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

Report Reference No……:	200827078GZU-001
Date of issue……:	28 Aug 2020
Total number of pages. ……:	81 pages

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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

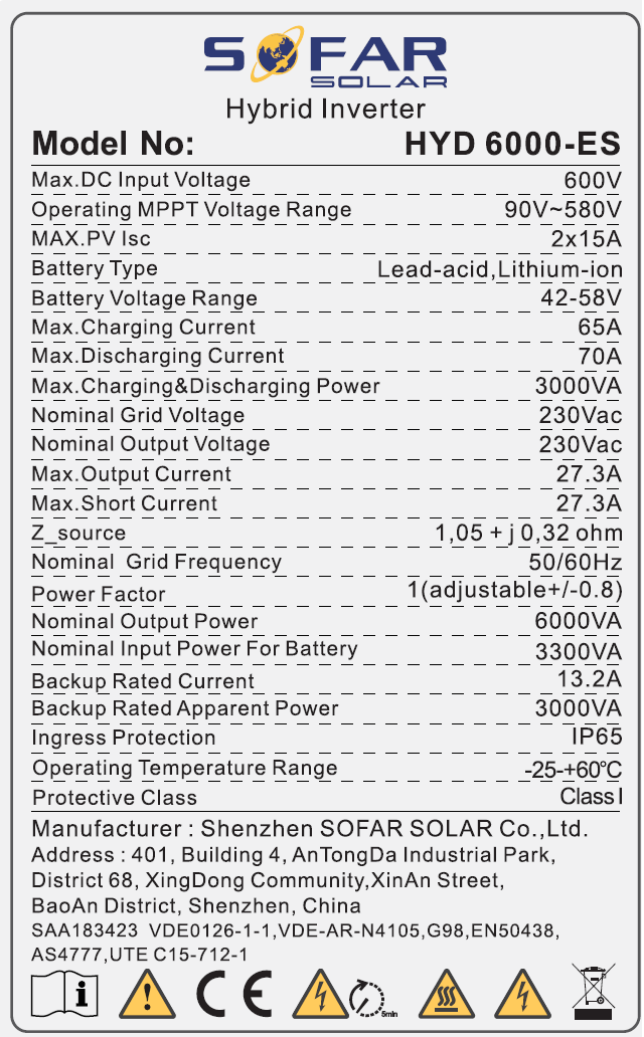
Test item description	Hybrid inverter
Trade Mark.....	SOFAR SOLAR
Manufacturer	Same as Applicant
Model/Type reference	HYD 6000-ES, HYD 5000-ES, HYD 4000-ES, HYD 4600-ES HYD 3600-ES, HYD 3000-ES

Ratings..... See ratings in page 6-7

Summary of testing:

Tests performed (name of test and test clause):	**Testing location:**
All applicable tests Remark: Other than special notice, for all clauses, the model HYD 6000-ES is type tested and valid for other models.	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 – 28 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 report No. 190430037GZU-001, dated 14 Dec 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 hybrid inverter, it can convert the high PV voltage and Grid voltage to low DC for charge battery, also converts PV voltage and battery voltage to AC output.

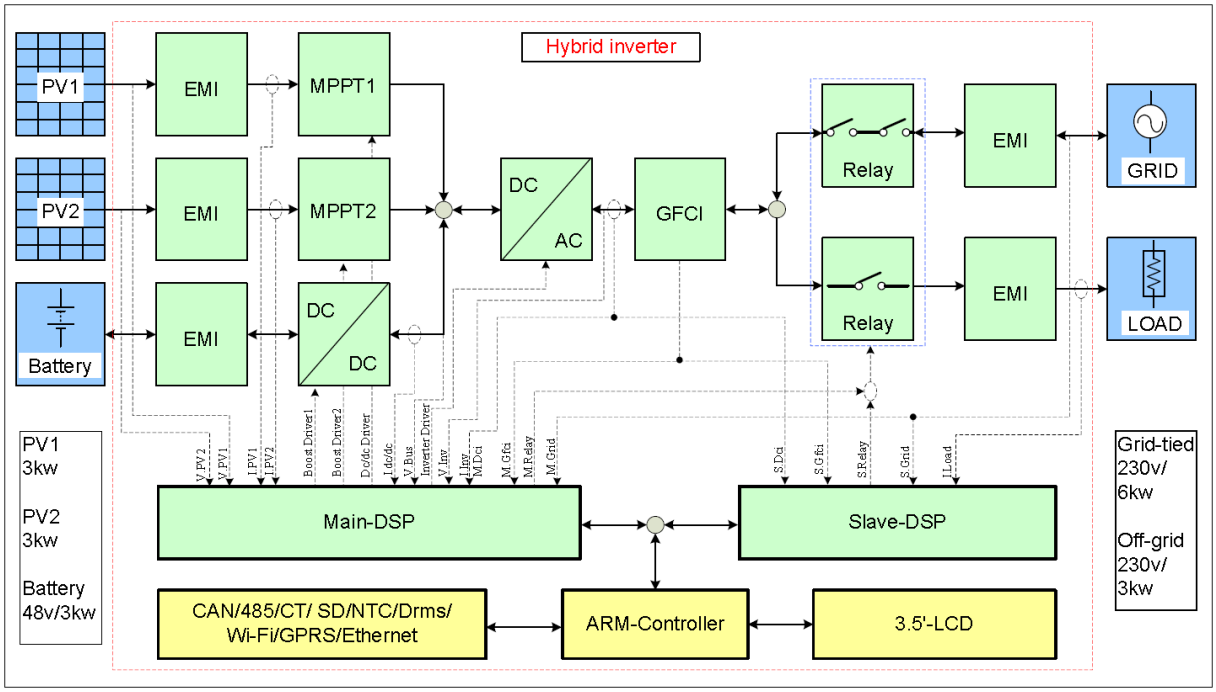
The unit is providing EMC filtering at the PV and battery side. It does provide galvanic separation from PV side to Grid. The battery circuit does provide high frequency isolation to PV side and AC mains.

The unit has two controllers. the master DSP controller monitor the charge or discharge statue; measure the PV voltage and current, battery voltage, bus voltage, buck voltage and current, AC voltage, current, GFCI and frequency.

The slave DSP controller monitor AC voltage, current, frequency, GFCI and communicate with the master controller

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

The topology diagram as following:



Model differences:

The models HYD 3000-ES, HYD 3600-ES, HYD 4000-ES , HYD 4600-ES, HYD 5000-ES and HYD 6000-ES are completely identical and output power derated by software, except for the following table.

Model	HYD 6000-ES	HYD 5000-ES HYD 4600-ES	HYD 4000-ES	HYD 3600-ES	HYD 3000-ES
R332, R334, R336	0Ω, NC, 0Ω		NC, 0Ω, NC		
Bus capacitance	8pcs		6pcs		
INV inductor	0.75mH		1.035mH		
R123, R132	1.5KΩ, 1.5KΩ		499Ω, 499Ω		

The product was tested on:
The Software Version: V2.10
The Hardware Version: V1.00

Ratings:

Model	HYD 3000-ES	HYD 3600-ES	HYD 4000-ES	HYD 4600-ES	HYD 5000-ES	HYD 6000-ES
Max. DC Input Voltage	600 d.c.V					
Max. PV Isc	2 X 15 d.c.A					
Battery Type	Lead-acid, Lithium-ion					
Battery Voltage Range	42-58 d.c.V					
Max. Charging Current	65 d.c.A					
Max. Discharging Current	70 d.c.A					
Max. Charging & Discharging Power	3000VA					
Nominal Grid voltage	230 a.c.V					
Nominal Output Voltage (backup)	230 a.c.V					
Max. output current	13.7 a.c.A	16 a.c.A	18.2 a.c.A	21.0 a.c.A	22.8 a.c.A	27.3 a.c.A
Nominal Grid Frequency	50Hz					
Power Factor	1 (adjustable +/-0.8)					
Nominal output power	3000VA	3680VA	4000VA	4600VA	5000VA	6000VA
Nominal output power for charging battery	3300VA					
Backup Rated	13.2 a.c.A					

current	
Backup Rated Apparent Power	3000VA
Ingress Protection	IP 65
Protective Class	Class I
Operating temperature range	-25 ~ +60℃

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

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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
	- 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

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

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Clause	Requirement - Test	Result - Remark	Verdict
	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
	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

C10/11: ed.2.1, 01 Sep 2019			
Clause	Requirement - Test	Result - Remark	Verdict
	For a synchronous power-generating unit that is part of a power-generating module with a maximum power ≥ 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
	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

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

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

HYD 3000-ES

Normal ambient

Output power:	Flicker limits according to:	Result:		
		Plt	Pst	dc%
33%	EN 61000-3-3	0,07	0,07	0,05
66%	EN 61000-3-3	0,09	0,10	0,09
100%*	EN 61000-3-3	0,14	0,14	0,05

HYD 6000-ES

Normal ambient

Output power:	Flicker limits according to:	Result:		
		Plt	Pst	dc%
33%	EN 61000-3-3	0,10	0,10	0,04
66%	EN 61000-3-3	0,18	0,18	0,07
100%*	EN 61000-3-3	0,35	0,36	1,17

Note:

*The stationary deviance of dc% is bigger than the dynamic deviance of d_{max} at starting and stopping.
Mains Impedance according EN 61000-3-3 / EN 61000-3-11: **R_{max} = 0,24 Ω; jX_{max}= 0,15 Ω @50Hz ($|Z_{max}|$ = 0,283 Ω)**
Bei Einphasigen Invertern Zmax sowie Rn und jxn angeben **R_n = 0,16 Ω; jX_n= 0,1 Ω**

Calculation of the maximum permissible grid impedance at the point of common coupling based on d_c:
$Z_{max} = Z_{ref} * 3,3\% / d_c(P_n)$

The tests should be based on the limits of the EN61000-3-3 for less than 16A and on EN 61000-3-11 for more than 16A.

The tests had been performed on the HYD 3000-ES and HYD 6000-ES are valid for the HYD 3600-ES, HYD 4000-ES and HYD 5000-ES since it is similar in hardware and just power derated by software.

8.2.4	TABLE: Current harmonics emission test	P

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

Model: HYD 3000-ES

100% rating power condition:

Normal ambient (EN 61000-3-2) Output power 100%				
HYD 3000-ES				
Watts		3091		
Vrms		230,54		
Arms		13,490		
Frequency		50,00 Hz		
THD		1,69 %		
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (A)
1st	13,488	99,982	Single Phase	--
2nd	0,027	0,196	Single Phase	1,080
3rd	0,197	1,459	Single Phase	2,300
4th	0,021	0,153	Single Phase	0,430
5th	0,073	0,543	Single Phase	1,140
6th	0,016	0,115	Single Phase	0,300
7th	0,045	0,334	Single Phase	0,770
8th	0,013	0,098	Single Phase	0,230
9th	0,026	0,193	Single Phase	0,400
10th	0,011	0,082	Single Phase	0,184
11th	0,016	0,118	Single Phase	0,330
12th	0,008	0,062	Single Phase	0,153
13th	0,014	0,107	Single Phase	0,210
14th	0,007	0,051	Single Phase	0,131
15th	0,014	0,103	Single Phase	0,150
16th	0,006	0,047	Single Phase	0,115
17th	0,014	0,106	Single Phase	0,132
18th	0,006	0,042	Single Phase	0,102
19th	0,016	0,118	Single Phase	0,118
20th	0,005	0,039	Single Phase	0,092
21th	0,016	0,117	Single Phase	0,107
22th	0,006	0,042	Single Phase	0,084
23th	0,015	0,113	Single Phase	0,098
24th	0,006	0,041	Single Phase	0,077
25th	0,016	0,116	Single Phase	0,090
26th	0,014	0,102	Single Phase	0,071
27th	0,015	0,109	Single Phase	0,083
28th	0,005	0,038	Single Phase	0,066
29th	0,014	0,102	Single Phase	0,078
30th	0,005	0,034	Single Phase	0,061
31th	0,013	0,096	Single Phase	0,073
32th	0,005	0,033	Single Phase	0,058
33th	0,012	0,088	Single Phase	0,068
34th	0,005	0,034	Single Phase	0,054
35th	0,012	0,087	Single Phase	0,064
36th	0,004	0,033	Single Phase	0,051
37th	0,012	0,087	Single Phase	0,061
38th	0,004	0,033	Single Phase	0,048
39th	0,011	0,078	Single Phase	0,058
40th	0,004	0,033	Single Phase	0,046

8.2.4	TABLE: Current harmonics emission test	P

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

Model: HYD 3000-ES

66% rating power condition:

Normal ambient (EN 61000-3-2) Output power 66%				
HYD 3000-ES				
Watts		2041		
Vrms		230,40		
Arms		8,963		
Frequency		50,00 Hz		
THD* (66% output power)		2,38%		
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (A)
1st	8,961	99,973	Single Phase	--
2nd	0,018	0,204	Single Phase	1,080
3rd	0,184	2,052	Single Phase	2,300
4th	0,014	0,158	Single Phase	0,430
5th	0,076	0,846	Single Phase	1,140
6th	0,012	0,137	Single Phase	0,300
7th	0,045	0,507	Single Phase	0,770
8th	0,010	0,108	Single Phase	0,230
9th	0,025	0,276	Single Phase	0,400
10th	0,007	0,081	Single Phase	0,184
11th	0,013	0,145	Single Phase	0,330
12th	0,006	0,068	Single Phase	0,153
13th	0,011	0,117	Single Phase	0,210
14th	0,005	0,060	Single Phase	0,131
15th	0,012	0,131	Single Phase	0,150
16th	0,005	0,057	Single Phase	0,115
17th	0,012	0,129	Single Phase	0,132
18th	0,005	0,055	Single Phase	0,102
19th	0,013	0,144	Single Phase	0,118
20th	0,005	0,054	Single Phase	0,092
21th	0,014	0,152	Single Phase	0,107
22th	0,005	0,057	Single Phase	0,084
23th	0,013	0,143	Single Phase	0,098
24th	0,005	0,052	Single Phase	0,077
25th	0,013	0,147	Single Phase	0,090
26th	0,012	0,136	Single Phase	0,071
27th	0,012	0,132	Single Phase	0,083
28th	0,005	0,051	Single Phase	0,066
29th	0,011	0,122	Single Phase	0,078
30th	0,004	0,048	Single Phase	0,061
31th	0,011	0,117	Single Phase	0,073
32th	0,004	0,049	Single Phase	0,058
33th	0,010	0,108	Single Phase	0,068
34th	0,004	0,047	Single Phase	0,054
35th	0,009	0,105	Single Phase	0,064
36th	0,004	0,047	Single Phase	0,051
37th	0,010	0,108	Single Phase	0,061
38th	0,004	0,046	Single Phase	0,048
39th	0,010	0,106	Single Phase	0,058
40th	0,004	0,046	Single Phase	0,046

8.2.4	TABLE: Current harmonics emission test	P

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

Model: HYD 3000-ES

33% rating power condition:

Normal ambient (EN 61000-3-2) Output power 33%				
HYD 3000-ES				
Watts		1009		
Vrms		230,23		
Arms		4,580		
Frequency		50,00		
THD* (33% output power)		5,11%		
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (A)
1st	4,560	99,572	Single Phase	--
2nd	0,012	0,255	Single Phase	1,080
3rd	0,192	4,197	Single Phase	2,300
4th	0,010	0,218	Single Phase	0,430
5th	0,083	1,803	Single Phase	1,140
6th	0,007	0,146	Single Phase	0,300
7th	0,042	0,913	Single Phase	0,770
8th	0,006	0,131	Single Phase	0,230
9th	0,019	0,421	Single Phase	0,400
10th	0,006	0,129	Single Phase	0,184
11th	0,011	0,229	Single Phase	0,330
12th	0,006	0,122	Single Phase	0,153
13th	0,011	0,238	Single Phase	0,210
14th	0,005	0,107	Single Phase	0,131
15th	0,013	0,286	Single Phase	0,150
16th	0,005	0,105	Single Phase	0,115
17th	0,015	0,332	Single Phase	0,132
18th	0,005	0,107	Single Phase	0,102
19th	0,017	0,371	Single Phase	0,118
20th	0,005	0,109	Single Phase	0,092
21th	0,018	0,391	Single Phase	0,107
22th	0,005	0,103	Single Phase	0,084
23th	0,018	0,384	Single Phase	0,098
24th	0,005	0,103	Single Phase	0,077
25th	0,017	0,365	Single Phase	0,090
26th	0,007	0,162	Single Phase	0,071
27th	0,016	0,349	Single Phase	0,083
28th	0,005	0,100	Single Phase	0,066
29th	0,016	0,347	Single Phase	0,078
30th	0,005	0,100	Single Phase	0,061
31th	0,016	0,341	Single Phase	0,073
32th	0,005	0,100	Single Phase	0,058
33th	0,014	0,314	Single Phase	0,068
34th	0,005	0,100	Single Phase	0,054
35th	0,013	0,293	Single Phase	0,064
36th	0,005	0,098	Single Phase	0,051
37th	0,013	0,290	Single Phase	0,061
38th	0,004	0,094	Single Phase	0,048
39th	0,013	0,290	Single Phase	0,058
40th	0,004	0,094	Single Phase	0,046

8.2.4	TABLE: Current harmonics emission test	P

Current harmonics emission test for class A limit (According to EN 61000-3-12)

Model: HYD 6000-ES

100% rating power condition:

Normal ambient (EN 61000-3-12) Output power 100%				
HYD 6000-ES				
Watts		5925		
Vrms		230,89		
Arms		25,73		
Frequency		50,00 Hz		
THD* (100% output power)		1,14		
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (%)
1st	25,730	99,993	Single Phase	--
2nd	0,053	0,207	Single Phase	8,000
3rd	0,238	0,925	Single Phase	21,600
4th	0,043	0,167	Single Phase	4,000
5th	0,050	0,195	Single Phase	10,700
6th	0,037	0,145	Single Phase	2,667
7th	0,054	0,210	Single Phase	7,200
8th	0,029	0,114	Single Phase	2,000
9th	0,033	0,127	Single Phase	3,800
10th	0,020	0,077	Single Phase	1,600
11th	0,039	0,152	Single Phase	3,100
12th	0,023	0,090	Single Phase	1,333
13th	0,024	0,092	Single Phase	2,000
14th	0,022	0,085	Single Phase	N/A
15th	0,038	0,148	Single Phase	N/A
16th	0,013	0,049	Single Phase	N/A
17th	0,033	0,130	Single Phase	N/A
18th	0,015	0,060	Single Phase	N/A
19th	0,024	0,095	Single Phase	N/A
20th	0,021	0,083	Single Phase	N/A
21th	0,036	0,142	Single Phase	N/A
22th	0,011	0,041	Single Phase	N/A
23th	0,025	0,097	Single Phase	N/A
24th	0,017	0,064	Single Phase	N/A
25th	0,027	0,104	Single Phase	N/A
26th	0,035	0,137	Single Phase	N/A
27th	0,030	0,118	Single Phase	N/A
28th	0,014	0,055	Single Phase	N/A
29th	0,018	0,069	Single Phase	N/A
30th	0,011	0,043	Single Phase	N/A
31th	0,021	0,083	Single Phase	N/A
32th	0,014	0,055	Single Phase	N/A
33th	0,022	0,085	Single Phase	N/A
34th	0,009	0,035	Single Phase	N/A
35th	0,015	0,057	Single Phase	N/A
36th	0,008	0,031	Single Phase	N/A
37th	0,017	0,068	Single Phase	N/A
38th	0,011	0,042	Single Phase	N/A
39th	0,018	0,068	Single Phase	N/A
40th	0,008	0,030	Single Phase	N/A

8.2.4	TABLE: Current harmonics emission test	P

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

Model: HYD 3000-ES

66% rating power condition:

Normal ambient (EN 61000-3-12) Output power 66%				
HYD 6000-ES				
Watts	3942			
Vrms	230,61			
Arms	17,17			
Frequency	50,00 Hz			
THD* (66% output power)	1,42%			
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (%)
1st	17,171	99,990	Single Phase	--
2nd	0,035	0,206	Single Phase	8,000
3rd	0,209	1,218	Single Phase	21,600
4th	0,027	0,156	Single Phase	4,000
5th	0,070	0,409	Single Phase	10,700
6th	0,020	0,115	Single Phase	2,667
7th	0,044	0,259	Single Phase	7,200
8th	0,016	0,095	Single Phase	2,000
9th	0,026	0,152	Single Phase	3,800
10th	0,013	0,073	Single Phase	1,600
11th	0,019	0,110	Single Phase	3,100
12th	0,011	0,064	Single Phase	1,333
13th	0,018	0,104	Single Phase	2,000
14th	0,009	0,054	Single Phase	N/A
15th	0,018	0,105	Single Phase	N/A
16th	0,008	0,045	Single Phase	N/A
17th	0,018	0,103	Single Phase	N/A
18th	0,007	0,040	Single Phase	N/A
19th	0,018	0,107	Single Phase	N/A
20th	0,006	0,035	Single Phase	N/A
21th	0,018	0,107	Single Phase	N/A
22th	0,007	0,038	Single Phase	N/A
23th	0,018	0,102	Single Phase	N/A
24th	0,006	0,038	Single Phase	N/A
25th	0,017	0,102	Single Phase	N/A
26th	0,015	0,086	Single Phase	N/A
27th	0,017	0,097	Single Phase	N/A
28th	0,006	0,033	Single Phase	N/A
29th	0,015	0,089	Single Phase	N/A
30th	0,005	0,029	Single Phase	N/A
31th	0,014	0,083	Single Phase	N/A
32th	0,005	0,029	Single Phase	N/A
33th	0,013	0,077	Single Phase	N/A
34th	0,005	0,028	Single Phase	N/A
35th	0,013	0,078	Single Phase	N/A
36th	0,004	0,026	Single Phase	N/A
37th	0,013	0,073	Single Phase	N/A
38th	0,005	0,027	Single Phase	N/A
39th	0,011	0,065	Single Phase	N/A
40th	0,005	0,027	Single Phase	N/A

8.2.4	TABLE: Current harmonics emission test	P

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

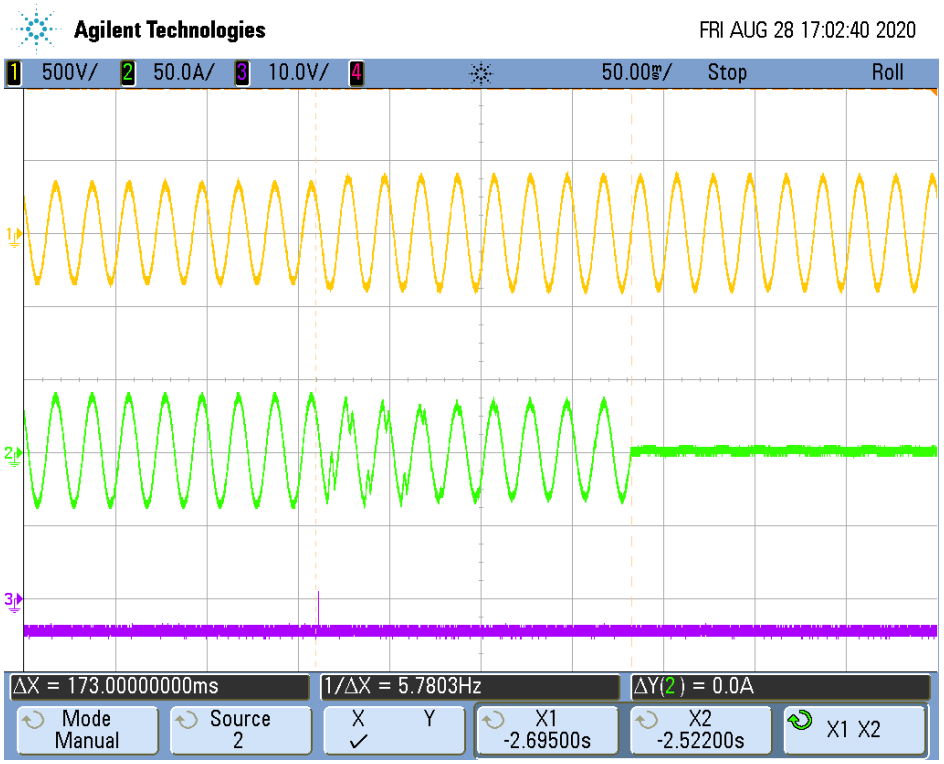
Model: HYD 3000-ES

33% rating power condition:

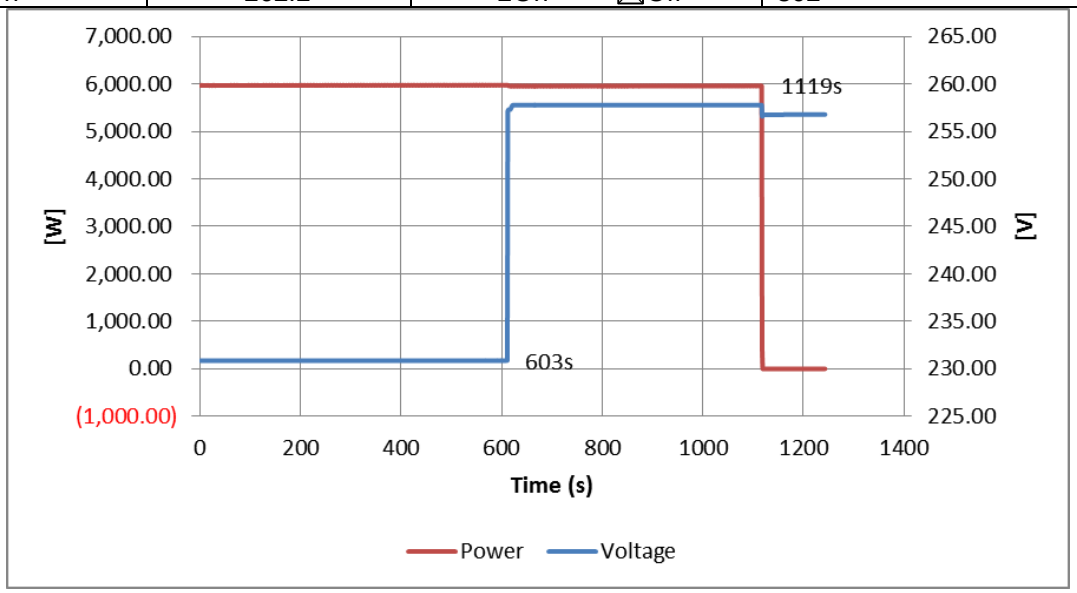
Normal ambient (EN 61000-3-12) Output power 33%				
HYD 6000-ES				
Watts	1975			
Vrms	230,42			
Arms	8,69			
Frequency	50,00			
THD* (33% output power)	2,44%			
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (%)
1st	8,688	99,970	Single Phase	--
2nd	0,018	0,206	Single Phase	8,000
3rd	0,183	2,102	Single Phase	21,600
4th	0,014	0,164	Single Phase	4,000
5th	0,076	0,872	Single Phase	10,700
6th	0,012	0,142	Single Phase	2,667
7th	0,045	0,519	Single Phase	7,200
8th	0,010	0,111	Single Phase	2,000
9th	0,024	0,280	Single Phase	3,800
10th	0,008	0,088	Single Phase	1,600
11th	0,013	0,148	Single Phase	3,100
12th	0,006	0,072	Single Phase	1,333
13th	0,011	0,124	Single Phase	2,000
14th	0,006	0,064	Single Phase	N/A
15th	0,011	0,129	Single Phase	N/A
16th	0,005	0,060	Single Phase	N/A
17th	0,011	0,132	Single Phase	N/A
18th	0,005	0,056	Single Phase	N/A
19th	0,013	0,151	Single Phase	N/A
20th	0,005	0,056	Single Phase	N/A
21th	0,014	0,156	Single Phase	N/A
22th	0,005	0,054	Single Phase	N/A
23th	0,013	0,147	Single Phase	N/A
24th	0,005	0,056	Single Phase	N/A
25th	0,013	0,150	Single Phase	N/A
26th	0,013	0,146	Single Phase	N/A
27th	0,012	0,137	Single Phase	N/A
28th	0,005	0,053	Single Phase	N/A
29th	0,011	0,127	Single Phase	N/A
30th	0,004	0,048	Single Phase	N/A
31th	0,010	0,119	Single Phase	N/A
32th	0,004	0,050	Single Phase	N/A
33th	0,009	0,106	Single Phase	N/A
34th	0,004	0,047	Single Phase	N/A
35th	0,009	0,105	Single Phase	N/A
36th	0,004	0,048	Single Phase	N/A
37th	0,010	0,110	Single Phase	N/A
38th	0,004	0,046	Single Phase	N/A
39th	0,010	0,110	Single Phase	N/A
40th	0,004	0,047	Single Phase	N/A

D.3	Table: Overvoltage threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [V]	264.5	264.87	264.48	264.36	264.5±2.3
Trip time [ms]	No delay	173.0	164.0	170.5	<200

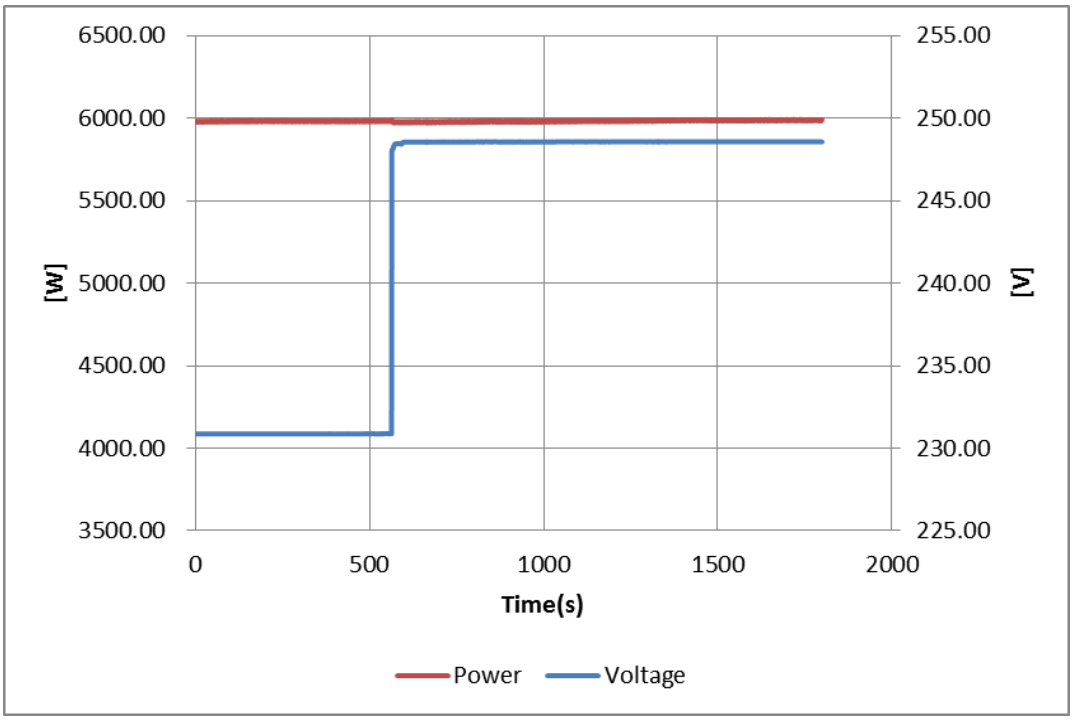
Trip time



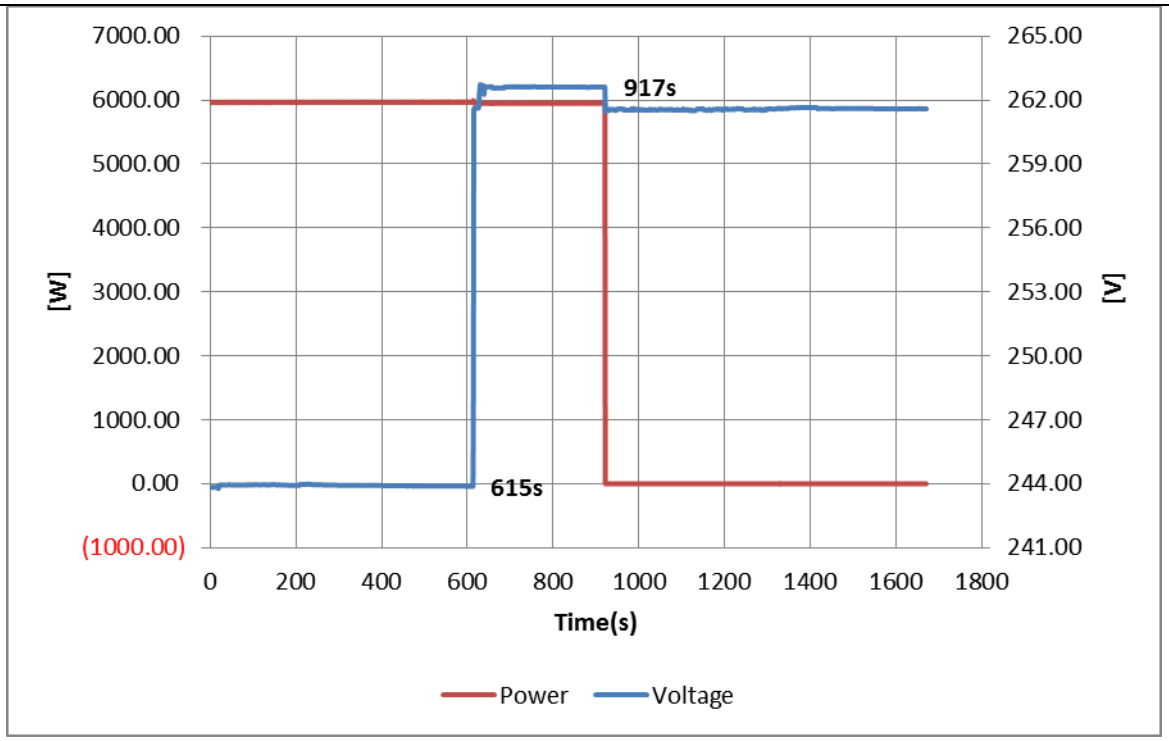
D.3	Protective functions (Results of the Protection of the Increase in Voltage as 10-min moving average)		
	Output Voltage (V)	Switch	
		On/Off state Finally	Time until Switch off (s)
100% Un	230.0	☒On □Off	Work normally
112% Un	257.6	□On ☒Off	516
100% Un	230.0	☒On □Off	Work normally
108% Un	248.4	☒On □Off	Work normally
106% Un	243.8	☒On □Off	Work normally
114% Un	262.2	□On ☒Off	302



Un to 1.12Un



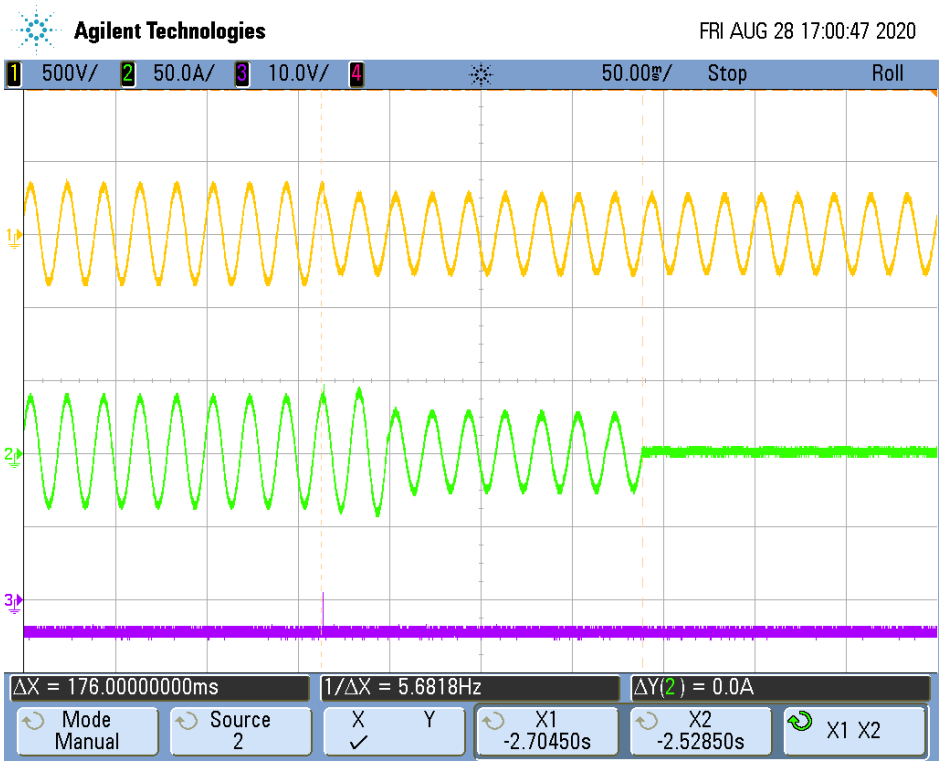
Un to 1.08Un



1.06 Un to 1.14Un

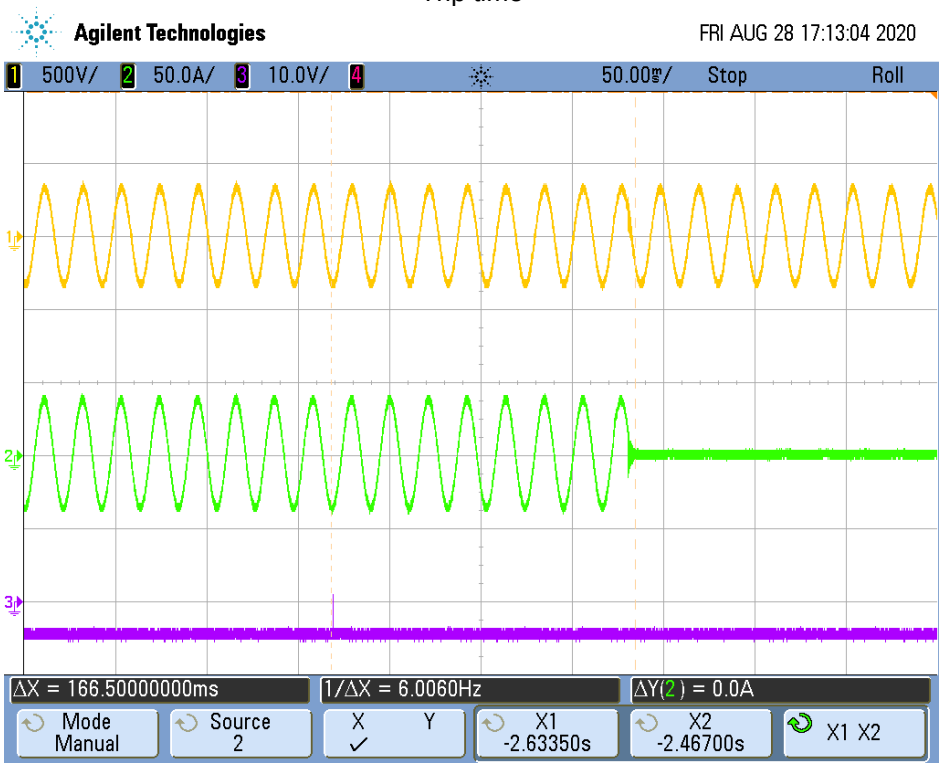
D.3	Table: Undervoltage threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [V]	184	183.59	183.67	183.95	184±2.3
Trip time [ms]	No delay	168.5	176.0	175.5	<200

Trip time



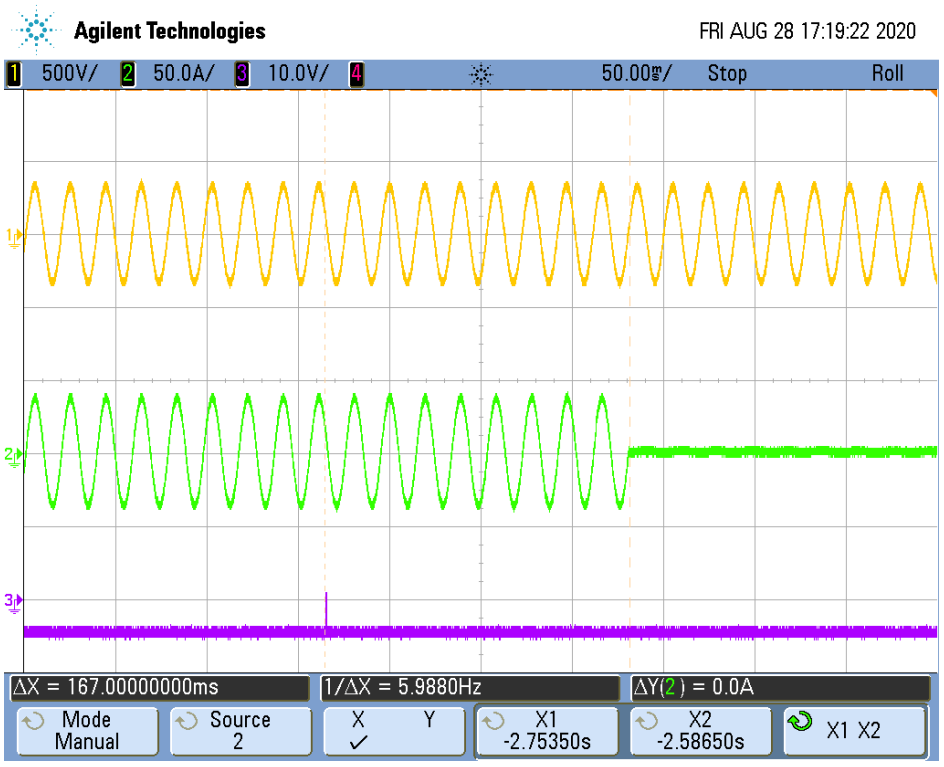
D.3	Table: Underfrequency threshold stage				P
Parameter	**Settings**	**Test 1**	**Test 2**	**Test 3**	**Limits**
Trip value [Hz]	47.5	47.48	47.48	47.48	47.5±0.05
Trip time [ms]	No delay	151.5	155.0	166.5	<200

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	51.52	51.52	51.5±0.05
Trip time [ms]	No delay	165.5	153.5	167.0	<200

Trip time

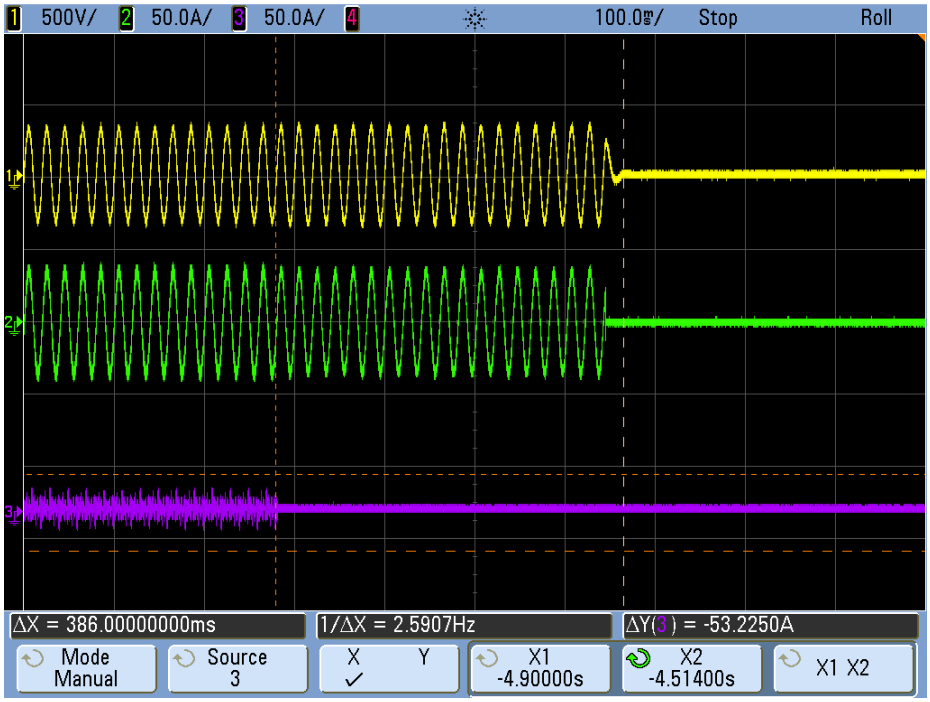


D.3	Table: Islanding	P

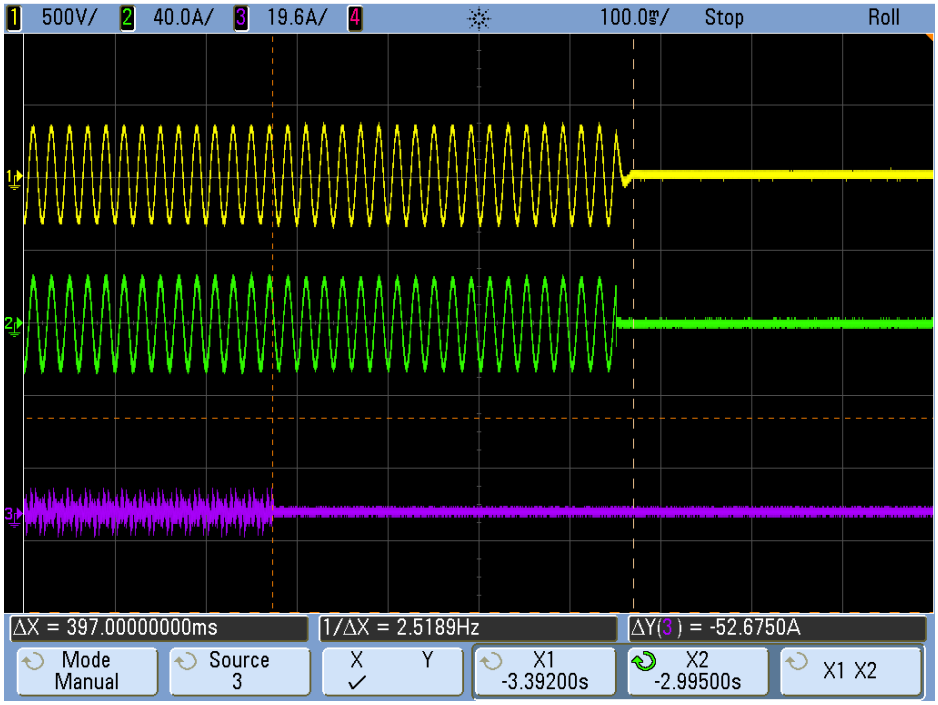
No.	PEUT[1] (% of EUT rating)	Reactive load (% of QL in 6.1.d)1)	PAC[2] (% of nominal)	QAC[3] (% of nominal)	Run on time (ms)	PEUT (W)	Actual Qf	VDC	Remarks[4]
1	100	100	0	0	386.0	6040	1.00	550	Test A at BL
2	66	66	0	0	242.0	3960	1.00	340	Test B at BL
3	33	33	0	0	312.0	1980	1.00	130	Test C at BL
4	100	100	-5	-5	210.0	6040	1.02	550	Test A at IB
5	100	100	-5	0	194.5	6040	1.00	550	Test A at IB
6	100	100	-5	5	244.5	6040	0.97	550	Test A at IB
7	100	100	0	-5	199.0	6040	1.02	550	Test A at IB
8	100	100	0	5	204.0	6040	1.00	550	Test A at IB
9	100	100	5	-5	268.0	6040	0.97	550	Test A at IB
10	100	100	5	0	288.0	6040	1.02	550	Test A at IB
11	100	100	5	5	274.0	6040	1.00	550	Test A at IB
12	66	66	0	-5	300.0	3960	1.02	340	Test B at IB
13	66	66	0	-4	345.0	3960	1.02	340	Test B at IB
14	66	66	0	-3	228.5	3960	1.01	340	Test B at IB
15	66	66	0	-2	228.0	3960	1.01	340	Test B at IB
16	66	66	0	-1	209.5	3960	1.00	340	Test B at IB
17	66	66	0	1	292.0	3960	0.99	340	Test B at IB
18	66	66	0	2	397.0	3960	0.99	340	Test B at IB
19	66	66	0	3	254.8	3960	0.98	340	Test B at IB
20	66	66	0	4	277.6	3960	0.98	340	Test B at IB
21	66	66	0	5	259.2	3960	0.97	340	Test B at IB
22	33	33	0	-5	252.9	1980	1.02	130	Test C at IB
23	33	33	0	-4	292.5	1980	1.02	130	Test C at IB
24	33	33	0	-3	198.8	1980	1.01	130	Test C at IB
25	33	33	0	-2	357.0	1980	1.01	130	Test C at IB
26	33	33	0	-1	231.3	1980	1.00	130	Test C at IB
27	33	33	0	1	315.0	1980	0.99	130	Test C at IB
28	33	33	0	2	234.4	1980	0.99	130	Test C at IB
29	33	33	0	3	266.4	1980	0.98	130	Test C at IB
30	33	33	0	4	247.8	1980	0.98	130	Test C at IB
31	33	33	0	5	216.9	1980	0.97	130	Test C at IB

Remark:

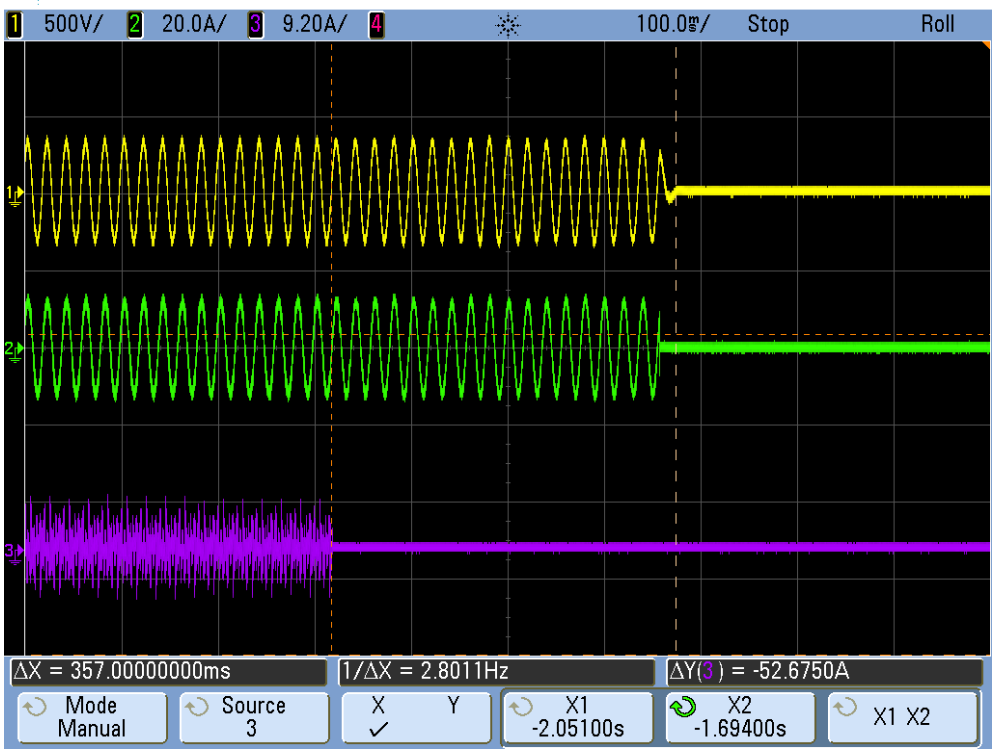
1) PEUT: EUT output power
2) PAC: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0% test condition value.
3) QAC: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0% test condition value.
4) BL: Balance condition, 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%, = 386.0ms



P_{EUT} 66%, P_{AC} 0%, Q_{AC} 2%, = 397.0ms



P_{EUT} 33%, P_{AC} 0%, Q_{AC} -2%, = 357.0ms

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 RY1 defect	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
2.	Relay RY2 defect	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
3.	Relay RY3 defect	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
4.	Relay RY4 defect	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
5.	Relay RY5 defect	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
6.	Relay RY6 defect	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
7.	Monitoring voltage defect R508	short	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid. Q59 damage. No hazards.

