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 **Power Generating Module** is **Fully Type Tested** and registered with the Energy Networks Association (ENA) Type Test Verification Report Register, the Installation Document (Form A3) should include the **Manufacturer's** reference number (the Product ID), and this form does not need to be submitted.

Where the **Power Generating Module** is not registered with the ENA Type Test Verification Report Register or is not **Fully Type Tested** this form (all or in parts as applicable) needs to be completed and provided to the **DNO**, to confirm that the **Power Generating Module** has been tested to satisfy all or part of the requirements of this EREC G99.

PGM technology		Inverter: Hyper-4600, Hyper-5000 Retro-4600, Retro-5000	
Manufacturer name		Hangzhou Livoltek Power Co., Ltd.	
Address		1418-35 Moganshan Road, Shangcheng Industrial Zone, 310011 Hangzhou, Zhejiang Province, P.R. China	
Tel	+86-571-28330320	Web site	www.livoltek.com
E:mail	info@livoltek.com		
Registered Capacity		4.6kW, 5.0kW	

Engineering Recommendation G99 Form A2-3

Type A Power Generating Modules

There are four options for Testing: (1) **Fully Type Tested**, (2) Partially **Type Tested**, (3) one-off installation, (4) tested on site at time of commissioning. The check box below indicates which tests in this Form have been completed for each of the options. With the exception of **Fully Type Tested PGMs** tests marked with * may be carried out at the time of commissioning (Form A4).

Tested option:	**1. Fully Type Tested**	**2. Partially Type Tested**	**3. One-off Man. Info.**	**4. Tested on Site at time of Commission -ing**
0. **Fully Type Tested** - all tests detailed below completed and evidence attached to this submission		**N/A**	**N/A**	**N/A**
1. Operating Range	**N/A**	✓		
2. PQ – Harmonics		✓		
3. PQ – Voltage Fluctuation and Flicker		✓		
4. PQ – DC Injection (**Power Park Modules** only)		✓		
5. **Power Factor** (PF)*		✓		
6. Frequency protection trip and ride through tests*		✓		
7. Voltage protection trip and ride through tests*		✓		
8. Protection – Loss of Mains Test*, Vector Shift and RoCoF Stability Test*		✓		
9. **LFSM-O** Test*		✓		
10. Protection – Reconnection Timer*		✓		
11. Fault Level Contribution		✓		
12. Self-monitoring Solid State Switch		✓		
13. Wiring functional tests if required by para 15.2.1 (attach relevant schedule of tests)*		✓		
14. Logic Interface (input port)*		✓		
15. Cyber security*		✓		

* may be carried out at the time of commissioning (Form A.2-4).

Document reference(s) for **Manufacturers' Information:**

Engineering Recommendation G99 Form A2-3

Type A Power Generating Modules

Manufacturer compliance declaration. - I certify that all products supplied by the company with the above **Type Tested Manufacturer's** 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.			
Signed	Jesse Xia	On behalf of	Hangzhou Livoltek Power Co., Ltd.
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.			

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

LIVOLTEK
POWERING YOUR LIFE

G99 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**	Test chart to confirm operation

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

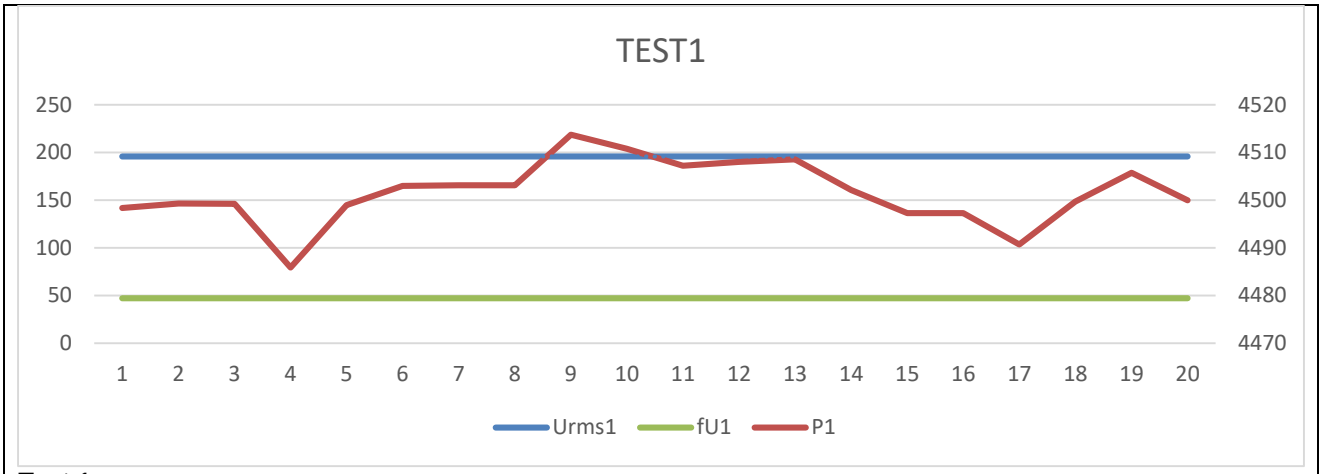
LIVOLTEK
POWERING YOUR LIFE

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.	

Model:				
Test 1:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (seconds)
195.92	47.00	4501.62	0.9989	15
Test 2:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
195.53	47.50	4268.12	0.9982	90
Test 3:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
253.38	51.5	4982.50	0.9964	90
Test 4:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
253.26	52.00	5027.79	0.9977	15
Test 5:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
230.54	50	4998.97	0.9976	90
Test 6:				
Measured Voltage (V)	Ramp range	Test frequency ramp	Test Duration	Confirm no trip
195.5	47.0 Hz to 52.0 Hz	+1 Hzs^{-1}	5s	No trip
253.0	52.0 Hz to 49.0 Hz	-1 Hzs^{-1}	3s	No trip

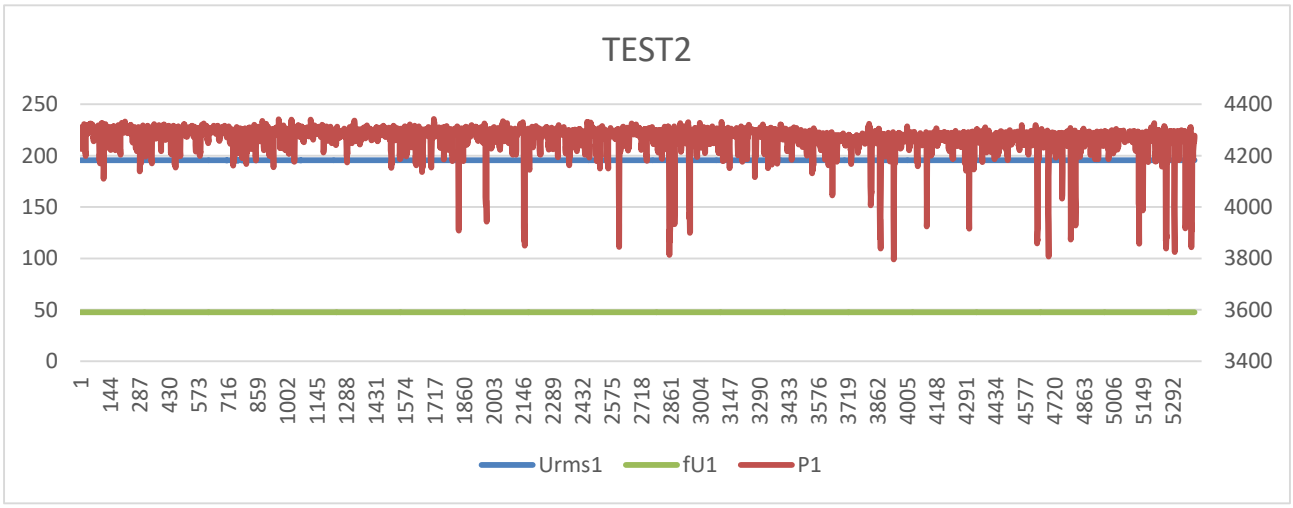
Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

