PV GAP RECOMMENDED SPECIFICATION

PVRS 8A

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Inverters for photovoltaic (PV) stand-alone systems

Annex — Specification and testing procedure, to PVRS 8

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This publication is an annex to PV GAP Recommended Specification PVRS 8, Inverters for photovoltaic (PV) stand-alone systems. Blank detail specification — Qualification Approval under the IEC System for Conformity Testing and Certification of Electrical Equipment and Components (IECEE).

PV GAP Secretariat c/o IEC Central Office
3 rue de Varembé - PO Box 131 - 1211 Geneva 20 - Switzerland
Tel: 41 22 919 02 16 Fax: 41 22 919 03 00 E-mail: rk@iec.ch

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The following is reproduced from solar photovoltaic systems and photovoltaic/wind hybrid systems specifications and qualifying requirements - GEF/WB Assisted China Renewable Energy Development Project

3.5 DC/AC Inverters

1. Rated output voltage shall be AC220V±10% over the full range of normal battery operating voltages. That is, when the input DC voltage varies from 90% to 120%, the output AC voltage must be within 10% of the rated voltage.

2. Output frequency is 50Hz and the variation should not be over 5%.

3. Inverter shall be capable of:
   a) Operating continuously for 4 hours at its rated power under ambient temperatures of 25° Centigrade
   b) Operate safely for at least one minute at 125% of rated power.
   c) Provide 150% of rated power for at least two seconds to facilitate starting of motors and other high capacitance loads.

4. If sine-wave inverters are utilized, the output waveform total harmonic distortion should be no more than 5%.

5. Inverter efficiency when operating resistive loads and power levels of above 75% should be greater than 80%.

6. Inverter or inverter circuits must include protection against:
   a) Low voltage: when input voltage is less than 1.8V/battery cell.
   b) Over-current: when working current is greater than 150% of the rated current
   c) Short circuit of input and output terminals.
   d) Reverse polarity on DC input terminals.
   e) Lightning induced transients when use in lightning-prone areas is expected.

7. The maximum quiescent current draw of the inverter, when no LEDs are illuminated, must not exceed 3% of the rated input current of the inverter.

8. Quiet operation: The noise produced by the inverter should be no more than 65dB at a distance of 3 meters from the inverter.

9. Easy to service: The inverter should be easy to repair or replace in the field by the service technicians.

10. The inverter input and output terminals must not be exposed to contact by the user and must be securely mounted in a location which is not accessible by children.

11. Each inverter must be labelled with the minimum information:
    a) Manufacturer name and model
    b) Serial number
    c) Input and output voltage and rated power
    d) Battery and load connection points and polarity

12. Complete documentation for the inverter must be included in the service technicians training manual and should include:
    a) Installation instructions
    b) Operating instructions
    c) Technical specifications and ratings
    d) Safety warning
    e) Troubleshooting instructions
    f) Information pertaining to serviceable parts
    g) Warranty

5.3.5 DC/AC Inverter

1. Manufacturer .....
2. Model Number .....
3. Continuous Power .....W
4. Rated Output AC Voltage .....V±_%
5. DC Input Voltage Range .....V±_%
6. Output Frequency .....Hz±_%
7. Inverters Type..... Sine/Modified Sine/Square
8. If Sine-wave, Harmonic Distortion..... %
9. Efficiency at 25% Rated Capacity..... %
10. Efficiency at Rated Capacity..... %
11. Low Voltage Protection.....V/cell
12. Over-current Protection .....Yes/No
13. Short-circuit Protection .....Yes/No
14. Input Terminal Reverse Polarity Protection.....Yes/No
15. Lightning Protection.....Yes/No
16. Label .....Yes/No
17. Documentation .....Yes/No
18. Certification Issued by .....

CHINA RENEWABLE ENERGY DEVELOPMENT PROJECT
PHOTOVOLTAIC MARKET DEVELOPMENT COMPONENT

STAND-ALONE INVERTER

TESTING PROCEDURE

Approval Date: March 23, 1999

PROJECT MANAGEMENT OFFICE (PMO)
WORLD BANK/GEF ASSISTED CHINA RENEWABLE ENERGY DEVELOPMENT PROJECT
STATE ECONOMIC AND TRADE COMMISSION
BEIJING, PEOPLE'S REPUBLIC OF CHINA

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FOREWORD

This test procedure is established in line with “Solar Photovoltaic Systems and Photovoltaic Hybrid Systems Specifications and Qualifying Requirements”, issued by the Project Management Office, State Economic and Trade Commission for systems to be used in the World Bank/GEF assisted China Renewable Energy Development Project, Photovoltaic Market Development Component. The objective of the project is to give an impetus to improvement in product quality of China’s Photovoltaic (PV) industry and to provide well performing and reliable PV systems. This test procedure specifies the tests to be conducted, the test methods, sampling plan, quality assurance for DC to AC inverters for stand-alone PV systems with maximum PV array size of 500 peak Watts (Wp).

