# TEST REPORT

# Engineering recommendation G99

## Requirements for the connection of generation equipment in parallel with public distribution networks

| | |
|---|---|
| **Report reference number.............. :** | **PVGB2401WDG0057-2** |
| Date of issue........................ ..……...: | 2024-01-19 |
| Total number of pages........... ..……...: | 101 |
| **Testing laboratory name............... :** | **Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch** |
| Address.............................................: | No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China |
| Accerditation .....................................: | ilac-MRA; A2LA ACCREDITED Certificate # 2951.01 |
| **Applicant's name .......................... :** | **Jiangsu Hanchu Energy Technology Co., Ltd** |
| Address.............................................: | No. 588, Jinhui Road, Huishan District, Wuxi City, Jiangsu Province, China |
| **Test specification** | |
| Standard ...........................................: | G99/1-9:2022 |
| | A2-3 Tests for a Type A Inverter Connected Power Generating Modules |
| **Certificate ...................................... :** | **Certificate of compliance** |
| Test report form number...................: | G99-1 VER.3 |
| Master TRF.......................................: | Dated 2022-11-01 |
| **Test item description**......................: | **Photovoltaic (PV) and battery inverter** |
| Trademark ........................................: | HANCHU ESS |
| Model / Type .....................................: | HESS-HY-T-12K, HESS-HY-T1-12K |

| **Ratings**.............................................: | **HESS-HY-T-12K** | **HESS-HY-T1-12K** |
|---|---|---|
| Max. input PV voltage [V] .................: | 1100 | |
| Input PV voltage range [V]................: | 200-950 | 200-950 |
| Max. Input PV current [A]..................: | 2*20,0 | 3*16,0 |
| Input Battery voltage range [V] ........: | 120-600 | |
| Max. Battery current [A] ...................: | 30,0 | 30,0 |
| Output AC voltage [V][Grid]: | 3L/N/PE, 230V, 50Hz | |
| Nominal Output AC current [A] [Grid]: | 17,4 | 17,4 |
| Max. Output AC current [A] [Grid]:....: | 19,2 | 19,2 |
| Nominal Output power [kW] [Grid]....: | 12,0 | 12,0 |
| Max. Output power [kVA] [Grid]........: | 12,0 | 12,0 |
| Output AC voltage [V][EPS]: | 3L/N/PE, 230V, 50Hz | |
| Nominal Output AC current [A] [EPS]: | 17,4 | 17,4 |
| Max. Output AC current [A] [EPS]: ...: | 19,2 | 19,2 |
| Nominal Output power [kW] [EPS] ...: | 12,0 | 12,0 |
| Max. Output power [kVA] [EPS] .......: | 12,0 | 12,0 |

| | |
|---|---|
| **Testing Location ............................ :** | **Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch** |
| Address............................................ : | No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China |
| Tested by (name and signature) .......................: | Ryan He |
| Approved by (name and signature) .......................: | Ken Chan |
| **Manufacturer's name..................... :** | **Jiangsu Hanchu Energy Technology Co., Ltd** |
| Manufacturer address...................... : | No. 588, Jinhui Road, Huishan District, Wuxi City, Jiangsu Province, China |
| **Factory's name .............................. :** | **AISWEI New Energy Technology (Yangzhong) Co., Ltd** |
| Factory address .............................. : | No.588 Gangxing Road, Economic Development Zone, 212200 Yangzhong, Jiangsu Province, P.R.China |

**Document History**

| Date | Internal reference | Modification / Change / Status | Revision |
|---|---|---|---|
| 2023-01-19 | Ryan He | This is a copy report, the test results is based on the original test report PVGB2306WDG0281-2, issue by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch, dated on 2023-10-23. | 0 |

Supplementary information:

**Test items particulars**

| | |
|---|---|
| Equipment mobility ...........................: | Permanent connection |
| Operating condition...........................: | Continuous |
| Class of equipment ...........................: | Class I |
| Protection against ingress of water ..: | IP66 according to EN 60529 |
| Mass of equipment [kg] ....................: | Approx. 26kg for all model |

**Test case verdicts**

| | |
|---|---|
| Test case does not apply to the test object ...............................: | N/A |
| Test item does meet the requirement.................................: | P(ass) |
| Test item does not meet the requirement.................................: | F(ail) |

**Testing**

| | |
|---|---|
| Date of receipt of test item................: | 2023-03-23 |
| Date(s) of performance of test..........: | 2023-03-23 to 2023-10-23 |

**General remarks:**

The test results presented in this report relate only to the object(s) tested.
This document may be published or passed on in full only. Extraction of parts needs the written permission of Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch.

Conformity statements are decided in accordance with IEC GUIDE 115:2021 Procedure 2 (accuracy method), unless otherwise normatively specified or contractually agreed.

”(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

Throughout this report a comma is used as the decimal separator.

- “$P_n$” for the nominal active power:

  $P_n = V_n \times I_n \times \cos \varphi_n$ (single-Phase); $P_n = \sqrt{3}\, V_n \times I_n \times \cos \varphi_n$ (three-Phase)
- “$P_m$” for the momentary power
- “(c)” for over-excited
- “(i)” for under-excited

**Active and reactive power:**

The regarded system of the voltage and current vectors is the load view (Figure 2):

- if the inverter feeds to the grid the active power is measured with negative sign. For the sake of reading the document the measured active infeed power has a positive sign.

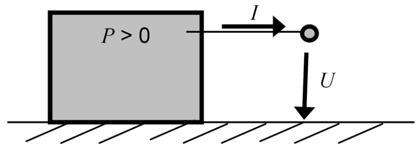



**Figure 1**

For the representation in quadrants, a power circle is chosen whose representation is compatible with mathematical representations of trigonometry and complex numbers (see Figure 2). Angles are counted positively counter-clockwise as in mathematics. The phase angle is defined as the angle from the current pointer to the voltage pointer. The current pointer is always in the real axis; the position of the voltage pointer corresponds to the apparent power and the phase angle.

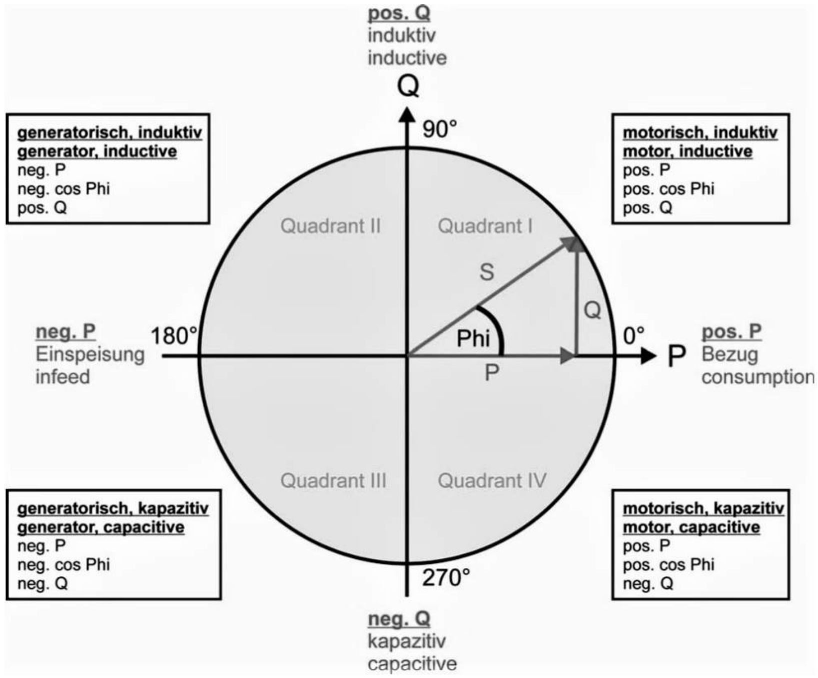



**Figure 2**

The different operating states can be represented in quadrants I to quadrant IV. The quadrants are named in a counter-clockwise direction.

- Quadrant I: Ohmic inductive load (coil)
- Quadrant II: One active power supplying generation plant with simultaneous reactive power consumption
- Quadrant III: A generation plant supplying active and reactive power
- Quadrant IV: Ohmic-capacitive load (capacitor)

**This Test Report consists of the following documents:**

1. Test Results
2. Annex No. 1 – EMC report
3. Annex No. 2 – Pictures of the unit
4. Annex No. 3 – Test equipment list

**Copy of marking plate:**

HANCHU ESS

Model: HESS-HY-T-12K

| | | |
|---|---|---|
| PV input | Max. PV input power | 18000Wp |
| | Max. PV input voltage | d.c. 1100V |
| | MPP voltage range | d.c. 200-950V |
| | Max. PV input current | d.c. 2X20A |
| | Isc PV (absolute maximum) | d.c. 2X30A |
| Battery input | Max. charge/discharge power | 12000W/12000W |
| | Battery voltage range | d.c. 120-600V |
| | Max. battery charge/discharge current | d.c. 30A/30A |
| | Battery type | LiFePO4 |
| Grid output | Rated grid voltage | 3/N/PE~400V |
| | Rated grid frequency | 50Hz/60Hz |
| | Rated grid output apparent power | 12000VA |
| | Max. grid output apparent power | 12000VA |
| | Rated grid output current | 17.4A |
| | Max. grid output current | 19.2A |
| Grid input | Rated grid voltage | 3/N/PE~400V |
| | Rated grid frequency | 50Hz/60Hz |
| | Max. grid input apparent power | 24000VA |
| | Max. grid input current | 34.8A |
| EPS output | Rated output voltage | 3/N/PE~400V |
| | Rated output frequency | 50Hz/60Hz |
| | Rated output apparent power | 12000VA |
| | Max. output apparent power | 12000VA |
| | Rated output current | 17.4A |
| General information | Adjustable cos(φ) | 0.8ind...0.8cap |
| | Operating temperature range | -25...+60°C |
| | Inverter topology | Non-Isolated |
| | Ingress protection | IP66 |
| | Protective class | I |
| | Overvoltage category | II(PV), III(MAINS) |

Support DRM0

10mins

Jiangsu Hanchu Energy Technology Co.,LTD
Web: www.hanchuess.com
Add.: No.588,Jinhui Road,Huishan District ,Wuxi City,Jiangsu Province,China

SN: L1102A35F0025 CODE: frNGM3PK

532-100006-00 Made in China

HANCHU ESS

Model: HESS-HY-T1-12K

| | | |
|---|---|---|
| PV input | Max. PV input power | 18000Wp |
| | Max. PV input voltage | d.c. 1100V |
| | MPP voltage range | d.c. 200-950V |
| | Max. PV input current | d.c. 3X16A |
| | Isc PV (absolute maximum) | d.c. 3X24A |
| Battery input | Max. charge/discharge power | 12000W/12000W |
| | Battery voltage range | d.c. 120-600V |
| | Max. battery charge / discharge current | d.c. 30A/30A |
| | Battery type | LiFePO4 |
| Grid output | Rated grid voltage | 3/N/PE~400V |
| | Rated grid frequency | 50Hz/60Hz |
| | Rated grid output apparent power | 12000VA |
| | Max. grid output apparent power | 12000VA |
| | Rated grid output current | 17.4A |
| | Max. grid output current | 19.2A |
| Grid input | Rated grid voltage | 3/N/PE~400V |
| | Rated grid frequency | 50Hz/60Hz |
| | Max. grid input apparent power | 24000VA |
| | Max. grid input current | 34.8A |
| EPS output | Rated output voltage | 3/N/PE~400V |
| | Rated output frequency | 50Hz/60Hz |
| | Rated output apparent power | 12000VA |
| | Max. output apparent power | 12000VA |
| | Rated output current | 17.4A |
| General information | Adjustable cos(φ) | 0.8ind...0.8cap |
| | Operating temperature range | -25...+60°C |
| | Inverter topology | Non-Isolated |
| | Ingress protection | IP66 |
| | Protective class | I |
| | Overvoltage category | II(PV), III(MAINS) |

Support DRM0

10mins

Jiangsu Hanchu Energy Technology Co.,LTD
Web: www.hanchuess.com
Add.: No.588,Jinhui Road,Huishan District ,Wuxi City,Jiangsu Province,China

XXXXXXXXXXXXXXXXXX

532-100006-00 Made in China

**General product information:**

The unit converts DC voltage into AC voltage.

The unit is a three phases type inverter.

The DC input of unit can be supplied from PV array and batteries.

The input and output are protected by Varistors to Earth. The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit will also operate in case of one error.

**Description of the electrical circuit:**

The internal control is redundant built. It consists of Microcontroller Main DSP (U519) and slave DSP (U536).

The Main DSP (U519) control the relays by switching signals; measures the PV voltage, PV current, Bus voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground. In addition it tests the current sensors and the RCMU circuit before each start up.

The slave DSP (U536) is measures the grid voltage, grid frequency and residual current, also can switch off the relays independently, and communicate with Main DSP (U519) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the Main DSP (U519). The Main DSP (U519) tests and calibrates before each start up all current sensors.

The unit provides two relays in series in all output conductors. When single fault applied to one relay, alarm an error code in display panel, another redundant relay provides basic insulation maintained between the PV array and the mains. All the relays are tested before each start up.

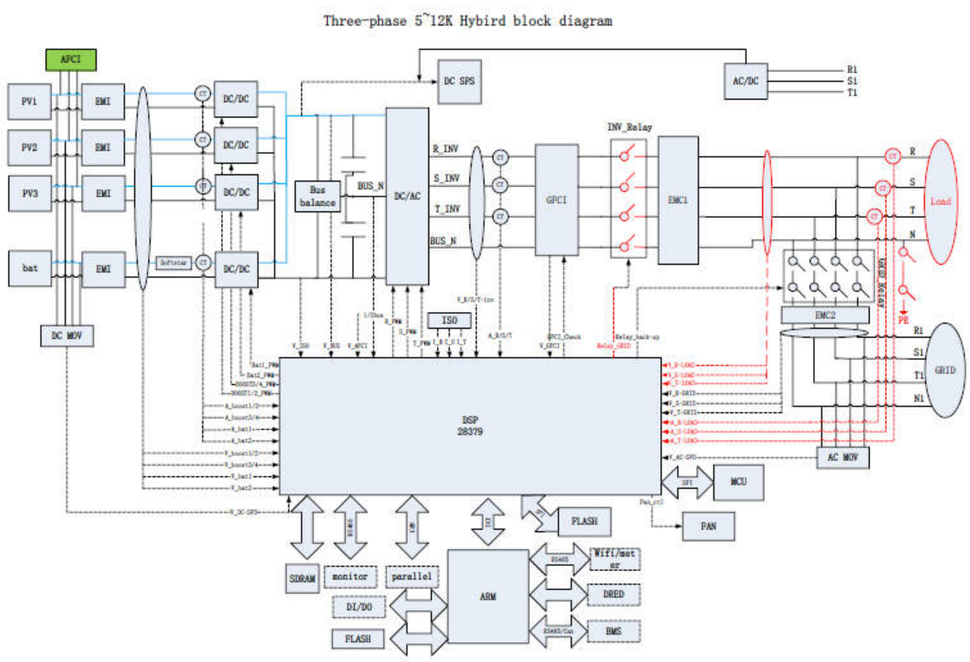



**Figure 3 – Block diagram**

**Differences of the models:**

The differences between four models refer to below description and table.
Model HESS-HY-T-12K is basic model.
Model HESS-HY-T1-12K is almost same with the model HESS-HY-T-12K but with 3 PV trackers and 6 pole DC switch.

| Model number | HESS-HY-T-12K | HESS-HY-T1-12K |
|---|---|---|
| PV tracker's number | 2 | 3 |
| EPS output terminal | With | With |
| DC switch's pole number | 4 | 6 |

Hardware version: 270-100501-01;
Master Software version: V610-05001-01;
Slave Software version: V610-60015-00;
Safety version: V610-11022-01.

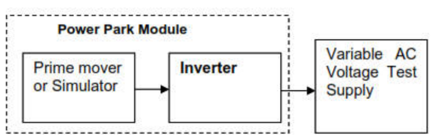
All tests were performed on HESS-HY-T-12K. Tests of the EUT of HESS-HY-T-12K not applicable for the models, HESS-HY-T1-12K were performed on the concerned models and a statement is given at the relevant test.

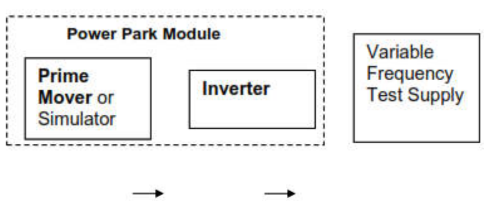
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| **A.7** | **Requirements for Type Testing Power Generating Modules** | | |
| | This Annex describes methodologies for undertaking compliance verification for Type A Power Generating Modules. The Annex describes approaches which were originally intended for small Power Park Modules. Manufacturers are free to adapt techniques described in Annex B where this is more economic or efficient, provided the Type A performance requirements are fully demonstrated. The Forms provided in Annex A.2 should be used as a basis for demonstration of compliance.<br>Annex A.7.1 Power Park Module Requirements.<br>Annex A.7.2 Synchronous Power Generating Module Requirements.<br>Annex A.7.3 Additional Technology Requirements.<br>• A.7.3.1. Domestic CHP<br>• A.7.3.2. Photo-voltaic<br>• A.7.3.3. Fuel Cells<br>• A.7.3.4. Hydro<br>• A.7.3.5. Wind<br>• A.7.3.6. Electricity Storage devices<br>Annex A.7.1 relates to any Generating Unit that uses an Inverter (or Converter) as its means of connecting to the Distribution Network.<br>Annex A.7.2 relates to any Synchronous Power Generating Module that during normal running operation is connected directly to the Distribution Network and has a Rated Capacity < 50 kW, although Manufacturers may choose to use these requirements for larger Type A Synchronous Power Generating Modules.<br>For type testing any Generating Unit select either Annex A.7.1 or Annex A.7.2 as is most appropriate to the Generating Unit under test. Annex A.7.2 should also be used for asynchronous Generating Units that are not connected to the Distribution Network via an Inverter (ie induction Generating Units).<br>The Generating Unit may also require additional technology type tests as identified in Annex A.7.3.<br>**Examples**<br>A Wind Turbine system using an **Inverter** (or **Inverter**s) for connection is required to use Annex A.7.1 – “Common **Power Park Module** Requirements” and Annex<br>A.7.3.5 – “Wind” Additional Technology | Test sample is a:<br>A.7.1 Power Park Module<br>A.7.3.2 Photovoltaic (Additional Power Generating Module Technology Requirements) | **P** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | Requirements.<br>A Hydro system using an induction generator connected directly to the **Distribution Network** is suggested to use Annex A.7.2 – "**Synchronous**" and Annex A.7.3.4– "Hydro" Additional Technology Requirements. | | |
| **A.7.1** | **Power Park Module Requirements** | | **P** |
| **A.7.1.1** | **Certification & Type Testing Generating Unit Requirements**<br>A.7.1 can apply to **Power Park Module**s or to individual **Inverter**s and/or **Generating Unit**s if the functionality is included in each unit of a **Power Park Module**. Within this Section A.7.1 the term **Power Park Module** will be used but its meaning can be interpreted within A.7.1 to mean **Power Park Module**, **Generating Unit or Inverter** as appropriate.<br>A.7.1 describes a methodology for obtaining type certification or type verification for a **Power Park Module** containing an **Inverter**. Typically, all interface functions are contained within the **Inverter** and in such cases it is only necessary to have the **Inverter Type Tested.** Alternatively, a package of specific separate parts of equivalent function may also be **Type Tested**.<br>The **Interface Protection** shall satisfy the requirements of all of the following standards. Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.<br>BS EN 61000 (Electromagnetic Standards)<br>BS EN 60255 (Electrical Relays)<br>BS EN 61810 (Electrical Elementary Relays)<br>BS EN 60947 (Low Voltage Switchgear and Control gear)<br>BS EN 61869 (Instrument Transformers: Additional requirements for current transformers)<br>Currently there are no harmonised functional standards that apply to the **Power Park Module**'s **Interface Protection**. Consequently, in cases where power electronics is used for energy conversion along with any separate **Interface Protection** unit they will need to be brought together and tested as a complete **Power Park Module** as described in this EREC G99, and recorded in format similar to that shown in Form A2-3 (Annex A.2).<br>Where the **Interface Protection** is physically integrated within the overall **Power Park Module** control system, the functionality of the **Interface Protection** unit should not be compromised by any | Considered.<br>Test results see below. | **P** |

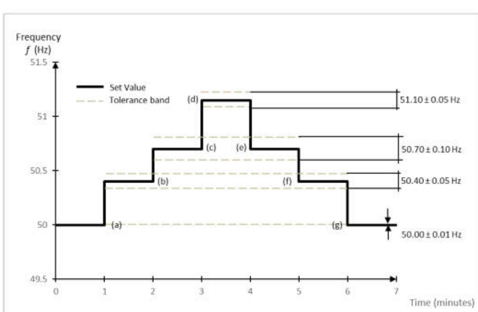
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | failure of other elements of the control system (fail safe). For a **Full Type Tested Power Park Module** the completed **Power Park Module**'s **Interface Protection** shall not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections shall be made by non-reversible plug and socket which the **Manufacturer** has made and tested prior to delivery to site.<br><br>Where **Type Tested** components are wired together on site, ie not using specifically designed plugs and sockets for the purpose, it will be necessary to<br><br>prove that all wiring has been correctly terminated by proving the functions which rely on the wiring at the time of commissioning as detailed in paragraph 15.2 and Form A2-4 (Annex A.2).<br><br>This Annex is primarily designed for the testing of three phase **Power Park Module**s. However, where practicable, a single phase, or split phase test may be carried out if it can be shown that it will produce the equivalent results.<br><br>This Annex applies to **Power Park Module**s either with or without load management or **Electricity Storage** devices connected on the prime mover side of the **Power Park Module**. | | |
| **A.7.1.2** | **Type Verification Functional Testing of the Interface Protection**<br><br>**Type Testing** is the responsibility of the **Manufacturer**. This test will verify that the operation of the **Power Park Module Interface Protection** shall result:<br><br>a) in the safe disconnection of the **Power Park Module** from the **DNO**'s **Distribution Network** in the event that system parameters exceed the protection settings specified in Table 10.1; and<br><br>b) in the **Power Park Module** remaining connected to the **DNO**'s **Distribution Network** while **Distribution Network** conditions are:<br><br>(1) within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in Table 10.1; and<br><br>(2) within the trip delay settings specified in Table 10.1.<br><br>Wherever possible the type testing of a **Power Park Module** designed for a particular type of prime mover should be proved under normal conditions of operation for that technology (unless otherwise noted). | Considered.<br><br>Test results see below. | **P** |
| **A.7.1.2.1** | **Disconnection times**<br><br>The minimum trip time delay settings, for over / under voltage, over / under frequency and loss of | Considered.<br><br>Test results see below. | **P** |

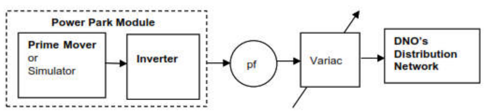
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | mains tests below, are presented in Table 10.1.<br><br>For over / under voltage, over / under frequency and loss of mains tests, reconnection shall be checked as detailed below. | | |
| **A.7.1.2.2** | **Over / Under Voltage**<br><br>The **Power Park Module** shall be tested by operating in parallel with a variable AC test supply, see Figure A.7.1. Correct protection and ride-through operation shall be confirmed during operation of the **Power Park Module.** The set points for over and under voltage at which the **Power Park Module** disconnects from the supply will be established by varying the AC supply voltage.<br><br>To establish the trip voltage, the test voltage should be applied in steps of ± 0.5% or less, of the voltage setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s starting at least 4 V below or above the setting. The test voltage at which this trip occurred is to be recorded. Additional tests just above and below the trip voltage should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the type verification test report Annex A.2-3.<br><br>To establish the trip time, the test voltage should be applied starting from 4 V below or above the recorded trip voltage and should be changed to 4 V above or below the recorded trip voltage in a single step. The time taken from the step change to the **Inverter** tripping is to be recorded on the type verification test report Annex A.2-3.<br><br>To establish correct ride-through operation, the test voltage should be applied at each setting ± 4 V and for the relevant times shown in the Table in Annex A.2-3.<br><br>For example to test over voltage setting stage 1 which is required to be set at nominally 262.2 V the circuit should be set up as shown below and the voltage adjusted to 254.2 V. The **Power Park Module** should then be powered up to export a measurable amount of energy so that it can be confirmed that the **Power Park Module** has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0.5% of nominal (1.15 V) maintaining the voltage for at least 1.5 s (trip time plus 0.5 s) at each voltage level. At each voltage level confirmation that the **Power Park Module** has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be | Considered.<br><br>Test results see below. | **P** |

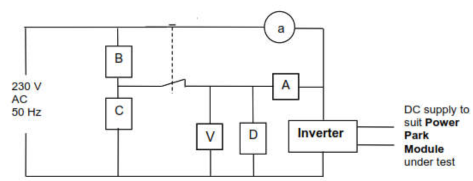
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as being 261 V. The variable voltage supply should be set to 257 V the **Power Park Module** set to produce a measurable output and then the voltage raised to 265 V in a single step. The time from the step change to the output of **Power Park Module** falling to zero should be recorded as the trip time.<br><br>The **Power Park Module** then needs to operate at 4 V below the nominal over voltage stage 1 setting which is 258.2 V for a period of at least 2 s without tripping and while producing a measurable output. This can be confirmed as a no trip in the relevant part of Annex A.2-3. The voltage then needs to be stepped up to the next level of 269.7 V for a period of 0.98 s and then back to 258.2 V during which time the output of the relay should continue with no interruption though it may change due to the change in voltage, this can be recorded as a no trip for the second value. The step up and step down test needs to be done a second time with a max value of 277.7 V and with a time of 0.48 s. The **Power Park Module** is allowed to shut down during this period to protect its self as allowed by note 1 of Table 10.1, but it shall resume production again when the voltage has been restored to 258.2 V or it may continue to produce an output during this period. There is no defined time for resumption of production but it shall be shown that restart timer has not operated so it will begin producing again in less than 20 s.<br><br>Note that this philosophy should be applied to the under voltage, over and under frequency, RoCoF and Vector shift stability tests which follow.<br><br>Note:<br><br>(1) The frequency required to trip is the setting ± 0.1 Hz<br><br>(2) Measurement of operating time should be measured at a value of 0.3 Hz<br><br>(suggestion – 2 x tolerance) above/below the setting to give “positive” operation<br><br>(3) The “No trip tests” need to be carried out at the relevant values and times as shown in the table in Annex A.2-3 to ensure that the protection will not trip in error.<br><br><br><br>**Figure A.7.1. Power Park Module test set up – over / under voltage** | | |
| **A.7.1.2.3** | **Over / Under Frequency**<br><br>The **Power Park Module** shall be tested by operating in parallel with a low impedance, variable | Considered.<br><br>Test results see below. | **P** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | frequency test supply system, see Figure A.7.2. Correct protection and ride-through operation should be confirmed during operation of the **Power Park Module**. The set points for over and under frequency at which the **Power Park Module** system disconnects from the supply will be established by varying the test supply frequency.<br><br>To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hzs-1 , or if this is not possible in steps of 0.05 Hz for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the type verification test report Annex A.2-3.<br><br>To establish the trip time, the test frequency should be applied starting from 0.3 Hz below or above the recorded trip frequency and should be changed to 0.3 Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the **Power Park Module** tripping is to be recorded on the type verification test report Annex A.2-3. It should be noted that with some loss of mains detection techniques this test may result in a faster trip due to operation of the loss of mains protection. There are two ways around this. Firstly the loss of mains protection may be able to be turned off in order to carry out this test. Secondly by establishing an accurate frequency for the trip a much smaller step change could be used to initiate the trip and establish a trip time. This may require the test to be repeated several times to establish that the time delay is correct.<br><br>To establish correct ride-through operation, the test frequency should be applied at each setting ± 0.2 Hz and for the relevant times shown in the table in Annex A.2-3.<br><br><br><br>**Figure A.7.2 Power Park Module test set up – over / under frequency** | | |
| **A.7.1.2.4** | **Loss of Mains Protection**<br><br>The tests should be carried out in accordance with BS EN 62116 and a subset of results should be | Considered.<br><br>Test results see below. | **P** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | recorded as indicated in the Protection – loss of mains test section of Annex A.2-3 Type Test Verification Report.<br>Multi phase **Power Park Module**s should be operated at part load while connected to a network running at about 50 Hz and one phase only shall be disconnected with no disturbance to the other phases. The **Power Park Module** should trip within 1 s. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the Type Test declaration. | | |
| **A.7.1.2.5** | **Re-connection**<br>The tests should be carried out in accordance with BS EN 62116 and a subset of results should be recorded as indicated in the Protection – loss of mains test section of Annex A.2-3 Type Test Verification Report.<br>Multi phase **Power Park Module**s should be operated at part load while connected to a network running at about 50 Hz and one phase only shall be disconnected with no disturbance to the other phases. The **Power Park Module** should trip within 1 s. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the Type Test declaration. | Considered.<br>Test results see below. | **P** |
| **A.7.1.2.6** | **Frequency Drift and Step Change Stability test.**<br>The tests will be carried out using the same circuit as specified in A.7.1.2.3 above and following confirmation that the **Power Park Module** has passed the under and over frequency trip tests and the under and over frequency stability tests.<br>Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the **Power Park Module** should not trip during the test.<br>For the step change test the **Power Park Module** should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The **Power Park Module** should not trip during this test.<br>For frequency drift tests the **Power Park Module** should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0.95 Hzs-1 to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The **Power** | Considered.<br>Test results see below. | **P** |

