



**BUREAU  
VERITAS**

# Certificate of compliance

**Applicant:** REFU Elektronik GmbH  
Marktstraße 185  
72793 Pfullingen  
Germany

**Product:** Grid-tied photovoltaic (PV) inverter

**Model:** REFUsol 40K (842P040)  
REFUsol 46K (842P046)

## Use in accordance with regulations:

Automatic disconnection device with three-phase mains surveillance in accordance with Engineering Recommendation G59/3 for photovoltaic systems with a three-phase parallel coupling via an inverter in the public mains supply. The automatic disconnection device is an integral part of the aforementioned inverter. This serves as a replacement for the disconnection device with isolating function that can access the distribution network provider at any time.

## Applied rules and standards:

**Engineering Recommendation G59/3:2013, G59/3-1:2014, G59/3-2:2015**

Recommendation for the Connection of Generating Plant to the Distribution Systems of licensed Distribution Network Operators.

**DIN V VDE V 0126-1-1:2006-02 (Functional safety)**

Automatic disconnection device between a generator and the public low-voltage grid

The REFUsol 40K (842P040) and REFUsol 46K (842P046) are rated  $>16A$  per phase and  $\leq 50kW$  (3 phase). The default values for "Small Power Stations" on the low-voltage grid were verified.

At the time of issue of this certificate the safety concept of an aforementioned representative product corresponds to the valid safety specifications for the specified use in accordance with regulations.

**Report number:** 16TH0364-G59/3\_0  
**Certificate number:** U17-0449  
**Date of issue:** 2017-09-19

**Certification body**



Holger Schaffer

Certification body of Bureau Veritas Consumer Products Services Germany GmbH  
Accredited according to DIN EN ISO/IEC 17065



Deutsche  
Akkreditierungsstelle  
D-ZE-12024-01-00

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

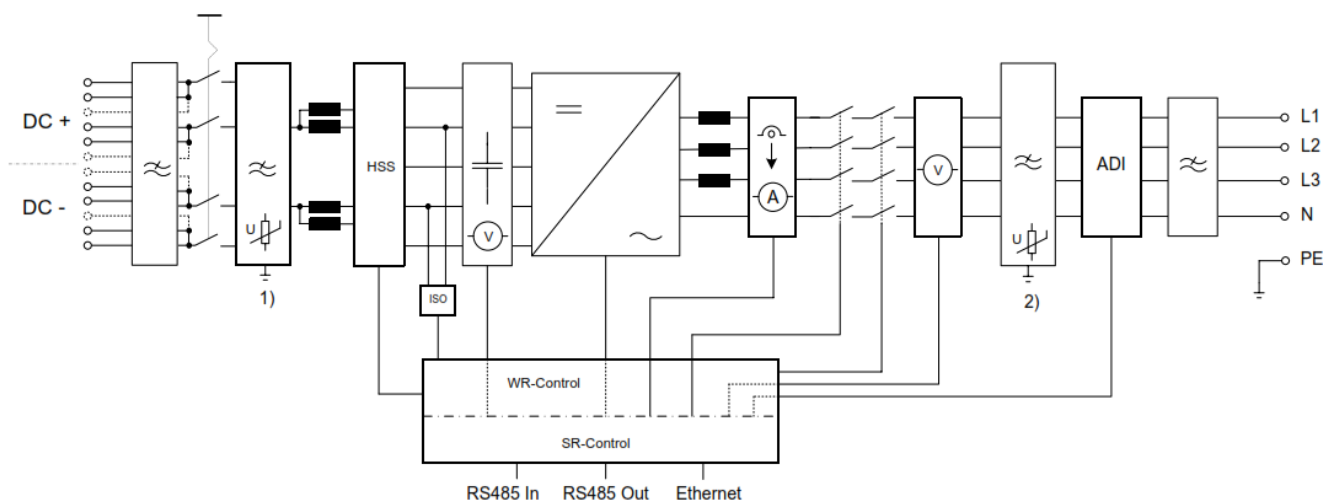
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**Type Approval and declaration of compliance with the requirements of Engineering Recommendation G59/3.**

