RESIDENTIAL PHOTOVOLTAIC

This information bulletin is published to guide applicants through a streamlined permitting process for solar photovoltaic (PV) projects 10 kW in size or smaller. This bulletin provides information about submittal requirements for plan review, required fees and inspections.

1. Approval Requirements

The following is required to install a solar PV system with a maximum power output of 10 kW or less:

a) RESIDENTIAL - SOLAR/PHOTOVOLTAIC PERMIT

Planning review IS required for solar PV installations of this size.
Fire Department approval IS NOT required for solar PV installations of this size.

2. Submittal Requirements

a) Completed permit application online through our our Online Permit Center. Visit our website, click on the Online Permit Center tile, register for an account, login and apply.

b) Upload photovoltaic standard form for systems 10 kW in size or smaller.

c) Demonstrate compliance with the eligibility checklist for expedited permitting. These criteria can be downloaded at www.cityofrc.us.
This Guidebook recommends use of a simple checklist to clearly identify eligibility criteria for expedited permitting, where established.

d) A completed Standard Electrical Plan. The standard plan may be used for proposed solar installations 10 kW in size or smaller and can be downloaded at www.cityofrc.us.
This Guidebook recommends use of a standard plan that allows permit applicants to simply fill in information regarding a solar system's electrical configuration. Template standard plans are provided in this Guidebook (PV Toolkit Documents 3 and4).
If standard electrical plans are not provided for use, an electrical plan should be submitted that includes the following.

- *Locations of main service or utility disconnect*
- *Total number of modules, number of modules per string and the total number of strings*
- *Make and model of inverter(s) and/or combiner box if used*
- *Single-line diagram of system*
- *Specify grounding/bonding, conductor type and size, conduit type and size and number of conductors in each section of conduit*
- *If batteries are to be installed, include them in the diagram and show their locations and venting*

- *Equipment cut sheets including inverters, modules, AC and DC disconnects, combiners and wind generators*
- *Labeling of equipment as required by CEC, Sections 690 and 705*
- *Site diagram showing the arrangement of panels on the roof or ground, north arrow, lot dimensions and the distance from property lines to adjacent buildings/structures (existing and proposed)*

d) A roof plan showing roof layout, PV panels and the following fire safety items: approximate location of roof access point, location of code-compliant access pathways, PV system fire classification and the locations of all required labels and markings. Examples of clear path access pathways are available in the State Fire Marshal Solar PV Installation Guide. **http://osfm.fire.ca.gov/pdf/reports/solarphotovoltaicguideline.pdf**.

e) Completed expedited Structural Criteria along with required documentation. Structural Criteria can be downloaded at www.cityofrc.us.

For non-qualifying systems, provide structural drawings and calculations stamped and signed by a California-licensed civil or structural engineer, along with the following information.

- The type of roof covering and the number of roof coverings installed
- Type of roof framing, size of members and spacing
- Weight of panels, support locations and method of attachment
- Framing plan and details for any work necessary to strengthen the existing roof structure
- Site-specific structural calculations
- Where an approved racking system is used, provide documentation showing manufacturer of the rack system, maximum allowable weight the system can support, attachment method to the roof or ground and product evaluation information or structural design for the racksystem

This Guidebook recommends that local jurisdictions adopt a prescriptive approach to establishing minimal structural requirements that avoids the need for structural calculations. A simple list of criteria is provided in this Guidebook (PV Toolkit Document 5). A full explanation of the methods and calculations used to produce these criteria can be found in the Structural Technical Appendix for Residential Rooftop Solar Installations, which is available at
http://www.opr.ca.gov/docs/Solar_Structural_Technical_Appendix.pdf.

3. Plan Review

Permit applications are submitted electronically through our Online Permit Center.
Permit applications are submitted electronically for expedited review approval [IF APPLICABLE] through our Online Permit Center.
Expedited review is one to three working days.

4. Fees - Subject to Annual Adjustment

$74.39-Inspection Fee, **$74.39-**Plan Review Fee, **$10.41-**Technology Fee, and **$14.88-**General Plan Maintenance Fee.

5. Inspections

Once all permits to construct the solar installation have been issued and the system has been installed, it must be inspected before final approval is granted for the solar system. On-site inspections are scheduled electronically at our Online Permit Center. Inspection requests received within business hours are typically scheduled for the next businessday. If next business day is not available, inspection should happen within a five-day window.

Permit holders must be prepared to show conformance with all technical requirements in the field at the time of inspection. The inspector will verify that the installation is in conformance with applicable code requirements and with the approved plans.

The inspection checklist provides an overview of common points of inspection that the applicant should be prepared to show compliance. If not available, common checks include the following.

- Number of PV modules and model number match plans and specification sheets number match plans and specification sheets.
- Array conductors and components are installed in a neat and workman-like manner.
- PV array is properly grounded.
- Electrical boxes are accessible and connections are suitable for environment.
- Array is fastened and sealed according to attachment detail.
- Conductor's ratings and sizes match plans.
- Appropriate signs are property constructed, installed and displayed, including the following.
  - Sign identifying PV power source system attributes at DC disconnect
  - Sign identifying AC point of connection
  - Sign identifying switch for alternative power system
- Equipment ratings are consistent with application and installed signs on the installation, including the following.
  - Inverter has a rating as high as max voltage on PV power source sign.
  - DC-side overcurrent circuit protection devices (OCPDs) are DC rated at least as high as max voltage on sign.
  - Switches and OCPDs are installed according to the manufacturer's specifications (i.e., many 600VDC switches require passing through the switch poles twice in a specific way).
  - Inverter is rated for the site AC voltage supplied and shown on the AC point of connection sign.
  - OCPD connected to the AC output of the inverter is rated at least 125% of maximum current on sign and is no larger than the maximum OCPD on the inverter listing label.
  - Sum of the main OCPD and the inverter OCPD is rated for not more than 120% of the bus bar rating.

6. Departmental Contact Information

For additional information regarding this permit process, please consult our departmental website at www.cityofrc.us or contact Building & Safety Services at (909) 477-2710.

Eligibility Checklist for Expedited Solar Photovoltaic Permitting for One- and Two- Family Dwellings

GENERAL REQUIREMENTS

A.	System size is 10 kW alternating current nameplate rating or less	☐ Y	☐ N
B.	The solar array is roof-mounted on one- or two-family dwelling or accessory structure	☐ Y	☐ N
C.	The solar panel/module arrays will not exceed the maximum legal building height	☐ Y	☐ N
D.	Solar system is utility interactive and without battery storage	☐ Y	☐ N
E.	Permit application is completed and attached	☐ Y	☐ N

ELECTRICAL REQUIREMENTS

A.	For central/string inverter systems, strings are not combined prior to the inverter	☐ Y	☐ N
B.	PV module short circuit current (I_{SC}) is less than 13 Amps	☐ Y	☐ N
C.	System does not utilize storage batteries, charge controllers, or trackers	☐ Y	☐ N
D.	PV system is not a hybrid or bipolar system	☐ Y	☐ N
E.	For central/string inverter systems: No more than two inverters are utilized	☐ Y	☐ N
F.	The PV system is interconnected to a single-phase AC service panel of nominal 120/220 Vac with a bus bar rating of 225 A or less	☐ Y	☐ N
G.	A Solar PV Standard Plan and supporting documentation is completed and attached	☐ Y	☐ N

STRUCTURAL REQUIREMENTS

A.	A completed Structural Criteria and supporting documentation is attached (if required)	☐ Y	☐ N

FIRE SAFETY REQUIREMENTS

A.	Clear access pathways provided	☐ Y	☐ N
B.	Fire classification solar system is provided	☐ Y	☐ N
C.	All required markings and labels are provided	☐ Y	☐ N
D.	A diagram of the roof layout of all panels, modules, clear access pathways and approximate locations of electrical disconnecting means and roof access points is completed and attached	☐ Y	☐ N

Notes:

1. *These criteria are intended for expedited solar permitting process.*
2. *If any items are checked NO, revise design to fit within Eligibility Checklist, otherwise permit application may go through standard process.*

Solar PV Standard Plan - Simplified
Central/String Inverter Systems for One - and Two- Family Dwellings

SCOPE: Use this plan ONLY for electrical review of utility central/string inverter systems not exceeding a system AC inverter output rating of 10kW on the roof of a one- or two-family dwelling or accessory building. The specific structural and fire requirements are covered in other parts of the California Solar Permitting Guidebook. This covers photovoltaic system interconnected to the load side of a single-phase AC service panel of nominal 120/240Vac with a bus bar rating of 225A or less. Plan also applies to supply side connections (between the meter and the service disconnects), where permitted by the local utility. This plan is not intended for bipolar systems, hybrid systems or systems that utilize storage batteries, charge controllers, trackers, more than two inverters, or strings combined. Systems must be in compliance with current California Building Standards Codes and local amendments of the authority having jurisdiction (AHJ). Other Articles of the California Electrical Code (CEC) shall apply as specified in 690.3. For systems beyond this scope or the criteria in this plan, consult the AHJ for details regarding comprehensive process.

MANUFACTURER'S SPECIFICATION SHEETS MUST BE PROVIDED for proposed inverters, modules, combiner/junction boxes, racking systems, and rapid shutdown system or equipment. Installation instructions for bonding and grounding equipment and rapid shutdown systems shall be provided, and local AHJs may require additional details. Listed and labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling (CEC 110.3). Equipment intended for use with PV system shall be listed for the PV application (CEC 690.4[B]).

Job Address:_____ Permit #:_____

Contractor/Engineer Name:_____ License # and Class: _____

Signature:_____ Date:_____ Phone Number: _____

Total # of Inverters installed:_____ (If more than one inverter, complete and attach the "Supplemental Calculation Sheets" and the "Load Center Calculations" if a new load center is to be used.)

Inverter 1 AC Output Power Rating: _____ Watts

Inverter 2 AC Output Power Rating (if applicable):_____ Watts

Combined Inverter Output Power Rating: _____ ≤ 10,000 Watts

Ambient Temperature Adjustment Factors: select the box for the expected lowest ambient temperature (T_L) with the corresponding Ambient Temperature Correction Factor (C_F):

1) ☐ If T_L is greater than or equal to -5°C, **C_F = 1.12**

☐ If T_L is between -6°C and -10°C, **C_F = 1.14**

Average ambient high temperature (T_H) ≤ 47° C

Note: For a lower T_L or a higher T_H, this plan is not applicable.

DC Information:

Module Manufacturer:_____ Model: _____

2) Module V_{OC} (from module nameplate): _____ Volts

3) Module I_{SC} (from module nameplate): _____ Amps

Is Module I_{SC} less than 13 Amps? ☐ Yes ☐ No (If No, this plan is not applicable.)

4) Module DC output power under standard test conditions (STC) = _____ Watts (STC)

5) DC Module Layout

Identify each source circuit (string) for inverter 1 shown on the roof plan with a Tag (e.g. A,B,C,…)	Number of modules per source circuit for inverter 1
Total number of source circuits for inverter 1:	

6) Are DC/DC Converters used? ☐ Yes ☐ No If No, skip to Step 7. If Yes enter info below.

DC/DC Converter Model #:_____

Max DC Output Current:_____Amps

Max # of DC/DC Converters in an Input Circuit:_____

DC/DC Converter Max DC Input Voltage:_____Volts

Max DC Output Current:_____Volts

DC/DC Converter Max DC Input Power:_____Watts

7) Maximum System DC Voltage

Only use for systems without DC/DC converters.

A. Module V_{OC} (Step 2) _____x # of modules in series (Step 5) _____x C_F (Step 1) _____ = _____V

Table 1. Maximum Number of PV Modules in Series Based on Module Rated V_{OC} for 600 Vdc Rated Equipment (CEC 690.7)													
Max. Rated Module V_{OC} if C_F = 1.12 (Volts)	29.76	31.51	33.48	35.71	38.27	41.21	44.64	48.70	53.57	59.52	66.96	76.53	89.29
Max. Rated Module V_{OC} if C_F = 1.14 (Volts)	29.24	30.96	32.89	35.09	37.59	40.49	43.86	47.85	52.63	58.48	65.79	75.19	87.72
Max # of Modules for 600 Vdc	18	17	16	15	14	13	12	11	10	9	8	7	6

Only use for systems with DC/DC converters. The value calculated below must be less than DC/DC converter max DC input voltage (Step 6).

