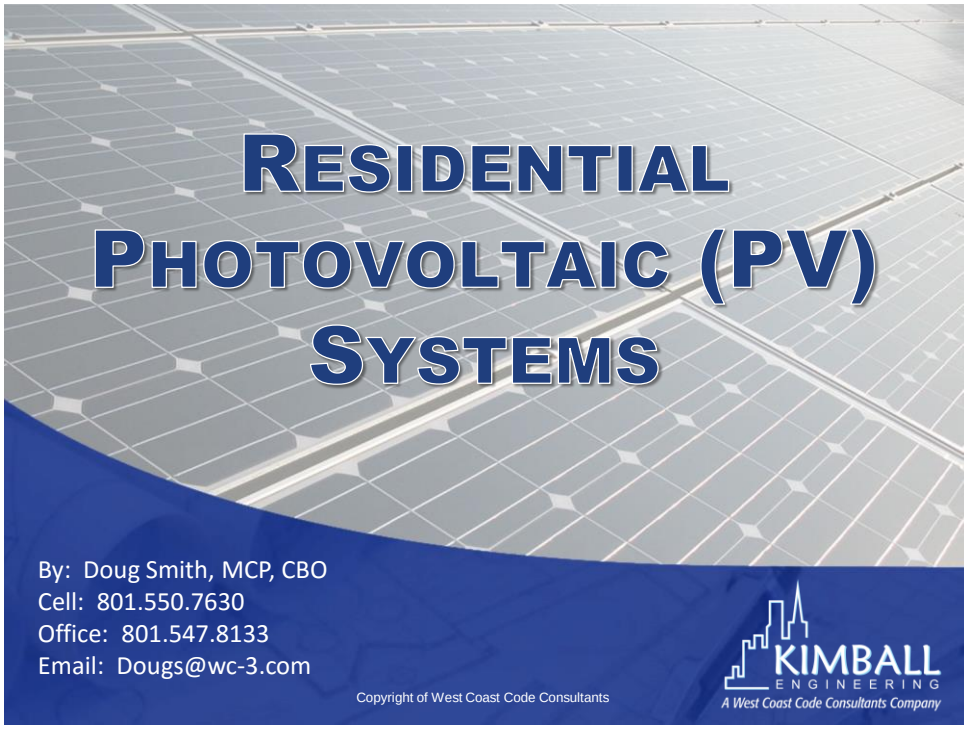


A little about me:

- Happily married for over 15 years
- I have 3 children (1 girl and 2 boys)
- Building Inspector for over 11 years
- Certified Master Code Professional
- Certified Combination Inspector (commercial & residential)
- Certified Combination Plans Examiner
- Fire Plans Examiner, Fire 1 & 2 Inspector
- Obtained over 19 ICC certifications
- President of the Utah Chapter IAEI
- Past President of the Bonneville Chapter ICC
- Owner of Master Inspections, LLC
- Joined Kimball Engineering in October 2013

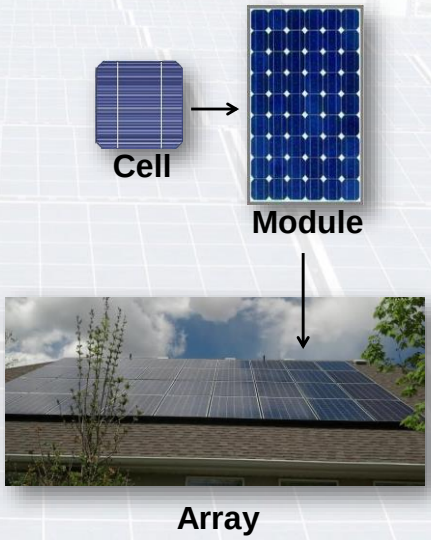
Good PV resources:

- White papers and articles by John Wiles: www.nmsu.edu (at search box type “codes and standards” and then follow the links)
- Photovoltaic Power Systems for Inspectors and Plan Reviewers, book by John Wiles. www.IAEI.org
- Solar American Board for Codes and Standards: www.solarabcs.org
- North American Board of Certified Energy Practitioners: www.NABCEP.org

PV Modules

PV Modules

- PV cells make up a module.
- A group of modules mounted together at the factory is called a panel (usually 3 or 4 modules).
- All modules together in a system make up the array.



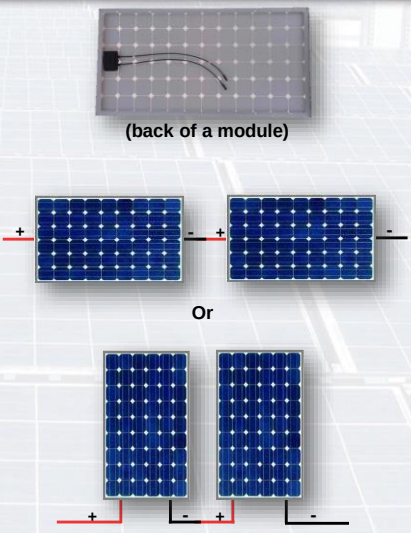
Module Listing

- All photovoltaic modules must be listed as meeting UL 1703.
- *NEC* 690.4(D)

PV Module Interconnections

PV Module Interconnections

- A circuit with multiple modules that are connected in series is referred to by the *NEC* as a “Source Circuit,” but is often called a string of modules by the PV industry.
- Multiple strings of modules can be connected together in parallel.
- All modules in a system form an array.

