TEST REPORT

EN 50438: 2013

Requirements for micro-generating plants to be connected in parallel with public low-voltage distribution networks

Report reference No. ..... :	140327083GZU-011
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Date of issue ..... :	30 May 2014
Contents ..... :	33 Pages
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Testing location ..... :	Same as above
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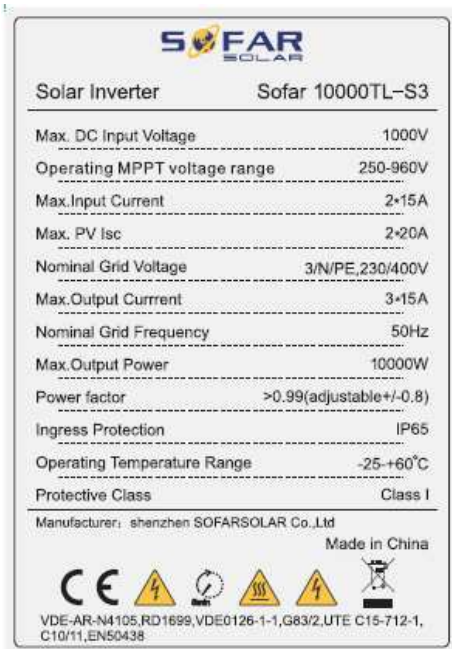
Applicant's Name ..... :	Shenzhen SOFARSOLAR Co., Ltd.
Address ..... :	3A-1, Huake Building, East Technology Park, Qiaoxiang Road, Nanshan District, Shenzhen, China
Test specification	
Standard ..... :	EN 50438: 2013
Test procedure ..... :	Type testing for Denmark compliance
Non-standard test method ..... :	N/A
Test Report Form No ..... :	EN50438b
TRF originator ..... :	Intertek
Master TRF ..... :	dated 2014-01
Test item description ..... :	Grid-connected PV inverter
Trademark ..... :	SOFAR SOLAR
Manufacturer ..... :	Same as applicant
Factory ..... :	Dongguan dingqiang Machinery & Electric Co., Ltd. No. 8, Fulong road, Qingxi town, Dongguan city, Guangdong, China
Model and/or type reference ..... :	Sofar 10000TL-Sx (x=0-6) （refer to General product information）

Rating(s)..... :	Maximum d.c. input voltage: 1000 V Input voltage rang: 250-960 V Max. Input current: 2×15 A Max. PV Isc: 2×20 A Nominal Grid voltage: 3/N/PE230V/400V Max. Output current: 3×15 A Nominal Grid frequency: 50 Hz Max. Output power: 10000 W Ingress protection: IP65 Operating temperature range: -25～60℃

Summary of testing:

The sample(s) tested complied with the default type test requirement of EN50438: 2013.
Denmark deviation had been considered.

Copy of marking plate



Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation

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 .....:	27 Mar 2014
Date(s) of performance of test .....:	27 Mar 2014 – 09 May 2014

General remarks

The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.

Throughout this report a point is used as the decimal separator.

When determining the test conclusion, the Measurement Uncertainty of test has been considered.

General product information:

1. Product covered by this report is non-isolated grid-connected PV inverter for connection with low voltage grid in terms of EN 50438.
2. The inverters intended to operate at ambient temperature -25℃ - +60℃ and 250-960 Vdc input, which will be specified in the user manual, The inverters will output full power when operated at 45℃. If operated at higher than 45℃ temperature, the output power derating.
3. if the DC input voltage is higher than 850 Vdc the output power will be derating; if the DC input voltage is lower than 350 Vdc, the output power will be derating.

"x" of model Sofar 10000TL-Sx denotes number from "0" to "6", and difference as following:

Model	DC Cable Gland	PV connector	DC inside connector	Fuse PCB+ String detection board	DC surge arrester	DC switch	AC switch	AC surge arrester
Sofar 10000TL-S0	√		√					
Sofar 10000TL-S1	√		√			√		
Sofar 10000TL-S2		√	√			√		
Sofar 10000TL-S3		√		√		√		
Sofar 10000TL-S4		√		√	√	√		
Sofar 10000TL-S5		√		√	√	√		√
Sofar 10000TL-S6		√		√	√	√	√	√
√ denote incorporating this component								

The product was tested on Software version: V1.00

Unless special notes, model Sofar 10000TL-S6 used for testing.

Software setting as following:

Different country can be set on switch SWT3 on communication board, digit "0" represents OFF, digit "1" represents ON

SWITCH 5	SWITCH 4	SWITCH 3	SWITCH 2	SWITCH 1	Country
0	0	1	0	1	Denmark

EN50438			
Cl.	Requirement - Test	Result	Verdict
4	**Technical requirements**		P
4.1	**Electrical installation**		N/A
4.1.1	**General**		N/A
	Low voltage electrical installations shall comply with national and local regulation. In case of any hardware malfunctioning, disconnection is required.	Shall be complied with end installation	N/A
4.1.2	**Over-current protection**		N/A
	The micro-generating plant shall be protected against over-current according to the HD 60364 series. When selecting the over-current protection within the domestic installation it is necessary to ensure correct selectivity with the DSO’s protection devices.	Shall be complied with end installation	N/A
4.1.3	**Earthing**	Shall be complied with end installation	N/A
	Earthing shall be according to HD 60364-5-551 and the relevant national standards.		N/A
	When a micro-generator is operating in parallel with the distribution network, there shall be no direct connection between the generator winding (or pole of the primary energy source in the case of a DC sourced micro-generator) and the DSO’s earth terminal. For installations where the customer provides his own earth terminal, e.g. when connected to a TT system, it is also advisable to avoid connecting the generator winding to this earth terminal.		N/A
	For a micro-generator which is designed to operate in parallel with a distribution network but which is connected via an inverter (e.g. a PV array or a stationary fuel cell power system) it is permissible to connect one pole of the DC side of the inverter to the distribution network if there is insulation between the AC and the DC sides of the inverter. In such cases, the installer/manufacturer shall take all reasonable precautions to ensure that the micro-generator will not impair the integrity of the distribution network and will not suffer unacceptable damage for all credible operating conditions, including faults on the distribution network.		N/A
4.2	**Normal operating range**		P
4.2.1	**General**		P

