TEST REPORT

NRS 097-2-1:2017

TUV SUD Test report for Grid interconnection of embedded generation
Part 2: Small-scale embedded generation
Section 1: Utility interface

Report reference No. .... :	64.290.23.30910.01
Date of issue .... :	2023-08-21
Project handler………… .... :	Lucas Lu
TÜV SÜD Branch.............................. :	TÜV SÜD Certification and Testing (China) Co., Ltd. Guangzhou Branch
Address .... :	TÜV SÜD Testing Center, D1 building, No. 63 Chuangqi Road, Shilou Town, Panyu District, Guangzhou 511447, China
Testing location .... :	TÜV SÜD Certification and Testing (China) Co., Ltd. Guangzhou Branch
Client.. :	EAST Group Co., Ltd.
Client number………… .... :	076644
Address .... :	No.6 Northern Industry Road, Songshan Lake Sci. & Tech. Industry Park, 523808 DongGuan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Contact person…… .... :	Haijian Pan
Standard .... :	This TUV SUD test report form is based on the following requirements: NRS 097-2-1:2017 Edition 2.1
TRF originated by.............................. :	TUV SUD Certification and Testing (China) Co., Ltd. Shanghai Branch, Mr. Pengdong Yang
Copyright blank test report................. :	This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TUV SUD Product Service GmbH. TUV SUD Group takes no responsibility for and will not assume liability for damages resulting from the reader’s interpretation of the reproduced material due to its placement and context.
Scheme .... :	☐ GS, ☐ TÜV Mark, ☐ EU-Directive, ☐ without certification ☒ Type verification of conformity
Non-standard test method .... :	☒ No ☐ Yes, see details under Summary
National deviations............................ :	N/A
Number of pages (Report)................. :	54
Number of pages (Attachments) .... :	N/A
Compiled by .... : Lucas Lu (+ signature) Lucas Lu	Approved by.....: Kennen Wang (+ signature) Kennen Wang

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn

TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

Test sample.....................................:	Hybrid Inverter
Type of test object.............................. :	Hybrid Inverter
Trademark... :	EAST®
Model and/or type reference.............. :	EAHI-6000-SL-S
Rating(s).. :	See characteristic data on page 8
Manufacturer...................................... :	EAST Group Co., Ltd.
Manufacturer number…..................... :	076644
Address .... :	No.6 Northern Industry Road, Songshan Lake Sci. & Tech. Industry Park, 523808 DongGuan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Sub-contractors/ tests (clause).......... :	N/A
Name.. :	N/A
Order description…........................... :	☒ Complete test according to TRF ☐ Partial test according to manufacturer's specifications ☐ Preliminary test ☐ Spot check
Date of order……… .... :	2023-04-23
Date of receipt of test item................. :	2023-04-25
Date(s) of performance of test........... :	2023-04-25 to 2023-05-28

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn

TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

Test item particulars: All the tests' results confirmed to the requirements of the standard.
Attachments: N/A
General remarks: "(see remark #)" refers to a remark appended to the report. "(see appended table)" refers to a table appended to the report. Throughout this report a comma is used as the decimal separator. The 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 testing laboratory.

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Telefax : +86 20 38320478
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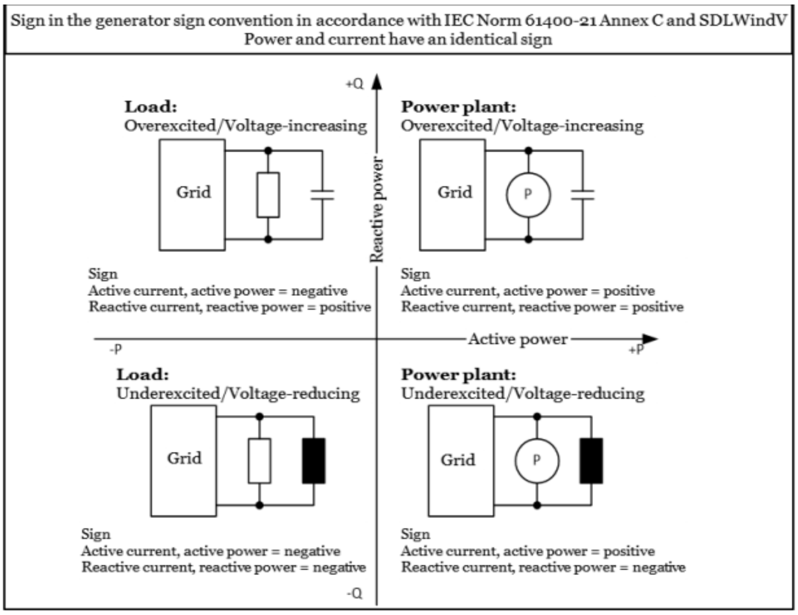
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

Summary of testing:

☐ deviation(s) found

☒ no deviations found

Generator sign convention has been applied for all measurements and results given in this report. This is described in the following figure and table.



	Inductive (under-excited)	Capacitive(over-excited)
Generator (Discharge mode)	IV. Quadrant P > 0, the equipment supplies active power from the mains (Discharge mode) Q < 0, the equipment draws reactive power from the mains (inductive behaviour)	I. Quadrant P > 0, the equipment supplies active power from the mains (Discharge mode) Q > 0, the equipment supplies reactive power to the mains (capacitive behaviour)
Consumer (Charge mode)	III. Quadrant P < 0, the equipment draws active power from the mains (Charge mode) Q < 0, the equipment draws reactive power from the mains (inductive behaviour)	II. Quadrant P < 0, the equipment draws active power from the mains (Charge mode) Q > 0, the equipment supplies reactive power to the mains (capacitive behaviour)

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Copy of marking plate:

EAST®

MODEL: EAHI-6000-SL-S HYBRID INVERTER

PV input

Max. input power	8000 W
Rated input voltage	360 Vd.c.
Max.input voltage	550 Vd.c.
MPPT voltage range	100 Vd.c.~540 Vd.c.
MPPT voltage range (full load)	250 Vd.c.-450 Vd.c
Max. input current	15 Ad.c./15 Ad.c.
PV short circuit current	20 Ad.c./20 Ad.c.

Battery input/output rating

Battery type	Li-ion
Rated voltage	51.2 Vd.c.
Battery voltage range	40.8 Vd.c.~57.6 Vd.c.
Max. charging power	5000 W
Max. charging current	100 Ad.c.
Max. discharging power	6000 W
Max. discharging current	120 Ad.c.

Grid rating

Rated voltage	230 Va.c. L/N/PE
Rated frequency	50/60 Hz
*Rated input/output power	6000 W
*Max. apparent power	6000 VA
*Max. output/input current	26.09 Aa.c.
Power factor range	0.8 leading~0.8 lagging

Backup load output rating

Rated output voltage	230 Va.c. L/N/PE
Rated output frequency	50/60 Hz
Rated output power	6000 W
Max. apparent output power	6000 VA
Max. output current	26.09 Aa.c.

General parameter

Protection rating	Class I
Ingress protection rating	IP66
Ambient temperature range	-25 ℃ to 60 ℃ (Derating above 45 ℃)
Altitude	≤4000 m

*** Local grid parameters**

Germany	4600 W/VA 230 Va.c. 20.00 Aa.c. 50 Hz
Italy	6000 W/VA 230 Va.c. 26.09 Aa.c. 50 Hz
Belgium	5000 W/VA 230 Va.c. 21.74 Aa.c. 50 Hz
Australia	6000 W/VA 230 Va.c. 26.09 Aa.c. 50 Hz
South Africa	4600 W/VA 230 Va.c. 20.00 Aa.c. 50 Hz

Safety symbols and certification marks

EAST GROUP CO. LTD.

TEL:0769-22897777
E-mail:info@eastups.com
ADD.:No.6 Northern Industry Road, Songshan Lake Sci&Tech Industrial Park, Dongguan city, Guangdong,China

Remark: For application of this standard, the nominal voltage is 230 Va.c., nominal frequency is 50Hz, and the power factor range: 0.8 capacitive(over-excited) - 0.8 inductive(under-excited)