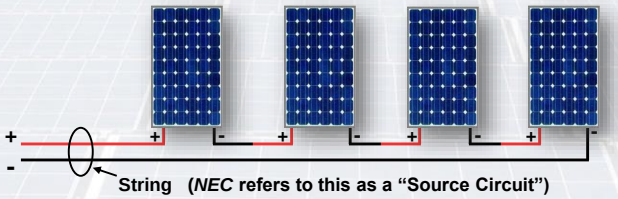


Series connected modules

Series vs. Parallel

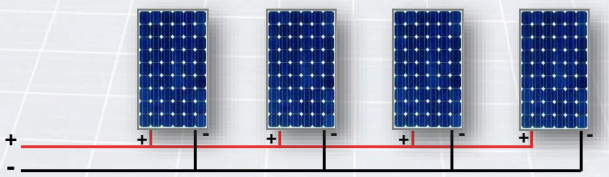
Series connected modules:

Volts from each module add together but amps stay the same:



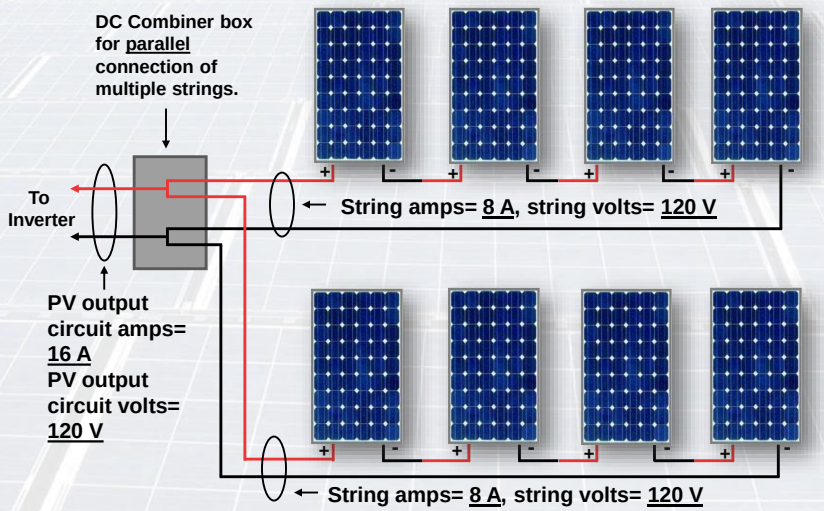
Parallel connected modules:

Amps from each module add together but voltage stays the same.



Example

If each module produced 8 amps and 30 volts…



Inverters

Inverters

- Inverters are required for PV systems in order to convert DC power into AC power.
- Inverter's AC output voltage for residential use can be either 120 V or 240 V single phase (depending on the model).

Sunnyboy (SMA®) 3000w

Sunnyboy (SMA®) 7000w

DC Ground Fault Protection (GFPD)

- PV systems providing power to a building are required to have ground fault protection, *NEC* 690.5.
- Most PV inverters incorporate a GFPD (always verify with the inverter manufacture!).
- The exception of *NEC* 690.5, states that DC GFPE is not required for ground-mounted or pole-mounted PV systems when the system only has two strings and all DC wiring is isolated from buildings.

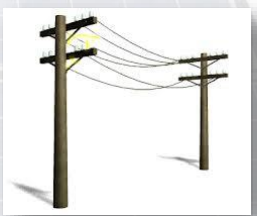
Solaredge®

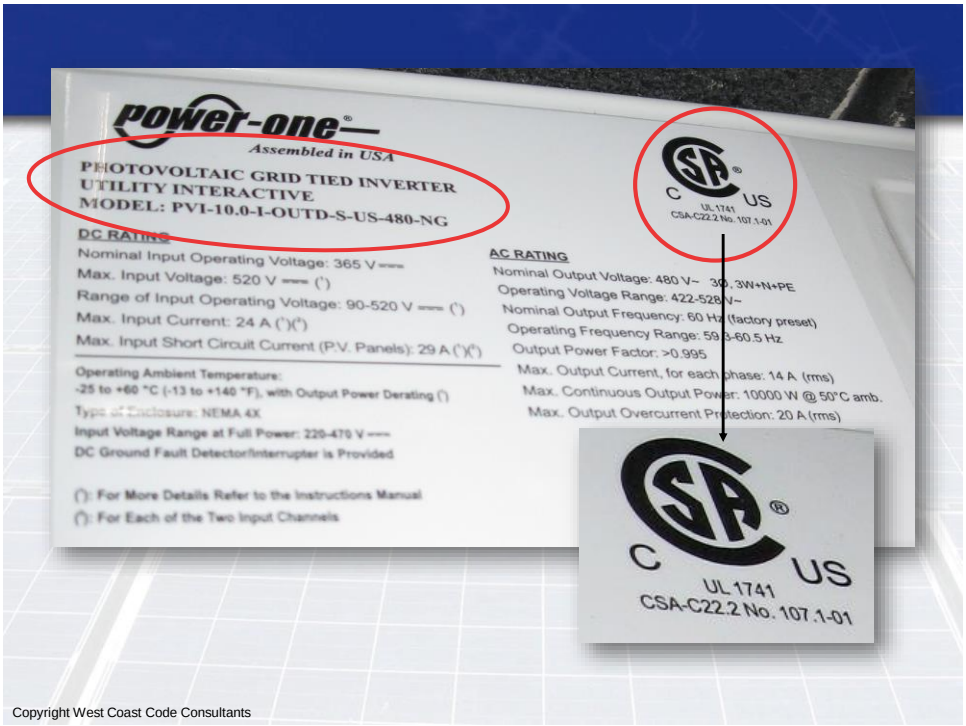
Fronius®
(Fronius International Gm bh)

