Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
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Form A2-3: Compliance Verification Report for Inverter Connected Power Generating Modules

This form should be used by the Manufacturer to demonstrate and declare compliance with the requirements of EREC G99. The form can be used in a variety of ways as detailed below:

1. To obtain Fully Type Tested status

The Manufacturer can use this form to obtain Fully Type Tested status for a Power Generating Module by registering this completed form with the Energy Networks Association (ENA) Type Test Verification Report Register.

2. To obtain Type Tested status for a product

This form can be used by the Manufacturer to obtain Type Tested status for a product which is used in a Power Generating Module by registering this form with the relevant parts completed with the Energy Networks Association (ENA) Type Test Verification Report Register.

3. One-off Installation

This form can be used by the Manufacturer or Installer to confirm that the Power Generating Module has been tested to satisfy all or part of the requirements of this EREC G99. This form must be submitted to the DNO as part of the application.

A combination of (2) and (3) can be used as required, together with Form A2-4 where compliance of the Interface Protection is to be demonstrated on site.

Note:

Within this Form A2-3 the term Power Park Module will be used but its meaning can be interpreted within Form A2-3 to mean Power Park Module, Generating Unit or Inverter as appropriate for the context.

However, note that compliance must be demonstrated at the Power Park Module level.

If the **Micro-generator** is **Fully Type Tested** and already registered with the ENA **Type Test Verification Report** Register, the **Installation Document** should include the **Manufacturer's** Reference Number (the Product ID), and this form does not need to be submitted.

Where the **Micro-generator** is not registered with the ENA **Type Test Verification Report** Register this form needs to be completed and provided to the DNO, to confirm that the **Micro-generator** has been tested to satisfy the requirements of this EREC G99.

Manufacturer's reference number	GT1-4KD1; GT1-4K6D1; GT1-5KD1; GT1-6KD1
Micro-generator Technology	Grid-Tied PV Inverter
Manufacturer	Hangzhou Livoltek Power Co., Ltd.
Address	1418-35 Moganshan Road, Shangcheng Industrial Zone,310011 Hangzhou, Zhejiang Province, P.R. China

Maximum Rated Capacity	Connection Option			
	4.0	kW Single Phase		
	4.6	kW Single Phase		
	5.0	kW Single Phase		
	6.0	kW Single Phase		
Tel	+86-571-28330320		Fax	/
E-mail	info@livoltek.com		Web site	www.livoltek.com

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Manufacturer Type Test declaration. - I certify that all products supplied by the company with the above Type Tested reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site modifications are required to ensure that the product meets all the requirements of EREC G99.	
Note that testing can be done by the Manufacturer of an individual component or by an external test house. Where parts of the testing are carried out by persons or organisations other than the Manufacturer then that person or organisation shall keep copies of all test records and results supplied to them to verify that the testing has been carried out by people with sufficient technical competency to carry out the tests.	
Signed: Li Dong	On behalf of Hangzhou Livoltek Power Co., Ltd.

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A2-3 Compliance Verification Report –Tests for Type A Inverter Connected Power Generating Modules – test record

1. Operating Range:	**P**

Two tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable test supply or grid simulation set. The power supplied by the primary source shall be kept stable within ± 5 % of the apparent power value set for the entire duration of each test sequence.

Frequency, voltage and **Active Power** measurements at the output terminals of the **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** can operate within the required ranges for the specified period of time.

The **Interface Protection** shall be disabled during the tests.
In case of a PV **Power Park Module** the PV primary source may be replaced by a DC source.
In case of a full converter **Power Park Module** (eg wind) the primary source and the prime mover I**nverter**/rectifier may be replaced by a DC source.

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.

Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required.

Test 1 Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz, **Power Factor** = 1, Period of test 20 s	Test chart to confirm operation
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz, **Power Factor** = 1, Period of test 90 minutes	Test chart to confirm operation
Test 3 Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz, **Power Factor** = 1, Period of test 90 minutes	Test chart to confirm operation
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, **Power Factor** = 1, Period of test 15 minutes	Test chart to confirm operation
Test 5 Voltage = 100% of nominal (230 V), Frequency = 50.0 Hz, **Power Factor** = 1, Period of test = 90 minutes	Test chart to confirm operation
Test 6 RoCoF withstand Confirm that the **Power Generating Module** 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. Note that this is not expected to be demonstrated on site.	Test chart to confirm operation

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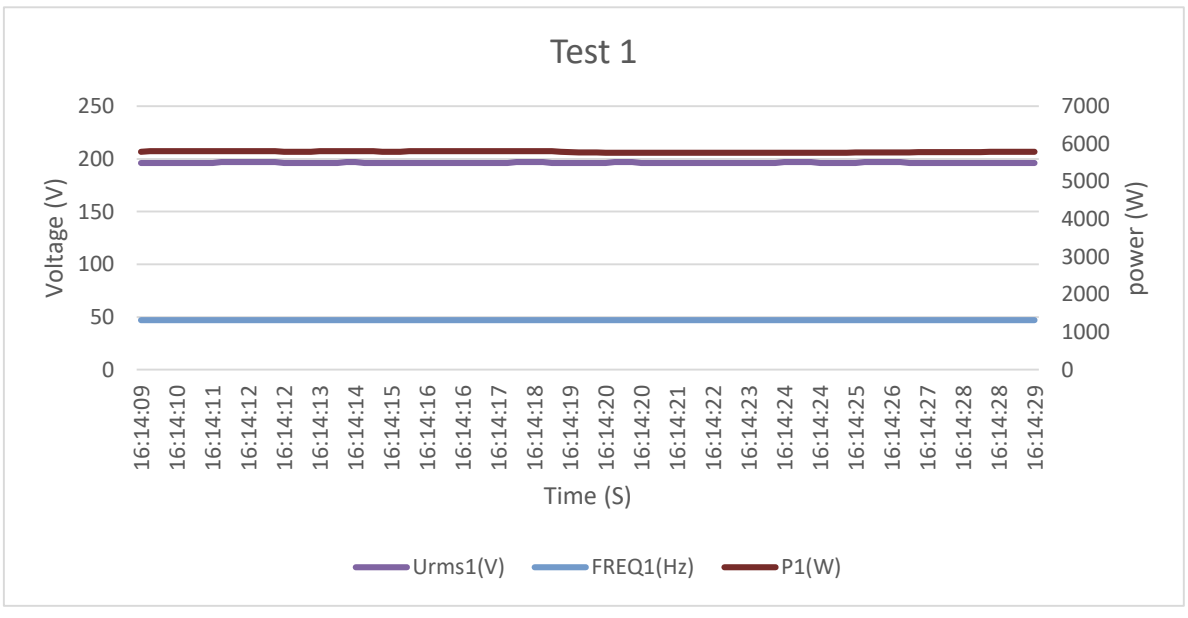
Model: GT1-6KD1				
Test 1:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (seconds)
196.25	47.00	5782.67	0.9974	20
Test 2:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
196.32	47.50	5785.62	0.9940	90
Test 3:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
254	51.50	6059.39	0.9982	90
Test 4:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
254	52.00	6072.90	0.9939	15
Test 5:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
231	50.00	6044.86	0.9981	90
Test 6:				
Measured Voltage (V)	Ramp range	Test frequency ramp	Test Duration	Confirm no trip
-	49.0 Hz to 51.0 Hz	+0.95 Hzs^{-1}	2.1s	No trip
-	51.0 Hz to 49.0 Hz	-0.95 Hzs^{-1}	2.1s	No trip



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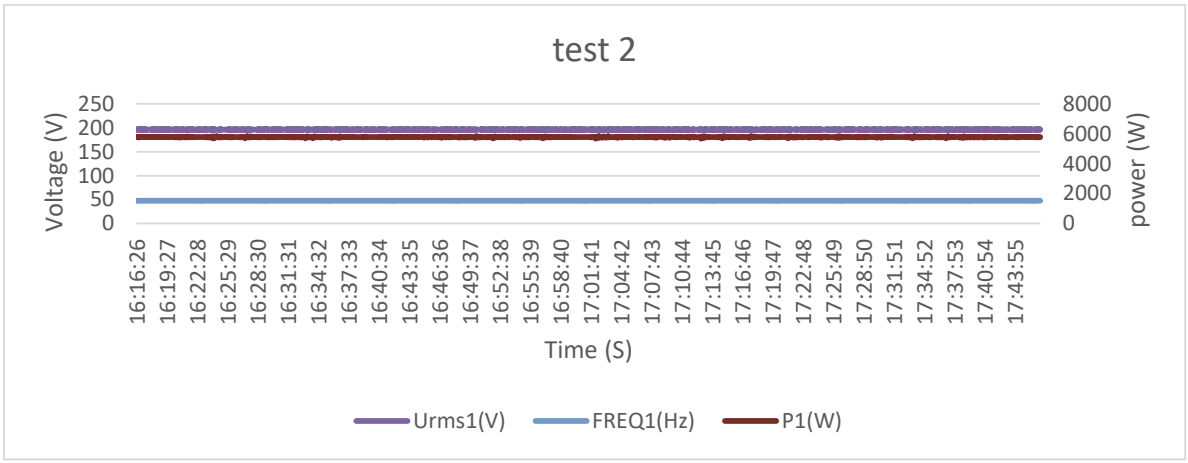

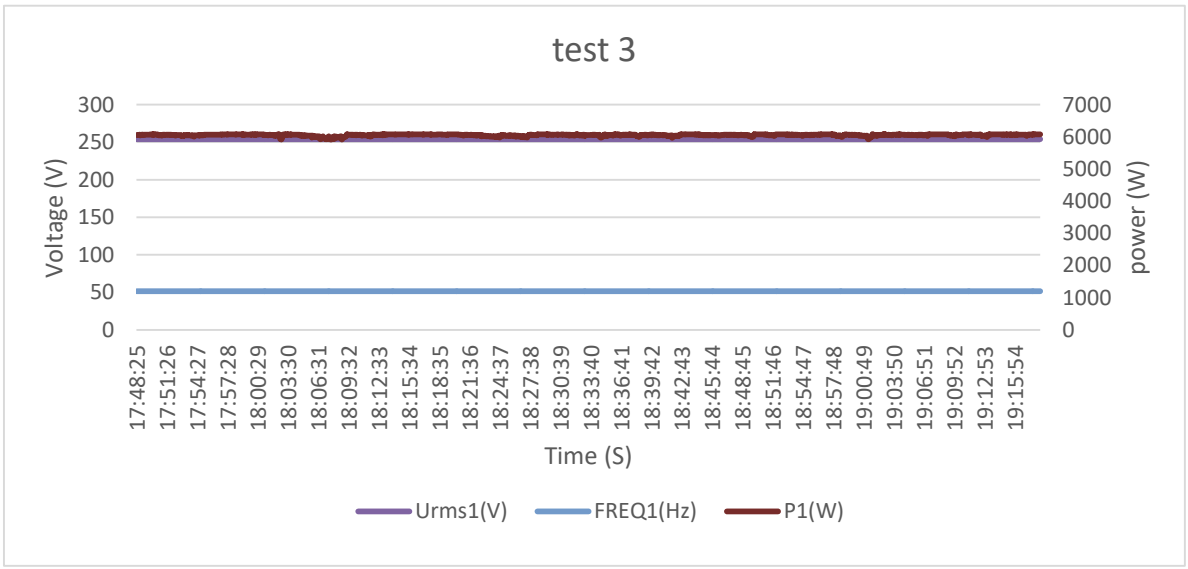

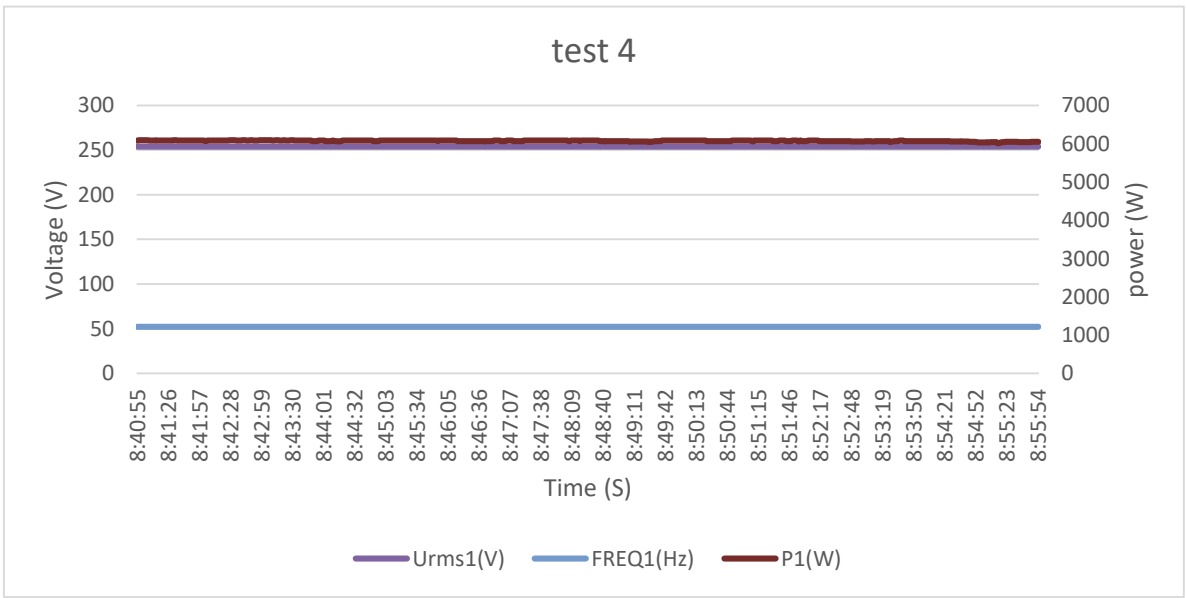

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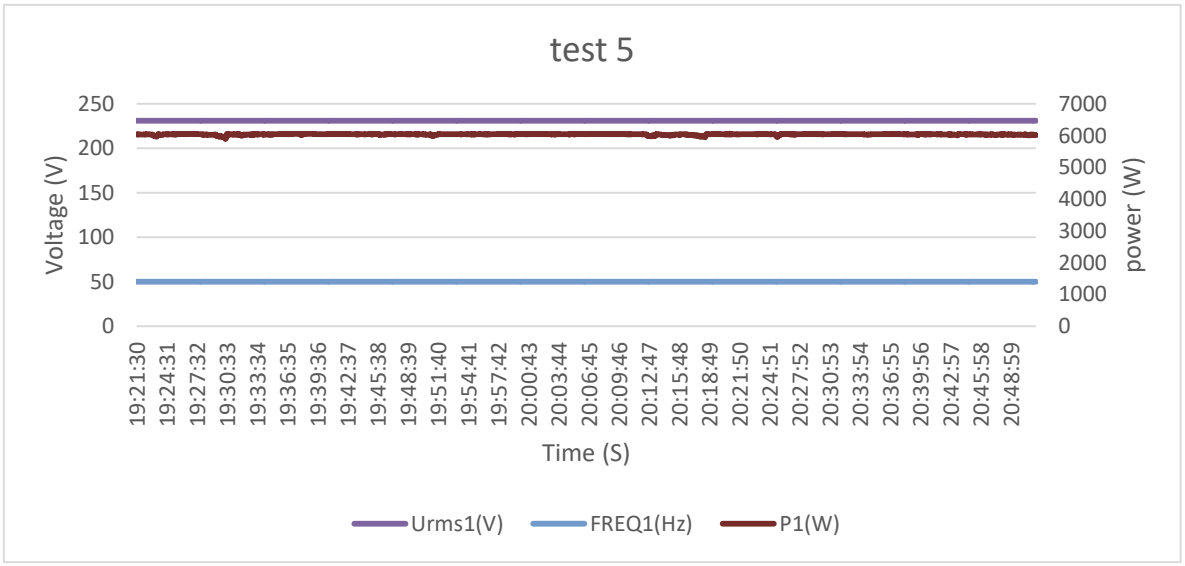