LIVOLTEK
POWERING YOUR LIFE

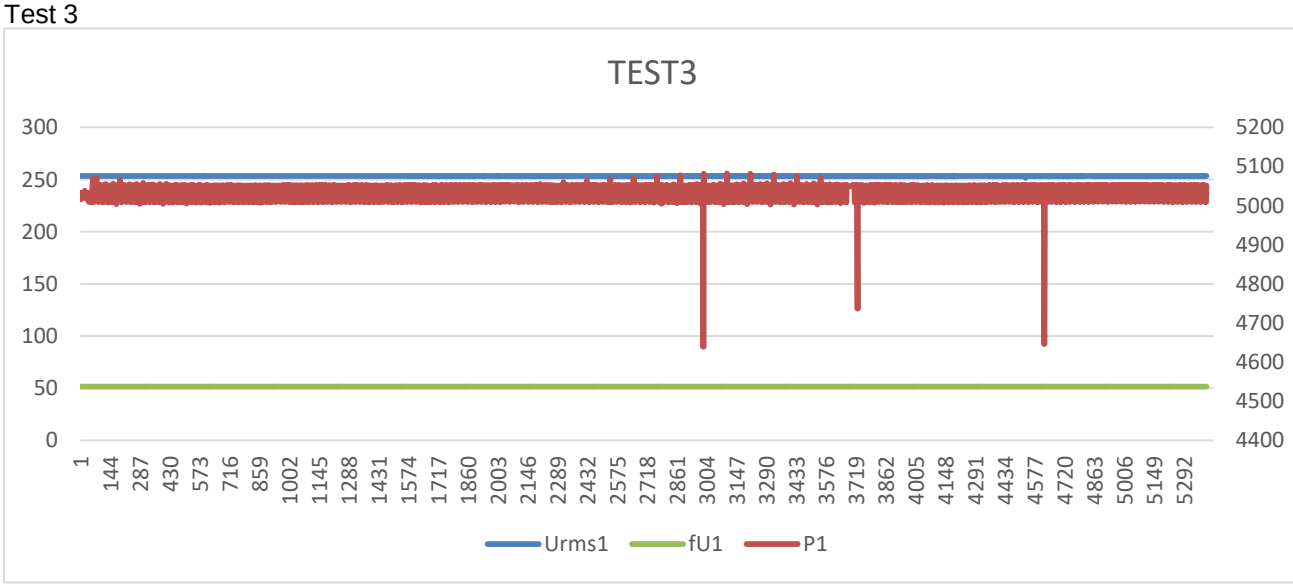


Test 1

Test 2



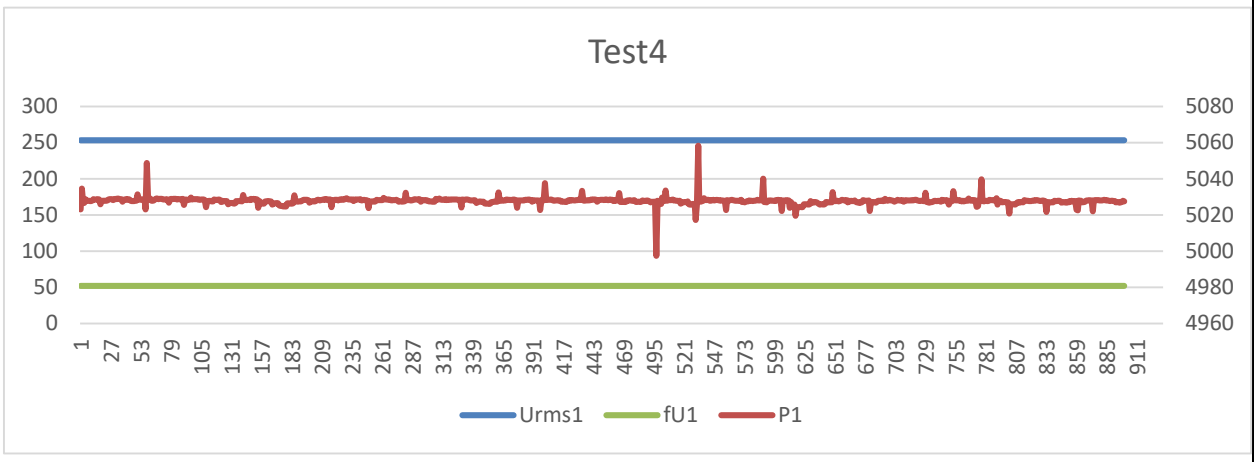
Test 3



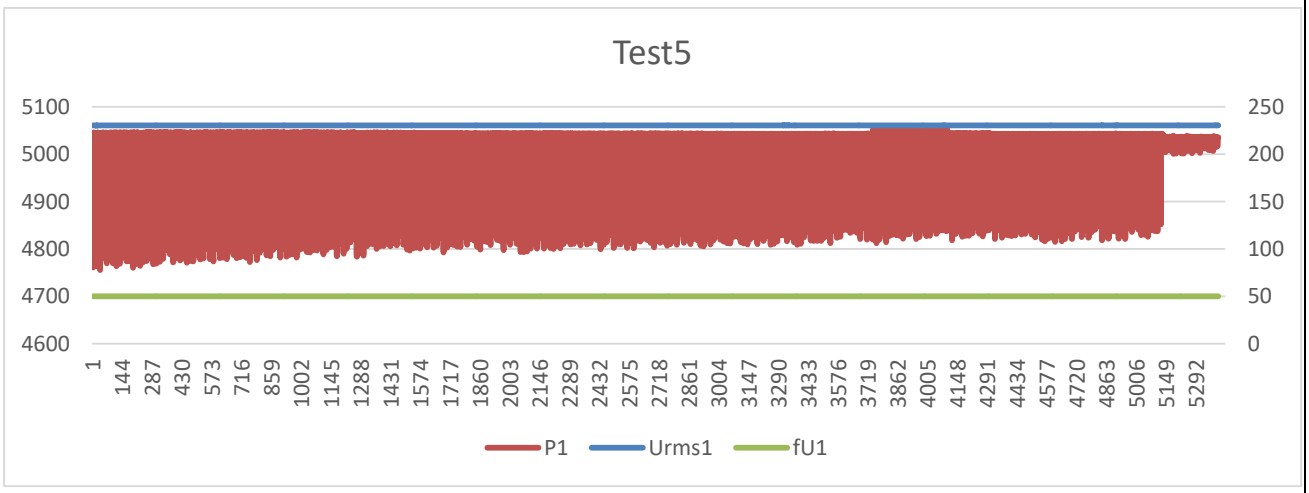
Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

LIVOLTEK
POWERING YOUR LIFE

Test 4



Test 5



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

LIVOLTEK
POWERING YOUR LIFE

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: Hyper-5000

Power Generating Module tested to BS EN 61000-3-12

Power Generating Module rating per phase (rpp)	5	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**		At 100% of **Registered Capacity**		Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps	%	Measured Value (MV) in Amps	%	1 phase	3 phase
2	0.0067	0.031	0.0075	0.034	8%	8%
3	0.2551	1.176	0.4319	1.990	21.6%	Not stated
4	0.0030	0.014	0.0015	0.007	4%	4%
5	0.1320	0.608	0.1562	0.720	10.7%	10.7%
6	0.0030	0.014	0.0043	0.020	2.67%	2.67%
7	0.1118	0.515	0.1243	0.573	7.2%	7.2%
8	0.0020	0.009	0.0014	0.007	2%	2%
9	0.0905	0.417	0.0996	0.459	3.8%	Not stated
10	0.0019	0.009	0.0024	0.011	1.6%	1.6%
11	0.0751	0.346	0.0888	0.409	3.1%	3.1%
12	0.0026	0.012	0.0029	0.014	1.33%	1.33%
13	0.0618	0.285	0.0782	0.360	2%	2%
THD		3.208		2.428	23%	13%
PWHD		4.115		3.607	23%	22%

