# TEST REPORT FOR THE VERIFICATION OF COMPLIANCE OF POWER CONVERTER WITH:

# NTS V2.1 SEPE + CORRECTION REV. 1.0 8/10/2021

**Procedure: PE.T-LE-62**

| | |
|---|---|
| Test Report Number..... : | **2221 / 0269-7** |
| Type..... : | Grid Connected PV Inverter |
| Tested Model..... : | **SIRIO-ES-50** |
| Variant Models..... : | SIRIO-ES-60 |

**APPLICANT**

| | |
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**HIRED BY**

| | |
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| | |
|---|---|
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**Data Provided By The Client:**

The following data has been provided by the applicant:

1. Any Information regarding Technical characteristics of the equipment, (Ratings, operation modes, software and hardware versions, dimensions & weight).
2. Equipment operation & construction information (Manuals, Electrical diagrams, information about components, Operation procedures).
3. Documental Information (Brand and models names, address or other information about applicant, company or manufacturer information).
4. Other information remarked within this report.

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**Test Report Historical Revision:**

| Test Report Version | Date | Summary of changes |
|---|---|---|
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## 1 SCOPE

SGS Tecnos, S.A. (Electrical Testing Laboratory) has been contracted by SGS Tecnos, S.A. (Certification Body) in order to perform the testing for UGE according to:

NTS SEPE

- "Norma Técnica de Supervisión (NTS) de la conformidad de los Módulos de Generación de Electricidad según el Reglamento UE 2016/631". Revisión 2.1 (09/07/2021).
- "Corrección de errores de la versión 2.1 (del 9/7/2021) de la Norma Técnica de Supervisión de la Conformidad de los Módulos de Generación de Electricidad según el Reglamento UE 2016/631". Revision 1.0 del (08/10/2021).

The Equipment Under Testing (EUT) is an UGE, without inertia, nonsynchronous. For the purpose of evaluation, the EUT is considered to be a **Type A**, and **Type B** UGE, as defined in the standard:

- Type A: At the point of connection, V < 110 kV, 0.8 kW ≤ P ≤ 100 kW.
- Type B: At the point of connection, V < 110 kV, 100 kW < P ≤ 5 MW.
- Type C: At the point of connection, V < 110 kV, 5 MW < P ≤ 50 MW.
- Type D: At the point of connection, V ≥110 kV, P > 50 MW.

# 2 GENERAL INFORMATION

## 2.1 TESTING PERIOD AND CLIMATIC CONDITIONS

Testing has been performed between two periods:

- From May 6th to November 3rd, 2022
- From July 19th to July 24th, 2023.

All the tests and checks have been performed at climatic conditions:

| | |
|---|---|
| Temperature | 25 ± 10 ºC |
| Relative Humidity | 50 ± 20 % |
| Pressure | 90 ± 10 kPa |

**SITE TEST**

Name.....: **SGS Tecnos, S.A. (Electrical Testing Laboratory)**

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## 2.2 EQUIPMENT UNDER TESTING

The following information has been provided by the manufacturer:

Apparatus type ..... : Three Phase Photovoltaic Inverter

Installation ..... : Wall mounted Installation

Manufacturer ..... : RIELLO SOLARTECH

Trademark ..... :

Model / Type reference ..... : **SIRIO-ES-50**

Serial Number ..... : AM42SPSE0000139

Software Version ..... : V013133

Rated Characteristics ..... : Input: MPPT 200 – 960 $V_{dc}$; $V_{max}$: 1100 $V_{dc}$; $V_n$: 620 $V_{dc}$; $I_{dc\_max}$ = 33/33/22/22 $A_{dc}$; $I_{sc}$ = 42/42/28/28 $A_{dc}$

Output: 400 $V_{ac}$; 50/60 Hz; $I_n$: 3x76 $A_{ac}$; $I_{max}$: 3x83 $A_{ac}$; $I_n$: 3x76A; $S_{max}$: 55 kW, $P_n$: 50kW

Date of manufacturing: 2021

Test item particulars

Input ..... : DC

Output ..... 3/N/PE

Class of protection against electric shock... : Class I

Degree of protection against moisture ..... : IP 65

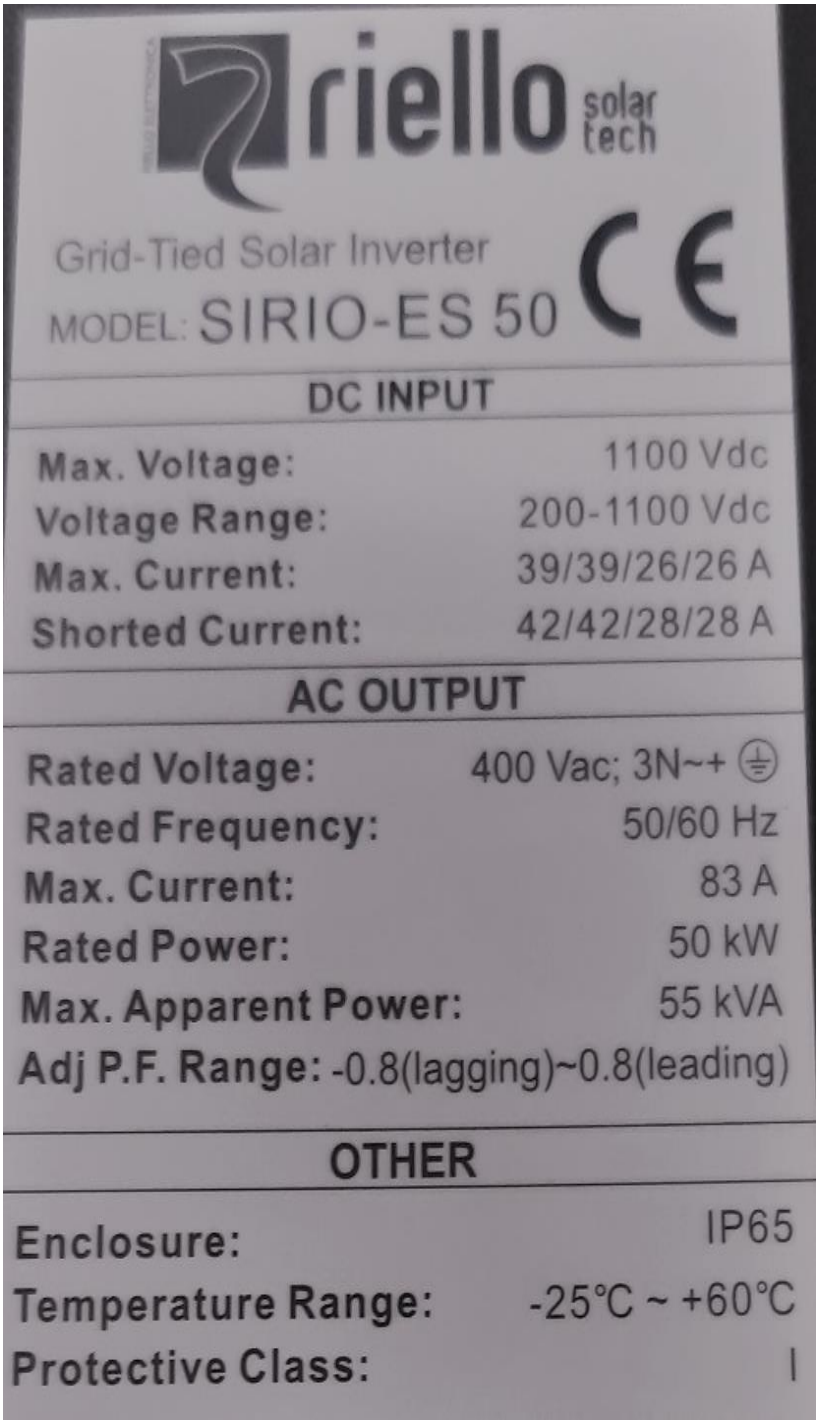
Type of connection to the main supply ..... : Three phase – Fixed installation

Cooling group ..... : Forced ventilation (Fan)

Modular ..... : No

Internal Transformer ..... : No

**Copy of marking plate (representative):**




Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation.

**Equipment under testing:**

- SIRIO-ES-50

**Variant models:**

- SIRIO-ES-60

The variant models can be included in this test report without tests because the following features don´t change in comparison with the tested model:

- Same topology of power stages. That is, the same arrangement of conversion stages, the same location of filters, the same location of relays, etc.
- Same isolation class (low-frequency transformer, high-frequency transformer or no transformer).
- Same AC connection state (1-phase or 3-phase).
- Nominal alternating current ±50% with respect to the type tested.
- Same control algorithm for all technical requirements.
- Groupings of several power stages (modular systems) shall be considered valid without the need for repeating tests.

The results obtained apply only to the particular sample tested that is the subject of the present test report.

The most unfavourable result values of the verifications and tests performed are contained herein. Throughout this report a point (~~comma~~) is used as the decimal separator.

The following table shows the full ratings of all models referenced in this report:

| MODELO | SIRIO ES 50 | SIRIO ES 60 | SIRIO ES 100 | SIRIO ES 110 |
|---|---|---|---|---|
| **ENTRADA** | | | | |
| Voltaje máximo de entrada [V] | 1100 | | | |
| Corriente máxima de entrada [A] | 2x39 + 2x26 | 4x39 | 3x40 + 5x32 | 3x40 + 6x32 |
| Corriente máxima de cortocircuito [A] | 2x42 + 2x28 | 4x42 | 3x50 + 5x45 | 3x50 + 6x45 |
| Realimentación máxima | OA | | - | |
| Voltaje nominal [V] | 620 | | 600 | |
| Rango del voltaje de operación del MPPT [V] | 200 ÷ 1100 | | | |
| Grado de sobretensión | II | | - | |
| Número máximo de entradas | 10 (3/3/2/2) | 12 (3/3/3/3) | 16 (8x2) | 18 (9x2) |
| Número de rutas del MPPT | 4 | | 8 | 9 |
| Protección de sobrecarga [V] | Fuse, 16A/1100 | | - | |
| **SALIDA** | | | | |
| Potencia nominal de salida [W] | 50000 | 60000 | 100000 | 110000 |
| Potencia aparente máxima [VA] | 55000 | 66000 | 111000 | 123000 |
| Potencia active máxima [W] | 55000 | 66000 | 110000 | 121000 |
| Corriente de salida nominal [A] | 3x83 | 3x92 | 3x168.8 | 3x187 |
| Voltaje nominal de la red eléctrica [V] | 380 / 400, 3W+N+PE | | 380 / 400 / 415, 3W+N+PE | |
| Voltaje de la red eléctrica [V] | 277 ÷ 520 (configurable) | | | |
| Frecuencia nominal de la red eléctrica [Hz] | 50 / 60 | | | |
| Rango de frecuencia de la red eléctrica [Hz] | 45-55 / 55-65 | | 45-55 / 55-65 (configurable) | |
| THDi [%] | < 3 % (potencia nominal) | | | |
| CC off-sets [%] | < 0.5 In | | | |
| Factor de potencia | > 0.99 potencia nominal (regulable 0.8 inductivo - 0.8 capacitivo) | | | |
| Grado de sobrecarga según IEC 62109-1 | III | | | |
| **PROTECCIÓN** | | | | |
| Protección del sistema | Interruptor de entrada de CC, entrada para protección para sobrecargas, entrada para protección de conexión inversa, detección de fallos en el string fotovoltaico, detección de resistencia térmica, paso de bajo tensión, salida para protección de sobrecargas, protección DDR, protección de CC off sets, protección para sobrecalentamiento, protección anti-islanding, protección de sobretensión o baja tensión de CA/CC, protección de alta o baja frecuencia de CA | | - | |
| Pararrayos CA/CC | Soportado: II tipo, Máximo 40KA | | - | |
| **SISTEMA** | | | | |
| Maximum efficiency [%] | 98.3 | | 98.4 | |
| European Efficiency [%] | 98 | | | |
| Topología | Sin transformador | | | |
| Nivel de protección | IP65 | | IP66 | |
| Grado de contaminación | PD3 | | - | |
| Refrigeración | Forzado con ventiladores de velocidad controlada | | | |
| **MONITOR Y COMUNICACIONES** | | | | |
| Monitor | Wireless por APP + LED/LCD | | | |
| Comunicaciones | Bluetooth, RS485, Wi-Fi (opcional), Ethernet (opcional) | | Bluetooth, 2xRS485, Wi-Fi (opcional), Ethernet (opcional) | |
| **PARÁMETROS MEDIOAMBIENTALES** | | | | |
| Temperatura del rango operativo [°C] | -25 ÷ 60 | | | |
| Humedad relativa | 0 ÷ 100 | | | |
| Altitud máxima operativa [m] | 4000 | | | |
| Ruido [dB] (@ 1 m) | <62 | | ≤65 (típico) | |
| **INSTALACIÓN FÍSICA** | | | | |
| Dimensiones (WxDxH) [mm] | 855x275x500 | | 936x365x678 | |
| Peso [kg] | 73 | 74 | 92 | |
| Modelo de instalación | Soporte para montar el inversor | | - | |
| Conector de entrada | Amphenol H4 | | - | |
| Conector de salida | Conector resistente al agua + Terminal OT | | | |
| **CUMPLIMENTO DE LA NORMATIVA** | | | | |
| Estándar de la corriente eléctrica | NB / T32004 | | | |
| Certificado de seguridad | IEC62109-I, IEC62109-2, N B / T32004 | | | |
| EMC | EN 61000-6-2/4 | | | |
| Reglamento | CEI 0.21 & CEI 0.16 - RD1699, RD 661, RD 413, UNE 206006, UNE 206007-1, UNE 217002, UNE 217001/RD244/RD647, NTS | | | |
| Garantía | 5 años | | | |

