

# SOLAR PV STANDARD ELECTRICAL PLAN

## Central Inverter Systems for Single Family Dwellings

**\*\*\* Provide this document to the inspector along with ALL system installation instructions \*\*\***

Project Address: \_\_\_\_\_

Permit Number: \_\_\_\_\_

**Scope:** Standard plan for installation of solar PV systems utilizing 2 wire multiple string central inverters, not exceeding a total AC output of 10kW, in single family dwellings having a 3 wire electrical service not larger than 225 amps at a voltage of 120/240. This plan covers Crystalline and Multi-Crystalline type modules where all the modules are mounted on the roof of the single family dwelling. For installations exceeding this scope, Electrical Plan review is required.

**NOTE:** This plan is intended for use with standard DC to AC inverters containing an isolation transformer. This plan is **NOT** intended to be used with micro inverters or transformer-less inverters and is limited to installations where the DC system voltage does not exceed 600 volts. This plan is not intended for systems containing batteries or power optimizer. This document addresses only the requirements of the 2010 California Electrical Code (CEC), refer to other toolkit documents for California Residential code (CRC) requirements.

**Installer information:**

Name: _____	Phone Number: (    )    -
Address: _____	Homeowner: <input type="checkbox"/>
City: _____	Contractor: <input type="checkbox"/>
State: _____ Zip _____	Contractor License # _____
	License type _____

**Required information for DC wiring:**

1. Total number of solar modules being installed: <input type="text"/>	2. Number of modules per string: <input type="text"/>
3. How many strings total? <input type="text"/>	4. Are any strings wired in parallel? <input type="checkbox"/> Yes <input type="checkbox"/> No
5. Are you installing a combiner box with fuses? <input type="checkbox"/> Yes <input type="checkbox"/> No  (If Yes, include calculation in Step # 13)	If "Yes", how many are paralleled together? <input type="checkbox"/> Two _____ <input type="checkbox"/> Other (specify) _____
6. Module Voc (from module nameplate): <input type="text"/>	7. Module Isc (from module nameplate): <input type="text"/>
8. Module maximum fuse or circuit breaker size (from module nameplate): <input type="text"/>	9. Temperature correction factor from <b>Table 690.7</b> of the 2010 CEC. Varies by location. (Check with the local building department for this figure) _____

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10. Calculate the maximum DC system voltage (Shall not exceed the inverter maximum DC input voltage and shall not exceed 600 volts):

**Maximum number of modules per string** \_\_\_\_\_ x **Voc** \_\_\_\_\_ x **temperature correction factor** \_\_\_\_\_ = \_\_\_\_\_ volts

**Note:** This formula is intended to provide a close approximation of the maximum DC system voltage possible at the job location under the lowest ambient temperature condition. This result will always be slightly higher than when using the module manufacturer supplied temperature coefficient. The intent is to alert the installer that the 600 volt limit is close to being exceeded and is not intended to provide as accurate a result as the calculation employing the manufacturer supplied coefficient. Where the installer chooses to use the manufacturer’s supplied coefficient, approval by the local enforcing agency is required.

11. Calculate the maximum DC current per string to allow for peak sunlight conditions and continuous operation in excess of three hours:

Module Isc \_\_\_\_\_ x 1.56 = \_\_\_\_\_ **Max amps carried by the conductor.**

12. **Choosing a conductor size for the DC source circuits & output circuit:**

Where Type USE-2 or other listed PV conductors are run in free air from the module locations to a junction box or combiner box, the minimum size permitted shall be #12 AWG per the module manufacturers’ installation instructions and the conductor material shall be copper.

If any part of the wiring from the modules to the combiner box or inverter is to be installed in a raceway, reductions in the amount of current the conductors can carry may have to be made. Conductors to be installed in a raceway shall be Type THWN-2 or equivalent and the conductor material shall be copper.

To select the correct conductor size for the PV source circuits from the modules to the combiner box or to the inverter, go to Table A on page 4. Select how many conductors you will have in the raceway and how high above the roof surface the raceway will be mounted. Using the appropriate “Ambient Temperature” section for the job location, select the number from the column in Table A that matches the result you entered in item #11. (The number in Table A may be the same or larger than the number in item #11, **but it shall not be less**). Move to the top of the column to see the minimum size conductor needed for this part of the installation. Enter the number here for the **Source Circuit conductor size: # \_\_\_\_\_ AWG.**

Note: Per Section 338.12(B)(1), USE-2 shall not be used for interior wiring.

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13. If a combiner box is to be installed to connect the string circuits together, then the size of the "Output circuit" conductors from the combiner to the inverter must be determined.  
To do this, multiply the number of strings that are to be combined (from item #3) with the "Max amps" (from item #11) \_\_\_\_\_ x \_\_\_\_\_ = \_\_\_\_\_ Amps. Using Table A, repeat the process used to select the conductor size for the source circuits and enter the number here for **Output Circuit conductor size: # \_\_\_\_\_ AWG.** (If no combiner box, enter N/A)

14. Where a combiner box is installed, or where more than two strings of modules are electrically connected together in "parallel", each individual string shall be protected by its own over current protection or feeders to be sized for sum of all short circuit current of all strings. The fuse or breaker shall be listed as being suitable for use in a DC circuit and shall meet or exceed the maximum voltage of the circuit. The rating of the fuse or circuit breaker shall not be larger than the maximum size specified on the lowest rated module in the string. All combiner boxes shall be listed by a recognized listing agency and labeled as such.  
**Max fuse / breaker size permitted (from step #8) \_\_\_\_\_ A. Fuse / breaker size installed \_\_\_\_\_ A.**

**Note:** Where the module specifies "Max fuse size" a circuit breaker shall not be substituted. Where the module specifies "Max overcurrent protective device" (Max OCPD), then either a fuse or DC rated circuit breaker may be used.

**NOTE:** Per **Section 690.31 (E)**, DC wiring can only be run inside of the house if it is installed in a listed **metallic raceway or enclosure**.

