



**BUREAU
VERITAS**

Certificate of compliance

Applicant: SMA Solar Technology AG
Sonnenallee 1
34266 Niestetal
Germany

Product: Photovoltaic (PV) inverter

Model: SHP 100-20, SHP 100-21
SHP 150-20, SHP 150-21
SHP 172-21
SHP 180-21

Use in accordance with regulations:

Automatic disconnection device with three-phase mains surveillance in accordance with Engineering Recommendation G99/1 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, which can be accessed the distribution network provider at any time.

Applied rules and standards:

Engineering Recommendation G99/1-9:2022

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

Including:

B.4.4 Fault Ride Through and Fast Fault Current Injection

B.6.2 Frequency response test

DIN V VDE V 0126-1-1:2006 (4.1 Functional safety)

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

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: 18TH0282_SHP 1xx-21_G99_1 **Certification program:** NSOP-0032-DEU-ZE-V01

Certificate number: U23-0491 **Date of issue:** 2023-06-14

Certification body



Georg Lörz

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

Testing laboratory accredited according to DIN EN ISO/IEC 17025

A partial representation of the certificate requires the written approval of Bureau Veritas Consumer Products Services Germany GmbH

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Type Approval and declaration of compliance with the requirements of Engineering Recommendation G99.

PGM Technology:	Photovoltaic (PV) inverter		
Manufacturer / applicant:	SMA Solar Technology AG		
Address:	Sonnenallee 1 34266 Niestetal Germany		
Tel	+49 5619522-0	Fax:	+49 5619522-100
Email:	info@SMA.de	Website:	www.SMA.de

Rated values	SHP 100-20 SHP 100-21	SHP 150-20 SHP 150-21	SHP 172-21	SHP 180-21
MPP DC voltage range [V]	590 – 1000	880 - 1450	968 - 1450	1012 - 1450
Input DC voltage range [V]	max. 1000	max. 1500	max. 1500	max. 1500
Input DC current [A]	max. 180 lsc: 325			
Output AC voltage [V]	400 / PE @ 50/60 Hz	600 / PE @ 50/60 Hz	660 / PE @ 50/60 Hz	690 / PE @ 50/60 Hz
Output AC current [A]	max. 151			
Output power [VA]	100000	150000	172000	180000

Firmware version ≥03.00.00.R

Description of the structure of the power generation unit:

The power generation unit is equipped with a PV and line-side EMC filter. The power generation unit has no galvanic isolation between DC input and AC output. Output switch-off is performed with single-fault tolerance based on two series-connected relays in line and neutral. This enables a safe disconnection of the power generation unit from the network in case of error.

Differences between Generating Units:

All inverter models use the same hardware platform and have the same output current.
The different output power is reached with the different AC voltage ranges.

The above stated Generating Units are tested according the requirements in the Engineering Recommendation G99/1. 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 G99/1.

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Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Operating Range. (SHP100-21/SHP100-20 with 400 V phase to phase)	
Test 1	Voltage = 85% of nominal (195,5 Vph-n / 338,6 Vph-ph) Frequency = 47,0Hz Power Factor = 1 Period of test 20 s
Connection:	Always connected
Limit:	Always connected
Test 2	Voltage = 85% of nominal (195,5 Vph-n / 338,6 Vph-ph) Frequency = 47,5Hz Power Factor = 1 Period of test 90 minutes
Connection:	Always connected
Limit:	Always connected
Test 3	Voltage = 110% of nominal (253 Vph-n / 438,2 Vph-ph) Frequency = 51,5Hz Power Factor = 1 Period of test 90 minutes
Connection:	Always connected
Limit:	Always connected
Test 4	Voltage = 110% of nominal (253 Vph-n / 438,2 Vph-ph) Frequency = 52,0Hz Power Factor = 1 Period of test 15 minutes
Connection:	Always connected
Limit:	Always connected
Test 5	Voltage = 100% of nominal (230 Vph-n / 400,0 Vph-ph) Frequency = 50,0 Hz Power Factor = 1 Period of test 90 minutes
Connection:	Always connected
Limit:	Always connected
Test 6	Confirm that the Power Generating Module is capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500ms. Note that this is not expected to be demonstrated on site.
Connection:	Always connected
Limit:	Always connected

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Extract from test report according to the Engineering
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Nr. 18TH0282_SHP 1xx-21_G99_1

Operating Range.

(SHP150-21/SHP150-20 with 600 V phase to phase)

Test 1	Voltage = 85% of nominal (294,4 Vph-n / 509,9 Vph-ph) Frequency = 47,0Hz Power Factor = 1 Period of test 20 s
Connection:	Always connected
Limit:	Always connected
Test 2	Voltage = 85% of nominal (294,4 Vph-n / 509,9 Vph-ph) Frequency = 47,5Hz Power Factor = 1 Period of test 90 minutes
Connection:	Always connected
Limit:	Always connected
Test 3	Voltage = 110% of nominal (381,0 Vph-n / 659,9Vph-ph) Frequency = 51,5Hz Power Factor = 1 Period of test 90 minutes
Connection:	Always connected
Limit:	Always connected
Test 4	Voltage = 110% of nominal (381,0 Vph-n / 659,9Vph-ph) Frequency = 52,0Hz Power Factor = 1 Period of test 15 minutes
Connection:	Always connected
Limit:	Always connected
Test 5	Voltage = 100% of nominal (346,4 Vph-n / 600,0Vph-ph) Frequency = 50,0 Hz Power Factor = 1 Period of test 90 minutes
Connection:	Always connected
Limit:	Always connected
Test 6	Confirm that the Power Generating Module is capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs-1 as measured over a period of 500ms. Note that this is not expected to be demonstrated on site.
Connection:	Always connected
Limit:	Always connected

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Protection. Voltage tests.

(SHP100-21/SHP100-20 with 400 V phase to phase)

Phase 1

Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
U/V	184,0ph-n (318,7ph-ph)	2,5	184,5ph-n (319,6ph-ph)	2,525	188Vph-n (325,6Vph-ph) / 5,0s	No trip
					180V / 2,45s	No trip
O/V stage 1	262,2ph-n (454,1ph-ph)	1,0	264,2ph-n (457,6ph-ph)	1,017	258,2Vph-n (447,2Vph-ph) / 5,0s	No trip
O/V stage 2	273,7ph-n (474,1ph-ph)	0,5	275,7ph-n (477,5ph-ph)	0,518	269,7Vph-n (467,1ph-ph) / 0,95s	No trip
					277,7V 0,45s	No trip

Protection. Voltage tests.

Phase 2

Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
U/V	184,0ph-n (318,7ph-ph)	2,5	184,6ph-n (319,7ph-ph)	2,529	188Vph-n (325,6Vph-ph) / 5,0s	No trip
					180Vph-n (311,8Vph-ph) / 2,45s	No trip
O/V stage 1	262,2ph-n (454,1ph-ph)	1,0	264,2ph-n (457,5ph-ph)	1,021	258,2Vph-n (447,2Vph-ph) / 5,0s	No trip
O/V stage 2	273,7ph-n (474,1ph-ph)	0,5	275,1ph-n (476,5ph-ph)	0,518	269,7Vph-n (467,1ph-ph) / 0,95s	No trip
					277,7Vph-n (481,0Vph-ph) / 0,45s	No trip

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Protection. Voltage tests.

Phase 3

Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
UV	184,0ph-n (318,7ph-ph)	2,5	184,3ph-n (319,2ph-ph)	2,513	188Vph-n (325,6Vph-ph) / 5,0s	No trip
					180Vph-n (311,8Vph-ph) / 2,45s	No trip
O/V stage 1	262,2ph-n (454,1ph-ph)	1,0	264,1ph-n (457,4ph-ph)	1,016	258,2Vph-n (447,2Vph-ph) / 5,0s	No trip
O/V stage 2	273,7ph-n (474,1ph-ph)	0,5	275,5ph-n (477,2ph-ph)	0,522	269,7Vph-n (467,1ph-ph) / 0,95s	No trip
					277,7Vph-n (481,0Vph-ph) / 0,45s	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.

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Extract from test report according to the Engineering
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Nr. 18TH0282_SHP 1xx-21_G99_1

Protection. Voltage tests.

(SHP150-21/SHP150-20 with 600 V phase to phase)

Phase 1

Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
U/V	276,8ph-n (479,4ph-ph)	2,5	275,8ph-n (477,7ph-ph)	2,515	282,8Vph-n (489,8Vph-ph) / 5,0s	No trip
					270,8Vph-n (469,0Vph-ph) / 2,45s	No trip
O/V stage 1	394,4ph-n (683,1ph-ph)	1,0	395,9ph-n (685,7ph-ph)	1,020	388,4Vph-n (672,7Vph-ph) / 5,0s	No trip
O/V stage 2	411,7ph-n (713,1ph-ph)	0,5	413,2ph-n (715,7ph-ph)	0,518	405,7Vph-n (702,6Vph-ph) / 0,95s	No trip
					417,8Vph-n (817,2Vph-ph) / 0,45s	No trip

Protection. Voltage tests.

Phase 2

Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
U/V	276,8ph-n (479,4ph-ph)	2,5	275,9ph-n (477,9ph-ph)	2,521	282,8Vph-n (489,8Vph-ph) / 5,0s	No trip
					270,8Vph-n (469,0Vph-ph) / 2,45s	No trip
O/V stage 1	394,4ph-n (683,1ph-ph)	1,0	396,1ph-n (686,1ph-ph)	1,021	388,4Vph-n (672,7Vph-ph) / 5,0s	No trip
O/V stage 2	411,7ph-n (713,1ph-ph)	0,5	413,4ph-n (716,0ph-ph)	0,521	405,7Vph-n (702,6Vph-ph) / 0,95s	No trip
					417,8Vph-n (817,2Vph-ph) / 0,45s	No trip

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Protection. Voltage tests.

