Prüfbericht-Nr.: *Test Report No.*:	**50121374 001**	**Auftrags-Nr.:** *Order No.*:	164109428	*Seite 1 von 57* *Page 1 of 57*
Kunden-Referenz-Nr.: *Client Reference No.*:	455841	**Auftragsdatum:** *Order date*:	26.10.2017	
Auftraggeber: *Client*:	Guangzhou Sanjing Electric Co., Ltd.			
Prüfgegenstand: *Test item*:	Grid-tied PV Inverter			
Bezeichnung / Typ-Nr.: *Identification / Type No.*:	Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K			
Auftrags-Inhalt: *Order content*:	TÜV Rheinland AK license approval			
Prüfgrundlage: *Test specification*:	EN 50438: 2013/Netherland DIN VDE V 0126-1-1/08.13			

Wareneingangsdatum: *Date of receipt*:	26.10.2017
Prüfmuster-Nr.: *Test sample No.*:	24030G1734CN14841, 25030G1734CN14841
Prüfzeitraum: *Testing period*:	27.10.2017 – 28.12.2017
Ort der Prüfung: *Place of testing*:	See page 4
Prüflaboratorium: *Testing laboratory*:	TÜV Rheinland (Shenzhen) Co., Ltd.
Prüfergebnis*: *Test result**:	Pass

geprüft von / *tested by*:			**kontrolliert von** / *reviewed by*:		
06.01.2018	Corney Zhang / PE		06.01.2018	Dean Cao / Reviewer	
Datum *Date*	**Name / Stellung** *Name / Position*	**Unterschrift** *Signature*	**Datum** *Date*	**Name / Stellung** *Name / Position*	**Unterschrift** *Signature*

Sonstiges / *Other*:
- See the following pages for General product information and comment.

Zustand des Prüfgegenstandes bei Anlieferung: *Condition of the test item at delivery*:	Prüfmuster vollständig und unbeschädigt *Test item complete and undamaged*

* Legende:	1 = sehr gut	2 = gut	3 = befriedigend	4 = ausreichend	5 = mangelhaft
	P(ass) = entspricht o.g. Prüfgrundlage(n)		F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
Legend:	*1 = very good*	*2 = good*	*3 = satisfactory*	*4 = sufficient*	*5 = poor*
	P(ass) = passed a.m. test specification(s)		*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

V04

Test Report issued under the responsibility of:

TÜVRheinland®

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TEST REPORT
EN 50438: 2013
Requirements for microgeneratingplants to beconnected in parallel withpublic low-voltage distributionnetworks

Report Reference No.....	50121374 001	
Tested by (name + signature)	See cover page	.....
Witnessed by (name + signature) ..	--	.....
Supervised by (name + signature)..	--	.....
Approved by (name + signature)	See cover page	.....
Date of issue.....	See cover page	
Testing Laboratory.....	See cover page	
Address	See cover page	
Testing location/ procedure	CBTL☐ TMP☐ WMT☐ SMT☐ RMT☐ CCATL ☐	
Testing location/ address.....	See page 4	
Applicant's name	Guangzhou Sanjing Electric Co., Ltd.	
Address	No.9, Lizhishan Road, Science City, Guangzhou High-tech Zone, Guangdong, P.R. China	
Test specification:		
Standard	EN 50438: 2013/Netherland DIN VDE V 0126-1-1/08.13	
Test procedure	AK certificate	
Non-standard test method……..:	N/A	
Test Report Form No.....	EN 50438/2013	
Test Report Form(s) Originator	TÜV Rheinland Group	
Master TRF.....	2014-07	

Test item description	Grid-tied PV Inverter
Trade Mark	SAJ
Manufacturer	Guangzhou Sanjing Electric Co., Ltd.
Model/Type reference.....	See rating labels for details
Ratings	See rating labels for details

Testing procedure and testing location:		
☐ **CB Testing Laboratory:**	See cover page	
Testing location/ address..... :	See cover page	
☐ **Associated CB Test Laboratory:**		
Testing location/ address..... :		
Tested by (name + signature) ..... :	See cover page	.....
Approved by (+ signature) ..... :	See cover page	.....
☐ Testing procedure: TMP		
Tested by (name + signature) ..... :		
Approved by (+ signature) ..... :		
Testing location/ address..... :		
☐ Testing procedure: WMT		
Tested by (name + signature) ..... :		
Witnessed by (+ signature) ..... :		
Approved by (+ signature) ..... :		
Testing location/ address..... :		
☐ Testing procedure: SMT		
Tested by (name + signature) ..... :		
Approved by (+ signature) ..... :		
Supervised by (+ signature) ..... :		
Testing location/ address..... :		
☐ Testing procedure: RMT		
Tested by (name + signature) ..... :		
Approved by (+ signature) ..... :		
Supervised by (+ signature) ..... :		
Testing location/ address..... :		

List of Attachments (including a total number of pages in each attachment):

- ATTACHMENT – Photo Documentation (14 pages)

Summary of testing

Tests performed (name of test and test clause):

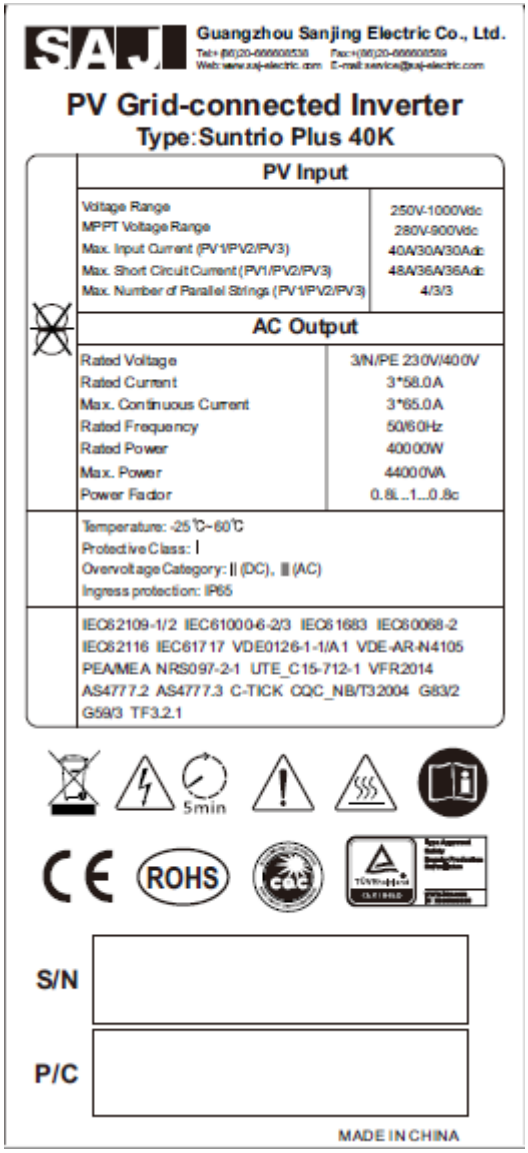
Clause	Test description	Models
☒ D.2.3	Tabel E.2.2 Over-/under-voltage	Suntrio Plus 60K
☒ D.2.4	Table E.2.3 Over-/under-Frequency	Suntrio Plus 60K
☒ D.2.5	Table E.2.4 LoM detection	Suntrio Plus 60K
☒ D.3.1	Table E.3.1 Operating range	Suntrio Plus 60K
☒ D.3.2	Table E.3.2 Active power at under-frequency	Suntrio Plus 60K
☒ D.3.3	Table E.3.3 Power response to over-frequency	Suntrio Plus 60K
☒ D.3.4.1	Table E.3.4.1 Uncontrollable reactive power	Suntrio Plus 40K Suntrio Plus 60K
☒ D.3.4.2	Table E.3.4.2 Controllable reactive power	Suntrio Plus 40K Suntrio Plus 60K
☒ D.3.4.2	Reactive power output according to an assigned level	Suntrio Plus 40K Suntrio Plus 60K
☒ D.3.6	Table E.3.5 Connection and starting to generate electrical power	Suntrio Plus 60K
☒ D.3.8	Table E.3.7 Power quality-Harmonic current emmission	Suntrio Plus 40K Suntrio Plus 60K
☒ D.3.9	Table E.3.7 Power quality-Voltage fluctuations and flicker	Suntrio Plus 60K
☒ D.3.10	Power quality- DC injection	Suntrio Plus 40K Suntrio Plus 60K

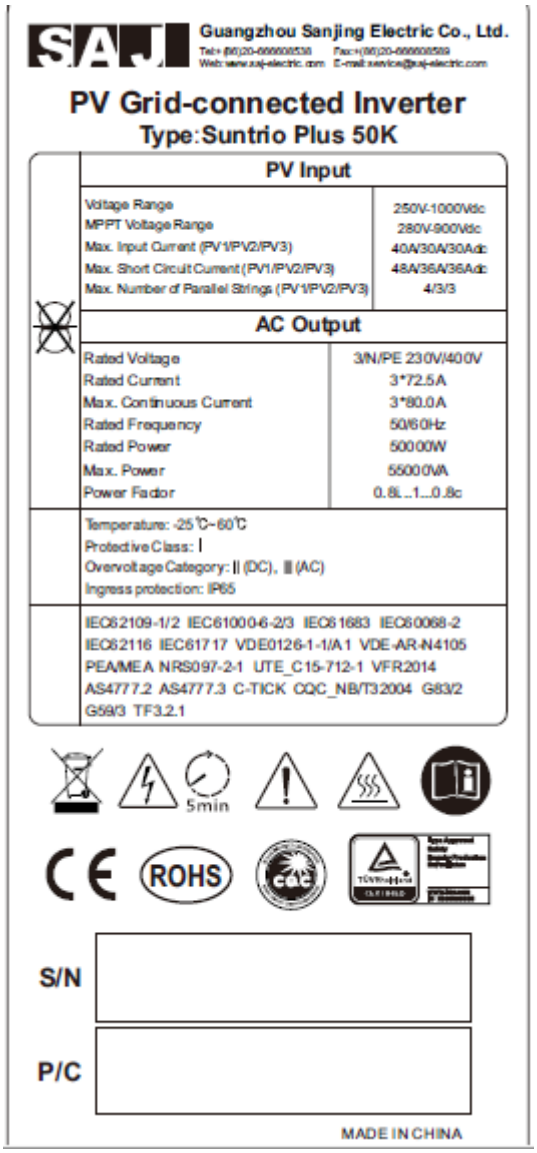
Testing location:

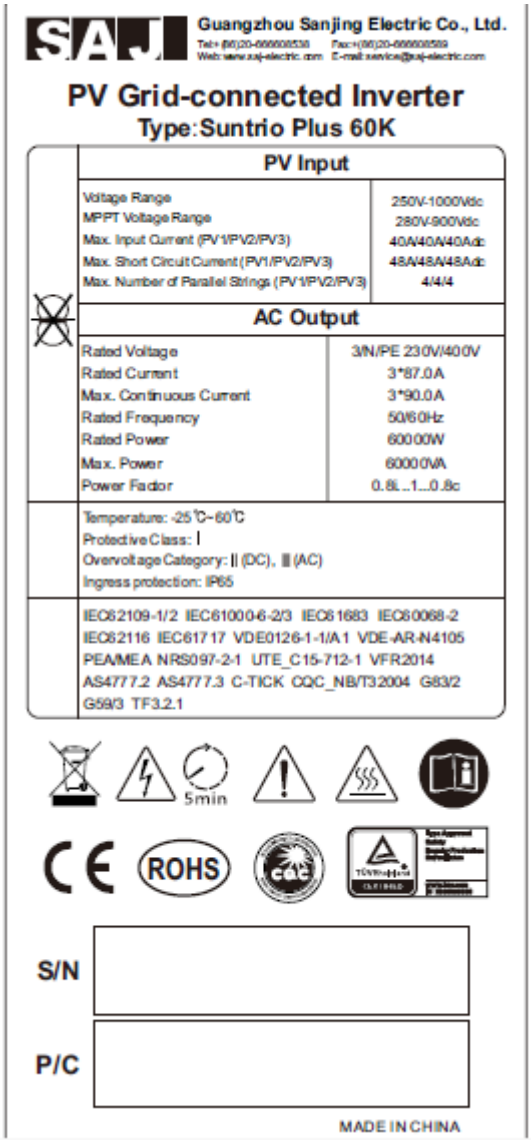
CCIC Southern Electronic Product Test-ing(Shenzhen) Co., Ltd.

Electronic Testing Building, Shahe Road 43 Xili, Nanshan District, Shenzhen, China

Copy of marking plate:






SAJ
Guangzhou Sanjing Electric Co., Ltd.
PV Grid-connected Inverter
Type:Suntrio Plus 60K
PV Input
Voltage Range 250V-1000Vdc
MPPT Voltage Range 280V-900Vdc
Max. Input Current (PV1/PV2/PV3) 40A/40A/40Adc
Max. Short Circuit Current (PV1/PV2/PV3) 48A/48A/48Adc
Max. Number of Parallel Strings (PV1/PV2/PV3) 4/4/4
AC Output
Rated Voltage 3/N/PE 230V/400V
Rated Current 3*87.0A
Max. Continuous Current 3*90.0A
Rated Frequency 50/60Hz
Rated Power 60000W
Max. Power 60000VA
Power Factor 0.8L...1...0.8c
Temperature: -25℃~60℃
Protective Class: I
Overvoltage Category: II (DC), III (AC)
Ingress protection: IP65
IEC62109-1/2 IEC61000-6-2/3 IEC61683 IEC60068-2
IEC62116 IEC61727 VDE0126-1-1/A1 VDE-AR-N4105
PEA/MEA NRS097-2-1 UTE_C15-712-1 VFR2014
AS4777.2 AS4777.3 C-TICK CQC_NB/T32004 G83/2
G59/3 TF3.2.1
5min
ROHS
S/N
P/C
MADE IN CHINA

Equipment mobility ..... :	☐ movable ☐ hand-held ☐ stationary ☒ fixed ☐ transportable ☐ for building-in
Connection to the mains..... :	☐ pluggable equipment ☐ direct plug-in ☒ permanent connection ☐ for building-in
Enviromental category..... :	☒ outdoor ☐ indoor conditional ☐ indoor unconditional
Operating condition ..... :	☒ continuous ☐ short-time ☐ intermittent
Over voltage category mains..... :	☐ OVC I ☐ OVC II ☒ OVC III ☐ OVC IV
Over voltage category PV/ Battery ..... :	☐ OVC I ☒ OVC II ☐ OVC III ☐ OVC IV
Mains supply tolerance (%) ..... :	See model list.
Tested for IT power systems ..... :	☐ Yes ☒ No
IT testing, phase-phase voltage (V) ..... :	N/A
Class of equipment ..... :	☒ Class I ☐ Class II ☐ Class III ☐ Not classified
Mass of equipment (kg)..... :	See model list.
Pollution degree ..... :	☐ PD 1 ☐ PD 2 ☒ PD 3
IP protection class ..... :	See model list.

Possible test case verdicts:	
- test case does not apply to the test object..... :	N/A
- test object was not evaluated for the requirement..... :	N/E
- test object does meet the requirement ..... :	Pass (P)
- test object does not meet the requirement ..... :	Fail (F)

Testing:	
Date of receipt of test items ..... :	See cover page.
Date(s) of performance of tests ..... :	See cover page.

General remarks:

"(see Attachment #)" refers to additional information appended to the report.

"(see appended table)" refers to a table appended to the report.

The tests 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.

List of test equipment must be kept on file and available for review.

Additional test data and/or information provided in the attachments to this report.

Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

Manufacturer's Declaration per sub-clause 6.2.5 of IECEE 02:	
The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided :	☐ Yes ☒ Not applicable
When differences exist; they shall be identified in the General product information section.	
Name and address of factory (ies) :	**Guangzhou Sanjing Electric Co., Ltd.** No.9, Lizhishan Road, Science City, Guangzhou High-tech Zone, Guangdong, P.R.China

Brief description:

The equipment is three phase utility-interactive type PV inverter which will be installed and connected to the grid network after installation.

It contains filters for smoothing the output voltage and for EMC, switching and control circuits. Electronic circuits are mounted on a number of PCBs interconnected by appropriate connectors and wires. Power board including electronics components is mounted on the heat sink to earthing by metal screw and spring washer.

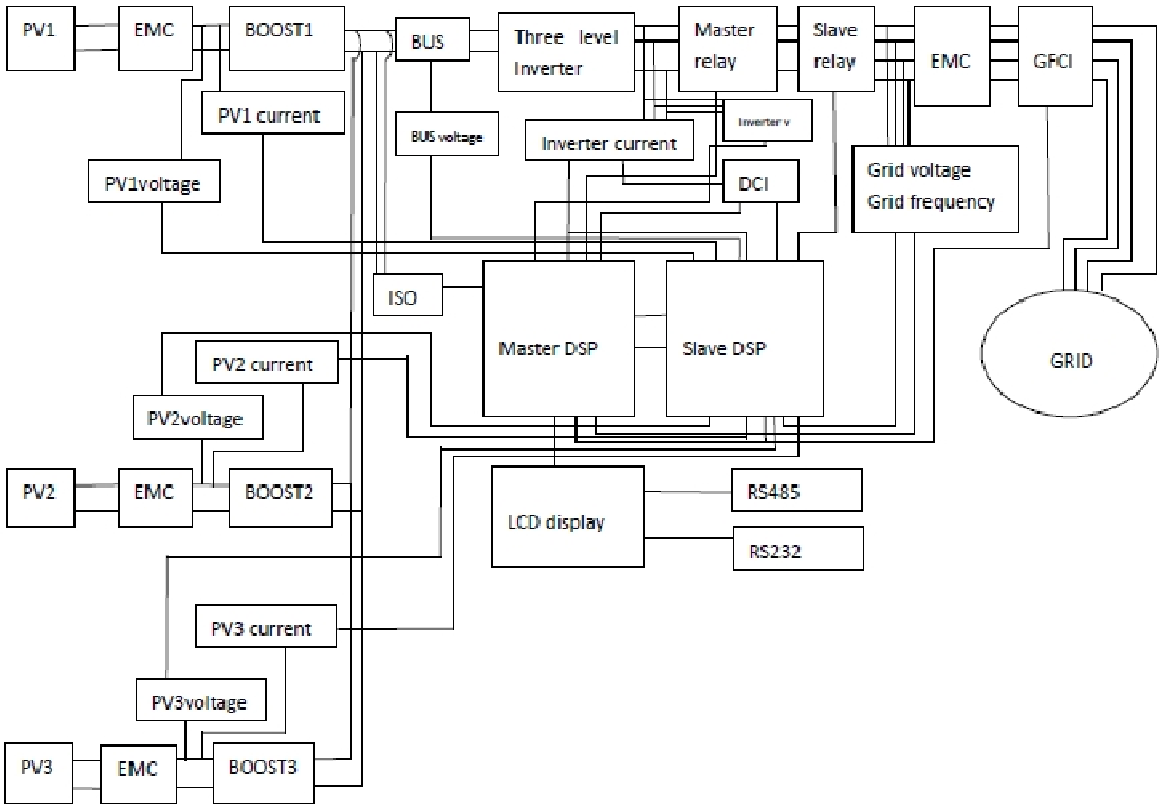
There are included a RS232 and RS485 communication ports which are connected to the monitors to monitor the status of the inverter by proprietary software.