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Cl.	Requirement - Test	Result	Verdict
	Generating plants have to be able to operate in the operating range specified below regardless the topology and the settings of the interface protection.		P
4.2.2	**Continuous voltage operation range**		P
	The generating plant shall be capable not to disconnect due to voltage when the voltage at the point of connection stays within the range of 0,85 U_n to 1,1 U_n.		P
	The generating plant owner shall take into account the voltage rise and voltage drop within the installation when considering the wider operating range for the generator unit itself.		P
4.2.3	**Continuous frequency operation range**		P
	The generating plant shall be capable to operate continuously when the frequency at the point of connection stays within the range of 49 Hz to 51 Hz.		P
	Linear generators, coupled directly and synchronously to the grid, and powered by free piston stirling engines are permitted to disconnect below 49,5 Hz and above 50,5 Hz.		N/A
4.2.4	**Response to under-frequencies**		P
	A generating plant shall be resilient to reductions of frequency at the point of connection while reducing the maximum power as little as possible.		P
	Table 1 shows the minimum time periods a generating plant has to be able to operate without disconnecting from the network.	See appended table	P
	The admissible active power reduction due to under-frequency below 49,5 Hz is limited by a reduction rate of 10 % of the momentary power P_M per 1 Hz frequency drop as given by the full line in Figure 2.	See appended table	P
	Respecting the legal framework, it is possible that a more stringent power reduction characteristic is required by the DSO in coordination with the TSO. Nevertheless this requirement shall be limited to an admissible active power reduction due to under-frequency below 49,0 Hz with a reduction rate of 2 % of the momentary power P_M per 1 Hz frequency drop as indicated by the dotted line in Figure 2.		N/A
	Acceptance of this reduction is limited to a selection of affected generation technologies and may be subject to further conditions decided by the relevant TSO.		P
4.2.5	**Power response to over-frequency**		P
	A generating plant shall be resilient to over-frequency at the point of connection.		P

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Cl.	Requirement - Test	Result	Verdict
	Table 2 shows the minimum time periods a generating plant has to be able to operate without disconnecting from the network.	See appended table	N/A
	Unless otherwise required by the DSO, the micro-generating plant shall be capable of activating activepower frequency response at a programmable frequency threshold f_1 at least between and including 50,2 Hz and 52 Hz with a programmable droop in a range of at least 2 % – 12 %. The droop is relative to P_M, the actual AC output power at the instance when the frequency reaches the threshold f_1. The resolution of the frequency measurement shall be +/- 10 mHz or less. After the programmable intentional delay, the active power frequency response shall be delivered with an accuracy of ± 10 % P_n and with a settling time less than 2 s.	Threshold f1 from 50.2Hz with programmable droop 12%	P
	The generator shall be capable of activating active power frequency response as fast as technically feasible with an initial delay that shall be as short as possible with a maximum of 2 s. If the initial delay is below 2 s an intentional delay shall be programmable to adjust the total response time to a value between the initial response time and 2 s.		P
	After activation, the frequency droop function shall use the actual frequency at any time.		P
	If the initial delay is greater than 2 s it shall be reasonably justified by the manufacturer to the DSO.		N/A
	The settings for the threshold frequency f1, the droop and the intentional delay are provided by the DSO and shall be field adjustable. If no settings are provided, the default settings in Table 3 shall be applied.	It can be filed adjustable accessed by communication port RS 485	P
	For field adjustable settings means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.	By password	P
	When applying active power response to over-frequency, the frequency threshold f1 should be set to a value from 50,2 Hz up to 50,5 Hz.	Setting of 50.2Hz	P
	It shall be taken into account that, in case of islanding, a power reduction would correct any excess of generation leading to a generation-consumption balance. In these circumstances, an islanding situation with stable frequency would take place, in which the correct behaviour of any LoM detection based on frequency as those mentioned in 4.6.2 (Table 4) might be hindered.		P

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	Generators for which it is technically not feasible to reduce power over the full droop range in the required time shall activate active power frequency response as above in the fast controllable range of output power. Once the limit of fast controllable frequency response is reached, this power level is maintained constant. The unit has to shut off at a random frequency between the frequency threshold f_1 and f_{max}; with f_{max} the disconnection limit for over-frequency as provided by the DSO. If no setting is provided, the default setting for f_{max} is 51,5 Hz.	Denmark: The default setting for f_{max} is 52Hz	P
	After European Network Codes will come into force, the decision about the ability should be according to the derogation process.		P
	The overall effect on transmission network level of multiple units with the random frequency disconnection function should emulate the droop curve given by Table 1 resp. the setting in Annex A.		P
	After a frequency excursion, once the frequency drops below the threshold frequency f_1 the microgenerating plant is allowed to rise the power above P_M. The active power generated by a generating plant shall not exceed the specified gradient expressed as a percentage of the active nominal power of the unit per minute. If no gradient is specified by the DSO, the default setting is 10 % P_n/min. Nonadjustable or partly adjustable generating plant that have been disconnected shall reconnect according to 4.7.2.	the default setting is 10 % P_n/min	P
4.3	**Reactive power capability**		P
4.3.1	**Inverter based micro-generator**		P
	The micro-generator shall be capable to operate, under normal stationary operating conditions in the voltage tolerance band according to 4.2.2, with the following reactive power exchange (see Figure 3):		P
	• following a characteristic curve provided by the DSO (see 4.4) within the active factors cos φ = $0{,}90_{\text{under-excited}}$ to $0{,}90_{\text{over-excited}}$ when the active power output of the micro-generator is more than or equal to 20 % of its nominal active power;		P
	• not exchanging more reactive power than 10 % of the micro-generator's nominal active power when the active power output is less than 20 % of its nominal active power.		P
4.3.2	**Directly coupled micro-generator with no inverter**		N/A

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	The power factor of the micro-generator at normal steady-state operating conditions across the statutory tolerance band of nominal voltage shall be above 0,95, provided the output active power of the micro-generator is above 20 % the nominal output power of the unit. Below 20 % nominal output power the micro-generator shall not exchange more reactive power than 10 % of its nominal active output power.		N/A
4.4	**Reactive power control modes**	See appended table	P
4.4.1	General		P
	Only when a reactive power exchange capability following a characteristic curve is required (see 4.3), the requirements of 4.4.3 shall apply.		P
	The control shall be delivered at the terminals of the micro-generator. The micro-generator shall be capable of operating in the following control modes within the limits stated in 4.3:		P
	Q (U)		P
	Cos φ fix		P
	Cos φ (P)		P
	The configuration of the control modes shall be field adjustable. The activation and deactivation of the control modes shall be field adjustable.		P
	For field adjustable configurations and activation/deactivation of the control mode, means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.		P
	The accuracy for controlled reactive power shall be below ± 2 % of nominal power of the microgenerator. The accuracy is always stated in reactive power, even if the used control mode is referring to the active factor.		P
	The type of contribution to voltage control by reactive power shall be specified by the DSO. If no characteristic curve is specified by the DSO, the micro-generator shall operate with an active factor = 1.		P
4.4.2	**Fix control mode cos φ**		N/A
	The fix control mode controls the active factor cos φ of the micro-generator's output according to a setpoint set in the control of the micro-generator.		N/A
4.4.3	**Voltage related control mode Q(U)**		N/A
	The voltage related control mode Q(U) controls the reactive power output as a function of the voltage.		N/A

