



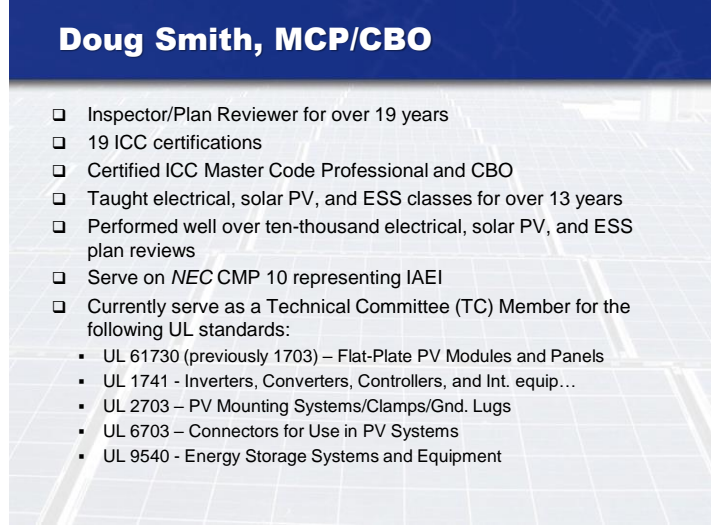
**SOLAR PV PLAN
REVIEWS**
(BASED ON THE 2020 *NEC* AND 2021 *IRC*)

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West Coast Code Consultants

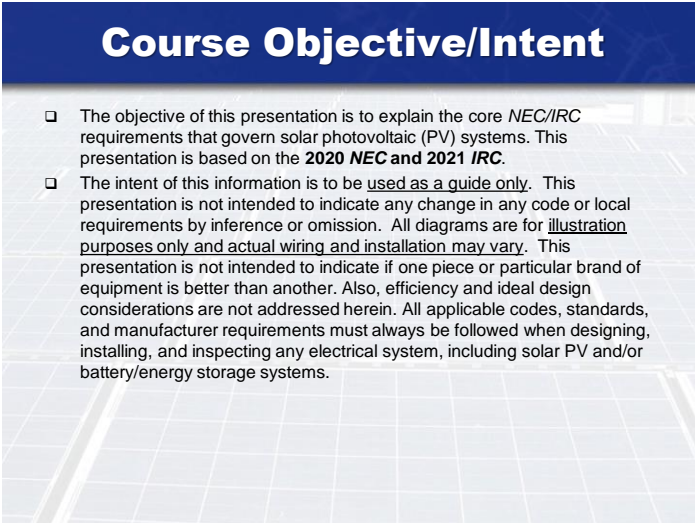
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Doug Smith, MCP/CBO

- ❑ Inspector/Plan Reviewer for over 19 years
- ❑ 19 ICC certifications
- ❑ Certified ICC Master Code Professional and CBO
- ❑ Taught electrical, solar PV, and ESS classes for over 13 years
- ❑ Performed well over ten-thousand electrical, solar PV, and ESS plan reviews
- ❑ Serve on *NEC* CMP 10 representing IAEE
- ❑ Currently serve as a Technical Committee (TC) Member for the following UL standards:
 - UL 61730 (previously 1703) – Flat-Plate PV Modules and Panels
 - UL 1741 - Inverters, Converters, Controllers, and Int. equip...
 - UL 2703 – PV Mounting Systems/Clamps/Gnd. Lugs
 - UL 6703 – Connectors for Use in PV Systems
 - UL 9540 - Energy Storage Systems and Equipment

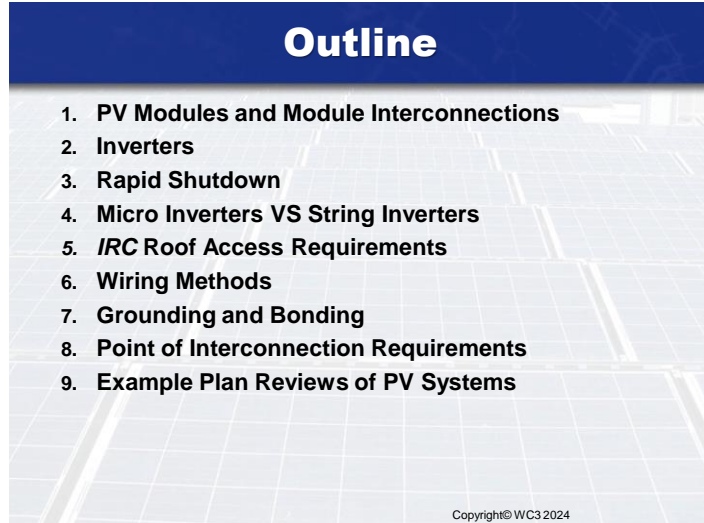
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Course Objective/Intent

- ❑ The objective of this presentation is to explain the core *NEC/IRC* requirements that govern solar photovoltaic (PV) systems. This presentation is based on the **2020 *NEC* and 2021 *IRC***.
- ❑ The intent of this information is to be used as a guide only. This presentation is not intended to indicate any change in any code or local requirements by inference or omission. All diagrams are for illustration purposes only and actual wiring and installation may vary. This presentation is not intended to indicate if one piece or particular brand of equipment is better than another. Also, efficiency and ideal design considerations are not addressed herein. All applicable codes, standards, and manufacturer requirements must always be followed when designing, installing, and inspecting any electrical system, including solar PV and/or battery/energy storage systems.

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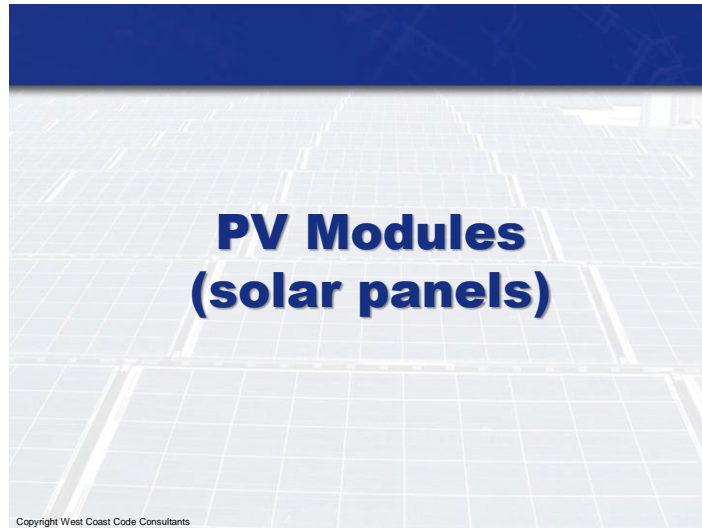


Outline

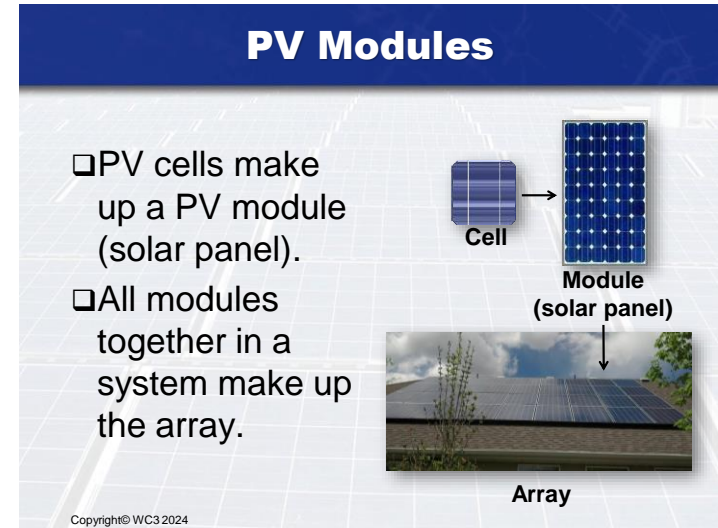
1. **PV Modules and Module Interconnections**
2. **Inverters**
3. **Rapid Shutdown**
4. **Micro Inverters VS String Inverters**
5. **IRC Roof Access Requirements**
6. **Wiring Methods**
7. **Grounding and Bonding**
8. **Point of Interconnection Requirements**
9. **Example Plan Reviews of PV Systems**

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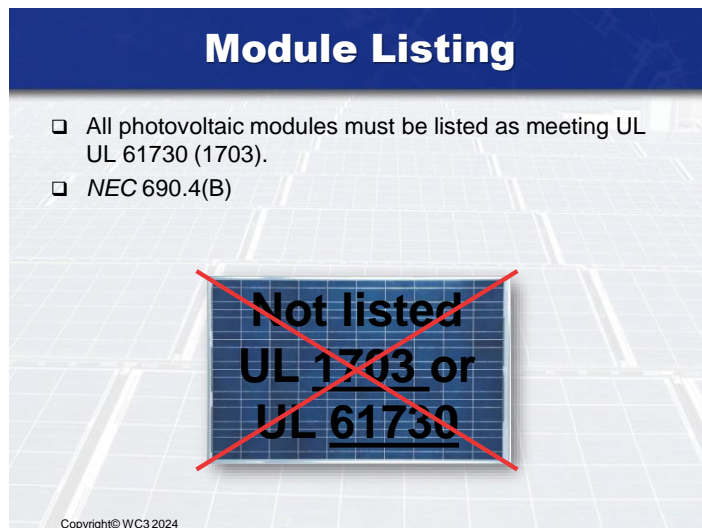
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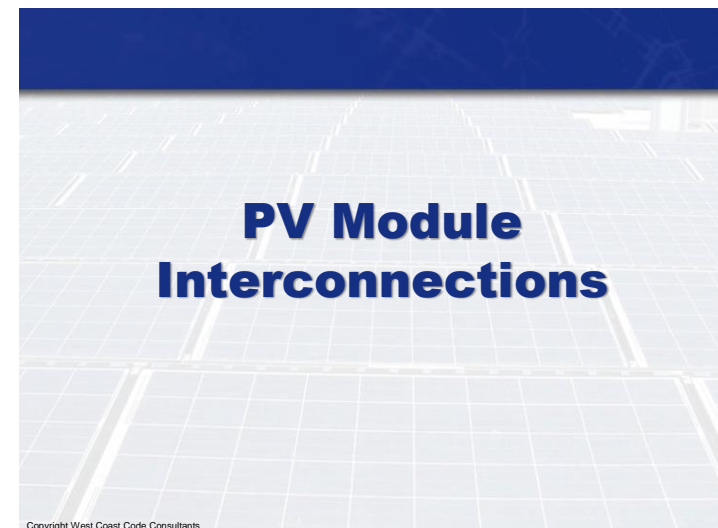
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Concept of Series-Connections

□ A circuit with multiple modules that are connected in series is referred to by the NEC as a "PV Source Circuit," but is often called a string of modules by the PV industry (PV string circuit).

(back of a module/solar panel)

Series connected modules

Or

Note: these diagrams are very basic in order to explain the concept of solar panels connected in series. Most modern-day systems are required to also include rapid shutdown components (such components are not shown here).

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Series vs. Parallel

Series connected modules (solar panels):
Volts from each module add together but amps stay the same:

String (NEC refers to this as a "PV Source Circuit")

Parallel connected modules:
Amps from each module add together but voltage stays the same.

Note: solar panels are never connected in this way, this is just an example of parallel connections.

Note: these diagrams are very basic in order to explain the concept of series versus parallel connections. Most modern-day systems are required to also include rapid shutdown components (such components are not shown here).

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Example of how series and parallel connections affect a system

If each module (solar panel) produced 8 amps and 30 volts...

DC Combiner box for parallel connection of multiple strings.

To Inverter

PV output circuit amps= 16 A
PV output circuit volts= 120 V

String amps= 8 A, string volts= 120 V

String amps= 8 A, string volts= 120 V

Note: these diagrams are very basic in order to explain the concept of series versus parallel connections. Most modern-day systems are required to also include rapid shutdown components (such components are not shown here).

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Inverters

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Inverters

- ❑ Inverters are required for PV systems in order to convert DC power into AC power.
- ❑ In most cases, inverter's AC output voltage for residential use is 240V single phase.



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Inverters

- ❑ For commercial use, inverter's AC output voltage can be 208V, 240V, 277V, or 480 volts for 3 phase systems (depending on the model).

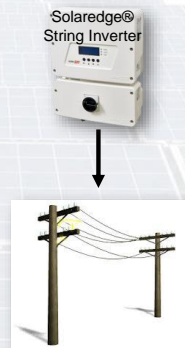


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Utility Interactive Inverters

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



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Rapid Shutdown

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Rapid Shutdown

690.12(B) Controlled Limits:

- The use of the term **array boundary** in this section is defined as **(1 ft) from the array in all directions (and 3' into the attic)**. Controlled conductors outside the array boundary shall comply with *NEC* 690.12(B)(1) and inside the array boundary shall comply with 690.12(B)(2).



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Rapid Shutdown

- **(B)(1) Outside the Array Boundary.** “Controlled conductors located outside the boundary or more than **(3 ft)** from the point of entry inside a building shall be limited to not more than **30 volts within 30 seconds** of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.”