The PV input combiner with 3 string MPPT tracers and each MPPT tracer including two PV input terminals. AC output direct connected to grid and protective earthing are provided by dedicated earthing terminals. Grid is protected combination with a two series of relays as redundant build for ensure the inverter can independent disconnected from gird while a relay was fault.

During fault condition defined in this standard, after the DSP receives the abnormal signal from the relevant protective detection circuit, the relays will operate to disconnect the PV inverter active lines from grid automatically.

The master DSP and slaver DSP has capacity independent disconnected from gird, when any grid fault had happened.

Block diagram:



Block diagram

The all models are identical to the hardware and software, except the power are different by software adjusted.

Model list:

MODEL LIST		Suntrio Plus 40K	Suntrio Plus 50K	Suntrio Plus 60K
INPUT(PV)	V_{MAX} PV [Vdc]	1000		
	I_{SC} PV [A]	48/36/36		48/48/48
	MPP Voltage Range V_{MPP}[Vdc]	280-900		
	Max. PV Input Current [A]	40/30/30		40/40/40
	Input PV Operating Voltage Range [Vdc]	250-1000		
	Start PV Voltage [Vdc]	300		
	Backfeed Current [A]	0		
	Overvoltage Category (OVC)	OVC II		
GRID CONNECTION	Rated Output Voltage Ur [Vac]	3/N/PE, 230/400		
	Rated Output Frequency F_{NETZ} [Hz]	50/60		
	Max. Apparent power S_{Emax} [kVA]	44	55	60
	Rated Output Current Ir [A]	58	72.5	87
	Max. Output Current Imax [A]	65	80	90
	Power Factor cosφ [λ]	0.8 leading ~0.8lagging		
	Efficiency max. η_{max}[%]	98.5	98.5	98.6
	Standby Power Consumption [W]	<10		
	Night Power Consumption [W]	<0.6		
	THD [V / I] (100% full power)	<3%		
	Acoustic Noise [dB]	<35		
	Overvoltage Category (OVC)	OVC III		
SYSTEM	Type of inverter	Non-isolated		
	Firmware [DSP]	V2.012		
	Hardware [Version]	V1.000		
	Working frequency [Hz]	50/60Hz		
	Separated by	Transformerless		
	MPPT strings	3		
	MPPT tracking	3		
	Protective Class	I		
	Enclosure Protection (IP)	IP65		

	Operating Temperature Range [ºC]	-25°C to +60°C (45°C to 60°C with derating)
	Pollution degree (PD)	PD 3 (outside), PD 2 (inside)
	Altitude [m]	Up to 3000
	Weight [kg]	68
	Size [mm] (HxWxD)	800x550x280
Note:		

Protection function of PGU:

1. Residual current monitoring.
2. Over & under grid voltage protection.
3. Over & under grid frequecny protection.
4. Anti-islanding protection.
5. NS protection redundantly.
6. Short-circuit protection rely on exteranl circuits break which was specified in installation manual.
7. Over temperature derating and protection.
8. Over current protection.
9. Relay function self-check.
10. RCM function self-check.

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
4	**Technical requirements**		**P**
4.1	**Electrical installation**		P
4.1.1	**General** Low voltage electrical installations shall comply with national and local regulation. In case of any hardware malfunctioning, disconnection is required. NOTE Only such hardware malfunctioning is taken into account that is relevant for the compliance of the micro-generating plant with this standard.	Cosidered	P
4.1.2	**Over-current protection** 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 ensurecorrect selectivity with the DSO's protection devices.	See instruciton manual	P
4.1.3	**Earthing** Earthing shall be according to HD 60364-5-551 and the relevant national standards. 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. 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.	Considered.	P
4.2	**Normal operating range**		P
4.2.1	General Generating plants have to be able to operate in the operating range specified below regardless the topology and the settings of the interface protection.	Complied.	P

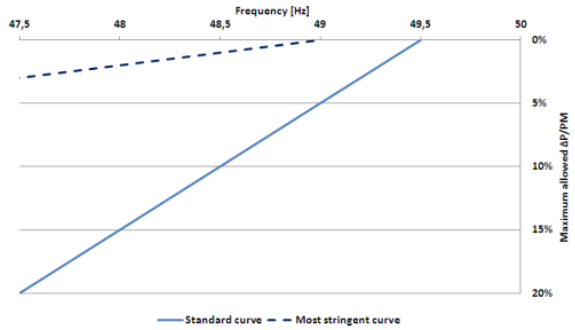
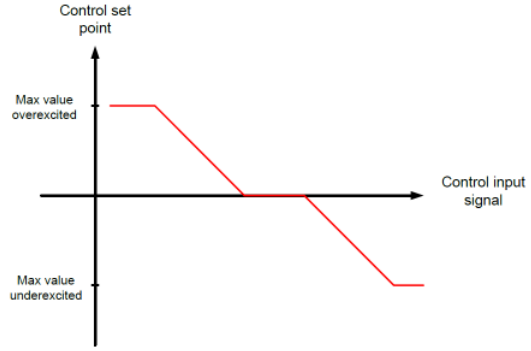
<table>
<tr><th colspan="4">EN 50438: 2013</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td>4.2.2</td><td>Continuous voltage operation range
The generating plant shall be capable not to disconnect due to voltage when the voltage at the point of connection stays within the range of 0,85 U_n to 1,1 U_n.</td><td>See appended table.</td><td>P</td></tr>
<tr><td>4.2.3</td><td>Continuous frequency operation range
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.
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.</td><td>See appended table.</td><td>P</td></tr>
<tr><td>4.2.4</td><td>Response to under-frequencies
A generating plant shall be resilient to reductions of frequency at the point of connection while reducing the maximum power as little as possible.
Table 1 Minimum time periods for operation in under-frequency situation
<table><tr><th>Frequency range</th><th>Time period for operation</th></tr><tr><td>47,5 Hz – 49 Hz</td><td>30 min</td></tr></table>
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.
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 PM per 1 Hz frequency drop as indicated by the dotted line in Figure 2.
 

Figure 2 Maximum allowable power reduction in case of under-frequency</td><td>See appended table.</td><td>P</td></tr>
</table>

<table>
<tr><td colspan="4">EN 50438: 2013</td></tr>
<tr><td>Clause</td><td>Requirement – Test</td><td>Result - Remark</td><td>Verdict</td></tr>
<tr><td>4.2.5</td><td>Power response to over-frequency
A generating plant shall be resilient to over-frequency at the point of connection.
Table 2 Minimum time periods for operation in over-frequency situation
<table><tr><th>Frequency range</th><th>Time period for operation</th></tr><tr><td>51 Hz – 51,5 Hz</td><td>30 min</td></tr></table>
Unless otherwise required by the DSO, the micro-generating plant shall be capable of activating active power frequency response at a programmable frequency threshold f1 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 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.
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.
Table 3 Standard settings for power response to over-frequency
<table><tr><th>Parameter</th><th>Value</th></tr><tr><td>Threshold frequency</td><td>50,2 Hz</td></tr><tr><td>Droop</td><td>5 %</td></tr><tr><td>Intentional delay</td><td>0 s</td></tr></table>
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 fmax 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.
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.</td><td>See appended table.</td><td>P</td></tr>
<tr><td>4.3</td><td>Reactive power capability</td><td></td><td>P</td></tr>
</table>

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
4.3.1	Inverter based micro-generator 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: • following a characteristic curve provided by the DSO (see 4.4) within the active factors cos ϕ = 0,90under-excited to 0,90over-excited when the active power output of the micro-generator is more than or equal to 20 % of its nominal active power; • 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.	See appended table.	P
4.3.2	**Directly coupled micro-generator with no inverter** 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.	Grid-connected PV inverter	N/A
4.4	**Reactive power control modes**		P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
4.4.1	General Only when a reactive power exchange capability following a characteristic curve is required (see 4.3), the requirements of 4.4.3 shall apply. 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: • Q (U); • cosφfix; • cosφ(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. 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.	See appended table.	P
4.4.2	**Fix control mode cosφ fix** The fix control mode controls the active factor cos φof the micro-generator's output according to a setpoint set in the control of the micro-generator.	See appended table.	P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
4.4.3	**Voltage related control mode Q(U)** The voltage related control mode Q(U) controls the reactive power output as a function of the voltage.For evaluating the voltage one of the following methods shall be used: • the positive sequence of the symmetrical components; • the average voltage of a three phase system; • the average voltage of a three phase system; A characteristic curve according to Figure 4 shall be configurable.  Figure 4 Reactive power control characteristic		P
4.4.4	**Power related control mode cos φ (P)** 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. A characteristic according to Figure 4 has to be configurable.		P
4.5	**Voltage control by active power** 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**		P
4.6.1	**General**		P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
4.6.1.1	**Introduction** 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. The interface protection, monitoring and control functions may be incorporated into the microgenerator control system, or may be fitted as discrete separate mounted devices. The minimum required accuracy is: • for frequency measurement ± 0,05 Hz; • for voltage measurement ± 1 % of Un.	The interface protection device was incorporated into the microgenerator control system.	P
4.6.1.2	**Response to protection operation** 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** 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.	The interface protection device was incorporated into the microgenerator control system.	P
4.6.1.4	**Changing settings of the interface protection** 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.	Considered.	P

<table>
<tr><th colspan="4">EN 50438: 2013</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td>4.6.1.5</td><td>Combined protection device for multiple generators

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.

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.

In the case of adding a generator to the combined protection device, the DSO shall be consulted.</td><td>Intergrated protection device used on for one PGU.</td><td>N/A</td></tr>
<tr><td>4.6.2</td><td>Interface protection settings

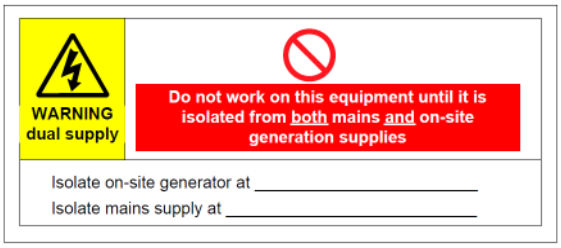
The interface protection settings are provided by the DSO. If no settings are provided, the default settings in Table 4 should be applied.

Table 4 — Default interface protection performance
<table><tr><th>Parameter</th><th>Maximum disconnection time</th><th>Minimum operate time</th><th>Trip value</th></tr><tr><td>Over-voltage – stage 1 [a]</td><td>3 s</td><td>-</td><td>230 V + 10 %</td></tr><tr><td>Over-voltage – stage 2</td><td>0,2 s</td><td>0,1 s</td><td>230 V + 15 %</td></tr><tr><td>Under-voltage</td><td>1,5 s</td><td>1,2 s</td><td>230 V – 15 %</td></tr><tr><td>Over-frequency</td><td>0,5 s</td><td>0,3 s</td><td>52 Hz</td></tr><tr><td>Under-frequency</td><td>0,5 s</td><td>0,3 s</td><td>47,5 Hz</td></tr><tr><td>LoM (if required)</td><td>See Annex A</td><td></td><td>See Annex A.</td></tr><tr><td></td><td colspan="3">The stated voltages are 'true r.m.s.' or fundamental component -values.</td></tr><tr><td></td><td colspan="3">[a] Over-voltage – stage 1: 10-min-value corresponding to EN 50160.
The calculation of the 10 min value shall comply with the 10 min aggregation of EN 61000-4-30, class S. The function shall be based on the calculation of the square root of the arithmetic mean of the squared input values over 10 min. In deviation from EN 61000-4-30, a moving window shall be used. The calculation of a new 10-min value at least every 3 s is sufficient, which is then to be compared with the trip value.
Tolerances on disconnection time are ± 10 % .</td></tr></table></td><td>Considered.</td><td>P</td></tr>
<tr><td>4.6.3</td><td>Requirements regarding single fault tolerance of interface protection system

The interface protection system consisting of the interface protection relay and the interface switch shall meet the requirements of single fault tolerance.</td><td>The testing has been evaluted in IEC62109-1/IEC62109-2 report 50078663 001.</td><td>P</td></tr>
<tr><td>4.7</td><td>Connection and starting to generate electrical power</td><td></td><td>--</td></tr>
</table>

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
4.7.1	General 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. The frequency range, the voltage range, the observation time and the power gradient shall be field adjustable. 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.	The frequency range, the voltage range, the observation time and the power gradient can be adjustable via a communication port and to be protected by password.	P
4.7.2	**Automatic reconnection after tripping** If no settings are specified by the DSO, the default settings for the reconnection after tripping of the interface protection are: • Frequency range: 47,5 Hz ≤ f ≤ 50,05 Hz; • Voltage range: 0,85 Un ≤ U ≤ 1,10 Un; • Minimum observation time: 60 s. 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 % Pn/min. Non-adjustable or partly adjustable generating units may connect after 1 min to 10 min (randomised value) or later.	See appended table.	P
4.7.3	**Starting to generate electrical power** 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: • Frequency range: 47,5 Hz ≤ f ≤ 50,1 Hz; • Voltage range: 0,85 Un ≤ U ≤ 1,10 Un; • Minimum observation time: 60 s. 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.	See appended table.	P
4.7.4	**Synchronisation** 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.	Cannot operated by user.	P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
4.8	**Power quality**		--
4.8.1	**General** As any other apparatus or fixed installation, micro-generators have to comply with the requirements on electromagnetic compatibility established in Directive 2004/108/EC. They are also expected to be compatible with voltage characteristics at the point of connection to the public network, as described in 4.2. 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, are: • Immunity: EN 61000-6-1 (residential, commercial and light-industrial environments); • Emission: EN 61000-6-3 (residential, commercial and light-industrial environments) 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.	see seperated EMC report.	P
4.8.2	**DC injection** The generating unit shall not inject a direct current.	<0.5% of I_n, see appended table.	P
5	**Operation and safety of the micro-generator**		--
5.1	**General** The micro-generator shall operate safely over the entire designed and declared operating range. 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.	The settings of field can be readable via a communication port. See instruction manual.	P
5.2	**Safety** 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. 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.	Considered	P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
5.3	**Information plate** In absence of product specific standards (e.g. EN 50524) the following information shall appear on the micro-generator nameplate: • manufacturer's name or trade mark; • type designation or identification number, or any other means of identification making it possible to obtain relevant information from the manufacturer; • nominal power; • nominal voltage; • nominal frequency; • phases; • active factor range or, if no active factor is adjustable, the minimal power factor. 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.	See marking plate.	P
5.4	**Labelling** 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.  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.	Warning label on the PV inverter itself and all the swithcboards and points of isolation for the PV inverter.	P
5.5	**Maintenance and routine testing** The manufacturer shall provide a time frame for maintenance and routine testing. NOTE Periodical routine testing of the interface protection system can be waived because of the provisions in 4.6.3.	See clause 4.6.3	N/A

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
6	**Commissioning** This European Standard applies to type-tested micro-generators. The following conditions shall be met for the installation: • the micro-generator (including the interface protection) shall fulfil the requirements of this standard and the other applicable standards; • the manufacturer shall provide an installation instruction in accordance with this standard and national or regional requirements; • access to the interface protection settings shall be tamper-proof; • in the absence of product standards the micro-generator shall be type tested against the interface requirements of this standard; • 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; • 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.	See the instruction manual.	P
Annex A	**National settings and requirements**		--
A.1	**General** In this European Standard reference is made to settings or conditions to be provided by the DSO, e.g.in case of: • the settings for the power response to over-frequency (see 4.2.5); • the settings of the interface protection (see 4.6.2); • the reconnection conditions (see 4.6.3); • the type of contribution to voltage control by reactive power (see 4.4.1) • the protection of the settings from unpermitted interference (e.g. password or seal); • the need of prior consent of the DSO (see Clause 6).	See appended table.	P

<table>
<tr><th colspan="4">EN 50438: 2013</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td></td><td>Moreover, respecting the legal framework, it is possible that, at a national level, more stringent
requirements are defined or alternative options are chosen. This is the case for following topics:
• minimum time periods for operation in under-frequency (see 4.2.4);
• admissible active power reduction due to under-frequency (see 4.2.4);
• minimum time periods for operation in over-frequency (see 4.2.5);
• reference power when activating the power response to over-frequency (see 4.2.5).</td><td>See appended table.</td><td>P</td></tr>
<tr><td>A.2</td><td>AT-Austria
– Energie-Control Austria (www.e-control.at): TOR D4 V2.0:2008 Technische und organisatorische Regeln für Betreiber und Benutzer von Netzen. Teil D: Besondere technische Regeln. Hauptabschnitt D4: Parallelbetrieb von Erzeugungsanlagen mit Verteilernetzen, Version 2.0 2008;
– ÖVE/ÖNORM E 8001-4-712 Errichtung von elektrischen Anlagen mit Nennspannungen bis AC 1000 V und DC 1500 V – Teil 4-712: Photovoltaische Energieerzeugungsanlagen – Errichtungs- und Sicherheitsanforderungen, Version 2009-12-01;
– market rules and the general conditions of network operators.</td><td></td><td>N/E</td></tr>
<tr><td>A.3</td><td>BE-Belgium
The national settings can be found on the website of Synergrid (www.synergrid.be) and more precisely in the Technical prescriptions CE10/11.</td><td></td><td>N/E</td></tr>
<tr><td>A.4</td><td>CY-Cyprus
<table>
<tr><th>Parameter</th><th>Clearance time
s</th><th>Trip setting</th></tr>
<tr><td>Over-voltage</td><td>0,5</td><td>230 V + 10%</td></tr>
<tr><td>Under-voltage</td><td>0,5</td><td>230 V - 10%</td></tr>
<tr><td>Over-frequency</td><td>0,5</td><td>50 Hz + 4%</td></tr>
<tr><td>Under-frequency</td><td>0,5</td><td>50 Hz - 6%</td></tr>
<tr><td>LoM</td><td>0,5</td><td>[a]</td></tr>
<tr><td colspan="3">[a] Based on ROCOF (Rate Of Change Of Frequency), trip value currently 0,6 Hz/s, final to be announced.</td></tr>
</table></td><td></td><td>N/E</td></tr>
</table>

<table>
<tr><td colspan="4">EN 50438: 2013</td></tr>
<tr><td>Clause</td><td>Requirement – Test</td><td>Result - Remark</td><td>Verdict</td></tr>
<tr><td>A.5</td><td>CZ-Czech Republic
In compliance with “Operational rules for distribution networks” of the Distribution System Operators.
<table>
<tr><th>Parameter</th><th>Maximum clearance time
s</th><th>Maximum trip setting</th></tr>
<tr><td>Over-voltage</td><td>0,2</td><td>230 V + 15%</td></tr>
<tr><td>Under-voltage</td><td>0,2</td><td>230 V - 15%</td></tr>
<tr><td>Over-frequency</td><td>0,5</td><td>52 Hz</td></tr>
<tr><td>Under-frequency</td><td>0,5</td><td>47,5 Hz</td></tr>
</table></td><td></td><td>N/E</td></tr>
<tr><td>A.6</td><td>DE-Germany
In Germany VDE-AR-N 4105 applies.</td><td></td><td>N/E</td></tr>
<tr><td>A.7</td><td>DK-Denmark
<table>
<tr><th>Parameter</th><th>Maximum disconnection time</th><th>Minimum relay operate time</th><th>Trip value [a]</th></tr>
<tr><td>Over voltage (stage 2) [b]</td><td>0,2 s</td><td>0,1 s</td><td>230 V + 13%</td></tr>
<tr><td>Over voltage (stage 1)</td><td>40 s</td><td>39 s</td><td>230 V + 10%</td></tr>
<tr><td>Under voltage (stage 1)</td><td>10 s</td><td>9 s</td><td>230 V – 10%</td></tr>
<tr><td>Over frequency</td><td>0,2 s</td><td>0,1 s</td><td>52 Hz</td></tr>
<tr><td>Under frequency</td><td>0,2 s</td><td>0,1 s</td><td>47,5 Hz</td></tr>
<tr><td>ROCOF [c]</td><td>0,2 s</td><td>0,1 s</td><td>2,5 Hz/s</td></tr>
<tr><td></td><td colspan="3">[a] All values are true 50 Hz RMS values. The micro-generator shall disconnect [d] if a parameter deviates more from its nominal value than the trip setting. A parameter shall not initiate a disconnection if it is between the nominal value and the trip setting.
Tolerances on trip values:
- voltage: ± 1 % of nominal voltage,
- frequency: ± 20 mHz,
- time: ± 10 %.
[b] A stage 2 protection is required if the micro-generator can generate voltages in excess of 230 V + 13 %.
[c] The use of phase shift relay as LoM detection is not allowed.
[d] Disconnection of the micro-generator in response to an interface protection operation shall be achieved by the separation of mechanical contacts providing at least the equivalent of basic insulation.</td></tr>
</table>
The “Technical Regulation 3.2.1 for electricity generation facilities with a rated current of 16 A per phase or lower” shall be considered.</td><td></td><td>N/E</td></tr>
<tr><td>A.8</td><td>EE-Estonia
The default settings of 4.6.2, Table 4 are applicable.

