TEST REPORT

NC RfG / PSE

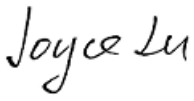
Requirements of general application resulting from Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators

PTPiREE

Conditions and procedures for using certificates in the process of connecting power generating modules to power networks

Report	
Report Number. ..... :	6209663.50
Date of issue ..... :	2025-01-15
Total number of pages ..... :	59
Testing Laboratory ..... :	DEKRA Testing and Certification (Suzhou) Co., Ltd.
Address ..... :	No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China
Applicant's name ..... :	Solenso electronic materials Co., LTD.
Address ..... :	4F., No. 56, Zili 5th St., Zhongli Dist., Taoyuan City 320, Taiwan
Test specification:	
Standard ..... :	COMMISSION REGULATION (EU) 2016/631 (NC RfG) PSE 2018-12 (Requirements for type A Generating Units) PTPiREE 2024-10
Test procedure ..... :	Type test
Non-standard test method ..... :	N/A
Test Report Form No. ..... :	PTPiREE_V1.1
Test Report Form(s) Originator ..... :	DEKRA Testing and Certification (Suzhou) Co., Ltd.
Master TRF ..... :	Dated 2021-10-28
Test item description ..... :	PV Microinverter
Trade Mark ..... :	Solenso
Manufacturer ..... :	Same as applicant
Model/Type reference ..... :	SG1600, SG2000

Ratings ..... :	Operating temperature range: - 40 °C to + 65 °C Protective class: I Ingress protection rating: IP67 Power factor range (adjustable): >0,99 (0,8 leading…0,8 lagging) Overvoltage category: III(Mains), II(PV) SG1600: Max input voltage: 65 V, MPPT voltage range: 25 - 55 V, Max input current: 14 * 4 A, PV Isc: 25 * 4 A. Rated grid frequency: 50 Hz, Rated output power: 1600 W, Rated grid voltage: L/N/PE, 230 V, Max output current: 6.96 A. SG2000: Max input voltage: 65 V, MPPT voltage range: 25 - 55 V, Max input current: 16 * 4 A, PV Isc: 25 * 4 A. Rated grid frequency: 50 Hz, Rated output power: 2000 W, Rated grid voltage: L/N/PE, 230 V, Max output current: 8.7 A

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

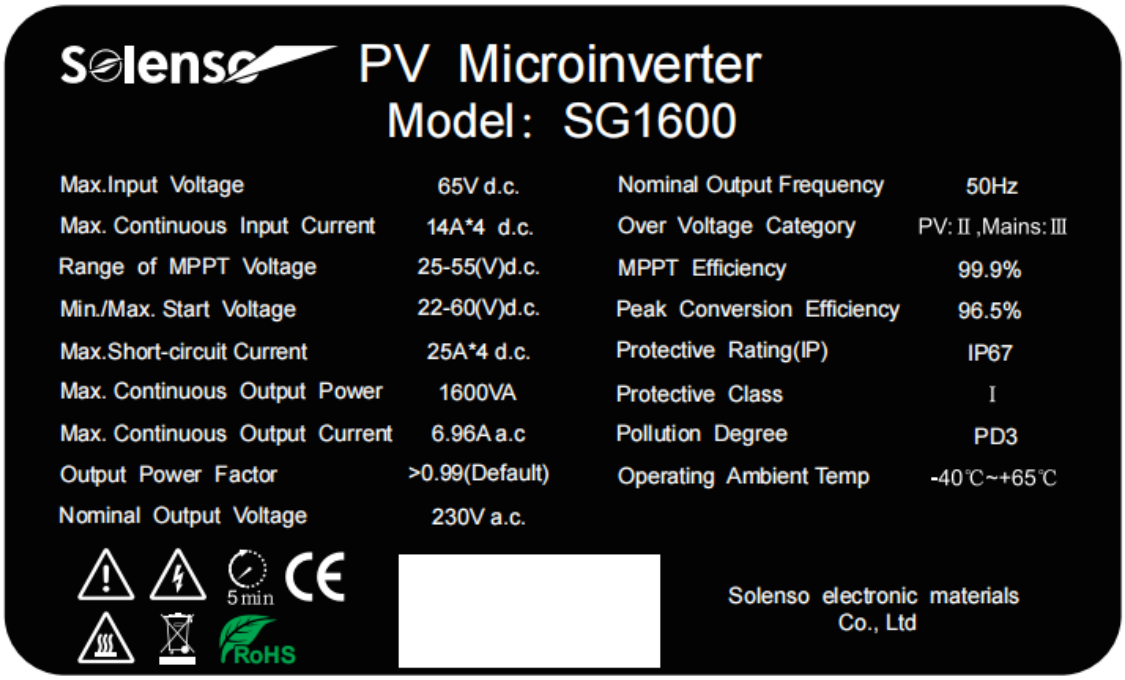
List of Attachments (including a total number of pages in each attachment):

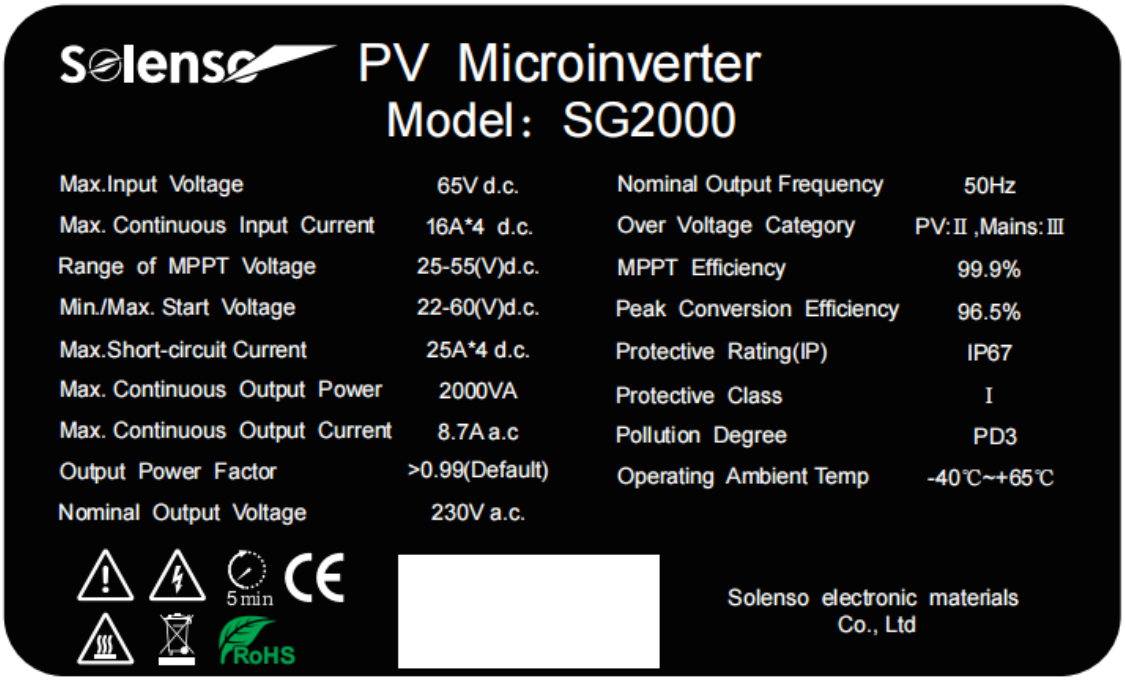
Appendix: Pictures (4 pages)

Summary of testing:

Tests performed (name of test and test clause):		**Testing location:**
Original Report No.: 6196344.50		
All applicable tests according to PSE 2018-12 (Requirements for type A Generating Units)		DEKRA Testing and Certification (Suzhou) Co., Ltd. No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China
Article 13(1)(a)(i)	Frequency Parameters	
Article 13(1)(b)	Rate of change of frequency	
Article 13(2)(a), (b), (f)	LFSM-O mode	
Article 13(4)	Admissive Power Reduction	
Article 13(7)	Automatic connection to the network	
Article 13(6)	Remote control of PGM	
Amendment 1: 6209663.50: This report is issued to check the identity against the main certificate No.6196344.01COC and its related test report 6196344.50 with some changes. No testing.		

Rating label:





Remark: According to customer's and market requirement, these models were evaluated under the grid voltage 230Vac and frequency of 50 Hz.

Test item particulars:				
Equipment mobility	:	movable fixed	hand-held transportable	stationary for building-in
Connection to the mains	:	pluggable equipment permanent connection		direct plug-in for building-in
Enviromental category	:	outdoor	indoor unconditional	indoor conditional
Over voltage category Mains	:	OVC I	OVC II	OVC III / OVC IV
Over voltage category PV	:	OVC I	OVC II	OVC III / OVC IV
Mains supply tolerance (%)	:	±10%		
Tested for power systems	:	TN		
IT testing, phase-phase voltage (V)	:	N/A		
Class of equipment	:	Class I Not classified	Class II	Class III
Mass of equipment (kg)	:	5.4		
Pollution degree	:	Outside PD3; Inside PD2		
IP protection class	:	IP67		
Possible test case verdicts:				
- test case does not apply to the test object	:	N/A		
- test object does meet the requirement	:	P (Pass)		
- test object does not meet the requirement	:	F (Fail)		
- this clause is information reference for installation	:	Info.		
Testing:				
Date of receipt of test item	:	2024-12-25 (samples provided by applicant) No sample. (Amendment 1)		
Date (s) of performance of tests	:	2024-12-26 to 2025-01-06 No test. (Amendment 1)		

General remarks:

"(See appended table)" refers to a table appended to the report.
"(see Appendix #)" refers to additional information appended to the report.
The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
The measurement result is considered in conformance with the requirement if it is within the prescribed limit, It is not necessary to account the uncertainty associated with the measurement result.
This report is only for reference and is not used for legal proof function in China market.

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

The unit under test complies with the following standards and regulations:

COMMISSION REGULATION (EU) 2016/631 (NC RfG) (Requirements for type A Power Generating Units).

The subject of the test report described above complies with the requirements of the following documents for type A PGM installations:

(a). Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on the requirements for connecting generating units to the network (Journal of Laws UE L 112/1 of 27 April 2016);

(b). General Application Requirements resulting from the Regulation of the EU Commission 2016/631 of April 14, 2016 establishing the network code on the requirements for connecting generating units to the grid - approved by the Decision of the President of the Energy Regulatory Office DRE.WOSE.7128.550.2.2018.ZJ of January 2, 2019 (PSE 2018-12);

(c). Conditions and procedures for the use of certificates in the process of connecting power generating modules to power grids (PTPiREE 2024-10).

Name and address of factory (ies):

Zhejiang Wellsun Intelligent Technology Co.,Ltd

109 Yongchang Road, Shifeng Street, Tiantai County, Taizhou City, Zhejiang Province, China

General product information:

This product is a Single-phase grid-connected photovoltaic inverter, which converts the DC voltage of solar panels into single-phase AC voltage and connects to the 230V grid to achieve power generation function.

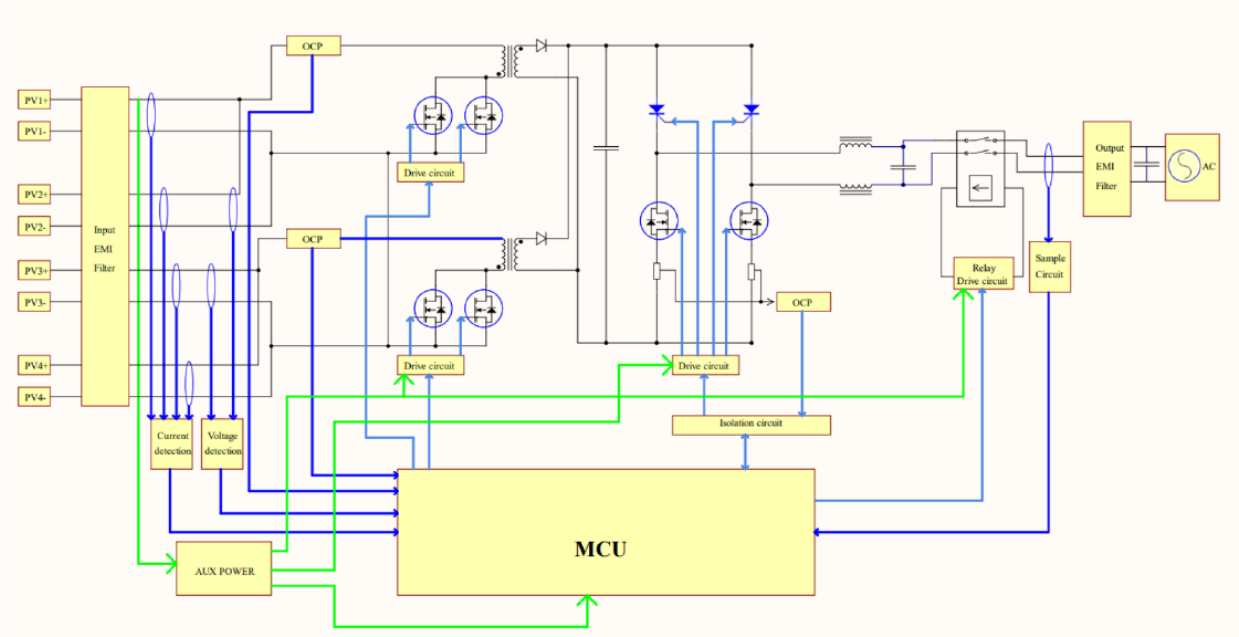
There is an auxiliary power supply inside the product. The AC side has a dedicate relay, which is to ensure the safety and reliability of the system. The product can generate full power up to ambient temperature 45 °C. When the temperature exceeds 45 °C, the output power derates linearly until maximum ambient temperature 60 °C (or the MCU detect the product's internal temperature reach to 85).

Description of the power circuit:

The booster part and the inverter part are controlled by the controller U25. U25 detects DC voltage and current, DC side insulation impedance, AC voltage, current, frequency, leakage current, etc., for boost circuit control and solar power tracking.

Model difference:

Models SG2000, SG1600 are identical except for different rated output power controlled by software.



Hardware version: WS0512NxA1.V03.

Software version: V2.10-2024.06.15

The product was tested on:

Unless otherwise specified, all tests are conducted on representative models of SG2000. Since other models have similar hardware and consistent software programs, and the power is reduced through software, they are applicable to other models.

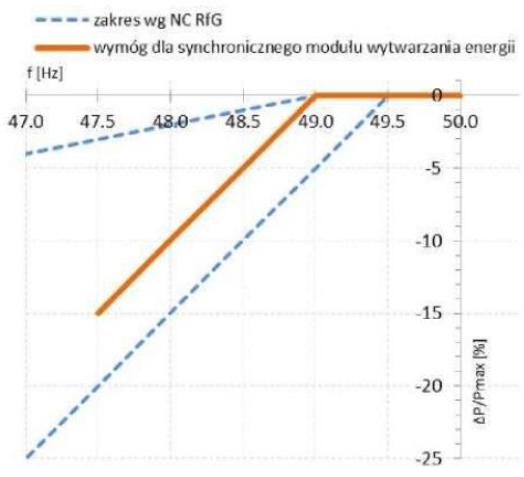
Amendment 1:
Report 6209663.50:
The report 6209663.50 was based on the report 6196344.50 issued by DEKRA Testing and Certification (Suzhou) Co., Ltd., issued on 2025-01-10.
It was issued due to below modifications:
1. Applicant and manufacturer's name was changed to Solenso electronic materials Co., LTD.
2. Change trade mark.
3. Updated the relative part of test report about Model/Type reference, rating label.

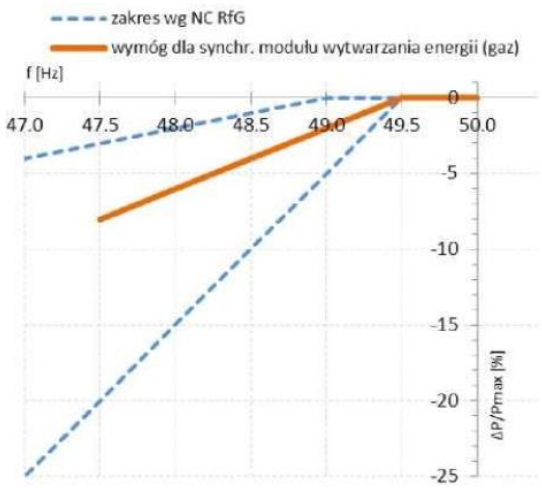
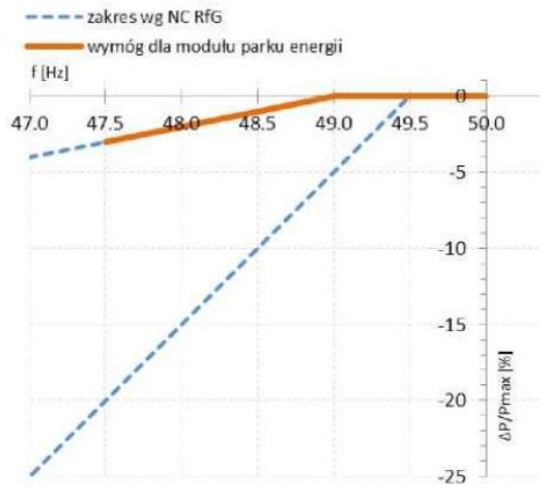
After technical review, no tests were considered necessary.

