

EXTRACT FROM REPORT N. 2220 / 0183 – TG3

REFERENCE STANDARD

FGW TG3: DETERMINATION OF THE ELECTRICAL CHARACTERISTICS OF POWER GENERATING UNITS AND SYSTEMS, STORAGE SYSTEMS AS WELL FOR THEIR COMPONENTS IN MV, HV AND EHV GRIDS.

(REV. 25 DATED ON 01/09/2018 + SUPPLEMENT 1 DATED ON 22/01/2019)

Reference Test Report Number.....: 2220 / 0183 – TG3

Product Type.....: 3 Phase Grid Connected PV Inverter

Tested Model: SUNNY TRIPOWER STP 50-40

Variant Models: --

APPLICANT

Name.....: SMA SOLAR TECHNOLOGY AG

Address: Sonnenallee 1, 34266 Niestetal (Germany)

TESTING LABORATORY

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1 Scope

SGS Tecnos, S.A. (Electrical Testing Laboratory) has been contracted by SMA SOLAR TECHNOLOGY AG, in order to perform testing according to FGW-TG3: Technical Guidelines for Power Generating Units and Systems. TG3 (Revision 25 Dated 01/09/2018 + Supplement 1 Dated 22/01/2019): Determination of Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well for their Components in MV, HV and EHV grids.

The following standards are covered with testing of FGW-TG3 (Revision 25 Dated 01/09/2018) (*):

- VDE-AR-N 4110: 2018-11. Technical requirements for the connection and operation of customer installations to the medium voltage network (TAR medium voltage).

This document is an extract from the test report 2220 / 0183 – TG3 compliant with the Annex B of FGW TG3 (Rev. 25 dated on 01/09/2018 + supplement 1 dated on 22/01/2019).

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2 General Information

2.1 Testing Period and Climatic conditions

The necessary testing has been performed between the 10th of June and the 29th of October 2020.
All the tests and checks have been performed at $25 \pm 10^{\circ}\text{C}$, $90 \text{ kPa} \pm 10 \text{ kPa}$ and $50\% \text{ RH} \pm 20\% \text{ RH}$.

SITE TEST

Name: **SMA SOLAR TECHNOLOGY AG**
Address: Sonnenallee 1, 34266 Niestetal (Germany)

2.2 Equipment under Testing

Apparatus type.....: Grid-Connected PV Inverter
Installation.....: 3 Phase ~ / Fixed installation
Manufacturer.....: SMA SOLAR TECHNOLOGY AG
Trademark: Sunny Tripower
Model / Type reference.....: STP 50-40
Serial Number: 3000733176
Software Version.....: 03.10.03.R (main processor)
Rated Characteristics: Input: $1000 \text{ V}_{\text{dc,max}}$ ($500\text{-}800 \text{ V}_{\text{dc,MPPT}}$); 20 A_{dc} Max/MPPT;
2strings per MPPT; total 6 MPPT.
Output: 3~+N 230/400Vac; 50/60 Hz; $72.5 \text{ A}_{\text{ac}}$ Max.; 50 kW;
50 kVA.

Date of manufacturing: 2017

Test item particulars

Input: DC PV
Output.....: 3 Phase ~+N+PE
Class of protection against electric shock ...: Class I
Degree of protection against moisture: IP 65
Type of connection to the main supply.....: Three-phase – Fixed installation
Cooling group.....: Forced ventilation (Fan)
Modular.....: No
Internal Transformer.....: No

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Copy of marking plate:



Note:

1. Label is attached on the side surface of enclosure and visible after installation.

Equipment under testing:

- STP 50-40

The results obtained apply only to the particular sample tested that is the subject of the present test report. The most unfavorable result values of the verifications and tests performed are contained herein. Throughout this report a point (comma) is used as the decimal separator.

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2.2.1 Reference Values

Reference Values	
Rated power, P_n in kW	50
Rated apparent power, S_n in kVA	50
Rated wind speed (only WT), v_n in m/s	Not applicable
Rated current (determined), I_n in A	72.5
Rated output voltage, (phase to phase) U_n in Vac	400
Note: In this report p.u. values are calculated as follows: -For Active & Reactive Power p.u values are reference to P_n -For Currents p.u values, the reference is always I_n -For Voltages p.u values, the reference is always U_n	

3 TEST RESULTS

3.1 Nenndaten / Rated data:

Nennscheinleistung S_n	50 kVA	Nennstrom I_n	72.5 A
Nennfrequenz f_n rated frequency f_n	50 Hz	Nennspannung U_n rated Voltage U_n	230 / 400 V

3.2 Power quality

3.2.1 Wirkleistungsspitzen / Power Peaks

Test results are offered in the following table:

Wirkleistungsspitzen in kW / Power peaks in kW		Wirkleistungsspitzen in p.u. / Power peaks in p.u.		Anzahl 10-Minuten Datensätze in / Number of 10-minute data set
$p_{600} = P_{600}/P_n$	50298	$p_{60} = P_{60}/P_n$	1.01	2
$p_{600} = P_{600}/P_n$	50295	$p_{60} = P_{60}/P_n$	1.01	2

Note: the MPP of the PV-generator is 56100W corresponding to 625 Vdc. The DC Power has been varied between 40800 W and 61200 W in the test performed.

3.2.2 Schalthandlungen / Switching Operation

- Test 1: Switching at $P_{\text{available}} < 10\% P_n$. Power gradient 25 % P_n /min.

Schalthandlungen / Case of switching operation	Einschalten bei $P_{\text{verfügbar}} < 10\% P_n$ (Einschaltwindgeschw.) / Start-up at $P_{\text{available}} < 10\% P_n$ (cut-in wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30°	50°	70°	85°
Flickerformfaktor / Flicker step factor, $k_f (\Psi_k)$	0.041	0.045	0.049	0.053
Spannungsänderungsfaktor / Voltage change factor, $k_U (\Psi_k)$	0.118	0.100	0.078	0.068

- Test 2: Switching at $P_{\text{available}} < 10\% P_n$. Power gradient Maximum.

Schalthandlungen / Case of switching operation	Einschalten bei $P_{\text{verfügbar}} < 10\% P_n$ (Einschaltwindgeschw.) / Start-up at $P_{\text{available}} < 10\% P_n$ (cut-in wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30°	50°	70°	85°
Flickerformfaktor / Flicker step factor, $k_f (\Psi_k)$	0.051	0.049	0.048	0.048
Spannungsänderungsfaktor / Voltage change factor, $k_U (\Psi_k)$	0.120	0.100	0.082	0.079

- Test 3: Switching at $P_{\text{available}} = P_n$. Power gradient 25 % P_n /min.