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Rapid Shutdown

690.12(B)(2) Inside the Array Boundary:

- The PV system must comply with *one* of the following:
 - (1) “A PV hazard control system listed for the purpose (per **UL 3741**) shall be installed in accordance with the instructions included with the listing or field labeling. Where a hazard control system requires initiation to transition to a controlled state, the rapid shutdown initiation device required in 690.12(C) shall perform this initiation.”
 - (2) “Controlled conductors located **inside the boundary** or not more than (3 ft) from the point of penetration of the surface of the building shall be limited to not more than **80 volts within 30 seconds** of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.”
 - (3) “PV arrays shall have no exposed wiring methods, no exposed conductive parts, and be installed more than 2.5 m (8 ft) from exposed grounded conductive parts or ground shall not be required to comply with 690.12(B)(2).”

NFPE 70, National Electrical Code

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Rapid Shutdown Initiation Device

NEC 690.12(C) Initiation Device:

- For a one-family and two-family dwelling, the initiation device must be located at a **readily accessible** location on the outside of the building.
- The rapid shutdown initiation device(s) shall consist of at least one of the following:
 - (1) Service disconnecting means.
 - (2) PV system disconnecting means.
 - (3) Readily accessible switch that plainly indicates whether it is in the “off” or “on” position.

Where multiple PV systems are installed with rapid shutdown functions on a single service, the initiation device(s) shall consist of **not more than six switches or six sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure, or in a group of separate enclosures.**

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Rapid Shutdown Initiation Device

Example of an older type of rapid shutdown initiation device – “Birdhouse” solar shut-off device by MidNite Solar

Pushbutton switch

Breaker

The type of rapid shutdown initiation device used will depend on the type of rapid shutdown components of the system.

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Examples of Rapid Shutdown Equipment

2020 NEC 690.12(D) Equipment:

- ❑ Equipment that performs the rapid shutdown functions, **other than** initiation devices such as listed disconnect switches, circuit breakers, or control switches, shall be listed for providing rapid shutdown protection.

Tigo® TS4-R-S DC to DC converter

Enphase® micro inverter

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Rapid Shutdown Signage

- ❑ **690.56(C) - Buildings with Rapid Shutdown.** Buildings with PV systems shall have permanent labels as described in 690.12(D)

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Rapid Shutdown Signage

2020 NEC Figure 690.56(C), and 2023 NEC Figure 690.12(D)

(note: this sign was removed from the 2020 NEC)

See also 1205.4 in the 2021 IFC for similar requirements.

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Rapid Shutdown Signage For Buildings with More Than One Rapid Shutdown Type

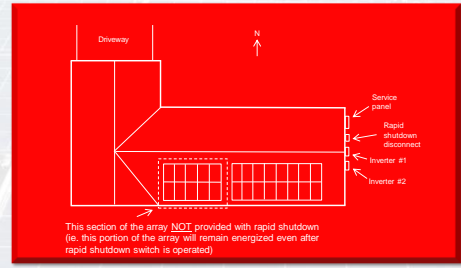
NEC 690.56(C)(1) - Buildings with More Than One Rapid Shutdown Type:

- ❑ For buildings that have PV systems with more than one type of rapid shutdown, **or** a PV system with a rapid shutdown type and a PV system with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system and a dotted line around areas that remain energized after the rapid shutdown switch is operated.

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Rapid Shutdown Signage For Buildings with More Than One Rapid Shutdown Type

Example of a plaque showing which portion(s) of the PV system are equipped with rapid shutdown and which are not:



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Rapid Shutdown Switch Signage

- ❑ **NEC 690.56(C)(2) Rapid Shutdown Switch.** A rapid shutdown switch shall have a label located on or no more than (3 ft) from the switch that includes the following wording: **“RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM”**
- ❑ The label shall be reflective, with all letters capitalized and having a minimum height of 9.5 mm (3/8 in.), in white on red background.



Sign located next to the rapid shutdown disconnect (and must be reflective)

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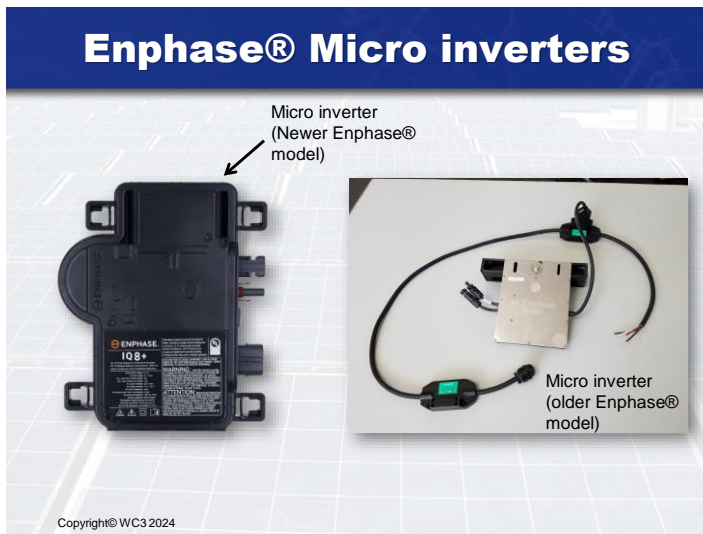
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Micro Inverter Systems VS String Inverter Systems

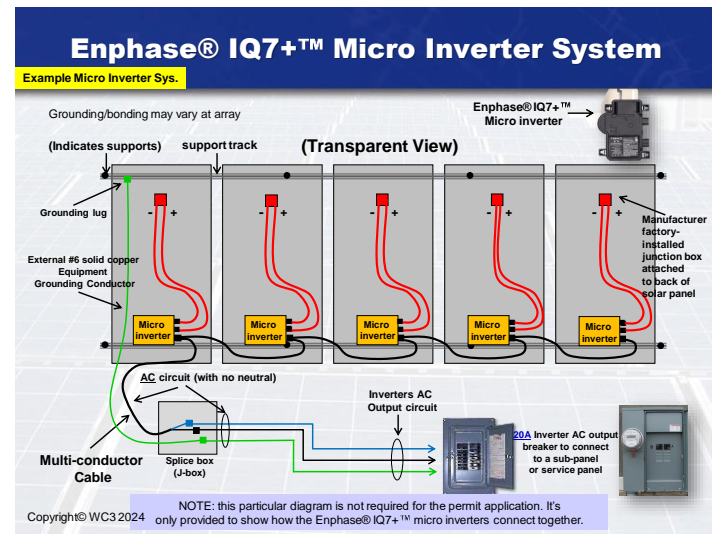
Micro Inverter Systems VS String Inverter Systems

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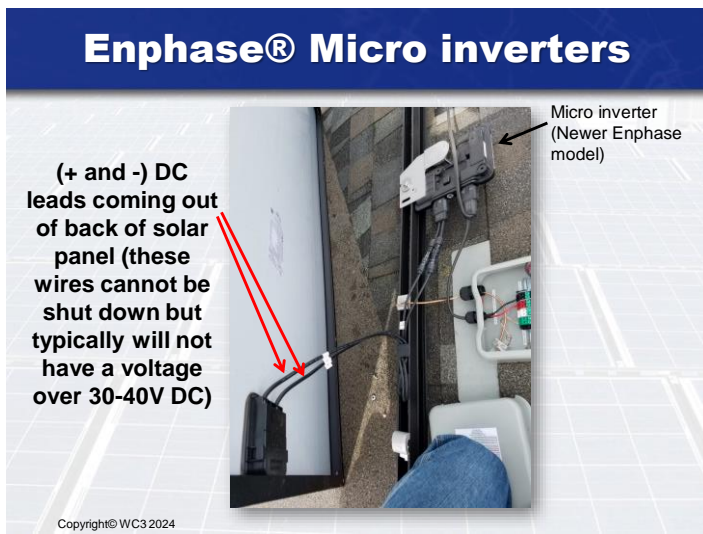
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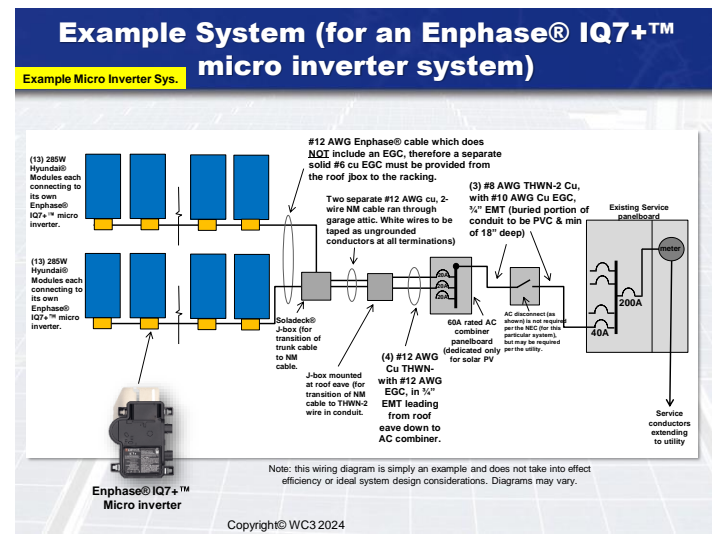
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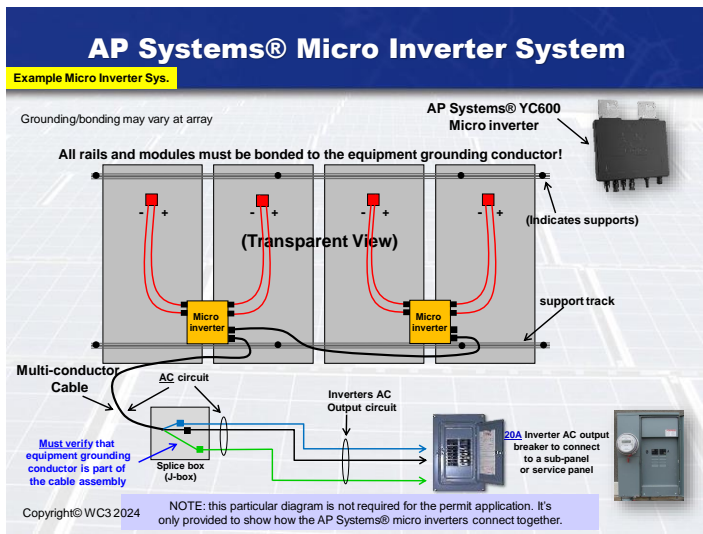
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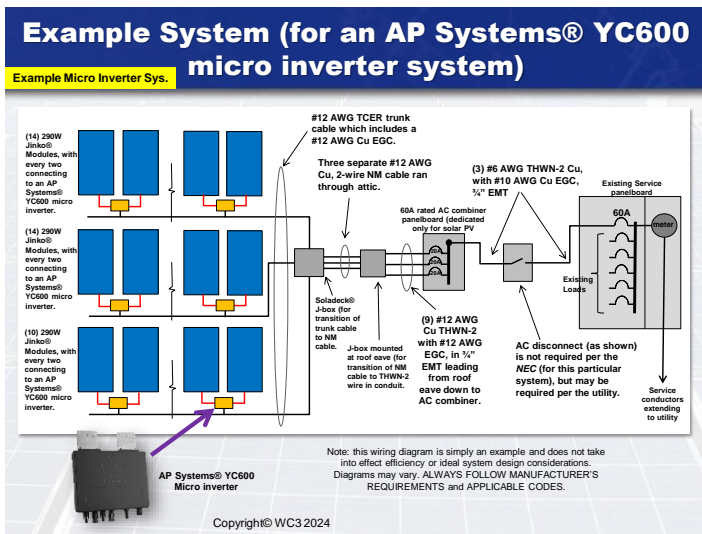
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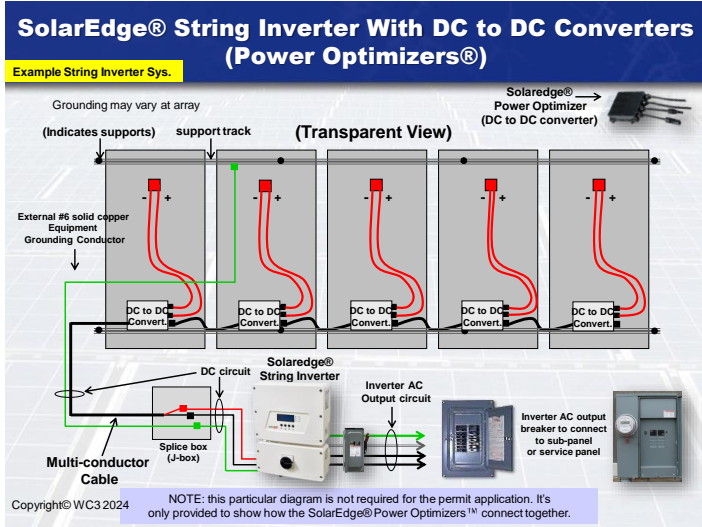
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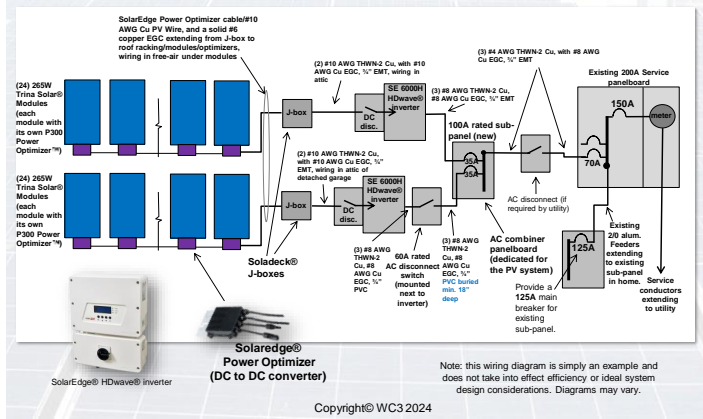
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A SolarEdge® system (with two HDwave® SolarEdge® inverters)

Example String Inverter Sys.