### 2.3 REFERENCE VALUES

The values presented in the following table have been used for calculation of referenced values (p.u.; %) through the report if not otherwise indicated.

| Reference Values | |
| --- | --- |
| Rated power, **Pn** in kW | 50 |
| Max. Active power, **Pmax** in kW | 55 |
| Rated apparent power, **Sn** in kVA | 55 |
| Max. apparent power, **Smax** in kVA | 55 |
| Rated wind speed (only WT), vn in m/s | Not applicable |
| Rated current (determined), **In** in A | 79.7 |
| Rated output voltage, (phase to phase) **Un** in Vac | 400 |
| Note: In this report p.u. values are calculated as follows:<br>-For Active & Reactive Power p.u values are reference to **Pn**<br>-For Currents p.u values, the reference is always **In**<br>-For Voltages p.u values, the reference is always **Un**<br><br>Rated current has been determined as follows: In = Smax / (Un*√3) | |

### 2.4 TEST EQUIPMENT LIST

The following table shows measurement equipment used in tests:

From May 6th to November 3rd, 2022

| No | EQUIPMENT | MARK/MODEL | SGS CODE(DIE) | CALIBRATION DATE |
|---|---|---|---|---|
| 1 | Power Analyzer | YOKOGAWA / WT3000 | DIE.510014 | 12/08/2021 to 12/08/2022 |
| 2 | Data Acquisition Equipment | DEWESsoft / SIRIUSi-4xHV-4xLV | DIE.630044 | 15/12/2021 to 15/12/2022 |
| 3 | Digital Thermohygrometer | TESTO / 622 | DIE.840050 | 19/10/2021 to 19/01/2023 |
| 4 | Current Clamp | HIOKI / 9660 | DIE.510012-1 | 05/02/2021 to 05/02/2023 |
| 5 | Current Clamp | HIOKI / 9660 | DIE.510012-2 | 05/02/2021 to 05/02/2023 |
| 6 | Current Clamp | HIOKI / 9660 | DIE.510012-3 | 05/02/2021 to 05/02/2023 |
| 7 | Current Clamp | HIOKI / 9660 | DIE.510012-4 | 05/02/2021 to 05/02/2023 |
| 8 | Digital Multimeter Current Clamp | HIOKI / 3285 | DIE.510051 | 15/05/2021 to 15/05/2022<br>30/05/2022 to 30/05/2023 |
| 9 | True Multimeter | FLUKE / 289 | DIE.560040 | 20/12/2021 to 20/12/2022 |
| 10 | MATLAB Function | SGS / RMS+Power | DIE.001461-1 | 15/02/2019 to -- |
| 11 | MATLAB Function | SGS / VoltageChangeMeasures | DIE.001461-2 | 15/02/2019 to -- |
| 12 | MATLAB Function | SGS / Sequences | DIE.001461-3 | 07/03/2019 to -- |
| 13 | MATLAB Function | SGS / Static+MobileWindow | DIE.001461-4 | 10/06/2019 to -- |
| 14 | MATLAB Function | SGS / Parameter | DIE.001461-5 | 14/02/2019 to -- |

Note:
1. All measurement equipment was used inside their corresponding calibration period. Copy of all calibration certificates are available at the laboratory for reference.
2. Since those are mathematical functions there is no need to establish a final calibration date.

From July 19th to July 24th, 2023.

| No | EQUIPMENT | MARK/MODEL | SGS CODE(DIE) | CALIBRATION DATE |
|---|---|---|---|---|
| 1 | Power Analyzer | YOKOGAWA / WT3000 | DIE.510014 | 12/08/2022 to 12/08/2023 |
| 2 | Digital Thermohygrometer | TESTO / 622 | DIE.840050 | 31/01/2023 to 01/05/2024 |
| 3 | Current Clamp | HIOKI / 9660 | DIE.510012-1 | 15/02/2023 to 15/02/2025 |
| 4 | Current Clamp | HIOKI / 9660 | DIE.510012-2 | 15/02/2023 to 15/02/2025 |
| 5 | Current Clamp | HIOKI / 9660 | DIE.510012-3 | 15/02/2023 to 15/02/2025 |
| 6 | Current Clamp | HIOKI / 9660 | DIE.510012-4 | 15/02/2023 to 15/02/2025 |
| 7 | Digital Multimeter Current Clamp | HIOKI / 3285 | DIE.510051 | 29/06/2023 to 29/06/2024 |
| 8 | True Multimeter | FLUKE / 289 | DIE.560040 | 19/12/2022 to 19/12/2023 |
| 9 | MATLAB Function | SGS / RMS+Power | DIE.001461-1 | 15/02/2019 to -- |
| 10 | MATLAB Function | SGS / VoltageChangeMeasures | DIE.001461-2 | 15/02/2019 to -- |
| 11 | MATLAB Function | SGS / Sequences | DIE.001461-3 | 07/03/2019 to -- |
| 12 | MATLAB Function | SGS / Static+MobileWindow | DIE.001461-4 | 10/06/2019 to -- |
| 13 | MATLAB Function | SGS / Parameter | DIE.001461-5 | 14/02/2019 to -- |

Note:

3. All measurement equipment was used inside their corresponding calibration period. Copy of all calibration certificates are available at the laboratory for reference.
4. Since those are mathematical functions there is no need to establish a final calibration date.

### 2.5 MEASUREMENT UNCERTAINTY AND DATA SAMPLING RATES

Associated uncertainties through measurements showed in this this report are the maximum allowable uncertainties.

| Magnitude | Uncertainty |
|---|---|
| Voltage measurement | ±1.5 % |
| Current measurement | ±2.0 % |
| Frequency measurement | ±0.2 % |
| Time measurement | ±0.2 % |
| Power measurement | ±2.5 % |
| Phase Angle | ±1º |
| Temperature | ±3º C |
| Note1: Measurements uncertainties showed in this table are maximum allowable uncertainties. The measurement uncertainties associated with other parameters measured during the tests are in the laboratory at disposal of the petitioner.<br>Note2: Where the standard requires lower uncertainties that those in this table. Most restrictive uncertainty has been considered and would be reported in this report. | |

The following measurements uncertainties have been verified by the used equipment (Oscilloscopes and/or Power Analysers) as specifically required by the standard for the performance of the testing process:

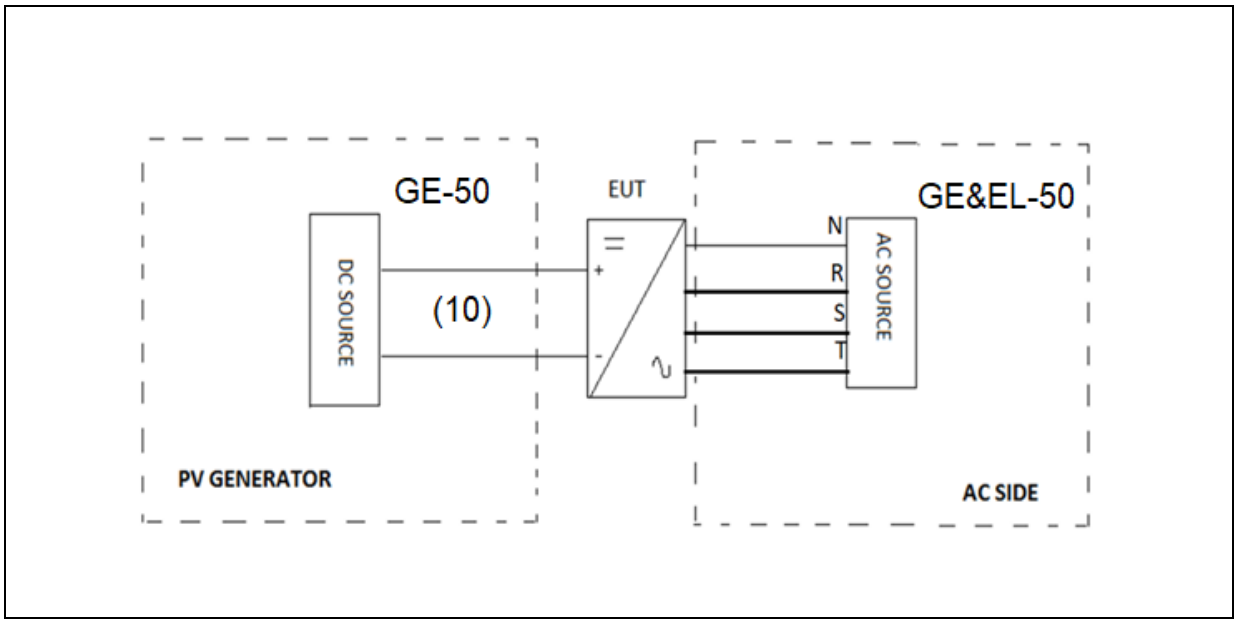
| Magnitude | Measurement uncertainty requirement | Maximum uncertainty Test equipment used |
|---|---|---|
| Voltage (Fundamental frequency) | ≤ 0.5 % of Un | ± 0.06 % |
| Current (Fundamental frequency) | ≤ 0.5 % of In | ± 0.4 % |
| Frequency | ±10mHz (±0.02%) | ± 6.6 mHz |

Data sampling rates have been applied as follows:

| Magnitude | Data sampling *(requested by standard)* | Data sampling *(used for testing)* |
|---|---|---|
| Voltage measurements | ≥ 3 kHz | > 10 kHz |
| Current measurements | ≥ 3 kHz | > 10 kHz |
| Robustness Requirements | ≥ 10 kHz | ≥ 20 kHz |

### 2.6 TEST SET UP

Below is the simplified construction of the test set up.




Different equipment has been used to take measures as it shown in chapter 2.4. Current and voltage clamps have been connected to the inverter input / output for all the tests.

All the tests described in the following pages have used this specified test setup.

