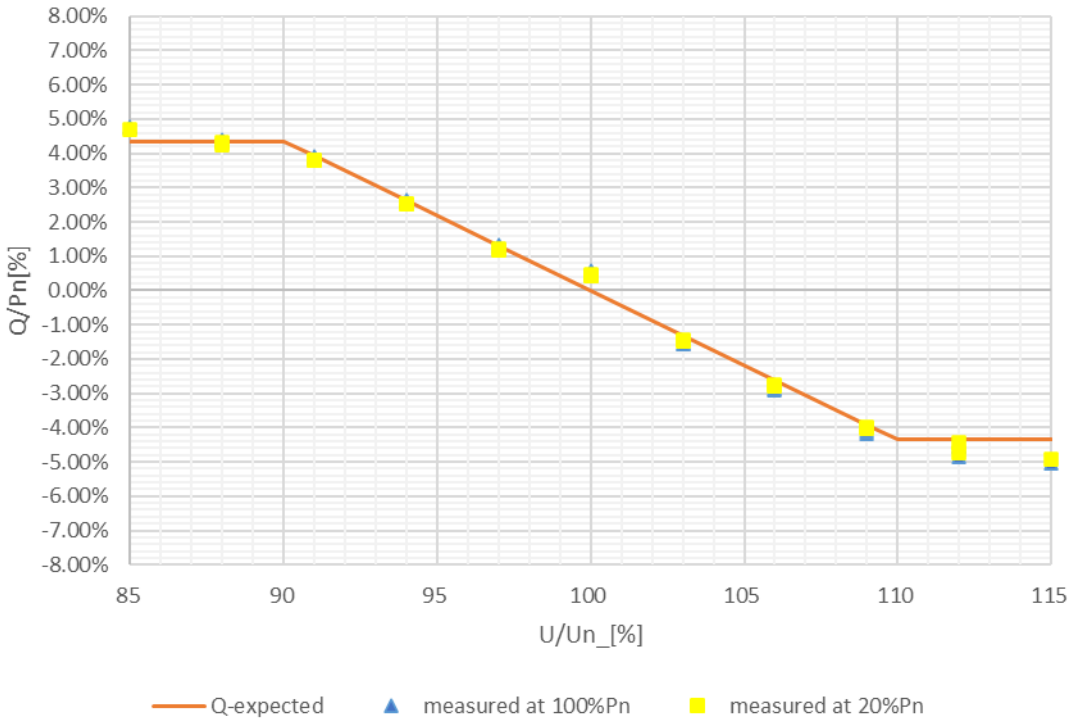

Note(s):
Time constant: as fast as possible but not slower as 3 s.
Min cos φ: 0.4,
P lock-in: deactivated; P lock-out: deactivated.
*：The accuracy exceeding 2% Smax is due to prioritizing the requirement of Min cos φ: 0.4.

Test procedure for accuracy-**Setting (b)**

| Q(U) curve settings: | Set points | X1 | X2 | X3 |
|---|---|---|---|---|
| | U/Un | 90% | 100% | 110% |
| | Q/Qmax | 10% | 0% | -10% |

| Test Conditions | | Measurements | | Target value | Δ | Δ Limits |
|---|---|---|---|---|---|---|
| U/Un | P/Pn | Q/Pn | U/Un | Q/Pn* | ΔQ/ Smax | ΔQ/ Smax |
| 100% | 100% | 0.52% | 100.5% | 0.00% | 0.52% | ≤ ±2 Smax% |
| 103% | 100% | -1.55% | 103.4% | -1.31% | 0.24% | |
| 106% | 100% | -2.89% | 106.4% | -2.62% | 0.28% | |
| 109% | 100% | -4.16% | 109.4% | -3.92% | 0.23% | |
| 112% | 100% | -4.84% | 112.4% | -4.36% | 0.48% | |
| 115% | 100% | -5.04% | 115.4% | -4.36% | 0.68% | |
| 112% | 100% | -4.56% | 112.4% | -4.36% | 0.20% | |
| 109% | 100% | -4.09% | 109.4% | -3.92% | 0.16% | |
| 106% | 100% | -2.85% | 106.4% | -2.62% | 0.24% | |
| 103% | 100% | -1.55% | 103.5% | -1.31% | 0.24% | |
| 100% | 100% | 0.51% | 100.5% | 0.00% | 0.51% | |
| 97% | 100% | 1.32% | 97.5% | 1.31% | 0.01% | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 94% | 100% | 2.65% | 94.5% | 2.62% | 0.04% | |
| 91% | 100% | 3.93% | 91.5% | 3.92% | 0.00% | |
| 88% | 100% | 4.41% | 88.5% | 4.36% | 0.05% | |
| 85% | 100% | 4.79% | 85.6% | 4.36% | 0.43% | |
| 88% | 100% | 4.36% | 88.5% | 4.36% | 0.00% | |
| 91% | 100% | 3.89% | 91.5% | 3.92% | 0.04% | |
| 94% | 100% | 2.61% | 94.5% | 2.62% | 0.01% | |
| 97% | 100% | 1.30% | 97.5% | 1.31% | 0.01% | |
| 100% | 100% | 0.58% | 100.3% | 0.00% | 0.58% | |
| 100% | 20% | 0.42% | 100.0% | 0.00% | 0.42% | |
| 103% | 20% | -1.43% | 102.8% | -1.31% | 0.12% | |
| 106% | 20% | -2.78% | 105.9% | -2.62% | 0.16% | |
| 109% | 20% | -4.03% | 108.9% | -3.92% | 0.10% | |
| 112% | 20% | -4.73% | 112.0% | -4.36% | 0.37% | |
| 115% | 20% | -4.94% | 115.1% | -4.36% | 0.58% | |
| 112% | 20% | -4.45% | 112.1% | -4.36% | 0.09% | |
| 109% | 20% | -3.98% | 109.0% | -3.92% | 0.05% | |
| 106% | 20% | -2.75% | 105.9% | -2.62% | 0.13% | |
| 103% | 20% | -1.47% | 102.9% | -1.31% | 0.16% | |
| 100% | 20% | 0.42% | 99.9% | 0.00% | 0.42% | |
| 97% | 20% | 1.21% | 97.1% | 1.31% | 0.09% | |
| 94% | 20% | 2.51% | 94.1% | 2.62% | 0.10% | |
| 91% | 20% | 3.79% | 91.2% | 3.92% | 0.13% | |
| 88% | 20% | 4.31% | 88.2% | 4.36% | 0.05% | |
| 85% | 20% | 4.69% | 85.2% | 4.36% | 0.33% | |
| 88% | 20% | 4.25% | 88.2% | 4.36% | 0.11% | |
| 91% | 20% | 3.79% | 91.2% | 3.92% | 0.13% | |
| 94% | 20% | 2.51% | 94.1% | 2.62% | 0.11% | |
| 97% | 20% | 1.19% | 97.1% | 1.31% | 0.12% | |
| 100% | 20% | 0.46% | 100.1% | 0.00% | 0.46% | |




Note(s):
Time constant: as slow as possible but not slower as 20 s.
P lock-in: 20%Pn; P lock-out: 5%Pn.

Test procedure for dynamic-Setting (a)

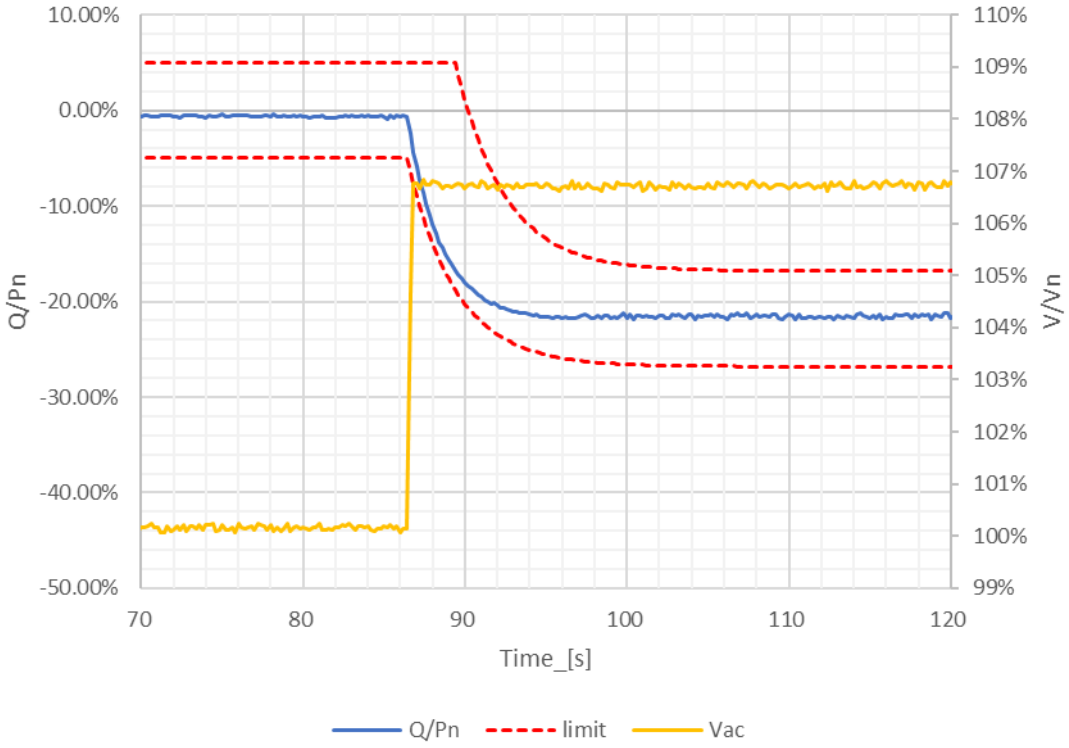
| Q(U) curve settings: | Set points | X1 | X2 | X3 | X4 |
|---|---|---|---|---|---|
| | U/Un | 93% | 94% | 106% | 108% |
| | Q/Qmax | 100% | 0% | 0% | 100% |
| | Tau | 3s | | | |

| Step No | Test Conditions | | Measurements | | | Deviation | Target value | $T_d$ | $T_r/T_s$* | Δ Limits |
|---|---|---|---|---|---|---|---|---|---|---|
| | U/Un | P/Pn | Q/Pn | P/Pn | U/Un | ΔQ/Pn | Q/Pn* | | | ΔQ/Pn |
| 1 | 100% | 100% | -0.59% | 99.89% | 100.16% | 0.59% | 0.0% | -- | -- | ≤ ±5% |
| 2 | 107% | 100% | -21.53% | 97.46% | 106.73% | 0.27% | -21.8% | 0.2 | 3.2 | |
| 3 | 109% | 100% | -43.64% | 90.52% | 108.73% | 0.04% | -43.6% | 0.2 | 5.2 | |
| 4 | 109% | 18% | -42.90% | 18.42% | 108.46% | 0.70% | -43.6% | -- | -- | |
| 5 | 109% | 3% | -0.69% | 2.73% | 108.48% | 0.69% | 0.0% | 0.2 | 6.2 | |
| 6 | 109% | 22% | -42.83% | 22.10% | 108.47% | 0.77% | -43.6% | 0.2 | 6.4 | |
| 7 | 109% | 100% | -43.65% | 89.87% | 108.73% | 0.05% | -43.6% | -- | -- | |
| 8 | 100% | 100% | -0.74% | 100.30% | 100.17% | 0.74% | 0.0% | 0.2 | 6.2 | |
| 9 | 92% | 100% | 43.59% | 89.94% | 91.99% | 0.01% | 43.6% | 0.2 | 7.0 | |
| 10 | 92% | 18% | 42.89% | 18.23% | 91.66% | 0.71% | 43.6% | -- | -- | |
| 11 | 92% | 3% | 0.63% | 3.12% | 91.61% | 0.63% | 0.0% | 0.2 | 6.0 | |

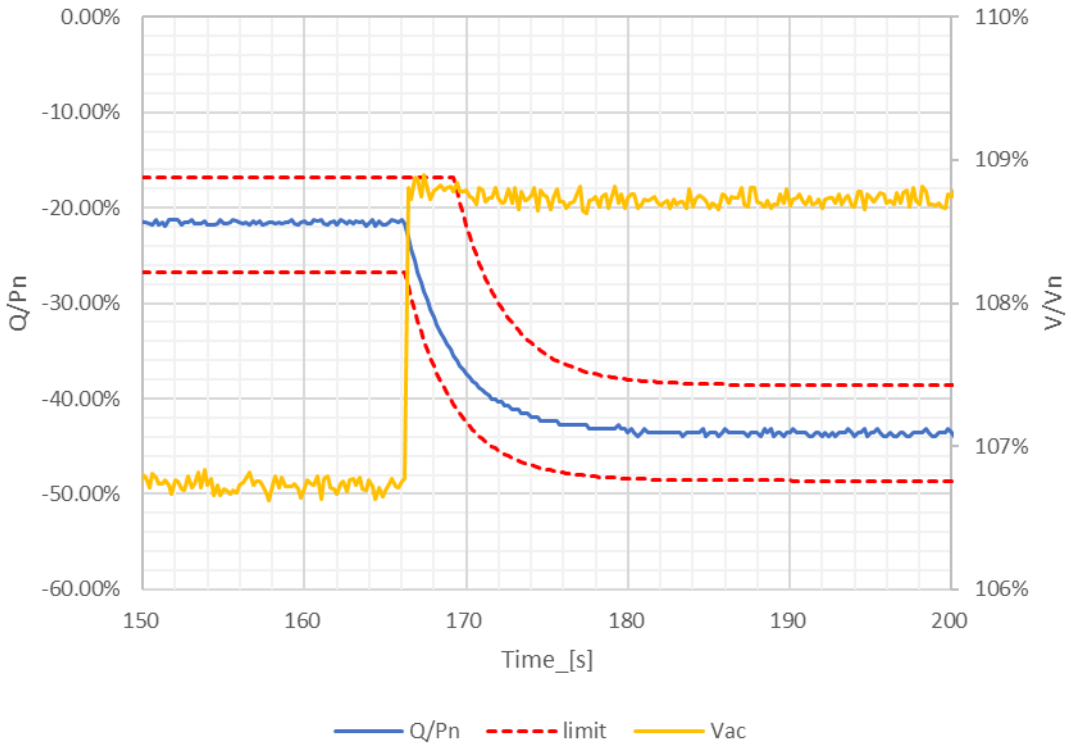
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 92% | 22% | 43.45% | 22.16% | 91.69% | 0.15% | 43.6% | 0.2 | 6.4 | |
| 13 | 92% | 100% | 43.42% | 90.46% | 91.90% | 0.18% | 43.6% | -- | -- | |
| 14 | 93% | 100% | 43.30% | 90.40% | 92.85% | 0.30% | 43.6% | -- | -- | |
| 15 | 100% | 100% | -0.62% | 100.16% | 100.17% | 0.62% | 0.0% | 0.2 | 5.8 | |

Note(s):
P lock-in: 20%Pn; P lock-out: 5%Pn.
*Step response time and settling time are identical.

