# TEST REPORT

# DIN VDE V 0124-100

## Test requirements for generation units to be connected and operated parallel with the low voltage distribution networks

| | | |
|---|---|---|
| **Report reference number** ............. : | **PVDE180712N013** | |
| Date of issue ......................... ……....: | 2019-04-24 | |
| Total number of pages........... ……....: | 109 | |
| **Testing laboratory name** ............... : | **Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch** | |
| Address ............................................ : | No. 34, Chenwulu Section, Guantai Rd., Houjie Town, Dongguan City, Guangdong 523942, China | Certificate # 2951.01 |
| **Applicant's name** .......................... : | **Shenzhen SOFAR SOLAR Co., Ltd.** | |
| Address ............................................ : | 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China. | |
| **Test specification** | | |
| Standard ......................................... : | DIN VDE V 0124-100:2012-07 | |
| **Zertifikate** ...................................... : | **Certificate of compliance** | |
| Test report form number. ................. : | DIN VDE V 0124-100 | |
| Master TRF ...................................... : | Bureau Veritas Consumer Products Services Germany GmbH | |
| **Test item description**..................... : | **Solar Grid-tied Inverter** | |
| Trademark........................................ : | SOFAR SOLAR | |
| Model / Type .................................... : | SOFAR 20000TL-G2, SOFAR 25000TL-G2, SOFAR 30000TL-G2, SOFAR 33000TL-G2 | |

| **Ratings........................................... :** | SOFAR 20000TL-G2 | SOFAR 25000TL-G2 | SOFAR 30000TL-G2 | SOFAR 33000TL-G2 |
|---|---|---|---|---|
| Input DC voltage range [V] .............. : | 230-1100 | | | |
| Full load MPPT DC voltage range [V]: | 480-850 | 460-850 | 520-850 | 580-850 |
| Input DC current [A] ......................... : | 24/24 | 28/28 | 30/30 | 30/30 |
| Output AC voltage [V] ...................... : | 400V, 3/N/PE, 50Hz | | | |
| Output AC current [A]....................... : | Max. 32 | Max. 40 | Max. 48 | Max. 53 |
| Output power [VA]............................ : | 22000 | 27500 | 33000 | 36300 |

| | |
|---|---|
| **Testing Location ............................ :** | **Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch** |
| Address............................................ : | No. 34, Chenwulu Section, Guantai Rd., Houjie Town, Dongguan City, Guangdong 523942, China |
| Tested by (name and signature)....................... : | Dora Zhang |
| Approved by (name and signature)....................... : | James Huang |
| **Manufacturer's name..................... :** | **Shenzhen SOFAR SOLAR Co., Ltd.** |
| Manufacturer address ...................... : | 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China. |
| **Factory's name............................... :** | **Dongguan SOFAR SOLAR Co.,Ltd.** |
| Factory address ............................... | 1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City |

**Document History**

| **Date** | **Internal reference** | **Modification / Change / Status** | **Revision** |
|---|---|---|---|
| 2019-04-24 | Dora Zhang | Initial report was written | 0 |
| Supplementary information: | | | |

**Test items particulars**

| | |
|---|---|
| Equipment mobility........................... : | Permanent connection |
| Operating condition.......................... : | Continuous |
| Class of equipment .......................... : | Class I |
| Protection against ingress of water.. : | IP65 according to EN 60529 |
| Mass of equipment [kg].................... : | Approx. 37 |

**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 ............... : | 2018-07-12 |
| Date(s) of performance of test ......... : | 2018-07-12 to 2019-04-20 |

**General remarks:**

The test result presented in this report relate only to the object(s) tested. The report shall state compliance of the tested objects with the requirements of DIN VDE V 0124-100. This report shall not be reproduced, except in full, without the written approval of the applicant.

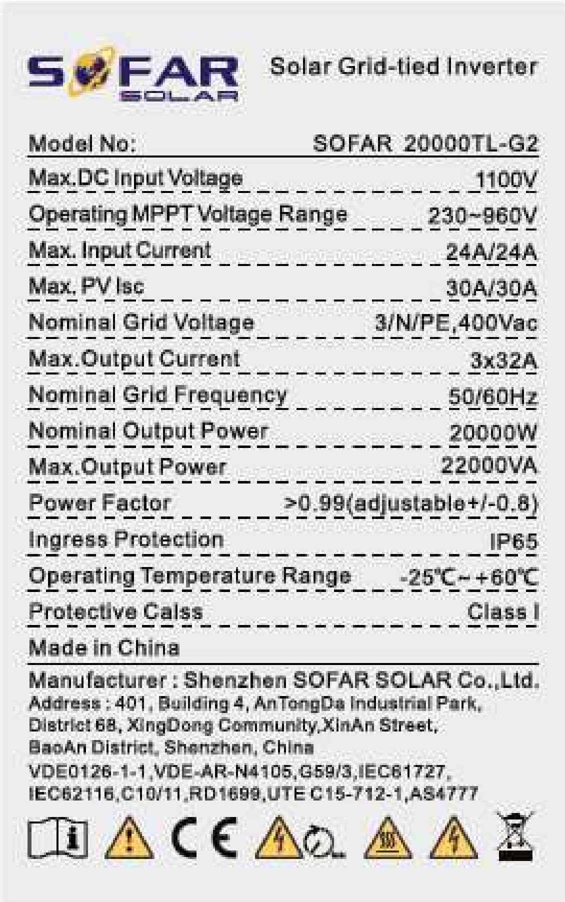
"(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

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

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

1. Test Report
   - 5.1. Verification of permissible system perturbations
   - 5.2. Verification of the symmetry characteristics of three-phase inverter modules
   - 5.3. Verification of the characteristics of the power generation unit on the network
   - 5.4. Testing of NS protection
   - 5.5. Testing of connecting conditions and synchronisation
2. Pictures of the unit – Annex No. 1
3. Test equipment list – Annex No. 2

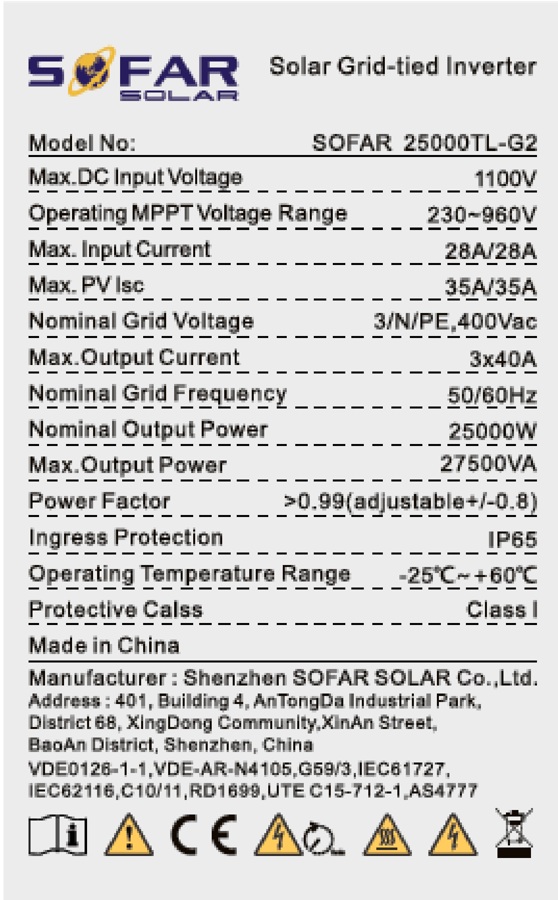
## Copy of marking plate



SOFAR SOLAR Solar Grid-tied Inverter

| | |
|---|---|
| Model No: | SOFAR 20000TL-G2 |
| Max.DC Input Voltage | 1100V |
| Operating MPPT Voltage Range | 230~960V |
| Max. Input Current | 24A/24A |
| Max. PV Isc | 30A/30A |
| Nominal Grid Voltage | 3/N/PE,400Vac |
| Max.Output Current | 3x32A |
| Nominal Grid Frequency | 50/60Hz |
| Nominal Output Power | 20000W |
| Max.Output Power | 22000VA |
| Power Factor | >0.99(adjustable+/-0.8) |
| Ingress Protection | IP65 |
| Operating Temperature Range | -25℃~+60℃ |
| Protective Calss | Class I |
| Made in China | |

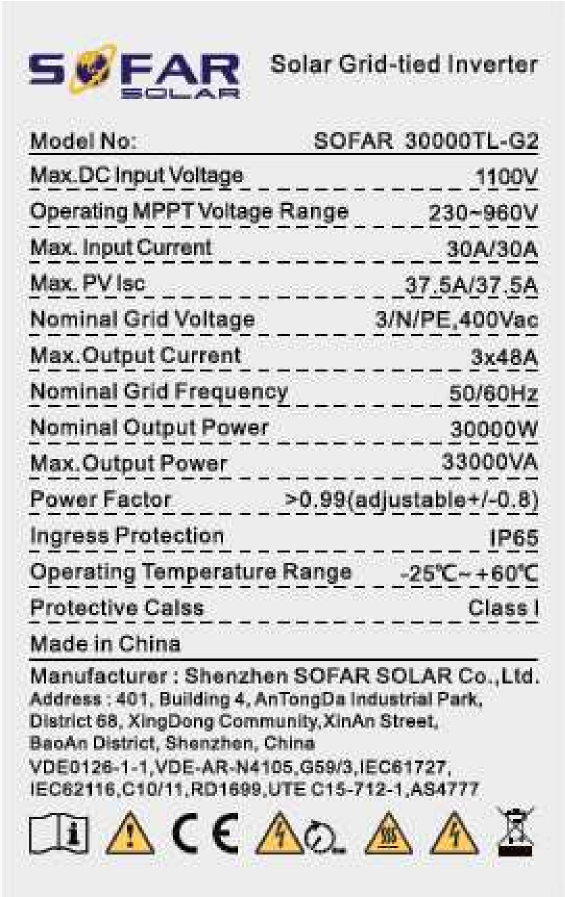
Manufacturer : Shenzhen SOFAR SOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G59/3,IEC61727, IEC62116,C10/11,RD1699,UTE C15-712-1,AS4777

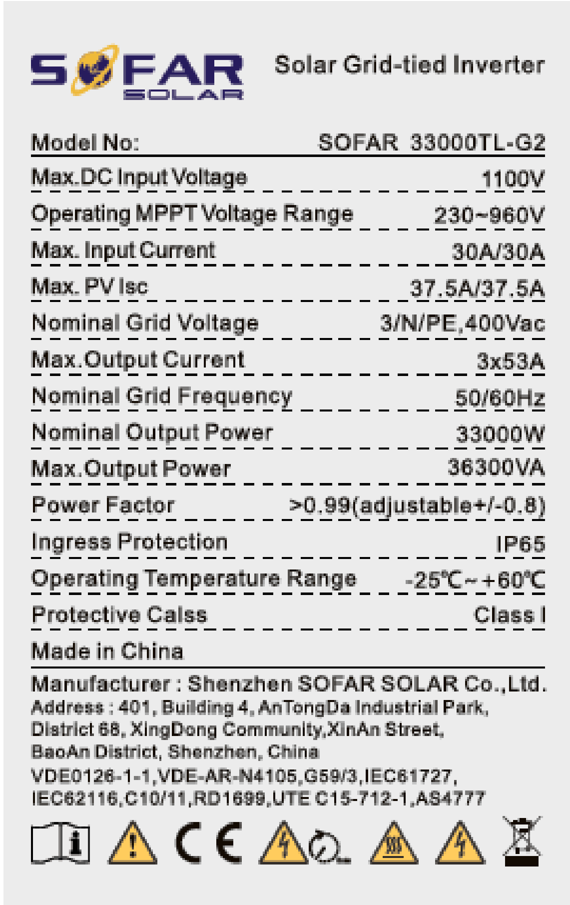


SOFAR SOLAR Solar Grid-tied Inverter

| | |
|---|---|
| Model No: | SOFAR 25000TL-G2 |
| Max.DC Input Voltage | 1100V |
| Operating MPPT Voltage Range | 230~960V |
| Max. Input Current | 28A/28A |
| Max. PV Isc | 35A/35A |
| Nominal Grid Voltage | 3/N/PE,400Vac |
| Max.Output Current | 3x40A |
| Nominal Grid Frequency | 50/60Hz |
| Nominal Output Power | 25000W |
| Max.Output Power | 27500VA |
| Power Factor | >0.99(adjustable+/-0.8) |
| Ingress Protection | IP65 |
| Operating Temperature Range | -25℃~+60℃ |
| Protective Calss | Class I |
| Made in China | |

Manufacturer : Shenzhen SOFAR SOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G59/3,IEC61727, IEC62116,C10/11,RD1699,UTE C15-712-1,AS4777


SOFAR SOLAR
Solar Grid-tied Inverter
Model No: SOFAR 30000TL-G2
Max.DC Input Voltage 1100V
Operating MPPT Voltage Range 230~960V
Max. Input Current 30A/30A
Max. PV Isc 37.5A/37.5A
Nominal Grid Voltage 3/N/PE,400Vac
Max.Output Current 3x48A
Nominal Grid Frequency 50/60Hz
Nominal Output Power 30000W
Max.Output Power 33000VA
Power Factor >0.99(adjustable+/-0.8)
Ingress Protection IP65
Operating Temperature Range -25℃~+60℃
Protective Calss Class I
Made in China
Manufacturer : Shenzhen SOFAR SOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G59/3,IEC61727, IEC62116,C10/11,RD1699,UTE C15-712-1,AS4777
CE


SOFAR SOLAR
Solar Grid-tied Inverter
Model No: SOFAR 33000TL-G2
Max.DC Input Voltage 1100V
Operating MPPT Voltage Range 230~960V
Max. Input Current 30A/30A
Max. PV Isc 37.5A/37.5A
Nominal Grid Voltage 3/N/PE,400Vac
Max.Output Current 3x53A
Nominal Grid Frequency 50/60Hz
Nominal Output Power 33000W
Max.Output Power 36300VA
Power Factor >0.99(adjustable+/-0.8)
Ingress Protection IP65
Operating Temperature Range -25℃~+60℃
Protective Calss Class I
Made in China
Manufacturer : Shenzhen SOFAR SOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community,XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G59/3,IEC61727, IEC62116,C10/11,RD1699,UTE C15-712-1,AS4777
CE

**General product information:**

The Photovoltaic grid-interactive inverter converts DC voltage, generated by photovoltaic modules, into AC voltage.
The units are three-phases inverter.

**Description of the power circuit (Figure 1):**

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 (transformer). 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.

The internal control is redundant built. It consists of Main DSP(UC20) and slave DSP(UC73).
The Main DSP(UC20) can control the relays, measures voltage, and frequency, AC current with injected DC, insulation resistance and residual current, In addition it tests the array insulation resistance and the RCMU circuit before each start up.
The slave DSP(UC73) is using for detect residual current, also can open the relays independently and communicate with Main DSP(UC20).
The unit provides two relays in series on Line 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 start up. Both controllers(Main DSP(UC20), Slave DSP(UC73) can open the relays.

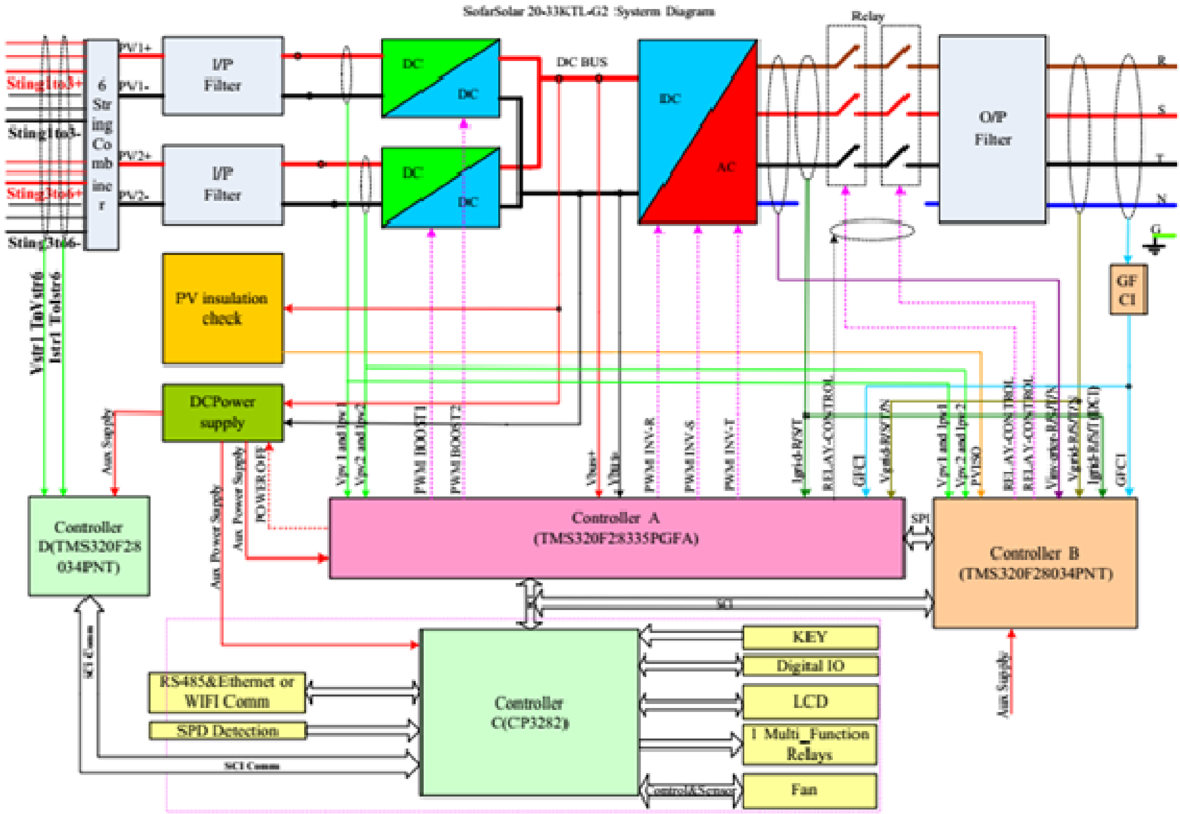



**Figure 1 – Block diagram**

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.

**Differences of the models**

The models SOFAR 20000TL-G2, SOFAR 25000TL-G2, SOFAR 30000TL-G2 and SOFAR 33000TL-G2 are almost identical in hardware except the shown in the following table and the output power derated by software.

<table>
<tr><th colspan="4">The difference in hardware</th></tr>
<tr><th>Item</th><th>SOFAR 20000TL-G2</th><th>SOFAR 25000TL-G2</th><th>SOFAR 30000TL-G2 / SOFAR 33000TL-G2</th></tr>
<tr><td>Number of PV terminal</td><td>2+2</td><td colspan="2">3+3</td></tr>
<tr><td>Number of BUS capacitance</td><td colspan="2">8 capacitors: 550V/110μF<br>2 capacitors: 1100V/40μF</td><td>10 capacitors: 550V/110μF<br>24 capacitors: 1100V/40μF</td></tr>
<tr><td>INV inductance</td><td>785μH</td><td colspan="2">735μH</td></tr>
<tr><td>BUS board</td><td>Not the board</td><td colspan="2">Have the board</td></tr>
<tr><td>External fan</td><td>Not the board</td><td>2</td><td>3</td></tr>
<tr><td>Relay of output board</td><td colspan="2">6pcs T9VV1K15-12S</td><td>3pcs AZSR250-2AE-12D</td></tr>
</table>

**The product was tested on**

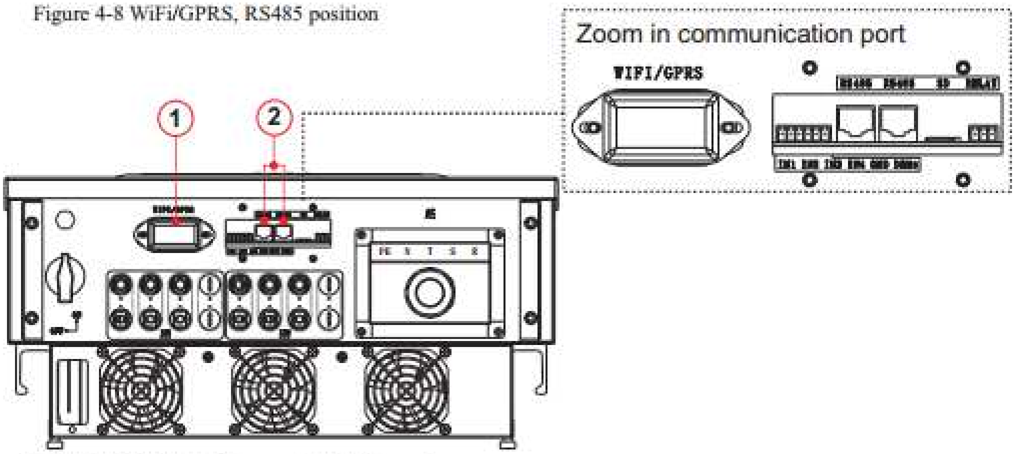
Hardware version: V1.00

Software version: V1.40

**Description of the remote control in a typical installation:**

The inverter has 3 communication poarts: 2RS485 ports, 1 Wifi port and 1 GPRS port,as show below:

Figure 4-8 WiFi/GPRS, RS485 position



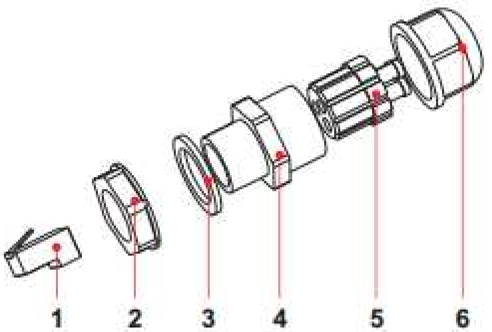

1. WIFI/GPRS Interface 2. RS485 port

**Conecting RS485 Communications Cables**

By the RS485 communication line, connecting Sofar 20~33KTL-G2 to communication equipment (such as data acquisition, PC terminal).
You are recommended to use 24 AWG outdoor shielded network cables with the internal resistance less than or equal to 1.5 ohms/10 m and external diameter of 4.5 mm to 7.5 mm
as RS485 communications cables.

A waterproof RJ45 connector has six parts: plug, screw nut, seals, housing, sealing plug and cable screw nut , as shown as follow.

Figure 4-9 Waterproof RJ45 connector composition



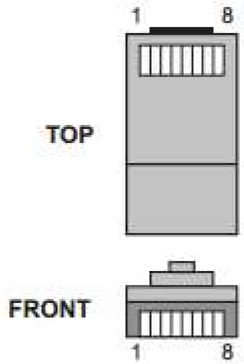

1. Plug 2. Screw nut 3. Seals 4. Housing 5. Sealing Plug 6. Cable Screw nut

When routing communications cables, ensure that communications cables are separated from power cables and away from interference sources to prevent communication interruptions.

**Procedure**

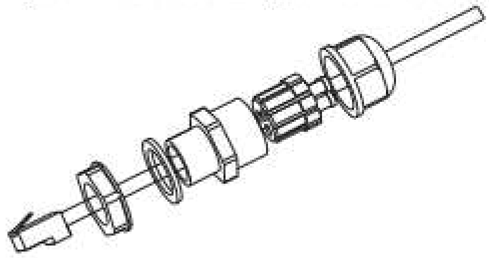
Step 1 Remove the insulation layer of an appropriate length from the shielded network cable using a wire stripper.
Step 2 Open sofar 20~33KTL-G2 lower cover and insert the shielded network cable into the cable screw nut, seals, screw nut.
Step 3 Connect the stripped network cable to corresponding pins on the plug, as shown as follow.

Figure 4-11 RS485 Connecting Communications Cables(1)



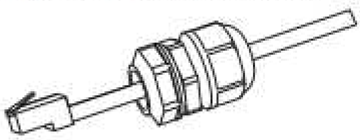

| No. | Color | Function |
|---|---|---|
| 1 | White and orange | RS485 B-,RS485differentialsignal- |
| 2 | Orange | RS485 A-,RS485differentialsignal+ |
| 3 | White and green | RS485 A-,RS485differentialsignal+ |
| 4 | Blue | RS485 A-,RS485differentialsignal+ |
| 5 | White and blue | RS485 B-,RS485differentialsignal- |
| 6 | Green | RS485 B-,RS485differentialsignal- |
| 7 | White and brown | NC |
| 8 | Brown | NC |

Figure 4-12 RS485 Connecting Communications Cables(2)



Step 4 Crystal plug with RJ45 crimping tool.
Step 5 Insert the plug into the RS485 port on the sofar 20~33KTL-G2.
Step 6 Insert sealing plug into housing, and tighten the screw nut.

Figure 4-13 RS485 Connecting Communications Cables(3)

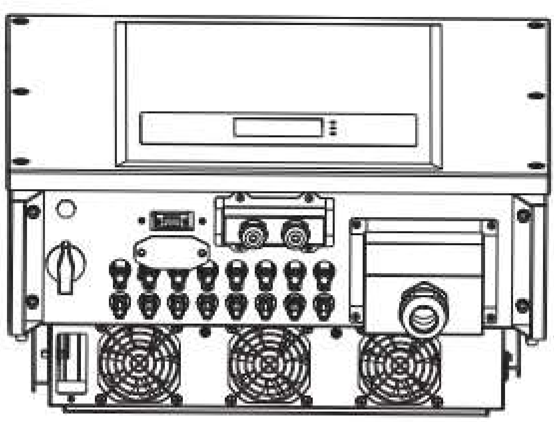


——— End

**WiFi/GPRS communication**

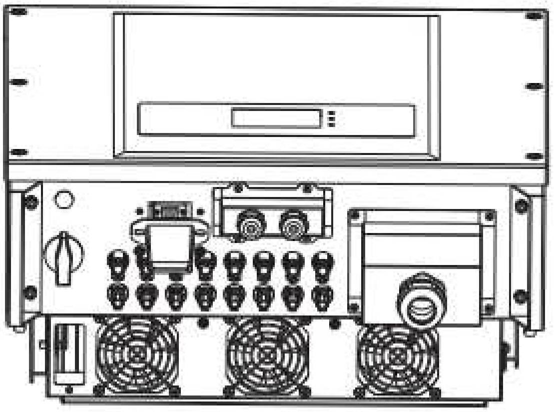
Monitor the inverter via WiFi/GPRS module.
Procedure:
Step 1 Remove waterproof cover using screwdriver.

Figure 4-13 WIFI Connecting Communications Cables(1)



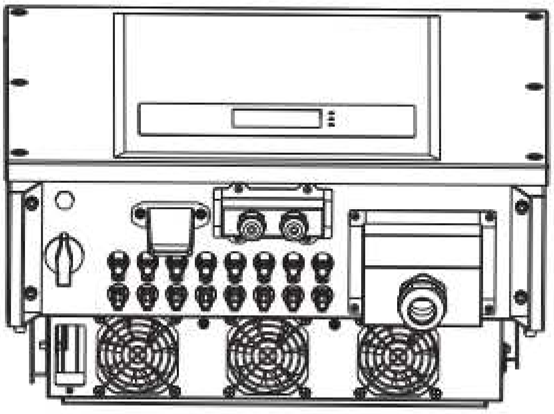
Step 2 Connect WiFi/GPRS module.

Figure 4-14 WIFI Connecting Communications Cables(2)



Step 3 Fix the WiFi/GPRS module using two screws.

Figure 4-15 WIFI Connecting Communications Cables(3)



Note: Follow the WiFi/GPRS manual to start monitoring your inverter.

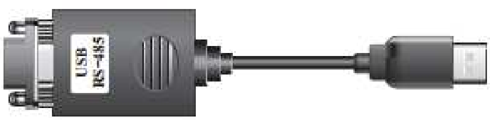
**Communications Port Description**

This topic describes the functions of the RS485 and WIFI ports.

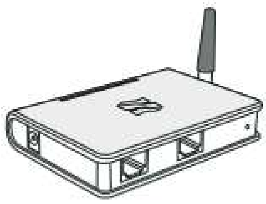
RS485

By RS485 interface, transfer the inverter power output information, alarm information,operation state to the PC terminal or local data acquisition device , then uploaded to the server (such as S-WE01S).

1. USB-RS485



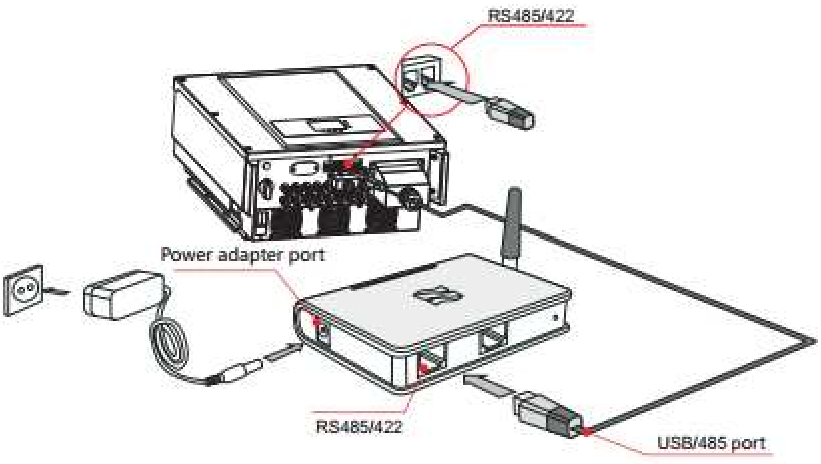

2. S-WE01S



Set the match resistor by the SWT2, the corresponding list as follows (0 OFF, 1 ON).

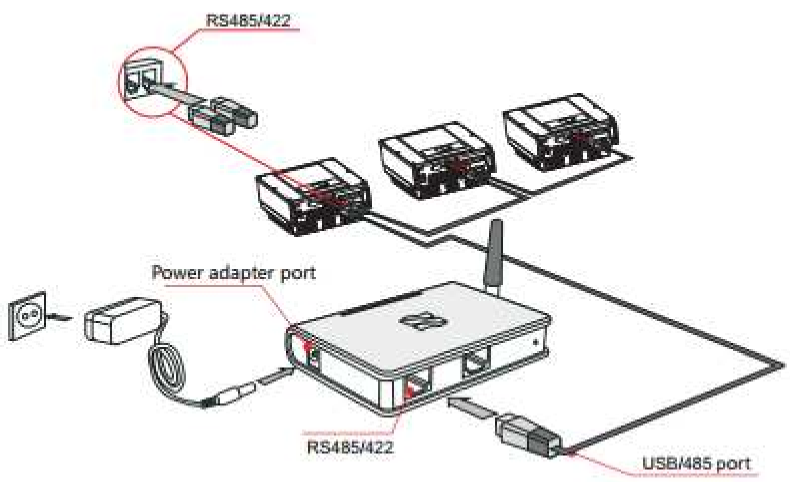
| SWT2_1 | SWT2_2 | State |
|---|---|---|
| 0 | Reserve | No connect |
| 1 | Reserve | Connect |

If only one Sofar 20~33KTL-G2 is used, use a communication cable with waterproof RJ45 connectors, and choose either of the two RS485 ports.




If multiple Sofar 20~33KTL-G2 are used, connect all Sofar 20~33KTL-G2 in daisy chain mode over the RS485 communication cable. Set different Modbus address(1~31) for each inverter in LCD display and set SWT2(match resistance) at the first and last inverter.

Figure 4-18 Multi Sofar 20~33KTL-G2 connecting Communications

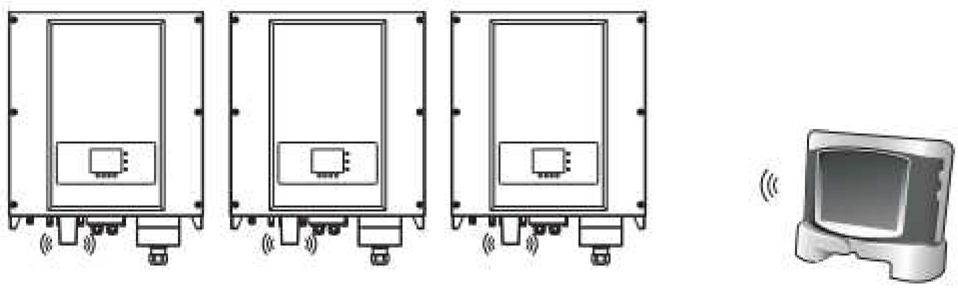



Register remote monitoring of Sofar 20~33KTL-G2 at its relevant website or APP according to monitoring device SN.

Wifi

By the WIFI interface, transfer the inverter power output information, alarm information, operation state to the PC terminal or local data acquisition device , then uploaded to the server (such as S-WE01S). Register remote monitoring of Sofar 20~33KTL-G2 at its relevant website or APP according to monitoring device SN.

Figure 4-19 Connect multiple Wifi to wireless router



**Description of the connection to the ripple control receiver:**

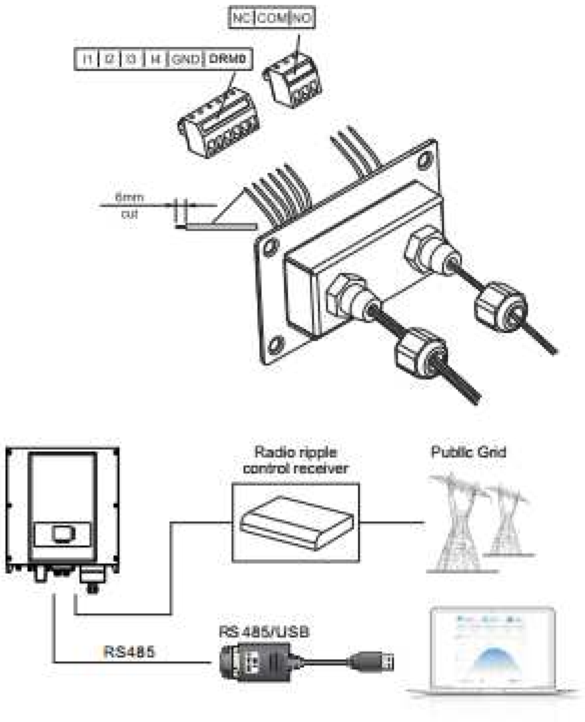



**Figure 2 – Connection of the ripple control receiver in an installation**

**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 Consumer Products Services GmbH.

"(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.

The following suffixes are used for variables in tables and figures:

- "$P_N$" for the nominal active power:
  $P_n = U_n \times I_n \times \cos \varphi_n$ (single-Phase); $P_n = \sqrt{3}\, U_n \times I_n \times \cos \varphi_n$ (three-Phase)
- "_E0,2" for gliding average values over 200 milliseconds
- "_E60" for gliding average values over 60 seconds.
- "_E600" for gliding average values over 10 minutes.
- "(c)" for over-excited
- "(i)" for under-excited

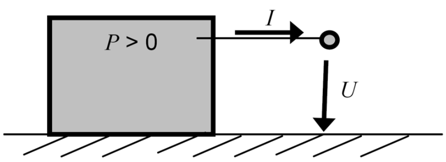
**Acronyms:**

PGU: power generating unit

PGS: power generating system

The regarded system of the voltage and current vectors is the load view (Figure 3):

- 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




- If the inverter consumes inductive reactive power the reactive power is marked "inductive" or has a positive sign.
- If the inverter consumes capacitive reactive power the reactive power is marked "capacitive" or has a negative sign.

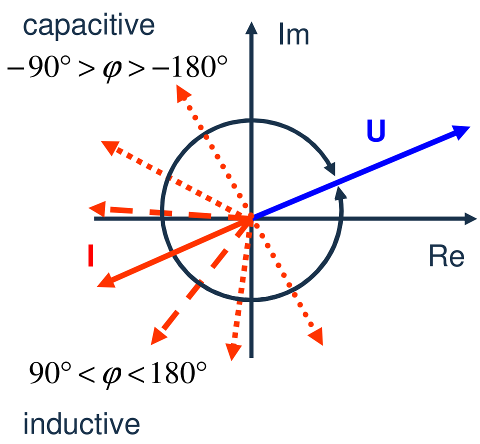



**Figure 3**

| 5 Prüfungen<br>DIN VDE V 0124-100:2012-07 | | |
|---|---|---|
| **Clause** | **Test** | **Result** |
| 5.1 | Verification of permissible system perturbations | **P** |
| 5.2 | Verification of the symmetry characteristics of three-phase inverter modules | **P** |
| 5.3 | Verification of the characteristics of the power generation unit on the network | **P** |
| 5.4 | Testing of NS protection | **P** |
| 5.5 | Testing of connecting conditions and synchronisation | **P** |

## 5.1 Verification of permissible system perturbations DIN VDE V 0124-100:2012-07

| Clause | Test | | Result |
|---|---|---|---|
| 5.1.1 | General | | P |
| 5.1.2 | Rapid voltage changes | | P |
| | 5.1.2.1 | Tests | P |
| | 5.1.2.2 | Documentation of tests | P |
| 5.1.3 | Flicker | | P |
| | 5.1.3.1 | Tests | P |
| | 5.1.3.2 | Documentation of tests | P |
| 5.1.4 | Harmonics and interharmonics | | P |
| | 5.1.4.1 | Tests | P |
| | 5.1.4.2 | Additional tests | P |
| | 5.1.4.3 | Documentation of tests | P |

| 5.1.1 **General**<br>These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4 are met. | **P** |
|---|---|
| The electrical equipment of the customer system has been planned and built, and will be operated, such that system perturbations affecting the network of the network operator and the installations of other customers are limited to a permissible level on a permanent basis.<br><br>System perturbations are defined as:<br>- Rapid voltage changes<br>- Flicker<br>- Harmonics, interharmonics and higher frequencies (up to 9 kHz) | |
| **Note:** | |

| **5.1.2 Rapid voltage changes**<br>These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4.2 are met. | **P** |
|---|---|

The purpose of the test is to determine $k_i$ and $k_{imax}$.

The following three cases must be tested to VDE-AR-N 4105, Annex F.3 (where applicable).

- Switch-on for any capacity
- Unfavourable case when switching the generator step
- Switch-on for nominal capacity

**Test conditions:**
Frequency: 50 Hz ± 0,5%
THD of the voltage supply: ≤ 3 %
Voltage rise of the PGU at 100 $P_{Emax}$ %: ≤ 3 %

| | | | |
|---|---|---|---|
| **L1 phase** | | | |
| **Switch-on for any capacity (10% $P_{Emax}$)** | | | |
| Single period effective values of the current [A] | 3,613 | 3,628 | 3,392 |
| Single period effective values of the voltage [V] | 229,97 | 229,97 | 229,97 |
| $k_i$ value | 0,076 | 0,076 | 0,071 |
| $k_{imax}$ value | 0,076 | | |
| **Unfavourable case when switching the generator step** | | | |
| Single period effective values of the current [A] | N/A | N/A | N/A |
| Single period effective values of the voltage [V] | N/A | N/A | N/A |
| $k_i$ value | N/A | N/A | N/A |
| $k_{imax}$ value | N/A | | |
| **Switch-on for nominal capacity** | | | |
| Single period effective values of the current [A] | 9,646 | 7,102 | 6,772 |
| Single period effective values of the voltage [V] | 229,90 | 229,92 | 230,02 |
| $k_i$ value | 0,202 | 0,148 | 0,142 |
| $k_{imax}$ value | 0,202 | | |
| **L2 phase** | | | |
| **Switch-on for any capacity (10% $P_{Emax}$)** | | | |
| Single period effective values of the current [A] | 3,820 | 3,822 | 3,561 |
| Single period effective values of the voltage [V] | 229,78 | 229,72 | 229,79 |
| $k_i$ value | 0,080 | 0,080 | 0,074 |
| $k_{imax}$ value | 0,080 | | |
| **Unfavourable case when switching the generator step** | | | |

| | | | |
|---|---|---|---|
| Single period effective values of the current [A] | N/A | N/A | N/A |
| Single period effective values of the voltage [V] | N/A | N/A | N/A |
| $k_i$ value | N/A | N/A | N/A |
| $k_{imax}$ value | N/A | | |
| **Switch-on for nominal capacity** | | | |
| Single period effective values of the current [A] | 10,080 | 7,436 | 7,062 |
| Single period effective values of the voltage [V] | 229,71 | 229,72 | 229,67 |
| $k_i$ value | 0,211 | 0,155 | 0,148 |
| $k_{imax}$ value | 0,211 | | |
| **L3 phase** | | | |
| **Switch-on for any capacity (10% $P_{Emax}$)** | | | |
| Single period effective values of the current [A] | 3,778 | 3,789 | 3,535 |
| Single period effective values of the voltage [V] | 229,97 | 229,97 | 229,98 |
| $k_i$ value | 0,079 | 0,079 | 0,074 |
| $k_{imax}$ value | 0,079 | | |
| **Unfavourable case when switching the generator step** | | | |
| Single period effective values of the current [A] | N/A | N/A | N/A |
| Single period effective values of the voltage [V] | N/A | N/A | N/A |
| $k_i$ value | N/A | N/A | N/A |
| $k_{imax}$ value | N/A | | |
| **Switch-on for nominal capacity** | | | |
| Single period effective values of the current [A] | 9,940 | 7,336 | 6,973 |
| Single period effective values of the voltage [V] | 229,94 | 229,95 | 229,95 |
| $k_i$ value | 0,208 | 0,153 | 0,146 |
| $k_{imax}$ value | 0,208 | | |
| **Highest $k_{imax}$ value for all switching operations** | | | |
| 0,211 | | | |

**Note:**
The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

**Switch-on for any capacity (10% $P_{Emax}$)**


**Switch-on for nominal capacity**

### 5.1.3 Flicker

These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.4.3 are met.

The purpose of the test is to determine long-term flicker strength $P_{lt}$.

For power generation systems with rated currents ≤ 75 A, system perturbations are deemed sufficiently limited when the generation units adhere to the thresholds in norms DIN EN 61000-3-3 (VDE 0838-3) and DIN EN 61000-3-11 (VDE 0838-11).