SAMPLE

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**Table A**

Table A is based on the following:

- A. Table 310.16 - Allowable Ampacity of Insulated Conductors, 90 C rated conductors.
- B. Table 310.16 - Correction Factors based on temperature ranges.
- C. Table 310.15(B)(2)(c) - Ambient Temperature Adjustments for Conduits Exposed to Sunlight On or Above Rooftops.
- D. Table 310.15(B)(2)(a) Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable.
- E. Sections 240.4(D)(5) and 240.4(D)(7) for 10 AWG and 12 AWG conductors

**Table A: Maximum Allowable Ampacity of Conductors Installed in a Circular Raceway, Exposed to Sunlight, On or Above Rooftops**

Number of Current Carrying Conductors in a Raceway	Height Above Rooftop	Highest Ambient Temp									
		Less than 30°C					30°C to 35°C				
		12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG
Up to 3 Conductors	0 to 0.5"	17	23	32	44	55	17	23	32	44	55
	above 0.5" to 3.5"	20	30	42	57	72	20	28	39	53	67
	above 3.5" to 12"	20	30	45	62	78	20	30	42	57	72
	above 12"	20	30	48	65	83	20	30	45	62	78
4 to 6 Conductors	0 to 0.5"	14	19	26	35	44	14	19	26	35	44
	above 0.5" to 3.5"	18	24	33	46	58	17	23	31	43	54
	above 3.5" to 12"	20	26	36	49	62	18	24	33	46	58
	above 12"	20	28	38	52	66	20	26	36	49	62
7 to 9 Conductors	0 to 0.5"	12	16	22	30	39	12	16	22	30	39
	above 0.5" to 3.5"	16	21	29	40	51	15	20	27	37	47
	above 3.5" to 12"	17	23	32	43	55	16	21	29	40	51
	above 12"	18	24	33	46	58	17	23	32	43	55
10 to 20 Conductors	0 to 0.5"	9	12	16	22	28	9	12	16	22	28
	above 0.5" to 3.5"	11	15	21	29	36	11	14	20	27	34
	above 3.5" to 12"	12	16	23	31	39	11	15	21	29	36
	above 12"	13	17	24	33	41	12	16	23	31	39
Up to 3 Conductors	0 to 0.5"	35°C to 40°C					40°C to 45°C				
	above 0.5" to 3.5"	12	16	23	31	39	12	16	23	31	39
	above 3.5" to 12"	17	23	32	44	55	17	23	32	44	55
	above 12"	20	28	39	53	67	20	28	39	53	67
4 to 6 Conductors	0 to 0.5"	10	13	18	25	31	10	13	18	25	31
	above 0.5" to 3.5"	14	19	26	35	44	14	19	26	35	44
	above 3.5" to 12"	17	23	31	43	54	14	19	26	35	44
	above 12"	18	24	33	46	58	17	23	31	43	54
7 to 9 Conductors	0 to 0.5"	9	11	16	22	27	9	11	16	22	27
	above 0.5" to 3.5"	12	16	22	30	39	12	16	22	30	39
	above 3.5" to 12"	15	20	27	37	47	12	16	22	30	39
	above 12"	16	21	29	40	51	15	20	27	37	47
10 to 20 Conductors	0 to 0.5"	6	8	11	15	19	6	8	11	15	19
	above 0.5" to 3.5"	9	12	16	22	28	9	12	16	22	28
	above 3.5" to 12"	11	14	20	27	34	9	12	16	22	28
	above 12"	11	15	21	29	36	11	14	20	27	34
Up to 3 Conductors	0 to 0.5"	45°C to 50°C					50°C to 55°C				
	above 0.5" to 3.5"	0	0	0	0	0	0	0	0	0	0
	above 3.5" to 12"	12	16	23	31	39	12	16	23	31	39
	above 12"	17	23	32	44	55	17	23	32	44	55
4 to 6 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	10	13	18	25	31	10	13	18	25	31
	above 3.5" to 12"	14	19	26	35	44	10	13	18	25	31
	above 12"	14	19	26	35	44	14	19	26	35	44
7 to 9 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	9	11	16	22	27	9	11	16	22	27
	above 3.5" to 12"	12	16	22	30	39	9	11	16	22	27
	above 12"	12	16	22	30	39	12	16	22	30	39
10 to 20 Conductors	0 to 0.5"	0	0	0	0	0	0	0	0	0	0
	above 0.5" to 3.5"	6	8	11	15	19	6	8	11	15	19
	above 3.5" to 12"	9	12	16	22	28	6	8	11	15	19
	above 12"	9	12	16	22	28	9	12	16	22	28

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**Grounding the DC side of the inverter:**

A minimum #8 copper Grounding Electrode conductor must be run un-spliced from the factory identified system grounding terminal of the inverter to the grounding electrode system of the house. The grounding electrode system may consist of one or more of the following: Ground rod(s), Ufer ground, or metallic water pipe with a minimum of 10 feet in the ground. (**Section 690.47**)

**AC wiring information:**

15. The inverter shall be listed and labeled by a recognized testing agency and be identified as "Utility interactive". Ground fault protection (GFP) shall comply with **Section 690.5** 2010 CEC.

**Specify inverter: Make \_\_\_\_\_ Model # \_\_\_\_\_ Elec rating \_\_\_\_\_ kW**

16. Per **Section 690.9** 2010 CEC, each inverter shall be protected by an overcurrent device on the AC output side of the inverter. This can be a fuse or a circuit breaker. To correctly size the overcurrent device, locate the maximum AC output of the inverter (in amps) on the inverter nameplate, and multiply by 1.25 (This is required because the unit will be in continuous use for more than three hours).

**Maximum AC output current \_\_\_\_\_ x 1.25 = \_\_\_\_\_ Amps.** (This number will also be used to size the inverter output circuit conductors.)

Where the "Maximum AC output" is shown only in Watts, divide that number by 240 and then multiply by 1.25 to get the correct size breaker or fuse.

If the maximum AC output is between standard breaker or fuse sizes, the next higher size can be used so long as the inverter output conductors are sized sufficiently large enough for the amount of current produced by the inverter.

**Important note:** Where a fused disconnect switch is installed, the output conductors from the inverter will connect to the "**LOAD**" side (**bottom**) terminals of the switch and the wiring from the utility will connect to the "**LINE**" side (**top**) terminals. This meets the requirement of **Section 404.6(C)** and will reduce the risk of electrical shock hazards when changing a fuse with the system still energized by the utility electrical supply.

17. Many utility providers require a performance meter and a safety disconnect switch to be installed between the PV power source and their equipment. This means that the AC power output from the inverter(s) may not connect directly into the electrical panel of the house. For a single inverter, the output from the inverter disconnect switch will connect to the performance meter (if required). Where multiple central inverters are installed, they will usually go first to a solar load center. This is just a standard circuit breaker panel that collects together the output circuits from the individual inverters. Each inverter will have its own circuit breaker. The size of each circuit breaker will be determined from step #16. From this panel one feeder will go to the performance meter, then to the safety disconnect switch and lastly to the point of interconnection at the house electrical panel. No electrical loads shall be connected between the output of the inverter and the connection to the house electrical panel. Contact your local utilities for performance meter and AC utility disconnect switch requirements.

18. Where a performance meter is required by the local utility to record the power produced by the PV system, the output wiring from the inverter shall always connect to the "**LINE**" side terminals of the meter.