B. Module V_{OC} (Step 2) _____x # of modules per converter (Step 6) _____x C_F (Step 1) _____ = _____V

Table 2. Largest Module V_{OC} for Single-Module DC/DC Converter Configurations (with 80 V AFCI Cap) (CEC 690.7 and 690.11)																
Max. Rated Module V_{OC} if C_F = 1.12 (Volts)	30.4	33.0	35.7	38.4	41.1	43.8	46.4	49.1	51.8	54.5	57.1	59.8	62.5	65.2	67.9	70.5
Max. Rated Module V_{OC} if C_F = 1.14 (Volts)	29.8	32.5	35.1	37.7	40.4	43.0	45.6	48.2	50.9	53.5	56.1	58.8	61.4	64.0	66.7	69.3
DC/DC Converter Max DC Input (Step #6) (Volts)	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79

8) Maximum System DC Voltage from DC/DC Converters to Inverter — Only required if Yes in Step 6

Maximum System DC Voltage =_____Volts

9) Sizing Source Circuit Conductors

Source Circuit Conductor Size = Min. #10 AWG copper conductor, 90° C wet (USE-2, PV Wire, XHHW-2, THWN-2, RHW-2)

For up to 8 current-carrying conductors in roof-mounted conduit exposed to sunlight at least ½" from the roof covering. (CEC 310)

Note: For over 8 current-carrying conductors in the conduit or mounting height of lower than ½" from the roof, this plan is not applicable.

10) Inverter DC Disconnect

Does the inverter have an integrated DC disconnect? ☐ Yes ☐ No If Yes, skip to Step 11.

If No, the external DC disconnect to be installed is rated for ____Amps (DC) and ____ Volts (DC)

11) Inverter Information

Manufacturer: _____ Model: _____

Max. Continuous AC Output Current Rating: _____ Amps

Max. Short Circuit Current Per Input: _____ Amps

Does PV Module I_{SC} (Step 3) exceed value above? ☐Yes No (If No, this plan is not applicable.)

Integrated DC Arc-Fault Circuit Protection? ☐ Yes ☐ No (If No is selected, this plan is not applicable.)

Grounded or Underground System? ☐ Grounded ☐ Ungrounded

AC Information:

12) Sizing Inverter Output Circuit Conductors and OCPD

Inverter Output OCPD rating = _____ Amps (Table 3)

Inverter Output Circuit Conductor Size = _____ AWG (Table 3)

Table 3. Minimum Inverter Output OCPD and Circuit Conductor Size									
Inverter Continuous Output Current Rating (Amps) (Step 11)	12	16	20	24	28	32	36	40	48
Minimum OCPD Size (Amps)	15	20	25	30	35	40	45	50	60
Minimum Conductor Size (AWG, 75°C, Copper)	14	12	10	10	8	8	6	6	6

13) Point of Connection to Utility – Inverter(s) must be connected to <u>either</u> load or supply side of service disconnecting means. Only one of the sub-sections below and <u>either</u> Single Line Diagram #1 or Single Line Diagram #2 should be filled out.

Only use this section for connections on the <u>load side</u> of the service disconnecting means.

Is the PV OCPD positioned at the opposite end from input feeder location or main OCPD location?

☐Yes ☐No (If No, then use 100% row in Table 4)

Load side connections (Per 705.12(D)(2)(3)(c)):

(Combined inverter output OCPD size + Main OCPD size) ≤ [bus bar size × (100% or 120%)]

Table 4. Maximum Combined Supply OCPDs Based on Bus Bar Rating (Amps) per CEC 705.12(D)(2)(3)(b)									
Bus Bar Rating (Amps)	100	125	125	200	200	200	225	225	225
Main OCPD (Amps)	100	100	125	150	175	200	175	200	225
Max Combined PV System OCPD(s) at 120% of Bus Bar Rating	20	50	25	60*	60*	40	60*	60*	45
Max Combined PV System OCPD(s) at 100% Bus Bar Rating	0	25	0	50	25	0	50	25	0

*This value has been lowered to 60 A from the calculated value to reflect 10 kW AC size maximum.

Reduction of the main breaker is not permitted with this plan. Interconnection to center-fed panelboards may be permitted per Informational Bulletin.[1]

Only use this section for connections on the <u>supply side</u> of the service disconnecting means (between the utility meter and the service disconnecting means). Select one:

☐ Utility- and AHJ-approved meter socket adapter.

Adapter name/model: _____

☐ Service equipment listed for the purpose of PV interconnection.

Description / model number(s): _____

[1] See Page 8, Part 1 of California Solar Permitting Guidebook for guidance. See CA BSC's Information Bulletin 16-03.

14) Rapid Shutdown[2]

The rapid shutdown initiation device shall be labeled according to CEC 690.56(C), and its location shall be shown on the site plan drawing. The rapid shutdown initiation device may be the inverter output or input circuits' disconnecting means, the service main disconnect, or a separate device as approved by the AHJ. The disconnecting means shall be identified for the purpose, suitable for their environment, and listed as a disconnecting means. A single rapid shutdown initiation device shall operate all disconnecting means necessary to control conductors in compliance with CEC 690.12. Note: Check with the AHJ regarding approval where field verification of reduction of voltage within the time required by CEC 690.12 is performed.

Rapid shutdown shall be provided as required by CEC 690.12 with one of the following methods (Select one):

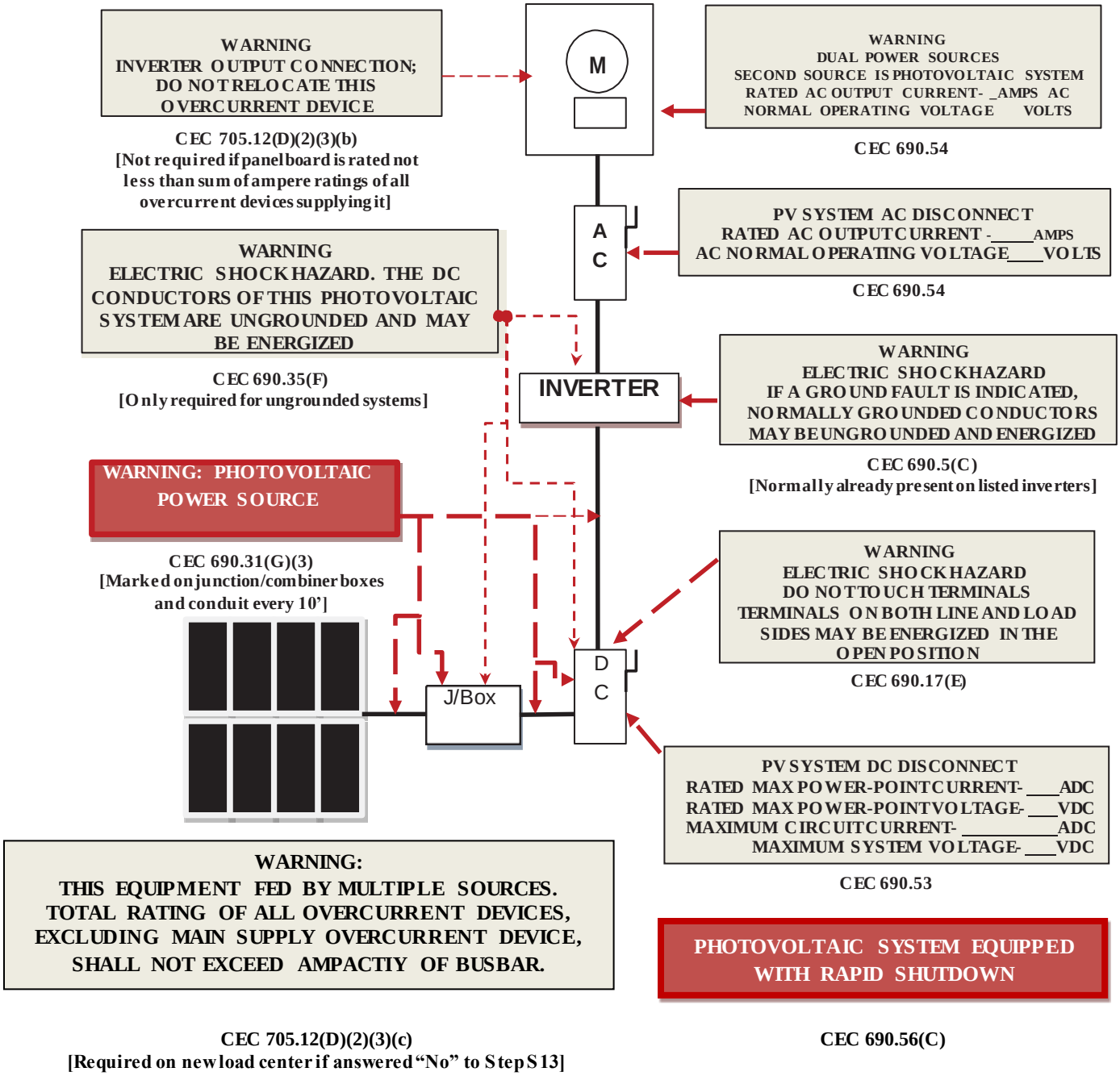
- ☐ The inverter(s) is within 10 feet of the array, and the location of the inverter is such that uncontrolled PV system conductors are no greater than 5 feet of length within the building. A remotely-controlled AC disconnecting means is required immediately adjacent to or as close as practicable to the inverters, and located within 10 feet of the array.
- ☐ The inverter(s) is within 10 feet of the array, and the location of the inverter is such that uncontrolled PV system conductors are no greater than 5 feet of length within the building. Reduction of the voltage for the inverter output within the time required by CEC 690.12 shall be verified in the field, or the inverter output is listed to UL 1741 with rapid shutdown capability.
- ☐ Remotely-controlled DC disconnecting means are located within 10 feet of the PV array and DC input of the inverter(s), and the locations of the disconnecting means are such that uncontrolled PV system conductors are no greater than 5 feet of length within the building. Reduction of the voltage for the inverter output within the time required by CEC 690.12 shall be verified in the field, or the inverter output is listed to UL 1741 with rapid shutdown capability.
- ☐ Remotely-controlled DC disconnecting means is located within 10 feet of the array at the DC input of inverter(s) connected to a module level DC-DC converter circuit where the DC-DC converter circuit meets the requirements for controlled conductors when disconnected from the inverter. Reduction of the voltage for the DC-DC converter output and the inverter output within the time required by CEC 690.12 shall be verified in the field, or the DC-DC converter output and the inverter output are listed to UL 1741 with rapid shutdown capability.
- ☐ A UL 1741-listed and identified inverter(s) with input and output rapid shutdown capability supplying module level DC-DC converter circuit where the DC-DC converter circuit meets the requirements for controlled conductors when disconnected from the inverter.
- ☐ A UL 1741-listed rapid shutdown system:
  Manufacturer: _____
  Testing Agency Name: _____
  System Model Number: _____
  System Components: _____

15) Grounding and Bonding of Modules and Racking System (select one):

- ☐ Racking system listed to UL 2703 using modules identified in the listing.
- ☐ Other method subject to AHJ approval

[2] See Page 8, Part 1 of the California Solar Permitting Guidebook for guidance. See CA BSC's Information Bulletin 16-03.

CEC Articles 690 and 705 and CA Residential Code Section R324 require the following labels or markings be installed at these components of the photovoltaic system:



Informational note: ANSI Z535.4-2011 provides guidelines for the design of safety signs and labels for application to products. 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.

CEC 705.12 requires a permanent plaque or directory denoting all electric power sources on or in the premises or rapid fire shutdown equipment.