Test Procedure for Certification of Stand-Alone Inverters Used in Solar Home System

1. Scope

This document describes the test items, technical requirements, testing methods, sampling plan, test equipment and quality assurance for certification of stand-alone PV inverters used in solar home systems. It covers the inverters for stand-alone PV systems with maximum PV array size of 500 peak Watts (Wp).

2. References

- GB/T 14162-93 Product Quality Supervision Count Sample Program and Sample Table.
- Solar Photovoltaic Systems and Photovoltaic/Wind Hybrid Systems Specifications and Qualifying Requirements, December 7, 1998.

3. Test Items, Technical Requirements and Test Methods

Table 1 describes the technical requirements (specifications) and test method for each test item. In Table 1, the number in parenthesis under Test Item refers to the specification number in the above reference document “Solar Photovoltaic Systems and Photovoltaic/Wind Hybrid Systems Specifications and Qualifying Requirements”, December 7, 1998.

Table 1. Photovoltaic (PV) Stand-Alone Inverter Test Items, Technical Requirements and Test Methods

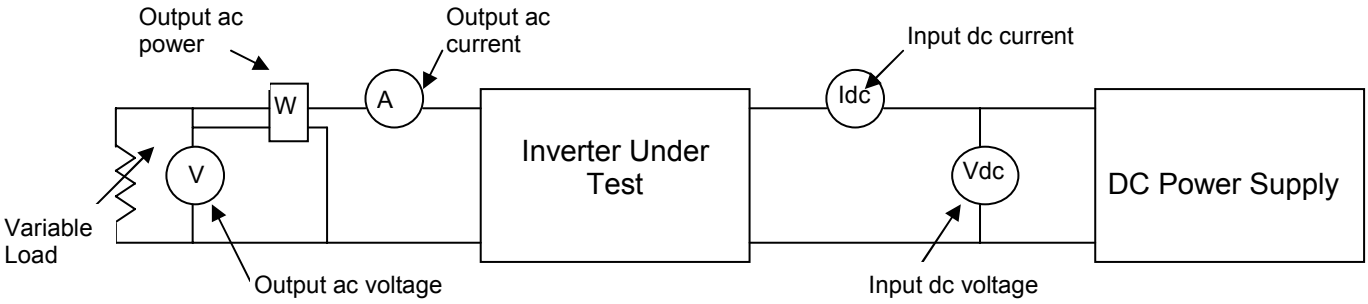
No	Test Item		Technical Requirements	Test Method
1	Appearance and Documentation (Spec.3.5.11 and 3.5.12)	Appearance	No physical damage (including damage due to shipping and handling), carton damage, moisture penetration and loose components.	Visually inspect the inverter for any physical damage, including damage due to shipping and handling. Also check the inverter for carton damage, moisture penetration and loose components.
		Labels	Clear labels with the following information: 1. Manufacturer name and model, 2. Serial number, 3. Input and output voltage and current ratings, 4. Battery and load connection points and polarity.	Visually check the inverter to verify that all the labels listed under technical requirements are included, also indicating the connection points and polarity of the battery and load.
		Documentation	The following documentation should be included: 1. Technical specifications and ratings, 2. Safety warnings, 3. Installation instructions, 4. Operating instructions, 5. Troubleshooting instructions, 6. Information on serviceable parts, and 7. Warranty	Check if all the documents listed under technical requirements are included with the inverter.
2	Efficiency vs. Power Level (Spec. 3.5.5)		Efficiency should be higher than 80%, when output power level is above 75% of the rated power level.	Using the test set-up with a variable resistive load as shown in Fig. 1, measure the inverter efficiency as: $\eta = \frac{\text{AC Power Output}}{\text{DC Power Input}} = \frac{Wac}{Vdc.Idc}$ Increase the AC power output from 10% to 100% of the rated power to obtain the plot of inverter efficiency vs. output power. The inverter efficiency should be higher than 80% for all output power levels above 75% of the nominal power.
3	Load (Output Power) Capability (Spec. 3.5.3)		Inverter can operate safely at an ambient temperature of 25°C for a minimum of: a) four hours at full rated output power b) one minute at 125% of the rated output power, and c) two seconds at 150% of the rated output power (to simulate high surge currents due to starting of motors).	Using the test set-up as shown in Fig. 1 at 25°C ambient temperature, adjust the load to provide full rated output power and maintain this power level for four hours. The inverter should operate safely and not reach temperatures high enough to result in a risk of fire, to damage any materials used, or to activate the operation of any protective device. Repeat this test at 125% of the rated output power for one minute, and then at 150% of the rated output power for two seconds. Verify the inverter's safe operation under both of these conditions as done previously (at rated power for four hours).