8.	Monitoring voltage defect Q59 pin 1-2	short	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). No damage, no hazards.
9.	Monitoring voltage defect U46 pin 1-2	short	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). U46 damage, no hazards.
10.	Monitoring voltage defect R511	short	Input:520Vdc Output:230Vac	23mins	--	--	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). U46 damage, no hazards.
11.	Monitoring voltage defect R509	open	Input:520Vdc Output:230Vac	10min	--	--	The unit was in check state. No damage. No hazards.
12.	Monitoring voltage defect U46 pin 3-4	short	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). U46 damage, no hazards.
13.	Voltage measurement disabled R204	Open	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid , error code “ID01” (The grid voltage is too high). No damage. No hazards.
14.	Loss of control XL1	Short	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid , error code “ID53, ID54” (SPI communication is fault, SCI communication is fault). No damage. No hazards.
15.	Loss of control C738(3.3VDD)	Short	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid , error code “ID53, ID54” (SPI communication is fault, SCI communication is fault). No damage. No hazards.

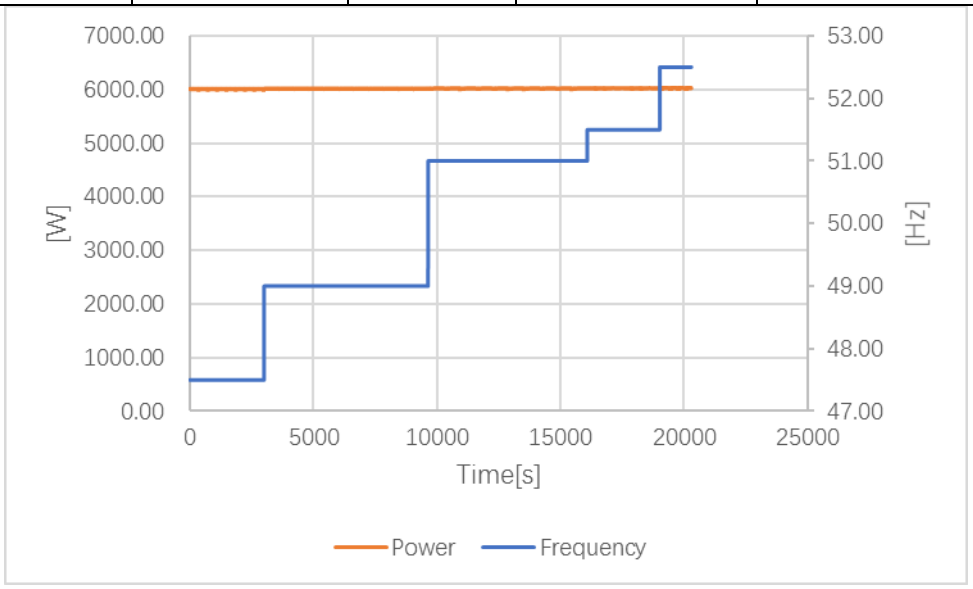
16.	Communication microcontroller defect U4 pin1 to pin2	Short	Input:520Vdc Output:230Vac	10min	--	--	Output a.c. relays operated, disconnected with grid , error code “ID53, ID54, ID75” (SPI communication is fault, SCI communication is fault, Unrecoverable EEPROM write). No damage. No hazards.
17.	ISO defect R531	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
18.	ISO defect R598	Open circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
19.	ISO defect R602	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
20.	ISO defect R605	Open circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
21.	ISO defect R355	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
22.	ISO defect R303	Open circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.

23.	ISO defect R307	Short circuit before energized	Input:520Vdc Output:230Vac	10min	--	--	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
24.	GFCI defect R292	GFCI defect R292	Input:520Vdc Output:230Vac	10min	--	--	Indicate GFCI fault, error code “ID48” (The GFCI sampling value between the master DSP and slave DSP is not consistent). Do not connect to AC mainsn. No damage, no hazards.
25.	GFCI defect R297	GFCI defect R297	Input:520Vdc Output:230Vac	10min	--	--	Indicate GFCI fault, error code “ID48” (The GFCI sampling value between the master DSP and slave DSP is not consistent). Do not connect to AC mainsn. No damage, no hazards.
Supplement: s-c: short-circuited, o-c: open-circuited, o-l: overload							

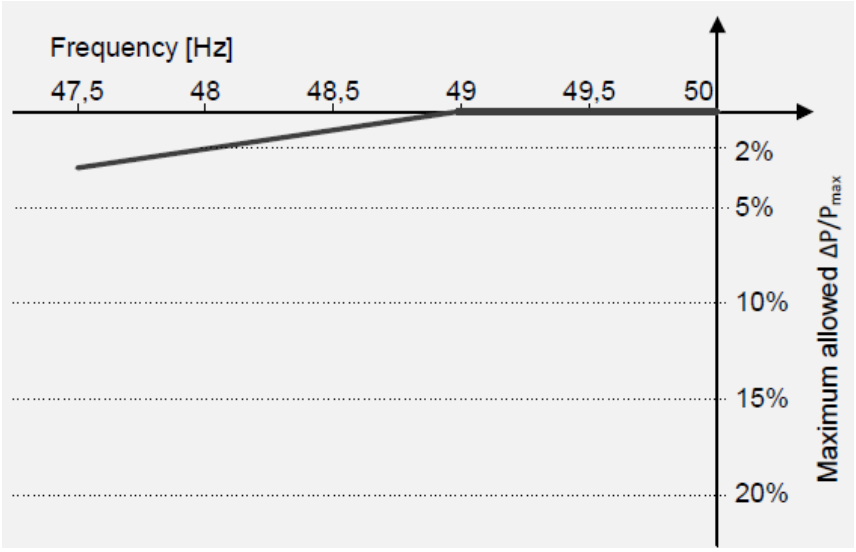
D.4.1	Table: Operating frequency range	P

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	31min	Operated normally.
2	49.0 Hz	49.00	Permanent	110min	Operated normally.
3	51.0 Hz	51.00	Permanent	110min	Operated normally.
4	51.5 Hz	51.50	>30 min	40min	Operated normally.
5	52.5 Hz	52.50	>15 min*	20min	Operated normally.

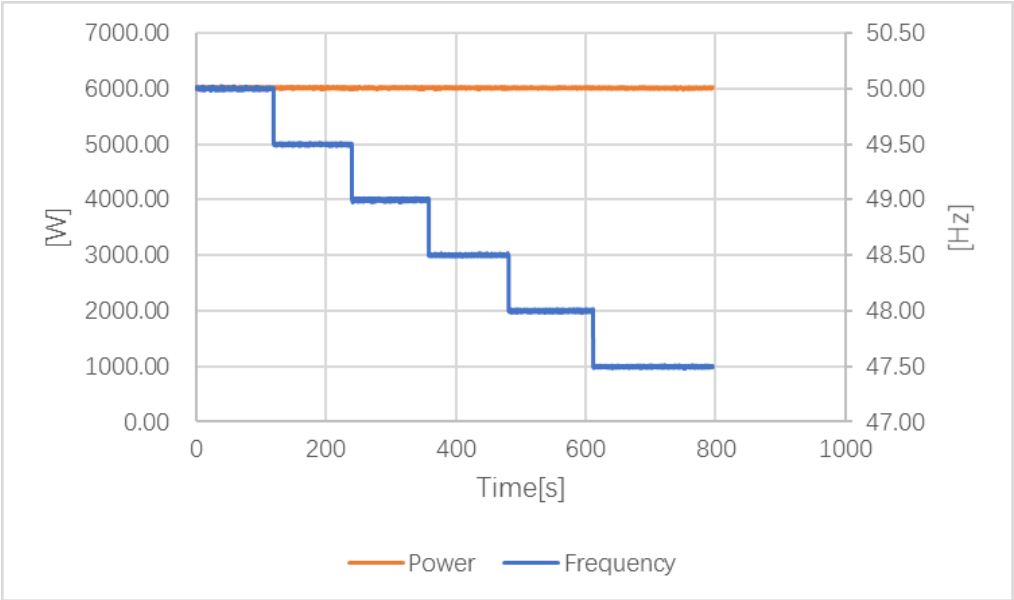


D.4.2	Table: Minimal requirements for active power delivery at underfrequency	P



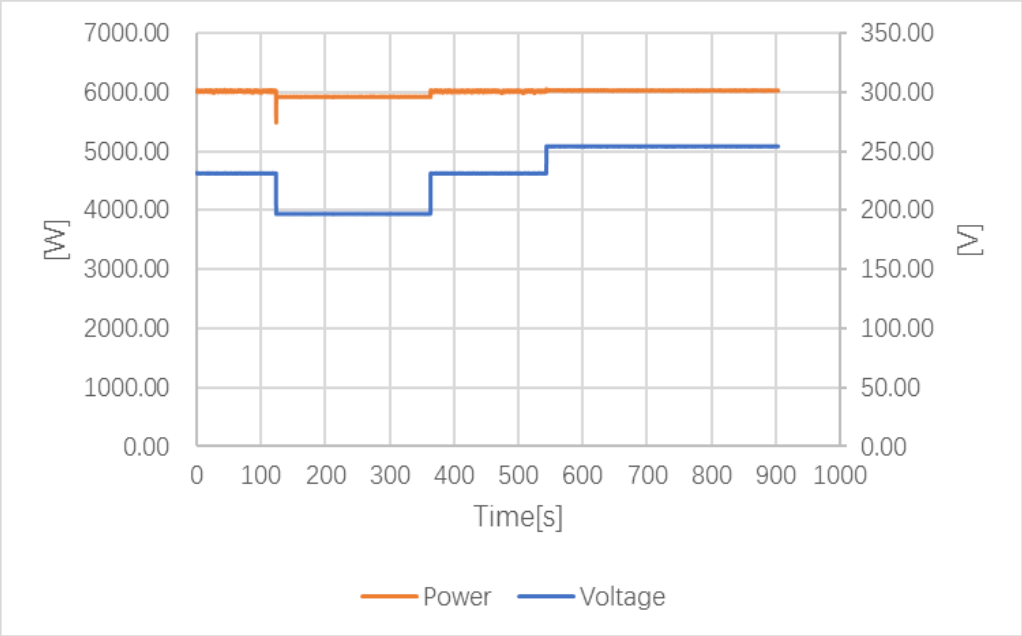
Step	f (Hz)	fmea. (Hz)	T (s)	T meas. (s)	P (%) - max	P (%) - min	P meas. (%)
1	50,00 ± 0.05	50.0	>60	90	100%	100%	100.26
2	49.50 ± 0,05	49.5	>60	90	100%	100%	100.24
3	49.00 ± 0,05	49.0	>60	89	100%	100%	100.23
4	48.50 ± 0,05	48.5	>60	89	100%	99%	100.21
5	48.00 ± 0,05	48.0	>60	89	100%	98%	100.23
6	47.50 ± 0,05	47.5	>60	89	100%	97%	100.15

Supplementary information:

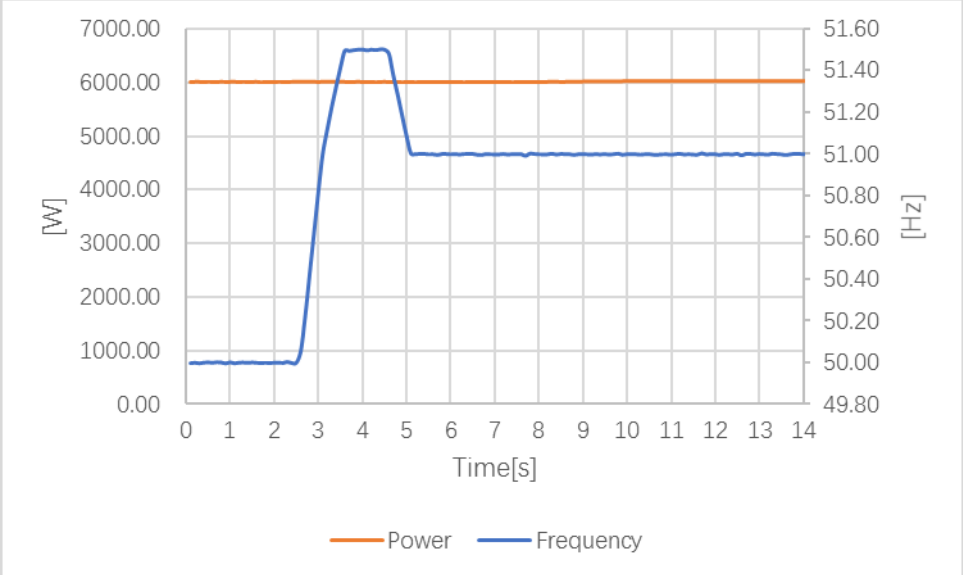


D.4.3	Table: Continuous voltage operation range				P
Step	Voltage (%)	P (%)	P meas. (%)	Time (s)	T meas (s)
1	100	100	101.82	>60	123.6
2	85	100 (*)	90.11	>120	240.00
3	100	100	99.83	>5	179.90
4	110	100	101.19	>120	360.00

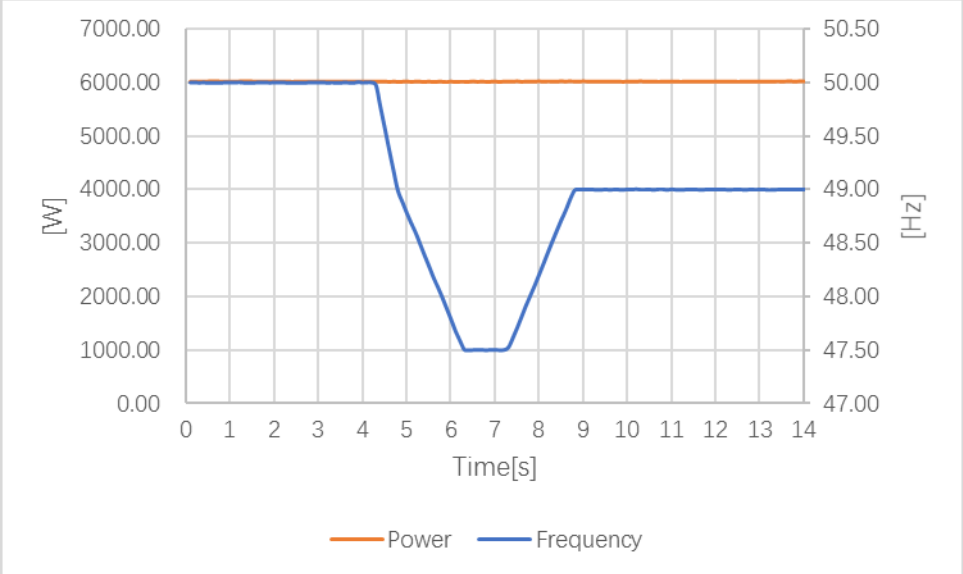
(*) Active power reduction is allowed due to current limitation.



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	6015.51	50,0 to 49.0	0.5	6018.71
2	51,0 to 51.5	0.5	6016.81	49,0 to 47.5	1.5	6018.03
3	51,5	1	6013.03	47,5	1	6020.05
4	51.5 to 51.0	0.5 s	6017.15	47.5 to 49.0	1.5	6020.46
5	51.0	3.0 s	6014.83	49.0	0.5	6019.93

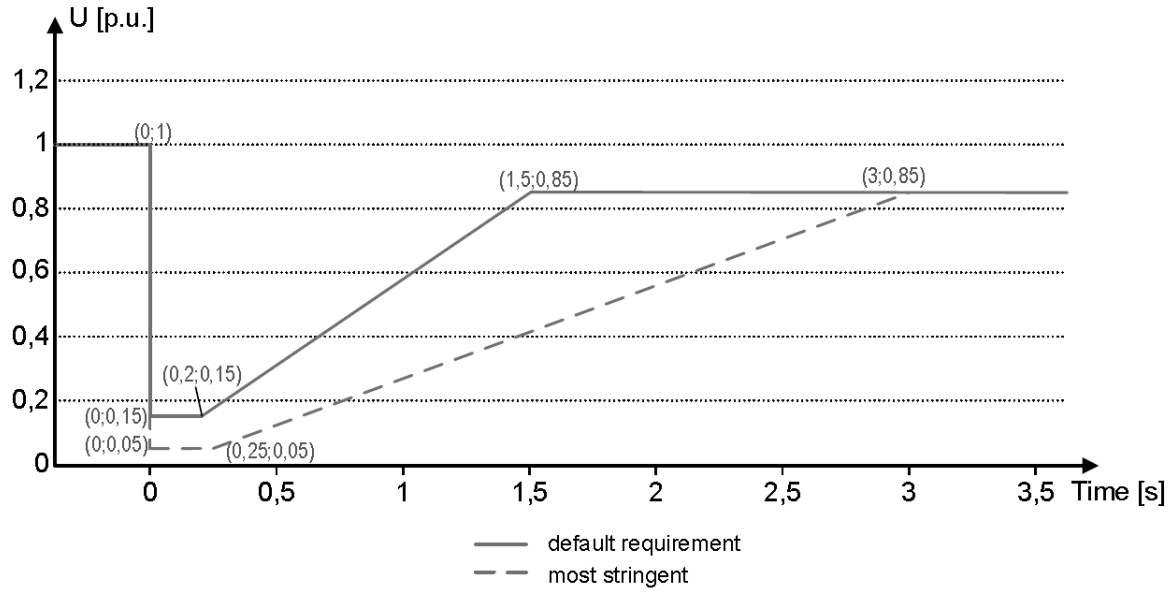


Overfrequency



Underfrequency

D.5.2	Table: UVRT	P



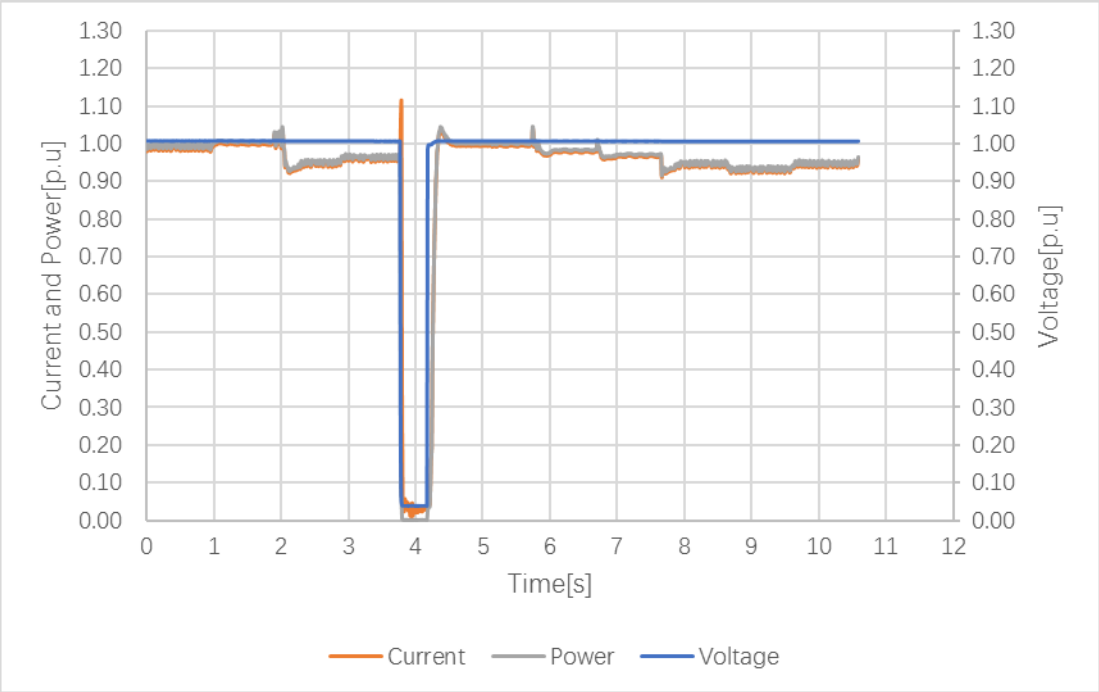
Test at full load (>90%)

Udip	Type	t min (ms)	U meas. (%)			T meas.(ms)	P recover (s)
			R	S	T		
5%	L-N	250	5.23	--	--	250.00	0.16
25%	L-N	938	24.96	--	--	970.00	0.14
50%	L-N	1797	49.89	--	--	1797.00	0.14
75%	L-N	2656	74.91	--	--	2656.00	0.14