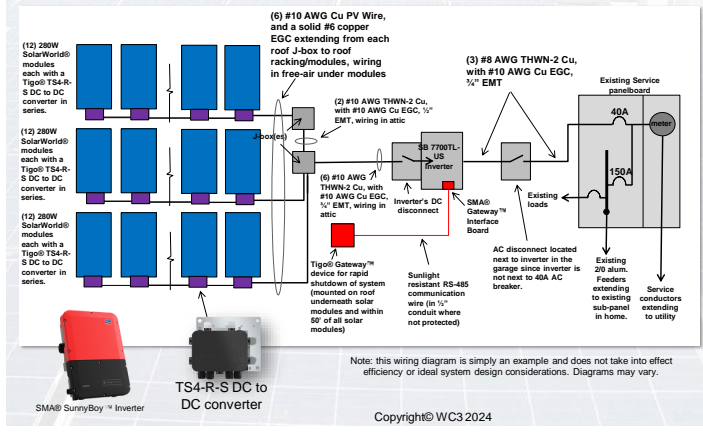
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SolarEdge® String inverters



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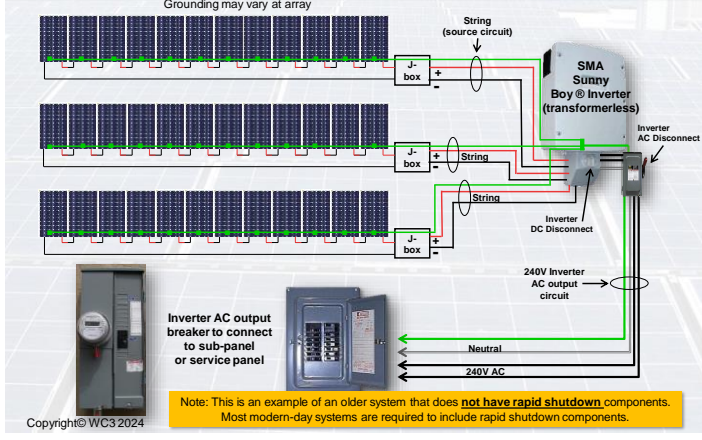
Example Single-Line Diagram (for an SMA® inverter with full rapid shutdown equipment)



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Example System – Older String Inverter

Example String Inverter Sys.



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Carports/Shade Structures



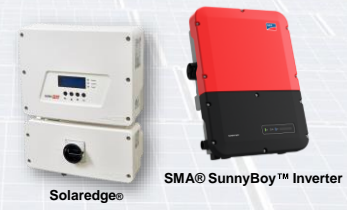
Per the 2023 NEC, Section 690.12, non-enclosed detached structures do **NOT** require rapid shutdown functionality.

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DC Ground Fault Protection (GFPD)

- ❑ PV systems operating at over 30V DC or 8 amps are required to have DC ground fault protection, NEC 690.41(B).
- ❑ Most PV inverters incorporate a DC GFPD (always verify with the inverter manufacturer!).



Note: even micro inverters are required to have listed DC ground fault protection.

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Tesla® Shingles (often considered as BIPV)

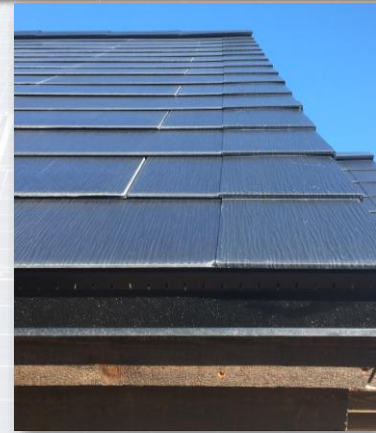


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Tesla® Shingles

Tesla® shingle systems are required to have what Tesla calls middle circuit interrupters (MCIs) throughout the solar array in order for the system to be rapid shutdown compliant.



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IRC Roof Access Provisions (per the 2021 IRC)

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Roof Access For Venting

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Roof Fire Access (2021 IRC Section R324.6)

Minimum of one 3' wide pathway from eave to ridge on each plane of the roof with solar panels. The 3' wide pathway is permitted to straddle a hip or valley or be located on an adjacent plane of the roof.

Note: these clearances are not required if waived by the Fire Department/Fire Marshall

Minimum of 3' from top of solar panels to ridge

Minimum of one 3' wide pathway from eave to ridge.

If solar modules cover more than 33% of the roof (for a non-sprinklered home) or more than 66% of the roof for a sprinklered home, then must have 3' clearance at ridge.

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Roof Fire Access (2021 IRC Section R324.6)

Minimum of one 3' wide pathway from eave to ridge.

Minimum of 18" from top of solar modules to ridge

Minimum of one 3' wide pathway from eave to ridge.

If the total roof is not covered by more than 33% with solar modules (panels), then the distance from the panels to the ridge of the home can be not less than 18".

If the home is equipped with a NFPA 13D sprinkler system, the roof is permitted to be covered up to 66% with solar panels.

Note: these clearances are not required if waived by the Fire Department/Fire Marshall

Note: fire spacing clearances are not required for non-habitable detached structures, or for roofs having a slope of 2/12 or less.

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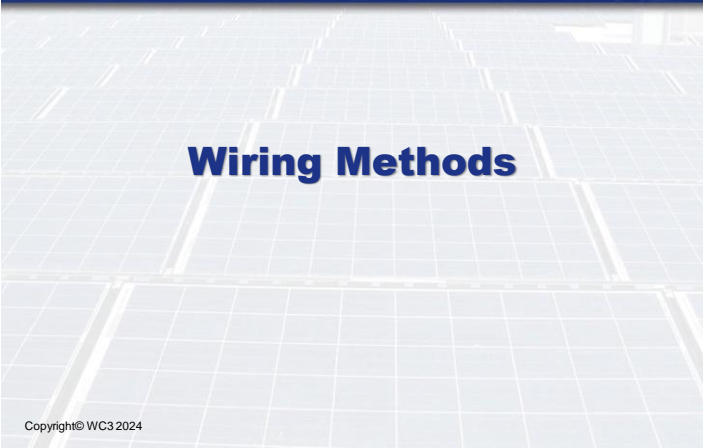
Access to Egress Openings (IRC R324.6.3)



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Wiring Methods



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Wire Types

- ❑ For PV DC circuits exposed outside, listed "PV wire" or USE-2 and RHW-2 wire must be used (and marked as sunlight resistant), *NEC* 690.31(C)(1).
- ❑ Cables to be secured every 24" using listed ties, straps, hangers, etc., where exposed.
- ❑ Wiring is also required to be protected from physical damage per *NEC* 300.4



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Installation Errors



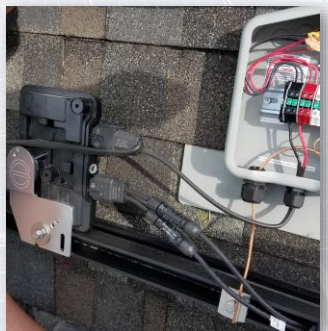
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690.31(C)(3) Multiconductor Cable

Multiconductor Cables:

- ❑ Where part of a listed PV assembly, multiconductor jacketed cables shall be installed in accordance with the included instructions.
- ❑ Where not part of a listed assembly, or where not otherwise covered in the *NEC*, multiconductor jacketed cables, including DG cable, shall be installed in accordance with the product listing and shall be permitted in PV systems and must meet the requirements of items 690.31(C)(3)(1) and (C)(3)(2).



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Wire Protection (where DC conductors are readily accessible)

NEC 690.31(A):

- ❑ Where PV source and output circuits operating at voltages greater than 30 volts are installed in readily accessible locations, circuit conductors shall be **guarded or installed in Type MC cable or in raceway.**



“Guarded circuit conductors?”

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Wire Protection (where DC conductors are readily accessible)



Fence around array could potentially be considered as “guarding” the wiring at the array, if approved by AHJ.

Wires located in readily accessible locations shall be installed in raceways, MC cable, or be guarded, *NEC 690.31(A).*

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Accessible DC Wiring?



Ground-mount solar array – DC wires guarded?

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Wiring Methods

690.31(D) – DC Circuits in/on Buildings:

- Whenever dc circuits for PV systems operate over 30V or 8 amps and are inside a building, such circuits must be in metal raceways, MC cable, or metal enclosures.
 - New exception: Non-metallic enclosures, raceways, or cables that are part of a listed PV hazard control system are permitted at the point of penetration of the building to the PV hazard control actuator.



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Wiring Methods

690.31(D)(2) – Markings/Labels:

- There must be provided labels on the exterior of all exposed raceways, enclosures, boxes, and conduit bodies. The wording of the labels must state either of the following: “PHOTOVOLTAIC POWER SOURCE” or “SOLAR PV DC CIRCUIT.”

PHOTOVOLTAIC POWER SOURCE

Or

SOLAR PV DC CIRCUIT

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Grounding and Bonding

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Grounding and Bonding of Equipment

Equipment to be grounded:

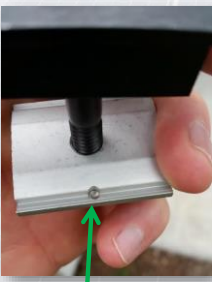
- **NEC 690.43:** The metal parts of all modules, support rails, elect. boxes, and other equipment associated with the PV system must be bonded together and connected to an equipment grounding conductor.
- **690.43(A):** Devices and systems used for mounting PV modules that are also used for bonding module frames shall be listed, labeled, and identified for bonding PV modules. Devices that mount adjacent PV modules shall be permitted to bond adjacent PV modules.

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Racking With Integrated Bonding

SnapRack® racking with integrated bonding



Bonding ring digs into rails




T-clamp pin digs into the PV modules (panels)

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Ground-Mounted System Racking With Integrated Bonding

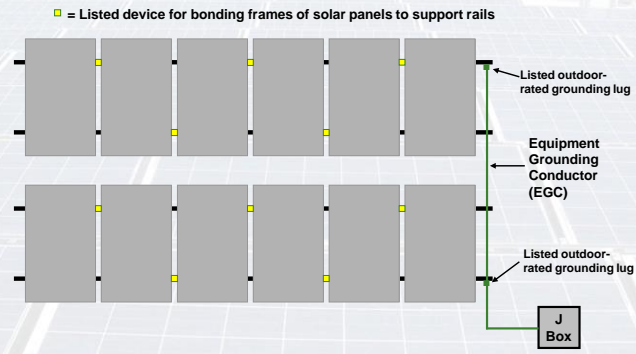


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Bonding Metal Parts To The Equipment Grounding Conductor (EGC)

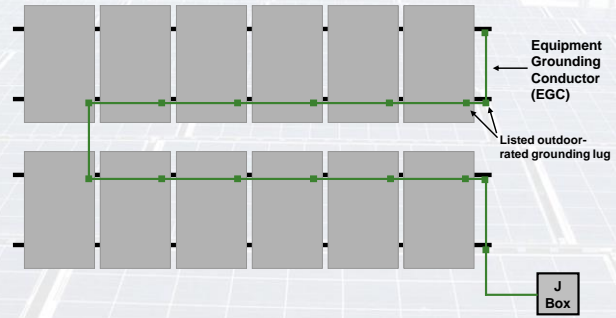
■ = Listed device for bonding frames of solar panels to support rails



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Bonding Supports And Modules



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If listed bonding devices are **not** used, each module and each rail must be individually connected to the equipment grounding conductor.

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Grounding and Bonding

690.45 – Size of EGCs:

- ❑ 690.45 of the 2020 *NEC* notes that it is not required to increase the size of the equipment grounding conductor (EGC) to address voltage drop considerations.