**The test bench used includes:**

| EQUIPMENT | MARK / MODEL | RATED CHARACTERISTICS | OWNER / ID. CODE |
|---|---|---|---|
| AC Power Source | CINERGIA / GE&EL+50 vAC/DC | 0-400 V<br>50/60Hz<br>3x73A | DIE.501051 |
| DC Power Source | CINERGIA / GE+50 vAC/DC | 0-800 $V_{dc}$<br>3x50A | DIE.501053 |

#### 2.6.1 AC Voltage source verification

According to point 5 of the standard, the accuracy of the equipment used as a source of voltage and frequency shall comply with the following requirements:

- Unbalance of the AC voltage μ <0.5%
- Harmonics of Voltage source THD <1%

| Variable | Required | Measured | Result |
|---|---|---|---|
| Unbalance (μ) | <0.5% | 0.02% | Pass |
| THD | <1.0% | 0.18% | Pass |

## 2.7 DEFINITIONS

| | | | |
| --- | --- | --- | --- |
| **A** | Ampere | **PGU** | Power Generation Unit |
| **EUT** | Equipment Under Testing | **$P_{ini}$** | Pre-disturbance active power of the UGE |
| **Exp** | Expected | **$P_M$** | Instantaneous Active Power |
| **Hz** | Hertz | **Pn** | Nominal Active Power |
| **Ih** | Harmonic Current | **PPC** | Power Plant Controller |
| **In** | Nominal Current | **$P_{st}$** | Short-term flicker disturbance factor |
| **Iq+** | Reactive Current in positive sequence | **Qn** | Nominal Reactive Power |
| **Iq-** | Reactive Current in negative sequence | **Sk** | Symmetrical Fault level |
| **LV** | Low Voltage | **Sn** | Nominal Apparent Power |
| **LVRT** | Low Voltage Ride Through | **TDC** | Total Demand Current Distortion |
| **Meas.** | Measured | **TDD** | Total Demand Distortion |
| **MGE** | Electrical Generation Module (can be either MPE or MGES) | **TSO** | Transmission System Operator |
| **MGES** | Electrical Synchronous Generation Module | **UGE** | Energy Generation Unit |
| **MPE** | Electrical Park Module | **Un** | Nominal Voltage |
| **MV** | Medium Voltage | **V** | Volt |
| **NCP** | Network connection point | **VAr** | Volt-Ampere reactive |
| **p.u.** | Per unit | **W** | Watt |

## 3 SUMMARY OF TEST RESULTS

**INTERPRETATION KEYS**

Test object does meet the requirement..... : **P** Pass
Test object does not meet the requirement ..... : **F** Fails
Test specification/standard does not include limits ..... : **P*** ··Performed
Test case does not apply to the test object..... : **N/A** Not applicable
To make a reference to a table or an annex. ..... : See additional sheet
To indicate that the test has not been realized ..... : **N/P** Not Performed

| NTS SEPE SECTION | TRF SECTION | CHAPTER OF THE STANDARD NTS | TYPE (1) | RESULT |
|---|---|---|---|---|
| **--** | **4.1** | **Frequency Requirements** | **--** | **P** |
| -- | 4.1.1 | Active power feed-in as a function of frequency | -- | P |
| 5.1 | 4.1.1.1 | Limited Frequency Sensitive Mode-Overfrequency (LFSM-O) | ≥A | P |
| 5.2 | -- | Power-frequency regulation mode limited to underfrequency (LFSM-U) | ≥C | N/A |
| 5.3 | -- | Frequency Sensitive Mode (FSM) | ≥C | N/A |
| 5.4 | -- | Power-Frequency Control | ≥C | N/A (2) |
| **5.5** | **4.2** | **Active power control capability and range** | ≥C | **N/A** |
| 5.5 | -- | Static error test | ≥C | N/A |
| 5.5 | -- | Dynamic response test | ≥C | N/A |
| **5.6** | **4.3** | **Inertia Emulations** | ≥C | **N/A** |
| **--** | **4.4** | **Reactive Power Requirements** | **--** | **P** |
| 5.7 | 4.4.1 | Reactive power capabilities at the EUT rated power and below | ≥B | P |
| 5.8 | 4.4.2 | Reactive power control modes | ≥B | P |
| **5.10** | **4.5** | **Control of oscillation damping** | ≥C | **N/A** |
| **--** | **4.6** | **Robustness Requirements** | **--** | **P** |
| 5.11 | 4.6 | Capability to withstand voltage grid faults for POC below 110 kV | ≥B | P |
| 5.11 | -- | Capability to withstand voltage grid faults for POC above 110 kV | D | N/A |
| 5.11 | 4.6 | Rapid current injection control | ≥B | P |
| 5.11 | 4.6 | Active power recovery after a grid fault | ≥B | P |
| **5.13** | **4.7** | **Islanding requirements** | ≥C | **N/A** |

(1) Type ≥A means that the corresponding chapter applies to equipment of type A, B, C and D. The same criteria have been applied for the rest of types.

(2) According to the standard, evaluation of this requirement will be carried out by the TSO in accordance with the test protocols established in the regulations in force at the time of commissioning of the MGE, which the TSO will indicate to the owner of the MGE.

Note: Decision Rule of Statements of conformity evaluated according to Guidelines ILAC G8:09/2019 and IEC 115:2023 (4.3.3 / 4.4) & ISO/IEC Guide 98-4 (8.3.12).

Decision Rules used: Binary Statement for Simple Acceptance (Guard Band with respect to the limit w=0). Specific Risk: Probability of False Accept or Reject lower than 50 %, (PFA / PFR < 50 %).

Measurement uncertainty is not applied when statements of conformity is the simple acceptance. For more information see ILAC G8/09 & 115 Guidelines.

# 4 TEST RESULTS

## 4.1 FREQUENCY REQUIREMENTS

### 4.1.1 Active power feed-in as a function of frequency

The aim of the test is to demonstrate the response of the EUT due to a deviation in grid frequency from rated value in terms of speed (rise/settling time) and the active power gradient.

#### 4.1.1.1 Overfrequency (LFSM-O)

This test has been done to verify the capacity of the EUT of activating the automatic response for active power reduction due to over frequency variations according to section 5.1.2 of the standard.

Different tests have been carried out, regarding different droop levels and activation thresholds:

- OS2F2: droop $S_2$= 2% and activation threshold of $\Delta f_1$ = 0.2 Hz (50.2 Hz).
- OS2F5: droop $S_2$= 2% and activation threshold of $\Delta f_1$ = 0.5 Hz (50.5 Hz).
- OS12F2: droop $S_2$= 12% and activation threshold of $\Delta f_1$ = 0.2 Hz (50.2 Hz).
- OS12F5: droop $S_2$= 12% and activation threshold of $\Delta f_1$ = 0.5 Hz (50.5 Hz).

Active power variation for a specific step is calculated using the following expression:

$$|\Delta P| = \frac{|\Delta f| - |\Delta f_1|}{f_n} \times \frac{P_{max}}{s_2} \times 100$$

The following conditions have been evaluated for each test performed.

| Criteria | Comments | Result |
|---|---|---|
| **CONDITIONS DURING MEASUREMENTS** | | |
| A power supply connected to the terminals of the UGE when the UGE is disconnected from the mains. | | P |
| UGE is connected to the mains. | | N/A |
| **Frequency variation method** | | P |
| A device (internal or external) introducing a digital or analogue input into the UGE control system. | | N/A |
| A direct change of the frequency reference value in the control system of the PGU. | | N/A |
| Direct modification of the frequency in the terminals of the UGE when the power supply has the capacity to modify the output frequency. | | P |
| **Test conditions** | | P |
| LFSM-U and FSM have been deactivated | | P |
| Voltage has been at Un+-5% during tests | | P |
| Tests have been performed at Pn with set Q=0 | | P |
| Every step should be measured during >1min. | | P |
| **GENERAL** | | |
| There are no oscillations that are no amortiguated as a response to an abrupt change | | P |
| Maximum deviations of active power according to the measured level of frequency shall not deviate more than 5%Pn | | P |
| Results comply with the following criteria from reference standards | | P |
| **APPLICABLE FOR ACTIVE POWER REDUCTIONS** | | |
| **Ta requirements** | | P |
| For type A & B MGE without inertia ≤ 2 s | | P |
| For type C & D Ta is less than or equal to the power response activation time set for the MRPF mode (max 0.5 s MGE without inertia) because it defines the technical capability of the MPE power response. | | N/A |
| If ta exceeds 2 s: the PGM owner shall provide the TSO with technical evidence to justify this value as established in the Regulation. If the TSO accepts the justification, the TSO shall give its written consent to the PGM owner, who shall forward it to the authorised certifier for incorporation in the final PGM certificate. | No Ta exceeds 2 s. | N/A |
| **Tr Requirements** | | P |
| For MGES UGE: less than or equal to 8 s for an active power variation of up to 45% of the maximum power. | UGE MPE Evaluated | N/A |
| For MPE UGE: less than or equal to 2 s for an active power variation of up to 50% of the maximum power. | | P |
| **Te Requirements** | | P |
| For MGES UGE: less than or equal to 30 s. | UGE MPE Evaluated | N/A |

| Criteria | Comments | Result |
|---|---|---|
| For MPE UGE: less than 20 s. | | P |
| **APPLICABLE FOR ACTIVE POWER INCREMENTS** | | |
| **Ta requirements** | | P |
| For type A & B MGE without inertia ≤ 2 s | | P |
| For type C & D Ta is less than or equal to the power response activation time set for the MRPF mode (max 0.5 s MGE without inertia) because it defines the technical capability of the MPE power response. | | N/A |
| **Tr Requirements** | | P |
| For MGES UGE: less than or equal to 5 minutes for an active power variation of up to 20% of the maximum power. This slow behaviour will not be acceptable when the direction of the frequency variation is reversed a few seconds before, in which case response times similar to the case of active power reduction will be expected. | UGE MPE Evaluated | N/A |
| For non-wind MPE UGE: less than or equal to 10 s for an active power variation of up to 50% of the maximum power. | | P |
| For wind MPE UGE: less than or equal to 5 s for an active power variation of up to 20% of the maximum power if the power is above 50% of the maximum power. For powers less than 50% of the maximum power, the response time will be as low as technically possible. | Non-wind MPE UGE evaluated | N/A |
| **Te Requirements** | | P |
| For MGES UGE: less than or equal to 6 minutes. This slow behaviour will not be acceptable when the direction of the frequency variation has reverted a few seconds before, in which case, response times similar to the case of active power reduction will be expected. | UGE MPE Evaluated | N/A |
| For MPE UGE: less than 30 s. | | P |

Results are presented in the following graphs and tables, where:

Ta Activation time: Time from a change on frequency that leads to a power frequency change of more than 1%, to the start of active power response.

Tr Response time: Time to reach the 90% of the measured active power response (ΔP), without including Ta.

Te Settling time: Time of settling of active power on a tolerance of ± 5% of the measured active power response (ΔP).

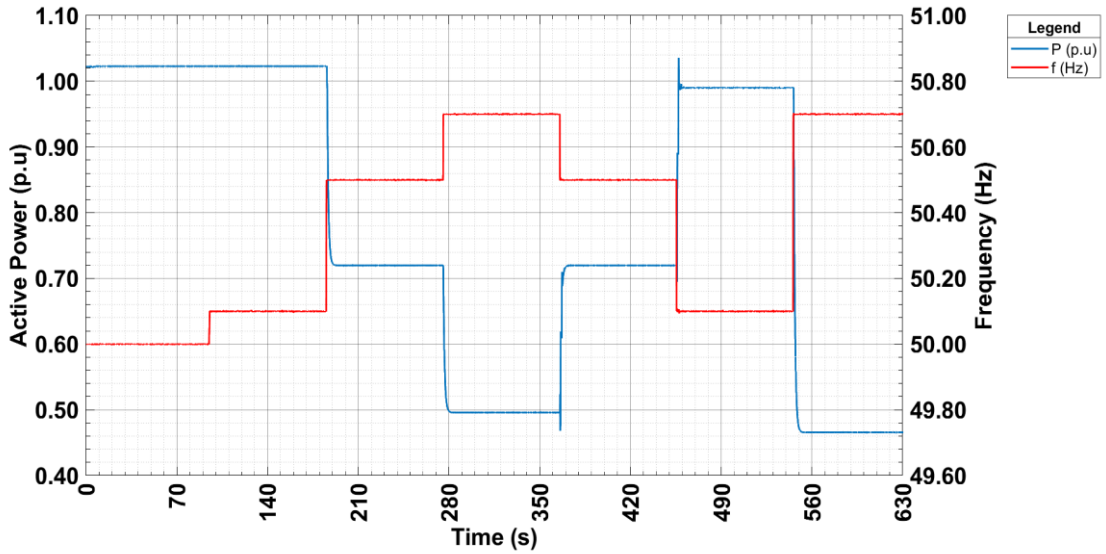
| OS2F2 (S=2%; Fstart=50.2 Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Step** | **Sim, f (Hz)** | **Meas, f (Hz)** | **Expected P (%$P_{max}$)** | **$P_{test}$ measured (%$P_{max}$)** | **Deviation (%$P_{max}$) (<5%$P_{max}$)** | **Ta (s)** | **Tr (s)** | **Te (s)** |
| 0 | 50.00 | 50.00 | 100% ± 5% | 102.3% | +2.3% | -- | -- | -- |
| 1 | 50.10 | 50.10 | 100% ± 5% | 102.3% | +2.3% | -- | -- | -- |
| 2 | 50.50 | 50.50 | 70% ± 5% | 72.0% | +2.0% | 0.2 | 1.1 | 1.4 |
| 3 | 50.70 | 50.70 | 50% ± 5% | 49.6% | -0.4% | 0.1 | 1.0 | 1.3 |
| 4 | 50.50 | 50.50 | 70% ± 5% | 71.9% | +1.9% | 0.1 | 0.8 | 1.4 |
| 5 | 50.10 | 50.10 | 100% ± 5% | 99.0% | -1.0% | -- | -- | -- |
| 6 | 50.70 | 50.70 | 50% ± 5% | 46.7% | -3.3% | 0.1 | 1.1 | 1.4 |
| Supplementary information:<br>- % Values given with reference Pmax, in this case Pmax=55 kW | | | | | | | | |