<table>
<tr><th colspan="4">Engineering recommendation G99-1</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td></td><td>Park Module should not trip during this test.<br><br>The results shall be recorded on the test sheet of Annex A.2-3.</td><td></td><td></td></tr>
<tr><td>A.7.1.3</td><td>Limited Frequency Sensitive Mode – Over (LFSM-O)<br><br>There are two possible approaches to demonstrating LFSM-O. The first to use the test set up of Figure A.7.2. The second approach can be used where it is possible to inject a frequency control signal into the Power Generating Module. The Manufacturer or Generator can choose which is the more appropriate test for the Power Generating Module.<br><br>The test below uses the test set up of Figure A.7.2 to demonstrate LFSM-O using a variable frequency supply. The alternative approach is covered in A.7.2.4.<br><br>The test should be carried out above 80% Registered Capacity and repeated at 40-60% Registered Capacity using the specific threshold frequency of 50.4 Hz and Droop of 10%.<br><br>The Power Park Module should be tested at the following frequencies:<br><br>Step a) 50.00 Hz ±0.01 Hz<br><br>Step b) 50.45 Hz ±0.05 Hz<br><br>Step c) 50.70 Hz ±0.10 Hz<br><br>Step d) 51.15 Hz ±0.05 Hz<br><br>Step e) 50.70 Hz ±0.10 Hz<br><br>Step f) 50.45 Hz ±0.05 Hz<br><br>Step g) 50.00 Hz ±0.01 Hz<br><br>The frequency at each step should be maintained for at least one minute as illustrated in Figure A.7.3 and the Active Power reduction in the form of a gradient determined and assessed for compliance with paragraph 11.2.3.<br><br>
<br>Figure A.7.3 Testing the Active Power feed-in of the Power Generating Module at over frequency<br><br>The Droop should be determined from the</td><td>Considered.<br><br>Test results see below.</td><td>P</td></tr>
</table>

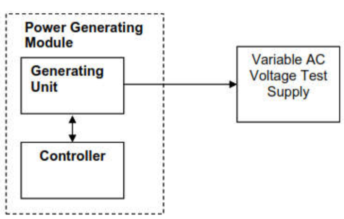
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | measurements between 50.4 Hz and 51.15 Hz. The allowed tolerance for the frequency measurement shall be ± 0.05 Hz. The allowed tolerance for **Active Power** output 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%. | | |
| **A.7.1.4** | **Power Quality** | | **P** |
| **A.7.1.4.1** | **Harmonics**<br><br>The tests should be carried out as specified in BS EN 61000-3-12 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of **Registered Capacity**. | Considered.<br><br>Test results see below. | **P** |
| **A.7.1.4.2** | **Power Factor**<br><br>The test set up shall be such that the **Power Park Module** supplies full load to the **DNO**'s **Distribution Network** via the **Power Factor** (pf) meter and the variac as shown below in Figure A.7.3. The **Power Park Module Power Factor** should be within the limits given in paragraph 11.1.5, for three test voltages 0.94 pu, 1 pu V[28] and 1.1 pu V.<br><br><br><br><br>NOTE 1 For reasons of clarity the points of isolation are not shown.<br>NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown.<br><br>**Figure A.7.3 Power Park Module test set up – Power Factor**<br><br>[28] For a **LV** connected **Power Generating Module** 1 pu V = 230 V | Considered.<br><br>Test results see below. | **P** |
| **A.7.1.4.3** | **Voltage Flicker**<br><br>The voltage fluctuations and flicker emissions from the **Power Park Module** shall be measured in accordance with BS EN 61000-3-11 and the technology specific Annex A.7.3. The required maximum supply impedance should be calculated and recorded in the relevant part of Compliance Verification Report in Form A2-3 (Annex A.2). | Considered.<br><br>Test results see below. | **P** |
| **A.7.1.4.4** | **DC Injection**<br><br>The level of **DC** injection from the **Power Park Module** -connected prime mover in to the **DNO**'s **Distribution Network** shall not exceed the levels specified in 9.4.6 when measured during operation at three levels, 10%, 55% and 100% of rating with a tolerance of ±5%.<br><br>The DC injection requirements can be satisfied by the installation of an isolation transformer on the AC side of an **Inverter**-connected **Power Park Module**. A declaration that an isolating transformer is fitted | Considered.<br><br>Test results see below. | **P** |

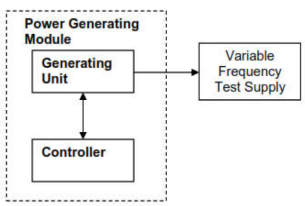
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | can be made in lieu of the tests noted above. | | |
| **A.7.1.5** | **Short Circuit Current Contribution**<br>**Power Park Module** connected **Power Generating Module**'s generally have small short circuit fault contributions however **DNO**s need to understand the contribution that they make to system fault levels in order to determine that they can continue to safely operate without exceeding design fault levels for switchgear and other circuit components.<br>The following type tests shall be carried out and the results noted in Annex A.2-3.<br><br><br>Figure A.7.4 Power Park Module short circuit test circuit | Considered.<br>Test results see below. | **P** |
| **A.7.1.6** | **Self-Monitoring - Solid State Disconnection**<br>Some **Power Park Modules** include solid state switching devices to disconnect from the **DNO**'s **Distribution Network**. In this case paragraph 9.7.9 requires the control equipment to monitor the output stage of the **Power Park Module** to ensure that in the event of a protection initiated trip the output voltage is either disconnected completely or reduced to a value below 50 V AC. This shall be verified either by self-certification by the **Manufacturer**, or additional material shall be presented to the tester sufficient to allow an assessment to be made. | Considered.<br>Test results see below.. | **P** |
| **A.7.1.7** | **Power Park Modules which include Electricity Storage**<br>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.<br>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**.<br>In both cases the test is to reduce frequency from 50 Hz at 2 Hzs$^{-1}$. 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.<br>In all cases the response shall meet the requirements of 11.2.3.3. | Considered.<br>Test results see below. | **P** |
| **A.7.2** | **Synchronous Power Generating Module Requirements (up to and including** | | **N/A** |

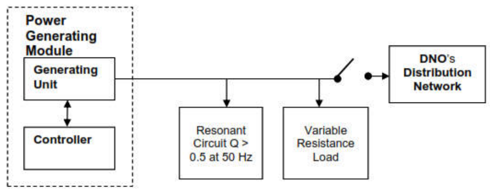
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | **50 kW)** | | |
| **A.7.2.1** | **Certification & Type Testing Generating Unit Requirements**<br><br>This Annex describes a methodology for obtaining type certification or type verification for a **Synchronous Power Generating Module** in conjunction with Form A2-1. Other compliance requirements are detailed in Form A2-2 which may be used as an alternative to this Annex.<br><br>The **Interface Protection** of the **Synchronous Power Generating Module** shall satisfy the requirements of all of the following standards. Where these standards have more than one part, the requirements of all such parts shall be satisfied, so far as they are applicable.<br><br>• BS EN 61000 (Electromagnetic Standards)<br><br>• BS EN 60255 (Electrical Relays)<br><br>• BS EN 61810 (Electrical Elementary Relays)<br><br>• BS EN 60947 (Low Voltage Switchgear and Control gear)<br><br>• BS EN 61869 (Instrument Transformers: Additional requirements for current transformers)<br><br>Currently there are no harmonised functional standards that apply to the **Power Generating Module Interface Protection**, therefore in order to achieve **Type Tested** status the **Power Generating Module** and any separate **Interface Protection** unit will require their functionality to be **Type Tested** as described in this Annex, and recorded in format similar to that shown in Annex A.2-1.<br><br>Where the **Interface Protection** is physically integrated within the overall **Power Generating Module** 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). For a **Fully Type Tested Power Generating Module** the completed **Power Generating Module**'s **Interface Protection** shall not rely on interconnection using cables which could be terminated incorrectly on site ie the interconnections shall be made by non-reversible plug and socket which the **Manufacturer** has made and tested prior to delivery to site.<br><br>Where **Type Tested** components are wired together on site, ie not using specifically designed plugs and sockets for the purpose, it will be necessary to prove that all wiring has been correctly terminated by proving the functions which rely on the wiring at the time of commissioning as detailed in paragraph 15.2 and Form A2-4 (Annex A.2). | No synchronous Power Generating Module | **N/A** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | Wherever possible the type testing of a **Power Generating Module** utilising a particular type of prime mover should be proved under normal conditions of operation for that prime mover (unless otherwise noted).<br>This Annex can also be used for asynchronous **Generating Unit**s that are not connected to the **Distribution Network** via an **Inverter** as appropriate.<br>This Annex also applies to any **Synchronous Power Generating Module**s that are powered by stored energy (eg compressed air), but the requirement to demonstrate the **LFSM-O** will not be required. | | |
| **A.7.2.2** | **Type Verification Testing of the Interface Protection Functions**<br>Type verification testing is the responsibility of the **Manufacturer**. This test will verify that the operation of the **Power Generating Module Interface Protection** shall result:<br>1. in the safe disconnection of the **Power Generating Module** from the **DNO**'s **Distribution Network** in the event that the protection settings specified in Table 10.1 are exceeded; and<br>2. in the **Power Generating Module** remaining connected to the **DNO**'s **Distribution Network** while network conditions are:<br>a. within the envelope specified by the settings plus and minus the tolerances specified for equipment operation in Table 10.1; and<br>b. within the trip delay settings specified in Table 10.1.<br>The **Interface Protection** may be incorporated into the **Power Generating Module** in which case it should be tested as part of the **Power Generating Module**. Alternatively, the constituent devices that form the **Interface Protection** may be discrete in which case the tests may be carried out on the discrete protection devices independently from the **Power Generating Module**.<br>In either case it will be necessary to verify that a protection operation will disconnect the **Power Generating Module** from the **DNO**'s **Distribution Network**. | No synchronous Power Generating Module | **N/A** |
| **A.7.2.2.1** | **Disconnection times**<br>he minimum trip time delay settings, for over / under voltage, over / under frequency and loss of mains tests below, are presented in Table 10.1.<br>For over / under voltage, over / under frequency and loss of mains tests, reconnection shall be checked | No synchronous Power Generating Module | **N/A** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | as detailed below.<br><br>In some systems it may be safer and more convenient to test the trip delay time and the disconnection time separately. This will allow the trip delay time to be measured in a test environment (in a similar way as for a protection relay). The disconnection time can be measured in the **Power Generating Module**'s normal operation, allowing accurate measurement with correct inertia and prime mover characteristics. This is permitted providing the total disconnection time does not exceed the value specified in Section 10.6.7.1. When measuring the disconnection time where the **Interface Protection** is included in the **Power Generating Module**, 5 s disconnections should be initiated, and the average time recorded. | | |
| **A.7.2.2.2** | Over / Under Voltage<br><br>The **Interface Protection** shall be tested by operating the **Power Generating Module** in parallel with a variable AC test supply, as an example see Figure A.7.5.<br><br>Correct protection and ride-through operation shall be confirmed. The set points for over and under voltage at which the **Interface Protection** disconnects from the supply, will be established by varying the frequency of the AC supply voltage. The disconnect sequence should be initiated when the network conditions mean the protection should trip in accordance with the settings in Table 10.1, otherwise normal operation should continue.<br><br>To establish the certified trip voltage, the test voltage should be applied in steps of ± 0.5% or less of the voltage setting for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s starting at least 4 V below or above the setting. Additional tests just above and below the trip voltage should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the type verification test report Annex A.2-1.<br><br>To establish the certified trip time, the test voltage should be applied starting from 4 V below or above the certified trip voltage and should be changed to 4 V above or below the certified trip voltage in a single step. The time taken from the step change to the **Power Generating Module** tripping is to be recorded on the type verification test report Annex A.2-1.<br><br>To establish correct ride-through operation, the test voltage should be applied at each setting ± 4 V and for the relevant times shown in the Table in Annex A.2-1.<br><br>For example, to test over voltage setting stage 1 | No synchronous Power Generating Module | **N/A** |

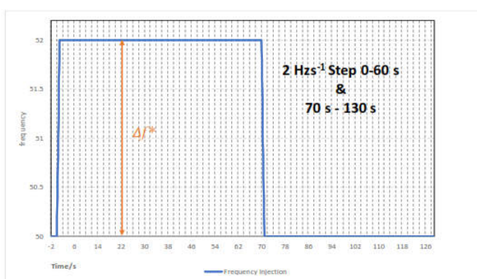
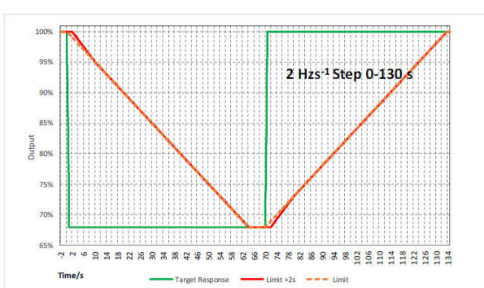
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | which is required to be set at nominally 262.2 V the circuit can be set up as shown below and the voltage adjusted to 254.2 V. In integrated designs where there is no separate way of establishing that the **Power Generating Module** is disconnected, the **Power Generating Module** should be powered up to export a measurable amount of energy so that it can be confirmed that the **Power Generating Module** has ceased to output energy. The variable voltage supply is then increased in steps of no more than 0.5% of nominal voltage (1.15 V) maintaining the voltage for at least 1.5 s (trip time plus 0.5 s) at each voltage level. At each voltage level confirmation that the **Power Generating Module** has not tripped after the time delay is required to be taken. At the voltage level at which a trip occurs then this should be recorded as the provisional trip voltage. Additional tests just below and if necessary just above the provisional trip voltage will allow the actual trip voltage to be established on a repeatable basis. This value should be recorded. For the sake of this example the actual trip level is assumed to have been established as being 261 V. The variable voltage supply should be set to 257 V the **Power Generating Module** set to produce a measurable output (if necessary) and then the voltage raised to 265 V in a single step. The time from the step change to the disconnection of the **Power Generating Module**, the output of the **Power Generating Module** falling to zero should be recorded as the trip time.<br><br>To confirm that the protection does not trip before the required time, the test voltage should be applied at each setting ± 4V and for the relevant times shown in the table in Annex A.2-1.<br><br>Test results should be recorded on the Test Sheet shown in Annex A.2-1<br><br><br><br>Figure A.7.5.- Power Generating Module test set up – over / under voltage | | |
| **A.7.2.2.3** | **Over / Under Frequency**<br><br>The **Interface Protection** shall be tested by operating the **Power Generating Module** in parallel with a low impedance, variable frequency test supply system,<br><br>as an example, see Figure A.7.6. Correct protection and ride-through operation should be confirmed during the test. The set points for over and under | No synchronous Power Generating Module | **N/A** |

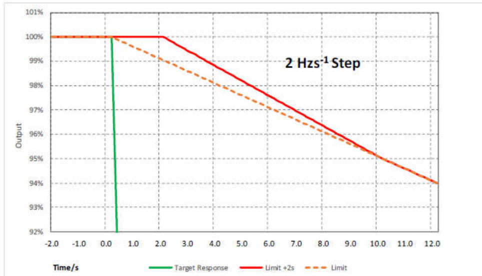
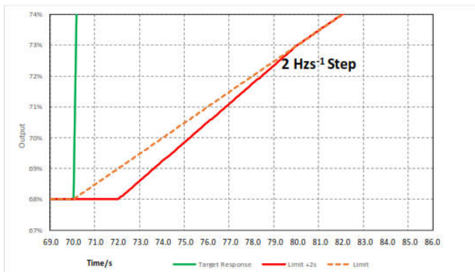
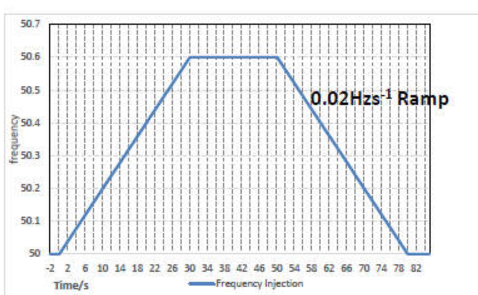
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | frequency at which the **Interface Protection** disconnects from the supply will be established by varying the test supply frequency.<br><br>To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hzs-1, or if this is not possible in steps of 0.05 Hz for a duration that is longer than the trip time delay, for example 1 s in the case of a delay setting of 0.5 s. The test frequency at which this trip occurred is to be recorded. Additional tests just above and below the trip frequency should be undertaken to show that the test is repeatable and the figure at which a repeatable trip occurs should be recorded on the type verification test report Annex A.2-1.<br><br>To establish the trip time, the test frequency should be applied starting from 0.3 Hz below or above the recorded trip frequency and should be changed to 0.3 Hz above or below the recorded trip frequency in a single step. The time taken from the step change to the Power Generating Module tripping is to be recorded on the type verification test report Annex A.2-1. It should be noted that with some loss of mains detection techniques this test may result in a faster trip due to operation of the loss of mains protection and if possible the loss of mains protection should be turned off in order to carry out this test. Otherwise a much smaller step change should be used to initiate the trip and establish a trip time which may require the test to be repeated several times to establish that the time delay is correct.<br><br><br>**Figure A.7.6. Power Generating Module test set up – over / under frequency** | | |
| **A.7.2.2.4** | **Loss of Mains Protection**<br><br>The resonant test circuit specified as an option for this test has been designed to model the interaction of the **Power Generating Module** under test with the local load including multiple **Power Generating Module**'s in parallel.<br><br>The **Power Generating Module** output shall be connected to a network combining a resonant circuit with a Q factor of >0.5 and a variable load. The value of the load is to match the **Power Generating Module** output. To facilitate the test for LoM there shall be a switch placed between the test load/ **Power Generating Module** combination and the | No synchronous Power Generating Module | **N/A** |

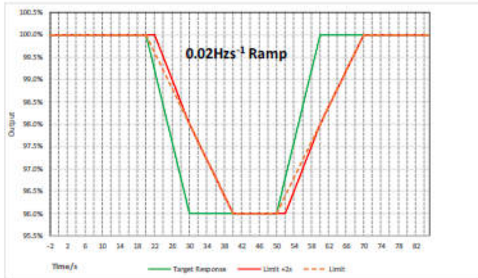
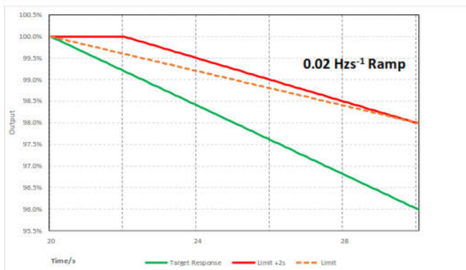
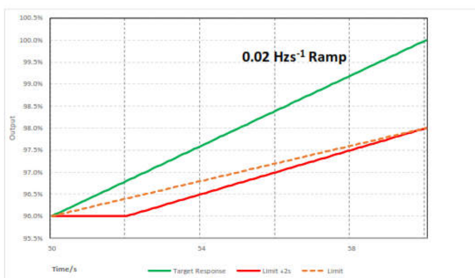
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | **DNO**'s **Distribution Network**, as shown in Figure A.7.7.<br><br><br>Figure A.7.7 Power Generating Module test set up - loss of mains<br><br>The **Power Generating Module** is to be tested at three levels of the **Power Generating Module**'s **Registered Capacity**: 10%, 55% and 100% and the results recorded on the test sheet of Annex A.2-1.<br><br>For each test the load match is to be within ± 5%. Each test is to be repeated five times.<br><br>Load match conditions are defined as being when the current from the **Power Generating Module** meets the requirements of the test load ie there is no export or import of supply frequency current to or from the **DNO**'s **Distribution Network**.<br><br>The tests will record the **Power Generating Module**'s output voltage and frequency from at least 2 cycles before the switch is opened until the protection system operates and disconnects itself from the **DNO**'s **Distribution Network**, or for 5 s whichever is the lower duration.<br><br>The time from the switch opening until the protection disconnection occurs is to be measured and shall comply with the requirements in Table 10.1.<br><br>Multi phase **Power Generating Module**s should be operated at part load while connected to a network running at about 50 Hz and one phase only shall be disconnected with no disturbance to the other phases. The **Power Generating Module** should trip within 1 s. The test needs to be repeated with each phase disconnected in turn while the other two phases remain in operation and the results recorded in the **Type Test** declaration. | | |
| **A.7.2.2.5** | **Re-connection**<br><br>Further tests will be carried out with the three test circuits above to check the **Power Generating Module** time- out feature prior to automatic network reconnection. This test will confirm that once the AC supply voltage and frequency have returned to within the stage 1 settings specified in Table 10.1 following an automatic protection trip operation there is a minimum time delay of 20 s before reconnection will be allowed. | No synchronous Power Generating Module | **N/A** |
| **A.7.2.2.6** | **Frequency drift and vector shift stability test.** | No synchronous Power | **N/A** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | The tests will be carried out using the same circuit as specified in A.7.2.2.3 above and following confirmation that the **Power Generating Module** has passed the under and over frequency trip and no trip tests.<br><br>Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the **Power Generating Module** should not trip during the test.<br><br>For the step change test the **Power Generating Module** should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period f at least 10 s to complete the test. The **Power Generating Module** should not trip during this test.<br><br>For frequency drift tests the **Power Generating Module** should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0.95 Hzs-1 to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The **Power Generating Module** should not trip during this test.<br><br>The results shall be recorded on the test sheet of Annex A.2-1. | Generating Module | |
| **A.7.2.3** | **Power Output with Falling Frequency** | No synchronous Power Generating Module | **N/A** |
| **A.7.2.3.1** | The **Generator** will propose and agree a test procedure with the **DNO**, which will demonstrate how the **Synchronous Power Generating Module Active Power** output responds to changes in system frequency.<br><br>The tests can be undertaken by the **Synchronous Power Generating Module** powering a suitable load bank, or alternatively using the test set up of Figure A.7.6.<br><br>In both cases a suitable test could be to start the test at nominal frequency with the **Synchronous Power Generating Module** operating at 100% of its **Registered Capacity**.<br><br>The frequency should then be set to 49.5 Hz for 5 minutes. The output should remain at 100% of **Registered Capacity**.<br><br>The frequency should then be set to 49.0 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output shall not be below 99% of **Registered Capacity**.<br><br>The frequency should then be set to 48.0 Hz and | No synchronous Power Generating Module | **N/A** |

