


ENA Engineering Recommendation G99-1 Amd.4 Type Verification Test Report

Type Approval and manufacturer/supplier declaration of compliance with the requirements of Engineering Recommendation G99-1 Amd.4			
Type Test reference number	PVS-60-TL , PVS-60-TL-S , PVS-60-TL-SX , PVS-60-TL-SX2 PVS-50-TL , PVS-50-TL-S , PVS-50-TL-SX , PVS-50-TL-SX2		
Generating unit technology	SOLAR GRID TIED INVERTER		
System Supplier name	Power-One Italy S.p.A.		
Address	Via S. Giorgio, 642 52028 Terranuova Bracciolini Arezzo - Italy		
Tel.	+39-055-91951	Fax	+39-055-9195248
E:mail	servicer.solarinverters@it.abb.com	Web site	www.abb.com/solarinverters www.abb.com
Maximum / Nominal rated capacity	Connection Option PVS-60-TL , PVS-60-TL-S , PVS-60-TL-SX , PVS-60-TL-SX2 Maximum / Nominal rated capacity: 66.0 kW / 60.0 kW (three phases) PVS-50-TL , PVS-50-TL-S , PVS-50-TL-SX , PVS-50-TL-SX2 Maximum / Nominal rated capacity: 55.0 kW / 50.0 kW (three phases)		
We, Power-One Italy S.p.A., as manufacturer/supplier of Generating Unit, certifies that all products manufactured/supplied by the company with the above Type Test reference number will be manufactured and tested to ensure that they perform as stated in this document, prior to shipment to site and that no site modifications are required to ensure that the products meet all the requirements of G99-1 Amd.4			
Attachment: Extract of Test Report Ref. 28111830 022 , released by TÜV Rheinland.			

Terranuova B.ni, 2019 September 05



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Type of System:	Solar Grid tied inverter							
System Manufacturer: Manufacturer data:	Power-One Italy S.p.A. Via S. Giorgio 642, 52028 Terranuova Bracciolini (AR) - Italy							
Reference test report:	28111830 022 Issued by TÜV Rheinland Italia S.r.l.							
Measuring period:	From 03/06/2019 to 28/06/2019							
Type Test reference number: Pacr / Pacmax <i>(Rated AC Power / Maximum AC output Power)</i>	<table border="1"> <thead> <tr> <th>Models</th> <th>Pacr / Pacmax</th> </tr> </thead> <tbody> <tr> <td>PVS-50-TL</td> <td>50 KW / 55 KW</td> </tr> <tr> <td>PVS-60-TL</td> <td>60 KW / 66 KW</td> </tr> </tbody> </table>		Models	Pacr / Pacmax	PVS-50-TL	50 KW / 55 KW	PVS-60-TL	60 KW / 66 KW
Models	Pacr / Pacmax							
PVS-50-TL	50 KW / 55 KW							
PVS-60-TL	60 KW / 66 KW							
Software version:	Bundle Firmware Update Version*: not less than: 1919B for PVS-50-TL 1919C for PVS-60-TL standard selection: UK G99							
Rated Voltage:	400/480 V, 3W+N+PE & 3W+PE							
Note *:	<p>“Update version” identifies the Bundle Firmware Features by a sequential code: xxxxy where:</p> <ul style="list-style-type: none"> • xxxx is a number indicates Year (two digits) and Week (two digits) • y is a letter from A to G indicates Day (from Sunday = A to Saturday=G) 							

Generating Unit Type Test Sheet

A2-3 Compliance Verification Report –Tests for Type A Inverter Connected Power Generating Modules – test record

1. Operating Range: Five tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable test supply or grid simulation set. The power supplied by the primary source shall be kept stable within $\pm 5\%$ of the apparent power value set for the entire duration of each test sequence.

Frequency, voltage and **Active Power** measurements at the output terminals of the **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** can operate within the required ranges for the specified period of time.

The **Interface Protection** shall be disabled during the tests.

In case of a PV **Power Park Module** the PV primary source may be replaced by a DC source.