| OS2F5 (S=2%; Fstart=50.5 Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Step** | **Sim, f (Hz)** | **Meas, f (Hz)** | **Expected P (%$P_{max}$)** | **$P_{test}$ measured (%$P_{max}$)** | **Deviation (%$P_{max}$) (<5%$P_{max}$)** | **Ta (s)** | **Tr (s)** | **Te (s)** |
| 0 | 50.00 | 50.00 | 100% ± 5% | 99.5% | -0.5% | -- | -- | -- |
| 1 | 50.40 | 50.40 | 100% ± 5% | 99.5% | -0.5% | -- | -- | -- |
| 2 | 50.80 | 50.80 | 70% ± 5% | 71.7% | +1.7% | 0.10 | 0.10 | 0.10 |
| 3 | 51.00 | 51.00 | 50% ± 5% | 49.9% | -0.1% | 0.10 | 0.10 | 0.10 |
| 4 | 50.80 | 50.80 | 70% ± 5% | 70.0% | 0.0% | 0.10 | 0.30 | 0.30 |
| 5 | 50.10 | 50.10 | 100% ± 5% | 99.5% | -0.5% | -- | -- | -- |
| 6 | 51.00 | 51.00 | 50% ± 5% | 49.4% | -0.6% | 0.10 | 0.10 | 0.10 |
| Supplementary information:<br>- % Values given with reference Pmax, in this case Pmax=55 kW | | | | | | | | |

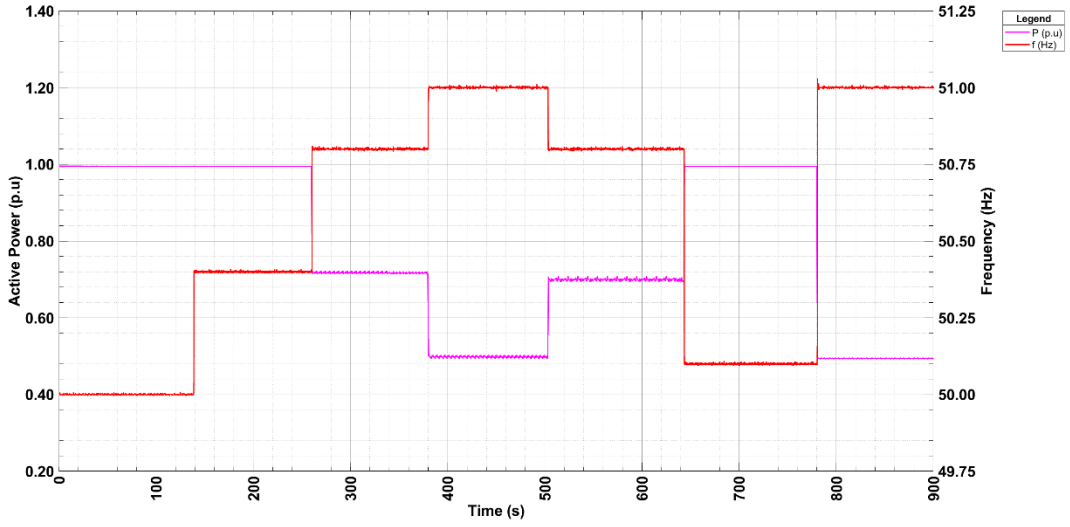
| OS12F2 (S=12%; Fstart=50.2 Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Step** | **Sim, f (Hz)** | **Meas, f (Hz)** | **Expected P (%$P_{max}$)** | **$P_{test}$ measured (%$P_{max}$)** | **Deviation (%$P_{max}$) (<5%$P_{max}$)** | **Ta (s)** | **Tr (s)** | **Te (s)** |
| 0 | 50.00 | 50.00 | 100% ± 5% | 99.0% | -1.0% | -- | -- | -- |
| 1 | 50.10 | 50.10 | 100% ± 5% | 99.0% | -1.0% | -- | -- | -- |
| 2 | 51.40 | 51.40 | 80% ± 5% | 80.0% | 0.0% | 0.1 | 1.1 | 1.5 |
| 3 | 50.30 | 50.30 | 98.3% ± 5% | 97.2% | -1.1% | 0.1 | 0.8 | 1.3 |
| Supplementary information:<br>- % Values given with reference Pmax, in this case Pmax=55 kW | | | | | | | | |

| OS12F5 (S=12%; Fstart=50.5 Hz) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Step** | **Sim, f (Hz)** | **Meas, f (Hz)** | **Expected P (%$P_{max}$)** | **$P_{test}$ measured (%$P_{max}$)** | **Deviation (%$P_{max}$) (<5%$P_{max}$)** | **Ta (s)** | **Tr (s)** | **Te (s)** |
| 0 | 50.00 | 50.00 | 100% ± 5% | 99.0% | -1.0% | -- | -- | -- |
| 1 | 50.40 | 50.40 | 100% ± 5% | 99.0% | -1.0% | -- | -- | -- |
| 2 | 51.40 | 51.40 | 85% ± 5% | 85.6% | +0.6% | 0.2 | 1.1 | 1.4 |
| 3 | 50.60 | 50.60 | 98.3% ± 5% | º | -1.1% | 0.1 | 0.7 | 1.5 |
| Supplementary information:<br>- % Values given with reference Pmax, in this case Pmax=55 kW | | | | | | | | |

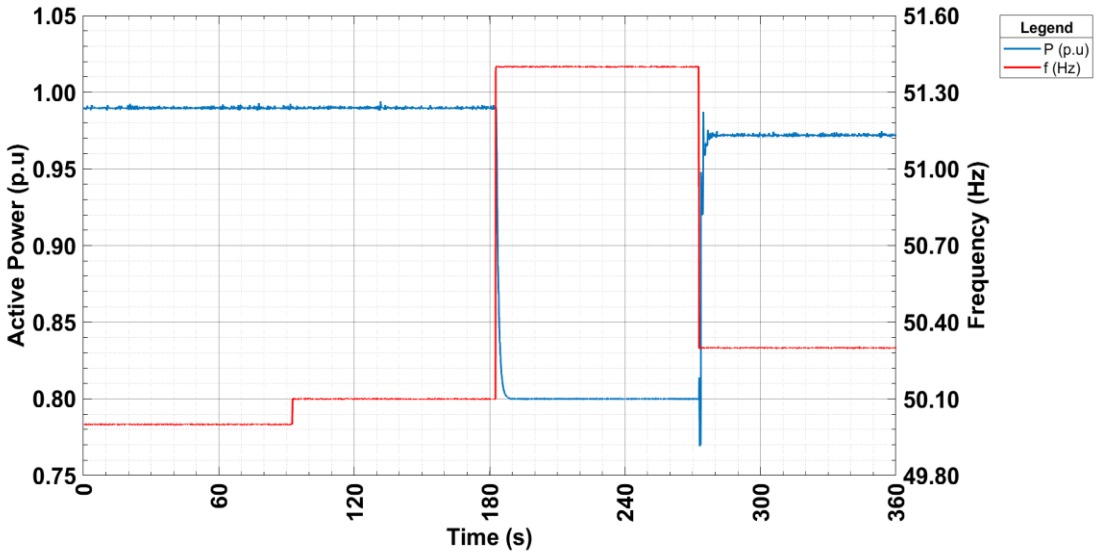
**OS2F2 (S=2%; Fstart=50.2 Hz)**



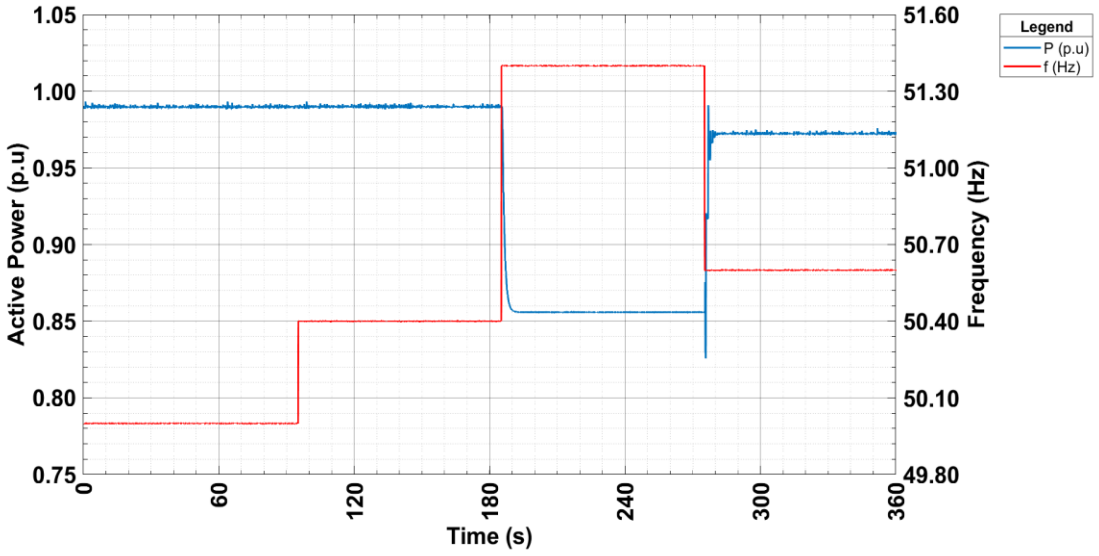

**OS2F5 (S=2%; Fstart=50.5 Hz)**



**OS12F2 (S=12%; Fstart=50.2 Hz)**




**OS12F5 (S=12%; Fstart=50.5 Hz)**



#### 4.1.1.2 Underfrequency (LFSM-U)

This point of frequency requirements is not applicable since the EUT is considered as Type B, and the requirements of this subclause apply only to Type C and/or Type D PGUs.

#### 4.1.1.3 Frequency Control (LFSM)

This point of frequency requirements is not applicable since the EUT is considered as Type B, and the requirements of this subclause apply only to Type C and/or Type D PGUs.

#### 4.1.1.4 Power Frequency Control

The compliance with section 5.4 Power Frequency Control Capability, on these tests UGE it is considered to have no influence. Compliance shall be determined by evaluation from GRT needed.

### 4.2 ACTIVE POWER REQUIREMENTS

This point of active power requirements is not applicable since the EUT is considered as Type B, and the requirements of this subclause apply only to Type C and/or Type D PGUs.

### 4.3 INERTIA EMULATIONS

This point is not applicable since the type of compliance assessment method for these requirements is not a test to be done over the EUT. The grid operator shall evaluate the compliance with the requirements stated in clause 5.6 of the NTS standard using as a reference the simulation methods defined in this point of the standard. The conformity shall be confirmed by the grid operator through written communication.

### 4.4 REACTIVE POWER REQUIREMENTS

Through this point the reactive power sign criteria is in the point of view of the generator.
Reactive Inductive power has positive sign and Reactive Capacity power has negative sign.

#### 4.4.1 Reactive power capability

The aim of this test is to evaluate the reactive power capability of the EUT at different active power levels.