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Cl.	Requirement - Test	Result	Verdict
	For evaluating the voltage one of the following methods shall be used:		N/A
	• the positive sequence of the symmetrical components;		N/A
	• the average voltage of a three phase system;		N/A
	• phase independently the voltage of every phase to determine the reactive power for every phase.		N/A
	A characteristic curve according to Figure 4 shall be configurable.		N/A
	Additional to the characteristic the dynamic response of the control should be configurable. The dynamics of the control should correspond with a first order filter having a time constant that is configurable in the range of 3 s to 60 s. The time to reach 95 % of a new set point due to a change in voltage will be 3 times the time constant.		N/A
4.4.4	**Power related control mode Cos φ (P)**		N/A
	The power related control mode Cos φ (P) controls the active factor Cos φ of the micro-generator's output as a function of its active power output.		N/A
	A characteristic according to Figure 4 has to be configurable.		N/A
	New set values due to a change of the active power output have to be adjusted within a settling time of 10 s. The rate of change of reactive power should be in the same time range as and synchronized with the rate of change of active power.		N/A
4.5	**Voltage control by active power**		N/A
	In order to avoid disconnection due to the over-voltage protection the micro-generating plant is allowed to reduce active power output as a function of this rising voltage. If this function is activated, the micro-generating plant may reduce active power according to a logic chosen by the manufacturer. Nevertheless, this logic shall not result in steps of output power.		N/A
4.6	**Interface protection**	incorporated within the micro-generator	P
4.6.1	**General**		P
4.6.1.1	**Introduction**		P

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Cl.	Requirement - Test	Result	Verdict
	The purpose of the interface protection is to ensure that the connection of a micro-generator will not impair the integrity or degrade the safety of the distribution network. The interface protection shall be insensitive to voltage and frequency variations in the distribution network within the voltage and frequency settings.		P
	The interface protection, monitoring and control functions may be incorporated into the microgenerator control system, or may be fitted as discrete separate mounted devices.		P
	The interface protection settings shall be field adjustable.	Accessed by communication ports	P
	For field adjustable settings means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.	By password	P
	The protection functions have to evaluate at least all phases where micro-generators, covered by this protection system, are connected to.		P
	In case of three phase generating units/plants and when the protection system is implemented as a external protection system in a three phase supply system, all phase to phase or all phase to neutral voltages have to be evaluated.		P
	The frequency has to be evaluated on at least one of the supply voltages.		P
	If multiple signals (e.g. three phase to phase voltages) are to be evaluated by one protection function, this function has to evaluate all of the signals separately. The output of each evaluation has to be OR connected, so that if one signal passes the threshold of a function, the function has to trip the protection in the specified time.		P
	The minimum required accuracy is:		P
	• for frequency measurement ± 0,05 Hz;		P
	• for voltage measurement ± 1 % of U_n.		P
	The measurement point can be inside the micro-generator or anywhere between the micro-generator terminals and up to the point of connection.		P
	If the interface protection system is external to the generating unit, it should measure as close as possible to the point of connection. The voltage rise between the point of connection and the measurement input of the interface protection system should be kept as small as possible to avoid nuisance tripping of the overvoltage protection.	Internal of inverter	N/A

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Cl.	Requirement - Test	Result	Verdict
	In order to avoid continuous starting and disengaging operations of the interface protection relay, the disengaging value of frequency and voltage functions shall be above 2 % deviating from the operate value.		N/A
4.6.1.2	**Response to protection operation**		P
	The micro-generator shall disconnect from the network in response to an interface protection operation.		P
4.6.1.3	**Place of the interface protection**		P
	The interface protection can either be incorporated within the micro-generator or implemented by separate devices. In either case, the interface protection shall meet the relevant requirements of IEC 60255-127 and the manufacturer of the micro-generator shall declare that the combined devices fulfil these requirements.	incorporated within the micro-generator	P
4.6.1.4	**Changing settings of the interface protection**		P
	The interface protection settings may only be altered from the settings chosen at the time of commissioning or during later reconfiguration, with the written agreement of the DSO and then only in accordance with the manufacturer instructions. It shall not be permissible for the user to alter the interface protection settings.		P
4.6.1.5	**Combined protection device for multiple generators**		N/A
	It is allowed to use a protection system that provides interface protection for two or more microgenerators up to and including 16 A per phase in aggregate. However, the possibility to use Inform and Fit then depends on the conditions of the type of conformity assessment of the protection system.		N/A
	If two or more micro-generators, each with their own interface device, are placed in parallel, the proper combined working of the protection devices shall be ensured.		N/A
	In the case of adding a generator to the combined protection device, the DSO shall be consulted.		N/A
4.6.2	**Interface protection settings**		P
	The interface protection settings are provided by the DSO. If no settings are provided, the default settings in Table 4 should be applied.		N/A
4.6.3	**Requirements regarding single fault tolerance of interface protection system**		P

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Cl.	Requirement - Test	Result	Verdict
	The interface protection system consisting of the interface protection relay and the interface switch shall meet the requirements of single fault tolerance.	Single fault condition have been considered	P
	A single fault shall not lead to a loss of the safety functions. Faults of common cause shall be taken into account if the probability for the occurrence of such a fault is significant. Whenever reasonably practical, the individual fault shall be displayed and lead to the disconnection of the power generation unit or system.		P
	Series-connected switches shall each have independently a breaking capacity corresponding to the rated current of the micro-generator and corresponding to the short circuit contribution of the microgenerator.		P
	The short-time withstand current of the switching devices shall be coordinated with maximum short circuit power at the connection point.		P
	At least one of the switches shall be a switch-disconnector suitable for over-voltage category 2. For single-phase micro-generators, the switch shall have one contact of this over-voltage category each for both the neutral conductor and the line conductor. For poly-phase supply systems, it is required to have one contact of this over-voltage category each for all active conductors. The second switch may be formed by electronic switching components of an inverter bridge or another circuit provided that the electronic switching components can be switched off by control signals and that it is ensured that a failure is detected and leads to prevention of the operation at the latest at the next reconnection.		P
	For PV-inverters without simple separation between the network and the PV generator (e.g. PV Inverter without transformer) both switches mentioned in the paragraph above shall be switch disconnectors with the requirements described therein, although one switching device is permitted to be located between PV generator and PV inverter.		P
4.7	**Connection and starting to generate electrical power**		P
4.7.1	General		P