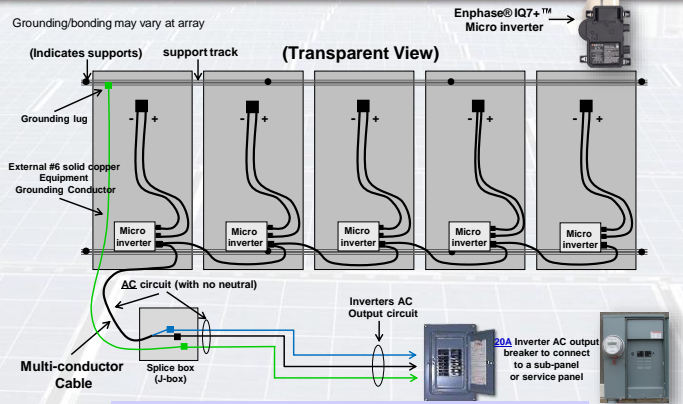
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Grounding and Bonding

2020 *NEC* 690.47(A) - Grounding Electrode System:

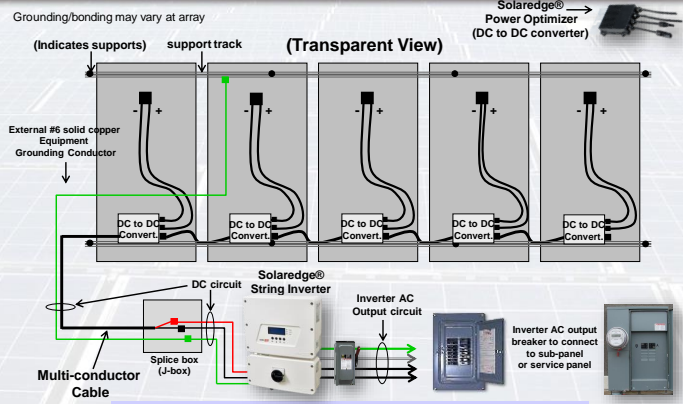
- ❑ A building or structure that supports a PV system must have a grounding electrode system (per Part III of *NEC* Article 250).
- ❑ For connection of the PV system to the grounding electrode system, either of the applicable following methods must be used:
 - PV systems that are NOT solidly grounded (such as functionally grounded systems) the equipment grounding conductor (EGC) of inverter's ac output circuit is permitted to be the only connection to ground for the PV system when such equipment ground wire is connected to a distribution system that is already connected to a grounding electrode system.
 - The second option applies to solidly grounded PV systems (see 690.47(A)(2)). These systems are very rare.

Enphase® IQ7+™ Micro Inverter System



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



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Point of Interconnection Requirements (Article 705)

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Splices and Taps

230.46 – Splices and Taps

- ❑ Any pressure connectors and devices for splicing or taps onto service conductors must be marked “suitable for use on the line side of the service equipment,” or equivalent wording.



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Multiple Sources of Power

705.10 – Identification of Power Sources:

- ❑ A permanent plaque or directory is required to be installed at each service equipment location (or other readily visible location). Such must denote the location of each power source disconnecting means for the building or structure and be grouped with any other plaques or directories.
- ❑ Such plaque or directory must be marked with the words “CAUTION: MULTIPLE SOURCES OF POWER.”

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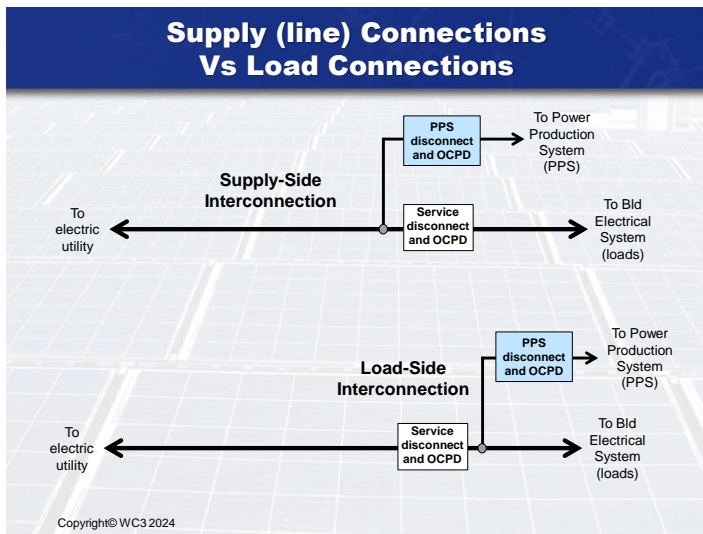
Point Of Interconnection

Connecting The PV System To The Bld's Elect. System:

- ❑ There are 2 general places a PV system can *potentially* connect to a building's electrical system:
 - On the supply side (line side) of the building's main service disconnect.
 - On the load side of the building's main service disconnect.

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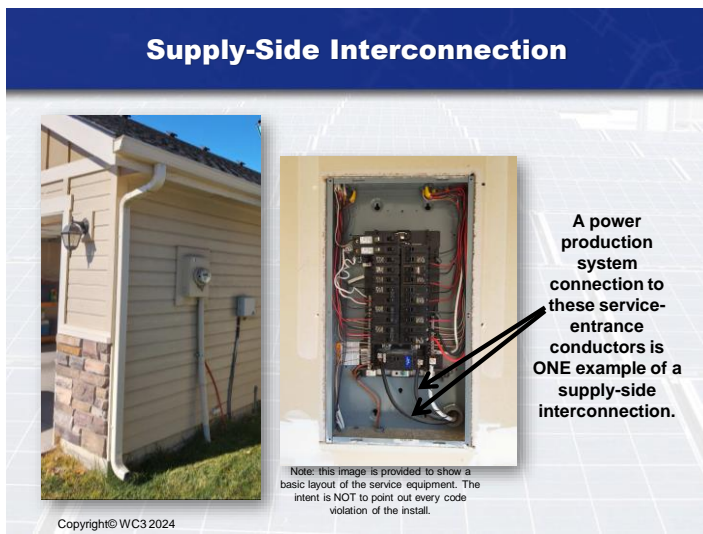
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Supply (Line) Side Connection

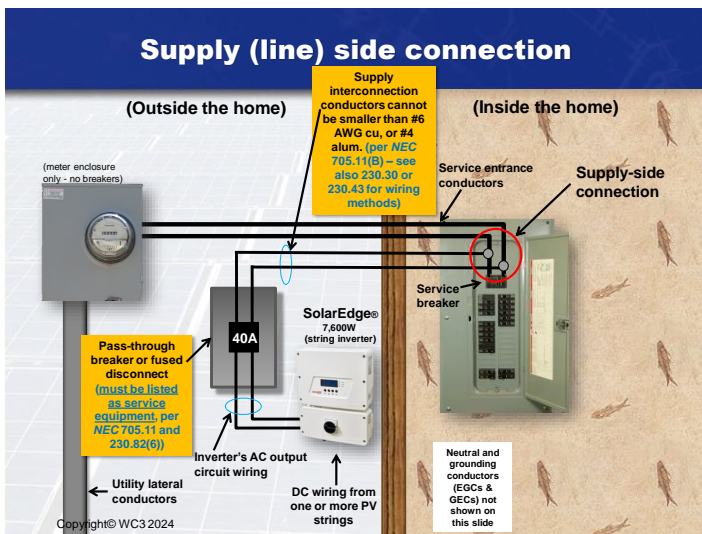
NEC 705.11:

- An electric power production source is permitted to be connected on the supply side of a service disconnecting means per 230.82(6). Such interconnection must also comply with the other requirements of 705.11.
 - Note: 230.82(6) specifies that solar PV systems are permitted to be on the supply side of the service disconnecting means if the PV system disconnecting means is listed as suitable for use as service equipment.

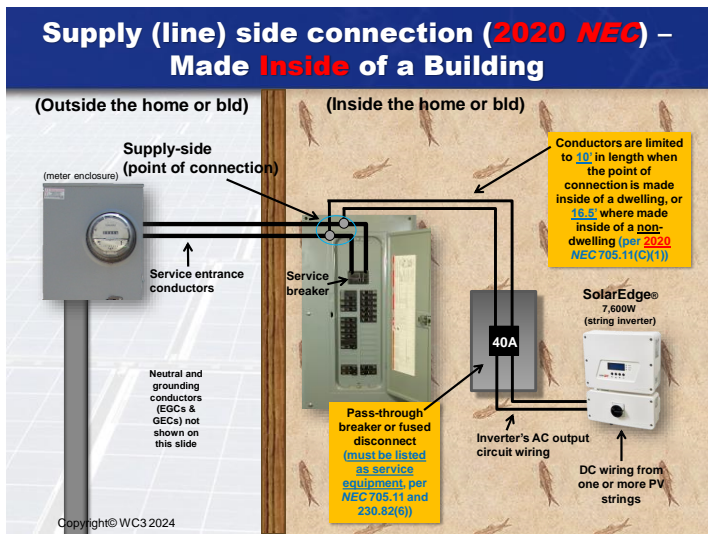
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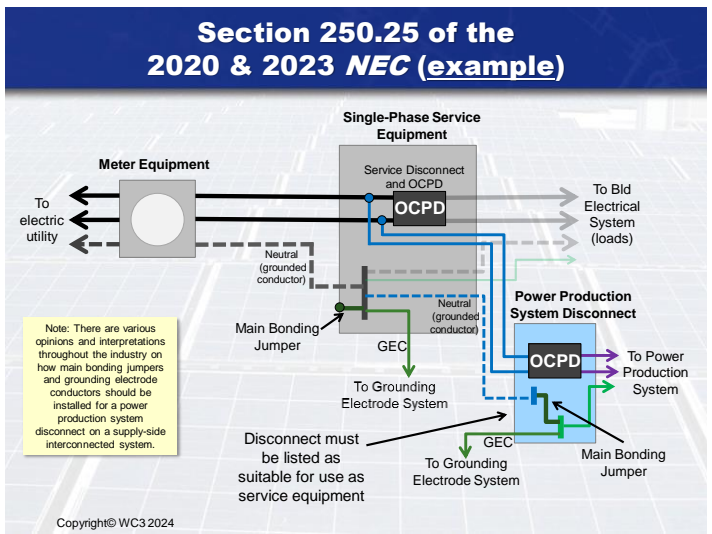
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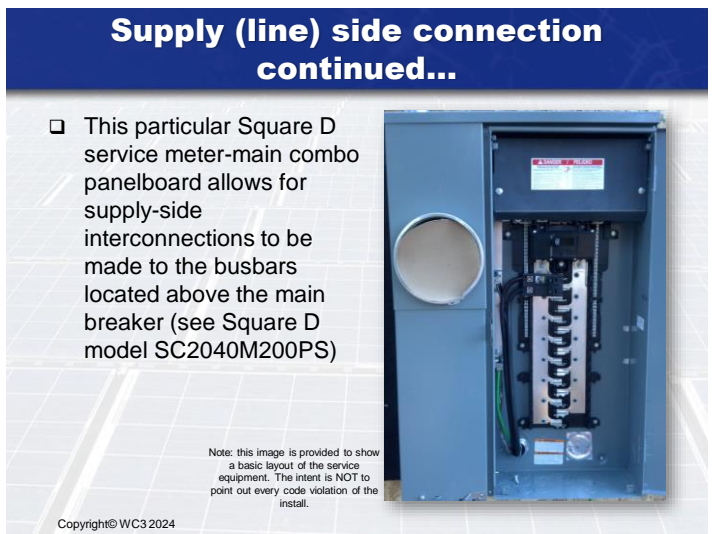
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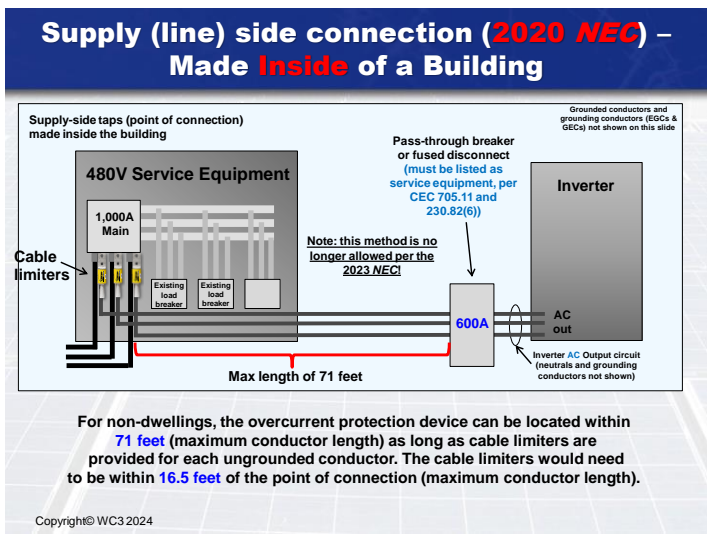
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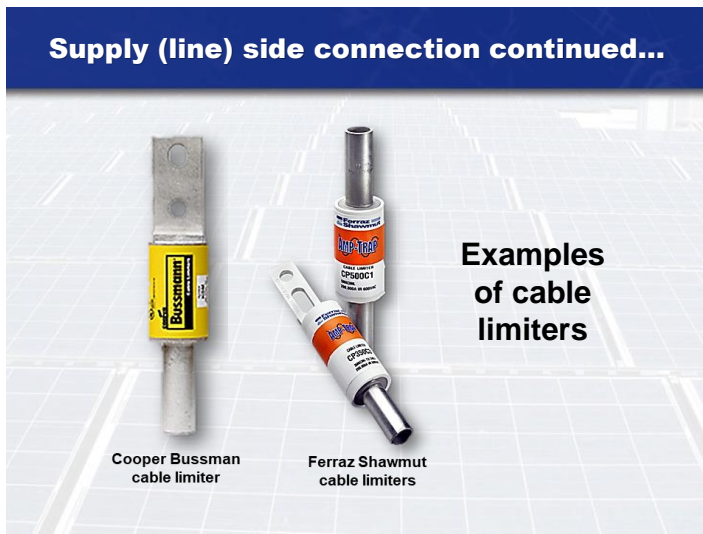
78