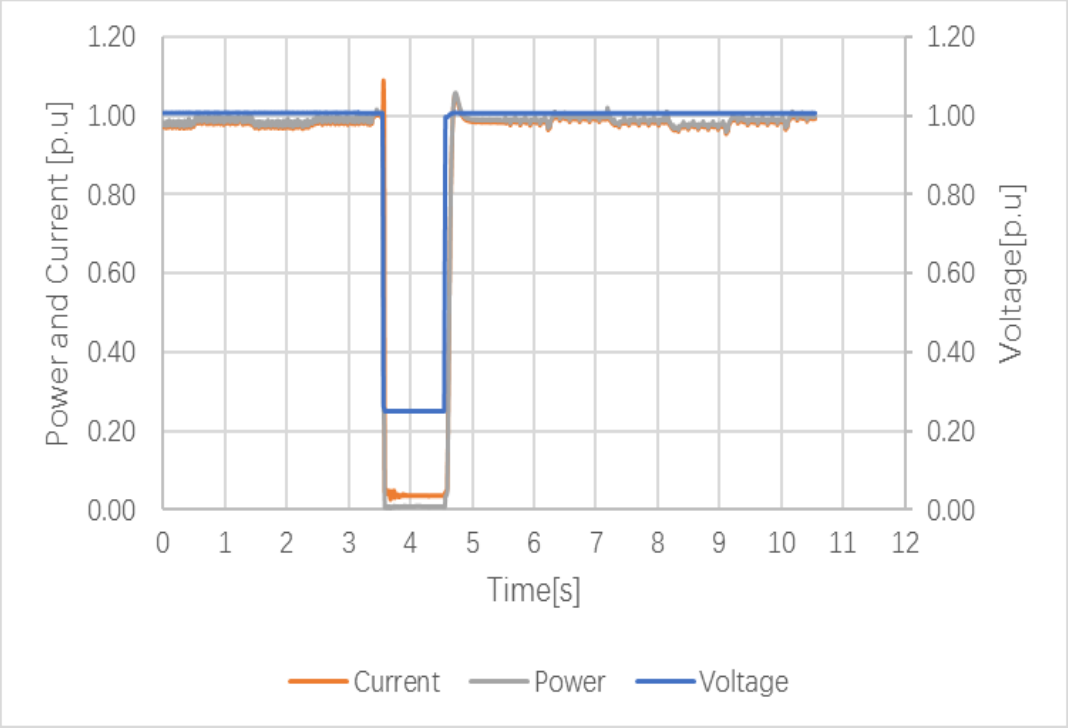
Remark:

The tests are performed together with clause 4.7.4.2.2 Zero current mode and enabling of default setting: undervoltage of 50%Un

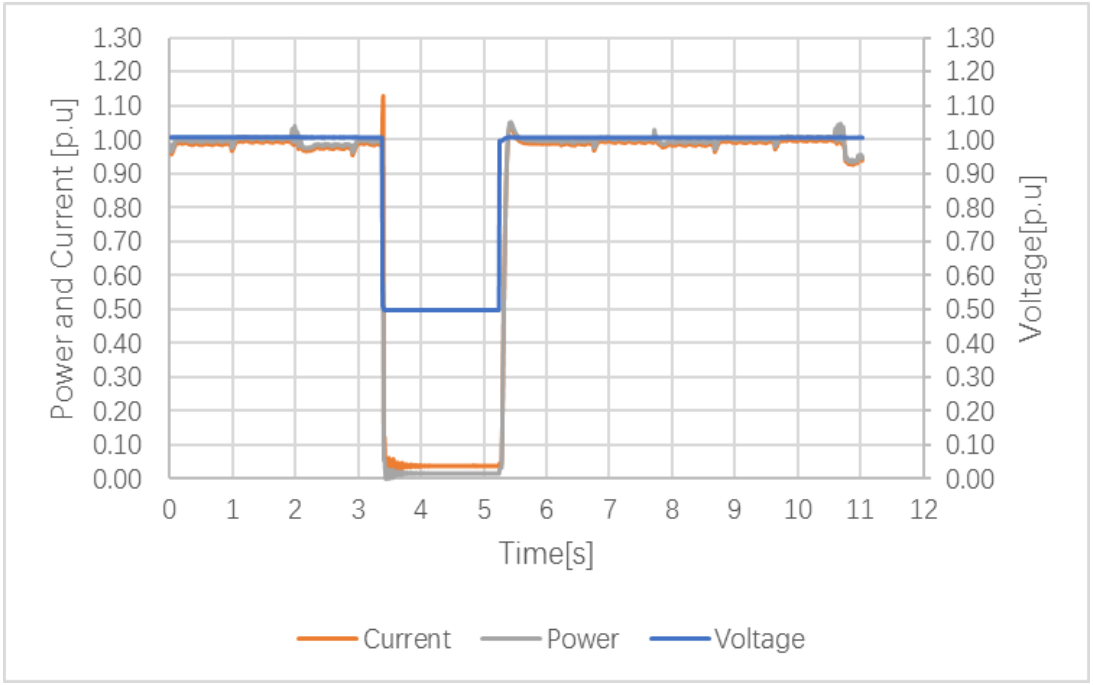
Graph_5%(L-N)



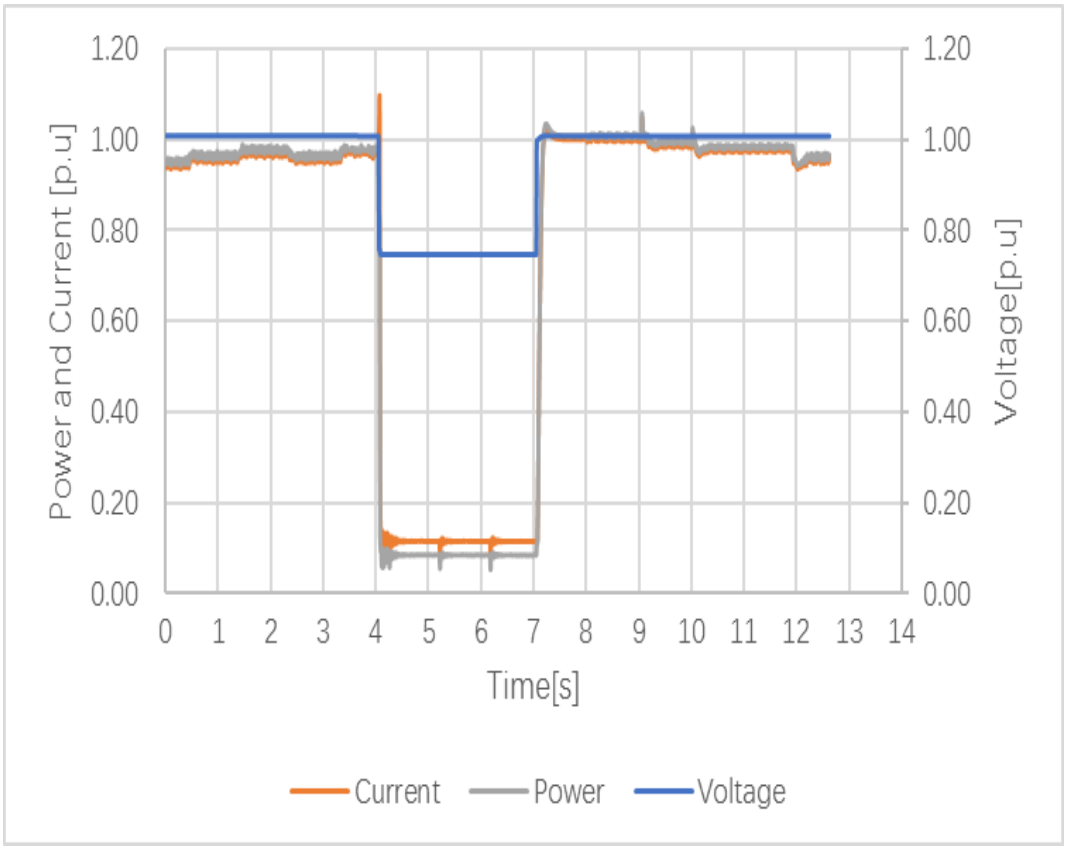
Graph_25%(L-N)



Graph_50%(L-N)

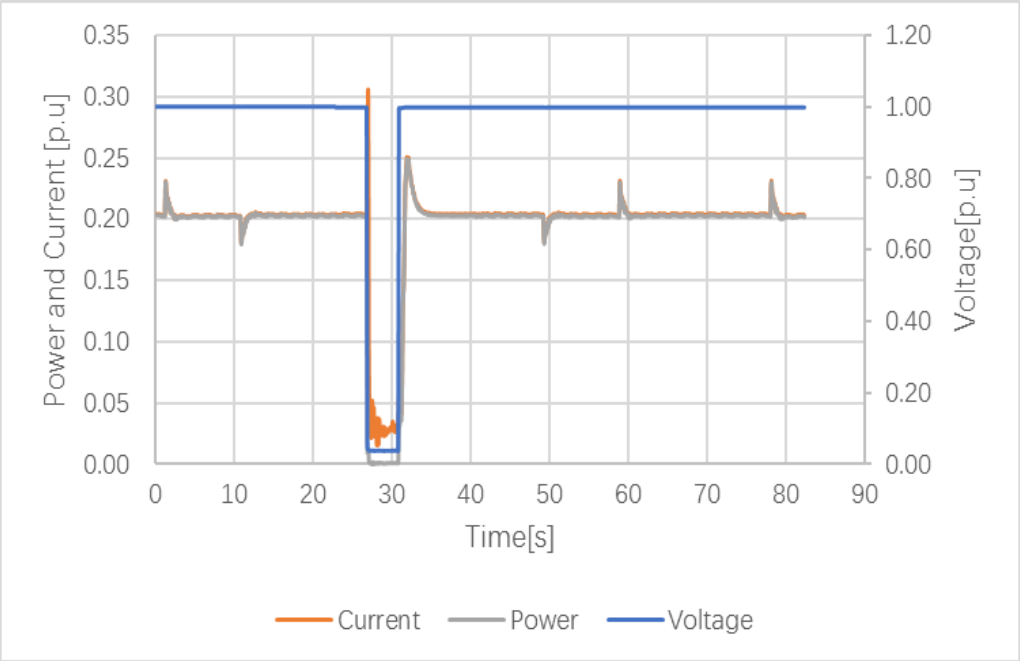


Graph_75%(L-N)

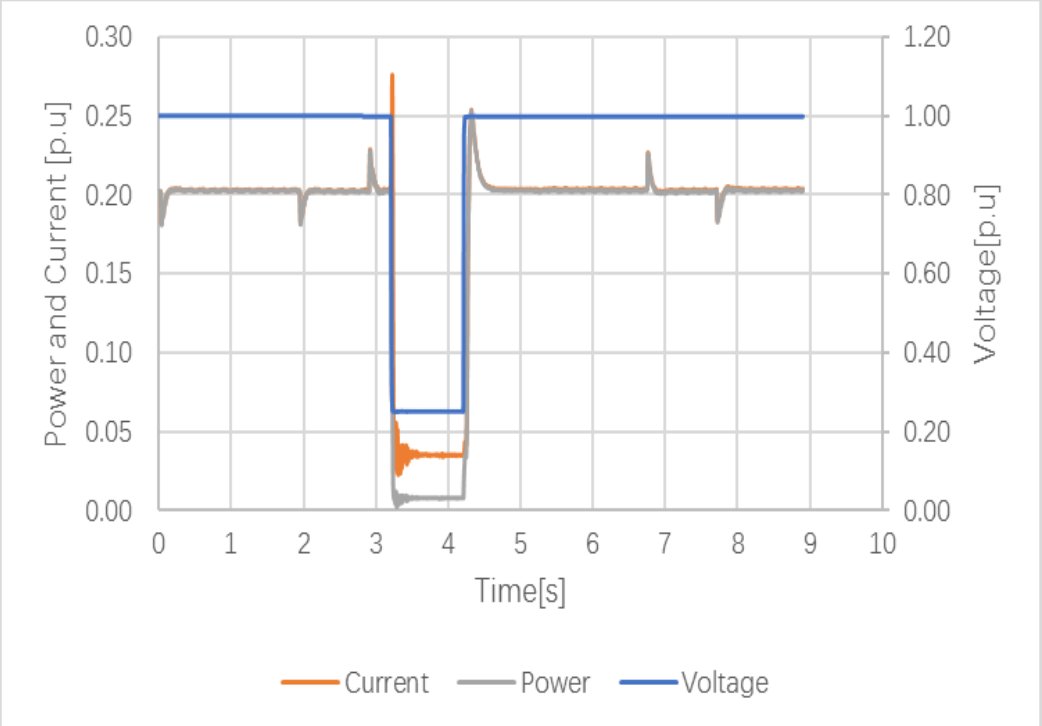


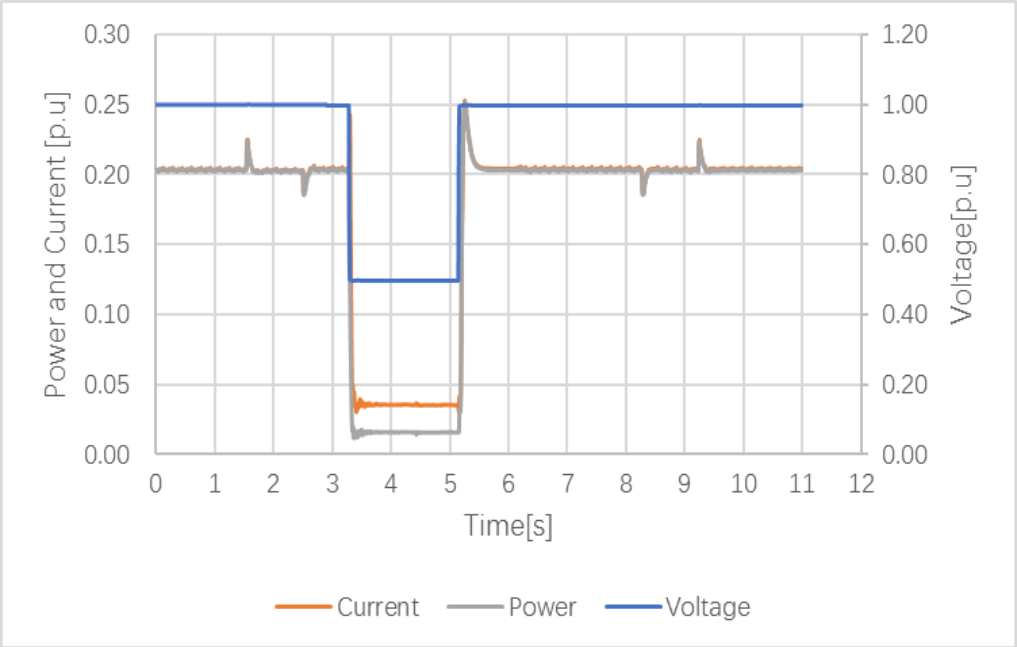
Test at partial load (20%)							
			U meas. (%)				
Udip	Type	t min (ms)	R	S	T	T meas.(ms)	P recover (s)
5%	L-N	250	4.02	--	--	250.00	0.08
25%	L-N	938	24.95	--	--	938.00	0.07
50%	L-N	1797	49.85	--	--	1797.20	0.07
75%	L-N	2656	74.86	--	--	2656.00	0.04
Remark: **The tests are performed together with clause 4.7.4.2.2 Zero current mode and enabling of default setting: undervoltage of 50%Un**							

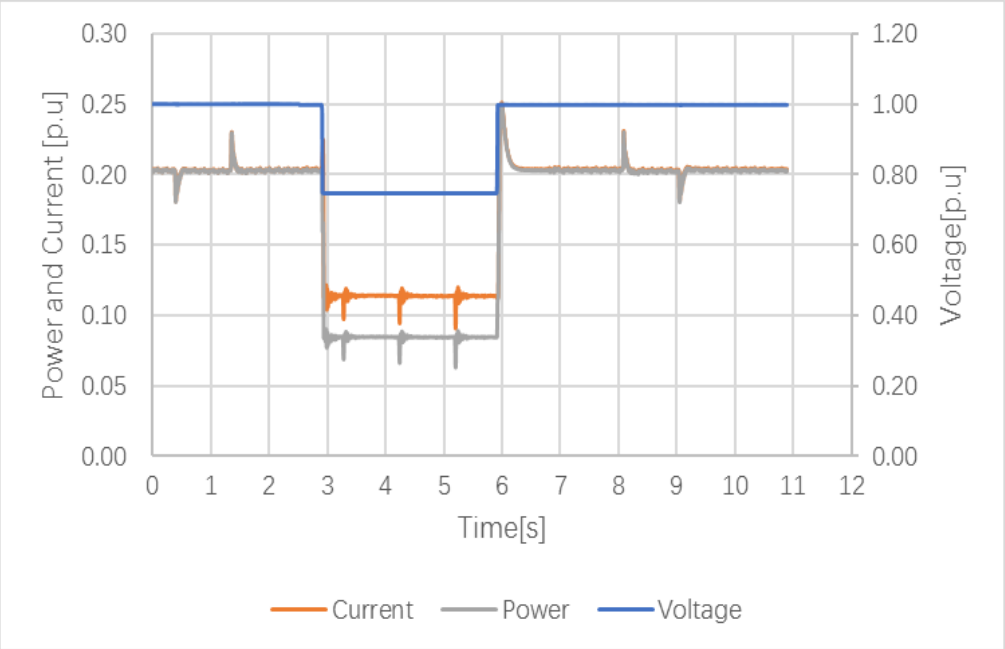
Graph_5%(L-N)



Graph_25%(L-N)

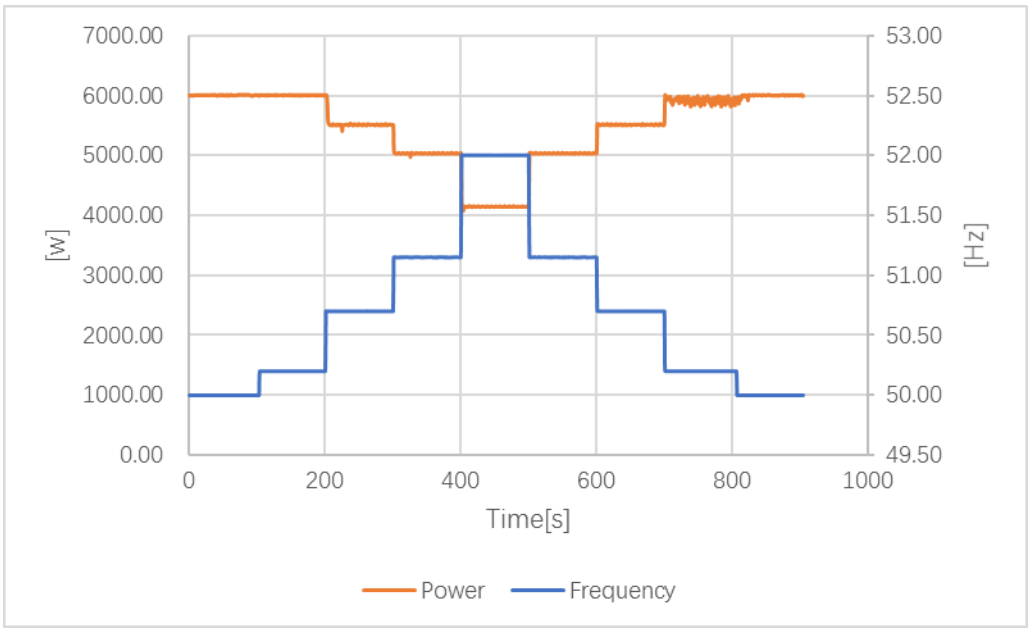


Graph_50%(L-N)


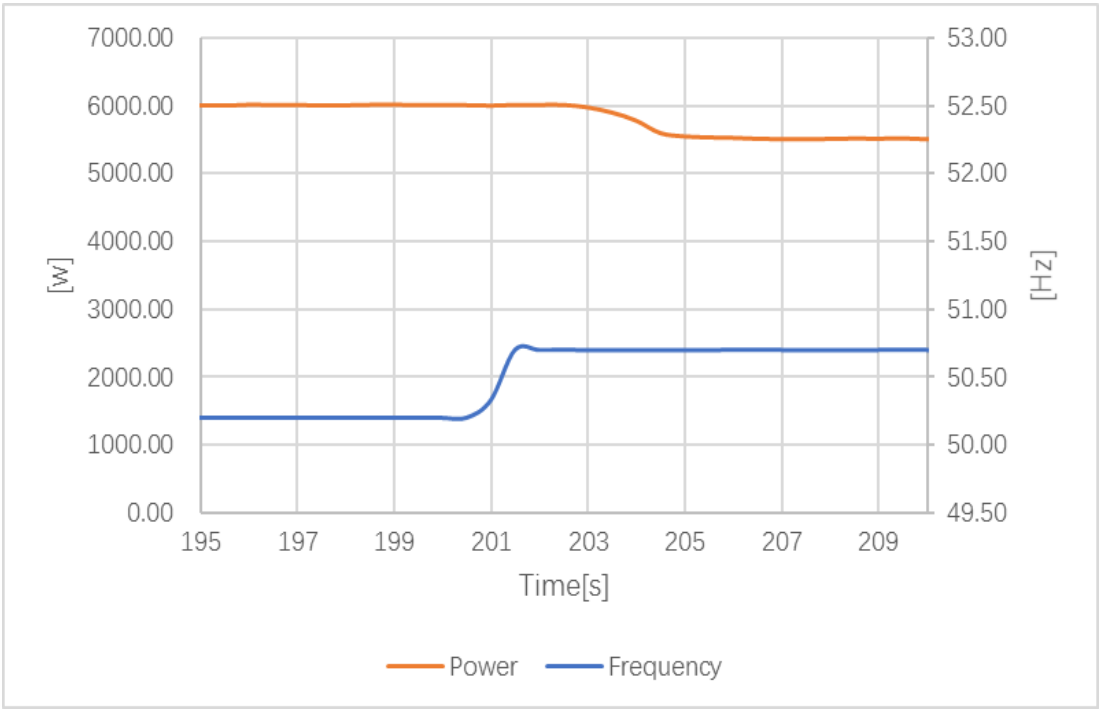
Graph_75%(L-N)


