TEST REPORT

NRS 097-2-1:2010

TUV SUD Test report for Grid interconnection of embedded generation

Part 2: Small-scale embedded generation

Section 1: Utility interface

Report reference No..... :	70.409.15.038.05-00
Date of issue..... :	2015-04-07
Project handler..... :	Pengdong Yang
TÜV SÜD Branch..... :	TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch
Address ..... :	3-13, No. 151 Heng Tong Road, Shanghai, 200 070, P.R. China
Testing location ..... :	Nanjing CQC-Trusted Testing Technology Co., Ltd. No.99, Wenlan Road, Xianlin University Zone, Qixia District, Nanjing, Jiangsu, China
Client..... :	JIANGSU GOODWE POWER SUPPLY TECHNOLOGY CO., LTD.
Client number..... :	N/A
Address ..... :	No. 189 Kun Lun Shan Road, Suzhou New District, 215163 Suzhou, Jiangsu, PEOPLE'S REPUBLIC OF CHINA
Contact person.....	Ms. Xie Jing
Standard..... :	This TUV SUD test report form is based on the following requirements: NRS 097-2-1:2010
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)..... :	33 pages
Number of pages (Attachments)..... :	N/A
Compiled by..... : Pengdong Yang	Approved by.....: Kai Zhao
(+ signature)	(+ signature)

Test sample……..:	Engineering prototype
Type of test object ..... :	PV Grid-Tied Inverter
Trademark ..... :	GOODWE your solar engine
Model and/or type reference ..... :	GW3648S-ES, GW3648D-ES, GW4248D-ES, GW5048D-ES
Rating(s) ..... :	See marking plate
Manufacturer ..... :	JIANGSU GOODWE POWER SUPPLY TECHNOLOGY CO., LTD.
Manufacturer number… ..... :	N/A
Address ..... :	No. 189 Kun Lun Shan Road, Suzhou New District, 215163 Suzhou, Jiangsu, 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…… ..... :	2015-03-31
Date of receipt of test item ..... :	2015-04-01
Date(s) of performance of test ..... :	2015-4-02 – 2015-04-07

Test item particulars:

Refer to Purpose of the product.

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.

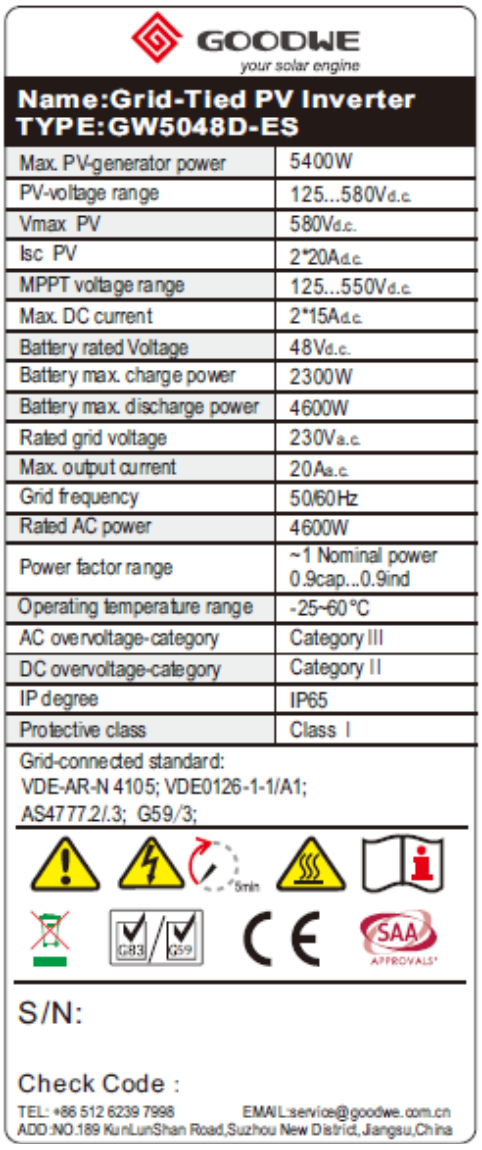
Summary of testing:

☐ deviation(s) found

☒ no deviations found

All tests were carried out according to NRS 097-2-1:2010.

Copy of marking plate:



GOODWE
your solar engine

Name:Grid-Tied PV Inverter
TYPE:GW5048D-ES

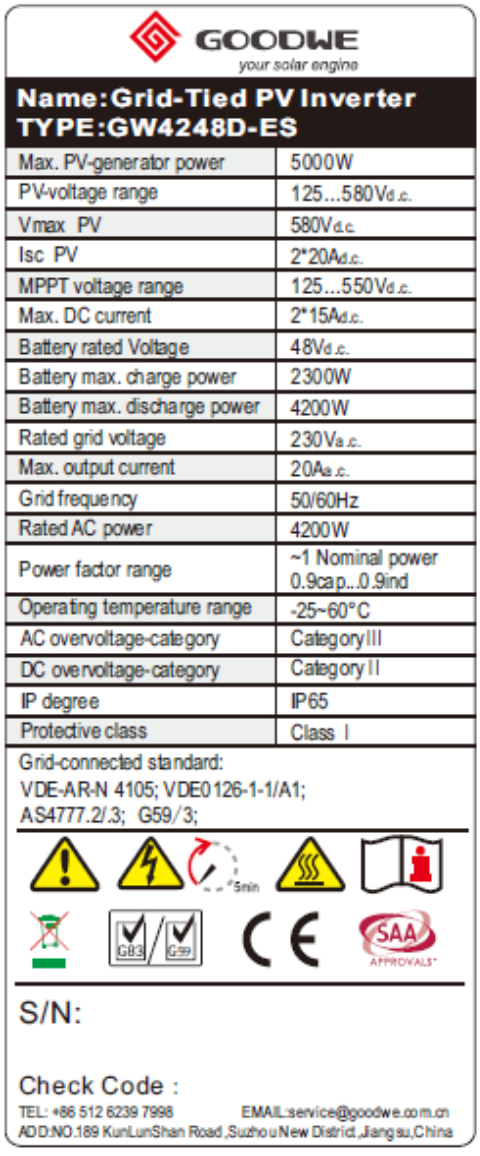
Max. PV-generator power	5400W
PV-voltage range	125...580Vd.c.
Vmax PV	580Vd.c.
Isc PV	2*20Ad.c.
MPPT voltage range	125...550Vd.c.
Max. DC current	2*15Ad.c.
Battery rated Voltage	48Vd.c.
Battery max. charge power	2300W
Battery max. discharge power	4600W
Rated grid voltage	230Va.c.
Max. output current	20Aa.c.
Grid frequency	50/60Hz
Rated AC power	4600W
Power factor range	~1 Nominal power 0.9cap...0.9ind
Operating temperature range	-25~60°C
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1/A1;
AS4777.2/.3; G59/3;

