PV GAP RECOMMENDED SPECIFICATION

PVRS 6A

First edition
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Charge controllers for photovoltaic (PV) stand-alone systems, with a nominal system voltage below 50V.

Annex — Specification and testing procedure, to PVRS 6

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This publication is an annex to PV GAP Recommended Specification PVRS 6, Charge controllers for photovoltaic (PV) stand-alone systems, with a nominal system voltage below 50V. Blank detail specification — Approval under the IEC System for Conformity Testing and Certification of Electrical Equipment and Components (IECEE).

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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

3.3 Charge Controller for PV System

1. The charge controller and associated devices must be designed to provide an average service life of 10 years under normal operating conditions.

2. The maximum quiescent current draw of the controller, when no LEDs are illuminated, must not exceed 1% of the controller rated charge current. (For example a charge controller with a 2.5A charging capacity would have a maximum quiescent current of 25mA).

3. Voltage drop across the charge controller when charging (PV to battery terminals) or discharging (battery to load terminals) should be less than 5% of the nominal system voltage.

4. The charge controller set points must be factory preset with the set points applicable to the specified battery characteristics to prevent battery over-charge (high-voltage-disconnect and reconnect set points) or over-discharge (low-voltage-disconnect and reconnect set points). It is recommended that circuitry to allow periodic equalizing charging of the battery be provided. Control set points for charging, discharging and other functions must be sufficiently stable to insure proper operation of the device over the range of anticipated ambient temperatures where the device will be installed.

5. Controller should include the following protective features:
a) Battery overcharge and over-discharge protection
b) Short circuit of any load
c) Reverse polarity of any load
d) Reverse polarity of module or battery
e) Internal shorts in charge controller
f) Lightning induced transients when use in lightning-prone areas is expected
g) Night-time discharge of the battery due to reverse current through the array.

6. Controller should be able to withstand voltages of 1.25 times the array nameplate open circuit voltage with the battery removed from the circuit for a 1 hour duration.

7. Controller should be able to withstand currents of 1.25 times the array nameplate short circuit current for a 1 hour duration. For switching type regulators the switching element must be capable of switching this current level without damage.

8. Charge controllers and associated devices must be able to withstand shocks and vibrations due to shipping and transport.

9. Charge controllers and associated devices must be clearly labelled with the minimum information:
a) Manufacturer name and model
b) Serial number
c) Voltage and current ratings for device
d) PV, battery and load connection points and polarity

10. Complete documentation for each charge controller must be included in the service technician’s training manual and should include:
a) Installation instructions
b) Operating instructions
c) Technical specifications and ratings
d) Safety warnings
e) Troubleshooting instructions
f) Information pertaining to serviceable parts
g) Warranty

5.3.3 PV Controller

1. Manufacturer Name and Model .....
2. Voltage and Current Ratings ..... V/_A
3. Design Life.....
4. Maximum Current Draw w/o Load .....A
5. Voltage Drop Across Controller When Charging (PV to Battery Terminals) or Discharging (battery to load terminals).....
6. Set Points ..... _Disconn./Reconn.(HVD), _Disconn./Reconn. (LVD)
7. State-of-Charge Indicator .....LED/Analog/LCD/Other
8. Boost Charging ? ..... Yes/No
9. Temperature Compensation ..... Yes/No
10. Open Circuit Protection..... Yes/No
11. Short Circuit Protection..... Yes/No
12. Reverse Polarity Protection ..... Yes/No
13. Battery Night-time Discharge Protection..... Yes/No
14. Lightning Protection ..... Yes/No
15. Shocks/vibration Protection ..... Yes/No
16. Charge Controller Label..... Yes/No
17. Documentation..... Yes/No
18. Certification Issued By ..... Yes/No
19. (Attach copy of certificate)

CHINA RENEWABLE ENERGY DEVELOPMENT PROJECT
PHOTOVOLTAIC MARKET DEVELOPMENT COMPONENT

CHARGE CONTROLLER

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 Utility 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 charge controllers for stand-alone PV systems with PV array size of 500 peak Watts (WP).

Test Procedure for Certification of Charge Controllers 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 PV charge controllers used in solar home systems. It covers the charge controllers 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 referenced document "Solar Photovoltaic Systems and Photovoltaic/Wind Hybrid Systems Specifications and Qualifying Requirements", December 7, 1998.