<b>Manufacturer / applicant:</b>	REFU Elektronik GmbH Marktstraße 185 72793 Pfullingen Germany	
<b>Generating Unit technology</b>	Grid-tied photovoltaic inverter	
<b>Rated values</b>	REFU <sub>sol</sub> 40K (842P040)	REFU <sub>sol</sub> 46K (842P046)
<b>Maximum rated capacity</b>	40kW	46kW
<b>Rated voltage</b>	230V / 400V	265,5V / 460V
<b>From Firmware version</b>	RFP_300-01-08-11-S	
<b>Measurement period:</b>	2014-05-26 to 2014-08-21 2017-07-03 to 2017-07-17 2017-07-03 to 2017-07-17	

**Description of the structure of the power generation unit (Figure 1):**

The units are photovoltaic inverters which converts DC voltage into AC voltage for feeding into the public grid. The input and output are protected by varistors to Earth. The unit is providing EMC filtering at the PV input and output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundantly by the high power switching bridge and two relays. This assures that the opening of the output circuit will also operate in case of a single error.



**Figure 1 – Schematic structure of the power generation unit**

**Differences between Generating Units:**

Generally the models provide the same hardware. The model REFU<sub>sol</sub> 46K (842P046) has a different output voltage of 460V phase to phase compared to the model REFU<sub>sol</sub> 40K (842P040) which has 400V phase to phase. In addition the model REFU<sub>sol</sub> 40K (842P040) is a software derated version of the model REFU<sub>sol</sub> 46K (842P046).

The above stated Generating Units are tested according the requirements in the Engineering Recommendation G59/3. Any modification that affects the stated tests must be named by the manufacturer/supplier of the product to ensure that the product meets all requirements of the Engineering Recommendation G59/3.

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

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Protection. Voltage tests. (@ Un 230V)						
REFUso1 40K (842P040) Phase 1						
Function	Setting		Trip test		No trip test	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V stage 1	200,1V	2,5s	199V	2,737s	204,1V / 3,5s	No trip
U/V stage 2	184V	0,5s	183V	0,633s	188V / 2,48s	No trip
					180V / 0,48s	No trip
O/V stage 1	262,2V	1,0s	261,8V	1,132s	258,2V 2,0s	No trip
O/V stage 2	273,7V	0,5s	273V	0,643s	269,7V 0,98s	No trip
					277,7V 0,48s	No trip
REFUso1 40K (842P040) Phase 2						
Function	Setting		Trip test		No trip test	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V stage 1	200,1V	2,5s	199,6V	2,723s	204,1V / 3,5s	No trip
U/V stage 2	184V	0,5s	183,4V	0,626s	188V / 2,48s	No trip
					180V / 0,48s	No trip
O/V stage 1	262,2V	1,0s	262,3V	1,126s	258,2V 2,0s	No trip
O/V stage 2	273,7V	0,5s	273,6V	0,627s	269,7V 0,98s	No trip
					277,7V 0,48s	No trip

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

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Protection. Voltage tests.						
REFUsol 40K (842P040) Phase 3						
Function	Setting		Trip test		No trip test	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V stage 1	200,1V	2,5s	198,3V	2,734s	204,1V / 3,5s	No trip
U/V stage 2	184V	0,5s	181,7V	0,624s	188V / 2,48s	No trip
					180V / 0,48s	No trip
O/V stage 1	262,2V	1,0s	263,1V	1,134s	258,2V 2,0s	No trip
O/V stage 2	273,7V	0,5s	274,8V	0,626s	269,7V 0,98s	No trip
					277,7V 0,48s	No trip

Note. For Voltage tests the Voltage required to trip is the setting  $\pm 3,45V$ . The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting  $\pm 4V$  and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Protection. Voltage tests. (@ Un 240V)						
REFUso1 40K (842P040) Phase 1						
Function	Setting		Trip test		No trip test	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V stage 1	208,8V	2,5s	206,8V	2,765s	204,1V / 3,5s	No trip
U/V stage 2	192V	0,5s	189,4V	0,678s	188V / 2,48s	No trip
					180V / 0,48s	No trip
O/V stage 1	273,6V	1,0s	273,5V	1,155s	258,2V 2,0s	No trip
O/V stage 2	285,6V	0,5s	285,5V	0,657s	269,7V 0,98s	No trip
					277,7V 0,48s	No trip

Protection. Voltage tests.						
REFUso1 40K (842P040) Phase 2						
Function	Setting		Trip test		No trip test	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V stage 1	208,8V	2,5s	206,8V	2,767s	204,1V / 3,5s	No trip
U/V stage 2	192V	0,5s	189,4V	0,660s	188V / 2,48s	No trip
					180V / 0,48s	No trip
O/V stage 1	273,6V	1,0s	273,5V	1,163s	258,2V 2,0s	No trip
O/V stage 2	285,6V	0,5s	285,5V	0,668s	269,7V 0,98s	No trip
					277,7V 0,48s	No trip