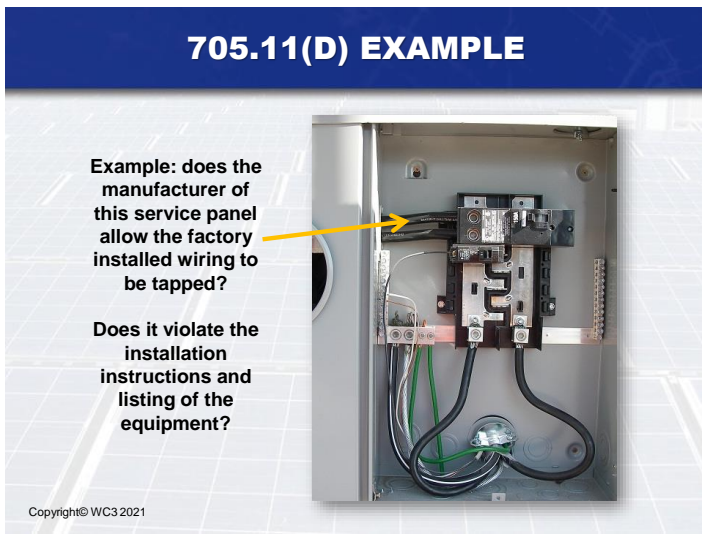
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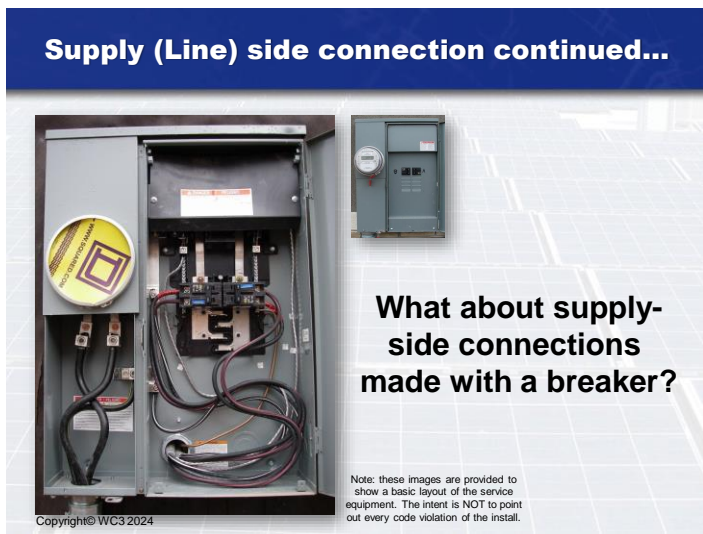
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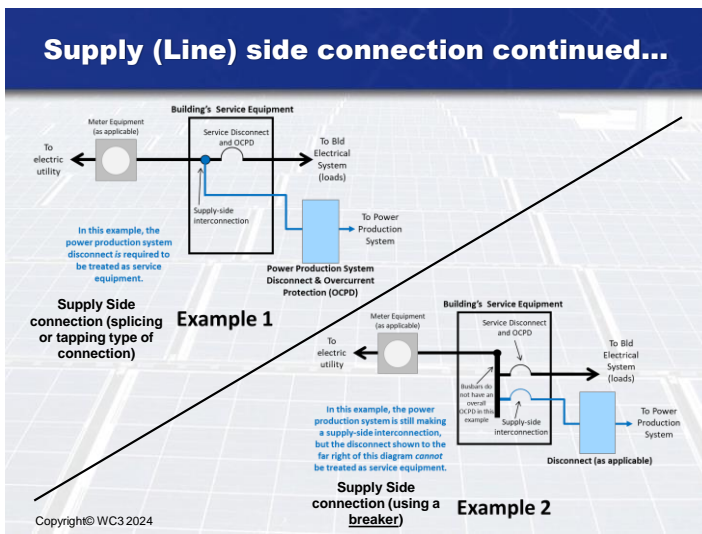
81



82




83



84

When Overcurrent Protection is Provided at the Supply End of the Conductors



In this scenario any disconnect or panelboard on the *load* side of the service breaker is **NOT** treated as service equipment, **NOR** can there be any neutral-to-ground bonding connections in it/them.

(disconnect switch, panelboard, etc.)

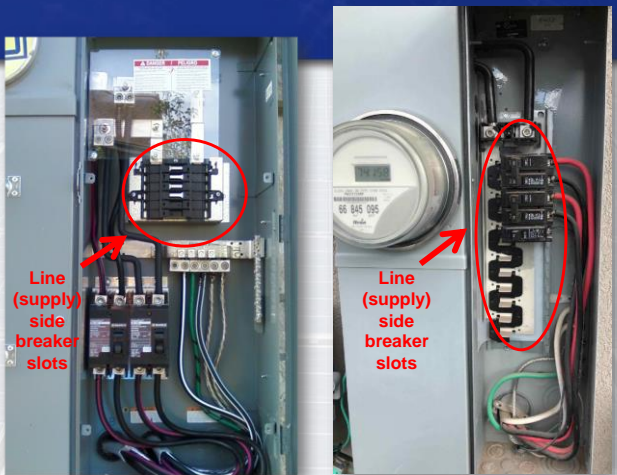
To Power Production System

NOT SERVICE EQUIPMENT

Note: this image is provided to show a basic layout of the service equipment. The intent is NOT to point out every code violation of the install.

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85



Line (supply) side breaker slots

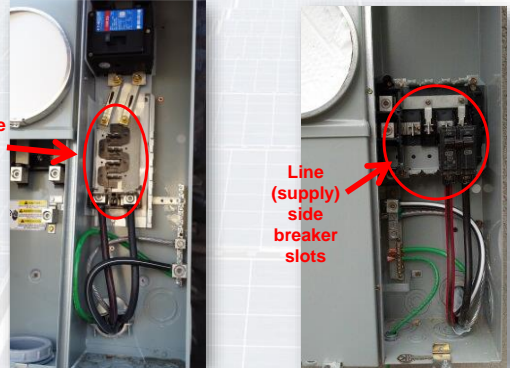
Line (supply) side breaker slots

Note: these images are provided to show a basic layout of the service equipment. The intent is NOT to point out every code violation of the install.

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86

Example service panelboards



Load side breaker slots

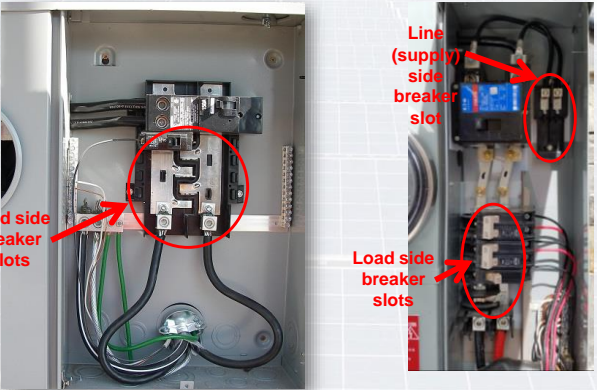
Line (supply) side breaker slots

Note: these images are provided to show a basic layout of the service equipment. The intent is NOT to point out every code violation of the install.

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87

Example service panelboards



Line (supply) side breaker slots

Load side breaker slots

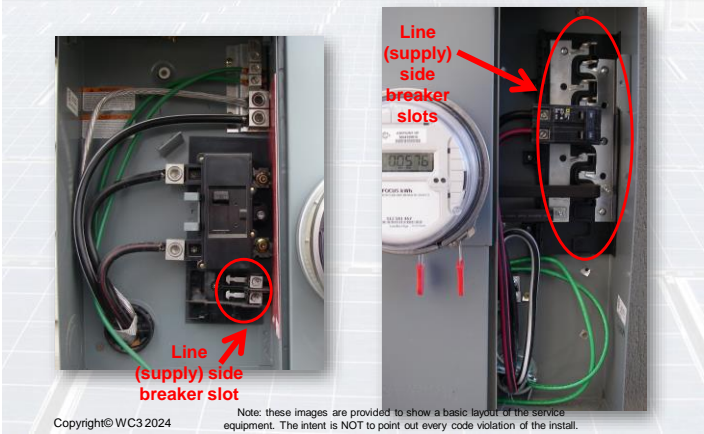
Load side breaker slots

Note: these images are provided to show a basic layout of the service equipment. The intent is NOT to point out every code violation of the install.

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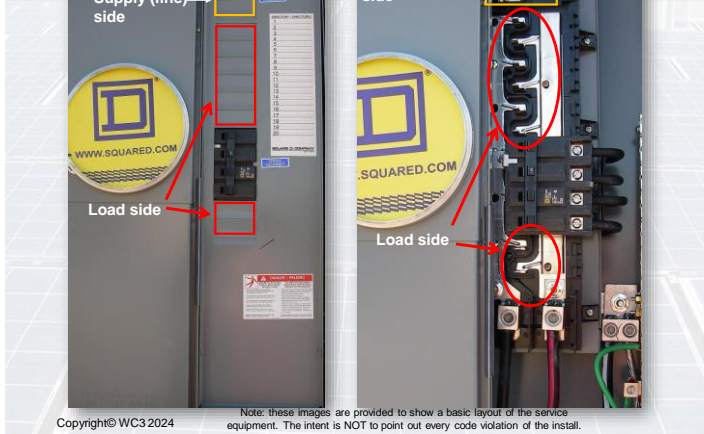
88

Example service panelboards



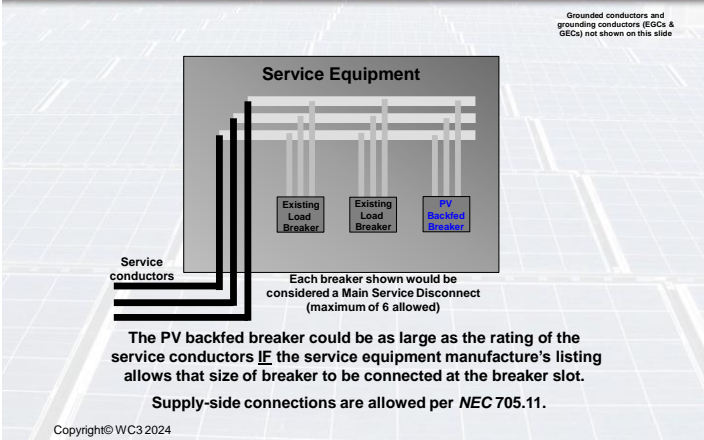
89

Example service panelboards



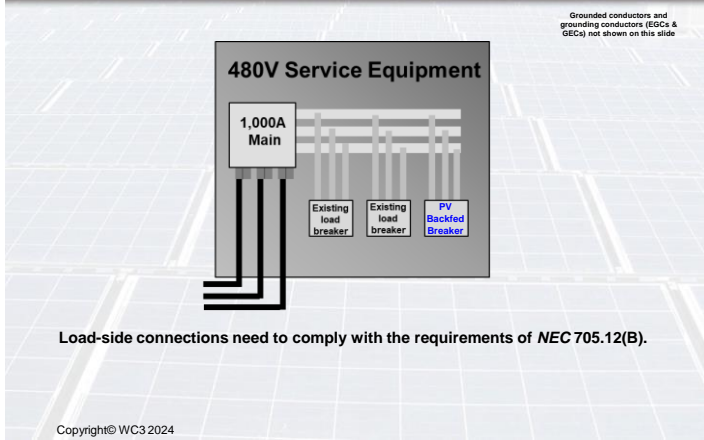
90

Supply (line) Side Of Main Service Disconnect (for large service equipment)



91

Load-Side Connections



92

Load Side Connections – 705.12

- ❑ Load side connections occur on the building's side of the main electrical service disconnect(s).
- ❑ For the purposes of this presentation, the methods of load side interconnections per the 2020 NEC will be shown on the following slides.

93

705.12(A) or (B) - Bus or Conductor Ampacity Rating

Bus or Conductor Calculations:

- ❑ 125% of the inverter(s) AC (or “power source”) output current is to be used when determining the ampacity calculations of 705.12(B)(1) through (B)(3).

solar edge Single Phase Inverters for North America
SE3000H-US / SE3800H-US / SE5000H-US / SE6000H-US / SE7600H-US

Example:
32 amps × 1.25 = 40 amps

| | SE6000H-US | | SE7600H-US | | | |
|---|------------------|------|------------|-------|-------|-----|
| OUTPUT | | | | | | |
| Rated AC Power Output | 3000 | 3800 | 5000 | 6000 | 7600 | VA |
| Max. AC Power Output | 3000 | 3800 | 5000 | 6000 | 7600 | VA |
| AC Output Voltage Min.-Nom.-Max. (119 - 208 - 279V) | ✓ | | | | | Vac |
| AC Output Voltage Min.-Nom.-Max. (211 - 240 - 264V) | ✓ | | | | | Vac |
| AC Frequency (Nominal) | 50.3 - 60 - 60.5 | | | | | Hz |
| Maximum Continuous Output Current 208V | | | | | 32 | A |
| Maximum Continuous Output Current 240V | 12.5 | 16 | 21 | 25 | 33 | A |
| GFDI Threshold | 1 | | | | | A |
| Utility Monitoring, Islanding Protection, Country Configurable Thresholds | Yes | | | | | |
| INPUT | | | | | | |
| Maximum DC Power | 6550 | 8000 | 12160 | 14400 | 18300 | W |

SolarEdge® Inverter specs (SolarEdge.com)

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705.12(B)(1) – Feeders

Feeders

- ❑ When an inverter (“power source”) connection is made to a feeder, the feeder is required to have an ampacity not less than 125% of the output current (amps) of the inverter(s).
- ❑ Per 705.12(B)(1), when the inverter (“power source”) AC output connection is made to a feeder at a location other than the opposite end of the feeder from the primary source overcurrent device, the portion of feeder on the load side of the inverter (“power source”) output connection must be protected by NEC 705.12(B)(1)(a) or (B)(1)(b).

