Product Service

TEST REPORT

EN 50549-1:2019

TUV SUD Test Report for *Requirements for generating plants to be connected in parallel with distribution networks - Part 1: Connection to a LV distribution network - Generating plants up to and including Type B*

Report No.:	64.290.23.30804.01
Date of issue:	2023-06-25
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Testing location:	Same as above
Client:	Shenzhen Kstar New Energy Company Limited
Client number:	075386
Address:	The 9th Floor, R&D Building, Kstar Industrial Park, Guangming Hi-tech Industrial Zone, 518107 Shenzhen, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA
Contact person:	Zeng Qi
Standard:	This TUV SUD test report form is based on the following requirements: *EN 50549-1:2019/AC:2019 & Belgium Deviation C10/11 ed.2.2, 2021*
TRF number and revision*:*	*TRF EN 50549-1:2019/AC:2019 rev.0/2019-04*
TRF originated by:	TUV SUD Product Service, Mr. Billy Qiu
Copyright blank test report:	This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TUV SUD Product Service. TUV SUD Group takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.
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Scheme:	☐ GS Mark ☐ NRTL Mark ☐ EU-Directive ☐ TUV Mark ☒ Type verification of conformity
Non-standard test method:	☒ No ☐ Yes, see details under Summary of testing
National deviations:	N/A
Number of pages *(Report)*:	69
Number of pages *(Attachments)*:	N/A
Compiled by:	Yuneng Chen *(Printed Name and Signature)* Yuneng Chen
Approved by:	Kennen Wang *(Printed Name and Signature)* Kennen Wang

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Test sample:	Hybrid Inverter
Type of test object:	Type test
Trademark:	KSTAR
Model and/or type reference:	KAC50DP
Rating(s):	See page 4
Manufacturer:	Same as applicant
Manufacturer number:	Same as applicant
Address:	Same as applicant
Sub-contractors/ tests (clause):	--
Name:	--
Order description:	☒ Complete test according to TRF
	☐ Partial test according to manufacturer's specifications
	☐ Preliminary test
	☐ Spot check
	☐ Others:
Date of order:	2023-05-05
Date of receipt of test item:	2023-05-05
Date(s) of performance of test:	2023-05-05 to 2023-06-25
Test item particulars:	
Equipment mobility ..... :	☐ movable ☐ hand-held ☒ stationary ☒ fixed ☐ transportable ☐ for building-in
Connection to the mains..... :	☐ pluggable equipment ☐ direct plug-in ☒ permanent connection ☐ for building-in
Enviromental category..... :	☒ outdoor ☐ indoor unconditional ☐ indoor conditional
Over voltage category Mains ..... :	☐ OVC I ☐ OVC II ☒ OVC III ☐ OVC IV
Over voltage category PV ..... :	☐ OVC I ☒ OVC II ☐ OVC III ☐ OVC IV
Mains supply tolerance (%)..... :	+/- 10%
Tested for power systems ..... :	TN system
IT testing, phase-phase voltage (V) ... :	N/A
Class of equipment..... :	☒ Class I ☐ Class II ☐ Class III ☐ Not classified
Mass of equipment (kg)..... :	75 kg (approx.)
Pollution degree ..... :	PD 3(External), PD 2(Internal)
IP protection class..... :	IP 65

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General product information:

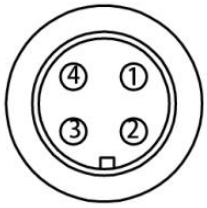
(1) The unit is non-isolated (transformerless) Hybrid Inverter with a maximum power ≤ 250 kVA connected to public grid, for indoor and outdoor use, and defined as type A generator according to Regulation (EU) 2016/631 (NC RfG) and C10/11:2021.

(2) Low voltage electrical installations shall comply with national and local regulation. Only qualified electricians are allowed to install and maintain the converter.

(3) In order to protect the inverter, user and installer, external DC and AC circuit breaker shall be equipped for all source port (battery, AC grid) at the end-use application.

(4) The unit has below reactive power control modes, shall comply with national and local regulation:
   1) Q setpoint mode
   2) Q(U) mode
   3) Cos φ setpoint mode
   4) Cos φ (P)

(5) The inverter use COM port as logic interface. External control command is sent via RS-485 signal and connected with pin 3 and pin4 of COM port.



PIN	Network
1	CAN-H
2	CAN-L
3	RS485-A
4	RS485-B

Figure 6-5 Connection Diagram of COM Port

(6) Firmware Version: REV001, software version: V000B000D001.

(7) The Grid Disconnection Protection System according to C10/21 or C10/23 must be installed externally between the inverter output and grid connection point.

(8) Stand-alone mode is not considered and evaluated in this report, the use of stand-alone mode and electrical installations for unit shall comply with national and local regulation.

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Characteristic data *(not shown on the marking plate)*:

Model:	KAC50DP
PV input parameter	
Maximum input voltage	1000 Vd.c.
MPPT voltage range	350~800 Vd.c.
MPPT voltage range (full load)	667~750 Vd.c.
Maximum input current	3*36 Ad.c.
PV I_{SC}	3*40 Ad.c.
Battery input/output parameter	
Battery type	Lithium-ion
Input voltage range	350~750 Vd.c.
Maximum input/output voltage	750 Vd.c.
Maximum charging current	2*55 Ad.c.
Maximum charging power	55000 W
Maximum discharging current	2*55 Ad.c.
Maximum discharging power	55000 W
Grid parameter	
Rated input/output voltage	230/400 Va.c., 3/N/PE
Rated input/output frequency	50 Hz
Maximum input current	80 Aa.c.
Maximum input active power	50000 W
Maximum input apparent power	55000 VA
Maximum input active power from grid to battery	50000 W
Rated output current	72 Aa.c.
Maximum continuous output current	80 Aa.c.
Rated output active power	50000 W
Maximum output active power	50000 W
Maximum output apparent power	55000 VA
Maximum output active power from battery to grid (without PV input)	50000 W
Power factor	0.9 inductive(under-excited) to 0.9 capacitive(over-excited)

Attachments:

N/A

General remarks:

*Defining the sign in the **generator** sign convention.*
"(see remark #)" refers to a remark appended to the report.
"(see appended table)" refers to a table appended to the report.
*Throughout this report **a point** is used as the decimal separator.*
The test results presented in this report relate only to the object tested.
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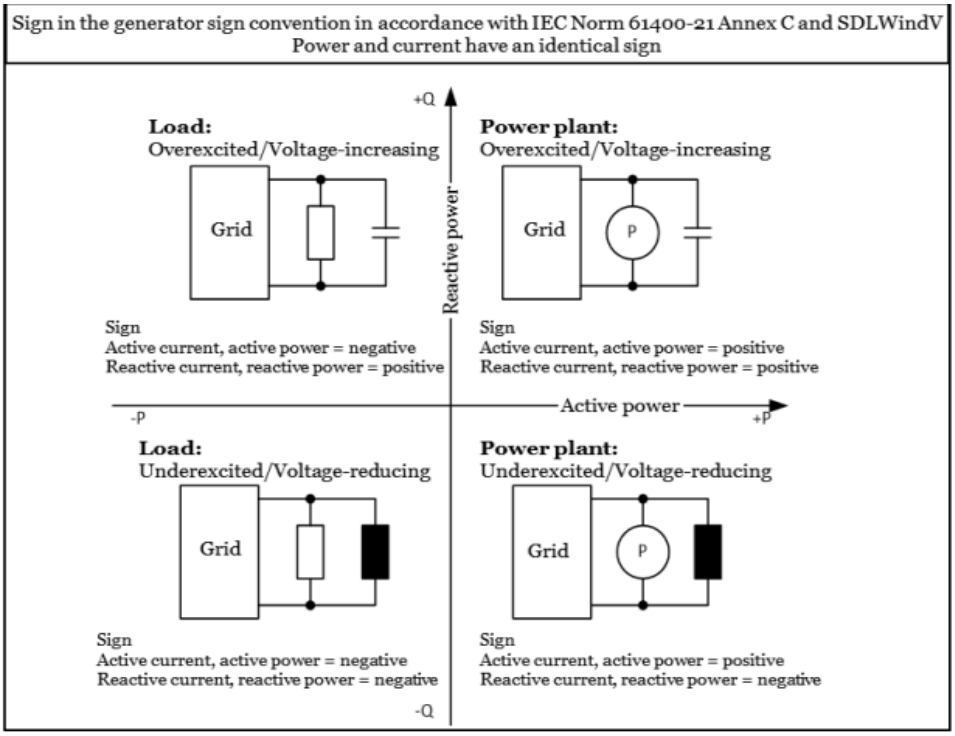
Summary of testing:

Full tests method is based on draft standard EN 50549-1:2019/AC:2019 and Belgium Deviation C10/11:2021 as a reference, test voltage is on nominal voltage 230/400 Va.c., and nominal frequency 50 Hz.

☐ deviation(s) found

☒ no deviations found

Generator sign convention has been applied for all measurements and results given in this report. This is described in the following figure and table:



	Inductive (under-excited)	Capacitive(over-excited)
Generator (Discharge mode)	IV. Quadrant P > 0, the equipment supplies active power from the mains (Discharge mode) Q < 0, the equipment draws reactive power from the mains (inductive behaviour)	I. Quadrant P > 0, the equipment supplies active power from the mains (Discharge mode) Q > 0, the equipment supplies reactive power to the mains (capacitive behaviour)
Consumer (Charge mode)	III. Quadrant P < 0, the equipment draw active power from the mains (Charge mode) Q < 0, the equipment draws reactive power from the mains (inductive behaviour)	II. Quadrant P < 0, the equipment draw active power from the mains (Charge mode) Q > 0, the equipment supplies reactive power to the mains (capacitive behaviour)

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Tests performed (name of test and test clause):

Clause of Belguim	Requirement	Clause of EN 50549-1 for type A	50549-1 requirement
Annex D.3	Integrated automatic separation system	4.9.3	Requirements on voltage and frequency protection
Annex D.3	Integrated automatic separation system (LoM)	4.9.4 & 4.13	Means to detect island situation Requirements regarding single fault tolerance of interface protec- tion system and interface switch
Annex D.4.1 & Annex D.4.3	Operating frequency range Continuous operating voltage range	4.4.2 & 4.4.4	Operating frequency range& Continuous operating voltage range
Annex D.4.2	Maximum admissible power reduction in case of underfrequency	4.4.3	Minimal requirement for active power delivery at under-frequencies
Annex D.5.1	Rate of change of frequency (RoCoF) immunity	4.5.2	Rate of change of frequency (ROCOF) immunity
Annex D.6.1	Power response to overfrequency	4.6.1	Power response to over frequency
Annex D.6.2	Power response to underfrequency	4.6.2	Power response under frequency
Annex D.7.1	Voltage support by reactive power	4.7.2	Voltage support by reactive power
Annex D.7.2	Voltage related active power reduction P(U)	4.7.3	Voltage related active power reduction
Annex D.8	Connection and reconnection	4.10	Connection and starting to generate electrical power
Annex D.9.1	Ceasing active power	4.11.1	Ceasing active power

Additional information on Non-standard test method(s)

Sub clause: N/A
Page: N/A
Rational: N/A

If additional information is necessary, please provide

N/A

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Copy of marking plate:

KSTAR

Hybrid Inverter

Model:	KAC50DP
PV input parameters	
Maximum input voltage	1000 V d.c.
MPPT voltage range	350 V d.c. ~ 800 V d.c.
MPPT voltage range (full load)	667 V d.c. ~ 750 V d.c.
Maximum continuous PV input current	36/36/36 A d.c.
Maximum PV short circuit current	40/40/40 A d.c.
Maximum continuous PV input power	75 kW
Battery input/output parameters	
Battery type	Lithium-ion battery
Rated voltage	512 V d.c.
Battery voltage range	350 V d.c. ~ 750 V d.c.
Rated charging power	50 kW
Maximum charging current	55/55 A d.c.
Rated discharging power	50 kW
Maximum discharging current	55/55 A d.c.
AC input parameters	
Rated input voltage	230/400 V a.c., 3/N/PE
Rated input frequency	50 / 60 Hz
Maximum continuous input current	80 Aa.c.
Maximum input active power	50 kW
Maximum input apparent power	55 kVA
AC output parameters	
Rated output voltage	230/400 V a.c., 3/N/PE
Rated output frequency	50 / 60 Hz
Maximum continuous output current	80 Aa.c.
Maximum continuous output active power	50 kW
Maximum continuous output apparent power	55 kVA
Power factor	0.9 leading to 0.9 lagging
General	
Operating temperature range	-25 °C ~ 60 °C (Derating above 45 °C)
Protection class	I
Ingress protection	IP65
Operating altitude range	≤3000m
Production serial number	

Shenzhen Kstar New Energy Company Limited

Made in China

Remark: For application of this standard, the nominal frequency is 50Hz.

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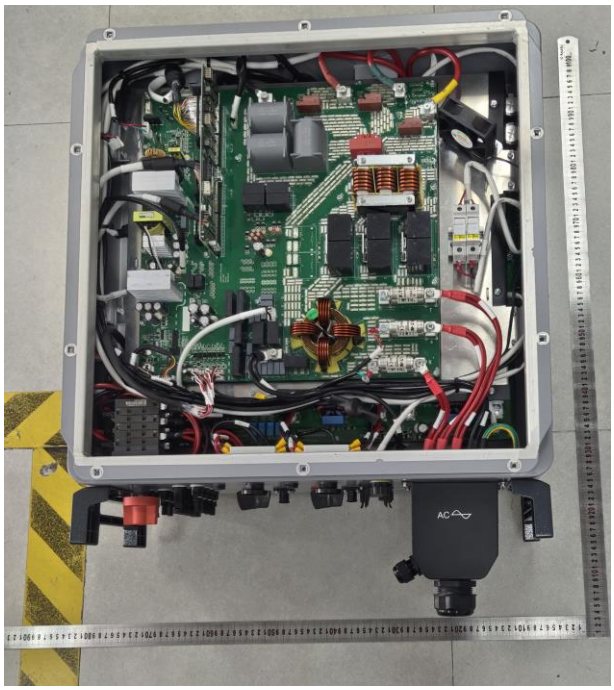
Picture of the product:

Over view



Internal view

Terminal view

side view

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Name and address of factory (ies) *(only if certification is provided)*: Shenzhen KSTAR Science & Technology Co., Ltd. Guangming Branch Kstar High Tech Park, Guangming High Technology Town, Gongming Street, Baoan District, 518107 Shenzhen City, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA

Possible test case verdicts:

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

Possible suffixes to the verdicts:

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

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EN 50549-1:2019/AC:2019			
Clause	Requirement + Test	Result – Remark	Verdict
4	**Requirements on generating plants**		P
4.1	**General**		P
4.2	**Connection scheme**		P
4.3	**Choice of switchgear**		P
4.3.1	General		P
4.3.2	Interface switch		P
4.4	**Normal operating range**		P
4.4.1	General		P
4.4.2	Operating frequency range	Amended to 47.5 to 51.5 Hz according to C10/11 ed.2.2	P
4.4.3	Minimal requirement for active power delivery at underfrequencies		P
4.4.4	Continuous operating voltage range		P
4.5	**Immunity to disturbances**		P
4.5.1	General		P
4.5.2	Rate of change of frequency (ROCOF) immunity	Test according to C10/C11 ed.2.2 figure 10	P
4.5.3	Under-voltage ride through (UVRT)	Not suitable for Type A unit	N/A
4.5.3.1	General		N/A
4.5.3.2	Generating plant with non-synchronous generating technology		N/A
4.5.3.3	Generating plant with synchronous generating technology		N/A
4.5.4	Over-voltage ride through (OVRT)	C10/11 ed.2.2 does not required OVRT	N/A
4.6	**Active response to frequency deviation**		P
4.6.1	Power response to overfrequency	Amended step response time and settling time according to C10/11 ed.2.2	P
4.6.2	Power response to underfrequency	Amended default droop to 2% and step response time and settling time according to C10/11 ed.2.2	P
4.7	**Power response to voltage changes**		P
4.7.1	General		P
4.7.2	Voltage support by reactive power		P

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EN 50549-1:2019/AC:2019			
Clause	Requirement + Test	Result – Remark	Verdict
4.7.2.1	General		P
4.7.2.2	Capabilities	See appendix table	P
4.7.2.3	Control modes	See appendix table	P
4.7.2.3.1	General		P
4.7.2.3.2	Setpoint control modes		P
4.7.2.3.3	Voltage related control modes		P
4.7.2.3.4	Power related Control mode:		P
4.7.3	Voltage related active power reduction	See appendix table	P
4.7.4	Short circuit current requirements on generating plants		N/A
4.7.4.1	General		N/A
4.7.4.2	Generating plant with non-synchronous generating technology		N/A
4.7.4.2.1	Voltage support during faults and voltage steps		N/A
4.7.4.2.2	Zero current mode for converter connected generating technology		N/A
4.7.4.2.3	Induction generator based units		N/A
4.7.4.3	Generating plant with synchronous generating technology - Synchronous generator based units		N/A
4.8	EMC and power quality		N/A
4.9	**Interface protection**		P
4.9.1	General	The Grid Disconnection Protection System according to C10/21 or C10/23 must be installed externally between the inverter output and grid connection point. Internal protection only consider for PGU protection.	P
4.9.2	Void		N/A
4.9.3	Requirements on voltage and frequency protection		P
4.9.3.1	General		P
4.9.3.2	Undervoltage protection [27]		P
4.9.3.3	Overvoltage protection [59]		P
4.9.3.4	Overvoltage 10 min mean protection		P
4.9.3.5	Underfrequency protection [81<]		P
4.9.3.6	Overfrequency protection [81>]		P

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EN 50549-1:2019/AC:2019			
Clause	Requirement + Test	Result – Remark	Verdict
4.9.4	Means to detect island situation		P
4.9.4.1	General		P
4.9.4.2	Active methods tested with a resonant circuit		P
4.9.4.3	Switch to narrow frequency band (see Annex E and Annex F)		N/A
4.9.5	Digital input to the interface protection		N/A
4.10	**Connection and starting to generate electrical power**		P
4.10.1	General	Amended according to C10/11 ed.2.2	P
4.10.2	Automatic reconnection after tripping		P
4.10.3	Starting to generate electrical power		P
4.10.4	Synchronization		P
4.11	**Active power reduction on set point**		P
4.11.1	Ceasing active power		P
4.11.2	Reduction of active power on set point	No requirement	N/A
4.12	**Remote information exchange**		N/A
4.13	**Requirements regarding single fault tolerance of interface protection system and interface switch**		P

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Belgium Deviation C10/11:2021			
Clause	Requirement + Test	Result – Remark	Verdict
D.3	Integrated automatic separation system	The Grid Disconnection Protection System according to C10/21 or C10/23 must be installed externally between the inverter output and grid connection point. Internal protection only consider for PGU protection.	N/A
	This clause is applicable to power-generating units with a maximum power ≤ 30 kVA.		N/A
	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 (see section § 7.5). For the integrated automatic separation system, the requirements of this clause apply.		N/A
	Following protection functions are required: • Overvoltage 10 min mean • Overvoltage • Undervoltage • Overfrequency • Underfrequency • A means to detect island situation (LoM) according to EN 62116. All of these protection functions must comply with the relevant requirements in EN 50549-1 (in edition 2019, section 4.9.3 « Requirements on voltage and frequency protection »).		N/A
	The integrated automatic separation system must have single fault tolerance according to EN 50549-1. (edition 2019, see clause 4.13 « Requirements regarding single fault tolerance of interface protection system and interface switch »). The integrated automatic separation system must be set in accordance with the settings as specified in ANNEXE C (C.1).		N/A
D.4	Operating ranges		P
	Generating plants shall have the capability to operate in the operating ranges specified below regardless of the topology and the settings of the interface protection.		P

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Belgium Deviation C10/11:2021			
Clause	Requirement + Test	Result – Remark	Verdict
D.4.1	Operating frequency range [NC RfG Art 13 1.]	See appendix table	P
	This clause in not applicable to backup power systems as specified in § 2.2.1.		P
	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 »)		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. 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 limited31	The operation range from 47.5Hz to 51.5Hz	P
D.4.2	Maximum admissible power reduction in case of underfrequency [NC RfG Art 13 4. + Art 13 5.]	See appendix table	P
	This clause is not applicable to backup power systems as specified in §2.2.1.		P
	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
	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 Remark: If the power-generating unit has the capability to raise the output in underfrequency situations, this is not forbidden but subject to specific requirements (see Section D.6.2 « Power response to underfrequency »).		N/A
D.4.2.1	Limit for non-synchronous power-generating technology (Power Park Modules)		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 »). The characteristics of the limiting curve are given in the Table 10. Table 10 – characteristics of the limiting curve for the non-synchronous power-generating technologies		P
D.4.2.2	Limits for synchronous power-generating technology		N/A

