Product Service

TEST REPORT

Standard Engineering Recommendation G99, Issue 1 – Amendment 10, 4 March 2024

TÜV SÜD Test report for Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019

Report reference No. ....:	704092472009-00
Date of issue ....:	2024-12-30
Project handler ....:	Xuehao Xu
Test laboratory.....................................:	TÜV SÜD New Energy Vehicle Testing (Jiangsu) Co., Ltd.
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Testing location ....:	Shanghai Moorewatt Energy Technology Co., Ltd. 3rd Floor, Building 2, No. 200 Zhangheng Road, China (Shanghai) Pilot Free Trade Zone, 201204 Shanghai, PEOPLE'S REPUBLIC OF CHINA
Client...:	Atmoce Holding B.V.
Client number ....:	126875
Address ....:	Singel 250, 1016 AB Amsterdam, THE NETHERLANDS
Contact person ....:	Mr. Sami Aihagga
Standard ....:	This TÜV SÜD test report form is based on the following requirements: G99/1-10:2024
TRF originated by.................................:	TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch Mr. Kai Zhao
Copyright blank test report....................:	This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TÜV SÜD Product Service GmbH. TÜV SÜD Group takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.
Scheme ....:	☐ GS, ☐ TÜV Mark, ☐ EU-Directive, ☐ without certification ☒ Type verification of conformity
Non-standard test method ....:	☒ No ☐ Yes, see details under Summary
National deviations...............................:	GB
Number of pages (Report)....................:	93
Number of pages (Attachments) ....:	See page 3

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(+ signature)	Xuehao Xu	(+ signature)	

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Test sample:	Engineering prototype
Type of test object:	Microinverter
Trademark:	ATMOCE
Model and/or type reference:	MI-360, MI-380, MI-400, MI-425, MI-450, MI-500
Rating(s):	See copy of marking plates
Manufacturer:	Atmoce Holding B.V.
Address:	Singel 250, 1016 AB Amsterdam, THE NETHERLANDS
Sub-contractors/ tests (clause):	N/A
Name:	N/A
Order description:	☒ Complete test according to TRF
	☐ Partial test according to manufacturer's specifications
	☐ Preliminary test
	☐ Spot check
	☐ Others:
Date of order:	2024-12-18
Date of receipt of test item:	2024-12-18
Date(s) of performance of test:	2024-12-20 to 2024-12-28

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Test item particulars:

All the tests results confirmed to the requirements of the standard.

Attachments:

Item	Description	Certificate No. / test report No.	Issued by	Models	Pages
1	CE-LVD	N8A 126875 0002 Rev. 00	TÜV SÜD	MI-360, MI-380, MI-400, MI-425, MI-450, MI-500	2
2	CE-EMC	E8A 126875 0003 Rev. 00	TÜV SÜD	MI-360, MI-380, MI-400, MI-425, MI-450, MI-500	3
3	Manufacturer's declaration of conformity	N/A	Atmoce Holding B.V.	MI-360, MI-380, MI-400, MI-425, MI-450, MI-500	6

General remarks:

"(see remark #)" refers to a remark appended to the report.
"(see appended table)" refers to a table appended to the report.
Throughout this report a point is used as the decimal separator.
The test results presented in this report relate only to the object tested.
This report shall not be reproduced except in full without the written approval of the testing laboratory.

Summary of testing:

☐ deviation(s) found

☒ no deviations found

Individual inverter assessed based on component basis.

Firmware version: 01.01.00

Basic model: MI-500
MI-360, MI-380, MI-400, MI-425, MI-450 are the same family design products, share the same control electronics, with the same firmware, with the same construction solutions including the power part, with the same number of phases. Test was carried out on representative model MI-500, results of the measurement of MI-500 can be transferred to other models.

All tests were conducted on MI-500, which is the representative model of family design products, test at rated voltage 230 V and rated frequency 50 Hz, the results of the measurement of MI-500 should be transferred in whole to other power generation units.

Test basis of manufacturer declaration for their products application.

☒ Type A	☐ Type B	☐ Type C	☐ Type D
A Power Generating Module with a Connection Point below 110 kV and a Registered Capacity of 0.8 kW or greater but less than 1 MW.	A Power Generating Module with a Connection Point below 110 kV and Registered Capacity of 1 MW or greater but less than 10 MW.	A Power Generating Module with a Connection Point below 110 kV and a Registered Capacity of 10 MW or greater but less than 50 MW.	A Power Generating Module with a Connection Point at or greater than 110 kV, and/or with a Registered Capacity of 50 MW or greater.

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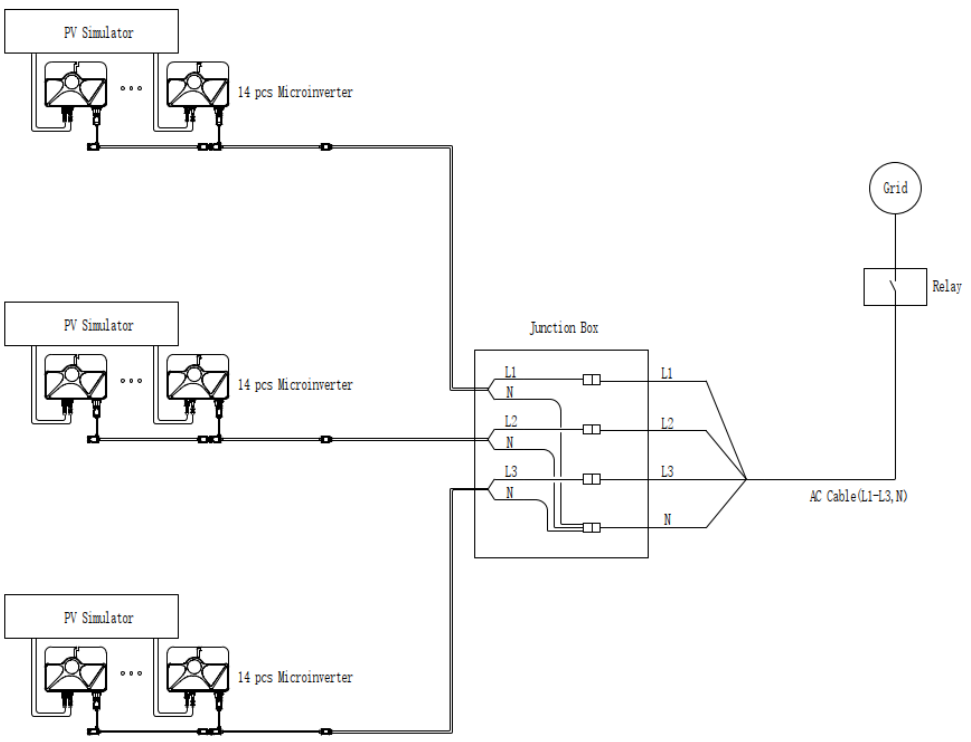
Test results provide the evidence that the capability of a combination of 42 microinverters (representative inverter MI-500) connected as the following diagram to compliance with technical requirements for Type A Power Park Module.

14 microinverters (representative inverter MI-500) are connected in parallel for each phase and connected to AC grid. Therefore, system capacity is up to 21kW (7kW for each phase).



Test items below according to G99/1-10:2024 in details:

1) Type A Compliance Verification Report for Inverter Connected Power Generating Modules		
Clause(s)	Tests	Samples for testing in details
A.7.1.2	Operating range	42 x MI-500
A.7.1.2.1	Disconnection times	42 x MI-500
A.7.1.2.2	Over / Under Voltage	42 x MI-500
A.7.1.2.3	Over / Under Frequency	42 x MI-500
A.7.1.2.4	Loss of Mains Protection	42 x MI-500
A.7.1.2.5	Re-connection	42 x MI-500
A.7.1.2.6	Frequency Drift and Step Change Stability test	42 x MI-500
A.7.1.3	Limited Frequency Sensitive Mode – Over (LFSM-O)	42 x MI-500
A.7.1.4.1	Harmonics	42 x MI-500

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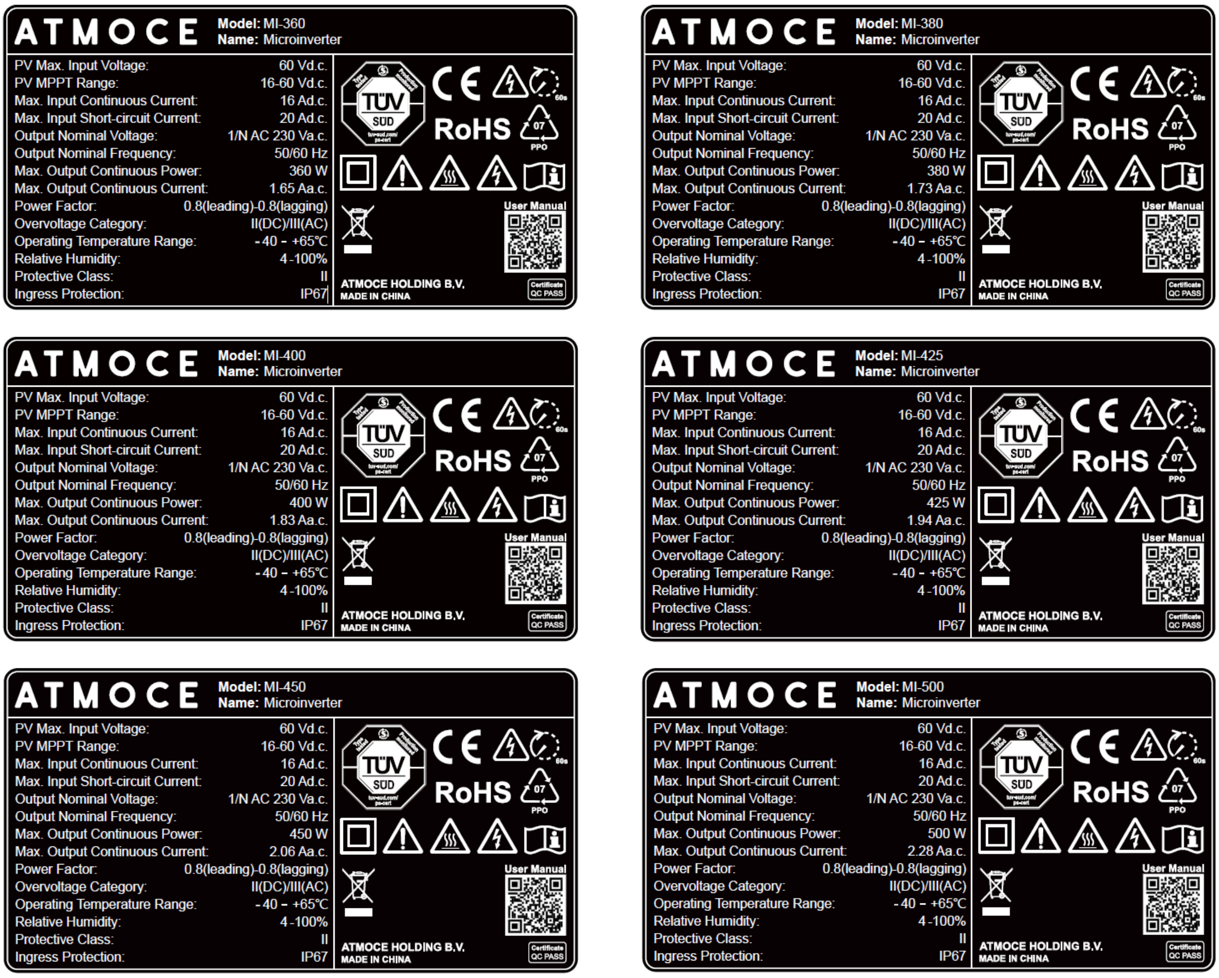
A.7.1.4.2	Power Factor	42 x MI-500
A. 7.1.4.3	Voltage Flicker	42 x MI-500
A.7.1.4.4	DC Injection	42 x MI-500
A.7.1.5	Short Circuit Current Contribution	42 x MI-500
A.7.1.6	Self-Monitoring - Solid State Disconnection	N/A
A.7.1.7	Power Park Modules which include Electricity Storage	N/A

Copy of marking plate:



Interface protection has been tested and evaluated on basis of rated grid voltage L/N/PE~, 230 V, 50Hz according to the grid code on page 1; Interface protection settings is limited to authorized installer, password and seal provided to protect these from unpermitted interference. Inverters with multi-voltage and/or frequencies ratings are available in difference versions based on output voltages and frequencies, the ratings on which the testing has been based was identified on paper tag and control panel.

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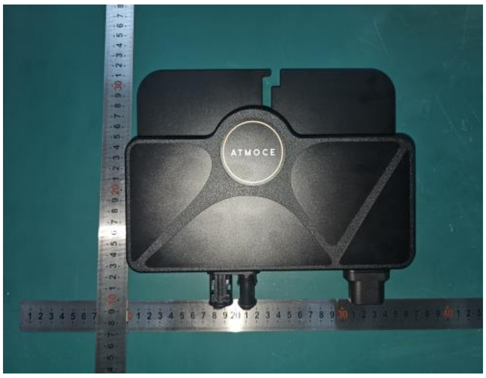
Picture of the product:			

Representative model: MI-500

Front view



Rear view

Characteristic data:

Model Name	MI-360	MI-380	MI-400
PV Input Parameters			
PV Max. Input Voltage	60 Vd.c.		
PV MPPT Range	16-60 Vd.c.		
Max. Input Continuous Current	16 Ad.c.		
Max. Input Short-circuit Current	20 Ad.c.		
A.C. Output Parameters			
Output Nominal Voltage	1/N 230 Va.c.		
Output Nominal Frequency	50 Hz		
Max. Output Continuous Power	360 W	380 W	400 W
Max. Output Continuous Current	1.65 Aa.c	1.73 Aa.c.	1.83 Aa.c.
Power Factor	0.8(leading)-0.8(lagging)		

Model Name	MI-425	MI-450	MI-500
PV Input Parameters			
PV Max. Input Voltage	60 Vd.c.		
PV MPPT Range	16-60 Vd.c.		
Max. Input Continuous Current	16 Ad.c.		
Max. Input Short-circuit Current	20 Ad.c.		
A.C. Output Parameters			
Output Nominal Voltage	1/N 230 Va.c.		
Output Nominal Frequency	50 Hz		
Max. Output Continuous Power	425 W	450 W	500 W

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Max. Output Continuous Current	1.94 Aa.c	2.06 Aa.c.	2.28 Aa.c.
Power Factor	0.8(leading)-0.8(lagging)		

Characteristic data Factory

N/A

Note: Type verification of conformity, no FI required.

Purpose of the product

These devices are transformer-less grid connected Microinverter which converts direct current to alternating current, and they are intended to be connected in parallel with the public LV grid directly. The Interface Protection System as a dedicated device at final installation. Detail settings of interface protection system and power controls should be discussed with local DSO and followed with local grid regulation.
They are intended for professional incorporation into PV array system, and they are assessed on a component test basis.

Protection settings (Manufacturer default settings)

Protection Function	Type A Power Generating Modules	
	Trip setting	Time Delay Setting
U/V	$V_{\varphi\text{-N}}$ – 20%	2.5s
O/V st 1	$V_{\varphi\text{-N}}$ + 14%	1.0s
O/V st 2	$V_{\varphi\text{-N}}$ + 19%	0.5s
U/F st 1	47.5 Hz	20s
U/F st 2	47 Hz	0.5s
OF	52 Hz	0.5s
Loss of Mains (RoCoF)	1 Hzs^{-1} time delay 0.5 s	

Tolerances on trip values:

- voltage: ±1.5%;
- frequency: ± 0.2%;

Unauthorised access to factory safety parameters setting and software should be prohibited.

A reset to the factory safety parameters requires retesting and verification in conjunction with the end-use system.

Protection integrated in inverter can not be used as an alternative central interface protection device at connection point.

Possible test case verdicts:

- test case does not apply to the test object....................: N/A (not applicable / not included in the order)
- test object does meet the requirement..........................: P (Pass)
- test object does not meet the requirement ....: F (Fail)

Possible suffixes to the verdicts:

- suffix for detailed information for the client ....: - C (Comment)
- suffix for important information for factory inspection ...: - M (Manufacturing)

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
6	**Connection Application**		N/A
6.1	General	Type test of PGU only, take into consideration in applicable connection application stage	N/A
6.1.1	This document describes the processes that shall be adopted for both connection of a single Power Generating Module and installations that comprise of a number of Power Generating Modules.		N/A
6.1.2	Type A Power Generating Module(s) ≤ 16A per phase and EREC G98 compliant		N/A
6.1.3	Power Park Modules		N/A
6.1.4	Synchronous Power Generating Modules		N/A
6.1.5	Illustrative examples		N/A
6.1.6	Interaction with the NETSO		N/A
6.2	Application for Connection		N/A
6.2.1	Information about the Power Generating Module(s) is needed by the DNO so that it can assess the effect that a Power Generating Facility may have on the Distribution Network. This document details the parameters to be supplied by a Generator wishing to connect Power Generating Module(s) that do not comply with EREC G98 to a Distribution Network. This EREC G99 also enables the DNO to request more detailed information if required.		N/A
6.2.2	Integrated Micro Generation and Storage procedure		N/A
6.2.3	Power Generating Facilities which include Type A Power Generating Modules		N/A
6.2.4	Power Generating Facilities which include Type B, Type C or Type D Power Generating Modules		N/A
6.3	System Analysis for Connection Design Type A, Type B, Type C and Type D		N/A
6.4	Provision of Information		N/A
6.4.1	General		N/A
6.4.2	Information Required for all Type A, Type B, Type C and Type D Power Generating Facilities		N/A
6.4.3	Additional Power Generating Module, Plant and Equipment Data Required for some Power		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
	Generating Facilities		
6.4.4	Extra Information for Embedded Medium Power Stations to be Provided to Meet Grid Code Requirements		N/A
6.4.5	Information Provided by the DNO to Generators		N/A

7	**Connection Arrangements**		P
7.1	Operating Modes		P
7.2	Long-Term Parallel Operation	Operation in this mode only	P
7.3	Infrequent Short-Term Parallel Operation		N/A
7.4	Switched Alternative-Only Operation		N/A
7.4.1	General		N/A
7.4.2	Changeover Operated at HV		N/A
7.4.3	Changeover Operated at LV		N/A
7.5	Phase Balance of Type A Power Generating Module output at LV	Take into consideration in final installations	N/A
7.6	Type A Power Generating Module capacity for single and split LV phase supplies	Take into consideration in final installations	N/A
7.7	Voltage Management Units in Generator's Installation	Integrated into inverter unit and external unit maybe required in final installations	P

8	**Earthing**		N/A
8.1	General		N/A
8.1.1	The earthing arrangements of the Power Generating Module shall satisfy the requirements of DPC4 of the Distribution Code.	Take into consideration in final installations	N/A
8.2	Power Generating Modules with a Connection Point at HV	Take into consideration in final installations	N/A
8.3	Power Generating Modules with a Connection Point at LV	Take into consideration in final installations	N/A

9	**Network Connection Design and Operation**		P
9.1	General Criteria	Inverter unit type test and cyber security requirements was evaluated based on manufacturer's declaration.	P
9.2	Network Connection Design for Power	Take into consideration in final	N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	Generating Modules	installations	
9.3	Step Voltage Change and Rapid Voltage Change		P
9.4	Power Quality		P
9.5	System Stability		N/A
9.6	Island Mode	Not operated in this mode	N/A
9.7	Fault Contributions and Switchgear Considerations	Take into consideration in final installation	N/A

10	**Protection**		P
10.1	General	The Interface Protection System as a dedicated device at final installation.	P
10.2	Coordinating with DNO's Distribution Network's Existing Protection	Take into consideration in final installation	N/A
10.3	Protection Requirements		P
10.4	Loss of Mains (LoM)		P
10.5	Additional DNO Protection	Take into consideration in final installation	N/A
10.6	Protection Settings		P
10.7	Typical Protection Application Diagrams	Noticed	N/A

11	**Type A Power Generating Module Technical Requirements**		P
11.1	Power Generating Module Performance and Control Requirements – General		P
11.1.1	The requirements of this Section 11 do not apply in full to:		P
	(a) Power Generation Facilities that are designed and installed for infrequent short term parallel operation only; or (b) Electricity Storage Power Generation Modules within the Power Generating Facility.		P
11.1.2	The Active Power output of a Power Generating Module should not be affected by voltage changes within the statutory limits declared by the DNO in accordance with the ESQCR.		P
11.1.3	Power Generating Modules connected to the DNO's Distribution Network shall be equipped with a logic interface (input port) in order to cease Active Power output within 5 s following an instruction being received at the input port.		P

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Clause	Requirement – Test	Result – Remark	Verdict
11.1.4	Each item of a Power Generating Module and its associated control equipment must be designed for stable operation in parallel with the Distribution Network.		P
11.1.5	When operating at rated power the Power Generating Module shall be capable of operating at a Power Factor within the range 0.95 lagging to 0.95 leading relative to the voltage waveform unless otherwise agreed with the DNO.		P
11.1.6	As part of the connection application process the Generator shall agree with the DNO the set points of the control scheme for voltage control, Power Factor control or Reactive Power control as appropriate. These settings, and any changes to these settings, shall be agreed with the DNO and recorded in the Connection Agreement. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.		P
11.1.7	Load flow and System Stability studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The Connection Agreement should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of Power Generating Module output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the Power Generating Module.		N/A
11.2	Frequency response		P
11.2.1	Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz.		P
	In exceptional circumstances, the frequency of the DNO's Distribution Network could rise above 50.5 Hz. Therefore all Power Generating Modules should be capable of continuing to operate in parallel with the Distribution Network in accordance with the following:		P
	(a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range.		P
	(b) 47.5 Hz – 49.0 Hz Operation for a period of		P

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	at least 90 minutes is required each time the frequency is within this range.		
	(c) 49.0 Hz – 51.0 Hz Continuous operation of the Power Generating Module is required		P
	(d) 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.		P
	(e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range		P
11.2.2	With regard to the rate of change of frequency withstand capability, a Power Generating Module shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hz/s as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the Power Generating Module's own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.		P
11.2.3	Output power with falling frequency		N/A
11.2.4	Limited Frequency Sensitive Mode – Over frequency		P
11.3	Fault Ride Through and Phase Voltage Unbalance		P
11.3.1	Where it has been specifically agreed between the DNO and the Generator that a Power Generating Facility will contribute to the DNO's Distribution Network security, (e.g. for compliance with EREC P2) the Power Generating Module(s) may be required to withstand, without tripping, the effects of a close up three phase fault and the Phase (Voltage) Unbalance imposed during the clearance of a close-up phase-to-phase fault, in both cases cleared by the DNO's main protection. The DNO will advise the Generator in each case of the likely tripping time of the DNO's protection, and for phase-phase faults, the likely value of Phase (Voltage) Unbalance during the fault clearance time.		P
11.3.2	In the case of phase to phase faults on the DNO's system that are cleared by system back-up protection which will be within the plant short time rating on the DNO's Distribution Network the DNO, on request during the connection		P

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	process, will advise the Generator of the expected Phase (Voltage) Unbalance.		
11.4	Voltage Limits and Control		P
11.4.1	Where a Power Generating Module is remote from a Network voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the DNO should agree with the Generator the declared voltage and voltage range at the Connection Point. Immunity of the Power Generating Module to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.		P
11.4.2	The connection of a Power Generating Module to the Distribution Network shall be designed in such a way that operation of the Power Generating Module does not adversely affect the voltage profile of and voltage control employed on the Distribution Network. ETR 126 provides DNOs with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the DNO if requested by the Generator.		P
11.4.3	The final responsibility for control of Distribution Network voltage does however remain with the DNO.		N/A
11.4.4	Automatic Voltage Control (AVC) schemes employed by the DNO often assume that power flows from parts of the Distribution Network operating at a higher voltage to parts of the Distribution Network operating at lower voltages. Export from Power Generating Modules in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the low voltage side may not operate correctly without an import of Reactive Power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of Power Generating Modules becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.		N/A
11.4.5	Power Generating Modules can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in Active Power and Reactive Power flows. ETR 126 provides guidance on		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.		

