TEST REPORT SUMMARY

NRS 097-2-1

Grid interconnection of embedded generation
Part 2: Small-scale embedded generation

Report reference number .....:	**11TH0290-NRS 097-2-1_SUM_2**
Date of issue .....……..:	2012-11-08
Total number of pages .....……..:	20
Testing laboratory name .....:	**Bureau Veritas Consumer Products Services Germany GmbH**
Address .....:	Businesspark A96 86842 Türkheim Germany
Applicant's name.....:	**SMA Solar Technology AG**
Address .....:	Sonnenallee 1, 34266 Niestetal
Test specification	
Standard.....:	NRS 097-2-1:2010
Certificate.....:	**Certificate of compliance**
Test report form number. .....:	NRS 097-2-1
Master TRF .....:	Bureau Veritas Consumer Products Services Germany GmbH
Test item description .....:	**Grid-tied photovoltaic and wind inverter**
Trademark.....:	SMA
Model / Type .....:	SB 3000TL-21, SB 3600TL-21, SB 4000TL-21, SB 5000TL-21 SB 2500TLST-21, SB 3000TLST-21 WB 3000TL-21, WB3600TL-21, WB 4000TL-21, WB 5000TL-21

Ratings .....:	**SB 3000TL-21**	**SB 3600TL-21**	**SB 4000TL-21**	**SB 5000TL-21**
MPP DC voltage range [V].....:	175V – 500V			
Input DC voltage range [V].....:	125V – 750V			
Input DC current [A] .....:	2 x 15A			
Output AC voltage [V] .....:	230 V / 50 Hz			
Output AC current [A].....:	nom. 13,1A max. 16A	nom. 16A max. 16A	nom. 17,4A max. 22A	nom. 20A max. 22A
Output power [VA].....:	nom. 3000W max. 3000VA	nom. 3680W max. 3680VA	nom. 4000W max. 4000VA	nom. 4600W max. 5000VA

SB-WB-TL_TLST-ZE-STR-NRS097-en-10

Ratings .....:	**SB 2500TLST-21**	**SB 3000TLST-21**
MPP DC voltage range [V].....:	180V – 500V	213V – 500V
Input DC voltage range [V].....:	125V – 750V	
Input DC current [A] .....:	15A	
Output AC voltage [V] .....:	230 V / 50 Hz	
Output AC current [A].....:	nom. 10,9A max. 10,9A	nom. 13,1A max. 13,1A
Output power [VA].....:	nom. 2500W max. 2500VA	nom. 3000W max. 3000VA

Ratings .....:	**WB 3000TL-21**	**WB3600TL-21**	**WB 4000TL-21**	**WB 5000TL-21**
MPP DC voltage range [V].....:	175V – 500V			
Input DC voltage range [V].....:	80V – 550V			
Input DC current [A] .....:	2 x 15A			
Output AC voltage [V] .....:	230 V / 50 Hz			
Output AC current [A].....:	nom. 13,1A max. 16A	nom. 16A max. 16A	nom. 17,4A max. 22A	nom. 20A max. 22A
Output power [VA].....:	nom. 3000W max. 3000VA	nom. 3680W max. 3680VA	nom. 4000W max. 4000VA	nom. 4600W max. 5000VA

Testing Location .....:	**Bureau Veritas Consumer Products Services Germany GmbH**
Address .....:	Businesspark A96, 86842 Türkheim, Germany
Tested by (name and signature) .....:	Frederic Schmitt
Approved by (name and signature) .....:	Georg Loritz
Manufacturer's name .....:	**SMA Solar Technology AG**
Factory address .....:	Sonnenallee 1, 34266 Niestetal

Document History

Date	Internal reference	Modification / Change / Status	Revision
2012-05-09	Frederic Schmitt	Initial report was written	0
2012-10-24	Urs Seifert	Output power of unit SB 3000TLST-21 updated	1
2012-11-06	Frederic Schmitt	Windy Boy inverter models WB 3000TL-21, WB3600TL-21, WB 4000TL-21, WB 5000TL-21 included	2