Type test:
All tests were performed under ISO/IEC 17025 accreditation lab DEKRA Testing and Certification (Suzhou) Co., Ltd. and were performed on model SG2000.

Test typu:
Wszystkie testy zostały przeprowadzone w laboratorium akredytacyjnym ISO/IEC 17025 DEKRA Testing and Certification (Suzhou) Co., Ltd. i zostały przeprowadzone na modelu SG2000.

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
ARTICLE 13	**GENERAL REQUIREMENTS FOR TYPE A POWER-GENERATING MODULES**		**P**
Article 13(1)(a)(i)	**Frequency parameters**		**P**
	Minimum operating time period of the power generating module at frequencies deviating from the nominal value: Frequency range: Operating time 47.5 Hz-48.5 Hz: 30 minutes 48.5 Hz-49.0 Hz: 30 minutes	(See appended table)	P
Article 13(1)(b)	**Rate of change of frequency**		**P**
	Required PGM capability of remaining connected to the network and operate at the rate of change of frequency up to: $\left\lvert\frac{df_{max}}{dt}\right\rvert = 2.0 \left\lvert\frac{Hz}{s}\right\rvert$ Where this value would be measured as an average value within a shiftable measurement window with a length of 500 ms. The requirement $\left\lvert\frac{df_{max}}{dt}\right\rvert = 2.0 \left\lvert\frac{Hz}{s}\right\rvert$ a minimum requirement. If the applied technology allows connection to the network and operation at a higher rate of change of frequency, limiting the operation of the PGM to the value defined above is not allowed, unless it results from the arranged rate-of-change-of-frequency-type loss of mains protection.	(See appended table)	P
Article 13(2)(a)	**Static parameters of the LFSM-O mode**		**P**
	• Capability of setting the frequency threshold of the LFSM-O in the range: 50.2 Hz-50.5 Hz, default value 50.2 Hz. • Capability of droop settings of the LFSM-O in the range: 2-12%, default value 5%. • As regards Power Park Modules, the Pref value means maximum active power. A possibility of selecting, upon TSO order, the setting of the frequency threshold for activating the LFSM-O and droop settings in the required range must be ensured. A possibility of selecting, upon TSO order, the setting of the frequency threshold for activating the LFSM-O and droop settings in the required range must be ensured.	(See appended table)	P
Article 13(2)(b)	**Disconnection of PGM type A instead of the LFSM-O**		**P**

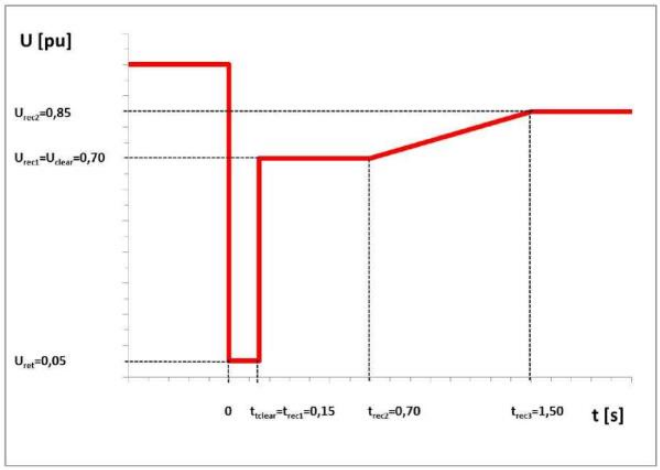
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	It is not allowed to disconnect PGM type A instead of providing capabilities for the LFSM-O. The above mentioned decision does not exclude adapting PGM type A to the LFSM-O through gradually disconnection of particular units generating electricity within PGM, in particular PPM.		P
Article 13(2)(f)	**Minimum regulating level of the LFSM-O**		**P**
	It is required that following the reaching the minimum regulating level in the LFSM-O, the power generation module is capable of stable operation at this level. Operation below the minimum regulating level is not required, unless such a requirement has been individually determined as part of adapting PGM to island operation. Reduction of active power of PPM resulting from operation in the LFSM-O is executed from the active power output in the moment of reaching the activation threshold of the LFSM-O to the power value resulting from the static characteristics of the LFSM-O, provided that the power of the primary source of energy has not been decreased below the level that allows reaching the required level of operation.		P
Article 13(4)	**Admissible active power reduction**		**P**
	Admissible active power reduction compared to the maximum generated power (defined at the frequency of 50 Hz), amounts to the following at dropping frequency:	(See appended table)	P
	a. for synchronous power-generating modules, excluding synchronous power-generating units referred to in (b): 10% of maximum power per 1 Hz, at a frequency drop below 49 Hz (Fig. a); **a)**  	Not synchronous power-generating modules.	N/A

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	b. for synchronous power-generating modules such as gas unit or combined cycle gas and steam unit: 4% of maximum power per 1 Hz, at a frequency drop below 49.5 Hz (Fig. b); **b)**  	Not synchronous power-generating modules.	N/A
	c. for power park modules: 2% of maximum power per 1 Hz, at a frequency drop below 49 Hz (Fig. c); **c)**  	(See appended table)	P
	If a given PGM can operate at a lower power reduction rate, it should ensure such operation (concerns PPM in particular).		P
Article 13(6)	**Remote control of PGM**		**P**
	It is required that PGM is adapted to remote control of the facility by a relevant SO, in terms of the cease of active power output. Telecommunication standards shall be determined by a relevant SO.	(See appended table)	P

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
Article 13(6)	**Automatic connection to the network**		**P**
	Conditions for the automatic connection of PGM to the network (must be met cumulatively): • Power frequency in the network shall be in the range between 49.00 Hz and 50.05 Hz, and • Time delay (understood as time between the moment in which frequency value returns to the range defined above and the moment of connecting the power-generating module to the network) - at least 60 sec., and • Maximum admissible gradient of increase in active power output amounts to 10% of the maximum power per minute.	(See appended table)	P
ARTICLE 14	**GENERAL REQUIREMENTS FOR TYPE B POWER-GENERATING MODULES**		**N/A**
Article 14(2)(b)	**Remote control of PGM type B**		**N/A**
	It is required that PGM has the capability of remote control of the facility by a relevant SO, in terms of active power reduction at an order of relevant SO. The reduction requirement remains active also where the primary source of energy is insufficient to achieve the set limit value. In order to allow remote operation of generated active power by means of additional devices, telecommunication standards determined and published by a relevant SO must be met.	(See appended table)	N/A
Article 14(3)(a)(i)	**FRT for symmetrical faults**		**N/A**
	PGM may disconnect from the network, if phase-to-phase voltage at the connection point falls below the required profile of the fault ride through and voltages at the connection point exceed the admissible value laid down in relevant legal regulations directly before the fault.	(See appended table)	N/A

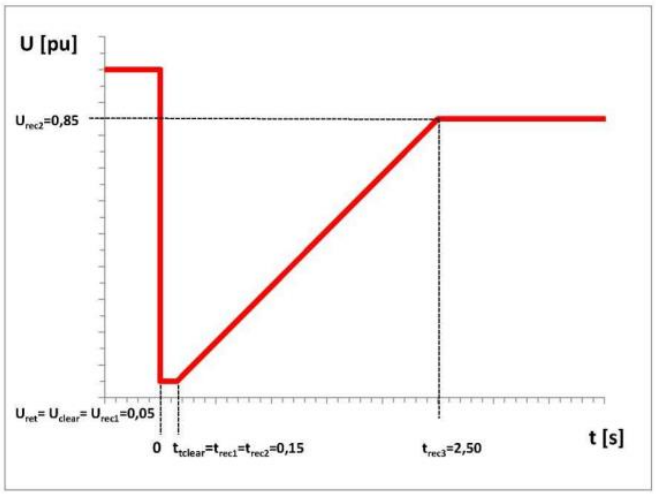
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	• Synchronous power-generating modules must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below. Parameters referring to the capability of synchronous power-generating modules of fault ride through: Required fault ride through profile for synchronous power-generating module:	Not synchronous power-generating modules.	N/A

Voltage parameters [pu]		Time parameters [s]	
Uret:	0.05	tclear:	0.15
Uclear:	0.70	trec1:	0.15
Urec1:	0.70	trec2:	0.70
Urec2:	0.85	trec3:	1.50



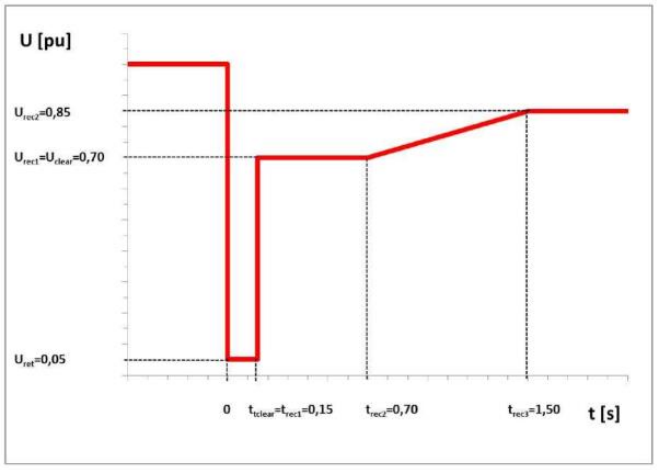
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	• Power park modules must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below: Parameters referring to the capability of power park modules of fault ride through: Required fault ride through profile for the power park module:	(See appended table)	N/A
Article 14(3)(b)	**FRT for non-symmetrical faults**		**N/A**
	The required PGM capabilities of fault ride through in the case of non-symmetrical faults concern the phase-to-phase voltage with the lowest amplitude. PGM may disconnect from the network during the non-symmetrical fault, if at least one phase-to phase voltage at the connection point falls below the required profile of the fault ride through and voltages at the connection point exceed the admissible value laid down in relevant legal regulations directly before the fault.	(See appended table)	N/A

Voltage	parameters [pu]	Time parameters [s]	
Uret:	0.05	tclear:	0.15
Uclear:	0.05	trecl:	0.15
Urecl:	0.05	trec2:	0.15
Urec2:	0.85	trec3:	2.50



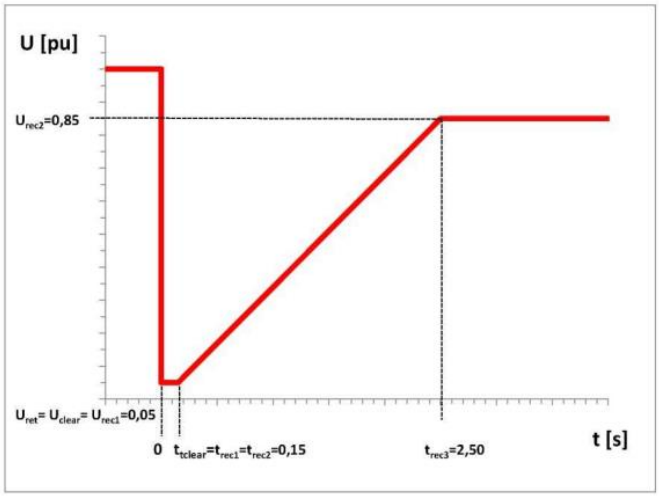
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	• Synchronous power-generating modules must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below. Parameters referring to the capability of synchronous power-generating modules of fault ride through: Required fault ride through profile for synchronous power-generating module:	Not synchronous power-generating modules.	N/A

Voltage parameters [pu]		Time parameters [s]	
Uret:	0.05	tclear:	0.15
Uclear:	0.70	trec1:	0.15
Urec1:	0.70	trec2:	0.70
Urec2:	0.85	trec3:	1.50



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	• Power park modules must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below: Parameters referring to the capability of power park modules of fault ride through: Required fault ride through profile for the power park module:	(See appended table)	N/A
Article 14(4)(a)	**Reconnection of PGM to the network**		**N/A**
	Conditions for the reconnection of PGM to the network after its accidental disconnection caused by network disturbance (must be met cumulatively): • Power frequency in the network shall be in the range between 49.00 Hz and 50.05 Hz, and • Voltage at the connection point falls into the range of admissive voltages laid down in relevant legal regulations, and • Time delay (understood as time between the moment in which the value of the abovementioned parameters returns to the range defined above and the moment of connecting the power-generating module to the network) - at least 60 sec.	(See appended table)	N/A

Voltage	parameters [pu]	Time parameters [s]	
Uret:	0.05	tclear:	0.15
Uclear:	0.05	trecl:	0.15
Urecl:	0.05	trec2:	0.15
Urec2:	0.85	trec3:	2.50



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	If PGM was disconnected from the network as a result of opening the circuit breaker in the power output line, reconnection for PGM type C and D may take place exclusively upon consent or order of a relevant SO. It is allowed to use delay time by a relevant SO in order to block the automatic reconnection, depending on the location of the power station and configuration of the network to which the power-generating module is connected.		N/A
Article 14(5)(d)(i)	**Data exchange**		**N/A**
	It is required that power-generating modules safeguard the capability of the power-generating facility to exchange information in real time: • Type B with a relevant SO • Type C and D with a relevant SO and TSO.		N/A
Article 14(5)(d)(ii)	**Real time data exchange**		**N/A**
	For entities connected to the DSO network the scope of real time data should cover at least: • Position of main circuit switch at the connection point; and • Active and reactive power flows, current and voltage at the connection point A relevant SO, in agreement with TSO, has the right to require a broader scope of exchanged information in real time that is necessary for planning and conducting the system operation.	(See appended table)	N/A
	For entities connected to the TSO network the scope of real time data should cover at least: • Position of main circuit switch at the connection point or another point of interaction agreed with TSO; • Active and reactive power flows, current and voltage at the connection point or another point of interaction agreed with TSO; • In the case of a power-generating facility consuming energy for other purposes than household operation - net active power and net reactive power at the connection point or another point of interaction agreed with TSO. TSO has the right to require a broader scope of information exchanged in real time that is necessary for planning the system operation and system management.		N/A
ARTICLE 15	**GENERAL REQUIREMENTS FOR TYPE C POWER-GENERATING MODULES**		**N/A**
Article 15(2)(a)	**Automatic power adjustment**		**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	A period in which the modified active power setpoint has to be reached must not be longer than 15 minutes. Accuracy of the adjustment should be no less than 1% of the maximum power for synchronous power generating modules and 2% of the active power setpoint for power park modules.		N/A
Article 15(2)(b)	**Manual power adjustment**		**N/A**
	A period in which the modified active power setpoint has to be reached when automatic power adjustment devices are not in operation must not be longer than 30 minutes from the moment an instruction has been issued by a relevant SO. Accuracy of the adjustment should be no less than 2% of the maximum power for synchronous power-generating modules and 5% of the active power setpoint for power park modules.		N/A
Article 15(2)(c)(i)	**Static parameters of the LFSM-U**		**N/A**
	• Capability of setting the frequency threshold of the LFSM-U in the range: 49.5 Hz - 49.8 Hz, default value 49.8 Hz. • Capability of making droop settings of the LFSM-U in the range: 2-12%, default value 5%. • As regards power park modules (PPM), the Pref value means maximum active power.		N/A
	A possibility of selecting, upon TSO order, the setting of the following must be ensured: • Frequency threshold for LFSM-U activation, • Droop.		N/A
	A possibility of blocking LFSM-U functions by a relevant SO should be ensured when network congestion are observed in real time (and not identified on the basis of forecasts). Application of LFSMU protection should be limited to the system area where network limitations occurred. A relevant SO should pass information to TSO on active LFSM-U protection. Network conditions to block the LFSM-U should be agreed between relevant SO and TSO.		N/A
Article 15(2)(d)(i)	**Static parameters of the FSM mode**		**N/A**
	The required parameters concerning active power frequency response in the FSM.		N/A

Parameters		Ranges or values
Active power range related to maximum power $\frac{\lvert\Delta P_t\rvert}{P_{max}}$		5%
Frequency response insensitivity	$\lvert\Delta f_t\rvert$	10 mHz
	$\frac{\lvert\Delta f_t\rvert}{f_n}$	0.02%
Frequency response deadband		0-500 mHz
Droop s_1		2-12%

