



Solar PV Standard Electric Plan Microinverter 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 the installation of microinverter solar PV systems, 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 and microinverters are mounted on the roof of the single family dwelling. For installations exceeding this scope, Electrical Plan review is required.

Note: This plan is not intended for systems containing batteries. This document addresses only the requirements of the 2019 California Electrical Code (CEC), refer to other toolkit documents for California Residential Code (CRC) requirements.

NOTE: Calculate the total AC output of the system.

of microinverters ____x Inverter AC Output Current ____amps x 240 volts = _____ watts divided by 1,000 = ____ **kW**.

Installer information:

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

A) Module information:

- 1) Manufacturer _____
- 2) Model number _____
- 3) Total number of modules being installed _____
- 4) Maximum DC output voltage (Voc) _____ Volts
- 5) Maximum DC current output (Isc) _____ Amps

Important: Not all modules are suitable for use with microinverter systems. Review the microinverter installation manual prior to beginning any installation to avoid costly errors.

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B) Microinverter information:

Each microinverter shall be listed by a recognized listing agency, have factory installed Ground Fault protection and be identified as "Utility-Interactive".

NOTE: Provide the following information from the microinverter installation manual. If any information is not provided by the manufacturer write "not given" in the appropriate box

- 6) Manufacturer _____
- 7) Model number _____
- 8) Minimum mounting height above the roof surface _____ inches
- 9) Maximum DC input voltage _____ Volts
- 10) Maximum DC input current _____ Amps
- 11) Maximum AC output current _____ Amps
- 12) Maximum size branch circuit breaker permitted _____ Amps
- 13) Maximum number of inverters permitted per branch circuit _____

NOTE: The number of microinverters installed per branch circuit may be less than the maximum number permitted by the manufacturer, but it shall not be more.

C) Manufacturer "Trunk" cable (if supplied):

Some microinverter manufacturers include as part of their installation kit a "Trunk" cable that each microinverter of the branch circuit plugs into. These cables must be listed by a recognized listing agency, have a wet insulation temperature rating of at least 90 degrees Celsius, be provided with an equipment grounding conductor inside of the overall cable sheath and contain no more than three current carrying conductors. Cables that will be exposed to sunlight must be listed as such. This cable will typically be run underneath the array where it will not be subject to physical damage. This cable, if provided, must be used. Non-manufacturer supplied cables or installer fabricated assemblies are not approved. Where the cable is exposed to physical damage, the cable shall be protected.

- 14) Provide the conductor size of the manufacturer supplied "Trunk" cable _____ AWG (From cable jacket)
- 15) Provide the **MINIMUM INSTALLATION** spacing above the roof surface to the bottom of the "Trunk" cable per the installation instructions _____ inches (If no dimension specified, write "None given").
- 16) Provide the **MINIMUM INSTALLATION** spacing below the array modules to the top of the "Trunk" cable per the installation instructions _____ inches (If no dimension specified write "None given").

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D) Temperature compensation for roof mounted cables under the array:

17) Temperatures under the array may be higher than the surrounding ambient air. Where cables are installed close to the roof surface or to the modules, local jurisdictions may require the ambient air temperature to be higher based on local conditions. Some local enforcing agencies use ASHRAE to determine the local ambient temperature. Below are the temperatures for the local jurisdiction.

(i) The Ambient Air Temperature for this jurisdiction is: _____ °C

NOTE: Some local jurisdictions may require this temperature to be increased when sizing conductors beneath the module or array.

E) Sizing the conductors for the microinverter branch circuit:

The amount of current that will be carried by the conductors shall be calculated as follows:

18) Maximum # of inverters installed per branch circuit _____ x Maximum inverter AC output (Step #11) _____ A x
1.25 (for long continuous load) = _____ Amps.

Where the manufacturer supplied cable transitions to regular building wire installed inside of a raceway, a reduction in the amount of current these conductors can carry may be required based on the exposed ambient air temperature and number of conductors in the raceway.

Note how many conductors will be in the raceway and how high above the roof surface the raceway will be mounted. Using **Table A** on page 4, select the appropriate "Ambient Temperature" section for your project location from (Step #17(i)) and choose a conductor size that will meet or exceed the result from Step #18. Your selected conductor size is permitted to have a higher ampacity than the number in step #18, **but it shall not be less.**

Selected conductor size for branch circuit wiring in raceway _____ AWG.