**Test conditions:**
Voltage: 86% $U_n$ to 109% $U_n$
Frequency: 50 Hz ± 0,5%
THD of the voltage supply: ≤ 3 %
Voltage rise of the PGU at 100 $P_{Emax}$ %: ≤ 3 %

**Flicker to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 (VDE 0838-11) for generator units ≤ 75 A**

| Flicker to: | Result: | | |
|---|---|---|---|
| | $P_{lt}$ | $P_{st}$ | *dc%* |
| | | | |
| DIN EN 61000-3-11 (SOFAR 33000TL-G2) | 0,33 | 0,34 | 0,30 |
| DIN EN 61000-3-11 (SOFAR 20000TL-G2) | 0,29 | 0,29 | 0,17 |

**Assessment criterion:**

Long-term flicker strength $P_{lt}$ to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 must be ≤ 0,5.

Determination of the flicker coefficient:

$$c_{\psi k} = P_{st} \times (S_k / P_n)$$

where $S_k$ is the short-circuit power of the network standby element (during the determination of the appropriate Pst values)

The following applies according to DIN EN 61000-3-3 (≤ 16 A) for the network standby element: $S_k$ = 339199
The value for the network standby element must be determined separately with measurements for rated currents > 75 A.

| Flicker to DIN EN 61400-21 (VDE 0127-21) (or FGW TR3) | |
|---|---|
| SOFAR 33000TL-G2 | |
| Grid impedance angle $\psi_k$ | 32° |
| Flicker coefficient $c(\psi_k)$ | 5,78 |
| Short-term flicker $P_{st}$ | 0,34 |
| SOFAR 20000TL-G2 | |
| Grid impedance angle $\psi_k$ | 32° |
| Flicker coefficient $c(\psi_k)$ | 8,13 |
| Short-term flicker $P_{st}$ | 0,29 |
| **Assessment criterion:**<br><br>Long-term flicker strength**:** $P_{lt} \leq 0,5$ | |
| **Note:**<br>The tests had been performed on the SOFAR 33000TL-G2 and SOFAR 20000TL-G2 are valid for the SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software. | |

| 5.1.4 **Harmonics and interharmonics**<br>These tests are designed to provide evidence that the requirements of VDE-AR-N 4015, 5.4.4 are met. | **P** |
|---|---|

Adherence to the thresholds for harmonic currents must be verified as followed:

- For nominal currents ≤ 16 A per conductor to DIN EN 61000-3-2 (VDE 0838-2)
- For nominal currents > 16 A and ≤ 75 A per conductor to DIN EN 61000-3-12 (VDE 0838-12)
- For PGUs intended for PGSs with nominal currents > 75 A, the measurements must be conducted as in 5.1.4.2.

**Test conditions:**
Voltage: 86% $U_n$ to 109% $U_n$
Frequency: 50 Hz ± 0,5%
THD of the voltage supply: ≤ 3 %
Voltage rise of the PGU at 100 $P_{Emax}$ %: ≤ 3 %

| 5.1.4.1 Tests | | | | | | | | | | | | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Note:**<br>The tests should be based on the limits of the EN61000-3-2 for less than 16A.<br>Covered by EMC Report 13.7.6.8 | | | | | | | | | | | | |
| **Maximum permissible harmonic current as per EN 61000-3-12** | | | | | | | | | | | | |
| **Harmonic** | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 11th | 12th | 13th |
| **Limit [%] 3phasig** | 8,00 | N/A | 4,00 | 10,70 | 2,67 | 7,20 | 2,00 | N/A | 1,60 | 3,10 | 1,33 | 2,00 |
| **Test value [%]** | See below | | | | | | | | | | | |
| | THD | | | | | | PWHD | | | | | |
| **Limit [%] 3-phase** | 13 | | | | | | 22 | | | | | |
| **Test value [%]** | See below | | | | | | | | | | | |

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.1630 | 8.0000 | 98.0 |
| 3 | 0.2320 | 21.9800 | 98.9 |
| 4 | 0.1577 | 4.0000 | 96.1 |
| 5 | 0.2393 | 11.3200 | 97.9 |
| 6 | 0.1395 | 2.6667 | 94.8 |
| 7 | 0.2206 | 7.3250 | 97.0 |
| 8 | 0.1227 | 2.0000 | 93.9 |
| 9 | 0.1026 | 3.8250 | 97.3 |
| 10 | 0.0917 | 1.6000 | 94.3 |
| 11 | 0.2270 | 3.1600 | 92.8 |
| 12 | 0.0915 | 1.3333 | 93.1 |
| 13 | 0.1915 | 2.0600 | 90.7 |
| THD | 0.7808 | 23.4750 | 96.7 |
| PWHD | 2.5497 | 23.4750 | 89.1 |

SOFAR 20000TL-G2: L1 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.1599 | 8.0000 | 98.0 |
| 3 | 0.1053 | 21.9800 | 99.5 |
| 4 | 0.0990 | 4.0000 | 97.5 |
| 5 | 0.1275 | 11.3200 | 98.9 |
| 6 | 0.1078 | 2.6667 | 96.0 |
| 7 | 0.2286 | 7.3250 | 96.9 |
| 8 | 0.0958 | 2.0000 | 95.2 |
| 9 | 0.1055 | 3.8250 | 97.2 |
| 10 | 0.0928 | 1.6000 | 94.2 |
| 11 | 0.2560 | 3.1600 | 91.9 |
| 12 | 0.0892 | 1.3333 | 93.3 |
| 13 | 0.1899 | 2.0600 | 90.8 |
| THD | 0.7180 | 23.4750 | 96.9 |
| PWHD | 2.5510 | 23.4750 | 89.1 |

SOFAR 20000TL-G2: L2 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.2493 | 8.0000 | 96.9 |
| 3 | 0.1531 | 21.9800 | 99.3 |
| 4 | 0.2172 | 4.0000 | 94.6 |
| 5 | 0.1309 | 11.3200 | 98.8 |
| 6 | 0.1072 | 2.6667 | 96.0 |
| 7 | 0.1019 | 7.3250 | 98.6 |
| 8 | 0.1077 | 2.0000 | 94.6 |
| 9 | 0.1794 | 3.8250 | 95.3 |
| 10 | 0.1135 | 1.6000 | 92.9 |
| 11 | 0.2053 | 3.1600 | 93.5 |
| 12 | 0.0968 | 1.3333 | 92.7 |
| 13 | 0.1942 | 2.0600 | 90.6 |
| THD | 0.7614 | 23.4750 | 96.8 |
| PWHD | 2.5960 | 23.4750 | 88.9 |

SOFAR 20000TL-G2: L3 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.0544 | 8.0000 | 99.3 |
| 3 | 0.1374 | 21.9800 | 99.4 |
| 4 | 0.0587 | 4.0000 | 98.5 |
| 5 | 0.2702 | 11.3200 | 97.6 |
| 6 | 0.0377 | 2.6667 | 98.6 |
| 7 | 0.2179 | 7.3250 | 97.0 |
| 8 | 0.0455 | 2.0000 | 97.7 |
| 9 | 0.2077 | 3.8250 | 94.6 |
| 10 | 0.0409 | 1.6000 | 97.4 |
| 11 | 0.0964 | 3.1600 | 97.0 |
| 12 | 0.0318 | 1.3333 | 97.6 |
| 13 | 0.1734 | 2.0600 | 91.6 |
| THD | 0.5264 | 23.4750 | 97.8 |
| PWHD | 0.9824 | 23.4750 | 95.8 |

SOFAR 25000TL-G2: L1 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.0575 | 8.0000 | 99.3 |
| 3 | 0.1467 | 21.9800 | 99.3 |
| 4 | 0.0470 | 4.0000 | 98.8 |
| 5 | 0.1691 | 11.3200 | 98.5 |
| 6 | 0.0353 | 2.6667 | 98.7 |
| 7 | 0.3284 | 7.3250 | 95.5 |
| 8 | 0.0506 | 2.0000 | 97.5 |
| 9 | 0.1283 | 3.8250 | 96.6 |
| 10 | 0.0452 | 1.6000 | 97.2 |
| 11 | 0.2357 | 3.1600 | 92.5 |
| 12 | 0.0235 | 1.3333 | 98.2 |
| 13 | 0.0667 | 2.0600 | 96.8 |
| THD | 0.5426 | 23.4750 | 97.7 |
| PWHD | 1.0347 | 23.4750 | 95.6 |

SOFAR 25000TL-G2: L2 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.0364 | 8.0000 | 99.5 |
| 3 | 0.2544 | 21.9800 | 98.8 |
| 4 | 0.0587 | 4.0000 | 98.5 |
| 5 | 0.2819 | 11.3200 | 97.5 |
| 6 | 0.0420 | 2.6667 | 98.4 |
| 7 | 0.2690 | 7.3250 | 96.3 |
| 8 | 0.0500 | 2.0000 | 97.5 |
| 9 | 0.1135 | 3.8250 | 97.0 |
| 10 | 0.0523 | 1.6000 | 96.7 |
| 11 | 0.2909 | 3.1600 | 90.8 |
| 12 | 0.0212 | 1.3333 | 98.4 |
| 13 | 0.1748 | 2.0600 | 91.5 |
| THD | 0.6778 | 23.4750 | 97.1 |
| PWHD | 1.5002 | 23.4750 | 93.6 |

SOFAR 25000TL-G2: L3 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.0641 | 8.0000 | 99.2 |
| 3 | 0.1295 | 21.9800 | 99.4 |
| 4 | 0.0331 | 4.0000 | 99.2 |
| 5 | 0.2264 | 11.3200 | 98.0 |
| 6 | 0.0384 | 2.6667 | 98.6 |
| 7 | 0.2437 | 7.3250 | 96.7 |
| 8 | 0.0540 | 2.0000 | 97.3 |
| 9 | 0.2007 | 3.8250 | 94.8 |
| 10 | 0.0443 | 1.6000 | 97.2 |
| 11 | 0.1019 | 3.1600 | 96.8 |
| 12 | 0.0249 | 1.3333 | 98.1 |
| 13 | 0.1583 | 2.0600 | 92.3 |
| THD | 0.4929 | 23.4750 | 97.9 |
| PWHD | 0.7877 | 23.4750 | 96.6 |

SOFAR 30000TL-G2: L1 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.0624 | 8.0000 | 99.2 |
| 3 | 0.1529 | 21.9800 | 99.3 |
| 4 | 0.0384 | 4.0000 | 99.0 |
| 5 | 0.1758 | 11.3200 | 98.4 |
| 6 | 0.0354 | 2.6667 | 98.7 |
| 7 | 0.3455 | 7.3250 | 95.3 |
| 8 | 0.0531 | 2.0000 | 97.4 |
| 9 | 0.1550 | 3.8250 | 96.0 |
| 10 | 0.0492 | 1.6000 | 96.9 |
| 11 | 0.2369 | 3.1600 | 92.5 |
| 12 | 0.0208 | 1.3333 | 98.4 |
| 13 | 0.0678 | 2.0600 | 96.7 |
| THD | 0.5527 | 23.4750 | 97.6 |
| PWHD | 0.8843 | 23.4750 | 96.2 |

SOFAR 30000TL-G2: L2 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.0407 | 8.0000 | 99.5 |
| 3 | 0.2057 | 21.9800 | 99.1 |
| 4 | 0.0435 | 4.0000 | 98.9 |
| 5 | 0.2279 | 11.3200 | 98.0 |
| 6 | 0.0414 | 2.6667 | 98.5 |
| 7 | 0.2385 | 7.3250 | 96.7 |
| 8 | 0.0597 | 2.0000 | 97.0 |
| 9 | 0.0880 | 3.8250 | 97.7 |
| 10 | 0.0554 | 1.6000 | 96.5 |
| 11 | 0.2736 | 3.1600 | 91.3 |
| 12 | 0.0188 | 1.3333 | 98.6 |
| 13 | 0.1557 | 2.0600 | 92.4 |
| THD | 0.5765 | 23.4750 | 97.5 |
| PWHD | 1.1667 | 23.4750 | 95.0 |

SOFAR 30000TL-G2: L3 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.2570 | 8.0000 | 96.8 |
| 3 | 0.0518 | 21.9800 | 99.8 |
| 4 | 0.1849 | 4.0000 | 95.4 |
| 5 | 0.1308 | 11.3200 | 98.8 |
| 6 | 0.0863 | 2.6667 | 96.8 |
| 7 | 0.3153 | 7.3250 | 95.7 |
| 8 | 0.1084 | 2.0000 | 94.6 |
| 9 | 0.1846 | 3.8250 | 95.2 |
| 10 | 0.0742 | 1.6000 | 95.4 |
| 11 | 0.1031 | 3.1600 | 96.7 |
| 12 | 0.0486 | 1.3333 | 96.4 |
| 13 | 0.1369 | 2.0600 | 93.4 |
| THD | 0.5800 | 23.4750 | 97.5 |
| PWHD | 0.7631 | 23.4750 | 96.7 |

SOFAR 33000TL-G2: L1 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.0864 | 8.0000 | 98.9 |
| 3 | 0.0877 | 21.9800 | 99.6 |
| 4 | 0.1054 | 4.0000 | 97.4 |
| 5 | 0.1255 | 11.3200 | 98.9 |
| 6 | 0.0705 | 2.6667 | 97.4 |
| 7 | 0.3614 | 7.3250 | 95.1 |
| 8 | 0.0729 | 2.0000 | 96.4 |
| 9 | 0.1751 | 3.8250 | 95.4 |
| 10 | 0.0584 | 1.6000 | 96.4 |
| 11 | 0.2082 | 3.1600 | 93.4 |
| 12 | 0.0636 | 1.3333 | 95.2 |
| 13 | 0.0903 | 2.0600 | 95.6 |
| THD | 0.6196 | 23.4750 | 97.4 |
| PWHD | 1.6734 | 23.4750 | 92.9 |

SOFAR 33000TL-G2: L2 phase

| Order | Measure[%] | Limit[%] | Margin[%] |
|---|---|---|---|
| 2 | 0.1077 | 8.0000 | 98.7 |
| 3 | 0.1146 | 21.9800 | 99.5 |
| 4 | 0.2133 | 4.0000 | 94.7 |
| 5 | 0.0882 | 11.3200 | 99.2 |
| 6 | 0.1126 | 2.6667 | 95.8 |
| 7 | 0.1645 | 7.3250 | 97.8 |
| 8 | 0.1328 | 2.0000 | 93.4 |
| 9 | 0.0669 | 3.8250 | 98.3 |
| 10 | 0.0851 | 1.6000 | 94.7 |
| 11 | 0.2197 | 3.1600 | 93.1 |
| 12 | 0.0565 | 1.3333 | 95.8 |
| 13 | 0.1198 | 2.0600 | 94.2 |
| THD | 0.5754 | 23.4750 | 97.5 |
| PWHD | 1.7267 | 23.4750 | 92.6 |

SOFAR 33000TL-G2: L3 phase

**Note:**
The tests should be based on the limits of the EN 61000-3-12 for more than 16A.
Covered by EMC Report 13.7.6.8

| 5.1.4.2 Additional measurements for PGUs intended for PGSs with nominal currents > 75 A | P |
|---|---|

The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.

**Test: SOFAR 33000TL-G2**

| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Order | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 1 | 2,949 | 9,590 | 19,208 | 30,528 | 42,973 | 48,038 | 60,882 | 67,202 | 76,749 | 86,500 | 96,031 |
| 2 | 0,081 | 0,086 | 0,096 | 0,101 | 0,109 | 0,111 | 0,117 | 0,120 | 0,126 | 0,135 | 0,285 |
| 3 | 0,142 | 0,114 | 0,110 | 0,127 | 0,163 | 0,176 | 0,199 | 0,208 | 0,212 | 0,214 | 0,197 |
| 4 | 0,062 | 0,075 | 0,087 | 0,097 | 0,099 | 0,102 | 0,105 | 0,108 | 0,108 | 0,109 | 0,169 |
| 5 | 0,247 | 0,143 | 0,089 | 0,137 | 0,170 | 0,173 | 0,192 | 0,202 | 0,224 | 0,227 | 0,176 |
| 6 | 0,047 | 0,064 | 0,080 | 0,092 | 0,093 | 0,092 | 0,092 | 0,091 | 0,090 | 0,089 | 0,110 |
| 7 | 0,241 | 0,129 | 0,081 | 0,106 | 0,129 | 0,142 | 0,168 | 0,184 | 0,218 | 0,254 | 0,360 |
| 8 | 0,038 | 0,041 | 0,054 | 0,062 | 0,065 | 0,065 | 0,069 | 0,071 | 0,078 | 0,079 | 0,128 |
| 9 | 0,099 | 0,066 | 0,060 | 0,055 | 0,071 | 0,083 | 0,102 | 0,113 | 0,126 | 0,146 | 0,170 |
| 10 | 0,037 | 0,035 | 0,038 | 0,037 | 0,037 | 0,038 | 0,039 | 0,042 | 0,048 | 0,051 | 0,068 |
| 11 | 0,237 | 0,140 | 0,072 | 0,086 | 0,107 | 0,122 | 0,165 | 0,186 | 0,203 | 0,214 | 0,236 |
| 12 | 0,035 | 0,029 | 0,027 | 0,029 | 0,032 | 0,034 | 0,034 | 0,035 | 0,034 | 0,034 | 0,049 |
| 13 | 0,120 | 0,078 | 0,055 | 0,068 | 0,088 | 0,097 | 0,116 | 0,121 | 0,126 | 0,138 | 0,134 |
| 14 | 0,035 | 0,029 | 0,028 | 0,028 | 0,028 | 0,028 | 0,028 | 0,027 | 0,028 | 0,028 | 0,038 |
| 15 | 0,032 | 0,030 | 0,033 | 0,052 | 0,059 | 0,064 | 0,076 | 0,083 | 0,084 | 0,082 | 0,066 |
| 16 | 0,031 | 0,028 | 0,027 | 0,029 | 0,029 | 0,029 | 0,030 | 0,030 | 0,029 | 0,028 | 0,034 |
| 17 | 0,097 | 0,089 | 0,054 | 0,039 | 0,068 | 0,079 | 0,097 | 0,103 | 0,108 | 0,107 | 0,097 |
| 18 | 0,031 | 0,031 | 0,029 | 0,028 | 0,026 | 0,026 | 0,026 | 0,025 | 0,025 | 0,025 | 0,028 |
| 19 | 0,045 | 0,059 | 0,041 | 0,034 | 0,057 | 0,066 | 0,084 | 0,092 | 0,098 | 0,106 | 0,105 |
| 20 | 0,031 | 0,032 | 0,032 | 0,032 | 0,030 | 0,028 | 0,028 | 0,025 | 0,025 | 0,024 | 0,024 |
| 21 | 0,040 | 0,038 | 0,030 | 0,042 | 0,049 | 0,053 | 0,054 | 0,056 | 0,057 | 0,052 | 0,052 |
| 22 | 0,026 | 0,025 | 0,026 | 0,026 | 0,025 | 0,026 | 0,026 | 0,023 | 0,022 | 0,021 | 0,022 |
| 23 | 0,056 | 0,052 | 0,043 | 0,030 | 0,049 | 0,057 | 0,064 | 0,071 | 0,078 | 0,084 | 0,083 |
| 24 | 0,026 | 0,026 | 0,025 | 0,025 | 0,023 | 0,023 | 0,024 | 0,024 | 0,023 | 0,024 | 0,023 |
| 25 | 0,053 | 0,049 | 0,043 | 0,028 | 0,044 | 0,050 | 0,056 | 0,060 | 0,064 | 0,070 | 0,067 |
| 26 | 0,024 | 0,024 | 0,024 | 0,026 | 0,024 | 0,024 | 0,025 | 0,023 | 0,022 | 0,022 | 0,022 |
| 27 | 0,028 | 0,027 | 0,027 | 0,030 | 0,034 | 0,038 | 0,043 | 0,044 | 0,045 | 0,042 | 0,035 |
| 28 | 0,026 | 0,026 | 0,027 | 0,026 | 0,025 | 0,024 | 0,023 | 0,022 | 0,022 | 0,021 | 0,022 |
| 29 | 0,057 | 0,048 | 0,041 | 0,030 | 0,036 | 0,043 | 0,046 | 0,049 | 0,051 | 0,053 | 0,053 |
| 30 | 0,025 | 0,025 | 0,023 | 0,024 | 0,023 | 0,022 | 0,022 | 0,021 | 0,021 | 0,020 | 0,020 |
| 31 | 0,047 | 0,042 | 0,035 | 0,025 | 0,034 | 0,040 | 0,047 | 0,052 | 0,056 | 0,061 | 0,058 |
| 32 | 0,024 | 0,025 | 0,025 | 0,025 | 0,025 | 0,025 | 0,025 | 0,023 | 0,023 | 0,022 | 0,021 |
| 33 | 0,027 | 0,026 | 0,027 | 0,028 | 0,031 | 0,033 | 0,034 | 0,035 | 0,034 | 0,031 | 0,028 |
| 34 | 0,024 | 0,024 | 0,025 | 0,025 | 0,024 | 0,025 | 0,025 | 0,022 | 0,022 | 0,022 | 0,021 |
| 35 | 0,035 | 0,043 | 0,034 | 0,031 | 0,031 | 0,036 | 0,045 | 0,051 | 0,055 | 0,056 | 0,056 |
| 36 | 0,025 | 0,024 | 0,023 | 0,022 | 0,021 | 0,021 | 0,023 | 0,023 | 0,022 | 0,021 | 0,020 |
| 37 | 0,042 | 0,043 | 0,031 | 0,029 | 0,030 | 0,033 | 0,035 | 0,038 | 0,039 | 0,040 | 0,040 |
| 38 | 0,024 | 0,025 | 0,026 | 0,027 | 0,026 | 0,026 | 0,025 | 0,023 | 0,023 | 0,024 | 0,023 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 0,024 | 0,026 | 0,024 | 0,025 | 0,025 | 0,027 | 0,027 | 0,028 | 0,027 | 0,026 | 0,024 |
| 40 | 0,025 | 0,026 | 0,027 | 0,027 | 0,025 | 0,025 | 0,024 | 0,023 | 0,022 | 0,022 | 0,022 |

| **Interharmonics : SOFAR 33000TL-G2** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| F [Hz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 75 | 0,174 | 0,225 | 0,262 | 0,301 | 0,321 | 0,323 | 0,349 | 0,365 | 0,388 | 0,413 | 0,443 |
| 125 | 0,129 | 0,225 | 0,271 | 0,288 | 0,287 | 0,288 | 0,291 | 0,297 | 0,299 | 0,298 | 0,301 |
| 175 | 0,104 | 0,192 | 0,262 | 0,275 | 0,279 | 0,286 | 0,288 | 0,290 | 0,295 | 0,304 | 0,314 |
| 225 | 0,084 | 0,156 | 0,212 | 0,239 | 0,246 | 0,259 | 0,267 | 0,273 | 0,273 | 0,270 | 0,273 |
| 275 | 0,064 | 0,118 | 0,153 | 0,164 | 0,177 | 0,174 | 0,178 | 0,185 | 0,201 | 0,222 | 0,236 |
| 325 | 0,059 | 0,084 | 0,115 | 0,115 | 0,121 | 0,124 | 0,142 | 0,152 | 0,166 | 0,175 | 0,184 |
| 375 | 0,049 | 0,064 | 0,091 | 0,080 | 0,081 | 0,075 | 0,074 | 0,077 | 0,088 | 0,104 | 0,118 |
| 425 | 0,045 | 0,057 | 0,069 | 0,061 | 0,060 | 0,061 | 0,066 | 0,075 | 0,087 | 0,099 | 0,112 |
| 475 | 0,042 | 0,049 | 0,049 | 0,046 | 0,048 | 0,050 | 0,051 | 0,052 | 0,056 | 0,066 | 0,075 |
| 525 | 0,048 | 0,045 | 0,043 | 0,043 | 0,047 | 0,049 | 0,054 | 0,058 | 0,065 | 0,077 | 0,092 |
| 575 | 0,052 | 0,043 | 0,040 | 0,042 | 0,045 | 0,044 | 0,045 | 0,042 | 0,043 | 0,043 | 0,043 |
| 625 | 0,042 | 0,038 | 0,035 | 0,038 | 0,038 | 0,037 | 0,038 | 0,037 | 0,037 | 0,036 | 0,036 |
| 675 | 0,043 | 0,036 | 0,037 | 0,038 | 0,037 | 0,036 | 0,036 | 0,036 | 0,037 | 0,037 | 0,037 |
| 725 | 0,037 | 0,034 | 0,037 | 0,037 | 0,035 | 0,034 | 0,034 | 0,033 | 0,034 | 0,034 | 0,033 |
| 775 | 0,036 | 0,036 | 0,038 | 0,036 | 0,034 | 0,034 | 0,034 | 0,033 | 0,033 | 0,033 | 0,030 |
| 825 | 0,033 | 0,034 | 0,036 | 0,033 | 0,032 | 0,032 | 0,032 | 0,032 | 0,032 | 0,030 | 0,030 |
| 875 | 0,035 | 0,035 | 0,034 | 0,035 | 0,034 | 0,033 | 0,033 | 0,033 | 0,033 | 0,033 | 0,034 |
| 925 | 0,033 | 0,033 | 0,033 | 0,032 | 0,033 | 0,033 | 0,033 | 0,032 | 0,031 | 0,031 | 0,031 |
| 975 | 0,034 | 0,034 | 0,032 | 0,033 | 0,034 | 0,033 | 0,033 | 0,032 | 0,032 | 0,031 | 0,031 |
| 1025 | 0,036 | 0,037 | 0,034 | 0,035 | 0,034 | 0,033 | 0,031 | 0,032 | 0,032 | 0,030 | 0,031 |
| 1075 | 0,035 | 0,036 | 0,036 | 0,038 | 0,034 | 0,033 | 0,032 | 0,031 | 0,030 | 0,029 | 0,029 |
| 1125 | 0,032 | 0,032 | 0,031 | 0,032 | 0,030 | 0,028 | 0,029 | 0,030 | 0,029 | 0,029 | 0,027 |
| 1175 | 0,034 | 0,033 | 0,034 | 0,033 | 0,032 | 0,031 | 0,030 | 0,030 | 0,031 | 0,033 | 0,033 |
| 1225 | 0,031 | 0,030 | 0,032 | 0,031 | 0,030 | 0,030 | 0,030 | 0,030 | 0,030 | 0,030 | 0,028 |
| 1275 | 0,031 | 0,031 | 0,031 | 0,032 | 0,035 | 0,037 | 0,041 | 0,040 | 0,044 | 0,047 | 0,044 |
| 1325 | 0,032 | 0,030 | 0,032 | 0,032 | 0,032 | 0,031 | 0,031 | 0,030 | 0,030 | 0,030 | 0,030 |
| 1375 | 0,033 | 0,033 | 0,033 | 0,033 | 0,032 | 0,032 | 0,031 | 0,029 | 0,030 | 0,030 | 0,029 |
| 1425 | 0,032 | 0,032 | 0,032 | 0,032 | 0,031 | 0,028 | 0,029 | 0,029 | 0,029 | 0,028 | 0,028 |
| 1475 | 0,031 | 0,031 | 0,031 | 0,031 | 0,030 | 0,029 | 0,029 | 0,029 | 0,029 | 0,029 | 0,028 |
| 1525 | 0,030 | 0,030 | 0,030 | 0,031 | 0,029 | 0,029 | 0,028 | 0,027 | 0,027 | 0,026 | 0,026 |
| 1575 | 0,031 | 0,031 | 0,032 | 0,031 | 0,030 | 0,030 | 0,031 | 0,030 | 0,029 | 0,029 | 0,029 |
| 1625 | 0,030 | 0,032 | 0,031 | 0,031 | 0,032 | 0,031 | 0,031 | 0,031 | 0,029 | 0,028 | 0,028 |
| 1675 | 0,032 | 0,033 | 0,033 | 0,034 | 0,032 | 0,033 | 0,031 | 0,030 | 0,030 | 0,029 | 0,027 |
| 1725 | 0,031 | 0,032 | 0,031 | 0,032 | 0,031 | 0,031 | 0,031 | 0,030 | 0,029 | 0,027 | 0,026 |
| 1775 | 0,032 | 0,032 | 0,031 | 0,031 | 0,029 | 0,029 | 0,029 | 0,029 | 0,029 | 0,029 | 0,027 |
| 1825 | 0,030 | 0,030 | 0,030 | 0,030 | 0,030 | 0,030 | 0,031 | 0,029 | 0,028 | 0,027 | 0,027 |
| 1875 | 0,032 | 0,033 | 0,033 | 0,033 | 0,031 | 0,030 | 0,030 | 0,030 | 0,030 | 0,031 | 0,029 |
| 1925 | 0,029 | 0,029 | 0,030 | 0,031 | 0,031 | 0,030 | 0,030 | 0,029 | 0,029 | 0,028 | 0,027 |
| 1975 | 0,031 | 0,031 | 0,032 | 0,032 | 0,032 | 0,031 | 0,032 | 0,032 | 0,032 | 0,030 | 0,029 |

| Higher Frequencies : SOFAR 33000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P/Pn [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| f [kHz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 2,1 | 0,042 | 0,045 | 0,034 | 0,026 | 0,028 | 0,034 | 0,039 | 0,044 | 0,048 | 0,052 | 0,051 |
| 2,3 | 0,022 | 0,031 | 0,027 | 0,022 | 0,026 | 0,031 | 0,037 | 0,041 | 0,044 | 0,045 | 0,046 |
| 2,5 | 0,020 | 0,035 | 0,026 | 0,021 | 0,019 | 0,022 | 0,027 | 0,031 | 0,033 | 0,035 | 0,035 |
| 2,7 | 0,031 | 0,040 | 0,033 | 0,029 | 0,025 | 0,028 | 0,034 | 0,038 | 0,040 | 0,044 | 0,044 |
| 2,9 | 0,028 | 0,057 | 0,042 | 0,028 | 0,020 | 0,025 | 0,032 | 0,037 | 0,038 | 0,039 | 0,039 |
| 3,1 | 0,021 | 0,037 | 0,029 | 0,028 | 0,042 | 0,033 | 0,025 | 0,026 | 0,026 | 0,027 | 0,027 |
| 3,3 | 0,024 | 0,029 | 0,022 | 0,016 | 0,033 | 0,043 | 0,051 | 0,043 | 0,040 | 0,041 | 0,041 |
| 3,5 | 0,018 | 0,019 | 0,018 | 0,014 | 0,023 | 0,033 | 0,050 | 0,050 | 0,047 | 0,043 | 0,041 |
| 3,7 | 0,011 | 0,012 | 0,011 | 0,011 | 0,014 | 0,019 | 0,039 | 0,046 | 0,037 | 0,028 | 0,026 |
| 3,9 | 0,015 | 0,015 | 0,011 | 0,009 | 0,011 | 0,013 | 0,027 | 0,043 | 0,074 | 0,071 | 0,059 |
| 4,1 | 0,012 | 0,012 | 0,009 | 0,009 | 0,009 | 0,010 | 0,017 | 0,026 | 0,076 | 0,077 | 0,064 |
| 4,3 | 0,011 | 0,011 | 0,010 | 0,008 | 0,008 | 0,008 | 0,011 | 0,015 | 0,027 | 0,045 | 0,050 |
| 4,5 | 0,014 | 0,011 | 0,010 | 0,008 | 0,009 | 0,009 | 0,010 | 0,012 | 0,016 | 0,031 | 0,058 |
| 4,7 | 0,010 | 0,013 | 0,011 | 0,008 | 0,008 | 0,008 | 0,008 | 0,009 | 0,012 | 0,021 | 0,045 |
| 4,9 | 0,010 | 0,010 | 0,009 | 0,008 | 0,008 | 0,008 | 0,008 | 0,010 | 0,010 | 0,012 | 0,014 |
| 5,1 | 0,012 | 0,016 | 0,011 | 0,010 | 0,009 | 0,008 | 0,008 | 0,010 | 0,010 | 0,012 | 0,012 |
| 5,3 | 0,008 | 0,011 | 0,010 | 0,008 | 0,008 | 0,007 | 0,008 | 0,008 | 0,009 | 0,011 | 0,013 |
| 5,5 | 0,009 | 0,009 | 0,009 | 0,009 | 0,008 | 0,007 | 0,007 | 0,008 | 0,009 | 0,011 | 0,010 |
| 5,7 | 0,012 | 0,011 | 0,010 | 0,010 | 0,010 | 0,008 | 0,008 | 0,008 | 0,009 | 0,011 | 0,011 |
| 5,9 | 0,009 | 0,011 | 0,010 | 0,009 | 0,009 | 0,007 | 0,008 | 0,008 | 0,009 | 0,011 | 0,011 |
| 6,1 | 0,009 | 0,010 | 0,010 | 0,009 | 0,009 | 0,008 | 0,007 | 0,008 | 0,009 | 0,010 | 0,010 |
| 6,3 | 0,011 | 0,014 | 0,012 | 0,008 | 0,010 | 0,009 | 0,008 | 0,008 | 0,010 | 0,011 | 0,011 |
| 6,5 | 0,011 | 0,014 | 0,012 | 0,012 | 0,015 | 0,009 | 0,008 | 0,007 | 0,009 | 0,011 | 0,011 |
| 6,7 | 0,011 | 0,013 | 0,012 | 0,008 | 0,014 | 0,018 | 0,015 | 0,008 | 0,010 | 0,010 | 0,010 |
| 6,9 | 0,013 | 0,019 | 0,015 | 0,010 | 0,011 | 0,011 | 0,019 | 0,018 | 0,017 | 0,013 | 0,011 |
| 7,1 | 0,016 | 0,020 | 0,016 | 0,011 | 0,012 | 0,009 | 0,010 | 0,015 | 0,019 | 0,020 | 0,018 |
| 7,3 | 0,018 | 0,020 | 0,017 | 0,011 | 0,011 | 0,009 | 0,008 | 0,008 | 0,012 | 0,019 | 0,018 |
| 7,5 | 0,020 | 0,025 | 0,021 | 0,015 | 0,017 | 0,013 | 0,012 | 0,011 | 0,012 | 0,012 | 0,014 |
| 7,7 | 0,041 | 0,038 | 0,032 | 0,021 | 0,020 | 0,016 | 0,013 | 0,011 | 0,012 | 0,011 | 0,010 |
| 7,9 | 0,067 | 0,063 | 0,047 | 0,026 | 0,025 | 0,018 | 0,015 | 0,011 | 0,012 | 0,012 | 0,011 |
| 8,1 | 0,057 | 0,073 | 0,060 | 0,039 | 0,041 | 0,028 | 0,022 | 0,018 | 0,018 | 0,017 | 0,014 |
| 8,3 | 0,086 | 0,081 | 0,062 | 0,050 | 0,048 | 0,036 | 0,027 | 0,021 | 0,020 | 0,019 | 0,016 |
| 8,5 | 0,060 | 0,074 | 0,064 | 0,050 | 0,054 | 0,047 | 0,037 | 0,027 | 0,025 | 0,022 | 0,018 |
| 8,7 | 0,038 | 0,052 | 0,051 | 0,040 | 0,042 | 0,042 | 0,041 | 0,039 | 0,036 | 0,031 | 0,024 |
| 8,9 | 0,027 | 0,034 | 0,032 | 0,039 | 0,028 | 0,025 | 0,033 | 0,037 | 0,035 | 0,032 | 0,027 |

**Note:**
The normalization current is 47,82A for SOFAR 33000TL-G2
The stated harmonics are maximum values of all 3 phases.

| Test: SOFAR 30000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Order | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 1 | 2,924 | 10,901 | 19,129 | 30,207 | 38,389 | 48,022 | 62,066 | 67,240 | 79,170 | 90,476 | 96,181 |
| 2 | 0,090 | 0,093 | 0,104 | 0,110 | 0,112 | 0,120 | 0,127 | 0,130 | 0,138 | 0,147 | 0,152 |
| 3 | 0,166 | 0,143 | 0,113 | 0,129 | 0,156 | 0,184 | 0,209 | 0,221 | 0,238 | 0,237 | 0,233 |
| 4 | 0,061 | 0,087 | 0,096 | 0,106 | 0,107 | 0,112 | 0,117 | 0,118 | 0,125 | 0,126 | 0,123 |
| 5 | 0,237 | 0,194 | 0,095 | 0,134 | 0,166 | 0,184 | 0,199 | 0,208 | 0,241 | 0,253 | 0,254 |
| 6 | 0,057 | 0,072 | 0,088 | 0,101 | 0,105 | 0,105 | 0,101 | 0,099 | 0,099 | 0,099 | 0,099 |
| 7 | 0,228 | 0,177 | 0,093 | 0,105 | 0,139 | 0,149 | 0,166 | 0,180 | 0,215 | 0,264 | 0,309 |
| 8 | 0,049 | 0,045 | 0,057 | 0,064 | 0,071 | 0,071 | 0,073 | 0,076 | 0,082 | 0,086 | 0,086 |
| 9 | 0,118 | 0,080 | 0,067 | 0,064 | 0,066 | 0,083 | 0,098 | 0,106 | 0,127 | 0,148 | 0,165 |
| 10 | 0,042 | 0,040 | 0,040 | 0,040 | 0,039 | 0,041 | 0,042 | 0,043 | 0,048 | 0,054 | 0,055 |
| 11 | 0,202 | 0,154 | 0,043 | 0,085 | 0,106 | 0,118 | 0,161 | 0,178 | 0,214 | 0,232 | 0,243 |
| 12 | 0,041 | 0,038 | 0,029 | 0,029 | 0,032 | 0,033 | 0,036 | 0,037 | 0,038 | 0,039 | 0,039 |
| 13 | 0,064 | 0,107 | 0,043 | 0,064 | 0,086 | 0,102 | 0,118 | 0,128 | 0,139 | 0,149 | 0,161 |
| 14 | 0,038 | 0,035 | 0,030 | 0,030 | 0,031 | 0,032 | 0,031 | 0,029 | 0,028 | 0,030 | 0,031 |
| 15 | 0,036 | 0,038 | 0,036 | 0,055 | 0,058 | 0,066 | 0,079 | 0,086 | 0,093 | 0,091 | 0,086 |
| 16 | 0,033 | 0,031 | 0,030 | 0,030 | 0,031 | 0,031 | 0,031 | 0,030 | 0,031 | 0,030 | 0,030 |
| 17 | 0,118 | 0,102 | 0,045 | 0,035 | 0,056 | 0,077 | 0,098 | 0,104 | 0,114 | 0,119 | 0,113 |
| 18 | 0,033 | 0,033 | 0,032 | 0,033 | 0,031 | 0,030 | 0,029 | 0,027 | 0,027 | 0,026 | 0,026 |
| 19 | 0,058 | 0,075 | 0,041 | 0,034 | 0,046 | 0,068 | 0,084 | 0,093 | 0,107 | 0,112 | 0,119 |
| 20 | 0,034 | 0,036 | 0,034 | 0,034 | 0,032 | 0,032 | 0,032 | 0,029 | 0,027 | 0,026 | 0,025 |
| 21 | 0,054 | 0,048 | 0,032 | 0,040 | 0,051 | 0,056 | 0,059 | 0,062 | 0,063 | 0,061 | 0,060 |
| 22 | 0,030 | 0,029 | 0,028 | 0,027 | 0,027 | 0,028 | 0,028 | 0,027 | 0,026 | 0,024 | 0,022 |
| 23 | 0,086 | 0,064 | 0,047 | 0,037 | 0,039 | 0,057 | 0,067 | 0,070 | 0,081 | 0,090 | 0,094 |
| 24 | 0,031 | 0,030 | 0,027 | 0,028 | 0,026 | 0,026 | 0,025 | 0,024 | 0,023 | 0,023 | 0,024 |
| 25 | 0,061 | 0,061 | 0,042 | 0,032 | 0,035 | 0,050 | 0,059 | 0,061 | 0,069 | 0,073 | 0,079 |
| 26 | 0,026 | 0,026 | 0,025 | 0,026 | 0,026 | 0,026 | 0,025 | 0,025 | 0,025 | 0,023 | 0,022 |
| 27 | 0,032 | 0,030 | 0,029 | 0,031 | 0,034 | 0,039 | 0,046 | 0,048 | 0,047 | 0,048 | 0,042 |
| 28 | 0,029 | 0,028 | 0,028 | 0,028 | 0,027 | 0,027 | 0,027 | 0,026 | 0,025 | 0,023 | 0,021 |
| 29 | 0,041 | 0,060 | 0,038 | 0,035 | 0,029 | 0,045 | 0,050 | 0,053 | 0,054 | 0,059 | 0,059 |
| 30 | 0,028 | 0,028 | 0,026 | 0,026 | 0,025 | 0,025 | 0,025 | 0,023 | 0,021 | 0,021 | 0,020 |
| 31 | 0,028 | 0,058 | 0,031 | 0,029 | 0,027 | 0,041 | 0,048 | 0,053 | 0,059 | 0,064 | 0,067 |
| 32 | 0,027 | 0,027 | 0,026 | 0,025 | 0,025 | 0,027 | 0,026 | 0,026 | 0,025 | 0,024 | 0,023 |
| 33 | 0,030 | 0,029 | 0,029 | 0,028 | 0,031 | 0,036 | 0,037 | 0,037 | 0,038 | 0,036 | 0,031 |
| 34 | 0,028 | 0,027 | 0,026 | 0,026 | 0,026 | 0,026 | 0,025 | 0,025 | 0,024 | 0,022 | 0,022 |
| 35 | 0,061 | 0,058 | 0,037 | 0,035 | 0,029 | 0,036 | 0,044 | 0,048 | 0,059 | 0,062 | 0,064 |
| 36 | 0,029 | 0,028 | 0,026 | 0,027 | 0,024 | 0,024 | 0,023 | 0,022 | 0,022 | 0,023 | 0,023 |
| 37 | 0,060 | 0,051 | 0,032 | 0,032 | 0,028 | 0,033 | 0,037 | 0,037 | 0,042 | 0,043 | 0,043 |
| 38 | 0,027 | 0,027 | 0,027 | 0,028 | 0,028 | 0,029 | 0,028 | 0,026 | 0,026 | 0,024 | 0,025 |
| 39 | 0,027 | 0,029 | 0,027 | 0,026 | 0,027 | 0,028 | 0,029 | 0,028 | 0,029 | 0,029 | 0,026 |
| 40 | 0,030 | 0,029 | 0,029 | 0,030 | 0,029 | 0,028 | 0,027 | 0,025 | 0,025 | 0,024 | 0,023 |