Utility Interactive Inverters

- Any PV Inverters (commercial or residential) that are connected to the electric utility grid must meet UL 1741 and be listed as "utility interactive" having anti-islanding protection, *NEC* 690.61 and 705.40.

Inverter (SMA® Sunny Boy)





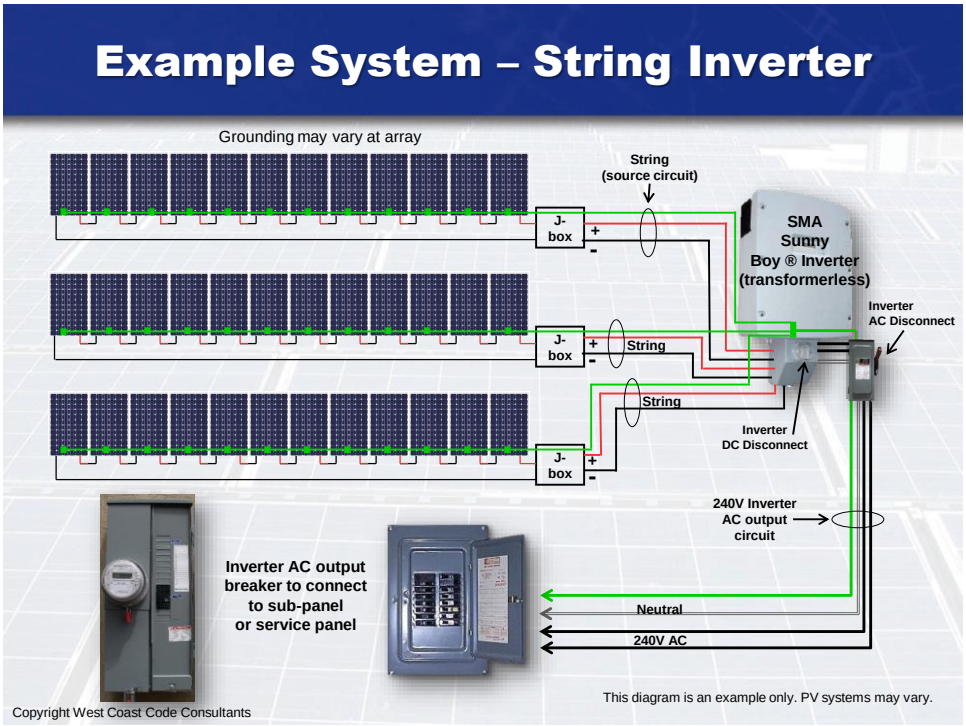
UL 1741 Utility Interactive Inverter

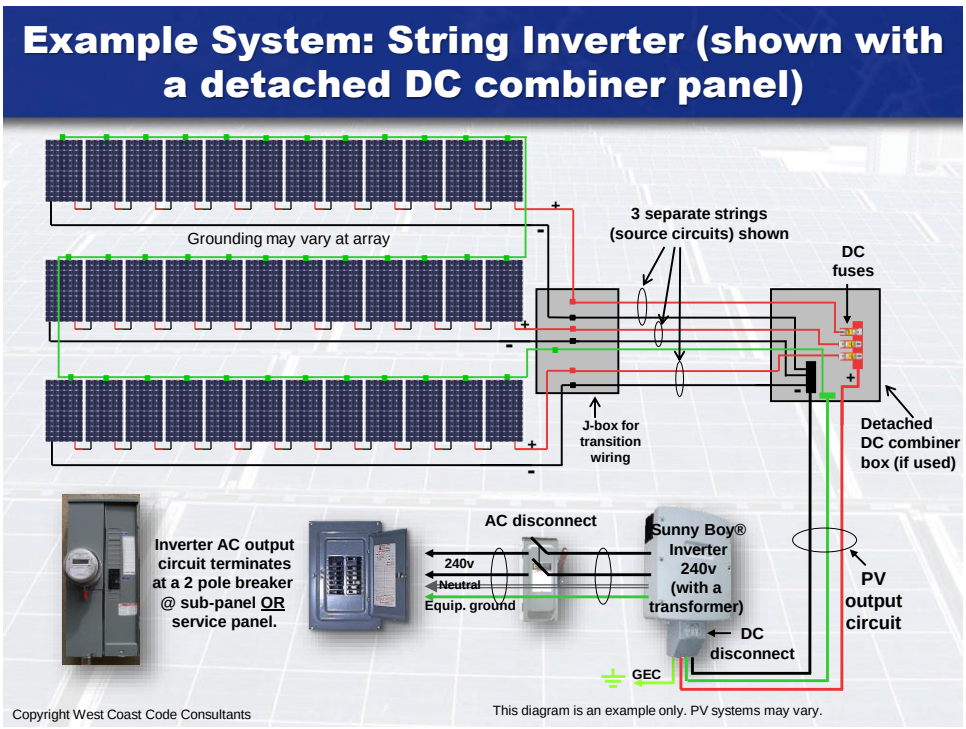
- An anti-islanding inverter detects when the utility grid goes dead and automatically shuts down to prevent backfeed to the grid.
- A utility interactive inverter is also required to produce an AC voltage, sine wave, and frequency that is compatible with that of the utility. If the output AC voltage, sine wave, or frequency from the inverter is not within a certain range the inverter is required to shut down (this is part of the UL 1741 listing). *NEC* 705.4