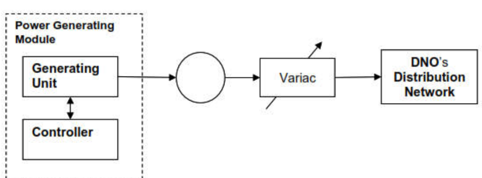
| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output shall not be below 97% of **Registered Capacity**.<br>The frequency should then be set to 47.6 Hz and once the output has stabilised, held at this frequency for 5 minutes. The **Active Power** output shall not be below 96.2% of **Registered Capacity**.<br>The frequency should then be set to 47.1 Hz and held at this frequency for 20 s.<br>The **Active Power** output shall not be below 95.0% of **Registered Capacity** and the **Synchronous Power Generating Module** shall not trip in less than the 20s of the test.<br>The **Generator** shall inform the **DNO** if any load limiter control is additionally employed. | | |
| **A.7.2.4** | **Synchronous Power Generating Modules which include Electricity Storage**<br>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 Synchronous Power Generating Module Active Power when acting as a load (ie replenishing its energy store) responds to changes in system frequency.<br>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.<br>In both cases the test is to reduce frequency from 50 Hz at 2 $Hzs^{-1}$. 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.<br>In all cases the response shall meet the requirements of 11.2.3.3. | No synchronous Power Generating Module | **N/A** |
| **A.7.2.5** | **Limited Frequency Sensitive Mode – Over (LFSM-O)**<br>The tests described in this Annex A.7.2.4 are also suitable for **Type A Power Generating Modules** > 50 kW. | No synchronous Power Generating Module | **N/A** |
| **A.7.2.5.1** | This paragraph is applicable to all **Synchronous Power Generating Modules** other than slow acting micro hydro **Synchronous Power Generating Modules** which should refer to paragraph A.7.2.4.2.<br>Note that this test is also an alternative to the test in A.7.1.3.<br>The two frequency response tests in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate **LFSM-O** capability to a frequency injection as shown by Figures A.7.8 and Figures A.7.9 are to be | No synchronous Power Generating Module | **N/A** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | conducted at **Registered Capacity** (although a lower power output may be agreed with the **DNO** if site conditions preclude attaining **Registered Capacity**, such as an absence of adequate wind).<br><br>There should be sufficient time allowed between tests for control systems to reach steady state. The injection signal should be maintained until the **Active Power** (MW) output of the **Power Generating Module** has stabilised. The **DNO** may require repeat tests should the tests give unexpected results.<br><br>The frequency input and the expected **Active Power** response are illustrated for different periods from 0 s to 130 s in Figure A.7.8 for a step change in frequency and in Figures A.7.9 for a ramp change in frequency. This should be in accordance with Section 11.2.4 (a threshold frequency of 50.4 Hz and a **Droop** of 10%) and undamped oscillations should not occur after the step or ramp frequency change.<br><br>Note for diagram purposes only a short interval is shown between the frequency increase and decrease for each test. In practice the return step or ramp can start any time after the output has stabilized after the first step or ramp.<br><br>The response should commence within 2 s and shall be to the left of the red line (ie between the green line and the red line) and be as close to the green line as possible when following the frequency step or ramp. Note that the red line represents the 0.5% s-1 specified in 11.2.4.1.<br><br><br>Figure A.7.8(i): LFSM-O step response test – frequency injection<br><br><br>Figure A.7.9(ii): LFSM-O step response test – target response and limits | | |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| Clause | Requirement – Test | Result – Remark | Verdict |
| |   Figure A.7.9(iii): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency increase)<br>  Figure A.7.8(iv): LFSM-O step response test – expansion of the allowed 2 s response delay (frequency decrease)<br>* This frequency step *Δf* will generally be +2.0 Hz unless an injection of this size causes a reduction in plant output that takes the operating point below **Minimum Stable Operating Level** in which case an appropriate injection should be calculated in accordance with the following:<br>For example 1.5 Hz is needed to take an initial output of 100% to a final output of 70%. If the initial output is not 100% and the **Minimum Stable Operating Level** is not 70% then the injected step should be adjusted accordingly as shown in the example given below:<br>Initial output 100%<br>**Minimum Stable Operating Level** 70%<br>Frequency controller **Droop** 10%<br>Frequency to be injected = (1.00 – 0.70) x 0.1 x 50 = 1.5Hz<br>  Figure A.7.10(i): LFSM-O ramp response test – frequency injection | | |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | <br>Figure A.7.10(ii): LFSM-O – target response and limits<br><br>Figure A.7.9(iii): LFSM-O ramp response test – expansion (frequency increase)<br><br>Figure A.7.9(iv): LFSM-O ramp response test – expansion (frequency decrease) | | |
| **A.7.2.5.2** | This paragraph is applicable to slow acting micro hydro **Synchronous Power Generating Modules.**<br>Recognising the significant engineering challenge of physically reducing the electrical energy exported from a slow acting micro hydro **Power Generating Module**, given the mechanical and hydraulic lags involved, the **Generator** may engineer an appropriate **LFSM-O** response by automatically switching in load banks to absorb the electrical energy, using frequency sensitive relays or control gear.<br>A single frequency response step test (ie no ramp test) is required in **Limited Frequency Sensitive Mode (LFSM)** to demonstrate the **LFSM-O** capability in response to a frequency injection of 2.0 Hzs-1 for 1 s as shown by the Figures A.7.10 below. The test is to be conducted at **Registered Capacity** (although a lower power output may be agreed with the **DNO** if site conditions preclude attaining **Registered Capacity**, such as an absence of | No synchronous Power Generating Module | **N/A** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | adequate water flow rate). Similarly if the frequency step takes the operating point below the **Minimum Stable Operating Leve**l an alternative appropriate injection should be calculated that demonstrates **LFSM-O** across the range that is available without breaching the **Minimum Stable Operating Level**.<br><br>There should be sufficient time allowed between the step up in frequency for control systems to reach steady state before the following step down in frequency. The injection signal should be maintained until the **Active Power** (MW) output of the **Power Generating Module** has stabilised. The **DNO** may require repeat tests should the tests give unexpected results.<br><br>The frequency input and the expected **Active Power** response are illustrated below. This should be in accordance with Section 11.2.4. Undamped oscillations should not occur after the step frequency change.<br><br>For both the step up and step down parts of the test the response should commence within 2 s and shall always be to the left of the red line and be as close as possible to the green line representing 10% **Droop** (unless some other **Droop** is desired by the **Generator**).  It is permissible to be to the left of the 2% **Droop** line when the first load bank is switched in (or the final one switched out, ie the first one to be switched out) but the output must be to the right of the 2% **Droop** line by the time the frequency has reached 52.0 Hz (or returned to 50.0 Hz).<br><br><br><br>**Figure A.7.10(i): LFSM-O step response test (frequency increase) for slow acting micro hydro** | | |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | <br>**Figure A.7.10(ii): LFSM-O step response test (frequency decrease) for slow acting micro hydro** | | |
| **A.7.2.6** | **Power Quality** | | **N/A** |
| **A.7.2.6.1** | **Harmonics**<br>The tests should be carried out as specified in BS EN 61000-3-12 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of maximum export capacity. | No synchronous Power Generating Module | **N/A** |
| **A.7.2.6.2** | **Power Factor**<br>The test set up shall be such that the **Power Generating Module** supplies full load to the **DNO**'s **Distribution Network** via the **Power Factor** (pf) meter and the variac as shown below in Figure A.7.10. The **Power Generating Module** pf should be within the limits given in paragraph 11.1.5, for three test voltages 230 V –6%, 230 V and 230 V +10%.<br><br>NOTE 1. For reasons of clarity the points of isolation are not shown<br>NOTE 2: It is permissible to use a voltage regulator or tapped transformer to perform this test rather than a variac as shown<br>**Figure A.7.10 Power Generating Module test set up – Power Factor** | No synchronous Power Generating Module | **N/A** |
| **A.7.2.6.3** | **Voltage Flicker**<br>The voltage fluctuations and flicker emissions from the **Generating Unit** shall be measured in accordance with BS EN 61000-3-11 and technology specific annex.<br>The required maximum supply impedance should be calculated and recorded in the **Type Test** declaration Annex A.2-1. | No synchronous Power Generating Module | **N/A** |
| **A.7.3** | **Additional Power Generating Module Technology Requirements** | | **P** |
| **A.7.3.1** | **Domestic CHP** | No Domestic CHP. | **N/A** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | or Domestic CHP **Power Park Module**s the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.1.<br><br>For Domestic CHP **Synchronous Power Generating Module**s the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.2. | | |
| **A.7.3.2** | **Photovoltaic**<br><br>As all current Photovoltaic **Power Park Module**s will connect to the **DNO**'s **Distribution Network** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.1. | Photovoltaic inverter | **P** |
| **A.7.3.3** | **Fuel Cells**<br><br>As all current Fuel Cell **Power Generating Module**s will connect to the **DNO**'s **Distribution Network** via an **Inverter**, the type verification testing and **Interface Protection** requirements will be as per the requirements defined in Annex A.7.1. | No fuel cell | **N/A** |
| **A.7.3.4** | **Hydro**<br><br>Hydro can be connected to the **DNO**'s **Distribution Network** directly using induction or **Synchronous Power Generating Module**s or it can be connected by an **Inverter**.<br><br>The common requirements for the generator technologies will apply to micro hydro in addition the following needs to be taken into consideration.<br><br>**Power Generating Module**s with manually fixed output or where the output is fixed by controlling the water flow through the turbine to a steady rate, need to comply with the maximum voltage change requirements of BS EN 61000-3-2 but do not need to be tested for $P_{st}$ or $P_{lt}$.<br><br>**Power Park Module**s where the output is controlled by varying the load on the generator using the **Inverter** and which therefore produces variable output need to comply with the maximum voltage change requirements of BS EN 61000-3-2 and also need to be tested for $P_{st}$ and $P_{lt}$ over a period where the range of flows varies over the design range of the turbine with a period of at least 2 hours at each step with there being 10 steps from min flow to maximum flow. $P_{st}$ and $P_{lt}$ values to recorded and normalised as per the method laid down in Annex A.3. | No Hydro | **N/A** |
| **A.7.3.5** | **Wind**<br><br>Wind turbines can be connected to the **DNO**'s **Distribution Network** directly, typically using asynchronous induction generators, or using | No wind | **N/A** |

| Engineering recommendation G99-1 | | | |
|---|---|---|---|
| **Clause** | **Requirement – Test** | **Result – Remark** | **Verdict** |
| | **Inverter**s.<br><br>For those connected via **Inverters**, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.1.<br><br>For those connected directly to the **DNO**'s **Distribution Network**, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.2.<br><br>For wind turbines, flicker testing should be carried out during the performance tests specified in BS EN 61400-12. Flicker data should be recorded from wind speeds of 1 ms-1 below cut-in to 1.5 times 85% of the rated power. The wind speed range should be divided into contiguous bins of 1ms-1 centred on multiples of 1 ms-1. The dataset shall be considered complete when each bin includes a minimum of 10 minutes of sampled data.<br><br>The highest recorded values across the whole range of measurements should be used as inputs to the calculations described in BS EN 61000-3-11 to remove background flicker values. Then the required maximum supply impedance values can be calculated as described in Annex A.2-3. Note that occasional very high values may be due to faults on the associated **HV** network and may be discounted, though care should be taken to avoid discounting values which appear regularly. | | |
| **A.7.3.6** | **Electricity Storage Device**<br><br>**Electricity Storage** devices can be connected to the **DNO**'s **Distribution Network** directly or using **Inverter**s.<br><br>For those connected via **Inverter**s, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.1<br><br>For those connected directly to the **DNO**'s **Distribution Network**, the type verification testing and **Interface Protection** requirements shall be as specified in Annex A.7.2.<br><br>The tests associated with any requirements which have been identified in Annex A4 as not being applicable to **Electricity Storage** devices can be considered to be excluded tests in this Annex A7. | No storage device | **N/A** |

# G99-1
# Test Results:
# A2-3 - Compliance Verification Report for Type A Inverter Connected Power Generating Modules

| A.7.1.2 Type Verification Functional Testing of the Interface Protection (Functional safety - fault condition tests according DIN V VDE V 0124-100) | P |
|---|---|

**Test result: HESS-HY-T-12K**

| | | |
|---|---|---|
| | ambient temperature [°C]: | 25,0 |
| | model/type of power supply: | DC:62150H-1000S<br>AC:61512 |
| | manufacturer of power supply: | Chroma |
| | rated markings of power supply: | DC:0-1000V, 15kW<br>AC:0-300V, 18kW |

| Component No. | Fault | Test condition | | Test time | Fuse No. | Fault condition | | Result |
|---|---|---|---|---|---|---|---|---|
| | | AC | DC | | | AC | DC | |
| PCE input | Reversed | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W<br>AC Output: 230Vac / 0A / 0W<br>FID: Cannot start<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE input | s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W<br>AC Output: 230Vac / 0A / 0W<br>FID: PEC stop, Fault code 59. PV1 string current abnormal.<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE input | Over-voltage | -- | DC 1100 | 10 min. | -- | -- | -- | DC Input: 1100Vdc / 0A / 0W<br>AC Output: 230Vac / 0A / 0W<br>FID: PEC stop, Fault code 37. PV over voltage<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PCE input (only for multistring) | Different input MPP1: low input MPP2: high input | -- | DC 850/ 420 | 10 min. | -- | -- | -- | DC1 Input: 850Vdc / 7,5A / 6050W<br>DC2 Input: 420Vdc / 15,5A / 6050W<br>AC Output: 230Vac / 52A / 12kW<br>FID: normal working.<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE output | Power over-feed (OCP & OTP function controlled by DSP / software is disable) | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W<br>AC Output: 230Vac / 0A / 0W<br>FID: PEC stop, Fault code 46. High DC bus.<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE output | Over-voltage (OVP function controlled by DSP / software is disable) | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W<br>AC Output: 230Vac / 0A / 0W<br>FID: PEC stop, Fault code 46. DC bus is to high.<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE output | s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W<br>AC Output: 230Vac / 0A / 0W<br>FID: PEC stop, overcurrent protect.<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE output | Phase sequence or polarity incorrect | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W<br>AC Output: 230Vac / 0A / 0W<br>FID: PEC cannot work, fault AC voltage fault<br>MT: N/A<br>SD: ☒Yes / ☐No<br>GD: ☒Yes / ☐No<br>RO: ☒Yes / ☐No<br>NCD: ☒Yes / ☐No<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PCE output | A-Phase miswiring grid connection | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PEC cannot work, fault AC voltage fault.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE cooling system failure | Fan locked (MF1) CN04 | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 18,5A / 12100W.<br>AC Output: 230Vac / 52,1A / 12kW.<br>FID: Normal work.<br>MT: Ambient=60℃，IGBT=75,3℃, Transformer=82℃, Inductance=86,8℃<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PCE cooling system failure | Opening blocked CN101 | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 18,5A / 12100W.<br>AC Output: 230Vac / 52,1A / 12kW.<br>FID: Normal work.<br>MT: Ambient=60℃，Enclosure=75,3℃.<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| MCU or DPS processer failure | | | | | | | | |
| DSP failure | +1.2V power supply disable C708 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: DSP reset.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DSP failure | +3.3V power supply disable C719 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: DSP reset.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| **DSP failure reset 20-30%P** | | | | | | | | |
| Loss of control & Function fault | | | | | | | | |
| IGBT PMW | Loss / failure (no power) C299 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| IGBT PMW | Loss / failure (no power) U124 pin 6 to Q121 G s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. IGBT Q121, Q111 broke.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☐Yes / ☒No.<br>RO: ☒Yes / ☐No.<br>NCD: ☐Yes / ☒No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| IGBT PMW | Loss / failure (no driver) U124 pin 6 to Q121 G s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 6. DC bus is to high.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PV/DC voltage detector | Loss / failure R440 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 8. AC HCT failure<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PV/DC voltage detector | Loss / failure R112 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 37. PV over voltage.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PV/DC current detector | Loss / failure U101 pin 11-12 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE cannot stop.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| BUS voltage detector | Loss / failure R186 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 6. DC bus is to high.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Inverter voltage detector | Loss / failure C589 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 34. AC voltage out of range.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Inverter voltage detector | Loss / failure R451 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 34. AC voltage out of range.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Grid/AC voltage detector | Loss / failure C643 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 34. AC voltage out of range.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Grid/AC voltage detector | Loss / failure R717 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 34. AC voltage out of range.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| DC isolation device function check | Loss / failure C584 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 53. ISO check: before enable constant current, ISO voltage > 300mV.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| DC isolation device function check | Loss / failure R429 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 53. ISO check: before enable constant current, ISO voltage > 300mV.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DC isolation device function check | Loss / failure R429 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 53. ISO check: before enable constant current, ISO voltage > 300mV.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Relay / Contact or function check (K1 s-c) | Loss / failure RY501 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 3. Relay check fail.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Relay / Contact or function check (K1 o-c) | Loss / failure RY502 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 10. Device fault.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Relay / Contact or function check (K2 s-c) | Loss / failure RY504 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 3. Relay check fail.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Relay / Contact or function check (K2 o-c) | Loss / failure RY508 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 10. Device fault.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Relay / Contact or function check (K3 s-c) | Loss / failure RY507 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 3. Relay check fail.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Relay / Contact or function check (K3 o-c) | Loss / failure RY510 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 10. Device fault.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Relay / Contact or function check (K4 s-c) | Loss / failure RY513 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 3. Relay check fail.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Relay / Contact or function check (K4 o-c) | Loss / failure RY515 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 10. Device fault.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| RCD/RCM function check | Loss / failure CT106 pin 1-5 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 36. GFCI failure.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RCD/RCM function check | Loss / failure R450 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 36. GFCI failure.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Ambient temperature detector | Loss / failure NTC 102 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 174.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Ambient temperature detector | Loss / failure NTC 102 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 174. Low air temperature.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Heat-sink temperature detector | Loss / failure NTC 102 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 40. Over temperature in inverter.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Heat-sink temperature detector | Loss / failure NTC 102 o-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. Fault code 40. Over temperature in inverter.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DC input BUS capacitor (390 μF) | C208 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: IGBT Q121, Q122, Q123, C208, C209, C210 broke, machine protection, no open fire, basic insulation after failure.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☐Yes / ☒No.<br>NCD: ☐Yes / ☒No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| IGBT (IGBT DS) | Q111 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: PCE stop. IGBT Q111, Q121 broke, machine protection, no open fire, basic insulation after failure.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☐Yes / ☒No.<br>RO: ☐Yes / ☒No.<br>NCD: ☐Yes / ☒No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| PSDR board | | | | | | | | |
| DC SPS unit +7V | Output s-c<br>C433 s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: No fault code, PCE stop.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |
| Power supply transformer | C435 s-c<br>+12V s-c | -- | DC 650 | 10 min. | -- | -- | -- | DC Input: 650Vdc / 0A / 0W.<br>AC Output: 230Vac / 0A / 0W.<br>FID: No fault code, PCE stop.<br>MT: N/A<br>SD: ☒Yes / ☐No.<br>GD: ☒Yes / ☐No.<br>RO: ☒Yes / ☐No.<br>NCD: ☒Yes / ☐No.<br>NH: ☒Pass/ ☐Fail.<br>DST: ☒Pass/ ☐Fail. |

| | | | |
|---|---|---|---|
| FID | Fault Indication | MT | Max. Temperature |
| SD | PCE Shut Down: | GD | Disconnection To Grid |
| RO | Recovered to Operate after removing the single fault setting | NCD | No comp. or parts damaged |
| NH | No hazards occurred | DST | Dielectric strength test |
| s-c | short-circuited | o-c | open-circuited |
| o-l | Over-load. | | |

The errors in the control circuit simulate that the safety is even under one error ensured.

**Addendum – Shutdown device**

| | |
|---|---|
| Each active phase can be switched. (L and N) | Yes. In each line and neutral a Relay with min. 2,3 mm gab used. |
| If no galvanic separation between AC and DC (PV):<br>Two relays in series on each active phase are necessary to fulfil the basic insulation or simple separation based on the PV working voltage. | Two relays in series on each active phase |
| **Note:**<br>The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software. | |

| **Operating Range** | | | | **P** |
|---|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | | |
| Setting values | Over-voltage [V]: | 253,0 | | |
| | Under-voltage [V]: | 195,5 | | |
| | Over-frequency [Hz]: | 52,00 | | |
| | Under-frequency [Hz]: | 47,50 | | |

- Test 1: U = 195,5 V; f = 47,0 Hz; P = 1,00 Sn; cosφ = 1; at least 20 s
- Test 2: U = 195,5 V; f = 47,5 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins
- Test 3: U = 253,0 V; f = 51,5 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins
- Test 4: U = 253,0 V; f = 52,0 Hz; P = 1,00 Sn; cosφ = 1; at least 15 mins
- Test 5: U = 230,0 V; f = 50,0 Hz; P = 1,00 Sn; cosφ = 1; at least 90 mins
- Test 6: U = 230,0 V; f = 50,0 to 50,5 Hz;RoCoF=1Hz/s; P = 1,00 Sn; cosφ = 1

| Test sequence | Voltage [V] | Frequency [Hz] | Output power [kW] | Cos φ [1] |
|---|---|---|---|---|
| Test 1 | 195,5 | 47,00 | 11,38 | 1,000 |
| Test 2 | 195,5 | 47,50 | 11,38 | 1,000 |
| Test 3 | 252,9 | 51,50 | 11,93 | 0,999 |
| Test 4 | 252,9 | 52,00 | 11,91 | 0,999 |
| Test 5 | 229,9 | 50,00 | 11,99 | 1,000 |
| Test 6 | 229,9 | 50,00 | 11,98 | 1,000 |

**Note:**

During the tests the interface protection was disabled.

Operation at reduced power is allowed during test 1 and test 2, equal to the maximum power that can be supplied on reaching the maximum output current limit (P ≥ 0,85 Sn).

During the sequence of test 3 and test 4, automatic adjustment to reduce power in the case of over-frequency was disabled.

The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

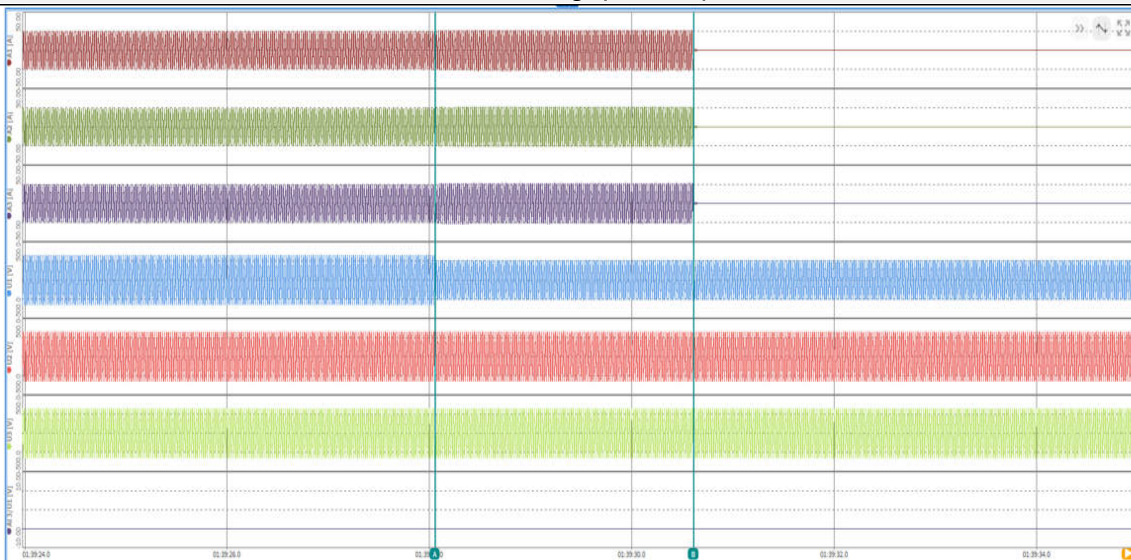
| A.7.1.2.2 Over / Under Voltage<br>These tests should be carried out in accordance with Annex A.7.1.2.2. | P |
|---|---|

| Test result: HESS-HY-T-12K | | | | | | |
|---|---|---|---|---|---|---|
| Phase 1 | | | | | | |
| Function | Setting | | Trip test | | No trip test | |
| | Voltage | Time delay | Voltage | Time delay | Voltage / time | Confirm no trip |
| U/V | 184,0V (0,8 pu) | 2,5s | 184,7V | 2,554s | 188V / 5,0s | No trip |
| | | | | | 180V / 2,45s | No trip |
| O/V stage 1 | 262,2V (1,14 pu) | 1,0s | 262,8V | 1,020s | 258,2V / 5,0s | No trip |
| O/V stage 2 | 273,7V (1,19 pu) | 0,5s | 273,4V | 0,520s | 269,7V / 0,95s | No trip |
| | | | | | 277,7V / 0,45s | No trip |
| Phase 2 | | | | | | |
| Function | Setting | | Trip test | | No trip test | |
| | Voltage | Time delay | Voltage | Time delay | Voltage / time | Confirm no trip |
| U/V | 184,0V (0,8 pu) | 2,5s | 184,3V | 2,560s | 188V / 5,0s | No trip |
| | | | | | 180V / 2,45s | No trip |
| O/V stage 1 | 262,2V (1,14 pu) | 1,0s | 262,2V | 1,001s | 258,2V / 5,0s | No trip |
| O/V stage 2 | 273,7V (1,19 pu) | 0,5s | 273,3V | 0,508s | 269,7V / 0,95s | No trip |
| | | | | | 277,7V / 0,45s | No trip |
| Phase 3 | | | | | | |
| Function | Setting | | Trip test | | No trip test | |
| | Voltage | Time delay | Voltage | Time delay | Voltage / time | Confirm no trip |
| U/V | 184,0V (0,8 pu) | 2,5s | 184,3V | 2,573s | 188V / 5,0s | No trip |
| | | | | | 180V / 2,45s | No trip |
| O/V stage 1 | 262,2V (1,14 pu) | 1,0s | 263,4V | 1,022s | 258,2V / 5,0s | No trip |
| O/V stage 2 | 273,7V (1,19 pu) | 0,5s | 274,4V | 0,511s | 269,7V / 0,95s | No trip |
| | | | | | 277,7V / 0,45s | No trip |

**Note:**
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 + 0,1 s.
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.

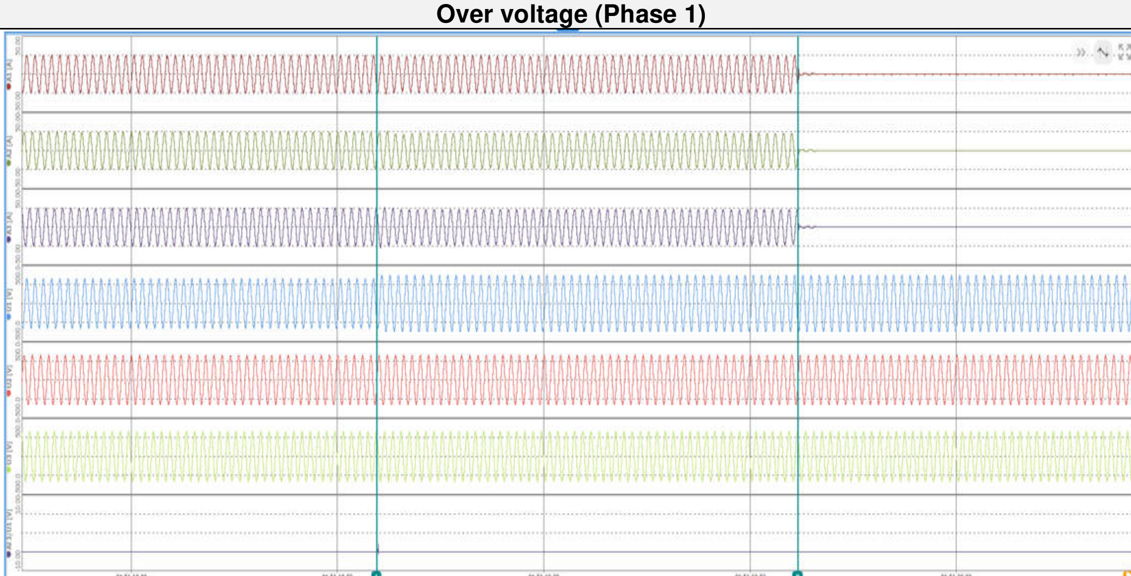
The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

**Under voltage(Phase 1)**



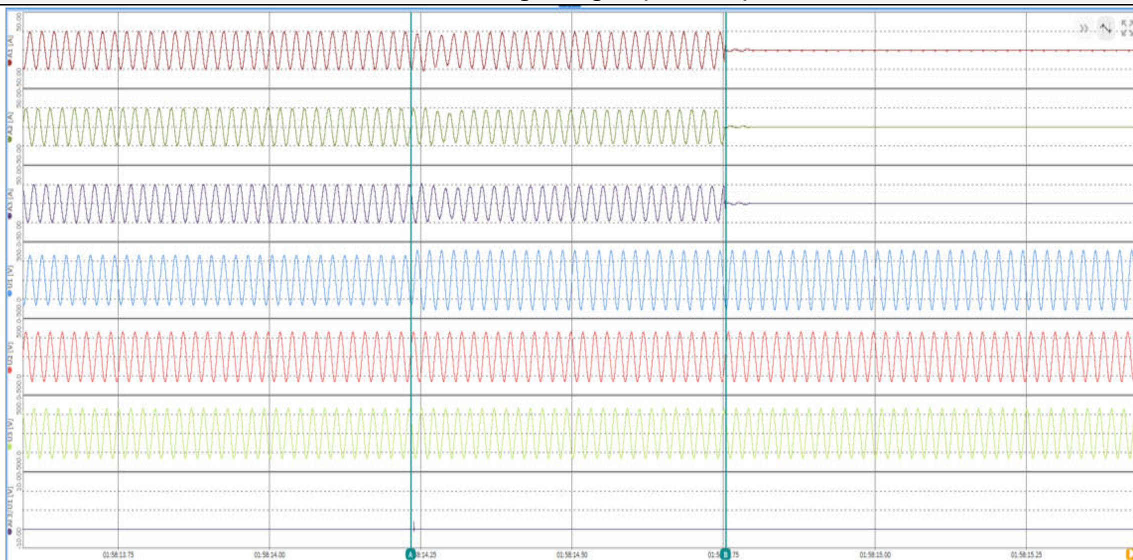
| 时间 [s] | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| | 01:39:28.056677 | 01:39:30.610252 | 2.553575 | |
| A1 [A] | 23.09740 | -1.417995 | -24.51539 | 18.58324 |
| A2 [A] | -18.15379 | 1.784563 | 19.93835 | 18.39280 |
| A3 [A] | -4.827977 | 0.030994 | 4.858971 | 18.75779 |
| U1 [V] | 309.2566 | -33.71573 | -342.9723 | 182.9304 |
| U2 [V] | -240.8600 | 292.5422 | 533.4022 | 229.9839 |
| U3 [V] | -68.36892 | -248.6386 | -180.2697 | 229.7506 |
| AI 3/U1 [V] | -4.034996 | -5.081892 | -1.046896 | 5.072676 |