| Interharmonics : SOFAR 30000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P/Pn [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| f [Hz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 75 | 0,183 | 0,250 | 0,281 | 0,314 | 0,325 | 0,345 | 0,377 | 0,382 | 0,414 | 0,443 | 0,453 |
| 125 | 0,136 | 0,245 | 0,290 | 0,309 | 0,314 | 0,317 | 0,317 | 0,318 | 0,326 | 0,328 | 0,324 |
| 175 | 0,110 | 0,210 | 0,276 | 0,299 | 0,302 | 0,311 | 0,315 | 0,315 | 0,321 | 0,330 | 0,333 |
| 225 | 0,090 | 0,172 | 0,221 | 0,259 | 0,262 | 0,275 | 0,290 | 0,293 | 0,300 | 0,301 | 0,299 |
| 275 | 0,073 | 0,127 | 0,164 | 0,174 | 0,188 | 0,196 | 0,194 | 0,197 | 0,213 | 0,235 | 0,243 |
| 325 | 0,067 | 0,091 | 0,124 | 0,125 | 0,127 | 0,133 | 0,146 | 0,153 | 0,170 | 0,186 | 0,192 |
| 375 | 0,051 | 0,068 | 0,100 | 0,091 | 0,086 | 0,086 | 0,083 | 0,082 | 0,090 | 0,105 | 0,114 |
| 425 | 0,050 | 0,062 | 0,078 | 0,068 | 0,065 | 0,065 | 0,070 | 0,073 | 0,086 | 0,102 | 0,109 |
| 475 | 0,045 | 0,053 | 0,056 | 0,051 | 0,049 | 0,053 | 0,055 | 0,055 | 0,058 | 0,067 | 0,071 |
| 525 | 0,048 | 0,050 | 0,045 | 0,043 | 0,046 | 0,050 | 0,057 | 0,059 | 0,067 | 0,078 | 0,085 |
| 575 | 0,054 | 0,048 | 0,044 | 0,046 | 0,047 | 0,048 | 0,047 | 0,046 | 0,046 | 0,046 | 0,047 |
| 625 | 0,043 | 0,042 | 0,037 | 0,040 | 0,040 | 0,041 | 0,040 | 0,040 | 0,041 | 0,039 | 0,038 |
| 675 | 0,046 | 0,043 | 0,039 | 0,041 | 0,040 | 0,040 | 0,039 | 0,037 | 0,037 | 0,038 | 0,038 |
| 725 | 0,040 | 0,039 | 0,039 | 0,039 | 0,038 | 0,037 | 0,037 | 0,036 | 0,036 | 0,036 | 0,036 |
| 775 | 0,039 | 0,039 | 0,041 | 0,039 | 0,037 | 0,036 | 0,036 | 0,035 | 0,036 | 0,034 | 0,033 |
| 825 | 0,037 | 0,038 | 0,038 | 0,035 | 0,034 | 0,034 | 0,033 | 0,033 | 0,033 | 0,032 | 0,031 |
| 875 | 0,039 | 0,040 | 0,039 | 0,038 | 0,038 | 0,037 | 0,037 | 0,033 | 0,035 | 0,035 | 0,036 |
| 925 | 0,037 | 0,037 | 0,036 | 0,034 | 0,035 | 0,035 | 0,035 | 0,035 | 0,035 | 0,034 | 0,033 |
| 975 | 0,040 | 0,039 | 0,035 | 0,036 | 0,037 | 0,036 | 0,035 | 0,033 | 0,033 | 0,033 | 0,032 |
| 1025 | 0,042 | 0,042 | 0,039 | 0,039 | 0,038 | 0,037 | 0,037 | 0,034 | 0,033 | 0,033 | 0,031 |
| 1075 | 0,041 | 0,040 | 0,039 | 0,039 | 0,039 | 0,038 | 0,036 | 0,034 | 0,033 | 0,031 | 0,030 |
| 1125 | 0,037 | 0,036 | 0,035 | 0,034 | 0,032 | 0,032 | 0,032 | 0,030 | 0,030 | 0,029 | 0,029 |
| 1175 | 0,037 | 0,038 | 0,036 | 0,036 | 0,035 | 0,034 | 0,034 | 0,032 | 0,033 | 0,032 | 0,033 |
| 1225 | 0,035 | 0,035 | 0,034 | 0,034 | 0,033 | 0,033 | 0,032 | 0,030 | 0,031 | 0,032 | 0,031 |
| 1275 | 0,034 | 0,035 | 0,033 | 0,032 | 0,034 | 0,037 | 0,043 | 0,040 | 0,041 | 0,039 | 0,038 |
| 1325 | 0,036 | 0,035 | 0,034 | 0,033 | 0,034 | 0,033 | 0,033 | 0,032 | 0,031 | 0,031 | 0,030 |
| 1375 | 0,038 | 0,038 | 0,036 | 0,036 | 0,035 | 0,035 | 0,035 | 0,033 | 0,032 | 0,031 | 0,029 |
| 1425 | 0,036 | 0,036 | 0,035 | 0,035 | 0,034 | 0,033 | 0,031 | 0,030 | 0,029 | 0,029 | 0,029 |
| 1475 | 0,036 | 0,036 | 0,034 | 0,033 | 0,032 | 0,032 | 0,031 | 0,030 | 0,029 | 0,029 | 0,029 |
| 1525 | 0,034 | 0,033 | 0,032 | 0,032 | 0,031 | 0,032 | 0,031 | 0,031 | 0,030 | 0,028 | 0,028 |
| 1575 | 0,035 | 0,035 | 0,033 | 0,033 | 0,032 | 0,033 | 0,033 | 0,032 | 0,032 | 0,030 | 0,029 |
| 1625 | 0,033 | 0,033 | 0,033 | 0,032 | 0,033 | 0,034 | 0,033 | 0,034 | 0,033 | 0,031 | 0,029 |
| 1675 | 0,036 | 0,036 | 0,035 | 0,036 | 0,036 | 0,036 | 0,035 | 0,033 | 0,032 | 0,029 | 0,028 |
| 1725 | 0,035 | 0,036 | 0,034 | 0,033 | 0,033 | 0,032 | 0,031 | 0,030 | 0,031 | 0,030 | 0,029 |
| 1775 | 0,036 | 0,035 | 0,034 | 0,034 | 0,033 | 0,032 | 0,033 | 0,032 | 0,030 | 0,029 | 0,029 |
| 1825 | 0,034 | 0,034 | 0,032 | 0,032 | 0,032 | 0,031 | 0,031 | 0,030 | 0,030 | 0,029 | 0,029 |
| 1875 | 0,036 | 0,036 | 0,035 | 0,035 | 0,034 | 0,033 | 0,034 | 0,032 | 0,032 | 0,031 | 0,030 |
| 1925 | 0,033 | 0,033 | 0,031 | 0,032 | 0,031 | 0,032 | 0,032 | 0,031 | 0,031 | 0,029 | 0,028 |
| 1975 | 0,036 | 0,036 | 0,035 | 0,035 | 0,034 | 0,034 | 0,034 | 0,033 | 0,034 | 0,033 | 0,032 |

| **Higher Frequencies : SOFAR 30000TL-G2** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P/Pn [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| f [kHz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 2,1 | 0,025 | 0,059 | 0,032 | 0,030 | 0,023 | 0,033 | 0,039 | 0,043 | 0,051 | 0,054 | 0,056 |
| 2,3 | 0,037 | 0,043 | 0,026 | 0,027 | 0,021 | 0,030 | 0,039 | 0,041 | 0,046 | 0,048 | 0,049 |
| 2,5 | 0,035 | 0,042 | 0,018 | 0,022 | 0,017 | 0,023 | 0,027 | 0,029 | 0,035 | 0,036 | 0,037 |
| 2,7 | 0,027 | 0,039 | 0,021 | 0,033 | 0,023 | 0,030 | 0,034 | 0,039 | 0,044 | 0,045 | 0,048 |
| 2,9 | 0,033 | 0,058 | 0,027 | 0,034 | 0,019 | 0,022 | 0,033 | 0,037 | 0,041 | 0,042 | 0,043 |
| 3,1 | 0,027 | 0,034 | 0,024 | 0,026 | 0,044 | 0,043 | 0,035 | 0,026 | 0,029 | 0,028 | 0,029 |
| 3,3 | 0,014 | 0,026 | 0,017 | 0,017 | 0,024 | 0,038 | 0,053 | 0,053 | 0,048 | 0,043 | 0,046 |
| 3,5 | 0,017 | 0,017 | 0,017 | 0,016 | 0,016 | 0,023 | 0,055 | 0,058 | 0,054 | 0,047 | 0,045 |
| 3,7 | 0,015 | 0,012 | 0,011 | 0,013 | 0,012 | 0,016 | 0,035 | 0,046 | 0,045 | 0,030 | 0,029 |
| 3,9 | 0,013 | 0,014 | 0,009 | 0,012 | 0,009 | 0,012 | 0,024 | 0,031 | 0,059 | 0,089 | 0,075 |
| 4,1 | 0,017 | 0,014 | 0,011 | 0,010 | 0,009 | 0,011 | 0,014 | 0,017 | 0,049 | 0,091 | 0,082 |
| 4,3 | 0,015 | 0,014 | 0,012 | 0,010 | 0,008 | 0,009 | 0,011 | 0,012 | 0,022 | 0,038 | 0,049 |
| 4,5 | 0,013 | 0,015 | 0,011 | 0,010 | 0,009 | 0,010 | 0,010 | 0,011 | 0,014 | 0,024 | 0,033 |
| 4,7 | 0,012 | 0,011 | 0,013 | 0,010 | 0,009 | 0,009 | 0,009 | 0,010 | 0,012 | 0,018 | 0,023 |
| 4,9 | 0,009 | 0,010 | 0,010 | 0,010 | 0,009 | 0,008 | 0,008 | 0,010 | 0,011 | 0,011 | 0,012 |
| 5,1 | 0,011 | 0,012 | 0,014 | 0,011 | 0,011 | 0,010 | 0,009 | 0,010 | 0,010 | 0,011 | 0,012 |
| 5,3 | 0,009 | 0,012 | 0,014 | 0,011 | 0,009 | 0,009 | 0,008 | 0,009 | 0,009 | 0,010 | 0,012 |
| 5,5 | 0,010 | 0,011 | 0,013 | 0,011 | 0,010 | 0,008 | 0,008 | 0,008 | 0,009 | 0,010 | 0,011 |
| 5,7 | 0,012 | 0,014 | 0,013 | 0,010 | 0,011 | 0,010 | 0,008 | 0,009 | 0,009 | 0,010 | 0,011 |
| 5,9 | 0,009 | 0,014 | 0,011 | 0,009 | 0,010 | 0,009 | 0,008 | 0,009 | 0,009 | 0,010 | 0,011 |
| 6,1 | 0,011 | 0,014 | 0,011 | 0,010 | 0,010 | 0,009 | 0,008 | 0,008 | 0,009 | 0,010 | 0,011 |
| 6,3 | 0,014 | 0,019 | 0,014 | 0,011 | 0,010 | 0,010 | 0,009 | 0,009 | 0,009 | 0,011 | 0,012 |
| 6,5 | 0,011 | 0,014 | 0,013 | 0,012 | 0,013 | 0,011 | 0,009 | 0,008 | 0,009 | 0,010 | 0,011 |
| 6,7 | 0,013 | 0,015 | 0,013 | 0,010 | 0,010 | 0,017 | 0,017 | 0,009 | 0,009 | 0,010 | 0,011 |
| 6,9 | 0,015 | 0,019 | 0,014 | 0,011 | 0,011 | 0,011 | 0,019 | 0,020 | 0,020 | 0,019 | 0,019 |
| 7,1 | 0,017 | 0,021 | 0,015 | 0,014 | 0,012 | 0,012 | 0,011 | 0,014 | 0,017 | 0,020 | 0,021 |
| 7,3 | 0,020 | 0,022 | 0,016 | 0,013 | 0,012 | 0,011 | 0,010 | 0,009 | 0,010 | 0,012 | 0,014 |
| 7,5 | 0,020 | 0,027 | 0,020 | 0,018 | 0,017 | 0,016 | 0,014 | 0,013 | 0,012 | 0,013 | 0,012 |
| 7,7 | 0,047 | 0,045 | 0,034 | 0,028 | 0,021 | 0,021 | 0,017 | 0,013 | 0,012 | 0,013 | 0,012 |
| 7,9 | 0,075 | 0,075 | 0,045 | 0,035 | 0,027 | 0,024 | 0,020 | 0,014 | 0,013 | 0,013 | 0,013 |
| 8,1 | 0,064 | 0,072 | 0,064 | 0,053 | 0,046 | 0,040 | 0,031 | 0,021 | 0,020 | 0,019 | 0,016 |
| 8,3 | 0,095 | 0,094 | 0,063 | 0,056 | 0,051 | 0,050 | 0,039 | 0,025 | 0,024 | 0,021 | 0,019 |
| 8,5 | 0,068 | 0,080 | 0,061 | 0,051 | 0,055 | 0,058 | 0,051 | 0,032 | 0,030 | 0,025 | 0,022 |
| 8,7 | 0,041 | 0,057 | 0,058 | 0,050 | 0,042 | 0,049 | 0,047 | 0,044 | 0,043 | 0,035 | 0,029 |
| 8,9 | 0,029 | 0,034 | 0,036 | 0,040 | 0,036 | 0,027 | 0,033 | 0,039 | 0,038 | 0,037 | 0,033 |

**Note:**

The normalization current is 43,48A for SOFAR 30000TL-G2
The stated harmonics are maximum values of all 3 phases.

| Test: SOFAR 25000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Order | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 1 | 2,906 | 9,588 | 19,213 | 28,625 | 38,287 | 47,927 | 57,540 | 69,516 | 76,733 | 86,283 | 95,840 |
| 2 | 0,097 | 0,105 | 0,121 | 0,127 | 0,133 | 0,138 | 0,144 | 0,152 | 0,154 | 0,159 | 0,165 |
| 3 | 0,227 | 0,159 | 0,138 | 0,143 | 0,160 | 0,192 | 0,223 | 0,248 | 0,262 | 0,279 | 0,289 |
| 4 | 0,060 | 0,100 | 0,111 | 0,120 | 0,129 | 0,131 | 0,135 | 0,142 | 0,143 | 0,145 | 0,148 |
| 5 | 0,276 | 0,176 | 0,118 | 0,120 | 0,168 | 0,208 | 0,227 | 0,239 | 0,253 | 0,269 | 0,293 |
| 6 | 0,068 | 0,077 | 0,096 | 0,115 | 0,124 | 0,126 | 0,124 | 0,121 | 0,118 | 0,120 | 0,118 |
| 7 | 0,222 | 0,154 | 0,103 | 0,106 | 0,137 | 0,154 | 0,177 | 0,206 | 0,240 | 0,251 | 0,288 |
| 8 | 0,048 | 0,050 | 0,063 | 0,076 | 0,081 | 0,086 | 0,085 | 0,087 | 0,090 | 0,094 | 0,098 |
| 9 | 0,089 | 0,092 | 0,083 | 0,071 | 0,073 | 0,073 | 0,093 | 0,117 | 0,131 | 0,147 | 0,164 |
| 10 | 0,045 | 0,044 | 0,046 | 0,048 | 0,048 | 0,048 | 0,049 | 0,051 | 0,051 | 0,053 | 0,058 |
| 11 | 0,129 | 0,204 | 0,099 | 0,069 | 0,108 | 0,127 | 0,140 | 0,183 | 0,208 | 0,244 | 0,267 |
| 12 | 0,051 | 0,039 | 0,036 | 0,035 | 0,036 | 0,038 | 0,040 | 0,041 | 0,042 | 0,044 | 0,046 |
| 13 | 0,143 | 0,162 | 0,080 | 0,053 | 0,085 | 0,102 | 0,121 | 0,140 | 0,155 | 0,165 | 0,176 |
| 14 | 0,041 | 0,038 | 0,037 | 0,036 | 0,037 | 0,038 | 0,038 | 0,036 | 0,035 | 0,034 | 0,034 |
| 15 | 0,072 | 0,044 | 0,042 | 0,052 | 0,068 | 0,069 | 0,078 | 0,089 | 0,096 | 0,109 | 0,111 |
| 16 | 0,037 | 0,038 | 0,035 | 0,035 | 0,036 | 0,037 | 0,036 | 0,035 | 0,036 | 0,036 | 0,037 |
| 17 | 0,116 | 0,140 | 0,081 | 0,052 | 0,048 | 0,070 | 0,091 | 0,114 | 0,124 | 0,135 | 0,141 |
| 18 | 0,041 | 0,041 | 0,039 | 0,039 | 0,038 | 0,037 | 0,036 | 0,036 | 0,035 | 0,031 | 0,030 |
| 19 | 0,089 | 0,109 | 0,065 | 0,046 | 0,040 | 0,060 | 0,081 | 0,097 | 0,106 | 0,119 | 0,135 |
| 20 | 0,042 | 0,043 | 0,041 | 0,041 | 0,041 | 0,040 | 0,039 | 0,038 | 0,035 | 0,034 | 0,032 |
| 21 | 0,056 | 0,044 | 0,039 | 0,039 | 0,052 | 0,062 | 0,065 | 0,072 | 0,074 | 0,074 | 0,076 |
| 22 | 0,035 | 0,034 | 0,034 | 0,033 | 0,032 | 0,032 | 0,033 | 0,032 | 0,032 | 0,031 | 0,031 |
| 23 | 0,087 | 0,080 | 0,057 | 0,050 | 0,040 | 0,050 | 0,067 | 0,078 | 0,081 | 0,093 | 0,099 |
| 24 | 0,036 | 0,036 | 0,036 | 0,034 | 0,033 | 0,033 | 0,030 | 0,030 | 0,029 | 0,028 | 0,027 |
| 25 | 0,055 | 0,083 | 0,050 | 0,046 | 0,039 | 0,043 | 0,059 | 0,069 | 0,072 | 0,077 | 0,085 |
| 26 | 0,030 | 0,031 | 0,031 | 0,031 | 0,032 | 0,031 | 0,031 | 0,030 | 0,029 | 0,029 | 0,029 |
| 27 | 0,040 | 0,037 | 0,037 | 0,035 | 0,038 | 0,040 | 0,046 | 0,052 | 0,055 | 0,058 | 0,058 |
| 28 | 0,033 | 0,034 | 0,033 | 0,034 | 0,033 | 0,032 | 0,031 | 0,032 | 0,032 | 0,031 | 0,029 |
| 29 | 0,075 | 0,095 | 0,056 | 0,047 | 0,041 | 0,038 | 0,052 | 0,059 | 0,061 | 0,064 | 0,066 |
| 30 | 0,032 | 0,032 | 0,032 | 0,030 | 0,030 | 0,030 | 0,030 | 0,030 | 0,028 | 0,027 | 0,025 |
| 31 | 0,079 | 0,099 | 0,053 | 0,043 | 0,034 | 0,035 | 0,048 | 0,056 | 0,060 | 0,068 | 0,071 |
| 32 | 0,032 | 0,031 | 0,031 | 0,030 | 0,031 | 0,031 | 0,032 | 0,032 | 0,030 | 0,031 | 0,029 |
| 33 | 0,034 | 0,035 | 0,034 | 0,035 | 0,034 | 0,038 | 0,041 | 0,044 | 0,044 | 0,044 | 0,044 |
| 34 | 0,033 | 0,032 | 0,031 | 0,031 | 0,031 | 0,030 | 0,030 | 0,031 | 0,030 | 0,030 | 0,028 |
| 35 | 0,043 | 0,088 | 0,054 | 0,045 | 0,040 | 0,036 | 0,044 | 0,050 | 0,055 | 0,067 | 0,074 |
| 36 | 0,036 | 0,035 | 0,032 | 0,030 | 0,029 | 0,029 | 0,028 | 0,027 | 0,026 | 0,025 | 0,027 |
| 37 | 0,040 | 0,073 | 0,043 | 0,037 | 0,039 | 0,034 | 0,040 | 0,043 | 0,044 | 0,048 | 0,051 |
| 38 | 0,032 | 0,033 | 0,033 | 0,034 | 0,034 | 0,033 | 0,034 | 0,033 | 0,033 | 0,032 | 0,031 |
| 39 | 0,035 | 0,033 | 0,031 | 0,031 | 0,032 | 0,032 | 0,032 | 0,034 | 0,033 | 0,034 | 0,035 |
| 40 | 0,034 | 0,035 | 0,035 | 0,035 | 0,034 | 0,034 | 0,033 | 0,032 | 0,032 | 0,031 | 0,029 |

| Interharmonics : SOFAR 20000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| f [Hz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 75 | 0,214 | 0,280 | 0,324 | 0,356 | 0,382 | 0,393 | 0,415 | 0,440 | 0,453 | 0,473 | 0,496 |
| 125 | 0,152 | 0,270 | 0,336 | 0,361 | 0,373 | 0,377 | 0,378 | 0,380 | 0,382 | 0,385 | 0,390 |
| 175 | 0,113 | 0,219 | 0,307 | 0,348 | 0,358 | 0,362 | 0,374 | 0,379 | 0,379 | 0,382 | 0,387 |
| 225 | 0,089 | 0,185 | 0,244 | 0,292 | 0,311 | 0,315 | 0,330 | 0,348 | 0,354 | 0,359 | 0,363 |
| 275 | 0,082 | 0,127 | 0,182 | 0,202 | 0,210 | 0,227 | 0,236 | 0,232 | 0,233 | 0,242 | 0,254 |
| 325 | 0,081 | 0,090 | 0,137 | 0,151 | 0,150 | 0,154 | 0,159 | 0,168 | 0,180 | 0,191 | 0,205 |
| 375 | 0,062 | 0,065 | 0,117 | 0,112 | 0,105 | 0,103 | 0,102 | 0,100 | 0,094 | 0,099 | 0,108 |
| 425 | 0,060 | 0,066 | 0,092 | 0,086 | 0,077 | 0,076 | 0,078 | 0,080 | 0,085 | 0,093 | 0,104 |
| 475 | 0,052 | 0,061 | 0,069 | 0,064 | 0,058 | 0,060 | 0,063 | 0,066 | 0,066 | 0,067 | 0,069 |
| 525 | 0,051 | 0,059 | 0,058 | 0,054 | 0,054 | 0,056 | 0,060 | 0,066 | 0,070 | 0,074 | 0,079 |
| 575 | 0,055 | 0,052 | 0,050 | 0,052 | 0,055 | 0,057 | 0,058 | 0,057 | 0,055 | 0,056 | 0,054 |
| 625 | 0,055 | 0,053 | 0,046 | 0,046 | 0,047 | 0,048 | 0,047 | 0,048 | 0,048 | 0,049 | 0,049 |
| 675 | 0,052 | 0,049 | 0,044 | 0,049 | 0,048 | 0,047 | 0,046 | 0,046 | 0,045 | 0,045 | 0,045 |
| 725 | 0,047 | 0,047 | 0,045 | 0,050 | 0,048 | 0,046 | 0,045 | 0,044 | 0,044 | 0,044 | 0,044 |
| 775 | 0,047 | 0,049 | 0,048 | 0,048 | 0,046 | 0,043 | 0,043 | 0,043 | 0,042 | 0,042 | 0,042 |
| 825 | 0,046 | 0,046 | 0,045 | 0,046 | 0,041 | 0,041 | 0,040 | 0,040 | 0,039 | 0,040 | 0,040 |
| 875 | 0,049 | 0,047 | 0,047 | 0,045 | 0,044 | 0,044 | 0,044 | 0,042 | 0,042 | 0,041 | 0,040 |
| 925 | 0,047 | 0,044 | 0,044 | 0,043 | 0,041 | 0,042 | 0,042 | 0,041 | 0,041 | 0,041 | 0,040 |
| 975 | 0,048 | 0,046 | 0,043 | 0,042 | 0,043 | 0,042 | 0,043 | 0,041 | 0,040 | 0,040 | 0,039 |
| 1025 | 0,050 | 0,049 | 0,047 | 0,046 | 0,046 | 0,046 | 0,044 | 0,043 | 0,042 | 0,041 | 0,039 |
| 1075 | 0,047 | 0,048 | 0,047 | 0,048 | 0,047 | 0,046 | 0,044 | 0,043 | 0,042 | 0,041 | 0,038 |
| 1125 | 0,044 | 0,043 | 0,041 | 0,041 | 0,040 | 0,039 | 0,038 | 0,037 | 0,036 | 0,036 | 0,035 |
| 1175 | 0,045 | 0,045 | 0,043 | 0,044 | 0,042 | 0,042 | 0,041 | 0,040 | 0,039 | 0,039 | 0,038 |
| 1225 | 0,042 | 0,042 | 0,041 | 0,041 | 0,039 | 0,039 | 0,038 | 0,038 | 0,036 | 0,037 | 0,037 |
| 1275 | 0,044 | 0,042 | 0,040 | 0,039 | 0,039 | 0,040 | 0,042 | 0,049 | 0,048 | 0,046 | 0,044 |
| 1325 | 0,043 | 0,042 | 0,041 | 0,040 | 0,040 | 0,040 | 0,040 | 0,039 | 0,039 | 0,038 | 0,037 |
| 1375 | 0,047 | 0,046 | 0,045 | 0,043 | 0,044 | 0,042 | 0,042 | 0,041 | 0,040 | 0,040 | 0,038 |
| 1425 | 0,043 | 0,042 | 0,042 | 0,042 | 0,041 | 0,040 | 0,039 | 0,038 | 0,036 | 0,036 | 0,035 |
| 1475 | 0,042 | 0,043 | 0,041 | 0,040 | 0,039 | 0,039 | 0,037 | 0,037 | 0,036 | 0,036 | 0,036 |
| 1525 | 0,042 | 0,040 | 0,039 | 0,039 | 0,039 | 0,038 | 0,037 | 0,036 | 0,036 | 0,035 | 0,035 |
| 1575 | 0,041 | 0,041 | 0,040 | 0,039 | 0,040 | 0,039 | 0,038 | 0,039 | 0,038 | 0,038 | 0,037 |
| 1625 | 0,039 | 0,039 | 0,040 | 0,041 | 0,039 | 0,040 | 0,041 | 0,040 | 0,040 | 0,039 | 0,037 |
| 1675 | 0,042 | 0,045 | 0,044 | 0,043 | 0,043 | 0,042 | 0,041 | 0,041 | 0,040 | 0,038 | 0,035 |
| 1725 | 0,042 | 0,042 | 0,040 | 0,039 | 0,039 | 0,038 | 0,038 | 0,039 | 0,037 | 0,037 | 0,038 |
| 1775 | 0,043 | 0,042 | 0,042 | 0,041 | 0,041 | 0,040 | 0,039 | 0,039 | 0,039 | 0,037 | 0,036 |
| 1825 | 0,041 | 0,041 | 0,039 | 0,039 | 0,038 | 0,037 | 0,037 | 0,037 | 0,036 | 0,037 | 0,036 |
| 1875 | 0,043 | 0,043 | 0,043 | 0,042 | 0,041 | 0,040 | 0,040 | 0,040 | 0,040 | 0,039 | 0,038 |
| 1925 | 0,039 | 0,039 | 0,038 | 0,038 | 0,038 | 0,038 | 0,038 | 0,038 | 0,037 | 0,037 | 0,037 |
| 1975 | 0,042 | 0,043 | 0,043 | 0,042 | 0,041 | 0,041 | 0,041 | 0,041 | 0,041 | 0,041 | 0,040 |

| Higher Frequencies : SOFAR 20000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| f [kHz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 2,1 | 1,270 | 1,032 | 0,754 | 0,743 | 0,712 | 0,795 | 0,840 | 0,812 | 0,678 | 0,621 | 0,533 |
| 2,3 | 4,399 | 5,220 | 3,547 | 2,936 | 2,688 | 2,304 | 2,042 | 2,088 | 2,133 | 2,121 | 2,081 |
| 2,5 | 1,969 | 2,346 | 3,575 | 3,153 | 2,797 | 2,756 | 2,562 | 2,268 | 1,540 | 1,408 | 1,210 |
| 2,7 | 3,050 | 2,126 | 1,802 | 1,814 | 1,473 | 1,252 | 1,207 | 1,127 | 0,830 | 0,744 | 0,613 |
| 2,9 | 6,549 | 7,872 | 6,148 | 9,851 | 7,721 | 4,732 | 2,820 | 2,635 | 2,525 | 2,438 | 2,234 |
| 3,1 | 4,360 | 7,335 | 8,719 | 6,728 | 8,558 | 11,654 | 8,612 | 5,824 | 1,982 | 1,698 | 1,284 |
| 3,3 | 1,698 | 1,836 | 1,796 | 1,802 | 2,047 | 3,240 | 4,534 | 4,212 | 2,259 | 1,809 | 1,151 |
| 3,5 | 3,197 | 3,682 | 3,156 | 4,303 | 4,096 | 3,724 | 4,684 | 9,131 | 9,483 | 7,558 | 4,620 |
| 3,7 | 1,478 | 0,984 | 1,989 | 1,339 | 1,013 | 1,886 | 2,703 | 3,356 | 3,724 | 5,037 | 4,220 |
| 3,9 | 1,005 | 0,847 | 0,840 | 0,692 | 0,598 | 0,610 | 0,829 | 1,250 | 1,433 | 1,993 | 3,068 |
| 4,1 | 2,579 | 1,554 | 2,138 | 1,711 | 1,208 | 0,959 | 0,810 | 1,417 | 2,235 | 3,663 | 6,471 |
| 4,3 | 1,239 | 1,520 | 1,293 | 0,840 | 0,647 | 0,976 | 1,076 | 1,013 | 0,863 | 1,063 | 1,534 |
| 4,5 | 1,081 | 0,913 | 0,789 | 0,569 | 0,421 | 0,429 | 0,424 | 0,502 | 0,534 | 0,636 | 0,808 |
| 4,7 | 1,647 | 1,933 | 1,930 | 1,458 | 0,946 | 0,653 | 0,476 | 0,694 | 0,960 | 1,229 | 1,524 |
| 4,9 | 0,805 | 1,800 | 1,479 | 0,922 | 0,534 | 0,770 | 0,753 | 0,670 | 0,470 | 0,533 | 0,679 |
| 5,1 | 0,473 | 0,665 | 0,887 | 0,734 | 0,464 | 0,397 | 0,340 | 0,342 | 0,350 | 0,394 | 0,475 |
| 5,3 | 0,382 | 1,022 | 1,806 | 1,419 | 1,032 | 0,736 | 0,405 | 0,483 | 0,671 | 0,785 | 0,873 |
| 5,5 | 0,266 | 0,320 | 0,611 | 0,601 | 0,691 | 0,812 | 0,723 | 0,601 | 0,375 | 0,409 | 0,517 |
| 5,7 | 0,227 | 0,201 | 0,262 | 0,382 | 0,533 | 0,498 | 0,351 | 0,321 | 0,312 | 0,330 | 0,394 |
| 5,9 | 0,252 | 0,222 | 0,307 | 0,359 | 0,737 | 0,747 | 0,492 | 0,423 | 0,563 | 0,611 | 0,634 |
| 6,1 | 0,121 | 0,257 | 0,248 | 0,339 | 0,506 | 0,696 | 0,794 | 0,679 | 0,413 | 0,416 | 0,500 |
| 6,3 | 0,603 | 0,749 | 0,944 | 0,614 | 0,269 | 0,367 | 0,461 | 0,405 | 0,432 | 0,424 | 0,458 |
| 6,5 | 0,112 | 0,210 | 0,274 | 1,227 | 1,556 | 1,404 | 0,814 | 0,669 | 0,549 | 0,599 | 0,604 |
| 6,7 | 0,082 | 0,110 | 0,117 | 0,135 | 0,243 | 1,881 | 2,560 | 2,836 | 1,287 | 1,189 | 1,224 |
| 6,9 | 0,070 | 0,083 | 0,097 | 0,095 | 0,132 | 0,187 | 0,336 | 1,233 | 2,870 | 3,072 | 2,980 |
| 7,1 | 0,052 | 0,083 | 0,116 | 0,106 | 0,120 | 0,178 | 0,195 | 0,343 | 0,424 | 0,478 | 0,828 |
| 7,3 | 0,055 | 0,086 | 0,099 | 0,087 | 0,084 | 0,152 | 0,198 | 0,234 | 0,241 | 0,224 | 0,273 |
| 7,5 | 0,319 | 0,323 | 0,324 | 0,323 | 0,326 | 0,330 | 0,337 | 0,343 | 0,371 | 0,386 | 0,396 |
| 7,7 | 0,066 | 0,108 | 0,098 | 0,090 | 0,086 | 0,110 | 0,118 | 0,127 | 0,159 | 0,168 | 0,182 |
| 7,9 | 0,118 | 0,129 | 0,127 | 0,116 | 0,108 | 0,131 | 0,153 | 0,151 | 0,147 | 0,156 | 0,174 |
| 8,1 | 0,323 | 0,325 | 0,329 | 0,324 | 0,325 | 0,328 | 0,331 | 0,329 | 0,334 | 0,337 | 0,338 |
| 8,3 | 0,114 | 0,115 | 0,094 | 0,073 | 0,065 | 0,087 | 0,100 | 0,094 | 0,101 | 0,095 | 0,109 |
| 8,5 | 0,072 | 0,110 | 0,099 | 0,080 | 0,068 | 0,068 | 0,074 | 0,084 | 0,082 | 0,077 | 0,091 |
| 8,7 | 0,046 | 0,061 | 0,076 | 0,069 | 0,057 | 0,065 | 0,059 | 0,059 | 0,070 | 0,073 | 0,081 |
| 8,9 | 0,041 | 0,045 | 0,045 | 0,042 | 0,051 | 0,061 | 0,053 | 0,048 | 0,055 | 0,054 | 0,068 |

Note:
The normalization current is 36,23A for SOFAR 25000TL-G2
The stated harmonics are maximum values of all 3 phases.

| Test: SOFAR 20000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Order | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 1 | 3,010 | 9,631 | 19,145 | 28,884 | 38,271 | 47,958 | 57,623 | 69,618 | 76,895 | 86,516 | 96,135 |
| 2 | 0,118 | 0,132 | 0,145 | 0,155 | 0,161 | 0,165 | 0,172 | 0,180 | 0,183 | 0,189 | 0,196 |
| 3 | 0,341 | 0,235 | 0,188 | 0,174 | 0,181 | 0,203 | 0,234 | 0,275 | 0,292 | 0,312 | 0,336 |
| 4 | 0,077 | 0,114 | 0,131 | 0,142 | 0,152 | 0,158 | 0,162 | 0,167 | 0,172 | 0,177 | 0,181 |
| 5 | 0,440 | 0,283 | 0,189 | 0,142 | 0,161 | 0,212 | 0,249 | 0,291 | 0,295 | 0,313 | 0,328 |
| 6 | 0,073 | 0,092 | 0,111 | 0,128 | 0,144 | 0,155 | 0,156 | 0,155 | 0,154 | 0,151 | 0,150 |
| 7 | 0,292 | 0,225 | 0,151 | 0,138 | 0,138 | 0,173 | 0,198 | 0,224 | 0,237 | 0,271 | 0,319 |
| 8 | 0,059 | 0,059 | 0,077 | 0,086 | 0,095 | 0,102 | 0,105 | 0,106 | 0,108 | 0,109 | 0,110 |
| 9 | 0,140 | 0,124 | 0,111 | 0,106 | 0,092 | 0,089 | 0,095 | 0,116 | 0,133 | 0,154 | 0,173 |
| 10 | 0,054 | 0,055 | 0,057 | 0,056 | 0,059 | 0,060 | 0,059 | 0,062 | 0,063 | 0,063 | 0,062 |
| 11 | 0,257 | 0,294 | 0,200 | 0,085 | 0,096 | 0,137 | 0,157 | 0,178 | 0,197 | 0,236 | 0,269 |
| 12 | 0,054 | 0,048 | 0,057 | 0,050 | 0,049 | 0,048 | 0,048 | 0,050 | 0,053 | 0,052 | 0,052 |
| 13 | 0,220 | 0,235 | 0,167 | 0,075 | 0,075 | 0,107 | 0,128 | 0,150 | 0,164 | 0,180 | 0,205 |
| 14 | 0,046 | 0,045 | 0,046 | 0,042 | 0,043 | 0,046 | 0,046 | 0,047 | 0,048 | 0,046 | 0,044 |
| 15 | 0,070 | 0,066 | 0,056 | 0,055 | 0,073 | 0,084 | 0,087 | 0,096 | 0,107 | 0,114 | 0,124 |
| 16 | 0,046 | 0,050 | 0,048 | 0,047 | 0,044 | 0,045 | 0,046 | 0,046 | 0,046 | 0,044 | 0,044 |
| 17 | 0,087 | 0,210 | 0,156 | 0,078 | 0,055 | 0,059 | 0,082 | 0,111 | 0,125 | 0,145 | 0,160 |
| 18 | 0,050 | 0,052 | 0,045 | 0,044 | 0,046 | 0,047 | 0,045 | 0,047 | 0,046 | 0,046 | 0,043 |
| 19 | 0,126 | 0,166 | 0,124 | 0,065 | 0,055 | 0,051 | 0,069 | 0,096 | 0,109 | 0,121 | 0,137 |
| 20 | 0,051 | 0,052 | 0,049 | 0,048 | 0,050 | 0,050 | 0,049 | 0,050 | 0,050 | 0,048 | 0,045 |
| 21 | 0,073 | 0,058 | 0,049 | 0,045 | 0,051 | 0,065 | 0,076 | 0,081 | 0,086 | 0,090 | 0,093 |
| 22 | 0,043 | 0,043 | 0,044 | 0,041 | 0,041 | 0,041 | 0,040 | 0,044 | 0,041 | 0,041 | 0,040 |
| 23 | 0,072 | 0,133 | 0,091 | 0,068 | 0,058 | 0,045 | 0,058 | 0,079 | 0,093 | 0,100 | 0,103 |
| 24 | 0,043 | 0,041 | 0,039 | 0,039 | 0,038 | 0,040 | 0,040 | 0,040 | 0,040 | 0,040 | 0,037 |
| 25 | 0,119 | 0,130 | 0,092 | 0,063 | 0,056 | 0,044 | 0,052 | 0,070 | 0,081 | 0,087 | 0,093 |
| 26 | 0,043 | 0,041 | 0,041 | 0,039 | 0,040 | 0,039 | 0,040 | 0,039 | 0,039 | 0,038 | 0,038 |
| 27 | 0,048 | 0,048 | 0,043 | 0,044 | 0,042 | 0,048 | 0,050 | 0,055 | 0,061 | 0,066 | 0,068 |
| 28 | 0,044 | 0,044 | 0,041 | 0,040 | 0,041 | 0,041 | 0,040 | 0,041 | 0,039 | 0,040 | 0,039 |
| 29 | 0,094 | 0,137 | 0,097 | 0,059 | 0,056 | 0,049 | 0,045 | 0,061 | 0,070 | 0,072 | 0,079 |
| 30 | 0,039 | 0,040 | 0,037 | 0,035 | 0,036 | 0,037 | 0,036 | 0,037 | 0,037 | 0,037 | 0,036 |
| 31 | 0,055 | 0,137 | 0,094 | 0,050 | 0,050 | 0,040 | 0,040 | 0,056 | 0,065 | 0,070 | 0,076 |
| 32 | 0,042 | 0,040 | 0,042 | 0,041 | 0,040 | 0,039 | 0,040 | 0,039 | 0,039 | 0,038 | 0,038 |
| 33 | 0,044 | 0,044 | 0,040 | 0,044 | 0,043 | 0,043 | 0,045 | 0,051 | 0,054 | 0,056 | 0,055 |
| 34 | 0,039 | 0,039 | 0,039 | 0,040 | 0,039 | 0,039 | 0,039 | 0,039 | 0,038 | 0,037 | 0,038 |
| 35 | 0,080 | 0,114 | 0,082 | 0,058 | 0,055 | 0,051 | 0,044 | 0,050 | 0,057 | 0,063 | 0,070 |
| 36 | 0,036 | 0,037 | 0,036 | 0,036 | 0,036 | 0,036 | 0,036 | 0,035 | 0,037 | 0,037 | 0,034 |
| 37 | 0,082 | 0,084 | 0,065 | 0,049 | 0,046 | 0,049 | 0,043 | 0,049 | 0,053 | 0,054 | 0,055 |
| 38 | 0,043 | 0,042 | 0,042 | 0,042 | 0,042 | 0,043 | 0,042 | 0,042 | 0,042 | 0,041 | 0,041 |
| 39 | 0,042 | 0,041 | 0,040 | 0,041 | 0,038 | 0,040 | 0,041 | 0,041 | 0,042 | 0,043 | 0,042 |
| 40 | 0,043 | 0,043 | 0,041 | 0,041 | 0,043 | 0,043 | 0,042 | 0,042 | 0,041 | 0,042 | 0,040 |