19. Where disconnect switches (with or without fuses) are installed in the circuit from the inverter output terminals to the house electrical panel, the wiring originating at the inverter(s) shall always connect to the "**LOAD**" side terminals of **ANY** disconnect that has been installed

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20. The connection to the breaker panel **shall** be through a dedicated circuit breaker that connects to the panel bus bars in an approved manner. "Load Side Taps" where the inverter AC wiring does not terminate using a dedicated breaker or set of fuses are prohibited under **ANY** condition by **Section 690.64 (B)**.
21. Per Section 690.64(B)(2), the sum of all overcurrent protective devices supplying power to the busbar or conductor shall not exceed 120% of their rating. In most PV installations, the breakers feeding the busbar are the main breaker and the backfed PV breaker. Per Section 690.64(B)(7), to utilize the 120% rule, the PV backfed breaker must be at the opposite end of the main breaker location. For a 100 amp rated bus, this means that the main breaker and the PV backfed breaker shall not add up to more than 120 amps. For a 200 amp rated bus, the combined ampacity of the two breakers (the main breaker and the PV breaker) shall not exceed 240 amps and so on. The location of the PV backfed breaker must be identified per 690.64(B)(7) with the following verbiage: "WARNING INVERTER OUTPUT CONNECTION. DO NOT RELOCATE THE OVERCURRENT DEVICE."

**Where it is not possible to locate the breakers at opposite ends of the panel bus, the sum of the two breakers is not permitted to exceed 100% of the bus rating.**

**Note:** In some cases it may be possible to reduce the size of the main circuit breaker to accommodate the addition of a PV breaker and still not exceed the bus bar rating. This requires that a "load calculation" of the house electrical power consumption be made in order to see if this is an acceptable solution.

22. Per **Section 690.53**, a permanent label for the DC power source shall be installed at the PV DC disconnecting means. This label shall show the following: (a) Rated maximum power-point current, (b) Rated maximum power-point voltage, (c) Maximum system voltage, (d) Short circuit current of the PV system.

(a) **Rated maximum power-point current (mppA)** (this is the actual current in amps produced by the PV system).  
Multiply the **Imax** value from the module nameplate by the number of strings in the system.

$$\mathbf{I_{max}} \text{ \_\_\_\_\_\_ } \times \mathbf{\# \text{ of strings }} \text{ \_\_\_\_\_\_ } = \text{ \_\_\_\_\_\_ } \mathbf{Amps.}$$

(b) **Rated maximum power-point voltage (mppV)** (this is the highest operating voltage of the PV system).  
Multiply the **Vmax** value from the module nameplate by the number of modules in the **largest** string.

$$\mathbf{V_{max}} \text{ \_\_\_\_\_\_ } \times \mathbf{\# \text{ of modules }} \text{ \_\_\_\_\_\_ } = \text{ \_\_\_\_\_\_ } \mathbf{Volts.}$$

(c) **Maximum system voltage** (see step #10)  $\text{ \_\_\_\_\_\_ } \mathbf{Volts}$

(d) **Short circuit current** of the PV system (module Isc from step #7 x 1.25).  $\mathbf{I_{sc}} \text{ \_\_\_\_\_\_ } \times \mathbf{1.25} = \text{ \_\_\_\_\_\_ } \mathbf{Amps.}$

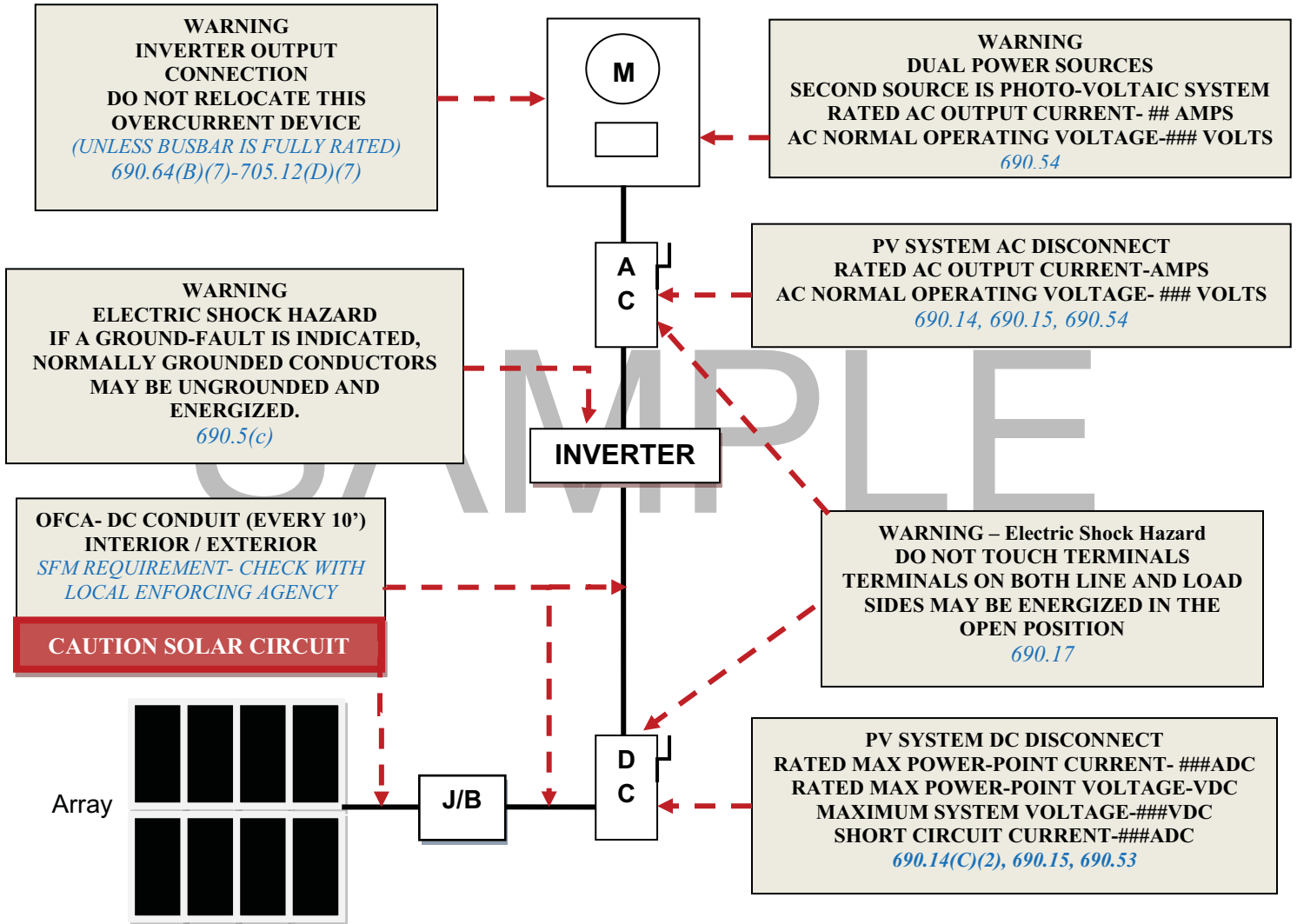
**Note:** A phenolic plaque with contrasting colors between the text and background would meet the intent of the code for permanency. No type size is specified, but 20 point (3/8") should be considered the minimum.