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Telefax : +86 20 38320478
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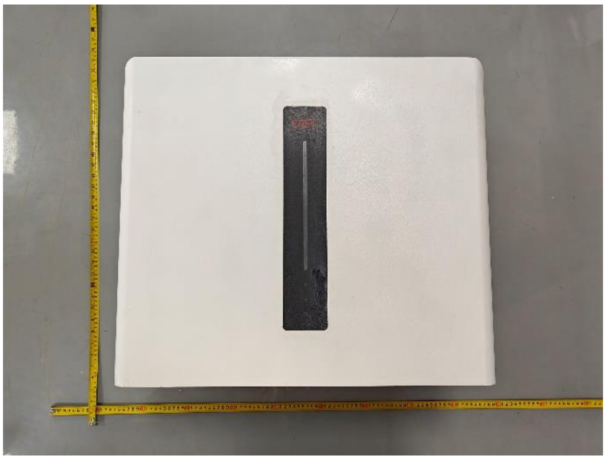
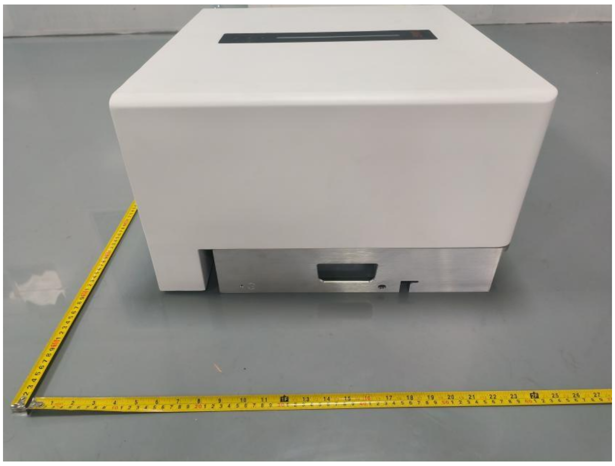
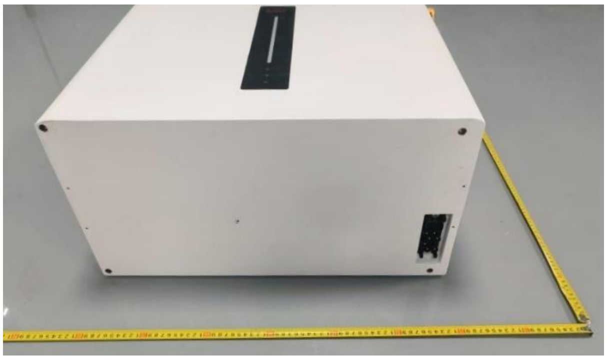
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

Picture of the product:	
Inverter front view 	Inverter right view 
Inverter left view 	Inverter top view 
Inverter bottom view 	Inverter terminal view 

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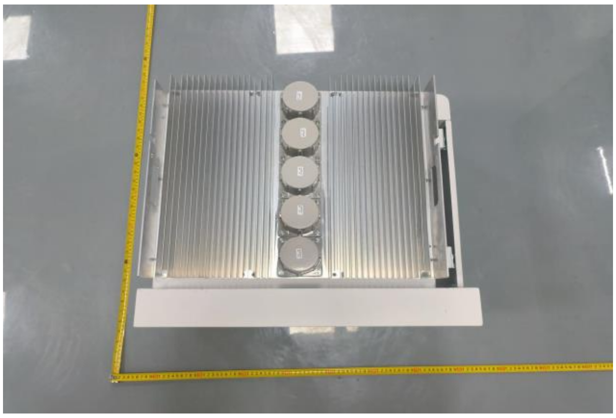
Overall view	Internal view after removing the cover
	

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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West,
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Characteristic data

Model	EAHI-6000-SL-S
PV terminal	
Vmax. PV	550 Vd.c.
MPPT voltage range	100~540 Vd.c.
MPPT voltage range (full load)	250~450 Vd.c.
Max. continuous PV input current	15/15 Ad.c.
Isc PV	20/20 Ad.c.
Max. continuous PV input power	8000 W
Battery terminal parameter	
Battery type	Li-ion
Voltage range	40.8-57.6 Vd.c.
Rated voltage	51.2 Vd.c.
Maximum charge/discharge current	100/120 Ad.c.
Maximum charge/discharge power	5000 W/6000 W
Grid terminal parameter	
Rated voltage	230 Va.c., L/N/PE
Rated frequency	50 Hz
Rated input current	20 Aa.c.
Maximum continuous input current	20.9 Aa.c.
Maximum continuous input power	4600 W
Rated output current	20 Aa.c.
Maximum continuous output current	20.9 Aa.c.
Power factor (Cos phi), adjustable	0.8inductive(under-excited)~0.8capacitive(over-excited)
Maximum continuous output power	4600 W
Maximum continuous apparent output power	4600 VA

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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

Model differences: N/A
Characteristic data Factory: Factory name: EAST Group Co., Ltd. Address: No.6 Northern Industry Road, Songshan Lake Sci. & Tech. Industry Park, 523808 DongGuan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Purpose of the product 1. The unit is non-isolated (transformerless) hybrid inverter for connection with public low voltage grid, for outdoor use. 2. If certain functions are not permitted by local regulation, the function shall be disabled by hardware or software setting (if applicable) by the manufacturer before putting into the market. For example, it's not permissible to draw electricity from the grid and then feed it back in order to claim statutory reimbursement in some nations. 3. Software version: V1002, Firmware version: V1.0. 4. Stand-alone mode are not considered and evaluated in this report, the use of stand-alone mode and electrical installations for unit shall comply with national and local regulation.

Possible test case verdicts:	
- test case does not apply to the test object................. :	N/A (not applicable / not included in the order)
- test object does meet the requirement....................... :	P (Pass)
- test object does not meet the requirement .... :	F (Fail)
Possible suffixes to the verdicts:	
- suffix for detailed information for the client……………...:	- C (Comment)
- suffix for important information for factory inspection...:	- M (Manufacturing)

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NRS 097-2-1:2017 Edition 2.1			
Clause	Requirement – Test	Measuring result – Remark	Verdict
4	Requirements		P
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.		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.		P
4.1.1.3	All power quality parameters (voltage, flicker, frequency and harmonics) shall be measured at the POC, unless otherwise specified		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.		P
	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.		P
4.1.1.5	The embedded generator shall be type approved, unless otherwise agreed upon with the utility (see annex A).		N/A
4.1.1.6	The maximum size of the embedded generator is limited to the rating of the supply point on the premises.		P
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		N/A

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NRS 097-2-1:2017 Edition 2.1			
Clause	Requirement – Test	Measuring result – Remark	Verdict
	required to create a separate supply point.		
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.		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.		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).		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 sub-categories:		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.		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
4.1.1.12	In accordance with SANS 10142-1, all generators shall be wired permanently.		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.		P
4.1.1.14	Stand by-generators are covered by SANS 10142-1.		P
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		N/A

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Clause	Requirement – Test	Measuring result – Remark	Verdict
	conditions/abnormal conditions. This includes several smaller units that totals more than 100 kVA at a single POC.		
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.		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).		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
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).		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
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.		N/A
4.1.3.5	The generator documentation and nameplate		P

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Clause	Requirement – Test	Measuring result – Remark	Verdict
	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.		
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.		P
	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		P
	The operation of the embedded generator, in conjunction with other existing and future loads at the same point of connection, shall not cause flicker levels to increase beyond the levels specified in NRS 048-2.		P
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:		P
	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
4.1.6	Voltage unbalance		N/A
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	The maximum apparent power of single phase inverter ≤4.6kVA	N/A

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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

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	than 4,6 kVA will be split evenly over the available phase connections so that this can be maintained.		
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.		N/A
4.1.7	Commutation notches		N/A
	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.		N/A
4.1.8	DC Injection		P
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.		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.		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 (in accordance with IEC 61727)		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
4.1.10.5	The harmonic and inter-harmonic distortion applies up to 3 kHz (60th harmonic).		P
4.1.11	Power factor		P

Telephone : +86 20 38320668
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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

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Clause	Requirement – Test	Measuring result – Remark	Verdict
	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:		P
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.		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.		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.		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.		N/A
	The power factor shall remain above 0,95 as shown in Figure 2. The embedded generator shall operate anywhere in the shaded area.		N/A
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.		N/A
4.1.11.10	These limits apply, unless otherwise agreed		P

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TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

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	upon with the utility (see annex A).		
4.1.11.11	Equipment for reactive power compensation shall either:		N/A
	a) be connected or disconnected with the embedded generator, or b) operated via automatic control equipment for disconnection when not required.		N/A
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.		N/A
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
4.1.12.2	Automatic synchronization equipment shall be the only method of synchronization.		P
4.1.12.3	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.		N/A
4.1.12.5	Mains excited generators may require soft-starting when the start-up voltage change is anticipated to be more than 3 %.		N/A
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.		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	4.1.13.2 to 4.1.13.3 applied	P

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	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.		
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+A2:2019 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.	Conducted emission in the frequency band 30kHz to 150 kHz is tested in this report. See appendix table.	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.	Refer to EMC report No.: 64.772.23.30907.01	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).	The frequency band higher than 150kHz is test and refer to EMC report No.: 64.772.23.30907.01	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

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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
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		P
	The safe operation of the embedded generator in conjunction with the utility network shall be ensured at all times.		P
4.2.2	Safety disconnect from utility network		P
4.2.2.1	General		P
4.2.2.1.1	All SSEG shall comply with the safety requirements in accordance with SANS/IEC 62109-1 and IEC 62109-2.	Refer to safety report No.: 64.290.23.30906.01	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		P

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	phase), d) and residual d.c. current (phase and neutral currents summated).		
4.2.2.2	Disconnection device (previously disconnection switching unit)		P
4.2.2.2.1	The embedded generator shall be equipped with a disconnection switching unit which separates the embedded generator from the grid due to the above abnormal conditions.		P
	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.	Integrated relays	P
4.2.2.2.2	The disconnection switching unit shall be able to operate under all operating conditions of the utility network.		P
4.2.2.2.3	A failure within the disconnection switching unit shall lead to disconnection and indication of the failure condition.	Type test in this report	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.	Type test in this report	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.	Type test in this report	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)		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.		N/A
4.2.2.2.9	A static power converter without simple separation shall make use of two series-connected electromechanical disconnection switches.		P
4.2.2.2.10	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		P

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	requires suitable coordination with the upstream short circuit protection device (circuit breaker).		
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.	Password protection	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.		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.		P
4.2.2.3	Overvoltage, undervoltage and frequency		P
4.2.2.3.1	General		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.		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
	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 2.8). 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

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	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		P
	The embedded generator shall cease to energize the utility distribution system should the network voltage deviate outside the conditions specified in table 2. This applies to any phase of a multiphase system. The system shall sense abnormal voltage and respond. The following conditions shall be met, with voltages in r.m.s. and measured at the PUC.		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.	