| Interharmonics : SOFAR 20000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| f [Hz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 75 | 0,265 | 0,329 | 0,384 | 0,421 | 0,448 | 0,468 | 0,485 | 0,519 | 0,528 | 0,544 | 0,566 |
| 125 | 0,181 | 0,304 | 0,394 | 0,433 | 0,456 | 0,466 | 0,470 | 0,476 | 0,472 | 0,473 | 0,478 |
| 175 | 0,137 | 0,244 | 0,343 | 0,413 | 0,439 | 0,448 | 0,451 | 0,462 | 0,472 | 0,474 | 0,477 |
| 225 | 0,104 | 0,210 | 0,276 | 0,330 | 0,373 | 0,388 | 0,394 | 0,409 | 0,421 | 0,435 | 0,443 |
| 275 | 0,096 | 0,144 | 0,207 | 0,246 | 0,254 | 0,264 | 0,280 | 0,294 | 0,291 | 0,285 | 0,289 |
| 325 | 0,081 | 0,096 | 0,156 | 0,183 | 0,189 | 0,186 | 0,191 | 0,197 | 0,203 | 0,210 | 0,226 |
| 375 | 0,073 | 0,073 | 0,130 | 0,147 | 0,139 | 0,128 | 0,128 | 0,131 | 0,126 | 0,121 | 0,119 |
| 425 | 0,076 | 0,075 | 0,107 | 0,113 | 0,106 | 0,096 | 0,093 | 0,098 | 0,099 | 0,100 | 0,105 |
| 475 | 0,064 | 0,074 | 0,083 | 0,082 | 0,075 | 0,071 | 0,073 | 0,077 | 0,081 | 0,083 | 0,082 |
| 525 | 0,064 | 0,078 | 0,074 | 0,070 | 0,067 | 0,068 | 0,071 | 0,075 | 0,079 | 0,082 | 0,086 |
| 575 | 0,063 | 0,067 | 0,065 | 0,065 | 0,067 | 0,069 | 0,070 | 0,072 | 0,070 | 0,069 | 0,070 |
| 625 | 0,065 | 0,072 | 0,062 | 0,057 | 0,059 | 0,061 | 0,060 | 0,060 | 0,059 | 0,058 | 0,061 |
| 675 | 0,065 | 0,065 | 0,061 | 0,059 | 0,061 | 0,061 | 0,060 | 0,059 | 0,058 | 0,057 | 0,056 |
| 725 | 0,063 | 0,065 | 0,060 | 0,060 | 0,060 | 0,057 | 0,058 | 0,057 | 0,056 | 0,054 | 0,054 |
| 775 | 0,063 | 0,062 | 0,061 | 0,062 | 0,062 | 0,057 | 0,057 | 0,056 | 0,054 | 0,054 | 0,052 |
| 825 | 0,058 | 0,059 | 0,057 | 0,057 | 0,055 | 0,052 | 0,051 | 0,051 | 0,050 | 0,050 | 0,050 |
| 875 | 0,061 | 0,061 | 0,058 | 0,055 | 0,055 | 0,055 | 0,055 | 0,056 | 0,055 | 0,054 | 0,052 |
| 925 | 0,056 | 0,056 | 0,057 | 0,056 | 0,054 | 0,052 | 0,053 | 0,054 | 0,054 | 0,051 | 0,052 |
| 975 | 0,055 | 0,057 | 0,057 | 0,052 | 0,052 | 0,053 | 0,055 | 0,053 | 0,052 | 0,052 | 0,050 |
| 1025 | 0,058 | 0,061 | 0,056 | 0,054 | 0,055 | 0,056 | 0,057 | 0,055 | 0,054 | 0,053 | 0,053 |
| 1075 | 0,060 | 0,061 | 0,058 | 0,057 | 0,058 | 0,058 | 0,059 | 0,056 | 0,054 | 0,054 | 0,053 |
| 1125 | 0,052 | 0,053 | 0,053 | 0,050 | 0,050 | 0,049 | 0,049 | 0,048 | 0,048 | 0,049 | 0,046 |
| 1175 | 0,057 | 0,056 | 0,053 | 0,052 | 0,053 | 0,053 | 0,051 | 0,051 | 0,050 | 0,050 | 0,049 |
| 1225 | 0,053 | 0,052 | 0,051 | 0,052 | 0,051 | 0,049 | 0,049 | 0,048 | 0,048 | 0,048 | 0,047 |
| 1275 | 0,056 | 0,054 | 0,054 | 0,052 | 0,052 | 0,051 | 0,051 | 0,053 | 0,057 | 0,061 | 0,060 |
| 1325 | 0,054 | 0,053 | 0,051 | 0,051 | 0,051 | 0,050 | 0,051 | 0,050 | 0,050 | 0,049 | 0,049 |
| 1375 | 0,054 | 0,055 | 0,053 | 0,052 | 0,051 | 0,054 | 0,053 | 0,053 | 0,052 | 0,053 | 0,050 |
| 1425 | 0,054 | 0,055 | 0,051 | 0,051 | 0,050 | 0,051 | 0,050 | 0,050 | 0,048 | 0,047 | 0,046 |
| 1475 | 0,052 | 0,053 | 0,052 | 0,053 | 0,050 | 0,049 | 0,047 | 0,047 | 0,047 | 0,046 | 0,046 |
| 1525 | 0,051 | 0,051 | 0,048 | 0,049 | 0,050 | 0,048 | 0,047 | 0,047 | 0,046 | 0,045 | 0,044 |
| 1575 | 0,053 | 0,052 | 0,050 | 0,049 | 0,050 | 0,049 | 0,050 | 0,049 | 0,049 | 0,048 | 0,048 |
| 1625 | 0,050 | 0,051 | 0,051 | 0,050 | 0,050 | 0,049 | 0,051 | 0,051 | 0,050 | 0,050 | 0,050 |
| 1675 | 0,054 | 0,055 | 0,051 | 0,051 | 0,053 | 0,054 | 0,053 | 0,053 | 0,052 | 0,051 | 0,050 |
| 1725 | 0,052 | 0,052 | 0,053 | 0,052 | 0,050 | 0,050 | 0,049 | 0,049 | 0,049 | 0,047 | 0,046 |
| 1775 | 0,050 | 0,052 | 0,052 | 0,049 | 0,048 | 0,049 | 0,049 | 0,049 | 0,050 | 0,049 | 0,047 |
| 1825 | 0,050 | 0,050 | 0,051 | 0,050 | 0,049 | 0,048 | 0,048 | 0,047 | 0,047 | 0,046 | 0,046 |
| 1875 | 0,055 | 0,053 | 0,051 | 0,051 | 0,051 | 0,051 | 0,051 | 0,051 | 0,051 | 0,050 | 0,050 |
| 1925 | 0,051 | 0,051 | 0,052 | 0,051 | 0,051 | 0,049 | 0,048 | 0,048 | 0,048 | 0,046 | 0,046 |
| 1975 | 0,053 | 0,053 | 0,052 | 0,052 | 0,051 | 0,051 | 0,051 | 0,052 | 0,051 | 0,051 | 0,052 |

| Higher Frequencies : SOFAR 20000TL-G2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P/P_n$ [%] | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| f [kHz] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] | I [%] |
| 2,1 | 1,389 | 1,247 | 1,021 | 0,808 | 0,849 | 0,871 | 0,991 | 1,050 | 1,059 | 0,989 | 0,890 |
| 2,3 | 6,276 | 4,943 | 3,352 | 4,522 | 4,036 | 3,260 | 2,892 | 2,573 | 2,568 | 2,606 | 2,665 |
| 2,5 | 3,181 | 7,201 | 6,998 | 4,324 | 3,371 | 3,479 | 3,438 | 3,353 | 2,954 | 2,590 | 2,130 |
| 2,7 | 4,119 | 3,395 | 2,963 | 2,553 | 2,285 | 1,633 | 1,530 | 1,540 | 1,456 | 1,324 | 1,134 |
| 2,9 | 6,339 | 17,759 | 16,249 | 11,891 | 10,893 | 8,338 | 6,015 | 3,736 | 3,323 | 3,211 | 3,173 |
| 3,1 | 4,813 | 5,049 | 11,937 | 8,047 | 7,130 | 10,725 | 14,325 | 12,772 | 7,759 | 5,386 | 3,213 |
| 3,3 | 1,783 | 2,326 | 2,566 | 2,301 | 2,410 | 2,541 | 3,605 | 5,352 | 5,620 | 4,871 | 3,542 |
| 3,5 | 3,896 | 3,163 | 6,856 | 4,937 | 5,634 | 5,067 | 4,657 | 5,435 | 7,615 | 12,526 | 12,103 |
| 3,7 | 1,707 | 3,022 | 2,587 | 2,079 | 1,355 | 1,249 | 2,103 | 3,165 | 3,659 | 4,146 | 4,629 |
| 3,9 | 1,133 | 1,190 | 1,148 | 0,872 | 0,713 | 0,724 | 0,754 | 0,954 | 1,218 | 1,587 | 1,789 |
| 4,1 | 2,168 | 3,661 | 3,614 | 2,103 | 1,611 | 1,470 | 1,206 | 0,986 | 1,148 | 1,711 | 2,821 |
| 4,3 | 1,649 | 1,578 | 1,661 | 1,290 | 0,843 | 0,786 | 1,140 | 1,314 | 1,300 | 1,182 | 1,097 |
| 4,5 | 1,203 | 1,182 | 0,987 | 0,746 | 0,593 | 0,506 | 0,555 | 0,529 | 0,574 | 0,630 | 0,658 |
| 4,7 | 2,501 | 2,222 | 1,870 | 1,496 | 1,298 | 1,087 | 0,800 | 0,574 | 0,639 | 0,857 | 1,209 |
| 4,9 | 0,863 | 2,210 | 2,198 | 1,489 | 0,827 | 0,648 | 0,920 | 0,964 | 0,868 | 0,744 | 0,628 |
| 5,1 | 0,572 | 0,786 | 0,917 | 0,913 | 0,726 | 0,481 | 0,507 | 0,433 | 0,425 | 0,429 | 0,422 |
| 5,3 | 0,557 | 1,087 | 1,277 | 2,282 | 1,805 | 1,238 | 0,887 | 0,550 | 0,484 | 0,590 | 0,852 |
| 5,5 | 0,348 | 0,620 | 0,965 | 1,186 | 0,975 | 0,823 | 0,969 | 0,966 | 0,787 | 0,635 | 0,523 |
| 5,7 | 0,251 | 0,343 | 0,349 | 0,496 | 0,600 | 0,667 | 0,622 | 0,479 | 0,421 | 0,386 | 0,369 |
| 5,9 | 0,233 | 0,413 | 0,453 | 0,568 | 0,564 | 1,007 | 0,985 | 0,745 | 0,498 | 0,504 | 0,720 |
| 6,1 | 0,154 | 0,310 | 0,339 | 0,383 | 0,466 | 0,690 | 0,890 | 0,957 | 0,896 | 0,745 | 0,629 |
| 6,3 | 0,791 | 0,902 | 1,084 | 1,362 | 0,426 | 0,390 | 0,489 | 0,578 | 0,655 | 0,558 | 0,472 |
| 6,5 | 0,145 | 0,229 | 0,275 | 1,133 | 1,800 | 2,237 | 2,582 | 1,494 | 1,361 | 1,180 | 0,986 |
| 6,7 | 0,104 | 0,166 | 0,172 | 0,163 | 0,188 | 0,343 | 0,607 | 3,241 | 3,785 | 3,869 | 3,939 |
| 6,9 | 0,076 | 0,111 | 0,117 | 0,106 | 0,128 | 0,167 | 0,215 | 0,352 | 0,459 | 0,513 | 1,098 |
| 7,1 | 0,074 | 0,173 | 0,154 | 0,123 | 0,117 | 0,153 | 0,228 | 0,251 | 0,265 | 0,446 | 0,441 |
| 7,3 | 0,070 | 0,108 | 0,133 | 0,109 | 0,102 | 0,111 | 0,158 | 0,256 | 0,282 | 0,322 | 0,343 |
| 7,5 | 0,410 | 0,412 | 0,418 | 0,417 | 0,416 | 0,417 | 0,418 | 0,422 | 0,424 | 0,424 | 0,431 |
| 7,7 | 0,074 | 0,124 | 0,134 | 0,115 | 0,103 | 0,104 | 0,140 | 0,157 | 0,154 | 0,167 | 0,203 |
| 7,9 | 0,160 | 0,161 | 0,169 | 0,158 | 0,149 | 0,145 | 0,163 | 0,190 | 0,197 | 0,196 | 0,203 |
| 8,1 | 0,417 | 0,417 | 0,423 | 0,426 | 0,417 | 0,414 | 0,414 | 0,421 | 0,415 | 0,414 | 0,411 |
| 8,3 | 0,142 | 0,142 | 0,131 | 0,104 | 0,083 | 0,079 | 0,104 | 0,127 | 0,124 | 0,122 | 0,122 |
| 8,5 | 0,082 | 0,116 | 0,114 | 0,097 | 0,083 | 0,085 | 0,084 | 0,095 | 0,101 | 0,111 | 0,102 |
| 8,7 | 0,060 | 0,074 | 0,077 | 0,087 | 0,082 | 0,067 | 0,081 | 0,079 | 0,071 | 0,077 | 0,077 |
| 8,9 | 0,049 | 0,078 | 0,080 | 0,059 | 0,054 | 0,063 | 0,078 | 0,074 | 0,061 | 0,063 | 0,063 |

**Note:**
The normalization current is 28,99A for SOFAR 20000TL-G2
The stated harmonics are maximum values of all 3 phases.

| 5.2 Verification of the symmetry characteristics of three-phase inverter modules<br>DIN VDE V 0124-100:2012-07 | | | |
|---|---|---|---|
| **Clause** | **Test** | | **Result** |
| 5.2.1 | General | | **P** |
| 5.2.2 | Test in the test laboratory: | | **P** |
| | 5.2.2.1 | Calculation of asymmetry | **P** |
| | 5.2.2 | Additional tests for communicatively coupled inverter modules | **N/A** |
| | 5.2.2.1 | Failure of individual inverter modules | **N/A** |
| | 5.2.2.2 | Power drop of individual inverter modules | **N/A** |
| 5.2.3 | Tests in the field | | **N/A** |

| | |
|---|---|
| **5.2.1 General**<br>These tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.5 and 5.6 are met. | **P** |
| The phase angles are specified by the distribution network and so only the power symmetry is discussed. | |
| **Note:** | |

| | | |
|---|---|---|
| **5.2.2 Test in the test laboratory** | | **P** |
| Test Condition: | The measurements were performed in the testing laboratory.<br>at the grid-simulator:<br>$U_N$ = between 86 % Un and 109% Un until the test<br>Frequency: 50 Hz +/- 0,5% | |
| Note:<br>If an examination is required for any other requirements, these apply to this test. | | |

| 5.2.2.1 Calculation of asymmetry | | | | | | P |
|---|---|---|---|---|---|---|
| Setting values | cos φ = 1: | | 1,00 | | | |
| | cos φ over-excited: | | 0,80 | | | |
| | cos φ under-excited: | | 0,80 | | | |
| **Test:** | | | | | | |
| 1-min mean value | L1 | L2 | L3 | L1 – L2 | L2 – L3 | L3 – L1 |
| a) cos φ = 1 at 100 % $P_n$ ± 5 % $P_{Emax}$ | | | | | | |
| $S_{E60}$ [kVA]: | 4,902 | 4,934 | 4,901 | -0,032 | 0,033 | 0,000 |
| | 4,900 | 4,933 | 4,900 | -0,033 | 0,033 | 0,000 |
| | 4,901 | 4,933 | 4,900 | -0,032 | 0,033 | -0,001 |
| | 4,900 | 4,933 | 4,900 | -0,033 | 0,033 | 0,000 |
| | 4,900 | 4,932 | 4,900 | -0,032 | 0,033 | -0,001 |
| cos $φ_{E60}$: | 0,995 | | | | | |
| max. asymmetry [kVA]: | -0,033 | | | | | |
| b) maximum under-excited (i) at 100 % $P_n$ ± 5 % $P_{Emax}$ | | | | | | |
| $S_{E60}$ [kVA]: | 5,391 | 5,361 | 5,337 | 0,030 | 0,025 | -0,055 |
| | 5,390 | 5,360 | 5,336 | 0,030 | 0,025 | -0,054 |
| | 5,390 | 5,360 | 5,335 | 0,030 | 0,024 | -0,054 |
| | 5,392 | 5,361 | 5,337 | 0,030 | 0,024 | -0,054 |
| | 5,390 | 5,360 | 5,335 | 0,030 | 0,024 | -0,054 |
| cos $φ_{E60}$: | 0,794 | | | | | |
| max. asymmetry [kVA]: | -0,055 | | | | | |
| c) maximum over-excited (c) at 100 % $P_n$ ± 5 % $P_{Emax}$ | | | | | | |
| $S_{E60}$ [kVA]: | 5,452 | 5,484 | 5,485 | -0,032 | 0,000 | 0,033 |
| | 5,451 | 5,483 | 5,484 | -0,033 | -0,001 | 0,033 |
| | 5,451 | 5,484 | 5,485 | -0,033 | -0,001 | 0,034 |
| | 5,452 | 5,485 | 5,486 | -0,033 | -0,001 | 0,034 |
| | 5,452 | 5,485 | 5,486 | -0,033 | -0,001 | 0,034 |
| cos $φ_{E60}$: | 0,796 | | | | | |
| max. asymmetry [kVA]: | 0,034 | | | | | |
| d) cos φ = 1 at 50 % $P_n$ ± 5 % $P_{Emax}$ | | | | | | |
| $S_{E60}$ [kVA]: | 2,480 | 2,515 | 2,480 | -0,035 | 0,035 | 0,000 |
| | 2,480 | 2,515 | 2,480 | -0,035 | 0,035 | 0,000 |
| | 2,480 | 2,516 | 2,480 | -0,036 | 0,036 | 0,000 |
| | 2,480 | 2,516 | 2,480 | -0,036 | 0,036 | 0,000 |
| | 2,480 | 2,514 | 2,480 | -0,034 | 0,034 | 0,000 |
| cos $φ_{E60}$: | 0,999 | | | | | |
| max. asymmetry [kVA]: | 0,036 | | | | | |

| e) maximum under-excited (i) at 50 % $P_n$ ± 5 % $P_{Emax}$ | | | | | | |
|---|---|---|---|---|---|---|
| $S_{E60}$ [kVA]: | 3,107 | 3,146 | 3,107 | -0,039 | 0,039 | 0,000 |
| | 3,105 | 3,144 | 3,105 | -0,039 | 0,039 | 0,000 |
| | 3,106 | 3,145 | 3,106 | -0,039 | 0,039 | 0,000 |
| | 3,106 | 3,144 | 3,106 | -0,039 | 0,039 | 0,000 |
| | 3,105 | 3,145 | 3,105 | -0,040 | 0,040 | 0,000 |
| cos $\varphi_{E60}$: | 0,791 | | | | | |
| max. asymmetry [kVA]: | 0,040 | | | | | |
| f) maximum over-excited (c) at 50 % $P_n$ ± 5 % $P_{Emax}$ | | | | | | |
| $S_{E60}$ [kVA]: | 3,050 | 3,092 | 3,050 | -0,042 | 0,042 | 0,000 |
| | 3,047 | 3,089 | 3,047 | -0,042 | 0,042 | 0,000 |
| | 3,047 | 3,089 | 3,047 | -0,042 | 0,042 | 0,000 |
| | 3,046 | 3,089 | 3,046 | -0,042 | 0,042 | 0,000 |
| | 3,046 | 3,088 | 3,046 | -0,042 | 0,042 | 0,000 |
| cos $\varphi_{E60}$: | 0,808 | | | | | |
| max. asymmetry [kVA]: | 0,042 | | | | | |
| **Limit [kVA]:** | ≤ 5 % $S_{Emax}$ and 4,6 kVA | | | | | |

**Test:**
The maximum absolute difference between the apparent powers of the three phases is determined for each of the five measurements (1-min means) in the respective operating point. The maximum of these five values is again determined.

**Assessment criterion:**
The test is passed if the maximum value from the above measurements does not exceed 5 % $S_{Emax}$ and 4,6 kVA.

**Note:**
The maximum inductive and capacitive values are specified by the manufacturer.

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

| **5.3 Verification of the characteristics of the power generation unit on the network<br>DIN VDE V 0124-100:2012-07** | | | |
|---|---|---|---|
| **Clause** | **Test** | | **Result** |
| 5.3.1 | General | | **P** |
| 5.3.2 | Measurement of the active reactive power range | | **P** |
| 5.3.3 | Active power reduction by specifying setpoints | | **P** |
| | 5.3.3.1 | Setpoint control | **P** |
| | 5.3.3.2 | Measurement of setting accuracy | **P** |
| | 5.3.3.3 | Measurement of setting time | **P** |
| 5.3.4 | Active power feed-in for overfrequency | | **P** |
| | 5.3.4.1.1 | Test cycle for adjustable/conditionally adjustable PGUs | **P** |
| | 5.3.4.1.2 | Test cycle for all PGUs (adjustable, conditionally adjustable and non-adjustable PGUs) | **P** |
| 5.3.5 | Active power feed-in for underfrequency | | **P** |
| 5.3.6 | Reactive power output | | **P** |
| | 5.3.6.1 | Tests of the cos φ setting accuracy | **P** |
| | 5.3.6.4 | Test for a displacement factor/<br>active power characteristic curve cos φ (P) | **P** |

| | | |
|---|---|---|
| **5.3.1 General**<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7 are met) | | **P** |
| Test Condition: | The measurements were performed in the testing laboratory.<br>at the grid-simulator:<br>$U_N$ = between 86 % Un and 109% Un until the test<br>Frequency: 50 Hz +/- 0,5% | |
| **Note:**<br>If an examination is required for any other requirements, these apply to this test. | | |

| | | | |
|---|---|---|---|
| **5.3.2 Measurement of the active power and reactive power range** (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7.5 are met) | | | **P** |

| | | |
|---|---|---|
| Setting values | cos φ = 1: | 1,00 |
| | cos φ max. over-excited: | 0,80 |
| | cos φ max. under-excited: | 0,80 |

| | | |
|---|---|---|
| **Test: SOFAR 33000TL-G2** | | |
| 600 s mean value | $U_n$ | 1,09 $U_n$ |
| a) cos φ 1 at 100% $P_{Emax}$ | | |
| U [V]: | 230,14 | 250,82 |
| $P_{Emax600\ a)}$ [kW] | 33,060 | 33,010 |
| $S_{Emax600\ a)}$ [kVa] | 33,066 | 33,016 |
| cos $\varphi_{Emax600}$ | 0,999 | 0,999 |
| b) maximum under-excited (i) at 100% $P_{Emax}$ | | |
| U [V]: | 229,95 | 250,78 |
| $P_{Emax600\ b)}$ [kW] | 29,763 | 29,715 |
| $S_{Emax600\ b)}$ [kVa] | 36,933 | 36,863 |
| cos $\varphi_{Emax600-under-excited}$ | 0,806 | 0,806 |
| c) maximum over-excited (c) at 100% $P_{Emax}$ | | |
| U [V]: | 229,95 | 250,71 |
| $P_{Emax600\ c)}$ [kW] | 29,763 | 29,080 |
| $S_{Emax600\ c)}$ [kVa] | 36,933 | 36,179 |
| cos $\varphi_{Emax600-over-excited}$ | 0,806 | 0,804 |
| d) maximum under-excited (i) at 20-30% $P_{Emax}$ | | |
| U [V]: | 230,04 | 250,72 |
| $P_{Emax60\ d)}$ [kW] | 8,243 | 8,265 |
| $S_{Emax60\ d)}$ [kVa] | 10,252 | 10,289 |
| cos $\varphi_{Emax60-over-excited}$ | 0,804 | 0,803 |
| e) maximum over-excited (c) at 20-30% $P_{Emax}$ | | |
| U [V]: | 229,61 | 250,72 |
| $P_{Emax60\ e)}$ [kW] | 8,254 | 8,262 |
| $S_{Emax60\ e)}$ [kVa] | 10,207 | 10,203 |
| cos $\varphi_{Emax60-over-excited}$ | 0,809 | 0,809 |

| | |
|---|---|
| $S_{Emax600}$ and $P_{Emax\ 600}$ | |
| $S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$) [kVa] | 36,933 |
| $P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$) [kW] | 33,060 |

| Test: SOFAR 30000TL-G2 | | |
|---|---|---|
| 600 s mean value | $U_n$ | 1,09 $U_n$ |
| a) cos φ 1 at 100% $P_{Emax}$ | | |
| U [V]: | 229,90 | 250,75 |
| $P_{Emax600\ a)}$ [kW] | 33,029 | 30,076 |
| $S_{Emax600\ a)}$ [kVa] | 33,039 | 30,086 |
| cos $\varphi_{Emax600}$ | 0,999 | 0,999 |
| b) maximum under-excited (i) at 100% $P_{Emax}$ | | |
| U [V]: | 230,27 | 250,72 |
| $P_{Emax600\ b)}$ [kW] | 29,496 | 29,137 |
| $S_{Emax600\ b)}$ [kVa] | 36,858 | 36,239 |
| cos $\varphi_{Emax600-under-excited}$ | 0,800 | 0,804 |
| c) maximum over-excited (c) at 100% $P_{Emax}$ | | |
| U [V]: | 230,01 | 250,80 |
| $P_{Emax600\ c)}$ [kW] | 29,253 | 29,406 |
| $S_{Emax600\ c)}$ [kVa] | 36,393 | 36,735 |
| cos $\varphi_{Emax600-over-excited}$ | 0,804 | 0,801 |
| d) maximum under-excited (i) at 20-30% $P_{Emax}$ | | |
| U [V]: | 230,12 | 250,87 |
| $P_{Emax60\ d)}$ [kW] | 7,476 | 7,490 |
| S $_{Emax60\ d)}$ [kVa] | 9,375 | 9,403 |
| cos $\varphi_{Emax60-over-excited}$ | 0,797 | 0,797 |
| e) maximum over-excited (c) at 20-30% $P_{Emax}$ | | |
| U [V]: | 229,76 | 250,72 |
| $P_{Emax60\ e)}$ [kW] | 7,505 | 7,516 |
| $S_{Emax60\ e)}$ [kVa] | 9,272 | 9,427 |
| cos $\varphi_{Emax60-over-excited}$ | 0,809 | 0,797 |
| $S_{Emax600}$ and $P_{Emax\ 600}$ | | |
| $S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$) [kVa] | 36,858 | |
| $P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$) [kW] | 30,076 | |

| **Test: SOFAR 25000TL-G2** | | |
|---|---|---|
| 600 s mean value | $U_n$ | 1,09 $U_n$ |
| a) cos φ 1 at 100% $P_{Emax}$ | | |
| U [V]: | 229,91 | 250,80 |
| $P_{Emax600\ a)}$ [kW] | 25,020 | 25,045 |
| $S_{Emax600\ a)}$ [kVa] | 25,030 | 25,057 |
| cos $φ_{Emax600}$ | 0,999 | 0,999 |
| b) maximum under-excited (i) at 100% $P_{Emax}$ | | |
| U [V]: | 230,21 | 250,86 |
| $P_{Emax600\ b)}$ [kW] | 25,022 | 24,977 |
| $S_{Emax600\ b)}$ [kVa] | 31,256 | 31,204 |
| cos $φ_{Emax600-under-excited}$ | 0,801 | 0,800 |
| c) maximum over-excited (c) at 100% $P_{Emax}$ | | |
| U [V]: | 229,66 | 250,74 |
| $P_{Emax600\ c)}$ [kW] | 25,069 | 25,027 |
| $S_{Emax600\ c)}$ [kVa] | 31,190 | 31,099 |
| cos $φ_{Emax600-over-excited}$ | 0,804 | 0,805 |
| d) maximum under-excited (i) at 20-30% $P_{Emax}$ | | |
| U [V]: | 230,11 | 250,77 |
| $P_{Emax60\ d)}$ [kW] | 6,259 | 6,244 |
| $S_{Emax60\ d)}$ [kVa] | 7,859 | 7,853 |
| cos $φ_{Emax60-over-excited}$ | 0,796 | 0,795 |
| e) maximum over-excited (c) at 20-30% $P_{Emax}$ | | |
| U [V]: | 230,00 | 250,72 |
| $P_{Emax60\ e)}$ [kW] | 6,246 | 6,249 |
| $S_{Emax60\ e)}$ [kVa] | 7,828 | 7,821 |
| cos $φ_{Emax60-over-excited}$ | 0,798 | 0,799 |
| $S_{Emax600}$ and $P_{Emax\ 600}$ | | |
| $S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$) [kVa] | 31,256 | |
| $P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$) [kW] | 25,045 | |

| **Test: SOFAR 20000TL-G2** | | |
|---|---|---|
| 600 s mean value | $U_n$ | 1,09 $U_n$ |
| a) cos φ 1 at 100% $P_{Emax}$ | | |
| U [V]: | 230,09 | 250,78 |
| $P_{Emax600\ a)}$ [kW] | 20,020 | 20,045 |
| $S_{Emax600\ a)}$ [kVa] | 20,025 | 20,050 |
| cos $\varphi_{Emax600}$ | 1,000 | 1,000 |
| b) maximum under-excited (i) at 100% $P_{Emax}$ | | |
| U [V]: | 230,06 | 250,76 |
| $P_{Emax600\ b)}$ [kW] | 17,864 | 17,831 |
| $S_{Emax600\ b)}$ [kVa] | 22,345 | 22,305 |
| cos $\varphi_{Emax600-under-excited}$ | 0,799 | 0,799 |
| c) maximum over-excited (c) at 100% $P_{Emax}$ | | |
| U [V]: | 230,08 | 250,79 |
| $P_{Emax600\ c)}$ [kW] | 17,784 | 17,764 |
| $S_{Emax600\ c)}$ [kVa] | 22,069 | 22,036 |
| cos $\varphi_{Emax600-over-excited}$ | 0,806 | 0,806 |
| d) maximum under-excited (i) at 20-30% $P_{Emax}$ | | |
| U [V]: | 230,03 | 250,72 |
| $P_{Emax60\ d)}$ [kW] | 4,987 | 4,999 |
| $S_{Emax60\ d)}$ [kVa] | 6,270 | 6,296 |
| cos $\varphi_{Emax60-over-excited}$ | 0,795 | 0,794 |
| e) maximum over-excited (c) at 20-30% $P_{Emax}$ | | |
| U [V]: | 230,01 | 250,71 |
| $P_{Emax60\ e)}$ [kW] | 5,026 | 5,026 |
| $S_{Emax60\ e)}$ [kVa] | 6,291 | 6,288 |
| cos $\varphi_{Emax60-over-excited}$ | 0,799 | 0,799 |
| $S_{Emax600}$ and $P_{Emax\ 600}$ | | |
| $S_{Emax600}$= max($S_{Emax600\ a)}$, $S_{Emax600\ b)}$, $S_{Emax600\ c)}$) [kVa] | 22,345 | |
| $P_{Emax\ 600}$= max($P_{Emax600\ a)}$, $P_{Emax600\ b)}$, $P_{Emax600\ c)}$) [kW] | 20,045 | |

| |
|---|
| **Test:**<br>The PGU is operated in all of the following, possible operating points. Every operating point must be retained for at least 600s after the transient effect has faded. During the measurements, there may be no power limitation by the primary energy source.<br>a) For cos φ, the maximum active power possible in this range is set.<br>b) For maximum under-excited operation, the maximum active power possible in this operating point is set<br><br>c) For maximum over-excited operation, the maximum active power possible in this operating point is set.<br>d) For maximum under-excited operation, the power set to 20-30% $P_{Emax}$.<br>e) For maximum over-excited operation, the power set to 20-30% $P_{Emax}$.<br><br>The operating points d) and e) must be retained for at least 60 s. |
| **Assessment criterion:**<br>$S_{Emax600}$ and $P_{Emax\ 600}$ are determined by the highest value measured.<br>$S_{Emax600} = \max(S_{Emax600a)}, S_{Emax600b)}, S_{Emax600c)})$<br>$P_{Emax600} = \max(P_{Emax600a)}, P_{Emax600b)}, P_{Emax600c)})$ |
| **Note:**<br>The maximum settable cos φ must be set.<br><br>No specification: PGU ≤ 3,68 kVA not in PGS > 3,68 kVA<br>φ 0,95 (i) and (c): PGU > 3,68 kVA and ≤ 13,8 kVA not in PGS > 13,8 kVA and for PGU ≤ 3,68 kVA also in PGS ≤ 13,8 kVA<br>φ 0,90 (i) and (c): PGU > 13,8 kVA and for PGU ≤ 13,8 kVA also in PGS > 13,8 kVA |

| 5.3.3 Active power reduction by specifying setpoints | P |
|---|---|
| The following tests apply for PGUs >100 kW and PGSs that, according to the manufacturers, can participate in feed-in management / network security management. | |
| **Note:**<br>The EEC also stipulates this test for PGUs with lower power ratings. | |

| 5.3.3.1 Setpoint control | P |
|---|---|

The following procedure must be used for the setpoint control test for the active power:

a) The test must be conducted with a chronologically coherent test procedure;
b) The available active power output must be at least 90% $P_{Emax}$ during the entire duration of the test
c) The active power must be measured at the three-phase/AC current connector of the PGU
d) If the PGU has several different interfaces for setpoint specification, the interface returning the most unfavourable results must be tested.

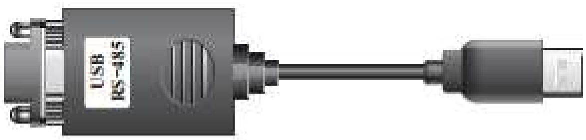
## Communications Port Description

This topic describes the functions of the RS485 and WIFI ports.

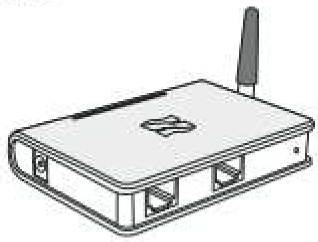
### RS485

By RS485 interface, transfer the inverter power output information, alarm information, operation state to the PC terminal or local data acquisition device , then uploaded to the server (such as S-WE01S).

**1. USB-RS485**




**2. S-WE01S**

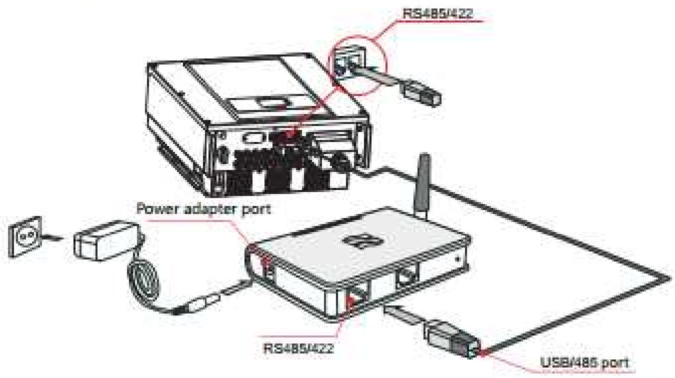


Set the match resistor by the SWT2, the corresponding list as follows (0 OFF, 1 ON).

| SWT2_1 | SWT2_2 | State |
|---|---|---|
| 0 | Reserve | No connect |
| 1 | Reserve | Connect |

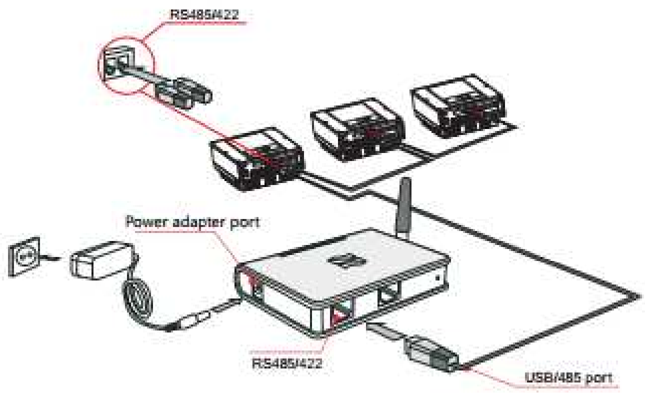
If only one Sofar 20~33KTL-G2 is used, use a communication cable with waterproof RJ45 connectors, and choose either of the two RS485 ports.

Figure 4-16 A single Sofar 20–33KTL-G2 connecting Communications




If multiple Sofar 20~33KTL-G2 are used, connect all Sofar 20~33KTL-G2 in daisy chain mode over the RS485 communication cable. Set different Modbus address(1~31) for each inverter in LCD display and set SWT2(match resistance) at the first and last inverter.

Figure 4-18 Multi Sofar 20–33KTL-G2 connecting Communications



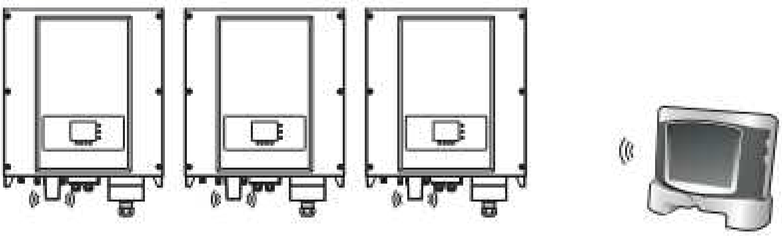

Register remote monitoring of Sofar 20~33KTL-G2 at its relevant website or APP according to monitoring device SN.

**WIFI**

By the WIFI interface, transfer the inverter power output information, alarm information, operation state to the PC terminal or local data acquisition device , then uploaded to the server (such as S-WE01S).

Register remote monitoring of Sofar 20~33KTL-G2 at its relevant website or APP according to monitoring device SN.

Figure 4-19 Connect multiple Wifi to wireless router

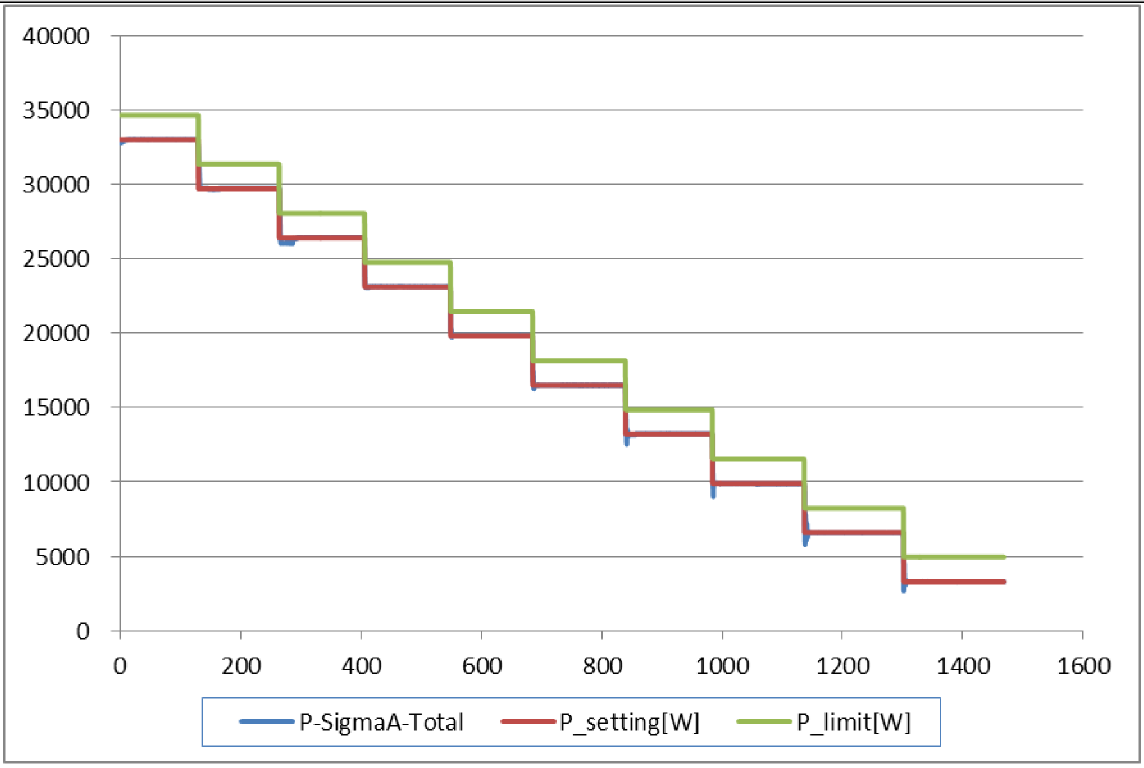


**Note:**

See 5.3.3.2 for measurements.

| 5.3.3.2 Measurement of setting accuracy | P |
|---|---|

**Graph of the setting accuracy:**




**Test:**

| 1-min mean value / $P_n/P$ [%] | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| $P_{Setpoint}$[kW]: | 33,000 | 29,700 | 26,400 | 23,100 | 19,800 | 16,500 | 13,200 | 9,900 | 6,600 | 3,300 |
| $P_{E60}$ [kW]: | 32,987 | 29,554 | 26,346 | 22,623 | 19,695 | 15,799 | 12,224 | 9,064 | 6,051 | 3,298 |
| $\Delta P_{E60}/P_{Setpoint}$ [%]: | -0,040 | -0,442 | -0,164 | -1,446 | -0,318 | -2,123 | -2,957 | -2,534 | -1,665 | -0,006 |
| **Limit $\Delta P_{E60}/P_{Setpoint}$:** | + 5 % of $P_{Emax}$ | | | | | | | | | |

**Test:**

The setpoint signal must be reduced from 100% to 10% $P_{Emax}$:

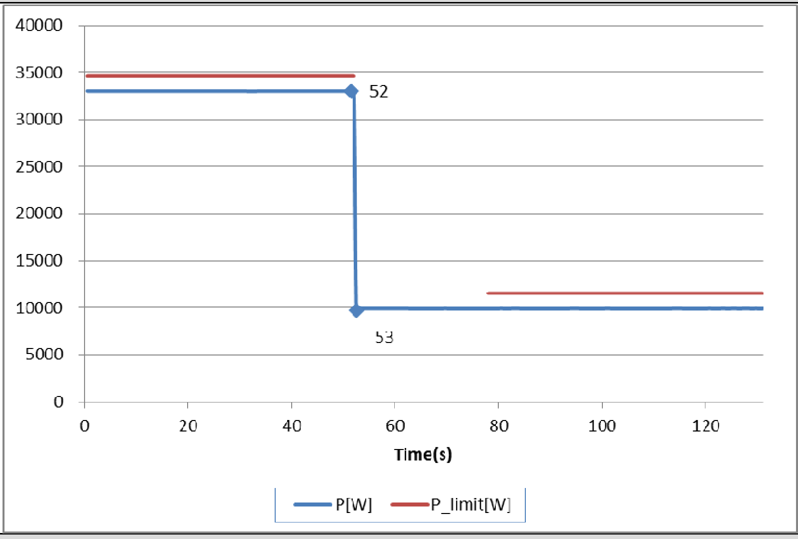
a) for adjustable PGUs in increments of 10% $P_{Emax}$. 1 minute must elapse after every change to the setpoint setting so that the PGU can settle at the new setpoint. Then the active power of the PGU must be measured as a 1-min mean value.

b) For all other PGUs, in line with their adjustable steps. 5 minutes must elapse after the setpoint setting is changed so that the PGU can settle at the new setpoint. Then the active power of the PGU must be measured as a 1-min mean value.

| |
|---|
| **Assessment criterion:**<br>a) for adjustable PGUs:<br>- no network disconnection<br>- the active power value does not exceed the setpoint by more than 5% $P_{Emax}$<br>- the setting time determined this way is ≤ 1min<br>b) For all other PGUs:<br>- the active power value does not exceed the setpoint by more than 5% PEmax or<br>- the setpoint is fallen below within 5 minutes or the PGU has switched off |
| Note:<br>The setting time is ≤ 1min. See below "Graph of the setting accuracy".<br><br>The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software. |

| 5.3.3.3 Measurement of setting time | P |
| --- | --- |

**Graph of the adjustment time:**




**Test:**

| 1-min mean value | 100% of $P_{Emax}$ | 30% of $P_{Emax}$ |
| --- | --- | --- |
| | | |
| $P_{Setpoint}$[kW]: | 33,000 | 9,900 |
| $P_{E60}$ [kW]: | 33,042 | 9,907 |
| $\Delta P_{E60}/P_{Setpoint}$ [%]: | 0,127 | 0,021 |
| **Limit $\Delta P_{E60}/P_{Setpoint}$:** | + 5 % of $P_{Emax}$ | |
| $T_0$[s]: | 2s | |
| **Limit $T_0$:** | ≤ 60 s | |

**Test:**
The setting time is measured with a setpoint change from 100% to 30% of nominal active power $P_{Emax}$ at time $t_0$. The setting time of the PGU must be determined in this test.

