TEST REPORT
C10/11: ed.2.1
SPECIFIC TECHNICAL PRESCRIPTIONS REGARDING POWER-GENERATING PLANTS OPERATING IN PARALLEL TO THE DISTRIBUTION NETWORK

Report Reference No……:	200827068GZU-001
Date of issue……:	31 Aug 2020
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Tested by (name + signature)……:	Max Gao Engineer
Approved by (name + signature) ..	Jason Fu Technical Team Leader
Applicant's name	Shenzhen SOFAR SOLAR Co., Ltd.
Address	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification:	
Standard	C10/11: ed.2.1, 01 Sep 2019
Test procedure	Type approval for type A
Non-standard test method……..:	N/A
Test Report Form No.	C10/11_a
Test Report Form(s) Originator	Intertek Guangzhou
Master TRF	Dated 2019-10

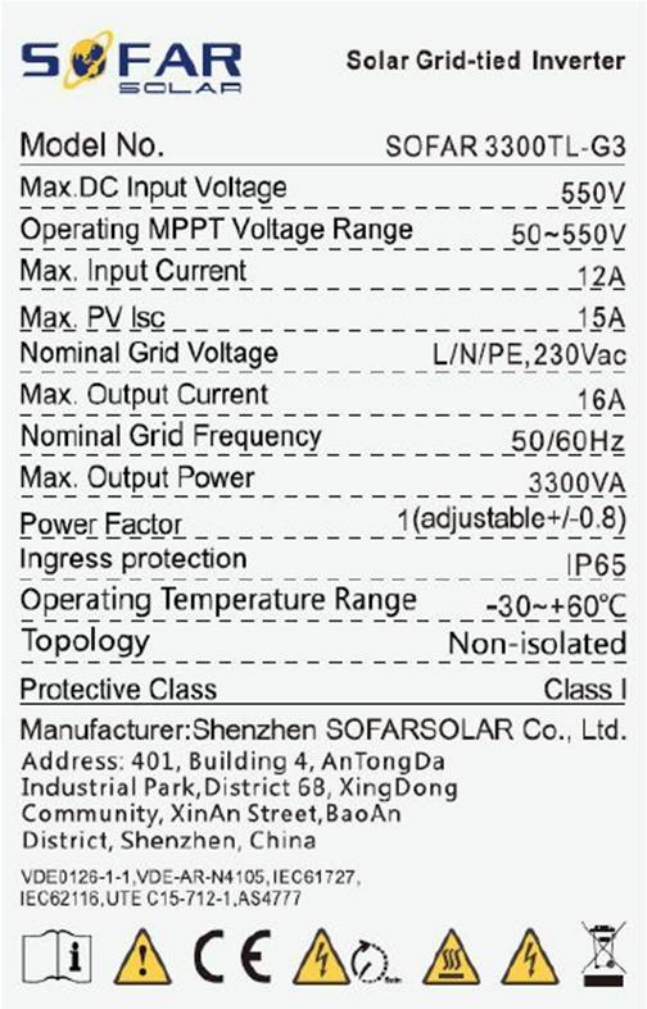
Test item description	Solar Grid-tied Inverter
Trade Mark.....	SOFAR SOLAR
Manufacturer	Same as Applicant
Model/Type reference	SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3 SOFAR 2700TL-G3, SOFAR 3000TL-G3, SOFAR 3300TL-G3

Ratings.....	Model	SOFAR 1100TL-G3	SOFAR 1600TL-G3	SOFAR 2200TL-G3
	Max.PV voltage	500 d.c.V		
	PV voltage range	50-500 d.c.V		
	PV Isc	15 d.c.A		
	Max.input current	12 d.c.A		
	Max.output power	1100W	1600W	2200W
	Max.apparent power	1100VA	1600VA	2200VA
	Nominal output voltage	230 a.c.V		
	Max.output current	5.3 a.c.A	7.7 a.c.A	10.6 a.c.A
	Nominal output Frequency	50Hz		
	Power factor range	0.8Leading – 0.8 lagging		
	Safety level	Class I		
	Ingress Protection	IP 65		
	Operation Ambient Temperature	-30℃ - +60℃		
	Model	SOFAR 2700TL-G3	SOFAR 3000TL-G3	SOFAR 3300TL-G3
	Max.PV voltage	550 d.c.V		
	PV voltage range	50-550 d.c.V		
	PV Isc	15 d.c.A		
	Max.input current	12 d.c.A		
	Max.output power	2700W	3000W	3300W
	Max.apparent power	2700VA	3000VA	3300VA
	Nominal output voltage	230 a.c.V		
	Max.output current	13.0 a.c.A	14.5 a.c.A	16.0 a.c.A
	Nominal output	50Hz		

	Frequency	
	Power factor range	0.8Leading – 0.8 lagging
	Safety level	Class I
	Ingress Protection	IP 65
	Operation Ambient Temperature	-30℃ - +60℃
	Software version	V2.10

Summary of testing:	
Tests performed (name of test and test clause): All applicable tests Remark: Other than special notice, for all clauses, the model SOFAR 3300TL-G3 is type tested and valid for other models.	**Testing location:** Intertek Testing Services Shenzhen Ltd. Guangzhou Branch Room 02, & 101/E201/E301/E401/E501/E601/E701/E801 of Room 01 1-8/F., No. 7-2. Caipin Road, Science City, GETDD, Guangzhou, Guangdong, China

Copy of marking plate



Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation
3. The other model labels are identical with label above, except the model name and rating.

Test item particulars.....:		
Temperature range .....:	-25˚C ~ 60˚C	
AC Overvoltage category.....:	☐ OVC I	☐ OVC II ☒ OVC III ☐ OVC IV
DC Overvoltage category .....:	☐ OVC I	☒ OVC II ☐ OVC III ☐ OVC IV
IP protection class .....:	IP66	
Possible test case verdicts:		
- test case does not apply to the test object.....:	N/A (Not applicable)	
- test object does meet the requirement .....:	P (Pass)	
- test object does not meet the requirement .....:	F (Fail)	
Testing.....:		
Date of receipt of test item.....:	27 Aug. 2020	
Date (s) of performance of tests.....:	27 Aug. 2020 – 30 Aug. 2020	

General remarks:

The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
"(see Enclosure #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

When determining for test conclusion, measurement uncertainty of tests has been considered.
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The test report only allows to be revised only within the report defined retention period unless standard or regulation was withdrawn or invalid.

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

This report is based on original report No.190411082GZU-001, dated 05 Nov 2019 and perform additional tests as required by C10/11: ed.2.1, 01 Sep 2019

General product information:

The unit is a single-phase PV Grid inverter, it can convert the high PV voltage to Grid voltage and feed into Grid network.

The unit is providing EMI filtering at the PV side and AC side. It does not provide galvanic separation from PV side to Grid.

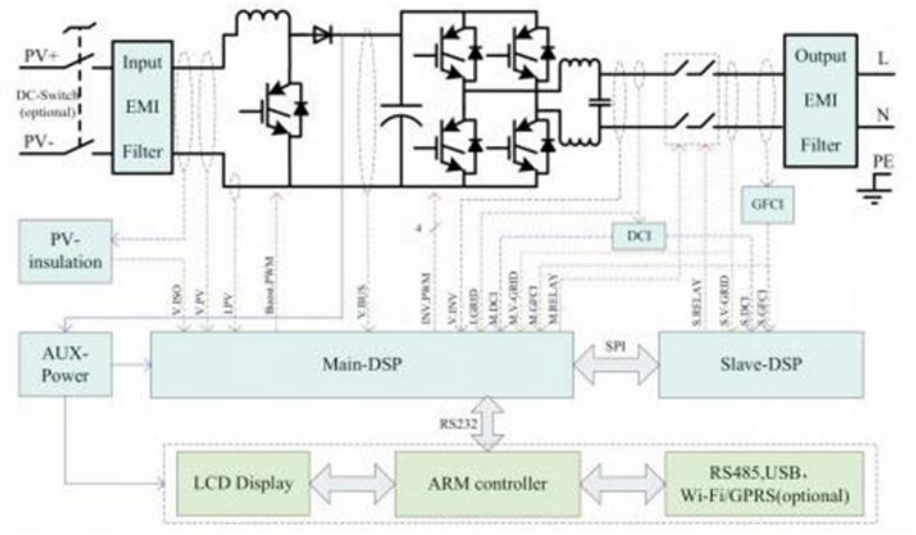
The unit has two controllers. The master controller A monitor the invert statue; measure the PV voltage and current, bus voltage, AC voltage, current, GFCI and frequency, also communicate with the slave controller B

The slave controller B monitor AC voltage, GFCI and communicate with the master controller A

The relays are designed to redundant structure that controlled by separately.

The master controller and slave controller are used together to control relay open or close, if the single fault on one controller, the other controller can be capable to open the relay, so that still providing safety means.

The topology diagram as following:



Model differences:

All models are completely identical, except the output power derating in software.

The models of SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3,

SOFAR 3000TL-G3 and SOFAR 3300TL-G3 are identical on topological schematic circuit diagram and control solution codes**.** The difference between each other as following table:

Model	SOFAR 1100TL-G3	SOFAR 1600TL-G3	SOFAR 2200TL-G3	SOFAR 2700TL-G3	SOFAR 3000TL-G3	SOFAR 3300TL-G3
Heatsink size	253*253.3*26.5mm			271*253.3*40mm		
Inverter inductance	0.99mH * 2pcs			0.676mH * 2 pcs		
Bus capacitance	470uF /500V* 2 pcs			470uF/550V * 3 pcs		
Size	303*260.5*118			321*260.5*131.5		

Factory information:

Dongguan SOFAR SOLAR Co., Ltd.

1F-6F, Building E, No.1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City P.R.China

C10/11: ed.2.1, 01 Sep 2019			
Clause	Requirement - Test	Result - Remark	Verdict

ANNEXE D	**Technical basic requirements regarding the power-generating units**		P
D.1	**General**	This report is only evaluated and tested for generating unit; The generating plant incorporated with the generating unit shall further consider this clause and sub-clause.	P
	In line with the scope of these technical specifications as well as the CENELEC standards EN 50549-1 and EN 50549-2, these requirements are applicable to all kinds of generation of electrical energy, including energy storage systems.	In line with the scope of EN 50549-1	P
D.2	**Order of priorities**		P
	If different requirements on the power-generating unit interfere with each other, the hierarchy listed in EN 50549-1 or EN 50549-2 shall be respected		P
	In brief, the standard specifies following hierarchy: 1. Generating unit protection, including regarding the prime mover. 2. Interface protection and protection against fault within the power-generating plant; 3. Voltage support during faults and voltage steps; 4. The lower value of: remote control command on active power limitation setpoint from the DSO and local response to overfrequency; 5. Local response to underfrequency if applicable; 6. Reactive power and active power (P(U)) controls; 7. Other control commands on active power set point for e.g. market, economic reasons, self-consumption optimization.		P
D.3	**Integrated automatic separation system**		P
	This clause is applicable to power-generating units with a maximum power ≤ 30 kVA.		P
	An integrated automatic separation system is strongly recommended in order to facilitate the installation procedure. Indeed, if the power-generating unit is not equipped with such an integrated system, an external device must be used	Incorporating integrated automatic separation system	P
	For the integrated automatic separation system, the requirements of this clause apply.		P
	Following protection functions are required: • Overvoltage 10 min mean • Overvoltage • Undervoltage • Overfrequency • Underfrequency • A means to detect island situation (LoM) according to EN 62116.	(See appended table D.3)	P

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Clause	Requirement - Test	Result - Remark	Verdict
	All of these protection functions must comply with the relevant requirements in EN 50549-1 (in edition 2019, section 4.9.3		P
	The integrated automatic separation system must have single fault tolerance according to EN 50549-1.	Two series relays in each line and may independent operation for each relay.	P
	The integrated automatic separation system must be set in accordance with the settings as specified in ANNEXE C		P
D.4	**Operating ranges**		P
	Generating plants shall have the capability to operate in the operating ranges specified below regard-less of the topology and the settings of the interface protection.		P
D.4.1	**Operating frequency range**		P
	This clause is not applicable to backup power systems as specified in § 2.2.1.	Not backup power system	N/A
	The power-generating unit must comply with the minimum requirements of the applicable standard EN 50549 or EN 5055-2 on the operating frequency range (edition 2019, see clause 4.4.2 « Operating frequency range »)	Comply with EN 50549-1	P
	In brief, the requirements in the standard are as follows: Frequency domain / Duration 47,5 Hz – 49,0 Hz / 30 minutes 49,0 Hz – 51,0 Hz / Permanent 51,0 Hz – 51,5 Hz / 30 minutes	(See appended table D.4.1)	P
	Additionally, the DSO shall be informed about the capability of the power-generating unit to operate in the frequency range from 51,5 Hz and 52,5 Hz and, where appropriate, the maximum duration of operation in this frequency range.		P
	The URD cannot without good reason refuse to apply wider frequency ranges or longer minimum operating periods than those specified above, provided that the technical and economic impact is limited.	Comply with above requirements	P
D.4.2	**Maximum admissible power reduction in case of underfrequency**		P
	This clause is not applicable to backup power systems as specified in § 2.2.1.	Not backup power system	N/A
	In general, a power-generating unit must continue to operate in case of a reduction of the frequency at the point of connection. This means that, in underfrequency, the power-generating unit should reduce the output power as little as possible and at least being capable of staying above the limit specified hereafter.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	Where the technical capabilities of the power-generating unit are influenced by ambient conditions, these technical capabilities may be demonstrated using the following reference conditions: • Temperature: 0 °C • Altitude: between 400 and 500 m • Humidity: between 15 and 20 g H2O/kg air		P
D.4.2.1	**Limit for non-synchronous power-generating technology (Power Park Modules)**	(See appended table D.4.2.1)	P
	The power-generating unit must comply with the most stringent requirement of EN 50549-1 or EN 50549-2 (edition 2019, see clause 4.4.3 « Minimal requirement for active power delivery at underfrequency »).	Comply with EN 50549-1	P
D.4.2.2	**Limits for synchronous power-generating technology**	Not synchronous power-generating	N/A
	In steady state (from t2 onwards), the power-generating unit must comply with the relevant default requirement of the applicable standard EN 50549-1 or EN 50549-2 (edition 2019, see section 4.4.3 « Minimal requirement for active power delivery at underfrequency »).		N/A
	Additionally, in the transient time (between t1 and t2), the power-generating unit must comply with the relevant most stringent requirement of EN 50549-1 or EN 50549-2. (In edition 2019 of the standard, the relevant requirements can be found in clause 4.4.3 « Minimal requirement for active power delivery at underfrequency »).		N/A
D.4.3	**Continuous operating voltage range**		P
	The power-generating unit must comply with the relevant requirement of EN 50549-1 or EN 50549-2 (edition 2019, see clause 4.4.4 « Continuous operating voltage range »).	Comply with EN 50549-1	P
	In brief, the requirement in the standard specifies the power-generating plant should be capable to operate continuously when he voltage at the point of connection is within the following range:	(See appended table D.4.3)	P
	• For a connection to the low voltage network: 85 % Un < U < 110 % Un where Un = 230 V		P
	• For a connection to the high voltage network: 90 % Uc < U < 110 % Uc where Uc is the declared voltage.		N/A
	It is also allowed to reduce apparent power in case of voltage is below respectively 95 % Un or 95 % Uc.		P
D.5	**Immunity to disturbances**		P
	Independent of the topology and the settings of the interface protection, a power-generating unit must have the following withstand capabilities.		P
D.5.1	**Rate of change of frequency (RoCoF) immunity**		P
	This clause does not apply to backup power systems as specified in § 2.2.1.	Not backup power system	N/A

C10/11: ed.2.1, 01 Sep 2019			
Clause	Requirement - Test	Result - Remark	Verdict
	The power-generating unit must comply with the relevant requirements of the applicable standard EN 50549-1 or EN 50549-2 (edition 2019, see section 4.5.2 « Rate of change of frequency (RoCoF) immunity ») taking the additional modifications and information specified hereunder into account.	(See appended table D.5.1)	P
	The power-generating unit shall have the capability to stay connected and operate when the frequen-cy at the point of connection changes with the frequency against time profiles as depicted in the fig-ures hereunder. When considering a sliding measurement window of 500ms, these profiles have a maximum RoCoF of 2 Hz/s.		P
	For synchronous generating technology, this requirement is more stringent than the default value in the applicable standard EN 50549-1 or EN 50549-2 (2 Hz/s instead of 1 Hz/s) as, in contrast with the standard, no distinction is made between power-generating technologies.	Not synchronous power-generating	N/A
D.5.2	**Under-voltage ride through UVRT**		P
	This section is not applicable to backup power systems as specified in § 2.2.1.	Not backup power system	N/A
	For a power-generating unit that is part of a power-generating module with a power ≥ 1 MW (type B in accordance with NC RfG) this paragraph is mandatory.		N/A
	For a power-generating unit that is part of a power-generating module with a power < 1 MW, this paragraph is non-mandatory and to be considered as a orienting capability, not as a hard requirement. However, the real withstand capability to voltage dips shall be provided during the homologation process.	Considered as an orienting capability	P
	The power-generating unit must comply with the relevant requirements of the applicable standard EN 50549-1 or EN 50549-2 (edition 2019, see clause 4.5.3 « Under-voltage ride through (UVRT) »), with the following change: • The voltage-time profiles are to be replaced by the profiles hereunder.	(See appended table D.5.2)	P
	As a consequence, for synchronous generating technology this profile is more stringent than the default requirement in EN 50549-1 or EN 50549-2.	Not synchronous power-generating	N/A
	For some power-generating technologies, the behaviour of the power-generating unit during and after voltage dips may be impacted by the short circuit power available at the point of connection.		N/A
	For such technologies different cases can be considered:		N/A

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Clause	Requirement - Test	Result - Remark	Verdict
	• Compliance with this UVRT requirement can be demonstrated considering a ratio of 10 be-tween the available short circuit power at the connection point and the maximum power of the considered power-generating module. In this case, no further checks are needed.		N/A
	• If not, the manufacturer must declare the minimum short-circuit power conditions for which the UVRT-requirement can be complied with. This value shall be considered during the installation process.		N/A
	In line with EN 50549-1 or EN 50549-2 at least 90% of the pre-fault power or 90% of the available power whichever is the smallest, shall be resumed as fast as possible, but at the latest within the following default time after the voltage returned to the continuous operating voltage range (85% Un < U < 110% Un for a connection to a low-voltage distribution network; 90% Uc < U < 110% Uc for a connection to a high-voltage distribution network):		P
	• 3 seconds for a power-generating unit with synchronous generating technology		N/A
	• 1 second for a power-generating unit with non-synchronous generating technology		P
	Another site specific maximum allowed time is to be agreed during the commissioning process. This decision must be taken with the DSO in coordination with the TSO.		N/A
	For a backup power system connected to the high voltage distribution network as specified in §2.2.1, the general requirement is this clause may be relaxed, replacing the voltage-time profile by the figure underneath.	Not backup power system	N/A
D.5.3	**Over-voltage ride through (OVRT)**		N/A
	Requirement under consideration for a future edition. No requirement in this edition.		N/A
D.6	**Active response to frequency deviations**		P
D.6.1	**Power response to overfrequency**		P
	This clause is not applicable to backup power system as specified in section §2.2.1	Not backup power system	N/A
	The power-generating unit must comply with the relevant requirements of the applicable standard EN 50549-1 or EN 50549-2 (edition 2019, see 4.6.1 « Power response to overfrequency ») taking into account the additional modifications and information specified hereunder.	Comply with EN 50549-1	P
	Instead of the default maximum step response time of 30s specified in the standards EN 50549-1 and EN 50549-2, the following dynamic step response characteristics are required:		P

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Clause	Requirement - Test	Result - Remark	Verdict
	• For synchronous power-generating technologies For power-generating units base on a gas turbine or an internal combustion engine with tech-nical specificities not allowing compliance with the prescriptions applied by default as de-scribed above, the following alternative prescription, relating to a minimum power gradient in increasing or decreasing frequency, is applicable:		N/A