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23. The following signage is required to be installed:

- (a) Per **Section 690.17** 2010 CEC, where both the line and load side terminals of any disconnect may be live in the "OFF" position the following warning shall be placed on the front of the disconnect "WARNING LINE AND LOAD TERMINALS MAY BE ENERGIZED IN THE OPEN POSITION".



**Note:** Italicized text shown inside the boxes is not required to be part of the sign, it is only for reference.

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TAG	DESCRIPTION
1	SOLAR PV MODULE
2	DC PV SOURCE CIRCUIT
3	COMBINER BOX (if installed), refer to item 14 on page 3
4	DC PV OUTPUT CIRCUIT
5	DC EQUIPMENT GROUNDING CONDUCTOR per 690.43 NEC
6	INVERTER DC DISCONNECT
7	DC TO AC INVERTER WITH ISOLATION TRANSFORMER
8	GROUND FAULT DETECTION INTERRUPTER
9	AC DISCONNECT
10	SOLAR LOAD CENTER (if installed)
11	UTILITY PERFORMANCE METER (if installed)
12	UTILITY SAFETY SWITCH (if installed)
13	INVERTER DC GROUNDING ELECTRODE CONDUCTOR (MIN #8 AWG COPPER)
14	ELECTRICAL SERVICE PANEL

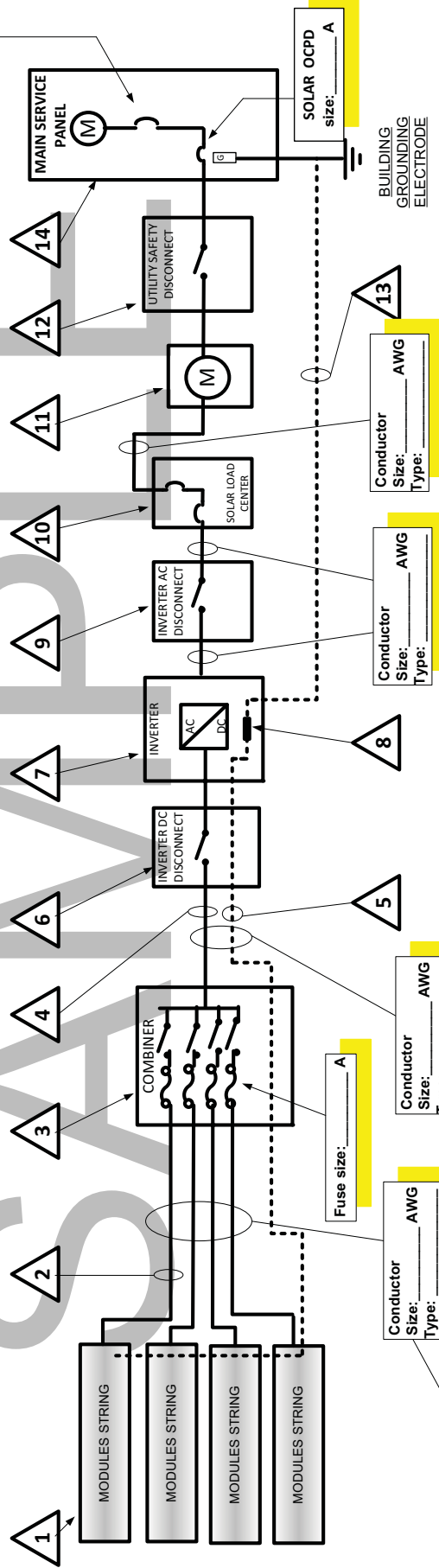
STANDARD PV PLAN FOR SINGLE FAMILY DWELLING  
CENTRAL INVERTER

MAXIMUM 10 KW  
MAXIMUM 225 AMP SERVICE

THIS PLAN MUST BE PROVIDED TO THE FIELD INSPECTOR

MAIN BREAKER / FUSE Size: \_\_\_\_\_ A  
SOLAR BREAKER/ FUSE Size: \_\_\_\_\_ A  
MAIN PANEL BUS Size: \_\_\_\_\_ A

MAIN OVERCURRENT  
PROTECTIVE DEVICE  
size: \_\_\_\_\_ A



Note: This plan is **Not** intended to be used with micro inverters or transformer-less inverters. Permitted DC conductor types are USE-2, PV Wire or equivalent listed cables. Conductors for DC and AC circuits, where installed in raceways outdoors, shall be "W" rated and have an insulation rating of 90 degrees Centigrade.

**Provide required information in these boxes**

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	<p><b>ROOF PLAN</b></p> <p>PROVIDE A ROOF PLAN SHOWING LOCATION OF ALL EQUIPMENT, DISCONNECTING MEANS AND REQUIRED CLEARANCES.</p>
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Project Address: \_\_\_\_\_

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**LISTING REPORT - MANUFACTURING**

Issued: Jan 7 2013 5:23PM

Inspection Tests And Evaluation Of

**Xandex Inc. SunMizer Solar Roofing System (SM-SRS) (29100)**

RENDERED TO  
**Xandex, Inc. - PENDING CERTIFICATION**  
**1360 Redwood Way**  
**Suite A**  
**Petaluma, CA 94954**

**GENERAL:** This Report gives the results of the inspection, tests and evaluation of the above for compliance with applicable requirements of the following standards : UL 790 (2004) : ASTM E108 (2010a)

This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to permit copying or distribution of this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program.

## Correlation for Multiple Listees

This information is only available to the applicant.

SAMPLE

## PRODUCT DESCRIPTION

### Product Covered:

Xandex Inc. SunMizer Solar Roofing System (SM-SRS)

### Product Description:

#### Xandex Inc. SunMizer Solar Roofing System (SM-SRS)

The SunMizer Solar Roofing System (SM-SRS) has been qualified to provide compliance to ASTM E108 (2010) and UL 790 (2004) for a Class A fire rating of a solar PV module array on fire rated roofs which incorporate listed and labeled fire rated three-tab or architectural asphalt roofing shingles.

Please see below for additional restrictions and limitations.

#### Class A Combustible Deck

##### Unlimited Slope

**Note:** Component materials must be applied in the order in which they are listed below:

Deck –Plywood\*

Minimum (1) Ply Grace Ice & Water Shield Underlayment

Minimum (2) Plies Elk Versashield

Minimum 24 Gauge Standing Seam Steel Roof Pans

Extruded Aluminum Cross Braces with Minimum 18 Gauge Steel Support Channels

PV Module (Options Listed Below, Manufacturer / Model):

- Hyundai HiS-M235MG

**Note:** The minimum setback from the edge of the roof shall be 24", and the system shall be installed in conjunction with listed and labeled fire rated three-tab or architectural asphalt roofing shingles. The metal roof pans shall overlap the roofing shingles by a minimum of 10".