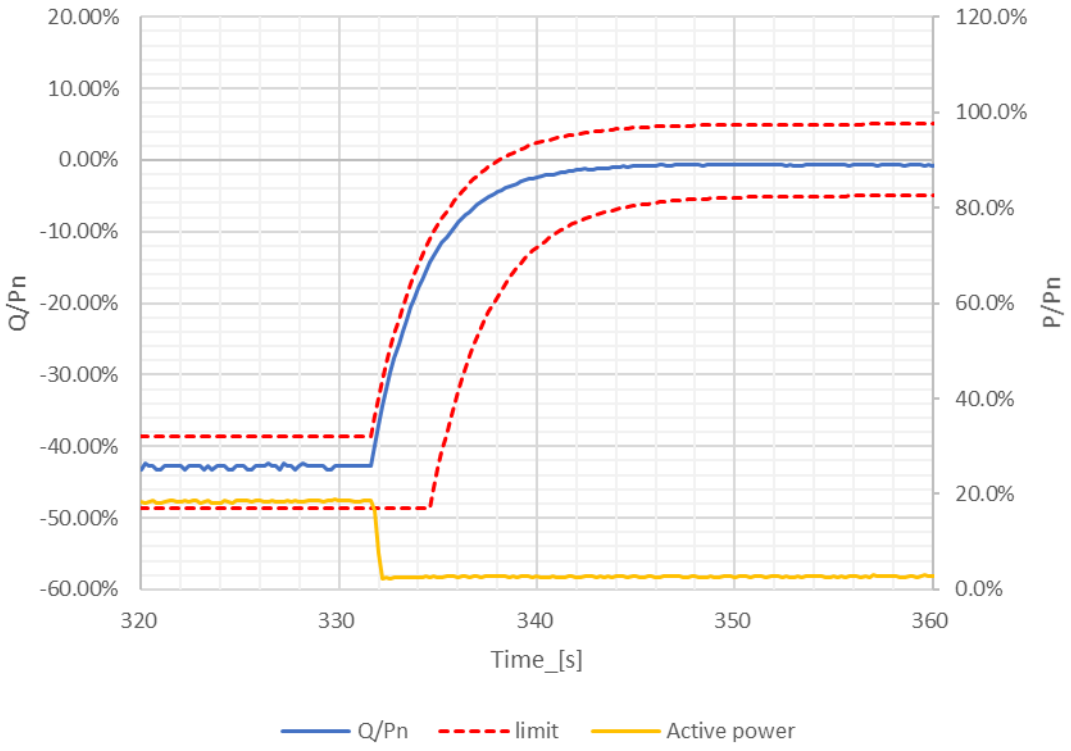
Step 2: 100%Un to 107%Un



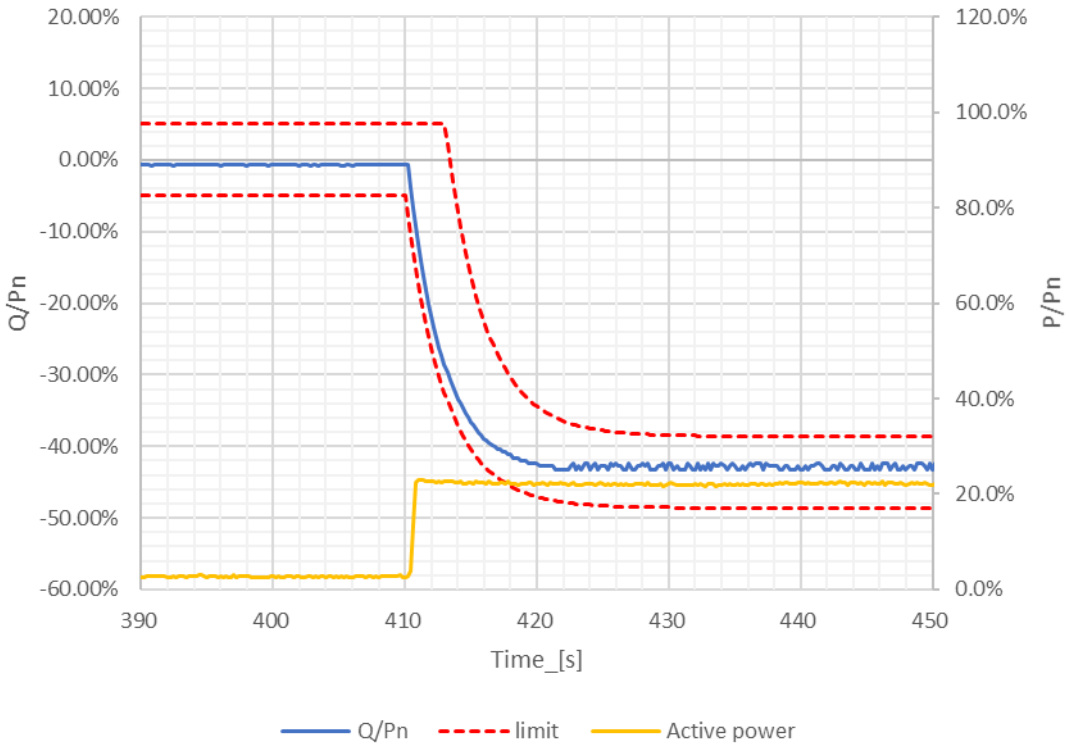
Step 3: 107%Un to 109%Un



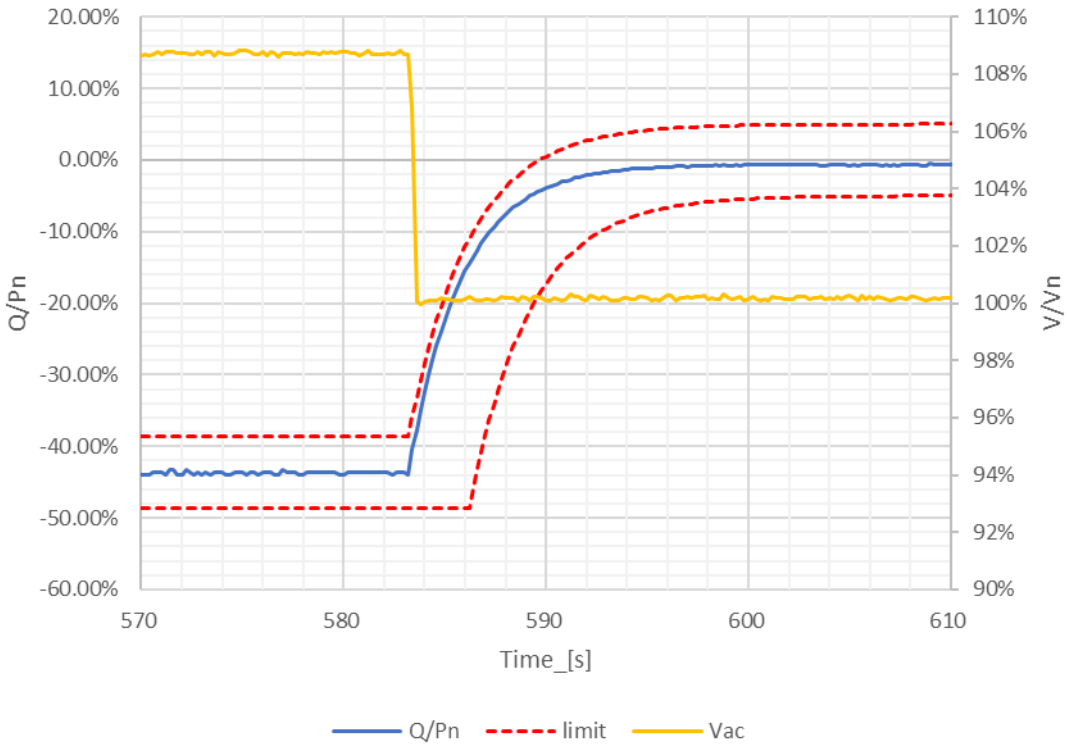

Step 5: 18%Pn to 3%Pn



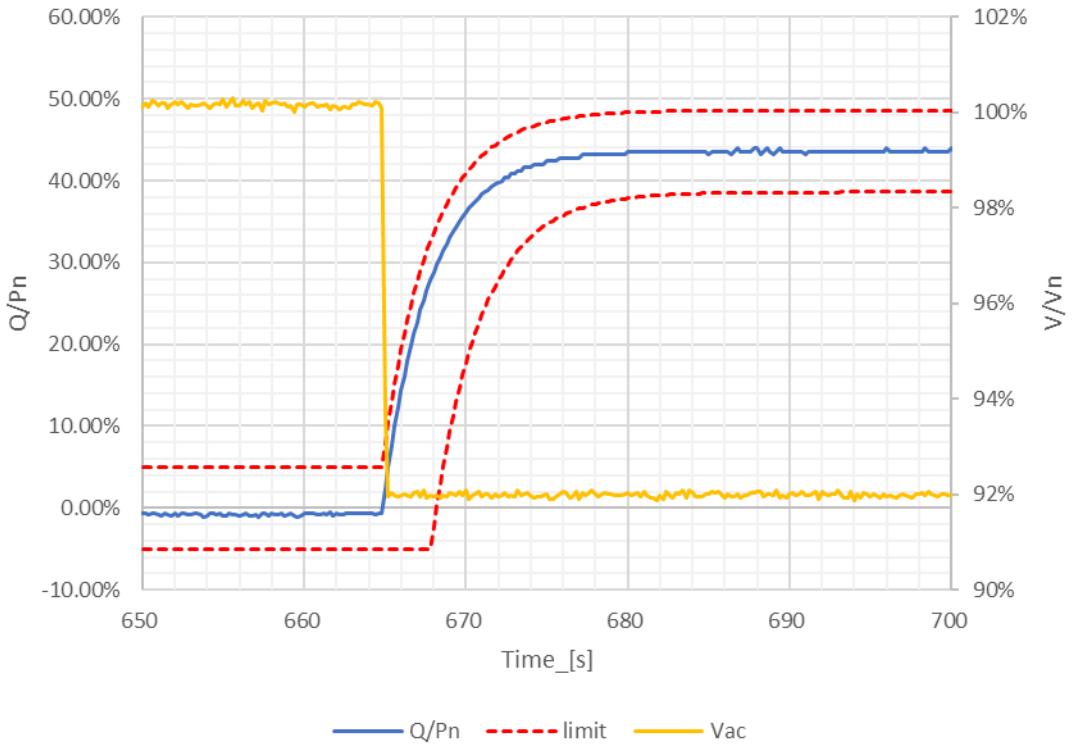
Step 6: 3%Pn to22%Pn



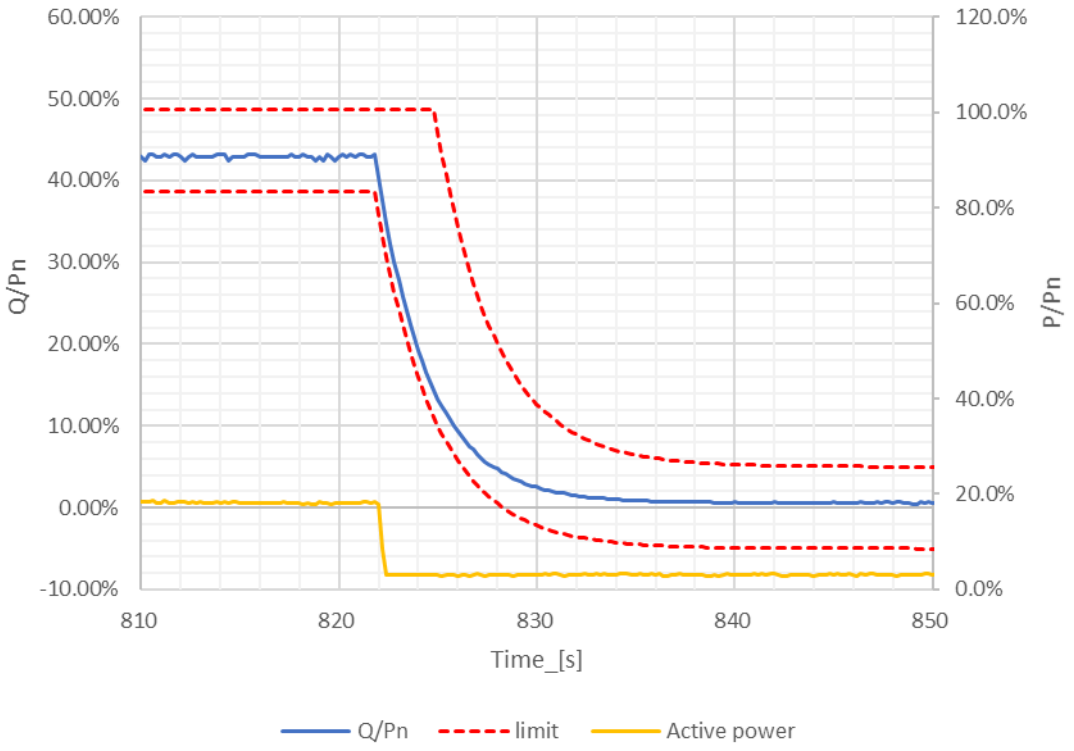

Step 8: 109%Un to 100%Un



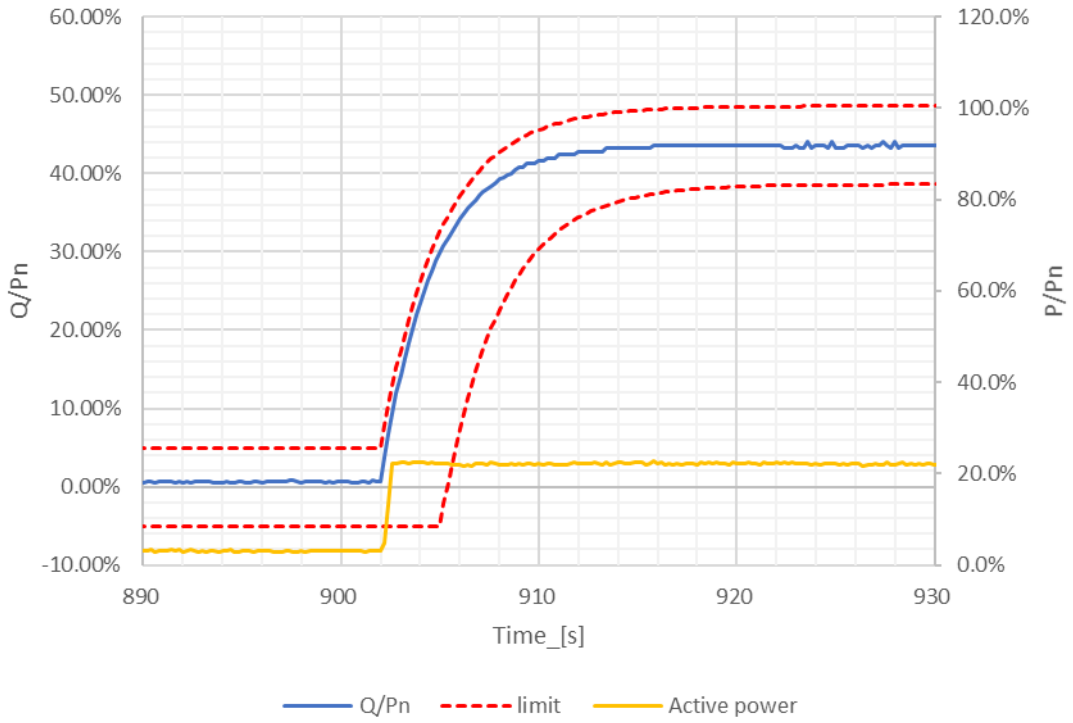
Step 9: 100%Un to 92%Un



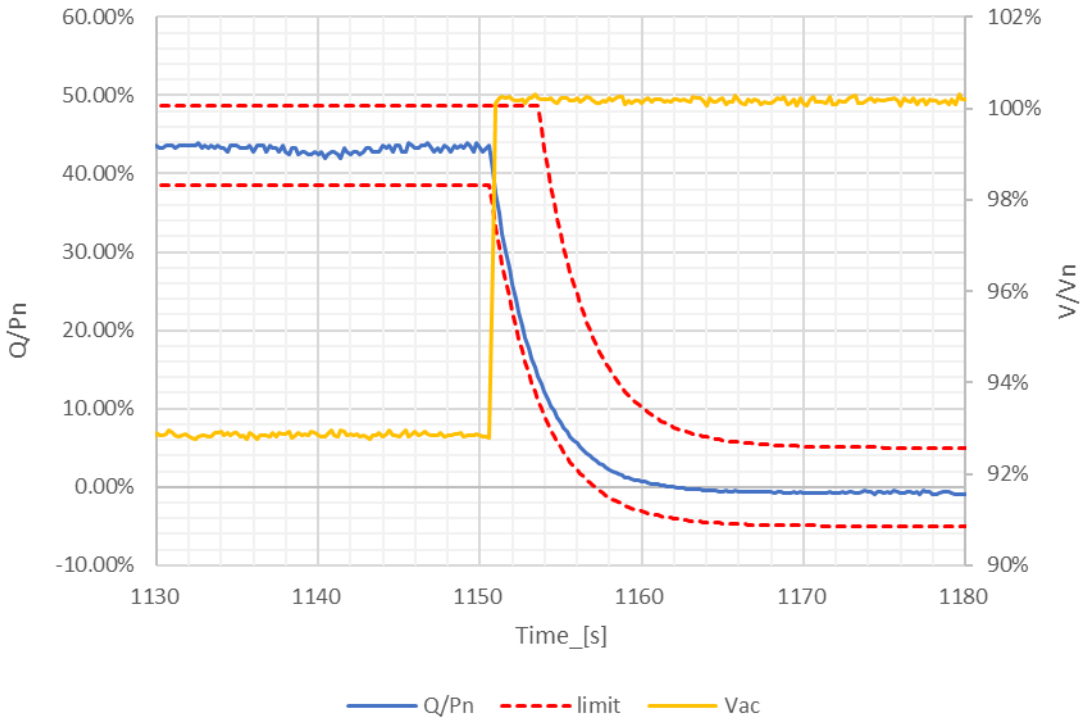

Step 11: 18%Pnto 3%Pn



Step 12: 3%Pnto 22%Pn



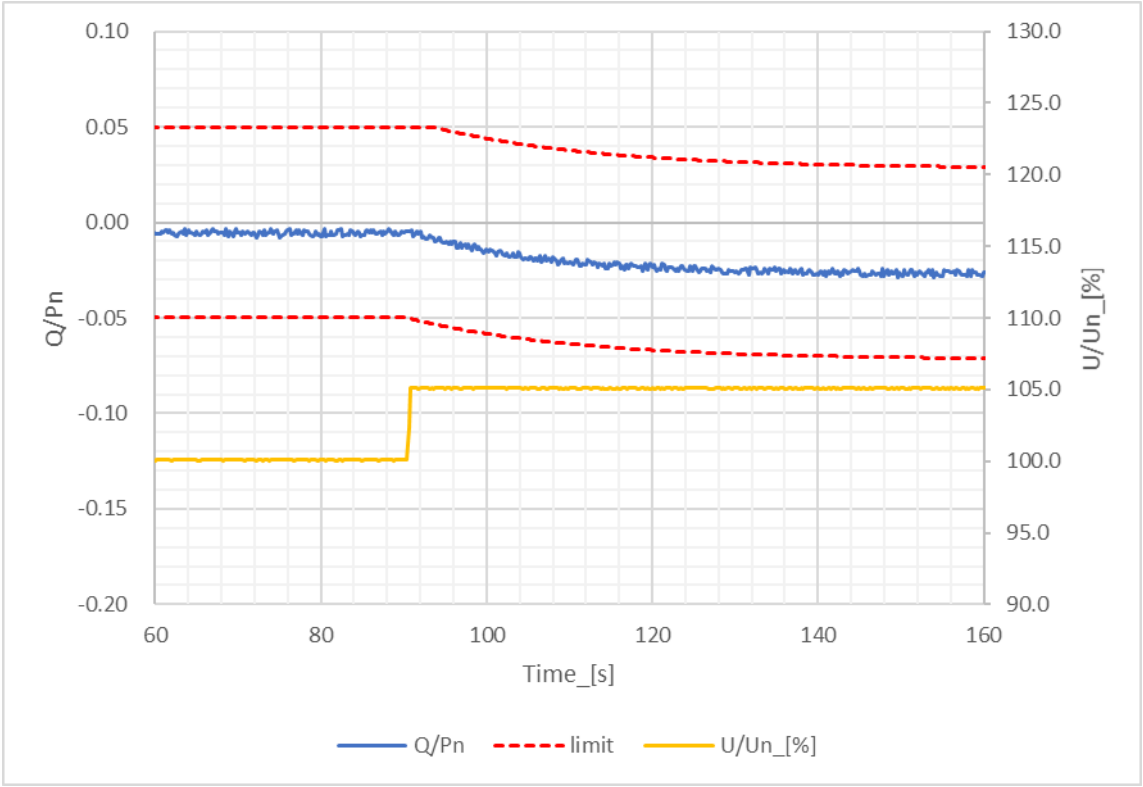

Step 15: 93%Un to 100%Un



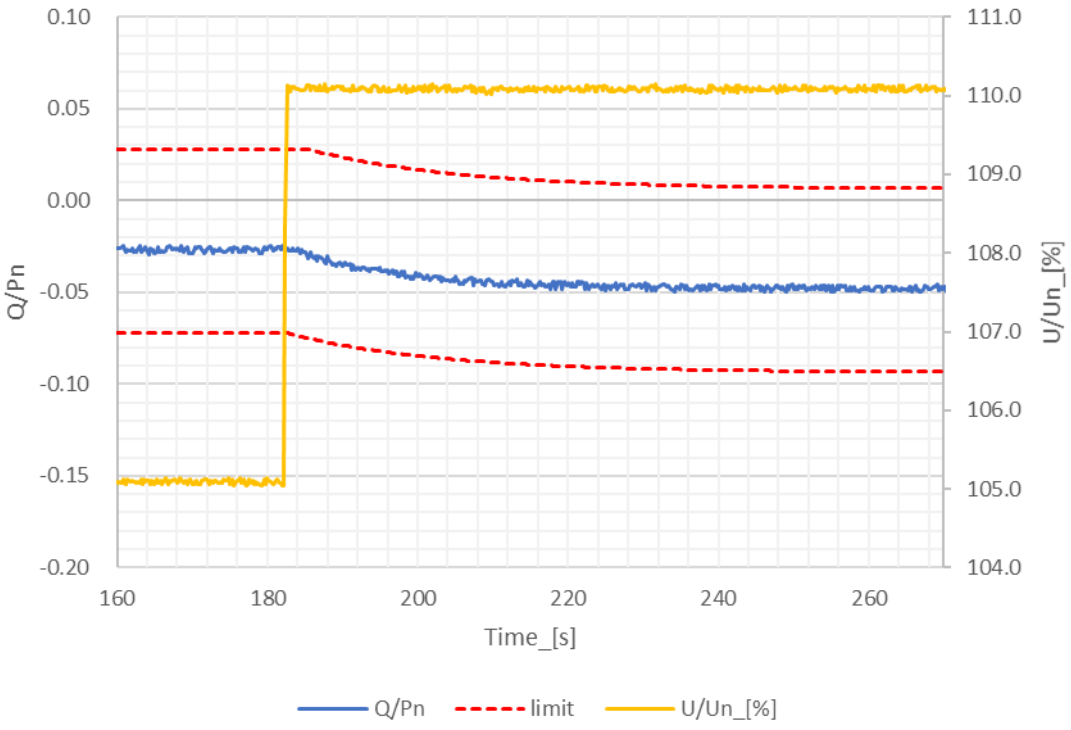
| Test procedure for dynamic-Setting (b) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Q(U) curve settings: | Set points | X1 | | X2 | | X3 | | | |
| | U/Un | 90% | | 100% | | 110% | | | |
| | Q/Qmax | 10% | | 0% | | -10% | | | |
| | Tau | 20s | | | | | | | |
| Test Conditions | | Measurements | | | Deviation | Target value | $T_d$ | $T_r/T_s$* | Δ Limits |
| U/Un | P/Pn | Q/Pn | P/Pn | U/Un | ΔQ/Pn | Q/Pn | | | ΔQ/Pn |
| 100% | 100% | -0.61% | 100.53% | 100.09% | 0.61% | 0.00% | -- | -- | ≤ ±5% |
| 105% | 100% | -2.54% | 100.56% | 105.09% | 0.36% | -2.18% | 0.2 | 0.2 | |
| 110% | 100% | -4.71% | 100.49% | 110.09% | 0.35% | -4.36% | 0.2 | 0.2 | |
| 110% | 18% | -4.10% | 18.86% | 110.09% | 0.26% | -4.36% | -- | -- | |
| 110% | 3% | -0.71% | 3.01% | 110.09% | 0.71% | 0.00% | 0.4 | 0.2 | |
| 110% | 22% | -4.31% | 22.74% | 110.09% | 0.05% | -4.36% | 0.4 | 0.2 | |
| 110% | 100% | -4.79% | 100.48% | 110.09% | 0.43% | -4.36% | -- | -- | |
| 100% | 100% | -0.64% | 100.52% | 100.09% | 0.64% | 0.00% | 0.4 | 0.2 | |
| 90% | 100% | 3.61% | 100.33% | 90.09% | 0.75% | 4.36% | 0.2 | 0.2 | |
| 90% | 18% | 4.81% | 18.46% | 90.09% | 0.45% | 4.36% | -- | -- | |
| 90% | 3% | -0.64% | 2.88% | 90.09% | 0.64% | 0.00% | 0.4 | 0.2 | |
| 90% | 22% | 4.65% | 22.56% | 90.09% | 0.29% | 4.36% | 0.2 | 0.2 | |
| 90% | 100% | 3.70% | 100.32% | 90.09% | 0.66% | 4.36% | -- | -- | |
| 95% | 100% | 1.62% | 100.45% | 95.09% | 0.56% | 2.18% | 0.2 | 0.2 | |
| 100% | 100% | -0.45% | 100.58% | 100.09% | 0.45% | 0.00% | 0.2 | 0.2 | |

Note(s):
P lock-in: 20%Pn; P lock-out: 5%Pn.
*Step response time and settling time are identical.

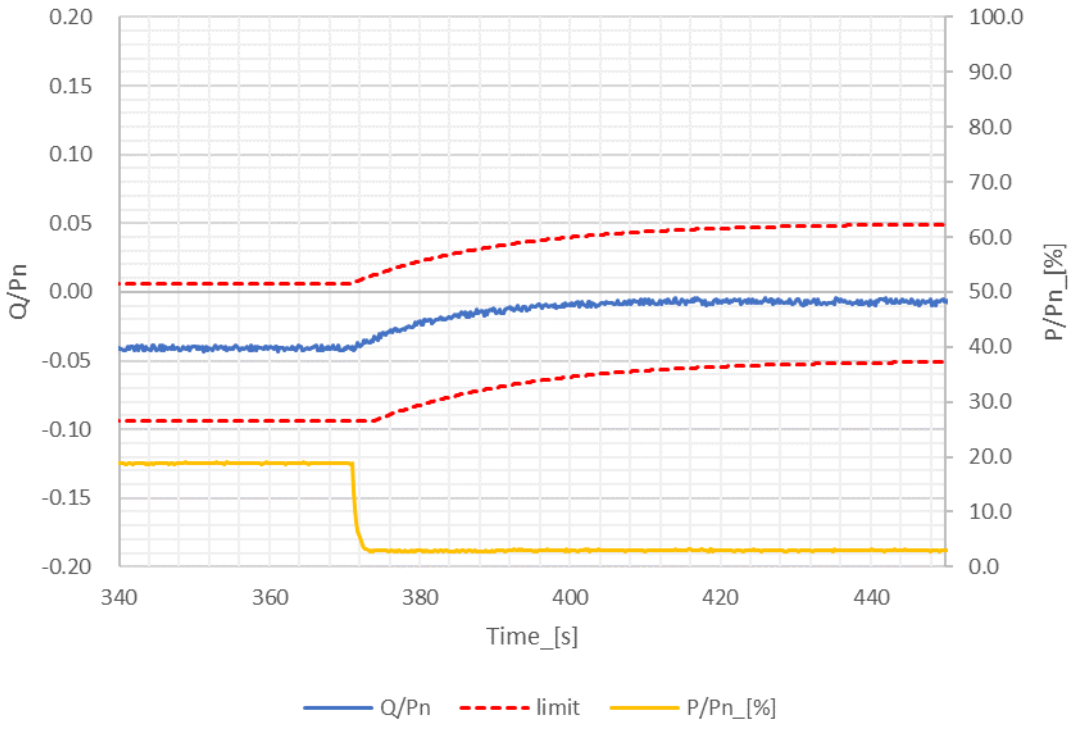
Step 2: 100%Un to 105%Un



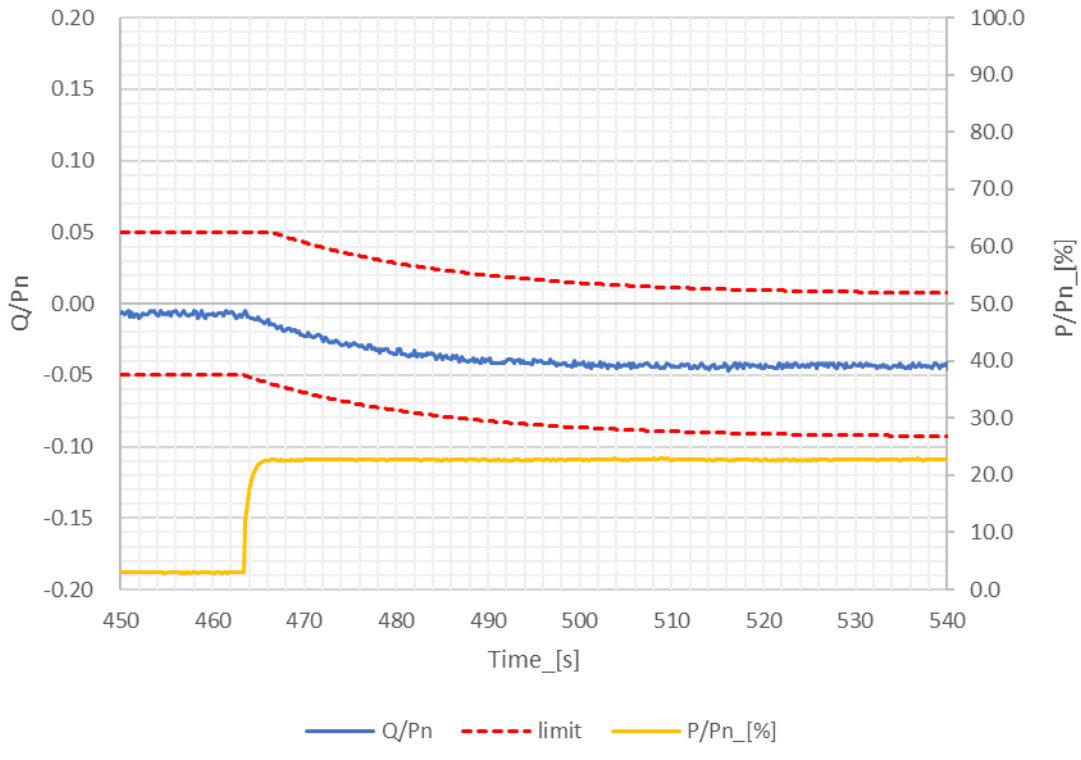

Step 3: 105%Un to 110%Un



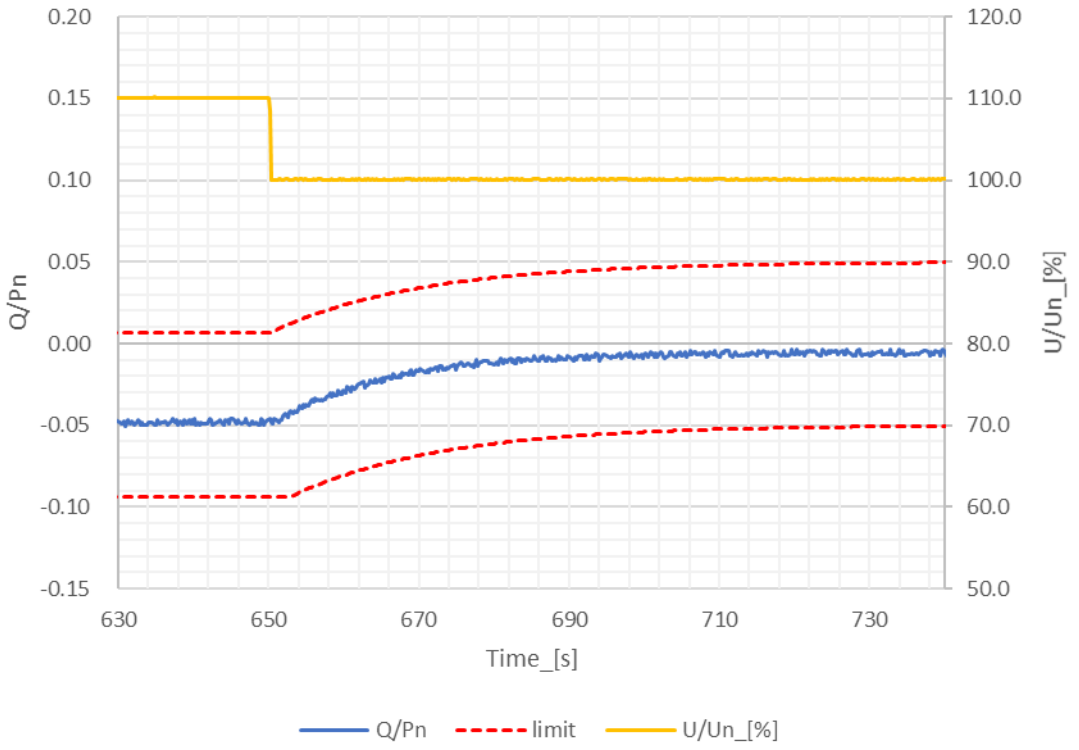
Step 5: 18%Pn to 3%Pn



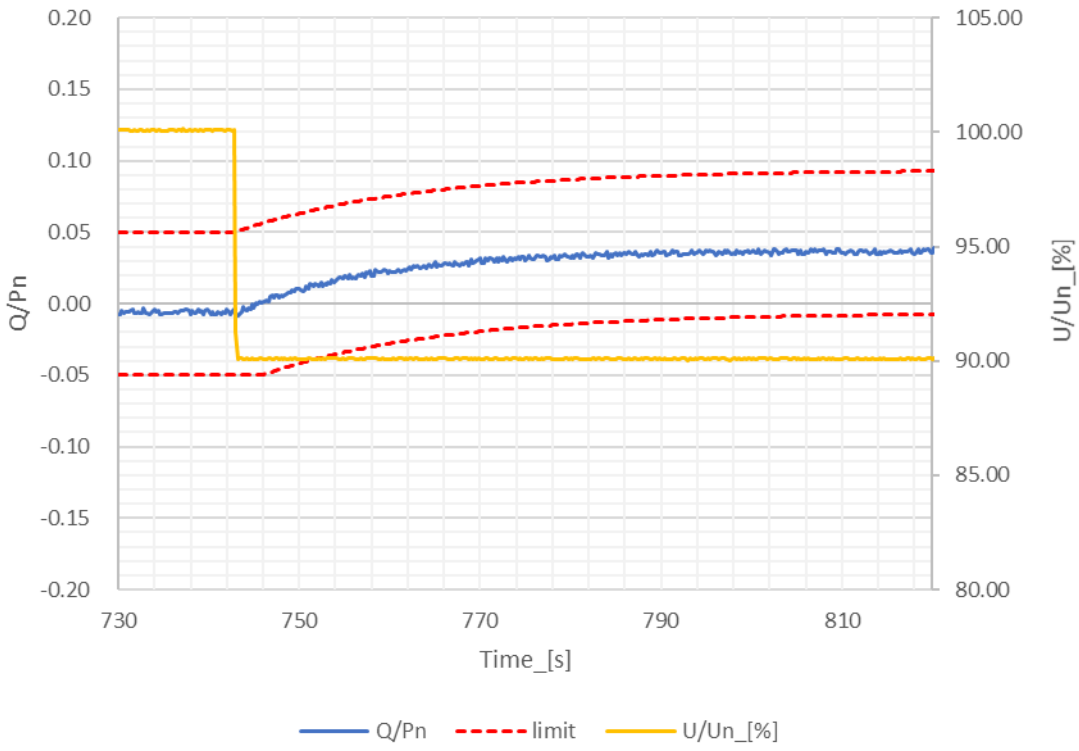

Step 6: 3%Pn to 22%Pn



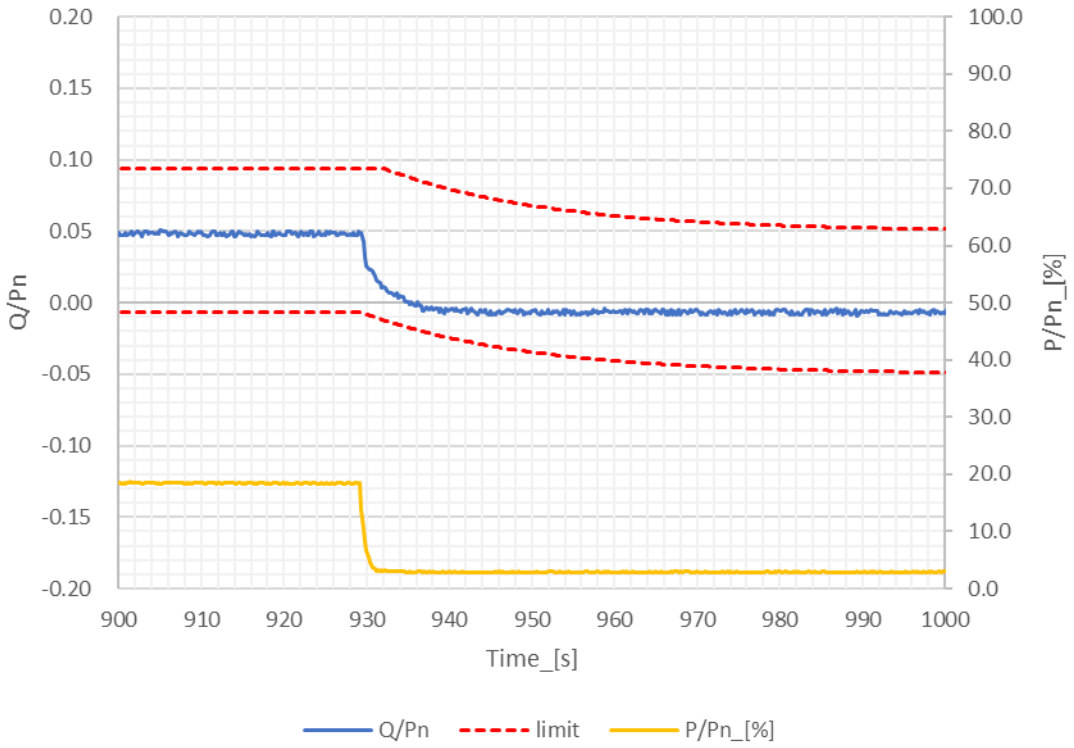
Step 8: 110%Un to 100%Un



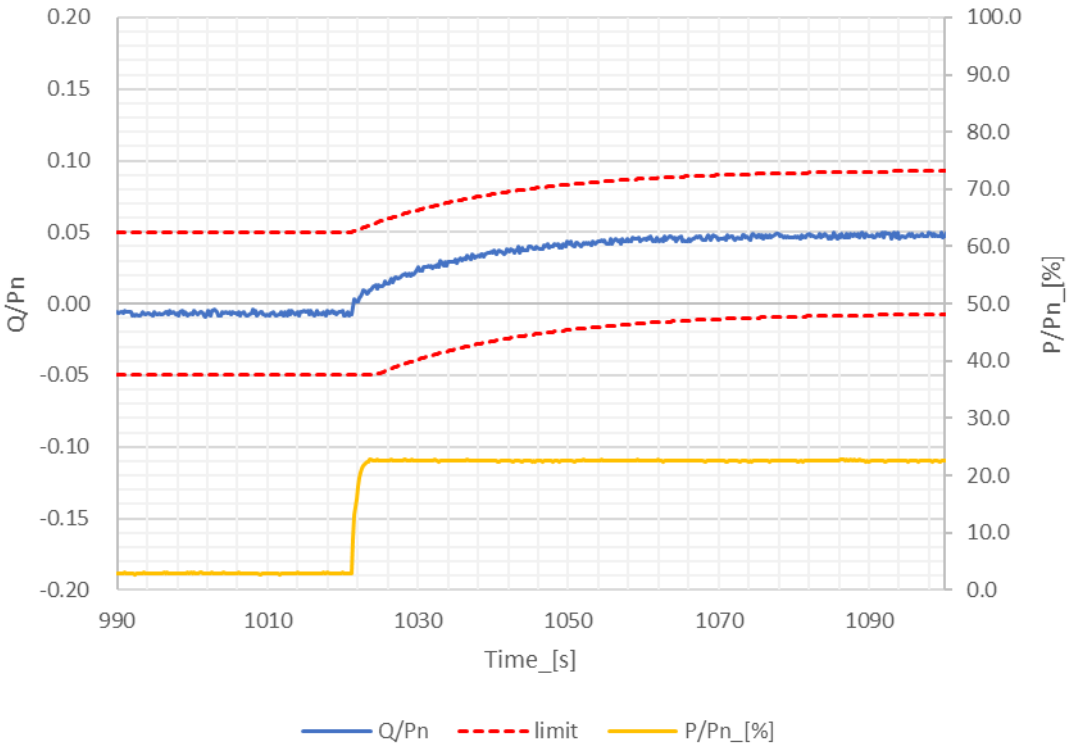

Step 9: 100%Un to 90%Un



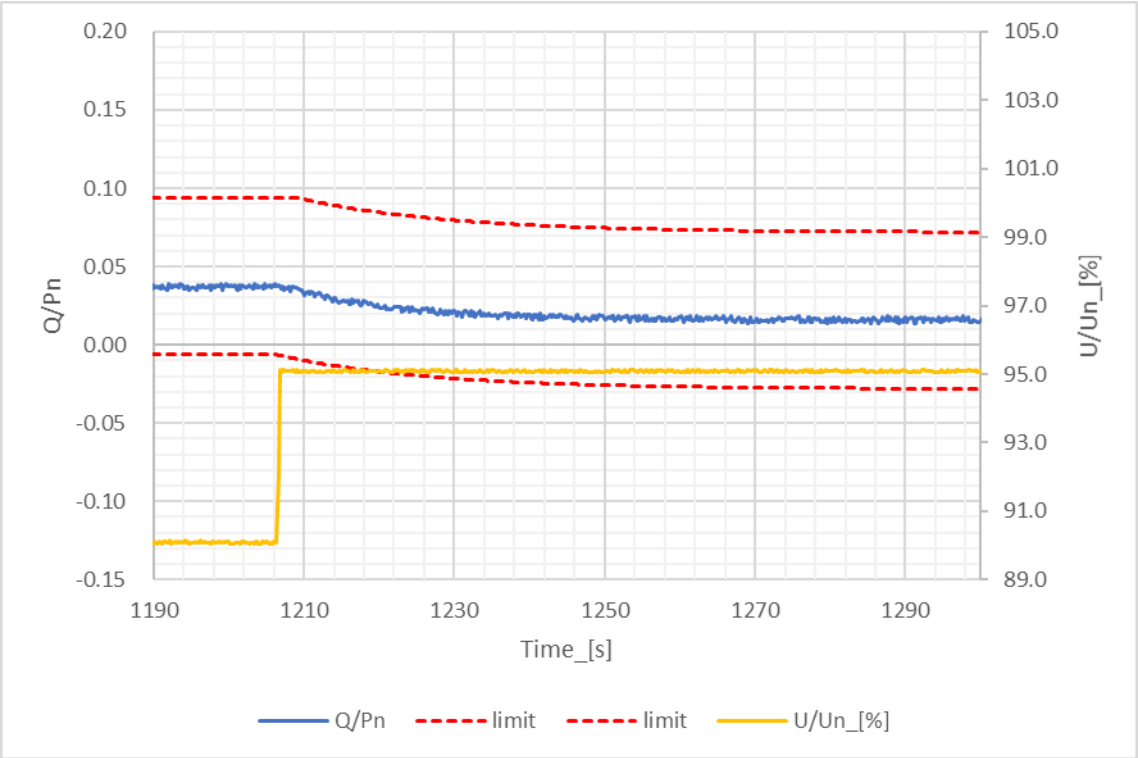
Step 11: 18%Pn to 3%Pn



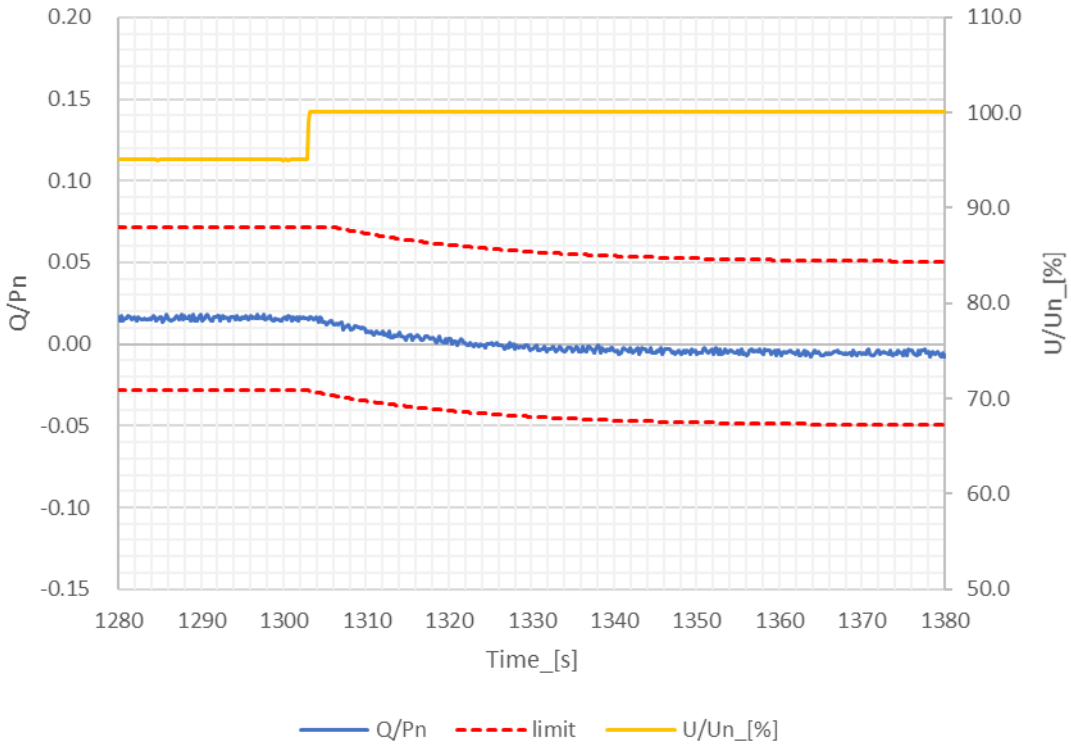

Step 12: 3%Pn to 22%Pn



Step 14: 90%Un to 95%Un




Step 15: 95%Un to 100%Un



### 6.4.2.3 Power related control mode for reactive power

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |

| Acceptance criteria |
|---|
| -The measured 30-s averages of the reactive power during steady-state conditions are within a tolerance band of ± 2 % Smax around the reactive power set point resulting from the measured active power and the given cos φ (P) or Q (P) characteristic. |

| Manufacturer's data |
|---|
| See *Annex 3 – Capability curve of the PGU(s)*. |

Test procedure for quasi-stationary behaviour - **Setting (a)**

| cos φ (P) curve settings: | Set points | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | P/Pn | 15% | 20% | 80% | 90% |
| | cos φ | 0.900 | 1.000 | 1.000 | -0.900 |

| Test Conditions | | Measurements | | | Target value | Δ | Δ Limits |
|---|---|---|---|---|---|---|---|
| P / Pn | U / Un | P / Pn | Q / Pn | cos φ | cos φ | Δ cos φ | Δ cos φ |
| 10% | 100% | 10.04% | 4.87% | 0.899 | 0.900 | 0.001 | ±0.01 |
| 15% | 100% | 14.64% | 6.93% | 0.903 | 0.900 | 0.003 | |
| 20% | 100% | 20.14% | 0.75% | 0.999 | 1.000 | 0.001 | |
| 30% | 100% | 29.97% | 0.70% | 0.999 | 1.000 | 0.001 | |
| 40% | 100% | 40.07% | 0.68% | 1.000 | 1.000 | 0.000 | |
| 50% | 100% | 50.14% | 0.84% | 1.000 | 1.000 | 0.000 | |
| 60% | 100% | 60.22% | 0.85% | 1.000 | 1.000 | 0.000 | |
| 70% | 100% | 70.32% | 0.89% | 1.000 | 1.000 | 0.000 | |
| 80% | 100% | 80.14% | 0.86% | 1.000 | 1.000 | 0.000 | |
| 85% | 100% | 84.98% | -28.73% | 0.947 | 0.950 | 0.003 | |
| 90% | 100% | 90.02% | -43.96% | 0.899 | 0.900 | 0.001 | |
| 100% | 100% | 90.23% | -44.20% | 0.898 | 0.900 | 0.002 | |
| 90% | 100% | 89.60% | -43.73% | 0.899 | 0.900 | 0.001 | |
| 85% | 100% | 85.05% | -28.77% | 0.947 | 0.950 | 0.003 | |
| 80% | 100% | 80.09% | 0.77% | 1.000 | 1.000 | 0.000 | |
| 70% | 100% | 70.04% | 0.71% | 1.000 | 1.000 | 0.000 | |
| 60% | 100% | 60.14% | 0.71% | 1.000 | 1.000 | 0.000 | |
| 50% | 100% | 49.91% | 0.73% | 1.000 | 1.000 | 0.000 | |
| 40% | 100% | 39.95% | 0.68% | 1.000 | 1.000 | 0.000 | |
| 30% | 100% | 29.86% | 0.59% | 0.999 | 1.000 | 0.001 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20% | 100% | 19.87% | 0.63% | 0.999 | 1.000 | 0.001 | |
| 15% | 100% | 15.01% | 6.91% | 0.908 | 0.900 | 0.008 | |
| 10% | 100% | 10.08% | 4.89% | 0.899 | 0.900 | 0.001 | |

