DEKRA

TEST REPORT
NRS 097-2-1:2017
Grid interconnection of embedded generation
Part 2: Small-scale embedded generation

Report	
Report Number. .... :	6108594.50
Date of issue.................................. :	2021-09-08
Total number of pages.....................	99 pages
Testing Laboratory .... :	DEKRA Testing and Certification (Shanghai) Ltd.
Address .... :	3F, #250 Jiangchangsan Road, Building 16, Headquarter Economy Park Shibei Hi-Tech Park, Zhabei District, Shanghai 200436, China
Applicant's name .... :	Ginlong Technologies Co., Ltd.
Address .... :	No. 57 Jintong Road, Binhai Industrial Park, Xiangshan, Ningbo, Zhejiang, 315712, P.R. China.
Test specification:	
Standard... :	NRS 097-2-1:2017 (Edition 2.1 July 2020)
Test procedure................................. :	Type test
Non-standard test method............... :	N/A
Test Report Form No. .... :	NRS 097-2-1_V2.1
Test Report Form(s) Originator .... :	DEKRA Testing and Certification (Shanghai) Ltd.
Master TRF...................................... :	Dated 2017-07
Test item description.................... :	Grid-Connected PV Inverter
Trade Mark .... :	solis inverters
Manufacturer .... :	Ginlong Technologies Co., Ltd.
	No. 57 Jintong Road, Binhai Industrial Park, Xiangshan, Ningbo, Zhejiang, 315712, P.R. China.
Model/Type reference .... :	Solis-1P1K-4G, Solis-1P1.5K-4G, Solis-1P2K-4G, Solis-1P2.5K-4G, Solis-1P3K-4G, Solis-1P3.6K-4G, Solis-1P4K-4G, Solis-1P4.6K-4G
	S5-GR1P2.5K, S5-GR1P3K, S5-GR1P3.6K, S5-GR1P4K, S5-GR1P4.6K
	S6-GR1P2.5K, S6-GR1P3K, S6-GR1P3.6K, S6-GR1P4K, S6-GR1P4.6K

Ratings……………………………..:	Ratings of the test product: Operating temperature range: - 25°C to + 60°C Protective class: I Ingress protection rating: IP66 for S6 series, IP65 for other models Power factor range (adjustable): 0.8 leading…0.8 lagging Solis-1P1K-4G: PV input: max 550Vdc, MPP voltage range: 50–450Vdc, max 11A, Isc PV: 17,2A AC output: 230V, 50Hz, max 5,2A, 1100W Solis-1P1.5K-4G: PV input: max 550Vdc, MPP voltage range: 50–450Vdc, max 11A, Isc PV: 17,2A AC output: 230V, 50Hz, max 8,1A, 1700W Solis-1P2K-4G: PV input: max 550Vdc, MPP voltage range: 50–450Vdc, max 11A, Isc PV: 17,2A AC output: 230V, 50Hz, max 10,5A, 2200W Solis-1P2.5K-4G: PV input: max 550Vdc, MPP voltage range: 50–450Vdc, max 2x11A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 13,3A, 2800W Solis-1P3K-4G PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x11A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 15,7A, 3300W Solis-1P3.6K-4G: PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x11A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 16A, 4000W Solis-1P4K-4G: PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x11A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 21A, 4400W Solis-1P4.6K-4G: PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x11A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 23,8A, 4600W S5-GR1P2.5K PV input: max 550Vdc, MPP voltage range: 50–450Vdc, max 2x12,5A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 13,3A, 2800W S5-GR1P3K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x12,5A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 15,7A, 3300W S5-GR1P3.6K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x12,5A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 16A, 4000W S5-GR1P4K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x12,5A, Isc PV: 2x17,2A

	AC output: 230V, 50Hz, max 21A, 4400W S5-GR1P4.6K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x12,5A, Isc PV: 2x17,2A AC output: 230V, 50Hz, max 23,8A, 4600W S6-GR1P2.5K PV input: max 550Vdc, MPP voltage range: 50–450Vdc, max 2x14A, Isc PV: 2x22A AC output: 230V, 50Hz, max 13,3A, 2800W S6-GR1P3K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x14A, Isc PV: 2x22A AC output: 230V, 50Hz, max 15,7A, 3300W S6-GR1P3.6K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x14A, Isc PV: 2x22A AC output: 230V, 50Hz, max 16A, 4000W S6-GR1P4K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x14A, Isc PV: 2x22A AC output: 230V, 50Hz, max 21A, 4400W S6-GR1P4.6K PV input: max 600Vdc, MPP voltage range: 90–520Vdc, max 2x14A, Isc PV: 2x22A AC output: 230V, 50Hz, max 23,8A, 4600W

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):			
☒	Testing Laboratory:	DEKRA Testing and Certification (Shanghai) Ltd.	
Testing location/ address ....:		3F, #250 Jiangchangsan Road, Building 16, Headquarter Economy Park Shibei Hi-Tech Park, Zhabei District, Shanghai 200436, China	
☒	Associated Testing Laboratory:	DEKRA Testing and Certification (Suzhou) Co., Ltd.	
Testing location/ address ....:		No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China	
Tested by (name, function, signature) ....:		Hua Yu	
Approved by (name, function, signature).......:		Jason Guo	
☐	~~Testing procedure: TMP/CTF Stage 1:~~		
~~Testing location/ address ....:~~			
~~Tested by (name, function, signature) ....:~~			
~~Approved by (name, function, signature).......:~~			
☐	~~Testing procedure: WMT/CTF Stage 2:~~		
~~Testing location/ address ....:~~			
~~Tested by (name + signature) ....:~~			
~~Witnessed by (name, function, signature) ......:~~			
~~Approved by (name, function, signature).......:~~			
☐	~~Testing procedure: SMT/CTF Stage 3 or 4:~~		
~~Testing location/ address ....:~~			
~~Tested by (name, function, signature) ....:~~			
~~Witnessed by (name, function, signature) ......:~~			
~~Approved by (name, function, signature).......:~~			
~~Supervised by (name, function, signature) .....:~~			

Copy of marking plate:
"The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective NCB' s that own these marks"

solis

Model: Solis-1P1K-4G

Max.input voltage d.c.	550V
Mppt voltage range d.c.	50-450V
Max.input current d.c.	11A
Isc PV(absolute maximum) d.c.	17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	1000W
Max.AC output active power	1100W
Max.AC output apparent power	1100VA
Max.continous output current a.c.	5.2A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model: Solis-1P1.5K-4G

Max.input voltage d.c.	550V
Mppt voltage range d.c.	50-450V
Max.input current d.c.	11A
Isc PV(absolute maximum) d.c.	17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	1500W
Max.AC output active power	1700W
Max.AC output apparent power	1700VA
Max.continous output current a.c.	8.1A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model: Solis-1P2K-4G

Max.input voltage d.c.	550V
Mppt voltage range d.c.	50-450V
Max.input current d.c.	11A
Isc PV(absolute maximum) d.c.	17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	2000W
Max.AC output active power	2200W
Max.AC output apparent power	2200VA
Max.continous output current a.c.	10.5A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model: Solis-1P2.5K-4G

Max.input voltage d.c.	550V
Mppt voltage range d.c.	50-450V
Max.input current d.c.	2X11A
Isc PV(absolute maximum) d.c.	2X17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	2500W
Max.AC output active power	2800W
Max.AC output apparent power	2800VA
Max.continous output current a.c.	13.3A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model: Solis-1P3K-4G

Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X11A
Isc PV(absolute maximum) d.c.	2X17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	3000W
Max.AC output active power	3300W
Max.AC output apparent power	3300VA
Max.continous output current a.c.	15.7A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model: Solis-1P3.6K-4G

Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X11A
Isc PV(absolute maximum) d.c.	2X17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	3600W
Max.AC output active power	4000W
Max.AC output apparent power	4000VA
Max.continous output current a.c.	16A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

Copy of marking plate:

solis

Model:	Solis-1P4K-4G
Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X11A
Isc PV(absolute maximum)d.c.	2X17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	4000W
Max.AC output active power	4400W
Max.AC output apparent power	4400VA
Max.continous output current a.c.	21A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model:	Solis-1P4.6K-4G
Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X11A
Isc PV(absolute maximum) d.c.	2X17.2A
Rated grid voltage a.c.	230V
Rated grid frequency	50/60Hz
Rated output power	4600W
Max.AC output active power	5000W *2
Max.AC output apparent power	5000VA *2
Max.continous output current a.c.	23.8A *1
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

*1:21.7A for AS/NZ 4777.2:2015
*2:4600 for VDE-AR N4105/NRS 097-2-1:2017

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model:	S5-GR1P2.5K
Max.input voltage d.c.	550V
Mppt voltage range d.c.	50-450V
Max.input current d.c.	2X12.5A
Isc PV(absolute maximum) d.c.	2X17.2A
Rated grid voltage a.c.	1/N/PE, 220/230 V
Rated grid frequency	50/60Hz
Rated output power	2500W
Max.AC output active power	2800W
Max.AC output apparent power	2800VA
Max.continous output current a.c.	13.3A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model:	S5-GR1P3K
Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X12.5A
Isc PV(absolute maximum) d.c.	2X17.2A
Rated grid voltage a.c.	1/N/PE, 220/230 V
Rated grid frequency	50/60Hz
Rated output power	3000W
Max.AC output active power	3300W
Max. AC output apparent power	3300VA
Max.continous output current a.c.	15.7A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model:	S5-GR1P3.6K
Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X12.5A
Isc PV(absolute maximum) d.c.	2X17.2A
Rated grid voltage a.c.	1/N/PE, 220/230 V
Rated grid frequency	50/60Hz
Rated output power	3600W
Max.AC output active power	4000W
Max. AC output apparent power	4000VA
Max.continous output current a.c.	16A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

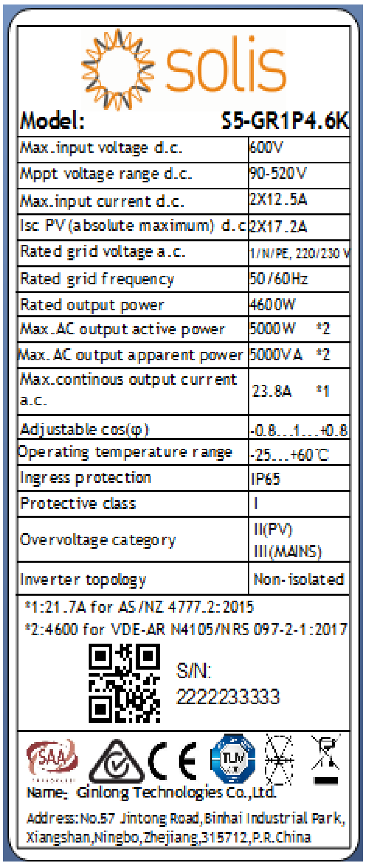
Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

solis

Model:	S5-GR1P4K
Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X12.5A
Isc PV(absolute maximum)d.c.	2X17.2A
Rated grid voltage a.c.	1/N/PE, 220/230 V
Rated grid frequency	50/60Hz
Rated output power	4000W
Max.AC output active power	4400W
Max. AC output apparent power	4400VA
Max.continous output current a.c.	21A
Adjustable cos(φ)	-0.8…1…+0.8
Operating temperature range	-25…+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address:No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China



solis

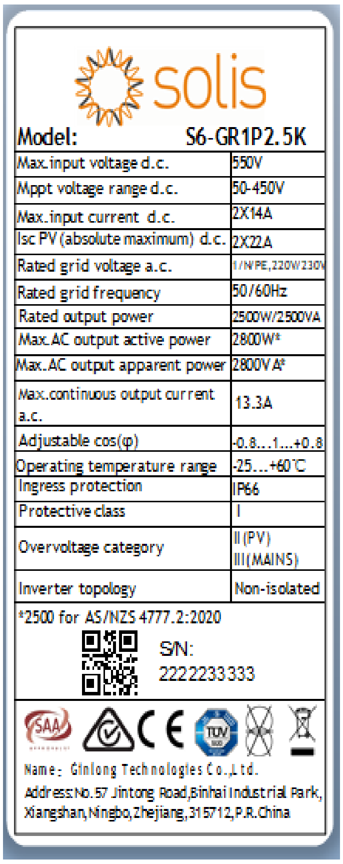
Model: S5-GR1P4.6K

Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X12.5A
Isc PV (absolute maximum) d.c	2X17.2A
Rated grid voltage a.c.	1/N/PE, 220/230 V
Rated grid frequency	50/60Hz
Rated output power	4600W
Max.AC output active power	5000W *2
Max. AC output apparent power	5000VA *2
Max.continous output current a.c.	23.8A *1
Adjustable cos(φ)	-0.8...1...+0.8
Operating temperature range	-25...+60℃
Ingress protection	IP65
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

*1:21.7A for AS/NZ 4777.2:2015
*2:4600 for VDE-AR N4105/NRS 097-2-1:2017

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address: No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China



solis

Model: S6-GR1P2.5K

Max.input voltage d.c.	550V
Mppt voltage range d.c.	50-450V
Max.input current d.c.	2X14A
Isc PV (absolute maximum) d.c.	2X22A
Rated grid voltage a.c.	1/N/PE,220V/230V
Rated grid frequency	50/60Hz
Rated output power	2500W/2500VA
Max.AC output active power	2800W*
Max.AC output apparent power	2800VA*
Max.continuous output current a.c.	13.3A
Adjustable cos(φ)	-0.8...1...+0.8
Operating temperature range	-25...+60℃
Ingress protection	IP66
Protective class	I
Overvoltage category	II (PV) III(MAINS)
Inverter topology	Non-isolated

*2500 for AS/NZS 4777.2:2020

S/N: 2222233333

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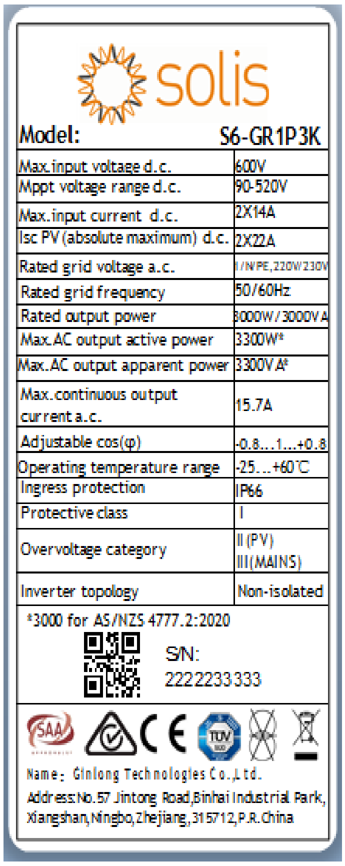
Address: No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China



solis

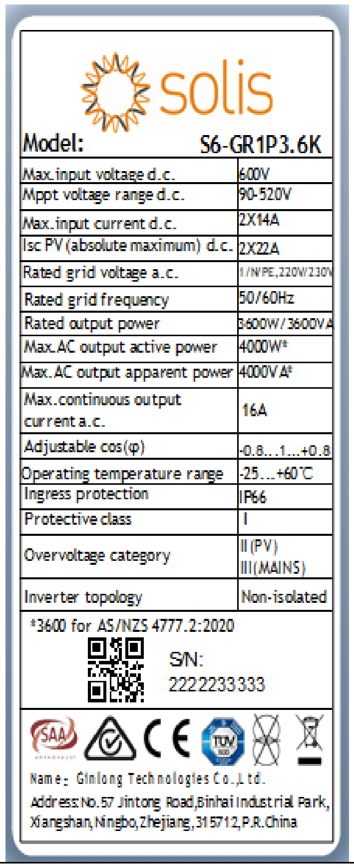
Model: S6-GR1P3K

Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X14A
Isc PV (absolute maximum) d.c.	2X22A
Rated grid voltage a.c.	1/N/PE,220V/230V
Rated grid frequency	50/60Hz
Rated output power	3000W/3000VA
Max.AC output active power	3300W*
Max.AC output apparent power	3300VA*
Max.continuous output current a.c.	15.7A
Adjustable cos(φ)	-0.8...1...+0.8
Operating temperature range	-25...+60℃
Ingress protection	IP66
Protective class	I
Overvoltage category	II (PV) III(MAINS)
Inverter topology	Non-isolated

*3000 for AS/NZS 4777.2:2020

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address: No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China



solis

Model: S6-GR1P3.6K

Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X14A
Isc PV (absolute maximum) d.c.	2X22A
Rated grid voltage a.c.	1/N/PE,220V/230V
Rated grid frequency	50/60Hz
Rated output power	3600W/3600VA
Max.AC output active power	4000W*
Max.AC output apparent power	4000VA*
Max.continuous output current a.c.	16A
Adjustable cos(φ)	-0.8...1...+0.8
Operating temperature range	-25...+60℃
Ingress protection	IP66
Protective class	I
Overvoltage category	II (PV) III(MAINS)
Inverter topology	Non-isolated

*3600 for AS/NZS 4777.2:2020

S/N: 2222233333

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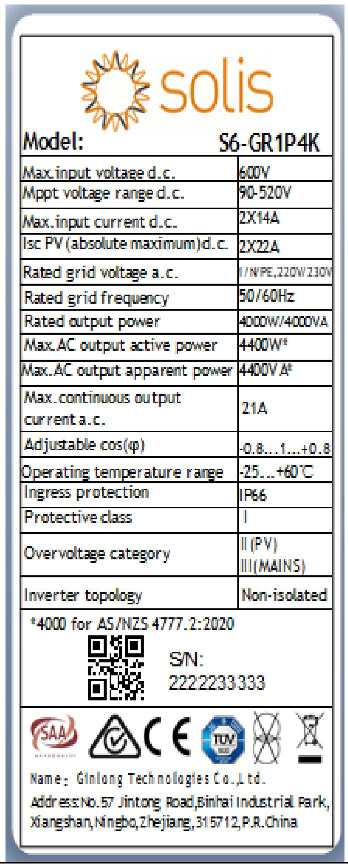

solis

Model: S6-GR1P4K

Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X14A
Isc PV (absolute maximum)d.c.	2X22A
Rated grid voltage a.c.	1/N/PE,220V/230V
Rated grid frequency	50/60Hz
Rated output power	4000W/4000VA
Max.AC output active power	4400W*
Max.AC output apparent power	4400VA*
Max.continuous output current a.c.	21A
Adjustable cos(φ)	-0.8...1...+0.8
Operating temperature range	-25...+60℃
Ingress protection	IP66
Protective class	I
Overvoltage category	II (PV) III(MAINS)
Inverter topology	Non-isolated

*4000 for AS/NZS 4777.2:2020

S/N: 2222233333

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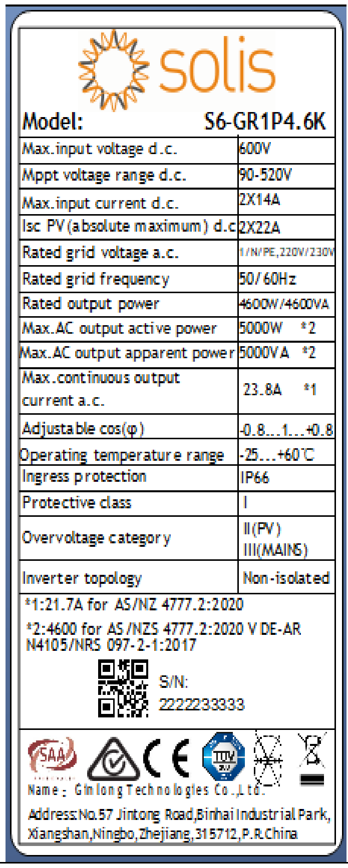


solis

Model: S6-GR1P4.6K

Max.input voltage d.c.	600V
Mppt voltage range d.c.	90-520V
Max.input current d.c.	2X14A
Isc PV (absolute maximum) d.c	2X22A
Rated grid voltage a.c.	1/N/PE,220V/230V
Rated grid frequency	50/60Hz
Rated output power	4600W/4600VA
Max.AC output active power	5000W *2
Max.AC output apparent power	5000VA *2
Max.continuous output current a.c.	23.8A *1
Adjustable cos(φ)	-0.8...1...+0.8
Operating temperature range	-25...+60℃
Ingress protection	IP66
Protective class	I
Overvoltage category	II(PV) III(MAINS)
Inverter topology	Non-isolated

*1:21.7A for AS/NZ 4777.2:2020
*2:4600 for AS/NZS 4777.2:2020 VDE-AR N4105/NRS 097-2-1:2017

S/N: 2222233333

Name: Ginlong Technologies Co.,Ltd.
Address: No.57 Jintong Road,Binhai Industrial Park, Xiangshan,Ningbo,Zhejiang,315712,P.R.China

Test item particulars:	
Equipment mobility ....:	movable hand-held stationary fixed transportable for building-in
Connection to the mains ....:	pluggable equipment direct plug-in permanent connection for building-in
Enviromental category ....:	outdoor indoor unconditional indoor conditional
Over voltage category Mains ....:	OVC I OVC II OVC III OVC IV
Over voltage category PV ....:	OVC I OVC II OVC III OVC IV
Mains supply tolerance (%) ....:	According to South African deviation in NRS 097-2-1:2017 (Edition 2.1 July 2020)
Tested for power systems ....:	TN
IT testing, phase-phase voltage (V) ....:	N/A
Class of equipment ....:	Class I Class II Class III Not classified
Mass of equipment (kg) ....:	About 11,5 kg
Pollution degree ....:	PD2
IP protection class ....:	IP66 for S6 series, IP65 for other models
Possible test case verdicts:	
- test case does not apply to the test object ....:	N/A
- test object does meet the requirement ....:	P (Pass)
- test object does not meet the requirement ....:	F (Fail)
- this clause is information reference for installation .:	Info.
Testing:	
Date of receipt of test item ....:	2017-05-16 (samples provided by applicant)
Date (s) of performance of tests ....:	2017-10-16 to 2017-11-06, 2020-12-01

General remarks:

The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.

The measurement result is considered in conformance with the requirement if it is within the prescribed limit. It is not necessary to account the uncertainty associated with the measurement result.

The information provided by the customer in this report may affect the validity of the results, the test lab is not responsible for it.

This report is not used for social proof function in China market.

"(see Enclosure #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.
Throughout this report a ☒ comma / ☐ point is used as the decimal separator.

Name and address of factory (ies):

Ginlong Technologies Co., Ltd.

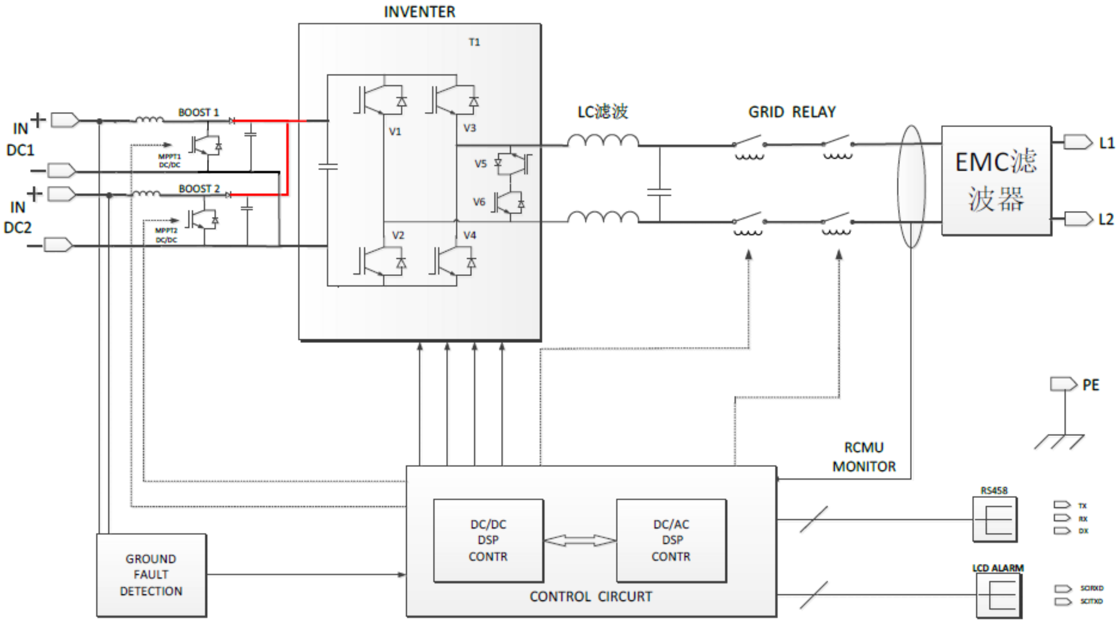
No. 57 Jintong Road, Binhai Industrial Park, Xiangshan, Ningbo, Zhejiang, 315712, P.R. China.

General product information:

The products are single phase grid-connected photovoltaic inverter converts DC voltage into AC voltage.

The unit is providing EMC filtering at the input and output towards mains. The output was switched off redundant by the high power switching bridge and two relays in series. This assures that the opening of the output circuit will also operate in case of one error.

Block Diagram



Description of the electrical circuit and functional safety (redundancy control):

The internal control is redundant built. It consists of two Microcontrollers; the master DSP can control the relays, sample the PV voltage, current and BUS voltage, measures grid voltage, frequency, AC current with injected DC, insulation resistance to ground and residual current. The slave DSP is redundant controller, it is using for control the relay, sample grid voltage, frequency and current. Both microcontrollers communicate with each other.

The voltage and frequency measurement were performed with resistors in serial that were connected directly to line and neutral. Both controllers get these signals and analyse the data.

The unit provides two relays in series in each phase. The relays are test before each start-up. When single-fault applied to one relay, an error code will appear on display panel, another redundant relay provides basic insulation maintained between the PV array and the mains.

Model difference:

1. The models Solis-1P1K-4G, Solis-1P1.5K-4G, Solis-1P2K-4G have single MPPT function and identical in hardware and just power derating according software.
2. The models Solis-1P2.5K-4G, Solis-1P3K-4G, Solis-1P3.6K-4G, Solis-1P4K-4G, Solis-1P4.6K-4G have dual MPPT function and identical in hardware and just power derating according software.
3. The models Solis-1P1K-4G, Solis-1P1.5K-4G, Solis-1P2K-4G are similar with Solis-1P2.5K-4G, Solis-1P3K-4G, Solis-1P3.6K-4G, Solis-1P4K-4G, Solis-1P4.6K-4G in software and hardware except the differences of electrical ratings, the number of BUS capacitors and the number of MPPT input.
4. The models S5-GR1P2.5K, S5-GR1P3K, S5-GR1P3.6K, S5-GR1P4K, S5-GR1P4.6K which are identical to Solis-1P2.5K-4G, Solis-1P3K-4G, Solis-1P3.6K-4G, Solis-1P4K-4G, Solis-1P4.6K-4G except max input current is different.
5. The models S6-GR1P2.5K, S6-GR1P3K, S6-GR1P3.6K, S6-GR1P4K, S6-GR1P4.6K which are identical to Solis-1P2.5K-4G, Solis-1P3K-4G, Solis-1P3.6K-4G, Solis-1P4K-4G, Solis-1P4.6K-4G

except max input current is different.

The detail rating difference please see rating label for reference.