Table 1. Photovoltaic (PV) Charge Controller Test Items, Technical Requirements and Test Methods

No	Test Items	Technical Requirements	Test Methods
1 Appearance and Documentation	Appearance	No physical damage (including damages due to shipping and handling), carton damage, moisture penetration and loose components	Visually inspect the controller for any physical damage, including damage due to shipping and handling. Also check the controller for carton damage, moisture penetration and loose components
	Labels (Spec. 3.3.9)	Clear labels with the following information: 1. Manufacturer name and model, 2. Serial number, 3. Voltage and current ratings, 4. PV array, battery and load connection points and polarity.	Visually inspect the controller to verify that all the labels listed under technical requirements are included, also indicating the connection points and polarity of the PV array, battery and load.
	Documentation (Spec. 3.3.10)	The following documents 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, 7. Warranty	Check if all the documents listed under technical requirements are included with the charge controller.
2	Adjustment of Set Points (Spec. 3.3.4)	a) High voltage disconnect and reconnect voltages and low voltage disconnect and reconnect voltages should be pre-set at factory in accordance with battery characteristics. b) The battery may have different charging modes at different states of charge. c) Average ambient temperature of the location of battery's installation should be taken into account when choosing set points (Spec. 3.3.4).	a) Measure the voltage set points with a voltmeter to see if they have been pre-set to correct values. b) Check to see if the charge controller has different charge modes. c) Check if the charge controller has the temperature compensation option.
3	Array High Voltage Disconnect (HVD) and Reconnect (Spec. 3.3.4) a) on/off controller	Charge controller should have the capability to prevent battery over-charge (high voltage disconnect HVD) and reconnect with the battery is partially discharged. a) The recommended HVD and reconnect voltages for on/off type charge controllers are: Flooded Lead-Antimony Battery: HVD: 14.6-14.8V, Reconnect;>13.7V Flooded Lead-Calcium Battery: HVD: 14.4-15.5V, Reconnect;>13.6-14.5V Sealed Valve-Regulated Lead-Acid Battery: HVD: 14.2-14.4V, Reconnect;>13.6V (Note: Above set point values are for 12 volt nominal battery. Batteries with other nominal voltages will have set point values in same ratio).	a) HVD threshold for on/off type: Using the test set-up as shown in Fig. 1, adjust the voltage of the DC power supply to the battery nominal voltage (V-2) and increase it gradually. The HVD value is obtained on the DC power supply, when the charge controller switches off the connection between the PV input and batter input (or short circuits the PV array for a shunt type controller). Lower the voltage of the DC power supply, and the reconnect voltage is determined, when the controller causes the PV input to be reconnected to the battery.

	b) PWM controller	b) For a pulse width modulated (PWM) type charge controller, there is no specific reconnect voltage. The recommended HVD voltage for PWM charge controllers are: Flooded Lead-Antimony Battery: 14.4-14.6V Flooded Lead-Calcium Battery: 14.4-15.5V Sealed Valve-Regulated Lead-Acid Battery: 14.0-14.2V (Note: Above set point values are for 12 volt nominal battery. Batteries with other nominal voltages will have set point values in same ratio).	b) If a bipolar power supply or a battery simulator is not available, this test can be done by using a real battery as shown in Fig. 5. Adjust the output current of the DC power supply to the rated value (which should be operating in a current source mode). The battery voltage will increase due to charging by the current source and when it reaches near HVD point, the charging current starts to decrease. The HVD value is obtained, when the charging current indicated by the ammeter A drops to zero. Vary the output current of the power supply and repeat this test with charging currents ranging from 10% to 125% of the nominal charging currents. For all charging currents, the HVD values should be in the range specified in the technical requirements.
4	Load Low Voltage Disconnect (LVD) and Reconnect (Spec. 3.3.4)	When battery voltage drops during discharging to LVD point (1.8-1.9V/cell for lead acid battery) at the rated load current, the load should be disconnected from the battery. When the battery voltage increases during charging to the load reconnect value, the load should be reconnected automatically.	Using the test set-up as shown in Fig. 1., first adjust the DC power supply output voltage at the nominal voltage of the battery V2. Then adjust the output current of the charge controller to the rated value with the variable resistor (VR). Then, decrease the voltage of the DC power supply gradually till the controller switches off the load connection automatically, and the LVD value is obtained. Increase the voltage of the DC power supply until the battery is connected to the load again, and the load reconnect voltage is determined. Vary the load resistor VR and repeat this test for different load currents ranging from 10% to 125% of the rated load current. For all load currents, the LVD values should be in the range specified in the technical requirements.
5	Temperature Compensation * (Spec. 3.3.4, optional test)	If battery temperature compensation option is specified with the charge controller, it should be verified for its effect on the set points. The temperature coefficient value should be in the range of –3 to –7mV/°C/cell.	For this test, the temperature sensor can be placed in a controllable temperature chamber and the procedure described under item 3 and item 4 should be repeated. From the measurements at various chamber temperatures, a plot of HVD vs. temperature and LVD vs. temperature can be obtained. The temperature coefficient value should be in the range of –3 to –7mV/°C/cell.
6	Quiescent Current (Spec. 3.3.2)	Charge controller's self-consumption current should not exceed 1% of the rated charge current.	Using the test set-up as shown in Fig. 4, measure the current drawn by the charge controller, while both the PV input and load output are disconnected.
7	Voltage Drop (Spec. 3.3.3)	The voltage drop between the PV array and battery during charging, and the voltage drop between the battery and load during discharging, each should be within 5% of the nominal voltage of the charge controller.	a) Using the test set-up as shown in Fig. 2, adjust charging current to its maximum rated value, and measure the voltage drop V between the DC power supply and battery terminals. b) Using the test set-up as shown in Fig. 1, adjust the discharge current to its maximum rated value, and measure the voltage drop V1 under discharge condition between the battery input and controller output terminals (if the switching component is in negative circuit, the voltage drop should also be measured between the negative terminals).