12	**Type B Power Generating Module Technical Requirements**		N/A
12.1	Power Generating Module Performance and Control Requirements - General	Intended to be used in type A power generating module	N/A
12.1.1	The requirements of this Section 12 do not apply in full to: (a) Power Generation Facilities that are designed and installed for infrequent short term parallel operation only; or (b) Electricity Storage Power Generation Modules within the Power Generating Facility.		N/A
12.1.2	The Active Power output of a Power Generating Module should not be affected by voltage changes within the statutory limits declared by the DNO in accordance with the ESQCR.		N/A
12.1.3	Power Generating Modules shall be equipped with a communication interface (input port) in order to be able to reduce Active Power output following an instruction at the input port.		N/A
12.1.4	The Power Generating Module and its associated control equipment must be designed for stable operation in parallel with the Distribution Network.		N/A
12.1.5	Load flow and System Stability studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The Connection Agreement should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of Power Generating Module output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the Power Generating Module.		N/A
12.2	Frequency response		N/A
12.2.1	Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	circumstances, the frequency of the DNO's Distribution Network could rise above 50.5 Hz. Therefore all Power Generating Modules should be capable of continuing to operate in parallel with the Distribution Network in accordance with the following:		
	(a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range.		N/A
	(b) 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.		N/A
	(c) 49.0Hz – 51.0 Hz Continuous operation of the Power Generating Module is required.		N/A
	(d) 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.		N/A
	(e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.		N/A
12.2.2	With regard to the rate of change of frequency withstand capability, a Power Generating Module shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the Power Generating Module's own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.		N/A
12.2.3	Output power with falling frequency		N/A
12.2.4	Limited Frequency Sensitive Mode – Over frequency		N/A
12.3	Fault Ride Through and Phase Voltage Unbalance		N/A
12.3.1	Paragraphs 12.3.1.1 to 12.3.1.7 inclusive set out the Fault Ride Through, principles and concepts applicable to Synchronous Power Generating Modules and Power Park Modules, subject to disturbances from faults on the Network up to 140 ms in duration.		N/A
12.3.2	In addition to paragraphs 12.3.1.1 – 12.3.1.7, where it has been specifically agreed between the DNO and the Generator that a Power Generating Facility will contribute to the DNO's Distribution Network security (e.g. for		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	compliance with EREC P2) the Power Generating Module(s) may be required to withstand, without tripping, the effects of a close up three phase fault and the Phase (Voltage) Unbalance imposed during the clearance of a close-up phase-to-phase fault, in both cases cleared by the DNO's main protection. The DNO will advise the Generator in each case of the likely tripping time of the DNO's protection, and for phase-phase faults, the likely value of Phase (Voltage) Unbalance during the fault clearance time.		
12.3.3	In the case of phase to phase faults on the DNO's system that are cleared by system back-up protection which will be within the plant short time rating on the DNO's Distribution Network the DNO, on request during the connection process, will advise the Generator of the expected Phase (Voltage) Unbalance.		N/A
12.3.4	Other Fault Ride Through Requirements		N/A
	(a) In the case of a Power Park Module, the requirements in this Section 12.3. do not apply when the Power Park Module is operating at less than 5% of its Registered Capacity or during very high primary energy source conditions when more than 50% of the Generating Units in a Power Park Module have been shut down or disconnected under an emergency shutdown sequence to protect Generator's plant and apparatus.		N/A
	(b) For the avoidance of doubt the requirements specified in this Section 12.3 do not apply to Power Generating Modules connected to an unhealthy circuit and islanded from the Distribution Network even for delayed auto reclosure times.		N/A
12.4	Voltage Limits and Control		N/A
12.4.1	Where a Power Generating Module is remote from a Network voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the DNO should agree with the Generator the declared voltage and voltage range at the Connection Point. Immunity of the Power Generating Module to voltage changes of ± 10% of the declared voltage is recommended, subject to design appraisal of individual installations.		N/A
12.4.2	The connection of a Power Generating Module to the Distribution Network shall be designed in		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	such a way that operation of the Power Generating Module does not adversely affect the voltage profile of and voltage control employed on the Distribution Network. ETR 126 provides DNOs with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the DNO if requested by the Generator.		
12.4.3	Excitation Performance Requirements		N/A
12.4.4	The final responsibility for control of Distribution Network voltage does however remain with the DNO.		N/A
12.4.5	Automatic Voltage Control (AVC) schemes employed by the DNO often assume that power flows from parts of the Distribution Network operating at a higher voltage to parts of the Distribution Network operating at lower voltages. Export from Power Generating Modules in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the low voltage side may not operate correctly without an import of Reactive Power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of Power Generating Modules becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.		N/A
12.4.6	Power Generating Modules can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in Active Power and Reactive Power flows. ETR 126 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.		N/A
12.5	Reactive Capability		N/A
12.5.1	When supplying Registered Capacity all Power Generating Modules must be capable of continuous operation at any points between the limits of 0.95 Power Factor lagging and 0.95 Power Factor leading at the Connection Point or the Generating Unit terminals as appropriate for the Power Generating Facility and as agreed with the DNO.		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
12.5.2	At Active Power output levels other than Registered Capacity, all Synchronous Power Generating Modules or Generating Units within a Power Park Module must be capable of continuous operation at any point between the Reactive Power capability limits identified on the Generator Performance Chart. Generators should take any site demand such as auxiliary supplies and the Active Power and Reactive Power losses of the Power Generating Module transformer or Station Transformer into account unless advised otherwise by the DNO.		N/A
12.6	Fast Fault Current Injection		N/A
12.6.1	Fast Fault Current injection is necessary to support the Total System during a fault on the Transmission System. The design of Fast Fault Current injection is tailored to this, and does not relate directly to faults on the Distribution Network, not least as those will tend to have longer clearing times than those of the Transmission System for which Fast Fault Current injection is designed. In this Section 12.6 the faults referred to are Transmission System faults which clear within 140 ms and which will be seen in the Distribution Network as a voltage depression.		N/A
12.6.2	Each Power Park Module shall be required to satisfy the following requirements:		N/A
	(a) For any balanced or unbalanced fault on the Transmission System which results in the voltage at the Connection Point falling below 0.9 p.u. each Power Park Module shall, unless otherwise agreed with the DNO, be required to inject a current above the shaded area shown in Figure 12.5 (a) and Figure 12.5 (b). For the purposes of this requirement, the maximum rated current is taken to be the maximum current each Generating Unit can supply when operating at Registered Capacity and 0.95 Power Factor at a nominal voltage of 1.0 p.u.. For example, in the case of a 1 MW Power Park Module the Registered Capacity would be taken as 1 MW and the rated Reactive Power would be taken as 0.33 MVAr (i.e. Rated MW output operating at 0.95 Power Factor lead or 0.95 Power Factor lag) giving a MVA rating of 1.05 MVA. For the avoidance of doubt, where the phase voltage at the Connection Point is not zero, the injected current shall be in proportion to the retained voltage at the Connection Point but shall still be required to remain above the		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	shaded area in Figure 12.5(a) and Figure 12.5(b).		
	(b) In addition, the injected current from each Power Park Module shall be in proportion and remain in phase with the change in system voltage at the Connection Point during the period of the voltage depression. For the avoidance of doubt, the injected current will be purely reactive for a retained voltage of zero and the reactive component of the injected current will fall in inverse proportion to the retained voltage at the Connection Point. The voltage generated from the injected current of the Power Park Module shall be in phase with the retained voltage at the Connection Point, whilst the total injected current remains above the shaded area in diagrams 12.5(a) and 12.5(b). Also, as can been seen on the diagrams a small delay time of no greater than 20 ms once the voltage falls to below 0.9 p.u. is permitted before injection of the in phase reactive current.		N/A
	(c) The Inverter is permitted to block (i.e. reduce the current injection) when the voltage at the Connection Point has returned to >0.85 p.u. in order to mitigate against the risk of transient overvoltage instability that would otherwise occur due to transient overvoltage excursions. Figure 12.5 (a) and Figure 12.5 (b) show the required current injection during the duration of the voltage depression. Where the Generator is able to demonstrate to the DNO that blocking is required in order to prevent the risk of transient over voltage excursions arising following clearance of the fault, Generators are required to both advise of, and agree on, the control strategy with the DNO, which must also include the approach taken to de-blocking. Notwithstanding this requirement, Generators should be aware of their requirement to fully satisfy the Fault Ride Through requirements of Section 12.3.		N/A
	(d) Each Power Park Module shall be designed to reduce the risk of transient overvoltage levels arising following voltage restoration. Generators shall be permitted to block where the anticipated transient overvoltage would not otherwise exceed the maximum permitted values specified in paragraph 12.4.1. Any additional requirements relating to transient overvoltage performance will be specified by the DNO.		N/A
12.7	Operational monitoring		N/A
12.7.1	At each Power Generating Facility the DNO will		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	install their own Telecontrol/SCADA outstation which will generally meet all the DNO's necessary and legal operational data requirements. The DNO will inform the Generator if additional specific data are required.		

13	**Type C and Type D Power Generating Module Technical Requirements**		N/A
13.1	Power Generating Module Performance and Control Requirements	Intended to be used in type A power generating module	N/A
13.1.1	The requirements of this Section 13 do not apply in full to: (a) Power Generation Facilities that are designed and installed for infrequent short term parallel operation only; or (b) Electricity Storage Power Generation Modules within the Power Generating Facility.		N/A
13.1.2	The Active Power output of a Power Generating Module should not be affected by voltage changes within the statutory limits declared by the DNO in accordance with the ESQCR.		N/A
13.1.3	Power Generating Modules shall be capable of adjusting the Active Power setpoint in accordance with instructions issued by the DNO.		N/A
13.1.4	Any changes to the Active Power or voltage/Reactive Power control setpoints must result in the Power Generating Module achieving the new Active Power or voltage/Reactive Power output, as appropriate, within 2 minutes.		N/A
13.1.5	Each item of a Power Generating Module and its associated control equipment must be designed for stable operation in parallel with the Distribution Network.		N/A
13.1.6	Load flow and System Stability studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The Connection Agreement should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of Power Generating Module output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the Power Generating		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	Module.		
13.2	Frequency response		N/A
13.2.1	Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional circumstances, the frequency of the DNO's Distribution Network could rise above 50.5 Hz. Therefore all Power Generating Modules should be capable of continuing to operate in parallel with the Distribution Network in accordance with the following:		N/A
	a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range		N/A
	b) 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range		N/A
	c) 49.0Hz – 51.0 Hz Continuous operation of the Power Generating Module is required		N/A
	d) 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.		N/A
	e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.		N/A
13.2.2	With regard to the rate of change of frequency withstand capability, a Power Generating Module shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the Power Generating Module's own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.		N/A
13.2.3	Output power with falling frequency		N/A
13.2.4	Limited Frequency Sensitive Mode – Over frequency		N/A
13.2.5	Limited Frequency Sensitive Mode – Under frequency (LFSM-U)		N/A
13.2.6	Frequency Sensitive Mode – (FSM)		N/A
13.3	Fault Ride Through		N/A
13.3.1	Paragraphs 13.3.1.1 to 13.3.1.10 inclusive set		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	out the Fault Ride Through, principles and concepts applicable to Synchronous Power Generating Modules and Power Park Modules, subject to disturbances from faults on the Network up to 140 ms in duration.		
13.3.2	In addition to paragraphs 13.3.1.1 – 13.3.1.11 where it has been specifically agreed between the DNO and the Generator that a Power Generating Facility will contribute to the DNO's Distribution Network security, (e.g. for compliance with EREC P2) the Power Generating Module(s) may be required to withstand, without tripping, the effects of a close up three phase fault and the Phase (Voltage) Unbalance imposed during the clearance of a close-up phase-to-phase fault, in both cases cleared by the DNO's main protection. The DNO will advise the Generator in each case of the likely tripping time of the DNO's protection, and for phase-phase faults, the likely value of Phase (Voltage) Unbalance during the fault clearance time.		N/A
13.3.3	In the case of phase to phase faults on the DNO's system that are cleared by system back-up protection which will be within the plant short time rating on the DNO's Distribution Network the DNO, on request during the connection process, will advise the Generator of the expected Phase (Voltage) Unbalance.		N/A
13.3.4	Other Fault Ride Through Requirements		N/A
	(a) In the case of a Power Park Module, the requirements in paragraph 13.3 do not apply when the Power Park Module is operating at less than 5% of its Registered Capacity or during very high primary energy source conditions when more than 50% of the Generating Units in a Power Park Module have been shut down or disconnected under an emergency shutdown sequence to protect Generator's plant and apparatus.		N/A
	(b) For the avoidance of doubt the requirements specified in this Section 13.3 do not apply to Power Generating Modules connected to an unhealthy circuit and islanded from the Distribution Network even for delayed auto reclosure times.		N/A
13.4	Voltage Limits and Control		N/A
13.4.1	Where a Power Generating Module is remote from a Network voltage control point it may be required to withstand voltages outside the		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	normal statutory limits. In these circumstances, the DNO should agree with the Generator the declared voltage and voltage range at the Connection Point. Immunity of the Power Generating Module to voltage changes of ± 10% of the declared voltage is recommended, but is mandatory for Type D Power Generating Modules, subject to design appraisal of individual installations.		
13.4.2	The connection of a Power Generating Module to the Distribution Network shall be designed in such a way that operation of the Power Generating Module does not adversely affect the voltage profile of and voltage control employed on the Distribution Network. ETR 126 provides DNOs with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the DNO if requested by the Generator.		N/A
13.4.3	Synchronous Power Generating Modules Excitation Performance Requirements		N/A
13.4.4	Voltage Control Performance Requirements for Power Park Modules		N/A
13.4.5	As part of the connection application process the Generator shall agree with the DNO the set points of the control scheme for voltage control, Power Factor control or Reactive Power control as appropriate. These settings, and any changes to these settings, shall be agreed with the DNO and recorded in the Connection Agreement. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.		N/A
13.4.6	The final responsibility for control of Distribution Network voltage does however remain with the DNO.		N/A
13.4.7	Automatic Voltage Control (AVC) schemes employed by the DNO often assume that power flows from parts of the Distribution Network operating at a higher voltage to parts of the Distribution Network operating at lower voltages. Export from Power Generating Modules in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the low voltage side may not operate correctly without an import of Reactive power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	penetration level of Power Generating Modules becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.		
13.4.8	Power Generating Modules can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in Active Power and Reactive Power flows. ETR 126 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.		N/A
13.5	Reactive Capability		N/A
13.5.1	All Synchronous Power Generating Modules shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.10 when operating at Registered Capacity. In some cases, for example, on large industrial sites etc where the Power Generating Module is embedded in the Generator's network, the DNO and Generator might agree a different control point, such as the Power Generating Module's terminals. The performance requirements of the control system including Slope (where applicable) shall be agreed between the DNO and the Generator.		N/A
13.5.2	At Active Power output levels other than Registered Capacity all Generating Units within a Synchronous Power Generating Module must be capable of continuous operation at any point between the Reactive Power capability limit identified on the Generator Performance Chart at least down to the Minimum Generation. At reduced Active Power output, Reactive Power supplied at the Connection Point shall correspond to the Generator Performance Chart of the Synchronous Power Generating Module, taking the auxiliary supplies and the Active Power and Reactive Power losses of the Power Generating Module transformer or Station Transformer into account.		N/A

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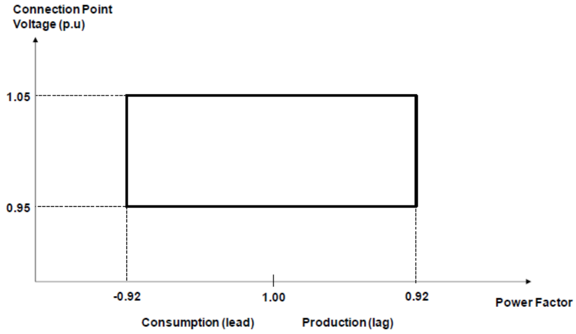
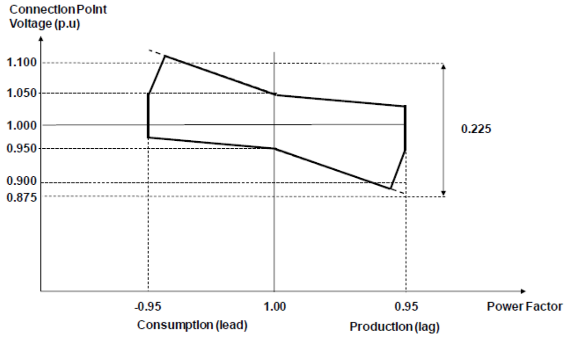
	 **Figure 13.10 Reactive Power capability requirements (Synchronous Power Generating Modules)**		
13.5.3	All Power Park Modules with a Connection Point voltage above 33 kV, shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.11 when operating at Registered Capacity.  **Figure 13.11 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage above 33 kV)**		N/A
13.5.4	All Power Park Modules with a Connection Point voltage at or below 33 kV shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.12 when operating at Registered Capacity.		N/A

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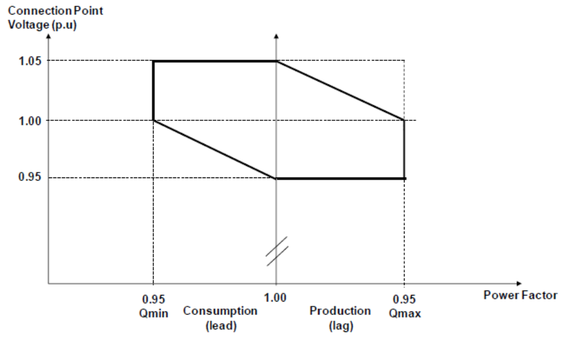
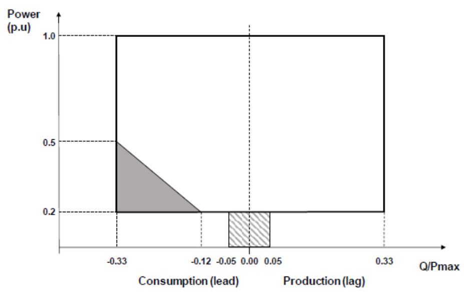
	 **Figure 13.12 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage at or below 33 kV)**		
13.5.5	All Power Park Modules shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.13 when operating below Registered Capacity. With all plant in service, the Reactive Power limits will reduce linearly below 50% Active Power output as shown in Figure 13.13 unless the requirement to maintain the Reactive Power limits defined at Registered Capacity under absorbing Reactive Power conditions down to 20% Active Power output has been specified by the DNO. These Reactive Power limits will be reduced pro rata to the amount of plant in service.  **Figure 13.13 Reactive Power capability requirements (Power Park Modules operating below Registered Capacity)**		N/A
13.6	Fast Fault Current Injection		N/A
13.6.1	Fast Fault Current injection is necessary to support the Total System during a fault on the Transmission System. The design of Fast Fault Current injection is tailored to this, and does not relate directly to faults on the Distribution Network, not least as these will tend to have longer clearing times than those of the Transmission System for which Fast Fault Current injection is designed. In this Section 13.6 the faults referred to are Transmission System faults which clear within 140 ms and which will be seen in the Distribution Network as		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	a voltage depression.		
13.6.2	Each Power Park Module shall be required to satisfy the following requirements.		N/A
	(a) For any balanced or unbalanced fault on the Transmission System which results in the voltage at the Connection Point falling below 0.9 p.u. each Power Park Module shall be required to inject a current above the shaded area shown in Figure 13.14(a) and Figure 13.14(b). For the purposes of this requirement, the maximum rated current is taken to be the maximum current each Generating Unit can supply when operating at Registered Capacity and 0.95 Power Factor at a nominal voltage of 1.0 p.u.. For example, in the case of a 10 MW Power Park Module the Registered Capacity would be taken as 10 MW and the rated Reactive Power would be taken as 3.28 MVAr (i.e. Rated MW output operating at 0.95 Power Factor lead or 0.95 Power Factor lag) giving an MVA rating of 10.53 MVA. For the avoidance of doubt, where the phase voltage at the Connection Point is not zero, the injected current shall be in proportion to the retained voltage at the Connection Point but shall still be required to remain above the shaded area in Figure 13.14(a) and Figure 13.14(b).		N/A
	(b) In addition, the injected current from each Power Park Module shall be in proportion and remain in phase with the change in system voltage at the Connection Point during the period of the voltage depression. For the avoidance of doubt, the injected current will be purely reactive for a retained voltage of zero and the reactive component of the injected current will fall in inverse proportion to the retained voltage at the Connection Point. The voltage generated from the injected current of the Power Park Module shall be in phase with the retained voltage at the Connection Point, whilst the total injected current remains above the shaded area in diagrams 12.5(a) and 12.5(b). Also, as can been seen on the diagrams a small delay time of no greater than 20 ms once the voltage falls to below 0.9 p.u. is permitted before injection of the in phase reactive current.		N/A
	(c) The Inverter is permitted to block (i.e. reduce the current injection) when the voltage at the Connection Point has returned to >0.85 p.u. in order to mitigate against the risk of transient overvoltage instability that would otherwise occur due to transient overvoltage excursions. Figure 12.5 (a) and Figure 12.5 (b) show the		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	required current injection during the duration of the voltage depression. Where the Generator is able to demonstrate to the DNO that blocking is required in order to prevent the risk of transient over voltage excursions arising following clearance of the fault, Generators are required to both advise of, and agree on, the control strategy with the DNO, which must also include the approach taken to de-blocking. Notwithstanding this requirement, Generators should be aware of their requirement to fully satisfy the Fault Ride Through requirements of Section 12.3.		
	(d) Each Power Park Module shall be designed to reduce the risk of transient overvoltage levels arising following voltage restoration. Generators shall be permitted to block where the anticipated transient overvoltage would not otherwise exceed the maximum permitted values specified in paragraph 12.4.1. Any additional requirements relating to transient overvoltage performance will be specified by the DNO.		N/A
13.7	Black Start Capability		N/A
13.7.1	The National Electricity Transmission System will be equipped with Black Start Stations. It will be necessary for each Generator to notify the DNO if its Power Generating Module has a restart capability without connection to an external power supply, unless the Generator shall have previously notified the NETSO accordingly under the Grid Code. Such generation may be registered by the NETSO as a Black Start Station.		N/A
13.8	Technical Requirements for Embedded Medium Power Stations		N/A
13.8.1	Where a Generator in respect of an Embedded Medium Power Station is a party to the CUSC this Section 13.8 will not apply.		N/A
13.8.2	In addition to the requirements of this EREC G99, the DNO has an obligation under ECC 3.3 of the Grid Code to ensure that all relevant Grid Code Connection Condition requirements are met by Embedded Medium Power Stations. These requirements are summarised in ECC 3.4 of the Grid Code. It is incumbent on the Generator who owns any Embedded Medium Power Station to comply with the relevant Grid Code requirements listed in ECC3.4 of the Grid Code as part of compliance with this EREC G99.		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
13.8.3	Where data is required by the NETSO from Embedded Medium Power Stations, nothing in the Grid Code or this EREC G99 precludes the Generator from providing the information directly to the NETSO in accordance with Grid Code requirements. However, a copy of the information should always be provided in parallel to the DNO.		N/A
13.8.4	Grid Code Connection Conditions Compliance		N/A
13.9	Operational monitoring		N/A
13.9.1	With regard to information exchange:		N/A
	(a) Power Generating Facilities shall be capable of exchanging information with the DNO in real time or periodically with time stamping;		N/A
	(b) the DNO, in coordination with the NETSO, shall specify the content of information exchanges including a precise list of data to be provided by the Power Generating Facility.		N/A
13.9.2	At each Power Generating Facility the DNO will install their own Telecontrol/SCADA outstation which will generally meet all the DNO's necessary and legal operational data requirements. The DNO will inform the Generator if additional specific data are required at the time of the connection offer.		N/A
13.9.3	Additionally each Power Generating Facility shall;		N/A
	(a) be fitted with fault recording and dynamic system monitoring facilities which shall be capable of recording System data including voltage, Active Power, Reactive Power and frequency in accordance with Annex C.6.		N/A
	(b) The settings of the fault recording equipment and dynamic system monitoring equipment (which is required to detect poorly damped power oscillations) including triggering criteria shall be agreed between the Generator and the DNO and recorded in the Connection Agreement.		N/A
	(c) The DNO may also specify that Generators must install power quality monitoring equipment. Any such requirement including the parameters to be monitored would be specified by the DNO in the Connection Agreement.		N/A
	(d) Provisions for the submission fault recording, dynamic system monitoring and power quality data to the DNO including the communications and protocols shall be specified by the DNO in the Connection Agreement.		N/A
13.9.4	The Generator will provide all relevant signals in a format to be agreed between the Generator		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	and the DNO for onsite monitoring. All signals shall be suitably terminated in a single accessible location at the Generators site.		
13.9.5	The Generator shall provide to the DNO a 230 V power supply adjacent to the signal terminal location.		N/A
13.9.6	Frequency sensitive mode (FSM) monitoring in real time		N/A
13.10	Steady State Load Inaccuracies		N/A
13.10.1	The standard deviation of load error at steady state load over a 30 minute period must not exceed 2.5% of a Power Generating Modules Registered Capacity. Where a Power Generating Module is instructed to operate in Frequency sensitive operation, allowance will be made in determining whether there has been an error according to the governor Droop characteristic registered under the DDRC. For the avoidance of doubt in the case of a Power Park Module allowance will be made for the full variation of mechanical power output.		N/A

14	**Installation, Operation and Control Interface**		N/A
14.1	General	Take into consideration in final installations	N/A
14.2	Isolation and Safety Labelling		N/A
14.3	Site Responsibility Schedule		N/A
14.4	Operational and Safety Aspects		N/A
14.5	Synchronizing and Operational Control		N/A

15	**Common Compliance and Commissioning Requirements for all Power Generating Modules**		P
15.1	Demonstration of Compliance	Test performed on PGU level	P
15.2	Wiring for Type Tested Power Generating Modules		N/A
15.3	Commissioning Tests / Checks required at all Power Generating Facilities		N/A
15.4	Additional Commissioning requirements for Non Type Tested Interface Protection		N/A
15.5	Compliance of Vehicle to Grid Electric Vehicles		N/A
15.6	Family approach to Type Testing		P
15.7	Compliance demonstration for Infrequent Short-		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	Term Parallel Power Generating Module		

16	**Type A Compliance Testing, Commissioning and Operational Notification**		P
16.1	Type Test Certification		P
16.2	Connection Process		N/A
16.3	Witnessing and Commissioning		N/A
16.4	Operational Notification		N/A

17	**Type B Compliance Testing, Commissioning and Operational Notification**		N/A
17.1	General		N/A
17.2	Connection Process		N/A
17.3	Witnessing and Commissioning		N/A
17.4	Final Operational Notification		N/A

18	**Type C Compliance Testing, Commissioning and Operational Notification**		N/A
18.1	General		N/A
18.2	Connection Process		N/A
18.3	Witnessing and Commissioning		N/A
18.4	Final Operational Notification		N/A

19	**Type D Compliance Testing, Commissioning and Operational Notification**		N/A
19.1	General		N/A
19.2	Connection Process		N/A
19.3	Interim Operational Notification		N/A
19.4	Witnessing and Commissioning		N/A
19.5	Final Operational Notification		N/A
19.6	Limited Operational Notification		N/A
19.7	Processes Relating to Derogation		N/A

20	**Ongoing Obligations**		N/A
20.1	Periodic Testing for Power Generating Modules		N/A
20.2	Operational Incidents affecting Compliance of any Power Generating Module		N/A
20.3	Changes to the Power Generating Facility or		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	Power Generating Module		
20.4	Notification of Decommissioning		N/A

21	**Manufacturers' Information applicable to Power Park Modules**		N/A
21.1	General		N/A
21.2	Manufacturers' Information in respect of Generating Units may cover one (or part of one) or more of the following provisions:		N/A
	(a) Fault Ride Through capability; (b) Power Park Module mathematical model DDRC 5c.		N/A
21.3	Reference to a Manufacturer's Data & Performance Report in a Generator's submissions does not by itself constitute compliance with EREC G99.		N/A
21.4	A Generator referencing Manufacturers' Information should insert the relevant Manufacturers' Information reference in the appropriate place in the submission forms detailed in the Annexes.		N/A
21.5	It is the responsibility of the Generator to ensure that the correct reference for the Manufacturers' Information is used and the Generator by using that reference accepts responsibility for the accuracy of the information.		N/A
21.6	The DNO may contact the Generating Unit Manufacturer directly to verify the relevance of the use of such Manufacturers' Information.		N/A

22	**Type Testing and Annex information**		P
22.1	Fully Type Tested and Partially Type Tested equipment	Fully Type Tested	P
22.2	Annex Contents and Form Guidance		P

Annex A	**Type A**		P
A.0	Type A Power Generating Module Forms Cover Sheet		P
A.1	Connection Application Forms for Type A Fully Type Tested Power Generating Facility (<50 kW) (Form A1-1) and Integrated Micro Generation and Storage (Form A1-2)		P

