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

Report Reference No……:	200827076GZU-001
Date of issue……:	03 Sep 2020
Total number of pages. ……:	79 pages

Testing Laboratory	Intertek Testing Services Shenzhen Ltd. Guangzhou Branch
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Testing location/ address	Same as above
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

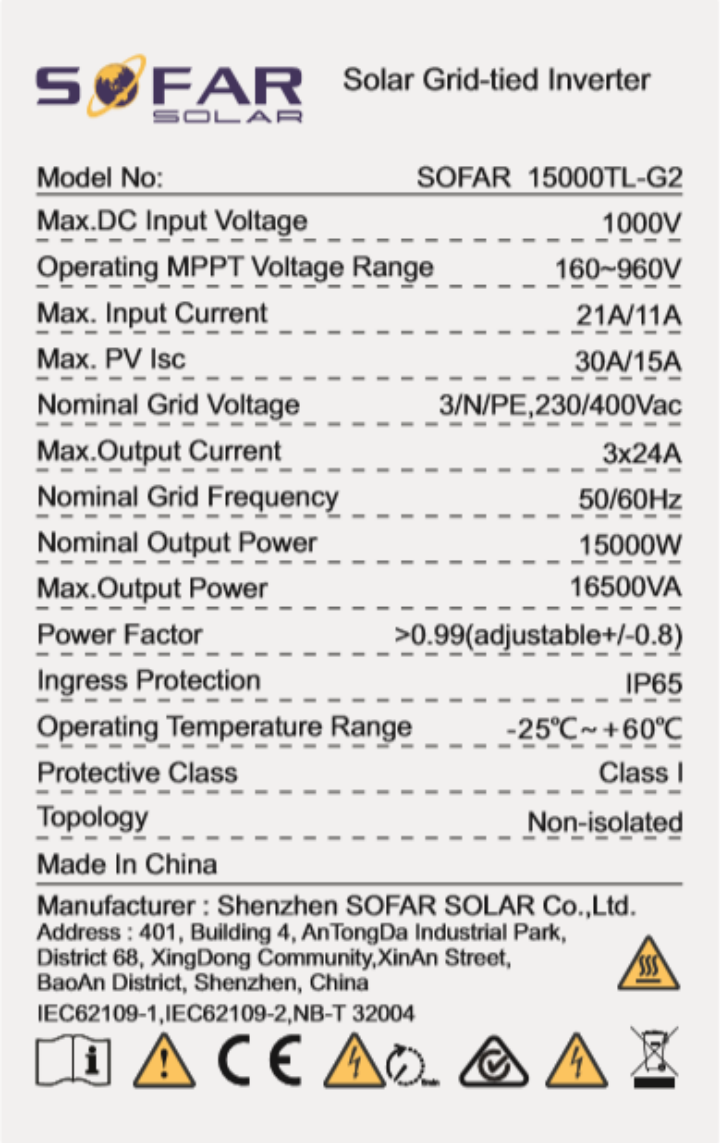
Test item description	Solar Grid-tied Inverter
Trade Mark.....	SOFAR SOLAR
Manufacturer	Same as Applicant
Model/Type reference	SOFAR 10000TL-G2, SOFAR 12000TL-G2, SOFAR 15000TL-G2

Ratings.....	Model	SOFAR 10000TL-G2	SOFAR 12000TL-G2	SOFAR 15000TL-G2
	Max.PV voltage	1000 d.c.V		
	PV MPPT voltage range	160-960 d.c.V		
	Max.input current	21 /11 d.c.A		
	PV Isc	30/15 d.c.A		
	Max.output power	10000W	12000W	15000W
	Max.apparent power	11000VA	13200VA	16500VA
	Nominal output voltage	3/N/PE, 230 /400 a.cV		
	Max.output current	3×16.5 a.c.A	3×20.0 a.c.A	3×24.0 a.c.A
	Nominal output Frequency	50 Hz		
	Power factor range	0.8Leading – 0.8 lagging		
	Inverter technology	Non-isolated		
	Safety level	Class I		
	Ingress Protection	IP 65		
	Operation Ambient Temperature	-25℃ - +60℃		
	Software Version	V1.20		

Summary of testing:

Tests performed (name of test and test clause):	**Testing location:**
All applicable tests Remark: For all clauses, the model SOFAR 15000TL-G2 is type tested.	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 .....:	IP65	
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 – 01 Sep 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 report No. 190411094GZU-001, dated 03 Jan 2020 and perform additional tests as required by C10/11: ed.2.1, 01 Sep 2019.

General product information:

The unit is a three-phases non-isolated PV Grid-tied 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 provide basic insulation from PV side to Grid.

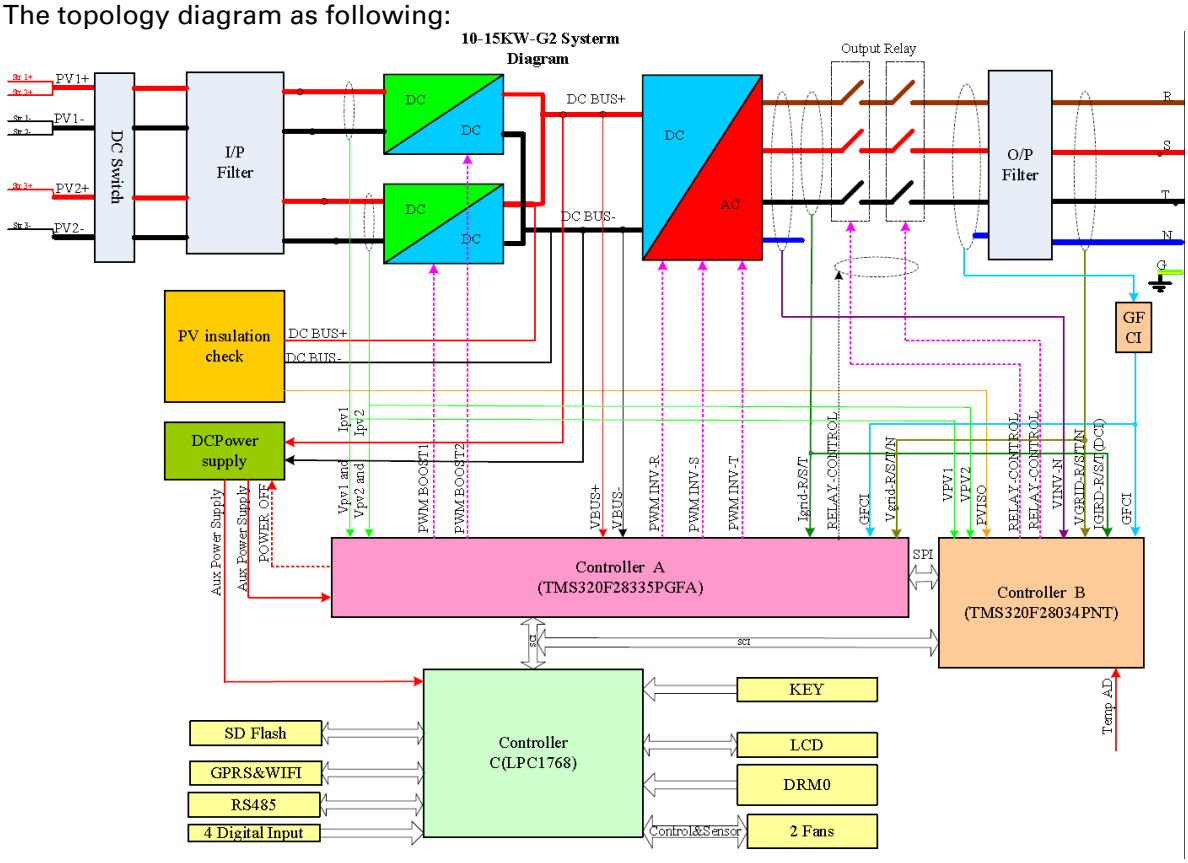
The unit has two controllers. The master controller A monitor the invert statue; measure the PV voltage and current, bus voltage, AC voltage, current, GFCI and frequency, also communicate with the slave controller B

The slave controller B monitor AC voltage, current, frequency, 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:

The model SOFAR 10000TL-G2, SOFAR 12000TL-G2 and SOFAR 15000TL-G2 are completely identical, except output power derating in software.

The only differences on hardware between the models SOFAR 10000TL-G2, SOFAR 12000TL-G2 and SOFAR 15000TL-G2 are below:

1.The main output inductor is NPS226060*2+NPF226060*2, 2.0Φ*2P /37Ts L=756μH for model SOFAR 15000TL-G2 while it's NPS226060*2+NPF226060*1, 2.0Φ*2P*42Ts L=0.73mH for model SOFAR 10000TL-G2, SOFAR 12000TL-G2

Factory information:

Dongguan SOFAR SOLAR Co., Ltd.

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

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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

C10/11: ed.2.1, 01 Sep 2019			
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

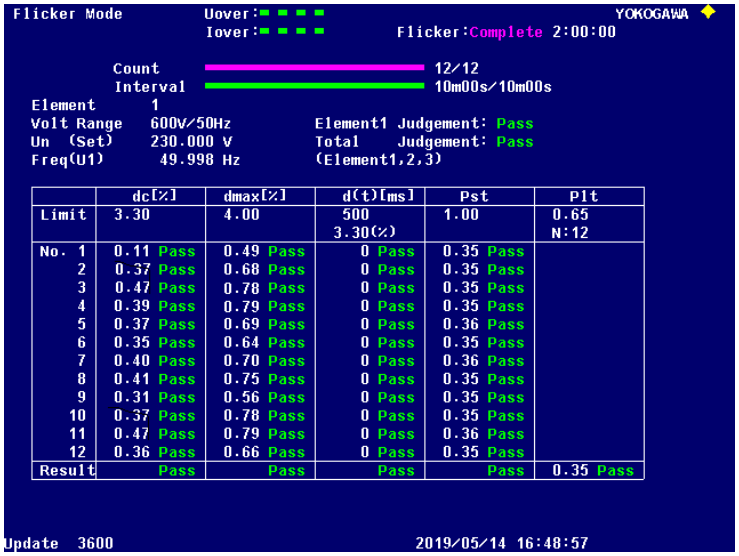
8.2.3	TABLE: Flicker	P

Flicker measurement

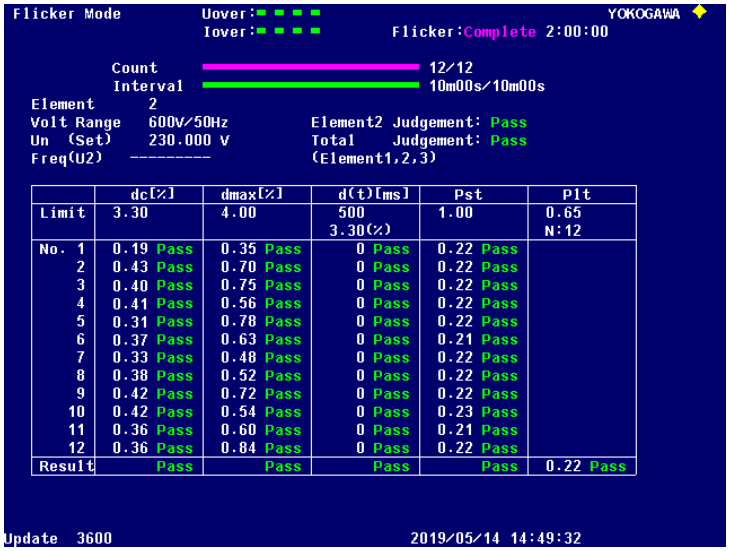
According to EN 61000-3-3/EN 61000-3-11

Model: SOFAR 15000TL-G2

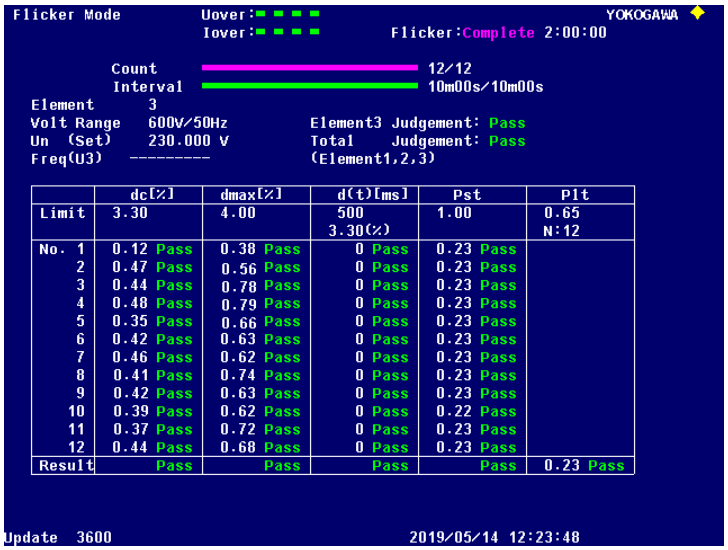
Value	P_{st}	P_{lt}	d_c	d_{max}
Limit	≤ 1	≤ 0.65	≤ 3.30%	4%
L1	0.36	0.35	0.47	0.79
L2	0.23	0.22	0.42	0.84
L3	0.23	0.23	0.48	0.79



L1 Phase



L2 phase



	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.12 Pass	0.38 Pass	0 Pass	0.23 Pass	
2	0.47 Pass	0.56 Pass	0 Pass	0.23 Pass	
3	0.44 Pass	0.78 Pass	0 Pass	0.23 Pass	
4	0.48 Pass	0.79 Pass	0 Pass	0.23 Pass	
5	0.35 Pass	0.66 Pass	0 Pass	0.23 Pass	
6	0.42 Pass	0.63 Pass	0 Pass	0.23 Pass	
7	0.46 Pass	0.62 Pass	0 Pass	0.23 Pass	
8	0.41 Pass	0.74 Pass	0 Pass	0.23 Pass	
9	0.42 Pass	0.63 Pass	0 Pass	0.23 Pass	
10	0.39 Pass	0.62 Pass	0 Pass	0.22 Pass	
11	0.37 Pass	0.72 Pass	0 Pass	0.23 Pass	
12	0.44 Pass	0.68 Pass	0 Pass	0.23 Pass	
Result	Pass	Pass	Pass	Pass	0.23 Pass

L3 phase

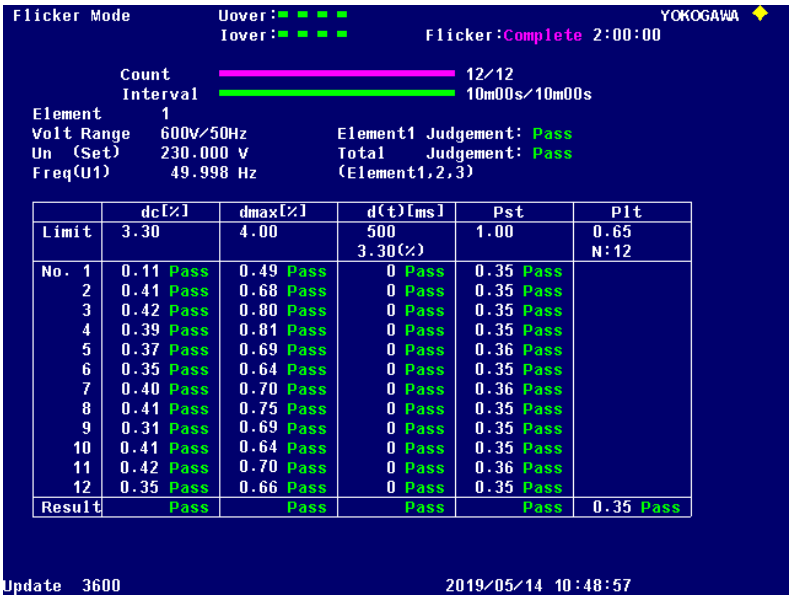
4.8	TABLE: Flicker	P

Flicker measurement

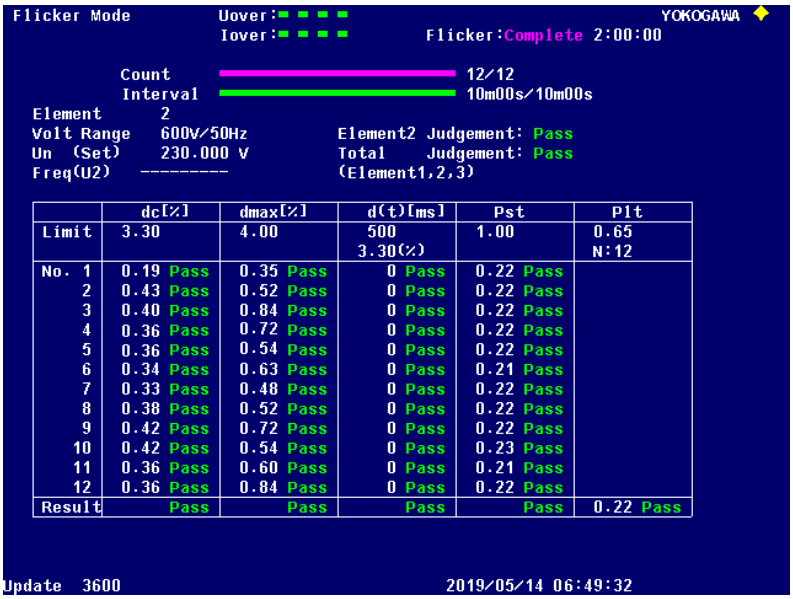
According to EN 61000-3-3/EN 61000-3-11

Model: SOFAR 10000TL-G2

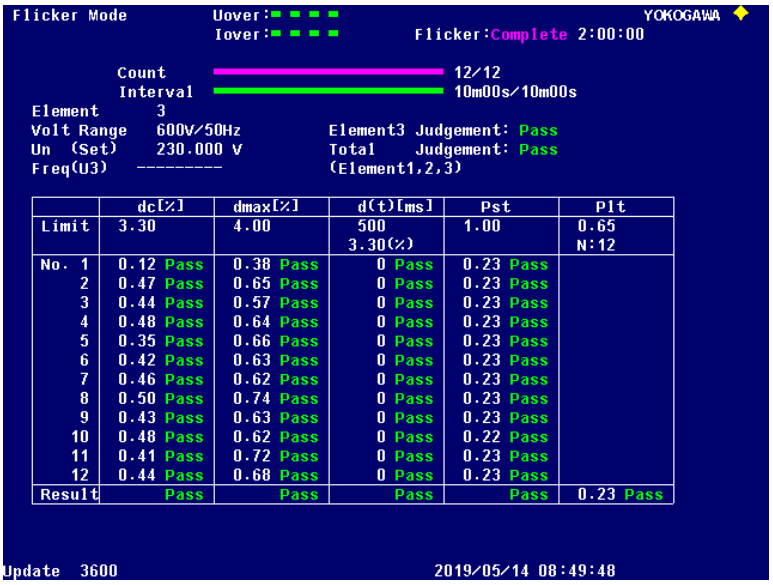
Value	P_{st}	P_{lt}	d_c	d_{max}
Limit	≤ 1	≤ 0.65	≤ 3.30%	4%
L1	0.36	0.35	0.42	0.81
L2	0.23	0.22	0.43	0.84
L3	0.23	0.23	0.50	0.74



L1 phase



L2 phase



	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.12 Pass	0.38 Pass	0 Pass	0.23 Pass	
2	0.47 Pass	0.65 Pass	0 Pass	0.23 Pass	
3	0.44 Pass	0.57 Pass	0 Pass	0.23 Pass	
4	0.48 Pass	0.64 Pass	0 Pass	0.23 Pass	
5	0.35 Pass	0.66 Pass	0 Pass	0.23 Pass	
6	0.42 Pass	0.63 Pass	0 Pass	0.23 Pass	
7	0.46 Pass	0.62 Pass	0 Pass	0.23 Pass	
8	0.50 Pass	0.74 Pass	0 Pass	0.23 Pass	
9	0.43 Pass	0.63 Pass	0 Pass	0.23 Pass	
10	0.48 Pass	0.62 Pass	0 Pass	0.22 Pass	
11	0.41 Pass	0.72 Pass	0 Pass	0.23 Pass	
12	0.44 Pass	0.68 Pass	0 Pass	0.23 Pass	
Result	Pass	Pass	Pass	Pass	0.23 Pass

L3 phase

8.2.4	TABLE: Current harmonics emission test			P
Current harmonics emission test for class A limit (According to EN 61000-3-12)				
Model: SOFAR 15000TL-G2				
100% rating power condition:				
Nr./Order	Ih(%)			LIMIT (%)
	R	S	T	
2	0.0728	0.0404	0.0583	8.00
3	0.0648	0.0556	0.0473	21.60
4	0.0483	0.0190	0.0340	4.00
5	0.2363	0.1533	0.2318	10.70
6	0.0281	0.0168	0.0236	2.67
7	0.2237	0.2481	0.1550	7.20
8	0.0215	0.0136	0.0135	2.00
9	0.0468	0.0180	0.0520	3.80
10	0.0298	0.0299	0.0110	1.60
11	0.1244	0.1191	0.0805	3.10
12	0.0318	0.0314	0.0186	1.33
13	0.0988	0.0858	0.1011	2.00
THD	0.4954	0.4935	0.4734	23
PWHD	1.5297	1.7251	1.6732	23