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Protection. Voltage tests.						
REFUso1 40K (842P040) Phase 3						
Function	Setting		Trip test		No trip test	
	Voltage	Time delay	Voltage	Time delay	Voltage / time	Confirm no trip
U/V stage 1	208,8V	2,5s	206,8V	2,758s	204,1V / 3,5s	No trip
U/V stage 2	192V	0,5s	189,4V	0,671s	188V / 2,48s	No trip
					180V / 0,48s	No trip
O/V stage 1	273,6V	1,0s	273,6V	1,169s	258,2V 2,0s	No trip
O/V stage 2	285,6V	0,5s	285,6V	0,669s	269,7V 0,98s	No trip
					277,7V 0,48s	No trip

Note. For Voltage tests the Voltage required to trip is the setting  $\pm 3,45V$ . The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting  $\pm 4V$  and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

Protection. Frequency tests.						
Function	Setting		Trip test		No trip test	
	Frequency	Time delay	Frequency	Time delay	Frequency / time	Confirm no trip
U/F stage 1	47,5Hz	20s	47,54Hz	20,86s	47,7Hz / 25s	No trip
U/F stage 2	47Hz	0,5s	46,99Hz	1,14s	47,2Hz / 19,98s	No trip
					46,8Hz / 0,48s	No trip
O/F stage 1	51,5Hz	90s	51,53Hz	90,44s	51,3Hz / 95s	No trip
O/F stage 2	52Hz	0,5s	52,01Hz	1,00s	51,8Hz / 89,98s	No trip
					52,2Hz / 0,48s	No trip

Note. For Frequency Trip tests the Frequency required to trip is the setting  $\pm 0,1Hz$ . In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The "No-trip tests" need to be carried out at the setting  $\pm 0,2Hz$  and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

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<b>Protection. Loss of Mains. BS EN 62116</b>						
<b>Balancing load on islanded network</b>	33% of -5% Q Test 22	66% of -5% Q Test 12	100% of -5% P Test 5	33% of +5% Q Test 31	66% of +5% Q Test 21	100% of +5% P Test 10
<b>Trip time. Ph1 fuse removed</b>	117 ms	131 ms	137 ms	104 ms	89 ms	145 ms
<b>Trip time. Ph2 fuse removed</b>	117 ms	131 ms	137 ms	104 ms	89 ms	145 ms
<b>Trip time. Ph3 fuse removed</b>	117 ms	131 ms	137 ms	104 ms	89 ms	145 ms

Note for technologies which have a substantial shut down time this can be added to the 0,5 seconds in establishing that the trip occurred in less than 0,5s. Maximum shut down time could therefore be up to 1,0 seconds for these technologies.

<b>Protection. Re-connection timer.</b>				
Test should prove that the reconnection sequence starts in no less than 20 seconds for restoration of voltage and frequency to within the stage 1 settings of table 10.5.7.1.				
<b>Voltage</b>				
<b>Time delay setting</b>		<b>Measured delay</b>		
20s		185s		
<b>Frequency</b>				
<b>Time delay setting</b>		<b>Measured delay</b>		
20s		189s		
	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1.			
	At 266,2V	At 196,1V	At 47,4Hz	At 51,6Hz
<b>Confirmation that the Generating Unit does not re-connect.</b>	No reconnection	No reconnection	No reconnection	No reconnection

<b>Protection. Frequency change, Stability test.</b>				
	<b>Start Frequency</b>	<b>Change</b>	<b>End Frequency</b>	<b>Confirm no trip</b>
<b>Positive Vector Shift</b>	49,5Hz	+9 degrees		No trip
<b>Negative Vector Shift</b>	50,5Hz	- 9 degrees		No trip
<b>Positive Frequency drift</b>	49,5Hz	+0,19Hz/sec	51,5Hz	No trip
<b>Negative Frequency drift</b>	50,5Hz	-0,19Hz/sec	47,5Hz	No trip



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Annex to the G59/3 certificate of compliance No. U17-0449