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Belgium Deviation C10/11:2021			
Clause	Requirement + Test	Result – Remark	Verdict
	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 »). t1, t2 and t3 are given in the following table, together with the characteristics of the limiting curves. Table 11 – Characteristics of the limiting curves for the synchronous power-generating technologies		N/A
D.4.3	Continuous operating voltage range	See appendix table	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 »).		P
	In brief, the requirement in the standard specifies the power-generating plant should be capable to operate continuously when the voltage at the point of connection is within the following range : • For a connection to the low voltage network: 85 % Un < U < 110 % Un where Un = 230 V • For a connection to the high voltage network: 90 % Uc < U < 110 % Uc where Uc is the declared voltage. It is also allowed to reduce apparent power in case of voltage is below respectively 95 % Un or 95 % Uc.	Connect to low voltage network	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 [NC RfG Art. 13 1.(b)]	See appendix table	P
	This clause does not apply to the backup power systems as specified in §2.2.1.		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 section 4.5.2 « Rate of change of frequency (RoCoF) immunity ») taking the additional modifications and information specified hereunder into account.		P
	The power-generating unit shall have the capability to stay connected and operate when the frequency at the point of connection changes with the frequency against time profiles as depicted in the figures hereunder. When considering a		P

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Clause	Requirement + Test	Result – Remark	Verdict
	sliding measurement window of 500ms, these profiles have a maximum RoCoF of 2 Hz/s. Figure 10 – Frequency against time profiles for rate of change of frequency immunity		
	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.		N/A
D.5.2	Under-voltage ride through UVRT [NC RfG Art. 14 3.(a) + Art. 17 3. + Art. 20 3.(a)]		N/A
	This section is not applicable to backup power systems as specified in §2.2.1.		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		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 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.		N/A
	As a consequence, for synchronous generating technology this profile is more stringent than the default requirement in EN 50549-1 or EN 50549-2.		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. For such technologies different cases can be considered: • Compliance with this UVRT requirement can be demonstrated considering a ratio of 10 between 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. • 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		N/A

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	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): • 3 seconds for a power-generating unit with synchronous generating technology • 1 second for a power-generating unit with non-synchronous generating technology		
	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. Figure 13 – Voltage-time profile for packup power systems		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 [NC RfG Art 13 2.]	See appendix table	P
	This clause is not applicable to backup power system as specified in section §2.2.1		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 4.6.1 « Power response to overfrequency ») taking into account the additional modifications and information specified hereunder.	Frequency threshold default setting 50.2 Hz is selected and tested respectively	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
	• For synchronous power-generating technologies Table 12 – Dynamic step response time characteristics (synchronous power-generating technologies)		N/A
	• For non-synchronous power-generating technology Tableau 13 - Dynamic step reponse time characteristics (non-synchronous power-generating technologies)		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%. Figure 14 – Timing data for step response behaviour		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		P

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	until a frequency decrease results in a power setpoint which is again above this level.		
	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. The parameter setting shall be as follows: Table 14 – Parameter settings for power response to overfrequency		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 [NC RfG Art. 13 2.(b)] are not permitted by default as per the TSO provisions.		P
D.6.2	Power response to underfrequency	See appendix table	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.	Frequency threshold default setting 49.8 Hz is selected and tested respectively	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.		P
	Instead of the default maximum step response time of 30s in EN 50549-1 and EN 50549-2, the required 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
	If the function is enabled, the parameters shall be set as following:		P

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Clause	Requirement + Test	Result – Remark	Verdict
	Table 15 – Parameters settings for power response to underfrequency		
	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 [NC RfG Art 17 2.(a) + Art 20 2.(a)]	See appendix table	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.		N/A
	The power-generating plant must at least comply with the corresponding requirements of the applicable standard EN 50549-1 or EN 50549-2 (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.	Q(U) control mode, voltage setting is 0.93Un ~ 0.97Un, 0.93Un for Qmax, 1.03Un ~ 1.07Un, 1.07Un for Qmin	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.		P
	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).		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.		N/A
	If the capabilities exceed the minimum requirement, and as far as this has only limited technical and economic impact34, 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)).		N/A
	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		N/A
	By default, the power generation unit must operate according to the following rules: • When the voltage ≤ 105 % Un : cos phi = 1 (Q=0)		N/A

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Clause	Requirement + Test	Result – Remark	Verdict
	• When the voltage > 105 % Un : free operation with 1 ≥ cos phi > 0,9under-excited. (no overexcited operation allowed)		
D.7.1.2	Specific for another (not small) power-generating plant	See appendix table	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.	The power factor set to 0.9 under-excited~0.9 over-excited.	P
	If the power-generating plant is connected to the high voltage distribution network, it may be necesary 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.	Considered in final installation	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 [NC RfG Art 17 2 (b)] :		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 reactive 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 appendix table	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 »).	The overvoltage derating setting and respone time setting: 1.10 Un.	P
	The figure below shows an example of the implementation of this function. Figure 15 - Example curve for P(U)		P
D.7.3	Provision of additional fast reactive current during faults and voltage steps [NC RfG Art 20 2.(b)]		N/A

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Clause	Requirement + Test	Result – Remark	Verdict
	This Section is only applicable to non-synchronous power-generating units connected to a high voltage distribution network and are not part of a small power-generating plant.		N/A
	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 capabilityto provide additional fast reactive current during faults and voltage steps, this function must be deactivated by default.		N/A
	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.		N/A
	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 [NC RfG Art 13 7 + Art 14 4]		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.		P
	Connection and reconnection after tripping of the interface protection relay is subject to the conditionslisted in the table hereunder. These settings are different than the default settings of EN 50549-1 and EN 50549-2. Table 16 – Conditions for automatic connection and reconnection	The connection and reconnection defult observation time is set to 60 s. The maximum active power increase gradient of reconnection and connection is selected to 10 %/min and tested.	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.		N/A
D.9	Ceasing and reduction of active power on set point		N/A

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Clause	Requirement + Test	Result – Remark	Verdict
	This clause is not applicable to the backup power systems specified in §2.2.1.		N/A
D.9.1	Ceasing active power [NC RfG Art 13 6]	See appendix table	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.		P
	In brief, the requirements in the standards are the following : 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. Remote operation is optional		P
	Respecting the regional regulatory provisions, the DSO can request additional equipment for a remote operation of this logic interface. 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 [NC RfG Art 14 2.]		N/A
	The requirement of this Section is applicable only to the power-generating units that are part of: • a power-generating module with a maximum power of ≥ 1 MW • a power-generating plant with a maximum power of > 250 kVA, if the DSO so requires, in accordance with the regional regulations.		N/A
	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.		N/A
	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		N/A

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Clause	Requirement + Test	Result – Remark	Verdict
	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 [NC RfG Art 14 5.d)]		N/A
	The requirements of this Section are applicable only to the power-generating units that are part of: • a power-generating module with a maximum power ≥ 1 MW • a power-generating plant with a maximum power > 250 kVA, if so required by the DSO, respecting the regional regulatory provisions.		N/A
	This paragraph is not applicable to backup power systems as defined in §2.2.1. However, special attention must be paid to § 7.12 Special supplemental requirement regarding backup power systems		N/A
	The power-generating unit must have the necessary functionalities to meet the requirements of § 7.13 concerning the communication (remote control and monitoring).		N/A

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Annex D.3	Integrated automatic separation system	P

Function	Trip setting
Overvoltage 10 min mean	230 V + 10 % no delay*
Overvoltage	230 V +15 % no delay*
Undervoltage	230 V -20 % no delay*
Overfrequency	51,5 Hz no delay*
Underfrequency	47,5 Hz no delay*
LoM	according to EN 62116
« No delay » means that no time delay is added to the intrinsic technical duration required to initiate the disconnection. The operate time may not exceed 200ms.	

Annexe C.1: Settings of the automatic separation system

		1		2		3	
		Value (V)	Time (ms)	Value (V)	Time (ms)	Value (V)	Time (ms)
L1-N voltage	UV level	183.92	134.0	183.91	136.0	183.92	126.0
		230.82		230.82		230.83	
		230.81		230.81		230.80	
	OV level 2	264.87	122.0	264.86	120.0	264.87	132.0
		230.75		230.77		230.75	
		230.83		230.83		230.84	
L2-N voltage	UV level	230.84	122.0	230.81	120.0	230.83	124.0
		183.80		183.80		183.81	
		230.85		230.78		230.85	
	OV level 2	230.86	126.0	230.86	120.0	230.88	120.0
		264.71		264.74		264.76	
		230.77		230.78		230.78	
L3-N voltage	UV level	230.89	126.0	230.90	128.0	230.90	132.0
		230.77		230.76		230.77	
		183.85		183.85		183.85	
	OV level 2	230.87	126.0	230.83	128.0	230.82	124.0
		230.78		230.78		230.77	
		264.81		264.75		264.75	

Voltage monitoring for 10-min-mean-value: OV Level 1	
Test procedure (for U>)	a) The voltage is maintained at 100% Un for 600s, afterwards the voltage is raised to 112%, the switch off must be within 600s. b) The voltage is maintained at Un for 600s, afterwards the voltage is raised to 108%. The switch off should not be activated. c) The voltage is maintained at 106% Un for 600s, afterwards the voltage is raised to 114%. The switch off should be within 225s-375s.

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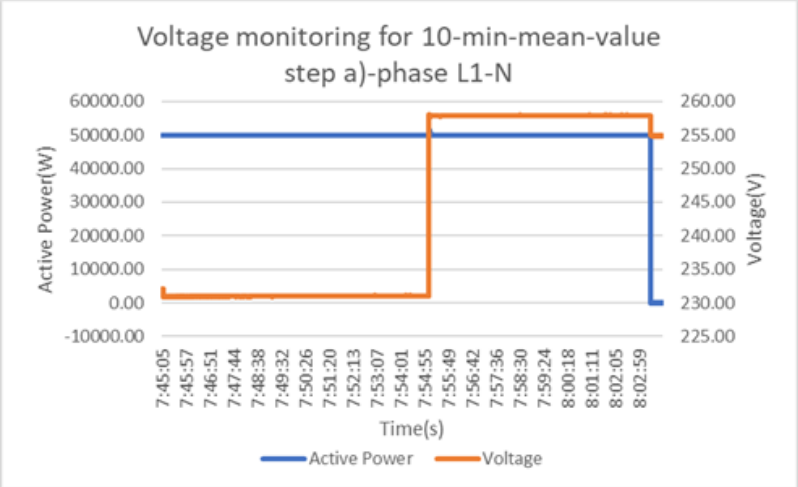
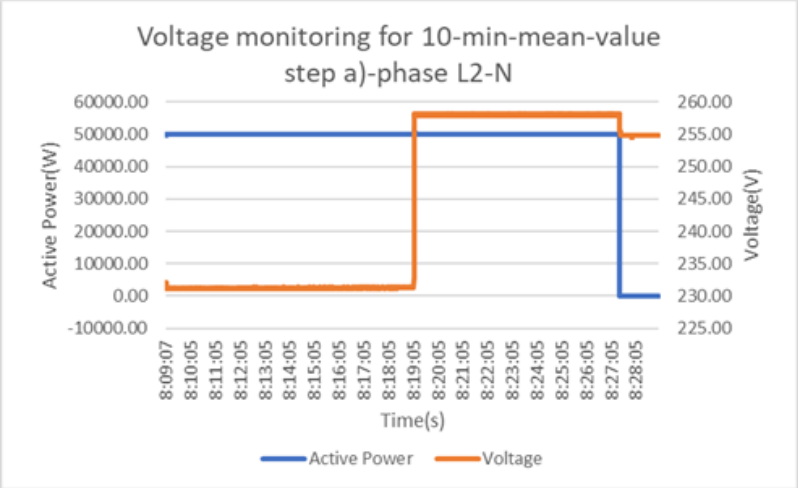
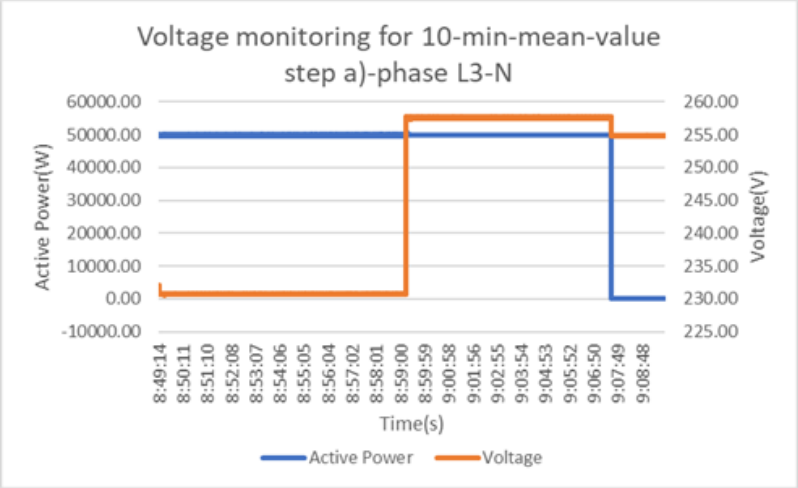
Applied phase	a		b		c	
	Switch off (Yes/No)	Time (s)	Switch off (Yes/No)	Time (s)	Switch off (Yes/No)	Time (s)
L1-N	Yes	500.0	No	--	Yes	299.8
L2-N	Yes	500.0	No	--	Yes	300.0
L3-N	Yes	499.8	No	--	Yes	299.8







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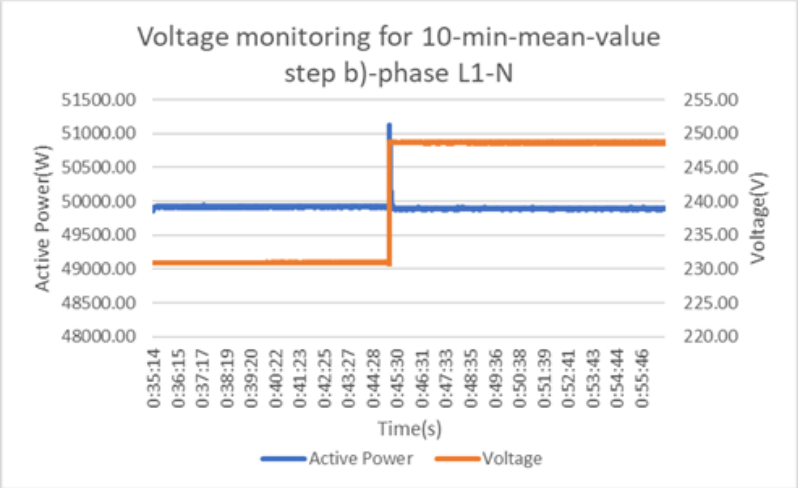

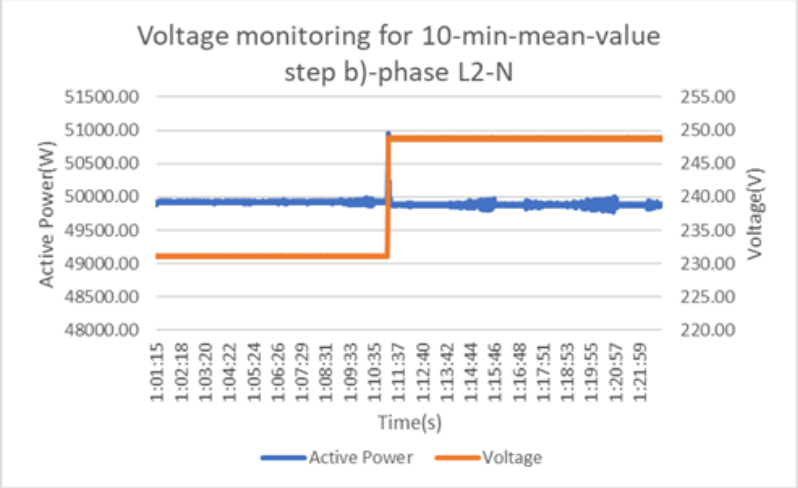

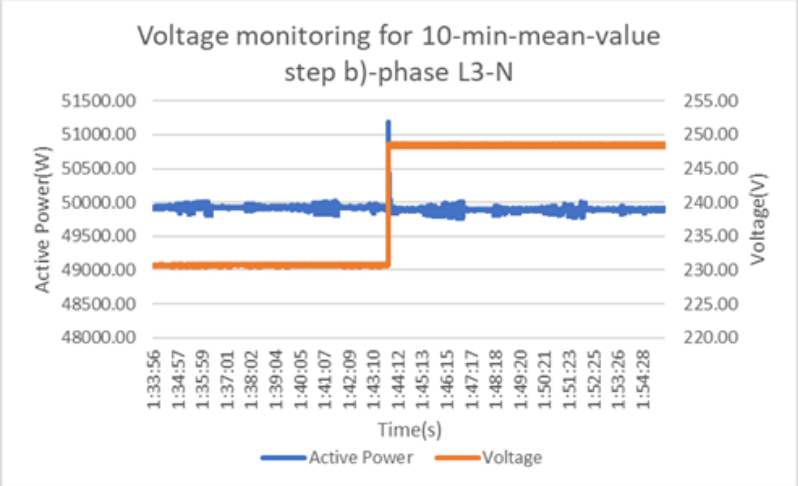

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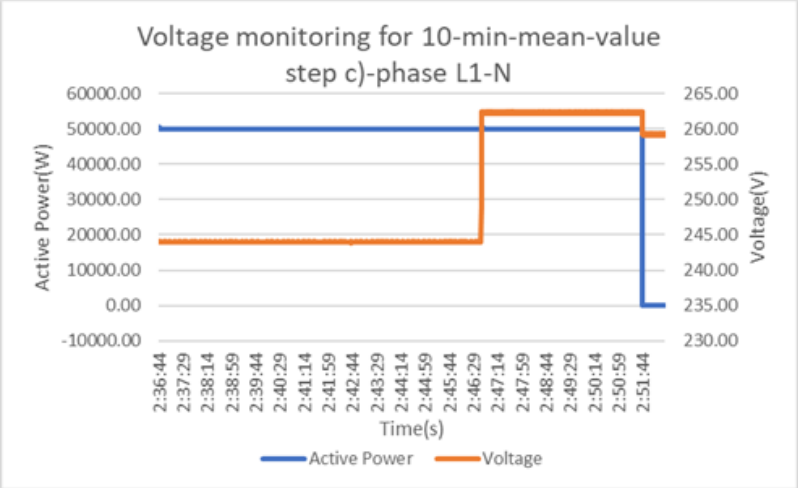

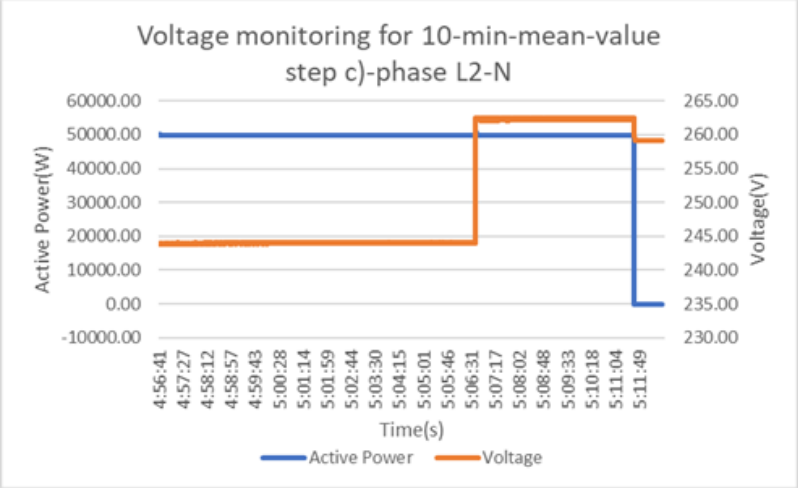

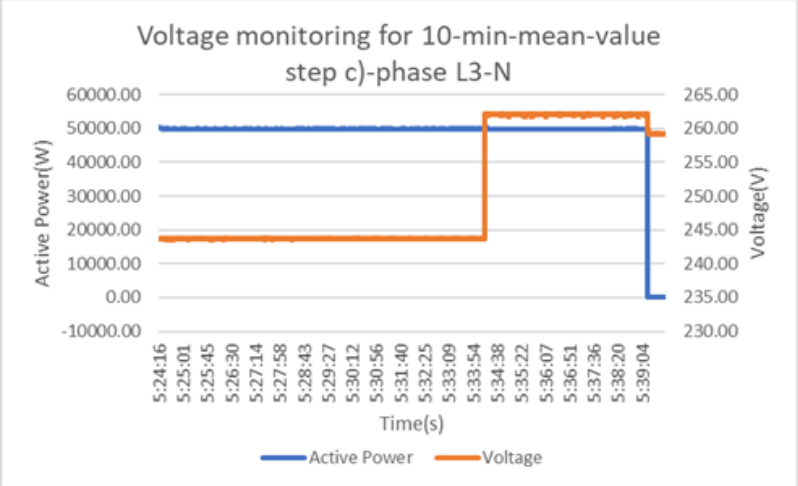

Frequency monitoring

		1		2		3	
		Value (Hz)	Time (ms)	Value (Hz)	Time (ms)	Value (Hz)	Time (ms)
Test procedure (for f>, f<)	f>	51.50	144.5	51.50	147.5	51.49	134.0
	f<	47.51	142.5	47.50	153.5	47.49	152.0