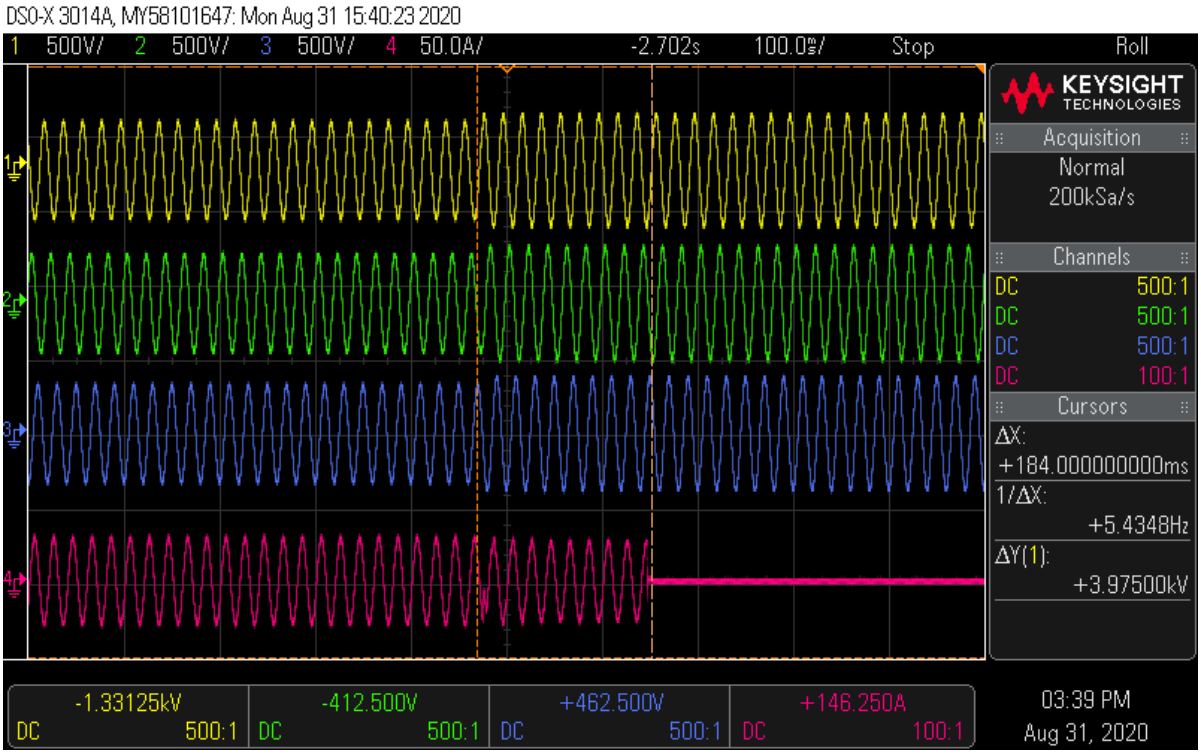
8.2.4	TABLE: Harmonics Model: SOFAR 10000TL-G2(According to EN 61000-3-2)	P

100% rating power condition:

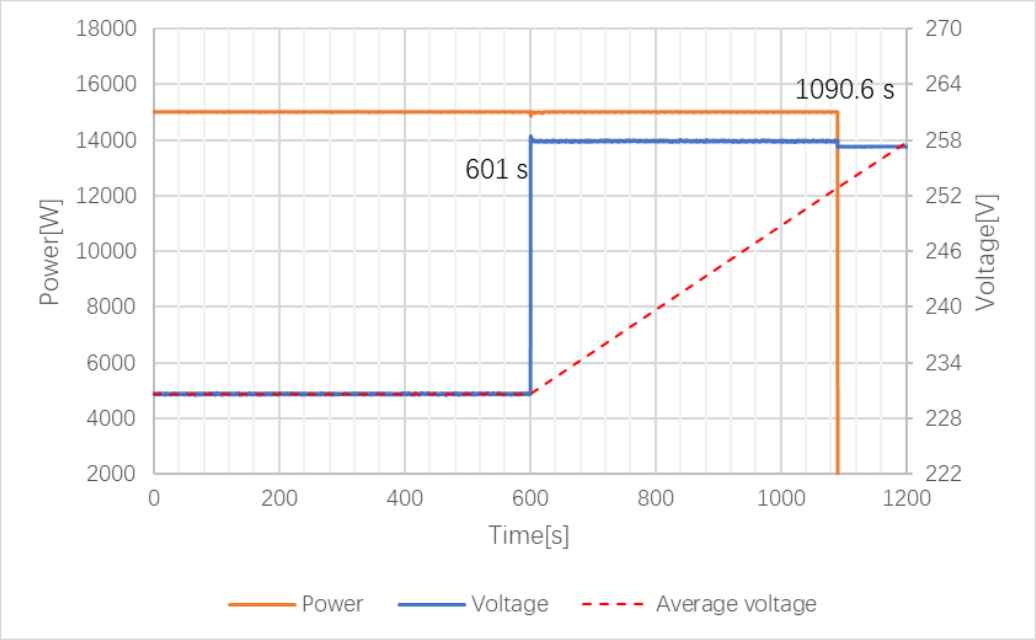
Pbin(%)	L1 Phase (A)	L2 Phase (A)	L3 Phase (A)	LIMIT (A)
Nr./Order	Ih(A)	Ih(A)	Ih(A)	
2	0.0038	0.0111	0.0068	1.080
3	0.0110	0.0103	0.0075	2.300
4	0.0024	0.0035	0.0027	0.430
5	0.0161	0.0227	0.0345	1.140
6	0.0015	0.0016	0.0016	0.300
7	0.0043	0.0160	0.0120	0.770
8	0.0020	0.0015	0.0013	0.230
9	0.0094	0.0054	0.0053	0.400
10	0.0015	0.0015	0.0014	0.184
11	0.0091	0.0031	0.0067	0.330
12	0.0028	0.0020	0.0027	0.153
13	0.0070	0.0023	0.0083	0.210
14	0.0016	0.0014	0.0017	0.131
15	0.0043	0.0015	0.0038	0.150
16	0.0016	0.0009	0.0013	0.115
17	0.0106	0.0194	0.0160	0.132
18	0.0015	0.0015	0.0016	0.102
19	0.0136	0.0150	0.0192	0.118
20	0.0012	0.0010	0.0011	0.092
21	0.0051	0.0040	0.0028	0.107
22	0.0016	0.0012	0.0015	0.084
23	0.0140	0.0184	0.0196	0.098
24	0.0015	0.0015	0.0019	0.077
25	0.0139	0.0173	0.0172	0.090
26	0.0013	0.0009	0.0013	0.071
27	0.0042	0.0020	0.0037	0.083
28	0.0020	0.0010	0.0014	0.066
29	0.0164	0.0175	0.0185	0.078
30	0.0013	0.0013	0.0021	0.061
31	0.0146	0.0158	0.0149	0.073
32	0.0010	0.0011	0.0011	0.058
33	0.0044	0.0015	0.0032	0.068
34	0.0025	0.0012	0.0016	0.054
35	0.0143	0.0138	0.0144	0.064
36	0.0014	0.0015	0.0025	0.051
37	0.0135	0.0124	0.0127	0.061
38	0.0033	0.0017	0.0031	0.048
39	0.0029	0.0017	0.0031	0.058
40	0.0034	0.0018	0.0021	0.046

D.3	Table: Overvoltage threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value L1 [V]	264.5	264.29	264.13	264.19	264.5±2.3
Trip time [ms]	100	182.0	172.0	176.0	<200
Trip value L2[V]	264.5	264.21	264.13	264.43	264.5±2.3
Trip time [ms]	100	172.0	164.0	182.0	<200
Trip value L3[V]	264.5	264.38	264.18	264.34	264.5±2.3
Trip time [ms]	100	180.0	180.0	181.0	<200
Trip value L1L2L3 [V]	264.5	264.59	264.16	264.18	264.5±2.3
Trip time [ms]	100	180.0	184.0	178.0	<200

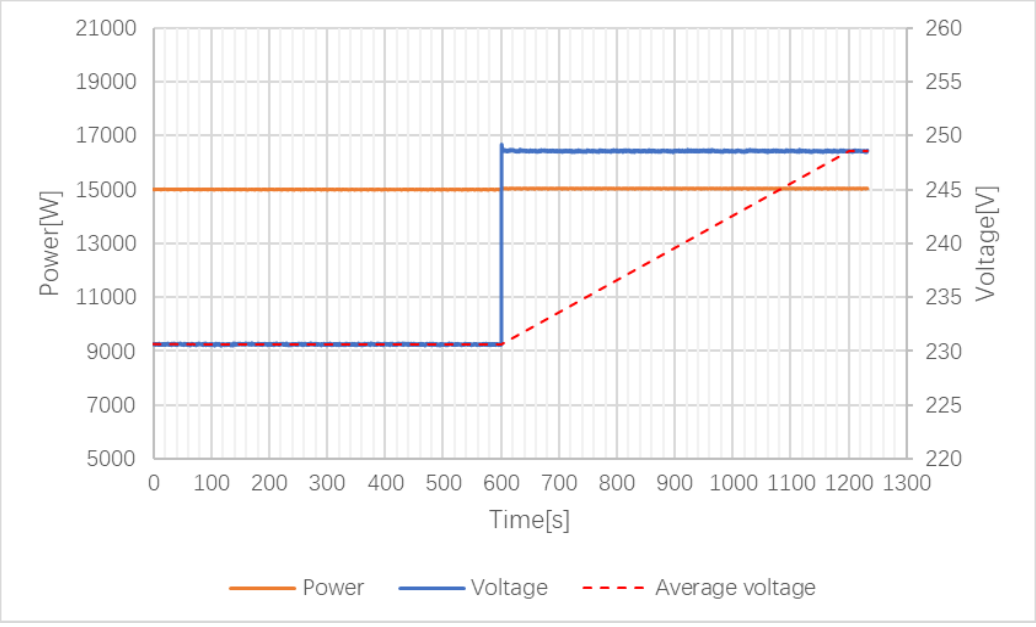
Trip time



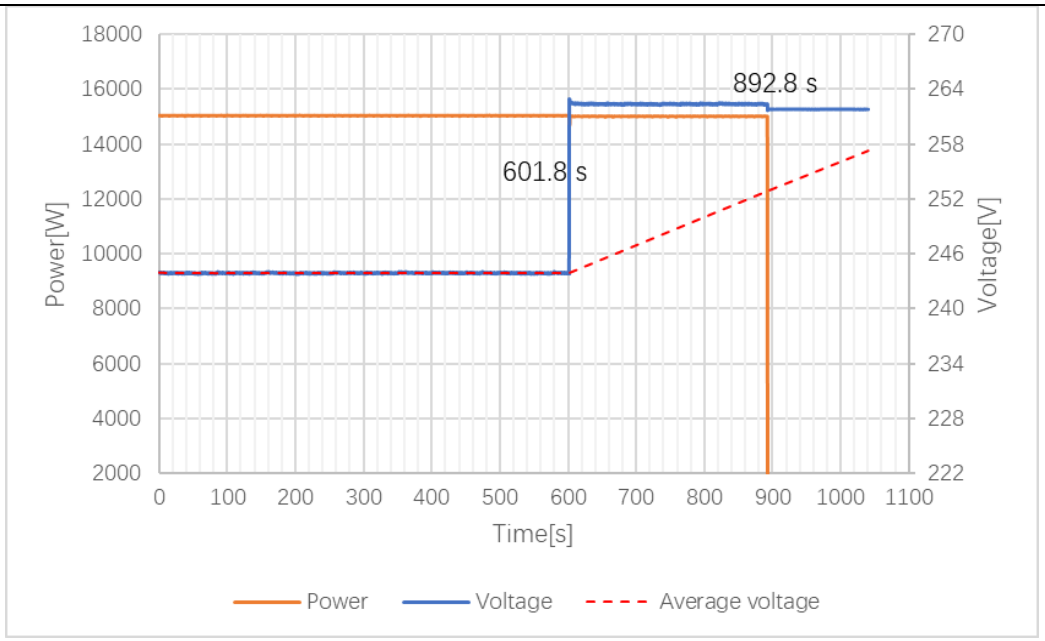
D.3	Protective functions (Results of the Protection of the Increase in Voltage as 10-min moving average)		
	Output Voltage (V)	Switch	
		On/Off state Finally	Time until Switch off (s)
100% Un	230.0	☒On □Off	Work normally
112% Un	257.6	□On ☒Off	489.6
100% Un	230.0	☒On □Off	Work normally
108% Un	248.4	☒On □Off	Work normally
106% Un	243.8	☒On □Off	Work normally
114% Un	262.2	□On ☒Off	291.0



Un to 1.12Un



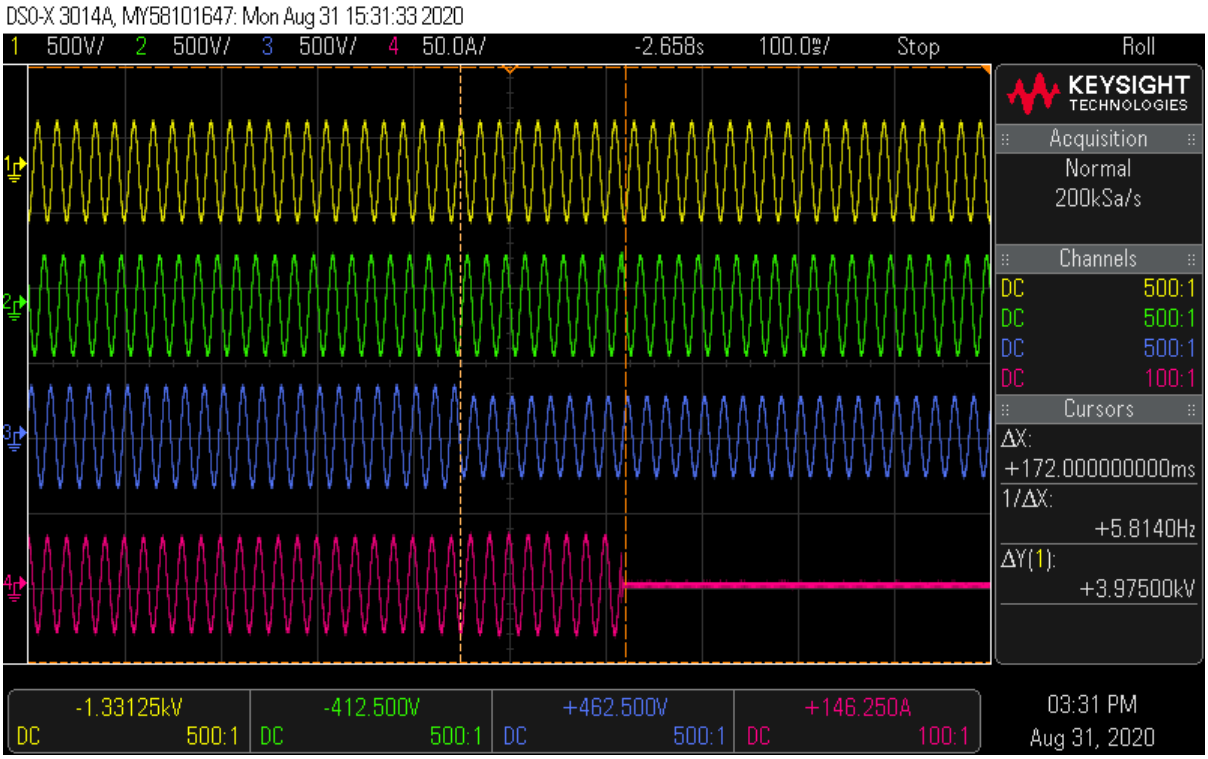
Un to 1.08Un



1.06 Un to 1.14Un

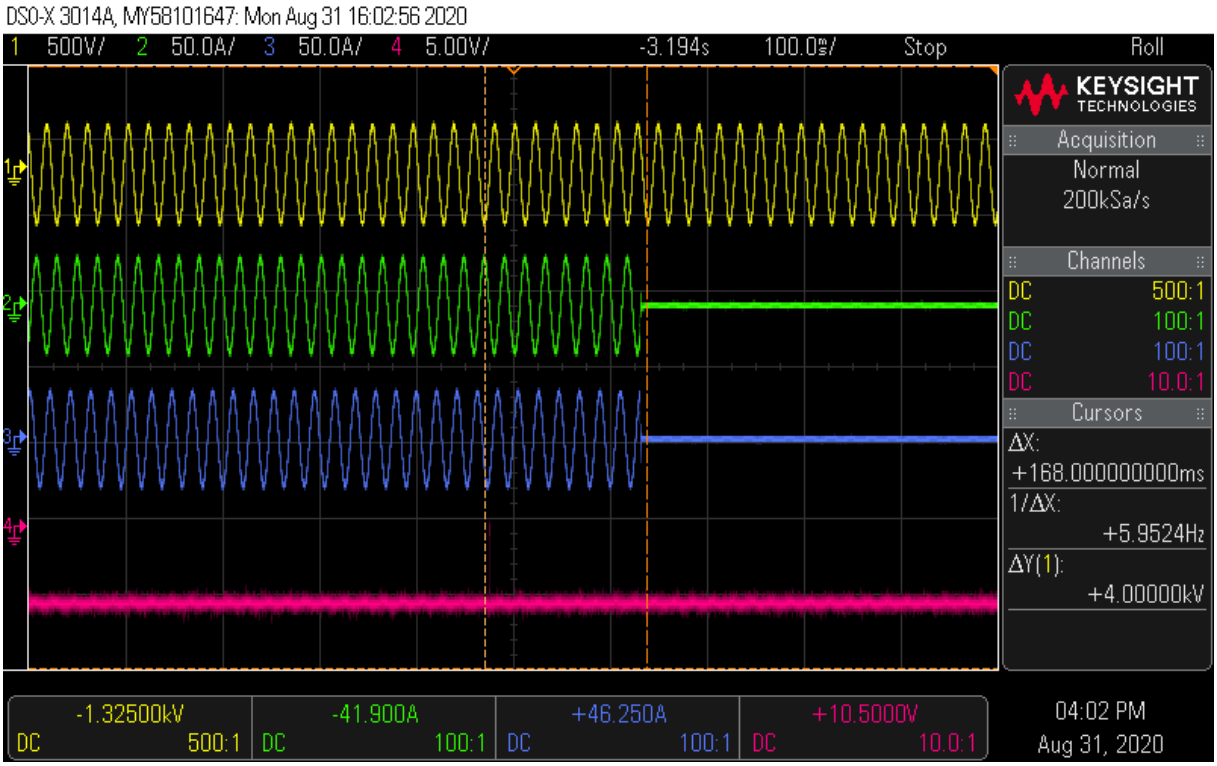
D.3	Table: Undervoltage threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value L1 [V]	184	183.73	184.16	184.18	184±2.3
Trip time [ms]	100	164	160	170	<200
Trip value L2[V]	184	184.15	184.07	184.96	184±2.3
Trip time [ms]	100	168	166	164	<200
Trip value L3[V]	184	183.83	184.04	183.99	184±2.3
Trip time [ms]	100	172	160	158	<200
Trip value L1L2L3 [V]	184	184.55	184.27	184.36	184±2.3
Trip time [ms]	100	168	164	166	<200

Trip time



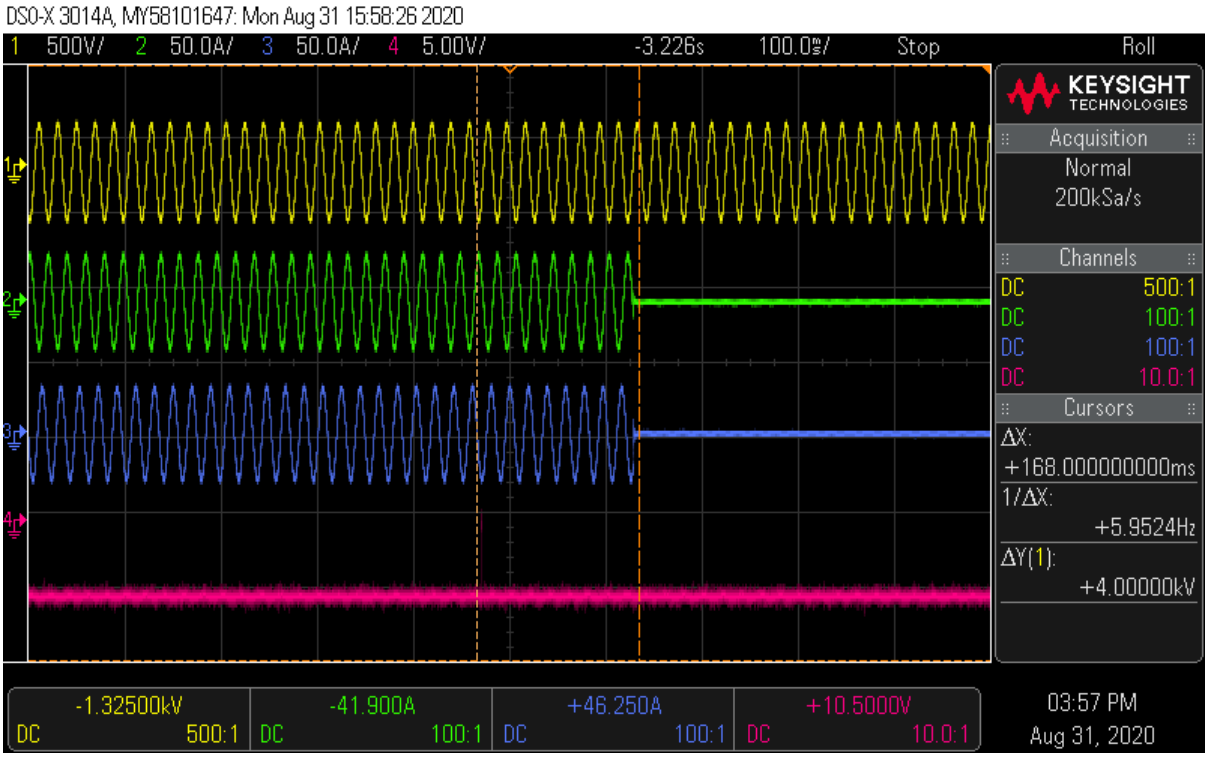
D.3	Table: Underfrequency threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [Hz]	47.5	47.50	47.51	47.52	47.5±0.05
Trip time [ms]	100	162.0	166.0	168.0	<200

Trip time



D.3	Table: Overfrequency threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [Hz]	51.5	51.50	51.50	51.50	51.5±0.05
Trip time [ms]	100	166.0	168.0	160.0	<200