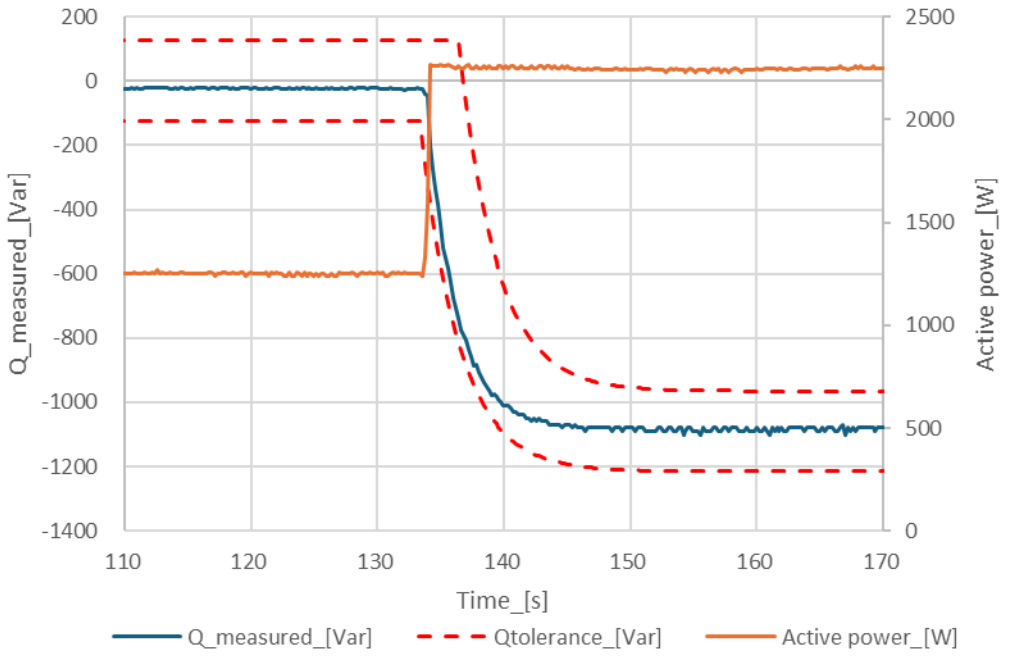
| Test procedure for quasi-stationary behaviour - **Setting (c)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| cos φ (P) curve settings: | Set points | 1 | 2 | 3 | 4 | | |
| | P/Pn | 20% | 40% | 50% | 100% | | |
| | cos φ | 1.000 | 1.000 | 1.000 | -0.900 | | |
| Test Conditions | | Measurements | | | Target value | Δ | Δ Limits |
| P / Pn | U / Un | P / Pn | Q / Pn | cos φ | cos φ | Δ cos φ | Δ cos φ |
| 10% | 100% | 10.19% | 0.49% | 0.998 | 1.000 | 0.002 | |
| 20% | 100% | 20.12% | 0.25% | 0.999 | 1.000 | 0.001 | |
| 30% | 100% | 30.07% | 0.44% | 1.000 | 1.000 | 0.000 | |
| 40% | 100% | 39.97% | 0.51% | 1.000 | 1.000 | 0.000 | |
| 50% | 100% | 50.16% | 0.34% | 1.000 | 1.000 | 0.000 | |
| 60% | 100% | 59.84% | -12.68% | 0.978 | 0.980 | 0.002 | |
| 70% | 100% | 69.84% | -20.93% | 0.958 | 0.960 | 0.002 | |
| 80% | 100% | 79.83% | -29.42% | 0.938 | 0.940 | 0.002 | |
| 90% | 100% | 89.67% | -38.53% | 0.919 | 0.920 | 0.001 | |
| 100% | 100% | 90.53% | -43.99% | 0.899 | 0.900 | 0.001 | ±0.01 |
| 90% | 100% | 89.70% | -38.67% | 0.918 | 0.920 | 0.002 | |
| 80% | 100% | 79.83% | -29.43% | 0.938 | 0.940 | 0.002 | |
| 70% | 100% | 69.83% | -20.79% | 0.958 | 0.960 | 0.002 | |
| 60% | 100% | 59.81% | -12.58% | 0.978 | 0.980 | 0.002 | |
| 50% | 100% | 49.86% | 0.38% | 1.000 | 1.000 | 0.000 | |
| 40% | 100% | 40.01% | 0.36% | 1.000 | 1.000 | 0.000 | |
| 30% | 100% | 30.05% | 0.30% | 1.000 | 1.000 | 0.000 | |
| 20% | 100% | 20.08% | 0.32% | 0.999 | 1.000 | 0.001 | |
| 10% | 100% | 9.91% | 0.53% | 0.998 | 1.000 | 0.002 | |

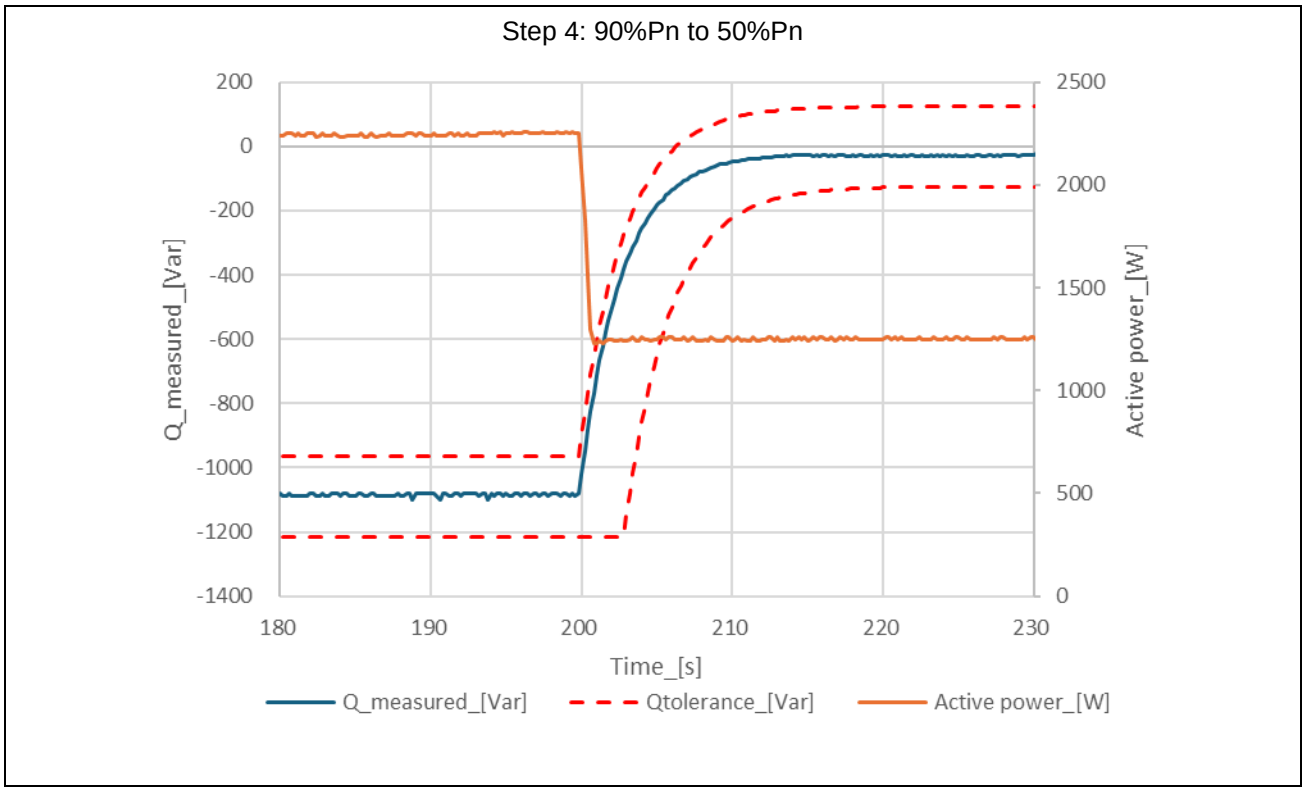
**Test procedure for dynamic behaviour:**

Setting (a)-Time constant: as fast as possible but not slower as 3s-3s

| Test Conditions | Measurements | | | | | |
|---|---|---|---|---|---|---|
| | Tsr [s] | Ts [s] | Td [s] | Reactive power/Pn [%] | Active power/Pn [%] | Grid voltage/Un [%] |
| 20%Pn | -- | -- | -- | -0.63% | 20.00% | 100.19% |
| 20%Pn -> 50%Pn | -- | -- | -- | -0.93% | 50.06% | 100.34% |
| 50%Pn -> 90%Pn | 5.6 | 5.6 | 0.2 | -43.32% | 89.86% | 100.43% |
| 90%Pn -> 50%Pn | 6.8 | 6.8 | 0.2 | -1.13% | 50.09% | 100.34% |
| 50%Pn -> 20%Pn | -- | -- | -- | -0.64% | 20.02% | 100.22% |

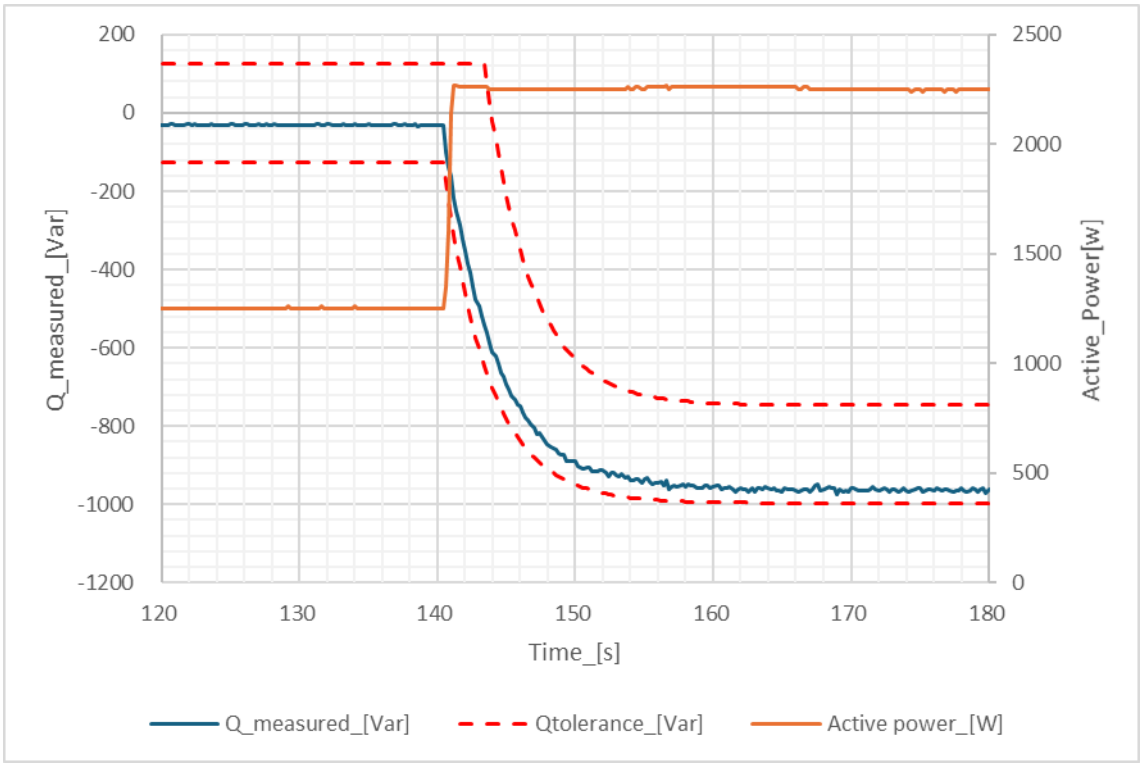
Step 3: 50%Pn to 90%Pn



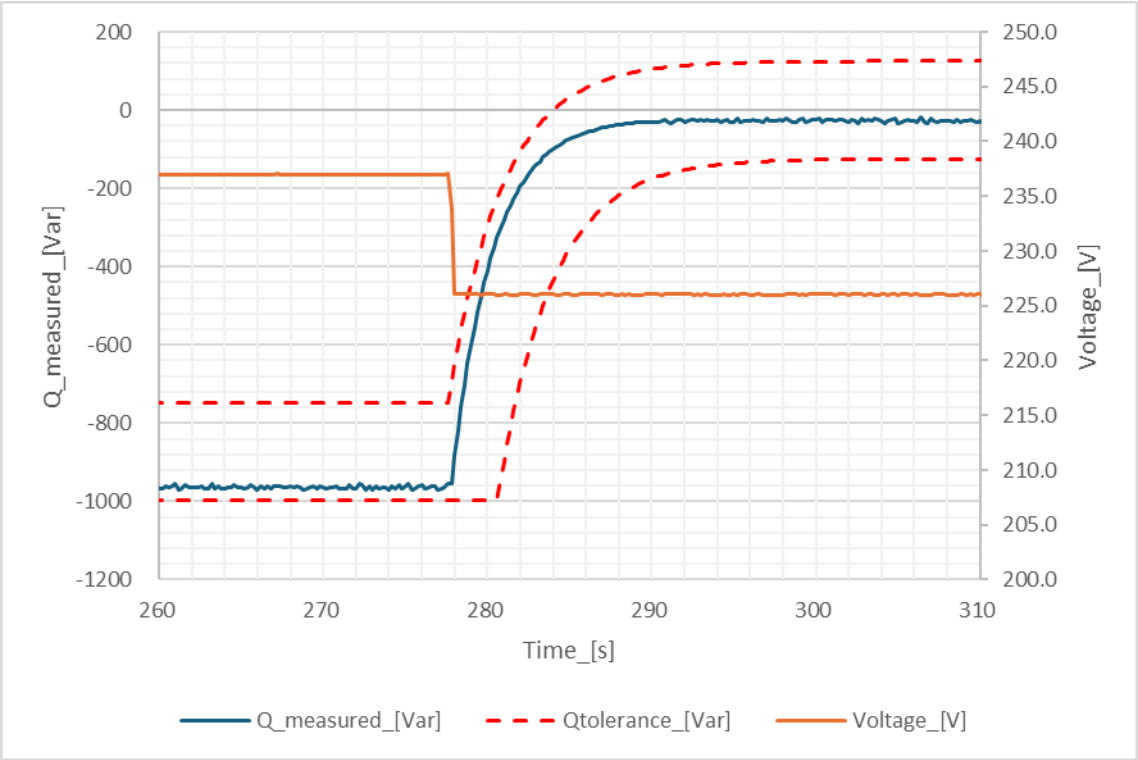

Step 4: 90%Pn to 50%Pn
200
0
-200
-400
-600
-800
-1000
-1200
-1400
Q_measured_[Var]
2500
2000
1500
1000
500
0
Active power_[W]
180
190
200
210
220
230
Time_[s]
Q_measured_[Var]
Qtolerance_[Var]
Active power_[W]

| Setting (c)--Time constant: 3.33s | | | | | | | |
|---|---|---|---|---|---|---|---|
| Test Conditions | | Measurements | | | | | |
| P | U/Un | Tsr [s] | Ts [s] | Td [s] | Reactive power [var] | Active power [W] | Grid voltage [V] |
| 20%Pn | 107% | -- | -- | -- | -21 | 501 | 246.4 |
| 20%Pn -> 50%Pn | 107% | -- | -- | -- | -30 | 1249 | 246.4 |
| 50%Pn -> 90%Pn | 107% | 5.6 | 5.6 | 0.2 | -962 | 2254 | 246.6 |
| 90% | 103% | -- | -- | -- | -964 | 2260 | 237.0 |
| 90% | 98% | 5.8 | 5.8 | 0.2 | -27 | 2266 | 226.0 |
| 90% | 107% | 4.6 | 4.6 | 0.2 | -963 | 2254 | 246.7 |
| 90% | 100% | -- | -- | -- | -961 | 2265 | 230.2 |
| 90%Pn -> 50%Pn | 100% | 7.2 | 7.2 | 0.2 | -24 | 1269 | 230.0 |
| 50%Pn -> 20%Pn | 100% | -- | -- | -- | -18 | 511 | 229.4 |

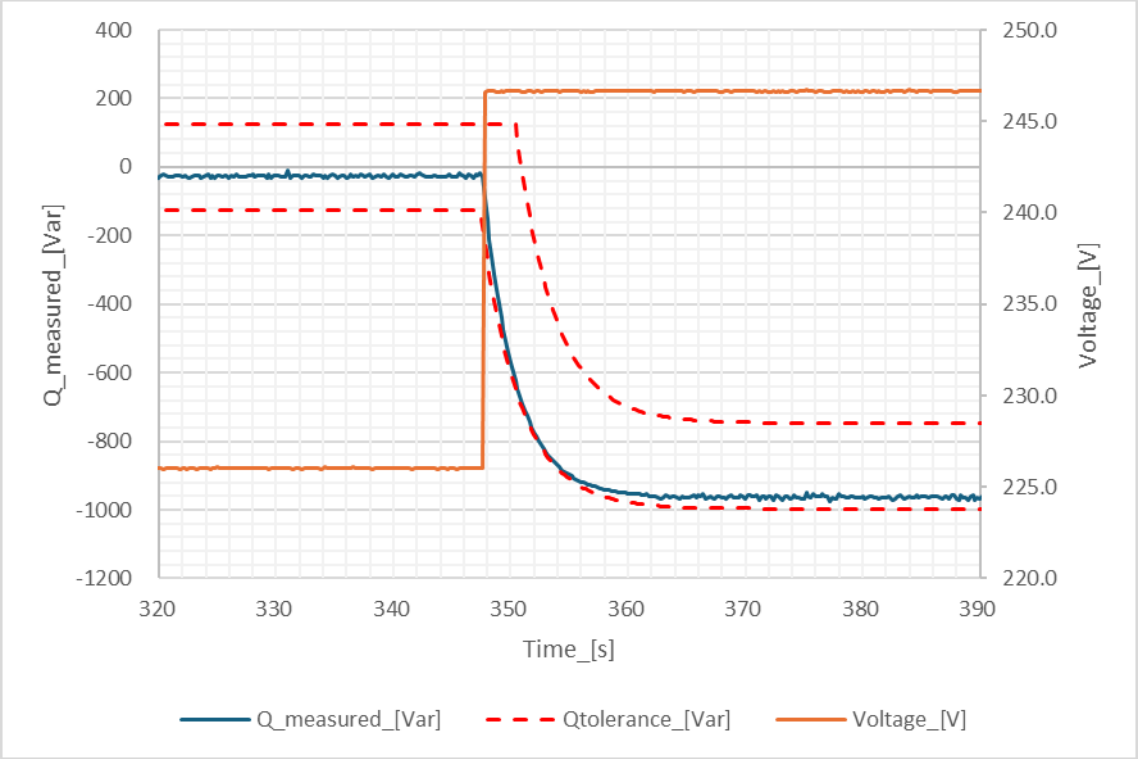
50%Pn to 90%Pn

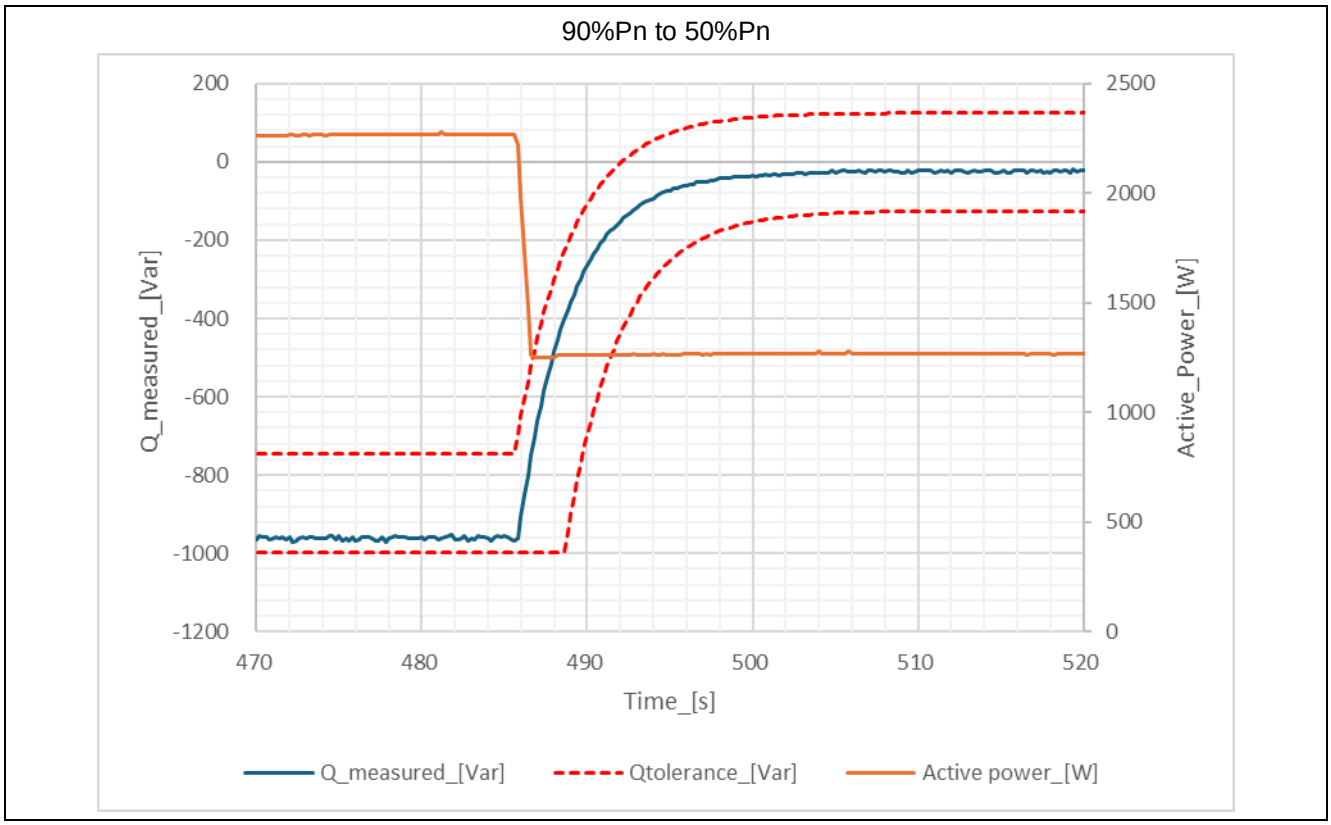


103%Un to 98%Un




98%Un to 107%Un






## 6.5 Voltage related active power reduction - P(U)

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.6.3 & 5.6.4, EN 50549-10 |

| | |
|---|---|
| Active Power level | 100%$P_n$ |
| Active factor | 1.000 |
| Voltage protection | deactivated |
| Relevant parameter setting | Default setting used for testing, see *Annex 1 – Parameter list* |
| Corresponding characteristic curve applied | Show figure |

| Acceptance criteria |
|---|
| - The measured 30-s averages of the active power (positive sequence components) during steady-state conditions are within a tolerance band of ±2%$S_{max}$ and ±1%$U_n$ of the set P(U) characteristic.<br>- the time response of the active power during the measurement represents the applied configuration within the tolerance band resulting from the behaviour of an equivalent first order filter element and the configured time constant tau. Accepted tolerances are<br>  ○ −5%$P_n$ for the active power values and 3 s for the time in case of a power decrease.<br>  ○ +5%$P_n$ for the active power values and 3 s for the time in case of a power increase.<br>- No discontinuities in the characteristic curve are detected and no oscillations of the active power after the end of the transient period of 5τ as configured and no disconnection of the EUT occur. |

- The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

**Manufacturer's data**

The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software.

**Test results**

Note:

* In the case of a single-phase unit, the RMS values of the active power are recorded in the following table instead of the positive sequence components of the active power ($P_+$).

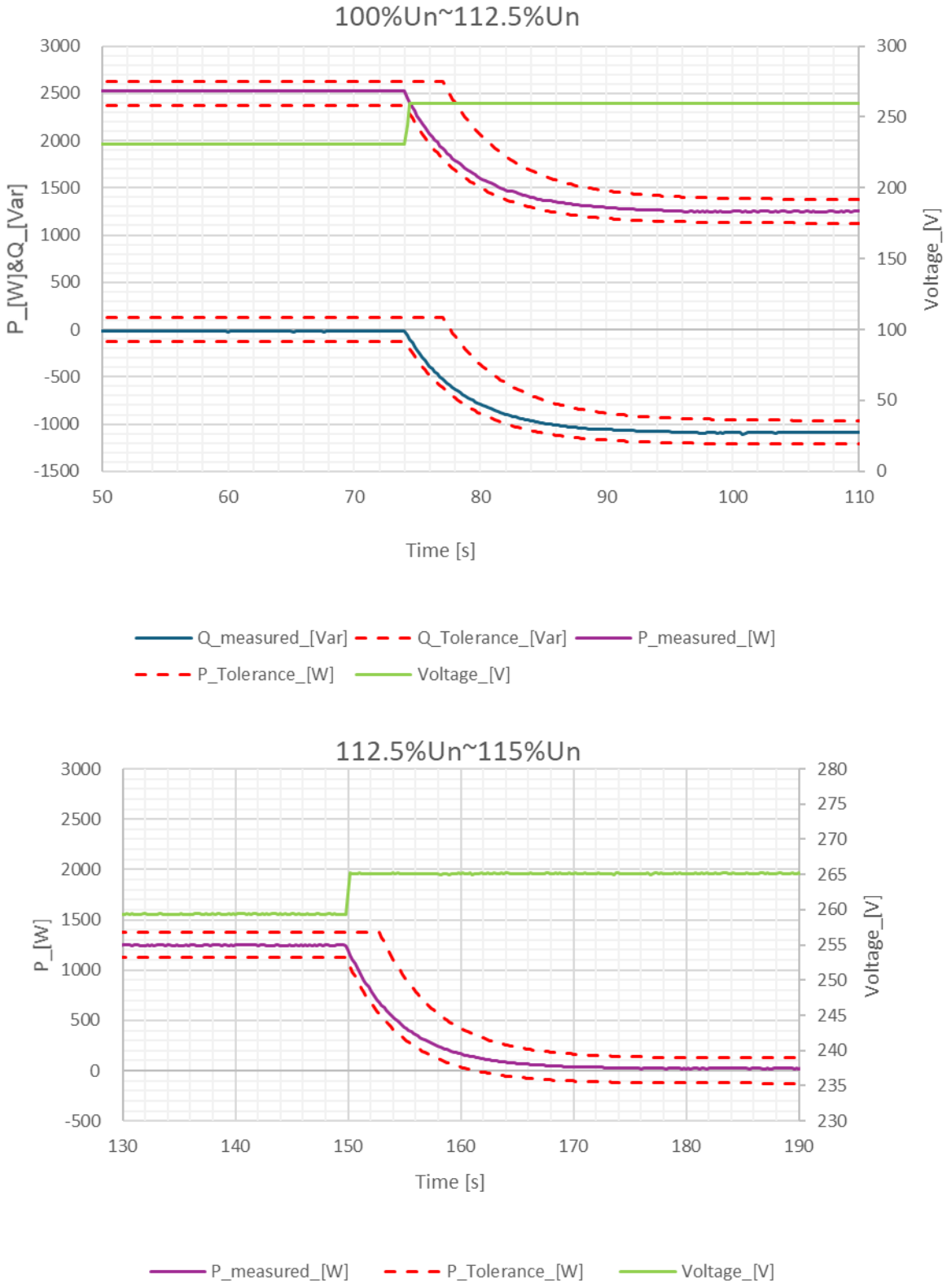
**Test 1 - Steady-state behaviour**

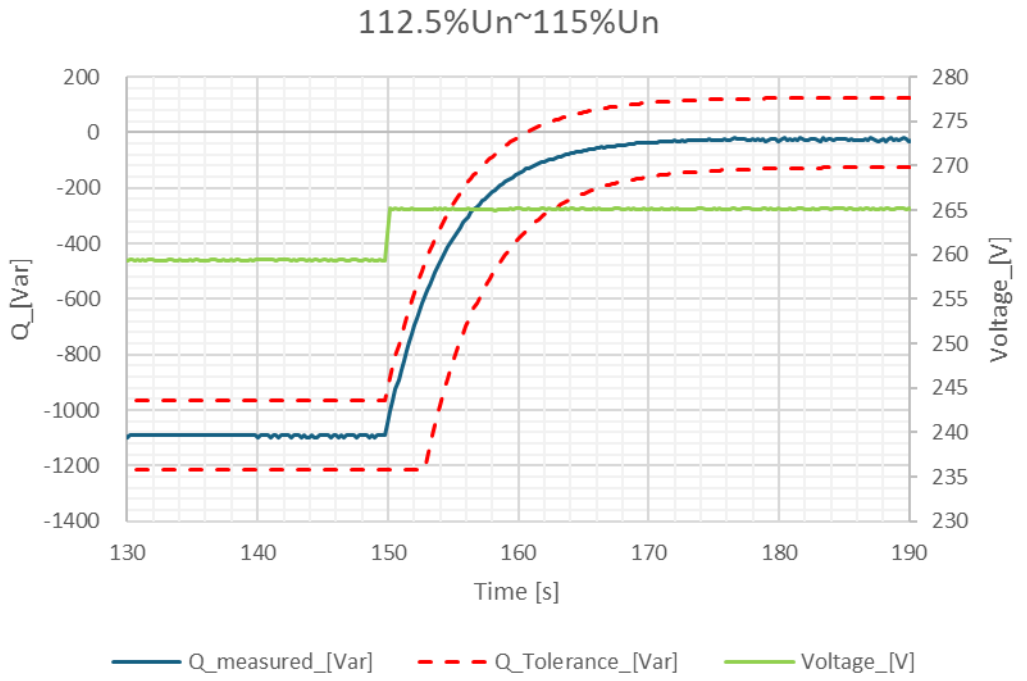
| Voltage step $U/U_n$ [%] | Measured value $U/U_n$ [%] | Deviation (Measured value - Set point) $U/U_n$ [%] | Measured value $P_+/P_n$ [%] * | Set point value $P_+/P_n$ [%] * | Deviation (Measured value - Set point) | |
|---|---|---|---|---|---|---|
| | | | | | $P_+/P_n$ [%] * | $P_+/S_{max}$ [%] * |
| 100 | 100.00 | 0.00 | 100.81 | 100.00 | 0.81 | 0.81 |
| 103 | 103.00 | 0.00 | 100.84 | 100.00 | 0.84 | 0.84 |
| 106 | 106.01 | 0.01 | 100.83 | 100.00 | 0.83 | 0.83 |
| 109 | 109.00 | 0.00 | 90.60 | 90.00 | 0.60 | 0.60 |
| 112 | 112.00 | 0.00 | 60.01 | 60.00 | 0.01 | 0.01 |
| 115 | 115.00 | 0.00 | 0.90 | 0.00 | 0.90 | 0.90 |
| 112 | 112.00 | 0.00 | 60.09 | 60.00 | 0.09 | 0.09 |
| 109 | 109.00 | 0.00 | 90.62 | 90.00 | 0.62 | 0.62 |
| 106 | 106.00 | 0.00 | 100.84 | 100.00 | 0.84 | 0.84 |
| 103 | 103.00 | 0.00 | 100.83 | 100.00 | 0.83 | 0.83 |
| 100 | 100.01 | 0.01 | 100.78 | 100.00 | 0.78 | 0.78 |