Appendix E Type Verification Test Report

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Power Quality. Harmonics.						
842P040 Phase 1						
Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)						
	At 45-55% of rated output 6,70kW		100% of rated output 13,25kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-12 in %	
					1 phase	3 phase
2nd	0,198	0,348	0,223	0,393	8%	8%
3rd	0,280	0,491	0,334	0,587	21,6%	N/A
4th	0,163	0,286	0,116	0,203	4%	4%
5th	0,106	0,187	0,202	0,354	10,7%	10,7%
6th	0,031	0,054	0,034	0,059	2,67%	2,67%
7th	0,065	0,115	0,063	0,110	7,2%	7,2%
8th	0,106	0,185	0,071	0,124	2%	2%
9th	0,082	0,145	0,026	0,045	3,8%	N/A
10th	0,053	0,093	0,039	0,068	1,6%	1,6%
11th	0,058	0,101	0,064	0,112	3,1%	3,1%
12th	0,024	0,042	0,026	0,045	1,33%	1,33%
13th	0,028	0,049	0,034	0,060	2%	2%
14th	0,023	0,040	0,031	0,054	N/A	N/A
15th	0,017	0,030	0,020	0,034	N/A	N/A
16th	0,011	0,019	0,020	0,035	N/A	N/A
17th	0,017	0,030	0,029	0,051	N/A	N/A
18th	0,014	0,024	0,016	0,027	N/A	N/A
19th	0,012	0,021	0,019	0,034	N/A	N/A
20th	0,013	0,023	0,022	0,039	N/A	N/A
21th	0,009	0,016	0,013	0,023	N/A	N/A
22th	0,010	0,017	0,013	0,022	N/A	N/A
23th	0,006	0,011	0,017	0,030	N/A	N/A
24th	0,010	0,017	0,014	0,024	N/A	N/A
25th	0,007	0,012	0,012	0,021	N/A	N/A
26th	0,009	0,016	0,016	0,028	N/A	N/A
27th	0,007	0,012	0,011	0,020	N/A	N/A
28th	0,006	0,011	0,009	0,015	N/A	N/A
29th	0,007	0,012	0,010	0,017	N/A	N/A
30th	0,007	0,012	0,009	0,016	N/A	N/A
31th	0,008	0,014	0,007	0,013	N/A	N/A
32th	0,007	0,012	0,011	0,020	N/A	N/A
33th	0,009	0,015	0,008	0,014	N/A	N/A
34th	0,005	0,008	0,006	0,010	N/A	N/A
35th	0,009	0,015	0,007	0,013	N/A	N/A
36th	0,006	0,010	0,008	0,014	N/A	N/A
37th	0,010	0,017	0,006	0,011	N/A	N/A
38th	0,005	0,009	0,009	0,016	N/A	N/A
39th	0,010	0,018	0,007	0,012	N/A	N/A
40th	0,004	0,007	0,005	0,010	N/A	N/A
THD <sub>40</sub>	1,4937%		0,8596%		23%	13%
PWHD	0,0004%		0,0002%		23%	22%