S/N:

Check Code :

TEL: +86 512 6239 7998 EMAIL:service@goodwe.com.cn
ADD:NO.189 KunLunShan Road,Suzhou New District,Jiangsu,China



GOODWE
your solar engine

Name:Grid-Tied PV Inverter
TYPE:GW4248D-ES

Max. PV-generator power	5000W
PV-voltage range	125...580Vd.c.
Vmax PV	580Vd.c.
Isc PV	2*20Ad.c.
MPPT voltage range	125...550Vd.c.
Max. DC current	2*15Ad.c.
Battery rated Voltage	48Vd.c.
Battery max. charge power	2300W
Battery max. discharge power	4200W
Rated grid voltage	230Va.c.
Max. output current	20Aa.c.
Grid frequency	50/60Hz
Rated AC power	4200W
Power factor range	~1 Nominal power 0.9cap...0.9ind
Operating temperature range	-25~60°C
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1/A1;
AS4777.2/.3; G59/3;

S/N:

Check Code :

TEL: +86 512 6239 7998 EMAIL:service@goodwe.com.cn
ADD:NO.189 KunLunShan Road,Suzhou New District,Jiangsu,China

GOODWE
your solar engine

Name:Grid-Tied PV Inverter
TYPE:GW3648D-ES

Max. PV-generator power	4200W
PV-voltage range	125...580Vd.c.
Vmax PV	580Vd.c.
Isc PV	2*20Ad.c.
MPPT voltage range	125...550Vd.c.
Max. DC current	2*15Ad.c.
Battery rated Voltage	48Vd.c.
Battery max. charge power	2300W
Battery max. discharge power	3600W
Rated grid voltage	230Va.c.
Max. output current	16Aa.c.
Grid frequency	50/60Hz
Rated AC power	3600W
Power factor range	~1 Nominal power 0.9cap...0.9ind
Operating temperature range	-25~60°C
AC overvoltage-category	CategoryIII
DC overvoltage-category	CategoryII
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1/A1;
AS4777.2/.3; G83/2;

S/N:

Check Code :

TEL: +86 512 6239 7998 EMAIL:service@goodwe.com.cn
ADD:NO.189 KunLunShan Road,Suzhou New District,Jiangsu,China

GOODWE
your solar engine

Name:Grid-Tied PV Inverter
TYPE:GW3648S-ES

Max. PV-generator power	4200W
PV-voltage range	125...580Vd.c.
Vmax PV	580Vd.c.
Isc PV	25Ad.c.
MPPT voltage range	125...550Vd.c.
Max. DC current	18Ad.c.
Battery rated Voltage	48Vd.c.
Battery max. charge power	2300W
Battery max. discharge power	3600W
Rated grid voltage	230Va.c.
Max. output current	16Aa.c.
Grid frequency	50/60Hz
Rated AC power	3600W
Power factor range	~1 Nominal power 0.9cap...0.9ind
Operating temperature range	-25~60°C
AC overvoltage-category	CategoryIII
DC overvoltage-category	CategoryII
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1/A1;
AS4777.2/.3; G83/2;

S/N:

Check Code :

TEL: +86 512 6239 7998 EMAIL:service@goodwe.com.cn
ADD:NO.189 KunLunShan Road,Suzhou New District,Jiangsu,China

Picture of the product

Characteristic data

Refer to the user manual for reference.