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Cl.	Requirement - Test	Result	Verdict
	Connection and starting to generate electrical power is only allowed after voltage and frequency is within the allowed voltage range and the allowed frequency range for at least the specified observation time. It shall be impossible to overrule these conditions. The setting of the conditions depends on whether the connection is due to a normal operational start-up or an automatic reconnection after tripping of the interface protection.		P
	The frequency range, the voltage range, the observation time and the power gradient shall be field adjustable.		P
	For field adjustable settings, means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.		P
4.7.2	**Automatic reconnection after tripping**		P
	If no settings are specified by the DSO, the default settings for the reconnection after tripping of the interface protection are:		P
	• Frequency range: 47,5 Hz ≤ f ≤ 50,05 Hz	See appended table	P
	• Voltage range: 0,85Un ≤ U ≤ 1,10Un	See appended table	P
	• Minimum observation time: 60 s	60 s	P
	After reconnection the active power generated by the generating plant shall not exceed a specified gradient expressed as a percentage of the active nominal power of the unit per minute. If no gradient is specified by the DSO, the default setting is 10 % P_n/min. Non-adjustable or partly adjustable generating units may connect after 1 min to 10 min (randomised value) or later.	The default setting is 10 % P_n/min	P
4.7.3	**Starting to generate electrical power**		P
	If no settings are specified by the DSO the default settings for connection or starting to generate electrical power due to normal operational start-up or activity are:		P
	• Frequency range: 47,5 Hz ≤ f ≤ 50,1 Hz	See appended table	P
	• Voltage range: 0,85Un ≤ U ≤ 1,10Un	See appended table	P
	• Minimum observation time: 60 s	60 s	P
	If applicable, the power gradient shall not exceed the maximum gradient specified by the DSO in the connection agreement. Heat driven CHP micro-generators do not need to keep a maximum gradient, since the start up is randomised by the nature of the heat demand.	The default setting is 10 % P_n/min	P

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Cl.	Requirement - Test	Result	Verdict
	For manual operations performed on site (e.g. for the purpose of initial start-up or maintenance) it is permitted to deviate from the observation time and ramp rate.		N/A
4.7.4	**Synchronisation**		P
	Synchronising a micro-generator with the distribution network shall be fully automatic i.e. it shall not be possible to manually close the switch between the two systems to carry out synchronisation.		P
4.8	**Power quality**		P
4.8.1	**General**		P
	As any other apparatus or fixed installation, micro-generators have to comply with the requirements on electromagnetic compatibility established in Directive 2004/108/EC.		P
	They are also expected to be compatible with voltage characteristics at the point of connection to the public network, as described in 4.2.		P
	As long as specific tests for generators are not available, generic EMC standards, regarding immunity as well as emission, should be applied. The applicable standards, which in turn describe the test in accordance with basic standards (EN 61000-3, all parts, and EN 61000-4, all parts), are:		P
	• Immunity: EN 61000-6-1 (residential, commercial and light-industrial environments);		P
	• Emission: EN 61000-6-3 (residential, commercial and light-industrial environments): in this generic emission standard reference is made to e.g. the harmonics and voltage variation basic standards listed in Table 5.		P
	In addition, the application of the requirements and tests described in IEC/TR 61000-3-15 is recommended, with the exception of those aspects already regulated by specific national rules.		P
	Generating plants can also disturb mains signaling (ripple control or power line carrier systems). EMC requirements on inter-harmonics and on conducted disturbances in frequency range between 2 kHz and 150 kHz are under development. In countries where such communication systems are used, national requirement may apply.		P
4.8.2	**DC injection**		P
4.8.2	The generating unit shall not inject a direct current.	See appended table	P

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Cl.	Requirement - Test	Result	Verdict
5	**Operation and safety of the micro-generator**		P
5.1	**General**		P
	The micro-generator shall operate safely over the entire designed and declared operating range.		P
	The settings of (country-specific) field adjustable set-points shall be readable from the microgenerator, for example on a display panel, user interface, or via a communication port.	Via a communication port	P
5.2	**Safety**		P
	This European Standard does not cover the safety of DSO personnel or their contracted parties, as their safety is a combination of electrical conditions and working instructions.		P
	General requirements for safety of persons at work in or near and operation of electrical installations are given in EN 50110 (all parts), also national regulations can be applicable.		P
5.3	**Information plate**		P
	In absence of product specific standards (e.g. EN 50524) the following information shall appear on the micro-generator nameplate:		P
	• manufacturer's name or trade mark;		P
	• type designation or identification number, or any other means of identification making it possible to obtain relevant information from the manufacturer;		P
	• nominal power;		P
	• nominal voltage;		P
	• nominal frequency;		P
	• phases;		P
	• active factor range or, if no active factor is adjustable, the minimal power factor.		P
	This information shall be provided on a plate on or in the micro-generator and shall be copied in the user manual as well as other related documentation. In addition, a serial number may be added to the plate only.		P
	This information could be part of the information plate of the entire micro-generator system.		P
	All the information shall be given in the language and in accordance with the practice of the country in which the micro-generator is intended to be installed or alternatively in English language.	English language	P

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Cl.	Requirement - Test	Result	Verdict
5.4	**Labelling**		P
	A warning notice shall be placed in such a position that any person gaining access to live parts will be warned in advance of the need to isolate those live parts from all points of supply.		P
	Special attention should be paid that the power supply, measuring circuits (sense lines) and other parts may not be isolated from the network when the switch of the interface protection is open.		P
	As a minimum, warning labels shall be placed:		P
	• on the switchboard (DSO panel and consumer unit) that has the micro-generator connected to it;		N/A
	• on all switchboards in between the consumer unit and the micro-generator itself;		N/A
	• on, or in the micro-generator itself;		P
	• at all points of isolation for the micro-generator.		N/A
	All the information shall be given in the language and in accordance with the practice of the country in which the micro-generator is intended to be installed.		P
5.5	**Maintenance and routine testing**		P
	The manufacturer shall provide a time frame for maintenance and routine testing.		P
	The user is responsible for the proper maintenance and routine testing.		P
	Maintenance and routine testing shall be carried out by qualified service technicians.		P
	With respect to service technicians, additional national requirements shall be taken into account.		P
6	**Commissioning**		P
	This European Standard applies to type-tested micro-generators.		P
	The following conditions shall be met for the installation:		P
	the micro-generator (including the interface protection) shall fulfil the requirements of this standard and the other applicable standards;		P
	the manufacturer shall provide an installation instruction in accordance with this standard and national or regional requirements;		P
	access to the interface protection settings shall be tamper-proof;		P
	in the absence of product standards the micro-generator shall be type tested against the interface requirements of this standard;		P

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	the installation shall be carried out by installers with recognised and approved qualification related to the fuels used, general electrical installations and a particular qualification relating to installation of micro-generators;		P
	the installer shall provide a single line diagram of the electricity generating facility. The single line diagram shall show the circuit breaker, the protections, the inverter, etc.		P
	The user respective the installer should be aware that in addition to the DSO the energy supplier and/or the metering authority will need to be informed for contractual reasons.		P
	Unless otherwise stated by national legislation or regulation, prior consent of the DSO is necessary.		P
Annex A	**National settings and requirements**		P
A.1	General		P
A.2	AT – Austria		N/A
A.3	BE – Belgium		N/A
A.4	CY – Cyprus		N/A
A.5	CZ – Czech Republic		N/A
A.6	DE – Germany		N/A
A.7	DK – Denmark		P
A.8	EE – Estonia		N/A
A.9	ES – Spain		N/A
A.10	FI – Finland		N/A
A.11	FR – France		N/A
A.12	GB – United Kingdom		N/A
A.13	IE – Ireland		N/A
A.14	IT – Italy		N/A
A.15	LV – Latvia		N/A
A.16	NL – The Netherlands		P
A.17	NO – Norway		N/A
A.18	PL – Poland		P
A.19	SI – Slovenia		N/A
A.20	SE – Sweden		N/A
Annex B	**Loss of Mains and overall system security**		P