**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Power Quality. Harmonics.						
Phase 2						
Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)						
	At 45-55% of rated output 6,72kW		100% of rated output 13,29kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-12 in %	
					1 phase	3 phase
2nd	0,292	0,513	0,313	0,551	8%	8%
3rd	0,279	0,491	0,343	0,602	21,6%	N/A
4th	0,152	0,267	0,096	0,170	4%	4%
5th	0,073	0,128	0,154	0,271	10,7%	10,7%
6th	0,035	0,061	0,036	0,063	2,67%	2,67%
7th	0,063	0,110	0,054	0,095	7,2%	7,2%
8th	0,101	0,178	0,069	0,121	2%	2%
9th	0,086	0,152	0,024	0,043	3,8%	N/A
10th	0,049	0,086	0,035	0,061	1,6%	1,6%
11th	0,055	0,097	0,045	0,079	3,1%	3,1%
12th	0,022	0,038	0,024	0,043	1,33%	1,33%
13th	0,028	0,049	0,035	0,062	2%	2%
14th	0,022	0,038	0,032	0,056	N/A	N/A
15th	0,018	0,031	0,018	0,032	N/A	N/A
16th	0,011	0,019	0,019	0,034	N/A	N/A
17th	0,018	0,032	0,024	0,043	N/A	N/A
18th	0,012	0,021	0,015	0,027	N/A	N/A
19th	0,014	0,024	0,022	0,038	N/A	N/A
20th	0,012	0,021	0,023	0,041	N/A	N/A
21th	0,011	0,019	0,013	0,023	N/A	N/A
22th	0,009	0,015	0,013	0,022	N/A	N/A
23th	0,007	0,012	0,016	0,027	N/A	N/A
24th	0,008	0,015	0,013	0,023	N/A	N/A
25th	0,007	0,012	0,013	0,023	N/A	N/A
26th	0,008	0,015	0,017	0,030	N/A	N/A
27th	0,007	0,012	0,012	0,021	N/A	N/A
28th	0,005	0,009	0,009	0,016	N/A	N/A
29th	0,007	0,012	0,009	0,016	N/A	N/A
30th	0,005	0,010	0,009	0,015	N/A	N/A
31th	0,007	0,013	0,008	0,014	N/A	N/A
32th	0,006	0,011	0,012	0,021	N/A	N/A
33th	0,008	0,014	0,009	0,015	N/A	N/A
34th	0,004	0,007	0,007	0,012	N/A	N/A
35th	0,008	0,014	0,007	0,013	N/A	N/A
36th	0,005	0,009	0,008	0,014	N/A	N/A
37th	0,009	0,015	0,007	0,012	N/A	N/A
38th	0,005	0,008	0,009	0,017	N/A	N/A
39th	0,010	0,017	0,007	0,012	N/A	N/A
40th	0,003	0,006	0,006	0,011	N/A	N/A
THD <sub>40</sub>	1,6355%		0,9118%		23%	13%
PWHD	0,0004%		0,0002%		23%	22%

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Power Quality. Harmonics.						
Phase 3						
Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)						
	At 45-55% of rated output 6,61kW		100% of rated output 13,07kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-12 in %	
					1 phase	3 phase
2nd	0,203	0,357	0,170	0,298	8%	8%
3rd	0,232	0,408	0,324	0,569	21,6%	N/A
4th	0,150	0,263	0,115	0,202	4%	4%
5th	0,087	0,153	0,119	0,208	10,7%	10,7%
6th	0,042	0,074	0,035	0,062	2,67%	2,67%
7th	0,070	0,123	0,067	0,118	7,2%	7,2%
8th	0,110	0,194	0,069	0,122	2%	2%
9th	0,102	0,179	0,043	0,075	3,8%	N/A
10th	0,041	0,071	0,033	0,058	1,6%	1,6%
11th	0,033	0,058	0,027	0,048	3,1%	3,1%
12th	0,026	0,046	0,025	0,044	1,33%	1,33%
13th	0,017	0,030	0,028	0,049	2%	2%
14th	0,026	0,046	0,033	0,058	N/A	N/A
15th	0,012	0,021	0,019	0,034	N/A	N/A
16th	0,015	0,026	0,022	0,038	N/A	N/A
17th	0,012	0,021	0,022	0,039	N/A	N/A
18th	0,015	0,027	0,018	0,031	N/A	N/A
19th	0,011	0,020	0,021	0,037	N/A	N/A
20th	0,015	0,027	0,024	0,041	N/A	N/A
21th	0,009	0,016	0,013	0,023	N/A	N/A
22th	0,013	0,022	0,015	0,026	N/A	N/A
23th	0,009	0,016	0,018	0,032	N/A	N/A
24th	0,012	0,021	0,015	0,026	N/A	N/A
25th	0,009	0,016	0,016	0,028	N/A	N/A
26th	0,012	0,021	0,018	0,031	N/A	N/A
27th	0,010	0,018	0,011	0,019	N/A	N/A
28th	0,009	0,016	0,011	0,019	N/A	N/A
29th	0,011	0,019	0,014	0,024	N/A	N/A
30th	0,009	0,016	0,011	0,019	N/A	N/A
31th	0,012	0,021	0,013	0,022	N/A	N/A
32th	0,009	0,016	0,014	0,024	N/A	N/A
33th	0,014	0,024	0,009	0,015	N/A	N/A
34th	0,008	0,013	0,009	0,015	N/A	N/A
35th	0,014	0,024	0,012	0,021	N/A	N/A
36th	0,008	0,014	0,009	0,017	N/A	N/A
37th	0,013	0,023	0,013	0,023	N/A	N/A
38th	0,008	0,014	0,012	0,021	N/A	N/A
39th	0,015	0,026	0,010	0,017	N/A	N/A
40th	0,007	0,013	0,008	0,014	N/A	N/A
THD <sub>40</sub>	1,3878%		0,7528%		23%	13%
PWHD	0,0005%		0,0002%		23%	22%