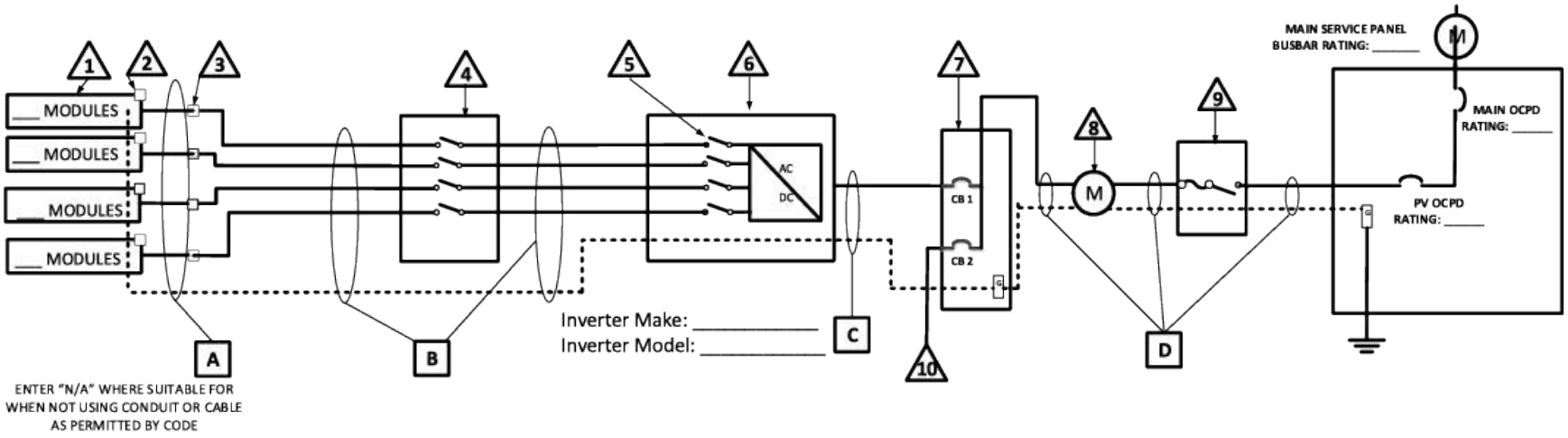
TAG	DESCRIPTION
1	SOLAR PV MODULE / STRING
2	DC/DC CONVERTERS INSTALLED? YES / NO (IF YES, STEPS 6 & 8 REQUIRED)
3	SOURCE CIRCUIT JUNCTION BOX INSTALLED?: YES / NO
4	SEPARATE DC DISCONNECT INSTALLED?: YES / NO
5	INTERNAL INVERTER DC DISCONNECT: YES / NO
6	CENTRAL INVERTER
7	LOAD CENTER INSTALLED?: YES / NO
8	PV PRODUCTION METER INSTALLED?: YES / NO
9	*SEPARATE AC DISCONNECT INSTALLED?: YES / NO
10	CONNECT TO INVERTER #2 (USE LINE DIAGRAM 3)

* Consult with your local AHJ and /or Utility

SINGLE-LINE DIAGRAM #1 – LOAD SIDE CONNECTION

CHECK A BOX FOR WHETHER SYSTEM IS GROUNDED OR UNGROUNDED: ☐ GROUNDED (INCLUDE GEC)
REFER TO STEP 14 FOR RAPID SHUTDOWN DETAILS ☐ UNGROUNDED

FOR UNGROUNDED SYSTEMS:
- DC OCPD MUST DISCONNECT BOTH CONDUCTORS OF EACH SOURCE CIRCUIT
- UNGROUNDED CONDUCTORS MUST BE IDENTIFIED PER 210.5(C). WHITE-FINISHED CONDUCTORS ARE NOT PERMITTED.



☐

CONDUCTOR/CONDUIT SCHEDULE					
TAG	DESCRIPTION AND CONDUCTOR TYPE	CONDUCTOR SIZE	NUMBER OF CONDUCTORS	CONDUIT/CABLE TYPE	CONDUIT SIZE
A	USE-2 ☐ OR PV-WIRE ☐				
	EGC/GEC:				
B					
	EGC/GEC:				
C					
	EGC/GEC:				
D					
	EGC/GEC:				

TAG	DESCRIPTION
1	SOLAR PV MODULE / STRING
2	DC/DC CONVERTERS INSTALLED? YES / NO (IF YES, STEPS 6 & 8 REQUIRED)
3	SOURCE CIRCUIT JUNCTION BOX INSTALLED?: YES / NO
4	SEPARATE DC DISCONNECT INSTALLED?: YES / NO
5	INTERNAL INVERTER DC DISCONNECT: YES / NO
6	CENTRAL INVERTER
7	LOAD CENTER INSTALLED?: YES / NO
8	PV PRODUCTION METER INSTALLED?: YES / NO
9	*SEPARATE AC DISCONNECT INSTALLED?: YES / NO
10	CONNECT TO INVERTER #2 (USE LINE DIAGRAM 3)

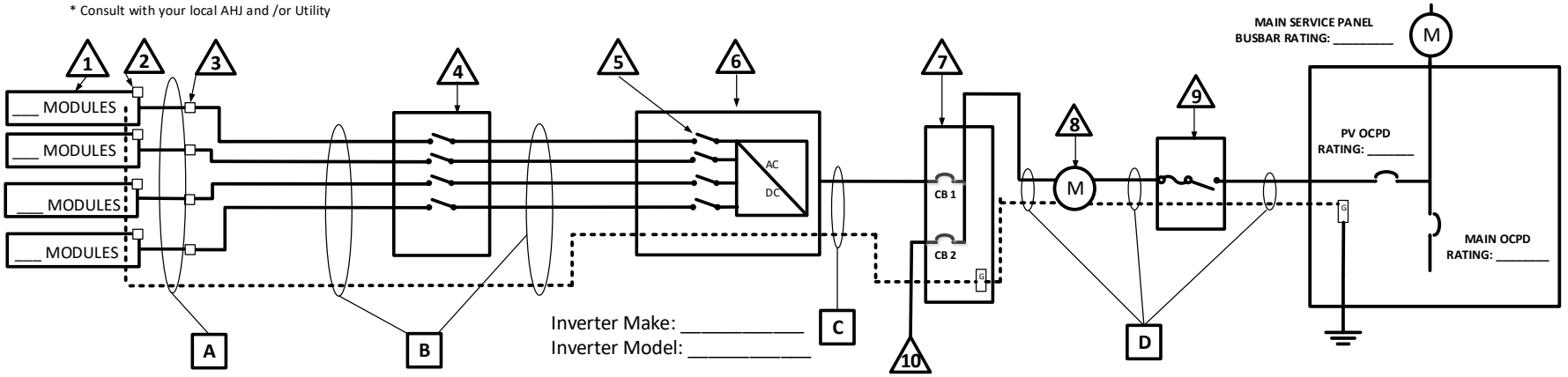
* Consult with your local AHJ and /or Utility

SINGLE-LINE DIAGRAM #2 – SUPPLY SIDE CONNECTION

CHECK A BOX FOR WHETHER SYSTEM IS GROUNDED OR UNGROUNDED: ☐ **GROUNDED (INCLUDE GEC)**

REFER TO STEP 14 FOR RAPID SHUTDOWN DETAILS ☐ **UNGROUNDED**

FOR UNGROUNDED SYSTEMS:
- DC OCPD MUST DISCONNECT BOTH CONDUCTORS OF EACH SOURCE CIRCUIT
- UNGROUNDED CONDUCTORS MUST BE IDENTIFIED PER 210.5(C). WHITE-FINISHED CONDUCTORS ARE NOT PERMITTED.



ENTER "N/A" WHERE SUITABLE FOR WHEN NOT USING CONDUIT OR CABLE AS PERMITTED BY CODE

CONDUCTOR/CONDUIT SCHEDULE

☐ TAG	DESCRIPTION AND CONDUCTOR TYPE	CONDUCTOR SIZE	NUMBER OF CONDUCTORS	CONDUIT/CABLE TYPE	CONDUIT SIZE
A	USE-2 □ OR PV-WIRE □				
	EGC/GEC:				
B					
	EGC/GEC:				
C					
	EGC/GEC:				
D					
	EGC/GEC:				

Select one interconnection method:

☐ Utility- and AHJ-approved meter socket adapter.
Adapter name/model: _____

☐ Service equipment listed for purpose of PV interconnection.
Description / model number: _____

Solar PV Standard Plan — Simplified
Central/String Inverter Systems for One- and Two-Family Dwellings

Supplemental Calculation Sheets for Inverter #2 (Only include if second inverter is used)

DC Information:

Module Manufacturer:_____ Model: _____

S2) Module V_{OC} (from module nameplate): _____ Volts

S3) Module I_{SC} (from module nameplate): ____ Amps

Is Module I_{SC} less than 13 Amps? ☐ Yes ☐ No (If No, this plan is not applicable.)

S4) Module DC output power under standard test conditions (STC) =_____Watts (STC)

S5) DC Module Layout

Identify each source circuit (string) for inverter 2 shown on the roof plan with a Tag (e.g. A,B,C,…)	Number of modules per source circuit for inverter 2
Total number of source circuits for inverter 2:	

S6) Are DC/DC Converters used? ☐ Yes ☐ No If No, skip to Step S7. If Yes, enter info below.

DC/DC Converter Model #:_____

Max DC Output Current:_____Amps

Max # of DC/DC Converters in an Input Circuit: _____

DC/DC Converter Max DC Input Voltage:_____Volts

Max DC Output Current:_____Volts

DC/DC Converter Max DC Input Power:_____Watts

S7) Maximum System DC Voltage

Only use for systems without DC/DC converters.

A. Module V_{OC} (Step S2)_____ x # of modules in series (Step S5) _____ x C_F (Step 1) _____ = _____V

Table S1. Maximum Number of PV Modules in Series Based on Module Rated V_{OC} for 600 Vdc Rated Equipment (CEC 690.7)													
Max. Rated Module V_{OC} if C_F = 1.12 (Volts)	29.76	31.51	33.48	35.71	38.27	41.21	44.64	48.70	53.57	59.52	66.96	76.53	89.29
Max. Rated Module V_{OC} if C_F = 1.14 (Volts)	29.24	30.96	32.89	35.09	37.59	40.49	43.86	47.85	52.63	58.48	65.79	75.19	87.72
Max # of Modules for 600 Vdc	18	17	16	15	14	13	12	11	10	9	8	7	6

Only use for systems with DC/DC converters. The value calculated below must be less than DC/DC converter max DC input voltage (Step S6).

B. Module V_{OC} (Step S2) _____ x # of modules per converter (Step S6)_____ x C_F (Step 1) _____ = _____V

Table S2. Largest Module V_{OC} for Single-Module DC/DC Converter Configurations (with 80 V AFCI Cap) (CEC 690.7 and 690.11)																
Max. Rated Module V_{OC} if C_F = 1.12 (Volts)	30.4	33.0	35.7	38.4	41.1	43.8	46.4	49.1	51.8	54.5	57.1	59.8	62.5	65.2	67.9	70.5
Max. Rated Module V_{OC} if C_F = 1.14 (Volts)	29.8	32.5	35.1	37.7	40.4	43.0	45.6	48.2	50.9	53.5	56.1	58.8	61.4	64.0	66.7	69.3
DC/DC Converter Max DC Input (Step #6) (Volts)	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79

S8) Maximum System DC Voltage from DC/DC Converters to Inverter — Only required if Yes in Step S6

Maximum System DC Voltage = _____ Volts

S9) Sizing Source Circuit Conductors

Source Circuit Conductor Size = Min. #10 AWG copper conductor, 90° C wet (USE-2, PV Wire, XHHW-2, THWN-2, RHW-2)

For up to 8 current-carrying conductors in roof-mounted conduit exposed to sunlight at least ½" from the roof covering. (CEC 310)

Note: For over 8 current-carrying conductors in the conduit or mounting height of lower than ½" from the roof, this plan is not applicable.

S10) Inverter Disconnect

Does the inverter have an integrated DC disconnect? ☐ Yes ☐ No If Yes, skip to Step S11.

If no, the external DC disconnect to be installed is rated for ____Amps (DC) and ____Volts (DC)

S11) Inverter Information

Manufacturer: _____ Model: _____

Max. Continuous AC Output Current Rating: _____ Amps

Max. Short Circuit Current Per Input: _____ Amps

Does PV Module I_{SC} (Step S3) exceed value above? ☐ Yes ☐ No (If No, this plan is not applicable.)