The product was tested on:

Hardware version:
Main board: MT2070-V3
Control board: DK1635-V2
LCD board: LG1635-V2

Software version:
DSP: V0C
LCD: V0C

Amendment 1 report:
The original report No. 6018912.50 issued by DEKRA dated on 2017-11-28 were updated and including below modifications which were considered as technical modifications:
--- The standard NRS 097-2-1:2017 was change to NRS 097-2-1:2017 (Edition 2.1 July 2020)
--- The Manufacturer name of “Ningbo Ginlong Technologies Co., Ltd.” was changed to “Ginlong Technologies Co., Ltd.”
--- Add model S5-GR1P2.5K, S5-GR1P3K, S5-GR1P3.6K, S5-GR1P4K, S5-GR1P4.6K. Deleted the model Solis-1P2.5K2-4G and Solis-1P3K-4G-ST of original report.
After reviewing, clause 4.1.13.2 unintentional conducted emissions were considered necessary, the test result see Appendix 3: EMC Report of Conducted Emission in the frequency band 30 kHz to 150 kHz.

Amendment 2 report:
The Amendment 1 No. 6092293.50 issued by DEKRA dated on 2020-12-30 were updated and including below modifications which were considered as technical modifications:
--- Add model S6-GR1P2.5K, S6-GR1P3K, S6-GR1P3.6K, S6-GR1P4K, S6-GR1P4.6K.

After reviewing and evaluated, no test was considered necessary.

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4	Requirements		–
	In South Africa, safety is regulated via regulations such as the Occupational Health and Safety (OHS) Act, calling on amongst others the electrical installation regulations, which invokes other standards such as SANS 10142-1.		–
	Performance aspects are regulated via international standards, industry specifications and licensing conditions, which include relevant parts of the grid code(s).		–
	In this part of NRS 097, 4.1 deals with performance aspects, 4.2 deals with safety aspects and 4.3 deals with metering.		–
4.1	Utility compatibility (Performance aspects)		P
4.1.1	General		P
4.1.1.1	This clause describes the technical issues and the responsibilities related to interconnecting an embedded generator to a utility network.	Noticed.	P
4.1.1.2	The quality of power provided by the embedded generator in the case of the on-site a.c. loads and the power delivered to the utility is governed by practices and standards on voltage, flicker, frequency, harmonics and power factor. Deviation from these standards represents out-of-bounds conditions. The embedded generator is required to sense the deviation and might need to disconnect from the utility network.	Noticed.	P
4.1.1.3	All power quality parameters (voltage, flicker, frequency and harmonics) shall be measured at the POC, unless otherwise specified (see annex A). NOTE The frequency cannot be changed by an EG.	See appended table.	P
	The power quality to be supplied to customers and influenced by SSEG shall comply with NRS 048-2. This implies that the combined voltage disturbances caused by the specific EG and other customers, added to normal background voltage disturbances, may not exceed levels stipulated by NRS 048-2. The maximum emission levels that may be contributed by SSEG are provided in this document (see 4.1.5 to 4.1.10).		P
	The customer can expect power quality at the POC in line with NRS 048-2. As such, the generator may not contribute significant disturbances to the voltage supplied at the POC. Typical contributions for small customer installations (total installation) are provided in Annex D of NRS 048-4.		P
4.1.1.4	The embedded generator's a.c. voltage, current and frequency shall be compatible with the utility at the POC.	Noticed.	P
4.1.1.5	The embedded generator shall be type approved, unless otherwise agreed upon with the utility (see annex A).	Noticed.	P
4.1.1.6	The maximum size of the embedded generator is limited to the rating of the supply point on the premises.	Rely in the responsibility of the installer.	N/A
4.1.1.7	The utility will approve the size of the embedded generator and will decide on the connection point and conditions. In some cases it may be required to create a separate supply point.		P

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.1.8	Embedded generators larger than 13.8 kVA shall be of the balanced three-phase type unless only a single-phase network supply is available, in which case NRS 097-2-3 recommendations can be applied based on the NMD. NOTE 1 This value refers to the maximum export potential of the generation device/system. NOTE 2 In the case of long feeder spurs the maximum desired capacity of the EG might require approval by the utility and might result in the requirement for a three-phase connection for smaller units.	Less than 13.8 kVA	N/A
4.1.1.9	A customer with a multiphase connection shall split the embedded generator in a balanced manner over all phases if the EG is larger than 4.6 kVA. NOTE Balancing phases in a multiphase embedded generator is deemed desirable.	Single phase inverter used in single phase network.	N/A
4.1.1.10	Embedded generators or generator systems larger than 100 kVA may have additional requirements, for example, they must be able to receive communication signals for ceasing generation/disconnection from the utility supply, if the utility requires such. Communication facilities shall be provided to utility at no charge for integration with SCADA or other system when required. See Annex G (G.1). NOTE The RPP Grid Code requires category A3 units to be able to interface with the utility in order to receive stop and start signals.	Less than 13.8 kVA	N/A
4.1.1.11	In line with the current Renewable Power Plant Grid Code, embedded generators smaller than 1000 kVA connected to low-voltage form part of Category A generators, with the following subcategories:		P
	a) Category A1: 0 – 13.8 kVA; This sub-category includes RPPs of Category A with rated power in the range from 0 to 13.8 kVA, inclusive of 13.8 kVA.	Category A1 generator	P
	b) Category A2: 13.8 kVA – 100 kVA; and This sub-category includes RPPs of Category A with rated power in the range greater than 13.8 kVA but less than 100 kVA.		N/A
	c) Category A3: 100 kVA – 1 MVA. This sub-category includes RPPs of Category A with rated power in the range from 100 kVA but less than 1 MVA.		N/A
	NOTE 1 These sub-categories must be cross-checked with the Renewable Power Plant Grid Code (or other part of the Grid Code where applicable); where applicable, requirements will apply per sub-category and not per sizes defined here.		N/A

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
	NOTE 2 Until a separate Grid Code for non-renewable technologies have been compiled and published, relevant categories from this document will apply to non-renewable SSEG.		N/A
4.1.1.12	In accordance with SANS 10142-1, all generators shall be wired permanently.		P
	NOTE 1 Some international companies are distributing so-called “plug-in” generators, where a small PV panel and inverter is connected to the supply circuit via a standard (load) plug. At present such installations are not regarded as safe and in contravention of SANS 10142-1.		P
	NOTE 2 This option will be reviewed when internationally accepted norms are finalised to ensure plugs and plug points are safe when feeding power into the grid as well as additional requirements for such generators or plugs.		P
4.1.1.13	Any UPS/generating device that operates in parallel with the grid may only connect to the grid when it complies fully with the requirements of this part of NRS 097. This includes UPS configurations with or without EG. NOTE The requirement is applicable irrespective of the duration of parallel operation.		P
4.1.1.14	Standby-generators are covered by SANS 10142-1.		N/A
4.1.1.15	All generators larger than 100 kVA will be controllable, i.e. be able to control the active output power dependent on network conditions/abnormal conditions. This includes several smaller units that totals more than 100 kVA at a single POC.		N/A
4.1.1.16	Maximum DC Voltage may not exceed 1000V. This is the voltage on the DC side of the inverter, for example when no load is taken and maximum source energy is provided, e.g. peak solar radiation occurs on the solar panels.	Maximum DC voltage 600 V.	P
4.1.2	Normal voltage operating range		P
4.1.2.1	In accordance with IEC 61727, utility-interconnected embedded generators do not normally regulate voltage, they inject current into the utility. Therefore the voltage operating range for embedded generators is designed as protection which responds to abnormal utility network conditions and not as a voltage regulation function.		P
4.1.2.2	The embedded generator shall synchronise (see 4.1.12) with the utility network before a connection is established. The embedded generator shall not control the voltage, unless agreed to by the utility (see annex A).	See clause 4.1.12	P
4.1.2.3	An embedded generator that operates in parallel with the utility system shall operate within the voltage trip limits defined in 4.2.2.3.2.		P
4.1.3	Reference source impedance and short-circuit levels (fault levels)		P

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.3.1	The impact of the generator on the network voltage and quality of supply levels is directly linked to the (complex) source impedance and short-circuit level. The minimum short-circuit level to which a generator can be connected should be based on the size of the generator as well as the design criteria.		P
4.1.3.2	For general purposes of testing and design for potential worst case conditions, a minimum network strength of the following may be assumed: Z_source = 1.05 + j 0.32 ohm, i.e. I_SC = 210 A and S_SC = 146 kVA (three-phase). NOTE This does not imply a guarantee that the fault level will be more than this at all times. Fault levels less than this may be sufficient for small loads in certain applications.		P
4.1.3.3	The maximum network strength will be assumed to be no more than 33 times the rated active power of the generator. The R/X ratio will be assumed between 0.33 to 3.		P
	NOTE 1 In practice, the generators will connect to the network at a wide range of short-circuit ratios. The assumption of a maximum ratio of 33 will allow safe connection of the SSEG in most practical situations. NOTE 2 The minimum fault level at which the generator may be connected is at the discretion of the manufacturer, provided that the requirements of this specification is met at the specified fault level.		P
4.1.3.4	The relevant utility will advise whether equipment may be connected at other network characteristics, i.e. for weaker parts of the network.		P
4.1.3.5	The generator documentation and nameplate shall state the reference impedance (complex impedance) and fault level that was used for design and certification and that it is not intended to connect the generator to a network with a higher network impedance than specified for the certification. NOTE See Annex C (Network Impedance), for more information.		P
4.1.4	General QOS requirements		P
4.1.4.1	Embedded generators can expect QOS levels on networks to be in line with NRS 048-2. It is expected that the embedded generator will be able to operate continuously under worst-case conditions.		P
4.1.4.2	Notwithstanding this, the embedded generator must protect itself from potential excursions beyond NRS 048-2 and ensure fail-safe conditions. Should the embedded generator be unable to operate according to requirements of this document for such excursions, it shall disconnect and cease generation onto the network.		P
4.1.5	Flicker and voltage changes	See appended table.	P

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.5.1	When connected to a network impedance equal to the reference impedance used during certification, no SSEG may generate flicker levels higher than the following: a) short-term flicker severity (Pst) = 0.35; and b) long-term flicker severity (Plt) = 0.30.		P
4.1.5.2	It is anticipated that the utility will plan the connections in line with acceptable flicker limits, i.e. the ratio of the size of the generator to the network strength at the point of connection.		P
4.1.5.3	According to VDE-AR-N 4105, no generator shall be connected to a system where generation rejection (i.e. tripping of SSEG while generating at full capacity, regardless of reason) will lead to a voltage change of 3 % or more at the PCC, thereby minimising the potential to exceed rapid voltage change limits.		P
	NOTE 1 A voltage change of 3 % aligns to a ratio of the network fault level to generator size of 33 (ignoring network impedance angle and load power factor). NOTE 2 Standard connection conditions for customers typically include a maximum flicker contribution in line with annex D of NRS 048-4. Should these flicker levels be exceeded, the customer will be required to put mitigating measures in place as and when required by the utility.		P
4.1.6	Voltage unbalance		P
4.1.6.1	Under normal circumstances, for single and dual-phase EG, the unbalanced generation may not exceed 4.6 kVA connected between any two or different phases at an installation. Units larger than 4.6 kVA will be split evenly over the available phase connections so that this can be maintained. NOTE Depending on the network capacity, the utility may impose more stringent conditions.		P
4.1.6.2	Three-phase generators may not contribute more than 0.2 % voltage unbalance when connected to a network with impedance equal to the reference impedance. NOTE Standard connection conditions for customers typically include a maximum voltage unbalance contribution in line with NRS 048-4, Annex D. Should a three-phase customer exceed these voltage unbalance levels, the customer will be required to put mitigating measures in place as and when required by the utility.	Single phase PV inverter.	N/A
4.1.7	Commutation notches		P
	The relative depth of commutation notches due to line-commutated inverters shall not exceed 5 % of nominal voltage at the POC for any operational state.		P
4.1.8	DC injection		P

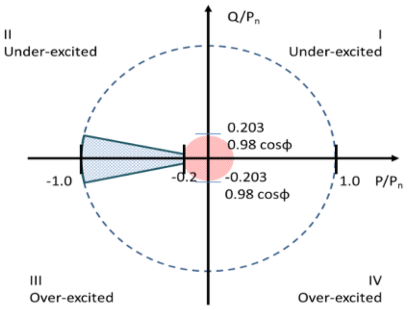
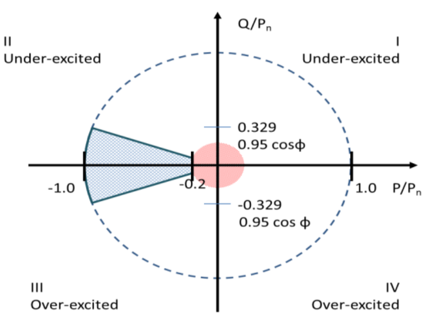
NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.8.1	The average d.c. current injected by the embedded generator shall not exceed 0.5 % of the rated a.c. output current over any 1-minute period, into the utility a.c. interface under any operating condition.	See appended table.	P
4.1.8.2	According to section 4.2.2.5, the generator(s) must disconnect within 500 ms when the d.c. current exceeds this value.	See appended table.	P
4.1.9	Normal frequency operating range		P
	An embedded generator that operates in parallel with the utility system shall operate within the frequency trip limits defined in 4.2.2.3.3.		P
4.1.10	Harmonics and waveform distortion		P
4.1.10.1	Only devices that inject low levels of current and voltage harmonics will be accepted; the higher harmonic levels increase the potential for adverse effects on connected equipment.		P
4.1.10.2	Acceptable levels of harmonic voltage and current depend upon distribution system characteristics, type of service, connected loads or apparatus, and established utility practice.		P
4.1.10.3	The embedded generator output shall have low current-distortion levels to ensure that no adverse effects are caused to other equipment connected to the utility system.		P
4.1.10.4	The harmonic and inter-harmonic current distortion shall comply with the relevant emission limits in accordance with IEC 61727, reproduced in table 1.		P

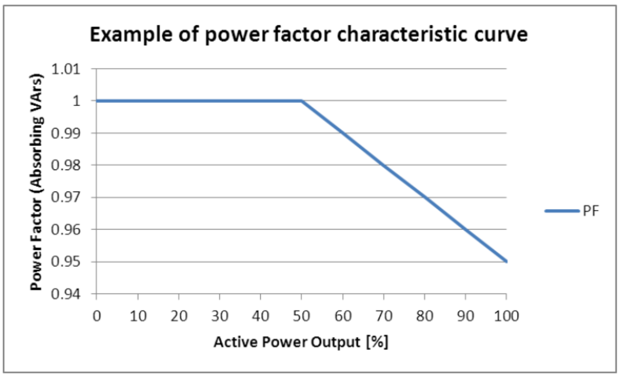
Table 1 — Maximum harmonic current distortion as percentage of rated current

1	2	3	4	5	6
Harmonic order (h)	**h<11**	**11≤h<17**	**17≤h<23**	**23≤h<35**	**35≤h**
Percentage of rated current (Odd harmonics)	4,0	2,0	1,5	0,6	0,3
Percentage of rated current (Even harmonics)	1,0	0,5	0,38	0,15	0,08
Percentage of rated current (Inter-harmonics)	0,1	0,25	0,19	0,08	0,03
Total Demand Distortion = 5%					

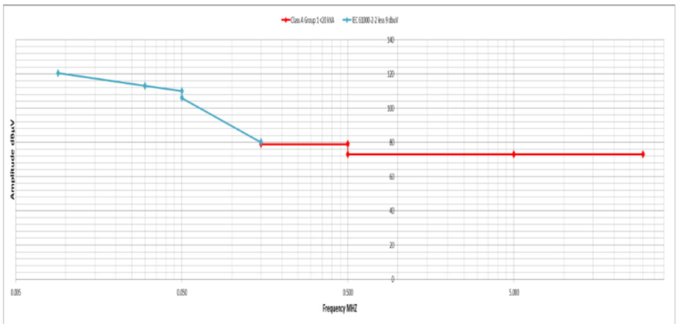
NOTE 1 Even harmonics are limited to 25 % of the odd harmonic limits
NOTE 2 Inter-harmonic are limited to 25 % of the odd harmonic limits and adjusted for the 200 Hz band measurement required by IEC 61000-4-7, except for the lower frequencies where the flicker contribution is more likely.
NOTE 3 Total Demand Distortion = Total Harmonic Distortion

4.1.10.5	The harmonic and inter-harmonic distortion applies up to 3 kHz (60th harmonic). NOTE The harmonic limits above 2.5 kHz and all inter-harmonic limits refer to limits measured in accordance with IEC 61000-4-7.	See appended table.	P
4.1.11	Power factor		P
4.1.11.1	Irrespective of the number of phases to which an embedded generator is connected, it shall comply with the power factor requirements in accordance with 4.1.11.2 to 4.1.11.12 on each phase for system normal conditions when the output power exceeds 20 % of rated active power.	See appended table.	P

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.11.2	For static power converter embedded generators and synchronous embedded generators of sub-categories A1 and A2, the power factor shall remain above 0.98 as shown in Figure 1. The embedded generator shall operate anywhere in the shaded area of figure 1.  **Figure 1 — Power factor operating requirements for SSEG categoried A1 and A2 (using the load-reference arrows system)** NOTE At the time of publication, this is in contradiction with the RPP Grid Code.	Category A1 static power converter generator.	P
4.1.11.3	For asynchronous embedded generators of sub-categories A1 and A2, which cannot control the power factor over any range, the power factor shall reach the shaded area of figure 1 within 60 s. The power factor shall remain above 0.98 as shown in figure 1. The embedded generator shall operate anywhere in the shaded area. NOTE At the time of publication, this is in contradiction with the RPP Grid Code.	Category A1 static power converter generator.	N/A
4.1.11.4	For static power converter embedded generators and synchronous embedded generators of sub-category A3, the power factor shall remain above 0.95 as shown in Figure 2. The embedded generator shall operate anywhere in the shaded area of Figure 2.	Category A1 static power converter generator.	N/A
4.1.11.5	For asynchronous embedded generators of sub-category A3, which cannot control the power factor over any range, the power factor shall reach the shaded area of Figure 2 within 60 s. The power factor shall remain above 0.95 as shown in Figure 2. The embedded generator shall operate anywhere in the shaded area.  **Figure 2 — Power factor operating requirements for SSEG categoried A3 (using the load-reference arrows system)**	Category A1 static power converter generator.	N/A

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.11.6	Where the EG is capable of controlling the power factor at the POC, the EG should improve the power factor at the POC towards unity.		P
4.1.11.7	Unless otherwise agreed with the utility, the standard power factor setting shall be unity for the full power output range.		P
4.1.11.8	The maximum tolerance on the reactive power setting is 5 % of the rated active power.		P
4.1.11.9	For embedded generators of sub-category A3, the power factor shall be settable to operate according to a characteristic curve provided by the utility, if required by the utility, within the range 0.95 leading and 0.95 lagging; An example of a standard characteristic curve is shown in figure 3.  **Figure 3 — Example of power factor characteristics curve (under-excited)**	Category A1 static power converter generator.	N/A
4.1.11.10	These limits apply, unless otherwise agreed upon with the utility (see annex A).		P
4.1.11.11	Equipment for reactive power compensation shall either:		P
	a) be connected or disconnected with the embedded generator, or b) operated via automatic control equipment for disconnection when not required.		P
4.1.11.12	The requirement for and type of detuning for reactive power compensation devices will be agreed upon by the owner of the generator and utility.		P
	NOTE Detuning is highly recommended for all reactive power compensation devices to prevent (a) potential current overloading of capacitors due to existing voltage harmonics, (b) potential voltage transient amplification at the POC due to upstream switching conditions, and (c) potential resonance with the network impedance that may lead to excessive harmonic amplification.		P
4.1.12	Synchronization		P
4.1.12.1	All embedded generators shall synchronize with the utility network before the parallel connection is made. This applies to all embedded generators where a voltage exists at the generator terminals before connection with the utility network.		P

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.12.2	Automatic synchronization equipment shall be the only method of synchronization.		P
4.1.12.3	For a synchronous generator, the limits for the synchronizing parameters for each phase are: a) frequency difference: 0.3 Hz, b) voltage difference: 5 % of nominal voltage per phase, and c) phase angle difference: 20 ° (degrees).		P
4.1.12.4	Mains excited generators do not need to synchronise when the generator is started as a motor before generation starts.		P
4.1.12.5	Mains excited generators may require soft-starting when the start-up voltage change is anticipated to be more than 3 %.		P
4.1.12.6	The start-up current for static power converters shall not exceed the full-power rated current of the generator.		P
4.1.12.7	Also refer to 4.2.4 for re-synchronising conditions.		P
4.1.12.8	The embedded generator shall synchronize with the utility network only when the voltage and frequency has been stable within the ranges provided in 4.2.2.3 for at least 60 seconds. NOTE Some utilities may require this to be longer than 60 seconds.		P
4.1.13	Electromagnetic compatibility (EMC)		P
4.1.13.1	Electromagnetic compatibility (EMC) refers to the ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. EMC comprises two components, namely a radiated and conducted component. Significant attention is given to radiated EMC due to the potential impact over larger distances. However, with advances in smart grids and business management systems, the potential impacts from conducted EMI must be considered. The conditions in 4.1.13.2 and 4.1.13.6 below apply to conducted unintentional signals, while clause 4.1.13.7 applies to radiated unintentional emissions from generating equipment.	See TUV SUD EMC test report no.: 64.772.21.80058.02 for reference.	P

NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict
4.1.13.2	All unintentional conducted emissions from generating equipment, in the frequency band 30 kHz to 150 kHz, shall be 9 dBµV lower than the compatibility levels specified in clause 4.12.3 of IEC 61000-2-2:2000+A2: 2018 when measured in unsymmetrical voltage mode (i.e. between any phase or neutral and the earth) using a quasi-peak detector. An illustration of the limits is provided in Figure 4, below.  **Figure 4 — NRS 097-2-1 emission limits**	See Appendix 3: EMC Report of Conducted Emission in the frequency band 30 kHz to 150 kHz with report No. 20C0120R-V2 by issued DEKRA.	P
4.1.13.3	The test method and set up for verifying compliance with 4.1.13.1, herein, shall be according to clause 7 of *CISPR 16-2-1*. The test receiver used for verification shall comply with clauses 4 and 5 of *CISPR 16-1-1:2019*, and the AMN or LISN used for verification shall comply with clause 4 of *CISPR 16-1-2*. NOTE When measuring conducted emissions at high currents, for example at ≥ 25 A, during testing, the AMN or LISN can be connected as a voltage probe. See clause A.5 in Annexure A of *CISPR 16-1-1*.		P
4.1.13.4	All unintentional conducted emissions from generating equipment, in the frequency band above 150 kHz to 30 MHz, shall comply with SANS 211 (CISPR11), in particular limits for Class A group 1 (< 20 kVA).	See TUV SUD EMC test report no.: 64.772.21.80058.02 for reference.	P
4.1.13.5	The conducted emission requirement applies to all ports or connections to the utility supply, whether the connection is intended for monitoring, communication, power transfer or any other reason for connecting to the utility supply.		P
4.1.13.6	In the event of susceptibility to electromagnetic interference, the unit shall be fail-safe, i.e. any deviation from intended performance must comply with all relevant specifications, both in terms of safety (i.e. disconnection) and impact on the network.		P
4.1.13.7	Notwithstanding this, should any interference be experienced to existing or new ripple-control, building management system equipment and/or other PLC-based communication, the owner of the embedded generator should take the necessary remedial action to prevent further interference as will be agreed with the utility or the other affected party.		P
4.1.13.8	All radiated emissions from generating equipment shall comply with ICASA requirements.		P

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Clause	Requirement – Test	Result – Remark	Verdict
4.1.14	Mains signalling (e.g. PLC and ripple control)		N/A
4.1.14.1	Mains signalling refers to intentional signals induced into the utility supply network, where the intention is to facilitate data transfer from one component to another.		N/A
4.1.14.2	All intentional emissions (communication signals) from generating equipment shall comply with limits for intentional emissions in SANS 50065-1, limited to an acceptable band as prescribed by SANS 50065-1.		N/A
4.1.14.3	Notwithstanding this, should any interference be experienced to existing or new ripple control, building management system equipment and/or other PLC-based communication, the owner of the embedded generator shall take the necessary remedial action to prevent further interference as will be agreed with the utility or the other affected party.		N/A
4.2	Safety protection and control		P
4.2.1	General	Noticed.	P
	The safe operation of the embedded generator in conjunction with the utility network shall be ensured at all times. Safe operation includes people and equipment safety, i.e.:		P
	a) People safety: and i) owner (including personnel and / or inhabitants of the property) of the embedded generator; ii) general public safety; iii) utility personnel; and iv) general emergency response personnel, e.g. fire brigade should a fire arise at the embedded generator.		P
	b) Equipment safety: i) utility equipment; ii) other customers' equipment connected to the same network(s); and iii) generator own equipment.		P
	Some of the safety aspects mentioned above may be covered in other specifications and standards and the embedded generator should ensure that safe operation is maintained at all times taking cognisance of all of the above aspects.		P
	Furthermore, the embedded generator owner is responsible for precautions against damage to its own equipment due to utility originating events, e.g. switching events, voltage and frequency variations, automatic reclosing onto the network etc. However, this protection may not conflict with the requirements of this specification.		P
4.2.2	Safety disconnect from utility network		P
4.2.2.1	General		P

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Clause	Requirement – Test	Result – Remark	Verdict
4.2.2.1.1	All SSEG shall comply with the safety requirements in accordance with SANS/IEC 62109-1 and IEC 62109-2. NOTE In principle, IEC 62109 documents only apply to PV inverters. However, other SSEG shall prove compliance to these safety requirements to the satisfaction of the utility.	See TUV SUD IEC 62109-1/-2 test report no.: 70.409.16.237.04-05 for reference.	P
4.2.2.1.2	The embedded generator shall automatically and safely disconnect from the grid in the event of an abnormal condition. Abnormal conditions include: a) network voltage or frequency out-of-bounds conditions, b) loss-of-grid conditions, c) d.c. current injection threshold exceeded (per phase), d) and residual d.c. current (phase and neutral currents summated).		P
4.2.2.2	Disconnection device (previously disconnection switching unit)	See appended table.	P
4.2.2.2.1	The embedded generator shall be equipped with a disconnection device, which separates the embedded generator from the grid due to abnormal conditions. The disconnection unit may be integrated into one of the components of the embedded generator (for example the PV utility-interconnected inverter) or may be an independent device installed between the embedded generator and the utility interface.	The grid-connected PV inverter provides two relays integrated in series for both line and neutral.	P
4.2.2.2.2	The disconnection switching unit shall be able to operate under all operating conditions of the utility network. NOTE It is the responsibility of the embedded generator owner to enquire about the operating conditions of the utility network, e.g. fault levels for the foreseeable future.		P
4.2.2.2.3	A failure within the disconnection device shall lead to disconnection of the generator from the utility supply and indication of the failure condition.	See appended table.	P
4.2.2.2.4	A single failure within the disconnection switching unit shall not lead to failure to disconnect. Failures with one common cause shall be taken into account and addressed through adequate redundancy.	See appended table.	P
4.2.2.2.5	The disconnection device shall disconnect the generator from the network by means of two series connected robust automated load disconnect switches.	The grid-connected PV inverter provides two relays integrated in series for both line and neutral.	P
4.2.2.2.6	Both switches shall be electromechanical switches.		P
4.2.2.2.7	Each electromechanical switch shall disconnect the embedded generator on the neutral and the live wire(s). NOTE The switching unit need not disconnect its sensing circuits.		P
4.2.2.2.8	All rotating generating units, e.g. synchronous or asynchronous generating units shall have adequate redundancy in accordance with 4.2.2.2.5.	Not rotating generating units.	N/A