C10/11: ed.2.1, 01 Sep 2019			
Clause	Requirement - Test	Result - Remark	Verdict
	- If Pmax ≤2 MW at minimum 1,11 % Pmax per second		N/A
	- If Pmax >2 MW at minimum 0,33 % Pmax per second		N/A
	• For non-synchronous power-generating technology	(See appended table D.6.1)	P
	The figure hereunder clarifies the terms « Step response time» and « Settling time». In this clause, the 'Value' is the active power and the tolerance is 10%.		P
	In line with the default requirement of the applicable standard EN 50549-1 :2019 or EN 50549-2: 2019, power-generating units reaching their minimum regulating level shall, in the event of further frequency increase, maintain this power level until a frequency decrease results in a power setpoint which is again above this level.	Comply with EN 50549-1	P
	The optional deactivation threshold fstop is not required. In case fstop is implemented, it shall be deactivated.		P
	At the time of deactivation of the active power frequency response (= frequency goes down below the threshold frequency f1), the active power can be increased to up to the level of the available power. Nevertheless this shall be done respecting a power limit with a gradient of 10% Pmax/min.		P
	For energy storage systems with a connection to the high-voltage distribution network, the DSU might, for justified technical or security reasons, agree with the DSO on applicable minimum state of charge limits in his connection agreement.		N/A
	The settings must be protected from unpermitted interference (e.g. by a password or seal).		P
	Automatic disconnection and reconnection as alternative for the droop function are not permitted by default as per the TSO provisions.		P
D.6.2	**Power response to underfrequency**		P
	The power-generating unit must comply with the relevant requirements of the applicable EN 50549-1 or EN 50549-2 (edition 2019, see clause 4.6.2 « Power response to underfrequency ») taking additional modifications and information as specified hereunder into account.		P
	This clause is applicable to energy storage systems. For justified technical or security reasons, the DSU might agree with the DSO (in his connection agreement is the power-generating plant is connected to the high-voltage distribution network) on applicable maximum state of charge limits in his connection agreement.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	This clause is optional for all other power-generating units. When, in such units, the capability of activating active power response to underfrequency is activated, the power-generating units must comply with the requirements of this clause.		N/A
	Instead of the default maximum step response time of 30s in EN 50549-1 and EN 50549-2, the re-quired dynamic step response characteristics (step response time and settling time) are identical to those stipulated above regarding the power response to overfrequency, including the alternative approach for power-generating units based on a gas turbine or an internal combustion engine (see D.6.1).		P
	The settings must be protected from unpermitted interference (e.g. by a password or seal).		P
D.7	**Power response to voltage changes**		P
D.7.1	**Voltage support by reactive power**		P
	A backup power system as referred to in section §2.2.1, must not comply with the requirements of this clause. Instead, for such a system, the power factor must be as close to 1 as possible and may definitely not fall below the limit of 0.85 during in-parallel operation. No control mode at all for the reactive power is imposed by the DSO.	Not backup power system	N/A
	The power-generating plant must at least comply with the corresponding requirements of the applicable standard EN 50549-1 or EN 50549-233 (edition 2019, see clause 4.7.2 « Voltage support by reactive power ») taking the modifications and additional information specified hereunder into account. It is usually the power-generating unit itself that meets this requirement, which is assessed at the time of the homologation. In the other cases, if for example additional equipment such as a capacitor bank is necessary in combination with the power-generating unit, this will be evaluated by the DSO during the procedure for commissioning.	Comply with EN 50549-1	P
	For a power-generating plant with a maximum power ≤ 250 kVA connected to the high-voltage distribution network, the DSU may decide to comply to the equivalent requirements of EN 50549-1 rather than those of EN 50549-2.		N/A
	The reactive power capability shall be evaluated at the terminals of the power-generating unit (including, when applicable, the step-up transformer specific to the power-generating unit).	(See appended table D.7.1)	P
	The real reactive power capabilities of the power-generating unit at the terminals should be communicated to the DSO. This can be done during the process of homologation.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	If the capabilities exceed the minimum requirement, and as far as this has only limited technical and economic impact, the DSU is not allowed to refuse without justification the DSO to make use of the reactive power capability (this is not applicable to a small power-generating plant (as defined in chapter 4)).		P
	The settings of the control mode must be protected from unpermitted interference (e.g. by a password or seal).		P
D.7.1.1	**Specific for a small power-generating plant**		P
	By default, the power generation unit must operate according to the following rules:		P
	• When the voltage ≤ 105 % Un: cos phi = 1 (Q=0)		P
	• When the voltage > 105 % Un: free operation with 1 ≥ cos phi > 0,9under-excited. (no over-excited operation allowed)		P
D.7.1.2	**Specific for another (not small) power-generating plant**		P
	If applicable, the details of the reactive power control mode to be activated in the power-generating unit shall be provided by the DSO during the installation procedure. This setting might be reviewed by the DSO during the lifetime of the power-generating module.		P
	If the power-generating plant is connected to the high voltage distribution network, it may be necessary to use additional resources such as, for example, a capacitor bank to meet the previous requirements related to the supply of reactive power. If the power-generating unit is disconnected, they must be disconnected as well.	Not connected to the high voltage distribution network	N/A
	For a synchronous power-generating unit that is part of a power-generating module with a maximum power of ≥ 1 MW (type B according to NC RfG), the following specific requirement is also applicable:	Not synchronous power-generating unit	N/A
	Alternatively to the Q(U) control mode specified above, a synchronous power-generating unit of type B (power ≥ 1 MW) shall be equipped with a permanent automatic excitation control system that can provide constant alternator terminal voltage at a selectable setpoint without instability over the entire operating range of the synchronous power-generating module. When the setpoint gives rise to a re-active power exchange beyond the capability requirements above, the reactive power exchange may be kept at the limits of the required capability.		N/A

C10/11: ed.2.1, 01 Sep 2019			
Clause	Requirement - Test	Result - Remark	Verdict
	The setpoint must be selectable in the continuous operating voltage range (see section D.4.3) and is given by the DSO.		P
	The DSO can give the required instructions to make the selection of the setpoint possible remotely by the DSO's control center (see § 7.13), respecting the applicable regional legal framework.		P
D.7.2	**Voltage related active power reduction P(U)**	(See appended table D.7.2)	P
	Voltage relating active power reduction is allowed and even recommended in order to avoid disconnection due to the operation of the overvoltage protection. When implemented, the power-generating unit must comply with the relevant requirements of the applicable standard EN 50549-1 or EN50549-2 (edition 2019, see clause 4.7.3 « Voltage related active power reduction »).	Comply with EN 50549-1	P
D.7.3	**Provision of additional fast reactive current during faults and voltage steps**		P
	This Section is only applicable to non-synchronous power-generating units connected to a high volt-age distribution network and are not part of a small power-generating plant.		P
	For power-generating units that are part of a power-generating module with a maximum power <1 MW, there is no capability requirement. However, if such a generating module has the capability to provide additional fast reactive current during faults and voltage steps, this function must be deactivated by default.		P
	Power-generating units that are part of a power-generating module with a maximum power ≥ 1 MW must comply with the relevant requirements of the standard EN 50549-2 (edition 2019, see clause 4.7.4.2.1 « Voltage support during faults and voltage steps »), taking the additional information specified in this Section into account. By default, this function must be deactivated.		P
	A directly connected asynchronous machine cannot provide voltage support in a controlled manner with regard to short circuit currents as a consequence of faults or when there are sudden voltage variations. The DSO will include these elements in its assessment of the demand for connection.		N/A
D.8	**Connection and reconnection**		P

C10/11: ed.2.1, 01 Sep 2019			
Clause	Requirement - Test	Result - Remark	Verdict
	The power-generating unit must comply with the relevant requirements of the applicable standard EN 50549-1 or EN 50549-2 (edition 2019, see clause 4.10 « Connection and starting to generate electrical power ») taking the additional information specified hereunder into account.	Comply with EN 50549-1	P
	Connection and reconnection after tripping of the interface protection relay is subject to the conditions listed in the table hereunder. These settings are different than the default settings of EN 50549-1 and EN 50549-2.	(See appended table D.8)	P
	The automatic connection and reconnection is allowed if the abovementioned conditions are met.		P
	If, at the power-generating unit connected to the HV distribution network, no distinct sets of conditions can be applied, it is not possible to make a distinction between the two connection modes, the conditions must be chosen such as they meet both sets of conditions.	Not connected to the HV distribution network	N/A
D.9	**Ceasing and reduction of active power on set point**		P
	This clause is not applicable to the backup power systems specified in §2.2.1.	Not backup power system	N/A
D.9.1	**Ceasing active power**	(See appended table D.9)	P
	The power-generating unit must comply with the relevant requirements of the applicable standard EN 5054-1 or EN 50549-2 (edition 2019, see clause 4.11.1 « Ceasing active power ») taking into account the additional information specified hereunder.	Comply with EN 50549-1	P
	In brief, the requirements in the standards are the following:		P
	For modules with a power > 800 W, a logic interface to cease the production of active power within 5 seconds after receiving the instruction is required.		P
	Remote operation is optional		P
	Respecting the regional regulatory provisions, the DSO can request additional equipment for a remote operation of this logic interface.		P
	Unless defined otherwise by the DSO, this logic interface is based on a contact rather than using a communicated protocol.		P
D.9.2	**Reduction of active power on set point**	(See appended table D.9)	P
	The requirement of this Section is applicable only to the power-generating units that are part of:		P
	• a power-generating module with a maximum power of ≥ 1 MW		N/A

C10/11: ed.2.1, 01 Sep 2019			
Clause	Requirement - Test	Result - Remark	Verdict
	• a power-generating plant with a maximum power of > 250 kVA, if the DSO so requires, in accordance with the regional regulations.		P
	The power-generating module must comply with the relevant requirements of the applicable standard EN 50549-1 or EN 50549-2 (edition 2019, see clause 4.11.2 « Reduction of active power on set point ») taking into account the additional information specified hereunder. Generally, the power-generating unit complies with this requirement, which is assessed when homologated. Otherwise, if, for example, additional equipment such as a capacitor bank is required in combination with the power-generating unit, this will be evaluated by the DSO during the commissioning procedure.	Comply with EN 50549-1	P
	In brief, the requirements in the standard are the following: For type B modules: The settings of the limit must be possible with a maximum increment of 10%. Reduction of the power generation to the respective limit in a range of maximum 0,66 % Pn/ s and of minimum 0,33 % Pn/ s Deconnection of the network is allowed when below minimum regulating level Remote operation is optional		P
	Depending of the modalities specified in section D.10 hereafter, the DSO can request additional equipment for a remote operation of this reduction.		N/A
D.10	**Communication – Remote monitoring and control**		N/A

Appended Table - Testing Result

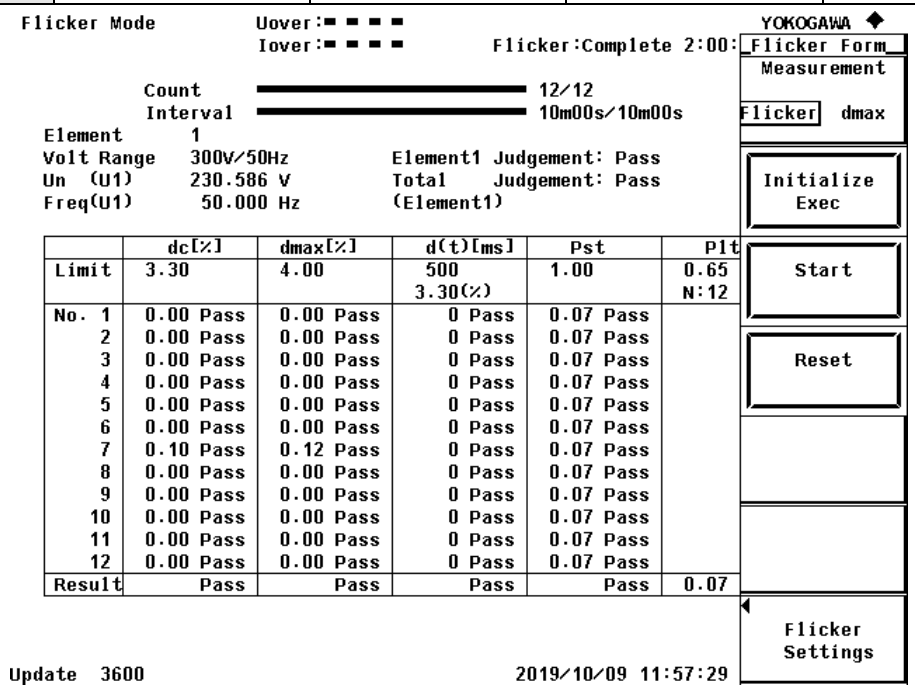
8.2.3	TABLE: Flicker	P

Flicker measurement

According to EN 61000-3-3/EN 61000-3-11

Model: 3300

Value	P_{st}	P_{lt}	d_c	d_{max}
Limit	≤ 1	≤ 0.65	≤ 3.30%	4%
L1	0.07	0.07	0.10	0.12
L2	--	--	--	--
L3	--	--	--	--



	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
2	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
3	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
4	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
5	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
6	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
7	0.10 Pass	0.12 Pass	0 Pass	0.07 Pass	
8	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
9	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
10	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
11	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
12	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
Result	Pass	Pass	Pass	Pass	0.07

L1 Phase

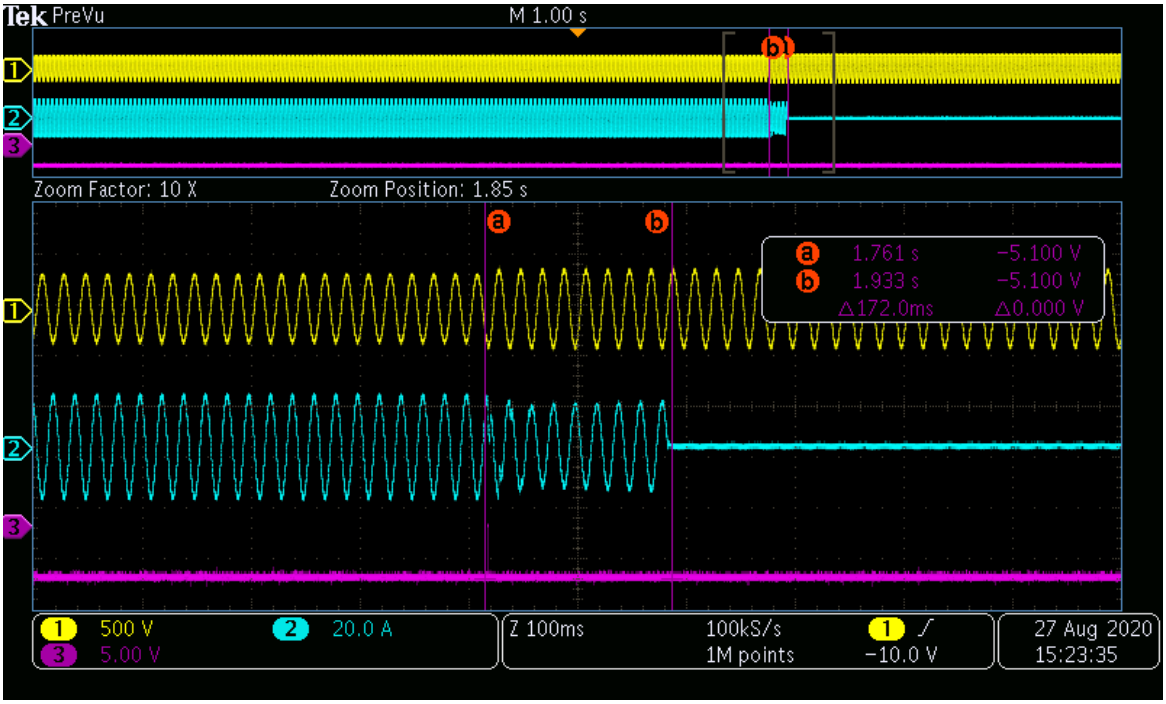
8.2.4	TABLE: Harmonics and inter-harmonics Model: SOFAR 3300TL-G3	P

Current harmonics emission test for class A limit (According to EN 61000-3-2)

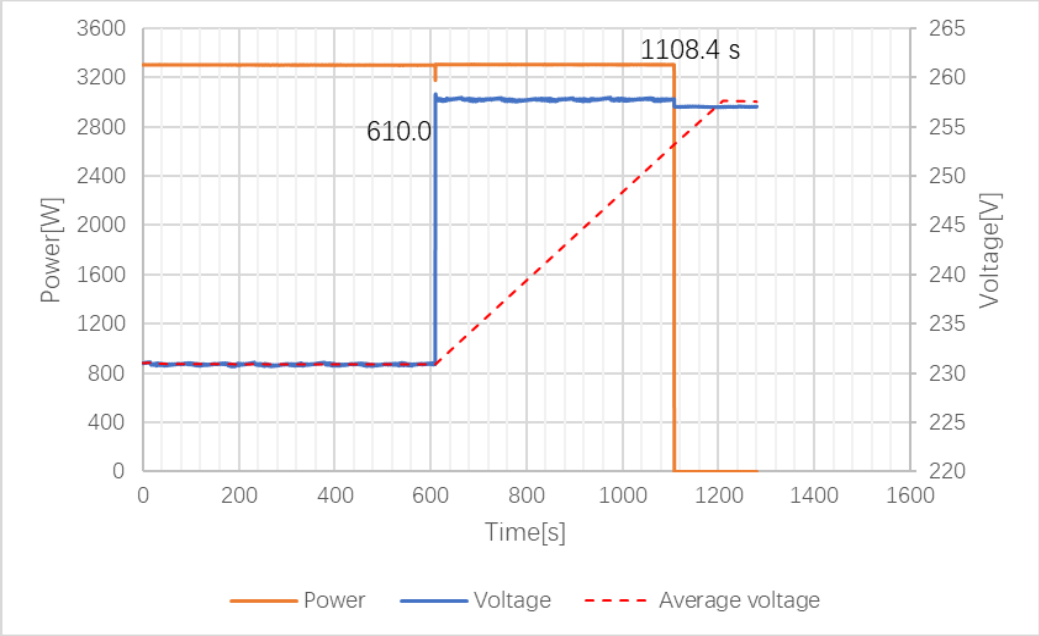
Nr./Order	Ih(A)	LIMIT (A)
2	0.0081	1.0800
3	0.1736	2.3000
4	0.0115	0.4300
5	0.1097	1.1400
6	0.0081	0.3000
7	0.0684	0.7700
8	0.0042	0.2300
9	0.0401	0.4000
10	0.0071	0.1840
11	0.0181	0.3300
12	0.0012	0.1530
13	0.0198	0.2100
14	0.0020	0.1310
15	0.0220	0.1500
16	0.0025	0.1150
17	0.0196	0.1320
18	0.0038	0.1020
19	0.0132	0.1180
20	0.0014	0.0920
21	0.0118	0.1070
22	0.0006	0.0840
23	0.0102	0.0980
24	0.0021	0.0770
25	0.0107	0.0900
26	0.0013	0.0710
27	0.0096	0.0830
28	0.0010	0.0660
29	0.0102	0.0780
30	0.0025	0.0610
31	0.0082	0.0730
32	0.0007	0.0580
33	0.0080	0.0680
34	0.0009	0.0540
35	0.0079	0.0640
36	0.0013	0.0510
37	0.0079	0.0610
38	0.0006	0.0480
39	0.0068	0.0580
40	0.0006	0.0460

D.3	Table: Overvoltage threshold stage (Tests are performed on model SOFAR 3300TL-G3 and valid for other models)				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [V]	264.5	264.26	264.21	264.22	264.5±2.3
Trip time [ms]	100	172.0	172.0	168.0	<200

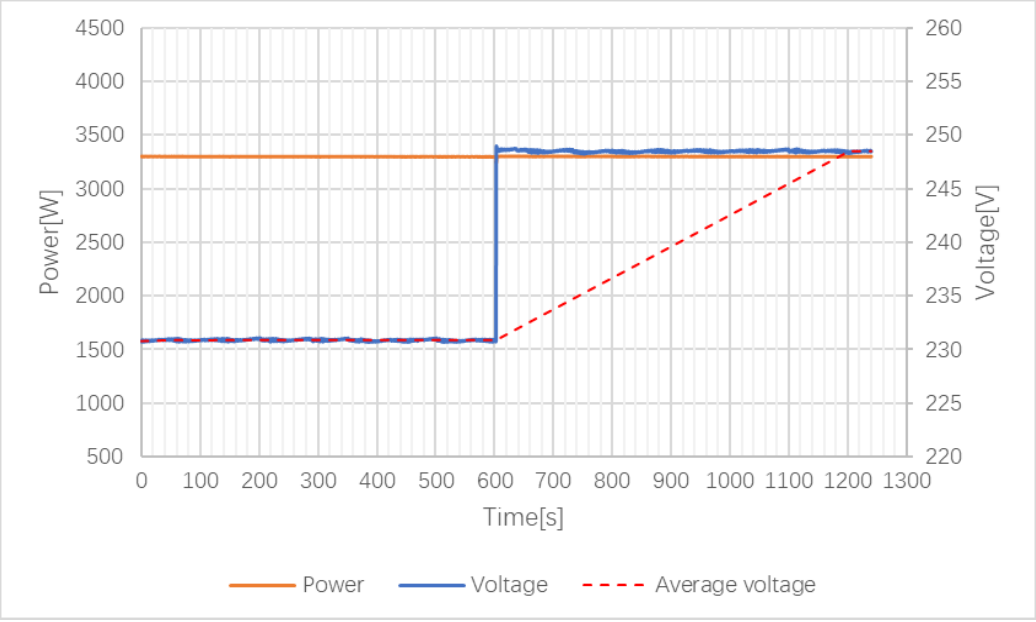
Trip time



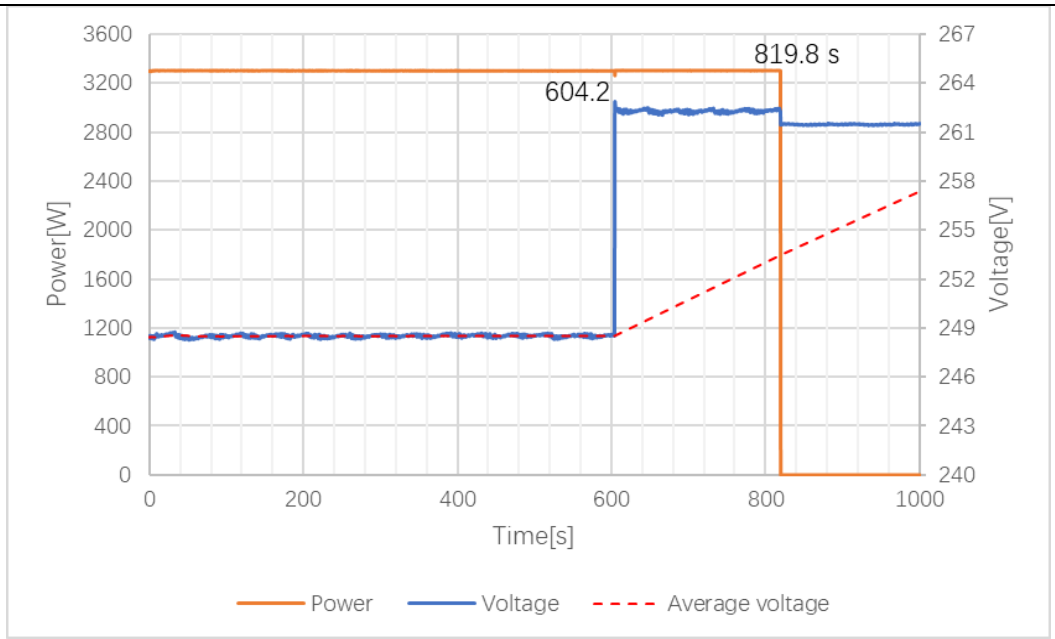
D.3	**Protective functions (Results of the Protection of the Increase in Voltage as 10-min moving average)**		
	Output Voltage (V)	Switch	
		On/Off state Finally	Time until Switch off (s)
100% Un	230.0	☒On □Off	Work normally
112% Un	257.6	□On ☒Off	498.4
100% Un	230.0	☒On □Off	Work normally
108% Un	248.4	☒On □Off	Work normally
106% Un	243.8	☒On □Off	Work normally
114% Un	262.2	□On ☒Off	215.6