Schalthandlungen / Case of switching operation	Einschalten bei $P_{\text{verfügbar}} = P_n$ (Nennwindgeschwindigkeit) Start-up at $P_{\text{available}} = P_n$ (rated wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30°	50°	70°	85°
Flickerformfaktor / Flicker step factor, $k_f (\Psi_k)$	0.041	0.045	0.049	0.053
Spannungsänderungsfaktor / Voltage change factor, $k_U (\Psi_k)$	0.199	0.161	0.115	0.093

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- Test 4: Switching at $P_{\text{available}} = P_n$. Power gradient Maximum.

Schalthandlungen / Case of switching operation	Einschalten bei $P_{\text{verfügbar}} - P_n$ (Nennwindgeschwindigkeit) Start-up at $P_{\text{available}} P_n$ (rated wind speed)			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	20			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	240			
Netzimpedanzwinkel / Grid impedance angle	30°	50°	70°	85°
Flickerformfaktor / Flicker step factor, $k_f (\Psi_k)$	0.076	0.082	0.065	0.052
Spannungsänderungsfaktor / Voltage change factor, $k_U (\Psi_k)$	0.967	0.634	0.495	0.359

- Test 5: Service shutdown at rated power (no emergency stop).

Schalthandlungen / Case of switching operation	Serviceabschaltung bei Nennleistung / Cut off at rated power			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{10}	10			
Max Anz. Schalthandlungen / Max, number of switching operations, N_{120}	120			
Netzimpedanzwinkel / Grid impedance angle	30°	50°	70°	85°
Flickerformfaktor / Flicker step factor, $k_f (\Psi_k)$	0.981	0.819	0.571	0.460
Spannungsänderungsfaktor / Voltage change factor, $k_U (\Psi_k)$	1.075	0.905	0.715	0.637

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3.2.3 Unsymmetrie / Unbalances
Table of results

P_{DC}/P_{max}	P_{AC} [W]	$U_{1,+}$ [V]	$U_{1,-}$ [V]	$I_{1,+}$ [A]	$I_{1,-}$ [A]	u_i [%]
10 %	4981.187	398.272	0.047	9.095	0.018	0.201
20 %	10002.888	398.259	0.055	18.209	0.031	0.168
30 %	15021.898	398.250	0.070	27.281	0.043	0.158
40 %	20018.701	398.237	0.091	36.484	0.058	0.159
50 %	25017.266	398.231	0.119	45.365	0.063	0.138
60 %	29877.247	398.225	0.137	54.299	0.081	0.149
70 %	34927.531	398.214	0.152	63.396	0.089	0.140
80 %	40201.057	398.202	0.173	72.994	0.112	0.153
90 %	44711.686	398.199	0.199	72.993	0.110	0.150
100 %	48910.222	398.181	0.216	72.998	0.101	0.138
110 %	50305.178	398.176	0.224	72.996	0.106	0.145
120 %	50306.152	398.175	0.221	72.992	0.100	0.137

According to VDE-AR-N 4110: 2018-11, from the 10%P_n, the generating unit shall not exceed a maximum limit defined at 1.5%.

[illegible]

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3.2.5 Oberschwingungsmessungen / Harmonics

Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n	I _h /I _n
1	2.99	10.00	19.92	29.94	39.89	49.19	58.92	68.73	78.40	88.07	97.57	97.57
2	0.06	0.08	0.23	0.21	0.17	0.24	0.16	0.20	0.20	0.18	0.13	0.24
3	0.03	0.03	0.03	0.04	0.04	0.03	0.05	0.06	0.04	0.07	0.06	0.07
4	0.08	0.11	0.10	0.05	0.09	0.14	0.09	0.03	0.13	0.03	0.11	0.14
5	0.37	0.18	0.38	0.26	0.40	0.42	0.45	0.49	0.45	0.53	0.50	0.53
6	0.06	0.05	0.06	0.06	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06
7	0.26	0.20	0.04	0.09	0.25	0.29	0.32	0.37	0.38	0.43	0.45	0.45
8	0.14	0.09	0.03	0.10	0.10	0.02	0.10	0.11	0.03	0.11	0.09	0.14
9	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.05	0.02	0.06	0.04	0.06
10	0.14	0.09	0.05	0.07	0.11	0.06	0.11	0.05	0.06	0.05	0.11	0.14
11	0.22	0.30	0.16	0.06	0.09	0.14	0.15	0.18	0.17	0.20	0.18	0.30
12	0.08	0.06	0.10	0.04	0.09	0.10	0.09	0.04	0.09	0.04	0.09	0.10
13	0.19	0.16	0.07	0.10	0.07	0.11	0.13	0.15	0.12	0.16	0.15	0.19
14	0.07	0.06	0.10	0.05	0.06	0.09	0.07	0.05	0.09	0.04	0.07	0.10
15	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.04	0.03	0.04
16	0.04	0.04	0.07	0.03	0.05	0.07	0.05	0.03	0.07	0.04	0.06	0.07
17	0.12	0.11	0.10	0.07	0.03	0.07	0.08	0.11	0.09	0.12	0.11	0.12
18	0.04	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.04
19	0.10	0.08	0.09	0.05	0.03	0.05	0.07	0.08	0.06	0.09	0.08	0.10
20	0.03	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.03
21	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02
22	0.03	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.02	0.03
23	0.05	0.03	0.06	0.04	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.07
24	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.02	0.02
25	0.03	0.04	0.05	0.04	0.03	0.03	0.04	0.05	0.05	0.06	0.05	0.06
26	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02
27	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02
28	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
29	0.02	0.01	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04
30	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
31	0.01	0.02	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.04
32	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01
33	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
34	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01
35	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03
36	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
37	0.00	0.00	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.03
38	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
41	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
THDi	0.60	0.50	0.53	0.41	0.55	0.61	0.66	0.73	0.68	0.80	0.77	0.80

3.2.6 Zwischenharmonische / Interharmonics

Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	I/In	I/In	I/In	I/In	I/In	I/In	I/In	I/In	I/In	I/In	I/In	I/In
1.5	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04
2.5	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
3.5	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
4.5	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
5.5	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
6.5	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
7.5	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
8.5	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
9.5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
10.5	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
11.5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
12.5	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
13.5	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.02
14.5	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02
15.5	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02
16.5	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02
17.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
18.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
19.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
20.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
21.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
22.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
23.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
24.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
25.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
26.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
27.5	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
28.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
29.5	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
30.5	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01
31.5	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01
32.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
33.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
34.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
35.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
36.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
37.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
39.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
44.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
46.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.2.7 Höhere Frequenzen / Higher Frequencies components

[illegible]