8	Vibration Durability (Spec. 3.3.8)	No damage is caused by the vibrations, tested in the range of 10 to 55 Hz, 0.35mm, three-axis directions for 30 minutes.	Put the charge controller to vibrations of 10 to 55 Hz, 0.35mm, at three-axis directions for 30 minutes. Then, check the charge controller to verify that no mechanical damage or electrical malfunction has occurred.
9	Protection Functions (Spec. 3.3.5)	a) The charge controller must avoid any damage to itself and connected equipment in case of an accidental short circuit at its load terminals or an internal short circuit. b) The charge controller must avoid any reverse discharge from battery to PV array at night. c) The charge controller should have protection against connecting the battery in reverse polarity. d) The charge controller should have protection to avoid damage due to lightning in the area of excessive lightning*.	a) Using the test set-up as shown in Fig. 1, short the charge controller output terminals by reducing the variable resistor VR to zero (or remove the variable resistor and short the output terminals), and verify that no damage to the charge controller or power supply occurs. b) Using the test set-up as shown in Fig. 3, start with the maximum value of the variable resistor and the DC power supply adjusted to nominal battery input voltage. Then, gradually reduce the variable resistor to zero, and verify that there is no reverse current flow indicated by the ammeter A. c) Connect the charge controller battery input terminals to DC power supply in reverse polarity for one hour, and verify that the controller or the power source is not damaged. d) Visually check the type and ratings of the surge arrestors to ensure that they are capable of absorbing the expected surge energy due to lightning at the locations.
10	Over Voltage Protection (Spec. 3.3.6)	The charge controller should withstand over voltage up to 1.25 times the nominal open circuit voltage of PV array for at least one hour duration.	Using the test set-up as shown in Fig. 2, adjust the voltage of the DC power supply to 1.25 times the nominal PV array open circuit voltage and also adjust the variable resistor VR to obtain the rated charge current. Continue the operation in this mode for one hour and verify that no damage has occurred to the charge controller.
11	Over Current Protection (Spec. 3.3.7)	The charge controller should withstand over current up to 1.25 times the maximum rated charge current for at least one hour duration.	Using the test set-up as shown in Fig. 2, adjust the voltage of the DC power supply to the nominal PV array operating voltage and adjust the variable resistor VR to obtain 1.25 times the maximum rated charge current. Continue the operation in this mode for one hour and verify that no damage has occurred to the charge controller and no excessive heat is generated.

*Temperature Compensation and Lightning Protection are optional for temperature climate and low lightning areas, respectively.
Note: There are no tests for Spec. 3.3.1.