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

LIVOLTEK
POWERING YOUR LIFE

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: Hyper-4600

Power Generating Module tested to BS EN 61000-3-12

Power Generating Module rating per phase (rpp)	4.6	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**		At 100% of **Registered Capacity**		Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps	%	Measured Value (MV) in Amps	%	1 phase	3 phase
2	0.0087	0.054	0.0065	0.040	8%	8%
3	0.2356	1.473	0.3200	2.000	21.6%	Not stated
4	0.0035	0.022	0.0033	0.020	4%	4%
5	0.1281	0.801	0.1412	0.882	10.7%	10.7%
6	0.0043	0.027	0.0027	0.017	2.67%	2.67%
7	0.1005	0.628	0.1146	0.716	7.2%	7.2%
8	0.0012	0.007	0.0014	0.009	2%	2%
9	0.0816	0.510	0.0978	0.611	3.8%	Not stated
10	0.0023	0.014	0.0034	0.021	1.6%	1.6%
11	0.0633	0.395	0.0860	0.537	3.1%	3.1%
12	0.0036	0.022	0.0024	0.015	1.33%	1.33%
13	0.0499	0.312	0.0702	0.439	2%	2%
THD		3.944		2.634	23%	13%
PWHD		3.765		4.004	23%	22%

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

LIVOLTEK
POWERING YOUR LIFE

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:	Hyper-5000		
Test start date	2022-07-27	Test end date	2022-07-27
Test location			

	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	0.133%	0.117%	0	1.048	0.656	0	0.026	0.06
Normalised to standard impedance	0.133%	0.117%	0	1.048	0.656	0	0.026	0.06
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	Xl	0.25	Ω
Standard Impedance	R	0.24 *	Ω	Xl	0.15 *	Ω

		0.4 ^			0.25 ^	
Maximum Impedance	R	N/A	Ω	XI	N/A	Ω

* Applies to three phase and split single phase **Power Generating Modules.**

^ Applies to single phase **Power Generating Module** and **Power Generating Modules** using two phases on a three phase system. Delete as appropriate.

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

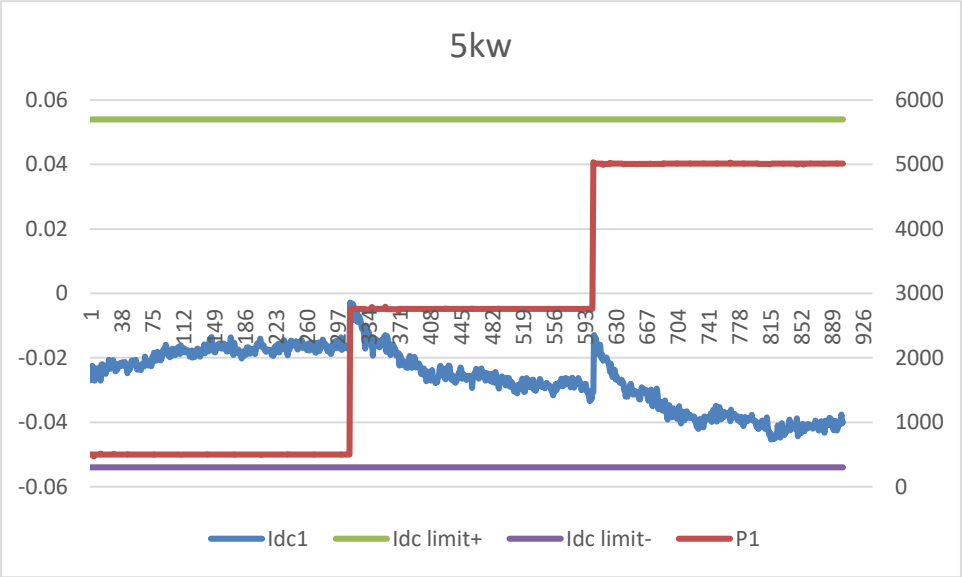
where the base current is the **Registered Capacity** (W) / Vphase. The % DC injection should not be greater than 0.25%.

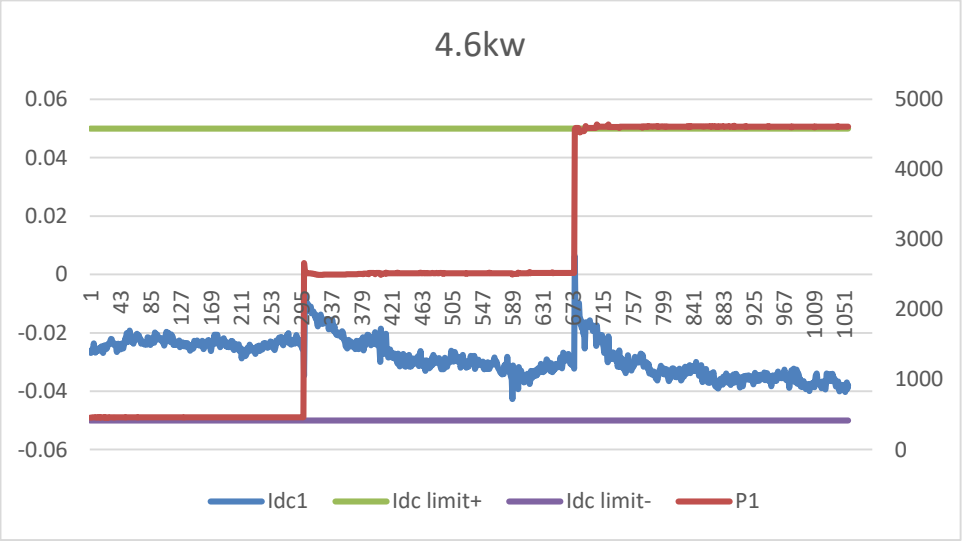
Model: Hyper-5000			
Test power level	10%	55%	100%
Recorded DC injection value in Amps	0.019	0.025	0.039
as % of rated AC current	0.09%	0.12%	0.18%
Limit	0.25%	0.25%	0.25%
Model: Hyper-4600			
Test power level	10%	55%	100%
Recorded DC injection value in Amps	0.024	0.027	0.036
as % of rated AC current	0.12%	0.14%	0.18%
Limit	0.25%	0.25%	0.25%

Equipment used:		(see instrument list)	
Model / Type:		Sample No.:	
Conclusion:	☒**Pass** ☐**Fail** ☐**N.A**	Ambient°C / % R.H.:	
Tested by:		Date:	