Integrated DC Arc-Fault Circuit Protection? ☐ Yes ☐ No (If No is selected, this plan is not applicable.)

Grounded or Underground System? ☐ Grounded ☐ Ungrounded

AC Information:

S12) Inverter Information

Inverter Output OCPD rating = _____ Amps (Table S3)

Inverter Output Circuit Conductor Size = _____ AWG (Table S3)

Table S3. Minimum Inverter Output OCPD and Circuit Conductor Size									
Inverter Continuous Output Current Rating (Amps) (Step S13)	12	16	20	24	28	32	36	40	48
Minimum OCPD Size (Amps)	15	20	25	30	35	40	45	50	60
Minimum Conductor Size (AWG, 75°C, Copper)	14	12	10	10	8	8	6	6	6

Load Center Calculations
(Omit if a load center will not be installed for PV OCPDs)

S11) Load Center Output:

Calculate the sum of the maximum AC outputs from each inverter.

Inverter #1 Max Continuous AC Output Current Rating [STEP 11] _____ × 1.25 = _____ Amps

Inverter #2 Max Continuous AC Output Current Rating [STEP S11] _____ × 1.25 = _____ Amps

Total inverter currents connected to load center (sum of above) = _____ Amps

Conductor Size: _____ AWG

Overcurrent Protection Device: _____ Amps

Load center bus bar rating: _____ Amps

Can the load center accept more than two breakers? ☐ Yes ☐ No

If Yes, the sum of 125% of the inverter output circuit currents and the rating of the overcurrent device protecting the busbar shall not exceed 120% of the ampacity of the busbar.

If No, the sum of ampere rating of the two PV overcurrent devices shall not exceed the rating of the busbar.

TAG	DESCRIPTION
1	SOLAR PV MODULE / STRING
2	DC/DC CONVERTERS INSTALLED? YES / NO (IF YES, STEPS 6 & 8 REQUIRED)
3	SOURCE CIRCUIT JUNCTION BOX INSTALLED?: YES / NO
4	SEPARATE DC DISCONNECT INSTALLED?: YES / NO
5	INTERNAL INVERTER DC DISCONNECT: YES / NO
6	CENTRAL INVERTER
7	*SEPARATE AC DISCONNECT INSTALLED?: YES / NO
8	TO LOAD CENTER ON LINE DIAGRAM 1

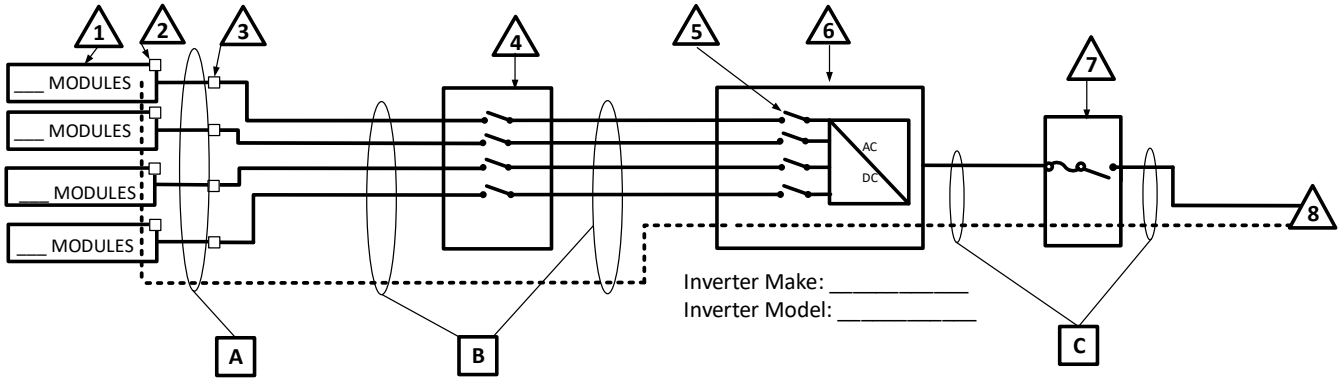
* Consult with your local AHJ and /or Utility

SINGLE-LINE DIAGRAM #3 – ADDITIONAL INVERTER

INVERTER # 2

CHECK A BOX FOR WHETHER SYSTEM IS GROUNDED OR UNGROUNDED: ☐ GROUNDED (INCLUDE GEC)
REFER TO STEP 14 FOR RAPID SHUTDOWN DETAILS ☐ UNGROUNDED

FOR UNGROUNDED SYSTEMS:
- DC OCPD MUST DISCONNECT BOTH CONDUCTORS OF EACH SOURCE CIRCUIT
- UNGROUNDED CONDUCTORS MUST BE IDENTIFIED PER 210.5(C). WHITE-FINISHED CONDUCTORS ARE NOT PERMITTED.



CONDUCTOR/CONDUIT SCHEDULE					
☐ TAG	DESCRIPTION AND CONDUCTOR TYPE	CONDUCTOR SIZE	NUMBER OF CONDUCTORS	CONDUIT/CABLE TYPE	CONDUIT SIZE
A	USE-2 ☐ OR PV-WIRE ☐				
	EGC/GEC:				
B					
	EGC/GEC:				
C					
	EGC/GEC:				

ENTER "N/A" WHERE SUITABLE FOR WHEN NOT USING CONDUIT OR CABLE AS PERMITTED BY CODE

SOLAR PV STANDARD PLAN

Roof Layout Diagram for One- and Two-Family Dwellings

Items required: roof layout of all panels, modules, clear access pathways and approximate locations of electrical disconnecting means, roof access points, and rapid shutdown initiation device.

SCOPE: Use this plan ONLY for electrical review of systems using utility-interactive Microinverters or AC Modules (ACM) not exceeding a combined system AC inverter output rating of 10 kW, with a maximum of 3 branch circuits, one PV module per inverter, and installed on the roof of a one-or two-family dwelling or accessory structure. The photovoltaic system must interconnect to a single-phase AC service panel of 120/240 Vac with service panel bus bar rating of 225 A or less. Plan also applies to supply side connections (between the meter and the service disconnects), where permitted by the local utility. This plan is not intended for bipolar systems, hybrid systems or systems that utilize storage batteries, charge controllers or trackers. Systems must be in compliance with current California Building Standards Codes and local amendments of the authority having jurisdiction (AHJ). Other articles of the California Electrical Code (CEC) shall apply as specified in section 690.3. For systems beyond this scope or the criteria in this plan, consult the AHJ for details regarding comprehensive process.

MANUFACTURER'S SPECIFICATION SHEETS MUST BE PROVIDED for proposed inverters, modules, combiner/junction boxes and racking systems. Installation instructions for bonding and grounding equipment shall be provided and local AHJs may require additional details. Listed and labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling (CEC 110.3). Equipment intended for use with PV system shall be identified and listed for the application CEC 690.4(D).

Applicant and Site Information

Job Address:_____ Permit #:_____

Contractor/Engineer Name:_____ License # and Class:_____

Signature:_____ Date:_____ Phone Number:_____

1. General Requirements and System Information

☐ Microinverter
Number of PV modules installed:_____
Number of Microinverters installed:_____

☐ AC Module (ACM)
Number of ACMs installed:_____
*Note: Listed Alternating-Current Module (ACM) is defined in **CEC 690.2** and installed per **CEC690.6***

1.1 Number of Branch Circuits, 1, 2 or 3:_____

1.2 Actual number of Microinverters or ACMs per branch circuit: 1._____ 2._____ 3._____

1.3 Total AC system power rating = (Total Number of Microinverters or ACMs) * (AC inverter power output) =_____Watts

1.4 Lowest expected ambient temperature for this plan in Table 1: For -1° to -5° C use 1.12 or for -6° to -10° C use 1.14 correction factors.

1.5 Average ambient high temperature for this plan: = +47° C
Note: For lower expected ambient or higher average ambient high temperatures, this plan is not applicable.

2. Microinverter or ACM Information and Ratings

Microinverters with ungrounded DC inputs shall be installed in accordance with CEC 690.35.

Microinverter or ACM Manufacturer:_____

Model:_____

2.1 Rated (continuous) AC output power:_____Watts

2.2 Nominal AC voltage rating:_____Volts

2.3 Rated (continuous) AC output current:_____Amps

If installing ACMs, skip [Steps 2.4 & 2.5]

2.4 Maximum DC input voltage rating:_____Volts (limited to 79 V, otherwise this plan is not applicable)

2.5 Maximum input short circuit current: _____Amps

2.6 Maximum AC output overcurrent protection device (OCPD): _____Amps

2.7 Maximum number of microinverters or ACMs per branch circuit: _____

3. PV Module Information

(If installing ACMs, skip to [Step 4])

PV Module Manufacturer: _____

Model: _____

Module DC output power under standard test conditions (STC) =_____Watts

3.1 Module V_{OC} at STC (from module nameplate):_____Volts

3.2 Module I_{SC} at STC (from module nameplate):_____Amps [**cannot exceed Step 2.5**]

3.3 Adjusted PV Module DC voltage at minimum temperature = [Table 1]_____[**cannot exceed Step 2.4**]

Table 1. Module V_{OC} at STC Based on Inverter Maximum DC Input Voltage Derived from CEC 690.7																
Microinverter Max. DC Input [Step 2.4] (Volts)	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79
Max. Module VOC @ STC, 1.12 (-1° to -5° C) Correction Factor (Volts)	30.4	33.0	35.7	38.4	41.1	43.8	46.4	49.1	51.8	54.5	57.1	59.8	62.5	65.2	67.9	70.5
Max. Module VOC @ STC, 1.14 (-6° to -10° C) Correction Factor (Volts)	29.8	32.5	35.1	37.7	40.4	43.0	45.6	48.2	50.9	53.5	56.1	58.8	61.4	64.0	66.7	69.3

4. Branch Circuit Output Information

Fill in [Table 3] to describe the branch circuit inverter output conductor and OCPD size. Use [Table 2] for determining the OCPD and Minimum Conductor size.

Table 2. Branch Circuit OCPD and Minimum Conductor Size*				
Circuit Current (Amps)	Circuit Power (Watts)	OCPD (Amps)	Minimum Conductor Size (AWG)	Minimum Metal Conduit Size for 6 Current Carrying Conductors
12	2880	15	12	¾"
16	3840	20	10	¾"
20	4800	25	8	1"
24	5760	30	8	1"

*CEC 690.8 and 210.19 (A)(1) factored in Table 2, conductors are copper, insulation must be 90° C wet-rated. Table 2 values are based on maximum ambient temperature of 69° C, which includes 22° C adder, exposed to direct sunlight, mounted > 0.5 inches above rooftop, ≤ 6 current-carrying conductors (3 circuits) in a circular raceway. Otherwise, this plan is not applicable.

Table 3. PV Array Configuration Summary			
	Branch 1	Branch 2	Branch 3
Number of Microinverters or ACMs [Step 1]			
Selected Conductor Size [Table 2] (AWG)			
Selected Branch and Inverter Output OCPD [Table 2]			

5. Solar Load Center (if used)

5.1 Circuit Power see [Step 1.3] = _____ Watts

5.2 Circuit Current = (Circuit Power) / (AC voltage) = _____ Amps

5.3 Solar Load Center Bus Bar Rating (use Table 4) = Min. _____ Amps

5.4 Solar Load Center Feeder Breaker Rating (use Table 4) = _____ Amps

NOTE: If OCPDs of circuits other than for the inverter outputs are present, solar load center bus bar rating must be a minimum of 100 Amps, and the feeder breaker is limited to a maximum of 60 Amps.

Table 4. Solar Load Center and Total Inverter Output OCPD and Conductor Size**					
Circuit Current (Amps)	Circuit Power (Watts)	OCPD (Amps)	Min. Solar Load Center Bus Bar Rating (Amps)***	Minimum Conductor Size	Minimum Metal Conduit Size
24	5760	30	30	10	½"
28	6720	35	35	8	¾"
32	7680	40	40	8	¾"
36	8640	45	45	8	¾"
40	9600	50	50	8	¾"
41.6	≤ 10000	60	60	6	¾"

**CEC 690.8 and 210.19 (A)(1) factored in Table 4, conductors are copper, insulation must be 90° C wet-rated. Table 4 values are based on maximum ambient temperature of 47° C (no rooftop temperature adder in this calculation), ≤ 3 current carrying conductors in a circular raceway. Otherwise, this plan is not applicable.