Supplementary information:

Test items particulars

Equipment mobility	:	Permanent connection
Operating condition	:	Continuous
Class of equipment	:	Class I
Protection against ingress of water	:	IP65 according to EN 60529
Mass of equipment [kg]	:	SB 3000TL-21 26kg SB 3600TL-21 26kg SB 4000TL-21 26kg SB 5000TL-21 26kg SB 2500TLST-21 23kg SB 3000TLST-21 23kg WB 3000TL-21 26kg WB3600TL-21 26kg WB 4000TL-21 26kg WB 5000TL-21 26kg

Test case verdicts

Test case does not apply to the test object	:	N/A
Test item does meet the requirement	:	P(ass)
Test item does not meet the requirement	:	F(ail)

Testing

Date of receipt of test item	:	2012-04-04
Date(s) of performance of test	:	2012-04-12 until 2012-04-18

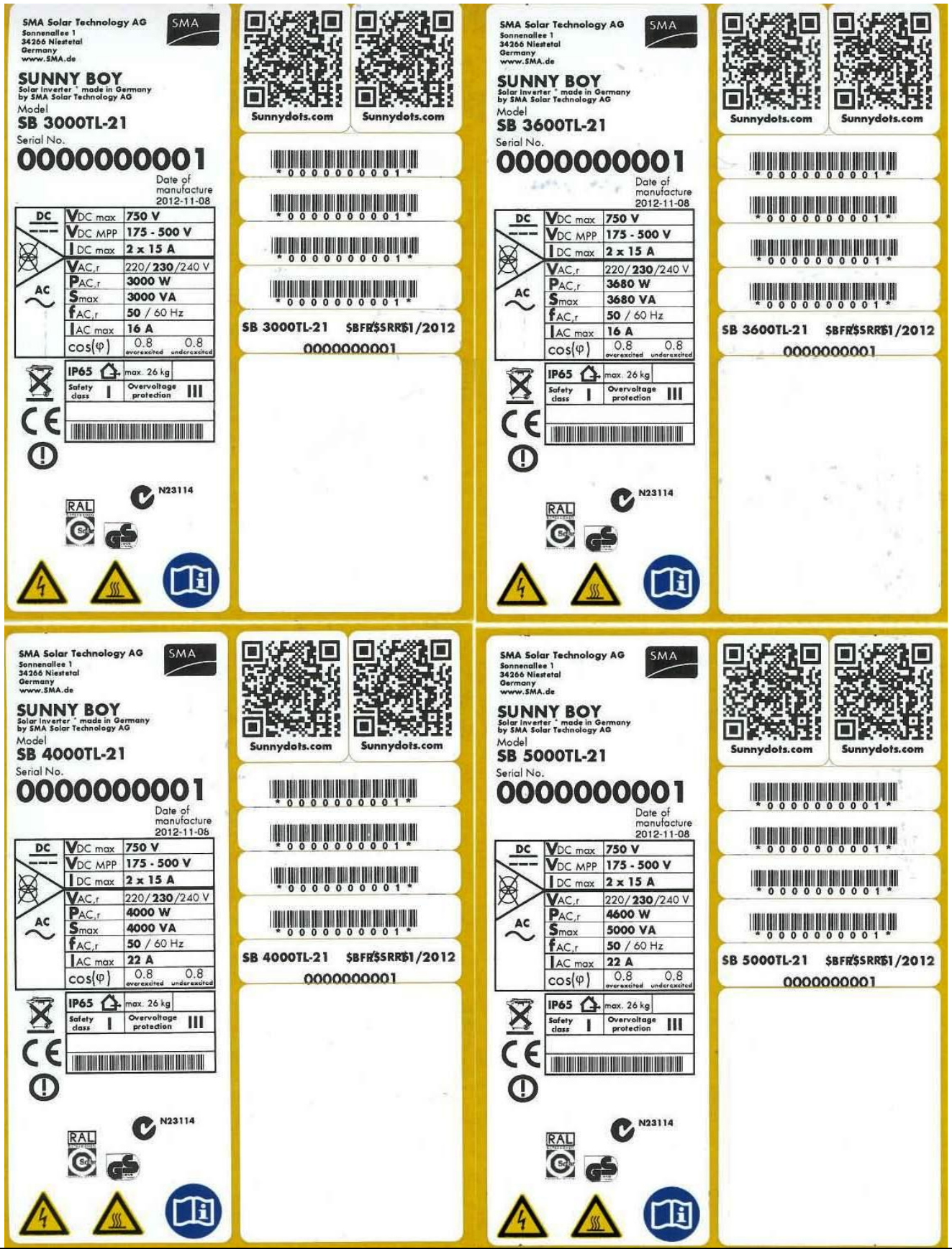
General remarks:

The test result presented in this report relate only to the object(s) tested.
This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

”(see Annex #)" refers to additional information 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.

Copy of marking plate:



General product information:

Description of the power circuit:
The input and output are protected by varistors to Earth. The unit is providing EMC filtering at the PV input and output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundantly by the high power switching bridge and two relays. This assures that the opening of the output circuit will also operate in case of one error.

Description of the differences of the models within a series:
The units are identical in the control circuit and the internal supply. Generally the units provide the same hardware except of some components:

- Group 1) SB 3000TL-21, SB 3600TL-21, SB 4000TL-21, SB 5000TL-21, WB 3000TL-21, WB3600TL-21, WB 4000TL-21, WB 5000TL-21
- Group 2) SB 2500TLST-21, SB 3000TLST-21,

All models within one group provide the same hardware. The models with lower power are derated via software.

Group 1 provides two MPP-Tracker
Group 2 provides one MPP-Tracker. The EMV-Filter, the boost converter and the DC-connections have been omitted of the second MPP-Tracker.

The different configurations have no influence on the device behaviour. All types have the same software.

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
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. Subclauses 4.1 and 4.2 are based on IEC 61727:2004.	Noticed.	**P**
4.1.1.2	The quality of power provided by the embedded generator in the case of the on-site a.c. loads and the power delivered to the utility is governed by practices and standards on voltage, flicker, frequency, harmonics and power factor. Deviation from these standards represents out-of-bounds conditions. The embedded generator is required to sense the deviation and might need to disconnect from the utility network.	Noticed.	**P**
4.1.1.3	All power quality parameters (voltage, flicker, frequency and harmonics) shall be measured at the PUC, unless otherwise specified (see annex A). The power quality 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. NOTE The frequency cannot be changed by an EG.	See appended table and Annex No. 1 – EMC Test Report.	**P**
4.1.1.4	The embedded generator's a.c. voltage, current and frequency shall be compatible with the utility system in accordance with IEC 61727.	Noticed.	**P**
4.1.1.5	The embedded generator shall be type approved, unless otherwise agreed upon with the utility (see annex A).	Noticed.	**P**
4.1.1.6	The maximum size of the embedded generator is limited to the rating of the supply point on the premises.	Rely in the responsibility of the installer.	**N/A**
4.1.1.7	Embedded generators larger than 10 kW shall be of the three-phase type. NOTE This value refers to the maximum export potential of the generation device.	The Inverter is rated for max. 4,6 kW and is a single phase type.	**P**
4.1.1.8	A customer with a multiphase connection shall split the embedded generator over all phases if the EG is larger than 6 kW. NOTE 1 Balancing phases in a multiphase embedded generator is deemed desirable. NOTE 2 In the case of long feeder spurs the maximum desired capacity of the EG might require approval by the utility and might result in the requirement for a three-phase connection.	Rely in the responsibility of the installer.	**N/A**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
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.	Derived from tests.	**P**
4.1.2.2	The embedded generator shall synchronise (see 4.1.8) with the utility network before a connection is established. The embedded generator shall not control the voltage, unless agreed to by the utility (see annex A).	See appended table.	**P**
4.1.3	**Flicker** 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.	See appended table and Annex No. 1 – EMC Test Report.	**P**
4.1.4	**DC injection** The static power converter of the embedded generator shall not inject d.c. current exceeding 1 % of the rated a.c. output current into the utility a.c. interface under any operating condition in accordance with IEC 61727. This relates specifically to embedded generators where the static power converter has no simple separation from the utility network (e.g. inverters that are transformer-less).	See appended table.	**P**
4.1.5	**Normal frequency operating range** 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.	See appended table.	**P**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.1: Utility compatibility			
4.1.6	**Harmonics and waveform distortion (in accordance with IEC 61727)**		**P**
4.1.6.1	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.	See appended table and Annex No. 1 – EMC Test Report.	**P**
4.1.6.2	Acceptable levels of harmonic voltage and current depend upon distribution system characteristics, type of service, connected loads or apparatus, and established utility practice.	See appended table and Annex No. 1 – EMC Test Report.	**P**
4.1.6.3	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.	See appended table and Annex No. 1 – EMC Test Report.	**P**