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

LIVOLTEK
POWERING YOUR LIFE





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

LIVOLTEK
POWERING YOUR LIFE

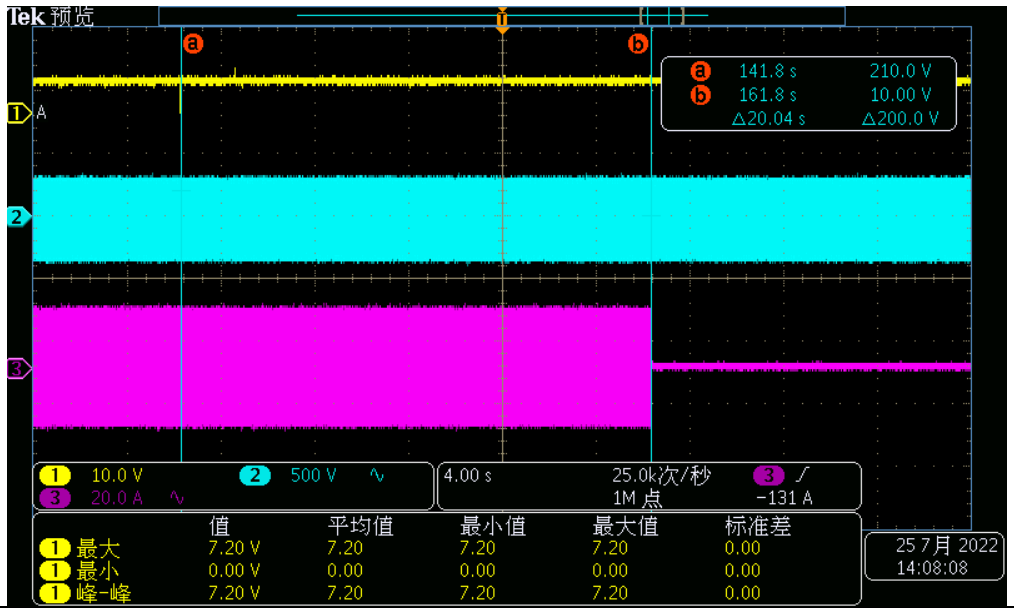
5. Power Factor:			**P**
The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity** and the measured **Power Factor** must be greater than 0.95 to pass. Voltage to be maintained within ±1.5% of the stated 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: Hyper-5000			
Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value	0.998	0.997	0.996
Power Factor Limit	>0.95	>0.95	>0.95
Model: Hyper-4600			
Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value	0.996	0.995	0.993
Power Factor Limit	>0.95	>0.95	>0.95

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

LIVOLTEK
POWERING YOUR LIFE

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: Hyper-5000						
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	47.4	20.04	47.7 Hz 30 s	No trip
U/F stage 2	47.0 Hz	0.5 s	46.9	625	47.2 Hz 19.5 s	No trip
					46.8 Hz 0.45 s	No trip
O/F	52.0 Hz	0.5 s	52.1	609	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.						

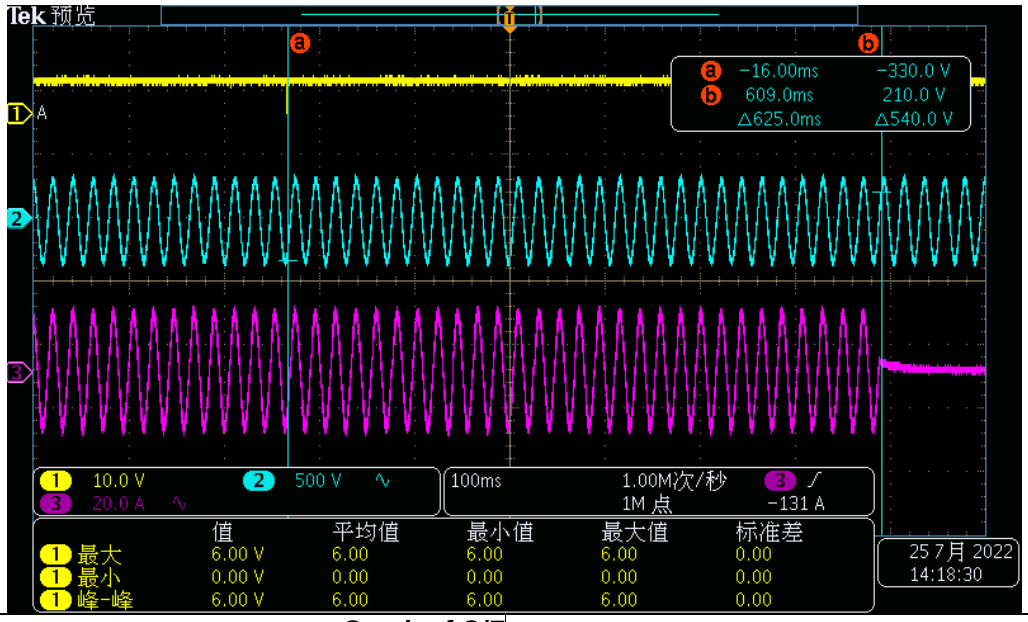
Graph of U/F stage 1



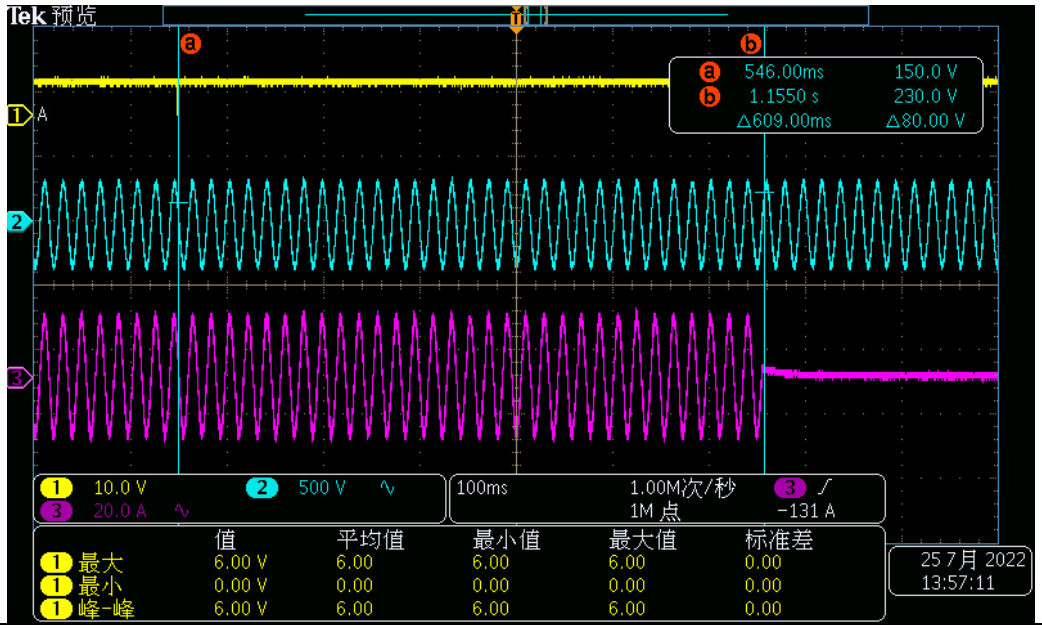
Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

LIVOLTEK
POWERING YOUR LIFE

Graph of U/F stage 2



Graph of O/F

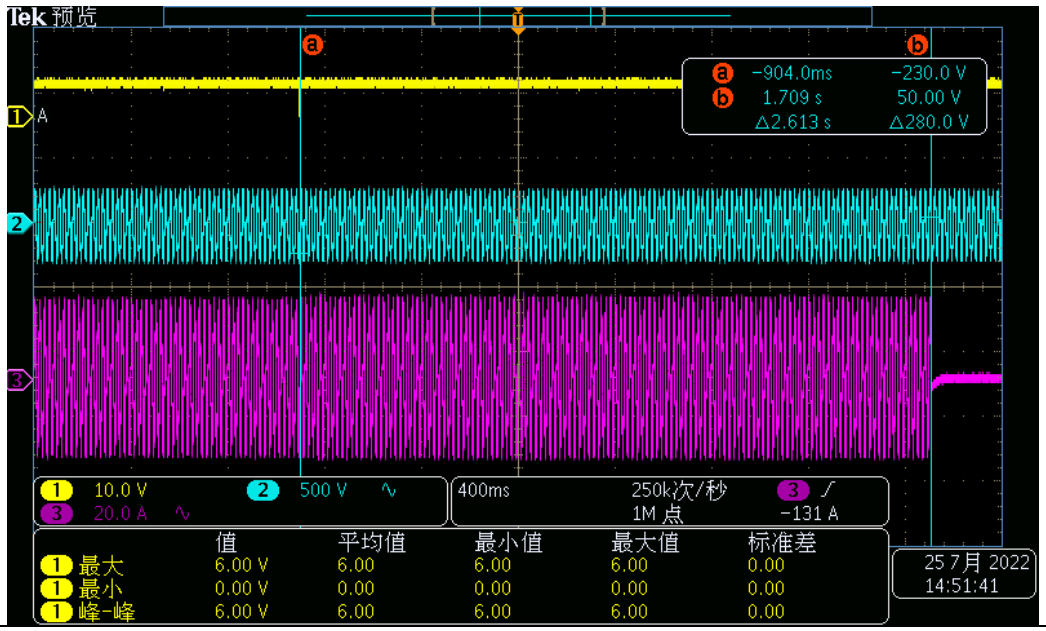


Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

LIVOLTEK
POWERING YOUR LIFE

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: Hyper-5000						
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	181	2.613	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	265.2	1.105	258.2 V 5.0 s	No trip
O/V stage 2	1.19 pu (273.7 V)	0.5 s	276.7	612	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.						