Arc-Fault Protection (AFPD)

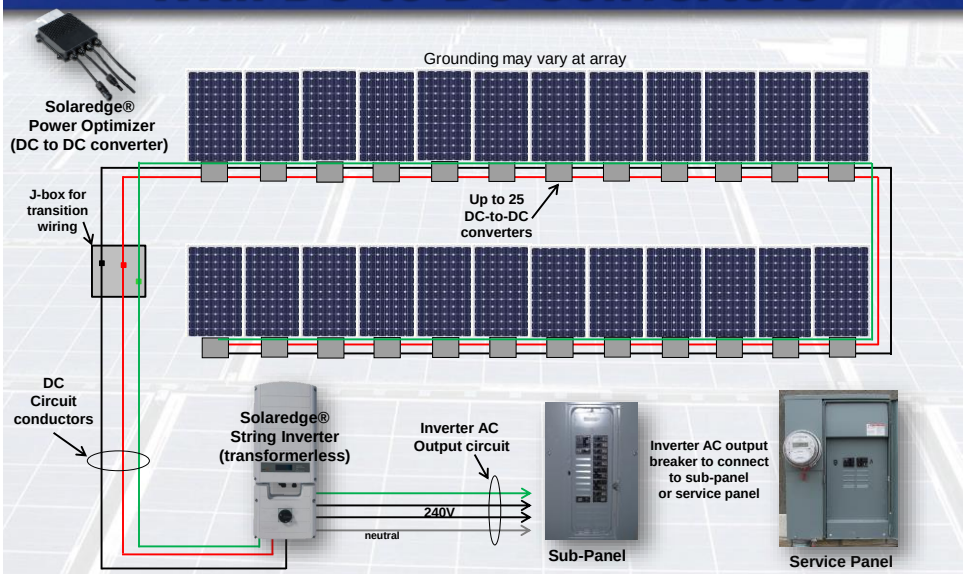
- The 2011 NEC requires that a PV system with DC circuits that are on or penetrate a building (commercial or residential) operating at 80 volts or greater, shall be protected by a listed “PV type” DC arc-fault circuit interrupter or have listed system components that provide equivalent protection, *NEC* 690.11.
- This section does not apply to micro inverter or AC module systems that are currently on the market.

Types Of PV Systems (non-battery)


Example System – String Inverter
Grounding may vary at array
String (source circuit)
J-box
SMA Sunny Boy ® Inverter (transformerless)
Inverter AC Disconnect
String
Inverter DC Disconnect
240V Inverter AC output circuit
Inverter AC output breaker to connect to sub-panel or service panel
Neutral
240V AC
This diagram is an example only. PV systems may vary.
Copyright West Coast Code Consultants


Example System: String Inverter (shown with a detached DC combiner panel)
Grounding may vary at array
3 separate strings (source circuits) shown
DC fuses
J-box for transition wiring
Detached DC combiner box (if used)
Inverter AC output circuit terminates at a 2 pole breaker @ sub-panel OR service panel.
AC disconnect
240v
Neutral
Equip. ground
Sunny Boy® Inverter 240v (with a transformer)
PV output circuit
DC disconnect
GEC
This diagram is an example only. PV systems may vary.
Copyright West Coast Code Consultants

Example System: String Inverter With DC-to-DC Converters



This diagram is an example only. PV systems may vary.

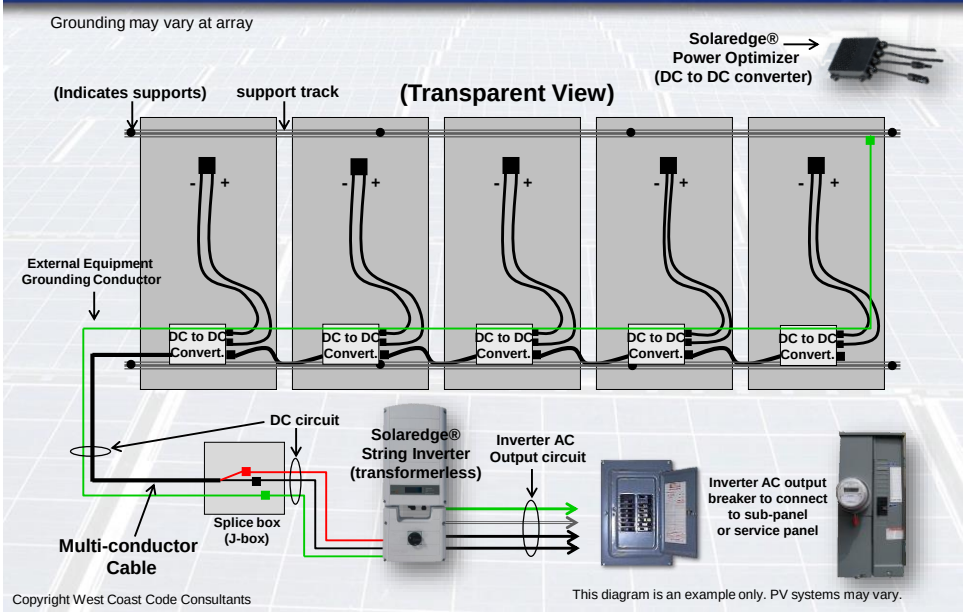
Solaredge® Maximum String Length

solaredge **SolarEdge Power Optimizer**
Module Add-On for North America
P300 / P320 / P400 / P405