***Exception: listed combiners are permitted to be used when they're installed in accordance with their listing and the manufacturer's instructions.

6. Point of Connection to Utility

6.1 Inverter(s) must be connected to either load or supply side of service disconnecting means. Either Step 6.2 or 6.3 below should be filled out, and either Single Line Diagram #1 or Single Line Diagram #2 should be filled out.

6.2 Load side connections only (Per 705.12(D)(2)(3)):
Is the PV OCPD positioned at the opposite end from input feeder location or main OCPD location?
☐ Yes ☐ No (If No, then use 100% row in Table 5)
(Combined inverter output OCPD size + Main OCPD size) ≤ [bus bar size × (100% or 120%)]

Table 5. Maximum Combined Inverter Output Circuit OCPD									
Bus Bar Size (Amps)	100	125	125	200	200	200	225	225	225
Main OCPD (Amps)	100	100	125	150	175	200	175	200	225
Maximum Combined Inverter OCPD with **120%** of bus bar rating (Amps)	20	50	25	60†	60†	40	60†	60†	45
Maximum Combined Inverter OCPD with **100%** of bus bar rating (Amps)	0	25	0	50	25	0	50	25	0

†This plan limits max system size to 10kW or less, so the OCPD size is limited to 60 A. Reduction of Main Breaker is not permitted with this plan. Interconnection to center-fed panelboards may be permitted per Informational Bulletin.

6.3 Supply side connections only (Per 705.12(A)):

Only use this section for connections on the supply side of the service disconnecting means. Select one:

☐ Utility- and AHJ-approved meter socket adapter.

Adapter name/model: _____

☐ Service equipment listed for the purpose of PV interconnection.

Description / model number(s): _____

7. Grounding and Bonding

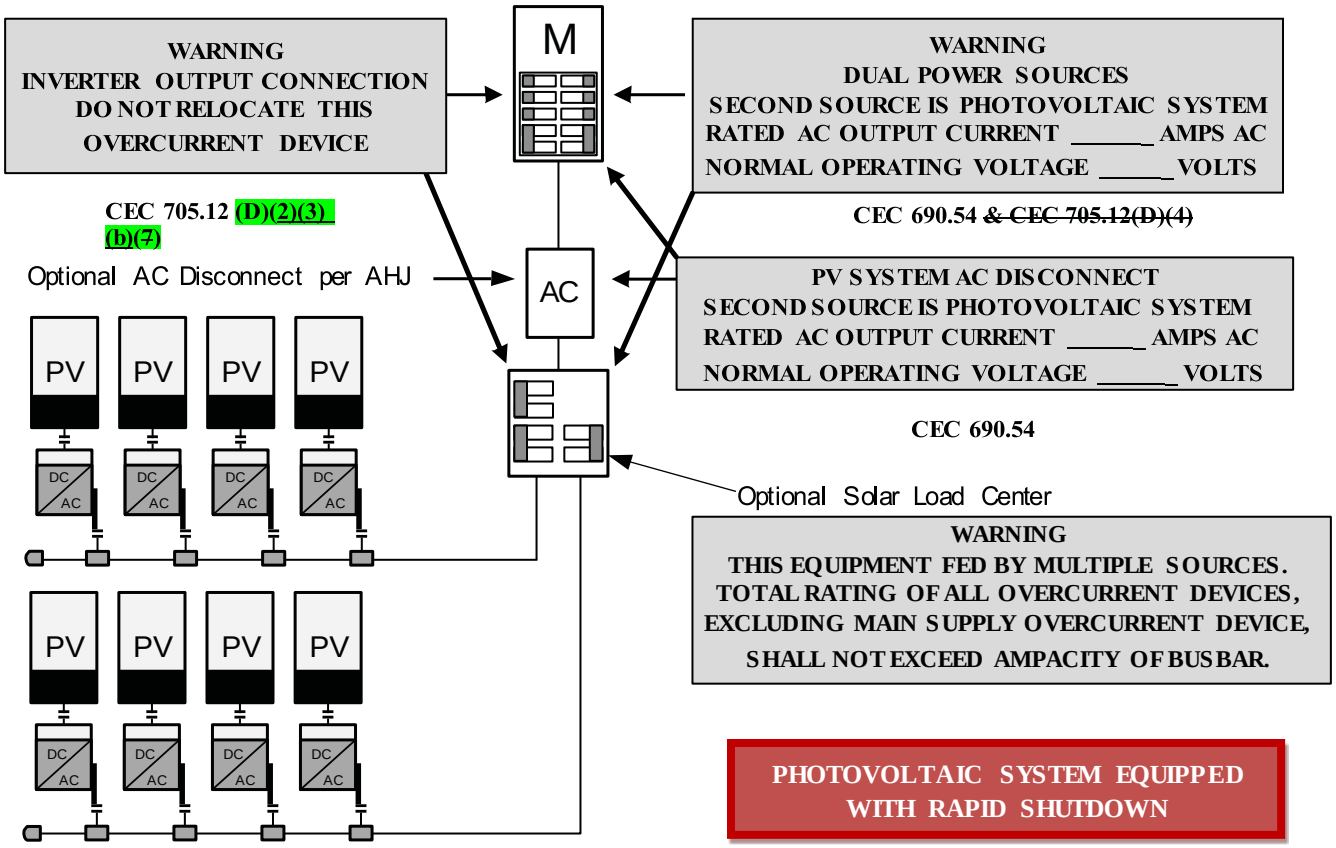
Check one of the boxes for whether system is grounded or ungrounded: ☐ Grounded ☐ Ungrounded

For Microinverters with a grounded DC input, systems must follow the requirements of GEC (CEC 690.47) and EGC (CEC 690.43).

For ACM systems and Microinverters with ungrounded a DC input follow the EGC requirements of (CEC 690.43).

8. Markings

Informational note: ANSI Z535.4-2011 provides guidelines for the design of safety signs and labels for application to products. 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.



NOTE: CEC 705.10 requires a permanent plaque or directory denoting all electric power sources on or in the premises.

Solar PV Standard Plan — Simplified
Microinverter & ACM Systems for One- and Two-Family Dwellings

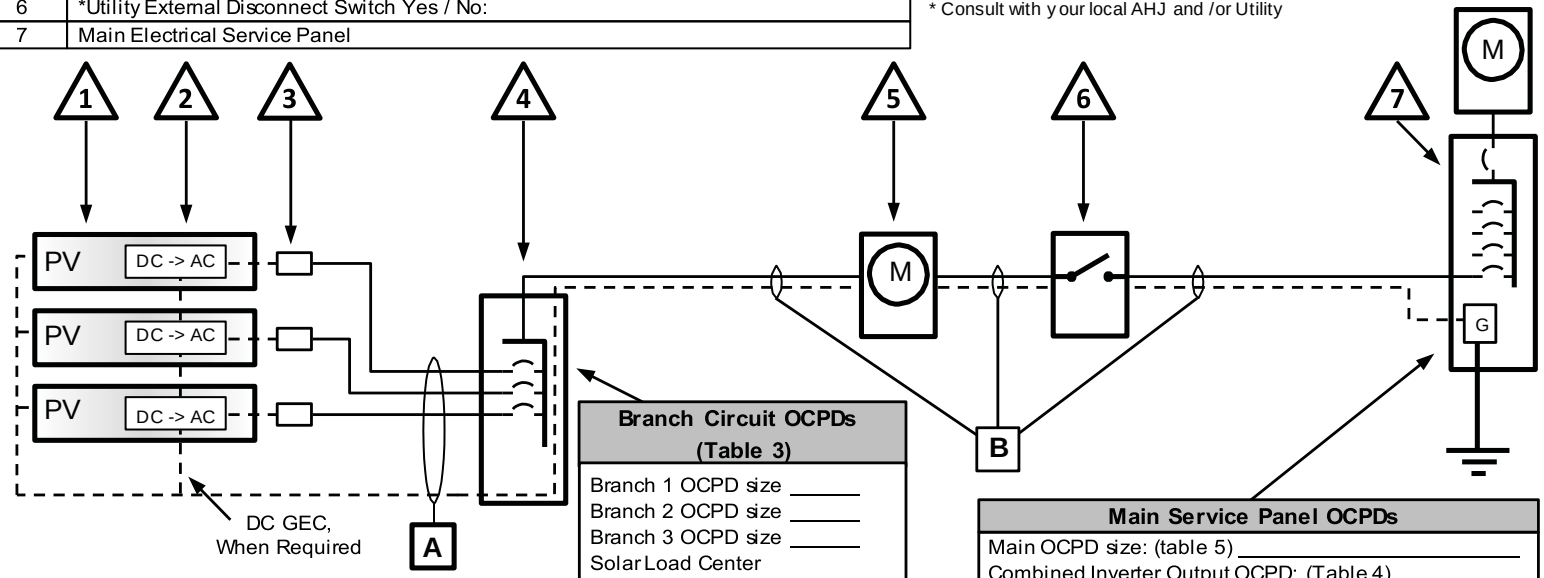
Equipment Schedule

TAG	DESCRIPTION: (Provide model # if provided)
1	Solar PV Module or ACM:
2	Microinverter (if not ACM):
3	Junction Box:
4	Solar Load Center, Yes / No:
5	Performance Meter Yes / No:
6	*Utility External Disconnect Switch Yes / No:
7	Main Electrical Service Panel

Single-Line Diagram #1 for Microinverters or ACMs (Load Side Connection)

Check a box for dc system grounding: ☐ Grounded, ☐ Ungrounded
For ungrounded dc power systems, EGC is required
For grounded dc power systems, GEC & EGC are required
Refer to CEC 250.120 for EGC installation & Table 250.122 for sizing

* Consult with your local AHJ and /or Utility



Branch Circuit OCPDs (Table 3)

Branch 1 OCPD size _____
Branch 2 OCPD size _____
Branch 3 OCPD size _____
Solar Load Center
Busbar(Section 5) _____

Main Service Panel OCPDs

Main OCPD size: (table 5) _____
Combined Inverter Output OCPD: (Table 4)_____
Main Service Panel Busbar: (Table 5)_____

Conductor, Cable and Conduit Schedule

TAG	Description and Conductor Type: (Table 3)	Conductor Size	Number of Conductors	Conduit/ Conductor/ Cable Type	Conduit Size
A	Current-Carrying Conductors: (for each branch circuit)				
	EGC:				
	GEC (when required):				
B	Current-Carrying Conductors:				
	EGC:				
	GEC (when required):				

Equipment Schedule

△ TAG	DESCRIPTION: (Provide model # if provided)
1	Solar PV Module or ACM:
2	Microinverter (if not ACM):
3	Junction Box:
4	Solar Load Center, Yes / No:
5	Performance Meter Yes / No:
6	*Utility External Disconnect Switch Yes / No:
7	Main Electrical Service Panel