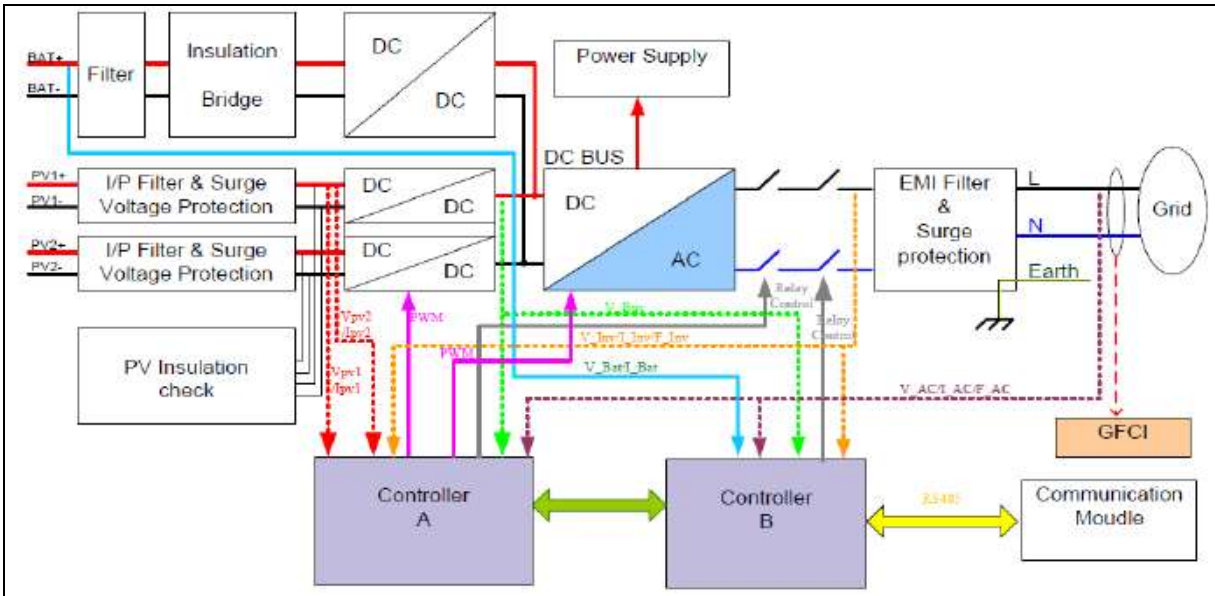
Characteristic data Factory

JIANGSU GOODWE POWER SUPPLY TECHNOLOGY CO., LTD.

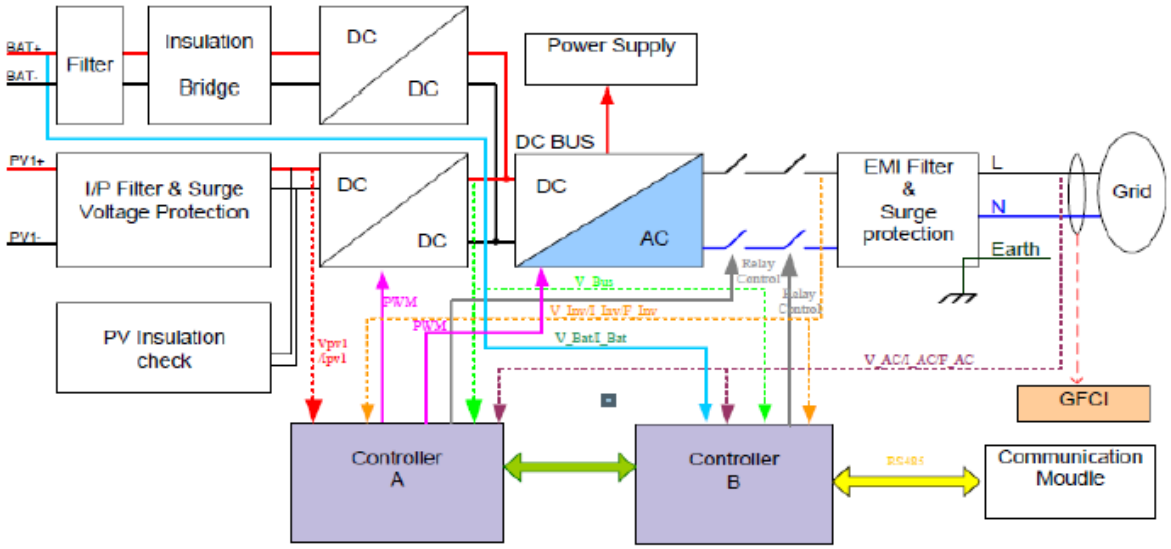
No. 189 Kun Lun Shan Road, Suzhou New District, 215163 Suzhou, Jiangsu, PEOPLE'S REPUBLIC OF CHINA

Purpose of the product

The Solar Inverter converts DC voltage into AC voltage.
The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output (transformer). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit will also operate in case of one error.
The PV inverters can also be used with an energy storage system, utilize the advanced power conversion technology IGBT to convert DC to AC. The external lithium batteries can store the DC power from PV array through a battery charger.
Model:GW5048D-ES, GW4248D-ES, GW3648D-ES



Model:GW3648S-ES



The internal control is redundant built, It consists of controller A master controller(U401) and controller slave controller(U500), the master controller(U401) and slave controller(U500) can control relays (RY1, RY2 RY3, RY4), measures voltage, frequency, master controller(U401) AC current with injected DC, insulation resistance and residual current. Both controllers communicate with each other.
The master controller (U401) measures PV1 and PV2 Voltage and current the slave controller (U500) measures Battery charge controller voltage and current.
The voltage and frequency measurement is achieved with resistors in serial which are connected directly to line and neutral. Both controllers get these signals and calculate the data.
The unit provides two relays in series in each phase. The relays are tested before each start up. In addition the power bridge can be stopped by both controllers.
The models GW-5048D-ES is identical to GW4248D-ES, GW3648D-ES in hardware and software.
The model GW3648S-ES is similar to model GW3648D-ES except Electric reactor, Inductance, MOS, IGBT, and BUS-cap
The product was tested on
Software version: V1.01
Hardware version: Main board: 290-00053, Control board: 290-00068

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)

Clause	Requirement – Test	Measuring result – Remark	Verdict
4	Requirements		P
4.1	Utility compatibility		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. Subclauses 4.1 and 4.2 are based on IEC 61727:2004.		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 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.		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.		P
4.1.1.5	The embedded generator shall be type approved, unless otherwise agreed upon with the utility (see annex A).		P
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	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.	Less than 10 kW	N/A
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.	Less than 6 kW, not intended to a multiphase connection	N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
	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.		
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.	See below	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).		P
4.1.3	Flicker		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.	(See appended table)	P
4.1.4	DC Injection		P
	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		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
4.1.6	Harmonics and waveform distortion (in accordance with IEC 61727)	(See appended table)	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.		P
4.1.6.2	Acceptable levels of harmonic voltage and current depend upon distribution system characteristics, type of service, connected loads		P