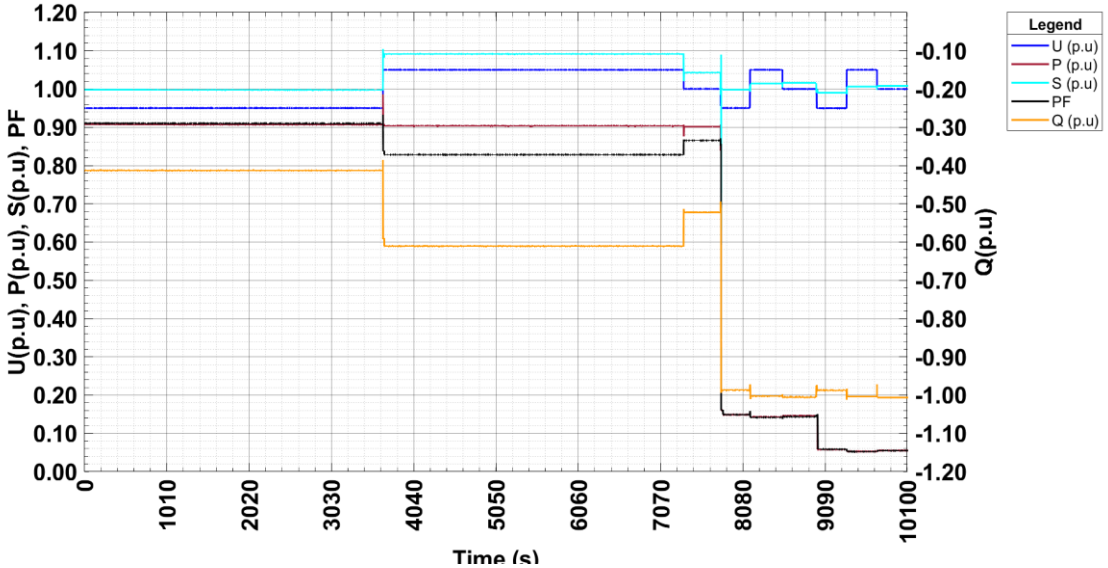
| Criteria | Comments | Result |
|---|---|---|
| **CONDITIONS DURING MEASUREMENTS** | | |
| The test conditions may be some of the following: | | P |
| A power supply connected to the terminals of the UGE when the UGE is disconnected from the mains. | | P |
| An element or method capable of modifying the voltage at the UGE connection point when the UGE is connected to the mains. | | N/A |
| A fictitious signal simulating voltage changes connected to the UGE controller. The UGE must behave as if this signal were the voltage reading on its terminals. | | N/A |
| Test bench, including all elements of reactive power management. | | N/A |
| The voltage values indicated for the tests are considered nominal values of the configuration under which each step of the test is performed, configurations with a value of ±2.5% of the nominal voltage on the proposed values will be admitted. | All the levels measured have been maintained to the desired level ±2.5% | P |
| **TEST SEQUENCE** | | |
| The reactive power control mode of the UGE will be selected to setpoint of fixed reactive power. | UGE Configuration:<br>-Qmax inductive<br>-Qmax capacitive<br>Except required by NTs, the manufacturer shall define the relationship between voltage, and reactive power at normal temperature. | P |
| The tests steps described in Table 17 of the standard have been carried out. | | P |

#### 4.4.1.1 Reactive power capability (Required by NTs standard)

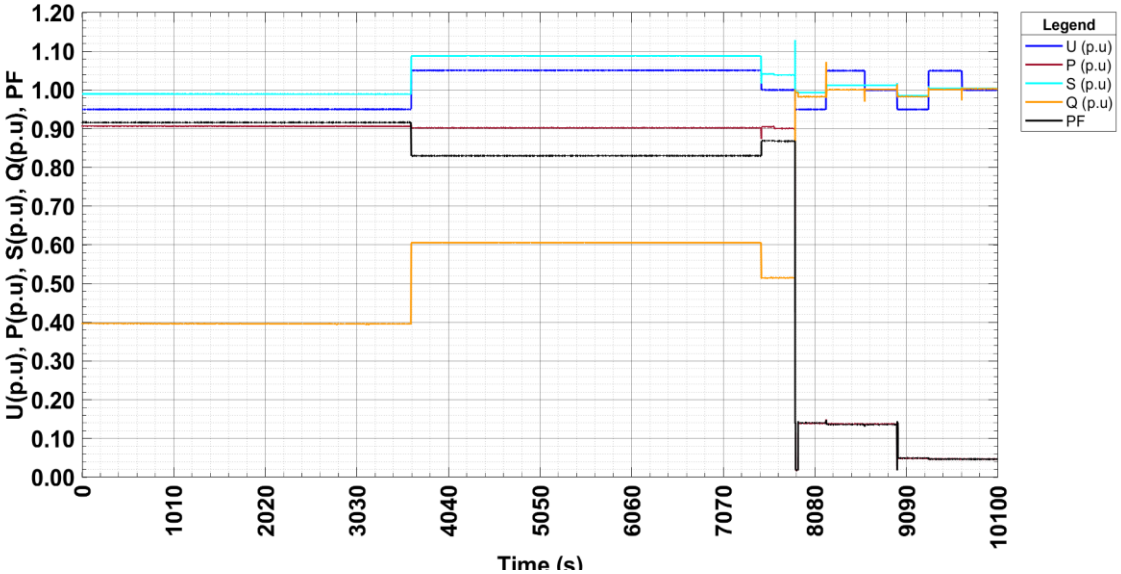
| Q capability – Capacitive | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Step** | **Active Power Setpoint (%Pmax)** | **Active Power measured (%Pmax)** | **Voltage setpoint (%Un)** | **Voltage measured (%Un)** | **$Q_{max}$ Capacitive (%Pmax)** | **$Q_{max}$ Capacitive (kVAr)** | **Test duration** |
| 1 | >90% | 90.7% | 95.00% | 95.0% | -41.4% | -22.7 | >60 min |
| 2 | >90% | 90.4% | 105.00% | 105.0% | -61.1% | -33.6 | >60 min |
| 3 | >90% | 90.2% | 100.00% | 100.1% | -52.2% | -28.7 | >5 min |
| 4 | 10-20% | 15.0% | 95.00% | 95.0% | -98.6% | -54.2 | >5 min |
| 5 | 10-20% | 14.4% | 105.00% | 105.0% | -100.3% | -55.1 | >5 min |
| 6 | 10-20% | 14.6% | 100.00% | 100.0% | -100.5% | -55.3 | >5 min |
| 7 | 0-10% | 5.8% | 95.00% | 95.0% | -98.8% | -54.3 | >5 min |
| 8 | 0-10% | 5.3% | 105.00% | 105.0% | -100.4% | -55.2 | >5 min |
| 9 | 0-10% | 5.5% | 100.00% | 100.0% | -100.6% | -55.3 | >5 min |
| Supplementary information:<br>- % Values given with reference Pmax, in this case Pmax=55 kW | | | | | | | |

| Q capability – Inductive | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Step** | **Active Power Setpoint (%Pmax)** | **Active Power measured (%Pmax)** | **Voltage setpoint (%Un)** | **Voltage measured (%Un)** | **$Q_{max}$ Inductive (%Pmax)** | **$Q_{max}$ Inductive (kVAr)** | **Test duration** |
| 1 | >90% | 90.6% | 95.00% | 95.0% | +39.6% | +21.8 | >60 min |
| 2 | >90% | 90.3% | 105.00% | 105.1% | +60.6% | +33.3 | >60 min |
| 3 | >90% | 90.2% | 100.00% | 100.0% | +51.5% | +28.3 | >5 min |
| 4 | 10-20% | 13.0% | 95.00% | 95.0% | +98.4% | +54.1 | >5 min |
| 5 | 10-20% | 13.8% | 105.00% | 105.0% | +100.2% | +55.1 | >5 min |
| 6 | 10-20% | 13.7% | 100.00% | 100.0% | +100.2% | +55.1 | >5 min |
| 7 | 0-10% | 4.9% | 95.00% | 95.0% | +98.4% | +54.1 | >5 min |
| 8 | 0-10% | 4.7% | 105.00% | 105.0% | +100.2% | +55.1 | >5 min |
| 9 | 0-10% | 4.7% | 100.00% | 100.0% | +100.2% | +55.1 | >5 min |
| Supplementary information:<br>- % Values given with reference Pmax, in this case Pmax=55 kW | | | | | | | |

**Capacitive Curve**




**Inductive Curve**

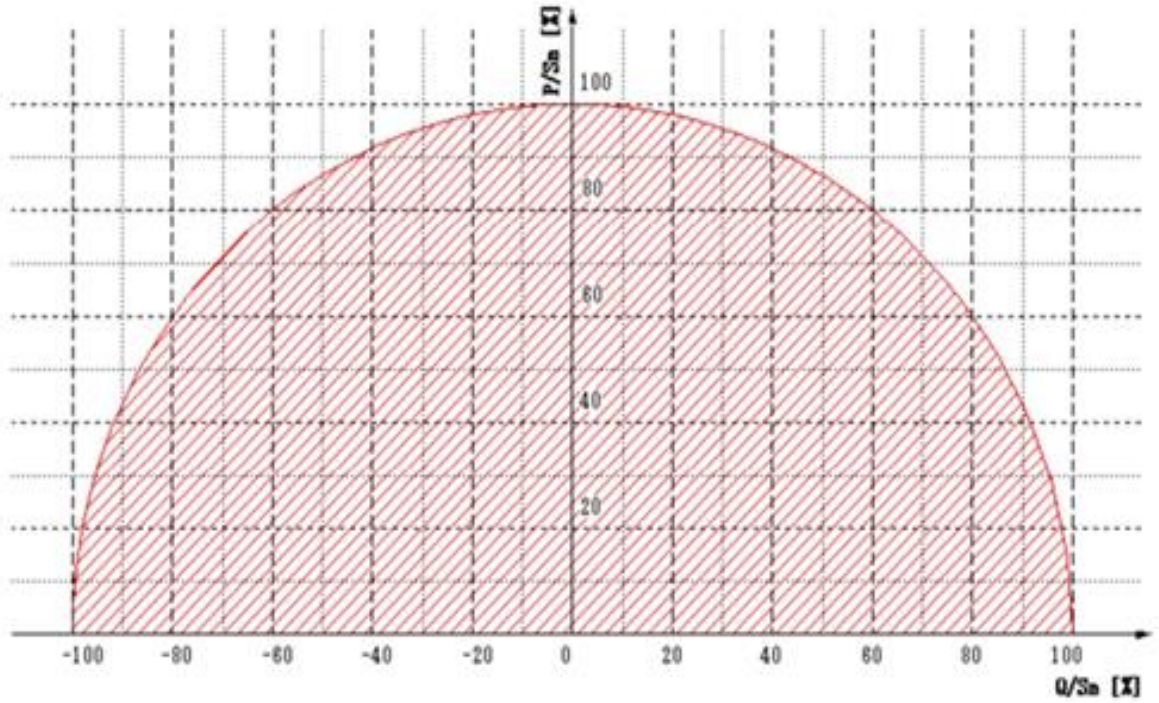


#### 4.4.1.2 Reactive power capability (Capabilities declared by the manufacturer)

The following graphic shows the reactive power capabilities of the UGE, based on the manufacturer's declaration, under voltage levels different from the normal operation range at normal temperature range.

The following diagram contains the manufacturer declared capability:

**P-Q Diagram**



### 4.4.2 Reactive power control

The aim of this test is to verify the capability of the EUT of applying different reactive power control modes. It has been tested each control mode separately in the following points according to section 5.8.2 of NTs standard.

#### 4.4.2.1 Reactive power control mode

The tests have been performed according to the procedures described by subclause 5.8.2.1 of the NTS 2.1 SEPE standard.

For this test, voltage has been set to its rated value and reactive power has been set to 0 before starting the test. Then, after keeping this 0-reactive power setpoints for 60 seconds, different reactive power setpoints have been applied and the time it takes for reactive power to stabilize has been measured.