In case of a full converter **Power Park Module** (eg wind) the primary source and the prime mover **Inverter/rectifier** may be replaced by a DC source.

Test 1 Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz, Power Factor = 1, Period of test 20 s	Inverters operated without disconnecting. Output power: 83.66 % Pmax
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz, Power Factor = 1, Period of test 90 minutes	Inverters operated without disconnecting. Output power: 82.66 % Pmax
Test 3 Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz, Power Factor = 1, Period of test 90 minutes	Inverters operated without disconnecting. Output power: 99.77 % Pmax
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, Power Factor = 1, Period of test 15 minutes	Inverters operated without disconnecting. Output power: 100.22 % Pmax
Test 5 RoCoF withstand Confirm that the Power Generating Module is capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms. Note that this is not expected to be demonstrated on site.	Confirmed. See diagrams

Unit set to PVS-60-TL

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2. Power Quality – Harmonics:

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5. These tests should be carried out as specified in BS EN 61000-3-12 The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 61000-3-12 for three phase equipment.

Power Generating Modules with emissions close to the limits laid down in BS EN 61000-3-12 may require the installation of a transformer between 2 and 4 times the rating of the **Power Generating Module** in order to accept the connection to a **Distribution Network**.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation shall be designed in accordance with EREC G5.

Power Generating Module tested to BS EN 61000-3-12

Tested model: PVS-50-TL

Power Generating Module rating per phase (rpp)		18.3	kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)		
Harmonic	At 45-55% of Registered Capacity		100% of Registered Capacity		Limit in BS EN 61000-3-12	
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2	0.026	0.032%	0.159	0.200%	8%	8%
3	0.081	0.102%	0.375	0.471%	21.6%	Not stated
4	0.002	0.003%	0.073	0.092%	4%	4%
5	0.884	1.109%	0.391	0.490%	10.7%	10.7%
6	0.001	0.001%	0.002	0.002%	2.67%	2.67%
7	0.539	0.676%	0.285	0.357%	7.2%	7.2%
8	0.001	0.001%	0.001	0.001%	2%	2%
9	0.001	0.001%	0.001	0.001%	3.8%	Not stated
10	0.001	0.001%	0.001	0.001%	1.6%	1.6%
11	0.001	0.001%	0.040	0.050%	3.1%	3.1%
12	0.001	0.001%	0.001	0.001%	1.33%	1.33%
13	0.000	0.000%	0.003	0.004%	2%	2%

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THD ¹	-	1.306%	-	0.802%	23%	13%
PWHD ²	-	0.102%	-	0.087%	23%	22%
Tested model: PVS-60-TL						
Power Generating Module rating per phase (rpp)		18.3	kVA	Harmonic % = Measured Value (A) x 23/rating per phase (kVA)		
Harmonic	At 45-55% of Registered Capacity		100% of Registered Capacity		Limit in BS EN 61000-3-12	
	Measured Value MV in Amps	%	Measured Value MV in Amps	%	1 phase	3 phase
2	0.043	0.054%	0.121	0.152%	8%	8%
3	0.078	0.098%	0.348	0.436%	21.6%	Not stated
4	0.014	0.018%	0.076	0.095%	4%	4%
5	0.887	1.113%	0.387	0.486%	10.7%	10.7%
6	0.010	0.012%	0.025	0.031%	2.67%	2.67%
7	0.540	0.677%	0.286	0.359%	7.2%	7.2%
8	0.007	0.009%	0.016	0.020%	2%	2%
9	0.006	0.007%	0.013	0.016%	3.8%	Not stated
10	0.006	0.007%	0.012	0.015%	1.6%	1.6%
11	0.005	0.006%	0.042	0.053%	3.1%	3.1%
12	0.005	0.006%	0.010	0.012%	1.33%	1.33%
13	0.004	0.005%	0.011	0.014%	2%	2%
THD	-	1.311%	-	0.773%	23%	13%
PWHD	-	0.106%	-	0.077%	23%	22%

¹ THD = Total Harmonic Distortion

² PWHD = Partial Weighted Harmonic Distortion

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3. Power Quality – Voltage fluctuations and Flicker:

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) these tests should be undertaken in accordance with Annex A.7.1.4.3. Results should be normalised to a standard source impedance, or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable Maximum Impedance.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation shall be designed in accordance with EREC P28.