Phase 3

Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
UV	276,8ph-n (479,4ph-ph)	2,5	275,8ph-n (477,7ph-ph)	2,517	282,8Vph-n (489,8Vph-ph) / 5,0s	No trip
					270,8Vph-n (469,0Vph-ph) / 2,45s	No trip
O/V stage 1	394,4ph-n (683,1ph-ph)	1,0	395,9ph-n (685,7ph-ph)	1,021	388,4Vph-n (672,7Vph-ph) / 5,0s	No trip
O/V stage 2	411,7ph-n (713,1ph-ph)	0,5	413,1ph-n (715,5ph-ph)	0,517	405,7Vph-n (702,6Vph-ph) / 0,95s	No trip
					417,8Vph-n (817,2Vph-ph) / 0,45s	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.

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Protection. Frequency tests.

(SHP100-21/SHP100-20 with 400 V phase to phase)

Function	Setting		Trip test		No trip test	
	Frequency [Hz]	Time delay [s]	Frequency [Hz]	Time delay [s]	Frequency / time	Confirm no trip
U/F stage 1	47,5	20	47,50	20,074	47,7Hz / 30s	No trip
U/F stage 2	47,0	0,5	47,00	0,579	47,2Hz / 19,5s	No trip
					46,8Hz / 0,45s	No trip
O/F stage 2	52,0	0,5	52,05	0,578	51,8Hz / 120s	No trip
					52,2Hz / 0,45s	No trip

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

Protection. Frequency tests.

(SHP150-21/SHP150-20 with 600 V phase to phase)

Function	Setting		Trip test		No trip test	
	Frequency [Hz]	Time delay [s]	Frequency [Hz]	Time delay [s]	Frequency / time	Confirm no trip
U/F stage 1	47,5	20	47,50	20,068	47,7Hz / 30s	No trip
U/F stage 2	47,0	0,5	47,01	0,580	47,2Hz / 19,5s	No trip
					46,8Hz / 0,45s	No trip
O/F stage 2	52,0	0,5	52,05	0,572	51,8Hz / 120s	No trip
					52,2Hz / 0,45s	No trip

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

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Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Protection. Loss of Mains.

(SHP100-21/SHP100-20 with 400 V phase to phase)

Inverters tested according to BS EN 62116.

Balancing load on islanded network	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
Trip time. Ph1 fuse removed [s]	0,425	0,427	0,804	0,447	0,442	0,424
Trip time. Ph2 fuse removed [s]	0,425	0,427	0,804	0,447	0,442	0,424
Trip time. Ph3 fuse removed [s]	0,425	0,427	0,804	0,447	0,442	0,424

Note. Trip time limit is 0,5s.

Protection. Loss of Mains.

(SHP150-21/SHP150-20 with 600 V phase to phase)

Inverters tested according to BS EN 62116.

Balancing load on islanded network	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
Trip time. Ph1 fuse removed [s]	0,421	0,420	0,454	0,440	0,444	0,430
Trip time. Ph2 fuse removed [s]	0,421	0,420	0,454	0,440	0,444	0,430
Trip time. Ph3 fuse removed [s]	0,421	0,420	0,454	0,440	0,444	0,430

Note. Trip time limit is 0,5s.

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Protection. Re-connection timer.

(SHP100-21/SHP100-20 with 400 V phase to phase)

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 10.1.

Over Voltage (266,2V)

Time delay setting	Measured delay
20s	47,54

Under Voltage (182V)

Time delay setting	Measured delay
20s	48,09

Over Frequency (52,1Hz)

Time delay setting	Measured delay
20s	47,54

Under Frequency (47,4Hz)

Time delay setting	Measured delay
20s	47,66

	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1.			
	At 266,2Vph-n (461,1Vph-ph)	At 180,0Vph-n (311,8Vph-ph)	At 47,4Hz	At 52,1Hz
Confirmation that the Generating Unit does not re- connect.	No reconnection	No reconnection	No reconnection	No reconnection

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Protection. Re-connection timer.

(SHP150-21/SHP150-20 with 600 V phase to phase)

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 10.1.

Over Voltage (400,4V)				
Time delay setting		Measured delay		
20s		47,55		
Under Voltage (273,8V)				
Time delay setting		Measured delay		
20s		48,08		
Over Frequency (52,1Hz)				
Time delay setting		Measured delay		
20s		48,14		
Under Frequency (47,4Hz)				
Time delay setting		Measured delay		
20s		47,65		
	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1.			
	At 400,4Vph-n (693,5Vph-ph)	At 273,8Vph-n (474,2Vph-ph)	At 47,4Hz	At 52,1Hz
Confirmation that the Generating Unit does not re- connect.	No reconnection	No reconnection	No reconnection	No reconnection

Protection. Frequency change, Stability test.

(SHP100-21/SHP100-20 with 400 V phase to phase)

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

Protection. Frequency change, Stability test.

(SHP150-21/SHP150-20 with 600 V phase to phase)

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

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Nr. 18TH0282_SHP 1xx-21_G99_1

Limited Frequency Sensitive Mode – Over Frequency (SHP100-21/SHP100-20 with 400 V phase to phase)

1-min mean value [Hz]:	a) 50,00	b) 50,45	c) 50,70	d) 51,15	e) 50,70	f) 50,45	g) 50,00
1. Measurement a) to g): Active power output > 80% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
P _{expected} [W]:	99898	94849	69849	24848	69828	94818	99898
P _{measured} [W]:	99898	94816	69825	24898	69828	94818	99898
2. Measurement a) to g): Active power output 40% and 60% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
P _{expected} [W]:	50003	44954	19953	0	19953	44953	50003
P _{measured} [W]:	50003	45130	20160	206	20161	45153	50003

Limited Frequency Sensitive Mode – Over Frequency – (SHP150-21/SHP150-20 with 600 V phase to phase)

1-min mean value [Hz]:	a) 50,00	b) 50,45	c) 50,70	d) 51,15	e) 50,70	f) 50,45	g) 50,00
1. Measurement a) to g): Active power output > 80% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
P _{expected} [W]:	149886	142311	104810	37311	104810	142311	149886
P _{measured} [W]:	149886	142311	104810	37311	104810	142311	149886
2. Measurement a) to g): Active power output 40% and 60% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
P _{expected} [W]:	75064	67489	29989	0	29989	67489	75064
P _{measured} [W]:	75064	67739	30286	264	30279	67784	75064

Output Power with falling Frequency (SHP100-21/SHP100-20 with 400 V phase to phase)

Frequency setpoint [Hz]:	50,00	49,50	49,00	48,00	47,60	47,10
Frequency [Hz]:	50,00	49,50	49,50	48,00	47,60	47,05
Active power [W]:	99150	99150	99163	99167	99172	99909
ΔP/P _{max} [%]:		0,00	0,00	0,00	0,00	0,00

Note.
No Power reduction takes place for electronic inverter

Output Power with falling Frequency (SHP150-21/SHP150-20 with 600 V phase to phase)

Frequency setpoint [Hz]:	50,00	49,50	49,00	48,00	47,60	47,10
Frequency [Hz]:	50,00	49,50	49,50	48,00	47,60	47,05
Active power [W]:	149648	149668	149692	149701	149715	149845
ΔP/P _{max} [%]:		0,00	0,00	0,00	0,00	0,00

Note.
No Power reduction takes place for electronic inverter

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Nr. 18TH0282_SHP 1xx-21_G99_1

Power Quality. Harmonics.

SHP100-21/SHP100-20

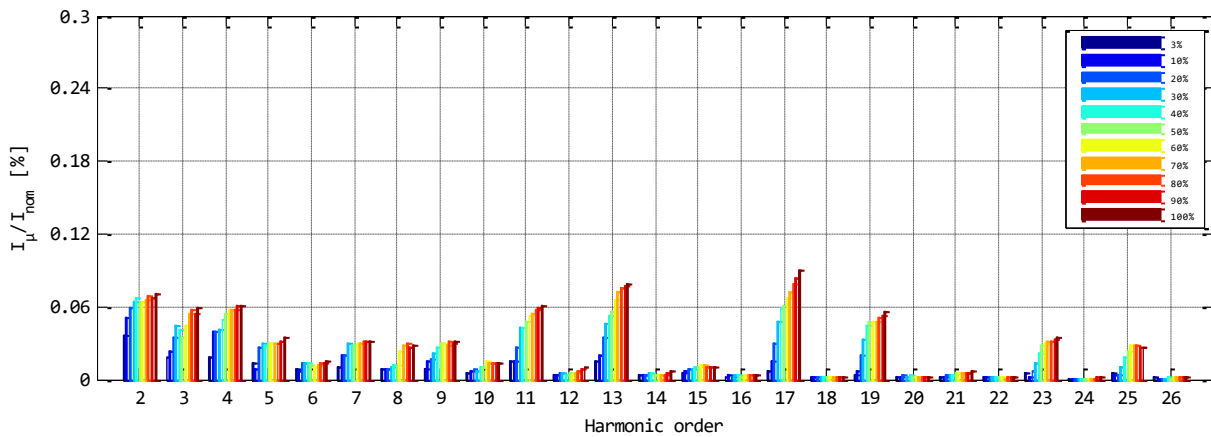
Testconditions: *CURRENT harmonics, interharmonics and higher frequency components according to TR3 Rev. 25:2018*

Device under test	: SHP100k-21	DC voltage	: 850 V
AC voltage	: 230.94V	power stage	: 3% to 100%
frequency	: 50 Hz	power factor	: 1u
test duration	: 1x 10 min	rated AC current	: 144.30A