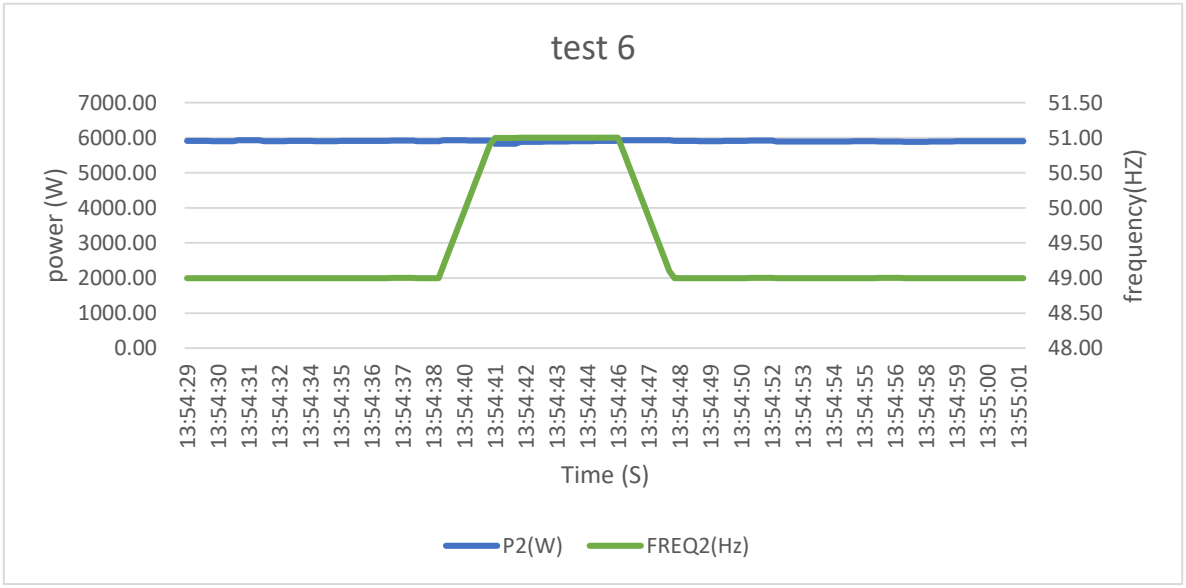

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2. Power Quality – Harmonics:	**P**

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5**.** These tests should be carried out as specified in BS EN 61000-3-12, and measurements for the 2nd – 13th harmonics should be provided. The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment. For three phase **Power Generating Modules**, measurements for all phases should be provided.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation must be designed in accordance with EREC G5.

The rating of the **Power Generating Module** (per phase) should be provided below, and the Total Harmonic Distortion (THD) and Partial Weighted Harmonic Distortion (PWHD) should be provided at the bottom of this section.

Model: GT1-6KD1

Micro-generator tested to BS EN 61000-3-12

Micro-generator rating per phase (rpp)	6	kVA	Harmonic % = Measured Value (A) x 23/rating per phase(kVA)
Single or three phase measurements (for single phase measurements, only complete L1 columns below)	Single phase PV inverter		

Harmonic	At 45-55% of Registered Capacity						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Harmonic containing rate(%)				
	L1	L2	L3	L1	L2	L3	1 phase	3 phase
2	0.01	-	-	0.04	-	-	8%	8%
3	0.32	-	-	1.20	-	-	21.6%	Not stated
4	0.00	-	-	0.00	-	-	4%	4%
5	0.13	-	-	0.50	-	-	10.7%	10.7%
6	0.01	-	-	0.04	-	-	2.67%	2.67%
7	0.08	-	-	0.30	-	-	7.2%	7.2%
8	0.01	-	-	0.04	-	-	2%	2%
9	0.03	-	-	0.10	-	-	3.8%	Not stated
10	0.01	-	-	0.04	-	-	1.6%	1.6%
11	0.01	-	-	0.04	-	-	3.1%	3.1%
12	0.01	-	-	0.04	-	-	1.33%	1.33%
13	0.03	-	-	0.10	-	-	2%	2%
THD	-	-	-	10.6	-	-	23%	13%
PWHD	-	-	-	8.70	-	-	23%	22%
Harmonic	At 100% of Registered Capacity						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Harmonic containing rate(%)				
	L1	L2	L3	L1	L2	L3	1 phase	3 phase
2	0.01	-	-	0.04	-	-	8%	8%

3	0.60	-	-	2.30	-	-	21.6%	Not stated
4	0.01	-	-	0.04	-	-	4%	4%
5	0.22	-	-	0.80	-	-	10.7%	10.7%
6	0.00	-	-	0.00	-	-	2.67%	2.67%
7	0.14	-	-	0.50	-	-	7.2%	7.2%
8	0.01	-	-	0.04	-	-	2%	2%
9	0.09	-	-	0.30	-	-	3.8%	Not stated
10	0.01	-	-	0.04	-	-	1.6%	1.6%
11	0.05	-	-	0.20	-	-	3.1%	3.1%
12	0.00	-	-	0.00	-	-	1.33%	1.33%
13	0.03	-	-	0.10	-	-	2%	2%
THD	-	-	-	9.70	-	-	23%	13%
PWHD	-	-	-	4.80	-	-	23%	22%

2. Power Quality – Harmonics:								**P**
For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5**.** These tests should be carried out as specified in BS EN 61000-3-12, and measurements for the 2nd – 13th harmonics should be provided. The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment. For three phase **Power Generating Modules**, measurements for all phases should be provided. For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation must be designed in accordance with EREC G5. The rating of the **Power Generating Module** (per phase) should be provided below, and the Total Harmonic Distortion (THD) and Partial Weighted Harmonic Distortion (PWHD) should be provided at the bottom of this section.								
Model: GT1-4KD1								
Micro-generator tested to BS EN 61000-3-12								
Micro-generator rating per phase (rpp)				4		kVA	Harmonic % = Measured Value (A) x 23/rating per phase(kVA)	
Single or three phase measurements (for single phase measurements, only complete L1 columns below)				Single phase PV inverter				
Harmonic	At 45-55% of Registered Capacity						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Harmonic containing rate(%)				
	L1	L2	L3	L1	L2	L3	1 phase	3 phase
2	0.06	-	-	0.36	-	-	8%	8%
3	0.38	-	-	2.17	-	-	21.6%	Not stated
4	0.03	-	-	0.17	-	-	4%	4%
5	0.18	-	-	1.06	-	-	10.7%	10.7%

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6	0.02	-	-	0.10	-	-	2.67%	2.67%
7	0.11	-	-	0.62	-	-	7.2%	7.2%
8	0.01	-	-	0.08	-	-	2%	2%
9	0.07	-	-	0.39	-	-	3.8%	Not stated
10	0.02	-	-	0.11	-	-	1.6%	1.6%
11	0.05	-	-	0.27	-	-	3.1%	3.1%
12	0.01	-	-	0.06	-	-	1.33%	1.33%
13	0.03	-	-	0.15	-	-	2%	2%
THD	-	-	-	4.85	-	-	23%	13%
PWHD	-	-	-	2.3	-	-	23%	22%
Harmonic	At 100% of Registered Capacity						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Harmonic containing rate(%)				
	L1	L2	L3	L1	L2	L3	1 phase	3 phase
2	0.10	-	-	0.57	-	-	8%	8%
3	0.50	-	-	2.87	-	-	21.6%	Not stated
4	0.04	-	-	0.23	-	-	4%	4%
5	0.25	-	-	1.44	-	-	10.7%	10.7%
6	0.02	-	-	0.11	-	-	2.67%	2.67%
7	0.16	-	-	0.89	-	-	7.2%	7.2%
8	0.02	-	-	0.11	-	-	2%	2%
9	0.10	-	-	0.57	-	-	3.8%	Not stated
10	0.02	-	-	0.11	-	-	1.6%	1.6%
11	0.09	-	-	0.52	-	-	3.1%	3.1%
12	0.01	-	-	0.57	-	-	1.33%	1.33%
13	0.07	-	-	0.40	-	-	2%	2%
THD	-	-	-	3.56	-	-	23%	13%
PWHD	-	-	-	1.72	-	-	23%	22%

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3. Power Quality – Voltage fluctuations and Flicker:	**P**

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) these tests should be undertaken in accordance with Annex A.7.1.4.3. Results should be normalised to a standard source impedance, or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation must be designed in accordance with EREC P28.

The standard test impedance is 0.4 Ω for a single phase **Power Generating Module** (and for a two phase unit in a three phase system) and 0.24 Ω for a three phase **Power Generating Module** (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.
The test date and location must be declared.

Model:	GT1-6KD1		
Test start date	28,July,2022	Test end date	28,July,2022
Test location	Hangzhou Livoltek Power Co., Ltd.		

	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	0.159%	0.122%	0	1.241%	0.964%	0	0.018	0.083
Normalised to standard impedance	0.159%	0.122%	0	1.241%	0.964%	0	0.018	0.083
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	0.24 * 0.4 ^	Ω	X	0.15 * 0.25 ^	Ω

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Maximum Impedance	R	N/A	Ω	X	N/A	Ω

*Applies to three phase and split single phase Micro-generators. Delete as appropriate.

^ Applies to single phase Micro-generators and Micro-generators using two phases on a three phase system. Delete as appropriate.

For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the power factor of the generation output is 0.98 or above.

Normalised value = Measured value*reference source resistance/measured source resistance at test point.

Single phase units reference source resistance is 0.4 Ω

Two phase units in a three phase system reference source resistance is 0.4 Ω.

Two phase units in a split phase system reference source resistance is 0.24 Ω.

Three phase units reference source resistance is 0.24 Ω.

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 need to conform to the particular requirements set out in the testing notes for the

technology under test. Dates and location of the test need to be noted below.

Diagram of test

	dc[%]		dmax[%]		d(t)[ms]		Pst		Plt	
Limit	3.30		4.00		200 3.30%		1.00		0.65 N:12	
No. 1	0.122	Pass	0.159	Pass	0.0	Pass	0.021	Pass		
2	0.000	Pass	0.000	Pass	0.0	Pass	0.018	Pass		
3	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
4	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
5	0.000	Pass	0.000	Pass	0.0	Pass	0.016	Pass		
6	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
7	0.000	Pass	0.000	Pass	0.0	Pass	0.016	Pass		
8	0.000	Pass	0.000	Pass	0.0	Pass	0.016	Pass		
9	0.000	Pass	0.000	Pass	0.0	Pass	0.016	Pass		
10	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
11	0.000	Pass	0.000	Pass	0.0	Pass	0.017	Pass		
12	0.964	Pass	1.241	Pass	0.0	Pass	0.189	Pass		
Result		Pass		Pass		Pass		Pass	0.083	Pass