Trip time

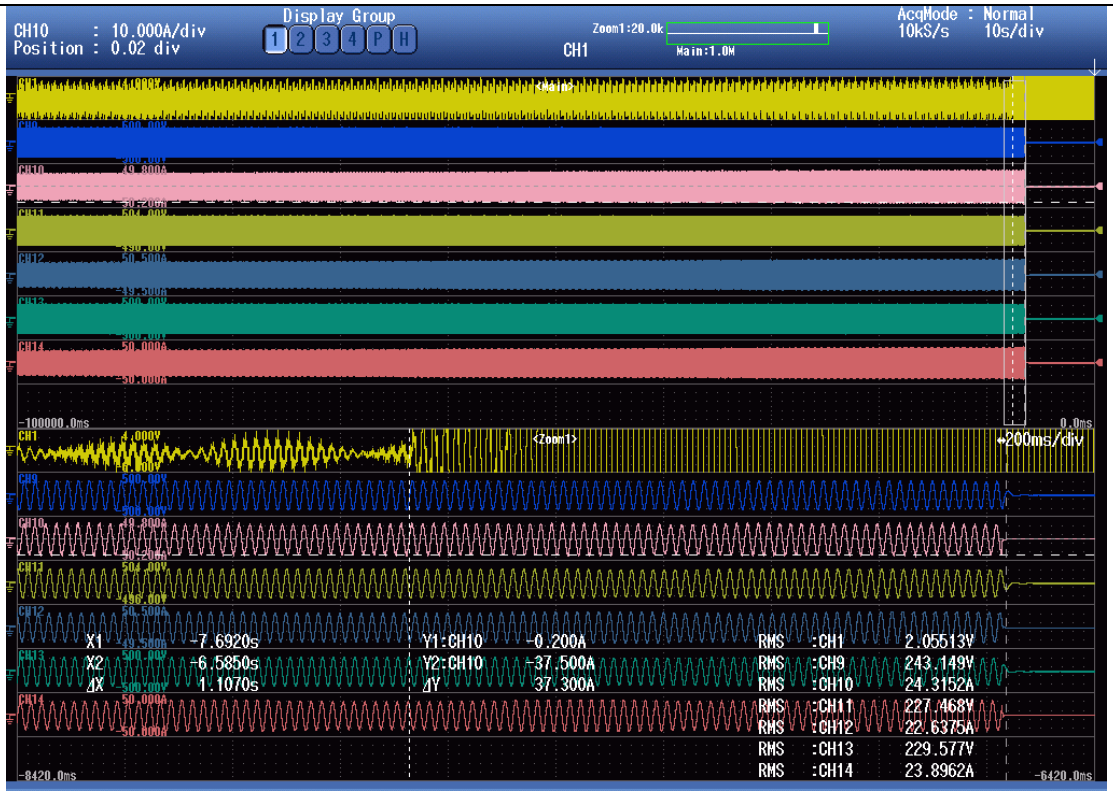


D.3	Table: Islanding	P

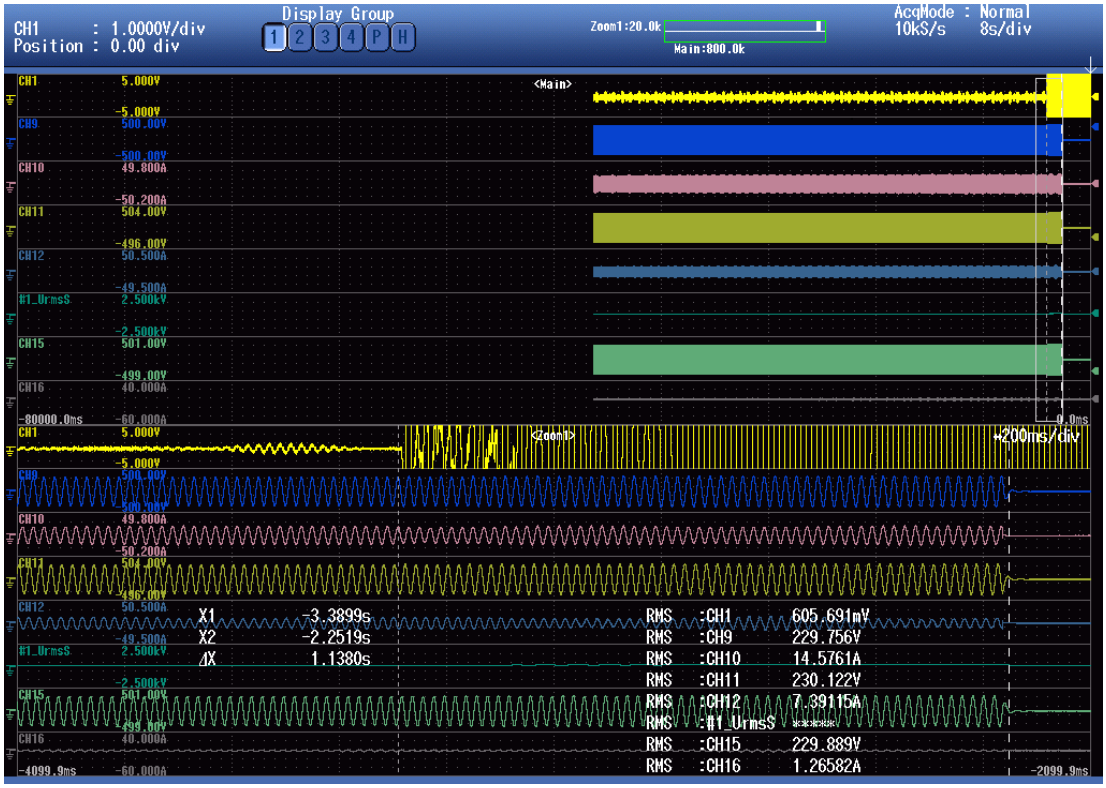
No.	PEUT[1] (% of EUT rating)	Reactive load (% of QL in 6.1.d)1)	PAC[2] (% of nominal)	QAC[3] (% of nominal)	Run on time (ms)	PEUT (KW)	Actual Qf	VDC	Remarks[4]
1	100	100	0	0	1107	14.5	1.00	850	Test A at BL
2	66	66	0	0	1042	9.9	1.00	560	Test B at BL
3	33	33	0	0	1016	4.5	1.00	230	Test C at BL
4	100	100	-5	-5	418	14.5	0.97	850	Test A at IB
5	100	100	-5	0	992	14.5	0.95	850	Test A at IB
6	100	100	-5	5	576	14.5	0.93	850	Test A at IB
7	100	100	0	-5	1051	14.5	1.03	850	Test A at IB
8	100	100	0	5	266	14.5	0.96	850	Test A at IB
9	100	100	5	-5	752	14.5	1.08	850	Test A at IB
10	100	100	5	0	1073	14.5	1.06	850	Test A at IB
11	100	100	5	5	212	14.5	1.03	850	Test A at IB
12	66	66	0	-5	600	9.9	1.04	560	Test B at IB
13	66	66	0	-4	971	9.9	1.04	560	Test B at IB
14	66	66	0	-3	1051	9.9	1.03	560	Test B at IB
15	66	66	0	-2	1012	9.9	1.03	560	Test B at IB
16	66	66	0	-1	1028	9.9	1.01	560	Test B at IB
17	66	66	0	1	1037	9.9	0.99	560	Test B at IB
18	66	66	0	2	971	9.9	0.99	560	Test B at IB
19	66	66	0	3	1138	9.9	0.98	560	Test B at IB
20	66	66	0	4	1026	9.9	0.98	560	Test B at IB
21	66	66	0	5	948	9.9	0.98	560	Test B at IB
22	33	33	0	-5	533	4.5	1.02	230	Test C at IB
23	33	33	0	-4	589	4.5	1.02	230	Test C at IB
24	33	33	0	-3	948	4.5	1.01	230	Test C at IB
25	33	33	0	-2	515	4.5	1.01	230	Test C at IB
26	33	33	0	-1	825	4.5	1.00	230	Test C at IB
27	33	33	0	1	808	4.5	0.98	230	Test C at IB
28	33	33	0	2	633	4.5	0.98	230	Test C at IB
29	33	33	0	3	545	4.5	0.98	230	Test C at IB
30	33	33	0	4	967	4.5	0.98	230	Test C at IB
31	33	33	0	5	839	4.5	0.97	230	Test C at IB

Remark:

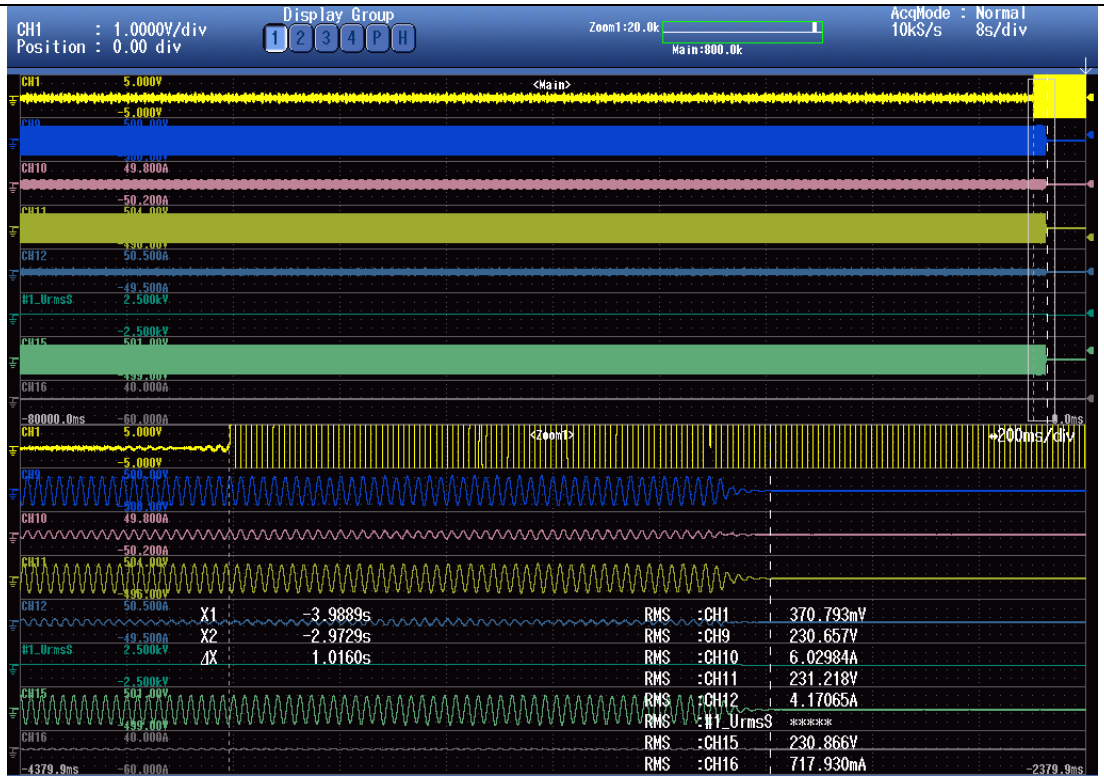
1) PEUT: EUT output power
2) PAC: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0% test condition value.
3) QAC: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0% test condition value.
4) BL: Balance condition, 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%, = 1107.0ms



P_{EUT} 66%, P_{AC} 0%, Q_{AC} 3%, = 1138ms



P_{EUT} 33%, P_{AC} 0%, Q_{AC} 0%, = 1016ms

Note: CH10, CH12,CH16 denotes current of EUT; CH1 denotes current of signal (the signal from Grid), CH9,CH11,CH15 denotes Voltage of EUT

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.	CY3	s-c	850	1min	--	--	PCE Shutdown, Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18 damaged. No hazard.
2.	EC2	s-c	850	1min	--	--	PCE Shutdown, C43, C44 damaged. No hazard.
3.	R131	s-c	850	1min	--	--	LCD displays 'ID27' for three times and then displays 'ID69'. Recoverable. No hazard, no damaged.
4.	R132	s-c	850	1min	--	--	LCD displays 'ID27' for three times and then displays 'ID69'. Recoverable. No hazard, no damaged.
5.	R150	s-c	850	1min	--	--	LCD displays 'ID27' for three times and then displays 'ID69'. Recoverable. No hazard, no damaged.
6.	R151	s-c	850	1min	--	--	LCD displays 'ID27' for three times and then displays 'ID69'. Recoverable. No hazard, no damaged.
7.	C3	s-c	850	1min	--	--	LCD displays 'ID02'. Recoverable. No hazard, no damaged.
8.	R21	s-c	850	1min	--	--	Work as normal.
9.	R20	o-c	850	1min	--	--	Work as normal.
10.	R27	s-c	850	1min	--	--	LCD displays 'ID24' for three times and then displays 'ID67'. Recoverable. No hazard, no damaged.
11.	R26	o-c	850	1min	--	--	LCD displays 'ID02'. Recoverable. No hazard, no damaged.
12.	R33	s-c	850	1min	--	--	LCD displays 'ID24' for three times and then displays 'ID67'. Recoverable. No hazard, no damaged.

13.	R32	o-c	850	1min	--	--	LCD displays 'ID02'. Recoverable. No hazard, no damaged.
14.	R39	s-c	850	1min	--	--	LCD displays 'ID24' for three times and then displays 'ID67'. Recoverable. No hazard, no damaged.
15.	R38	o-c	850	1min	--	--	LCD displays 'ID02'. Recoverable. No hazard, no damaged.
16.	R45	s-c	850	1min	--	--	LCD displays 'ID27'. Recoverable. No hazard, no damaged.
17.	R44	o-c	850	1min	--	--	LCD displays 'ID27'. Recoverable. No hazard, no damaged.
18.	C112	s-c	850	1min	--	--	The monitor shutdown. Recoverable. No hazard, no damaged.
19.	CY5	s-c	850	1min	--	--	Work as normal.
20.	R246	s-c	850	1min	--	--	LCD displays 'ID27'. Recoverable. No hazard, no damaged.
21.	R271	s-c	850	1min	--	--	The EUT cannot start, LCD displays "ID56'. Recoverable. No hazard, no damaged.
23.	R268	o-c	850	1min	--	--	The EUT cannot start, LCD displays "ID56'. Recoverable. No hazard, no damaged.
24.	R283	s-c	850	1min	--	--	The EUT cannot start, LCD displays "ID56'. Recoverable. No hazard, no damaged.
25.	R282	o-c	850	1min	--	--	The EUT cannot start, LCD displays "ID56'. Recoverable. No hazard, no damaged.
26.	R88	s-c	850	10min	--	--	PCE makes noisy. No hazard, no damaged.
27.	R90	s-c	850	10min	--	--	PCE makes noisy. No hazard, no damaged.
28.	R201	s-c	850	1min	--	--	LCD displays 'ID52'. Recoverable. No hazard, no damaged.

29.	R214	s-c	850	1min	--	--	LCD displays ‘ID52’. Recoverable. No hazard, no damaged.
30.	Q25 pin1-2	s-c	850	1min	--	--	LCD displays ‘ID52’. Recoverable. No hazard, no damaged.
31.	R50	s-c	850	1min	--	--	PCE Shutdown, U1 damaged. No hazard.
32.	R47	s-c	850	1min	--	--	PCE Shutdown, no damaged. No hazard.
33.	C20	s-c	850	1min	--	--	PCE Shutdown, D1, D3 damaged. No hazard.
34.	R167	s-c	850	1min	--	--	LCD displays ‘ID24’. Recoverable. No hazard, no damaged.
35.	RL1 Pin3-4	s-c	850	1min	--	--	The EUT cannot start, LCD displays “ID55’. Recoverable. No hazard, no damaged.
36.	RL3 Pin3-4	s-c	850	1min	--	--	The EUT cannot start, LCD displays “ID55’. Recoverable. No hazard, no damaged.
37.	RL5 Pin3-4	s-c	850	1min	--	--	The EUT cannot start, LCD displays “ID55’. Recoverable. No hazard, no damaged.
38.	C394	s-c	850	1min	--	--	PCE Shutdown, LCD displays ‘ID53’. Recoverable. No hazard, no damaged.
39.	RC609	s-c	850	1min	--	--	PCE Shutdown, LCD displays ‘ID53’. Recoverable. No hazard, no damaged.
40.	RC649	o-c	850	1min	--	--	PCE Shutdown, LCD displays ‘ID53’. Recoverable. No hazard, no damaged.
41.	CC209	s-c	850	1min	--	--	PCE Shutdown, Q9 damaged. No hazard.
42.	CC224	s-c	850	1min	--	--	PCE Shutdown, Q12 damaged. No hazard.
43.	CC234	s-c	850	1min	--	--	PCE Shutdown, Q15 damaged. No hazard.

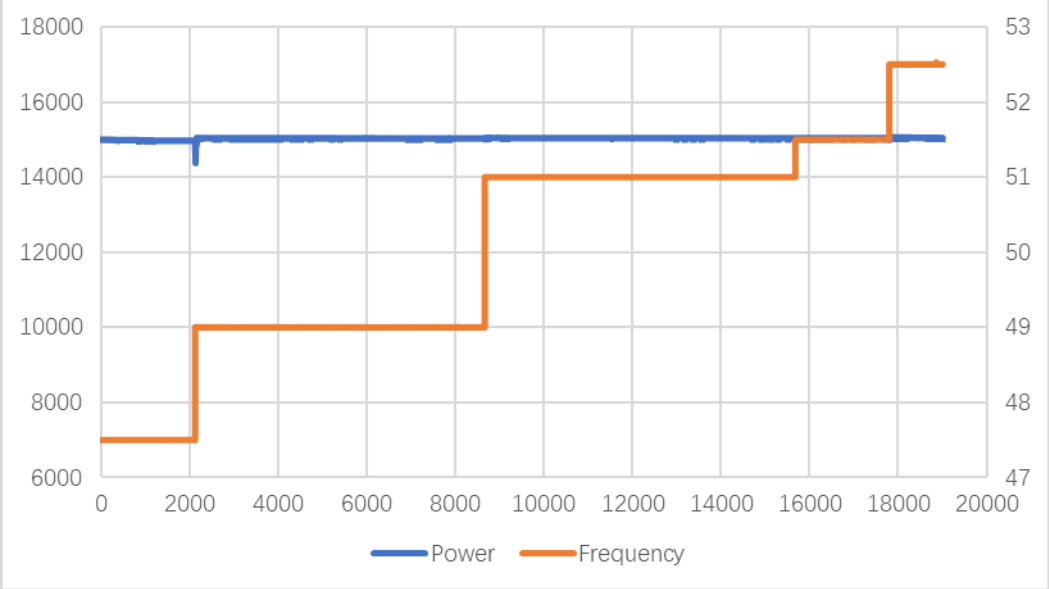
44.	CC243	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID53'. Recoverable. No hazard, no damaged.
45.	CC207	s-c	850	1min	--	--	PCE Shutdown, Q7 damaged. No hazard.
46.	C208	s-c	850	1min	--	--	PCE Shutdown, Q8 damaged. No hazard.
47.	CC222	s-c	850	1min	--	--	LCD displays 'ID55'. Recoverable. No hazard, no damaged.
48.	UC609A Pin4-5	s-c	850	1min	--	--	Work as normal.
49.	UC637 Pin12-13	s-c	850	1min	--	--	Work as normal.
50.	UC634 pin5-6	s-c	850	1min	--	--	Work as normal.
51.	CC132	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID49'. Recoverable. No hazard, no damaged.
52.	QC40 D-S	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID14'. Recoverable. No hazard, no damaged.
53.	RC459	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID59'. Recoverable. No hazard, no damaged.
54.	RL6	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID55'. Recoverable. No hazard, no damaged.
55.	RL4	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID55'. Recoverable. No hazard, no damaged.
56.	RL2	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID55'. Recoverable. No hazard, no damaged.

57.	R162	s-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID24'. Recoverable. No hazard, no damaged.
58.	R177	o-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID24'. Recoverable. No hazard, no damaged.
59.	R187	o-c	850	1min	--	--	PCE Shutdown, LCD displays 'ID24'. Recoverable. No hazard, no damaged.
supplementary information: s-c: short-circuited, o-c: open-circuited, o-l: overload.							

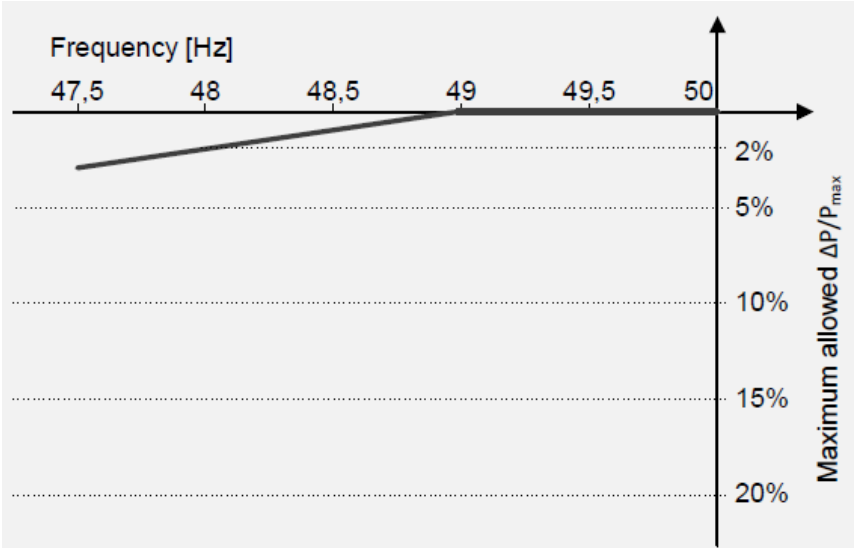
D.4.1	Table: Operating frequency range	P

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	35.43 min	Operated normally.
2	49.0 Hz	49.00	Permanent	109.01 min	Operated normally.
3	51.0 Hz	51.00	Permanent	116.92 min	Operated normally.
4	51.5 Hz	51.50	>30 min	35.34 min	Operated normally.
5	52.5 Hz	52.50	>15 min*	20.08 min	Operated normally.