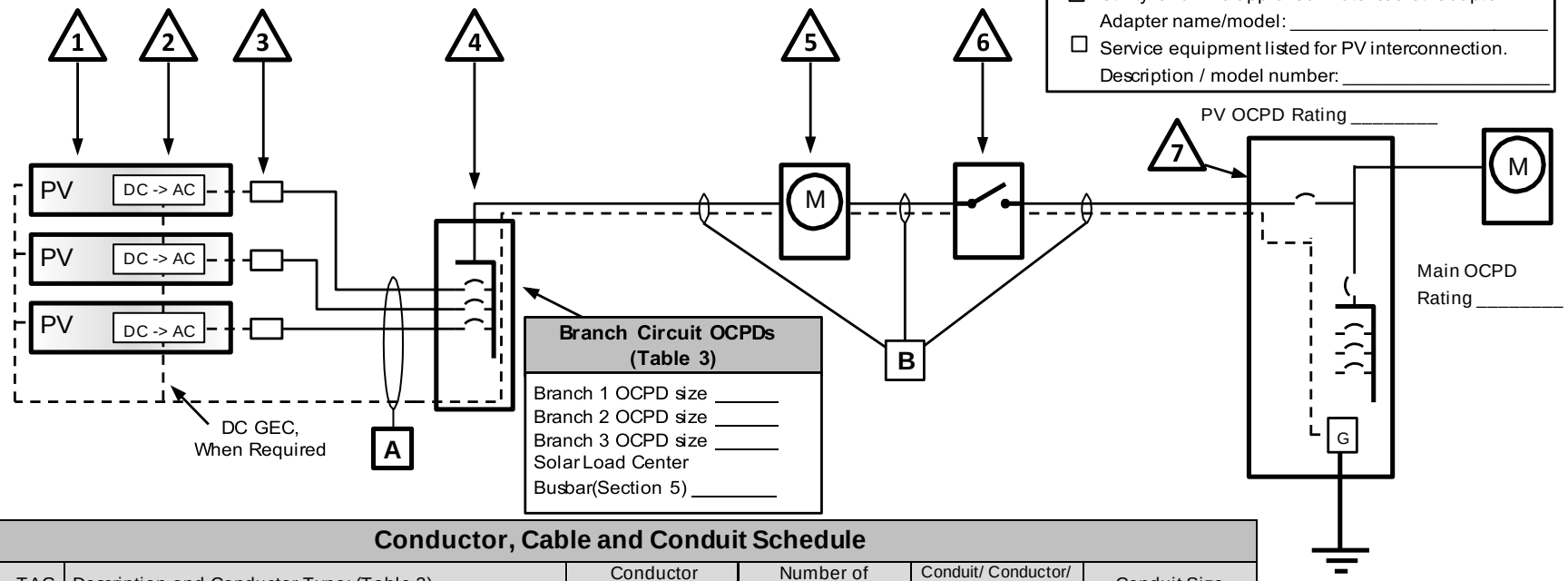
Single-Line Diagram #2 for Microinverters or ACMs (Supply Side Connection)

Check a box for dc system grounding: ☐ Grounded, ☐ Ungrounded
For ungrounded dc power systems, EGC is required
For grounded dc power systems, GEC & EGC are required
Refer to CEC 250.120 for EGC installation & Table 250.122 for sizing

* Consult with your local AHJ and /or Utility

Supply Side Connection (Select One)

☐ Utility-and AHJ-approved meter socket adapter.
Adapter name/model: _____
☐ Service equipment listed for PV interconnection.
Description / model number: _____



Branch Circuit OCPDs (Table 3)

Branch 1 OCPD size _____
Branch 2 OCPD size _____
Branch 3 OCPD size _____
Solar Load Center
Busbar(Section 5) _____

Conductor, Cable and Conduit Schedule

TAG	Description and Conductor Type: (Table 3)	Conductor Size	Number of Conductors	Conduit/ Conductor/ Cable Type	Conduit Size
A	Current-Carrying Conductors: (for each branch circuit)				
	EGC:				
	GEC (when required):				
B	Current-Carrying Conductors:				
	EGC:				
	GEC (when required):				

SOLAR PV STANDARD PLAN — SIMPLIFIED

Microinverter and ACM Systems for One- and Two-Family Dwellings

ROOF LAYOUT PLAN

Items required: roof layout of all panels, modules, clear access pathways and approximate locations of electrical disconnecting means and roof access points.

Use of this document

This toolkit document includes a one-page list of structural criteria for over-the-counter or online approval, as well as attached tables and figures that supplement the criteria and explain their use.

This document applies to flush-mounted solar arrays installed on the roofs of wood-framed one- and two-family dwellings. "Flush-mounted" means the modules are installed parallel to, and relatively close to, the roof surface (see the "Solar Array Check" section of the Structural Criteria for specific qualifying requirements). This list is intended to be a simple pre-installation check to gain reasonable assurance that the design of the solar array complies with the structural provisions of the 2016 California Building Code (CBC) and 2016 California Residential Code (CRC). It is not intended to provide post-installation inspection criteria.

Currently Used Expedited Solar Permitting Approaches

This document is intended for jurisdictions without an expedited process for residential solar structural permitting, and is not intended to replace or supplant procedures for jurisdictions with an expedited process already in place. Good examples from jurisdictions with provisions for expedited structural permitting include the City of Los Angeles, which exempts residential solar installations from structural permitting if five simple requirements are met, and the East Bay Green Corridor's streamlined solar permitting process, which uses structural criteria tailored to typical conditions for that consortium of nine cities.

Regional and Site Assumptions

This document is based on the following regional and site assumptions:

- The dwelling is located in a ZERO snow load area (see Map 1).
- The dwelling is not in Wind Exposure D (within 200 yards of the ocean or a large coastal bay).
- If in Wind Exposure B (urban, suburban or wooded areas), the dwelling may be located:
  - in a Special Wind Region (see Map 2) with design wind speeds between 110 and 130 mph.
  - on a tall hill, provided average slope is no steeper than 15%.
- If in Wind Exposure C (within 500 yards of large open fields or grasslands), the dwelling is:
  - in a standard 110 mph design wind speed region.
  - not on a hill with a grade steeper than 5%.

Additional Options

The Chief Building Official (CBO) may consider adding rows to the structural criteria, based on personal judgment and their jurisdiction's conditions and history. Possible additional questions include:

- Regional and Site Checks
  - If the jurisdiction is in a mixed snow load area, with zero snow load only at lower elevations, consider asking, "Is the dwelling lower than elevation_feet?"

  - If the jurisdiction is in a coastal region, consider asking, "Is the dwelling farther than 200 yards from the ocean or a large coastal bay?" to verify the dwelling is not in Wind Exposure D.
  - If the jurisdiction is in a Special Wind Region with design wind speeds between 115 and 130 mph, consider verifying that the dwelling is in Wind Exposure B by asking, "Is the dwelling in an urban, suburban or wooded area, and *not* within 500 yards of open fields and grasslands?"
  - If the jurisdiction is in a Special Wind Region with design wind speeds between 115 and 130 mph, consider verifying that there are no significant topographic wind speed-up effects by asking, "Is the dwelling in a relatively flat area (grade less than 5%) and not within 500 yards of the crest of a tall hill?"

- Roof Check
  - Based on the jurisdiction's one- and two-family housing stock and code compliance history, many CBOs will find it reasonable to assume that most dwellings' roof structures were designed to the building code in effect at the time the houses were built. If so, the roof structure code compliance check consists of the Contractor's visual roof audit, checking for unusual sagging or deterioration, without requiring additional measurements of existing rafters to check against span tables.
  - For CBOs of jurisdictions with evidence of structurally deficient one- and two-family housing stock or poor structural code compliance history, the CBO may elect to add the rafter span check option described in the criteria.

The Structural Toolkit and CRC Wind Speeds

The 2013 CRC contained an inconsistency related to wind speeds. Despite referencing ASCE 7-10 as its standard, the 2016 CRC's text and tables use outdated ASCE 7-05 wind speeds. Under the old ASCE 7-05/CBC 2010, the basic design wind speed in most regions of the state was 85 mph (max. 3 second gust in 50 years).
Under ASCE 7-10/CBC 2016, the design wind speed has increased to 110 mph (max. 3 second gust in 700 years). Despite the different definitions of wind speed, design wind pressures remain essentially unchanged.

Because the toolkit's structural document is intended to be forward looking, all wind speeds in the toolkit document are based on the ASCE 7-10. This is clearly stated in the caption to the state wind speed map, and in the Table 1 footnotes. This anticipates an obvious and expected correction to the CRC; otherwise the toolkit would become immediately outdated when the CRC is amended to change the base design wind speed from 85 mph to 110 mph.

2013 CRC text (ASCE 7-05) wind speeds equivalent to the 2016 CRC and CBC Reference Standard (ASCE 7-10) are shown below. See ASCE 7-10 Table C26.5-6 for additional information.

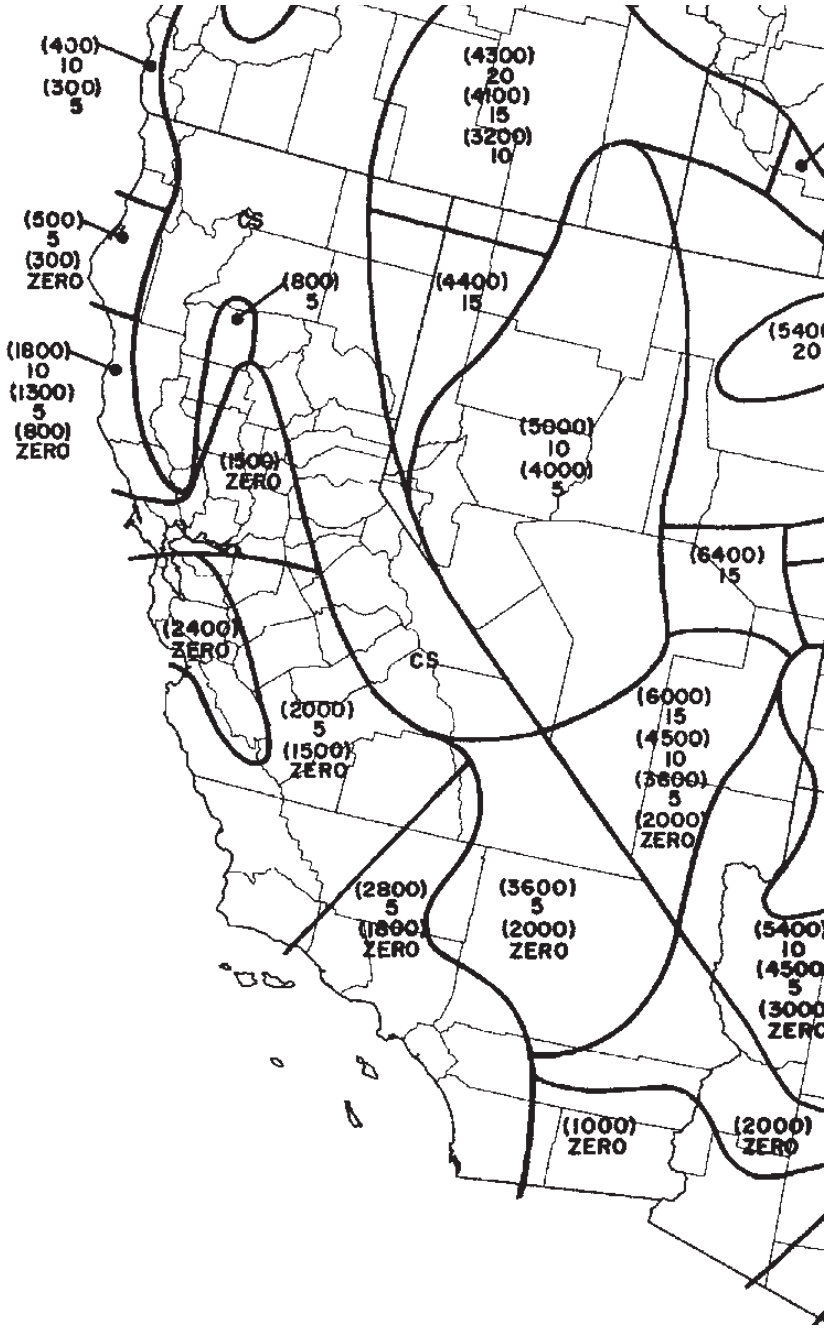
2013 CRC text Standard ASCE 7-05	2016 CRC and CBC Referenced ASCE 7-10
85 mph	110 mph
90 mph	115 mph
95 mph	120 mph
100 mph	126 mph
105 mph	133 mph

Structural Technical Appendix

This toolkit document is supported by a Structural Technical Appendix that describes the technical analysis behind these criteria, which are based on structural engineering principles and the California Building and Residential Codes. The Technical Appendix also provides some additional guidance to address non-conforming items, such as when an anchor layout is not based on a solar support component manufacturer's guidelines, or when a coastal site is located within 200 yards of the ocean (Exposure D). This document can be found **online**.