3.3 Grid Control Capability

3.3.1 Wirkleistungseinspeisung in Abhängigkeit der Netzfrequenz / Active power vs frequency

Überfrequenz / overfrequency	Mittlerer Gradient der Wirkleistung sum Zeitpunkt der Frequenzüberhöhung / Mean power gradient at overfrequency	mittl. Gradient / mean gradient Test at 100%Pn: -39.98 % P _M /Hz Test at 50%Pn: -39.95 % P _M /Hz	
	Max. Einschwingzeit / Max. Settling time	0.96 s	
	Gradient der Wirkleistung nach Rückkehr aus Überfrequenz / Power gradient after recovery of over frequency	mittl. Gradient / mean gradient 8.8 %Pn/Hz max. Gradient / max. gradient 9.0 %Pn/Hz	
Unterfrequenz / underfrequency	Mittlerer Gradient der Wirkleistung sum Zeitpunkt der Frequenzunterschreitung / Mean power gradient at underfrequency	mittl. Gradient / mean gradient 40.16 % P _M /Hz	
	Max. Einschwingzeit / Max. Settling time	0.2 s	
	Gradient der Wirkleistung nach Rückkehr aus Unterfrequenz / Power gradient after recovery of under frequency	mittl. Gradient / mean gradient 8.9 %Pn/Hz max. Gradient / max. gradient 9.0 %Pn/Hz	
Die EZE kann mit reduzierter Leistung betrieben werden. / The unit is able to run at reduced power		☒ Ja / Yes	☐ Nein / No
Maximale Sollwertabweichung der Wirkleistung Max. deviation of power setting		Überschreitung / Exceeding 338.7 W	Unterschreitung / Undercut 0.0 kW
Trennung vom Nets bei Wirkleistungssollwertvorgabe von: Disconnection from the grid at external active power setpoints at:		-- % Pn No disconnection is recorded. Operation at 0%Pn is evidenced.	
Einschwingzeit der Leistung für einen Sollwertsprung mit minimalem Gradienten / Response time of the power output after a change in setpoint with minimal gradient	P0 -> Pmin	Zeit / time : 47.0 s Gradient: 0.33 % Pn / s	
	Pmin -> P0	Zeit / time : 43.8 s Gradient: 0.33 % Pn / s	
Einschwingzeit der Leistung für einen Sollwertsprung mit maximalem Gradienten / Response time of the power output after a change in setpoint with maximum gradient	P0 -> Pmin	Zeit / time : 131.0 s Gradient: 0.65 % Pn / s	
	Pmin -> P0	Zeit / time : 129.6 s Gradient: 0.66 % Pn / s	

3.3.2 Blindleistungsbereitstellung / Provision of reactive power

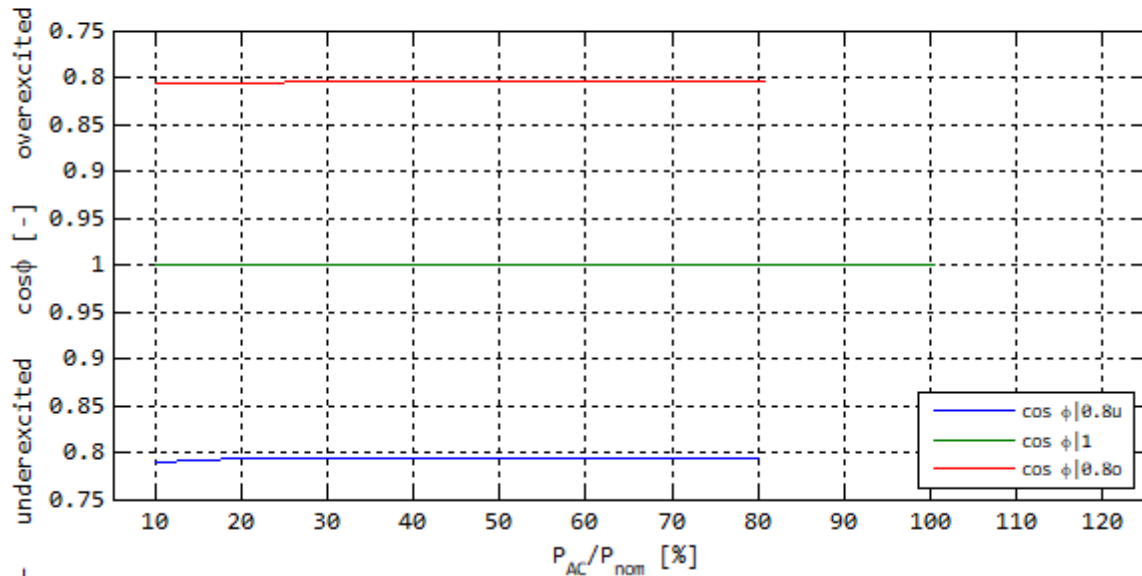
Blindleistungsregelung im Normalbetrieb und maximaler Blindleistungstellbereich / Control of reactive power in normal operation and maximum reactive power range	P/Pn	Qind	Q0	Qkap	P/Pn	Qind	Q0	Qkap
	10%	3.637	-0.026	-3.847	70%	25.642	0.153	-26.556
	20%	7.304	0.003	-7.659	80%	29.480	0.188	-30.567
	30%	11.019	0.032	-11.429	90%	29.882	0.216	-30.572
	40%	14.716	0.061	-15.300	100%	29.884	0.243	-30.575
	50%	18.318	0.091	-19.013	110%	29.885	0.253	-30.574
	60%	21.924	0.121	-22.722	120%	29.886	0.254	-30.575
Arbeitspunkte des spannungsabhängigen P-Q Diagramms / Working points of the voltage dependent P-Q diagram	Q in kVAr							
	AP / WP		U/Un in %		P/Pn in %		Q in kVAr	
	See measured points and results in the following pages of this annex							
Blindleistungsregelung durch Sollwertvorgabe / Control of reactive power through set point signal	☒Verschiebungsfaktor / power factor				☒Blindleistung / reactive power			
	Pbin bei / at Qmax				Maximum PF range: 0.8 Maximum Q range: 99%Sn			
Längste Einsschwingzeit / Longest response time	Parameter				Einsschwingzeit / settling time			
	T < 6 s				8.8 s (maximum measured)			
	Standardzeit / standard time				--			
	T < 60 s				79.2 s (maximum measured)			
Einstellgenauigkeit des Verschiebungsfaktors bzw. Blindleistung / Positioning accuracy of power factor or reactive power	Sollwert / setpoint. Mode tested: <i>PF Const at 100%Pn</i>				Istwert / measured value			
	PF = 0.8 (Under excited)				0.804			
	PF = 0.8 (Over excited)				-0.795			
	PF = 1.0				1.000			
	Sollwert / setpoint. Mode tested: <i>PF Const at 50%Pn</i>				Istwert / measured value			
	PF = 0.8 (Under excited)				0.805			
	PF = 0.8 (Over excited)				-0.794			
	PF = 1.0				1.000			
	Sollwert / setpoint. Mode tested: <i>VAr Const at 50%Pn</i>				Istwert / measured value			
	25.000 kVAr				25.365 kVAr			
	-25.000 kVAr				-25.000 kVAr			
	0.000 kVAr				0.175 kVAr			
	Sollwert / setpoint. Mode tested: <i>VAr Const Nominal at 50%Pn</i>				Istwert / measured value			
	50%Sn				50.9%Sn			
	-50%Sn				-49.8%sn			
	0%Sn				0.5%Sn			
Anmerkung / remark	Soweit Q(U) und Q(P)- Regelung wurde, sind diese im Prüfbericht hinterlegt / See Q(U) and Q(P) in test report							

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In following charts, they are offered main results after performed tests included in the FGW TG3 test report.