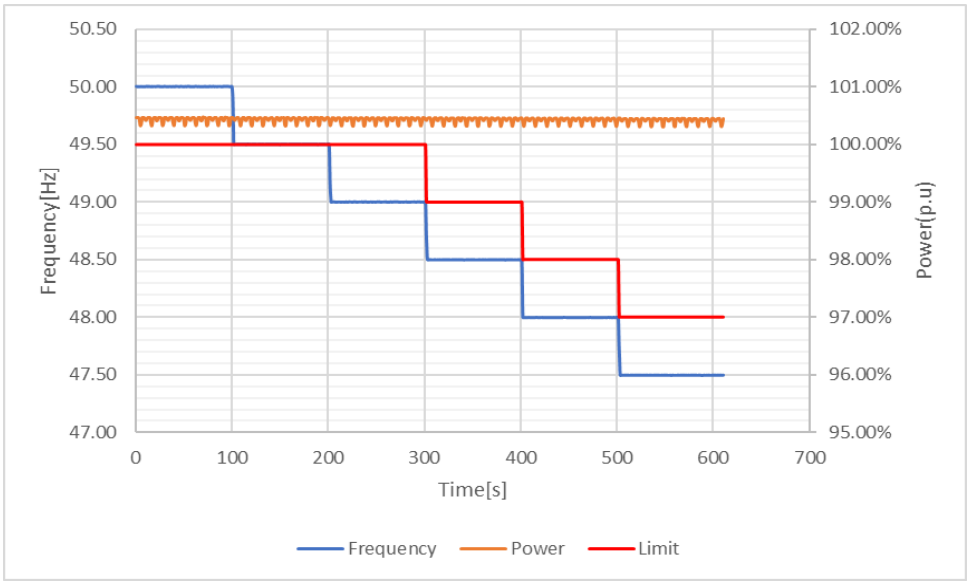


D.4.2	Table: Minimal requirements for active power delivery at underfrequency	P



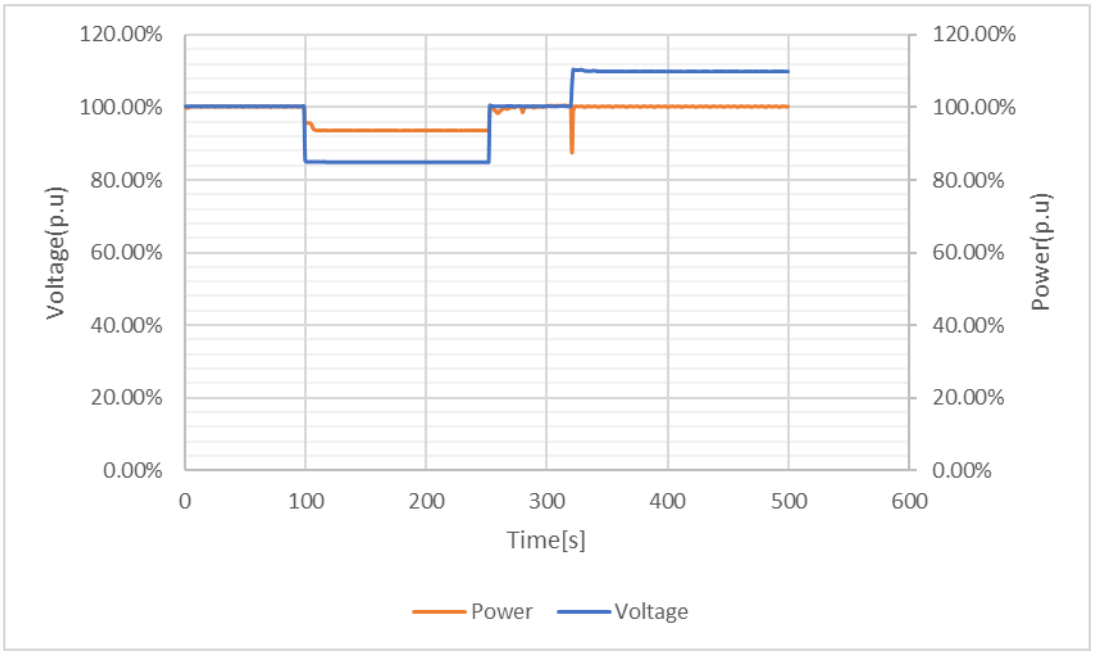
Step	f (Hz)	fmea. (Hz)	T (s)	T meas. (s)	P (%) - max	P (%) - min	P meas. (%)
1	50,00 ± 0.05	50.0	>60	100	100%	100%	100.44
2	49.50 ± 0,05	49.5	>60	100	100%	100%	100.44
3	49.00 ± 0,05	49.0	>60	100	100%	100%	100.44
4	48.50 ± 0,05	48.5	>60	100	100%	99%	100.44
5	48.00 ± 0,05	48.0	>60	100	100%	98%	100.43
6	47.50 ± 0,05	47.5	>60	100	100%	97%	100.43

Supplementary information:

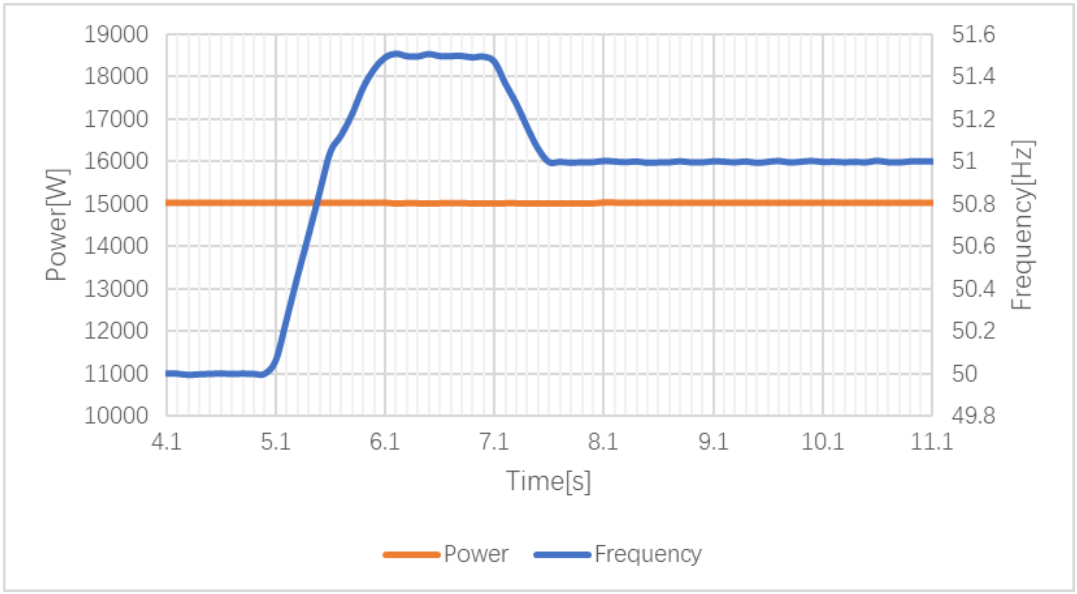


D.4.3	Table: Continuous voltage operation range				P
Step	Voltage (%)	P (%)	P meas. (%)	Time (s)	T meas (s)
1	100	100	100.24	>60	99.00
2	85	100 (*)	93.81	>120	153.00
3	100	100	100.07	>5	68.00
4	110	100	100.19	>120	180.00

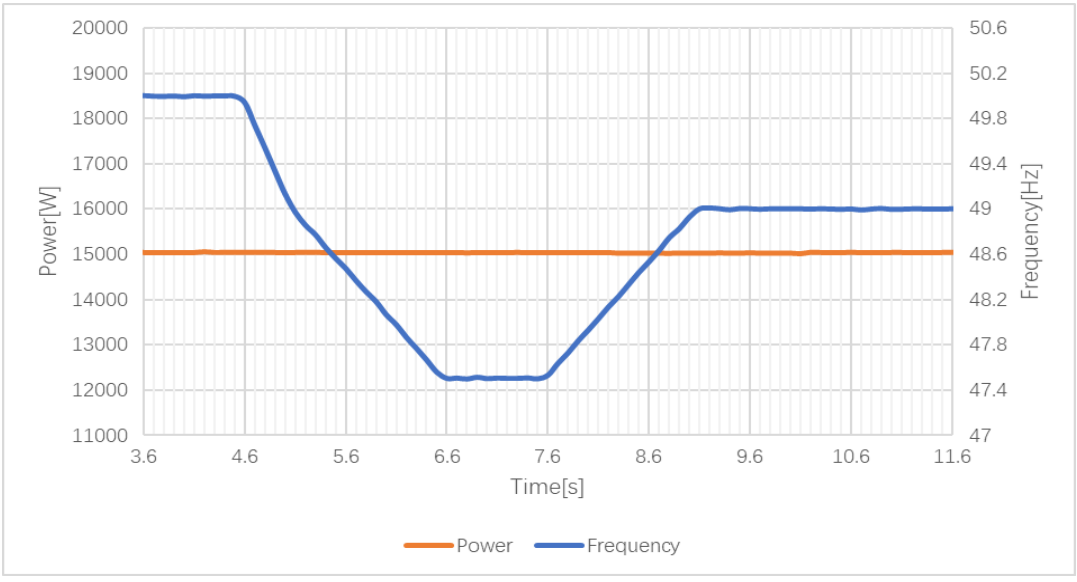
(*) Active power reduction is allowed due to current limitation.



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	15038.70	50,0 to 49.0	0.5	15038.75
2	51,0 to 51.5	0.5	15040.18	49,0 to 47.5	1.5	15039.30
3	51,5	1	15024.37	47,5	1	15037.05
4	51.5 to 51.0	0.5 s	15022.32	47.5 to 49.0	1.5	15036.60
5	51.0	3.0 s	15037.20	49.0	0.5	15026.75

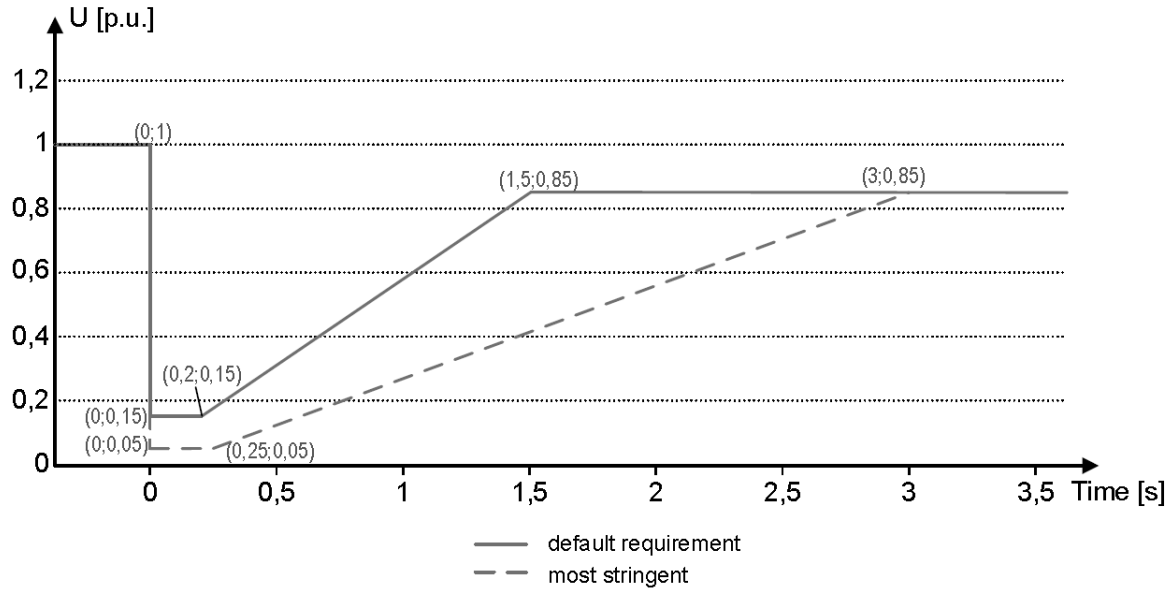


Overfrequency



Underfrequency

D.5.2	Table: UVRT	P

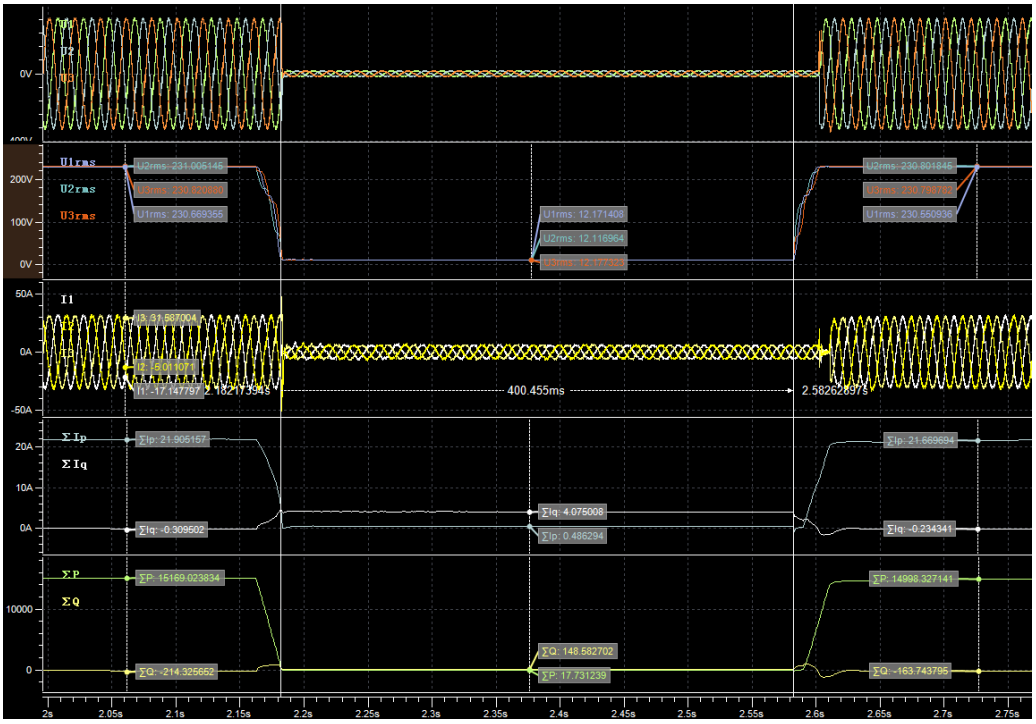


Test at full load (>90%)

Udip	Type	t min (ms)	U meas. (%)			T meas.(ms)	P recover (s)
			R	S	T		
5%	L1-N	250	5.05	100.19	100.16	410.053	0.236
	L2-N		100.17	5.02	100.20	400.77	0.235
	L3-N		100.19	100.17	4.99	401.03	0.236
	L1-L2-N		5.01	5.02	100.20	401.77	0.232
	L2-L3-N		100.20	5.03	5.01	400.65	0.232
	L1-L3-N		5.03	100.19	5.02	400.51	0.232
	L1-L2-L3-N		5.29	5.27	5.30	400.46	0.027
25%	L1-N	938	25.00	100.15	100.18	1001.00	0.233
	L2-N		100.15	25.01	100.18	1001.00	0.233
	L3-N		100.18	100.27	25.03	1001.00	0.234
	L1-L2-N		25.02	25.03	100.21	1004.00	0.233
	L2-L3-N		100.17	25.04	25.05	1002.00	0.233
	L1-L3-N		25.05	100.18	25.03	1003.00	0.236
	L1-L2-L3-N		25.22	25.24	25.23	1000.00	0.027

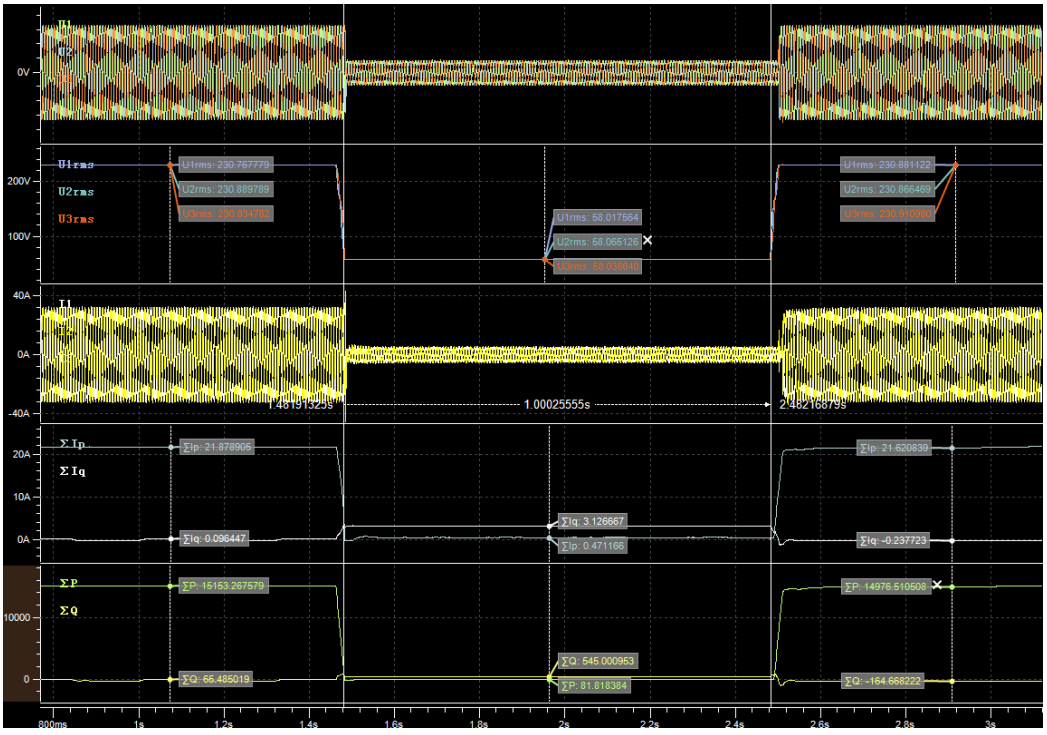
50%	L1-N	1797	50.05	100.17	100.17	1861.00	0.231
	L2-N		100.13	50.05	100.18	1860.00	0.232
	L3-N		100.17	100.16	50.08	1860.00	0.234
	L1-L2-N		50.05	50.06	100.17	1860.00	0.236
	L2-L3-N		100.19	50.06	50.08	1857.00	0.237
	L1-L3-N		50.07	100.16	50.07	1861.00	0.231
	L1-L2-L3-N		50.07	50.08	50.09	1860.00	0.234
75%	L1-N	2656	75.10	100.14	100.15	3004.00	0.234
	L2-N		100.15	75.10	100.21	3005.00	0.236
	L3-N		100.16	100.17	75.12	3001.00	0.236
	L1-L2-N		75.10	75.10	100.16	3008.00	0.234
	L2-L3-N		8.78	75.10	75.17	3010.00	0.233
	L1-L3-N		75.10	100.18	75.14	3000.00	0.233
	L1-L2-L3-N		75.10	75.10	75.13	3004.00	0.232

Graph_5%

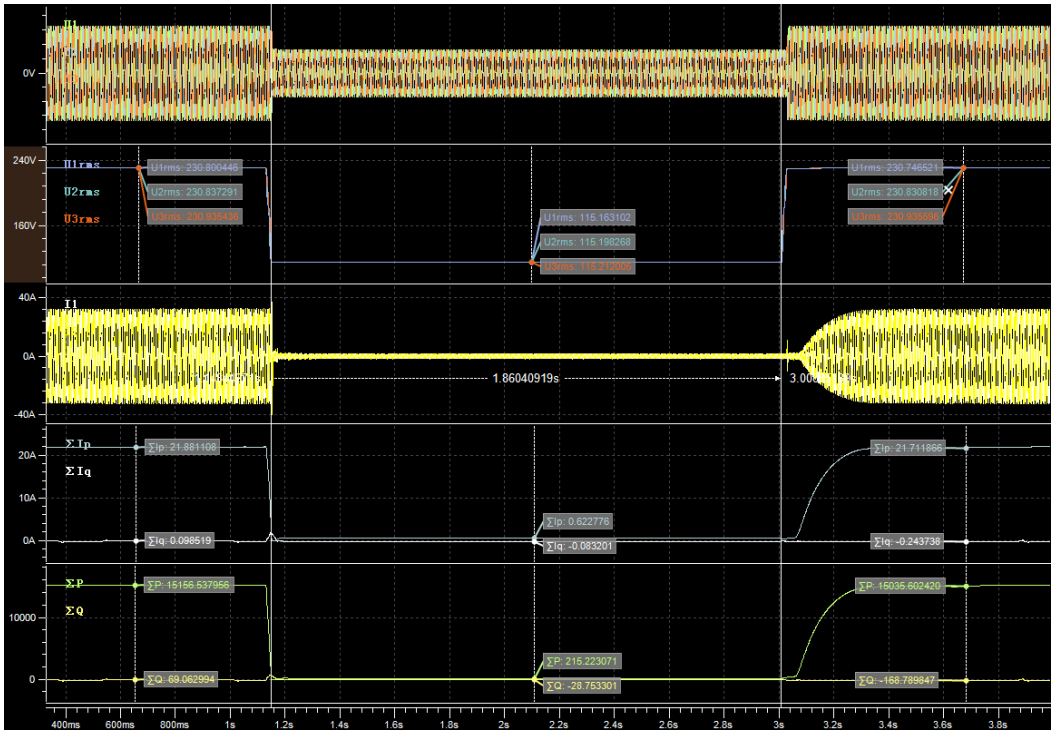
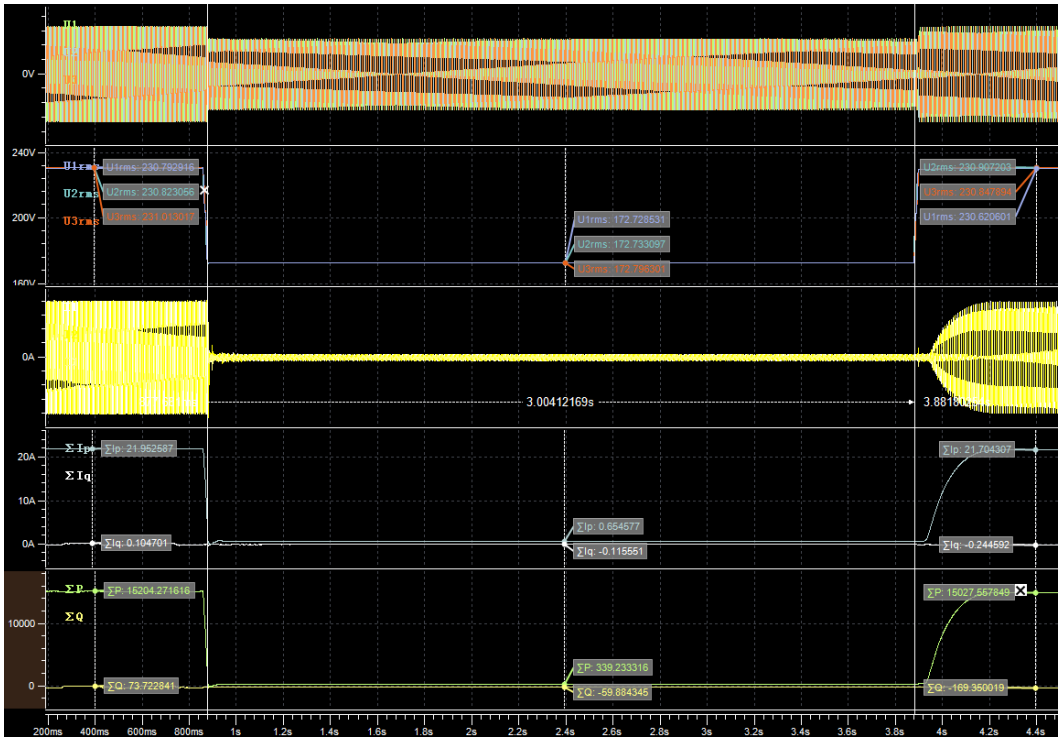