95

705.12(B)(1) (Feeders) continued...

- ❑ If the PV connection to a feeder is not at the opposite end of the feeder from the feeder’s main breaker (primary overcurrent protection device), the feeder’s ampacity on the load side of the PV connection must be as per NEC 705.12(B)(1)(a) or (B)(1)(b):
 - a) The feeder ampacity must not be less than the sum of the primary source OCPD and 125% of the inverter(s) (power source) output current.
 - OR
 - b) An overcurrent device on the load side of the inverter (power source) AC output connection must be rated not greater than the ampacity of the feeder.

96

Feeders – Example For Option “a” (NEC 705.12(B)(1)(a))

Option “a”: The feeder must have an ampacity of the sum of the primary source OCPD and the inverter AC output amps x 1.25:

150 amp breaker

From PV inverter

2/0 aluminum wire

Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

PV disconnect with 40 amp PV breaker (or fuses)

(feeder Taps)

(Inverter output $32A \times 1.25$)

150A + 40A = 190 amps – 2/0 aluminum is too small!

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Feeders – Another Example For Option “a” (NEC 705.12(B)(1)(a))

Option “a”: The feeder wires must have an ampacity of the sum of the primary source OCPD and the inverter AC output amps x 1.25:

150 amp Service Breaker

2/0 aluminum wire

Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

40A PV Breaker

Feed through lugs

(Inverter AC output amps x 1.25)

150A + 40A = 190 amps – 2/0 aluminum is too small!

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Feeders – Example For Option “b” (NEC 705.12(B)(1)(b))

Option “b”: An OCPD on the load side of the inverter (power source) connection must be rated not greater than the ampacity of the feeder.

150 amp breaker

From PV inverter

2/0 aluminum wire

Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

PV disconnect with 40 amp PV breaker (or fuses)

(feeder Taps)

(Inverter output $32A \times 1.25$)

150A + 40A = 190 amps – 2/0 aluminum is too small!

A New 125A OCPD somewhere between the tap and the sub-panel

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Feeders – Another Example For Option “b” (NEC 705.12(B)(1)(b))

Option “b”: An OCPD on the load side of the inverter (power source) connection must be rated not greater than the ampacity of the feeder.

150 amp Service Breaker

2/0 aluminum wire

Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

40A PV Breaker

A New 125A OCPD somewhere between the Service panel and the sub-panel

Feed through lugs

(Inverter AC output amps x 1.25)

150A + 40A = 190 amps – 2/0 aluminum is too small!

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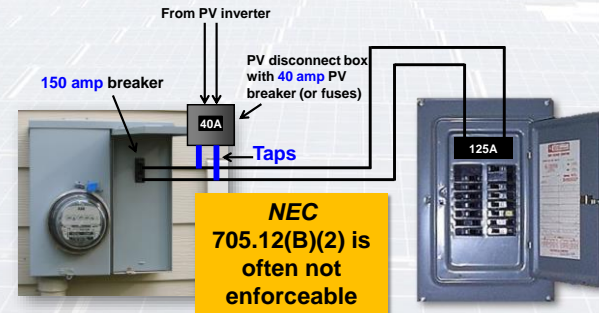
NEC 705.12(B)(2) – Taps

Feeder Taps:

- Where inverter (power source) AC output circuits tap feeder conductors, the **taps** must be sized based on the sum of 125% of the inverter (power source) output circuit current and the rating of the OCPD that is protecting the feeder conductors as calculated per 240.21(B).
- The above noted code section is very confusing and often is not enforceable. Because of this, consider NEC 705.28(B) as an alternate code section for dealing with feeder taps (see next couple slides for explanation):

101

NEC 705.12(B)(2) – Taps continued...



Strict reading of NEC 705.12(B)(2) suggests that the taps shown above must be sized per $150A + 40A = 190 \text{ amps!!}$ Is this enforceable?? The taps ampacity must also be as per NEC 240.21(B).

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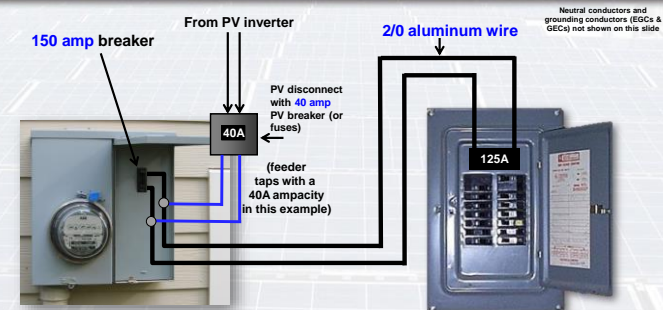
NEC 705.12(B)(2) – Taps (per the 2023 NEC)

Feeder Taps:

- Where inverter (power source) AC output circuits tap feeder conductors, the **taps** are to be sized based on 125% of the inverter (power source) output circuit current.
- If either 240.21(B)(2) or (B)(4) will be used (for taps over 10 feet and up to 25 feet long), then the ampacity of the taps cannot be less than 1/3 of the sum of the rating of the OCPD that is protecting the feeder conductors plus the rating of the power source OCPD.

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NEC 705.12(A)(3) – Taps continued... (per the 2023 NEC)



As long as the feeder taps are **not over 10 feet long**, per NEC 705.12(A)(3) the tap conductors must have an ampacity of 125% of the rated output amps of the inverter (which is 40A for a 32A inverter).

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NEC 705.12(A)(3) – Taps OVER 25 Feet Long (per the 2023 NEC)

From PV inverter

150 amp breaker (1/3 of 150A is 50A)

40A

2/0 aluminum wire

125A

PV disconnect with 40 amp PV breaker (or fuses)

(feeder taps with a 90A ampacity in this example)

Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

IF the feeder taps are longer than 10 feet but not over 25 feet, per NEC 705.12(A)(3) the tap conductors must have an ampacity of at least 1/3 of the 150A main breaker plus the rating of the inverter's OCPD (which is 90A for this example).

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NEC 705.12(B)(3) – Busbars

Busbars

- NEC 705.12(B)(3)(1) through (B)(3)(6) must be used for determining the minimum ratings of panelboard busbars.

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Panelboards with only power source connections (i.e. often called AC combiners)

- It's a common interpretation by AHJs that panelboards which are dedicated only for the PV (and/or ESS) system are not required to comply with the requirements of 705.12(B).

1 or more DC strings (source circuits) in.

Sunny Boy (SMA)

20A

20A

40A

Tie-in PV breaker

(bid. sub-panel or service box)

Main breaker

Inverter AC output combiner panel example (no loads in this panelboard)

Grounded conductors and ground wires (EGCs & GECs) not shown on this slide

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Busbars – Example For Method “1” (NEC 705.12(B)(3)(1))

- 1) The busbars in a panel must be rated for at least the sum of the rating of the OCPD protecting the busbar and the inverter(s) AC output amps x 125%.

200 amp breaker

4/0 aluminum wire

40 amp PV breaker

(Inverter output amps x 1.25)

200A + 40A = 240A
The panel's busbar rating is exceeded! Violation!

200A rated panel

Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

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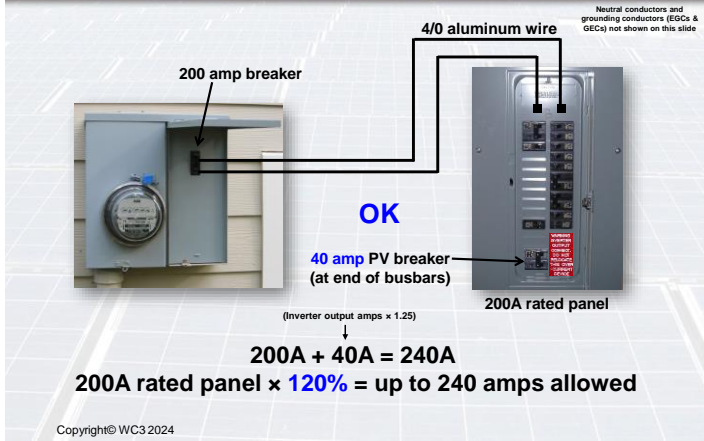
108

Method "2" (NEC 705.12(B)(3)(2))

- 2) Where two sources, one a utility (primary power source) and the other an inverter (or other power source), are located at opposite ends of a busbar that also has other loads, the sum of the rating of the OCPD protecting the busbar and the inverter(s) (power source) current rating $\times 125\%$ cannot exceed 120% of the rating of the busbar.
 - The busbars must already be sized for the connected loads as per Article 220 in the NEC.
 - A sign must be provided next to the backfed PV breaker stating: "WARNING: POWER SOURCE OUTPUT - DO NOT RELOCATE THIS OVERCURRENT DEVICE"

109

Example for method "2" (NEC 705.12(B)(3)(2))



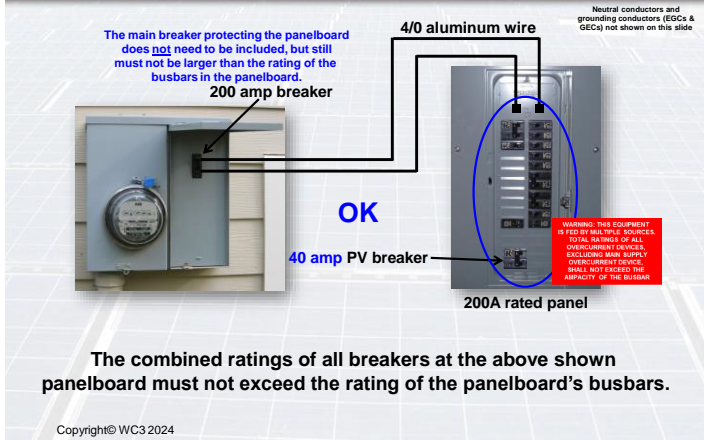
110

Method "3" (NEC 705.12(B)(3)(3))

- 3) The sum of the ampere ratings of all breakers (OCPDs) on panelboards, including load and supply breakers (but NOT counting the main breaker protecting the panel), must not exceed the rating of the panelboard's busbars.
 - The rating of the main breaker protecting the panelboard must not exceed the rating of the busbars.
 - Permanent warning label must be applied to the panel (distribution equipment) with the words: "WARNING: EQUIPMENT FED BY MULTIPLE SOURCES. TOTAL RATINGS OF ALL OVERCURRENT DEVICES, EXCLUDING MAIN SUPPLY OVERCURRENT DEVICE, SHALL NOT EXCEED THE AMPACITY OF BUSBAR."

111

Example for method "3" (NEC 705.12(B)(3)(3))



112

Another example for method “3” (NEC 705.12(B)(3)(3))

Note: this image is provided to show a basic layout of the service equipment. The intent is NOT to point out every code violation of the install.

200A rated service panelboard with a 200A main service breaker.

The sum of the breakers in this panel (including the solar PV breaker but NOT counting the main 200A service breaker) could not exceed 200A, per NEC 705.12(B)(3)(3).

WARNING: THIS EQUIPMENT IS FED BY MULTIPLE SOURCES. TOTAL RATINGS OF ALL OVERCURRENT DEVICES, EXCLUDING MAIN SUPPLY OVERCURRENT DEVICE, SHALL NOT EXCEED THE AMPACITY OF THE BUSBAR

(Required sign)

100A exist. load breaker

40 amp PV breaker

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Method “4” (NEC 705.12(B)(3)(4))

4) A connection at *either* end (but not both ends) of a **center-fed** panel board in dwellings is allowed where the sum of 125 percent of the power source(s) output circuit current and the rating of the overcurrent device protecting the busbar does not exceed 120 percent of the current rating of the busbar.

114

Center-Fed Busbars (dwellings)

Don't forget about protection for the feeder wires per NEC 705.12(B)(1) if the PV system will backfeed a breaker on the same busbars that the existing feeder wires connect to (see previous slides talking about this issue)

Note: these images are provided to show a basic layout of the service equipment. The intent is NOT to point out every code violation of the install.

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Example Of Center-Fed Equipment:

Commercial Electrical Switchgear

Service entrance conductors from electric Utility

Main Service Disconnect

OCPD OCPD OCPD OCPD OCPD OCPD


Note: Cannot use the 120% allowance of NEC 705.12(B)(3)(4) for commercial center-fed electrical systems!!