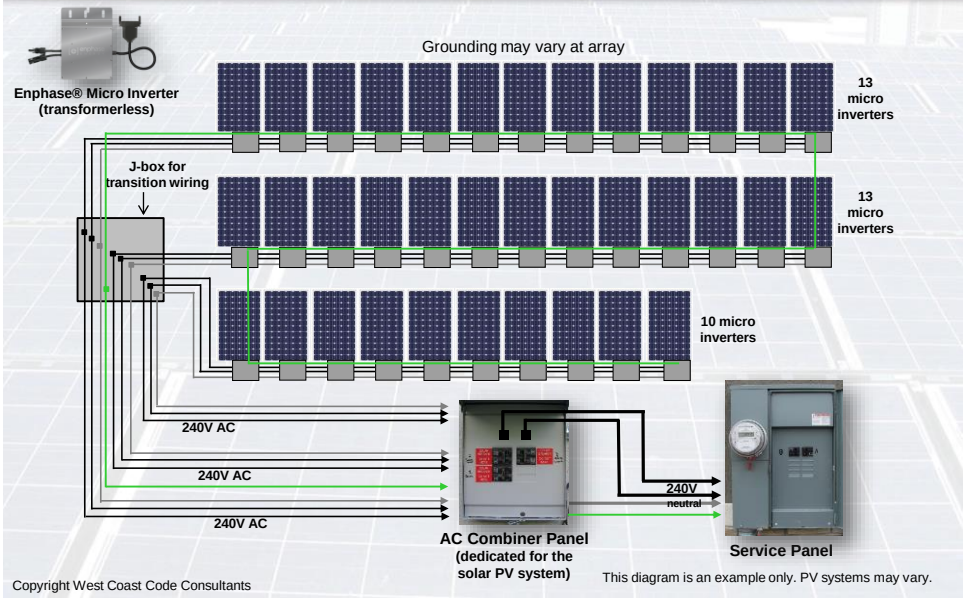
PV SYSTEM DESIGN USING A SOLAREDGE INVERTER[2]	SINGLE PHASE	THREE PHASE 208V	THREE PHASE 480V
Minimum String Length (Power Optimizers)	8	10	18
Maximum String Length (Power Optimizers)	25	25	50
Maximum Power per String	5250	6000	12750
Parallel Strings of Different Lengths or Orientations	Yes		

Info from Solaredge® Power Optimizer specification sheets

Solaredge® String Inverter With DC to DC Converters (Power Optimizers®)

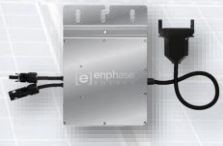


Example System: Micro Inverters



Each Module Is Connected To Its Own Micro Inverter

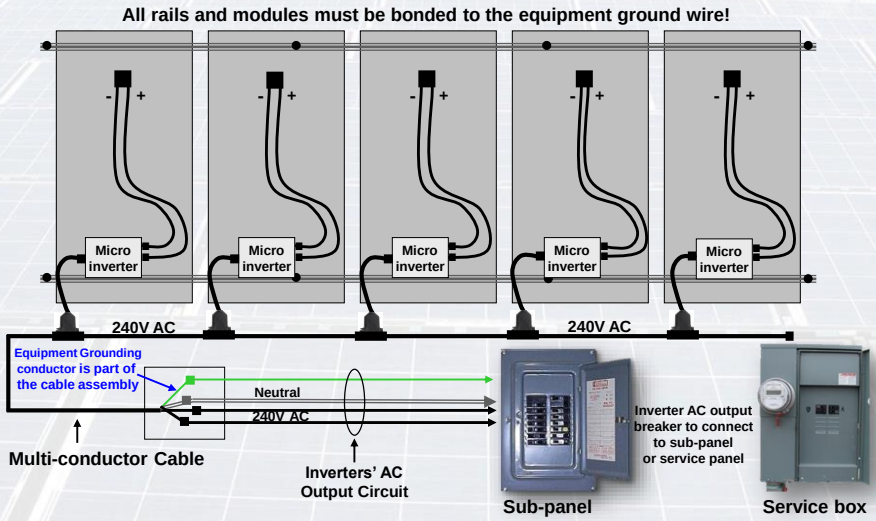
Installation by Scott Call



Enphase micro inverters

Enphase M215 and M250 Micro Inverters (transformerless)

Grounding may vary at array



This diagram is an example only. PV systems may vary.