L1-L2-L3-N

Graph_25%

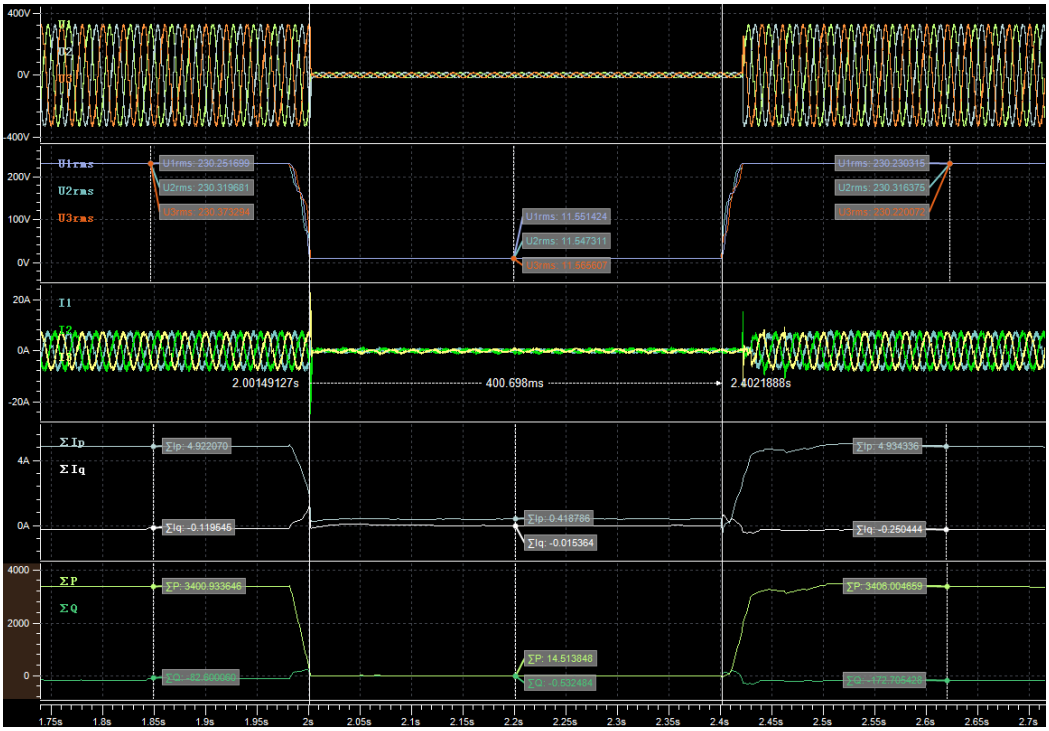
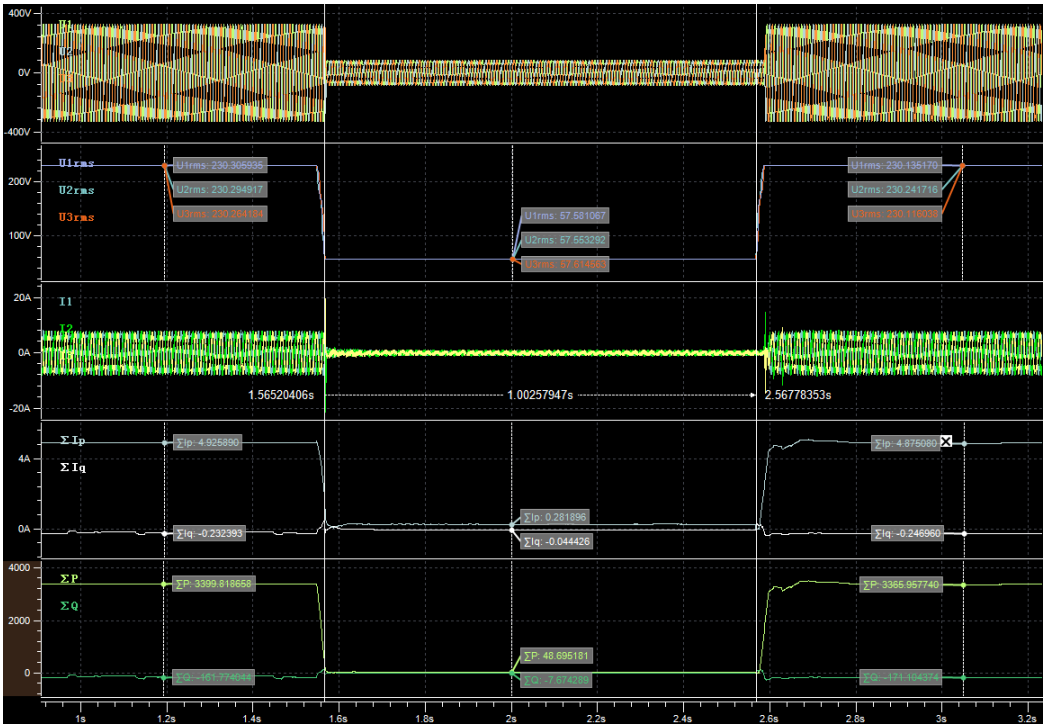


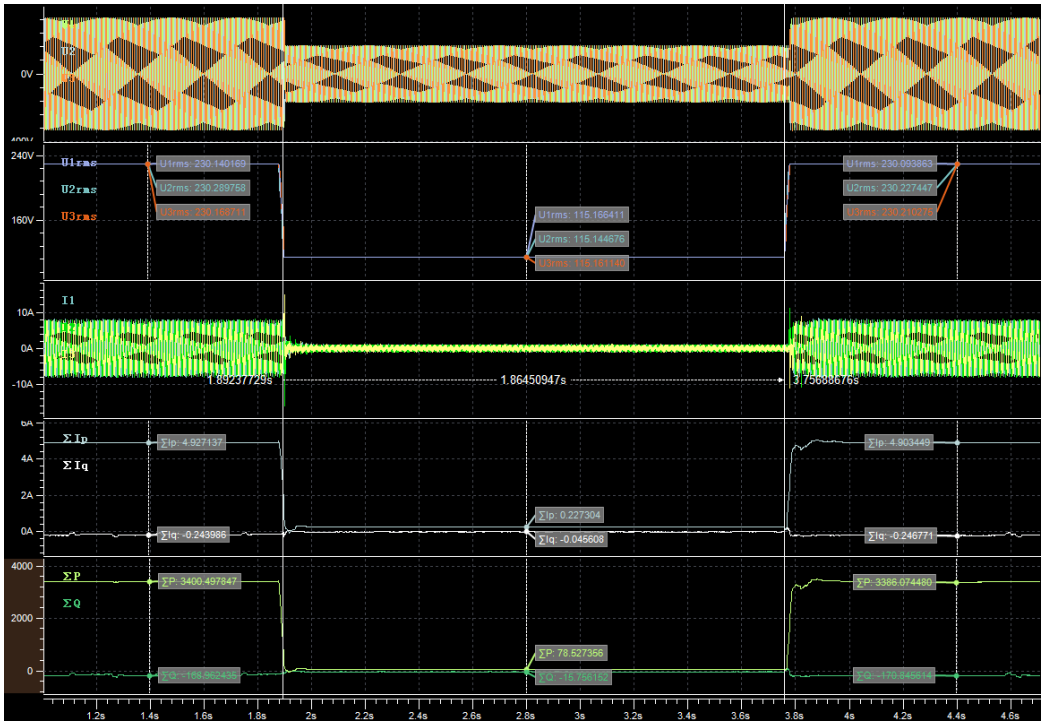
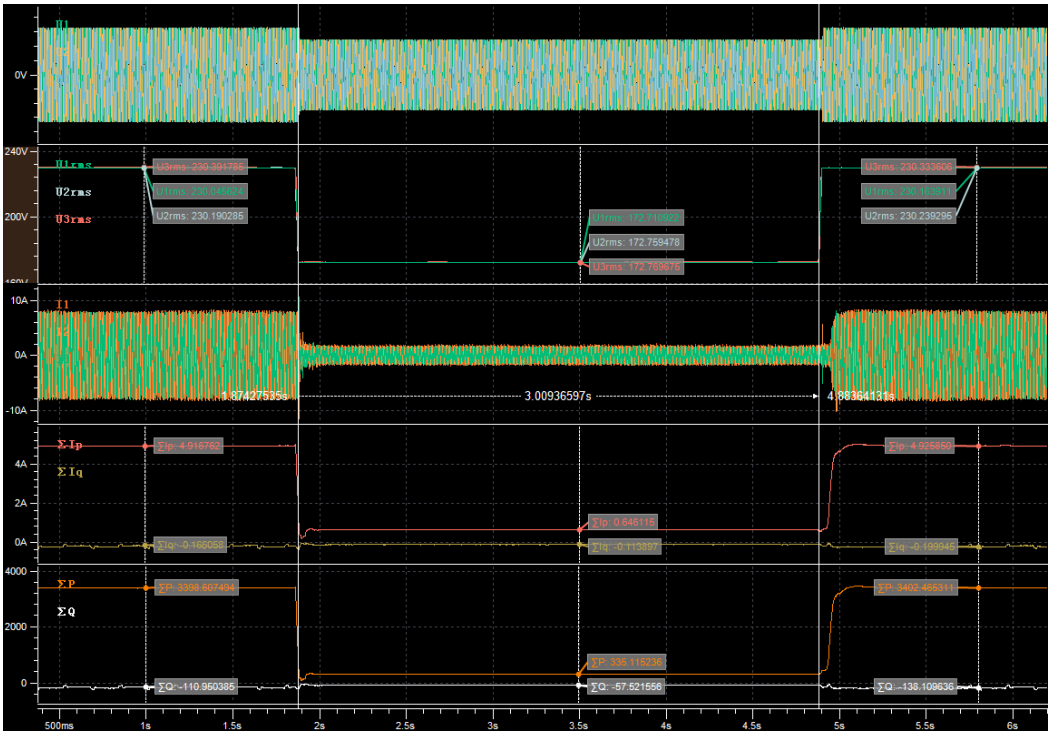
L1-L2-L3-N

Graph_50%

L1-L2-L3-N
Graph_75%

L1-L2-L3-N

Test at partial load (30%)							
			U meas. (%)				
Udip	Type	t min (ms)	R	S	T	T meas.(ms)	P recover (s)
5%	L1-N	250	5.03	100.18	100.21	402.00	0.081
	L2-N		100.17	5.01	100.20	400.00	0.083
	L3-N		100.18	100.18	5.05	400.00	0.082
	L1-L2-N		5.00	5.03	100.20	401.00	0.082
	L2-L3-N		100.17	5.00	5.00	401.00	0.027
	L1-L3-N		5.02	100.20	5.03	400.00	0.082
	L1-L2-L3-N		5.02	5.02	5.03	400.00	0.027
25%	L1-N	938	25.01	100.15	100.20	1005.00	0.083
	L2-N		100.17	25.00	100.17	1001.00	0.081
	L3-N		100.16	100.17	25.01	1002.00	0.082
	L1-L2-N		25.02	25.04	100.19	1005.00	0.082
	L2-L3-N		100.16	25.44	25.03	1002.00	0.027
	L1-L3-N		25.04	100.16	25.01	1000.00	0.083
	L1-L2-L3-N		25.03	25.02	25.05	1002.00	0.027
50%	L1-N	1797	50.06	100.15	100.19	1866.00	0.082
	L2-N		100.16	50.04	100.17	1860.00	0.081
	L3-N		100.17	100.17	50.06	1864.00	0.084
	L1-L2-N		50.07	50.06	100.19	1868.00	0.082
	L2-L3-N		100.17	50.05	50.07	1858.00	0.082
	L1-L3-N		50.06	100.15	50.08	1861.00	0.084
	L1-L2-L3-N		50.07	50.06	50.07	1864.00	0.029
75%	L1-N	2656	75.12	100.15	100.17	3006.00	0.083
	L2-N		100.14	75.10	100.17	3005.00	0.084
	L3-N		100.15	100.17	75.12	3006.00	0.084
	L1-L2-N		75.11	75.12	100.20	3002.00	0.079

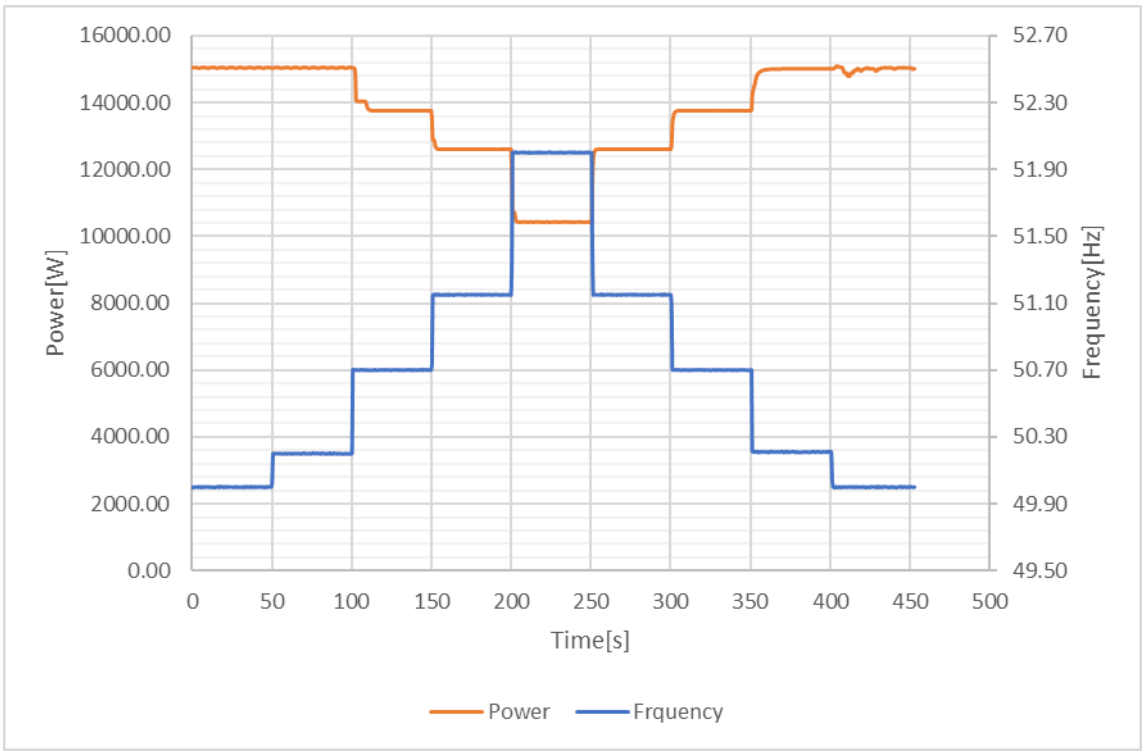
	L2-L3-N		100.15	75.11	75.15	3003.00	0.081
	L1-L3-N		75.13	100.14	75.12	3008.00	0.082
	L1-L2-L3-N		75.09	75.11	75.11	3009.00	0.083
Remark: **The tests are performed together with clause 4.7.4.2.2 Zero current mode and enabling of default setting: undervoltage of 50%Un**							

Graph_5%

L1-L2-L3-N
Graph_25%

L1-L2-L3-N

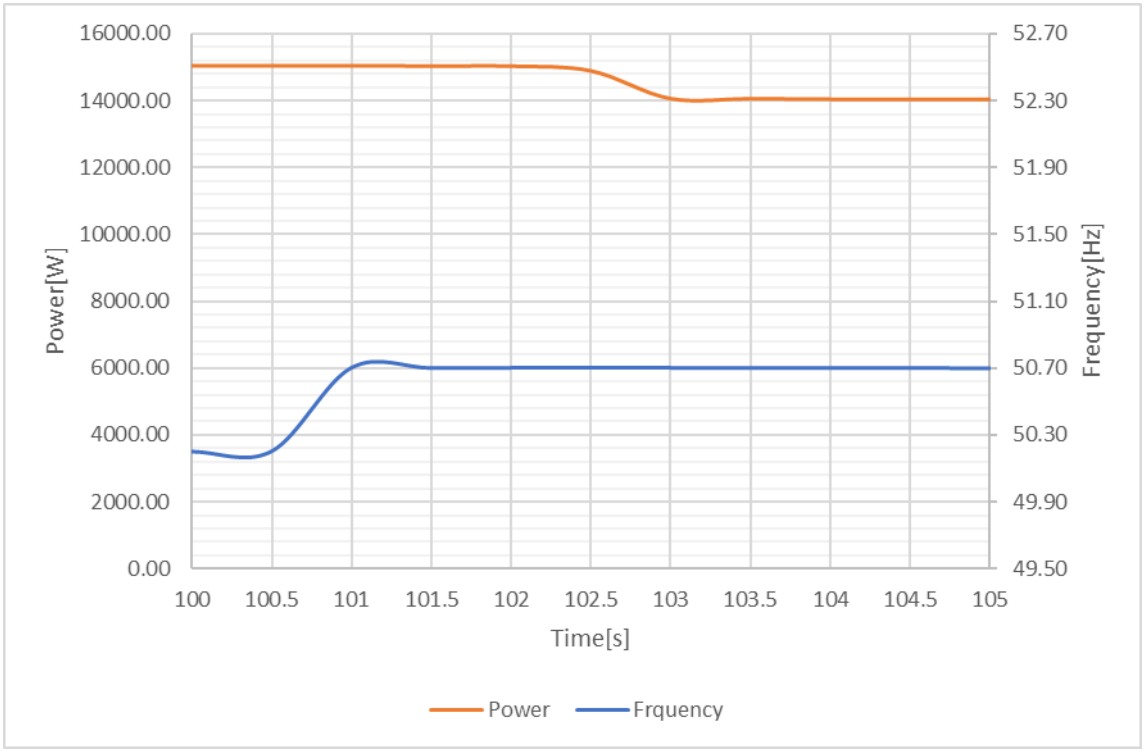
Graph_50%

L1-L2-L3-N
Graph_75%

L1-L2-L3-N

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	15041.15	15000.00	--	--	--	--
50.2Hz ± 0.01Hz	50.20	15040.29	15000.00	--	--	--	--
50.70Hz ± 0.01Hz	50.70	13758.82	13750.00	8.82	± 1500	1.9	9.0
51.15Hz ± 0.01Hz	51.15	12604.94	12625.00	-20.06	± 1500	1.9	3.5
52.0Hz ± 0.01Hz	52.00	10442.31	10500.00	-57.69	± 1500	1.0	3.0
51.15Hz ± 0.01Hz	51.15	12615.76	12625.00	-9.24	± 1500	1.3	2.0
50.70Hz ± 0.01Hz	50.70	13763.59	13750.00	13.59	± 1500	1.8	3.0
50.2Hz ± 0.01Hz	50.20	15006.22	15000.00	--	--	--	--
50Hz ± 0.01Hz	50.00	15000.32	15000.00	--	--	--	--
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	15081.11	15000.00	--	--	--	--
50.2Hz ± 0.01Hz	50.20	15062.18	15000.00	--	--	--	--
50.70Hz ± 0.01Hz	50.70	7648.26	7500.00	148.26	± 1500	0.9	14.5
51.15Hz ± 0.01Hz	51.15	754.79	750.00	4.79	± 1500	0.9	3.7
52.0Hz ± 0.01Hz	52.00	51.55	0.00	51.55	± 1500	0.6	1.0
51.15Hz ± 0.01Hz	51.15	759.84	750.00	9.84	± 1500	0.5	0.6
50.70Hz ± 0.01Hz	50.70	7580.97	7500.00	80.97	± 1500	0.9	1.3
50.2Hz ± 0.01Hz	50.20	14890.15	15000.00	--	--	1.5	3.4
50Hz ± 0.01Hz	50.00	15050.66	15000.00	--	--	--	--

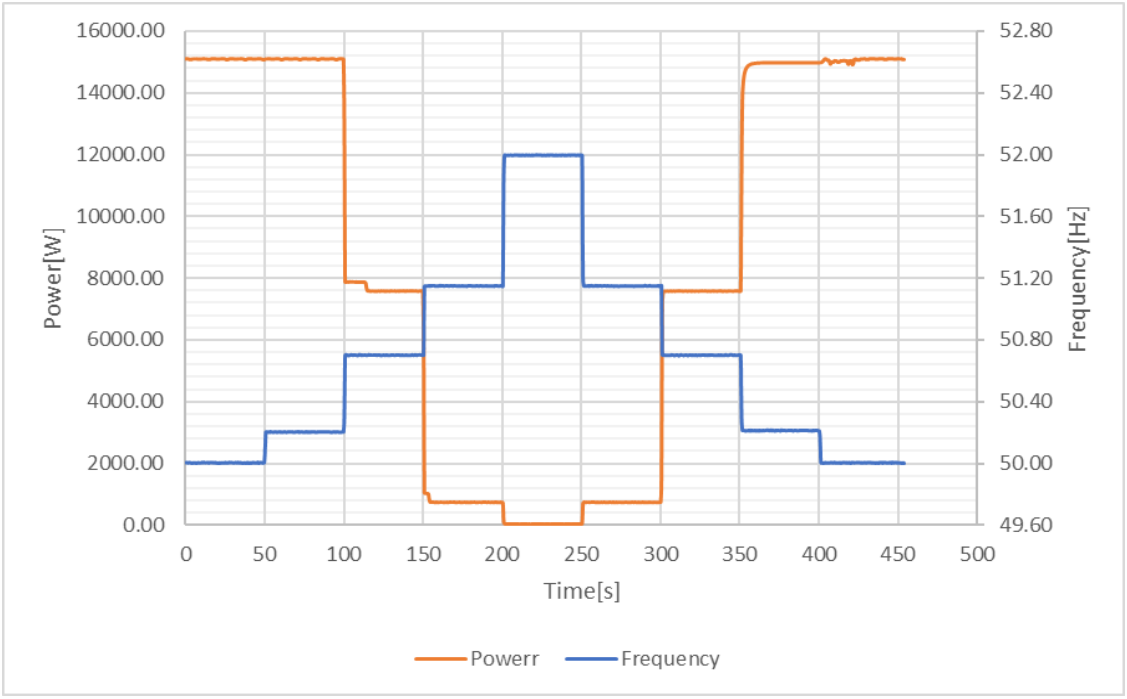
Test 3	50% Pn, f1 =52.0Hz; droop=5%; f-stop deactivated, no delay						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <2s	For The settling times T≤20s
50Hz ± 0.01Hz	50.00	7583.99	--	--	--	--	--
51.0Hz ± 0.01Hz	51.00	7584.39	7500.00	84.39	± 1500	--	--
51.70Hz ± 0.01Hz	51.70	7584.58	7500.00	84.58	± 1500	--	--
52.0Hz ± 0.01Hz	52.00	7584.65	7500.00	84.65	± 1500	--	--
51.70Hz ± 0.01Hz	51.70	7584.62	7500.00	84.62	± 1500	--	--
51.00Hz ± 0.01Hz	51.00	7584.46	7500.00	84.46	± 1500	--	--
50Hz ± 0.01Hz	50.00	7584.16	--	--	--	--	--
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	15079.09	15000.00	--	--	--	--
50.2Hz ± 0.01Hz	50.20	15075.24	15000.00	--	--	--	--
50.70Hz ± 0.01Hz	50.70	12079.04	12000.00	79.04	± 1500	1.0	11
51.15Hz ± 0.01Hz	51.15	9337.06	9300.00	37.06	± 1500	1.0	3.1
52.0Hz ± 0.01Hz	52.00	4157.84	4200.00	-42.16	± 1500	0.7	2.7
51.15Hz ± 0.01Hz	51.15	4158.20	4200.00	-41.80	± 1500	--	--
50.70Hz ± 0.01Hz	50.70	4158.22	4200.00	-41.78	± 1500	--	--
50.2Hz ± 0.01Hz	50.20	4158.26	4200.00	79.04	± 1500	--	--
50Hz ± 0.01Hz	50.00	15075.26	4200.00	--	--	--	--