4	Input Voltage Range (Spec. 3.5.1)	Inverter should operate normally, when the input DC voltage is in the range of 90% to 120% of the nominal input voltage. During the normal operation of the inverter, its AC output voltage must remain in the range of 220 volts ± 10%.	Using the test set-up as shown in Fig. 1, keep the output power constant at half rated power and vary the input DC voltage from 90% to 120% of the nominal input voltage, while also measuring the inverter output frequency with an oscilloscope or a meter. Repeat this test at different output power levels ranging from 10% to 100% of the rated power. For all power levels, the inverter should meet the technical requirements as described for items 4 and 5.
5	Frequency Check (Spec. 3.5.2)	Inverter output operating frequency should be in the range of 50 Hz ± 5%.	
6	Voltage Harmonics (Spec. 3.5.4)	For a sine-wave inverter, the maximum total harmonic distortion in the output voltage should not exceed 5% of the fundamental component at the full rated output power of the inverter.	This test should be conducted only for sine-wave inverters. Using a harmonic analyzer, measure the total harmonic distortion in the output voltage at different power levels, and at any power level it should not exceed 5% of the fundamental component at the full rated power.
7	Noise (Spec. 3.5.8)	Audio noise produced by the inverter should be less than 65dB at a distance of three meters, when the inverter is operating.	Measure the inverter noise at a distance of three meters from the inverter at half and full rated power, and verify that it is below 65dB.
8	Quiescent Current (Spec. 3.5.7)	Inverter self-consumption should not exceed 3% of the rated input current.	Using the test set-up as shown in Fig 1 and with the load disconnected, measure the DC input current drawn by the inverter at different DC input voltages from 90% to 120% of the nominal input voltage, and verify that the current drawn at no load is within 3% of rated input current for all conditions.

9	Protection Functions (Spec. 3.5.6)	a) Low Voltage Protection	Inverter should be able to shut down automatically to protect the battery when the input voltage is lower than 90% of the rated value (1.8 volts per battery cell).	Start with the DC power supply voltage at the inverter nominal input voltage, and gradually decrease the power supply voltage. Check if the inverter shuts down automatically, when its input voltage falls below 90% of the rated value.
		b) Output Over-Current Protection	Inverter should shut down if the output power exceeds 150% of the rated power.	Using the test set-up as shown in Fig. 1, adjust the load to provide the full rated AC power. Then increase the load gradually, and verify that the inverter stops operating as the load increases above 150% of the rated power.
		c) Short Circuit Protection	If the inverter output is shorted, a circuit breaker in the inverter output circuit should trip or a fuse should blow to protect the inverter from any damage.	Again using the test set-up as shown in Fig. 1, short the inverter AC output by reducing the variable load to zero (or remove the load and short the inverter output terminals). The circuit breaker should trip or the fuse should blow, but no damage to the inverter or other hazard should occur.
		d) Reverse Polarity Protection	If the polarity of the inverter DC input connections is reversed, the inverter should not get damaged.	With the DC power supply voltage output adjusted to its minimum, connect the output terminals of the power supply in reverse polarity to the inverter DC input. Then, increase the power supply voltage gradually to the nominal input voltage of the inverter and maintain this voltage for at least one hour. Verify that no damage to the inverter or power supply occurs.
		e) Lightning Protection	Inverter should have a protection to avoid damage due to lightning in the area of excessive lightning*.	Visually check the type and rating of the surge arrestors to ensure that they are capable of absorbing expected surge energy due to lightning at the location of the inverter.