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Clause	Requirement – Test	Result – Remark	Verdict
4.2.2.2.9	A static power converter without simple separation shall make use of two series connected electromechanical disconnection switches.	The grid-connected PV inverter provides two relays integrated in series for both line and neutral.	P
4.2.4.2.10	The current breaking capacity of each disconnecting switch shall be appropriately sized for the application. In cases where the disconnecting device is an electromechanical switching device such as a contactor, this requires suitable coordination with the upstream short circuit protection device (circuit breaker).		P
4.2.2.2.11	Any programmable parameters of the disconnection switching unit shall be protected from interference by third-parties, i.e. password protected or access physically sealed.		P
4.2.2.2.12	In order to allow customers to supply their own load in isolated operation (islanded) where this is feasible and required, the disconnection device may be incorporated upstream of part of or all of a customers' loads, provided that none of the network disconnection requirements in this document are violated.		P
4.2.2.2.13	All EG installations larger than 30 kVA shall have a central disconnection device. NOTE 1 This requirement may be amended by the utility, i.e. the utility may require a central disconnection switch unit for any size and type of generator. NOTE 2 This requirement may be amended by the utility. The central disconnection switch unit will typically be waived only when a lockable disconnection switch, accessible to the utility, is installed. NOTE 3 This is an interim requirement based on requirements of VDE-AR-N 4105 and will be revisited as more information becomes available.	Category A1 static power converter generator less than 30kVA.	N/A
4.2.2.2.14	The network and system grid protection voltage and frequency relay for the central disconnection device will be type-tested and certified on its own (stand-alone tested). All clauses of 4.2.2, except 4.2.2.4 (anti-islanding) apply.	Not used central disconnection device.	N/A
4.2.2.3	Overvoltage, undervoltage and frequency		
4.2.2.3.1	General	See appended table.	P
	The values in 4.2.2.3 relate to SSEG in sub-categories A1 and A2. These are kept from a historical perspective. The Grid Code requirements will override values and requirements in this category.	Category A1 static power converter generator.	P
	Sub-category A3 generators shall disconnect from the network according to the RPP Grid Code for all abnormal conditions as well as stay connected in accordance with the voltage ride-through requirements of the RPP Grid Code.		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
	Abnormal conditions can arise on the utility system and requires a response from the connected embedded generator. This response is to ensure the safety of utility maintenance personnel and the general public, and also to avoid damage to connected equipment. The abnormal utility conditions of concern are voltage and frequency excursions above or below the values stated in this clause and the RPP Grid Code (section 5.2 of version 3.0). The embedded generator shall disconnect in accordance with the requirements of 4.2.2.3 if these conditions occur.		P
	The accuracy for voltage trip values shall be within 0 % to +1 % of the nominal voltage from the upper boundary trip setting, and within -1% to 0% of the nominal voltage from the lower boundary trip setting.		P
	The accuracy for frequency trip values shall be within 0 to +0.1 % of the fundamental frequency from the upper boundary trip setting, and within -0.1 % to 0 % of the fundamental frequency from the lower boundary the trip setting.		P
4.2.2.3.2	Overvoltage and undervoltage	See appended table.	P
	The embedded generator in sub-category A1 and A2 shall cease to energize the utility distribution system should the network voltage deviate outside the conditions specified in table 2. The following conditions shall be met, with voltages in r.m.s. and measured at the POC. NOTE 1 All discussions regarding system voltage refer to the nominal voltage. NOTE 2 At the time of publication, these settings are in contradiction to the RPP Grid Code. These may only be applied with exemption to the relevant clause or after the RPP Grid Code has been suitably amended. NOTE 3 Measurements at the generator terminals will generally be sufficient for the overvoltage settings. If the expected voltage drop across the cable connecting the EG to the POC is too high, undervoltage settings might have to be adjusted.		P

Table 2 — Response to abnormal voltages for SSEG in sub-categories A1 and A2

1	2
Voltage range (at point of connection)	**Maximum trip time** S
V < 50 %	0,2 s
50 % ≤ V < 85 %	10 s
85 % ≤ V ≤ 110 %	Continuous operation
110 % < V < 115 %	40 s
115% ≤ V < 120%	2 s
120 % ≤ V	0,16 s
NOTE If multi-voltage control settings are not possible, the more stringent trip time should be implemented, e.g. 2 s between 110% and 120% of voltage.	

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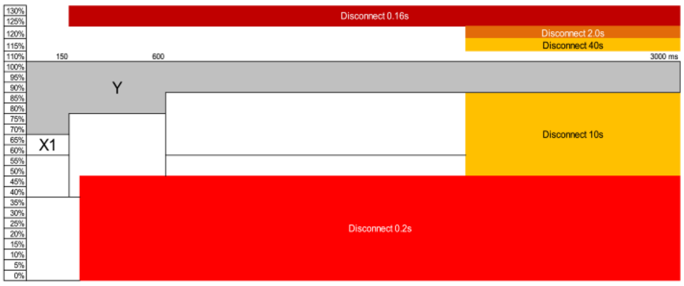
Clause	Requirement – Test	Result – Remark	Verdict
	The purpose of the allowed time delay is to ride through short-term disturbances to avoid excessive nuisance tripping. The generator does not have to cease to energize if the voltage returns to the normal utility continuous operating condition within the specified trip time. NOTE Induction/synchronous generators need to be mindful of synchronisation issues and may have to apply faster trip times.		P
	A customer with a multiphase connection shall monitor all phases for out-of-bounds voltage conditions. The EG shall be disconnected if an out-of-bounds voltage condition is detected on any of the phases.		P
	In line with NRS 048-2, it is recommended that A1 and A2 SSEG be able to ride through at least Y and X1 type dips, i.e. not disconnect for these events. The purpose is to avoid excessive nuisance tripping.		P
	Category A3 SSEG shall be able to ride through low and/or high voltage events in accordance with the RPP Grid Code.		N/A
	The generator shall maintain the pre-dip current during any dip event for which it remains connected.		P
	The ride-through and trip times are shown graphically in figure 4.  **Figure 5 — Graphical representation of voltage-ride-through and voltage disconnect requirements for A1 and A2 EG**		P
4.2.2.3.3	Over-frequency and under-frequency	See appended table.	P
	This requirement is in line with the RPP Grid Code (version 3.0) and applies to all EG in category A. NOTE The RPP Grid Code should be consulted for developments in the requirements for response to over-frequency and under-frequency events.		P
	The embedded generation system shall cease to energize the utility network when the utility frequency deviates outside the specified conditions. Both over- and under-frequency conditions indicate system abnormal conditions and all generators are expected to assist in stabilising the system during such periods.		P
	When the utility frequency is less than 47 Hz, the embedded generator shall disconnect from the utility network within 0.2 s.		P

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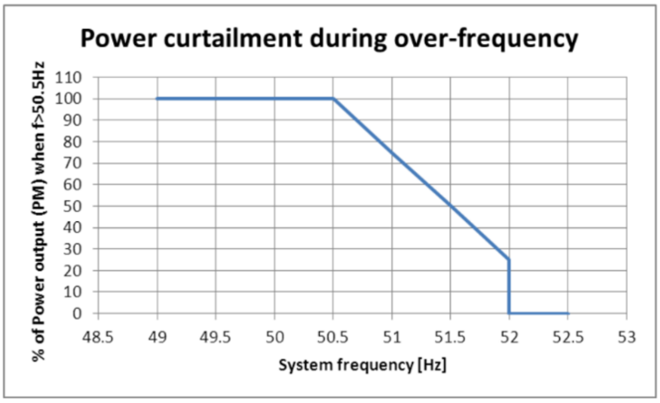
Clause	Requirement – Test	Result – Remark	Verdict
	While the utility frequency is in the range of 47 Hz and 50.5 Hz, the system shall operate normally. In order to prevent hysteresis switching (on-off toggling) during over-frequency conditions, the output power shall be reduced as follows:		P
	When the utility frequency exceeds 50.5 Hz, the active power available at the time shall be stored as the maximum power value P_M; this value P_M shall not be exceeded until the frequency has stabilised below 50.5 Hz for at least 4 seconds.		P
	The EG system shall control the output power as a function of PM at a gradient of 50 % per Hertz as illustrated in figure 5. The power generation shall follow the curve shown in figure 5 up and down while the system frequency is in the range 50.5 Hz to 52 Hz.		P
	When the utility frequency is more than 52 Hz for longer than 4 seconds, the embedded generator shall cease to energise the utility line within 0.5 s.		P
4.2.2.3.3.1	Relaxation for non-controllable generators		P
	Non-controllable generators may disconnect randomly within the frequency range 50.5 Hz to 52 Hz. The disconnect frequency for non-controllable generators will each be set at a random value by the manufacturer, with the option of changing this to a utility provided setting. The random disconnect frequency shall be selected so that all generators from any specific manufacturer will disconnect uniformly over the range with 0.1 Hz increments.		P
	When the utility frequency is more than the non-controllable generator over-frequency setpoint for longer than 4 seconds, the non-controllable generator shall cease to energise the utility line within 0.5 s. NOTE At the time of publication, this is in contradiction with the RPP Grid Code.  **Figure 6 — Power curtailment during over-frequency**		P
4.2.2.4	Prevention of islanding		P

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Clause	Requirement – Test	Result – Remark	Verdict
4.2.2.4.1	A utility distribution network can become de-energized for several reasons: for example, a substation breaker that opens due to a fault condition or the distribution network might be switched off for maintenance purposes. Should the load and (embedded) generation within an isolated network be closely matched, then the voltage and frequency limits may not be triggered. If the embedded generator control system only made use of passive voltage and frequency out-of-bounds detection, this would result in an unintentional island that could continue beyond the allowed time limits.	See appended table.	P
4.2.2.4.2	In order to detect an islanding condition, the embedded generator shall make use of at least one active islanding detection method. An active islanding detection method intentionally varies an output parameter and monitors the response or it attempts to cause an abnormal condition at the utility interface to trigger an out-of-bounds condition. If the utility supply is available, the attempt to vary an output parameter or cause an abnormal condition will fail and no response will be detected. However, if the utility supply network is de-energized, there will be a response to the change which can be detected. This signals an island condition to the embedded generator upon detection of which the embedded generator shall cease to energize the utility network within a specific time period.	The active islanding detection methods frequency shifting was employed in the grid-connected PV inverter.	P
4.2.2.4.3	Active island detection shall be used in all cases where the EG interfaces with the utility network.		P
4.2.2.4.4	An islanding condition shall cause the embedded generator to cease to energize the utility network within 2 s, irrespective of connected loads or other embedded generators. The embedded generator employing active islanding detection shall comply with the requirements of IEC 62116 (ed.1). NOTE Prevention of islanding measures is only considered on the embedded generator side, i.e. no utility installed anti-islanding measures are considered.	See appended table.	P
4.2.2.4.5	All rotating generators shall use a minimum of two islanding detection methods (e.g. rate-of-change-of-frequency and voltage vector shift detection due to the dead bands (slow detection) of islands in both methods). NOTE It is possible for a condition to exist, where a mains-excited generator becomes self-excited due to capacitance of the network (either cable capacitance or power factor correction). Under such conditions, the mains-excited generator will not disconnect from an island, hence effective islanding detection is required for all rotating generators.	Not rotating generator.	N/A
4.2.2.4.6	Passive methods of islanding detection shall not be the sole method to detect an island condition. When used, passive methods of islanding detection shall be done by three-phase voltage detection and shall be verified by an AC voltage source.		P

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Clause	Requirement – Test	Result – Remark	Verdict
4.2.2.4.7	The embedded generator shall physically disconnect from the utility network in accordance with the requirements in 4.2.2.2.		P
4.2.2.5	DC current injection	See appended table.	P
	The embedded generator shall not inject d.c. current greater than 0.5 % of the rated a.c. output current into the utility interface under any operating condition, measured over a 1-minute interval. The EG shall cease to energize the utility network within 500 ms if this threshold is exceeded.		P
4.2.3	Emergency personnel safety		Info.
	No requirements for emergency personnel safety (e.g. fire brigade) existed at the time of publication. It is expected that such issues will be dealt with in other documents, e.g. OHS Act, SANS 10142-1.		Info.
4.2.4	Response to utility recovery		P
4.2.4.1	The embedded generator shall ensure synchronisation before re-energizing at all times in accordance with 4.1.12.		P
4.2.4.2	After a voltage or frequency out-of-range condition that has caused the embedded generator to cease energizing the utility network, the generator shall not re-energize the utility network until the utility service voltage and frequency have remained within the specified ranges for a continuous and uninterrupted period of 60 s. The reconnection shall commence as follows:		P
4.2.4.2.1	Non-controllable generators may connect randomly within the 1 minute to 10 minute period after voltage and frequency recovery (period includes the 60 s to confirm recovery). The delay for non-controllable generators will each be set at a random value by the manufacturer, with the option of changing this to a utility provided setting. The random value shall be selected so that no more than 2 % of generators from any specific manufacturer will reconnect within 10s of each other.		P
4.2.4.2.2	Controllable generators may reconnect immediately after the 60 s delay confirming recovery of the system voltage and frequency at a maximum rate of 10 % of rated power per minute, i.e. full power output will only be reached after 10 minutes.		N/A
	This ramp rate may be modified at the request of the utility or in consultation with the utility.		P
4.2.5	Isolation		P
4.2.5.1	In line with SANS 10142-1 (as amended), each energy source should have its own, appropriately rated, isolation device.		P
4.2.5.2	It is expected that isolation requirements will be dealt with in more detail in future in e.g. SANS 10142-1/3. Such requirements shall supersede 4.2.5.		P

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Clause	Requirement – Test	Result – Remark	Verdict
4.2.5.3	The embedded generator shall provide a means of isolating from the utility interface in order to allow for safe maintenance of the EG. The disconnection device shall be a double pole for a single-phase EG, a three-pole for a three-phase delta-connected EG, and a four-pole for a three phase star-connected EG. The grid supply side shall be wired as the source.		P
4.2.5.4	The breaking capacity of the isolation circuit-breaker closest to the point of utility connection shall be rated appropriately for the installation point in accordance with SANS 60947-2. This disconnection device does not need to be accessible to the utility.		P
4.2.5.5	For dedicated supplies, a means shall be provided of isolating from the point of supply in order to allow for safe maintenance of the utility network. The disconnection device shall be a double pole for a single-phase EG, a three-pole for a three-phase delta-connected EG, and a four-pole for a three-phase star-connected EG.		P
	This disconnection device shall be lockable and accessible to the utility. NOTE 1 A device inside a lockable box is deemed a lockable device. NOTE 2 This disconnection device may become the new point of control as defined by SANS10142-1.		P
4.2.5.6	The requirement for the utility accessible disconnection device may only be waived by the utility where the risk to the network is deemed acceptable to the utility. Such permission shall be provided in writing. NOTE Full verification form to be signed off and accepted by the utility.		P
4.2.6	Earthing		P
4.2.6.1	The electrical installation shall be earthed in accordance with SANS 10142-1 (as applicable). The earthing requirements for different embedded generation configurations in conjunction with the customer network are described in annex B for the most common earthing systems. NOTE SANS 10142-1 applies to EG feeding a UPS and no connection to the utility supply (see table B5).	Rely in the responsibility of the installer.	N/A

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Clause	Requirement – Test	Result – Remark	Verdict
4.2.6.2	Installations with utility-interconnected inverters without simple separation shall make use of earth leakage protection which are able to respond to d.c. fault currents including smooth d.c. fault currents (i.e. without zero crossings) according to IEC 62109-2 unless the inverter can exclude the occurrence of d.c. earth fault currents on any phase, neutral or earth connection through its circuit design[1)]. This function may be internal or external to the inverter. NOTE IEC 62109-2, Edition 2011, section 4.8.3.5 gives selection criteria for RCD sensitivities. [1)] The appropriate earth leakage unit should be selected to accommodate the higher leakage current of inverters without transformers to avoid nuisance tripping.	Rely in the responsibility of the installer.	N/A
4.2.6.3	Where an electrical installation includes a PV power supply system without at least simple separation between the AC side and the DC side, an integrated RCD function shall be present to provide fault protection by automatic disconnection of supply shall be type B according to IEC/TR 60755, amendment 2. Where the PV inverter by construction is not able to feed DC fault currents into the electrical installation, an RCD of type B according to IEC/TR 60755 amendment 2 is not required. NOTE 1 Consideration must also be given to ensure that any d.c. currents do not impair the effectiveness of any other RCD'S installed throughout the a.c. system. NOTE 2 The earth leakage unit may also fulfil the requirement of the all-pole disconnection device as stated in 4.2.6. NOTE 3 The function of this RCD is not to provide protection against circulating d.c. currents in the inverter and a.c. supply, i.e. does not override 4.1.8.	The inverter was tested and fulfils IEC 62109-1 and IEC 62109-2 for the residual current device (RCD) or residual current monitor (RCM). However if an external residual current device (RCD) is mandatory, the switch must be triggered at a failure current of 300 mA or higher was required in the user manual.	P
4.2.7	Short-circuit protection		P
4.2.7.1	The embedded generator shall have suitably rated short-circuit protection at the connection to the AC mains in accordance with SANS 10142-1 and 3.		P
4.2.7.2	The short-circuit characteristics for the SSEG shall be supplied to the utility.	Not rotating generators.	N/A
4.2.8	Maximum short-circuit contribution		P
	Embedded generators have the potential to increase the fault level of the network to which it is connected. In order to limit the fault level changes in low voltage networks and allow coordination of fault levels with the utility, no generator will exceed the following fault level contribution:		P
	a) for synchronous generators: 8 times the rated current; b) for asynchronous generators: 6 times the rated current; and c) for generators with inverters: 1 times the rated current.		P

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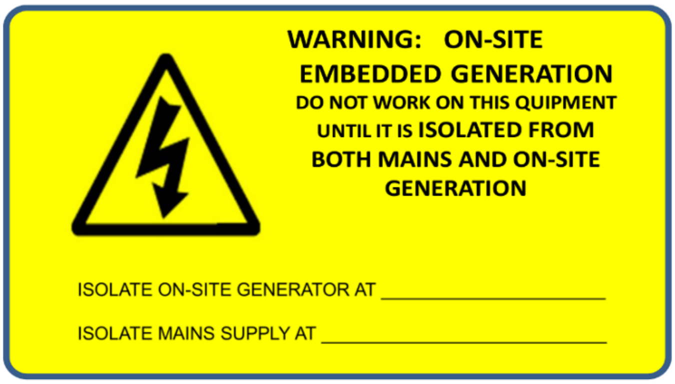
Clause	Requirement – Test	Result – Remark	Verdict
	NOTE At the time of installation, the short-circuit capacity of all existing equipment should be confirmed and upgraded where necessary. Suitable fault current limiting devices may be required to ensure a safe installation. The potential impact on neighbouring installations should also be considered to ensure that those installations remain safe.		P
4.2.9	Labelling		P
4.2.9.1	A label on the distribution board of the premises where the embedded generator is connected shown in figure 7, shall state: “WARNING: ON-SITE EMBEDDED GENERATION. DO NOT WORK ON THIS EQUIPMENT UNTIL IT IS ISOLATED FROM BOTH MAINS AND ON-SITE GENERATION SUPPLIES.” or similar warning. Disconnection points for all supplies shall be indicated.  **Figure 7 — Example of labelling (more isolation points to be added as required)**	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	N/A
4.2.9.2	The label shall be permanent with lettering of height at least 8 mm.		N/A
4.2.9.3	The label shall comply to requirements of SABS 1186-1.		P
4.2.9.4	The absence of emergency shutdown capabilities will be indicated on signage in accordance with 4.2.2.		P
4.2.10	Robustness requirements		P
	According to 4.2.2.1 all SSEG shall comply with safety requirements in accordance to SANS/IEC 62109-1 and IEC 62109-2. NOTE This section will be expanded in future revisions.	See TUV SUD IEC 62109-1/-2 test report no.: 70.409.16.237.04-05 for reference.	P
4.3	Metering	The meter was not part of the equipment under evaluation in this report.	N/A
4.3.1	General		N/A
4.3.1.1	All meters utilized by the utility shall be the property of the utility even when the meters are located on the premises of the customer. Meters that are embedded in the customer’s network shall be accessible to the utility on request.		N/A

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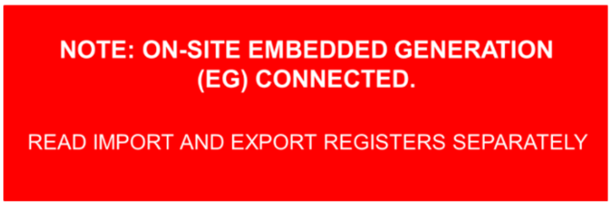
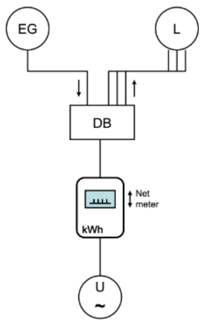
Clause	Requirement – Test	Result – Remark	Verdict
4.3.1.2	Three metering configurations are known in the case of premises where embedded generators are operated, dependent on the tariff structure required or implemented by the supplier. The details are given in 4.3.2 and 4.3.3.		N/A
4.3.1.3	The utility will advise what metering is required based on the application and location of the embedded generator.		N/A
4.3.1.4	Metering will comply to SANS 474/NRS 057 and SANS 473/NRS 071.		N/A
4.3.1.5	Where applicable (manual reading), suitable signage will be attached at the meter, indicating that import and export registers need to be read. Refer to Figure 8 and 4.2.9.  **Figure 8 — Example of labelling for metering points (Colouring and other requirements to be confirmed with the utility).**		N/A
4.3.2	Single-quadrant meter installation		N/A
4.3.2.1	The single-meter arrangement is given in figure 9.  Legend DB distribution board EG embedded generation L customer network U utility network NOTE This type of installation requires an electronic meter where differentiated import and export rates apply. **Figure 9 — Single meter installation**		N/A
4.3.2.2	The EG feeds into the customer network (L), offsetting the customer's own consumption. If the customer is a net electricity importer from the utility (U), the cumulative consumption meter reading will increase. If the customer is a net exporter, the cumulative consumption meter reading decreases.		N/A
4.3.2.3	As a result of using a single meter, the overall consumption and generation of the customer is not recorded. The net import and export of energy is metered and balanced over the metering period.		N/A

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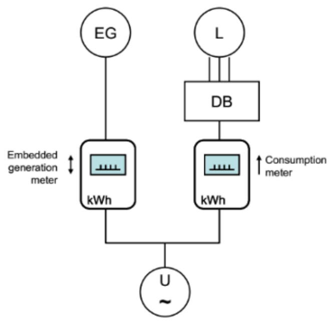
Clause	Requirement – Test	Result – Remark	Verdict
4.3.2.4	A net meter records and balances energy in a single register. An alternative to the net meter is a bi-directional meter which records energy import and export in separate registers. The registers need to be balanced off against each other to provide the necessary information to the billing system. Separate register meters may be preferred by utilities for reasons of revenue protection.		N/A
4.3.3	Multiple meter installation		N/A
	NOTE The feed-in tariff may be worded differently in policy documents, however, the principle is discussed in this section.		N/A
4.3.3.1	Feed-in tariff metering records all the energy generated from the embedded generator and reimburses the EG customer at the set FIT. The consumption of the EG customer is recorded in full and billed in the conventional manner. A customer with embedded generation and consumption therefore requires two meters or a bi-directional active energy meter that records energy flow in both directions.		N/A
4.3.3.2	The metering configuration for FIT metering is given in figure 8 and is referred to as “separate metering”. An existing consumption meter, whether prepayment or conventional, can remain in place. The embedded generation meter shall be a bi-directional active energy meter that records energy flow in both directions.		N/A
4.3.3.3	This metering configuration records overall consumption (L) and overall generation (EG) which is exported to the utility network (U).		N/A
4.3.3.4	The separate metering configuration in figure 10 is the most basic FIT metering configuration. NOTE The relevant regulations applicable in municipalities may not allow this metering configuration in which case the EG can be connected through the separate embedded generation metering configuration shown in figure 10.  Legend DB distribution board EG overall generation L overall consumption U utility network NOTE The EG may have auxiliary supply (electricity usage) **Figure 10 — Separate metering**		N/A