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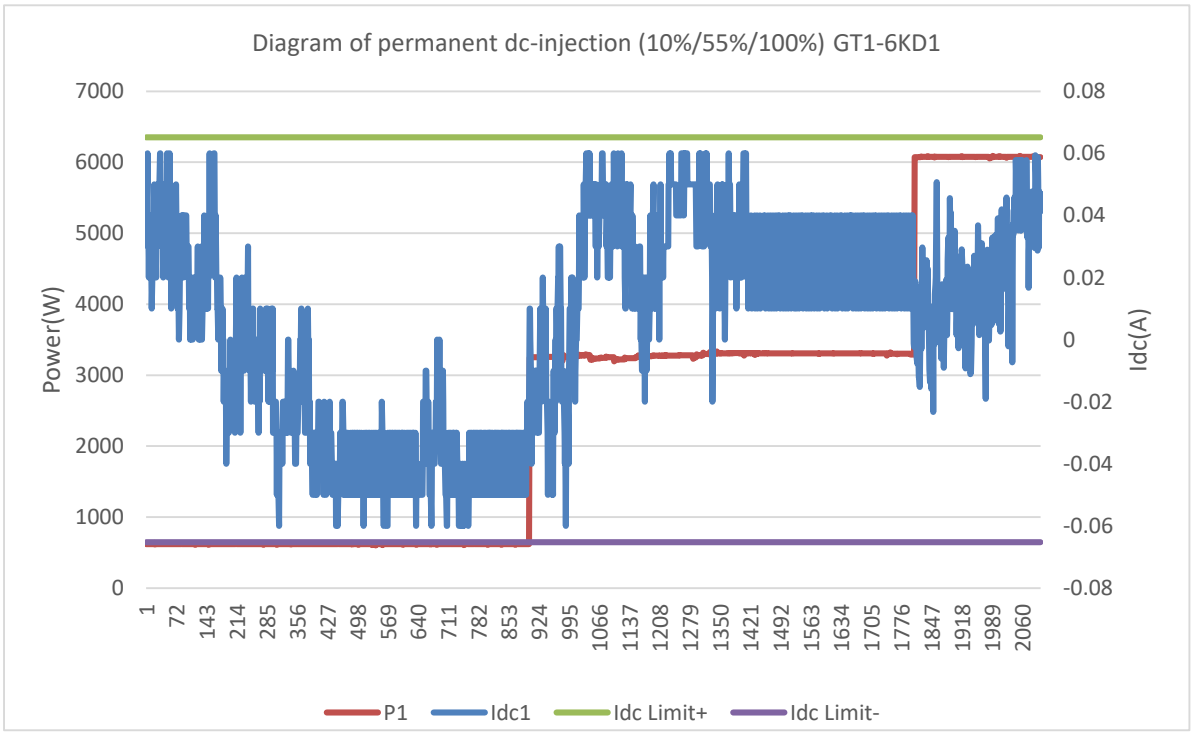
4. Power quality – DC injection:			P
The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three defined power levels ±5%. At 230 V a 50 kW three phase **Inverter** has a current output of 217 A so DC limit is 543 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4. 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) / Vphase. The % DC injection should not be greater than 0.25%.			
Model: GT1-6KD1			
Test power level	10%	55%	100%
Recorded DC injection value in Amps	0.02	0.025	0.02
as % of rated AC current	0.077%	0.096%	0.077%
Limit	0.25%	0.25%	0.25%
Model: GT1-4KD1			
Test power level	10%	55%	100%
Recorded DC injection value in Amps	0.02	0.025	0.02
as % of rated AC current	0.11%	0.14%	0.11%
Limit	0.25%	0.25%	0.25%



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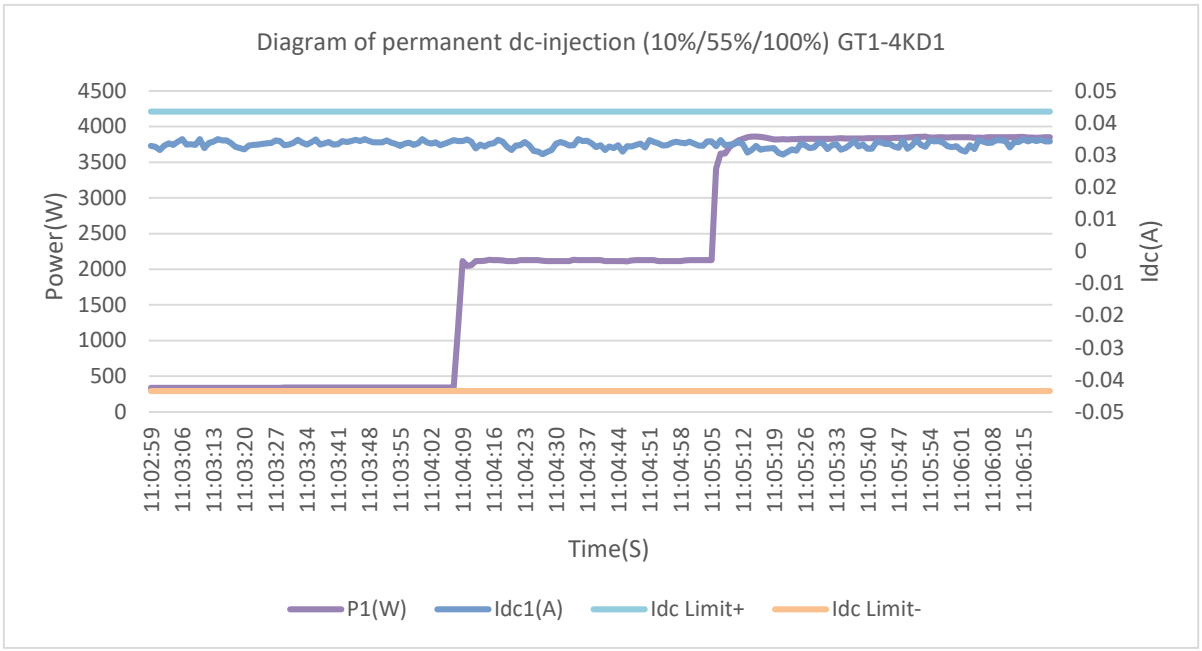

5. Power Factor:			P
The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity** and the measured **Power Factor** must be greater than 0.95 to pass. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2 Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required.			
Model:GT1-6KD1			
Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value	0.998	0.998	0.997
Power Factor Limit	>0.95	>0.95	>0.95
Model:GT1-4KD1			
Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value	0.998	0.998	0.997
Power Factor Limit	>0.95	>0.95	>0.95

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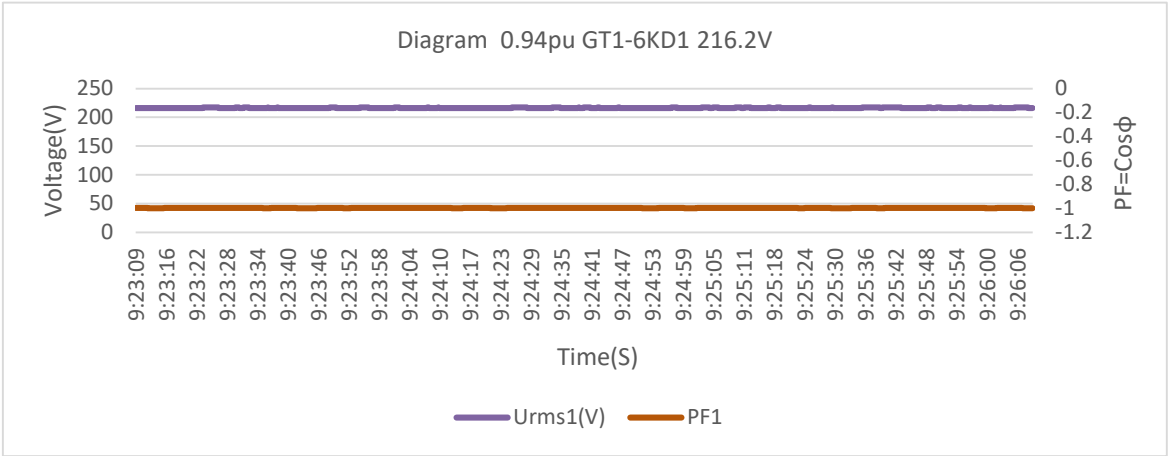

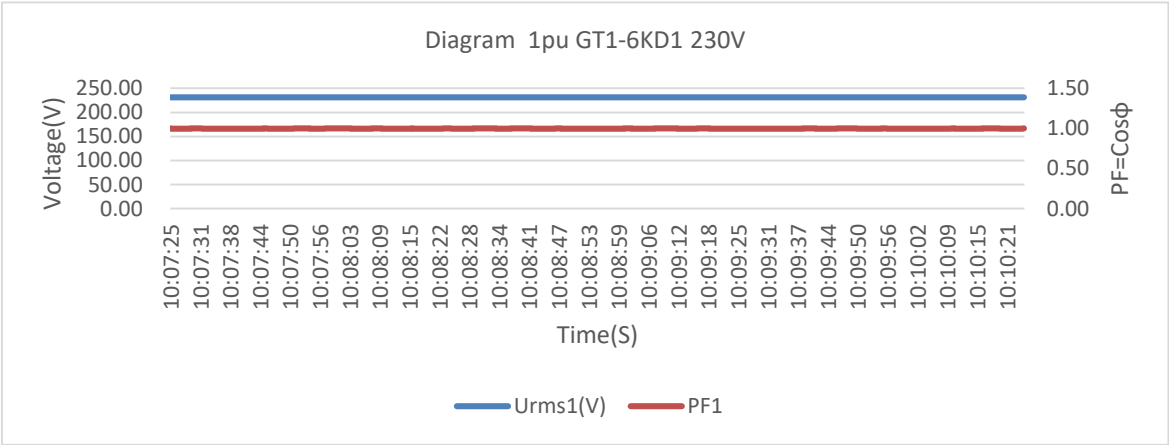

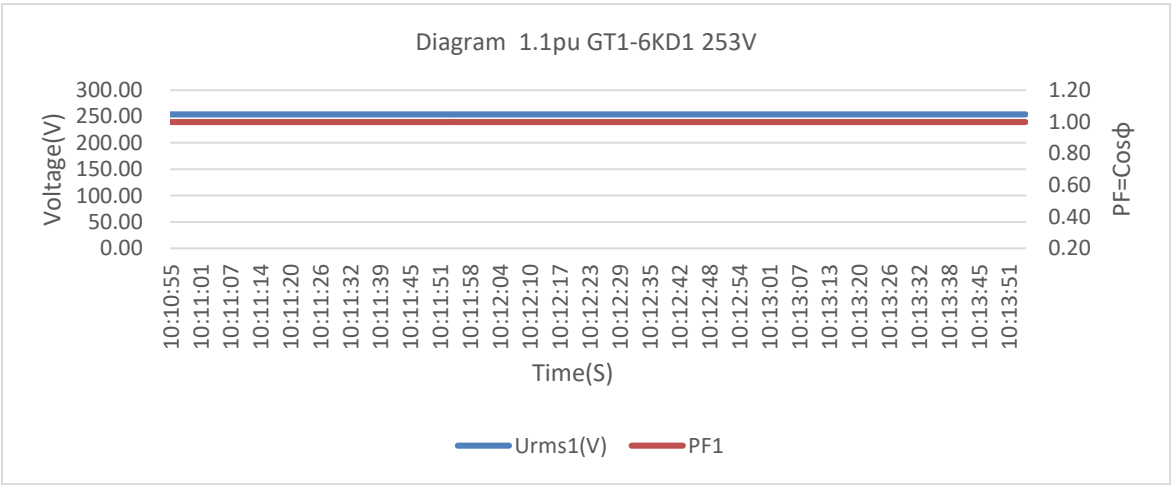

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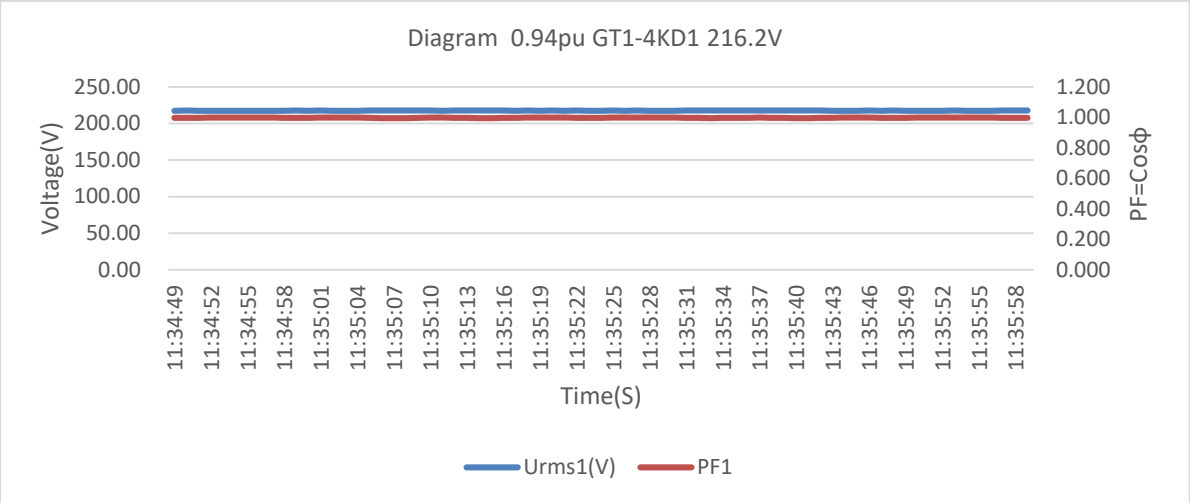