Un to 1.12Un



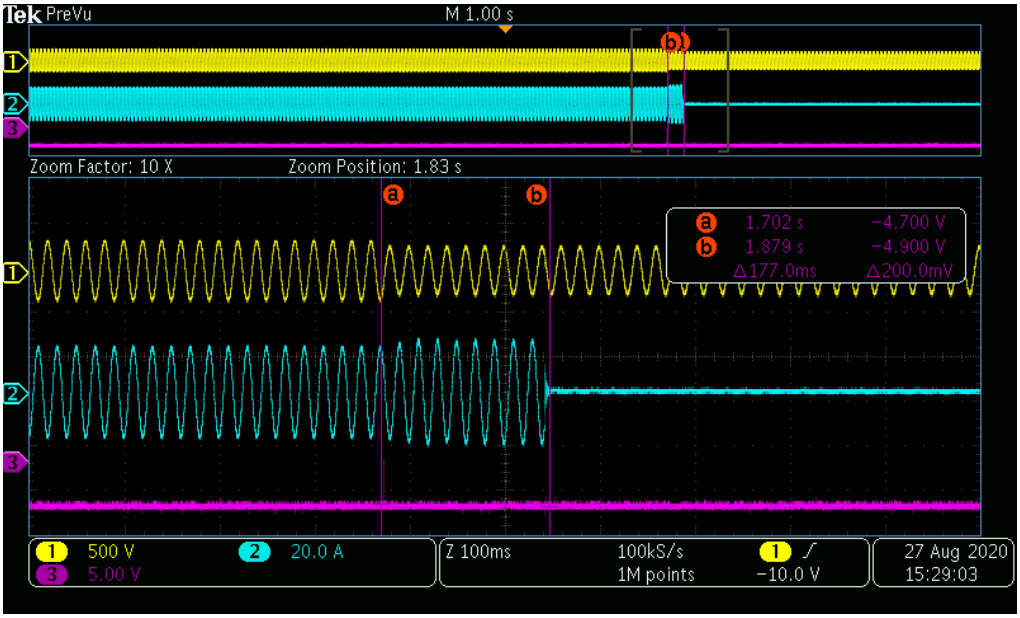
Un to 1.08Un



1.06 Un to 1.14Un

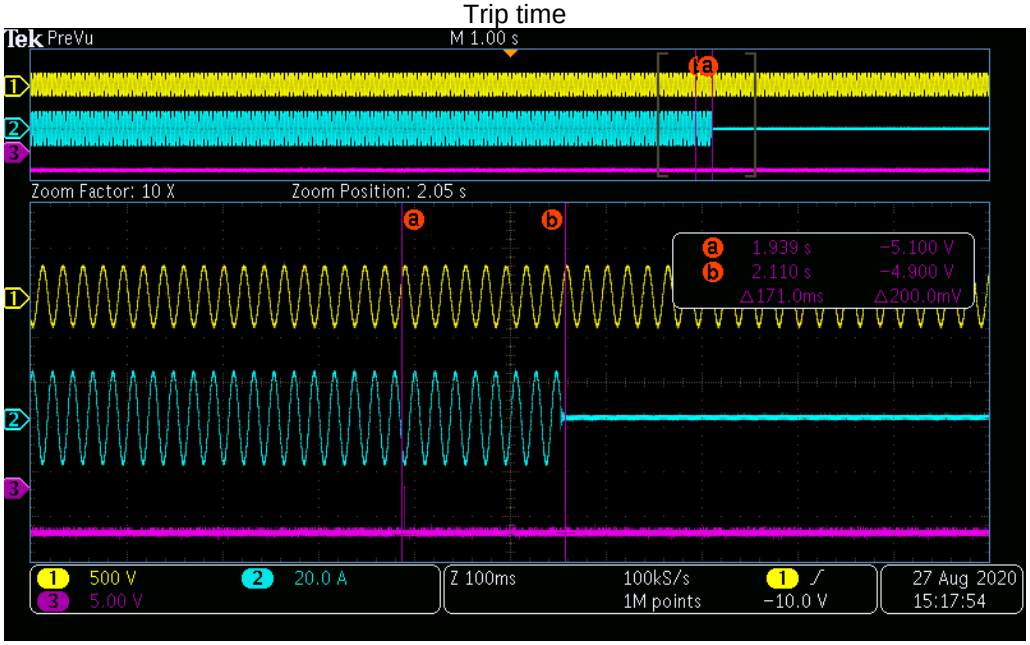
D.3	Table: Undervoltage threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [V]	184	185.34	184.97	185.22	184±2.3
Trip time [ms]	100	177.0	165.0	175.0	<200

Trip time



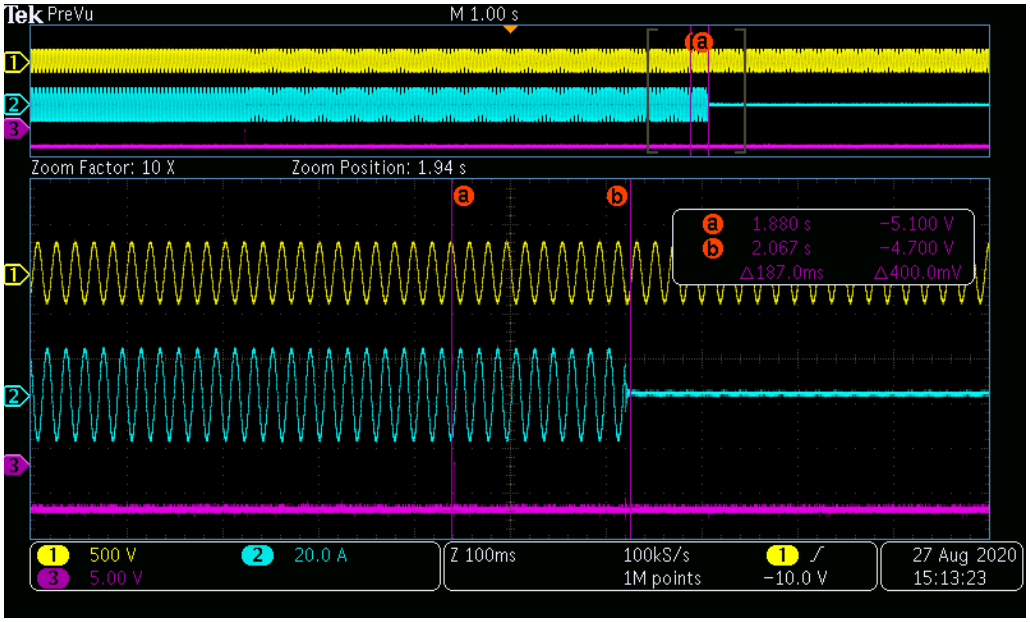
D.3	Table: Underfrequency threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [Hz]	47.5	47.50	47.51	47.51	47.5±0.05
Trip time [ms]	100	171.0	169.0	158.0	<200

Trip time



D.3	Table: Overfrequency threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [Hz]	51.5	51.51	51.53	51.52	51.5±0.05
Trip time [ms]	100	180.0	187.0	183.0	<200

Trip time

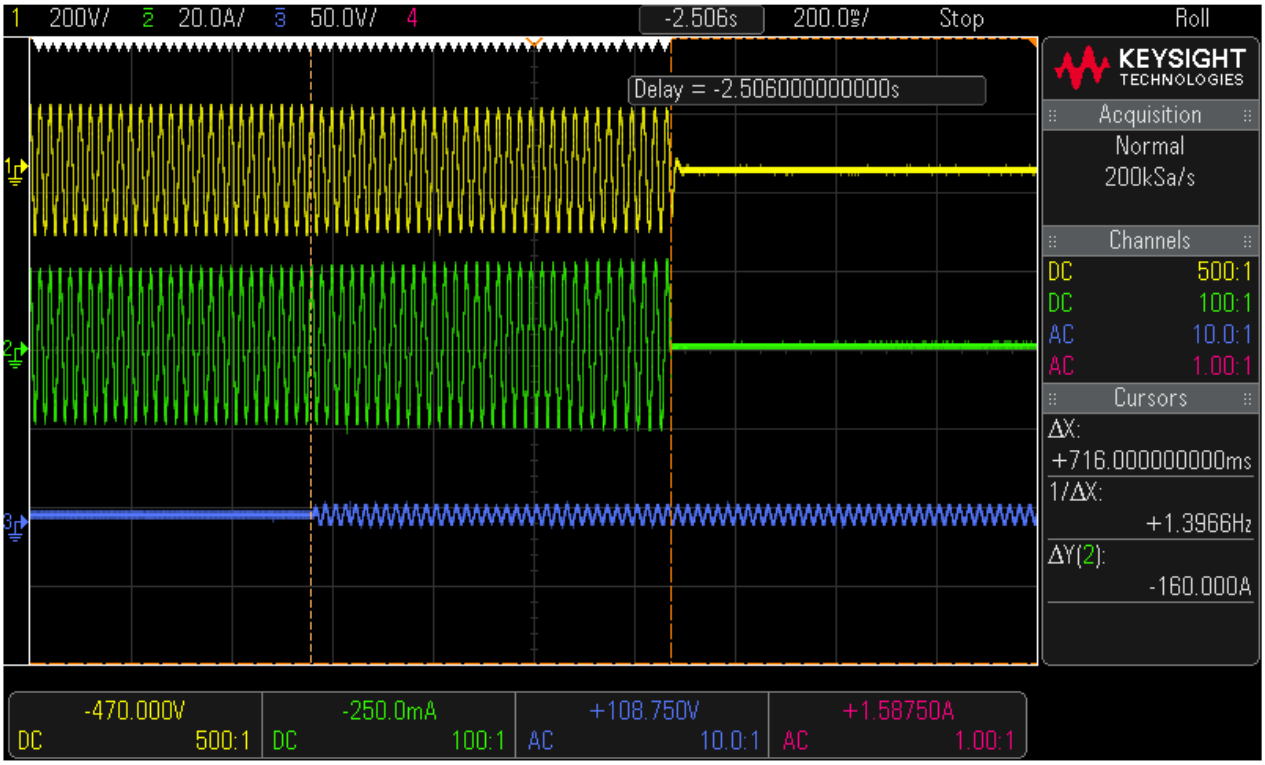


D.3	Table: Islanding	P

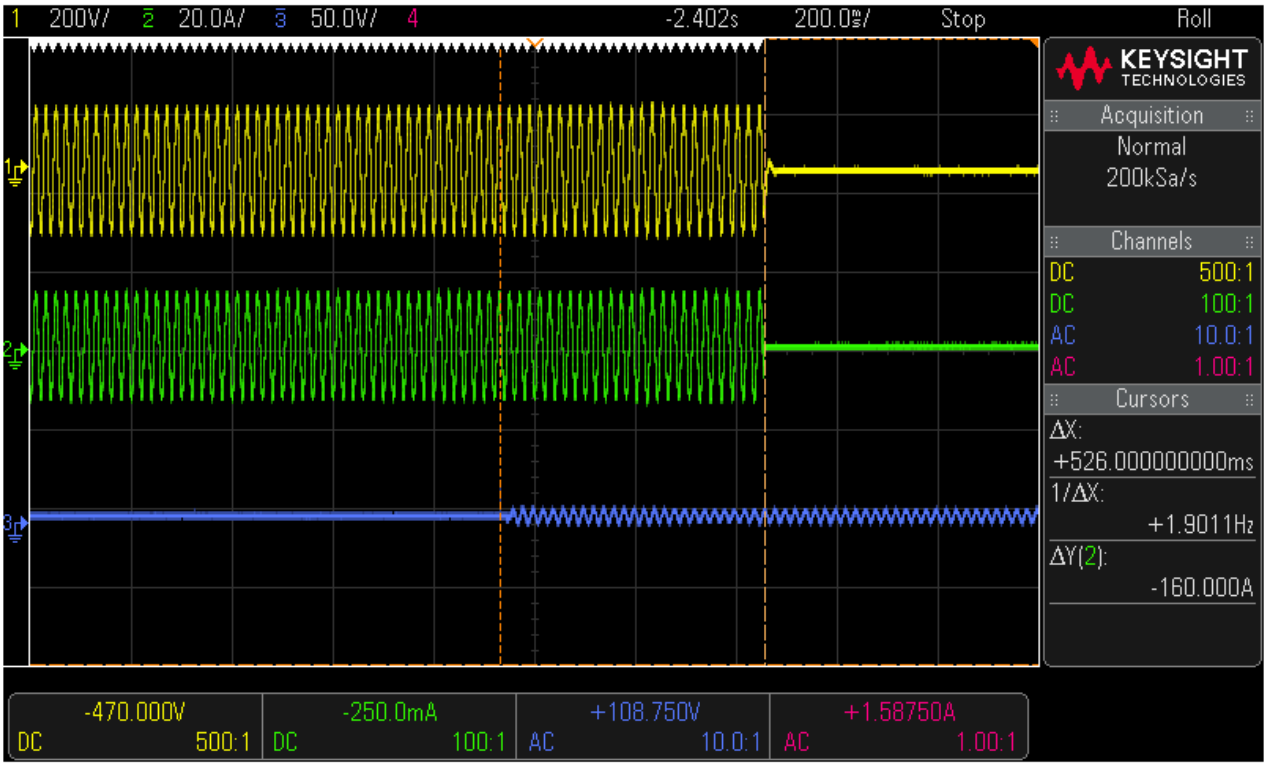
No.	PEUT[1] (% of EUT rating)	Reactive load (% of QL in 6.1.d)1)	PAC[2] (% of nominal)	QAC[3] (% of nominal)	Run on time (ms)	PEUT (W)	Actual Qf	VDC	Remarks[4]
1	100	100	0	0	716.0	3.19	1.00	500	Test A at BL
2	66	66	0	0	526.0	2.07	1.00	350	Test B at BL
3	33	33	0	0	366.0	1.08	1.00	200	Test C at BL
4	100	100	-5	-5	588.0	3.19	0.98	500	Test A at IB
5	100	100	-5	0	692.0	3.19	0.95	500	Test A at IB
6	100	100	-5	5	654.0	3.19	0.93	500	Test A at IB
7	100	100	0	-5	588.0	3.19	1.02	500	Test A at IB
8	100	100	0	5	556.0	3.19	0.97	500	Test A at IB
9	100	100	5	-5	588.0	3.19	1.08	500	Test A at IB
10	100	100	5	0	672.0	3.19	1.05	500	Test A at IB
11	100	100	5	5	574.0	3.19	1.03	500	Test A at IB
12	66	66	0	-5	626.0	2.07	1.02	350	Test B at IB
13	66	66	0	-4	636.0	2.07	1.02	350	Test B at IB
14	66	66	0	-3	594.0	2.07	1.02	350	Test B at IB
15	66	66	0	-2	652.0	2.07	1.01	350	Test B at IB
16	66	66	0	-1	654.0	2.07	1.01	350	Test B at IB
17	66	66	0	1	434.0	2.07	1.00	350	Test B at IB
18	66	66	0	2	422.0	2.07	0.99	350	Test B at IB
19	66	66	0	3	534.0	2.07	0.99	350	Test B at IB
20	66	66	0	4	608.0	2.07	0.98	350	Test B at IB
21	66	66	0	5	572.0	2.07	0.97	350	Test B at IB
22	33	33	0	-5	618.0	1.08	1.03	200	Test C at IB
23	33	33	0	-4	638.0	1.08	1.02	200	Test C at IB
24	33	33	0	-3	596.0	1.08	1.02	200	Test C at IB
25	33	33	0	-2	596.0	1.08	1.01	200	Test C at IB
26	33	33	0	-1	610.0	1.08	1.01	200	Test C at IB
27	33	33	0	1	692.0	1.08	0.99	200	Test C at IB
28	33	33	0	2	634.0	1.08	0.99	200	Test C at IB
29	33	33	0	3	610.0	1.08	0.99	200	Test C at IB
30	33	33	0	4	608.0	1.08	0.98	200	Test C at IB
31	33	33	0	5	584.0	1.08	0.98	200	Test C at IB

Remark:

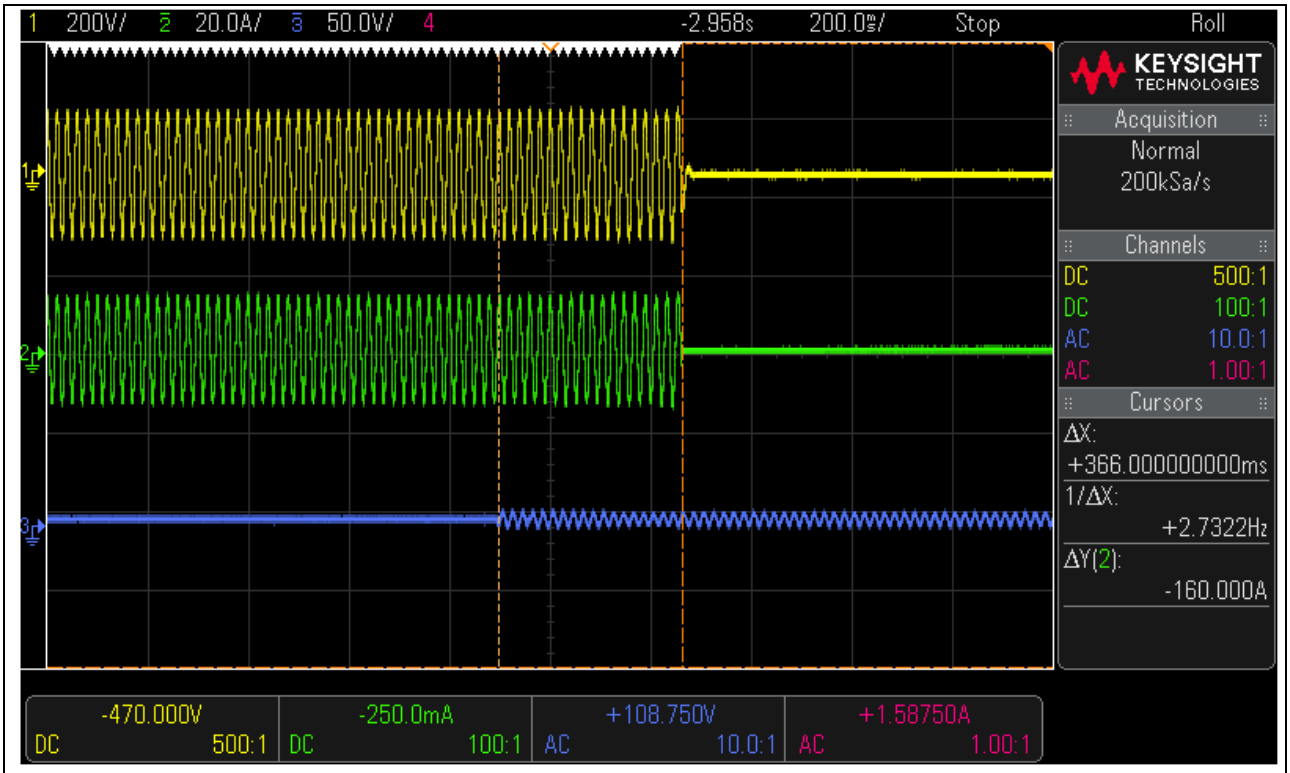
1) PEUT: EUT output power
2) PAC: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0% test condition value.
3) QAC: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0% test condition value.
4) BL: Balance condition, IB: Imbalance condition.
5) *Note: test condition A (100%): If any of the recorded run-on times are longer than the one recorded for the rated balance condition, i.e. test procedure 6.1 f), then the non-shaded parameter combinations (no.32~47) also require testing.



P_{EUT} 100%, P_{AC} 0%, Q_{AC} 0%, = 716.0ms



P_{EUT} 66%, P_{AC} 0%, Q_{AC} 4%, = 526.0ms



P_{EUT} 33%, P_{AC} 0%, Q_{AC} -0%, = 366.0ms

Note: CH1 represents output voltage of inverter, CH2 represents output current of inverter, CH3 represents signal trip.