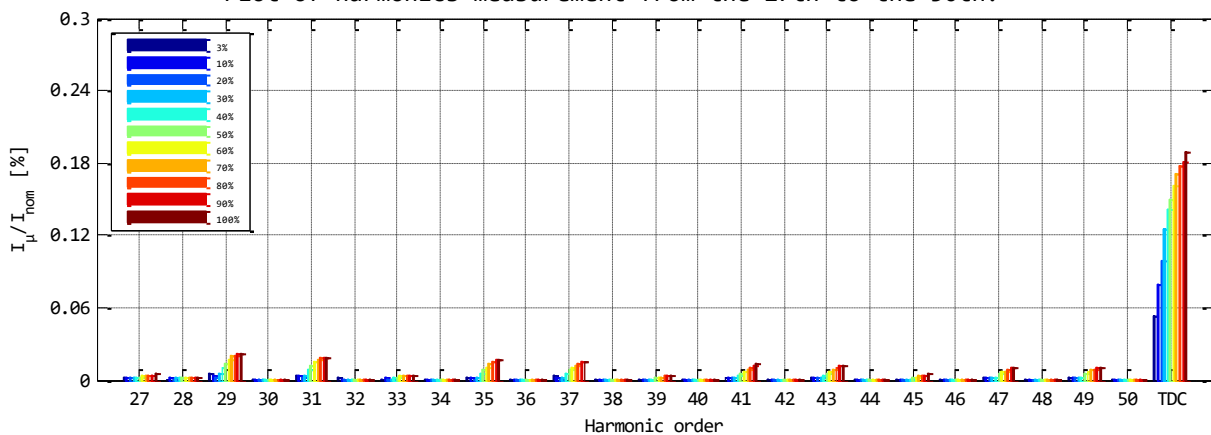
Line Impedance Simulation:

phase:	: 0.125 Ohm + 0.0790 Ohm
neutral:	: 0.000 Ohm + 0.0000 Ohm

Plot of harmonics-measurement from the 2nd to the 26th:



Plot of harmonics-measurement from the 27th to the 50th:





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Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values of line current
harmonics based on rated current for equal power bins:

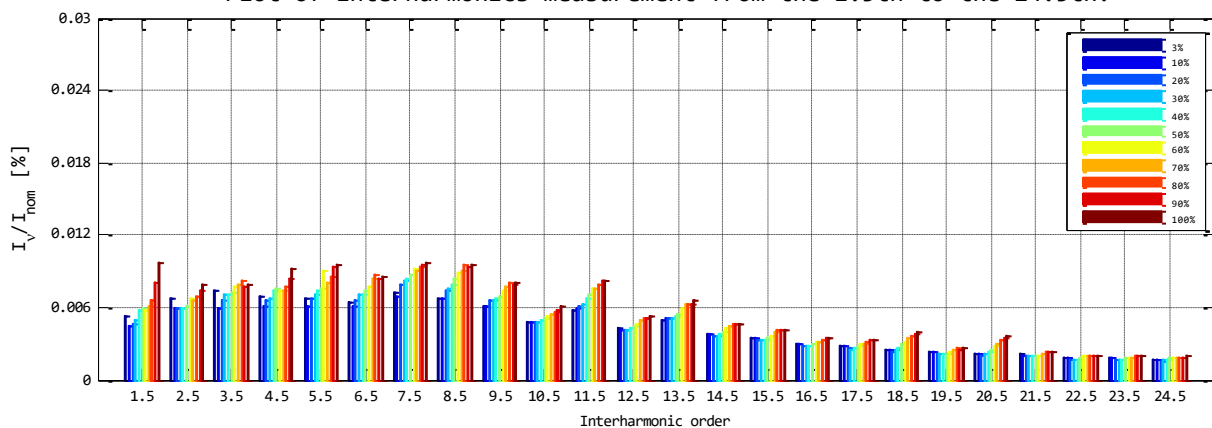
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$	$I_{\mu}/I_n[\%]$
1	3.01	9.93	19.71	29.31	38.78	48.15	57.38	66.18	75.20	84.00	92.56	92.56
2	0.04	0.05	0.06	0.06	0.07	0.06	0.06	0.07	0.07	0.07	0.07	0.07
3	0.02	0.02	0.04	0.05	0.04	0.04	0.05	0.05	0.06	0.05	0.06	0.06
4	0.02	0.04	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5	0.01	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
7	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
8	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.03
9	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
11	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06
12	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01
13	0.01	0.02	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.08	0.08
14	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01
15	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.01	0.02	0.03	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.01	0.02	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.01	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.01	0.00	0.00	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	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	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	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
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	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
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	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
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	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
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
TDC	0.05	0.08	0.10	0.13	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.19
TDD	0.11	0.07	0.10	0.13	0.16	0.17	0.21	0.22	0.24	0.24	0.25	0.25

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

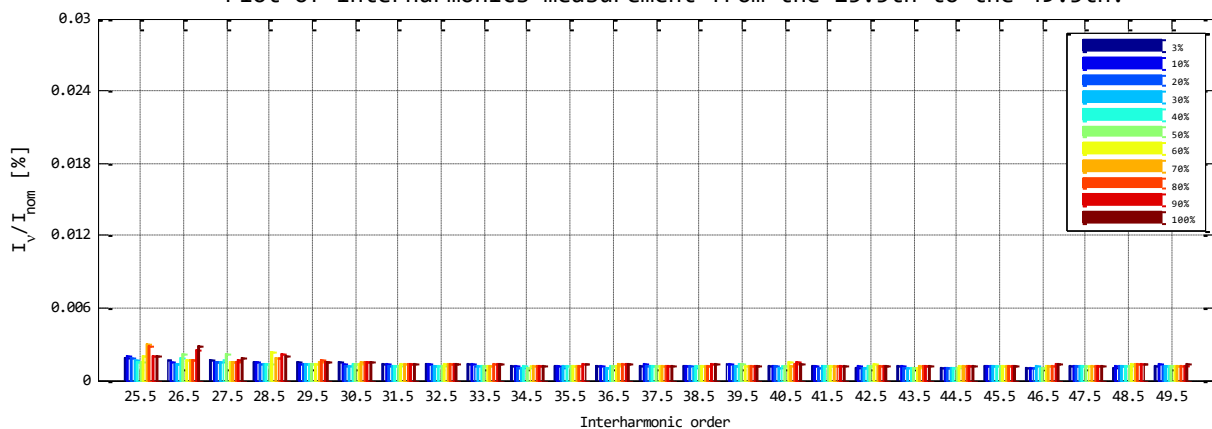
Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of interharmonics-measurement from the 1.5th to the 24.5th:



Plot of interharmonics-measurement from the 25.5th to the 49.5th:





Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for line current
interharmonics based on rated current for equal power bins:

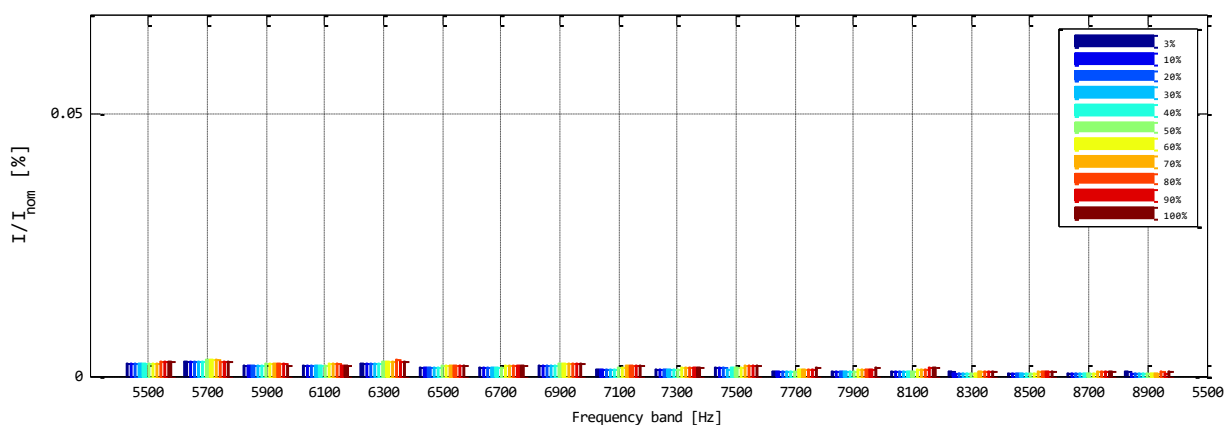
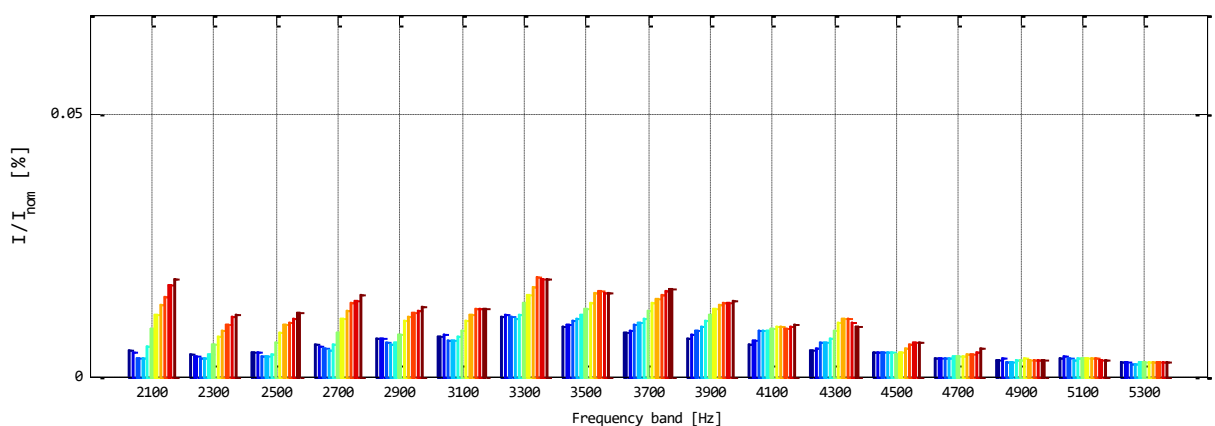
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$
1.5	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
6.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
7.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
8.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10.5	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
11.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
13.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of higher frequency line current components
based on rated current from 2 kHz up to 9 kHz in 200 Hz bands:





Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for higher frequency line
current components based on rated current for equal power bins:

Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Band	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]
2100	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
2300	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2500	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2700	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
2900	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3300	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
3500	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
3700	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
3900	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4300	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
4700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
4900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