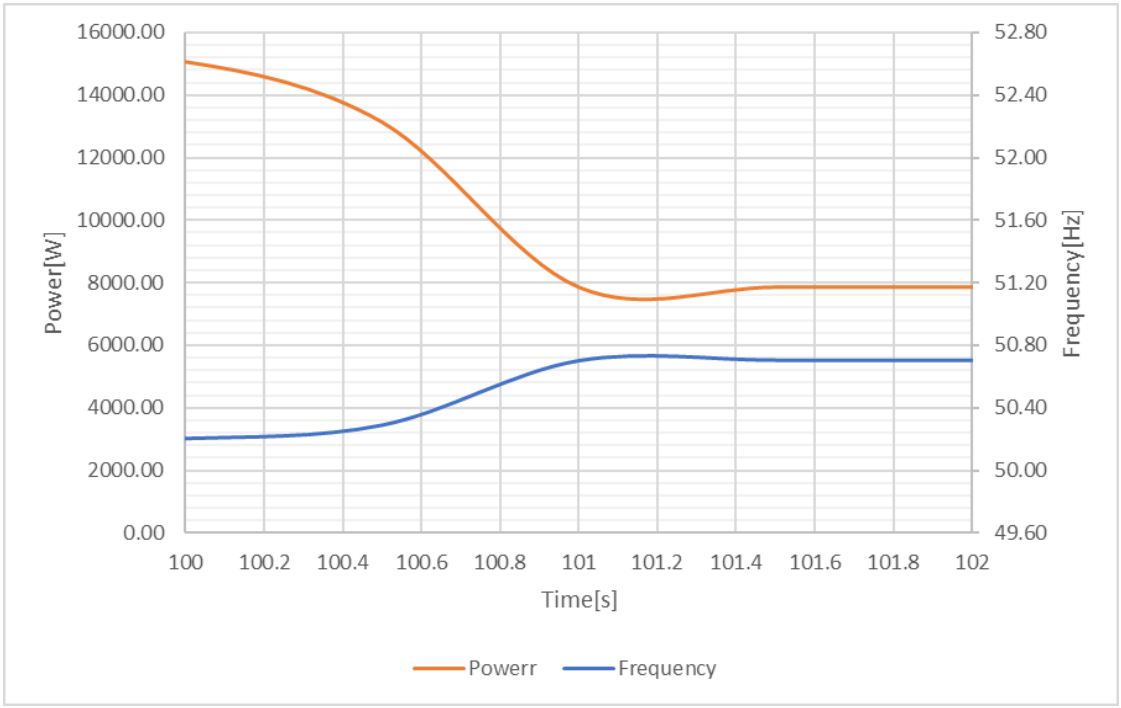
Intentional delay time (2s)



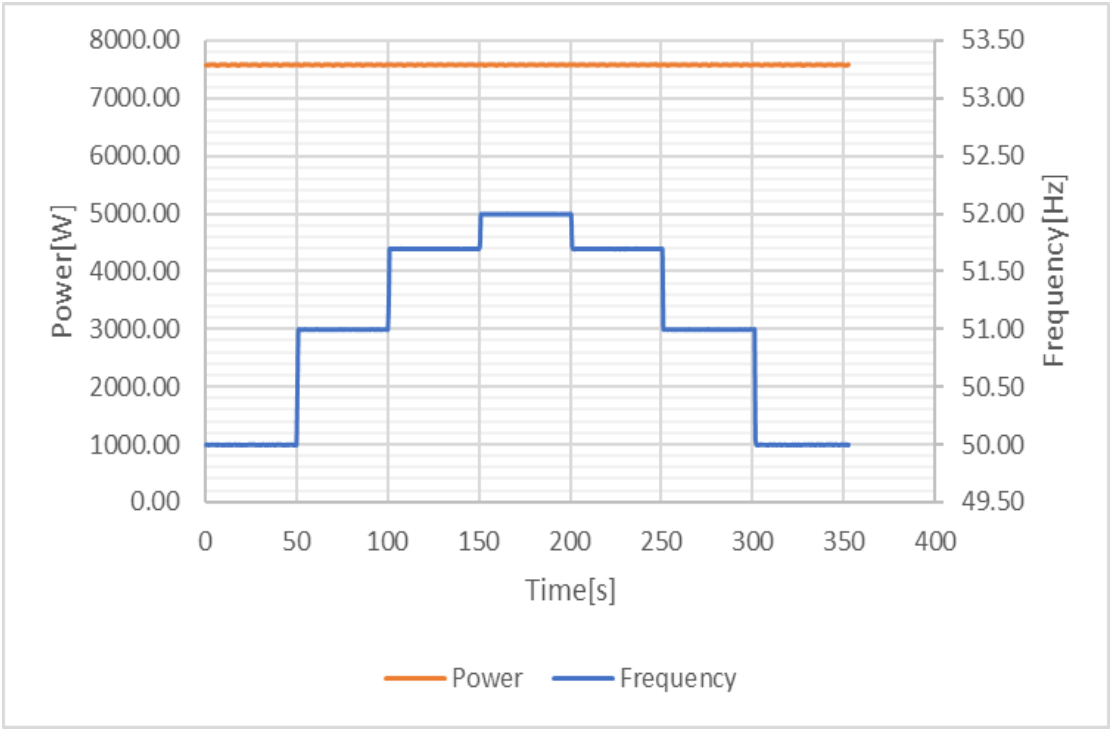
Test 2_Graph



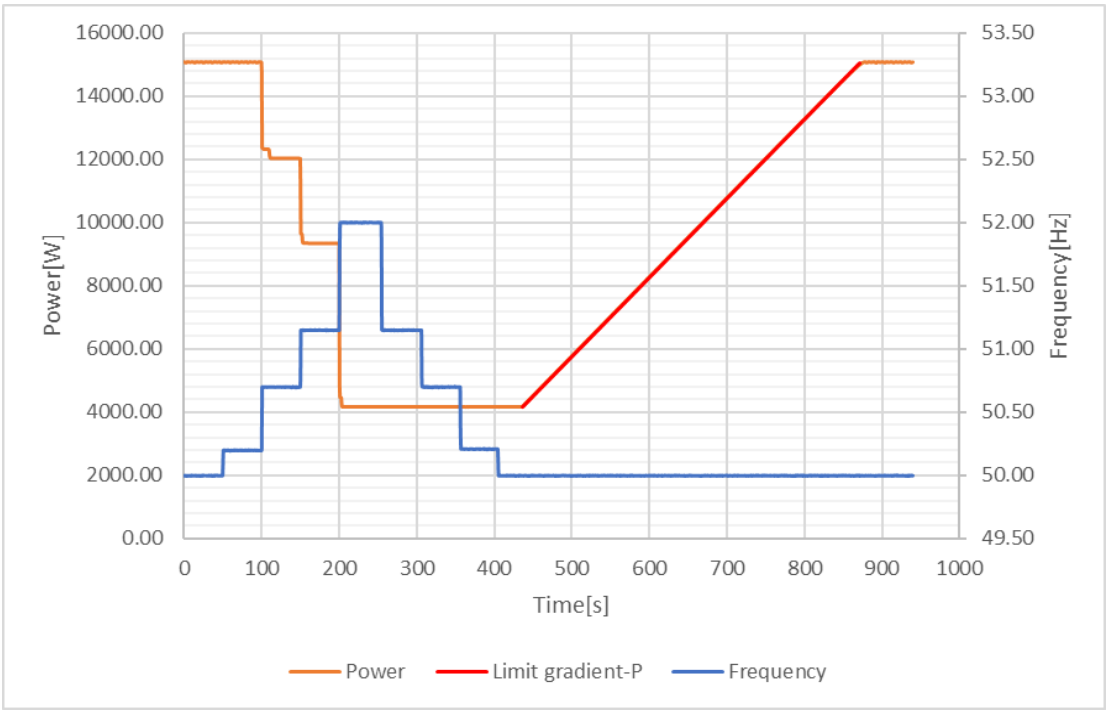
Intentional delay time (no delay)



Test 3_Graph



Test 4_Graph



D.6.2	Table: Power response to under frequency	P

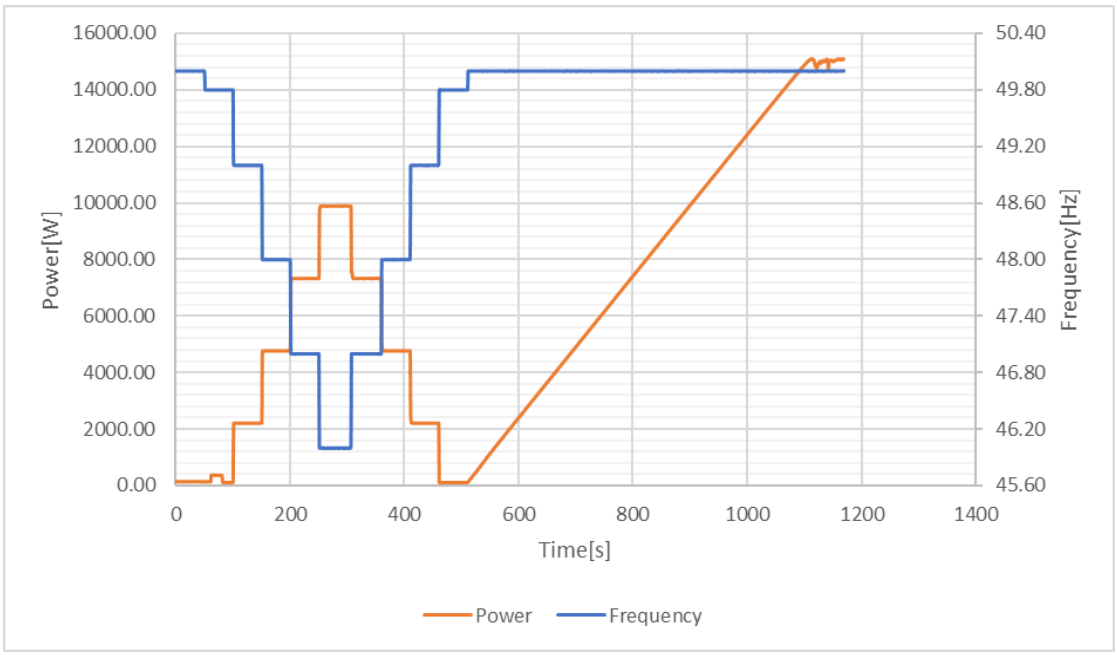
Test 1	0% Pn, f1 =49.8Hz; droop=12%; with delay of 2 s						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	136.04	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	214.95	0.00	214.95	± 1500	--	--
49.0Hz ± 0.01z	49.00	2208.45	2000.00	208.45	± 1500	0.8	0.9
48.0Hz ± 0.01z	48.00	4761.95	4500.00	261.95	± 1500	1.0	1.3
47.0Hz ± 0.01z	47.00	7320.81	7000.00	320.81	± 1500	1.0	1.4
46.0Hz ± 0.01z	46.00	9872.93	9500.00	372.93	± 1500	1.3	1.7
47.0Hz ± 0.01z	47.00	7318.26	7000.00	318.26	± 1500	1.0	3.0
48.0Hz ± 0.01z	48.00	4754.94	4500.00	254.94	± 1500	1.0	2.0
49.0Hz ± 0.01z	49.00	2197.44	2000.00	197.44	± 1500	1.0	1.7
49.8Hz ± 0.01Hz	49.80	107.35	0.00	107.35	± 1500	9.9	10.5
50.0Hz ± 0.01Hz	50.00	15003.18	--	--	--	--	--

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	135.07	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	238.33	0.00	238.33	± 1500	--	--
49.0Hz ± 0.01Hz	49.00	4977.50	4800.00	177.50	± 1500	0.9	1.0
48.0Hz ± 0.01Hz	48.00	10992.71	10800.00	192.71	± 1500	1.2	1.7
47.0Hz ± 0.01Hz	47.00	14972.11	15000.00	-27.89	± 1500	--	--
46.0Hz ± 0.01Hz	46.00	15028.01	15000.00	28.01	± 1500	--	--
47.0Hz ± 0.01Hz	47.00	15027.92	15000.00	27.92	± 1500	--	--
48.0Hz ± 0.01Hz	48.00	11068.34	10800.00	268.34	± 1500	--	--
49.0Hz ± 0.01Hz	49.00	4979.08	4800.00	179.08	± 1500	0.9	1.0
49.8Hz ± 0.01Hz	49.80	113.87	0.00	113.87	± 1500	0.9	1.1
50.0Hz ± 0.01Hz	50.00	14992.42	--	--	--	--	--

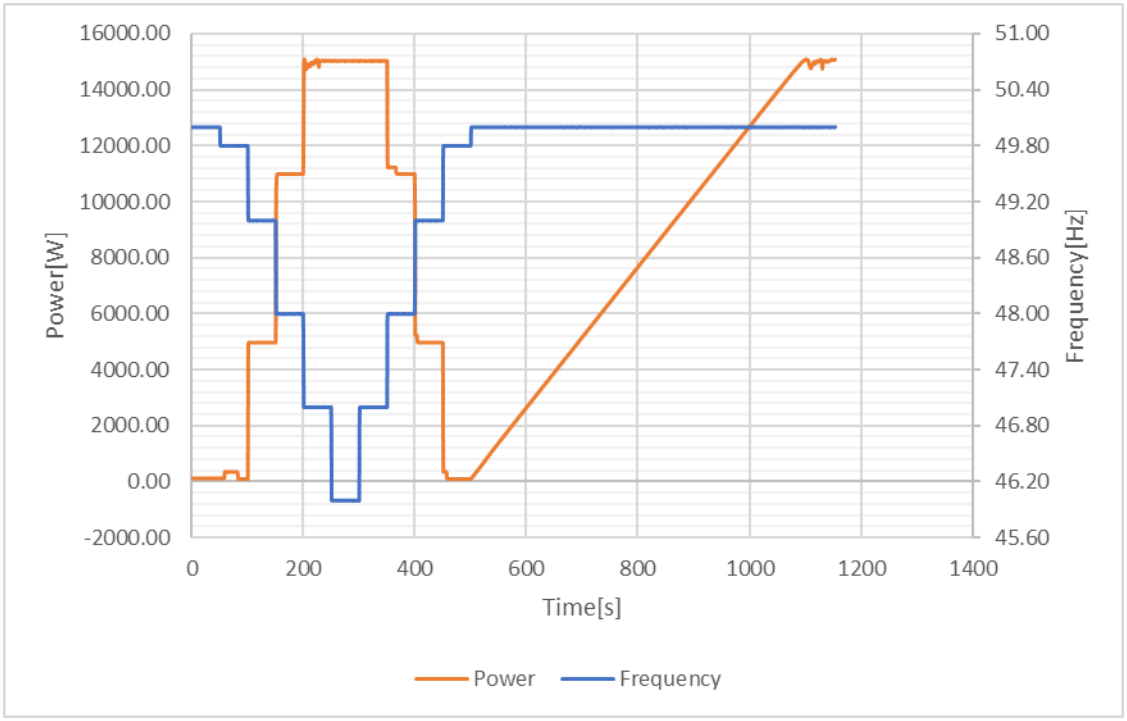
Test 3	50% Pn, f1 =46.0Hz; droop=5%; no delay						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	7574.42	--	--	--	--	--
49.0Hz ± 0.01Hz	49.00	7575.57	7500.00	75.57	± 1500	--	--
48.0Hz ± 0.01Hz	48.00	7575.30	7500.00	75.30	± 1500	--	--
47.0Hz ± 0.01Hz	47.00	7574.92	7500.00	74.92	± 1500	--	--
46.0Hz ± 0.01Hz	46.00	7574.01	7500.00	74.01	± 1500	--	--
47.0Hz ± 0.01Hz	47.00	7574.54	7500.00	74.54	± 1500	--	--
48.0Hz ± 0.01Hz	48.00	7575.58	7500.00	75.58	± 1500	--	--
49.0Hz ± 0.01Hz	49.00	7575.91	7500.00	75.91	± 1500	--	--
50.0Hz ± 0.01Hz	50.00	7576.37	--	--	--	--	--

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	7576.48	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	7669.19	7500.00	169.19	± 1500	--	--
49.0Hz ± 0.01Hz	49.00	12421.32	12300.00	121.32	± 1500	1.2	1.7
48.0Hz ± 0.01Hz	48.00	15016.91	15000.00	16.91	± 1500	1.2	1.4
47.0Hz ± 0.01Hz	47.00	15022.68	15000.00	22.68	± 1500	--	--
46.0Hz ± 0.01Hz	46.00	15027.35	15000.00	27.35	± 1500	--	--
47.0Hz ± 0.01Hz	47.00	15070.41	15000.00	70.41	± 1500	--	--
48.0Hz ± 0.01Hz	48.00	15071.58	15000.00	71.58	± 1500	0.2	0.3
49.0Hz ± 0.01Hz	49.00	12475.46	12300.00	175.46	± 1500	1.0	12.0
49.8Hz ± 0.01Hz	49.80	7607.10	7500.00	107.10	± 1500	--	--
50.0Hz ± 0.01Hz	50.00	15043.05	--	--	--	--	--