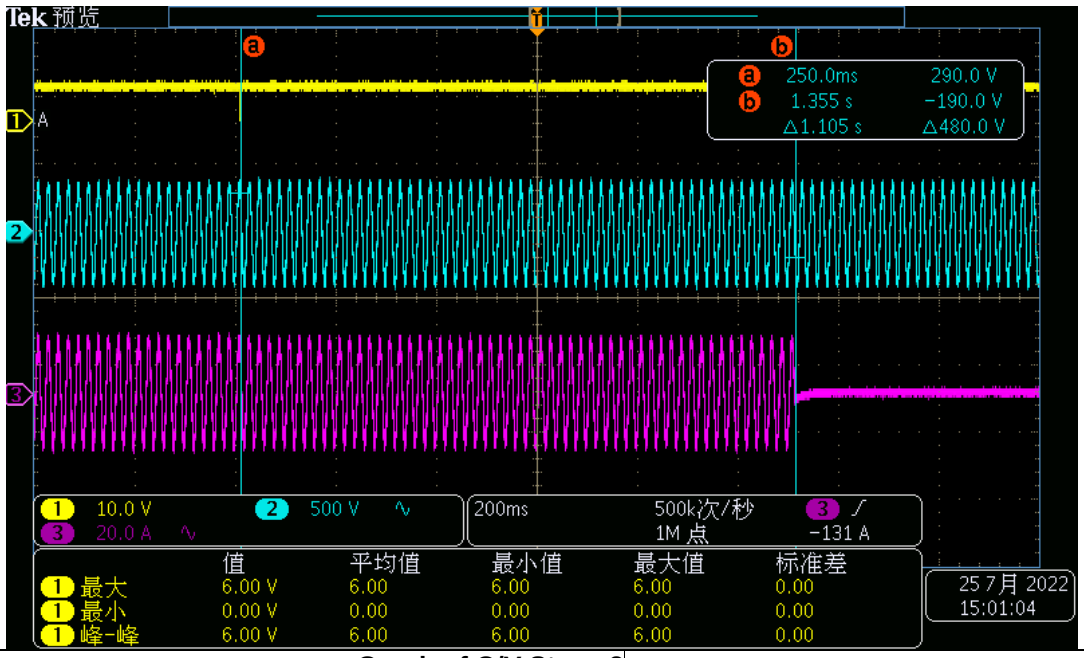
Graph of U/V



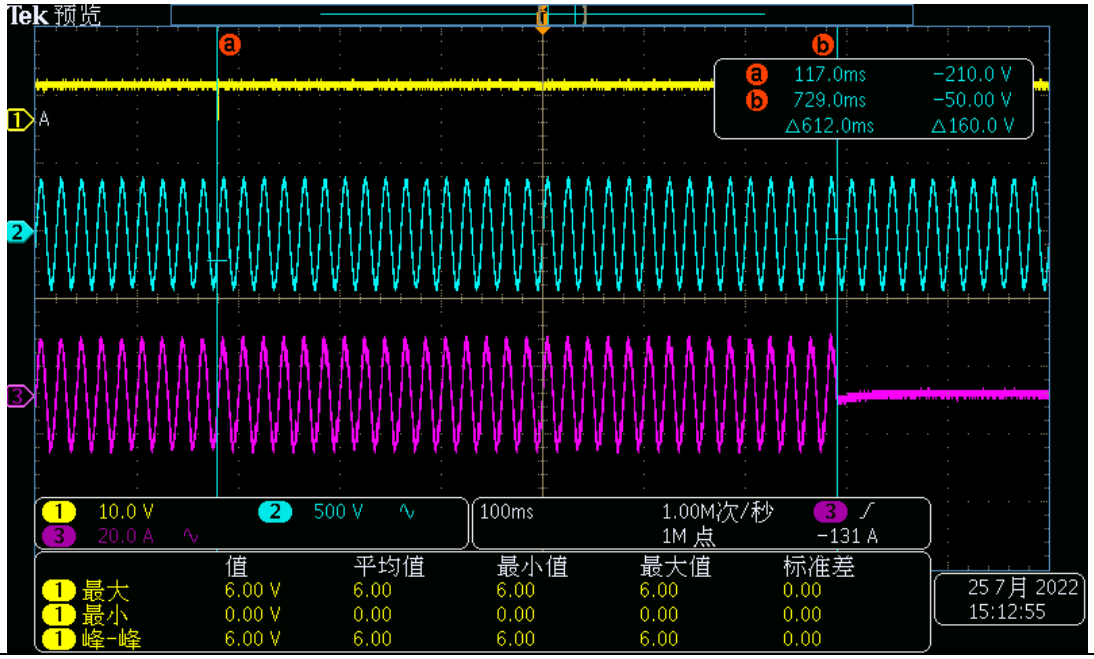
Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

LIVOLTEK
POWERING YOUR LIFE

Graph of O/V Stage 1



Graph of O/V Stage 2



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

LIVOLTEK
POWERING YOUR LIFE

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: Hyper-5000

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**	120ms	231.6 ms	213.4 ms	66.4 ms	131.6 ms	211 ms

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} (W)	Actual Q_f	V_{DC} d)	Remarks e)
1	100	100	0	0	216	5000	0.98	500	Test A at BL
2	66	66	0	0	231	3300	0.99	350	Test B at BL
3	33	33	0	0	114	1650	0.98	180	Test C at BL
4	100	100	-5	-5	168	5000	0.98	500	Test A at IB
5	100	100	-5	0	213.4	5000	0.97	500	Test A at IB
6	100	100	-5	+5	135	5000	-0.98	500	Test A at IB
7	100	100	0	-5	214.5	5000	0.98	500	Test A at IB
8	100	100	0	+5	136.10	5000	-0.98	500	Test A at IB
9	100	100	+5	-5	239.0	5000	0.96	500	Test A at IB
10	100	100	+5	0	211	5000	0.97	500	Test A at IB
11	100	100	+5	+5	129	5000	-0.97	500	Test A at IB
12	66	66	0	-5	231.6	3300	0.97	350	Test B at IB
13	66	66	0	-4	221	3300	0.98	350	Test B at IB
14	66	66	0	-3	272	3300	0.97	350	Test B at IB
15	66	66	0	-2	193	3300	0.97	350	Test B at IB
16	66	66	0	-1	159	3300	0.96	350	Test B at IB
17	66	66	0	+1	150.6	3300	-0.96	350	Test B at IB
18	66	66	0	+2	133	3300	-0.95	350	Test B at IB
19	66	66	0	+3	114.6	3300	-0.96	350	Test B at IB
20	66	66	0	+4	126.6	3300	-0.98	350	Test B at IB
21	66	66	0	+5	131.6	3300	-0.98	350	Test B at IB
22	33	33	0	-5	120	3300	0.98	350	Test B at IB
23	33	33	0	-4	239.2	1650	0.97	180	Test C at IB
24	33	33	0	-3	166.4	1650	0.95	180	Test C at IB
25	33	33	0	-2	129.8	1650	0.96	180	Test C at IB

26	33	33	0	-1	118.8	1650	0.95	180	Test C at IB
27	33	33	0	+1	98.4	1650	-0.96	180	Test C at IB
28	33	33	0	+2	84.8	1650	-0.95	180	Test C at IB
29	33	33	0	+3	74	1650	-0.94	180	Test C at IB
30	33	33	0	+4	82.2	1650	-0.95	180	Test C at IB
31	33	33	0	+5	66.4	1650	-0.95	180	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.