\*Each system listing identifies the deck substrate as either non-combustible or combustible. Systems evaluated for combustible decks will provide the same ratings when applied over non-combustible decks. Unless otherwise noted in individual listings, combustible decks shall be sheathed with a minimum 15/32" veneer A-C plywood or minimum 7/16" non-veneer APA rated sheathing panel (oriented strand board panels, structural particleboard panels, composite panels or wafer-board panels) or 3/4" thick solid wood sheathing boards. The component materials of each system must be applied in the order in which they are listed. All components of the system must be listed for external fire exposure by an agency acceptable to the AHJ.

Some Roof Covering Systems have been evaluated for other performance characteristics, in addition to external fire exposure. Where applicable, such additional performance characteristics are noted within the specific listing.

In all cases, manufacturer's instructions should be consulted for installation procedures and details not covered by these listings.

Listed Materials are identified by a label or marking bearing the wording, "Listed Roofing Component", a reference number or code and the WHI Certification Mark.

<u>Attribute</u>	<u>Value</u>
CSI Code	07 41 63 Fabricated Roof Panel Assemblies
Roofing: Deck Type	Combustible
Roofing: Fire Rating	Class A
Roofing: Maximum Slope	Unlimited
Listed or Inspected	LISTED
Report Number	100761143MID-002
Criteria	UL 790 (2004)
Criteria	ASTM E108 (2010a)
Intertek Services	Certification
Listing Section	ROOF COVERING SYSTEMS
Test Original Issue Date	June 22, 2012

SAMPLE

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REVISIONS					
REV	DESCRIPTION	CHANGE NUMBER	BY	DATE	APPROVED
A	INITIAL RELEASE, NO CHANGES FROM REVISION 2, TWR CHANGED TO 0496 (WAS 0495)	0496	MRW	10/05/12	



**SEE SUPPLIER/MANUFACTURER PRODUCT SPECIFICATIONS IN THE FOLLOWING DOCUMENT(S)**

SHEETS 2-3 OF 3

**MANUFACTURER:**

HYUNDAI HEAVY INDUSTRIES CO., LTD. SOLAR  
 HYUNDAI BUILDING, 75, YULGOK-RO  
 JONGNO-GU, SEOUL, 110-793, KOREA  
 PHONE: +82-2-746-8406  
 FAX:  
 EMAIL: [hyundaisolar@hhi.co.kr](mailto:hyundaisolar@hhi.co.kr)  
 WEB: [www.hyundaisolar.com](http://www.hyundaisolar.com)

**MANUFACTURER PART No:**  
 HIS-M235MG (BK)

SOURCE CONTROL:

ALTERNATE MANUFACTURER IS NOT ALLOWED

# SPECIFICATION CONTROL DRAWING

APPROVALS		DATE	INTERPRET DRAWING PER ASME Y14.5M-1994		1360 REDWOOD WAY, SUITE A PETALUMA, CA 94954 (707) 763-7799			
DRAWN	MRW	8/23/2012						
CHECKED		10/5/12	TOLERANCES	TITLE <b>PV MODULE 235W 6 IN SQ POLYCRYSTALLINE</b>				
ENGRG	R. GLAZIER	8/23/2012	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES					
NEXT ASSEMBLIES.....USED ON			DECIMALS	DO NOT SCALE DRAWING				
			1 PL ±.1      FRACTIONS ±					
			2 PL ±.01      ANGLES ± 1°	SIZE	SCALE	SHEET	DRAWING NUMBER	REV
			3 PL ±.005	<b>A</b>	<b>1:24</b>	<b>1 OF 3</b>	<b>159-2020</b>	<b>A</b>
			4 PL ±					
THIRD ANGLE PROJECTION			✓ ALL SURFACES					

# Hyundai Solar Module Black-Black | MG-Series |



- **Multi-crystalline Type**  
 HiS-M225MG(BK) | HiS-M230MG(BK)  
 HiS-M235MG(BK) | HiS-M240MG(BK)
- **Mono-crystalline Type**  
 HiS-S240MG(BK) | HiS-S245MG(BK)

## Mechanical Characteristics

Dimensions	983 mm (38.7") (W) × 1645 mm (64.76") (L) × 35 mm (1.38") (H)
Weight	Approx. 19.0 kg (41.9 lbs)
Solar cells	60 cells in series (6 × 10 matrix)
Output cables	4 mm <sup>2</sup> (12AWG) cables with polarized weatherproof connectors, IEC certified (UL listed), Length 1.0 m (39.4")
Junction box	IP65, weatherproof, IEC certified (UL listed)
Bypass diodes	3 bypass diodes to prevent power decrease by partial shade
Construction	Front : High transmission low-iron tempered glass, 3.2 mm (0.126") Encapsulant : EVA      Back Sheet : Weatherproof film (Black)
Frame	Clear anodized aluminum alloy type 6063 (Black)

## High Quality

- IEC 61215 (Ed.2) and IEC 61730 by TÜV Rheinland
- UL listed (UL 1703), Class C Fire Rating
- Output power tolerance +3/-0%
- ISO 9001:2000 and ISO 14001:2004 Certified
- Advanced Mechanical Test (5,400 Pa) Passed (IEC)
- Mechanical Load Test (40 lbs/ft<sup>2</sup>) Passed (UL)

## Fast and Inexpensive Mounting

- Delivered ready for connection
- Pre-confectioned cables
- IEC (UL) certified and weatherproof connectors
- Integrated bypass diodes

## Limited Warranty

- 10 years for product defect
- 10 years for 90% of warranted min. power
- 25 years for 80% of warranted min. power

### ※ Important Notice on Warranty

The warranties apply only to the PV modules with Hyundai Heavy Industries Co., Ltd.'s logo (shown below) and product serial number on it.



# Electrical Characteristics

## I Multi-crystalline Type I

		HiS-M□□MG			
		225	230	235	240
Nominal output (Pmpp)	W	225	230	235	240
Voltage at Pmax (Vmpp)	V	30.1	30.2	30.4	30.7
Current at Pmax (Impp)	A	7.5	7.7	7.8	7.9
Open circuit voltage (Voc)	V	36.8	37.1	37.3	37.5
Short circuit current (Isc)	A	8.0	8.1	8.2	8.3
Output tolerance	%	+3/-0			
No. of cells & connections	pcs	60 in series			
Cell type	-	6" Multi-crystalline silicon			
Module efficiency	%	13.9	14.2	14.5	14.8
Temperature coefficient of Pmpp	%/K	-0.43	-0.43	-0.43	-0.43
Temperature coefficient of Voc	%/K	-0.32	-0.32	-0.32	-0.32
Temperature coefficient of Isc	%/K	0.056	0.056	0.056	0.056

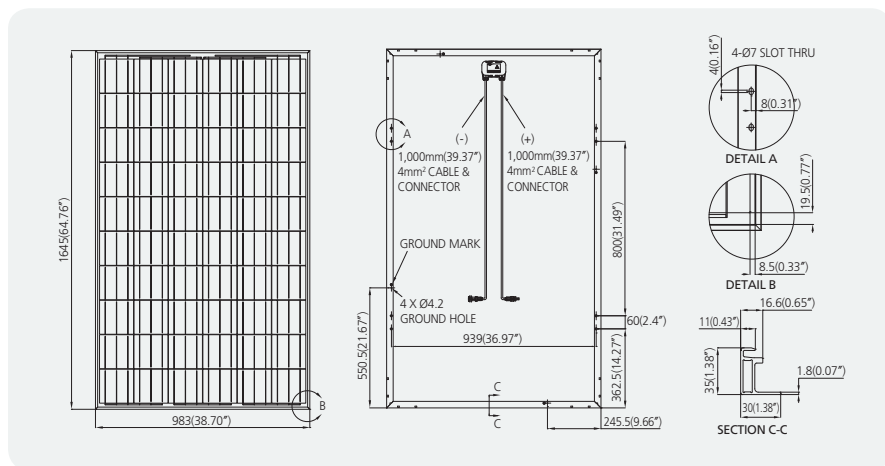
※ All data at STC (Standard Test Conditions). Above data may be changed without prior notice.