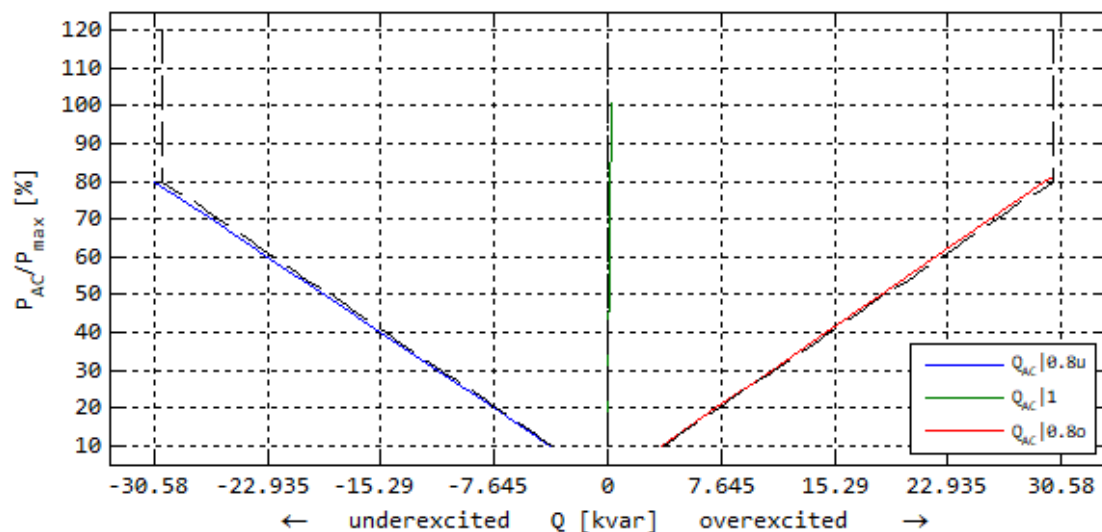
Active Power over Power Factor. Fixed Power Factor

Verification of reactive power (power factor, permitted deviation(max) = 0.01 @ $P/P_{nom} \geq 20\%$)
deviation of $\cos \phi_u$ (avg/max) = -0.006 / -0.007
deviation of $\cos \phi_g$ (avg/max) = 0.000 / 0.000
deviation of $\cos \phi_o$ (avg/max) = -0.005 / -0.006
↑ overall deviation (avg/max))= -0.003 / 0.007 → ok



Active Power over Reactive Power. Fixed Power Factor

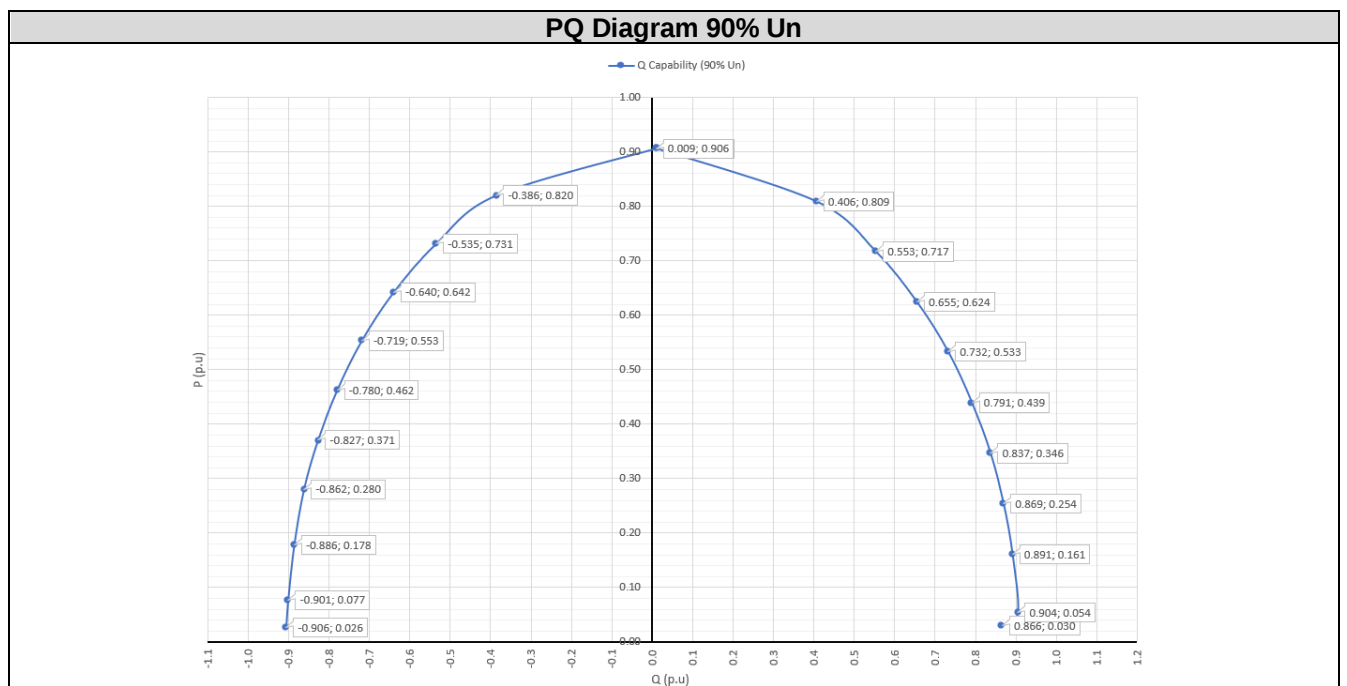
Verification of reactive power (reactive power, permitted deviation(max) = 2.00% @ $P/P_{nom} \geq 20\%$)
deviation of Q_u (avg/max) = -0.79 % / -1.15 %
deviation of Q_g (avg/max) = 0.30 % / 0.51 %
deviation of Q_o (avg/max) = -0.60 % / -1.22 %
overall deviation (avg/max))= -0.37 % / -1.22 % → ok



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The table below shows measured values for each power step tested to verify the voltage-dependent PQ diagram:

PQ Diagram 90% Un								
Step	V _{AC} (V)	P measured (kW)	P meas. (P/Sn)	S meas. (kVA)	S meas. (P/Sn)	Q meas. (kVar)	Q meas. (P/Sn)	PF
1	358.4	0.750	0.030	21.675	0.867	21.650	0.866	0.034
2	358.4	1.350	0.054	22.625	0.905	22.600	0.904	0.059
3	358.4	4.025	0.161	22.625	0.905	22.275	0.891	0.178
4	358.4	6.350	0.254	22.625	0.905	21.725	0.869	0.281
5	358.4	8.650	0.346	22.625	0.905	20.925	0.837	0.382
6	358.4	10.975	0.439	22.625	0.905	19.775	0.791	0.485
7	358.4	13.325	0.533	22.625	0.905	18.300	0.732	0.588
8	358.4	15.600	0.624	22.625	0.905	16.375	0.655	0.690
9	358.4	17.925	0.717	22.625	0.905	13.825	0.553	0.792
10	358.4	20.225	0.809	22.625	0.905	10.150	0.406	0.894
11	358.4	22.650	0.906	22.650	0.906	0.275	0.011	1.000
12	358.4	22.650	0.906	22.650	0.906	0.225	0.009	1.000
13	358.4	20.500	0.820	22.650	0.906	-9.650	-0.386	0.905
14	358.4	18.275	0.731	22.650	0.906	-13.375	-0.535	0.807
15	358.4	16.050	0.642	22.675	0.907	-16.000	-0.640	0.708
16	358.4	13.825	0.553	22.675	0.907	-17.975	-0.719	0.610
17	358.4	11.550	0.462	22.675	0.907	-19.500	-0.780	0.510
18	358.4	9.275	0.371	22.675	0.907	-20.675	-0.827	0.409
19	358.4	7.000	0.280	22.650	0.906	-21.550	-0.862	0.309
20	358.4	4.450	0.178	22.600	0.904	-22.150	-0.886	0.196
21	358.4	1.925	0.077	22.625	0.905	-22.525	-0.901	0.085
22	358.4	0.650	0.026	22.650	0.906	-22.650	-0.906	0.029

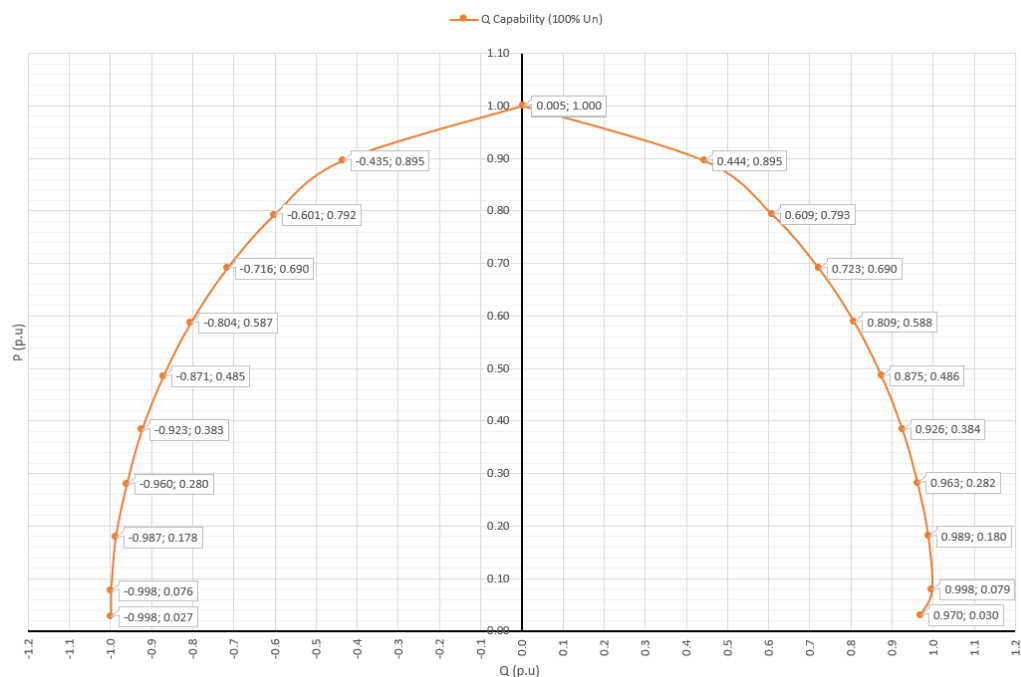


FGW-TG3+SP1

PQ Diagram 100% Un

Step	V _{AC} (V)	P measured (kW)	P meas. (P/Sn)	S meas. (kVA)	S meas. (P/Sn)	Q meas. (kVAr)	Q meas. (P/Sn)	PF
1	398.4	0.750	0.030	24.250	0.970	24.250	0.970	0.031
2	398.4	1.975	0.079	25.025	1.001	24.950	0.998	0.079
3	398.4	4.500	0.180	25.125	1.005	24.725	0.989	0.179
4	398.4	7.050	0.282	25.075	1.003	24.075	0.963	0.281
5	398.4	9.600	0.384	25.075	1.003	23.150	0.926	0.383
6	398.4	12.150	0.486	25.025	1.001	21.875	0.875	0.486
7	398.4	14.700	0.588	25.000	1.000	20.225	0.809	0.588
8	398.4	17.250	0.690	25.000	1.000	18.075	0.723	0.690
9	398.4	19.825	0.793	25.000	1.000	15.225	0.609	0.793
10	398.4	22.375	0.895	24.975	0.999	11.100	0.444	0.896
11	398.4	24.975	0.999	24.975	0.999	0.125	0.005	1.000
12	398.4	25.000	1.000	25.000	1.000	0.125	0.005	1.000
13	398.4	22.375	0.895	24.875	0.995	-10.875	-0.435	0.899
14	398.4	19.800	0.792	24.850	0.994	-15.025	-0.601	0.797
15	398.4	17.250	0.690	24.875	0.995	-17.900	-0.716	0.694
16	398.4	14.675	0.587	24.875	0.995	-20.100	-0.804	0.590
17	398.4	12.125	0.485	24.925	0.997	-21.775	-0.871	0.487
18	398.4	9.575	0.383	24.975	0.999	-23.075	-0.923	0.384
19	398.4	7.000	0.280	25.000	1.000	-24.000	-0.960	0.280
20	398.4	4.450	0.178	25.075	1.003	-24.675	-0.987	0.177
21	398.4	1.900	0.076	25.025	1.001	-24.950	-0.998	0.076
22	398.4	0.675	0.027	24.950	0.998	-24.950	-0.998	0.027