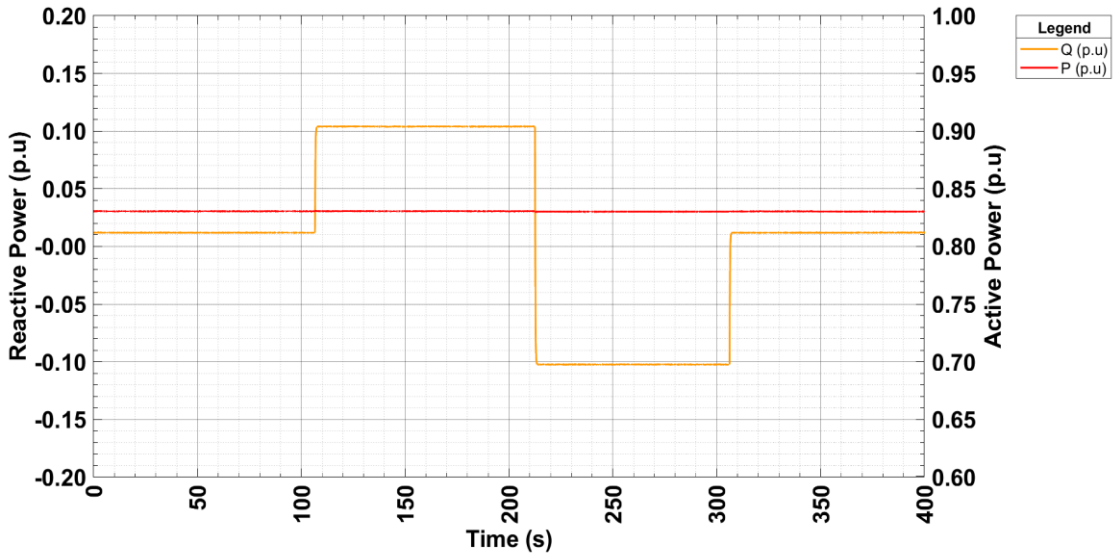
The following conditions have been evaluated for each test performed:

| Criteria | Comments | Result |
|---|---|---|
| **CONDITIONS DURING MEASUREMENTS** | | |
| Active power between 20% and 100% of the maximum capacity of the UGE. | Test at 75% Pmax; | P |
| Voltage has been set to Un | | P |
| the reactive power setpoint will be null at the start of the test | | P |
| During the test, the reactive power settings as shown in Table 24 (of the standard) shall be established sequentially | | P |
| Prior to performing a test shall be reserved for at least 1 minute without sending new reactive power settings. | | P |
| **Report result table indicates:** | | **P** |
| In the measured Q column: the reactive power measured in the UGE terminals. | | P |
| In column t measured: the time it takes to stabilize at the new reactive power value after receiving a new setpoint, taking into account the tolerances Indicated in Table 24. | | P |
| **ACEPTANCE CRITERIA** | | |
| The UGE is capable of modifying the reactive power output of the UGE in the event of a reactive power setpoint change. | | P |
| The measured reactive power values are within the range defined in Table 24. (Setpoint ±1,5 %Pmax) | | P |
| The response time, *Te*, is less than the value indicated in Table 24 (60 s) | Settling time: Time of settling of reactive power within a tolerance band of ± 1.5% of the measured reactive power setpoint. | P |

The different setpoints applied and results are presented in the following graph and table:

| Reactive Power Control Mode | | | | | | |
|---|---|---|---|---|---|---|
| **Step** | **Reactive Power Steps ($\%P_{max}$)** | **Set Point Q ($\%P_{max}$)** | **Measured Q ($\%P_{max}$)** | **ΔQ ($\%P_{max}$)** | **Max. Te (s)** | **Meas. Te (s)** |
| 1 | 0.0% → +10.0% | +10.0% | +10.4% | +0.4% | 60 | 1.4 |
| 2 | +10.0% → -10.0% | -10.0% | -10.2% | -0.2% | 60 | 1.4 |
| 3 | -10.0% → 0.0% | +0.0% | +1.2% | +1.2% | 60 | 1.4 |
| Supplementary information:<br>1. In % Q meas. Inside of the tolerance: ±1.5%Pn<br>2. Pmax is considered as Pn due to the EUT can output Pmax=55kW at whole working temperature range. | | | | | | |

**Reactive Power Control Mode**



#### 4.4.2.2 Voltage control mode

The procedure for this test consists of applying variations between the voltage setpoint and the voltage at the connection point to verify that the inverter is capable of exchanging reactive power to compensate that ΔU. Test has been done twice applying different gradients of 7% (Test 1) and 2% (Test 2).

The following conditions have been evaluated for each test performed:

| Criteria | Comments | Result |
|---|---|---|
| **CONDITIONS DURING MEASUREMENTS** | | |
| Active power between 20% and 100% of the maximum capacity of the UGE. | Active power was set at 33% Pmax during test. | P |
| The test conditions may be some of the following: | | P |
| A power supply connected to the terminals of the UGE when the UGE is disconnected from the mains. | | P |
| An element or method capable of modifying the voltage at the UGE connection point when the UGE is connected to the mains. | | N/A |
| A fictitious signal simulating voltage changes connected to the UGE controller. The UGE must behave as if this signal were the voltage reading on its terminals. | | N/A |
| Test bench, including all elements of reactive power management. | | P |
| **TEST SEQUENCE** | | |
| Prior to performing a test shall be reserved for at least 1 minute without sending new reactive power settings. | | P |
| Test sequence as per Table 25 (of the standard). For voltage control mode with 7% slope. | Deviation according to the standard.<br>See remarks of evaluation in Table 25. | P |
| Test sequence as per Table 26 (of the standard). For voltage control mode with 2% slope. | Deviation according to the standard.<br>See remarks of evaluation in Table 26. | P |
| **Report result table indicates:** | | **P** |
| Reactive power measured at terminals of the UGE after stabilization, calculated from voltage and current measurements. | | P |
| Times t1 and t2, where t1 is the time in which the reactive power response reaches 90% of the final value, and t2 is the time in which it stabilizes in the final value, according to the definition of the Regulation (EU) 631/2016. Accuracy ± 5 %Qmax<br>(± 5 % * 30%Pn = 0.015 p.u) | Accuracy ± 1.5 %Qmax | P |

| Criteria | Comments | Result |
| --- | --- | --- |
| **ACEPTANCE CRITERIA** | | |
| The UGE is capable of modifying the reactive power output in the event of a voltage change. | | P |
| The measured values of reactive power once stabilized in the final value are in the range according to the limits established in Table 25 and Table 26. | | P |
| The response times t1 and t2 are equal to or less than the values specified in each case. | | P |

$t_1$ Response time: Time to reach the 90% of the expected reactive power response (ΔQ) at each change step.

$t_2$ Settling time: Time of settling of reactive power on a tolerance of ± 5% Pn.

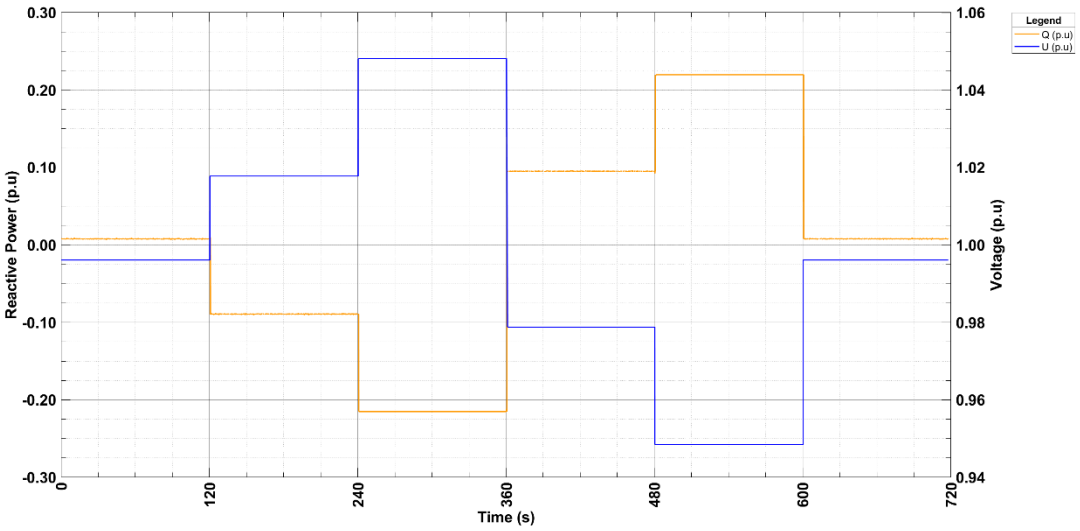
The table below shows measured values:

| Test 1: Table 25 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **U at NCP (%$U_n$)** | **U Setpoint (%$U_n$)** | **Exp. Q (%$P_{max}$)** | **Meas. Q (%$P_{max}$)** | **ΔQ (%$P_{max}$)** | **Max. $t_1$ (s)** | **Meas. $t_1$ (s)** | **Max. $t_2$ (s)** | **Meas. $t_2$ (s)** |
| 100% | 100% | 0.0% ± 1.5% | +0.8% | +0.8% | -- | -- | -- | -- |
| 102% | 100% | -8.6% ± 1.5% | -8.9% | -0.3% | 1.0 | 0.30 | 5.0 | 0.30 |
| 105% | 100% | -21.4% ± 1.5% | -21.5% | -0.1% | 1.0 | 0.10 | 5.0 | 0.10 |
| 98% | 100% | 8.6% ± 1.5% | +9.5% | +0.9% | 1.0 | 0.30 | 5.0 | 0.30 |
| 95% | 100% | 21.4% ± 1.5% | +22.0% | +0.6% | 1.0 | 0.30 | 5.0 | 0.30 |
| 100% | 100% | 0.0% ± 1.5% | +0.8% | +0.8% | 1.0 | 0.10 | 5.0 | 0.10 |
| Supplementary information:<br>- Slope 7% V1=1.07; Q1=-30%; V2=0.93; Q2=+30%.<br>- % Values are given in reference to Pmax, in this case Pmax= 55 kW.<br>- $T_2$ has been settled on a tolerance band of ±5%ΔQ. (It is more restricted than standard requirement indicated in subclause 5.8.2.2). | | | | | | | | |

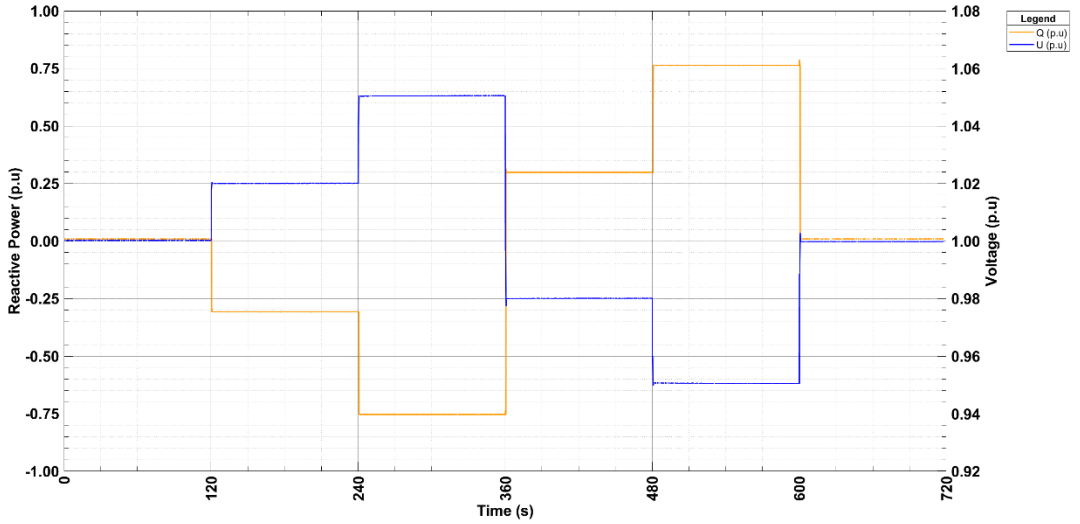
| Test 2: Table 26 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **U at NCP (%$U_n$)** | **U Setpoint (%$U_n$)** | **Exp. Q (%$P_{max}$)** | **Meas. Q (%$P_{max}$)** | **ΔQ (%$P_{max}$)** | **Max. $t_1$ (s)** | **Meas. $t_1$ (s)** | **Max. $t_2$ (s)** | **Meas. $t_2$ (s)** |
| 100.0% | 100.0% | 0.0% ± 1.5% | +0.9% | +0.9% | -- | -- | -- | -- |
| 102.0% | 100.0% | -30.0% ± 1.5% | -30.8% | -0.8% | 1.0 | 0.10 | 5.0 | 0.10 |
| 105.0% | 100.0% | -75.0% ± 1.5% | -75.4% | -0.4% | 1.0 | 0.10 | 5.0 | 0.10 |
| 98.0% | 100.0% | 30.0% ± 1.5% | +29.9% | -0.1% | 1.0 | 0.50 | 5.0 | 0.50 |
| 95.0% | 100.0% | 75.0% ± 1.5% | +76.3% | +1.3% | 1.0 | 0.10 | 5.0 | 0.10 |
| 100.0% | 100.0% | 0.0% ± 1.5% | +0.9% | +0.9% | 1.0 | 0.50 | 5.0 | 0.50 |
| Supplementary information:<br>- Slope 2% V1=1.02; Q1=-30%, V2=0.98; Q2=+30%<br>- % Values are given in reference to Pmax, in this case Pmax= 55 kW.<br>- $T_2$ has been settled on a tolerance band of ±5%ΔQ. (It is more restricted than standard requirement indicated in subclause 5.8.2.2). | | | | | | | | |

Test results are represented in the following graphs:

**Test 1: Table 25**




**Test 2: Table 26**



#### 4.4.2.3 Power Factor Control Mode

For this test, different power factor setpoints have been applied to verify reactive power variations as well as the settling time of the power factor after each setpoint change. Voltage has been set at its rated value during this test.

