Product Service

TEST REPORT Standard Engineering Recommendation G98, Issue 1 – Amendment 7, 3 October 2022 TUV SUD Test report for Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019	
Report reference No. ..... :	704092327701-00
Date of issue ..... :	2023-07-28
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Testing location ..... :	Hangzhou Livoltek Power Co., Ltd. 1418-35 Moganshan Road, Shangcheng Industrial Park, 310011 Hangzhou City, Zhejiang Province, PEOPLE'S REPUBLIC OF CHINA
Client ..... :	Hangzhou Livoltek Power Co., Ltd.
Client number ..... :	110005
Address ..... :	1418-35 Moganshan Road, Shangcheng Industrial Park, 310011 Hangzhou City, Zhejiang Province, PEOPLE'S REPUBLIC OF CHINA
Contact person	Mr. Dong Li
Standard ..... :	This TUV SUD test report form is based on the following requirements: G98/1-7:2022
TRF originated by. ..... :	TUV SUD Certification and Testing (China) Co., Ltd. Shanghai Branch Mr. Kai Zhao
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 GmbH. 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.
Scheme ..... :	☐ GS, ☐ TÜV Mark, ☐ EU-Directive, ☐ without certification ☒ Type verification of conformity
Non-standard test method ..... :	☒ No ☐ Yes, see details under Summary
National deviations ..... :	GB
Number of pages (Report) ..... :	70
Number of pages (Attachments) ..... :	See page 3

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Test sample……..:	Engineering prototype
Type of test object .....:	ON-GRID SOLAR INVERTER
Trademark .....:	LIVOLTEK
Model and/or type reference .....:	GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1
Rating(s) .....:	See copy of marking plates on page 5
Manufacturer .....:	Hangzhou Livoltek Power Co., Ltd.
Address .....:	1418-35 Moganshan Road, Shangcheng Industrial Park, 310011 Hangzhou City, Zhejiang Province, PEOPLE'S REPUBLIC OF CHINA
Sub-contractors/ tests (clause) .....:	N/A
Name .....:	N/A
Order description… .....:	☒ Complete test according to TRF
	☐ Partial test according to manufacturer's specifications
	☐ Preliminary test
	☐ Spot check
	☐ Others:
Date of order…….....:	2023-05-17
Date of receipt of test item .....:	2023-05-17
Date(s) of performance of test .....:	2023-05-18 to 2023-06-08

Test item particulars:

All the tests results confirmed to the requirements of the standard.

Attachments:

Item	Description	Certificate No. / test report No.	Issue by	Model	Pages
1	CE-LVD certificate	AN 50541814 0001	TÜV Rheinland	GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1	2
2	CE-EMC certificate	AE 50533067 0001	TÜV Rheinland	GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1	3

General remarks:

"(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.
This report shall not be reproduced except in full without the written approval of the testing laboratory.

Summary of testing:

☐ deviation(s) found

☒ no deviations found

Individual inverter assessed based on component basis.

DSP1:GT1xLTK1ACA_Ver1.30
DSP2:GT1xLTK1DCA_Ver1.05
ARM:GT11LTK_Ver1.42

All tests were conducted on model GT1-3K3S1, which is the representative mode of family design products, at rated voltage 230VAC and rated frequency 50 Hz, the results of the measurement of GT1-3K3S1 should be transferred in whole to other power generation units.

Test items below according to G98/1-7:2022 in details:

Clause(s)	Tests	Samples for testing in details
9.1	Operating range	GT1-3K3S1
9.4.4	Logic Interface	GT1-3K3S1
11.3	Electromagnetic Compatibility (EMC)	Refer to certificate issued by TÜV Rheinland and NO.: AE 50533067 0001
A.1.2.1 and	Protection – Voltage tests	GT1-3K3S1

A.1.2.2		
A.1.2.1 and A.1.2.3	Protection – Frequency tests	GT1-3K3S1
A.1.2.4	Loss of Mains Protection	GT1-3K3S1
A.1.2.5	Reconnection	GT1-3K3S1
A.1.2.6	Frequency Drift and Step Change Stability test	GT1-3K3S1
A.1.2.6	Frequency change, ROCOF Stability test	GT1-3K3S1
A.1.2.7	Active power feed-in at under-frequency	GT1-3K3S1
A.1.2.8	Micro-generators which include Electricity Storage	N/A
A.1.2.9	Power response to over-frequency	GT1-3K3S1
A.1.3.1	Harmonics	GT1-3K3S1
A.1.3.2	Power Factor	GT1-3K3S1
A.1.3.3	Voltage fluctuations and Flicker	GT1-3K3S1
A.1.3.4	DC Injection for Inverters	GT1-3K3S1
A.1.3.5	Short Circuit Current Contribution for Inverters	GT1-3K3S1
A.1.3.6	Self-Monitoring - Solid State Disconnection	N/A

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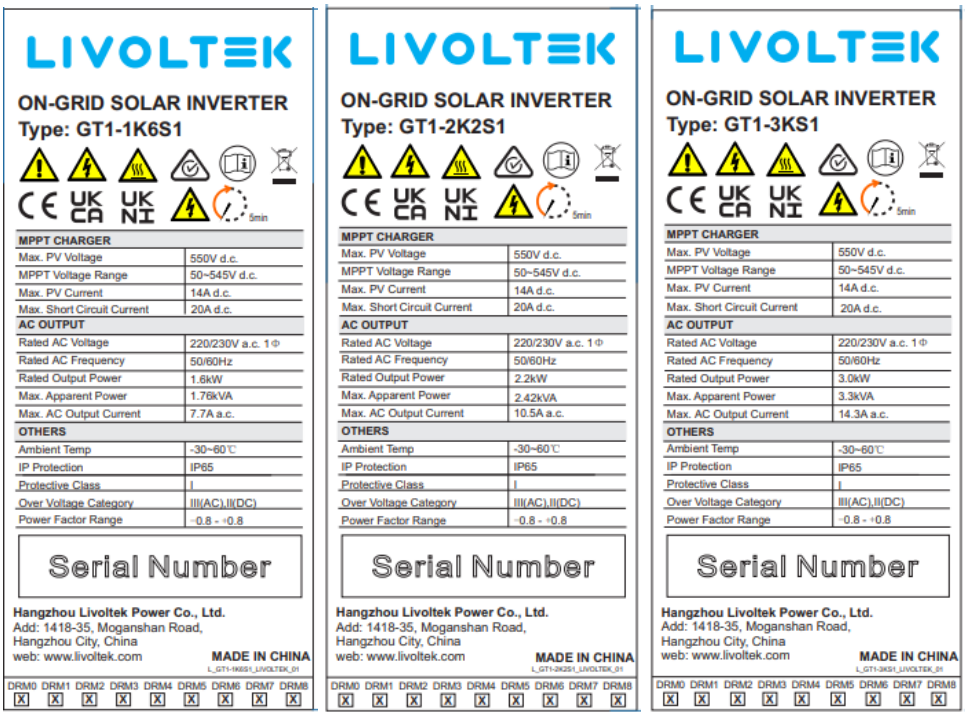
Copy of marking plate:



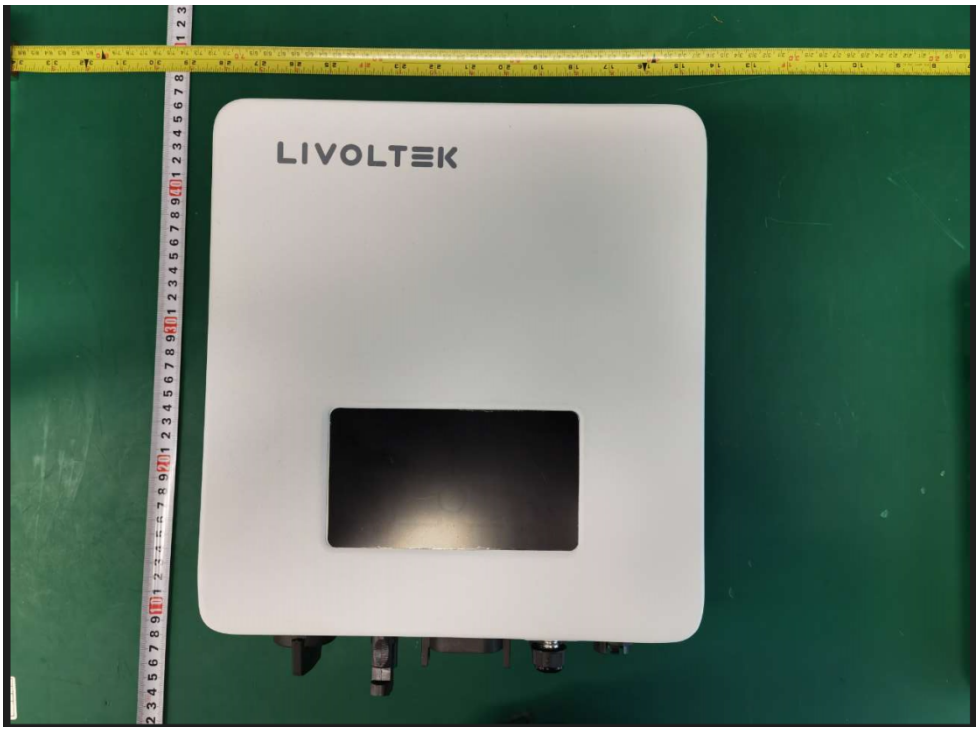
Interface protection has been tested and evaluated on basis of rated grid voltage L/N/PE~, 230 V, 50Hz according to the grid code on page 1;

Interface protection settings is limited to authorized installer, password and seal provided to protect these from unpermitted interference.

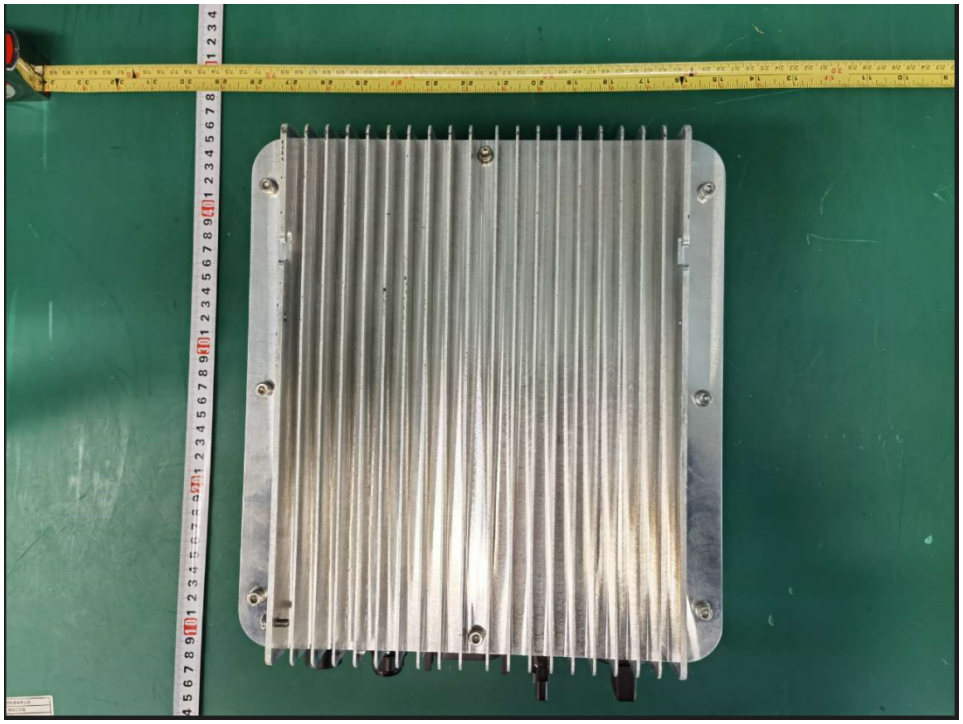
Inverters with multi-voltage and/or frequencies ratings are available in difference versions based on output voltages and frequencies, the ratings on which the testing has been based was identified on paper tag and control panel.

Picture of the product:

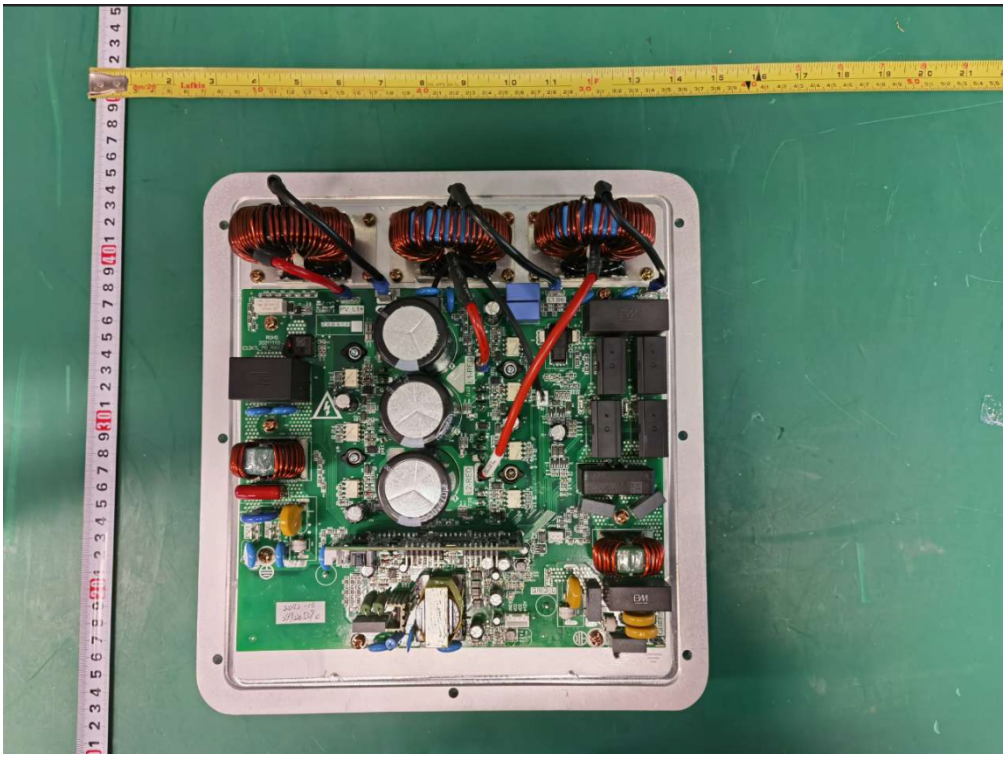
Representative model: GT1-3K3S1



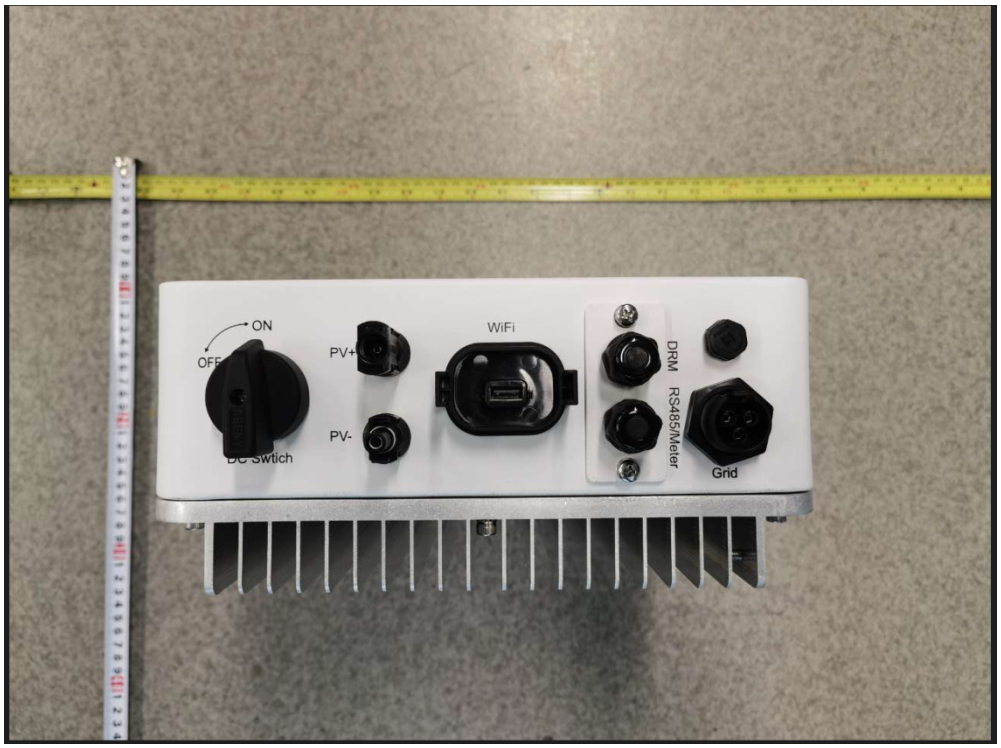
Front view



Rear view



Internal view



Bottom view

Characteristic data

Model	GT1-1K6S1	GT1-2K2S1	GT1-3KS1	GT1-3K3S1	GT1-3K6D1
MPPT CHARGER					
Max. PV Voltage	550V d.c.				
MPPT Voltage Range	50~545V d.c.				70~545V d.c.
Max. PV Current	14A d.c.				14A\14A d.c.
Max. Short Circuit Current	20A d.c.				20A\20A d.c.
AC OUTPUT					
Rated AC Voltage	1/N/PE AC 230 V				
Rated AC Frequency	50Hz				
Rated Output Power	1.6kW	2.2kW	3.0kW	3.3kW	3.60kW
Max. Apparent Power	1.76kVA	2.42kVA	3.3kVA	3.3kVA	3.60kVA
Max. AC Output Current	7.7A a.c.	10.5A a.c.	14.3A a.c.	14.3A a.c.	15.7 A a.c.
Power Factor Range	-0.8 - +0.8				

Characteristic data Factory:

Hangzhou Livoltek Power Co., Ltd.
Floor 1, Building 1, 1418-7 Moganshan Road, Hangzhou City, Zhejiang Province (Shangcheng Science and Technology Industrial Base)

Note: Type verification of conformity, no FI required.

Purpose of the product:

Interface protection settings (Manufacturer default settings)

Protection function	Trip setting	Time Delay Setting
U/V	$V_{\varphi\text{-}N}$ – 20%	2.5s
O/V st 1	$V_{\varphi\text{-}N}$ + 14%	1.0s
O/V st 2	$V_{\varphi\text{-}N}$ + 19%	0.5s
U/F st 1	47.5 Hz	20s
U/F st 2	47 Hz	0.5s
OF	52 Hz	0.5s
Loss of Mains (RoCoF)	1 Hzs^{-1}	

Tolerances on trip values:

- voltage: ±1.5%;
- frequency: ± 0.2%;

Unauthorised access to factory safety parameters setting and software should be prohibited.
A reset to the factory safety parameters requires retesting and verification in conjunction with the end-use system.

Protection integrated in inverter can not be used as an alternative central interface protection device at connection point.