D.3	TABLE: Single fault tolerance Refer to EN 50549-1:2019		P
	ambient temperature (°C) :	25	
	model/type of power supply :	PV simulator	

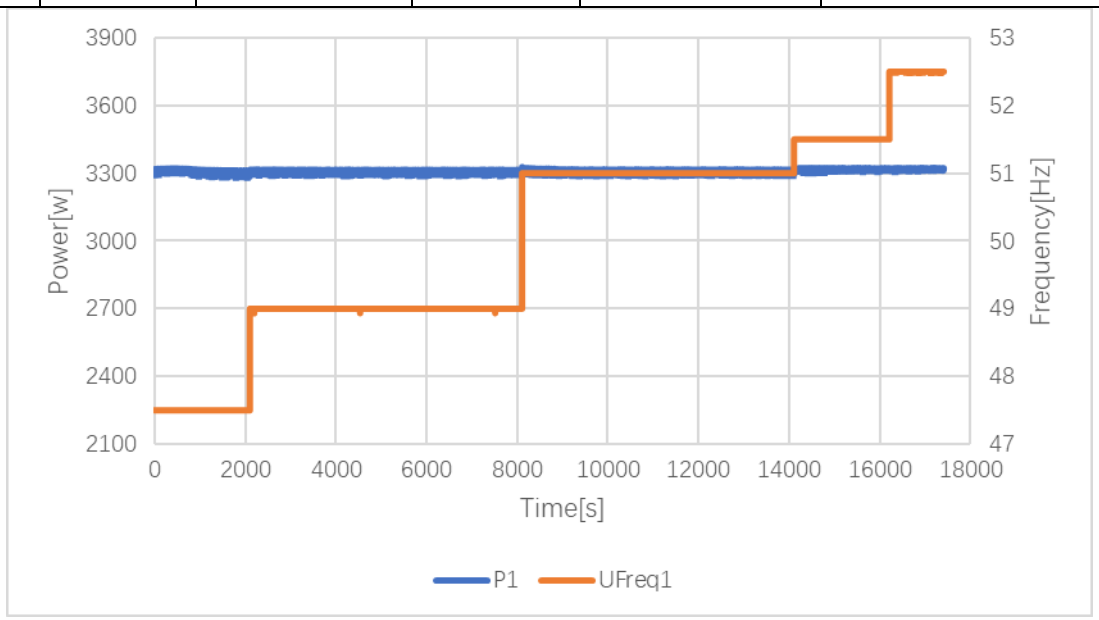
No.	component No.	fault	test voltage (V)	test time	fuse No.	fuse current (A)	result
1.	Relay defect RY3 (4-3pin)	S-C before start up	500	1 min	--	--	PV inverter does not start up and connected to grid. No damaged, no hazard.
2.	Relay defect RY2 (4-3pin)	S-C before start up	500	1 min	--	--	PV inverter does not start up and connected to grid. No damaged, no hazard.
3.	Relay defect RY4 (4-3pin)	S-C before start up	500	1 min	--	--	PV inverter does not start up and connected to grid. No damaged, no hazard.
4.	Relay defect RY5 (4-3pin)	S-C before start up	500	1 min	--	--	PV inverter does not start up and connected to grid. No damaged, no hazard.
5.	AC current monitoring defect RP85	O-C	500	1 min	--	--	PV inverter disconnected from grid immediately. No damaged, no hazard.
6.	AC voltage monitoring defect R88	O-C	500	1 min	--	--	PCE protected immediately. Report ID01, No damaged. No hazard.
7.	ECP63	S-C	500	1 min	--	--	PCE protected immediately. Disconnect from the grid. After fault removed, it can be work normally. No damaged. No hazard.
8.	U13 Pin 8	O-C	500	1 min	--	--	PCE protected immediately. Disconnect from the grid. After fault removed, it can be work normally. No damaged. No hazard.
9.	XL2 Pin1-3	S-C	500	1 min	--	--	PV inverter disconnected from grid immediately. No damaged, no hazard.
10.	U5 Pin2-3	S-C	500	1 min	--	--	PCE protected immediately. Report ID05, No damaged. No hazard.
11.	RC62	S-C	500	1 min	--	--	PCE protected immediately. Report ID20, No damaged. No hazard.

12.	CC76	S-C	500	1 min	--	--	PCE protected immediately. Report ID20, No damaged. No hazard.
13.	U1 Pin2-3	S-C	500	1 min	--	--	PCE protected immediately. Report ID02, No damaged. No hazard.
14.	U1 Pin5-6	S-C	500	1 min	--	--	PCE protected immediately. Report ID55, No damaged. No hazard.
15.	U6 Pin2-3	S-C	500	1 min	--	--	PCE protected immediately. Report ID23, No damaged. No hazard.
16.	UC3 Pin5-6	S-C	500	1 min	--	--	PCE protected immediately. Report ID17,ID18, No damaged. No hazard.
17.	XLC1 Pin 1-3	S-C	500	1 min	--	--	PCE protected immediately. No damaged. No hazard.
Supplement: s-c: short-circuited, o-c: open-circuited, o-l: overload							

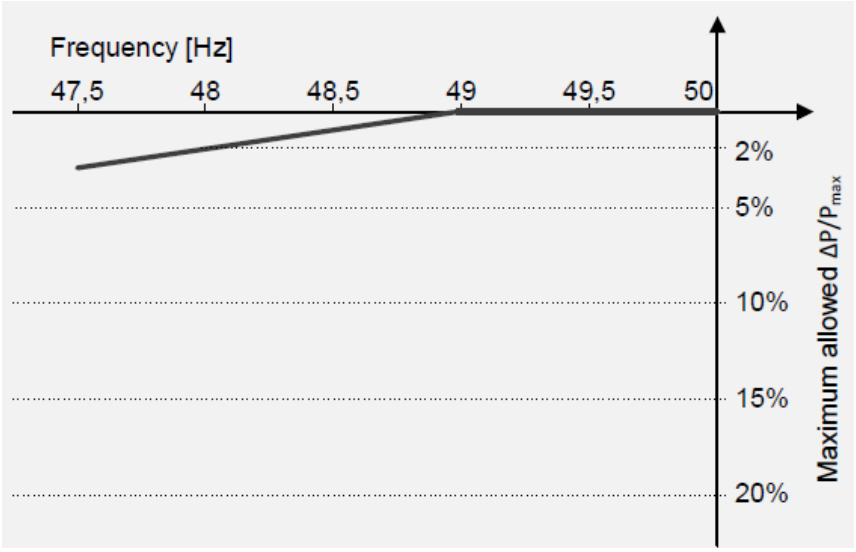
D.4.1	Table: Operating frequency range	P

Frequency domain	Duration
47,5 Hz – 49,0 Hz	30 minutes
49,0 Hz – 51,0 Hz	Permanent
51,0 Hz – 51,5 Hz	30 minutes

Steps	f (Hz)	f (Hz) Measured	Time	Time measured	Comments
1	47.5 Hz	47.50	>30 min	35.05min	Operated normally.
2	49.0 Hz	49.00	Permanent	100.10min	Operated normally.
3	51.0 Hz	51.00	Permanent	100.03min	Operated normally.
4	51.5 Hz	51.50	>30 min	35.05min	Operated normally.
5	52.5 Hz	52.50	>15 min*	20.02min	Operated normally.

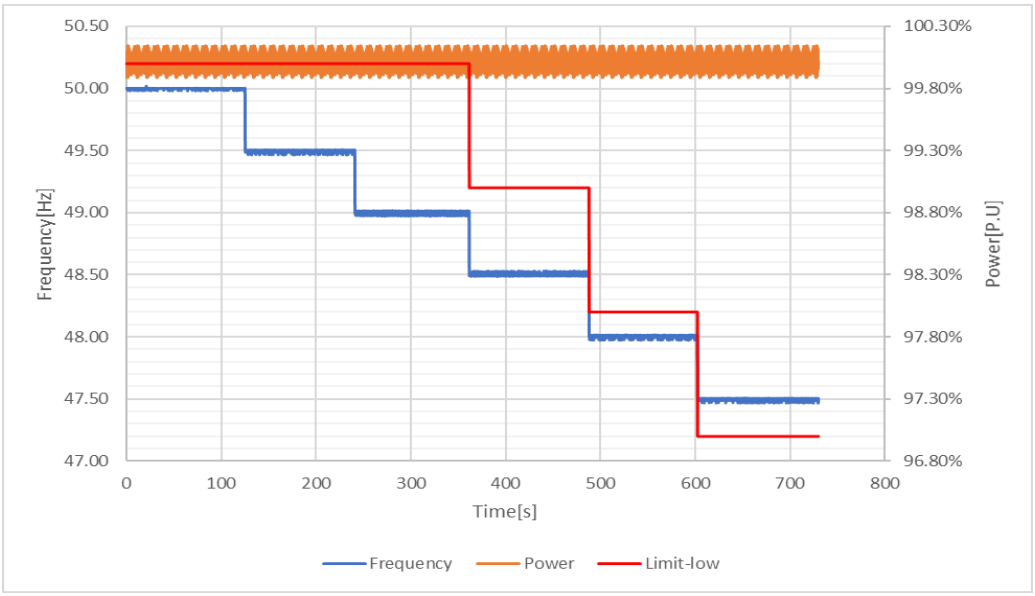


D.4.2	Table: Minimal requirements for active power delivery at underfrequency	P



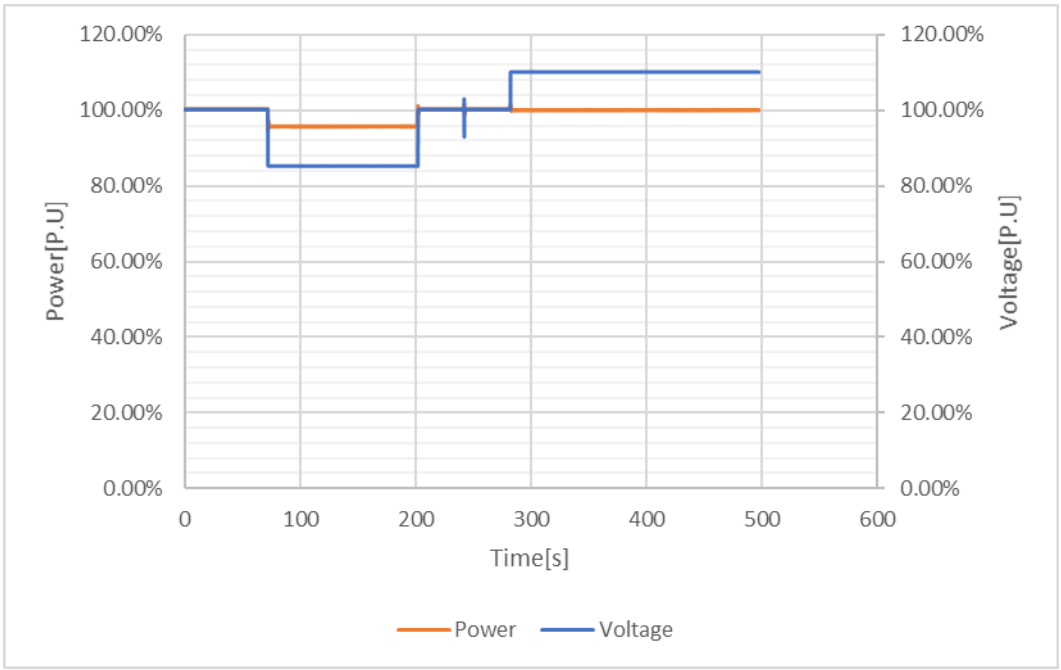
Step	f (Hz)	fmea. (Hz)	T (s)	T meas. (s)	P (%) - max	P (%) - min	P meas. (%)
1	50,00 ± 0.05	50.0	>60	125.2	100%	100%	100.00
2	49.50 ± 0,05	49.5	>60	115.8	100%	100%	100.01
3	49.00 ± 0,05	49.0	>60	120.6	100%	100%	100.02
4	48.50 ± 0,05	48.5	>60	126.4	100%	99%	99.68
5	48.00 ± 0,05	48.0	>60	114.4	100%	98%	99.92
6	47.50 ± 0,05	47.5	>60	127.6	100%	97%	100.15

Supplementary information:

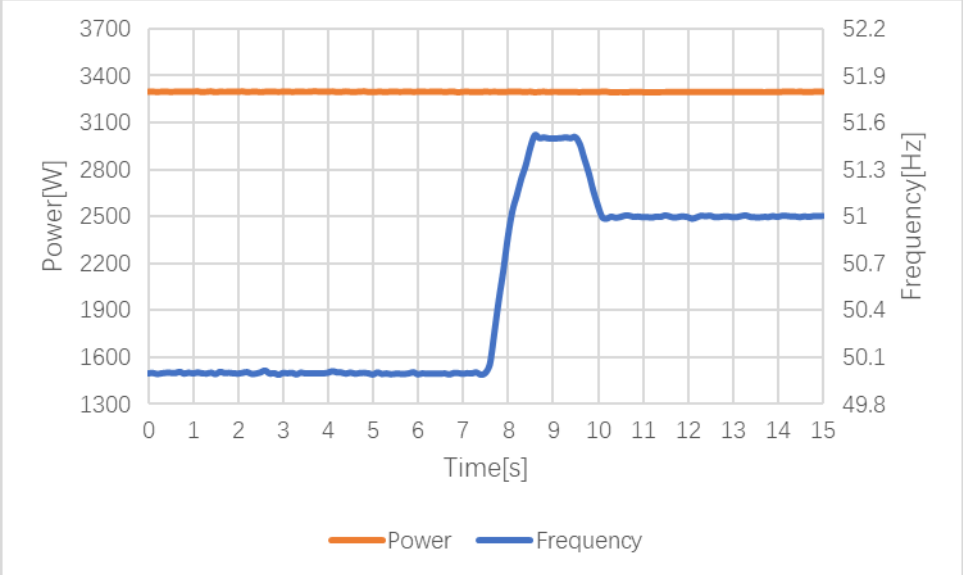


D.4.3	Table: Continuous voltage operation range				P
Step	Voltage (%)	P (%)	P meas. (%)	Time (s)	T meas (s)
1	100	100	100.32	>60	72.1
2	85	100 (*)	95.78	>120	129.9
3	100	100	100.32	>5	80.2
4	110	100	100.09	>120	215.1

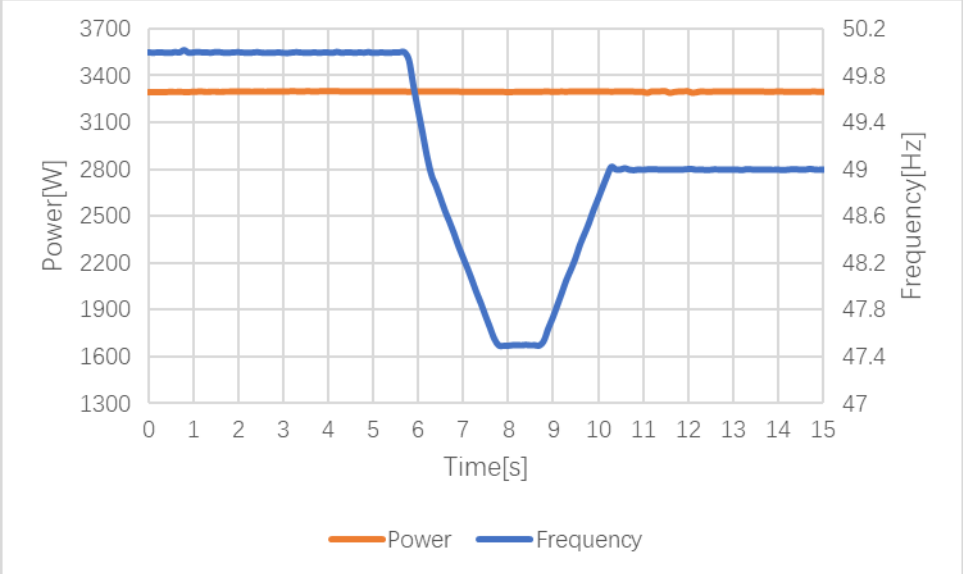
(*) Active power reduction is allowed due to current limitation.



D.5.1	Table: Rate of change of frequency (ROCOF)					P
Steps	Overfrequency			Underfrequency		
	f (Hz)	Step time (s)	Output power (W)	f (Hz)	Step time (s)	Output power (W)
1	50,0 to 51.0	0.5	3299.98	50,0 to 49.0	0.5	3301.04
2	51,0 to 51.5	0.5	3300.20	49,0 to 47.5	1.5	3300.58
3	51,5	1	3299.42	47,5	1	3298.47
4	51.5 to 51.0	0.5 s	3298.81	47.5 to 49.0	1.5	3299.53
5	51.0	3.0 s	3298.78	49.0	0.5	3300.45