**Assessment criterion:**
a) for adjustable PGUs:
- no network disconnection
- the active power value does not exceed the setpoint by more than 5% $P_{Emax}$
- the setting time determined this way is ≤ 1min

b) For all other PGUs:
- the active power value does not exceed the setpoint by more than 5% $P_{Emax}$ or
- the setpoint is fallen below within 5 minutes or the PGU has switched off

**Note:**
The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

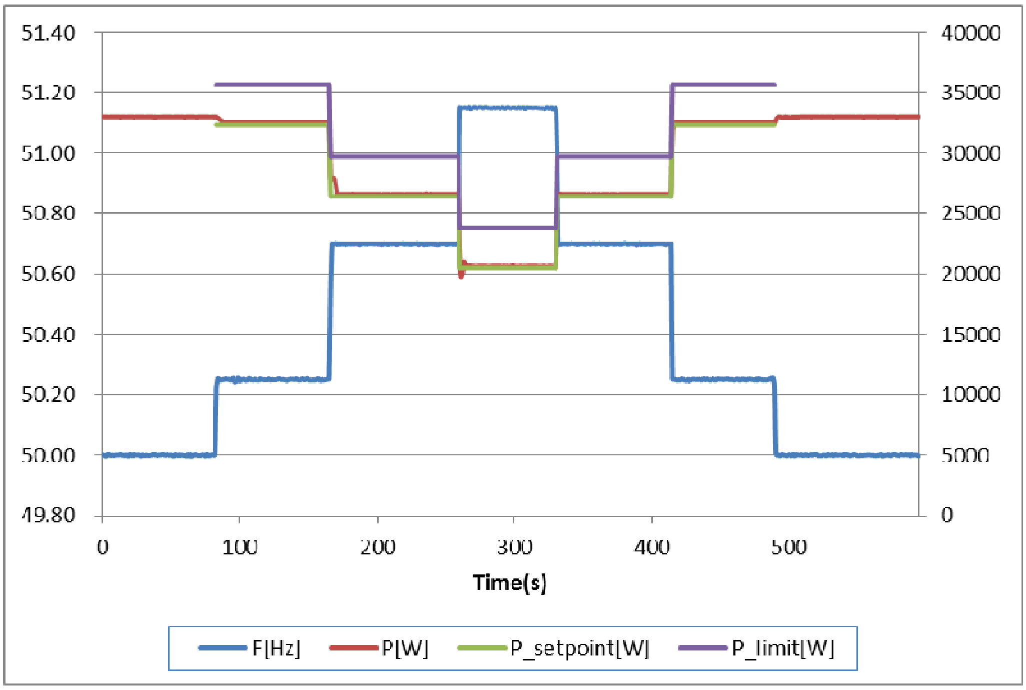
**5.3.4 Active power feed-in for overfrequency**
(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7.3.3 are met)

| **5.3.4.1.1 Test cycle for adjustable/conditionally adjustable PGUs** | **P** |
|---|---|

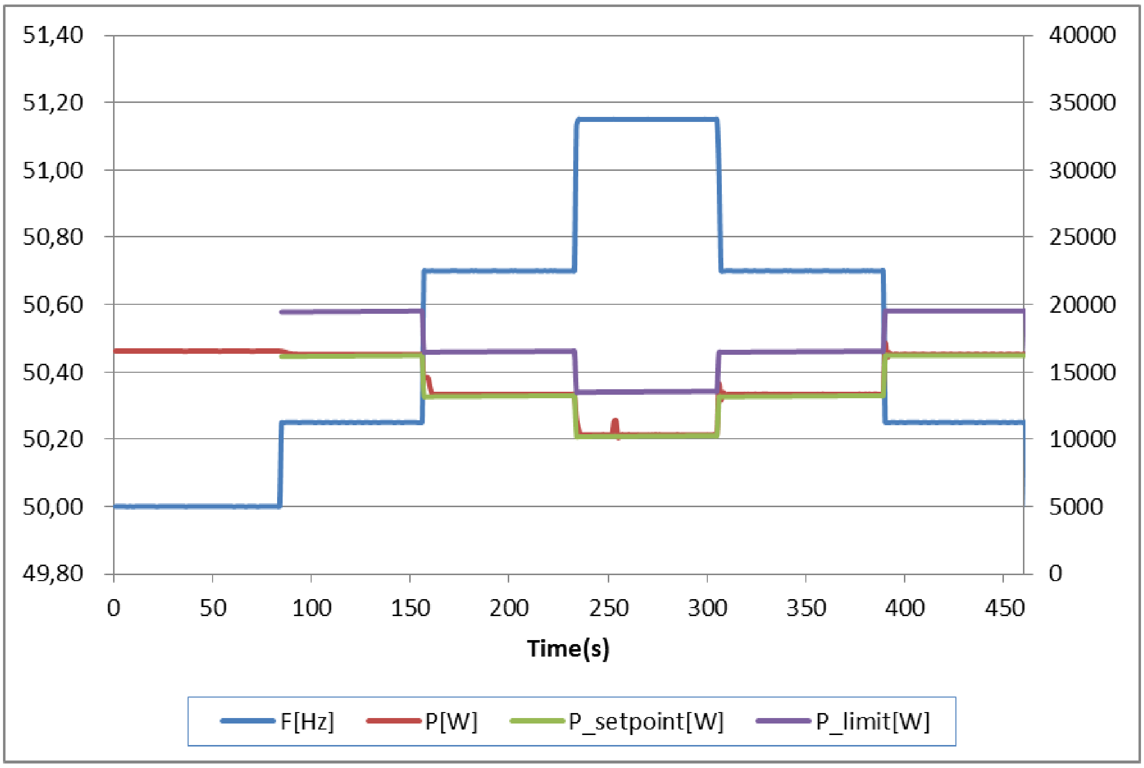
**Test:**

| 1-min mean value | a) 50,00 Hz | b) 50,25 Hz | c) 50,70 Hz | d) 51,15 Hz | e) 50,70 Hz | f) 50,25 Hz | g) 50,00 Hz |
|---|---|---|---|---|---|---|---|
| 1. Measurement a) to g): Active power output > 80% $P_{Emax}$ | | | | | | | |
| Frequency [Hz]: | 50,00 | 50,25 | 50,70 | 51,15 | 50,70 | 50,25 | 50,00 |
| $P_{setpoint}$ [kW]: | N/A | 32,355 | 26,412 | 20,502 | 26,407 | 32,355 | N/A |
| $P_{E60}$ [kW]: | 33,013 | 32,602 | 26,629 | 20,698 | 26,599 | 32,599 | 33,015 |
| $\Delta P_{E60}/P_{Setpoint}$ [%]: | N/A | 0,749 | 0,659 | 0,594 | 0,580 | 0,742 | N/A |
| 2. Measurement a) to g): Active power output 40% and 60% after freezing > 80% $P_{Emax}$ | | | | | | | |
| Frequency [Hz]: | 50,00 | 50,25 | 50,70 | 51,15 | 50,70 | 50,25 | N/A |
| $P_{setpoint}$ [kW]: | N/A | 16,216 | 13,235 | 10,258 | 13,234 | 16,215 | N/A |
| $P_{E60}$ [kW]: | 16,545 | 16,312 | 13,325 | 10,361 | 13,329 | 16,325 | N/A |
| $\Delta P_{E60}/P_{Setpoint}$ [%]: | N/A | 0,293 | 0,274 | 0,314 | 0,286 | 0,332 | N/A |
| **Limit $\Delta P_{E60}/P_{Setpoint}$:** | + 10 % of $P_{Emax}$ | | | | | | |

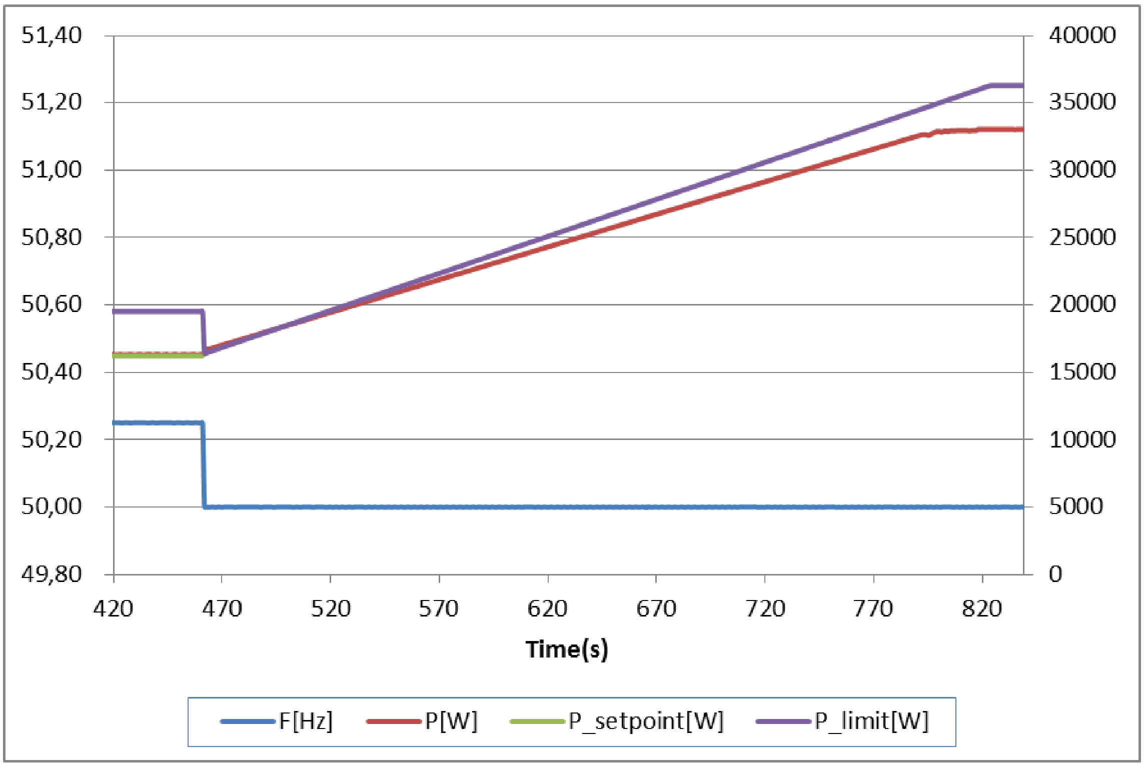
**Graph of Measurement 1.: Active power output > 80% $P_{Emax}$**



**Graph of Measurement 2.:Active power output 40% and 60% after freezing > 80% $P_{Emax}$**



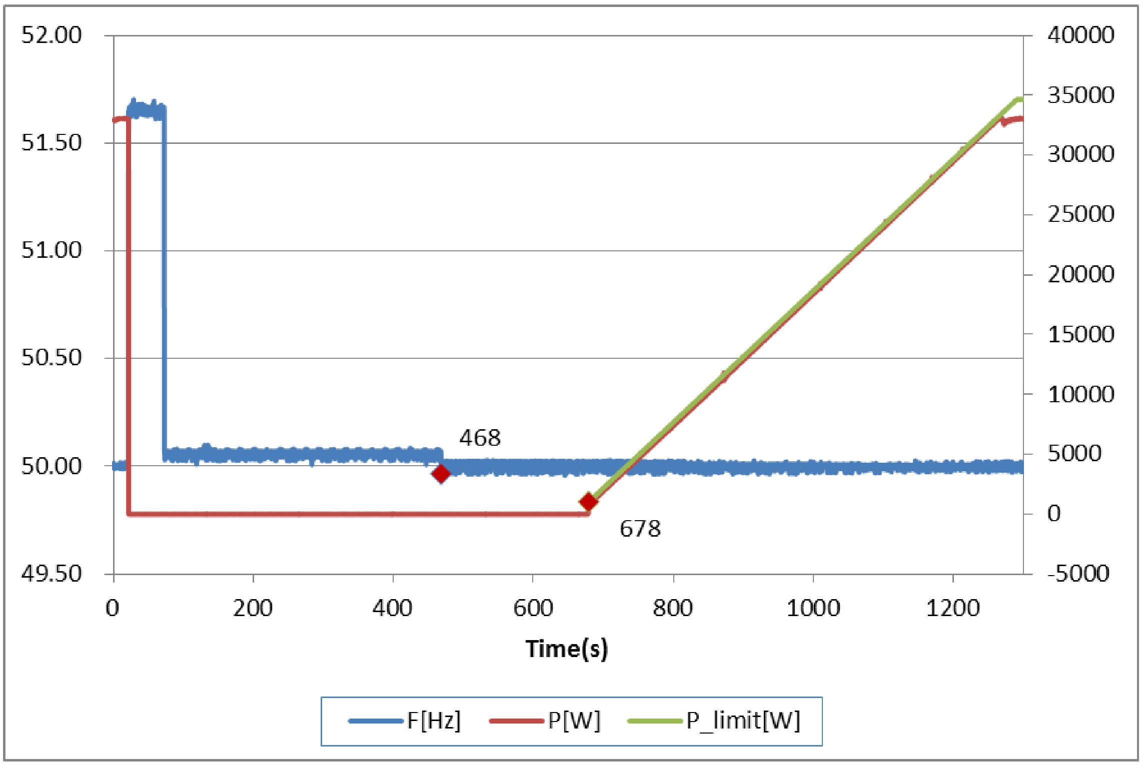

**Graph of power gradient:**



| |
|---|
| **Test:**<br>The test is conducted for two powers. First, the test must start at a power > 80% $P_{Emax}$ ("Measurement 1"), and in a second test, for a power between 40% to 60% $P_{Emax}$ ("Measurement 2"). In the second test, after freezing of the PM, the available active power output must be increased to a value > 80% $P_{Emax}$, and after the network frequency of 50,2 Hz is fallen below, the rise of the active power gradient must be recorded.<br><br>Point g) must be held until the PGU is again feeding in with the active power output available. |
| **Assessment criterion:**<br>For f=50,2 Hz, the value of the PM active power currently being generated is "frozen".<br><br>a) For adjustable PGUs when:<br>1) the active power reduces between measuring points b) and f) given above with a gradient of 40% PM per Hz for a decreasing frequency (or rises for a frequency decreasing again).<br>2) the maximum active power gradient occurring in point g) is lower than 10% of maximum active power $P_{Emax}$ every minute, and<br>3) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from $P_{Emax}$ by more than ± 10%.<br>b) For conditionally adjustable PGUs<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.<br><br>The PGU must have disconnected from the network no later than 200ms after frequency h) is reached. |
| **Note:**<br>The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software. |

| 5.3.4.1.2 Test cycle for all PGUs (adjustable, conditionally adjustable and non-adjustable) | P |
|---|---|

**Graph of frequency g) to j):**




**Test:**

| 1-min mean value | g) 50,00 ± 0,01 Hz | h) 51,65 ± 0,05 Hz | i) 50,06 Hz ± 0,01 Hz | j) 50,00 Hz ± 0,01 Hz |
|---|---|---|---|---|

**1)** g) 50,00 ± 0,01 Hz to h) 51,65 ± 0,05 Hz

| Disconnection time [ms]: | 156 | Limit [ms]: | 200 |
|---|---|---|---|

**Test:**

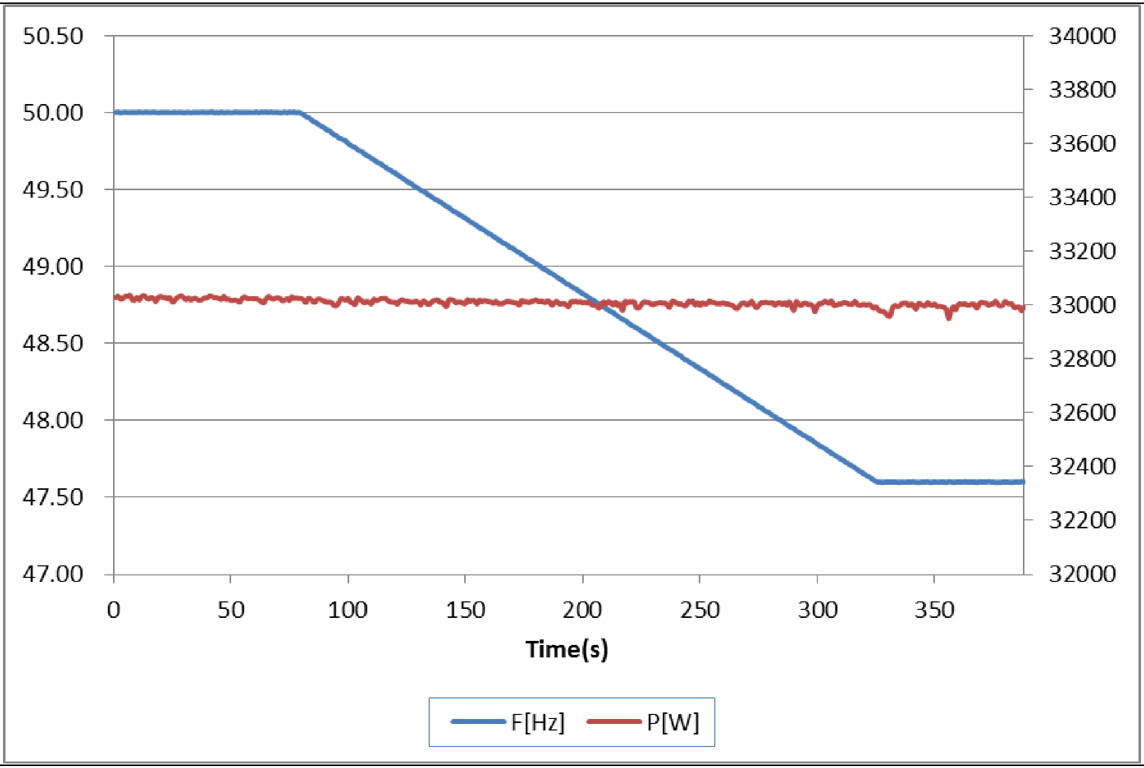
Following tests a) to g), frequency h) 51,65 Hz ± 0,05 Hz must be set for at least 200ms. Afterwards, frequency i) 50,06 Hz ± 0,01 Hz is enabled and kept for at least 3 minutes.

Afterwards, frequency j) 50,00 Hz ± 0,01 Hz is enabled and kept until transient oscillation of the active power at the earliest.

| **Assessment criterion:**<br>The PGU must have disconnected from the network no later than 200ms after frequency h) is reached. Thereafter, also whilst frequency i) is being held, there may be no resynchronisation or active power feed-in, i.e. not on the characteristic curve as tested before in a) to g).<br><br>a) For adjustable PGUs when:<br>ab) the maximum active power gradient occurring in point j) is lower than 10% of maximum active power $P_{Emax}$ every minute, and<br>ac) the reaction value of the setpoint determined by the gradient characteristic curve does not differ from $P_{Emax}$ by more than ± 10%.<br>b) For conditionally adjustable PGUs<br>ba) when they behave as in a) within their adjustment range, and<br>bb) 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 SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software. |

| 5.3.5 Active power feed-in for underfrequency | P |
|---|---|

**Graph of frequency a) to b):**




**Test:**

| | Switch to: | |
|---|---|---|
| 1-min mean value | a) 50 ± 0,01 [Hz] | b) - 2,4 to - 2,5 [Hz] |
| Frequency [Hz]: | 50,00 | 47,60 |
| $P_{E60}$ [kW]: | 33,026 | 32,996 |
| $\Delta P_{a)}/P_{b)}$ [%]: | -0,089 | |

**Test:**

Operating point b) must be kept for at least 1 minute.
The test must be carried out at 100% $P_{Emax}$.

With a programmable AC source, the PGU is operated at 100% $P_{Emax}$ and 50 ± 0,01 Hz, thereafter the frequency is reduced by 1 Hz/min. to - 2,4 to - 2,5 Hz. A 1-min mean value is recorded both before and after the frequency change.

**Assessment criterion:**

The test is passed when the PGU does not disconnect from the network on a network frequency change and continues to feed in 100% $P_{Emax}$ .

**Note:**

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

## 5.3.6 Reactive power output

(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 5.7.5 are met)

The PGU has:
- passed for use for the adjustable cos φ range
- not passed for use for the adjustable cos φ range
- limitations for use in PGSs **> 3,68 kVA** or **≤ 13,8 kVA**

### 5.3.6.1 Tests of the cos φ setting accuracy — P

| | | |
|---|---|---|
| Setting values | cos φ over-excited: | 0,80 |
| | cos φ under-excited: | 0,80 |

**d) and e) PGUs used in PGSs > 13,8 kVA**

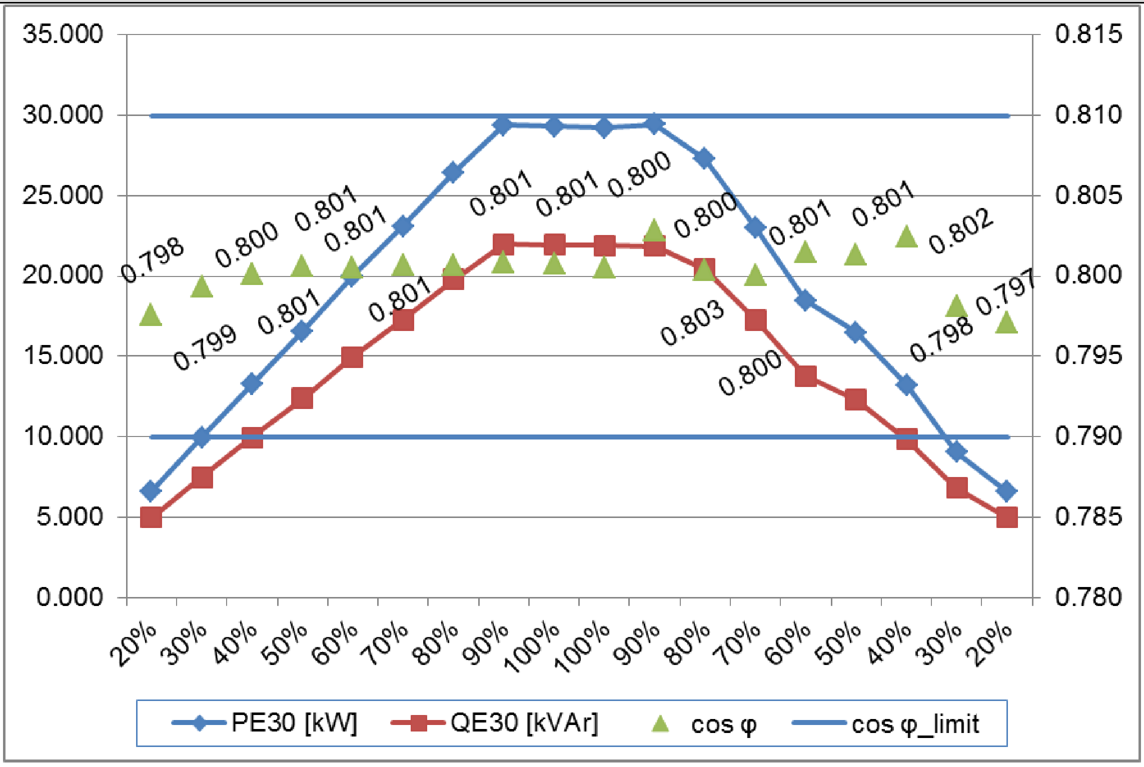
**Test: SOFAR 33000TL-G2**

| 30 s mean value | $U_n$ | | $1,09\ U_n$ | |
|---|---|---|---|---|
| Active power | $S_{Emax}$ | 40 – 60 %$P_{Emax}$ | $S_{Emax}$ | 40 – 60 %$P_{Emax}$ |
| d) cos φ 0,8 over-excited | | | | |
| U [V]: | 230,08 | 229,93 | 250,71 | 250,73 |
| $P_{E30}$ [kW]: | 29,331 | 16,583 | 29,361 | 16,556 |
| $Q_{E30}$ [kVAr]: | 21,967 | 12,400 | 21,963 | 12,409 |
| $\cos \varphi_{E30\text{-over-excited}}$: | 0,801 | 0,801 | 0,801 | 0,800 |
| e) cos φ 0,8 under-excited | | | | |
| U [V]: | 230,12 | 230,05 | 250,82 | 250,77 |
| $P_{n30}$ [kW]: | 29,240 | 16,495 | 29,123 | 16,517 |
| $Q_{E30}$ [kVAr]. | -21,891 | -12,314 | -21,824 | -12,326 |
| $\cos \varphi_{E30\text{-under-excited}}$: | 0,800 | 0,801 | 0,800 | 0,801 |
| **Limit cos $\varphi_{E30}$:** | cos φ= 0,79 to 0,81 (c) and cos φ= 0,79 to 0,81 (i) | | | |

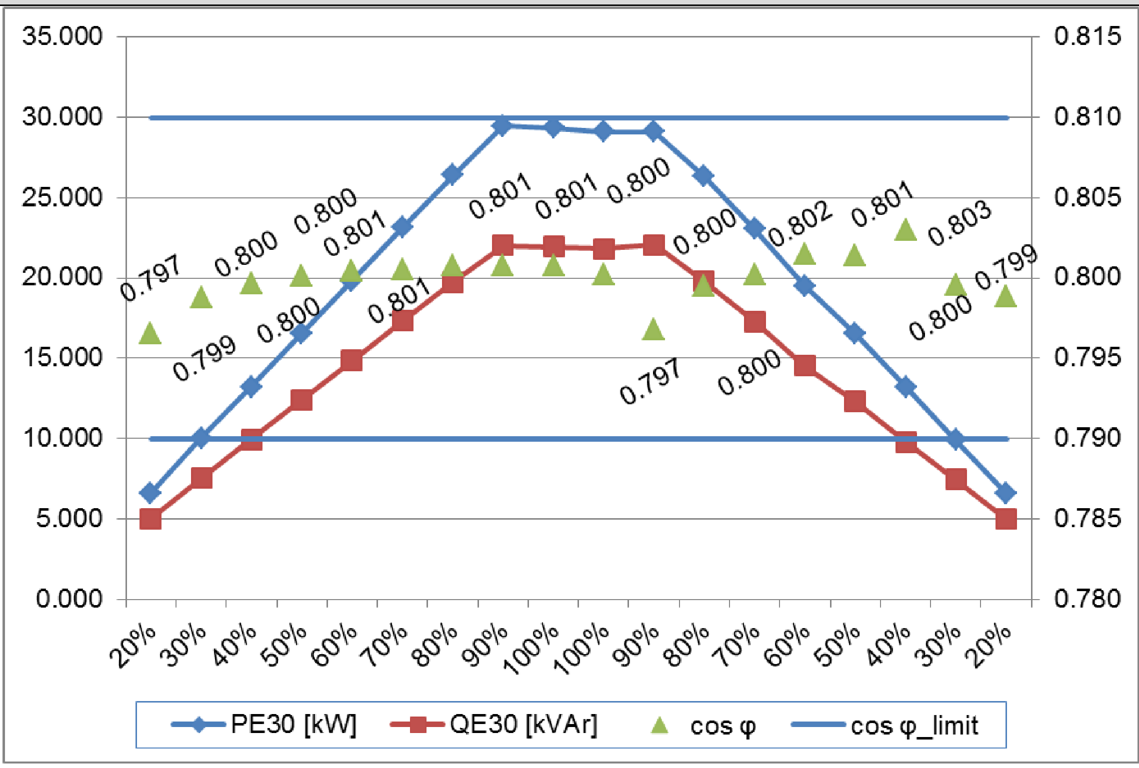
| $P_n/P$ [%] | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 80 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 s mean value | cos φ over-excited (c) @ $U_n$ | | | | | | | | | |
| U [V]: | N/A | 230,04 | 230,03 | 229,98 | 229,93 | 229,91 | 229,94 | 230,00 | 230,08 | 230,08 |
| $P_{E30}$ [kW]: | N/A | 6,605 | 9,940 | 13,268 | 16,583 | 20,002 | 23,096 | 26,434 | 29,377 | 29,331 |
| $Q_{E30}$ [kVAr]: | N/A | 4,996 | 7,474 | 9,948 | 12,400 | 14,991 | 17,300 | 19,799 | 21,999 | 21,967 |
| $\cos \varphi_{E30\text{-over-excited}}$: | N/A | 0,798 | 0,799 | 0,800 | 0,801 | 0,801 | 0,801 | 0,801 | 0,801 | 0,801 |
| | cos φ over-excited (c) @ $U_{1,09}$ | | | | | | | | | |
| U [V]: | N/A | 250,71 | 250,72 | 250,72 | 250,73 | 250,70 | 250,70 | 250,71 | 250,72 | 250,71 |
| $P_{n30}$ [kW]: | N/A | 6,605 | 10,019 | 13,242 | 16,556 | 19,856 | 23,141 | 26,413 | 29,460 | 29,361 |
| $Q_{E30}$ [kVAr]: | N/A | 5,013 | 7,547 | 9,943 | 12,409 | 14,866 | 17,322 | 19,758 | 22,035 | 21,963 |
| $\cos \varphi_{E30\text{-over-excited}}$: | N/A | 0,797 | 0,799 | 0,800 | 0,800 | 0,800 | 0,801 | 0,801 | 0,801 | 0,801 |

| 30 s mean value | cos φ under-excited (i) @ $U_n$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| U [V]: | N/A | 230,03 | 230,06 | 230,08 | 230,05 | 230,09 | 230,12 | 230,11 | 230,11 | 230,12 |
| $P_{E30}$ [kW]: | N/A | 6,592 | 9,039 | 13,208 | 16,495 | 18,485 | 23,034 | 27,297 | 29,444 | 29,240 |
| $Q_{E30}$ [kVAr]: | N/A | -4,993 | -6,819 | -9,822 | -12,314 | -13,790 | -17,268 | -20,440 | -21,851 | -21,891 |
| cos $φ_{E30\text{-under-excited}}$: | N/A | 0,797 | 0,798 | 0,802 | 0,801 | 0,801 | 0,800 | 0,800 | 0,803 | 0,800 |
| | cos φ under-excited (i) @ $U_{1,09}$ | | | | | | | | | |
| U [V]: | N/A | 250,70 | 250,86 | 250,73 | 250,77 | 250,80 | 250,80 | 250,80 | 250,81 | 250,82 |
| $P_{E30}$ [kW]: | N/A | 6,590 | 9,910 | 13,219 | 16,517 | 19,515 | 23,073 | 26,331 | 29,124 | 29,123 |
| $Q_{E30}$ [kVAr]: | N/A | -4,962 | -7,442 | -9,809 | -12,326 | -14,557 | -17,289 | -19,780 | -22,082 | -21,824 |
| cos $φ_{E30\text{-under-excited}}$: | N/A | 0,799 | 0,800 | 0,803 | 0,801 | 0,802 | 0,800 | 0,800 | 0,797 | 0,800 |
| **Limit cos $φ_{E30}$:** | cos φ= 0,79 to 0,81 (c) and cos φ= 0,79 to 0,81 (i) | | | | | | | | | |

**Graph of cos φ over-excited (c) and under-excited (i) @ $U_n$: SOFAR 33000TL-G2**



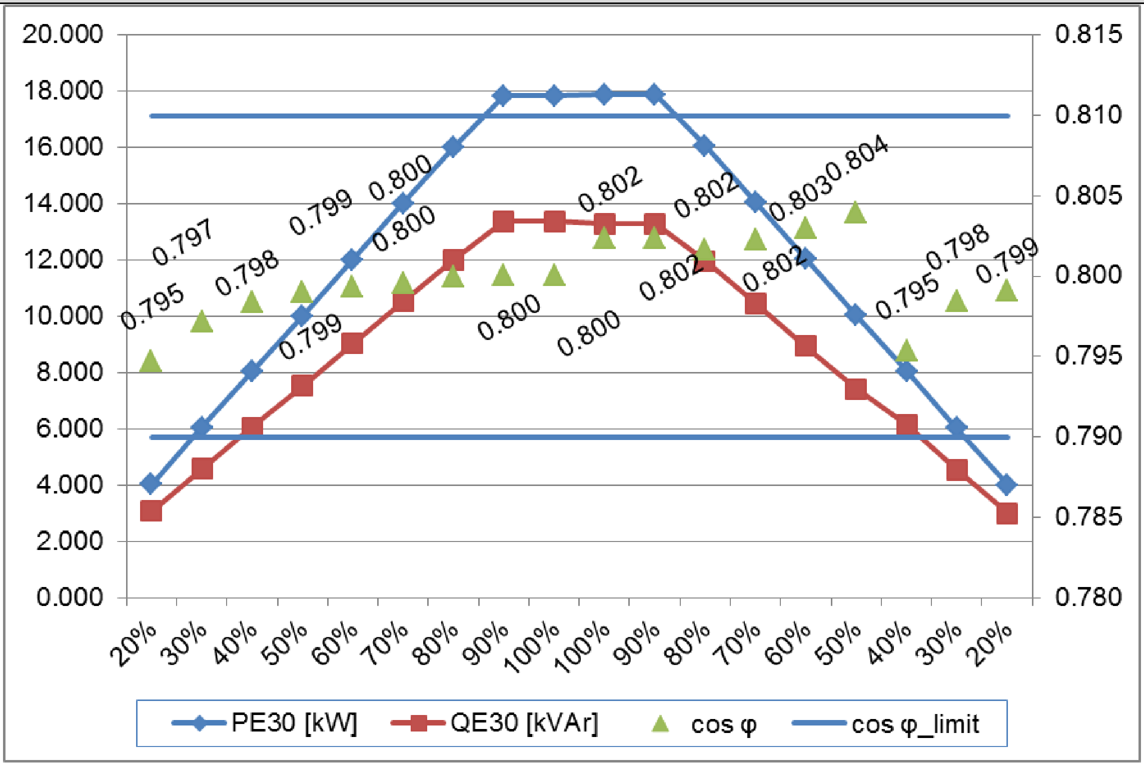

**Graph of cos φ over-excited (c) and under-excited (i) @ $U_{1,09}$: SOFAR 33000TL-G2**



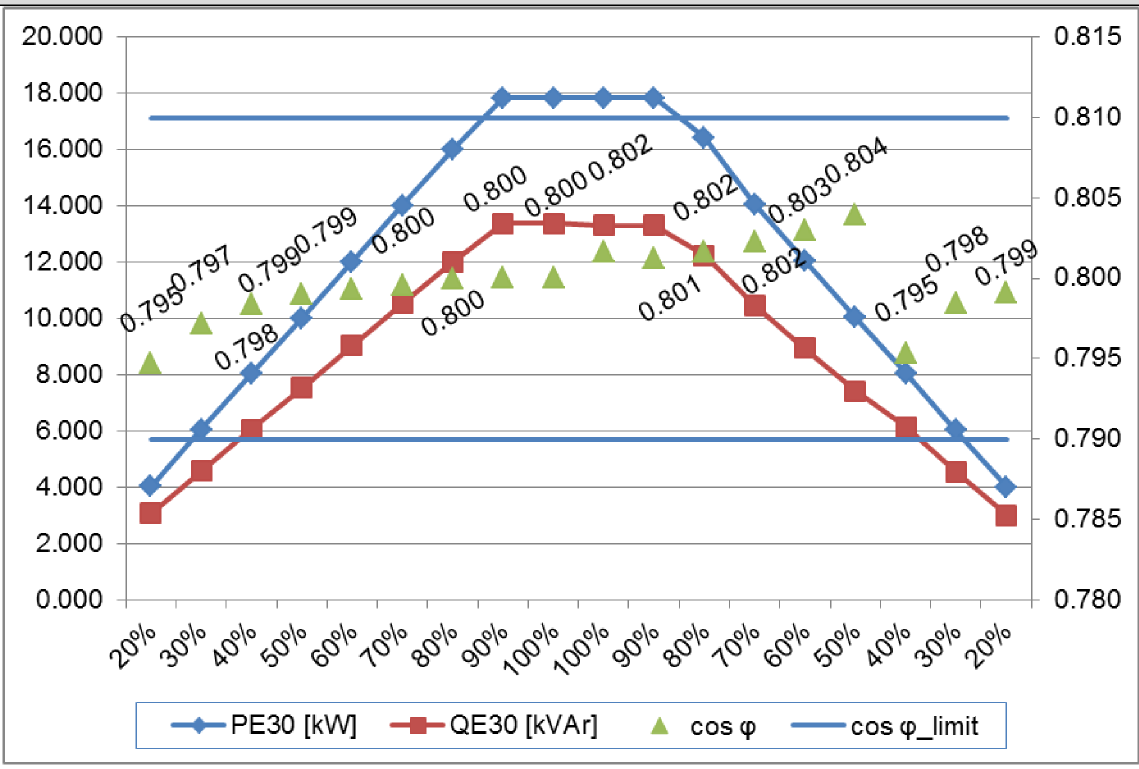
| Test: SOFAR 20000TL-G2 | | | | |
|---|---|---|---|---|
| 30 s mean value | $U_n$ | | 1,09 $U_n$ | |
| Active power | $S_{Emax}$ | 40 – 60 %$P_{Emax}$ | $S_{Emax}$ | 40 – 60 %$P_{Emax}$ |
| d) cos φ 0,8 over-excited | | | | |
| U [V]: | 230,06 | 230,04 | 251,15 | 250,71 |
| $P_{E30}$ [kW]: | 17,851 | 10,021 | 17,856 | 10,058 |
| $Q_{E30}$ [kVAr]: | 13,384 | 7,541 | 13,311 | 7,417 |
| cos $\varphi_{E30\text{-over-excited}}$: | 0,800 | 0,799 | 0,802 | 0,805 |
| e) cos φ 0,8 under-excited | | | | |
| U [V]: | 230,32 | 230,08 | 250,76 | 250,73 |
| $P_{n30}$ [kW]: | 17,884 | 10,049 | 17,667 | 10,024 |
| $Q_{E30}$ [kVAr]. | -13,300 | -7,432 | -13,259 | -7,559 |
| cos $\varphi_{E30\text{-under-excited}}$: | 0,802 | 0,804 | 0,800 | 0,798 |
| **Limit cos $\varphi_{E30}$:** | cos φ= 0,79 to 0,81 (c) and cos φ= 0,79 to 0,81 (i) | | | |

| $P_n$/P [%] | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 s mean value | cos φ over-excited (c) @ $U_n$ | | | | | | | | | |
| U [V]: | N/A | 230,01 | 230,02 | 230,02 | 230,04 | 230,02 | 230,05 | 230,05 | 230,06 | 230,06 |
| $P_{E30}$ [kW]: | N/A | 4,037 | 6,045 | 8,036 | 10,021 | 12,027 | 14,032 | 16,032 | 17,851 | 17,851 |
| $Q_{E30}$ [kVAr]: | N/A | 3,083 | 4,578 | 6,061 | 7,541 | 9,042 | 10,539 | 12,025 | 13,385 | 13,384 |
| cos $\varphi_{E30\text{-over-excited}}$: | N/A | 0,795 | 0,797 | 0,798 | 0,799 | 0,799 | 0,800 | 0,800 | 0,800 | 0,800 |
| | cos φ over-excited (c) @ $U_{1,09}$ | | | | | | | | | |
| U [V]: | N/A | 250,71 | 250,74 | 250,76 | 250,71 | 250,74 | 250,77 | 251,11 | 251,15 | 251,15 |
| $P_{n30}$ [kW]: | N/A | 3,987 | 6,015 | 8,036 | 10,058 | 12,071 | 14,081 | 16,436 | 17,849 | 17,856 |
| $Q_{E30}$ [kVAr]: | N/A | 2,997 | 4,520 | 6,097 | 7,417 | 8,940 | 10,464 | 12,254 | 13,326 | 13,311 |
| cos $\varphi_{E30\text{-over-excited}}$: | N/A | 0,799 | 0,799 | 0,797 | 0,805 | 0,804 | 0,803 | 0,802 | 0,801 | 0,802 |
| 30 s mean value | cos φ under-excited (i) @ $U_n$ | | | | | | | | | |
| U [V]: | N/A | 230,00 | 230,05 | 230,04 | 230,08 | 230,10 | 230,05 | 230,11 | 230,32 | 230,32 |
| $P_{E30}$ [kW]: | N/A | 3,999 | 6,043 | 8,069 | 10,049 | 12,060 | 14,065 | 16,064 | 17,884 | 17,884 |
| $Q_{E30}$ [kVAr]: | N/A | -3,008 | -4,557 | -6,149 | -7,432 | -8,950 | -10,464 | -11,976 | -13,301 | -13,300 |
| cos $\varphi_{E30\text{-under-excited}}$: | N/A | 0,799 | 0,798 | 0,795 | 0,804 | 0,803 | 0,802 | 0,802 | 0,802 | 0,802 |
| | cos φ under-excited (i) @ $U_{1,09}$ | | | | | | | | | |
| U [V]: | N/A | 250,72 | 250,72 | 250,72 | 250,73 | 250,74 | 250,75 | 250,74 | 250,74 | 250,76 |
| $P_{E30}$ [kW]: | N/A | 3,954 | 5,982 | 8,004 | 10,024 | 12,035 | 14,047 | 16,048 | 17,880 | 17,667 |
| $Q_{E30}$ [kVAr]: | N/A | -3,039 | -4,549 | -6,055 | -7,559 | -9,061 | -10,564 | -12,052 | -13,414 | -13,259 |
| cos $\varphi_{E30\text{-under-excited}}$: | N/A | 0,793 | 0,796 | 0,798 | 0,798 | 0,799 | 0,799 | 0,800 | 0,800 | 0,800 |
| **Limit cos $\varphi_{E30}$:** | cos φ= 0,79 to 0,81 (c) and cos φ= 0,79 to 0,81 (i) | | | | | | | | | |