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	- C (Comment)
- suffix for important information for factory inspection...:	- M (Manufacturing)

Engineering Recommendation G98/1-7			
Clause	Requirement – Test	Result – Remark	Verdict
6	**Certification requirement**		P
6.1	Type test certification		P
6.1.1	Type test certification is the responsibility of the **Manufacturer**.		P
	The report shall detail the type and model of **Micro-generator** tested, the test conditions and results recorded.		P
	The required verification report and declaration are shown in Appendix 3 Form C.		P
6.1.2	**Manufacturers** of a **Fully Type Tested Micro-generator** should allocate a **Manufacturer**'s reference number with the required details of the **Micro-generator** with the Energy Networks Association **Type Test Verification Report** Register.		P
6.2	Compliance		P
6.2.1	Compliance with the requirements detailed in this EREC G98 will ensure that the **Micro-generator(s)** is considered to be approved for connection to the **DNO's Distribution Network**.		P
6.2.2	The Micro-generator(s) shall conform to all relevant compliance and safety legislation.		P
6.3	Family approach to Type Testing		P
6.3.1	The approach is permissible in the following range of **Micro-generator** electrical output:		P
	• For synchronous **Micro-generator**s:		N/A
	o Lower limit: 1/√10 (0.3162) times the tested **Micro-generator** nameplate rating (W)		N/A
	o Upper limit: √10 (3.162) times the tested **Micro-generator** nameplate rating (W)		N/A
	• For all other **Micro-generator**s:	Family design and type tested model comply with following requirements	P
	o Lower limit: 1/√10 (0.3162) times the tested **Micro-generator** nameplate rating (W)		P
	o Upper limit: 2 times the tested **Micro-generator** nameplate rating (W)		P
6.3.2	All absolute values (e.g. operating range tests) from the tested **Micro-generator** shall be transferred directly in the compliance forms of an assumed compliant **Micro-generator** of the same family.		P
	All relative results related to design **Active Power** or current (e.g. power quality		P

Engineering Recommendation G98/1-7			
Clause	Requirement – Test	Result – Remark	Verdict
	fluctuation and flicker) from the tested **Micro-generator** shall be transferred to the compliance form of a **Micro-generator** in the same family according to the ratio of the respective nameplate rating (W)of the tested **Micro-generator** and the assumed compliant **Micro-generator**.		
6.3.3	It is the responsibility of the **Manufacturer** to provide technical justification that the results are transferable.		P
7	**Operation and Safety**		P
7.1	Operational Requirements		P
7.1.1	Compliance with this EREC G98 in respect of the design, installation, operation and maintenance of a **Micro-generating Plant**, will ensure that the **Customer** is discharging their legal obligations under **ESQCR** 22(1)(a) and the EU Network Code on Requirements for Grid Connection of Generators.	Take into consideration in final installations	N/A
7.2	Installation Wiring and Isolation		N/A
7.2.1	The **Micro-generator(s)** shall be connected via an accessible isolation switch that is capable of isolating all phases and neutral. The isolation switch shall be capable of being secured in the 'off' (isolated) position.	Take into consideration in final installations	N/A
7.3	Labelling		N/A
7.3.1	The Installer shall provide labelling at the Connection Point with the DNO's Distribution Network (cut-out), meter position, consumer unit and at all points of isolation between the Connection Point and the Micro-generating Plant within the Customer's premises to indicate the presence of a Micro-generating Plant. T	Take into consideration in final installations	N/A
7.3.2	In addition to the warning label, this EREC G98 requires the following, up to date, information to be displayed at the **Connection Point** with the **DNO's Distribution Network.**	Take into consideration in final installations	N/A
	a) A circuit diagram relevant to the installation showing the circuit wiring, including all protective devices, between the **Micro-generator** and the **DNO's** fused cut-out.		N/A
	b) A summary of the **Interface Protection** settings incorporated within the **Micro-generator**.		N/A
7.3.3	Figure 1 shows an outline example of the type of	Take into consideration in final	N/A

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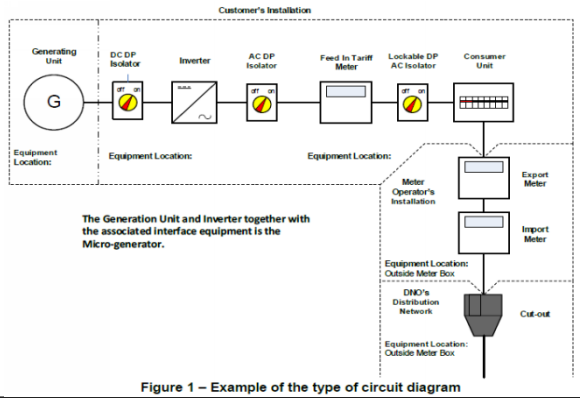
Clause	Requirement – Test	Result – Remark	Verdict
	circuit diagram that will need to be displayed. Figure 1 is non-prescriptive and is for illustrative purposes only.  Figure 1 – Example of the type of circuit diagram	installations	
7.3.4	The Installer shall advise the Customer that it is the Customer's responsibility to ensure that this safety information is kept up to date. The installation operating instructions shall contain the Manufacturer's contact details eg name, telephone number and web address		N/A
7.4	Maintenance & Routine Testing	Type test only	N/A
7.4.1	Periodic testing of the **Micro-generator** is recommended at intervals prescribed by the **Manufacturer**.		N/A
	This information shall be included in the installation and user instructions.		N/A
	The method of testing and/or servicing should be included in the servicing instructions.		N/A
7.5	Phase Unbalance		P
7.5.1	There is no requirement to balance phases on installations below or equal to 16 A per phase.		P
7.5.2	For multiple premises installations of **Micro-generators** (eg new housing developments), balancing the **Micro-generators** evenly against the load on the three phases will need to be considered by the **DNO**.		N/A
	The **DNO** will advise the **Installer** of any phase balancing requirements.		N/A
7.6	Voltage Management Units		N/A
7.6.1	If a Voltage Management Unit is installed in a **Customer's Installation** between the **Connection Point** and the **Micro-generator**, it may result in the voltage at the **Micro-generator**	Take into consideration in final installations	N/A

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Clause	Requirement – Test	Result – Remark	Verdict
	side of the Voltage Management Unit remaining within the limits of the protection settings defined in Table 2 while the voltage at the **Connection Point** side of the unit might be outside the limits of the protection settings.		
7.7	Earthing	Take into consideration in final installations	N/A
7.7.1	There shall be no direct connection between the **Micro-generator** current carrying conductors and earth with the following exception:		N/A
	• For a **Micro-generator** that is connected via an **Inverter** (eg a PV array or fuel cell) it is permissible to connect one pole of the **DC** side of the **Inverter** to the **DNO**'s earth terminal if the insulation between the AC and the **DC** sides of the **Inverter** meets the requirements for at least simple separation.		N/A
7.7.2	Earthing of all exposed conductive parts shall comply with the requirements of BS 7671.		N/A
8	**Commissioning, Notification and Decommissioning**		N/A
8.1	General		N/A
8.2	Commissioning		N/A
8.3	Notification of Commissioning		N/A
8.4	Notification of Changes		N/A
8.5	Notification of Decommissioning		N/A
9	**General Technical Requirements**		P
9.1	Frequency withstand		P
9.1.1	**Table 1 – Minimum time periods for which a Micro-generator has to be capable of operating within different frequency ranges without disconnecting from the Distribution Network** 47.0 Hz – 47.5 Hz: 20 seconds 47.5 Hz – 48.5 Hz: 90 minutes 48.5 Hz -49.0 Hz: 90 minutes 49.0 Hz – 51.0 Hz: Unlimited 51.0 Hz – 51.5 Hz: 90 minutes 51.5 Hz – 52.0 Hz: 15 minutes The **Micro-generator** shall be capable of remaining connected to the **Distribution Network** and operating within the frequency ranges and time periods specified in Table 1 unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection.		P

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Clause	Requirement – Test	Result – Remark	Verdict
9.2	Rate of Change of Frequency		P
9.2.1	With regard to the rate of change of frequency withstand capability, a **Micro-generator** shall be capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1.0 Hzs-1 measured over 500 ms.		P
9.3	Limited Frequency Sensitive Mode – Overfrequency		P
9.3.1	With regard to the Limited Frequency Sensitive Mode — Overfrequency (LFSM-O), the Micro-generator shall be capable of reducing its Active Power output when the frequency rises above 50.4 Hz. The Droop shall be 10%. No intentional delay should be programmed to ensure that the initial delay is as short as possible with a maximum of 2 s		P
9.3.2	The **Micro-generator** will continue to reduce power with rising frequency with a **Droop** of 10% until 52.0 Hz, at which point the **Micro-generator** should disconnect.		P
9.3.3	If the reduction in **Active Power** output is such that the **Micro-generator** reaches its minimum stable operating level, it shall continue to operate stably at this level.		P
9.3.4	Steady state operation below a Micro-generator's minimum stable operating level is not expected but if system frequency would cause operation below its minimum stable operating level then the **Micro-generator** shall be able to deliver an output of not less than the minimum stable operating level.		P
9.4	Active Power Output		P
9.4.1	The **Micro-generator** shall be capable of maintaining constant output at its **Registered Capacity** regardless of changes in frequency, except where the output follows the changes defined in the context of paragraphs 9.3.1 and 9.4.2.		P

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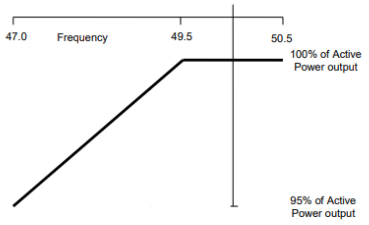
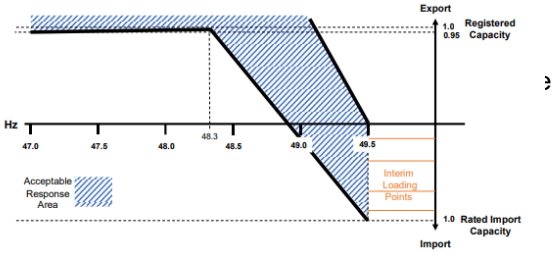
Clause	Requirement – Test	Result – Remark	Verdict
9.4.2	The **Micro-generator** shall be capable of maintaining constant output at its **Registered Capacity** regardless of changes in frequency in the range 49.5 – 50.4 Hz. Below 49.5 Hz, the power output should not drop by more than pro-rata with frequency, ie the maximum permitted requirement is 100% power at 49.5 Hz falling linearly to 95% power at 47.0 Hz as illustrated in Figure 3.  **Figure 3 – Change in Active Power output with falling frequency**		P
9.4.3	This paragraph describes an optional performance characteristic as discussed in the foreword. A Micro-generating Plant that  **Figure 4 Change in Active Power of Electricity Storage with falling frequency** (not to scale)	Optional performance	N/A
	The required characteristics are: (a) When the frequency falls to 49.5 Hz the automatic response shall start; (b) The frequency response characteristic shall be within the shaded area of Figure 3; (c) If the Electricity Storage device is not capable of moving from an import level to an appropriate export level within 20 s of the frequency falling to 49.2 Hz, then it shall cease to import; and (d) If the Electricity Storage device has not achieved at least zero Active Power import when the frequency has reached 48.9 Hz it shall cease to import immediately.		N/A
9.4.4	The **Micro-generator** shall be equipped with a logic interface (input port) in order to cease	Take into consideration in final installations	N/A

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Clause	Requirement – Test	Result – Remark	Verdict
	Active Power output within 5 s following an instruction being received from the **DNO** at the input port.		
	By default the logic interface will take the form of a simple binary output that can be operated by a simple switch or contactor.		N/A
	The signal from the **Micro-generator** that is being switched can be either AC (maximum value 240 V) or **DC** (maximum value 110 V).		N/A
	The **DNO** may specify any additional requirements particularly regarding remote operation of this facility.		N/A
9.5	Power Factor		P
9.5.1	The power factor capability of the Micro-generator shall conform to EN 50549-1 as applicable to Micro-generating Plant. When operating at Registered Capacity the Micro-generator shall operate at a power factor within the range 0.95 lagging to 0.95 leading relative to the voltage waveform unless otherwise agreed with the DNO eg for power factor improvement.		P
9.6	Automatic Connection		P
9.6.1	Micro-generators shall conform to EN 50549-1 in respect of connection and starting to generate electric power. Connection, reconnection and starting to generate electrical power is only allowed after the voltage and frequency at the Connection Point is within the limits of the Interface Protection settings for a minimum of 20 s.		P
9.7	Cyber Security		P
9.7.1	Every **Micro-generator** and any associated equipment must be designed and operated appropriately to ensure cyber security.		P
9.7.2	The statement will make appropriate reference to the **Micro-generator**'s compliance with	Statement by manufacturer provided	P
	• ETSI EN 303 645		P
	• relevant aspects of PAS 1879 "Energy smart appliances – Demand side response operation – Code of practice;		N/A
	• relevant aspects of "Distributed Energy Resources – Cyber Security Connection Guidance" published by BEIS and the ENA;		N/A
	• Any other relevant standard that has been incorporated in the design of the		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
	Micro-Generator.		

10	**Interface Protection**		P
10.1	General		P
10.1.1	The **Micro-generator** shall conform to the **Interface Protection** settings set out below (Table 2).		P
	Means shall be provided to protect the settings from unpermitted interference (eg via a password or seal).		P
10.1.2	The **DNO** is responsible under the **Distribution Code** for ensuring, by design, that the voltage and frequency at the **Connection Point** remains within statutory limits.		P
10.1.3	**Interface Protection** shall be installed which disconnects the **Micro-generator** from the **DNO's Distribution Network** when any parameter is outside of the settings shown in Table 2.		P
10.1.4	The total disconnection time for voltage and frequency protection, including the operating time of the disconnection device, shall be the time delay setting with a tolerance of, -0s + 0.5 s.		P
10.1.5	For the avoidance of doubt, where the **Distribution Network** voltage or frequency exceed the trip settings in Table 2, for less than the time delay setting, the **Micro-generator** should not disconnect from the **Distribution Network**.		P
10.1.6	**Fully Type Tested Micro-generators** shall have protection settings set during manufacture.		P
10.1.7	The **Manufacturer** shall establish a secure way of displaying the **Interface Protection** setting information in one of the following ways:		P
	- A display on a screen;		P

Table 2 – Interface Protection settings

Protection Function	Trip Setting	Time Delay Setting
U/V	Vφ-n† - 20% = 184 V	2.5 s
O/V stage 1	Vφ-n† +14% = 262.2 V	1.0 s
O/V stage 2	Vφ-n†+ 19% = 273.7 V[4]	0.5 s
U/F stage 1	47.5 Hz	20 s
U/F stage 2	47 Hz	0.5 s
O/F	52 Hz	0.5 s
LoM (RoCoF)	1.0 Hzs^{-1}	

† A value of 230 V phase to neutral

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Clause	Requirement – Test	Result – Remark	Verdict
	- A display on a PC which can communicate with the **Micro-generator** and confirm that it is the correct **Micro-generator** by means of a serial number permanently fixed to the **Micro-generator** and visible on the PC screen at the same time as the settings; or		P
	- Display of all **Interface Protection** settings and nominal voltage and current outputs, alongside the serial number of the **Micro-generator**, permanently fixed to the **Micro-generator**.		N/A
10.1.8	The provision of loose documents, documents attached to the **Micro-generator** by cable ties etc, or provision of data on adhesive paper based products which are not likely to survive due to fading, or failure of the adhesive, for at least 20 years is not acceptable.	Take into consideration in final installations	N/A
10.1.9	In response to a protection operation the **Micro-generator** shall be automatically disconnected from the **DNO's Distribution Network**.		N/A
	This disconnection shall be achieved by the separation of mechanical contacts or alternatively by the operation of a suitably rated solid state switching device.		N/A
10.1.10	The Interface Protection shall function correctly, ie operate within the required tolerance range as given in paragraph 10.1.4, across the expected range of ambient operating temperatures and other environmental factors.		P
10.1.12	Once the **Micro-generator** has been installed and commissioned the protection settings shall only be altered following written agreement between the **DNO** and the **Customer** or their agent.		N/A
10.2	Loss of Mains Protection		P
10.2.1	Loss of mains protection shall be incorporated and tested as defined in the relevant compliance type testing annex of this EREC G98.		
10.3	Frequency Drift and Step Change Stability Test		P
10.3.1	Under normal operation of the **Distribution Network**, the frequency changes over time due to continuous unbalance of load and generation or can experience a step change due to the loss of a **Distribution Network** component which does not cause a loss of supply.		P
10.3.2	In order to ensure that such phenomena do not cause unnecessary tripping of **Micro-generators**, stability type tests shall be carried out.		P
10.3.3	The Rate of Change of Frequency (RoCoF) and		P

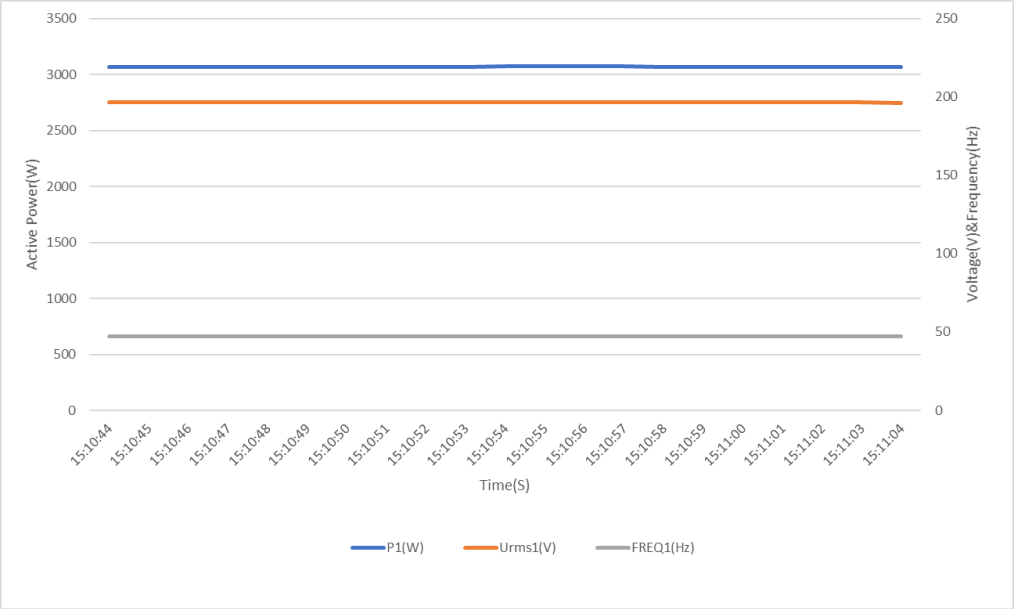
Engineering Recommendation G98/1-7			
Clause	Requirement – Test	Result – Remark	Verdict
	Vector Shift values required for these tests are marginally less than the corresponding protection settings for RoCoF in Table 2 and vector shifts of up to 50º. Both stability tests shall be carried out in all cases.		
10.3.4	The stability tests are to be carried out as per the table in Appendix 3 Form C of this document and the **Micro-generator** should remain connected during each and every test.		P
	The tests shall check that the **Micro-generator** remains stable and connected during the following scenarios:		P
	- RoCoF: 0.95 Hzs-1 from 49.0 Hz to 51.0 Hz on both rising and falling frequency; and		P
	- Vector shift: 50º plus from 49.5 Hz and 50º minus from 50.5 Hz.		P
11	**Quality of Supply**		P
11.1	Harmonics and voltage fluctuation		P
11.2	DC injection.		P
11.3	Electromagnetic Compatibility (EMC)		P
11.4	Short Circuit Current Contribution		P
Appendix 1	**Emerging Technologies and other Exceptions**		P
	Emerging Technologies		P
	For **Micro-generators** classified as an emerging technology at the time of their connection to a **DNO's Distribution Network**, the following sections of EREC G98 do not apply.		P
	- 9.1 (frequency withstand capability);		P
	- 9.2 (rate of change of frequency);		P
	- 9.3 (**Limited Frequency Sensitive Mode – Overfrequency**);		P
	- 9.4 (constant **Active Power** output); and		P
	- 10.1.3 (**Interface Protection** settings).		P
	Other Exceptions, for		P
	- **Electricity Storage** devices, and/or		P
	- **Micro-generating Plant** with a **Registered Capacity** of less than 800 W	More than 800W	N/A
	the following sections of EREC G98 do not apply:		N/A

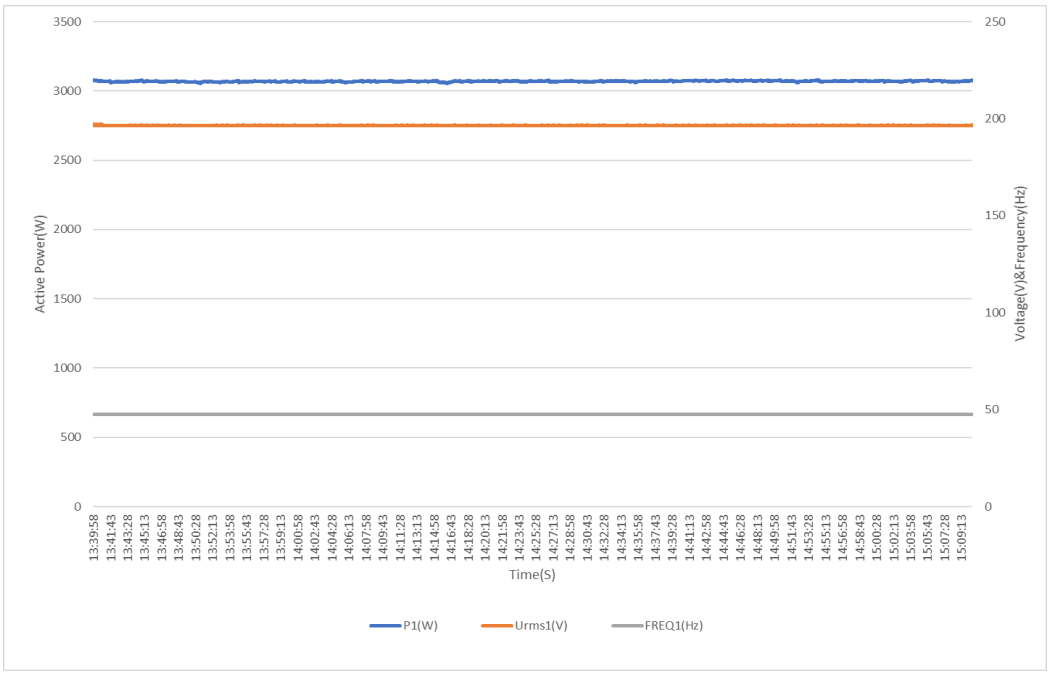
Engineering Recommendation G98/1-7			
Clause	Requirement – Test	Result – Remark	Verdict
	- 9.3 (Limited Frequency Sensitive Mode – Overfrequency); and		N/A
	- 9.4.2 and 9.4.3 (constant **Active Power** output).		N/A
Appendix 2	**Connection Procedure Flow Chart**		N/A
Appendix 3	**Micro-generator Documentation**		P
	Form A: Application for connection of multiple Micro-Generating installations		N/A
	Form B: Installation Document for connection under G98		N/A
	Form C: Type Test Verification Report		P
	Form D: Micro-generator Decommissioning Confirmation		N/A
Appendix 4	**Relaxation of Commissioning Notification Timescales for Micro-generator: HSE Certificate of Exemption (August 2008)**		N/A
A.1	**Annex A1 Requirements for Type Testing of Inverter Connected Micro-generators**		P
A.1.1	General		P
	This Annex describes a methodology for obtaining type certification or type verification for **Micro-generators** which are connected to the **Distribution Network** via an **Inverter**.		P
	Where the **Interface Protection** is physically integrated within the overall **Micro-generator** control system, the functionality of the **Interface Protection** unit should not be compromised by any failure of other elements of the control system (fail safe).		P
	This Annex applies to **Micro-generator**s:		P
	- with or without or energy storage systems connected on the energy source or prime mover side of the **Micro-generator**; and		P
	- with or without load management devices.		P
A.1.2	**Type Verification Functional Testing of the Interface Protection**		P
	Type testing is the responsibility of the **Manufacturer**.		P
	The type testing will verify that the operation of the **Interface Protection** shall result:		P
	a) in the safe disconnection of the **Micro-generator** from the **DNO's Distribution**		P