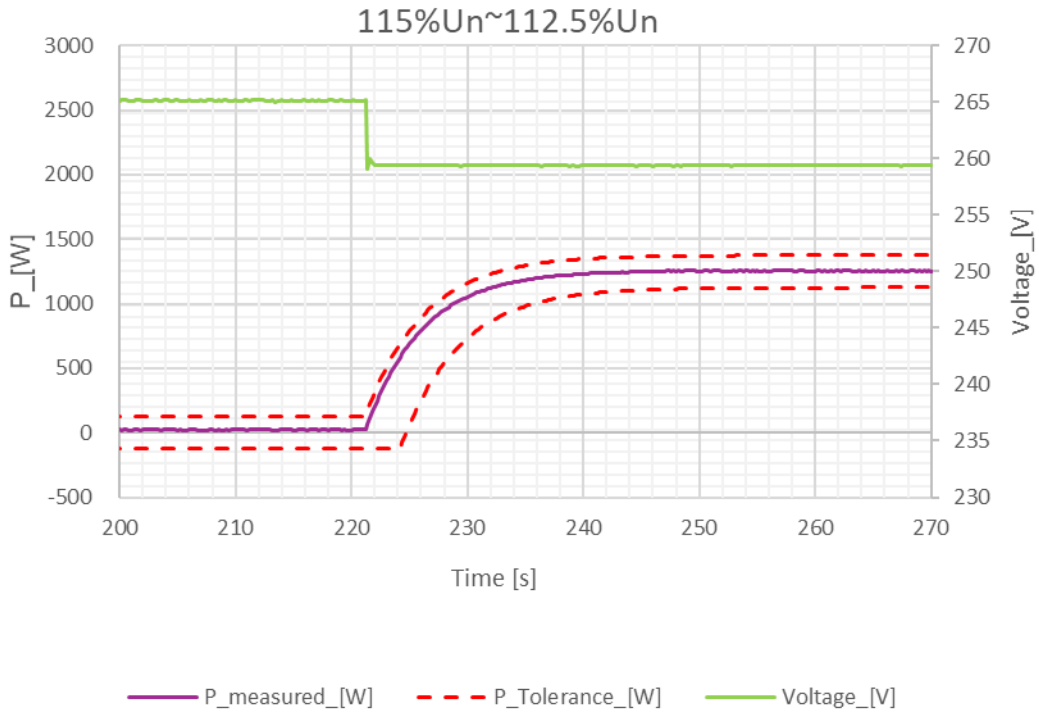
**Test 2 - Dynamic behaviour**

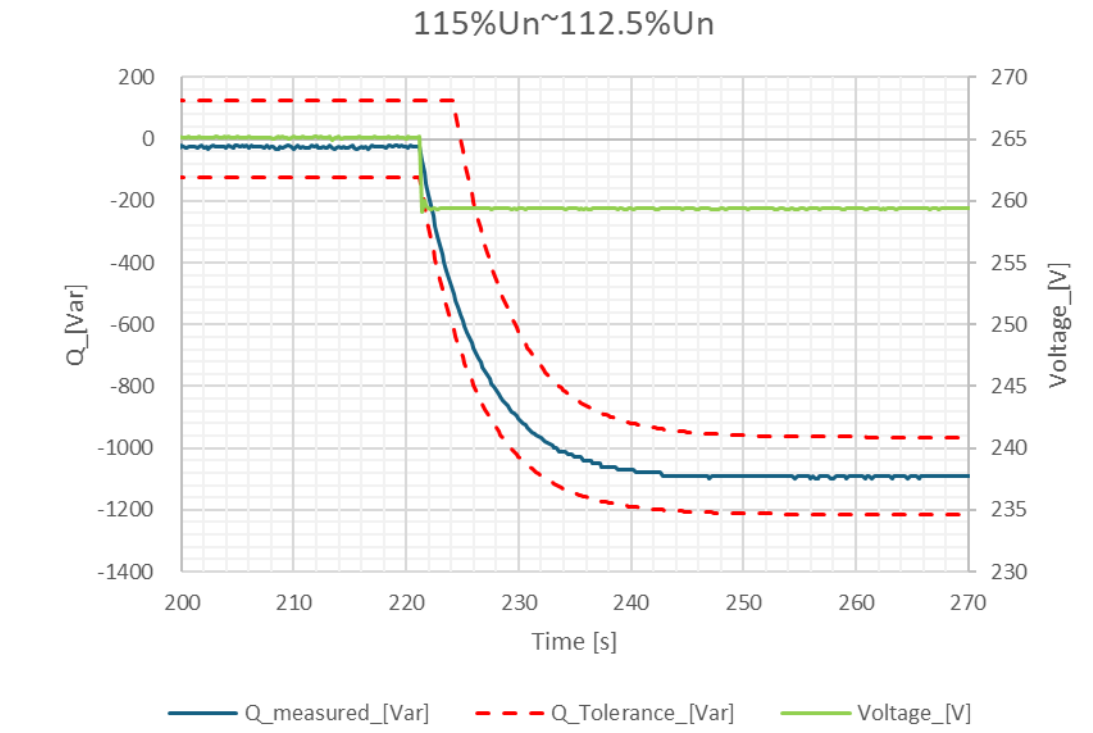
| Voltage step $U/U_n$ [%] | Measured value $P_+/P_n$ [%] * | Set point value $P_+/P_n$ [%] * | Dead time [s] | Response time [s] | Settling time [s] |
|---|---|---|---|---|---|
| 100 | 100.92% | 100.0% | -- | -- | -- |
| 112.5 | 49.87% | 50.0% | 0.2 | 11.0 | 11.0 |
| 115 | 0.92% | 0.0% | 0.2 | 12.0 | 12.0 |
| 112.5 | 50.12% | 50.0% | 0.2 | 11.0 | 11.0 |
| 100 | 100.32% | 100.0% | 0.2 | 11.6 | 11.6 |

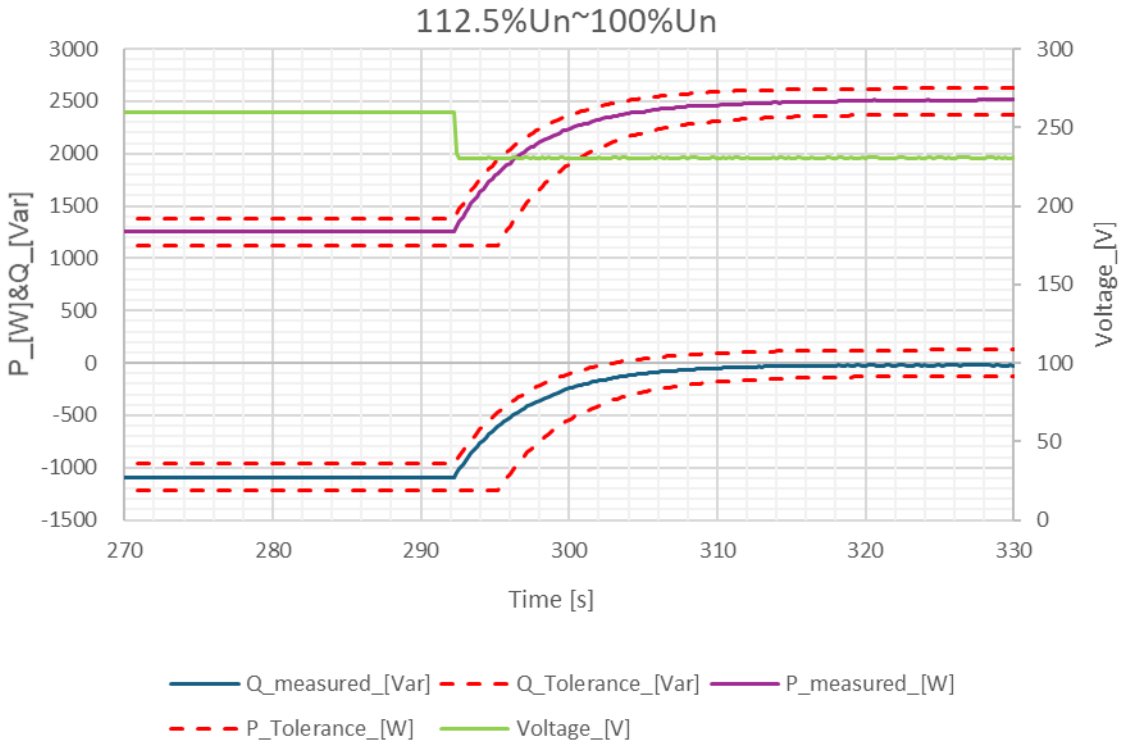
**Test 2 - Dynamic behaviour**




112.5%Un~115%Un
Q_[Var]
Voltage_[V]
Time [s]
Q_measured_[Var]
Q_Tolerance_[Var]
Voltage_[V]


115%Un~112.5%Un
P_[W]
Voltage_[V]
Time [s]
P_measured_[W]
P_Tolerance_[W]
Voltage_[V]


115%Un~112.5%Un
200
0
-200
-400
-600
-800
-1000
-1200
-1400
Q_[Var]
270
265
260
255
250
245
240
235
230
Voltage_[V]
200
210
220
230
240
250
260
270
Time [s]
Q_measured_[Var]
Q_Tolerance_[Var]
Voltage_[V]


112.5%Un~100%Un
3000
2500
2000
1500
1000
500
0
-500
-1000
-1500
P_[W]&Q_[Var]
300
250
200
150
100
50
0
Voltage_[V]
270
280
290
300
310
320
330
Time [s]
Q_measured_[Var]
Q_Tolerance_[Var]
P_measured_[W]
P_Tolerance_[W]
Voltage_[V]

## 6.6 EMC and power quality

### 6.6.1 EMC

| | |
|---|---|
| The generating units comply with the requirements on electromagnetic compatibility | EMC test report, see *Annex 2 – EMC report*. |
| The interface protection systems, including integrated systems, comply to EN 60255-26 | N/A |

### 6.6.2 Power Quality

#### 6.6.2.1 Harmonics

| **Verdict** | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| **Standards applied** |
|---|
| ☒ generating units with rated current ≤ 16A: EN 61000-3-2 |
| ☐ generating units with rated current > 16A and ≤ 75A: EN 61000-3-12 |
| ☐ generating units with rated current > 75A: EN 61000-4-7 |

| **Test conditions** | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22<br>Note: The line impedances depicted in *Figure 2* primarily represent the impedance of the connection cable.<br>Grid impedance $R_A$ [mΩ]: 0.675<br>Grid reactance $X_A$ [mΩ]: 2.312 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.7.2.2, EN 50549-10 |

**Test results**

**EN 61000-3-2**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Classification: | Class A | | | | | | |
| Voltage [V] | 230.0 | | | | | | |
| Frequency [Hz] | 50.00 | | | | | | |
| Active factor | 0.999 | | | | | | |
| Test at | 45-55%$P_n$ | | | 100%$P_n$ | | | |
| Active Power [W] | 1253 | | | 2499 | | | |
| Phase | L1 | L2 | L3 | L1 | L2 | L3 | |
| Harmonic order | Measured Value [A] | | | Measured Value [A] | | | Limit [A] |
| 1 | 5.420 | -- | -- | 10.808 | -- | -- | -- |
| 2 | 0.129 | -- | -- | 0.179 | -- | -- | 1.080 |
| 3 | 0.244 | -- | -- | 0.101 | -- | -- | 2.300 |
| 4 | 0.034 | -- | -- | 0.034 | -- | -- | 0.430 |
| 5 | 0.143 | -- | -- | 0.174 | -- | -- | 1.140 |
| 6 | 0.032 | -- | -- | 0.024 | -- | -- | 0.300 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7 | 0.111 | -- | -- | 0.156 | -- | -- | 0.770 |
| 8 | 0.007 | -- | -- | 0.010 | -- | -- | 0.230 |
| 9 | 0.067 | -- | -- | 0.116 | -- | -- | 0.400 |
| 10 | 0.017 | -- | -- | 0.020 | -- | -- | 0.184 |
| 11 | 0.057 | -- | -- | 0.106 | -- | -- | 0.330 |
| 12 | 0.006 | -- | -- | 0.014 | -- | -- | 0.153 |
| 13 | 0.041 | -- | -- | 0.091 | -- | -- | 0.210 |
| 14 | 0.013 | -- | -- | 0.013 | -- | -- | 0.131 |
| 15 | 0.043 | -- | -- | 0.078 | -- | -- | 0.150 |
| 16 | 0.009 | -- | -- | 0.014 | -- | -- | 0.115 |
| 17 | 0.021 | -- | -- | 0.059 | -- | -- | 0.132 |
| 18 | 0.008 | -- | -- | 0.018 | -- | -- | 0.102 |
| 19 | 0.016 | -- | -- | 0.050 | -- | -- | 0.118 |
| 20 | 0.009 | -- | -- | 0.022 | -- | -- | 0.092 |
| 21 | 0.021 | -- | -- | 0.044 | -- | -- | 0.107 |
| 22 | 0.007 | -- | -- | 0.007 | -- | -- | 0.084 |
| 23 | 0.015 | -- | -- | 0.030 | -- | -- | 0.098 |
| 24 | 0.004 | -- | -- | 0.009 | -- | -- | 0.077 |
| 25 | 0.016 | -- | -- | 0.030 | -- | -- | 0.090 |
| 26 | 0.005 | -- | -- | 0.011 | -- | -- | 0.071 |
| 27 | 0.017 | -- | -- | 0.026 | -- | -- | 0.083 |
| 28 | 0.004 | -- | -- | 0.008 | -- | -- | 0.066 |
| 29 | 0.013 | -- | -- | 0.026 | -- | -- | 0.078 |
| 30 | 0.003 | -- | -- | 0.008 | -- | -- | 0.061 |
| 31 | 0.008 | -- | -- | 0.021 | -- | -- | 0.073 |
| 32 | 0.002 | -- | -- | 0.007 | -- | -- | 0.058 |
| 33 | 0.009 | -- | -- | 0.019 | -- | -- | 0.068 |
| 34 | 0.002 | -- | -- | 0.005 | -- | -- | 0.054 |
| 35 | 0.008 | -- | -- | 0.018 | -- | -- | 0.064 |
| 36 | 0.002 | -- | -- | 0.005 | -- | -- | 0.051 |
| 37 | 0.009 | -- | -- | 0.018 | -- | -- | 0.061 |
| 38 | 0.002 | -- | -- | 0.004 | -- | -- | 0.048 |
| 39 | 0.007 | -- | -- | 0.014 | -- | -- | 0.058 |
| 40 | 0.003 | -- | -- | 0.005 | -- | -- | 0.046 |

### 6.6.2.2 Flicker and rapid voltage changes

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Standards applied |
|---|
| ☒ generating units with rated current ≤ 16A: EN 61000-3-3 |
| ☐ generating units with rated current > 16A and ≤ 75A: EN 61000-3-11 |
| ☐ generating units with rated current > 75A |

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.7.2.3, EN 50549-10 |

**Test results**

**EN 61000-3-3**

| | | Starting | | | Stopping | | | Running | |
|---|---|---|---|---|---|---|---|---|---|
| | Phase no. | $d_{max}$ [%] | $d_c$ [%] | d(t) [ms] | $d_{max}$ [%] | $d_c$ [%] | d(t) [ms] | $P_{st}$ | $P_{lt}$ 2 hours |
| Measured Values at test impedance | L1 | 0.245 | 0.019 | 0.000 | 0.723 | 0.321 | 0.000 | 0.308 | 0.243 |
| | L2 | -- | -- | -- | -- | -- | -- | -- | -- |
| | L3 | -- | -- | -- | -- | -- | -- | -- | -- |
| | Overall worst case | -- | -- | -- | -- | -- | -- | -- | -- |
| Normalised to standard impedance | L1 | 0.245 | 0.019 | 0.000 | 0.723 | 0.321 | 0.000 | 0.308 | 0.243 |
| | L2 | -- | -- | -- | -- | -- | -- | -- | -- |
| | L3 | -- | -- | -- | -- | -- | -- | -- | -- |
| | Overall worst case | -- | -- | -- | -- | -- | -- | -- | -- |
| Normalised to required maximum impedance | L1 | 1.073 | 0.081 | 0.000 | 3.162 | 1.404 | 0.000 | 0.824 | 0.650 |
| | L2 | -- | -- | -- | -- | -- | -- | -- | -- |
| | L3 | -- | -- | -- | -- | -- | -- | -- | -- |
| | Overall worst case | -- | -- | -- | -- | -- | -- | -- | -- |
| Limits | | 4 | 3.3 | 500 (3.3%) | 4 | 3.3 | 500 (3.3%) | 1.0 | 0.65 |

| | | | | |
|---|---|---|---|---|
| Test Impedance | R: | 0.40 | Ω | X: 0.25 Ω |
| Standard Impedance | R: | ☐ 0.24 * ☒ 0.4 ^ | Ω | X: ☐ 0.15 * ☒ 0.25 ^ Ω |
| Maximum Impedance | R: | 1.75 | Ω | X: 1.09 Ω |

| | | | |
|---|---|---|---|
| * | ☐ | three-phase **Power Generating Module**s | ☐ split single phase **Power Generating Module**s |
| ^ | ☒ | single phase **Power Generating Module** | ☐ **Power Generating Module**s using two phases on a three-phase system |

### 6.6.2.3 DC injection

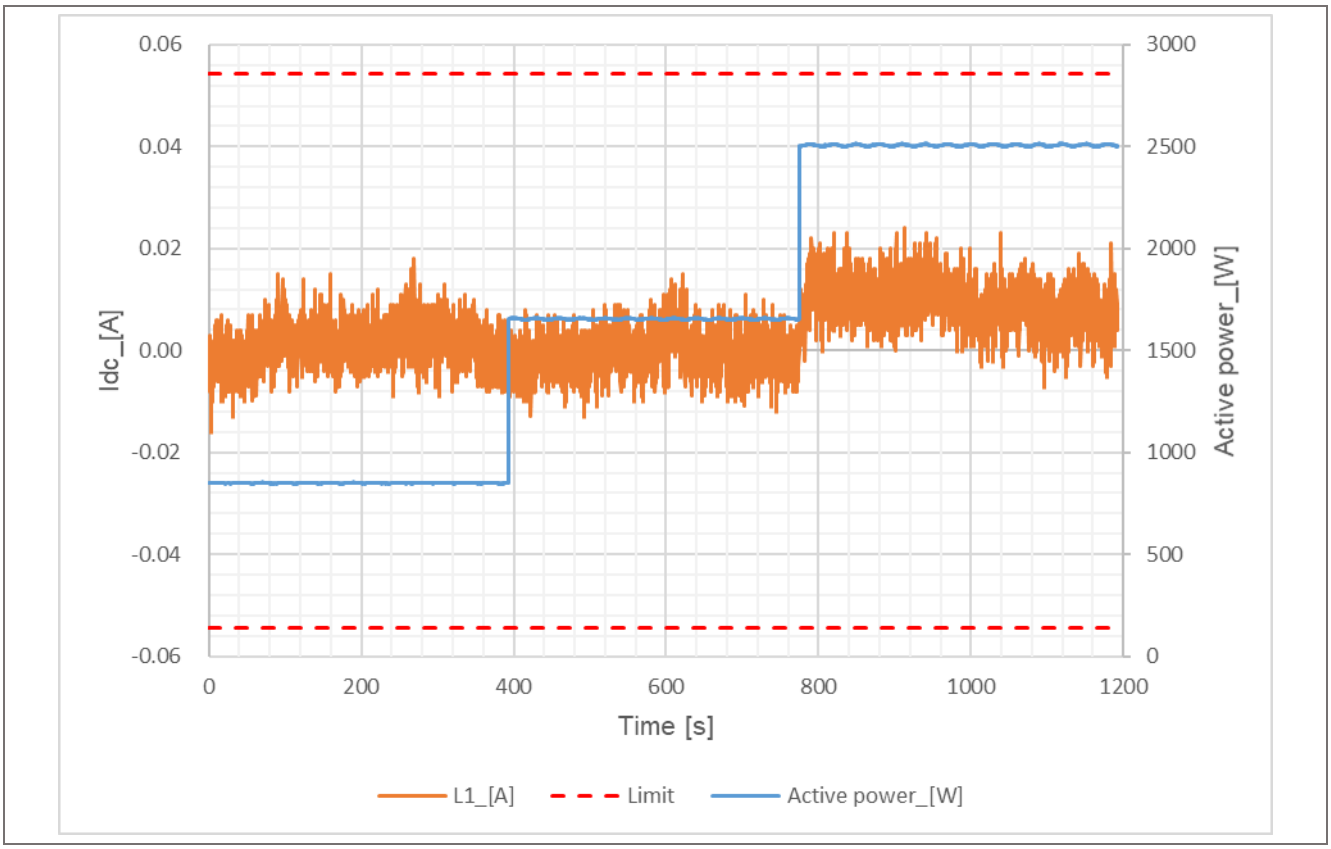
| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.7.2.4, EN 50549-10 |
| Voltage [V] | 230.0 |
| Frequency [Hz] | 50.00 |
| THD of the mains voltage: < 2,5 %? | The test equipment used met the requirements. |
| Network simulators used, DC component of the voltage < 0,1 %? | The test equipment used met the requirements. |

| | |
|---|---|
| Operating mode of the EUT | ☐ MPP-Tracking operation mode:<br>input voltage equal to the nominal value declared by the manufacturer<br>☒ Fixed voltage control operation mode:<br>input voltage equal to the nominal value declared by the manufacturer |

| Acceptance criteria |
|---|
| DC current for all 5 min average values calculated is lower than 0,5% of nominal current or 20 mA whatever is the higher value |

| Test results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Test power level | 30 ~ 40%$P_{max}$ | | | 60 ~ 70%$P_{max}$ | | | >95%$P_{max}$ | | |
| P [W] | 849 | | | 1655 | | | 2507 | | |
| Phase | L1 | L2 | L3 | L1 | L2 | L3 | L1 | L2 | L3 |
| Max. DC current [mA] | 18 | -- | -- | 15 | -- | -- | 24 | -- | -- |
| Max. DC current [%$I_n$] | 0.166 | -- | -- | 0.138 | -- | -- | 0.221 | -- | -- |
| Avg. DC current [mA] | 3 | -- | -- | 3 | -- | -- | 9 | -- | -- |
| Avg. DC current [%$I_n$] | 0.032 | -- | -- | 0.031 | -- | -- | 0.087 | -- | -- |
| Limit [%] | max{0.5%$I_n$, 54mA} | | | | | | | | |




## 6.7 Interface protection

| | |
|---|---|
| Verification methodology & Test setup | See section 4.3.1 & 4.5. |
| **Manufacturer data** | |
| Type of interface protection | ☒ Interface protection as internal device (Section 5.8.3, EN 50549-10)<br>☐ Interface protection as dedicated device (Section 5.8.4, EN 50549-10) |
| | ☒ Single-phase interface protection<br>☐ Three-phase interface protection |
| Test terminal | ☒ Test terminal available, tests were carried out on the test terminal without disconnecting wires<br>☐ Test terminal NOT available |
| Voltage evaluation principle | ☒ phase-to-neutral (star)<br>☐ phase-to-phase (delta) |
| Disconnection device | **Relay- Models (main): HF3FF**, opening time ($T_{open}$): max. 10 ms |
| Start time of protection relay [ms] | 5 |
| Time delay setting ($T_{setting}$) of protection relay includes | ☒ Start time ($T_{start}$) of the protection relay<br>☐ Opening time ($T_{open}$) of the disconnection device<br>Note:<br>The shown disconnection times ($T_{disc}$) in this test report include the operate time ($T_{OP}$) of the protection relay and opening time ($T_{open}$) of the disconnection device. |

| | |
|---|---|
| Reset time | <50ms |
| Reset ratio | Voltage: <2%$U_n$<br>Frequency: <0.2Hz |

### 6.7.1 Voltage and frequency protections

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.8.3, EN 50549-10 |

| | |
|---|---|
| Relevant parameter setting | Default setting used for testing, see *Annex 1 – Parameter list* |

**Acceptance criteria**

- For tests with ramp signal (Ramp), if for all tests the tolerance between the setting value and value of the characteristic quantity that causes the operation of the relay is less than the required accuracy for the voltage and for the frequency. (EN 50549-1:2019 requires a voltage measurement accuracy of 1%$U_n$ and a frequency accuracy of 0,05 Hz.)
- For tests with jump signal (Jump), if for all tests the operate time is equal to or below the configured time delay setting plus the start time as stated in the product documentation. If due to the test setup the disconnection time is evaluated instead of the operate time the test is passed if for all tests the disconnection time is equal to or below the configured time delay setting plus the start time plus the circuit breaker opening time as stated in the product documentation. If the configured time delay setting includes the start time or the opening time, the condition has to be modified accordingly.
- For criteria 1) and 2) it is ensured that no voltage other than the voltage to be tested exceeds one of the setting values
- For tests with non-operation signal (NOP) the relay does not operate.
- If the interface protection operates the interface switch opens.

**Manufacturer's data**

The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software.

**Test results**

Note:

Test procedure acc. Section 5.8.3, EN 50549-10.

For the parameter setting range, please refer to *Annex 1 – Parameter list*.

1) Overvoltage protection stage 1 (>) - Accuracy of the setting values (Ramp tests)

| Test cases | Setting [%Un] | Tripping values [%Un] | | | | | | | Limit |
|---|---|---|---|---|---|---|---|---|---|
| | | (U > 1) $U_{all-phases}$ | (U > 2) $U_{L1-N}$ | (U > 3) $U_{L2-N}$ | (U > 4) $U_{L3-N}$ | (U > 5) $U_{L1-L2}$ | (U > 6) $U_{L2-L3}$ | (U > 7) $U_{L3-L1}$ | |
| Min. of setting range | 110 | -- | 110.2 | -- | -- | -- | -- | -- | $\lvert U_{meas} - U_{set} \rvert \leq 1\%U_n$ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 30% of setting range | 113 | -- | 113.7 | -- | -- | -- | -- | -- | |
| 60% of setting range | 116 | -- | 116.5 | -- | -- | -- | -- | -- | |
| Max. of setting range | 120 | -- | 120.6 | -- | -- | -- | -- | -- | |
| Maximum deviation from setting value [%$U_n$] | | | | | 0.7 | | | | |

Note:

For **time delay setting** during tests, the following applied:

- "Min. of setting range" of threshold: min. of setting range of time delay, time delay was limited to 0.1 s for testing
- "30% of setting range" of threshold: 30% of setting range of time delay, time delay was limited to 30 s for testing
- "60% of setting range" of threshold: 60% of setting range of time delay, time delay was limited to 60 s for testing
- "Max. of setting range" of threshold: max. of setting range of time delay, time delay was limited to 100 s for testing

2) Overvoltage protection stage 1 (>) - Time measurements (Jump tests)

| Test cases | Setting [s] | Tripping times [s] | | | | | | | Limit [s] |
|---|---|---|---|---|---|---|---|---|---|
| | | (U > 8) $U_{all\text{-}phases}$ | (U > 9) $U_{L1\text{-}N}$ | (U > 10) $U_{L2\text{-}N}$ | (U > 11) $U_{L3\text{-}N}$ | (U > 12) $U_{L1\text{-}L2}$ | (U > 13) $U_{L2\text{-}L3}$ | (U > 14) $U_{L3\text{-}L1}$ | |
| Min. of setting range | 0.1 | -- | 0.140 | -- | -- | -- | -- | -- | 0.1-0.2 |
| 30% of setting range | 30.0 | -- | 30.000 | -- | -- | -- | -- | -- | 30.0-30.1 |
| 60% of setting range | 60.0 | -- | 60.000 | -- | -- | -- | -- | -- | 60.0-60.1 |
| Max. of setting range | 100.0 | -- | 100.000 | -- | -- | -- | -- | -- | 100.0 - 100.1 |
| Maximum deviation from operate time / time delay setting [s] | | | | | 0.040 | | | | |

Note:

For **tripping threshold setting** during tests, the following applied:

- "Min. of setting range" of tripping time: min. of setting range of tripping threshold
- "30% of setting range" of tripping time: 30% of setting range of tripping threshold
- "60% of setting range" of tripping time: 60% of setting range of tripping threshold
- "Max. of setting range" of tripping time: max. of setting range of tripping threshold

* The start (pick-up) signal is NOT accessible.

The shown Tripping / disconnection times ($T_{disc}$) in this test report include the operate time ($T_{OP}$) of the protection relay and opening time ($T_{open}$) of the disconnection device:

$T_{disc} = T_{OP} + T_{open}$

The determined deviation calculated from the measured value and the (setting value + max. opening time of the disconnection device (30ms)).

3) Overvoltage protection stage 1 (>) - Reset time (NOP tests)

| Test cases | Setting ($G_S$) [%$U_n$] | (U > 15) $U_{L1\text{-}N}$ | (U > 15) $U_{L2\text{-}N}$ | (U > 15) $U_{L3\text{-}N}$ | Relay operated / interface switch opened? |
|---|---|---|---|---|---|
| Min of setting range | 110 | Test sequence see below | -- | -- | ☐ yes ☒ no |

Note:

Test sequence modified acc. Figure 42, EN 50549-10:

Step 0: $G_{Start} = G_S - 2.5\%U_n$, $\Delta t_1 = T_S + 200$ ms

↓

Step 1: $G_{End} = G_S + 2.5\%U_n$, $\Delta t_2 = T_{OP} - 60$ ms

↓

Step 2: Signal value = $G_S - 2\%U_n$, $\Delta t_1 = T_S + 200$ ms

4) Overvoltage protection stage 2 (≫) - Accuracy of the setting values (Pulsed ramp tests)

| Test cases | Setting [%$U_n$] | Tripping values [%Un] | | | | | | | Limit |
|---|---|---|---|---|---|---|---|---|---|
| | | (U ≫ 1) $U_{all-phases}$ | (U ≫ 2) $U_{L1-N}$ | (U ≫ 3) $U_{L2-N}$ | (U ≫ 4) $U_{L3-N}$ | (U ≫ 5) $U_{L1-L2}$ | (U ≫ 6) $U_{L2-L3}$ | (U ≫ 7) $U_{L3-L1}$ | |
| Min. of setting range | 120.0 | -- | 120.0 | -- | -- | -- | -- | -- | $\lvert U_{meas} - U_{set} \rvert \leq 1\%U_n$ |
| 30% of setting range | 121.4 | -- | 121.5 | -- | -- | -- | -- | -- | |
| 60% of setting range | 122.8 | -- | 123.5 | -- | -- | -- | -- | -- | |
| Max. of setting range | 124.8 | -- | 125.2 | -- | -- | -- | -- | -- | |
| Maximum deviation from setting value [%$U_n$] | | 0.7 | | | | | | | |

Note:

For **time delay setting** during tests, the following applied:

- "Min. of setting range" of threshold: min. of setting range of time delay, time delay was limited to 0.1 s for testing
- "30% of setting range" of threshold: 30% of setting range of time delay, time delay was limited to 1.5 s for testing
- "60% of setting range" of threshold: 60% of setting range of time delay, time delay was limited to 3.0 s for testing
- "Max. of setting range" of threshold: max. of setting range of time delay, time delay was limited to 5.0 s for testing

5) Overvoltage protection stage 2 (≫) - Time measurements (Jump tests)

| Test cases | Setting [s] | Tripping times [s] | | | | | | | Limit [s] |
|---|---|---|---|---|---|---|---|---|---|
| | | (U ≫ 8) $U_{all-phases}$ | (U ≫ 9) $U_{L1-N}$ | (U ≫ 10) $U_{L2-N}$ | (U ≫ 11) $U_{L3-N}$ | (U ≫ 12) $U_{L1-L2}$ | (U ≫ 13) $U_{L2-L3}$ | (U ≫ 14) $U_{L3-L1}$ | |
| Min. of setting range | 0.1 | -- | 0.132 | -- | -- | -- | -- | -- | 0.10-0.20 |
| 30% of setting range | 1.5 | -- | 1.540 | -- | -- | -- | -- | -- | 1.50-1.60 |
| 60% of setting range | 3.0 | -- | 3.040 | -- | -- | -- | -- | -- | 3.00-3.10 |
| Max. of setting range | 5.0 | -- | 5.030 | -- | -- | -- | -- | -- | 5.00-5.10 |
| Maximum deviation from time delay setting [s] | | 0.040 | | | | | | | |

Note:

For **tripping threshold setting** during tests, the following applied:

- "Min. of setting range" of tripping time: min of setting range of tripping threshold
- "30% of setting range" of tripping time: 30% of setting range of tripping threshold
- "60% of setting range" of tripping time: 60% of setting range of tripping threshold
- "Max. of setting range" of tripping time: max. of setting range of tripping threshold

* The start (pick-up) signal is NOT accessible.