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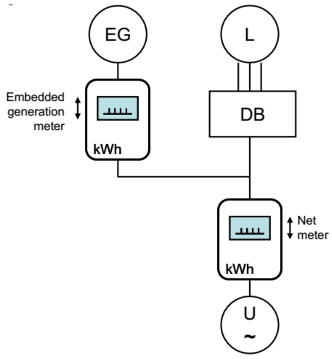
Clause	Requirement – Test	Result – Remark	Verdict
4.3.3.5	In the case where the output of the EG cannot physically be taken to the main distribution board of the customer's premises, an EG meter may be embedded in the customer's network. The appropriate metering configuration is given in figure 11.  Legend DB distribution board EG embedded generation L consumption U utility network **Figure 11 — Separate embedded metering**		N/A
4.3.3.6	The overall generation of the EG is recorded in the bi-directional embedded generation meter while the overall consumption is balanced off between the net meter and the EG meter[2)]. The net meter shall be a bi-directional meter. [2)] The overall electricity consumption over a period is equivalent to the sum of the net meter differential reading and the EG meter differential reading.		N/A
4.3.4	Types of meter		N/A
4.3.4.1	Energy meters used in conjunction with embedded generation shall record active energy. The meters shall be bi-directional type meters. The meters can either be of the single or the separate register type.		N/A
4.3.4.2	The current specification for pre-payment meters does not cater for embedded generation.		N/A
4.3.4.3	In the event that installations with embedded generators are required to record reactive energy in conjunction with active energy, four-quadrant electronic meters shall be utilized.		N/A
4.3.4.4	Meters with the capability of metering quality of supply parameters shall activate the monitoring facility on the meter. NOTE The modalities of the billing and revenue procedures for EG customers will be addressed in the future NRS 097-2-4 specification.		N/A
Annex A	Notes to purchasers		N/A
	NOTE The customer is advised to contact the utility to discuss potential further connection requirements.		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
A.1	The following requirement shall be specified in tender invitations and in each order or contract:		N/A
	Whether all power quality parameters shall be measured at the POC (see 4.1.1.3).		N/A
A.2	The following requirements shall be agreed upon between the customer and the utility:		N/A
	a) whether the EG shall be type approved (see 4.1.1.5);		N/A
	b) whether the EG may control the voltage (see 4.1.2.2);		N/A
	c) the power factor limits (see 4.1.11).		N/A
Annex B	Earthing systems		P
	NOTE SANS 10142-1 does not apply to embedded generators (i.e. connected in parallel to the utility network). Annex B is provided as minimum requirements for earthing systems until the update of SANS 10142-1.		P
B.1	Application of SANS 10142-1	See below.	P
B.1.1	General		P
	SANS 10142-1 applies to low-voltage wiring, earthing, bonding and safety. The requirements in B.1.2 to B.1.5 relating to earthing and to neutral and earth path connections apply.		P
B.1.2	Neutral conductor		P
	The neutral conductor shall not be connected direct to earth or to the earth continuity conductor on the load side of the point of control (see 6.1.6 in SANS 10142-1:2012).		P
B.1.3	Customer's earth terminal		N/A
	Each installation shall have a consumer's earth terminal (see 3.18 of SANS 10142-1:2012) at or near the point where the supply cables enter the building or structure. All conductive parts that are to be earthed (see 6.12.3 in SANS 10142-1:2012) shall be connected to the main earthing terminal (see 3.29.4 in SANS 10142-1:2012), which shall be connected to the consumer's earth terminal. The consumer's earth terminal shall be earthed by connecting it to the supply earth terminal (see 3.78 in SANS 10142-1:2012) or the protective conductor (see 3.15.8 in SANS 10142-1:2012) and, if installed, the earth electrode. The effectiveness of the supply protective conductor shall be determined in accordance with 8.7.5 in SANS 10142-1:2012 (see 6.11.1 as amended by amendment No. 6 in SANS 10142-1:2012).	Rely in the responsibility of the installer.	N/A
B.1.4	Earthing of combined sources		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
	When an installation that has a common neutral is supplied from a combination of transformers and generators located near one another, the neutral terminal of these shall be connected to a single neutral bar. This neutral bar shall be the only point at which the neutral of the installation is earthed except in the case in 7.12.3.1.3 in SANS 10142-1:2012 (see 6.12.4 as amended by amendment No. 6 in SANS 10142-1:2012).	Rely in the responsibility of the installer.	N/A
B.1.5	Neutral bar earthing	Rely in the responsibility of the installer.	N/A
B.1.5.1	Protection in accordance with the requirements in 6.7 in SANS 10142-1:2012 shall be provided for the electrical installation in such a manner as to ensure correct operation of the protection devices, irrespective of the supply or combination of sources of supply. Operation of the protection devices shall not rely upon the connection to the earthing point of the main supply.		N/A
B.1.5.2	Where there is no existing earth electrode in the electrical installation, a suitable earth electrode may be installed in accordance with SANS 10199. When installed, the electrode shall be bonded to the consumer's earth terminal and to the earthing point of the generating set with a conductor of at least half the cross-section of that of the phase conductor, but not less than 6 mm copper, or equivalent. This also applies to a single-phase supply. NOTE 1 In the case of the TN system of electricity supply, an earth electrode is normally not required in an electrical installation (see 7.12.3.1.1 as amended by amendment No. 6 in SANS 10142-1:2012). NOTE 2 IEC 60364-1 distinguishes three families of earthing arrangement, using the two-letter codes TN, TT, and IT. The first letter indicates the connection between earth and the power-supply equipment (generator or transformer). The second letter indicates the connection between earth and the electrical device being supplied. In the case of TN systems, T indicates a direct connection of a point with earth (Latin: terra) and N indicates direct connection to neutral at the origin of the installation, which is connected to the earth.		N/A
B.1.5.3	When an installation is supplied from a combination of transformers and generators located near one another, including alternative supplies, the neutral terminal of these shall be connected to a single earthed neutral bar. This neutral bar shall be the only point at which the neutral of the installation is earthed. Any earth leakage unit shall be positioned to avoid incorrect operation due to the existence of the parallel neutral or earth path (see 7.12.3.1.2 as amended by amendment No. 6 in SANS 10142-1:2012).		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
B.1.5.4	Where alternative supplies are installed remotely from the installation and it is not possible to make use of a single neutral bar, which is earthed, the neutral of each unit shall be earthed at the unit and these points shall be bonded to the consumer’s earth terminal (see 6.12.4 of SANS 10142-1:2012). The supply that supplies the installation or part of the installation shall be switched by means of a switch that breaks all live conductors operating substantially together (see annex S of SANS 10142-1:2012), to disconnect the earthed neutral point from the installation neutral when the alternative supply is not connected (see also 6.1.6 of SANS 10142-1:2012 and 7.12.3.1.3 (as amended by amendment No. 6 in SANS 10142-1:2012)).		N/A
B.1.5.5	Where only part of an installation is switched to the alternative supply in the same distribution board, the neutral bar shall be split (see figure S.2 in annex S of SANS 10142-1:2012) and 7.12.3.1.3 (as amended by amendment No. 6 in SANS 10142-1: 2012).		N/A
B.2	Embedded generator and UPS configurations		P
B.2.1	Various configurations of embedded generator and UPS systems were examined, and cross-referenced with the main electrical supply earthing configurations (i.e. TN-S, TN-C-S). Table B.1 shows the permutations explored. NOTE The TT configuration is generally not used in South Africa, but could sometimes be found in certain rural electrification network spurs.	TN, except corner-earthed system.	P

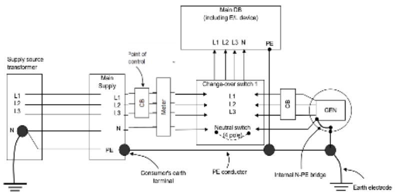
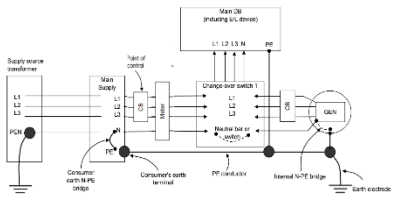
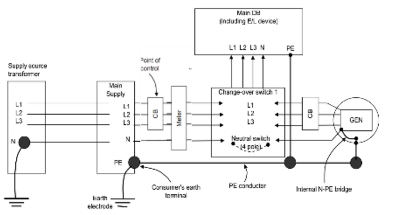
Table B.1 — Generic embedded generation/UPS type versus electricity supply configuration

1	2	3	4	5	6
Figure reference	**Application type**	**Alternative supply characteristic**	**Main electricity supply system configuration examined**		
		Internal N-PE bridge connection	**TN-S**	**TN-C-S**	**TT**
Table B.2	Alternative generator, e.g. stand-by diesel or stand-alone generator	Unbridged N-PE	Y	Y	Y
		N-PE bridged	Y	Y	Y
Table B.3	Embedded generator, e.g. utility interconnected PV system		Y	Y	Y
Table B.4	UPS system with a.c. coupled embedded generator	Unbridged N-PE	Y	Y	Y
		N-PE bridged	Y	Y	Y
Table B.5	UPS system	Unbridged N-PE	Y	Y	Y
		N-PE bridged	Y	Y	Y
	UPS system with d.c. coupled embedded generator (e.g. PV or wind)	Unbridged N-PE	Y	Y	Y
		N-PE bridged	Y	Y	Y
NOTE For information only.					

B.2.2	Tables B.2 to B.5 illustrate the typical system application types and connections.		N/A

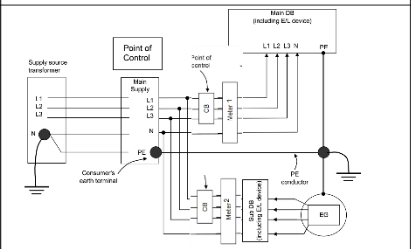
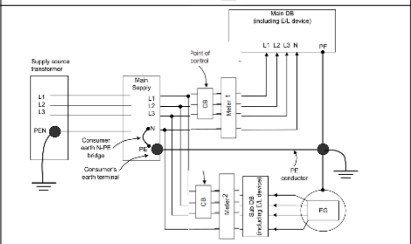
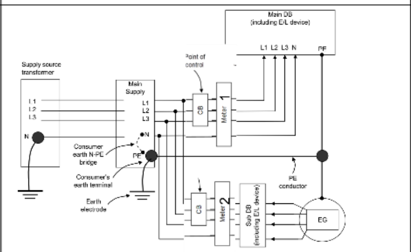
Clause	Requirement – Test	Result – Remark	Verdict
	Table B.2 — Diesel generator in alternative supply configuration	The unit under test was single phase Grid-Connected PV Inverter and not diesel generator.	N/A

Table B.2 — Diesel generator in alternative supply configuration

1	2	3
Supply earthing system	**Wiring diagram**	**Earthing comments**
TN-S • Five-wire supply. • Consumer's earth electrode not required. • No N-PE bridge on consumer's earth terminal		**Requirements** • Alternative supply earth electrode required • Bridge N-PE required on alternative supply. • Four-pole change-over switch required.
TN-C-S • Four-wire supply. • Consumer's earth electrode not required. • Bridge N-PE required on consumer's earth terminal		**Requirements** • Alternative supply earth electrode required **Options** • If bridged N-PE on alternative supply, then four-pole change-over switch required. • If open N-PE on alternative supply, then three-pole change-over switch required.
TT • Four-wire supply. • Consumer's earth electrode required. • No N-PE bridge on consumer's earth terminal		**Requirements** • Bridge N-PE required on alternative supply. • Four-pole change-over switch required.
Key: CB circuit-breaker; GEN alternative generator	DB distribution board; UPS battery alternative supply	E/L earth leakage

Clause	Requirement – Test	Result – Remark	Verdict
	Table B.3 — Embedded generator without alternative supply		N/A

Table B.3 — Embedded generator without alternative supply

1 Supply earthing system	2 Wiring diagram	3 Earthing comments
TN-S • Five-wire supply. • Consumer's earth electrode not required. • No N-PE bridge on consumer's earth terminal • Main supply = Point of Control • Main DB		**Requirements** • RCD (Type B) required for transformerless inverters. **Options** • EG earth electrode desired
TN-C-S • Four-wire supply. • Consumer's earth electrode not required. • Bridge N-PE required on consumer's earth terminal		**Requirements** • EG on E/L device **Options** • EG earth electrode desired
TT • Four-wire supply. • Consumer's earth electrode required. • No N-PE bridge on consumer's earth terminal		**Requirements** • EG on E/L device

Key: CB circuit-breaker; DB distribution board; E/L earth leakage; GEN alternative generator; EG embedded generator; UPS battery alternative supply

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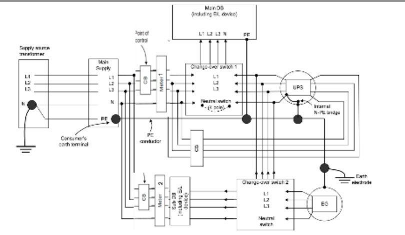
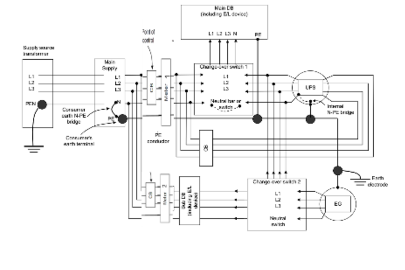
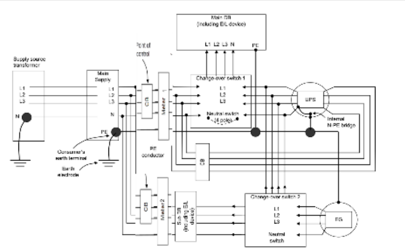
Clause	Requirement – Test	Result – Remark	Verdict
	Table B.4 — Alternative supply with a.c. coupled embedded generator		N/A

Table B.4 — Alternative supply with a.c. coupled embedded generator

1 Supply earthing system	2 Wiring diagram	3 Earthing comments
TN-S • Five-wire supply. • Consumer's earth electrode not required. • No N-PE bridge on consumer's earth terminal		**Requirements** • EG on E/L device • Alternative supply earth electrode required • Bridge N-PE required on alternative supply. • Change-over switch 1 required to be four-pole • Change-over switch 2 required to be four-pole.
TN-C-S • Four-wire supply. • Consumer's earth electrode not required. • Bridge N-PE required on consumer's earth terminal		**Requirements** • EG on E/L device • Alternative supply earth electrode required **Options** • If bridged N-PE on alternative supply, then change-over switch 1 required to be four-pole. • If open N-PE on alternative supply, then change-over switch 1 required to be three-pole. • Change-over switch 2 required to be four-pole.
TT • Four-wire supply. • Consumer's earth electrode required. • No N-PE bridge on consumer's earth terminal		**Requirements** • EG on E/L device • Bridge N-PE required on alternative supply. • Change-over switch 1 required to be four-pole • Change-over switch 2 required to be four-pole.

Key: CB circuit-breaker; DB distribution board; E/L earth leakage; GEN alternative generator; EG embedded generator; UPS battery alternative supply

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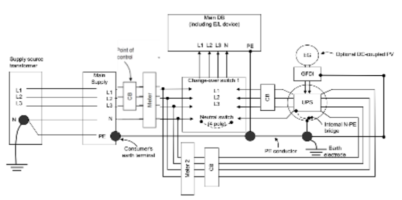
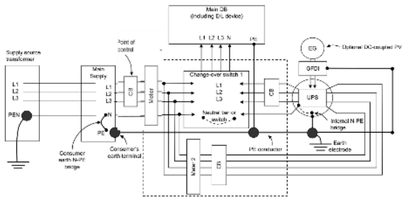
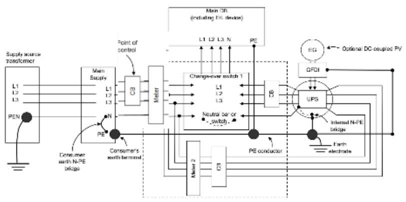
Clause	Requirement – Test	Result – Remark	Verdict
	Table B.5 — Alternative supply with or without d.c. coupled embedded generator		N/A

Table B.5 — Alternative supply with or without d.c. coupled embedded generator

1	2	3
Supply earthing system	**Wiring diagram**	**Earthing comments**
TN-S • Five-wire supply. • Consumer's earth electrode not required. • No N-PE bridge on consumer's earth terminal		**Requirements** • If bridged N-PE on alternative supply, then four-pole change-over switch required. • If open N-PE on alternative supply, then three-pole change-over switch required
TN-C-S • Four-wire supply. • Consumer's earth electrode not required. • Bridge N-PE required on consumer's earth terminal		**Options** • If bridged N-PE on alternative supply, then four-pole change-over switch required. • If open N-PE on alternative supply, then three-pole change-over switch required.
TT • Four-wire supply. • Consumer's earth electrode required. • No N-PE bridge on consumer's earth terminal		**Requirements** • Bridged N-PE required on alternative supply. • Four-pole change-over switch required.

Key: CB circuit-breaker; DB distribution board; GFDI ground fault detector interrupter; GEN alternative generator; EG embedded generator; UPS battery alternative supply

Clause	Requirement – Test	Result – Remark	Verdict
B.3	Rules of thumb established for embedded generation and backup systems		P
B.3.1	General		P
	Earthing and wiring guidelines were developed as a result of the above rigorous analysis. See tables B.2 to B.5.		P
B.3.2	Earth electrode		N/A
B.3.2.1	All alternative systems shall have an own earth electrode connected to the consumer's earth terminal and shall comply with 7.12.3.1.1 in SANS 10142-1:2012.		N/A
B.3.2.2	Embedded generators need not have their own earth electrode in accordance with SANS 10142-1, but an own earth electrode is preferred.		N/A
B.3.3	N-PE bridge on consumer's earth terminal	Rely in the responsibility of the installer.	N/A
B.3.3.1	The TN-C-S system shall be bridged between N and PE on the consumer's earth terminal in the installation on the supply side of the point of control.		N/A
B.3.3.2	TN-S and TT systems shall be un-bridged (as normal practice). NOTE This is to comply with standard installation requirements for safety.		N/A

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Clause	Requirement – Test	Result – Remark	Verdict
B.3.4	N-PE bridge on alternative supply	Rely in the responsibility of the installer.	N/A
B.3.4.1	TN-S and TT systems shall be bridged.		N/A
B.3.4.2	The TN-C-S may be either bridged or un-bridged. This, however, impacts on change-over switch requirements.		N/A
B.3.5	Change-over switch No. 1 (between main supply and backup supply)	Rely in the responsibility of the installer.	N/A
B.3.5.1	In the case of backup systems WITHOUT an internal N-PE bridge (i.e. where N and PE are isolated), the following is required:		N/A
	a) for a three-phase system: a three-pole change-over switch with common neutral bar; and b) for a single-phase system: a single-pole change-over switch with common neutral bar.		N/A
B.3.5.2	In the case of backup systems WITH an internal N-PE bridge, the following is required:		N/A
	a) for a three-phase system: a four-pole change-over switch including neutral, or a three-pole with overlapping neutral; and b) for a single-phase system: a two-pole change-over switch including neutral, or a single pole with overlapping neutral.		N/A
B.3.5.3	Manual change-over switches shall be three position switches, i.e. break-before-make.		N/A
B.3.6	Change-over switch No. 2 (between a.c. coupled embedded generator and backup supply)	Rely in the responsibility of the installer.	N/A
B.3.6.1	In the case of a three-phase system, there shall be a four-pole change-over switch including neutral, or a three-pole with overlapping neutral.		N/A
B.3.6.2	In the case of a single-phase system, there shall be a two-pole change-over switch including neutral, or a single pole with overlapping neutral.		N/A
Annex C	Network impedance		Info.
Annex D	(Annex A of VDE-AR-N 4105) Explanations		Info.
Annex E	(Annex B of VDE-AR-N 4105) Connection examples		Info.
Annex F	(Annex C of VDE-AR-N 4105) Example of meter panel configurations		Info.
Annex G	Generation management network security management		P
G.1	Generation management network security management		P

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Clause	Requirement – Test	Result – Remark	Verdict
	NOTE While no South African utility currently has the required communication systems in place for LV systems, embedded generators may be NERSA exempt in providing on-line communication interfaces. However, should the utility require this in future, the embedded generator will provide the required interface at their own cost. Section G.1 provides the recommended requirements for such an interface. At the time of publication, basic communication requirements for category A3 generators are provided in the RPP Grid Code.		P
G.1.1	In addition to requirements elsewhere in this specification, the embedded generator shall be able to control the following parameters as and where signals are sent by the utility:		P
G.1.1.1	Active power control, typically a temporary reduction in active power output;		P
G.1.1.2	Reactive power control, i.e. change of the operating power factor or power factor curve of the generator.		P
G.1.2	For each operational state and/or operational point, the embedded generator must be able to reduce the output power to less than or equal to an active power set-point provided by the utility.		P
G.1.3	Embedded generation systems with a power output capability of 100 kVA or more shall be able to control the output power in steps of 10 % or less of the rated active power.		P
G.1.4	The embedded generator active power output shall reach the new set-point within a period of 1 minute. If this set-point cannot be reached within 5 minutes, the embedded generator shall disconnect from the system. NOTE This implies that embedded generators without the capability to control the output power adequately or in adequate steps, shall disconnect from the system when a reduction in active power output is requested.		P
G.1.5	Embedded generation systems with a power output capability of 100 kVA or more shall be able to control the reactive power (power factor) is steps of 5 % or less of the rated power.		P
G.1.6	Reactive power shall reach the new set-point within a period of 1 minute. If this set-point cannot be reached within 5 minutes, the embedded generator shall disconnect from the system.		P

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Clause	Requirement – Test	Result – Remark	Verdict
G.1.7	According to the RPP Grid Code version 3.0, the accuracy of the control performed for both the active power and reactive power controls, and of the setpoint of both the active power and reactive power, shall not deviate by more than ± 2 % of the setpoint value or by ± 0.5 % of the rated power, depending on which yields the highest tolerance. NOTE Appropriate communication protocols are under discussion with the Grid Code Advisory Committee and will be provided in a future edition of this document. This capability will then become compulsory for all new equipment.		P
G.2	Principles for network support		P
	As a rule, power generation systems of subcategory A3 shall be able to contribute to the static voltage stability in the utility network. Static voltage stability is the voltage stability in the low-voltage network at which the slow voltage changes are maintained within compatible limits in the distribution network. If required due to network related circumstances and by the utility, the embedded generator shall contribute to the static voltage stability in the low-voltage network.		P
	Dynamic grid support, i.e. voltage stability in the event of voltage drops in higher voltage levels, is not required for embedded generators connected to low-voltage networks. NOTE This requirement applies tor units larger than 100 kVA only, smaller units on dedicated circuits (i.e. part of sub-category A3) are exempt.		P
G.3	Emergency personnel safety		P
	The safety of emergency personnel, e.g. fire brigade, shall be dealt with elsewhere.		P
	DC installations will be covered by SANS 10142-X (future document).		P
	A utility accessible disconnector will be available to emergency personnel that will disconnect the a.c. NOTE This clause will be superseded by requirements in the future SANS 10142-X document or other relevant requirements based on the Occupational Health and Safety act (Act No. 85 of 1993) as amended.		P
G.3.1	Appropriate signage shall be installed. The requirements shall be cross-checked with requirements of SANS 10142-1. An example of signage as required by this section of NRS 097 is provided in 4.2.10.		P
G.3.2	It is preferable that all SSEG be installed with emergency shutdown equipment. Examples of requirements are listed in G.3.2.1 to G.3.2.4. The manufacturer shall prove that the emergency shutdown processes and procedures are in line with current international best practices.		P

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Clause	Requirement – Test	Result – Remark	Verdict
G.3.2.1	All a.c. voltages should be shut off, regardless of the operating mode of the equipment at the time of shutdown.		P
G.3.2.2	All fuel inputs to a SSEG (e.g. water feed to a hydro-generator, d.c. input to an inverter, etc.) should be shut off; regardless of the operating mode of the equipment at the time of shutdown. NOTE PV panels cannot be switched off.		P
G.3.2.3	Equipment that have emergency shutdown capabilities, shall have a “fireman’s switch” installed in accordance with SANS 10142-1 at the time of installation in order to activate emergency shutdown. NOTE The d.c. from PV panels and/or battery storage will be assumed to be live.		P
G.3.3	The absence of emergency shutdown capabilities will be indicated on signage referred to in G.3.1.		P

Test overview:		
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Clause	Test item	Result
4.1.5	Flicker and voltage changes	P
4.1.6	Voltage unbalance	P
4.1.8.1	DC injection	P
4.1.8.2 & 4.2.2.5	DC current injection	P
4.1.10	Harmonics and waveform distortion	P
4.1.11	Power factor	P
4.2.2.2	Disconnection device (previously disconnection switching unit)	P
4.2.2.3.2	Overvoltage and undervoltage	P
4.2.2.3.3	Overfrequency and underfrequency	P
4.2.2.4	Prevention of islanding (in accordance with IEC 62116)	P
4.2.4	Response to utility recovery (see table 4.2.2.3.2 & 4.2.2.3.3)	P

4.1.5	TABLE: Flicker and voltage changes		P
Test conditions:	Maximum permissible voltage fluctuation (expressed as a percentage of nominal voltage at 100 % power) and flicker		
Model: Solis-1P4.6K-4G			
Limit	dc = 3,3 (%)	P_{st}=0,35	P_{lt}=0,30
Test value	0,08	0,12	0,08

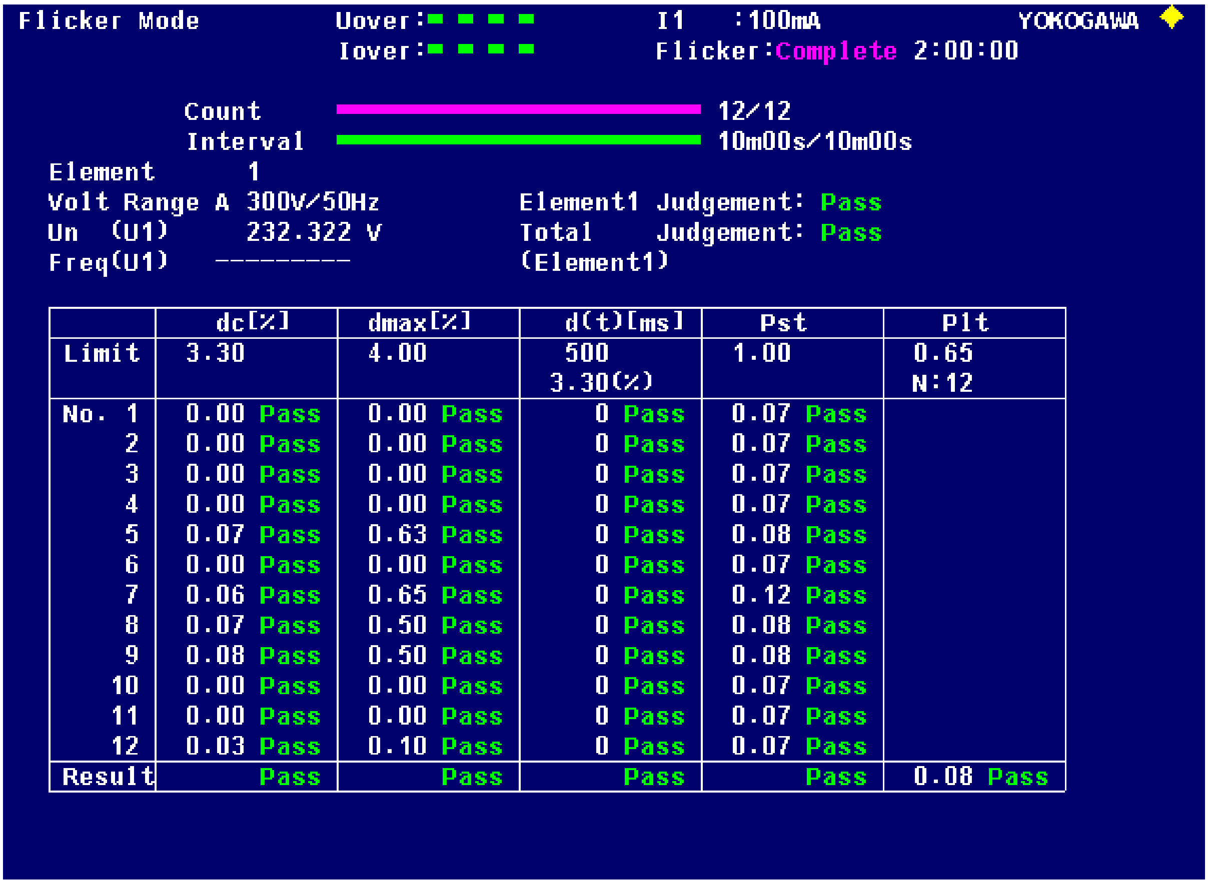
Note:

Calculation of the maximum permissible grid impedance at the point of common coupling based on dc:

Zmax = Zref * 3,3% / dc(Pn)

The tests should be based on the limits of the EN 61000-3-11 for more than 16A.
The tests were performed on model Solis-1P4.6K-4G and are also applicable for all other models stated in this report.