Clause	Requirement – Test	Measuring result – Remark	Verdict
	or apparatus, and established utility practice.		
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.		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.		P
4.1.7	Power factor	(See appended table)	P
	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).		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.		P
4.1.8.2	Automatic synchronization equipment shall be the only method of synchronization.		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°.		P
4.2	Safety and protection		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
	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.		P

Clause	Requirement – Test	Measuring result – Remark	Verdict
4.2.2.2	Disconnection switching unit		
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 conductor.	P
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. (See appended table.)	P
4.2.2.2.3	A failure within the disconnection switching unit shall lead to disconnection and indication of the failure condition.	See appended table.	P
4.2.2.2.4	A single failure within the disconnection switching unit shall not lead to failure to disconnect. Failures with one common cause shall be taken into account and addressed through adequate redundancy.	The disconnection switching unit was tested according the single fault safety of the VDE0126-1-1. See appended table.	P
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 conductor.	P
4.2.2.2.6	The fault current breaking capacity of the disconnecting switch shall be appropriately sized for the application.		P

<table>
<tr><th>Clause</th><th>Requirement – Test</th><th>Measuring result – Remark</th><th>Verdict</th></tr>
<tr><td>4.2.2.3</td><td>Overvoltage, undervoltage and frequency</td><td></td><td>P</td></tr>
<tr><td>4.2.2.3.1</td><td>General</td><td></td><td>P</td></tr>
<tr><td></td><td>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.</td><td></td><td>P</td></tr>
<tr><td>4.2.2.3.2</td><td>Overvoltage and undervoltage</td><td>(see appended table)</td><td>P</td></tr>
<tr><td></td><td>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.
Table 2 – Response to abnormal voltages
<table>
<tr><td>1</td><td>2</td></tr>
<tr><td>Voltage range
(at point of utility connection)</td><td>Maximum trip time
s</td></tr>
<tr><td>V < 50 %</td><td>0,2 s</td></tr>
<tr><td>50 % ≤ V < 85 %</td><td>2 s</td></tr>
<tr><td>85 % ≤ V ≤ 110 %</td><td>Continuous operation</td></tr>
<tr><td>110 % < V < 120 %</td><td>2 s</td></tr>
<tr><td>120 % ≤ V</td><td>0,16 s</td></tr>
</table></td><td></td><td>P</td></tr>
<tr><td></td><td>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.</td><td></td><td>P</td></tr>
<tr><td></td><td>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.</td><td>No for multiphase connection</td><td>N/A</td></tr>
<tr><td>4.2.2.3.3</td><td>Overfrequency and underfrequency</td><td>(see appended table)</td><td>P</td></tr>
<tr><td></td><td>The embedded generation system shall cease to energize the utility network when the utility frequency deviates outside the specified</td><td></td><td>P</td></tr>
</table>

Clause	Requirement – Test	Measuring result – Remark	Verdict
	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.		P
4.2.2.4	Prevention of islanding	(see appended table)	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 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.		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.		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-	Inverter based generator	N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
	change-of-frequency or voltage vector shift detection). Mains-excited induction generators are not required to be fitted with such islanding detection capabilities.		
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.		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.		P
4.2.2.5	DC current injection	(see appended table)	P
	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.		
4.2.3	Response to utility recovery		P
	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		N/A
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 an 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