G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
A.2	Type A Compliance Verification Report		P
A.3	Installation Document for Type A Power Generating Modules (Form A3-1) and Integrated Micro Generation and Storage (Form A3-2)		P
A.4	Emerging Technologies and other Exceptions		P
A.5	Example calculations to determine if unequal generation across different phases is acceptable or not		P
A.6	Scenario examples in respect of the application of EREC G59 and EREC G99 to new or modified sites after 27/04/19		N/A
A.7	Requirements for Type Testing Power Generating Modules		P
A.7.1	Power Park Module Requirements		P
A.7.1.1	Certification & Type Testing Generating Unit Requirements		P
A.7.1.2	Type Verification Functional Testing of the Interface Protection		P
A.7.1.3	Limited Frequency Sensitive Mode – Over (LFSM-O)		P
A.7.1.4	Power Quality		P
A.7.1.5	Short Circuit Current Contribution		P
A.7.1.6	Self-Monitoring - Solid State Disconnection		N/A
A.7.2	Synchronous Power Generating Module Requirements (up to and including 50 kW)		N/A
A.7.2.1	Certification & Type Testing Generating Unit Requirements		N/A
A.7.2.2	Type Verification Testing of the Interface Protection Functions		N/A
A.7.2.3	Power Output with Falling Frequency		N/A
A.7.2.4	Synchronous Power Generating Modules which include Electricity Storage		N/A
A.7.2.5	Limited Frequency Sensitive Mode – Over (LFSM-O)		N/A
A.7.2.6	Power Quality		N/A
A.7.3	Additional Power Generating Module Technology Requirements		N/A
A.7.3.1	Domestic CHP		N/A
A.7.3.2	Photovoltaic		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
A.7.3.3	Fuel Cells		N/A
A.7.3.4	Hydro		N/A
A.7.3.5	Wind		N/A
A.7.3.6	Electricity Storage Device		N/A

Annex B	**Type B**		N/A
B.1	Application		N/A
B.2	Power Generating Module Document Type B		N/A
B.3	Installation and Commissioning Confirmation Form		N/A
B.4	Simulation Studies for Type B Power Generating Modules		N/A
B.4.1	Scope		N/A
B.4.2	Reactive Capability across the Voltage Range		N/A
B.4.3	Not used		N/A
B.4.4	Fault Ride Through and Fast Fault Current Injection		N/A
B.4.5	Limited Frequency Sensitive Mode – Over Frequency (LFSM-O)		N/A
B.5	Compliance Testing of Synchronous Power Generating Modules		N/A
B.5.1	Scope		N/A
B.5.2	Governor and Load Controller Response Performance		N/A
B.5.3	Compliance with Output Power with falling frequency Functionality Test		N/A
B.5.4	Synchronous Power Generating Modules incorporating Electricity Storage		N/A
B.6	Compliance Testing of Power Park Modules		N/A
B.6.1	Scope		N/A
B.6.2	Frequency Response Tests		N/A
B.6.3	Power Park Modules incorporating Electricity Storage		N/A

Annex C	**Type C and Type D**		N/A
C.1	Application		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
C.2	Power Generating Module Document Type C and Type D		N/A
C.3	Installation and Commissioning Confirmation Form		N/A
C.4	Performance Requirements For Continuously Acting Automatic Excitation Control Systems For Type C and Type D Synchronous Power Generating Modules		N/A
C.4.1	Scope		N/A
C.4.2	Requirements		N/A
C.5	Performance Requirements for Continuously Acting Automatic Voltage Control Systems for Type C and Type D Power Park Modules		N/A
C.5.1	Scope		N/A
C.5.2	Requirements		N/A
C.5.3	Steady State Voltage Control		N/A
C.5.4	Transient Voltage Control		N/A
C.5.5	Overall Voltage Control System Characteristics		N/A
C.5.6	Reactive Power Control		N/A
C.5.7	Power Factor Control		N/A
C.6	Functional Specification for Dynamic System Monitoring, Fault Recording and Power Quality Monitoring Equipment for Type C and Type D Power Generating Modules		N/A
C.6.1	Purpose and Scope		N/A
C.6.2	Functional Requirements		N/A
C.6.3	Relevant Standards		N/A
C.6.4	Calibration and Testing		N/A
C.7	Simulation Studies for Type C and Type D Power Generating Modules		N/A
C.7.1	Scope		N/A
C.7.2	Power System Stabiliser Tuning		N/A
C.7.3	Reactive Capability across the Voltage Range		N/A
C.7.4	Voltage Control and Reactive Power Stability		N/A
C.7.5	Fault Ride Through and Fast Fault Current Injection		N/A
C.7.6	Limited Frequency Sensitive Mode – Over Frequency (LFSM-O)		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
C.7.7	Limited Frequency Sensitive Mode – Under Frequency (LFSM-U)		N/A
C.7.8	Voltage and Frequency Controller Model Verification and Validation		N/A
C.8	Compliance Testing of Type C and Type D Synchronous Power Generating Modules		N/A
C.8.1	Scope		N/A
C.8.2	Excitation System Open Circuit Step Response Tests		N/A
C.8.3	Open & Short Circuit Saturation Characteristics		N/A
C.8.4	Excitation System On-Load Tests		N/A
C.8.5	Reactive Capability		N/A
C.8.6	Governor and Load Controller Response Performance		N/A
C.8.7	Compliance with Output Power with falling frequency Functionality Test		N/A
C.9	Compliance Testing of Type C and Type D Power Park Modules		N/A
C.9.1	Scope		N/A
C.9.2	Pre 20% Synchronised Power Park Module Basic Voltage Control Tests		N/A
C.9.3	Reactive Capability Test		N/A
C.9.4	Voltage Control Tests		N/A
C.9.5	Frequency Response Tests		N/A
C.9.6	Power Park Modules incorporating Electricity Storage		N/A
C.10	Minimum Frequency Response Capability Requirement Profile and Operating Range for Type C and Type D Power Generating Modules		N/A
C.10.1	Scope		N/A
C.10.2	Plant Operating Range		N/A
C.10.3	Repeatability of Response		N/A
C.10.4	Testing of Frequency Response Capability		N/A

Annex D			P
D.0	Power Generating Module Decommissioning Confirmation		N/A
D.1	Additional Information Relating to System		N/A

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G99/1-10:2024			
Clause	Requirement – Test	Result – Remark	Verdict
	Stability Studies		
D.2	Loss of Mains (LoM) Protection Analysis		N/A
D.3	Main Statutory and Other Obligations		N/A
D.4	Summary of Reactive Power and voltage control requirements for Type A, Type B, Type C and Type D Power Generating Modules	Type A Power Generating Modules to be evaluated	P

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TYPE TEST SHEET (refer to Form A2-3):

Tests for Type A Inverter Connected Power Generating Modules – test record:

1. Operating Range: Tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable test supply, grid simulation set or load bank. The power supplied by the primary source shall be kept stable within ± 5 % of the apparent power value set for the entire duration of each test sequence.

Frequency, voltage and **Active Power** measurements at the output terminals of the **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** can operate within the required ranges for the specified period of time.

The **Interface Protection** shall be disabled during the tests.

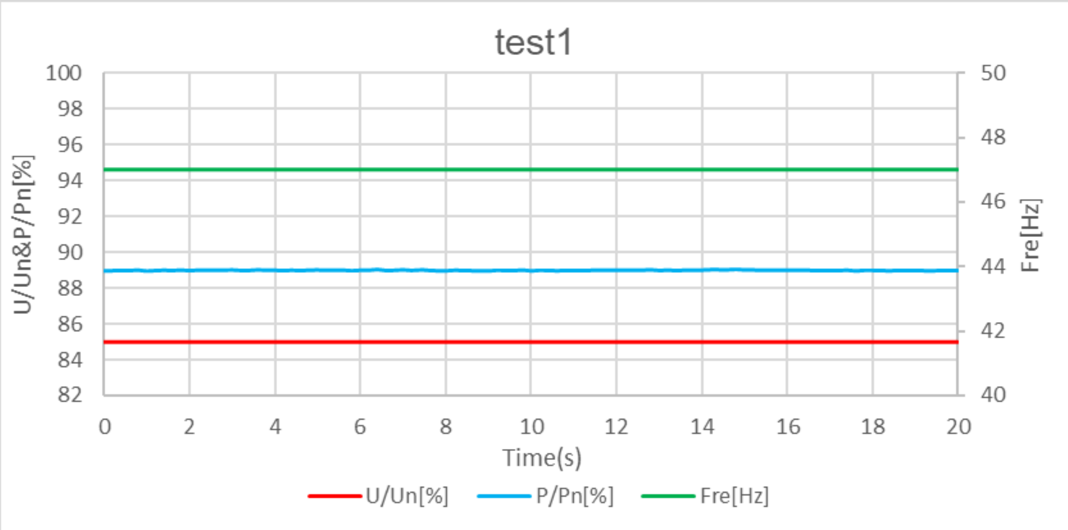
In case of a PV **Power Park Module** the PV primary source may be replaced by a DC source.

In case of a full converter **Power Park Module** (e.g. wind) the primary source and the prime mover **Inverter**/rectifier may be replaced by a DC source.

Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement “Pass”, “No disconnection occurs”, etc. Graphical evidence is preferred.

Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required.

	Frequency (Hz)	Voltage (V)	Active power (kW)	Pass or failure
Test 1 Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz, **Power Factor** = 1, Period of test 20 s	47.00	195.47	18.687	Pass



	Frequency (Hz)	Voltage (V)	Active power (kW)	Pass or failure
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz,	47.5	195.47	18.686	Pass

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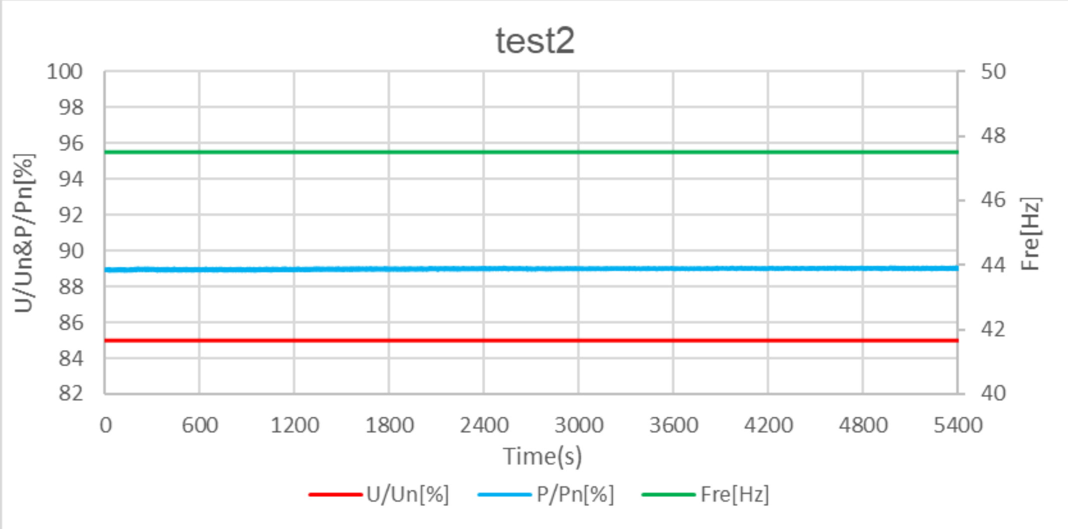
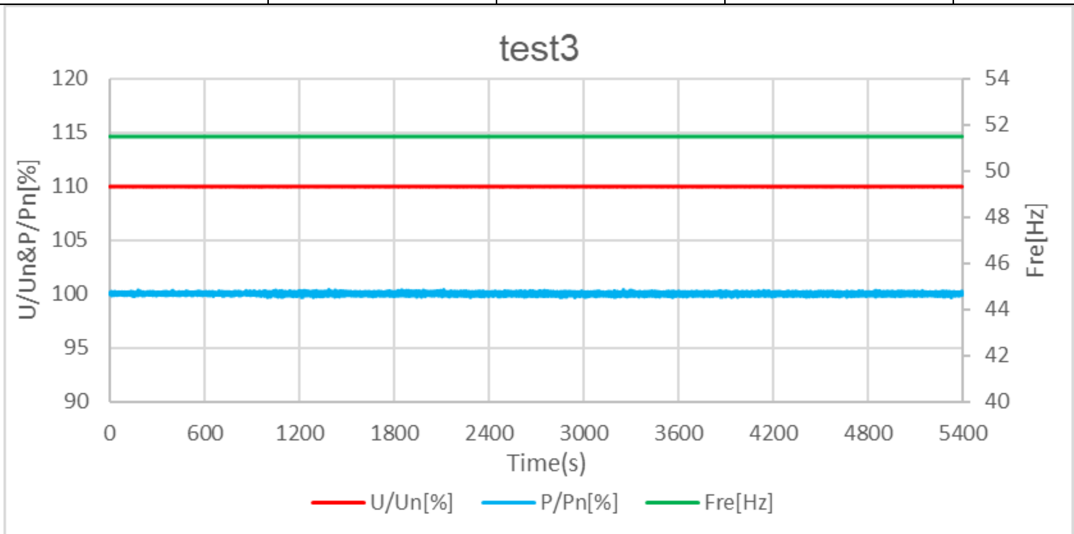
Power Factor = 1, Period of test 90 minutes				
				
Test 3 Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz, **Power Factor** = 1, Period of test 90 minutes	51.5	252.97	21.021	Pass
				
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, **Power Factor** = 1, Period of test 15 minutes	52	252.97	21.044	Pass

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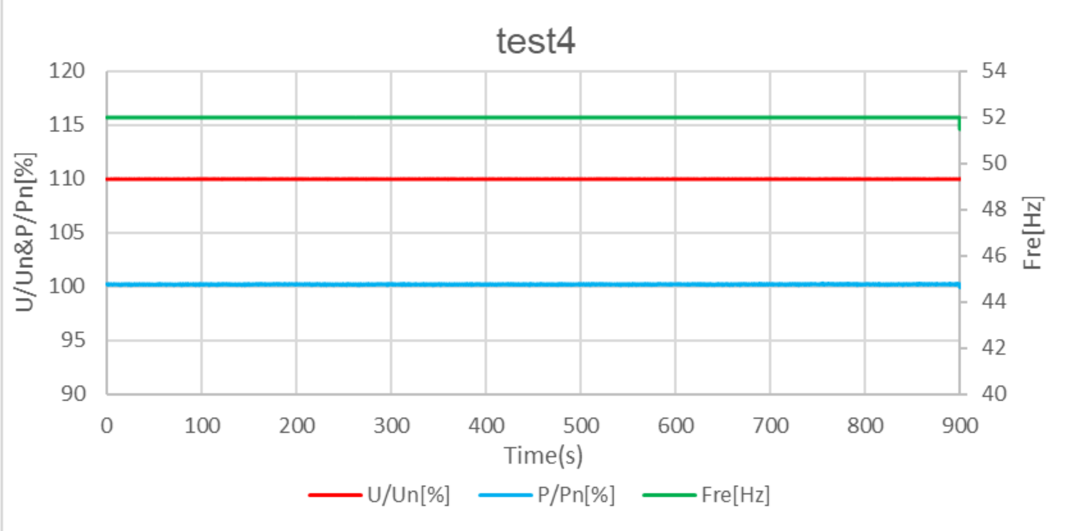
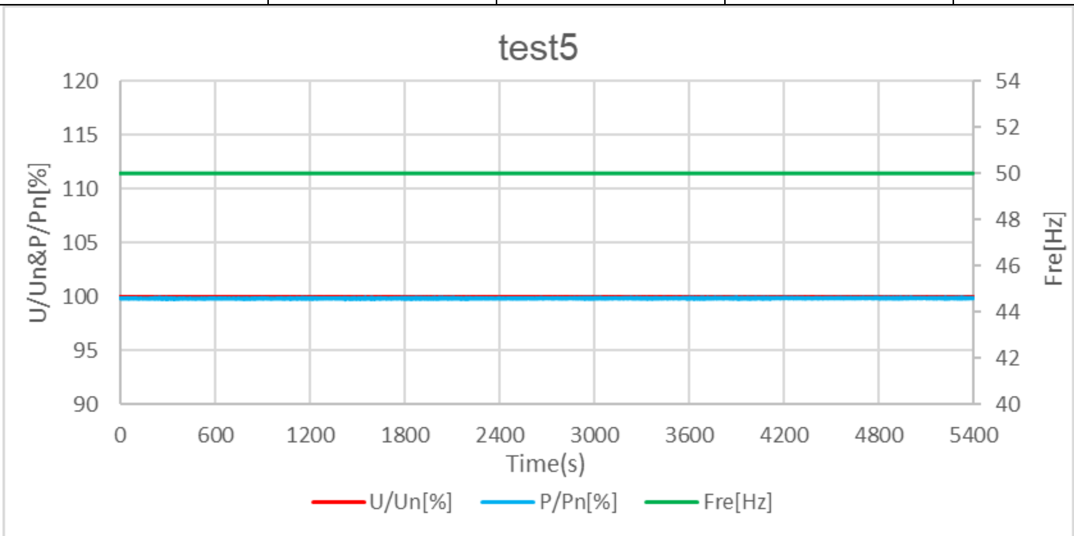
				
Test 5 Voltage = 100% of nominal (230 V), Frequency = 50.0 Hz, **Power Factor** = 1, Period of test 90 minutes	50	229.94	21.000	Pass
				
Test 6 RoCoF withstand Confirm that the **Power Generating Module** is capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms. Note that this is not expected to be demonstrated on site.				

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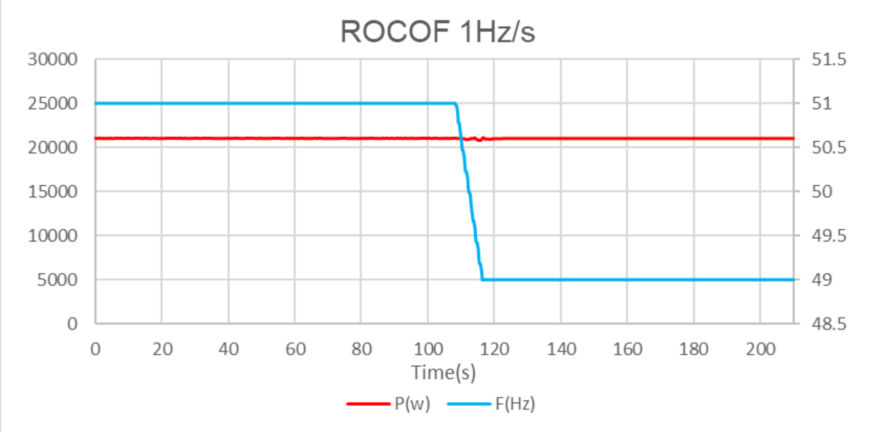

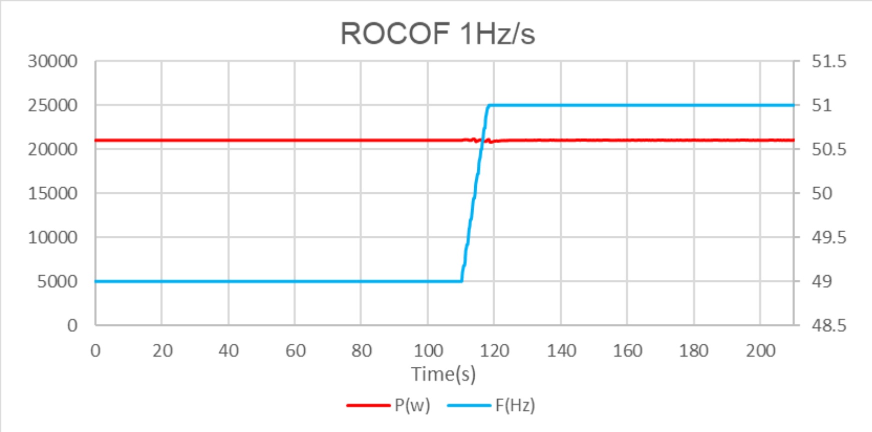

2. Power Quality – Harmonics:

For **Power Generating Modules of Registered Capacity** of less than 75 A per phase (i.e. 50 kW) the test requirements are specified in Annex A.7.1.5. These tests should be carried out as specified in BS EN 61000- 3-12, and measurements for the 2nd – 13th harmonics should be provided. The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment. For three phase **Power Generating Modules**, measurements for all phases should be provided.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (i.e. 50 kW) the installation must be designed in accordance with EREC G5.

The rating of the **Power Generating Module** (per phase) should be provided below, and the Total Harmonic Distortion (THD) and Partial Weighted Harmonic Distortion (PWHD) should be provided at the bottom of this section.

Power Generating Module tested to BS EN 61000-3-12

Power Generating Module rating per phase (rpp)	7	kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)
Single or three phase measurements (for single phase measurements, only complete L1 columns below).			

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Harmonic	At 45-55% of **Registered Capacity**						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Measured Value (MV) in %				
	L1	L2	L3	L1	L2	L3	1 phase(%)	3 phase(%)
2	0.003	0.006	0.004	0.011	0.021	0.012	8.00	8.00
3	0.059	0.065	0.064	0.193	0.212	0.210	21.60	Not stated
4	0.003	0.002	0.003	0.010	0.007	0.009	4.00	4.00
5	0.074	0.053	0.071	0.244	0.173	0.232	10.70	10.70
6	0.004	0.002	0.003	0.012	0.007	0.009	2.67	2.67
7	0.305	0.301	0.303	1.004	0.990	0.994	7.20	7.20
8	0.003	0.002	0.003	0.010	0.007	0.011	2.00	2.00
9	0.243	0.240	0.239	0.799	0.788	0.787	3.80	Not stated
10	0.003	0.003	0.003	0.009	0.009	0.009	1.60	1.60
11	0.261	0.257	0.259	0.857	0.844	0.851	3.10	3.10
12	0.003	0.002	0.004	0.009	0.008	0.012	1.33	1.33
13	0.225	0.228	0.226	0.739	0.751	0.742	2.00	2.00
14	0.002	0.002	0.003	0.007	0.008	0.009	--	--
15	0.130	0.126	0.125	0.428	0.412	0.412	--	--
16	0.002	0.003	0.003	0.008	0.011	0.011	--	--
17	0.080	0.085	0.082	0.262	0.278	0.271	--	--
18	0.003	0.004	0.004	0.011	0.012	0.012	--	--
19	0.092	0.091	0.085	0.302	0.299	0.279	--	--
20	0.003	0.003	0.004	0.009	0.010	0.012	--	--
21	0.130	0.128	0.130	0.428	0.420	0.427	--	--
22	0.003	0.004	0.004	0.011	0.012	0.012	--	--
23	0.154	0.159	0.151	0.508	0.521	0.497	--	--
24	0.003	0.005	0.004	0.011	0.015	0.012	--	--
25	0.105	0.111	0.112	0.344	0.364	0.368	--	--
26	0.003	0.003	0.003	0.011	0.009	0.011	--	--
27	0.024	0.037	0.023	0.080	0.122	0.074	--	--
28	0.004	0.003	0.004	0.013	0.009	0.013	--	--
29	0.025	0.021	0.030	0.084	0.068	0.097	--	--
30	0.003	0.004	0.004	0.009	0.013	0.013	--	--
31	0.031	0.019	0.028	0.102	0.061	0.094	--	--
32	0.003	0.003	0.004	0.009	0.008	0.013	--	--

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33	0.054	0.047	0.054	0.177	0.155	0.177	--	--
34	0.004	0.004	0.005	0.012	0.013	0.018	--	--
35	0.080	0.084	0.100	0.263	0.276	0.328	--	--
36	0.007	0.004	0.006	0.023	0.012	0.021	--	--
37	0.084	0.087	0.084	0.274	0.286	0.275	--	--
38	0.006	0.004	0.006	0.018	0.014	0.020	--	--
39	0.045	0.049	0.053	0.149	0.160	0.175	--	--
40	0.005	0.004	0.005	0.018	0.014	0.016	--	--
THD	-	-	-	2.037	2.025	2.034	23	13
PWHD	-	-	-	5.123	5.198	5.267	23	22
Harmonic	100% of **Registered Capacity**						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Measured Value (MV) in %				
	L1	L2	L3	L1	L2	L3	1 phase(%)	3 phase(%)
2	0.010	0.020	0.013	0.034	0.065	0.042	8.00	8.00
3	0.052	0.071	0.077	0.172	0.233	0.254	21.60	Not stated
4	0.009	0.004	0.004	0.030	0.012	0.014	4.00	4.00
5	0.041	0.039	0.042	0.134	0.130	0.139	10.70	10.70
6	0.003	0.003	0.004	0.010	0.009	0.012	2.67	2.67
7	0.046	0.052	0.050	0.150	0.170	0.166	7.20	7.20
8	0.004	0.003	0.003	0.013	0.010	0.011	2.00	2.00
9	0.094	0.099	0.103	0.308	0.326	0.338	3.80	Not stated
10	0.004	0.003	0.003	0.013	0.009	0.011	1.60	1.60
11	0.200	0.202	0.206	0.656	0.663	0.676	3.10	3.10
12	0.005	0.003	0.003	0.017	0.010	0.011	1.33	1.33
13	0.218	0.216	0.216	0.715	0.710	0.708	2.00	2.00
14	0.004	0.003	0.004	0.012	0.009	0.015	--	--
15	0.175	0.173	0.172	0.575	0.568	0.565	--	--
16	0.004	0.003	0.005	0.014	0.010	0.015	--	--
17	0.052	0.050	0.052	0.170	0.163	0.169	--	--
18	0.003	0.004	0.004	0.011	0.014	0.012	--	--
19	0.084	0.083	0.081	0.276	0.273	0.267	--	--
20	0.003	0.004	0.004	0.011	0.013	0.012	--	--
21	0.111	0.110	0.116	0.364	0.360	0.381	--	--
22	0.004	0.004	0.004	0.012	0.014	0.013	--	--

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23	0.139	0.128	0.136	0.458	0.419	0.448	--	--
24	0.005	0.005	0.004	0.016	0.016	0.012	--	--
25	0.158	0.176	0.172	0.518	0.579	0.565	--	--
26	0.004	0.003	0.003	0.012	0.011	0.011	--	--
27	0.178	0.176	0.178	0.583	0.578	0.583	--	--
28	0.004	0.004	0.004	0.014	0.012	0.012	--	--
29	0.134	0.157	0.144	0.442	0.516	0.472	--	--
30	0.004	0.004	0.004	0.013	0.012	0.014	--	--
31	0.111	0.105	0.106	0.363	0.345	0.347	--	--
32	0.004	0.005	0.004	0.013	0.016	0.014	--	--
33	0.079	0.074	0.081	0.259	0.243	0.267	--	--
34	0.005	0.004	0.004	0.015	0.013	0.013	--	--
35	0.060	0.070	0.067	0.196	0.229	0.220	--	--
36	0.005	0.004	0.006	0.016	0.012	0.018	--	--
37	0.051	0.054	0.059	0.168	0.177	0.195	--	--
38	0.005	0.005	0.006	0.017	0.017	0.021	--	--
39	0.052	0.050	0.047	0.171	0.166	0.153	--	--
40	0.006	0.004	0.008	0.018	0.015	0.026	--	--
THD	-	-	-	1.728	1.764	1.771	23	13
PWHD	-	-	-	6.779	6.955	6.936	23	22
Remark: I_{ref}=30.43 A								

3. Power Quality – Voltage fluctuations and Flicker:

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (i.e. 50 kW) these tests should be undertaken in accordance with Annex A.7.1.4.3. Results should be normalised to a standard source impedance, or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (i.e. 50 kW) the installation must be designed in accordance with EREC P28.