**Over voltage (Phase 1)**



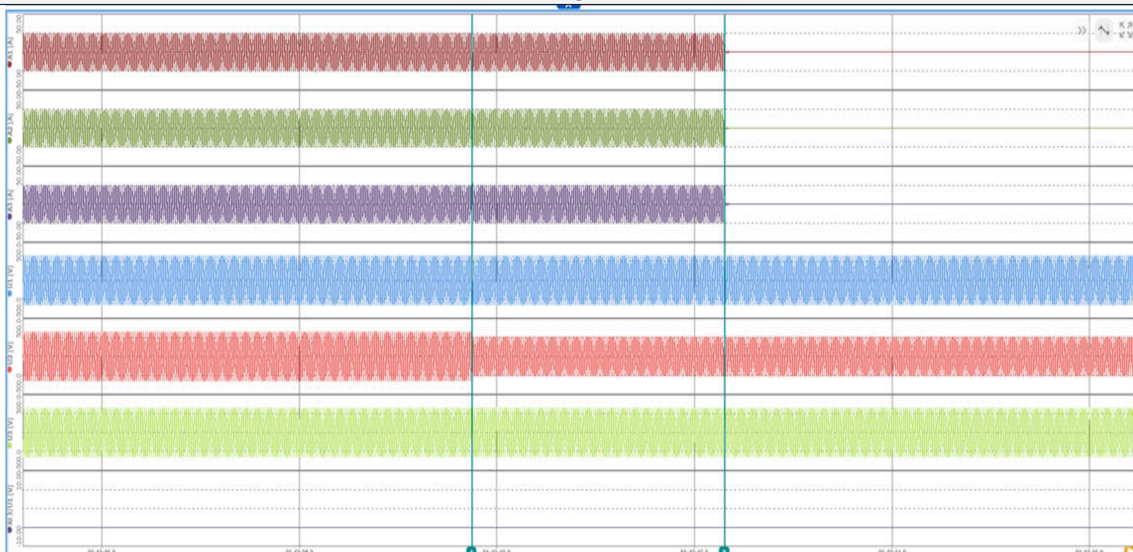
| 时间 [s] | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| | 01:51:18.595860 | 01:51:19.616141 | 1.020281 | |
| A1 [A] | -15.71834 | -16.62195 | -0.903606 | 16.67061 |
| A2 [A] | -8.449555 | -5.700589 | 2.748966 | 16.34702 |
| A3 [A] | 24.12677 | 22.34519 | -1.781583 | 16.57662 |
| U1 [V] | -209.2040 | -266.7039 | -57.49989 | 263.4764 |
| U2 [V] | -111.4774 | -80.93834 | 30.53904 | 229.7096 |
| U3 [V] | 320.5049 | 313.8151 | -6.689787 | 229.8628 |
| AI 3/U1 [V] | -5.072117 | -5.072356 | -2.384e-4 | 5.068542 |

**Over voltage stage 2(Phase 1)**



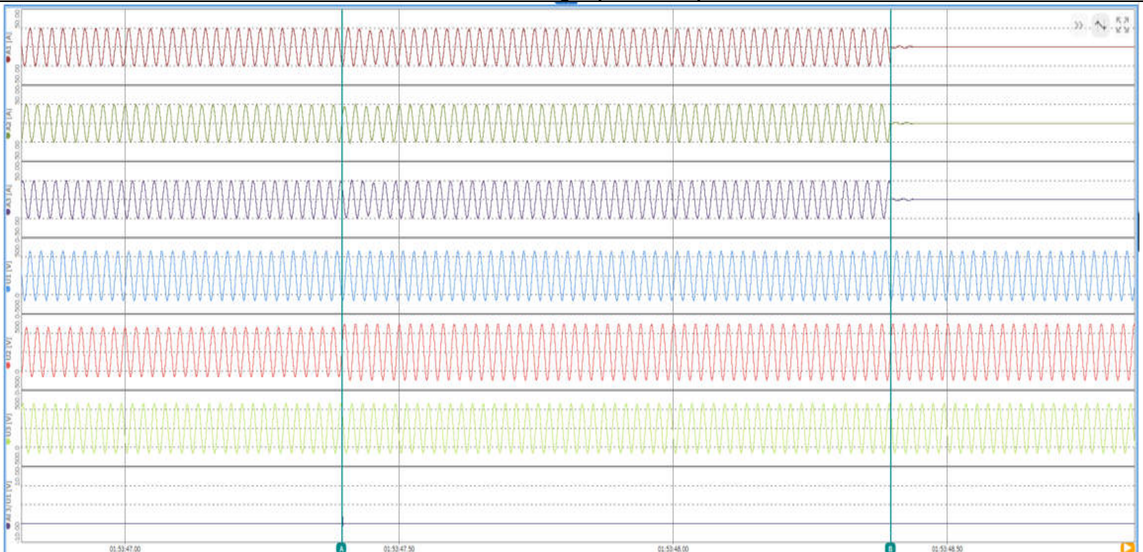
| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 01:58:14.234142 | 01:58:14.754080 | 0.519938 | |
| A1 [A] | -24.84322 | 0.150800 | 24.99402 | 16.30679 |
| A2 [A] | 9.810329 | -1.210570 | -11.02090 | 15.99610 |
| A3 [A] | 15.02931 | 1.040697 | -13.98861 | 16.20898 |
| U1 [V] | -322.4070 | -382.8821 | -60.47511 | 274.0991 |
| U2 [V] | 130.1155 | 115.2623 | -14.85324 | 229.7206 |
| U3 [V] | 192.7500 | 205.0991 | 12.34913 | 229.7651 |
| AI 3/U1 [V] | -5.059004 | -5.065203 | -6.199e-3 | 5.065265 |

**Under voltage(Phase 2)**



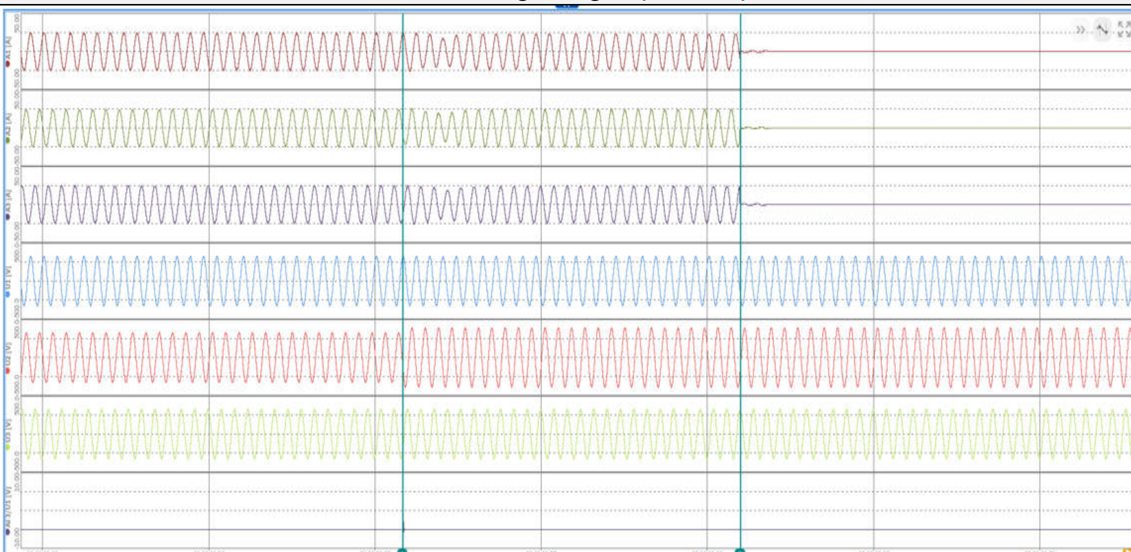
| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 01:42:39.747015 | 01:42:42.306060 | 2.559045 | |
| A1 [A] | -11.96206 | -18.30459 | -6.342531 | 17.33038 |
| A2 [A] | 24.07313 | 23.29826 | -0.774860 | 17.27108 |
| A3 [A] | -12.21180 | -5.075336 | 7.136465 | 17.49560 |
| U1 [V] | -167.3527 | -243.7692 | -76.41650 | 229.8549 |
| U2 [V] | 325.5060 | 245.4298 | -80.07622 | 182.9878 |
| U3 [V] | -157.9976 | -64.59165 | 93.40597 | 229.8722 |
| AI 3/U1 [V] | -5.076409 | -5.071402 | 5.007e-3 | 5.068676 |

## Over voltage (Phase 2)



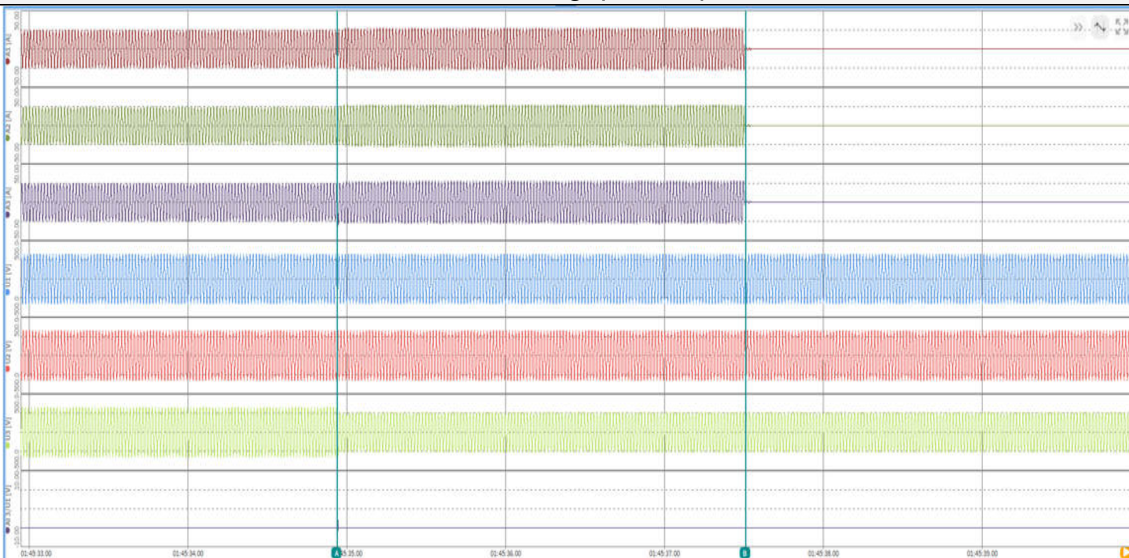
| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 01:53:47.395618 | 01:53:48.396825 | 1.001207 | |
| A1 [A] | -22.10677 | 0.152588 | 22.25936 | 17.03802 |
| A2 [A] | 0.018477 | -1.349449 | -1.367927 | 17.24142 |
| A3 [A] | 22.02511 | 1.049638 | -20.97547 | 17.37076 |
| U1 [V] | -288.9226 | -324.1420 | -35.21943 | 229.8764 |
| U2 [V] | 15.01393 | 149.4603 | 134.4464 | 263.5485 |
| U3 [V] | 275.1808 | 194.0322 | -81.14863 | 229.7444 |
| AI 3/U1 [V] | -5.062342 | -5.064249 | -1.907e-3 | 5.066539 |

## Over voltage stage 2(Phase 2)



| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 02:00:29.542057 | 02:00:30.049807 | 0.507750 | |
| A1 [A] | 23.38052 | -0.774264 | -24.15478 | 16.53188 |
| A2 [A] | -3.983975 | -3.191233 | 0.792742 | 16.83787 |
| A3 [A] | -19.47820 | 3.423691 | 22.90189 | 16.85630 |
| U1 [V] | 304.5819 | -153.2881 | -457.8700 | 229.6370 |
| U2 [V] | -55.53413 | -184.8540 | -129.3199 | 275.0634 |
| U3 [V] | -249.3611 | 305.9931 | 555.3542 | 229.3438 |
| AI 3/U1 [V] | -5.060911 | -5.067587 | -6.676e-3 | 5.064098 |

**Under voltage(Phase 3)**



| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 01:45:34.936757 | 01:45:37.509438 | 2.572680 | |
| A1 [A] | 0.967383 | -1.040697 | -2.008081 | 19.19708 |
| A2 [A] | -21.45469 | 1.225472 | 22.68016 | 19.19827 |
| A3 [A] | 20.45393 | -0.239611 | -20.69354 | 19.51172 |
| U1 [V] | 28.50723 | 220.5522 | 192.0450 | 229.7782 |
| U2 [V] | -295.0764 | 95.73866 | 390.8150 | 229.8687 |
| U3 [V] | 266.1209 | -251.9691 | -518.0900 | 183.2813 |
| AI 3/U1 [V] | -5.060196 | -5.064965 | -4.768e-3 | 5.067132 |

Over voltage (Phase 3)

| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 01:56:14.837293 | 01:56:15.859711 | 1.022419 | |
| A1 [A] | -21.45350 | -1.303554 | 20.14995 | 15.69221 |
| A2 [A] | 20.81812 | 0.243783 | -20.57433 | 15.51939 |
| A3 [A] | 0.593066 | 1.041293 | 0.448227 | 16.18179 |
| U1 [V] | -288.0314 | -100.0676 | 187.9637 | 229.6080 |
| U2 [V] | 275.0600 | 317.6420 | 42.58204 | 230.0256 |
| U3 [V] | 12.69031 | -249.8632 | -262.5535 | 263.2930 |
| AI 3/U1 [V] | -5.064011 | -5.063057 | 9.537e-4 | 5.065889 |

| Over voltage stage 2(Phase 3) |
| --- |


| | A | B | 间隔 | 有效值 |
| --- | --- | --- | --- | --- |
| 时间 [s] | 02:02:41.682664 | 02:02:42.193819 | 0.511155 | |
| A1 [A] | 23.39900 | -3.446937 | -26.84593 | 15.01233 |
| A2 [A] | -17.01474 | 4.835725 | 21.85047 | 14.89303 |
| A3 [A] | -6.430746 | -1.567006 | 4.863739 | 15.52142 |
| U1 [V] | 315.0296 | -275.9018 | -590.9315 | 229.7905 |
| U2 [V] | -228.6132 | 315.5470 | 544.1602 | 229.8383 |
| U3 [V] | -85.89221 | -44.96646 | 40.92574 | 274.2641 |
| AI 3/U1 [V] | -5.064011 | -5.062819 | 1.192e-3 | 5.063487 |

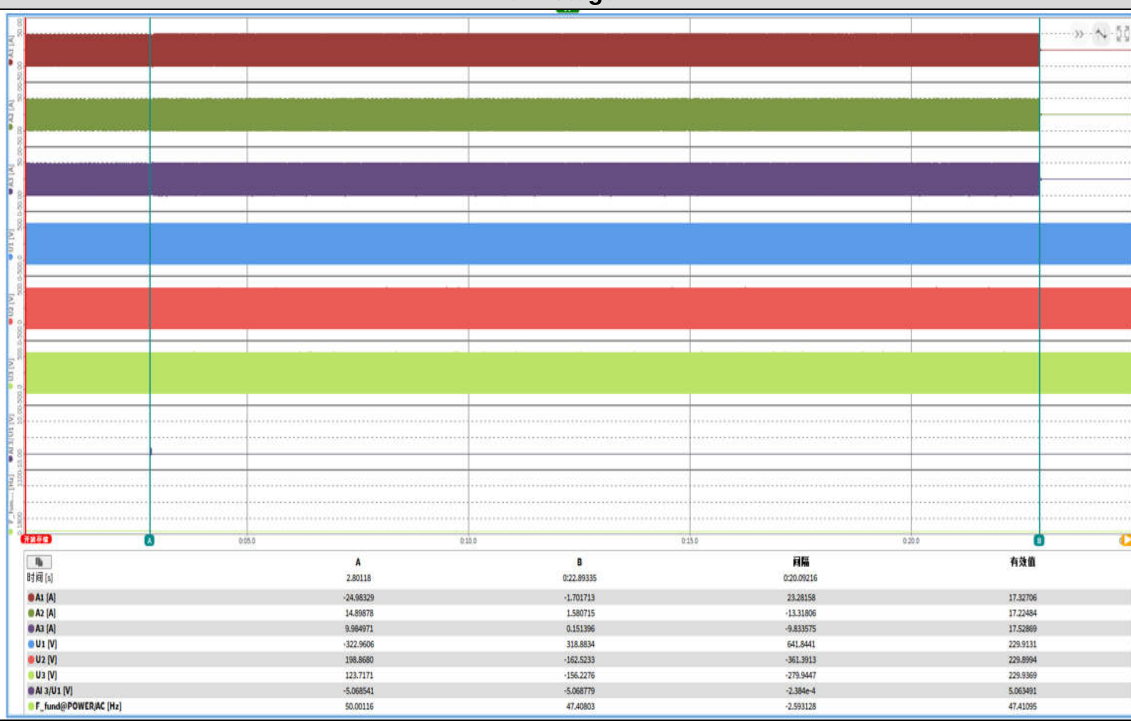
| A.7.1.2.3 **Over / Under Frequency**<br>These tests should be carried out in accordance with Annex A.7.1.2.3. | | | | | | **P** |
|---|---|---|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | | | | |
| Function | Setting | | Trip test | | No trip test | |
| | Frequency | Time delay | Frequency | Time delay | Frequency / time | Confirm no trip |
| U/F stage 1 | 47,5Hz | 20,0s | 47,50Hz | 20,092s | 47,7Hz / 30s | No trip |
| U/F stage 2 | 47,0Hz | 0,5s | 47,00Hz | 0,556s | 47,2Hz / 19,5s | No trip |
| | | | | | 46,8 Hz / 0,45s | No trip |
| O/F | 52,0Hz | 0,5s | 52,00Hz | 0,550s | 51,8Hz / 120s | No trip |
| | | | | | 52,2 Hz / 0,45s | No trip |

**Note:**

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 + 0,1 s.

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.
The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

**U/F stage 1**



## U/F stage 2

| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 5:32.818223 | 5:33.374465 | 0.556242 | |
| A1 [A] | 10.18941 | 1.029968 | -9.159446 | 17.28400 |
| A2 [A] | -24.63699 | -1.408458 | 23.22853 | 17.23180 |
| A3 [A] | 14.32300 | 0.333190 | -13.98981 | 17.51224 |
| U1 [V] | 134.3470 | -153.7438 | -288.0907 | 229.3202 |
| U2 [V] | -323.6091 | -170.0769 | 153.5323 | 230.1067 |
| U3 [V] | 189.6153 | 325.6562 | 136.0409 | 230.1600 |
| AI 3/U1 [V] | -5.065441 | -5.064249 | 1.192e-3 | 5.067833 |

## O/F

| | A | B | 间隔 | 有效值 |
|---|---|---|---|---|
| 时间 [s] | 7:34.022892 | 7:34.572866 | 0.549974 | |
| A1 [A] | -3.119707 | 1.155138 | 4.274845 | 17.31028 |
| A2 [A] | 22.33207 | -1.173019 | -23.50509 | 17.19492 |
| A3 [A] | -19.30833 | -0.057817 | 19.25051 | 17.51751 |
| U1 [V] | -52.99163 | -134.9940 | -82.00241 | 229.2914 |
| U2 [V] | 305.2089 | -186.0361 | -491.2451 | 229.7795 |
| U3 [V] | -251.5481 | 320.8685 | 572.4166 | 229.9553 |
| AI 3/U1 [V] | -5.074740 | -5.062819 | 0.011921 | 5.066731 |

| **A.7.1.2.4 Loss of mains protection according BS EN 62116**<br>These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.<br>Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%) | **P** |
|---|---|

**Test result: HESS-HY-T-12K**

| Test conditions | Frequency: 50+/-0,1Hz<br>$U_N$=230+/-3Vac<br>Distortion factor of chokes < 2%<br>Quality =1 |
|---|---|
| Disconnection limit | 0,5 s |

| No | $P_{EUT}$ 1) (% of EUT rating) | Reactive load (% of $Q_L$ in 6.1.d) 1) | $P_{AC}$ 2) (% of nominal) | $Q_{AC}$ 3) (% of nominal) | $I_{AC}$ 4) [A] | $P_{EUT}$ [kW per phase] | $V_{DC}$ [V] | $Q_f$ [1] | Run on Time [ms] | Remarks5) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 100 | 0 | 0 | 0,137 | 4,0 | 620,0 | 1,002 | 423,0 | BL |
| 4 | 100 | 100 | -5 | -5 | -- | 4,0 | 620,0 | 1,026 | 253,5 | IB |
| 5 | 100 | 100 | -5 | 0 | -- | 4,0 | 620,0 | 1,053 | 254,0 | IB |
| 6 | 100 | 100 | -5 | +5 | -- | 4,0 | 620,0 | 1,079 | 258,0 | IB |
| 7 | 100 | 100 | 0 | -5 | -- | 4,0 | 620,0 | 0,975 | 180,5 | IB |
| 8 | 100 | 100 | 0 | +5 | -- | 4,0 | 620,0 | 1,025 | 181,0 | IB |
| 9 | 100 | 100 | +5 | -5 | -- | 4,0 | 620,0 | 0,928 | 317,5 | IB |
| 10 | 100 | 100 | +5 | 0 | -- | 4,0 | 620,0 | 0,952 | 251,5 | IB |
| 11 | 100 | 100 | +5 | +5 | -- | 4,0 | 620,0 | 0,976 | 382,5 | IB |

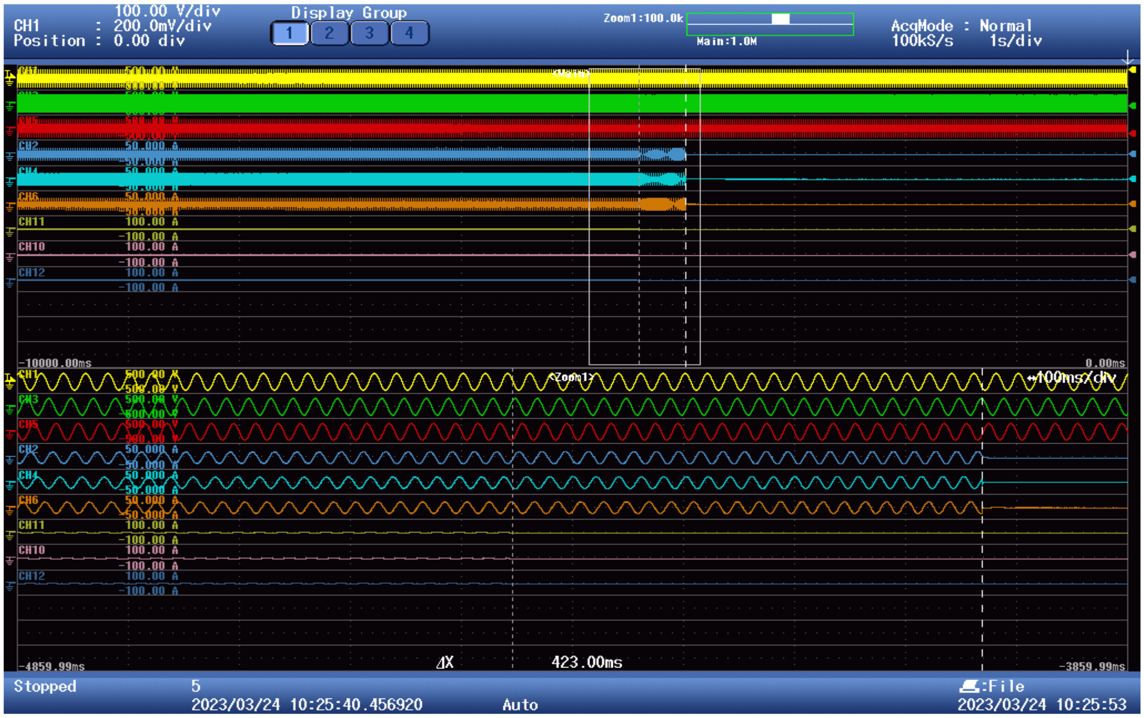
| Parameter at 0% per phase | L= 42,12mH | R= 13,23Ω | C= 240,81µF |
|---|---|---|---|

| Indicate additional shut down time included in above results.<br>(Disconnection device operation time) | 20 ms |
|---|---|

**Note:**
Note for technologies which have a substantial shut down time this can be added to the 0,5 seconds in establishing that the trip occurred in less than 0,5s. Maximum shut down time could therefore be up to 1,0 seconds for these technologies.
RLC is adjusted to min. +/-1% of the inverter rated output power
1) $P_{EUT}$: EUT output power
2) $P_{AC}$: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) $Q_{AC}$: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) Fundamental of $I_{AC}$ when RLC is adjusted.
5) BL: Balance condition, IB: Imbalance condition.
Condition A:
EUT output power PEUT = Maximum 5)
EUT input voltage 6) = >75% of rated input voltage range
6) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.
7) 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.
The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

**Disconnection at $P_{AC}$ 0% and $Q_{AC}$ 0% reactive load and 100% nominal power**

**Disconnection at No. 1**



| **A.7.1.2.4 Loss of mains protection according BS EN 62116**<br>These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.<br>Load imbalance (real, reactive load) for test condition A (EUT output = 50 % – 66 %) | **P** |
|---|---|

**Test result: HESS-HY-T-12K**

| Test conditions | Frequency: 50+/-0,1Hz<br>$U_N$=230+/-3Vac<br>Distortion factor of chokes < 2%<br>Quality =1 |
|---|---|
| Disconnection limit | 0,5 s |

| No | $P_{EUT}$ 1) (% of EUT rating) | Reactive load (% of $Q_L$ in 6.1.d) 1) | $P_{AC}$ 2) (% of nominal) | $Q_{AC}$ 3) (% of nominal) | $I_{AC}$ 4) [A] | $P_{EUT}$ [kW per phase] | $V_{DC}$ [V] | $Q_f$ [1] | Run on Time [ms] | Remarks5) |
|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 66 | 66 | 0 | -5 | -- | 2,64 | 480,0 | 0,975 | 218,5 | IB |
| 13 | 66 | 66 | 0 | -4 | -- | 2,64 | 480,0 | 0,980 | 221,0 | IB |
| 14 | 66 | 66 | 0 | -3 | -- | 2,64 | 480,0 | 0,985 | 225,5 | IB |
| 15 | 66 | 66 | 0 | -2 | -- | 2,64 | 480,0 | 0,990 | 256,5 | IB |
| 16 | 66 | 66 | 0 | -1 | -- | 2,64 | 480,0 | 0,995 | 312,5 | IB |
| 2 | 66 | 66 | 0 | 0 | 0,103 | 2,64 | 480,0 | 1,000 | 491,5 | BL |
| 17 | 66 | 66 | 0 | 1 | -- | 2,64 | 480,0 | 1,005 | 325,0 | IB |
| 18 | 66 | 66 | 0 | 2 | -- | 2,64 | 480,0 | 1,010 | 263,0 | IB |
| 19 | 66 | 66 | 0 | 3 | -- | 2,64 | 480,0 | 1,015 | 247,0 | IB |
| 20 | 66 | 66 | 0 | 4 | -- | 2,64 | 480,0 | 1,020 | 222,0 | IB |
| 21 | 66 | 66 | 0 | 5 | -- | 2,64 | 480,0 | 1,025 | 194,5 | IB |

| Parameter at 0% per phase | L= 63,81mH | R= 20,04Ω | C= 158,93µF |
|---|---|---|---|

| Indicate additional shut down time included in above results.<br>(Disconnection device operation time) | 20 ms |
|---|---|

**Note:**
RLC is adjusted to min. +/-1% of the inverter rated output power
1) $P_{EUT}$: EUT output power
2) $P_{AC}$: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) $Q_{AC}$: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) Fundamental of $I_{AC}$ when RLC is adjusted.
5) BL: Balance condition, IB: Imbalance condition.
Condition B:
EUT output power PEUT = 50 % – 66 % of maximum
EUT input voltage 5) = 50 % of rated input voltage range, ±10 %
6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 50 % of range =X + 0,5 × (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.
The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

**Disconnection at $P_{AC}$ 0% and $Q_{AC}$ 0% reactive load and 66% nominal power**

**Disconnection at No. 2**

| **A.7.1.2.4 Loss of mains protection according BS EN 62116**<br>These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.<br>Load imbalance (real, reactive load) for test condition A (EUT output = 25 % – 33 %) | **P** |
|---|---|