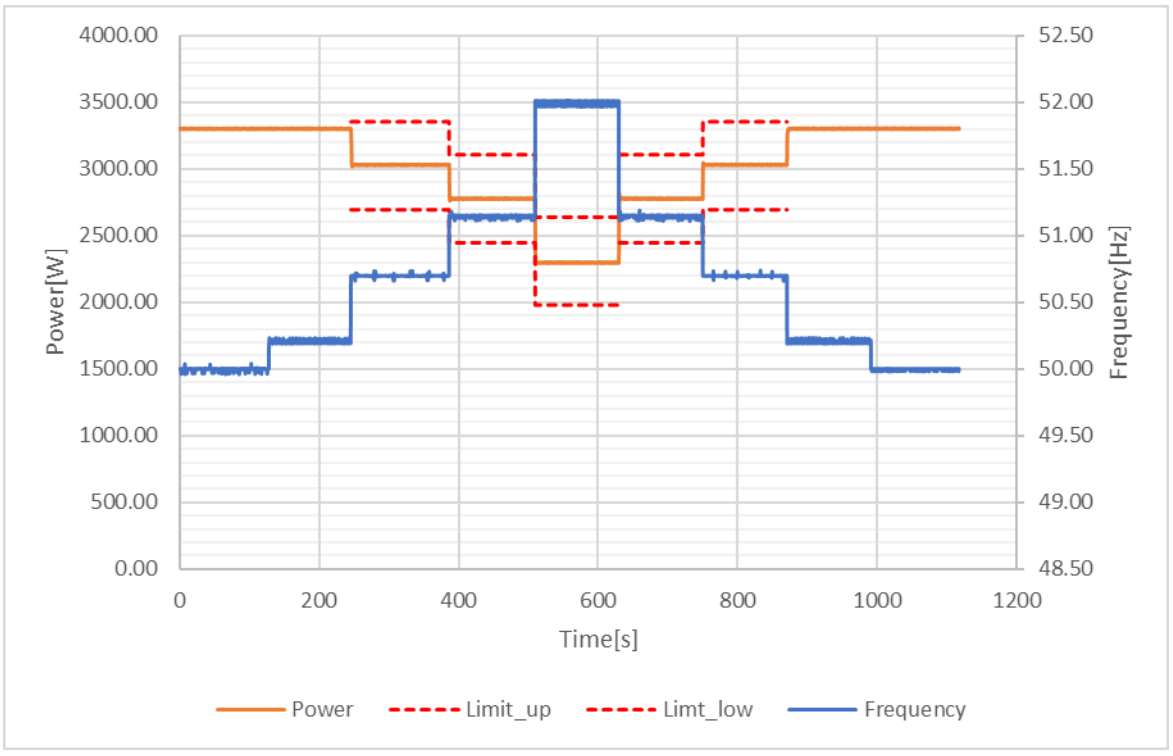
Overfrequency



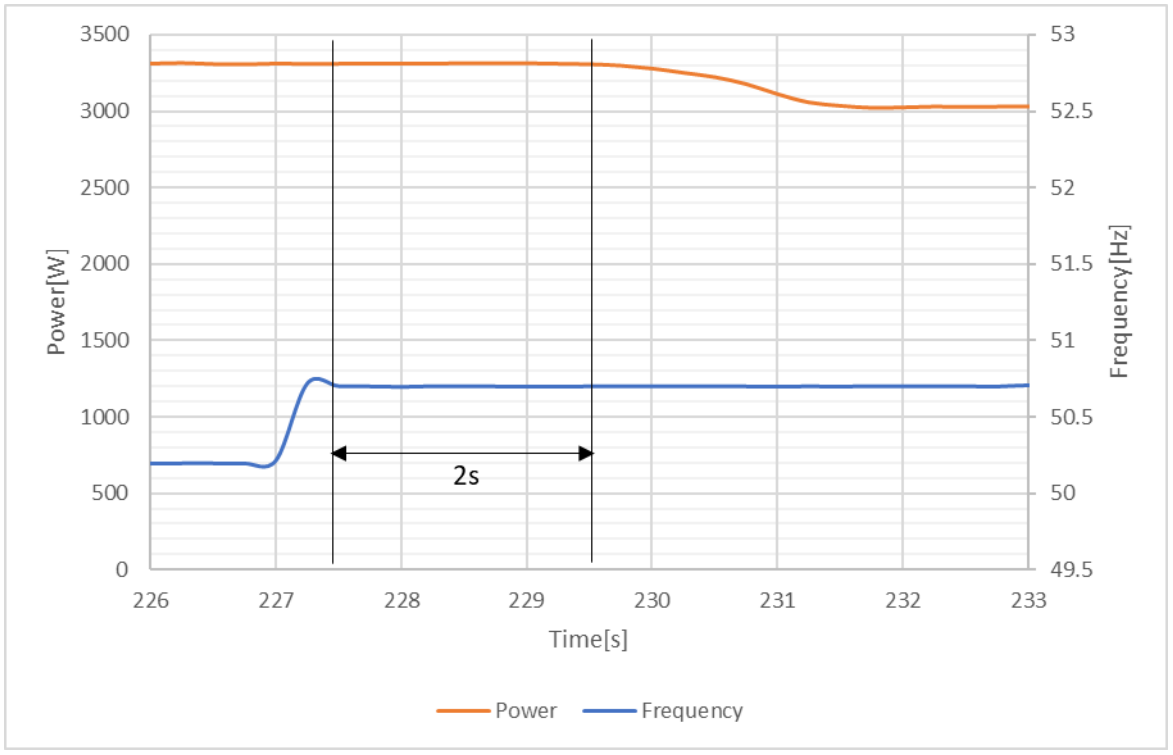
Underfrequency

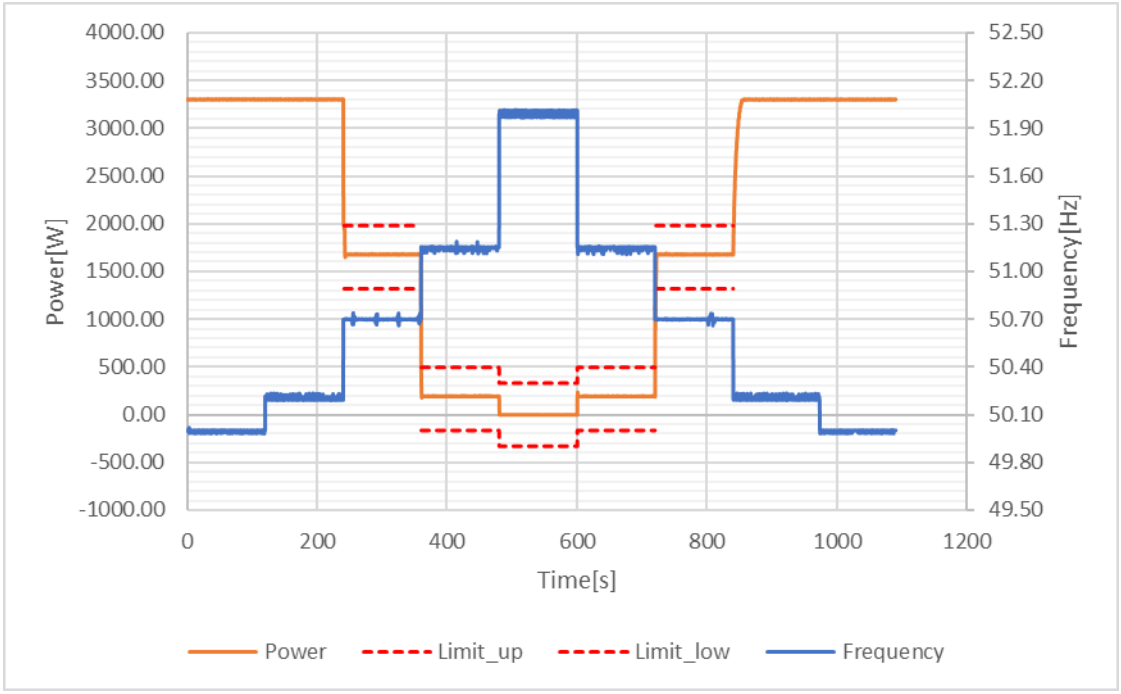
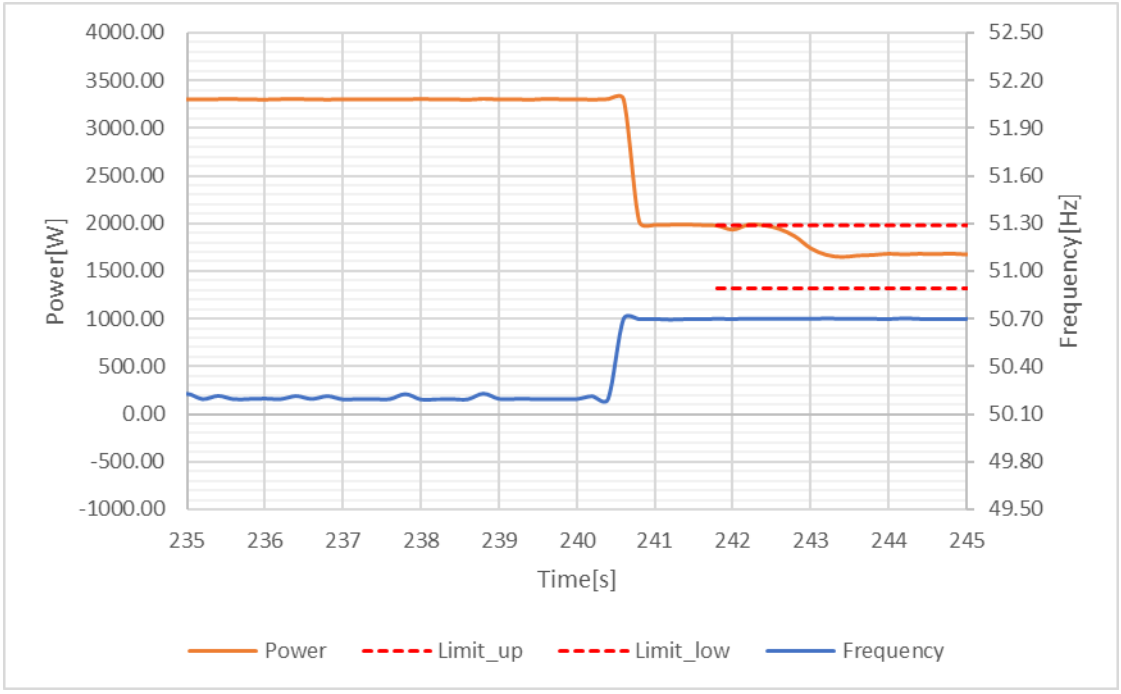
D.6.1	Table: Power response to over frequency						P
Test 1	100% Pn, f1 =50.2Hz; droop=12%; f-stop deactivated, with delay of 2 s						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <2s	For The settling times T≤20s
50Hz ± 0.01Hz	50.00	3302.54	3300.00	--	--	--	--
50.2Hz ± 0.01Hz	50.20	3302.73	3300.00	--	--	--	--
50.70Hz ± 0.01Hz	50.70	3031.57	3025.00	6.57	± 330	1.2	1.8
51.15Hz ± 0.01Hz	51.15	2778.35	2777.50	0.85	± 330	0.6	1.0
52.0Hz ± 0.01Hz	52.00	2298.56	2310.00	-11.44	± 330	0.6	1.0
51.15Hz ± 0.01Hz	51.15	2778.36	2777.50	0.86	± 330	0.6	0.8
50.70Hz ± 0.01Hz	50.70	3032.17	3025.00	7.17	± 330	0.4	0.8
50.2Hz ± 0.01Hz	50.20	3303.14	3300.00	--	--	0.8	1.4
50Hz ± 0.01Hz	50.00	3303.54	3300.00	--	--	--	--
Test 2	100% Pn, f1 =50.2Hz; droop=2%; f-stop deactivated, no delay						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <2s	For The settling times T≤20s
50Hz ± 0.01Hz	50.00	3302.47	3300.00	--	--	--	--
50.2Hz ± 0.01Hz	50.20	3302.57	3300.00	--	--	--	--
50.70Hz ± 0.01Hz	50.70	1678.91	1650.00	28.91	± 330	1.9	2.6
51.15Hz ± 0.01Hz	51.15	192.66	165.00	27.66	± 330	0.4	0.8
52.0Hz ± 0.01Hz	52.00	-1.12	0.00	-1.12	± 330	0.5	0.6
51.15Hz ± 0.01Hz	51.15	191.68	165.00	26.68	± 330	0.3	1.0
50.70Hz ± 0.01Hz	50.70	1678.48	1650.00	28.48	± 330	1.7	2.0
50.2Hz ± 0.01Hz	50.20	3301.30	3300.00	--	--	--	--
50Hz ± 0.01Hz	50.00	3301.70	3300.00	--	--	--	--

Test 3	50% Pn, f1 =52.0Hz; droop=5%; f-stop deactivated, no delay						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <2s	For The settling times T≤20s
50Hz ± 0.01Hz	50.00	1645.94	--	--	--	--	--
51.0Hz ± 0.01Hz	51.00	1644.94	1650.00	-5.06	± 330	--	--
51.70Hz ± 0.01Hz	51.70	1644.52	1650.00	-5.48	± 330	--	--
52.0Hz ± 0.01Hz	52.00	1644.49	1650.00	-5.51	± 330	--	--
51.70Hz ± 0.01Hz	51.70	1644.38	1650.00	-5.62	± 330	--	--
51.00Hz ± 0.01Hz	51.00	1644.70	1650.00	-5.30	± 330	--	--
50Hz ± 0.01Hz	50.00	1644.95	--	--	--	--	--
Test 4	100% Pn, f1 =50.2Hz; droop=5%; f-stop =50.1, no delay, Deactivation time t_{stop} 30s						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <2s	For The settling times T≤20s
50Hz ± 0.01Hz	50.00	3310.21	3300.00	--	--	--	--
50.2Hz ± 0.01Hz	50.20	3310.16	3300.00	--	--	--	--
50.70Hz ± 0.01Hz	50.70	2652.58	2640.58	12.00	± 330	1.5	1.8
51.15Hz ± 0.01Hz	51.15	2056.47	2045.53	10.94	± 330	0.6	1.0
52.0Hz ± 0.01Hz	52.00	919.63	926.64	-7.01	± 330	0.3	0.4
51.15Hz ± 0.01Hz	51.15	919.76	926.64	-6.88	± 330	--	--
50.70Hz ± 0.01Hz	50.70	919.80	926.64	-6.85	± 330	--	--
50.2Hz ± 0.01Hz	50.20	919.80	926.64	-6.84	± 330	--	--
50Hz ± 0.01Hz	50.00	3309.43	3300.00	--	--	--	--

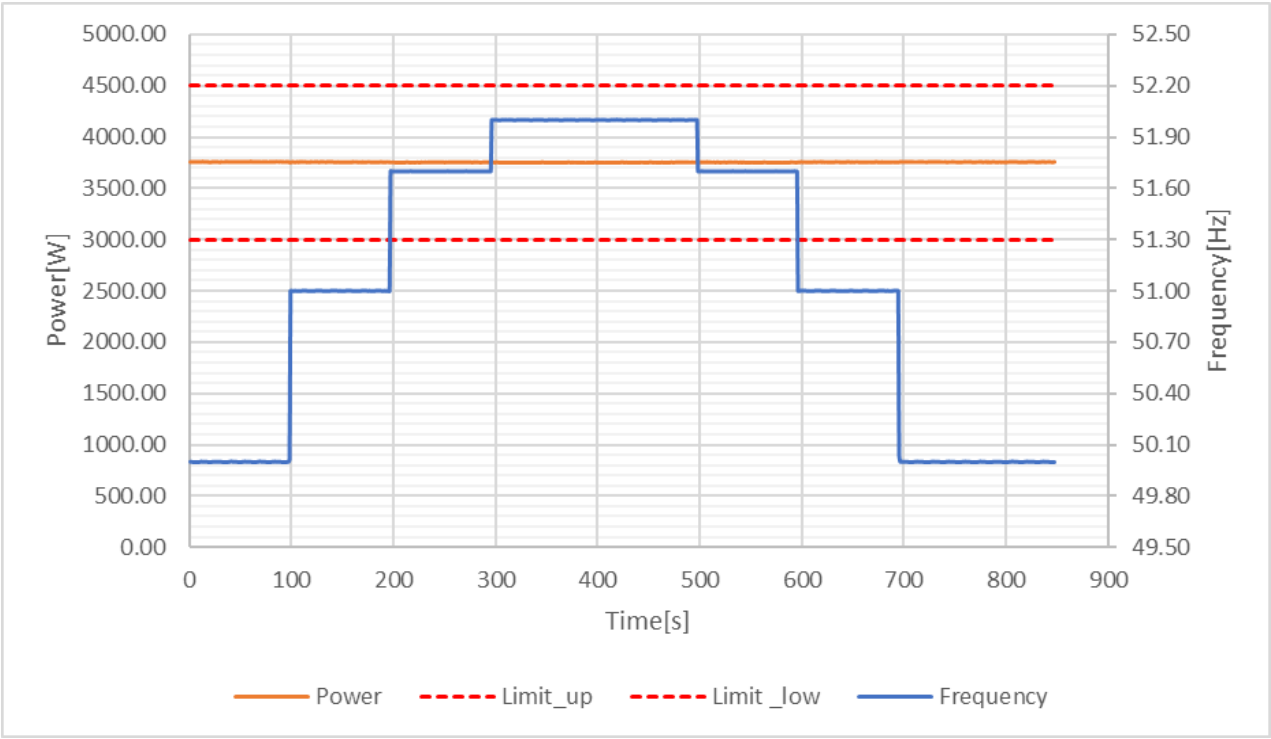


Intentional delay time (2s)

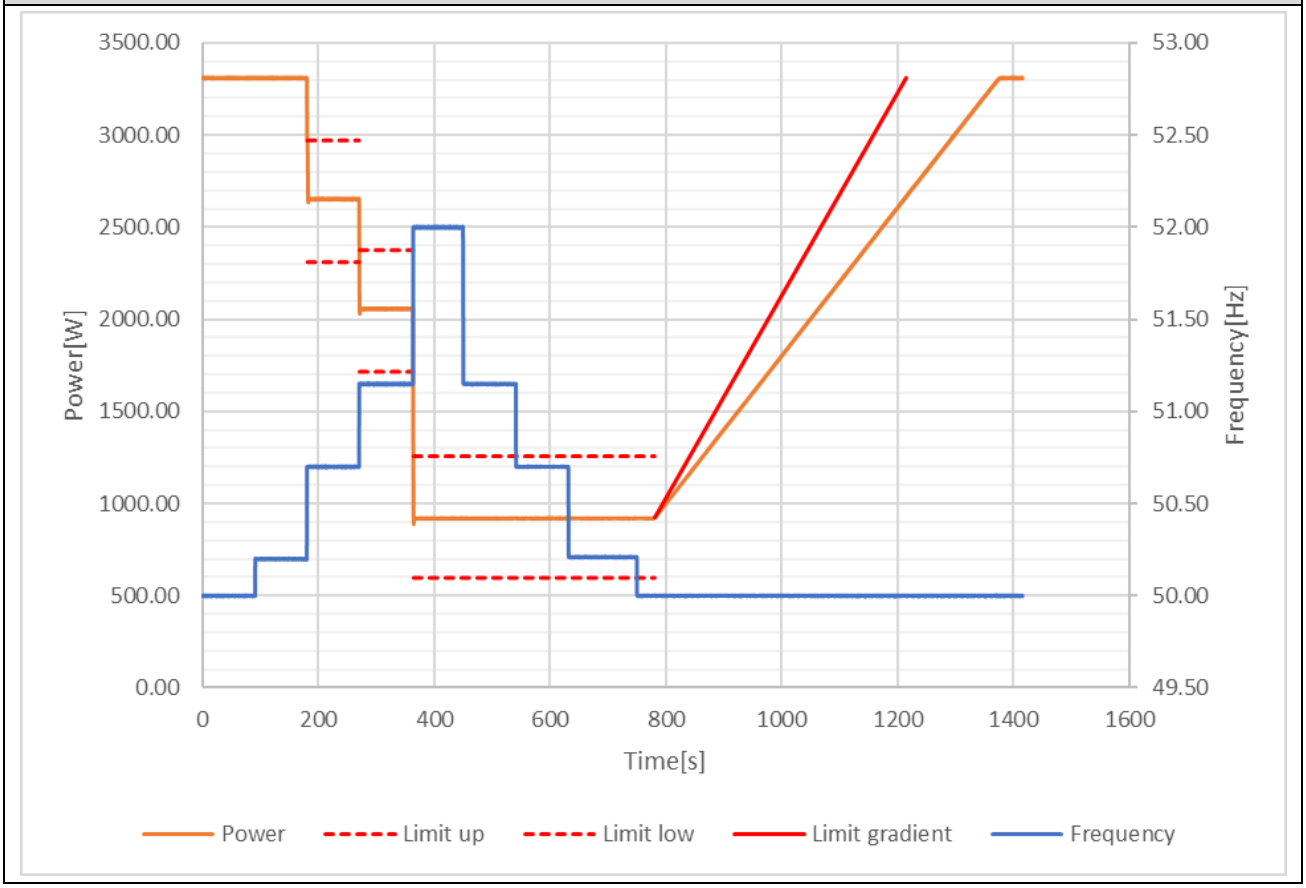


Test 2_Graph

Intentional delay time (no delay)


Test 3_Graph



Test 4_Graph



D.6.2	Table: Power response to under frequency	P

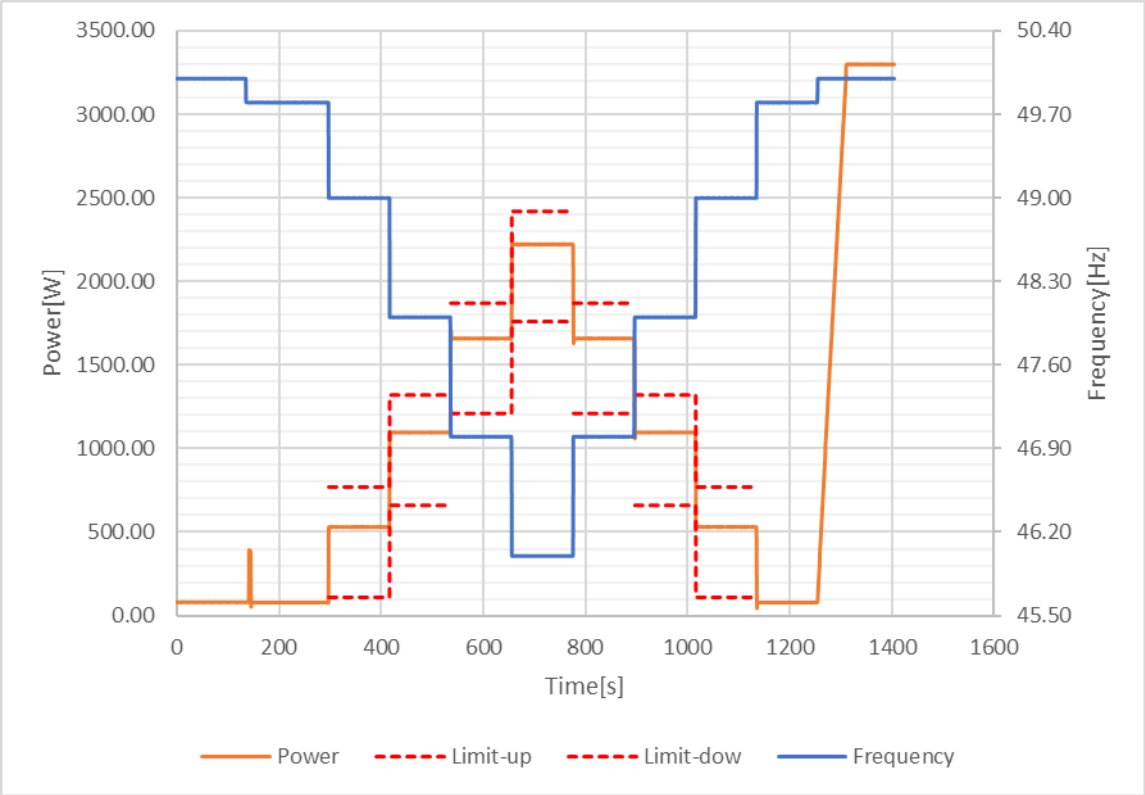
Test 1	0% Pn, f1 =49.8Hz; droop=12%; with delay of 2 s						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	80.01	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	85.99	0.00	91.68	± 330	--	--
49.0Hz ± 0.01z	49.00	531.68	440.00	106.69	± 330	0.4	0.5
48.0Hz ± 0.01z	48.00	1096.69	990.00	119.53	± 330	0.8	1.0
47.0Hz ± 0.01z	47.00	1659.53	1540.00	132.41	± 330	0.8	1.0
46.0Hz ± 0.01z	46.00	2222.41	2090.00	119.94	± 330	0.5	1.5
47.0Hz ± 0.01z	47.00	1659.94	1540.00	106.12	± 330	0.8	1.5
48.0Hz ± 0.01z	48.00	1096.12	990.00	90.70	± 330	0.7	1.5
49.0Hz ± 0.01z	49.00	530.70	440.00	91.68	± 330	0.8	1.0
49.8Hz ± 0.01Hz	49.80	79.06	0.00	106.69	± 330	1.0	1.5
50.0Hz ± 0.01Hz	50.00	3299.53	--	--	--	--	--

Test 2	0% Pn, f1 =49.8Hz; droop=5%; no delay						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	83.15	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	104.74	0.00	73.24	± 330	--	--
49.0Hz ± 0.01Hz	49.00	1156.01	1056.00	86.75	± 330	0.7	1.75
48.0Hz ± 0.01Hz	48.00	2481.08	2376.00	27.30	± 330	0.7	1.0
47.0Hz ± 0.01Hz	47.00	3302.07	3300.00	-37.87	± 330	--	--
46.0Hz ± 0.01Hz	46.00	3301.96	3300.00	-52.44	± 330	--	--
47.0Hz ± 0.01Hz	47.00	3300.90	3300.00	-40.86	± 330	--	--
48.0Hz ± 0.01Hz	48.00	2478.38	2376.00	37.12	± 330	--	--
49.0Hz ± 0.01Hz	49.00	1153.65	1056.00	90.76	± 330	1.0	1.5
49.8Hz ± 0.01Hz	49.80	93.49	0.00	87.96	± 330	1.0	1.5
50.0Hz ± 0.01Hz	50.00	3299.21	--	--	--	--	--