**Graph of cos φ over-excited (c) and under-excited (i) @ $U_n$: SOFAR 20000TL-G2**




**Graph of cos φ over-excited (c) and under-excited (i) @ $U_{1,09}$: SOFAR 20000TL-G2**

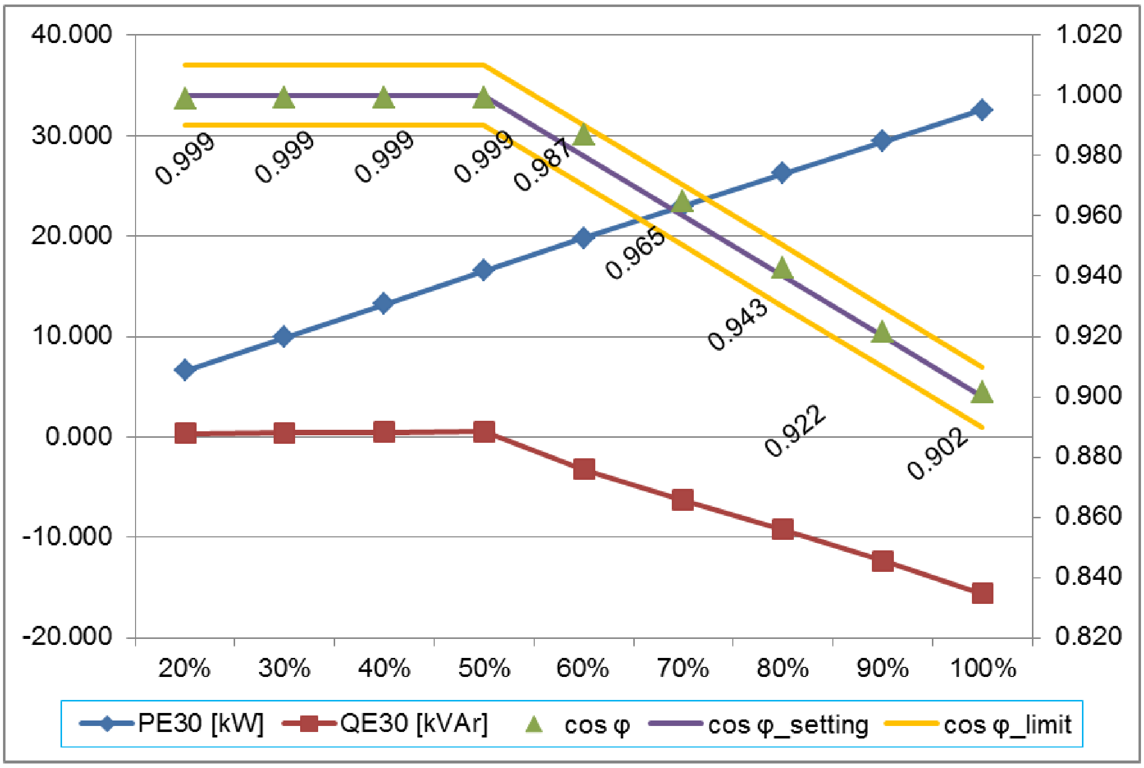


| |
|---|
| **Test:**<br>a) With no specification of cos φ, the active power must be adjust between 40 % $P_{Emax}$ and 60 % $P_{Emax}$ and to $S_{Emax}$<br>b) & c) For cos φ 0,95 over-excited and φ 0,95 under-excited, the active power must be adjust between 40 % $P_{Emax}$ and 60 % $P_{Emax}$ and to $S_{Emax}$<br>d) & e) For cos φ 0,90 over-excited and φ 0,90 under-excited, the active power must be adjust between 40 % $P_{Emax}$ and 60 % $P_{Emax}$ and to $S_{Emax}$<br><br>For measurements a) to c), there may be no power limitation by the primary energy source. |
| **Assessment criterion:**<br>a) Applicable for PGUs ≤ 3,68 kVA that cannot be used in PGSs > 3,68 kVA:<br>The test is passed when all operating points of a) of the PGU lie in range cos φ= 0,95 over-excited to cos φ= 0,95 under-excited.<br>b) and c) For PSUs > 3,68 kVA and ≤ 13,8 kVA that cannot be used in PGSs > 13,8 kVA, and for PGUs ≤ 3,68 kVA that can be used in PGSs ≤ 13,8 kVA, the following applies:<br>The test is passed when all measurement points of b) lie within range cos φ= 0,94 to 0,96 over-excited and of c) in range cos φ= 0,94 to 0,96.<br>d) and e) For PGUs > 13,8 kVA and for PGUs ≤ 13,8kVA also in PGSs > 13,8 kVA<br>The test is passed when all measurement points of d) lie within range cos φ= 0,89 to 0,91 over-excited and of e) in range cos φ= 0,89 to 0,91. |
| **Note:**<br>The tests had been performed on the SOFAR 33000TL-G2 and SOFAR 20000TL-G2 are valid for the SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software. |

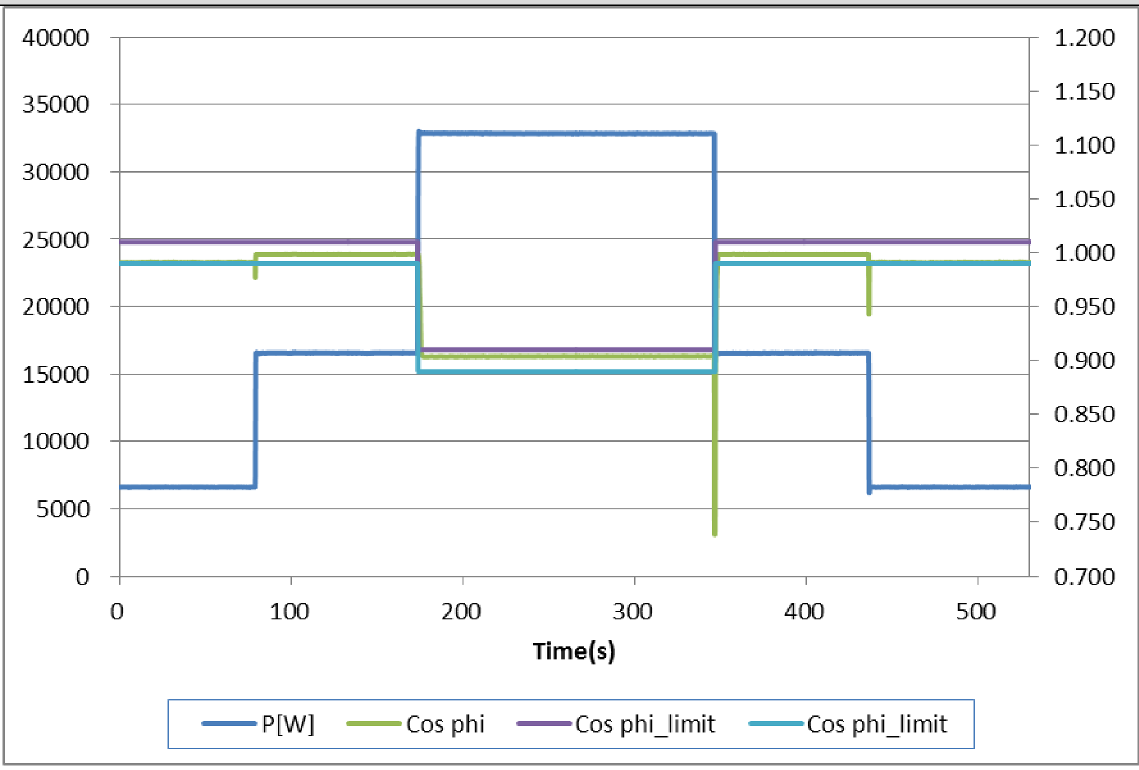
| 5.3.6.4 Test for a displacement factor/active power characteristic curve cos φ (P) | | | | | | | | | | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| **Test a):** | | | | | | | | | | |
| $P_{Emax}/P$ [%] | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 30 s mean value | 20% to 100% $P_{Emax}$ | | | | | | | | | |
| U [V]: | N/A | 230,03 | 230,09 | 230,14 | 230,19 | 230,24 | 230,27 | 230,33 | 230,39 | 230,43 |
| $P_{E30}$ [kW]: | N/A | 6,573 | 9,914 | 13,227 | 16,529 | 19,776 | 23,003 | 26,212 | 29,403 | 32,576 |
| $P_{E30}$ of $P_{Emax}$ [%]: | N/A | 19,92 | 30,04 | 40,08 | 50,09 | 59,93 | 69,71 | 79,43 | 89,10 | 98,71 |
| $Q_{E30}$ [kVAr]: | N/A | 0,317 | 0,368 | 0,439 | 0,535 | -3,228 | -6,277 | -9,264 | -12,378 | -15,620 |
| cos $φ_{E30}$: | N/A | 0,999 | 0,999 | 0,999 | 0,999 | 0,987 | 0,965 | 0,943 | 0,922 | 0,902 |
| cos $φ_{setpoint}$ of $P_{E30}$: | N/A | 1,0 | 1,0 | 1,0 | 1,0 | 0,98 | 0,96 | 0,94 | 0,92 | 0,92 |
| **Limit cos φ $_{E30}$:** | cos $φ_{setpoint}$ ± 0,01 | | | | | | | | | |

| **Test b):** | | | |
|---|---|---|---|
| $P_{Emax}/P_n$ [%] | 20 | 50 | 90 |
| 30 s mean value | 20% to 50% to 100% $P_{Emax}$ | | |
| U [V]: | 230,00 | 230,05 | 230,10 |
| $P_{E30}$ [kW]: | 6,616 | 16,575 | 32,868 |
| $P_{E30}$ of $P_{Emax}$ [%]: | 20,05 | 50,23 | 99,60 |
| $Q_{E30}$ [kVAr]: | 0,868 | 0,897 | -15,556 |
| cos φ $_{E30}$: | 0,991 | 0,998 | 0,904 |
| cos $φ_{setpoint}$ of $P_{E30}$: | 1,0 | 1,0 | 0,90 |
| $T_0$[s]: | < 1 s | | 2 s |
| 30 s mean value | 100% to 50% to 20% $P_{Emax}$ | | |
| U [V]: | 230,00 | 230,09 | 230,11 |
| $P_{E30}$ [kW]: | 6,615 | 16,557 | 32,841 |
| $P_{E30}$ [%]: | 20,05 | 50,17 | 99,52 |
| $Q_{E30}$ [kVAr]: | 0,866 | 0,894 | -15,531 |
| cos φ $_{E30}$: | 0,991 | 0,998 | 0,904 |
| cos $φ_{setpoint}$ of $P_{E30}$: | 1,0 | 1,0 | 0,90 |
| $T_0$ [s]: | < 1 s | | 2s |
| **Limit $T_0$ [s]:** | 10 s | | |
| **Limit cos φ $_{E30}$:** | cos $φ_{setpoint}$ ± 0,01 | | |

**Graph of cos φ(P): Test a)**



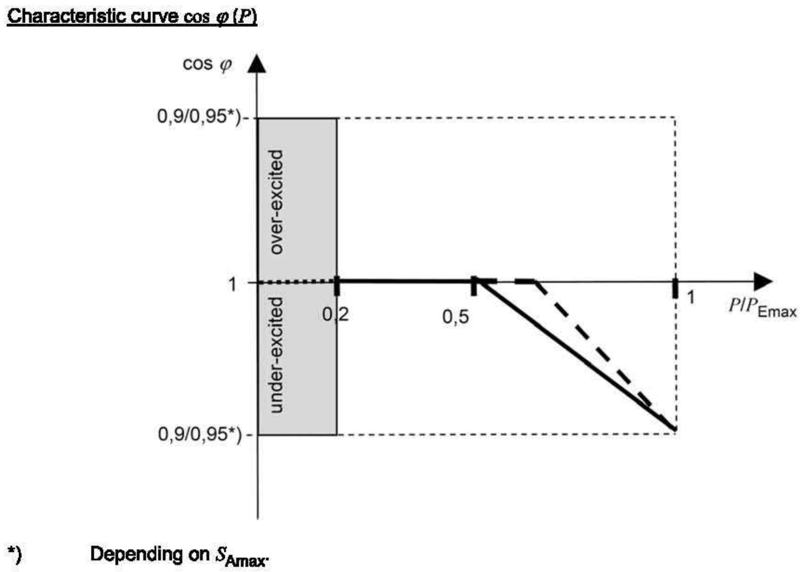

**Graph of setting ($T_0$) time: Test b)**



**Test:**

Test 1: Using the standard characteristic curve increases the active power from 20% $P_{Emax}$ in increments of 10% $P_{Emax}$ to $P_{Emax}$. The test is carried out in reverse.

Test 2: Using the standard characteristic curve increases the active power from 20% $P_{Emax}$ to 50% $P_{Emax}$ and to $P_{Emax}$. The test is carried out in reverse. After the PGU has settled, the end value reached is determined as a 30 s mean value.




**Assessment criterion:**

Test 1: cos φ accuracy cos φ (±0,01)

Test 2: cos φ accuracy cos φ (±0,01)

For the test to be passed, the cos φ setpoint from the active power must be measured at the terminals of the PGU within a settling time of 10 s.

**Note:**

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

**5.4 Testing of NS protection**
**5.5 Testing of connecting conditions and synchronisation**
**DIN VDE V 0124-100:2012-07**

| Clause | Test | | Result |
|---|---|---|---|
| 5.4.1 | General<br>These tests are designed to provide evidence that the requirements of VDE-AR-N 4105 are met | | **P** |
| 5.4.2 | Central NS protection | | **N/A** |
| 5.4.3 | Integrated NS protection | | **P** |
| 5.4.4 | Interface switch | | |
| | 5.4.4.1 General | | **P** |
| | 5.4.4.2 Integrated interface switch | | **P** |
| 5.4.5 | Protection devices for the interface switch | | |
| | 5.4.5.1 | General | **P** |
| | 5.4.5.2 | Functional safety | **P** |
| | 5.4.5.3 | Voltage control | **P** |
| | 5.4.5.3.3 | Measurement of the rise-in voltage protection as a running 10-min mean value | **P** |
| | 5.4.5.4 | Frequency measurement | **P** |
| | 5.4.5.5 | Reporting NS protection | **P** |
| 5.4.6 | Islanding detection | | **P** |
| 5.5 | Connecting conditions and synchronisation | | **P** |
| | 5.5.2 | Short interruption | **P** |

| | |
|---|---|
| **5.4.2 Central NS protection**<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.2 are met) | **N/A** |
| NS protection provides the possibility for sealing<br>or<br>Password protection is given for protection functions.<br><br>The interface switch is triggered when the switch in the "NS protection interface switch" circuit is actuated (only relevant for external NS protection).<br><br>Actuation of the interface switch is displayed on the power generation unit. Display is provided by warning light or display text . | |

| | |
|---|---|
| **5.4.3 Integrated NS protection**<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.3 are met) | **P** |
| Password protection is given for protection function U >. | |

| 5.4.4 Interface switch | |
|---|---|
| **5.4.4.1 General**<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.4.1 are met) | **P** |
| The interface switch consists of two electrical break devices connected in series and is therefore designed with redundancy.<br><br>See 5.4.5.2 Functional safety for the test for single-fault tolerance and fault finding with subsequent disconnection for the entire functional chain.<br><br>An all-pole galvanic break device is provided. | |
| **Note:**<br>For synchronous machines, the break device for synchronisation is designed three pole instead of four pole. | |

| 5.4.4.2 **Integrated interface switch**<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.4.3 are met) | **P** |
|---|---|

The inverter that is not galvanically separated has two independent galvanically separating breaking devices

See 5.4.5.2 Functional safety for the test for single-fault tolerance of the interface switch
The interface switch is short-circuit proof for the maximum short-circuit current of the power generation unit.
max. short-circuit current of the power generation unit= 50A, 250 Vac
max. switching current relay= 50 A, 440Vac

**Datasheet of the relay:**

# AZSR235/250

## 50 A (35 A)
## MINIATURE POWER RELAY

RoHS compliant !


**FEATURES**

- 50 Amp switching (AZSR250)
- 35 Amp switching (AZSR235)
- Wide contact gap > 1.85mm (AZSR250)
- Wide contact gap > 2.05mm (AZSR235)
- Holding power <100 mW
- Dielectric strength 5000 Vrms
- Isolation spacing greater than 10 mm
- Reinforced insulation, EN 60730-1 (VDE 0631, part 1), EN 60335-1 (VDE 0700, part 1)
- UL, CUR file E44211
- VDE certificate 40033251

**CONTACTS**

| | |
|---|---|
| **Arrangement** | SPST (1 Form A)<br>DPST (2 Form A) |
| **Ratings** | Resistive load:<br><br>AZSR235<br>Max. switched power: 1050 W or 9695 VA<br>Max. switched current: 35 A<br>Max. switched voltage: 150 VDC* or 440 VAC<br><br>AZSR250<br>Max. switched power: 1500 W or 13850 VA<br>Max. switched current: 50 A<br>Max. switched voltage: 150 VDC* or 440 VAC<br><br>* Note: If switching voltage is greater than 30 VDC, special precautions must be taken. Please contact the factory. |
| **Rated Load**<br>**UL** | AZSR235<br>35 A at 277 VAC, resistive<br><br>AZSR250<br>50 A at 277 VAC, resistive |
| **VDE** | AZSR235<br>35 A at 263 VAC, test referring to AC-7a, 85°C<br><br>AZSR250<br>50 A at 263 VAC, test referring to AC-7a, 85°C |
| **Material** | Silver tin oxide |
| **Resistance** | < 50 milliohms initially |

**COIL**

| | |
|---|---|
| **Power**<br>**At Pickup Voltage (typical)** | 270 mW (AZSR250) |
| **Max. Continuous Dissipation** | 2.0 W at 20°C (68°F) ambient |
| **Temperature Rise** | 15°C (27°F) at nominal coil voltage |
| **Temperature** | Max. 155°C (311°F) Class F |

**GENERAL DATA**

| | |
|---|---|
| **Life Expectancy**<br>**Mechanical**<br>**Electrical** | Minimum operations<br>1 x 10^6^<br>5 x 10^4^ at 35 A 250 VAC Res. (AZSR235)<br>5 x 10^4^ at 50 A 250 VAC Res. (AZSR250) |
| **Operate Time (typical)** | 40 ms at nominal coil voltage |
| **Release Time (typical)** | 5 ms at nominal coil voltage<br>(with no coil suppression) |
| **Dielectric Strength (at sea level for 1 min.)** | 5000 Vrms coil to contact<br>2500 Vrms between contact sets<br>2500 Vrms between open contacts |
| **Insulation Resistance** | 1000 megohms min. at 20°C<br>500 VDC 50% RH |
| **Insulation (according to DIN VDE 0110, IEC 60664-1)** | C250<br>Overvoltage category: III<br>Pollution degree: 3<br>Nominal voltage: 250 VAC |
| **Dropout** | Greater than 5% of nominal coil voltage |
| **Ambient Temperature**<br>**Operating** | At nominal coil voltage<br>-40°C (-40°F) to 85°C (185°F) |
| **Vibration** | 0.062" (1.5 mm) DA at 10–55 Hz |
| **Shock** | 10 g |
| **Enclosure** | P.B.T. polyester |
| **Terminals** | Tinned copper alloy, P.C. |
| **Max. Solder Temp.** | 270°C (518°F) |
| **Max. Solder Time** | 5 seconds |
| **Weight** | 105 grams |
| **Packing unit in pcs** | 10 per inner carton / 100 per carton box |

**NOTES**

1. All values at 20°C (68°F).
2. Relay may pull in with less than "Must Operate" value.
3. Specifications subject to change without notice.

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This product specification to be used only together with the application notes which can be downloaded from http://www.ZETTLERelectronics.com/pdfs/relais/ApplicationNotes.pdf

2013-06-27

TE connectivity RELAY PRODUCTS

General Purpose Relays
Power Relays

**Potter & Brumfield**

## Power PCB Relay T9V Solar

- **1 pole 40A, 1 form A (NO) contact**
- **Contact gap >1.8mm (suffix S)**
- **350mW hold power**
- **Ambient temperature up to 85°C at 35A**
- **The appliance is able to meet VDE V 0126-1-1**
- **Product in accordance to IEC 60335-1**
- **EN61095: AC7a at 85°C**

f0156_bc_inv

Typical applications
Electrical vehicle loading stations
Electrical vehicle
Photovoltaic inverter

### Approvals

VDE 40030974, UL E58304, CQC16002145203, TUV R50369970
Technical data of approved types on request

### Contact Data

| | |
|---|---|
| Contact arrangement | 1 form A (NO) |
| Contact gap | >1.8mm |
| Rated voltage | 277VAC (1.8mm gap) |
| Rated current | 40A1) |
| Breaking capacity max. | 10 000 VA |
| Contact material | AgNi |
| Initial contact resistance | 75mΩ max. at 1A 6VDC |
| Frequency of operation, with/without load | 6/300min$^{-1}$ |
| Operate/release time max., incl bounce time | 18/15ms |

**Contact ratings2)**

| Type | Contact | Load | Cycles |
|---|---|---|---|
| **IEC 61810** | | | |
| T9VV1K15-12S | A (NO) | 35A, 250VAC, cosφ=1, 85°C | 20x10$^3$ |
| **UL 508** | | | |
| T9VV1K15-12S | A (NO) | 35A, 250VAC, resistive, 85°C | 20x10$^3$ |
| T9VV1K15-12S | A (NO) | 40A, 30VDC, resistive, 70°C | 60x10$^3$ |
| **CQC** | | | |
| T9VV1K15-12S | A (NO) | 40A, 250VAC, resistive, 60°C | 20x10$^3$ |
| **TUV** | | | |
| T9VV1K15-12S | A (NO) | 40A, 30VDC, resistive, 70°C | 60x10$^3$ |

Mechanical endurance, DC coil 1x10$^6$ operations

1) The relay connections and wiring have to be designed with an adequate cross sections to ensure the current flow and heat dissipation.
2) Contact ratings with relay properly verted.

### Coil Data

| | |
|---|---|
| Rated coil voltage | 12VDC |
| Coil insulation system according UL | class F |

**Coil versions, DC coil**

| Coil code | Rated voltage VDC | Operate voltage VDC | Release voltage VDC | Coil resistance Ω±10% | Rated coil power W |
|---|---|---|---|---|---|
| 12 | 122) | 9.6 | 0.8 | 64+10% | 2.25 / min. 0.35 hold |

2) After the energization time of 100 ms with 12 VDC the coil requires a reduction of the coil voltage to 4.7...6.0 VDC.
All figures are given for coil without pre-energization, at ambient temperature +23°C.
Other coil voltages on request.

### Insulation Data

| | |
|---|---|
| Initial dielectric strength | |
| between open contacts | 2500V$_{rms}$ |
| between contact and coil | 4000V$_{rms}$ |
| Clearance/creepage | |
| between contact and coil | 3/4mm |
| Material group of insulation parts | III |
| Tracking index of relay base | PTI 325 |

### Other Data

Material compliance: EU RoHS/ELV, China RoHS, REACH, Halogen content refer to the Product Compliance Support Center at www.te.com/customersupport/rohssupportcenter

| | |
|---|---|
| Ambient temperature | -40 to +85°C1) |
| Category of environmental protection | |
| IEC 61810 | RTII - flux proof |
| Vibration resistance (functional) | 10g |
| Shock resistance (functional) | 10g |
| Shock resistance (destructive) | 100g |
| Terminal type | PCB-THT |
| Mounting | see note1) |
| Mounting distance | ≥10mm |
| Weight | appr. 30g |
| Resistance to soldering heat THT | |
| IEC 60068-2-20 | 260°C/5s |
| Packaging unit | box/500 pcs. |

1) The relay connections and wiring have to be designed with an adequate cross sections to ensure the current flow and heat dissipation.

1

12-2016, Rev. 1216
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Datasheets and product specification according to IEC 61810-1 and to be used only together with the 'Definitions' section.

Datasheets and product data is subject to the terms of the disclaimer and all chapters of the 'Definitions' section, available at http://relays.te.com/definitions

Datasheets, product data, 'Definitions' section, application notes and all specifications are subject to change.

**Note:**

AZSR250-2AE-12D for SOFAR 30000TL-G2, SOFAR 33000TL-G2

T9VV1K15-12S for SOFAR 20000TL-G2, SOFAR 25000TL-G2-G2

| 5.4.5 Protection devices for the interface switch | |
|---|---|
| **5.4.5.1 General**<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.5.1 are met) | **P** |
| **Test condition:** | The measurements were performed in the testing laboratory.<br>at the grid-simulator:<br>$U_N$ = between 86 % Un and 109% Un until the test<br>Frequency: 50 Hz +/- 0,5% |
| **Note:**<br>If an examination is required for any other requirements, these apply to this test. | |

| **5.4.5.2 Functional safety** | | | | | | | | **P** |
|---|---|---|---|---|---|---|---|---|
| Component No. | Fault | Test condition: | | Test time | Fuse no. | Fault condition | | Result |
| | | AC | DC | | | AC | DC | |
| Relay defect RYB1 pin4-pin5 | Short before start up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Error message"Relay test fail", PV inverter do not connect to the grid. |
| Relay defect RYB2 pin4-pin5 | Short before start up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Error message"Relay test fail", PV inverter do not connect to the grid. |
| Relay defect RYB3 pin4-pin5 | Short before start up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Error message"Relay test fail", PV inverter do not connect to the grid. |
| Relay defect RYB4 pin4-pin5 | Short before start up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Error message"Relay test fail", PV inverter do not connect to the grid. |
| Relay defect RYB5 pin4-pin5 | Short before start up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Error message"Relay test fail", PV inverter do not connect to the grid. |
| Relay defect RYB6 pin4-pin5 | Short before start up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Error message"Relay test fail", PV inverter do not connect to the grid. |
| Grid voltage monitoring RB137 | Open | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |
| Grid voltage monitoring RB 139 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |
| Grid voltage monitoring RB 131 | Open | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Grid voltage monitoring RB 128 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |
| Grid voltage monitoring RB 122 | Open | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |
| Grid voltage monitoring RB 120 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |
| Grid voltage monitoring RB 112 | Open | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |
| Grid voltage monitoring RB 110 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The grid voltage error". |
| RCMU detect defect RB 96 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect RB 11 | Open | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect RB 8 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect UB1 PIN5 to 6 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect QB1 PIN2 to 3 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect QB3 PIN2 to 3 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect UB2 PIN5 to 7 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect RB23 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect CB17 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect UB2 PIN12 to 14 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| RCMU detect defect RB25 | Open | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RCMU detect defect UB2 PIN10 to 8 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"GFCI error". |
| Grid voltage monitoring RC6 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage error". No damaged.No hazard. |
| Grid voltage monitoring RC19 | Open | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage error". No damaged.No hazard. |
| Grid voltage monitoring UC627 PIN2 to 3 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage error". No damaged.No hazard. |
| Grid voltage monitoring UC627 PIN5 to 7 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage sample error". No damaged.No hazard. |
| Grid voltage monitoring UC627 PIN8 to 10 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage sample error". No damaged.No hazard. |
| Grid voltage monitoring RC73 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage error". No damaged.No hazard. |
| Grid voltage monitoring UC629 PIN2 to 3 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage error". No damaged.No hazard. |
| Grid voltage monitoring RC70 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage error". No damaged.No hazard. |
| Grid voltage monitoring UC629 PIN8 to 10 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage sample error". No damaged.No hazard. |
| Grid voltage monitoring UC629 PIN5 to 7 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter disconnected from grid immediately. Error message:"The gird voltage sample error". No damaged.No hazard. |
| ISO detect defect RC167 | Short before start-up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Inverter did not start-up. Error message:"The ISO error". |
| ISO detect defect RC98 | Short before start-up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Inverter did not start-up. Error message:"The ISO error". |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ISO detect defect RC113 | Short before start-up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Inverter did not start-up. Error message:"The ISO error". |
| ISO detect defect RC116 | Short before start-up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Inverter did not start-up. Error message:"The ISO error". |
| ISO detect defect UC634 PIN6 to 7 | Short before start-up | 230V <1A | 850V <1A | 10min. | -- | 230V <1A | 850V <1A | Inverter did not start-up. Error message:"The ISO error". |
| DSP communication defect XLC1 PIN1 to 2 | Short | 230V 47.7 A | 850V 40A | 10min. | -- | 230V <1A | 850V <1A | Inverter did not start-up. Error message:"The SPI error" |

**Note:**
The errors in the control circuit simulate that the safety is even ensured during a single fault.

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

| **5.4.5.3 Voltage control** | | | | | | P |
|---|---|---|---|---|---|---|
| **Integrated NS protection three phase** ≤ 30kVA (phase to neutral) | | | | | | |
| Setting values of the NS protection: | Setting U< [V]: | | 184,0 | | | |
| | Setting U>> [V]: | | 264,5 | | | |
| | Setting $T_{disconnection}$ [ms] | | 150 | | | |
| **Operating time of the monitoring device:** | | | | | | |
| | **Under voltage:** | | | **Over voltage:** | | |
| L1 to N: | | | | | | |
| Step [V to V]: | 230,0 V to 177,1 V | | | 230,0 V to 271,4 V | | |
| Limit [V]: | 184,0 V | | | 264,5 V | | |
| Measurement [V:] | 183,7 | 183,7 | 183,7 | 264,9 | 264,9 | 264,9 |
| Limit [ms]: | 200 ms | | | 200 ms | | |
| Disconnection time [ms]: | 160,5 | 161,5 | 174,7 | 196,1 | 198,1 | 197,7 |
| L2 to N: | | | | | | |
| Step [V to V]: | 230,0 V to 177,1 V | | | 230,0 V to 271,4 V | | |
| Limit [V]: | 184,0 V | | | 264,5 V | | |
| Measurement [V:] | 183,6 | 183,6 | 183,6 | 263,9 | 263,9 | 263,9 |
| Limit [ms]: | 200 ms | | | 200 ms | | |
| Disconnection time [ms]: | 184,7 | 160,7 | 162,7 | 193,7 | 197,7 | 199,7 |
| L3 to N: | | | | | | |
| Step [V to V]: | 230,0 V to 177,1 V | | | 230,0 V to 271,4 V | | |
| Limit [V]: | 184,0 V | | | 264,5 V | | |
| Measurement [V:] | 183,1 | 183,1 | 183,1 | 264,6 | 264,6 | 264,6 |
| Limit [ms]: | 200 ms | | | 200 ms | | |
| Disconnection time [ms]: | 182,7 | 172,7 | 168,7 | 193,7 | 199,7 | 198,5 |

**Test:**

The voltages per phase conductor are measured, into which current is fed between the line conductor and the neutral conductor.

To measure the disconnection time a surge of 77%$_n$ is taken from the nominal voltage and of 118%$_n$ from the nominal voltage for undervoltage and undervoltage.

**Assessment criterion:**

The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1% of $U_n$ .

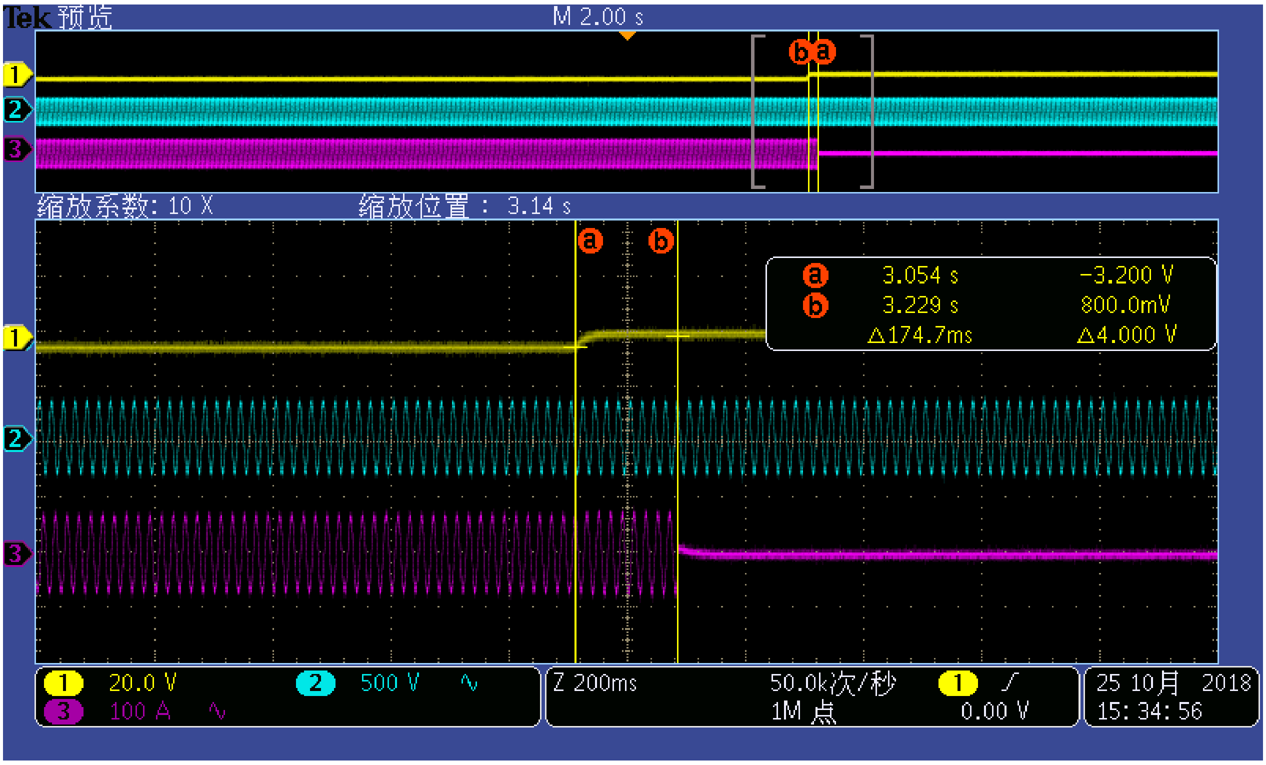
Limit values:

| | | | |
|---|---|---|---|
| Voltage drop protection | U< | 0,8 $U_n$ | 200 ms |
| Rise-in voltage protection | U>> | 1,15 $U_n$ | 200 ms |