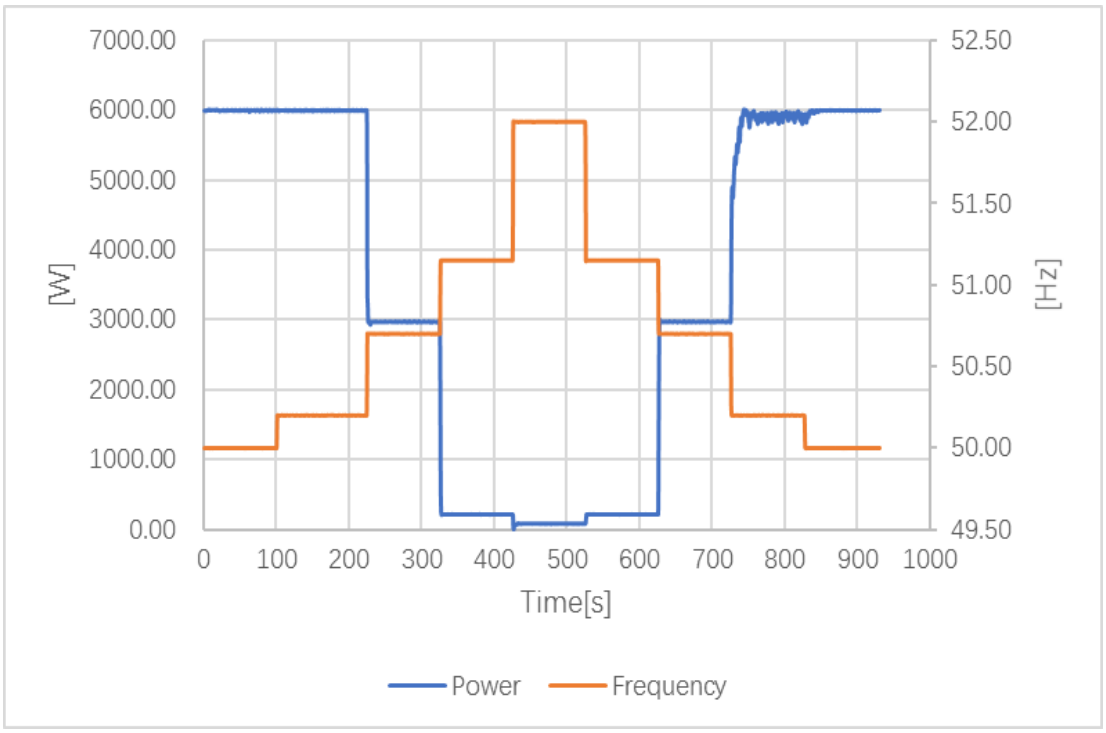
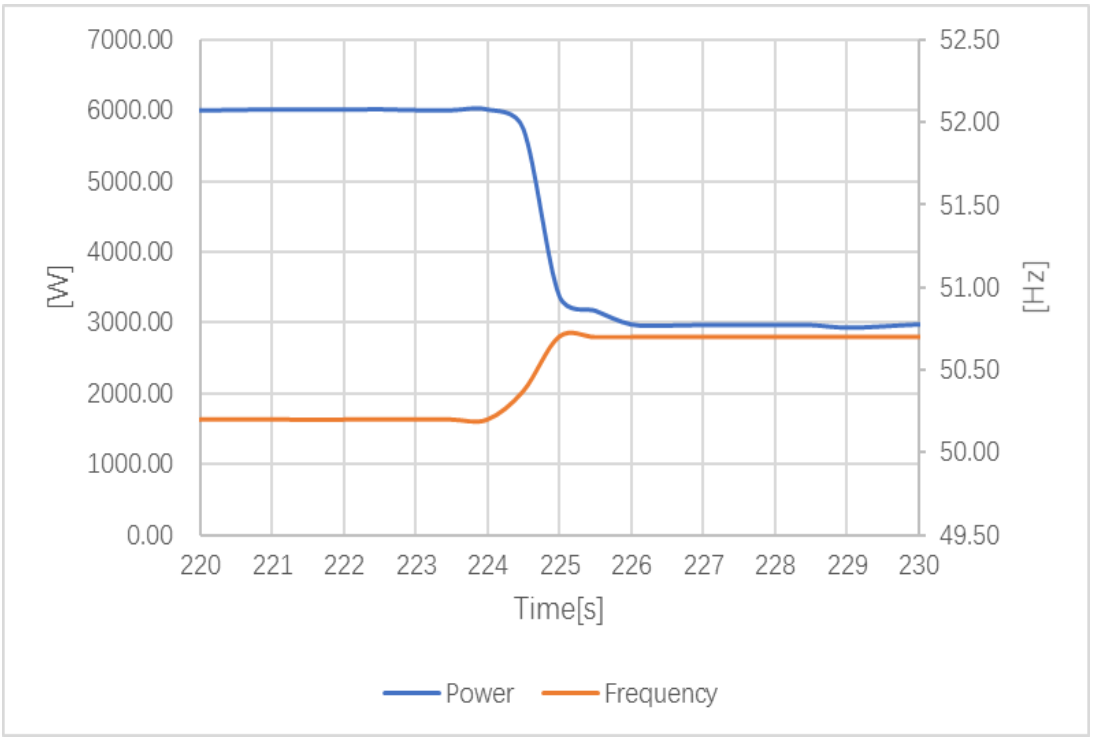
D.6.1	Table: Power response to over frequency						P
Test 1	100% Pn, f1 =50.2Hz; droop=12%; f-stop deactivated, with delay of 2 s						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <2s	For The settling times T≤20s
50Hz ± 0.01Hz	50.00	6006.47	6000	--	--	--	--
50.2Hz ± 0.01Hz	50.20	6005.70	6000	--	--	--	--
50.70Hz ± 0.01Hz	50.70	5512.93	5499	13.93	± 600	1.2	1.8
51.15Hz ± 0.01Hz	51.15	5040.99	5048.1	-7.11	± 600	1.4	3.5
52.0Hz ± 0.01Hz	52.00	4152.64	4196.4	-43.76	± 600	1.3	2.5
51.15Hz ± 0.01Hz	51.15	5039.26	5048.1	-8.84	± 600	1.2	24
50.70Hz ± 0.01Hz	50.70	5514.60	5499	15.6	± 600	1.4	2.6
50.2Hz ± 0.01Hz	50.20	5921.76	6000	--	--	1.2	2.3
50Hz ± 0.01Hz	50.00	6000.46	6000	--	--	--	--
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	6005.92	6000	--	--	--	--
50.2Hz ± 0.01Hz	50.20	6005.74	6000	--	--	--	--
50.70Hz ± 0.01Hz	50.70	2974.97	3000	-25.03	± 600	1.0	1.8
51.15Hz ± 0.01Hz	51.15	209.69	300	-90.31	± 600	1.5	2.6
52.0Hz ± 0.01Hz	52.00	75.20	0	75.2	± 600	0.8	1.7
51.15Hz ± 0.01Hz	51.15	209.67	300	-90.33	± 600	1.1	1.2
50.70Hz ± 0.01Hz	50.70	2973.43	3000	-26.57	± 600	1.2	2.4
50.2Hz ± 0.01Hz	50.20	5843.29	6000	--	--	1.3	2.4
50Hz ± 0.01Hz	50.00	6002.18	6000	--	--	--	--

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	3020.36	--	--	--	--	--
51.0Hz ± 0.01Hz	51.00	3020.51	3000.00	20.51	± 600	--	--
51.70Hz ± 0.01Hz	51.70	3020.45	3000.00	20.45	± 600	--	--
52.0Hz ± 0.01Hz	52.00	3020.39	3000.00	20.39	± 600	--	--
51.70Hz ± 0.01Hz	51.70	3020.45	3000.00	20.45	± 600	--	--
51.00Hz ± 0.01Hz	51.00	3020.35	3000.00	20.35	± 600	--	--
50Hz ± 0.01Hz	50.00	3020.38	--	--	--	--	--
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	6007.41	6000	--	--	--	--
50.2Hz ± 0.01Hz	50.20	6006.97	6000	--	--	--	--
50.70Hz ± 0.01Hz	50.70	4829.71	4800	29.71	± 600	1.0	2.6
51.15Hz ± 0.01Hz	51.15	3724.61	3720	4.61	± 600	0.8	2.5
52.0Hz ± 0.01Hz	52.00	1642.10	1680	-37.9	± 600	0.8	2.6
51.15Hz ± 0.01Hz	51.15	1641.13	1680	-38.87	± 600	--	--
50.70Hz ± 0.01Hz	50.70	1641.54	1680	-38.46	± 600	--	--
50.2Hz ± 0.01Hz	50.20	1641.03	1680	-38.97	± 600	--	--
50Hz ± 0.01Hz	50.00	6004.68	6000	--	--	--	--

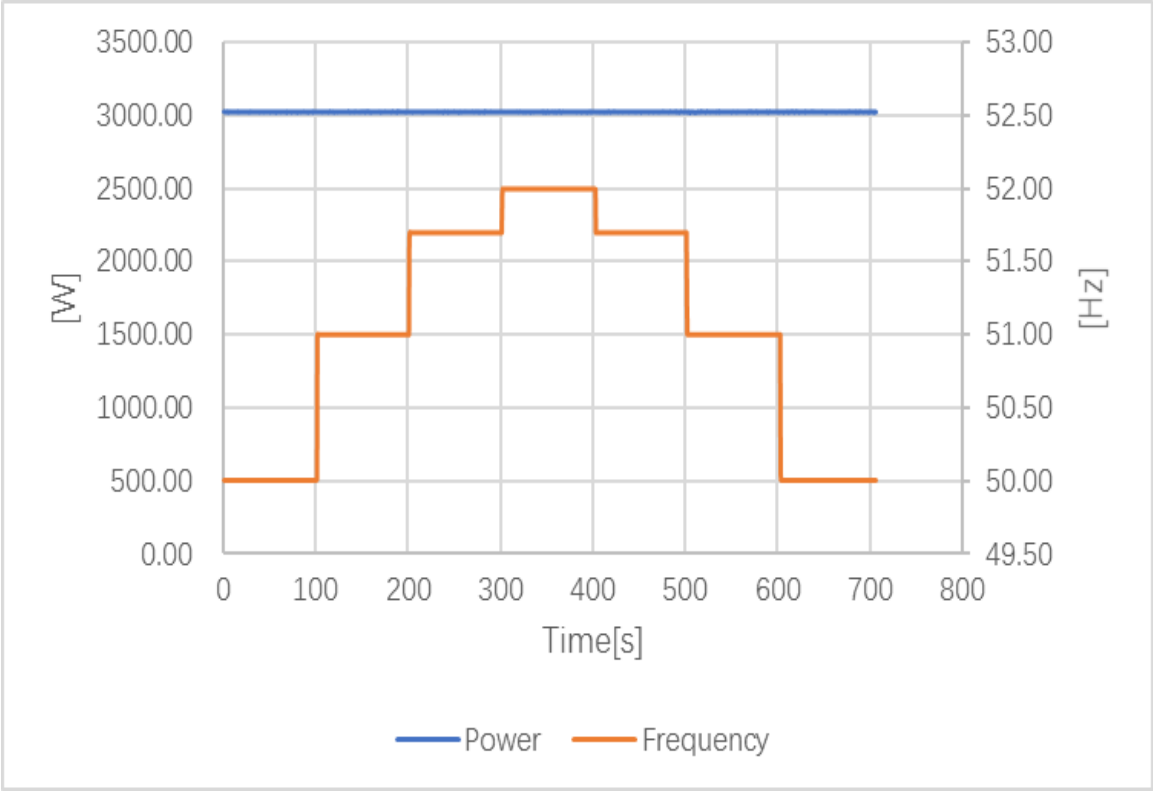


Intentional delay time (2s)

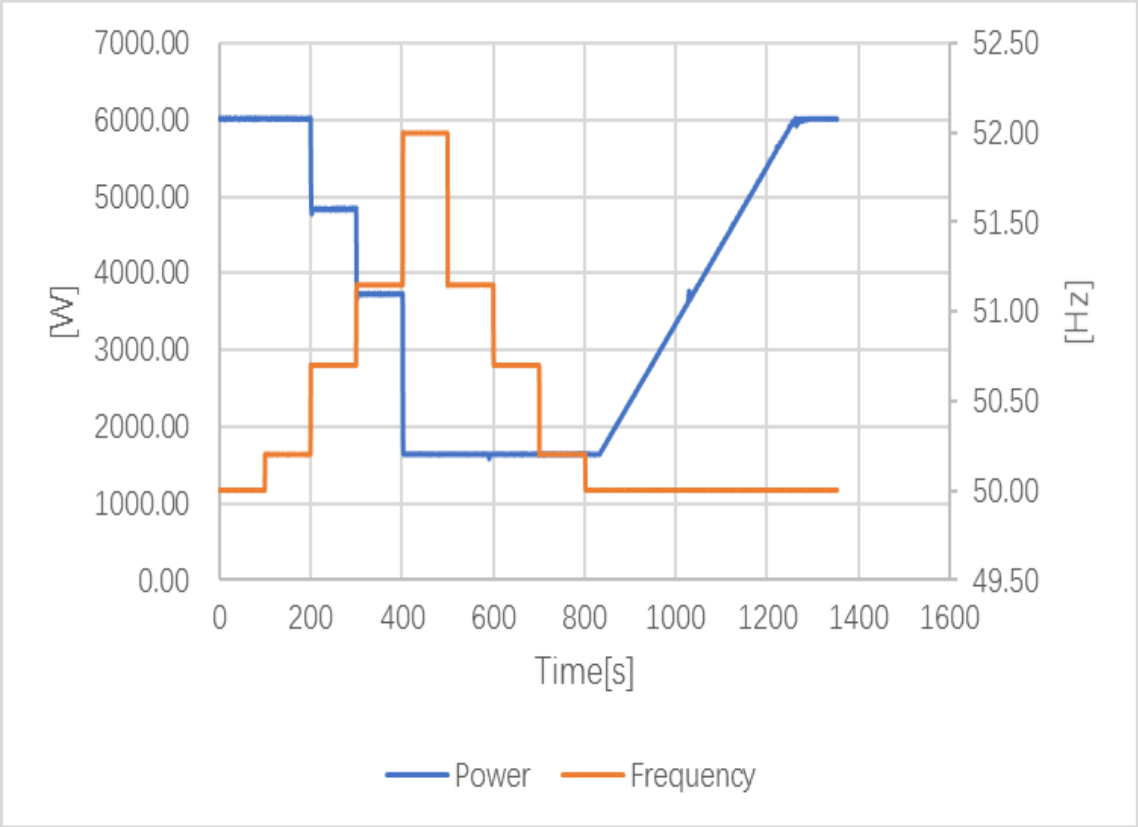


Test 2_Graph

Intentional delay time (no delay)


Test 3_Graph



Test 4_Graph



D.6.2	Table: Power response to under frequency	P

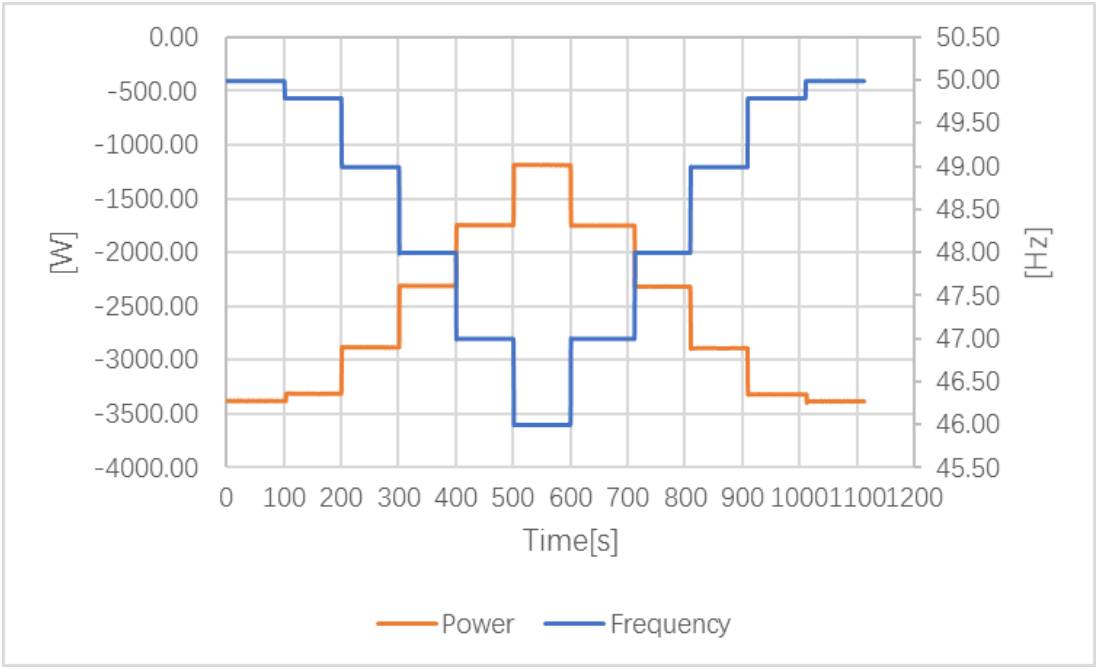
Test 1	-100% Pn, f1 =49.8Hz; droop=12%; with delay of 2 s						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	-3372.70	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	-3307.47	-3300.00	-7.47	± 330	--	--
49.0Hz ± 0.01z	49.00	-2877.72	-2859.12	-18.6	± 330	3.3	8.8
48.0Hz ± 0.01z	48.00	-2311.49	-2308.02	-3.47	± 330	3.2	8.6
47.0Hz ± 0.01z	47.00	-1747.00	-1756.92	9.92	± 330	3.2	8.3
46.0Hz ± 0.01z	46.00	-1192.41	-1316.04	123.63	± 330	3.2	8.3
47.0Hz ± 0.01z	47.00	-1750.95	-1756.92	5.97	± 330	3.2	8.3
48.0Hz ± 0.01z	48.00	-2313.08	-2308.02	-5.06	± 330	3.4	8.9
49.0Hz ± 0.01z	49.00	-2883.38	-2859.12	-24.26	± 330	3.3	8.5
49.8Hz ± 0.01Hz	49.80	-3311.32	-3300.00	-11.32	± 330	3.6	8.7
50.0Hz ± 0.01Hz	50.00	-3375.03	--	--	--	--	--

Test 2	-100% Pn, f1 =49.8Hz; droop=2%; 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	-3178.21	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	-3316.37	-3300	-16.37	± 330	--	--
49.0Hz ± 0.01Hz	49.00	-794.52	-660	-134.52	± 330	3.2	8.3
48.0Hz ± 0.01Hz	48.00	2451.61	2640	-188.39	± 330	3.2	8.3
47.0Hz ± 0.01Hz	47.00	3201.84	3300	-98.16	± 330	--	--
46.0Hz ± 0.01Hz	46.00	3200.17	3300	-99.83	± 330	--	--
47.0Hz ± 0.01Hz	47.00	3200.54	3300	-99.46	± 330	--	--
48.0Hz ± 0.01Hz	48.00	2443.80	2640	-196.2	± 330	--	--
49.0Hz ± 0.01Hz	49.00	-816.50	-660	-156.5	± 330	3.2	8.3
49.8Hz ± 0.01Hz	49.80	-3321.23	-3300	-21.23	± 330	3.0	8.2
50.0Hz ± 0.01Hz	50.00	-3183.73	--	--	--	--	--

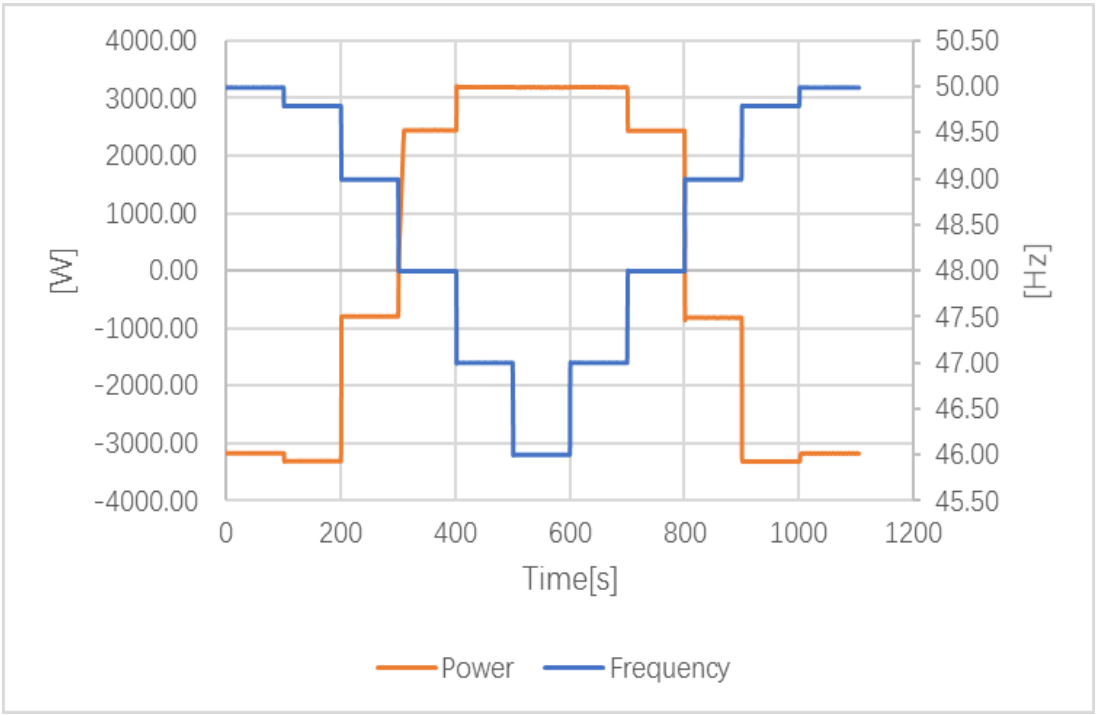
Test 3	-50% Pn, f1 =46.0Hz; droop=5%; no delay						
	f (Hz)	Measured output Power (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)	Tolerance Limit (W)	The response times Tan_90 % <10s	For The settling times T≤30s
50Hz ± 0.01Hz	50.00	20244.58	-1613.44	--	--	--	--
49.0Hz ± 0.01Hz	49.00	20244.30	-1614.99	-1650	35.01	--	--
48.0Hz ± 0.01Hz	48.00	20246.04	-1618.40	-1650	31.6	--	--
47.0Hz ± 0.01Hz	47.00	20244.66	-1617.80	-1650	32.2	--	--
46.0Hz ± 0.01Hz	46.00	20247.36	-1762.34	-1650	-112.34	--	--
47.0Hz ± 0.01Hz	47.00	20248.38	-1759.53	-1650	-109.53	--	--
48.0Hz ± 0.01Hz	48.00	20247.94	-1616.85	-1650	33.15	--	--
49.0Hz ± 0.01Hz	49.00	20247.49	-1616.60	-1650	33.4	--	--
50.0Hz ± 0.01Hz	50.00	20248.34	-1613.50	--	--	--	--

Test 4	-50% 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	-1606.69	--	--	--	--	--
49.8Hz ± 0.01Hz	49.80	-1754.91	-1650	-104.91	± 330	--	--
49.0Hz ± 0.01Hz	49.00	-709.66	-594	-115.66	± 330	3.1	8.2
48.0Hz ± 0.01Hz	48.00	627.16	726	-98.84	± 330	3.2	8.3
47.0Hz ± 0.01Hz	47.00	1900.58	2046	-145.42	± 330	--	--
46.0Hz ± 0.01Hz	46.00	3147.53	3300	-152.47	± 330	--	--
47.0Hz ± 0.01Hz	47.00	1886.31	2046	-159.69	± 330	--	--
48.0Hz ± 0.01Hz	48.00	606.87	726	-119.13	± 330	3.2	8.3
49.0Hz ± 0.01Hz	49.00	-740.08	-594	-146.08	± 330	3.2	8.3
49.8Hz ± 0.01Hz	49.80	-1760.02	-1650	-110.02	± 330	--	--
50.0Hz ± 0.01Hz	50.00	-1609.08	--	--	--	--	--