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Annex D.3		Integrated automatic separation system (LoM)									P
No.	P_{EUT} (% of EUT rating)	Reactive Load (% of Q_L)	P_{AC} (% of nominal)	Q_{AC} (% of nominal)	Run on time (ms)	P_{EUT} (kW)	Actual Q_f (L1)	Actual Q_f (L2)	Actual Q_f (L3)	V_{DC} (V)	Remarks
1	100	100	0	0	1293.5	50.0	0.998	1.003	0.998	700	Test A at BL
2	66	66	0	0	408.0	33.0	0.998	0.999	1.001	575	Test B at BL
3	33	33	0	0	327.5	16.5	1.000	0.999	0.999	400	Test C at BL
4	100	100	-5	-5	110.0	50.0	1.054	1.016	1.015	700	Test A at IB
5	100	100	-5	0	130.0	50.0	1.050	1.041	1.042	700	Test A at IB
6	100	100	-5	5	116.0	50.0	1.069	1.088	1.078	700	Test A at IB
7	100	100	0	-5	175.0	50.0	0.993	0.959	0.979	700	Test A at IB
8	100	100	0	5	466.0	50.0	1.017	1.042	1.015	700	Test A at IB
9	100	100	5	-5	118.5	50.0	0.960	0.921	0.929	700	Test A at IB
10	100	100	5	0	160.0	50.0	0.961	0.960	0.952	700	Test A at IB
11	100	100	5	5	118.5	50.0	0.977	0.985	0.980	700	Test B at IB
12	66	66	0	-5	93.5	33.0	0.973	0.971	0.982	575	Test B at IB
13	66	66	0	-4	113.5	33.0	0.975	0.975	0.965	575	Test B at IB
14	66	66	0	-3	128.5	33.0	0.979	0.979	0.986	575	Test B at IB
15	66	66	0	-2	153.5	33.0	0.988	0.988	0.990	575	Test B at IB
16	66	66	0	-1	208.5	33.0	1.010	0.992	0.975	575	Test B at IB
17	66	66	0	1	238.5	33.0	1.010	1.008	0.993	575	Test B at IB
18	66	66	0	2	143.5	33.0	1.009	1.007	1.005	575	Test B at IB
19	66	66	0	3	111.0	33.0	1.002	1.021	1.025	575	Test B at IB

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20	66	66	0	4	96.0	33.0	1.004	1.026	1.029	575	Test B at IB
21	66	66	0	5	88.5	33.0	1.013	1.028	1.035	575	Test B at IB
22	33	33	0	-5	67.5	16.5	0.977	0.982	0.975	400	Test C at IB
23	33	33	0	-4	92.5	16.5	0.975	0.982	0.978	400	Test C at IB
24	33	33	0	-3	100.0	16.5	0.983	0.987	0.981	400	Test C at IB
25	33	33	0	-2	110.0	16.5	0.986	0.990	0.985	400	Test C at IB
26	33	33	0	-1	155.0	16.5	0.989	0.998	0.989	400	Test C at IB
27	33	33	0	1	200.0	16.5	1.002	1.007	1.008	400	Test C at IB
28	33	33	0	2	130.0	16.5	1.011	1.007	1.009	400	Test C at IB
29	33	33	0	3	117.5	16.5	1.014	1.007	1.011	400	Test C at IB
30	33	33	0	4	105.0	16.5	1.018	1.011	1.018	400	Test C at IB
31	33	33	0	5	80.0	16.5	1.021	1.021	1.017	400	Test C at IB
Supplementary information: N/A											

EN 50549-1, 4.13	**Requirements regarding single fault tolerance of interface protection system and interface switch**					P
Ambient temperature (°C) .....:						24.8
No.	Component	Fault	Supply voltage (V)	Test time	Fuse #	Fuse current (A)	Observation
1.	Grid relay RLY1 for L1 relay	S-C	750 Vd.c.	1 min	--	--	The fault was applied before the unit operation, after applied the fault, the unit could not connect to grid, “Output Relay Short-Circuit Fault” was detected. No hazard. No damage. After removed the fault, the unit worked normally.
2.	Grid relay RLY2 for L1 relay						
3.	Grid relay RLY3 for L2 relay						
4.	Grid relay RLY4 for L2 relay						
5.	Grid relay RLY5 for L3 relay						
6.	Grid relay RLY6 for L3 relay						
7.	Grid relay RLY7 for N relay						
8.	Grid relay RLY8 for N relay						

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Check that the relays fulfil the basic insulation or simple separation based on the PV circuit working voltage.	Yes L distance: 2*3mm=6mm N distance: 2*3mm=6mm
Each active phase can be switched. (L and N)	Yes
Supplementary information: S-C: short circuit	

Annex D.4.1 & D.4.3	**Operating frequency range & Continuous operating voltage range**			P
Frequency range operation test				
	Setting	Measured power		
		P (W)	Q (Var)	S (VA)
Test #1	47.5Hz, 85% of Un, 30min, cosφ=1	46850.15	-1706.73	46900.54
Test #2	47.5Hz, 110% of Un, 30imn, cosφ=1	50073.19	-383.80	50124.84
Test #3	51.5Hz, 85% of Un, 30min, cosφ=1	46520.00	321.32	46521.12
Test #4	51.5Hz, 110% of Un, 30min, cosφ=1	50126.52	733.36	50131.93
Supplementary information: N/A				

Annex D4.2	**Maximum admissible power reduction in case of underfrequency**			P
Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{minimum}$ (W)	Deviation of $P_{measure}$ (W) higher than $P_{minimum}$? (Yes/No)
1	50.00	11991.4	50000	Yes
2	49.50	11989.1	50000	Yes
3	49.00	11986.4	50000	Yes
4	48.50	11982.9	49500	Yes
5	48.00	11988.6	49000	Yes
6	47.50	11982.8	48500	Yes
Supplementary information: N/A				

Annex D5.1	**Rate of change of frequency (RoCoF) immunity**	P
RoCoF operation test, +/-2.0Hz/s for smooth time wunow of 0.5s		
	Setting	Disconnection during RoCoF
Point #1	50.0Hz to 51.0Hz, +2.0Hz/s for 0.5s, 85% of Un, cosφ=1 (stay 0 second, to Test #2)	No disconnection
Point #2	51.0Hz to 51.5Hz, +1.0Hz/s for 0.5s, 85% of Un, cosφ=1 (stay 1 second, to Test #3)	No disconnection

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Point #3	51.5Hz to 51.0Hz, -1.0Hz/s for 0.5s, 85% of Un, cosφ=1 (stay 5 second, to Test #4)	No disconnection
Point #4	51.0 to 50.0Hz, -2.0Hz/s for 0.5s, 85% of Un, cosφ=1 (stay 5 second, to Test #5)	No disconnection
Point #5	50.0Hz to 49.0Hz, -2.0Hz/s for 0.5s, 85% of Un, cosφ=1 (stay 0 second, to Test #6)	No disconnection
Point #6	49.0Hz to 47.5Hz, -1.0Hz/s for 1.5s, 85% of Un, cosφ=1 (stay 1 second, to Test #7)	No disconnection
Point #7	47.5Hz to 49.0Hz, +1.0Hz/s for 1.5s, 85% of Un, cosφ=1	No disconnection
Point #8	50.0Hz to 51.0Hz, +2.0Hz/s for 0.5s, 100% of Un, cosφ=1 (stay 0 second, to Test #9)	No disconnection
Point #9	51.0Hz to 51.5Hz, +1.0Hz/s for 0.5s, 100% of Un, cosφ=1 (stay 1 second, to Test #10)	No disconnection
Point #10	51.5Hz to 51.0Hz, -1.0Hz/s for 0.5s, 100% of Un, cosφ=1 (stay 5 second, to Test #11)	No disconnection
Point #11	51.0 to 50.0Hz, -2.0Hz/s for 0.5s, 100% of Un, cosφ=1 (stay 5 second, to Test #12)	No disconnection
Point #12	50.0Hz to 49.0Hz, -2.0Hz/s for 0.5s, 100% of Un, cosφ=1 (stay 0 second, to Test #13)	No disconnection
Point #13	49.0Hz to 47.5Hz, -1.0Hz/s for 1.5s, 100% of Un, cosφ=1 (stay 1 second, to Test #14)	No disconnection
Point #14	47.5Hz to 49.0Hz, +1.0Hz/s for 1.5s, 100% of Un, cosφ=1	No disconnection
Point #15	50.0Hz to 51.0Hz, +2.0Hz/s for 0.5s, 110% of Un, cosφ=1 (stay 0 second, to Test #16)	No disconnection
Point #16	51.0Hz to 51.5Hz, +1.0Hz/s for 0.5s, 110% of Un, cosφ=1 (stay 1 second, to Test #17)	No disconnection
Point #17	51.5Hz to 51.0Hz, -1.0Hz/s for 0.5s, 110% of Un, cosφ=1 (stay 5 second, to Test #18)	No disconnection
Point #18	51.0 to 50.0Hz, -2.0Hz/s for 0.5s, 110% of Un, cosφ=1 (stay 5 second, to Test #19)	No disconnection
Point #19	50.0Hz to 49.0Hz, -2.0Hz/s for 0.5s, 110% of Un, cosφ=1 (stay 0 second, to Test #20)	No disconnection
Point #20	49.0Hz to 47.5Hz, -1.0Hz/s for 1.5s, 110% of Un, cosφ=1 (stay 1 second, to Test #21)	No disconnection
Point #21	47.5Hz to 49.0Hz, +1.0Hz/s for 1.5s, 110% of Un, cosφ=1	No disconnection
Supplementary information: N/A		

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Annex D.6.1	Power response to overfrequency	P

a) For Type 2 generation unit (PV or PV+ESS), over-frequency regulation, with active power reduction frequency start point=50.2Hz, gradient s=5%

Stage 1: TYPE 2 inverter DC input power is set to 100% of maximum active output power till the end of the test. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_M = 49997.83 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max\text{-}limit}$ (W)	Deviation of $P_{measure}$ and $P_{max\text{-}limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	50153.60	--	--	--
2.	50.20	49997.83	--	--	--
3.	50.25	49027.88	48997.87	30.01	Yes
4.	50.70	40230.86	39998.26	232.60	Yes
5.	51.15	31153.45	30998.65	154.80	Yes
6.	50.70	40227.27	39998.26	229.01	Yes
7.	50.25	49030.68	48997.87	32.81	Yes
8.	50.00	50156.28	--	--	--

Stage 2: TYPE 2 inverter DC input power is set to 50% of maximum active output power first. After the TYPE 2 inverter step into frequency range above 50.2Hz, the TYPE 2 inverter available input power is set to 100% of maximum active output. The output active power should not be changed. When the TYPE 2 inverter step back below the frequency 50.2Hz, the output active power should arise with a gradient of 10 % Pn/min.

P_M = 25086.57 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max\text{-}limit}$ (W)	Deviation of $P_{measure}$ and $P_{max\text{-}limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	25157.59	--	--	--
2.	50.20	25086.57	--	--	--
3.	50.25	24578.67	24584.84	-6.17	Yes
4.	50.70	19997.53	20069.26	-71.73	Yes
5.	51.15	15417.50	15553.67	-136.17	Yes
6.	50.70	20000.02	20069.26	-69.24	Yes
7.	50.25	24579.06	24584.84	-5.78	Yes
8.	50.00	See below table	--	--	--
Test sequence	Freq (Hz)	Time after step back from 50.2Hz t (min)	Measured active output power $P_{measure}$ (W)	ΔP Arise during next 1 min	Gradient of arising powerΔP/t under 10% P_{max} (Yes/No)
9.	50.00	0.0 min	25183.33	--	--
10.	50.00	0.5 min	27556.67	--	--

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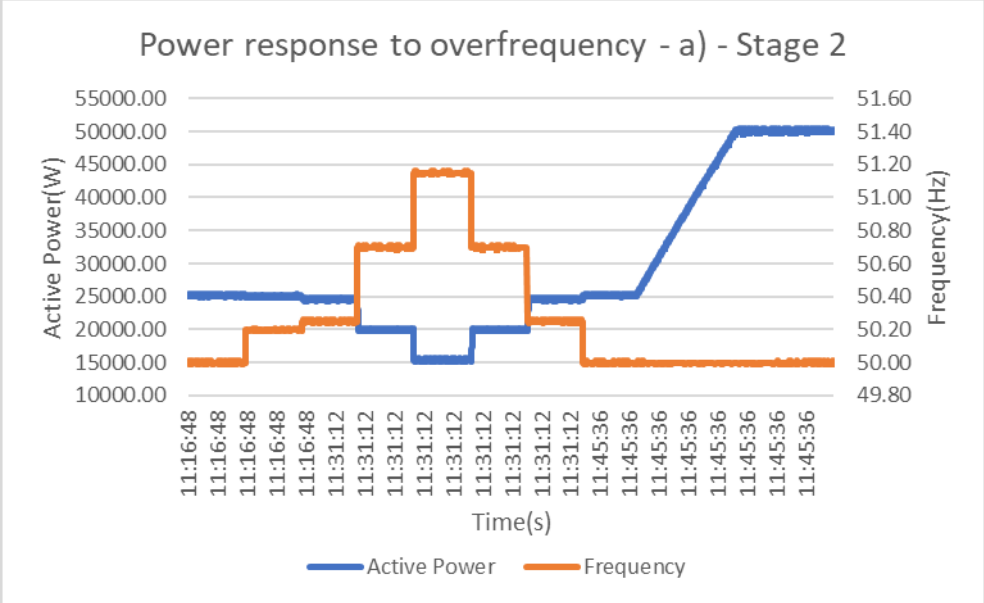
11.	50.00	1.0 min	29946.67	4763.34	Yes
12.	50.00	1.5 min	32354.00	4797.33	Yes
13.	50.00	2.0 min	34743.33	4796.66	Yes
14.	50.00	2.5 min	36947.50	4593.50	Yes
15.	50.00	3.0 min	39453.33	4710.00	Yes
16.	50.00	3.5 min	41664.00	4716.50	Yes
17.	50.00	4.0 min	44126.00	4672.67	Yes
18.	50.00	4.5 min	46261.42	4597.42	Yes
19.	50.00	5.0 min	48593.33	4467.33	Yes
20.	50.00	5.5 min	50236.67	3975.25	Yes



b) For Type 2 generation unit (PV or PV+ESS), over-frequency regulation, with active power reduction frequency start point=50.2Hz, gradient s=12%

Stage 1: TYPE 2 inverter DC input power is set to 100% of maximum active output power till the end of the test. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_M = 50080.85 W, 10% P_n= 5000 W, intentional delay time: 0.4 s (should ⩽2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max-limit}$ (W)	Deviation of $P_{measure}$ and $P_{max-limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	50151.84	--	--	--
2.	50.20	50080.85	--	--	--
3.	50.25	49655.63	49663.51	-7.88	Yes
4.	50.70	46065.81	45907.45	158.36	Yes
5.	51.15	42395.93	42151.38	244.55	Yes
6.	50.70	46074.65	45907.45	167.20	Yes

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7.	50.25	49675.45	49663.51	11.94	Yes
8.	50.00	50141.72	--	--	--

Stage 2: TYPE 2 inverter DC input power is set to 50% of maximum active output power first. After the TYPE 2 inverter step into frequency range above 50.2Hz, the TYPE 2 inverter available input power is set to 100% of maximum active output. The output active power should not be changed. When the TYPE 2 inverter step back below the frequency 50.2Hz, the output active power should arise with a gradient of 10 % Pn/min.

P_M = 25141.04 W, 10% P_n= 5000 W, intentional delay time: 0.4 s (should ⩽2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max-limit}$ (W)	Deviation of $P_{measure}$ and $P_{max-limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	25169.07	--	--	--
2.	50.20	25141.04	--	--	--
3.	50.25	24925.25	24931.53	-6.28	Yes
4.	50.70	22992.24	23045.95	-53.71	Yes
5.	51.15	21057.10	21160.38	-103.28	Yes
6.	50.70	22995.26	23045.95	-50.69	Yes
7.	50.25	24924.41	24931.53	-7.12	Yes
8.	50.00	See below table	--	--	--
Test sequence	Freq (Hz)	Time after step back from 50.2Hz t (min)	Measured active output power $P_{measure}$ (W)	ΔP Arise during next 1 min	Gradient of arising powerΔP/t under 10% P_{max} (Yes/No)
9.	50.00	0.0 min	24928.90	--	--
10.	50.00	0.5 min	26742.20	--	--
11.	50.00	1.0 min	28614.80	3685.90	Yes
12.	50.00	1.5 min	30485.30	3743.10	Yes
13.	50.00	2.0 min	32340.30	3725.50	Yes
14.	50.00	2.5 min	34178.10	3692.80	Yes
15.	50.00	3.0 min	36037.30	3697.00	Yes
16.	50.00	3.5 min	38007.30	3829.20	Yes
17.	50.00	4.0 min	39856.40	3819.10	Yes
18.	50.00	4.5 min	41696.80	3689.50	Yes
19.	50.00	5.0 min	43506.90	3650.50	Yes
20.	50.00	5.5 min	45378.50	3681.70	Yes
21.	50.00	6.0 min	47211.90	3705.00	Yes
22.	50.00	6.5 min	49036.90	3658.40	Yes
23.	50.00	7.0 min	50027.20	2815.30	Yes

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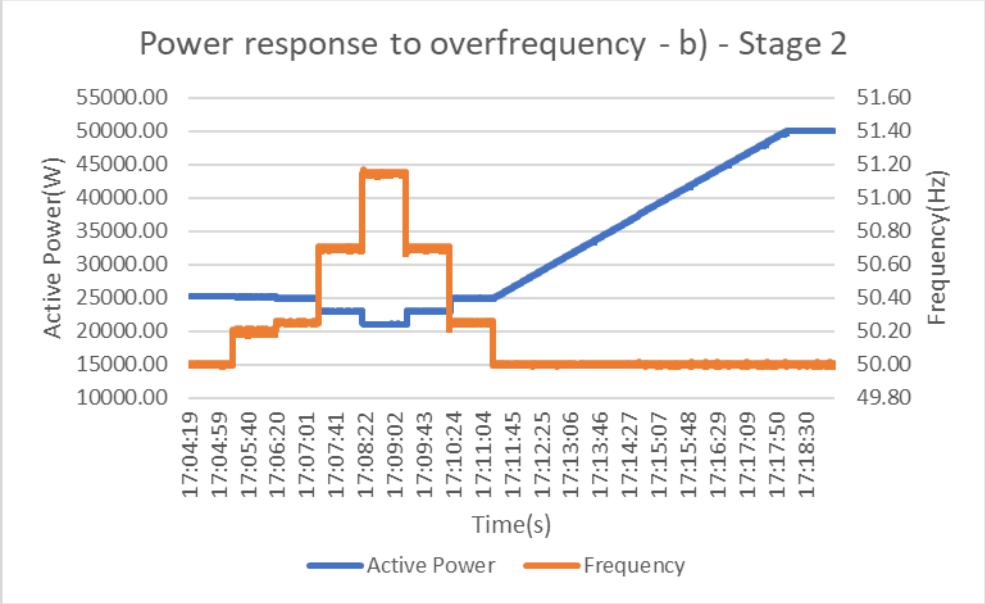

c) For Type 2 generation unit (PV or PV+ESS), over-frequency regulation, with active power reduction frequency start point=50.2Hz, gradient s=2%

Stage 1: TYPE 2 inverter DC input power is set to 100% of maximum active output power till the end of the test. The active power value shall not be deviated from the required value calculated from the feature curve 10% P_n.