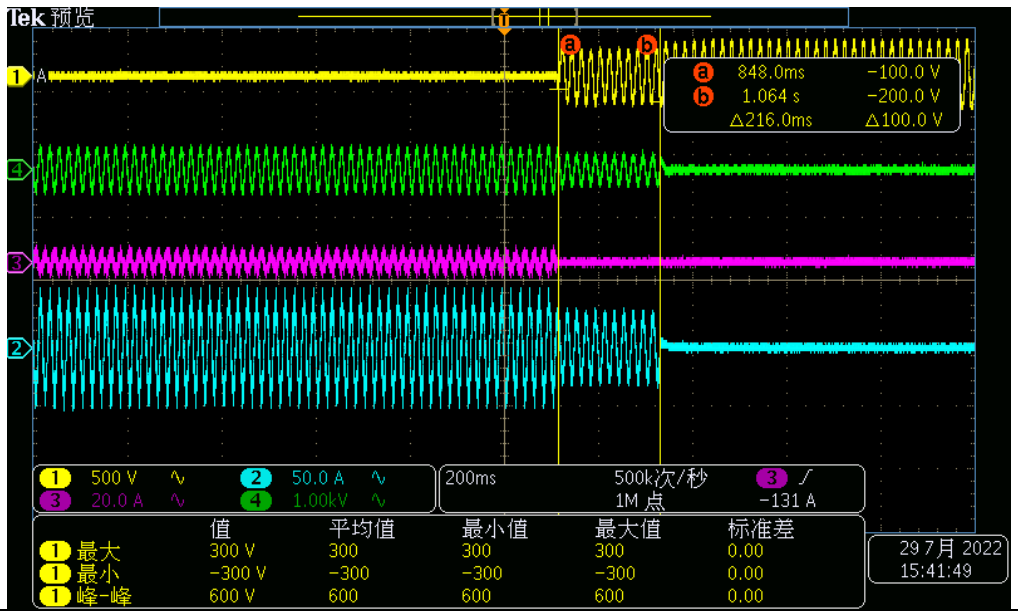
d) For test condition A, > 75 % of rated input voltage range used, for test condition B, 50 % of rated input voltage range, ±10 % used, for test condition C, < 20 % of rated input voltage range used. Based on EUT rated input operating range. For example, if range is between X volts and Y volts, 75 % 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.

Equipment used:			(see instrument list)
Model / Type:		Sample No.:	
Conclusion:	☒**Pass** ☐**Fail** ☐**N.A**	Ambient°C / % R.H.:	
Tested by:		Date:	

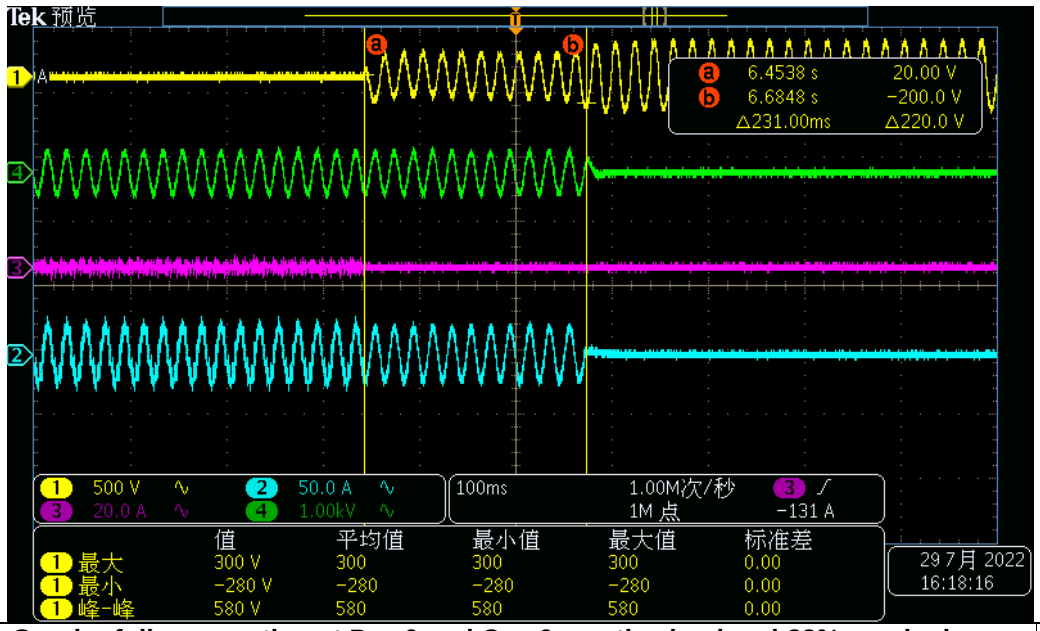
Graph of disconnection at Pac 0 and Qac 0 reactive load and 100% nominal power



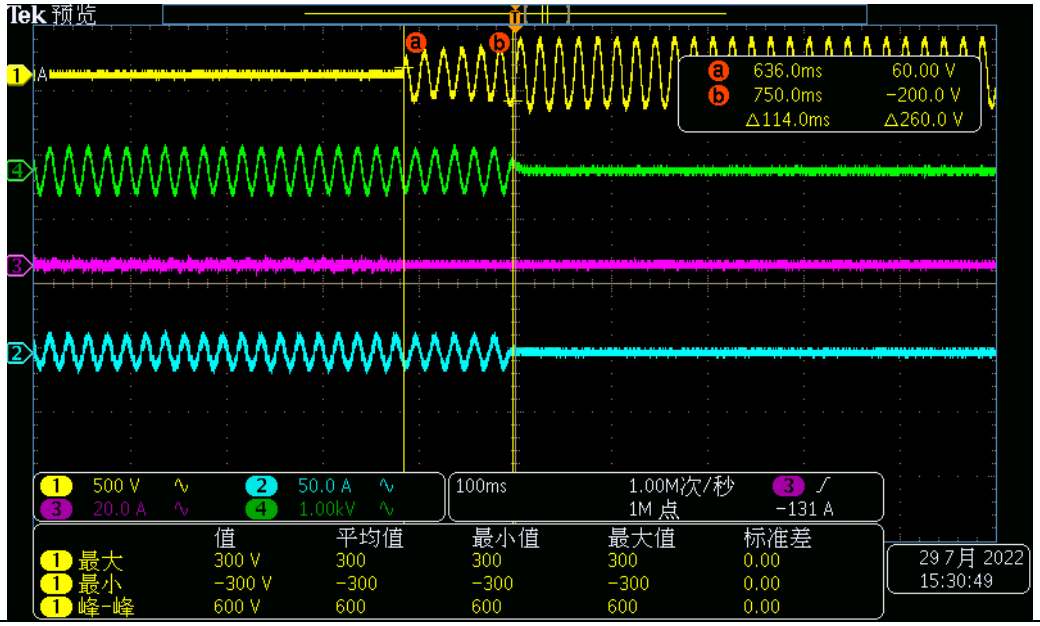
Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