PQ Diagram 100% Un

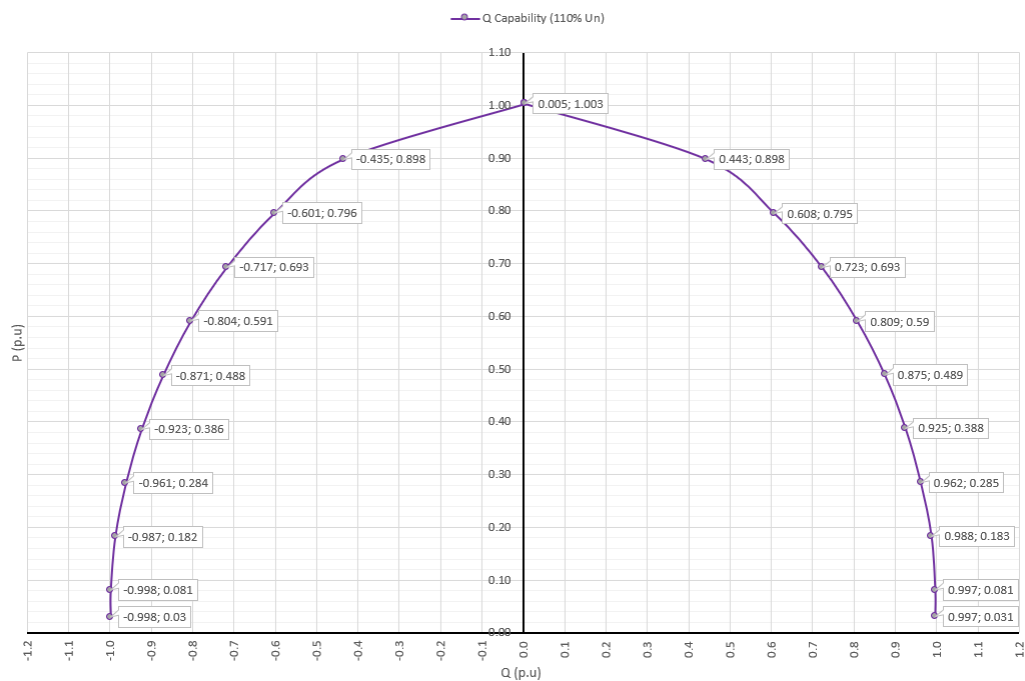


FGW-TG3+SP1

PQ Diagram 110% Un

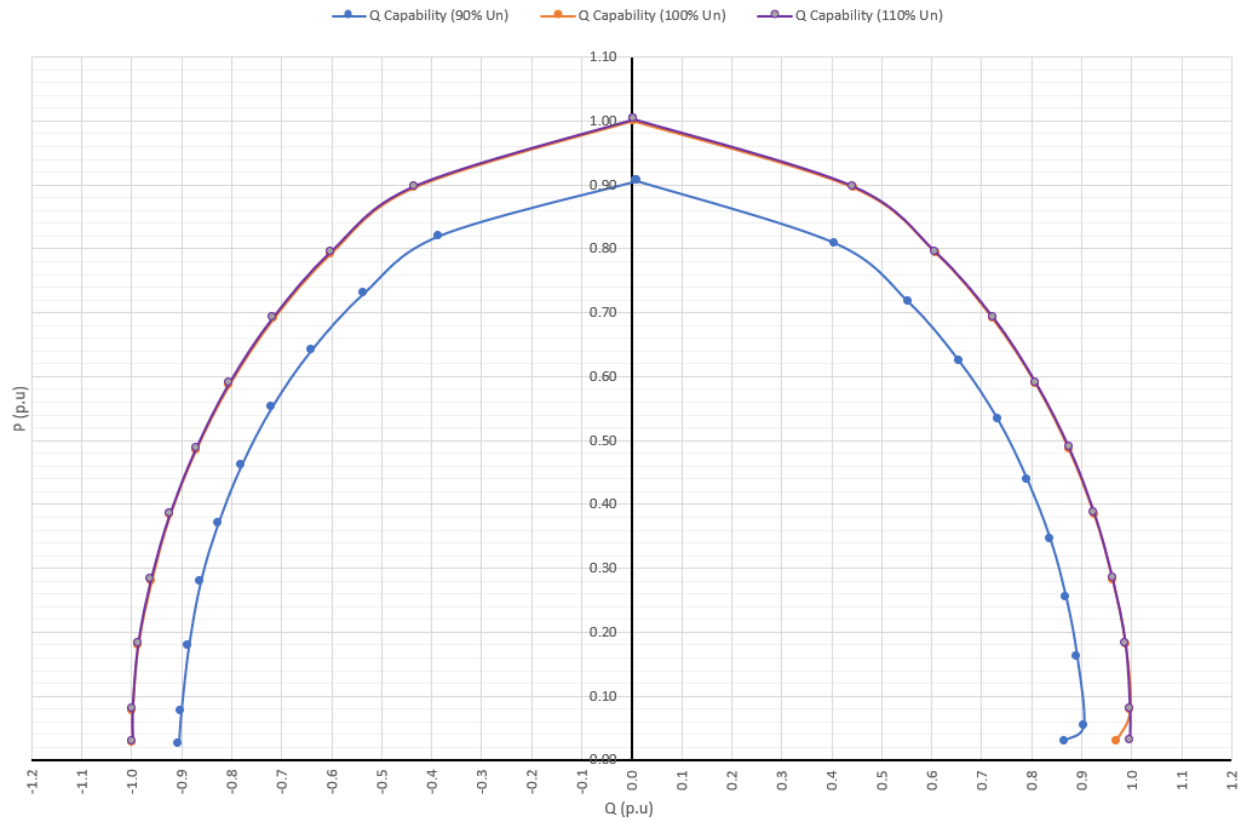
Step	V _{AC} (V)	P measured (kW)	P meas. (P/Sn)	S meas. (kVA)	S meas. (P/Sn)	Q meas. (kVAr)	Q meas. (P/Sn)	PF
1	438.0	0.775	0.031	24.950	0.998	24.925	0.997	0.031
2	438.0	2.025	0.081	25.025	1.001	24.925	0.997	0.081
3	438.0	4.575	0.183	25.125	1.005	24.700	0.988	0.182
4	438.0	7.125	0.285	25.100	1.004	24.050	0.962	0.284
5	438.0	9.700	0.388	25.075	1.003	23.125	0.925	0.386
6	438.0	12.225	0.489	25.050	1.002	21.875	0.875	0.488
7	438.0	14.750	0.590	25.025	1.001	20.225	0.809	0.589
8	438.0	17.325	0.693	25.025	1.001	18.075	0.723	0.692
9	438.0	19.875	0.795	25.025	1.001	15.200	0.608	0.794
10	438.0	22.450	0.898	25.025	1.001	11.075	0.443	0.897
11	438.0	25.075	1.003	25.075	1.003	0.125	0.005	1.000
12	438.0	25.075	1.003	25.075	1.003	0.125	0.005	1.000
13	438.0	22.450	0.898	24.950	0.998	-10.875	-0.435	0.900
14	438.0	19.900	0.796	24.925	0.997	-15.025	-0.601	0.798
15	438.0	17.325	0.693	24.925	0.997	-17.925	-0.717	0.695
16	438.0	14.775	0.591	24.950	0.998	-20.100	-0.804	0.592
17	438.0	12.200	0.488	24.950	0.998	-21.775	-0.871	0.489
18	438.0	9.650	0.386	25.025	1.001	-23.075	-0.923	0.386
19	438.0	7.100	0.284	25.050	1.002	-24.025	-0.961	0.283
20	438.0	4.550	0.182	25.100	1.004	-24.675	-0.987	0.181
21	438.0	2.025	0.081	25.025	1.001	-24.950	-0.998	0.081
22	438.0	0.750	0.030	24.975	0.999	-24.950	-0.998	0.030