The standard test impedance is 0.4 Ω for a single phase **Power Generating Module** (and for a two phase unit in a three phase system) and 0.24 Ω for a three phase **Power Generating Module** (and for a two phase unit in a split phase system). Please ensure that both test and standard impedance are completed on this form. If the test impedance (or the measured impedance) is different to the standard impedance, it must be normalised to the standard impedance as follows (where the **Power Factor** of the generation output is 0.98 or above):

d max normalised value = (Standard impedance / Measured impedance) x Measured value.

Where the **Power Factor** of the output is under 0.98 then the X to R ratio of the test impedance should be close to that of the standard impedance.

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The stopping test should be a trip from full load operation.

The duration of these tests needs to comply with the particular requirements set out in the testing notes for the technology under test.

The test date and location must be declared.

Test start date	2024-12-24	Test end date	2024-12-24
Test location	Shanghai Moorewatt Energy Technology Co., Ltd. 3rd Floor, Building 2, No. 200 Zhangheng Road, China (Shanghai) Pilot Free Trade Zone, 201204 Shanghai, PEOPLE'S REPUBLIC OF CHINA		

		Starting			Stopping			Running	
		d max	d c	d(t)	d max	d c	d(t)	Pst	Plt 2 hours
Measured Values at test impedance	L1-N	0.498	0.004	0	0.502	0.138	0	0.021	0.012
	L2-N	0.499	0.004	0	0.504	0.009	0	0.020	0.012
	L3-N	0.499	0.004	0	0.504	0.009	0	0.020	0.012
Normalised to standard impedance	L1-N	0.498	0.004	0	0.502	0.138	0	0.021	0.012
	L2-N	0.499	0.004	0	0.504	0.009	0	0.020	0.012
	L3-N	0.499	0.004	0	0.504	0.009	0	0.020	0.012
Normalised to required maximum impedance		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Limits set under BS EN 61000-3-11		4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

Test Impedance	R	0.24	Ω	X	0.15	Ω
Standard Impedance	R	0.2 *	Ω	X	0.15 *	Ω
Maximum Impedance	R	N/A	Ω	X	N/A	Ω

* Applies to three phase and split single phase **Power Generating Module**s.

4. Power quality. DC injection. The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three defined power levels ±5%. At 230 V a 50 kW three phase **Inverter** has a current output of 217 A so DC limit is 543 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.

The % DC injection ("as % of rated AC current" below) is calculated as follows:

% DC injection = Recorded DC value in Amps / Base current

where the base current is the **Registered Capacity** (W) / Vphase. The % DC injection should not be

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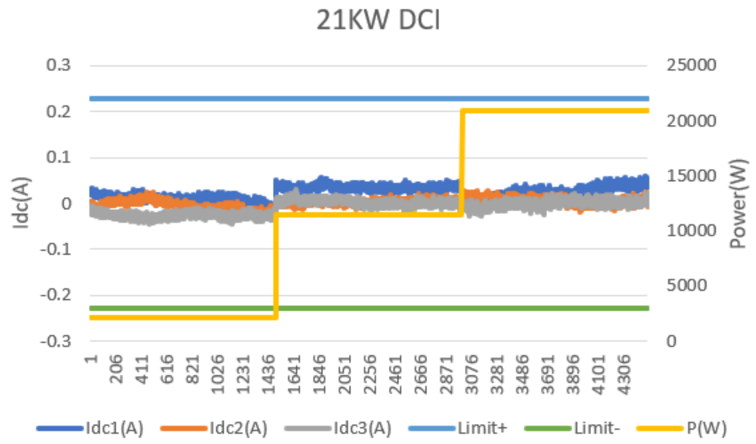
greater than 0.25%.									
Test power level	10%			55%			100%		
	L1	L2	L3	L1	L2	L3	L1	L2	L3
Recorded value (A)	0.012	0.010	0.025	0.035	0.005	0.006	0.024	0.008	0.006
As % of rated AC current	0.013 %	0.011 %	0.027 %	0.038 %	0.005 %	0.007 %	0.026 %	0.009 %	0.007 %
Limit %	0.25			0.25			0.25		
Remark: Ir=30.43 A									



5. Power Factor: The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity** and the measured **Power Factor** must be greater than 0.95 to pass. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2.

Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required.

Voltage	0.94 p.u. (216.2 V)	1 p.u. (230 V)	1.1 p.u. (253 V)
Measured value (L1/L2/L3)	0.999/0.999/0.999	0.999/0.999/0.999	0.999/0.999/0.999
Power Factor Limit	>0.95	>0.95	>0.95

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6. Protection – Frequency tests: These tests should be carried out in accordance with the Annex A.7.1.2.3. For trip tests, frequency and time delay should be stated. For "no trip tests", "no trip" can be stated.						
-25°C						
Function	Setting		Trip test		"No trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.48Hz	20.071s	47.7Hz / 30 s	No trip
U/F stage 2	47Hz	0.5s	46.98Hz	0.594s	47.2Hz / 19.5 s	No trip
					46.8Hz / 0.45 s	No trip
OF	52Hz	0.5s	52.02Hz	0.554s	51.8Hz / 120 s	No trip
					52.2Hz / 0.45 s	No trip
Note. For frequency trip tests the frequency required to trip is the setting ± 0,1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The "No trip tests" need to be carried out at the setting ± 0,2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						
+25°C						
Function	Setting		Trip test		"No trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.48Hz	20.071s	47.7Hz / 30 s	No trip
U/F stage 2	47Hz	0.5s	46.98Hz	0.589s	47.2Hz / 19.5 s	No trip

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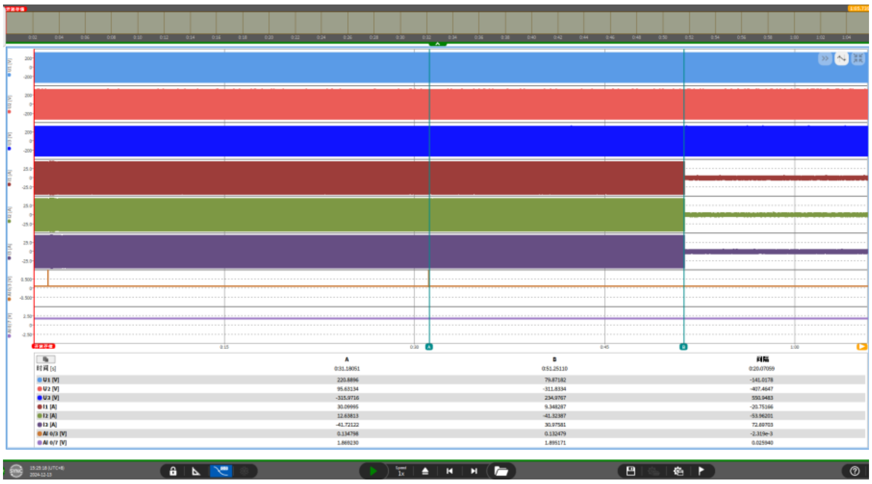
					46.8Hz / 0.45 s	No trip
OF	52Hz	0.5s	52.02Hz	0.588s	51.8Hz / 120 s	No trip
					52.2Hz / 0.45 s	No trip
Note. For frequency trip tests the frequency required to trip is the setting ± 0,1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0,2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						
+60°C						
Function	Setting		Trip test		“No trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.48Hz	20.089s	47.7Hz / 30 s	No trip
U/F stage 2	47Hz	0.5s	46.98Hz	0.588s	47.2Hz / 19.5 s	No trip
					46.8Hz / 0.45 s	No trip
OF	52Hz	0.5s	52.02Hz	0.579s	51.8Hz / 120 s	No trip
					52.2Hz / 0.45 s	No trip
Note. For frequency trip tests the frequency required to trip is the setting ± 0,1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0,2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

Test data record for frequency protection measurement and tripping time			
Iteration	Measured trip frequency (Hz)	Deviation from nominal value (%)	Limit (%)
Under frequency stage 1			
1@-25°C	47.48	-0.04	± 0.2
2@+25°C	47.48	-0.04	± 0.2
3@+60°C	47.48	-0.04	± 0.2

Verification of disconnecting time		
Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Under frequency stage 1@-25°C		
1. 47.8Hz—47.2Hz (UF st1 trip setting minus 0.3Hz)	20.071	
Under frequency stage 1@+25°C		

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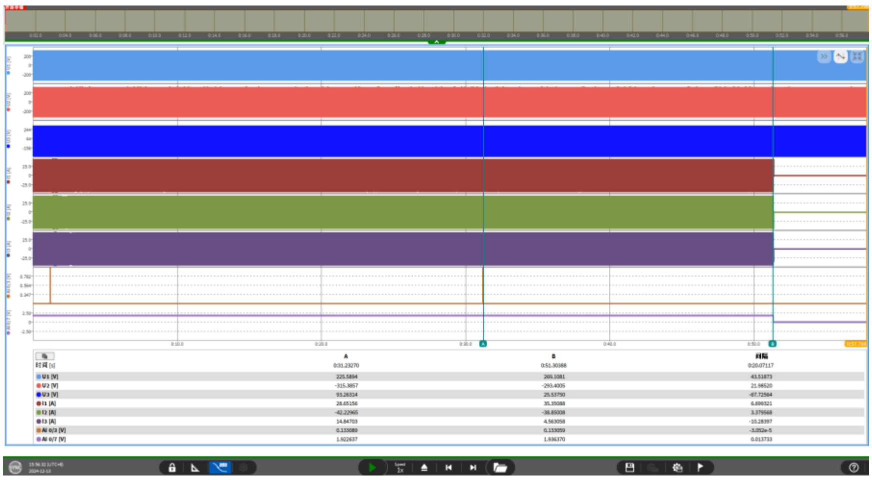
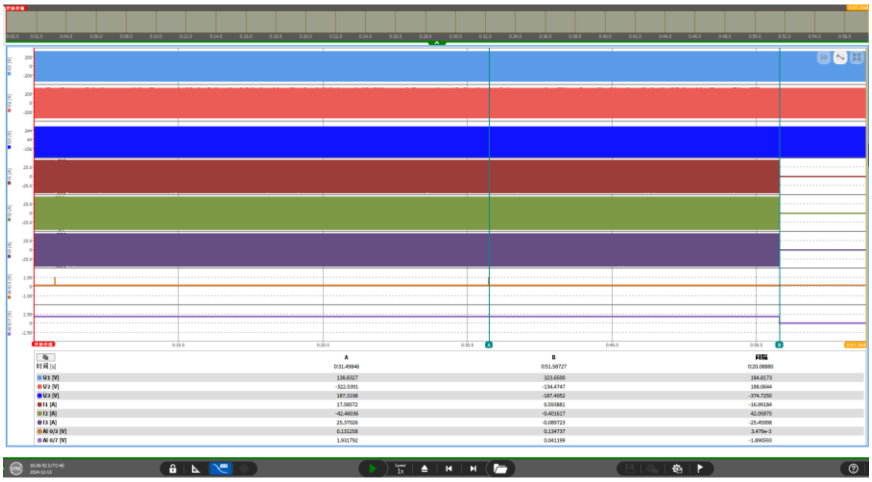
1. 47.8Hz—47.2Hz (UF st1 trip setting minus 0.3Hz)	20.071	
Under frequency stage 1@+60°C		
1. 47.8Hz—47.2Hz (UF st1 trip setting minus 0.3Hz)	20.089	

No trip tests - U/F stage 1

Frequency	Hold on time	Confirm no trip
47.7Hz (U/F st1 trip setting plus 0.2Hz)	30 s	No trip

Iteration	Measured trip frequency (Hz)	Deviation from nominal value (%)	Limit (%)
Under frequency stage 2			
1@-25°C	46.98	-0.04	± 0.2

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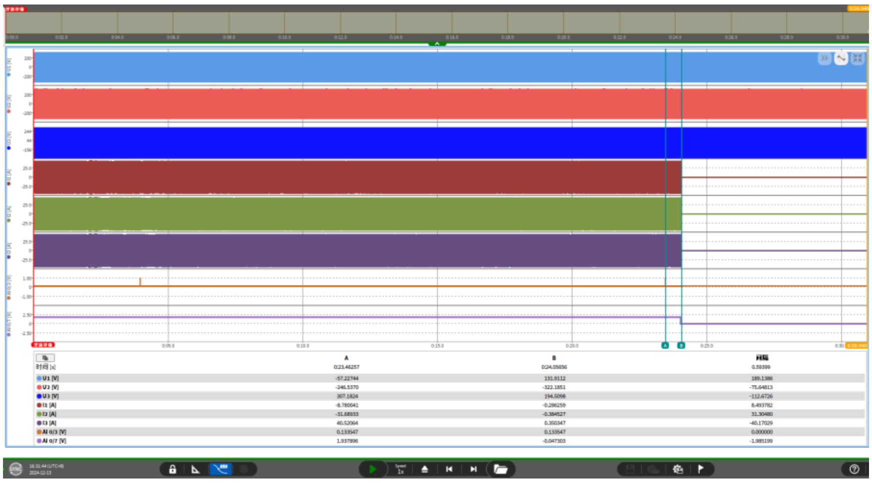
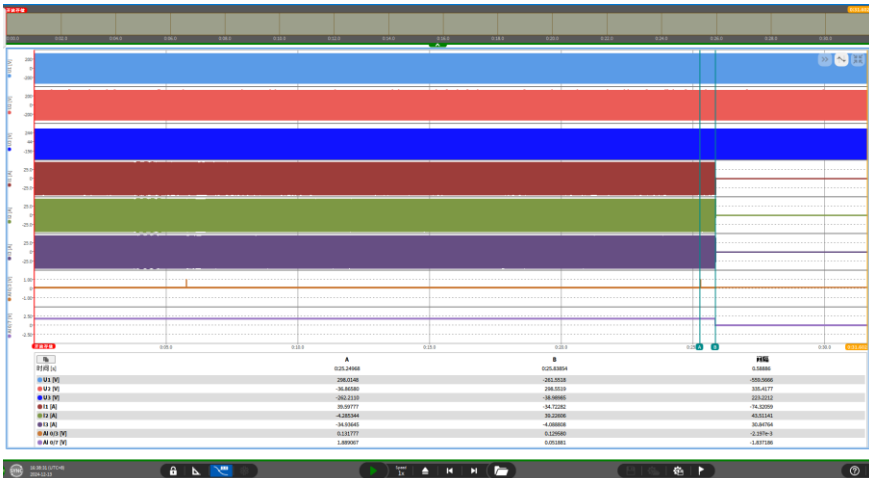
2@+25°C	46.98	-0.04	± 0.2
3@+60°C	46.98	-0.04	± 0.2
Verification of disconnecting time			
Iteration	Disconnection time (s)	Oscilloscope recorded waveforms	
Under frequency stage 2@-25°C			
1. 47.3Hz—46.7Hz (UF st2 trip setting minus 0.3Hz)	0.594		
Under frequency stage 2@+25°C			
1. 47.3Hz—46.7Hz (UF st2 trip setting minus 0.3Hz)	0.589		
Under frequency stage 2@+60°C			

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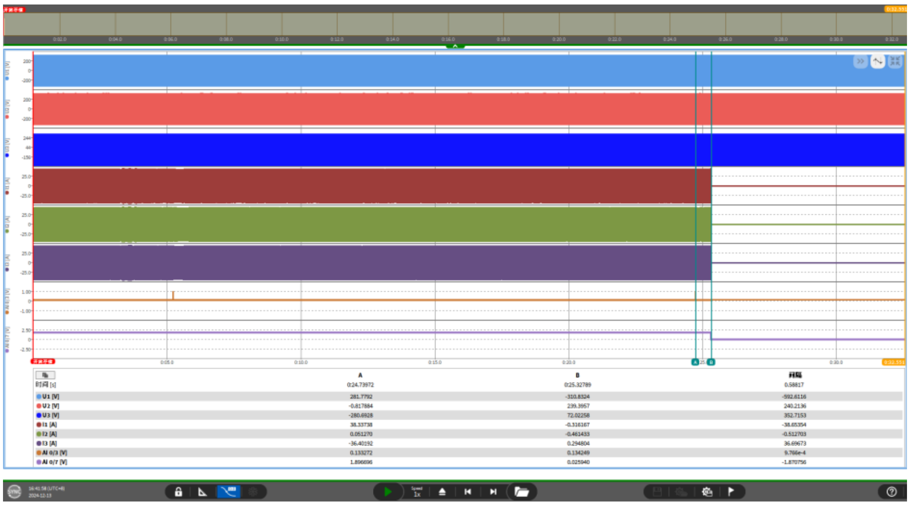
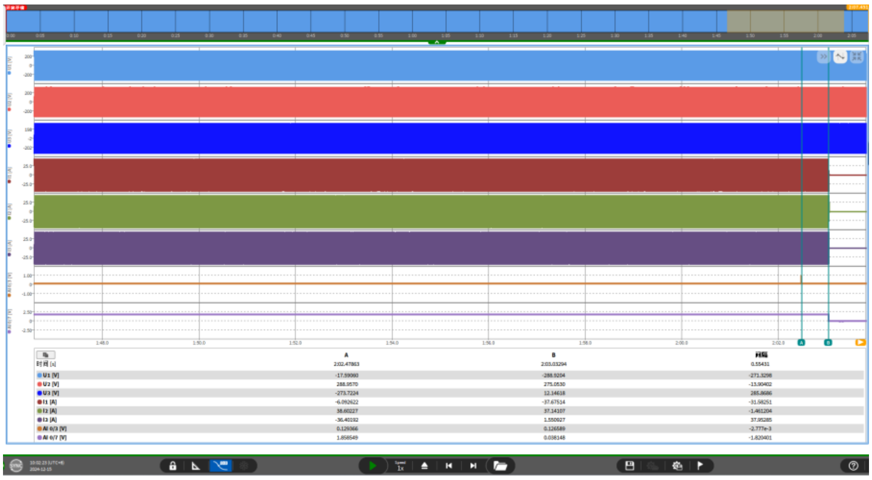
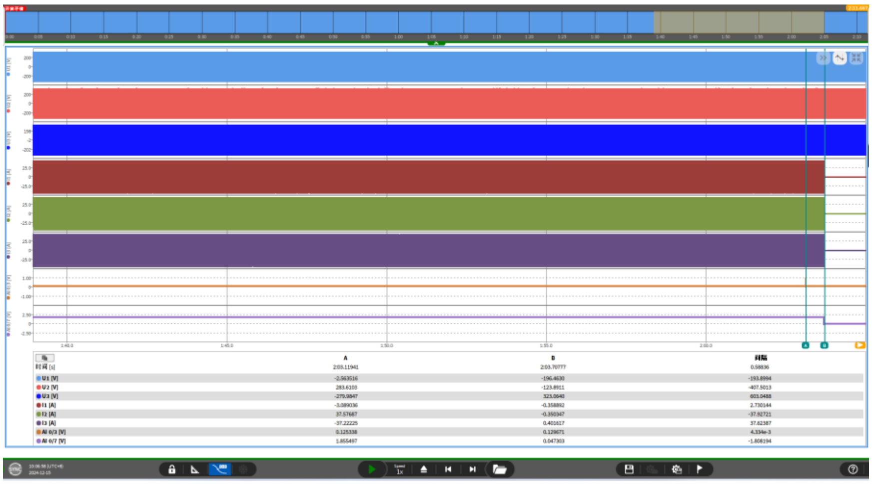
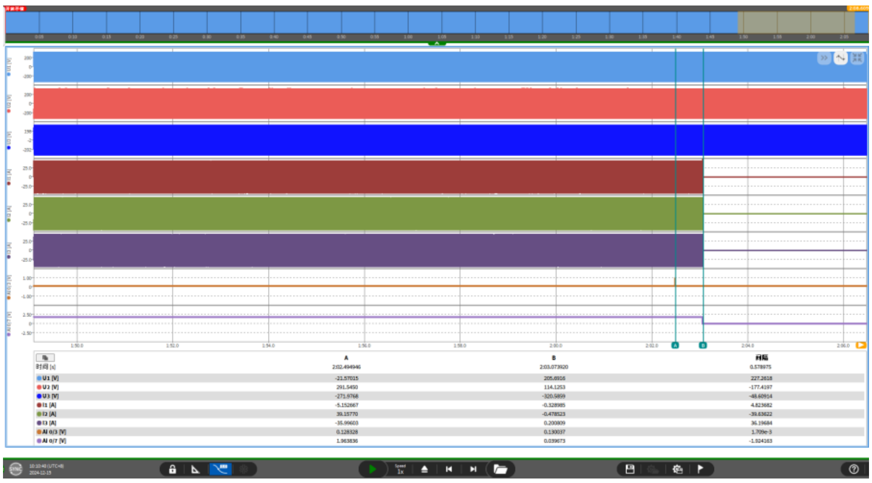
Zone, Changzhou City, Jiangsu Province, P. R. China

1. 47.3Hz—46.7Hz (UF st2 trip setting minus 0.3Hz)	0.588	

No trip tests - U/F stage 2		
Frequency	Hold on time	Confirm no trip
47.2Hz (U/F st2 trip setting plus 0.2Hz)	19.5 s	No trip
46.8Hz (U/F st2 trip setting minus 0.2Hz)	0.45 s	No trip

Iteration	Measured trip frequency (Hz)	Deviation from nominal value (%)	Limit (%)
Over frequency			
1@-25°C	52.02	0.04	± 0.2
2@+25°C	52.02	0.04	± 0.2
3@+60°C	52.02	0.04	± 0.2
Verification of disconnecting time			

Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Over frequency stage 1@-25°C		

1. 51.7Hz—52.3Hz (OF trip setting plus 0.3Hz)	0.554	
Over frequency stage 1@+25°C		
1. 51.7Hz—52.3Hz (OF trip setting plus 0.3Hz)	0.588	
Over frequency stage 1@+60°C		
1. 51.7Hz—52.3Hz (OF trip setting plus 0.3Hz)	0.579	

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Product Service

No trip tests - O/F		
Frequency	Hold on time	Confirm no trip
51.8Hz (O/F trip setting minus 0.2Hz)	120 s	No trip
52.2Hz (O/F trip setting plus 0.2Hz)	0.45 s	No trip
Remark: Channels description in above waveforms: Channel 1,2,3: voltage signal Channel 4,5,6: current signal Channel 7: trigger signal		

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Calibration and Accuracy Tests										
(-25°C)										
Setting	Time Delay	Pickup Frequency				Relay Operating Time				
Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52 Hz	0.5 s	51.90 Hz	52.02Hz	52.10 Hz	Pass	51.7-52.3 Hz	0.50 s	0.554s	0.60 s	Pass
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20 s	47.40 Hz	47.48Hz	47.60 Hz	Pass	47.8-47.2 Hz	20.0 s	20.071s	20.2 s	Pass
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	46.90 Hz	46.98Hz	47.10 Hz	Pass	47.3-46.7 Hz	0.50 s	0.594s	0.60 s	Pass
(+25°C)										
Setting	Time Delay	Pickup Frequency				Relay Operating Time				
Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52 Hz	0.5 s	51.90 Hz	52.02Hz	52.10 Hz	Pass	51.7-52.3 Hz	0.50 s	0.588s	0.60 s	Pass
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20 s	47.40 Hz	47.48Hz	47.60 Hz	Pass	47.8-47.2 Hz	20.0 s	20.071s	20.2 s	Pass
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	46.90 Hz	46.98Hz	47.10 Hz	Pass	47.3-46.7 Hz	0.50 s	0.589s	0.60 s	Pass
(+60°C)										
Setting	Time Delay	Pickup Frequency				Relay Operating Time				
Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52 Hz	0.5 s	51.90 Hz	52.02Hz	52.10 Hz	Pass	51.7-52.3 Hz	0.50 s	0.579s	0.60 s	Pass
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20 s	47.40 Hz	47.47Hz	47.60 Hz	Pass	47.8-47.2 Hz	20.0 s	20.089s	20.2 s	Pass
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	46.90	46.98Hz	47.10	Pass	47.3-	0.50 s	0.588s	0.60 s	Pass

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		Hz		Hz		46.7 Hz				

7. Protection – Voltage tests: These tests should be carried out in accordance with Annex A.7.2.2.2. For trip tests, voltage and time delay should be stated. For "no trip tests", "no trip" can be stated.