**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Power Quality. Harmonics.						
842P046 Phase 1						
Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)						
	At 45-55% of rated output 7,70kW		100% of rated output 15,1kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-12 in %	
					1 phase	3 phase
2nd	0,094	0,165	0,171	0,301	8%	8%
3rd	0,072	0,126	0,265	0,466	21,6%	N/A
4th	0,024	0,042	0,053	0,093	4%	4%
5th	0,121	0,212	0,128	0,225	10,7%	10,7%
6th	0,029	0,051	0,068	0,119	2,67%	2,67%
7th	0,105	0,186	0,052	0,092	7,2%	7,2%
8th	0,061	0,107	0,081	0,143	2%	2%
9th	0,187	0,329	0,248	0,438	3,8%	N/A
10th	0,050	0,088	0,062	0,109	1,6%	1,6%
11th	0,095	0,168	0,093	0,164	3,1%	3,1%
12th	0,019	0,034	0,033	0,058	1,33%	1,33%
13th	0,021	0,037	0,045	0,079	2%	2%
14th	0,014	0,024	0,058	0,102	N/A	N/A
15th	0,023	0,041	0,034	0,061	N/A	N/A
16th	0,018	0,032	0,041	0,071	N/A	N/A
17th	0,048	0,085	0,049	0,086	N/A	N/A
18th	0,013	0,023	0,031	0,055	N/A	N/A
19th	0,020	0,035	0,062	0,110	N/A	N/A
20th	0,012	0,021	0,024	0,043	N/A	N/A
21th	0,061	0,108	0,035	0,061	N/A	N/A
22th	0,014	0,025	0,021	0,036	N/A	N/A
23th	0,020	0,035	0,032	0,057	N/A	N/A
24th	0,010	0,018	0,026	0,045	N/A	N/A
25th	0,027	0,048	0,020	0,035	N/A	N/A
26th	0,009	0,017	0,021	0,038	N/A	N/A
27th	0,018	0,031	0,016	0,028	N/A	N/A
28th	0,008	0,014	0,024	0,043	N/A	N/A
29th	0,010	0,018	0,018	0,031	N/A	N/A
30th	0,008	0,015	0,020	0,035	N/A	N/A
31th	0,020	0,036	0,019	0,034	N/A	N/A
32th	0,006	0,011	0,023	0,041	N/A	N/A
33th	0,015	0,027	0,016	0,029	N/A	N/A
34th	0,006	0,010	0,015	0,027	N/A	N/A
35th	0,014	0,026	0,018	0,032	N/A	N/A
36th	0,005	0,010	0,012	0,020	N/A	N/A
37th	0,010	0,017	0,016	0,028	N/A	N/A
38th	0,005	0,009	0,011	0,020	N/A	N/A
39th	0,008	0,013	0,017	0,030	N/A	N/A
40th	0,006	0,011	0,011	0,019	N/A	N/A
THD <sub>40</sub>	1,1069%		0,8487%		23%	13%
PWHD	0,0025%		0,0009%		23%	22%



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Annex to the G59/3 certificate of compliance No. U17-0449