EN50438			
Cl.	Requirement - Test	Result	Verdict
Annex C	**Example notification sheets**		--
Annex D	**Compliance type testing**		P
D.1	General		P
D.2	Type testing of the interface protection		P
D.2.1	Introduction		P
D.2.2	General		P
D.2.3	Over-/under-voltage		P
D.2.4	Over- /under-frequency		P
D.2.5	Loss of Mains (LoM) detection		P
D.3	Type testing of a micro-generator		P
D.3.1	Operating range		P
D.3.2	Active power feed-in at under-frequency		P
D.3.3	Power response to over-frequency		P
D.3.4	Reactive power capability		P
D.3.5	Voltage control by active power		N/A
D.3.6	Connection and starting to generate electrical power		P
D.3.7	Short-circuit current contribution		N/A
D.3.8	Harmonic current emission		P
D.3.9	Voltage fluctuations and flicker		P
D.3.10	DC injection		P
Annex E	**Example test results sheet**		--
Annex F	**Commissioning**		P
Annex G	**Countries allowing extension of the scope > 16 A**		N/A
G.1	General		N/A
G.2	CY – Cyprus		N/A
G.3	FI – Finland		N/A
G.4	IE – Ireland		N/A

Appendix A: Tables

D.2.3 Over-/under-voltage					**P**
		Over Voltage		Under Voltage	
Parameter		Voltage	Disconnection Time	Voltage	Disconnection Time
Protection limit		259.9V	0.1-0.2s	207V	9-10s
Actual setting (as applied to interface protection)		260.0V	0.16s	207V	9.6s
Trip value (test result)-1	All phases	260.0V	0.180s	206.7V	9.62s
	Phase R	259.9V	0.185s	206.5V	9.64s
	Phase S	259.9V	0.186s	206.7V	9.62s
	Phase T	260.0V	0.187s	206.6V	9.62s
Trip value (test result)-2	All phases	260.1V	0.184s	206.6V	9.62s
	Phase R	260.0V	0.186s	206.5V	9.62s
	Phase S	260.0V	0.186s	206.5V	9.64s
	Phase T	260.1V	0.184s	206.5V	9.62s
Trip value (test result)-3	All phases	260.0V	0.186s	206.7V	9.63s
	Phase R	260.1V	0.188s	206.7V	9.63s
	Phase S	260.1V	0.188s	206.6V	9.62s
	Phase T	260.1V	0.188s	206.6V	9.62s
Trip value (test result)-4	All phases	260.0V	0.186s	206.7V	9.62s
	Phase R	259.9V	0.184s	206.6V	9.64s

Appendix A: Tables

	Phase S	260.0V	0.184s	206.6V	9.64s
	Phase T	260.0V	0.186s	206.6V	9.62s
Trip value (test result)-5	All phases	260.1V	0.186s	206.7V	9.63s
	Phase R	259.9V	0.186s	206.6V	9.64s
	Phase S	259.9V	0.186s	206.7V	9.63s
	Phase T	260.0V	0.184s	206.7V	9.64s
		Over Voltage		--	
Parameter		Voltage	Disconnection Time	--	--
Protection limit		253V	39-40s	--	--
Actual setting (as applied to interface protection)		253V	39s	--	--
Trip value (test result)-1	All phases	252.7V	39.035s	--	--
	Phase R	252.8V	39.037s	--	--
	Phase S	252.7V	39.027s	--	--
	Phase T	252.7V	39.029s	--	--
Trip value (test result)-2	All phases	252.8V	39.036s	--	--
	Phase R	252.9V	39.034s	--	--
	Phase S	252.8V	39.028s	--	--
	Phase T	252.7V	39.028s	--	--
	All phases	252.8V	39.034s	--	--

Appendix A: Tables

Trip value (test result)-3	Phase R	252.8V	39.032s	--	--
	Phase S	252.8V	39.030s	--	--
	Phase T	252.8V	39.032s	--	--
Trip value (test result)-4	All phases	252.7V	39.032s	--	--
	Phase R	252.7V	39.032s	--	--
	Phase S	252.7V	39.034s	--	--
	Phase T	252.7V	39.030s	--	--
Trip value (test result)-5	All phases	252.6V	39.028s	--	--
	Phase R	252.6V	39.026s	--	--
	Phase S	252.7V	39.026s	--	--
	Phase T	252.7V	39.032s	--	--

D.2.4 Over- /under-frequency				**P**
	Over Frequency		Under Frequency	
Parameter	Frequency	Time	Frequency	Time
Protection limit	52Hz	0.1-0.2s	47.5Hz	0.1-0.2s
Actual setting (as applied to interface protection)	52Hz	0.12s	47.5Hz	0.12s
Trip value (test result)-1	52.01Hz	0.182s	47.49Hz	0.169s
Trip value (test result)-2	52.01Hz	0.188s	47.49Hz	0.166s
Trip value (test result)-3	52.01Hz	0.186s	47.49Hz	0.172s
Trip value (test result)-4	52.01Hz	0.148s	47.49Hz	0.156s
Trip value (test result)-5	52.01Hz	0.148s	47.49Hz	0.156s