## I Mono-crystalline Type I

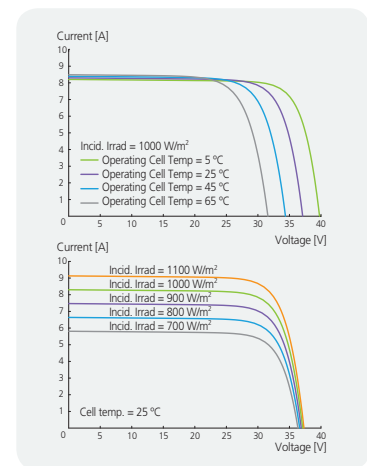
		HiS-S□□MG	
		240	245
Nominal output (Pmpp)	W	240	245
Voltage at Pmax (Vmpp)	V	30.9	31.1
Current at Pmax (Impp)	A	7.8	7.9
Open circuit voltage (Voc)	V	37.4	37.5
Short circuit current (Isc)	A	8.3	8.5
Output tolerance	%	+3/-0	
No. of cells & connections	pcs	60 in series	
Cell type	-	6" Mono-crystalline silicon	
Module efficiency	%	14.8	15.2
Temperature coefficient of Pmpp	%/K	-0.44	-0.44
Temperature coefficient of Voc	%/K	-0.34	-0.34
Temperature coefficient of Isc	%/K	0.052	0.052

※ All data at STC (Standard Test Conditions). Above data may be changed without prior notice.

## I Module Diagram



## I I-V Curves I



## I Installation Safety Guide

Only qualified personnel should install or perform maintenance.  
 Be aware of dangerous high DC voltage.  
 Do not damage or scratch the rear surface of the module.  
 Do not handle or install modules when they are wet.

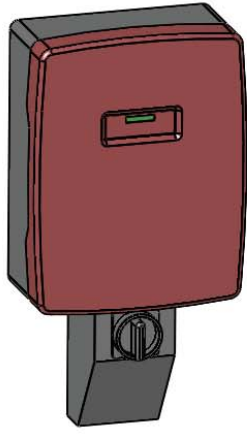
Nominal Operating Cell Temperature	46 °C ± 2
Operating Temperature	-40 - 85 °C
Maximum System Voltage	DC 1,000 V (IEC) DC 600 V (UL)
Maximum Reverse Current	15 A





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REVISIONS					
REV	DESCRIPTION	CHANGE NUMBER	BY	DATE	APPROVED
B	REVISE TABLE AND DESCRIPTION (REMOVED RS485)	4106	MRW	01/15/13	



**SEE SUPPLIER/MANUFACTURER PRODUCT SPECIFICATIONS IN THE FOLLOWING DOCUMENT(S)**

SHEETS 2-5 OF 5

**MANUFACTURER:**

SMA AMERICA, LLC  
 6020 WEST OAKS BLVD, STE 300  
 ROCKLIN, CA 95765 U.S.A.  
 PHONE: (916) 625-0870  
 FAX: (916) 625-0871  
 EMAIL:  
 WEB: www.sma-america.com



**DESCRIPTION:**

SUNNY BOY INVERTER  
 240 VOLTS  
 NEGATIVE GROUND  
 DC DISCONNECT  
 STANDARD WARRANTY

**MANUFACTURER PART No:**

**SEE TABLE**

**SOURCE CONTROL:**

ALTERNATE MANUFACTURER IS NOT ALLOWED



PART NUMBER	MODEL	MANUFACTURER P/N	REV
159-2021-01	SUNNY BOY 3000-US	SB 3000US	B
159-2021-02	SUNNY BOY 3800-US	SB 3800-US-10	B
159-2021-03	SUNNY BOY 4000-US	SB 4000US	B
159-2021-04	SUNNY BOY 5000-US	SB 5000US	B
159-2021-05	SUNNY BOY 6000-US	SB 6000US	B
159-2021-06	SUNNY BOY 7000-US	SB 7000US	B
159-2021-07	SUNNY BOY 8000-US	SB 8000US	B

# SPECIFICATION CONTROL DRAWING

APPROVALS	DATE
DRAWN MRW	10/25/2012
CHECKED	
ENGRG R.GLAZIER	10/25/2012
NEXT ASSEMBLIES.....USED ON	

INTERPRET DRAWING PER ASME Y14.5M-1994

**TOLERANCES**  
 UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

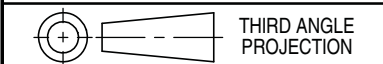
**DECIMALS**  
 1 PL ±.1      FRACTIONS ±  
 2 PL ±.01      ANGLES ± 1°  
 3 PL ±.005  
 4 PL ±

✓ ALL SURFACES

1125 N. McDOWELL BLVD.  
 PETALUMA, CA 94954  
 (707) 763-7799

TITLE  
**INVERTER, SUNNY BOY**

DO NOT SCALE DRAWING				
SIZE <b>A</b>	SCALE <b>1:16</b>	SHEET <b>1 OF 5</b>	DRAWING NUMBER <b>159-2021</b>	REV <b>B</b>







# SUNNY BOY 3000-US / 3800-US / 4000-US

SB 3000US / SB 3800-US-10 / SB 4000US



**SB 3800-US NOW AVAILABLE**



<p><b>UL Certified</b></p> <ul style="list-style-type: none"> <li>• For countries that require UL certification (UL 1741/IEEE 1547)</li> </ul>	<p><b>Efficient</b></p> <ul style="list-style-type: none"> <li>• 96.8% peak efficiency</li> <li>• OptiCool™ active temperature management system</li> </ul>	<p><b>Safe</b></p> <ul style="list-style-type: none"> <li>• Galvanic isolation</li> </ul>	<p><b>Simple</b></p> <ul style="list-style-type: none"> <li>• Patented automatic grid voltage detection*</li> <li>• Integrated DC disconnect switch</li> </ul>
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## SUNNY BOY 3000-US / 3800-US / 4000-US