The shown Tripping / disconnection times ($T_{disc}$) in this test report include the operate time ($T_{OP}$) of the protection relay and opening time ($T_{open}$) of the disconnection device:

$T_{disc} = T_{OP} + T_{open}$

The determined deviation calculated from the measured value and the (setting value + max. opening time of the disconnection device (30ms)).

6) Overvoltage protection stage 2 (≫) - Reset time (NOP tests)

| Test cases | Setting ($G_S$) [%$U_n$] | (U ≫ 15) $U_{L1-N}$ | (U ≫ 15) $U_{L2-N}$ | (U ≫ 15) $U_{L3-N}$ | Relay operated / interface switch opened? |
|---|---|---|---|---|---|
| Min of setting range | 120 | Test sequence see below | -- | -- | ☐ yes ☒ no |

Note:

Test sequence modified acc. Figure 42, EN 50549-10:

Step 0: $G_{Start} = G_S - 2.5\%U_n$, $\Delta t_1 = T_S + 200$ ms

↓

Step 1: $G_{End} = G_S + 2.5\%U_n$, $\Delta t_2 = T_{OP} - 60$ ms

↓

Step 2: Signal value = $G_S - 2\%U_n$, $\Delta t_1 = T_S + 200$ ms

7) Undervoltage protection stage 1 (<) - Accuracy of the setting values (Ramp tests)

| Test cases | Setting [%$U_n$] | Tripping values [%Un] | | | | | | | Limit |
|---|---|---|---|---|---|---|---|---|---|
| | | (U < 1) $U_{all-phases}$ | (U < 2) $U_{L1-N}$ | (U < 3) $U_{L2-N}$ | (U < 4) $U_{L3-N}$ | (U < 5) $U_{L1-L2}$ | (U < 6) $U_{L2-L3}$ | (U < 7) $U_{L3-L1}$ | |
| Min. of setting range | 78.3 | -- | 78.4 | -- | -- | -- | -- | -- | $\lvert U_{meas} - U_{set} \rvert \le 1\%U_n$ |
| 30% of setting range | 81.8 | -- | 82.0 | -- | -- | -- | -- | -- | |
| 60% of setting range | 85.3 | -- | 85.2 | -- | -- | -- | -- | -- | |
| Max. of setting range | 90.0 | -- | 90.0 | -- | -- | -- | -- | -- | |
| Maximum deviation from setting value [%$U_n$] | | 0.2 | | | | | | | |

Note:

For **time delay setting** during tests, the following applied:

- "Min. of setting range" of threshold: min. of setting range of time delay, time delay was limited to 0.1 s for testing
- "30% of setting range" of threshold: 30% of setting range of time delay, time delay was limited to 30 s for testing
- "60% of setting range" of threshold: 60% of setting range of time delay, time delay was limited to 60 s for testing
- "Max. of setting range" of threshold: max. of setting range of time delay, time delay was limited to 100 s for testing

8) Undervoltage protection stage 1 (<) - Time measurements (Jump tests)

| Test cases | Setting [s] | Tripping times [s] | | | | | | | Limit [s] |
|---|---|---|---|---|---|---|---|---|---|
| | | (U < 8) $U_{all-phases}$ | (U < 9) $U_{L1-N}$ | (U < 10) $U_{L2-N}$ | (U < 11) $U_{L3-N}$ | (U < 12) $U_{L1-L2}$ | (U < 13) $U_{L2-L3}$ | (U < 14) $U_{L3-L1}$ | |
| Min. of setting range | 0.1 | -- | 0.134 | -- | -- | -- | -- | -- | 0.1-0.2 |
| 30% of setting range | 30.0 | -- | 30.000 | -- | -- | -- | -- | -- | 30.0-30.1 |
| 60% of setting range | 60.0 | -- | 60.000 | -- | -- | -- | -- | -- | 60.0-60.1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Max. of setting range | 100.0 | -- | 100.000 | -- | -- | -- | -- | -- | 100.0 - 100.1 |
| Maximum deviation from operate time / time delay setting [s] | 0.034 | | | | | | | | |

Note:
For **tripping threshold setting** during tests, the following applied:
- "Min. of setting range" of tripping time: min. of setting range of tripping threshold
- "30% of setting range" of tripping time: 30% of setting range of tripping threshold
- "60% of setting range" of tripping time: 60% of setting range of tripping threshold
- "Max. of setting range" of tripping time: max. of setting range of tripping threshold

9) Undervoltage protection stage 1 (<) - Reset time (NOP tests)

| Test cases | Setting ($G_S$) [%$U_n$] | (U < 15) $U_{L1-N}$ | (U < 15) $U_{L2-N}$ | (U < 15) $U_{L3-N}$ | Relay operated / interface switch opened? |
|---|---|---|---|---|---|
| Max of setting range | 90 | Test sequence see below | -- | -- | ☐ yes ☒ no |

Note:
Test sequence modified acc. Figure 42, EN 50549-10:

Step 0: $G_{Start} = G_S + 2.5\%U_n$, $\Delta t_1 = T_S + 200$ ms
↓
Step 1: $G_{End} = G_S - 2.5\%U_n$, $\Delta t_2 = T_{OP} - 60$ ms
↓
Step 2: Signal value = $G_S + 2\%U_n$, $\Delta t_1 = T_S + 200$ ms

10) Undervoltage protection stage 1 (≪) - Accuracy of the setting values (Pulsed ramp tests)

| Test cases | Setting [%$U_n$] | Tripping values [%Un] | | | | | | | Limit |
|---|---|---|---|---|---|---|---|---|---|
| | | (U ≪ 1) $U_{all-phases}$ | (U ≪ 2) $U_{L1-N}$ | (U ≪ 3) $U_{L2-N}$ | (U ≪ 4) $U_{L3-N}$ | (U ≪ 5) $U_{L1-L2}$ | (U ≪ 6) $U_{L2-L3}$ | (U ≪ 7) $U_{L3-L1}$ | |
| Min. of setting range | 40 | -- | 40.0 | -- | -- | -- | -- | -- | $\lvert U_{meas} - U_{set} \rvert \le 1\%U_n$ |
| 30% of setting range | 49 | -- | 49.0 | -- | -- | -- | -- | -- | |
| 60% of setting range | 58 | -- | 58.0 | -- | -- | -- | -- | -- | |
| Max. of setting range | 70 | -- | 70.0 | -- | -- | -- | -- | -- | |
| Maximum deviation from setting value [%$U_n$] | 0.0 | | | | | | | | |

Note:
For **time delay setting** during tests, the following applied:
- "Min. of setting range" of threshold: min. of setting range of time delay, time delay was limited to 0.1 s for testing
- "30% of setting range" of threshold: 30% of setting range of time delay, time delay was limited to 1.5 s for testing
- "60% of setting range" of threshold: 60% of setting range of time delay, time delay was limited to 3.0 s for testing
- "Max. of setting range" of threshold: max. of setting range of time delay, time delay was limited to 5.0 s for testing

11) Undervoltage protection stage 1 (≪) - Time measurements (Jump tests)

| Test cases | | Tripping times [s] | Limit |
|---|---|---|---|

| | Setting [s] | (U ≪ 8) $U_{all\text{-}phases}$ | (U ≪ 9) $U_{L1\text{-}N}$ | (U ≪ 10) $U_{L2\text{-}N}$ | (U ≪ 11) $U_{L3\text{-}N}$ | (U ≪ 12) $U_{L1\text{-}L2}$ | (U ≪ 13) $U_{L2\text{-}L3}$ | (U ≪ 14) $U_{L3\text{-}L1}$ | [s] |
|---|---|---|---|---|---|---|---|---|---|
| Min. of setting range | 0.1 | -- | 0.139 | -- | -- | -- | -- | -- | 0.1-0.2 |
| 30% of setting range | 1.5 | -- | 1.550 | -- | -- | -- | -- | -- | 1.5-1.6 |
| 60% of setting range | 3.0 | -- | 3.020 | -- | -- | -- | -- | -- | 3.0-3.1 |
| Max. of setting range | 5.0 | -- | 5.010 | -- | -- | -- | -- | -- | 5.0-5.1 |
| Maximum deviation from operate time / time delay setting [s] | | | | | 0.039 | | | | |

Note:

For **tripping threshold setting** during tests, the following applied:

- "Min. of setting range" of tripping time: min. of setting range of tripping threshold
- "30% of setting range" of tripping time: 30% of setting range of tripping threshold
- "60% of setting range" of tripping time: 60% of setting range of tripping threshold
- "Max. of setting range" of tripping time: max. of setting range of tripping threshold

* The start (pick-up) signal is NOT accessible.

The shown Tripping / disconnection times ($T_{disc}$) in this test report include the operate time ($T_{OP}$) of the protection relay and opening time ($T_{open}$) of the disconnection device:

$T_{disc} = T_{OP} + T_{open}$

The determined deviation calculated from the measured value and the (setting value + max. opening time of the disconnection device (30ms)).

12) Undervoltage protection stage 1 (≪) - Reset time (NOP tests)

| Test cases | Setting ($G_S$) [%$U_n$] | (U ≪ 15) $U_{L1\text{-}N}$ | (U ≪ 15) $U_{L2\text{-}N}$ | (U ≪ 15) $U_{L3\text{-}N}$ | Relay operated / interface switch opened? |
|---|---|---|---|---|---|
| Max of setting range | 70 | Test sequence see below | -- | -- | ☐ yes ☒ no |

Note:

Test sequence modified acc. Figure 42, EN 50549-10:

Step 0: $G_{Start} = G_S + 2.5\%U_n$, $\Delta t_1 = T_S + 200$ ms

↓

Step 1: $G_{End} = G_S - 2.5\%U_n$, $\Delta t_2 = T_{OP} - 60$ ms

↓

Step 2: Signal value = $G_S + 2\%U_n$, $\Delta t_1 = T_S + 200$ ms

13) Overfrequency protection stage 1 (>) and 2 (≫) - Accuracy of the setting values (Ramp tests) and time measurements (Jump tests)

| Test cases | Setting [Hz] (f > 1) | Tripping values [Hz] (f > 1) | Setting [Hz] (f ≫ 1) | Tripping values [Hz] (f ≫ 1) | Tripping times [s] (f > 2) | Tripping times [s] (f ≫ 2) | Limit |
|---|---|---|---|---|---|---|---|
| Min. of setting range | 50.00 | 50.02 | 51.00 | 51.03 | 100.000 | 0.186 | $\lvert f_{meas} - f_{set} \rvert \leq 0.05$ Hz |
| 30% of setting range | 50.45 | 50.44 | 51.30 | 51.30 | 60.100 | 1.660 | |
| 6075% of setting range | 50.90 | 50.91 | 51.60 | 51.61 | 30.100 | 3.100 | |
| Max. of setting range | 51.50 | 51.50 | 52.00 | 52.01 | 0.181 | 5.060 | |
| Maximum deviation from setting value [Hz] | | | | | 0.03 | | |

| Maximum deviation from operate time / time delay setting [s] | 0.100 |
|---|---|

14) Overfrequency protection stage 1 (>) and 2 (≫) - Reset time (NOP tests)

| Test cases | Setting ($G_S$) [Hz] | (f > 3) | (f ≫ 3) | Relay operated / interface switch opened? |
|---|---|---|---|---|
| 33% of setting range | 50.5 | Test sequence see below | | ☐ yes ☒ no |
| 50% of setting range | 51.5 | | | ☐ yes ☒ no |

Note:
Test sequence modified acc. Figure 42, EN 50549-10:

Step 0: $G_{Start} = G_S - 0.3$ Hz, $\Delta t_1 = T_S + 200$ ms

↓

Step 1: $G_{End} = G_S + 0.3$ Hz, $\Delta t_2 = T_{OP} - 60$ ms

↓

Step 2: Signal value = $G_S - 0.2$ Hz, $\Delta t_1 = T_S + 200$ ms

15) Underfrequency protection stage 1 (<) and 2 (≪) - Accuracy of the setting values (Ramp tests) and time measurements (Jump tests)

| Test cases | Setting [Hz] (f < 1) | Tripping values [Hz] (f < 1) | Setting [Hz] (f ≪ 1) | Tripping values [Hz] (f ≪ 1) | Tripping times [s] (f < 2) | Tripping times [s] (f ≪ 2) | Limit |
|---|---|---|---|---|---|---|---|
| Min. of setting range | 47.50 | 47.49 | 47.00 | 46.97 | 0.158 | 0.172 | $\lvert f_{meas} - f_{set} \rvert \leq 0.05$ Hz |
| 30% of setting range | 48.25 | 48.25 | 47.15 | 48.00 | 30.100 | 1.670 | |
| 60% of setting range | 49.00 | 49.00 | 47.30 | 49.00 | 60.100 | 3.100 | |
| Max. of setting range | 50.00 | 50.00 | 47.50 | 50.00 | 100.000 | 5.080 | |

| Maximum deviation from setting value [Hz] | 0.03 |
|---|---|
| Maximum deviation from operate time / time delay setting [s] | 0.100 |

16) Underfrequency protection stage 1 (<) and 2 (≪) - Reset time (NOP tests)

| Test cases | Setting ($G_S$) [Hz] | (f > 3) | (f ≫ 3) | Relay operated / interface switch opened? |
|---|---|---|---|---|
| 40% of setting range | 48.5 | Test sequence see below | | ☐ yes ☒ no |
| 80% of setting range | 49.5 | | | ☐ yes ☒ no |

Note:
Test sequence modified acc. Figure 42, EN 50549-10:

Step 0: $G_{Start} = G_S + 0.3$ Hz, $\Delta t_1 = T_S + 200$ ms

↓

Step 1: $G_{End} = G_S - 0.3$ Hz, $\Delta t_2 = T_{OP} - 60$ ms

↓

Step 2: Signal value = $G_S + 0.2$ Hz, $\Delta t_1 = T_S + 200$ ms

17) Immunity to voltage harmonics

| Test cases | Setting [%$U_n$] | Tripping values [%Un] | Limit | Setting [Hz] | Tripping values [Hz] | Limit |
|---|---|---|---|---|---|---|

| | | (U < 1) $U_{all\text{-}phases}$ | | | (f < 1) | |
|---|---|---|---|---|---|---|
| Min. of setting range | 78.3 | 77.9 | $\lvert U_{meas} - U_{set} \rvert \leq 1\%U_n$ | 47.50 | 47.49 | $\lvert f_{meas} - f_{set} \rvert \leq 0.05$ Hz |
| 30% of setting range | 81.8 | 81.3 | | 48.25 | 48.24 | |
| 60% of setting range | 85.3 | 85.2 | | 49.00 | 48.99 | |
| Max. of setting range | 90.0 | 89.5 | | 50.00 | 49.98 | |
| Maximum deviation from setting value [%$U_n$ or Hz] | | 0.5 | | | 0.01 | |

Note:

For test U<1: under the voltage conditions as described in EN 61000-4-13:2002, Table 8 class 3 (see Annex C.2, EN 50549-10).

For test f<1: under the voltage conditions as described in EN IEC 60255-181:2019, Table 26 (see Annex C.1, EN 50549-10).

For **time delay setting** during tests, the following applied:

- "Min of setting range" of threshold: min. of setting range of time delay.
- "30% of setting range" of threshold: 30% of setting range of time delay.
- "60% of setting range" of threshold: 60% of setting range of time delay.
- "Max of setting range" of threshold: max. of setting range of time delay.

### 6.7.2 Overvoltage 10 min mean protection

| **Verdict** | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| **Test conditions** | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.8.3, EN 50549-10 |

| | |
|---|---|
| Overvoltage threshold 10 min mean protection | 1.10 $U_n$ |
| Time delay setting | 0 ms |
| Another relevant parameter setting | Default setting used for testing, see *Annex 1 – Parameter list* |

**Acceptance criteria**

- For tests U10M 1 and U10M 3 if the operation occurs between T1 and T2 after the jump, see Figure 43, where

$$T1 = \frac{\left(G_S - A_r\right) - U_{Start}}{U_{End} - U_{Start}} \times 600\,;$$

$$T2 = \frac{\left(G_S + A_r\right) - U_{Start}}{U_{End} - U_{Start}} \times 600\,;$$

- For tests U10M 2 if no operation occurred within and after 600 s, see Figure 43.
- The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

| **Manufacturer's data** |
|---|
| The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software. |

**Test results**

Note:

Test procedure acc. Section 5.8.3.3.2, EN 50549-10.

For the parameter setting range, please refer to *Annex 1 – Parameter list*.

| Test cases | Test on | Test sequency | Disconnection time [s] | Limit | Relay operated / interface switch opened? |
|---|---|---|---|---|---|
| U10M 1 | L1-N | (see below) | 518 | Between 450 s and 550 s after voltage jump | ☒ yes ☐ no |
| | L2-N | | -- | | ☐ yes ☐ no |
| | L3-N | | -- | | ☐ yes ☐ no |
| U10M 2 | L1-N | (see below) | -- | no operation of relay occurred within and after 600 s after voltage jump | ☐ yes ☒ no |
| | L2-N | | -- | | ☐ yes ☐ no |
| | L3-N | | -- | | ☐ yes ☐ no |
| U10M 3 | L1-N | (see below) | 310 | Between 225 s and 375 s after voltage jump | ☒ yes ☐ no |
| | L2-N | | -- | | ☐ yes ☐ no |
| | L3-N | | -- | | ☐ yes ☐ no |
| Maximum deviation from setting value [%$U_n$] (from tests U10M 1 & U10M 3) | | | 0.36 | | |
| Maximum deviation from configured operate time [s] (from tests U10M 1 & U10M 3) | | | 18 | | |

Note:

Test sequence modified acc. Section 5.8.3.3.1 & Figure 43, EN 50549-10:

U10M 1: $U_n$ (600 s) → 1.12·$U_n$ ((≥600.2 s, test can be stopped after operation of the protection)

U10M 2: $U_n$ (600 s) → 1.08·$U_n$ (≥600.2 s)

U10M 3: 1.06·$U_n$ (600 s) → 1.14·$U_n$ ((≥600.2 s, test can be stopped after operation of the protection)

* The start (pick-up) signal is NOT accessible.

The shown Tripping / disconnection times ($T_{disc}$) in this test report include the operate time ($T_{OP}$) of the protection relay and opening time ($T_{open}$) of the disconnection device:

$T_{disc} = T_{OP} + T_{open}$

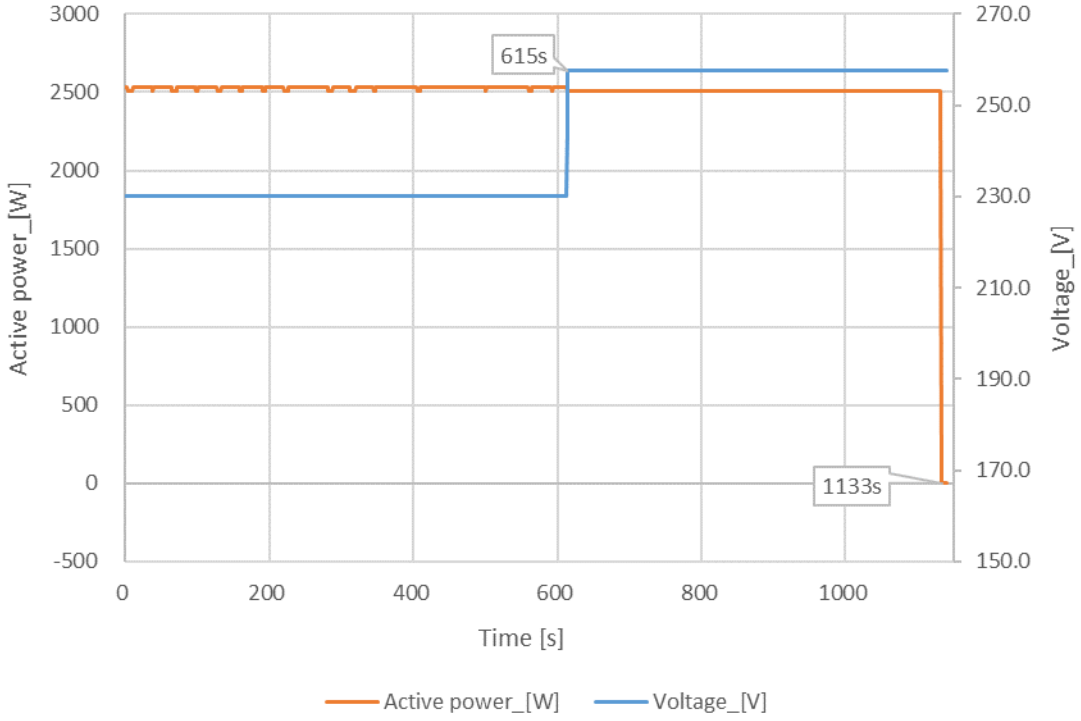
The "maximum deviation from setting value" is simplified to the deviation from the measured value and the setting value, calculated using the simplified formula:

$$\left(\frac{T_{disc,meas}}{600} * 12 + 100 - 110\right)\%$$

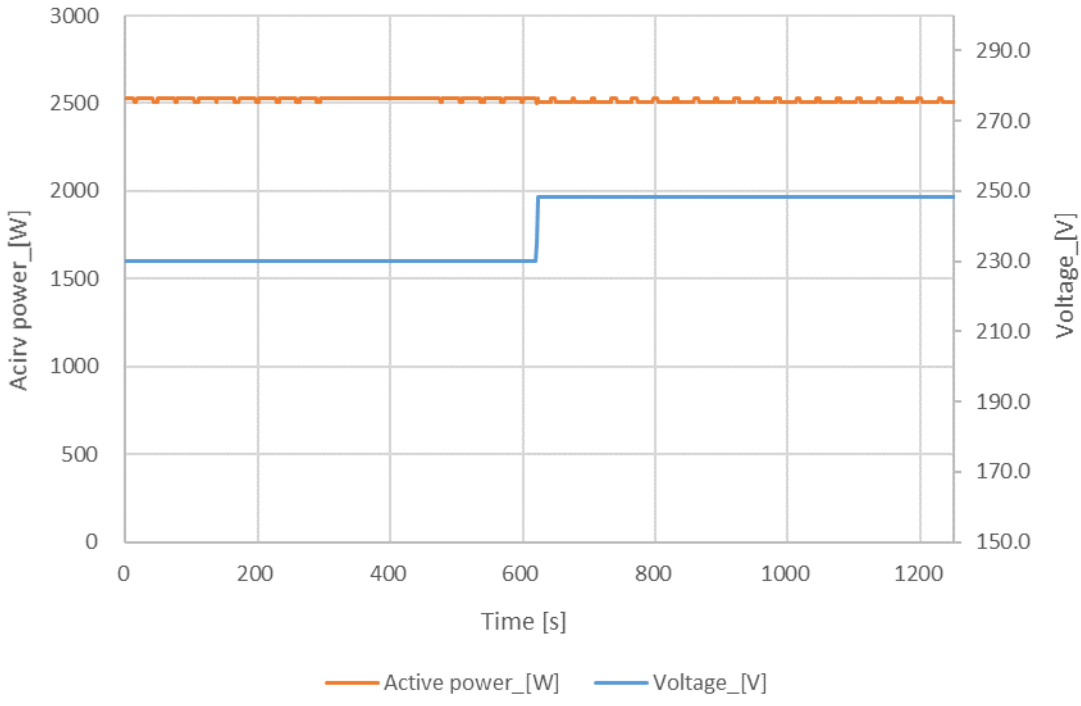
The "deviation from configured operate time or time delay setting" is simplified to:

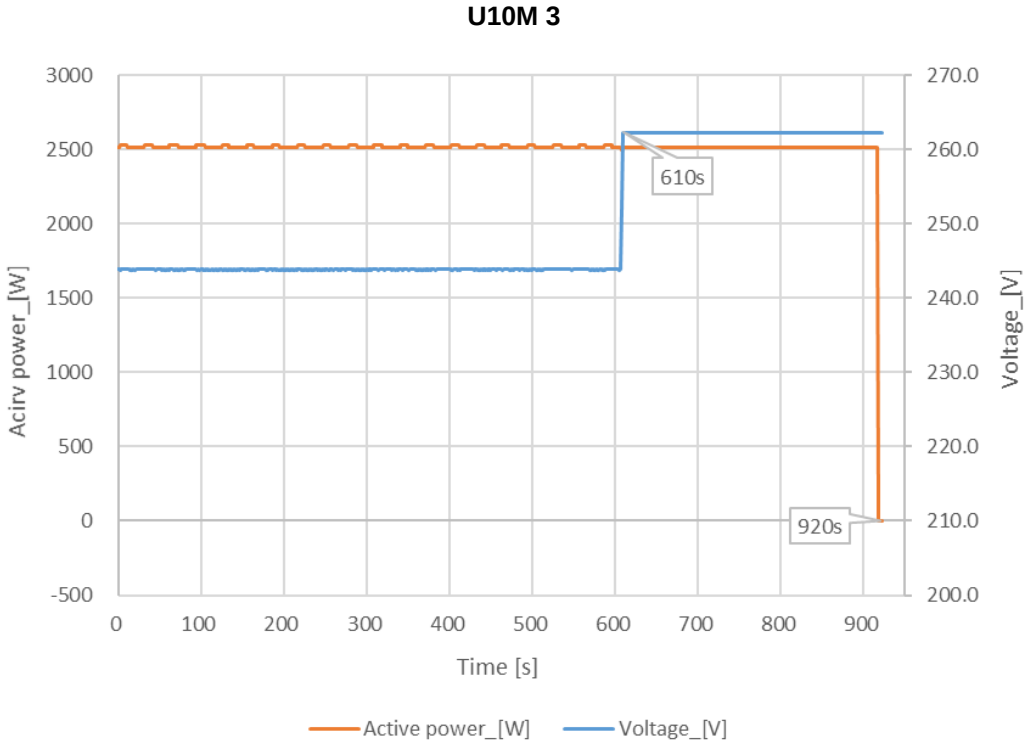
the deviation from the measured disconnection time and the ideal disconnection time (U10M 1: 500 s, U10M 3: 300 s).

**U10M 1**


3000
2500
2000
1500
1000
500
0
-500
Active power_[W]
270.0
250.0
230.0
210.0
190.0
170.0
150.0
Voltage_[V]
615s
1133s
0
200
400
600
800
1000
Time [s]
Active power_[W]
Voltage_[V]

**U10M 2**


3000
2500
2000
1500
1000
500
0
Aciry power_[W]
290.0
270.0
250.0
230.0
210.0
190.0
170.0
150.0
Voltage_[V]
0
200
400
600
800
1000
1200
Time [s]
Active power_[W]
Voltage_[V]




### 6.7.3 ROCOF protection

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.8.3.4.3, EN 50549-10 |

| | |
|---|---|
| Frequency protection | deactivated / set to values not interfering to the tests |
| ROCOF protection setting | 2 Hz /s |
| Time delay setting | 500 ms |
| Another relevant parameter setting | Default setting used for testing, see *Annex 1 – Parameter list* |

| Acceptance criteria |
|---|
| - For test item RVAL POS 2 and RVAL NEG 2, the protection function operates, and operate time is equal to or below the configured time delay setting plus the start time as stated in the product documentation. If due to the test setup the disconnection time is evaluated instead of the operate time the test is passed if for all tests the disconnection time is equal to or below the configured time delay setting plus the start time plus the circuit breaker opening time as stated in the product documentation. If the configured time delay setting includes the start time or the opening time, the condition has to be modified accordingly.<br>- For test item RVAL POS 1, RVAV NEG 1, NOP POS and NOP NEG, the protection function does not operate.<br>- If the interface protection operates the interface switch opens.<br>- The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal). |

| Manufacturer's data |
|---|
| The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software. |

## Test results

**accuracy of the setting values and operate time measurements**

| Test cases | Test sequency | Disconnection time [s] | Limit | Relay operated / interface switch opened? |
|---|---|---|---|---|
| RVAL POS 1 | (see below) | -- | protection function does not operate | ☐ yes ☒ no |
| RVAL POS 2 | (see below) | 0.904 | -- | ☒ yes ☐ no |
| RVAL NEG 1 | (see below) | -- | protection function does not operate | ☐ yes ☒ no |
| RVAL NEG 2 | (see below) | 0.908 | -- | ☒ yes ☐ no |
| Maximum deviation from configured operate time or time delay setting [s] (from tests RVAL POS 2 & RVAL NEG 2) | | 0.408 | | |

Note:

For testing, $A_r$ defined as 0.1 Hz/s (or manufacturer definition).