**Test result: HESS-HY-T-12K**

| Test conditions | Frequency: 50+/-0,1Hz<br>$U_N$=230+/-3Vac<br>Distortion factor of chokes < 2%<br>Quality =1 |
|---|---|
| Disconnection limit | 0,5 s |

| No | $P_{EUT}$ 1) (% of EUT rating) | Reactive load (% of $Q_L$ in 6.1.d) 1) | $P_{AC}$ 2) (% of nominal) | $Q_{AC}$ 3) (% of nominal) | $I_{AC}$ 4) [A] | $P_{EUT}$ [kW per phase] | $V_{DC}$ [V] | $Q_f$ [1] | Run on Time [ms] | Remarks5) |
|---|---|---|---|---|---|---|---|---|---|---|
| 22 | 33 | 33 | 0 | -5 | -- | 1,32 | 312,0 | 0,975 | 205,5 | IB |
| 23 | 33 | 33 | 0 | -4 | -- | 1,32 | 312,0 | 0,980 | 206,0 | IB |
| 24 | 33 | 33 | 0 | -3 | -- | 1,32 | 312,0 | 0,985 | 216,0 | IB |
| 25 | 33 | 33 | 0 | -2 | -- | 1,32 | 312,0 | 0,990 | 236,5 | IB |
| 26 | 33 | 33 | 0 | -1 | -- | 1,32 | 312,0 | 0,995 | 244,5 | IB |
| 3 | 33 | 33 | 0 | 0 | 0,051 | 1,32 | 312,0 | 1,000 | 428,0 | BL |
| 27 | 33 | 33 | 0 | 1 | -- | 1,32 | 312,0 | 1,005 | 422,5 | IB |
| 28 | 33 | 33 | 0 | 2 | -- | 1,32 | 312,0 | 1,010 | 237,0 | IB |
| 29 | 33 | 33 | 0 | 3 | -- | 1,32 | 312,0 | 1,015 | 235,5 | IB |
| 30 | 33 | 33 | 0 | 4 | -- | 1,32 | 312,0 | 1,020 | 214,5 | IB |
| 31 | 33 | 33 | 0 | 5 | -- | 1,32 | 312,0 | 1,025 | 202,5 | IB |

| Parameter at 0% per phase | L= 127,63mH | R= 40,08Ω | C= 79,47µF |
|---|---|---|---|

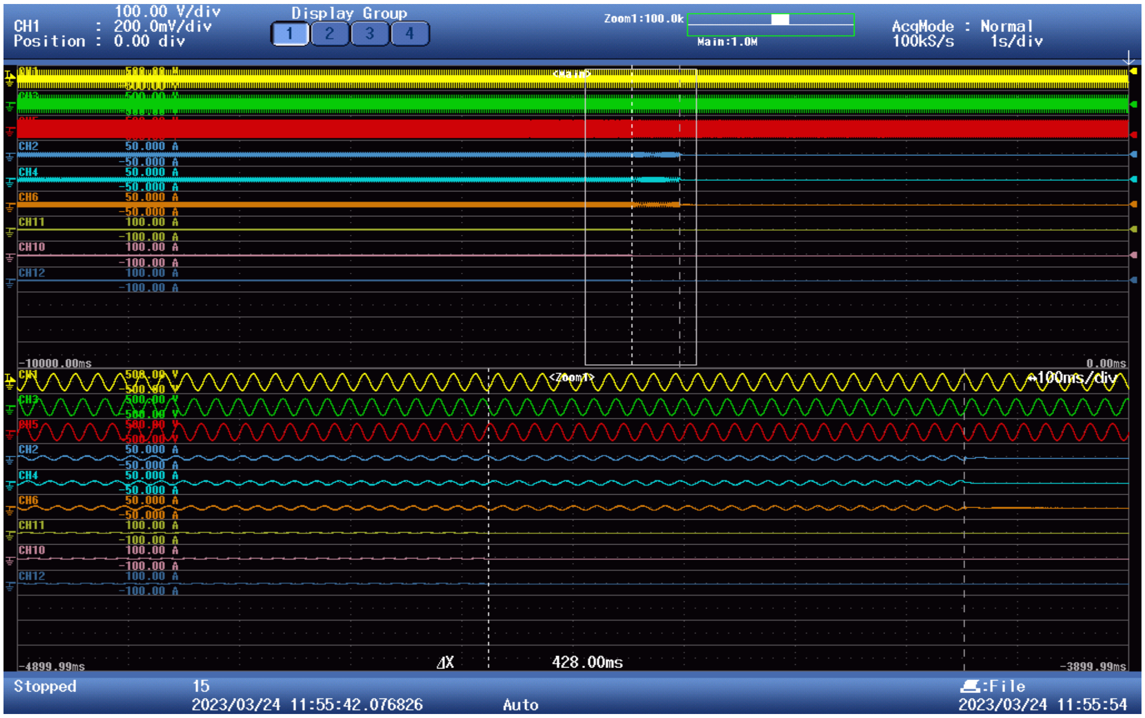
| Indicate additional shut down time included in above results.<br>(Disconnection device operation time) | 20 ms |
|---|---|

**Note:**
RLC is adjusted to min. +/-1% of the inverter rated output power
1) $P_{EUT}$: EUT output power
2) $P_{AC}$: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) $Q_{AC}$: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
4) Fundamental of $I_{AC}$ when RLC is adjusted.
5) BL: Balance condition, IB: Imbalance condition.
Condition C:
EUT output power PEUT = 25 % – 33 % 5) of maximum
EUT input voltage 6) = <20 % of rated input voltage range
6) Or minimum allowable EUT output level if greater than 33 %.
7) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 20 % of range =X + 0,2 × (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.
The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost

same as in hardware and software.

**Disconnection at $P_{AC}$ 0% and $Q_{AC}$ 0% reactive load and 33% nominal power**

**Disconnection at No. 3**



| A.7.1.2.5 Re-connection | | | | P |
|---|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | | |
| Test should prove that the reconnection sequence starts after a minimum delay of 20 seconds for restoration of voltage and frequency to within the stage 1 settings of table 10.1. | | | | |
| Under Voltage (188,0 V) | | | | |
| Time delay setting | | Measured delay | | |
| 60s | | 60,6s | | |
| Over Voltage (258,2 V) | | | | |
| Time delay setting | | Measured delay | | |
| 60s | | 60,2s | | |
| | | | | |
| Under Frequency (47,6 Hz) | | | | |
| Time delay setting | | Measured delay | | |
| 60s | | 62,2s | | |
| Over Frequency (51,9 Hz) | | | | |
| Time delay setting | | Measured delay | | |
| 60s | | 60,2s | | |
| | | | | |
| | Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1. | | | |
| | At 266,2V | At 180,0V | At 47,4Hz | At 52,1Hz |
| Confirmation that the Power Generating Module does not re-connect | No reconnection | No reconnection | No reconnection | No reconnection |
| **Note:**<br>The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software. | | | | |

| **A.7.1.2.6 Frequency Drift and Step Change Stability test**<br>This test should be carried out in accordance with Annex A.7.1.2.6. | **P** |
|---|---|

**Test result: HESS-HY-T-12K**

| | Start Frequency | Change | Test Time | Confirm no trip |
|---|---|---|---|---|
| Positive Vector Shift | 49,5Hz | +50 degrees | | No trip |
| Negative Vector Shift | 50,5Hz | -50 degrees | | No trip |
| Positive Frequency drift | 49,0Hz – 51,0 Hz | +0,95Hz/sec | 2,1s | No trip |
| Negative Frequency drift | 51,0Hz – 49,0 Hz | -0,95Hz/sec | 2,1s | No trip |

**Note:**

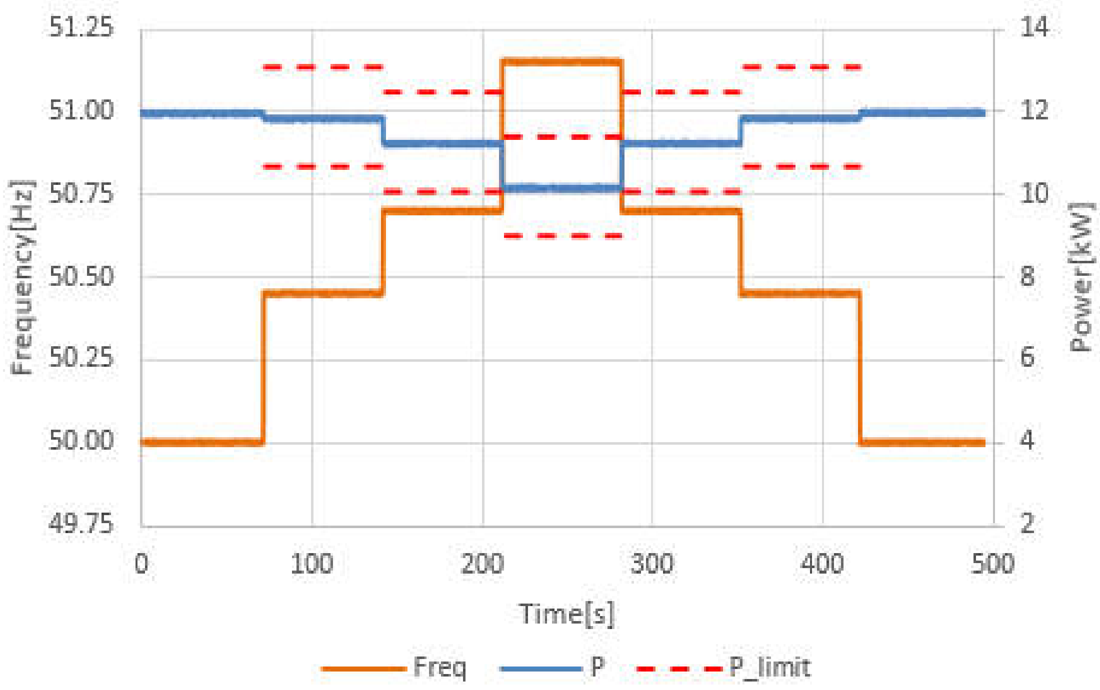
Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the Power Park Module should not tip during the test.

For the step change test the Power Park Module should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The Power Park Module should not trip during this test.

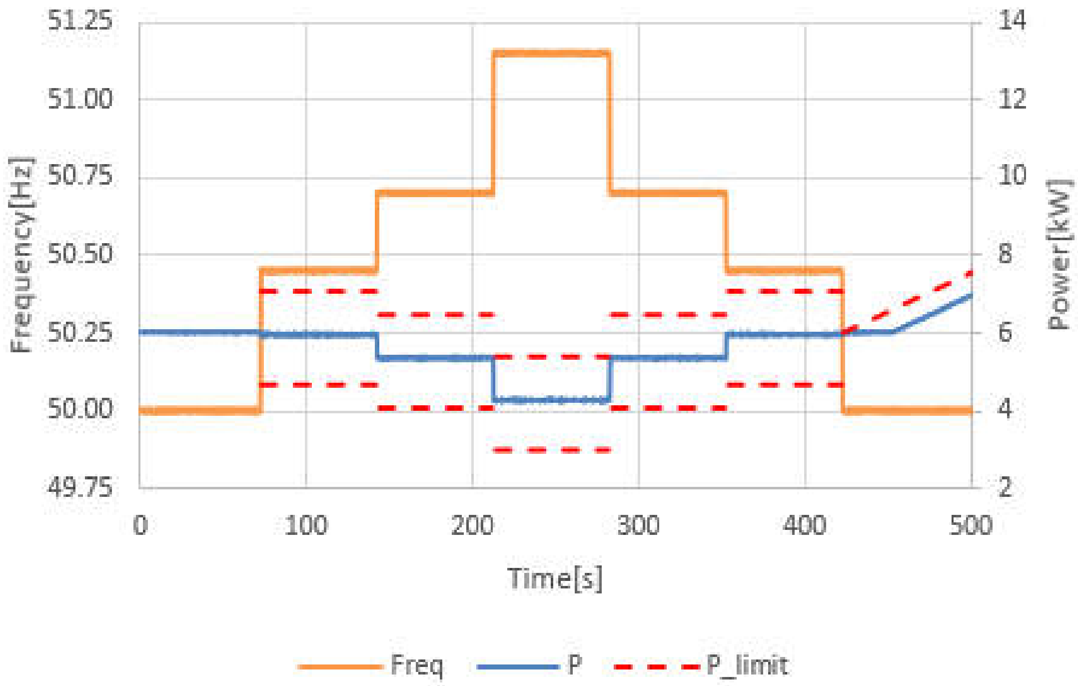
For frequency drift tests the Power Park Module should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0,95 $Hzs^{-1}$ to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The Power Park Module should not trip during this test.

The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

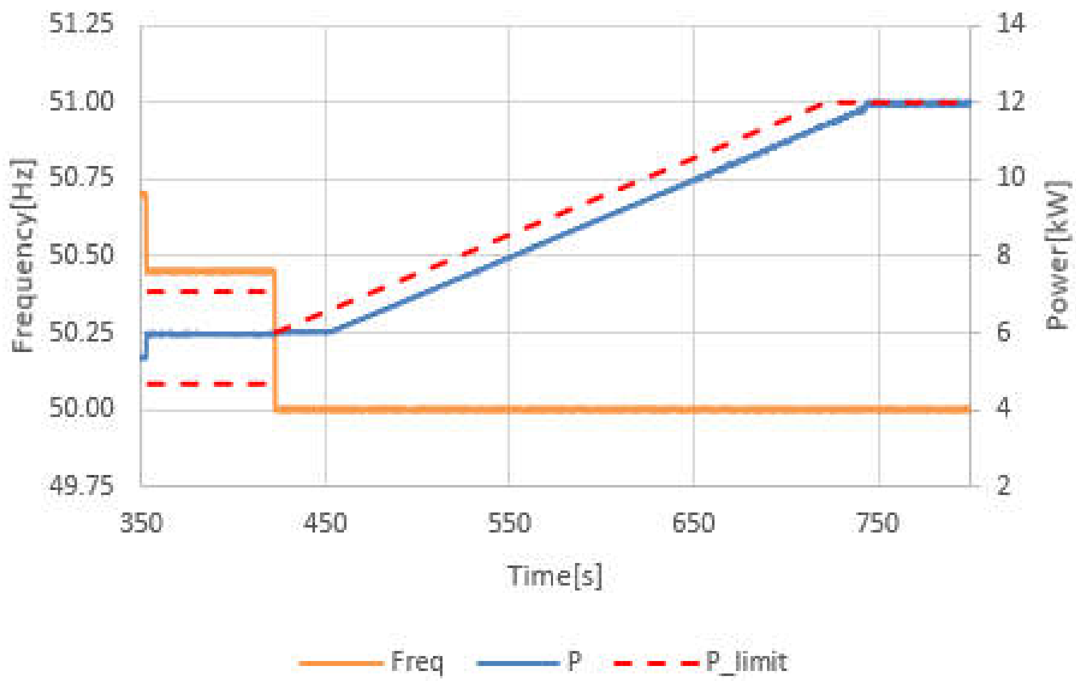
| **A.7.1.3 Limited Frequency Sensitive Mode – Over frequency test**<br>The test should be carried out using the specific threshold frequency of 50.4 Hz and Droop of 10%. This test should be carried out in accordance with Annex A.7.1.3. | | | | | | | **P** |
|---|---|---|---|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | | | | | |
| 1-min mean value [Hz]: | a) 50,00 | b) 50,45 | c) 50,70 | d) 51,15 | e) 50,70 | f) 50,45 | g) 50,00 |
| 1. Measurement a) to g): Active power output > 80% $P_n$ | | | | | | | |
| Frequency [Hz]: | 50,00 | 50,45 | 50,70 | 51,15 | 50,70 | 50,45 | 50,00 |
| $P_{expected}$ [kW]: | N/A | 11,88 | 11,28 | 10,20 | 11,28 | 11,88 | N/A |
| $P_{measured}$ [kW]: | 11,96 | 11,83 | 11,23 | 10,16 | 11,24 | 11,84 | 11,98 |
| $\Delta P_{measured}$ /$P_M$ [%]: | N/A | -0,42 | -0,42 | -0,33 | -0,33 | -0,33 | N/A |
| 2. Measurement a) to g): Active power output 40% and 60% after freezing > 80% $P_n$ | | | | | | | |
| Frequency [Hz]: | 50,00 | 50,45 | 50,70 | 51,15 | 50,70 | 50,45 | 50,00 |
| $P_{expected}$ [kW]: | N/A | 5,88 | 5,28 | 4,20 | 5,28 | 5,88 | N/A |
| $P_{measured}$ [kW]: | 6,02 | 5,96 | 5,36 | 4,28 | 5,36 | 5,96 | 11,97 |
| $\Delta P_{measured}$ /$P_M$ [%]: | N/A | 0,67 | 0,67 | 0,67 | 0,67 | 0,67 | N/A |
| **Limit $\Delta P/P_{1min}$:** | + 10 % of $P_M$ | | | | | | |
| **Graph of Measurement 1.: Active power output > 80% $P_n$** | | | | | | | |



**Graph of Measurement 2.:Active power output 40% and 60% after freezing > 80% $P_n$**




**Graph of power gradient:**




**Test:**

The test is conducted for two powers. First, the test must start at a power > 80% $P_n$ ("Measurement 1"), and in a second test, for a power between 40% to 60% $P_n$ ("Measurement 2"). In the second test, after freezing of the $P_M$, the available active power output must be increased to a value > 80% $P_n$, and after the network frequency of 50,4 Hz is fallen below, the rise of the active power gradient must be recorded.

| |
|---|
| Point g) must be held until the micro-generator is again feeding in with the active power output available. |
| **Assessment criterion:**<br>For f = 50,4 Hz, the value of the $P_M$ active power currently being generated is "frozen".<br>a) For adjustable micro-generators when:<br>1) the active power reduces between measuring points b) and f) given above with the set gradient $P_M$ per Hz for a increasing frequency (or rises for a frequency decreasing again).<br>2) the maximum active power gradient occurring in point is less than the configured maximum active power per minute<br>3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from $P_n$ by more than ± 10%.<br>4) the settling time is equal or below 2 s with an intentional delay set to zero<br>b) For partly adjustable micro-generators<br>1) when they behave as in a) within their adjustment range, and<br>2) when, outside the adjustable range, the power fed in on leaving the adjustment range remains constant until shutdown. Shutdown must be no later than at 51,5 Hz. |
| **Note:**<br>The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software. |

| **A.7.1.4.1 Harmonic Current Emissions**<br>The test requirements are specified in Annex A.7.1.4.1. | **P** |
|---|---|

**Generating Unit tested to BS EN 61000-3-12**

**Test result: HESS-HY-T-12K**

| Generating Unit rating per phase (rpp) | | | 4,0 kW | | | | |
|---|---|---|---|---|---|---|---|
| Harmonic order | At 45-55% of Registered Capacity 6,0 kW | | | | | | Harmonic % | |
| | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 1st | 8,923 | 8,983 | 8,848 | 51,305 | 51,652 | 50,875 | -- | -- |
| 2nd | 0,108 | 0,053 | 0,066 | 0,623 | 0,306 | 0,381 | 8,00 | 8,00 |
| 3rd | 0,040 | 0,030 | 0,026 | 0,232 | 0,175 | 0,151 | 21,60 | N/A |
| 4th | 0,139 | 0,132 | 0,141 | 0,797 | 0,761 | 0,808 | 4,00 | 4,00 |
| 5th | 0,131 | 0,134 | 0,134 | 0,755 | 0,771 | 0,769 | 10,70 | 10,70 |
| 6th | 0,010 | 0,005 | 0,007 | 0,059 | 0,030 | 0,042 | 2,67 | 2,67 |
| 7th | 0,058 | 0,060 | 0,057 | 0,334 | 0,344 | 0,328 | 7,20 | 7,20 |
| 8th | 0,058 | 0,051 | 0,062 | 0,335 | 0,295 | 0,357 | 2,00 | 2,00 |
| 9th | 0,014 | 0,006 | 0,015 | 0,079 | 0,034 | 0,088 | 3,80 | N/A |
| 10th | 0,030 | 0,033 | 0,029 | 0,173 | 0,188 | 0,169 | 1,60 | 1,60 |
| 11th | 0,225 | 0,237 | 0,240 | 1,294 | 1,362 | 1,379 | 3,10 | 3,10 |
| 12th | 0,007 | 0,005 | 0,005 | 0,038 | 0,030 | 0,029 | 1,33 | 1,33 |
| 13th | 0,131 | 0,130 | 0,125 | 0,752 | 0,746 | 0,717 | 2,00 | 2,00 |
| 14th | 0,016 | 0,015 | 0,018 | 0,091 | 0,087 | 0,104 | N/A | N/A |
| 15th | 0,010 | 0,005 | 0,008 | 0,060 | 0,031 | 0,047 | N/A | N/A |
| 16th | 0,028 | 0,031 | 0,028 | 0,162 | 0,177 | 0,163 | N/A | N/A |
| 17th | 0,041 | 0,044 | 0,048 | 0,234 | 0,252 | 0,276 | N/A | N/A |
| 18th | 0,006 | 0,005 | 0,005 | 0,036 | 0,031 | 0,030 | N/A | N/A |
| 19th | 0,046 | 0,047 | 0,045 | 0,265 | 0,273 | 0,259 | N/A | N/A |
| 20th | 0,022 | 0,026 | 0,023 | 0,127 | 0,147 | 0,132 | N/A | N/A |
| 21th | 0,008 | 0,006 | 0,007 | 0,045 | 0,036 | 0,039 | N/A | N/A |
| 22th | 0,016 | 0,016 | 0,016 | 0,094 | 0,094 | 0,092 | N/A | N/A |
| 23th | 0,017 | 0,020 | 0,014 | 0,100 | 0,117 | 0,082 | N/A | N/A |
| 24th | 0,006 | 0,006 | 0,006 | 0,036 | 0,035 | 0,034 | N/A | N/A |
| 25th | 0,037 | 0,039 | 0,037 | 0,211 | 0,225 | 0,210 | N/A | N/A |
| 26th | 0,019 | 0,020 | 0,020 | 0,111 | 0,113 | 0,116 | N/A | N/A |
| 27th | 0,006 | 0,006 | 0,007 | 0,035 | 0,034 | 0,039 | N/A | N/A |
| 28th | 0,028 | 0,028 | 0,026 | 0,158 | 0,162 | 0,149 | N/A | N/A |
| 29th | 0,020 | 0,021 | 0,022 | 0,118 | 0,120 | 0,129 | N/A | N/A |
| 30th | 0,005 | 0,006 | 0,006 | 0,031 | 0,034 | 0,032 | N/A | N/A |

| **A.7.1.4.1 Harmonic Current Emissions**<br>The test requirements are specified in Annex A.7.1.4.1. | | | | | | | | **P** |
|---|---|---|---|---|---|---|---|---|
| **Generating Unit tested to BS EN 61000-3-12** | | | | | | | | |
| **Test result: HESS-HY-T-12K** | | | | | | | | |
| Generating Unit rating per phase (rpp) | | | | 4,0 kW | | | | |
| Harmonic order | At 45-55% of Registered Capacity<br>6,0 kW | | | | | | Harmonic % | |
| | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 31th | 0,020 | 0,022 | 0,020 | 0,114 | 0,124 | 0,113 | N/A | N/A |
| 32th | 0,020 | 0,021 | 0,023 | 0,114 | 0,118 | 0,131 | N/A | N/A |
| 33th | 0,006 | 0,006 | 0,006 | 0,034 | 0,033 | 0,036 | N/A | N/A |
| 34th | 0,017 | 0,017 | 0,018 | 0,100 | 0,099 | 0,101 | N/A | N/A |
| 35th | 0,016 | 0,018 | 0,017 | 0,093 | 0,106 | 0,095 | N/A | N/A |
| 36th | 0,005 | 0,005 | 0,005 | 0,030 | 0,029 | 0,031 | N/A | N/A |
| 37th | 0,020 | 0,021 | 0,019 | 0,115 | 0,122 | 0,110 | N/A | N/A |
| 38th | 0,013 | 0,012 | 0,013 | 0,072 | 0,071 | 0,075 | N/A | N/A |
| 39th | 0,006 | 0,005 | 0,005 | 0,034 | 0,026 | 0,029 | N/A | N/A |
| 40th | 0,014 | 0,013 | 0,014 | 0,081 | 0,074 | 0,079 | N/A | N/A |
| 41th | 0,011 | 0,010 | 0,010 | 0,065 | 0,057 | 0,057 | N/A | N/A |
| 42th | 0,004 | 0,005 | 0,005 | 0,024 | 0,027 | 0,026 | N/A | N/A |
| 43th | 0,018 | 0,018 | 0,016 | 0,102 | 0,101 | 0,094 | N/A | N/A |
| 44th | 0,011 | 0,011 | 0,011 | 0,063 | 0,065 | 0,065 | N/A | N/A |
| 45th | 0,005 | 0,004 | 0,004 | 0,029 | 0,023 | 0,023 | N/A | N/A |
| 46th | 0,013 | 0,015 | 0,013 | 0,076 | 0,085 | 0,077 | N/A | N/A |
| 47th | 0,014 | 0,013 | 0,014 | 0,081 | 0,074 | 0,078 | N/A | N/A |
| 48th | 0,004 | 0,004 | 0,004 | 0,022 | 0,024 | 0,025 | N/A | N/A |
| 49th | 0,010 | 0,010 | 0,009 | 0,056 | 0,055 | 0,050 | N/A | N/A |
| 50th | 0,012 | 0,013 | 0,013 | 0,070 | 0,074 | 0,075 | N/A | N/A |
| THD_[%] | | | | 2,136 | 2,098 | 2,132 | 23 | 13 |
| PWHD_[%] | -- | -- | -- | 3,265 | 3,396 | 3,314 | 23 | 22 |
| **Note:**<br>The normalization current is 17,391A. | | | | | | | | |

| A.7.1.4.1 Harmonic Current Emissions<br>The test requirements are specified in Annex A.7.1.4.1. | P |
|---|---|