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
Article 15(2)(d)(iii)	**Dynamic parameters of the FSM mode**		**N/A**
	Parameters of full active power activation in response to a change in frequency, resulting from a frequency step change: Parameters | Ranges or values Active power range related to maximum power (frequency response range) $\frac{\lvert\Delta P_1\rvert}{P_{ref}}$ | 5% For power-generating modules with inertia, the maximum admissible initial delay $t1$, unless justified otherwise in line with Article 15(2)(d)(iv) | 2 s For power-generating modules without inertia, the maximum admissible initial delay $t1$, unless justified otherwise in line with Article 15(2)(d)(iv) | 0.5 s Maximum admissible choice of full activation time $t2$ | 30 s		N/A
Article 15(2)(d)(iv)	**Initial delay of the FSM mode**		**N/A**
	For power-generating modules without inertia, the maximum admissible initial delay t1 should amount to 0.5 s, in line with the Table 5 of NC RfG.		N/A
Article 15(2)(d)(v)	**Operating time of the FSM mode**		**N/A**
	The power-generating module must be capable of providing full active power frequency response for at least 30 minutes, provided the primary source of energy is available. Power correction signal following a change in frequency must remain active until there are frequency conditions for the operation of FSM automation. It is not allowed to withdraw the power correction signal following a change in frequency in the case of a temporary loss of the primary source of energy.		N/A
Article 15(2)(g)(i)	**Transmission of signals for the monitoring of the FSM mode**		**N/A**
	If a given PGM participates in the FSM frequency adjustment process, signals for the monitoring of FSM active power frequency response shall be sent to the TSO.		N/A
Article 15(2)(g)(ii)	**Signals for the monitoring of the FSM mode**		**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	If a given PGM participates in the FSM frequency adjustment process, additional signals that are to be sent by the power-generating module by means of monitoring devices and recording devices for the purpose of verifying the operation of the active power frequency response back-up, shall include at least: • Local frequency or rotational velocity; • PGM operating mode (i.e. LFSM-U/LFSM-O, household operation and island operation - if PGM is adapted thereto), whereas, in the phase of connecting the facility to the network or activating the capability of PGM to adjust the frequency in the system by TSO, a relevant SO in agreement with TSO shall determine additional signals necessary for monitoring, taking account of the power generation technology.		N/A
Article 15(3)	**Voltage protection**		**N/A**
	Terms and conditions for actual disconnection of power-generating modules: If a relevant SO, in agreement with TSO, decides on admitting, for systemic reasons, the use of these protective devices, then the voltage threshold values at the point of connection at which an automatic disconnection of the facility can take place should be correlated with voltage limits admissible by a relevant SO in the MV network administered, i.e.: • Undervoltage protection setpoint should be lower than the minimum voltage at which PGM should maintain the capability of operating within the network • Whereas overvoltage protection setpoint should be higher than the maximum voltage at which PGM should maintain the capability of operating within the network. Voltage protection devices at the connection point should not be active, unless they are used to prepare the unit to defend/restore the PPS, e.g. through an pre-emptive switch into household operation. They should not be used for protecting PGM from damage - protection devices installed directly on the device, referred to in Article 14(5)(b)(iii), serve this very purpose. Voltage level settings of protection devices are determined individually as facility-specific.		N/A
Article 15(5)(c)(iii)	**Household operation**		**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	The minimum required household operation time of power-generating modules incapable of quick resynchronization shall be determined individually, taking account of the execution technology, whereas the said time must not be shorter than 2 hours. Household operation must not be intentionally interrupted when exceeding the above mentioned minimum time limit of 2 hours, as long as its further operation does not pose a threat to the safety of persons and devices. Longer household operation will be required, as part of separate arrangements, for PGMs provided for being used in the process of defending and restoring PPS, in particular the ones adapted to island operation.		N/A
Article 15(6)(a)	**Angular stability**		**N/A**
	Synchronous power-generating modules must feature protection devices that react to rotor pole slip, where impedance is a criterial value. The application of another, equivalent protection device for detecting the loss of angular stability is allowed.		N/A
Article 15(6)(b)(i)	**Fault recorder**		**N/A**
	Unless a relevant SO decides otherwise, power-generating facilities must feature an installation that safeguards recording of the voltage and current wave shape during failures/faults and monitoring the dynamic behaviour of the system with the following accuracy (for nominal values at steady state): • voltage - accuracy 0.5%, • current - accuracy 0.5%, • active power - accuracy 1.0%, • reactive power - accuracy 1.0%, • frequency - accuracy 0.02%. Current and voltage temporary values must be recorded at a recording frequency and time synchronization required by a relevant SO.		N/A
Article 15(6)(b)(ii)	**Triggering criteria and sampling rates**		**N/A**

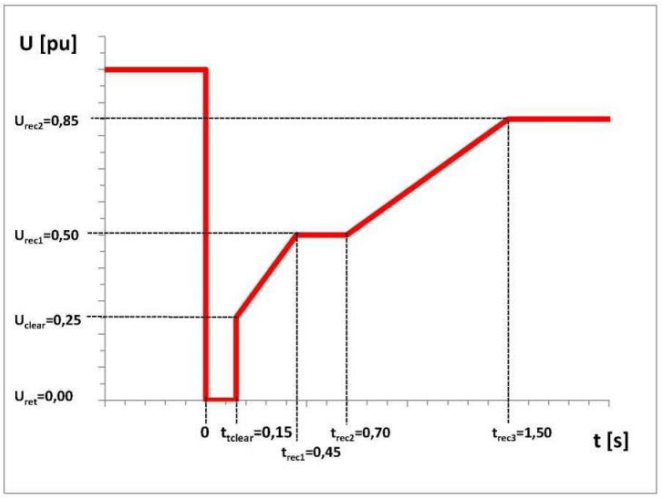
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	Unless specified otherwise, it is proposed to assume the following thresholds that trigger recording for the purpose of making arrangements with the power-generating facility owner: • For voltage (single-period RMS value, updated every 10 ms in a shiftable measurement window): a) for a network with voltage of 400 kV and higher: U_{RMS}<0.9 pu or U_{RMS}>1.05 pu, b) for a network with voltage of 220 kV and 110 kV: U_{RMS}<0.9 pu or U_{RMS}>1.118 pu, c) for a network with voltage lower than 110 kV: U_{RMS}<0.9 pu or U_{RMS}>1.1 pu • For frequency: f< 49.8 Hz or f>50.2 Hz.		N/A
Article 15(6)(b)(iii)	**Oscillation trigger**		**N/A**
	As part of detecting poorly damped power oscillations, the monitoring of oscillations with a frequency between 0.1 Hz and 5 Hz and a simultaneous application of the following thresholds that trigger oscillation recording has been assumed (a simultaneous exceeding of 2 value thresholds has been assumed): • oscillation amplitudes - Arel > 2% where Arel=A/P, A - oscillation amplitude [MW], P - active power of a generator [MW] • damping factor ξ < 5% where: ξ =(A1-A2)/A1, A1, A2 - subsequent oscillation amplitudes The abovementioned approach does not exclude the application of ongoing recording, subject to processing, during which cases of exceeding the arranged thresholds will be identified.		N/A
Article 15(6)(b)(iv)	**Communication protocols**		**N/A**
	Simulation models that appropriately reflect the power-generating module's behaviour, both at a steady state and for dynamic simulations (50 Hz component) or in short electromagnetic simulations, should comply with the CGMES 2.4.15 standard or newer, unless arranged otherwise between a power-generating facility owner and a relevant SO and TSO.		N/A
Article 15(6)(c)(iii)	**Simulation models**		**N/A**

<table>
<tr><th colspan="4">PTPiREE 2024-10; PSE 2018-12; NC RfG</th></tr>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>On request of a relevant SO, a power-generating facility owner must provide simulation models. Simulation models that appropriately reflect the power-generating module's behaviour, both at a steady state and for dynamic simulations (50 Hz component) or in short electromagnetic simulations, should comply with the CGMES 2.4.15 standard or newer, unless decided otherwise by a relevant SO, in coordination with TSO.</td><td></td><td>N/A</td></tr>
<tr><td>Article 15(6)(e)</td><td colspan="2">rate of change of power</td><td>N/A</td></tr>
<tr><td></td><td>Unless a relevant SO and a power-generating module owner, in agreement with TSO, arrange otherwise, the minimum and maximum limits of the rate of change of generated active power (limit values), in both up and down direction of active power generated by the power-generating module, taking account of the specificity of technology of the prime mover, shall fall into the ranges laid down in the table below.
<table>
<tr><th>Type of power-generating module</th><th>Limits of the rate of change of generated active power in the negative and positive direction [% of maximum power / minute]</th></tr>
<tr><td>Thermal power units (hard coal)</td><td>4 ÷ 6</td></tr>
<tr><td>thermal power units (brown coal)</td><td>3 ÷ 4</td></tr>
<tr><td>gas-fired thermal power units (Combined Cycle Gas Turbine)</td><td>5 ÷ 8</td></tr>
<tr><td>gas-fired thermal power units (Simple Cycle Gas Turbine)</td><td>12 ÷ 20</td></tr>
<tr><td>combustion engine-driven thermal power units</td><td>80 ÷ 100</td></tr>
<tr><td>hydro power units</td><td>40 ÷ 50</td></tr>
<tr><td>wind PPM</td><td>90 ÷ 100</td></tr>
<tr><td>photovoltaic PPM</td><td>90 ÷ 100</td></tr>
</table>
Limits of the rates of change of active power provided in the table mean average values of the rate of change of base load from technical minimum to maximum power of the PGM. In technically justified cases, for thermal power units in the range between 0.9 of the maximum power to 1.0 of the maximum power, lower limit rates of change of active power are admissible, however, they must be arranged with a relevant SO, in agreement with TSO.</td><td></td><td>N/A</td></tr>
<tr><td>ARTICLE 16</td><td colspan="2">GENERAL REQUIREMENTS FOR TYPE D POWER-GENERATING MODULES</td><td>N/A</td></tr>
<tr><td>Article 16(2)(a)(i)</td><td colspan="2">voltage conditions</td><td>N/A</td></tr>
</table>

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	Minimum time during which a power-generating module must be capable of operating at voltages deviating from the reference voltage 1 pu at the connection point without disconnecting from the network is as follows: for base voltage between 110 kV and 300 kV: Voltage range: 1.118 pu - 1.15 pu; Time period for operation: 60 minutes for base voltage between 300 kV and 400 kV: Voltage range: 1.05 pu - 1.10 pu; Time period for operation: 60 minutes		N/A
Article 16(2)(a)(ii)	**voltage and frequency conditions**		**N/A**
	In the event of a simultaneous overvoltage and underfrequency or simultaneous overvoltage and overfrequency, the required operating time will be shorter time, considering separately frequency and voltage requirements.		N/A
Article 16(2)(c)	**voltage protection**		**N/A**
	If a relevant SO, in agreement with TSO, decides on admitting, for system reasons, the use of protection devices, then the voltage threshold values at the connection point at which an automatic disconnection of the facility can take place should be correlated with voltage limits defined for undervoltage and overvoltage setpoints (pursuant to Article 16(2)(a)(i)) for PGM connected to the network of 110 kV and more and determined by a relevant SO for PGM connected to the network with a voltage below 110 kV, i.e.: • Undervoltage protection setpoint should be lower than the minimum voltage at which PGM should maintain the capability of operating within the network; • Overvoltage protection setpoint should be higher than the maximum voltage at which PGM should maintain the capability of operating within the network. Undervoltage protection devices at the connection point should not be active, unless they are used to prepare the PGM to defend/restore the PPS, e.g. through an anticipative switch into household operation. They should not be used for protecting PGM from damage - protection devices installed directly on the device, referred to in Article 14(5)(b)(iii), serve this very purpose. Settings for automatic disconnection of PGM are determined individually as facility-specific setpoints.		N/A

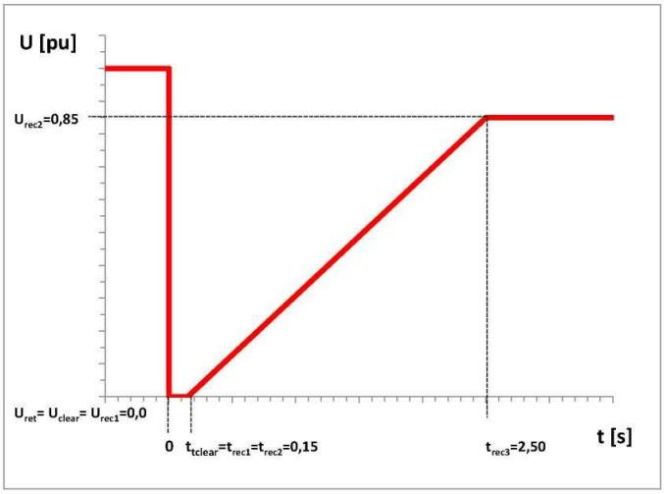
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
Article 16(3)(a)(i)	**FRT for symmetrical faults**		**N/A**
	PGM may disconnect from the network during the fault, if phase-to-phase voltage at the connection point falls below the required profile of the fault ride through and voltages at the connection point directly before the fault exceed: • The value determined in Article 16(2)(a) (for networks of 110 kV and more); • The admissible value determined in relevant legal regulations (for networks below 110 kV);		N/A
	Synchronous PGM type D must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below. Parameters referring to the capability of synchronous power-generating modules of fault ride through		N/A

Voltage parameters [pu]		Time parameters [s]	
Uret:	0.00	tclear:	0.15
Uclear:	0.25	trec1:	0.45
Urec1:	0.50	trec2:	0.70
Urec2:	0.85	trec3:	1.50



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	PPM type D must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below: Parameters referring to the capability of power park modules of fault ride through		N/A

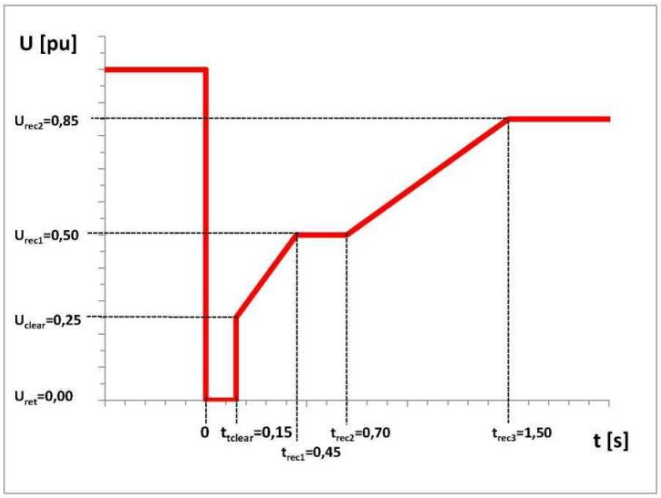
Voltage parameters [pu]		Time parameters [s]	
Uret:	0.00	tclear:	0.15
Uclear:	0.00	trec1:	0.15
Urec1:	0.00	trec2:	0.15
Urec2:	0.85	trec3:	2.5



Article 16(3)(c)	**FRT for non-symmetrical faults**		**N/A**
	Requirements for fault ride through in the case of non-symmetrical faults refer to the phase-to-phase voltage profile with the lowest amplitude. A power-generating module may disconnect from the network during the non-symmetrical fault, if at least one phase-to-phase voltage at the connection point falls below the curve presented in the relevant figure below and voltage at the connection point directly before the fault exceeds: • The value determined in Article 16(2)(a) (for networks of 110 kV and more); • The admissible value determined in relevant legal regulations (for networks below 110 kV);		N/A

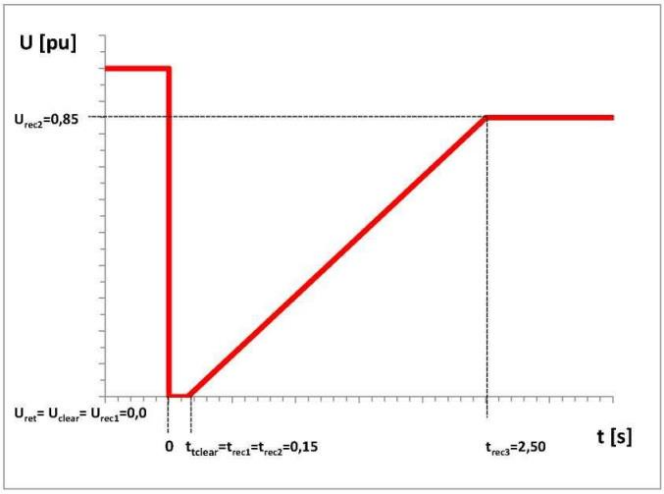
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	Synchronous PGM type D must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below. Parameters referring to the capability of synchronous power-generating modules of fault ride through		N/A

Voltage parameters [pu]		Time parameters [s]	
Uret:	0.00	tclear:	0.15
Uclear:	0.25	trec1:	0.45
Urec1:	0.50	trec2:	0.70
Urec2:	0.85	trec3:	1.50