Clause	Requirement – Test	Measuring result – Remark	Verdict
4.2.4.3	This disconnection device does not need to be accessible to the utility.		N/A
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.		P
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.		P
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 design1). 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.	P
4.2.6	Short-circuit protection		N/A
	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		N/A
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.”		N/A
4.2.7.2	The label shall be permanent, coloured red, and with white lettering of height at least 8 mm.		N/A
4.3	Metering		N/A
4.3.1	General		N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
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 acceptable in the case of premises where embedded generators are operated. One configuration applies to net metering where price symmetry is given between consumption and generation and two configurations apply to feed-in tariff (FIT) metering. The details are given in 4.3.2 and 4.3.3.		N/A
4.3.2	Net metering		N/A
4.3.2.1	Net metering applies when the consumption tariff is equal to the embedded generation tariff.		N/A
4.3.2.2	The net metering arrangement is given in figure 1 and is based on a single bi-directional meter.		N/A
4.3.2.3	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
4.3.2.4	As a result of using a single meter, the overall consumption and generation of the customer is not recorded. Only the net import and export of energy is metered and balanced. NOTE 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	Feed-in tariff metering		N/A
4.3.3.1	Feed-in tariff metering records all the energy generated from the embedded generator and reimburses the EG customer at the set FIT. The consumption of the EG customer is recorded in full and billed in the conventional manner. A customer with embedded generation and consumption therefore requires two meters.		N/A
4.3.3.2	The metering configuration for FIT metering is given in figure 2 and is referred to as "separate		N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
	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.		
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 2 is the most basic FIT metering configuration. NOTE The relevant regulations applicable in municipalities may not allow this metering configuration in which case the EG can be connected through the separate embedded generation metering configuration shown in figure 3.		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 3		N/A
4.3.3.6	The overall generation of the EG is recorded in the bi-directional embedded generation meter while the overall consumption is balanced off between the net meter and the EG meter 2). The net meter shall be a bi-directional meter. 2) The overall electricity consumption over a period is equivalent to the sum of the net meter differential reading and the EG meter differential reading.		N/A
4.3.4	Types of meter		N/A
4.3.4.1	Energy meters used in conjunction with embedded generation shall record active energy. The meters shall be conventional electronic, bi-directional type meters. The meters can either be of the single or the separate register type.		N/A
4.3.4.2	Pre-payment meters require separate registers in order to record import and export of power separately 3). 3) Single register prepayment meters deduct credit when load is drawn by the customer. However, when a customer exports energy to the utility network, credit is still decremented from the register or, alternatively, the meter goes into tamper alert. This is a revenue protection feature that renders single register prepayment meters unsuitable for embedded generation.		N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
4.3.4.3	In the event that embedded generators are required to record reactive energy in conjunction with active energy, four-quadrant conventional electronic meters shall be utilized. This applies to all the meters shown in figures 1 to 3, except for the consumption meter in figure 2 which shall be either a uni-directional or a two-quadrant meter, depending on the type of connection.		N/A
4.3.4.4	In the event that embedded generation projects of less than 100 kW can levy demand charges, four-quadrant electronic demand meters shall be utilized. This applies to all meters shown in figures 1 to 3, except for the consumption meter in figure 2 which shall either be a uni-directional, a two-quadrant or a two-quadrant demand meter, depending on the type of connection.		N/A
4.3.4.5	Meters with the capability of metering quality of supply parameters shall activate the monitoring facility on the meter. NOTE The modalities of the billing and revenue procedures for EG customers will be addressed in the future NRS 097-2-4.		N/A
4.4	UPS with embedded generation		P
4.4.1	General		P
4.4.1.1	A UPS powers all or part of the customer's network during loss-of-grid conditions and recharges its storage during utility network energization.		P
4.4.1.2	A UPS that cannot operate in parallel with the utility network (i.e. is unable to export energy to the utility side) shall comply with 7.12.2.5 of SANS 10142-1:2009 with regard to a change-over switch between the main supply and the backup supply.		N/A
4.4.1.3	A UPS that can operate in parallel with the utility network (i.e. is able to export energy to the utility side) shall comply with the safety disconnection requirements in 4.2.2.2.	The label shall be provided in the end installation on the distribution board to the local load output terminals connected.	N/A
4.4.1.4	A label shall be fitted on the distribution board to which the UPS is connected stating: "BACKUP POWER SUPPLY CONNECTED." The label shall be permanent, coloured red, and with white lettering of height at least 8 mm.		N/A
4.4.1.5	The customer's network, which is powered through the UPS, shall have earth leakage protection in accordance with the requirements in 6.7.5 in SANS 10142-1:2009.	Compliance shall be checked at the end installation	N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
4.4.2	UPS with a.c. coupled EG		N/A
4.4.2.1	A system that consists of a UPS with an a.c. utility-interconnected EG, where the EG can energize the UPS during loss-of-grid, shall comply with the requirements in 4.4.1.3 if the UPS is capable of exporting to the utility network. If the UPS is not able to export to the utility network, the system shall comply with the requirements in 4.4.1.2.		N/A
4.4.2.2	The metering configurations applicable in the case of a UPS with a.c. coupled EG are a) net metering as in figure 1 where the EG now represents both the UPS and the EG, and b) FIT metering as given in figure 4. NOTE Figure 4 illustrates only the embedded generator change-over switch. The additional switches required to comply with the requirements for safety disconnection of the EG and the UPS are given in 4.2.2.		N/A
4.4.2.3	The UPS is tied to the load side and will power the customer loads (or a selection thereof) during loss-of-grid conditions. The EG changes over to the UPS during a power failure to assist the UPS load circuit or storage. The UPS is recharged through the consumption meter on utility network recovery and the EG switches back to generate through the EG meter.		N/A
4.4.2.4	An existing consumption meter can remain in place.		N/A
4.4.2.5	The metering configuration in figure 4 can also follow the metering arrangement as given in figure 3 if the arrangement in figure 4 is not acceptable to the utility in which the EG is connected.		N/A
4.4.3	UPS with d.c. coupled EG		N/A
4.4.3.1	A system that consists of a UPS with a d.c. coupled EG can only export energy through the UPS if that function is available. If the UPS can export energy to the utility network, it shall comply with the requirements in 4.4.1.3. If the UPS cannot export energy, it shall comply with the requirements in 4.4.1.2.		N/A
4.4.3.2	The metering configurations applicable in the case of a UPS with d.c. coupled EG and exporting capabilities are a) net metering as in figure 1 where the EG now represents both the UPS and the EG, and		N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
	b) FIT metering as given in figure 5. NOTE Figure 5 illustrates only the UPS change-over switch. The additional switches required to comply with the requirement for safety disconnection of the UPS are given in 4.2.2.		
4.4.3.3	The UPS is linked to the embedded generator and exports energy through the EG meter at FIT rates. The UPS powers the customer loads (or a selection thereof). On utility network re-energization, the UPS storage is recharged by the EG and through the embedded generation meter. The logic of this metering configuration is similar to figure 3.		N/A
4.4.3.4	The embedded generation meter and the consumption meter shall be bi-directional meters.		N/A
4.5	Generation license4 4) The appropriate authority (see foreword) has submitted a request to the relevant government department (see foreword) which recommends that all generators above 1 MW require a license from the authority (see foreword) while generators of less than 1 MW are required to register with the authority. The license requirements may change depending on the outcome of the government department's review.		N/A
	In terms of the applicable national regulations (see foreword), all electricity generators, regardless of size, require a generation license. The owner of the embedded generator therefore needs to file a license application (Application for a license to generate electricity) in accordance with relevant legislation (see foreword) with the appropriate authority (see foreword).		N/A
Annex A (normative)	Notes to purchasers		N/A
A.1	The following requirements shall be specified in tender invitations and in each order or contract: – whether all power quality parameters shall be measured at the PUC (see 4.1.1.3).		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		N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
	4.1.2.2); c) the power factor limits (see 4.1.7).		
Annex B (normative)	Earthing systems		N/A
B.1	Application of SANS 10142-1		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 10142-1:2009).		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 10142-1:2009) 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 10142-1:2009) shall be connected to the main earthing terminal (see 3.29.4 in SANS 10142-1:2009), 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 10142-1:2009) or the protective conductor (see 3.15.8 in SANS 10142-1:2009) and, if installed, the earth electrode. The effectiveness of the supply protective conductor shall be determined in accordance with 8.7.5 in SANS 10142-1:2009 (see 6.11.1 as amended by amendment No. 6 in SANS 10142-1:2009).		N/A
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 10142-1:2009 (see 6.12.4 as amended by amendment No. 6 in SANS 10142-1:2009).		N/A
B.1.5	Neutral bar earthing		N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
B.1.5.1	Protection in accordance with the requirements in 6.7 in SANS 10142-1:2009 shall be provided for the electrical installation in such a manner as to ensure correct operation of the protection devices, irrespective of the supply or combination of sources of supply. Operation of the protection devices shall not rely upon the connection to the earthing point of the main supply.		N/A
B.1.5.2	Where there is no existing earth electrode in the electrical installation, a suitable earth electrode may be installed in accordance with SANS 10199. When installed, the electrode shall be bonded to the consumer's earth terminal and to the earthing point of the generating set with a conductor of at least half the cross-section of that of the phase conductor, but not less than 6 mm copper, or equivalent. This also applies to a single-phase supply. NOTE 1 In the case of the TN system of electricity supply, an earth electrode is normally not required in an electrical installation (see 7.12.3.1.1 as amended by amendment No. 6 in SANS 10142-1:2009). NOTE 2 IEC 60364-1 distinguishes three families of earthing arrangement, using the two-letter codes TN, TT, and IT. The first letter indicates the connection between earth and the power-supply equipment (generator or transformer). The second letter indicates the connection between earth and the electrical device being supplied. In the case of TN systems, T indicates a direct connection of a point with earth (Latin: terra) and N indicates direct connection to neutral at the origin of the installation, which is connected to the earth.		N/A
B.1.5.3	When an installation is supplied from a combination of transformers and generators located near one another, including alternative supplies, the neutral terminal of these shall be connected to a single earthed neutral bar. This neutral bar shall be the only point at which the neutral of the installation is earthed. Any earth leakage unit shall be positioned to avoid incorrect operation due to the existence of the parallel neutral or earth path (see 7.12.3.1.2 as amended by amendment No. 6 in SANS 10142-1:2009).		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		N/A