**Generating Unit tested to BS EN 61000-3-12**

**Test result: HESS-HY-T-12K**

| Generating Unit rating per phase (rpp) | | | 4,0kW | | | | |
|---|---|---|---|---|---|---|---|
| Harmonic order | At 100% of rated output power 12,0kW | | | | | Harmonic [%] | |
| | Measured Value (MV) in Amps | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 1st | 17,614 | 17,685 | 17,544 | 101,280 | 101,686 | 100,877 | -- | -- |
| 2nd | 0,129 | 0,074 | 0,068 | 0,741 | 0,425 | 0,388 | 8,00 | 8,00 |
| 3rd | 0,035 | 0,032 | 0,023 | 0,204 | 0,182 | 0,133 | 21,60 | N/A |
| 4th | 0,124 | 0,120 | 0,125 | 0,715 | 0,691 | 0,720 | 4,00 | 4,00 |
| 5th | 0,168 | 0,169 | 0,170 | 0,964 | 0,974 | 0,978 | 10,70 | 10,70 |
| 6th | 0,009 | 0,005 | 0,006 | 0,054 | 0,031 | 0,037 | 2,67 | 2,67 |
| 7th | 0,058 | 0,060 | 0,058 | 0,332 | 0,343 | 0,333 | 7,20 | 7,20 |
| 8th | 0,023 | 0,026 | 0,025 | 0,130 | 0,149 | 0,143 | 2,00 | 2,00 |
| 9th | 0,013 | 0,005 | 0,014 | 0,077 | 0,029 | 0,082 | 3,80 | N/A |
| 10th | 0,057 | 0,052 | 0,057 | 0,330 | 0,299 | 0,327 | 1,60 | 1,60 |
| 11th | 0,225 | 0,237 | 0,232 | 1,291 | 1,363 | 1,335 | 3,10 | 3,10 |
| 12th | 0,008 | 0,005 | 0,006 | 0,044 | 0,027 | 0,036 | 1,33 | 1,33 |
| 13th | 0,327 | 0,328 | 0,322 | 1,883 | 1,884 | 1,849 | 2,00 | 2,00 |
| 14th | 0,026 | 0,022 | 0,026 | 0,150 | 0,127 | 0,151 | N/A | N/A |
| 15th | 0,005 | 0,005 | 0,009 | 0,029 | 0,028 | 0,051 | N/A | N/A |
| 16th | 0,015 | 0,016 | 0,013 | 0,087 | 0,093 | 0,075 | N/A | N/A |
| 17th | 0,110 | 0,115 | 0,116 | 0,635 | 0,662 | 0,666 | N/A | N/A |
| 18th | 0,005 | 0,005 | 0,005 | 0,030 | 0,026 | 0,027 | N/A | N/A |
| 19th | 0,104 | 0,104 | 0,098 | 0,598 | 0,597 | 0,565 | N/A | N/A |
| 20th | 0,030 | 0,027 | 0,027 | 0,174 | 0,153 | 0,153 | N/A | N/A |
| 21th | 0,006 | 0,005 | 0,005 | 0,035 | 0,027 | 0,031 | N/A | N/A |
| 22th | 0,035 | 0,036 | 0,035 | 0,199 | 0,205 | 0,199 | N/A | N/A |
| 23th | 0,049 | 0,046 | 0,049 | 0,279 | 0,262 | 0,282 | N/A | N/A |
| 24th | 0,005 | 0,005 | 0,005 | 0,030 | 0,028 | 0,031 | N/A | N/A |
| 25th | 0,051 | 0,054 | 0,051 | 0,293 | 0,310 | 0,292 | N/A | N/A |
| 26th | 0,021 | 0,022 | 0,017 | 0,123 | 0,126 | 0,098 | N/A | N/A |
| 27th | 0,006 | 0,006 | 0,005 | 0,036 | 0,034 | 0,028 | N/A | N/A |
| 28th | 0,031 | 0,030 | 0,030 | 0,177 | 0,175 | 0,175 | N/A | N/A |
| 29th | 0,030 | 0,026 | 0,026 | 0,170 | 0,149 | 0,148 | N/A | N/A |
| 30th | 0,006 | 0,006 | 0,007 | 0,033 | 0,033 | 0,038 | N/A | N/A |

| **A.7.1.4.1 Harmonic Current Emissions**<br>The test requirements are specified in Annex A.7.1.4.1. | | | | | | | | **P** |
|---|---|---|---|---|---|---|---|---|
| **Generating Unit tested to BS EN 61000-3-12** | | | | | | | | |
| **Test result: HESS-HY-T-12K** | | | | | | | | |
| Generating Unit rating per phase (rpp) | | | 4,0kW | | | | | |
| Harmonic order | At 100% of rated output power 12,0kW | | | | | | Harmonic [%] | |
| | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 31th | 0,045 | 0,046 | 0,044 | 0,256 | 0,267 | 0,253 | N/A | N/A |
| 32th | 0,020 | 0,024 | 0,024 | 0,114 | 0,139 | 0,139 | N/A | N/A |
| 33th | 0,007 | 0,006 | 0,006 | 0,041 | 0,034 | 0,033 | N/A | N/A |
| 34th | 0,015 | 0,015 | 0,016 | 0,087 | 0,087 | 0,091 | N/A | N/A |
| 35th | 0,014 | 0,016 | 0,019 | 0,082 | 0,089 | 0,111 | N/A | N/A |
| 36th | 0,006 | 0,006 | 0,006 | 0,033 | 0,037 | 0,033 | N/A | N/A |
| 37th | 0,021 | 0,022 | 0,022 | 0,121 | 0,125 | 0,124 | N/A | N/A |
| 38th | 0,026 | 0,027 | 0,026 | 0,151 | 0,157 | 0,150 | N/A | N/A |
| 39th | 0,006 | 0,006 | 0,006 | 0,032 | 0,032 | 0,033 | N/A | N/A |
| 40th | 0,026 | 0,026 | 0,027 | 0,148 | 0,152 | 0,154 | N/A | N/A |
| 41th | 0,024 | 0,027 | 0,030 | 0,140 | 0,157 | 0,170 | N/A | N/A |
| 42th | 0,006 | 0,007 | 0,006 | 0,034 | 0,041 | 0,034 | N/A | N/A |
| 43th | 0,040 | 0,043 | 0,039 | 0,232 | 0,248 | 0,225 | N/A | N/A |
| 44th | 0,010 | 0,008 | 0,011 | 0,055 | 0,049 | 0,063 | N/A | N/A |
| 45th | 0,008 | 0,006 | 0,006 | 0,046 | 0,035 | 0,036 | N/A | N/A |
| 46th | 0,021 | 0,022 | 0,022 | 0,122 | 0,125 | 0,129 | N/A | N/A |
| 47th | 0,031 | 0,028 | 0,029 | 0,179 | 0,164 | 0,167 | N/A | N/A |
| 48th | 0,006 | 0,006 | 0,006 | 0,036 | 0,034 | 0,036 | N/A | N/A |
| 49th | 0,027 | 0,027 | 0,024 | 0,155 | 0,154 | 0,135 | N/A | N/A |
| 50th | 0,029 | 0,028 | 0,030 | 0,165 | 0,163 | 0,171 | N/A | N/A |
| THD_[%] | -- | -- | -- | 2,988 | 2,960 | 2,922 | 23 | 13 |
| PWHD_[%] | -- | -- | -- | 5,942 | 6,020 | 5,938 | 23 | 22 |
| **Note:**<br>The normalization current is 17,391A. | | | | | | | | |

| A.7.1.4.1 Harmonic Current Emissions<br>The test requirements are specified in Annex A.7.1.4.1. | | | | | | | | P |
|---|---|---|---|---|---|---|---|---|
| **Generating Unit tested to BS EN 61000-3-12** | | | | | | | | |
| **Test result: HESS-HY-T1-12K** | | | | | | | | |
| Generating Unit rating per phase (rpp) | | | 4,0 kW | | | | | |
| Harmonic order | At 45-55% of Registered Capacity<br>6,0 kW | | | | | | Harmonic % | |
| | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 1st | 8,874 | 8,934 | 8,799 | 51,025 | 51,371 | 50,592 | -- | -- |
| 2nd | 0,108 | 0,053 | 0,068 | 0,622 | 0,303 | 0,388 | 8,00 | 8,00 |
| 3rd | 0,040 | 0,031 | 0,027 | 0,232 | 0,179 | 0,153 | 21,60 | N/A |
| 4th | 0,139 | 0,133 | 0,141 | 0,799 | 0,764 | 0,812 | 4,00 | 4,00 |
| 5th | 0,131 | 0,134 | 0,134 | 0,754 | 0,770 | 0,768 | 10,70 | 10,70 |
| 6th | 0,011 | 0,005 | 0,008 | 0,063 | 0,031 | 0,045 | 2,67 | 2,67 |
| 7th | 0,059 | 0,061 | 0,058 | 0,337 | 0,348 | 0,331 | 7,20 | 7,20 |
| 8th | 0,057 | 0,050 | 0,061 | 0,326 | 0,290 | 0,350 | 2,00 | 2,00 |
| 9th | 0,014 | 0,006 | 0,016 | 0,080 | 0,035 | 0,090 | 3,80 | N/A |
| 10th | 0,029 | 0,032 | 0,029 | 0,166 | 0,182 | 0,164 | 1,60 | 1,60 |
| 11th | 0,225 | 0,237 | 0,240 | 1,292 | 1,361 | 1,377 | 3,10 | 3,10 |
| 12th | 0,007 | 0,005 | 0,005 | 0,038 | 0,031 | 0,029 | 1,33 | 1,33 |
| 13th | 0,133 | 0,132 | 0,127 | 0,764 | 0,758 | 0,728 | 2,00 | 2,00 |
| 14th | 0,017 | 0,015 | 0,019 | 0,095 | 0,088 | 0,107 | N/A | N/A |
| 15th | 0,010 | 0,005 | 0,008 | 0,059 | 0,030 | 0,048 | N/A | N/A |
| 16th | 0,030 | 0,033 | 0,030 | 0,173 | 0,188 | 0,174 | N/A | N/A |
| 17th | 0,044 | 0,047 | 0,052 | 0,253 | 0,271 | 0,297 | N/A | N/A |
| 18th | 0,006 | 0,005 | 0,005 | 0,035 | 0,032 | 0,028 | N/A | N/A |
| 19th | 0,043 | 0,044 | 0,042 | 0,244 | 0,254 | 0,243 | N/A | N/A |
| 20th | 0,023 | 0,027 | 0,024 | 0,132 | 0,154 | 0,140 | N/A | N/A |
| 21th | 0,008 | 0,006 | 0,007 | 0,046 | 0,036 | 0,038 | N/A | N/A |
| 22th | 0,017 | 0,016 | 0,016 | 0,096 | 0,092 | 0,094 | N/A | N/A |
| 23th | 0,018 | 0,021 | 0,015 | 0,106 | 0,122 | 0,084 | N/A | N/A |
| 24th | 0,006 | 0,006 | 0,006 | 0,037 | 0,035 | 0,033 | N/A | N/A |
| 25th | 0,038 | 0,040 | 0,037 | 0,216 | 0,228 | 0,215 | N/A | N/A |
| 26th | 0,018 | 0,019 | 0,019 | 0,105 | 0,108 | 0,109 | N/A | N/A |
| 27th | 0,006 | 0,006 | 0,006 | 0,037 | 0,034 | 0,037 | N/A | N/A |
| 28th | 0,026 | 0,027 | 0,025 | 0,152 | 0,157 | 0,144 | N/A | N/A |
| 29th | 0,021 | 0,020 | 0,022 | 0,119 | 0,118 | 0,129 | N/A | N/A |
| 30th | 0,005 | 0,006 | 0,006 | 0,032 | 0,034 | 0,033 | N/A | N/A |

| **A.7.1.4.1 Harmonic Current Emissions**<br>The test requirements are specified in Annex A.7.1.4.1. | | | | | | | | **P** |
|---|---|---|---|---|---|---|---|---|
| **Generating Unit tested to BS EN 61000-3-12** | | | | | | | | |
| **Test result: HESS-HY-T1-12K** | | | | | | | | |
| Generating Unit rating per phase (rpp) | | | | 4,0 kW | | | | |
| Harmonic order | At 45-55% of Registered Capacity 6,0 kW | | | | | | Harmonic % | |
| | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 31th | 0,020 | 0,022 | 0,020 | 0,114 | 0,125 | 0,113 | N/A | N/A |
| 32th | 0,019 | 0,020 | 0,022 | 0,107 | 0,112 | 0,124 | N/A | N/A |
| 33th | 0,006 | 0,005 | 0,006 | 0,035 | 0,031 | 0,036 | N/A | N/A |
| 34th | 0,018 | 0,017 | 0,018 | 0,101 | 0,099 | 0,101 | N/A | N/A |
| 35th | 0,016 | 0,018 | 0,017 | 0,091 | 0,104 | 0,095 | N/A | N/A |
| 36th | 0,005 | 0,005 | 0,005 | 0,029 | 0,030 | 0,030 | N/A | N/A |
| 37th | 0,021 | 0,022 | 0,019 | 0,118 | 0,126 | 0,112 | N/A | N/A |
| 38th | 0,013 | 0,013 | 0,014 | 0,074 | 0,074 | 0,079 | N/A | N/A |
| 39th | 0,006 | 0,005 | 0,005 | 0,033 | 0,027 | 0,029 | N/A | N/A |
| 40th | 0,014 | 0,013 | 0,014 | 0,079 | 0,075 | 0,079 | N/A | N/A |
| 41th | 0,012 | 0,010 | 0,010 | 0,068 | 0,060 | 0,059 | N/A | N/A |
| 42th | 0,004 | 0,005 | 0,005 | 0,025 | 0,027 | 0,026 | N/A | N/A |
| 43th | 0,018 | 0,018 | 0,016 | 0,103 | 0,101 | 0,094 | N/A | N/A |
| 44th | 0,012 | 0,012 | 0,012 | 0,068 | 0,067 | 0,069 | N/A | N/A |
| 45th | 0,005 | 0,004 | 0,004 | 0,029 | 0,023 | 0,023 | N/A | N/A |
| 46th | 0,013 | 0,015 | 0,014 | 0,076 | 0,086 | 0,079 | N/A | N/A |
| 47th | 0,014 | 0,013 | 0,014 | 0,083 | 0,076 | 0,079 | N/A | N/A |
| 48th | 0,004 | 0,004 | 0,004 | 0,024 | 0,025 | 0,025 | N/A | N/A |
| 49th | 0,009 | 0,009 | 0,008 | 0,054 | 0,052 | 0,048 | N/A | N/A |
| 50th | 0,012 | 0,013 | 0,013 | 0,070 | 0,073 | 0,075 | N/A | N/A |
| THD_[%] | -- | -- | -- | 2,142 | 2,106 | 2,141 | 23 | 13 |
| PWHD_[%] | -- | -- | -- | 3,294 | 3,409 | 3,334 | 23 | 22 |
| **Note:**<br>The normalization current is 17,391A. | | | | | | | | |

| **A.7.1.4.1 Harmonic Current Emissions**<br>The test requirements are specified in Annex A.7.1.4.1. | | | | | | | | **P** |
|---|---|---|---|---|---|---|---|---|
| **Generating Unit tested to BS EN 61000-3-12** | | | | | | | | |
| **Test result: HESS-HY-T1-12K** | | | | | | | | |
| Generating Unit rating per phase (rpp) | | | 4,0kW | | | | | |
| Harmonic order | At 100% of rated output power 12,0kW | | | | | | Harmonic [%] | |
| | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 1st | 17,580 | 17,638 | 17,502 | 101,087 | 101,416 | 100,637 | -- | -- |
| 2nd | 0,134 | 0,080 | 0,071 | 0,772 | 0,459 | 0,408 | 8,00 | 8,00 |
| 3rd | 0,034 | 0,033 | 0,022 | 0,194 | 0,189 | 0,126 | 21,60 | N/A |
| 4th | 0,125 | 0,121 | 0,126 | 0,717 | 0,695 | 0,727 | 4,00 | 4,00 |
| 5th | 0,153 | 0,155 | 0,155 | 0,880 | 0,889 | 0,893 | 10,70 | 10,70 |
| 6th | 0,010 | 0,005 | 0,006 | 0,059 | 0,031 | 0,037 | 2,67 | 2,67 |
| 7th | 0,073 | 0,075 | 0,074 | 0,422 | 0,433 | 0,423 | 7,20 | 7,20 |
| 8th | 0,038 | 0,042 | 0,041 | 0,217 | 0,243 | 0,234 | 2,00 | 2,00 |
| 9th | 0,012 | 0,005 | 0,011 | 0,070 | 0,026 | 0,066 | 3,80 | N/A |
| 10th | 0,058 | 0,054 | 0,060 | 0,335 | 0,311 | 0,346 | 1,60 | 1,60 |
| 11th | 0,240 | 0,252 | 0,247 | 1,382 | 1,450 | 1,423 | 3,10 | 3,10 |
| 12th | 0,009 | 0,005 | 0,007 | 0,051 | 0,026 | 0,040 | 1,33 | 1,33 |
| 13th | 0,334 | 0,332 | 0,329 | 1,919 | 1,911 | 1,893 | 2,00 | 2,00 |
| 14th | 0,016 | 0,022 | 0,018 | 0,091 | 0,125 | 0,102 | N/A | N/A |
| 15th | 0,006 | 0,005 | 0,011 | 0,033 | 0,028 | 0,062 | N/A | N/A |
| 16th | 0,041 | 0,036 | 0,038 | 0,234 | 0,210 | 0,218 | N/A | N/A |
| 17th | 0,120 | 0,126 | 0,120 | 0,688 | 0,724 | 0,692 | N/A | N/A |
| 18th | 0,006 | 0,003 | 0,005 | 0,034 | 0,020 | 0,028 | N/A | N/A |
| 19th | 0,207 | 0,204 | 0,202 | 1,188 | 1,175 | 1,160 | N/A | N/A |
| 20th | 0,008 | 0,004 | 0,007 | 0,044 | 0,022 | 0,040 | N/A | N/A |
| 21th | 0,005 | 0,005 | 0,008 | 0,029 | 0,030 | 0,048 | N/A | N/A |
| 22th | 0,023 | 0,022 | 0,019 | 0,133 | 0,127 | 0,111 | N/A | N/A |
| 23th | 0,011 | 0,017 | 0,017 | 0,065 | 0,099 | 0,095 | N/A | N/A |
| 24th | 0,005 | 0,004 | 0,004 | 0,026 | 0,021 | 0,022 | N/A | N/A |
| 25th | 0,083 | 0,085 | 0,081 | 0,477 | 0,489 | 0,465 | N/A | N/A |
| 26th | 0,026 | 0,021 | 0,025 | 0,149 | 0,120 | 0,143 | N/A | N/A |
| 27th | 0,004 | 0,006 | 0,005 | 0,024 | 0,035 | 0,030 | N/A | N/A |
| 28th | 0,028 | 0,029 | 0,028 | 0,159 | 0,164 | 0,159 | N/A | N/A |
| 29th | 0,049 | 0,047 | 0,051 | 0,281 | 0,270 | 0,294 | N/A | N/A |
| 30th | 0,005 | 0,005 | 0,005 | 0,027 | 0,027 | 0,026 | N/A | N/A |

| **A.7.1.4.1 Harmonic Current Emissions**<br>The test requirements are specified in Annex A.7.1.4.1. | | | | | | | | **P** |
|---|---|---|---|---|---|---|---|---|
| **Generating Unit tested to BS EN 61000-3-12** | | | | | | | | |
| **Test result: HESS-HY-T1-12K** | | | | | | | | |
| Generating Unit rating per phase (rpp) | | | | 4,0kW | | | | |
| Harmonic order | At 100% of rated output power 12,0kW | | | | | | Harmonic [%] | |
| | Measured Value (MV) in Amps | | | Measured Value (MV) in % | | | Limit in BS EN61000-3-12 | |
| | L1 | L2 | L3 | L1 | L2 | L3 | 1 phase | 3 phase |
| 31th | 0,052 | 0,055 | 0,055 | 0,299 | 0,316 | 0,315 | N/A | N/A |
| 32th | 0,025 | 0,022 | 0,021 | 0,144 | 0,127 | 0,124 | N/A | N/A |
| 33th | 0,005 | 0,005 | 0,004 | 0,031 | 0,028 | 0,023 | N/A | N/A |
| 34th | 0,034 | 0,032 | 0,034 | 0,195 | 0,187 | 0,198 | N/A | N/A |
| 35th | 0,044 | 0,040 | 0,041 | 0,256 | 0,229 | 0,237 | N/A | N/A |
| 36th | 0,005 | 0,007 | 0,006 | 0,029 | 0,038 | 0,032 | N/A | N/A |
| 37th | 0,053 | 0,052 | 0,054 | 0,304 | 0,300 | 0,312 | N/A | N/A |
| 38th | 0,017 | 0,019 | 0,015 | 0,100 | 0,108 | 0,085 | N/A | N/A |
| 39th | 0,005 | 0,005 | 0,004 | 0,030 | 0,029 | 0,025 | N/A | N/A |
| 40th | 0,021 | 0,023 | 0,024 | 0,123 | 0,130 | 0,138 | N/A | N/A |
| 41th | 0,017 | 0,013 | 0,010 | 0,099 | 0,077 | 0,058 | N/A | N/A |
| 42th | 0,006 | 0,009 | 0,007 | 0,034 | 0,053 | 0,040 | N/A | N/A |
| 43th | 0,013 | 0,014 | 0,015 | 0,077 | 0,082 | 0,084 | N/A | N/A |
| 44th | 0,017 | 0,017 | 0,012 | 0,099 | 0,096 | 0,072 | N/A | N/A |
| 45th | 0,006 | 0,006 | 0,006 | 0,034 | 0,034 | 0,036 | N/A | N/A |
| 46th | 0,046 | 0,049 | 0,045 | 0,264 | 0,280 | 0,257 | N/A | N/A |
| 47th | 0,028 | 0,022 | 0,024 | 0,161 | 0,126 | 0,140 | N/A | N/A |
| 48th | 0,007 | 0,007 | 0,006 | 0,039 | 0,039 | 0,036 | N/A | N/A |
| 49th | 0,028 | 0,029 | 0,029 | 0,158 | 0,166 | 0,169 | N/A | N/A |
| 50th | 0,044 | 0,042 | 0,044 | 0,255 | 0,243 | 0,255 | N/A | N/A |
| THD_[%] | -- | -- | -- | 3,279 | 3,239 | 3,203 | 23 | 13 |
| PWHD_[%] | -- | -- | -- | 8,218 | 8,183 | 8,087 | 23 | 22 |
| **Note:**<br>The normalization current is 17,391A. | | | | | | | | |

| **A.7.1.4.2 Power factor**<br>The test requirements are specified in Annex A.7.1.4.2. | | | | **P** |
|---|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | | |
| Output power | 216,2 V | 230,0 V | 253,0 V | Measured at three voltage levels and at full output. Voltage to be maintained within ±1.5% of the stated level during the test. |
| 20% | 0,998 | 0,998 | 0,993 | |
| 50% | 1,000 | 0,999 | 0,999 | |
| 75% | 1,000 | 1,000 | 0,999 | |
| 100% | 1,000 | 1,000 | 0,999 | |
| Limit | >0,95 | >0,95 | >0,95 | |

**Note:**
The test set up shall be such that the Power Park Module supplies full load to the DNO's Distribution System via the power factor (pf) meter and the variac as shown below in figure A.7.3. The Power Park Module pf should be within the limits given in paragraph 11.1.5, for three test voltages 230 V – 6%, 230V and 230 V + 10%.
The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

| **A.7.1.4.3 Voltage Flicker**<br>The test requirements are specified in Annex A.7.1.4.3. | **P** |
| --- | --- |

**Test result: HESS-HY-T-12K**

| | | 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 | L1 | 0,716 | 0,185 | 0,000 | 0,716 | 0,185 | 0,000 | 0,134 | 0,123 |
| Normalised to standard impedance | L1 | 0,716 | 0,185 | 0,000 | 0,716 | 0,185 | 0,000 | 0,134 | 0,123 |
| Normalised to maximum impedance | L1 | 0,716 | 0,185 | 0,000 | 0,716 | 0,185 | 0,000 | 0,134 | 0,123 |
| Measured values at test impedance | L2 | 0,578 | 0,183 | 0,000 | 0,578 | 0,183 | 0,000 | 0,130 | 0,120 |
| Normalised to standard impedance | L2 | 0,578 | 0,183 | 0,000 | 0,578 | 0,183 | 0,000 | 0,130 | 0,120 |
| Normalised to maximum impedance | L2 | 0,578 | 0,183 | 0,000 | 0,578 | 0,183 | 0,000 | 0,130 | 0,120 |
| Measured values at test impedance | L3 | 0,549 | 0,195 | 0,000 | 0,549 | 0,195 | 0,000 | 0,139 | 0,125 |
| Normalised to standard impedance | L3 | 0,549 | 0,195 | 0,000 | 0,549 | 0,195 | 0,000 | 0,139 | 0,125 |
| Normalised to maximum impedance | L3 | 0,549 | 0,195 | 0,000 | 0,549 | 0,195 | 0,000 | 0,139 | 0,125 |
| Limits set under BS EN 61000-3-11 | | 4% | 3,3% | 3,3% 500ms | 4% | 3,3% | 3,3% 500ms | 1,0 | 0,65 |

| | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Test impedance | R | 0,240 | Ω | Xl | 0,150 | Ω |
| | Z | 0,283 | Ω | | | |
| Standard impedance | R | 0,240 | Ω | Xl | 0,150 | Ω |
| | Z | 0,283 | Ω | | | |
| Maximum Impedance | R | 0,240 | Ω | Xl | 0,150 | Ω |
| | Z | 0,283 | Ω | | | |

**Test result: HESS-HY-T1-12K**

| | | 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 | L1 | 0,720 | 0,186 | 0,000 | 0,720 | 0,186 | 0,000 | 0,136 | 0,124 |
| Normalised to standard | L1 | 0,720 | 0,186 | 0,000 | 0,720 | 0,186 | 0,000 | 0,136 | 0,124 |

| **A.7.1.4.3 Voltage Flicker**<br>The test requirements are specified in Annex A.7.1.4.3. | | | | | | | | | **P** |
|---|---|---|---|---|---|---|---|---|---|
| impedance | | | | | | | | | |
| Normalised to maximum impedance | L1 | 0,720 | 0,186 | 0,000 | 0,720 | 0,186 | 0,000 | 0,136 | 0,124 |
| Measured values at test impedance | L2 | 0,581 | 0,184 | 0,000 | 0,581 | 0,184 | 0,000 | 0,131 | 0,120 |
| Normalised to standard impedance | L2 | 0,581 | 0,184 | 0,000 | 0,581 | 0,184 | 0,000 | 0,131 | 0,120 |
| Normalised to maximum impedance | L2 | 0,581 | 0,184 | 0,000 | 0,581 | 0,184 | 0,000 | 0,131 | 0,120 |
| Measured values at test impedance | L3 | 0,552 | 0,196 | 0,000 | 0,552 | 0,196 | 0,000 | 0,139 | 0,126 |
| Normalised to standard impedance | L3 | 0,552 | 0,196 | 0,000 | 0,552 | 0,196 | 0,000 | 0,139 | 0,126 |
| Normalised to maximum impedance | L3 | 0,552 | 0,196 | 0,000 | 0,552 | 0,196 | 0,000 | 0,139 | 0,126 |
| Limits set under BS EN 61000-3-11 | | 4% | 3,3% | 3,3%<br>500ms | 4% | 3,3% | 3,3%<br>500ms | 1,0 | 0,65 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Test impedance | R | 0,240 | Ω | Xl | 0,150 | Ω |
| | Z | 0,283 | Ω | | | |
| Standard impedance | R | 0,240 | Ω | Xl | 0,150 | Ω |
| | Z | 0,283 | Ω | | | |
| Maximum Impedance | R | 0,240 | Ω | Xl | 0,150 | Ω |
| | Z | 0,283 | Ω | | | |

**Note**

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.

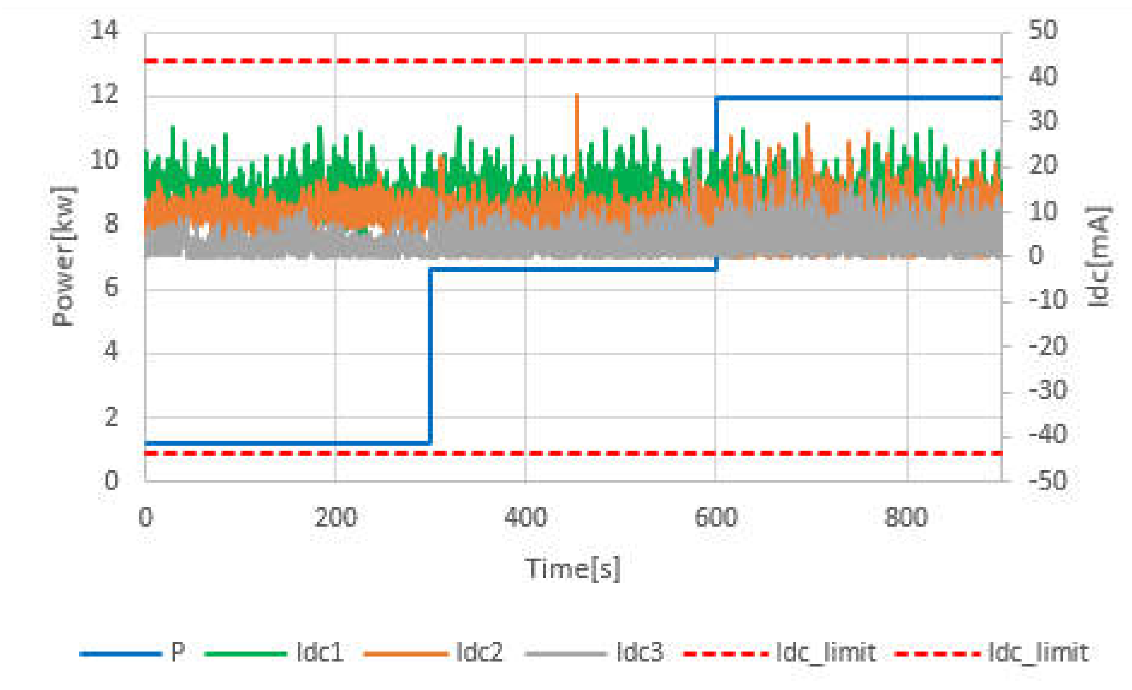
Normalised value = Measured value*reference source resistance/measured source resistance at test point.