Appendix A: Tables

D.2.5 Loss of Mains (LoM) detection										P
No.	PEUT[1] (% of EUT rating)	Reactive load (% of QL in 6.1.d)1)	PAC[2] (% of nominal)	QAC[3] (% of nominal)	Run on time (ms)	PEUT (W)	Actual Qf	VDC	Remarks[4]	
1	100	100	0	0	648	10000	1.00	800	Test A at	BL
2	66	66	0	0	720	6600	1.00	600	Test B at	BL
3	33	33	0	0	682	3300	1.00	300	Test C at	BL
4	100	100	-5	-5	364	10000	1.00	800	Test A at	IB
5	100	100	-5	0	412	10000	1.05	800	Test A at	IB
6	100	100	-5	5	294	10000	1.10	800	Test A at	IB
7	100	100	0	-5	284	10000	0.95	800	Test A at	IB
8	100	100	0	5	291	10000	1.05	800	Test A at	IB
9	100	100	5	-5	312	10000	0.90	800	Test A at	IB
10	100	100	5	0	417	10000	0.95	800	Test A at	IB
11	100	100	5	5	384	10000	1.00	800	Test A at	IB
12	66	66	0	-5	284	6600	0.95	600	Test B at	IB
13	66	66	0	-4	294	6600	0.96	600	Test B at	IB
14	66	66	0	-3	290	6600	0.97	600	Test B at	IB
15	66	66	0	-2	312	6600	0.98	600	Test B at	IB
16	66	66	0	-1	267	6600	0.99	600	Test B at	IB
17	66	66	0	1	412	6600	1.01	600	Test B at	IB
18	66	66	0	2	264	6600	1.02	600	Test B at	IB
19	66	66	0	3	374	6600	1.03	600	Test B at	IB
20	66	66	0	4	698	6600	1.04	600	Test B at	IB
21	66	66	0	5	513	6600	1.05	600	Test B at	IB
22	33	33	0	-5	644	3300	0.95	300	Test C at	IB
23	33	33	0	-4	652	3300	0.96	300	Test C at	IB
24	33	33	0	-3	640	3300	0.97	300	Test C at	IB
25	33	33	0	-2	656	3300	0.98	300	Test C at	IB
26	33	33	0	-1	672	3300	0.99	300	Test C at	IB
27	33	33	0	1	668	3300	1.01	300	Test C at	IB
28	33	33	0	2	660	3300	1.02	300	Test C at	IB
29	33	33	0	3	652	3300	1.03	300	Test C at	IB
30	33	33	0	4	548	3300	1.04	300	Test C at	IB
31	33	33	0	5	517	3300	1.05	300	Test C at	IB

Remark:

1) PEUT: 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) QAC: 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.
5) *Note: test condition A (100%): If any of the recorded run-on times are longer than the one recorded for the rated balance condition, i.e. test procedure 6.1 f), then the non-shaded parameter combinations (no.32~47) also require testing.

D.3.1 Operating range				**P**
Test sequence	Voltage	Frequency	Output power	Primary power source
Test 1	207V	48Hz	9378W	9640W
Test 2	253V	51.5Hz	10062W	10278W

D.3.2 Active power feed-in at under-frequency			**P**
Test sequence	Frequency	Output power	Primary power source
Test a)	50.0Hz	10033W	10272W
Test b)	49.5Hz	10032W	10272W
Test c)	47.5Hz	10031W	10272W

D.3.3 Power response to over-frequency				**P**
Test sequence at power level >80%	Output Power	Frequency	Primary Power source	Power gradient
Step a)	10036W	50Hz	10278W	--
Step b)	9972W	50.25Hz	10213W	-64W/1min
Step c)	9198W	50.70Hz	9424W	-774W/1min
Step d)	8427W	51.15Hz	8637W	-771W/1min
Step e)	9198W	50.70Hz	9433W	771W/1min
Step f)	9509W	50.25Hz	9742W	311W/1min
Step g)	10035W	50Hz	10278W	526W/1min

D.3.3 Power response to over-frequency				**P**
Test sequence at power level 40%-60%	Output Power	Frequency	Primary Power source	Power gradient
Step a)	4993W	50.00Hz	5118W	--
Step b)	4965W	50.25Hz	5087W	-28W/1min

Appendix A: Tables

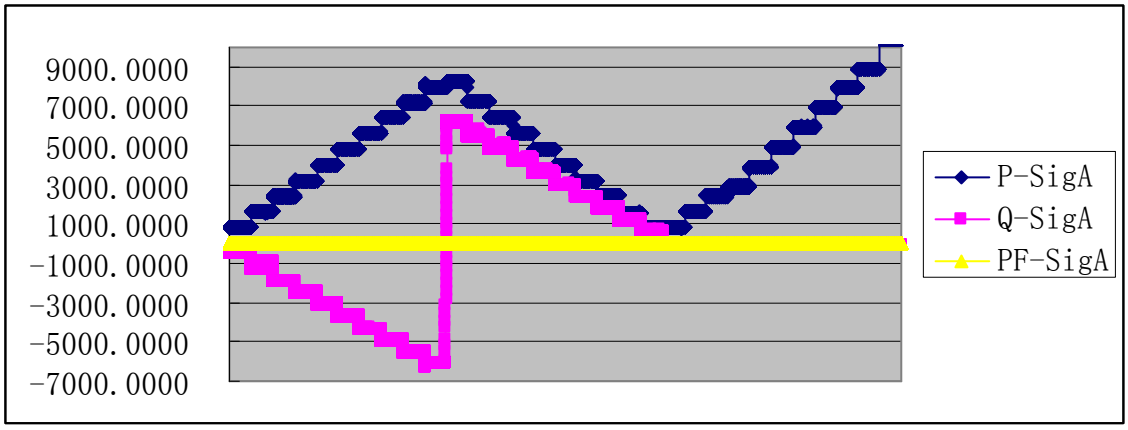
Step c)	4631W	50.70Hz	4698W	-334W/1min
Step d)	4187W	51.15Hz	4316W	-444W/1min
Step e)	4571W	50.70Hz	4706W	384W/1min
Step f)	4954W	50.25Hz	5096W	383W/1min
Step g)	4993W	50.00Hz	5118W	39W/1min

D.3.4.1 Uncontrollable reactive power

	Power factor		
Limit	+ 0,95 - 0,95 at three voltage levels and four power levels		
	210V	230V	250V
20% of nominal active power	--	--	--
50% of nominal active power	--	--	--
75% of nominal active power	--	--	--
100% of nominal active power	--	--	--

Reactive power output capability

Plot of P over Q of all measured points



Test sequence start of generation	Output power	Measured reactive power 1	Measured reactive power 2	Measured reactive power 3	Measured power factor
Max Over excited	837.99W	442.61VA	441.29VA	440.33VA	0.7844
	1625.70W	1073.88	1070.30VA	1063.80VA	0.7907
	2411.51W	1879.84VA	1879.83VA	1879.91VA	0.7924
	3184.57W	2466.42VA	2474.78VA	2474.80VA	0.7931
	3978.55W	3069.93VA	3088.88VA	3087.44VA	0.7936