Clause	Requirement – Test	Measuring result – Remark	Verdict
	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 10142-1:2009). The supply that supplies the installation or part of the installation shall be switched by means of a switch that breaks all live conductors operating substantially together (see annex S of SANS 10142-1:2009), to disconnect the earthed neutral point from the installation neutral when the alternative supply is not connected (see also 6.1.6 of SANS 10142-1:2009 and 7.12.3.1.3 (as amended by amendment No. 6 in SANS 10142-1:2009)).		
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 10142-1:2009) and 7.12.3.1.3 (as amended by amendment No. 6 in SANS 10142-1: 2009).		N/A
B.2	Embedded generator and UPS configurations		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. NOTE The TT configuration is generally not used in South Africa, but could sometimes be found in certain rural electrification network spurs.		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 SANS 10142-1:2009.		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

Clause	Requirement – Test	Measuring result – Remark	Verdict
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
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

Clause	Requirement – Test	Measuring result – Remark	Verdict

4.1.3	flicker				P
Limit	d_{max}=4,0%	d_c=3,3%	Pst = 1,0	Plt=0,65	
Measured (GW5048D-ES)	0,29	0,10	0,61	0,34	
Measured (GW3648S-ES)	0,17	0,10	0,28	0,25	
Remark: GW3648S-ES: according to IEC 61000-3-3, GW5048D-ES to IEC 61000-3-11. Plt limit in NRS 084-2:2003 is 1,0.					

4.1.4 (4.2.2.5)	Direct current injection								P
Biggest type of the sereis, if	Ratio of rated output power (VA)	Measured DC output current between terminals (mA)						Isolated transformer? (Yes/No)	Limit (mA) 1% of Inom
		L1-L2	L1-L3	L2-L3	L1-N	L2-N	L3-N		
GW5048D-ES	25%	--	--	--	10	--	--	No	200
	50%	--	--	--	17,2	--	--	No	200
	100%	--	--	--	70	--	--	No	200
smallest type of the sereis, if	Ratio of rated output power (VA)	Measured DC output current between terminals						Isolated transformer? (Yes/No)	Limit (mA) 1% of Inom
		L1-L2	L1-L3	L2-L3	L1-N	L2-N	L3-N		
GW3648S-ES	25%	--	--	--	23,0	--	--	No	156
	50%	--	--	--	15,0	--	--	No	156
	100%	--	--	--	13,7	--	--	No	156
Supplementary information:									

4.1.4 (4.2.2.5)	Direct current injection			P
DC injection (A)	Limits	Trip time 1 (ms)	Trip time 2 (ms)	Trip time 3 (ms)
+0,2	Idc: > 1%, then disconnection within 0,5s	181	177,5	175
-0,2	Idc: > 1%, then disconnection within 0,5s	191	189	184

Clause	Requirement – Test	Measuring result – Remark	Verdict

Supplementary information:

A dc-current of greater than 1% of Iac nom cause a disconnection time of max. 0,5s

4.1.6	Harmonics and waveform distortion (GW5048D-ES)	P

Order	Harmonic	Harmonic limit %	Order	Harmonic	Harmonic limit %
2	1,010	1%	3	0,506	4%
4	0,251	1%	5	0,080	4%
6	0,079	1%	7	0,202	4%
8	0,256	1%	9	0,125	4%
10	0,124	0,5%	11	0,270	2%
12	0,090	0,5%	13	0,271	2%
14	0,063	0,5%	15	0,232	2%
16	0,070	0,5%	17	0,313	1,5%
18	0,003	0,5%	19	0,171	1,5%
20	0,104	0,5%	21	0,186	1,5%
22	0,015	0,5%	23	0,120	0,6%
24	0,156	0,5%	25	0,122	0,6%
26	0,091	0,5%	27	0,112	0,6%
28	0,114	0,5%	29	0,132	0,6%
30	0,204	0,5%	31	0,088	0,6%
32	0,172	0,5%	33	0,026	0,6%
THD	4,31	5%	--	--	--