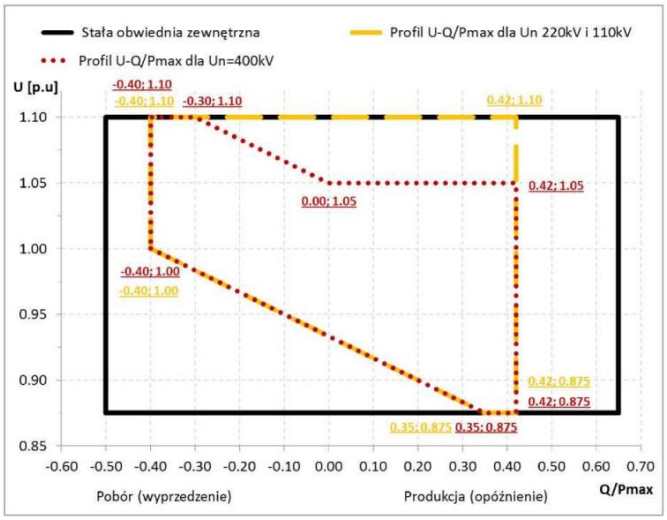
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	PPM type D must meet the requirements concerning the capability of fault ride through that are described in the table below and in the figure below: Parameters referring to the capability of power park modules of fault ride through		N/A

Voltage parameters [pu]		Time parameters [s]	
Uret:	0.00	tclear:	0.15
Uclear:	0.00	trec1:	0.15
Urec1:	0.00	trec2:	0.15
Urec2:	0.85	trec3:	2.5

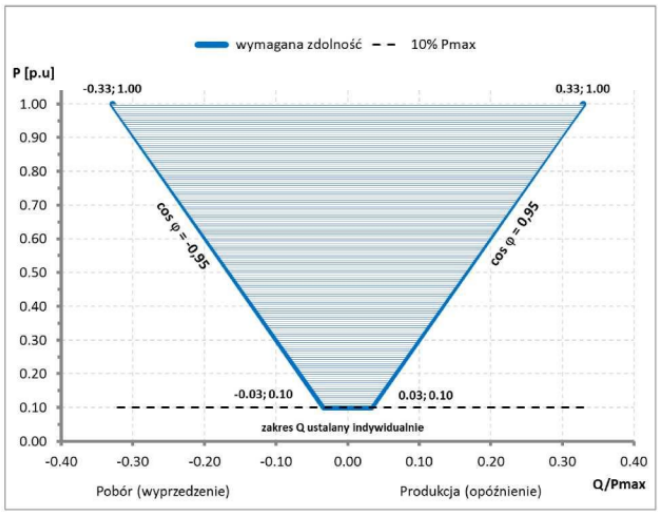
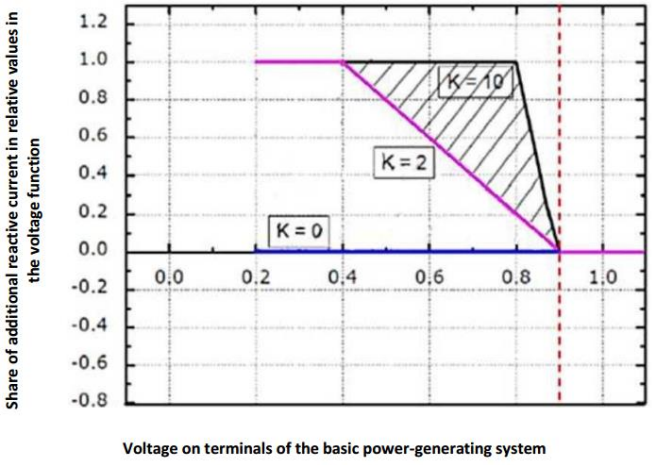


Article 16(4)(d)	**Synchronization conditions**	**N/A**
	Unless a relevant SO has arranged otherwise with a power-generating facility owner, the following requirements concerning the synchronization with the network shall be specified:	**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	(i) voltage, whereas the agreed voltage difference should fall in the range between 0% and +5% of network voltage; (ii) frequency, whereas the agreed frequency difference should not exceed 0.067 Hz; (iii) phase angle range, whereas the agreed phase angle difference should fall in the range between 0° and +10°, whereas the "+" sign means leading of the generator phase compared to the network; (iv) phase sequence (checking phase sequence before synchronization); (v) voltage and frequency deviations - synchronization should be possible in the scope of network frequencies resulting from the provisions of Article 13(1)(a) and in the scope of voltages: • Defined in Article 16(2)(a)(i) (for PGM connected to the network of 110 kV and more), • Defined by a relevant SO (for PGM connected to the network with a voltage lower than 110kV).		N/A
ARTICLE 17	**REQUIREMENTS FOR SYNCHRONOUS POWER-GENERATING MODULES**		**N/A**
Article 17(2)(a)	**Reactive power**		**N/A**
	Unless a relevant SO determines otherwise, a synchronous power-generating module, at maximum generated active power, must be capable of providing (on device terminals) reactive power with a power factor in the range cos φ = 0.85 towards reactive power generation and cos φ = 0.95 towards reactive power consumption. When active power generated is below the maximum power ($P<P_{max}$), the synchronous power-generating unit must be capable of generating reactive power (Mvar) in the range resulting from the pie chart of the P-Q capability of the synchronous power-generating unit.	Not synchronous power-generating modules.	N/A
Article 17(3)	**Post-fault active power recovery**		**N/A**
	Post-fault active power recovery by the synchronous power-generating module should take place without undue delay, in line with the natural (inherent) characteristics of a synchronous machine. In the case of applying fast valving automation, the post-fault restoration of active power may take place according to a different characteristics than the one resulting from natural characteristics of the synchronous PGM, agreed with a relevant SO, in agreement with TSO.		N/A
ARTICLE 18	**REQUIREMENTS FOR TYPE C SYNCHRONOUS POWER-GENERATING MODULES**		**N/A**

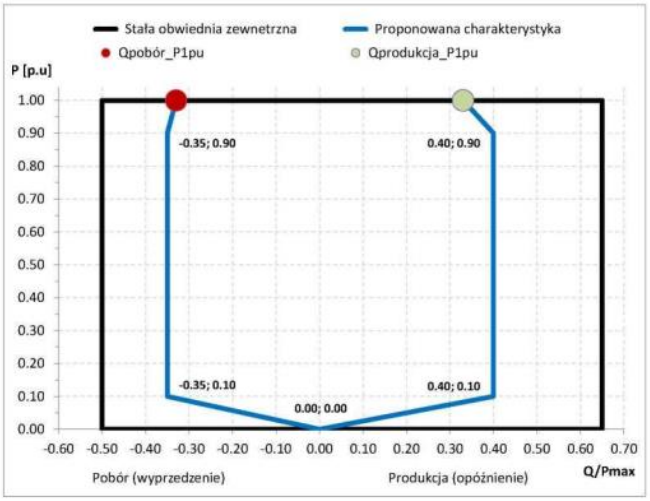
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
Article 18(2)(b)(i), (ii), (iii)	**Reactive power**		**N/A**
	Capability of a synchronous power-generating module type D, connected at or above 110 kV, to generate reactive power at the maximum power has been defined in the table below and in the figure below. **Inner envelope parameters** Network rated voltage / Maximum range Q/Pmax / Maximum range of the voltage level at steady state in relative units 400 kV / 0.82 / 0.225 220 kV and 110 kV / 0.82 / 0.225 **U-Q/Pmax profile of the synchronous power-generating module**		N/A
			N/A
	The chart presents the boundaries of the U-Q/Pmax profile, divided into voltages at connection point, expressed as a ratio of its actual value to reference voltage 1 pu, compared to the ratio of reactive power (Q) to maximum power (P_{max}). Location, size and shape of the inner envelope are separately marked for 400 kV network voltage (with a dotted red line) and for a 220 kV and 110 kV network voltage (with a dashed orange line). A relevant SO has the right to modify the presented range of the U-Q/Pmax profile (within the framework of maximum values and fixed outer envelope provided for in the Regulation), should such need be expressed by an expert opinion concerning the connection. Unless a relevant SO determines otherwise, a synchronous power-generating module type C or D connected to a network with a voltage below 110 kV, at maximum generated active power, must be capable of providing (on device terminals) reactive power with a power factor in the range cos φ =0.85 towards reactive power generation and cos φ =0.95 towards reactive power consumption.		N/A

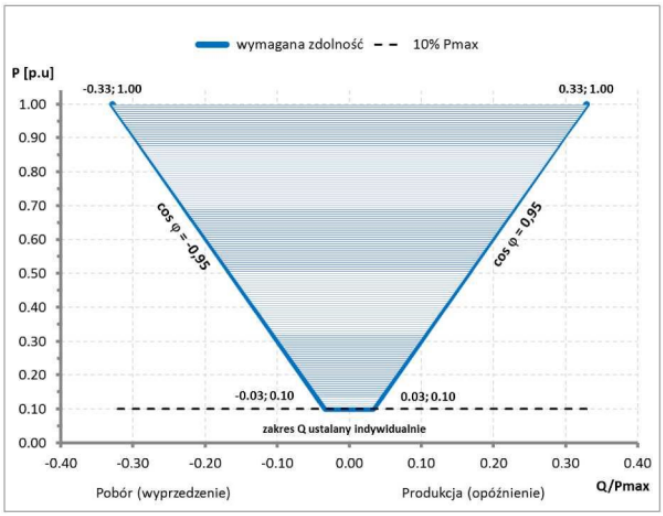
PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
Article 18(2)(b)(iv)	**Rate of change of reactive power**		**N/A**
	A synchronous power-generating unit must be capable of moving to any operating point set by a relevant SO within its U-Q/P_{max} profile in a time of up to 150 seconds. The adjustment time is determined individually, if a change in the operating point forces a change in the operating status of static measures for compensating reactive power or a change of a gear of a network transformer of a synchronous power-generating module, if exists. The abovementioned requirement defines the maximum capacity and does not exclude slower activation of reactive power, if it results from the properties of the superior voltage adjustment system or other network conditions.		N/A
ARTICLE 19	**REQUIREMENTS FOR TYPE D SYNCHRONOUS POWER-GENERATING MODULES**		**N/A**
Article 19(2)(b)(v)	**PSS**		**N/A**
	In order to guarantee stable operation of the system, all synchronous power-generating modules type D, with maximum power of 20 MW and more, must be equipped with a PSS function (power oscillation damping).		N/A
ARTICLE 20	**REQUIREMENTS FOR POWER PARK MODULES**		**N/A**
Article 20(2)(a)	**Reactive power**		**N/A**
	Unless a relevant SO decides otherwise, PPM type B must be capable of providing reactive power at the connection point, at maximum power, resulting from cos φ =0.95 towards reactive power consumption and generation. When PPM operates at active power in the range below the maximum power to 0.1 of the maximum power, the entire remaining reactive power shall be made available, in line with technical capabilities, however no less than resulting from cos φ =0.95 (for current active power), both towards reactive power consumption and generation. When PPM operates at active power in the range below 0.1 of the maximum power, the entire remaining reactive power shall be made available, in line with technical capabilities, however detailed requirements from the power generating module for the purpose of reactive power generation will be arranged individually with a relevant SO.	(See appended table)	N/A

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	P-Q/Pmax profile of the power park module type B  		N/A
Article 20(2)(b)	**Fast fault current (symmetrical faults)**		**N/A**
	Unless a relevant SO, in agreement with TSO, decides otherwise, PPM should be capable of generating additional fast fault current, in line with the below static characteristics with a settable K factor value in the range between 2 and 10, in the following time: (i) 90% of additional reactive current on terminals of basic power-generating systems in time no longer than 60 ms. (ii) The target value of this current should be reached with accuracy of -10%/+20% within 100 ms from the moment the voltage deviation has occurred. At faults resulting in voltage dips below 0.2 U_n on terminals of the basic generation unit, no generation of additional reactive current is admissible.  	(See appended table)	N/A
Article 20(2)(c)	**Fast fault current (non-symmetrical faults)**		**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	Unless a relevant SO, in agreement with TSO, decides otherwise, power park module should be capable of generating fast fault current during non-symmetrical faults in phases affected by undervoltage. The capability in question shall be provided while meeting the requirements as regards static and dynamic parameters as well as symmetrical faults and taking account of limitations resulting from a non-symmetrical load on the basic power-generating system.	(See appended table)	N/A
Article 20(3)(a)	**Active power restoration following a fault**		**N/A**
	As regards the post-fault restoration of active power, PPM must meet the following requirements: (i) Post-fault active power restoration begins when post-fault voltage is restored to the value no lower than 90% U_n on the basic power-generating system included in the PPM. (ii) Maximum time for post-fault active power restoration (time counted from the removal of fault): 5 seconds. (iii) Volume of restored active power: 90% of pre-fault power, if the primary source of energy is available. (iv) Accuracy of active power restoration, understood as offset: 10% (v) Undamped oscillations after the active power restoration are not allowed.	(See appended table)	N/A
ARTICLE 21	**REQUIREMENTS FOR TYPE C POWER PARK MODULES**		**N/A**
Article 21(2)(a)	**Synthetic inertia**		**N/A**
	It is not required to apply synthetic inertia, therefore its operating parameters are not defined.		N/A
Article 21(3)(b)(i)	**Reactive power at the maximum power**		**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	Capability of a PPM type D, connected to a network of 110 kV and more, to generate reactive power at the maximum power has been defined in the table below and in the figure below. **Inner envelope parameters** Network rated voltage / Maximum range Q/Pmax / Maximum range of the voltage level at steady state in relative units 400 kV / 0.66 / 0.225 220 kV and 110 kV / 0.66 / 0.225 **U-Q/Pmax profile of the power park module** 		N/A
	The chart presents the boundaries of the U-Q/Pmax profile, divided into voltages at connection point, expressed as a ratio of its actual value to reference voltage 1 pu, compared to the ratio of reactive power (Q) to maximum power (Pmax). Location, size and shape of the inner envelope are separately marked for 400 kV network voltage (with a dotted red line) and for a 220 kV and 110 kV network voltage (with a dashed orange line). A relevant SO may modify the presented range of the U-Q/P_{max} profile (within the framework of maximum values and fixed outer envelope provided for in the Regulation), should such need be expressed by an expert opinion concerning the connection. Unless a relevant SO decides otherwise, PPM type C or D, connected to the network with a voltage below 110 kV, must be capable of providing reactive power at the connection point, at maximum power, resulting from cosφ=0.95 towards reactive power consumption and generation.		N/A
Article 21(3)(c)(i)	**Reactive power below the maximum power**		**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	The required capability of PPM to generate reactive power below the maximum power has been defined below: 	Network rated voltage	Maximum range Q/Pmax
---	---
400 kV	0.75
220 kV and 110 kV	0.75 | **P-Q/Pmax profile of the power park module**  		N/A
	The chart presents the boundaries of the P-Q/P_{max} profile, expressed as a ratio of its actual active power to maximum power in relative units (pu), compared to the ratio of reactive power (Q) to maximum power (P_{max}). A relevant SO may modify the presented range of the P-Q/P_{max} profile (within the framework of maximum values and fixed outer envelope provided for in NC RfG), should such need be expressed by an expert opinion concerning the connection. Unless a relevant SO decides otherwise, PPM type C or D, connected to the network with a voltage below 110 kV, must be capable of providing full reactive power at the connection point, in the range below the maximum power to 0.1 of the maximum power, in line with technical capabilities, however no less than resulting from cos φ = 0.95 (for current active power), both towards reactive power consumption and generation. When PPM operates at active power in the range below 0.1 of P_{max}, the entire remaining reactive power shall be made available, in line with technical capabilities, however detailed requirements from the power-generating module for the purpose of reactive power generation will be arranged individually with a relevant SO.		N/A

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	P-Q/Pmax profile of the power park module type C or D connected to the network with voltage below 110 kV  		N/A
Article 21(3)(c)(iv)	**Rate of adjustment of reactive power**		**N/A**
	The power park module must be capable of moving to any operating point within the confines of the P-Q/P_{max} profile, defined pursuant to Article 21(3)(c)(i), within 150 seconds, unless specified otherwise for a given adjustment type, in line with the requirements laid down on the basis of Article 21(3)(d). In the event of applying static measures for adjusting reactive power, longer adjustment time of moving between extreme reactive power values (however no longer than 15 minutes). Longer adjustment time will be agreed between a relevant SO and a power-generating facility owner. If moving between two PGM operating points requires a change in the position of a gear of on-load tap changer of the PGM transformer, then the indicated time shall be extended by the time of adjusting the position of the tap changer.		N/A
Article 21(3)(d)(iv)	**Dynamics of reactive power activation in the voltage function**		**N/A**
	PPM must meet the following additional requirements concerning the stable voltage level: When working in the voltage adjustment mode (in line with the set static characteristics, individually parameterized in the range resulting from Article 21(3)(d)(ii), (iii)), following a voltage step change the power park module must be capable of reaching 90% of the change in the generated reactive power in no more than t_1 = 5 seconds and must reach the value determined by the slope in no more than t_2 = 60 seconds.		N/A
Article 21(3)(d)(vi)	**Dynamics of power factor adjustment**		**N/A**