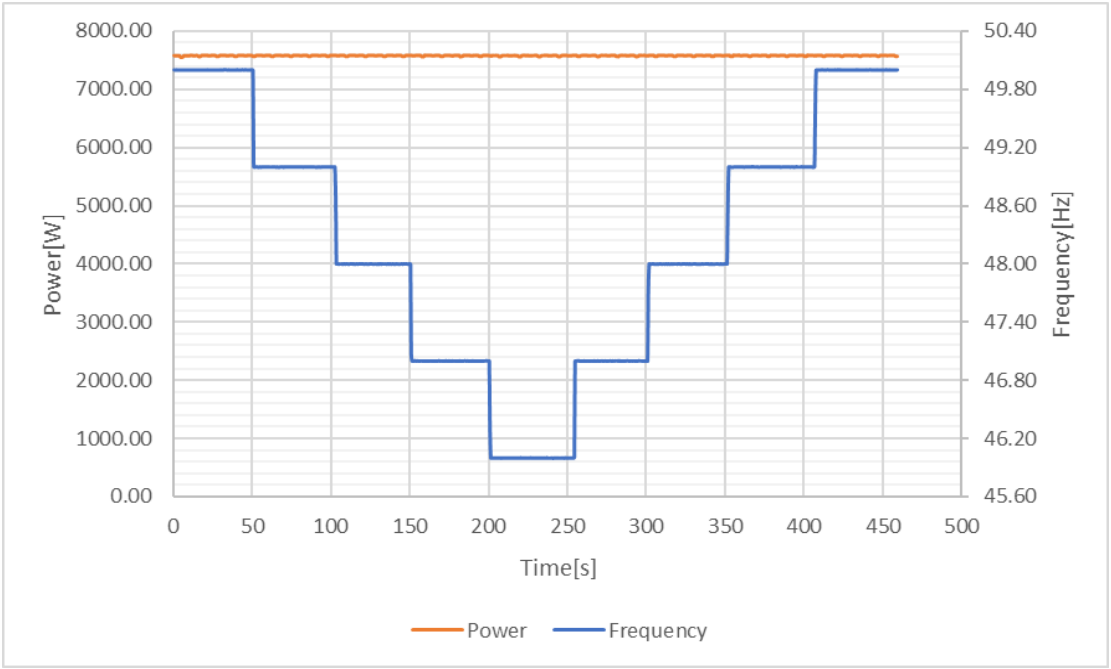
Test 1_Graph



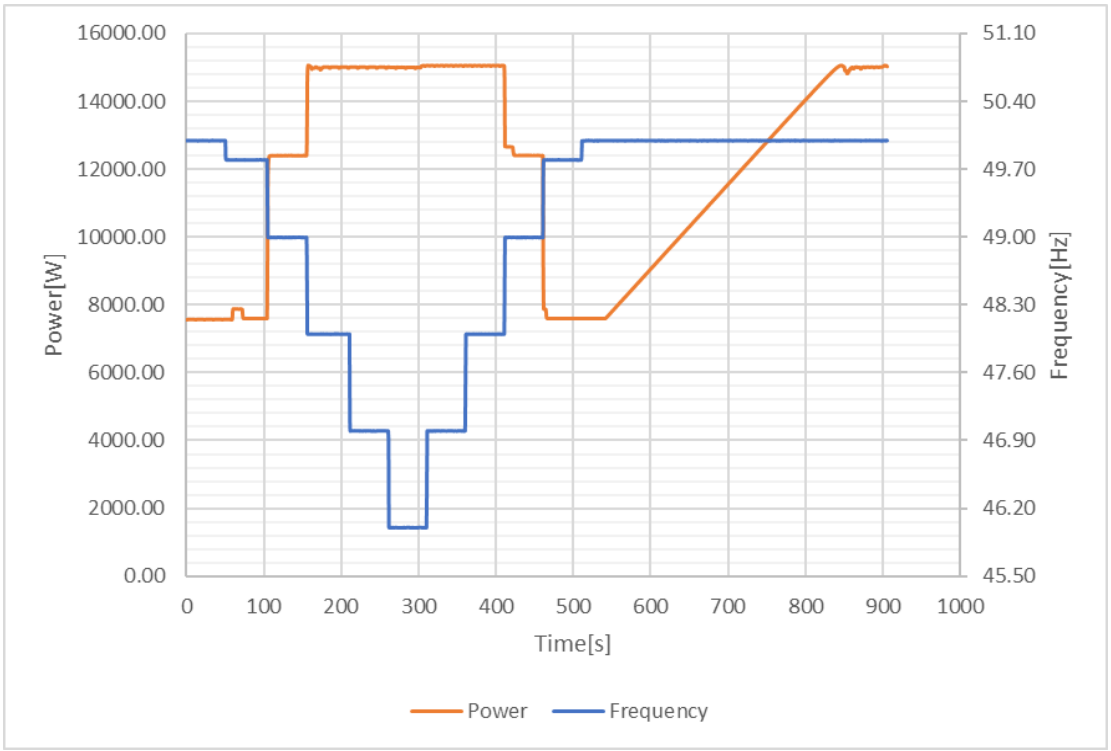
Test 2_Graph



Test 3_Graph



Test 4_Graph



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

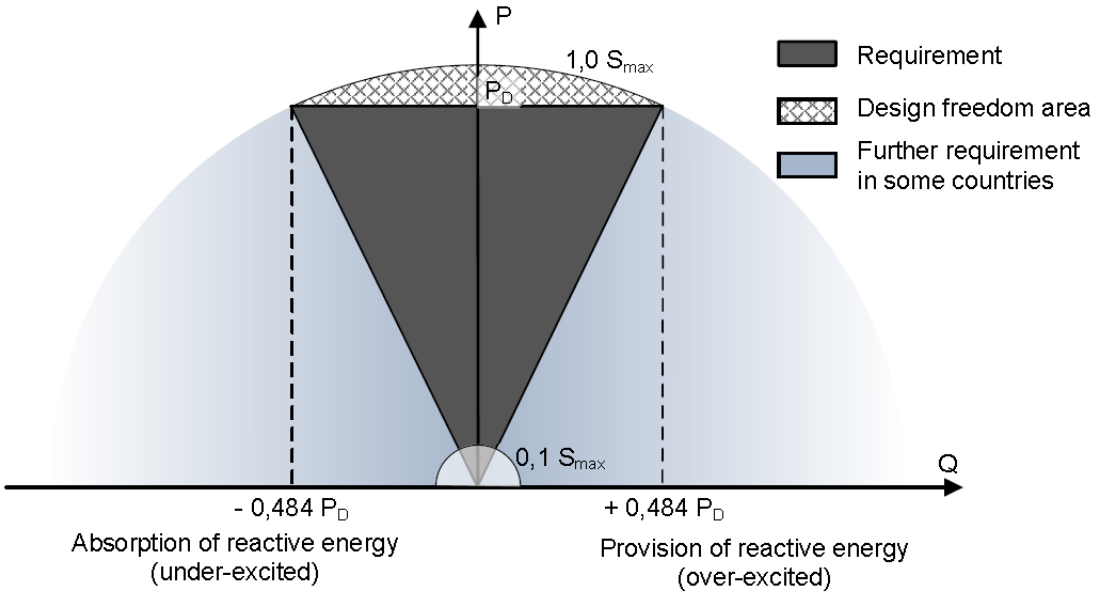


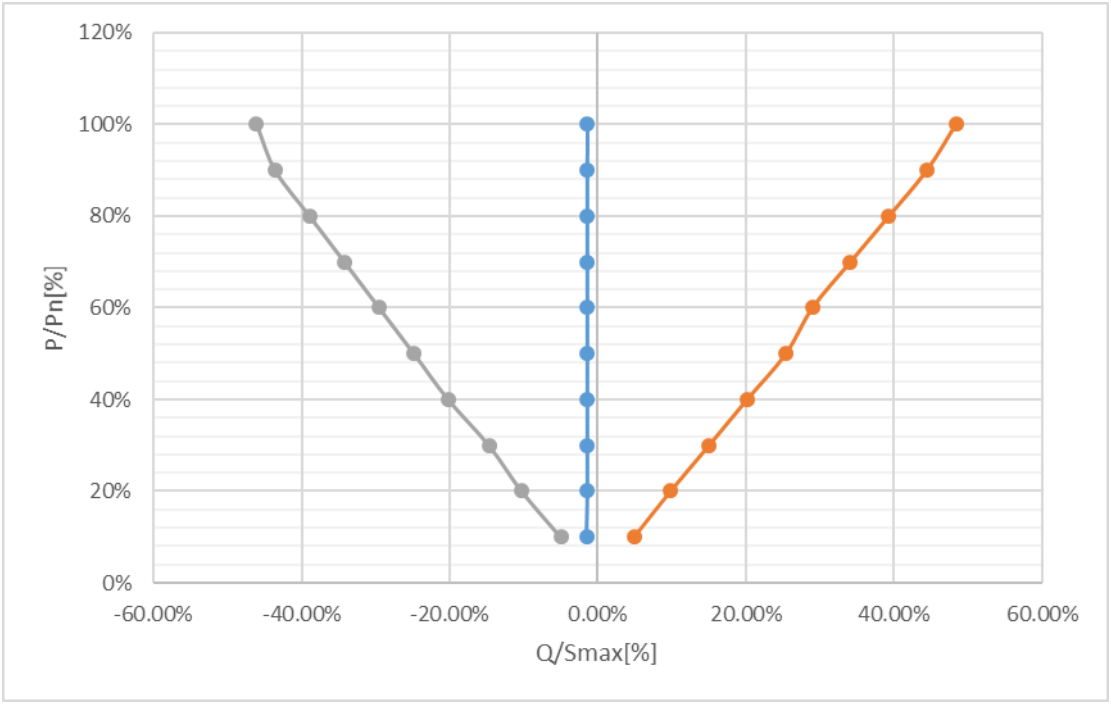
Figure 12 — Reactive power capability at nominal voltage

Lagging PF=0.9:

P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	ΔQ/Smax [%]	LIMITE [%]
10	1497.15	-748.19	0.8945	0.9	-0.0055	-726.48	-0.14	± 2
20	3026.71	-1539.84	0.8913	0.9	-0.0087	-1452.97	-0.58	± 2
30	4543.37	-2202.54	0.8998	0.9	-0.0002	-2179.45	-0.15	± 2
40	6052.72	-3029.80	0.8942	0.9	-0.0058	-2905.93	-0.83	± 2
50	7555.99	-3723.24	0.8970	0.9	-0.0030	-3632.42	-0.61	± 2
60	9064.06	-4429.28	0.8985	0.9	-0.0015	-4358.90	-0.47	± 2
70	10558.84	-5133.03	0.8994	0.9	-0.0006	-5085.38	-0.32	± 2
80	12051.40	-5838.92	0.8999	0.9	-0.0001	-5811.87	-0.18	± 2
90	13538.19	-6538.93	0.9005	0.9	0.0005	-6538.35	0.00	± 2
100*	14932.45	-6912.64	0.9075	0.9	--	--	--	--

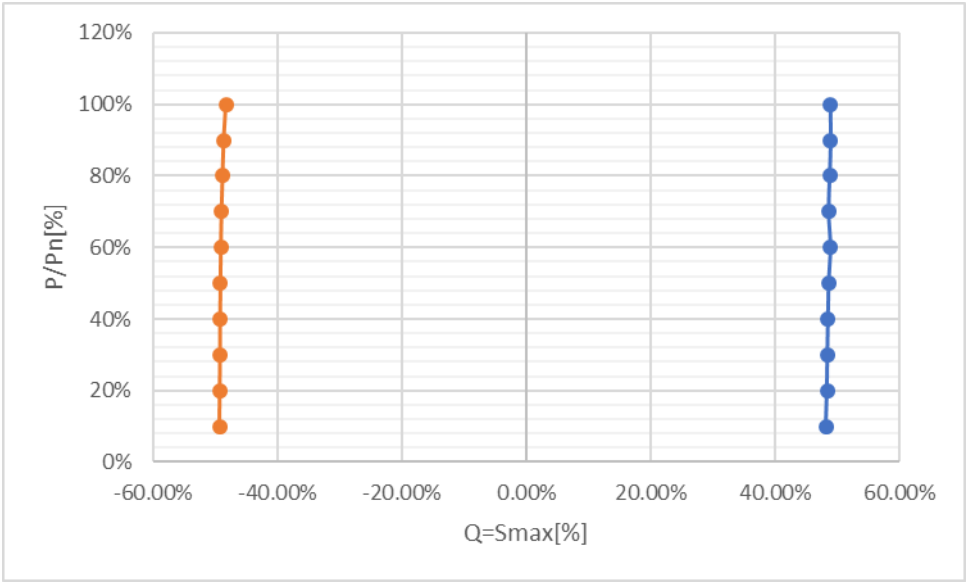
Leading PF=0.9:								
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	1512.68	732.88	0.8999	0.9	-0.0001	726.48	0.04	± 2
20	3038.83	1471.25	0.9001	0.9	0.0001	1452.97	0.12	± 2
30	4554.85	2249.05	0.8966	0.9	-0.0034	2179.45	0.46	± 2
40	6066.83	3020.30	0.8952	0.9	-0.0048	2905.93	0.76	± 2
50	7572.32	3807.33	0.8934	0.9	-0.0066	3632.42	1.17	± 2
60	9082.47	4345.01	0.9021	0.9	0.0021	4358.90	-0.09	± 2
70	10579.82	5113.14	0.9004	0.9	0.0004	5085.38	0.19	± 2
80	12073.31	5893.27	0.8987	0.9	-0.0013	5811.87	0.54	± 2
90	13561.29	6661.82	0.8975	0.9	-0.0025	6538.35	0.82	± 2
100	14839.71	7251.01	0.8985	0.9	--	--	--	--
Q=0:								
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	1497.18	-226.92	0.9769	1	-0.0231	0.00	-1.51	± 2
20	3035.04	-226.45	0.9950	1	-0.0050	0.00	-1.51	± 2
30	4560.23	-226.49	0.9980	1	-0.0020	0.00	-1.51	± 2
40	6069.81	-226.48	0.9989	1	-0.0011	0.00	-1.51	± 2
50	7584.55	-226.48	0.9993	1	-0.0007	0.00	-1.51	± 2
60	9060.81	-226.52	0.9995	1	-0.0005	0.00	-1.51	± 2
70	10579.48	-226.48	0.9996	1	-0.0004	0.00	-1.51	± 2
80	12099.32	-226.47	0.9997	1	-0.0003	0.00	-1.51	± 2
90	13592.82	-226.50	0.9997	1	-0.0003	0.00	-1.51	± 2
100	15080.89	-226.40	0.9998	1	-0.0002	0.00	-1.51	± 2

Graph


120%
100%
80%
60%
40%
20%
0%
P/Pn[%]
-60.00%
-40.00%
-20.00%
0.00%
20.00%
40.00%
60.00%
Q/Smax[%]

Q=48.43%Pn						
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	1427.02	7229.63	0.1936	7264.5	-0.23	± 2
20	2960.58	7254.05	0.3779	7264.5	-0.07	± 2
30	4486.65	7264.67	0.5255	7264.5	0.00	± 2
40	6006.93	7277.24	0.6366	7264.5	0.08	± 2
50	7518.19	7292.24	0.7178	7264.5	0.18	± 2
60	9031.32	7333.09	0.7763	7264.5	0.46	± 2
70	10540.10	7292.31	0.8224	7264.5	0.19	± 2
80	12038.77	7317.19	0.8545	7264.5	0.35	± 2
90	13534.20	7339.45	0.8791	7264.5	0.50	± 2
100*	14794.84	7331.77	0.8960	7264.5	0.45	± 2
Q=-48.43%Pn						
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	1365.05	-7405.72	0.1813	-7264.5	-0.94	± 2
20	2925.07	-7399.32	0.3676	-7264.5	-0.90	± 2
30	4463.71	-7387.82	0.5171	-7264.5	-0.82	± 2
40	5985.57	-7385.69	0.6296	-7264.5	-0.81	± 2
50	7495.91	-7378.08	0.7127	-7264.5	-0.76	± 2
60	9011.48	-7370.20	0.7741	-7264.5	-0.70	± 2
70	10515.81	-7350.19	0.8196	-7264.5	-0.57	± 2
80	12015.88	-7325.89	0.8538	-7264.5	-0.41	± 2
90	13513.25	-7297.78	0.8799	-7264.5	-0.22	± 2
100	14769.27	-7240.81	0.8979	-7264.5	0.16	± 2

Graph


120%
100%
80%
60%
40%
20%
0%
P/Pn[%]
-60.00%
-40.00%
-20.00%
0.00%
20.00%
40.00%
60.00%
Q=Smax[%]

D.7.1	Table: Q(U) Capabilities	P

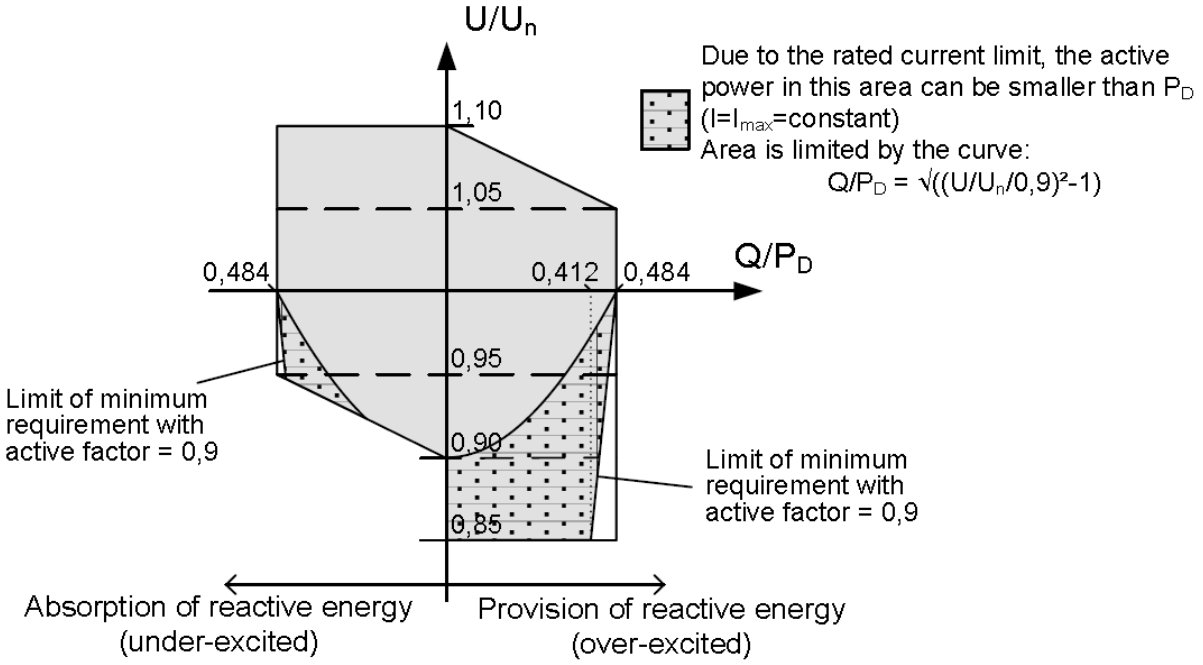


Figure 13 — Reactive power capability at active power P_D in the voltage range (positive sequence component of the fundamental)

Over-excited:

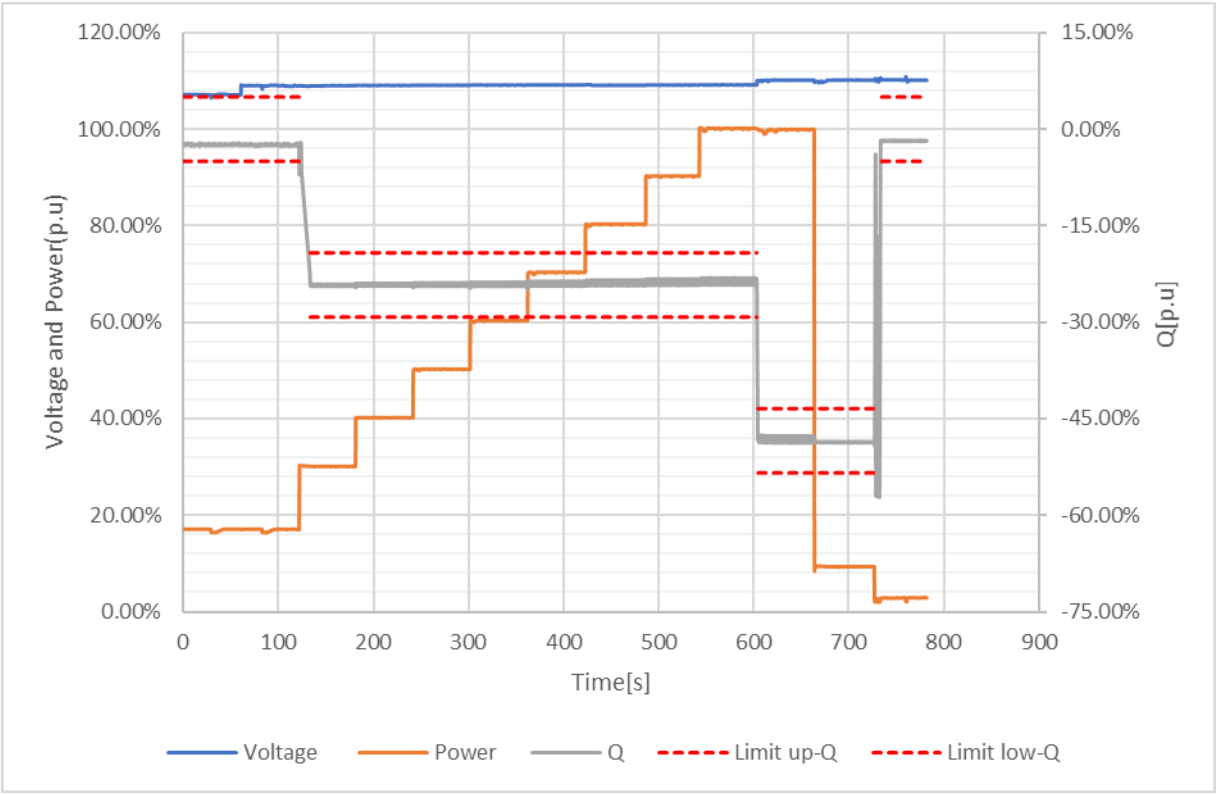
AC output				Reactive power measured		
Voltage setting [V/Vn]	Measured			Reactive power [Var]	Value [Q/Pn]	Limits
	Voltage [V]	[V/Vn]	Active power [W]			
1.10	253.33	1.10	15020.42	-226.51	-0.0151	±0.02
1.08	248.53	1.08	15014.56	2969.87	0.1980	0.194±0.02
1.05	241.89	1.05	14795.67	7311.76	0.4875	--
1.00	230.01	1.00	14783.19	7333.04	0.4889	--
0.95	218.46	0.95	13885.50	7338.43	0.4892	--
0.92	211.90	0.92	13327.75	7341.86	0.4895	--
0.90	207.08	0.90	12926.21	7343.97	0.4896	--
0.85	195.59	0.85	11949.86	7348.60	0.4899	--

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	253.14	1.1006	11918.43	-5827.78	-0.4857	--
1.08	248.23	1.0793	11923.99	-5816.60	-0.4847	--
1.05	241.41	1.0496	11930.47	-5808.39	-0.4840	--
1.00	229.89	0.9995	11933.09	-5787.05	-0.4822	--
0.95	218.44	0.9497	11700.19	-5772.13	-0.4810	--
0.92	211.35	0.9189	11591.18	-2333.34	-0.1944	-0.194±0.02
0.90	206.74	0.8988	12026.11	-167.38	-0.0139	±0.02

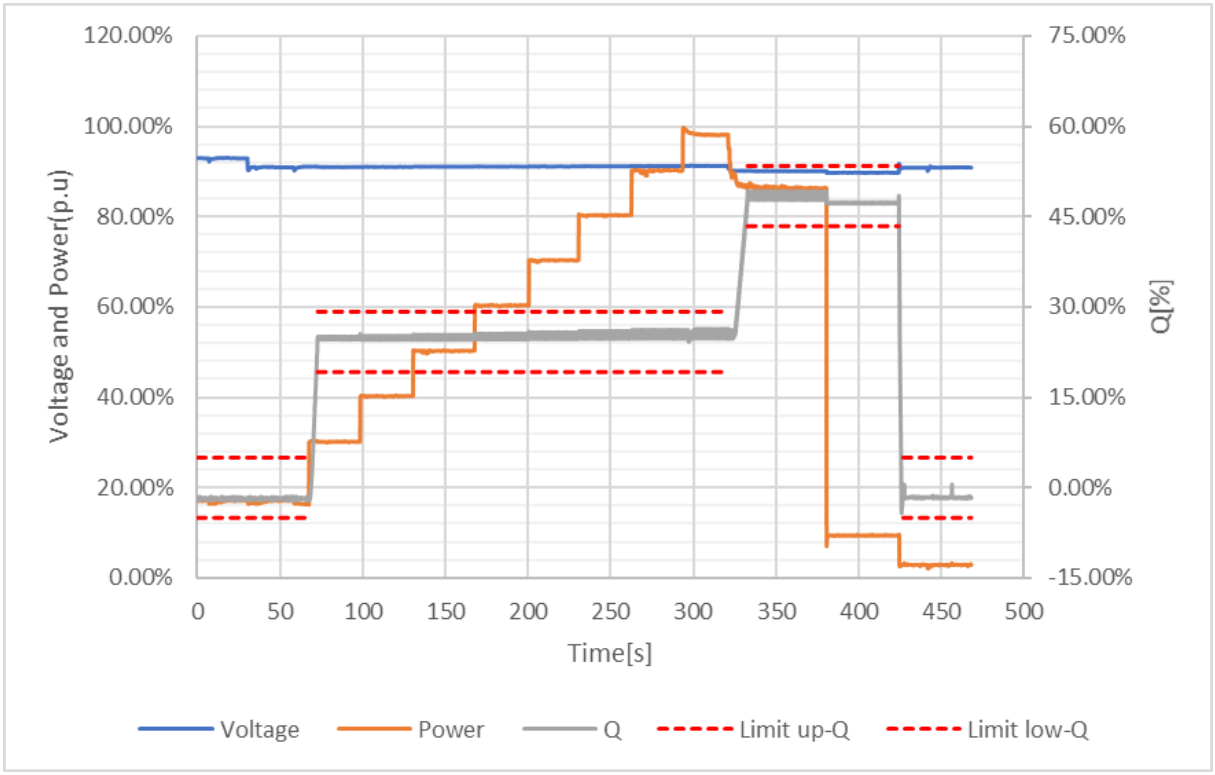
D.7.1	Table: Q Control. Voltage related control mode					P
P/Pn [%] Set-point	Vac [V] Set-point	P/Pn [%] measured	Vac [V] Measured	Q [VAr] measured	Q [Var] expected	Δ Q [Var] (≤ ± 5 % Pn)
< 20 %	1,07 Vn	17.01	246.40	-357.29	≈0 (< ± 5 % Pn)	-2.38
< 20 %	1,09 Vn	17.00	250.70	-364.24	≈0 (< ± 5 % Pn)	-2.43
<20 % →30 %	1,09 Vn	30.11	250.70	-3638.49	-3663 (within 10sec)	-0.04
40 %	1,09 Vn	40.22	250.84	-3625.23	-3663	0.05
50 %	1,09 Vn	50.26	250.92	-3620.93	-3663	0.08
60 %	1,09 Vn	60.31	251.00	-3615.09	-3663	0.12
70 %	1,09 Vn	70.31	251.07	-3601.72	-3663	0.21
80 %	1,09 Vn	80.30	250.94	-3582.76	-3663	0.33
90 %	1,09 Vn	90.25	251.01	-3565.56	-3663	0.45
100 %	1,09 Vn	100.13	251.11	-3550.07	-3663	0.55
100 %	1,1 Vn	99.84	253.31	-7229.07	-7264.50	0.24
100 % →10 %	1,1 Vn	9.36	253.22	-7295.17	-7264.50	-0.20
10 % → ≤ 5 %	1,1 Vn	2.85	253.38	-272.91	≈0 (< ± 5 % Pn)	-1.82
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	16.99	213.74	-277.39	≈0 (< ± 5 % Pn)	-1.85
< 20 %	0.91 Vn	16.80	209.13	-274.54	≈0 (< ± 5 % Pn)	-1.83
<20 % → 30 %	0.91 Vn	30.16	209.27	3728.45	3663 (within 10sec)	0.64
40 %	0.91 Vn	40.26	209.38	3736.61	3633.00	0.69
50 %	0.91 Vn	50.28	209.49	3749.27	3633.00	0.78
60 %	0.91 Vn	60.34	209.54	3767.64	3633.00	0.90
70 %	0.91 Vn	70.34	209.59	3788.69	3633.00	1.04
80 %	0.91 Vn	80.31	209.70	3807.43	3633.00	1.16
90 %	0.91 Vn	90.19	209.79	3824.09	3633.00	1.27