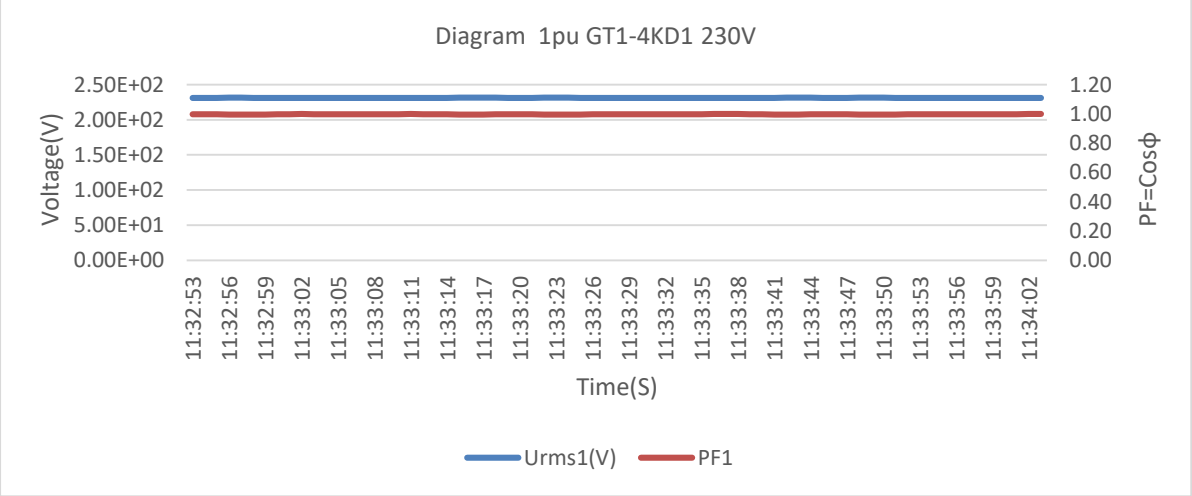

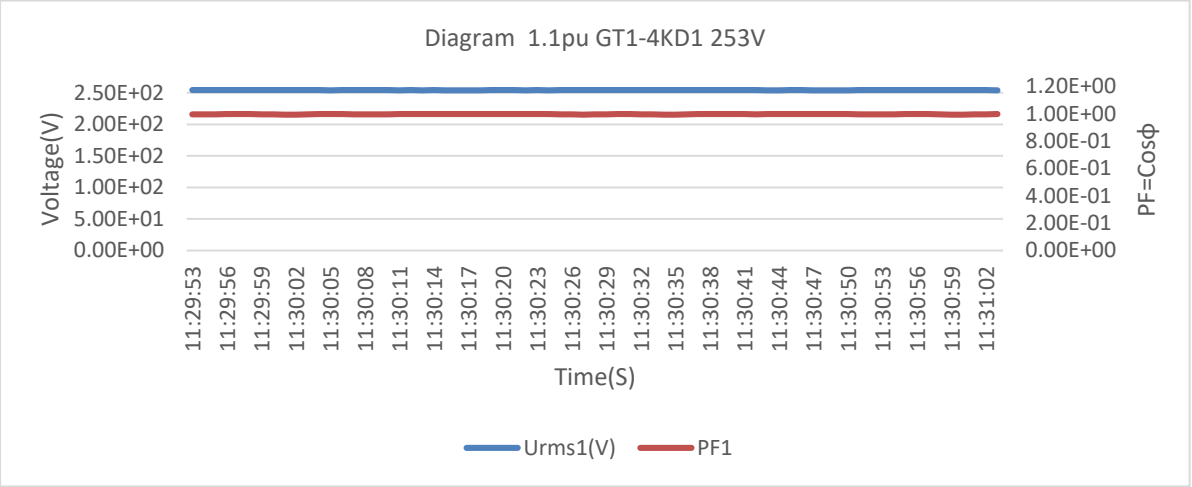

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6. Protection – Frequency tests:	**P**

These tests should be carried out in accordance with the Annex A.7.1.2.3. For trip tests, frequency and time delay should be stated. For “no trip tests”, “no trip” can be stated.

Model: GT1-6KD1

Function	Setting		Trip test		“No trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency / time	Confirm no trip
U/F stage 1	47.5 Hz	20 s	47.45HZ	20.04s	47.7 Hz 30 s	No trip
U/F stage 2	47.0 Hz	0.5 s	46.95HZ	0.506s	47.2 Hz 19.5 s	No trip
					46.8 Hz 0.45 s	No trip
O/F	52.0 Hz	0.5 s	52.05HZ	0.521s	51.8 Hz 120.0 s	No trip
					52.2 Hz 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.

Calibration and Accuracy Tests.

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*		*52.10*	Pass/ Fail	51.7-52.3 Hz	*0.50 s*		*0.60 s*	Pass/ Fail
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20	*47.40*		*47.60*	Pass /Fail	47.8-47.2 Hz	*20.0 s*		*20.2 s*	Pass/ Fail
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*		*47.1*	Pass/ Fail	47.3-46.7 Hz	*0.50 s*		*0.60 s*	Pass /Fail

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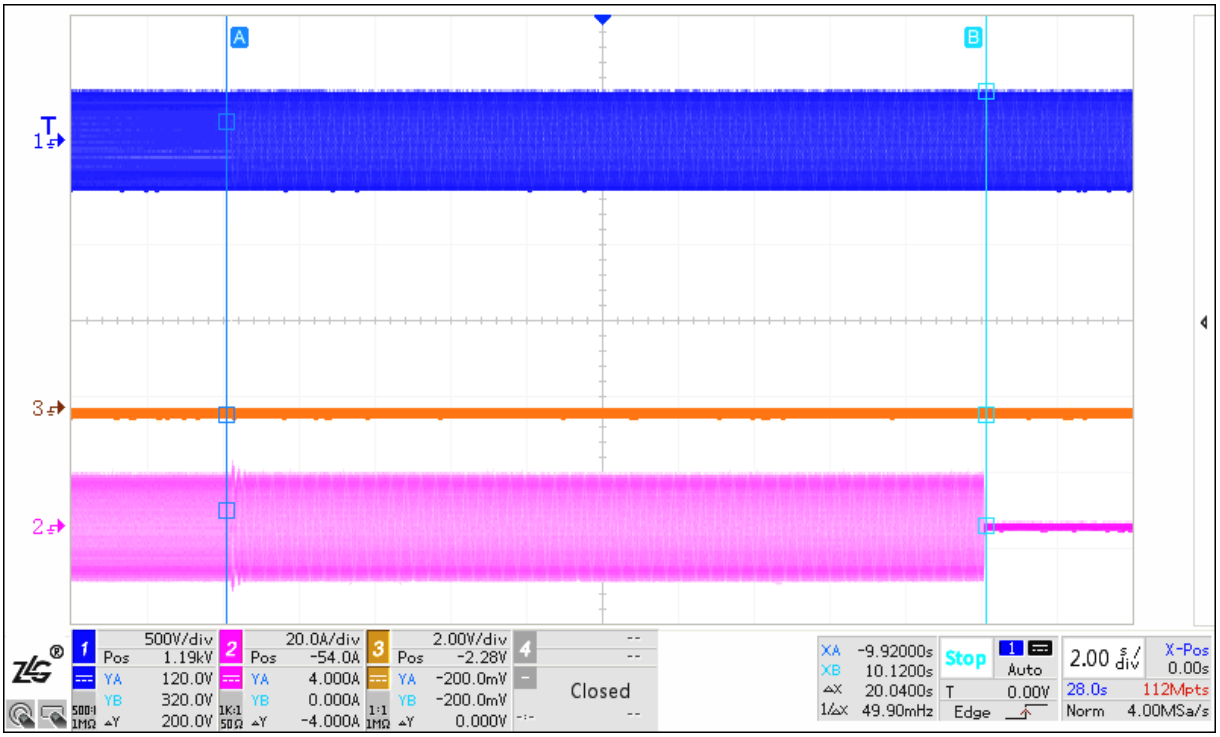
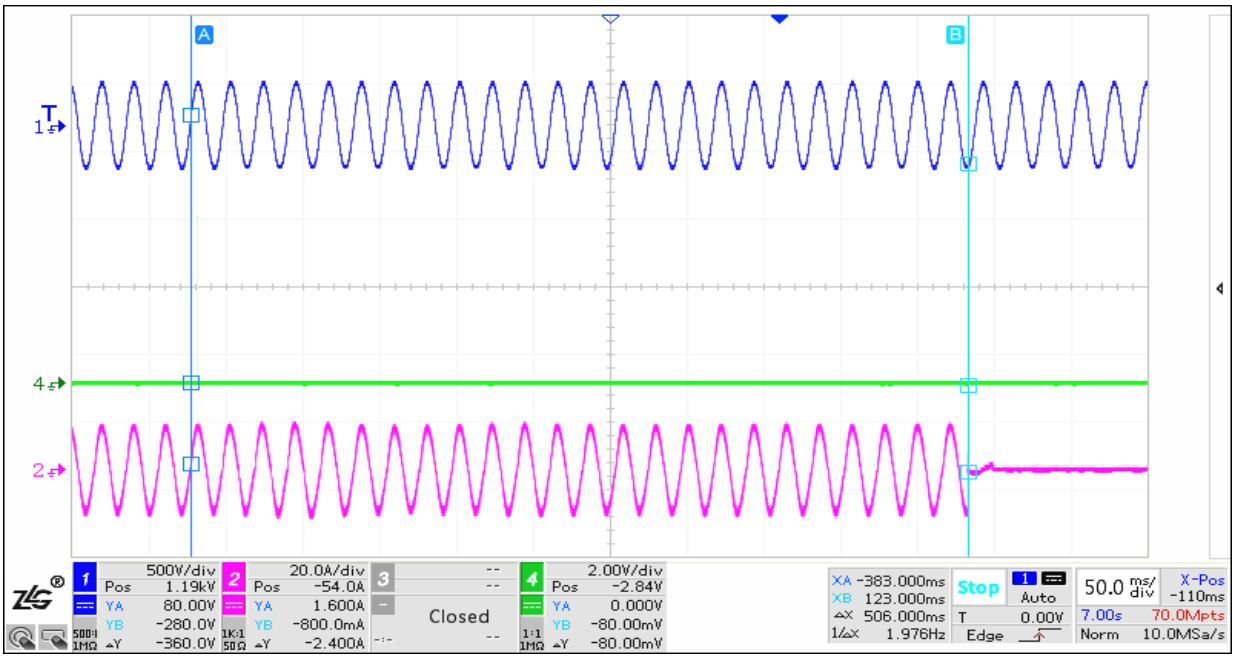
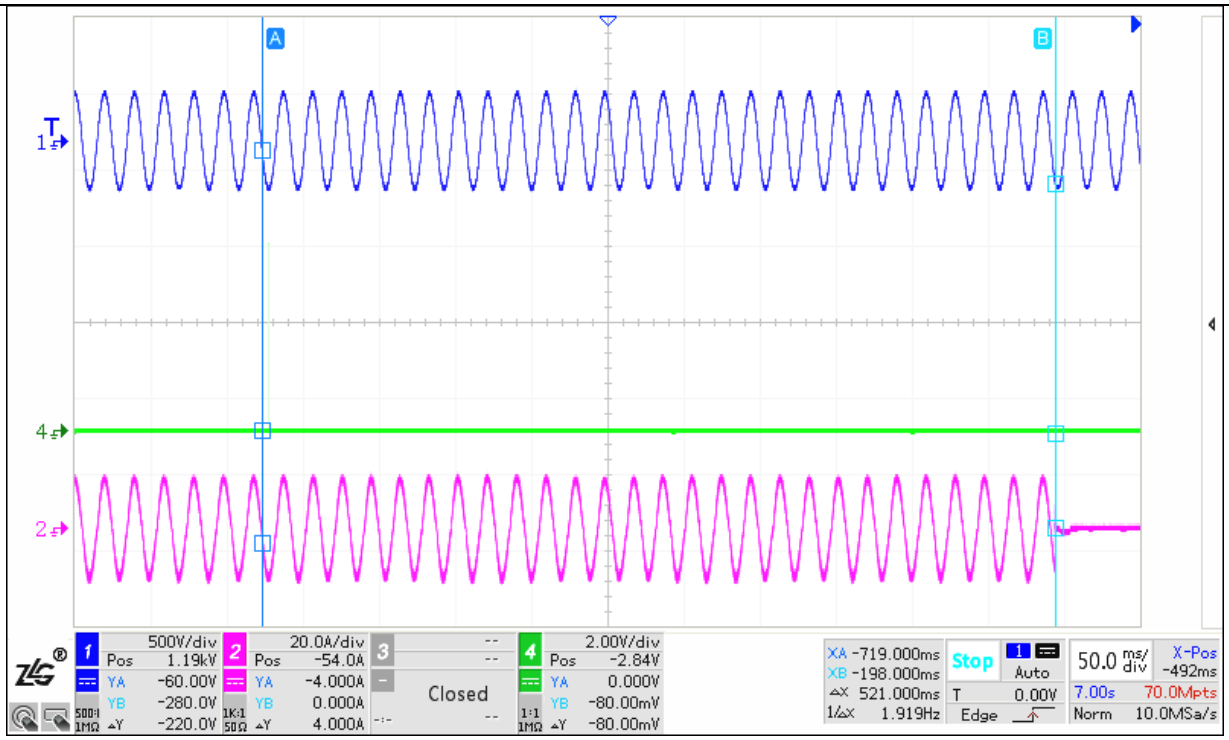
Graph of U/F stage 1



Graph of U/F stage 2



Graph of O/F stage



7. Protection – Voltage tests:						**P**
These tests should be carried out in accordance with Annex A.7.1.2.2. For trip tests, voltage and time delay should be stated. For “no trip tests”, “no trip” can be stated. Note that the value of voltage stated below assumes a **LV** connection This should be adjusted for **HV** taking account of the VT ratio as required.						
Model:GT1-6KD1						
Function	Setting		Trip test		“No trip tests”	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V	0.8 pu (184 V)	2.5 s	183V	2.516s	188 V 5.0 s	no trip
					180 V 2.45 s	no trip
O/V stage 1	1.14 pu (262.2 V)	1.0 s	262.7V	1.026s	258.2 V 5.0 s	no trip
O/V stage 2	1.19 pu (273.7 V)	0.5 s	274.2V	0.517s	269.7 V 0.95 s	no trip
					277.7 V 0.45 s	no trip
Note: For Voltage tests the Voltage required to trip is the setting ±3.45 V. 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 ±4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