Flicker Test Result



Flicker Mode Uover:■ ■ ■ ■ I1 :100mA YOKOGAWA
Iover:■ ■ ■ ■ Flicker:Complete 2:00:00

Count 12/12
Interval 10m00s/10m00s
Element 1
Volt Range A 300V/50Hz Element1 Judgement: Pass
Un (U1) 232.322 V Total Judgement: Pass
Freq(U1) --------- (Element1)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
2	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
3	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
4	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
5	0.07 Pass	0.63 Pass	0 Pass	0.08 Pass	
6	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
7	0.06 Pass	0.65 Pass	0 Pass	0.12 Pass	
8	0.07 Pass	0.50 Pass	0 Pass	0.08 Pass	
9	0.08 Pass	0.50 Pass	0 Pass	0.08 Pass	
10	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
11	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
12	0.03 Pass	0.10 Pass	0 Pass	0.07 Pass	
Result	Pass	Pass	Pass	Pass	0.08 Pass

4.1.6.2	**TABLE: Voltage unbalance for three-phase generators**				N/A
Measurement No.	1	2	3	4	5
Test at rated power @ cos φ = 1					
U_{E60} [V]: L1					
U_{E60} [V]: L2					
U_{E60} [V]: L3					
U_{E60} [V]: |L1 - L2|					
U_{E60} [V]: |L2 - L3|					
U_{E60} [V]: |L3 - L1|					
cos φ_{E60} max.:					
max voltage unbalance [V]:					
Limit, 0,2%U_{Rated} [V]:					

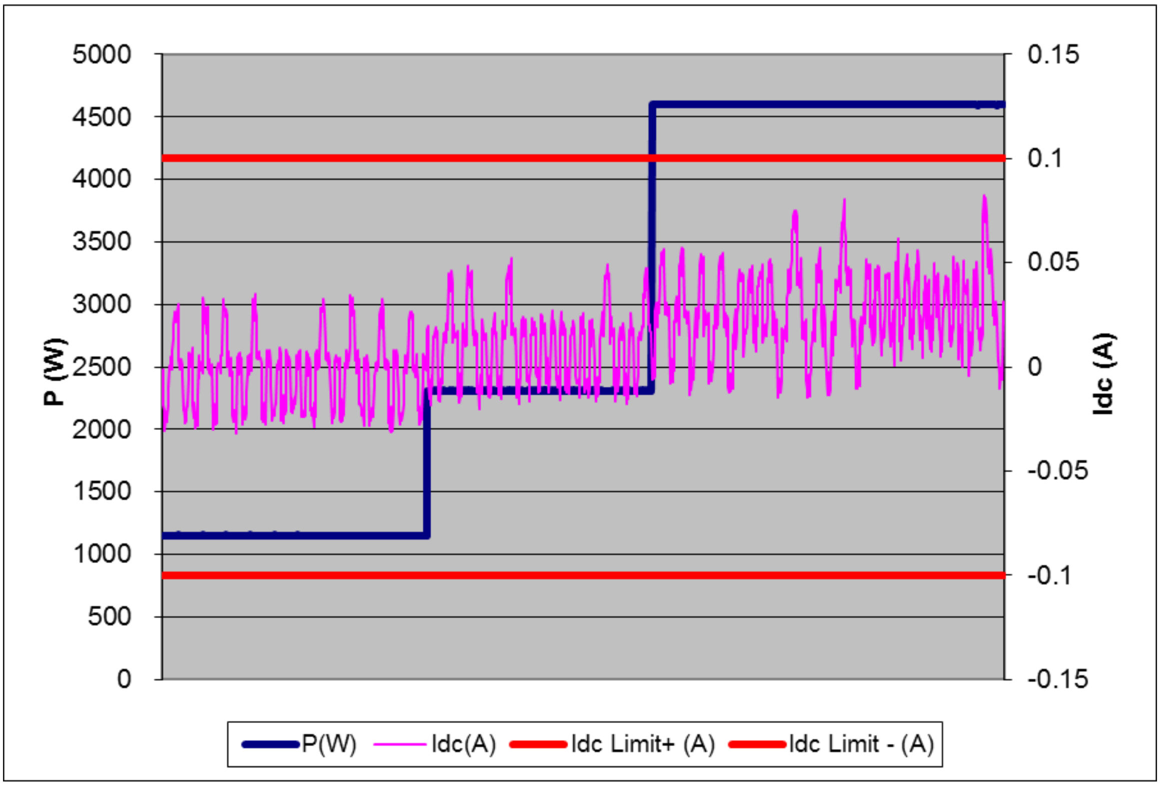
Note:

Three-phase generators may not contribute more than 0,2 % voltage unbalance when connected to a network with impedance equal to the reference impedance.

The PV inverters were single phase not used in three-phase system.

4.1.8.1	TABLE: DC injection		P
Model: Solis-1P4.6K-4G			
Limit:	0,5% of I_{rated} (0,1 A)		
Output power level (%)	25%	50%	100%
Max test value (A)	0,035	0,052	0,082
Percent of rated AC current (%)	0,18%	0,26%	0,41%

Diagram of permanent DC-Injection
(25% / 50% / 100%Pn)

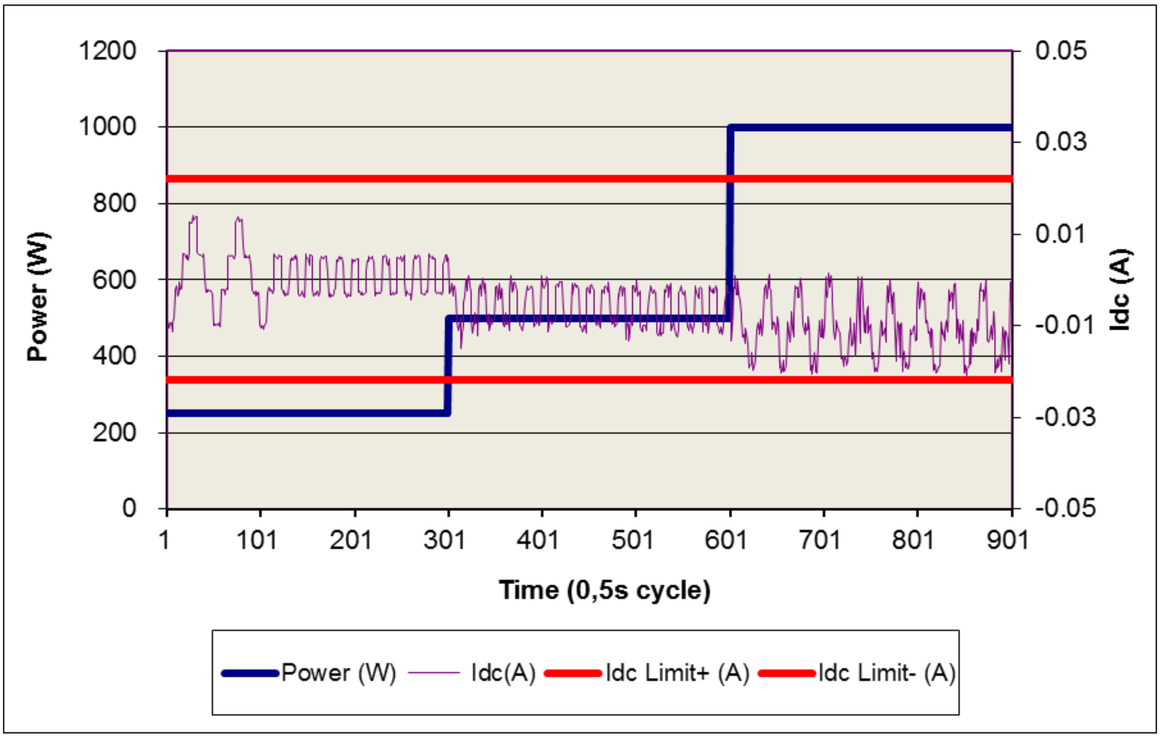


Note:

The average d.c. current injected by the embedded generator shall not exceed 0,5 % of the rated a.c. output current over any 1-minute period, into the utility a.c. interface under any operating condition.

4.1.8.1	TABLE: DC injection		P
Model: Solis-1P1K-4G			
Limit:	0,5% of I_{rated} (0,022 A)		
Output power level (%)	25%	50%	100%
Max test value (A)	0,014	-0,015	-0,021
Percent of rated AC current (%)	0,32%	0,35%	0,49%

Diagram of permanent DC-Injection
(25% / 50% / 100%Pn)



Note:

The average d.c. current injected by the embedded generator shall not exceed 0,5 % of the rated a.c. output current over any 1-minute period, into the utility a.c. interface under any operating condition.

The tests were performed on model Solis-1P4.6K-4G and Solis-1P1K-4G are also applicable for all other models stated in this report.

4.1.8.2& 4.2.2.5	**TABLE: DC current injection**				**P**
Model: Solis-1P4.6K-4G					
Test conditions:	U_N = 230 Vac Uinput = 360 Vdc Rated Power = 4600 W				
DC Injection (A)	Limits	Trip Time (ms)			
Tested with +0,1 A	I_{DC}:>0,5% I_{rated}, EG disconnection within 500 ms	146	138	129	
Tested with -0,1 A	I_{DC}:>0,5% I_{rated}, EG disconnection within 500 ms	135	116	128	

Note:

The EG shall cease to energize the utility network within 500 ms if inject d.c. current greater than 0,5 % of the rated a.c. output current into the utility interface.

The tests were performed on model Solis-1P4.6K-4G and are also applicable for all other models stated in this report.

4.1.10	TABLE: Harmonics and waveform distortion			P
Harmonics				
Model: Solis-1P4.6K-4G				
Active power (kW)		4,604		
Voltage (V)		230,23		
Current (A)		19,99		
Frequency (Hz)		50,00		
THD (%)		1,62		
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (%)
1st	19,999	--	Single Phase	--
2nd	0,081	0,406	Single Phase	1%
3rd	0,121	0,607	Single Phase	4%
4th	0,02	0,098	Single Phase	1%
5th	0,177	0,883	Single Phase	4%
6th	0,012	0,060	Single Phase	1%
7th	0,134	0,669	Single Phase	4%
8th	0,008	0,039	Single Phase	1%
9th	0,099	0,496	Single Phase	4%
10th	0,006	0,032	Single Phase	1%
11th	0,082	0,409	Single Phase	2%
12th	0,006	0,029	Single Phase	0,5%
13th	0,064	0,319	Single Phase	2%
14th	0,004	0,021	Single Phase	0,5%
15th	0,055	0,275	Single Phase	2%
16th	0,004	0,019	Single Phase	0,5%
17th	0,046	0,232	Single Phase	1,5%
18th	0,002	0,012	Single Phase	0,38%
19th	0,044	0,218	Single Phase	1,5%
20th	0,002	0,011	Single Phase	0,38%
21th	0,037	0,185	Single Phase	1,5%
22th	0,003	0,013	Single Phase	0,38%
23th	0,032	0,162	Single Phase	0,6%
24th	0,003	0,016	Single Phase	0,15%
25th	0,026	0,131	Single Phase	0,6%
26th	0,002	0,010	Single Phase	0,15%
27th	0,023	0,114	Single Phase	0,6%

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28th	0,002	0,008	Single Phase	0,15%
29th	0,021	0,105	Single Phase	0,6%
30th	0,001	0,007	Single Phase	0,15%
31th	0,020	0,098	Single Phase	0,6%
32th	0,002	0,009	Single Phase	0,15%
33th	0,017	0,084	Single Phase	0,6%
34th	0,003	0,013	Single Phase	0,15%
35th	0,015	0,077	Single Phase	0,3%
36th	0,003	0,016	Single Phase	0,08%
37th	0,014	0,069	Single Phase	0,3%
38th	0,002	0,011	Single Phase	0,08%
39th	0,012	0,062	Single Phase	0,3%
40th	0,002	0,010	Single Phase	0,08%
41th	0,011	0,053	Single Phase	0,3%
42th	0,002	0,011	Single Phase	0,08%
43th	0,010	0,050	Single Phase	0,3%
44th	0,003	0,017	Single Phase	0,08%
45th	0,009	0,047	Single Phase	0,3%
46th	0,002	0,012	Single Phase	0,08%
47th	0,008	0,042	Single Phase	0,3%
48th	0,003	0,013	Single Phase	0,08%
49th	0,008	0,038	Single Phase	0,3%
50th	0,002	0,012	Single Phase	0,08%

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Clause	Requirement – Test	Result – Remark	Verdict

4.1.10	TABLE: Harmonics and waveform distortion			P
Inter-harmonics				
Model: Solis-1P4.6K-4G				
Frequency [Hz]	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (%)
75	0,013	0,064	Single Phase	0,1%
125	0,02	0,098	Single Phase	0,1%
175	0,019	0,095	Single Phase	0,1%
225	0,008	0,041	Single Phase	0,1%
275	0,004	0,021	Single Phase	0,1%
325	0,004	0,020	Single Phase	0,1%
375	0,003	0,015	Single Phase	0,1%
425	0,003	0,015	Single Phase	0,1%
475	0,003	0,014	Single Phase	0,1%
525	0,006	0,028	Single Phase	0,1%
575	0,005	0,023	Single Phase	0,25%
625	0,004	0,021	Single Phase	0,25%
675	0,002	0,012	Single Phase	0,25%
725	0,003	0,016	Single Phase	0,25%
775	0,003	0,014	Single Phase	0,25%
825	0,003	0,013	Single Phase	0,25%
875	0,002	0,010	Single Phase	0,19%
925	0,003	0,013	Single Phase	0,19%
975	0,002	0,011	Single Phase	0,19%
1025	0,002	0,011	Single Phase	0,19%
1075	0,002	0,009	Single Phase	0,19%
1125	0,002	0,008	Single Phase	0,19%
1175	0,002	0,008	Single Phase	0,08%
1225	0,003	0,015	Single Phase	0,08%
1275	0,002	0,011	Single Phase	0,08%
1325	0,002	0,008	Single Phase	0,08%
1375	0,001	0,006	Single Phase	0,08%
1425	0,001	0,007	Single Phase	0,08%
1475	0,001	0,007	Single Phase	0,08%
1525	0,004	0,022	Single Phase	0,08%
1575	0,002	0,008	Single Phase	0,08%
1625	0,004	0,019	Single Phase	0,08%

Clause	Requirement – Test	Result – Remark	Verdict

1675	0,005	0,025	Single Phase	0,08%
1725	0,003	0,017	Single Phase	0,08%
1775	0,001	0,007	Single Phase	0,03%
1825	0,001	0,005	Single Phase	0,03%
1875	0,001	0,006	Single Phase	0,03%
1925	0,001	0,006	Single Phase	0,03%
1975	0,002	0,008	Single Phase	0,03%

4.1.10	TABLE: Harmonics and waveform distortion			P
Harmonics				
Model: Solis-1P1K-4G				
Active power (kW)		1,076		
Voltage (V)		230,41		
Current (A)		4,687		
Frequency (Hz)		50,00		
THD (%)		2,64		
Harmonics	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (%)
1st	4,685	--	Single Phase	--
2nd	0,025	0,542	Single Phase	1%
3rd	0,076	1,613	Single Phase	4%
4th	0,024	0,509	Single Phase	1%
5th	0,062	1,324	Single Phase	4%
6th	0,007	0,155	Single Phase	1%
7th	0,049	1,039	Single Phase	4%
8th	0,006	0,129	Single Phase	1%
9th	0,027	0,579	Single Phase	4%
10th	0,004	0,081	Single Phase	1%
11th	0,019	0,412	Single Phase	2%
12th	0,004	0,078	Single Phase	0,5%
13th	0,010	0,222	Single Phase	2%
14th	0,004	0,075	Single Phase	0,5%
15th	0,007	0,155	Single Phase	2%
16th	0,003	0,073	Single Phase	0,5%
17th	0,003	0,074	Single Phase	1,5%
18th	0,003	0,059	Single Phase	0,38%
19th	0,003	0,056	Single Phase	1,5%
20th	0,002	0,048	Single Phase	0,38%
21th	0,002	0,037	Single Phase	1,5%
22th	0,003	0,058	Single Phase	0,38%
23th	0,002	0,043	Single Phase	0,6%
24th	0,001	0,029	Single Phase	0,15%
25th	0,001	0,027	Single Phase	0,6%
26th	0,001	0,021	Single Phase	0,15%
27th	0,001	0,020	Single Phase	0,6%

28th	0,003	0,054	Single Phase	0,15%
29th	0,001	0,028	Single Phase	0,6%
30th	0,003	0,054	Single Phase	0,15%
31th	0,003	0,066	Single Phase	0,6%
32th	0,002	0,037	Single Phase	0,15%
33th	0,005	0,110	Single Phase	0,6%
34th	0,002	0,046	Single Phase	0,15%
35th	0,006	0,133	Single Phase	0,3%
36th	0,001	0,025	Single Phase	0,08%
37th	0,005	0,113	Single Phase	0,3%
38th	0,002	0,046	Single Phase	0,08%
39th	0,005	0,107	Single Phase	0,3%
40th	0,002	0,053	Single Phase	0,08%
41th	0,005	0,111	Single Phase	0,3%
42th	0,002	0,040	Single Phase	0,08%
43th	0,005	0,108	Single Phase	0,3%
44th	0,001	0,021	Single Phase	0,08%
45th	0,005	0,117	Single Phase	0,3%
46th	0,001	0,018	Single Phase	0,08%
47th	0,005	0,115	Single Phase	0,3%
48th	0,001	0,026	Single Phase	0,08%
49th	0,006	0,119	Single Phase	0,3%
50th	0,001	0,017	Single Phase	0,08%

4.1.10	**TABLE: Harmonics and waveform distortion**			**P**
Inter-harmonics				
Model: Solis-1P1K-4G				
Frequency [Hz]	Current Magnitude (A)	% of Fundamental	Phase	Harmonic Current Limits (%)
75	0,005	0,097	Single Phase	0,1%
125	0,001	0,026	Single Phase	0,1%
175	0,001	0,027	Single Phase	0,1%
225	0,001	0,028	Single Phase	0,1%
275	0,001	0,027	Single Phase	0,1%
325	0,001	0,026	Single Phase	0,1%
375	0,001	0,025	Single Phase	0,1%
425	0,001	0,030	Single Phase	0,1%
475	0,001	0,025	Single Phase	0,1%
525	0,001	0,025	Single Phase	0,1%
575	0,001	0,028	Single Phase	0,25%
625	0,001	0,028	Single Phase	0,25%
675	0,001	0,030	Single Phase	0,25%
725	0,001	0,029	Single Phase	0,25%
775	0,001	0,028	Single Phase	0,25%
825	0,001	0,029	Single Phase	0,25%
875	0,001	0,031	Single Phase	0,19%
925	0,002	0,033	Single Phase	0,19%
975	0,002	0,035	Single Phase	0,19%
1025	0,002	0,033	Single Phase	0,19%
1075	0,002	0,034	Single Phase	0,19%
1125	0,002	0,035	Single Phase	0,19%
1175	0,002	0,037	Single Phase	0,08%
1225	0,002	0,036	Single Phase	0,08%
1275	0,002	0,042	Single Phase	0,08%
1325	0,002	0,040	Single Phase	0,08%
1375	0,002	0,042	Single Phase	0,08%
1425	0,003	0,054	Single Phase	0,08%
1475	0,002	0,045	Single Phase	0,08%
1525	0,002	0,046	Single Phase	0,08%
1575	0,002	0,052	Single Phase	0,08%
1625	0,002	0,046	Single Phase	0,08%

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1675	0,002	0,049	Single Phase	0,08%
1725	0,003	0,057	Single Phase	0,08%
1775	0,001	0,028	Single Phase	0,03%
1825	0,001	0,029	Single Phase	0,03%
1875	0,001	0,028	Single Phase	0,03%
1925	0,001	0,029	Single Phase	0,03%
1975	0,001	0,028	Single Phase	0,03%

Note:

The tests were performed on model Solis-1P4.6K-4G and Solis-1P1K-4G are also applicable for all other models stated in this report.

4.1.11	**TABLE: Power factor**								**P**
Model	**Solis-1P4.6K-4G**								—
Output Power Level (%)	20 ± 5	30 ± 5	40 ± 5	50 ± 5	60 ± 5	70 ± 5	80 ± 5	90 ± 5	100 ± 5
Vrms (V)	230,1	230,2	230,2	230,3	230,4	230,4	230,5	230,6	230,7
Arms (A)	3,997	6,021	8,041	10,042	12,048	14,038	16,028	18,010	19,987
Active Power (kW)	0,917	1,383	1,849	2,312	2,773	3,233	3,693	4,151	4,609
Reactive Power (kVar)	0,069	0,076	0,084	0,091	0,099	0,107	0,115	0,124	0,134
Apparent Power (kVA)	0,920	1,386	1,851	2,314	2,775	3,235	3,695	4,153	4,611
PF Limit	>0,98	>0,98	>0,98	>0,98	>0,98	>0,98	>0,98	>0,98	>0,98
Power Factor	0,997	0,998	0,999	0,999	0,999	0,999	0,999	0,999	0,999

Note:

For static power converter embedded generators and synchronous embedded generators of sub-categories A1 and A2, the power factor shall remain above 0,98 as shown in Figure 1. For static power converter embedded generators and synchronous embedded generators of sub-category A3, the power factor shall remain above 0,95 as shown in Figure 2.

In line with the current Renewable Power Plant Grid Code, embedded generators smaller than 1000 kVA connected to low-voltage form part of Category A generators, with the following subcategories:

a) Category A1: 0 – 13,8 kVA;
This sub-category includes RPPs of Category A with rated power in the range from 0 to 13,8 kVA, inclusive of 13,8 kVA.

b) Category A2: 13,8 kVA – 100 kVA; and
This sub-category includes RPPs of Category A with rated power in the range greater than 13,8 kVA but less than 100 kVA.

c) Category A3: 100 kVA – 1 MVA.
This sub-category includes RPPs of Category A with rated power in the range from 100 kVA but less than 1 MVA.

4.1.11	**TABLE: Power factor**								**P**
Model	**Solis-1P1K-4G**								—
Output Power Level (%)	20 ± 5	30 ± 5	40 ± 5	50 ± 5	60 ± 5	70 ± 5	80 ± 5	90 ± 5	100 ± 5
Vrms (V)	230,0	230,0	230,0	230,0	230,0	230,0	230,0	230,1	230,1
Arms (A)	0,981	1,396	1,763	2,194	2,614	3,077	3,496	3,917	4,389
Active Power (kW)	0,221	0,318	0,403	0,503	0,599	0,706	0,803	0,900	1,008
Apparent Power (kVA)	0,225	0,321	0,406	0,505	0,601	0,708	0,804	0,901	1,010
PF Limit	>0,90	>0,90	>0,90	>0,90	>0,90	>0,90	>0,90	>0,90	>0,90
Power Factor	0,980	0,990	0,994	0,996	0,997	0,998	0,998	0,999	0,999

Note:

For static power converter embedded generators and synchronous embedded generators of sub-categories A1 and A2, the power factor shall remain above 0,98 as shown in Figure 1. For static power converter embedded generators and synchronous embedded generators of sub-category A3, the power factor shall remain above 0,95 as shown in Figure 2.

In line with the current Renewable Power Plant Grid Code, embedded generators smaller than 1000 kVA connected to low-voltage form part of Category A generators, with the following subcategories:

a) Category A1: 0 – 13,8 kVA;
This sub-category includes RPPs of Category A with rated power in the range from 0 to 13,8 kVA, inclusive of 13,8 kVA.

b) Category A2: 13,8 kVA – 100 kVA; and
This sub-category includes RPPs of Category A with rated power in the range greater than 13,8 kVA but less than 100 kVA.

c) Category A3: 100 kVA – 1 MVA.
This sub-category includes RPPs of Category A with rated power in the range from 100 kVA but less than 1 MVA.

The tests were performed on model Solis-1P4.6K-4G and Solis-1P1K-4G are also applicable for all other models stated in this report.

4.2.2.2	TABLE: Disconnection switching unit - fault condition tests						P
No.	component No.	fault	test voltage [V]	test time	fuse No.	fuse current [A]	Test result
1.	Relay K1	Pin 1 and pin 2 short circuit before start	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate RelayChk-FAIL, EUT can recover after removing the fault, no damage, no hazard.
2.	Relay K2	Pin 1 and pin 2 short circuit before start	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate RelayChk-FAIL, EUT can recover after removing the fault, no damage, no hazard.
3.	Relay K3	Pin 1 and pin 2 short circuit before start	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate RelayChk-FAIL, EUT can recover after removing the fault, no damage, no hazard.
4.	Relay K4	Pin 1 and pin 2 short circuit before start	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate RelayChk-FAIL, EUT can recover after removing the fault, no damage, no hazard.
5.	AC Voltage measurement disabled, R54	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate UN-G-V01, EUT can recover after removing the fault, no damage, no hazard.
6.	AC Voltage measurement disabled, R54	Open circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate UN-G-V01, EUT can recover after removing the fault, no damage, no hazard.
7.	DC Voltage measurement disabled, R52	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT run normally. EUT can recover after removing the fault, no damage, no hazard.
8.	DC Voltage measurement disabled, R52	Open circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, No error. LCD indicate waiting, EUT can recover after removing the fault, no damage, no hazard.
9.	DC BUS Voltage measurement disabled, R65	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT run normally. EUT can recover after removing the fault, no damage, no hazard.

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Clause	Requirement – Test	Result – Remark	Verdict

10.	DC BUS Voltage measurement disabled, R65	Open circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate Grid-INTF, EUT can recover after removing the fault, no damage, no hazard.
11.	Frequency Measurement disabled, R54	Open circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate UN-G-F01, EUT can recover after removing the fault, no damage, no hazard.
12.	Frequency Measurement disabled, R54	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT can't start up, LCD indicate UN-G-F01, EUT can recover after removing the fault, no damage, no hazard.
13.	DC Current sensor defect, C6	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT shutdown and disconnected from grid immediately, LCD indicate DC-INTF. EUT can recover after removing the fault, no damage, no hazard.
14.	Leakage Sensor defect, R38	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT shutdown and disconnected from grid immediately, LCD indicate ILeak-PR; EUT can recover after removing the fault, no damage, no hazard.
15.	Leakage Sensor defect, R37	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT shutdown and disconnected from grid immediately, LCD indicate ILeak-PR; EUT can recover after removing the fault, no damage, no hazard.
16.	Leakage Sensor defect, C47	Short circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT shutdown and disconnected from grid immediately, LCD indicate ILeak-PR; EUT can recover after removing the fault, no damage, no hazard.
17.	Main DSP loss of control, R5	Open circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT shutdown and disconnected from grid immediately, all data show "0" in LCD, EUT can recover after removing the fault, no damage, no hazard.
18.	Slave DSP loss of control, R222	Open circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT shutdown and disconnected from grid immediately, LCD indicate DSP-B-FAULT. EUT can recover after removing the fault, no damage, no hazard.

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Clause	Requirement – Test	Result – Remark	Verdict

19.	Communication Microcontroller defect, R101	Open circuit	MAINS: 230V; PV: 500V	10mim	--	--	The EUT shutdown and disconnected from grid immediately, all data show “0” in LCD, EUT can recover after removing the fault, no damage, no hazard.
Note: The tests were performed on model Solis-1P4.6K-4G are also applicable for all other models stated in this report.							

4.2.2.3.2	TABLE: Overvoltage and undervoltage							P
Model: Solis-1P4.6K-4G								
Test conditions:	Output power: 4603 W Frequency: 50 Hz							
First Level								
	Under Voltage				Over Voltage			
Parameter	Voltage	Time			Voltage	Time		
Limit	195,5V	<= 10s			253,0V	<= 40s		
Trip value (V)	195,2V				255,2V			
Disconnection time (s)	200V to 190V	8,02	8,04	8,02	248V to 258V	38,03	38,0	38,0
Reconnection time (s)	min. 60s	69,0			min. 60s	70,8		
Second Level								
	Under Voltage				Over Voltage			
Parameter	Voltage	Time			Voltage	Time		
Limit	115,0V	<= 0,2 s			264,5V	<= 2s		
Trip value (V)	114,5V				264,7V			
Disconnection time (s)	230V to 110V	0,144	0,143	0,143	230V to 270V	0,152	0,153	0,154
Reconnection time (s)	min. 60s	78,0			min. 60s	72,6		
Third Level								
	Under Voltage				Over Voltage			
Parameter					Voltage	Time		
Limit					276,0V	<= 160ms		
Trip value (V)					276,7V			
Disconnection time (s)					230V to 280V	0,154	0,153	0,153
Reconnection time (s)					min. 60s	74,0		

Note:

The accuracy for voltage trip values shall be within 0 % to +1 % of the nominal voltage from the upper boundary trip setting, and within -1% to 0% of the nominal voltage from the lower boundary trip setting.