LIVOLTEK
POWERING YOUR LIFE

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



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

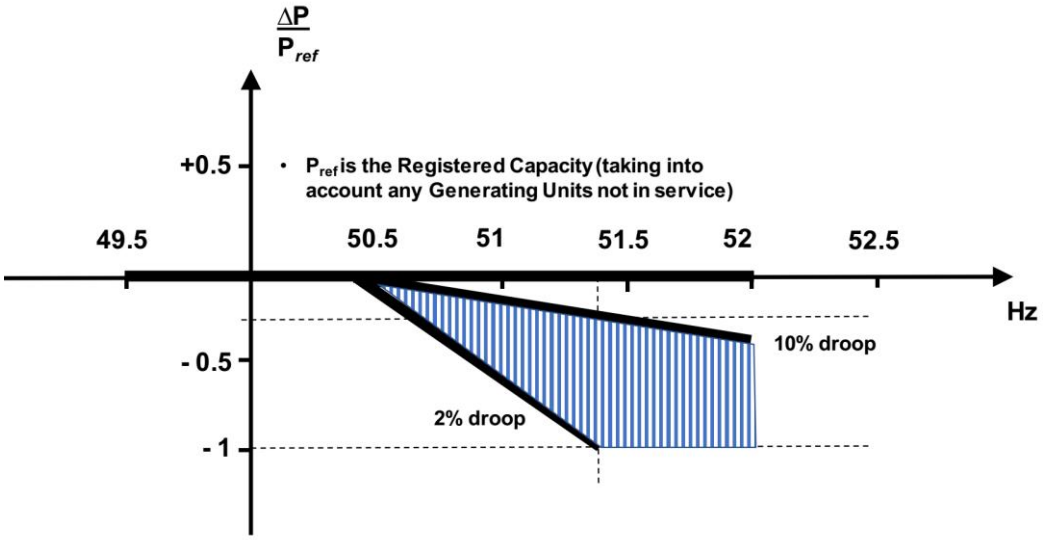
LIVOLTEK
POWERING YOUR LIFE

8. 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:Hyper-5000			
	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
8. 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: Hyper-5000			
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

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

LIVOLTEK
POWERING YOUR LIFE

9. 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: Hyper-5000					
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	5009.24	50.00	-	Photovoltaic array simulator	-
Step b) 50.45 Hz ±0.05 Hz	4950.42	50.45	-		-
Step c) 50.70 Hz ±0.10 Hz	4689.19	50.70	9.4		-
Step d) 51.15 Hz ±0.05 Hz	4233.46	51.15	9.7		-
Step e) 50.70 Hz ±0.10 Hz	4692.54	50.70	9.5		-
Step f) 50.45 Hz ±0.05 Hz	4950.30	50.45	-		-
Step g) 50.00 Hz ±0.01 Hz	4981.11	50.00	-		7.39%
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	2512.17	50.00	-	Photovoltaic array simulator	-
Step b) 50.45 Hz ±0.05 Hz	2458.02	50.45	-		-
Step c) 50.70 Hz ±0.10 Hz	2338.83	50.70	8.7		-
Step d) 51.15 Hz ±0.05 Hz	2111.70	51.15	9.4		-
Step e) 50.70 Hz ±0.10 Hz	2335.71	50.70	8.5		-
Step f) 50.45 Hz ±0.05 Hz	2459.67	50.45	-		-
Step g) 50.00 Hz ±0.01 Hz	2506.20	50.00	-		16.92%
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

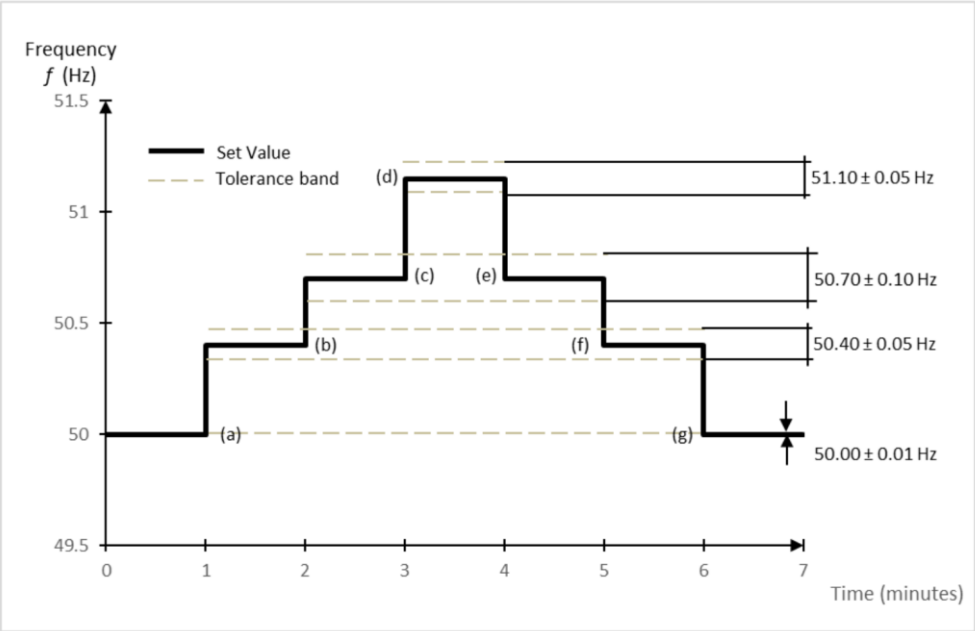
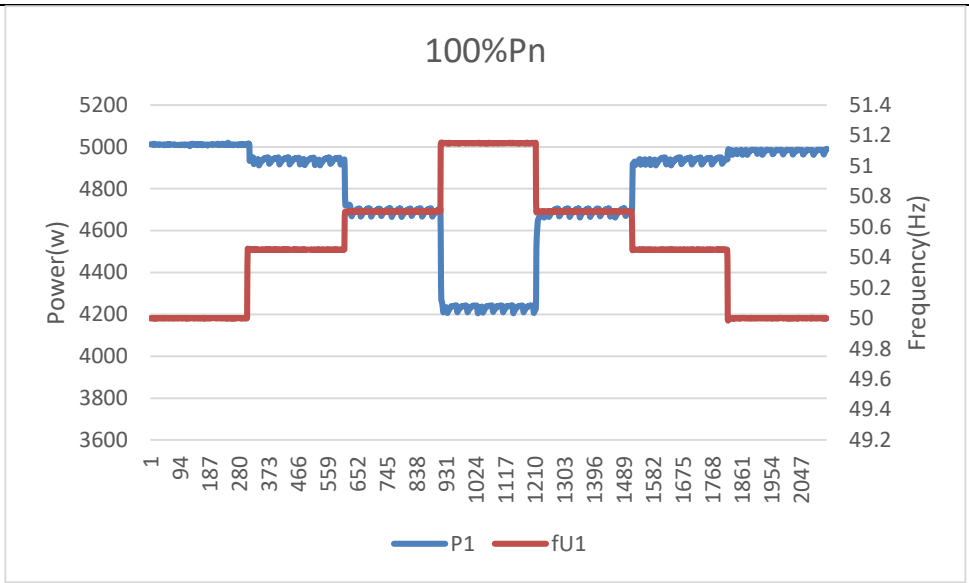


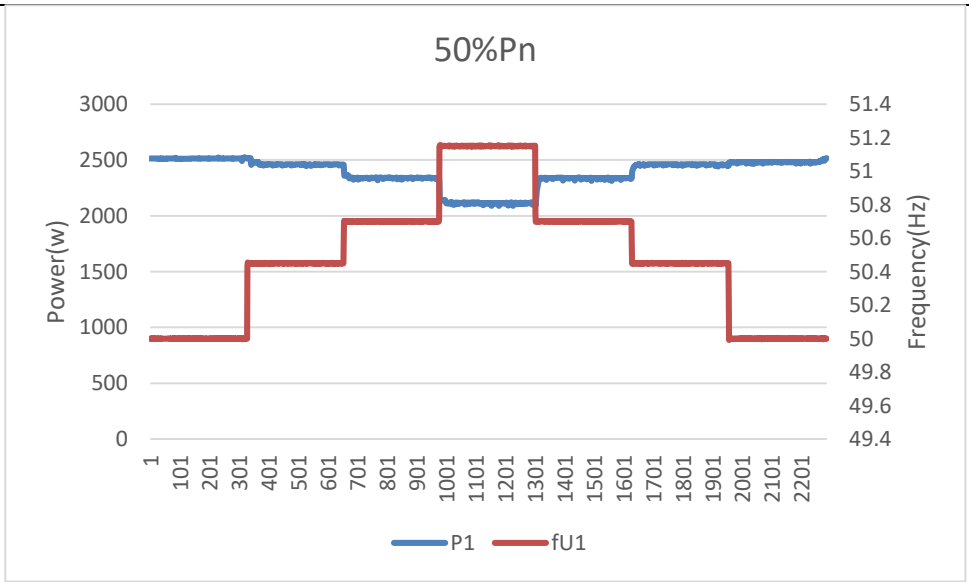
Figure A.7.3 Testing the **Active Power** feed-in of the **Power Generating Module** at over frequency