PQ Diagram 110% Un



FGW-TG3+SP1

PQ Diagram Summary



FGW-TG3+SP1

The certified PV inverter fulfils the following P-Q diagram at different voltage levels, as stated in the Manufacturer Declaration: “SUNNY TRIPOWER CORE1 (STP 50-40). Reactive Power Capability”

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 Vorsitzender des Aufsichtsrats (Chairman of the Supervisory Board): Uwe Kleinkauf
 Vorstand (Managing Board): Dr.-Ing. Jürgen Reinert (CEO), Ulrich Hadding



SUNNY TRIPOWER CORE1 (STP 50-40)
Reactive Power Capability

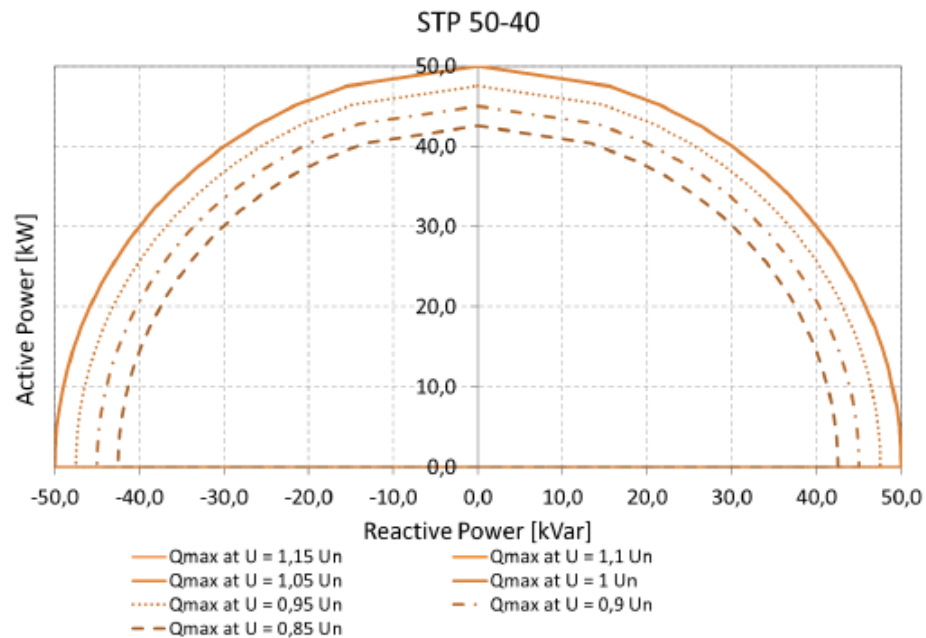


Figure 1: STP 50-40 operating range depending on the grid voltage

FGW-TG3+SP1

$U_{grid} = 0,85 \text{ p.u. } U_n$					$U_{grid} = 0,90 \text{ p.u. } U_n$				
P_{bin} [kW]	$Q_{undershot}$ [kVar]	$P_{available}$ [kW]	$Q_{overshot}$ [kVar]	$P_{available}$ [kW]	P_{bin} [kW]	$Q_{undershot}$ [kVar]	$P_{available}$ [kW]	$Q_{overshot}$ [kVar]	$P_{available}$ [kW]
42,5	0,0	42,5	0,0	42,5	45,0	0,0	45,0	0,0	45,0
40,4	13,3	40,4	-13,3	40,4	42,8	14,1	42,8	-14,1	42,8
38,3	18,5	38,3	-18,5	38,3	40,5	19,6	40,5	-19,6	40,5
36,1	22,4	36,1	-22,4	36,1	38,3	23,7	38,3	-23,7	38,3
34,0	25,5	34,0	-25,5	34,0	36,0	27,0	36,0	-27,0	36,0
31,9	28,1	31,9	-28,1	31,9	33,8	29,8	33,8	-29,8	33,8
29,8	30,4	29,8	-30,4	29,8	31,5	32,2	31,5	-32,2	31,5
27,6	32,3	27,6	-32,3	27,6	29,3	34,2	29,3	-34,2	29,3
25,5	34,0	25,5	-34,0	25,5	27,0	36,0	27,0	-36,0	27,0
23,4	35,5	23,4	-35,5	23,4	24,8	37,6	24,8	-37,6	24,8
21,3	36,8	21,3	-36,8	21,3	22,5	39,0	22,5	-39,0	22,5
19,1	38,0	19,1	-38,0	19,1	20,3	40,2	20,3	-40,2	20,3
17,0	39,0	17,0	-39,0	17,0	18,0	41,3	18,0	-41,3	18,0
14,9	39,8	14,9	-39,8	14,9	15,8	42,2	15,8	-42,2	15,8
12,8	40,6	12,8	-40,6	12,8	13,5	42,9	13,5	-42,9	13,5
10,6	41,2	10,6	-41,2	10,6	11,3	43,6	11,3	-43,6	11,3
8,5	41,7	8,5	-41,7	8,5	9,0	44,1	9,0	-44,1	9,0
6,4	42,0	6,4	-42,0	6,4	6,8	44,5	6,8	-44,5	6,8
4,3	42,3	4,3	-42,3	4,3	4,5	44,8	4,5	-44,8	4,5
2,1	42,5	2,1	-42,5	2,1	2,3	45,0	2,3	-45,0	2,3
0,0	42,5	0,0	-42,5	0,0	0,0	45,0	0,0	-45,0	0,0
$U_{grid} = 0,95 \text{ p.u. } U_n$					$U_{grid} = 1,00 \text{ p.u. } U_n$				
P_{bin} [kW]	$Q_{undershot}$ [kVar]	$P_{available}$ [kW]	$Q_{overshot}$ [kVar]	$P_{available}$ [kW]	P_{bin} [kW]	$Q_{undershot}$ [kVar]	$P_{available}$ [kW]	$Q_{overshot}$ [kVar]	$P_{available}$ [kW]
47,5	0,0	47,5	0,0	47,5	50,0	0,0	50,0	0,0	50,0
45,1	14,8	45,1	-14,8	45,1	47,5	15,6	47,5	-15,6	47,5
42,8	20,7	42,8	-20,7	42,8	45,0	21,8	45,0	-21,8	45,0
40,4	25,0	40,4	-25,0	40,4	42,5	26,3	42,5	-26,3	42,5
38,0	28,5	38,0	-28,5	38,0	40,0	30,0	40,0	-30,0	40,0
35,6	31,4	35,6	-31,4	35,6	37,5	33,1	37,5	-33,1	37,5
33,3	33,9	33,3	-33,9	33,3	35,0	35,7	35,0	-35,7	35,0
30,9	36,1	30,9	-36,1	30,9	32,5	38,0	32,5	-38,0	32,5
28,5	38,0	28,5	-38,0	28,5	30,0	40,0	30,0	-40,0	30,0
26,1	39,7	26,1	-39,7	26,1	27,5	41,8	27,5	-41,8	27,5
23,8	41,2	23,8	-41,2	23,8	25,0	43,3	25,0	-43,3	25,0
21,4	42,4	21,4	-42,4	21,4	22,5	44,7	22,5	-44,7	22,5
19,0	43,6	19,0	-43,6	19,0	20,0	45,8	20,0	-45,8	20,0
16,6	44,5	16,6	-44,5	16,6	17,5	46,8	17,5	-46,8	17,5
14,3	45,3	14,3	-45,3	14,3	15,0	47,7	15,0	-47,7	15,0
11,9	46,0	11,9	-46,0	11,9	12,5	48,4	12,5	-48,4	12,5
9,5	46,6	9,5	-46,6	9,5	10,0	49,0	10,0	-49,0	10,0
7,1	47,0	7,1	-47,0	7,1	7,5	49,4	7,5	-49,4	7,5
4,8	47,3	4,8	-47,3	4,8	5,0	49,7	5,0	-49,7	5,0
2,4	47,5	2,4	-47,5	2,4	2,5	49,9	2,5	-49,9	2,5
0,0	47,5	0,0	-47,5	0,0	0,0	50,0	0,0	-50,0	0,0