Example of Maximum Micro Inverters Per 20A Circuit

Enphase® M250 micro inverter specification sheet:

OUTPUT DATA (AC)	@208 VAC	@240 VAC
Peak output power	250 W	250 W
Rated (continuous) output power	240 W	240 W
Nominal output current	1.15 A (A rms at nominal duration)	1.0 A (A rms at nominal duration)
Nominal voltage/range	208 V / 183-229 V	240 V / 211-264 V
Nominal frequency/range	60.0 / 57-61 Hz	60.0 / 57-61 Hz
Extended frequency range*	57-62.5 Hz	57-62.5 Hz
Power factor	>0.95	>0.95
Maximum units per 20 A branch circuit	24 (three phase)	16 (single phase)
Maximum output fault current	850 mA rms for 6 cycles	850 mA rms for 6 cycles

Roof Junction Box

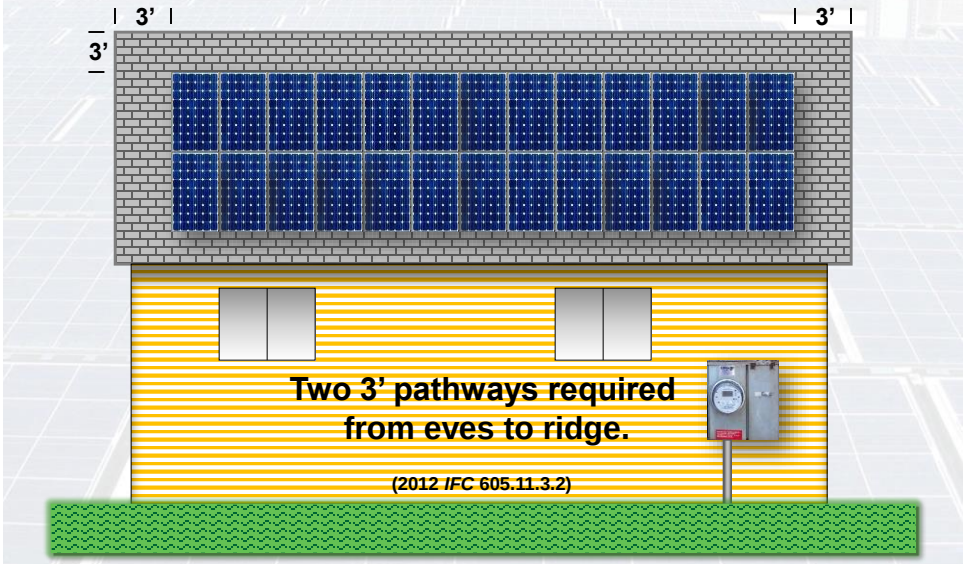
Non-fused splice box (J-box) for transition wiring.
SolaDeck box (RSTC Enterprises, Inc.)

Roof Junction Box

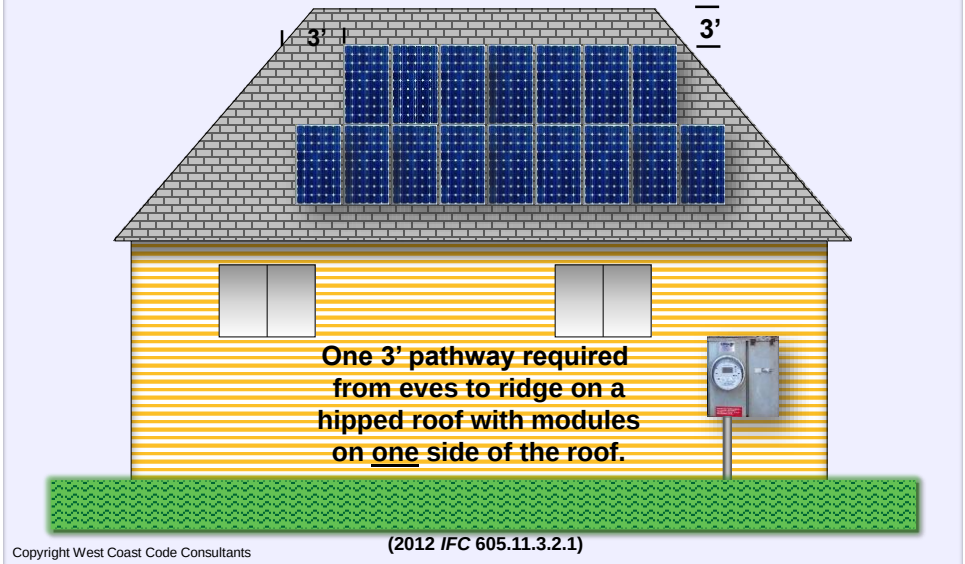
Splice terminals at a SolaDeck J-box
Photo courtesy of RSTC Enterprises, Inc.