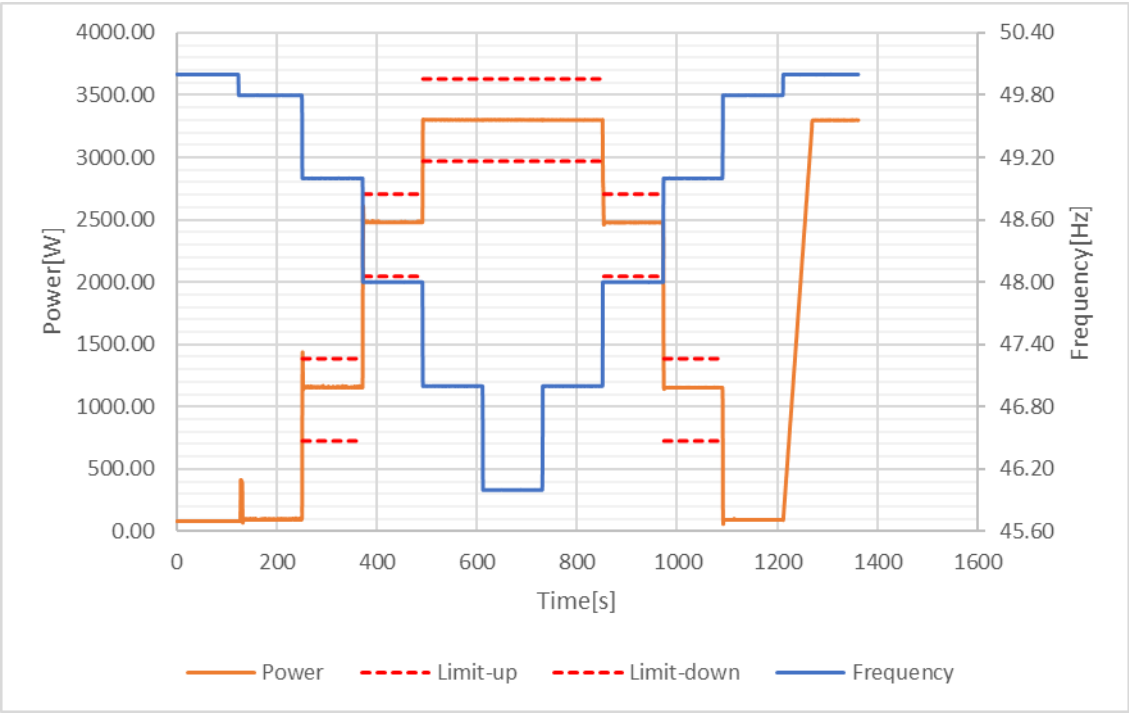
Test 3	50% Pn, f1 =46.0Hz; droop=5%; no delay						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	1680.44	--	--	--	--	--
49.0Hz ± 0.01Hz	49.00	1680.45	1650.00	30.45	± 330	--	--
48.0Hz ± 0.01Hz	48.00	1680.35	1650.00	30.35	± 330	--	--
47.0Hz ± 0.01Hz	47.00	1679.81	1650.00	29.81	± 330	--	--
46.0Hz ± 0.01Hz	46.00	1668.95	1650.00	18.95	± 330	--	--
47.0Hz ± 0.01Hz	47.00	1678.27	1650.00	28.27	± 330	--	--
48.0Hz ± 0.01Hz	48.00	1680.16	1650.00	30.16	± 330	--	--
49.0Hz ± 0.01Hz	49.00	1680.56	1650.00	30.56	± 330	--	--
50.0Hz ± 0.01Hz	50.00	1680.81	--	--	--	--	--

Test 4	50% Pn, f1 =49.8Hz; droop=5%;						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	1681.06	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	1701.60	1650.00	51.60	± 330	--	--
49.0Hz ± 0.01Hz	49.00	2753.69	2706.00	47.69	± 330	0.9	1.0
48.0Hz ± 0.01Hz	48.00	3293.40	3300.00	-6.60	± 330	0.5	1.0
47.0Hz ± 0.01Hz	47.00	3294.37	3300.00	-5.63	± 330	--	--
46.0Hz ± 0.01Hz	46.00	3294.94	3300.00	-5.06	± 330	--	--
47.0Hz ± 0.01Hz	47.00	3294.10	3300.00	-5.90	± 330	--	--
48.0Hz ± 0.01Hz	48.00	3293.93	3300.00	-6.07	± 330	0.0	1.0
49.0Hz ± 0.01Hz	49.00	2758.70	2706.00	52.70	± 330	1.5	2.0
49.8Hz ± 0.01Hz	49.80	1697.90	1650.00	47.90	± 330	--	--
50.0Hz ± 0.01Hz	50.00	3293.21	--	--	--	--	--

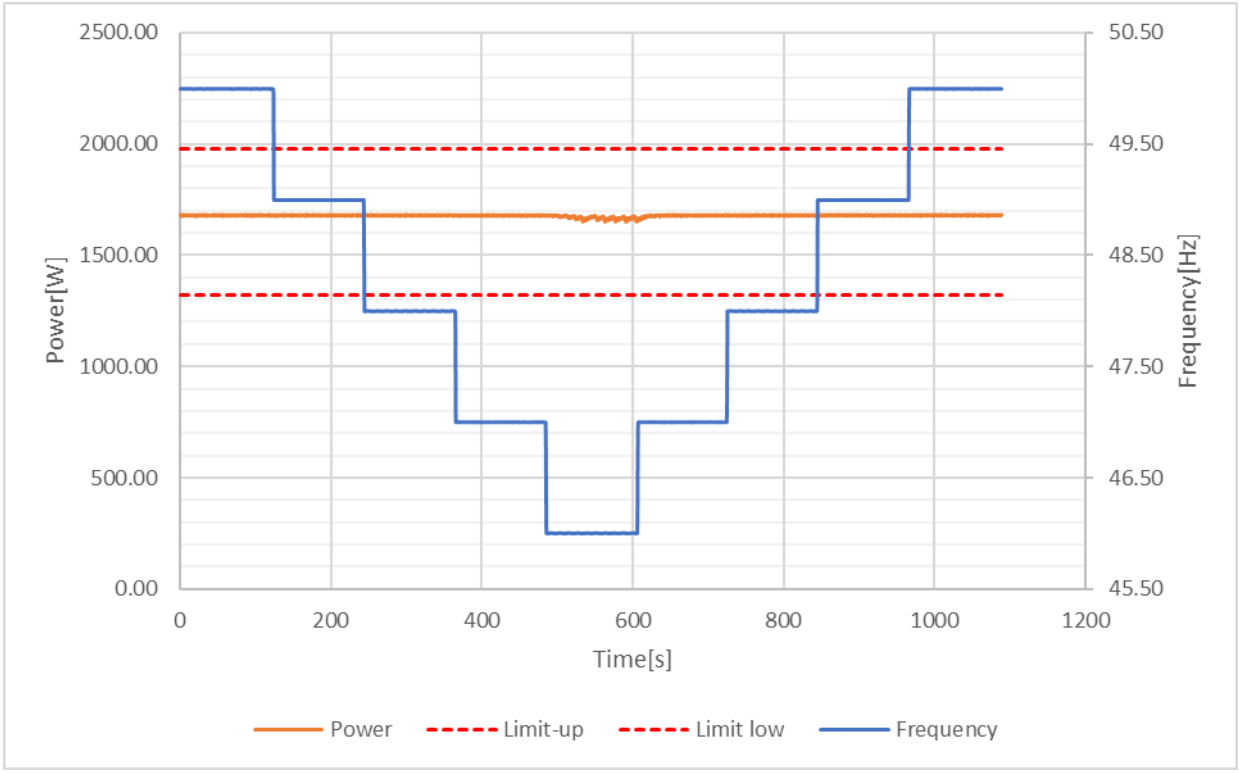
Test 1_Graph



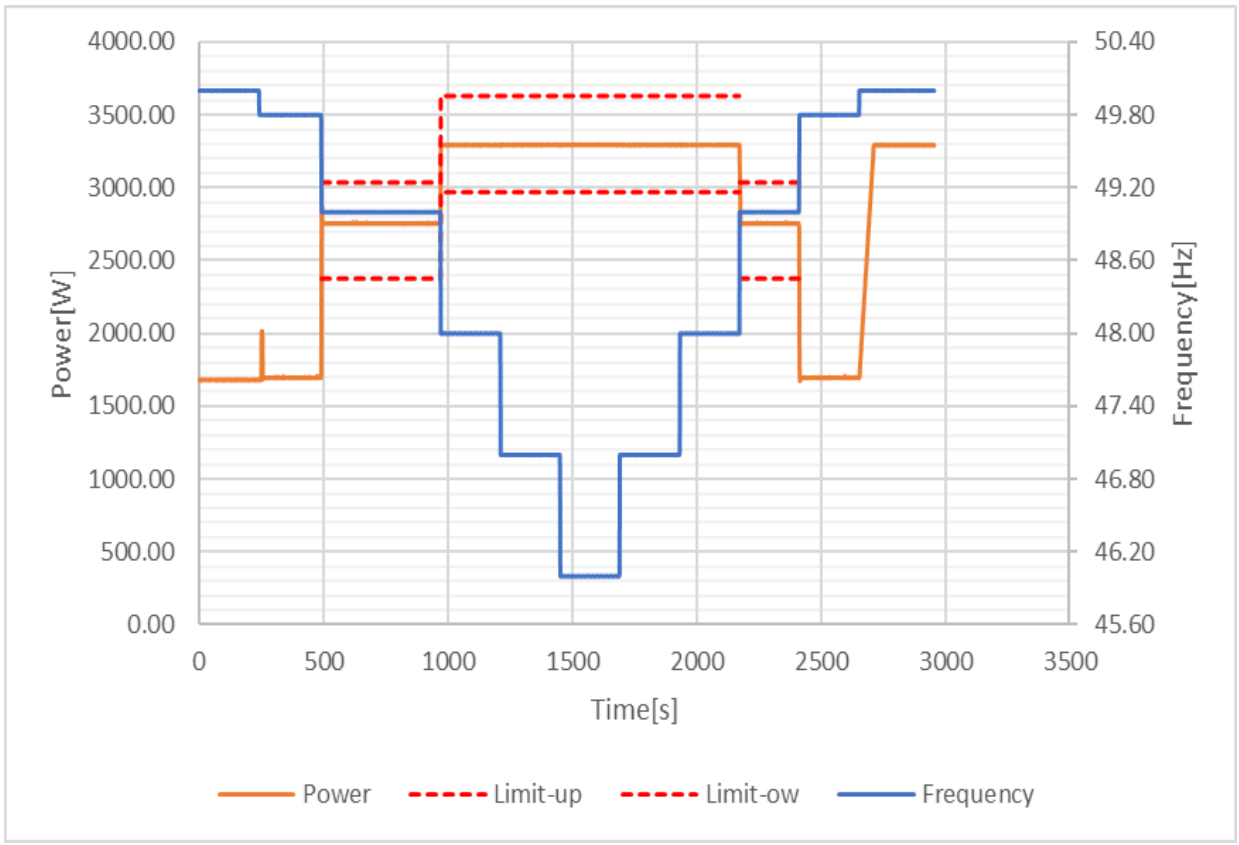
Test 2_Graph



Test 3_Graph



Test 4_Graph



D.7.1	Table: Q Capabilities (Power Factor)	P

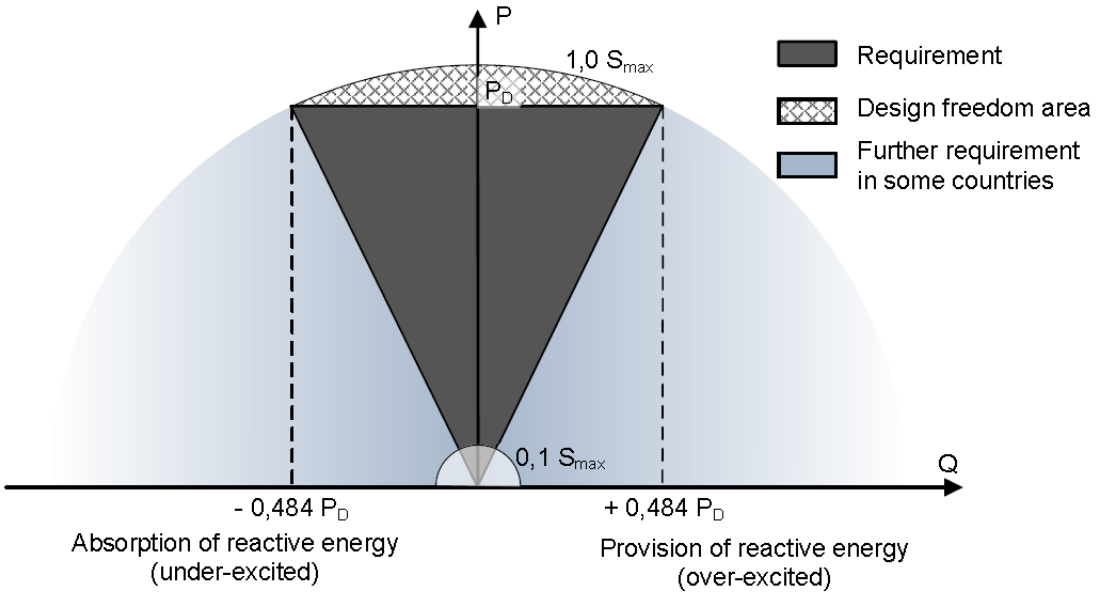


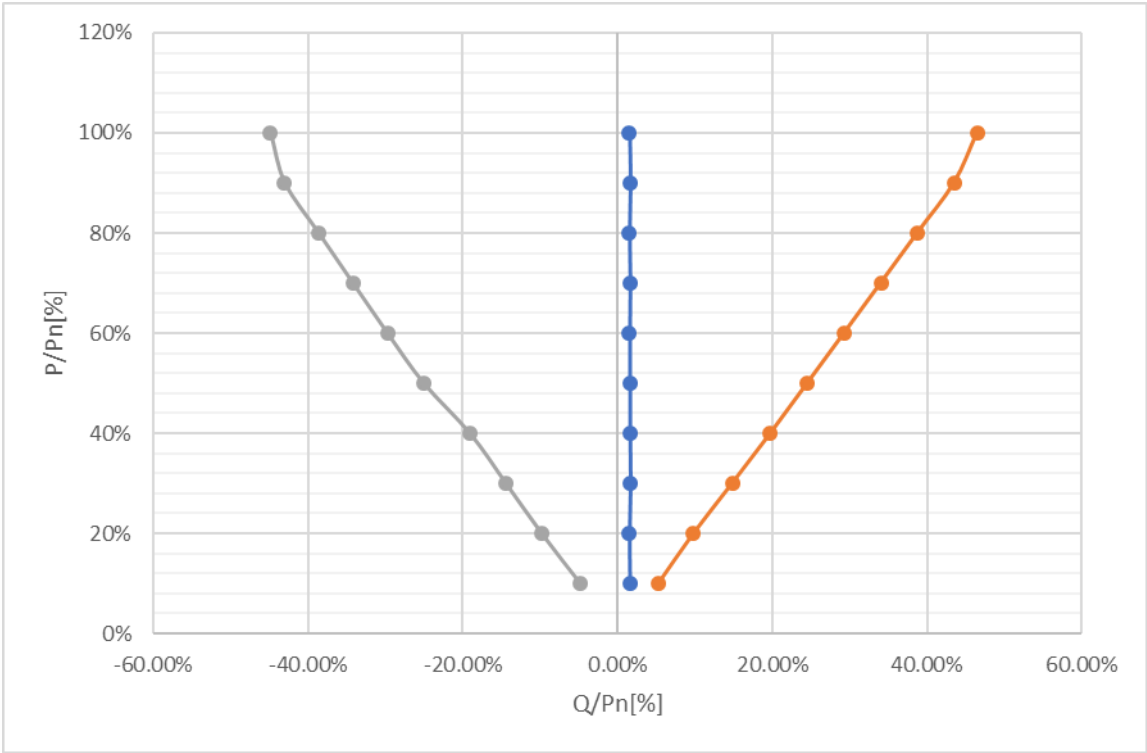
Figure 12 — Reactive power capability at nominal voltage

Lagging PF=0.9:

P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	ΔQ/S_{max} [%]	LIMITE [%]
10	324.43	-158.45	0.8985	0.90	-0.0015	-159.83	0.04	± 2
20	665.39	-323.51	0.8993	0.90	-0.0007	-319.65	-0.12	± 2
30	1006.37	-476.37	0.9038	0.90	0.0038	-479.48	0.09	± 2
40	1345.74	-629.87	0.9057	0.90	0.0057	-639.31	0.29	± 2
50	1674.75	-827.10	0.8966	0.90	-0.0034	-799.13	-0.85	± 2
60	2002.37	-982.08	0.8978	0.90	-0.0022	-958.96	-0.70	± 2
70	2328.28	-1129.71	0.8996	0.90	-0.0004	-1118.78	-0.33	± 2
80	2652.51	-1275.87	0.9011	0.90	0.0011	-1278.61	0.08	± 2
90	2974.38	-1420.05	0.9024	0.90	0.0024	-1438.44	0.56	± 2
100*	3102.84	-1480.62	0.9025	0.90	--	--	--	--

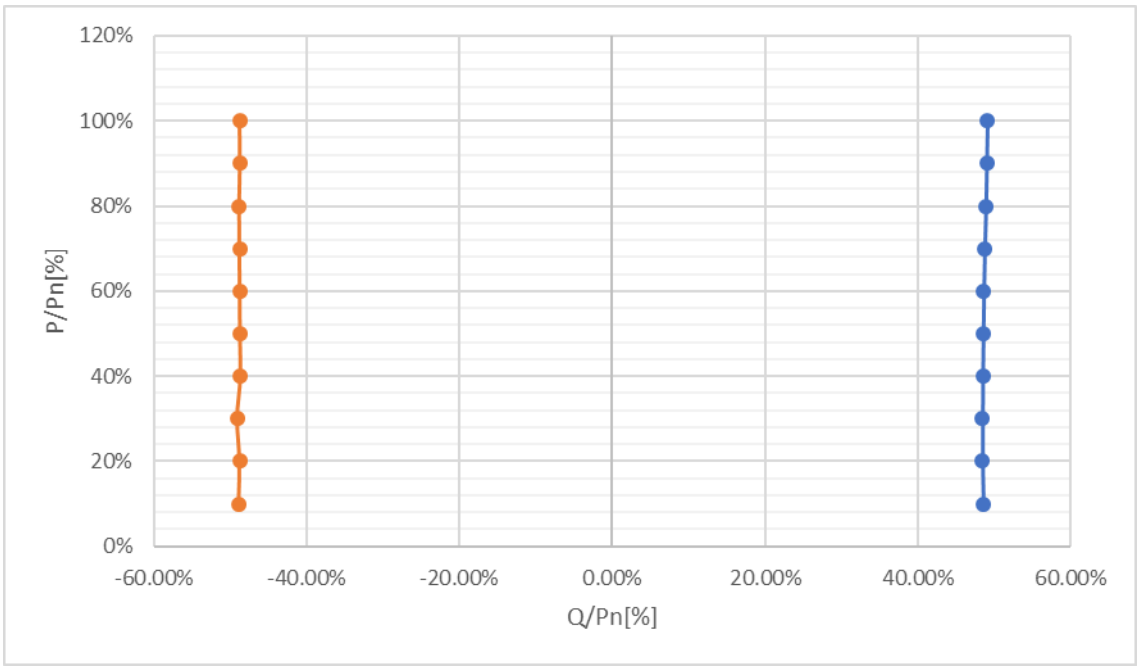
Leading PF=0.9:								
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	357.56	173.95	0.8992	0.90	-0.0008	159.83	0.43	± 2
20	664.21	323.53	0.8990	0.90	-0.0010	319.65	0.12	± 2
30	1003.27	488.87	0.8989	0.90	-0.0011	479.48	0.28	± 2
40	1342.02	652.10	0.8994	0.90	-0.0006	639.31	0.39	± 2
50	1671.38	809.80	0.8999	0.90	-0.0001	799.13	0.32	± 2
60	1999.75	966.58	0.9003	0.90	0.0003	958.96	0.23	± 2
70	2327.55	1123.62	0.9005	0.90	0.0005	1118.78	0.15	± 2
80	2652.44	1279.85	0.9006	0.90	0.0006	1278.61	0.04	± 2
90	2978.59	1436.93	0.9006	0.90	0.0006	1438.44	-0.05	± 2
100	3176.13	1535.47	0.9003	0.90	--	--	--	--
Q=0:								
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	325.36	51.47	0.9877	1.00	-0.0123	0.00	1.56	± 2
20	667.23	50.67	0.9971	1.00	-0.0029	0.00	1.54	± 2
30	1008.29	52.40	0.9985	1.00	-0.0015	0.00	1.59	± 2
40	1348.76	51.61	0.9989	1.00	-0.0011	0.00	1.56	± 2
50	1680.61	51.47	0.9991	1.00	-0.0009	0.00	1.56	± 2
60	2010.08	51.27	0.9992	1.00	-0.0008	0.00	1.55	± 2
70	2338.10	51.95	0.9992	1.00	-0.0008	0.00	1.57	± 2
80	2664.41	50.83	0.9992	1.00	-0.0008	0.00	1.54	± 2
90	2989.00	52.36	0.9992	1.00	-0.0008	0.00	1.59	± 2
100	3310.73	51.02	0.9991	1.00	-0.0009	0.00	1.55	± 2

Graph



Q=48.43%Pn						
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	299.01	1607.11	0.1829	1598.19	0.27	± 2
20	610.57	1591.67	0.3581	1598.19	-0.20	± 2
30	950.16	1597.22	0.5112	1598.19	-0.03	± 2
40	1287.89	1600.24	0.6270	1598.19	0.06	± 2
50	1623.86	1606.64	0.7109	1598.19	0.26	± 2
60	1926.04	1604.93	0.7682	1598.19	0.20	± 2
70	2259.16	1601.20	0.8158	1598.19	0.09	± 2
80	2589.71	1607.03	0.8497	1598.19	0.27	± 2
90	2915.81	1602.67	0.8763	1598.19	0.14	± 2
100*	2949.20	1602.41	0.8786	1598.19	0.13	± 2
Q=-48.43%Pn						
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	281.79	-1546.39	0.1956	-1598.19	1.57	± 2
20	609.54	-1613.00	0.3554	-1598.19	-0.45	± 2
30	949.72	-1605.40	0.5095	-1598.19	-0.22	± 2
40	1287.58	-1605.63	0.6256	-1598.19	-0.23	± 2
50	1623.37	-1602.72	0.7117	-1598.19	-0.14	± 2
60	1925.80	-1577.41	0.7737	-1598.19	0.63	± 2
70	2258.56	-1594.64	0.8168	-1598.19	0.11	± 2
80	2589.73	-1591.23	0.8520	-1598.19	0.21	± 2
90	2902.53	-1593.00	0.8767	-1598.19	0.16	± 2
100*	2943.94	-1590.64	0.8797	-1598.19	0.23	± 2

