# SOLAR PV STANDARD ELECTRICAL 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 multicrystalline 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 2010 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: _____<br>City: _____<br>State: _____ Zip _____ | Homeowner: ☐<br>Contractor: ☐<br>Contractor License # _____<br>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-Iinteractive".

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 310.16 - 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 |
| | | 35°C to 40°C | | | | | 40°C to 45°C | | | | |
| Up to 3 Conductors | 0 to 0.5" | 12 | 16 | 23 | 31 | 39 | 12 | 16 | 23 | 31 | 39 |
| | above 0.5" to 3.5" | 17 | 23 | 32 | 44 | 55 | 17 | 23 | 32 | 44 | 55 |
| | above 3.5" to 12" | 20 | 28 | 39 | 53 | 67 | 17 | 23 | 32 | 44 | 55 |
| | above 12" | 20 | 30 | 42 | 57 | 72 | 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 |
| | | 45°C to 50°C | | | | | 50°C to 55°C | | | | |
| Up to 3 Conductors | 0 to 0.5" | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 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 | 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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**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 bus bar 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 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)**.

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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 bus bars 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 **Section 690.64 (B)(2)**, 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 bus bars. 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 **Section 690.64 (B)(7)**. "WARNING INVERTER 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 bus bars, 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 bus bars 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 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. 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 **Section 250.64 (C)** using an irreversible means or by the installation of a "Ground Plate". (A Ground Plate is defined as a copper bus bar 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:**

Section 690.15 requires that means are provided to disconnect equipment from all ungrounded conductors of all sources. Such disconnecting means shall comply with Sections 690.16 and 690.17.

Note: Section 690.17 contains an exception which states "A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for the use."

**L) Signage:**

**Per 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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# SOLAR PV STANDARD ELECTRICAL PLAN
## Microinverter Systems for Single Family Dwellings

Array (Modules and Microinverters)

J/B

Collector Panel / Solar Load Center

PV SYSTEM AC DISCONNECT
RATED AC OUTPUT CURRENT-AMPS
AC NORMAL OPERATING
VOLTAGE- ### VOLTS
*690.54*

PHOTOVOLTAIC SYSTEM UTILITY SAFETY DISCONNECT SWITCH

A C

UTILITY PERFORMANCE METER

M

M

WARNING
DUAL POWER SOURCES
SECOND SOURCE IS PHOTO-VOLTAIC SYSTEM
RATED AC OUTPUT CURRENT- ## AMPS
AC NORMAL OPERATING
VOLTAGE-### VOLTS
*690.54*

INTALL PERMANENT PLAQUE OR DIRECTORY PROVIDING THE LOCATION OF THE SERVICE DISCONNECTING MEANS, AND PHOTOVOLTAIC SYSTEM DISCONNECTING MEANS IF NOT INSTALLED AT THE SAME LOCATION. PLAQUE SHALL BE MOUNTED ON THE EXTERIOR OF THE BUILDING

*Minimum 20 point type on a sharply contrasting background*

*690.56-(B), 705.10*

WARNING
PV OUTPUT CONNECTION
DO NOT RELOCATE THIS OVERCURRENT DEVICE
*(UNLESS BUSBAR IS FULLY RATED)*
*690.64(B)(7), 705.12(D)(7)*

**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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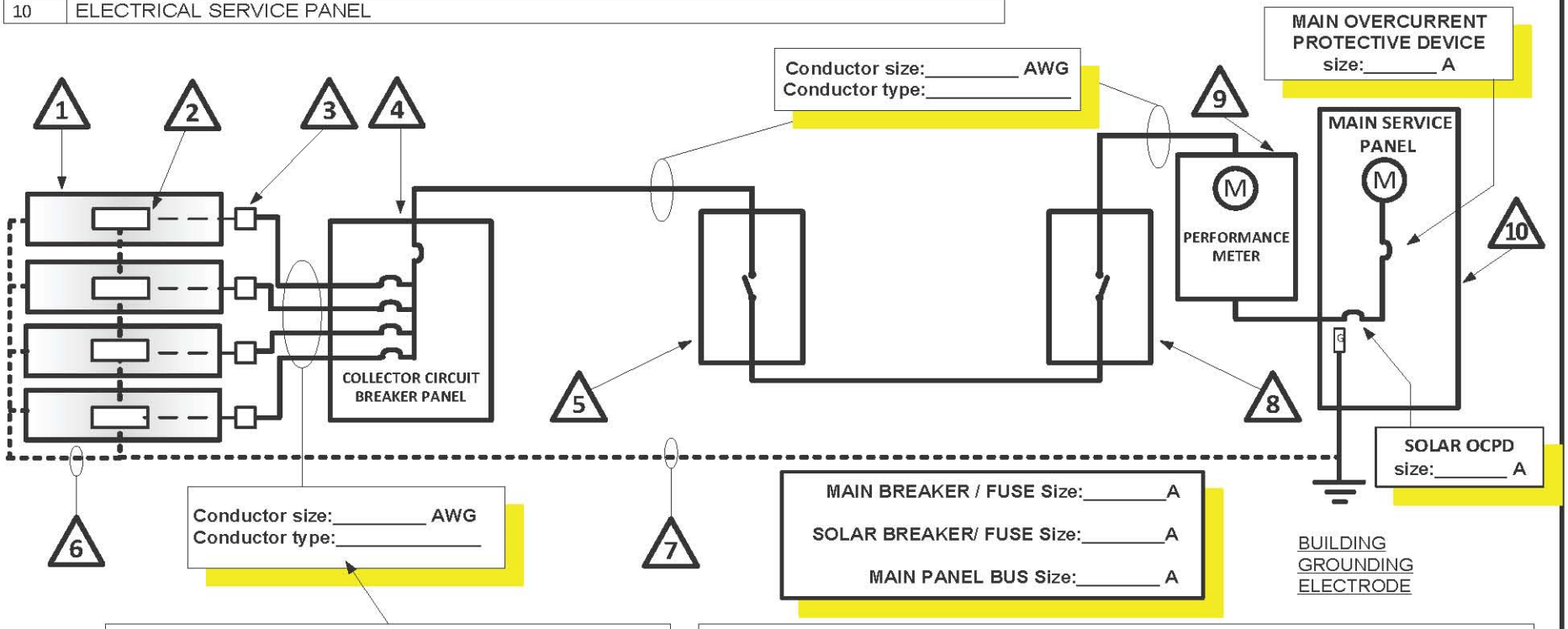
# SOLAR PV STANDARD PLAN

## Microinverter Systems for Single Family Dwellings

| 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 | AC DISCONNECT AT ROOF |
| 6 | ARRAY EQUIPMENT GROUNDING CONDUCTOR |
| 7 | MICROINVERTER GROUNDING ELECTRODE CONDUCTOR (MIN #8 AWG COPPER) |
| 8 | UTILITY SAFETY DISCONNECT SWITCH |
| 9 | PERFORMANCE METER |
| 10 | 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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glendale Community Development

# SOLAR PV STANDARD PLAN

## Microinverter Systems for Single Family Dwellings

**ROOF PLAN**

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

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