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Method "5" (NEC 705.12(B)(3)(5))

6) Connections made to switchgear, switchboards, and panelboards that are in configurations differing from NEC 705.12(B)(3)(1) through (B)(3)(5) are permitted as long as designed under engineering supervision that includes available fault-current and busbar load calculations.



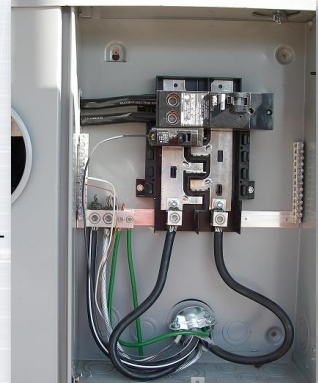
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Method "6" (NEC 705.12(B)(3)(6))

5) "Connections shall be permitted on busbars of panelboards that supply lugs connected to feed-through conductors. The feed-through conductors shall be sized in accordance with 705.12(B)(1)."

"Where an overcurrent device is installed at either end of the feed-through conductors, panelboard busbars on either side of the feed-through conductors shall be permitted to be sized in accordance with 705.12(B)(3)(1) through (B)(3)(3)."

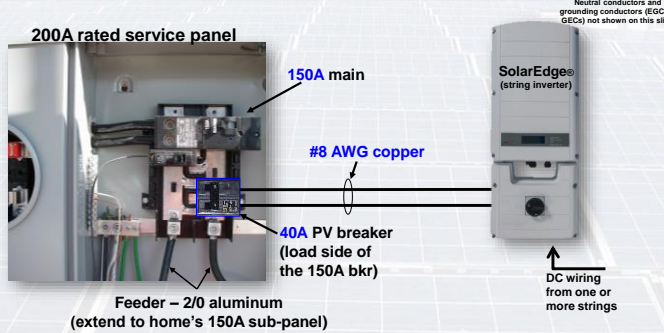


Note: this image is provided to show a basic layout of the service equipment. The intent is NOT to point out every code violation of the install.

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Example System



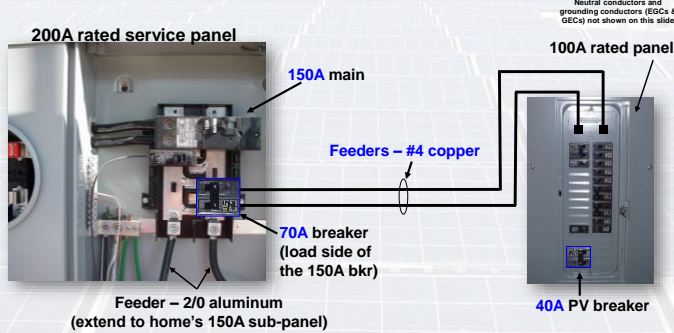
Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

NEC 705.12(B)(1) and (B)(6) violation for the existing 2/0 feeders!
The 2/0 feeders need to be increased to 250kcmil OR a 125A breaker (or fused disconnect) must be added between the service and the existing sub-panel.

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Example System

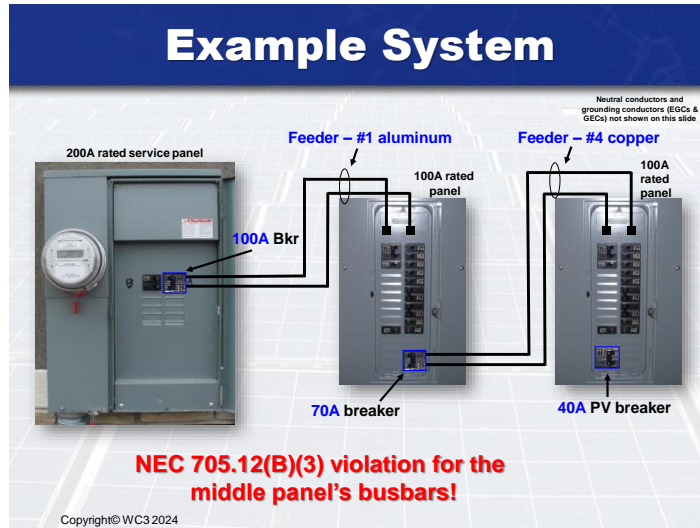


Neutral conductors and grounding conductors (EGCs & GECs) not shown on this slide

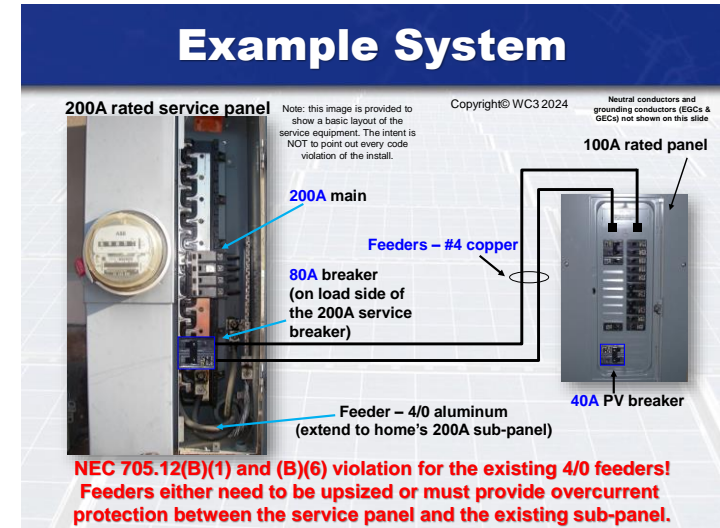
NEC 705.12(B)(1) and (B)(6) violation for the existing 2/0 feeders!

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705.13 – Power Control Systems

- ❑ **705.13:** “A power control system (PCS) shall be listed and evaluated to control the output of one or more power production sources, energy storage systems (ESS), and other equipment. The PCS shall limit current and loading on the busbars and conductors supplied by the PCS.”
- ❑ **705.13(E):** “The access to settings of the PCS shall be restricted to qualified personnel in accordance with the requirements of **240.6(C)**.”

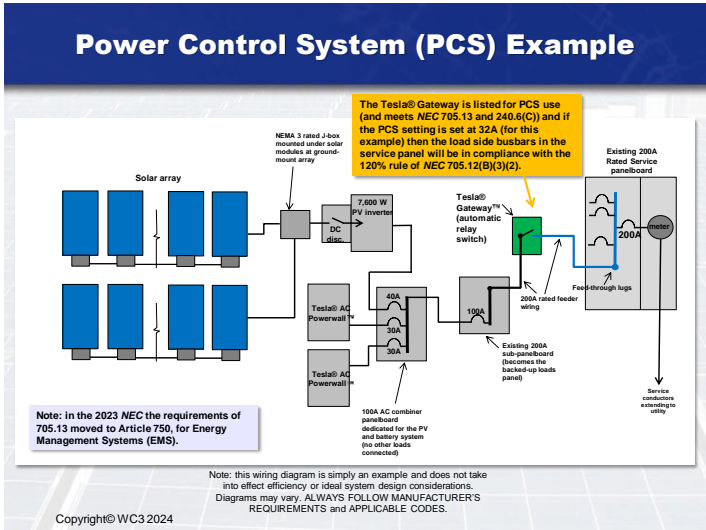
Note: the requirements of *NEC 705.13* moved to Article 750 in the 2023 *NEC* (for Energy Management Systems)

123

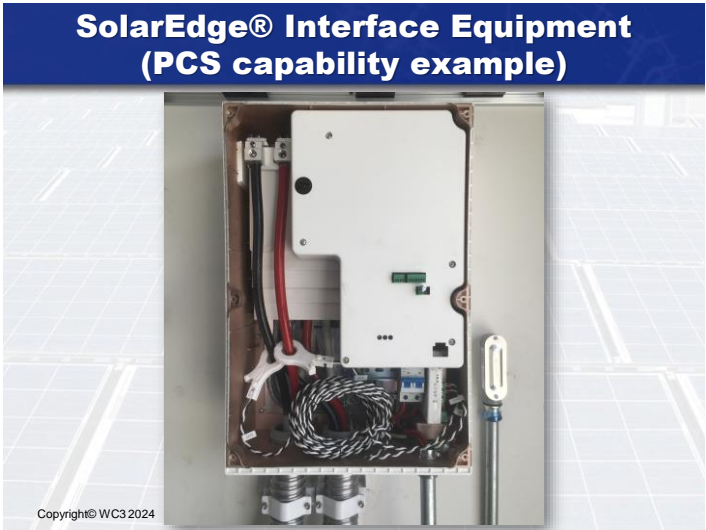
Power Control Systems (continued)

- ❑ **240.6(C)** requires restricted access to be achieved by one of the following methods:
 - (1) Located behind removable and sealable covers over the adjusting means
 - (2) Located behind bolted equipment enclosure doors
 - (3) Located behind locked doors accessible only to qualified personnel
 - (4) Password protected, with password accessible only to qualified personnel