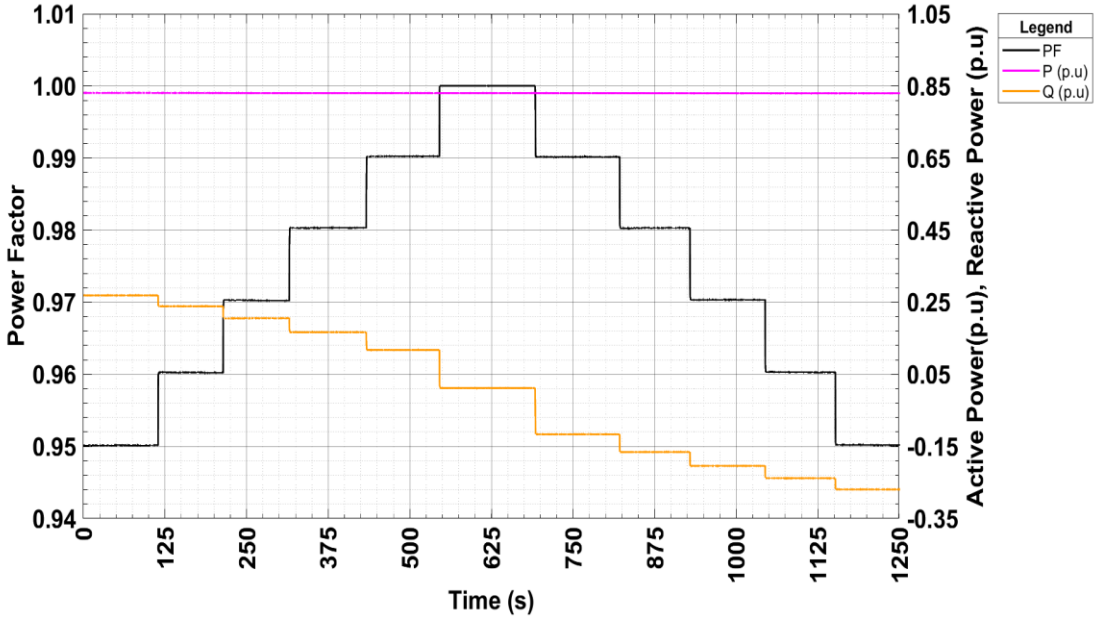
The following conditions have been evaluated for each test performed:

| Criteria | Comments | Result |
|---|---|---|
| **CONDITIONS DURING MEASUREMENTS** | | |
| Active power between 20% and 100% of the maximum capacity of the UGE. | Tests were performed at P = 83%$P_{max}$ | P |
| Voltage has been set to Un | | P |
| During the test the power factor setpoints have been established as shown in Table 27 (of NTS 2.1 SEPE standard). | | P |
| Each measurement shall be at least 1 minute and at least 1 minute of stabilization shall be allowed prior to each recording. | | P |
| **Report result table indicates:** | | **P** |
| In the measured Q column: the reactive power measured in the UGE terminals. | | P |
| Active power produced by the UGE at the time of Q measurement. | | P |
| The time it takes the power factor to stabilize the in the ±5% band. | Reactive power has been used to determine this settling time | P |
| **ACEPTANCE CRITERIA** | | |
| The UGE is capable of modifying the reactive power output in the event of a power factor change. | | P |
| The measured values of reactive power output from the power factor control are within the range defined in Table 27. | Tolerance = ±1.5% $P_{max}$ | P |
| The response time is less than the value indicated in Table 27 | | P |

Results are presented in tables and graphs below:

| Power Factor Control Mode | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Power Factor Setpoint** | **Power Factor Measured** | **Meas. P (%$P_{max}$)** | **Exp Q (%$P_{max}$)** | **Meas. Q (%$P_{max}$)** | **Deviation (%$P_{max}$)** | **Max. Settling Time** | **Meas. Settling Time (s)** |
| 0.950 inductive | 0.950 | 83.1% | +26.3% | +26.9% | +0.6% | 60 s | -- |
| 0.960 inductive | 0.960 | 83.1% | +23.3% | +23.9% | +0.6% | 60 s | 0.7 |
| 0.970 inductive | 0.970 | 83.0% | +20.0% | +20.6% | +0.6% | 60 s | 0.8 |
| 0.980 inductive | 0.980 | 83.0% | +16.2% | +16.7% | +0.5% | 60 s | 0.9 |
| 0.990 inductive | 0.990 | 83.0% | +11.4% | +11.8% | +0.4% | 60 s | 2.0 |
| 1.000 | 1.000 | 83.0% | 0.0% | +1.2% | +1.2% | 60 s | 1.4 |
| 0.990 capacitive | 0.990 | 83.0% | -11.4% | -11.6% | -0.2% | 60 s | 1.3 |
| 0.980 capacitive | 0.980 | 83.0% | -16.2% | -16.5% | -0.3% | 60 s | 1.1 |
| 0.970 capacitive | 0.970 | 83.0% | -20.0% | -20.4% | -0.4% | 60 s | 0.9 |
| 0.960 capacitive | 0.960 | 82.9% | -23.3% | -23.8% | -0.5% | 60 s | 1.5 |
| 0.95 capacitive | 0.950 | 82.9% | -26.3% | -26.9% | -0.6% | 60 s | 1.1 |
| Supplementary information:<br>- % Values given with reference Pmax, in this case Pmax=55 kW | | | | | | | |

**Power Factor Control Mode**



### 4.5 CONTROL OF OSCILLATION DAMPING

This point is not applicable since the type of compliance assessment method for these requirements is not a test to be done over the EUT. The grid operator shall evaluate the compliance with the requirements stated in subclause 5.10 of the NTS standard using as a reference the simulation methods defined in this point of the standard. The conformity shall be confirmed by the grid operator through written communication.

### 4.6 RESPONSE DURING GRID FAULTS

The aim of this test is to determine whether the EUT is capable of detecting a grid fault and riding through it without disconnecting.

This point will be evaluated in the attached report: **2221 / 0269-7 – Attachment.I**.

For each voltage level at which the EUT is going to be tested, several test conditions will be done according to the following tables:

| Category | Operation point | Fault Type |
|---|---|---|
| 1 | Partial Load | 3-Phase |
| 2 | Full Load | 3-Phase |
| 3 | Partial Load | 2-Phase |
| 4 | Full Load | 2-Phase |

| Load | Operation point |
|---|---|
| Full Load | >90%$P_{max}$ |
| Partial Load ($P_{med}$) | 15-50%$P_{max}$ |
| Minimum Load ($P_{min}$) | <15%$P_{max}$ |

For the evaluation of these faults, the tolerances represented in the following picture have been taken into account:

**Voltage and Time Tolerances**

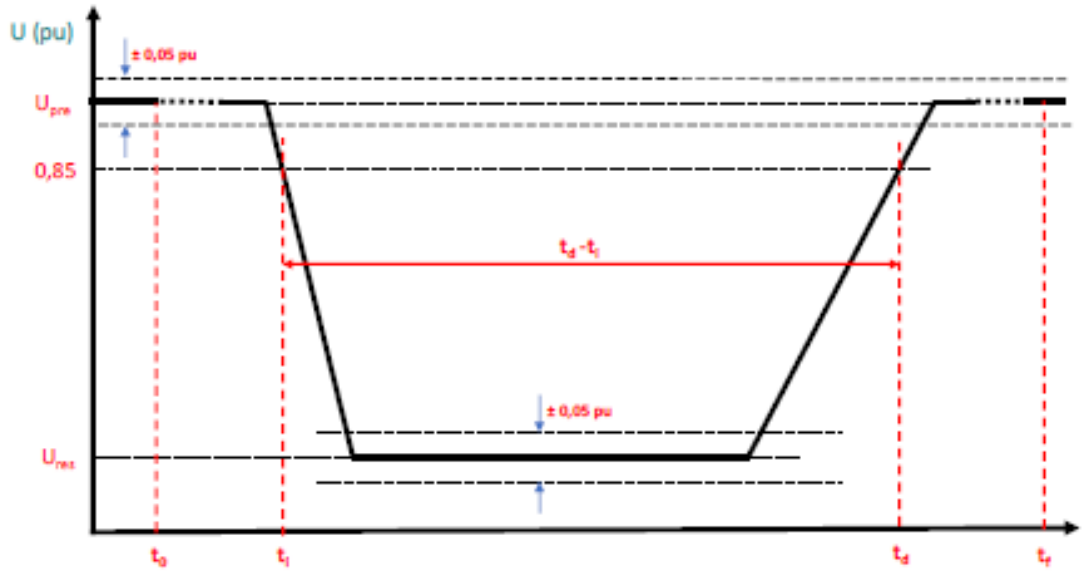
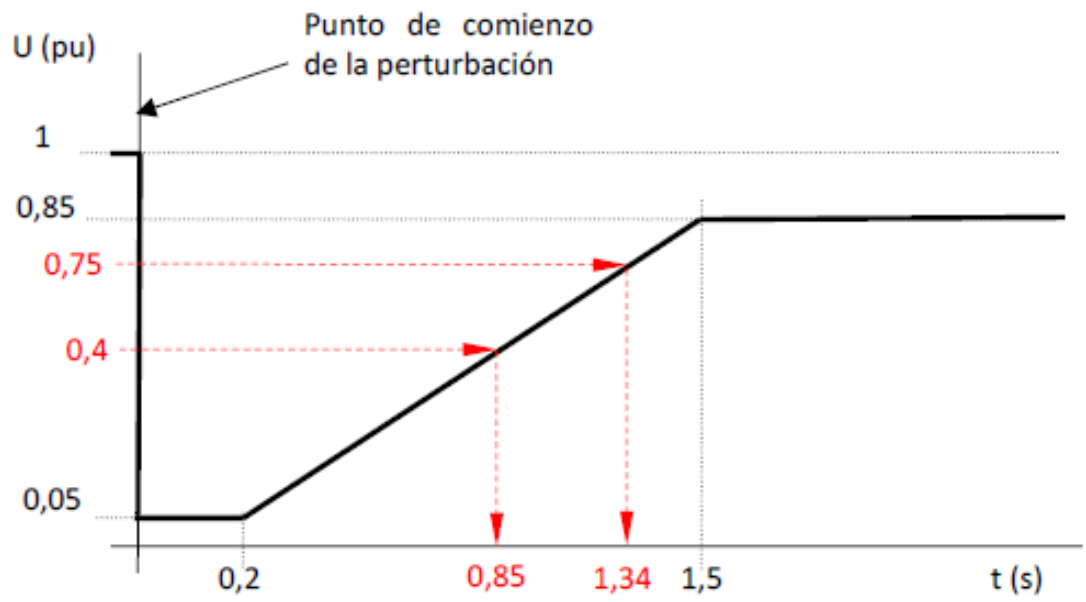



Figura 25. Ensayo de hueco. Tensiones y tiempos. Tolerancias.