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict
	At operation in the power factor adjustment mode, the accuracy of reaching target power factor value following a sudden change in the generated active power is expressed by tolerance concerning the equivalent change in the reactive power and should not exceed 5% of the maximum reactive power or 5 MVAr (depending on which of these values is lower) and should be completed in no more than 150 seconds.		N/A
Article 21(3)(d)(vii)	**Operating modes of reactive power adjustment systems**		**N/A**
	In order to select the reactive power adjustment mode and define related setpoints, a relevant SO should have a possibility of remotely selecting one of three adjustment modes and requesting an operating point, unless a relevant SO decides otherwise in agreement with a power park module owner.		N/A
Article 21(3)(e)	**Active or reactive power contribution priority**		**N/A**
	During faults, where fault ride through is required, generation of reactive power has priority.		N/A
Article 21(3)(f)	**Oscillation damping**		**N/A**
	PPM contribution to power oscillation damping capability is not required.		N/A
Article 25(1)	**Voltage conditions**		**N/A**
	An offshore power park module must be capable of remaining in connection with the network and operating in the network voltage ranges at the connection point, expressed as a ratio of voltage at the connection point to reference voltage 1 pu and in periods defined in the table below: Voltage range / Operating time 1.118 pu - 1.15 pu (*) / 60 minutes 1.05 pu - 1.10 pu (**) / 60 minutes (*) Concerns a network with base voltage lower than 300 kV. (**) Concerns a network with base voltage between 300 kV and 400 kV.		N/A

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Summary of Test							
NC RfG	PSE 2018-12	Test Item	Type A	Type B	Type C	Type D	Result
13.1(a)	13(1)(a)(i)	Frequency range	x	x	x	x	P
16.2(a)	16(2)(a)(i)(ii)	voltage range				x	N/A
13.1(b)	13(1)(b)	Rate of change of frequency	x	x	x	x	P
13.6	13(6)	Remote cessation of active power	x	x			P
14.2	14(2)(b)	Remote control of active power		x	x	x	N/A
13.4	13(4)	Admissive Power Reduction	x	x			P
13.2 (*)	13(2) (a), (b), (f)	LFSM-O	x	x	x	x	P
15.2(c)	15(2)(c)(i)	LFSM-U			x	x	N/A
15.3(d)	15(2)(d)(i), (iii), (iv), (v)	FSM			x	x	N/A
14.3	14(3)(a)(i), (b)	Capability to withstand voltage dips for connection (FRT) below 110 kV		x	x		N/A
16.3	16(3)(a)(i), (c)	Capability to withstand voltage dips for connection (FRT) above 110 kV				x	N/A
20.2 (b), (c), 21.3 (e)	20(2)(b), (c), 21(3)(e)	Fast fault current injection, symmetric and asymmetric faults		x	x	x	N/A
20.3	20(3)(a)	Active power recovery after fault clearance		x	x	x	N/A
13.7	13(7)	Automatic connection to the network	x	x	x	x	P
14.4	14(4)(a)	Reconnection of PGM to the network		x	x	x	N/A
20.2(a), 21.3(c)	20(2)(a), 21(3)(c)(iv)	reactive power (fixed cos ϕ)		x	x	x	N/A
21.3(b), 21.3(d)	21(3)(b)(i), 21(3)(d)(iv)	reactive power at the maximum power (U-Q/Pmax)			x	x	N/A
21.3(c), 21.3(d)	21(3)(c)(i), 21(3)(d)(vi)	reactive power below the maximum power (P-Q/Pmax)			x	x	N/A

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Summary of Test

(*) Article 13.2(b) only applicable for type A PPMs according to NC RfG.

Refer to follow standards:

Conditions and procedures for the use of certificates in the process of connecting power generating modules to power grids (PTPiREE 2024-10).
Warunki i procedury stosowania certyfikatów w procesie przyłączania modułów wytwórczych do sieci elektroenergetycznych (PTPiREE 2024-10).

General Application Requirements resulting from Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (NC RfG) – approved by the decision of the President of the Energy Regulatory Office DRE.WOSE.7128.550.2.2018.ZJ dated January 2nd 2019. (PSE 2018-12)
Wymogi ogólnego stosowania wynikające z Rozporządzenia Komisji (UE) 2016/631 z dnia 14 kwietnia 2016 r. ustanawiającego kodeks sieci dotyczący wymogów w zakresie przyłączenia jednostek wytwórczych do sieci (NC RfG), PSE S.A., 2018-12-18 zatwierdzone Decyzją Prezesa Urzędu Regulacji Energetyki DRE.WOSE.7128.550.2.2018.ZJ z dnia 2 stycznia 2019 r. (PSE 2018-12)

Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators, published in the Official Journal of the European Union L112/1, European Commision, 27.04.2016. (NC RfG)

Rozporządzenie Komisji (UE) 2016/631 z dnia 14 kwietnia 2016 r. ustanawiające kodeks sieci dotyczący wymogów w zakresie przyłączenia jednostek wytwórczych do sieci, opublikowane w Dzienniku Urzędowym Unii Europejskiej L112/1, KOMISJA EUROPEJSKA, 27.04.2016. (NC RfG)

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Article 13(1)(a)(i)	**TABLE: Frequency Parameters**							**P**
Model	SG2000							
Test sequence	Test condition		Measurement				Limits	
	U/U_n	f (Hz)	f (Hz)	U/U_n (p.u.)	P/P_n (p.u.)	Cosϕ	Duration T (s)	Cont. Time
Test 1	85%	47.0	46.99	0.849	0.929	0.999	200	≥ 20 s
Test 2	85%	47.5	47.49	0.849	0.930	0.999	5500	≥ 5400 s
Test 3	95%	47.5	47.49	0.949	0.992	0.999	5500	≥ 5400 s
Test 4	110%	51.5	51.49	1.091	1.012	0.999	5500	≥ 5400 s
Test 5	110%	52.0	51.99	1.091	1.006	0.999	920	≥ 900 s

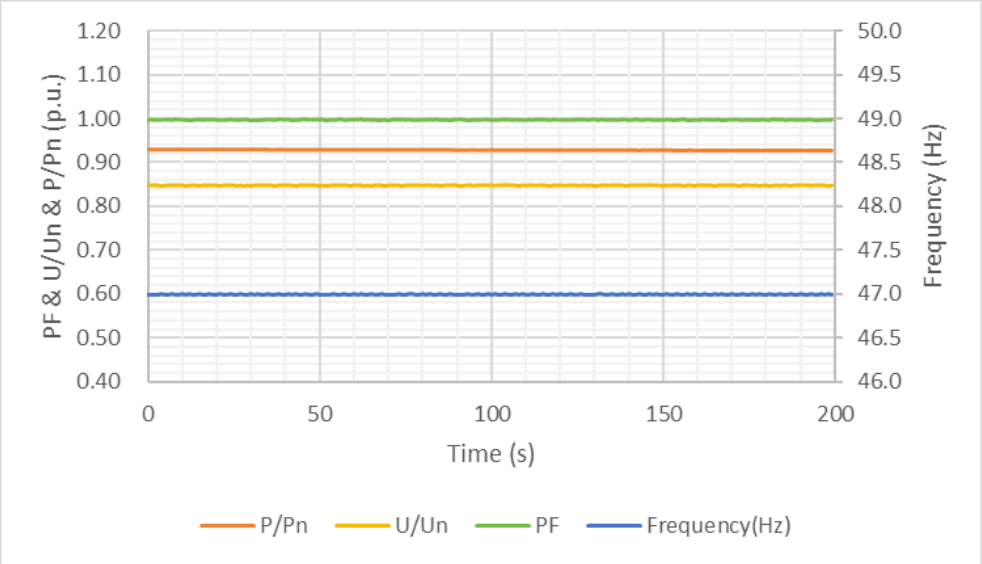
Note:

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

In case of voltages below U_n, the output apparent power may be not reaching the max value due to the lower voltage and the limitation of inverter max output current.

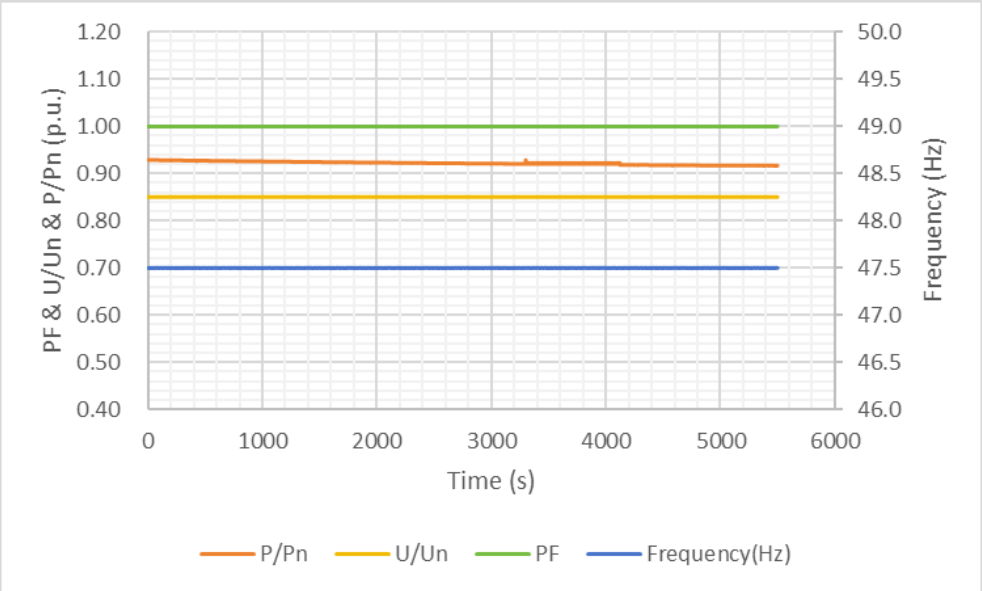
*The overfrequency load drop function is enabled.

Graph of test 1

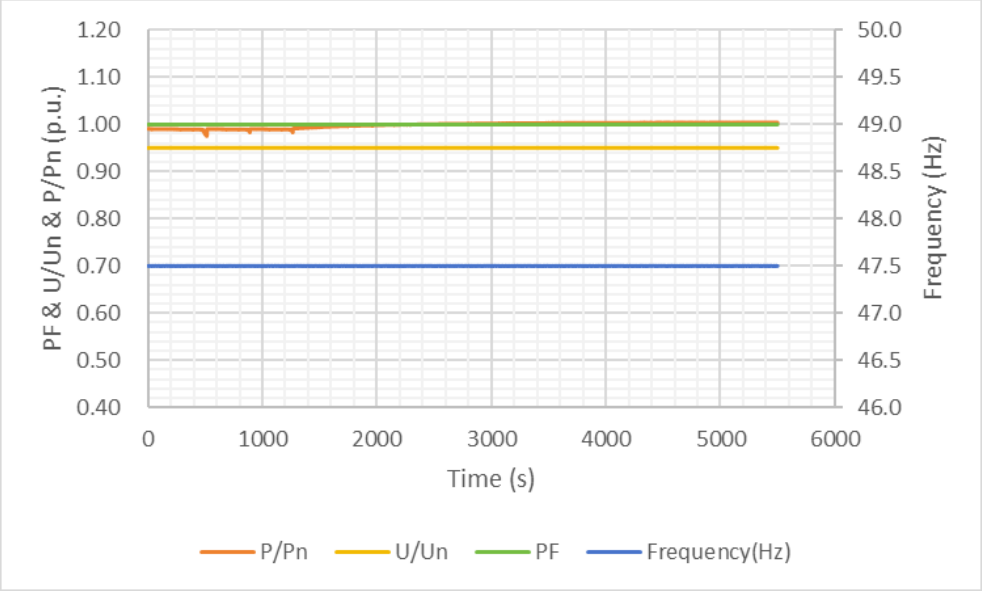


PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of test 2

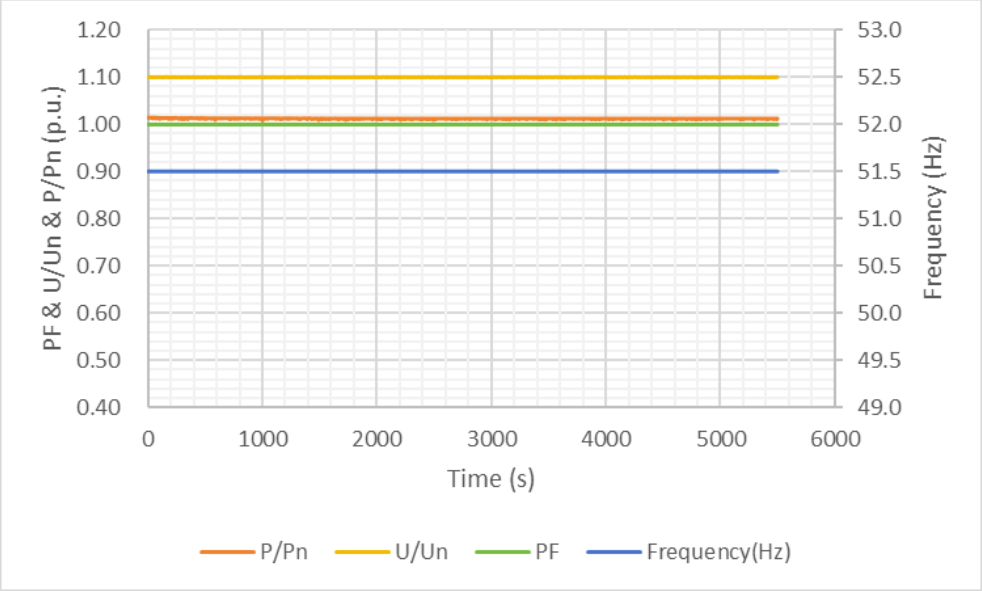


Graph of test 3

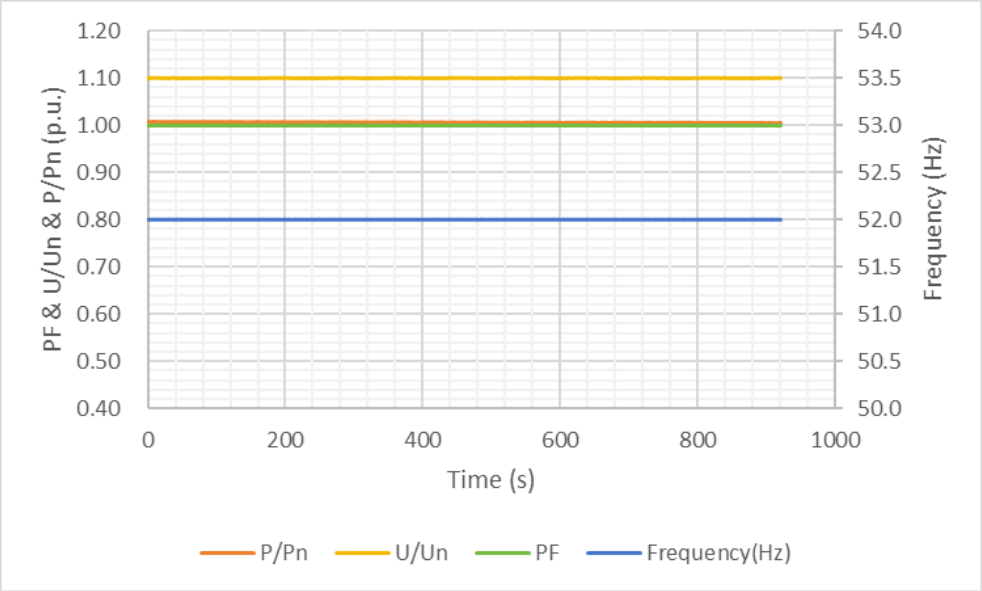


PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of test 4



Graph of test 5



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Article 13(1)(b)	**TABLE: Rate of change of frequency**					**P**
Model	SG2000					
Test step	Ramp	From (Hz)	To (Hz)	Time (s)	Power (W)	Limit
1	dwell	50.0	50.0	5.0	2013.4	No disconnection
2	+2 Hz/s	50.0	51.0	0.5	2007.6	
3	dwell	51.0	51.0	5.0	2010.1	
4	-2 Hz/s	51.0	48.0	1.5	2013.4	
5	dwell	48.0	48.0	5.0	2010.4	
6	2 Hz/s	48.0	50.0	1.0	2000.9	
7	dwell	50.0	50.0	5.0	2014.2	

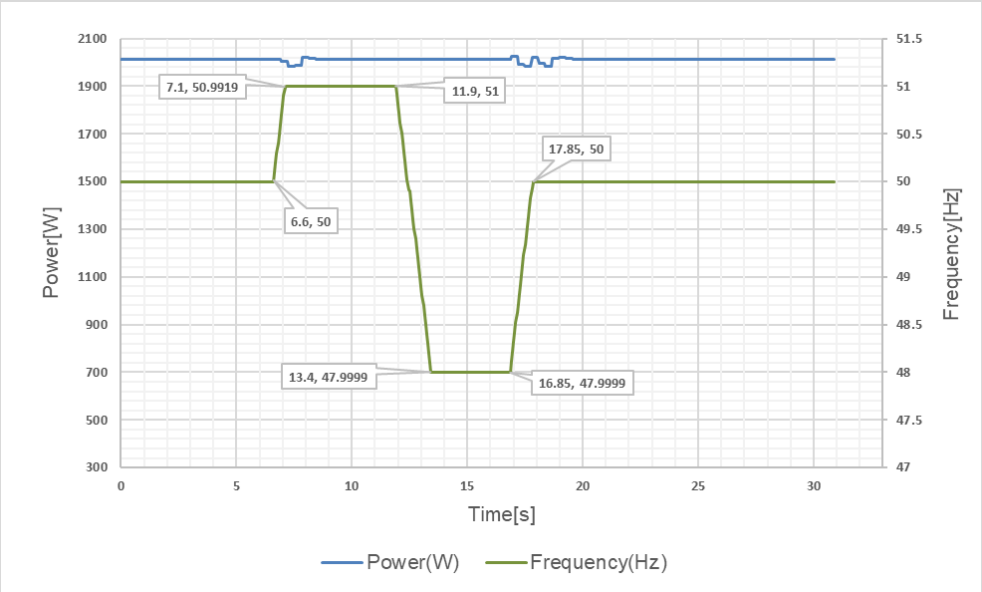
Note:

Required PGM capability of remaining connected to the network and operate at the rate of change of frequency up to:

$$\left|\frac{df_{max}}{dt}\right| = 2.0 \left|\frac{Hz}{s}\right|$$

The ROCOF immunity is defined with a sliding measurement window of 500 ms.