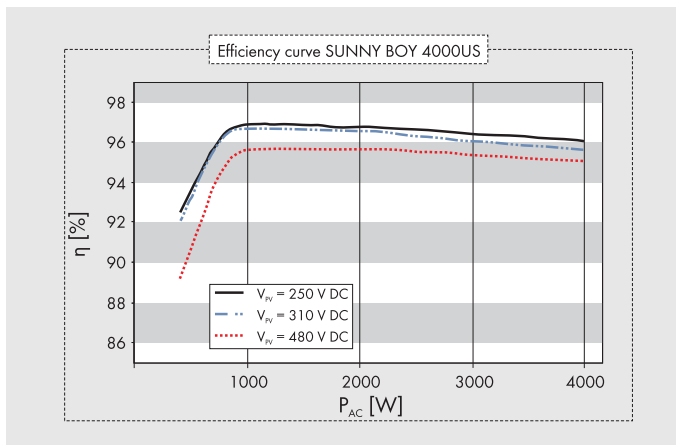
UL certified, reliable system managers

The Sunny Boy 3000-US, 3800-US and 4000-US inverters are specially designed for countries that require UL certification. Automatic grid voltage detection\* and an integrated DC disconnect switch simplifies installation, ensuring safety as well as saving time. These models feature galvanic isolation and can be used with all types of modules—crystalline as well as thin-film. The die-cast aluminum enclosure, with the OptiCool active temperature management system, guarantees the highest yields possible and a long service life, even under extreme conditions. The Sunny Boy 3800-US is designed for projects with a current limit of 16A.


\* US Patent US7352549B1

Technical data	Sunny Boy 3000-US		Sunny Boy 3800-US	Sunny Boy 4000-US	
	208 V AC	240 V AC	240 V AC	208 V AC	240 V AC
<b>Input (DC)</b>					
Max. recommended PV power (@ module STC)	3750 W		4750 W	4375 W	5000 W
Max. DC power (@ $\cos \phi = 1$ )	3200 W		4200 W	4200 W	
Max. DC voltage	500 V		600 V	600 V	
DC nominal voltage	250 V		310 V	310 V	
MPP voltage range	175 - 400 V	200 - 400 V	250 - 480 V	220 - 480 V	250 - 480 V
Min. DC voltage / start voltage	175 / 228 V	200 / 228 V	250 / 285 V	220 / 285 V	250 / 285 V
Max. input current / per string (at DC disconnect)	17 A / 17 A 36 A @ combined terminal		18 A / 18 A 36 A @ combined terminal	18 A / 18 A 36 A @ combined terminal	
Number of MPP trackers / fused strings per MPP tracker	1 / 4 (DC disconnect)				
<b>Output (AC)</b>					
AC nominal power	3000 W		3800 W	3500 W	4000 W
Max. AC apparent power	3000 VA		3800 VA	3500 VA	4000 VA
Nominal AC voltage / adjustable	208 V / ●	240 V / ●	240 V / -	208 V / ●	240 V / ●
AC voltage range	183 - 229 V	211 - 264 V	211 - 264 V	183 - 229 V	211 - 264 V
AC grid frequency; range	60 Hz; 59.3 - 60.5 Hz		60 Hz; 59.3 - 60.5 Hz	60 Hz; 59.3 - 60.5 Hz	
Max. output current	15 A	13 A	16 A	17 A	
Power factor ( $\cos \phi$ )	1		1	1	
Phase conductors / connection phases	1 / 2		1 / 2	1 / 2	
Harmonics	< 4%		< 4%	< 4%	
<b>Efficiency</b>					
Max. efficiency	96.0%	96.5%	96.8%	96.5%	96.8%
CEC efficiency	95.0%	95.5%	96.0%	95.5%	96.0%
<b>Protection devices</b>					
DC reverse-polarity protection	●		●	●	
AC short circuit protection	●		●	●	
Galvanically isolated / all-pole sensitive monitoring unit	●/-		●/-	●/-	
Protection class / overvoltage category	I / III		I / III	I / III	
<b>General data</b>					
Dimensions (W / H / D) in mm (in)	450 / 350 / 235 (18 / 14 / 9)				
DC Disconnect dimensions (W / H / D) in mm (in)	187 / 297 / 190 (7 / 12 / 7.5)				
Packing dimensions (W / H / D) in mm (in)	390 / 580 / 470 (15 / 23 / 18.5)				
DC Disconnect packing dimensions (W / H / D) in mm (in)	370 / 240 / 280 (15 / 9 / 11)				
Weight / DC Disconnect weight	38 kg (84 lb) / 3.5 kg (8 lb)				
Packing weight / DC Disconnect packing weight	44 kg (97 lb) / 4 kg (9 lb)				
Operating temperature range (full power)	-25 °C ... +45 °C (-13 °F ... +113 °F)				
Noise emission (typical)	40 dB(A)	www.SMA-Solar.com		37 dB(A)	
Internal consumption at night	0.1 W		0.1 W	0.1 W	
Topology	LF transformer		LF transformer	LF transformer	
Cooling concept	OptiCool		OptiCool	OptiCool	
Electronics protection rating / connection area	NEMA 3R / NEMA 3R		NEMA 3R / NEMA 3R	NEMA 3R / NEMA 3R	
<b>Features</b>					
Display: text line / graphic	●/-		●/-	●/-	
Interfaces: RS485 / Bluetooth	○/○		○/○	○/○	
Warranty: 10 / 15 / 20 years	●/○/○		●/○/○	●/○/○	
Certificates and permits (more available on request)	UL1741, UL1998, IEEE 1547, FCC Part 15 (Class A & B), CSA C22.2 No. 107.1-2001				
NOTE: US inverters ship with gray lids.					
Data at nominal conditions					
● Standard features ○ Optional features - Not available					
Type designation	SB 3000US		SB 3800-US-10	SB 4000US	


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### Accessories




RS485 interface  
485USPB-NR



Bluetooth® Piggy Back  
BTPBINV-NR



Combi-Switch  
DC disconnect and PV  
array combiner box  
COMBO-SWITCH



Combiner Box  
Simplify wiring for added  
convenience and safety  
SBCB-6-3R or SBCB-6-4



# SUNNY BOY 5000-US / 6000-US / 7000-US / 8000-US

SB 5000US / SB 6000US / SB 7000US / SB 8000US



**ASSEMBLED IN THE USA**



### UL Certified

- For countries that require UL certification (UL 1741/IEEE 1547)