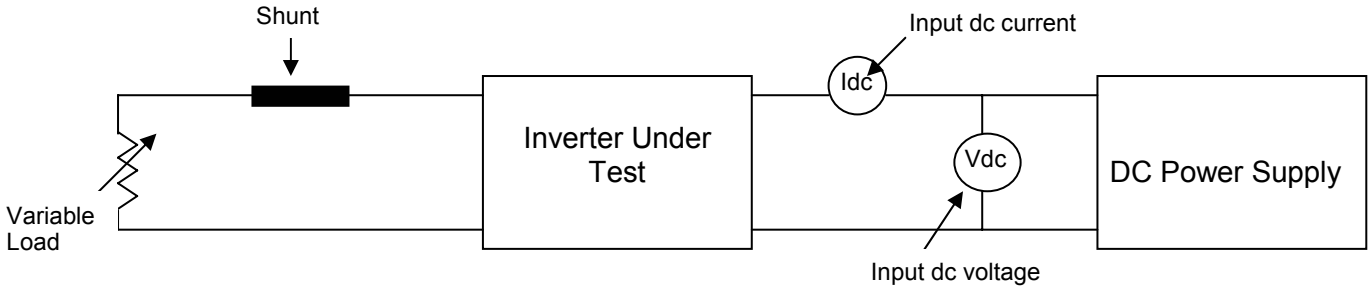
*Lightning protection is optional for low lightning areas.
Note: There are no tests for specs. 3.5.9 and 3.5.10

Fig. 1. Inverter Testing



Note: The ac voltmeter and wattmeter are true RMS meters with frequency response up to few kHz.

Fig. 2 Optional Method for Square Wave Inverter Testing with Digital Oscilloscope



Note: In case the true RMS meters are not available, the test for square-wave inverter can be done by using a digital oscilloscope which can measure the effective values of output voltage and current (by measuring the voltage across the shunt), and also obtain the effective output power as the product of the effective voltage and effective current.

4. Sampling Procedure and Plan

4.1 Sampling Procedure

4.1.1 The manufacturer will provide quantity of stand-alone PV inverters in storage batch to be tested and their original testing records.

4.1.2 The testing institution will check the brand, type, model, serial number and appearance of the inverters. When satisfied with the check, the testing institution will randomly select the samples from the batch.

4.1.3 After the agreement is signed between the manufacturer and the testing institution, these samples will be sealed and shipped to the testing institution.

4.2 Sampling Plan

4.2.1 The inverters will be categorized according to their nominal output power.

4.2.2 The inverter samples to be tested should be from the normal production in the batch and the total inverters in the batch should not be less than 10 units.

4.2.3 For each inverter type and model, two samples will be tested.

4.2.4 Sampling and quality assurance will be in accordance with GB/T14162-93 (Quality Supervision Test, Sampling Procedure and Judgement Table).

5. Quality Assurance and Norm

5.1 Quality Assurance

5.1.1 Method: In the quality control system, failure of the test for the inverters being tested is divided into columns B and C.

The level of controlled quality p_o for the column B failure of inverters is 2.5% the testing level is I, and the sampling method is n=2, r=1, where n is the sampling number, and r is the number of failed test units.

The level of controlled quality p_o for the column C failure of inverters is 40%, the testing level is II, and the sampling method is n=2, r=4, where n is the sampling number, and r is the number of failed test units.

5.1.2 Test item and quality assurance: See Table 2.

5.2 Quality Assurance Norm

5.2.1 The products being tested shall be assured to have passed under the conditions when all the test results and the performance meet the requirements.

5.2.2 The products being tested shall be judged to have passed under the conditions that there is no failure in column B and two or less failures in column C.

5.2.3 The products tested shall be assured not to have passed under the conditions that there is one item failure in column B or at least three failures in column C.

5.3 Repeat Testing and Assurance

5.3.1 For column B failure item, if it can be repaired through adjustment, it is allowed for testing once more after the adjustment.

5.3.2 The products should be judged not to have passed under the conditions that there still is failure in the repeat testing.

Table 2. Stand-Alone PV Inverter Test Items and Quality Assurance

No	Test Item		Fault class	
			B	C
1	Appearance and Documentation	Appearance	O	
		Labels		O
		Documentation		O
2	Efficiency vs. Power Level		O	
3	Load (Output Power) Capability		O	
4	Input Voltage Range		O	
5	Frequency Check		O	
6	Voltage Harmonics		O	
7	Noise		O	
8	Quiescent Current		O	
9	Protection Functions	a) Low Voltage Protection	O	
		b) Output Over-Current Protection	O	
		c) Short Circuit Protection	O	
		d) Reverse Polarity Protection	O	
		e) Lightning protection		O