Test sequence modified acc. Section 5.8.3.4.1 & Figure 44, EN 50549-10:

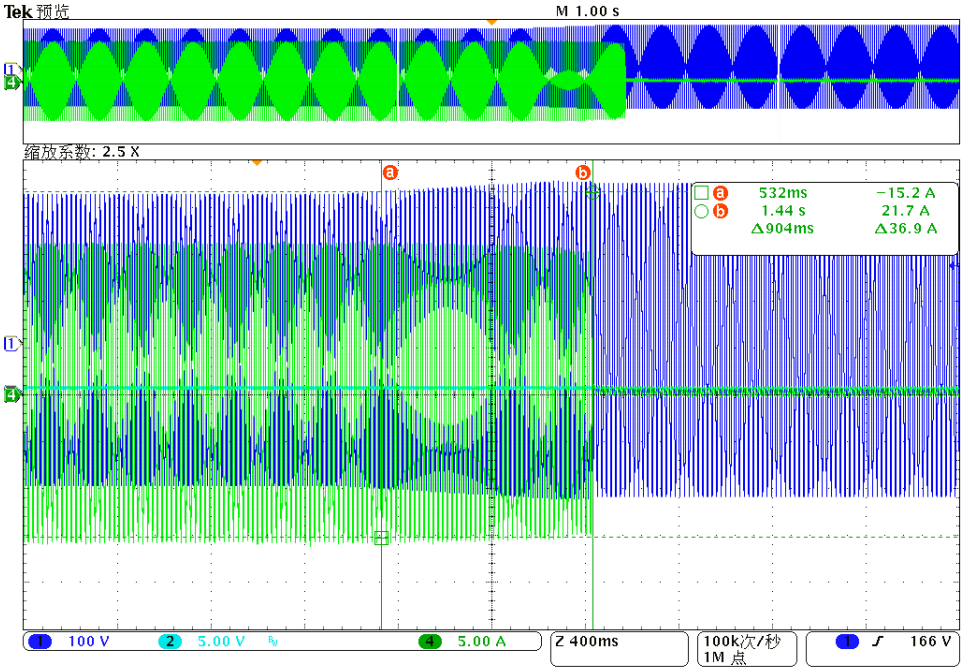
RVAL POS 1: 49 Hz (1 s) $\xrightarrow{\text{Rocof=1.8 Hz/s}}$ 51 Hz (or ROCOF maintain 1 s)

RVAL POS 2: 49 Hz (1 s) $\xrightarrow{\text{Rocof=2.2 Hz/s}}$ 51 Hz (or until the protection operates)

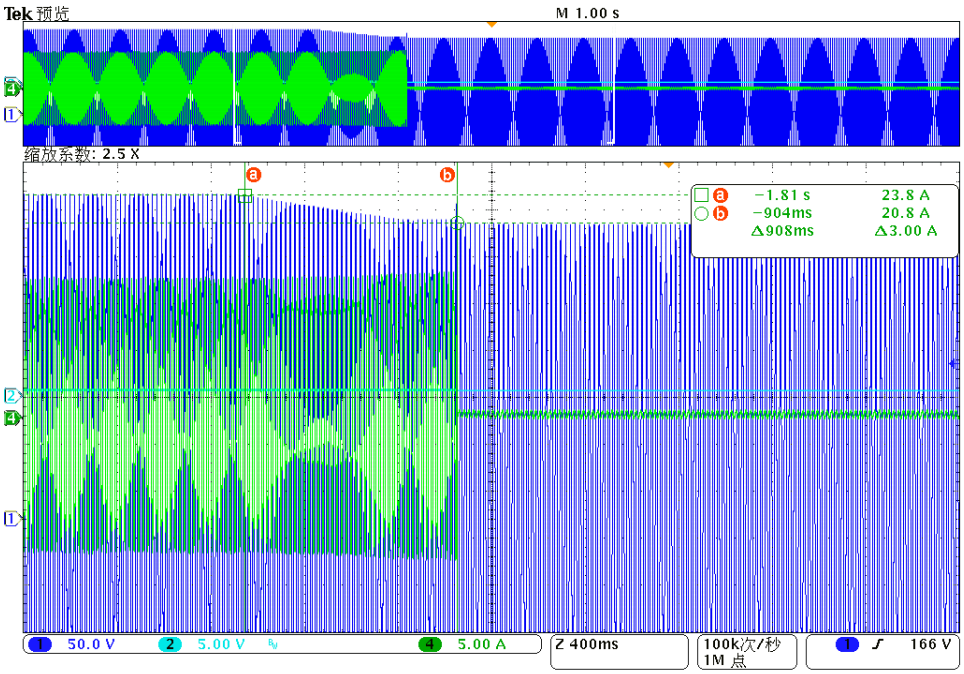
RVAL NEG 1: 51 Hz (1 s) $\xrightarrow{\text{Rocof=1.8 Hz/s}}$ 49 Hz (or ROCOF maintain 1 s)

RVAL NEG 2: 51 Hz (1 s) $\xrightarrow{\text{Rocof=2.2 Hz/s}}$ 49 Hz (or until the protection operates)

**RVAL POS 2**



**RVAL NEG 2**




### 6.7.4 Islanding detection

| **Verdict** | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| **Test conditions** | |
|---|---|
| Test setup | See *Figure 3*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |

| **Manufacturer's data** |
|---|
| The PGU(s) provide(s) the following Islanding Detection Technique(s): |
| ☐ Passive anti islanding detection ONLY |
| ☒ Active anti islanding detection: Active Frequency Drift |

**Test results**

Note:
Only passive anti islanding detection provided. See section 6.7.1 ~ 6.7.3.
Test procedure acc. section 6.1, IEC 62116: 2014

| Condition | EUT output power, $P_{EUT}$ | EUT input voltage | | EUT trip settings | Pass/fail criteria |
|---|---|---|---|---|---|
| A | 100% of EUT rating | > 75% of rated input voltage range: | 40 V | Default setting used for testing, see *Annex 1 – Parameter list* | run-on time < 2s |
| B | 66% of EUT rating | 50% of rated input voltage range, ±10%: | 32 V | | |
| C | 33% of EUT rating | < 20% of rated input voltage range: | 22 V | | |

| No. | $P_{EUT}$ [a] (% of EUT rating) | Reactive load (% of $Q_L$ in 6.1d)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 | 1030 | 2500 | 1.004 | 40 | Test A at BL |
| 2 | 66 | 66 | 0 | 0 | 1230 | 1650 | 1.004 | 32 | Test B at BL |
| 3 | 33 | 33 | 0 | 0 | 1330 | 825 | 1.002 | 22 | Test C at BL |
| 4 | 100 | 100 | -5 | -5 | 998 | 2500 | 1.030 | 40 | Test A at IB |
| 5 | 100 | 100 | -5 | 0 | 790 | 2500 | 1.056 | 40 | Test A at IB |
| 6 | 100 | 100 | -5 | +5 | 638 | 2500 | 1.082 | 40 | Test A at IB |
| 7 | 100 | 100 | 0 | -5 | 980 | 2500 | 0.978 | 40 | Test A at IB |
| 8 | 100 | 100 | 0 | +5 | 676 | 2500 | 1.028 | 40 | Test A at IB |
| 9 | 100 | 100 | +5 | -5 | 1020 | 2500 | 0.932 | 40 | Test A at IB |
| 10 | 100 | 100 | +5 | 0 | 682 | 2500 | 0.956 | 40 | Test A at IB |
| 11 | 100 | 100 | +5 | +5 | 640 | 2500 | 0.979 | 40 | Test A at IB |
| 12 | 66 | 66 | 0 | -5 | 844 | 1650 | 0.978 | 32 | Test B at IB |
| 13 | 66 | 66 | 0 | -4 | 894 | 1650 | 0.983 | 32 | Test B at IB |
| 14 | 66 | 66 | 0 | -3 | 994 | 1650 | 0.988 | 32 | Test B at IB |
| 15 | 66 | 66 | 0 | -2 | 1060 | 1650 | 0.994 | 32 | Test B at IB |
| 16 | 66 | 66 | 0 | -1 | 1080 | 1650 | 0.999 | 32 | Test B at IB |
| 17 | 66 | 66 | 0 | +1 | 910 | 1650 | 1.009 | 32 | Test B at IB |
| 18 | 66 | 66 | 0 | +2 | 734 | 1650 | 1.014 | 32 | Test B at IB |
| 19 | 66 | 66 | 0 | +3 | 716 | 1650 | 1.019 | 32 | Test B at IB |
| 20 | 66 | 66 | 0 | +4 | 700 | 1650 | 1.023 | 32 | Test B at IB |
| 21 | 66 | 66 | 0 | +5 | 678 | 1650 | 1.028 | 32 | Test B at IB |
| 22 | 33 | 33 | 0 | -5 | 952 | 825 | 0.976 | 22 | Test B at IB |
| 23 | 33 | 33 | 0 | -4 | 1030 | 825 | 0.982 | 22 | Test B at IB |
| 24 | 33 | 33 | 0 | -3 | 1060 | 825 | 0.987 | 22 | Test B at IB |
| 25 | 33 | 33 | 0 | -2 | 1150 | 825 | 0.992 | 22 | Test B at IB |
| 26 | 33 | 33 | 0 | -1 | 1180 | 825 | 0.997 | 22 | Test B at IB |
| 27 | 33 | 33 | 0 | +1 | 1320 | 825 | 1.007 | 22 | Test B at IB |
| 28 | 33 | 33 | 0 | +2 | 1220 | 825 | 1.012 | 22 | Test B at IB |
| 29 | 33 | 33 | 0 | +3 | 744 | 825 | 1.017 | 22 | Test B at IB |
| 30 | 33 | 33 | 0 | +4 | 716 | 825 | 1.022 | 22 | Test B at IB |
| 31 | 33 | 33 | 0 | +5 | 694 | 825 | 1.027 | 22 | Test B at IB |

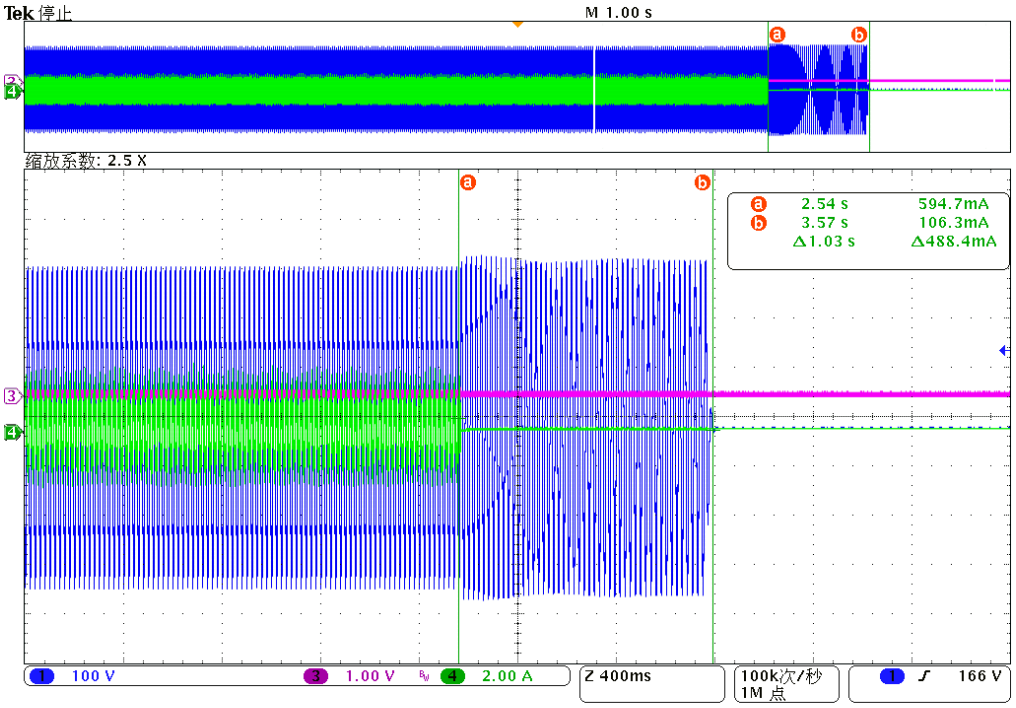
[a] $P_{EUT}$: EUT output power.

[b] $P_{AC}$: Active power flow at S1 in Figure 1, IEC / EN 62116. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

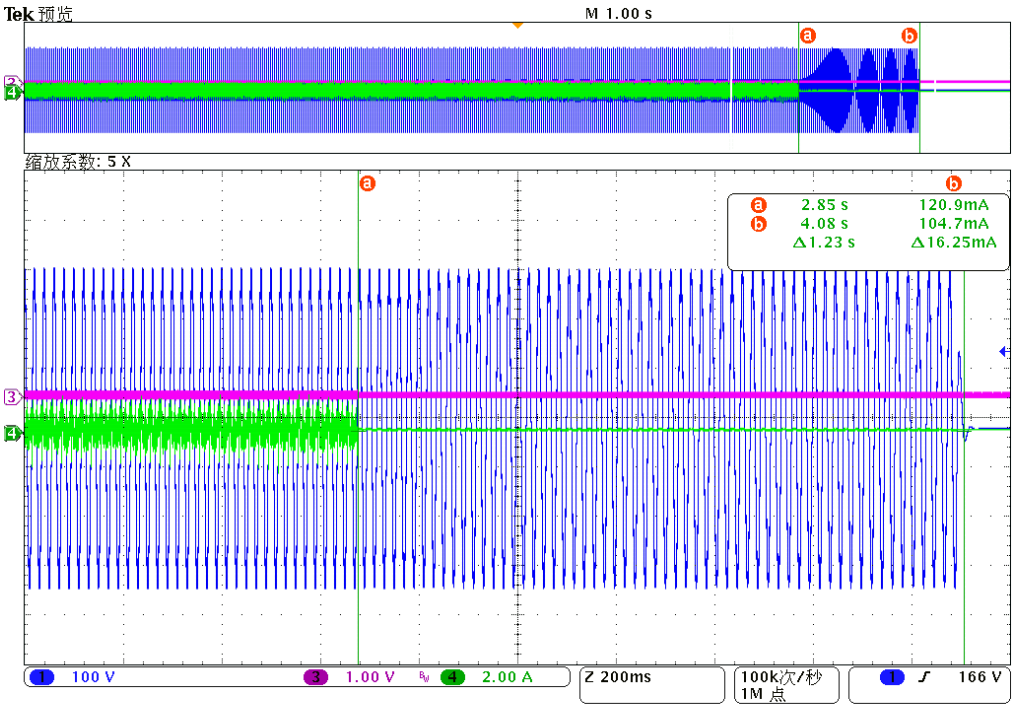
[c] $Q_{AC}$: Reactive power flow at S1 in Figure 1, IEC/ EN 62116. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

[d] BL: balance condition, IB: imbalance condition.

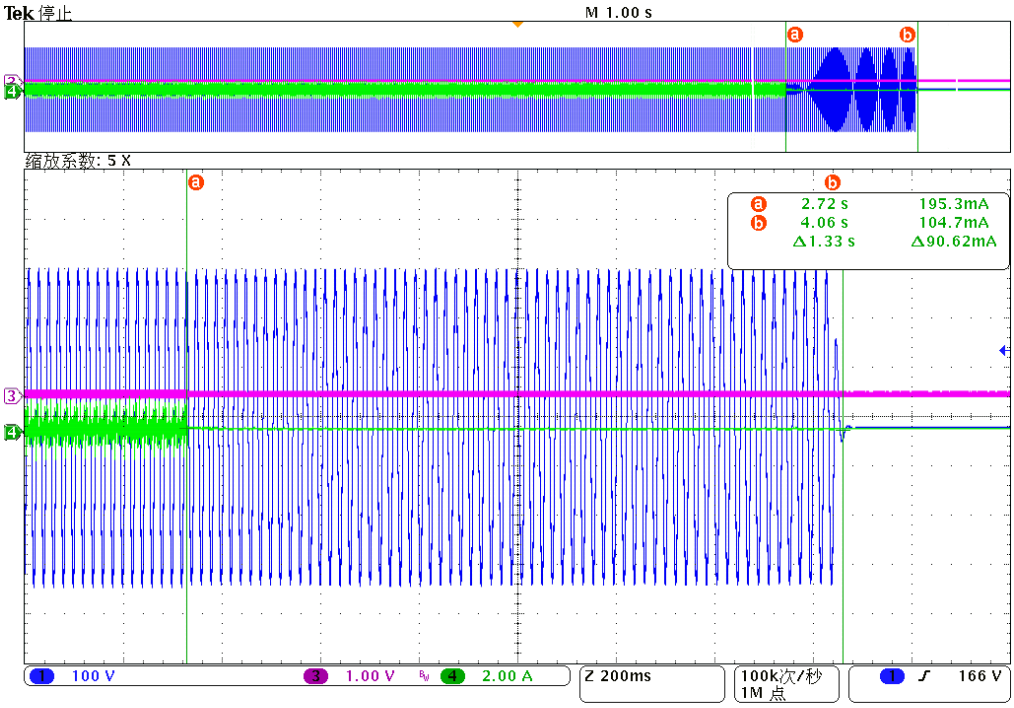
**Disconnection at PAC 0% and QAC 0% reactive load No. 1 (100% of EUT rating)**




**Disconnection at PAC 0% and QAC 0% reactive load No. 2 (66% of EUT rating)**



**Disconnection at PAC 0% and QAC 0% reactive load No. 3 (33% of EUT rating)**



## 6.8 Connection and starting

### 6.8.1 Automatic reconnection after tripping

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.9.3.1, EN 50549-10 |

| | |
|---|---|
| Active factor | 1.000 |
| Relevant parameter setting | Default setting used for testing, see *Annex 1 – Parameter list* |

**Acceptance criteria**

- the generating unit does not start reconnection process when it is out of voltage band or frequency band;
- he generating unit does not connect before the end of observation time after the interface protection trip provided voltage or frequency are constantly within the permitted band during observation time;
- the active power ramp-up rate, evaluated for each minute, stays below 11%/min

or

- for non-adjustable or partly adjustable generating units, the connection happens at 1 min to 10 min (randomized value) or later. The randomization can be done via the manufacturer's portfolio and has to be documented.
- Products that do have different setups implemented to fulfil different requirements for specific settings can be additionally evaluated:
- It is evaluated that the relevant setup has the correct values programmed.
- The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

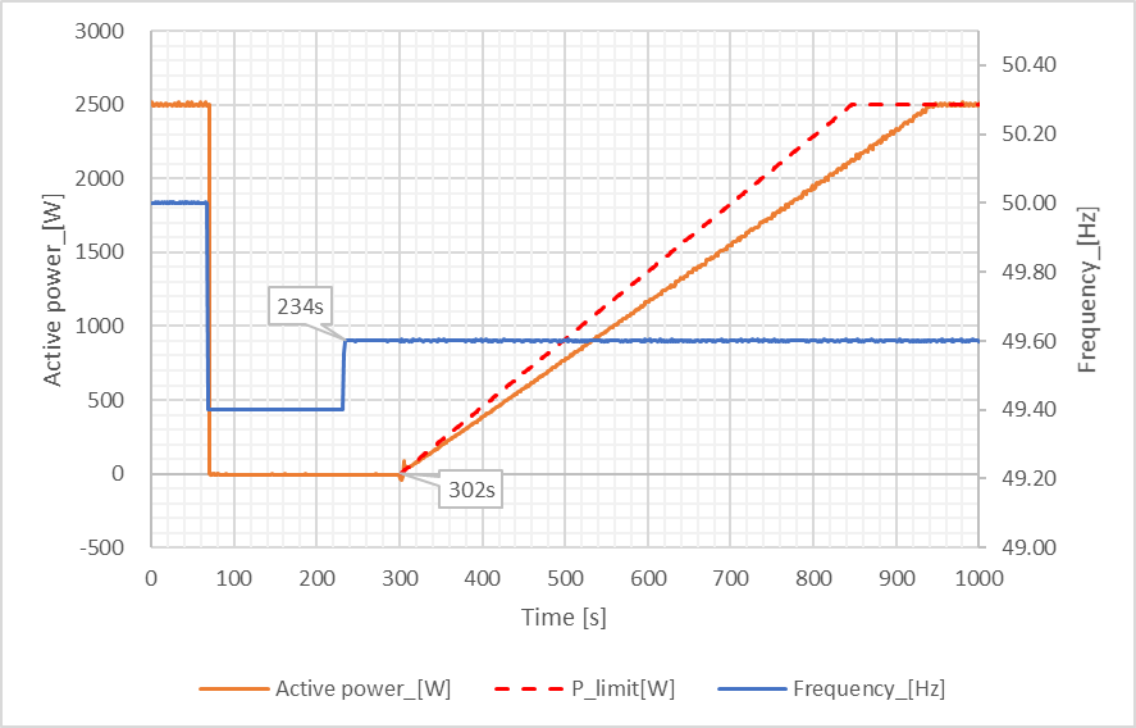
**Manufacturer's data**

The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software.

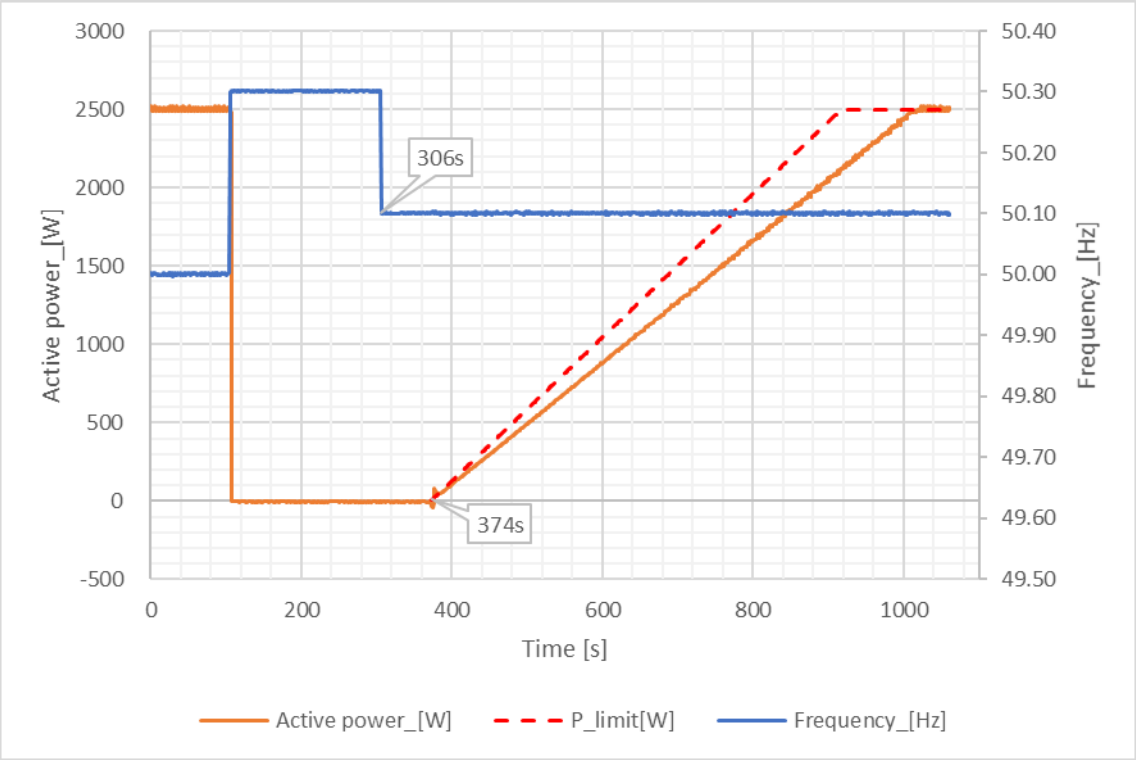
**Test results**

| Test case | Outside reconnection range | | Within reconnection range | | Observation time [s] | Active power increase gradient |
|---|---|---|---|---|---|---|
| | Value [Hz / %$U_n$] | Reconnection yes / no | Value [Hz / %$U_n$] | Reconnection yes / no | ≥ 60s | [%/min] |
| Underfrequency | 49.45 | no | 49.55 | yes | 68 | < 11 |
| Overfrequency | 50.10 | no | 50.00 | yes | 68 | |
| Undervoltage | 84.0 | no | 86.0 | yes | 87 | |
| Overvoltage | 111.0 | no | 109.0 | yes | 71 | |

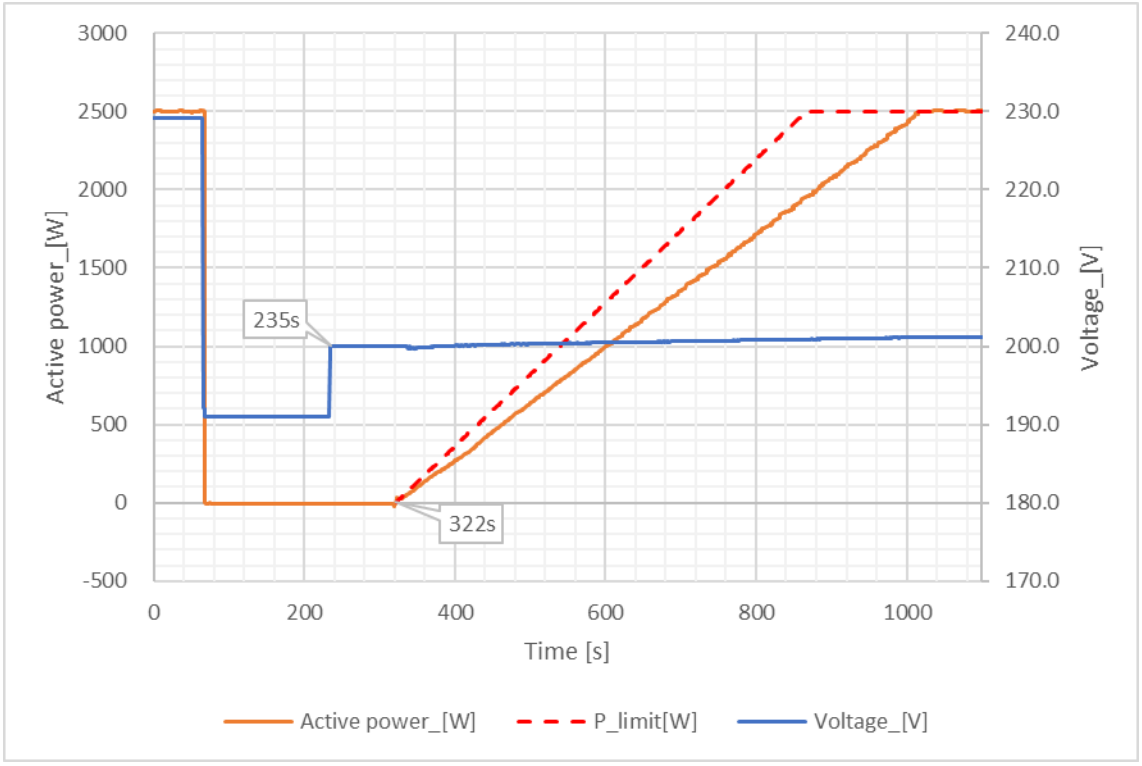
**Underfrequency**



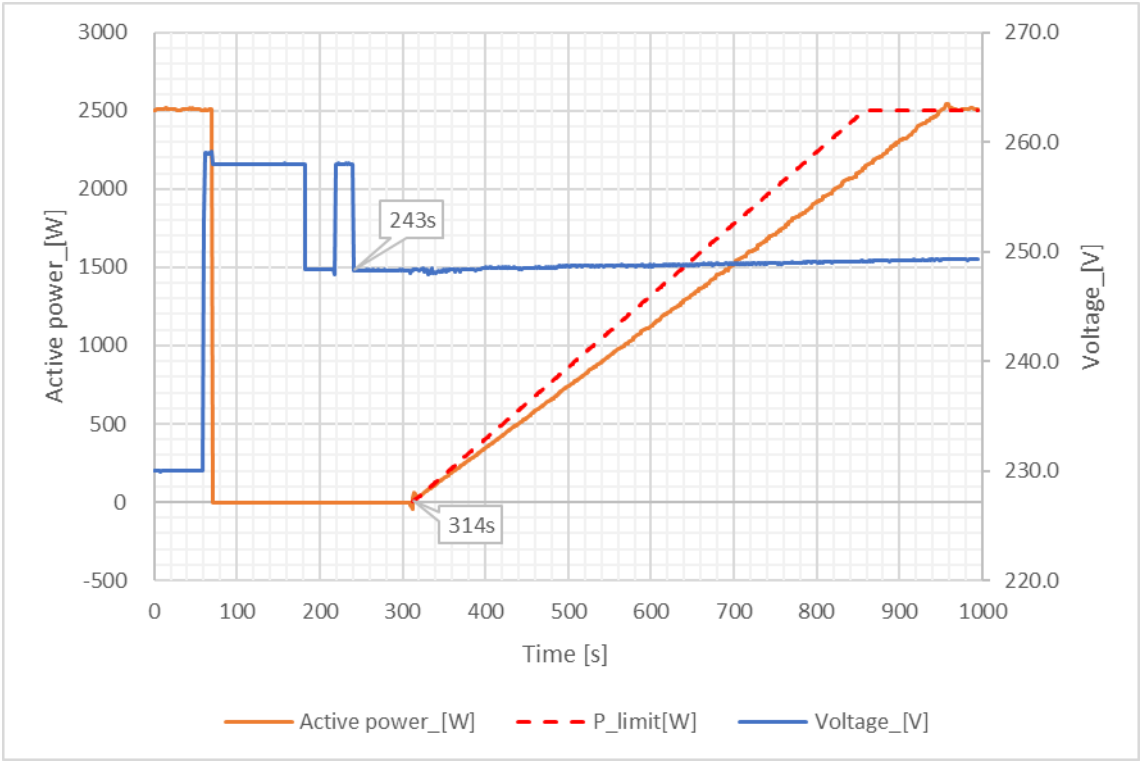

**Overfrequency**



**Undervoltage**




**Overvoltage**




### 6.8.2 Starting to generate electrical power

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.9.4.1, EN 50549-10 |

| | |
|---|---|
| Active factor | 1.000 |
| Relevant parameter setting | Default setting used for testing, see *Annex 1 – Parameter list* |

**Acceptance criteria**

- the generating unit does not start reconnection process when it is out of voltage band or frequency band;
- the generating unit does not connect before the end of observation time;
- it is evaluated that the relevant setup has the correct values programmed;
- the settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

Additionally for Automatic reconnection after tripping if:

- the active power ramp-up rate is evaluated for each minute and stays below 11 %$P_n$/min;

or

- for non-adjustable or partly adjustable generating units, the connection happens at 1 min to 10 min (randomized value) or later. The randomization can be done via the manufacturer's portfolio and has to be documented.

Products that do have different setups implemented to fulfil different requirements for specific settings can be additionally evaluated:

- It is evaluated that the relevant setup has the correct values programmed.
- The settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal).

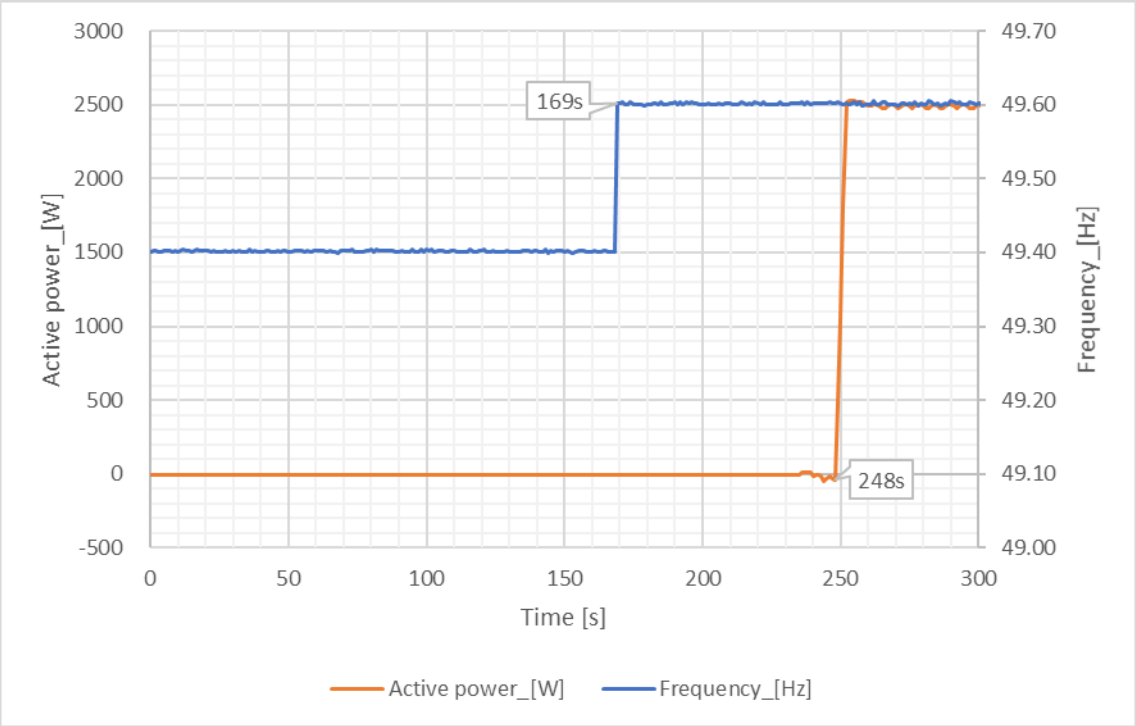
**Manufacturer's data**

The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software.