	Starting			Stopping			Running	
	d max	d c	d(t)	d max	d c	d(t)	P st	P lt 2 hours
Measured Values at test impedance	0.86%	0.54%	--	0.72%	0.47%	--	0.34	0.32
Normalised to standard impedance	0.86%	0.54%	--	0.72%	0.47%	--	0.34	0.32
Normalised to required maximum impedance	--	--	--	--	--	--	--	--
Limits set under BS EN 61000-3-11	4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

Test Impedance	R	0.24	Ω	XI	0.15	Ω
Standard Impedance	R	0.24 * 0.4 ^	Ω	XI	0.15 * 0.25 ^	Ω
Maximum Impedance	R	--	Ω	XI	--	Ω

* Applies to three phase and split single phase **Power Generating Modules**.

^ Applies to single phase **Power Generating Module** and **Power Generating Modules** using two phases on a three phase system

For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the **Power Factor** of the generation output is 0.98 or above.

Normalised value = Measured value x reference source resistance/measured source resistance at test point

Single phase units reference source resistance is 0.4 Ω

Two phase units in a three phase system reference source resistance is 0.4 Ω

Two phase units in a split phase system reference source resistance is 0.24 Ω

Three phase units reference source resistance is 0.24 Ω

Where the **Power Factor** of the output is under 0.98 then the XI to R ratio of the test impedance should be close to that of the Standard Impedance.

The stopping test should be a trip from full load operation.

The duration of these tests need to comply with the particular requirements set out in the testing notes for the technology under test. Dates and location of the test need to be noted below

Test start date	2019-06-24	Test end date	2019-06-24
Test location	TÜV Rheinland Italia S.r.l.		

4. Power quality – DC injection: The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three defined power levels $\pm 5\%$. At 230 V a 50 kW three phase **Inverter** has a current output of 217 A so DC limit is 543 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.

Test power level	10%	55%	100%
Recorded value in Amps	0.08 A	0.076 A	0.09 A
as % of rated AC current	0.11%	0.10%	0.12%
Limit	0.25%	0.25%	0.25%

Supplementary information:

When measured during operation at three levels, 10%, 55% and 100% of rating with a tolerance of plus or minus 5%.

The test has been performed on PVS-60-TL are valid for all the other models since they are identical in hardware and just power derated by software.

5. Power Factor: The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity**. Voltage to be maintained within $\pm 1.5\%$ of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2.

Voltage	0.94 pu (216.2 V)	1 pu (230 V)	1.1 pu (253 V)
Measured value	0.9996	0.9997	0.9997
Power Factor Limit	>0.95	>0.95	>0.95

Supplementary information:

The test has been performed on PVS-60-TL are valid for all the other models since they are identical in hardware and just power derated by software.

6. Protection – Frequency tests: These tests should be carried out in accordance with the Annex A.7.1.2.3.

Function	Setting		Trip test		"No trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5 Hz	20 s	47.49	20.13	47.7 Hz 30 s	No Trip
U/F stage 2	47 Hz	0.5 s	46.98	0.582	47.2 Hz 19.5 s	No Trip
					46.8 Hz 0.45 s	No Trip
O/F	52 Hz	0.5 s	52.01	0.575	51.8 Hz 120.0 s	No Trip
					52.2 Hz 0.45 s	No Trip

Note. For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The "No trip tests" need to be carried out at the setting ± 0.2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

The test has been performed on PVS-60-TL are valid for all the other models since they are identical in hardware and just power derated by software.