Supplementary information:

Clause	Requirement – Test	Measuring result – Remark	Verdict
4.1.6	Harmonics and waveform distortion (GW3648S-ES)		P

Order	Harmonic	Harmonic limit %	Order	Harmonic	Harmonic limit %
2	0,599	1%	3	0,519	4%
4	0,061	1%	5	0,434	4%
6	0,129	1%	7	0,344	4%
8	0,138	1%	9	0,287	4%
10	0,152	0,5%	11	0,239	2%
12	0,129	0,5%	13	0,221	2%
14	0,143	0,5%	15	0,174	2%
16	0,130	0,5%	17	0,188	1,5%
18	0,138	0,5%	19	0,153	1,5%
20	0,112	0,5%	21	0,100	1,5%
22	0,090	0,5%	23	0,127	0,6%
24	0,076	0,5%	25	0,105	0,6%
26	0,098	0,5%	27	0,111	0,6%
28	0,094	0,5%	29	0,082	0,6%
30	0,079	0,5%	31	0,080	0,6%
32	0,075	0,5%	33	0,079	0,6%
THD	1,226	5%	--	--	--

Supplementary information:

4.1.7	**Power factor (GW3648S-ES)**							P
	Input			output				
Power level (% of VA)	Voltage (V d.c.)	Current (A d.c.)	Power (W)	Active power	Apparent power (VA)	voltage (V)	current (A)	Power factor (+/-

Clause	Requirement – Test			Measuring result – Remark				Verdict
				(W)				)
(50±5)%	401	4,759	1909	1839	1853	230,3	8,043	0,993
(60±5)%	402	5,502	2210	2131	2142	230,0	9,313	0,995
(70±5)%	402	6,493	2609	2518	2527	230,2	10,979	0,996
(80±5)%	402	7,482	3008	2904	2912	230,3	12,646	0,997
(90±5)%	402	8,479	3407	3291	3298	230,4	14,314	0,998
(100±5)%	402	9,480	3807	3675	3682	230,2	15,992	0,998
Supplementary information: N/A								

4.1.7	**Power factor (GW5048D-S)**							P
	Input			output				
Power level (% of VA)	Voltage (V d.c.)	Current (A d.c.)	Power (W)	Active power (W)	Apparent power (VA)	voltage (V)	current (A)	Power factor (+/-)
(50±5)%	367	6,531	2392	2311	2320	231,6	10,019	0,996
(60±5)%	366	7,810	2854	2759	2766	231,7	11,937	0,997
(70±5)%	364	9,198	3348	3233	3239	231,8	13,969	0,998
(80±5)%	363	10,463	3800	3666	3672	231,9	15,829	0,999
(90±5)%	362	12,236	4428	4267	4272	232,1	18,400	0,999
(100±5)%	363	13,168	4775	4599	4604	232,2	19,824	0,999
Supplementary information:								

4.2.2.3.2	Overvoltage and under voltage						P
Under voltage stage 2: < 50% Un							
	Voltage			Trip time (s)			Reconnection time
Measured voltage (V)	114	114	115	0,079	0,068	0,0725	75,97

Clause	Requirement – Test	Measuring result – Remark	Verdict

Limit	115,0V			0,2s			Min. 60s
Under voltage stage 1: 50% Un ≤ V < 85% Un							
	Voltage			Trip time (s)			Reconnection time
Measured voltage (V)	195	195	195	1,737	1,732	1,711	75,63
Limit	195,5V			2,0s			Min. 60s
Over voltage stage 1: 110% Un < V 120% Un							
	Voltage			Trip time (s)			Reconnection time
Measured voltage (V)	254	254	254	1,574	1,575	1,922	76,27s
Limit	253,0V			2,0s			Min. 60s
Over voltage stage 2: ≥ 120% Un							
	Voltage			Trip time (s)			Reconnection time
Measured voltage (V)	276,0	276,0	276,0	0,04	0,036	0,024	75,0
Limit	276,0V			0,16s			Min. 60s
Supplementary information: N/A							

4.2.2.3.3	Over frequency and under frequency	P

Under Frequency							
	Frequency			Trip time (s)			Reconnection time (s)
Output voltage	0,85Un	Un	1,10Un	0,85Un	Un	1,10Un	
Measured Frequency (Hz)	47,53	47,53	47,53	0,075	0,086	0,100	75,9
Limit	47,5 Hz			0,5s			Min. 60s
Over Frequency							

Clause	Requirement – Test	Measuring result – Remark	Verdict

	Frequency			Trip time (s)			Reconnection time (s)
Output voltage	0,85Un	Un	1,10Un	0,85Un	Un	1,10Un	
Measured Frequency (Hz)	51,97	51,97	51,97	0,106	0,100	0,091	75,7
Limit	52,0 Hz			0,5s			Min. 60s
Supplementary information: N/A							

4.2.2.4	**Prevention of islanding** **Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (EUT ouput = 100%)**	P

Rated Frequency = (Hz)	50 Hz ± 0,1 Hz	Rated Voltage = (Vac)	230 Vac ± 3Vac
PCE rated Output power (W)		4600	
Disconnection limit:	2s (IEC 62116)		