LoM protection shall use recognised techniques suitable for the distribution network protection. LoM protection shall be verified by test procedures which are in conformity with current standard Annex D or in compliance with other recognised document, e.g. VDE-AR-N
4105:2011. Detection of an isolated network and disconnection of the power generation system shall be completed in 5 s.</td><td></td><td>N/E</td></tr>
</table>

<table>
<tr><th colspan="4">EN 50438: 2013</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td>A.9</td><td>ES-Spain
In Spain (ES), the following Laws and Decrees deal with requirements for the connections to the
public distribution network:
<table>
<tr><td>Ley 54/1997,
Electricity Sector law</td><td>General rules for the interconnection of RES and CHP plants to the grid. Utilities are bound to buy the surplus of electricity generated by these installations and to pay for that energy higher price.</td></tr>
<tr><td>RD 1955/2000,
Gives rules for transmission, distribution, commercialisation, supply and permission procedures or electric energy plants</td><td>It establishes the legal framework applicable to the activities of transmission, distribution, marketing and electricity supply.</td></tr>
<tr><td>RD 661/2007
Regulates the activity of electricity production in special regime.</td><td>Administrative and some technical rules for generation in special regime of any technology, power and voltage level. Partially superseded for small generation by RD 1699/2011.</td></tr>
<tr><td>RD 1699/2011
Regulates the connection of small generation</td><td>Administrative and technical rules for generation in special regime of any technology. Up to 100 kW in LV networks.</td></tr>
<tr><td colspan="2">National grid-code or similar documents in ES (Spain)</td></tr>
<tr><td>RD 842/2002,
Spanish Low Voltage Code, part: ICT-BT 40,
"Low voltage generating installations"</td><td>Complementary instruction (ICT) applicable to generating installations, namely installations aimed at the transformation of any kind of non-electric energy into electric energy.</td></tr>
</table></td><td></td><td>N/E</td></tr>
<tr><td>A.10</td><td>FI-Finland
<table>
<tr><th>Parameter</th><th>Clearance time
s</th><th>Trip setting</th></tr>
<tr><td>Over-voltage</td><td>0,2</td><td>U_n + 10%</td></tr>
<tr><td>Under-voltage</td><td>0,2</td><td>U_n - 15%</td></tr>
<tr><td>Over-frequency</td><td>0,2</td><td>51,5 Hz</td></tr>
<tr><td>Under-frequency</td><td>0,2</td><td>47,5 Hz</td></tr>
<tr><td>LoM [a]</td><td colspan="2">Maximum clearance time: 5 s</td></tr>
<tr><td colspan="3">[a] LoM protection shall use recognised techniques suitable for the distribution network protection.
REMARK Isolation of the micro-generator shall be achieved by the separation of mechanical contacts. This mechanical device shall be a lockable isolation switch.</td></tr>
</table>
Minimum time period for which a micro-generator shall be capable of operating when frequency is
within limits 47,5 Hz -49 Hz and 51,0 Hz -51,5 Hz is 30 min.
Micro-generator shall operate normally while rate of change of frequency is under 2 Hz/s.</td><td></td><td>N/E</td></tr>
</table>

<table>
<tr><th colspan="4">EN 50438: 2013</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td>A.11</td><td>FR-France
• « Décret n° 2008-386 du 23 avril 2008 relatif aux prescriptions techniques générales de
conception et de fonctionnement pour le raccordement d'installations de production aux réseaux
publics d'électricité » ;
• « Arrêté du 23 avril 2008 relatif aux prescriptions techniques de conception et de fonctionnement
pour le raccordement à un réseau public de distribution d'électricité en basse tension ou en
moyenne tension d'une installation de production d'énergie électrique » ;
• « Guide Pratique UTE C 15-400, Raccordement des générateurs d'énergie électrique dans les
installations alimentées par un réseau public de distribution » ;
• « Guide Pratique UTE C 15-712-1, Installations photovoltaïques raccordées au réseau public de
distribution » ;
• « Documentation Technique de Référence d'ERDF », in particular « ERDF-NOI-RES_13E -
Protections des installations de production raccordées au réseau public de distribution ».</td><td></td><td>N/E</td></tr>
<tr><td>A.12</td><td>GB-United Kingdom
G83/2</td><td></td><td>N/E</td></tr>
<tr><td>A.13</td><td>IE-Ireland
DTIS-230206-BRL Mar 2009: Conditions Governing the Connection and Operation of Microgeneration</td><td></td><td>N/E</td></tr>
<tr><td>A.14</td><td>IT-Italy
CEI 0-21</td><td></td><td>N/E</td></tr>
<tr><td>A.15</td><td>LV-Latvia
<table>
<tr><th>Parameter</th><th>Maximum disconnection time, s</th><th>Trip setting</th></tr>
<tr><td>Over voltage</td><td>1,5</td><td>230 V + 11 %</td></tr>
<tr><td>Under voltage</td><td>3</td><td>230 V – 11 %</td></tr>
<tr><td>Over frequency</td><td>0,5</td><td>50 Hz + 1 %</td></tr>
<tr><td>Under frequency</td><td>0,5</td><td>50 Hz – 1,6%</td></tr>
<tr><td colspan="3">An explicit Loss of Mains functionality shall be included. Established methods such as, but not limited to, Rate of Change of Frequency, Vector Shift may be used. Any implementation which involves the injection of pulses onto the distribution network shall not be permitted.</td></tr>
<tr><td>ROCOF (where used)</td><td>0,5</td><td>0,4 Hz/s</td></tr>
<tr><td>Vector Shift (where used)</td><td>0,5</td><td>8°</td></tr>
</table></td><td></td><td>N/E</td></tr>
</table>

<table>
<tr><td colspan="4">EN 50438: 2013</td></tr>
<tr><td>Clause</td><td>Requirement – Test</td><td>Result - Remark</td><td>Verdict</td></tr>
<tr><td>A.16</td><td>NL-The Netherlands
<table>
<tr><th>Parameter</th><th>Time
s</th><th>Setting</th></tr>
<tr><td>Over-voltage</td><td>2,0</td><td>230 V + 10 %</td></tr>
<tr><td>Under-voltage [a]</td><td>2,0</td><td>230 V – 20 %</td></tr>
<tr><td>Over-frequency</td><td>2,0</td><td>50,0 Hz + 2 %</td></tr>
<tr><td>Under frequency</td><td>2,0</td><td>50,0 Hz – 4 %</td></tr>
<tr><td>LoM</td><td></td><td></td></tr>
<tr><td colspan="3">[a] For synchronous generators the disconnecting time is 0,2 s, or a shorter time depending on the Critical Short-circuit Time of the generator.
In the Netherlands it is only necessary to provide a single stage for under/over-voltage and for frequency protection.</td></tr>
</table></td><td>Complied.</td><td>P</td></tr>
<tr><td>A.17</td><td>NO-Norway
In Norway, the Regulation REG. N° 301 of 11 March 1999: “Regulations governing metering,
settlement and coordinated action in connection with electricity trading and invoicing of network
services.” do not allow connection of a generator to the network without prior setting up of a new
connection agreement with the DSO.</td><td></td><td>N/E</td></tr>
<tr><td>A.18</td><td>PL-Poland
If no specific national settings for the Interface Settings are supplied by the Polish National Committee, the default settings in 4.6.2, Table 4 are applicable.</td><td></td><td>N/E</td></tr>
<tr><td>A.19</td><td>SI-Slovenia
Slovenian national rules for connection and operation of generators in the distribution network were officially announced in the Uradni list RS (Official Gazzette of the Republic of Slovenia) No. 41/2011 and are published on the website of the SODO – Slovenian Electricity Distribution System Operator.</td><td></td><td>N/E</td></tr>
<tr><td>A.20</td><td>SE-Sweden
<table>
<tr><th>Parameter</th><th>Clearance time
s</th><th>Trip setting</th></tr>
<tr><td>Over-voltage (stage 2)</td><td>60</td><td>230 V + 11 %</td></tr>
<tr><td>Over-voltage (stage 1)</td><td>0,2</td><td>230 V + 15 %</td></tr>
<tr><td>Under-voltage (stage 1)</td><td>0,2</td><td>230 V – 15 %</td></tr>
<tr><td>Over-frequency</td><td>0,5</td><td>51 Hz</td></tr>
<tr><td>Under frequency</td><td>0,5</td><td>47 Hz</td></tr>
<tr><td>Loss of Mains (LoM)</td><td>0,15</td><td></td></tr>
</table>
Swedish laws and regulations:
- SFS 1997:857, in particular 3 kap 10 § and 8 kap 6 §;
- SFS 1999:716, in particular 4 §;</td><td></td><td>N/E</td></tr>
<tr><td>Annex B</td><td>Loss of Mains and overall system security</td><td>Considered.</td><td>P</td></tr>
<tr><td>Annex C</td><td>Example notification sheets</td><td>Considered.</td><td>P</td></tr>
</table>

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
Annex D	**Compliance type testing**		P
D.1	**General** At this time, with compliance type testing still under development, it is only possible for this annex to provide guidance for a methodology how a micro-generator could comply with the applicable requirements of this standard. The default values in this annex have to be replaced by the specific national values in Annex A if supplied.		P
D.2	**Type testing of the interface protection**		P
D.2.1	**Introduction** 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
D.2.2	**General** The tests will verify that the operation of the micro-generator interface protection will result in a disconnection from the distribution network when the network parameters are exceeded or LoM occurs. The manufacturer shall declare the ambient operating temperature range of the micro-generator and verify where appropriate that the interface protection control system operates satisfactory throughout this temperature range.		P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
D.2.3	**Over-/under-voltage** For each trip setting five tests shall be carried out. a) Over voltage protection threshold Uth-high 1) Evaluation of the trip value: Test: The applied voltage is varied from Un up to Uth-high + 2 % of Un in steps of 0,5 % of Un with a time duration per step exceeding the configured disconnection time.Operate value: value of the applied voltage at which the protection function trips Evaluation: the operate value shall be within (Uth-high ± 1 % of Un) 2) Evaluation of the disconnection time: Test: application of a positive voltage step from Un to the operate value + 5 % of Un Evaluation: The time elapsed between the application of the voltage step and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time. b) Under-voltage protection threshold Uth-low 1) Evaluation of the trip value: Test: The applied voltage is varied from Un down to Uth-low – 2 % of Un in steps of 0,5 % of Un with a time duration per step exceeding the configured disconnection time. Operate value: value of the applied voltage at which the protection function trips Evaluation: the operate value shall be within (Uth-low ± 1 % of Un) 2) Evaluation of the disconnection time: Test: application of a negative voltage step from Un to the operate value – 5 % of Un Evaluation: The time elapsed between the application of the voltage step and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.	See appended table.	P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
D.2.4	**Over- /under-frequency** For each trip setting five tests shall be carried out. a) Over-frequency protection threshold fth-high: 1) Evaluation of the trip value: Test: The applied frequency is varied from fn up to fth-high +0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time. Operate value: value of the applied frequency at which the protection function trips Evaluation: the operate value shall be within fth-high ± 0,05 Hz. 2) Evaluation of the disconnection time: Test: application of a positive frequency step or ramp from fn to the operate value +0,1 Hz Evaluation: The time elapsed between the application of the frequency step respectively the applied ramp passes the operate value and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time. b) Under-frequency protection threshold fth-low: 1) Evaluation of the trip value: Test: The applied frequnecy is varied from fn down to fth-low -0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time. Operate value: value of the applied frequency at which the protection function trips Evaluation: the operate value shall be within fth-low ± 0,05 Hz. 2) Evaluation of the disconnection time Test: application of a negative frequency step or ramp from fn to the operate value -0,1 Hz Evaluation: The time elapsed between the application of the frequency step respectively the applied ramp passes the operate value and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.	See appended table.	P
D.2.5	**Loss of Mains (LoM) detection**	Complied.	P

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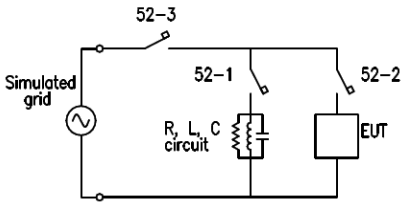
Clause	Requirement – Test	Result - Remark	Verdict
D.2.5.1	**General** In case of loss of supply from the distribution network, the LoM protection shall ensure that the microgenerator disconnects from the distribution network until all DSO protection operations have cleared and normal network supplies have been restored.		P
D.2.5.2	Test on active LoM detection methods For PV inverters EN 62116 applies, for all other technologies the following test environment applies. Protection settings shall be applied that ensure disconnection within 2 s.  **Figure D.1 — LoM test arrangement**	See appended table.	P
D.3	**Type testing of a micro-generator**		P
D.3.1	**Operating range** At least 2 tests shall be conducted, with the micro generator operating at nominal power connected to a grid simulator set as follows: • Test 1(*): U = 0,85 Un; f = 47,5 Hz; P = 1,00 Sn; cosϕ = 1 • Test 2(**): U = 1,1 Un; f = 51,5 Hz; P = 1,00 Sn; cosϕ = 1 During the tests the interface protection has to be disabled. (*) Operation at reduced power is allowed during test 1, equal to the maximum power that can be supplied on reaching the maximum output current limit (P ≥ 0,85 Sn). (**) During the sequence of test 2, automatic adjustment to reduce power in the case of overfrequency shall be disabled.	Complied.	P
D 3.2	**Active power feed-in at under-frequency**	Complied.	P

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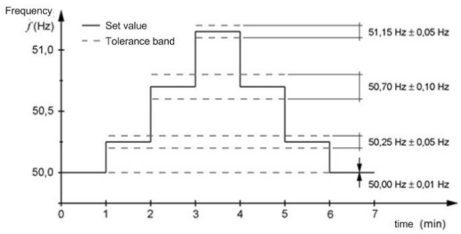
Clause	Requirement – Test	Result - Remark	Verdict
D 3.2.1	**Tests** Measurements are carried out at the following operating points: a) nominal frequency ± 0,01 Hz; b) a point between the nominal frequency –0,4 Hz to −0,5 Hz; c) a point between the nominal frequency –2,4 Hz to –2,5 Hz. The operating point b) and c) shall be maintained for at least 5 min. Linear generators such as free piston Stirling machines are not tested according to Point c).		P
D.3.2.2	**Assessment criterion**		P
D.3.2.3	**Test documentation**		P
D.3.3	**Power response to over-frequency**	Complied.	P
D.3.3.1	**General** The test serves to verify the active power reduction of the micro-generator at over-frequency. The test can either be carried out for on specific threshold frequency and droop setting or in general by testing two following settings: • threshold frequency 50,2 Hz in combination with a droop of 12 % and • threshold frequency 50,5 Hz in combination with a droop of 2 %.		P
D.3.3.2	Tests The following measuring points a) to g) shall be tested (refer to Figure D.2):  Figure D.2 — Example of testing the active power feed-in at over-frequency with f_1 = 50,2 Hz	See appended table.	P

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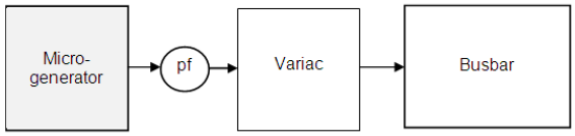
Clause	Requirement – Test	Result - Remark	Verdict
D.3.3.3	**Test procedure for adjustable and partly adjustable micro-generators** At f1 the value of the currently generated active power PM is "frozen". The test is carried out at two power levels. First the test shall be started at a power of > 80 % of nominal power and then a second time at a power of between 40 % nominal power and 60 % nominal power. (ΔP /1min) ($P_t = t_{1 + 1min}$ Pt = t_1) /1min		P
D.3.3.4	**Assessment criteria**		P
D.3.3.5	**Test documentation**		P
D.3.4	**Reactive power capability**		P
D.3.4.1	Test of no controllable reactive power This test applies to micro-generators with no controllable reactive power output.  **Figure D.3 — Power factor test arrangement**	Considered.	P
D.3.4.2	**Test of controllable reactive power**	Complied.	P
D.3.4.2.1	**Reactive power output capability** The micro-generator shall be set to maximum under/over excited operation possible for the micro generator. The micro-generator shall be operated with the settings above at 10 active power levels 0 %-10 %; 10 %-20 % ; ...; 90 %-100 % of the nominal output. 1 min-average-values shall be calculated using measurements at the basic frequency in a period of 200 ms. In addition to the measurements at maximum reactive power, the power levels shall be measured when setting the output reactive power to 0 (cosϕ. = 1).	See appended table.	P
D.3.4.2.2	**Assessment criterion**		P
D.3.4.2.3	**Test documentation**		P
D.3.4.2.4	**Reactive power output according to an assigned level**	Complied.	P