Diagram



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Article 13(2)(a), (b), (f)	**TABLE: Power response to over-frequency (LFSM-O)**	**P**
Model	SG2000	

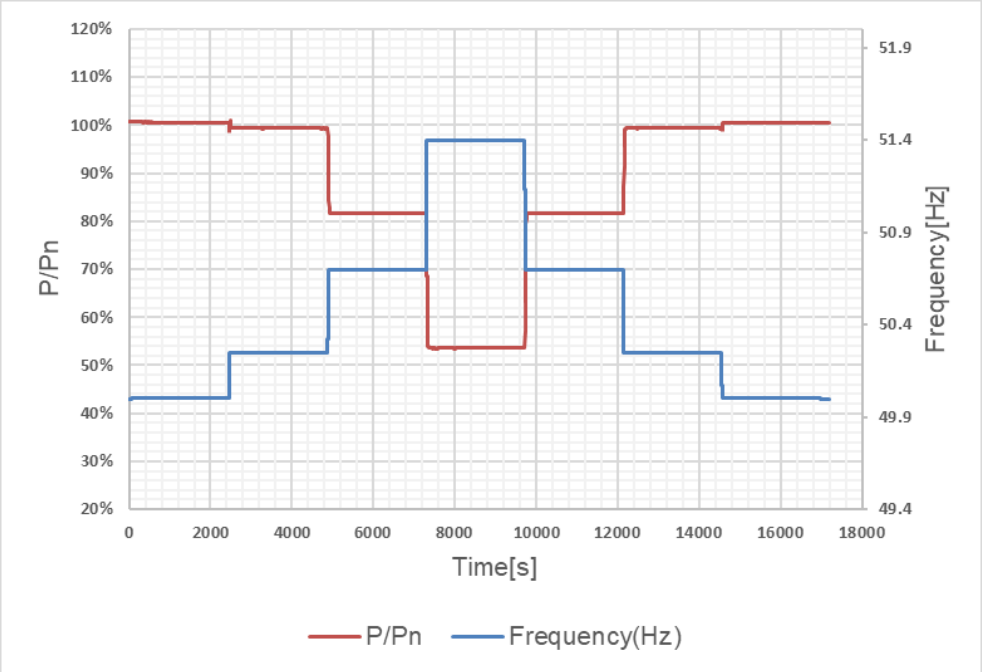
Test No. 1:

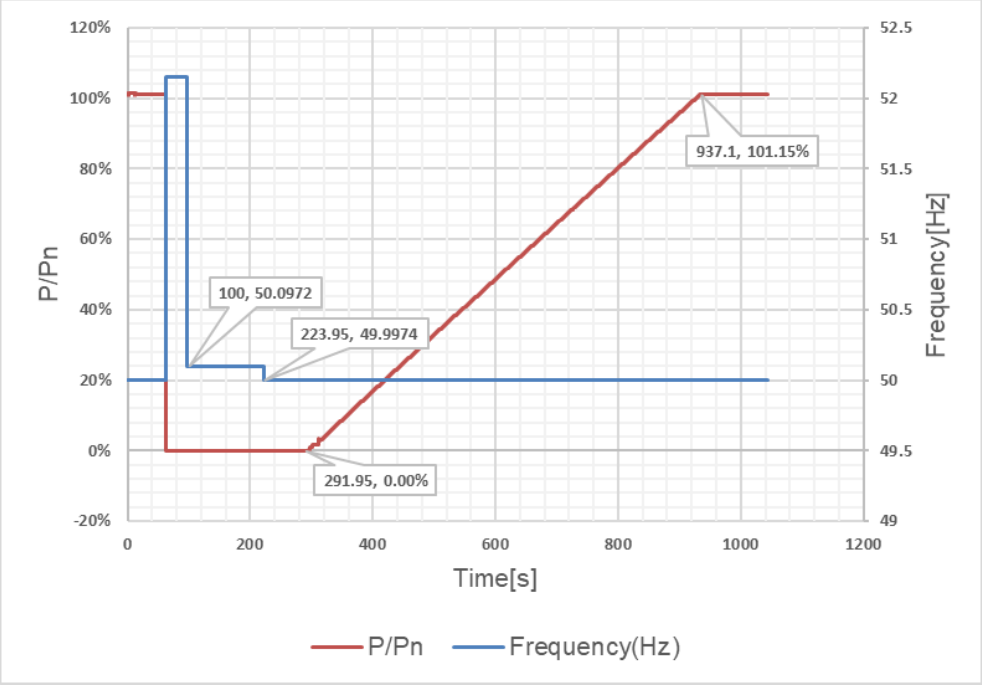
Power output:	100% P_n
Starting frequency f_1:	50.2 Hz
Deactivation threshold f_{stop}:	50.2 Hz (Deactivated)
Droop:	5% (40% P_{ref} / Hz)

Test condition		Measurement						Limit $\Delta P/P_n$
f (Hz)	Target P/P_n	f (Hz)	P/P_n (%)	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	$\Delta P/P_n$ (%)	
a) 50.00	100%	49.99	100.54%	--	--	--	0.54%	± 10%
b) 50.25	97.8%	50.24	99.39%	--	1.4	0.4	1.39%	
c) 50.70	78%	50.69	81.66%	--	2.1	0.4	1.66%	
d) 51.40	52%	51.39	53.54%	--	2.2	0.4	1.54%	
e) 50.70	78%	50.69	81.72%	--	1.7	0.4	1.72%	
f) 50.25	97.8%	50.24	99.38%	--	2.1	0.4	1.38%	
g) 50.00	100%	49.99	100.47%	--	0.8	0.4	0.47%	

Test condition	Measurement		Limit
g) 50 to h) 52.15	Disconnection Time (ms):	468.0	500 ms
h) 52.15 to i) 50.15	Reconnection:	No reconnection	No reconnection
i) 50.15 to j) 50	Reconnection time (s):	68.0	≥ 60 s
	Max. power gradient (%P_n / min):	9.4	≤ 10% P_n / min

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

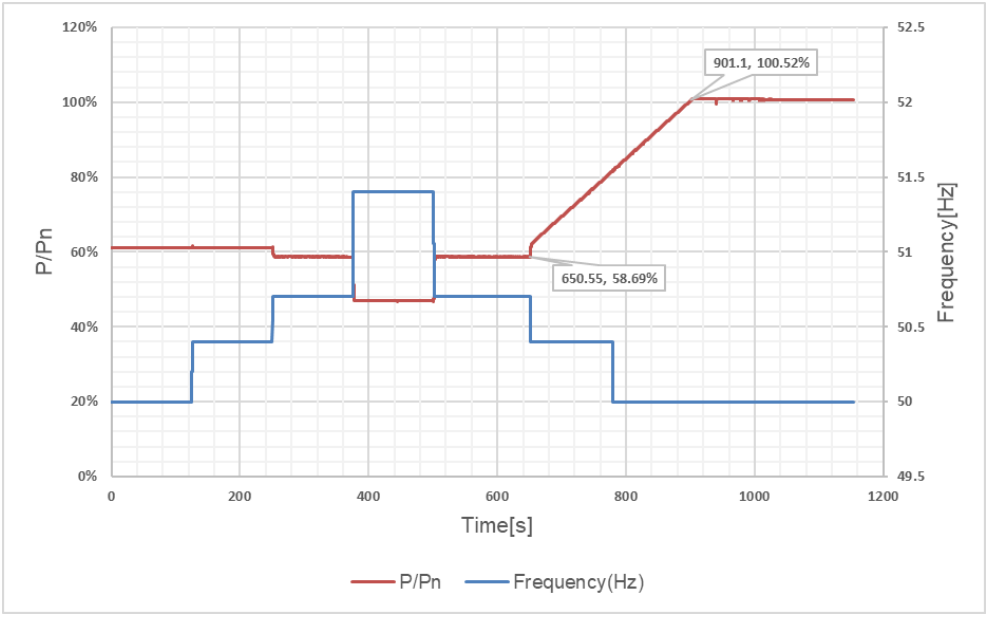




PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Test No. 2:								
Power output:		60% P_n						
Starting frequency f_1:		50.5 Hz						
Deactivation threshold f_{stop}:		50.5 Hz (Deactivated)						
Droop:		12% (16.67% P_{ref} / Hz)						
Test condition		Measurement						Limit $\Delta P/P_n$
f (Hz)	Target P/P_n	f (Hz)	P/P_n (%)	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	$\Delta P/P_n$ (%)	
a) 50.00	60%	49.99	61.07%	--	--	--	1.07%	± 10%
b) 50.40	60%	50.39	61.06%	--	1.7	0.5	1.06%	
c) 50.70	56.7%	50.70	58.70%	--	2.8	0.5	2.00%	
d) 51.40	45%	51.40	46.88%	--	3.5	0.5	1.88%	
e) 50.70	56.7%	50.70	58.70%	--	3.5	0.5	2.00%	
f) 50.40	60% to 100%	50.39	100.81%	--	--	0.5	0.81%	
g) 50.00	100%	49.99	100.74%	--	--	--	0.74%	
Test condition		Measurement					Limit	
e) 50.7 to f) 50.4		Max. power gradient (%P_n / min):			10.0		≤ 10% P_n / min	

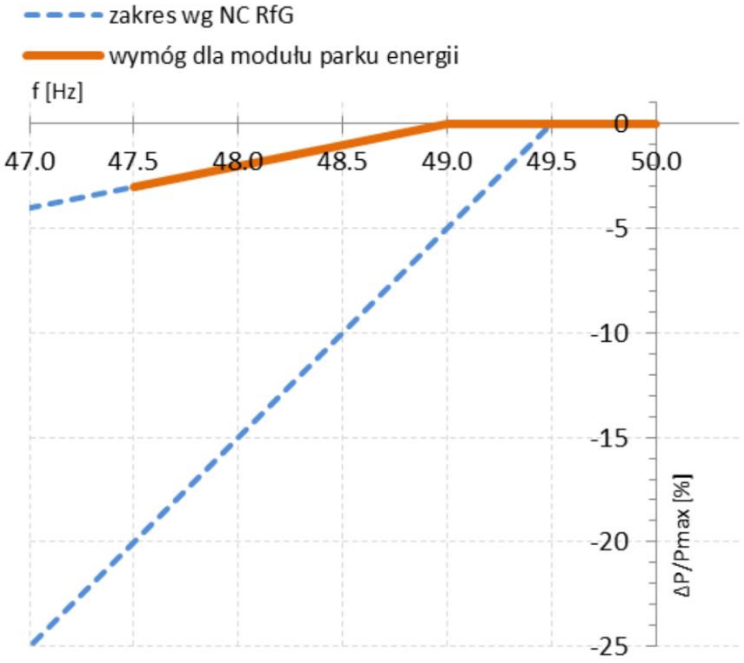
Note:Capability of setting the frequency threshold of the LFSM-O in the range: 50.2 Hz-50.5 Hz, default value 50.2 Hz.
Capability of droop settings of the LFSM-O in the range: 2-12%, default value 5%.
As regards Power Park Modules, the P_{ref} value means maximum active power P_n.



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

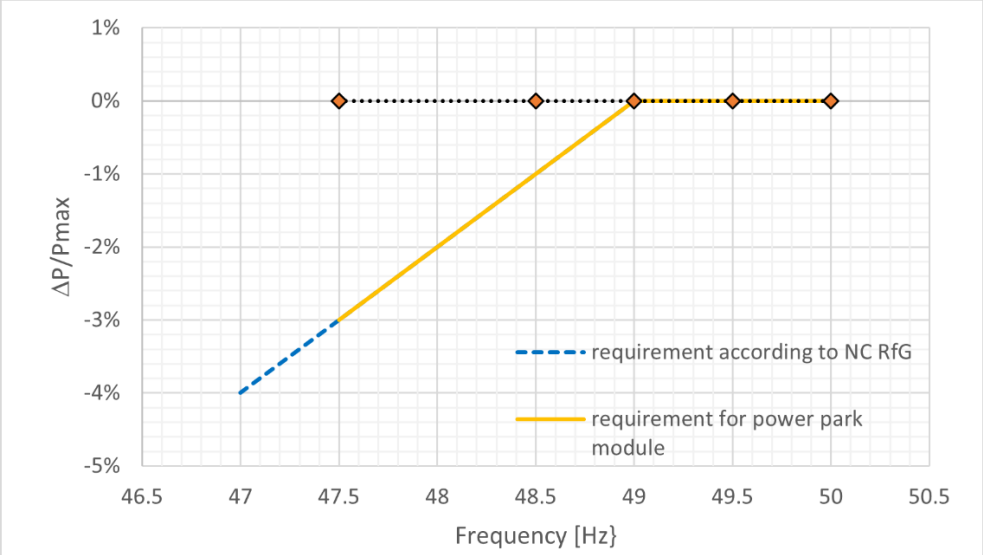
Article 13(4)	**TABLE: Admissive Power Reduction**								**P**
Model	SG2000								
Test sequence	Test condition		Measurement						Limits
	U/U_n	f (Hz)	Vol (V)	f (Hz)	P (W)	Cos φ (PF)	$\Delta P/P_n$ (%)	$\Delta P/P_n$ per 1 Hz	$\Delta P/P_n$ per 1 Hz
1	100%	50.0	229.9	49.90	2010.5	0.999	--	--	--
2	100%	49.5	229.9	49.49	2006.5	0.999	-0.20%	-0.40%	--
3	100%	49.0	229.9	48.99	2005.3	0.999	-0.06%	-0.12%	≥ -2% *
4	100%	48.5	229.9	48.49	2002.9	0.999	-0.12%	-0.24%	
5	100%	47.5	229.9	47.49	1999.8	0.999	-0.15%	-0.15%	

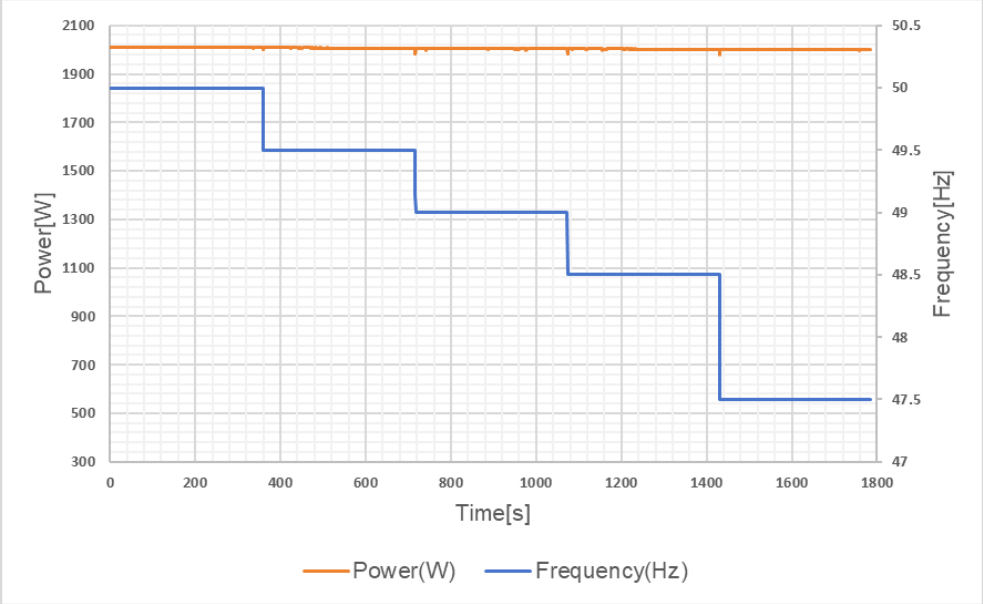
Note:
Requirement for power park module in PSE 2018-12 and refer the Figure as attached.