Graph



D.7.1	Table: Q(U) Capabilities	P

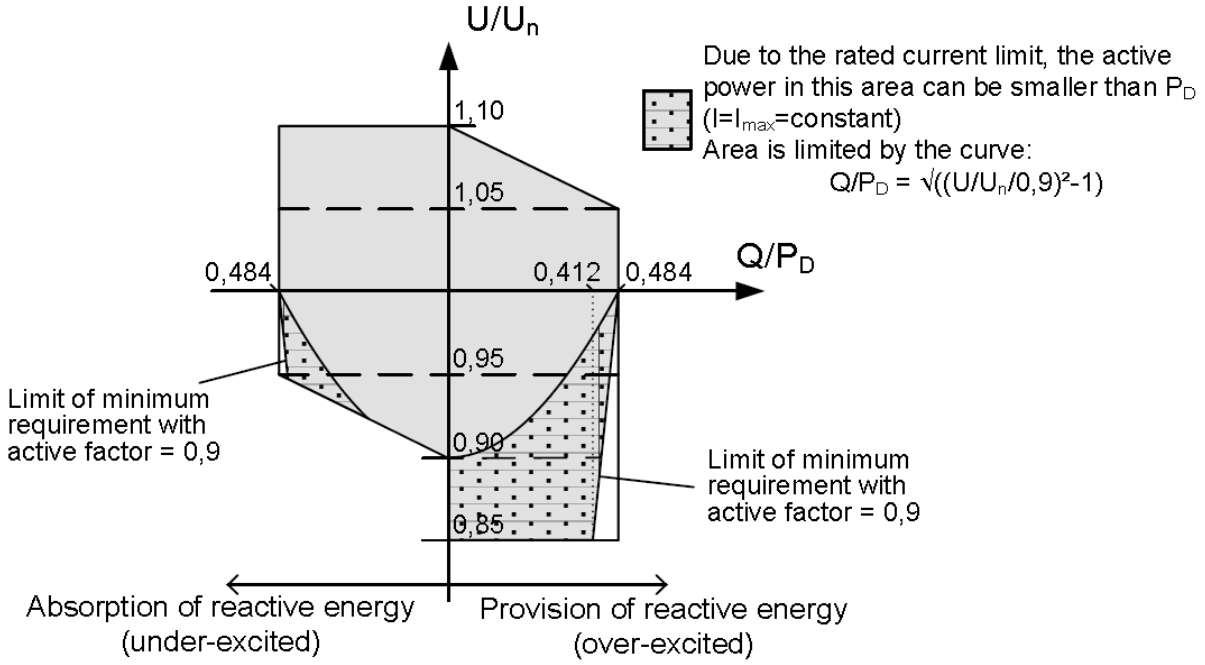


Figure 13 — Reactive power capability at active power P_D in the voltage range (positive sequence component of the fundamental)

Over-excited:

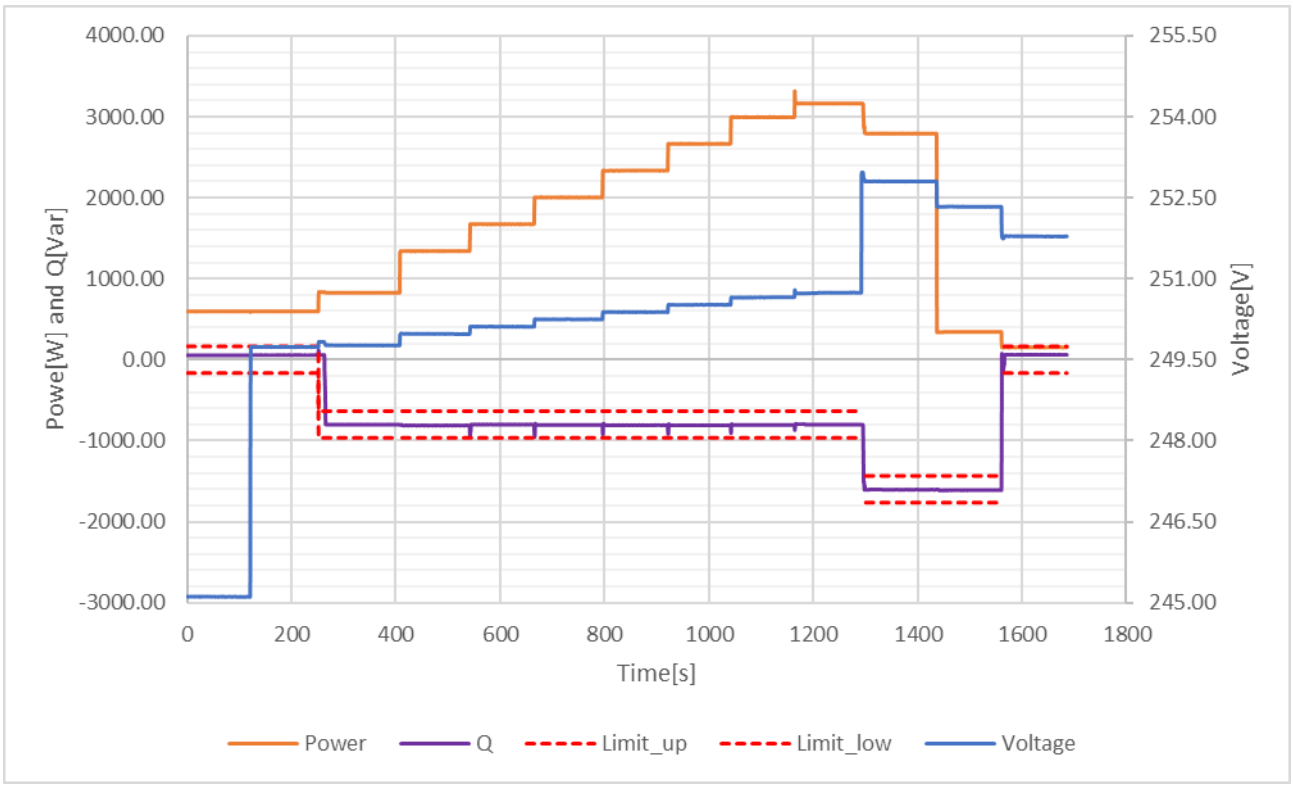
AC output				Reactive power measured		
Voltage setting [V/Vn]	Measured			Reactive power [Var]	Value [Q/Pn]	Limits
	Voltage [V]	[V/Vn]	Active power [W]			
1.10	253.07	1.1003	3291.86	96.04	0.0181	±0.02
1.08	248.57	1.0807	3291.24	637.31	0.1931	0.194±0.02
1.05	241.70	1.0509	3145.73	1591.76	0.4824	0.484±0.02
1.00	230.36	1.0016	3149.68	1591.26	0.4822	0.484±0.02
0.95	218.90	0.9517	3082.70	1603.20	0.4858	--
0.90	207.46	0.9020	2878.39	1606.08	0.4867	--
0.85	196.02	0.8522	2668.00	1610.52	0.4880	--

Under-excited:						
AC output				**Reactive power measured**		
Voltage setting [V/Vn]	**Measured**			**Reactive power [Var]**	**Value [Q/P_n]**	**Limits**
	Voltage [V]	**[V/Vn]**	**Active power [W]**			
1.10	252.90	1.0995	2991.56	-1597.84	-0.4842	--
1.08	248.44	1.0802	2982.39	-1617.01	-0.4900	--
1.05	241.52	1.0501	2994.36	-1605.42	-0.4865	--
1.00	230.18	1.0008	2999.16	-1607.75	-0.4872	--
0.95	218.72	0.9510	2934.44	-1612.35	-0.4886	--
0.92	212.05	0.9220	3223.51	-647.84	-0.1963	-0.175±0.02
0.90	207.56	0.9014	3289.38	130.03	0.0181	±0.02

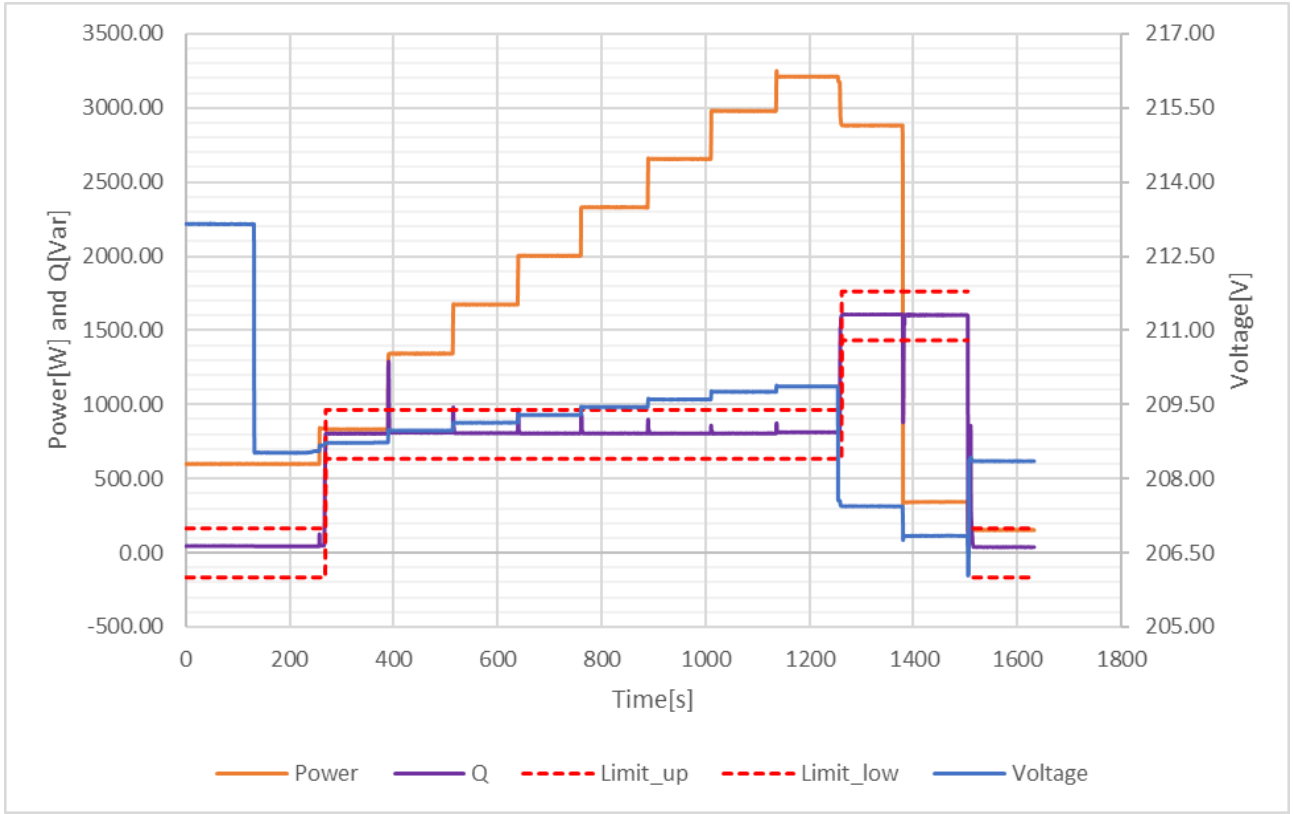
D.7.1	Table: Q Control. Voltage related control mode					P
P/Pn [%] Set-point	Vac [V] Set-point	P/Pn [%] measured	Vac [V] Measured	Q [VAr] measured	Q [Var] expected	Δ Q [Var] (≤ ± 5 % Pn)
< 20 %	1,07 Vn	597.17	245.11	55.91	≈0 (< ± 5 % Pn)	1.69
< 20 %	1,09 Vn	597.25	249.73	57.54	≈0 (< ± 5 % Pn)	1.74
<20 %→30 %	1,09 Vn	828.46	249.77	-801.54	-799.26 (within 10sec)	-0.07
40 %	1,09 Vn	1342.14	249.98	-810.65	-799.26	-0.35
50 %	1,09 Vn	1674.25	250.11	-799.39	-799.26	0.00
60 %	1,09 Vn	2005.34	250.25	-804.33	-799.26	-0.15
70 %	1,09 Vn	2336.66	250.38	-807.15	-799.26	-0.24
80 %	1,09 Vn	2667.22	250.52	-809.36	-799.26	-0.31
90 %	1,09 Vn	2996.04	250.66	-804.57	-799.26	-0.16
100 %	1,09 Vn	3164.95	250.74	-799.88	-799.26	-0.02
100 %	1,1 Vn	2794.12	252.80	-1603.43	-1598.19	-0.16
100 % →10 %	1,1 Vn	343.08	252.33	-1607.76	-1598.19	-0.29
10 %→ ≤ 5 %	1,1 Vn	152.05	251.79	60.76	≈0 (< ± 5 % Pn)	1.84
P/Pn [%] Set-point	Vac [V] Set-point	P/Pn [%] measured	Vac [V] Measured	Q [VAr] measured	Q [Var] expected	Δ Q [Var] (≤ ± 5 % Pn)
< 20 %	0.93 Vn	600.29	213.15	45.86	≈0 (< ± 5 % Pn)	1.39
< 20 %	0.91 Vn	600.46	208.53	44.94	≈0 (< ± 5 % Pn)	1.36
<20 %→30 %	0.91 Vn	833.14	208.73	804.38	799.26 (within 10sec)	0.16
40 %	0.91 Vn	1344.29	208.98	811.75	799.26	0.38
50 %	0.91 Vn	1674.99	209.13	807.97	799.26	0.26
60 %	0.91 Vn	2003.69	209.29	805.82	799.26	0.20
70 %	0.91 Vn	2331.27	209.45	805.74	799.26	0.20
80 %	0.91 Vn	2656.85	209.60	805.42	799.26	0.19
90 %	0.91 Vn	2980.35	209.76	805.72	799.26	0.20

100 %	0.91 Vn	3211.88	209.87	813.47	799.26	0.43
100 %	0.90 Vn	2880.98	207.44	1606.93	1598.19	0.26
100 % →10 %	0.90 Vn	342.71	206.84	1599.07	1598.19	0.03
10 % →≤ 5 %	0.91 Vn	154.53	208.36	38.84	≈0 (< ± 5 % Pn)	1.18

Graph: Lock-in at 1.08Vn



Graph: Lock-in at 0.92Vn

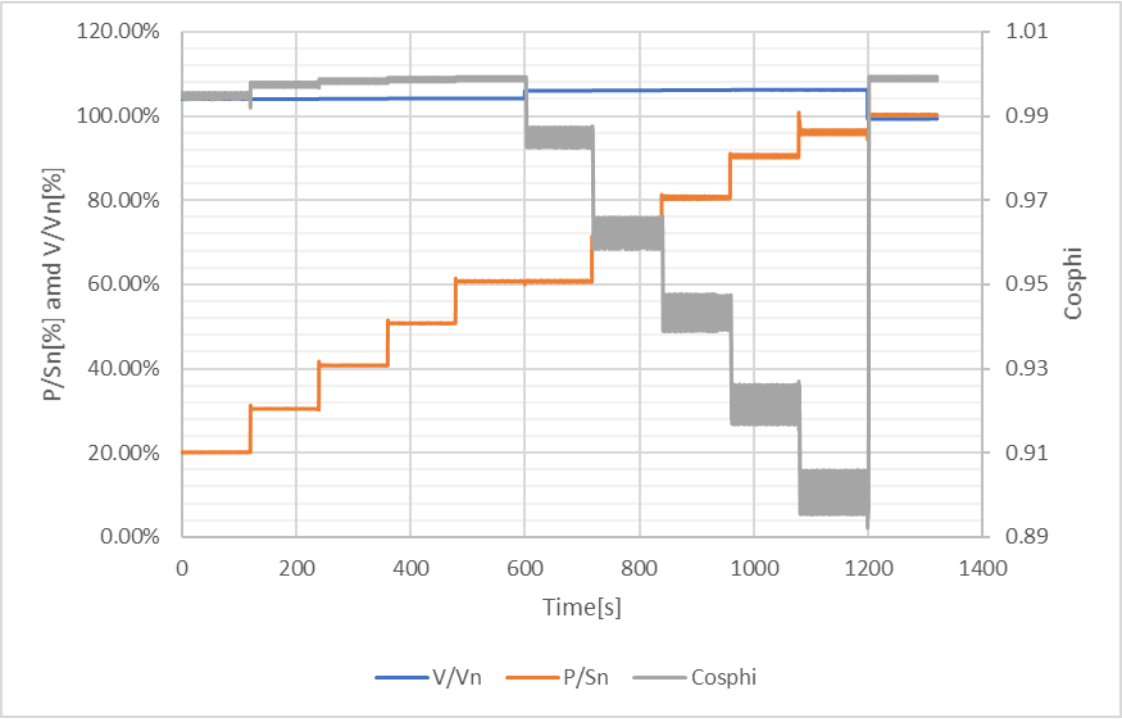


D.7.1	Table: Q Control Power related control modes							P
P Desired (%Sn)	**P measured (%Sn)**	**Q measured (Var)**	**Voltage Desired (%Un)**	**Voltage Measured (%Un)**	**Power Factor desired (cos φ)**	**Power Factor measured (cos φ)**	**ΔQ (%S_{Max})**	**Limit (%S_{Max})**
20%	20.13	27.63	<105%	103.99	1.0000	0.9949	0.8372	±2
30%	30.47	41.83	<105%	104.04	1.0000	0.9974	1.2677	±2
40%	40.76	48.20	<105%	104.09	1.0000	0.9983	1.4606	±2
50%	50.79	54.39	<105%	104.14	1.0000	0.9987	1.6482	±2
60%	60.75	54.21	<105%	104.21	1.0000	0.9989	1.6427	±2
60%	60.75	351.33	>105%	106.03	0.9800	0.9849	-1.5371	±2
70%	70.73	655.66	>105%	106.08	0.9600	0.9626	-0.5482	±2
80%	80.63	932.83	>105%	106.14	0.9400	0.9436	-0.7686	±2
90%	90.48	1255.08	>105%	106.20	0.9200	0.9218	-0.3070	±2
100%	96.15	1601.22	>105%	106.21	0.9000	0.9006	0.0897	±2
100%	100.27	64.43	<100%	99.33	1.0000	0.9990	1.9524	±2

Remark: Tested at lock-in voltage 1.05 Vn and lock-out voltage Vn.