Controllable generators may reconnect immediately after the 60 s delay confirming recovery of the system voltage and frequency at a maximum rate of 10 % of rated power per minute, i.e. full power output will only be reached after 10 minutes.

The tests were performed on model Solis-1P4.6K-4G are also applicable for all other models stated in this report.

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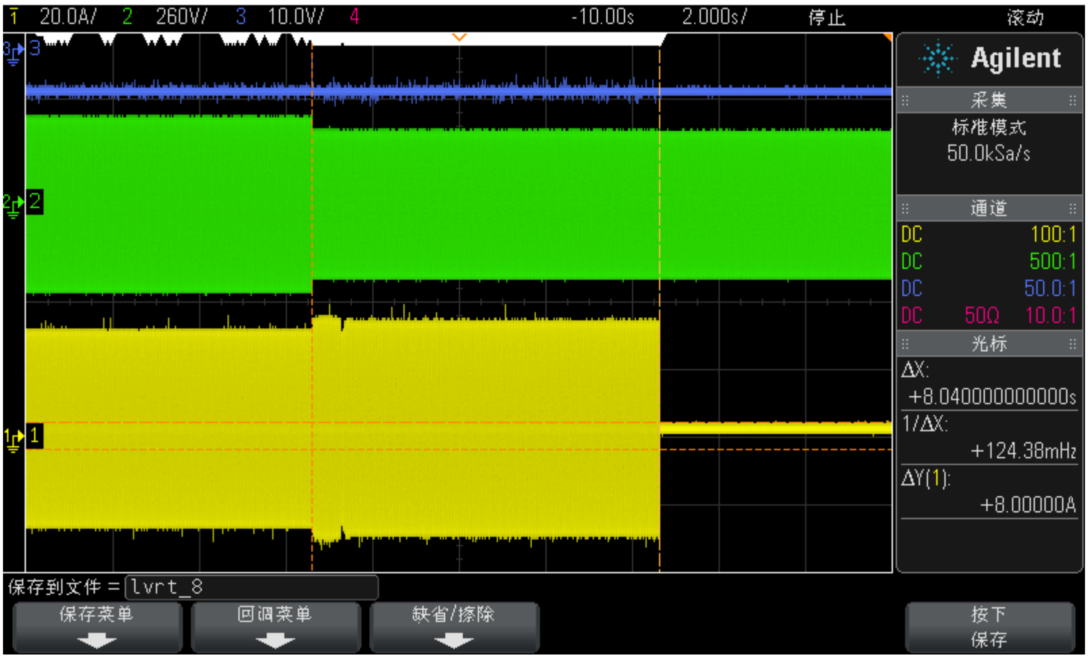
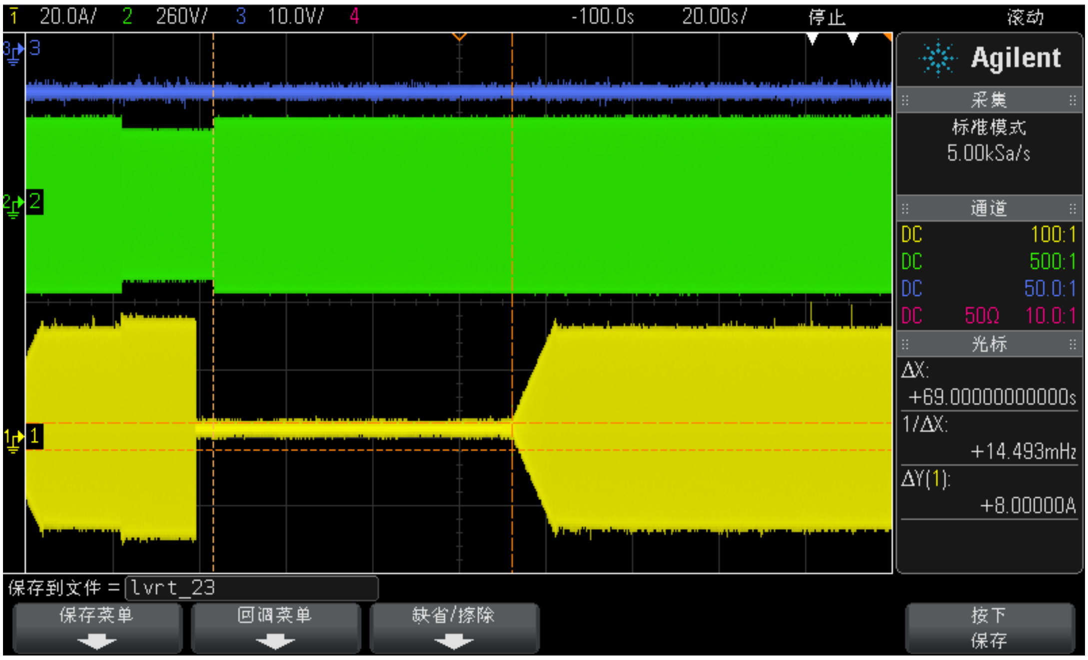
Clause	Requirement – Test	Result – Remark	Verdict

Disconnection Time - Under Voltage First Level

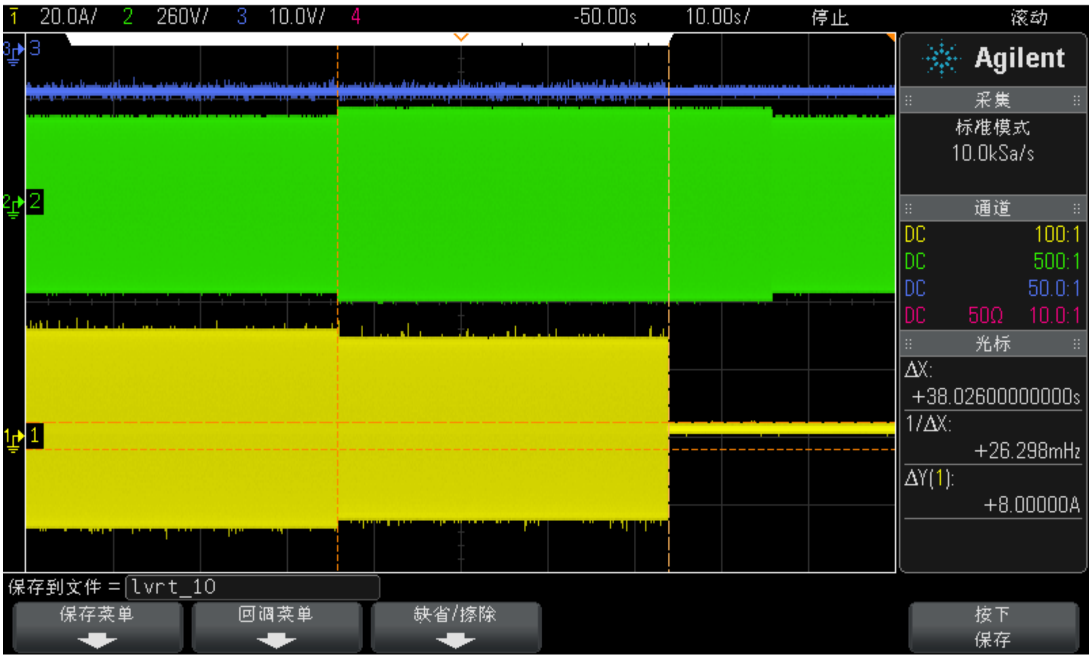


Reconnection Time - Under Voltage First Level

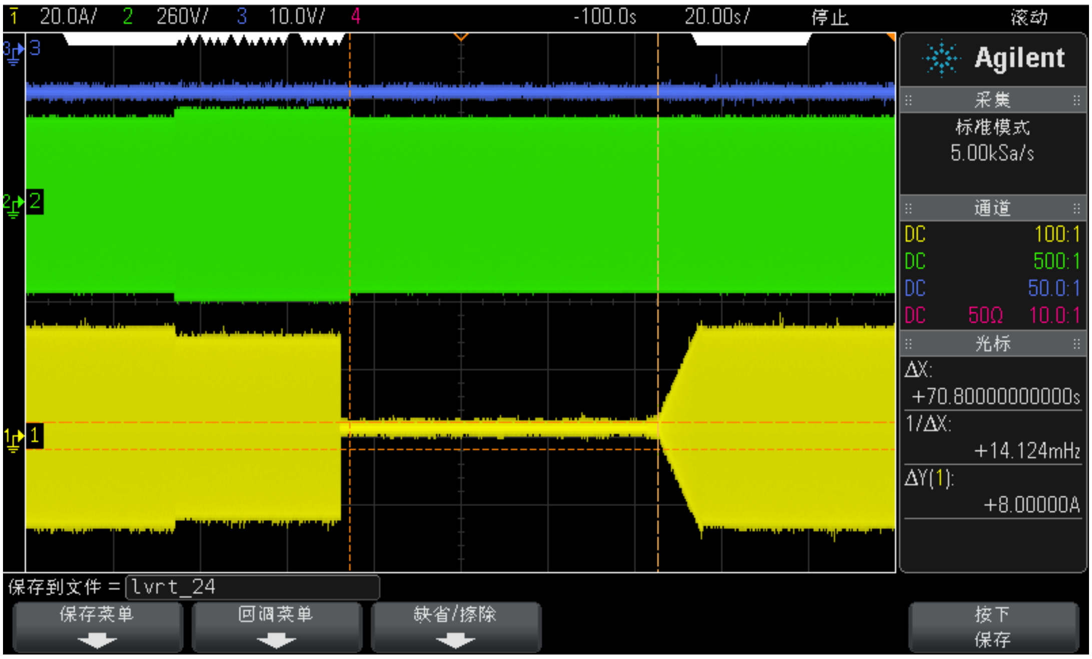


NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict

Disconnection Time - Over Voltage First Level



Reconnection Time - Over Voltage First Level



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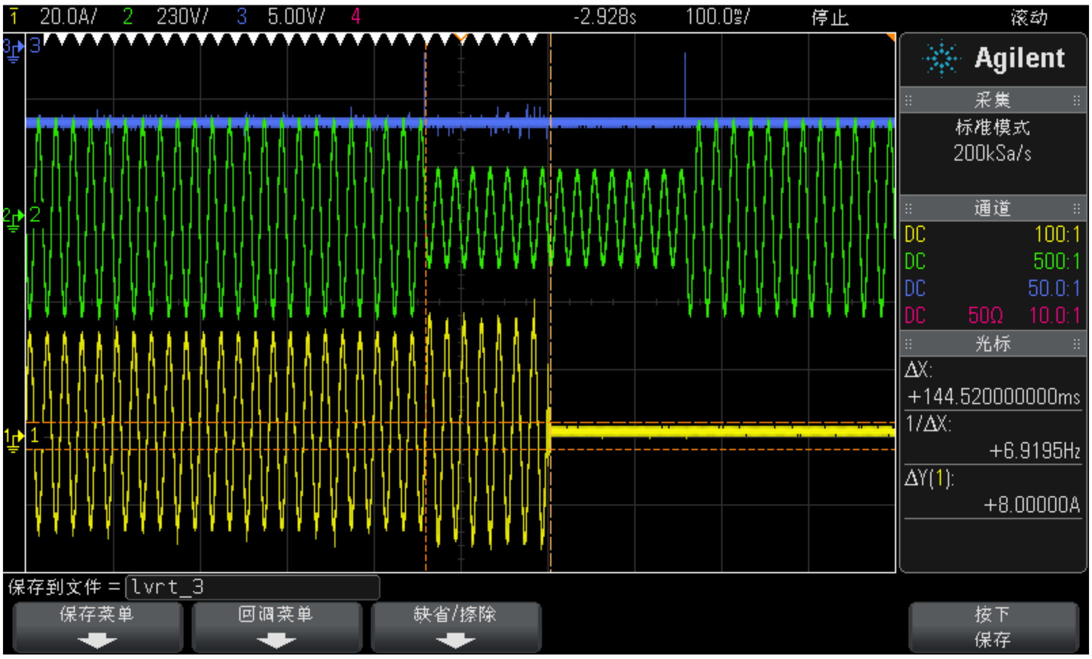
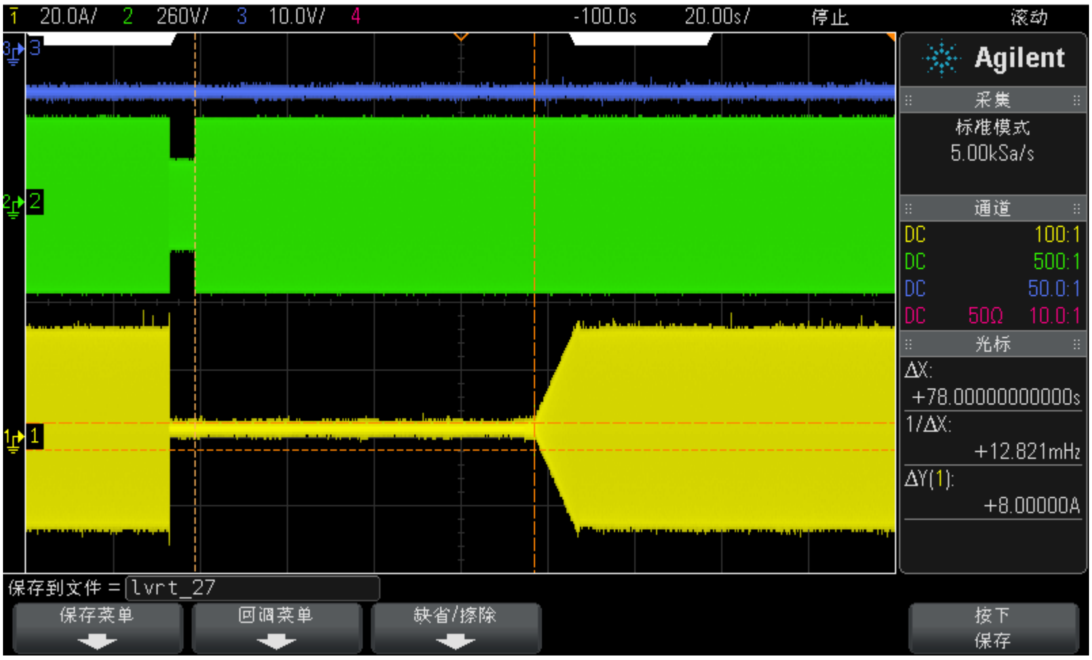
Clause	Requirement – Test	Result – Remark	Verdict

Disconnection Time - Under Voltage Second Level

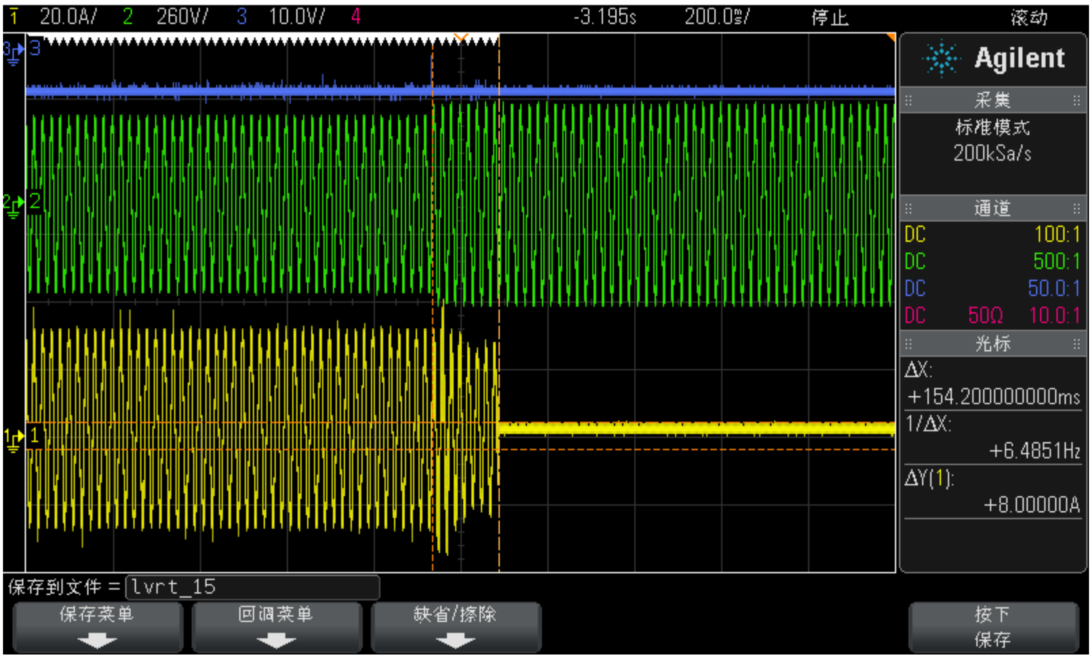


Reconnection Time - Under Voltage Second Level

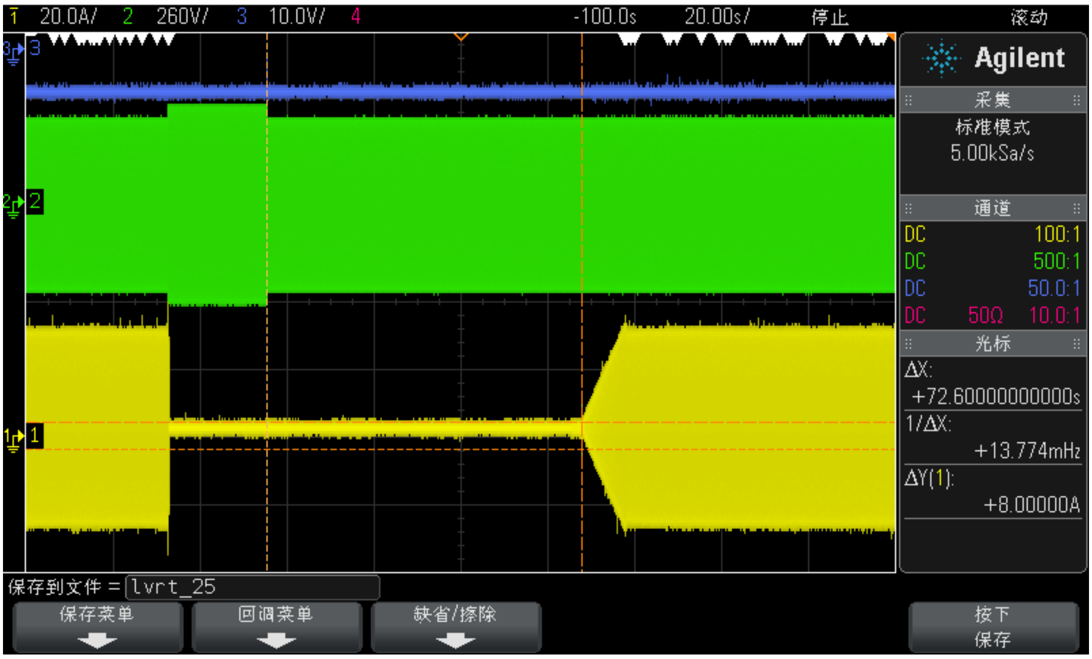


NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict

Disconnection Time - Over Voltage Second Level

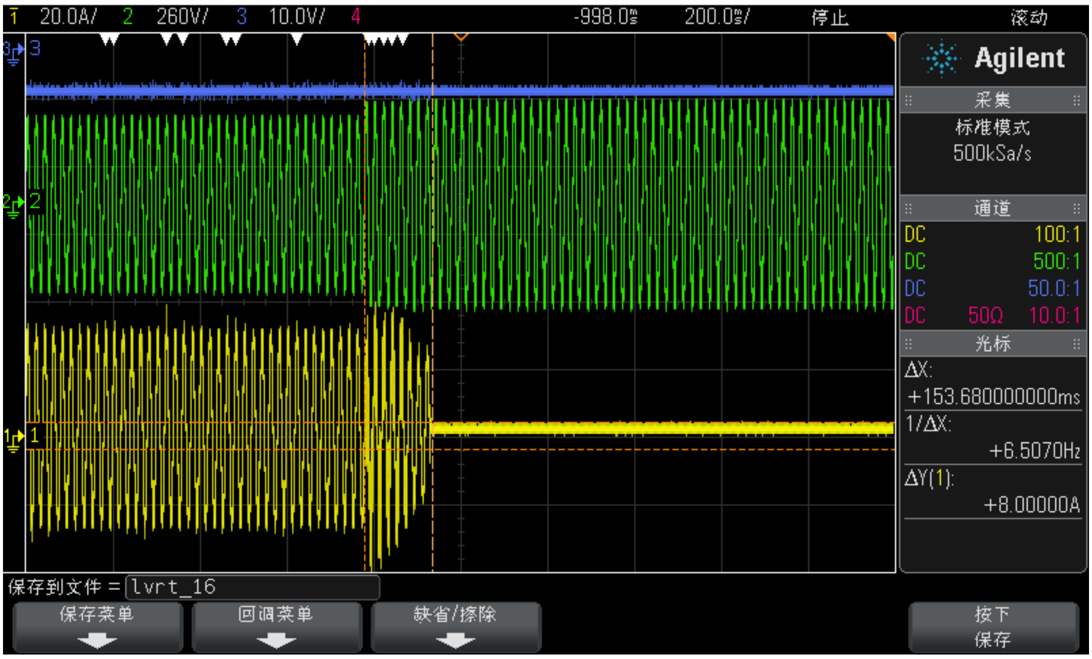


Reconnection Time - Over Voltage Second Level

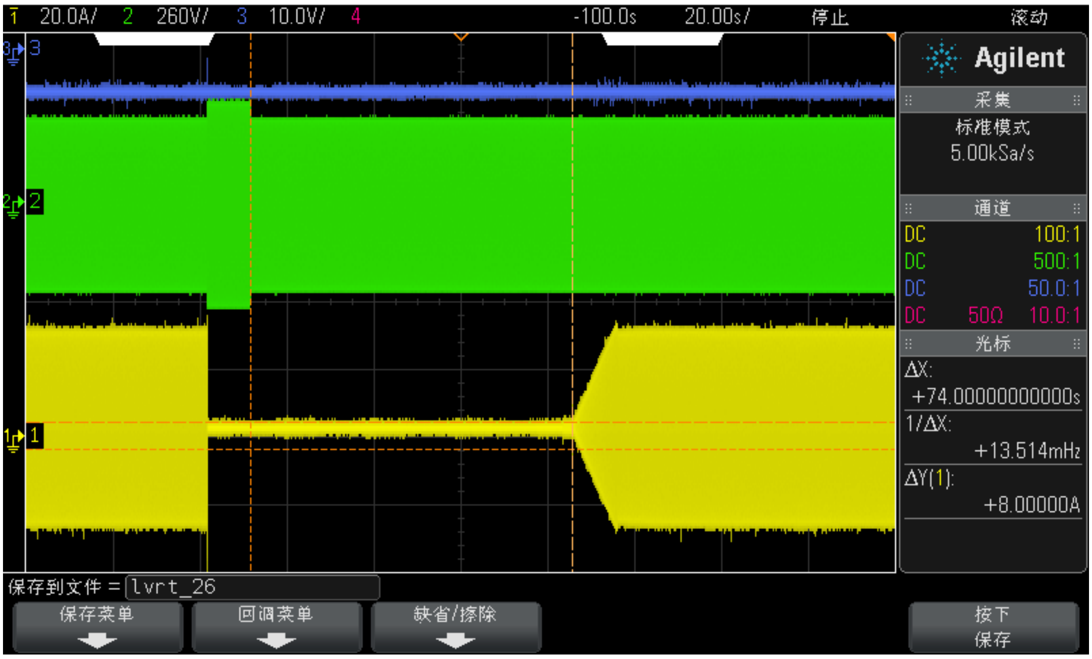


NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict

Disconnection Time - Over Voltage Third Level



Reconnection Time - Over Voltage Third Level



4.2.2.3.3	TABLE: Overfrequency and underfrequency							P
Model: Solis-1P4.6K-4G								
Test conditions	Output power: 4609 W Frequency: 50 Hz							
	Under frequency				Over frequency			
Parameter	Frequency	Time			Frequency	Time		
Output Voltage		90%U_N	U_N	110%U_N		90%U_N	U_N	110%U_N
Limit (ms)	47,00Hz	200			52,00Hz	4000+500		
Trip value (Hz)		47,0	47,0	47,0		52,00	52,00	52,00
Disconnection time (ms)	48,00Hz to 47,00Hz	146,4	158,0	160,0	51,50Hz to 52,50Hz	4250	4300	4230
Reconnection time (s)	min. 60s	72,9			min. 60s	72,4		

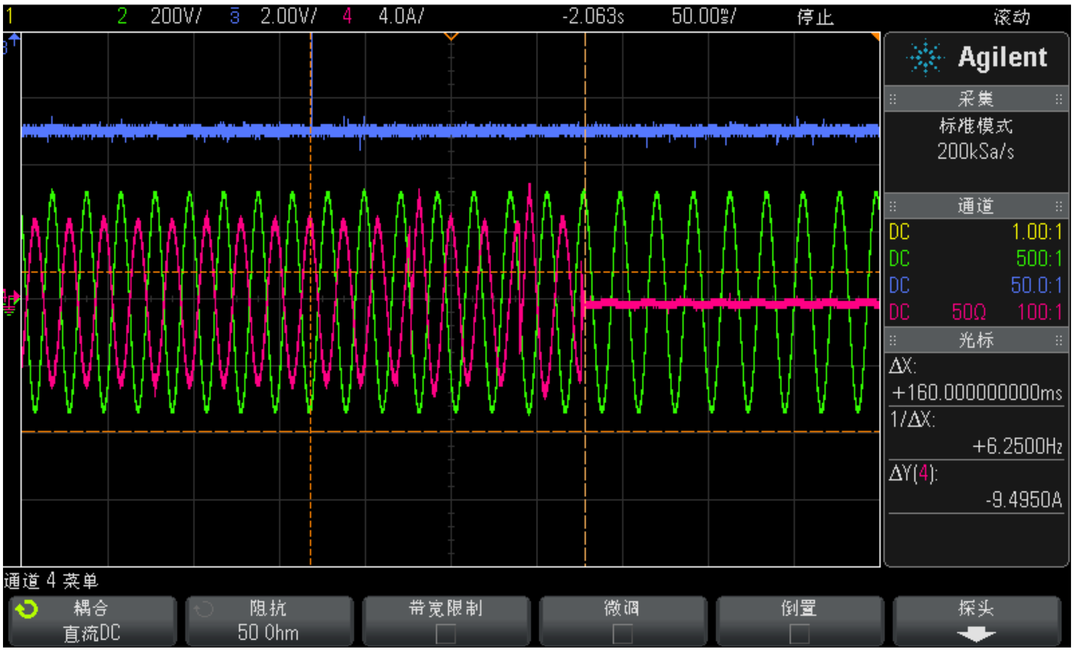
Note:

When the utility frequency is less than 47 Hz, the embedded generator shall disconnect from the utility network within 0,2 s. **When the utility frequency is more than 52 Hz for longer than 4 seconds, the embedded generator shall cease to energise the utility line within 0,5 s.**

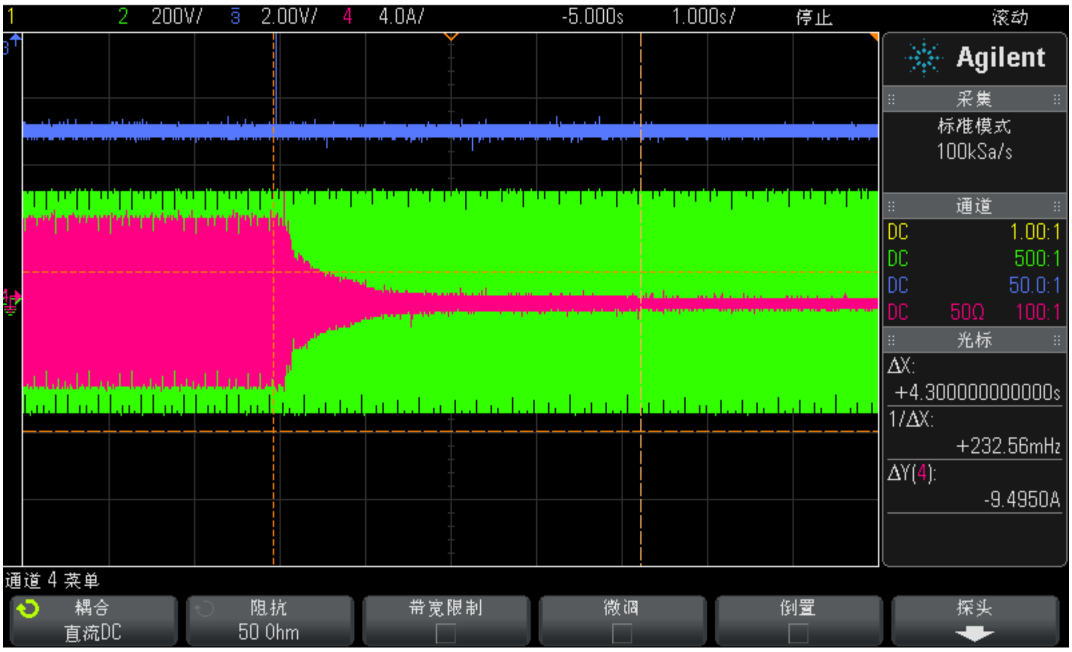
Controllable generators may reconnect immediately after the 60 s delay confirming recovery of the system voltage and frequency at a maximum rate of 10 % of rated power per minute, i.e. full power output will only be reached after 10 minutes.