SHP150-21/SHP150-20

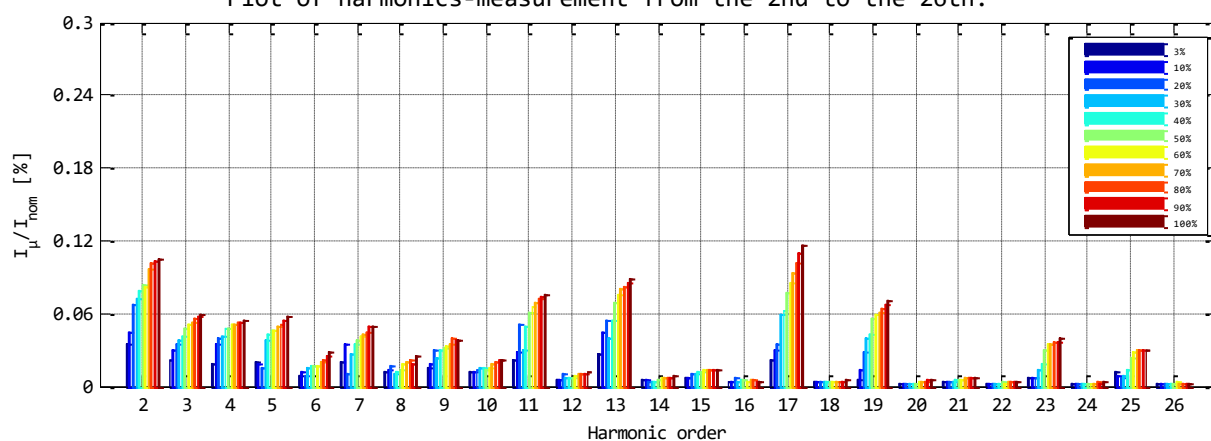
Test conditions: *CURRENT harmonics, interharmonics and higher frequency components according to TR3 Rev. 25:2018*

Device under test	: SHP150k-21	DC voltage	: 1200 V
AC voltage	: 346.41V	power stage	: 3% to 100%
frequency	: 50 Hz	power factor	: 1u
test duration	: 1x 10 min	rated AC current	: 144.30A

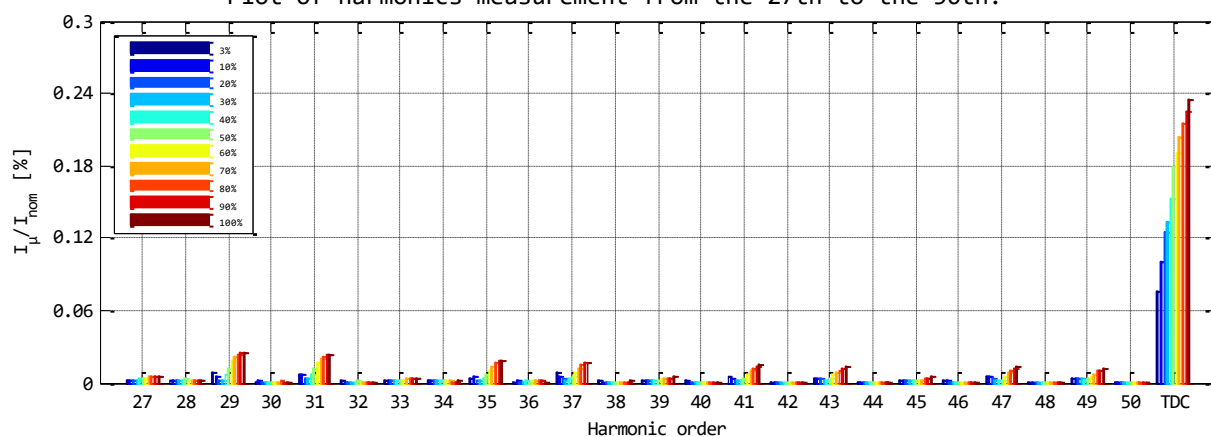
Line Impedance Simulation:

phase:	: 0.125 Ohm + 0.0790 Ohm
neutral:	: 0.000 Ohm + 0.0000 Ohm

Plot of harmonics-measurement from the 2nd to the 26th:



Plot of harmonics-measurement from the 27th to the 50th:





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Annex to the G99/1 certificate of compliance No. U23-0491

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values of line current
harmonics based on rated current for equal power bins:

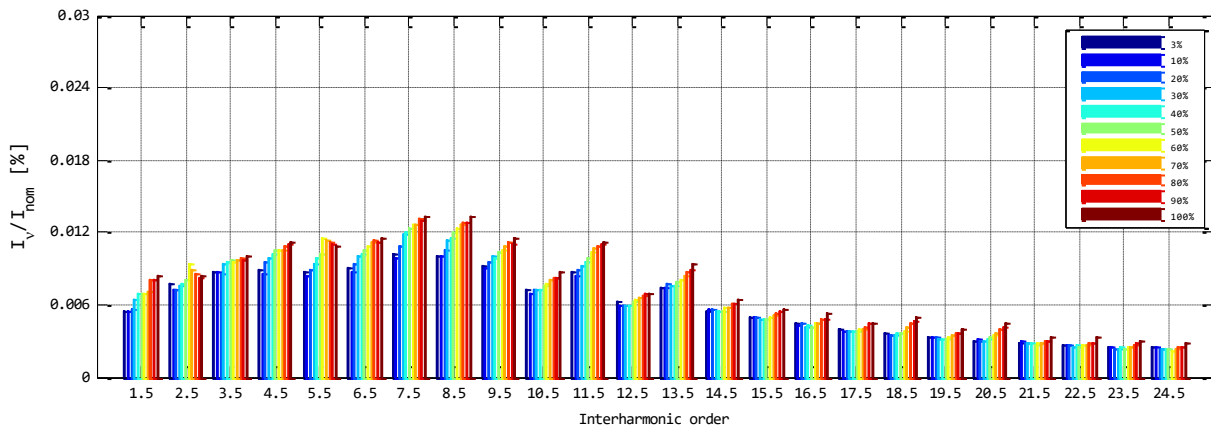
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]
1	3.02	9.96	19.81	29.53	39.18	48.84	58.39	67.68	76.92	85.95	94.98	94.98
2	0.04	0.05	0.07	0.07	0.08	0.08	0.08	0.10	0.10	0.10	0.11	0.11
3	0.02	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06
4	0.02	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
5	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06
6	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
7	0.02	0.03	0.01	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
8	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
9	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
10	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
11	0.02	0.03	0.05	0.03	0.05	0.06	0.07	0.07	0.07	0.07	0.08	0.08
12	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
13	0.03	0.05	0.05	0.04	0.05	0.07	0.08	0.08	0.08	0.09	0.09	0.09
14	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
15	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
16	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01
17	0.02	0.03	0.03	0.06	0.06	0.08	0.09	0.09	0.10	0.11	0.12	0.12
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
19	0.01	0.01	0.03	0.04	0.04	0.06	0.06	0.06	0.06	0.07	0.07	0.07
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
21	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.04	0.04	0.04	0.04
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.01	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.01	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	0.00	0.00
41	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	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	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
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	0.00	0.00	0.00	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	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
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	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
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
TDC	0.08	0.10	0.13	0.13	0.15	0.18	0.19	0.20	0.22	0.23	0.24	0.24
TDD	0.08	0.08	0.09	0.09	0.11	0.13	0.15	0.17	0.18	0.19	0.20	0.20

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

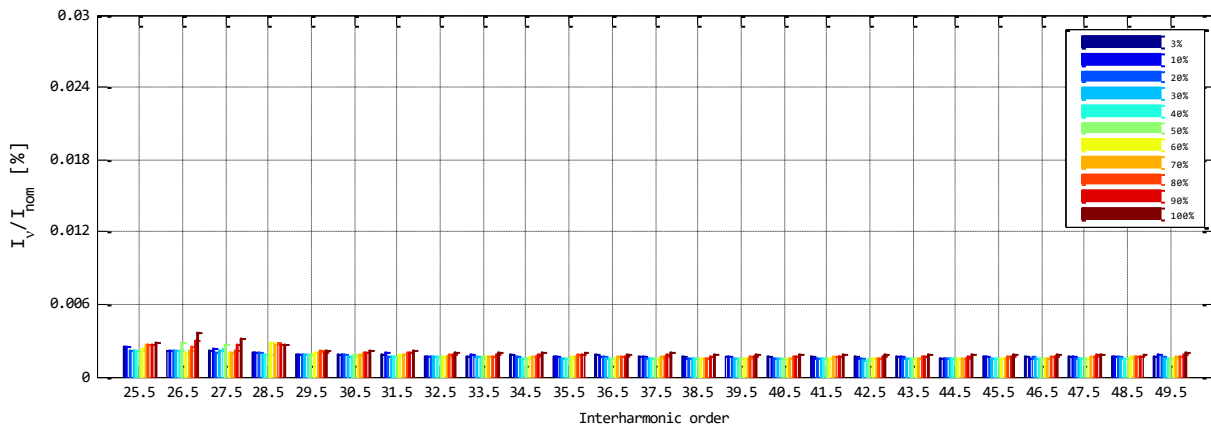
Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of interharmonics-measurement from the 1.5th to the 24.5th:



Plot of interharmonics-measurement from the 25.5th to the 49.5th:





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Annex to the G99/1 certificate of compliance No. U23-0491

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for line current
interharmonics based on rated current for equal power bins:

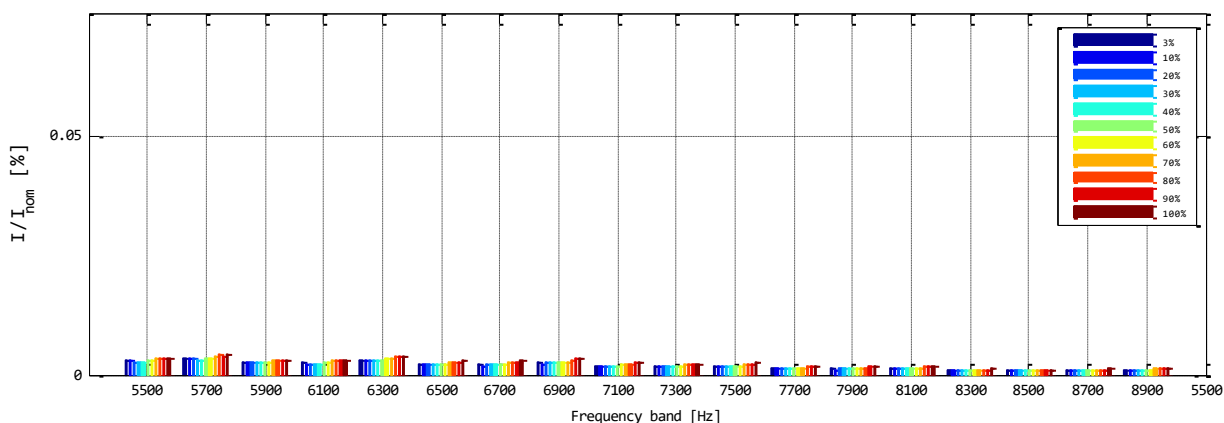
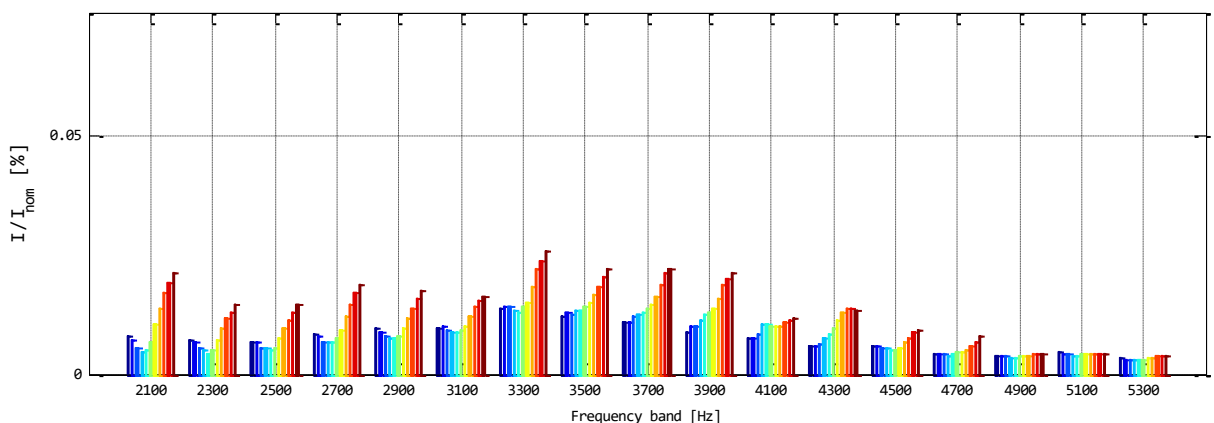
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$
1.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
6.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
7.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
8.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
11.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
12.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
13.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
14.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
15.5	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of higher frequency line current components based on rated current from 2 kHz up to 9 kHz in 200 Hz bands:





Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for higher frequency line
current components based on rated current for equal power bins:

Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Band	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]
2100	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
2300	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2500	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2700	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
2900	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
3100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
3300	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
3500	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
3700	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
3900	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
4100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4300	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4500	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
4900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

SHP172-21

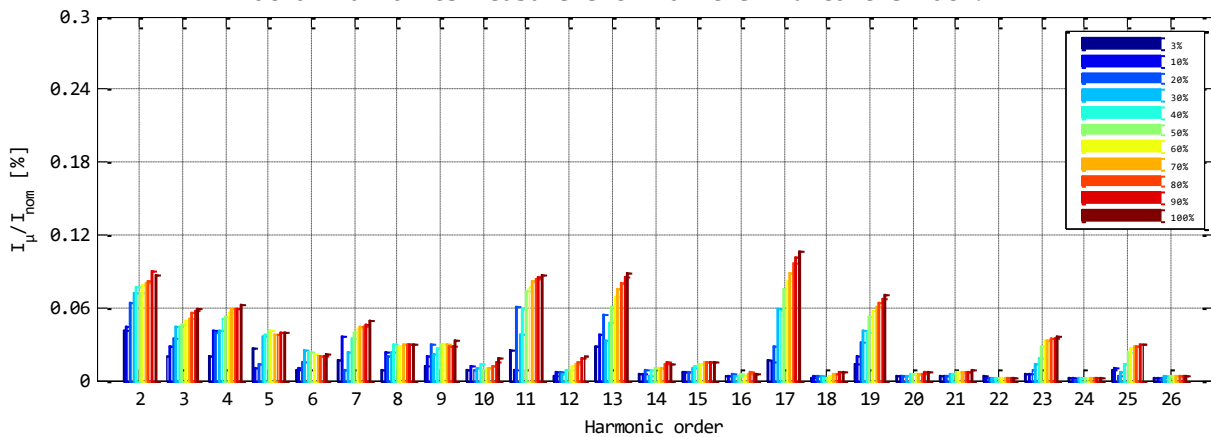
Testconditions: *CURRENT harmonics, interharmonics and higher frequency components according to TR3 Rev. 25:2018*

Device under test	: SHP172k-21	DC voltage	: 1200 V
AC voltage	: 381.05V	power stage	: 3% to 100%
frequency	: 50 Hz	power factor	: 1u
test duration	: 1x 10 min	rated AC current	: 150.4A

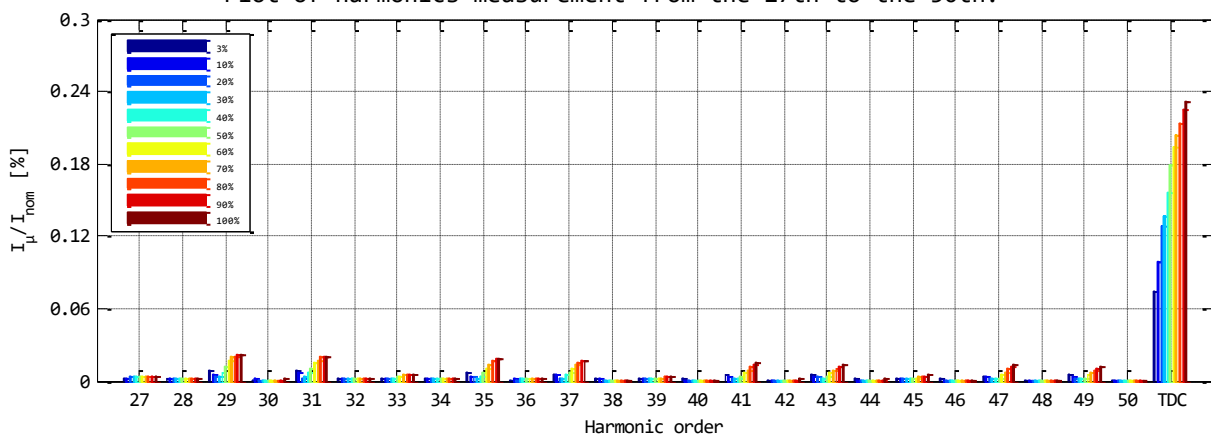
Line Impedance Simulation:

phase:	: 0.125 Ohm + 0.0790 Ohm
neutral:	: 0.000 Ohm + 0.0000 Ohm

Plot of harmonics-measurement from the 2nd to the 26th:



Plot of harmonics-measurement from the 27th to the 50th:





Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values of line current
harmonics based on rated current for equal power bins:

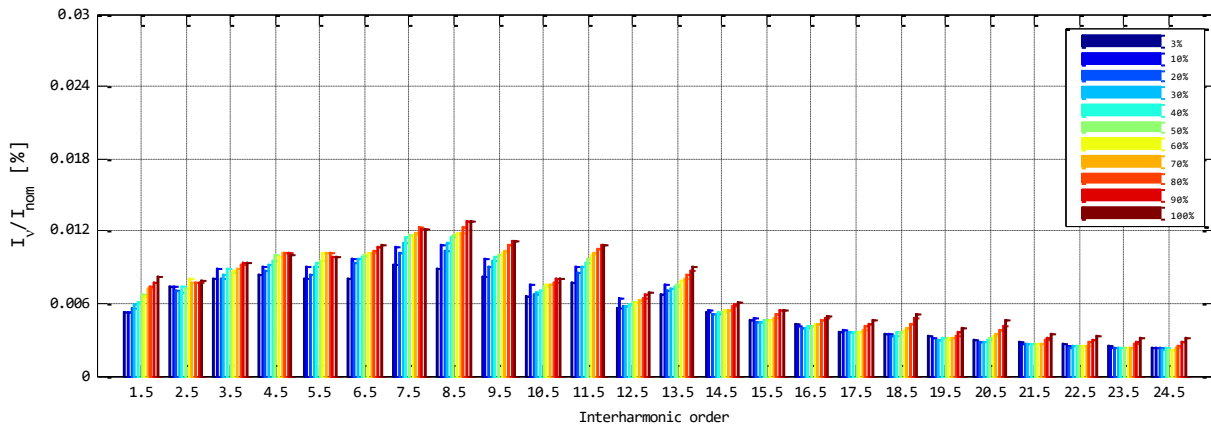
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]
1	3.02	9.97	19.82	29.56	39.22	49.05	58.50	67.84	77.01	86.19	95.23	95.23
2	0.04	0.05	0.06	0.07	0.08	0.07	0.08	0.08	0.08	0.09	0.09	0.09
3	0.02	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06
4	0.02	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
5	0.03	0.01	0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
6	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7	0.02	0.04	0.01	0.02	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05
8	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
9	0.01	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
11	0.03	0.01	0.06	0.04	0.06	0.07	0.08	0.08	0.08	0.09	0.09	0.09
12	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
13	0.03	0.04	0.05	0.03	0.05	0.06	0.07	0.08	0.08	0.09	0.09	0.09
14	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02
15	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
17	0.02	0.02	0.03	0.06	0.06	0.08	0.08	0.09	0.10	0.10	0.11	0.11
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
19	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.06	0.06	0.07	0.07	0.07
20	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
21	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.01	0.01	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.01	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	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	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	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	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	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
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	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
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	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
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
TDC	0.08	0.10	0.13	0.14	0.16	0.18	0.19	0.20	0.21	0.22	0.23	0.23
TDD	0.08	0.08	0.09	0.09	0.11	0.13	0.15	0.16	0.17	0.18	0.19	0.19