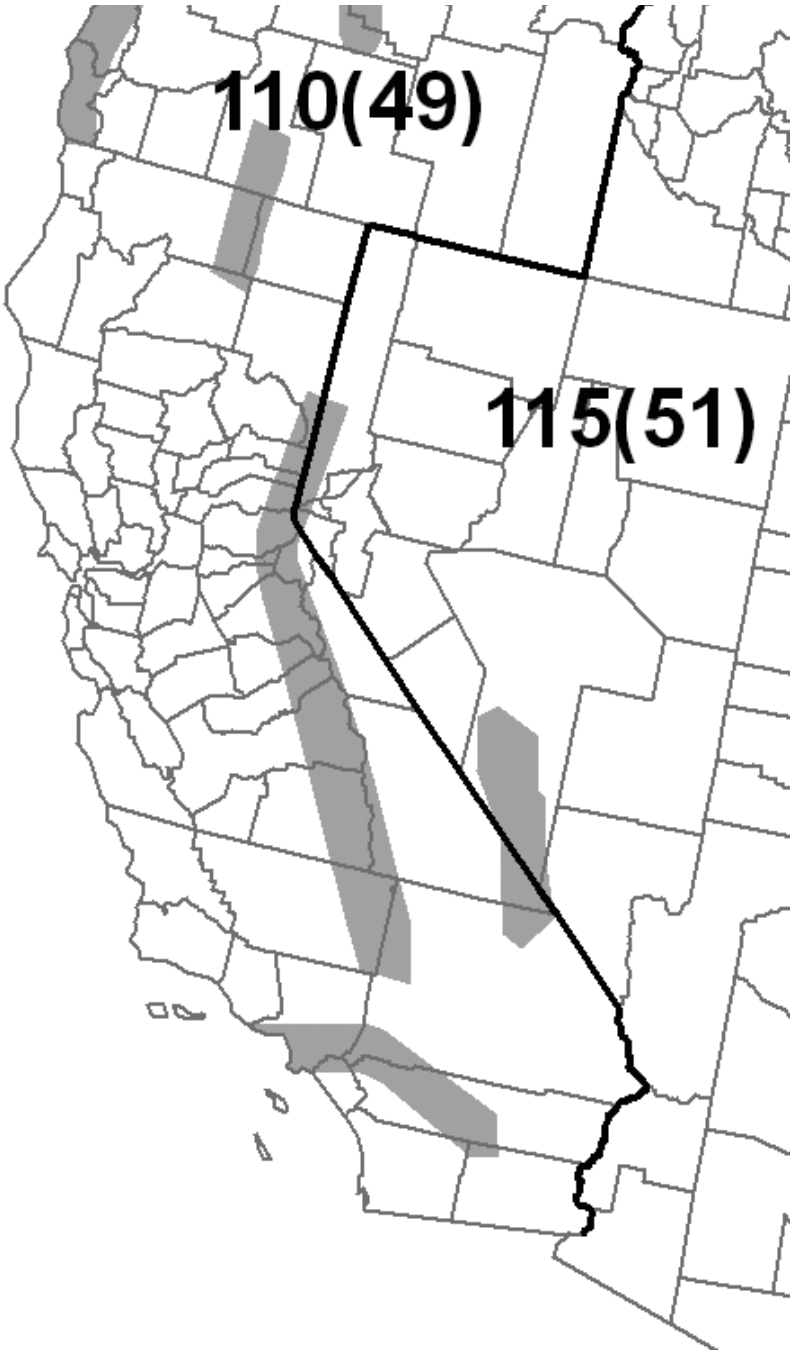
Probability of Code Compliance

The Structural Technical Appendix includes a section that examines the probabilities associated with the assumptions behind Table 1 that allows six feet cross-slope anchor spacing in some circumstances. That statistical analysis estimates that the probability of code noncompliance for six feet anchor spacing is only 2 in a thousand installations (0.2%). Note that probability of structural failure is orders of magnitude lower than the probability of code *noncompliance*.



Map 1. California Ground Snow Load Map (Ref: ASCE 7-10).

The numbers in parentheses represent the upper elevation limits in feet for the ground snow load in psf listed below the elevation. Example: (2400) ZERO in the South San Francisco Bay Area indicates that zero ground snow loads occur from sea level up to an elevation of 2,400 feet. CS indicates "Case Studies" where extreme local variations in ground snow loads occur. Non-zero snow load areas and CS areas are excluded from the use of this structural toolkit document. See the Technical Appendix for additional information.



Map 2. California Design Wind Speed Map (Ref: ASCE 7-10).

The number outside the parentheses represents the design wind speed in mph. Typical design wind speed is 110 mph. The gray shaded areas on the map indicate "Special Wind Regions" where higher wind speeds may apply. When the project is in a gray shaded area, contact the local building department for the design wind speed.

STRUCTURAL CRITERIA FOR RESIDENTIAL FLUSH-MOUNTED SOLAR ARRAYS

1. ROOF CHECKS

A. Visual Review/Contractor's Site Audit of Existing Conditions:

1) Is the roof a single roof without a reroof overlay? ☐ Y ☐ N

2) Does the roof structure appear structurally sound, without signs of alterations or significant structural deterioration or sagging, as illustrated in Figure 1? ☐ Y ☐ N

B. Roof Structure Data:

1) Measured roof slope (e.g. 6:12): _____:12

2) Measured rafter spacing (center-to-center): _____inch

3) Type of roof framing (rafter or manufactured truss): ☐ Rafter ☐ Truss

2. SOLAR ARRAY CHECKS

A. Flush-mounted Solar Array:

1) Is the plane of the modules (panels) parallel to the plane of the roof? ☐ Y ☐ N

2) Is there a 2" to 10" gap between underside of module and the roof surface? ☐ Y ☐ N

3) Modules do not overhang any roof edges (ridges, hips, gable ends, eaves)? ☐ Y ☐ N

B. Do the modules plus support components weigh no more than:
4 psf for photovoltaic arrays or 5 psf for solar thermal arrays? ☐ Y ☐ N

C. Does the array cover no more than half of the total roof area (all roof planes)? ☐ Y ☐ N

D. Are solar support component manufacturer's project-specific completed worksheets, tables with relevant cells circled, or web-based calculator results attached? ☐ Y ☐ N

E. Is a roof plan of the module and anchor layout attached? (see Figure 2) ☐ Y ☐ N

F. Downward Load Check (Anchor Layout Check):

1) Proposed anchor horizontal spacing (see Figure 2): ____' - ____"ft-in

2) Horizontal anchor spacing per Table 1: ____' - ____"ft-in

3) Is proposed anchor horizontal spacing equal to or less than Table 1 spacing? ☐ Y ☐ N

G. Wind Uplift Check (Anchor Fastener Check):

1) Anchor fastener data (see Figure 3):

a. Diameter of lag screw, hanger bolt or self-drilling screw: _____inch

b. Embedment depth of rafter: _____inch

c. Number of screws per anchor (typically one): _____

d. Are 5/16" diameter lag screws with 2.5" embedment into the rafter used, OR does the anchor fastener meet the manufacturer's guidelines? ☐ Y ☐ N

3. SUMMARY

☐ A. All items above are checked YES. No additional calculations are required.

☐ B. One or more items are checked NO. Attach project-specific drawings and calculations stamped and signed by a California-licensed civil or structural engineer.

Job Address: _____ Permit #: _____

Contractor/Installer: _____ License # & Class: _____

Signature: _____ Date: _____ Phone #: _____

Optional Additional Rafter Span Check Criteria

[At option of CBO, insert rows (4) to (7) below into table above after row 1.B.(3)]

1. ROOF CHECKS

B. Roof Structure Data:

4) Measured rafter size (e.g. 13/4 x 33/4, not 2x4): ____ x ____ inch

5) Measured rafter horizontal span (see Figure 4): ____' - ____"ft-in

6) Horizontal rafter span per Table 2: ____' - ____"ft-in

7) Is measured horizontal rafter span less than Table 2 span? ☐ Y ☐ N ☐ Truss

Table 1. Maximum Horizontal Anchor Spacing				
Roof Slope		Rafter Spacing		
		16" o.c.	24" o.c.	32" o.c.
Photovoltaic Arrays (4 psf max)				
Flat to 6:12	0° to 26°	5'-4"	6'-0"	5'-4"
7:12 to 12:12	27° to 45°	1'-4"	2'-0"	2'-8"
13:12 to 24:12	46° to 63°	1'-4"	2'-0"	2'-8"
Solar Thermal Arrays (5 psf max)				
Flat to 6:12	0° to 26°	4'-0"	4'-0"	5'-4"
7:12 to 12:12	27° to 45°	1'-4"	2'-0"	2'-8"
13:12 to 24:12	46° to 63°	Calc. Req'd	Calc. Req'd	Calc. Req'd

Solar support component manufacturer's guidelines may be relied upon to ensure the array above the roof is properly designed, but manufacturer's guidelines typically do NOT check to ensure that the roof itself can support the concentrated loads from the solar array. Table 1 assumes that the roof complied with the building code in effect at the time of construction, and places limits on anchor horizontal spacing to ensure that a roof structure is not overloaded under either downward loads or wind uplift loads. Note 4 below lists the basic assumptions upon which this table is based.

Table 1 Notes:

1. Anchors are also known as "stand-offs," "feet," "mounts" or "points of attachment." Horizontal anchor spacing is also known as "cross-slope" or "east-west" anchor spacing (see Figure 2).
2. If anchors are staggered from row-to-row going up the roof, the anchor spacing may be twice that shown above, but no greater than 6'-0".
3. For manufactured plated wood trusses at slopes of flat to 6:12, the horizontal anchor spacing shall not exceed 4'-0" and anchors in adjacent rows shall be staggered.
4. This table is based on the following assumptions:
    - The roof structure conformed to building code requirements at the time it was built.
    - The attached list of criteria is met.
    - Mean roof height is not greater than 40 feet.
    - Roof sheathing is at least 7/16" thick oriented strand board or plywood. 1x skip sheathing is acceptable.
    - If the dwelling is in Wind Exposure B (typical urban, suburban or wooded areas farther than 500 yards from large open fields), no more than one of the following conditions apply:
        - The dwelling is located in a Special Wind Region with design wind speed between 115 and 130 mph per ASCE 7-10.
        - The dwelling is located on the top half of a tall hill, provided average slope is less than 15%.
    - If the dwelling is in Wind Exposure C (within 500 yards of large open fields or grasslands), all of the following conditions apply.
        - Design wind speed is 110 mph or less (not in a Special Wind Region).
        - The dwelling is not located on the top half of a tall hill.
    - The solar array displaces roof live loads (temporary construction loads) that the roof was originally designed to carry.
    - The Structural Technical Appendix provides additional information about analysis assumptions.

Table 2. Roof Rafter Maximum Horizontal Span (feet - inches)1								
Assumed Vintage	Nominal Size	Actual Size	Non-Tile Roof[2]			Tile Roof[3]		
			Rafter Spacing					
			16" o.c.	24" o.c.	32" o.c.	16" o.c.	24" o.c.	32" o.c.
Post-1960	2x4	1½"x3½"	9'-10"	8'-0"	6'-6"	8'-6"	6'-11"	5'-6"
	2x6	1½"x5½"	14'-4"	11'-9"	9'-6"	12'-5"	10'-2"	8'-0"
	2x8	1½"x7¼"	18'-2"	14'-10"	12'-0"	15'-9"	12'-10"	10'-3"
Pre-1960	2x4	1¾"x3¾"	11'-3"	9'-9"	7'-9"	10'-3"	8'-6"	6'-9"
	2x6	1¾"x5¾"	17'-0"	14'-0"	11'-3"	14'-9"	12'-0"	9'-9"
	2x8	1¾"x7¾"	22'-3"	18'-0"	14'-6"	19'-0"	15'-6"	12'-6"

Beyond a visual review by the contractor checking for unusual sagging or deterioration, some CBOs may want additional assurance that the roof structure complies with structural building code requirements. Table 2 is an optional table some CBOs may elect to use to provide additional assurance by requiring a check of existing roof rafter spans, and supports optional criteria 1.B.5 and 1.B.6. For post-1960 construction, these span tables match the rafter span tables found in the 2016 California Building and Residential codes. For pre-1960 construction, the rafter span tables are based on structural calculations with lumber sizes and wood species and grade appropriate for older construction. Note 5 below lists the basic assumptions upon which this table is based.