100 %	0.91 Vn	98.30	209.90	3827.75	3633.00	1.30
100 %	0.90 Vn	86.26	207.24	7275.72	7264.50	0.07
100 % →10 %	0.90 Vn	9.40	206.43	7094.81	7264.50	-1.13
10 % →≤ 5 %	0.91 Vn	2.90	208.98	-241.13	≈0 (< ± 5 % Pn)	-1.61

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%	20.24%	-226.50	<105%	100.48%	1.0000	0.9950	-1.51	±2
30%	30.35%	-226.51	<105%	100.52%	1.0000	0.9980	-1.51	±2
40%	40.43%	-226.49	<105%	100.56%	1.0000	0.9989	-1.51	±2
50%	50.50%	-226.49	<105%	100.61%	1.0000	0.9993	-1.51	±2
60%	60.55%	-226.50	<105%	100.65%	1.0000	0.9995	-1.51	±2
60%	60.32%	-1967.00	>105%	105.39%	0.9800	0.9772	-0.93	±2
70%	70.27%	-3164.36	>105%	105.42%	0.9600	0.9578	-0.68	±2
80%	80.16%	-4405.50	>105%	105.45%	0.9400	0.9390	-0.33	±2
90%	90.00%	-5758.33	>105%	105.48%	0.9200	0.9198	-0.05	±2
100%	99.54%	-7206.29	>105%	105.52%	0.9000	0.9006	0.39	±2
100%	100.39%	-226.40	<100%	99.18%	1.0000	0.9998	-1.51	±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

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

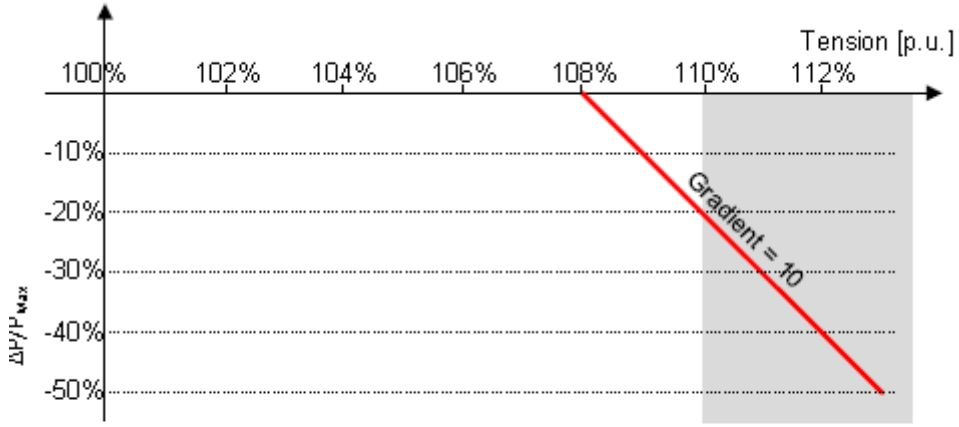
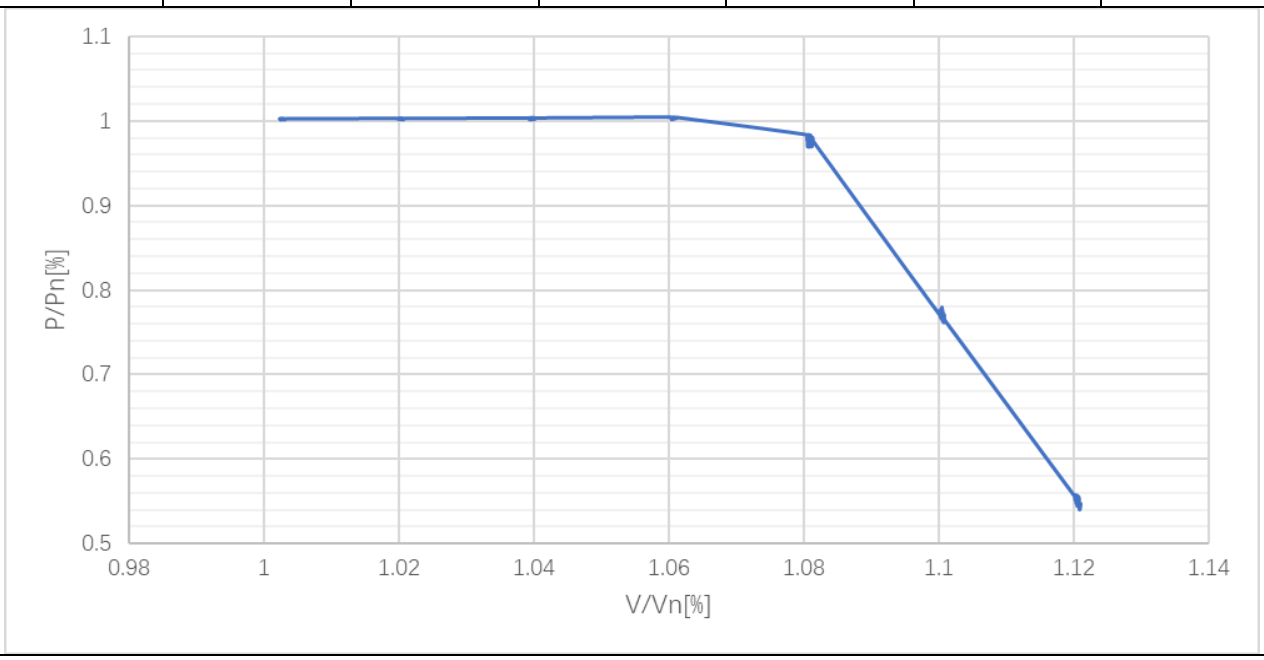


Figure 15 - Example curve for P(U)

Step #	Set voltage vaule V/Vn [%]	Measured voltage vaule V/Vn [%]	Measured power values [W]	Measured power bin [%]	Limit [%]	RESULT
1	100	100.27	15045.573	100.30	--	
2	102	102.02	15052.617	100.35	--	
3	104	103.96	15061.333	100.41	--	
4	106	106.06	15070.155	100.47	--	P
5	108	108.08	14669.732	97.80	--	
6	110	110.04	11529.399	76.86	<80	
7	112	112.04	8259.115	55.06	<60	



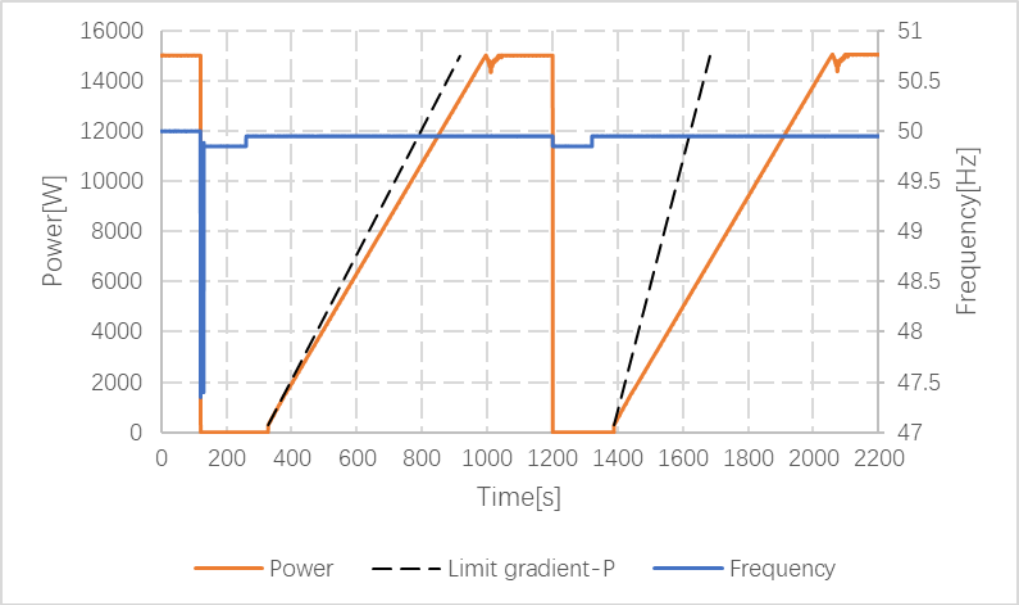
D.8	Table: Connection and reconnection	P

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.*		

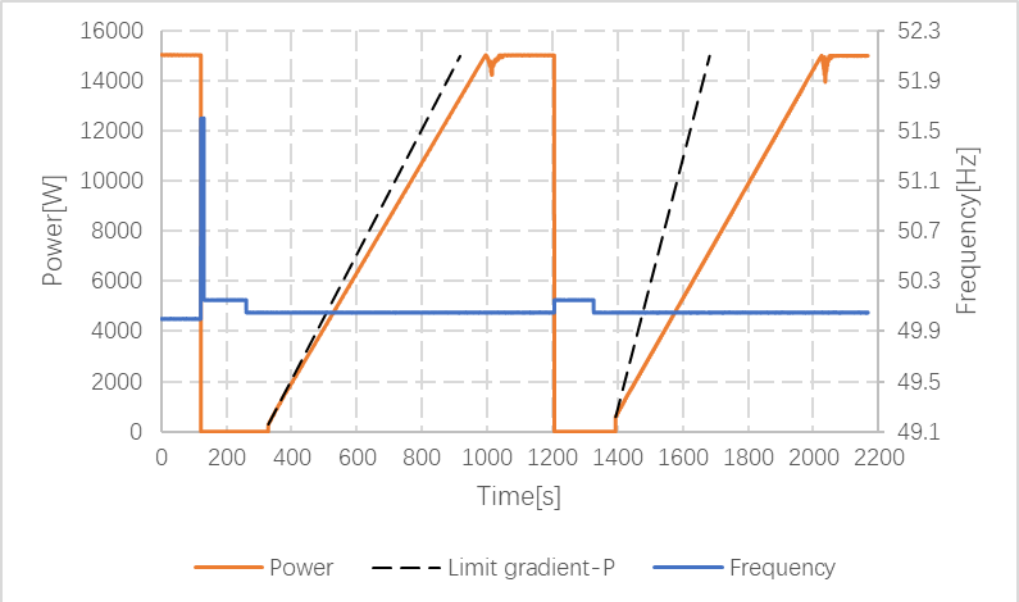
Test sequence after trip	connection	connection allowed	Observation time (s)	Power gradient after connection (%/min)
Step a)	**<49.9Hz**	**No**	--	--
Step b)	**≥49.9Hz**	**Yes**	67.2	8.80
Step c)	**>50.1Hz**	**No**	--	--
Step d)	**≤50.1Hz**	**Yes**	67.6	9.13
Step e)	**<195.5V**	**No**	--	--
Step f)	**≥195.5V**	**Yes**	67.0	8.83
Step g)	**>253V**	**No**	--	--
Step h)	**≤253V**	**Yes**	67.4	8.79
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**	67.4	8.80
Step c)	**>50.1Hz**	**No**	--	--
Step d)	**≤50.1Hz**	**Yes**	67.0	8.82
Step e)	**<195.5V**	**No**	--	--
Step f)	**≥195.5V**	**Yes**	66.6	8.83
Step g)	**>253V**	**No**	--	--
Step h)	**≤253V**	**Yes**	67.6	8.79
Remark: Maximum active power increase gradient 20 %/min.				

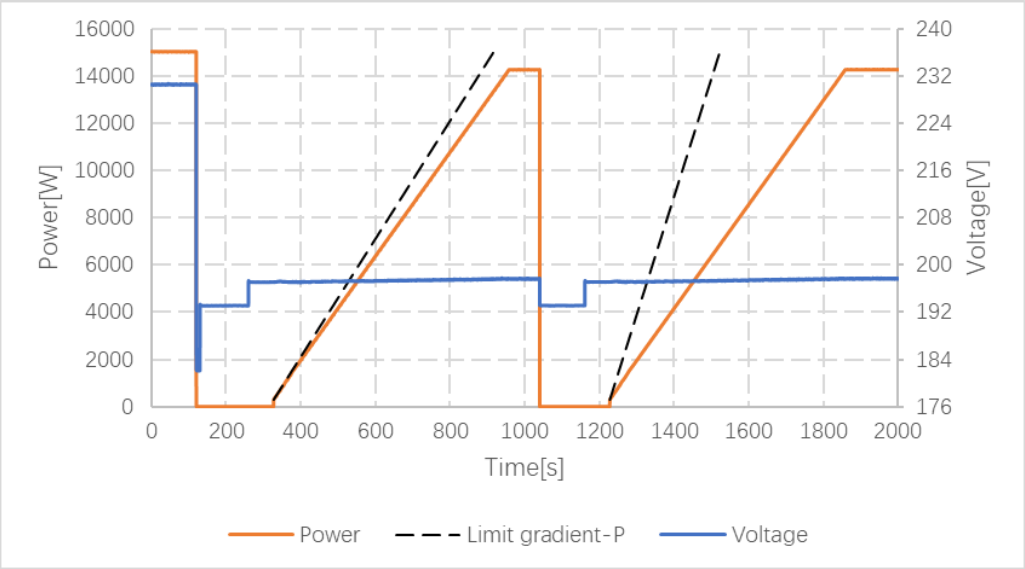
Graph_49.9Hz



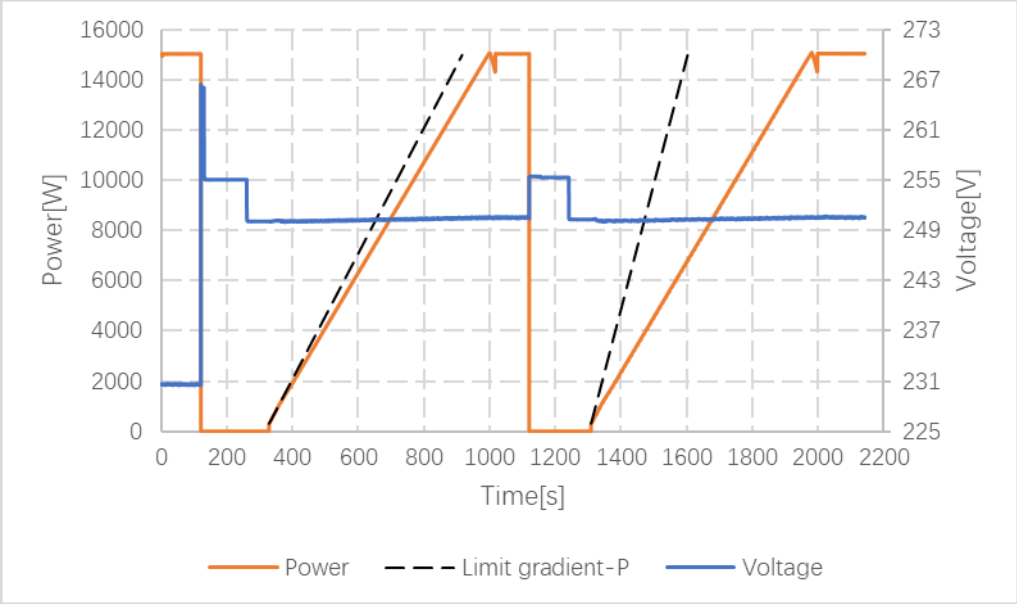
Graph_50.1Hz



Graph_195.5V

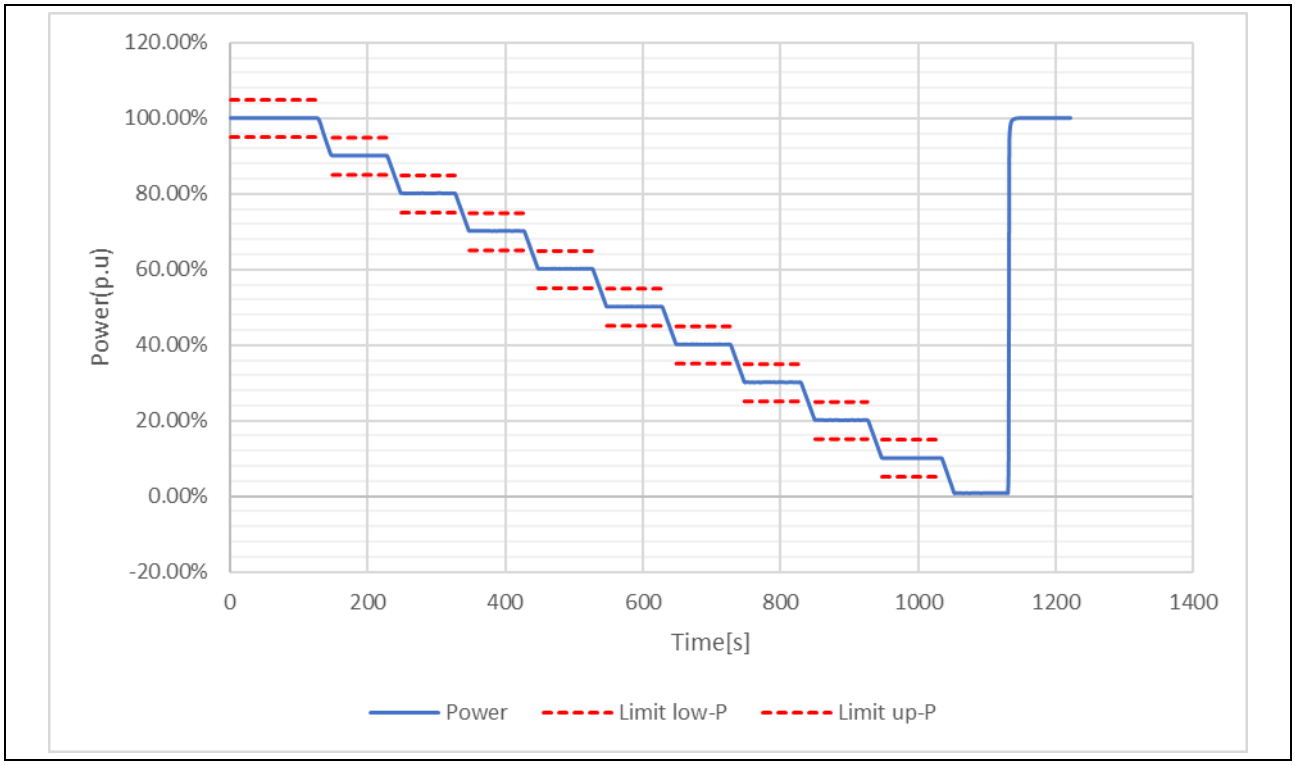


Graph_253V



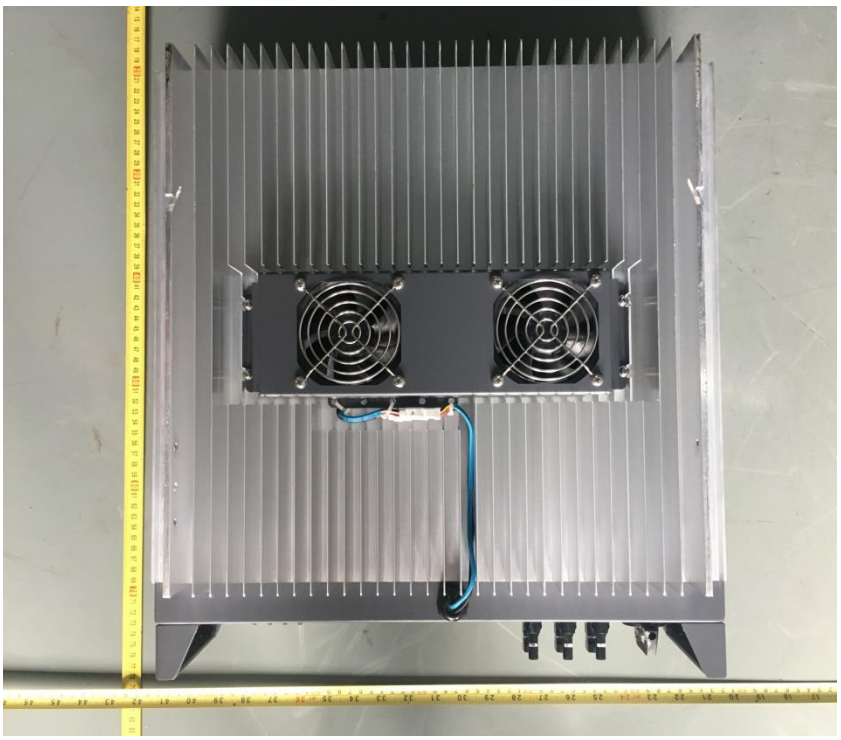
D.9	Table: Ceasing and reduction of active power on set point (Logic interface)						P
String	1	U_{DC} =	600 Vdc	Uac = Un	230 Vac	P_{Emax} (KW)	15.0

1 min mean value P/Pn Psetpoint (%)	Pmeasured (%)	△Pmeasured (%)	Limit [%]
100%	100.24	0.24	±5%
90%	90.29	0.29	±5%
80%	80.28	0.28	±5%
70%	70.26	0.26	±5%
60%	60.23	0.23	±5%
50%	50.20	0.20	±5%
40%	40.17	0.17	±5%
30%	30.13	0.13	±5%
20%	20.09	0.09	±5%
10%	10.04	0.04	±5%
The power gradient for increasing and reducing (%P_n/s)			0.49 %P_n/s
Time for Logic interface (at input port) activated			1.58 s



Annex 1: Photo document

Front view



Rear view

Connection view

Internal view

Internal view (for model SOFAR 10000TL-G2, SOFAR 12000TL-G2)

Internal view (for model SOFAR 15000TL-G2)

(End of Report)