P_M = 49763.24 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max-limit}$ (W)	Deviation of $P_{measure}$ and $P_{max-limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	50176.85	--	--	--
2.	50.20	49763.24	--	--	--
3.	50.25	47340.00	47275.08	64.92	Yes
4.	50.70	24760.17	24881.62	-121.45	Yes
5.	51.15	1581.42	2488.16	-906.74	Yes
6.	50.70	24762.40	24881.62	-119.22	Yes
7.	50.25	47343.44	47275.08	68.36	Yes
8.	50.00	50184.11	--	--	--

Stage 2: TYPE 2 inverter DC input power is set to 50% of maximum active output power first. After the TYPE 2 inverter step into frequency range above 50.2Hz, the TYPE 2 inverter available input power is set to 100% of maximum active output. The output active power should not be changed. When the TYPE 2 inverter step back below the frequency 50.2Hz, the output active power should arise with a gradient of 10 % Pn/min.

P_M = 24961.04 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max-limit}$ (W)	Deviation of $P_{measure}$ and $P_{max-limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	25165.18	--	--	--

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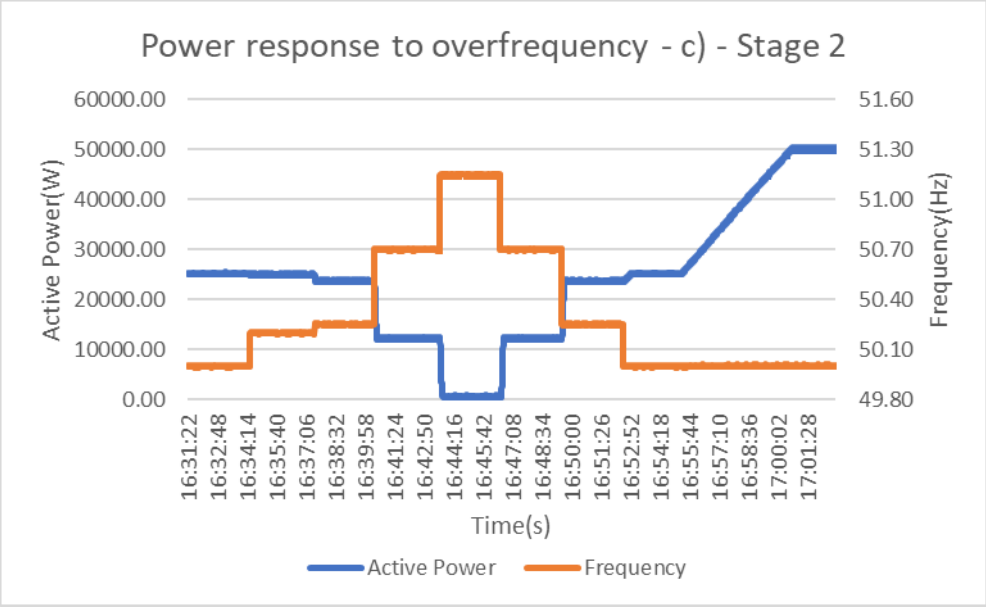
2.	50.20	24961.04	--	--	--
3.	50.25	23683.39	23712.99	-29.60	Yes
4.	50.70	12203.66	12480.52	-276.86	Yes
5.	51.15	605.17	1248.05	-642.88	Yes
6.	50.70	12205.92	12480.52	-274.60	Yes
7.	50.25	23688.39	23712.99	-24.60	Yes
8.	50.00	25168.03	--	--	--
Test sequence	Freq (Hz)	Time after step back from 50.2Hz t (min)	Measured active output power $P_{measure}$ (W)	ΔP Arise during next 1 min	Gradient of arising powerΔP/t under 10% P_{max} (Yes/No)
9.	50.00	0.0 min	25295.00	--	--
10.	50.00	0.5 min	27450.00	--	--
11.	50.00	1.0 min	30015.00	4720.00	Yes
12.	50.00	1.5 min	32425.00	4975.00	Yes
13.	50.00	2.0 min	34655.00	4640.00	Yes
14.	50.00	2.5 min	37100.00	4675.00	Yes
15.	50.00	3.0 min	39460.00	4805.00	Yes
16.	50.00	3.5 min	41695.00	4595.00	Yes
17.	50.00	4.0 min	44125.00	4665.00	Yes
18.	50.00	4.5 min	46445.00	4750.00	Yes
19.	50.00	5.0 min	48685.00	4560.00	Yes
20.	50.00	5.5 min	50210.00	3765.00	Yes



d) For Type 2 generation unit (ESS in charging mode), over-frequency regulation

TYPE 2 inverter EES units in charging mode is set to 100% of maximum charging power till the end of the

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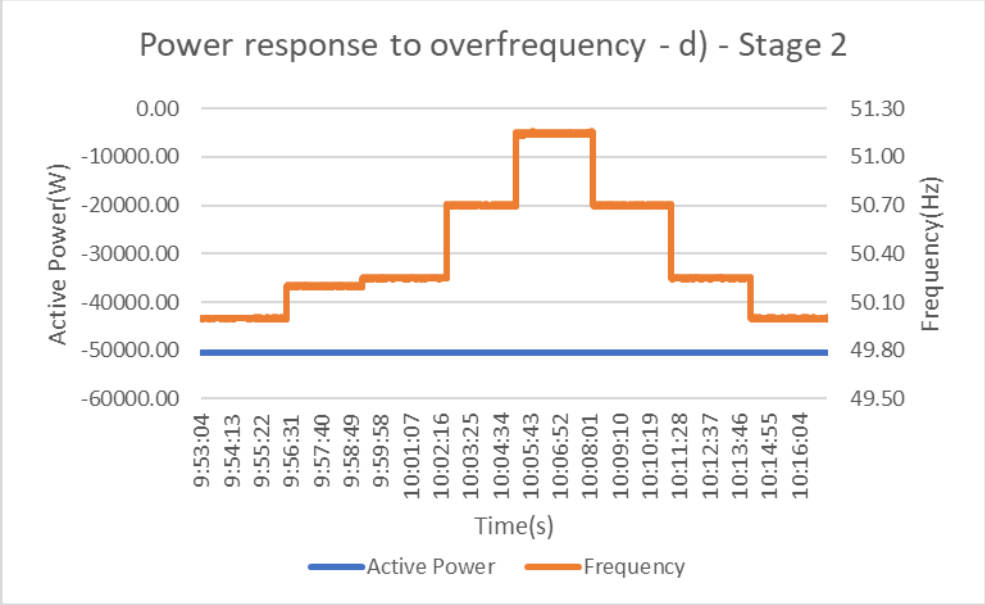
test. The frequency passes the threshold f_1 shall not reduce the charging power below PM until frequency returns below f_1

$P_{max\text{-}charge}$ = -50000 W , intentional delay time: 0.4 s (should ⩽2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max\text{-}limit}$ (W)	Deviation of $P_{measure}$ and $P_{max\text{-}limit}$ (W)	Deviation within 10% $P_{max\text{-}charge}$ (Yes/No)
1.	50.00	-50070.16	--	--	--
2.	50.20	-50045.45	--	--	--
3.	50.25	-50043.51	-50000.00	-43.51	Yes
4.	50.70	-50042.14	-50000.00	-42.14	Yes
5.	51.15	-50041.50	-50000.00	-41.50	Yes
6.	50.70	-50045.35	-50000.00	-45.35	Yes
7.	50.25	-50047.32	-50000.00	-47.32	Yes
8.	50.00	-50081.41	--	--	--



Active power reaction time

Test with active power reduction frequency start point 50.2Hz, gradient s=5%

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	Step response time (s) (≤ 2s)	Settling time (s) (≤ 20s)
1.	50.00	50091.63	-	-
2.	50.20	49916.08	-	-
3.	50.70	39873.65	0.4	0.8

Fstop-Active power reaction time

Test with active power reduction frequency start point 50.2Hz, gradient s=5%, f_{stop} set to 50.1Hz, t_{stop} set to 30s. TYPE 2 inverter DC input power is set to 100% of maximum active output till the end of the test. The active power value shall not be deviated from the required value calculated from the feature curve 10% Pn. When the TYPE 2 inverter step back below the frequency 50.1Hz, the output active power should arise with a gradient of 10 % Pmax/min.

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P_M = 24961.04 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)				
Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	Step response time (s) (≤ 2s)	Settling time (s) (≤ 20s)
1.	50.00	50015.65	-	-
2.	50.20	49878.90	-	-
3.	50.70	39703.39	0.1	0.3
4.	51.15	30495.05	0.1	0.2
5.	51.00	30495.82	-	-
6.	50.50	30495.53	-	-
7.	50.20	30497.12	-	-
8.	50.10	After 32.3 s, then power return up with gradient of ≤10% Pmax	-	-
Test sequence	Freq (Hz)	Time after step back from 50.1Hz t (min)	ΔP Arise during next 1 min	Gradient of arising powerΔP/t under 10% Pmax (Yes/No)
9.	0.0 min	30503.50	--	--
10.	0.5 min	32377.00	--	--
11.	1.0 min	34221.70	3718.20	Yes
12.	1.5 min	36074.90	3697.90	Yes
13.	2.0 min	37904.30	3682.60	Yes
14.	2.5 min	39743.40	3668.50	Yes
15.	3.0 min	41574.30	3670.00	Yes
16.	3.5 min	43415.70	3672.30	Yes
17.	4.0 min	45256.70	3682.40	Yes
18.	4.5 min	47096.60	3680.90	Yes
19.	5.0 min	48908.80	3652.10	Yes
20.	5.5 min	50005.20	2908.60	Yes
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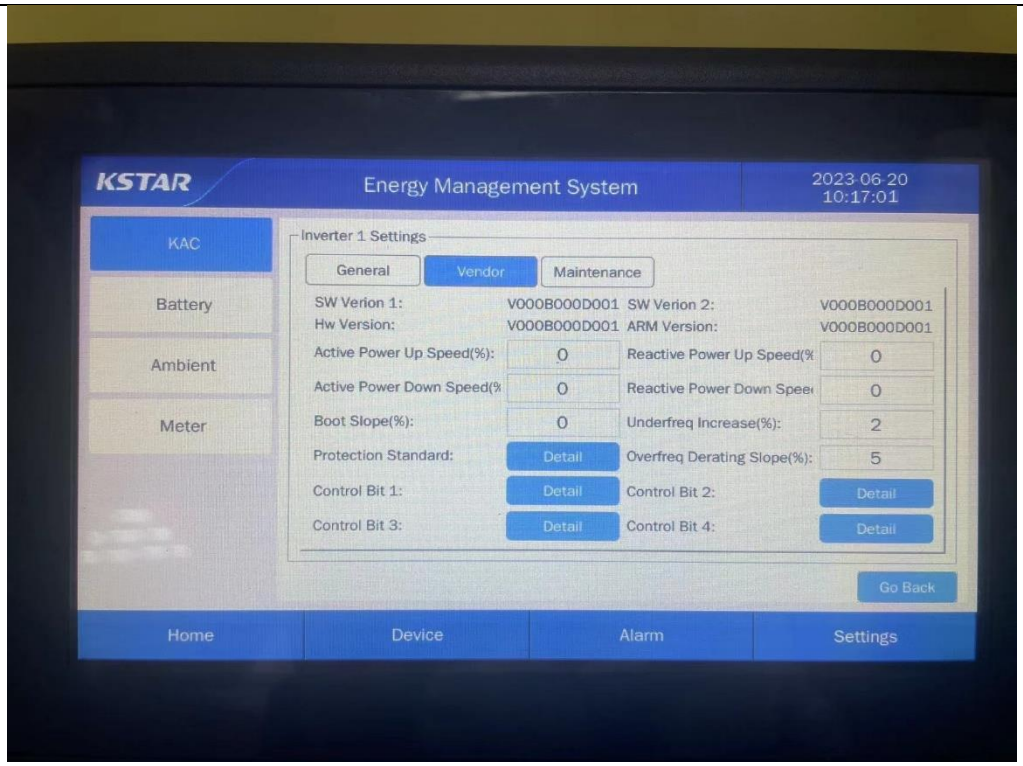

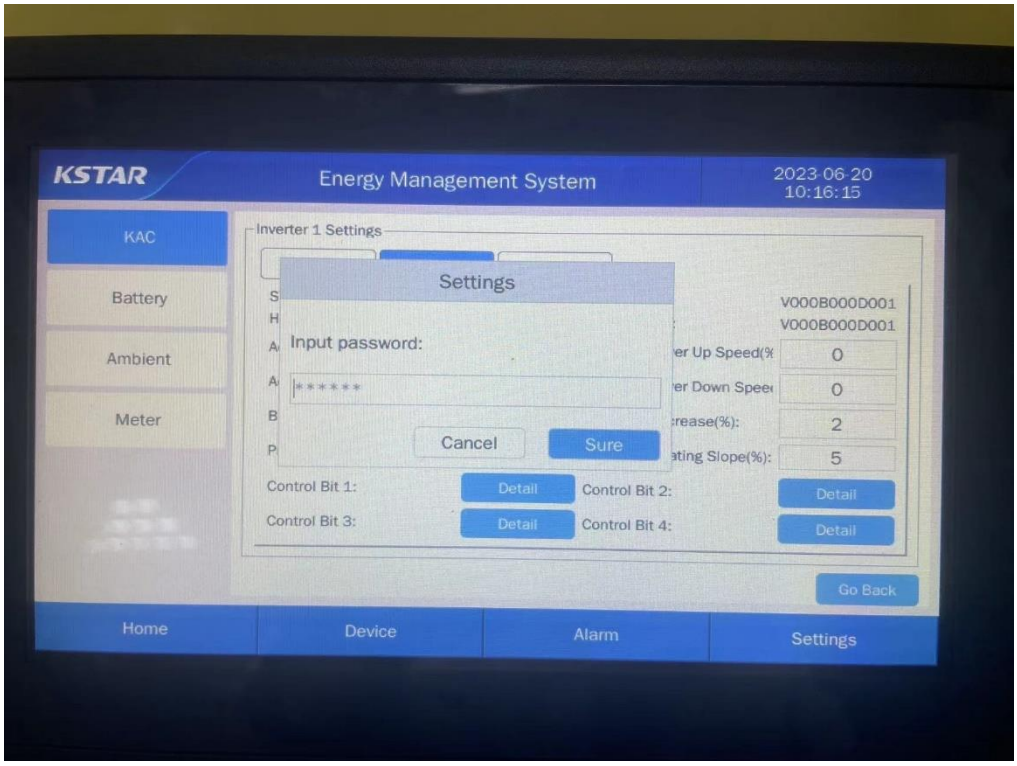

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Annex D.6.2	Power response to underfrequency	P

a) under-frequency regulation, with active power reduction frequency start point=49.8Hz, gradient s=5%

Stage 1: TYPE 2 inverter DC input power is set to 50% of maximum active output power first. After the TYPE 2 inverter step into frequency range under 49.8Hz, the TYPE 2 inverter available input power is set to 100% of maximum active output. The output active power should regulate the active power with gradient of 40% P_{max}/Hz till technical maximum power. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_{Max} = 50000 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max\text{-}limit}$ (W)	Deviation of $P_{measure}$ and $P_{max\text{-}limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	25157.91	--	--	--
2.	49.80	25156.98	--	--	--
3.	49.75	26175.42	26156.98	18.44	Yes
4.	48.80	45114.50	45156.98	-42.48	Yes
5.	48.30	50500.56	50000.00	500.56	Yes
6.	47.80	50476.07	50000.00	476.07	Yes
7.	48.30	50506.74	50000.00	506.74	Yes
8.	48.80	45119.00	45156.98	-37.98	Yes
9.	49.80	25157.45	25156.98	0.47	Yes
10.	50.00	25164.76	--	--	--

Stage 2: TYPE 2 inverter EES units in charging mode is set to 50% of maximum charging power first, After the TYPE 2 inverter EES units step into frequency range under 49.8Hz, the output active power should regulate the active power with gradient of 40% P_{max}/Hz till technical maximum power. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_{Max} = 50000 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max\text{-}limit}$ (W)	Deviation of $P_{measure}$ and $P_{max\text{-}limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	-25727.76	-	-	-
2.	49.80	-25730.89	-	-	-
3.	49.75	-24732.15	-24730.89	-1.26	Yes
4.	48.80	-5666.16	-5730.89	64.73	Yes
5.	48.30	4458.91	4269.11	189.80	Yes
6.	47.30	24784.39	24269.11	515.28	Yes
7.	46.30	44838.42	44269.11	569.31	Yes
8.	46.00	49810.50	50000.00	-189.50	Yes
9.	46.30	44848.60	44269.11	579.49	Yes

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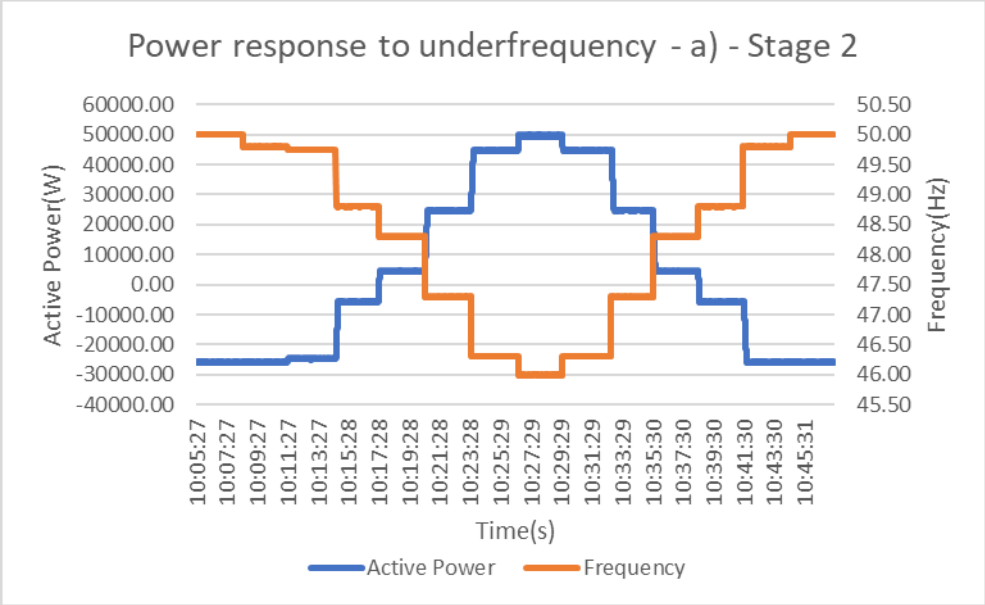
10.	47.30	24803.76	24269.11	534.65	Yes
11.	48.30	4464.09	4269.11	194.98	Yes
12.	48.80	-5663.42	-5730.89	67.47	Yes
13.	49.80	-25730.59	-	-	-
14.	50.00	-25727.44	-	-	-



b) under-frequency regulation, with active power reduction frequency start point=49.8Hz, gradient s=12%

Stage 1: TYPE 2 inverter DC input power is set to 50% of maximum active output power first. After the TYPE 2 inverter step into frequency range under 49.8Hz, the TYPE 2 inverter available input power is set to 100% of maximum active output. The output active power should regulate the active power with gradient of 16.67% P_{max}/Hz till technical maximum power. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_{Max} = 50000 W, 10% P_n= 5000 W, intentional delay time: 0.4 s (should ⩽2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max\text{-}limit}$ (W)	Deviation of $P_{measure}$ and $P_{max\text{-}limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	25168.76	--	--	--
2.	49.80	25157.72	--	--	--
3.	49.75	26174.83	25574.39	600.44	Yes
4.	48.80	33540.84	33491.05	49.79	Yes
5.	47.30	45894.16	45991.05	-96.89	Yes
6.	46.80	49922.03	50000.00	-77.97	Yes
7.	46.30	50364.20	50000.00	364.20	Yes
8.	46.80	49925.31	50000.00	-74.69	Yes
9.	47.30	45899.43	45991.05	-91.62	Yes
10.	48.80	33539.09	33491.05	48.04	Yes