The tests were performed on model Solis-1P4.6K-4G are also applicable for all other models stated in this report.

Disconnection Time - Under Frequency

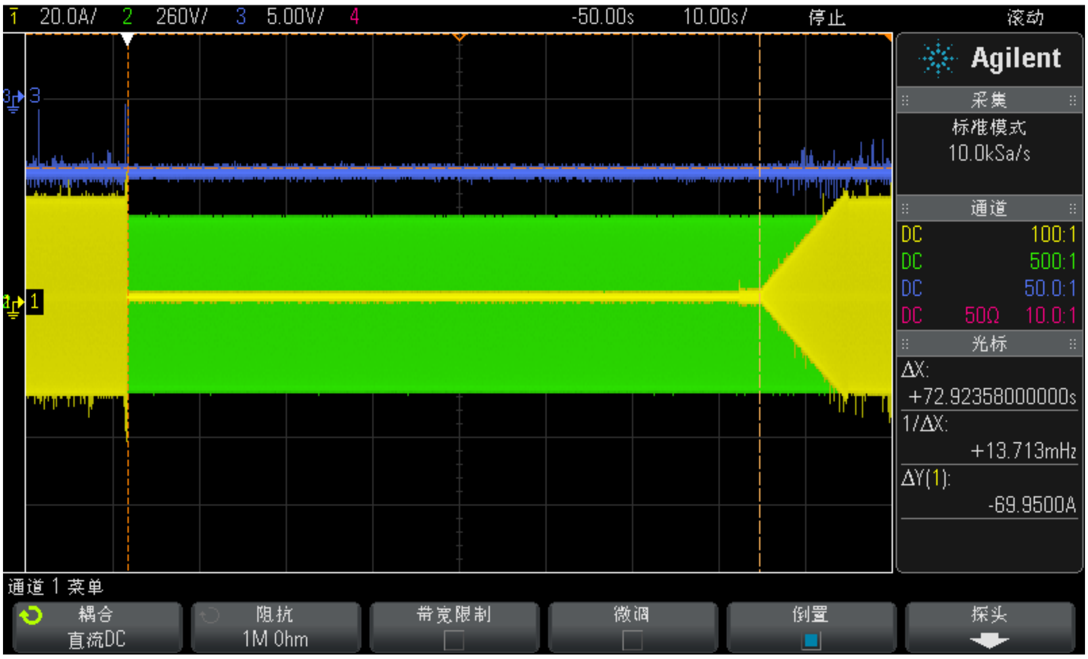


Disconnection time - Over Frequency

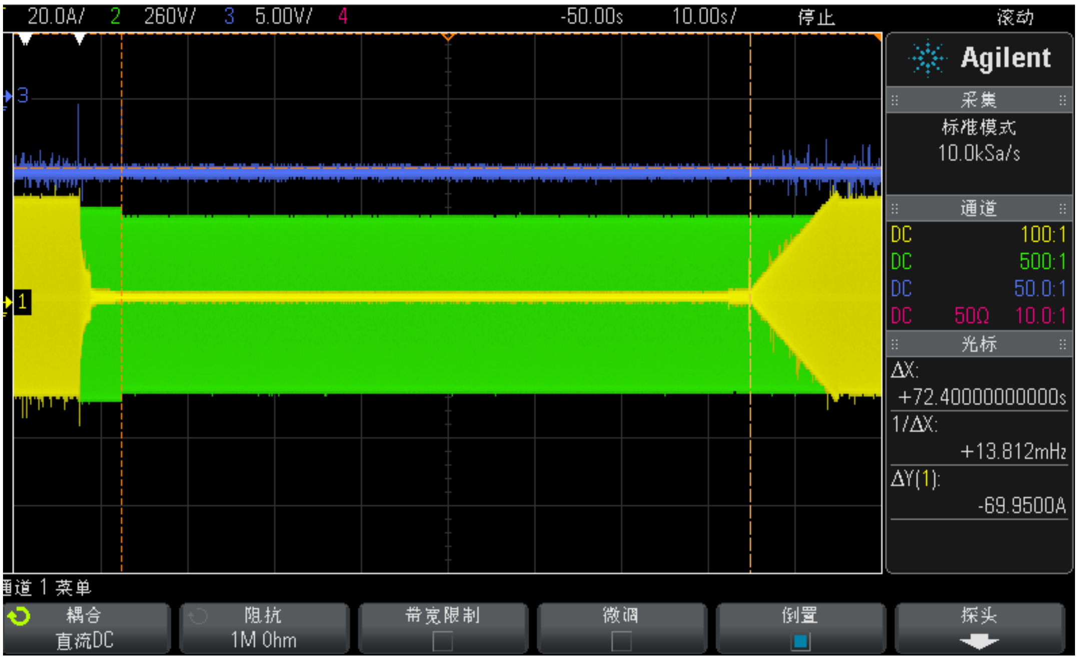


NRS 097-2-1:2017			
Clause	Requirement – Test	Result – Remark	Verdict

Reconnection Time - Under Frequency



Reconnection time - Over Frequency



4.2.2.3.3	TABLE: Power curtailment during over-frequency						P
Test:							
1-min mean value	a) 50,00 Hz	b) 50,60 Hz	c) 51,25 Hz	d) 51,75 Hz	e) 51,25 Hz	f) 50,60 Hz	g) 50,00 Hz
1. Measurement a) to g): Active power output > 80% P_{Emax}							
Frequency [Hz]:	50,00	50,60	51,25	51,75	51,25	50,60	50,00
$P_{setpoint}$ [kW]:	N/A	4,405	2,773	1,664	2,773	4,215	N/A
P_{E60} [kW]:	4,637	4,447	2,949	1,793	2,948	4,447	4,645
$\Delta P_{E60}/P_{Setpoint}$ [%]:	N/A	0,95	6,34	7,75	6,31	5,50	N/A
2. Measurement a) to g): Active power output 40% and 60% after freezing > 80% P_{Emax}							
Frequency [Hz]:	50	50,6	51,25	51,75	51,25	50,6	50
$P_{setpoint}$ [kW]:	N/A	2,209	1,453	0,872	1,453	2,209	N/A
P_{E60} [kW]:	2,325	2,229	1,479	0,906	1,481	2,232	2,325
$\Delta P_{E60}/P_{Setpoint}$ [%]:	N/A	0,92	1,78	3,91	1,92	1,05	N/A
Limit $\Delta P_{E60}/P_{Setpoint}$:	+ 10 % of P_{Emax}						

Note:

The EG system shall control the output power as a function of PM at a gradient of 50 % per Hertz as illustrated in figure 5. The power generation shall follow the curve shown in figure 5 up and down while the system frequency is in the range 50,5 Hz to 52 Hz.

The tests were performed on model Solis-1P4.6K-4G are also applicable for all other models stated in this report.

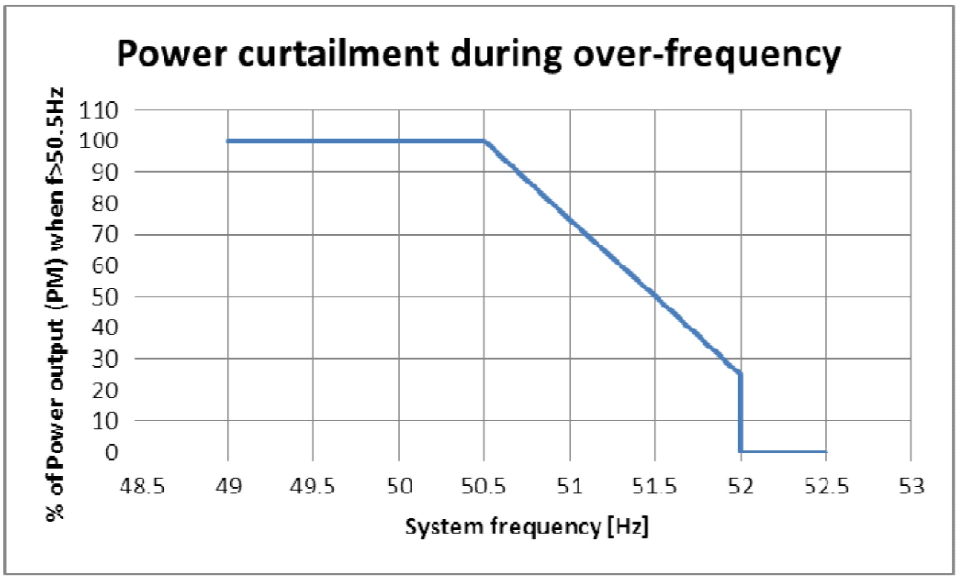


Figure 5 — Power curtailment during over-frequency

4.2.2.4	TABLE: Prevention of islanding (In accordance with IEC 62116)		P

Test circuit and parameters

Parameter	Symbol	Units
EUT DC Input		
DC voltage	V_{DC}	V
DC Current	I_{DC}	A
DC Power	P_{DC}	W
EUT AC ouput		
AC voltage	V_{EUT}	V
AC current	I_{EUT}	A
Real power	P_{EUT}	W
Reactive power	Q_{EUT}	VAr
Test Load		
Resistive load current	I_R	A
Inductive load current	I_L	A
Capacitive load current	I_C	A
AC (utility) power source		
Utility real power	P_{AC}	W
Utility reactive power	Q_{AC}	VAr
Utility current	I_{AC}	A

Block diagram test circuit IEC 62116.

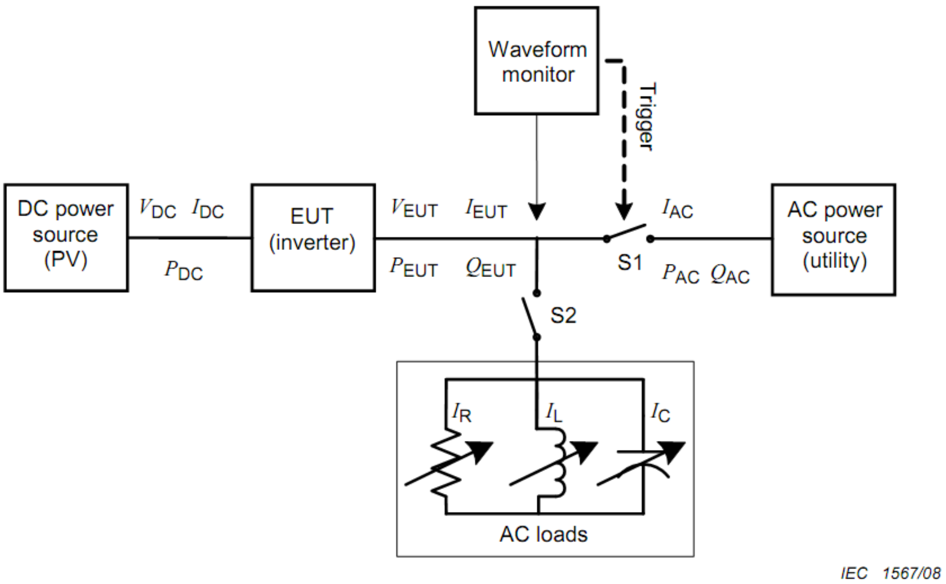


Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

4.2.2.4	TABLE: Prevention of islanding In accordance with IEC 62116, For test condition A (EUT output = 100%)								P
Model: Solis-1P4.6K-4G									
Disconnection limit	2,0 s								
No	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{ac} b) (% of nominal)	Q_{ac} c) (% of nominal)	Run on Time (ms)	P_{EUT} (kW)	Actual Q_f	V_{DC} d)	Remarks e)
1	100	100	0	0	279	4,60	1,00	400	Test A at BL
2	100	100	- 5	- 5	201	4,60	0,97	400	Test A at IB
3	100	100	- 5	0	225	4,60	0,98	400	Test A at IB
4	100	100	- 5	+ 5	266	4,60	1,01	400	Test A at IB
5	100	100	0	- 5	222	4,60	0,97	400	Test A at IB
6	100	100	0	+ 5	182	4,60	1,02	400	Test A at IB
7	100	100	+ 5	- 5	154	4,60	0,99	400	Test A at IB
8	100	100	+ 5	0	180	4,60	1,02	400	Test A at IB
9	100	100	+ 5	+ 5	125	4,60	1,03	400	Test A at IB

Note:

a) *P*EUT: EUT output power

b) *P*ac: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

c) Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

d) For test condition A, > 75 % of rated input voltage range used, for test condition B, 50 % of rated input voltage range, ±10 % used, for test condition C, < 20 % of rated input voltage range used. Based on EUT rated input operating range. For example, if range is between X volts and Y volts, 75 % of range = X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

e) BL: Balance condition, IB: Imbalance condition.

4.2.2.4	**TABLE: Prevention of islanding In accordance with IEC 62116, For test condition B (EUT output = 50 % – 66 %)**								**P**
Model: Solis-1P4.6K-4G									
Disconnection limit			2,0 s						
No	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{ac} b) (% of nominal)	Q_{ac} c) (% of nominal)	Run on Time (ms)	P_{EUT} (kW)	Actual Q_f	V_{DC} d)	Remarks e)
1	66	66	0	- 5	171	3,03	0,96	300	Test B at IB
2	66	66	0	- 4	271	3,03	0,97	300	Test B at IB
3	66	66	0	- 3	280	3,03	0,98	300	Test B at IB
4	66	66	0	- 2	257	3,03	0,98	300	Test B at IB
5	66	66	0	- 1	282	3,03	0,99	300	Test B at IB
6	66	66	0	0	280	3,03	1,00	300	Test B at BL
7	66	66	0	+ 1	264	3,03	1,01	300	Test B at IB
8	66	66	0	+ 2	181	3,03	1,02	300	Test B at IB
9	66	66	0	+ 3	178	3,03	1,02	300	Test B at IB
10	66	66	0	+ 4	176	3,03	1,03	300	Test B at IB
11	66	66	0	+ 5	157	3,03	1,04	300	Test B at IB

Note:
a) *P*EUT: EUT output power
b) *P*ac: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
c) Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
d) For test condition A, > 75 % of rated input voltage range used, for test condition B, 50 % of rated input voltage range, ±10 % used, for test condition C, < 20 % of rated input voltage range used. Based on EUT rated input operating range. For example, if range is between X volts and Y volts, 75 % of range = X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.
e) BL: Balance condition, IB: Imbalance condition.

4.2.2.4	**TABLE: Prevention of islanding** **In accordance with IEC 62116, For test condition C (EUT output = 25 % – 33 %)**								**P**
Model: Solis-1P4.6K-4G									
Disconnection limit		2,0 s							
No	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L in 6.1.d) 1)	P_{ac} b) (% of nominal)	Q_{ac} c) (% of nominal)	Run on Time (ms)	P_{EUT} (kW)	Actual Q_f	V_{DC} d)	Remarks e)
1	33	33	0	- 5	183	1,52	0,96	160	Test C at IB
2	33	33	0	- 4	204	1,52	0,97	160	Test C at IB
3	33	33	0	- 3	232	1,52	0,98	160	Test C at IB
4	33	33	0	- 2	295	1,52	0,98	160	Test C at IB
5	33	33	0	- 1	213	1,52	0,99	160	Test C at IB
6	33	33	0	0	202	1,52	1,00	160	Test C at BL
7	33	33	0	+ 1	178	1,52	1,01	160	Test C at IB
8	33	33	0	+ 2	192	1,52	1,02	160	Test C at IB
9	33	33	0	+ 3	182	1,52	1,03	160	Test C at IB
10	33	33	0	+ 4	182	1,52	1,04	160	Test C at IB
11	33	33	0	+ 5	174	1,52	1,05	160	Test C at IB

Note:
a) *P*EUT: EUT output power
b) *P*ac: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
c) Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
d) For test condition A, > 75 % of rated input voltage range used, for test condition B, 50 % of rated input voltage range, ±10 % used, for test condition C, < 20 % of rated input voltage range used. Based on EUT rated input operating range. For example, if range is between X volts and Y volts, 75 % of range = X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.
e) BL: Balance condition, IB: Imbalance condition.
The tests were performed on model Solis-1P4.6K-4G are also applicable for all other models stated in this report.

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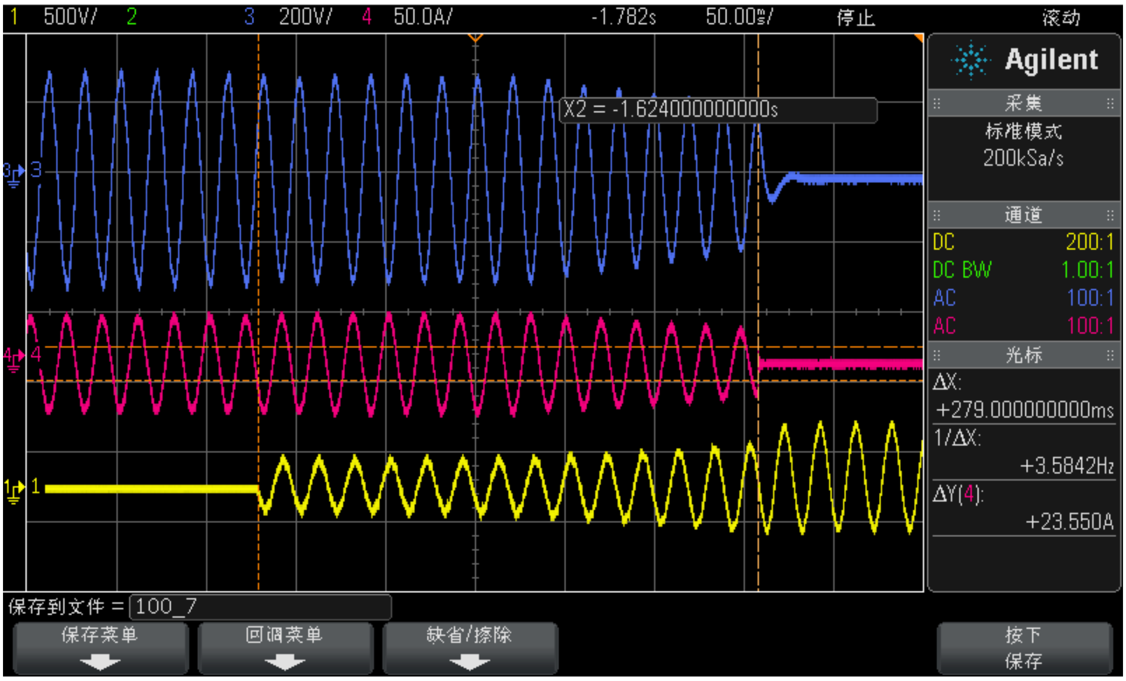
Clause	Requirement – Test	Result – Remark	Verdict

Graph of disconnection at balance condition (P_{AC} 0 and Q_{AC} 0 reactive load) @100% nominal power



Graph of disconnection at balance condition (P_{AC} 0 and Q_{AC} -1% reactive load) @66% nominal power

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Clause	Requirement – Test	Result – Remark	Verdict

Graph of disconnection at balance condition (P_{AC} 0 and Q_{AC} -2% reactive load) @33% nominal power

Appendix 1: Specification of the relay

AZSR131

35 AMP MINIATURE POWER RELAY

FEATURES:

- Dielectric strength 4500Vrms
- 35 Amp switching
- Contact gap : 1.8mm/2.3 mm available
- Clearance / creepage > 6.4 / 7.5mm
- UL CUR file：E469841
- TUV Pending
- CQC Pending

CONTACTS

Arrangement	SPST (1 Form A)
Ratings	Resistive load: Max. switched power: 9695VA Max. switched current: 35A Max. switched voltage: 277VAC
Rated Load **UL**	26A at 277 VAC, resistive, 85°C, 50k cycles 31A at 277 VAC, resistive, 85°C, 30k cycles 35A at 277 VAC, resistive, 85°C, 30k cycles
TUV	26A at 277 VAC, resistive, 85°C, 50k cycles 31A at 277 VAC, cos phi 0.8, 85°C, 30k cycles * 35A at 277 VAC, cos phi 0.8, 85°C, 30k cycles * * duty factor: 0.1 seconds on / 10 seconds off
Material	Silver tin oxide
Resistance	< 100 mΩ initially (at 6V, 1A, voltage drop method)

Coil

Power **At pickup Voltage** **Max. Continuous Dissipation** **Temperature Rise**	 790 mw (typical) 2.0 W at 20℃(68℉) ambient 70℃ Max. at Rated voltage,35A,85℃
Temperature	Max. 155℃(311℉) class F

Notes

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

GENERAL DATA

Life Expectancy: Mechanical Electrical	Minimum operations 100,000 cycles Min. (2.3mm gap) 300,000 cycles Min. (1.8mm gap) 30k cycles @35A 277VAC Res. 30k cycles @35A 277VAC cos phi 0.8
Operate Time(typical)	20 ms Max. at nominal coil voltage
Release Time(typical)	10 ms Max. at nominal coil voltage (with no coil suppression)
Dielectric Strength (at sea level for 1min.)	4500 Vrms(coil to contacts) 3500 Vrms(between open contacts)
Surge Voltage	10KV @1.2/50μs (coil to contacts)
Insulation Resistance	1,000MΩ min. at 20℃ 500VDC 50% RH
Holding voltage	Greater than 35% of nominal coil voltage
Dropout	Greater than 5% of nominal coil voltage
Ambient Temperature Operating Storage	At rated coil voltage -40℃(-40F)to 85℃(140℉) -40℃(-40F)to 105℃(221℉)
Vibration	1.5mm DA at 10-55 Hz,
Shock	20g
Enclosure	P.B.T, Polyester
Terminals	Tinned copper alloy, P.C.
Max. Solder Temp.	270℃(518℉)
Max. solder time	5 seconds
Weight	25g

ZETTLER RELAY (XIAMEN) CO., LTD. www.zettlercn.com
East of 3/F, Yinfeng Building No. 48-50 Huli Road Huli District, Xiamen Tel:(0592)6151211 Fax: (0592)6151221

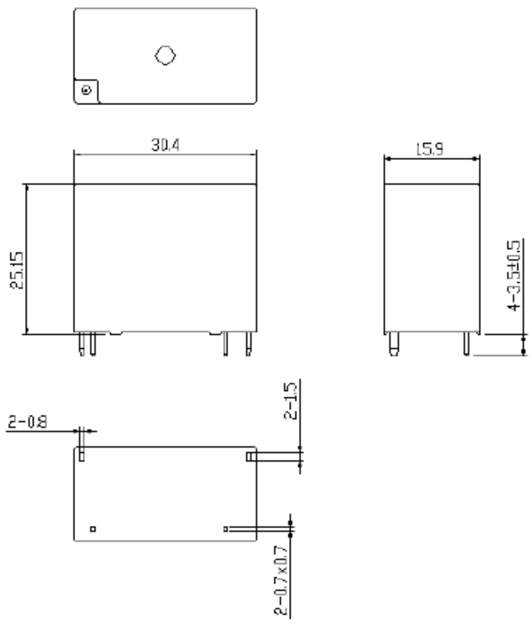
AZSR131

Relay ordering data

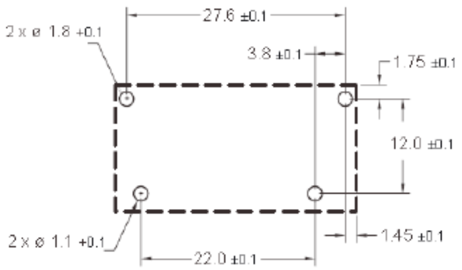
COIL SPECIFICATIONS					ORDER NUMBER
Nominal Coil VDC	**Must Operate VDC**	**Min holding VDC**	**Max. Continuous VDC**	**Coil Resistance Ω±10%**	
5	3.75	1.75	6	18	AZSR131-1AE-5D
9	6.75	3.15	10.8	58	AZSR131-1AE-9D
12	9	4.2	14.4	103	AZSR131-1AE-12D
18	13.5	6.3	21.6	230	AZSR131-1AE-18D
24	18	8.4	28.8	410	AZSR131-1AE-24D
48	36	16.8	57.6	1650	AZSR131-1AE-48D

Add suffix "GW" after "D" for glow wire version. Add suffix "（200）" for 2.3mm gap version.
All values at 20℃