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Clause	Requirement – Test	Result - Remark	Verdict
D.3.4.2.5	**Procedures for performing tests and recording results (Q adjustment)** • Set the primary source so that the micro-generator supplies approximately 50 % of the nominal active power Pn. • Use the method and the adjustment parameter specified by the manufacturer, change the reactive power supplied by the micro-generator, passing from a set value close to the maximum over excited directly to zero (Q = 0), and then from zero to a set value close to the maximum under excited value. • For each set point, at least 3 values shall be recorded after the end of all transient effects, as 1-min-average value calculated on the basis of the measurements at basic frequency in a period of 200 ms.	See appended table.	P
D.3.4.2.6	**Assessment criterion**		P
D.3.4.2.7	**Test documentation**		P
D.3.5	**Voltage control by active power (under consideration)**		N/A
D.3.6	**Connection and starting to generate electrical power**		P
D.3.6.1	**General**		P
D.3.6.2	**Connection after trip of interface protection** The test sequence below is configured for the default setting according to 4.7.2. In case of differing settings, the sequence has to be altered accordingly. Before the sequence and after each connection a trip of the interface protection shall be initiated. Sequence for test after trip of interface protection (with actual frequency fact and actual Voltage Uact): a) fact < 47,45 Hz: no reconnection permitted; b) switch to fact ≥ 47,45 Hz: reconnection is permitted 60 s after switch to new frequency; c) fact > 50,10 Hz: no reconnection permitted; d) switch to fact ≤ 50,10 Hz: reconnection is permitted 60 s after switch to new frequency; e) Uact < 0,84 Un: no reconnection permitted; f) switch to Uact ≥ 0,84 Un: reconnection is permitted 60 s after switch to new voltage; g) Uact > 1,11 Un: no reconnection permitted; h) switch to Uact ≤ 1,11 Un: reconnection is permitted 60 s after switch to new voltage.	See appended table.	P

EN 50438: 2013			
Clause	Requirement – Test	Result - Remark	Verdict
D.3.6.3	**Start of generating electrical power** After the stop of generating electrical power due to operational reasons of the micro generator, it shall be examined whether the system can only start generating power within the tolerance ranges defined according to 4.7.3 and after the voltage and frequency remain within the tolerance ranges for at least the observation time according to 4.7.3. The test sequence below is configured for the default setting according to 4.7.2. In case of differing settings, the sequence has to be altered accordingly. Before the sequence and after each start of generating electrical power a stop of production has to be initiated e.g. by reducing the primary energy source to zero power. Sequence for test for starting to generate electrical power: a) fact < 47,45 Hz: no starting permitted; b) Switch to fact ≥ 47,45 Hz: starting is permitted 60 s after switch to new frequency; c) fact > 50,15 Hz: no starting permitted; d) Switch to fact ≤ 50,15 Hz: starting is permitted 60 s after switch to new frequency; e) Uact < 0,84 Un: no starting permitted; f) Switch to Uact ≥ 0,84 Un: starting is permitted 60 s after switch to new voltage; g) Uact > 1,11 Un: no starting permitted; h) Switch to Uact ≤ 1,11 Un: starting is permitted 60 s after switch to new voltage.	See appended table.	P
D.3.6.4	**Assessment criteria**		P
D.3.7	**Short-circuit current contribution** The micro-generator short-circuit parameters shall be determined by means of a short-circuit test carried out in a similar manner to that for larger alternators as described in EN 60034 series. For electronic inverters, manufacturers shall declare the short circuit contribution.	Considered.	P
D.3.8	**Harmonic current emission** Manufacturers to declare their test procedure to demonstrate compliance with the emission limits of class A of EN 61000-3-2.	Complied.	P
D.3.9	**Voltage fluctuations and flicker** Manufacturers to declare their test procedure to demonstrate compliance with the emission limits of EN 61000-3-3.	Complied.	P

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Clause	Requirement – Test	Result - Remark	Verdict
D.3.10	**DC injection**	Complied.	P
D.3.10.1	**General** This test is only relevant for inverter-based systems without output transformers. The DC component can be measured by one of the following two methods: • the average of the current samples (preferred); • root mean square of frequencies components below 1 Hz.		P
D.3.10.2	**Test** The DC component shall be measured under steady-state conditions for the following power levels: 20 %, 50 %, 75 %, and 100 % of nominal power with a tolerance of ± 5 % of nominal power and as far as adjustable for the tested micro-generator.	See appended table.	P
D.3.10.3	**Acceptance criteria**		P
Annex E	**Example test results sheet**		P
Annex F	**Commissioning**		P
F.1	**Installation** **The micro-generator shall be installed in accordance with all of the following requirements:** • this standard; • HD 60364 series; • national regulations; • the manufacturer's installation instructions; •technical requirements of the DSO (e.g. grid codes).		P
F.2	**Notification procedure**		P
F.2.1	**Ordinary procedure**		P
F.2.2	**Inform and Fit for a single installation**		P
Annex G	**Countries allowing extension of the scope > 16 A**		N/A
G.1	**General** In some countries there is a national deviation to extend the scope of this standard for equipment rated greater than 16 A. Whenever the scope is extended to equipment rated greater than 16 A additional standards could be applicable.		N/A

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Clause	Requirement – Test	Result - Remark	Verdict
G.2	**CY-Cyprus** The scope of this standard is extended for generation rated up to and including 25 A per phase. In terms of rated power this refers to 5,75 kVA for a single phase equipment and 17,3 kVA for three phase equipment.		N/A
G.3	**FI-Finland** The scope of this standard is extended to a rated power of up to 50 kVA for three phase equipment.		N/A
G.4	**IE-Ireland** The scope of this standard is extended to 25 A at low voltage, when the distribution network connection is single-phase. The scope of this standard remains unchanged at 16 A at low voltage, when the distribution network connection is three-phase.		N/A

Table E.2.2	Over-/under- frequency tests	P

☒National deviation-Netherland

	Over-frequency		Under-frequency	
Parameter	Frequency [Hz]	Disconnection time [ms]	Frequency [Hz]	Disconnection time [ms]
Protection limit	51.00	t≤2000	48.00	t≤2000
Actual setting	51.00	1100	48.00	1170
Trip value				
Trip value 1	50.98	1104	48.02	1173
Trip value 2	50.98	1112	48.02	1177
Trip value 3	50.99	1108	48.02	1173
Trip value 4	50.98	1101	48.02	1169
Trip value 5	50.98	1105	48.02	1173

Note:
1) Evaluation of the trip value:
Test: The applied frequency is varied from fn to Ftrip +/-0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time.
Operate value: value of the applied frequency at which the protection function trips
Evaluation: the operate value shall be within Ftrip ± 0,05 Hz.
2) Evaluation of the disconnection time:
Test: application of a frequency step or ramp from Fn to the operate value +0,1 Hz
Evaluation: The time elapsed between the application of the frequency step respectively the applied ramp passes the operate value and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.

Table E.2.3	Over-/under- voltage tests	P

☒National deviation-Netherland

L1 phase

	Over-voltage		Under-voltage	
Parameter	Voltage [V]	Disconnection time [ms]	Voltage [V]	Disconnection time [ms]
Protection limit	253.0	t≤2000	184.0	t≤2000
Actual setting	253.0	1000	184.0	1000
Trip value				
Trip value 1	252.7	1045	184.3	1091
Trip value 2	252.7	1041	184.3	1039

Trip value 3	252.6	1033	184.3	1099
Trip value 4	252.8	1041	184.3	1091
Trip value 5	252.7	1037	184.3	1047
L2 phase				
	Over-voltage		Under-voltage	
Parameter	Voltage [V]	Disconnection time [ms]	Voltage [V]	Disconnection time [ms]
Protection limit	253.0	t≤2000	184.0	t≤2000
Actual setting	253.0	1000	184.0	1000
Trip value				
Trip value 1	252.7	1045	184.2	1095
Trip value 2	252.6	1037	184.2	1091
Trip value 3	252.7	1033	184.2	1101
Trip value 4	252.7	1041	184.2	1049
Trip value 5	252.6	1035	184.3	1045
L3 phase				
	Over-voltage		Under-voltage	
Parameter	Voltage [V]	Disconnection time [ms]	Voltage [V]	Disconnection time [ms]
Protection limit	253.0	t≤2000	184.0	t≤2000
Actual setting	253.0	1000	184.0	1000
Trip value				
Trip value 1	252.7	1031	184.2	1047
Trip value 2	252.7	1035	184.2	1091
Trip value 3	252.7	1047	184.2	1090
Trip value 4	252.6	1039	184.2	1094
Trip value 5	252.7	1051	184.3	1046

Note:

1) Evaluation of the trip value:

Test: The applied voltage is varied from Un down to Utrip +/- 2 % of Un in steps of 0,5 % of Un with a time duration per step exceeding the configured disconnection time.

Operate value: value of the applied voltage at which the protection function trips

Evaluation: the operate value shall be within (Utrip ± 1 % of Un)

2) Evaluation of the disconnection time:

Test: application of a voltage step from Un to the operate value +/- 5 % of Un

Evaluation: The time elapsed between the application of the voltage step and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.

Table E.2.3	TABLE: over voltage protection as sliding 10-min-average value				P
	Rated voltage Un: 230V				
No.	U_{start} [V]	U_{end} [V]	Limitation T [s]	Trigger time [s]	Recover time [s]
1	230.4	257.8	600	491	67
2	230.4	248.8	No disconnect	No disconnect	N/A
3	244.1	262.4	300	279	68

Note:
Over-voltage – stage 1: 10-min-value corresponding to EN 50160.
The calculation of the 10 min value shall comply with the 10 min aggregation of EN 61000-4-30, class S. The function shall be based on the calculation of the square root of the arithmetic mean of the squared input values over 10 min. In deviation from EN 61000-4-30, a moving window shall be used. The calculation of a new 10-min value at least every 3 s is sufficient, which is then to be compared with the trip value.
Tolerances on disconnection time are ± 10 % .

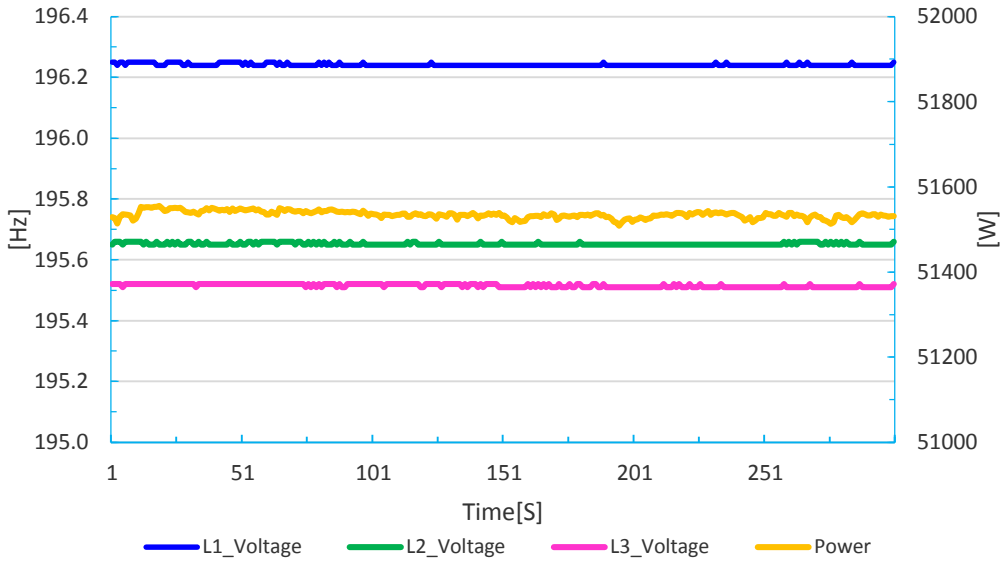
Table E.2.4	LoM test				P
Power 100%					
Conditions	P_W [kw]	Q_L [kVA]	Q_C [kVA]	Q_f	Trip time [ms]	Limitation [ms]
PR: 95% PQ: 105%	L1: 18.77	L1: 20.28	L1: 20.14	1.08	114	2000
	L2: 18.78	L2: 20.44	L2: 20.20	1.08		
	L3: 18.74	L3: 20.46	L3: 20.30	1.09		
PR: 95% PQ: 100%	L1: 18.77	L1: 19.31	L1: 20.14	1.05	118	2000
	L2: 18.78	L2: 19.47	L2: 20.20	1.06		
	L3: 18.74	L3: 19.49	L3: 20.30	1.06		
PR: 95% PQ: 95%	L1: 18.77	L1: 18.34	L1: 20.14	1.02	83	2000
	L2: 18.78	L2: 18.50	L2: 20.20	1.03		
	L3: 18.74	L3: 18.52	L3: 20.30	1.03		
PR: 100% PQ: 105%	L1: 19.76	L1: 20.28	L1: 20.14	1.02	180	2000
	L2: 19.77	L2: 20.44	L2: 20.20	1.03		
	L3: 19.73	L3: 20.46	L3: 20.30	1.03		
PR: 100% PQ: 100%	L1: 19.76	L1: 19.31	L1: 20.14	1.00	185	2000
	L2: 19.77	L2: 19.47	L2: 20.20	1.00		
	L3: 19.73	L3: 19.49	L3: 20.30	1.01		
PR: 100% PQ: 95%	L1: 19.76	L1: 18.34	L1: 20.14	0.97	87	2000
	L2: 19.77	L2: 18.50	L2: 20.20	0.98		
	L3: 19.73	L3: 18.52	L3: 20.30	0.98		
PR: 105% PQ: 105%	L1: 20.75	L1: 20.28	L1: 20.14	0.97	105	2000
	L2: 20.76	L2: 20.44	L2: 20.20	0.98		
	L3: 20.72	L3: 20.46	L3: 20.30	0.98		
PR: 105% PQ: 100%	L1: 20.75	L1: 19.31	L1: 20.14	0.95	127	2000
	L2: 20.76	L2: 19.47	L2: 20.20	0.96		
	L3: 20.72	L3: 19.49	L3: 20.30	0.96		
PR: 105% PQ: 95%	L1: 21.79	L1: 18.34	L1: 20.14	0.88	91	2000
	L2: 21.80	L2: 18.50	L2: 20.20	0.89		
	L3: 21.75	L3: 18.52	L3: 20.30	0.89		

Power 66%						
Conditions	P_W [kw]	Q_L [kVA]	Q_C [kVA]	Q_f	Trip time [ms]	Limitation [ms]
PR: 100% PQ: 95%	L1: 13.48	L1: 12.81	L1: 13.39	0.97	93	2000
	L2: 13.40	L2: 12.68	L2: 13.44	0.97		
	L3: 13.54	L3: 12.83	L3: 13.31	0.97		
PR: 100% PQ: 96%	L1: 13.48	L1: 12.94	L1: 13.39	0.98	99	2000
	L2: 13.40	L2: 12.82	L2: 13.44	0.98		
	L3: 13.54	L3: 12.97	L3: 13.31	0.97		
PR: 100% PQ: 97%	L1: 13.48	L1: 13.08	L1: 13.39	0.98	112	2000
	L2: 13.40	L2: 12.95	L2: 13.44	0.98		
	L3: 13.54	L3: 13.10	L3: 13.31	0.98		
PR: 100% PQ: 98%	L1: 13.48	L1: 13.21	L1: 13.39	0.99	119	2000
	L2: 13.40	L2: 13.08	L2: 13.44	0.99		
	L3: 13.54	L3: 13.24	L3: 13.31	0.98		
PR: 100% PQ: 99%	L1: 13.48	L1: 13.35	L1: 13.39	0.99	142	2000
	L2: 13.40	L2: 13.22	L2: 13.44	0.99		
	L3: 13.54	L3: 13.37	L3: 13.31	0.99		
PR: 100% PQ: 100%	L1: 13.48	L1: 13.48	L1: 13.39	1.00	336	2000
	L2: 13.40	L2: 13.35	L2: 13.44	1.00		
	L3: 13.54	L3: 13.51	L3: 13.31	0.99		
PR: 100% PQ: 101%	L1: 13.48	L1: 13.61	L1: 13.39	1.00	216	2000
	L2: 13.40	L2: 13.48	L2: 13.44	1.00		
	L3: 13.54	L3: 13.65	L3: 13.31	0.99		
PR: 100% PQ: 102%	L1: 13.48	L1: 13.75	L1: 13.39	1.00	197	2000
	L2: 13.40	L2: 13.62	L2: 13.44	1.00		
	L3: 13.54	L3: 13.78	L3: 13.31	0.99		
PR: 100% PQ: 103%	L1: 13.48	L1: 13.88	L1: 13.39	1.00	149	2000
	L2: 13.40	L2: 13.75	L2: 13.44	1.00		
	L3: 13.54	L3: 13.92	L3: 13.31	0.99		
PR: 100% PQ: 104%	L1: 13.48	L1: 14.02	L1: 13.39	1.00	110	2000
	L2: 13.40	L2: 13.88	L2: 13.44	1.00		
	L3: 13.54	L3: 14.05	L3: 13.31	0.99		
PR: 100% PQ: 105%	L1: 13.48	L1: 14.15	L1: 13.39	1.00	108	2000
	L2: 13.40	L2: 14.02	L2: 13.44	1.00		
	L3: 13.54	L3: 14.19	L3: 13.31	0.99		