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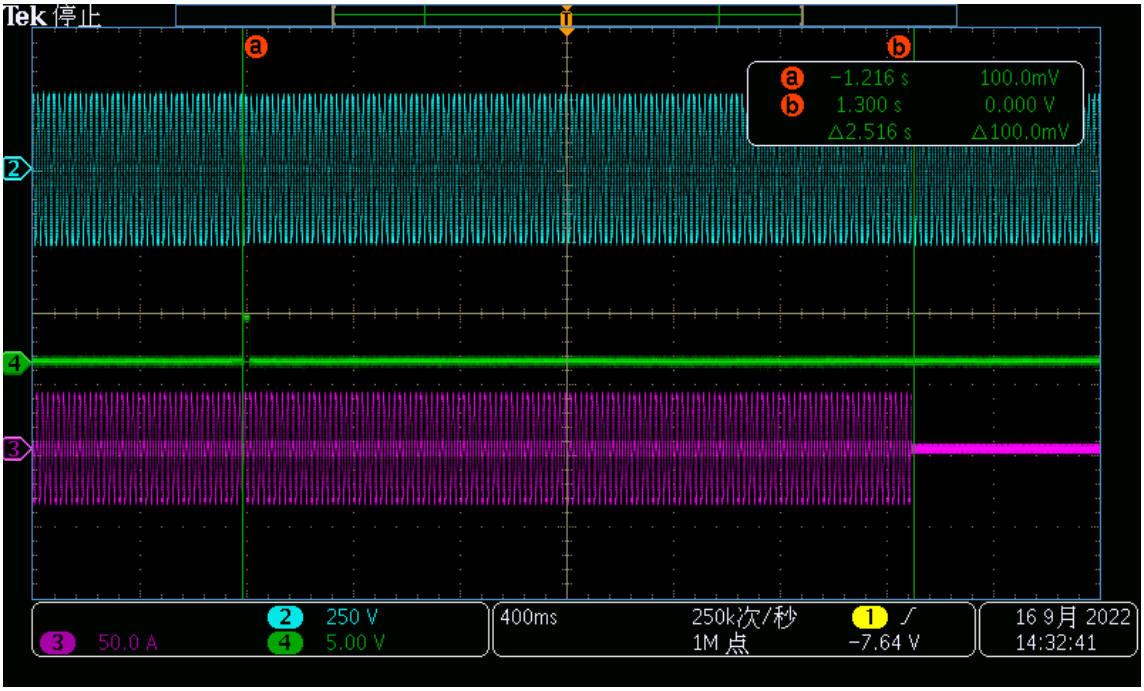
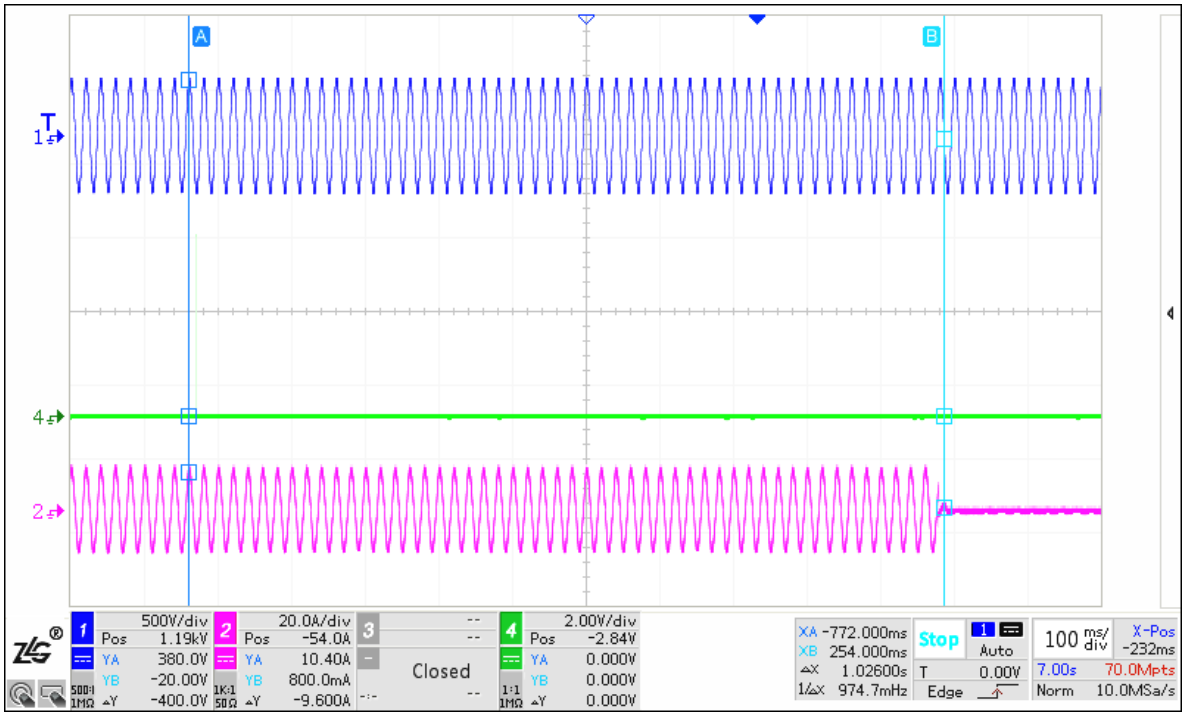
Graph of U/V **Stage**



Graph of O/V stage 1



Graph of O/V stage 2

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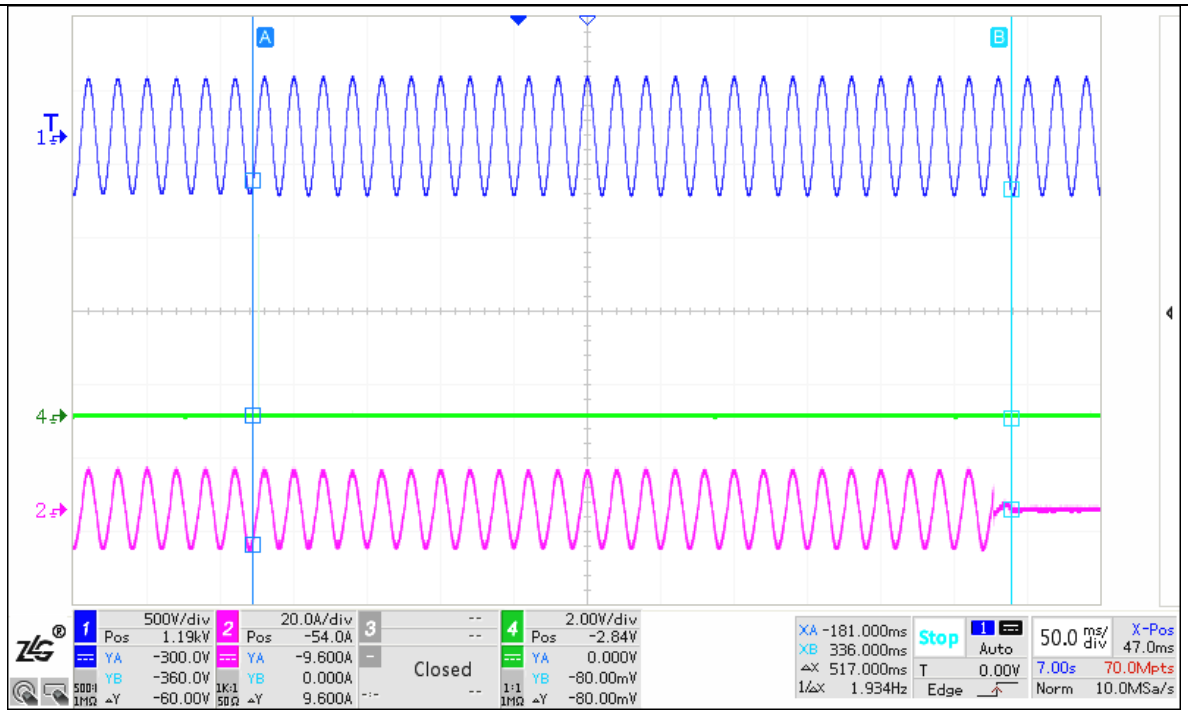

8. Protection – Loss of Mains test:	**P**
These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4. For test condition A, EUT output = 100 % P_n, test condition B, EUT output = 50 % to 66 % P_n, and test condition C, EUT output = 25 % to 33 % P_n.	
Model:GT1-6KD1	
The following 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% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. **Limit is 0.5s**	467ms	437ms	447ms	465ms	387ms	455ms

No.	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L)	P_{AC} b) (% of nominal)	Q_{AC} c) (% of nominal)	Run-on time (ms)	P_{EUT}	Actual Q_f	V_{DC} d)	Remarks e)
1	100	100	0	0	555	6000	1.00	468	Test A at BL
2	66	66	0	0	615	4000	1.00	388	Test B at BL
3	33	33	0	0	565	2000	1.00	306	Test C at BL
4	100	100	-5	-5	585	6000	0.95	468	Test A at IB
5	100	100	-5	0	447	6000	1.00	468	Test A at IB
6	100	100	-5	+5	415	6000	1.05	468	Test A at IB
7	100	100	0	-5	565	6000	0.95	468	Test A at IB
8	100	100	0	+5	445	6000	1.05	468	Test A at IB
9	100	100	+5	-5	565	6000	0.95	468	Test A at IB

10	100	100	+5	0	455	6000	1.00	468	Test A at IB
11	100	100	+5	+5	465	6000	1.05	468	Test A at IB
12	66	66	0	-5	437	4000	0.95	388	Test B at IB
13	66	66	0	-4	725	4000	0.96	388	Test B at IB
14	66	66	0	-3	705	4000	0.97	388	Test B at IB
15	66	66	0	-2	575	4000	0.98	388	Test B at IB
16	66	66	0	-1	515	4000	0.99	388	Test B at IB
17	66	66	0	+1	485	4000	1.01	388	Test B at IB
18	66	66	0	+2	465	4000	1.02	388	Test B at IB
19	66	66	0	+3	515	4000	1.03	388	Test B at IB
20	66	66	0	+4	467	4000	1.04	388	Test B at IB
21	66	66	0	+5	387	4000	1.05	388	Test B at IB
22	33	33	0	-5	467	2000	0.95	388	Test C at IB
23	33	33	0	-4	565	2000	0.96	306	Test C at IB
24	33	33	0	-3	525	2000	0.97	306	Test C at IB
25	33	33	0	-2	505	2000	0.98	306	Test C at IB
26	33	33	0	-1	575	2000	0.99	306	Test C at IB
27	33	33	0	+1	625	2000	1.01	306	Test C at IB
28	33	33	0	+2	445	2000	1.02	306	Test C at IB
29	33	33	0	+3	455	2000	1.03	306	Test C at IB
30	33	33	0	+4	495	2000	1.04	306	Test C at IB
31	33	33	0	+5	465	2000	1.05	306	Test C at IB

Note:

a) P_{EUT}: EUT output power.

b) P_{ac}: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

c) Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

d) For test condition A, > 75 % of rated input voltage range used, for test condition B, 50 % of rated input voltage range, ±10 % used, for test condition C, < 20 % of rated input voltage range used. Based on EUT rated input operating range. For example, if range is between X volts and Y volts, 75 % of range = X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

e) BL: Balance condition, IB: Imbalance condition.

If the device requires additional shut down time (beyond 0.5 s but less than 1 s) then this should be stated on this form.