	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.		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.		N/A
	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.		P

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	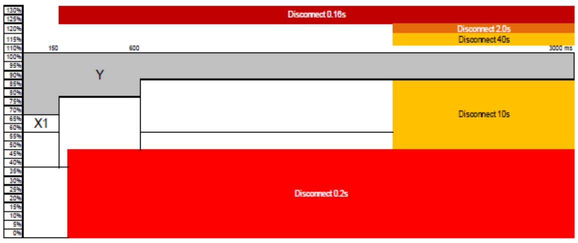 **Figure 4 — Graphical representation of voltage-ride-through and voltage disconnect requirements for A1 and A2 EG**		
4.2.2.3.3	Overfrequency and underfrequency		P
	This requirement is in line with the RPP Grid Code (version 2.8) and applies to all EG in category A.		P
	The embedded generation system 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
	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 P_M 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

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	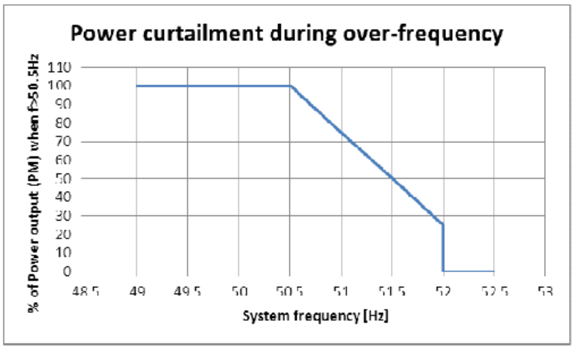 **Figure 5 — Power curtailment during over-frequency**		
	When the utility frequency is more than 52 Hz for longer than 4 seconds, the embedded generator shall cease to energise the utility line within 0,5 s.		P
4.2.2.3.3.1	Relaxation for non-controllable generators		N/A
	Non-controllable generators 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.		N/A
	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.		N/A
4.2.2.4	Prevention of islanding		P
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		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		P

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	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.		
4.2.2.4.3	Active islanding shall be detected 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).		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).		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
4.2.2.7	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		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		N/A
	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.		N/A

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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.		N/A
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.		P
	This ramp rate may be modified at the request of the utility or in consultation with the utility.		P
4.2.5	Isolation	To be considered when installed	N/A
4.2.5.1	In line with SANS 10142-1 (as amended), each energy source should have its own, appropriately rated, isolation device.		N/A
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.		N/A
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 threephase star-connected EG. The grid supply side shall be wired as the source.		N/A

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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.	To be considered when installed	N/A
	This disconnection device does not need to be accessible to the utility.		N/A
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.	To be considered when installed	N/A
	This disconnection device shall be lockable and accessible to the utility.	To be considered when installed	N/A
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.	To be considered when installed	N/A
4.2.6	Earthing		P
4.2.6.1	The electrical installation shall be earthed in accordance with SANS 10142-1. 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.		P
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 design1). This function may be internal or external to the inverter.		P
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.		P
4.2.7	Short-circuit protection		P

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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.		P
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
4.2.9	Labelling	To be considered when installed	N/A
4.2.9.1	A label on the distribution board of the premises where the embedded generator is connected shown in figure 6, 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.		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.		N/A
4.2.9.4	The absence of emergency shutdown capabilities will be indicated on signage in accordance with 4.2.2.		N/A
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.	Refer to safety report No.: 64.290.23.30906.01	P
4.3	Metering		N/A
4.3.1	General	To be considered when	N/A

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		installed	
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
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. See 4.2.9.		N/A
4.3.2	Single-quadrant meter installation		N/A
4.3.2.1	The single-meter arrangement is given in figure 8.		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
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
4.3.3.1	Feed-in tariff metering records all the energy generated from the embedded generator and	To be considered when	N/A

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn

TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

Clause	Requirement – Test	Measuring result – Remark	Verdict
	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.	installed	
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 9 is the most basic FIT metering configuration.		N/A
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 10.		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. The net meter shall be a bi-directional meter.		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 conventional electronic, bi-directional type meters. The meters can either be of the single or the separate register type.	To be considered when installed	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.		N/A
4.3.4.5	Meters with the capability of metering quality of supply parameters shall activate the monitoring		N/A

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Clause	Requirement – Test	Measuring result – Remark	Verdict
	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.		
Annex A	Notes to purchasers (informative)		N/A
A.1	The following requirements shall be specified in tender invitations and in each order or contract: a) whether all power quality parameters shall be measured at the POC (see 4.1.1.3).	To be considered when installed	N/A
A.2	The following requirements shall be agreed upon between the customer and the utility: a) whether the EG shall be type approved (see 4.1.1.5); b) whether the EG may control the voltage (see 4.1.2.2); c) the power factor limits (see 4.1.11).		N/A
Annex B	Earthing systems (informative)		N/A
B.1	Application of SANS 10142-1	To be considered when installed	N/A
B.1.1	General		N/A
	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.		N/A
B.1.2	Neutral conductor		N/A
	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).		N/A
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		N/A

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn
TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

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	SANS 10142-1:2012).		
B.1.4	Earthing of combined sources		N/A
	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).	To be considered when installed	N/A
B.1.5	Neutral bar earthing		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.	To be considered when installed	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.		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
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		N/A

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn

TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

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	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)).		
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	To be considered when installed	N/A
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.	TN system	N/A
B.2.2	Tables B.2 to B.5 illustrate the typical system application types and connections.		N/A
B.3	Rules of thumb established for embedded generation and backup systems		N/A
B.3.1	General		N/A
	Earthing and wiring guidelines were developed as a result of the above rigorous analysis. See tables B.2 to B.5.		N/A
B.3.2	Earth electrode		N/A
B.3.2.1	All backup systems shall have an own earth electrode connected to the consumer's earth terminal and shall comply with 7.12.3.1.1 in ANS 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		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.3.3.3	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
B.3.4	N-PE bridge on backup supply		N/A

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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

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Clause	Requirement – Test	Measuring result – Remark	Verdict
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)		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: 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: 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)		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 (normative)		P
Annex D	(Annex A of VDE-AR-N 4105) Explanations (normative)		P
Annex E	(Annex B of VDE-AR-N 4105) Connection examples (normative)		P
Annex F	(Annex C of VDE-AR-N 4105) Example of meter panel configurations (normative)		P
Annex G	Generation management network security management (normative)		P

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn
TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West,
Guangzhou, 501656, P.R.China

4.1.5	Flicker				P
Limit	P_{st} = 0.35		P_{lt}=0.3		
	Measured Values at test impedance	Normalised to reference impedance	Measured Values at test impedance	Normalised to reference impedance	
L-N	0.16	0.27	0.16	0.27	
Remark: test impedance: 0.24 + j0.15 Ω reference impedance: 0.4 + j0.25 Ω					

4.1.8, 4.2.2.5	Direct current injection at normal condition								P
Rated output current (A)	Ratio of rated output power (Sn%)	Measured DC output current between terminals (mA)						Isolated transformer? (Yes/No)	Limit (mA) 0.5% of Inom
		L1	L2	L3	L1-N	L2-N	L3-N		
20	25%	--	--	--	50	--	--	No	100
	50%	--	--	--	20	--	--	No	100
	75%	--	--	--	30	--	--	No	100
	100%	--	--	--	10	--	--	No	100

4.1.8, 4.2.2.5	Direct current injection protection		P
DC injection (A)	Limits	Trip time (ms)	
(Positive)	Idc: > 0.5%, then disconnection within 0.5s	321	
(Negative)	Idc: > 0.5%, then disconnection within 0.5s	220	

Test sequence	Disconnecting time (ms)	Oscilloscope recorded waveforms

Telephone : +86 20 38320668
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TÜV SÜD Certification and Testing (China) Co., Ltd.
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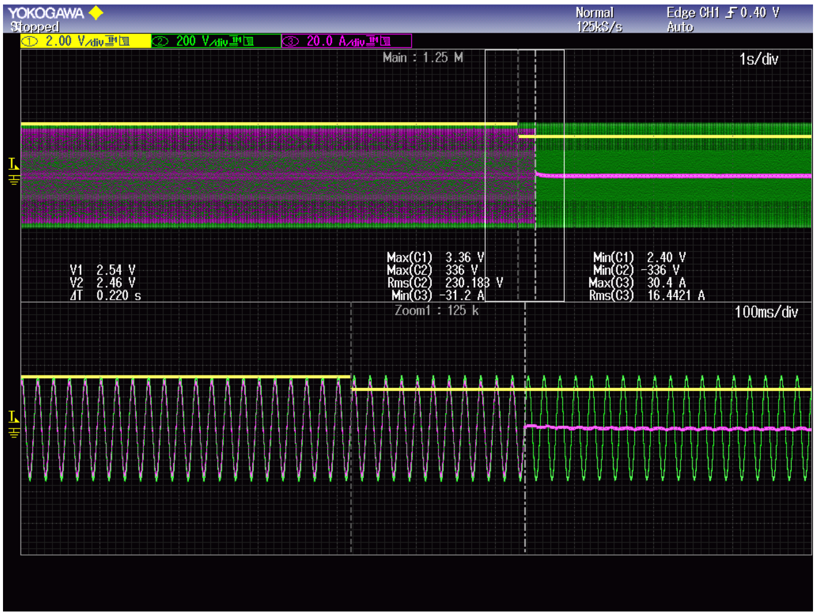
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