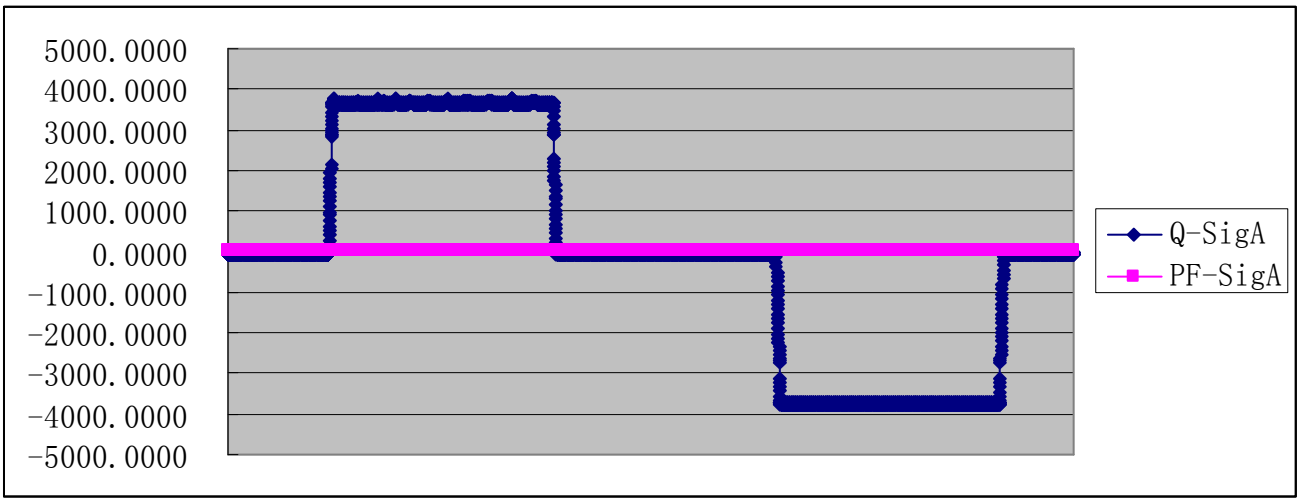
	4811.92W	3695.79VA	3682.19VA	3710.61VA	0.7955
	5641.46W	4359.34VA	4344.34VA	4328.65VA	0.7925
	6413.11W	4894.16VA	4930.74VA	4914.12VA	0.7941
	7199.22W	5490.19VA	5542.24VA	5509.16VA	0.7951
	7944.81W	6086.14VA	6084.83VA	6085.83VA	0.7944
Max Under excited	848.22w	658.37VA	653.95VA	658.23VA	0.8064
	1586.59W	1191.62VA	1193.91VA	1190.47VA	0.8044
	2422.13W	1795.76VA	1797.66VA	1799.81VA	0.8068
	3211.65W	2386.03VA	2391.05VA	2384.83VA	0.8057
	3996.08W	2992.01VA	2996.91VA	2999.67VA	0.8036
	4824.33W	3626.34VA	3620.34VA	3622.54VA	0.8021
	5660.86W	4279.19VA	4275.17VA	4276.66VA	0.8011
	6439.90W	4839.11VA	4844.99VA	4856.30VA	0.8014
	7214.16W	5386.03VA	5441.51VA	5386.06VA	0.8038
	8255.80W	6188.83VA	6183.13VA	6183.80VA	0.8026
Q=0	858.65W	36.68VA	34.22VA	30.94VA	0.9903
	1631.10W	44.31VA	43.48VA	43.14VA	0.9989
	2426.36W	42.41VA	49.19VA	42.97VA	0.9999
	2917.71W	44.26VA	44.94VA	43.83VA	0.9999
	3897.83W	43.43VA	42.46VA	42.08VA	0.9999
	4880.82W	41.43VA	41.03VA	41.41VA	0.9999
	5978.12W	52.09VA	52.57VA	52.21VA	0.9995
	6951.16W	51.95VA	44.87VA	81.11VA	0.9992
	7933.69	47.51VA	48.76VA	49.23VA	0.9990
	8911.66W	64.99VA	66.21VA	67.28VA	0.9992

Appendix A: Tables

D.3.4.2 Controllable reactive power

Q adjustment

Plot of P over Q of all measured points



Test sequence start of generation	Output power	Set reactive power	Measured reactive power	Tolerance
Max Over excited	4860.40W	3750.00VA	3717.43VA	32.57VA
	4858.02W	3750.00VA	3722.94VA	27.06VA
	4859.35W	3750.00VA	3730.71VA	19.29VA
Max under excited	4877.20W	3750.00VA	3673.57VA	76.43VA
	4877.91W	3750.00VA	3662.92VA	87.08VA
	4877.87W	3750.00VA	3664.30VA	85.70VA
Q=0	4888.98W	0	61.58VA	61.58VA
	4888.86W	0	48.70VA	48.70VA
	4889.18W	0	54.76VA	54.76VA

D.3.6.2 Connection after trip of interface protection				**P**
Test sequence after trip	connection	connection allowed	Primary power source	Power gradient after connection
Step a)	<47.45Hz	No	10600W	--
Step b)	≥47.45Hz	Yes	10600W	928W/1min
Step c)	>50.10Hz	No	10600W	--
Step d)	≤50.10Hz	Yes	10600W	926W/1min

Appendix A: Tables

Step e)	<206V	No	10600W	--
Step f)	≥207V	Yes	10600W	912W/1min
Step g)	>255.3V	No	10600W	--
Step h)	≤253V	Yes	10600W	929W/min

D.3.6.3 Start of generating electrical power				**P**
Test sequence after trip	connection	connection allowed	Primary power source	Power gradient after connection
Step a)	<47.40Hz	No	10600W	0
Step b)	≥47.45Hz	Yes	10600W	896W/1min
Step c)	>50.15Hz	No	10600W	0
Step d)	≤50.10Hz	Yes	10600W	908W/1min
Step e)	<206V	No	10600W	0
Step f)	≥207V	Yes	10600W	912W/1min
Step g)	>255.3V	No	10600W	0
Step h)	≤253V	Yes	10600W	911W/1min