Engineering Recommendation G98/1-7			
Clause	Requirement – Test	Result – Remark	Verdict
	Network in the event that the protection settings specified in Table 2 are exceeded; and		
	b) in the **Micro-generator** remaining connected to the **DNO's Distribution Network** while **Distribution Network** conditions are:		P
	1) within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in Table 2; and		P
	2) within the time delay settings specified in Table 2.		P
A 1.2.1	Disconnection times		P
	The minimum trip time delay settings, for over / under voltage, over / under frequency and loss of mains tests below, are presented in Table 2.		P
A 1.2.2	Over / Under Voltage		P
A 1.2.3	Over / Under Frequency		P
A 1.2.4	Loss of Mains Protection		P
A 1.2.5	Reconnection		P
A 1.2.6	Frequency Drift and Step Change Stability test		P
A 1.2.7	Active power feed-in at under-frequency		P
A 1.2.8	Micro-generators which include Electricity Storage	Optional performance only	N/A
A 1.2.9	Power response to over-frequency		P
A.1.3	POWER QUALITY		P
A 1.3.1	Harmonics		P
A 1.3.2	Power Factor		P
A 1.3.3	Voltage Flicker		P
A 1.3.4	DC Injection for Inverters		P
A 1.3.5	Short Circuit Current Contribution for Inverters		P
A 1.3.6	Self-Monitoring - Solid State Disconnection	Relay as integrated interface switch	N/A
A.2	**Annex A2 Requirements for Type Testing of Synchronous Micro-generators**		N/A
A.2.1	General		N/A
A.2.2	Type Verification Functional Testing of the Interface Protection		N/A
A.2.2.1	Disconnection times		N/A
A.2.2.2	Over / Under Voltage		N/A
A.2.2.3	Over / Under Frequency		N/A
A.2.2.4	Loss of Mains Protection		N/A

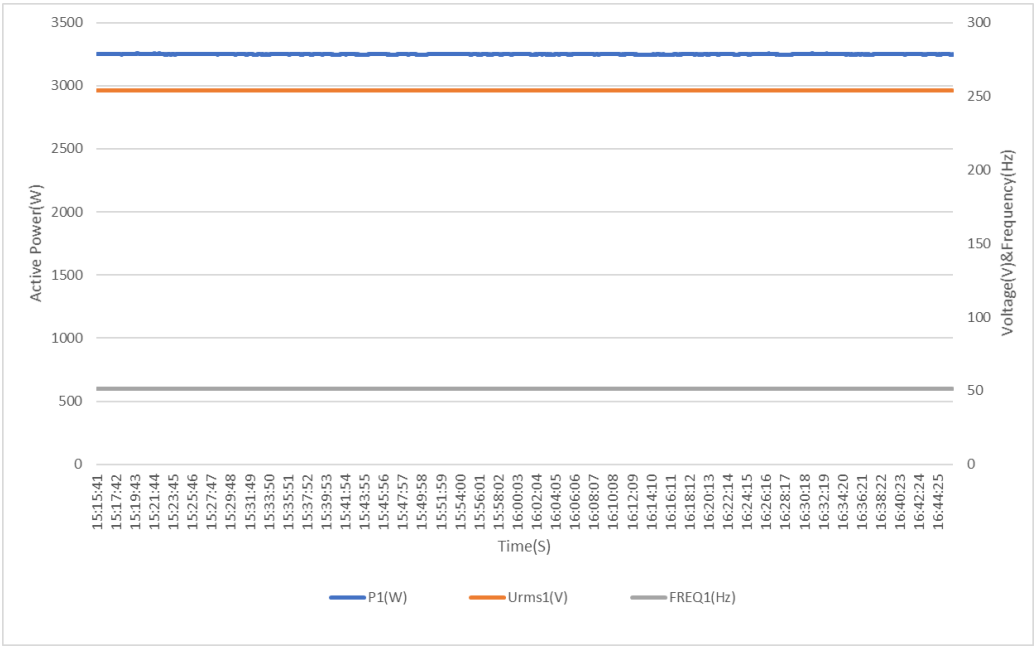
Engineering Recommendation G98/1-7			
Clause	Requirement – Test	Result – Remark	Verdict
A.2.2.5	Reconnection		N/A
A.2.2.6	Frequency Drift and Step Change Stability test		N/A
A.2.2.7	Active power feed-in at under-frequency		N/A
A.2.2.8	Micro-generators which include Electricity Storage		N/A
A.2.2.9	Power response to over-frequency		N/A
	POWER QUALITY		N/A
A.2.3.1	Harmonics		N/A
A.2.3.2	Power Factor		N/A
A.2.3.3	Voltage Flicker		N/A
A.2.3.4	Short Circuit Current Contribution for Directly Coupled technology		N/A

Form C: TYPE TEST VERIFICATION REPORT

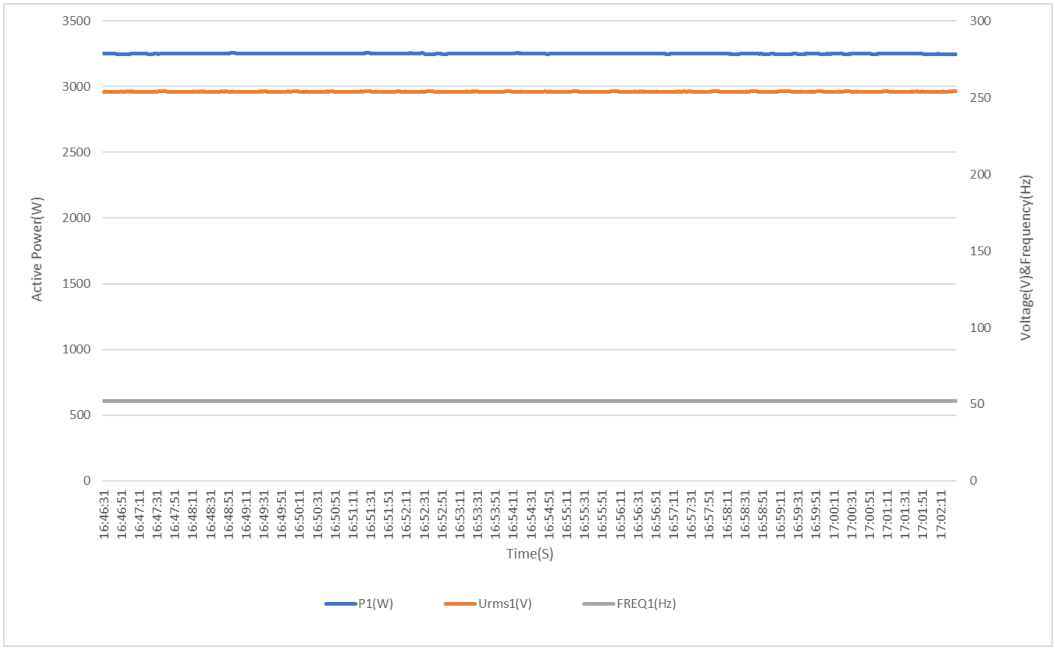
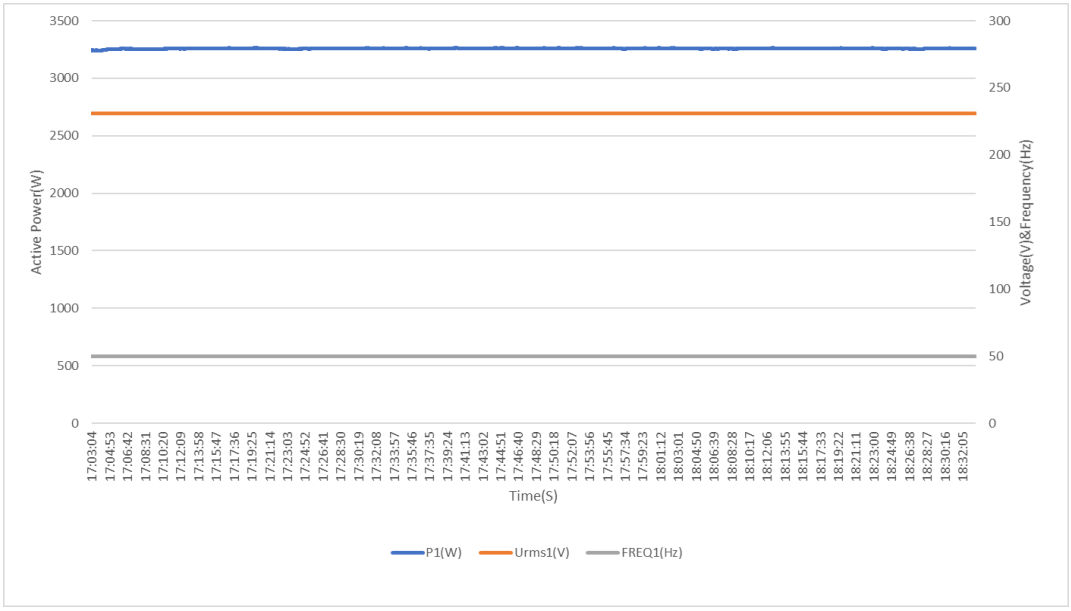
Operating Range: This test should be carried out as specified in A.1.2.10. Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement “Pass”, “No disconnection occurs”, etc. Graphical evidence is preferred.				
GT1-3K3S1				
	Frequency (Hz)	Voltage (V)	Active power (kW)	Pass or failure
Test 1 Voltage = 85% of nominal (195.5 V). Frequency = 47.0 Hz. Power Factor = 1 Period of test 20 seconds	47	196.53	3.070	Pass
				
Test 2 Voltage = 85% of nominal (195.5 V). Frequency = 47.5 Hz. Power Factor = 1. Period of test 90 minutes	47.5	196.50	3.069	Pass

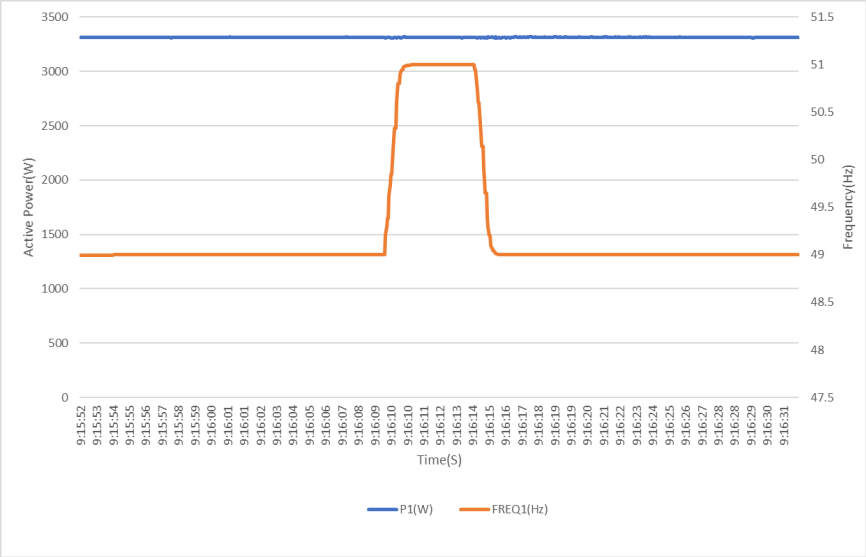


Test 3 Voltage = 110% of nominal (253 V). Frequency = 51.5 Hz. Power Factor = 1. Period of test 90 minutes	51.5	253.82	3.249	Pass



Test 4 Voltage = 110% of nominal (253 V). Frequency = 52 Hz. Power Factor = 1	52	253.84	3.250	Pass

Period of test 15 minutes				
				
Test 5 Voltage = 100% of nominal (230 V). Frequency = 50.0 Hz. Power Factor = 1 Period of test 90 minutes	50	230.91	3.258	Pass
				

Test 6 RoCoF withstandConfirm that the Micro-Generating Plant is capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms.	

Power Quality – Harmonics. These tests should be carried out as specified in BS EN 61000-3-2. The chosen test should be undertaken with a fixed source of energy at two power levels a) between 45 and 55% and b) at 100% of **Registered Capacity**. The test requirements are specified in Annex A1 A.1.3.1 (**Inverter** connected) or Annex A2 A.2.3.1 (Synchronous).

GT1-3K3S1						
Micro-generator tested to BS EN 61000-3-2						
Micro-generator rating per phase (rpp)			3.3	kW		
Harmonic	At 45-55% of Registered Capacity		At 100% of Registered Capacity			
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2	0.007	0.050	0.007	0.048	1.080	
3	0.095	0.674	0.192	1.365	2.300	
4	0.005	0.033	0.005	0.035	0.430	
5	0.036	0.253	0.014	0.097	1.140	
6	0.005	0.033	0.004	0.031	0.300	
7	0.037	0.262	0.018	0.124	0.770	
8	0.004	0.027	0.004	0.031	0.230	
9	0.038	0.273	0.024	0.171	0.400	
10	0.004	0.027	0.004	0.027	0.184	
11	0.036	0.255	0.026	0.184	0.330	
12	0.004	0.030	0.004	0.030	0.153	
13	0.034	0.241	0.027	0.189	0.210	
14	0.004	0.028	0.004	0.028	0.131	
15	0.032	0.230	0.026	0.183	0.150	
16	0.005	0.033	0.005	0.037	0.115	
17	0.030	0.214	0.026	0.186	0.132	
18	0.004	0.030	0.006	0.046	0.102	
19	0.028	0.200	0.024	0.168	0.118	
20	0.005	0.037	0.006	0.044	0.092	
21	0.028	0.197	0.021	0.147	0.107	0.160

22	0.007	0.050	0.009	0.061	0.084	
23	0.025	0.180	0.021	0.148	0.098	0.147
24	0.006	0.045	0.008	0.060	0.077	
25	0.022	0.158	0.021	0.151	0.090	0.135
26	0.008	0.057	0.010	0.069	0.071	
27	0.021	0.147	0.022	0.153	0.083	0.124
28	0.006	0.043	0.009	0.063	0.066	
29	0.021	0.145	0.021	0.152	0.078	0.117
30	0.008	0.057	0.012	0.084	0.061	
31	0.020	0.142	0.022	0.159	0.073	0.109
32	0.010	0.073	0.015	0.107	0.058	
33	0.024	0.168	0.031	0.221	0.068	0.102
34	0.013	0.090	0.026	0.182	0.054	
35	0.019	0.137	0.029	0.203	0.064	0.096
36	0.008	0.054	0.021	0.146	0.051	
37	0.033	0.235	0.050	0.357	0.061	0.091
38	0.021	0.147	0.035	0.248	0.048	
39	0.017	0.119	0.031	0.220	0.058	0.087
40	0.021	0.149	0.034	0.241	0.046	
Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.						

Power Quality – Voltage fluctuations and Flicker: These tests should be undertaken in accordance with EREC G98 Annex A1 A.1.3.3 (**Inverter** connected) or Annex A2 A.2.3.3 (Synchronous).

The standard test impedance is 0.4 Ω for a single phase **Micro-generating Plant** (and for a two phase unit in a three phase system) and 0.24 Ω for a three phase **Micro-generating Plant** (and for a two phase unit in a split phase system). Please ensure that both test and standard impedance are completed on this form. If the test impedance (or the measured impedance) is different to the standard impedance, it must be normalised to the standard impedance as follows (where the **Power Factor** of the generation output is 0.98 or above):

d max normalised value = (Standard impedance / Measured impedance) x Measured value.

Where the **Power Factor** of the output is under 0.98 then the X to R ratio of the test impedance should be close to that of the standard impedance.

The stopping test should be a trip from full load operation.

The duration of these tests needs to comply with the particular requirements set out in the testing notes for the technology under test.

GT1-3K3S1

	Starting			Stopping			Running	
	d max	d c	d(t)	d max	d c	d(t)	P st	P lt 2 hours
Measured Values at test impedance	0.142	0.110	0	0.719	0.517	0	0.124	0.121
Normalised to standard impedance	0.142	0.110	0	0.719	0.517	0	0.124	0.121
Normalised to required maximum impedance	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Limits set under BS EN 61000-3-11	4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

Test Impedance	R	0.4	Ω	X	0.25	Ω
Standard Impedance	R	0.4 ^	Ω	X	0.25 ^	Ω
Maximum Impedance	R	N/A	Ω	X	N/A	Ω

^ Applies to single phase **Micro-generator** and **Micro-generator** using two phases on a three phase

system.

Power quality – DC injection: This test should be carried out in accordance with A 1.3.4 as applicable.

The % **DC** injection ("as % of rated AC current" below) is calculated as follows:

% **DC** injection = Recorded **DC** value in Amps / base current

where the base current is the **Registered Capacity** (W) / 230 V. The % **DC** injection should not be greater than 0.25%.