### Efficient

- 97% peak efficiency
- OptiCool™ active temperature management system

### Safe

- Galvanic isolation

### Simple

- Patented automatic grid voltage detection\*
- Integrated DC disconnect switch

## SUNNY BOY 5000-US / 6000-US / 7000-US / 8000-US

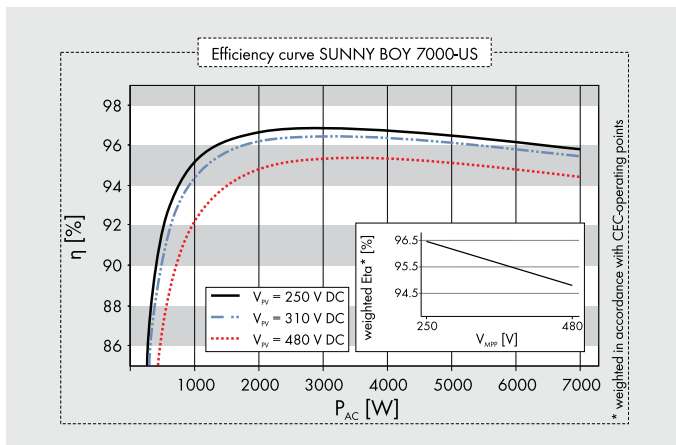
Versatile performer with UL Certification

The Sunny Boy 5000-US, 6000-US, 7000-US and 8000-US inverters are UL Certified and feature excellent efficiency. Graduated power classes provide flexibility in system design. Automatic grid voltage detection\* and an integrated DC disconnect switch simplify installation, ensuring safety as well as saving time. These models feature galvanic isolation and can be used with all types of modules—crystalline as well as thin-film.

\* US Patent US7352549B1

Technical data	Sunny Boy 5000-US			Sunny Boy 6000-US			Sunny Boy 7000-US			Sunny Boy 8000-US	
	208 V AC	240 V AC	277 V AC	208 V AC	240 V AC	277 V AC	208 V AC	240 V AC	277 V AC	240 V AC	277 V AC
<b>Input (DC)</b>											
Max. recommended PV power (@ module STC)	6250 W			7500 W			8750 W			10000 W	
Max. DC power (@ cos φ = 1)	5300 W			6350 W			7400 W			8600 W	
Max. DC voltage	600 V			600 V			600 V			600 V	
DC nominal voltage	310 V			310 V			310 V			345 V	
MPP voltage range	250 V - 480 V			250 V - 480 V			250 V - 480 V			300 V - 480 V	
Min. DC voltage / start voltage	250 V / 300 V			250 V / 300 V			250 V / 300 V			300 V / 365 V	
Max. input current / per string (at DC disconnect)	21 A / 20 A 36 A @ combined terminal			25 A / 20 A 36 A @ combined terminal			30 A / 20 A 36 A @ combined terminal			30 A / 20 A 36 A @ combined terminal	
Number of MPP trackers / fused strings per MPP tracker	1 / 4 (DC disconnect)										
<b>Output (AC)</b>											
AC nominal power	5000 W			6000 W			7000 W			7680 W 8000 W	
Max. AC apparent power	5000 VA			6000 VA			7000 VA			8000 VA	
Nominal AC voltage / adjustable	208 V / ●	240 V / ●	277 V / ●	208 V / ●	240 V / ●	277 V / ●	208 V / ●	240 V / ●	277 V / ●	240 V / ●	277 V / ●
AC voltage range	183 - 229 V	211 - 264 V	244 - 305 V	183 - 229 V	211 - 264 V	244 - 305 V	183 - 229 V	211 - 264 V	244 - 305 V	211 - 264 V	244 - 305 V
AC grid frequency; range	60 Hz; 59.3 - 60.5 Hz			60 Hz; 59.3 - 60.5 Hz			60 Hz; 59.3 - 60.5 Hz			60 Hz; 59.3 - 60.5 Hz	
Max. output current	24 A	21 A	18 A	29 A	25 A	22 A	34 A	29 A	25 A	32 A	29 A
Power factor (cos φ)	1			1			1			1	
Phase conductors / connection phases	1/2	1/2	1/1	1/2	1/2	1/1	1/2	1/2	1/1	1/2	1/1
Harmonics	< 4%			< 4%			< 4%			< 4%	
<b>Efficiency</b>											
Max. efficiency	96.7%	96.8%	96.8%	96.9%	96.8%	97.0%	97.1%	96.9%	97.0%	96.3%	96.5%
CEC efficiency	95.5%	95.5%	95.5%	95.5%	95.5%	96.0%	95.5%	96.0%	96.0%	96.0%	96.0%
<b>Protection devices</b>											
DC reverse-polarity protection	●			●			●			●	
AC short circuit protection	●			●			●			●	
Galvanically isolated / all-pole sensitive monitoring unit	●/-			●/-			●/-			●/-	
Protection class / overvoltage category	I / III			I / III			I / III			I / III	
<b>General data</b>											
Dimensions (W / H / D) in mm (in)	470 / 615 / 240 (18.5 / 24 / 9)										
DC Disconnect dimensions (W / H / D) in mm (in)	187 / 297 / 190 (7 / 12 / 7.5)										
Packing dimensions (W / H / D) in mm (in)	390 / 580 / 800 (16 / 23 / 31.5)										
DC Disconnect packing dimensions (W / H / D) in mm (in)	370 / 240 / 280 (15 / 9 / 11)										
Weight / DC Disconnect weight	64 kg (141 lb) / 3.5 kg (8 lb)									66 kg (145 lb) / 3.5 kg (8 lb)	
Packing weight / DC Disconnect packing weight	67 kg (147 lb) / 4 kg (9 lb)									69 kg (152 lb) / 4 kg (9 lb)	
Operating temperature range (full power)**	-25 °C ... +45 °C (-13 °F ... +113 °F)										
Noise emission (typical)	44 dB(A)			45 dB(A)			46 dB(A)			49 dB(A)	
Internal consumption at night	0.1 W			0.1 W			0.1 W			0.1 W	
Topology	LF transformer			LF transformer			LF transformer			LF transformer	
Cooling concept	OptiCool			OptiCool			OptiCool			OptiCool	
Electronics protection rating / connection area	NEMA 3R / NEMA 3R			NEMA 3R / NEMA 3R			NEMA 3R / NEMA 3R			NEMA 3R / NEMA 3R	
<b>Features</b>											
Display: text line / graphic	●/-			●/-			●/-			●/-	
Interfaces: RS485 / Bluetooth®	○/○			○/○			○/○			○/○	
Warranty: 10 / 15 / 20 years	●/○/○			●/○/○			●/○/○			●/○/○	
Certificates and permits (more available on request)	UL1741, UL1998, IEEE 1547, FCC Part 15 (Class A & B), CSA C22.2 No. 107.1-2001										
**Extended operating temperature range to -40 °C available. Specify when ordering.											
NOTE: US inverters ship with gray lids. Data at nominal conditions											
● Standard features ○ Optional features - Not available											
Type designation	SB 5000US			SB 6000US			SB 7000US			SB 8000US	

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### Accessories

RS485 interface  
485USPB-SMC-NR

Bluetooth Piggy Back  
BTPBINV-NR

Combi-Switch  
DC disconnect and PV  
array combiner box  
COMBO-SWITCH

Combiner Box  
Simplify wiring for added  
convenience and safety  
SBCB-6-3R or SBCB-6-4