2012 *IFC* Roof Access Requirements

Residential Roof Access Requirements – Single Ridge

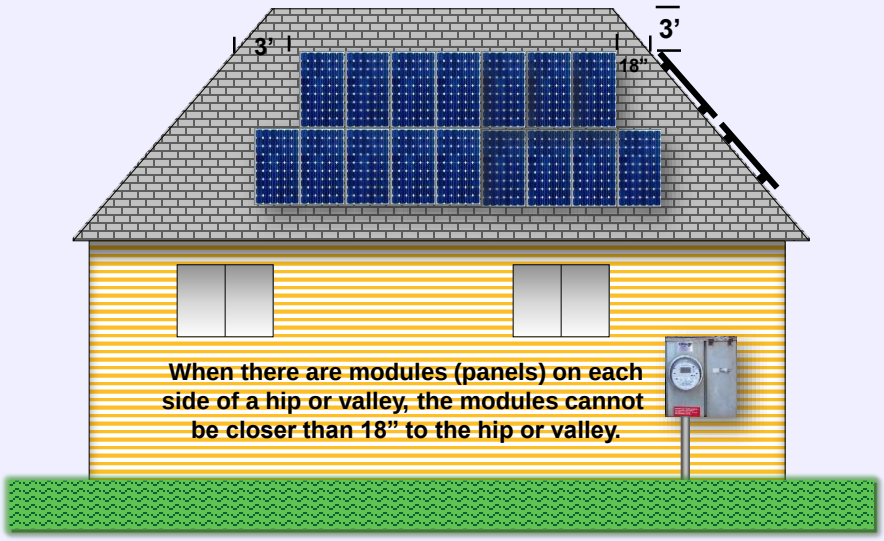


Residential Roof Access Requirements – Hip Roofs



(2012 *IFC* 605.11.3.2.1)

Hip/Valley Roof Access



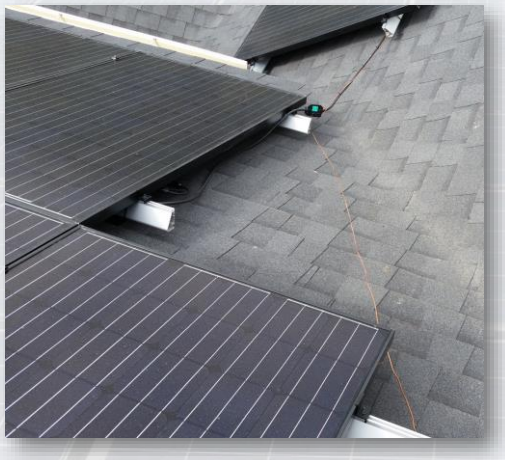
(2012 *IFC* 605.11.3.2.3)