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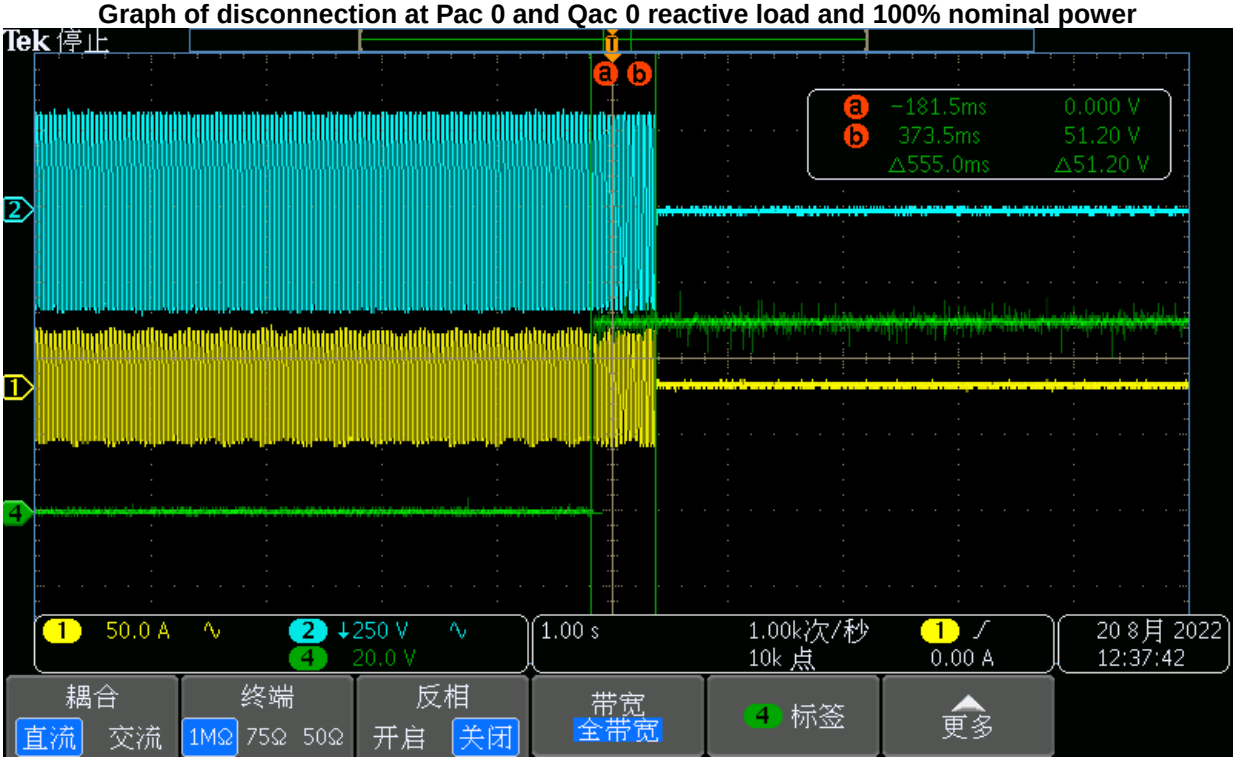
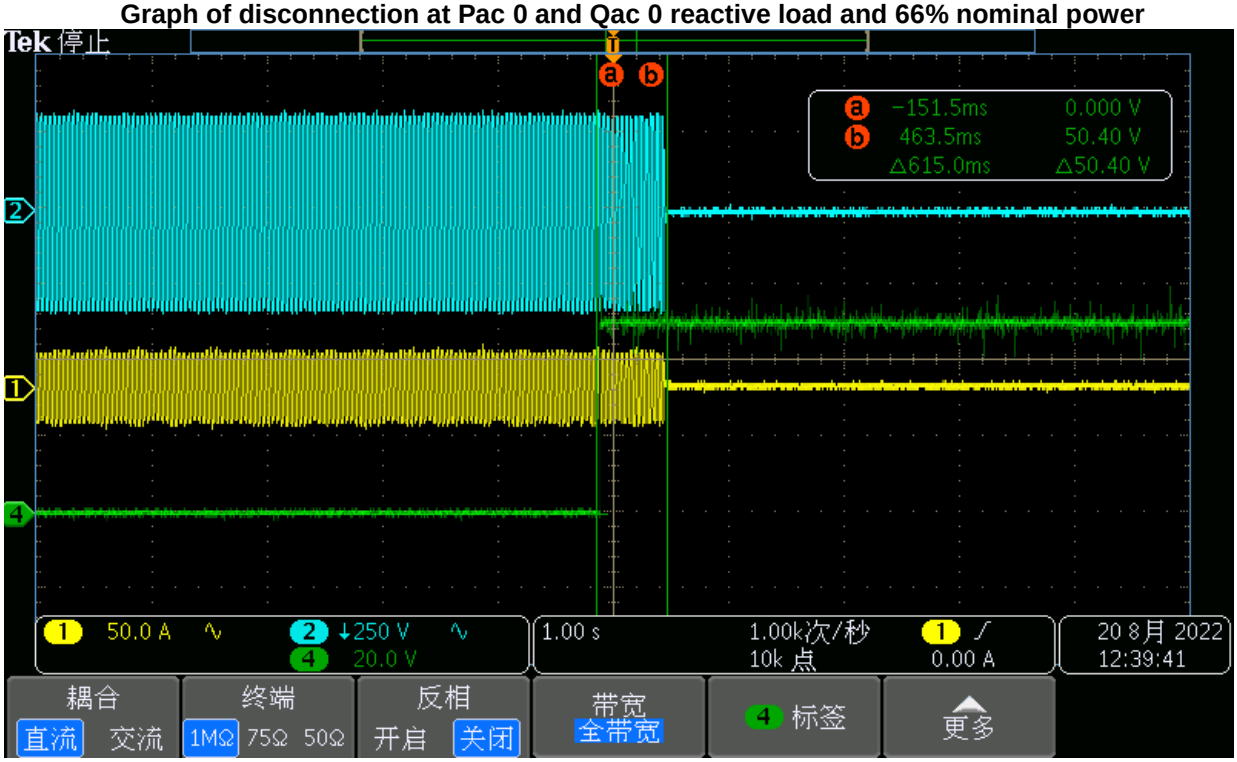
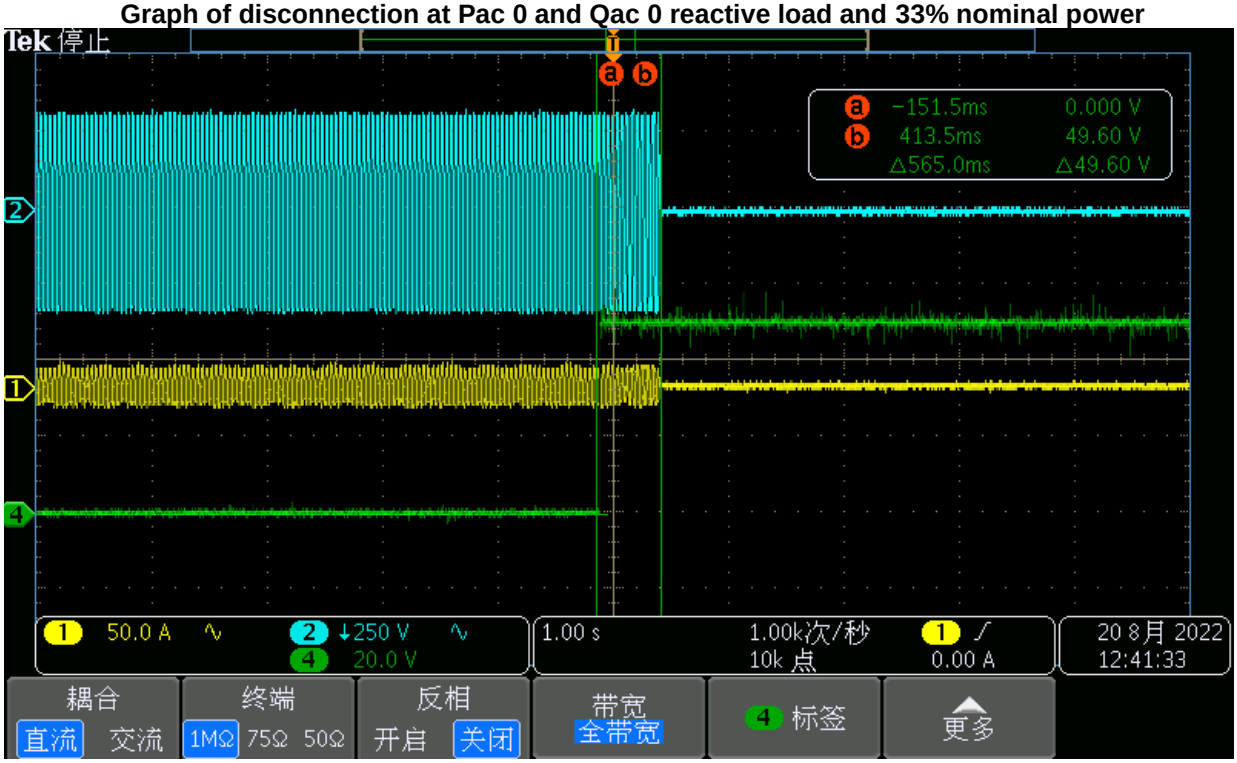
Graph of disconnection at Pac 0 and Qac 0 reactive load and 100% nominal power



Graph of disconnection at Pac 0 and Qac 0 reactive load and 66% nominal power



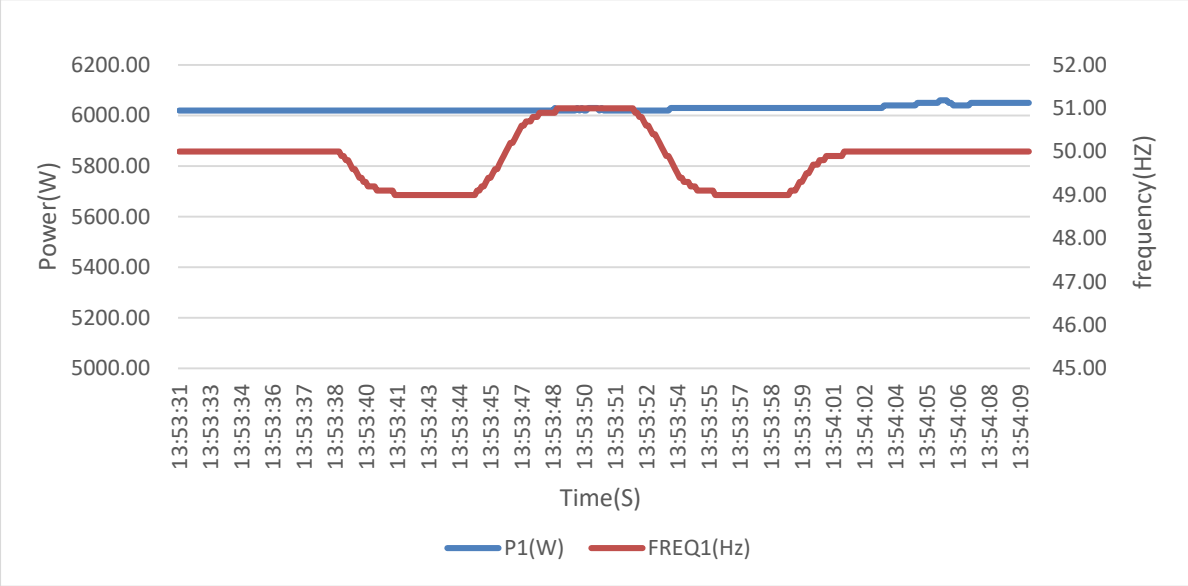
Graph of disconnection at Pac 0 and Qac 0 reactive load and 33% nominal power



Channel 1: AC current Channel 2: AC voltage Channel 4: trigger signal

9. Loss of Mains Protection, Vector Shift Stability test:			**P**
This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip under positive / negative vector shift.			
Model:GT1-6KD1			
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+50 degrees	No trip
Negative Vector Shift	50.5 Hz	- 50 degrees	No trip
10. Loss of Mains Protection, RoCoF Stability test:			**P**
This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip for the duration of the ramp up and ramp down test.			
Model:GT1-6KD1			
Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.95 Hzs^{-1}	2.1 s	No trip
51.0 Hz to 49.0 Hz	-0.95 Hzs^{-1}	2.1 s	No trip

Diagram Frequency change 49Hz-51Hz-49Hz

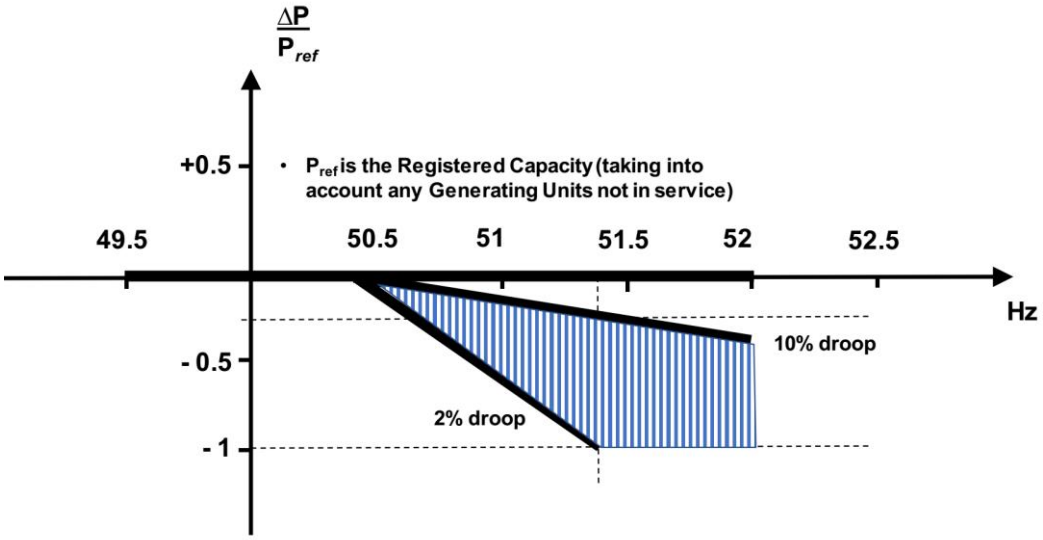


11. Limited Frequency Sensitive Mode – Over frequency test:					**P**
The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%. This test should be carried out in accordance with A.7.1.3, which also contains the measurement tolerances.					
Active Power response to rising frequency/time plots are attached if frequency injection tests are undertaken in accordance with Annex A.7.2.4					Y
Model:GT1-6KD1					
Alternatively, simulation results should be noted below:					
Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output (W)	Frequency (Hz)	Calculated droop (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	6000	50.00	-	Photovoltaic array simulator (100%Pn)	-
Step b) 50.45 Hz ±0.05 Hz	5930	50.45	8.6%		-
Step c) 50.70 Hz ±0.10 Hz	5600	50.70	9.1%		-
Step d) 51.15 Hz ±0.05 Hz	5000	51.15	9%		-
Step e) 50.70 Hz ±0.10 Hz	5600	50.70	9%		-
Step f) 50.45 Hz ±0.05 Hz	5930	50.45	8.6%		-
Step g) 50.00 Hz ±0.01 Hz	6000	50.00	-		10%Pn/min
Test sequence at **Registered Capacity** 40-60%	Measured **Active Power** Output (W)	Frequency (Hz)	Calculated droop (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	3000	50.00	-	Photovoltaic array simulator	-
Step b) 50.45 Hz ±0.05 Hz	2934	50.45	9.1%		-

Step c) 50.70 Hz ±0.10 Hz	2648	50.70	10.5%	（50%Pn）	-
Step d) 51.15 Hz ±0.05 Hz	2161	51.15	11%		-
Step e) 50.70 Hz ±0.10 Hz	2656	50.70	10.9%		-
Step f) 50.45 Hz ±0.05 Hz	2934	50.45	10.8%		-
Step g) 50.00 Hz ±0.01 Hz	3018	50.00	-		10%Pn/min

The frequency at each step should be maintained for at least one minute and the Active Power reduction in the form of a gradient determined and assessed for compliance with paragraph 11.2.3. The Droop should be determined from the measurements between 50.4 Hz and 51.15 Hz. The allowed tolerance for the frequency measurement shall be ± 0.05 Hz. The allowed tolerance for Active Power output measurement shall be ±10% of the required change in Active Power.

The resulting overall tolerance range for a nominal 10% Droop is +2.8% and – 1.5%, ie a Droop less than 12.8% and greater than 8.5%.



P_{ref} is the reference **Active Power** to which ΔP is related and. ΔP is the change in **Active Power** output from the **Power Generating Module**.