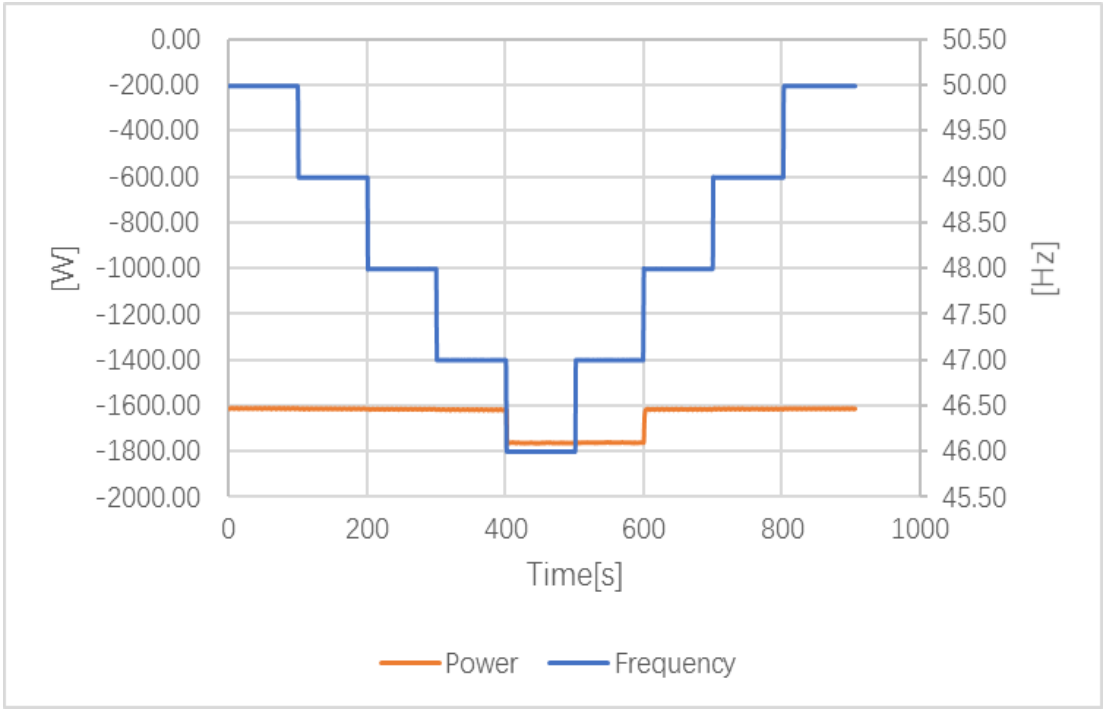
Test 1_Graph



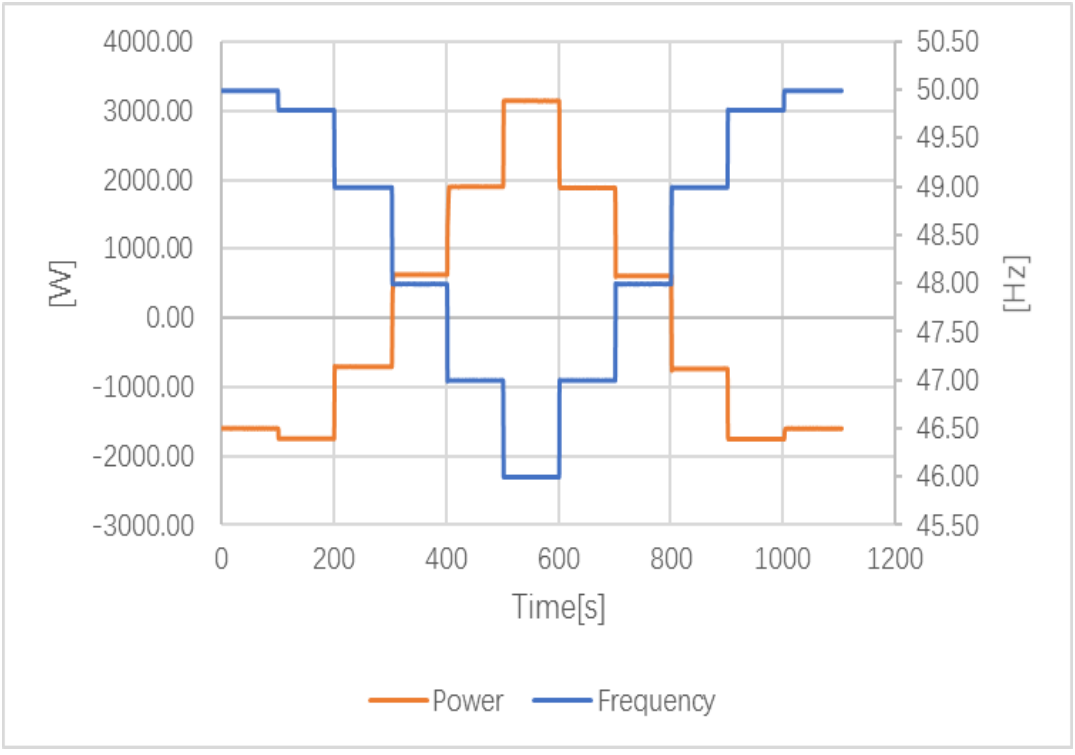
Test 2_Graph



Test 3_Graph



Test 4_Graph



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

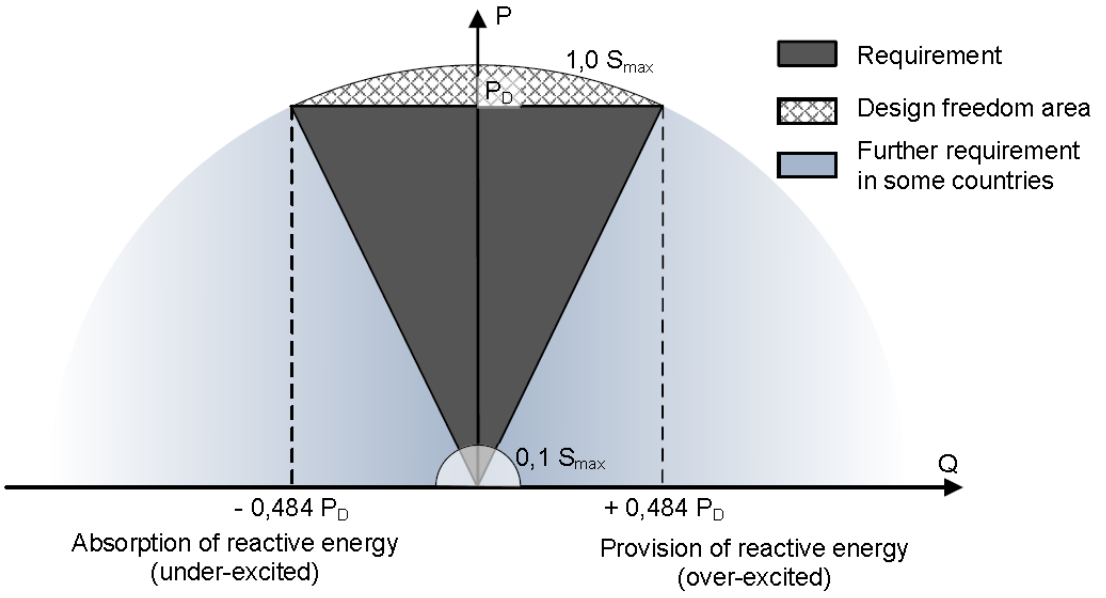


Figure 12 — Reactive power capability at nominal voltage

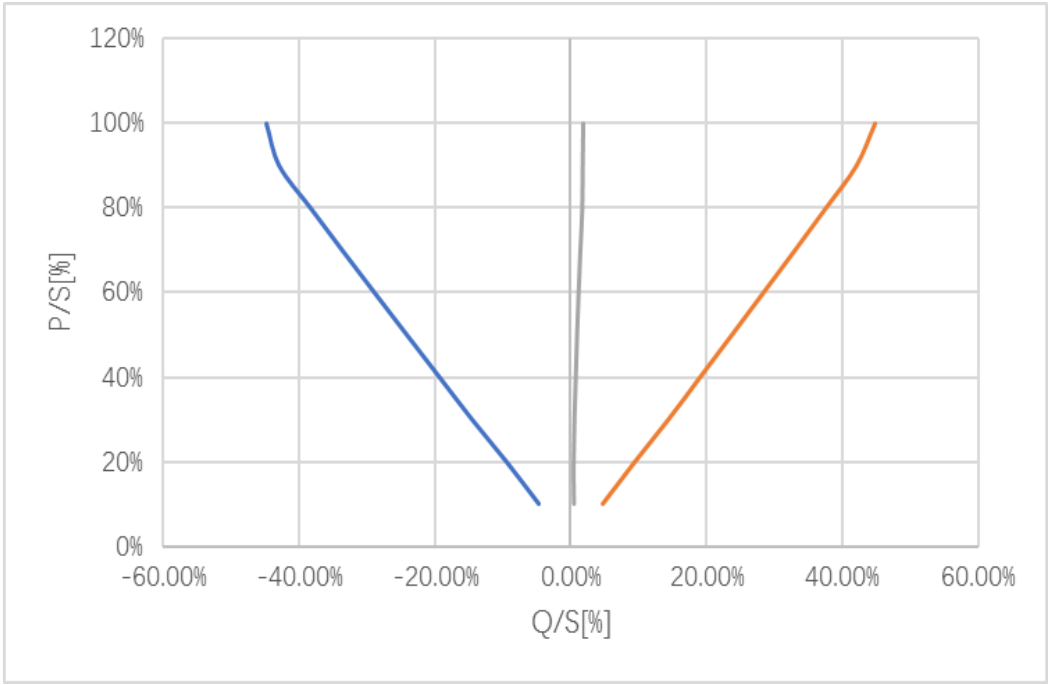
Lagging PF=0.9:

P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	ΔQ/Smax [%]	LIMITE [%]
10	589.65	-282.62	0.8960	0.9	-0.0040	-290.59	0.1328	± 2
20	1215.78	-569.18	0.9050	0.9	0.0050	-581.19	0.2002	± 2
30	1821.20	-872.65	0.9025	0.9	0.0025	-871.78	-0.0145	± 2
40	2439.15	-1160.25	0.9030	0.9	0.0030	-1162.37	0.0353	± 2
50	3044.91	-1448.07	0.9031	0.9	0.0031	-1452.97	0.0817	± 2
60	3646.72	-1734.03	0.9031	0.9	0.0031	-1743.56	0.1588	± 2
70	4242.77	-2017.71	0.9031	0.9	0.0031	-2034.15	0.2740	± 2
80	4834.25	-2298.08	0.9031	0.9	0.0031	-2324.75	0.4445	± 2
90	5419.11	-2574.39	0.9033	0.9	0.0033	-2615.34	0.6825	± 2
100*	5657.56	-2687.92	0.9032	0.9	--	--	--	--

* Remark: Due to the max current limit, the active power can't get to 100%.

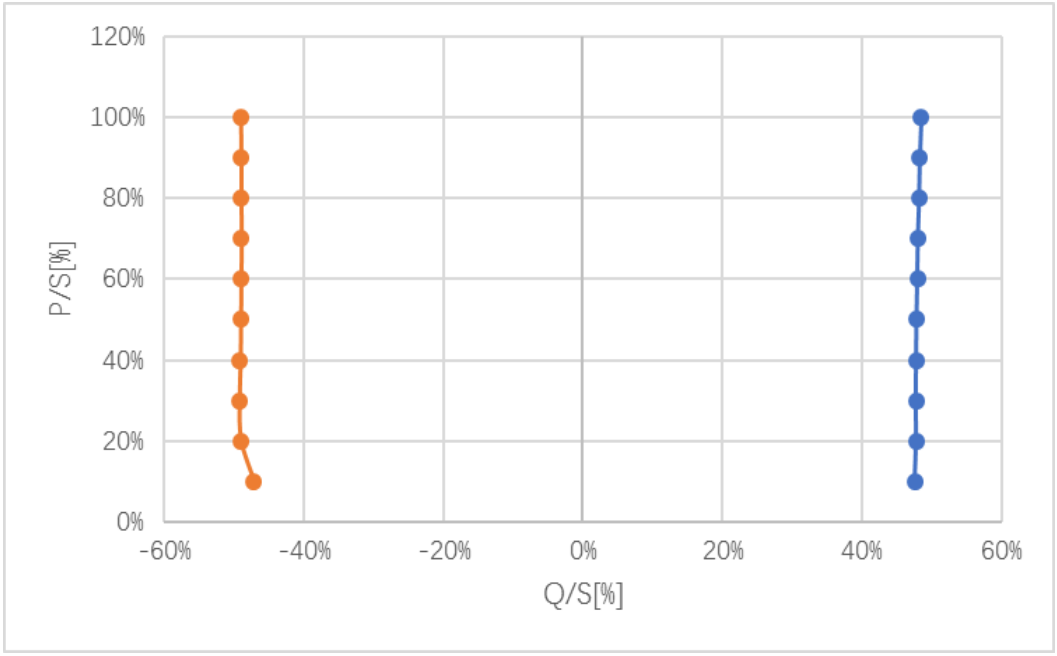
Leading PF=0.9:								
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Cosφ Set-point	Δcosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	603.50	276.84	0.9078	0.9	0.0078	290.59	-0.2292	± 2
20	1216.31	562.24	0.9070	0.9	0.0070	581.19	-0.3158	± 2
30	1831.37	858.06	0.9055	0.9	0.0055	871.78	-0.2287	± 2
40	2439.17	1138.14	0.9062	0.9	0.0062	1162.37	-0.4038	± 2
50	3046.95	1419.13	0.9065	0.9	0.0065	1452.97	-0.5640	± 2
60	3647.68	1697.43	0.9066	0.9	0.0066	1743.56	-0.7688	± 2
70	4246.69	1975.30	0.9067	0.9	0.0067	2034.15	-0.9808	± 2
80	4838.69	2249.35	0.9068	0.9	0.0068	2324.75	-1.2567	± 2
90	5416.51	2518.94	0.9067	0.9	0.0067	2615.34	-1.6067	± 2
100	5780.26	2684.45	0.9069	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	597.77	22.06	0.9688	1	-0.0312	0	0.3677	± 2
20	1218.73	19.70	0.9923	1	-0.0077	0	0.3283	± 2
30	1833.42	27.19	0.9963	1	-0.0037	0	0.4532	± 2
40	2446.22	38.76	0.9976	1	-0.0024	0	0.6460	± 2
50	3056.40	49.83	0.9983	1	-0.0017	0	0.8305	± 2
60	3659.54	64.30	0.9986	1	-0.0014	0	1.0717	± 2
70	4261.27	79.82	0.9988	1	-0.0012	0	1.3303	± 2
80	4842.65	96.55	0.9985	1	-0.0015	0	1.6092	± 2
90	5439.76	100.76	0.9985	1	-0.0015	0	1.6793	± 2
100	6033.30	105.49	0.9985	1	-0.0015	0	1.7582	± 2

Graph



Q=48.43%Pn						
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	555.37	2857.15	0.1908	2905.8	-0.8108	± 2
20	1175.95	2868.14	0.3794	2905.8	-0.6277	± 2
30	1795.92	2866.55	0.5309	2905.8	-0.6542	± 2
40	2409.49	2868.16	0.6432	2905.8	-0.6273	± 2
50	3020.42	2872.35	0.7246	2905.8	-0.5575	± 2
60	3625.32	2877.67	0.7832	2905.8	-0.4688	± 2
70	4227.38	2882.89	0.8262	2905.8	-0.3818	± 2
80	4822.34	2892.70	0.8575	2905.8	-0.2183	± 2
90	5405.01	2898.82	0.8812	2905.8	-0.1163	± 2
100*	5720.41	2911.62	0.8912	2905.8	0.0970	± 2
Q=-48.43%Pn						
P/Pn[%] setpoint	P[W]	Q[Var]	Cosφ	Q[Var] setpoint	$\Delta Q/S_{max}$ [%]	LIMITE [%]
10	548.94	-2833.47	0.1902	-2905.8	1.2055	± 2
20	1166.90	-2943.54	0.3685	-2905.8	-0.6290	± 2
30	1784.66	-2956.04	0.5168	-2905.8	-0.8373	± 2
40	2402.90	-2948.35	0.6318	-2905.8	-0.7092	± 2
50	3012.73	-2944.45	0.7152	-2905.8	-0.6442	± 2
60	3619.39	-2941.79	0.7760	-2905.8	-0.5998	± 2
70	4221.17	-2938.46	0.8207	-2905.8	-0.5443	± 2
80	4818.29	-2941.73	0.8535	-2905.8	-0.5988	± 2
90	5388.93	-2941.68	0.8777	-2905.8	-0.5980	± 2
100*	5547.52	-2944.77	0.8833	-2905.8	-0.6495	± 2
* Remark: Due to the max current limit, the active power can't get to 100%.						

Graph



D.7.1	Table: Q(U) Capabilities	P

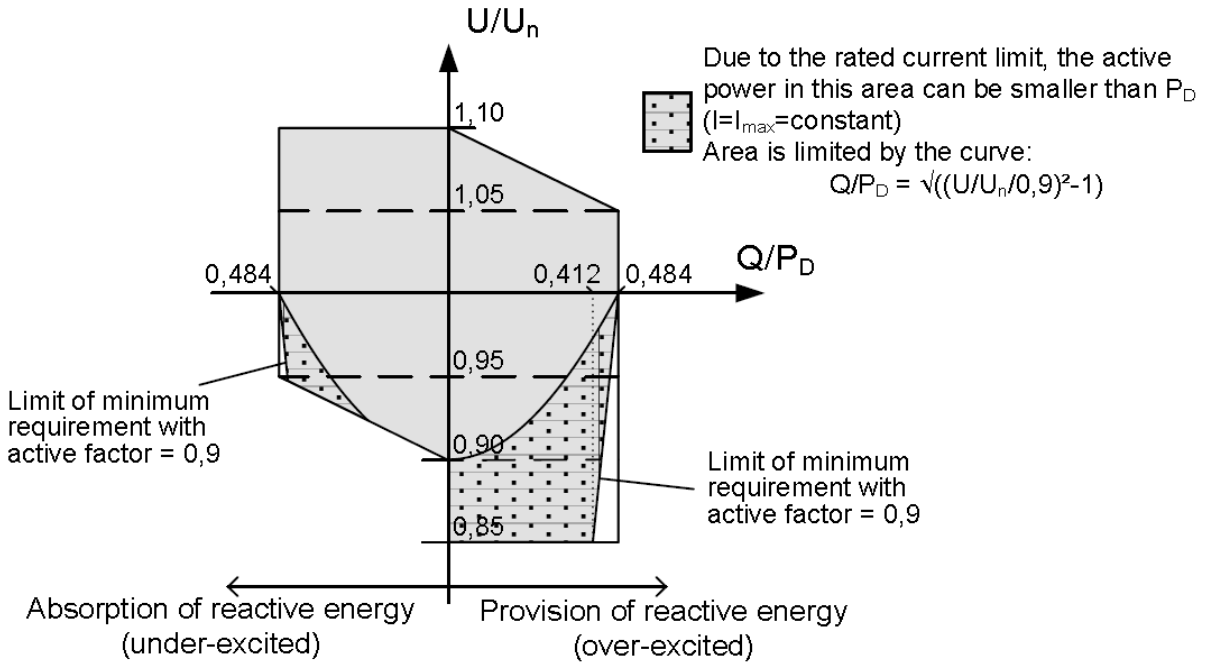


Figure 13 — Reactive power capability at active power P_D in the voltage range (positive sequence component of the fundamental)

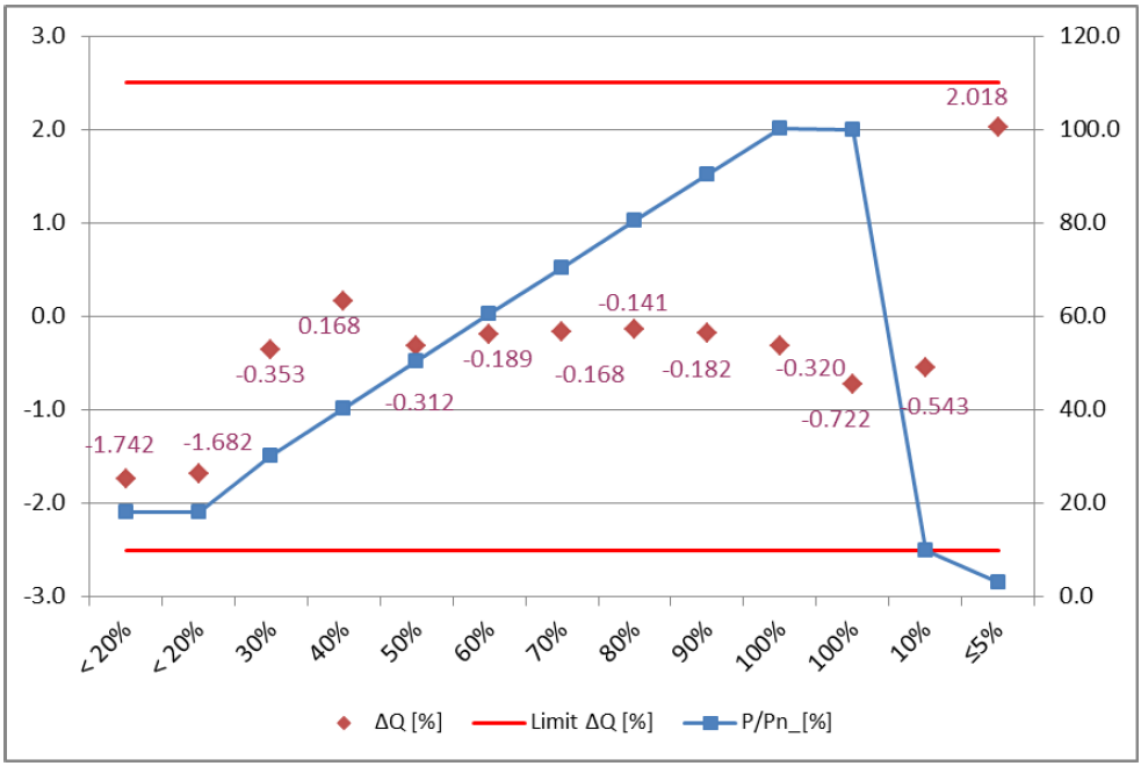
Over-excited:

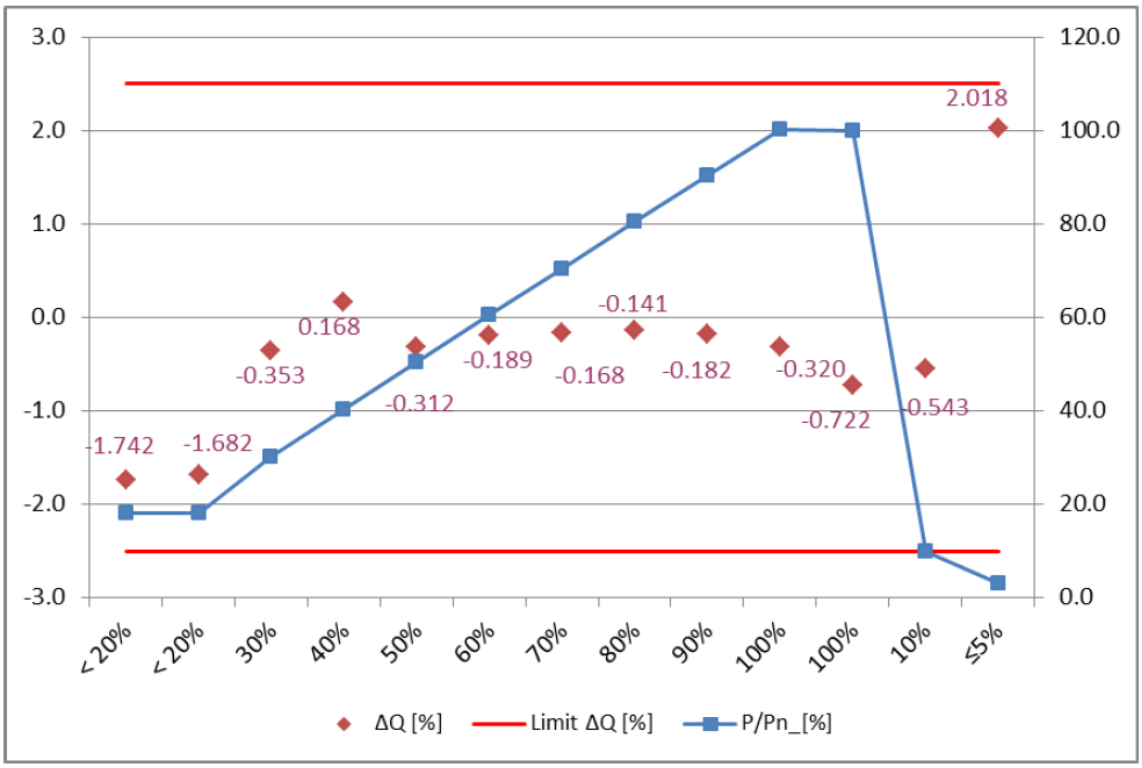
AC output				Reactive power measured		
Voltage setting [V/Vn]	Measured			Reactive power [Var]	Value [Q/Pn]	Limits
	Voltage [V]	[V/Vn]	Active power [W]			
1.10	251.64	1.09	6032.99	78.48	0.0131	±0.02
1.08	248.55	1.08	6029.21	1143.90	0.1907	0.194±0.02
1.05	241.74	1.05	5657.28	2882.82	0.4805	--
1.00	230.38	1.00	5638.83	2942.33	0.4904	--
0.95	218.98	0.95	5644.48	2931.46	0.4886	--
0.92	212.02	0.92	5645.22	2922.82	0.4871	--
0.90	207.38	0.90	5649.21	2919.53	0.4866	--
0.85	197.23	0.85	5647.81	2921.77	0.4870	--

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	251.65	1.09	6033.92	-2920.78	-0.4868	--
1.08	248.68	1.08	6027.82	-2907.07	-0.4845	--
1.05	241.55	1.05	5486.93	-2894.01	-0.4823	--
1.00	230.12	1.00	5490.74	-2905.92	-0.4843	--
0.95	218.73	0.95	5493.52	--2915.52	0.4859	--
0.92	212.09	0.92	5946.78	-1159.78	-0.1933	-0.175±0.02
0.90	207.14	0.90	5996.57	61.58	0.0103	±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	18.04	246.13	-94	≈0 (< ± 5 % Pn)	-1.5667
< 20 %	1,09 Vn	18.05	250.67	-91	≈0 (< ± 5 % Pn)	-1.5167
<20 %→30 %	1,09 Vn	30.06	250.77	-1327	-1308 (within 10sec)	-0.3167
40 %	1,09 Vn	40.25	250.90	-1299	-1308	0.1500
50 %	1,09 Vn	50.36	250.82	-1324	-1308	-0.2667
60 %	1,09 Vn	60.44	250.81	-1318	-1308	-0.1667
70 %	1,09 Vn	70.47	250.81	-1317	-1308	-0.1500
80 %	1,09 Vn	80.45	250.82	-1315	-1308	-0.1167
90 %	1,09 Vn	90.38	250.84	-1317	-1308	-0.1500
100 %	1,09 Vn	100.24	250.74	-1325	-1308	-0.2833
100 %	1,1 Vn	99.92	253.08	-2654	-2615	-0.6500
100 % →10 %	1,1 Vn	10.01	253.07	-2645	-2615	-0.5000
10 %→ ≤ 5 %	1,1 Vn	2.91	253.11	109	≈0 (< ± 5 % Pn)	1.8167
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	17.98	214.20	-60	≈0 (< ± 5 % Pn)	-1.0000
< 20 %	0.91 Vn	17.97	209.44	-57	≈0 (< ± 5 % Pn)	-0.9500
<20 %→30 %	0.91 Vn	29.97	209.38	1320	1308 (within 10sec)	0.2000
40 %	0.91 Vn	40.11	209.41	1317	1308	0.1500
50 %	0.91 Vn	50.15	209.40	1329	1308	0.3500
60 %	0.91 Vn	60.14	209.53	1305	1308	-0.0500
70 %	0.91 Vn	70.09	209.61	1320	1308	0.2000
80 %	0.91 Vn	79.97	209.65	1352	1308	0.7333
90 %	0.91 Vn	89.82	209.61	1311	1308	0.0500