Equipment used:			(see instrument list)
Model / Type:		Sample No.:	
Conclusion:	☒**Pass** ☐**Fail** ☐**N.A**	Ambient°C / % R.H.:	
Tested by:		Date:	

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

LIVOLTEK
POWERING YOUR LIFE





9-2. 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: Hyper-5000				
Test sequence	Measured **Active Power** Output (W)	Acceptable **Active Power**	Frequency (Hz)	Primary power source
49.5 Hz for 5 minutes	5028.01	100% **Registered Capacity**	49.50	Photovoltaic array simulator
49.0 Hz for 5 minutes	4978.56	99% **Registered Capacity**	49.00	Photovoltaic array simulator
48.0 Hz for 5 minutes	4963.81	97% **Registered Capacity**	48.00	Photovoltaic array simulator

47.6 Hz for 5 minutes	4963.10	96.2% **Registered Capacity**	47.60	Photovoltaic array simulator
47.1 Hz for 20 s		95% **Registered Capacity**		Photovoltaic array simulator

NOTE:

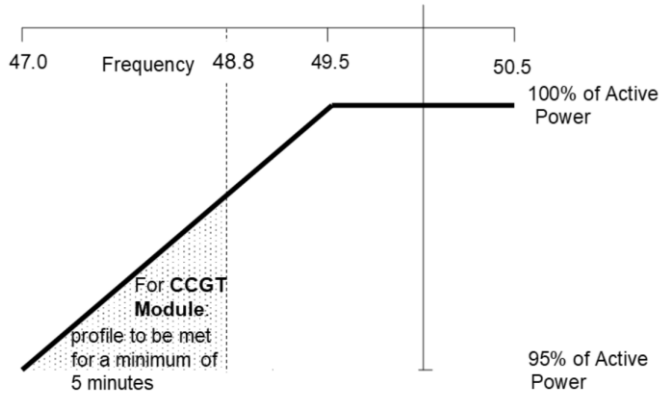


Figure 11.1 Change in Active Power with falling frequency

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

LIVOLTEK
POWERING YOUR LIFE

9-3. Power output with falling frequency test (For Electricity Storage Device)				**P**
This test should be carried out in accordance with clause 11.2.3.3 and A.7.1.7				
Model: Hyper-5000				
Test 1: 50 Hz to 49.0 Hz, from **100%** $P_{rated\text{-}import}$				
Test sequence (Hz)	Measured **Active Power** Output (W)	Steady frequency (Hz)	Calculated droop (%)	Primary power source
50.0	-4844.59	50.00		AC grid / Storage Battery
49.5	-4846.96	49.50		AC grid / Storage Battery
49.2	-1976.28	49.20	1	AC grid / Storage Battery
49.0	15.13	49.00	1	AC grid / Storage Battery
Test 2: 50 Hz to 48.8 Hz, from **100%** $P_{rated\text{-}import}$				
Test sequence (Hz)	Measured **Active Power** Output (W)	Steady frequency (Hz)	Calculated droop (%)	Primary power source
50.0	··-4845.11	50.00		AC grid / Storage Battery
49.5	-4848.51	49.50		AC grid / Storage Battery
49.2	-2010.08	49.20	1.1	AC grid / Storage Battery
49.0	-21.85	49.00	1	AC grid / Storage Battery
48.9	939.71	48.90	1	AC grid / Storage Battery
48.8	1917.53	48.80	1	AC grid / Storage Battery
Test 3: 50 Hz to 49.0 Hz, from **40%** $P_{rated\text{-}import}$				
Test sequence (Hz)	Measured **Active Power** Output (W)	Steady frequency (Hz)	Calculated droop (%)	Primary power source
50.0	-2015.85	50.00		AC grid / Storage Battery
49.5	-2019.21	49.50		AC grid / Storage Battery
49.2	920.38	49.20	1	AC grid / Storage Battery
49.0	2936.84	49.00	1	AC grid / Storage Battery
Test 4: 50 Hz to 48.8 Hz, from **40%** $P_{rated\text{-}import}$				
Test sequence (Hz)	Measured **Active Power** Output (W)	Steady frequency (Hz)	Calculated droop (%)	Primary power source
50.0	-2003.47	50.00		AC grid / Storage Battery
49.5	-2012.93	49.50		AC grid / Storage Battery
49.2	921.11	49.20	1	AC grid / Storage Battery
49.0	2943.64	49.00	1	AC grid / Storage Battery
48.9	3933.95	48.90	1	AC grid / Storage

				Battery
48.8	4513.28	48.80	1.1	AC grid / Storage Battery

NOTE:
This paragraph provides a method for demonstrating compliance with the optional performance characteristic as discussed in the foreword. The tests shall be carried out to demonstrate how the **Power Park Module Active Power** when acting as a load (ie replenishing its energy store) responds to changes in system frequency.
In general four tests are proposed, one set of two at rated import capacity, and one set of two at 40% of rated import capacity.
In both cases the test is to reduce frequency from 50 Hz at rate of 2 Hz/s. In the first case the lower frequency reached will be 49.0 Hz and the second case the lower frequency will be 48.8 Hz.
In all cases the response shall meet the requirements of 11.2.3.3.

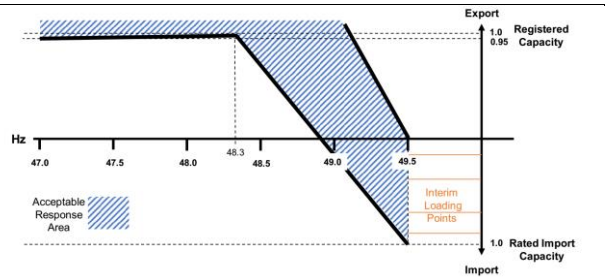


Figure 11.2 Change in Active Power of Electricity Storage Device with falling frequency (not to scale)

Chart:

10. Protection – Re-connection timer					**P**
Model: Hyper-5000					
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	62.4	At 1.16 pu (266.2 V **LV** connection, 127.6 V **HV** connection assuming 110 Vph-ph VT)	At 0.78 pu (180.0 V **LV** connection, 85.8 V **HV** connection assuming 110 V ph-ph VT)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Power Generating Module** does not re-connect.		No reconnection	No reconnection	No reconnection	No reconnection

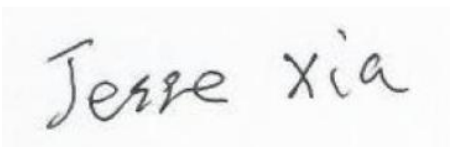
Hangzhou Livoltek Power CO., Ltd
1418-35 Moganshan Road, Shangcheng Industrial Zone
310011 Hangzhou City China
www.livoltek.com

LIVOLTEK
POWERING YOUR LIFE

11. Fault level contribution:		
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:		
For **Inverter** output		
Time after fault	Volts	Amps
20ms	260V	22A
100ms	240V	22A
250ms	200V	20A
500ms	150V	10A
Time to trip	629.5ms	In seconds

12. 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
13. 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
14. Logic interface (input port).	
Confirm that an input port is provided and can be used to shut down the module.	Yes
Provide high level description of logic interface, e.g. details in 11.1.3.1 such as AC or DC signal (the additional comments box below can be used)	NA
15. 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.	

Signed



Hangzhou Livoltek Power Co., Ltd.