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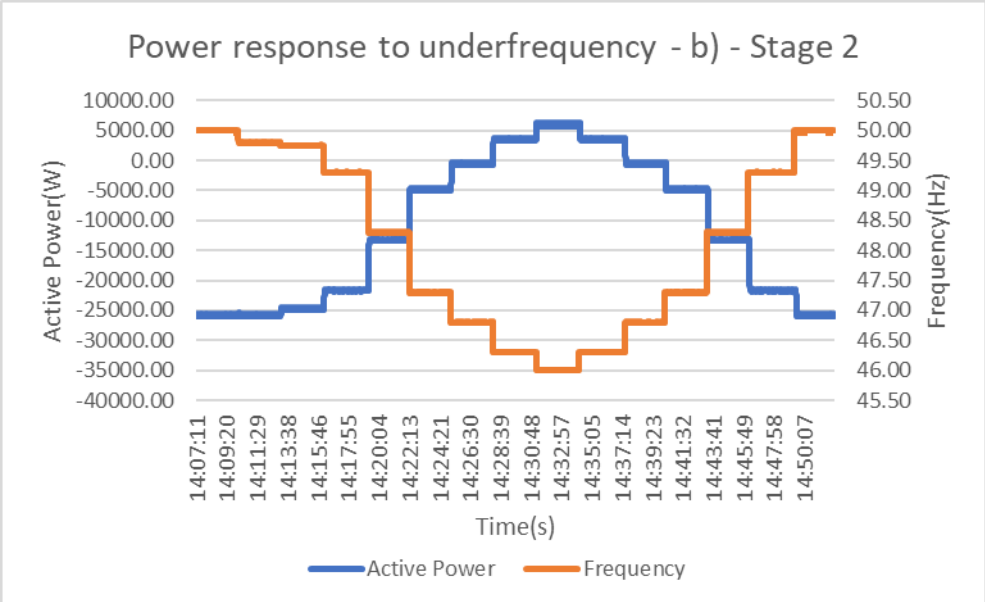
11.	50.00	25168.94	--	--	--

Stage 2: TYPE 2 inverter EES units in charging mode is set to 50% of maximum charging power first, After the TYPE 2 inverter EES units step into frequency range under 49.8Hz, the output active power should regulate the active power with gradient of 16.67% P_{max}/Hz till technical maximum power. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_{Max} = 50000 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max\text{-}limit}$ (W)	Deviation of $P_{measure}$ and $P_{max\text{-}limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	-25737.34	--	--	--
2.	49.80	-25739.10	--	--	--
3.	49.75	-24738.95	-25322.43	583.48	Yes
4.	49.30	-21620.81	-21572.43	-48.38	Yes
5.	48.30	-13236.56	-13239.10	2.54	Yes
6.	47.30	-4811.22	-4905.77	94.55	Yes
7.	46.80	-527.31	-739.10	211.79	Yes
8.	46.30	3558.44	3427.57	130.87	Yes
9.	46.00	6116.88	5927.57	189.31	Yes
10.	46.30	3557.05	3427.57	129.48	Yes
11.	46.80	-526.56	-739.10	212.54	Yes
12.	47.30	-4813.52	-4905.77	92.25	Yes
13.	48.30	-13237.01	-13239.10	2.09	Yes
14.	49.30	-21624.22	-21572.43	-51.79	Yes
15.	50.00	-25731.52	--	--	--



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c) under-frequency regulation, with active power reduction frequency start point=49.8Hz, gradient s=2%

Stage 1: TYPE 2 inverter DC input power is set to 50% of maximum active output power first. After the TYPE 2 inverter step into frequency range under 49.8Hz, the TYPE 2 inverter available input power is set to 100% of maximum active output. The output active power should regulate the active power with gradient of 100% P_{max}/Hz till technical maximum power. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_{Max} = 50000 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max-limit}$ (W)	Deviation of $P_{measure}$ and $P_{max-limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	25184.54	--	--	--
2.	49.80	25158.05	--	--	--
3.	49.75	27463.85	27658.05	-194.20	Yes
4.	49.30	49884.59	50000.00	-115.41	Yes
5.	48.80	50522.78	50000.00	522.78	Yes
6.	49.30	49870.34	50000.00	-129.66	Yes
7.	50.00	25167.68	--	--	--

Stage 2: TYPE 2 inverter EES units in charging mode is set to 50% of maximum charging power first, After the TYPE 2 inverter EES units step into frequency range under 49.8Hz, the output active power should regulate the active power with gradient of 100% P_{max}/Hz till technical maximum power. The active power value shall not be deviated from the required value calculated from the feature curve for more than 10% P_n.

P_{Max} = 50000 W , 10% P_n= 5000 W , intentional delay time: 0.4 s (should ≤2s)

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	The calculated active output power as per feature curve $P_{max-limit}$ (W)	Deviation of $P_{measure}$ and $P_{max-limit}$ (W)	Deviation within 10% P_n (Yes/No)
1.	50.00	-25765.92	--	--	--
2.	49.80	-25764.88	--	--	--
3.	49.75	-23488.15	-23264.88	-223.27	Yes
4.	49.30	-612.41	-764.88	152.47	Yes
5.	48.80	24705.01	24235.12	469.89	Yes
6.	48.30	49719.28	49235.12	484.16	Yes
7.	47.80	49938.86	50000.00	-61.14	Yes
8.	48.30	49742.25	49235.12	507.13	Yes
9.	48.80	24725.00	24235.12	489.88	Yes
10.	49.30	-615.38	-764.88	149.50	Yes
11.	50.00	-25741.86	--	--	--

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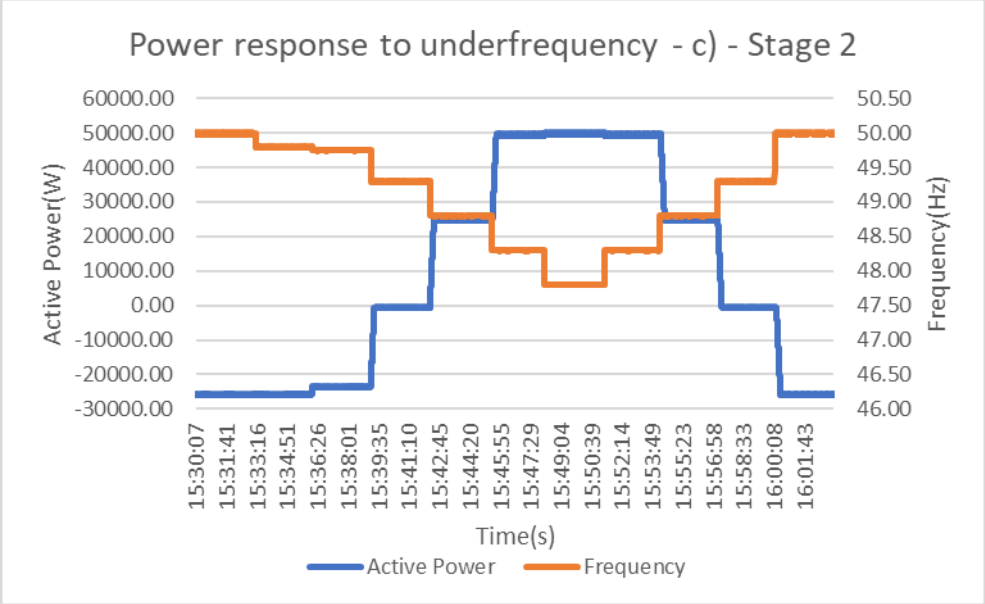
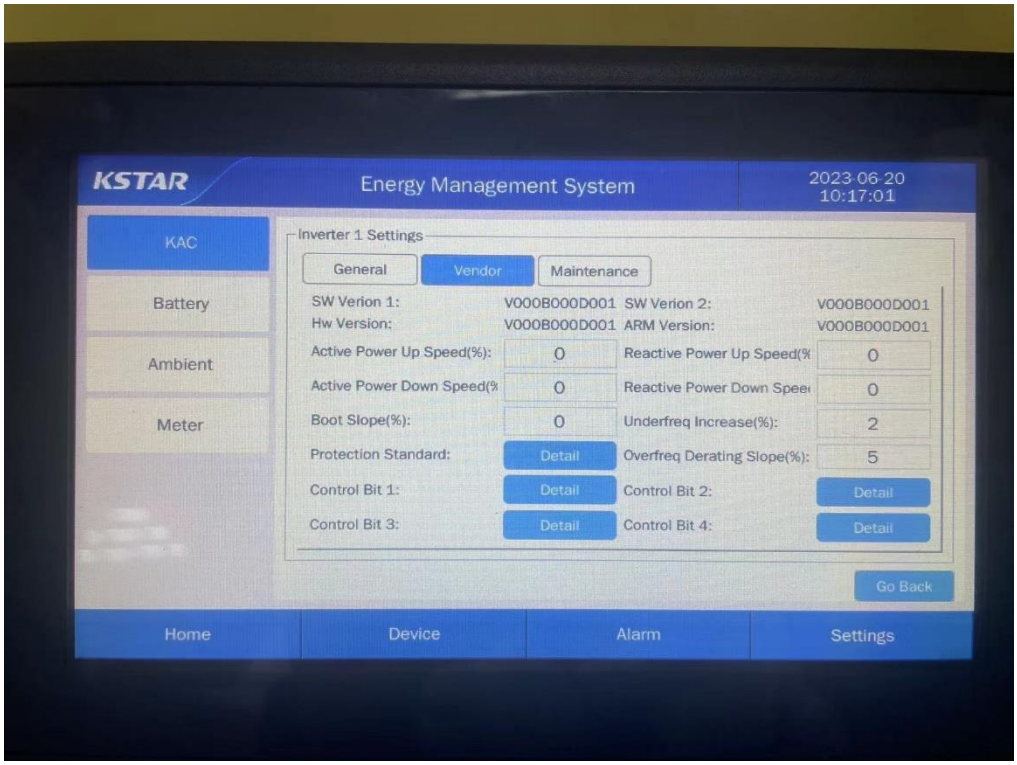


Active power reaction time

Test with active power reduction frequency start point 49.8Hz, gradient s=5%

Test sequence	Freq (Hz)	Measured active output power $P_{measure}$ (W)	Step response time (s) (≤ 10 s)	Settling time (s) (≤ 30 s)
1.	50.00	-26388.46	-	-
2.	49.80	-26392.72	-	-
3.	49.30	-21233.20	0.40	0.45

Supplementary information:



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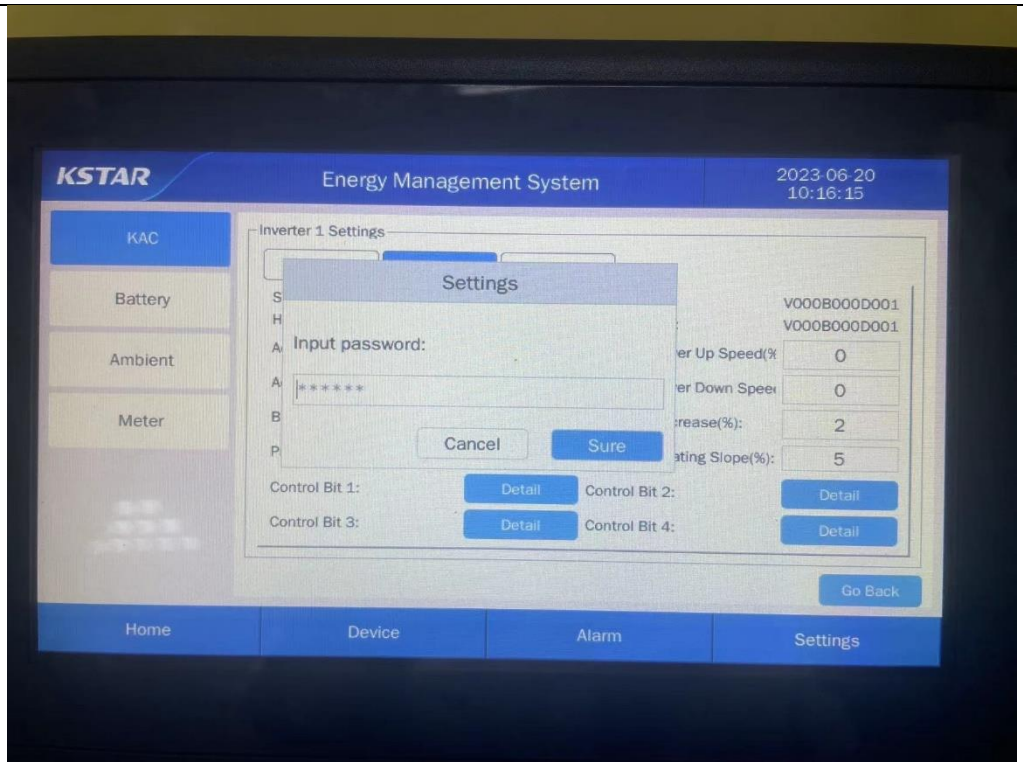

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Annex D7.1	Voltage support by reactive power		P
S_{max} (VA)	55209.55	P_{max}(W)	50232.29

Fixed reactive mode			
Case A Tested at Nominal voltage 1.00Un			
P/ S_{max} (%)	Max.	Max.	Max.
Q set value generation(Var)	23980	0	-23980
Tested cosφ	0.8987 ov	0.9998 un	0.9010 un
Active power P (W)	49351.24	50224.05	49582.44
Reactive power Q (Var)	24074.58	-906.40	-23878.92
Apparent power S (VA)	54910.21	50232.29	55033.17
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case B Tested at Nominal voltage 1.10Un			
P/ S_{max} (%)	Max.	Max.	Max.
Q set value generation(Var)	23980	0	-23980
Tested cosφ	0.9051 ov	0.9999 un	0.9009 un
Active power P (W)	49350.34	49891.03	49671.92
Reactive power Q (Var)	24073.96	-4.03	-23925.53
Apparent power S (VA)	54909.13	49891.06	55133.85
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case C: Tested at Nominal voltage 1.05Un			
P/ S_{max} (%)	Max.	Max.	Max.
Q set value generation(kVA)	23980	0	-23980
Tested cosφ	0.8988 ov	0.9999 un	0.8999 un
Active power P (W)	49351.85	49829.31	49624.51
Reactive power Q (Var)	24074.94	-46.75	-24041.54
Apparent power S (VA)	54910.92	49829.36	55141.78
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case D: Tested at Nominal voltage 0.95Un			
P/ S_{max} (%)	Max.	Max.	Max.

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Q set value generation(Var)	23980	0	-23980
Tested cosφ	0.8898 ov	1.0000 ov	0.8966 un
Active power P (W)	47171.37	50064.80	47456.27
Reactive power Q (Var)	23062.42	165.97	-23296.99
Apparent power S (VA)	53015.58	50065.07	52930.79
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case E: Tested at Nominal voltage 0.90Un			
P/ S_{max} (%)	Max.	Max.	Max.
Q set value generation(Var)	23980	0	-23980
Tested cosφ	0.8762 ov	1.0000 ov	0.8790 un
Active power P (W)	43459.93	49640.46	43614.94
Reactive power Q (Var)	24037.80	24.60	-23770.52
Apparent power S (VA)	49615.09	49640.47	49630.81
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case F: Tested at Nominal voltage 0.85Un			
P/ S_{max} (%)	Max.	Max.	Max.
Q set value generation(Var)	23980	0	-23980
Tested cosφ	0.8642 ov	1.0000 un	0.8632 un
Active power P (W)	40195.71	46891.35	39997.19
Reactive power Q (Var)	23402.32	-48.62	-24136.32
Apparent power S (VA)	46511.98	46891.38	46335.04
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Fixed power factor mode			
Case A: Tested at Nominal voltage 1.00Un			
P/ S_{max} (%)	Max.	Max.	Max.
Q set value generation(Var)	0.9 ov	1.0	0.9 un
Tested cosφ	0.9067 ov	1.0000 ov	0.9010 un
Active power P (W)	49844.02	50000.31	49967.60
Reactive power Q (Var)	23190.75	326.18	-24054.88

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Apparent power S (VA)	54974.88	50001.38	55456.05
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case B Tested at Nominal voltage 1.10Un			
P/ S_{max} (%)	Max.	Max.	Max.
Cosφ set value generation	0.9 ov	1.0	0.9 un
Tested cosφ	0.9041 ov	0.9999 ov	0.8989 un
Active power P (W)	49619.13	50053.73	49625.94
Reactive power Q (Var)	23454.51	659.19	-24193.66
Apparent power S (VA)	54883.26	50058.08	55209.55
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case C: Tested at Nominal voltage 1.05Un			
P/ S_{max} (%)	Max.	Max.	Max.
Cosφ set value generation	0.9 ov	1.0	0.9 un
Tested cosφ	0.9022 ov	1.0000 ov	0.9015 un
Active power P (W)	49544.66	50086.48	49492.68
Reactive power Q (Var)	23688.57	480.91	-23756.29
Apparent power S (VA)	54916.50	50088.79	54898.88
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case D: Tested at Nominal voltage 0.95Un			
P/ S_{max} (%)	Max.	Max.	Max.
Cosφ set value generation	0.9 ov	1.0	0.9 un
Tested cosφ	0.9004 ov	1.0000 ov	0.9010 un
Active power P (W)	47282.56	50076.90	47300.87
Reactive power Q (Var)	22834.56	164.39	-23026.13
Apparent power S (VA)	52523.21	50077.18	52516.94
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case E: Tested at Nominal voltage 0.90Un			
P/ S_{max} (%)	Max.	Max.	Max.