7. Protection – Voltage tests: These tests should be carried out in accordance with Annex A.7.1.2.2.

Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	0.8 pu (184 V)	2.5 s	184.5 V	2.555 s	188 V 5.0 s	No Trip
					180 V 2.45 s	No Trip
O/V stage 1	1.14 pu (262.2 V)	1.0 s	262.5 V	1.061 s	258.2 V 5.0 s	No Trip
O/V stage 2	1.19 pu (273.7 V)	0.5 s	273.9 V	0.575 s	269.7 V 0.95 s	No Trip
					277.7 V 0.45 s	No Trip

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Note for Voltage tests the Voltage required to trip is the setting ± 3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ± 4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

8. Protection – Loss of Mains test: These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4.

The following sub set of tests should be recorded in the following table.

Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. Limit is 0.5s	0.422	0.352	0.374	0.434	0.360	0.400

Loss of Mains Protection, Vector Shift Stability test. This test should be carried out in accordance with Annex A.7.1.2.6.

	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+50 degrees	No Trip
Negative Vector Shift	50.5 Hz	- 50 degrees	No Trip

Loss of Mains Protection, RoCoF Stability test: This test should be carried out in accordance with Annex A.7.1.2.6.

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.95 Hzs ⁻¹	2.1 s	No Trip
51.0 Hz to 49.0 Hz	-0.95 Hzs ⁻¹	2.1 s	No Trip

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9. Limited Frequency Sensitive Mode – Over frequency test: The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%.

This test should be carried out in accordance with Annex A.7.1.3.

Active Power response to rising frequency/time plots are attached if frequency injection tests are undertaken in accordance with Annex A.7.2.4.

 Yes

 No

Alternatively, simulation results should be noted below:

Droop is 20%

Test sequence at Registered Capacity >80%	Measured Active Power Output [W]	Frequency [Hz]	Primary Power Source	Active Power Gradient
Step a) 50.00Hz ±0.01Hz	65778	50.00	PV simulator with maximum power peak = 70000W	-
Step b) 50.45Hz ±0.05Hz	64568	50.45		-
Step c) 50.70Hz ±0.10Hz	61314	50.70		-19.788%
Step d) 51.15Hz ±0.05Hz	55464	51.15		-19.763%
Step e) 50.70Hz ±0.10Hz	61301	50.70		-19.720%
Step f) 50.45Hz ±0.05Hz	64548	50.45		-19.745%
Step g) 50.00Hz ±0.01Hz	65815	50.00		-
Test sequence at Registered Capacity 40% - 60%	Measured Active Power Output [W]	Frequency [Hz]	Primary Power Source	Active Power Gradient
Step a) 50.00Hz ±0.01Hz	32656	50.00	PV simulator with maximum power peak = 35000W	-
Step b) 50.45Hz ±0.05Hz	32088	50.45		-
Step c) 50.70Hz ±0.10Hz	30474	50.70		-19.770%
Step d) 51.15Hz ±0.05Hz	27572	51.15		-19.748%

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Step e) 50.70Hz ±0.10Hz	30470	50.70		-19.721%
Step f) 50.45Hz ±0.05Hz	32083	50.45		-19.757%
Step g) 50.00Hz ±0.01Hz	32677	50.00		-

10. Protection – Re-connection timer.

Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 10.1.

Time delay setting	Measured delay	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of Table 10.1.			
25 s	30.02 s	At 1.16 pu (266.2 V)	At 0.78 pu (180.0 V)	At 47.4 Hz	At 52.1 Hz
Confirmation that the Power Generating Module does not re-connect.		No reconnection	No reconnection	No reconnection	No reconnection

11. Fault level contribution: These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5.

 For **Inverter** output

Time after fault	Volts	Amps
20ms	119.88	82.172
100ms	58.36	36.796
250ms	46.39	26.018
500ms	37.57	16.444
Time to trip	0.033	In seconds

12. Self-Monitoring solid state switching: No specified test requirements. Refer to Annex A.7.1.7.

 It has been verified that in the event of the solid state switching device failing to disconnect the **Power Park Module**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 s.

 Yes
 NA

13. Wiring functional tests: If required by para 15.2.1.

Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)

 Yes
 NA

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14. Logic interface (input port).

Confirm that an input port is provided and can be used to shut down the module.

Yes

NA

Additional comments.

none

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