100 %	0.91 Vn	99.58	209.66	1331	1308	0.3833
100 %	0.90 Vn	99.61	207.13	2618	2615	0.0500
100 % →10 %	0.90 Vn	8.95	207.19	2658	2615	0.7167
10 % →≤ 5 %	0.91 Vn	1.69	207.10	99	≈0 (< ± 5 % Pn)	1.6500

Graph: Lock-in at 1.08Vn


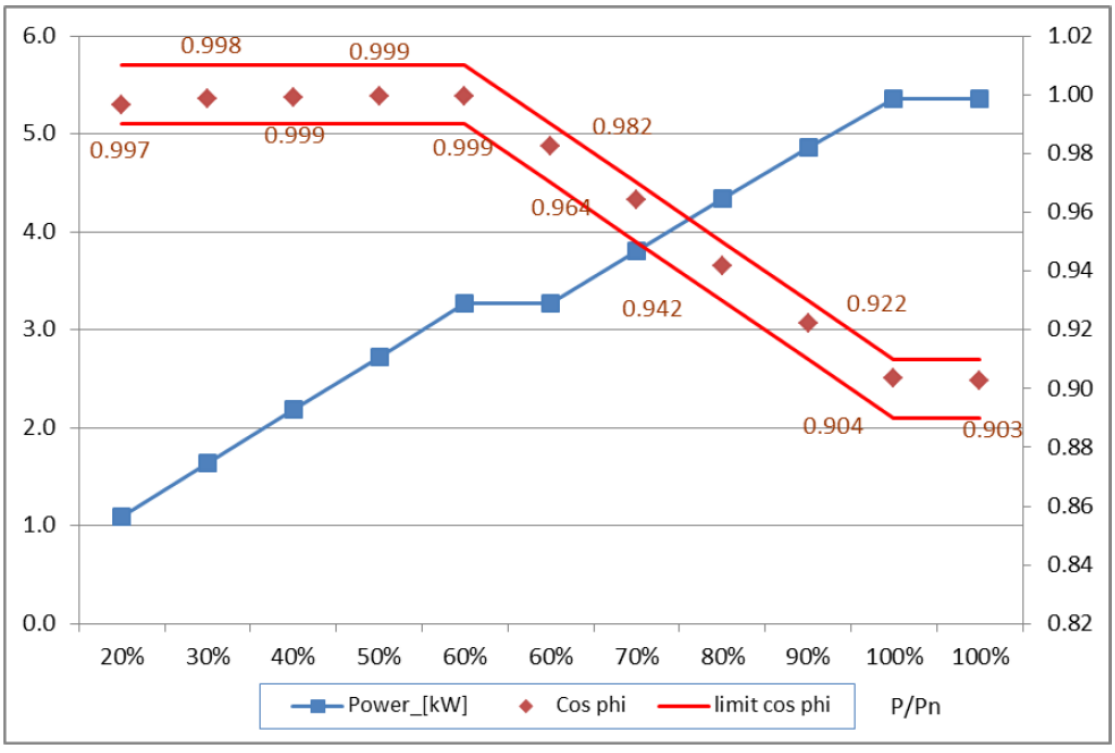
Graph: Lock-in at 0.92Vn


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%	18.15	86	<105%	103.99	1.0000	0.9966	1.4333	±2
30%	27.32	87	<105%	104.02	1.0000	0.9984	1.4500	±2
40%	36.48	91	<105%	104.04	1.0000	0.9991	1.5167	±2
50%	45.43	99	<105%	104.07	1.0000	0.9993	1.6500	±2
60%	54.47	109	<105%	104.10	1.0000	0.9995	1.8167	±2
60%	54.47	-623	>105%	106.14	0.9800	0.9823	1.8002	±2
70%	63.43	-1249	>105%	106.16	0.9600	0.9640	-0.4000	±2
80%	72.30	-1752	>105%	106.18	0.9400	0.9415	-0.1639	±2
90%	81.12	-2242	>105%	106.20	0.9200	0.9221	0.9732	±2
100%	89.23	-2538	>105%	106.21	0.9000	0.9036	1.2890	±2
100%	100.00	109	<100%	99.28	1.0000	0.9998	1.8167	±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

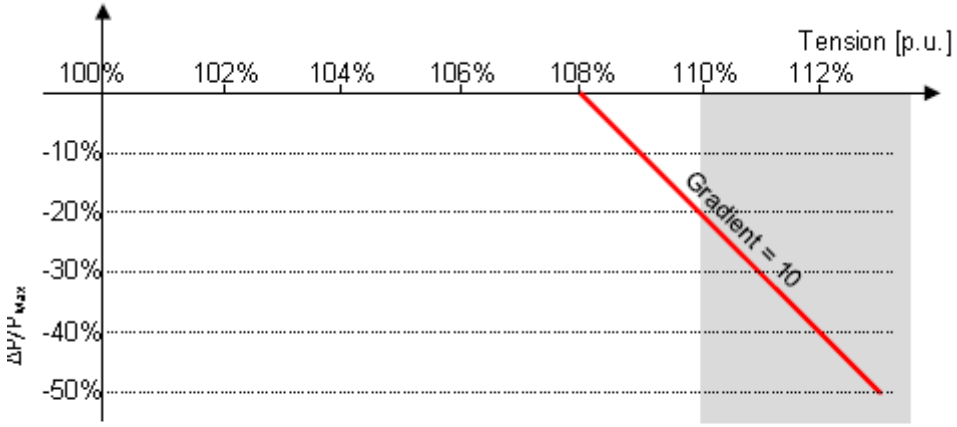
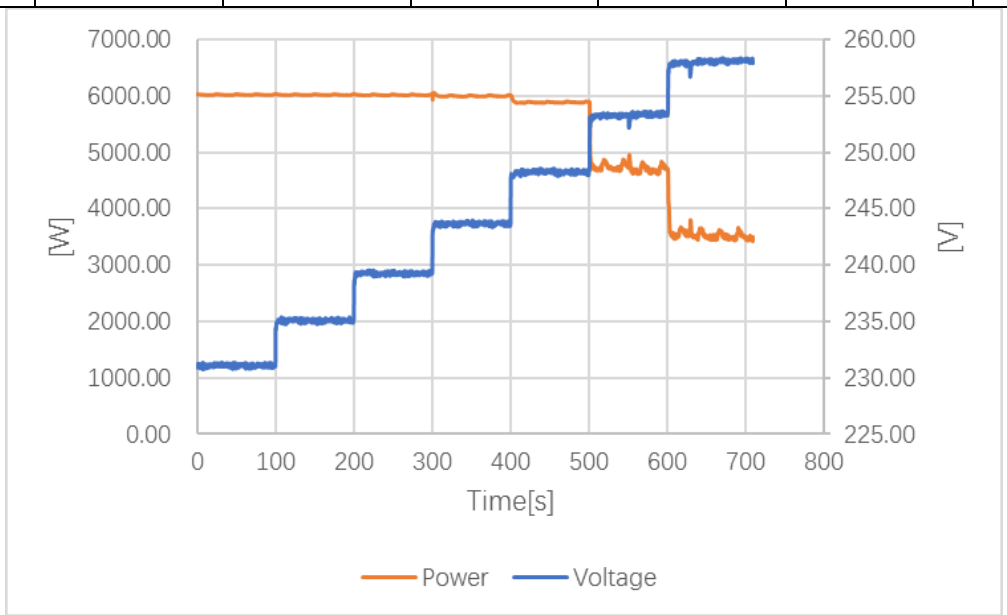


Figure 15 - Example curve for P(U)

Step #	Set voltage vaule V/Vn [%]	Measured voltage vaule V/Vn [%]	Measured power values [W]	Measured power bin [%]	Limit [%]	RESULT
1	100	100.14	6015.35	100.26	--	P
2	102	102.14	6015.02	100.25	--	
3	104	104.14	6016.16	100.27	--	
4	106	106.13	6015.72	100.26	--	
5	108	108.01	6014.20	100.24	--	
6	110	110.19	4720.58	78.67	<80	
7	112	112.20	3528.00	58.80	<60	

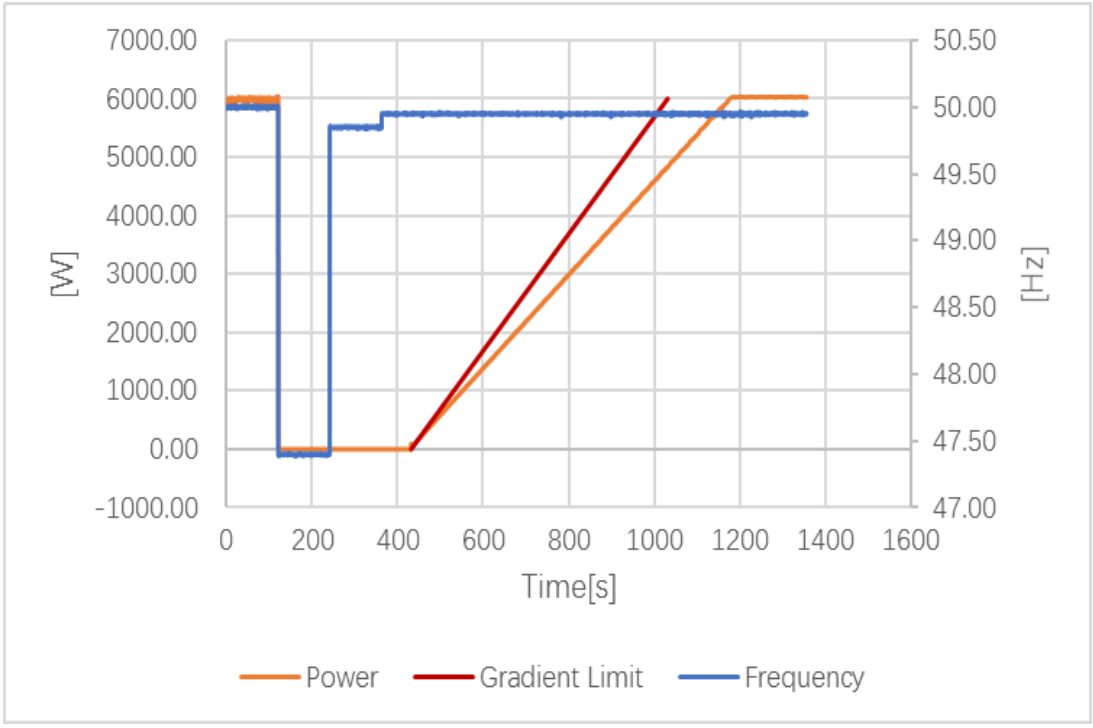


D.8	Table: Connection and reconnection	P

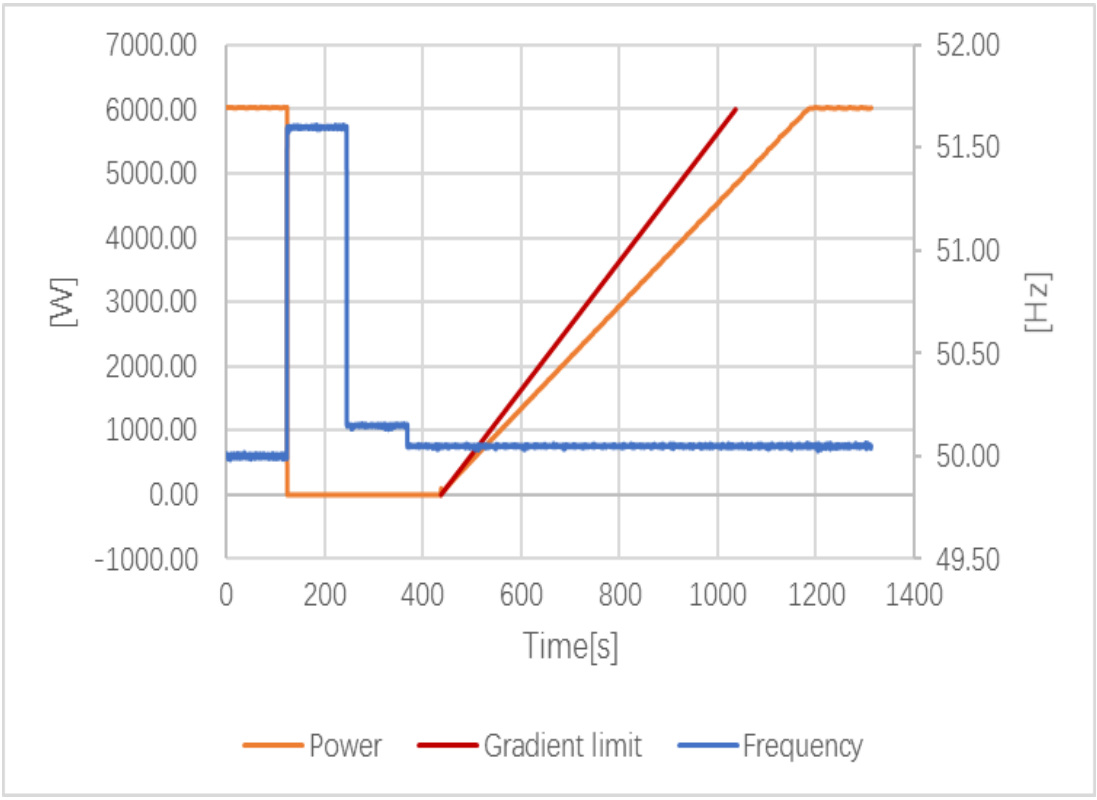
Parameter	Reconnection after tripping of the interface protection relay	Normal operation starting
Lower frequency	49,9 Hz	49,9 Hz
Upper frequency	50,1 Hz	50,1 Hz
Lower voltage	If connection to the LV distribution network: 85% U_n	If connection to the LV distribution network: 85% U_n
	If connection to 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**	68.4	8.06
Step c)	**>50.1Hz**	**No**	--	--
Step d)	**≤50.1Hz**	**Yes**	68.4	8.03
Step e)	**<195.5V**	**No**	--	--
Step f)	**≥195.5V**	**Yes**	68.8	7.01
Step g)	**>253V**	**No**	--	--
Step h)	**≤253V**	**Yes**	67.8	8.02
Remark: Maximum active power increase gradient 10 %/min.				

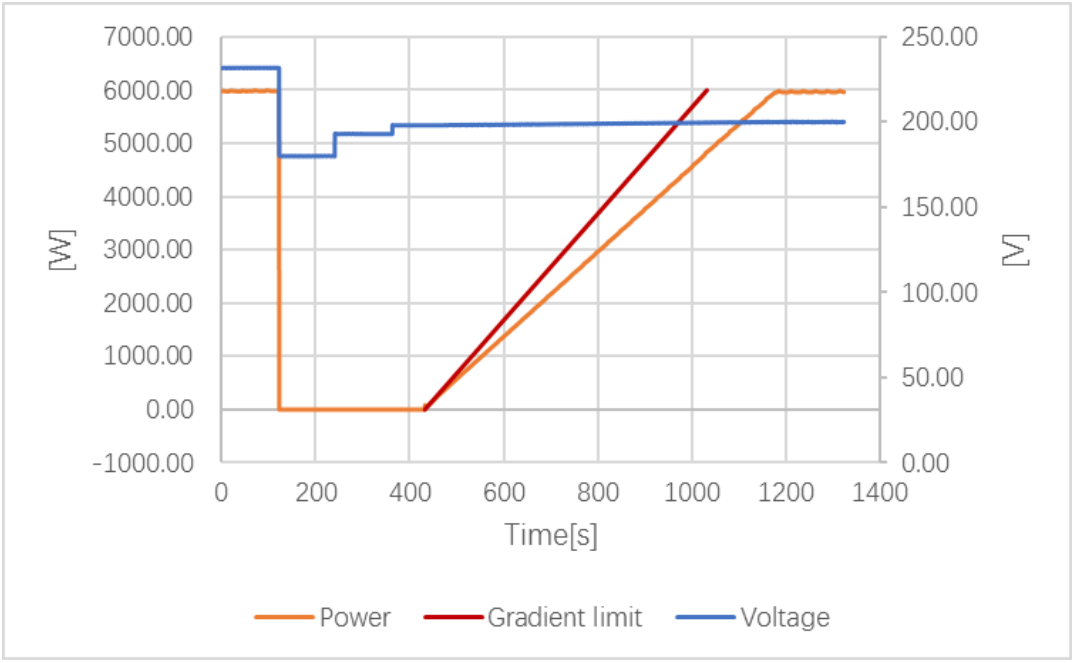
Graph_49.9Hz



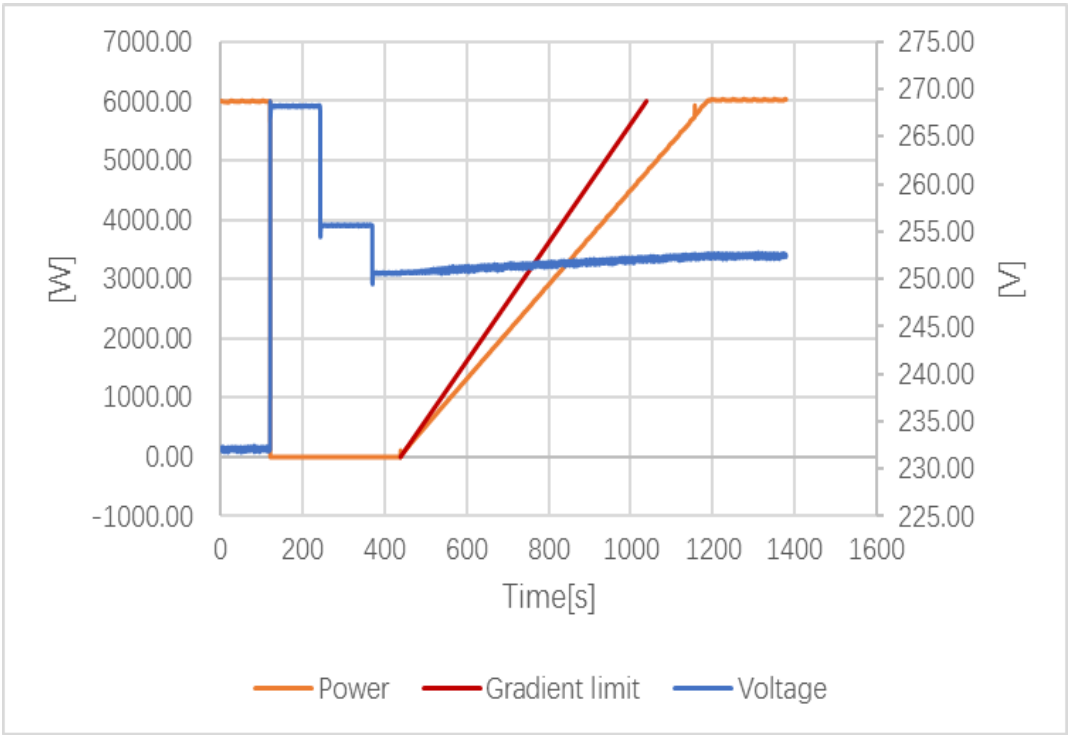
Graph_50.1Hz



Graph_195.5V

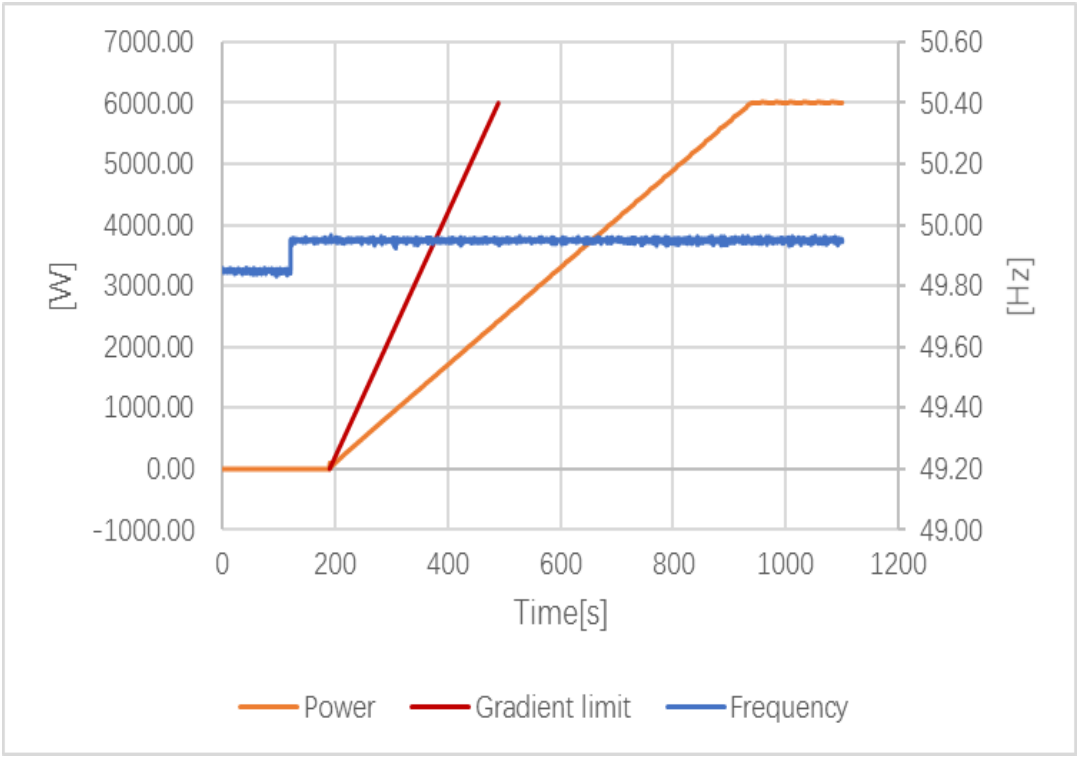


Graph_253V

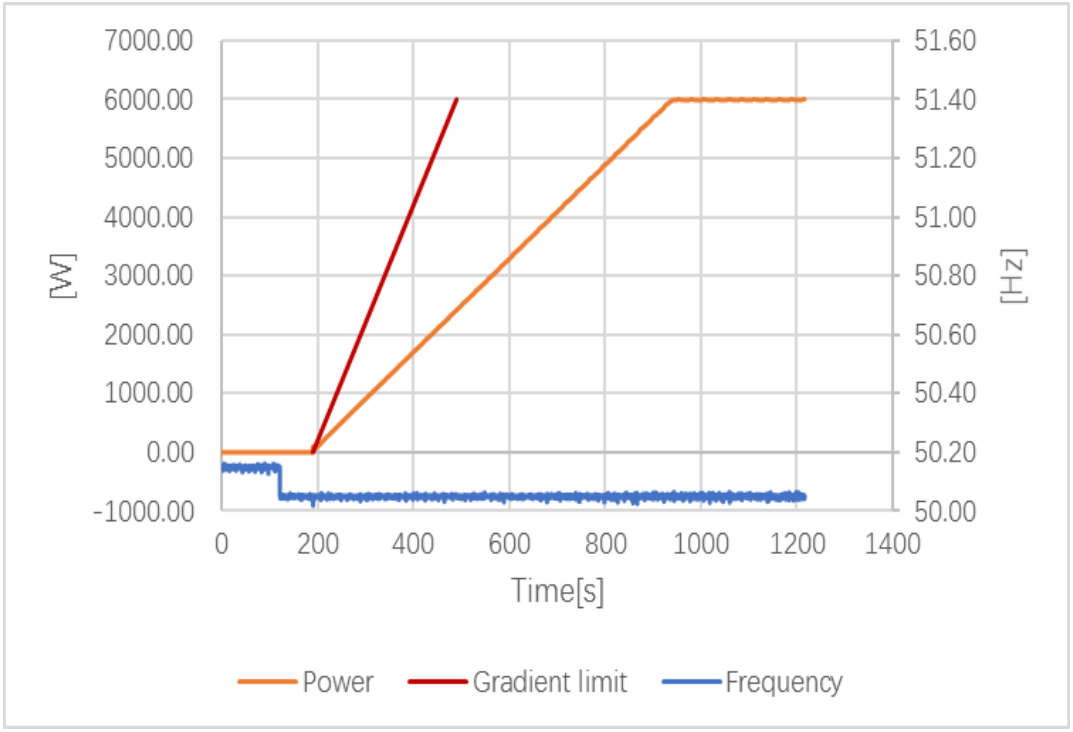


Test sequence at normal operation starting	connection	connection allowed	Observation time (s)	Power gradient after connection (%/min)
Step a)	**<49.9Hz**	**No**	--	--
Step b)	**≥49.9Hz**	**Yes**	69.2	8.01
Step c)	**>50.1Hz**	**No**	--	--
Step d)	**≤50.1Hz**	**Yes**	68.8	7.88
Step e)	**<195.5V**	**No**	--	--
Step f)	**≥195.5V**	**Yes**	67.6	7.64
Step g)	**>253V**	**No**	--	--
Step h)	**≤253V**	**Yes**	68.6	8.03
Remark: Maximum active power increase gradient 20 %/min.				