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Cosφ set value generation	0.9 ov	1.0	0.9 un
Tested cosφ	0.9007 ov	1.0000 ov	0.9011 un
Active power P (W)	44564.03	49651.10	44506.71
Reactive power Q (Var)	21496.15	22.56	-21418.26
Apparent power S (VA)	49477.65	49651.10	49392.20
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes
Case F: Tested at Nominal voltage 0.85Un			
P/ S_{max} (%)	Max.	Max.	Max.
Cosφ set value generation	0.9 ov	1.0	0.9 un
Tested cosφ	0.9013 ov	1.0000 un	0.9019 un
Active power P (W)	42083.97	46698.85	42102.18
Reactive power Q (Var)	20227.54	-44.97	-20159.89
Apparent power S (VA)	46692.77	46698.88	46679.92
Deviation within 2% S_{max} (Yes/No)	Yes	Yes	Yes

Annex D.7.1.2	**Power related Control mode**					**P**
Maximal active power P_{Emax} with the tested displacement factor (W)						49500
Percentage of output active power P/P_{Emax} (%)	Measured active power P (W)	Measured apparent power S (VA)	Measured displacement factor cosφ	Measured reactive power Q(Var)	Displacement factor as to feature curve	Whether the accuracy fulfill according to clause 4.7.2.2 (± 2% Smax)
Set point 1: P=0 P_{Emax}, cosφ=1 Set point 2: P=0.5 P_{Emax}, cosφ=1 Set point 3: P=1 P_{Emax}, cosφ=0.9						
10%	5034.85	5036.45	0.9997 ov	123.41	1.000	Yes
20%	9832.80	9832.97	1.0000 un	-40.97	1.000	Yes
30%	14949.31	14950.73	0.9999 un	-196.26	1.000	Yes
40%	20059.24	20062.29	0.9999 un	-343.75	1.000	Yes
50%	25163.03	25169.83	0.9998 un	-555.14	1.000	Yes
60%	30147.93	30590.49	0.9855 un	-5182.27	0.980 un	Yes
70%	35080.28	36453.05	0.9623 un	-9910.96	0.960 un	Yes
80%	39965.12	42501.57	0.9403 un	-14463.01	0.940 un	Yes
90%	44787.09	48696.71	0.9197 un	-19118.51	0.920 un	Yes

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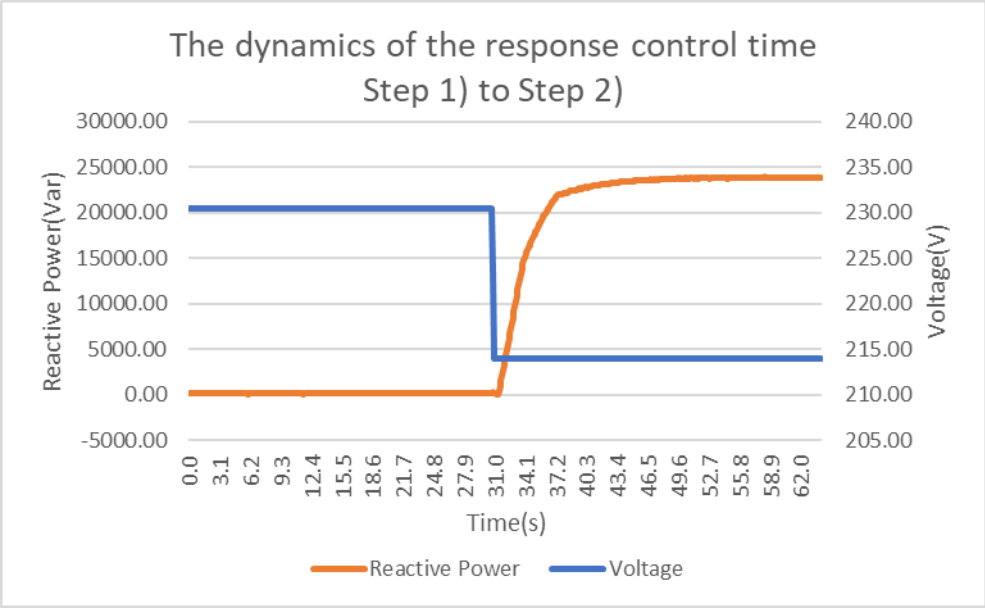
100%	49552.54	54890.78	0.9027 un	-23612.67	0.900 un	Yes
90%	45081.18	49067.51	0.9188 un	-19371.56	0.920 un	Yes
80%	39963.12	42506.34	0.9402 un	-14482.51	0.940 un	Yes
70%	35063.34	36428.94	0.9625 un	-9879.37	0.960 un	Yes
60%	30134.02	30581.93	0.9854 un	-5215.27	0.980 un	Yes
50%	25167.10	25172.54	0.9998 un	-524.69	1.000	Yes
40%	20065.86	20069.04	0.9998 un	-352.98	1.000	Yes
30%	14958.34	14959.73	0.9999 un	-221.62	1.000	Yes
20%	9831.05	9831.22	1.0000 un	-45.48	1.000	Yes
10%	5038.10	5039.27	0.9997 ov	121.73	1.000	Yes
Supplementary information: N/A						

Annex D.7.1.2	**Voltage related control modes**	**P**
The dynamics of the Response control time		
Set fixed P=0.5 S_{max}, the setting response time is 10 s (the setting should within the range of 3s to 60s), change the voltage by steps: 1) 1.00 Un, stable operation 2) 0.97 - 0.93 Un, 30s 3) 1.03 - 1.07 Un, 30s 4) 1.00 Un, 30s		
Step from 1) to 2)		
Response curve:  		

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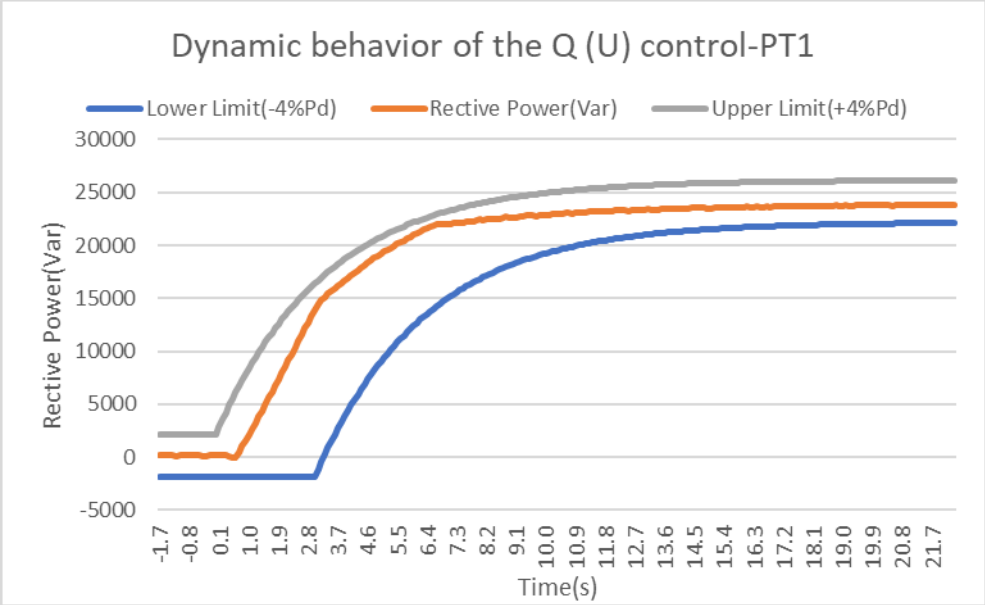

Start reactive power Q_S (Var)	187.3
Target reactive power Q_T (Var)	24167.3
Required change of reactive power $\|Q_T-Q_S\|$ (Var)	23980.0
Point in time of settling (s)	10.2
Measure reactive Power $Q_{Measure}$ (Var)	23900.6
Step from 2) to 3)	

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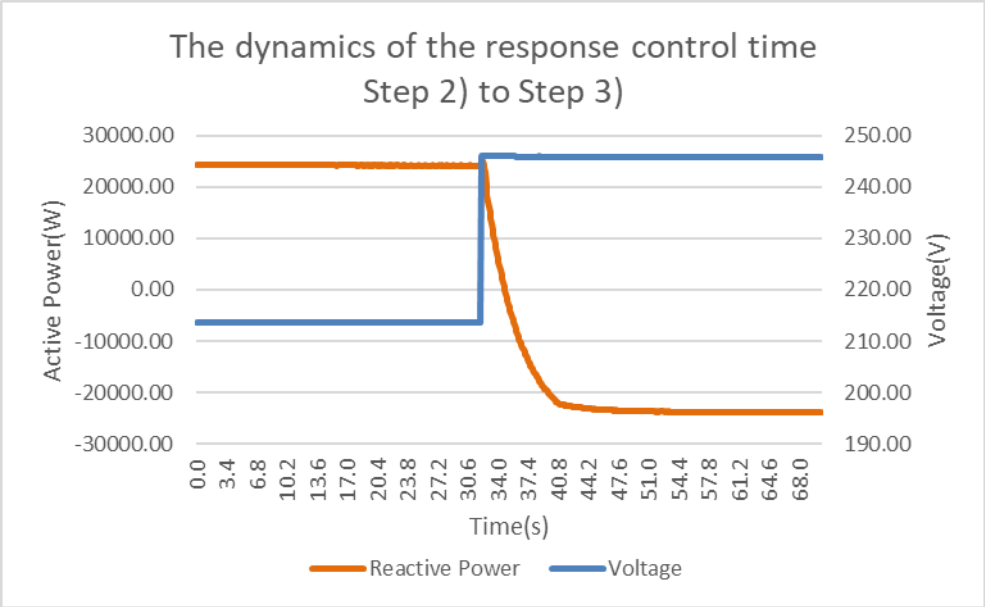
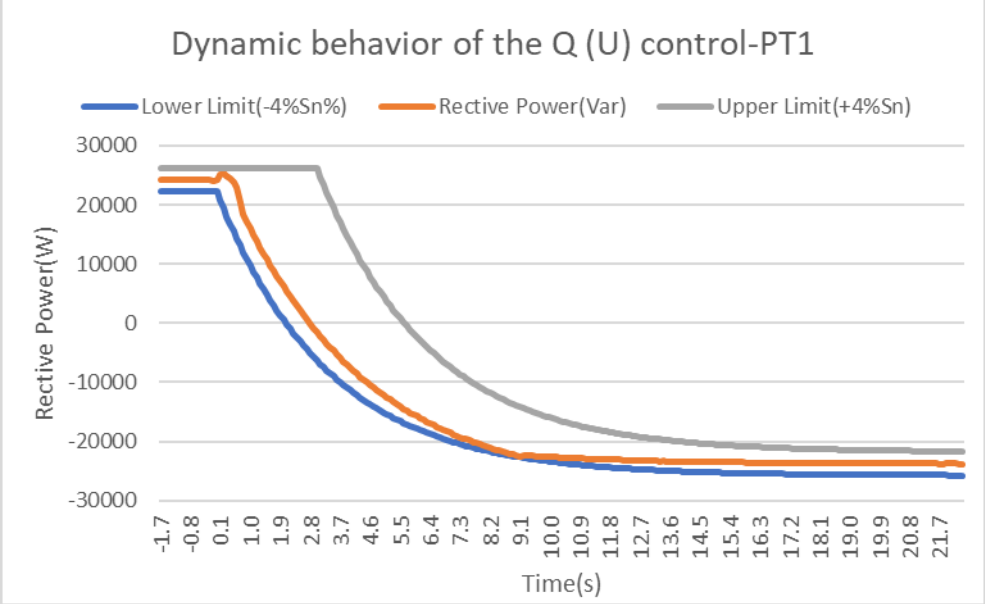
Response curve:





Start reactive power Q_S (Var)	24146.8
Target reactive power Q_T (Var)	-23813.2
Required change of reactive power $\|Q_T-Q_S\|$ (Var)	47960.0
Point in time of settling (s)	8.6
Measure reactive Power $Q_{Measure}$ (Var)	-23789.4
Step from 3) to 4)	
Response curve:	

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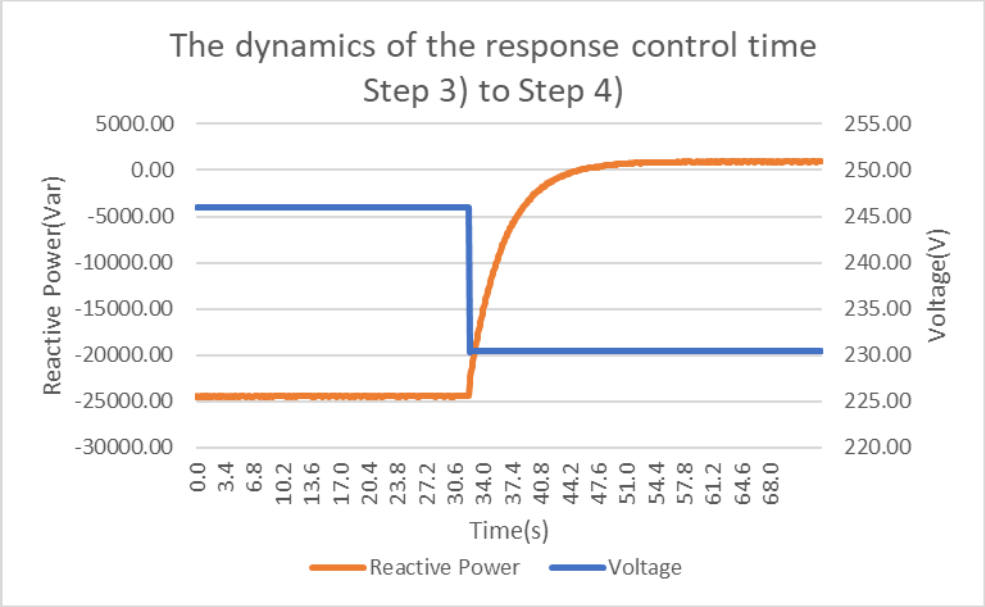

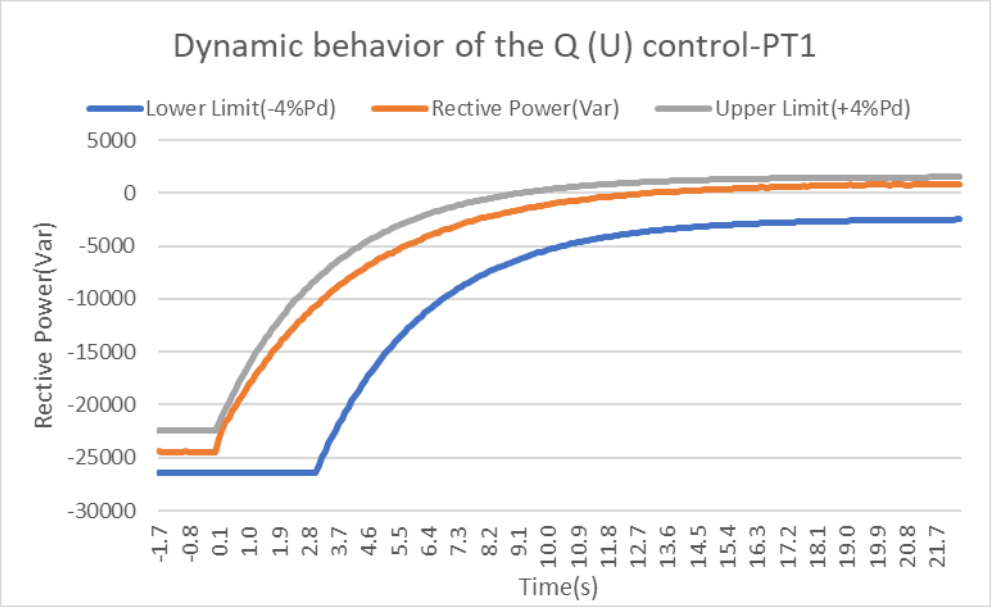

Start reactive power Q_s (Var)	-24430.5
Target reactive power Q_T (Var)	-450.5
Required change of reactive power $\|Q_T-Q_S\|$ (Var)	23980.0
Point in time of settling (s)	9.2
Measure reactive Power $Q_{Measure}$ (Var)	925.4

The voltage related control modes control the reactive power output

$-Q_{max}$ and Q_{max} is defined by testing in Cl.4.7.2. Fixed active power setting 0.5 S_{Emax}

Q_{max} at this active power (Var)	±23980

Grid simulator voltage	Measured Voltage U_{L-N} (V)	Measured active power P	Measured apparent power S	Measured displacement	Measured reactive power	Required reactive power as	Deviation of reactive

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(Un)	L1-N	L2-N	L3-N	(W)	(VA)	factor cosφ	Q(Var)	to feature curve Q(Var)	power (%S_{max})
0.91 Un	209.42	209.34	209.39	28418.62	37756.34	0.7527 ov	24858.05	23980.00	1.60%
0.93 Un	214.08	214.01	214.06	28321.13	36894.43	0.7676 ov	23645.50	23980.00	-0.61%
0.95 Un	218.34	218.26	218.32	28016.73	30402.14	0.9215 ov	11804.74	11990.00	-0.34%
0.97 Un	223.10	223.02	223.08	27688.37	27688.56	1.0000 ov	95.43	0.00	0.17%
1.00 Un	230.58	230.51	230.56	27637.79	27638.27	1.0000 ov	161.26	0.00	0.29%
1.03 Un	236.87	236.79	236.85	27578.85	27590.26	0.9996 un	-792.74	0.00	-1.44%
1.05 Un	241.04	240.95	241.02	27261.78	29791.39	0.9151 un	-12013.39	-11990.00	-0.04%
1.07 Un	246.09	246.02	246.08	26895.20	36384.93	0.7392 un	-24505.32	-23980.00	-0.96%
1.09 Un	250.49	250.41	250.48	26890.67	36281.20	0.7412 un	-24356.05	-23980.00	-0.68%
1.07 Un	246.10	246.02	246.08	26899.09	36312.76	0.7408 un	-24393.77	-23980.00	-0.75%
1.05 Un	241.03	240.96	241.02	27263.93	29760.85	0.9161 un	-11932.54	-11990.00	0.10%
1.03 Un	236.86	236.79	236.85	27579.27	27590.90	0.9996 un	-800.48	0.00	-1.46%
1.00 Un	230.58	230.50	230.56	27639.47	27639.93	1.0000 ov	157.46	0.00	0.29%
0.97 Un	223.09	223.02	223.08	27686.87	27687.01	1.0000 ov	80.49	0.00	0.15%
0.95 Un	218.34	218.27	218.31	28028.09	30548.65	0.9175 ov	12150.93	11990.00	0.29%
0.93 Un	214.08	214.01	214.06	28320.46	36840.56	0.7687 ov	23562.21	23980.00	-0.76%
0.91 Un	204.41	204.34	204.39	28408.88	37498.64	0.7576 ov	24476.18	23980.00	0.90%

Limit the reactive power at low active power

Qmin

P/P_{MAX} [%] Set-point	Vac [V] set-point	P/P_{MAX} [%] Measured	Vac [V] measured			Q [Var] measured	Q [Var] expected	Δ Q (< ± 2 % S_{max})
			L1-N	L2-N	L3-N			
< 20 %	1.03 Vn	14.97	236.50	236.48	236.52	755.74	0	1.37%
< 20 %	1.05 Vn	14.94	240.70	240.68	240.71	808.08	0	1.47%
<20 % -> 30 %	1.05 Vn	30.11	241.10	241.06	241.12	-12207.89	-11990	-0.40%
50 %	1.05 Vn	50.10	240.97	240.90	240.99	-11920.93	-11990	0.13%
100 %	1.05 Vn	99.39	241.18	241.06	241.22	-12564.96	-11990	-1.05%
100 %*	1.07 Vn	98.67	246.43	246.32	246.48	-24281.34	-23980	-0.55%
100 % -> 10 %	1.07 Vn	10.37	245.72	245.69	245.72	-24464.85	-23980	-0.88%
10 % -> ≤ 5 %	1.07 Vn	3.07	245.71	245.70	245.71	818.85	0	1.49%

Qmax

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P/P_{MAX} [%] Set-point	Vac [V] set-point	P/P_{MAX} [%] Measured	Vac [V] measured			Q [Var] measured	Q [Var] expected	Δ Q (< ± 2 % S_{max})
			L1-N	L2-N	L3-N			
< 20 %	0.97 Vn	15.10	223.02	223.00	223.03	610.90	0	1.22%
< 20 %	0.95 Vn	15.16	218.22	218.20	218.23	556.45	0	1.11%
<20 % -> 30 %	0.95 Vn	30.15	218.39	218.35	218.39	11771.22	11990	-0.44%
50 %	0.95 Vn	50.13	218.56	218.51	218.58	11239.42	11990	-1.50%
100 %	0.95 Vn	99.84	218.53	218.41	218.56	11898.87	11990	-0.18%
100 %*	0.93 Vn	90.84	214.18	214.09	214.21	23807.83	23980	-0.34%
100 % -> 10 %	0.93 Vn	10.37	213.74	213.73	213.73	24236.09	23980	0.51%
10 % -> ≤ 5 %	0.93 Vn	2.98	213.62	213.61	213.61	678.42	0	1.36%
Remark:*This case limited by the maximum output current, active power cannot reach the set point.								