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

P-f Diagram





PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Article 13(7) Article 14(4)(a)	**TABLE: Automatic connection and Reconnection of PGM to the network (Starting connection and reconnection)**	**P**

Model: SG2000

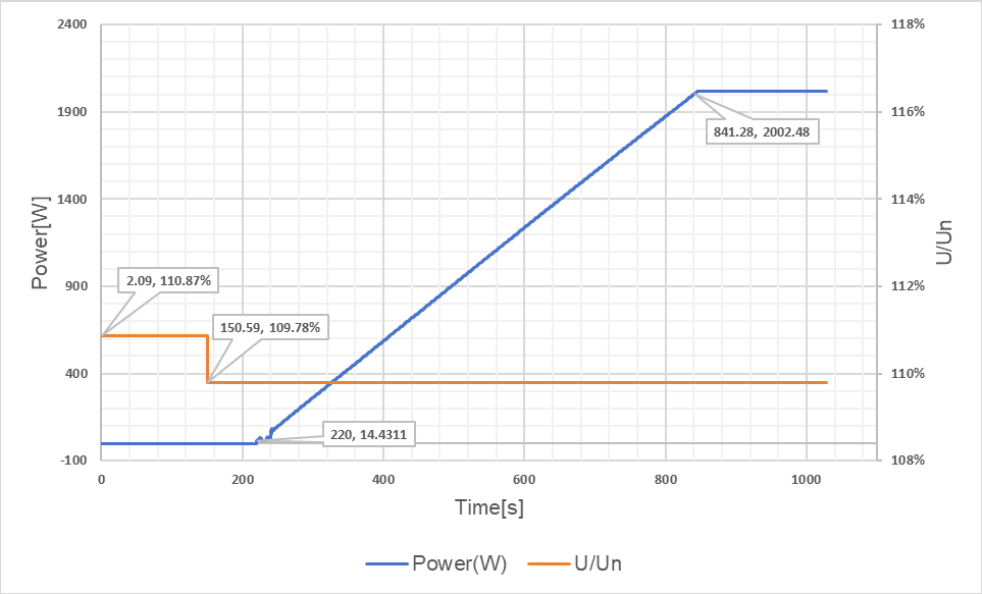
Parameter		Range	Default setting	
			Starting connection	Reconnection
Setting values	Upper voltage (U >) (V):	230.0 – 276.0	253.0	253.0
	Lower voltage (U <) (V):	115.0 – 230.0	195.5	195.5
	Upper frequency (f >) (Hz):	50.0 – 50.2	50.05	50.05
	Lower voltage (f <) (Hz):	47.0 – 50.0	49.0	49.0
	Observation time [s]:	10 – 600	60	60
	Active power increase gradient:	6% – 3000% Pn / min	≤ 10% P_n / min	≤ 10% P_n / min

Test condition	Measurement		Limitation	
	Observation time [s]	Power gradient [%P_n / min]	Observation time	Power gradient
Starting connection:				
U >	69.4	9.59%	≥ 60s	≤ 10% P_n / min
U <	70.8	9.45%		
f >	69.9	9.33%		
f <	65.6	9.42%		
Reconnection:				
U >	66.5	9.61%	≥ 60s	≤ 10% P_n / min
U <	63.9	9.47%		
f >	62.3	9.55%		
f <	66.4	9.49%		

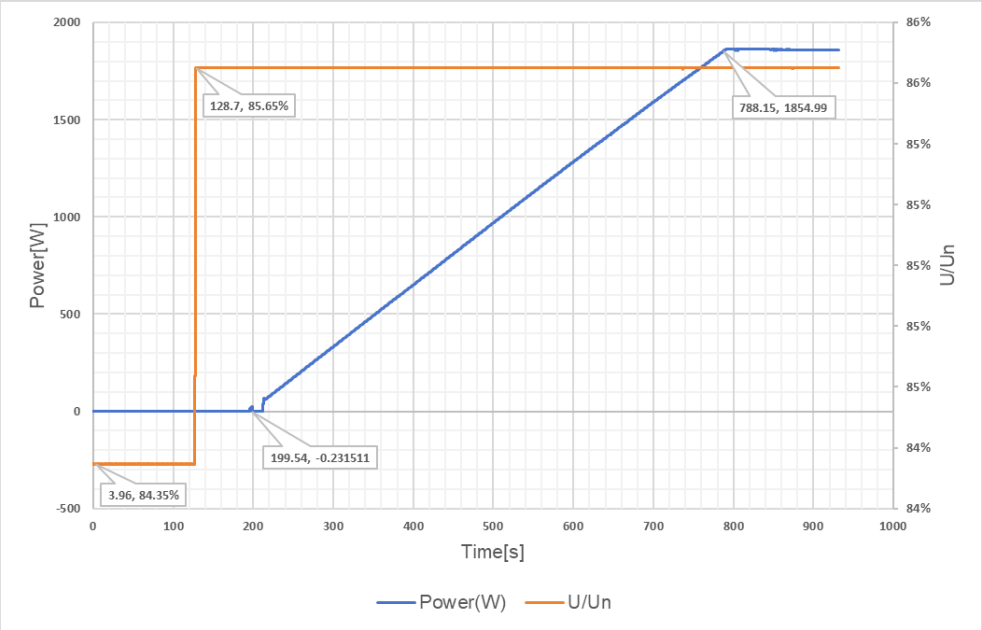
Note: N/A

PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Starting connection: U >

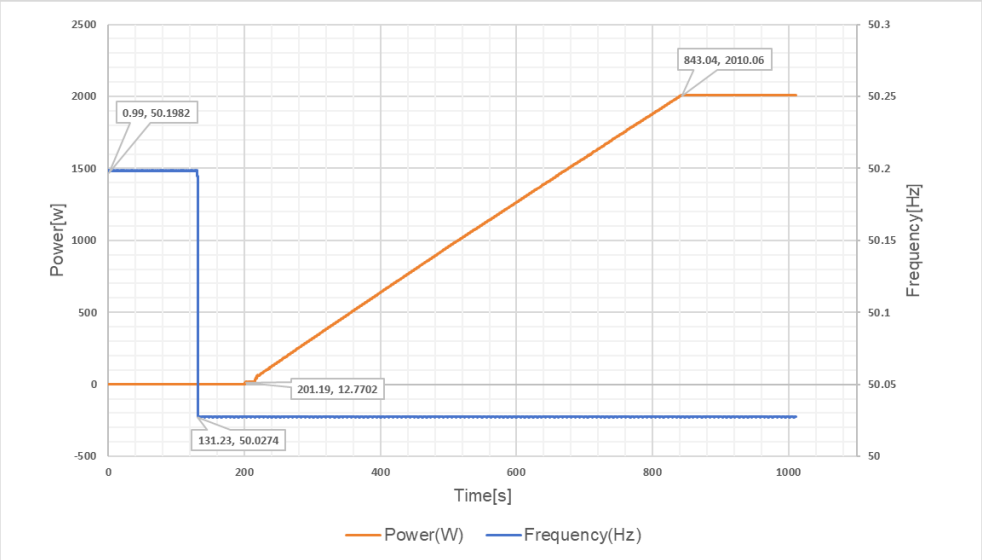


Starting connection: U <

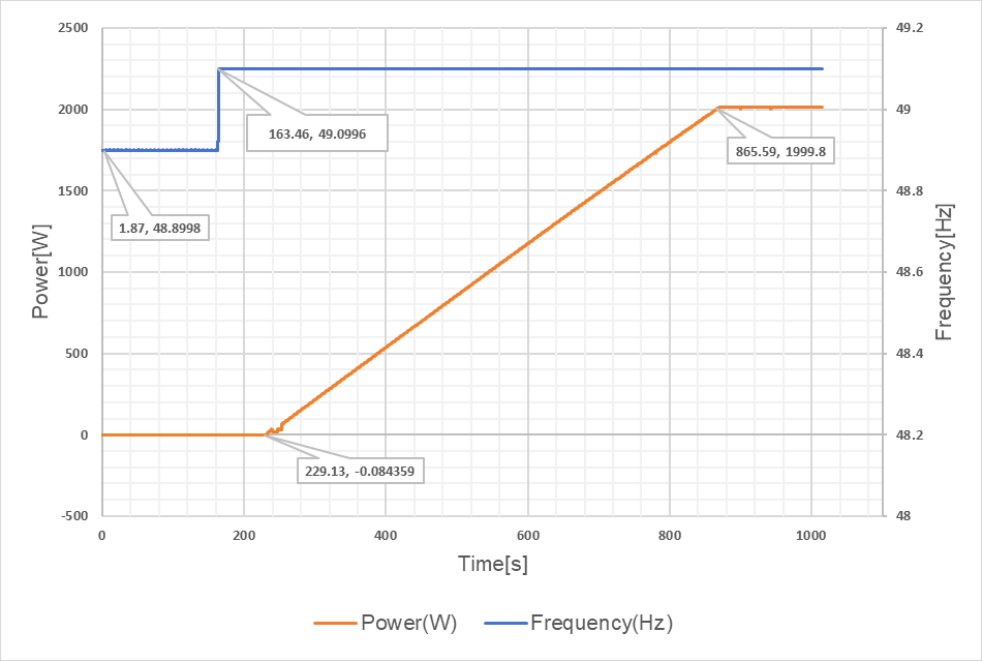


PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Starting connection: f >

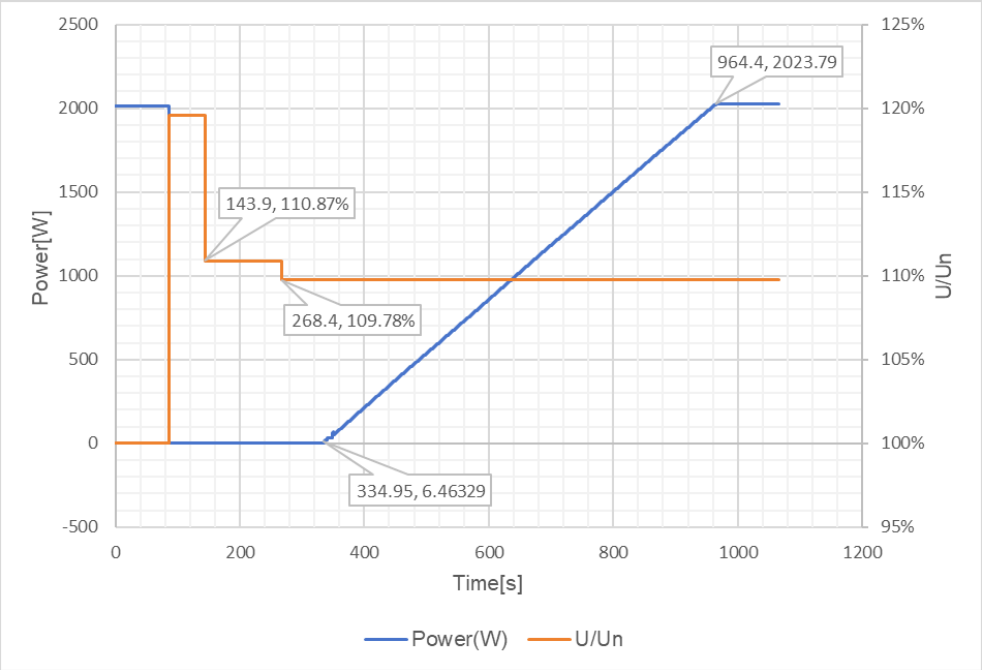


Starting connection: f <

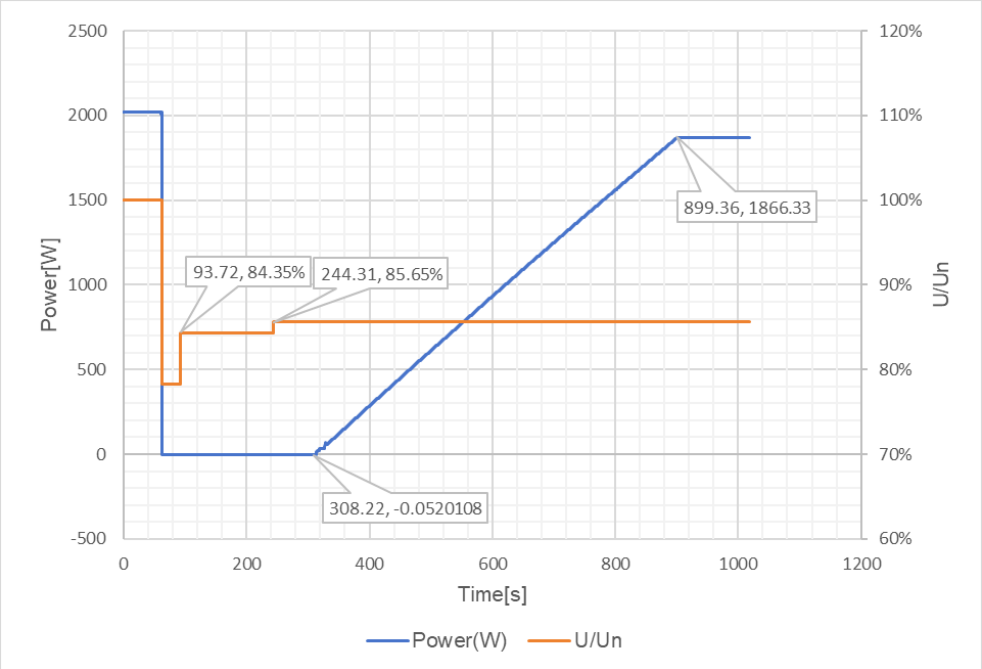


PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Reconnection: U >

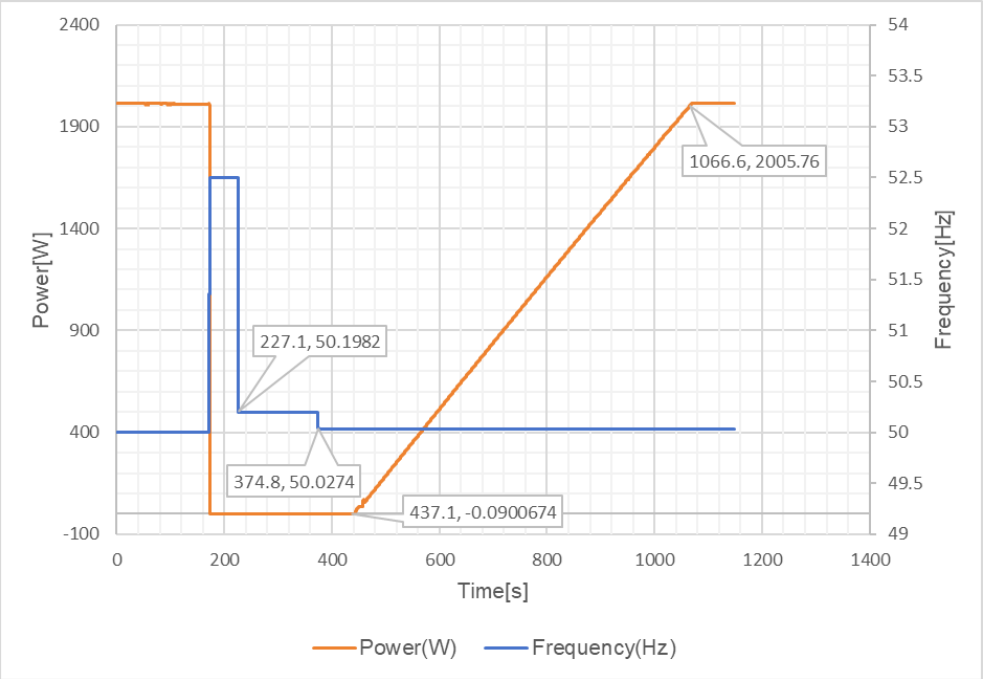


Reconnection: U <



PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Reconnection: f >



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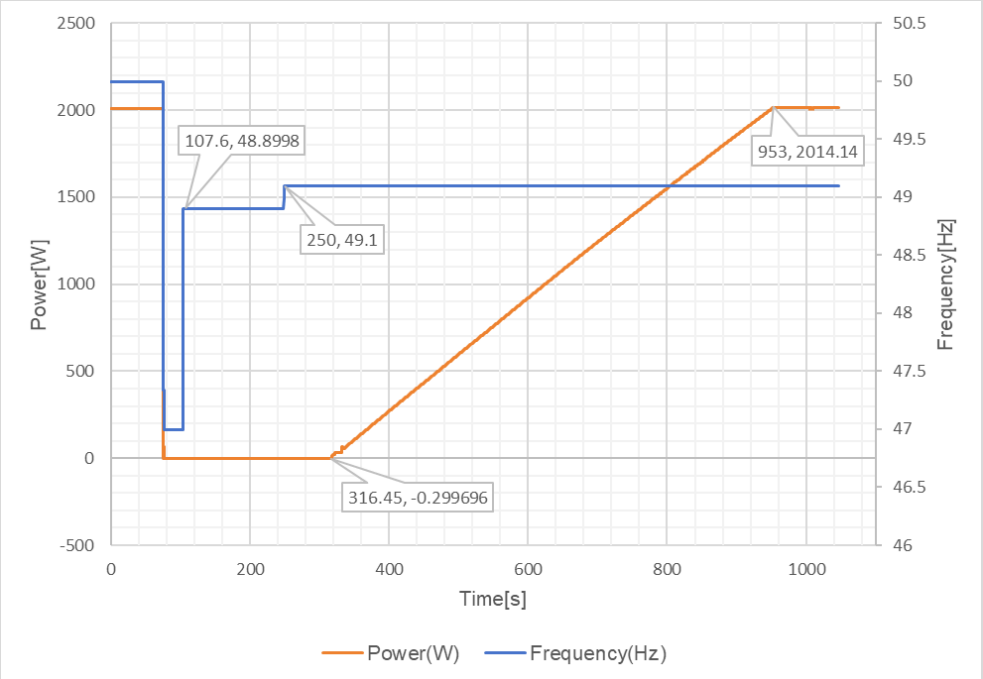