Figure 11.3 Active Power Frequency Response capability when operating in LFSM-O

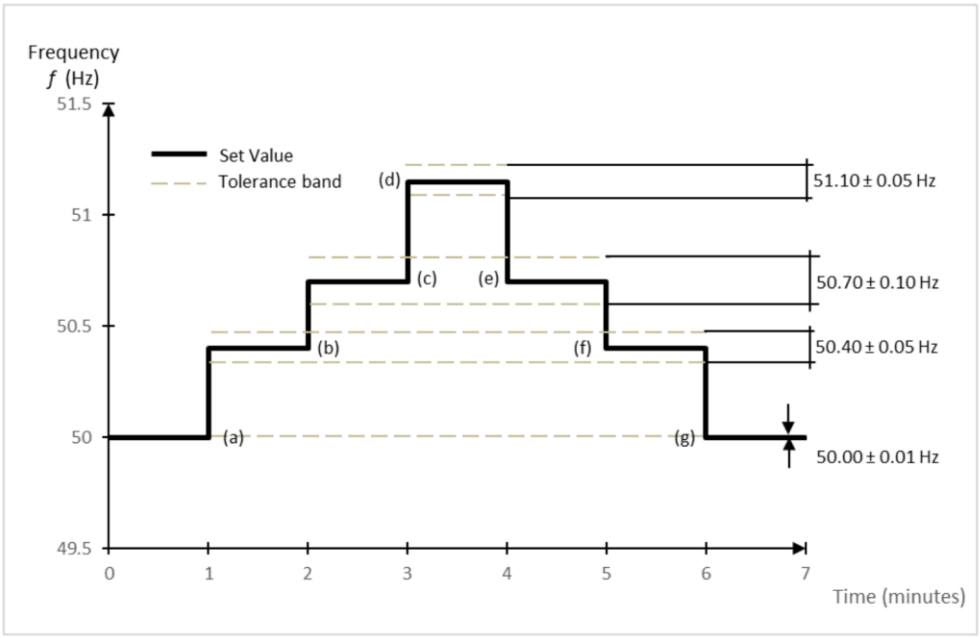
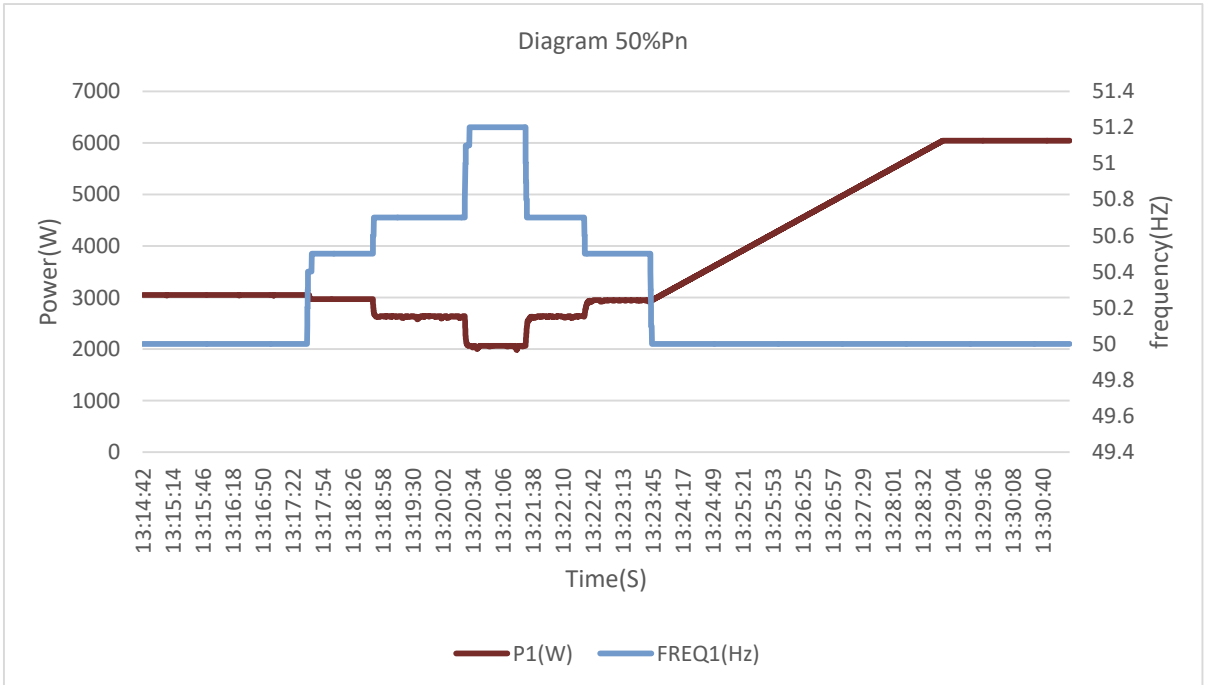
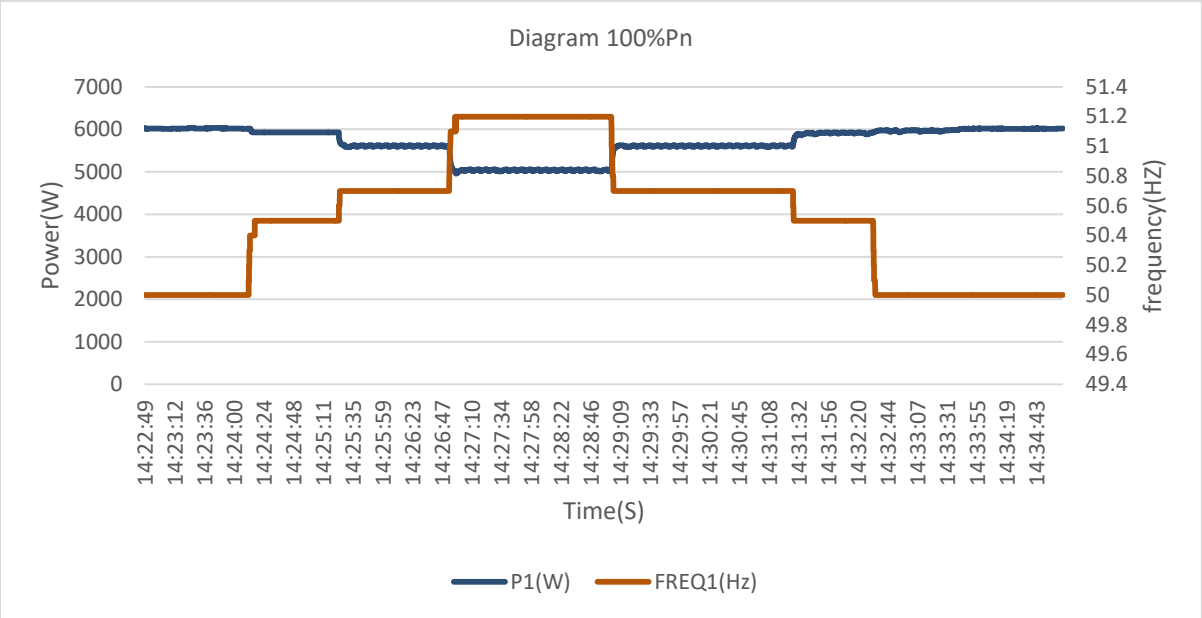


Figure A.7.3 Testing the **Active Power** feed-in of the **Power Generating Module** at over frequency





12. Power output with falling frequency test (For PV Inverter):				**P**
Tests should prove that the Power Generating Module does not reduce output power as the frequency falls. These tests should be carried out in accordance with Annex A.7.2.3.				
Model: GT1-6KD1				
Test sequence	Measured Active Power Output (W)	Acceptable Active Power	Frequency (Hz)	Primary power source
49.5 Hz for 5 minutes	6028.32	100% Registered Capacity	49.50	Photovoltaic array simulator
49.0 Hz for 5 minutes	5999.78	99% Registered Capacity	49.00	Photovoltaic array simulator
48.0 Hz for 5 minutes	5989.78	97% Registered Capacity	48.00	Photovoltaic array simulator
47.6 Hz for 5 minutes	5988.28	96.2% Registered Capacity	47.60	Photovoltaic array simulator
47.1 Hz for 5 minutes	6004.87	95% Registered Capacity	47.10	Photovoltaic array simulator
NOTE:				

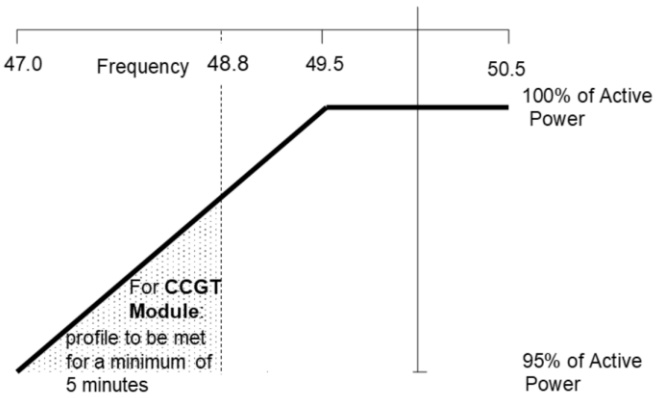


Figure 11.1 Change in Active Power with falling frequency

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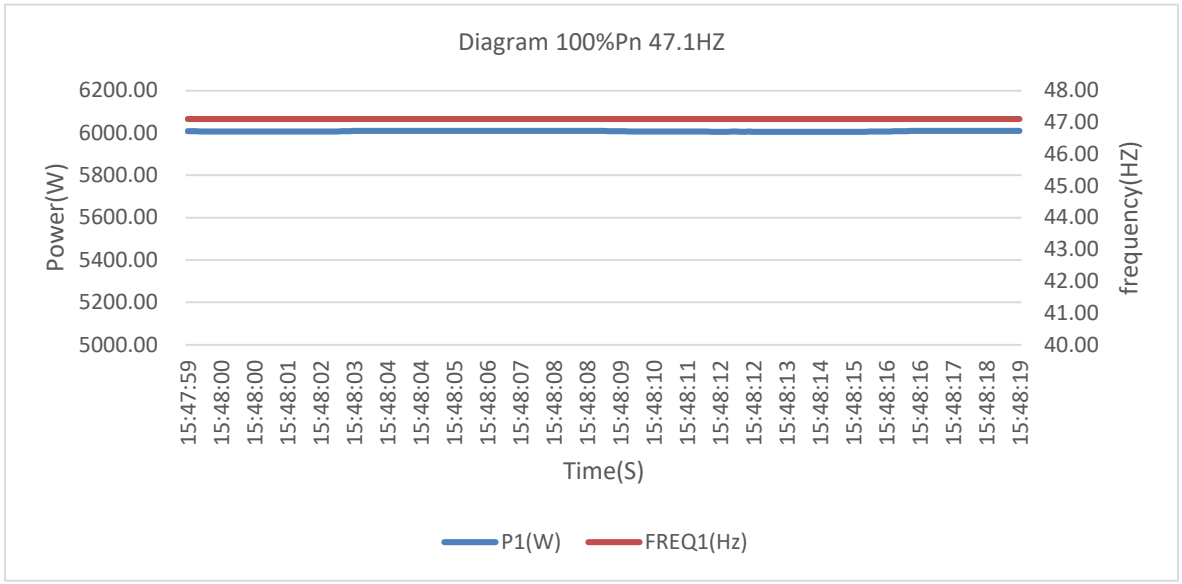

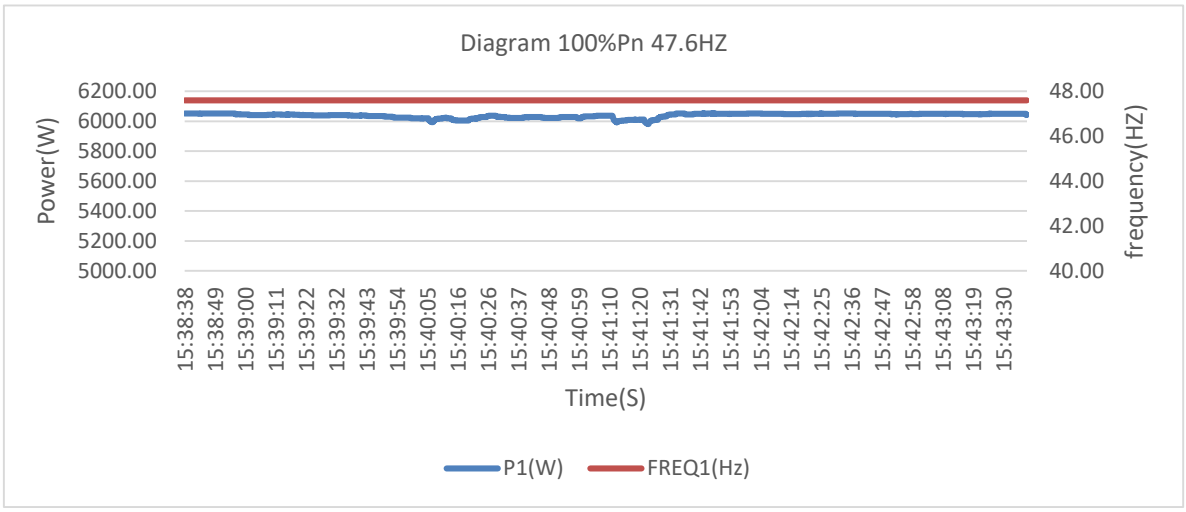

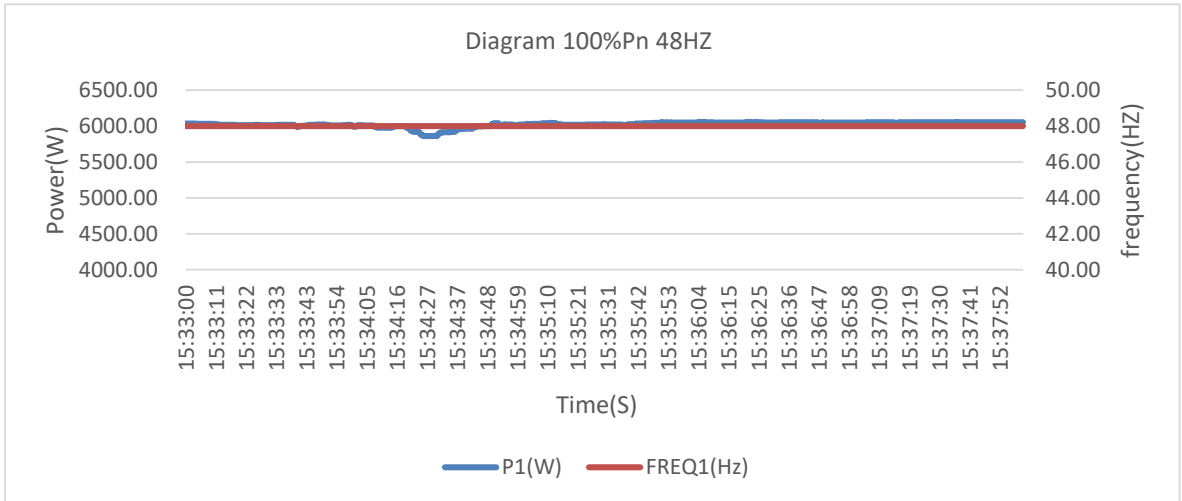

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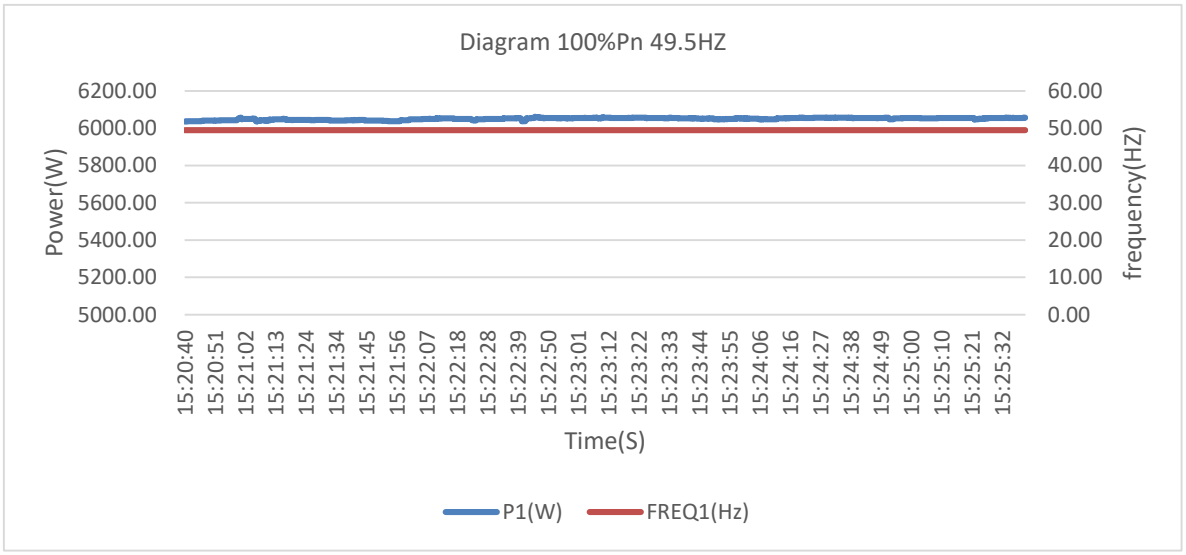