L1-N (positive)	321	
L1-N (negative)	220	
Max. Break time(ms)	321	
Supplementary information: 1. Channel 1: Inverter AC current 2. Channel 2: Grid voltage 3. Channel 3: Grid voltage signal		

Telephone : +86 20 38320668
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TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West,
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4.1.10	Table: Measurement of harmonic currents										P
Harmonics											
Pbin [%]	0	10	20	30	40	50	60	70	80	90	100	Limit
H	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	%
2	0.01	0.08	0.09	0.10	0.12	0.12	0.09	0.08	0.10	0.10	0.09	1.0
3	0.24	0.23	1.34	1.63	1.72	1.75	0.62	0.72	0.93	1.17	1.44	4.0
4	0.01	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.04	0.03	1.0
5	0.19	0.25	0.55	0.94	1.04	1.10	0.45	0.39	0.29	0.25	0.27	4.0
6	0.01	0.03	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.04	1.0
7	0.12	0.27	0.17	0.53	0.66	0.72	0.32	0.31	0.34	0.41	0.46	4.0
8	0.01	0.02	0.03	0.03	0.05	0.03	0.02	0.03	0.02	0.03	0.03	1.0
9	0.06	0.34	0.09	0.31	0.44	0.51	0.28	0.34	0.38	0.37	0.37	4.0
10	0.00	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	1.0
11	0.02	0.10	0.07	0.17	0.29	0.37	0.23	0.24	0.22	0.22	0.23	2.0
12	0.00	0.02	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.5
13	0.01	0.04	0.09	0.09	0.19	0.25	0.17	0.17	0.22	0.26	0.30	2.0
14	0.00	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.5
15	0.02	0.09	0.10	0.05	0.13	0.19	0.16	0.17	0.17	0.16	0.17	2.0
16	0.00	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.5
17	0.02	0.08	0.10	0.04	0.09	0.15	0.15	0.15	0.15	0.17	0.19	1.5
18	0.00	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.38
19	0.01	0.01	0.05	0.02	0.05	0.10	0.10	0.12	0.14	0.14	0.13	1.5
20	0.00	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.38
21	0.00	0.01	0.03	0.03	0.03	0.07	0.10	0.11	0.12	0.12	0.14	1.5
22	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.38
23	0.01	0.04	0.04	0.04	0.04	0.07	0.11	0.12	0.14	0.15	0.15	0.6
24	0.00	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.15
25	0.01	0.02	0.02	0.03	0.02	0.04	0.08	0.09	0.10	0.10	0.11	0.6
26	0.00	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.15
27	0.01	0.01	0.01	0.03	0.01	0.02	0.06	0.07	0.07	0.09	0.10	0.6
28	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.15
29	0.00	0.01	0.02	0.03	0.02	0.02	0.06	0.07	0.08	0.08	0.08	0.6
30	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.15
31	0.00	0.01	0.02	0.03	0.03	0.03	0.06	0.07	0.07	0.08	0.09	0.6
32	0.00	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.15
33	0.00	0.01	0.02	0.03	0.03	0.02	0.06	0.06	0.07	0.08	0.08	0.6
34	0.00	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.03	0.03	0.03	0.15
35	0.00	0.02	0.02	0.03	0.03	0.02	0.05	0.05	0.06	0.06	0.07	0.3
36	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.08
37	0.00	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.04	0.06	0.06	0.3
38	0.00	0.01	0.01	0.01	0.04	0.01	0.02	0.02	0.02	0.02	0.01	0.08
39	0.00	0.01	0.03	0.02	0.02	0.01	0.03	0.04	0.05	0.05	0.05	0.3
40	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
41	0.00	0.02	0.03	0.02	0.02	0.01	0.03	0.03	0.04	0.05	0.05	0.3
42	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.03	0.02	0.08
43	0.00	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.05	0.05	0.05	0.3
44	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.08	0.02	0.08
45	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.06	0.04	0.04	0.3
46	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.03	0.01	0.08
47	0.00	0.02	0.02	0.02	0.02	0.02	0.04	0.03	0.04	0.04	0.04	0.3
48	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.08

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn

TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

49	0.00	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.3
50	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
51	0.00	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.3
52	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.08
53	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.3
54	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.08
55	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.3
56	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.08
57	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.3
58	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
59	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.3
60	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
THD	0.32	0.59	1.48	2.00	2.20	2.31	0.99	1.06	1.21	1.43	1.68	5.0
Interharmonics												
Pbin [%]	0	10	20	30	40	50	60	70	80	90	100	limit
f[Hz]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	%
75/90	0.01	0.07	0.08	0.07	0.07	0.08	0.09	0.08	0.08	0.10	0.08	0.1
125/150	0.02	0.04	0.05	0.06	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.1
175/210	0.02	0.04	0.07	0.06	0.04	0.05	0.05	0.05	0.05	0.05	0.07	0.1
225/270	0.02	0.03	0.05	0.05	0.03	0.04	0.04	0.04	0.04	0.04	0.06	0.1
275/330	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.06	0.1
325/390	0.02	0.02	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.04	0.06	0.1
375/450	0.02	0.02	0.02	0.03	0.04	0.02	0.03	0.03	0.05	0.04	0.05	0.1
425/510	0.01	0.02	0.02	0.03	0.04	0.02	0.03	0.03	0.08	0.04	0.04	0.1
475/570	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.04	0.03	0.1
525/630	0.01	0.01	0.02	0.02	0.02	0.04	0.02	0.05	0.03	0.04	0.03	0.1
575/690	0.00	0.01	0.01	0.02	0.02	0.04	0.05	0.04	0.02	0.04	0.03	0.25
625/750	0.00	0.01	0.01	0.01	0.01	0.02	0.04	0.02	0.02	0.04	0.02	0.25
675/810	0.00	0.01	0.01	0.01	0.01	0.04	0.04	0.03	0.02	0.03	0.02	0.25
725/870	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.04	0.02	0.03	0.02	0.25
775/930	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.25
825/990	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.03	0.02	0.02	0.25
875/1050	0.00	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.04	0.02	0.03	0.19
925/1110	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.19
975/1170	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.19

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn

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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

1025/ 1230	0.00	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.19
1075/ 1290	0.00	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.19
1125/ 1350	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.19
1175/ 1410	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.08
1225/ 1470	0.00	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.08
1275/ 1530	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.03	0.02	0.02	0.08
1325/ 1590	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.01	0.08
1375/ 1650	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.08
1425/ 1710	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.08
1475/ 1770	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
1525/ 1830	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.08
1575/ 1890	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
1625/ 1950	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
1675	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.08
1725	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.08
1775	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03
1825	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.03
1875	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.03
1925	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.03
1975	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03

Higher frequency components

Pbin [%]	0	10	20	30	40	50	60	70	80	90	100
f[kHz]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]	Ih[%]
2.1	0.01	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.05	0.06	0.07
2.3	0.01	0.05	0.05	0.05	0.04	0.03	0.03	0.04	0.04	0.05	0.07
2.5	0.00	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.07
2.7	0.00	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.04
2.9	0.00	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.04	0.03	0.03
3.1	0.00	0.05	0.04	0.03	0.03	0.04	0.04	0.04	0.03	0.04	0.03
3.3	0.00	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.05
3.5	0.00	0.07	0.08	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.06
3.7	0.01	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.10	0.11	0.11
3.9	0.00	0.14	0.13	0.12	0.12	0.12	0.12	0.12	0.14	0.12	0.11
4.1	0.01	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12
4.3	0.01	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08
4.5	0.01	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
4.7	0.02	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
4.9	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
5.1	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
5.3	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5.5	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn
TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

5.7	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5.9	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
6.1	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
6.3	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
6.5	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
6.7	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
6.9	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
7.1	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
7.3	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7.5	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7.7	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
7.9	0.00	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
8.1	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
8.3	0.00	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
8.5	0.00	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02
8.7	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
8.9	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