Annex D.7.2	**Voltage related active power reduction P(U)**	P

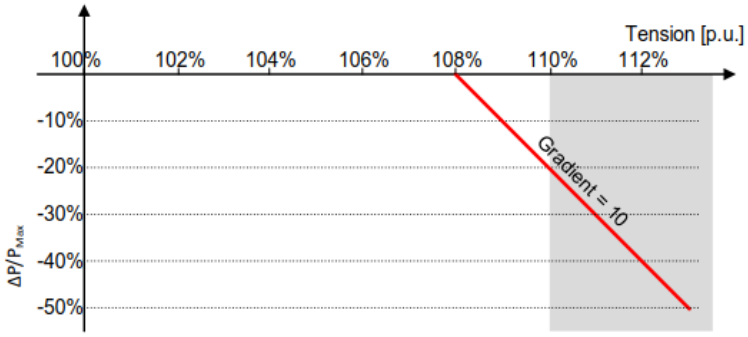

Figure 15 - Example curve for P(U)

Setting active power =P_{max}		
Voltage in % of Un	Measured power(W)	Standard power(W)
100%	50028.06	50000
108%	49943.02	50000
110%	39802.99	40000
112%	29774.62	30000
114%	19778.39	20000
116%	9789.83	10000
118%	-183.88	0
Setting active power =50% P_{max}		
Voltage in % of Un	Measured power(W)	Standard power(W)
100%	25050.83	25000

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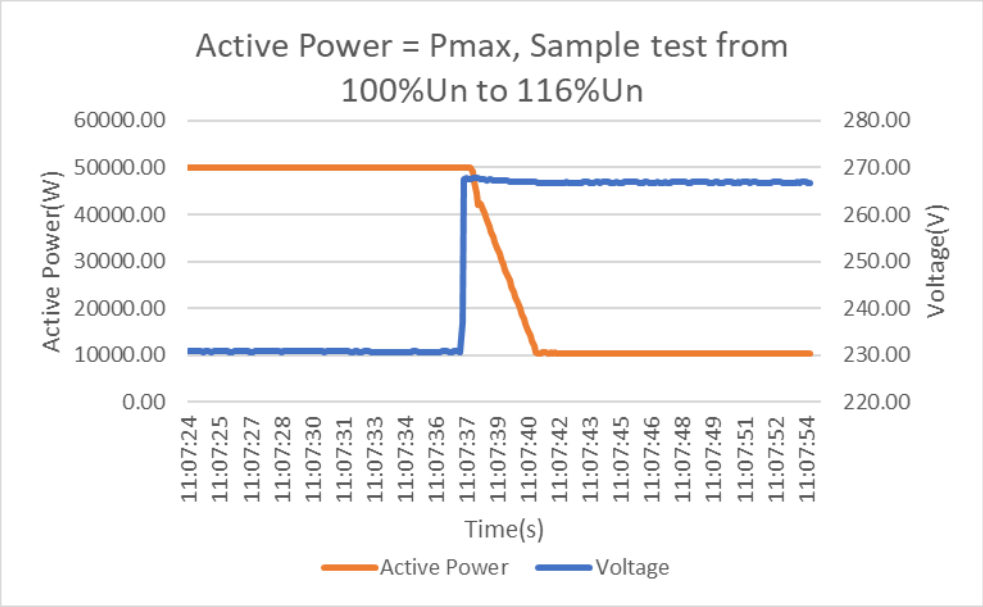
108%	24995.74	25000
110%	14926.45	15000
112%	5425.74	5000
114%	-227.81	0
116%	-205.31	0
118%	-178.43	0

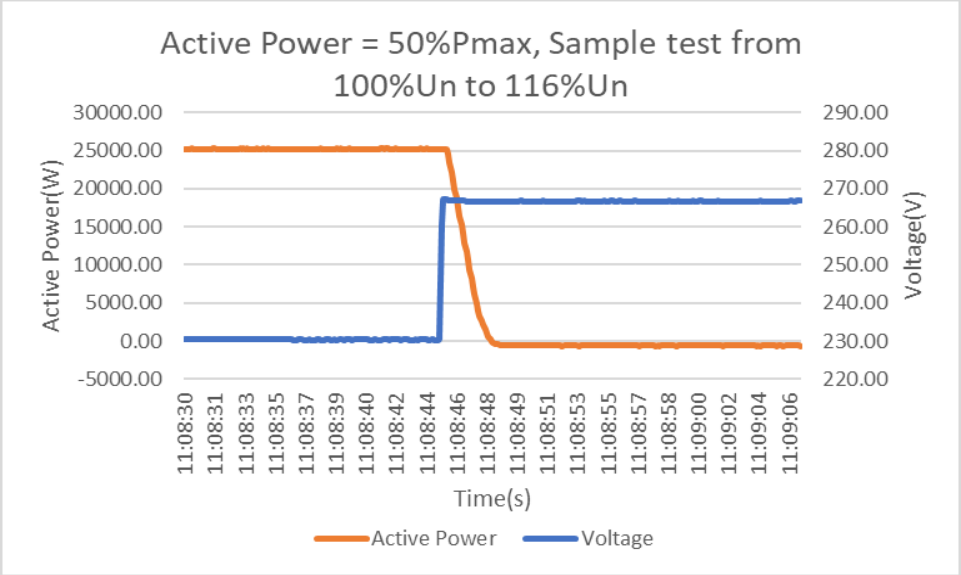
Response Time	
Active power = P_{max}, Sample test from 100%Un to 116%Un the reaching time:	3.7 s

Response curve:



Active power = 50%P_{max}, Sample test from 100%Un to 116%Un the reaching time:	3.4 s

Response curve:



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Annex D.8	Connection and reconnection				P
Normal operation starting					
Test 1)					
Test sequence	Freq (Hz)	Time stay in step (min.)	Whether reconnect to main and the active power generated? (Yes/No)		
1.	49.85	0.5 min	No		
2.	49.85	1.0 min	No		
3.	49.85	1.5 min	No		
4.	49.85	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 49.55 Hz (min)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 20% P_n (Yes/No)
5.	49.95	0.0 min	--	Reconnection time (s)	70.4 s
After reconnection					
6.	49.95	0.0 min	0.76	3189.12	Yes
7.	49.95	0.5 min	1332.10	3742.51	Yes
8.	49.95	1.0 min	3189.88	3814.75	Yes
9.	49.95	1.5 min	5074.61	3774.57	Yes
10.	49.95	2.0 min	7004.63	3683.37	Yes
11.	49.95	2.5 min	8849.18	3677.71	Yes
12.	49.95	3.0 min	10688.00	3678.23	Yes
13.	49.95	3.5 min	12526.89	3668.21	Yes
14.	49.95	4.0 min	14366.23	3706.00	Yes
15.	49.95	4.5 min	16195.10	3747.94	Yes
16.	49.95	5.0 min	18072.23	3760.18	Yes
17.	49.95	5.5 min	19943.04	3774.81	Yes
18.	49.95	6.0 min	21832.41	3777.14	Yes
19.	49.95	6.5 min	23717.85	3779.46	Yes
20.	49.95	7.0 min	25609.55	3781.48	Yes
21.	49.95	7.5 min	27497.31	3783.56	Yes
22.	49.95	8.0 min	29391.03	3761.46	Yes
23.	49.95	8.5 min	31280.87	3728.07	Yes
24.	49.95	9.0 min	33152.49	3699.62	Yes
25.	49.95	9.5 min	35008.94	3693.76	Yes
26.	49.95	10.0 min	36852.11	3713.53	Yes
27.	49.95	10.5 min	38702.70	3710.73	Yes
28.	49.95	11.0 min	40565.64	3710.47	Yes

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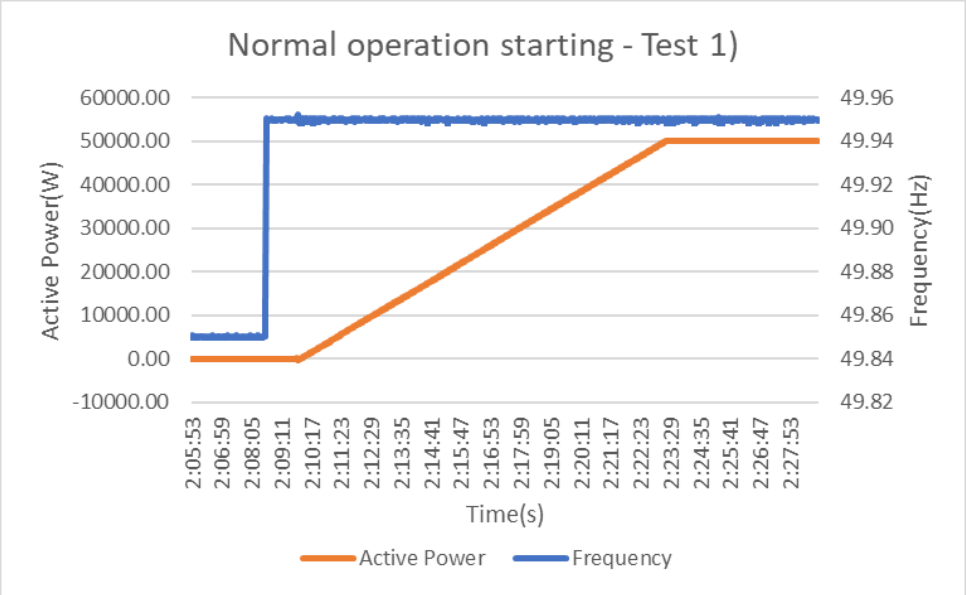
29.	49.95	11.5 min	42413.43	3714.77	Yes
30.	49.95	12.0 min	44276.11	3699.17	Yes
31.	49.95	12.5 min	46128.20	3707.43	Yes
32.	49.95	13.0 min	47975.28	2017.62	Yes
33.	49.95	13.5 min	49835.63	--	--
34.	49.95	14.0 min	49992.90	--	--

Response curve:



Test 2)					
Test sequence	Freq (Hz)	Time stay in step (min.)	Whether reconnect to main and the active power generated? (Yes/No)		
1.	50.15	0.5 min	No		
2.	50.15	1.0 min	No		
3.	50.15	1.5 min	No		
4.	50.15	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 50.15 Hz (min.)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 20% P_n (Yes/No)
5.	50.05	0.0 min	--	Reconnection time (s)	79.2 s
After reconnection					
6.	50.05	0.0 min	0.59	3215.99	Yes
7.	50.05	0.5 min	1366.65	3701.10	Yes
8.	50.05	1.0 min	3216.58	3714.98	Yes
9.	50.05	1.5 min	5067.75	3730.89	Yes
10.	50.05	2.0 min	6931.56	3717.33	Yes
11.	50.05	2.5 min	8798.64	3690.68	Yes

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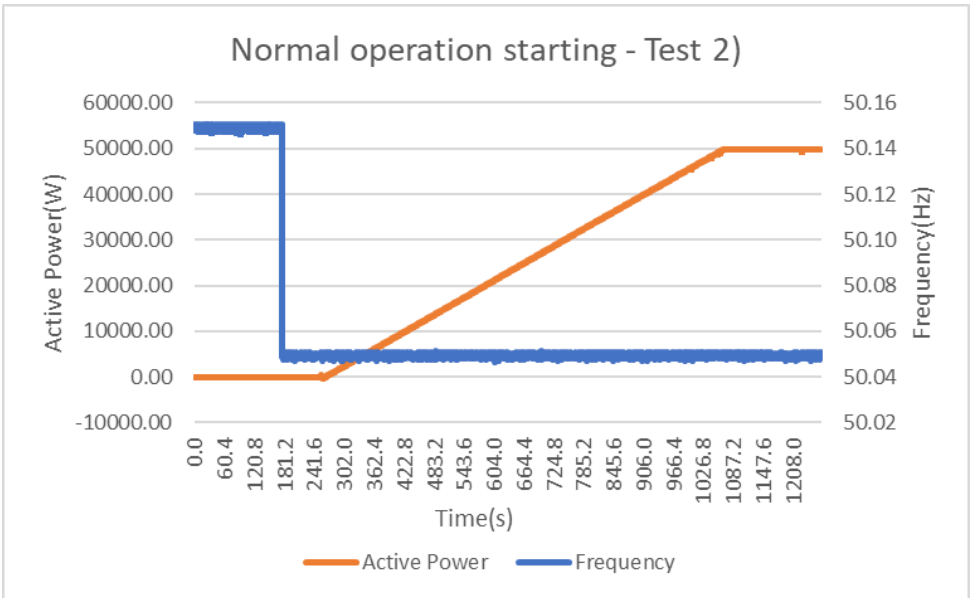
12.	50.05	3.0 min	10648.89	3713.33	Yes
13.	50.05	3.5 min	12489.32	3742.09	Yes
14.	50.05	4.0 min	14362.22	3742.77	Yes
15.	50.05	4.5 min	16231.41	3743.17	Yes
16.	50.05	5.0 min	18104.99	3740.35	Yes
17.	50.05	5.5 min	19974.58	3756.43	Yes
18.	50.05	6.0 min	21845.34	3757.89	Yes
19.	50.05	6.5 min	23731.01	3738.36	Yes
20.	50.05	7.0 min	25603.23	3742.06	Yes
21.	50.05	7.5 min	27469.37	3773.87	Yes
22.	50.05	8.0 min	29345.29	3731.35	Yes
23.	50.05	8.5 min	31243.24	3700.68	Yes
24.	50.05	9.0 min	33076.64	3730.59	Yes
25.	50.05	9.5 min	34943.92	3684.53	Yes
26.	50.05	10.0 min	36807.23	3662.15	Yes
27.	50.05	10.5 min	38628.45	3687.45	Yes
28.	50.05	11.0 min	40469.38	3694.40	Yes
29.	50.05	11.5 min	42315.90	3671.04	Yes
30.	50.05	12.0 min	44163.78	3676.64	Yes
31.	50.05	12.5 min	45986.94	3703.97	Yes
32.	50.05	13.0 min	47840.42	1887.23	Yes
33.	50.05	13.5 min	49690.91	--	--
34.	50.05	14.0 min	49727.65	--	--

Response curve:



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Test 3)					
Test sequence	Vol. (V)	Time stay in step (min.)	Whether reconnect to main and the active power generated? (Yes/No)		
1.	84%Un	0.5 min	No		
2.	84%Un	1.0 min	No		
3.	84%Un	1.5 min	No		
4.	84%Un	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 86% Un (min.)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 20% P_n (Yes/No)
5.	86%Un	0.0 min	--	Reconnection time (s)	70.4 s
After reconnection					
6.	86%Un	0.0 min	-1.51	3008.40	Yes
7.	86%Un	0.5 min	1328.88	3236.33	Yes
8.	86%Un	1.0 min	3006.89	3188.46	Yes
9.	86%Un	1.5 min	4565.21	3235.88	Yes
10.	86%Un	2.0 min	6195.35	3191.79	Yes
11.	86%Un	2.5 min	7801.09	3188.51	Yes
12.	86%Un	3.0 min	9387.14	3169.36	Yes
13.	86%Un	3.5 min	10989.60	3160.90	Yes
14.	86%Un	4.0 min	12556.50	3188.70	Yes
15.	86%Un	4.5 min	14150.50	3204.70	Yes
16.	86%Un	5.0 min	15745.20	3213.80	Yes
17.	86%Un	5.5 min	17355.20	3203.40	Yes
18.	86%Un	6.0 min	18959.00	3230.60	Yes
19.	86%Un	6.5 min	20558.60	3235.30	Yes
20.	86%Un	7.0 min	22189.60	3201.70	Yes
21.	86%Un	7.5 min	23793.90	3210.80	Yes
22.	86%Un	8.0 min	25391.30	3203.80	Yes
23.	86%Un	8.5 min	27004.70	3185.10	Yes
24.	86%Un	9.0 min	28595.10	3179.80	Yes
25.	86%Un	9.5 min	30189.80	3182.20	Yes
26.	86%Un	10.0 min	31774.90	3181.90	Yes
27.	86%Un	10.5 min	33372.00	3188.50	Yes
28.	86%Un	11.0 min	34956.80	3195.80	Yes
29.	86%Un	11.5 min	36560.50	3176.10	Yes
30.	86%Un	12.0 min	38152.60	3185.10	Yes

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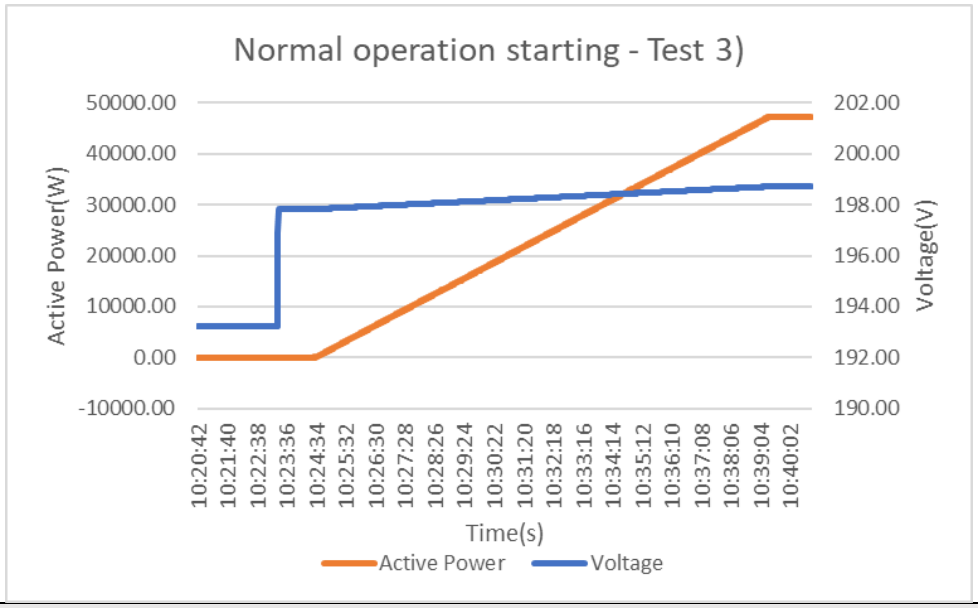
31.	86%Un	12.5 min	39736.60	3197.90	Yes
32.	86%Un	13.0 min	41337.70	3177.60	Yes
33.	86%Un	13.5 min	42934.50	3168.30	Yes
34.	86%Un	14.0 min	44515.30	2713.60	Yes
35.	86%Un	14.5 min	46102.80	1120.50	Yes
36.	86%Un	15.0 min	47228.90	--	--
37.	86%Un	15.5 min	47223.30	--	--

Response curve:



Test 4)					
Test sequence	Vol. (V)	Time stay in step (min.)	Whether reconnect to main and the active power generated? (Yes/No)		
1.	111%Un	0.5 min	No		
2.	111%Un	1.0 min	No		
3.	111%Un	1.5 min	No		
4.	111%Un	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 109% Un (min.)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 20% P_n (Yes/No)
5.	109%Un	0.0 min	--	Reconnection time (s)	77.6 s
After reconnection					
6.	109%Un	0.0 min	2.39	3291.79	Yes
7.	109%Un	0.5 min	1277.16	4054.99	Yes
8.	109%Un	1.0 min	3294.18	4044.28	Yes
9.	109%Un	1.5 min	5332.15	4055.18	Yes
10.	109%Un	2.0 min	7338.46	4047.51	Yes

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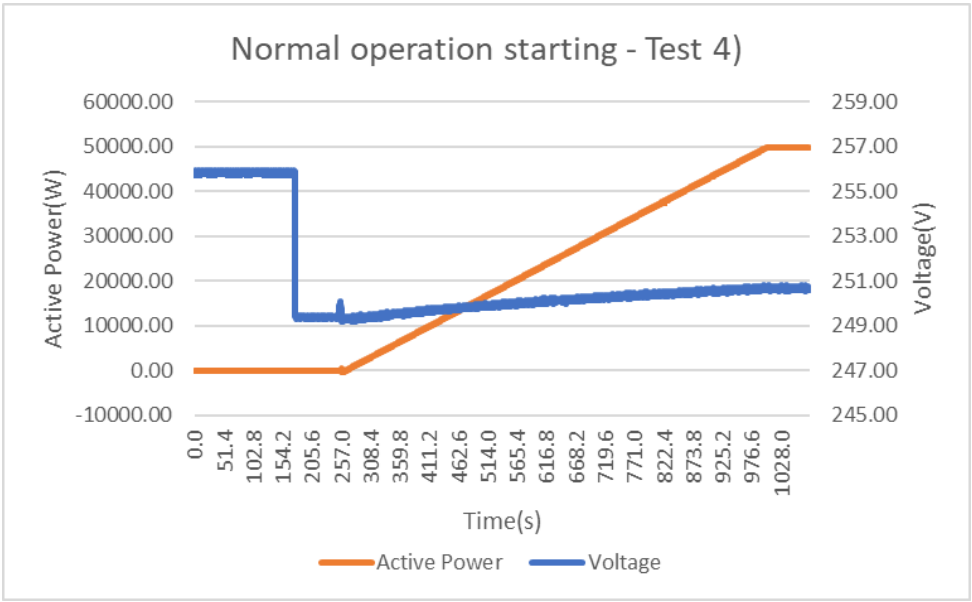
11.	109%Un	2.5 min	9387.33	4024.41	Yes
12.	109%Un	3.0 min	11385.97	4017.22	Yes
13.	109%Un	3.5 min	13411.74	4058.05	Yes
14.	109%Un	4.0 min	15403.19	4099.50	Yes
15.	109%Un	4.5 min	17469.79	4062.33	Yes
16.	109%Un	5.0 min	19502.69	4058.78	Yes
17.	109%Un	5.5 min	21532.12	4087.94	Yes
18.	109%Un	6.0 min	23561.47	4054.59	Yes
19.	109%Un	6.5 min	25620.06	4028.46	Yes
20.	109%Un	7.0 min	27616.06	4126.48	Yes
21.	109%Un	7.5 min	29648.52	4117.30	Yes
22.	109%Un	8.0 min	31742.54	4024.28	Yes
23.	109%Un	8.5 min	33765.82	4046.66	Yes
24.	109%Un	9.0 min	35766.82	4023.39	Yes
25.	109%Un	9.5 min	37812.48	3995.11	Yes
26.	109%Un	10.0 min	39790.21	4042.10	Yes
27.	109%Un	10.5 min	41807.59	4018.31	Yes
28.	109%Un	11.0 min	43832.31	3972.98	Yes
29.	109%Un	11.5 min	45825.90	3875.62	Yes
30.	109%Un	12.0 min	47805.29	1898.50	Yes
31.	109%Un	12.5 min	49701.52	--	--
32.	109%Un	13.0 min	49703.79	--	--