Three phase units reference source resistance is 0,24 Ω

Where the power factor of the output is under 0,98 then the $X_l$ 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.

| **A.7.1.4.4 DC injection**<br>The test requirements are specified in Annex A.7.1.4.4. | | | **P** |
|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | |
| Phase 1 | | | |
| Test level power | 10% | 55% | 100% |
| Recorded DC value [mA] | 29,1 | 29,0 | 28,5 |
| As % of rated AC current | 0,17 | 0,17 | 0,16 |
| Limit | 0,25% $I_{ACrated}$ | | |
| Phase 2 | | | |
| Test level power | 10% | 55% | 100% |
| Recorded DC value [mA] | 18,4 | 36,2 | 29,5 |
| As % of rated AC current | 0,11 | 0,21 | 0,17 |
| Limit | 0,25% $I_{ACrated}$ | | |
| Phase 3 | | | |
| Test level power | 10% | 55% | 100% |
| Recorded DC value [mA] | 10,7 | 24,2 | 21,1 |
| As % of rated AC current | 0,06 | 0,14 | 0,12 |
| Limit | 0,25% $I_{ACrated}$ | | |
| **Sum of all Phases**<br>Tests are to be carried out at three defined power levels ±5%. At 230 V a 12,0kW three phase Inverter has a current output of 52,174 A so DC limit is 130,434 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.<br>The % DC injection (“as % of rated AC current” below) is calculated as follows:<br>% DC injection = Recorded DC value in Amps / Base current where the base current is the Registered Capacity (W) / V phase. The % DC injection should not be greater than 0,25%. | | | |
| Test level power | 10% | 55% | 100% |
| Recorded DC value Sum [mA] | 58,2 | 89,4 | 79,1 |
| As % of rated AC current | 0,11 | 0,17 | 0,15 |
| Limit | 0,25% $I_{ACrated}$ | | |




| | | | |
|---|---|---|---|
| **Test result: HESS-HY-T1-12K** | | | |
| Phase 1 | | | |
| Test level power | 10% | 55% | 100% |
| Recorded DC value [mA] | 30,9 | 31,2 | 31,2 |
| As % of rated AC current | 0,18 | 0,18 | 0,18 |
| Limit | 0,25% $I_{ACrated}$ | | |
| Phase 2 | | | |
| Test level power | 10% | 55% | 100% |
| Recorded DC value [mA] | 15,5 | 19,6 | 32,4 |
| As % of rated AC current | 0,09 | 0,11 | 0,19 |
| Limit | 0,25% $I_{ACrated}$ | | |
| Phase 3 | | | |
| Test level power | 10% | 55% | 100% |
| Recorded DC value [mA] | 16,5 | 16,7 | 25,4 |
| As % of rated AC current | 0,09 | 0,10 | 0,15 |
| Limit | 0,25% $I_{ACrated}$ | | |

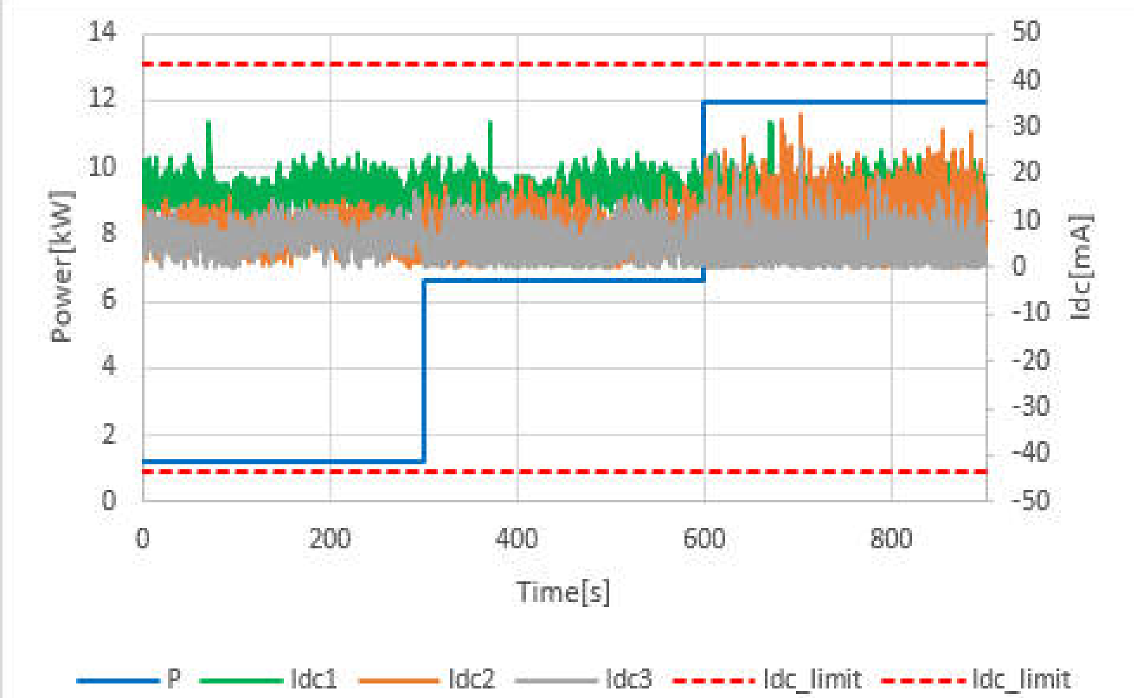
**Sum of all Phases**

Tests are to be carried out at three defined power levels ±5%. At 230 V a 12,0kW three phase Inverter has a current output of 52,174 A so DC limit is 130,434 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) / V phase. The % DC injection should not be greater than 0,25%.

| | | | |
|---|---|---|---|
| Test level power | 10% | 55% | 100% |
| Recorded DC value Sum [mA] | 62,9 | 67,5 | 89,0 |
| As % of rated AC current | 0,12 | 0,13 | 0,17 |
| Limit | 0,25% $I_{ACrated}$ | | |




**Note:**
The tests should be carried out on a single Generating Unit.

| **A.7.1.5 Short Circuit Current Contribution for Inverters**<br>The test requirements are specified in Annex A.7.1.5. | | | | | **P** |
|---|---|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | | | |
| For a directly coupled SSEG | | | For a Inverter SSEG | | |
| Phase 1 | | | | | |
| Parameter | Symbol | Value | Time after fault | Volts | Amps |
| Peak Short Circuit current | $i_p$ | N/A | 20ms | -28,7Vac | -22,65A |
| Initial Value of aperiodic current | $A$ | N/A | 100ms | 27,8Vac | 0,02A |
| Initial symmetrical short-circuit current* | $I_k$ | N/A | 250ms | -17,4Vac | 0,00A |
| Decaying (aperiodic) component of short circuit current* | $i_{DC}$ | N/A | 500ms | -22,8Vac | -0,04A |
| Reactance/Resistance Ratio of source* | $^X/_R$ | N/A | Time to trip | 0,050s | In seconds |
| Phase 2 | | | | | |
| Parameter | Symbol | Value | Time after fault | Volts | Amps |
| Peak Short Circuit current | $i_p$ | N/A | 20ms | 28,0Vac | 4,32A |
| Initial Value of aperiodic current | $A$ | N/A | 100ms | 12,1Vac | 0,07A |
| Initial symmetrical short-circuit current* | $I_k$ | N/A | 250ms | -27,8Vac | 0,07A |
| Decaying (aperiodic) component of short circuit current* | $i_{DC}$ | N/A | 500ms | 4,4Vac | 0,00A |
| Reactance/Resistance Ratio of source* | $^X/_R$ | N/A | Time to trip | 0,050s | In seconds |
| Phase 3 | | | | | |
| Parameter | Symbol | Value | Time after fault | Volts | Amps |
| Peak Short Circuit current | $i_p$ | N/A | 20ms | -10,2Vac | 8,61A |
| Initial Value of aperiodic current | $A$ | N/A | 100ms | 0,82Vac | -0,10A |
| Initial symmetrical short-circuit current* | $I_k$ | N/A | 250ms | -27,6Vac | 0,10A |
| Decaying (aperiodic) component of short circuit current* | $i_{DC}$ | N/A | 500ms | 9,6Vac | 0,00A |
| Reactance/Resistance Ratio of source* | $^X/_R$ | N/A | Time to trip | 0,050s | In seconds |
| **Note:**<br>The values of voltage and current should be recorded for a period of up to 1 second when the changeover switch should be returned to the normal position. The voltage and current at relevant times shall be recorded in the type test report (Appendix A2-3) including the time taken for the Power Park Modul to trip. (It is expected that the Power Park Module will trip on either loss of mains or under voltage in less than 1 s).<br>The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software. | | | | | |

| **A.7.1.6 Self Monitoring – Solid state Disconnection**.<br>The test requirements are specified in Annex A.7.1.6. | **N/A** |
|---|---|
| | |
| It has been verified that in the event of the solid state switching device failing to disconnect the SSEG, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0,5 seconds. | N/A |
| **Note:**<br>Unit do not provide solid state switching relays. In case the semiconductor bridge is switched off, then the voltage on the output drops to 0. In this case the relays on the output will also open (5.5.2.1 Functional safety to VDE 0124-100). | |

| A.7.1.7 | **Power Park Modules which include Electricity Storage**<br>This test should be carried out in accordance with 11.2.3.3. | | **P** |
|---|---|---|---|
| | Test 1:<br>100% rated import power, 50,00 Hz to 49,00 Hz with 2 Hzs$^{-1}$ | | |
| | Start: 50 ± 0,01 Hz | End: 49,00 Hz | |
| Frequency [Hz]: | 50,00 | 49,00 | |
| Active power [kW]: | -11,74 | -1,80 | |
| Reactive Power [kVar]: | 0,37 | 0,30 | |
| | Test 2:<br>100% rated import power 50,00 Hz to 48,80 Hz with 2 Hzs$^{-1}$ | | |
| | Start: 50 ± 0,01 Hz | End: 48,80Hz | |
| Frequency [Hz]: | 50,00 | 48,80 | |
| Active power [kW]: | -11,91 | 2,39 | |
| Reactive Power [kVar]: | 0,37 | 0,45 | |
| | Test 3:<br>40% rated import power 50,00 Hz to 49,00 Hz with 2 Hzs$^{-1}$ | | |
| | Start: 50 ± 0,01 Hz | End: 49,00 Hz | |
| Frequency [Hz]: | 50,00 | 49,00 | |
| Active power [kW]: | -4,78 | 5,20 | |
| Reactive Power [kVar]: | 0,32 | 0,37 | |
| | Test 4:<br>40% rated import power 50,00 Hz to 48,80 Hz with 2 Hzs$^{-1}$ | | |
| | Start: 50 ± 0,01 Hz | End: 48,80 Hz | |
| Frequency [Hz]: | 50,00 | 48,80 | |
| Active power [kW]: | -4,77 | 9,16 | |
| Reactive Power [kVar]: | 0,33 | 0,26 | |

**Test:**

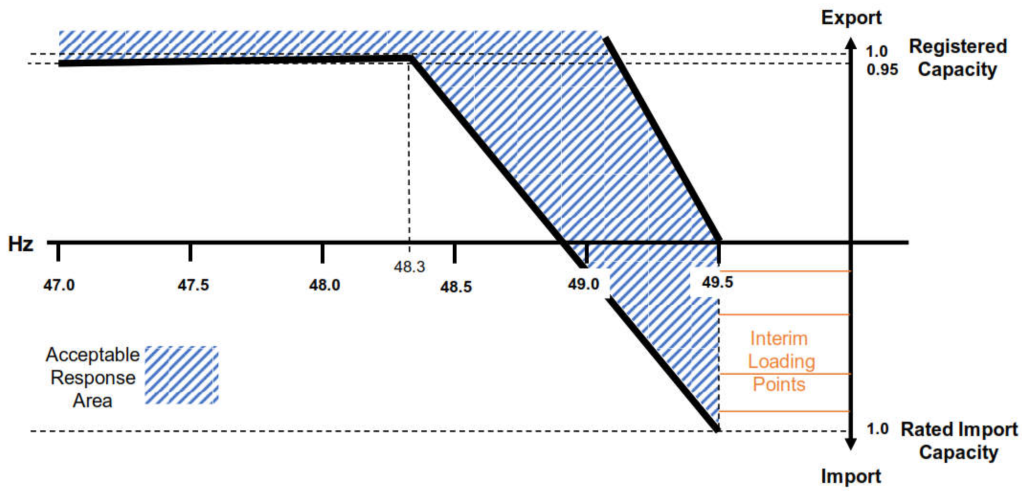
(a) When the frequency falls to 49,5 Hz the automatic response shall start;

(b) The frequency response characteristic shall be within the shaded area of Figure 4;

(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.

| A.7.1.7 | **Power Park Modules which include Electricity Storage**<br>This test should be carried out in accordance with 11.2.3.3. | P |
|---|---|---|

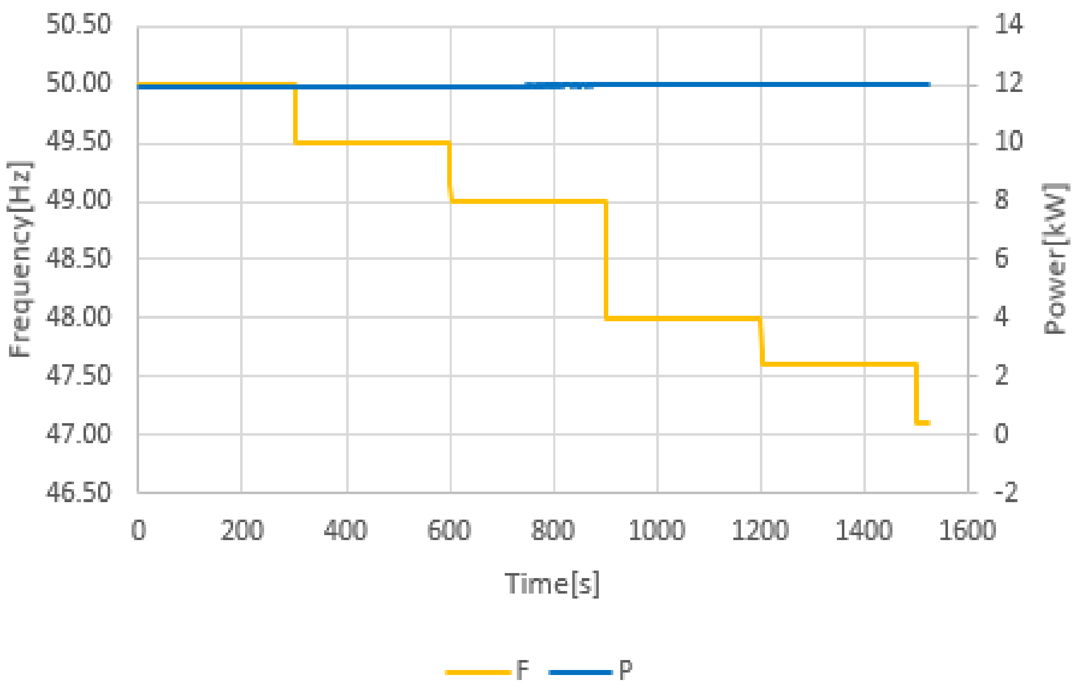



In general four tests are proposed, one set of two at rated import capacity, and one set of two at 40% of rated import capacity**.** In both cases the test is to reduce frequency from 50 Hz at 2 $Hzs^{-1}$. In the first case the lower frequency reached will be 49,0 Hz and the second case the lower frequency will be 48,8 Hz.

**Note:**

The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

| A.7.2.3 | Output Power with falling Frequency | | | | | P |
|---|---|---|---|---|---|---|
| **Test result: HESS-HY-T-12K** | | | | | | |
| 5-min mean value (each) | a) | b) | c) | d) | e) | f) |
| Frequency [Hz]: | 50,00 | 49,50 | 49,00 | 48,00 | 47,60 | 47,10 |
| Active power [kW]: | 11,91 | 11,92 | 11,97 | 11,97 | 11,99 | 11,99 |
| ΔP/$P_{max}$ [%]: | | -0,67 | -0,25 | -0,25 | -0,08 | -0,08 |
| **Graph of frequency a) to b) to c) to d) to e) to f):** | | | | | | |




Note:

For a CHP the test point a) at 50,00 Hz is taken as Registered capacity ($P_{max}$) due to limited discrete operating point of the CHP's thermal process.

Electronic inverter no power reduction take place.

The tests had been performed on the HESS-HY-T-12K are valid for the HESS-HY-T1-12K since it is almost same as in hardware and software.

| **Wiring fuctional tests: If required by para 15.2.1.** | **N/A** |
|---|---|
| Confirm that the relevant test schedule is attached (test to be undertaken at time of commissioning) | N/A |
| **Note:**<br>The inverter was tested in a test laboratory. The correct wiring functional test in the filed has to be done by the responsible person for the installation of the plant. | |

| **Cyber security, required by paragraph 9.1.7** | **P** |
|---|---|
| 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 9.1.7. | Yes |

Jiangsu Hanchu Energy Technology Co.,Ltd

**Manufacturer's declaration**

We, （Company: Jiangsu Hanchu Energy Technology Co.,Ltd, Address: No.588,Jinhui Road,Huishan District ,Wuxi City,Jiangsu Province,China）, hearby declare that all our below listed inverters comply with the cyber security requirements of the standard G99-1 and G98-1:

- Model no.:

For G98-1: HESS-HY-T-05K, HESS-HY-T-06K, HESS-HY-T-08K, HESS-HY-T-10K,
HESS-HY-T1-05K, HESS-HY-T1-06K, HESS-HY-T1-08K, HESS-HY-T1-10K,
For G99-1: HESS-HY-T-12K, HESS-HY-T1-12K

- Requirements listed in the standard(s):
  - ETSI EN 303 645;
  - relevant aspects of PAS 1879 "Energy smart appliances – Demand side response operation – Code of practice";
  - relevant aspects of "Distributed Energy Resources – Cyber Security Connection Guidance" published by BEIS and the ENA;
  - Any other relevant standard that has been incorporated in the design of the **Power Generating Module**.

Page 1 of 2

Jiangsu Hanchu Energy Technology Co.,Ltd

Declared by:

Company name: Jiangsu Hanchu Energy Technology Co.,Ltd

Responsible person: Allen Zhu

Signature (and/or Stamp): Allen Zhu

Date: 2024.01.10

Page 2 of 2

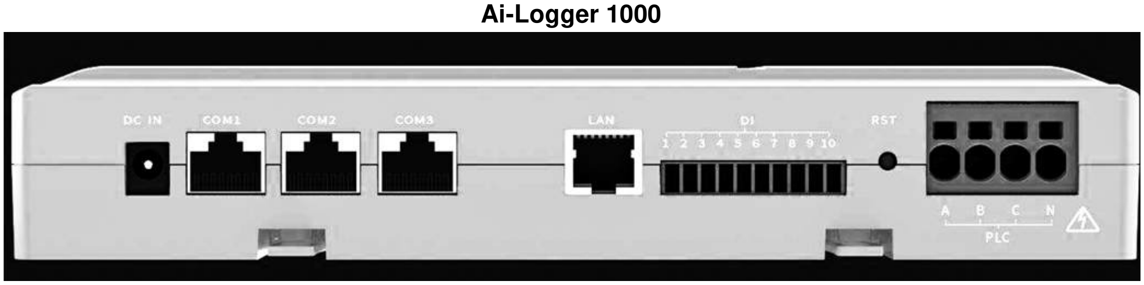
**Note:**

Different levels of access, all are password protected, only certain parameters can be changed on maintenance level.

| Logic Interface (input port) Required by paragraph 11.1.3.1 | P |
|---|---|
| Confirm that an input port is provided and can be used to shut down the module. | Yes |
| **Note:**<br>Manufacturer information provided. | |
| Provide high level description of logic interface, e.g. details in 11.1.3.1 such as AC or DC signal | Yes |

Logical interfaces are implemented by external devices (model: Ai-Logger 1000). COM1 or 2 or 3 of the external device is connected to COM0 of the power generation module (Figure 4 and Figure 5).
Pins 1 and 10 of the DI port of the external device are connected to the switch or contactor.
When the switch is closed, the generating module can work normally.
When the switch is opened, the logical port has a DC voltage of 5V, and the power module reduces the active power to zero within 5 seconds.


**Ai-Logger 1000**




**Ai-Logger 1000 communication interface**

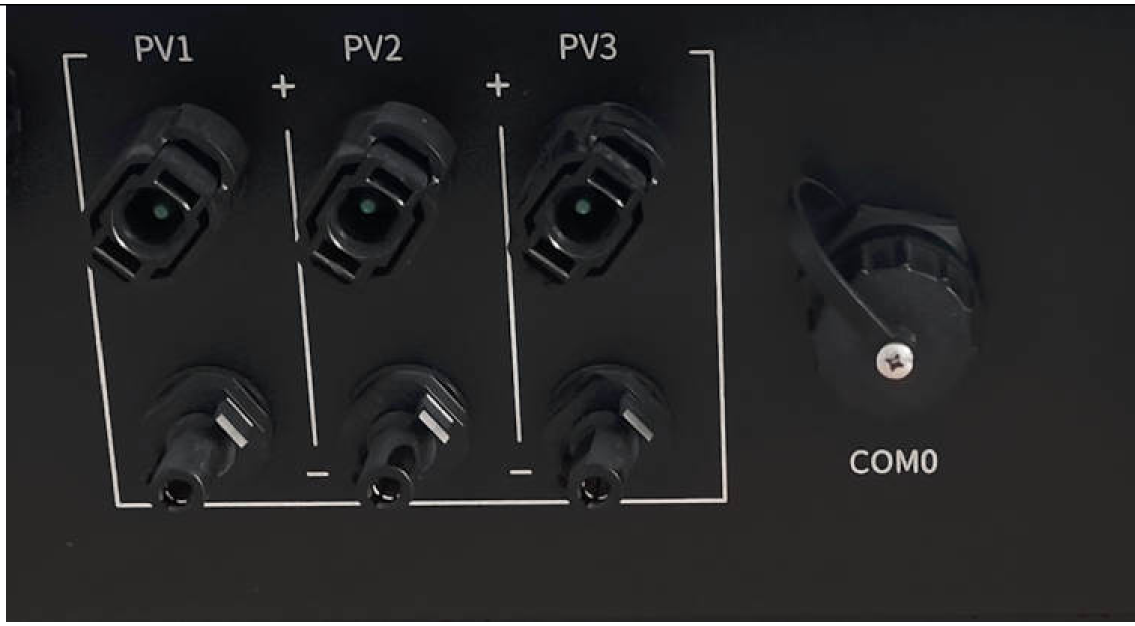



Figure 4 (For HESS-HY-T1-12K)

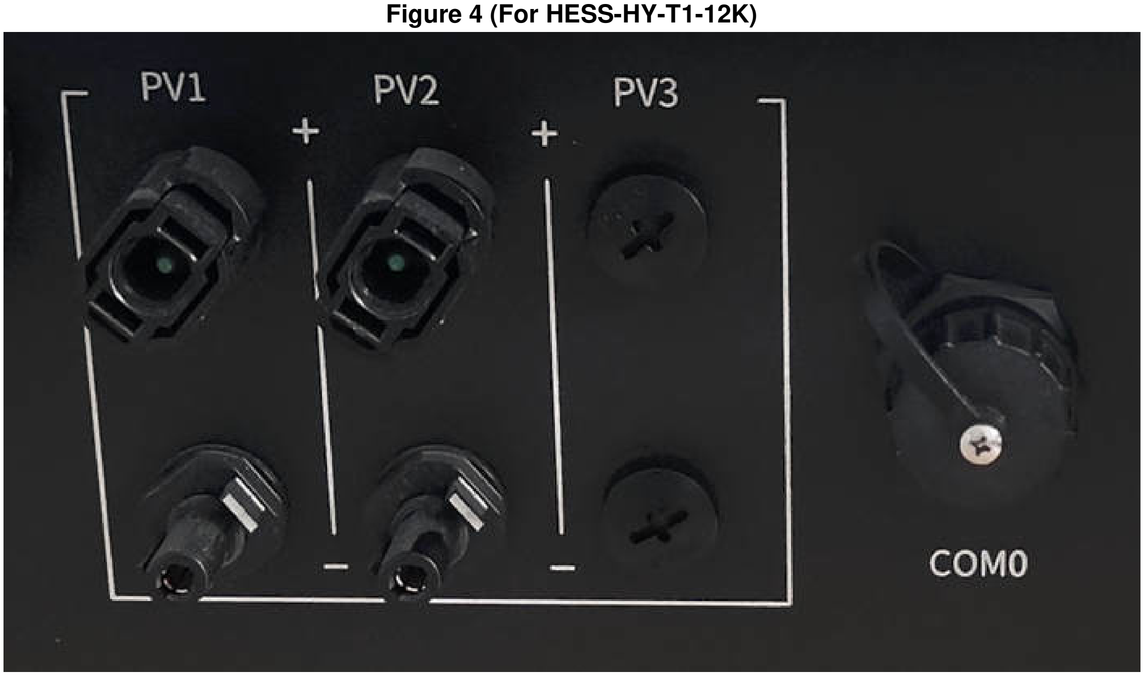



Figure 5 (For HESS-HY-T-12K)

# Annex No. 1
# EMC report

# EMC TEST REPORT

REPORT NO.: BVKJ-ESH-P23121382B-1
MODEL NO.: Refer to model list
RECEIVED: Dec.21, 2023
ISSUED: Dec.27, 2023

APPLICANT: Jiangsu Hanchu Energy Technology Co.,Ltd
ADDRESS: No.588,Jinhui Road,Huishan District ,Wuxi City,Jiangsu Province,China

ISSUED BY: BUREAU VERITAS ADT (Shanghai) Corporation
LAB LOCATION: No. 829, Xinzhuan Road, Shanghai, P.R.China (201612)

This test report consists of 219 pages in total. It may be duplicated completely for legal use with the approval of the applicant. It should not be reproduced except in full, without the written approval of our laboratory. The test results in the report only apply to the tested item. The test results in this report are traceable to the national or international standards.

Report No.:BVKJ-ESH-P23121382B-1 Page 1 of 219 CE-EMC-ITE V1.1

# 1 TEST PROGRAM

PRODUCT: Grid-connected hybrid Inverter

BRAND: HANCHU ESS

MODEL NO.: Refer to model list

APPLICANT: Jiangsu Hanchu Energy Technology Co.,Ltd

TESTED: --

Standards :
Emission : EN 62920 :2017+A11 :2020, EN 62920 :2017+A1 :2021
(IEC 62920 :2017+A1 :2021) ;
EN 61000-2-2 :2002+A1 :2017, EN 61000-2-2 :2002+A2 :2019
(IEC 61000-2-2 :2002+A1 :2017+A2 :2018) ;
EN61000-6-4 :2007+A1 :2011, EN IEC 61000-6-4 :2019(IEC 61000-6-4 :2018) ;
EN 61000-6-3 :2007+A1 :2011+AC :2012, EN IEC 61000-6-3 :2021(IEC 61000-6-3 :2020) ;
EN 55011 :2016+A1 :2017, EN 55011 :2016+A11 :2020, EN 55011 :2016+A2 :2021
(CISPR 11 :2015+A1 :2016+A2 :2019) ;
EN 61000-3-12 :2011 (IEC 61000-3-12 :2011+A1 :2021) ;
EN 61000-3-11 :2000, EN IEC 61000-3-11 : 2019 (IEC 61000-3-11 :2017) ;
EN 61000-3-2 :2014, EN IEC 61000-3-2 :2019+A1 :2021(IEC 61000-3-2 :2018+A1 :2020) ;
EN 61000-3-3 :2013+A1 :2019, EN 61000-3-3 :2013+A2 :2021,
EN 61000-3-3 :2013+A2 :2021+AC :2022 (IEC 61000-3-3 :2013+A1 :2017+A2 :2021)
Immunity : EN 62920 :2017+A11:2020, EN 62920 :2017+A1 :2021(IEC 62920:2017+A1:2021
EN 61000-6-2 :2005+AC :2005, EN IEC 61000-6-2 :2019(IEC 61000-6-2 :2016) ;
EN61000-6-1 :2007, EN IEC 61000-6-1 :2019(IEC 61000-6-1 :2016) ;
(IEC 61000-4-2 :2008 ; IEC 61000-4-3 :2020 ; IEC 61000-4-4 :2012 ;
IEC 61000-4-5 :2014+A1 :2017 ; IEC 61000-4-6 :2013 ;
IEC 61000-4-8 :2009 ; IEC 61000-4-34 :2005+A1 :2009)

We, BUREAU VERITAS ADT (Shanghai) Corporation, declare that the equipment above has been tested and found compliance with the requirement limits of applicable standards. The test record, data evaluation and Equipment Under Test (EUT) configurations represented herein are true and accurate under the standards herein specified.