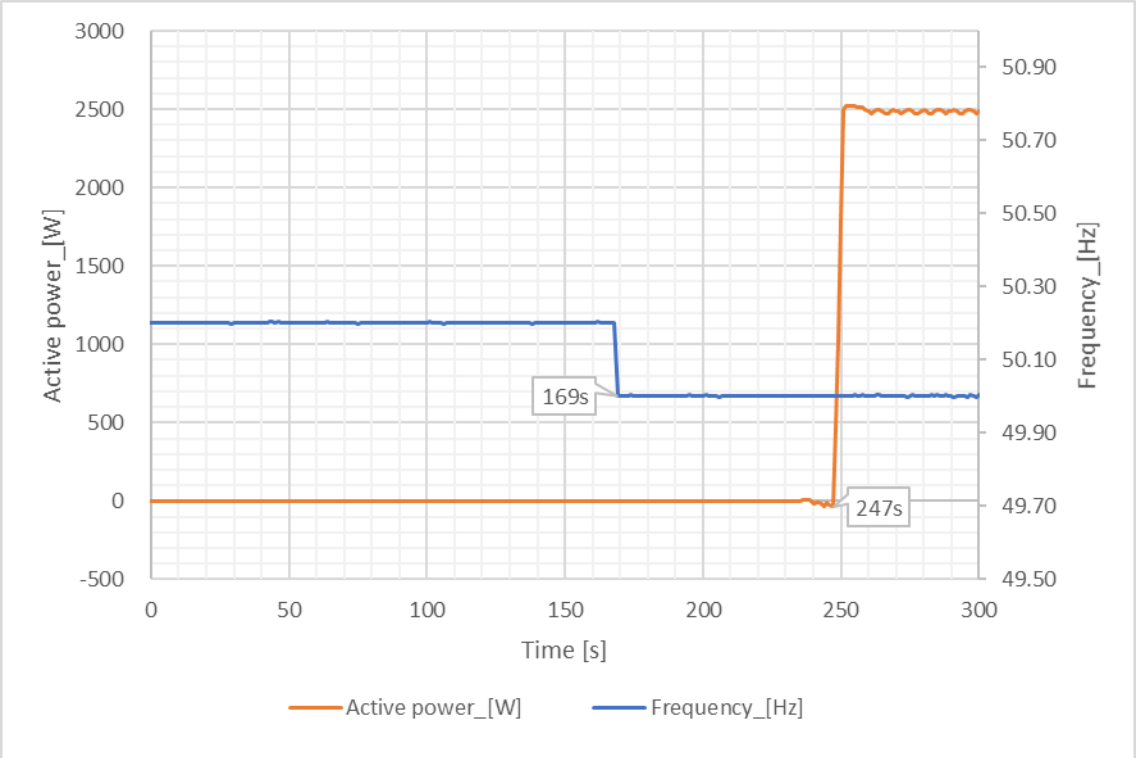
**Test results**

| Test case | Outside connection range | | Within connection range | | Observation time [s] | Active power increase gradient |
|---|---|---|---|---|---|---|
| | Value [Hz / %$U_n$] | Connection yes / no | Value [Hz / %$U_n$] | Connection yes / no | ≥ 60s | [%/min] |
| Underfrequency | 49.45 | no | 49.55 | yes | 79 | disabled |
| Overfrequency | 50.10 | no | 50.00 | yes | 78 | |
| Undervoltage | 84.0 | no | 86.0 | yes | 75 | |
| Overvoltage | 111.0 | no | 109.0 | yes | 78 | |

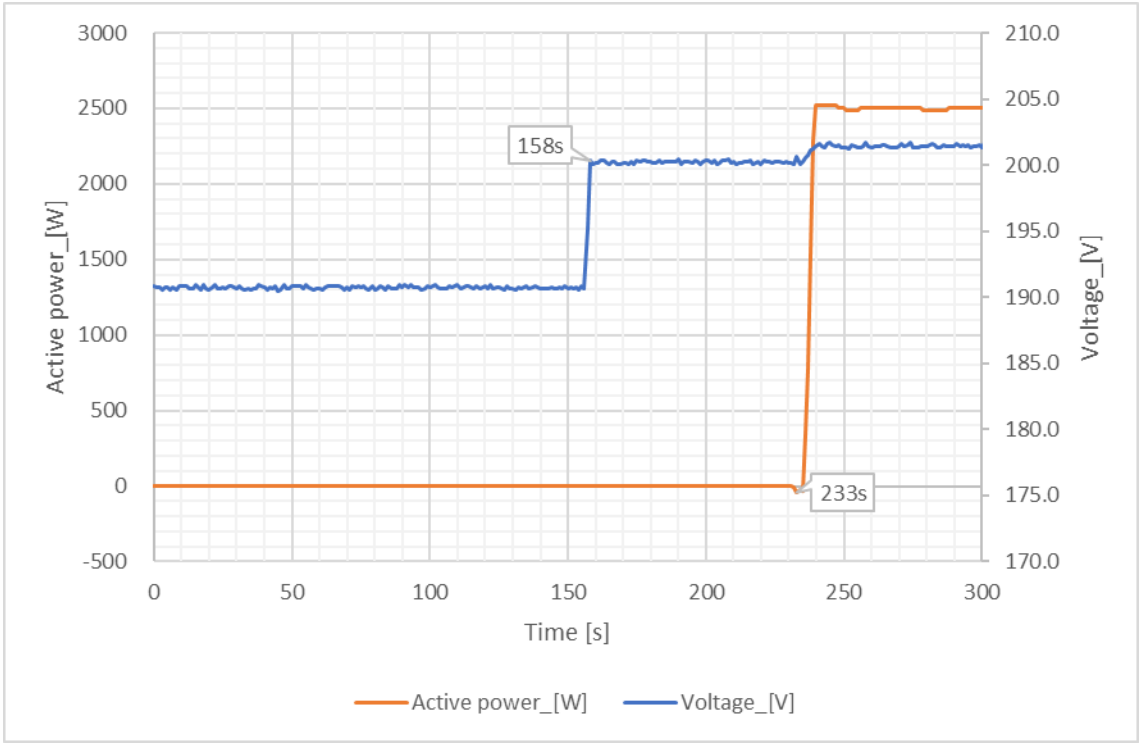
**Underfrequency**



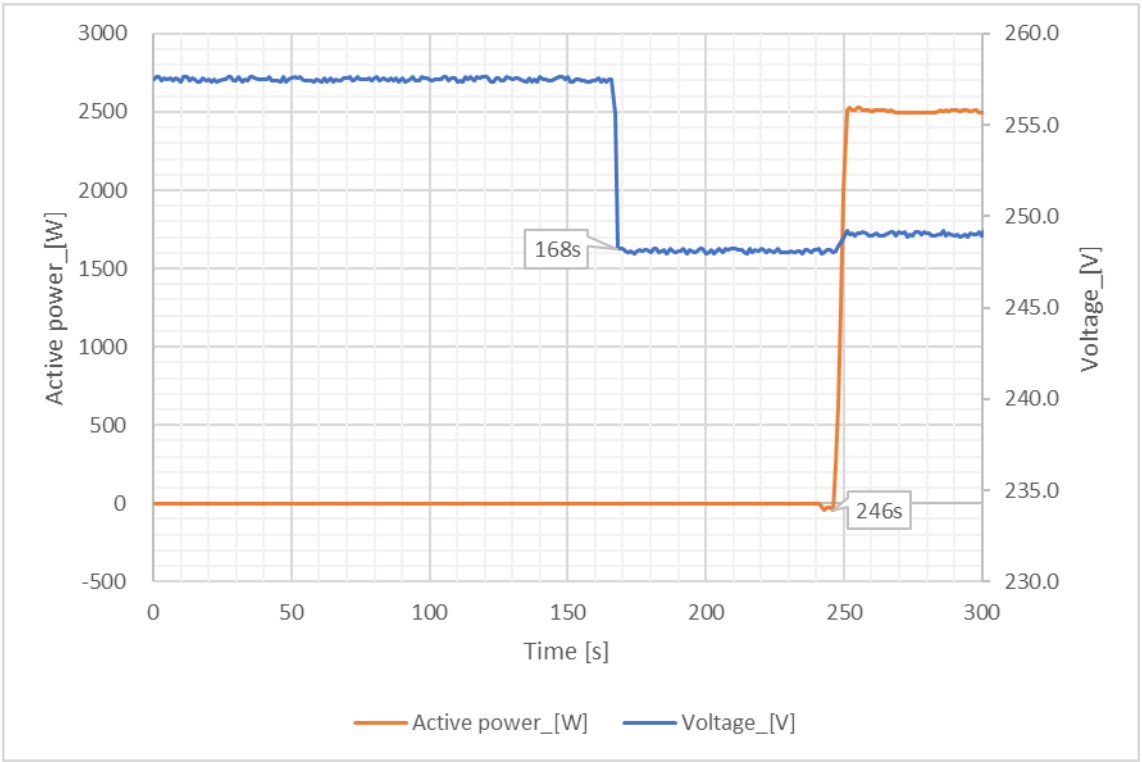

**Overfrequency**



**Undervoltage**




**Overvoltage**



### 6.8.3 Synchronisation

| Verdict | ☐ P | ☐ F | ☒ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

Note:
PGU(s) considered in this test report are inverter-based generators. See section 6.6.2.2.

## 6.9 Active power reduction on set point

### 6.9.1 Verification of the accuracy

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.10.3, EN 50549-10 |

| | |
|---|---|
| Active Power level | See table *Test results* below |
| Active factor | 1.000 |

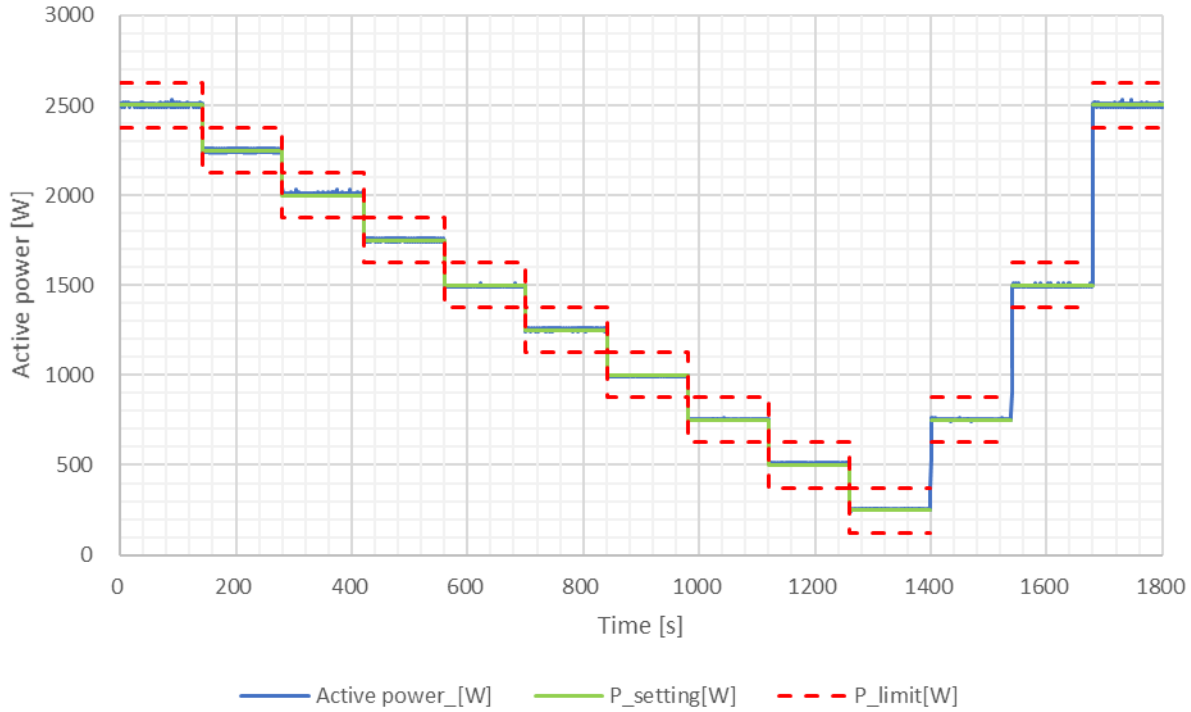
| | |
|---|---|
| The interface used to provide active power set points | Using specialized software tool *at_**Modbus Poll**_tool* through the RS485 interface. |
| Active power set points | Parameter: Pow (see *Annex 1 – Parameter list*) |

| Acceptance criteria |
|---|
| - for power set point reduction all average values recorded are within the tolerance range ± 5 %$P_n$ around the power reduction set point.<br>- for power set point increase all average values recorded are below the tolerance maximum +5 %$P_n$ above the power reduction set point. |

**Test results**

| Active power step [p.u. of $P_n$] | Requested set point value | | Actual value | | Accuracy Actual value - Set point | |
|---|---|---|---|---|---|---|
| | W | $P/P_n$ [p.u.] | W | $P/P_n$ [p.u.] | W | $P/P_n$ [p.u.] |
| 1.0 | 2500 | 1.00 | 2504 | 1.00 | 4 | 0.00 |
| 0.9 | 2250 | 0.90 | 2251 | 0.90 | 1 | 0.00 |
| 0.8 | 2000 | 0.80 | 2006 | 0.80 | 6 | 0.00 |
| 0.7 | 1750 | 0.70 | 1752 | 0.70 | 2 | 0.00 |
| 0.6 | 1500 | 0.60 | 1496 | 0.60 | -4 | 0.00 |
| 0.5 | 1250 | 0.50 | 1253 | 0.50 | 3 | 0.00 |
| 0.4 | 1000 | 0.40 | 996 | 0.40 | -4 | 0.00 |
| 0.3 | 750 | 0.30 | 753 | 0.30 | 3 | 0.00 |
| 0.2 | 500 | 0.20 | 510 | 0.20 | 10 | 0.00 |
| 0.1 | 250 | 0.10 | 254 | 0.10 | 4 | 0.00 |
| 0.3 | 750 | 0.30 | 753 | 0.30 | 3 | 0.00 |
| 0.6 | 1500 | 0.60 | 1496 | 0.60 | -4 | 0.00 |
| 1.0 | 2500 | 1.00 | 2504 | 1.00 | 4 | 0.00 |

**Graph of active power on set point:**




### 6.9.2 Verification of dynamic behaviour

| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |
| Verification procedure | acc. Section 5.10.3, EN 50549-10 |

| | |
|---|---|
| Active Power level | See table *Test results* below |
| Active factor | 1.000 |

| | |
|---|---|
| The interface used to provide active power set points | Using specialized software tool *at_**Modbus Poll**_tool* through the RS485 interface. |
| Active power set points | Parameter: Pow (see *Annex 1 – Parameter list*) |
| Further relevant parameter setting | 0.50·$P_n$/s, see also *Annex 1 – Parameter list* |

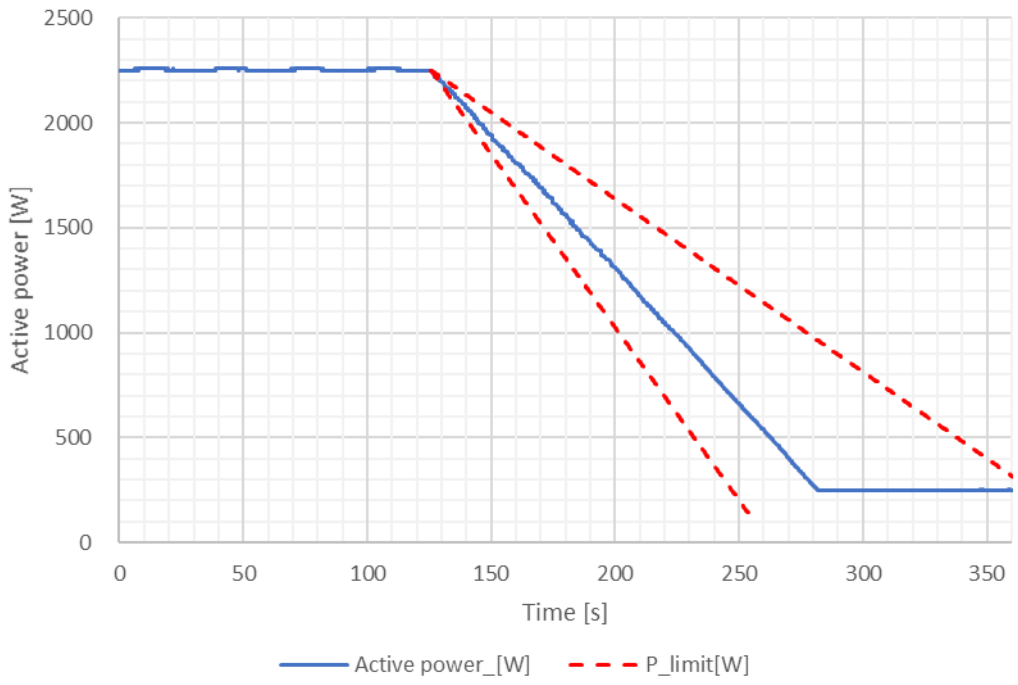
| Acceptance criteria |
|---|
| - the settling time measured during the test has the value stated in EN 50549-1:2019 or EN 50549-2:2019 or settling time values as defined by the relevant party or as defined by the manufacturer;<br>and<br>- the slope equals or exceeds that corresponding to a (0.33·$P_n$/s) slope and does not exceed that corresponding to a (0.66·$P_n$/s) slope as defined by the relevant party or a slope as defined by the manufacturer;<br>- the settings of the function, as well as the enabling and disabling of the function, are field adjustable and means are provided to protect these from unpermitted interference (e.g. password or seal). |

| Manufacturer's data |
|---|
| The settings of the function, as well as the enabling and disabling of the function, are field adjustable and are protected from unauthorized interference through special software. |

**Test results**

| Active power step [p.u. of $P_n$] | Requested set point value | | Actual value | | Accuracy Actual value - Set point | | Settling time [s] | Calculated slope [$P_n$/s] |
|---|---|---|---|---|---|---|---|---|
| | W | $P/P_n$ [p.u.] | W | $P/P_n$ [p.u.] | W | $P/P_n$ [p.u.] | | |
| 0.9 | 2250 | 0.9 | 2254 | 0.902 | 4 | 0.002 | | |
| ↓ | | | | | | | 156.2 | 0.51% |
| 0.1 | 250 | 0.1 | 249 | 0.100 | -1 | 0.000 | | |

**Graph of the gradient 90% to 10% Pn:**




### 6.9.3 Ceasing active power

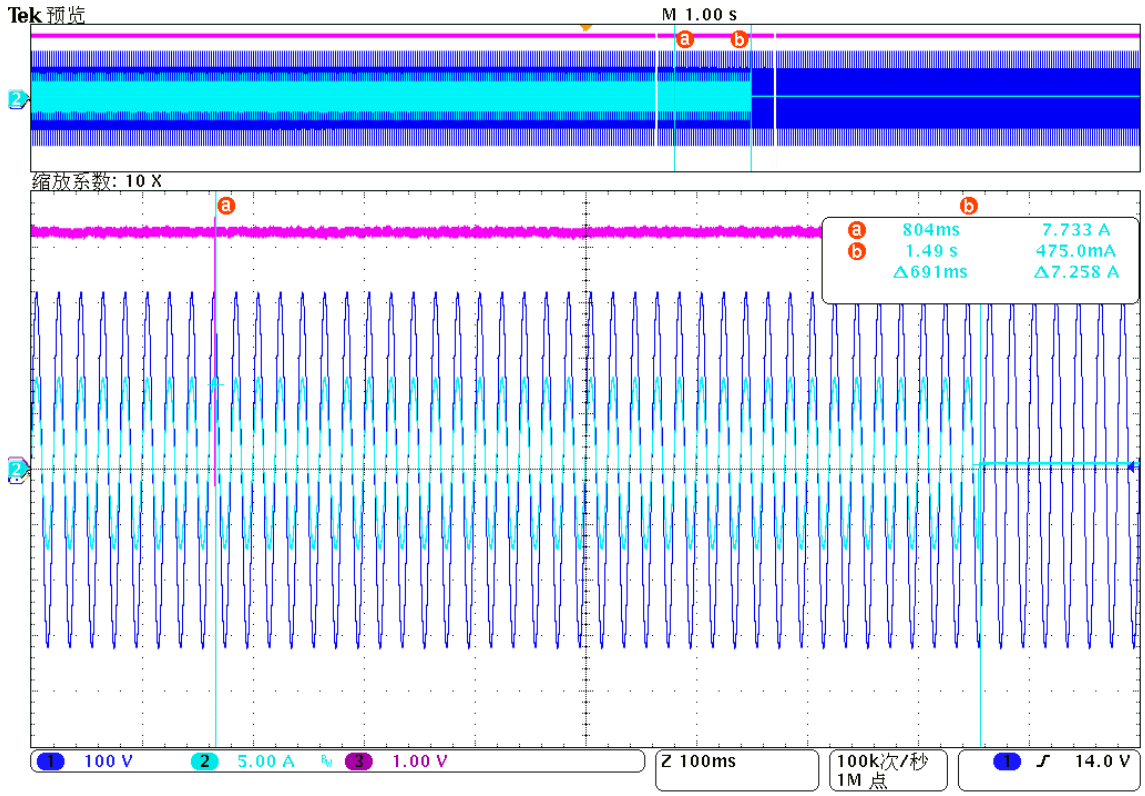
| Verdict | ☒ P | ☐ F | ☐ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Test conditions | |
|---|---|
| Test setup | See *Figure 2*, *Measurement setup*, p.22 |
| Other test environment conditions | See section 4.7 & 4.9 |

| Acceptance criteria |
|---|
| Generating plants with a maximum capacity of 0,8 kW or more shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port. |

| Test results | | |
|---|---|---|
| Test Conditions | Measurements [s] | Δ Limit |
| Command signal from connection to disconnection | 0.691 | ≤ 5s |

**Graph of Command signal from connection to disconnection:**




Note:

The units in the series are equipped with a logic interface (input port) to terminate the active power output.

The test result shows that the tested device can cease the active power output within 0.691 s after receiving a command at the logical interface.

## 6.10 Remote information exchange

| Verdict | ☐ P | ☐ F | ☒ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

Note:

Requirements for communication protocols must be considered and assessed at the project level.

## 6.11 Requirements regarding single fault tolerance of interface protection system and interface switch

| Verdict | ☐ P | ☐ F | ☒ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| Load Relay drive circuit IC16 VCC and GND | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1008 Inverter relay abnormality<br>No damage, no hazard, no fire |
| Load Relay drive circuit Q30 Pin1 and Pin2 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1008 Inverter relay abnormality<br>No damage, no hazard, no fire |
| Relay drive circuit R167 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1008 Inverter relay abnormality<br>No damage, no hazard, no fire |
| Inverter IGBT QA1 Pin1 and Pin2 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 0V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection error<br>no hazard, no fire, QA1/QA2/QA3/QA4 damage. |
| Inverter IGBT QA1 Pin2 and Pin3 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 0V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message:1019 Battery low voltage protection error<br>no hazard, no fire, QA1/QA2/QA3/QA4 damage. |
| Inverter voltage sampling circuit R428 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1000 Inverter over voltage<br>No damage, no hazard, no fire |
| Inverter voltage sampling circuit R415 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1000 Inverter over voltage<br>No damage, no hazard, no fire |
| Inverter voltage sampling circuit R332 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1001 Inverter under voltage<br>No damage, no hazard, no fire |
| Inverter voltage sampling circuit R425 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| | | | | | | | | Error message: 1000 Inverter Over voltage<br>No damage, no hazard, no fire |
| Inverter voltage sampling circuit R417 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1000 Inverter Over voltage<br>No damage, no hazard, no fire |
| INV current sampling circuit R328 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1002 Inverter Over current<br>No damage, no hazard, no fire |
| Inverter current sampling circuit R220 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1002 Inverter Over current<br>No damage, no hazard, no fire |
| Inverter current sampling circuit HALL2B Pin15 and Pin10 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 0V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection and 1002 Inverter Over current.<br>No hazard, no fire, QA1/QA2/QA3/QA4 damage. |
| Relay RLY1A Pin5 and Pin6 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1008 Inverter relay abnormality No damage, no hazard, no fire |
| Relay RLY1A Pin4 and Pin3 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1008 Inverter relay abnormality<br>No damage, no hazard, no fire |
| Relay RLY2A Pin4 and Pin3 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1048 AC Grid replay error<br>No damage, no hazard, no fire |
| Relay RLY4A Pin3 | Open before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Relay RLY3A Pin5 | Open before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Output current sampling circuit | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| CT1B Pin2 and Pin1 | | | | | | | | Error message: 1002 Inverter Over current<br>No damage, no hazard, no fire |
| Output voltage sampling circuit R252 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1000 Inverter over voltage<br>No damage, no hazard, no fire |
| Output voltage sampling circuit R243 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1001 Inverter under voltage<br>No damage, no hazard, no fire |
| Output voltage sampling circuit R254 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1000 Inverter over voltage<br>No damage, no hazard, no fire |
| Output voltage sampling circuit R249 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1001 Inverter under voltage<br>No damage, no hazard, no fire |
| grid voltage sampling circuit R432 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1040 AC Grid over voltage |
| grid voltage sampling circuit R430 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1041 Grid under voltage<br>No damage, no hazard, no fire |
| grid Transformer VT1 Pin1 and Pin2 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1041 AC Grid under voltage<br>No damage, no hazard, no fire |
| grid voltage sampling circuit R315 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1040 AC Grid over voltage<br>No damage, no hazard, no fire |
| grid voltage sampling circuit R218 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1040 AC Grid over voltage<br>No damage, no hazard, no fire |
| grid voltage sampling circuit | Open | 50V/42.1A | 230.7V | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| R226 | | | /8.7A | | | | | Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| grid voltage sampling circuit R228 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1040 AC Grid overvoltage<br>No damage, no hazard, no fire |
| grid voltage sampling circuit R182 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1045 AC Grid overload alarm<br>No damage, no hazard, no fire |
| 60V bus capacitor C44 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection<br>No damage, no hazard, no fire |
| Q4 Pin2 and Pin3 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection<br>No hazard, no fire, Q4/Q5/Q13/Q14 damage. |
| T2 Pin3 and Pin4 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection<br>No damage, no hazard, no fire |
| T2 Pin9 and Pin10 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection<br>No hazard, no fire, Q12/Q8 damage. |
| 60Vus voltage sampling circuit R284 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| 60Vus voltage sampling circuit R289 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| BUS voltage sampling circuit R241 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| BUS voltage sampling circuit R179 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| BUS voltage sampling circuit IC24 pin6 and pin7 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No hazard, no fire, Q4/Q5/Q13/Q14 damage. |
| LLC driver R90 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection<br>No hazard, no fire, Q7/Q17damage. |
| BUS current sampling circuit R14 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| BUS current sampling circuit R15 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| BUS current limit circuit R371 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/42.1A | 230.7V /8.7A | The unit works normally.<br>No hazard. No damage. Can resettable. |
| Power wake-up circuit D34 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/42.1A | 230.7V /8.7A | The unit works normally.<br>No hazard. No damage. Can resettable. |
| Power wake-up circuit Z4 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/42.1A | 230.7V /8.7A | The unit works normally.<br>No hazard. No damage. Can resettable. |
| Power wake-up circuit Q28 Pin2 and Pin1 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/42.1A | 230.7V /8.7A | The unit works normally.<br>No hazard. No damage. Can resettable. |
| Power wake-up circuit R163 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/42.1A | 230.7V /8.7A | The unit works normally.<br>No hazard. No damage. Can resettable. |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| IC23A Pin5 and Pin7 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| BAT voltage sampling circuit R341 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection<br>No damage, no hazard, no fire |
| BAT voltage sampling circuit R342 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1019 Battery low voltage protection<br>No damage, no hazard, no fire |
| BAT current sampling circuit R339 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message:1002 Battery over current<br>No damage, no hazard, no fire |
| BAT current sampling circuit R340 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1002 Battery over current<br>No damage, no hazard, no fire |
| 60V voltage sampling circuit R255 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| 60V voltage sampling circuit R274 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| R292 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1094 Internal overheat protection error<br>No damage, no hazard, no fire |
| Inductor current limit R394 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message:1099 Internal protection fault<br>No damage, no hazard, no fire |
| IC40A Pin4 and Pin8 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/42.1A | 230.7V/8.7A | The inverter is functioning normally.<br>No damage, no hazard, no fire |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| D50 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/42.1A | 230.7V/8.7A | The inverter is functioning normally.<br>No damage, no hazard, no fire |
| Isolation R407 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1105 Insulation fault<br>No damage, no hazard, no fire |
| Isolation Q37 Pin1 and Pin3 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1105 Insulation fault<br>No damage, no hazard, no fire |
| Isolation R386 | Open before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1105 Insulation fault<br>No damage, no hazard, no fire |
| Isolation R326 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1105 Insulation fault<br>No damage, no hazard, no fire |
| Isolation R356 | Open before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1105 Insulation fault<br>No damage, no hazard, no fire |
| Isolation R349 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1105 Insulation fault<br>No damage, no hazard, no fire |
| Isolation R321 | short before start-up | 50V/0A | 230.7V/0A | 10min | -- | 50V/0A | 0V/0A | The inverter cannot start-up.<br>Error message: 1105 Insulation fault<br>No damage, no hazard, no fire |
| Temperature detection circuit NTC5 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1089 Radiator overheat protection<br>Erro No damage, no hazard, no fire |
| PV1 voltage sampling circuit R259 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1056 PV1 over voltage protection error<br>No damage, no hazard, no fire |
| PV1 voltage sampling circuit R276 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1056 PV1 over voltage protection error<br>No damage, no hazard, no fire |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| PV1 voltage sampling circuit R266 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1058 PV1 over current protection error No damage, no hazard, no fire |
| PV2 voltage sampling circuit R275 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1064 PV2 over voltage protection error No damage, no hazard, no fire |
| PV2 voltage sampling circuit R267 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1066 PV2 over current protection error No damage, no hazard, no fire |
| PV3 voltage sampling circuit R278 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1072 PV3 over voltage protection error No damage, no hazard, no fire |
| PV3 voltage sampling circuit R269 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1074 PV3 over current protection error No damage, no hazard, no fire |
| PV4 voltage sampling circuit R277 | Open | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1080 PV4 over voltage protection error No damage, no hazard, no fire |
| PV4 voltage sampling circuit R272 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1082 PV4 overcurrent protection No damage, no hazard, no fire |
| Temperature detection circuit NTC4 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1089 Radiator overheat protection No damage, no hazard, no fire |
| INV detection circuit R10 | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message: 1002 Inverter over current No damage, no hazard, no fire |
| Communication fault CTL2 0Vbat and +5Vbat | Short | 50V/42.1A | 230.7V /8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid. Error message:1021 Battery management system |

| Component No. | Fault | Test condition: | | Test time: [min] | Fuse no.[A] | Fault condition: | | Result: |
|---|---|---|---|---|---|---|---|---|
| | | DC | AC | | | DC | AC | |
| | | | | | | | | ^ BMSv communication error<br>No damage, no hazard, no fire |
| Communication fault CTL2 Pin96 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Communication fault CTL2 Pin95 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Communication fault CTL1 Pin95 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Communication fault CTL1 0Vbat and +5Vbat | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Communication fault CTL1 Pin96 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Main-Slave DSP Communication fault R285 | Open | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Main-Slave DSP Communication fault R300 | Short | 50V/42.1A | 230.7V/8.7A | 10min | -- | 50V/0A | 0V/0A | The inverter immediately disconnection from grid.<br>Error message: 1099 Internal protection fault<br>No damage, no hazard, no fire |
| Note:<br>The errors in the control circuit simulate that the safety is even ensured during a single fault. | | | | | | | | |
| Assessment criterion:<br>The NS protection must send a shutdown command to the coupling switch.<br>If the error is detected, the device is switched off within 10 s after error detection.<br>If the auxiliary voltage fails with the central NS protection or if the control fails with the integrated NS protection, the switch-off command must be given immediately. | | | | | | | | |

## 6.12 Model definition and model validation for generating units of synchronous generating technology

| Verdict | ☐ P | ☐ F | ☒ N/A | ☐ N/R | ☐ R/D |
|---|---|---|---|---|---|

Note:

PGU(s) considered in this test report utilizing non-synchronous generating technology. Model validation is not covered within the scope of this report.