4.1.6.4	Total harmonic current distortion shall be less than 5 % at rated generator output in accordance with IEC 61727. Each individual harmonic shall be limited to the percentages listed in table 1.	See appended table and Annex No. 1 – EMC Test Report.	**P**
4.1.7	**Power factor** The embedded generator shall not inject reactive power into the utility network, while the drain of reactive power shall be limited to a power factor of 0,9. These limits apply, unless otherwise agreed upon with the utility (see annex A).	See appended table.	**P**
4.1.8	**Synchronization**		**P**
4.1.8.1	The embedded generator shall synchronize with the utility network before the parallel connection is made.	Derived from tests.	**P**
4.1.8.2	Automatic synchronization equipment shall be the only method of synchronization.	Derived from tests.	**P**
4.1.8.3	The limits for the synchronizing parameters for each phase are a) frequency difference: 0,3 Hz, b) voltage difference: 5 % = 11,5 V per phase, and c) phase angle difference: 20°.	Derived from tests.	**P**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
4.2.1	**General** The safe operation of the embedded generator in conjunction with the utility network shall be ensured at all times.	Noticed.	**P**
4.2.2	**Safety disconnect from utility network**		**P**
4.2.2.1	**General** 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, and d.c. current injection threshold exceeded.	Derived from tests.	**P**
4.2.2.2	**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. The disconnection unit may be integrated into one of the components of the embedded generator (for example the PV utility-interconnected inverter) or may be an independent device installed between the embedded generator and the utility interface.	The transformer less inverter provides two relays in series for each line.	**P**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
4.2.2.2.2	The disconnection switching unit shall be able to operate under all operating conditions of the utility network.	**The disconnection switching unit was tested according the single fault safety of the VDE0126-1-1.** "Fachausschuss Elektrotechnik Prüf- und Zertifizierungsstelle im BG-PRÜFZERT" **Report No.:** UB.010.17/06-122 PL/Ow **Adress:** Berufsgenossenschaft Energie Textil Elektro Gustav-Heinemann-Ufer 130 50968 Köln The requirements of functional safety with regard to the changeover to be met. The grid measures, the measures for detection and control of faults in the microprocessor system are described in (1) Section 3.1. These measures are based inter alia Ul1998:1998-08, and are comparable with measures such as they were described in DIN V VDE 0801. The software is created in the (certified) integrated OMS. The VDE0126-1-1 test report is stored at the Bureau Veritas Consumer Products Services Germany Server; Project: 11TH0290.	**P**
4.2.2.2.3	A failure within the disconnection switching unit shall lead to disconnection and indication of the failure condition.	See 4.2.2.2.2	**P**
4.2.2.2.4	A single failure within the disconnection switching unit shall not lead to failure to disconnect. Failures with one common cause shall be taken into account and addressed through adequate redundancy.	See 4.2.2.2.2	**P**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
4.2.2.2.5	The disconnection switching unit shall disconnect from the network by means of two series switches. Each switch shall be separately rated to the embedded generator's nominal power output. At least one of the switches shall be an electromechanical switch while the second switch may be part of the existing solid state switching circuits of a utility-interconnected static power converter. The electromechanical switch shall disconnect the embedded generator on the neutral and the live wire(s). NOTE 1 The switching unit need not disconnect its sensing circuits. NOTE 2 A mains-excited induction generator requires only a single disconnection switch as the generator requires excitation from the utility network to operate. NOTE 3 A static power converter without simple separation should make use of two series-connected electromechanical disconnection switches.	The transformer less inverter provides two relays in series for each line.	**P**
4.2.2.2.6	The fault current breaking capacity of the disconnecting switch shall be appropriately sized for the application.	See Annex No. 2 – Datasheet of the relay.	**P**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
4.2.2.3	**Overvoltage, undervoltage and frequency**		**P**
4.2.2.3.1	**General** 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. The embedded generator shall disconnect if these conditions occur.	See appended table.	**P**
4.2.2.3.2	**Overvoltage and undervoltage** 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. NOTE All discussions regarding system voltage refer to the nominal 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. A customer with a multiphase connection and a single-phase embedded generator above 3 kW 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.	See appended table.	**P**