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TABLE A

Table A is based on the following:

- A. Table 310.15(B)(16) - Allowable Ampacity of Insulated Conductors, 90 C rated conductors.
- B. Table 310.15(B)(2)(a) - Correction Factors based on temperature ranges.
- C. Table 310.15(B)(3)(c) - Ambient Temperature Adjustments for Conduits Exposed to Sunlight On or Above Rooftops.
- D. Table 310.15(B)(3)(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 12 AWG and 10 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" above	17	23	32	44	55	17	23	32	44	55
	0.5" to 3.5" above	20	30	42	57	72	20	28	39	53	67
	3.5" to 12" above	20	30	45	62	78	20	30	42	57	72
	12" above	20	30	48	65	83	20	30	45	62	78
4 to 6 Conductors	0 to 0.5" above	14	19	26	35	44	14	19	26	35	44
	0.5" to 3.5" above	18	24	33	46	58	17	23	31	43	54
	3.5" to 12" above	20	26	36	49	62	18	24	33	46	58
	12" above	20	28	38	52	66	20	26	36	49	62
7 to 9 Conductors	0 to 0.5" above	12	16	22	30	39	12	16	22	30	39
	0.5" to 3.5" above	16	21	29	40	51	15	20	27	37	47
	3.5" to 12" above	17	23	32	43	55	16	21	29	40	51
	12" above	18	24	33	46	58	17	23	32	43	55
10 to 20 Conductors	0 to 0.5" above	9	12	16	22	28	9	12	16	22	28
	0.5" to 3.5" above	11	15	21	29	36	11	14	20	27	34
	3.5" to 12" above	12	16	23	31	39	11	15	21	29	36
	12" above	13	17	24	33	41	12	16	23	31	39
Up to 3 Conductors		35°C to 40°C					40°C to 45°C				
	0 to 0.5" above	12	16	23	31	39	12	16	23	31	39
	0.5" to 3.5" above	17	23	32	44	55	17	23	32	44	55
	3.5" to 12" above	20	28	39	53	67	17	23	32	44	55
12" above	20	30	42	57	72	20	28	39	53	67	
4 to 6 Conductors	0 to 0.5" above	10	13	18	25	31	10	13	18	25	31
	0.5" to 3.5" above	14	19	26	35	44	14	19	26	35	44
	3.5" to 12" above	17	23	31	43	54	14	19	26	35	44
	12" above	18	24	33	46	58	17	23	31	43	54
7 to 9 Conductors	0 to 0.5" above	9	11	16	22	27	9	11	16	22	27
	0.5" to 3.5" above	12	16	22	30	39	12	16	22	30	39
	3.5" to 12" above	15	20	27	37	47	12	16	22	30	39
	12" above	16	21	29	40	51	15	20	27	37	47
10 to 20 Conductors	0 to 0.5" above	6	8	11	15	19	6	8	11	15	19
	0.5" to 3.5" above	9	12	16	22	28	9	12	16	22	28
	3.5" to 12" above	11	14	20	27	34	9	12	16	22	28
	12" above	11	15	21	29	36	11	14	20	27	34
Up to 3 Conductors		45°C to 50°C					50°C to 55°C				
	0 to 0.5" above	0	0	0	0	0	0	0	0	0	0
	0.5" to 3.5" above	12	16	23	31	39	12	16	23	31	39
	3.5" to 12" above	17	23	32	44	55	12	16	23	31	39
12" above	17	23	32	44	55	17	23	32	44	55	
4 to 6 Conductors	0 to 0.5" above	0	0	0	0	0	0	0	0	0	0
	0.5" to 3.5" above	10	13	18	25	31	10	13	18	25	31
	3.5" to 12" above	14	19	26	35	44	10	13	18	25	31
	12" above	14	19	26	35	44	14	19	26	35	44
7 to 9 Conductors	0 to 0.5" above	0	0	0	0	0	0	0	0	0	0
	0.5" to 3.5" above	9	11	16	22	27	9	11	16	22	27
	3.5" to 12" above	12	16	22	30	39	9	11	16	22	27
	12" above	12	16	22	30	39	12	16	22	30	39
10 to 20 Conductors	0 to 0.5" above	0	0	0	0	0	0	0	0	0	0
	0.5" to 3.5" above	6	8	11	15	19	6	8	11	15	19
	3.5" to 12" above	9	12	16	22	28	6	8	11	15	19
	12" above	9	12	16	22	28	9	12	16	22	28

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F) Solar Load Center and circuit breakers, sizing information:

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 microinverter branch circuits may not connect directly into the electrical panel of the house. They may go first to a solar load center. This is just a standard circuit breaker panel that collects together the individual branch circuits from the microinverters. Each branch circuit **shall** have its own dedicated circuit breaker. From this panel one feeder will go to the performance meter (if required), then to the safety disconnect switch (if required), and finally to the point of interconnection at the house electrical panel. Only PV system monitoring equipment/devices are permitted to be connected between the output of the inverter and the house electrical panel. Contact your local utilities for performance meter and AC utility disconnect switch requirements.