GT1-3K3S1				
Test power level	20%	50%	75%	100%
Recorded value (A)	0.02	0.03	0.02	0.02
As % of rated AC current	0.14	0.21	0.14	0.14
Limit	0.25%	0.25%	0.25%	0.25%

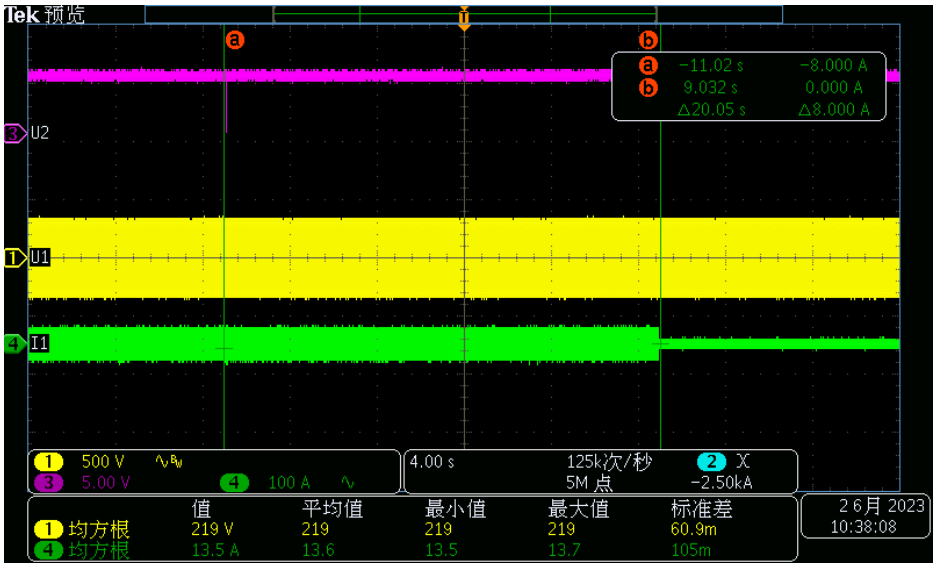
Power quality – Power Factor: This test shall be carried out in accordance with A.1.3.2 and A.2.3.2 at three voltage levels and at Registered Capacity and the measured Power Factor must be greater than 0.95 to pass. Voltage to be maintained within ±1.5% of the stated level during the test.			
GT1-3K3S1			
Voltage	216.2 V	230 V	253 V
Measured value	0.999	0.999	0.999
Power Factor Limit	>0.95	>0.95	>0.95

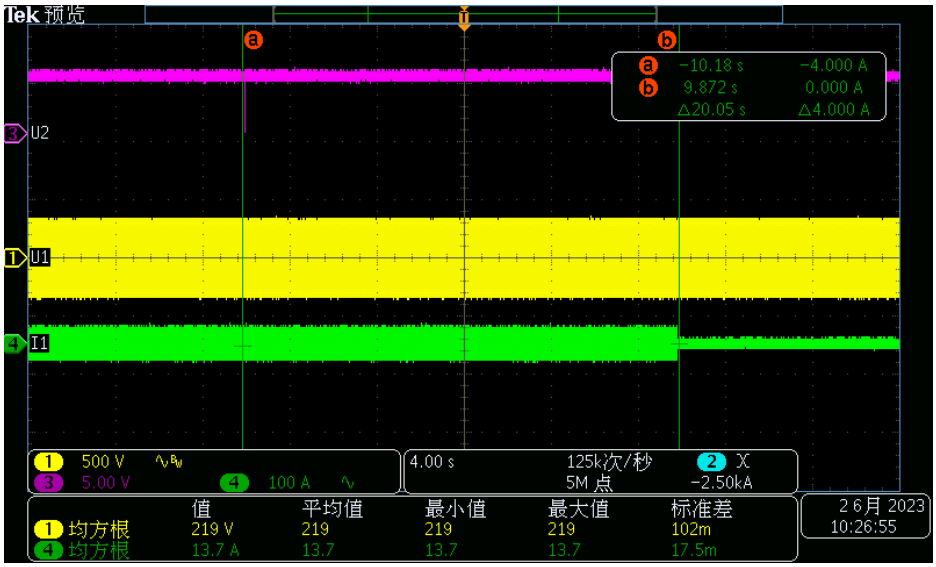
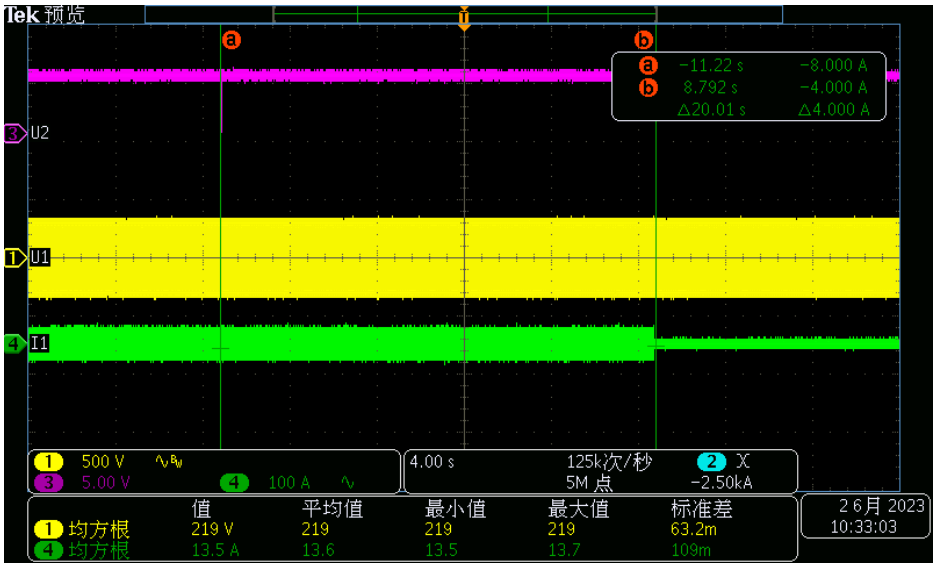
Protection – Frequency tests: These tests should be carried out in accordance with Annex A1 A.1.2.3 (Inverter connected) or Annex A2 A.2.2.3 (Synchronous). For trip tests, frequency and time delay should be stated. For “no trip tests”, “no trip” can be stated.						
GT1-3K3S1						
-30°C						
Function	Setting		Trip test		“No trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.48Hz	20.05s	47.7Hz / 30 s	No trip
U/F stage 2	47Hz	0.5s	46.97Hz	0.506s	47.2Hz / 19.5 s	No trip
					46.8Hz / 0.45 s	No trip
OF	52Hz	0.5s	52.03Hz	0.532s	51.8Hz / 120 s	No trip
					52.2Hz / 0.45 s	No trip
Note. For frequency trip tests the frequency required to trip is the setting ± 0,1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0,2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						
+25°C						
Function	Setting		Trip test		“No trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.48Hz	20.05s	47.7Hz / 30 s	No trip
U/F stage 2	47Hz	0.5s	46.97Hz	0.535s	47.2Hz / 19.5 s	No trip

					46.8Hz / 0.45 s	No trip
OF	52Hz	0.5s	52.03Hz	0.550s	51.8Hz / 120 s	No trip
					52.2Hz / 0.45 s	No trip
Note. For frequency trip tests the frequency required to trip is the setting ± 0,1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0,2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						
+60°C						
Function	Setting		Trip test		“No trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.49Hz	20.01s	47.7Hz / 30 s	No trip
U/F stage 2	47Hz	0.5s	46.98Hz	0.544s	47.2Hz / 19.5 s	No trip
					46.8Hz / 0.45 s	No trip
OF	52Hz	0.5s	52.03Hz	0.531s	51.8Hz / 120 s	No trip
					52.2Hz / 0.45 s	No trip
Note. For frequency trip tests the frequency required to trip is the setting ± 0,1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0,2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						
Test data record for frequency protection measurement and tripping time						

Iteration	Measured trip frequency (Hz)	Deviation from nominal value (%)	Limit (%)
Under frequency stage 1			
1@-30°C	47.48	-0.04	± 0.2
2@+25°C	47.48	-0.04	± 0.2
3@+60°C	47.49	-0.02	± 0.2

Verification of disconnecting time

Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Under frequency stage 1@-30°C		
1. 47.8Hz—47.2Hz (UF st1 trip setting minus 0.3Hz)	20.05	
Under frequency stage 1@+25°C		

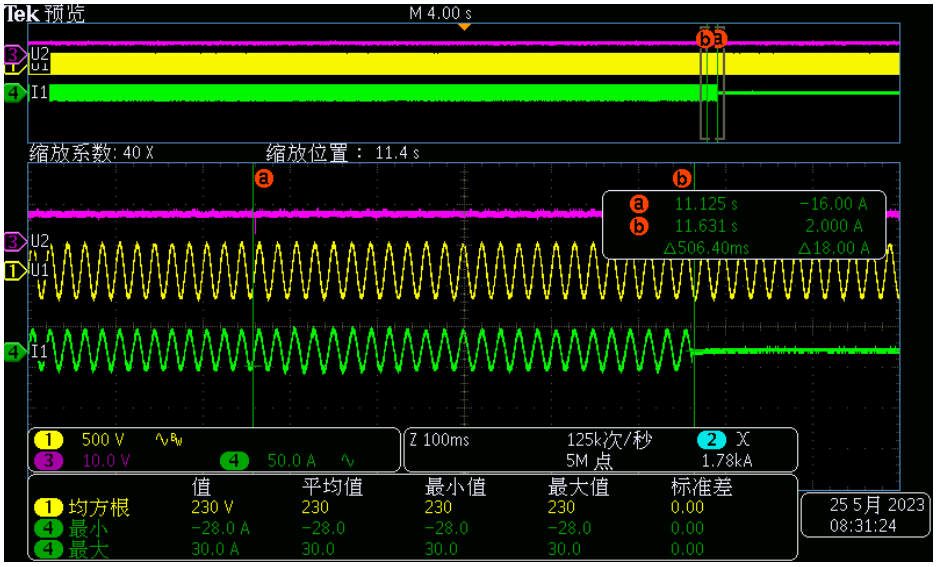
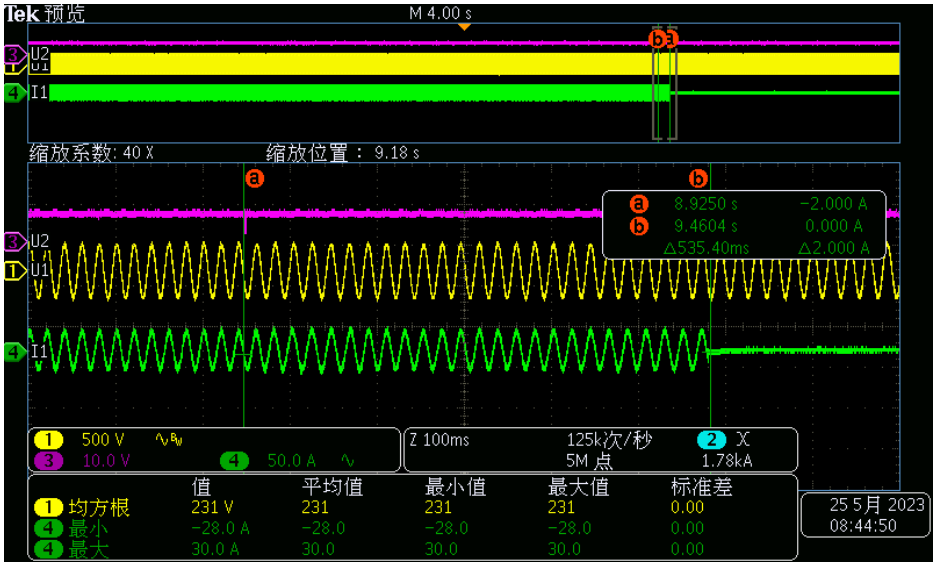
1. 47.8Hz—47.2Hz (UF st1 trip setting minus 0.3Hz)	20.05	
Under frequency stage 1@+60°C		
1. 47.8Hz—47.2Hz (UF st1 trip setting minus 0.3Hz)	20.01	

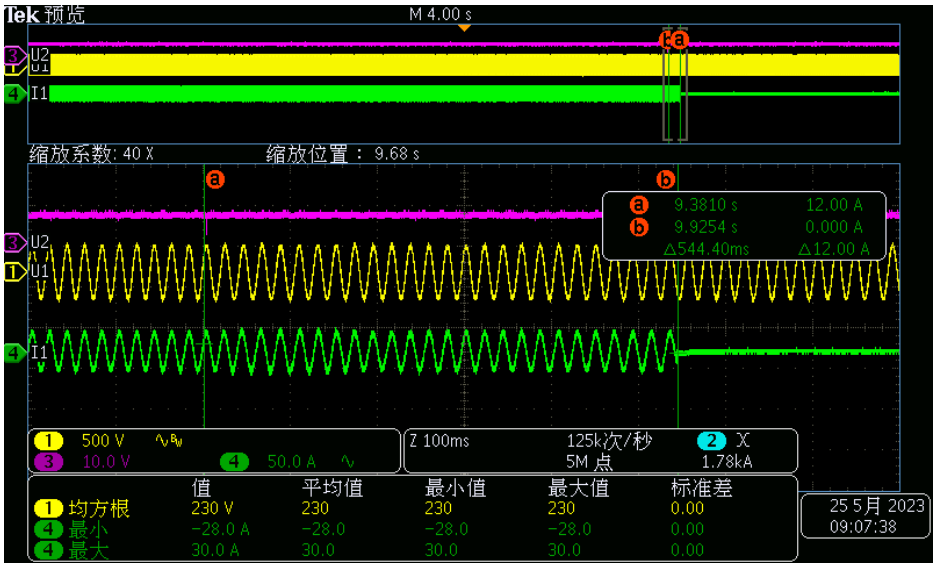
No trip tests - U/F stage 1

Frequency	Hold on time	Confirm no trip
47.7Hz (U/F st1 trip setting plus 0.2Hz)	30 s	no trip

Iteration	Measured trip frequency (Hz)	Deviation from nominal value (%)	Limit (%)

Under frequency stage 2			
1@-30°C	46.97	-0.06	± 0.2
2@+25°C	46.97	-0.06	± 0.2
3@+60°C	46.98	-0.04	± 0.2

Verification of disconnecting time		
Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Under frequency stage 2@-30°C		
1. 47.3Hz—46.7Hz (UF st2 trip setting minus 0.3Hz)	0.506	
Under frequency stage 2@+25°C		
1. 47.3Hz—46.7Hz (UF st2 trip setting minus 0.3Hz)	0.535	

Under frequency stage 2@+60°C		
1. 47.3Hz—46.7Hz (UF st2 trip setting minus 0.3Hz)	0.544	

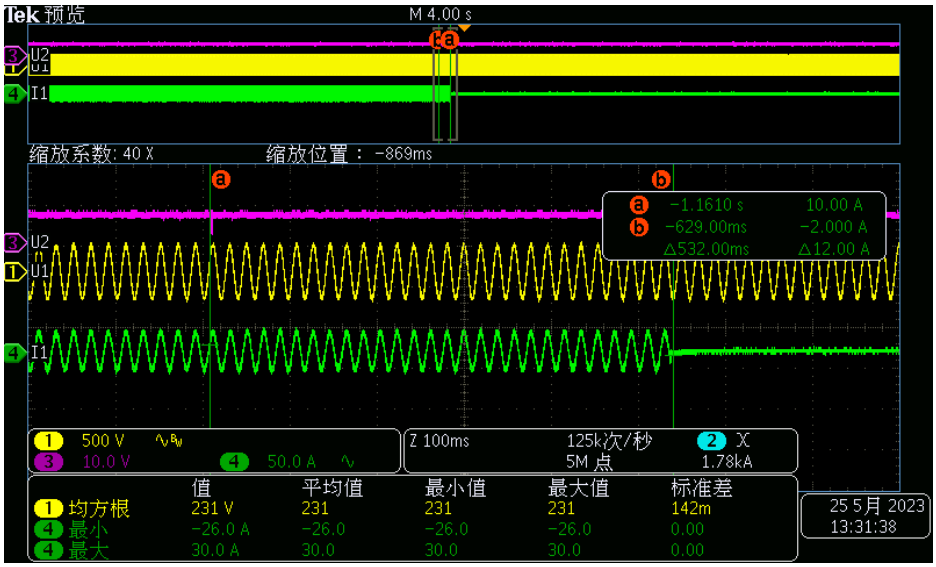
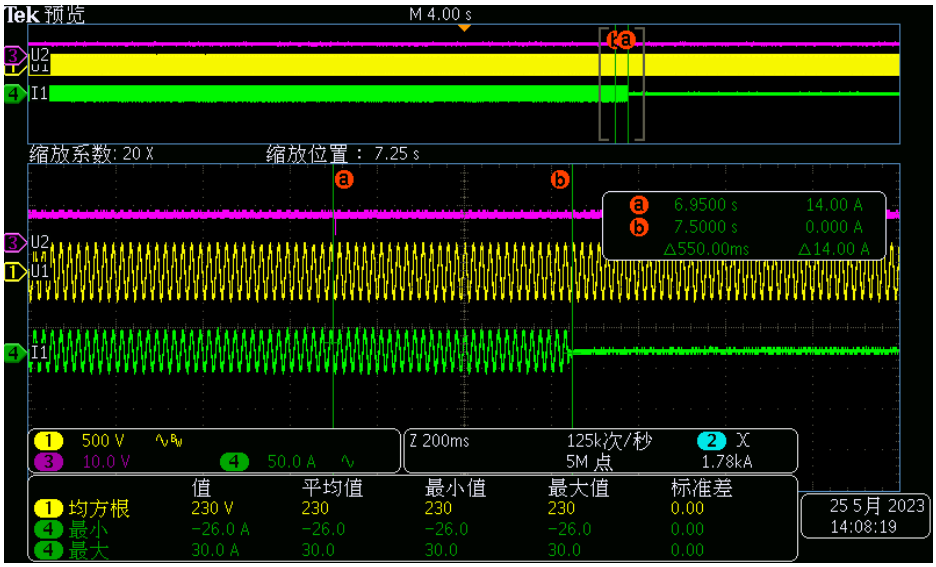
No trip tests - U/F stage 2

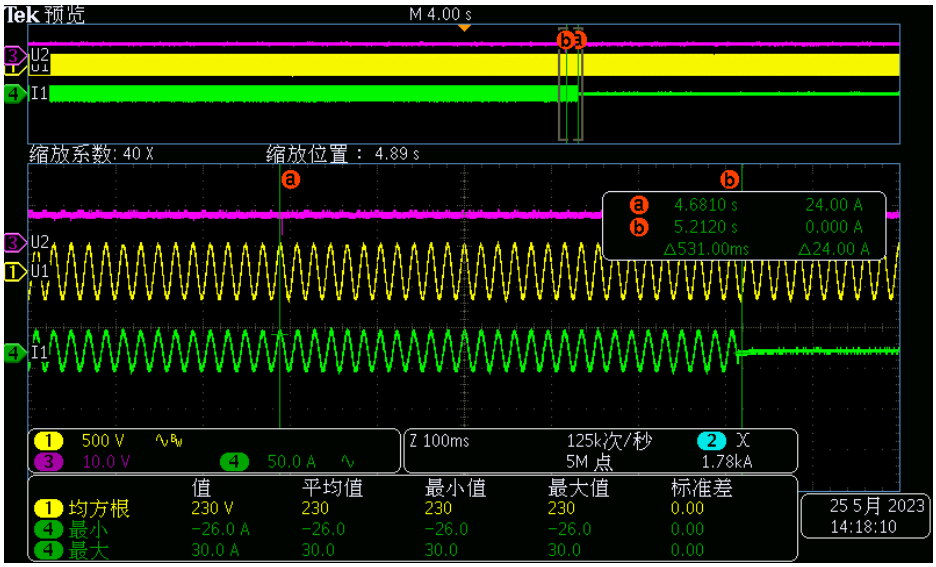
Frequency	Hold on time	Confirm no trip
47.2Hz (U/F st2 trip setting plus 0.2Hz)	19.5 s	no trip
46.8Hz (U/F st2 trip setting minus 0.2Hz)	0.45 s	no trip

Iteration	Measured trip frequency (Hz)	Deviation from nominal value (%)	Limit (%)
Over frequency			
1@-30°C	52.03	0.06	± 0.2
2@+25°C	52.03	0.06	± 0.2
3@+60°C	52.03	0.06	± 0.2

Verification of disconnecting time

Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Over frequency stage 1@-30°C		

1. 51.7Hz—52.3Hz (OF trip setting plus 0.3Hz)	0.532	
Over frequency stage 1@+25°C		
1. 51.7Hz—52.3Hz (OF trip setting plus 0.3Hz)	0.550	
Over frequency stage 1@+60°C		

1. 51.7Hz—52.3Hz (OF trip setting plus 0.3Hz)	0.531	

No trip tests - O/F

Frequency	Hold on time	Confirm no trip
51.8Hz (O/F trip setting minus 0.2Hz)	120 s	no trip
52.2Hz (O/F trip setting plus 0.2Hz)	0.45 s	no trip

Remark:
Channels description in above waveforms:

Channel 1: voltage signal

Channel 4: current signal

Channel 3: trigger signal

Calibration and Accuracy Tests										
GT1-3K3S1										
(-30°C)										
Setting	Time Delay	**Pickup Frequency**				**Relay Operating Time**				
Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52 Hz	0.5 s	51.90 Hz	52.03 Hz	52.10 Hz	Pass	51.7-52.3 Hz	0.50 s	0.532 s	0.60 s	Pass
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20 s	47.40 Hz	47.48 Hz	47.60 Hz	Pass	47.8-47.2 Hz	20.0 s	20.05 s	20.1 s	Pass
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	46.90 Hz	46.97 Hz	47.10 Hz	Pass	47.3-46.7 Hz	0.50 s	0.506 s	0.60 s	Pass
(+25°C)										
Setting	Time Delay	**Pickup Frequency**				**Relay Operating Time**				
Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52 Hz	0.5 s	51.90 Hz	52.03 Hz	52.10 Hz	Pass	51.7-52.3 Hz	0.50 s	0.550 s	0.60 s	Pass
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20 s	47.40 Hz	47.48 Hz	47.60 Hz	Pass	47.8-47.2 Hz	20.0 s	20.05 s	20.1 s	Pass
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	46.90 Hz	46.97 Hz	47.10 Hz	Pass	47.3-46.7 Hz	0.50 s	0.535 s	0.60 s	Pass
(+60°C)										
Setting	Time Delay	**Pickup Frequency**				**Relay Operating Time**				
Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52 Hz	0.5 s	51.90 Hz	52.03 Hz	52.10 Hz	Pass	51.7-52.3 Hz	0.50 s	0.531 s	0.60 s	Pass
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5	20 s	47.40	47.49 Hz	47.60	Pass	47.8-	20.0 s	20.01 s	20.1 s	Pass

Hz		Hz		Hz		47.2 Hz				
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47 Hz	0.5 s	46.90 Hz	46.98 Hz	47.10 Hz	Pass	47.3-46.7 Hz	0.50 s	0.544 s	0.60 s	Pass

Protection – Voltage tests: These tests should be carried out in accordance with Annex A1 A.1.2.2 (Inverter connected) or Annex A2 A.2.2.2 (Synchronous). For trip tests, voltage and time delay should be stated. For “no trip tests”, “no trip” can be stated.