Appendix E Type Verification Test Report

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Power Quality. Harmonics.						
Phase 2						
Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)						
	At 45-55% of rated output 7,70kW		100% of rated output 15,01kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-12 in %	
					1 phase	3 phase
2nd	0,156	0,276	0,285	0,503	8%	8%
3rd	0,059	0,104	0,273	0,483	21,6%	N/A
4th	0,022	0,038	0,058	0,103	4%	4%
5th	0,144	0,254	0,136	0,240	10,7%	10,7%
6th	0,029	0,051	0,074	0,130	2,67%	2,67%
7th	0,104	0,184	0,057	0,100	7,2%	7,2%
8th	0,064	0,113	0,083	0,146	2%	2%
9th	0,186	0,329	0,245	0,432	3,8%	N/A
10th	0,055	0,097	0,071	0,125	1,6%	1,6%
11th	0,096	0,169	0,092	0,163	3,1%	3,1%
12th	0,021	0,038	0,031	0,055	1,33%	1,33%
13th	0,020	0,035	0,048	0,086	2%	2%
14th	0,016	0,029	0,054	0,096	N/A	N/A
15th	0,026	0,045	0,036	0,063	N/A	N/A
16th	0,018	0,032	0,044	0,077	N/A	N/A
17th	0,050	0,088	0,047	0,083	N/A	N/A
18th	0,013	0,023	0,031	0,054	N/A	N/A
19th	0,016	0,029	0,067	0,118	N/A	N/A
20th	0,012	0,021	0,023	0,041	N/A	N/A
21th	0,062	0,109	0,037	0,065	N/A	N/A
22th	0,014	0,025	0,021	0,038	N/A	N/A
23th	0,019	0,033	0,033	0,058	N/A	N/A
24th	0,011	0,019	0,025	0,044	N/A	N/A
25th	0,032	0,057	0,020	0,036	N/A	N/A
26th	0,010	0,017	0,022	0,039	N/A	N/A
27th	0,018	0,032	0,016	0,027	N/A	N/A
28th	0,008	0,014	0,022	0,039	N/A	N/A
29th	0,010	0,018	0,016	0,029	N/A	N/A
30th	0,008	0,015	0,021	0,037	N/A	N/A
31th	0,021	0,036	0,018	0,031	N/A	N/A
32th	0,006	0,011	0,025	0,044	N/A	N/A
33th	0,013	0,024	0,015	0,026	N/A	N/A
34th	0,006	0,010	0,016	0,029	N/A	N/A
35th	0,017	0,031	0,018	0,033	N/A	N/A
36th	0,006	0,010	0,011	0,019	N/A	N/A
37th	0,009	0,016	0,018	0,032	N/A	N/A
38th	0,006	0,010	0,011	0,019	N/A	N/A
39th	0,008	0,015	0,017	0,031	N/A	N/A
40th	0,006	0,011	0,010	0,018	N/A	N/A
THD <sub>40</sub>	1,2191%		0,9557%		23%	13%
PWHD	0,0026%		0,0009%		23%	22%



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Annex to the G59/3 certificate of compliance No. U17-0449

Appendix E Type Verification Test Report

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Power Quality. Harmonics.						
Phase 3						
Generating Unit tested to BS EN 61000-3-12						
Generating Unit rating per phase (rpp)						
	At 45-55% of rated output 7,70kW		100% of rated output 15,01kW			
Harmonic	Measured Value (MV) in Amps	Measured Value (MV) in %	Measured Value (MV) in Amps	Measured Value (MV) in %	Limit in BS EN61000-3-12 in %	
					1 phase	3 phase
2nd	0,115	0,203	0,191	0,337	8%	8%
3rd	0,032	0,056	0,298	0,525	21,6%	N/A
4th	0,025	0,044	0,049	0,086	4%	4%
5th	0,105	0,185	0,104	0,184	10,7%	10,7%
6th	0,027	0,048	0,070	0,124	2,67%	2,67%
7th	0,111	0,196	0,062	0,109	7,2%	7,2%
8th	0,070	0,123	0,089	0,157	2%	2%
9th	0,195	0,344	0,252	0,445	3,8%	N/A
10th	0,053	0,093	0,063	0,111	1,6%	1,6%
11th	0,085	0,149	0,080	0,141	3,1%	3,1%
12th	0,020	0,035	0,029	0,052	1,33%	1,33%
13th	0,023	0,040	0,052	0,091	2%	2%
14th	0,015	0,026	0,059	0,103	N/A	N/A
15th	0,015	0,026	0,032	0,057	N/A	N/A
16th	0,017	0,030	0,043	0,077	N/A	N/A
17th	0,037	0,065	0,051	0,089	N/A	N/A
18th	0,013	0,022	0,034	0,060	N/A	N/A
19th	0,023	0,040	0,064	0,114	N/A	N/A
20th	0,011	0,019	0,023	0,041	N/A	N/A
21th	0,050	0,088	0,039	0,069	N/A	N/A
22th	0,014	0,025	0,022	0,038	N/A	N/A
23th	0,025	0,045	0,039	0,068	N/A	N/A
24th	0,010	0,018	0,024	0,042	N/A	N/A
25th	0,024	0,041	0,024	0,042	N/A	N/A
26th	0,010	0,018	0,020	0,036	N/A	N/A
27th	0,014	0,024	0,018	0,032	N/A	N/A
28th	0,008	0,015	0,023	0,041	N/A	N/A
29th	0,012	0,022	0,018	0,031	N/A	N/A
30th	0,008	0,015	0,019	0,033	N/A	N/A
31th	0,017	0,030	0,016	0,029	N/A	N/A
32th	0,006	0,011	0,026	0,045	N/A	N/A
33th	0,018	0,032	0,018	0,031	N/A	N/A
34th	0,006	0,011	0,016	0,028	N/A	N/A
35th	0,011	0,020	0,017	0,031	N/A	N/A
36th	0,006	0,011	0,014	0,024	N/A	N/A
37th	0,015	0,027	0,019	0,033	N/A	N/A
38th	0,006	0,010	0,011	0,020	N/A	N/A
39th	0,009	0,016	0,017	0,031	N/A	N/A
40th	0,007	0,012	0,010	0,018	N/A	N/A
THD <sub>40</sub>	1,0994%		0,8935%		23%	13%
PWHD	0,0017%		0,0009%		23%	22%