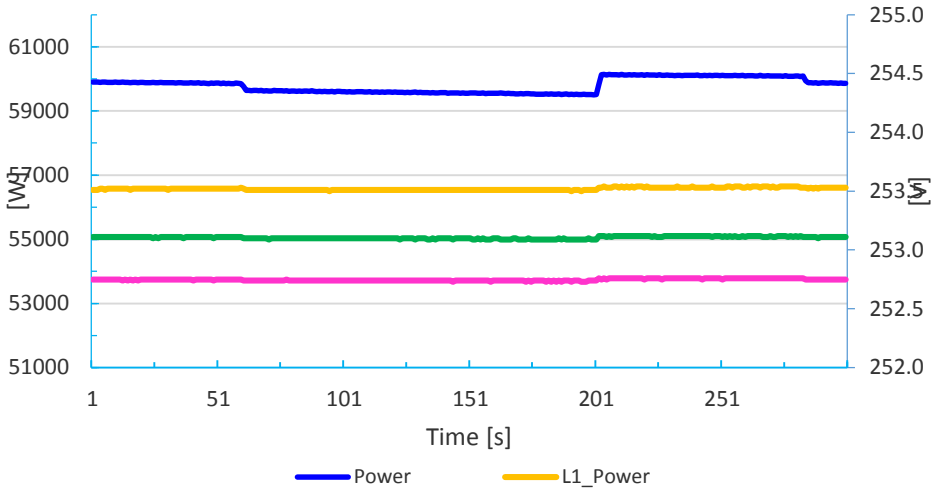
Power 33%						
Conditions	P_W [kw]	Q_L [kVA]	Q_C [kVA]	Q_f	Trip time [ms]	Limitation [ms]
PR: 100% PQ: 95%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.50 L2: 6.43 L3: 6.56	L1: 6.65 L2: 6.73 L3: 6.65	0.98 0.99 0.98	93	2000
PR: 100% PQ: 96%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.57 L2: 6.50 L3: 6.62	L1: 6.65 L2: 6.73 L3: 6.65	0.98 0.99 0.98	104	2000
PR: 100% PQ: 97%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.63 L2: 6.57 L3: 6.69	L1: 6.65 L2: 6.73 L3: 6.65	0.99 1.00 0.99	116	2000
PR: 100% PQ: 98%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.70 L2: 6.63 L3: 6.76	L1: 6.65 L2: 6.73 L3: 6.65	1.00 1.00 0.99	144	2000
PR: 100% PQ: 99%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.77 L2: 6.70 L3: 6.83	L1: 6.65 L2: 6.73 L3: 6.65	1.00 1.01 1.00	202	2000
PR: 100% PQ: 100%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.84 L2: 6.77 L3: 6.90	L1: 6.65 L2: 6.73 L3: 6.65	1.01 1.01 1.00	308	2000
PR: 100% PQ: 101%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.91 L2: 6.84 L3: 6.97	L1: 6.65 L2: 6.73 L3: 6.65	1.01 1.02 1.01	186	2000
PR: 100% PQ: 102%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 6.98 L2: 6.91 L3: 7.04	L1: 6.65 L2: 6.73 L3: 6.65	1.02 1.02 1.01	165	2000
PR: 100% PQ: 103%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 7.05 L2: 6.98 L3: 7.11	L1: 6.65 L2: 6.73 L3: 6.65	1.02 1.03 1.02	153	2000
PR: 100% PQ: 104%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 7.11 L2: 7.04 L3: 7.17	L1: 6.65 L2: 6.73 L3: 6.65	1.03 1.03 1.02	143	2000
PR: 100% PQ: 105%	L1: 6.71 L2: 6.67 L3: 6.77	L1: 7.18 L2: 7.11 L3: 7.24	L1: 6.65 L2: 6.73 L3: 6.65	1.03 1.04 1.03	125	2000
Note:						

Table E.3.1	D3.1 Operating Range					P
Test sequence	Voltage[V]			Frequency [Hz]	Output power [kW]	Primary power source [kW]
	L1	L2	L3			
Test 1	196.24	195.65	195.52	47.50	51.536	52.321
Test 2	253.51	253.10	252.74	51.50	20.634	20.927

Test 1 measurement:



Test 2 measurement:



Note: Setting:

Test 1: U = 0,85 Un; f = 48 Hz; P = 1,00 Sn; cosϕ = 1

Test 2: U = 1,1 Un; f = 51 Hz; P = 1,00 Sn; cosϕ = 1

Test 1: Operation at reduced power is allowed during test 1, equal to the maximum power that can be supplied on reaching the maximum output current limit (P ≥ 0.85 Sn).

Table E.3.2	D3.2 Active power at under-frequency	P

Test sequence	Output Power [kW]	Frequency [Hz]	Primary power source [kW]
Test a) 50 Hz	60.013	50.00	61.933
Test b) 49,6 Hz	60.006	49.55	61.935
Test c) 48 Hz	59.997	47.55	61.923

Note:

The operating point b) and c) shall be maintained for at least 5 min.

Table E.3.3	D.3.3 Power response to over-frequency	P

Test1: Droop of 5%

Test sequence at power level >80%	Output Power Setpoint(kW)	Output Power [kW]	Frequency [Hz]	Active power gradient (kW)
Step a) 50 Hz	--	54.060	50.00	--
Step b) 50.25 Hz	52.978	52.912	50.25	12.885
Step c) 50.7 Hz	43.248	43.170	50.70	11.560
Step d) 51.15 Hz	33.517	33.298	51.15	8.314
Step e) 50.7 Hz	43.248	43.430	50.70	10.754
Step f) 50.25 Hz	52.978	52.748	50.25	11.351
Step g) 50 Hz	--	54.045	50.00	--
Test sequence at power level 40%-60%	Output Power Setpoint(kW)	Output Power [kW]	Frequency [Hz]	Active power gradient (kW)
Step a) 50 Hz	--	30.052	50.00	--
Step b) 50.25 Hz	29.451	29.411	50.06	10.171
Step c) 50.7 Hz	24.042	23.985	50.70	11.534
Step d) 51.15 Hz	18.632	18.557	50.70	9.705
Step e) 50.7 Hz	24.042	24.017	50.89	10.269
Step f) 50.25 Hz	29.451	29.422	50.34	10.358
Step g) 50 Hz	--	30.007	50.00	--

Note(s):

Droop= - (Δf/fn) / (ΔP/ PM)

Active power gradient=($P_{t=t1+1min}$-$P_{t=t1}$)/1min

E.3.4.1	Uncontrollable reactive power		P
Test Voltage / Power factor	211.6V	230V	248.4V
Suntrio Plus 40K			
25% P_N	0.997	0.997	0.997
50%P_N	0.999	0.999	0.999
75%P_N	0.999	1.000	1.000
100%P_N	1.000	1.000	1.000
Suntrio Plus 60K			
25% P_N	0.999	0.998	0.999
50%P_N	1.000	0.999	1.000
75%P_N	1.000	1.000	1.000
100%P_N	1.000	1.000	1.000
Limit	≥0.950	≥0.950	≥0.950

Note:
When operating at the 25%, 50%, 75% and 100% rated power the micro-generator shall operate at a power factor within the range 0.95 lagging to 0.95 leading relative to the voltage waveform unless otherwise agreed with the DNO eg for power factor improvement.

Table E.3.4.2	D.3.4.2.1 Controllable reactive power	P

Reactive power output capability- **Suntrio Plus 40K**

Inductive reactive power absorbation

Power-BIN	Active power [W]	Reactive power [Var]	Apperance power [VA]	Power factor [cos φ]
0% -10%	1968	-787	2205	0.893
	1968	-800	2205	0.892
	1967	-820	2203	0.893
10% -20%	5966	-3221	6782	0.880
	5967	-3221	6783	0.880
	5966	-3208	6776	0.880
20% -30%	9967	-5711	11489	0.868
	9967	-5711	11489	0.868
	9968	-5712	11490	0.868
30% -40%	13967	-7878	16037	0.871
	13966	-7878	16036	0.871
	13965	-7878	16035	0.871
40% -50%	17967	-10326	20723	0.867
	17965	-10324	20721	0.867
	17965	-10324	20722	0.867
50% -60%	21955	-12773	25401	0.864
	21957	-12775	25404	0.864
	21955	-12773	25401	0.864
60% -70%	25920	-15209	30054	0.862
	25921	-15210	30054	0.862
	25918	-15208	30052	0.862
70% -80%	29923	-17677	34756	0.861
	29923	-17677	34755	0.861
	29922	-17676	34753	0.861
80% -90%	33917	-20141	39448	0.860
	33918	-20142	39449	0.860
	33910	-20138	39440	0.860
90% -100%	37914	-22614	44147	0.859
	37915	-22612	44146	0.859
	37916	-22610	44147	0.859

Capability reactive power supply				
Power-BIN	Active power [W]	Reactive power [Var]	Apperance power [VA]	Power factor [cos φ]
0% -10%	2023	1679	2631	0.769
	2023	1679	2631	0.769
	2024	1679	2632	0.769
10% -20%	6078	3568	7049	0.862
	6079	3568	7050	0.862
	6078	3568	7049	0.862
20% -30%	10115	6024	11774	0.859
	10115	6024	11774	0.859
	10116	6024	11774	0.859
30% -40%	14103	8502	16468	0.856
	14105	8502	16470	0.856
	14105	8501	16469	0.856
40% -50%	18136	11217	21326	0.850
	18138	11218	21327	0.850
	18135	11216	21324	0.850
50% -60%	22176	13551	25989	0.853
	22166	13546	25978	0.853
	22160	13541	25971	0.853
60% -70%	25968	15741	30367	0.855
	25958	15737	30356	0.855
	25926	15717	30318	0.855
70% -80%	30024	18085	35050	0.857
	30014	18080	35039	0.857
	29999	18069	35021	0.857
80% -90%	34061	20415	39711	0.858
	34065	20414	39714	0.858
	34052	20407	39699	0.858
90% -100%	37888	22619	44127	0.859
	37937	22641	44180	0.859
	37916	22632	44157	0.859

Reactive power supply with set point Q=0				
Power-BIN	Active power [W]	Reactive power [Var]	Apperance power [VA]	Power factor [cos φ]
0% -10%	1999	732	2131	0.938
	1999	733	2132	0.938
	2000	733	2132	0.938
10% -20%	6049	717	6093	0.993
	6050	715	6093	0.993
	6049	713	6092	0.993
20% -30%	10112	770	10142	0.997
	10112	772	10142	0.997
	10113	772	10143	0.997
30% -40%	14164	783	14186	0.998
	14164	783	14186	0.998
	14165	784	14187	0.998
40% -50%	18141	794	18159	0.999
	18140	797	18158	0.999
	18142	795	18160	0.999
50% -60%	22119	771	22133	0.999
	22116	776	22130	0.999
	22114	773	22128	0.999
60% -70%	26040	760	26051	1.000
	26064	761	26075	1.000
	26077	757	26088	1.000
70% -80%	30149	734	30158	1.000
	30139	735	30148	1.000
	30188	714	30197	1.000
80% -90%	34275	703	34282	1.000
	34274	705	34281	1.000
	34263	711	34270	1.000
90% -100%	38089	702	38095	1.000
	38089	699	38095	1.000
	38086	703	38093	1.000

Reactive power output capability- **Suntrio Plus 60K**				
Inductive reactive power absorbation				
Power-BIN	Active power [W]	Reactive power [Var]	Apperance power [VA]	Power factor [cos φ]
0% -10%	2964	-1710	3425	0.865
	2964	-1711	3426	0.865
	2964	-1711	3426	0.865
10% -20%	8951	-4873	10193	0.878
	8954	-4877	10198	0.878
	8950	-4872	10191	0.878
20% -30%	14974	-8496	17217	0.870
	14975	-8496	17219	0.870
	14975	-8496	17219	0.870
30% -40%	20962	-12162	24235	0.865
	20961	-12161	24235	0.865
	20966	-12163	24240	0.865
40% -50%	26895	-15819	31203	0.862
	26892	-15817	31200	0.862
	26898	-15821	31207	0.862
50% -60%	32892	-19508	38243	0.860
	32893	-19508	38244	0.860
	32891	-19508	38242	0.860
60% -70%	39075	-23333	45512	0.859
	39075	-23333	45513	0.859
	39073	-23331	45509	0.859
70% -80%	44859	-26913	52313	0.858
	44867	-26918	52323	0.857
	44853	-26908	52306	0.858
80% -90%	50955	-30695	59487	0.857
	50953	-30694	59485	0.857
	50953	-30694	59485	0.857
90% -100%	51432	-30989	60047	0.857
	51430	-30988	60045	0.857
	51432	-30989	60047	0.857

Capability reactive power supply				
Power-BIN	Active power [W]	Reactive power [Var]	Apperance power [VA]	Power factor [cos φ]
0% -10%	3049	2147	3730	0.817
	3048	2147	3730	0.817
	3049	2147	3731	0.817
10% -20%	9006	5469	10538	0.855
	9003	5469	10535	0.855
	8998	5463	10527	0.855
20% -30%	15145	9487	17872	0.847
	15146	9488	17873	0.847
	15144	9487	17870	0.847
30% -40%	21301	13055	24984	0.853
	21299	13055	24982	0.853
	21304	13054	24986	0.853
40% -50%	26947	16319	31504	0.855
	26958	16326	31517	0.855
	26995	16348	31560	0.855
50% -60%	33093	19861	38596	0.857
	33106	19870	38612	0.857
	33058	19842	38556	0.857
60% -70%	38853	23184	45245	0.859
	38856	23188	45249	0.859
	38846	23178	45236	0.859
70% -80%	44891	26675	52219	0.860
	44868	26660	52191	0.860
	44902	26680	52231	0.860
80% -90%	50959	30183	59228	0.860
	50961	30182	59229	0.860
	50956	30182	59224	0.860
90% -100%	51724	30619	60107	0.861
	51724	30623	60110	0.860
	51744	30613	60122	0.861

Reactive power supply with set point Q=0				
Power-BIN	Active power [W]	Reactive power [Var]	Apperance power [VA]	Power factor [cos φ]
0% -10%	3013	865	3135	0.961
	3014	818	3124	0.965
	3013	795	3118	0.967
10% -20%	9098	756	9130	0.996
	9098	755	9130	0.997
	9097	754	9129	0.997
20% -30%	15187	799	15209	0.999
	15186	797	15207	0.999
	15188	790	15209	0.999
30% -40%	21024	748	21037	0.999
	21024	770	21038	0.999
	21019	780	21034	0.999
40% -50%	27107	742	27117	1.000
	27108	737	27118	1.000
	27108	736	27118	1.000
50% -60%	32994	727	33002	1.000
	32993	727	33001	1.000
	32993	724	33001	1.000
60% -70%	39054	702	39061	1.000
	39070	686	39076	1.000
	39089	677	39095	1.000
70% -80%	45174	693	45180	1.000
	45160	699	45166	1.000
	45153	700	45159	1.000
80% -90%	51020	631	51024	1.000
	51021	649	51025	1.000
	51014	625	51019	1.000
90% -100%	57089	-693	57093	1.000
	57090	-695	57094	1.000
	57098	-693	57102	1.000
Note:				

Table E.3.4.2	D3.4.2.5 Controllable reactive power (Q adjustment)	P

Suntrio Plus 40K

Test result:

Ractive power setpoint Q(Var)	Measured active power P(W)	Measured Power factor	Measured reactive power Q(Var)	Deviation compared to setpoint factor (%)
11548	20206	0.857	12151	+1.5%
0	20161	0.999	731	+1.8%
-11308	19954	0.866	-11544	+0.6%

Suntrio Plus 60K

Test result:

Ractive power setpoint Q(Var)	Measured active power P(W)	Measured Power factor	Measured reactive power Q(Var)	Deviation compared to setpoint factor (%)
17845	30075	0.860	18105	+0.43%
0	30097	0.999	650	+1.1%
-17758	29928	0.860	-17678	-0.13%

Note:

- ΔQ ≤ ± 5% of nominal active power.
- the primary source so that the micro-generator supplies approximately 50 % of the nominal active power Pn.

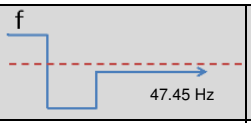
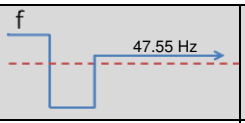
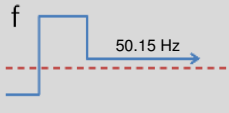
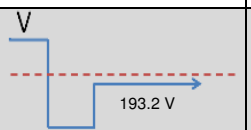
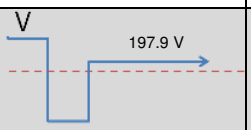
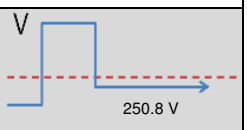
Tabel E3.5	TABLE: Connection and starting to generate electrical power-After trip condition			P
Conditions				
Reconnection	☐ Yes/ ☒ No	☒ Yes/ ☐ No	☐ Yes/ ☒ No	☒ Yes/ ☐ No
Time [s]	N/A	68	N/A	71
Conditions				
Reconnection	☐ Yes/ ☒ No	☒ Yes/ ☐ No	☐ Yes/ ☒ No	☒ Yes/ ☐ No
Time [s]	N/A	66	N/A	70
Note:				

Table E.3.7	Power quality- HarmInic current emmission	P

Harmonic current emission (**Suntrio Plus 40K**)							
	Maximum permissible harmonic current as per EN 61000-3-12.						
Harmonic	L1 phase		L2 phase		L3 phase		Limit (%)
	A	%	A	%	A	%	
2nd	0.122	0.211	0.121	0.207	0.100	0.172	8.00
3rd	0.256	0.442	0.399	0.684	0.148	0.253	N/A
4th	0.093	0.161	0.079	0.135	0.081	0.139	4.00
5th	0.044	0.076	0.034	0.058	0.052	0.090	10.70
6th	0.020	0.035	0.018	0.030	0.024	0.042	2.67
7th	0.608	1.050	0.627	1.075	0.636	1.090	7.20
8th	0.047	0.080	0.042	0.072	0.055	0.094	2.00
9th	0.020	0.034	0.021	0.036	0.022	0.037	N/A
10th	0.045	0.078	0.039	0.066	0.041	0.071	1.60
11th	0.341	0.588	0.342	0.587	0.344	0.589	3.10
12th	0.017	0.030	0.015	0.026	0.019	0.032	1.33
13th	0.273	0.472	0.278	0.476	0.274	0.469	2.00
THD	1.528		1.623		1.514		13
PWHD	2.914		2.851		2.986		22

Harmonic current emission (**Suntrio Plus 60K**)							
	Maximum permissible harmonic current as per EN 61000-3-12.						
Harmonic	L1 phase		L2 phase		L3 phase		Limit (%)
	A	%	A	%	A	%	
2nd	0.125	0.145	0.093	0.107	0.095	0.109	8.00
3rd	0.197	0.228	0.292	0.336	0.097	0.112	N/A
4th	0.060	0.069	0.051	0.059	0.056	0.065	4.00
5th	0.036	0.042	0.035	0.040	0.052	0.061	10.70
6th	0.015	0.018	0.013	0.016	0.016	0.018	2.67
7th	0.596	0.690	0.651	0.750	0.686	0.791	7.20
8th	0.034	0.040	0.033	0.038	0.045	0.052	2.00
9th	0.031	0.036	0.014	0.016	0.025	0.029	N/A
10th	0.055	0.064	0.045	0.051	0.050	0.057	1.60
11th	0.366	0.424	0.375	0.433	0.376	0.434	3.10
12th	0.015	0.017	0.013	0.015	0.016	0.018	1.33
13th	0.319	0.369	0.322	0.372	0.315	0.364	2.00
THD	1.044		1.104		1.098		13
PWHD	2.147		2.071		2.185		22
Note:							