GT1-3K3S1

-30°C

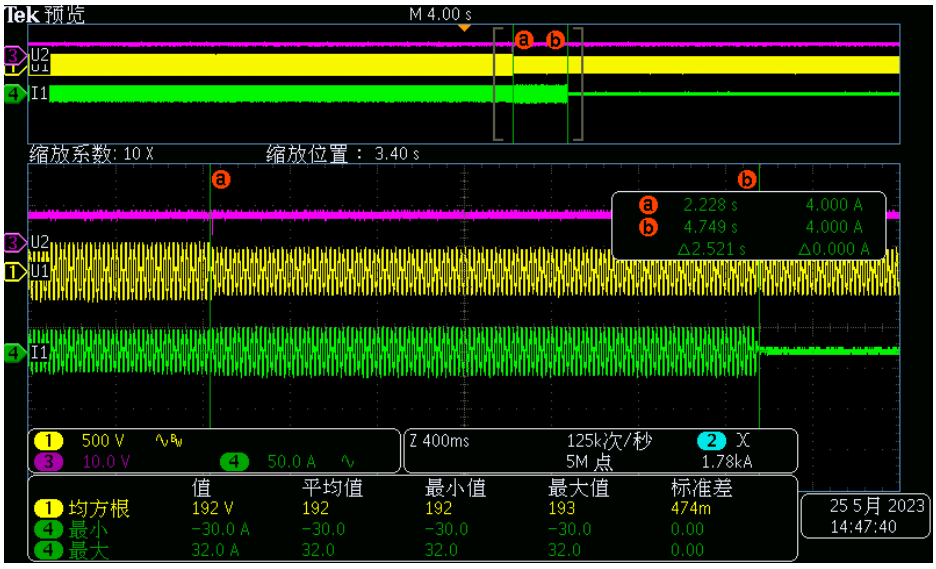
Function	Setting		Trip test		“No trip tests”	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	$V_{\varphi-N}$:184 V (0.8pu)	2.5s	182.1V	2.521s	$V_{\varphi-N}$: 188 V / 5 s	No trip
					$V_{\varphi-N}$: 180 V / 2.45 s	No trip
O/V stage 1	$V_{\varphi-N}$:262.2 V (1.14pu)	1.0s	261.3V	1.030s	$V_{\varphi-N}$: 258.2 V / 5 s	no trip
O/V stage 2	$V_{\varphi-N}$:273.7 V (1.19pu)	0.5s	272.8V	0.537s	$V_{\varphi-N}$: 269.7 V / 0.95 s	No trip
					$V_{\varphi-N}$: 277.7 V / 0.45 s	No trip

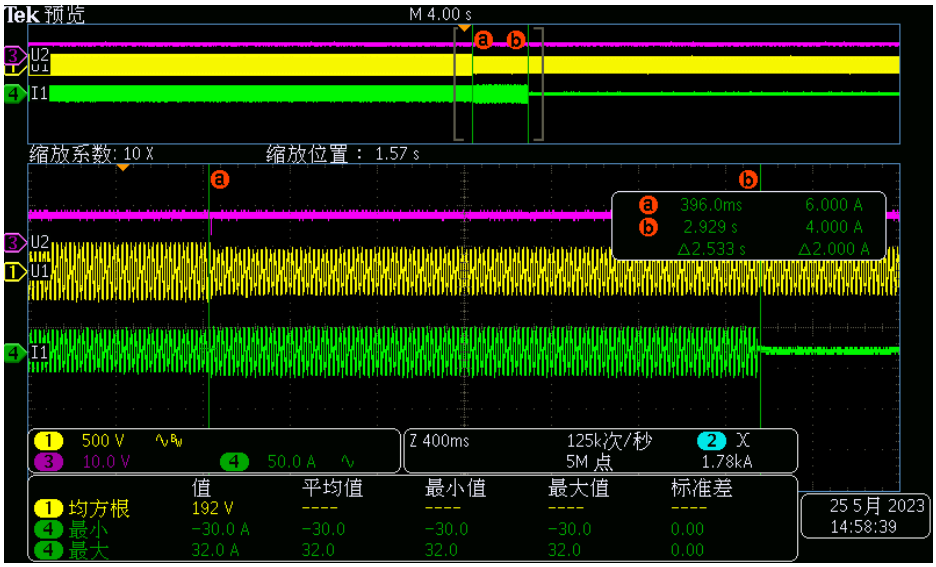
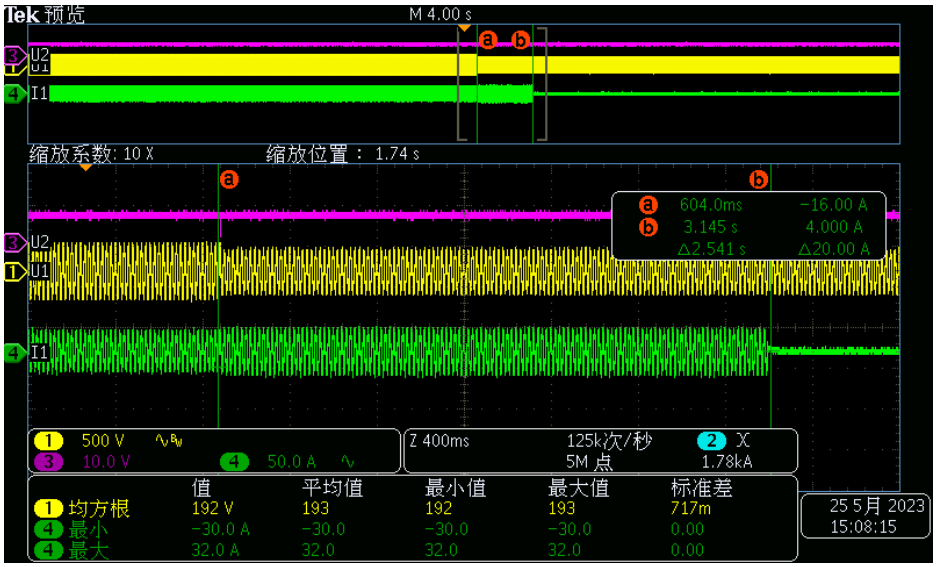
Note for Voltage tests the Voltage required to trip is the setting ±3.45V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

+25°C

Function	Setting		Trip test		“No trip tests”	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip

U/V	$V_{\varphi-N}$:184 V (0.8pu)	2.5s	182.1V	2.533s	$V_{\varphi-N}$: 188 V / 5 s	No trip
					$V_{\varphi-N}$: 180 V / 2.45 s	No trip
O/V stage 1	$V_{\varphi-N}$:262.2 V (1.14pu)	1.0s	261.3V	1.052s	$V_{\varphi-N}$: 258.2 V / 5 s	no trip
O/V stage 2	$V_{\varphi-N}$:273.7 V (1.19pu)	0.5s	272.7V	0.526s	$V_{\varphi-N}$: 269.7 V / 0.95 s	No trip
					$V_{\varphi-N}$: 277.7 V / 0.45 s	No trip
Note for Voltage tests the Voltage required to trip is the setting ±3.45V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						
+60°C						
Function	Setting		Trip test		“No trip tests”	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	$V_{\varphi-N}$:184 V (0.8pu)	2.5s	182.1V	2.541s	$V_{\varphi-N}$: 188 V / 5 s	No trip
					$V_{\varphi-N}$: 180 V / 2.45 s	No trip
O/V stage 1	$V_{\varphi-N}$:262.2 V (1.14pu)	1.0s	261.2V	1.034s	$V_{\varphi-N}$: 258.2 V / 5 s	no trip
O/V stage 2	$V_{\varphi-N}$:273.7 V (1.19pu)	0.5s	272.8V	0.538s	$V_{\varphi-N}$: 269.7 V / 0.95 s	No trip
					$V_{\varphi-N}$: 277.7 V / 0.45 s	No trip
Note for Voltage tests the Voltage required to trip is the setting ±3.45V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be						

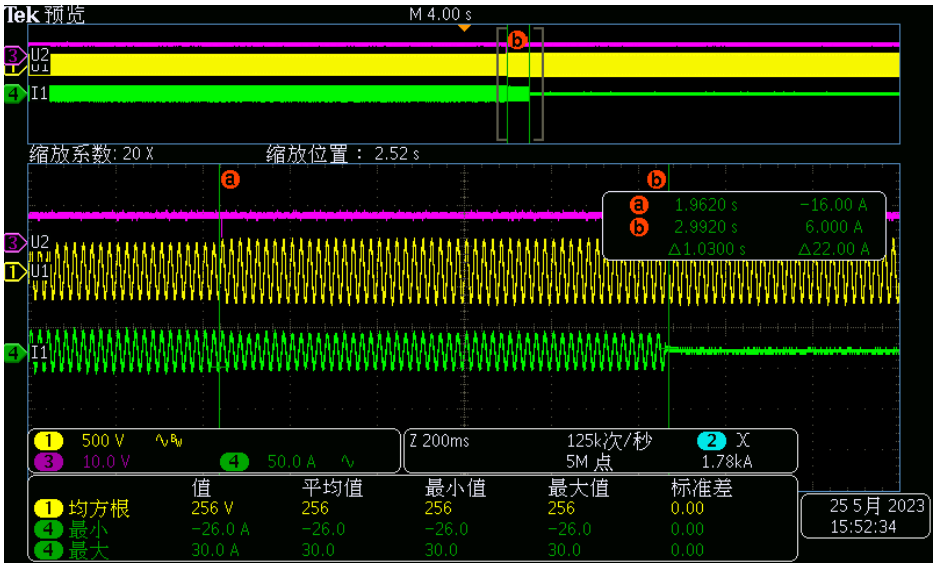
carried out at the setting ±4V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.			
Test data record for frequency protection measurement and tripping time			
Iteration	Measured voltage(V) and deviation from nominal value (%)		
	Phase L-N (V)	Deviation (%Un)	Deviation limit (%Un)
Under voltage			
1 - $V_{\varphi\text{-}N}$ @-30°C	182.1	-0.826	± 1.5
1 - $V_{\varphi\text{-}N}$ @+25°C	182.1	-0.826	± 1.5
1 - $V_{\varphi\text{-}N}$ @+60°C	182.1	-0.826	± 1.5
Verification of disconnecting time			
Iteration	Disconnection time (s)	Oscilloscope recorded waveforms	
Under voltage			
L-N@-30°C:			
1. 188V—180V (trip setting minus 4V)	2.521		
L-N@+25°C:			

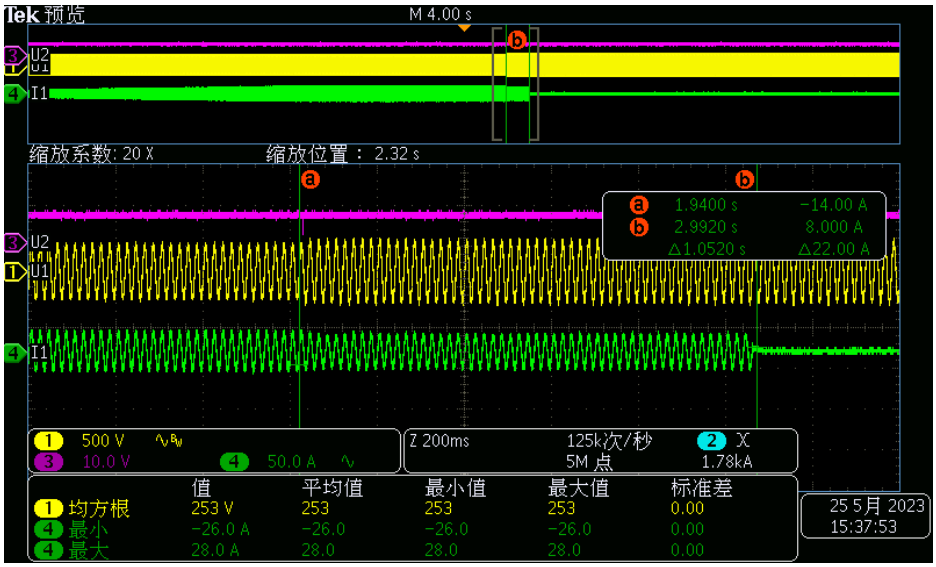
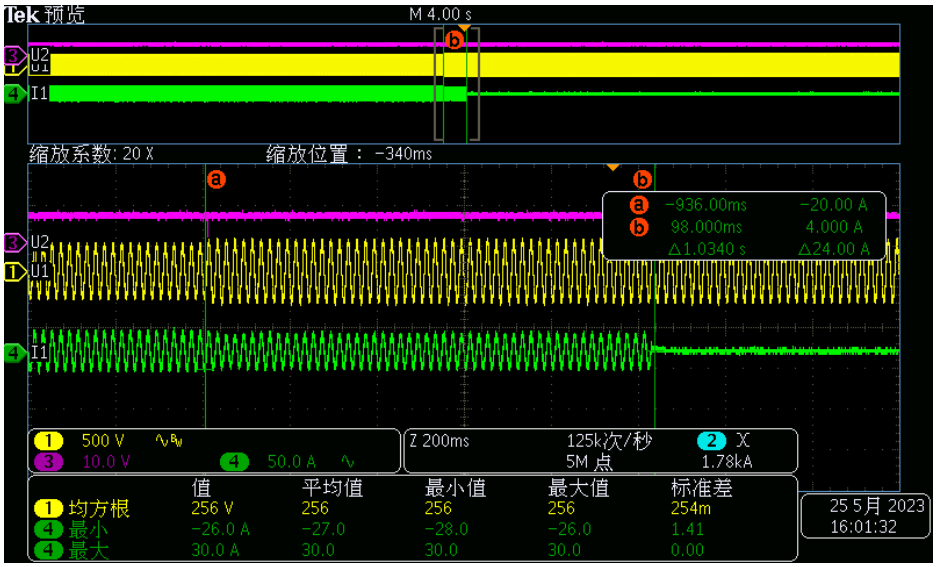
1. 188V—180V (trip setting minus 4V)	2.533	
L-N@+60°C:		
1. 188V—180V (trip setting minus 4V)	2.541	

No trip tests - U/V

voltage	Hold on time	Confirm no trip
$V_{\varphi\text{-}N}$: 188V	5s	no trip
$V_{\varphi\text{-}N}$: 180V	2.45s	no trip

Iteration	Measured voltage(V) and deviation from nominal value (%)

	Phase L-N (V)	Deviation (%Un)	Deviation limit (%Un)
Over voltage stage 1			
1 - $V_{\varphi-N}$ @-30°C	261.3	-0.391	± 1.5
1 - $V_{\varphi-N}$ @+25°C	261.3	-0.391	± 1.5
1 - $V_{\varphi-N}$ @+60°C	261.2	-0.435	± 1.5
Verification of disconnecting time			
Iteration	Disconnection time (s)	Oscilloscope recorded waveforms	
Over voltage stage 1			
L-N@-30°C:			
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.030		
L-N@+25°C:			

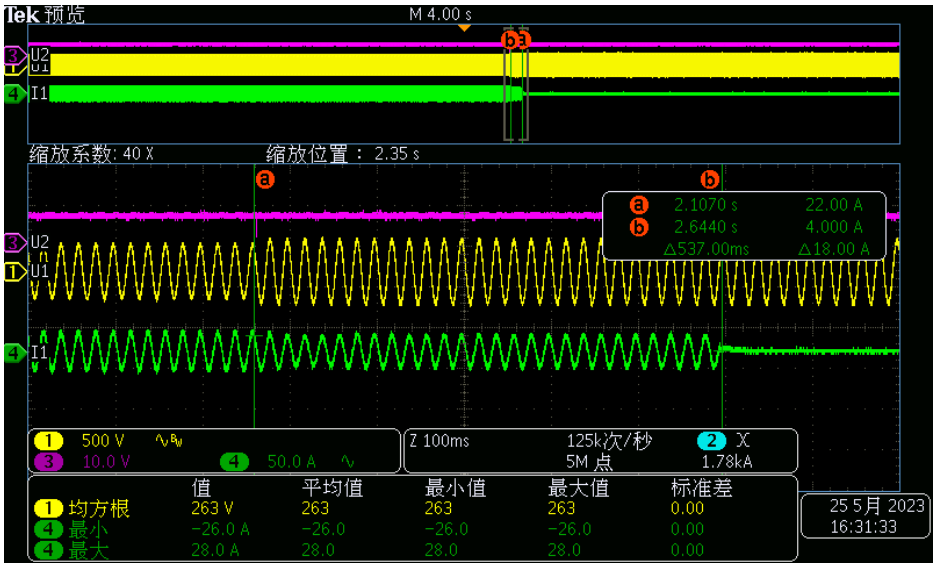
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.052	
L-N@+60°C:		
1. 258.2V—266.2V (OV st1 trip setting plus 4V)	1.034	

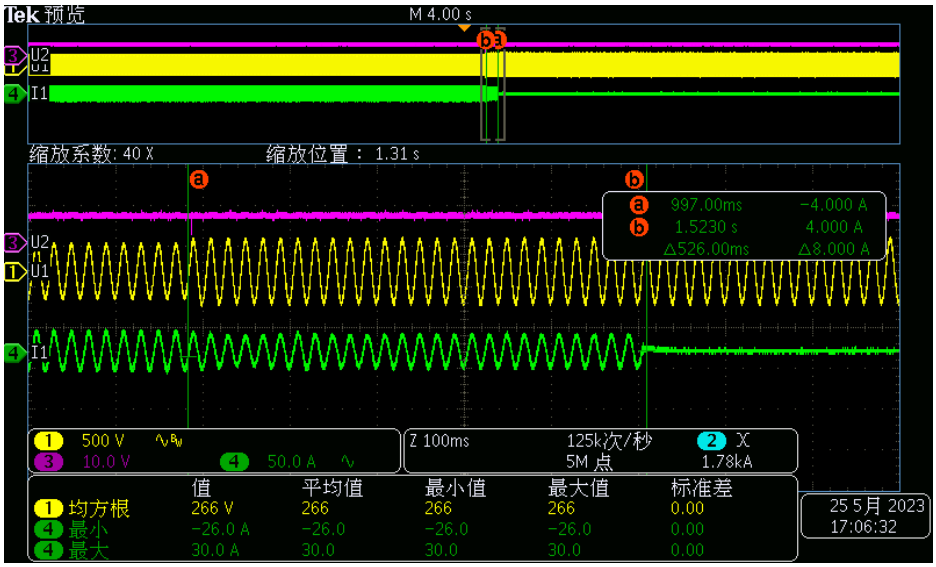
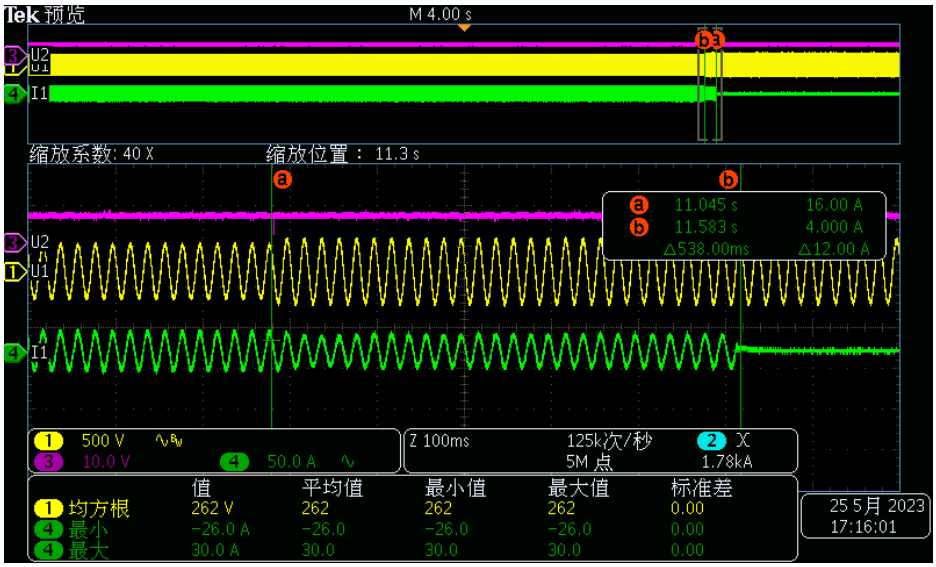
No trip tests - O/V stage 1

voltage	Hold on time	Confirm no trip
$V_{\varphi\text{-}N}$: 258.2V	5s	no trip

Iteration	Measured voltage(V) and deviation from nominal value (%)		
	Phase L-N (V)	Deviation (%Un)	Deviation limit (%Un)