MI-500

-25°C (LV protection)

Function		Setting		Trip test		"No trip tests" All phases at same voltage	
		Voltage	Time delay	Voltage (V)	Time delay (s)	Voltage /time	Confirm no trip
U/V stage	L1–N	0.80 U_{L-N} (184V)	2.5 s	182.98	2.516	0.80 Un + 4V 5.0 s	No trip
	L2–N	0.80 U_{L-N} (184V)	2.5 s	183.01	2.511		
	L3–N	0.80 U_{L-N} (184V)	2.5 s	182.97	2.512		
						0.80 Un - 4V 2.45 s	no trip
O/V stage 1	L1–N	1.14 U_{L-N} (262.2V)	1.0 s	263.23	1.027	1.14 Un - 4V 5.0 s	No trip
	L2–N	1.14 U_{L-N} (262.2V)	1.0 s	263.27	1.014		
	L3–N	1.14 U_{L-N} (262.2V)	1.0 s	263.18	1.018		
O/V stage 2	L1–N	1.19 U_{L-N} (273.7V)	0.5 s	274.65	0.506	1.19 Un - 4V 0.95 s	No trip
	L2–N	1.19 U_{L-N} (273.7V)	0.5 s	274.72	0.517		
	L3–N	1.19 U_{L-N} (273.7V)	0.5 s	274.69	0.512		
						1.19 Un + 4V 0.45 s	No trip

Note for Voltage tests the Voltage required to trip is the setting ±1.5% Vn. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting >±1.5% Vn and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

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+25°C (LV protection)							
Function		Setting		Trip test		"No trip tests" All phases at same voltage	
		Voltage	Time delay	Voltage (V)	Time delay (s)	Voltage /time	Confirm no trip
U/V stage	L1–N	0.80 U_{L-N} (184V)	2.5 s	182.97	2.513	0.80 Un + 4V 5.0 s	No trip
	L2–N	0.80 U_{L-N} (184V)	2.5 s	182.86	2.511		
	L3–N	0.80 U_{L-N} (184V)	2.5 s	182.94	2.519		
						0.80 Un - 4V 2.45 s	no trip
O/V stage 1	L1–N	1.14 U_{L-N} (262.2 V)	1.0 s	263.24	1.020	1.14 Un - 4V 5.0 s	No trip
	L2–N	1.14 U_{L-N} (262.2 V)	1.0 s	263.17	1.007		
	L3–N	1.14 U_{L-N} (262.2 V)	1.0 s	263.25	1.011		
O/V stage 2	L1–N	1.19 U_{L-N} (273.7 V)	0.5 s	274.64	0.509	1.19 Un - 4V 0.95 s	No trip
	L2–N	1.19 U_{L-N} (273.7 V)	0.5 s	274.73	0.501		
	L3–N	1.19 U_{L-N} (273.7 V)	0.5 s	274.78	0.508		
						1.19 Un + 4V 0.45 s	No trip

Note for Voltage tests the Voltage required to trip is the setting ±1.5% Vn. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting >±1.5% Vn and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

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+60°C (LV protection)							
For Type A, Type B and Type C Power Generating Modules intend to be connected to LV (LV setting only suit for the Un=230 V, and also if the Power Generating Modules intend to be connected to High voltage grid, also should use HV setting)							
Function		Setting		Trip test		"No trip tests" All phases at same voltage	
		Voltage	Time delay	Voltage (V)	Time delay (s)	Voltage /time	Confirm no trip
U/V stage	L1–N	0.80 U_{L-N} (184V)	2.5 s	182.84	2.501	0.80 Un + 4V 5.0 s	No trip
	L2–N	0.80 U_{L-N} (184V)	2.5 s	182.93	2.517		
	L3–N	0.80 U_{L-N} (184V)	2.5 s	182.91	2.511		
						0.80 Un - 4V 2.45 s	no trip
O/V stage 1	L1–N	1.14 U_{L-N} (262.2 V)	1.0 s	263.26	1.010	1.14 Un - 4V 5.0 s	No trip
	L2–N	1.14 U_{L-N} (262.2 V)	1.0 s	263.17	1.003		
	L3–N	1.14 U_{L-N} (262.2 V)	1.0 s	263.25	1.008		
O/V stage 2	L1–N	1.19 U_{L-N} (273.7 V)	0.5 s	274.62	0.502	1.19 Un - 4V 0.95 s	No trip
	L2–N	1.19 U_{L-N} (273.7 V)	0.5 s	274.69	0.512		
	L3–N	1.19 U_{L-N} (273.7 V)	0.5 s	274.74	0.513		
						1.19 Un + 4V 0.45 s	No trip
Note for Voltage tests the Voltage required to trip is the setting ±1.5% Vn. The time delay can be							

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measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting >±1.5% Vn and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

Test data record for frequency protection measurement and tripping time

Iteration	Measured voltage(V) and deviation from nominal value (%)		
	Phase L_n-N (V)	Deviation (%Un)	Deviation limit (%Un)
Under voltage			
1 – V_{L1-N} @-25°C	182.98	-0.44	± 1.5
1 – V_{L2-N} @-25°C	183.01	-0.43	± 1.5
1 – V_{L3-N} @-25°C	182.97	-0.45	± 1.5
1 – V_{L1-N} @+25°C	182.97	-0.45	± 1.5
1 – V_{L2-N} @+25°C	182.86	-0.50	± 1.5
1 – V_{L3-N} @+25°C	182.94	-0.46	± 1.5
1 – V_{L1-N} @+60°C	182.84	-0.50	± 1.5
1 – V_{L2-N} @+60°C	182.93	-0.47	± 1.5
1 – V_{L3-N} @+60°C	182.91	-0.47	± 1.5

Verification of disconnecting time

Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Under voltage		
L1-N@-25°C:		

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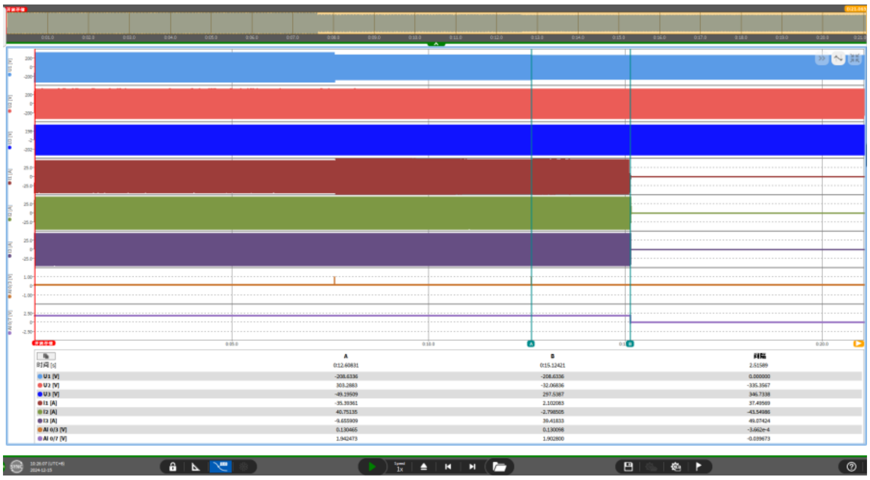
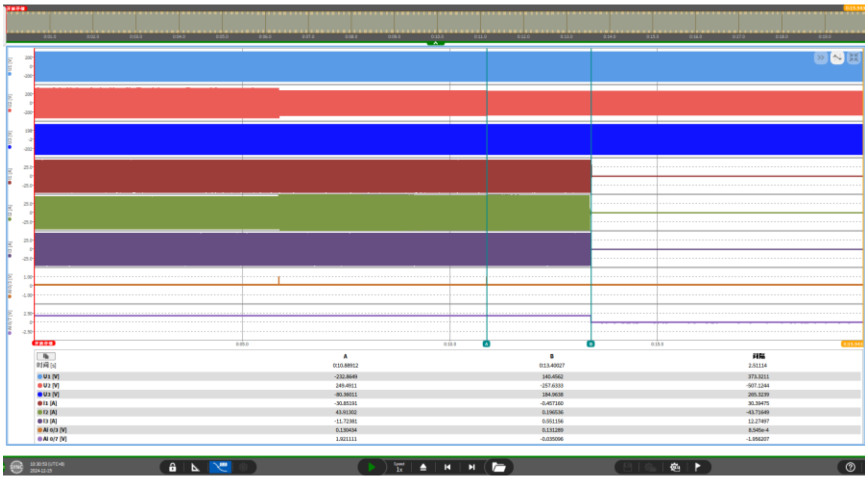
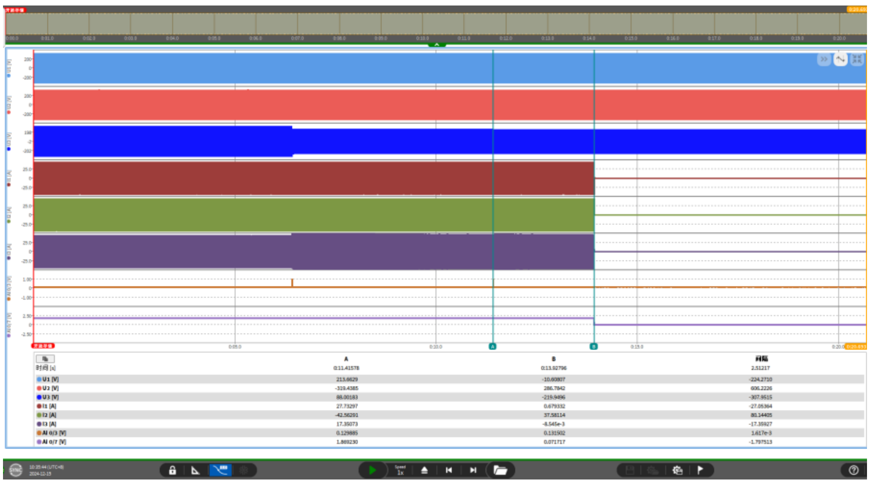
1. 188V—180V (trip setting minus 4V)	2.516	
L2-N@-25°C:		
1. 188V—180V (trip setting minus 4V)	2.511	
L3-N@-25°C:		
1. 188V—180V (trip setting minus 4V)	2.512	

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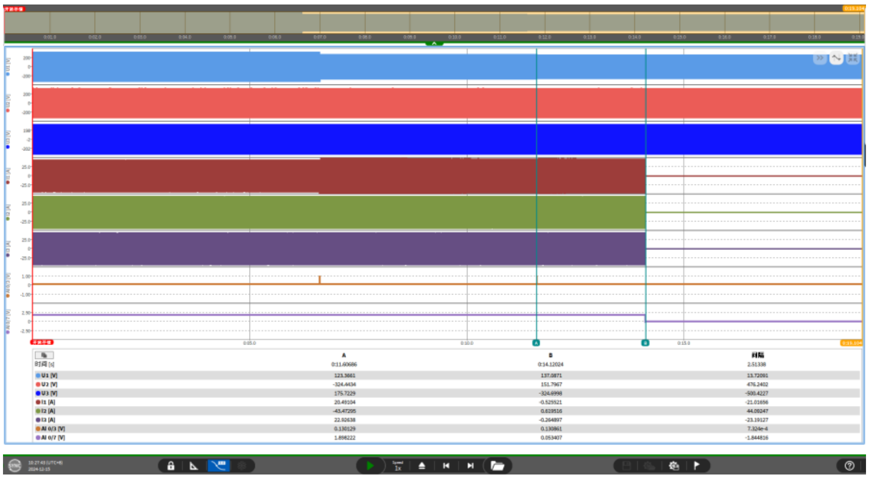
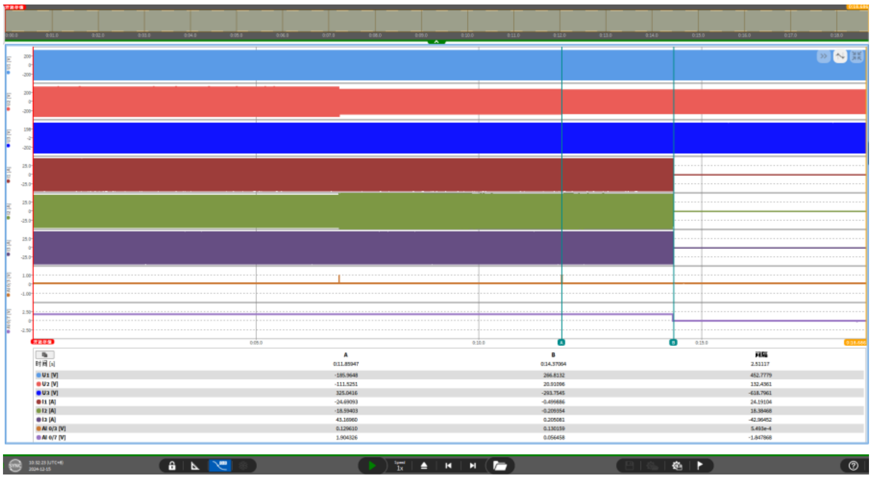
L1-N@+25°C:		
1. 188V—180V (trip setting minus 4V)	2.513	
L2-N@+25°C:		
1. 188V—180V (trip setting minus 4V)	2.511	
L3-N@+25°C:		

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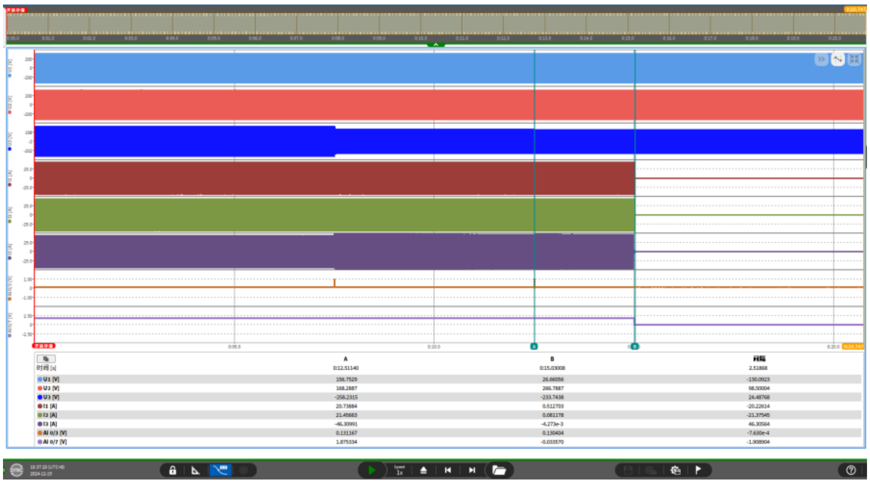
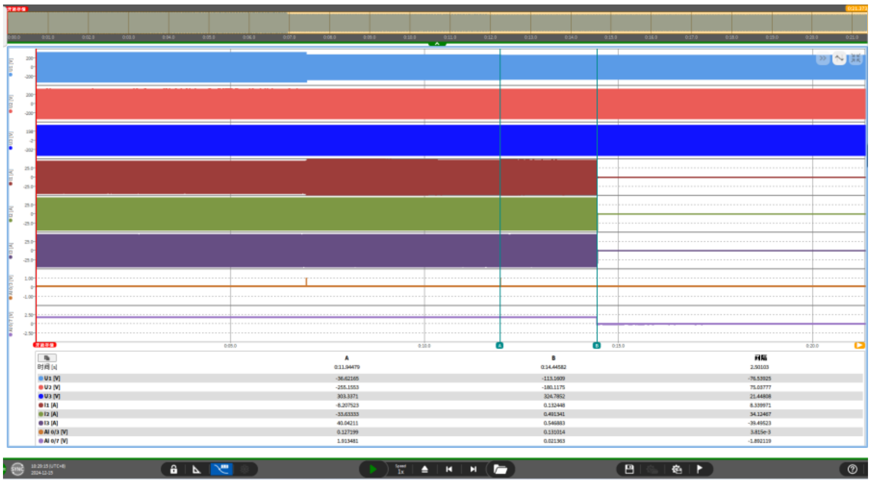
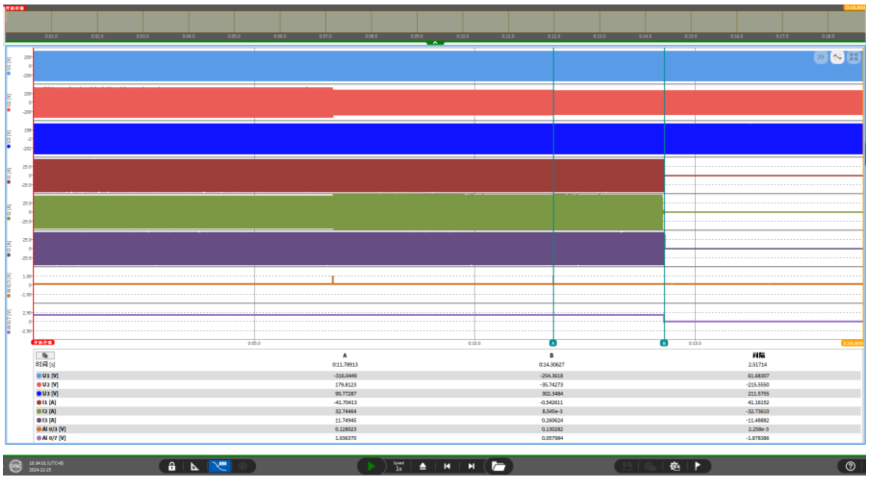
1. 188V—180V (trip setting minus 4V)	2.519	
L1-N@+60°C:		
1. 188V—180V (trip setting minus 4V)	2.501	
L2-N@+60°C:		
1. 188V—180V (trip setting minus 4V)	2.517	

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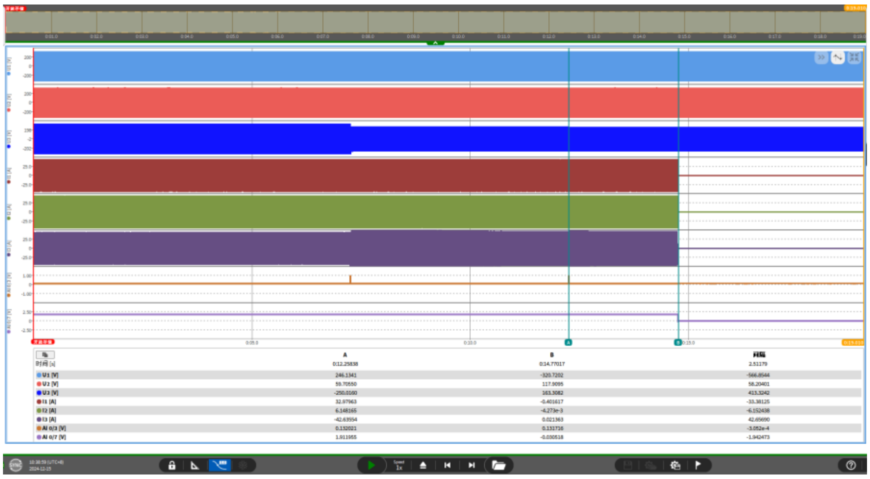
L3-N@+60°C:		
1. 188V—180V (trip setting minus 4V)	2.511	

No trip tests - U/V

voltage	Hold on time	Confirm no trip
$V_{\varphi-N}$: 188V	5s	No trip
$V_{\varphi-N}$: 180V	2.45s	No trip

Iteration	Measured voltage(V) and deviation from nominal value (%)		
	Phase L-N (V)	Deviation (%Un)	Deviation limit (%Un)
Over voltage stage 1			
1 – V_{L1-N} @-25°C	263.23	0.45	± 1.5
1 – V_{L2-N} @-25°C	263.27	0.47	± 1.5
1 – V_{L3-N} @-25°C	263.18	0.43	± 1.5
1 – V_{L1-N} @+25°C	263.24	0.45	± 1.5
1 – V_{L2-N} @+25°C	263.17	0.42	± 1.5
1 – V_{L3-N} @+25°C	263.25	0.46	± 1.5
1 – V_{L1-N} @+60°C	263.26	0.46	± 1.5
1 – V_{L2-N} @+60°C	263.17	0.42	± 1.5

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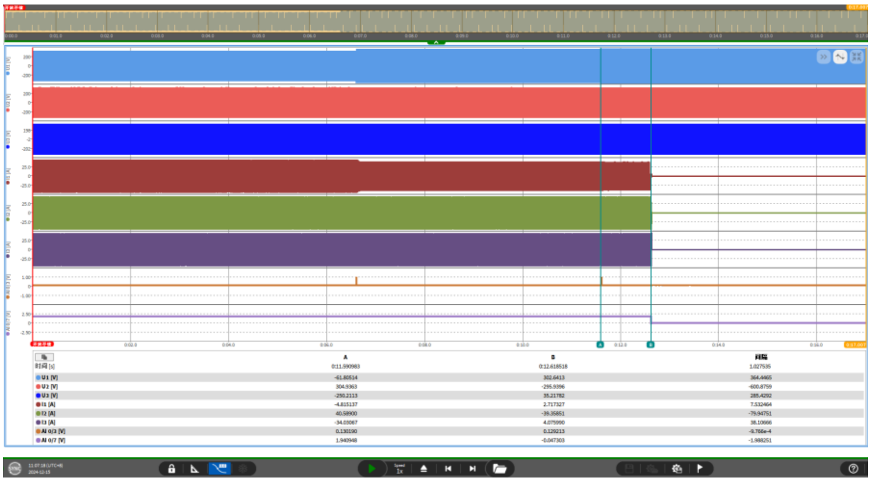
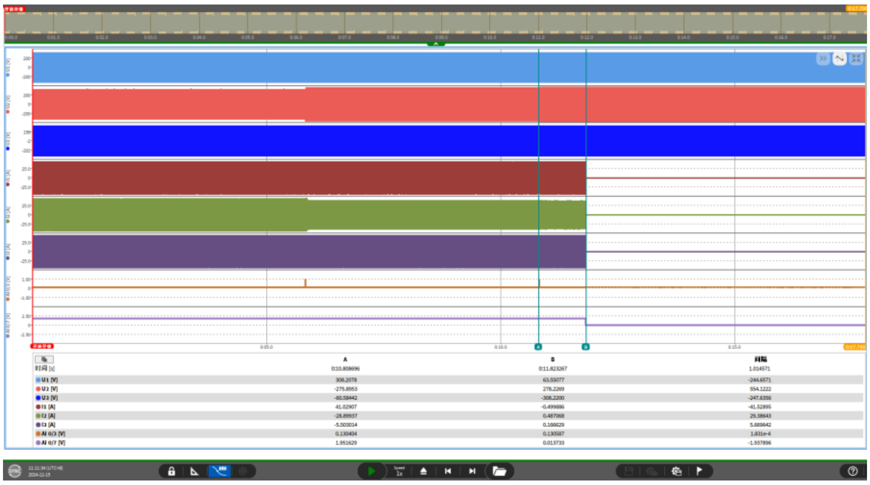
1 – $V_{L3\text{-}N}$ @+60°C	263.25	0.46	± 1.5

Verification of disconnecting time		
Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Over voltage stage 1		
L1-N@-25°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.027	
L2-N@-25°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.015	
L3-N@-25°C:		

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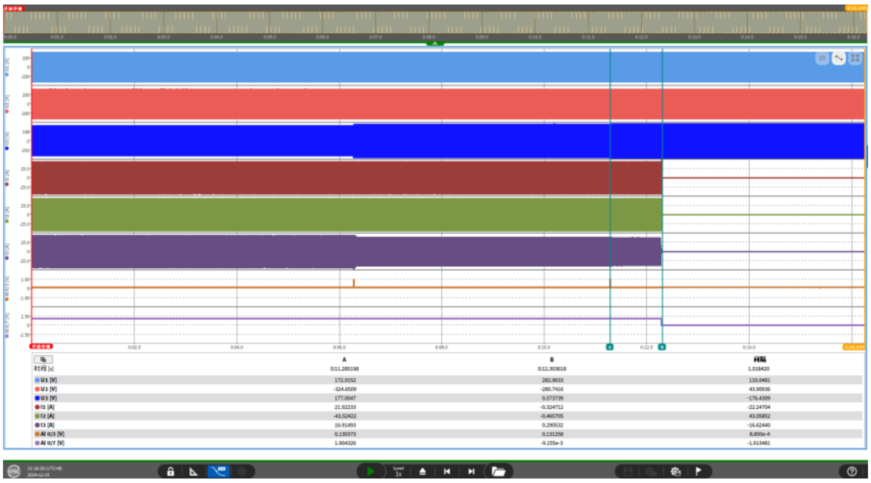
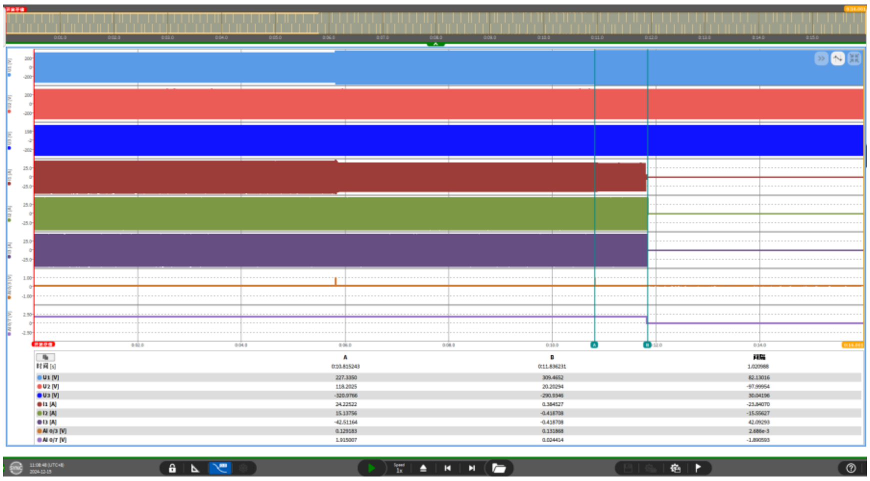
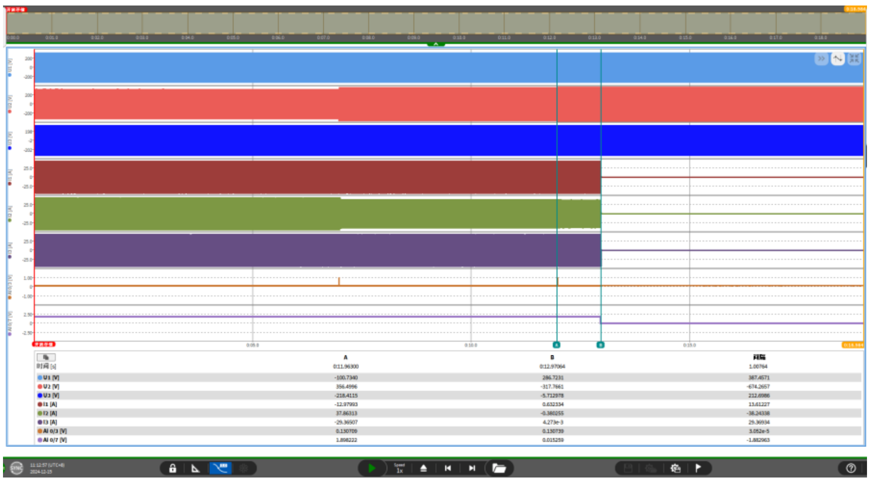
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.018	
L1-N@+25°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.020	
L2-N@+25°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.008	