5.1.2	TABLE: Power quality- Voltage fluctuations and flicker	P

Suntrio Plus 60K

Phase A

Measurement

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.32 Pass	0.45 Pass	0 Pass	0.09 Pass	
2	0.34 Pass	0.51 Pass	0 Pass	0.11 Pass	
3	0.33 Pass	0.52 Pass	0 Pass	0.10 Pass	
4	0.31 Pass	0.55 Pass	0 Pass	0.09 Pass	
5	0.33 Pass	0.42 Pass	0 Pass	0.10 Pass	
6	0.31 Pass	0.60 Pass	0 Pass	0.09 Pass	
7	0.34 Pass	0.43 Pass	0 Pass	0.09 Pass	
8	0.31 Pass	0.55 Pass	0 Pass	0.09 Pass	
9	0.33 Pass	0.43 Pass	0 Pass	0.09 Pass	
10	0.33 Pass	0.42 Pass	0 Pass	0.09 Pass	
11	0.30 Pass	0.48 Pass	0 Pass	0.11 Pass	
12	0.32 Pass	0.41 Pass	0 Pass	0.11 Pass	
Result	Pass	Pass	Pass	Pass	0.10 Pass

Plt	0.10		
Limit	0.65		
Pst	dc(%)	dmax(%)	d(t) (ms)
Limit= 1.0	Limit= 3.3	Limit= 4.0	Limit= 500
0.45	0.16	0.55	0.00

Phase B

Measurement

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.36 Pass	0.42 Pass	0 Pass	0.08 Pass	
2	0.36 Pass	0.62 Pass	0 Pass	0.10 Pass	
3	0.32 Pass	0.41 Pass	0 Pass	0.09 Pass	
4	0.31 Pass	0.40 Pass	0 Pass	0.09 Pass	
5	0.28 Pass	0.59 Pass	0 Pass	0.10 Pass	
6	0.37 Pass	0.46 Pass	0 Pass	0.09 Pass	
7	0.31 Pass	0.40 Pass	0 Pass	0.08 Pass	
8	0.31 Pass	0.41 Pass	0 Pass	0.09 Pass	
9	0.34 Pass	0.41 Pass	0 Pass	0.08 Pass	
10	0.28 Pass	0.41 Pass	0 Pass	0.09 Pass	
11	0.33 Pass	0.52 Pass	0 Pass	0.10 Pass	
12	0.27 Pass	0.58 Pass	0 Pass	0.10 Pass	
Result	Pass	Pass	Pass	Pass	0.09 Pass

Plt	0.09		
Limit	0.65		
Pst	dc(%)	dmax(%)	d(t) (ms)
Limit= 1.0	Limit= 3.3	Limit= 4.0	Limit= 500
0.44	0.14	0.63	0.00

Phase C

Measurement

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.17 Pass	0.36 Pass	0 Pass	0.08 Pass	
2	0.14 Pass	0.44 Pass	0 Pass	0.10 Pass	
3	0.03 Pass	0.46 Pass	0 Pass	0.10 Pass	
4	0.05 Pass	0.51 Pass	0 Pass	0.09 Pass	
5	0.06 Pass	0.56 Pass	0 Pass	0.10 Pass	
6	0.02 Pass	0.49 Pass	0 Pass	0.09 Pass	
7	0.00 Pass	0.00 Pass	0 Pass	0.08 Pass	
8	0.02 Pass	0.46 Pass	0 Pass	0.09 Pass	
9	0.00 Pass	0.00 Pass	0 Pass	0.08 Pass	
10	0.01 Pass	0.44 Pass	0 Pass	0.09 Pass	
11	0.07 Pass	0.52 Pass	0 Pass	0.10 Pass	
12	0.09 Pass	0.54 Pass	0 Pass	0.10 Pass	
Result	Pass	Pass	Pass	Pass	0.09 Pass

Plt	0.09		
Limit	0.65		
Pst	dc(%)	dmax(%)	d(t) (ms)
Limit= 1.0	Limit= 3.3	Limit= 4.0	Limit= 500
0.41	0.37	0.59	0.00

Note:

Table E3.8	Power quality- DC injection			P
Suntrio Plus 40K				
Test level power	20%	50%	75%	100%
Recorded value (A) L1	0.02	0.029	0.050	0.05
As % of rated AC current L1	0.04	0.051	0.087	0.09
Recorded value (A) L2	0.040	0.019	0.020	0.035
As % of rated AC current L2	0.070	0.033	0.034	0.060
Recorded value (A) L3	0.045	0.049	0.078	0.021
As % of rated AC current L3	0.078	0.085	0.134	0.036
Limit	0.5%	0.5%	0.5%	0.5%
Suntrio Plus 60K				
Test level power	20%	50%	75%	100%
Recorded value (A) L1	0.04	0.058	0.024	0.091
As % of rated AC current L1	0.08	0.100	0.042	0.156
Recorded value (A) L2	0.037	0.037	0.03	0.049
As % of rated AC current L2	0.065	0.064	0.04	0.085
Recorded value (A) L3	0.036	0.082	0.05	0.054
As % of rated AC current L3	0.063	0.141	0.09	0.093
Limit	0.5%	0.5%	0.5%	0.5%
Note: When measured during operation at levels: 20%, 50%, 75% and 100% of rating with a tolerance of plus or minus 5%, 1 sample per sec., 1min. for each level.				

- End of test report -

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

Figure 1. Oversize view

Figure 2. View of terminals for Suntiro Plus 60K

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

Figure 3. View of terminals for Suntiro Plus 40, Suntiro Plus 50K

Figure 4. Side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

Figure 5. Side view

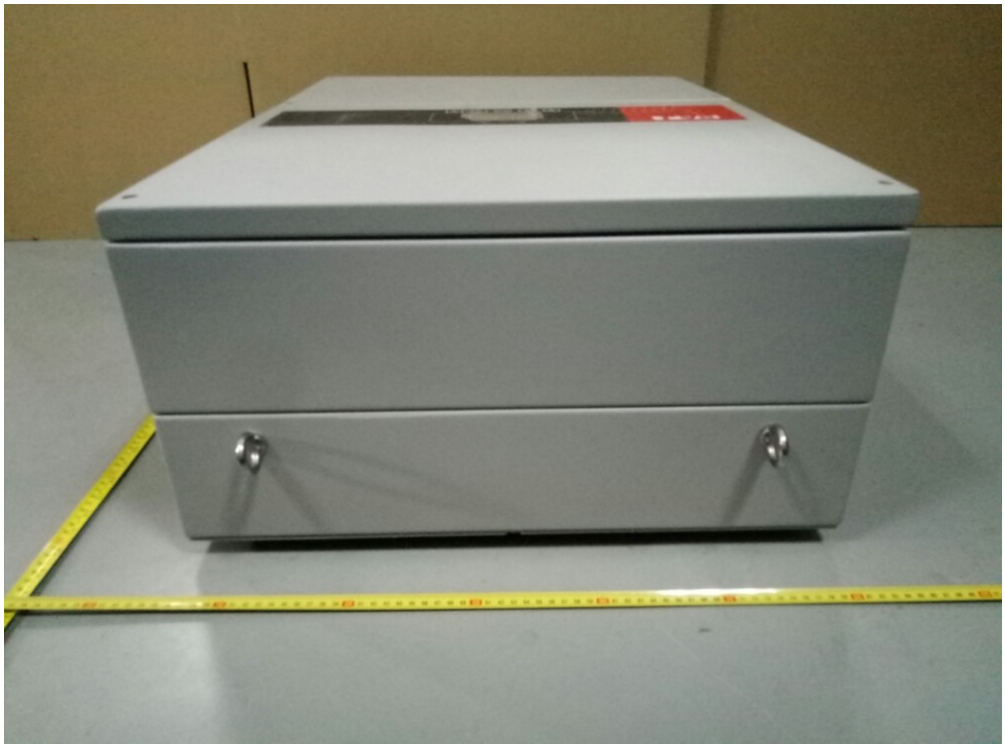


Figure 6. Side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

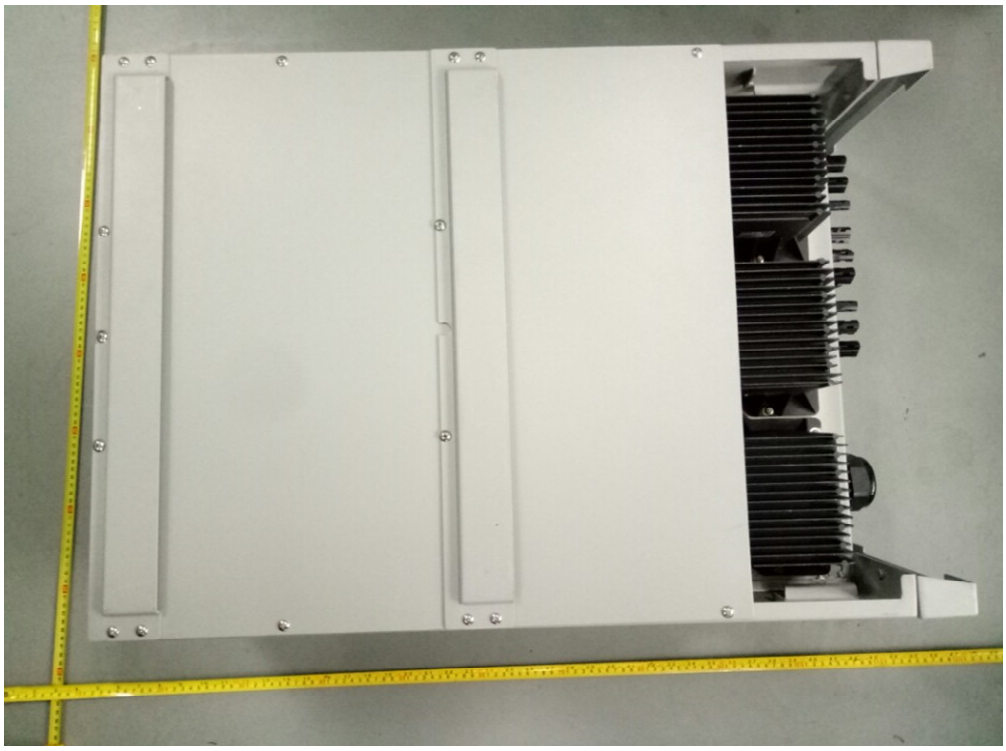


Figure 7. Bottom view

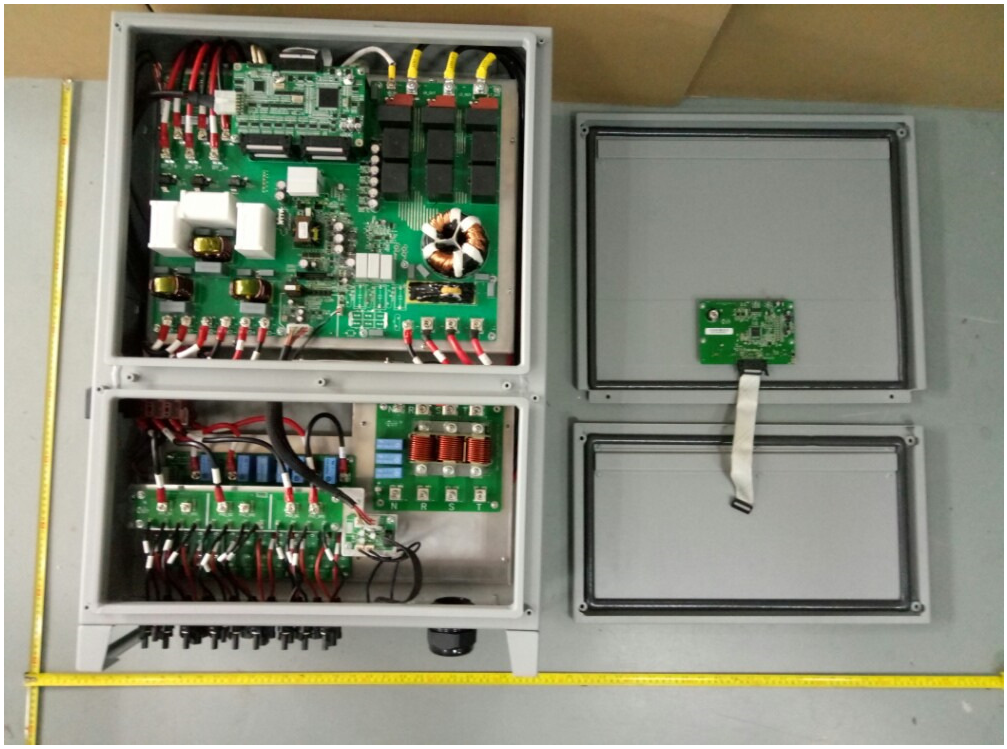


Figure 8. Internal view for Suntio Plus 60K

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

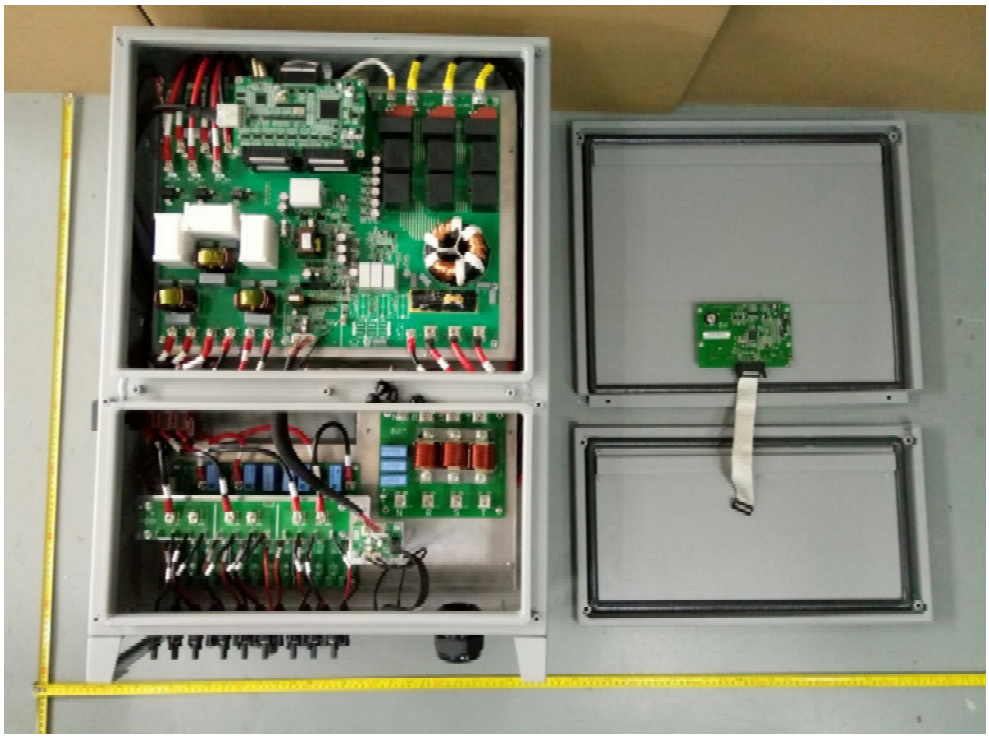


Figure 9. Internal view for Suntiro Plus 40, Suntiro Plus 50K

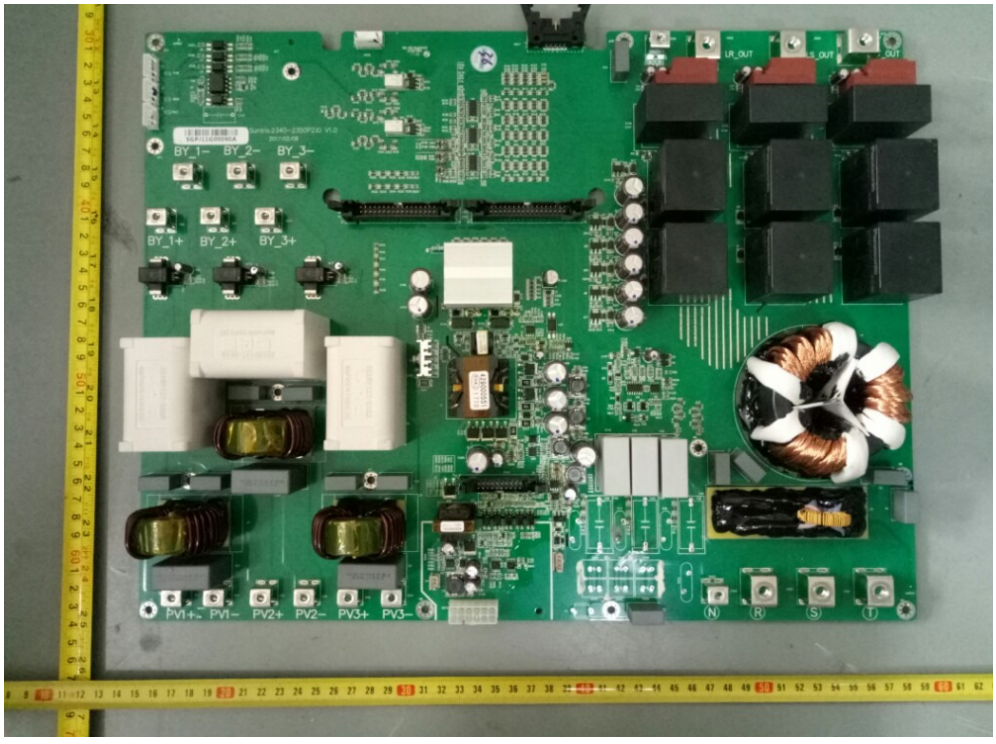


Figure 10. Input/output board component side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