4.2.2.3.3	**Overfrequency and underfrequency** The embedded generation system shall cease to energize the utility network when the utility frequency deviates outside the specified conditions. When the utility frequency is outside the range of 47,5 Hz and 52 Hz, the system shall cease to energize the utility line within 0,5 s in accordance with EA Engineering Recommendation G83/1-1: Amendment 1-June 2008. The purpose of the allowed range and time delay is to allow continued operation for short-term disturbances and to avoid excessive nuisance tripping in weak utility system conditions. The plant does not have to cease to energize if the frequency returns to the normal utility continuous operating condition within the specified trip time.	See appended table.	**P**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
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.	See appended table.	**P**
4.2.2.4.2	In order to detect an islanding condition, the embedded generator shall make use of at least one active islanding detection method. An active islanding detection method intentionally varies an output parameter and monitors the response or it attempts to cause an abnormal condition at the utility interface to trigger an out-of-bounds condition. If the utility supply is available, the attempt to vary an output parameter or cause an abnormal condition will fail and no response will be detected. However, if the utility supply network is de-energized, there will be a response to the change which can be detected. This signals an island condition to the embedded generator upon detection of which the embedded generator shall cease to energize the utility network within a specific time period.	See appended table.	**P**
4.2.2.4.3	Active islanding shall be detected in all cases where the EG interfaces with the utility network through one or more static power converters.	See appended table.	**P**
4.2.2.4.4	Synchronous generators, power-factor corrected induction generators and self-excited induction generators shall use an islanding detection method acceptable to the utility (e.g. rate-of-change-of-frequency or voltage vector shift detection). Mains-excited induction generators are not required to be fitted with such islanding detection capabilities.	See appended table.	**P**
4.2.2.4.5	This section of NRS 097-2 requires that 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 shall comply with the requirements of IEC 62116 (ed. 1). NOTE Prevention of islanding measures are only considered on the embedded generator side, i.e. no utility installed anti-islanding measures are considered.	See appended table.	**P**
4.2.2.4.6	The embedded generator shall physically disconnect from the utility network in accordance with the requirements in 4.2.2.2.	The transformer less inverter provides two relays in series for each line. Derived from tests.	**P**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
4.2.2.5	**DC current injection** The static power converter of the embedded generator shall not inject d.c. current greater than 1 % (see IEC 61727:2004) of the rated a.c. output current into the utility interface under any operating condition. The EG shall cease to energize the utility network within 500 ms if this threshold is exceeded.	**DC-Injection was tested by** "Fachausschuss Elektrotechnik Prüf- und Zertifizierungsstelle im BG-PRÜFZERT" **Report No.:** UB.010.17/06-122 PL/Ow **Adress:** Berufsgenossenschaft Energie Textil Elektro Gustav-Heinemann-Ufer 130 50968 Köln 3.5 DC monitoring The disconnection takes place through both channels with a DC current from exceeding 0.7 A within 175 ms. The VDE0126-1-1 test report is stored on Server Bureau Veritas Consumer Products Services Germany Server. Project: 11TH0290. The permanent DC injection see table 5.2 below.	**P**
4.2.3	**Response to utility recovery** 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 for 60 s after the utility service voltage and frequency have recovered to within the specified ranges.	See appended table.	**P**
4.2.4	**Isolation**		**P**
4.2.4.1	The embedded generator shall provide a means of isolating from the utility interface in order to allow for safe maintenance of the EG. The disconnection device shall be a double pole for a single-phase EG, a three-pole for a three-phase delta-connected EG, and a four-pole for a three-phase star-connected EG. The grid supply side shall be wired as the source.	Disconnecting device is not integral part of the unit. The installation instructions specify a disconnection device for the final installation. The correct assembling is part of the installer.	**N/A**
4.2.4.2	The breaking capacity of the isolation circuit-breaker closest to the point of utility connection shall have a minimum fault current level of 6 kA in accordance with SANS 60947-2.	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
4.2.4.3	This disconnection device does not need to be accessible to the utility.		**P**
4.2.5	**Earthing**		**P**
4.2.5.1	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.	Rely in the responsibility of the installer.	**N/A**
4.2.5.2	The embedded generator shall be protected by an earth leakage unit. The embedded generator shall not be connected to any of the customer network earth leakage protection units.	Rely in the responsibility of the installer.	**N/A**