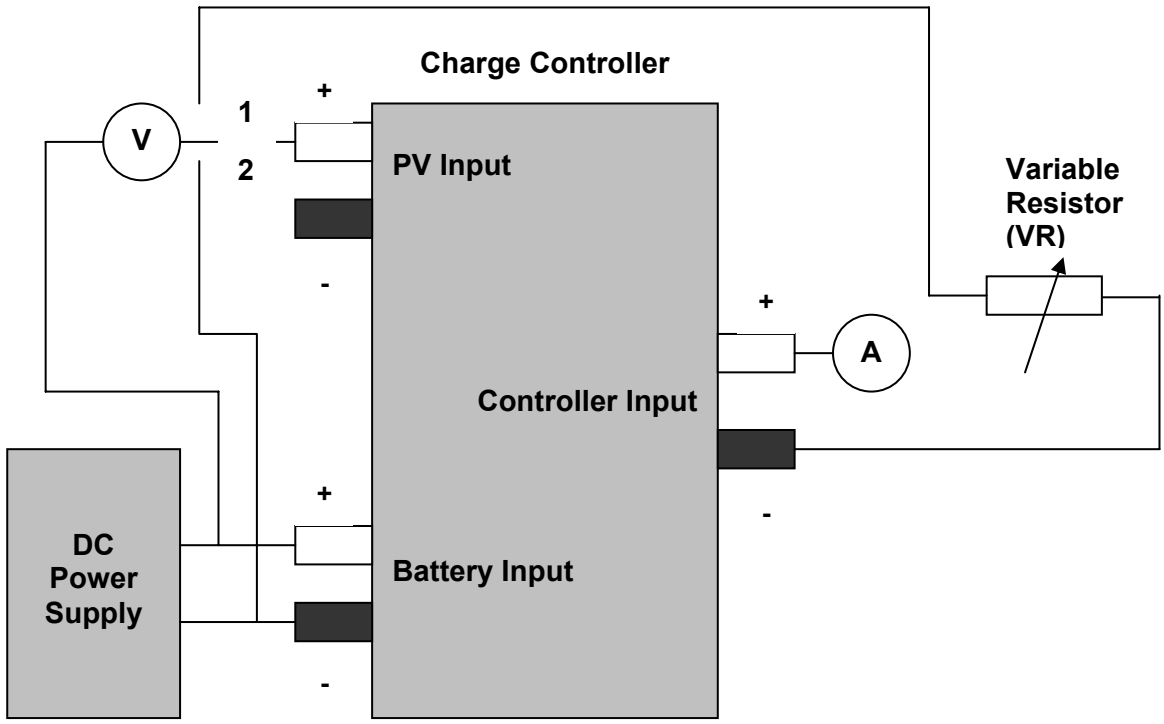

Fig. 1. Test for HVD (on/off controller) and LVD and Test for Voltage Drop When Discharging

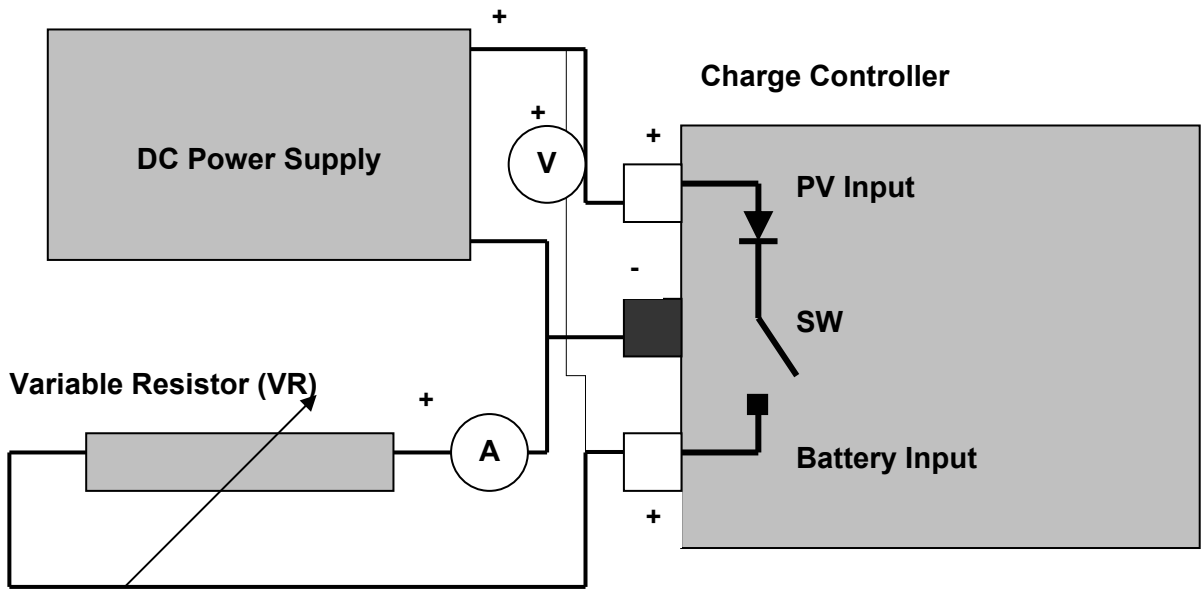

Fig. 2. Test for Voltage Drop When Charging and Tests for Over-Voltage and Over Current Protection