*Also applicable to $U_{grid}=1,05 - 1,15 \text{ pu}$ *Also applicable to $U_{grid}=1,05 - 1,15 \text{ pu}$

Table 1: STP 50-40 P/Q operating range at different grid voltages between 0,85 and 1,15 p.u.

3.4 Protection system

3.4.1 Trennung der EZE vom Netz / Cut-off from grid

☒ Die Überprüfung der Gesamtschaltkette führte zu einer erfolgreichen Abschaltung. The test of the whole trip circuit led to a successful shut down							
	Einstellwert Setting In pu oder/or [Hz]		Auslösewert / Release value In pu oder/or [Hz]		Abschaltzeit / Disconnection time [ms]		Rückfallverhältnis Disengaging ratio
	Schwelle / value	Zeit / Time (ms)	Min.	Max.	Min.	Max.	
Spannungssteigerungsschutz/ Overvoltage protection: U>	1.000	180000	1.009	1.010	179970	179970	☑≥0.98 ☐<0.98
	1.200	50	1.208	1.210	37	37	
Spannungssteigerungsschutz/ Overvoltage protection: U>>	1.000	59000	1.004	1.005	58970	58980	---
	1.300	50	1.299	1.305	37	37	
Spannungsrückgangsschutz/ Undervoltage protection: U<	0.200	50	0.197	0.201	37	37	☑≤1.02 ☐>1.02
	1.000	10000	1.000	1.006	9970	9970	
Spannungsrückgangsschutz/ Undervoltage protection: U<<	0.200	50	0.198	0.201	37	37	☑≤1.02 ☐>1.02
	1.000	10000	1.004	1.005	9970	9970	
Frequenzsteigerungsschutz/ Overfrequency protection: F>	50.00	10000	50.00		9970		---
	55.00	50	54.99		32		
Frequenzsteigerungsschutz/ Overfrequency protection: F>>	50.00	10000	50.00		9960		---
	55.00	50	54.99		36		
Frequenzrückgangsschutz/ Underfrequency protection: F<	44.00	10000	44.00		9970		---
	50.00	50	50.00		38		
Eigenzeit der Abschalteinheit / Operating time of a circuit breaker:	☐ aus Messung by measurement				☑ aus Prüfzertifikat by test certificate		
	According to the relay specification, the operation time of circuit breaker is: - Declared operate time given by the supplier: 40 ms at nominal coil voltage. - Declared release time given by the supplier: 5 ms at nominal coil voltage. See next page.						

AZSR235/250

50 A (35 A) POWER RELAY

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

COIL

Power 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

RoHS compliant !



GENERAL DATA

Life Expectancy Mechanical Electrical	Minimum operations 1 x 10 ⁶ 5 x 10 ⁴ at 35 A 250 VAC Res. (AZSR235) 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 (with no coil suppression)
Dielectric Strength (at sea level for 1 min.)	5000 Vrms coil to contact 2500 Vrms between contact sets 2500 Vrms between open contacts
Insulation Resistance	1000 megohms min. at 20°C 500 VDC 50% RH
Insulation (according to DIN VDE 0110, IEC 60664-1)	C250 Overvoltage category: III Pollution degree: 3 Nominal voltage: 250 VAC
Dropout	Greater than 5% of nominal coil voltage
Ambient Temperature Operating	At nominal coil voltage -40°C (-40°F) to 85°C (185°F)
Vibration	0.062" (1.5 mm) DA at 10–55 Hz
Shock	10 g
Enclosure	PA
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>

2015-03-31

FGW-TG3+SP1
3.4.2 Zuschaltbedingungen / Cut-in conditions

Since this is optional testing, this test has not been performed as is an optional measurement according to point 4.5.1.1 of the standard.

3.4.3 Zuschaltbedingungen nach Auslösung des Entkupplungsschutzes / Cut-in conditions after tripping of protection

	Bereich / range In pu order/ or [Hz]	Zuschaltung erfolgte im angegebenen Bereich cut in occurred within the given range
Unterspannung / Undervoltage:	> 0,95	☐ nein / no ☒ ja / yes
Unterfrequenz / Underfrequency:	≥ 49,9	☐ nein / no ☒ ja / yes
Überfrequenz / Overfrequency:	≤ 50,1	☐ nein / no ☒ ja / yes

As evidenced in the evaluated documentation, the certified unit is able to follows a ramp gradient inside of the range 33%Pn/s – 66%Pn/s after the reconnection occurs.

3.5 Response during grid faults

The compliance with these requirements including all calculations defined in the FGW TR3 standard is stated in the attachement to the test report:

- 2220 / 0183-Att1 : FGW-TG3: Grid Fault Tests Results