# Annex 1 – Parameter list

| Name of parameter set | | 8 | | | | |
|---|---|---|---|---|---|---|
| Clause(s) / subclause(s) of EN 50549-1:2019+A1:2023 | Parameter | Remarks / additional information | configurable value range | Step size | unit | default value |
| 4.3.2 Interface switch | Single fault tolerance for interface switch required | Requirement met | --- | --- | --- | --- |
| 4.4.2 Operating frequency range | Internal parameter not configurable | Requirement acc. EN 50549-1, table 1 can be met | not configurable | 0.01 | Hz | 47.5 |
| | Internal parameter not configurable | Requirement acc. EN 50549-1, table 1 can be met | not configurable | 0.01 | Hz | 51.50 |
| 4.4.3 Minimal requirement for active power delivery at under frequency | UnderFrequencyStartFrequency1 | Requirement acc. EN 50549-1, clause 4.4.3 can be met | --- | --- | Hz | 49.5 |
| 4.4.4 Continuous operating voltage range | Internal parameter not configurable | Requirement acc. EN 50549-1, table 1 can be met | not configurable | 0.1 | V | 195.5 |
| | Internal parameter not configurable | Requirement acc. EN 50549-1, table 1 can be met | not configurable | 0.1 | V | 253.0 |
| 4.5.2 Rate of change of frequency (ROCOF) immunity | --- | ROCOF withstand capability ≥ 2Hz/s | not configurable | --- | Hz/s | 2 |
| 4.5.3.2 Generating plant with non-synchronous generating technology (FRT) | LowThroughRevTime | --- | Not configurable | --- | --- | ≤ 1s |
| | LVRT_Enable | Enable under voltage ride through | 1: Enable, 0: Disable | --- | --- | 1 |
| | LVRT_V1 | LVRT-voltage level1 | 0.0-100.0 | 0.1 | %Un | 85.0 |
| | LVRT_V2 | LVRT-voltage level2 | 0.0-100.0 | 0.1 | $\%U_n$ | 5.0 |
| | LVRT_T1 | LVRT-time level1 | 0.00-60.00 | 0.01 | s | 3.00 |
| | LVRT_T2 | LVRT-time level2 | 0.00-60.00 | 0.01 | s | 0.25 |
| | LVRT_Vin | LVRT-entry voltage | 0.0-100.0 | 0.1 | $\%U_n$ | 85.0 |
| | LVRT_Vout | LVRT-exit voltage | 0.0-100.0 | 0.1 | $\%U_n$ | 90.0 |
| | LVRT_ZCM | LVRT-zero current mode | 1: Enable, 0: Disable | --- | --- | 1 |
| | LVRT_ZCTV | LVRT-zero current trigger voltage | 0.0-100.0 | 0.1 | $\%U_n$ | 50.0 |
| 4.5.4 Over-voltage ride through (OVRT) | HVRT_Enable | Enable over voltage ride through | 1: Enable, 0: Disable | --- | --- | 0 |
| | HVRT_V1 | HVRT-voltage level1 | 0.0 - 150.0 | 0.1 | %Un | 115.0 |
| | HVRT_V2 | HVRT-voltage level2 | 0.0 - 150.0 | 0.1 | $\%U_n$ | 120.0 |
| | HVRT_V3 | HVRT-voltage level3 | 0.0 - 150.0 | 0.1 | $\%U_n$ | 125.0 |
| | HVRT_T1 | HVRT-time level1 | 0.00 - 60.00 | 0.01 | s | 60.00 |
| | HVRT_T2 | HVRT-time level2 | 0.00 - 60.00 | 0.01 | s | 5.00 |
| | HVRT_T3 | HVRT-time level3 | 0.00 - 60.00 | 0.01 | s | 0.10 |
| | HVRT_Vin | HVRT-entry voltage | 100.0 - 150.0 | 0.1 | %Un | 115.0 |
| | HVRT_Vout | HVRT-exit voltage | 100.0 - 150.0 | 0.1 | $\%U_n$ | 110.0 |
| | HVRT_ZCM | HVRT-zero current mode | 1: Enable, 0: Disable | --- | --- | 1 |

| Name of parameter set | | 8 | | | | |
|---|---|---|---|---|---|---|
| Clause(s) / subclause(s) of EN 50549-1:2019+A1:2023 | Parameter | Remarks / additional information | configurable value range | Step size | unit | default value |
| | HVRT_ZCTV | HVRT-zero current trigger voltage | 100.0-150.0 | 0.1 | $\%U_n$ | 120.0 |
| 4.6.1 Power response to over frequency (LFSM-O) | OverFrequencyStartPoint | Threshold frequency f1 | 50.00 - 52.00 | 0.01 | Hz | 50.20 |
| | P-OF-F1 | --- | 47.50-52.50 | 0.01 | Hz | 50.00 |
| | P-OF -P1 | --- | 0.0-100.0 | 0.1 | % | 100.0 |
| | P-OF-F2 | --- | 47.50-52.50 | 0.01 | Hz | 50.20 |
| | P-OF -P2 | --- | 0.0-100.0 | 0.1 | % | 100.0 |
| | P-OF-F3 | --- | 50.00-55.00 | 0.01 | Hz | 52.70 |
| | P-OF -P3 | --- | 0.0-100.0 | 0.1 | % | 0.0 |
| | P_OF_F_R | --- | 47.50-52.50 | 0.01 | Hz | 50.20 |
| | P_OF_Tin | Intentional delay | 0-50 | 1 | s | 0 |
| | P_OF_Tout | Deactivation time tstop | 0-50 | 1 | s | 0 |
| | P_OF_PrefSet | Power reference | 0-1000 | 1 | --- | 1000 |
| | P_OF_SSRin | --- | 6-6000 | 1 | %Pn/min | 6000 |
| | P_OF_RRout | --- | 6-6000 | 1 | %Pn/min | 10 |
| 4.6.2 Power response to under frequency (LFSM-U) | P-LF-F1 | --- | 47.50-52.50 | 0.01 | Hz | 50.00 |
| | P-LF -P1 | --- | 0.0-10.0 | 0.1 | % | 0.0 |
| | P-LF-F2 | --- | 47.50-52.50 | 0.01 | Hz | 49.80 |
| | P-LF -P2 | --- | 0.0-10.0 | 0.1 | % | 0.0 |
| | P-LF-F3 | --- | 45.00-52.50 | 0.01 | Hz | 47.30 |
| | P-LF -P3 | --- | 0.0-100.0 | 0.1 | % | 100.0 |
| | P-LF-F_R | --- | 47.50-52.50 | 0.01 | Hz | 49.80 |
| | P_LF_Tin | Intentional delay | 0-10 | 1 | s | 0 |
| | P_LF_Tout | Deactivation time tstop | 0-10 | 1 | s | 0 |
| | P_LF_PrefSet | Power reference | 0-1000 | 1 | --- | 1000 |
| | P_LF_SSRin | --- | 6-6000 | 1 | %Pn/min | 6000 |
| | P_LF_RRout | --- | 6-6000 | 1 | %Pn/min | 6000 |
| 4.7.2.2 voltage support by reactive power - Capabilities | Reactive power range | --- | -1087 - 1087 | 1 | Var | 0 |
| | PFSet | --- | -0.90 - 1.00 – 0.90 | 0.01 | --- | 1.00 |
| 4.7.2.3 Control modes | VQEnable | --- | Q setpoint<br>Q(U)<br>cosφ setpoint<br>cosφ(P) | --- | --- | Q setpoint |
| 4.7.2.3.2 Set point control modes (Q setpoint and excitation) | Reactive power setting value | --- | -1087 - 1087 | 1 | Var | 0 |
| | tau | PT1-filtering time constant | 0.00 - 60.00 | 0.01 | s | 3.33 |
| 4.7.2.3.2 Set point control modes (cosφ setpoint and excitation) | cosφ setting value | --- | -0.90 - 1.00 - 0.90 | 0.01 | --- | 1.00 |
| | tau | PT1-filtering time constant | 0.00 - 60.00 | 0.01 | s | 3.33 |
| 4.7.2.3.3 Voltage related control modes - Q(U) | QU -U1 | --- | 90.0-110.0 | 0.1 | % | 93.0 |
| | QU -Q1 | --- | -100.0 - 100.0 | 0.1 | $\%Q_n$ | 100.0 |
| | QU -U2 | --- | 90.0-110.0 | 0.1 | % | 94.0 |

| Name of parameter set | | 8 | | | | |
|---|---|---|---|---|---|---|
| Clause(s) / subclause(s) of EN 50549-1:2019+A1:2023 | Parameter | Remarks / additional information | configurable value range | Step size | unit | default value |
| | QU -Q2 | --- | -100.0 - 100.0 | 0.1 | $\%Q_n$ | 0.0 |
| | QU -U3 | --- | 90.0-110.0 | 0.1 | % | 100.0 |
| | QU -Q3 | --- | -100.0 - 100.0 | 0.1 | $\%Q_n$ | 0.0 |
| | QU -U4 | --- | 90.0-110.0 | 0.1 | % | 106.0 |
| | QU -Q4 | --- | -100.0 - 100.0 | 0.1 | $\%Q_n$ | 0.0 |
| | QU -U5 | --- | 90.0-110.0 | 0.1 | % | 108.0 |
| | QU -Q5 | --- | -100.0 - 100.0 | 0.1 | $\%Q_n$ | -100.0 |
| | tau | PT1-filtering time constant | 0.0 - 60.0 | 0.1 | s | 10.0 |
| | QU_Pin | --- | 0.0 – 20.0 | 0.1 | % | deactivated |
| | QU_Pout | --- | 0.0 – 20.0 | 0.1 | % | deactivated |
| | QU_PFmin | --- | 0.00 – 1.00 | 0.01 | --- | 0.40 |
| 4.7.2.3.4 Power related control mode - cosφ(P) | Cosφ-P Ctrl | Cos ϕ (P) curve Mode 1: Cosφ-P 0: Disable | [0 / 1] | --- | --- | 0 |
| | Cosφ-P-P1 | --- | 0.0-100.0 | 0.1 | %Sn | 10.0 |
| | Cosφ-P-F1 | --- | -0.90 – 0.90 | 0.01 | --- | 0.90 |
| | Cosφ-P-P2 | --- | 0.0-100.0 | 0.1 | % Sn | 20.0 |
| | Cosφ-P-F2 | --- | -0.90 – 0.90 | 0.01 | --- | 1.00 |
| | Cosφ-P-P3 | --- | 0.0-100.0 | 0.1 | % Sn | 50.0 |
| | Cosφ-P-F3 | --- | -0.90 – 0.90 | 0.01 | --- | 1.00 |
| | Cosφ-P-P4 | --- | 0.0-100.0 | 0.1 | % Sn | 80.0 |
| | Cosφ-P-F4 | --- | -0.90 – 0.90 | 0.01 | --- | 1.00 |
| | Cosφ-P-P5 | --- | 0.0-100.0 | 0.1 | % Sn | 90.0 |
| | Cosφ-P-F5 | --- | -0.90 – 0.90 | 0.01 | --- | -0.90 |
| | tau | PT1-filtering time constant | 0.0 - 60.0 | 0.1 | s | 2.0 |
| | Cosφ-P-Vin | --- | 0.0 - 110.0 | 0.1 | %Un | deactivated |
| | Cosφ-P-Vout | --- | 0.0 - 110.0 | 0.1 | %Un | deactivated |
| 4.7.4.2.2 Zero current mode for converter connected generating technology | LVRT_ZCTV | --- | 0.0-100.0 | 0.1 | $\%U_n$ | 50.0 |
| | HVRT_ZCTV | --- | 100.0-125.0 | 0.1 | $\%U_n$ | 120.0 |
| 4.9.2 Requirements on voltage and frequency protection | LowVoltageProtectPoint1 | Undervoltage threshold stage 1 | 180.0 - 207.0 | 0.1 | V | 193.5 |
| | LowVoltageTripTime1 | Undervoltage operate time stage 1 | 100 - 100000 | 10 | ms | 10000 |
| | LowVoltageProtectPoint2 | Undervoltage threshold stage 2 | 92.0 - 161.0 | 0.1 | V | 114.0 |
| | LowVoltageTripTime2 | Undervoltage operate time stage 2 | 100 - 5000 | 10 | ms | 120 |
| | HighVoltageProtectPoint1 | Overvoltage threshold stage 1 | 253.0-276.0 | 0.1 | V | 276.0 |
| | HighVoltageTripTime1 | Overvoltage operate time stage 1 | 100 - 100000 | 10 | ms | 10000 |
| | HighVoltageProtectPoint2 | Overvoltage threshold stage 2 | 276.0 – 288.5 | 0.1 | V | 288.5 |

| Name of parameter set | | 8 | | | | |
|---|---|---|---|---|---|---|
| Clause(s) / subclause(s) of EN 50549-1:2019+A1:2023 | Parameter | Remarks / additional information | configurable value range | Step size | unit | default value |
| | HighVoltageTripTime2 | Overvoltage operate time stage 2 | 100 - 5000 | 10 | ms | 200 |
| | OverVoltageProtectVoltage10Minute | Overvoltage threshold 10min mean protection | 230.0 – 264.5 | 0.1 | V | 253.0 |
| | LowFrequencyProtectPoint1 | Underfrequency threshold stage 1 | 47.49 – 50.00 | 0.01 | Hz | 47.49 |
| | LowFrequencyTripTime1 | Underfrequency operate time stage 1 | 100 - 100000 | 10 | ms | 2000 |
| | LowFrequencyProtectPoint2 | Underfrequency threshold stage 2 | 46.99 –47.50 | 0.01 | Hz | 46.99 |
| | LowFrequencyTripTime2 | Underfrequency operate time stage 2 | 100 - 5000 | 10 | ms | 120 |
| | HighFrequencyProtectPoint1 | Overfrequency threshold stage 1 | 50.00 – 51.51 | 0.01 | Hz | 51.51 |
| | HighFrequencyTripTime1 | Overfrequency operate time stage 1 | 100 - 100000 | 10 | ms | 2000 |
| | HighFrequencyProtectPoint2 | Overfrequency threshold stage 2 | 51.00 - 52.50 | 0.01 | Hz | 52.01 |
| | HighFrequencyTripTime2 | Overfrequency operate time stage 2 | 100 - 5000 | 10 | ms | 120 |
| 4.10.2 Automatic reconnection after tripping | OnGirdWaitTime2 | --- | 10.0 - 600.0 | 0.1 | s | 60.0 |
| | ReconnectUpwardSlope | --- | 6 - 3000 | 10 | s/100%Pn | 660 |
| | ConnectVoltageMaxThreshold2 | --- | 230.0 - 276.0 | 0.1 | V | 253.0 |
| | ConnectVoltageMinThreshold2 | --- | 190.0 - 230.0 | 0.1 | V | 195.5 |
| | ConnectFrequencyMaxThreshold2 | --- | 50.00 – 50.50 | 0.01 | Hz | 50.20 |
| | ConnectFrequencyMaxThreshold2 | --- | 47.00 - 50.00 | 0.01 | Hz | 49.50 |
| 4.10.3 Starting to generate electrical power | OnGirdWaitTime1 | --- | 10.0 - 600.0 | 0.1 | s | 60.0 |
| | ReconnectUpwardSlope | --- | 6 - 3000 | 10 | s/100%Pn | 660 |
| | ConnectVoltageMaxThreshold1 | --- | 230.0 - 276.0 | 0.1 | V | 253.0 |
| | ConnectVoltageMinThreshold1 | --- | 115.0 - 230.0 | 0.1 | V | 195.5 |
| | ConnectFrequencyMaxThreshold1 | --- | 50.00 - 52.00 | 0.01 | Hz | 50.10 |
| | ConnectFrequencyMinThreshold1 | --- | 47.00 - 50.00 | 0.01 | Hz | 49.50 |
| 4.11.1 Ceasing active power | --- | --- | --- | --- | --- | RS485 |
| 4.11.2 Reduction of active power on set point | ActivePowerControlPower | --- | 0.0 - 100.0 | 0.1 | % | 100.0 |
| | ActivePowerSlope | --- | 6 - 3000 | 10 | s/100%Pn | 660 |
| 4.12 Remote information exchange | --- | --- | --- | --- | --- | --- |

# Annex 2 – EMC report

LYNS-TCi

Test Report No.: 26011602-RE-EU-01

## EMC
## Test Report

| | |
|---|---|
| Applicant: | Danyang Weisheng Electronics Co., Ltd |
| Address: | No. 88, Qiliang North Road, Danyang Development Zone, Zhenjiang City, Jiangsu Province |
| Manufacturer: | Danyang Weisheng Electronics Co., Ltd |
| Address: | No. 88, Qiliang North Road, Danyang Development Zone, Zhenjiang City, Jiangsu Province |
| Product(s): | Hybrid inverter |
| Brand(s): | BIENESOL |
| Test Model(s): | Cube-5200 |
| Series Model(s): | Cube-5200-800 |
| Test Date: | Feb. 01, 2026 ~ Mar. 13, 2026 |
| Issued Date: | Mar. 18, 2026 |
| Issued By: | Hwa-Hsing (Dongguan) Testing Co., Ltd. |
| Address: | No. 101, Building N1, Yuyuan 2 Road, Yuyuan Industrial Park, HuangJiang Town, Dongguan City, People's Republic of China |
| Standards: | EN IEC 61000-6-1:2019; IEC 61000-6-1:2016<br>EN IEC 61000-6-3:2021; IEC 61000-6-3:2020<br>EN IEC 61000-3-2:2019+A1:2021+A2:2024; IEC 61000-3-2:2018/AMD2:2024<br>EN 61000-3-3:2013+A2:2021; IEC 61000-3-3:2013/AMD2:2021<br>EN 62920:2017/A1:2021 ; IEC 62920:2017/AMD1:2021<br>EN 301 489-1 V2.2.3 (2019-11)<br>EN 301 489-17 V3.3.1 (2024-09) |

The above equipment has been tested by **Hwa-Hsing (Dongguan) Testing Co., Ltd.** found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report.

Prepared by : Aaron Xiao — *Aaron Xiao*

Reviewed by : Sye Yang — *Sye Yang*

Approved by : Scott He — *Scott He*

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Release Ver. 1.5

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LYNS-TCi

Test Report No.: 26011602-RE-EU-01

**Release Control Record**

| Issue No. | Description | Issued Date |
|---|---|---|
| 26011602-RE-EU-01 | Original release. | Mar. 18, 2026 |

## 1 Summary of Test Results

| EN IEC 61000-6-3:2021; IEC 61000-6-3:2020;<br>EN IEC 61000-3-2:2019+A1:2021+A2:2024; IEC 61000-3-2:2018/AMD2:2024<br>EN 61000-3-3:2013+A2:2021; IEC 61000-3-3:2013/AMD2:2021<br>EN 62920:2017/A1:2021; IEC 62920:2017/AMD1:2021<br>EN 301 489-1 V2.2.3 (2019-11); EN 301 489-17 V3.3.1 (2024-09) | | | |
|---|---|---|---|
| Clause | Test Item | Result | Verdict |
| EN 62920:2017/A1:2021<br>IEC 62920:2017/AMD1:2021<br>EN IEC 61000-6-3:2021<br>IEC 61000-6-3:2020<br>EN 301 489-17 V3.3.1 | Conducted Emissions AC | Minimum passing Class B margin with -4.34dB at 0.2220MHz | Pass |
| | Conducted Emissions DC | Minimum passing Class B margin with -0.50dB at 0.2419MHz | Pass |
| | Radiated Emissions 30MHz to 1GHz | Minimum passing Class B margin with -3.10dB at 104.6900MHz | Pass |
| | Radiated test (1GHz~6GHz) | Meets limits minimum passing margin with -4.49dB at 1925.000 MHz | Pass |
| EN IEC 61000-3-2:2019+A1:2021+A2:2024<br>IEC 61000-3-2:2018/AMD2:2024<br>EN IEC 62920:2017+A1:2021<br>IEC 62920:2017/AMD1:2021 | Harmonic current emissions | Meets the requirements of limit | Pass |
| EN 61000-3-3:2013+A2:2021;<br>IEC 61000-3-3:2013/AMD2:2021<br>EN IEC 62920:2017+A1:2021<br>IEC 62920:2017/AMD1:2021 | Voltage fluctuations & flicker | Meets the requirements of limit | Pass |

| EN IEC 61000-6-1:2019; IEC 61000-6-1:2016 | | | |
|---|---|---|---|
| Clause | Test Item | Result | Verdict |
| EN 61000-4-2:2009<br>IEC 61000-4-2:2025 | Electrostatic discharge immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN IEC 61000-4-3:2020<br>IEC 61000-4-3:2020 | Radiated, radio-frequency, electromagnetic field immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-4:2012<br>IEC 61000-4-4:2012 | Electrical fast transient / burst immunity test. | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-5:2014 + A1:2017<br>IEC 61000-4-5:2014+ AMD1:2017 | Surge immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-6:2014<br>IEC 61000-4-6:2023 | Immunity to conducted disturbances, induced by radio-frequency fields | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-8:2010<br>IEC 61000-4-8:2009 | Power frequency magnetic field immunity test. | Meets the requirements of Performance Criterion A | Pass |
| EN IEC 61000-4-11:2020<br>IEC 61000-4-11:2020 | Voltage dips, short interruptions and voltage variations immunity tests | Vltage dips:<br>Meets the requirements of Performance Criterion A<br>Voltage interruptions:<br>Meets the requirements of Performance Criterion B | Pass |

| EN 62920:2017/A1:2021, IEC 62920:2017/AMD1:2021 | | | |
|---|---|---|---|
| Clause | Test Item | Result | Verdict |
| EN 61000-4-2:2009<br>IEC 61000-4-2:2025 | Electrostatic discharge immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN IEC 61000-4-3:2020<br>IEC 61000-4-3:2020 | Radiated, radio-frequency, electromagnetic field immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-4:2012<br>IEC 61000-4-4:2012 | Electrical fast transient / burst immunity test. | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-5:<br>2014 + A1:2017<br>IEC 61000-4-5:<br>2014+AMD1:2017 | Surge immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-6:2014<br>IEC 61000-4-6:2023 | Immunity to conducted disturbances, induced by radio-frequency fields | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-8:2010<br>IEC 61000-4-8:2009 | Power frequency magnetic field immunity test. | Meets the requirements of Performance Criterion A | Pass |
| EN IEC 61000-4-11:2020<br>IEC 61000-4-11:2020 | Voltage dips, short interruptions and voltage variations immunity tests | Vltage dips:<br>Meets the requirements of Performance Criterion A<br>Voltage interruptions:<br>Meets the requirements of Performance Criterion B | Pass |

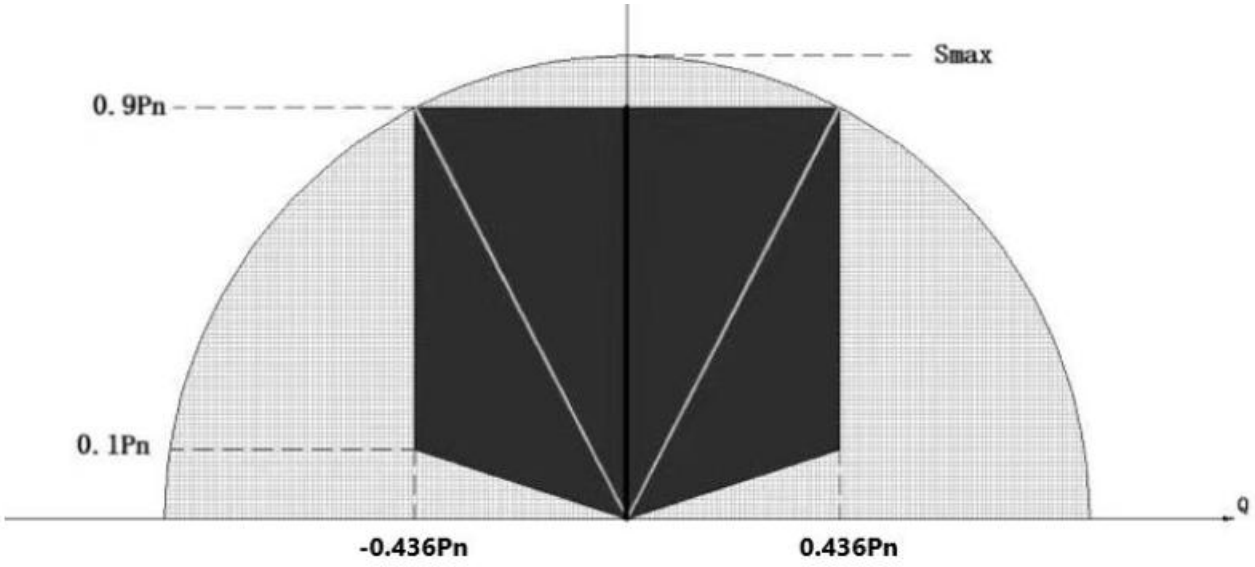
**Note:** There is no deviation to the applied test methods and requirements covered by the scope of this report.

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Address: No. 101, Building N1, Yuyuan 2 Road, Yuyuan Industrial Park, HuangJiang Town, Dongguan City, People's Republic of China
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E-Mail: service-hs@lyns-tci.com

| (EN 301 489-1 V2.2.3, EN 301489-17 V3.3.1) | | | |
|---|---|---|---|
| Clause | Test Item | Verdict | Result |
| EN 61000-4-2:2009 | Electrostatic discharge immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN IEC 61000-4-3: 2020 | Radiated, radio-frequency, electromagnetic field immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-4:2012 | Electrical fast transient / burst immunity test. | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-5:2014 + A1:2017 | Surge immunity test | Meets the requirements of Performance Criterion A | Pass |
| EN 61000-4-6:2014 | Immunity to conducted disturbances, induced by radio-frequency fields | Meets the requirements of Performance Criterion A | Pass |
| EN IEC 61000-4-11:2020 | Voltage dips, short interruptions and voltage variations immunity tests | Vltage dips: Meets the requirements of Performance Criterion A Voltage interruptions: Meets the requirements of Performance Criterion B | Pass |

**Note:** There is no deviation to the applied test methods and requirements covered by the scope of this report.

## Annex 3 – Capability curve of the PGU(s)

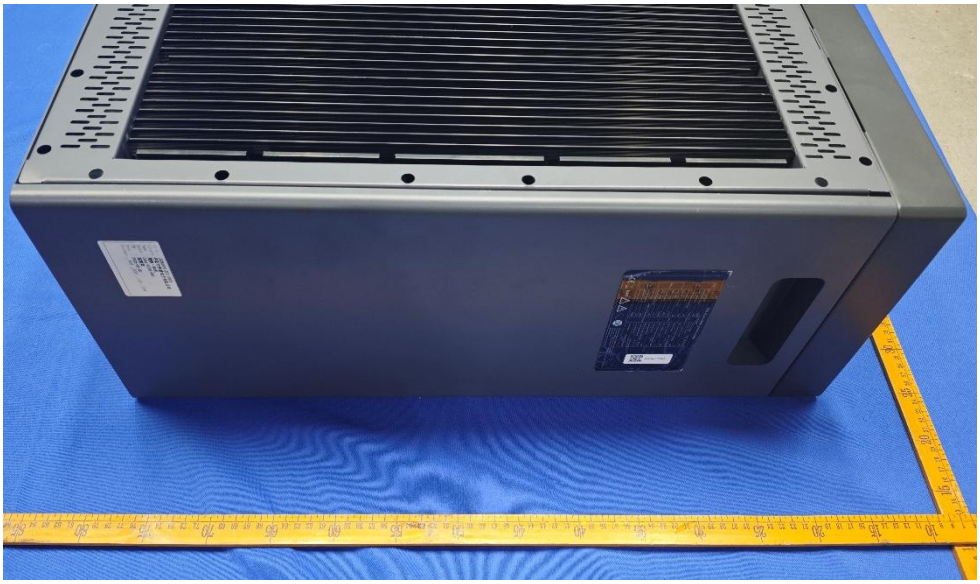


## Annex 4 - Photo of the unit

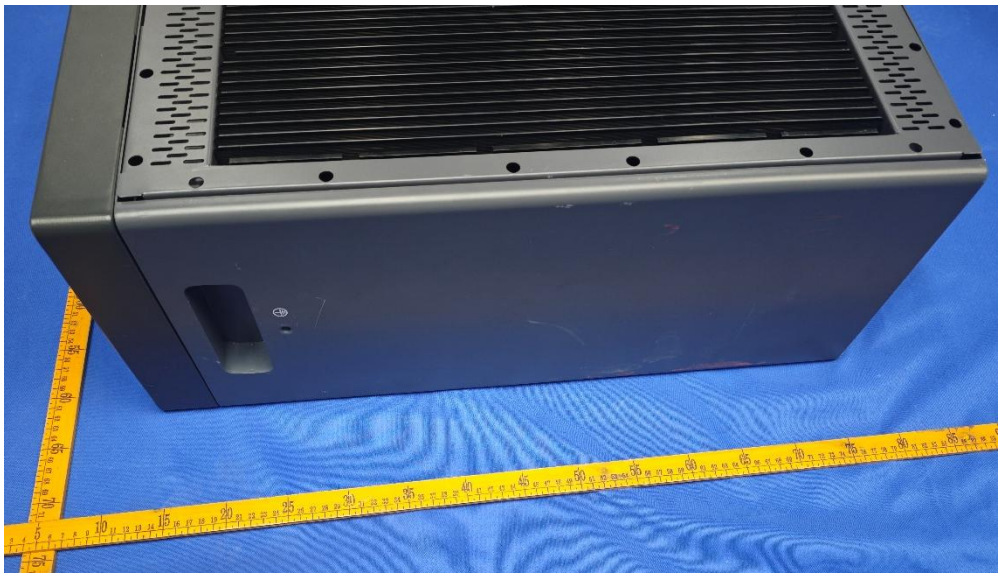
**`Enclosure front view**



**Enclosure side view-1**



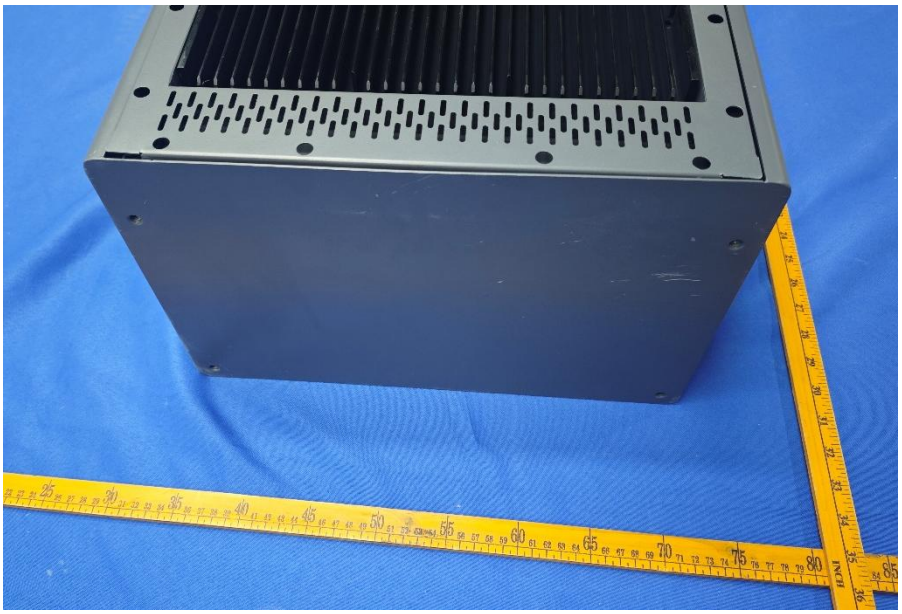
**Enclosure side view-2**



**Enclosure rear view**



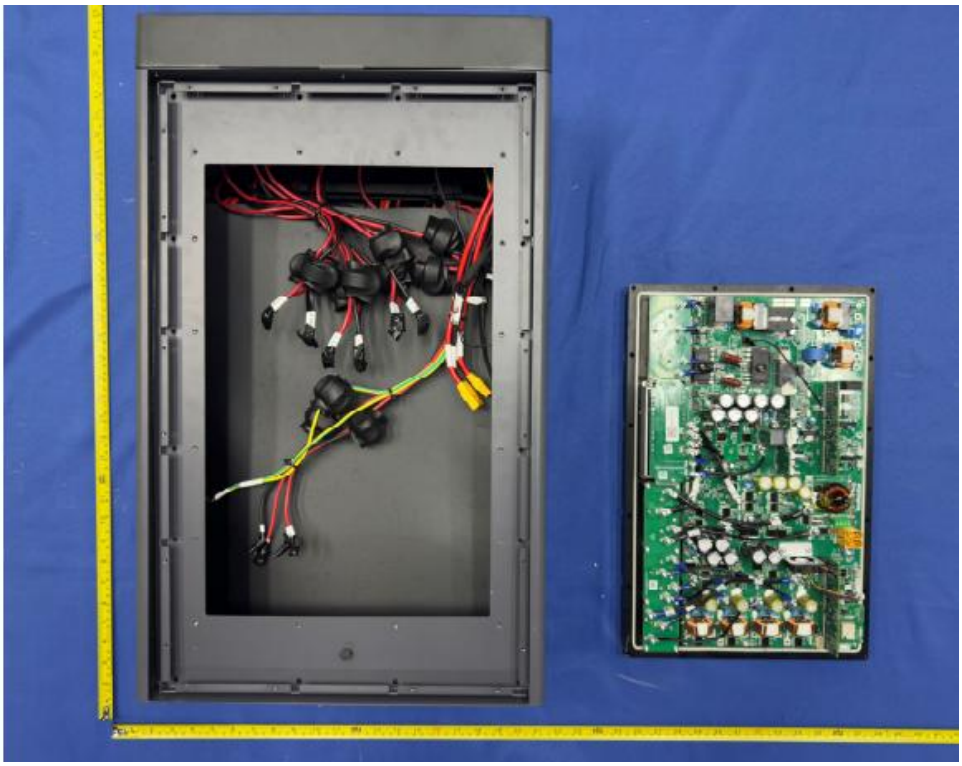
**Enclosure bottom view**



**Enclosure top view**



**Enclosure internal view**



»»»» **End of Test Report** ««««