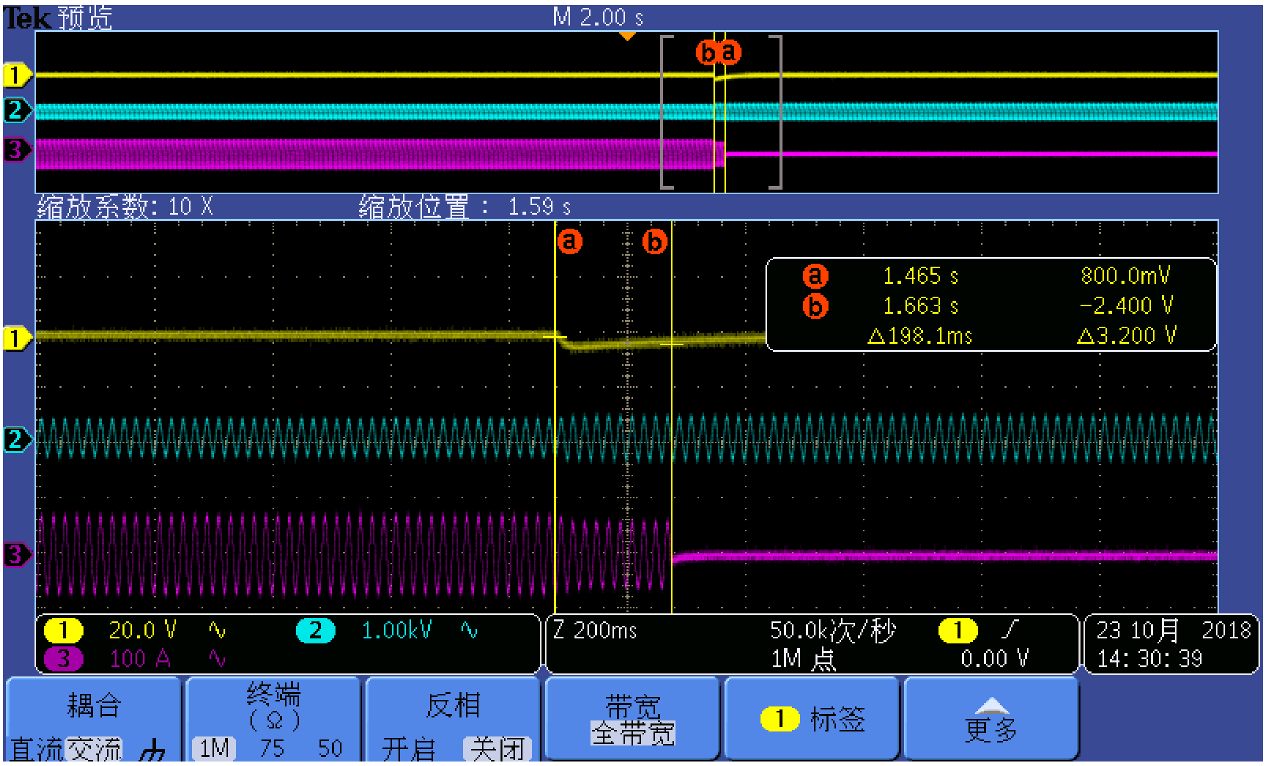
**Note:**

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

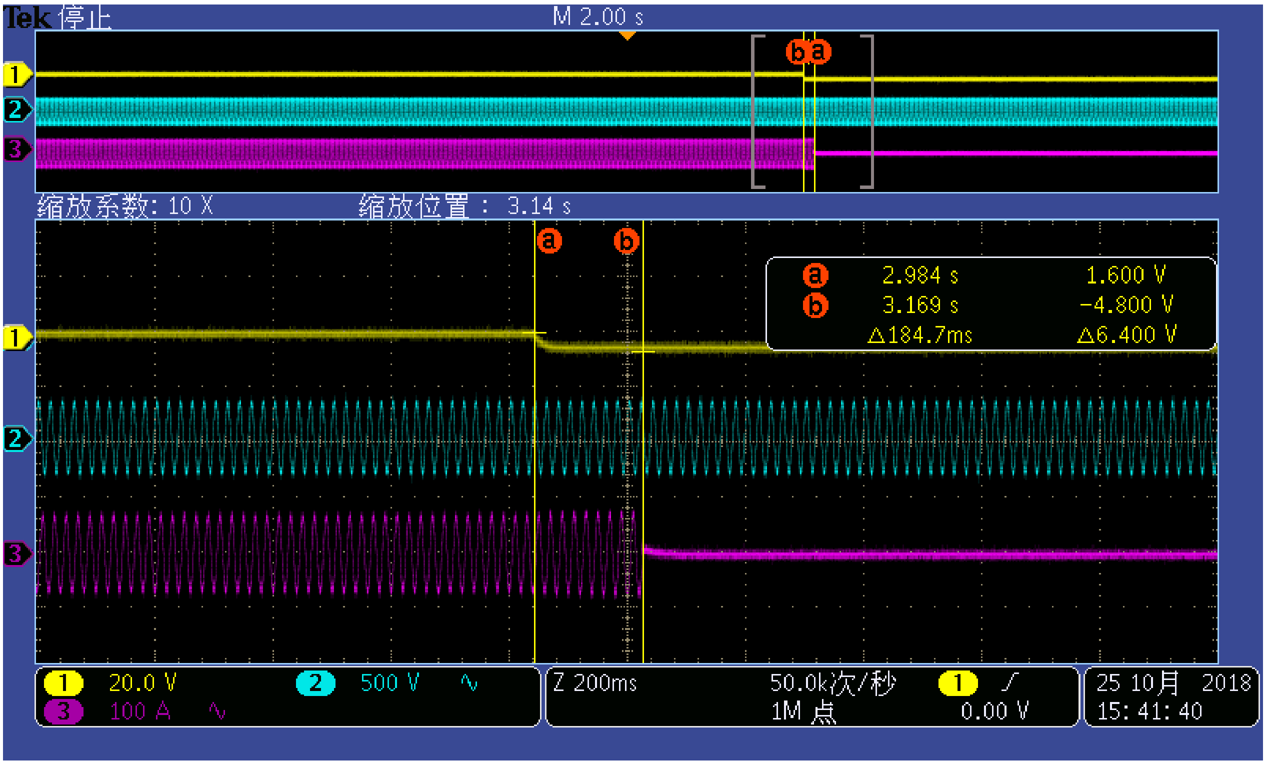
## Graph of under voltage : L1 to N



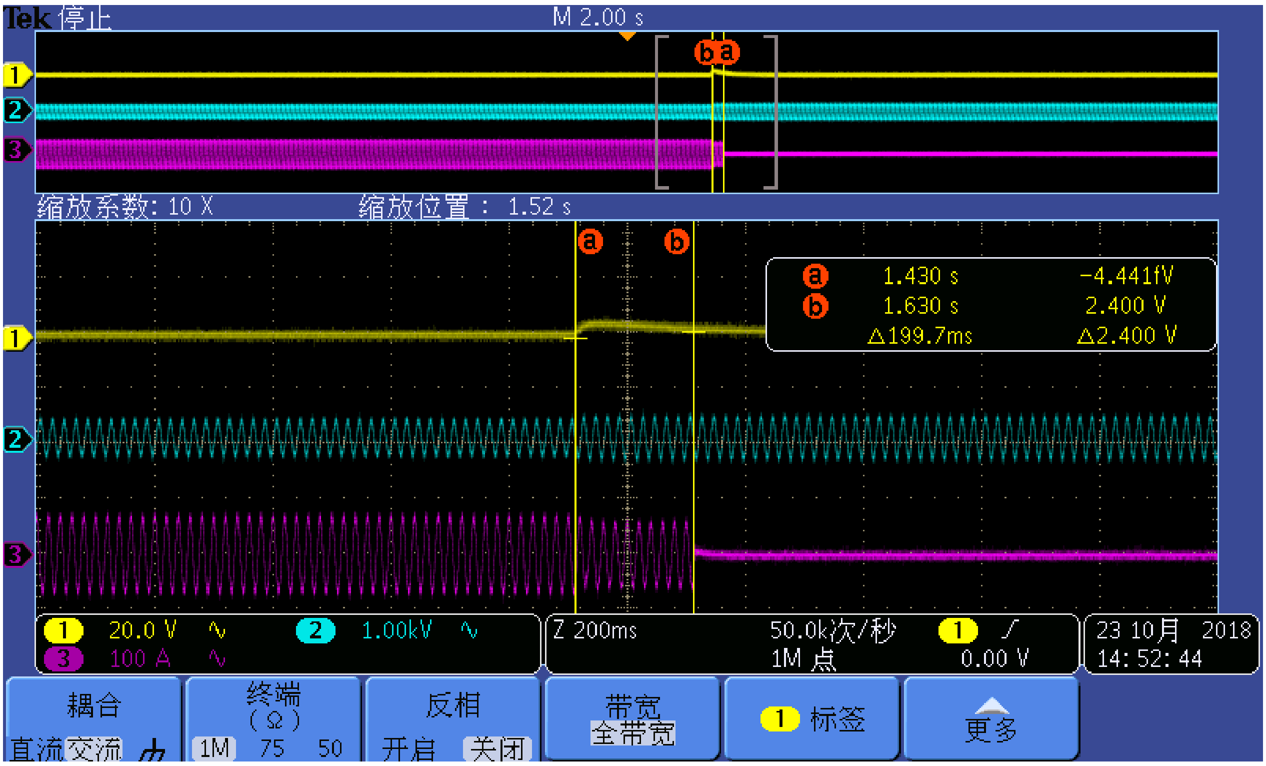

## Graph of over voltage : L1 to N



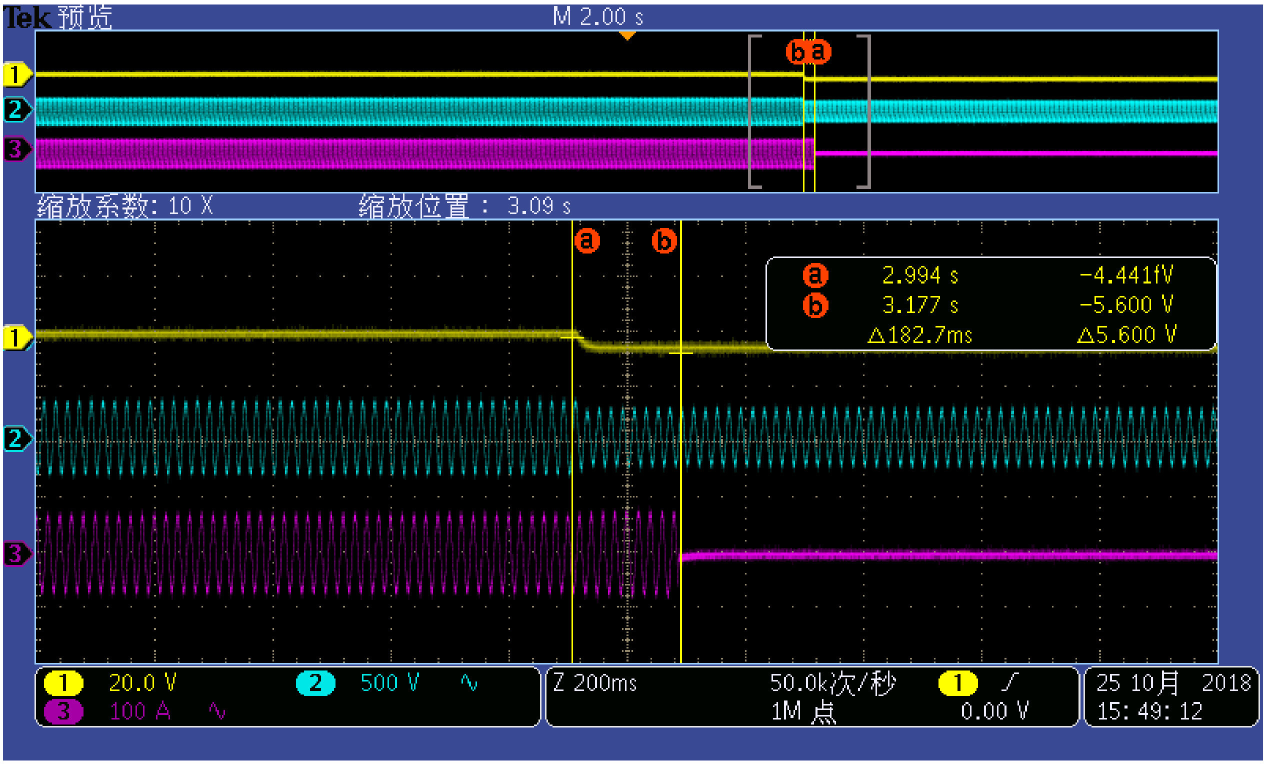
**Graph of under voltage : L2 to N**



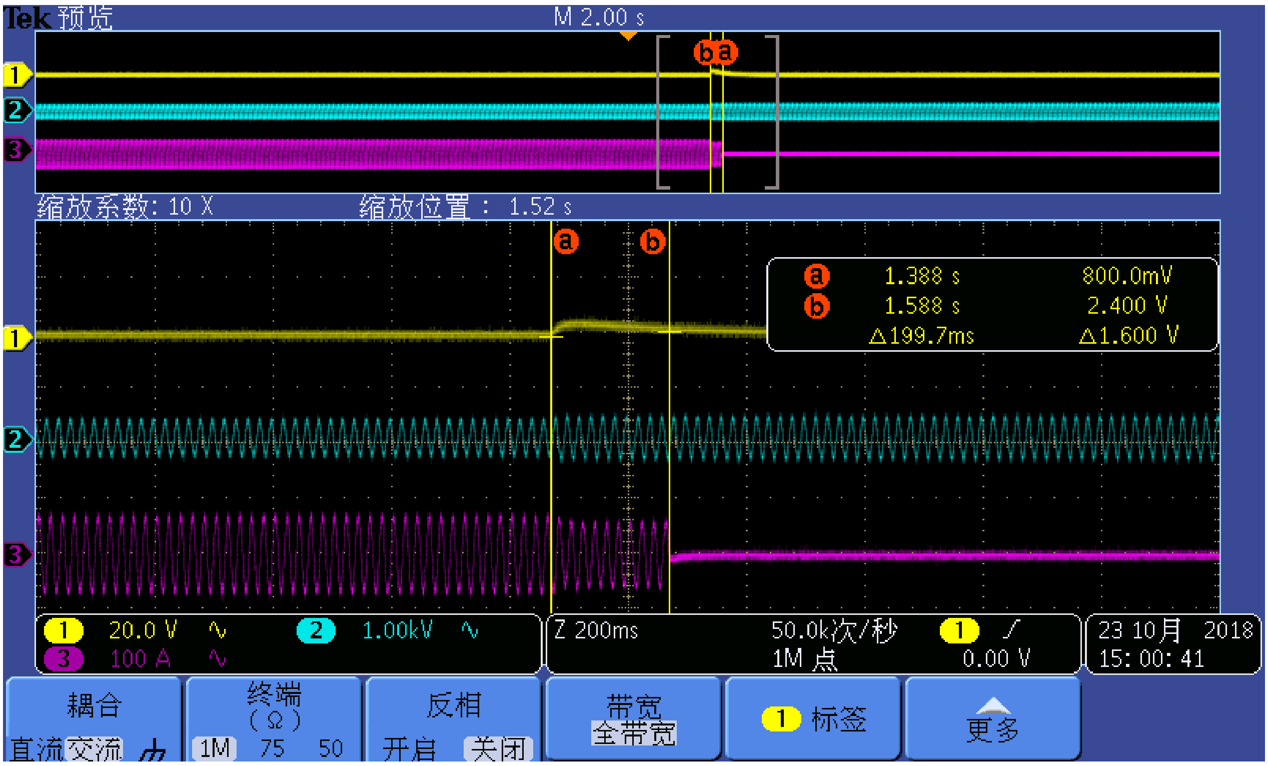

**Graph of over voltage : L2 to N**



**Graph of under voltage : L3 to N**




**Graph of over voltage : L3 to N**



| 5.4.5.3.3 Measuring the rise-in voltage protection as a running 10-minute mean value | | | P |
|---|---|---|---|
| | | | |
| **Test:** | | | |
| | | Disconnection time: | Limit: |
| **a)** | The voltage is set to 100% $U_n$ and held for 600 s. Thereafter the voltage is set to 112% $U_n$. Disconnection must take place within 600 s. | | |
| | Phase 1: | 484 s | 600 s |
| | Phase 2: | 530 s | |
| | Phase 3: | 482 s | |
| **b)** | The voltage is set to $U_n$ for 600 s and then to 108% $U_n$ for 600 s. No disconnection should take place. | | |
| | Phase 1: | No disconnected | Disconnection should not take place. |
| | Phase 2: | No disconnected | |
| | Phase 3: | No disconnected | |
| **c)** | The voltage is set to 106 % $U_n$ and held for 600 s. Thereafter the voltage is set to 114 % $U_n$. *The disconnection should last for half the period as in Point a) | | |
| | Phase 1: | 302 s | * |
| | Phase 2: | 245 s | |
| | Phase 3: | 271 s | |

**Test:**
a) This test serves as proof of the measurement accuracy and the maximum set time.
b) This test serves as proof of the measurement accuracy.
c) This test serves as proof of the correct formation of the 10 minute running mean value.

**Assessment criterion:**
The permitted tolerance between setting value and trip value of the voltage may not exceed ± 1 % of Un.

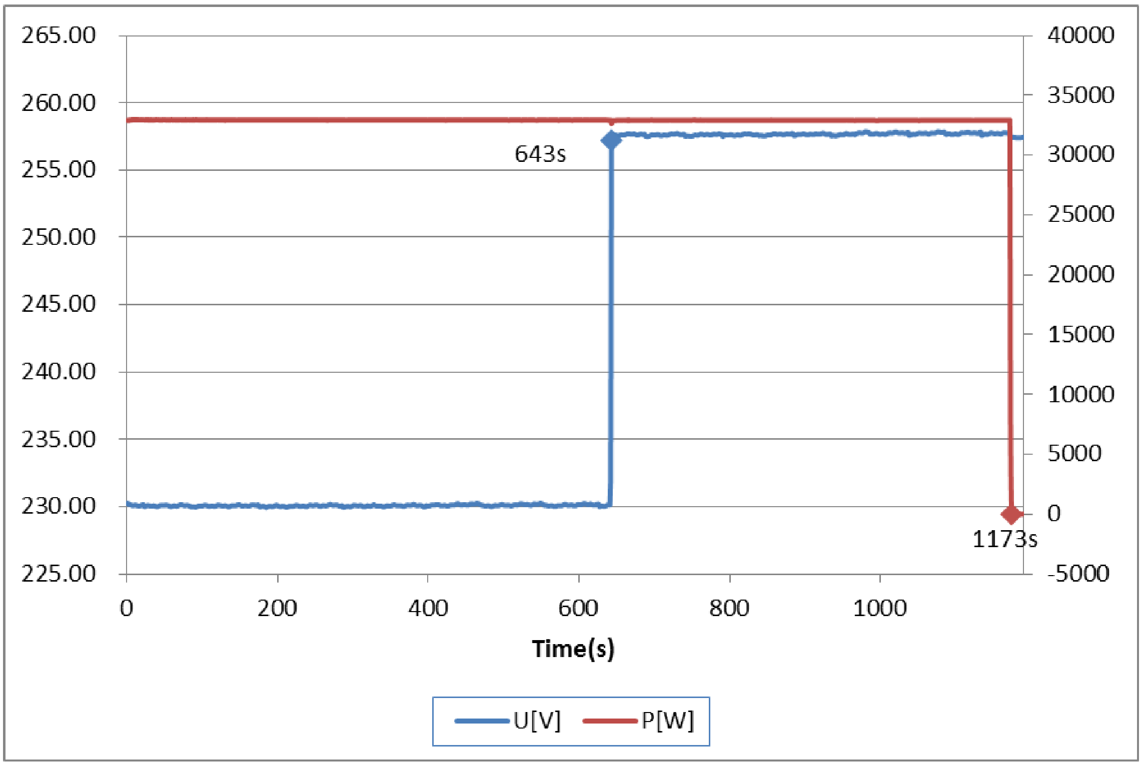
Limit values:
Rise-in voltage protection U> 1,1 $U_n$ after a max. 600 s, the switch off after 200 ms.

**Note:**
If only one integrated NS protection is used for the power generation systems ≤30kVA, the value of the rise-in voltage protection U> of 1,1 $U_n$ may not be changed.

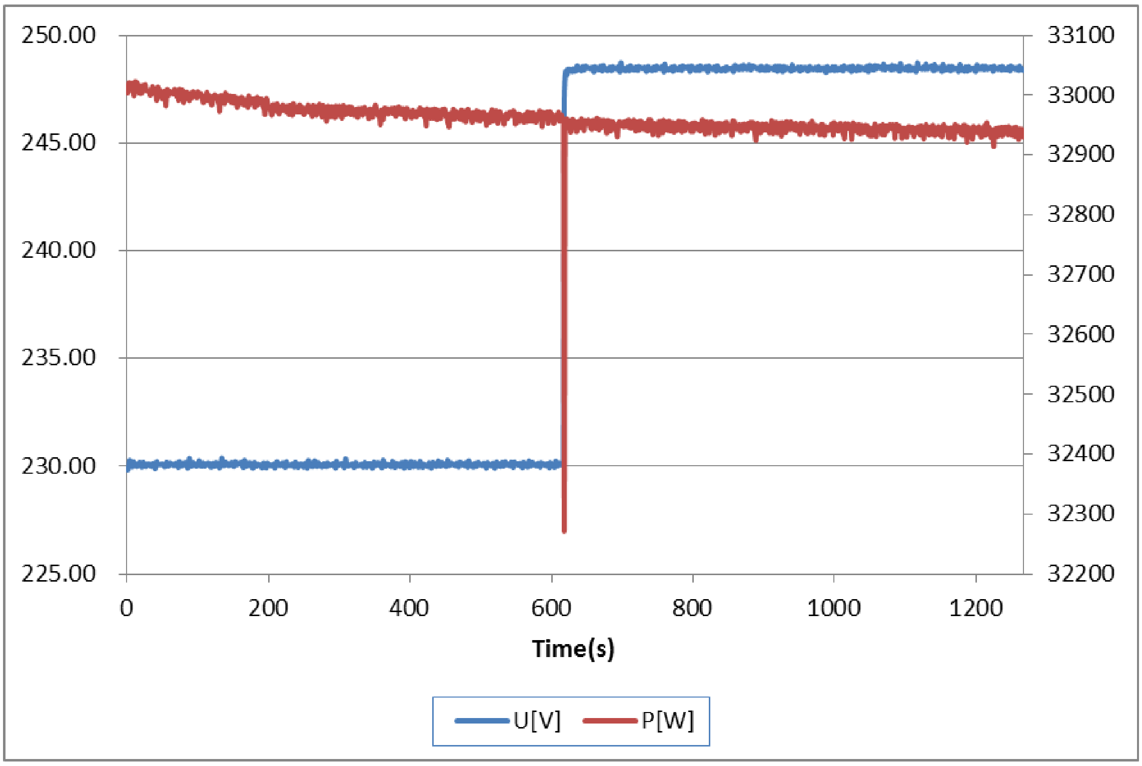
* The disconnection time for test c) may vary due to tolerances of the measurement accuracy of the voltage of the NS protection. For a setting value 600 s a range from 225 s to 375 s is within the permissable tolerance.

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

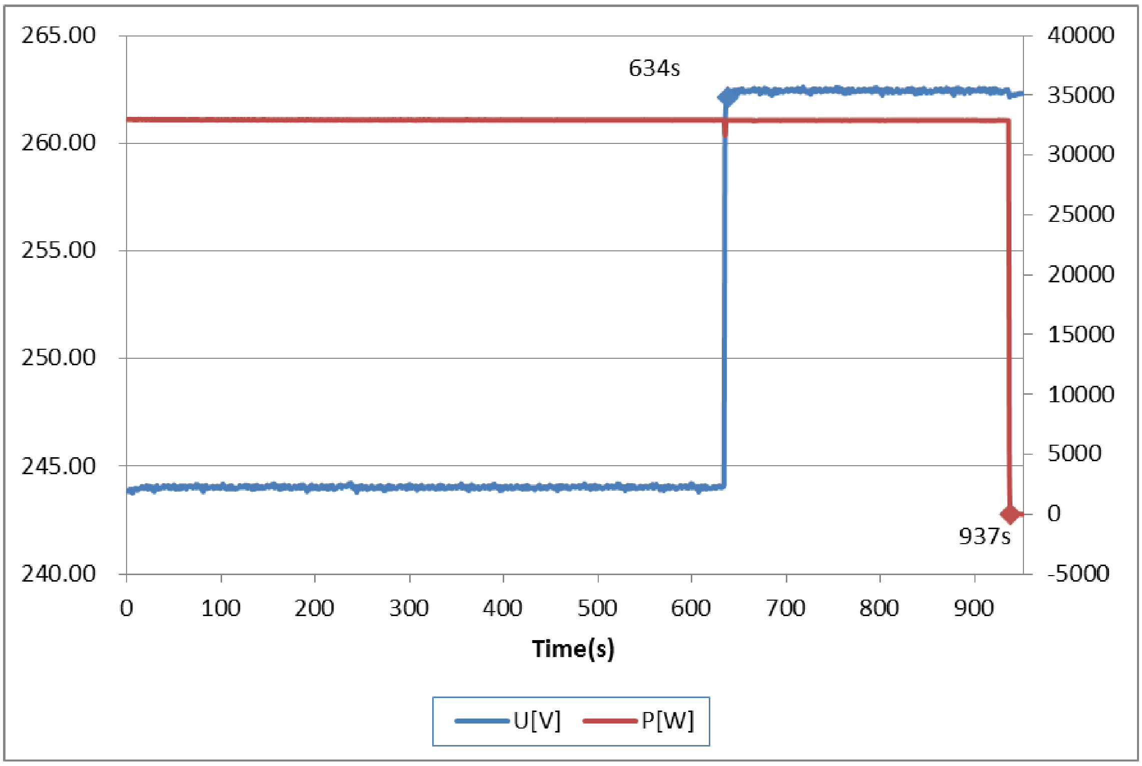
**Graph of test a) Voltage set to 112 % $U_n$:**




**Graph of test b) Voltage set to 108% $U_n$:**



**Graph of test c) Voltage set to 106 % $U_n$, thereafter 114% $U_n$:**



| **5.4.5.4 Frequency measurement** | | | | | | | **P** |
|---|---|---|---|---|---|---|---|
| Setting values of the NS protection: | Setting f< [Hz]: | | 47,50 | | | | |
| | Setting f>[Hz]: | | 51,50 | | | | |
| | Setting $T_{disconnection}$ [ms] | | 150 | | | | |
| **Operating time of the monitoring device** | | | | | | | |
| | **Under frequency** | | | **Over frequency** | | | |
| Ramp [Hz to Hz]: | 48,00 Hz -> 47,00 Hz | | | 51,00 Hz -> 52,00 Hz | | | |
| Limit [Hz]: | 47,50 Hz | | | 51,50 Hz | | | |
| Measurement [Hz]: | 47,50 | 47,50 | 47,50 | 51,50 | 51,50 | 51,50 | |
| Limit [ms]: | 200 ms | | | 200 ms | | | |
| Disconnection time [ms]: | 181 | 199 | 198 | 156 | 152 | 156 | |

**Test:**
The measuring is performed at a continuous change of frequency of 1 Hz/s. The trip value was determined manually by reducing the frequency in 10 mHz steps. When the trip value is known (e.g. 47,50 Hz), the grid simulator is programmed to run from e.g. 48,00 Hz to 47,00 Hz with 1 Hz/s. The disconnection time is calculated by the measured time minus the 500 ms from 48,00 Hz to 47,50 Hz.

**Assessment criterion:**
The setting value and the trip value of the frequency may not vary by more than ±0.1 % $f_n$ .

For frequencies of between 47,5 Hz and 51,5 Hz (±0,1% $f_n$) automatic disconnection from the network as a result of a deviation in frequency is not permitted.

Limit values:

| | | | |
|---|---|---|---|
| Frequency decrease protection | f< | 47,5 Hz | 200 ms |
| Frequency increase protection | f< | 51,5 Hz | 200 ms |

**Note:**
The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

**Graph of under frequency:**


**Graph of over frequency:**

| 5.4.5.5 Reporting NS protection | P |
|---|---|
| The last 5 dated failure reports on the NS protection can be read. An interruption in the supply voltage of ≤ 3s does not result in any loss of failure reports.<br><br>Central NS protection:<br>It is possible to read the setting values and the failure reports of the NS protection independently of the operational state and without any additional aids.<br><br>Integrated NS protection:<br>It is possible to read out the values of the NS protection via the data interface, if the values are not directly readable. | |
| **Note:** | |

**5.4.6 Islanding detection**
(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 6.5.3 are met)

For power generation systems, islanding detection must be carried out using one of the following processes:

a) active method, e.g. by means of frequency – shift process (oscillating circuit)

b) passive method with the help of the three-phase voltage control (only possible for power generation systems without converters or for single-phase generation units with converters).

(see 5.4.5.3 3-phase voltage control)

With the passive process, it is important to provide evidence that the power generation unit can be set not equal to 120°.

| **5.4.6.1 Active method**<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, D.1 are met) | | | **P** |
|---|---|---|---|
| **Test condition:** | Frequency: 50+/-0,01 Hz<br>$U_N$ = 230+/-1% $V_{ac}$<br>RLC consumes inverter real power within +/-3%<br>Distortion factor of chokes <3%<br>Quality Q>2 | | |
| Disconnection limit: | 5 s | | |
| **L1 phase** | | | |
| Output power:<br>Osc. parameter | 25% | 50% | 100% |
| - 5% | 77,4 | 194,2 | 120,2 |
| - 4% | 92,4 | 190,2 | 229,2 |
| - 3% | 98,4 | 151,2 | 219,2 |
| - 2% | 87,4 | 180,2 | 230,2 |
| - 1% | 89,4 | 196,2 | 220,2 |
| 0% | 98,8 | 197,2 | 234,2 |
| +1% | 89,4 | 147,2 | 216,2 |
| +2% | 87,8 | 168,2 | 136,2 |
| +3% | 88,8 | 181,2 | 201,2 |
| +4% | 76,8 | 149,2 | 210,2 |
| +5% | 85,8 | 151,6 | 135,2 |
| Parameter at 0% | L=32,26 mH<br>R= 20,27 Ω<br>C= 314,10µF | L= 14,93 mH<br>R= 9,38 Ω<br>C= 678,74 µF | L= 7,34 mH<br>R= 4,61 Ω<br>C= 1380,35 µF |
| **L2 phase** | | | |
| Output power:<br>Osc. parameter | 25% | 50% | 100% |
| - 5% | 90,2 | 149,2 | 145,2 |
| - 4% | 84,2 | 134,2 | 138,2 |
| - 3% | 79,2 | 106,2 | 143,2 |
| - 2% | 85,2 | 108,2 | 119,2 |
| - 1% | 88,2 | 133,2 | 470,2 |
| 0% | 92,2 | 153,2 | 652,2 |
| +1% | 82,2 | 120,2 | 138,2 |
| +2% | 92,2 | 120,2 | 155,2 |
| +3% | 83,2 | 146,2 | 147,2 |
| +4% | 91,2 | 136,2 | 137,2 |
| +5% | 88,2 | 137,2 | 121,2 |
| Parameter at 0% | L=32,38 mH<br>R= 20,35 Ω<br>C= 312,89µF | L= 16,64 mH<br>R= 10,45 Ω<br>C= 608,94 µF | L= 8,34 mH<br>R= 5,24Ω<br>C= 1215,47 µF |

**L3 phase**

| Output power: / Osc. parameter | 25% | 50% | 100% |
|---|---|---|---|
| - 5% | 97,4 | 128,6 | 94,6 |
| - 4% | 77,4 | 128,4 | 216,0 |
| - 3% | 87,2 | 139,4 | 224,0 |
| - 2% | 72,6 | 129,4 | 218,0 |
| - 1% | 79,4 | 131,6 | 210,0 |
| 0% | 88,4 | 143,4 | 268,6 |
| +1% | 80,4 | 123,6 | 210,6 |
| +2% | 87,4 | 123,6 | 217,6 |
| +3% | 86,4 | 110,6 | 194,6 |
| +4% | 82,4 | 95,4 | 226,6 |
| +5% | 88,4 | 137,6 | 202,6 |
| Parameter at 0% | L=32,13 mH<br>R= 20,19 Ω<br>C= 315,30μF | L= 16,64 mH<br>R= 10,45 Ω<br>C= 608,94μF | L= 8,44 mH<br>R= 5,31 Ω<br>C= 1199,83 μF |

**Test:**

The capacitors and the chokes of the resonant circuit were adjusted in order to reach a quality of >2. $P_{QC}+P_{QL}=-P_{Q,WR}$. The resistors of the resonant circuit consumed the real power of the inverter ($P_{WR}$) within +/-3%.

$$L = \frac{U^2}{2 \cdot \pi \cdot 50Hz \cdot P \cdot Q} \qquad C = \frac{P \cdot Q}{2 \cdot \pi \cdot 50Hz \cdot U^2}$$

**Assessment criterion:**

Limit values:

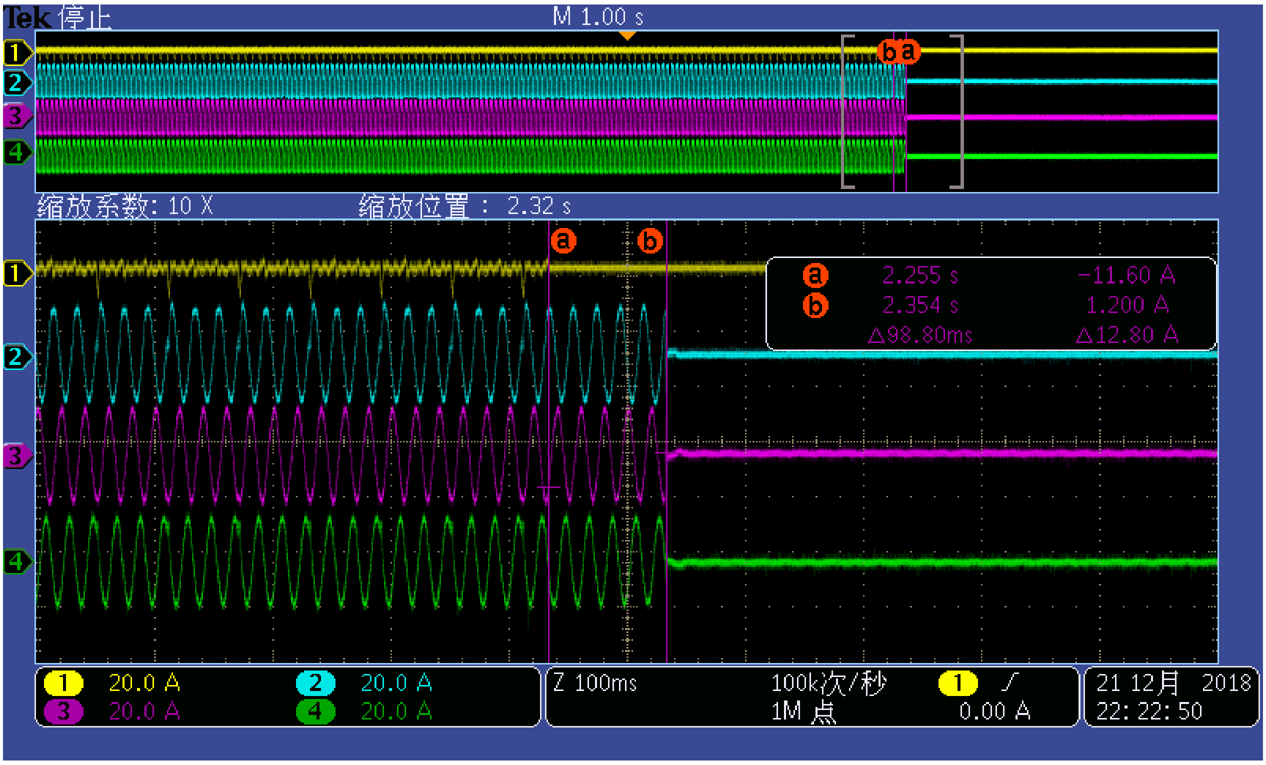
Quality factor Q > 2

Disconnection t ≤ 5 s

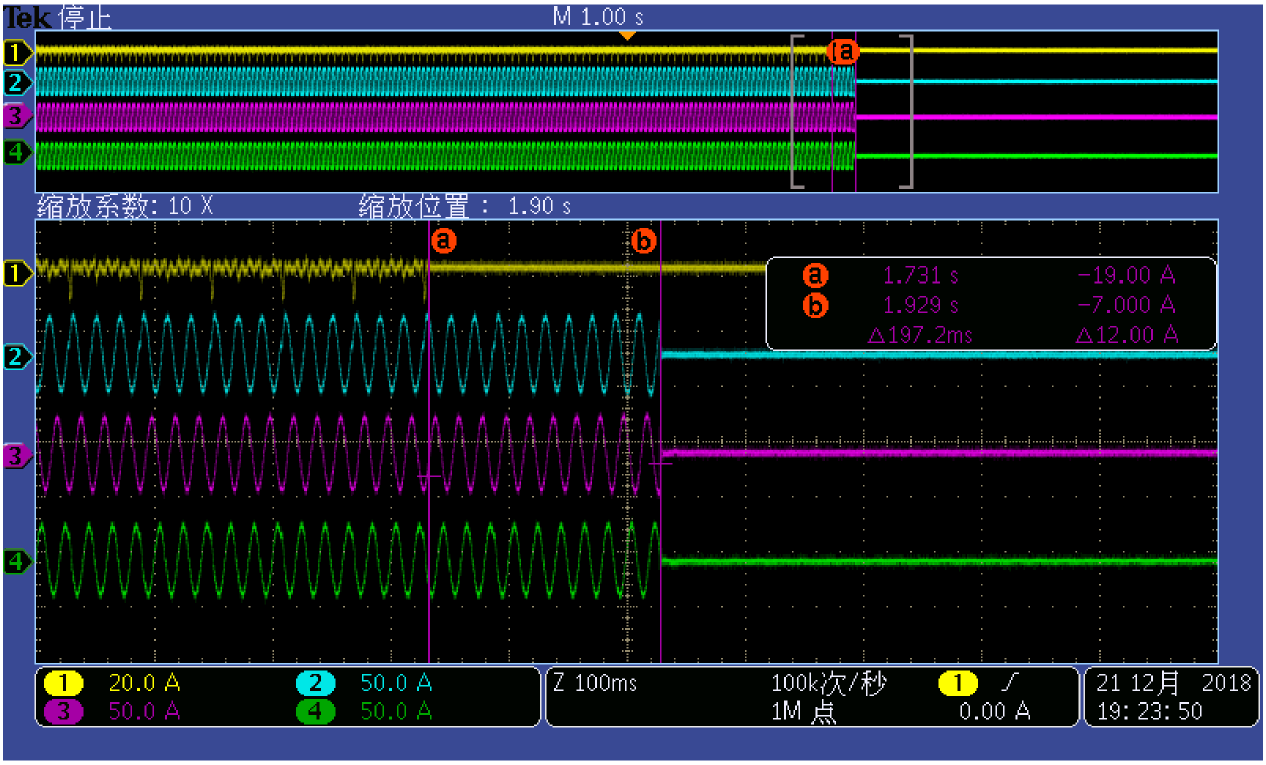
**Note:**

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

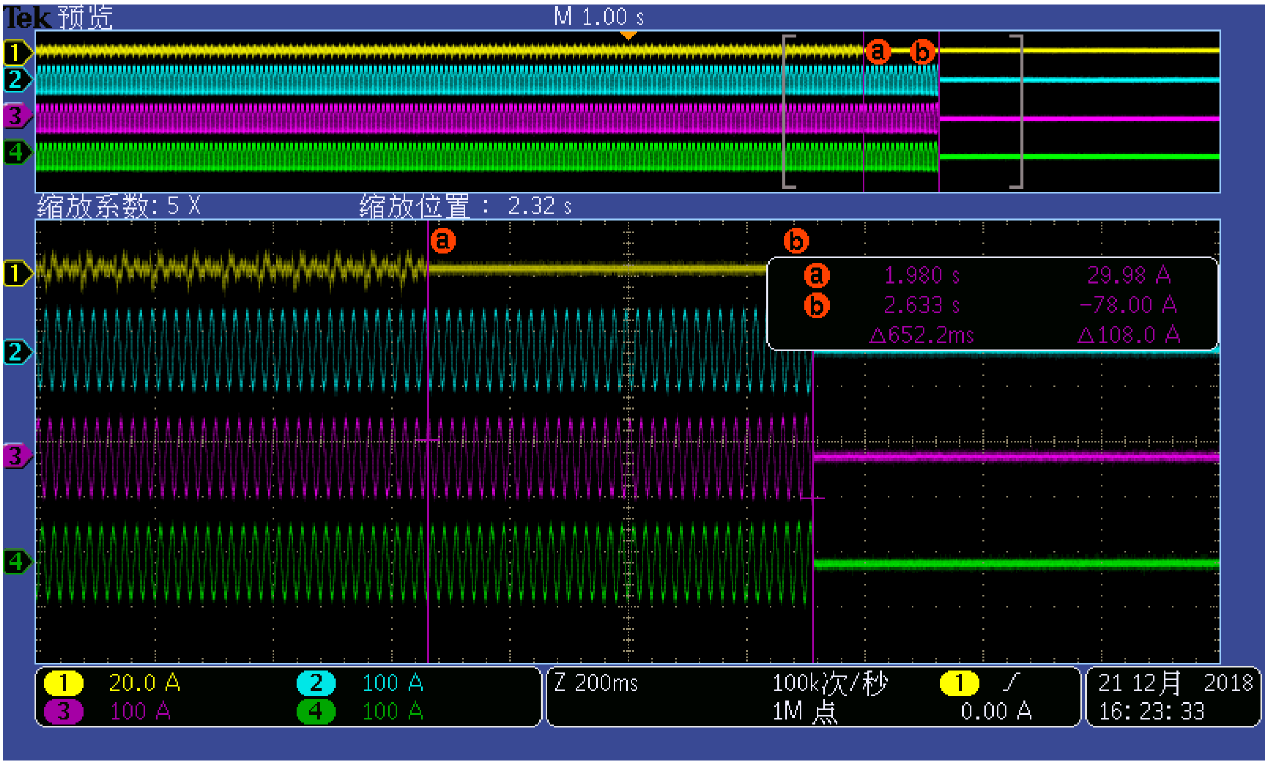
**Oscillating circuit test: 25% output power**




**Oscillating circuit test: 50% output power**



**Oscillating circuit test: 100% output power**



| 5.4.6.1 Passive method | N/A |
|---|---|
| Three-phase voltage control is permitted for islanding detection, as the currents of the power generation unit are controlled independently, so that arbitrary phase relationships can develop. | |
| **Test:**<br>The test is performed according to the voltage disconnection testing clause 5.4.5.3.1 a). The test is passed, if the current follows without phase displacement of the voltage on the displaced phase.<br><br>For test results, see clause 5.4.5.3.1 a) above. | |
| **Note:** | |

| 5.5 Testing of connecting conditions and synchronisation<br>DIN VDE V 0124-100:2012-07 | | |
|---|---|---|
| **Clause** | **Test** | **Result** |
| 5.5 | Connecting conditions and synchronisation | **P** |
| | 5.5.2 Short interruption | **P** |

| 5.5 | Connecting conditions and synchronisation (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105, 8.3.1 are met) | P |
|---|---|---|

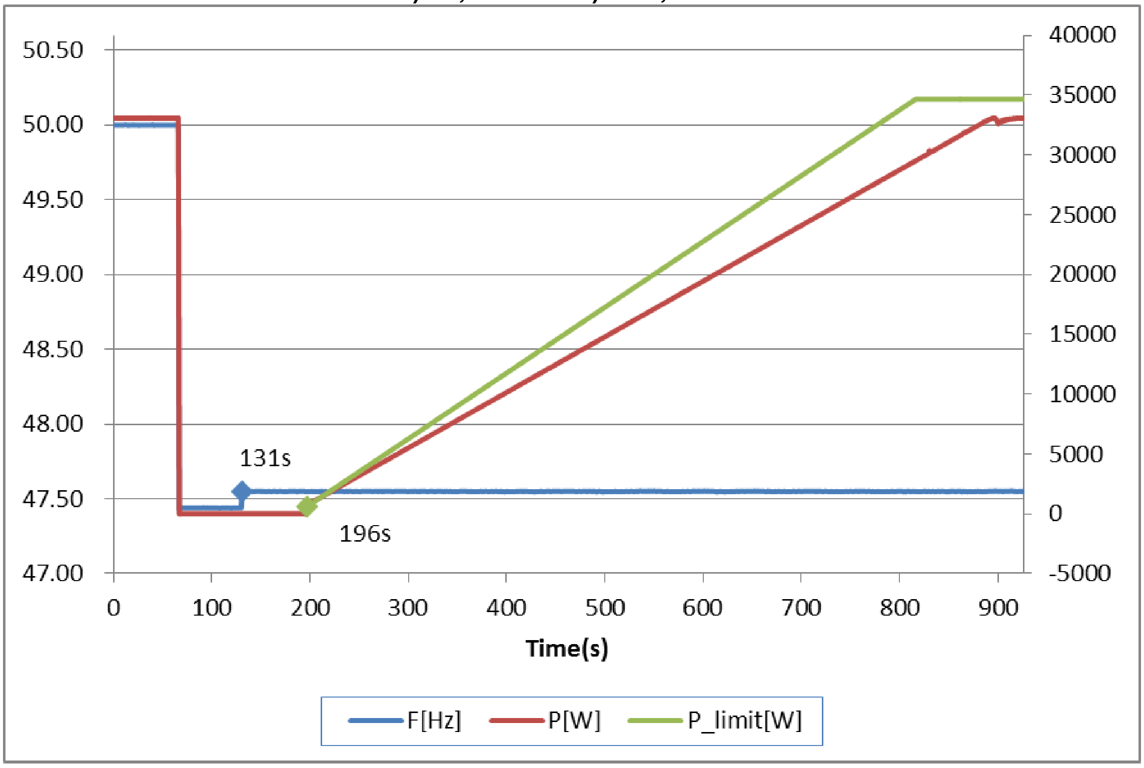
| | | |
|---|---|---|
| Setting values of the NS protection: | Setting $T_{reconnection\ 60s}$ [s]: | 70 |
| | Setting f< [Hz]: | 47,5 |
| | Setting f> [Hz]: | 51,5 |
| | Setting V< [V]: | 184,0 |
| | Setting V>> [V]: | 264,5 |