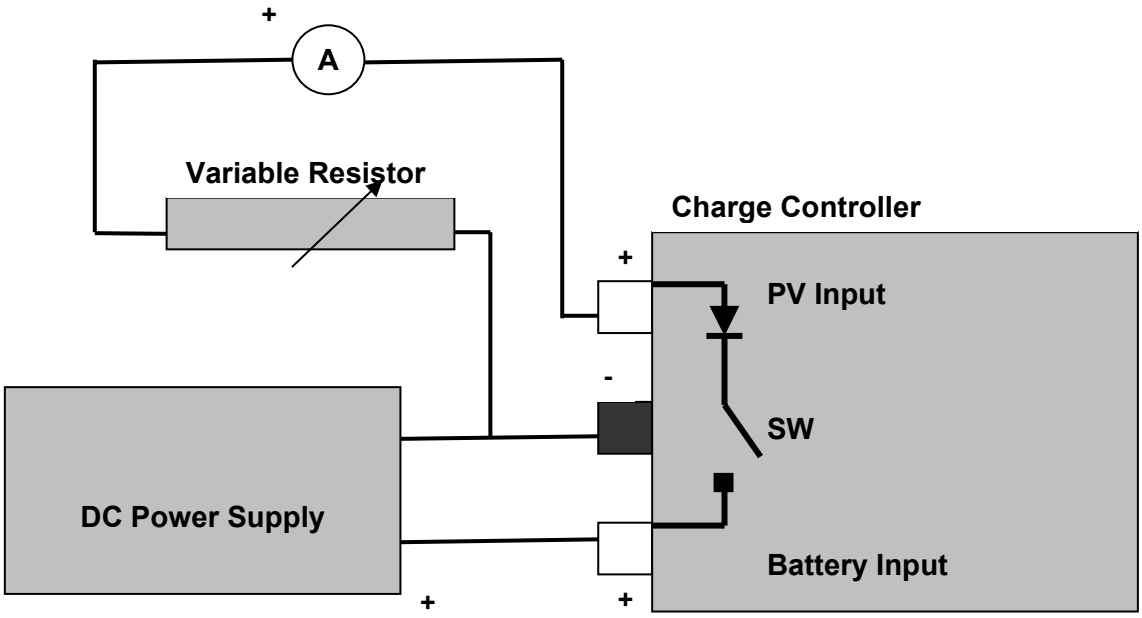

Fig. 3. Test for Reverse Discharge from Battery to PV

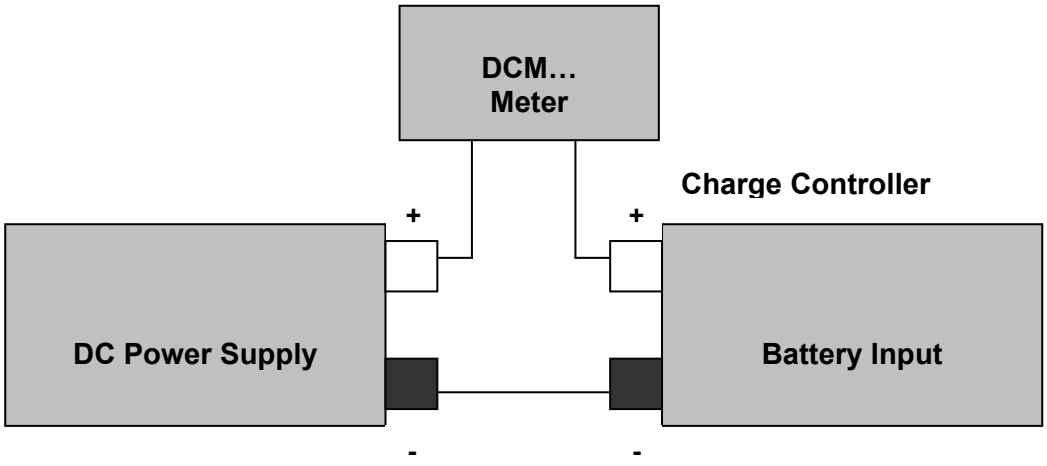

Fig. 4. Test for Quiescent Current (self consumption)