Over voltage stage 2			
1 - $V_{\varphi-N}$ @-30°C	272.8	-0.391	± 1.5
1 - $V_{\varphi-N}$ @+25°C	272.7	-0.435	± 1.5
1 - $V_{\varphi-N}$ @+60°C	272.8	-0.391	± 1.5

Verification of disconnecting time		
Iteration	Disconnection time (s)	Oscilloscope recorded waveforms
Over voltage stage 2		
L-N@-30°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.537	
L-N@+25°C:		

1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.526	
L-N@+60°C:		
1. 269.7V—277.7V (OV st2 trip setting plus 4V)	0.538	

No trip tests - O/V stage 2

voltage	Hold on time	Confirm no trip
$V_{\varphi\text{-}N}$: 269.7 V	0.95s	no trip
$V_{\varphi\text{-}N}$: 277.7 V	0.45s	no trip

Remark:
Channels description in above waveforms:

Channel 1: voltage signal

Channel 4: current signal

Channel 3: trigger signal

Calibration and Accuracy Tests

GT1-3K3S1

(-30°C)

Phase	Setting	Time Delay	Pickup Voltage				Relay Operating Time				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	262.2 V	1.0 s	258.7 V	261.3 V	265.6 V	Pass	262.2 V	1.0 s	1.030 s	1.1 s	Pass
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	273.7V	0.5 s	270.2 V	272.8 V	277.1 V	Pass	273.7 V	0.5 s	0.537 s	0.6 s	Pass
Under Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	184 V	2.5 s	180.5 V	182.1 V	187.4 V	Pass	184 V	2.50 s	2.521 s	2.60 s	Pass

(+25°C)

Phase	Setting	Time Delay	Pickup Voltage				Relay Operating Time				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	262.2 V	1.0 s	258.7 V	261.3 V	265.6 V	Pass	262.2 V	1.0 s	1.052 s	1.1 s	Pass
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	273.7V	0.5 s	270.2 V	272.7 V	277.1 V	Pass	273.7 V	0.5 s	0.526 s	0.6 s	Pass
Under Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	184 V	2.5 s	180.5 V	182.1 V	187.4 V	Pass	184 V	2.50 s	2.533 s	2.60 s	Pass

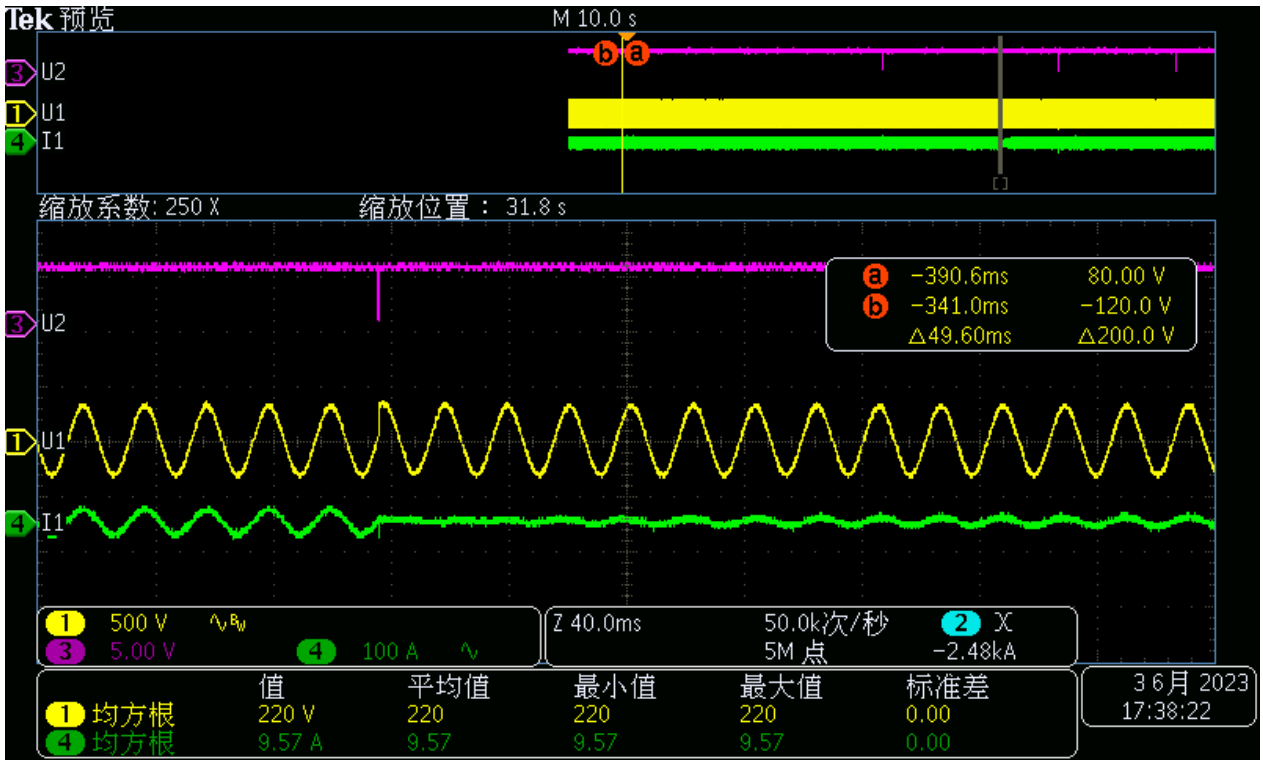
(+60°C)

Phase	Setting	Time Delay	Pickup Voltage				Relay Operating Time				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	262.2 V	1.0 s	258.7 V	261.2 V	265.6 V	Pass	262.2 V	1.0 s	1.034 s	1.1 s	Pass

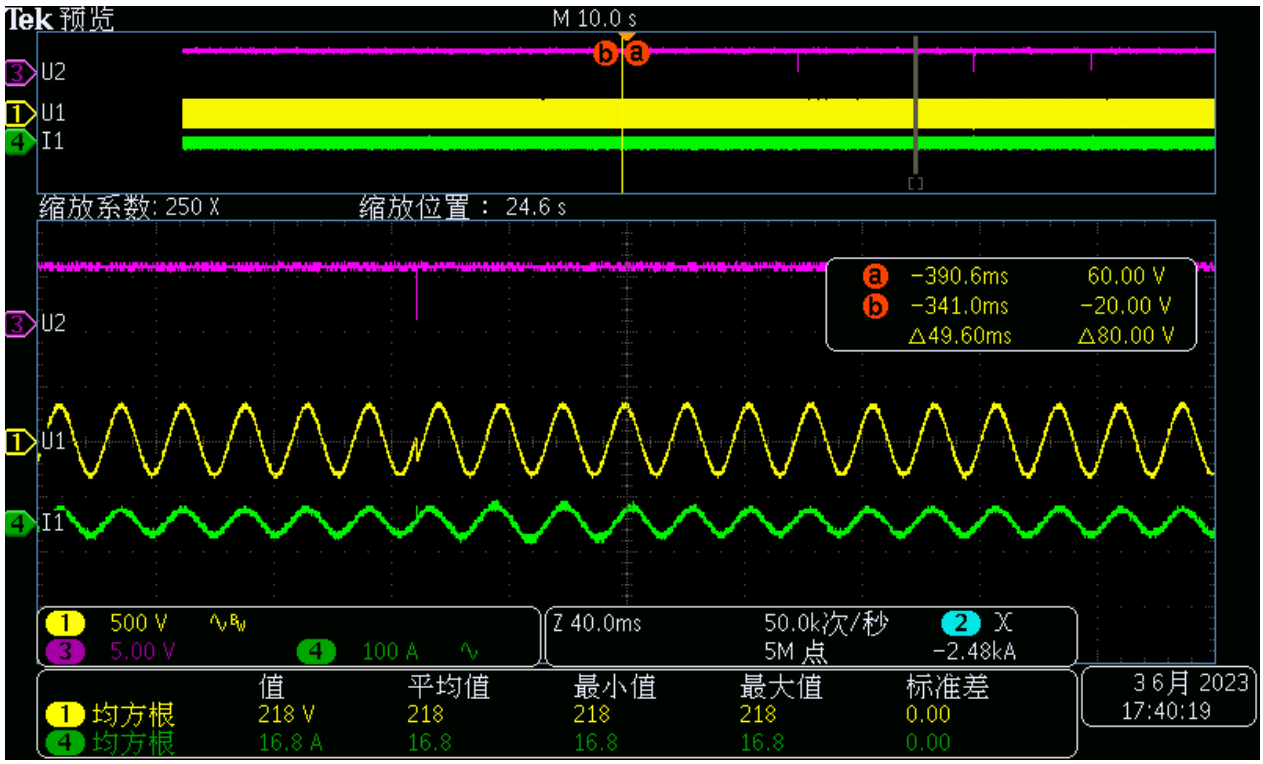
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	273.7V	0.5 s	270.2 V	272.8 V	277.1 V	Pass	273.7 V	0.5 s	0.538 s	0.6 s	Pass
Under Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L-N	184 V	2.5 s	180.5 V	182.1 V	187.4 V	Pass	184 V	2.50 s	2.541 s	2.60 s	Pass

Protection – Loss of Mains test: For PV Inverters shall be tested in accordance with BS EN 62116. Other Micro-generators should be tested in accordance with A.2.2.4 at 10%, 55% and 100% of rated power.						
GT1-3K3S1						
For inveters tested to BS EN 62116 the following sub set of tests should be recorded in the following table						
Test power and imbalance	33% -5%Q Test 22	66% -5%Q Test 12	100% -5%Q Test 5	33% +5%Q Test 31	66% +5%Q Test 21	100% +5%Q Test 10
Trip time. Limit is 0.5 s	0.465s	0.477s	0.467s	0.407s	0.417s	0.455s

Protection – Frequency change, Vector Shift Stability test: This test should be carried out in accordance with EREC G98 Annex A1 A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous). Confirmation is required that the **Micro-generating Plant** does not trip under positive / negative vector shift.			
GT1-3K3S1			
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.0 Hz	+50 degrees	No trip



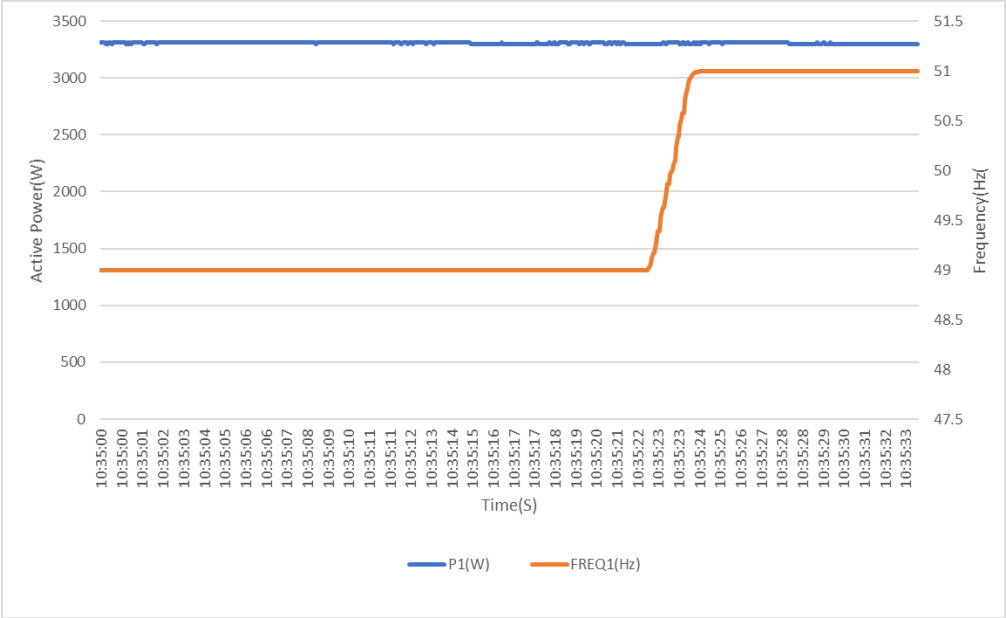
Negative Vector Shift	50.0 Hz	- 50 degrees	No trip



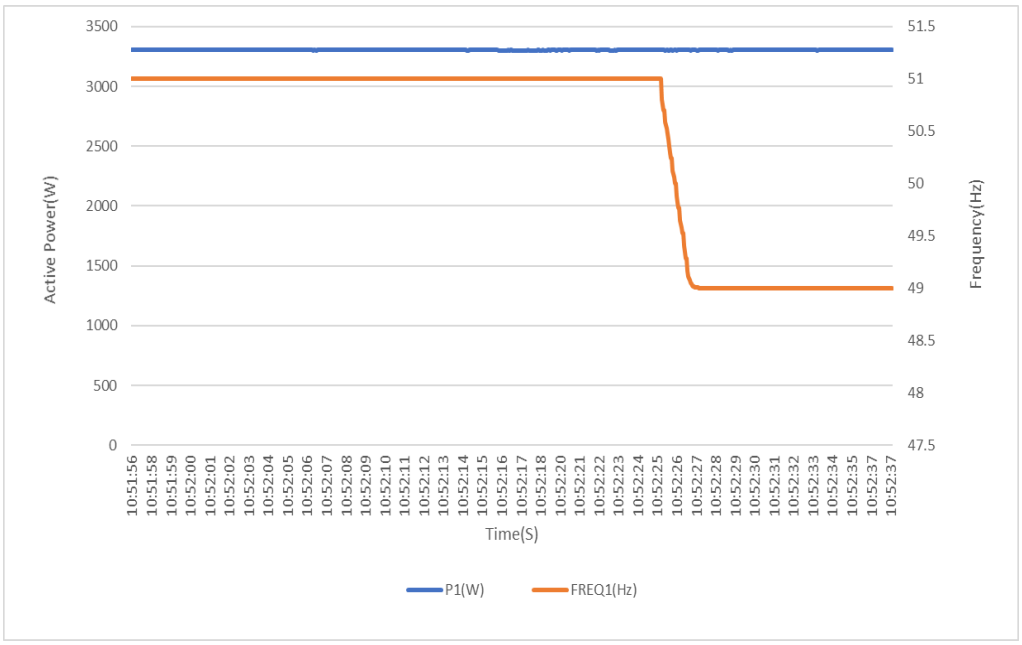
Protection – Frequency change, RoCoF Stability test: The requirement is specified in section 11.3, test procedure in Annex A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous). Confirmation is required that the **Micro-generating Plant** does not trip for the duration of the ramp up and ramp down test.

GT1-3K3S1

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0Hz to 51.0Hz	+0.95 Hzs^{-1}	2.1 s	No trip



51.0Hz to 49.0Hz	-0.95 Hzs^{-1}	2.1 s	No trip

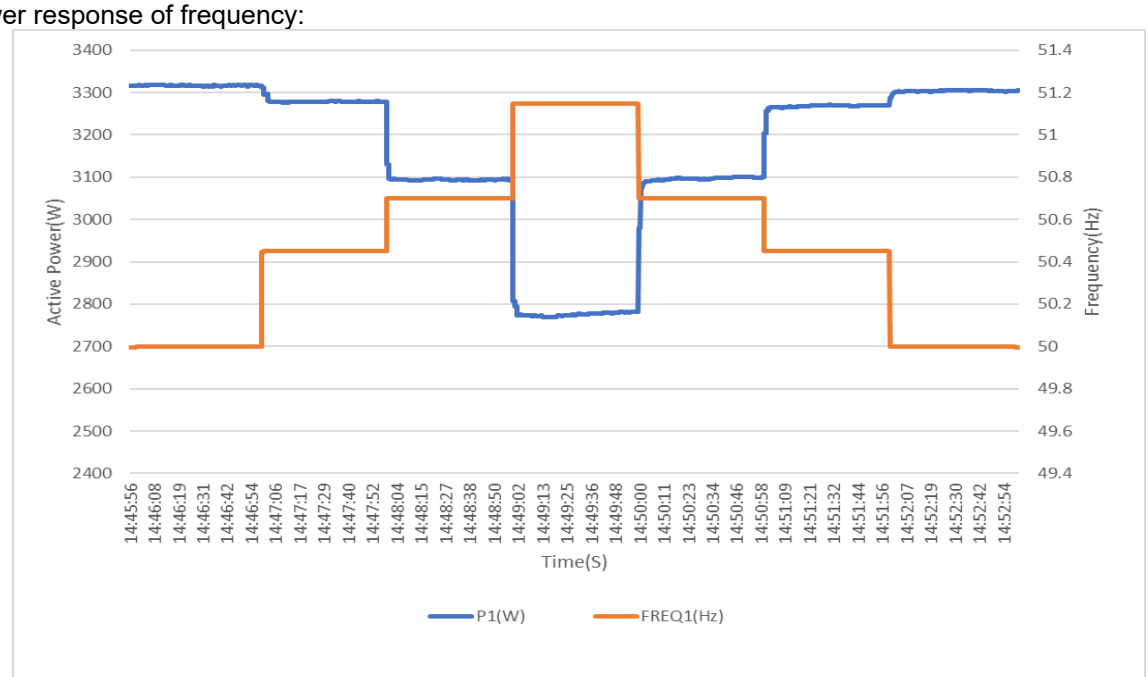


Limited Frequency Sensitive Mode – Over frequency test: This test should be carried out in accordance with A.1.2.8. The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%. The measurement tolerances are contained in A.1.2.8.

GT1-3K3S1

Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output (kW)	**Droop (%)**	Primary Power Source	**Active Power** Gradient (% of P_{Emax})
Step a) 50.00Hz ±0.01Hz	3.316	-	the available active power output during testing (100%Pn)	-
Step b) 50.45Hz ±0.05Hz	3.277	-		-
Step c) 50.70Hz ±0.10Hz	3.094	9.02		-
Step d) 51.15Hz ±0.05Hz	2.776	9.22		-
Step e) 50.70Hz ±0.10Hz	3.097	9.17		-
Step f) 50.45Hz ±0.05Hz	3.268	-		-
Step g) 50.00Hz ±0.01Hz	3.304	-		-

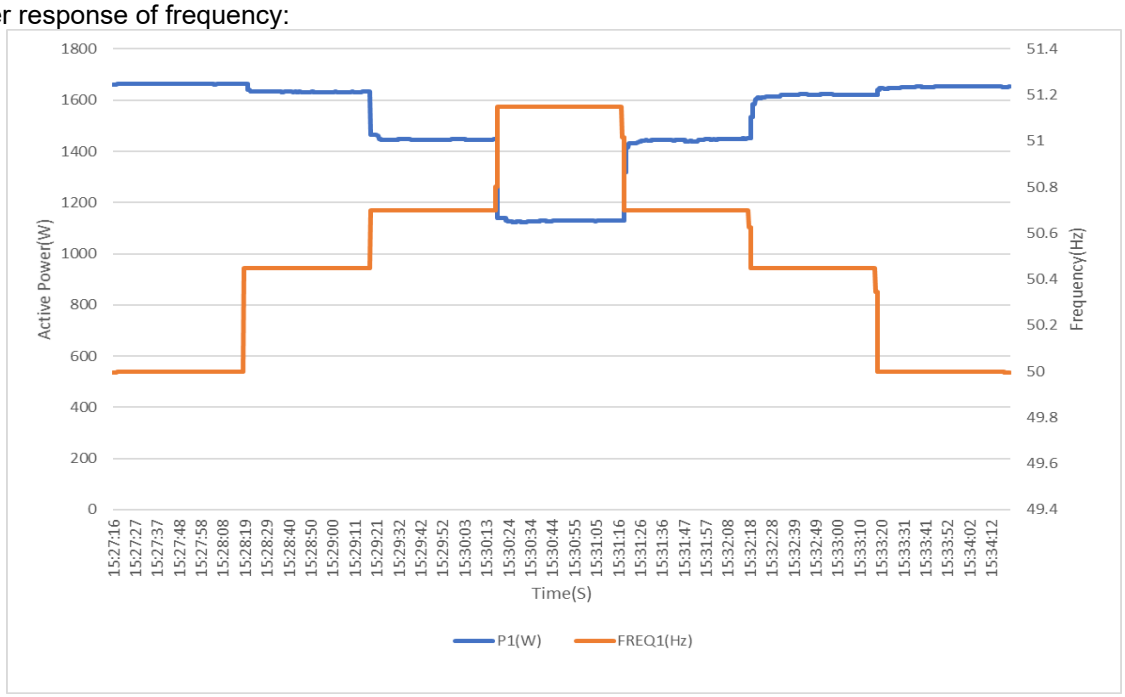
Power response of frequency:



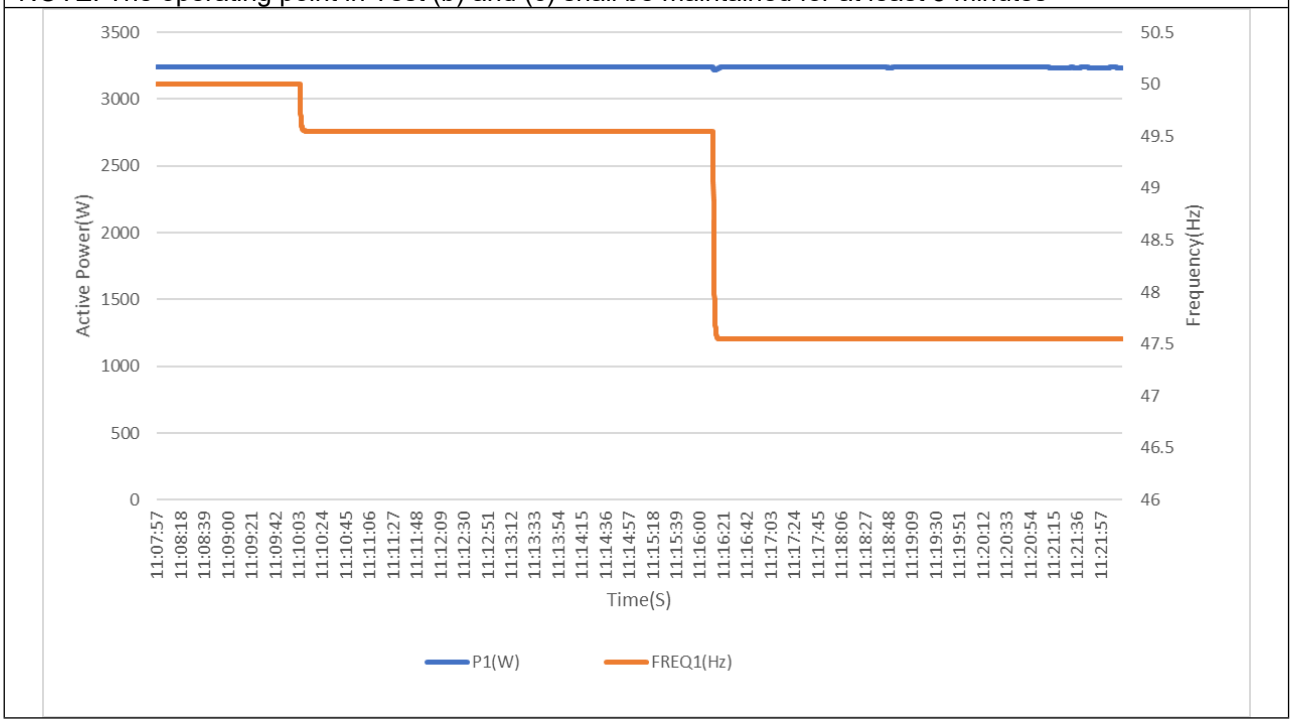
Test sequence at **Registered Capacity** 40% - 60%	Measured **Active Power** Output (kW)	**Droop (%P_M)**	Primary Power Source	**Active Power** Gradient (% of P_{Emax})
Step a) 50.00Hz ±0.01Hz	1.663	-	the available active power output during testing (50%Pn)	-
Step b) 50.45Hz ±0.05Hz	1.632	-		-
Step c) 50.70Hz ±0.10Hz	1.445	8.82		-

Step d) 51.15Hz ±0.05Hz	1.127	9.15		-
Step e) 50.70Hz ±0.10Hz	1.444	8.78		-
Step f) 50.45Hz ±0.05Hz	1.621	-		-
Step g) 50.00Hz ±0.01Hz	1.652	-		-

Power response of frequency:



Power output with falling frequency test: This test should be carried out in accordance with A.1.2.7.			
GT1-3K3S1			
Test sequence	Measured **Active Power** Output (kW)	Frequency (Hz)	Primary Power Source
Step a) 50.00Hz ±0.01Hz	3.321	50.00	the available active power output during testing (100%Pn)
Step b) point between 49.5 Hz and 49.6 Hz	3.318	49.55	
Step c) point between 47.5Hz and 47.6 Hz	3.315	47.55	
NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes			



Re-connection timer.					
Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 2. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Micro-generating Plant** does not reconnect at the voltage and frequency settings below; a statement of "no reconnection" can be made.					
GT1-3K3S1					
Time delay setting for testing (s)	Measured delay (s)	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of Table 2.			
60	63.2	At 1.16 pu (266.2 V)	At 0.78 pu (180.0 V)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Micro-generator** does not re-connect.		No reconnection	No reconnection	No reconnection	No reconnection
Supplementary information: 1. Min. delay time recorded in all cases in above table. 2. "*": Reconnecting time is the sum of waiting time of both the mains voltage and the mains frequency are within the tolerance range(setting 60s) plus additional delay time for all control and adjustment processes safely finished time.					

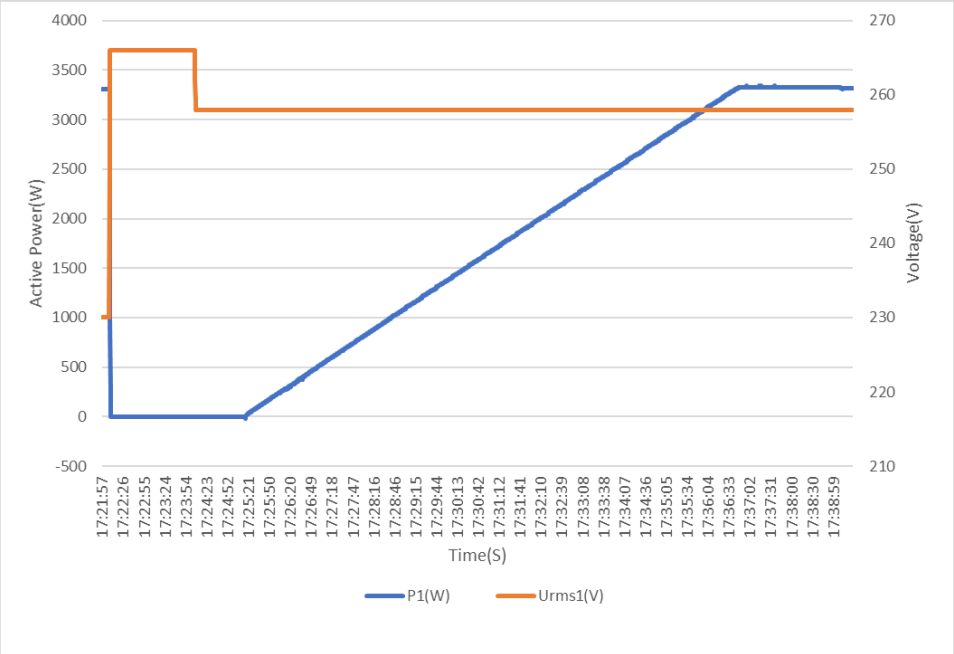
Test data record for reconnection

Test sequence after trip	connection	Connection allowed	Reconnection time ≥ 20s	Power gradient (% Pn/min)
a) U ≥ (1.14pu + 4V)	No	No	N/A	N/A
b) U ≤ (1.14pu - 4V)	Yes	Yes	Yes	10.0
c) U ≤ (0.8pu - 4V)	No	No	N/A	N/A
d) U ≥ (0.8pu + 4V)	Yes	Yes	Yes	10.0
e) F ≤ 47.4 Hz	No	No	N/A	N/A
f) F ≥ 47.6 Hz	Yes	Yes	Yes	10.0
g) F ≥ 52.1 Hz	No	No	N/A	N/A
h) F ≤ 51.9 Hz	Yes	Yes	Yes	10.0

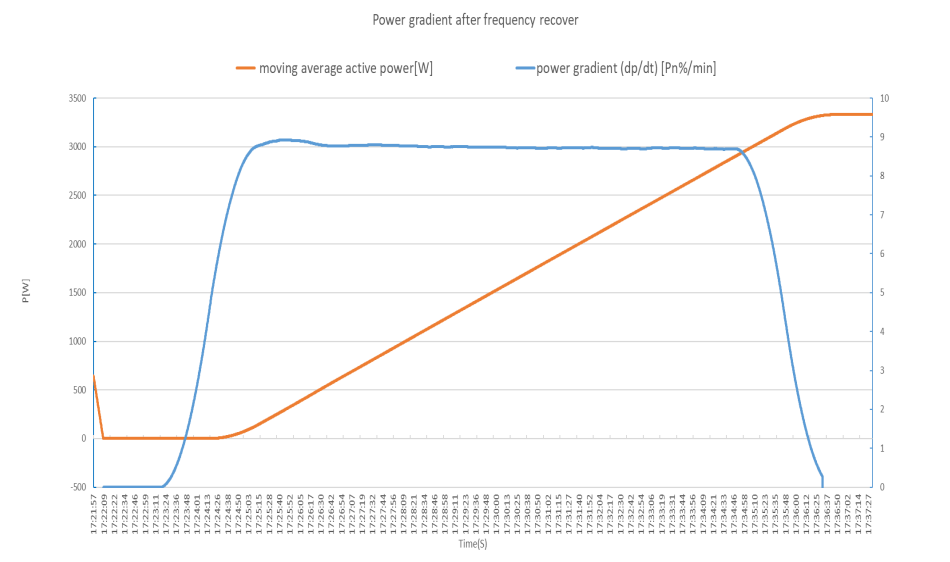
Over voltage

a) U ≥ (1.14p.u. + 4V) – no reconnection

b) U ≤ (1.14p.u. - 4V) – reconnection after 70.8 s



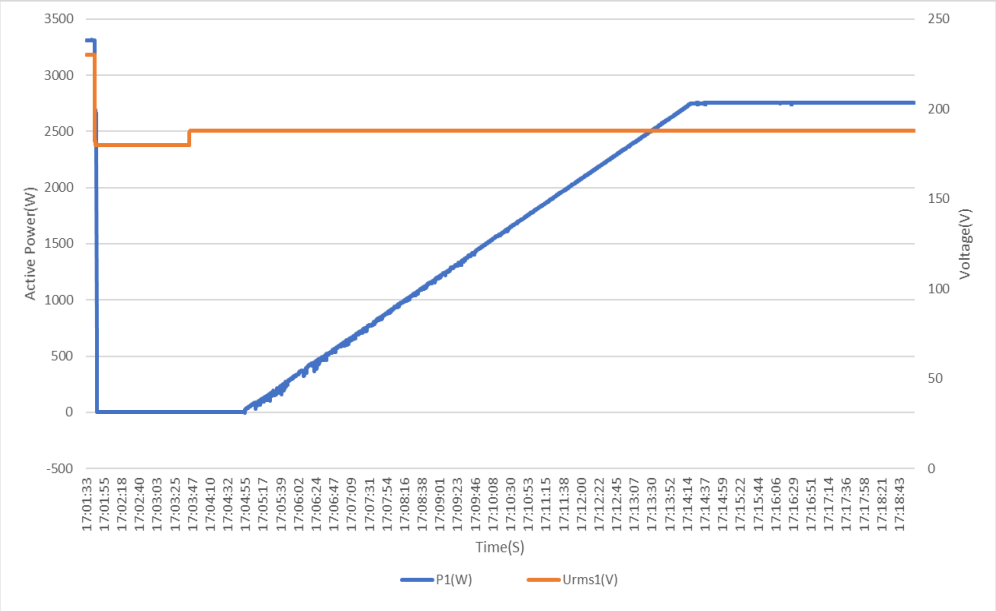
Max Power gradient after reconnection: 8.93 %Pn/min



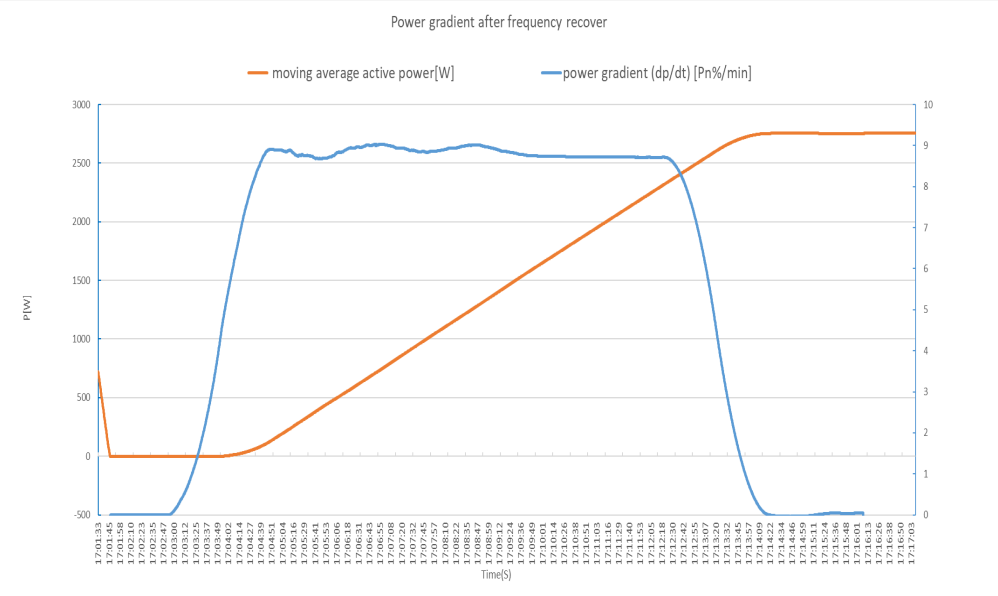
Under voltage

c) U ≤ (0.8p.u. - 4V) – no reconnection

d) U ≥ (0.8p.u. + 4V) – reconnection after 70.4 s



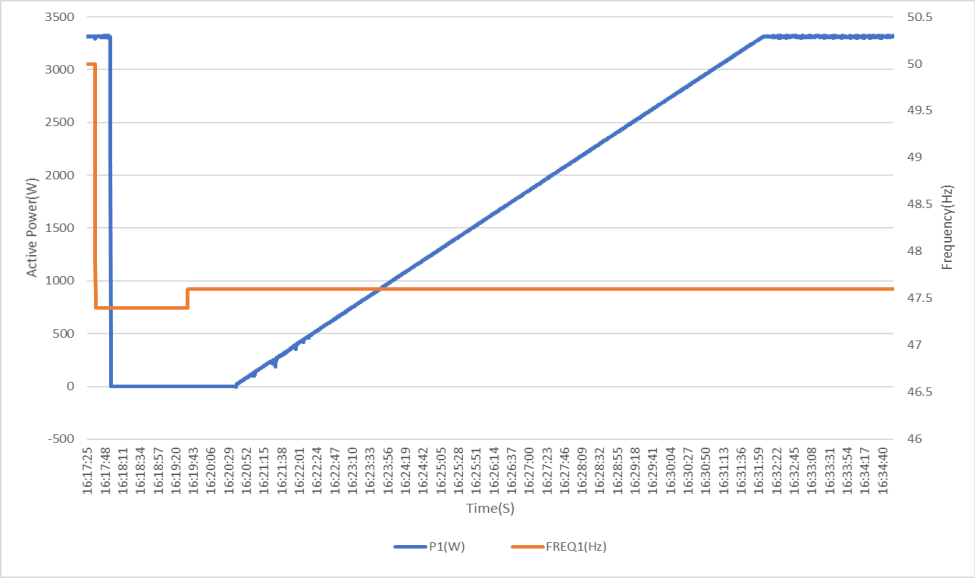
Max Power gradient after reconnection: 9.03 %Pn/min



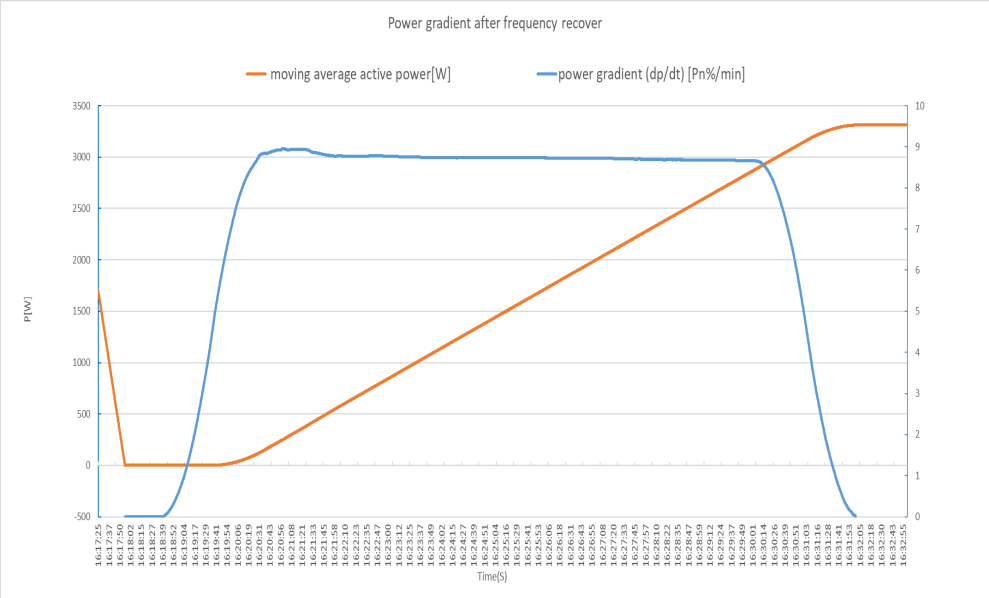
Under frequency

e) F ≤ 47.4 Hz – no reconnection

f) F ≥ 47.6 Hz – reconnection after 63.6 s



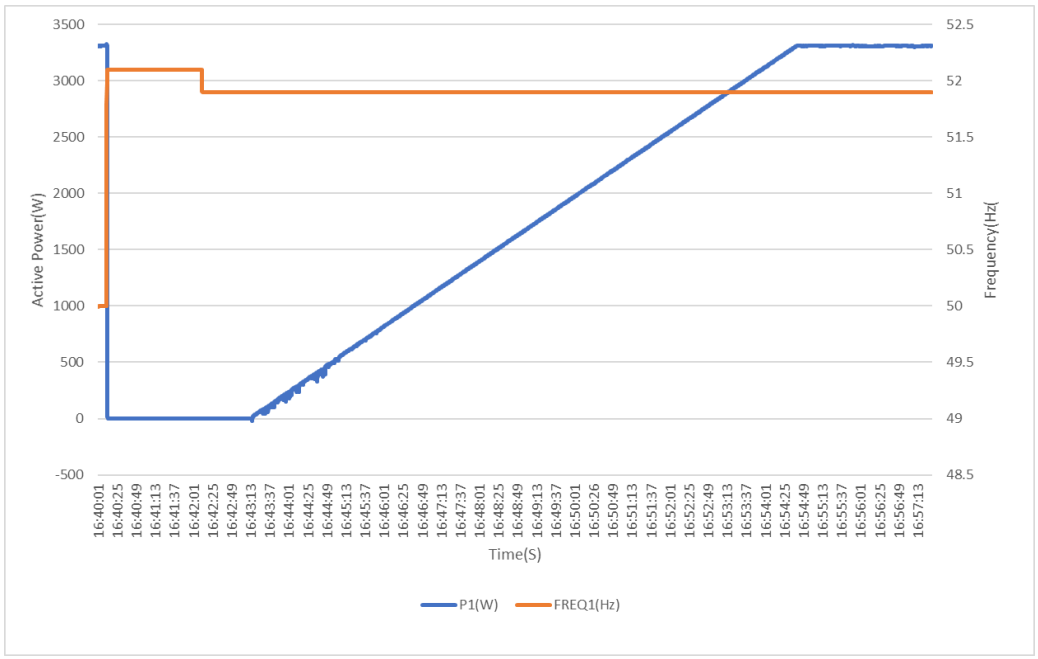
Max Power gradient after reconnection: 8.96 %Pn/min