19) Total number of microinverter branch circuits installed in the solar load center _____

20) List the current in Amps (from step 18) for each individual branch circuit in the solar load center.

Circuit #1 output _____ Amps, Circuit #2 output _____ Amps, Circuit #3 _____ Amps, Circuit #4 _____ Amps.

21) Total PV current in Amps connected to the panel (sum of the individual branch circuits from step 20) = _____ Amps

22) Panel busbar rating (from panel label) _____ Amps. This figure must be larger than the number at step #21 or the panel will be undersized.

23) Size of Main breaker if installed (If no main write NONE) _____ Amps

24) To size the feeder conductors leaving the solar load center use the result from step #21 and go to table 310.16, using the 75°C column, to select the correct size conductor for your installation.

G) Utility “Performance” meter (if required):

Where an additional meter is required by the local Utility to record the power produced by the PV system the output wiring from the microinverters shall always connect to the “**LINE**” side terminals at the top of the meter. The wiring from the meter to the electrical panel will connect to the “**LOAD**” side terminals at the bottom. Not all utility providers have the same requirements for connecting solar power systems to their electrical systems. Contact the local utility for specific requirements in the local jurisdiction.

H) Utility “Safety Disconnect Switch” (if required):

Where disconnect switches (with or without fuses) are installed in the circuit(s) from the microinverters to the house electrical panel, the wiring originating at the microinverters shall always connect to the “**LOAD**” side (**bottom**) terminals of **ANY** disconnect switch that has been installed. The wiring originating at the electric service panel shall always connect to the “**LINE**” side (**top**) terminals. Check with the local utility for specific requirements.

I) Connection to the house electrical panel:

The connection to the service panel **shall** be through a dedicated circuit breaker that connects to the panel busbars 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 CEC **Section 705.12**.

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Where the main breaker of the electrical panel that the PV system will interconnect to is located at either the top or bottom of the panel distribution busbars and the PV interconnect breaker is located at the opposite end, the code permits the

sum of the ratings of the main breaker and the PV breaker to exceed the rating of the panel bus bars. Per CEC **Section 705.12**, the sum of the electrical panel main breaker and the microinverter PV interconnect breaker shall not add up to more than 120% of the rating of the panel busbars. For a 100 amp rated bus this means that both breakers together shall not add up to more than **120 amps**. For a 200 amp rated bus, not more than **240 amps** and for 225 amps, not more than **270 amps**. In order to qualify for this additional allowance, the PV breaker **must** be located at the opposite end of the breaker panel from the main breaker and shall have the warning label installed next to it per CEC **Section 705.12(B)(2)(3)(b)**. “WARNING POWER SOURCE OUTPUT CONNECTION. DO NOT RELOCATE THIS OVERCURRENT DEVICE”.

NOTE

Certain “All-in-One” service panels have the factory installed main breaker in the center of the distribution section. Because of the possibility of overloading the busbars, this type of service is not able to take advantage of the 120% overage permitted for top or bottom fed bussing. For this type of installation the sum of the main circuit breaker and the PV breaker may not exceed 100% of the rating of the factory bussing. For example, if the service panel label states that the busbars are rated for 200 amps you cannot exceed that figure. 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 busbar 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. Where it is necessary to install the PV interconnection as a “Line Side Tap” and where the electrical service panel at the dwelling is an “All-in-One” type, the service shall be provided with factory installed terminals designed specifically to accommodate this type of connection. Where these terminals are not provided there shall be **NO** PV connection between the load side of the meter and the line side of the main circuit breaker.

J) Grounding the photovoltaic system:

A **Grounding Electrode Conductor** sized per the manufacturer's installation instructions, (minimum #8 AWG solid copper), shall be run **UNSPLICED** from the factory identified grounding terminal of each microinverter to the grounding electrode system of the house, (i.e. ground rod, Ufer ground, or metallic water pipe with a minimum of 10 feet in the ground).