PREPARED BY : Yuan Zhang , DATE: Dec.27, 2023

Yuan ZHANG
Project Engineer

APPROVED BY : Sean Yu , DATE: Dec.27, 2023

Sean YU
RF Supervisor

Report No.:BVKJ-EGH-P23121382B-1 Page 4 of 219 CE-EMC-ITE V1.1

## 3.4 TECHNICAL DATA SHEET

| | Model | HESS-HY-T-05K | HESS-HY-T-06K | HESS-HY-T-08K | HESS-HY-T-10K | HESS-HY-T-12K |
|---|---|---|---|---|---|---|
| PV input | VMaxpv [Vdc] | 1100 | | | | |
| | Iscpv [A] | 30 | | | | |
| | MPP Voltage Range [Vdc] | 150 - 950 | | 200-950 | | |
| | Full Power MPP Voltage Range [Vdc] | 250-850 | 290-850 | 350-850 | 380-850 | 450-850 |
| | Max. Input Current [A] | 20 | | | | |
| | Start PV Voltage [Vdc] | 180 | | | | |
| | Back feed Current [A] | 0 | | | | |
| | Overvoltage Category (OVC) | II | | | | |
| Battery input | Battery voltage range[Vdc] | 120 - 600 | | | | |
| | Max. charging / discharging power[kW] | 5 | 6 | 8 | 10 | 12 |
| | Battery voltage range@nominal power[Vdc] | 200-600 | 210-600 | 270-600 | 340-600 | 400-600 |
| | Max. charging current / Max. discharging current [A] | 30 | | | | |
| | Battery type | LiFePO4 | | | | |
| AC output | Rated Output Voltage [Vac] | 220 / 380 V,230 / 400 V,240 / 415 ,3L/N/PE | | | | |
| | Rated Output Frequency [Hz] | 50 / 60 | | | | |
| | Rated Output Power [kW] | 5 | 6 | 8 | 10 | 12 |
| | Max.Apparent Power [kVA] | 5.5 | 6.6 | 8.8 | 11.0 | 13.2 |
| | Rated Output Current [A](@400V) | 7.3 | 8.7 | 11.6 | 14.5 | 17.4 |
| | Max.Output Current [A](@400V) | 8.0 | 9.6 | 12.8 | 16.0 | 19.2 |
| | Power Factor (cosφ) | 1.0 (default), 0.80 lead, 0.80 lag | | | | |
| | Overvoltage Category (OVC) | III | | | | |
| AC input | Rated Input Voltage [Vac] | 220 / 380 V,230 / 400 V,240 / 415 ,3L/N/PE | | | | |
| | Rated Input Frequency [Hz] | 50 / 60 | | | | |
| | Max. input power from grid [kW] | 10 | 12 | 16 | 20 | 24 |
| | Max. input current from grid[A] | 14.5 | 17.4 | 23.2 | 29.0 | 34.8 |
| EPS output | Nominal Output Voltage [Vac] | 220 / 380 V,230 / 400 V,240 / 415 ,3L/N/PE | | | | |
| | Nominal Output Frequency [Hz] | 50 /60 | | | | |
| | Max. apparent power[kVA] | 5 | 6 | 8 | 10 | 12 |
| | Rated Current[A] (@400V) | 7.3 | 8.7 | 11.6 | 14.5 | 17.4 |
| SYSTEM | Protective Class | I | | | | |
| | Enclosure Protection [IP] | IP66 | | | | |
| | Operating Temperature Range [°C] | -25 °C ... +60 °C | | | | |
| | Pollution degree (PD) | PD 3 | | | | |
| | Max. operating altitude [m] | 3000 | | | | |
| | Acoustic Noise [dB] | < 60 | | | | |
| | Weight [Kg] | 24.5 | | | | |
| | Size (W / H / D) [mm] | 545 / 465 / 205 | | | | |
| | Firmware Version | Master DSP：610-05001-00<br>Slave DSP：610-60015-00<br>Safety：610-11022-00 | | | | |

1) For European market and Australian market, the max. apparent AC output power is equal to the rated power.

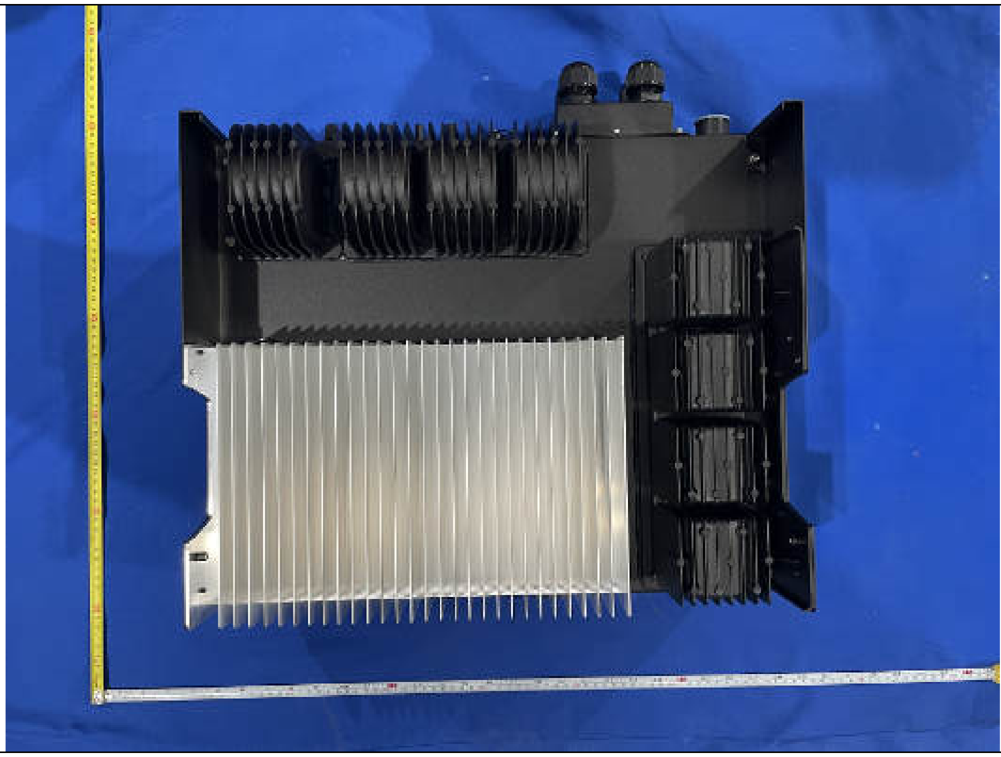
Report No.:BVKJ-ESH-P23121382B-1 Page 11 of 219 CE-EMC-ITE V1.1

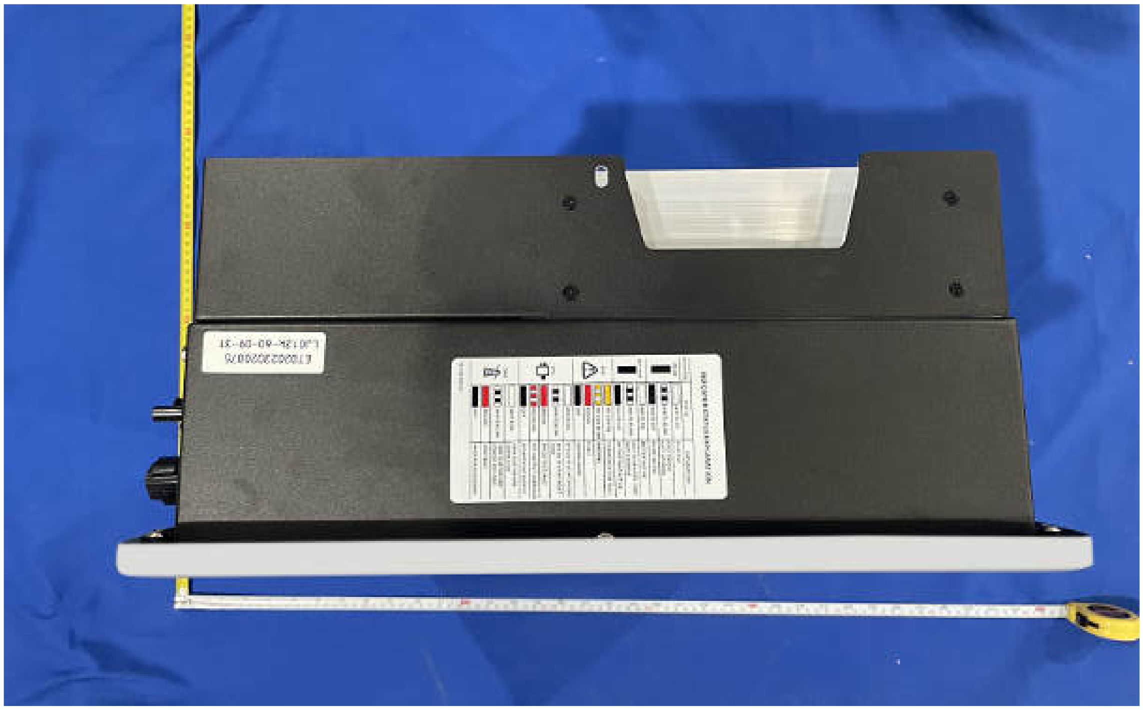
| Model | | HESS-HY-T1-05K | HESS-HY-T1-06K | HESS-HY-T1-08K | HESS-HY-T1-10K | HESS-HY-T1-12K |
|---|---|---|---|---|---|---|
| PV input | VMaxpv [Vdc] | 1100 | | | | |
| | Iscpv [A] | 24 | | | | |
| | MPP Voltage Range [Vdc] | 150 - 950 | | 200-950 | | |
| | Full Power MPP Voltage Range [Vdc] | 180~850V | 200~850V | 250~850V | 320~850V | 380~850V |
| | Max. Input Current [A] | 16 | | | | |
| | Start PV Voltage [Vdc] | 180 | | | | |
| | Back feed Current [A] | 0 | | | | |
| | Overvoltage Category (OVC) | II | | | | |
| Battery input | Battery voltage range[Vdc] | 120 - 600 | | | | |
| | Max. charging / discharging power[kW] | 5 | 6 | 8 | 10 | 12 |
| | Battery voltage range@nominal power[Vdc] | 200-600 | 210-600 | 270-600 | 340-600 | 400-600 |
| | Max. charging current / Max. discharging current [A] | 30 | | | | |
| | Battery type | LiFePO4 | | | | |
| AC output | Rated Output Voltage [Vac] | 220 / 380 V,230 / 400 V,240 / 415 ,3L/N/PE | | | | |
| | Rated Output Frequency [Hz] | 50 / 60 | | | | |
| | Rated Output Power [kW] | 5 | 6 | 8 | 10 | 12 |
| | Max.Apparent Power [kVA] | 5.5 | 6.6 | 8.8 | 11.0 | 13.2 |
| | Rated Output Current [A](@400V) | 7.3 | 8.7 | 11.6 | 14.5 | 17.4 |
| | Max.Output Current [A](@400V) | 8.0 | 9.6 | 12.8 | 16.0 | 19.2 |
| | Power Factor (cosφ) | 1.0 (default)，0.80 lead，0.80 lag | | | | |
| | Overvoltage Category (OVC) | III | | | | |
| AC input | Rated Input Voltage [Vac] | 220 / 380 V,230 / 400 V,240 / 415 ,3L/N/PE | | | | |
| | Rated Input Frequency [Hz] | 50 / 60 | | | | |
| | Max. input power from grid [kW] | 10 | 12 | 16 | 20 | 24 |
| | Max. input current from grid[A] | 14.5 | 17.4 | 23.2 | 29.0 | 34.8 |
| EPS output | Nominal Output Voltage [Vac] | 220 / 380 V,230 / 400 V,240 / 415 ,3L/N/PE | | | | |
| | Nominal Output Frequency [Hz] | 50 /60 | | | | |
| | Max. apparent power[kVA] | 5 | 6 | 8 | 10 | 12 |
| | Rated Current[A] (@400V) | 11.6 | 14.5 | 11.6 | 14.5 | 17.4 |
| SYSTEM | Protective Class | I | | | | |
| | Enclosure Protection [IP] | IP66 | | | | |
| | Operating Temperature Range [°C] | -25 °C ... +60 °C | | | | |
| | Pollution degree (PD) | PD 3 | | | | |
| | Max. operating altitude [m] | 3000 | | | | |
| | Acoustic Noise [dB] | < 60 | | | | |
| | Weight [Kg] | 26 | | | | |
| | Size (W / H / D) [mm] | 545 / 465 / 205 | | | | |
| | Firmware Version | Master DSP：610-05001-00<br>Slave DSP：610-60015-00<br>Safety：610-11022-00 | | | | |

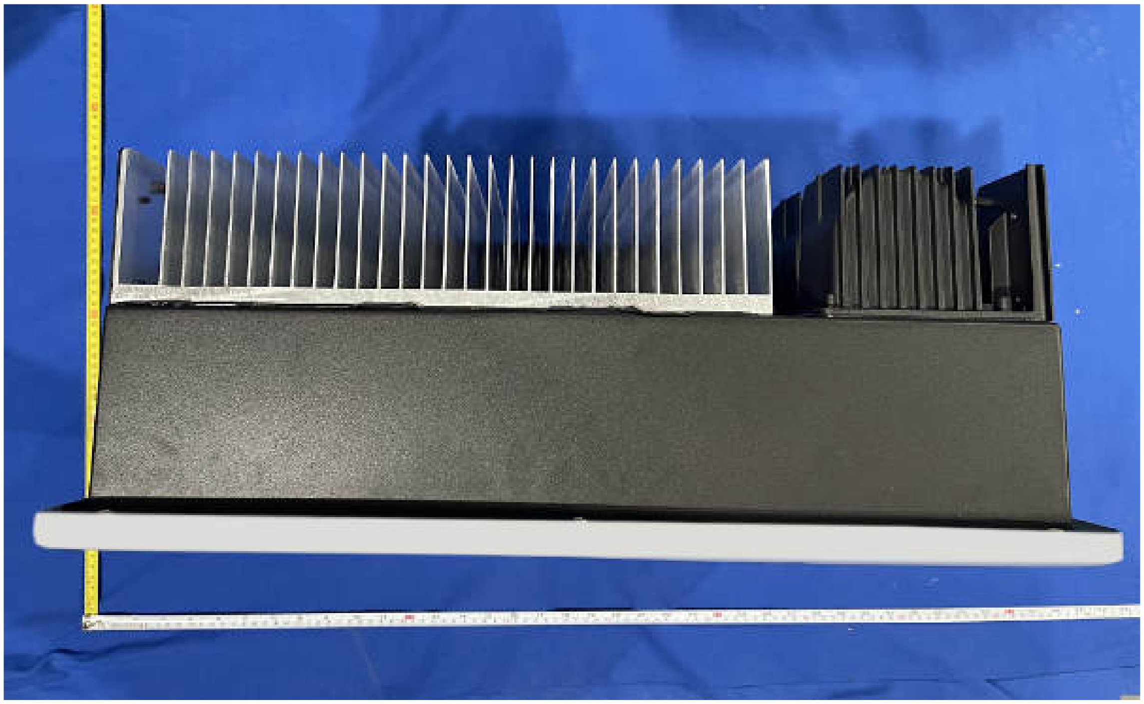
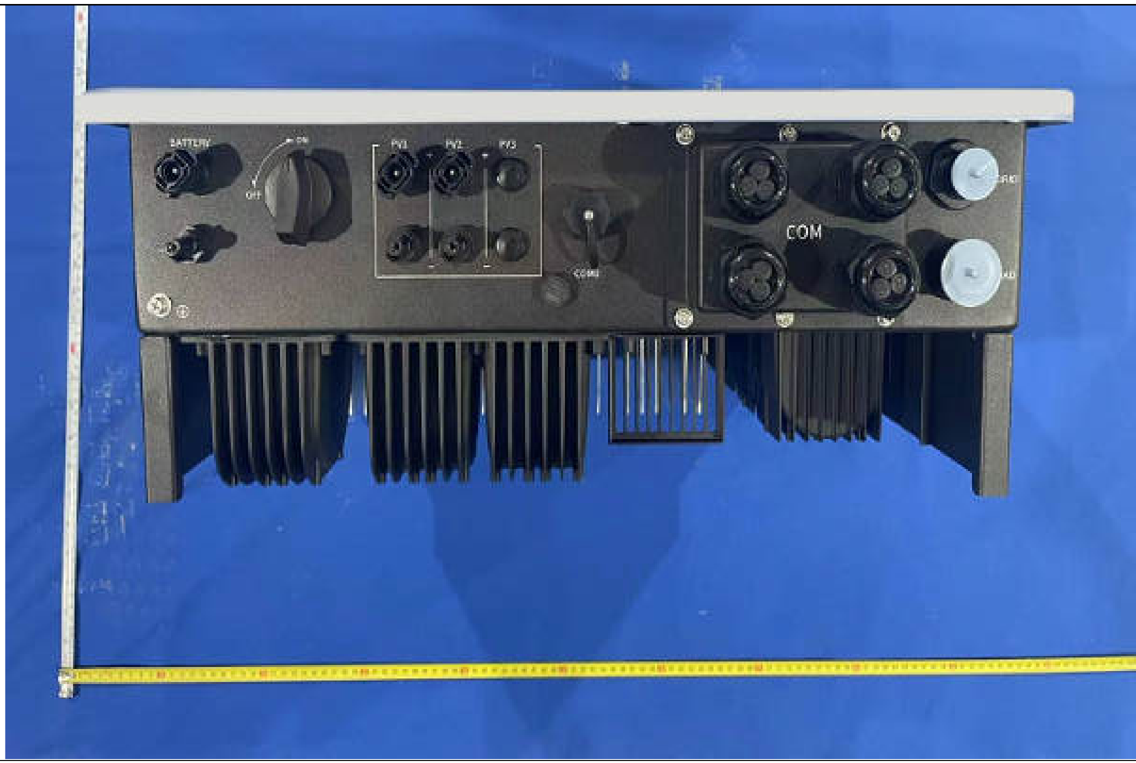
1) For European market and Australian market, the max. apparent AC output power is equal to the rated power.

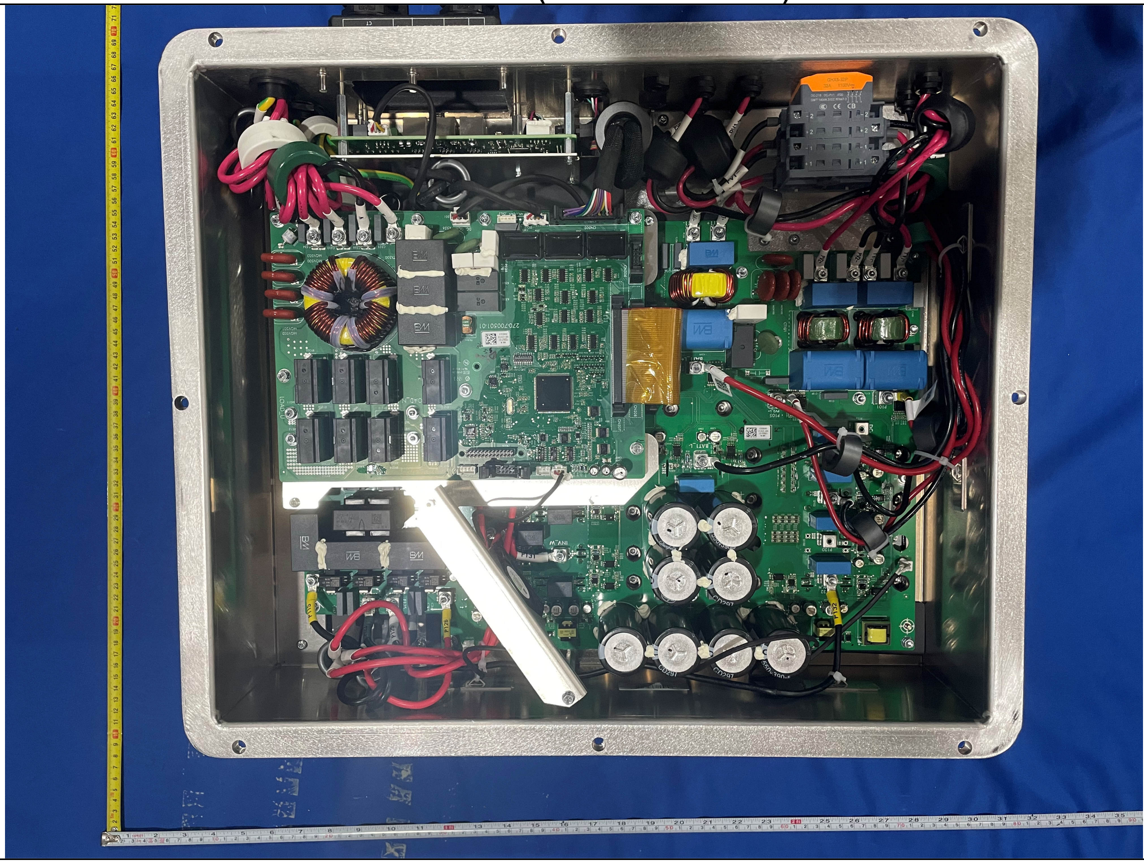
Report No.:BVKJ-ESH-P23121382B-1 Page 12 of 219 CE-EMC-ITE V1.1

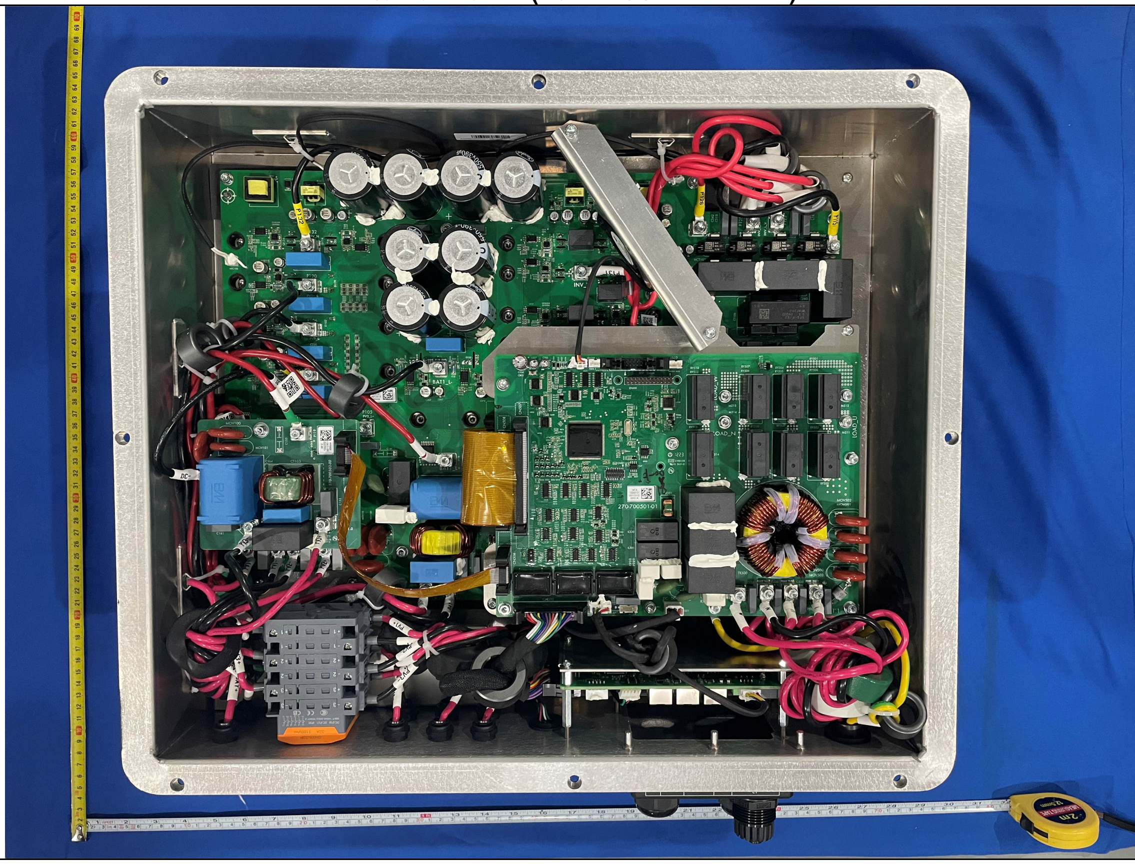
# Annex No. 2
## Pictures of the unit

| Photo of EUT |
|---|
| Enclosure front view |
|  |
| Enclosure back view |
|  |

| Enclosure left view |
|---|
|  |
| **Enclosure right view** |
|  |

| Enclosure top view |
|---|
|  |
| **Enclosure bottom view-1 (For HESS-HY-T-12K)** |
|  |

| Enclosure bottom view-2 (For HESS-HY-T1-12K) |
| --- |
|  |
| **Internal view-1 (For HESS-HY-T-12K)** |
|  |

| Internal view-2 (For HESS-HY-T1-12K) |
| --- |
|  |

# Annex No. 3
## Test Equipment list

**Date(s) of performance test: 2023-03-23 to 2023-10-23**

| Equipment | Internal No. | Manufacturer | Type | Serial No. | Next Calibration |
|---|---|---|---|---|---|
| Power Analyzer | A4080002DG | YOKOGAWA | WT3000 | 91M210852 | Jul. 21, 2024 |
| Power Analyser | A4080004DG | DEWESoft | SIRIUSi-HS-4xHV-4xLV | DB19104221 | Jul. 21, 2024 |
| AC Source | A7040019DG | Chroma | 61512 | 61512000439 | Monitored by Power Analyzer |
| DC Simulation Power Supply | A7040015DG | Chroma | 62150H-1000S | 62150EF00488 | |
| | A7040016DG | Chroma | 62150H-1000S | 62150EF00490 | |
| | A7040017DG | Chroma | 620028 | 620028EF00120 | |
| | A7040021DG | Chroma | 62150H-1000S | 62150EF00609 | |
| | A7040022DG | Chroma | 62150H-1000S | 62150EF00595 | |
| RLC Load | A7150027DG | Qunling | ACLT-3803H | 93VOO2869 | |
| Current transducer | A1060007DG | YOKOGAWA | CT200 | 1130700012 | Jul. 16, 2024 |
| | A1060008DG | YOKOGAWA | CT200 | 1130700017 | Jul. 16, 2024 |
| | A1060009DG | YOKOGAWA | CT200 | 1130700019 | Jul. 16, 2024 |
| | A10600010DG | YOKOGAWA | CT200 | 1130700016 | Jul. 16, 2024 |
| | A10600011DG | YOKOGAWA | CT200 | 1130700011 | Jul. 16, 2024 |
| | A10600012DG | YOKOGAWA | CT200 | 1130700018 | Jul. 16, 2024 |
| Eight Channel Digital Phosphor Oscilloscope | A4089017DG | YOKOGAWA | DL850 | 91N726247 | Jul. 11, 2024 |
| Oscilloscope probe | A1490008DG | YOKOGAWA | 701901 | // | Jul. 18, 2024 |
| Oscilloscope probe | A1490009DG | YOKOGAWA | 701901 | // | Jul. 18, 2024 |
| Oscilloscope probe | A1490010DG | YOKOGAWA | 701901 | // | Jul. 18, 2024 |
| Oscilloscope probe | A1490011DG | YOKOGAWA | 701901 | // | Jul. 18, 2024 |
| Temp. & Humi. Recorder | A7440034DG | HUATO | S580-TH | HT20103923 | Jan. 31, 2024 |

**--End of Test Report--**