**Test:**

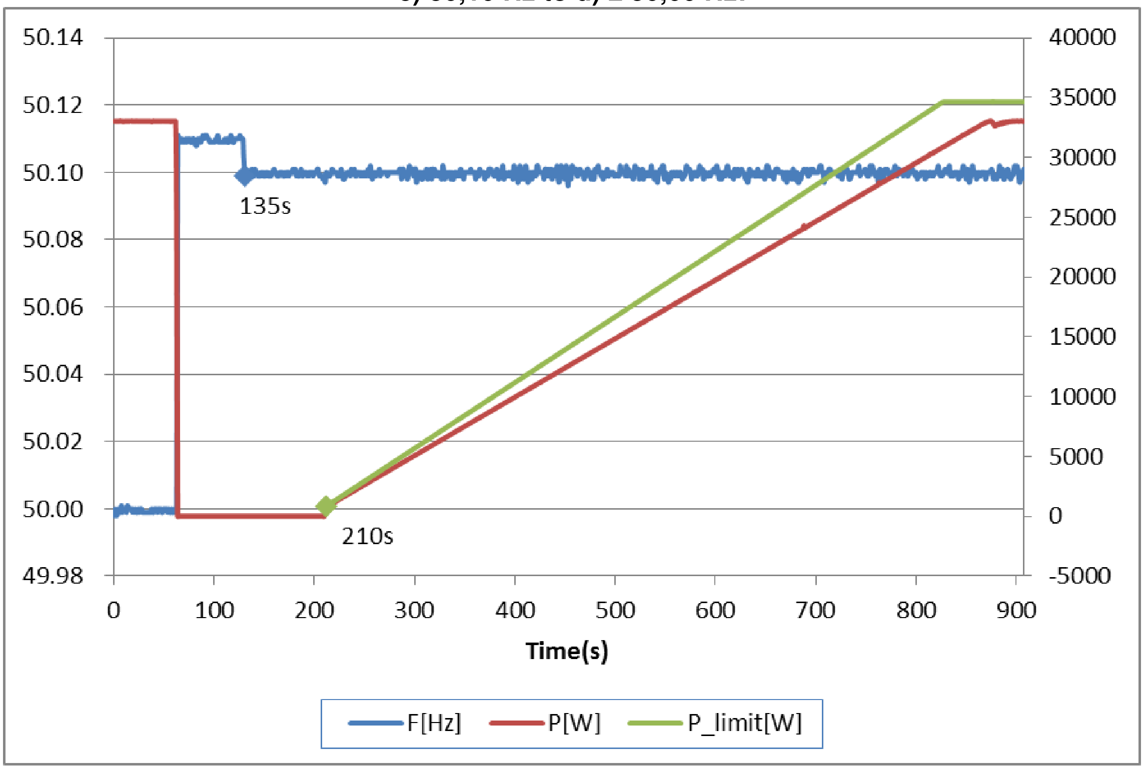
| | $f_{ist}$ | Reset time: | Limit: |
|---|---|---|---|
| **Connecting conditions for frequencies:** | | | |
| a) | 47,45 Hz | No reconnected. | No resetting allowed |
| | Switch to: | | |
| b) | ≥ 47,55 Hz | 65 s | ≥ 60 s |
| c) | 50,06 Hz | No reconnected. | No resetting allowed |
| | Switch to: | | |
| d) | ≥ 50,0 Hz | 75 s | ≥ 60 s |
| **Connecting conditions for voltages: L1 phase** | | | |
| e) | 84% | No reconnected. | No resetting allowed |
| | Switch to: | | |
| f) | ≥ 86% | 67 s | ≥ 60 s |
| g) | 111 % | No reconnected. | No resetting allowed |
| | Switch to: | | |
| h) | ≤ 109% | 71 s | ≥ 60 s |
| **Connecting conditions for voltages: L2 phase** | | | |
| e) | 84% | No reconnected. | No resetting allowed |
| | Switch to: | | |
| f) | ≥ 86% | 66 s | ≥ 60 s |
| g) | 111 % | No reconnected. | No resetting allowed |
| | Switch to: | | |
| h) | ≤ 109% | 66 s | ≥ 60 s |
| **Connecting conditions for voltages: L3 phase** | | | |
| e) | 84% | No reconnected. | No resetting allowed |
| | Switch to: | | |
| f) | ≥ 86% | 66 s | ≥ 60 s |
| g) | 111 % | No reconnected. | No resetting allowed |
| | Switch to: | | |
| h) | ≤ 109% | 67 s | ≥ 60 s |

| |
|---|
| **Test:**<br>see points a) to h) for the test process.<br>The measurement was carried out with a programmable AC source.<br>e.g. connecting conditions for frequencies: Point a) and b). The AC source was programmed in such a way that the first step of 230 V / 50 Hz to 200 V / 47,0 Hz resulted in a faulty disconnection. Thereafter the voltage and frequency for 100 s is set to 215 V / 47,45 Hz. Switching on again is not permitted. After a lapse of 100 s the voltage is set to 230 V / 47,55 Hz. Setting again after 60 s is permitted. |
| **Assessment criterion:**<br>After actuating the NS protection it should be checked that the system can only be switched within the tolerance ranges ((85% $U_n \leq U \leq$ 110% $U_n$) and (47,5 Hz ≤ f ≤ 50,05Hz)) at the earliest after 60 s after voltage and frequency has remained within the tolerance ranges. |
| **Note:**<br>The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software. |

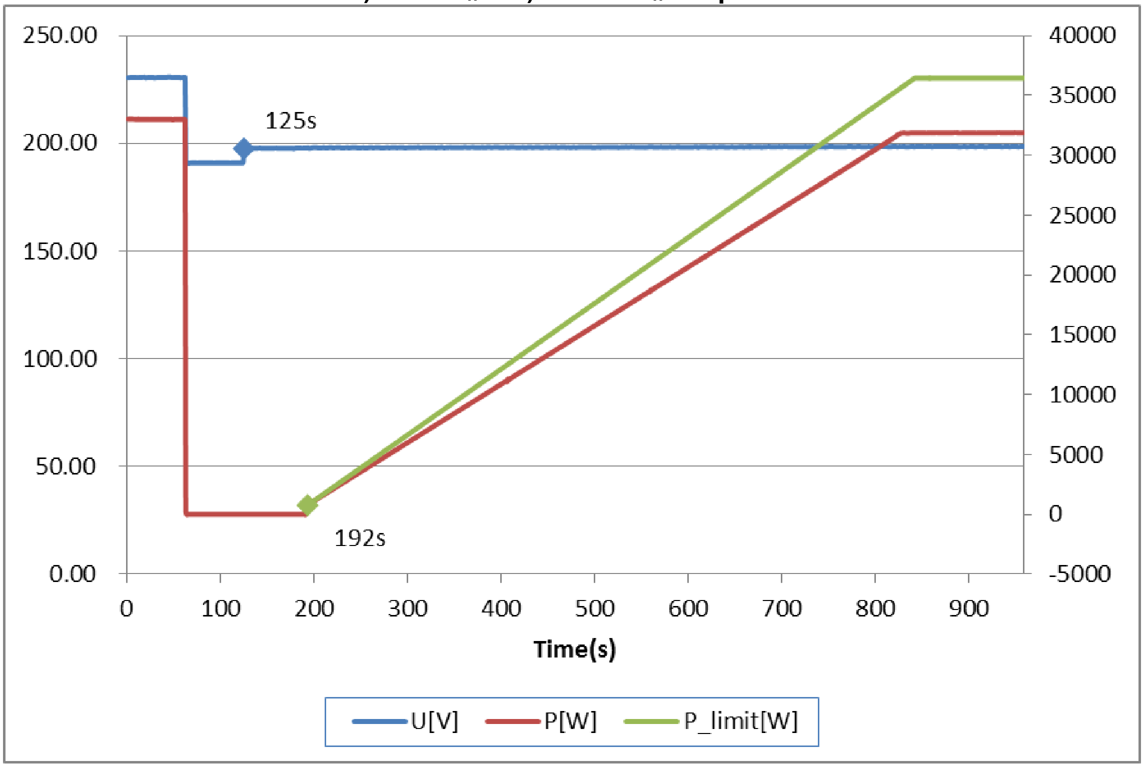
a) 47,50 Hz to b) ≥ 47,55 Hz:



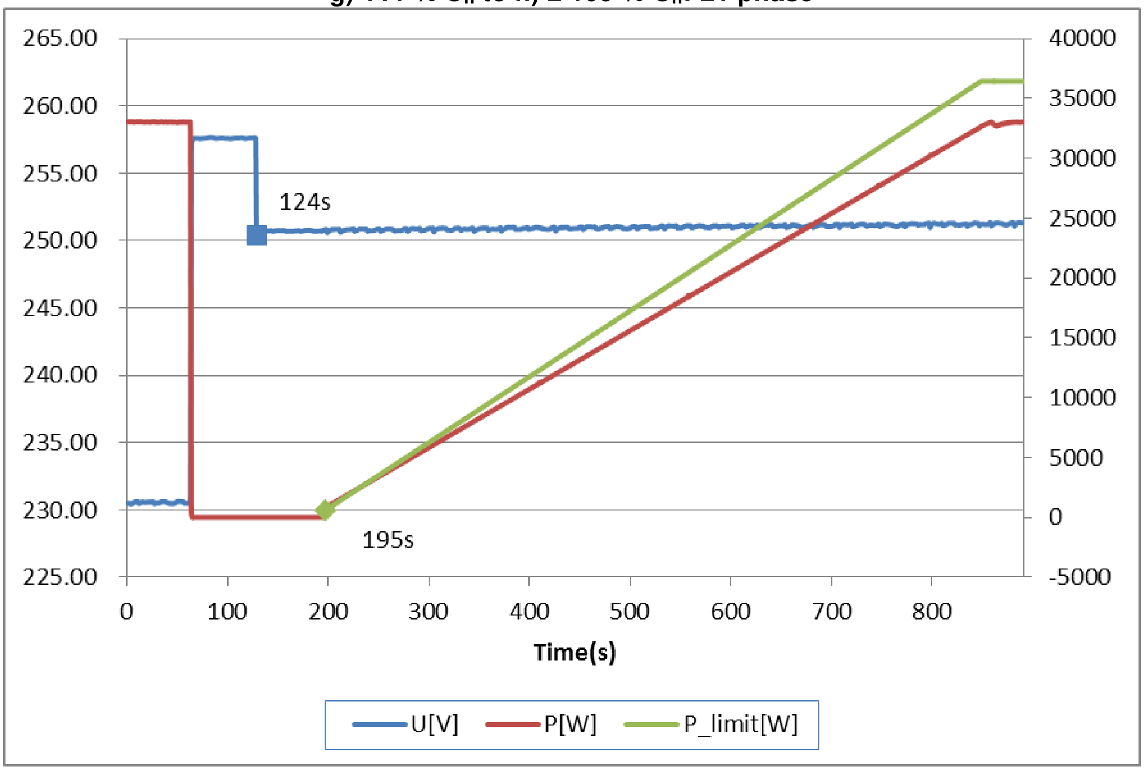

c) 50,10 Hz to d) ≤ 50,00 Hz:



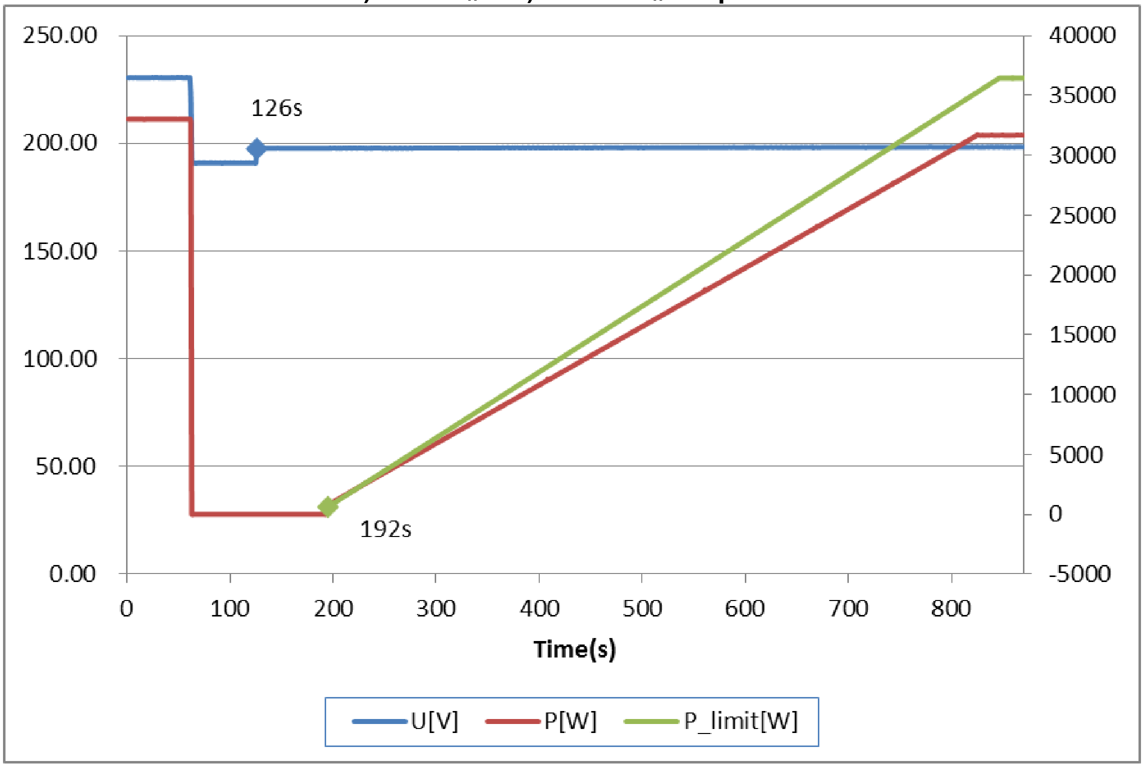
**e) 84 % $U_n$ to f) ≥ 86 % $U_n$: L1 phase**



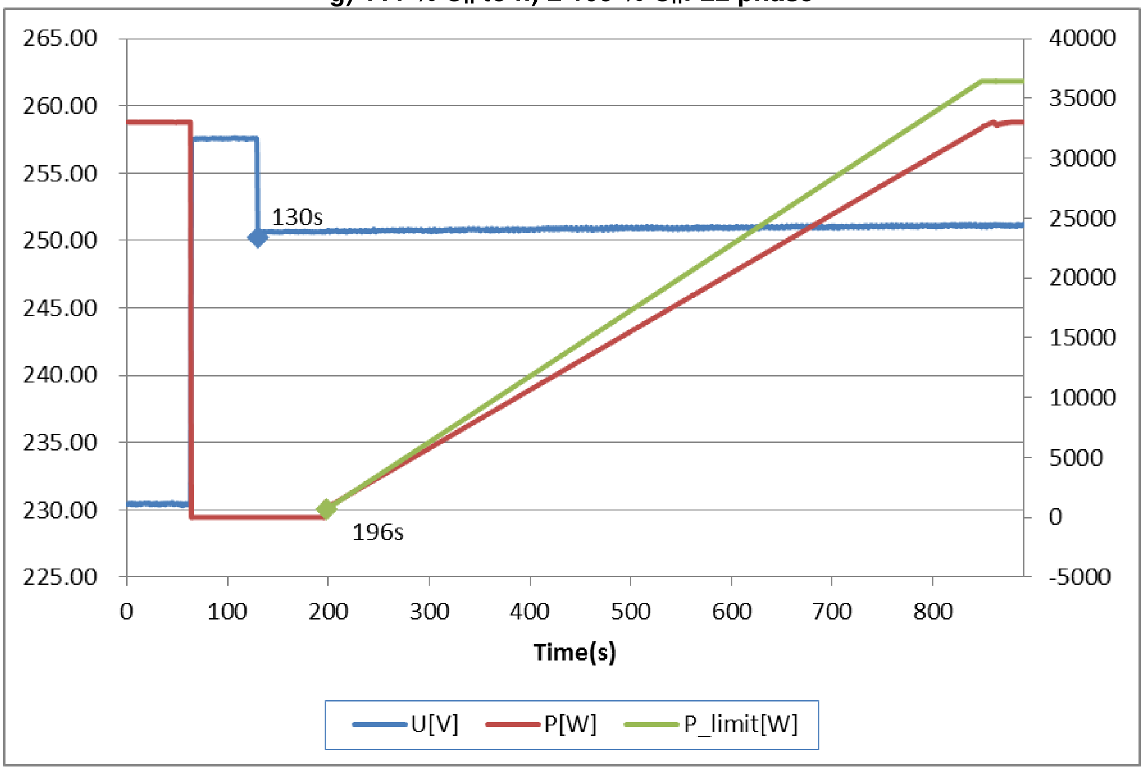

**g) 111 % $U_n$ to h) ≤ 109 % $U_n$: L1 phase**



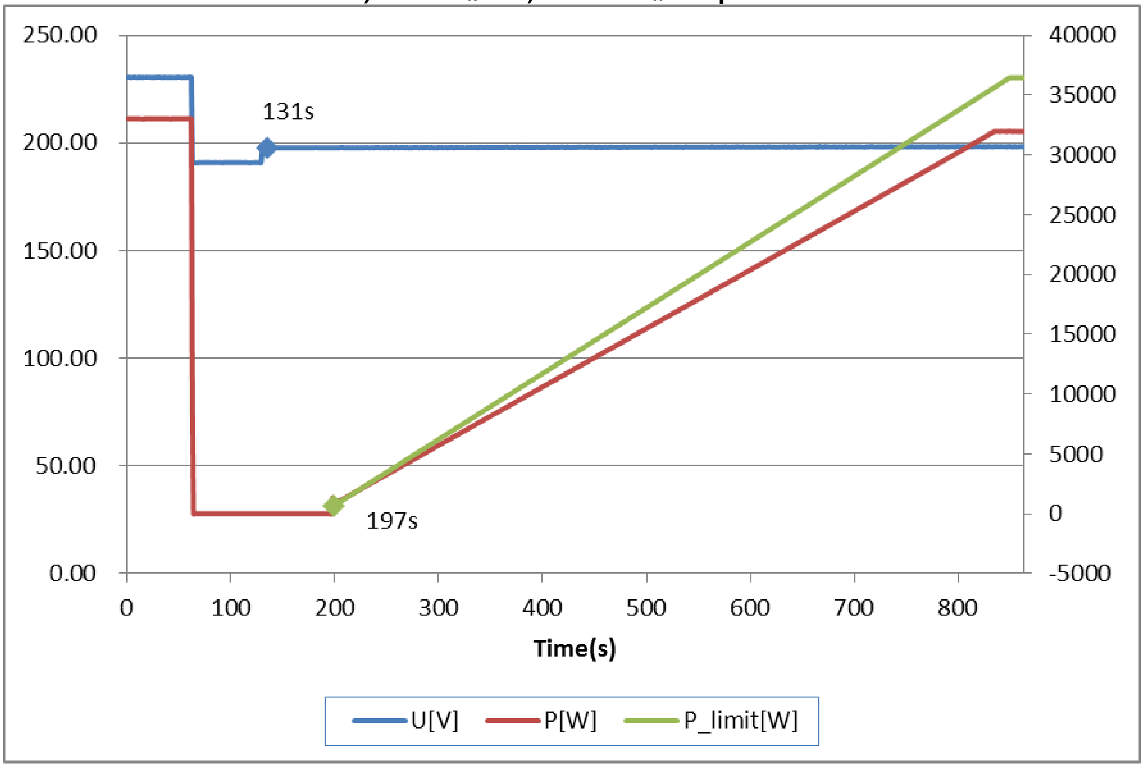
e) 84 % $U_n$ to f) ≥ 86 % $U_n$: L2 phase



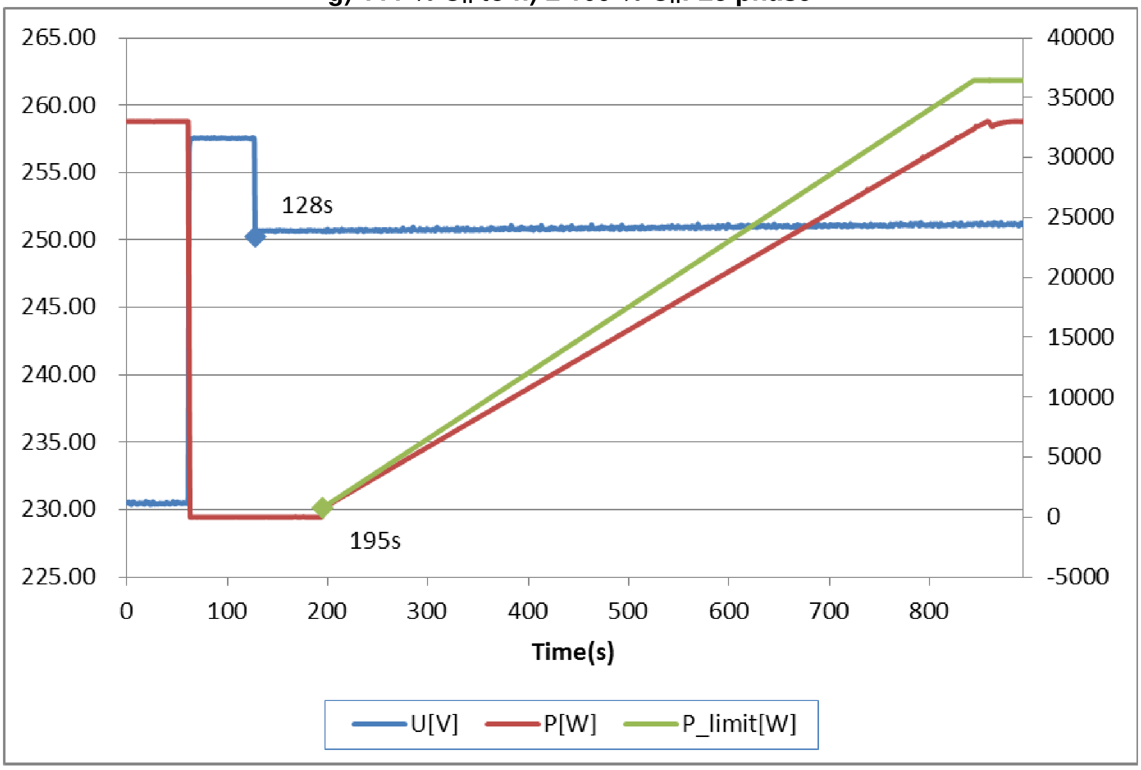

g) 111 % $U_n$ to h) ≤ 109 % $U_n$: L2 phase



**e) 84 % $U_n$ to f) ≥ 86 % $U_n$: L3 phase**




**g) 111 % $U_n$ to h) ≤ 109 % $U_n$: L3 phase**



| 5.5.2 Short interruption | | | P |
|---|---|---|---|
| Setting values of the NS protection: | Setting $T_{disconnection\ 5s}$ [s]: | 30 | |
| | Setting $T_{reconnection\ 60s}$ [s]: | 70 | |
| | Setting V< [V]: | 184,0 | |
| | **Step 1:** | **Step 2:** | |
| Step [V to V] | 230 V to 177,1 V | 230 V to 177,1 V | |
| Jump Duration [s]: | 2 s | 4 s | |
| Limit [s]: | ≥ 5 s | ≥ 60 s | |
| Reconnection Time [s]: | 36 | 67 | |

**Test:**
After providing evidence of a short interruption the network voltage is reduced from the nominal voltage with a surge of 77% $U_n$. A surge to the nominal voltage takes place after 2 s.
After providing evidence of a short interruption the network voltage is reduced from the nominal voltage with a surge of 77% $U_n$. A surge to the nominal voltage takes place after 4 s.

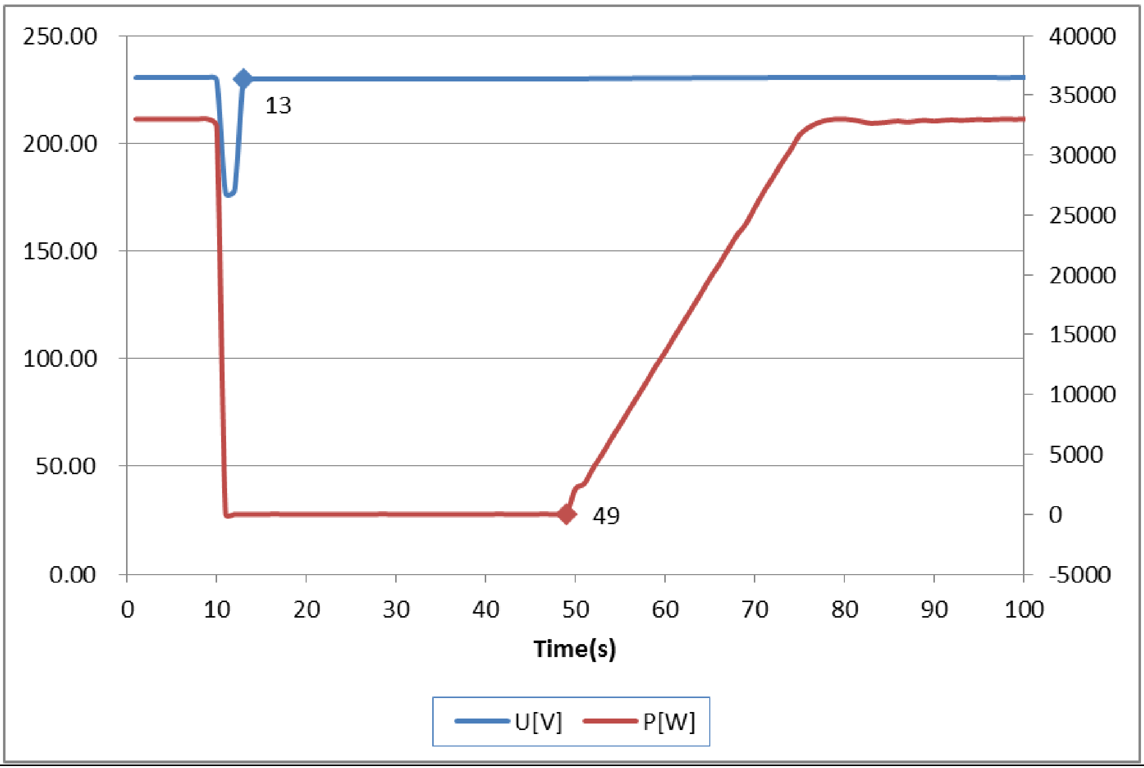
**Assessment criterion:**
Limit values:
Short interruption ≤ 2 s Reset time ≥ 5 s
Short interruption ≥ 3 s Reset time ≥ 60 s

**Note:**
A short interruption is characterised by exceeding or not reaching the NS protection settings for the network frequency and/or network voltage for a maximum period of 3 seconds.

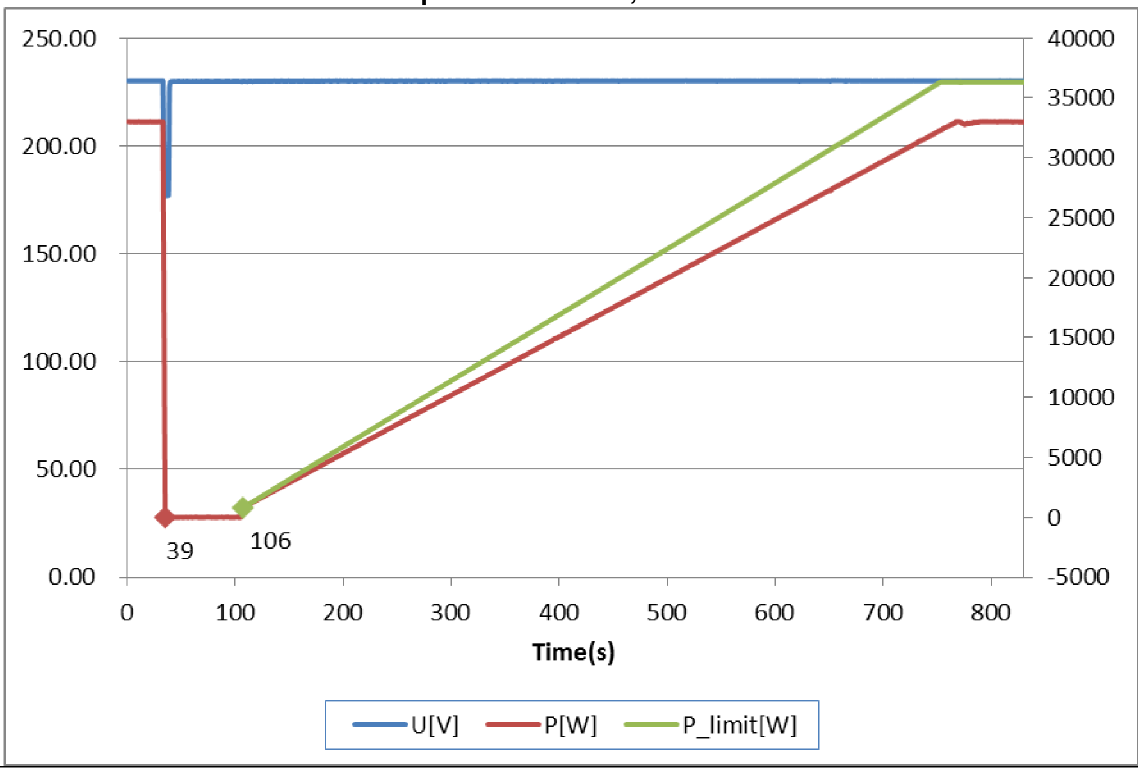
A ramp of 10% $P_n$ is not necessary after short interruptions.

The tests had been performed on the SOFAR 33000TL-G2 is valid for the and SOFAR 20000TL-G2, SOFAR 25000TL-G2 and SOFAR 30000TL-G2, since it is similar in hardware and just power derated by software.

**Step 1: 230 V to 177,1 V in 2 s:**



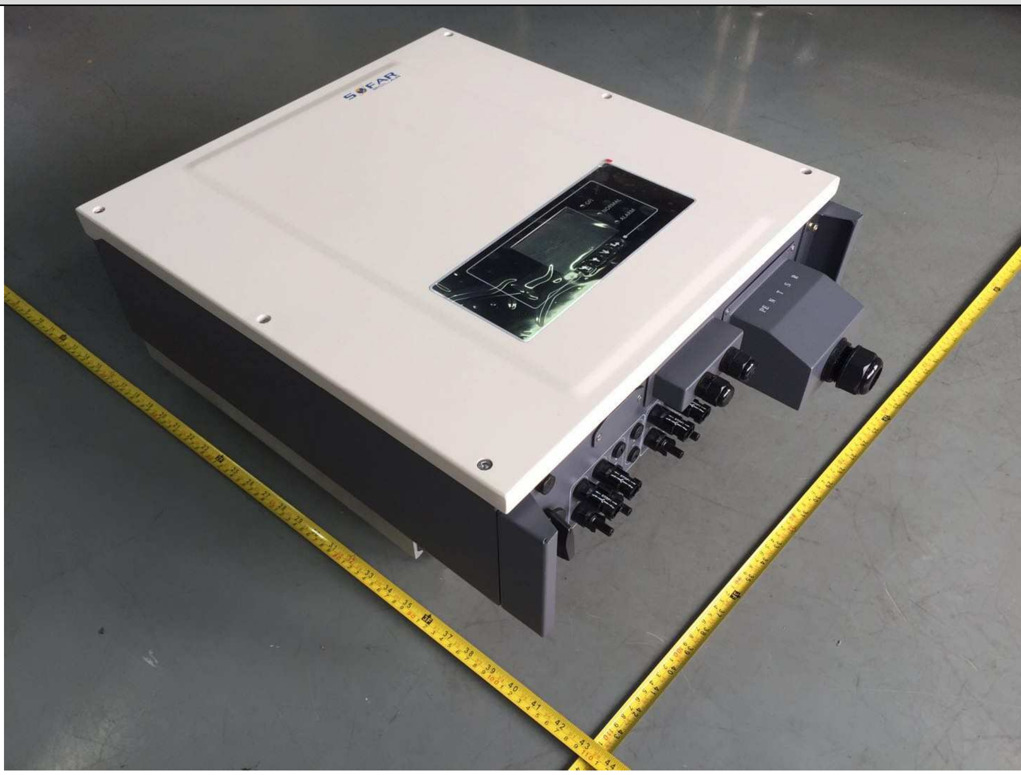

**Step 2: 230 V to 177,1 V in 4 s:**



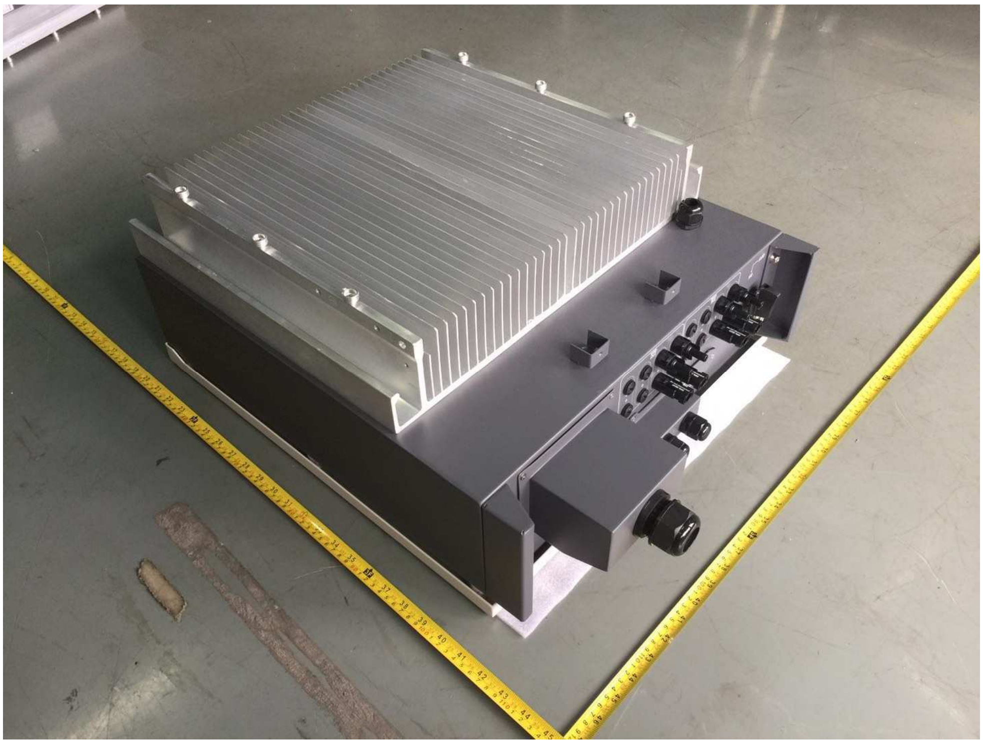
# Annex No. 1

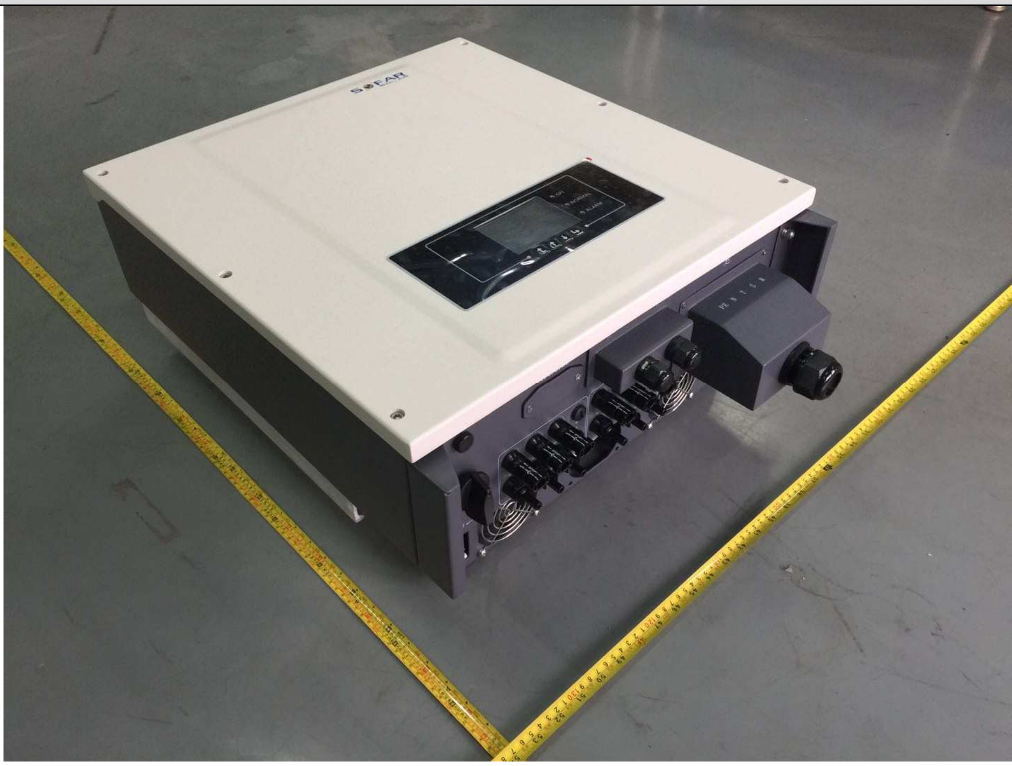
## Pictures of the unit
## The full pictures refer to PHOTO DOCUMENT
## Project No.: 180712N013
## Date: 20190424

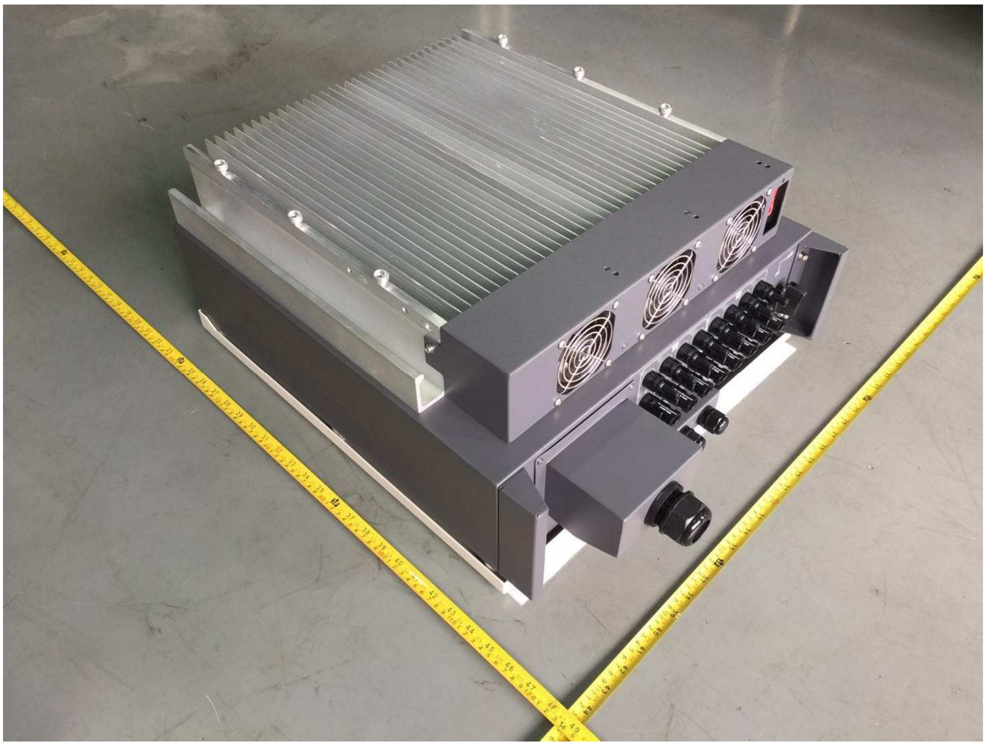
**Enclosure front view: SOFAR 20000TL-G2**




**Enclosure rear view: SOFAR 20000TL-G2**



| Enclosure front view: SOFAR 25000TL-G2 |
|---|
|  |
| **Enclosure rear view: SOFAR 25000TL-G2** |
|  |

| Enclosure front view: SOFAR 30000TL-G2, SOFAR 33000TL-G2 |
| --- |
|  |
| **Enclosure rear view: SOFAR 30000TL-G2, SOFAR 33000TL-G2** |
|  |

# Annex No. 2

## Test Equipment list

**Test location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**

**Dates of performance test: 2018-07-12 to 2019-04-20**

| Equipment | Internal No. | Manufacturer | Type | Serial No. | Last Calibration |
|---|---|---|---|---|---|
| Power Analyzer | A4080002DG | YOKOGAWA | WT3000 | 91M210852 | Dec. 13, 2018 |
| AC Source | A7040019DG | Chroma | 61512 | 61512000439 | Monitored by Power Analyzer |
| | A7040020DG | Chroma | 61512 | 61512000438 | |
| DC Simulation Power Supply | A7040015DG | Chroma | 62150H-1000S | 62150EF00488 | |
| | A7040016DG | Chroma | 62150H-1000S | 62150EF00490 | |
| | A7040017DG | Chroma | 620028 | 620028EF00120 | |
| RLC Load | A7150027DG | Qunling | ACLT-3803H | 93VOO2869 | |
| Eight Channel Digital Phosphor Oscilloscope | A4089017DG | YOKOGAWA | DL850 | 91N726247 | Sep. 14, 2018 |
| Four Channel Digital Phosphor Oscilloscope | A4089003DG | Tektronix | DPO4104B | C010624 | Oct. 25, 2018 |
| Oscilloscope probel | A1490009DG | YOKOGAWA | 701901 | // | Nov. 01, 2018 |
| | A1490010DG | YOKOGAWA | 701901 | // | Nov. 01, 2018 |
| | A1490011DG | YOKOGAWA | 701901 | // | Nov. 01, 2018 |
| Current transducer | A1060008DG | YOKOGAWA | CT200 | 1130700017 | Nov. 17, 2018 |
| | A1060009DG | YOKOGAWA | CT200 | 1130700019 | Nov. 17, 2018 |
| | A1060009DG | YOKOGAWA | CT200 | 1130700019 | Nov. 17, 2018 |