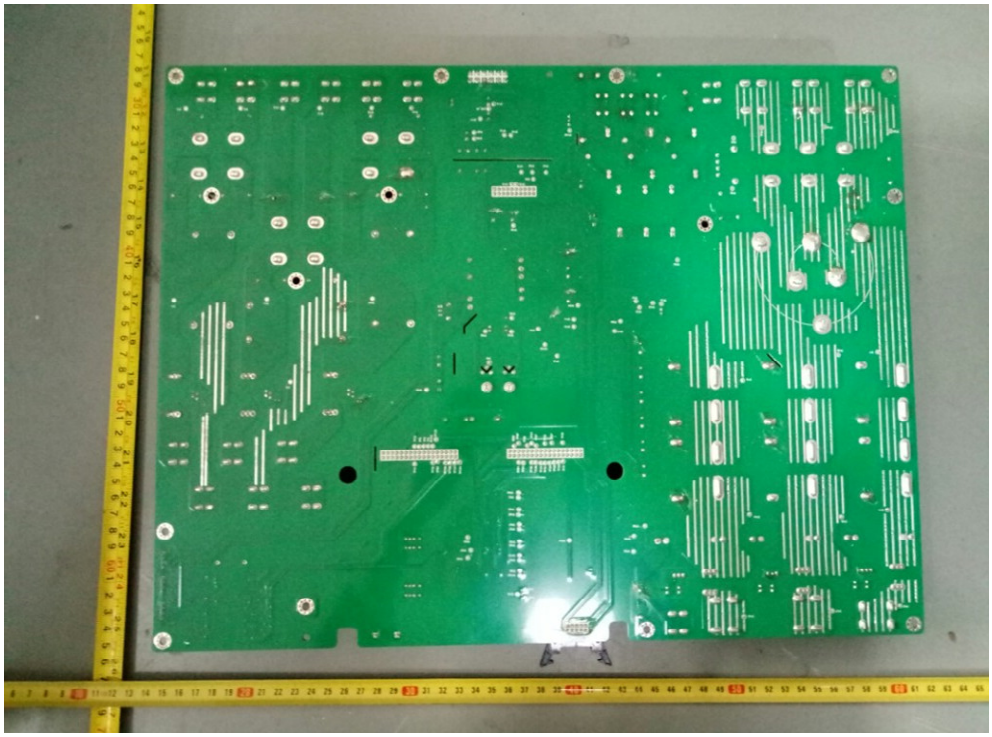


Figure 11. Input/output board solder side view

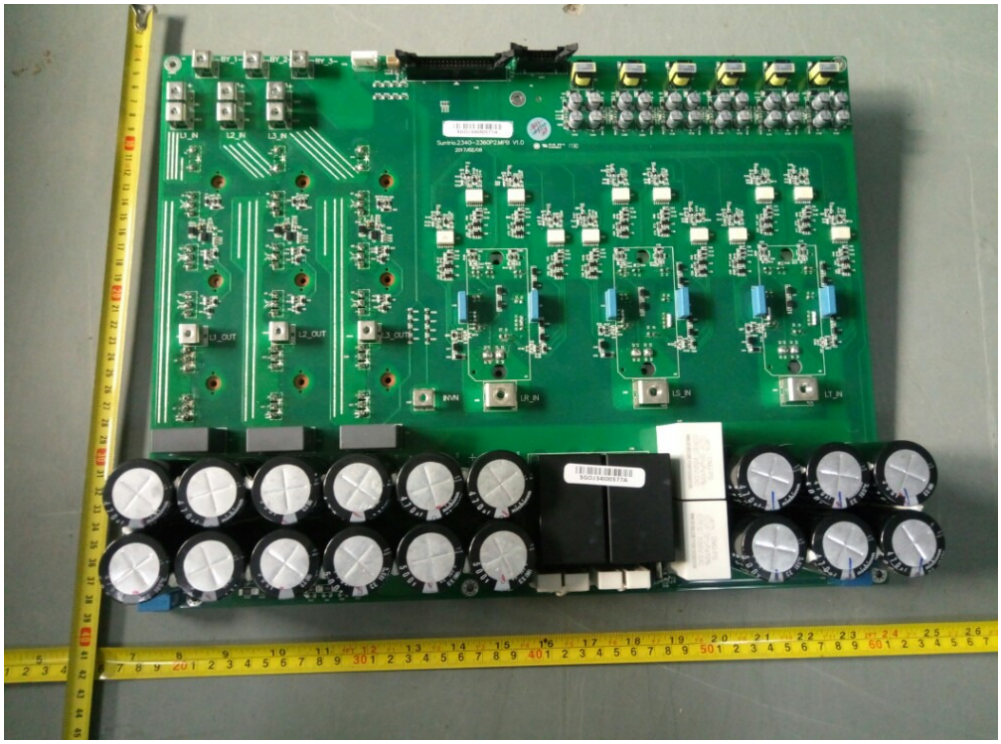


Figure 12. Main power board component side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

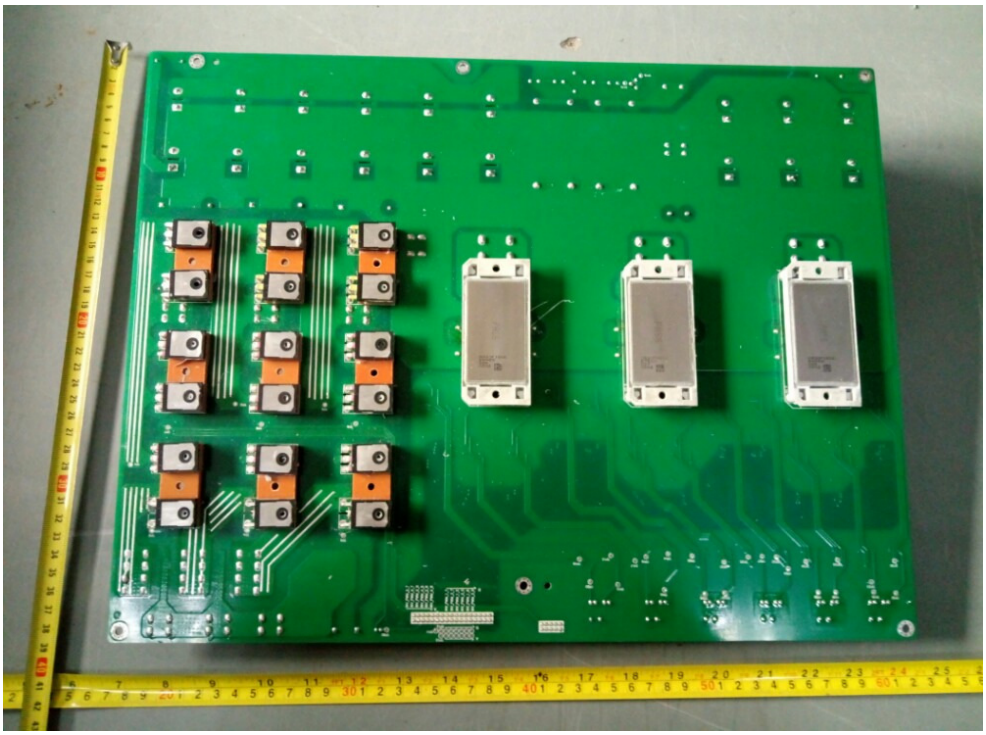


Figure 13. Main power board solder side view

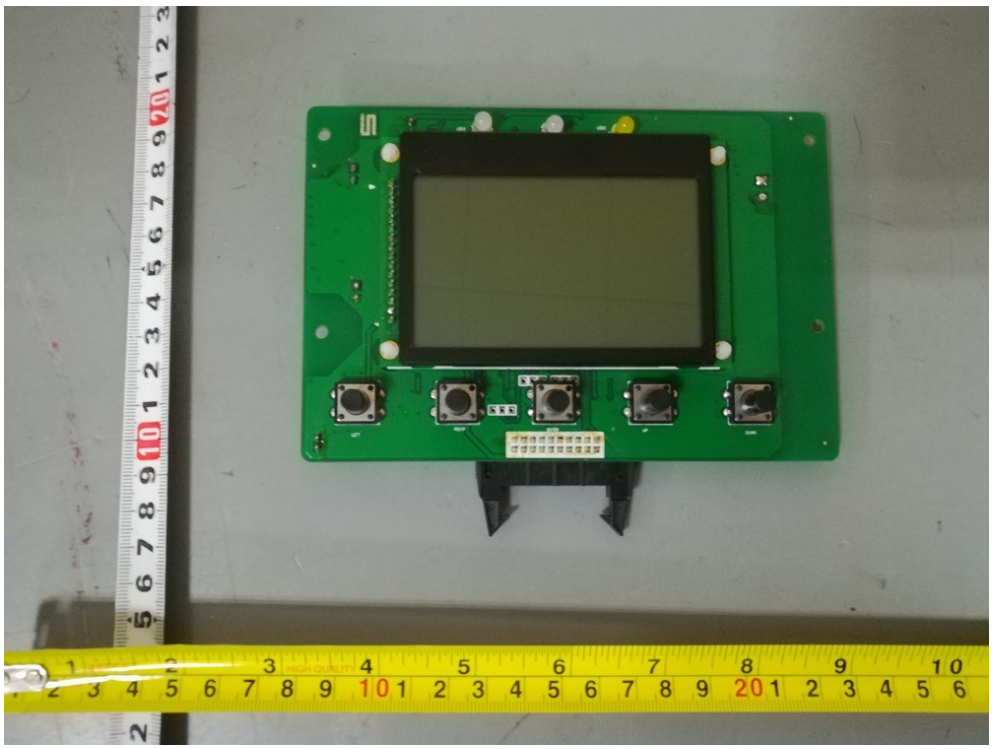


Figure 14. Display board component side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

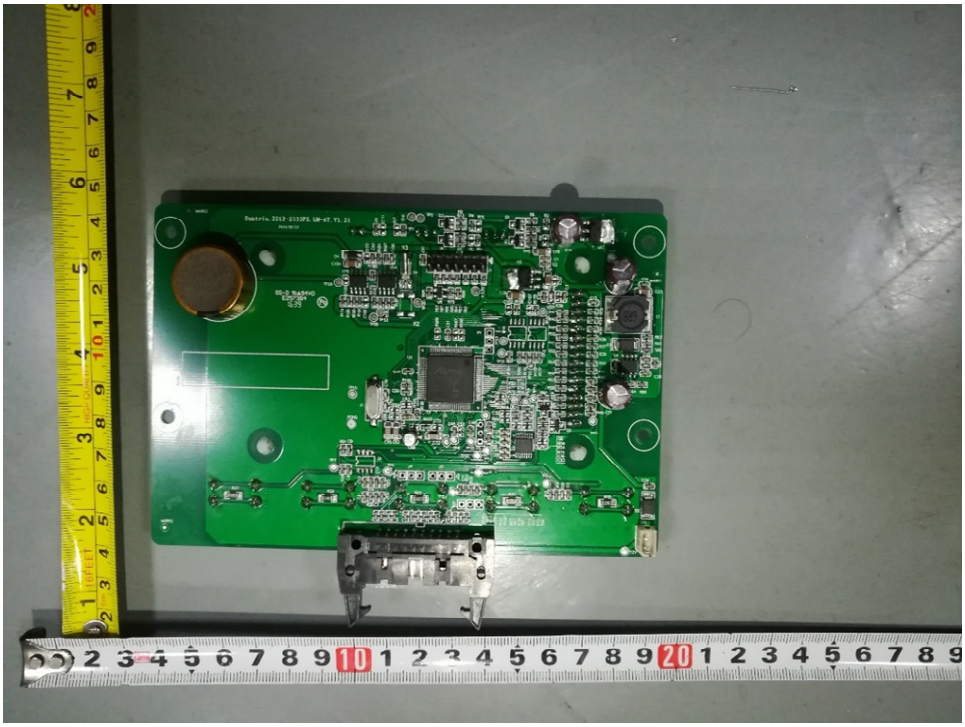


Figure 15. Display board solder side view

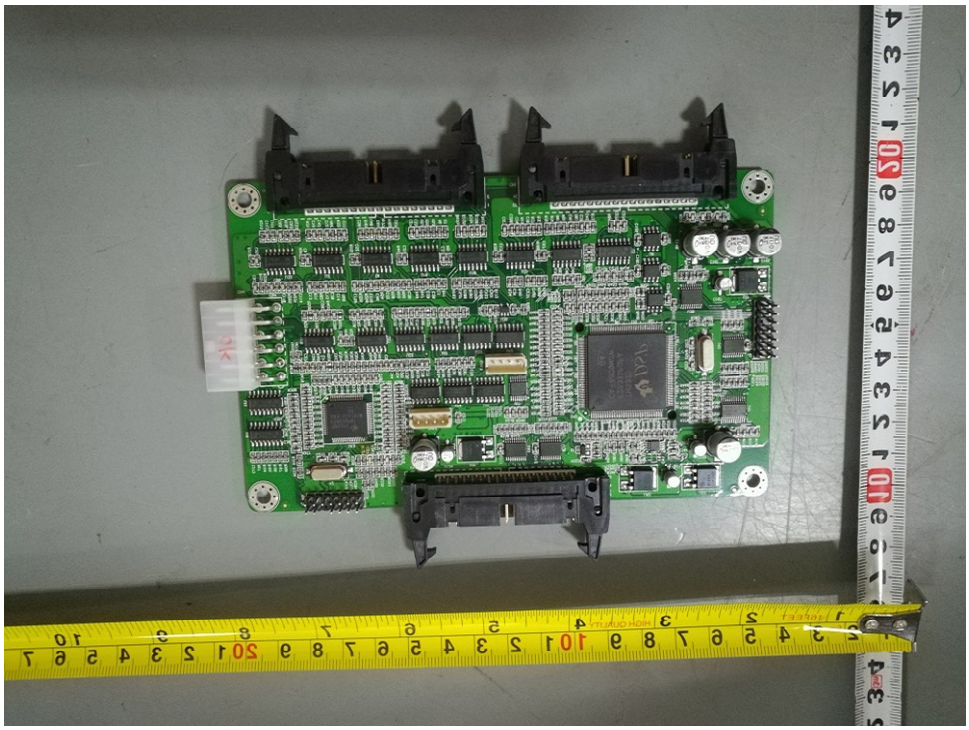


Figure 16. Control board component side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

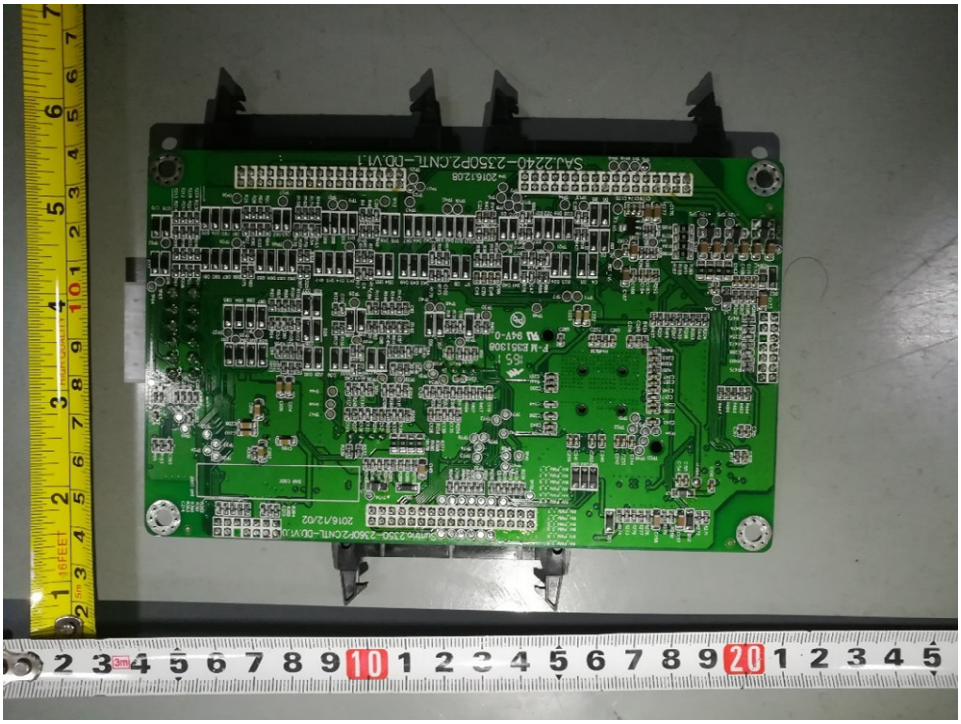


Figure 17. Control board solder side view

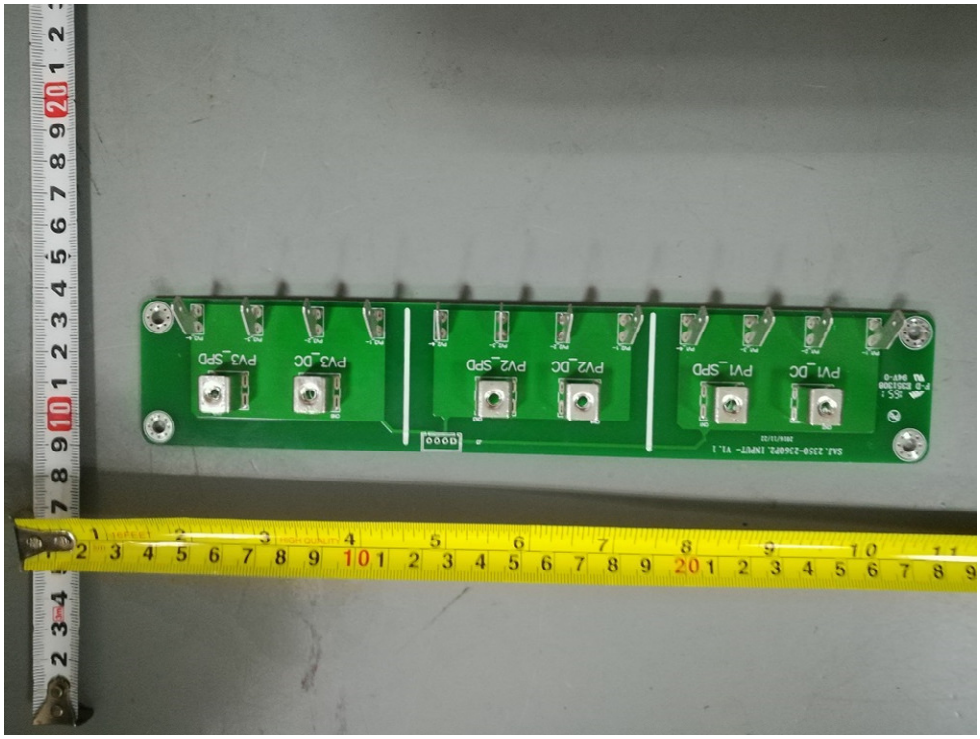


Figure 18. Input board component side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