NRS 097-2-1:2010			
Clause	Requirement – Test	Result – Remark	Verdict
SECTION 4.2: Safety and protection			
4.2.5.3	Utility-interconnected inverters without simple separation shall make use of earth leakage circuit-breakers which are able to respond to d.c. fault currents including smooth d.c. fault currents (i.e. without zero crossings) unless the inverter can exclude the occurrence of d.c. leakage currents through its circuit design[1]). NOTE The earth leakage unit may also fulfil the requirement of the all-pole disconnection device as stated in 4.2.4. 1) The appropriate earth leakage unit should be selected to accommodate the higher leakage current of inverters without transformers to avoid nuisance tripping.	The unit can be provided with an external RMCU type A, based on the construction and internal protection. See self-declaration from SMA Solar Technology AG The declaration is stored on Server Bureau Veritas Consumer Products Services Germany Server. Project: 11TH0290	**P**
4.2.6	**Short-circuit protection** The embedded generator shall have short-circuit protection in accordance with IEC 60364-7-712. The short-circuit characteristics for rotating generators shall be supplied to the utility.	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
4.2.7	**Labelling**		**P**
4.2.7.1	A label on the distribution board of the premises where the embedded generator is connected, shall state: “ON-SITE EMBEDDED GENERATION (EG) CONNECTED. THE EG IS FITTED WITH AN AUTOMATIC DISCONNECTION SWITCH WHICH DISCONNECTS THE EG IN THE CASE OF UTILITY NETWORK DE-ENERGIZATION.”	Rely in the responsibility of the installer and is stated in the installation instruction of the manufacturer.	**N/A**
4.2.7.2	The label shall be permanent, coloured red, and with white lettering of height at least 8 mm.	Noticed.	**N/A**

Test overview:

NRS 097-2-1:2010		
Clause	**Test**	**Result**
1	Response to protection operation - fault condition tests (according VDE0126-1-1:2006)	**P**
4.	**Type test:**	
4.1.3	Voltage fluctuations and Flicker	**P**
4.1.4	Monitoring of DC-Injection	**P**
4.1.5	Normal frequency operating range (see 4.2.2.3.3 below)	**P**
4.1.6	Harmonics and waveform distortion	**P**
4.1.7	Power factor	**P**
4.2.2.3.2	Voltage monitoring	**P**
4.2.2.3.3	Frequency monitoring	**P**
4.2.2.4	Prevention of islanding	**P**