The following profiles have been studied in order to prove compliance with the grid fault conditions provided by the standard, taking into consideration the criteria presented above:

**NTS SEPE REQUIREMENTS FOR EUT WITH UN < 110 kV**

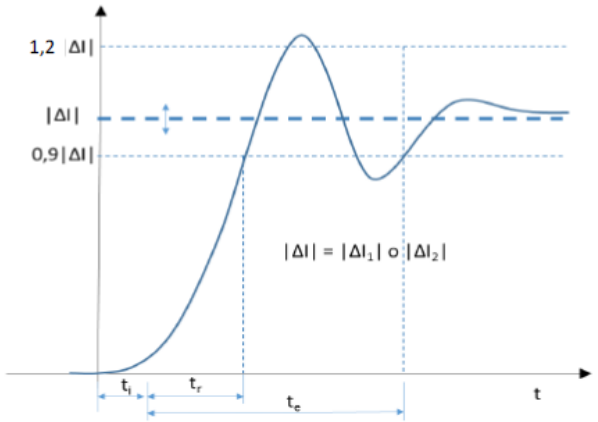



| Test | $U_{res}$(p.u.) | $T_f$(ms) | Fault Type | Load | Q/$P_{max}$ | K |
|---|---|---|---|---|---|---|
| U5$TP_{max}$ | 5%Un (±5%) | ≥200 | 3-Phase | Full | 0 ± 10% | K=3.5 |
| U5$TP_{med}$ | | | | Partial | 0 ± 10% | K=3.5 |
| U5$BP_{max}$ | | | 2-Phase | Full | 0 ± 10% | K=3.5 |
| U5$BP_{med}$ | | | | Partial | 0 ± 10% | K=3.5 |
| U40$TP_{max}$ | 40%Un (±5%) | ≥850 | 3-Phase | Full | 0 ± 10% | K=3.5 |
| U40$TP_{med}$ | | | | Partial | 0 ± 10% | K=3.5 |
| U40$BP_{max}$ | | | 2-Phase | Full | 0 ± 10% | K=3.5 |
| U40$BP_{med}$ | | | | Partial | 0 ± 10% | K=3.5 |
| U75$TP_{max}$ | 75%Un (±5%) | ≥1340 | 3-Phase | Full | 0 ± 10% | K=3.5 |
| U75$TP_{med}$ | | | | Partial | 0 ± 10% | K=3.5 |
| U75$TP_{med}Q_{max}$ | | | | | $Q_{max}/P_{max}$ | K=3.5 |
| U75$TP_{med}Q_{min}$ | | | | | $Q_{min}/P_{max}$ | K=3.5 |
| U75$TP_{min}$ | | | | $P_{min}$ | 0 ± 10% | K=6 |
| U75$BP_{max}$ | | | 2-Phase | Full | 0 ± 10% | K=3.5 |
| U75$BP_{med}$ | | | | Partial | 0 ± 10% | K=3.5 |
| U75$BP_{min}$ | | | | $P_{min}$ | 0 ± 10% | K=6 |

Note: this table is the one corresponding to tests performed by SGS in order to verify requirements of both of the tables 49 and 50 of the NTS at the same time.

Additionally, Injection of positive and negative sequence of reactive current have to follow the characteristic shown below:

**Evaluation of response times for $I_Q$ injection**




The following conditions have been evaluated for each test performed

| Criteria | Comments | Result |
|---|---|---|
| **TEST BENCH CONDITIONS** | | |
| **For Photovoltaic UGE:** The use of a test bench is permitted for testing the UGE, the presence of photovoltaic panels is not necessary, and the use of a DC source is permitted instead. | | P |
| **GENERAL** | | |
| The evolution of the voltage during the tests should remain above the curve indicated in Figure 25 of NTS V2.1 SEPE, considering the tolerance margins indicated. | | P |
| Two consecutive tests shall be carried out for each type (or category) of test. This must be understood as between one test and another, no intermediate failed test has been performed under the same conditions. | | P |
| For each test category, it is a necessary condition that the active and reactive power recorded prior to the creation of the voltage dip is within the ranges defined in the standard. | | P |
| **FOR UGE MPE < 110 kV** Several voltage dips will be generated, corresponding to the requirement established in Figure 26, which are enumerated according to the first column of Table 49. | | P |
| **FOR UGE MPE ≥ 110 kV** Several voltage dips will be generated, corresponding to the requirement established in Figure 26, which are enumerated according to the first column of Table 50. | | N/A |
| The following parameters have been used as defined in the standard: t0, ti, ta, tr, te, td, tf. | | P |
| The pre-fault recorded time (ti-t0) must be at least 60 seconds | | P |

| Criteria | Comments | Result |
|---|---|---|
| The post-fault recording time (tf-td) should be at least 10 seconds or until a damped response is appreciated. | | P |
| Information evaluated and documented according to Tables: 51, 52 and 53 of NTS V2.1 SEPE | Result tables and graphs have been included in Attachment I of this report. | P |
| **Continuity of supply for Wind UGE:** | | N/A |
| It shall be verified that there is no disconnection of the UGE during the application of the voltage dip in 2 consecutive tests corresponding to the same category. | | N/A |
| In the event of a disconnection in this sequence of tests (first 2 consecutive tests), the condition of continuity of supply will be considered valid only when in the following 3 tests, corresponding to the same category, there is no disconnection of the UGE. | | N/A |
| If the active power of the UGE is outside the limits established in the previous tables for its corresponding test, and there is no disconnection of the UGE, it will be considered invalid from the test but will not be computed for the purpose of considering it consecutive, i.e. it will be rejected. | | N/A |
| **Continuity of supply for Photovoltaic UGE:** | | **P** |
| If the UGE is disconnected during the application of the voltage dip, in one of two consecutive tests for each test category, the test will be considered as not passed. | | P |
| **REACTIVE CURRENT RAPID INJECTION: EVALUATION CRITERIA** | | |
| In those cases where Ures < 20% and there is a blockage of the power electronics as indicated in PO12.2, it is not necessary to check this requirement. | There is not a blockage of the power electronics in these cases | N/A |
| For current injection plots, the positive sequence apparent current shall be used. | | P |
| For the calculation of the K-factors and the response times (tr) and setting times (te), the gap depth (for both two-phase and three-phase faults) shall be evaluated from the positive and negative sequence voltages for a period of 100ms from the occurrence of the fault (ti) to 20ms before its clearance (td). | | P |
| The UGE of the MPE will be able to inject the required current increase, considering the tolerances, determined according to Figure 28, according to the times indicated below (see Figure 29), as long as there is no blocking condition of the power electronics: | | P |
| The delay time for the start of the injection/current draw (ta) should be a maximum of 20 ms. | | P |
| The response time (tr) from the start of injection/current draw until it reaches 90% of the required step response in the voltage error must be a maximum of Ta + 50 ms | | P |
| The settling time (te) from the start of the current injection/absorption until the response | | P |

| Criteria | Comments | Result |
|---|---|---|
| remains in the range +20% to -10% around the required response must be maximum 60 ms. | | |
| A reduction in the reactive current will be allowed in the positive and negative sequences with respect to the current values required in Figure 28, provided that at least the injected current is greater than or equal to the nominal apparent current. This means that the sum of the real RMS currents, equivalent to the total current, must be greater than or equal to 1 p.u. | | P |
| In the case of fulfilling the previous condition, the test will be considered valid if one of the following two conditions is met:<br>1. The positive and negative sequence components will be limited in the same proportion.<br>2. The positive sequence component will be greater than 40% of the nominal apparent current. | | P |
| **ACTIVE POWER RECOVERY CRITERIA AFTER VOLTAGE DIP** | | |
| If the $U_{res}$ at the terminals of the UGE does not fall below 0.5 p.u., the UGE must reach 95% of the predisturbance power (if the primary resource permits) within less than 1 second once the voltage reaches or exceeds 0.85 p.u. and must reach the pre-disturbance power (if the primary resource permits) within a further 2 s. | | P |
| If the $U_{res}$ in terminals of the UGE drops by 0.5 p.u. but it does not fall below 0.2 p.u., the UGE must reach 95% of the power prior to the disturbance in less than 2 s once the voltage reaches or exceeds 0.85 p.u. and it must reach the power before the disturbance in a time of less than 2 additional s. | | P |
| If the Ures at the terminals of the UGE falls below 0.2 p.u., the UGE must reach 95% of the pre-disturbance power within 3 s once the voltage reaches or exceeds 0.85 p.u. and must reach the pre-disturbance power within a further 2 s | | P |

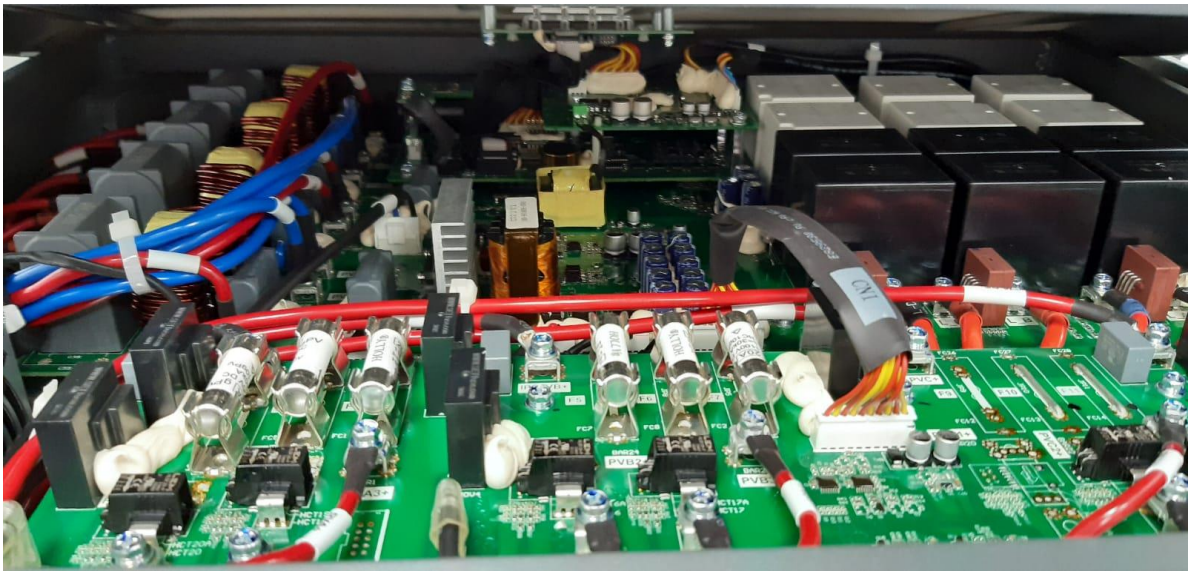
Result tables and graphs have been included in the attachment **2221 / 0269-7 – Attachment.I** of this report.

### 4.7 ISLANDING REQUIREMENTS

This point is not applicable since the type of compliance assessment method for these requirements is not a test to be done over the EUT. In case of a request by the grid operator, compliance with the requirements stated in the clause 5.13 of the NTS SEPE standard shall be evaluated, using as a reference the simulation methods defined in this point of the standard.

## 5 PICTURES

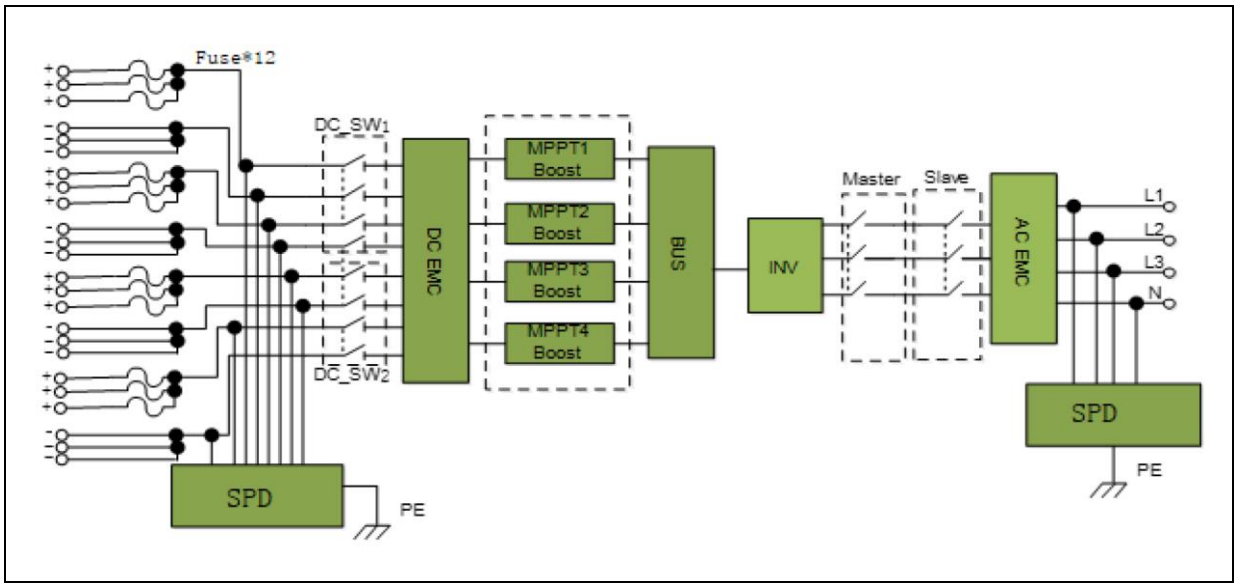
| Front view |
| --- |
|  |
| **Back view** |
|  |

| Internal view |
| --- |
|  |

| Serial number of model |
| --- |
|   |

## 6 ELECTRICAL SCHEMES

The picture below shows internal wiring scheme of the inverter:




**----------END OF REPORT----------**