Mechanical data

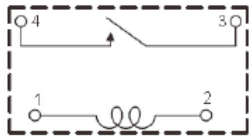


PC BOARD LAYOUT



Viewed toward terminals

WIRING DIAGRAM



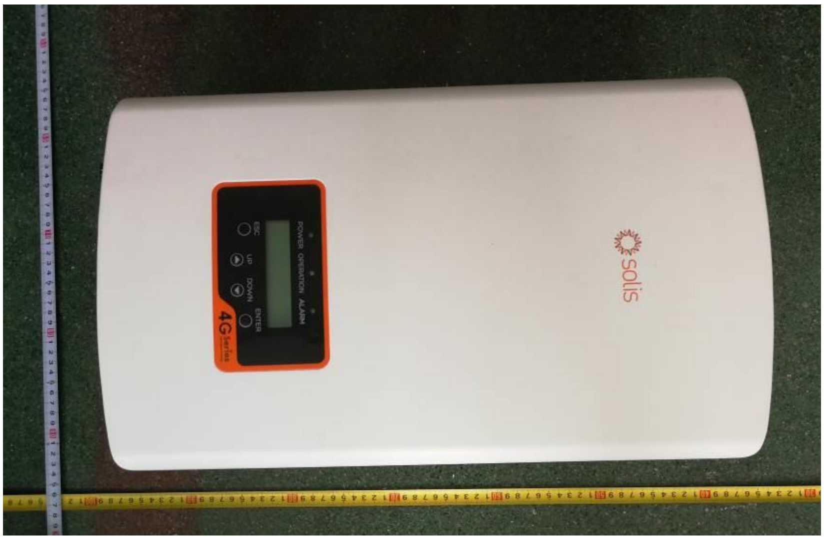
Viewed toward terminals

Tolerance: ±0.3mm

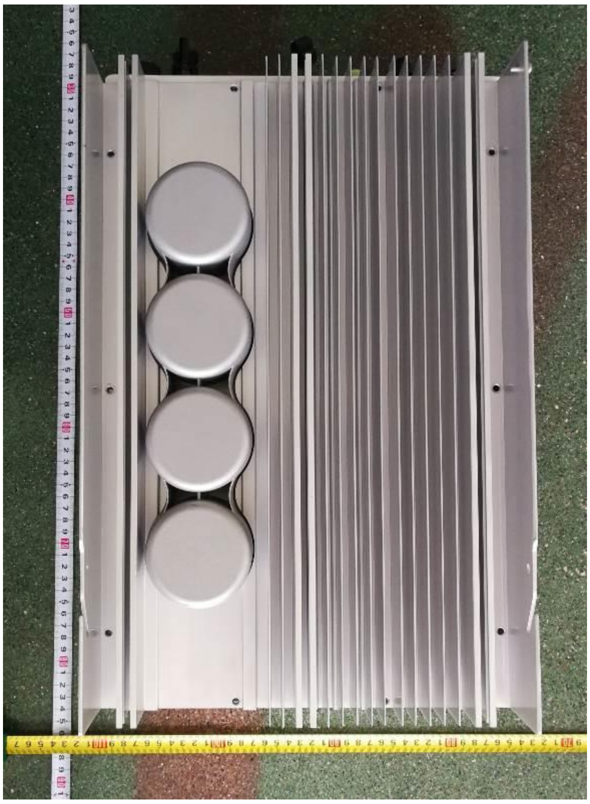
ZETTLER RELAY (XIAMEN) CO., LTD. www.zettlercn.com
East of 3/F, Yinfeng Building No. 48-50 Huli Road Huli District, Xiamen Tel:(0592)6151211 Fax: (0592)6151221

Appendix 2: Photo documentation

Enclosure – Front View

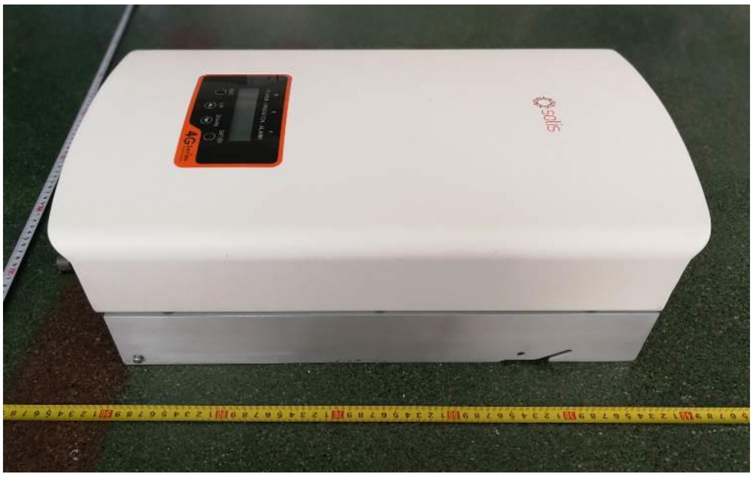


Enclosure – Rear View



Enclosure – Left Side View

Enclosure – Right Side View

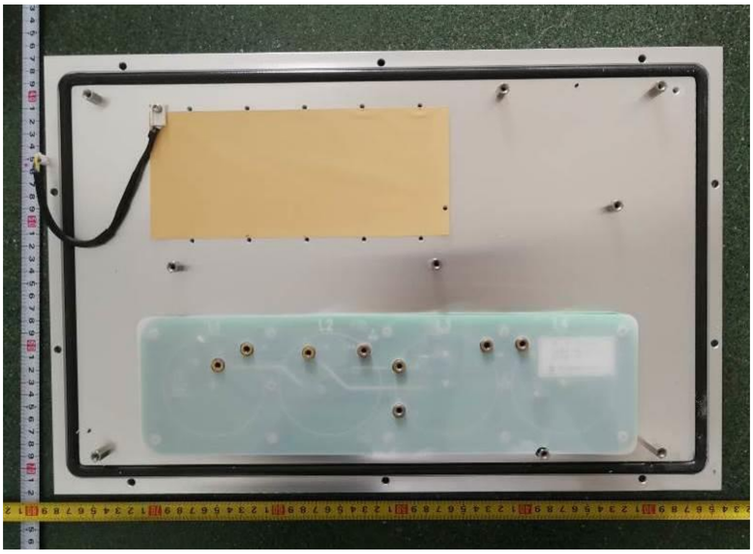


Enclosure – Bottom View (Dual Channel MPPT Input)

Enclosure – Bottom View (Single Channel MPPT Input)

Enclosure – Top View

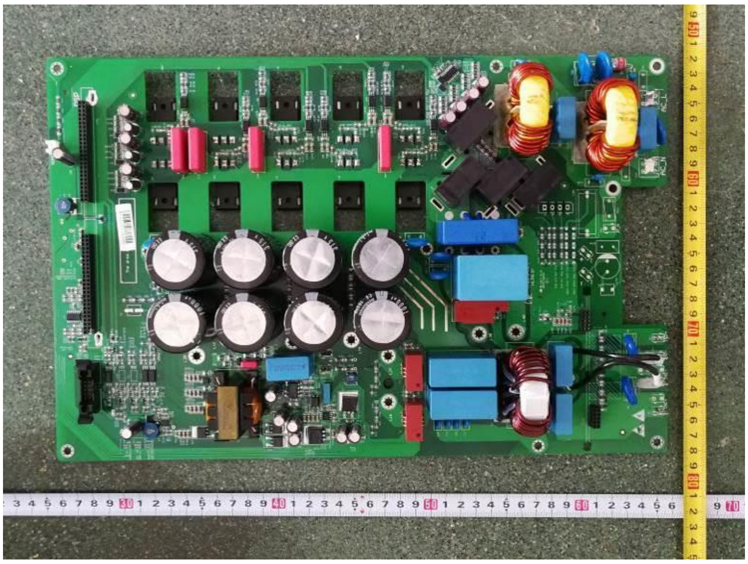
Heat-sink Internal View



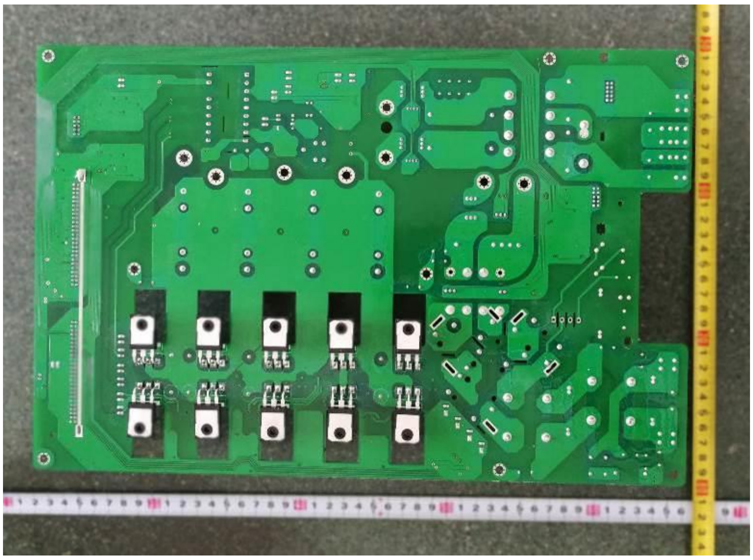
Internal View of Open Top Cover

Internal View of Open Top Cover

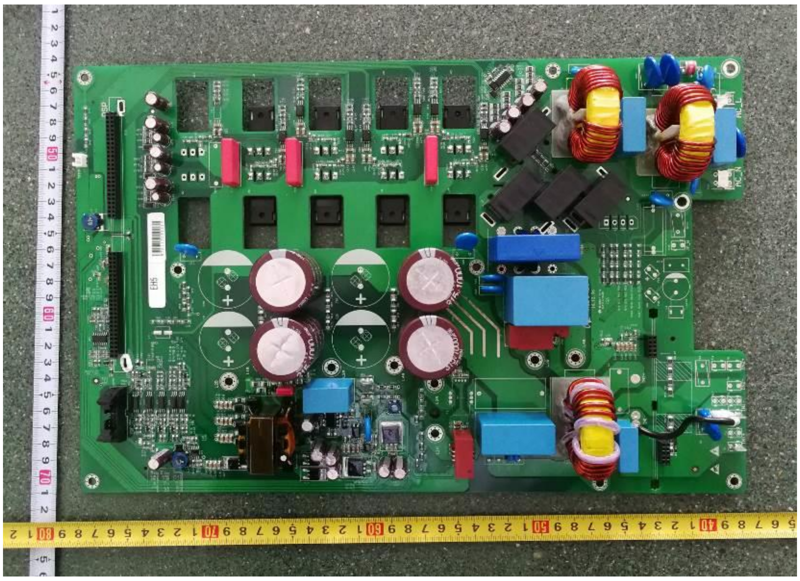
Main Board - Component Side



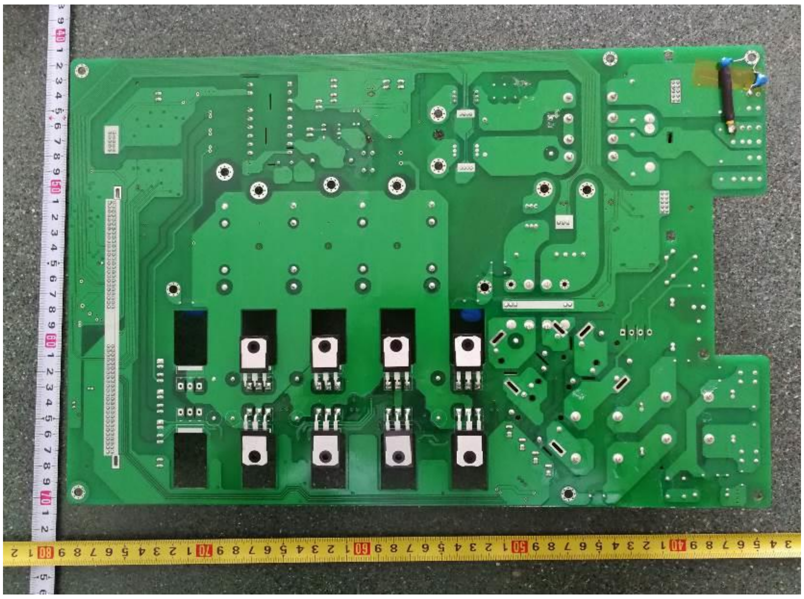
Main Board - Solder Side



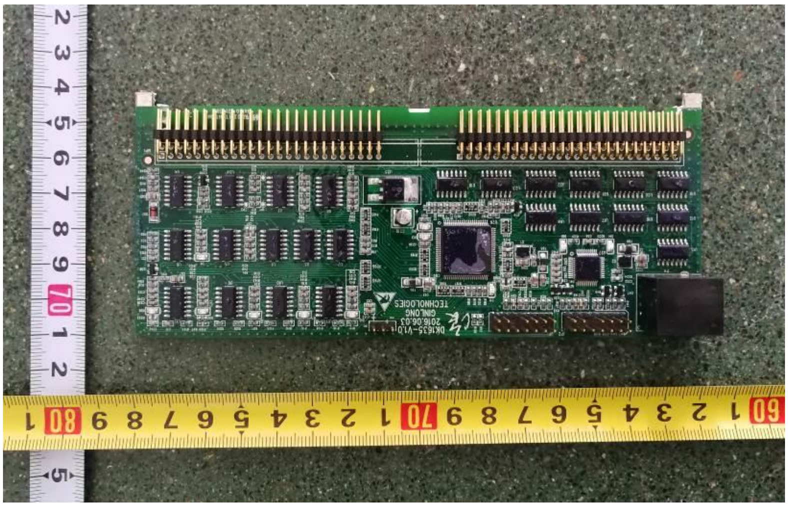
Main Board - Component Side



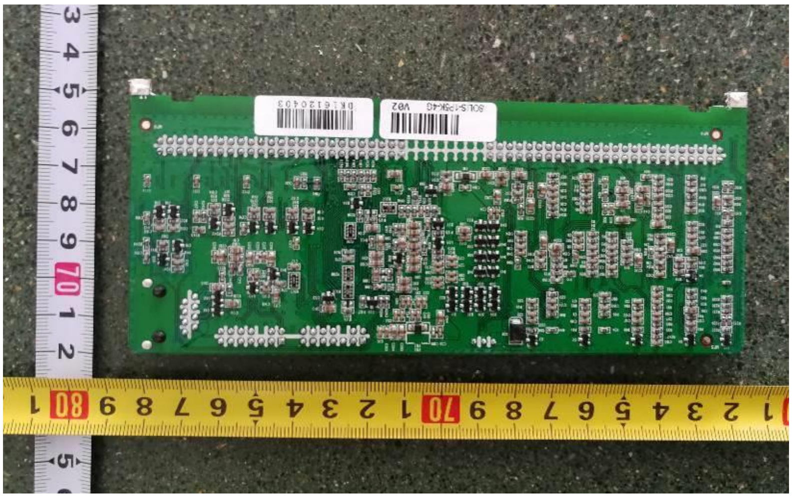
Main Board - Solder Side



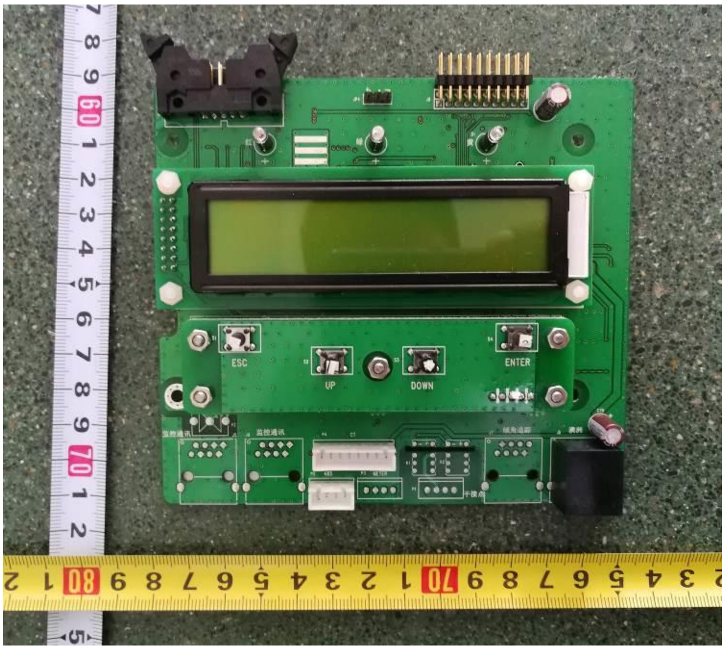
Control Board - Component Side



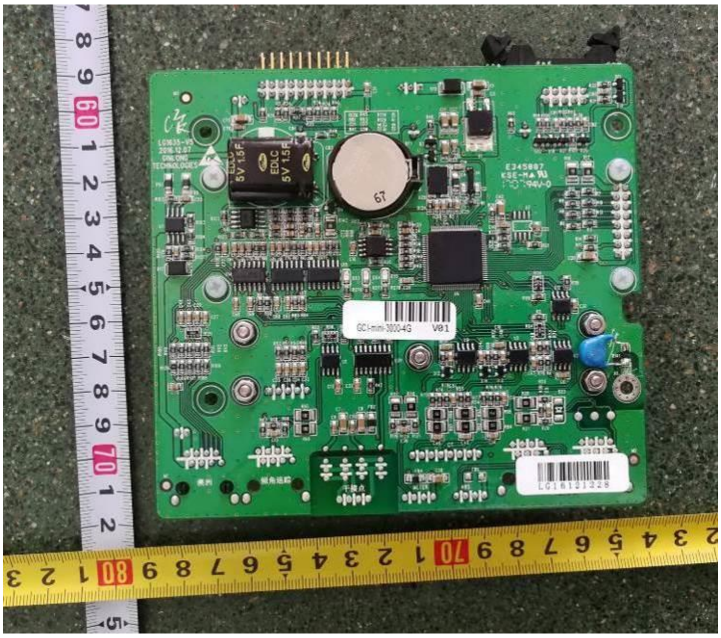
Control Board - Solder Side



LCD Board - Component Side



LCD Board - Solder Side



Appendix 3:
EMC Report of Conducted Emission in the frequency band 30 kHz to 150 kHz

DEKRA

Test Report

Product Name	:	PV Grid-Tied Inverter
Model No.	:	Solis-1P4.6K-4G
Applicable Standard	:	IEC 61000-2-2:2002+A1:2017+A2:2018 (Clause 4.12.3:30KHz-150KHz)
Test Result	:	PASS
Report No.	:	20C0120R-V2

Applicant	:	Ginlong Technologies Co., Ltd.
Address	:	No.57 Jintong Road, Binhai Industrial Park, Xiangshan, Ningbo, Zhejiang, PEOPLE'S REPUBLIC OF CHINA

Test Laboratory	:	DEKRA Testing and Certification (Suzhou) Co., Ltd.
Address	:	No.99 Hongye Rd., Suzhou Industrial Park, Suzhou,215006, Jiangsu,China
Tel / Fax	:	0512-6251-5088 / 0512-6251-5098

Documented By	:	Hui Yu (Project Assistant: Hui Yu)
Reviewed By	:	Star Wang (Supervisor: Star Wang)
Approved By	:	Jerry Pan (Manager: Jerry Pan)

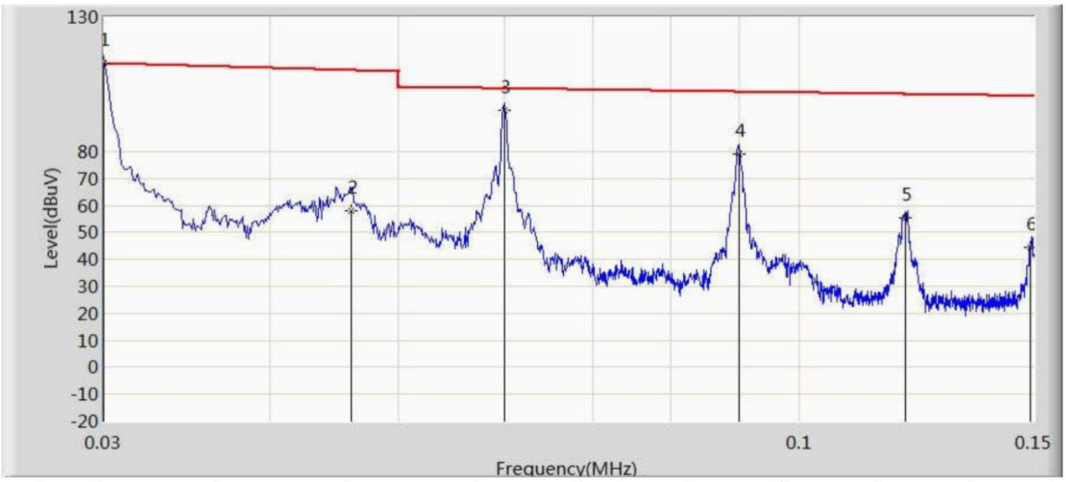
Note: The test results relate only to the samples tested.

1. Overview of results

EMISSION TESTS			
Requirement – Test case	Basic standard(s)	Verdict	Remark
Conducted disturbance voltage at AC mains power port	IEC 61000-2-2	PASS	---

2. Conducted Emission
2.1. Test Result

Engineer: Yves	
Site: AC1	Time: 2020/12/01
Limit: IEC61000-2-2-CE-Mains(30KHz-150KHz)	Margin: 0
Probe: NNLK 8129(0.009-30MHz)	Polarity: Line
EUT: PV Grid-Tied Inverter	Power: Input :400V DC, Output : 230Vac,50Hz
Note: PV Mode	

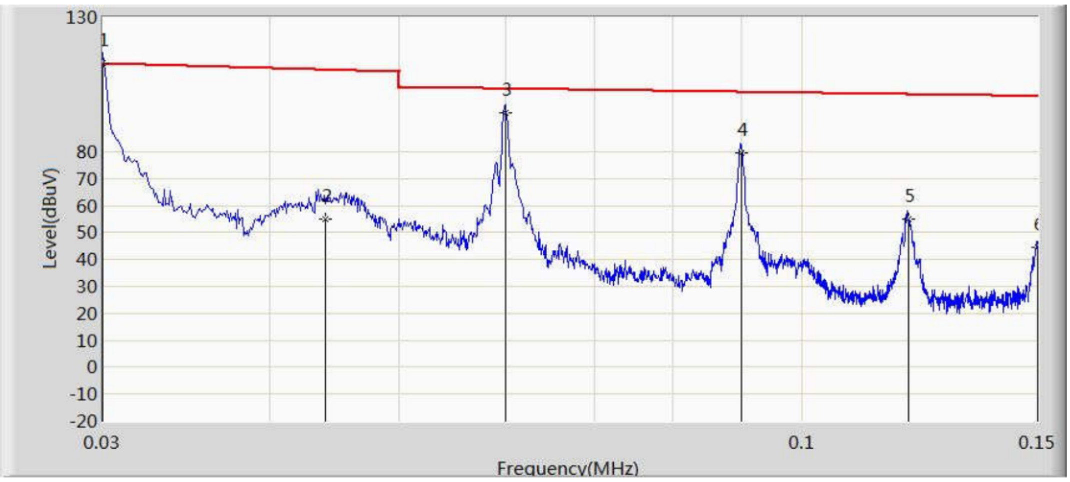


No	Mark	Frequency (MHz)	Measure Level (dBuV)	Reading Level (dBuV)	Over Limit (dB)	Limit (dBuV)	Probe (dB)	Cable (dB)	Amp (dB)	Type
1	*	0.030	112.736	112.348	-0.264	113.000	0.359	0.029	0.000	QP
2		0.046	57.860	57.764	-52.610	110.469	0.067	0.029	0.000	QP
3		0.060	95.441	95.358	-8.013	103.453	0.054	0.029	0.000	QP
4		0.090	79.013	78.945	-23.222	102.235	0.039	0.029	0.000	QP
5		0.120	55.425	55.361	-45.939	101.364	0.035	0.029	0.000	QP
6		0.149	44.658	44.597	-56.061	100.720	0.033	0.029	0.000	QP

Note:

1. " * ", means this data is the worst emission level.
2. Measurement Level = Reading Level + Factor(Probe+Cable-Amp).

Engineer: Yves	
Site: AC1	Time: 2020/12/01
Limit: IEC61000-2-2-CE-Mains(30KHz-150KHz)	Margin: 0
Probe: NNLK 8129(0.009-30MHz)	Polarity: Neutral
EUT: PV Grid-Tied Inverter	Power: Input :400V DC, Output : 230Vac,50Hz
Note: PV Mode	



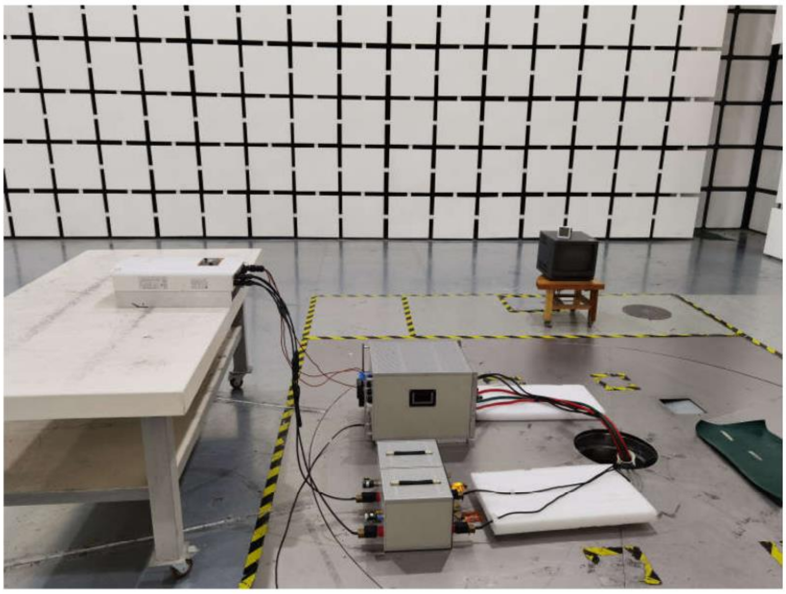
No	Mark	Frequency (MHz)	Measure Level (dBuV)	Reading Level (dBuV)	Over Limit (dB)	Limit (dBuV)	Probe (dB)	Cable (dB)	Amp (dB)	Type
1	*	0.030	112.880	112.496	-0.120	113.000	0.355	0.029	0.000	QP
2		0.044	54.802	54.703	-56.013	110.815	0.071	0.029	0.000	QP
3		0.060	94.670	94.587	-8.783	103.453	0.055	0.029	0.000	QP
4		0.090	79.763	79.694	-22.478	102.241	0.040	0.029	0.000	QP
5		0.120	55.042	54.978	-46.338	101.380	0.035	0.029	0.000	QP
6		0.150	44.467	44.405	-56.246	100.713	0.033	0.029	0.000	QP

Note:

1. " * ", means this data is the worst emission level.
2. Measurement Level = Reading Level + Factor(Probe+Cable-Amp).

Test Photograph

Description: Conducted Emission Test Setup



3. Test and measure equipment list

Conducted disturbance voltage (AC mains port)

Instrument	Manufacturer	Model No.	Serial No.	Cali. Due Date
EMI Test Receiver	R&S	ESCI	100906	2021.04.17
Artificial Mains Network	SCHWARZBECK	NNLK 8129	8129-282	2021.04.16
Coaxial Cable	Huber+Suhner	RG 223	TR1-C1	2021.08.26
Temperature/Humidity Meter	RTS	RTS-8S	AC1-TH	2021.08.18

4. EUT PHOTOS

EUT PHOTOS (1)


EUT PHOTOS (2)


EUT PHOTOS (3)

EUT PHOTOS (4)

The End

--END--