Figure 19. Input board solder side view

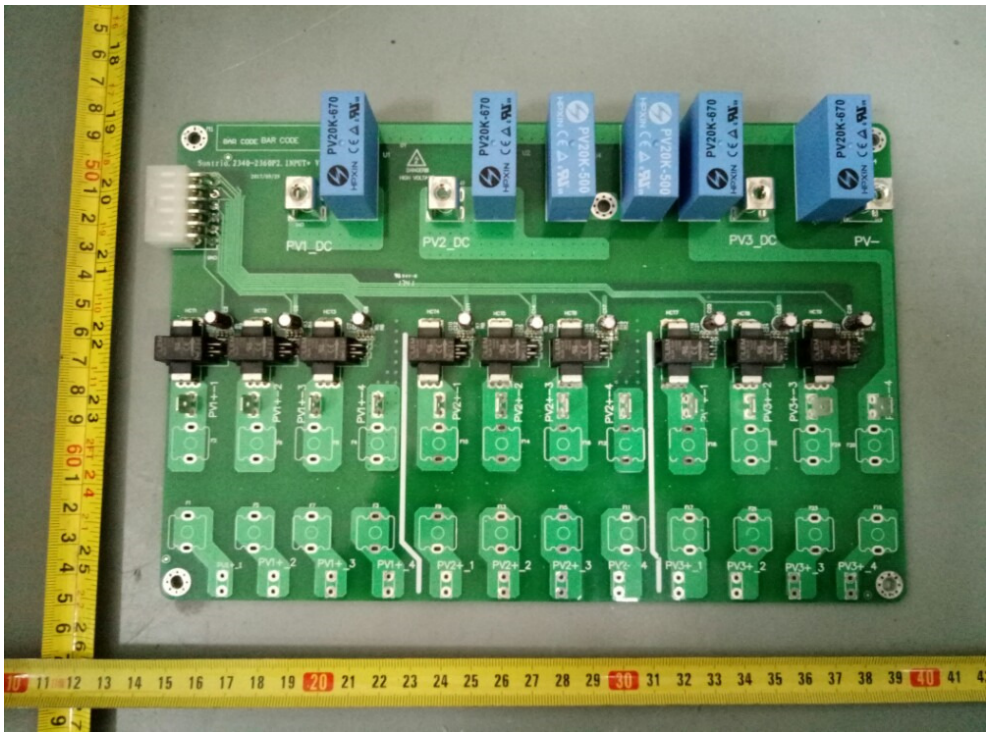


Figure 20. Input board component side view for Suntrio Plus 60K

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

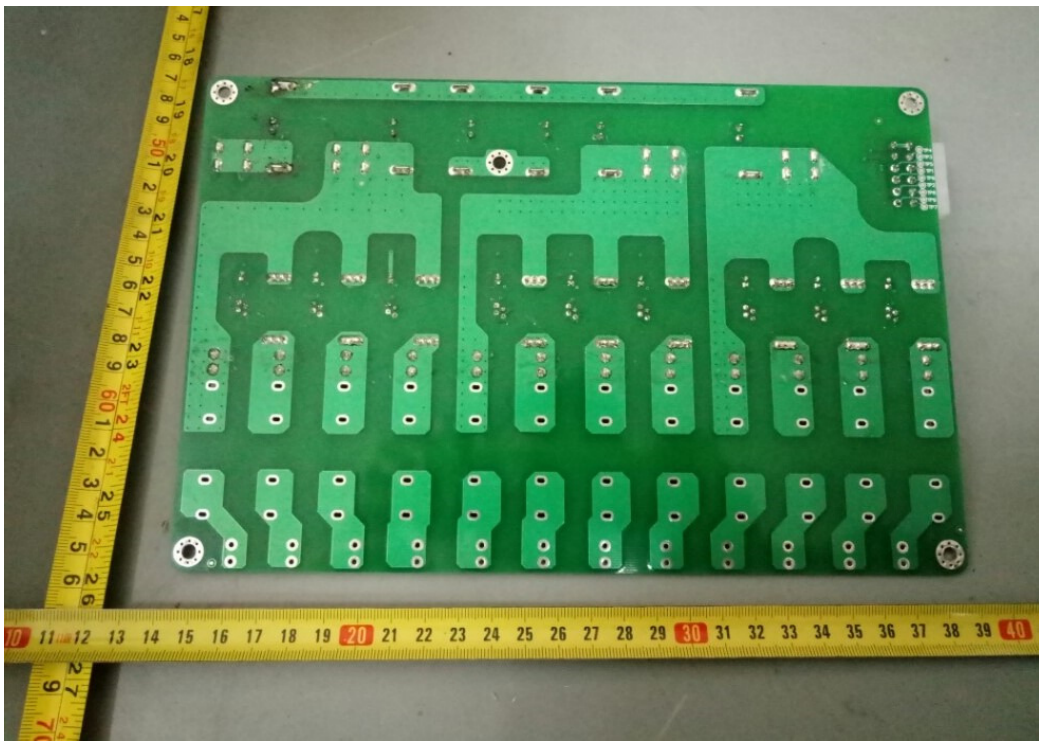


Figure 21. Input board solder side view for Suntrio Plus 60K

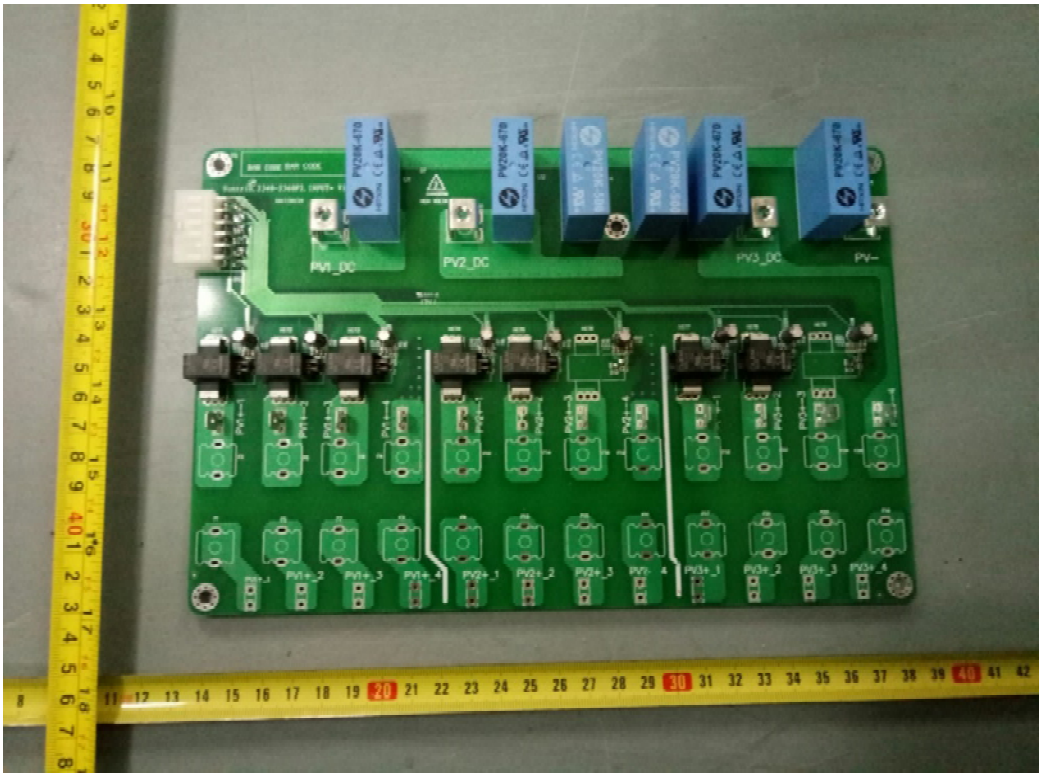


Figure 22. Input board component side view for Suntrio Plus 40K, Suntrio Plus 50K

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

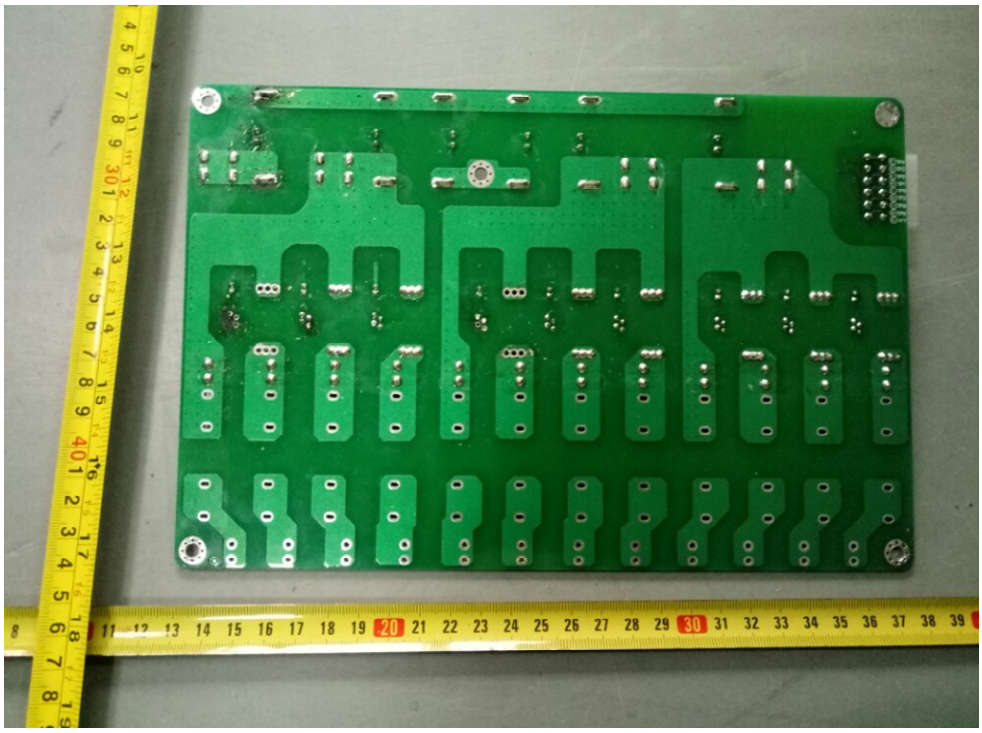


Figure 23. Input board solder side view for Suntrio Plus 40K, Suntrio Plus 50K

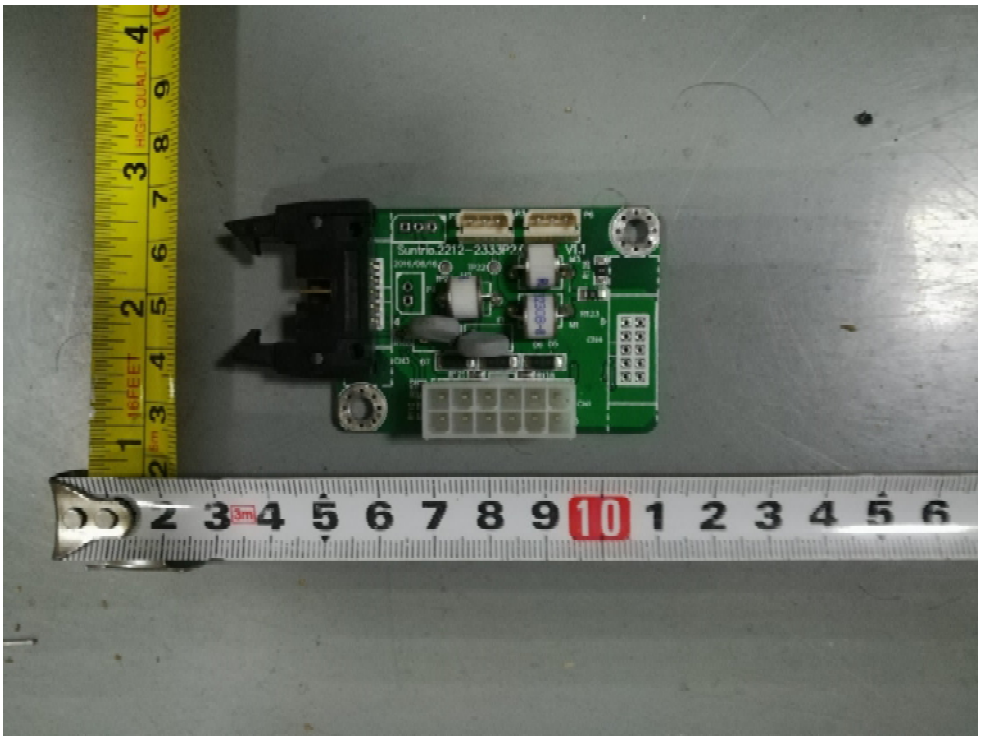


Figure 24. communication board component side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

Figure 25. communication board solder side view

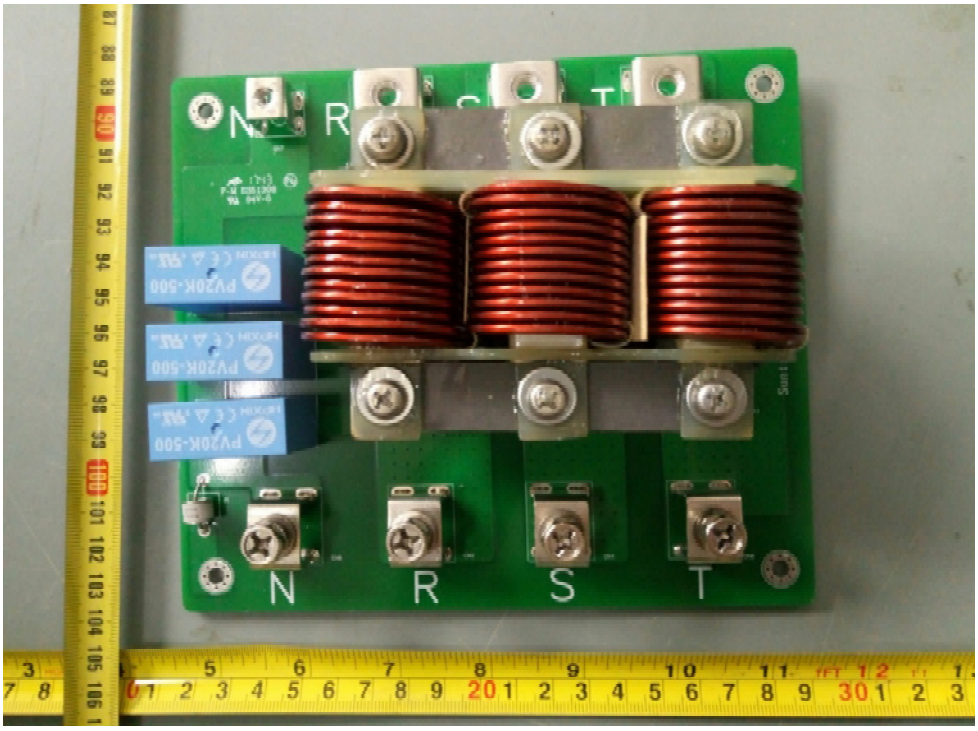


Figure 26. AC board component side view

Product: Photovaltaic grid-connected inverter
Type: Suntrio Plus 40K, Suntrio Plus 50K, Suntrio Plus 60K

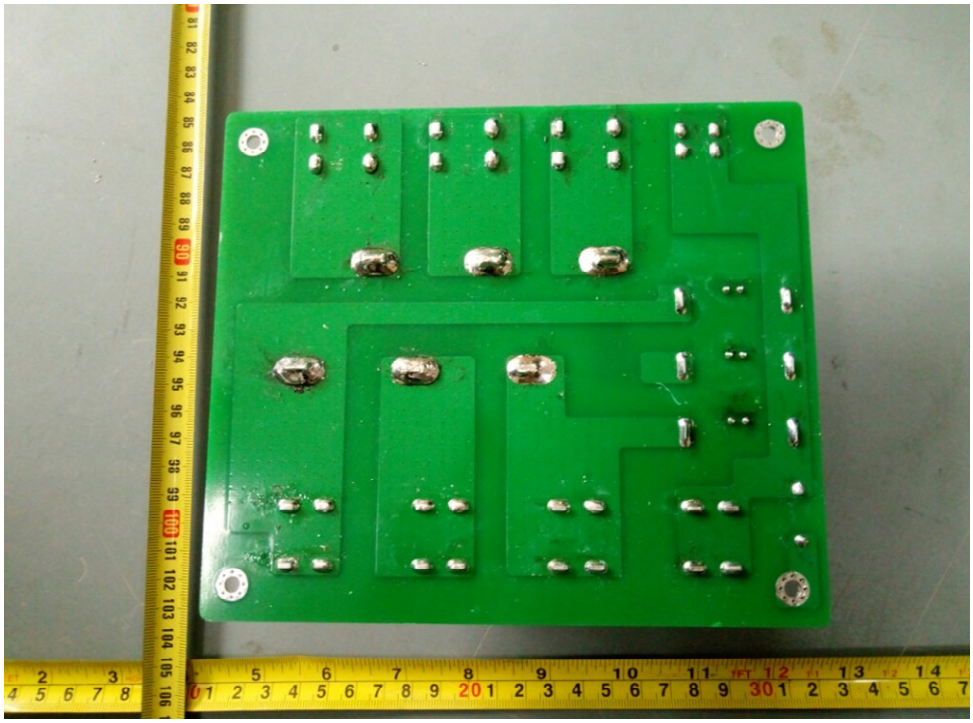


Figure 27. AC board solder side view

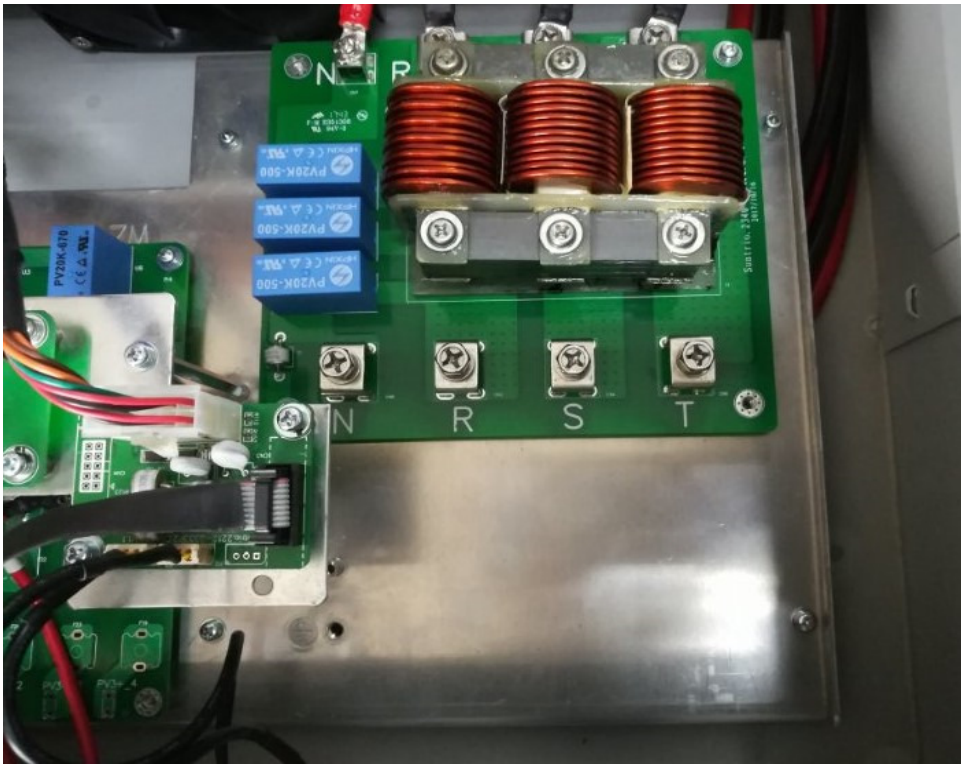


Figure 28. AC terminal side view