4.1.11	**Power factor for SSEG categoried A1 and A2**						P
Pn (%)	Cosφ setting	Apparent Power (VA)	Active Power (W)	Reactive Power (Var)	Measured cosφ	Measured tolerance of Q(△Q/Pn) (%)	Limit tolerance of Q (%)
20%	cosφ = 0.80 over-excited	1153	928	684	0.8049 over-excited	-0.13%	±5
	cosφ = 0.98 over-excited	931	911	190	0.9788 over-excited	0.07%	±5
	cosφ = 1	941	940	36	0.9993	0.78%	±5
	cosφ = 0.98 under-excited	832	817	-157	0.9821 under-excited	0.65%	±5
	cosφ = 0.80 under-excited	1120	897	-672	0.8004 under-excited	0.39%	±5
30%	cosφ = 0.80 over-excited	1643	1323	974	0.8053 over-excited	-1.33%	±5
	cosφ = 0.98 over-excited	1420	1392	284	0.9798 over-excited	0.08%	±5
	cosφ = 1	1371	1371	-9	0.9999	-0.20%	±5
	cosφ = 0.98 under-excited	1352	1325	-269	0.9800 under-excited	0.24%	±5
	cosφ = 0.80 under-excited	1694	1361	-1008	0.8035 under-excited	0.59%	±5
40%	cosφ = 0.80 over-excited	2280	1825	1367	0.8005 over-excited	-0.28%	±5
	cosφ = 0.98	1934	1897	377	0.9808	0.07%	±5

Telephone : +86 20 38320668
Telefax : +86 20 38320478
http://www.tuv-sud.cn
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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

	over-excited				over-excited		
	cosφ = 1	1855	1855	27	0.9999	0.59%	±5
	cosφ = 0.98 under-excited	1832	1797	-354	0.9811 under-excited	0.43%	±5
	cosφ = 0.80 under-excited	2263	1823	-1339	0.8060 under-excited	0.89%	±5
50%	cosφ = 0.80 over-excited	2829	2274	1683	0.8038 over-excited	-0.91%	±5
	cosφ = 0.98 over-excited	2365	2319	466	0.9804 over-excited	-0.02%	±5
	cosφ = 1	2279	2279	27	0.9999	0.59%	±5
	cosφ = 0.98 under-excited	2268	2222	-452	0.9799 under-excited	0.33%	±5
	cosφ = 0.80 under-excited	2862	2289	-1718	0.7999 under-excited	0.15%	±5
60%	cosφ = 0.80 over-excited	3390	2725	2017	0.8037 over-excited	-1.15%	±5
	cosφ = 0.98 over-excited	2841	2785	565	0.9801 over-excited	0.10%	±5
	cosφ = 1	2765	2764	42	0.9999	0.91%	±5
	cosφ = 0.98 under-excited	2748	2692	-553	0.9796 under-excited	0.16%	±5
	cosφ = 0.80 under-excited	3435	2751	-2057	0.8009 under-excited	0.28%	±5
70%	cosφ = 0.80 over-excited	4039	3220	2439	0.7972 over-excited	0.52%	±5
	cosφ = 0.98 over-excited	3311	3248	645	0.9808 over-excited	-0.19%	±5
	cosφ = 1	3245	3245	37	0.9999	0.80%	±5
	cosφ = 0.98 under-excited	3271	3204	-658	0.9795 under-excited	-0.09%	±5
	cosφ = 0.80 under-excited	4027	3221	-2417	0.7998 under-excited	-0.04%	±5
80%	cosφ = 0.80 over-excited	4591	3676	2751	0.8006 over-excited	-0.20%	±5
	cosφ = 0.98 over-excited	3807	3732	752	0.9803 over-excited	0.10%	±5

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Guangzhou, 501656, P.R.China

	cosφ = 1	3672	3672	33	0.9999	0.72%	±5
	cosφ = 0.98 under-excited	3768	3694	-744	0.9803 under-excited	0.07%	±5
	cosφ = 0.80 under-excited	4602	3670	-2776	0.7975 under-excited	-0.35%	±5
90%	cosφ = 0.80 over-excited	4635	3711	2777	0.8006 over-excited	0.37%	±5
	cosφ = 0.98 over-excited	4259	4174	846	0.9801 over-excited	0.12%	±5
	cosφ = 1	4110	4110	14	0.9999	0.30%	±5
	cosφ = 0.98 under-excited	4178	4096	-825	0.9803 under-excited	0.34%	±5
	cosφ = 0.80 under-excited	4620	3697	-2771	0.8002 under-excited	-0.24%	±5
100%	cosφ = 0.80 over-excited	4659	3717	2810	0.7977 over-excited	1.09%	±5
	cosφ = 0.98 over-excited	4606	4514	917	0.9800 over-excited	0.04%	±5
	cosφ = 1	4640	4640	19	0.9999	0.41%	±5
	cosφ = 0.98 under-excited	4617	4527	-907	0.9805 under-excited	0.18%	±5
	cosφ = 0.80 under-excited	4637	3691	-2808	0.7959 under-excited	-1.04%	±5

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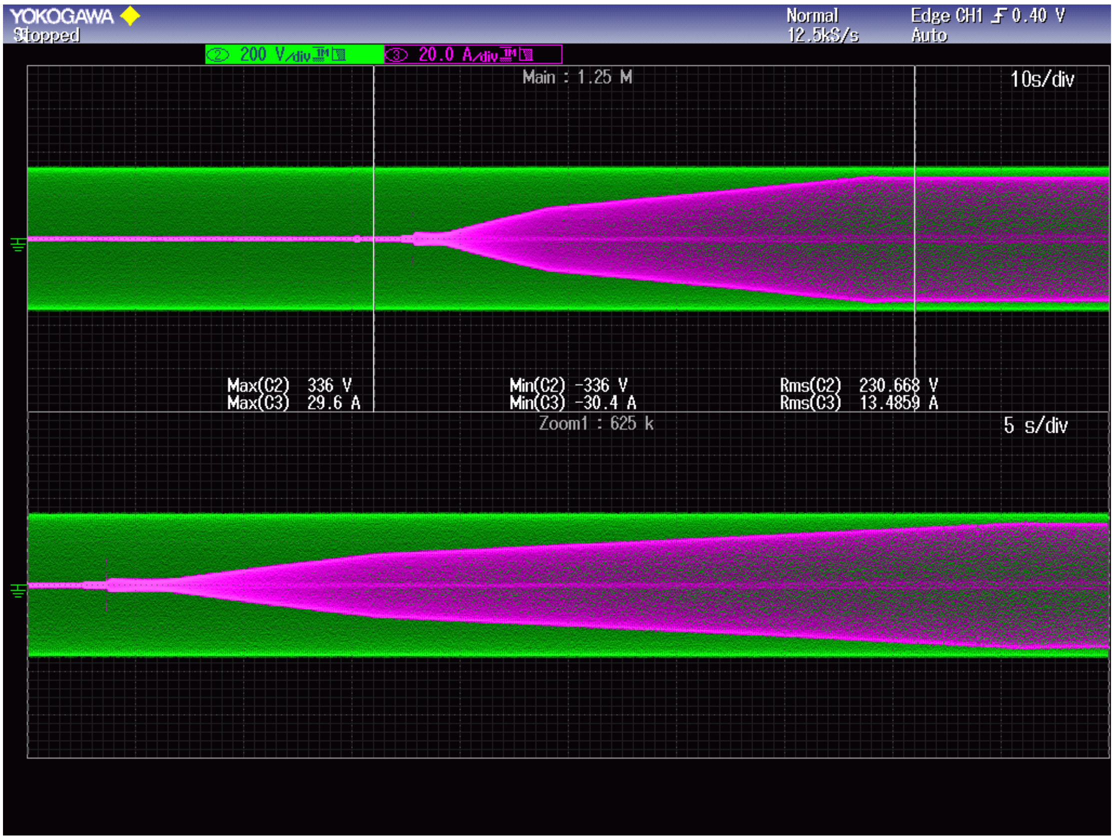
4.1.12.6	Start-up current					P
Scenarios		Fac(Hz)	Voltage (V)	Max. current measured (A)	Current limit (A)	
Starting at nominal output(100%P_n with deviating cosφ specifications);	Switching-on operation, 100%P_n cosφ=1,00	50.00	230.76	1.14	20	
	Switching-on operation, 100%P_n, cosφ=Max. over-excited	50.00	230.52	0.15	20	
	Switching-on operation, 100%P_n, cosφ=Max. under-excited	50.00	230.76	0.96	20	