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

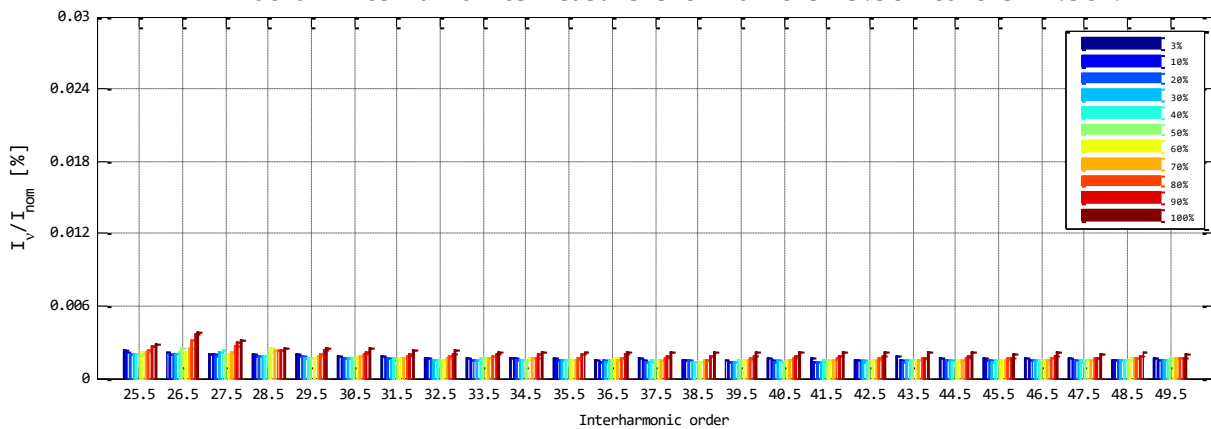
Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of interharmonics-measurement from the 1.5th to the 24.5th:



Plot of interharmonics-measurement from the 25.5th to the 49.5th:





Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for line current
interharmonics based on rated current for equal power bins:

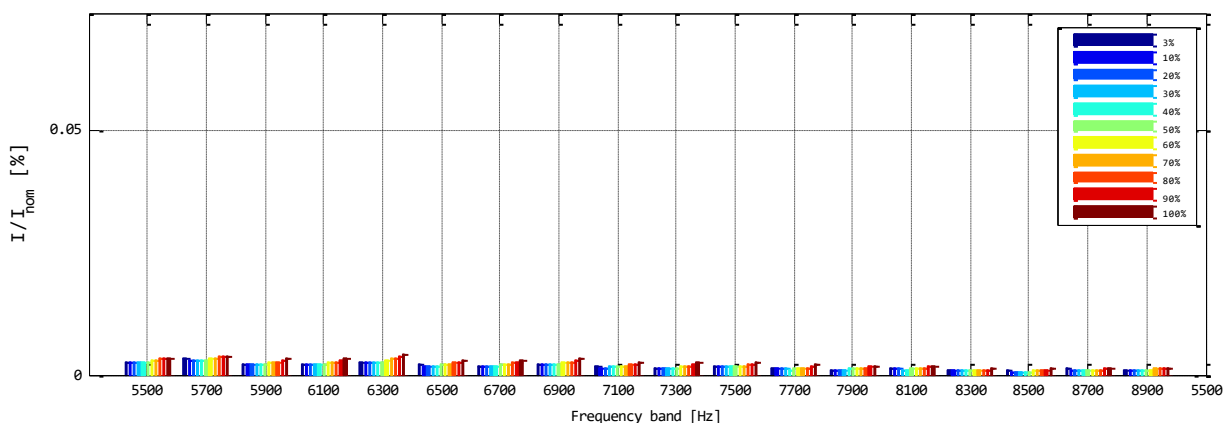
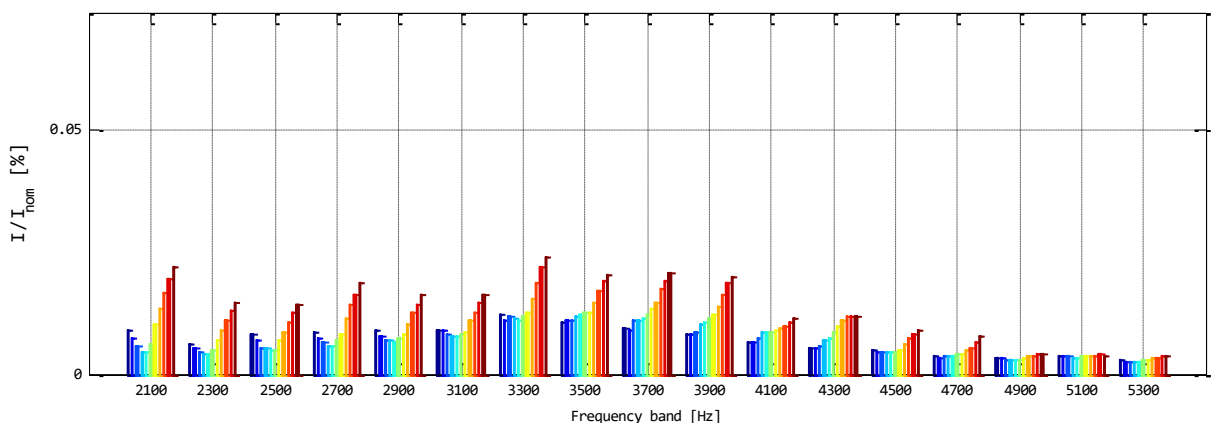
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$	$I_V / I_n [\%]$
1.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
6.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
7.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
8.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
9.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
11.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
12.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
13.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
14.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of higher frequency line current components based on rated current from 2 kHz up to 9 kHz in 200 Hz bands:





Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for higher frequency line
current components based on rated current for equal power bins:

Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Band	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]
2100	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02
2300	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2500	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
2700	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
2900	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
3100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
3300	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
3500	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
3700	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
3900	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
4100	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4300	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4500	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
4700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
4900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

SHP180-21

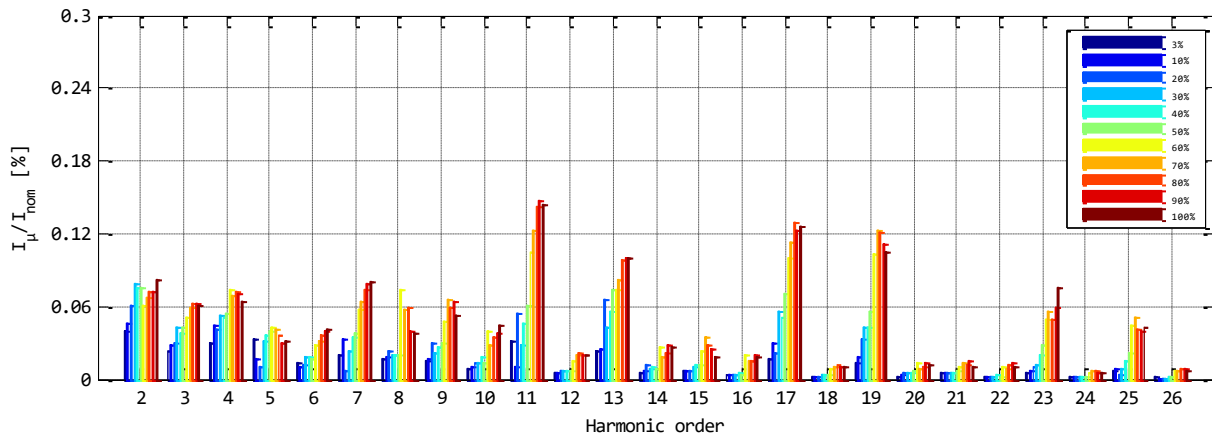
Test conditions: CURRENT harmonics, interharmonics and higher frequency components according to TR3 Rev. 25:2018

Device under test	: SHP180k-21	DC voltage	: 1200 V
AC voltage	: 398.37V	power stage	: 3% to 100%
frequency	: 50 Hz	power factor	: 1u
test duration	: 1x 10 min	rated AC current	: 150.61A

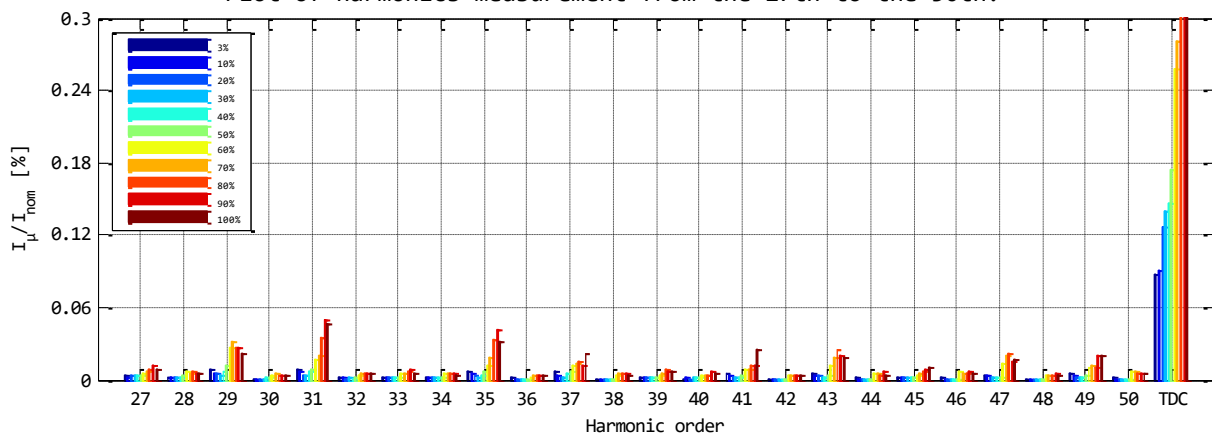
Line Impedance Simulation:

phase:	: 0.125 Ohm + 0.0790 Ohm
neutral:	: 0.000 Ohm + 0.0000 Ohm

Plot of harmonics-measurement from the 2nd to the 26th:



Plot of harmonics-measurement from the 27th to the 50th:





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Annex to the G99/1 certificate of compliance No. U23-0491

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values of line current
harmonics based on rated current for equal power bins:

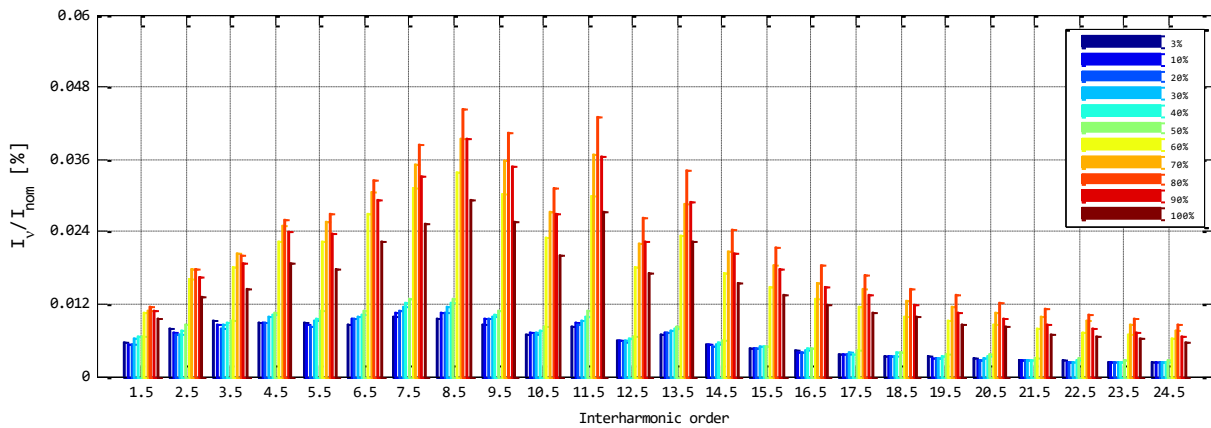
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]	I_{μ}/I_n [%]
1	3.01	9.96	19.82	29.60	39.26	49.14	58.54	68.00	77.25	86.48	95.59	95.59
2	0.04	0.05	0.06	0.08	0.08	0.08	0.06	0.07	0.07	0.07	0.08	0.08
3	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.06
4	0.03	0.04	0.04	0.05	0.05	0.05	0.07	0.07	0.07	0.07	0.06	0.07
5	0.03	0.02	0.01	0.03	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.04
6	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
7	0.02	0.03	0.01	0.02	0.04	0.04	0.06	0.06	0.07	0.08	0.08	0.08
8	0.02	0.02	0.02	0.02	0.02	0.02	0.07	0.06	0.06	0.04	0.04	0.07
9	0.02	0.02	0.03	0.02	0.03	0.03	0.05	0.07	0.06	0.06	0.05	0.07
10	0.01	0.01	0.01	0.01	0.02	0.01	0.04	0.03	0.04	0.04	0.04	0.04
11	0.03	0.01	0.05	0.03	0.05	0.06	0.11	0.12	0.14	0.15	0.14	0.15
12	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
13	0.02	0.02	0.07	0.04	0.06	0.07	0.07	0.08	0.10	0.10	0.10	0.10
14	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.02	0.03	0.03	0.03
15	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.02	0.03
16	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.02	0.02	0.02	0.02
17	0.02	0.03	0.02	0.06	0.05	0.07	0.10	0.11	0.13	0.12	0.13	0.13
18	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
19	0.01	0.02	0.03	0.04	0.04	0.06	0.10	0.12	0.12	0.11	0.11	0.12
20	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
21	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02
22	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
23	0.01	0.01	0.01	0.01	0.02	0.03	0.05	0.06	0.05	0.06	0.08	0.08
24	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
25	0.01	0.01	0.00	0.01	0.02	0.02	0.05	0.05	0.04	0.04	0.04	0.05
26	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
28	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
29	0.01	0.00	0.01	0.00	0.01	0.01	0.03	0.03	0.03	0.03	0.02	0.03
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.01	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.04	0.05	0.05	0.05
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
33	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
35	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.03	0.04
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	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	0.01	0.01	0.01
41	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	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	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02
44	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
46	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01
47	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	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	0.01	0.00	0.01
49	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
50	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
TDC	0.09	0.09	0.13	0.14	0.15	0.17	0.26	0.28	0.31	0.31	0.30	0.31
TDD	0.10	0.06	0.08	0.09	0.10	0.12	0.18	0.21	0.22	0.23	0.23	0.23

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

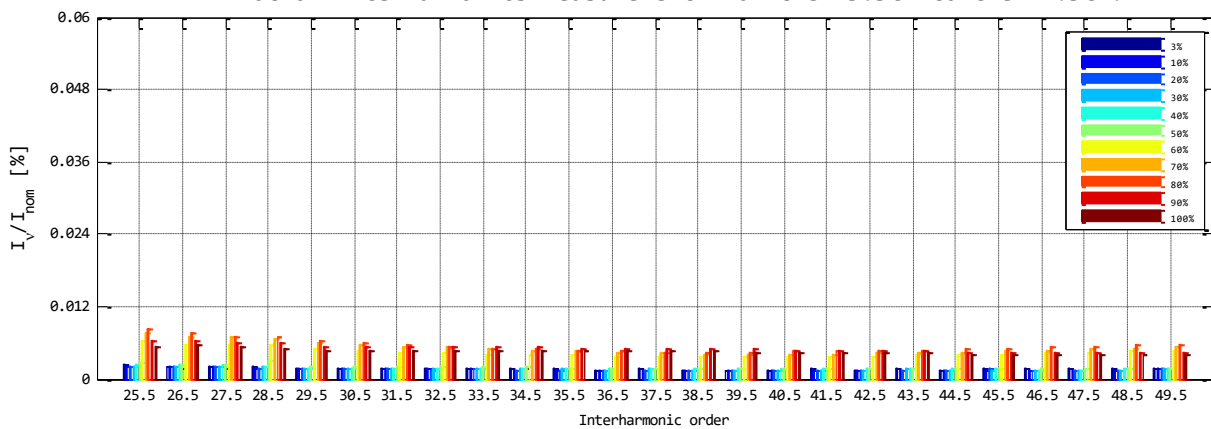
Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of interharmonics-measurement from the 1.5th to the 24.5th:



Plot of interharmonics-measurement from the 25.5th to the 49.5th:





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Annex to the G99/1 certificate of compliance No. U23-0491

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for line current
interharmonics based on rated current for equal power bins:

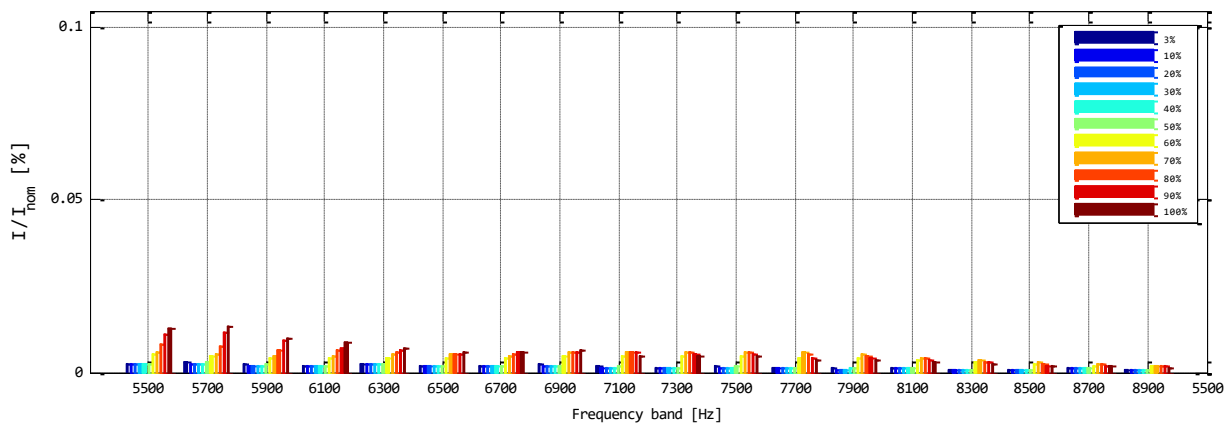
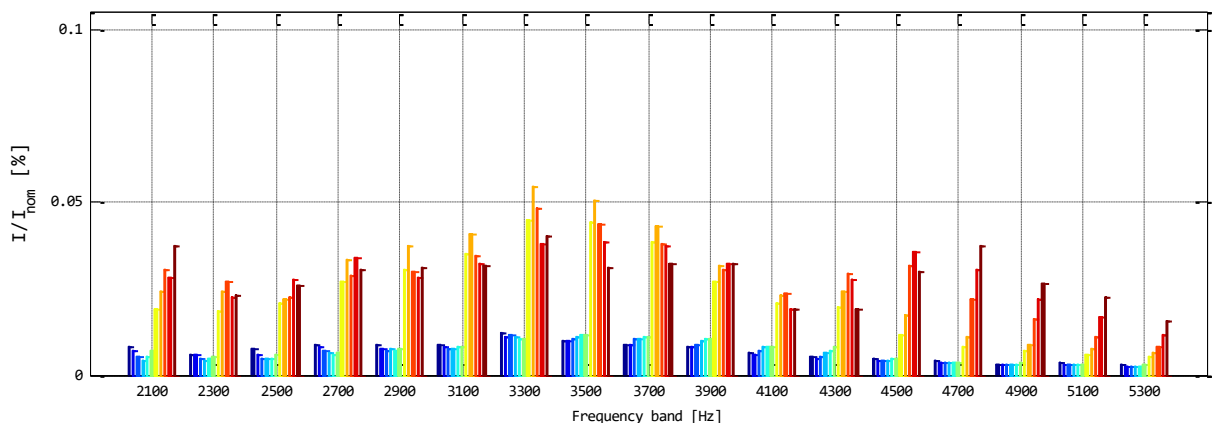
Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Order	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$	$I_{\text{V}}/I_{\text{n}}[\%]$
1.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02
3.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02
4.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.02	0.02	0.03
5.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.02	0.02	0.03
6.5	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.02	0.03
7.5	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.04	0.03	0.03	0.04
8.5	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.04	0.04	0.03	0.04
9.5	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.04	0.03	0.03	0.04
10.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.02	0.03
11.5	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.04	0.04	0.03	0.04
12.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.03
13.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.02	0.03
14.5	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
15.5	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.02	0.02	0.01	0.02
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.01	0.01	0.02
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.02
18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
23.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
25.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
26.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
27.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
28.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01
30.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
31.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
32.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
33.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
34.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
35.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
36.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
37.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
38.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
46.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
47.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
48.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01
49.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Plot of higher frequency line current components based on rated current from 2 kHz up to 9 kHz in 200 Hz bands:





Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Maximum 10 minutes average values for higher frequency line
current components based on rated current for equal power bins:

Pbin [%]	3	10	20	30	40	50	60	70	80	90	100	Max
Band	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]	I/In[%]
2100	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04
2300	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.02	0.02	0.03
2500	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03
2700	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.03	0.03
2900	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.03	0.03	0.03	0.04
3100	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.04	0.03	0.03	0.03	0.04
3300	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.05	0.05	0.04	0.04	0.05
3500	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.05	0.04	0.04	0.03	0.05
3700	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.04	0.04	0.04	0.03	0.04
3900	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.03	0.03
4100	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
4300	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.02	0.03
4500	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.03	0.04
4700	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.04
4900	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.03
5100	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
5300	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02
5500	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
5700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
5900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
6100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
6300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
6500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
6700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
6900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
7100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
7300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
7500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
7700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01
7900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
8100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Power Quality. Power factor.

(SHP100-20/SHP100-20 with 400 V phase to phase)

Output power	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.
20%	1,000	1,000	1,000	
50%	1,000	1,000	1,000	
75%	1,000	1,000	1,000	
100%	1,000	1,000	1,000	
Limit	>0,95	>0,95	>0,95	

Power Quality. Power factor.

(SHP150-20/SHP150-20 with 600 V phase to phase)

Output power	325,2 V	346 V	380,6V	Measured at three voltage levels and at full output. Voltage to be maintained within $\pm 1,5\%$ of the stated level during the test.
20%	1,000	1,000	1,000	
50%	1,000	1,000	1,000	
75%	1,000	1,000	1,000	
100%	1,000	1,000	1,000	
Limit	>0,95	>0,95	>0,95	

Power Quality. Voltage fluctuation and Flicker.

(SHP100-21/SHP100-20 with 400 V phase to phase)

	Starting			Stopping			Running	
	dmax	dc	d(t)	dmax	dc	d(t)	Pst	Plt 2 hours
Measured values at test impedance	7,3%	7,2%	--	9,5%	7,5%	--	0,09	0,07
Measured values at standard impedance	13,9%	13,8%	--	18,2%	14,0%	--	0,17	0,13
Values for maximum impedance	3,3%	3,3%	--	4,0%	3,2%	--	0,04	0,03
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	0,13	Ω	XI		0,09	Ω	
	Z	0,158	Ω					
Standard impedance	R	0,24	Ω	XI		0,15	Ω	
	Z	0,283	Ω					
Maximum impedance	R	0,06	Ω	XI		0,04	Ω	
	Zmax	0,072	Ω					

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Power Quality. Voltage fluctuation and Flicker.
(SHP150-20/SHP150-20 with 600 V phase to phase)

	Starting			Stopping			Running	
	dmax	dc	d(t)	dmax	dc	d(t)	Pst	Plt 2 hours
Measured values at test impedance	5,8%	5,0%	--	6,5%	5,1%	--	0,06	0,03
Measured values at standard impedance	9,8%	9,6%	--	12,5%	9,8%	--	0,11	0,06
Values for maximum impedance	3,4%	3,3%	--	4,0%	3,2%	--	0,04	0,02
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	0,13	Ω	XI		0,09	Ω	
	Z	0,158	Ω					
Standard impedance	R	0,24	Ω	XI		0,15	Ω	
	Z	0,283	Ω					
Maximum impedance	R	0,08	Ω	XI		0,05	Ω	
	Zmax	0,094	Ω					

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Power Quality. DC injection.

(SHP100-21/SHP100-20 with 400 V phase to phase)

Phase 1

Test level power [%]	10	55	100
Recorded value [mA]	17,34	20,72	59,73
Recorded value [%]	0,01	0,01	0,04
Limit [%]	0,25	0,25	0,25

Phase 2

Test level power [%]	10	55	100
Recorded value [mA]	10,77	62,39	101,81
Recorded value [%]	0,01	0,04	0,07
Limit [%]	0,25	0,25	0,25

Phase 3

Test level power [%]	10	55	100
Recorded value [mA]	9,75	37,79	95,93
Recorded value [%]	0,01	0,03	0,07
Limit [%]	0,25	0,25	0,25

Note. Informative measurement of DC-injection of each phase of the inverter and a limit of 0,25% per phase of the rated current per phase as pass criteria.

Sum of all Phases

Tests are carried out at three defined power levels $\pm 5\%$. At 230 V a 100 kW three phase Inverter has a current output of 435 A so DC limit is 272 mA. These tests is undertaken in accordance with Annex A.7.1.4.4.

The % DC injection ("as % of rated AC current" below) is calculated as follows:

% DC injection = Recorded DC value in Amps / Base current where the base current is the Registered Capacity (W) / V phase.
The % DC injection should not be greater than 0,25%.

Sum of all Phases

Test level power [%]	10	55	100
Recorded value [mA]	37,87	121,01	257,47
Recorded value [%]	0,008	0,028	0,059
Limit [%]	0,25	0,25	0,25

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Power Quality. DC injection.

(SHP150-21/SHP150-20 with 600 V phase to phase)

Phase 1

Test level power [%]	10	55	100
Recorded value [mA]	8,65	5,67	48,17
Recorded value [%]	0,01	0,00	0,03
Limit [%]	0,25	0,25	0,25

Phase 2

Test level power [%]	10	55	100
Recorded value [mA]	1,49	43,06	83,53
Recorded value [%]	0,00	0,03	0,06
Limit [%]	0,25	0,25	0,25

Phase 3

Test level power [%]	10	55	100
Recorded value [mA]	11,90	35,61	90,16
Recorded value [%]	0,01	0,02	0,06
Limit [%]	0,25	0,25	0,25

Note. Informative measurement of DC-injection of each phase of the inverter and a limit of 0,25% per phase of the rated current per phase as pass criteria.

Sum of all Phases

Tests are carried out at three defined power levels $\pm 5\%$. At 230 V a 150 kW three phase Inverter has a current output of 435 A so DC limit is 272 mA. These tests is undertaken in accordance with Annex A.7.1.4.4.

The % DC injection ("as % of rated AC current" below) is calculated as follows:

% DC injection = Recorded DC value in Amps / Base current where the base current is the Registered Capacity (W) / V phase.
The % DC injection should not be greater than 0,25%.

Sum of all Phases

Test level power [%]	10	55	100
Recorded value [mA]	22,04	84,34	221,86
Recorded value [%]	0,005	0,019	0,051
Limit [%]	0,25	0,25	0,25

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Fault level Contribution.

(SHP100-21/SHP100-20 with 400 V phase to phase)

For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts [V]	Amps [A]
Peak Short Circuit current	I_p	N/A	20ms	230,82	172,00
Initial Value of aperiodic current	A	N/A	100ms	20,09	149,86
Initial symmetrical short-circuit current*	I_k	N/A	250ms	20,69	150,53
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	20,57	150,88
Reactance/Resistance Ratio of source*	X/R	N/A	Time to Trip [s]	2,52	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.

Fault level Contribution.

(SHP150-21/SHP150-20 with 600 V phase to phase)

For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts [V]	Amps [A]
Peak Short Circuit current	I_p	N/A	20ms	346,20	177,72
Initial Value of aperiodic current	A	N/A	100ms	20,90	150,18
Initial symmetrical short-circuit current*	I_k	N/A	250ms	21,58	150,24
Decaying (aperiodic) component of short circuit current*	i_{DC}	N/A	500ms	21,58	150,84
Reactance/Resistance Ratio of source*	X/R	N/A	Time to Trip [s]	2,51	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 Power Park Module, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0,5 seconds.

N/A

Note. 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 (Functional safety of the internal automatic disconnection device according to VDE 0126-1-1.

Appendix A2-3 Compliance Verification Report for Inverter Connected Power Generating Modules

Extract from test report according to the Engineering
Recommendation G99

Nr. 18TH0282_SHP 1xx-21_G99_1

Cyber security	P
Confirm that the Manufacturer or Installer of the Micro-generator has provided a statement describing how the Micro-generator has been designed to comply with cyber security requirements, as detailed in 9.7.	Yes
Note. Different levels of access, all are password protected, only certain parameters can be changed on maintenance level. Manufacturer information provided, see test report.	

Wiring functional tests if required by para. 15.2.1	N/A
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning).	N/A
Note. Type test of components wired correct together on site is part of the commissioning test. The inverter was tested in a test laboratory. The correct wiring functional test in the field has to be done by the responsible person for the installation of the plant.	

Logic Interface (input port) Required by paragraph 11.1.3.1	P
Confirm that an input port is provided and can be used to reduce the Active Power output to zero	Yes
Note. Manufacturer information provided. A Modbus signal can be used to cease Active Power output within 5 s. See test report.	
Provide high level description of logic interface, e.g. details in 11.1.3.1 such as AC or DC signal	Yes

Data format SMA	TAGLIST		
Access SMA	RW		
Register adresse SunSpec	40348		
Name SunSpec	Conn		
Information model SunSpec	123		
Number of contiguous SunSpec registers	1		
Data type SunSpec	uint16		
Access SunSpec	RW		
Unit	-		
Value range SMA	381: Stop (Stop)	1467: Start (Str)	1749: Full stop (FulStop)
Definition (SMA Speedwire)	Fast shut-down		

Note. Manufacturer information provided.
For more functions and more detailed information see SunSpec Modbus Interace manual and installation manual.