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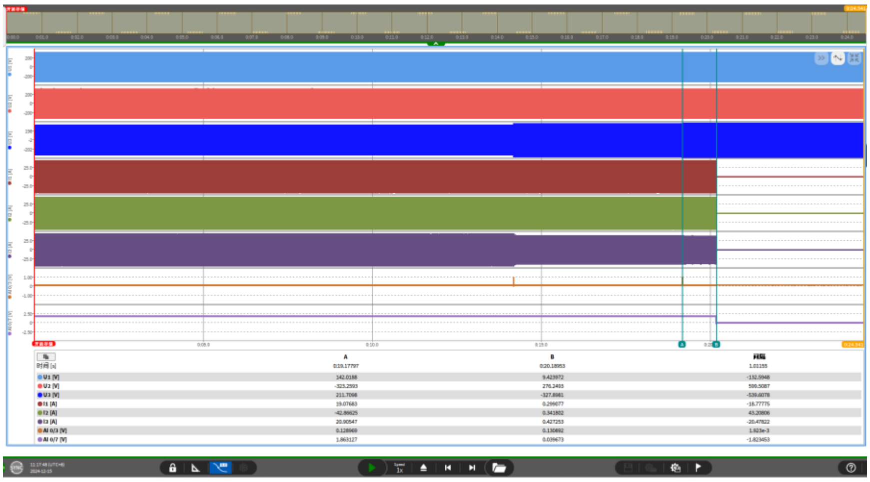
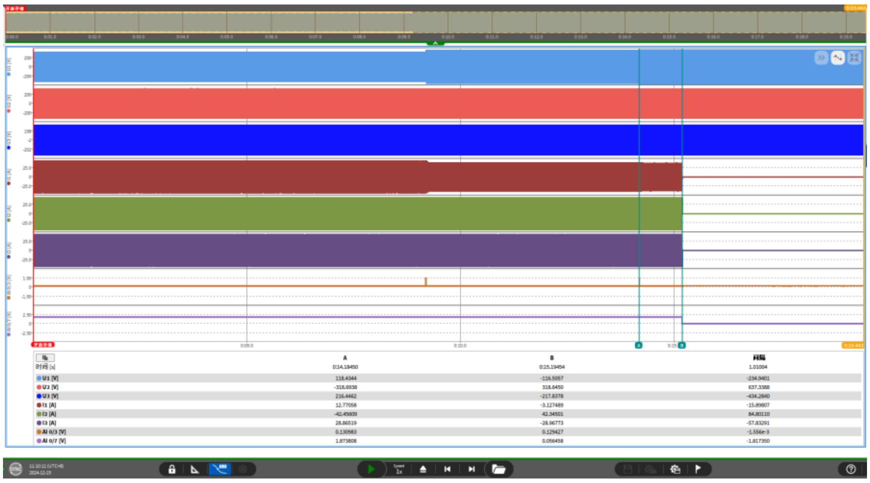
L3-N@+25°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.012	
L-N@+60°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.010	
L-N@+60°C:		

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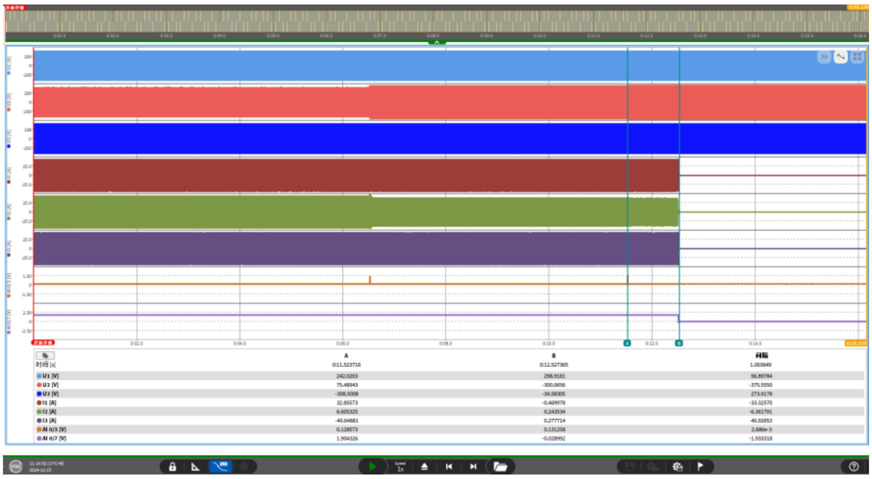
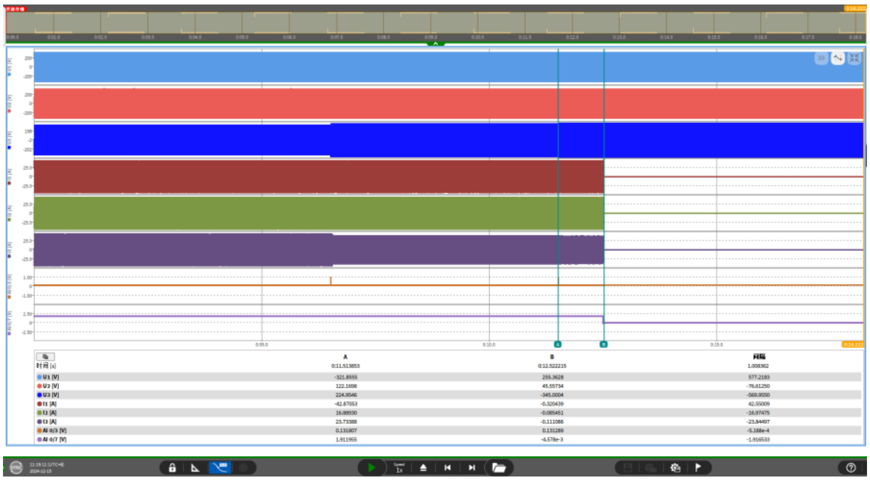
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.004	
L-N@+60°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.008	

No trip tests - O/V stage 1		
voltage	Hold on time	Confirm no trip
$V_{\varphi\text{-}N}$: 258.2V	5 s	No trip

Iteration	Measured voltage(V) and deviation from nominal value (%)		
	Phase L-N (V)	Deviation (%Un)	Deviation limit (%Un)
Over voltage stage 2			
1 – $V_{L1\text{-}N}$ @-25°C	274.65	0.41	± 1.5

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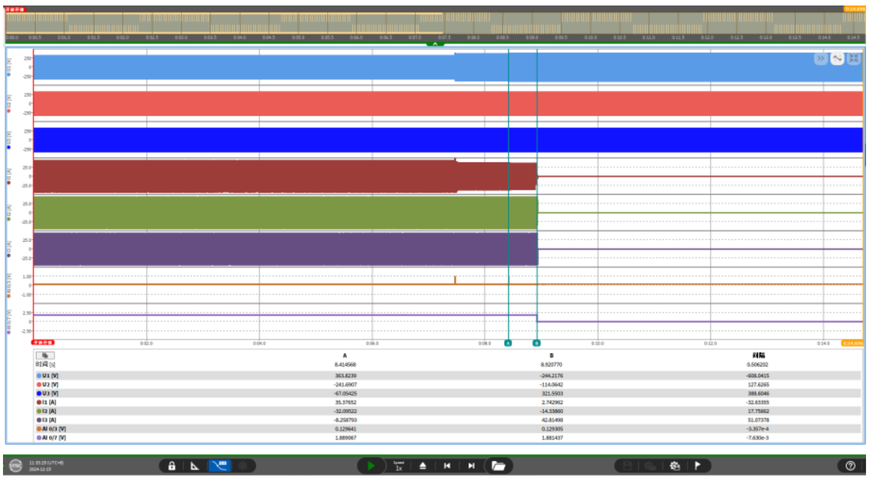
1 – V_{L2-N} @-25°C	274.72	0.44	± 1.5
1 – V_{L3-N} @-25°C	274.69	0.43	± 1.5
1 – V_{L1-N} @+25°C	274.64	0.41	± 1.5
1 – V_{L2-N} @+25°C	274.73	0.45	± 1.5
1 – V_{L3-N} @+25°C	274.78	0.47	± 1.5
1 – V_{L1-N} @+60°C	274.62	0.40	± 1.5
1 – V_{L2-N} @+60°C	274.69	0.43	± 1.5
1 – V_{L3-N} @+60°C	274.74	0.45	± 1.5

Verification of disconnecting time

Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Over voltage stage 2		
L1-N@-25°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.506	
L2-N@-25°C:		

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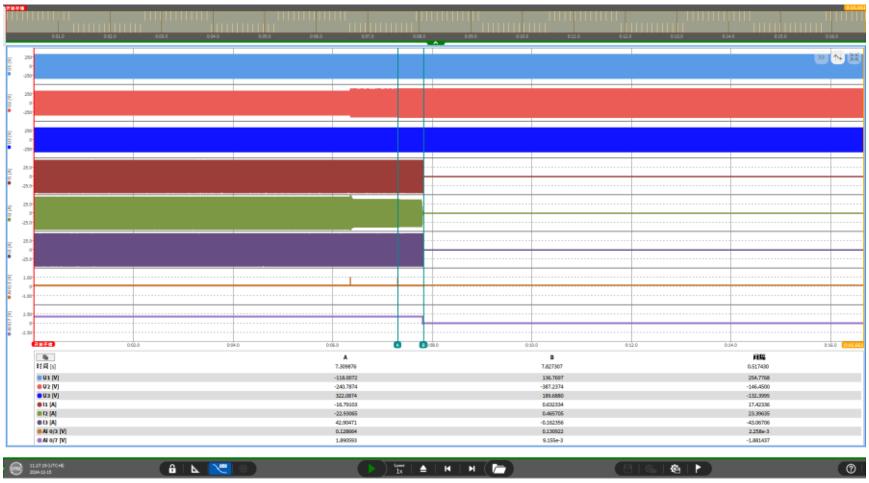
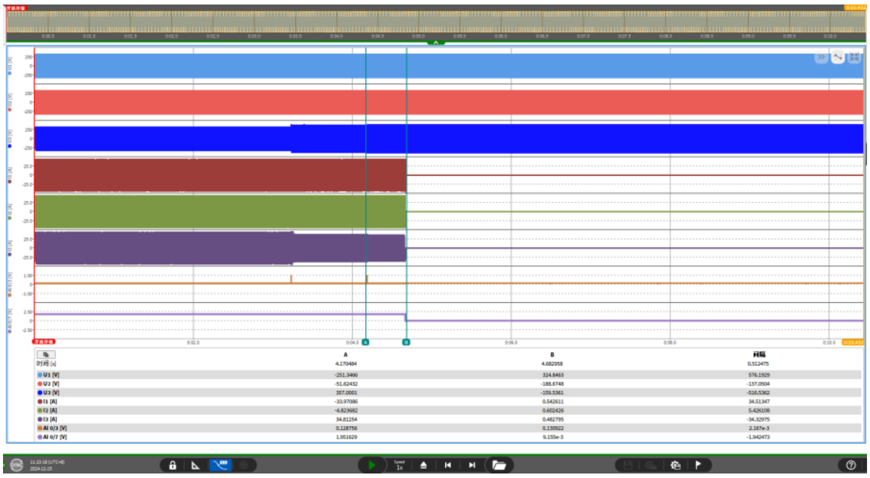
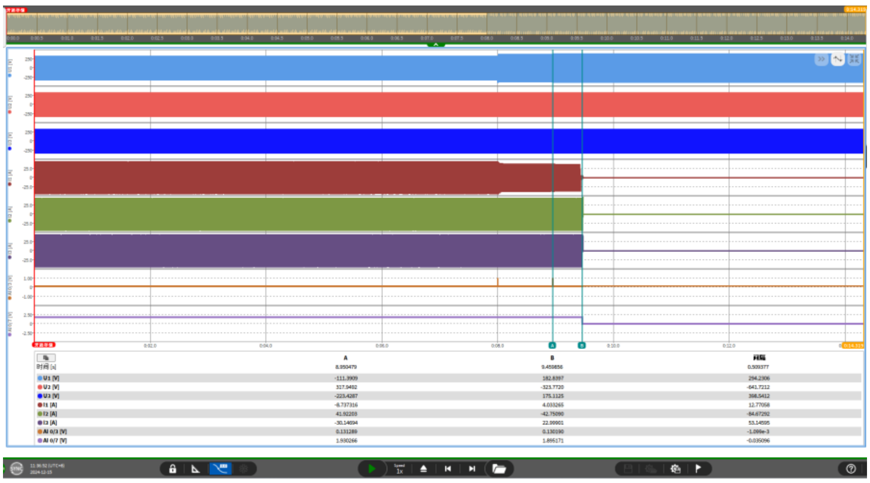
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.517	
L3-N@-25°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.512	
L1-N@+25°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.509	

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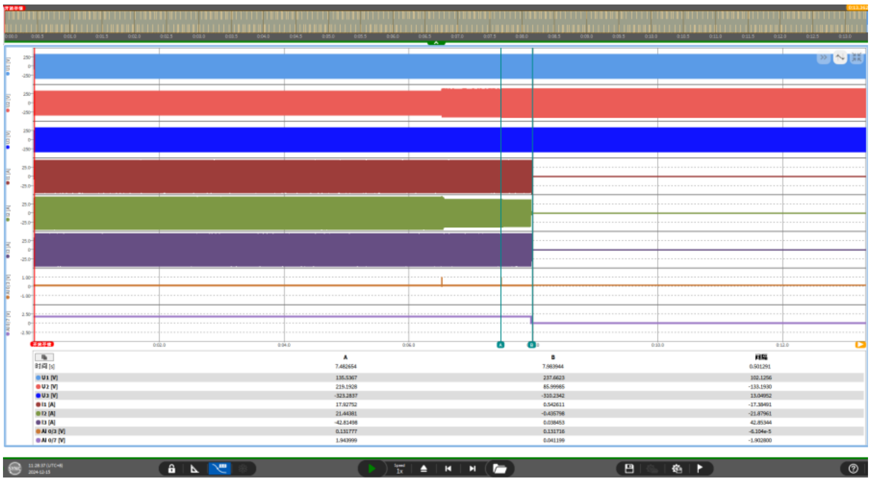
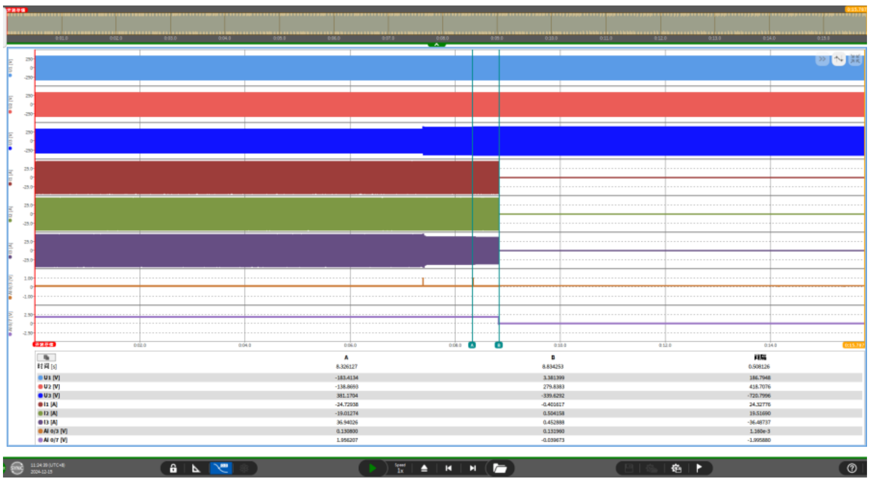
L2-N@+25°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.501	
L3-N@+25°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.508	
L1-N@+60°C:		

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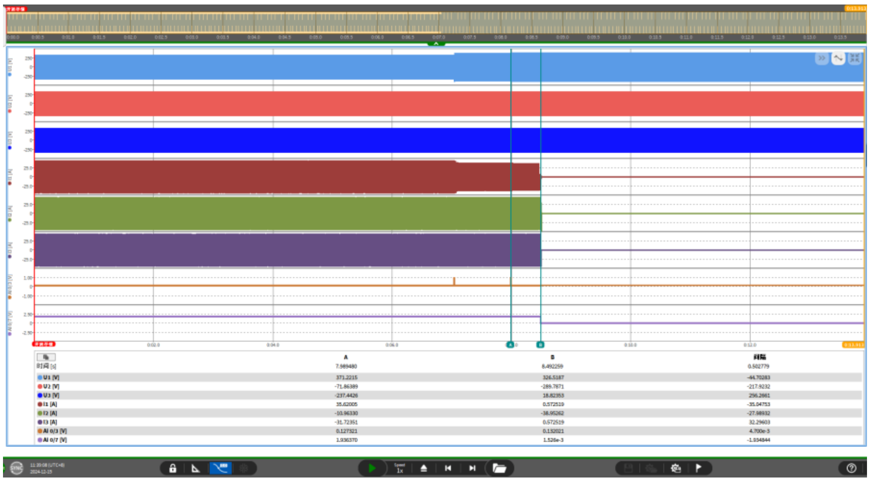
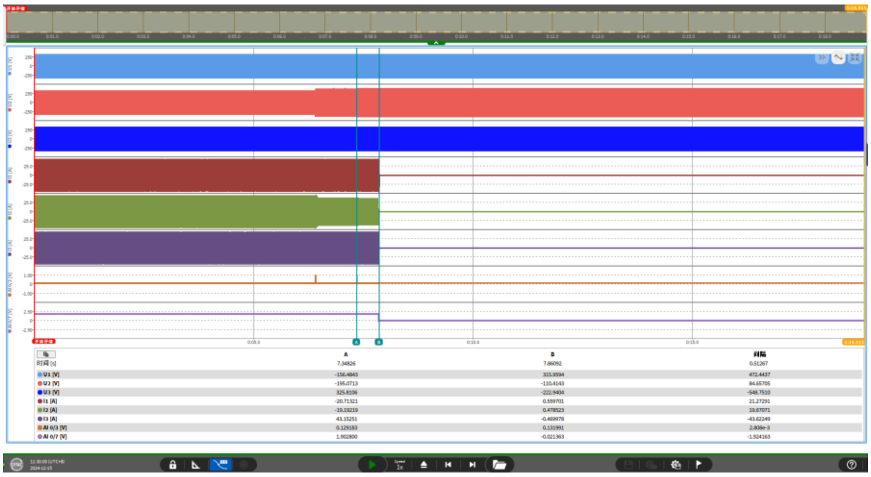
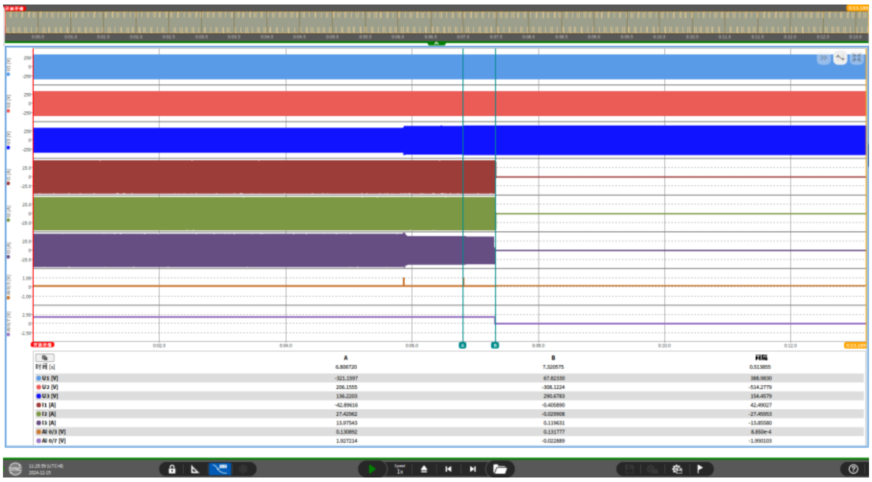
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.503	
L2-N@+60°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.513	
L3-N@+60°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.514	

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No trip tests - O/V stage 2		
voltage	Hold on time	Confirm no trip
$V_{φ\text{-}N}$: 269.7 V	0.95 s	No trip
$V_{φ\text{-}N}$: 277.7 V	0.45 s	No trip
Remark: Channels description in above waveforms: Channel 1: voltage signal Channel 4: current signal Channel 3: trigger signal		

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Calibration and Accuracy Tests												
(-25°C)												
Phase	Setting	Time Delay	Pickup Voltage				Relay Operating Time					
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	262.2 V	1.0 s	258.7 V	263.23 V	265.6 V	Pass	262.2 V	1.0 s	1.027 s	1.1 s	Pass
L2-N	262.2 V	1.0 s	258.7 V	263.27 V	265.6 V	Pass	262.2 V	1.0 s	1.015 s	1.1 s	Pass
L3-N	262.2 V	1.0 s	258.7 V	263.18 V	265.6 V	Pass	262.2 V	1.0 s	1.018 s	1.1 s	Pass
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	273.7V	0.5 s	270.2 V	274.65 V	277.1 V	Pass	273.7V	0.5 s	0.506 s	0.6 s	Pass
L2-N	273.7V	0.5 s	270.2 V	274.72 V	277.1 V	Pass	273.7V	0.5 s	0.517 s	0.6 s	Pass
L3-N	273.7V	0.5 s	270.2 V	274.69 V	277.1 V	Pass	273.7V	0.5 s	0.512 s	0.6 s	Pass
Under Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	184 V	2.5 s	180.5 V	182.98 V	187.4 V	Pass	184 V	2.50 s	2.516 s	2.60 s	Pass
L2-N	184 V	2.5 s	180.5 V	183.01 V	187.4 V	Pass	184 V	2.50 s	2.511 s	2.60 s	Pass
L3-N	184 V	2.5 s	180.5 V	182.97 V	187.4 V	Pass	184 V	2.50 s	2.512 s	2.60 s	Pass
(+25°C)												
Phase	Setting	Time Delay	Pickup Voltage				Relay Operating Time					
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	262.2 V	1.0 s	258.7 V	263.24 V	265.6 V	Pass	262.2 V	1.0 s	1.020 s	1.1 s	Pass
L2-N	262.2 V	1.0 s	258.7 V	263.17 V	265.6 V	Pass	262.2 V	1.0 s	1.008 s	1.1 s	Pass
L3-N	262.2 V	1.0 s	258.7 V	263.25 V	265.6 V	Pass	262.2 V	1.0 s	1.012 s	1.1 s	Pass
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	273.7V	0.5 s	270.2 V	274.64 V	277.1 V	Pass	273.7V	0.5 s	0.509 s	0.6 s	Pass
L2-N	273.7V	0.5 s	270.2 V	274.73 V	277.1 V	Pass	273.7V	0.5 s	0.501 s	0.6 s	Pass
L3-N	273.7V	0.5 s	270.2 V	274.78 V	277.1 V	Pass	273.7V	0.5 s	0.508 s	0.6 s	Pass
Under Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	184 V	2.5 s	180.5 V	182.97 V	187.4 V	Pass	184 V	2.50 s	2.513 s	2.60 s	Pass
L2-N	184 V	2.5 s	180.5 V	182.86 V	187.4 V	Pass	184 V	2.50 s	2.511 s	2.60 s	Pass

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L3-N	184 V	2.5 s	180.5 V	182.94 V	187.4 V	Pass	184 V	2.50 s	2.519 s	2.60 s	Pass
(+60°C)											
Phase	Setting	Time Delay	**Pickup Voltage**				**Relay Operating Time**				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	262.2 V	1.0 s	258.7 V	263.26 V	265.6 V	Pass	262.2 V	1.0 s	1.010 s	1.1 s	Pass
L2-N	262.2 V	1.0 s	258.7 V	263.17 V	265.6 V	Pass	262.2 V	1.0 s	1.004 s	1.1 s	Pass
L3-N	262.2 V	1.0 s	258.7 V	263.25 V	265.6 V	Pass	262.2 V	1.0 s	1.008 s	1.1 s	Pass
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	273.7V	0.5 s	270.2 V	274.62 V	277.1 V	Pass	273.7V	0.5 s	0.503 s	0.6 s	Pass
L2-N	273.7V	0.5 s	270.2 V	274.69 V	277.1 V	Pass	273.7V	0.5 s	0.513 s	0.6 s	Pass
L3-N	273.7V	0.5 s	270.2 V	274.74 V	277.1 V	Pass	273.7V	0.5 s	0.514 s	0.6 s	Pass
Under Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1-N	184 V	2.5 s	180.5 V	182.84 V	187.4 V	Pass	184 V	2.50 s	2.501 s	2.60 s	Pass
L2-N	184 V	2.5 s	180.5 V	182.93 V	187.4 V	Pass	184 V	2.50 s	2.517 s	2.60 s	Pass
L3-N	184 V	2.5 s	180.5 V	182.91 V	187.4 V	Pass	184 V	2.50 s	2.511 s	2.60 s	Pass

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8. Protection – Loss of Mains test: These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.						
These tests should be carried out in accordance with the Annex A.7.1.2.3.						
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5%P Test 7	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. Limit is 0.5 s	0,080	0,093	0,466	0,113	0,096	0,460

Test data recorded for islanding protection according BS EN 62116	
Disconnection limit:	< 1s

No.	P_{EUT} (% of rated)	Reactive power (Q_L)	P_{AC} (% of rated)	Q_{AC} (% of rated)	Run on time (s)	P_{EUT} (kW)	Q_f	V_{dc}	Remarks
1	100	100	0	0	0,753	21	1,00	50	BL
2	66	66	0	0	0,446	14	1,00	38	BL
3	33	33	0	0	0,306	7	0,99	24	BL
4	100	100	0	-5	0,406	21	--	50	IB
5	100	100	0	+5	0,466	21	--	50	IB
6	100	100	-5	-5	0,426	21	--	50	IB
7	100	100	-5	0	0,466	21	--	50	IB
8	100	100	-5	+5	0,457	21	--	50	IB
9	100	100	+5	-5	0,430	21	--	50	IB
10	100	100	+5	0	0,460	21	--	50	IB
11	100	100	+5	+5	0,413	21	--	50	IB
12	66	66	0	-5	0,093	14	--	38	IB
13	66	66	0	-4	0,213	14	--	38	IB
14	66	66	0	-3	0,216	14	--	38	IB
15	66	66	0	-2	0,320	14	--	38	IB
16	66	66	0	-1	0,393	14	--	38	IB

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17	66	66	0	+1	0,353	14	--	38	IB
18	66	66	0	+2	0,336	14	--	38	IB
19	66	66	0	+3	0,230	14	--	38	IB
20	66	66	0	+4	0,170	14	--	38	IB
21	66	66	0	+5	0,096	14	--	38	IB
22	33	33	0	-5	0,080	7	--	24	IB
23	33	33	0	-4	0,156	7	--	24	IB
24	33	33	0	-3	0,166	7	--	24	IB
25	33	33	0	-2	0,193	7	--	24	IB
26	33	33	0	-1	0,236	7	--	24	IB
27	33	33	0	+1	0,233	7	--	24	IB
28	33	33	0	+2	0,210	7	--	24	IB
29	33	33	0	+3	0,156	7	--	24	IB
30	33	33	0	+4	0,136	7	--	24	IB
31	33	33	0	+5	0,113	7	--	24	IB

Loss of Mains Protection, Vector Shift Stability test. This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip under positive / negative vector shift.