Roof Access For Venting

Installation Errors

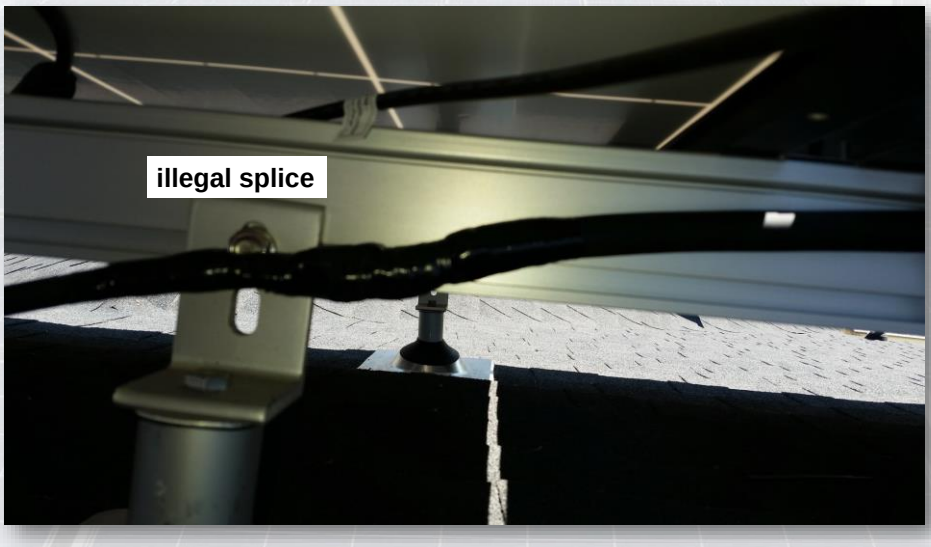
Installation Errors

Installation Errors



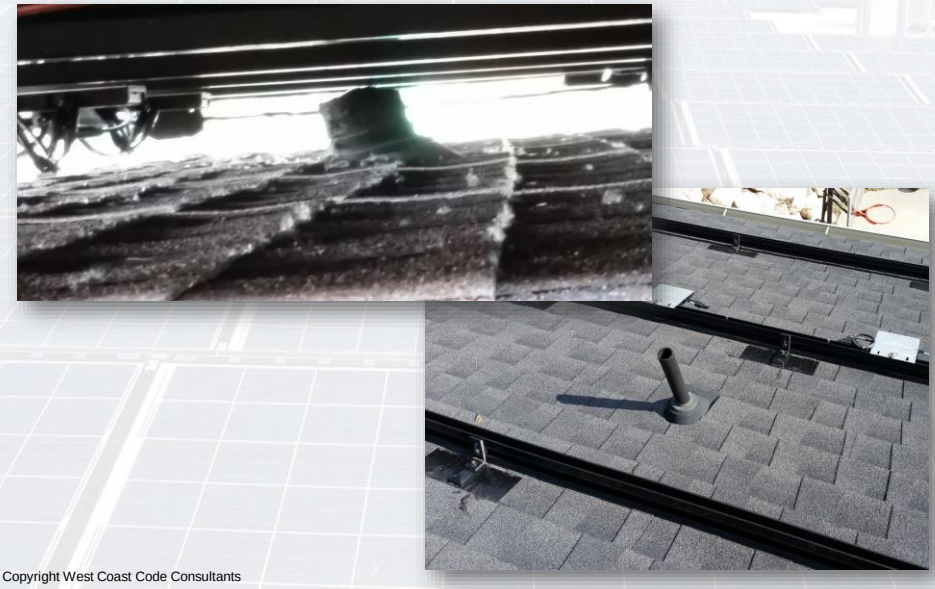
Corrected

Installation Errors



Corrected

Installation Errors



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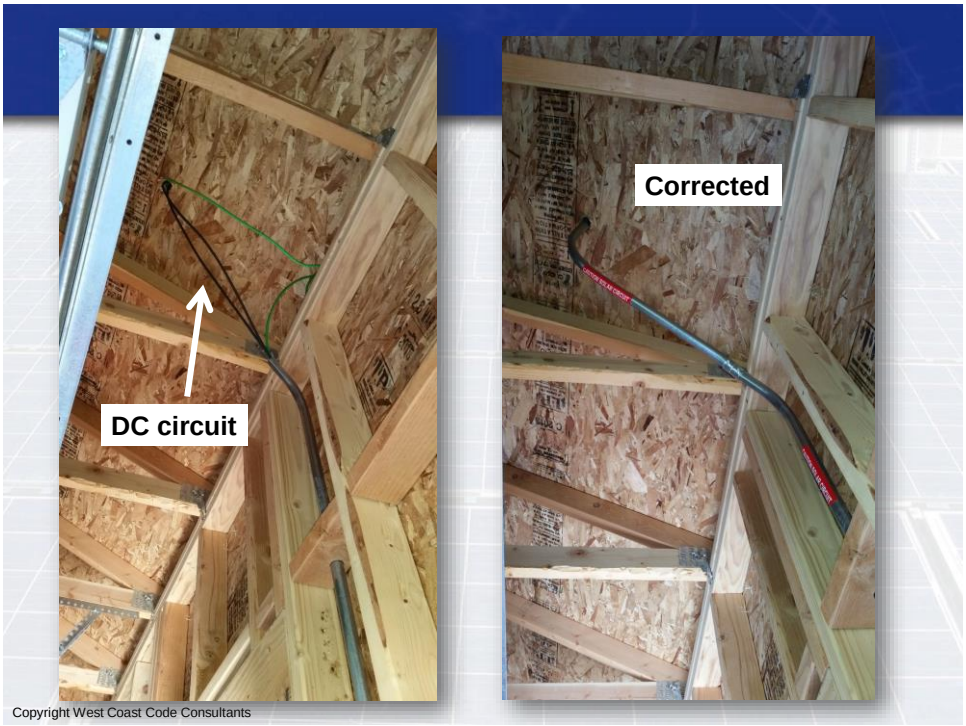
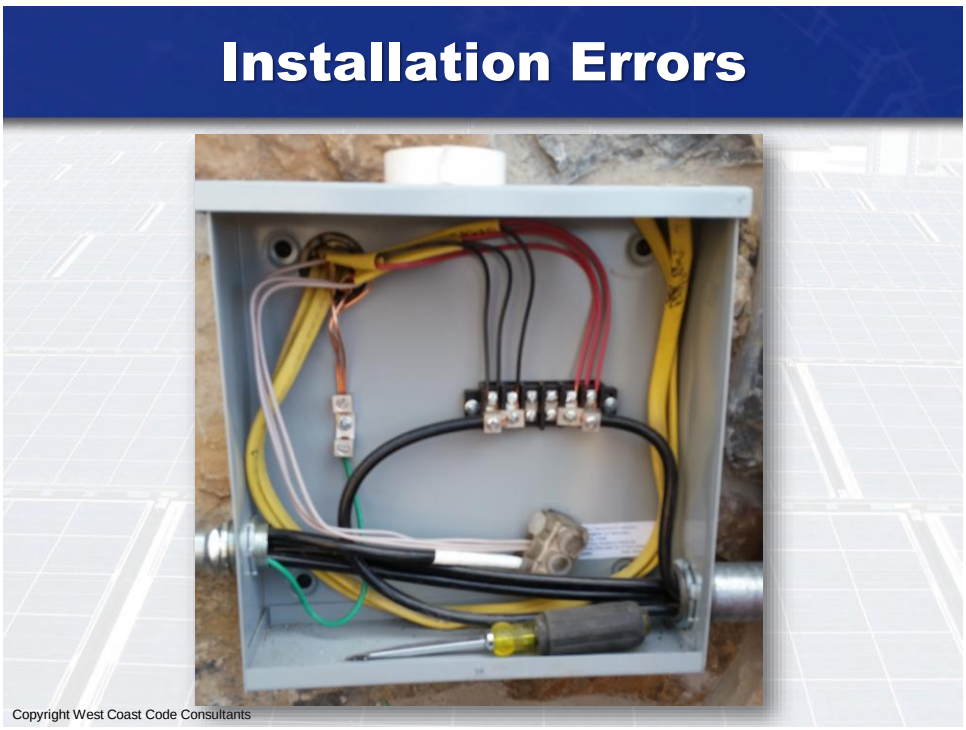

DC circuit
Corrected
Copyright West Coast Code Consultants


Installation Errors
Copyright West Coast Code Consultants