Response curve:



Reconnection after tripping of the interface protection relay

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Test 1)					
Test sequence	Freq (Hz)	Time stay in step (min.)	Whether reconnect to main and the active power generated? (Yes/No)		
1.	49.85	0.5 min	No		
2.	49.85	1.0 min	No		
3.	49.85	1.5 min	No		
4.	49.85	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 49.55 Hz (min)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 10% P_n (Yes/No)
5.	49.95	0.0 min	--	Reconnection time (s)	69.6 s
After reconnection					
6.	49.95	0.0 min	1.72	3277.39	Yes
7.	49.95	0.5 min	1366.79	3759.78	Yes
8.	49.95	1.0 min	3279.11	3718.64	Yes
9.	49.95	1.5 min	5126.57	3733.68	Yes
10.	49.95	2.0 min	6997.75	3707.35	Yes
11.	49.95	2.5 min	8860.25	3697.45	Yes
12.	49.95	3.0 min	10705.10	3689.60	Yes
13.	49.95	3.5 min	12557.70	3695.30	Yes
14.	49.95	4.0 min	14394.70	3704.90	Yes
15.	49.95	4.5 min	16253.00	3713.70	Yes
16.	49.95	5.0 min	18099.60	3732.30	Yes
17.	49.95	5.5 min	19966.70	3753.80	Yes
18.	49.95	6.0 min	21831.90	3756.70	Yes
19.	49.95	6.5 min	23720.50	3732.90	Yes
20.	49.95	7.0 min	25588.60	3731.10	Yes
21.	49.95	7.5 min	27453.40	3756.80	Yes
22.	49.95	8.0 min	29319.70	3716.40	Yes
23.	49.95	8.5 min	31210.20	3697.20	Yes
24.	49.95	9.0 min	33036.10	3707.40	Yes
25.	49.95	9.5 min	34907.40	3674.90	Yes
26.	49.95	10.0 min	36743.50	3686.20	Yes
27.	49.95	10.5 min	38582.30	3689.40	Yes
28.	49.95	11.0 min	40429.70	3674.20	Yes
29.	49.95	11.5 min	42271.70	3658.80	Yes
30.	49.95	12.0 min	44103.90	3683.40	Yes

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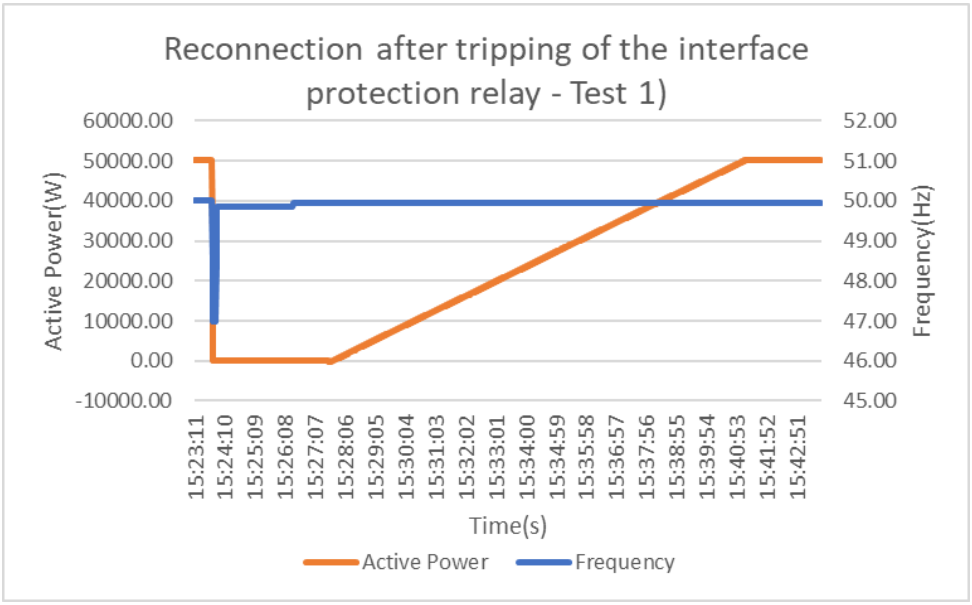
31.	49.95	12.5 min	45930.50	3694.90	Yes
32.	49.95	13.0 min	47787.30	2345.10	Yes
33.	49.95	13.5 min	49625.40	--	--
34.	49.95	14.0 min	50132.40	--	--

Response curve:



Test 2)					
Test sequence	Freq (Hz)	Time stay in step (min.)	Whether reconnect to main and the active power generated? (Yes/No)		
1.	50.15	0.5 min	No		
2.	50.15	1.0 min	No		
3.	50.15	1.5 min	No		
4.	50.15	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 50.15 Hz (min.)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 10% P_n (Yes/No)
5.	50.05	0.0 min	--	Reconnection time (s)	68.9 s
After reconnection					
6.	50.05	0.0 min	1.54	3247.79	Yes
7.	50.05	0.5 min	1343.50	3754.67	Yes
8.	50.05	1.0 min	3249.33	3738.50	Yes
9.	50.05	1.5 min	5098.17	3743.36	Yes
10.	50.05	2.0 min	6987.83	3702.27	Yes
11.	50.05	2.5 min	8841.53	3695.77	Yes
12.	50.05	3.0 min	10690.10	3689.30	Yes
13.	50.05	3.5 min	12537.30	3687.70	Yes

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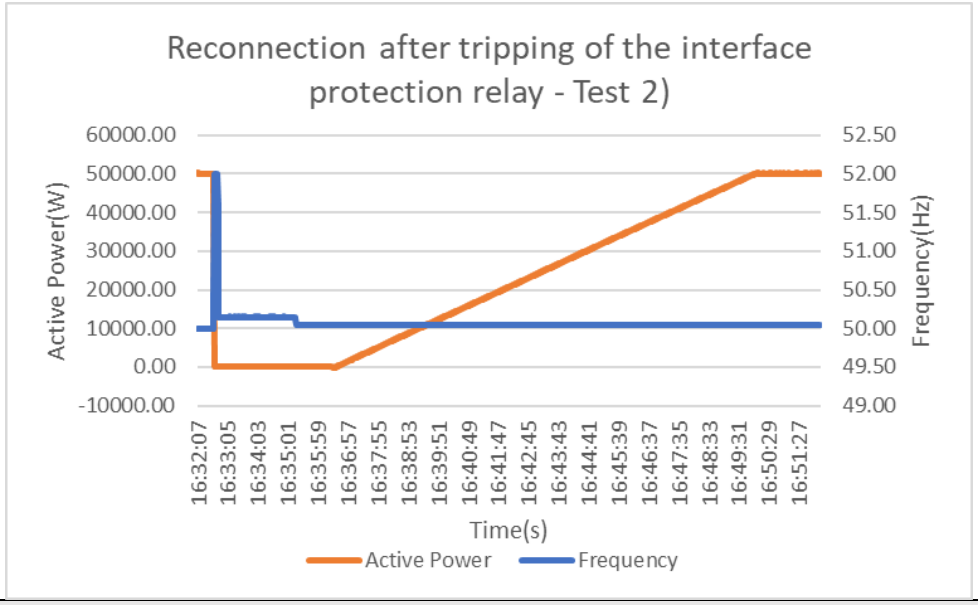
14.	50.05	4.0 min	14379.40	3708.20	Yes
15.	50.05	4.5 min	16225.00	3711.50	Yes
16.	50.05	5.0 min	18087.60	3721.90	Yes
17.	50.05	5.5 min	19936.50	3751.20	Yes
18.	50.05	6.0 min	21809.50	3758.10	Yes
19.	50.05	6.5 min	23687.70	3752.00	Yes
20.	50.05	7.0 min	25567.60	3739.80	Yes
21.	50.05	7.5 min	27439.70	3739.30	Yes
22.	50.05	8.0 min	29307.40	3723.40	Yes
23.	50.05	8.5 min	31179.00	3695.50	Yes
24.	50.05	9.0 min	33030.80	3684.50	Yes
25.	50.05	9.5 min	34874.50	3679.50	Yes
26.	50.05	10.0 min	36715.30	3691.00	Yes
27.	50.05	10.5 min	38554.00	3675.50	Yes
28.	50.05	11.0 min	40406.30	3677.90	Yes
29.	50.05	11.5 min	42229.50	3701.30	Yes
30.	50.05	12.0 min	44084.20	3674.80	Yes
31.	50.05	12.5 min	45930.80	3678.90	Yes
32.	50.05	13.0 min	47759.00	2359.20	Yes
33.	50.05	13.5 min	49609.70	--	--
34.	50.05	14.0 min	50118.20	--	--

Response curve:



Test 3)			
Test	Vol. (V)	Time stay in step (min.)	Whether reconnect to main and the active power generated?

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sequence			(Yes/No)		
1.	84%Un	0.5 min	No		
2.	84%Un	1.0 min	No		
3.	84%Un	1.5 min	No		
4.	84%Un	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 86% Un (min.)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 10% P_n (Yes/No)
5.	86%Un	0.0 min	--	Reconnection time (s)	70.1 s
After reconnection					
6.	86%Un	0.0 min	2.53	3035.54	Yes
7.	86%Un	0.5 min	1366.00	3242.00	Yes
8.	86%Un	1.0 min	3038.07	3212.55	Yes
9.	86%Un	1.5 min	4608.00	3222.47	Yes
10.	86%Un	2.0 min	6250.62	3166.81	Yes
11.	86%Un	2.5 min	7830.47	3177.13	Yes
12.	86%Un	3.0 min	9417.43	3180.77	Yes
13.	86%Un	3.5 min	11007.60	3171.40	Yes
14.	86%Un	4.0 min	12598.20	3179.70	Yes
15.	86%Un	4.5 min	14179.00	3210.70	Yes
16.	86%Un	5.0 min	15777.90	3200.20	Yes
17.	86%Un	5.5 min	17389.70	3198.70	Yes
18.	86%Un	6.0 min	18978.10	3226.40	Yes
19.	86%Un	6.5 min	20588.40	3207.70	Yes
20.	86%Un	7.0 min	22204.50	3203.10	Yes
21.	86%Un	7.5 min	23796.10	3223.10	Yes
22.	86%Un	8.0 min	25407.60	3193.50	Yes
23.	86%Un	8.5 min	27019.20	3182.70	Yes
24.	86%Un	9.0 min	28601.10	3182.60	Yes
25.	86%Un	9.5 min	30201.90	3172.00	Yes
26.	86%Un	10.0 min	31783.70	3172.20	Yes
27.	86%Un	10.5 min	33373.90	3167.80	Yes
28.	86%Un	11.0 min	34955.90	3184.40	Yes
29.	86%Un	11.5 min	36541.70	3195.10	Yes
30.	86%Un	12.0 min	38140.30	3169.80	Yes
31.	86%Un	12.5 min	39736.80	3177.60	Yes

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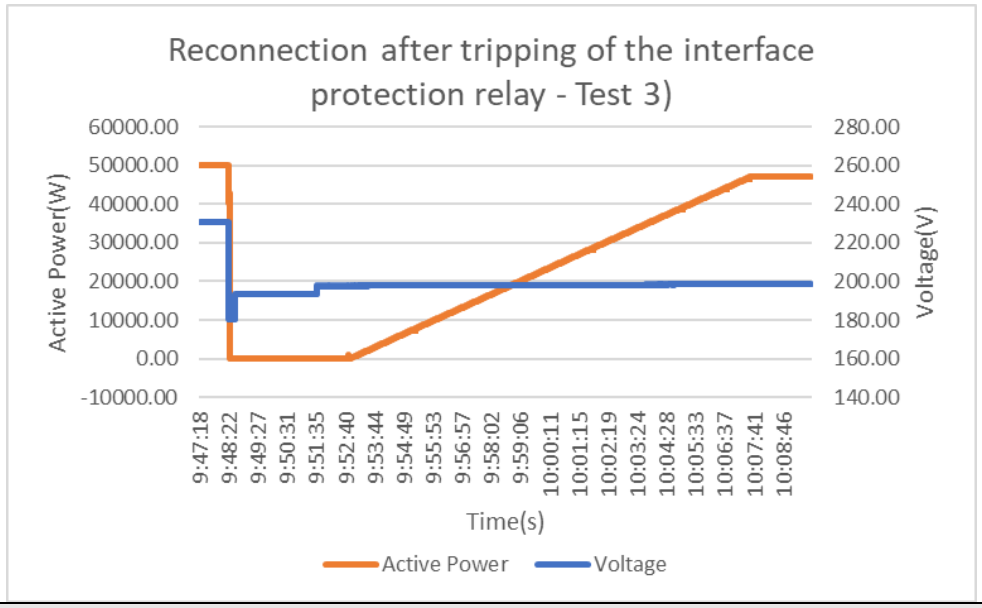
32.	86%Un	13.0 min	41310.10	3187.70	Yes
33.	86%Un	13.5 min	42914.40	3196.80	Yes
34.	86%Un	14.0 min	44497.80	2720.60	Yes
35.	86%Un	14.5 min	46111.20	1111.00	Yes
36.	86%Un	15.0 min	47218.40	--	--
37.	86%Un	15.5 min	47222.20	--	--

Response curve:



Test 4)					
Test sequence	Vol. (V)	Time stay in step (min.)	Whether reconnect to main and the active power generated? (Yes/No)		
1.	111%Un	0.5 min	No		
2.	111%Un	1.0 min	No		
3.	111%Un	1.5 min	No		
4.	111%Un	2.0 min	No		
Test sequence	Freq (Hz)	Time after reach 109% Un (min.)	Measured charge rate $P_{Measured}$ (W)	Arised charge rate ΔP during next 1 minute (W)	Deviation within 10% P_n (Yes/No)
5.	109%Un	0.0 min	--	Reconnection time (s)	70.0 s
After reconnection					
6.	109%Un	0.0 min	2.06	3590.03	Yes
7.	109%Un	0.5 min	1555.37	4054.64	Yes
8.	109%Un	1.0 min	3592.09	4041.75	Yes
9.	109%Un	1.5 min	5610.01	4329.53	Yes
10.	109%Un	2.0 min	7633.84	4329.16	Yes
11.	109%Un	2.5 min	9939.54	4054.36	Yes

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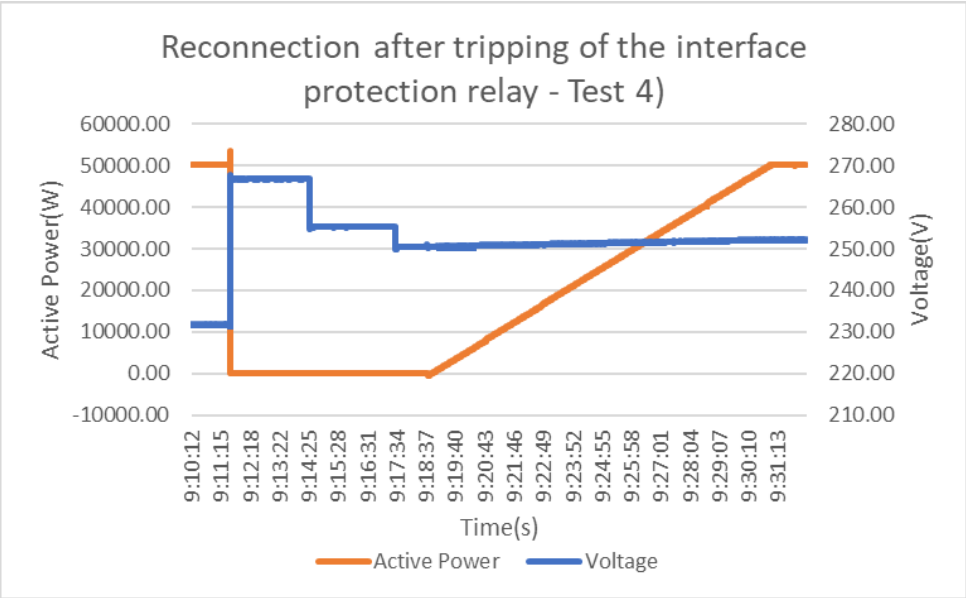
12.	109%Un	3.0 min	11963.00	4054.30	Yes
13.	109%Un	3.5 min	13993.90	4264.20	Yes
14.	109%Un	4.0 min	16017.30	4297.30	Yes
15.	109%Un	4.5 min	18258.10	4093.10	Yes
16.	109%Un	5.0 min	20314.60	4080.90	Yes
17.	109%Un	5.5 min	22351.20	4100.40	Yes
18.	109%Un	6.0 min	24395.50	4084.70	Yes
19.	109%Un	6.5 min	26451.60	4078.00	Yes
20.	109%Un	7.0 min	28480.20	4091.00	Yes
21.	109%Un	7.5 min	30529.60	4065.60	Yes
22.	109%Un	8.0 min	32571.20	4040.50	Yes
23.	109%Un	8.5 min	34595.20	4067.30	Yes
24.	109%Un	9.0 min	36611.70	4041.10	Yes
25.	109%Un	9.5 min	38662.50	4254.60	Yes
26.	109%Un	10.0 min	40652.80	4300.00	Yes
27.	109%Un	10.5 min	42917.10	4038.20	Yes
28.	109%Un	11.0 min	44952.80	4048.30	Yes
29.	109%Un	11.5 min	46955.30	3121.60	Yes
30.	109%Un	12.0 min	49001.10	--	--
31.	109%Un	12.5 min	50076.90	--	--

Response curve:



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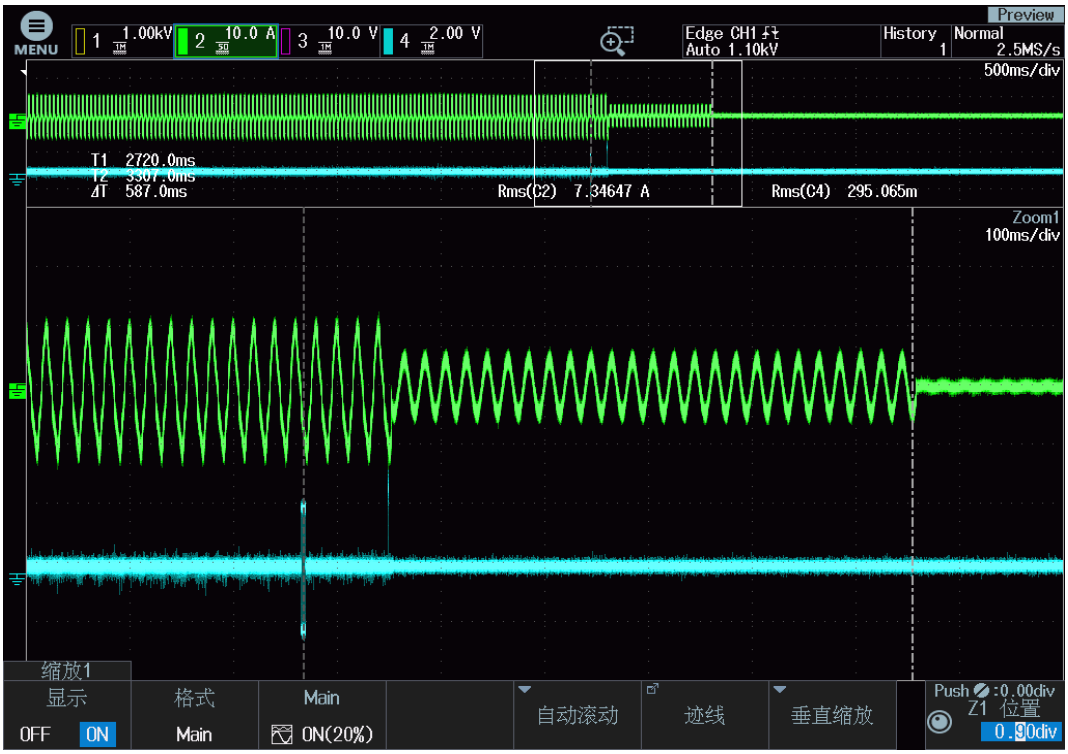
Annex D.9.1	Ceasing active power	P
Logic interface provided?	Yes	
Ceasing active power response time(s)	0.587	
stop the generation of active power time(s)	0.587	

Ceasing active power log:



Channel 2: Waveform of Phase A current signals at grid connection terminals.
Channel 4: Waveform of RS485 communication signal.

……End of test report……

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