NOTE: The Grounding Electrode Conductor is permitted to be spliced per CEC **Section 250.64 (C)** using an irreversible means or by the installation of a “Ground Plate”. (A Ground Plate is defined as a copper busbar ¼” thick by 2” wide by whatever length is needed to terminate the conductors). This conductor may also be used as the required equipment grounding conductor for the modules and the frame rails of the array. (Equipment grounding conductors may be connected to the Grounding Electrode Conductor by non-irreversible means such as listed split bolts).

K) Disconnection of photovoltaic equipment:

CEC **Section 690.15** requires that means are provided to disconnect equipment from all ungrounded conductors of all sources. Such disconnecting means shall comply with CEC **Sections 690.15 (A) thru (D)**.

L) Signage:

Per CEC **Section 690.54**, a permanent label for the microinverter AC power source shall be installed at the point of interconnection at an accessible location. This label shall show that it is a PV source and additionally, the rated AC output current and the nominal operating AC voltage.

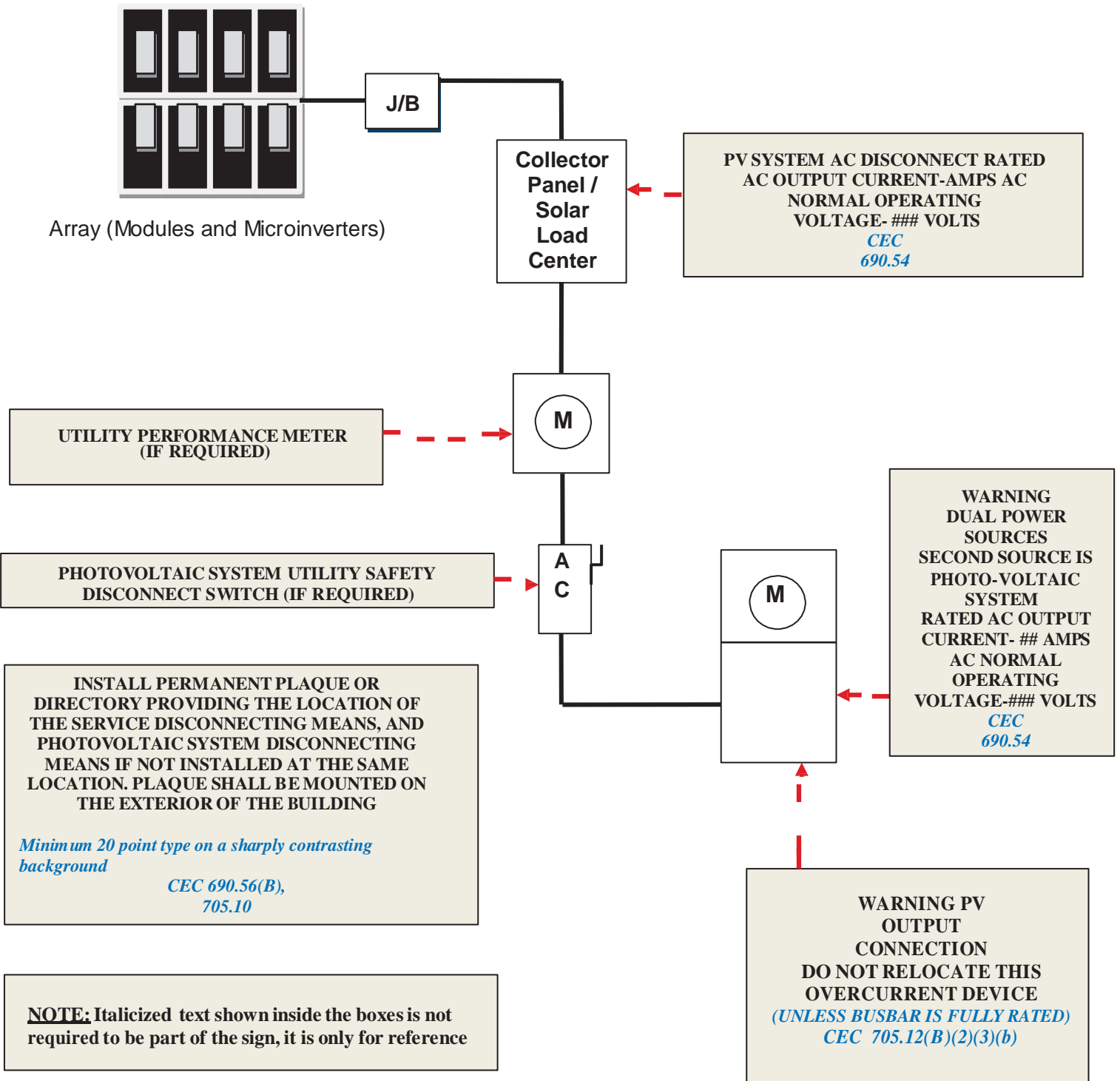
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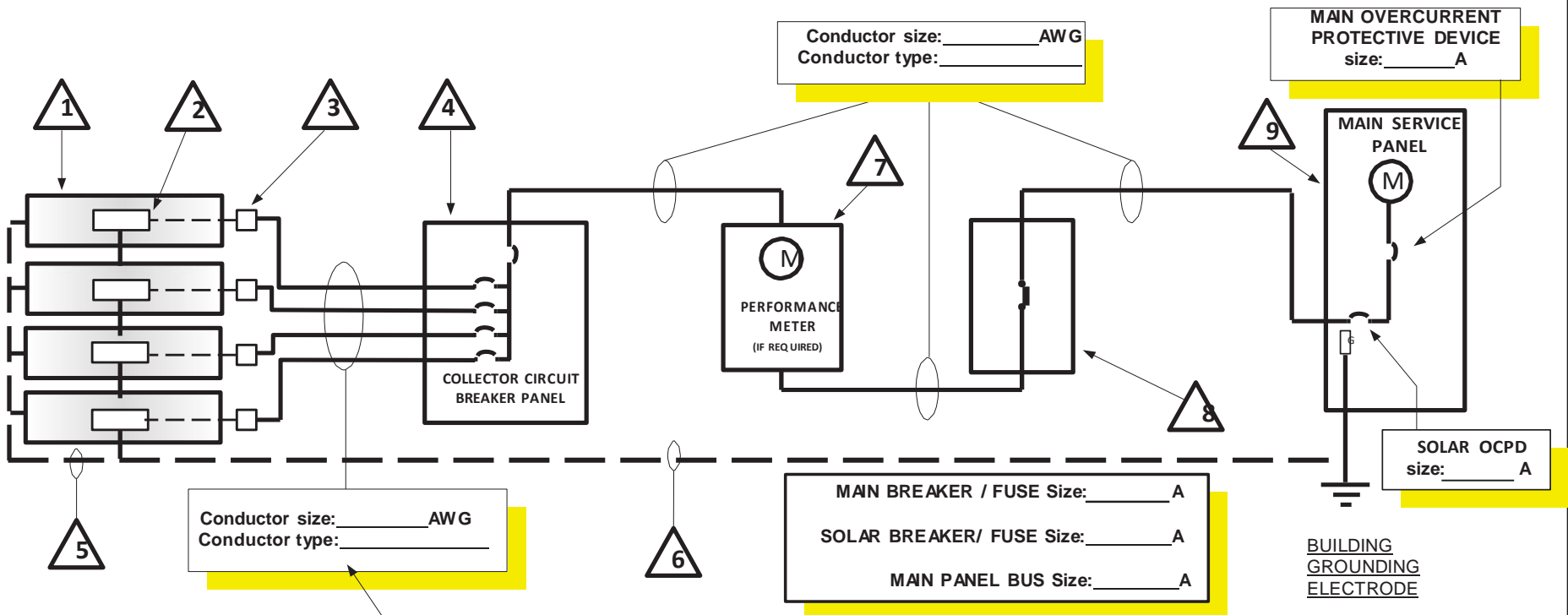
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TAG	DESCRIPTION
1	SOLAR PV MODULE
2	MICROINVERTER
3	JUNCTION BOX FOR THE MANUFACTURER SUPPLIED CABLE TO RACEWAY TRANSITION
4	"COLLECTOR" CIRCUIT BREAKER PANEL
5	ARRAY EQUIPMENT GROUNDING CONDUCTOR
6	MICROINVERTER GROUNDING ELECTRODE CONDUCTOR (MIN #8 AWG COPPER)
7	PERFORMANCE METER (IF REQUIRED BY THE UTILITY COMPANY)
8	UTILITY SAFETY DISCONNECT SWITCH (IF REQUIRED BY THE UTILITY COMPANY)
9	ELECTRICAL SERVICE PANEL

MAXIMUM 10 KW OUTPUT
MAXIMUM 225 AMP SERVICE
120/240 SINGLE PHASE

THIS PLAN MUST BE PROVIDED TO THE FIELD INSPECTOR



Provide required information in these boxes

Note: This plan is intended to be used ONLY with Microinverter Systems.

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ROOF PLAN

PROVIDE A ROOF PLAN SHOWING ALL EQUIPMENT,
DISCONNECTING MEANS AND REQUIRED CLEARANCES

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