100%P_n, cosφ=1.00



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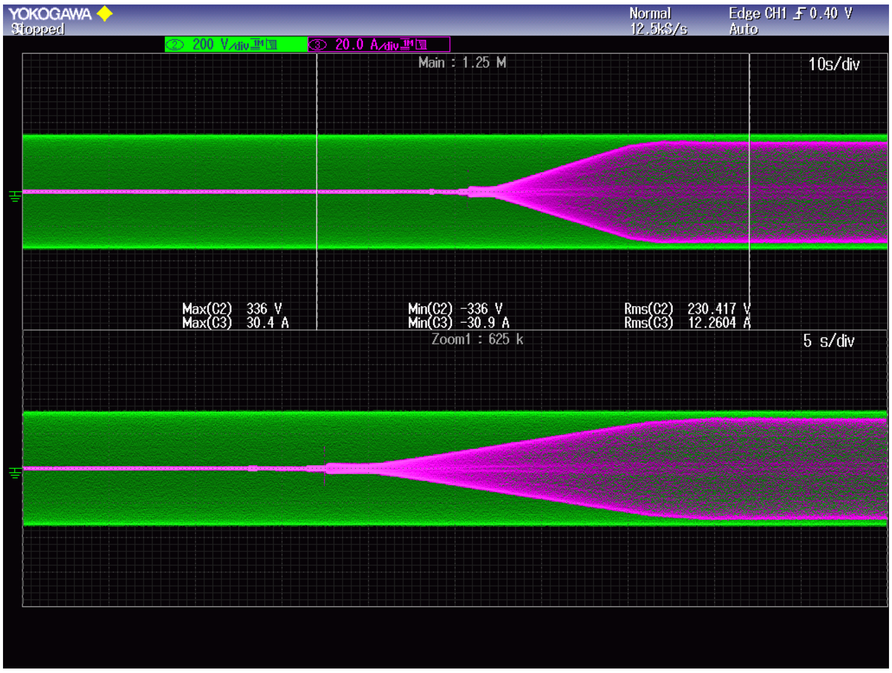
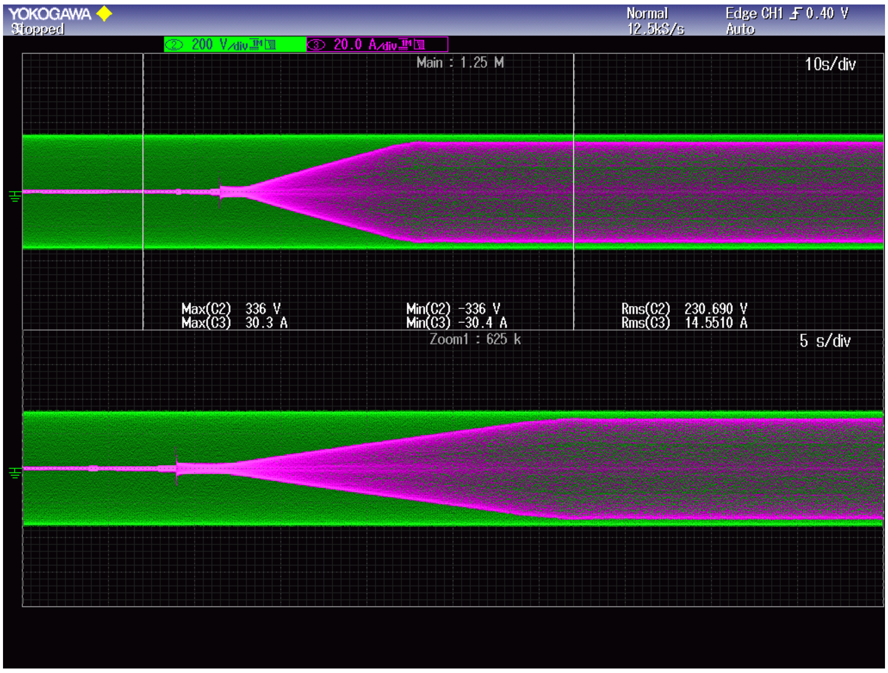
100%Pn, cosφ= Max. over-excited



100%Pn, cosφ=Max. under-excited



Supplementary information:

1. Channel 2: grid voltage signal

2. Channel 3:.inverter AC current signal.

Telephone : +86 20 38320668
Telefax : +86 20 38320478

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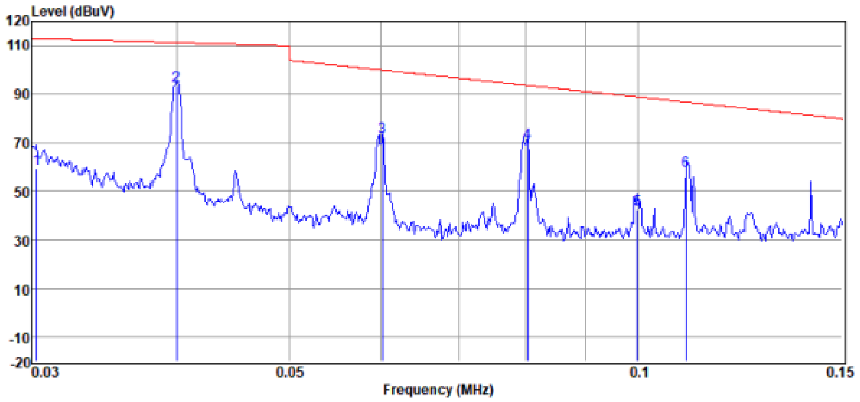
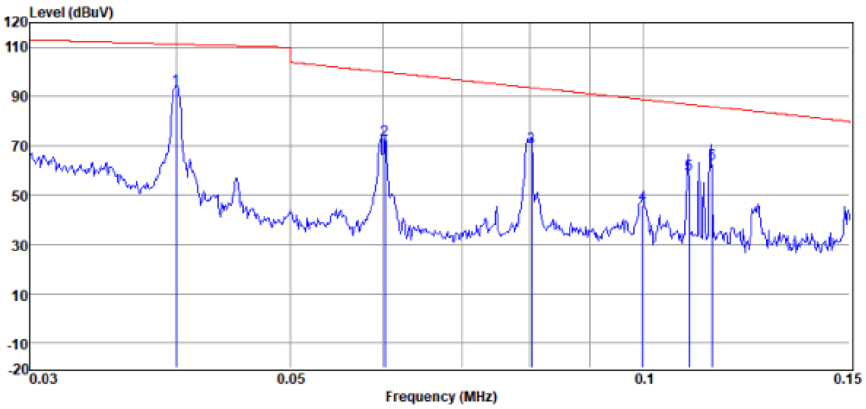
4.1.13	**Electromagnetic compatibility (EMC)**	P

Conductive emission, L1 line of grid ports (DC input: PV)



Item (Mark)	Freq. (MHz)	Read Level (dBμV)	LISN Factor (dB)	Cable Loss (dB)	Pulse Limiter Factor (dB)	Result Level (dBμV)	Limit Line (dBμV)	Over Limit (dB)	Detector	Phase
1	0.03	49.28	0.39	0.02	9.83	59.52	112.94	-53.42	QP	LINE
2	0.04	83.24	0.23	0.02	9.83	93.32	111.32	-18.00	QP	LINE
3	0.06	62.58	0.10	0.02	9.83	72.53	99.94	-27.41	QP	LINE
4	0.08	60.08	0.15	0.03	9.83	70.09	93.64	-23.55	QP	LINE
5	0.10	32.47	0.18	0.03	9.83	42.51	88.90	-46.39	QP	LINE
6	0.11	48.31	0.16	0.03	9.83	58.33	86.79	-28.46	QP	LINE

Conductive emission, N line of grid ports (DC input: PV)



Item (Mark)	Freq. (MHz)	Read Level (dBμV)	LISN Factor (dB)	Cable Loss (dB)	Pulse Limiter Factor (dB)	Result Level (dBμV)	Limit Line (dBμV)	Over Limit (dB)	Detector	Phase
1	0.04	83.17	0.23	0.02	9.83	93.25	111.32	-18.07	QP	NEUTRAL
2	0.06	62.52	0.10	0.02	9.83	72.47	99.94	-27.47	QP	NEUTRAL
3	0.08	59.60	0.15	0.03	9.83	69.61	93.64	-24.03	QP	NEUTRAL
4	0.10	35.79	0.18	0.03	9.83	45.83	88.90	-43.07	QP	NEUTRAL
5	0.11	48.30	0.16	0.03	9.83	58.32	86.90	-28.58	QP	NEUTRAL
6	0.11	52.50	0.15	0.03	9.83	62.51	85.90	-23.39	QP	NEUTRAL

Supplementary information: N/A

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Telefax : +86 20 38320478
http://www.tuv-sud.cn

TÜV SÜD Certification and Testing (China) Co., Ltd.
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

4.2.2.1.2 d)	Detection of residual d.c. currents (continuos)								P
Tracker No.	PV (+ or -)	Input (Vdc)	Output (Vac)	Baseline trigger current (mA)	Measured trigger time (ms), shall < 300 ms (repeat 5 times)				
PV1	+	360	230	250	254	237	239	258	239
PV1	-	360	230	250	273	249	267	262	270
PV2	+	360	230	250	250	273	241	269	259
PV2	-	360	230	250	255	263	263	270	248
Remark:									

4.2.2.1.2 d)	Detection of residual d.c. currents (sudden change)								P
Tracker No.	PV (+ or -)	Input (Vdc)	Output (Vac)	Baseline trigger current (mA)	Measured trigger time (ms), shall < 300 ms for (30 mA); (repeat 5 times)				
30 mA sudden changes in residual current									
PV1	+	360	230	30	262.2	254.7	275.7	241.2	270.0
PV1	+	360	230	30	240.0	263.0	241.0	257.0	234.0
PV2	-	360	230	30	264.2	245.2	252.7	235.7	270.2
PV2	-	360	230	30	246.7	275.2	259.2	260.2	239.2
Tracker No.	PV (+ or -)	Input (Vdc)	Output (Vac)	Baseline trigger current (mA)	Measured trigger time (ms), shall <150 ms for (60 mA); (repeat 5 times)				
60 mA sudden changes in residual current									
PV1	+	360	230	60	129.5	128.5	116.5	138.5	118.0
PV1	+	360	230	60	119.0	100.5	123.5	111.0	139.5
PV2	-	360	230	60	127.5	100.5	119.0	115.0	117.5
PV2	-	360	230	60	110.5	127.0	102.5	138.0	118.0
Tracker No.	PV (+ or -)	Input (Vdc)	Output (Vac)	Baseline trigger current (mA)	Measured trigger time (ms), shall <40 ms for (150 mA); (repeat 5 times)				
150 mA sudden changes in residual current									
PV1	+	360	230	150	11.5	39.5	38.5	32.0	37.0
PV1	+	360	230	150	34.5	19.0	39.0	35.0	33.0
PV2	-	360	230	150	29.5	33.0	31.5	25.5	37.0
PV2	-	360	230	150	24.5	28.0	36.5	31.5	36.0
Remark: This machine has PV1, PV2 terminals									