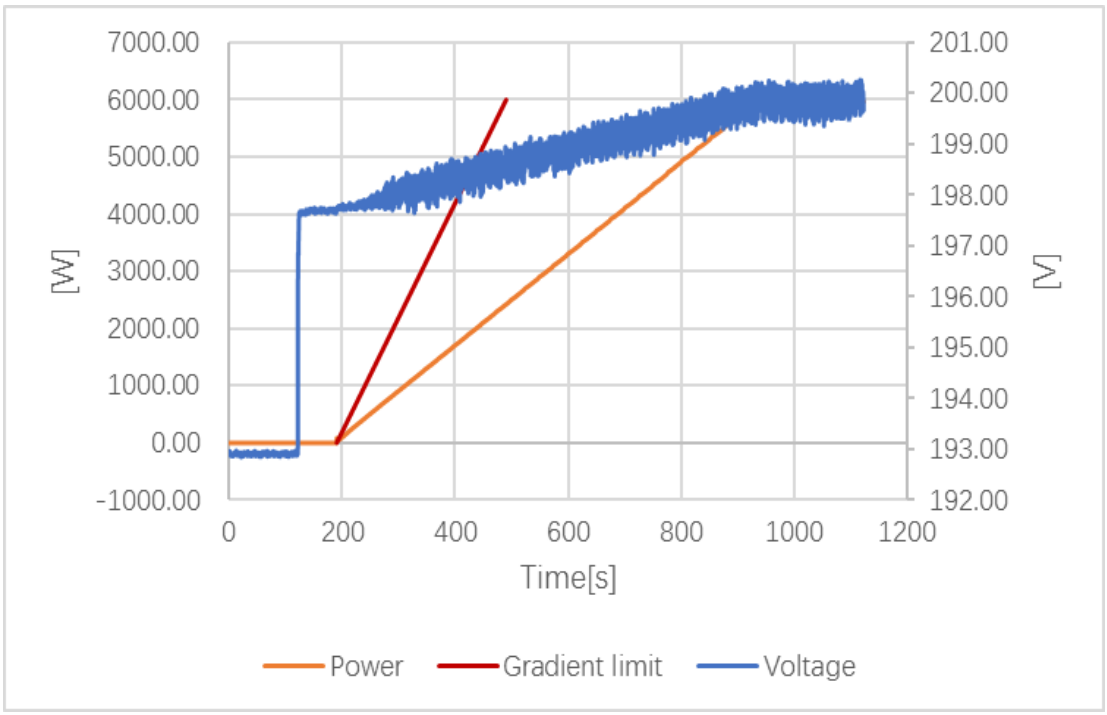
Graph_49.9Hz



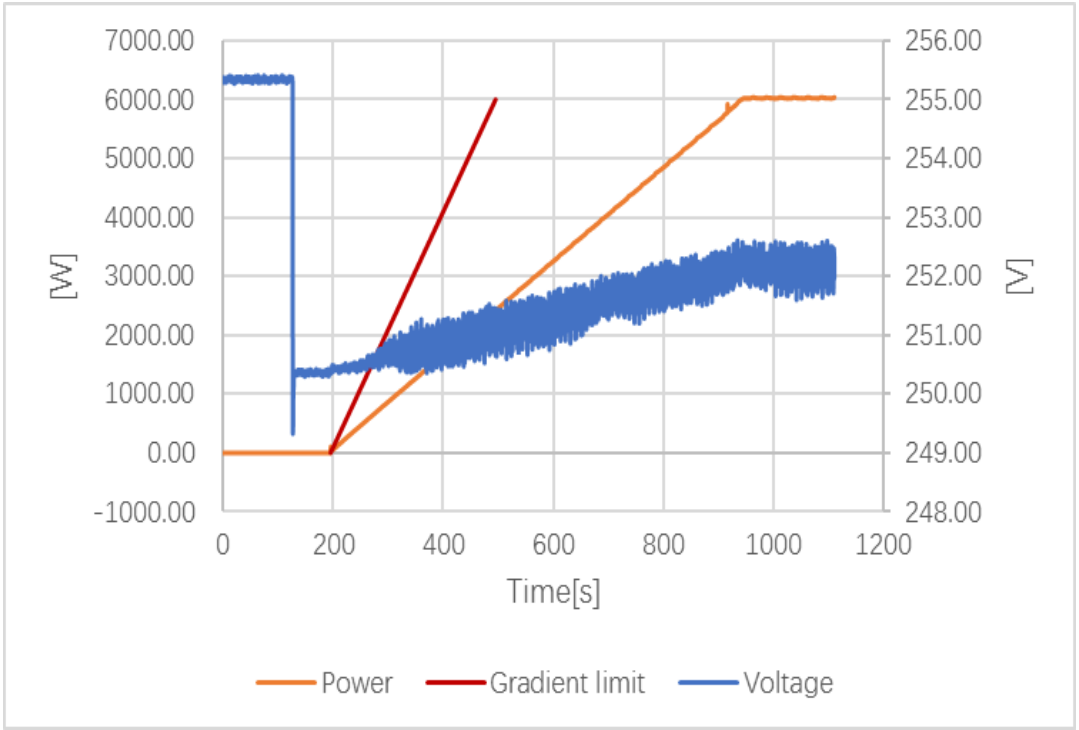
Graph_50.1Hz



Graph_195.5V



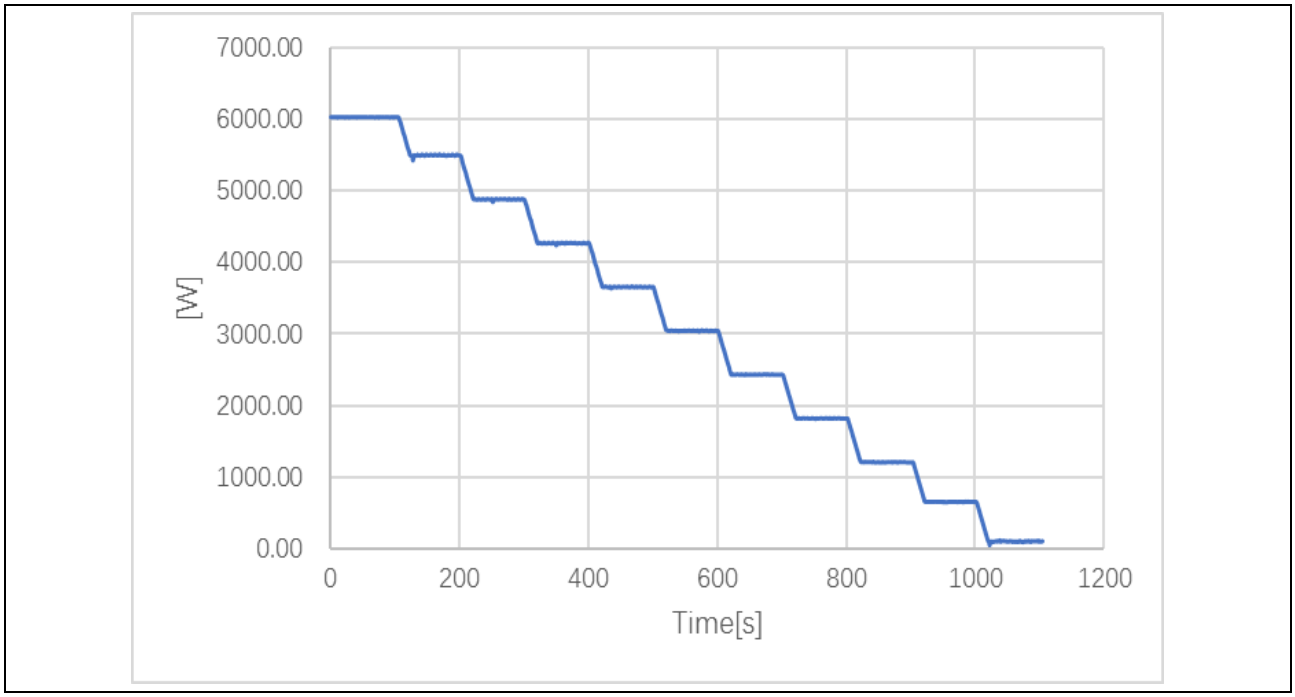
Graph_253V



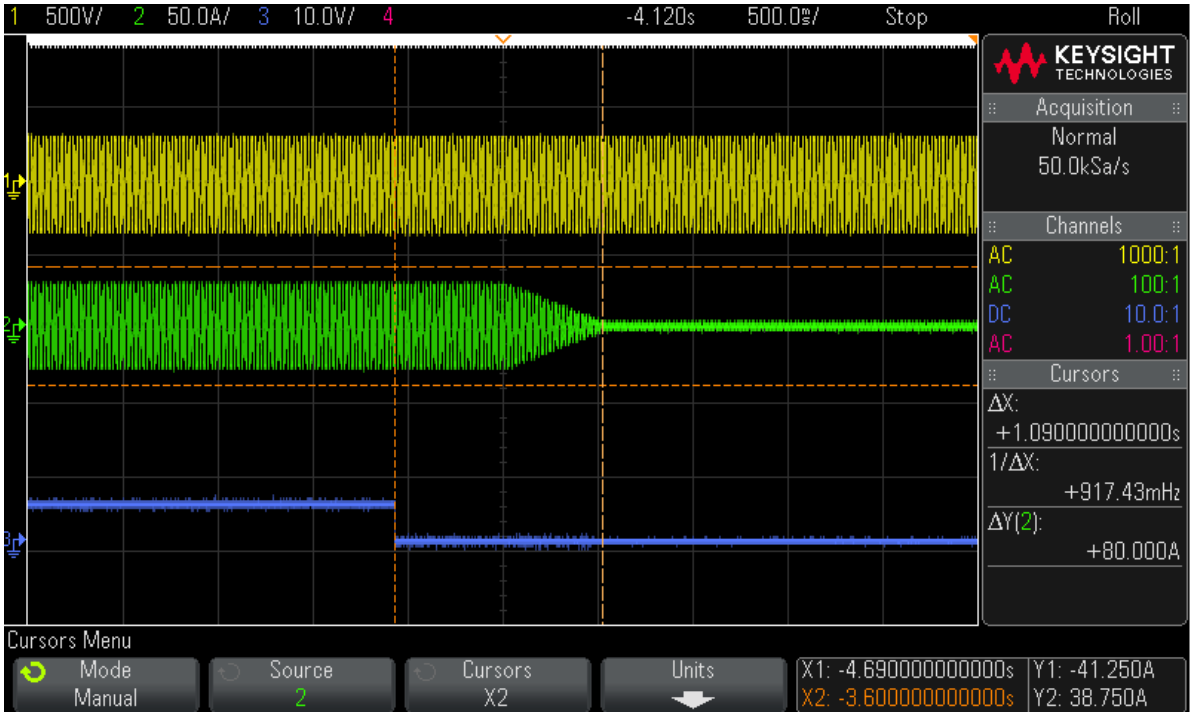
D.9	Table: Ceasing and reduction of active power on set point (Logic interface)	P

String	1	U_{DC} =	358 Vdc	Uac = Un	230 Vac	P_{Emax} (KW)	6.0

1 min mean value P/Pn Psetpoint (%)	Pmeasured (%)	ΔPmeasured (%)	Limit [%]
100%	100.42	0.42	±5%
90%	91.57	1.57	±5%
80%	81.29	1.29	±5%
70%	71.08	1.08	±5%
60%	60.86	0.86	±5%
50%	50.66	0.66	±5%
40%	40.45	0.45	±5%
30%	30.24	0.24	±5%
20%	20.04	0.04	±5%
10%	10.80	0.80	±5%
The power gradient for increasing and reducing (%P_n/s)			0.55%P_n/s
Time for Logic interface (at input port) activated			1.09s



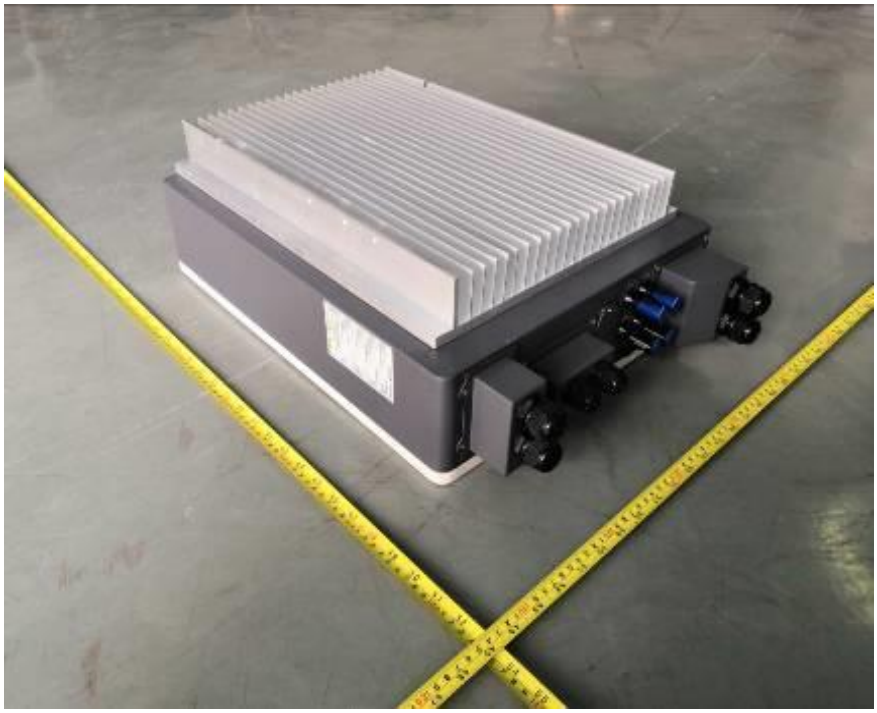
Waveform for logic interface



Remark: Once activation, the inverter will cease the power during 5s, detail also refer to instruction manual

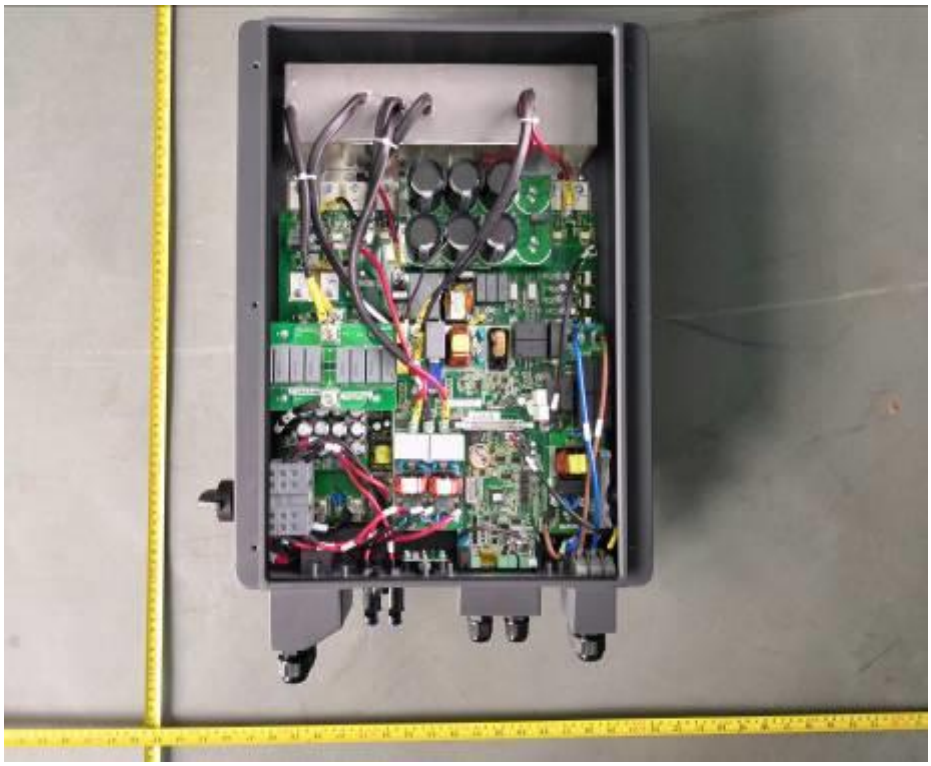
Annex 1: Photo document

Overview

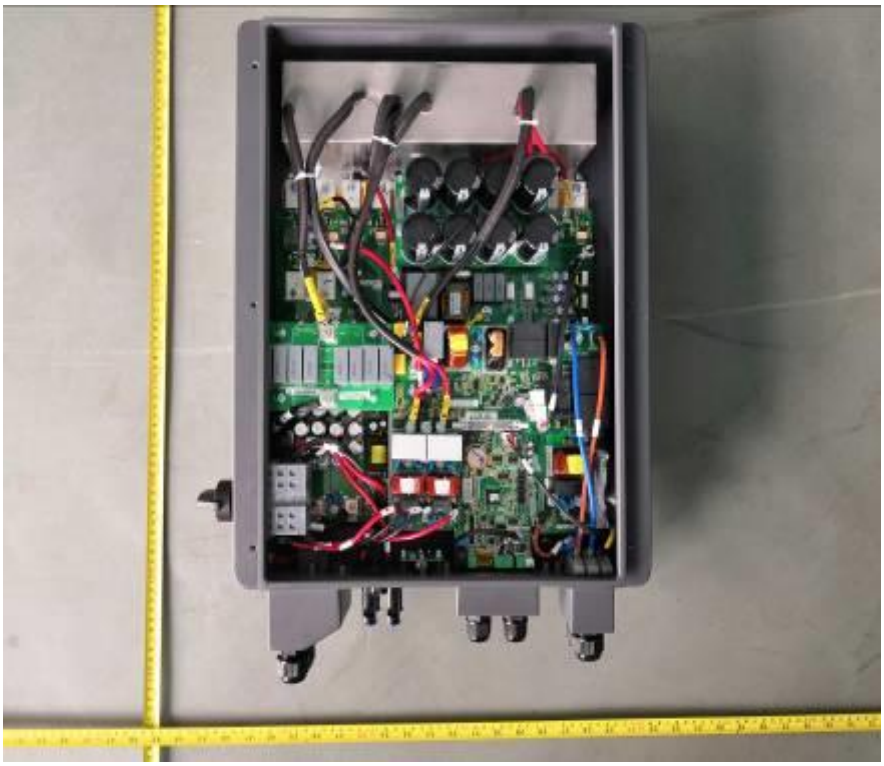


Bottom view

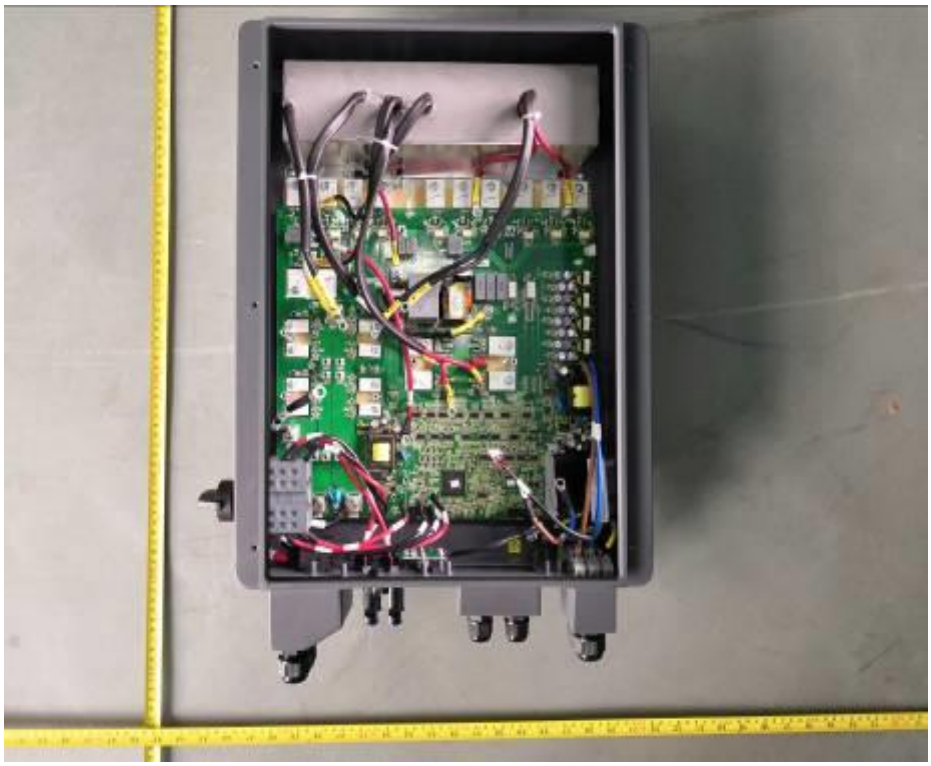
Connection view



Internal view for model HYD 4000-ES, HYD 3600-ES, HYD 3000-ES

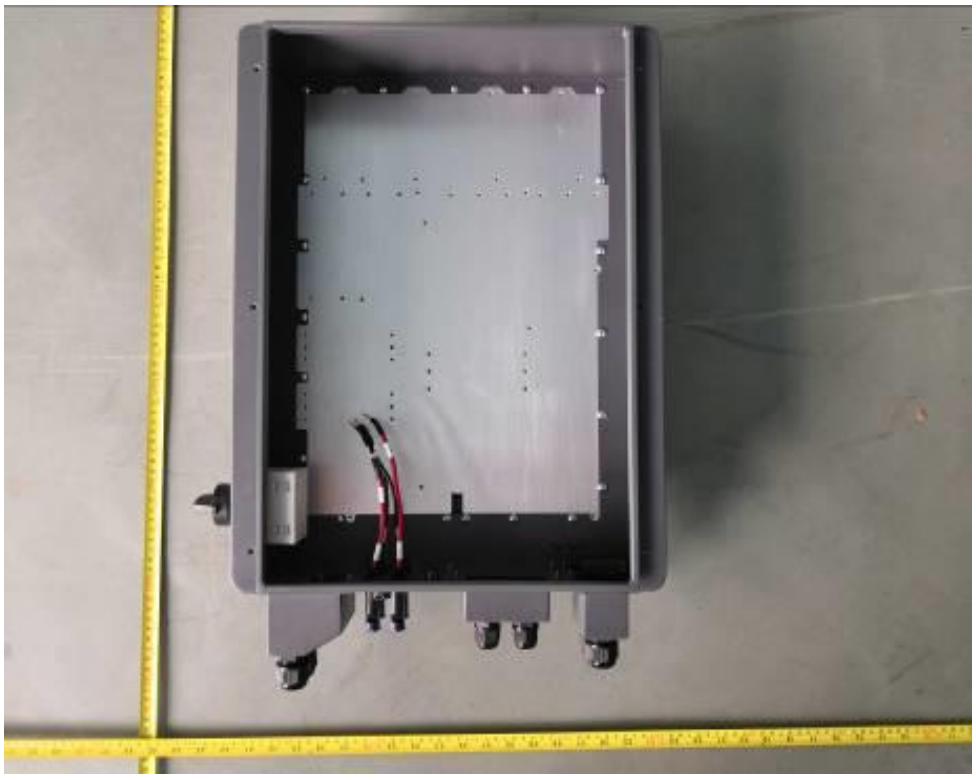


Internal view for model HYD 5000-ES, HYD 6000-ES



Internal view

Earthing view



Internal view

(End of Report)