No.	P_{EUT} (% of rated)	Reactive power (Q_L)	P_{AC} (% of rated)	Q_{AC} (% of rated)	Run time (ms)	P_{EUT} (kW)	Actual Qf	Vdc	Remarks
1	100	100	0	0	409	4600	1,01	550	Test A, IB
2	100	100	-10	-10	N/A	N/A	N/A	N/A	Test A, IB
3	100	100	-10	-5	N/A	N/A	N/A	N/A	Test A, IB
4	100	100	-10	0	N/A	N/A	N/A	N/A	Test A, IB
5	100	100	-10	+5	N/A	N/A	N/A	N/A	Test A, IB
6	100	100	-10	+10	N/A	N/A	N/A	N/A	Test A, IB
7	100	100	-5	-10	N/A	N/A	N/A	N/A	Test A, IB
8	100	100	-5	-5	140	4600	1,03	550	Test A, IB
9	100	100	-5	0	108	4600	1,05	550	Test A, IB
10	100	100	-5	+5	102	4600	1,08	550	Test A, IB
11	100	100	-5	+10	N/A	N/A	N/A	N/A	Test A, IB

Clause	Requirement – Test					Measuring result – Remark			Verdict
12	100	100	0	-10	N/A	N/A	N/A	N/A	Test A, IB
13	100	100	0	-5	150	4600	0,97	550	Test A, IB
14	100	100	0	+5	100	4600	1,02	550	Test A, IB
15	100	100	0	+10	N/A	N/A	N/A	N/A	Test A, IB
16	100	100	+5	-10	N/A	N/A	N/A	N/A	Test A, IB
17	100	100	+5	-5	155	4600	0,93	550	Test A, IB
18	100	100	+5	0	150	4600	0,95	550	Test A, IB
19	100	100	+5	+5	191	4600	0,98	550	Test A, IB
20	100	100	+5	+10	N/A	N/A	N/A	N/A	Test A, IB
21	100	100	+10	-10	N/A	N/A	N/A	N/A	Test A, IB
22	100	100	+10	-5	N/A	N/A	N/A	N/A	Test A, IB
23	100	100	+10	0	N/A	N/A	N/A	N/A	Test A, IB
24	100	100	+10	+5	N/A	N/A	N/A	N/A	Test A, IB
25	100	100	+10	+10	N/A	N/A	N/A	N/A	Test A, IB

RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) PAC: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 %test condition value.
4) BL: Balance condition, IB: Imbalance condition.
Condition A:
EUT output power PEUT = Maximum 5)
EUT input voltage 6) = >90% of rated input voltage range
5) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.
6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,9 x (Y – X). Y shall not exceed 0,8 x EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

4.2.2.4	**Prevention of islanding** **Islanding protection according Table 7 - Load imbalance (reactive load) for test condition B (EUT output = 50 % – 66 %)**	P

Clause	Requirement – Test	Measuring result – Remark	Verdict

Rated Frequency = (Hz)	50 Hz ± 0,1 Hz	Rated Voltage = (Vac)	230 Vac ± 3Vac
PCE rated Output power (W)		4600	
Disconnection limit:	2s (IEC 62116)		

No.	P_{EUT} (% of rated)	Reactive power (Q_L)	P_{AC} (% of rated)	Q_{AC} (% of rated)	Run time (ms)	P_{EUT} (kW)	Actual Qf	Vdc	Remarks
1	66	66	0	0	182	2800	1,00	400	Test B, IB
2	66	66	0	-5	141	2800	0,95	400	Test B, IB
3	66	66	0	-4	120	2800	0,96	400	Test B, IB
4	66	66	0	-3	138	2800	0,97	400	Test B, IB
5	66	66	0	-2	113	2800	0,98	400	Test B, IB
6	66	66	0	-1	142	2800	0,99	400	Test B, IB
7	66	66	0	1	167	2800	1,01	400	Test B, IB
8	66	66	0	2	294	2800	1,02	400	Test B, IB
9	66	66	0	3	173	2800	1,03	400	Test B, IB
10	66	66	0	4	118	2800	1,04	400	Test B, IB
11	66	66	0	5	122	2800	1,05	400	Test B, IB

RLC is adjusted to min. +/-1% of the inverter rated output power
1) P_{EUT}: EUT output power
2) PAC: Real power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
3) Q_{AC}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 %test condition value.
4) BL: Balance condition, IB: Imbalance condition.
Condition A:
EUT output power PEUT = Maximum 5)
EUT input voltage 6) = >90% of rated input voltage range
5) Maximum EUT output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.

6) Based on EUT rated input operating range. For example, If range is between X volts and Y volts, 90 % of range =X + 0,9 x (Y – X). Y shall not exceed 0,8 x EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.

Clause	Requirement – Test	Measuring result – Remark	Verdict
4.2.2.4	**Prevention of islanding** **Islanding protection according Table 7 - Load imbalance (reactive load) for test condition C (EUT output = 25 % – 33 %)**		

Rated Frequency = (Hz)	50 Hz ± 0,1 Hz	Rated Voltage = (Vac)	230 Vac ± 3Vac
PCE rated Output power (W)		4600W	
Disconnection limit:	2s (IEC 62116)		

No.	P_{EUT} (% of rated)	Reactive power (Q_L)	P_{AC} (% of rated)	Q_{AC} (% of rated)	Run time (ms)	P_{EUT} (kW)	Actual Qf	Vdc	Remarks
1	33	33	0	0	189	1400	1,00	360	Test C, IB
2	33	33	0	-5	315	1400	0,95	360	Test C, IB
3	33	33	0	-4	312	1400	0,96	360	Test C, IB
4	33	33	0	-3	194	1400	0,97	360	Test C, IB
5	33	33	0	-2	386	1400	0,98	360	Test C, IB
6	33	33	0	-1	310	1400	0,99	360	Test C, IB
7	33	33	0	1	425	1400	1,01	360	Test C, IB
8	33	33	0	2	178	1400	1,02	360	Test C, IB
9	33	33	0	3	173	1400	1,03	360	Test C, IB
10	33	33	0	4	219	1400	1,04	360	Test C, IB
11	33	33	0	5	156	1400	1,05	360	Test C, IB

Supplementary information:

--- End of test report---