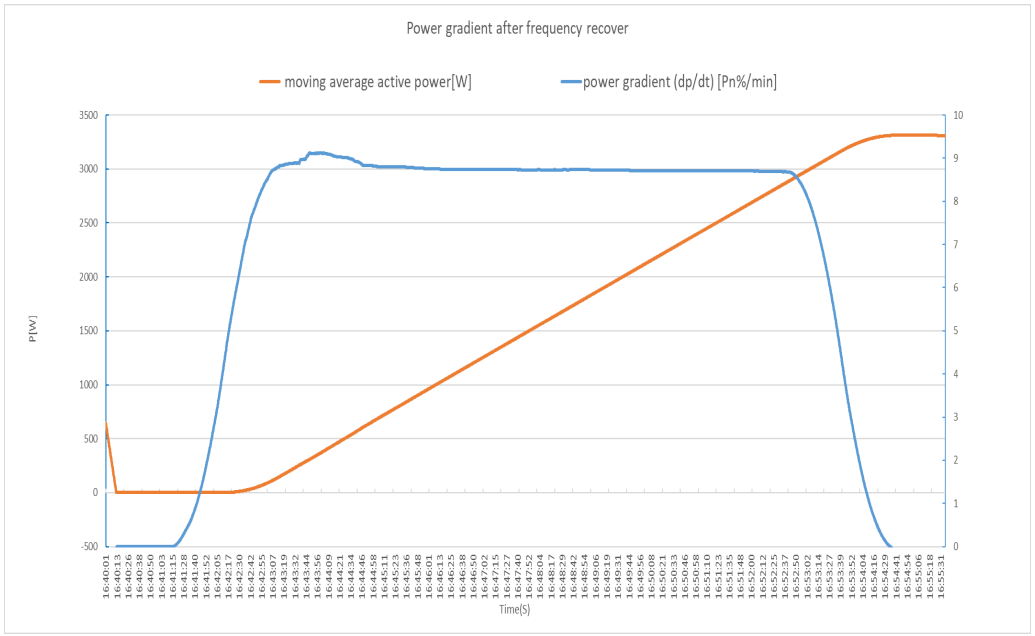
Over frequency

g) F ≥ 52.1 Hz – no reconnection

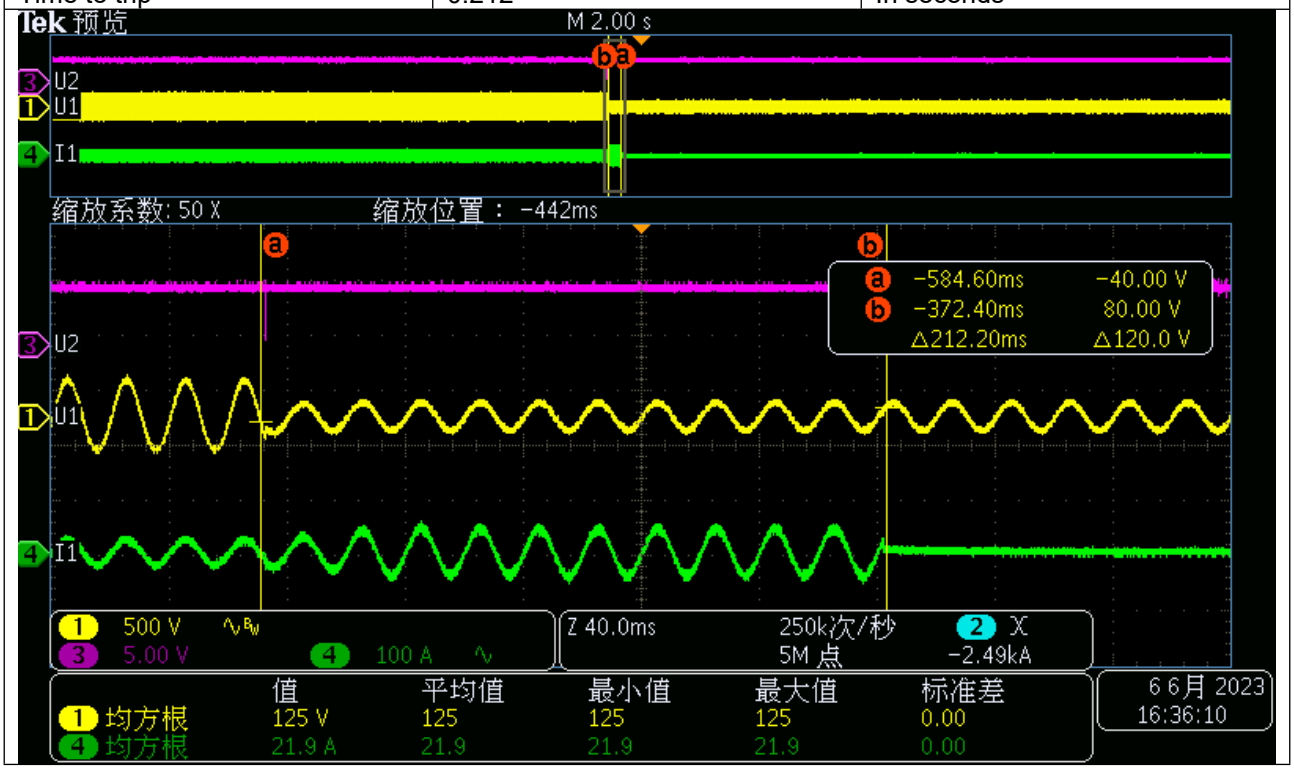
h) F ≤ 51.9 Hz – reconnection after 63.2 s



Max Power gradient after reconnection: 9.12 %Pn/min



Fault level contribution: These tests shall be carried out in accordance with EREC G98 Annex A1 A.1.3.5 (**Inverter** connected) and Annex A2 A.2.3.4 (Synchronous). Please complete each entry, even if the fault contribution is zero.		
GT1-3K3S1		
For an Inverter output		
Time after fault	Volts	Amps
20 ms	153	21.5
100 ms	126	25.7
250 ms	-	-
500 ms	-	-
Time to trip	0.212	In seconds



Logic interface (input port)	
Confirm that an input port is provided and can be used to reduce the Active Power output to zero	Yes
Provide high level description of logic interface, e.g. details in 9.4.3 such as AC or DC signal (the additional comments box below can be used)	Yes
This equipment is equipped with RJ45 terminal for logic interface that being received the signal from the DNO, the connection should be installed per installation manual, and the signal should be a simple binary output that captured by RJ45 terminal(PIN 5 and 1 for detecting the signal). Once the signal actived, the inverter will reduce its active power to zero within 5s. The signal from the Micro generator that is being switched is DC 3.3 V.	

Self-Monitoring solid state switching: No specified test requirements. Refer to EREC G98 Annex A1 A.1.3.6 (Inverter connected).	
It has been verified that in the event of the solid state switching device failing to disconnect the **Power Park Module**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 s.	N/A

Cyber security	
Confirm that the **Manufacturer** or Installer of the Micro-generator has provided a statement describing how the Micro-generator has been designed to comply with cyber security requirements, as detailed in 9.7.	Yes

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DECLARATION OF CONFORMITY

Hangzhou Livoltek power Co.,Ltd.
1418-35 Moganshan Road,
Shangcheng Industrial Zone, Hangzhou,
Zhejiang Province, P.R. China

Model(s):
GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1

Technical Data	GT1-1K6S1	GT1-2K2S1	GT1-3KS1	GT1-3K3S1	GT1-3K6D1	GT1-4KD1	GT1-4K6D1	GT1-5KD1	GT1-6KD1
PV Input Data									
Max. DC Input Voltage[V]	550				550				
MPPT Operating Range[V]	50-545				70-545				
MPPT Operating Range(Full-Load)[V]	120-500	165-500	225-500	250-500	135-500	150-500	170-500	185-500	225-500
Max. DC Input Current[A]	14				14+14				
Max.Short Circuit current[A]	20				20+20				
AC Output Data									
Max. Apparent Power [VA]	1760	2420	3300	3300	3960 (3600@G98)	4400	4600	5500	6600
Max. AC Output Current[A]	7.7	10.5	14.3	14.3	17.2 (15.7@G98)	19.1	20.0	23.9	28.7
Rated AC Grid Voltage[V]	220V/230V,L+N+PE								
Rated Grid Frequency [Hz]	50/60								
Power Factor	> 0.99 Rated power (Adjustable 0.8 Leading - 0.8Lagging)								
Cyber security design for all models	Identical								

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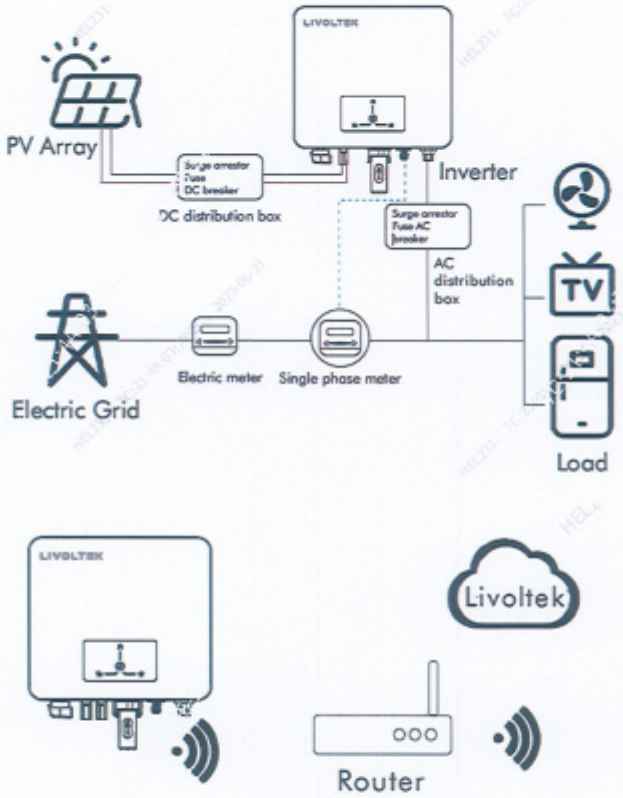
Declares the following:

1) The inverter include a system of internal and external logic communications as summarized in the following scheme:



where the main components involved and their main functions are explained in the following table:

Name	Meaning	Function	Location
Module/Stick Logger (PSD200-F1-Dongle)	Monitoring Device	Collect Inverter data and upload data to the remote server by WiFi, and establish the tunnel between the inverter and the remote server	Monitoring device
Monitoring	WIFI	Monitoring device to realize remote monitoring function	Monitoring device
Router	Router device	transmission of data to cloud	Third-party device

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		server, reception of commands/settings from external stakeholder	
Inverter	Inverter device	Convert the DC power output of photovoltaic module into AC power,	Inverter device
Livoltek Cloud Platform	Cloud	Management platform that supports data collection, plant monitoring, and operation and maintenance of PV power plants	Cloud Server

2) The module /Stick Logger communicates with the external inverter through the USB port.
3) The communication between the module/Stick Logger and the remote server via WiFi.
4) All communications between the server and the subjects/parties are cyber-protected by SSL/TLS technology.
5) The cyber-security assessment of the inverter communication system was performed according to the ETSI EN 303 645 v2.1.1 (2020-06) standard, and it is reported according to the Table B.1 form of the same standard:

ETSI EN 303 645 v2.1.1 (2020-06) Table B.1 Implementation of provisions for consumer IoT security			
Implementation of provisions			
Reference	Status	Support	Detail
5.1 No universal default passwords			
5.1-1	MC (1)	Y	For web login and app login, passwords are defined by the user. For app BLE access, private modbus protocol is used. Authentication mechanism is special ID for the device and password set by user.
5.1-2	MC (2)	Y	For Web login and App login, no pre-installed passwords. For app BLE access, Special Modbus ID and CRC16 are used. The mechanism is sufficiently randomized.
5.1-3	M	Y	Authentication mechanism is of best practice.
5.1-4	MC (8)	Y	The user can find information for changing the authentication values in page 8 of LIVOLTEK APP UserGuide-Ver2022.11 .
5.1-5	MC (5)	Y	After 3 invalid login attempts the login interface is inaccessible for 5 minutes.
5.2 Implement a means to manage reports of vulnerabilities			
5.2-1	M	Y	Vulnerability disclosure policy is publicly available. User can retrieve the vulnerability disclosure policy in LIVOLTEK's Cyber Security Statement. Contact information: info@livoltek.com Initial acknowledgement timeline: 5 business days Status updates timeline: 14 business days

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5.2-2	R	Y	Disclosed vulnerabilities are acted on in a timely manner.
5.2-3	R	Y	manufacturer to continually monitor for, identify and rectify security vulnerabilities.
5.3 Keep software updated			
5.3-1	R	Y	Software component consists of ARM firmware, DSP1 firmware and DSP2 firmware. They are updateable.
5.3-2	MC (5)	Y	Update mechanism is: 1) online via web platform, and 2) bluetooth network.
5.3-3	MC (12)	Y	Update is simple for the user to apply.
5.3-4	RC (12)	Y	Automatic mechanism is used.
5.3-5	RC (12)	Y	Initialization check and periodically check for security updates are available.
5.3-6	RC (9,12)	Y	User can enable, disable installation. But can not postpone.
5.3-7	MC (12)	Y	Best practice cryptography is used.
5.3-8	MC (12)	Y	
5.3-9	RC (12)	Y	Authenticity and integrity of software updates are verified.
5.3-10	M (11,12)	Y	Updates are delivered over a network interface, a trust relationship is provided.
5.3-11	RC (12)	Y	The user can check the update on the web or app.
5.3-12	RC (12)	Y	No basic functioning is disrupted.
5.3-13	M	Y	
5.3-14	RC (3,4)	N/A	Not a constrained device.
5.3-15	RC (3,4)	N/A	Not a constrained device.
5.3-16	M	Y	
5.4 Securely store sensitive security parameters			
5.4-1	M	Y	The TLS private key is stored in the flash of PSD200-F1 and cannot be modified by the user.
5.4-2	MC (10)	Y	The inverter serial number and Wi-Fi module serial number are both hard coded
5.4-3	M	Y	Hard-coded critical security parameters is not in softwaresource code
5.4-4	M	Y	Unique secret key is assigned by the manufacturer.
5.5 Communicate securely			
5.5-1	M	Y	Communication security is assured.
5.5-2	R	Y	Network and security functionalities reviews are implemented.
5.5-3	R	Y	Cryptographic algorithms and primitives can be updated along with the firmware.
5.5-4	R	Y	Authentication mechanism is provided.
5.5-5	M	Y	Authentication mechanism is provided.

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5.5-6	R	Y	Critical security parameters are encrypted in transit.
5.5-7	M	Y	Critical security parameters are protected.
5.5-8	M	Y	
5.6 Minimize exposed attack surfaces			
5.6-1	M	Y	No redundant network and logical interface.
5.6-2	M	Y	In the initialized state, information is minimized.
5.6-3	R	Y	No unnecessarily physical interface is exposed.
5.6-4	MC (13)	Y	Debug interface is disabled.
5.6-5	R	Y	No redundant software.
5.6-6	R	Y	No redundant functionality.
5.6-7	R	Y	No OS and thread mechanism.
5.6-8	R	N/A	DUT has no memory mechanism mentioned by the standard.
5.6-9	R	Y	System Development process chart defines secure development processes.
5.7 Ensure software integrity			
5.7-1	R	Y	Bootloader is used.
5.7-2	R	Y	The device will alert the user and not connect to wider networks than those necessary to perform the alerting function.
5.8 Ensure that personal data is secure			
5.8-1	R	Y	Personal data includes email, mobile number, devicegeneration energy. They are transmitted via MQTT protocol and TLS 1.2 authentication.
5.8-2	M	Y	Personal data includes email, mobile number, devicegeneration energy. They are transmitted via MQTT protocol and TLS 1.2 authentication.
5.8-3	M	Y	No external sensing capability.
5.9 Make systems resilient to outages			
5.9-1	R	Y	Outages of data networks and power are taken into account.
5.9-2	R	Y	
5.9-3	R	Y	
5.10 Examine system telemetry data			
5.10-1	RC (6)	Y	Telemetry data is properly collected.
5.11 Make it easy for users to delete user data			
5.11-1	M	Y	User data can be erased from the device in a simple manner.
5.11-2	R	Y	Personal data can be removed from associated services by resetting the device.
5.11-3	R	Y	User can delete their personal data from the device by resetting the device.
5.11-4	R	Y	

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5.12 Make installation and maintenance of devices easy			
5.12-1	R	Y	Minimal decisions by the user concept is applied.
5.12-2	R	Y	User Manual describes how to securely set up device.
5.12-3	R	Y	User Manual describes how to check the device.
5.13 Validate input data			
5.13-1	M	Y	Input data are validated.
6 Data protection provisions			
6-1	M	Y	User can find privacy policy on web server.
6-2	MC (7)	Y	1. Email and mobile number: users shall input their personal data (email and mobile number). That is the consent. 2. Device Information and IP address: this is automatically collected by the app. The users must check the privacy agreement and service terms to register as a user of thed livoltek-portal platform.
6-3	M	Y	1. User can delete the account through online login. 2. User can withdraw his/her consent in the app.
6-4	RC (6)	Y	Telemetry data does not include personal data. Telemetry data is anonymous when it is collected to allow manufacturers to take action on issues on a per device basis.
6-5	MC (6)	Y	User can find privacy policy on web server.

Abbreviation

M the provision is a mandatory requirement
R the provision is a recommendation
MC the provision is a mandatory requirement and conditional
RC the provision is a recommendation and conditional
Y supported by the implementation
N not supported by the implementation
N/A the provision is not applicable

Conditions

1) passwords are used;
2) pre-installed passwords are used;
3) software components are not updateable;
4) the device is constrained;
5) the device is not constrained;
6) telemetry data being collected;
7) personal data is processed on the basis of consumers' consent;
8) the device allowing user authentication;
9) the device supports automatic updates and/or update notifications;
10) a hard-coded unique per device identity is used for security purposes;
11) updates are delivered over a network interface;

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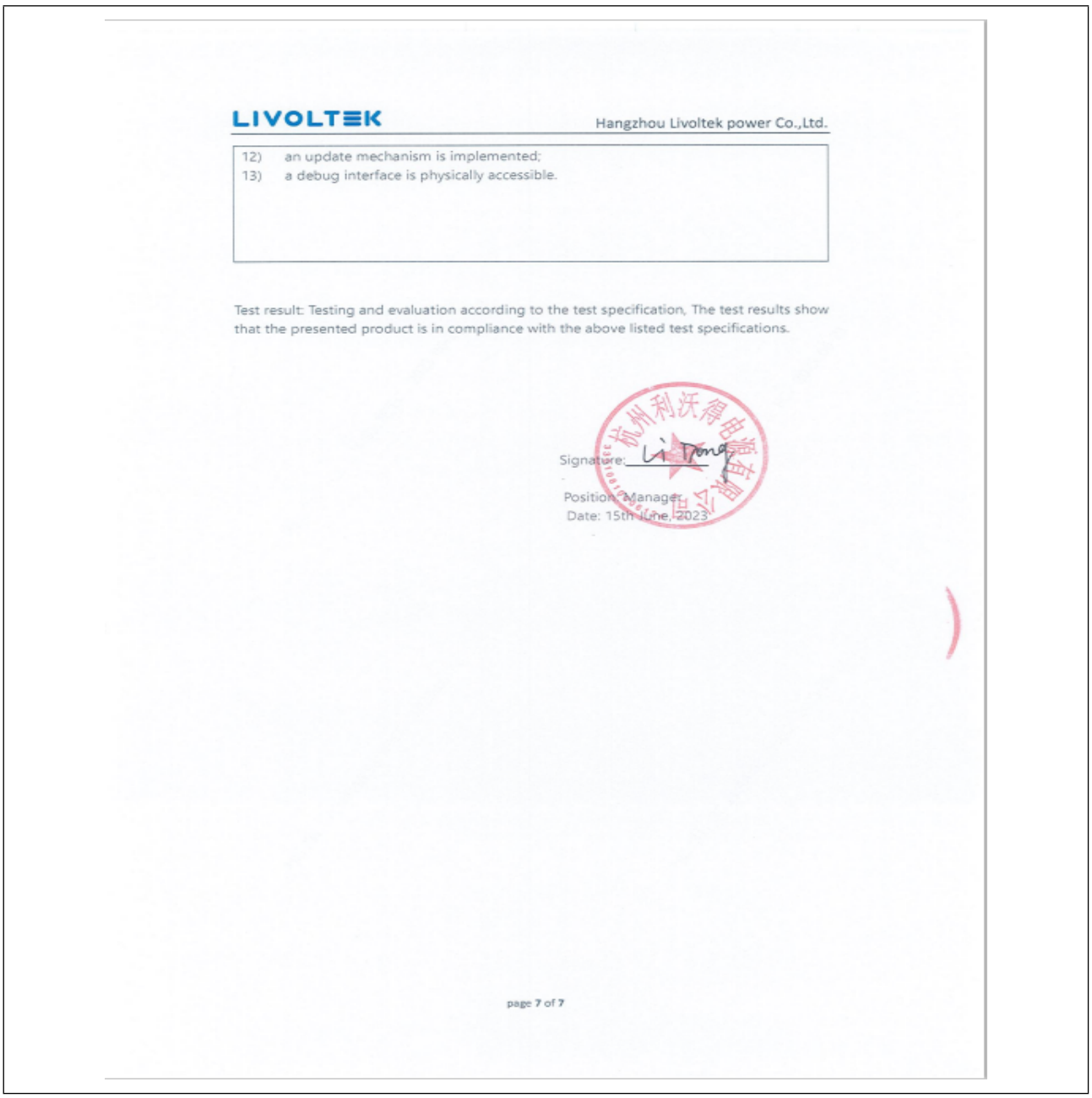

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12) an update mechanism is implemented;
13) a debug interface is physically accessible.

Test result: Testing and evaluation according to the test specification, The test results show that the presented product is in compliance with the above listed test specifications.

Signature: Li Tong

Position: Manager

Date: 15th June, 2023

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--- End of test report---