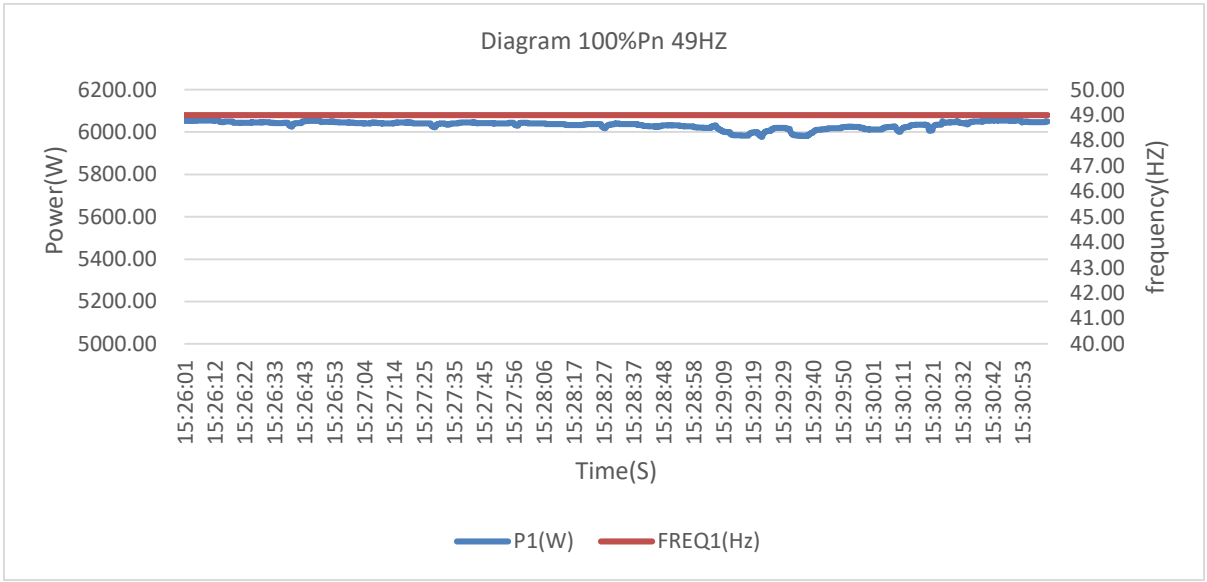

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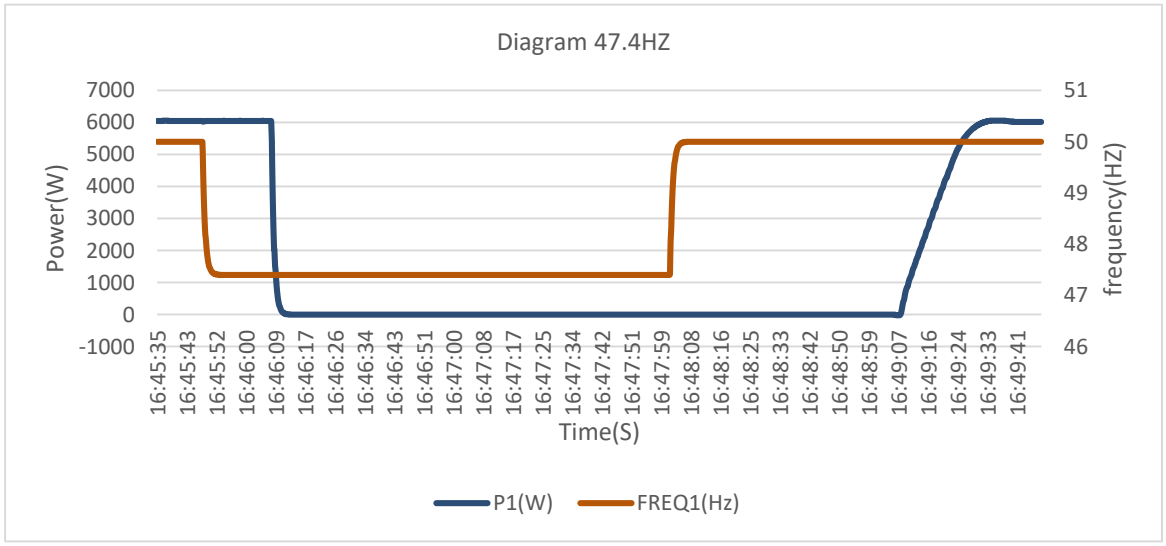
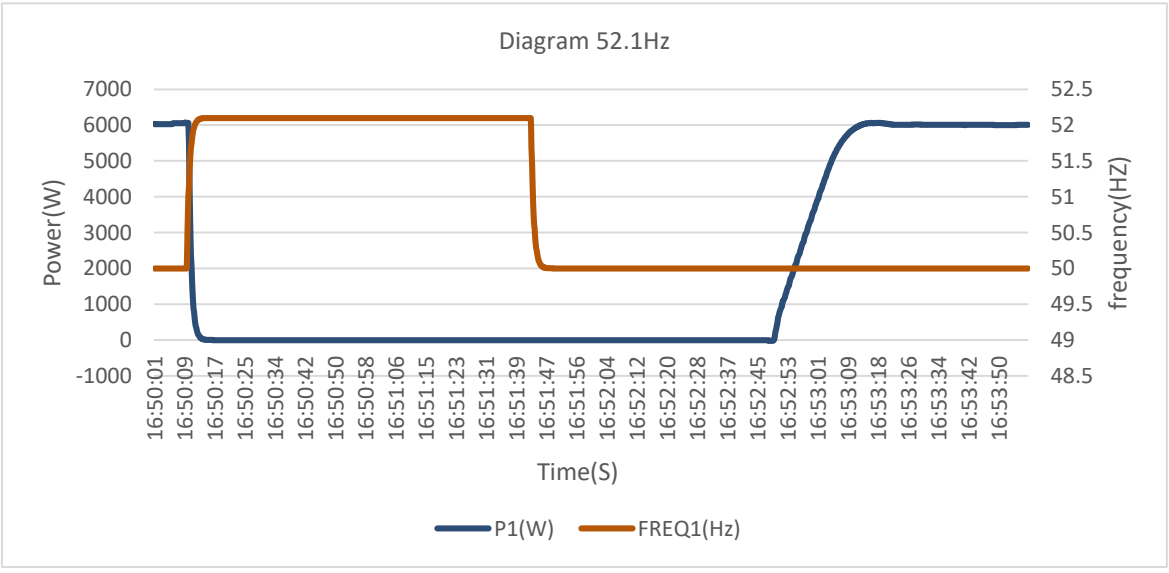
13. Protection – Re-connection timer					P
Model:GT1-6KD1					
Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 10.1. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Power Generating Module** does not reconnect at the voltage and frequency settings below; a statement of “no reconnection” can be made.					
Time delay setting	Measured delay	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of Table 10.1.			
60 s	60 s	At 1.16 pu (266.2 V **LV** connection)	At 0.78 pu (180.0 V **LV** connection)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Power Generating Module** does not re-connect.		Yes	Yes	Yes	Yes





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1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

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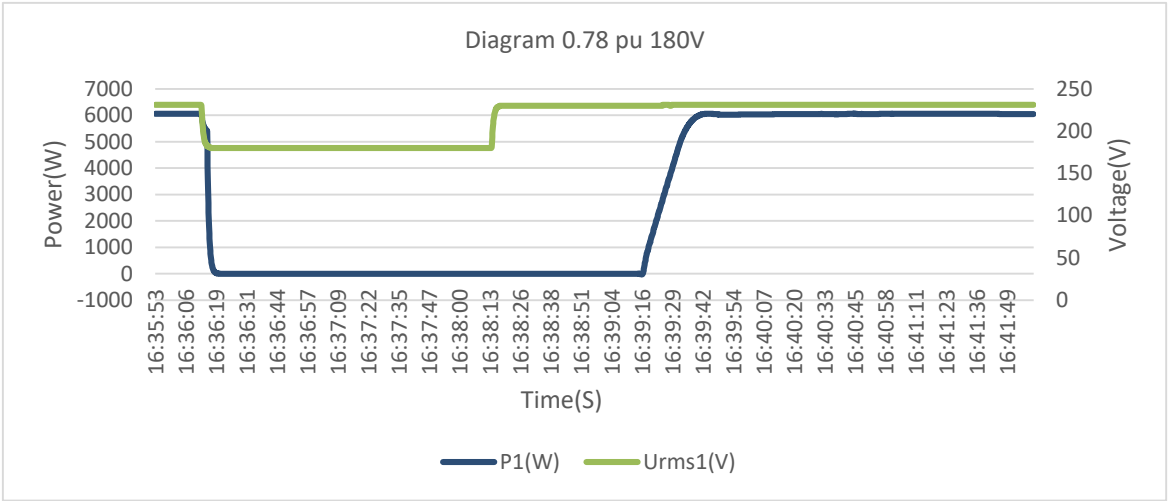

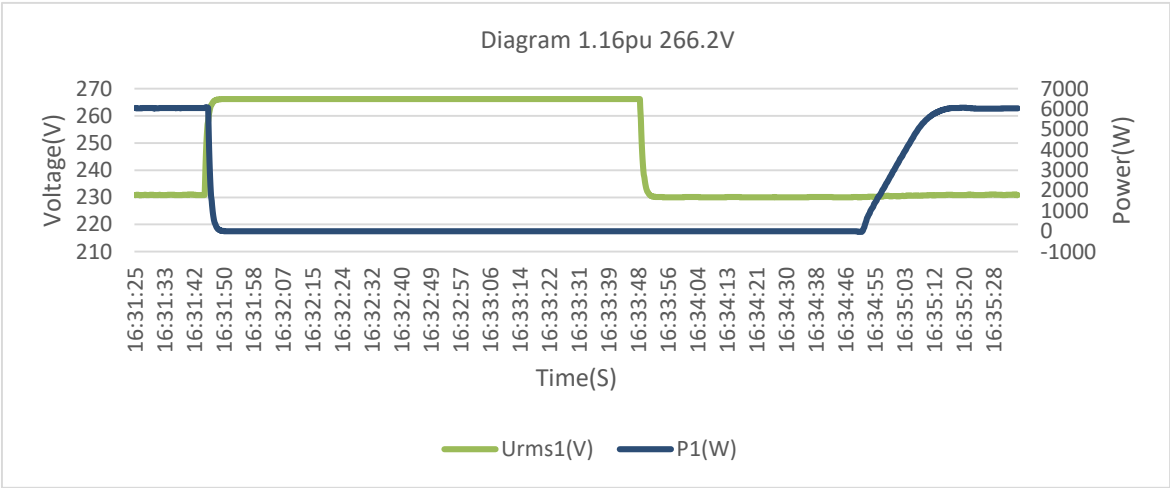

14. Fault level contribution:					**P**
These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5. Please complete each entry, even if the contribution to the fault level is zero.					
Model: GT1-6KD1					
For machines with electro-magnetic output			For **Inverter** output		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	N/A	20ms	260V	22A
Initial Value of aperiodic current	A	N/A	100ms	240V	22A
Initial symmetrical short-circuit current*	I_k	N/A	250ms	200V	20A
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	150V	10A
Reactance/Resistance Ratio of source*	$^X/_R$	N/A	Time to trip	629.5ms	In seconds

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For rotating machines and linear piston machines the test should produce a 0 s – 2 s plot of the short circuit current as seen at the **Micro-generator** terminals.

* Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot.

15. Self-Monitoring solid state switching: No specified test requirements. Refer to Annex A.7.1.6.	
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.	NA
16. Wiring functional tests: If required by para 15.2.1.	
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)	NA
17. Logic interface (input port).	
Confirm that an input port is provided and can be used to shut down the module.	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.	
18. Cyber security	
Confirm that the Power Generating Module has been designed to comply with cyber security requirements, as detailed in 9.1.7.	Yes
Additional comments.	
The Manufacturer of the Micro-generator has provided a statement describing how the Microgenerator has been designed to comply with cyber security requirements in 9.1.7.	

Signed

Hangzhou Livoltek Power Co., Ltd.