	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+50 degrees	No trip

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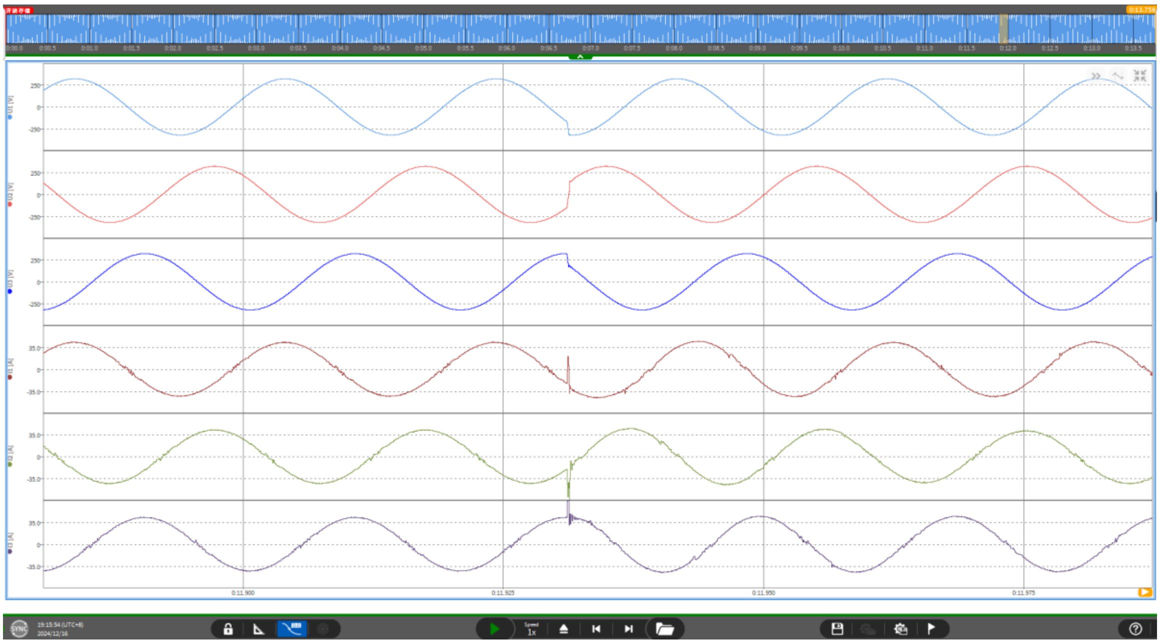
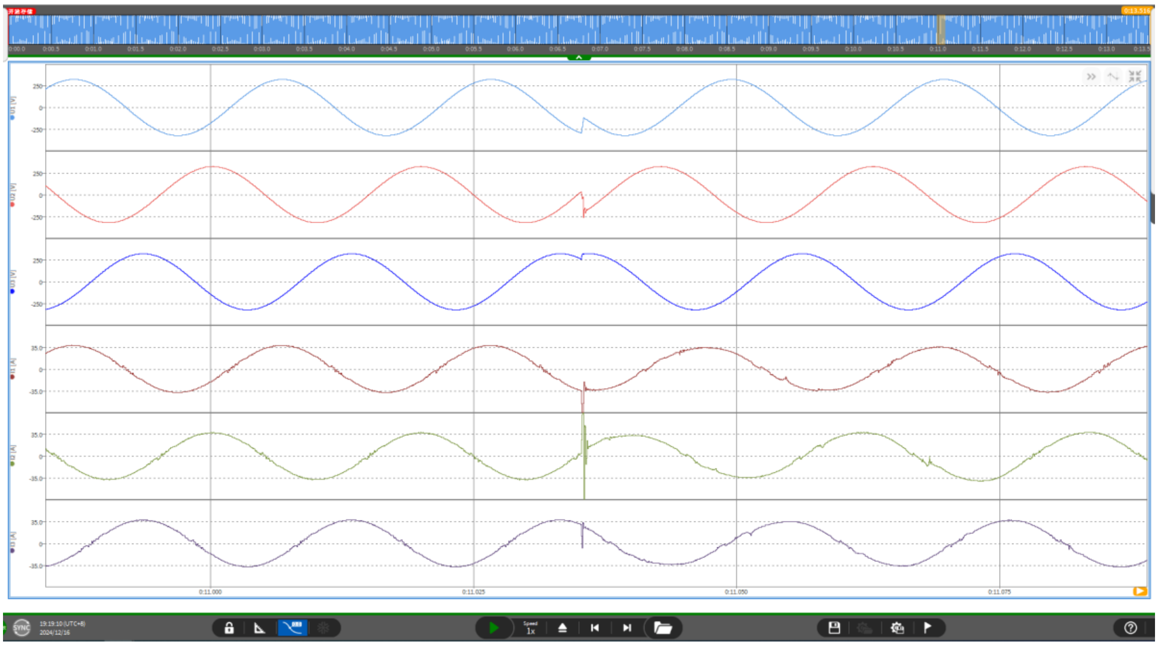
			
Negative Vector Shift	50.5 Hz	- 50 degrees	No trip
			
Loss of Mains Protection, RoCoF Stability test: This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip for the duration of the ramp up and ramp down test.			
Ramp range	Test frequency ramp:	Test Duration	Confirm no trip

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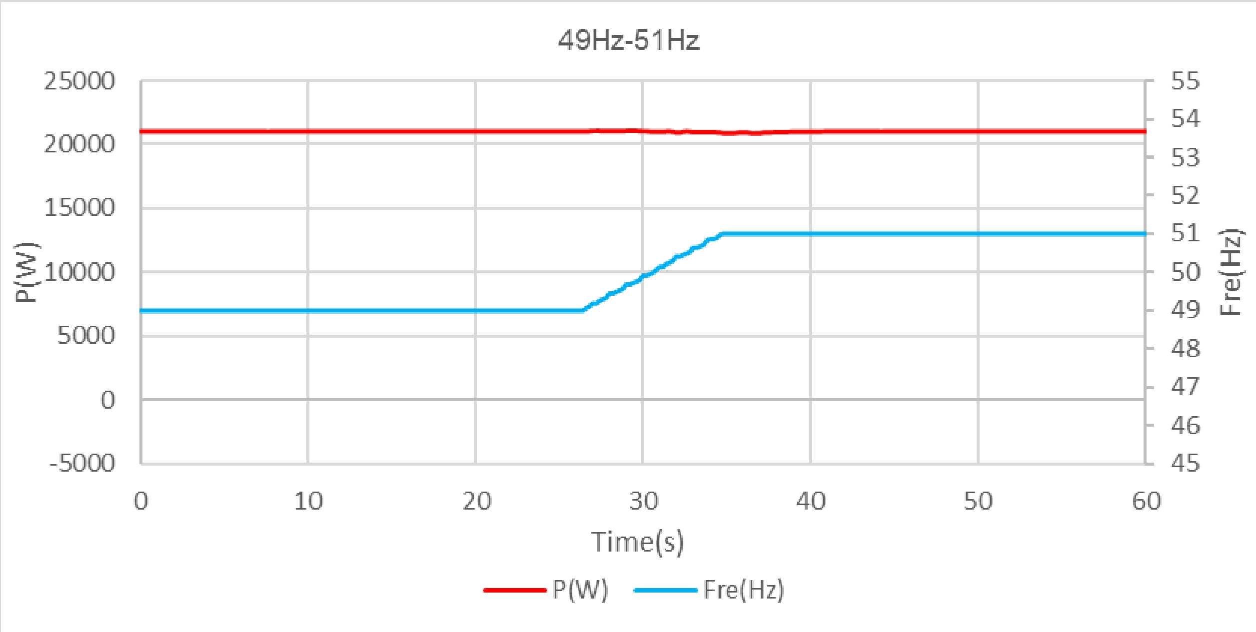
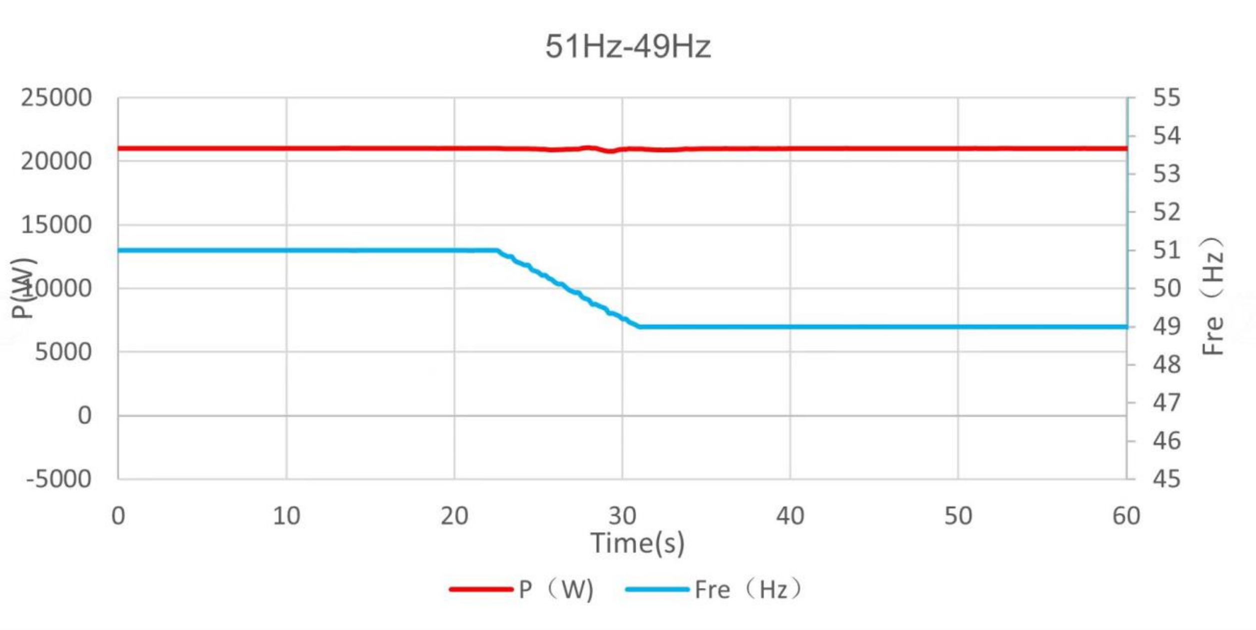
49.0Hz to 51.0Hz	+0.95 Hzs-1	2.1 s	No trip
			
51.0Hz to 49.0Hz	-0.95 Hzs-1	2.1 s	No trip
			
Remark: clause 11.2.2 is taken into consideration			

9. Limited Frequency Sensitive Mode – Over frequency test: The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%.

This test should be carried out in accordance with Annex A.7.1.3, which also contains the measurement

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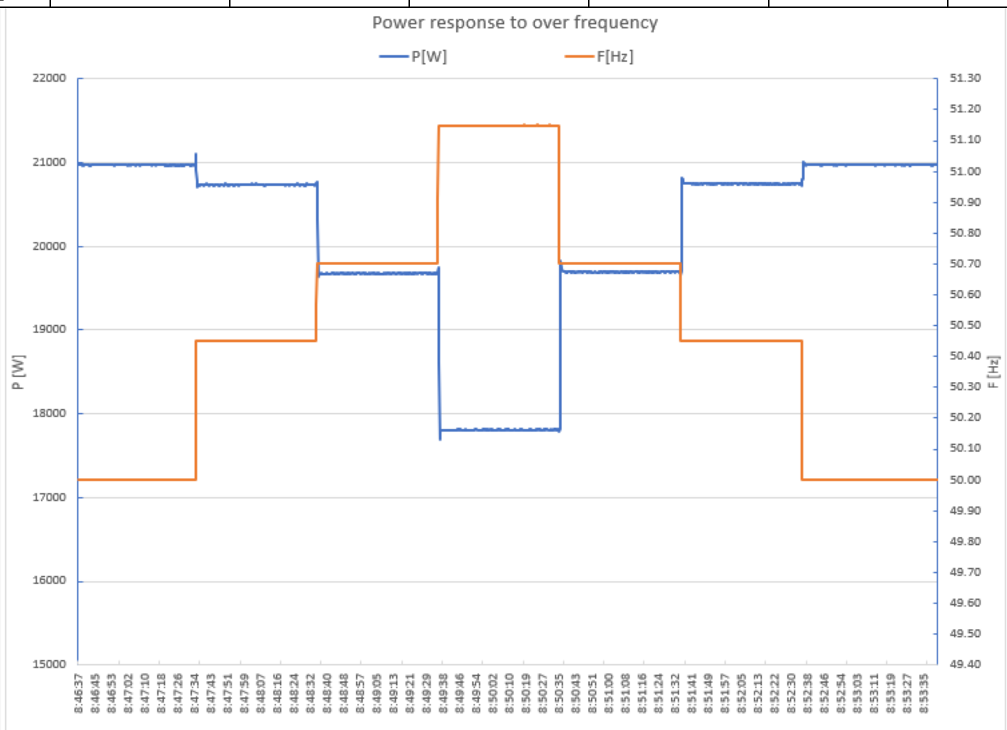
tolerances.						
Active Power response to rising frequency/time plots are attached if frequency injection tests are undertaken in accordance with Annex A.7.2.4.					**Yes**	
Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output (W)	**Δ Active Power** %achieved within 10s **(%Pmax)**	**Required Δ Active Power** %achieved within 10s **(%Pmax)**	Frequency (Hz)	Primary Power Source	**droop %**
Step a) 50.00Hz ±0.01Hz	20970	-	-	50.00	PV simulator (100%Pn)	-
Step b) 50.45Hz ±0.05Hz	20743	-	-	50.45		-
Step c) 50.70Hz ±0.10Hz	19674	5.21	≥3%	50.70		10.29
Step d) 51.15Hz ±0.05Hz	17805	9.24	≥5%	51.45		10.05
Step e) 50.70Hz ±0.10Hz	19688	9.10	≥3%	50.70		10.17
Step f) 50.45Hz ±0.05Hz	20743	-	-	50.45		-
Step g) 50.00Hz ±0.01Hz	20968	-	-	50.00		-



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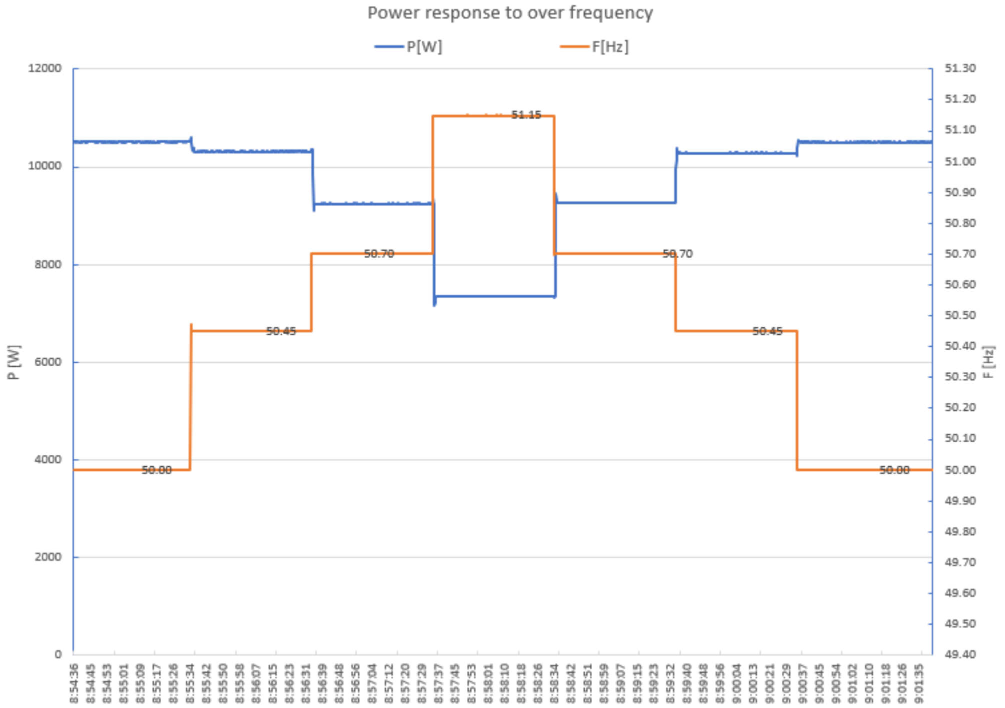
Test sequence at **Registered Capacity** 40% - 60%	Measured **Active Power** Output (W)	**Δ Active Power** achieved within 10s (**%Pmax**)	**Required Δ Active Power** achieved within 10s **(%Pmax)**	Frequency (Hz)	Primary Power Source	**droop %**
Step a) 50.00Hz ±0.01Hz	10506	-	-	50.00	PV simulator (50%Pn)	-
Step b) 50.45Hz ±0.05Hz	10312	-	-	50.45		-
Step c) 50.70Hz ±0.10Hz	9245	5.20	≥3%	50.70		10.01
Step d) 51.15Hz ±0.05Hz	7345	9.67	≥5%	51.45		10.03
Step e) 50.70Hz ±0.10Hz	9260	9.17	≥3%	50.70		9.89
Step f) 50.45Hz ±0.05Hz	10288	-	-	50.45		-
Step g) 50.00Hz ±0.01Hz	10509	-	-	50.00		-



Remark: clause 11.2.4 is taken into consideration

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10. Protection – Re-connection timer.

Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 10.1. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Power Generating Module** does not reconnect at the voltage and frequency settings below; a statement of "no reconnection" can be made.

Time delay setting for testing (s)	Measured delay (s)	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of Table 10.1.			
60	65.2*	At 1.16 p.u. (266.2 V)	At 0.78 p.u. (180.0 V)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Power Generating Module** does not re-connect.		No reconnection	No reconnection	No reconnection	No reconnection

Supplementary information:

1. Min. delay time recorded in all cases in above table.

2. "*": Reconnecting time is the sum of waiting time of both the mains voltage and the mains frequency are within the tolerance range(setting 60s) plus additional delay time for all control and adjustment processes safely finished time.

Test data record for reconnection

Test sequence after trip	connection	Connection allowed	Reconnection time ≥ 20s	Power gradient (% Pn/min)
a) U ≥ (1.14pu + 4V)	No	No	N/A	N/A
b) U ≤ (1.14pu - 4V)	Yes	Yes	Yes	10.0
c) U ≤ (0.8pu - 4V)	No	No	N/A	N/A
d) U ≥ (0.8pu + 4V)	Yes	Yes	Yes	10.0
e) F ≤ 47.4 Hz	No	No	N/A	N/A
f) F ≥ 47.6 Hz	Yes	Yes	Yes	10.0
g) F ≥ 52.1 Hz	No	No	N/A	N/A
h) F ≤ 51.9 Hz	Yes	Yes	Yes	10.0

Over voltage

a) U ≥ (1.14pu + 4V) – no reconnection

b) U ≤ (1.14pu - 4V) – reconnection after 65.2 s

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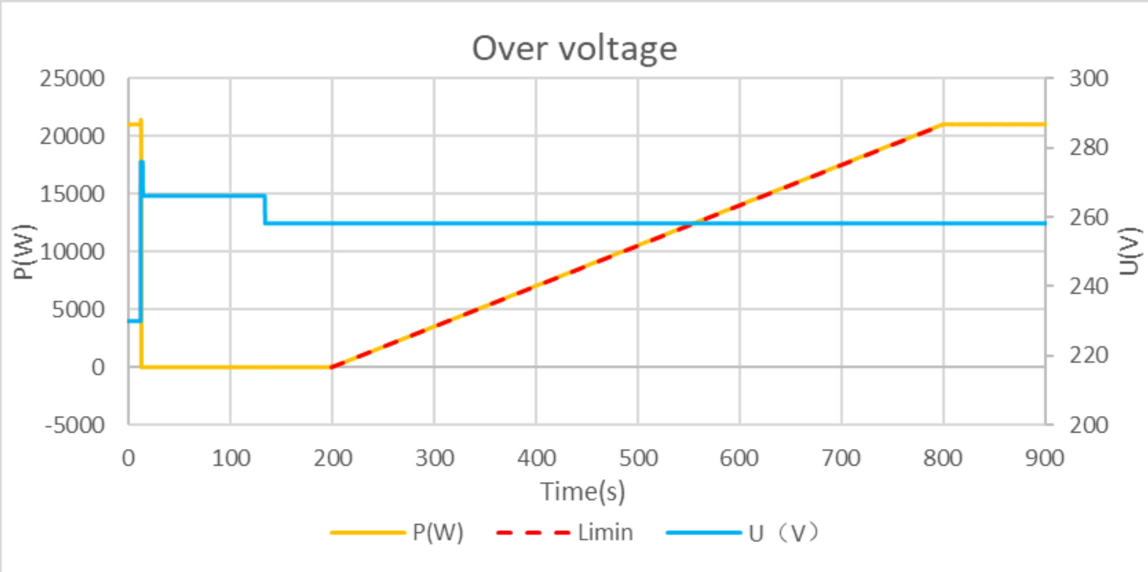
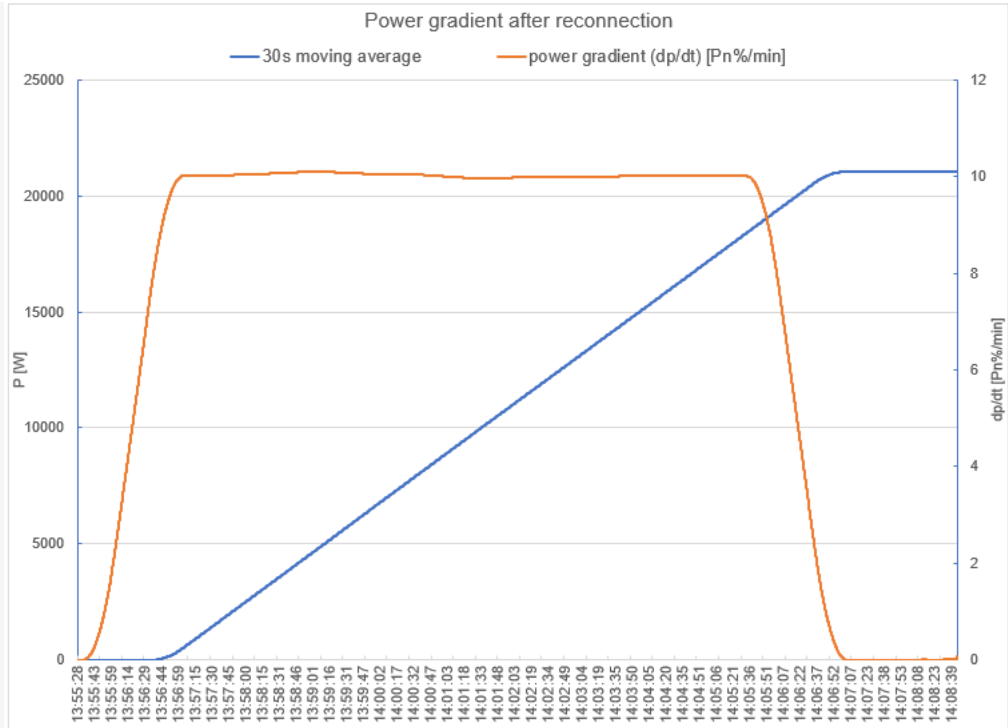


Max. power gradient after reconnection:10.10%Pn/min



Under voltage

c) U ≤ (0.8pu - 4V) – no reconnection

d) U ≥ (0.8pu + 4V) – reconnection after 65.2 s

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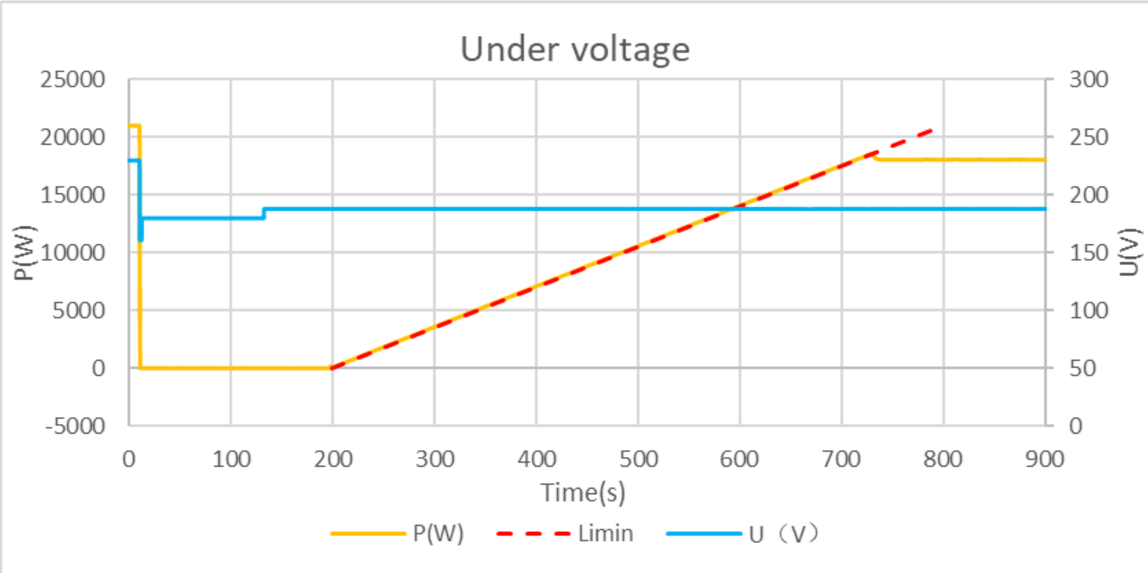
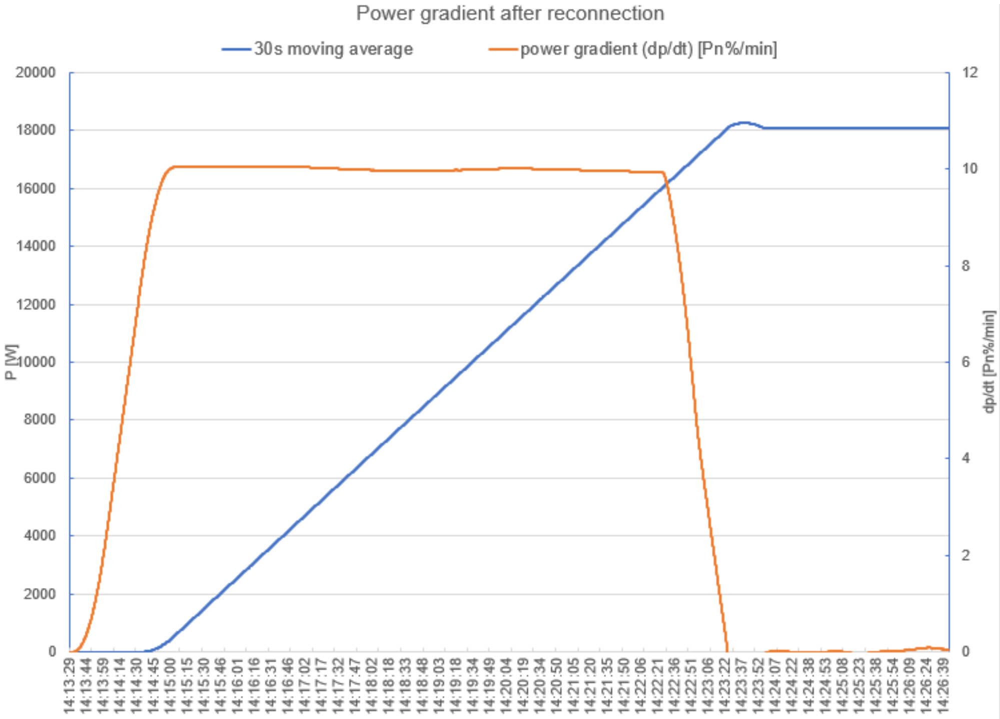