PTPiREE 2024-10; PSE 2018-12; NC RfG			
Clause	Requirement - Test	Result - Remark	Verdict

Article 13(6) Article 14(2)(b)	**TABLE: Remote control - Ceasing active power**	**P**
Model	SG2000	

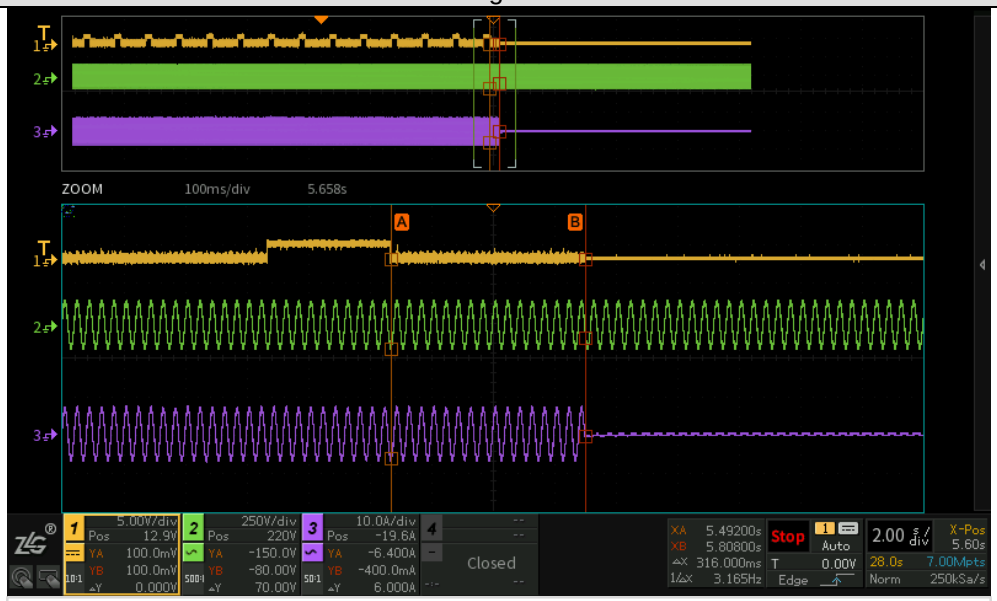
Reducing the active power from 100% P_n to 0

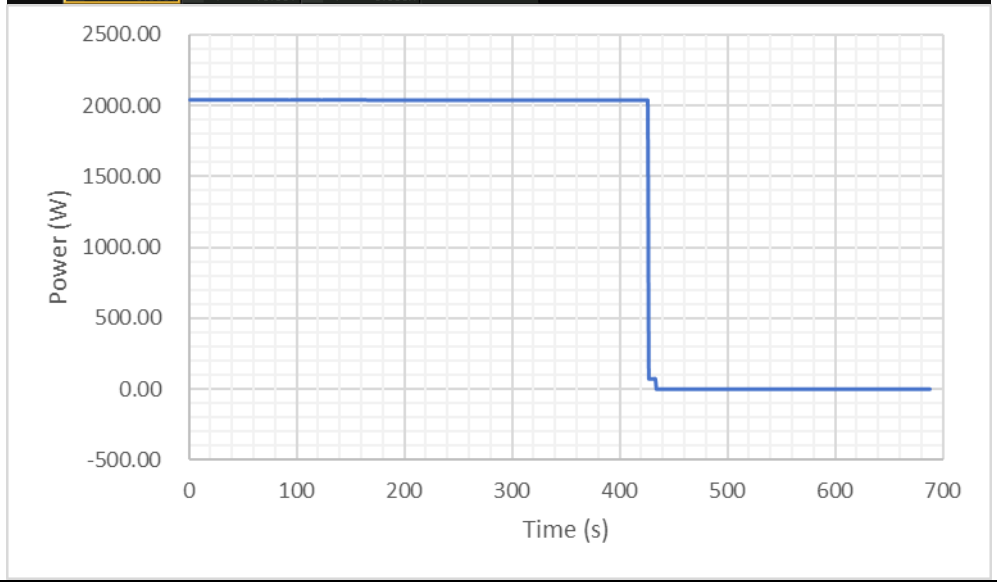
Measured max power [kW]	Ceasing time [s]	Limit [s]
2.036	0.316	5.0

Note: Generating plants with a maximum capacity of 0.8 kW or more shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being recieved at the input port. If required by the DSO and the responsible party, this includes remote operation.

The product provides multiple ways for remote control, includes Wifi, RS485 and so on. The product receive commands through RS485 Interface during network security test.

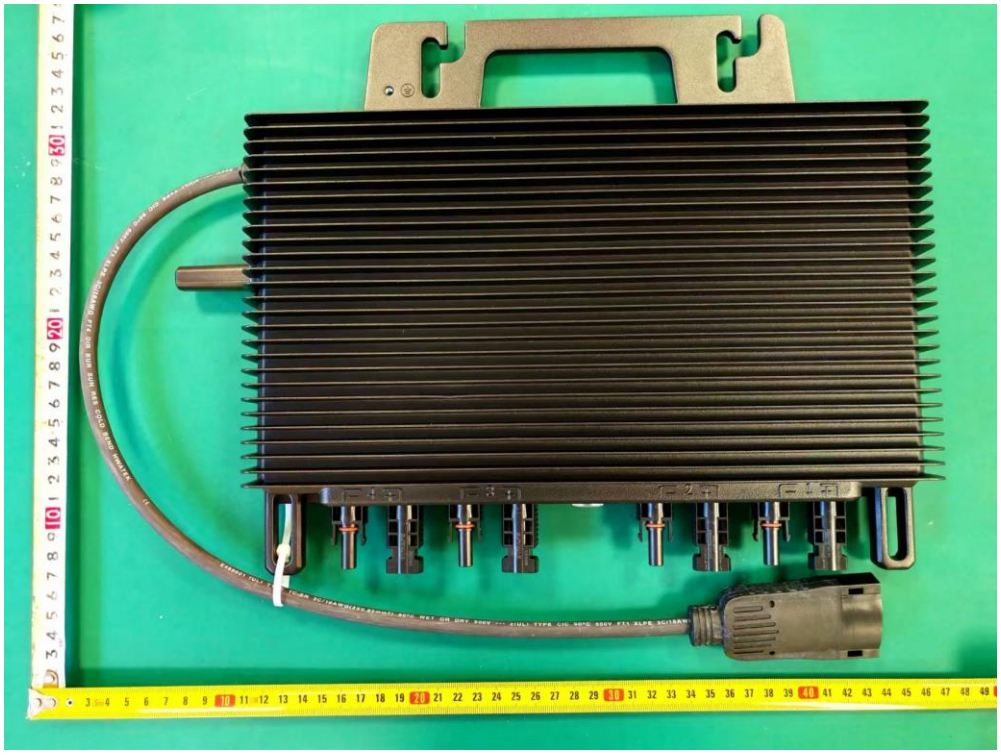
Diagram



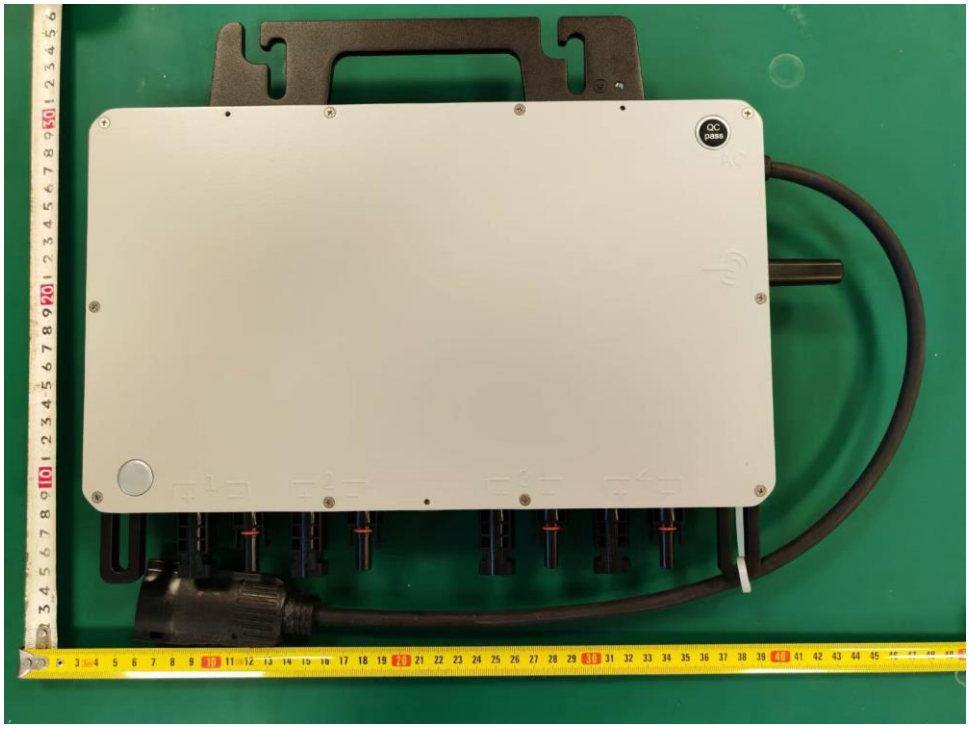


Appendix: Pictures

Enclosure – Front View



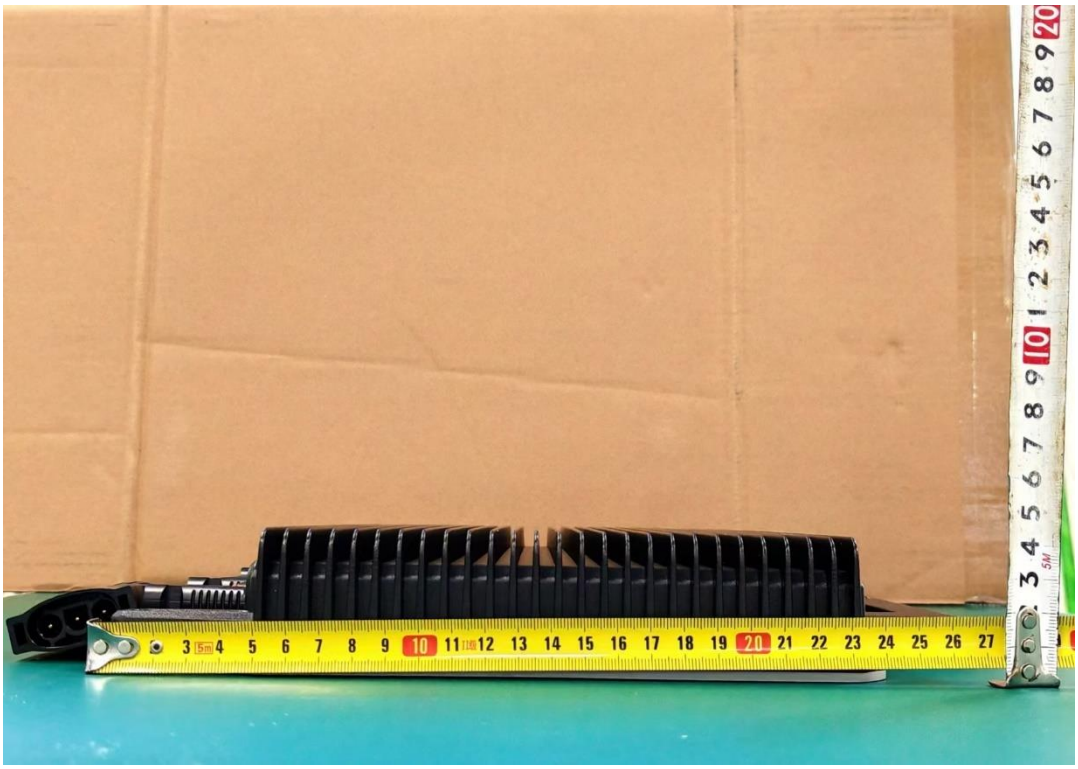
Enclosure – Rear View



Enclosure – Bottom View

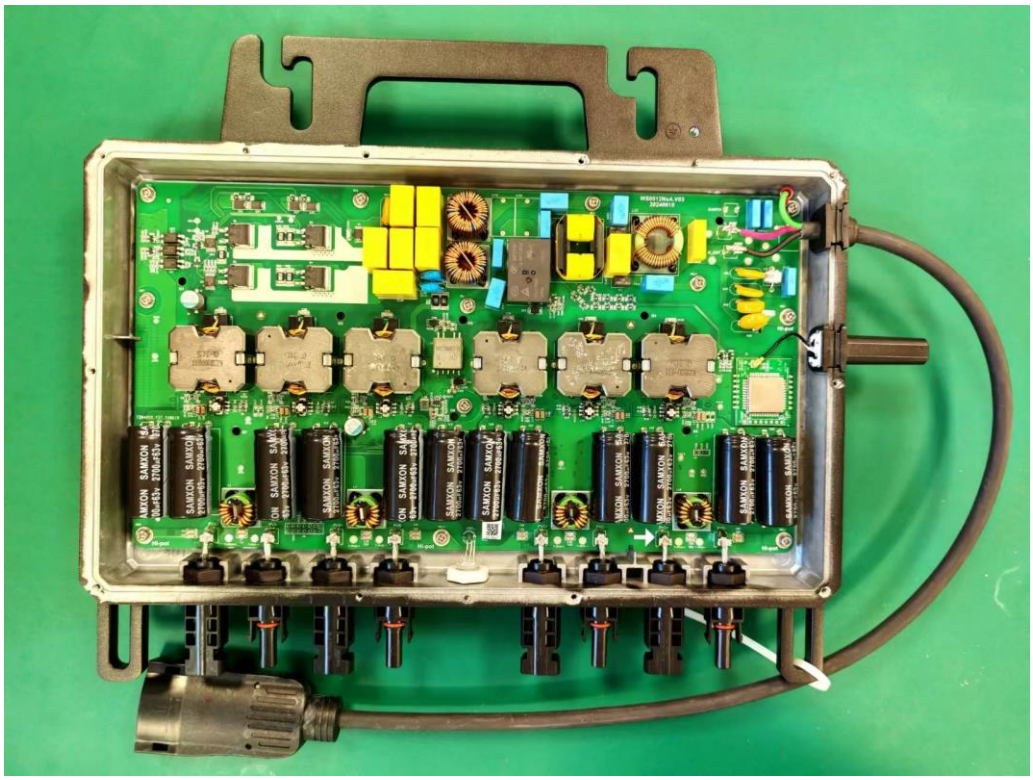
Enclosure – Top View

Enclosure – Right View



Enclosure – Left View

Internal View



--- End of test report---