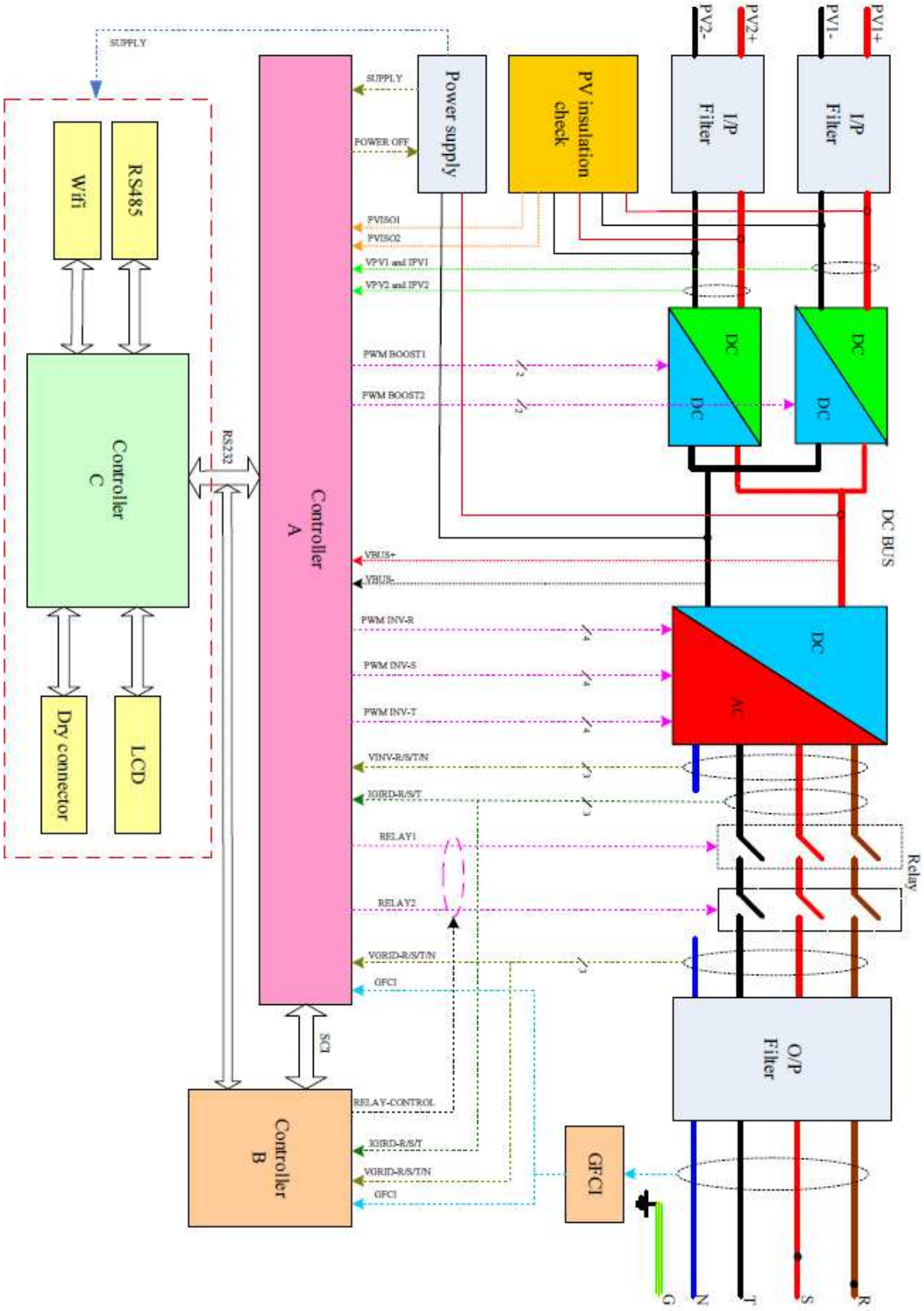
Appendix A: Tables

D 3.8 Harmonic current emissions											
		Maximum permissible harmonic current as per EN 61000-3-2 Class A									
		Odd harmonics							Even harmonics		
Harmonic Order n		3	5	7	9	11	13	15th ≤ n ≤39th	2	4	6	8th ≤ n ≤40th
Limit		2.30	1.14	0.77	0.40	0.33	0.21	0.15 （15/n）	1.08	0.43	0.30	0.23(8/n)
Test value	R:	0.023	0.198	0.127	0.011	0.042	0.039	0.003	0.063	0.030	0.002	0.005
	S:	0.013	0.231	0.122	0.040	0.049	0.036	0.004	0.063	0.034	0.004	0.008
	T:	0.030	0.225	0.135	0.031	0.051	0.038	0.004	0.061	0.028	0.005	0.010

D 3.9 Voltage Fluctuations and Flicker					
	Maximum permissible flicker and voltage fluctuation as per EN 61000-3-3				
Value	P_{st}	P_{lt}	d(t) – 500ms	dc	dmax
Limit	1.0	0.65	3.3%	3.3%	4%
Test value	0.083	0.192	0.96	0	1.28

D.3.10 DC injection					
		Power level			
		20%	50%	75%	100%
DC current	R:	0.0041	0.0061	0.0102	0.0136
	S:	0.0023	0.0022	0.0030	0.0106
	T:	0.0016	0.0039	0.0073	0.0035
0.5% of nominal current	R:	0.0273%	0.041%	0.068%	0.091%
	S:	0.0153%	0.015%	0.020%	0.071%
	T:	0.0107%	0.026%	0.049%	0.023%

Appendix B: System diagram



Appendix C: Photos

Overview

Bottom view

Appendix C: Photos

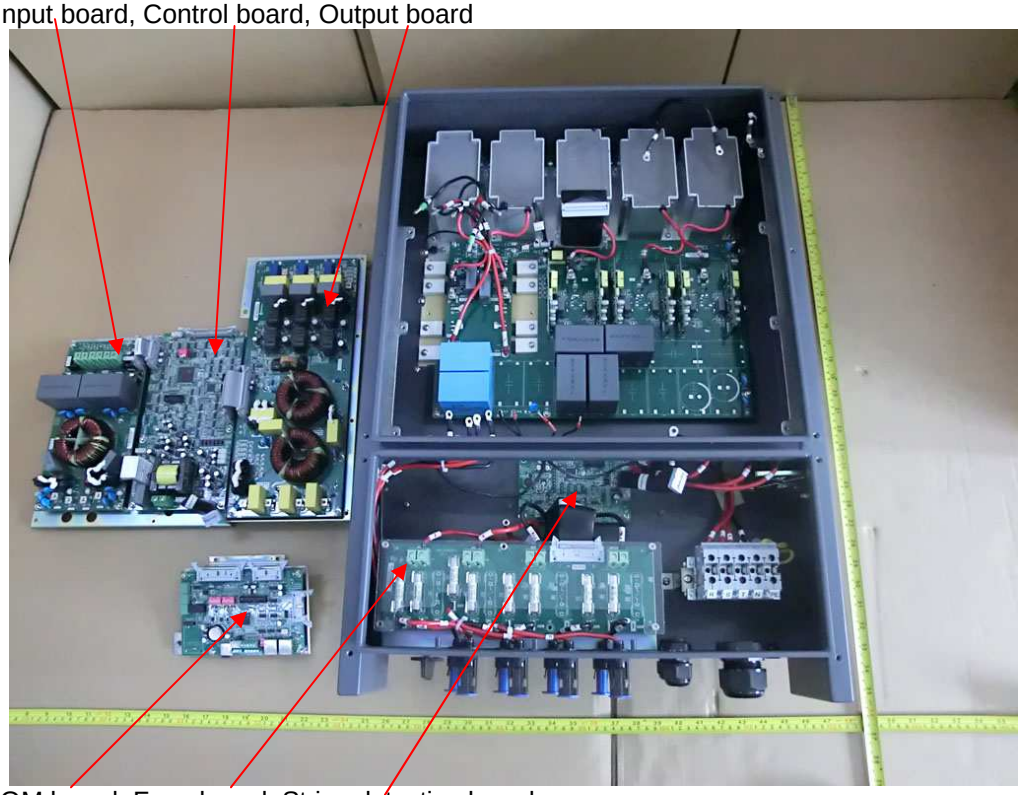
Terminal view

Internal view of the unit

Appendix C: Photos

Internal view of the unit

Input board, Control board, Output board



COM board, Fuse board, String detection board

Internal view of the unit