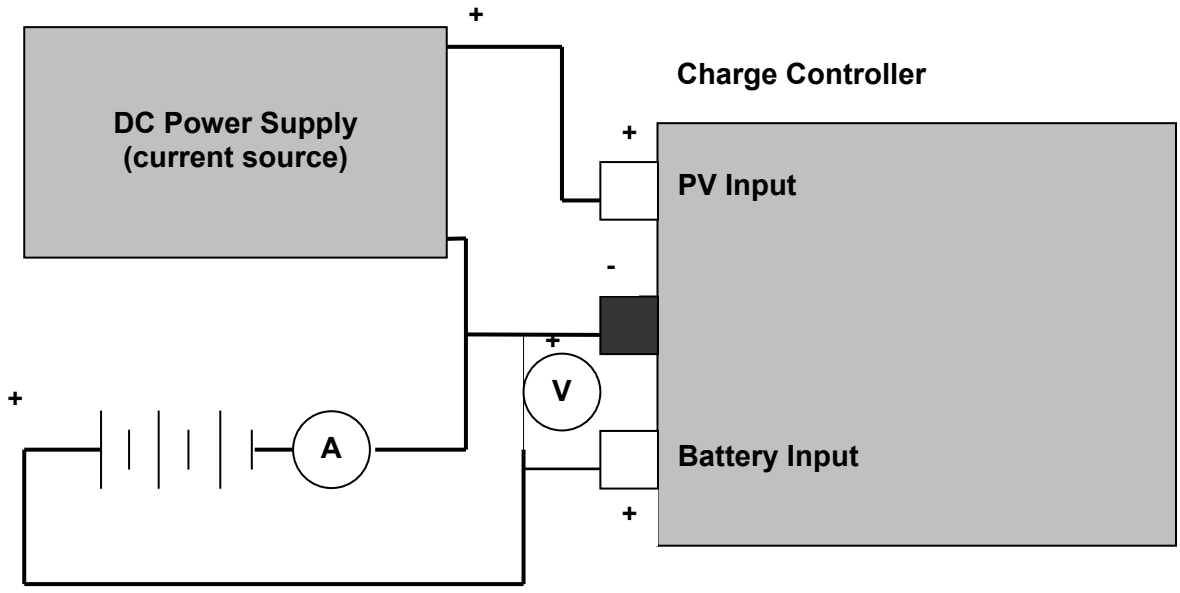

Fig. 5. Test for HVD for PWM Controller

4. Sampling Procedure and Plan

4.1 Sampling Procedure

4 1.1 The manufacturer will provide quantity of charge controllers 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 controllers. 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 charge controllers will be categorized according to their nominal input voltage.

4 2.2 The controller samples to be tested should be from the normal production in the hatch and the total controllers in the batch should not be less than 10 units.

4 2.3 For each charge controller 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 controllers being tested is divided into columns B and C

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

The level of controlled quality po for the column C failure of charge controller is 65%, the testing level is IV, 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 assured to have passed under the conditions that there is no failure in column B and three 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 four 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 assured not to have passed under the conditions that there still is failure in the repeat testing.

Table 2. PV Charge Controller Test Items and Quality Assurance

No	Test Item		Fault class	
			B	C
1	Appearance and Documentation	Appearance	O	
		Labels		O
		Documentation		O
2	Adjustment of Set Points		O	
3a	Array High Voltage Disconnect (HVD) and Reconnect: On/OFF Controller		O	
3b	Array High Voltage Disconnect (HVD) and Reconnect: PWM Controller		O	
4	Boost Charge Capability (optional test)			O
5	Temperature Compensation (optional test)			O
6	Load Low Voltage Disconnect (LVD) and Reconnect		O	
7	No-load Consumption (Quiescent current)		O	
8	Voltage Drop		O	
9	Vibration Durability		O	
10	Protection Capability	a) Protection against PV array, load and any internal short circuit	O	
		b) Protection to avoid reverse discharge from battery to PV array at night	O	
		c) Battery reverse polarity protection	O	
		d) Lightning/surge protection		O
11	Over Voltage Protection		O	
12	Over Current Protection		O	