Max. power gradient after reconnection:10.06%Pn/min



Under frequency

e) F ≤ 47.4 Hz – no reconnection

f) F ≥ 47.6 Hz – reconnection after 65.4 s

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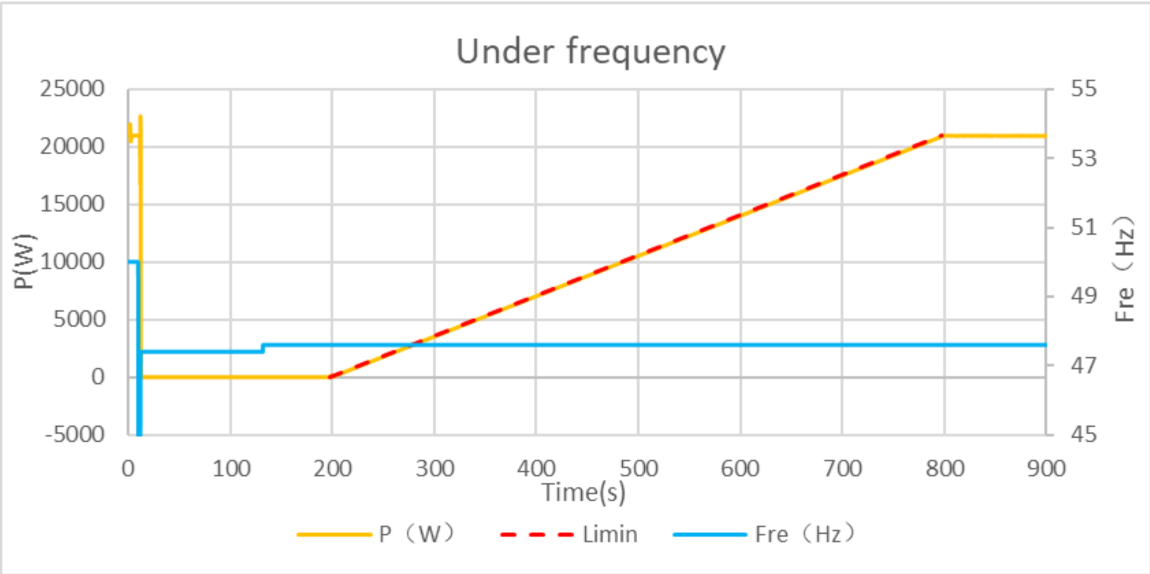
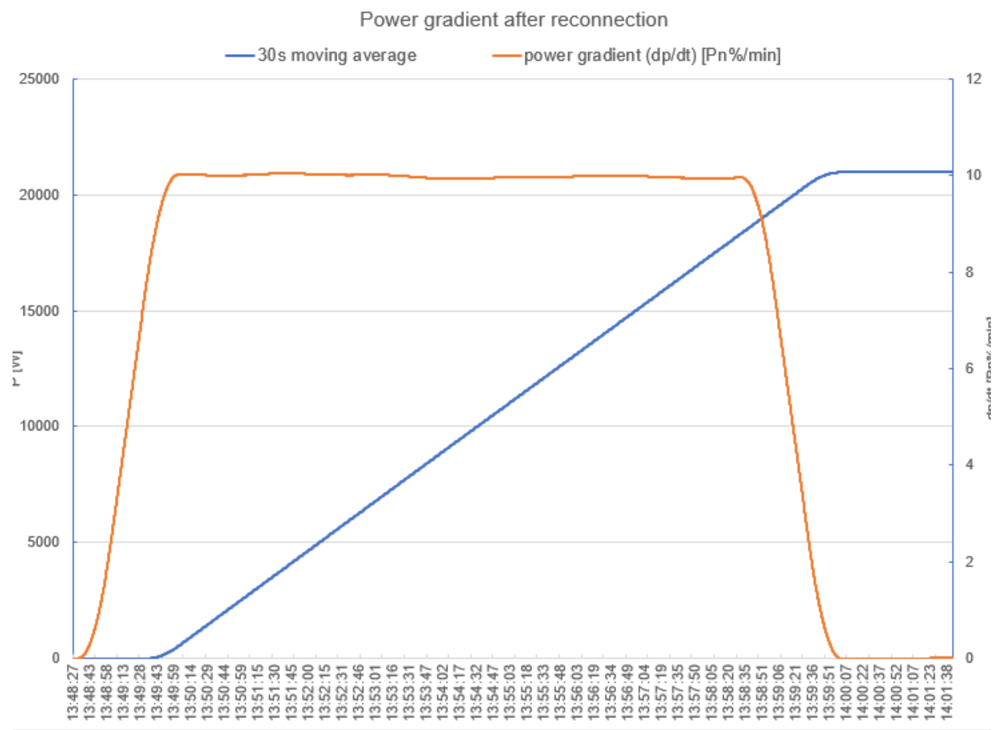


Max. power gradient after reconnection: 10.04%Pn/min



Over frequency

g) F ≥ 52.1 Hz – no reconnection

h) F ≤ 51.9 Hz – reconnection after 65.4 s

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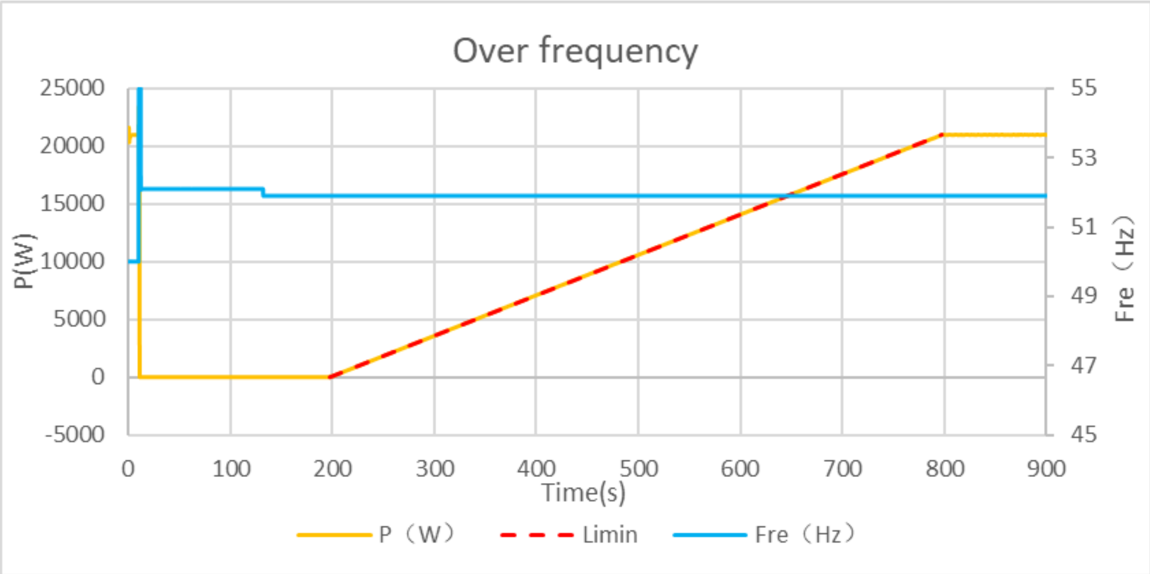
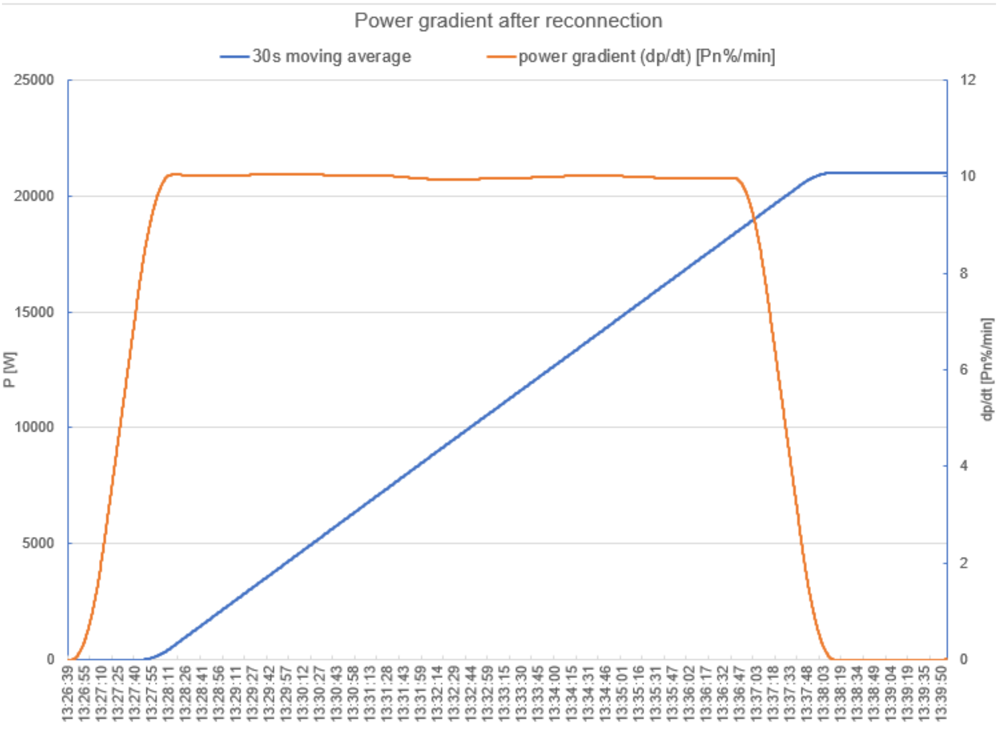


Max. power gradient after reconnection: 10.06%Pn/min



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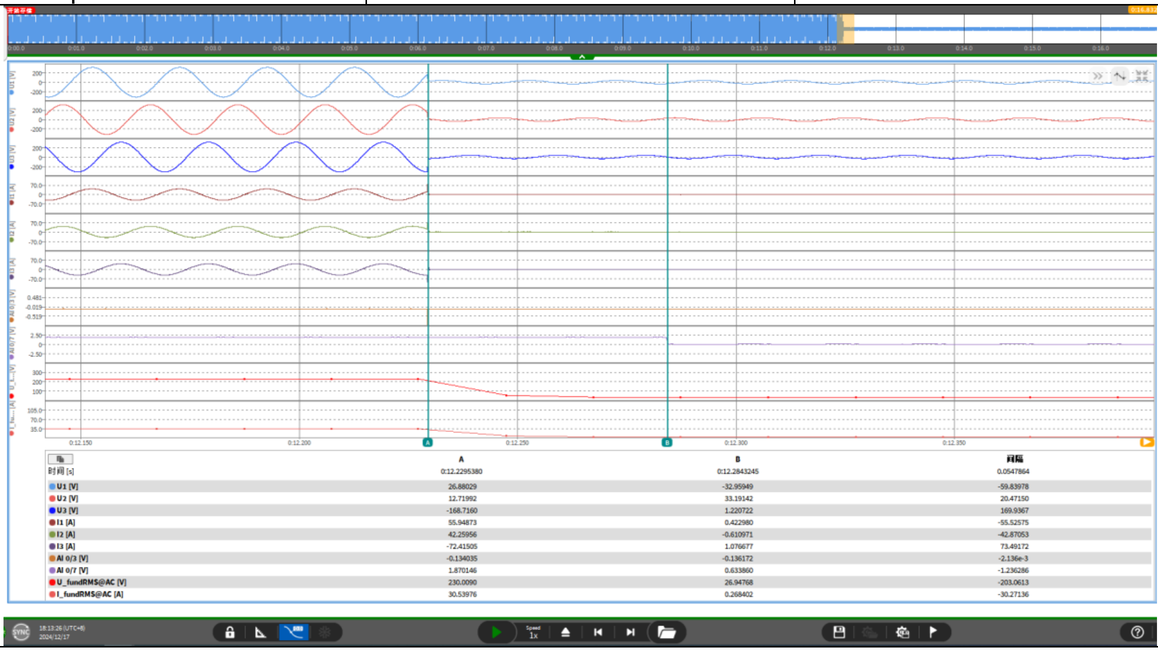
Product Service

11. Fault level contribution: These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5. Please complete each entry, even if the contribution to the fault level is zero.		
For an Inverter output		
Time after fault	Volts	Amps
20 ms	26.9	26.2
100 ms	26.9	0.27
250 ms	26.9	0.27
500 ms	26.9	0.27
Time to trip	0.055	In seconds



12. Self-Monitoring solid state switching: No specified test requirements. Refer to Annex A.7.1.6.	
It has been verified that in the event of the solid state switching device failing to disconnect the **Power Park Module**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0. 5 s.	N/A

13. Wiring functional tests: If required by para 15.2.1.	
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)	N/A

14. Logic interface (input port)	
Confirm that an input port is provided and can be used to shut down the module.	Yes
Provide high level description of logic interface, e.g. details in 11.1.3.1 such as AC or DC signal (the additional comments box below can be used)	Yes

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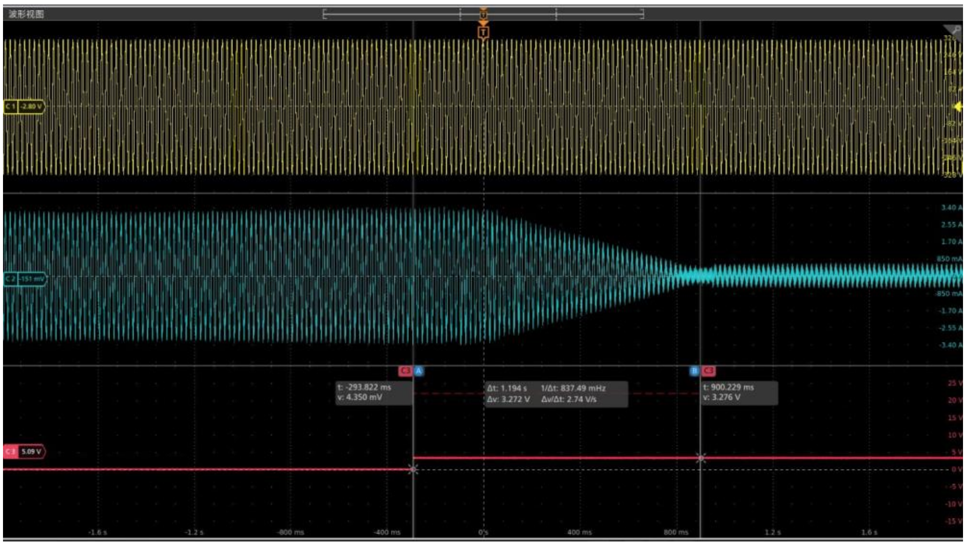
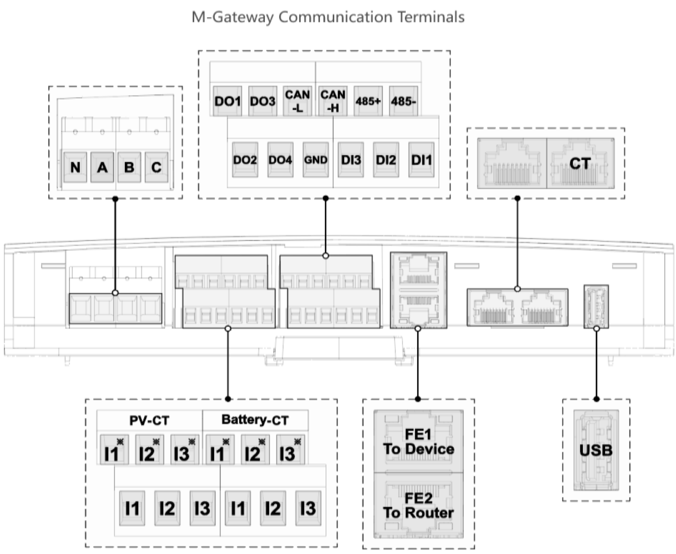
This equipment communicates with M-Gateway through power line communication (PLC), the M-Gateway is in the Energy Control Combiner (M-Combiner). The M-Gateway is equipped with DI (any one of the DI1/2/3) terminal and GND for logical interface to receive signals. The connection should be made according to the M-Gateway installation manual, the signals are simple binary outputs captured by the DI terminals (DI and the GND are used to detect the signals). The signal is activated when voltage between DI and GND turns to DC 3.3V, M-Gateway send commends to the microinverters via PLC, and then the microinverters will reduce the active power to zero within 5s. The DI terminal is DC 3.3V.

Confirm remote disconnection within 5s:YES, disconnection after 1.194 s.



External Communication Section Interface Diagram



15. Cyber security	
Confirm that the Power Generating Module has been designed to comply with cyber	Yes

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security requirements, as detailed in 9.1.7.

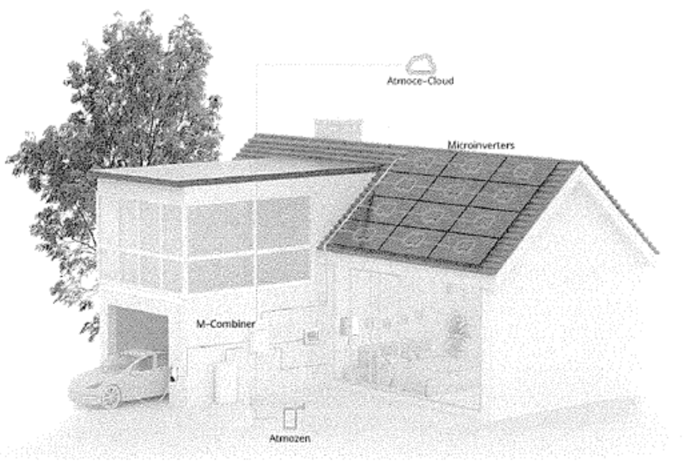
Manufacturer’s declaration of conformity

ATMOCE

Atmoce Holding B.V.
Singel 250, 1016AB Amsterdam, the Netherlands

Bin Xu, born on 10 October 1989 in China, as Regulation Compliance Manager of the Company Atmoce, based in the Netherlands, on behalf of the same Company declares the following:

1) The Atmoce Solar power generation system include a system of internal and external logic communication as summarized in the following scheme:



Where the main components involved and their main functions are described in the following table:

Acronym/Name	Function
Microinverter	Microinverters are compact and efficient devices for home power distribution systems. The grid–connected microinverter converts the DC output of a PV module into an AC grid.
M-Combiner	Collect and transfer the data of microinverters to the cloud server, reception of commands/setting from external stakeholder.

2) The communication between internal components of the Solar power generation system is between Microinverters and M-Combiner which is used the Power-line communication technology (PLC) is not directly connected to any device or system outside the Solar power generation system.

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3) The only communication port between the device and the outside is constituted by the M-Combiner, the communication between Solar power generation system and the outside world can take place via Bluetooth or WiFi router to the customer's request.
4) The M-Combiner and cloud server use TCP/IP , and achieve bidirectional authentication and data encryption during transmission through TLS1.2/1.3;
5) Coustomer can access the cloud through mobile apps and browsers. Users access the cloud using the HTTP and protect their data through SSL/TLS. SSL/TLS uses SHA-256 to implement digital signatures and encrypted transmission;
6) The cyber-security assessment of the Atmoce Solar power generation system was performed according to the ETSI EN 303 645 standard, and it is reported according to the Table B.1 form of the same standard:

ETSI EN 303 645 V2.1.1(2020-06) Table B.1: Implementation of provisions for consumer IoT security			
Clause number and title			
Reference	Status	Support	Detail
5.1 No universal default passwords			
Provision 5.1-1	M C (1)	Y	Password change is mandatory for the first login.
Provision 5.1-2	M C (2)	N/A	No pre-installed passwords.
Provision 5.1-3	M	Y	Use secure encryption algorithms.
Provision 5.1-4	M C (8)	Y	Passwords can be changed.
Provision 5.1-5	M C (5)	Y	Lock the IP address/account after multiple failed attempts.
5.2 Implement a means to manage reports of vulnerabilities			
Provision 5.2-1	M	Y	The official website supports vulnerability disclosure.
Provision 5.2-2	R	Y	Vulnerability response time is defined.
Provision 5.2-3	R	Y	Continuously track vulnerabilities against open source and third-party software listings.
5.3 Keep software updated			
Provision 5.3-1	R	Y	Support software upgrades.
Provision 5.3-2	M C (5)	Y	The software package supports digital signature integrity checking.
Provision 5.3-3	M C (12)	Y	Over-the-air (OTA) upgrades are supported.
Provision 5.3-4	R C (12)	Y	Automatic replacement and backup recovery are supported.
Provision 5.3-5	R C (12)	Y	Over-the-air (OTA) upgrades are supported.

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Provision 5.3-6	R C (9, 12)	Y	Users can choose whether or not to accept the update request.
Provision 5.3-7	M C (12)	Y	Use digital signatures.
Provision 5.3-8	M C (12)	Y	Vulnerability response time is defined.
Provision 5.3-9	R C (12)	Y	The software package supports digital signature integrity checking.
Provision 5.3-10	M (11, 12)	Y	The upgrade channel is encrypted via TLS
Provision 5.3-11	R C (12)	Y	Over-the-air (OTA) upgrades are supported.
Provision 5.3-12	R C (12)	Y	Release notes.
Provision 5.3-13	M	Y	Same as warranty period.
Provision 5.3-14	R C (3, 4)	N/A	
Provision 5.3-15	R C (3, 4)	N/A	
Provision 5.3-16	M	Y	Identified by nameplate.
5.4 Securely store sensitive security parameters			
Provision 5.4-1	M	Y	Sensitive data is stored encrypted.
Provision 5.4-2	M C (10)	N/A	
Provision 5.4-3	M	Y	Sensitive data is not hard-coded.
Provision 5.4-4	M	Y	A different certificate for each device.
5.5 Communicate securely			
Provision 5.5-1	M	Y	Use TLS to encrypt the communication channel.
Provision 5.5-2	R	Y	It is implemented using OpenSSL/MBEDTLS industry-wide open source software.
Provision 5.5-3	R	Y	Support software upgrades.
Provision 5.5-4	R	Y	You can only access it after you have passed the certification.
Provision 5.5-5	M	Y	You can only access it after you have passed the certification.
Provision 5.5-6	R	Y	Use TLS to encrypt the communication channel.
Provision 5.5-7	M	Y	Use TLS to encrypt the communication channel.
Provision 5.5-8	M	Y	Support key management.
5.6 Minimize exposed attack surfaces			
Provision 5.6-1	M	Y	Unused interfaces are disabled
Provision 5.6-2	M	Y	System information is not exposed until it is authenticated.

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Provision 5.6-3	R	Y	Only the necessary business functions are available on the hardware interface.
Provision 5.6-4	M C (13)	Y	The debug interface is disabled
Provision 5.6-5	R	Y	Services that you don't need are turned off.
Provision 5.6-6	R	Y	The deprecated code has been removed.
Provision 5.6-7	R	Y	The web service runs with non-root privileges.
Provision 5.6-8	R	N	Memory access control is not supported.
Provision 5.6-9	R	Y	Secure compilation options are supported
5.7 Ensure software integrity			
Provision 5.7-1	R	N	No root of trust.
Provision 5.7-2	R	N	Secure boot is not supported.
5.8 Ensure that personal data is secure			
Provision 5.8-1	R	Y	Use TLS to encrypt the communication channel.
Provision 5.8-2	M	Y	Use TLS to encrypt the communication channel.
Provision 5.8-3	M	N/A	No external sensing capabilities.
5.9 Make systems resilient to outages			
Provision 5.9-1	R	Y	Power generation can be generated normally when the network is interrupted.
Provision 5.9-2	R	Y	Power generation can be generated normally when the network is interrupted.
Provision 5.9-3	R	Y	After the link is disconnected, the access timing control is restored.
5.10 Examine system telemetry data			
Provision 5.10-1	R C (6)	N	Intrusion detection is not supported.
5.11 Make it easy for users to delete user data			
Provision 5.11-1	M	Y	Factory reset is supported.
Provision 5.11-2	R	Y	Factory reset is supported.
Provision 5.11-3	R	Y	Support for Privacy Statements.
Provision 5.11-4	R	Y	Support for Privacy Statements.
5.12 Make installation and maintenance of devices easy			
Provision 5.12-1	R	Y	Wizard-based installation is supported

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Provision 5.12-2	R	Y	Wizard-based installation is supported
Provision 5.12-3	R	Y	Support for safety maintenance manuals.
5.13 Validate input data			
Provision 5.13-1	M	Y	Data validity verification is supported.
6 Data protection provisions for consumer IoT			
Provision 6.1	M	Y	Support for Privacy Statements.
Provision 6.2	M C (7)	Y	Support for Privacy Statements.
Provision 6.3	M	Y	Support for Privacy Statements.
Provision 6.4	M C (6)	Y	Support for Privacy Statements.
Provision 6.5	M C (6)	Y	Support for Privacy Statements.

Conditions

1) passwords are used;
2) pre-installed passwords are used;
3) software components are not updateable;
4) the device is constrained;
5) the device is not constrained;
6) telemetry data being collected;
7) personal data is processed on the basis of consumers' consent;
8) the device allowing user authentication;
9) the device supports automatic updates and/or update notifications;
10) a hard-coded unique per device identity is used for security purposes;
11) updates are delivered over a network interface;
12) an update mechanism is implemented;
13) a debug interface is physically accessible.

Status' Column:

M	Mandatory provision
R	Recommended provision
MC	Mandatory and conditional provision
RC	Recommended and conditional provision

Support' Column:

Y	Implemented
N	Not implemented
N/A	Not applicble

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Date: 2024-10-16

Name: Bin Xu

Title: Regulation Compliance Manager

Signature: Bin Xu

---End of test report---

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