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4.2.2.2.3 and 4.2.2.2.4	single fault tolerance of interface protection system							P
Ambient temperature (°C) .... :								25 °C
Power source for EUT: Manufacturer, model/type, output rating :								--
No.	Component	Fault	Supply voltage (V)	Test time	Fuse #	Fuse current (A)	Observation	
AC Filter board								
1.	K3 (L Relay)	S-C	420Vd.c.	3min	/	/	The fault was applied before the unit operation, after applied the fault, the LED was steady red, grid relay fault was detected. No output voltage. No hazard. No damage. After removed the fault, the unit operated normally.	
2.	K4 (N Relay)	S-C	420Vd.c.	3min	/	/	The fault was applied before the unit operation, after applied the fault, the LED was steady red, grid relay fault was detected. No output voltage. No hazard. No damage. After removed the fault, the unit operated normally.	
3.	K5 (L Relay)	S-C	420Vd.c.	3min	/	/	The fault was applied before the unit operation, after applied the fault, the LED was steady red, grid relay fault was detected. No output voltage. No hazard. No damage. After removed the fault, the unit operated normally.	
4.	K6 (N Relay)	S-C	420Vd.c.	3min	/	/	The fault was applied before the unit operation, after applied the fault, the LED was steady red, grid relay fault was detected. No output voltage. No hazard. No damage. After removed the fault, the unit operated normally.	
Supplementary information: S-C: short circuit, O-C: open circuit								

4.2.2.3.2 and 4.2.4.2.2	Overvoltage and under voltage protection and reconnection for SSEG categoried A1 and A2							P
Under voltage stage 2: V < 50% Un								
Measurement	Voltage (V)			Trip time (s)			Reconnection time (s)	Power gradient (%Pn/min)
L-N	112.79	112.83	112.86	0.16	0.16	0.15	60.06	9.52%/min
Limit	L-N: 50% Un			≤ 0.2s			≥ 60s	≤ 10%
Under voltage stage 1: 50% Un ≤ V < 85% Un								
	Voltage (V)			Trip time (s)			Reconnection time (s)	Power gradient (%Pn/min)

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L-N	192.21	192.25	192.25	9.01	9.04	9.01	60.05	9.52%/min
Limit	L-N: 85% Un			≤ 10.0s			≥ 60s	≤ 10%
Over voltage stage 1: 110% Un < V < 115% Un								
	Voltage (V)			Trip time (s)			Reconnection time (s)	Power gradient (%Pn/min)
L-N	255.10	255.06	255.17	39.03	39.04	39.02	60.06	9.52%/min
Limit	L-N: 110% Un			≤ 40.0s			≥ 60s	≤ 10%
Over voltage stage 2: 115% Un ≤ V < 120% U								
	Voltage (V)			Trip time (s)			Reconnection time (s)	Power gradient (%Pn/min)
L-N	266.80	266.78	266.77	1.83	1.83	1.84	60.07	9.52%/min
Limit	L-N: 115% Un			≤ 2s			≥ 60s	≤ 10%
Over voltage stage 3: V ≥ 120% Un								
	Voltage (V)			Trip time (s)			Reconnection time (s)	Power gradient (%Pn/min)
L-N	278.17	278.24	278.17	0.11	0.10	0.13	60.06	9.52%/min
Limit	L-N: V ≥120% Un			≤ 0.16s			≥ 60s	≤ 10%
Supplementary information: Automatic synchronization condtions: normal voltage operation range: 85% ≤ V ≤ 110% normal frequency operation range: 47 Hz ≤ F ≤ 50.5 Hz								

4.2.2.3.2	**LVFRT for for SSEG categoried A1 and A2**						P
Pn in %		20%					
Item	test	Measured active power before fault [W]	Measured active power during fault [W]	Measured reactive current during fault [A]	Measured fault duration [ms]	Amplitude of the residual voltage V/Vn [p.u.]	Required duration [ms]
1	Asymmetrical single-phase fault (X1 type dip)	895.44	578.99	4.44	200	0.60±0.05	150
2	Asymmetrical single-phase fault (Y type dip)	894.69	781.48	4.28	650	0.80±0.05	600
Pn in %		100%					
Item	test	Measured active power before fault [W]	Measured active power during fault [W]	Measured reactive current during fault [A]	Measured fault duration [ms]	Amplitude of the residual voltage V/Vn [p.u.]	Required duration [ms]

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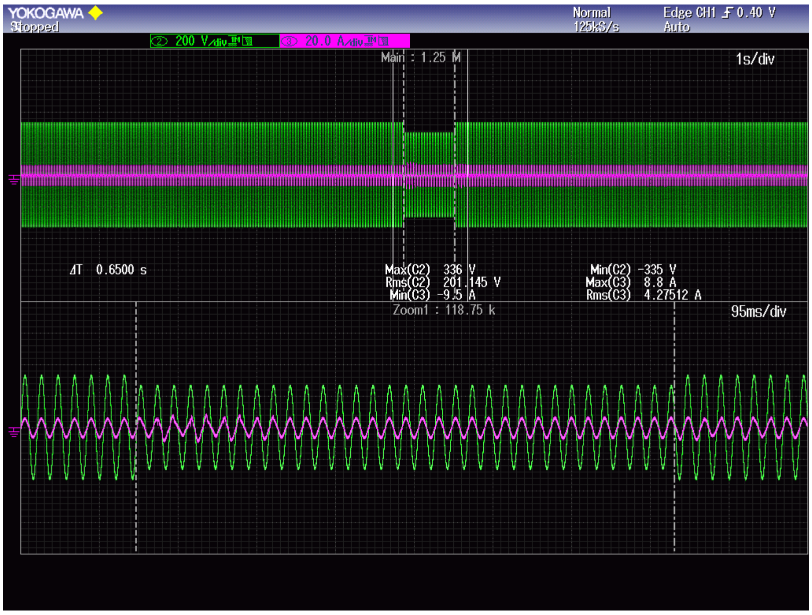
<table>
<tr><td>1</td><td>Asymmetrical single-phase fault (X1 type dip)</td><td>4563.72</td><td>2846.57</td><td>20.72</td><td>200</td><td>0.60±0.05</td><td>150</td></tr>
<tr><td>2</td><td>Asymmetrical single-phase fault (Y type dip)</td><td>4565.41</td><td>3782.60</td><td>20.40</td><td>650</td><td>0.80±0.05</td><td>600</td></tr>
<tr><td colspan="8">Test curve (20%Pn)</td></tr>
<tr><td colspan="2">0.60±0.05</td><td colspan="6">
</td></tr>
<tr><td colspan="2">0.80±0.05</td><td colspan="6">
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5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China

Test curve (100%Pn)	
0.60±0.05	
0.80±0.05	
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4.2.2.3.3	Over frequency and under frequency for all SSEG categoried A								P
Under Frequency									
	Frequency (Hz)			Trip time (s)			Reconnection time (s)	Power gradient (%Pn/min)	
Measured	46.95	46.95	46.94	0.14	0.16	0.15	65.03	9.52%/min	
Limit	F < 47 ± 0.05 Hz			≤ 0.2s			≥ 60s	≤ 10%	
Over Frequency									
	Frequency (Hz)			Trip time (s)			Reconnection time (s)	Power gradient (%Pn/min)	
Measured	52.05	52.05	52.06	4.03	4.02	4.02	64.99	9.52%/min	
Limit	F >52 ± 0.05 Hz			4 – 4.5s			≥ 60s	≤ 10%	

4.2.2.3.3	Power curtailment during over-frequency all SSEG categoried A			P
Test 1: measurement a) to i): Available active output power: 100%Pn(during a) to i))				
Freq. (Hz)	Measured active output power (P_{out})	$P_{set-point}$(W)	Actual gradient = (P_M - P_{out}) / P_M (%) (%P_M/Hz)	Gradient setting (%P_M/Hz)
a) 50.00	4601	4600	--	--
b) 50.50	4605	4600	--	--
c) 51.00	3458	3450	49.82%	50%
d) 51.50	2297	2300	50.12%	50%
e) 51.90	1369	1380	50.18%	50%
f) 51.50	2293	2300	50.19%	50%
g) 51.00	3456	3450	49.89%	50%
h) 50.50	4604	4600	--	--
i) 50.00	4603	4600	--	--
Intentional time delay for rise power when frequency below 50.50 Hz				--