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**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Power Quality. Power factor.				
	216,2V	230V	253V	Measured at three voltage levels and at full output. Voltage to be maintained within $\pm 1.5\%$ of the stated level during the test.
Measured value	0,999	0,999	0,999	
Limit	>0,95	>0,95	>0,95	

Power Quality. Voltage fluctuation and Flicker.								
	Starting			Stopping			Running	
	dmax	dc	d(t)	dmax	dc	d(t)	Pst	Plt 2 hours
Measured values at test impedance	0,47%	3,3%	0,0%	0,47%	3,3%	0,0%	0,42	0,42
Limits set under BS EN 61000-3-11	4%	3,3%	3,3% 500ms	4%	3,3%	3,3% 500ms	1,0	0,65
Test impedance	R	0,24* 0,4^	$\Omega$	XI	0,15* 0,25	$\Omega$		
Standard impedance	R	0,24* 0,4^	$\Omega$	XI	0,15* 0,25^	$\Omega$		

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

<b>Power Quality. DC injection.</b>			
<b>842P040</b>			
<b>Test level power</b>	10%	55%	100%
<b>Phase 1</b>			
<b>Recorded value</b>	29,78mA	93,58mA	56,93mA
<b>As % of rated AC current</b>	0,05%	0,16%	0,11%
<b>Phase 2</b>			
<b>Recorded value</b>	72,36mA	37,34mA	104,38mA
<b>As % of rated AC current</b>	0,12%	0,06%	0,18 %
<b>Phase 3</b>			
<b>Recorded value</b>	25,29mA	77,37mA	121,09mA
<b>As % of rated AC current</b>	0,04%	0,13%	0,21%
<b>Limit</b>	0,25%	0,25%	0,25%
<b>842P046</b>			
<b>Test level power</b>	10%	55%	100%
<b>Phase 1</b>			
<b>Recorded value</b>	7,47mA	4,73mA	27,79mA
<b>As % of rated AC current</b>	0,01%	0,01%	0,05%
<b>Phase 2</b>			
<b>Recorded value</b>	85,83mA	8,22mA	83,26mA
<b>As % of rated AC current</b>	0,15%	0,01%	0,14%
<b>Phase 3</b>			
<b>Recorded value</b>	8,66mA	94,32mA	139,59mA
<b>As % of rated AC current</b>	0,01%	0,16%	0,24%
<b>Limit</b>	0,25%	0,25%	0,25%

**Appendix E Type Verification Test Report**

Extract from test report according to the Engineering Recommendation G59/3

Nr. 16TH0364-G59/3\_0

Fault level Contribution.					
For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	$I_p$	N/A	20ms	56,0	0,82
Initial Value of aperiodic current	A	N/A	100ms	50,0	0,37
Initial symmetrical short-circuit current*	$I_k$	N/A	250ms	49,1	0,25
Decaying (aperiodic) component of short circuit current*	$i_{DC}$	N/A	500ms	48,6	0,18
Reactance/Resistance Ratio of source*	X/R	N/A	Time to trip	0,006	In seconds

For rotating machines and linear piston machines the test should produce a 0s – 2s plot of the short circuit current as seen at the Generating Unit terminals.

\* Values for these parameters should be provided where the short circuit duration is sufficiently long to enable interpolation of the plot.

Self Monitoring – Solid state switching.	N/A
It has been verified that in the event of the solid state switching device failing to disconnect the Generating Unit, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0,5 seconds.	
Note. Unit do not provide solid state switching relays. In case the semiconductor bridge is switched off, then the voltage on the output drops to 0. In this case the relays on the output will also open.	