Table 2 Notes:

1. See Figure 4 for definition of roof rafter maximum horizontal span.
2. "Non-tile Roof" = asphalt shingle, wood shingle and wood shake, with an assumed roof assembly weight of 10 psf.
3. "Tile Roof" = clay tile or cement tile, with an assumed roof assembly weight of 20 psf
4. Unaltered manufactured plated-wood trusses may be assumed to be code compliant and meet intent of Table 2.
5. This table is based on the following assumptions:
    - Span/deflection ratio is equal to or greater than 180.
    - For post-1960 construction, wood species and grade is Douglas Fir-Larch No. 2.
    - For pre-1960 construction, wood species and grade is Douglas Fir-Larch No. 1.
    - Other wood species and/or grade are also acceptable if allowable bending stress is equal or greater to that listed.

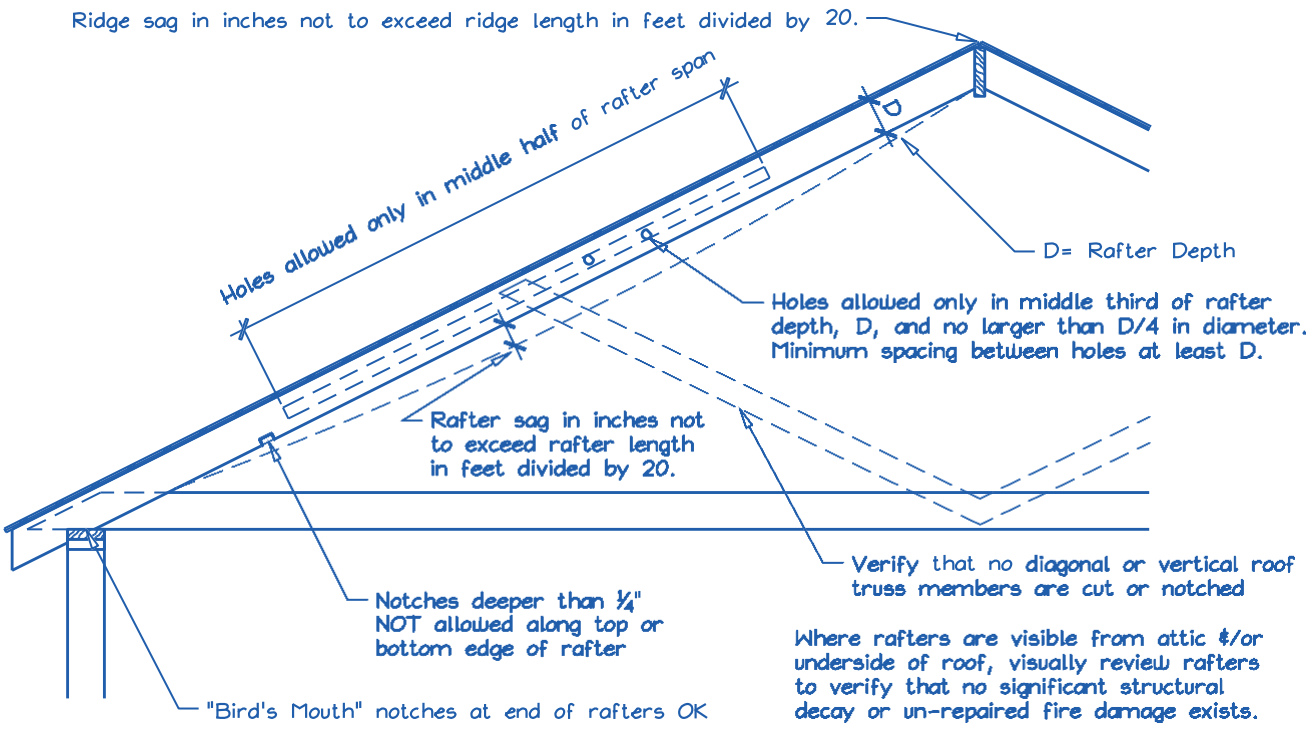


Figure 1. Roof Visual Structural Review (Contractor's Site Audit) of Existing Conditions.

The site auditor should verify the following.

1. No visually apparent disallowed rafter holes, notches and truss modifications as shown above.
2. No visually apparent structural decay or unrepaired fire damage.
3. Roof sag, measured in inches, is not more than the rafter or ridge beam length in feet divided by 20.

Rafters that fail the above criteria should not be used to support solar arrays unless they are first strengthened.

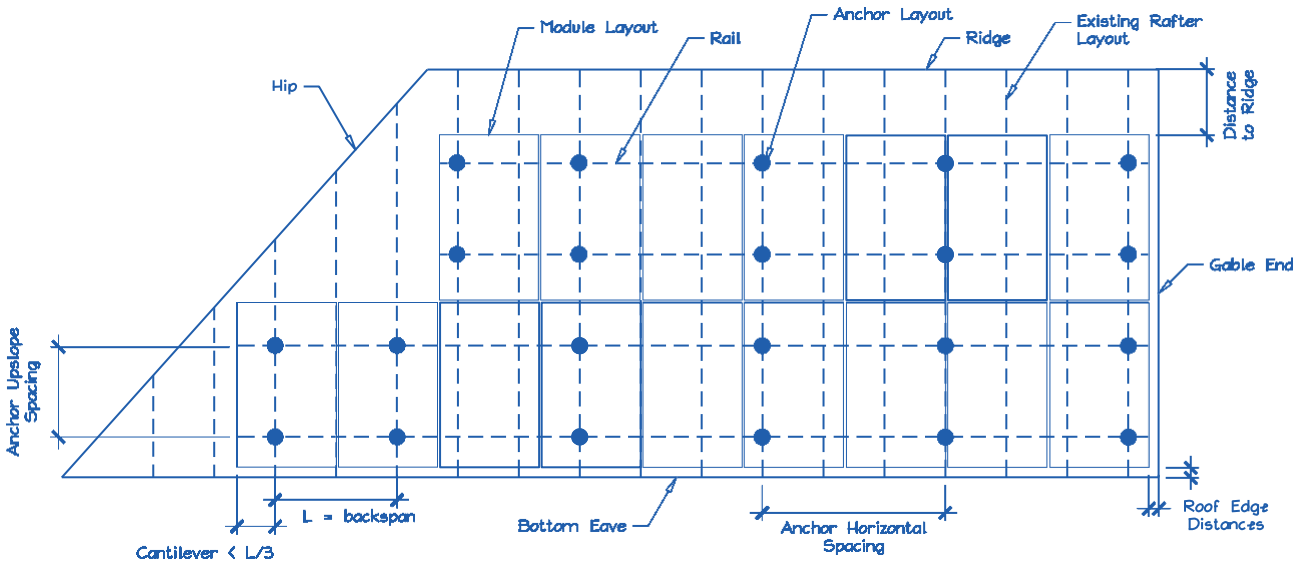


Figure 2. Sample Solar Panel Array and Anchor Layout Diagram (RoofPlan).

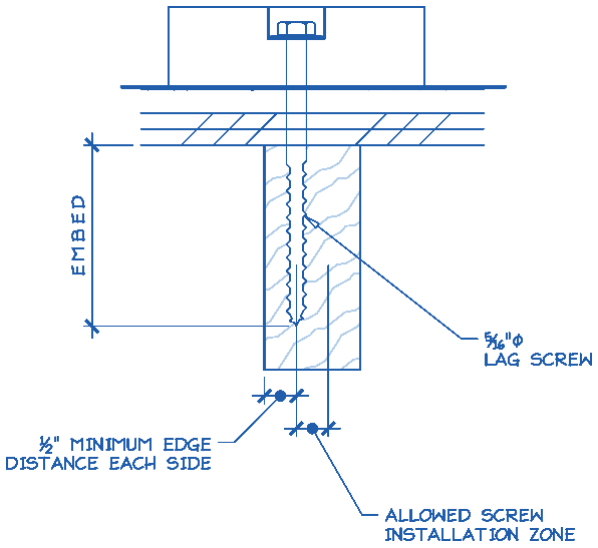


Figure 3. Typical Anchor with Lag Screw Attachment.

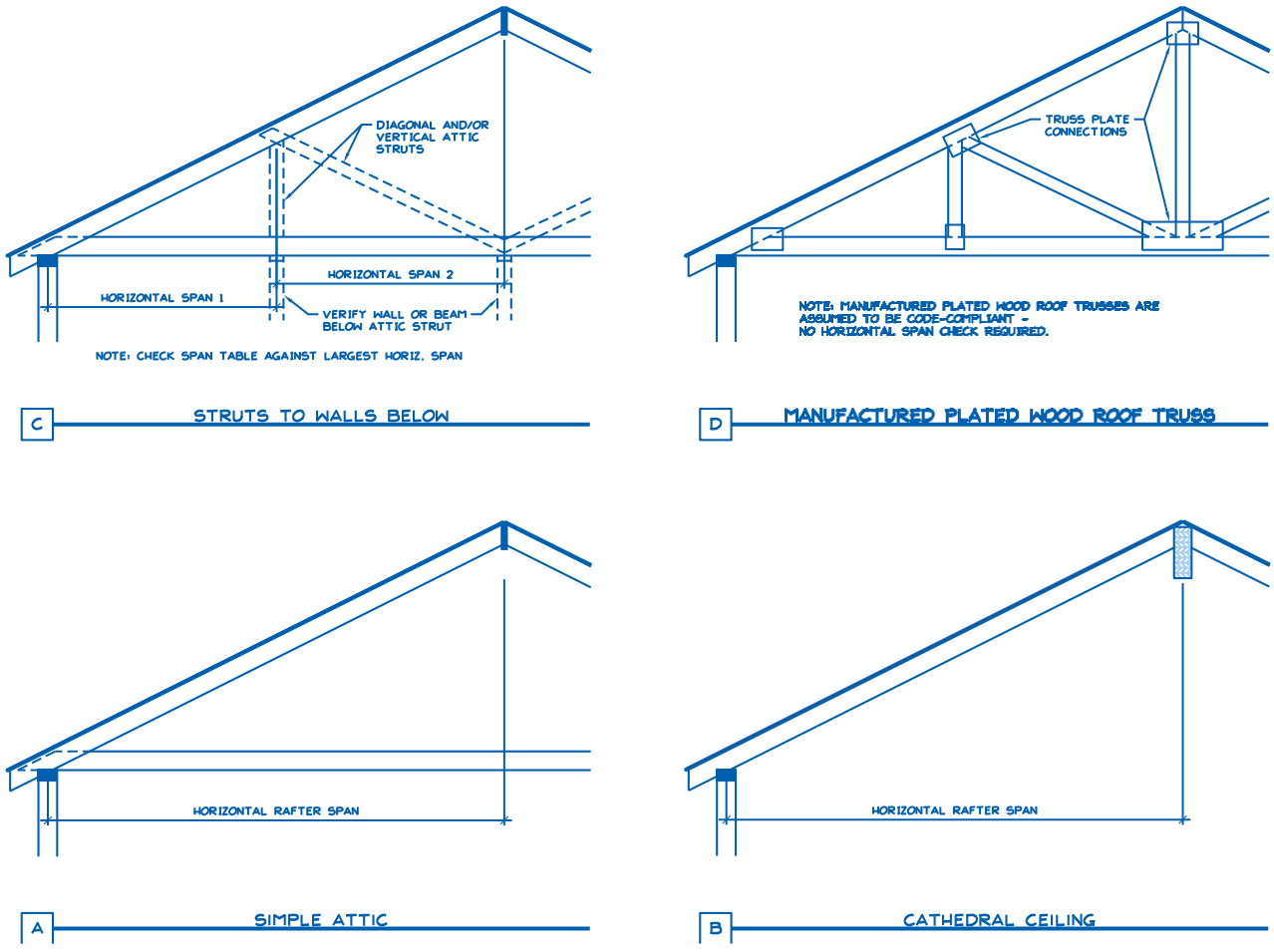


Figure 4. Definition of Rafter Horizontal Span.