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http://www.tuv-sud.cn

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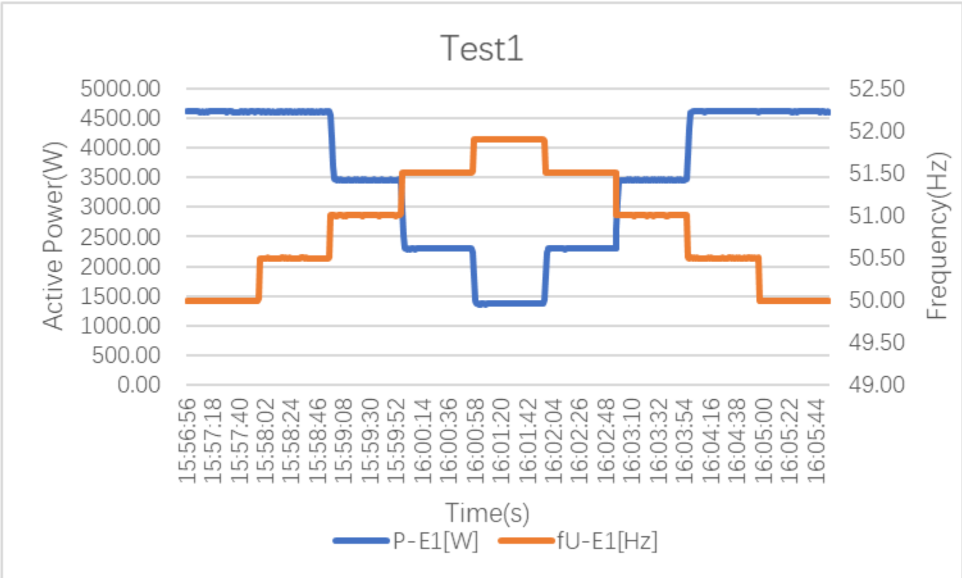
Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West, Guangzhou, 501656, P.R.China



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Telefax : +86 20 38320478

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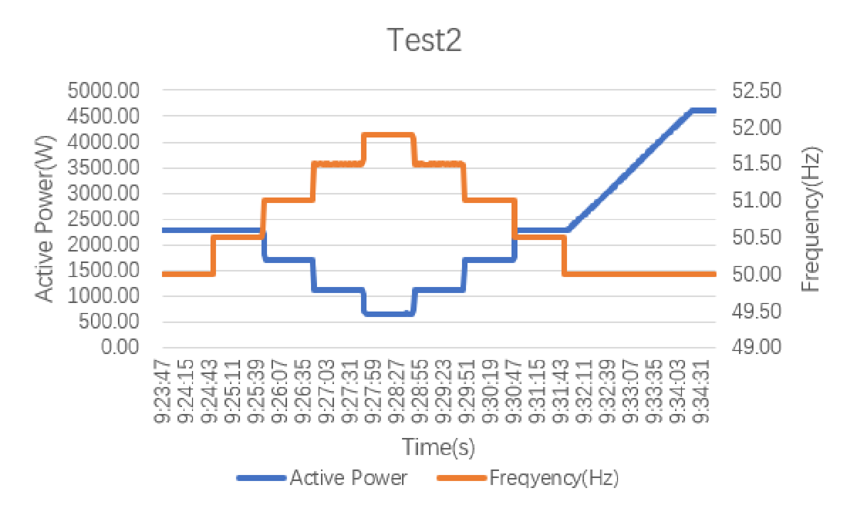
4.2.2.3.3	Power curtailment during over-frequency all SSEG categoried A			P
Test 1: measurement a) to i): Available active output power: 50%Pn(start) → 100%Pn(during c) to g))				
Freq. (Hz)	Measured active output power (P_{out})	$P_{set-point}$(W)	Actual gradient = (P_M - P_{out}) / P_M (%) (%P_M/Hz)	Gradient setting (%P_M/Hz)
a) 50.00	2290	2300	--	--
b) 50.50	2280	2300	--	--
c) 51.00	1708	1725	50.17%	50%
d) 51.50	1122	1150	50.78%	50%
e) 51.90	656	690	50.87%	50%
f) 51.50	1163	1150	48.99%	50%
g) 51.00	1706	1725	50.35%	50%
h) 50.50	2281	2300	--	--
i) 50.00	4612	4600	--	--
Intentional time delay for rise power when frequency below 50.50 Hz				4s



4.2.2.4.3	Active anti-islanding										P
No.	P_{EUT} (% of EUT rating)	Reactive Load (% of Q_L)	P_{AC} (% of nominal)	Q_{AC} (% of nominal)	Run on time (ms)	P_{EUT} (W)	Actual Q_f (Var)			V_{DC} (V)	Remarks
							L1	L2	L3		
1	100	100	0	0	286	4613	1.00	--	--	58.0	Test A at BL
2	66	66	0	0	706	3087	1.00	--	--	51.0	Test B at BL
3	33	33	0	0	161	1511	1.00	--	--	41.7	Test C at BL

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4	100	100	-5	-5	137	4637	1.05	--	--	58.0	Test A at IB
5	100	100	-5	0	288	4638	1.05	--	--	58.0	Test A at IB
6	100	100	-5	5	331	4639	1.07	--	--	58.0	Test A at IB
7	100	100	0	-5	295	4643	0.99	--	--	58.0	Test A at IB
8	100	100	0	5	348	4642	1.01	--	--	58.0	Test A at IB
9	100	100	5	-5	296	4634	0.95	--	--	58.0	Test A at IB
10	100	100	5	0	295	4635	0.95	--	--	58.0	Test A at IB
11	100	100	5	5	327	4634	0.97	--	--	58.0	Test B at IB
12	100	100	-10	10	753	4638	1.23	--	--	58.0	Test A at IB
13	100	100	-5	10	895	4646	1.17	--	--	58.0	Test A at IB
14	100	100	0	10	846	4643	1.11	--	--	58.0	Test A at IB
15	100	100	5	10	785	4637	1.06	--	--	58.0	Test A at IB
16	100	100	10	10	829	4634	1.01	--	--	58.0	Test A at IB
17	100	100	-10	5	336	4632	1.12	--	--	58.0	Test A at IB
18	100	100	10	5	347	4637	0.92	--	--	58.0	Test A at IB
19	100	100	-10	0	337	4638	1.11	--	--	58.0	Test A at IB
20	100	100	10	0	355	4634	0.90	--	--	58.0	Test A at IB
21	100	100	-10	-5	302	4637	1.10	--	--	58.0	Test A at IB
22	100	100	10	-5	288	4632	0.90	--	--	58.0	Test A at IB
23	100	100	-10	-10	270	4636	1.10	--	--	58.0	Test A at IB
24	100	100	-5	-10	291	4639	1.04	--	--	58.0	Test A at IB
25	100	100	0	-10	276	4641	0.99	--	--	58.0	Test A at IB
26	100	100	5	-10	271	4632	0.94	--	--	58.0	Test A at IB
27	100	100	10	-10	273	4638	0.90	--	--	58.0	Test A at IB
28	66	66	0	-5	173	2949	1.00	--	--	51.0	Test B at IB
29	66	66	0	-4	768	2945	0.99	--	--	51.0	Test B at IB
30	66	66	0	-3	783	2954	1.00	--	--	51.0	Test B at IB
31	66	66	0	-2	609	2949	1.00	--	--	51.0	Test B at IB
32	66	66	0	-1	857	2951	0.99	--	--	51.0	Test B at IB
33	66	66	0	1	930	2951	1.00	--	--	51.0	Test B at IB
34	66	66	0	2	722	2953	1.00	--	--	51.0	Test B at IB
35	66	66	0	3	817	2957	1.00	--	--	51.0	Test B at IB
36	66	66	0	4	826	2953	1.00	--	--	51.0	Test B at IB

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37	66	66	0	5	132	2955	1.02	--	--	51.0	Test B at IB
38	33	33	0	-5	233	1526	1.01	--	--	41.7	Test C at IB
39	33	33	0	-4	259	1504	0.99	--	--	41.7	Test C at IB
40	33	33	0	-3	251	1502	1.00	--	--	41.7	Test C at IB
41	33	33	0	-2	310	1505	1,01	--	--	41.7	Test C at IB
42	33	33	0	-1	289	1529	1.00	--	--	41.7	Test C at IB
43	33	33	0	1	258	1527	1.01	--	--	41.7	Test C at IB
44	33	33	0	2	194	1508	1.00	--	--	41.7	Test C at IB
45	33	33	0	3	326	1508	1.01	--	--	41.7	Test C at IB
46	33	33	0	4	347	1528	1.00	--	--	41.7	Test C at IB
47	33	33	0	5	130	1527	1.01	--	--	41.7	Test C at IB
Remark:The test method according to UNE-EN 62116.											

4.2.8	**Maximum short-circuit contribution**				P
For a directly coupled SSEG			For a Inverter SSEG		
Parameter	Symbol	Value	Time after fault	Volts	Amps
Peak Short Circuit current	i_p	-	20ms	--	1.18
Initial Value of aperiodic current	A	-	100ms	--	1.15
Initial symmetrical short-circuit current*	I_k	-	250ms	--	1.19
Decaying (aperiodic) component of short circuit current*	i_{DC}	-	500ms	--	1.16
Reactance/Resistance Ratio of source*	$^X/_R$	0.625	Time to trip	0.0036	In seconds

--- **End of Test Report**---

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Guangzhou Branch, TÜV SÜD Group
5F, Communication Building, 163 Pingyun Rd, Huangpu Ave. West,
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