The Lock-in value is adjustable between Vn and 1.1Vn in 0.01V steps, the Lock-out value is adjustable between 0.9Vn and Vn in 0.01V steps

Graph



D.7.2	Table: Voltage related active power reduction P(U)	P

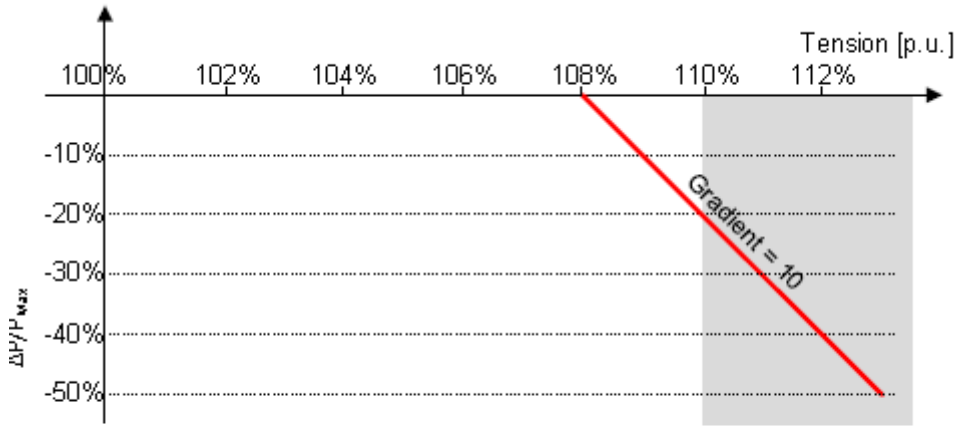
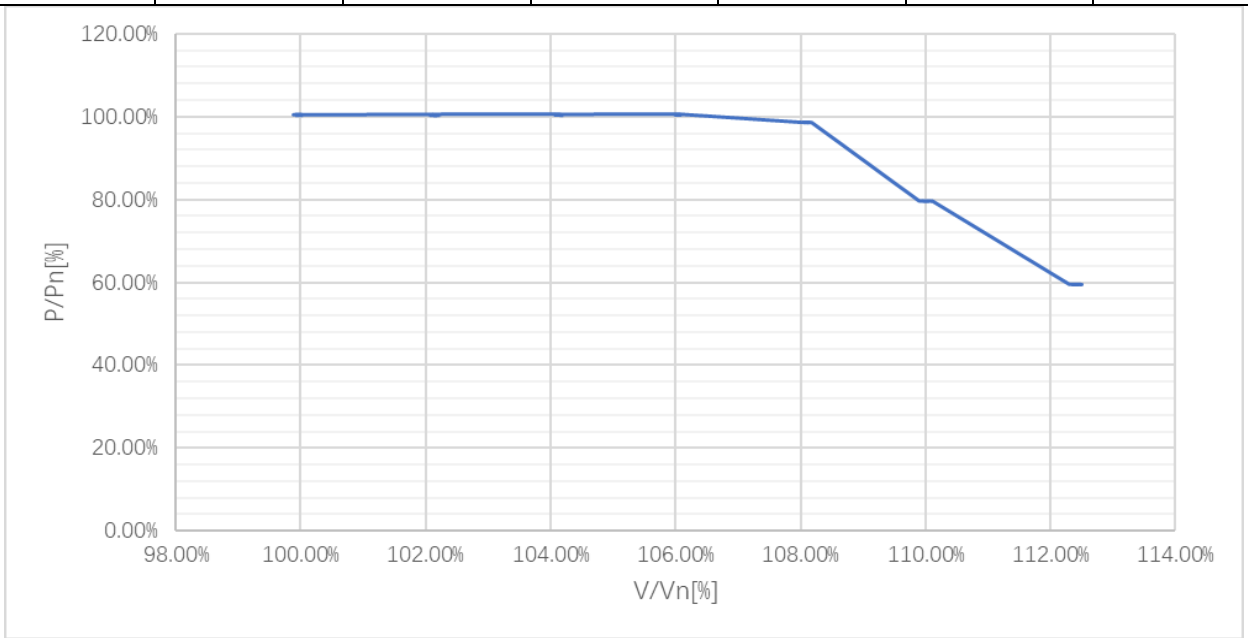


Figure 15 - Example curve for P(U)

Step #	Set voltage vaule V/Vn [%]	Measured voltage vaule V/Vn [%]	Measured power values [W]	Measured power bin [%]	Limit [%]	RESULT
1	100	99.98	3314.44	100.44	--	
2	102	102.15	3315.64	100.47	--	
3	104	104.13	3317.08	100.52	--	
4	106	106.04	3317.82	100.54	--	P
5	108	108.10	3253.13	98.58	--	
6	110	110.00	2626.16	79.58	<80	
7	112	112.40	1962.32	59.46	<60	



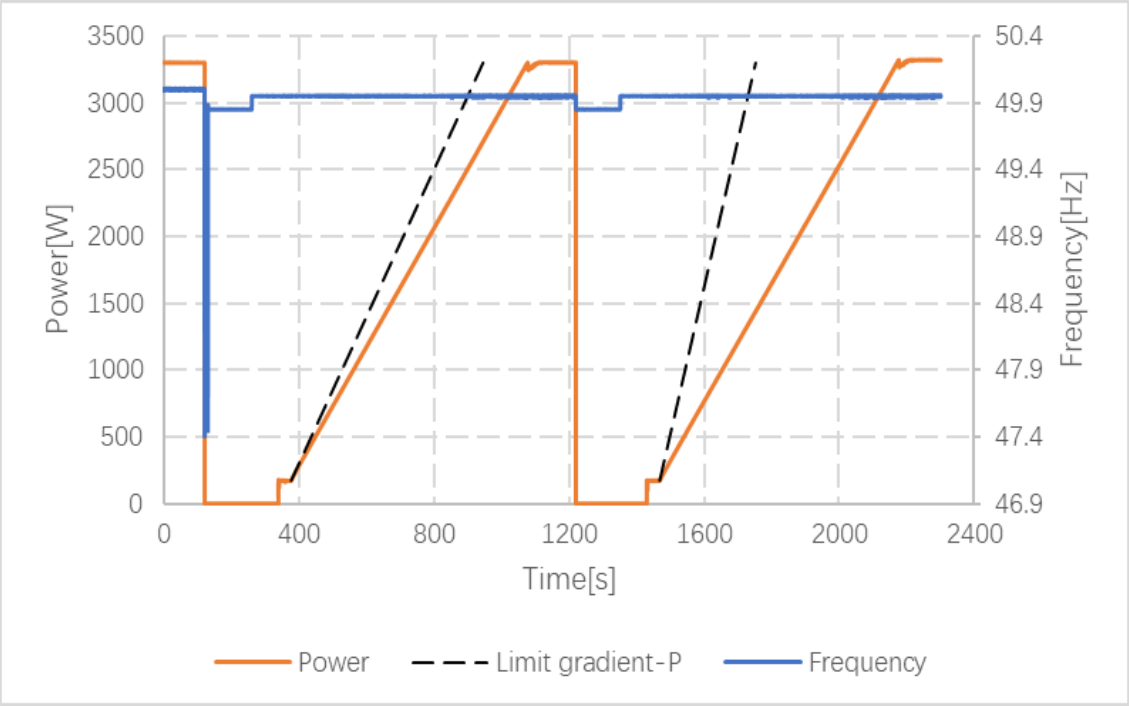
D.8	Table: Connection and reconnection	P

Parameter	Reconnection after tripping of the interface protection relay	Normal operation starting
Lower frequency	49,9 Hz	49,9 Hz
Upper frequency	50,1 Hz	50,1 Hz
Lower voltage	If connection to the LV distribution network: 85% U_n	If connection to the LV distribution network: 85% U_n
	If connection to the HV distribution network: 90 % U_c	If connection to the HV distribution network: 90 % U_c
Upper voltage	If connection to the LV distribution network: 110 % U_n	If connection to the LV distribution network: 110 % U_n
	If connection to the HV distribution network: 110 % U_c	If connection to the HV distribution network: 110 % U_c
Observation time	60 s	60 s
Maximum active power increase gradient	10 %/min*	20 %/min
** Power-generating units that have not the ability to apply a certain gradient shall take into account an additional delay.*		

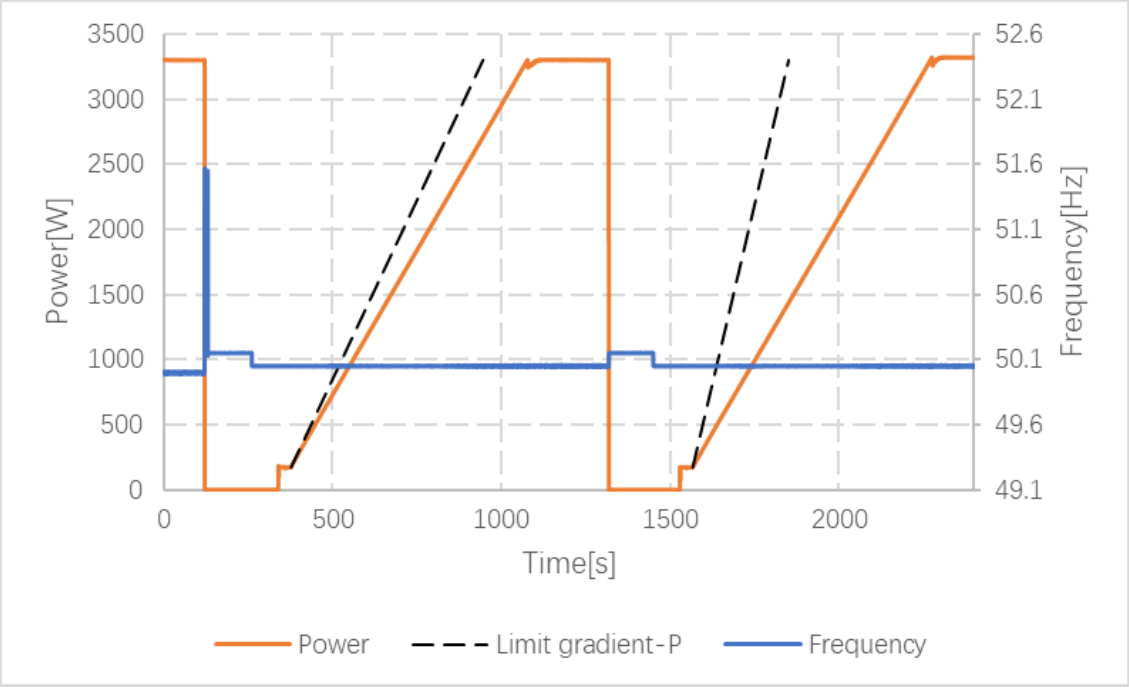
Test sequence after trip	connection	connection allowed	Observation time (s)	Power gradient after connection (%/min)
Step a)	**<49.9Hz**	**No**	--	--
Step b)	**≥49.9Hz**	**Yes**	78.8	8.09
Step c)	**>50.1Hz**	**No**	--	--
Step d)	**≤50.1Hz**	**Yes**	78.2	8.09
Step e)	**<195.5V**	**No**	--	--
Step f)	**≥195.5V**	**Yes**	78.6	7.82
Step g)	**>253V**	**No**	--	--
Step h)	**≤253V**	**Yes**	79.0	8.07
Remark: Maximum active power increase gradient 10 %/min.				

Test sequence at normal operation starting	connection	connection allowed	Observation time (s)	Power gradient after connection (%/min)
Step a)	**<49.9Hz**	**No**	--	--
Step b)	**≥49.9Hz**	**Yes**	78.6	8.04
Step c)	**>50.1Hz**	**No**	--	--
Step d)	**≤50.1Hz**	**Yes**	78.8	8.04
Step e)	**<195.5V**	**No**	--	--
Step f)	**≥195.5V**	**Yes**	79.2	7.80
Step g)	**>253V**	**No**	--	--
Step h)	**≤253V**	**Yes**	78.6	8.13
Remark: Maximum active power increase gradient 20 %/min.				

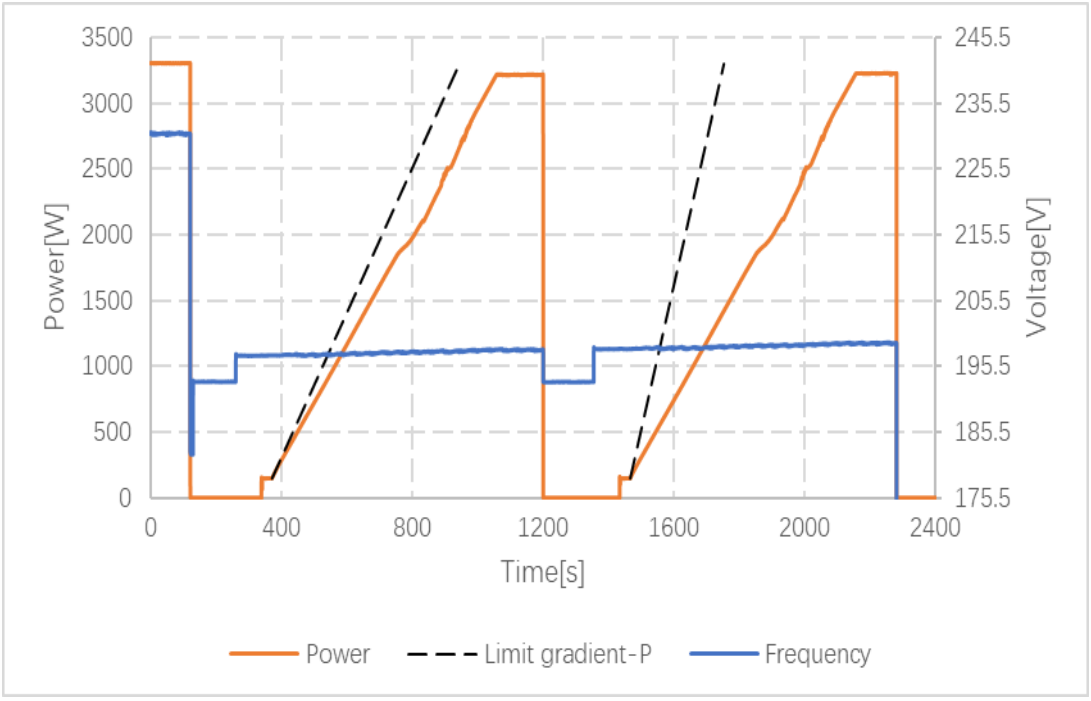
Graph_49.9Hz



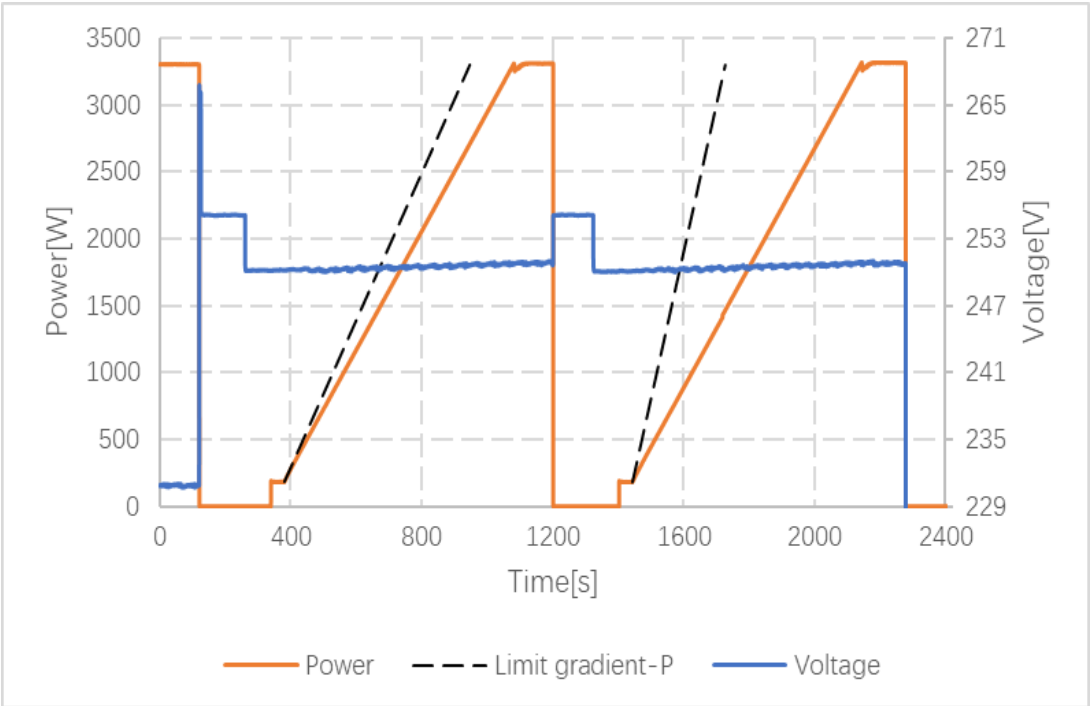
Graph_50.1Hz



Graph_195.5V

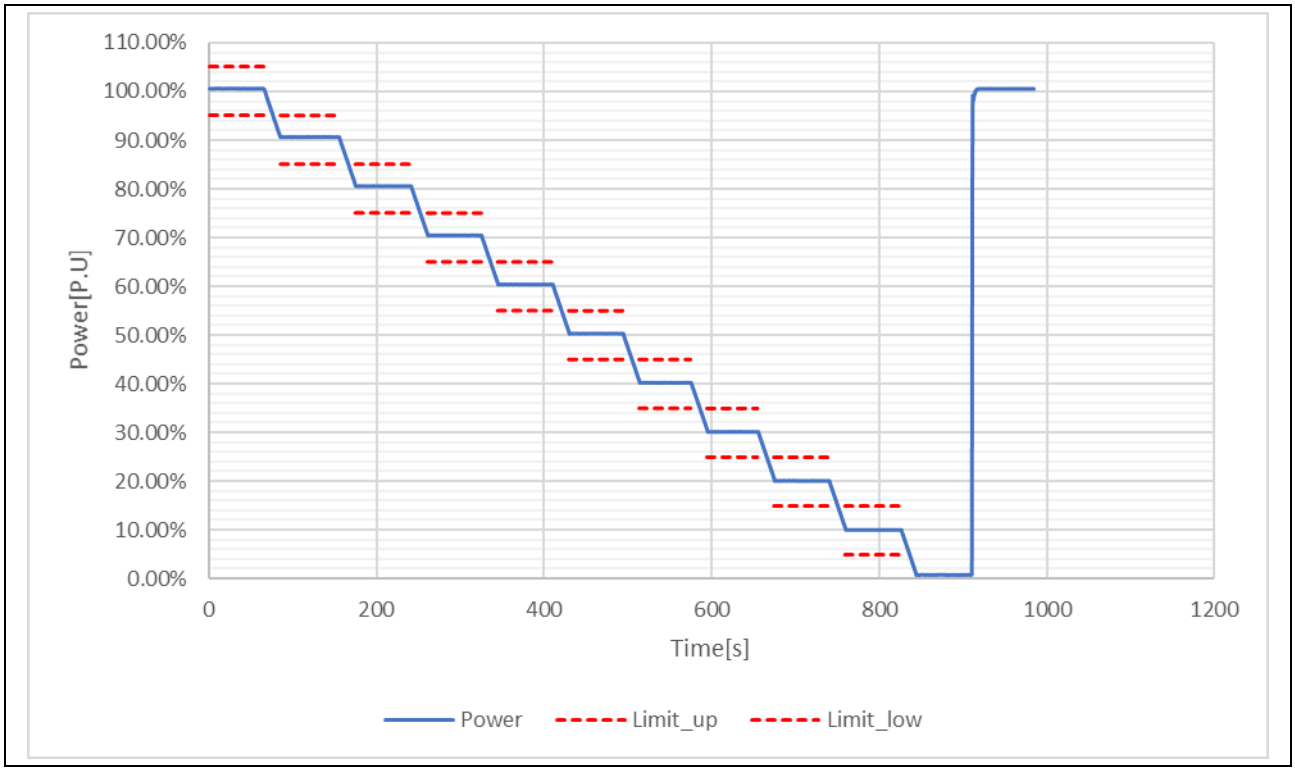


Graph_253V



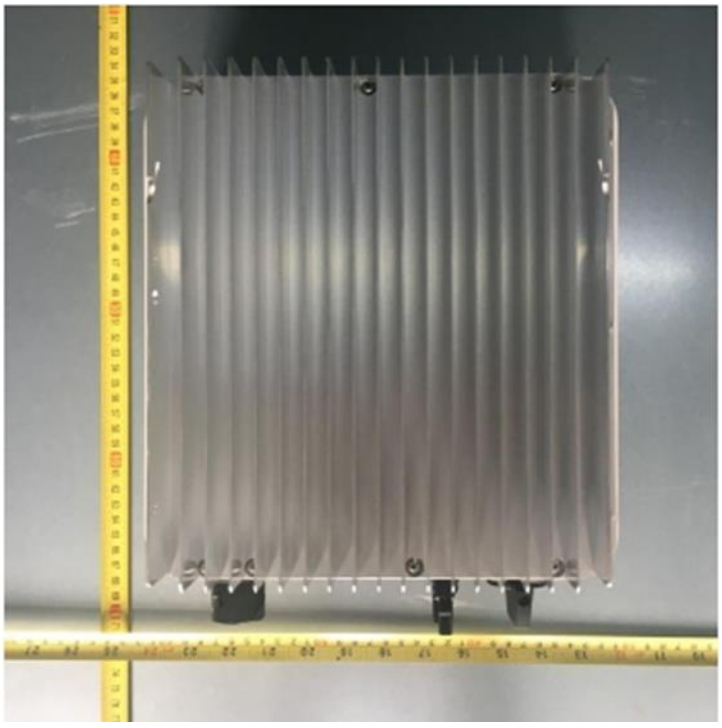
D.9	Table: Ceasing and reduction of active power on set point (Logic interface)					P
String	1	U_{DC} =	375.0 Vdc	Uac = Un	230 Vac	P_{Emax} (KW)	3.3

1 min mean value P/Pn Psetpoint (%)	Pmeasured (%)	ΔPmeasured (%)	Limit [%]
100%	100.59	0.59	±5%
90%	90.65	0.65	±5%
80%	80.58	0.58	±5%
70%	70.49	0.49	±5%
60%	60.42	0.42	±5%
50%	50.33	0.33	±5%
40%	40.26	0.26	±5%
30%	30.19	0.19	±5%
20%	20.14	0.14	±5%
10%	10.08	0.08	±5%
The power gradient for increasing and reducing (%P_n/s)			0.501%Pn /s
Time for Logic interface (at input port) activated			0.498s



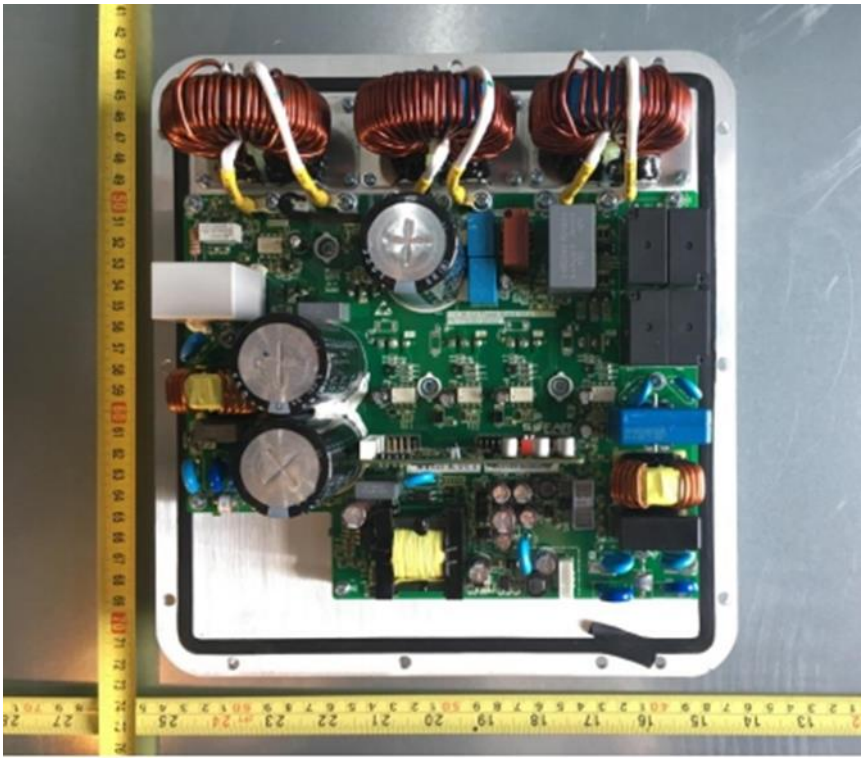
Annex 1: Photo document

Overview



Bottom view

Connection view



Internal view

(End of Report)