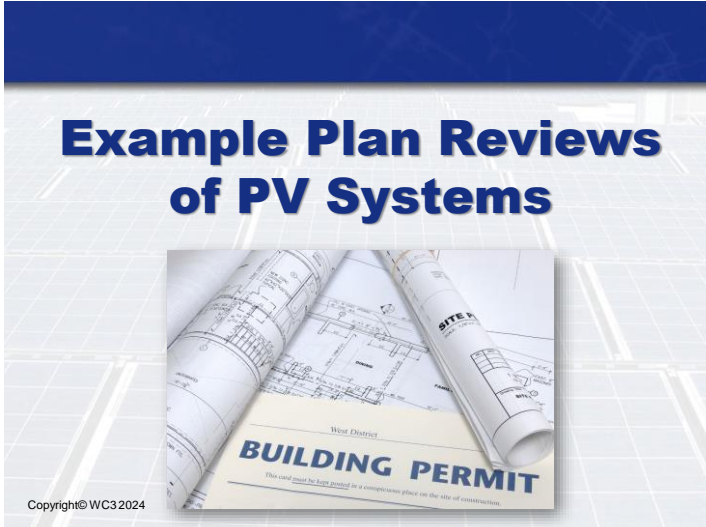
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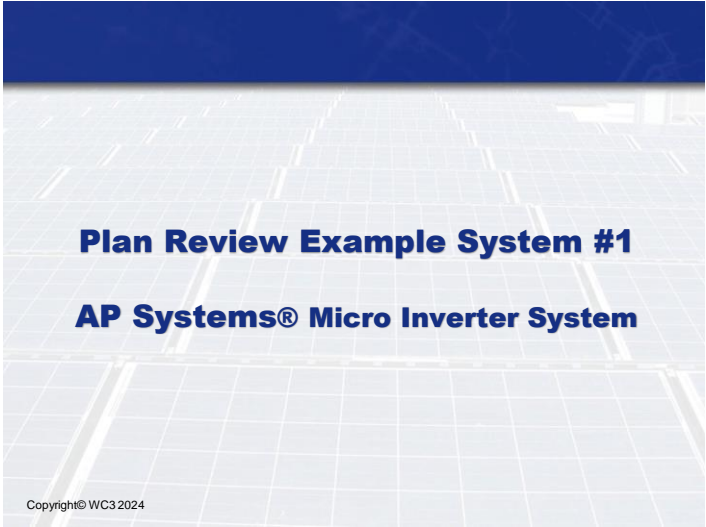
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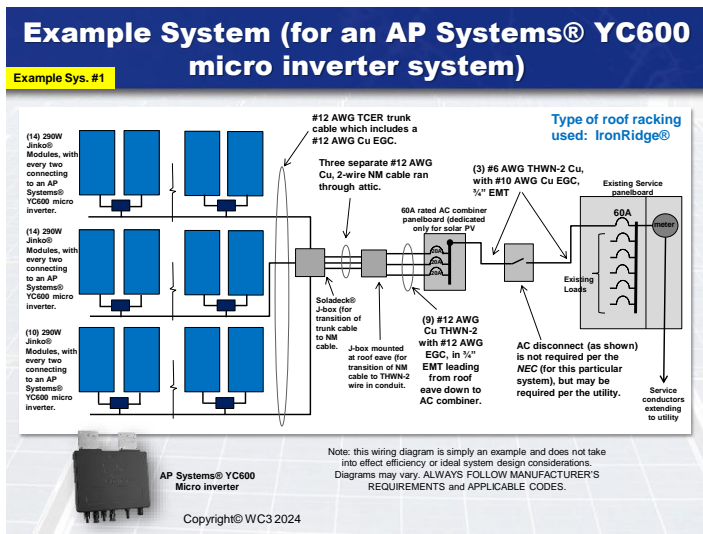
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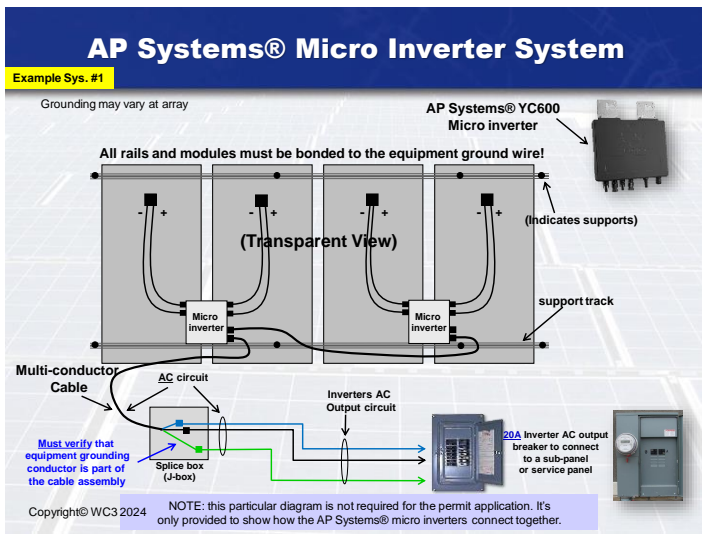
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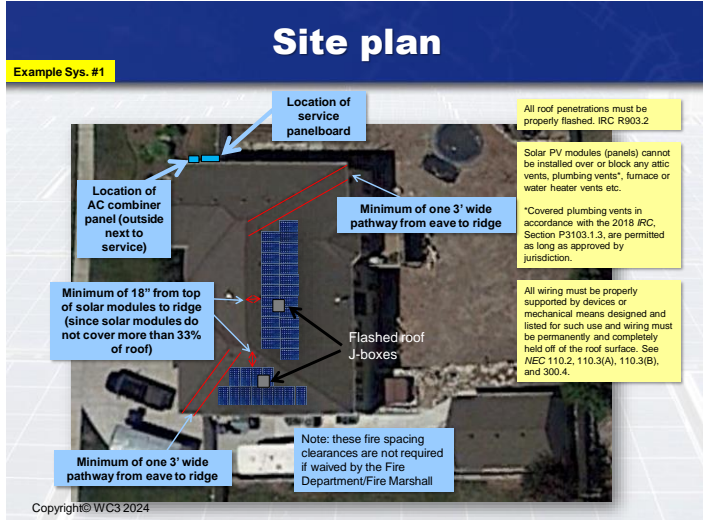
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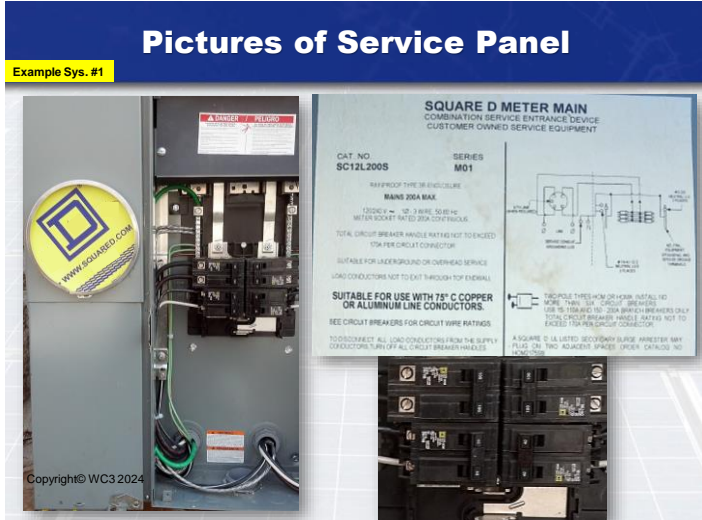
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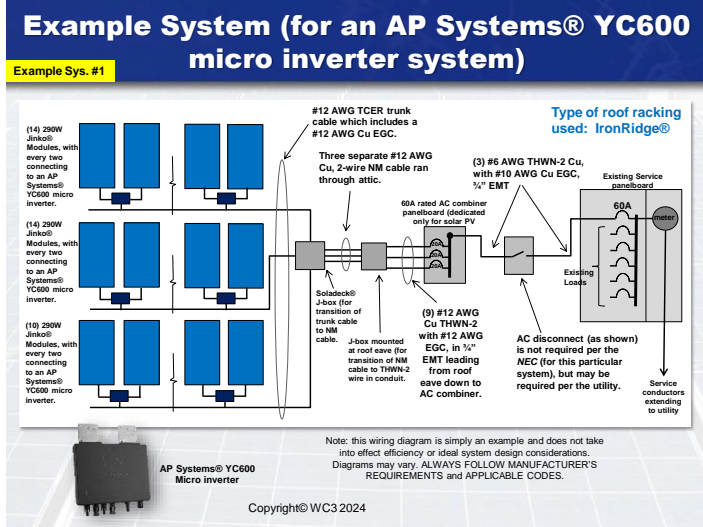
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National Electrical Code® Tables (for wire ampacity deration, if needed)

Example Sys. #1

Table 310.15(B)(16) (formerly Table 310.16) Allowable Ampacities of Insulated Conductors Rated Up to and Including 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)*

| Size AWG or kcmil | Temperature Rating of Conductor (See Table 310.106(A)) | | | | | | Size AWG or kcmil |
|-------------------|--|--------------|--------------|----------------------------------|--------------|--------------|-------------------|
| | 60°C (140°F) | 75°C (167°F) | 90°C (194°F) | 60°C (140°F) | 75°C (167°F) | 90°C (194°F) | |
| | COPPER | | | ALUMINUM OR COPPER-CLAD ALUMINUM | | | |
| 10** | — | — | 14 | — | — | — | 10** |
| 12** | — | — | 18 | — | — | — | 12** |
| 14** | 15 | 20 | 25 | 15 | 20 | 25 | 14** |
| 16** | 20 | 25 | 30 | 15 | 20 | 25 | 16** |
| 18 | 25 | 30 | 35 | 20 | 25 | 30 | 18 |
| 20 | 30 | 35 | 40 | 25 | 30 | 35 | 20 |
| 22 | 35 | 40 | 45 | 30 | 35 | 40 | 22 |
| 24 | 40 | 45 | 50 | 35 | 40 | 45 | 24 |
| 26 | 45 | 50 | 55 | 40 | 45 | 50 | 26 |
| 28 | 50 | 55 | 60 | 45 | 50 | 55 | 28 |
| 30 | 55 | 60 | 65 | 50 | 55 | 60 | 30 |
| 32 | 60 | 65 | 70 | 55 | 60 | 65 | 32 |
| 34 | 65 | 70 | 75 | 60 | 65 | 70 | 34 |
| 36 | 70 | 75 | 80 | 65 | 70 | 75 | 36 |
| 38 | 75 | 80 | 85 | 70 | 75 | 80 | 38 |
| 40 | 80 | 85 | 90 | 75 | 80 | 85 | 40 |
| 42 | 85 | 90 | 95 | 80 | 85 | 90 | 42 |
| 44 | 90 | 95 | 100 | 85 | 90 | 95 | 44 |
| 46 | 95 | 100 | 105 | 90 | 95 | 100 | 46 |
| 48 | 100 | 105 | 110 | 95 | 100 | 105 | 48 |
| 50 | 105 | 110 | 115 | 100 | 105 | 110 | 50 |
| 54 | 110 | 115 | 120 | 105 | 110 | 115 | 54 |
| 60 | 120 | 125 | 130 | 115 | 120 | 125 | 60 |
| 66 | 130 | 135 | 140 | 125 | 130 | 135 | 66 |
| 70 | 140 | 145 | 150 | 135 | 140 | 145 | 70 |
| 75 | 150 | 155 | 160 | 145 | 150 | 155 | 75 |
| 80 | 160 | 165 | 170 | 155 | 160 | 165 | 80 |
| 90 | 175 | 180 | 185 | 170 | 175 | 180 | 90 |
| 100 | 190 | 195 | 200 | 185 | 190 | 195 | 100 |
| 125 | 220 | 225 | 230 | 215 | 220 | 225 | 125 |
| 150 | 240 | 245 | 250 | 235 | 240 | 245 | 150 |
| 175 | 260 | 265 | 270 | 255 | 260 | 265 | 175 |
| 200 | 280 | 285 | 290 | 275 | 280 | 285 | 200 |
| 250 | 310 | 315 | 320 | 305 | 310 | 315 | 250 |

Since we have (6) current-carrying #12 THWN-2 (90°C) copper wires in the same conduit (from the eave j-box down to the AC combiner panel), we can use 30A (shown in the 90C column) to start our ampacity deration. 30A x .80= 24A, which #12 AWG cu THWN-2 conductors are still acceptable for our micro inverter circuits)

Table 310.15(B)(3)(a) Adjustment Factors for More Than Three Current-Carrying Conductors

| Number of Conductors* | Percent of Values in Table 310.15(B)(16) through Table 310.15(B)(19) as Adjusted for Ambient Temperature if Necessary |
|-----------------------|---|
| 4-6 | .80 |
| 7-9 | .75 |
| 10-20 | .70 |
| 21-30 | .65 |
| 31-40 | .60 |
| 41 and Above | .55 |

*Number of conductors is the total number of conductors in the raceway or cable including spare conductors. The count shall be adjusted in accordance with 310.15(B)(5) and (6). The count shall not include conductors that are connected to electrical components but that cannot be simultaneously energized.

NEC Table 310.15(B)(16)

NEC Table 310.15(B)(3)(a)

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National Electrical Code® Tables (for wire ampacity deration, if needed)

Example Sys. #1

NEC Table 310.15(B)(3)(c) Ambient Temperature Adjustment for Raceways or Cables Exposed to Sunlight on or Above Roofing

| Distance Above Roof to Bottom of Raceway or Cable (0 = 3/8 in.) | Temperature Adder | |
|---|-------------------|----|
| | °C | °F |
| On roof 0 - 13 mm (0 - 3/8 in.) | 33 | 60 |
| Above roof 13 mm - 50 mm (1/2 in. - 3/8 in.) | 22 | 40 |
| Above 50 mm - 100 mm (2 in. - 4 in.) | 17 | 30 |
| Above 100 mm - 300 mm (4 in. - 12 in.) | 14 | 25 |
| Above 300 mm - 900 mm (12 in. - 36 in.) | 14 | 25 |

The table has been removed but conduit on the roof (exposed to sunlight) must still be kept at least 7/8" above the roof otherwise a 60°F temperature added applies (for derating the ampacity of the conductors)

NEC Table 310.15(B)(2)(a) Ambient Temperature Correction Factors Based on 30°C (86°F)

| Ambient Temperature (°C) | Temperature Rating of Conductor | | | Ambient Temperature (°F) |
|--------------------------|---------------------------------|------|------|--------------------------|
| | 60°C | 75°C | 90°C | |
| 10 or less | 1.29 | 1.20 | 1.15 | 50 or less |
| 11-15 | 1.22 | 1.15 | 1.12 | 51-59 |
| 16-20 | 1.15 | 1.11 | 1.08 | 60-68 |
| 21-25 | 1.08 | 1.05 | 1.04 | 69-77 |
| 26-30 | 1.00 | 1.00 | 1.00 | 78-86 |
| 31-35 | 0.91 | 0.94 | 0.96 | 87-95 |
| 36-40 | 0.82 | 0.88 | 0.91 | 96-104 |
| 41-45 | 0.71 | 0.82 | 0.87 | 105-113 |
| 46-50 | 0.58 | 0.75 | 0.82 | 114-122 |
| 51-55 | 0.41 | 0.67 | 0.76 | 123-131 |
| 56-60 | — | 0.58 | 0.71 | 132-140 |
| 61-65 | — | 0.47 | 0.65 | 141-149 |
| 66-70 | — | 0.33 | 0.58 | 150-158 |
| 71-75 | — | — | 0.50 | 159-167 |
| 76-80 | — | — | 0.41 | 168-176 |
| 81-85 | — | — | 0.29 | 177-185 |

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AP Systems® YC600 Micro Inverters (usa.apsystems.com)

Example Sys. #1

APsystems YC600 Microinverter Datasheet

INPUT DATA (DC)

- Module Compatibility: 60 & 72 Cell PV Modules
- MPPT Voltage Range: 220-480V
- Operation Voltage Range: 300-500V
- Maximum Input Voltage: 600V
- Maximum Input Current: 10A @ 25°C
- Maximum Short PV Array Short Circuit Current: 15A

OUTPUT DATA (AC)

- Maximum Continuous Output Power: 600W
- Maximum Output Power: 600W
- Maximum Output Current: 10A
- Maximum Output Frequency: 60Hz
- Adjustable Output Voltage Range: 210-264V
- Adjustable Output Frequency Range: 59.8 - 60.2Hz
- Power Factor (Adjustable): 0.8 leading, 0.8 lagging
- Total Harmonic Distortion: <math>THD < 5\%</math>
- Maximum Units per Branch: 6 (12 PV modules) / 6 (12 PV modules)

EFFICIENCY

- Peak Efficiency: 96.7%
- ETC Weighted Efficiency: 96.5%
- Maximum Efficiency: 96.5%
- Typical Power Consumption: 60mW

MECHANICAL DATA

- Operating Ambient Temperature Range: -40°F to 149°F (-40°C to 65°C)
- Storage Temperature Range: -40°F to 149°F (-40°C to 65°C)
- Dimensions (WxDxH) inches: 2.00x1.50x1.50
- Dimensions (WxDxH) mm: 50.8x38.1x38.1
- Weight: 2.0A
- AC BUS Maximum Current: 10A
- Connector Type: IP65
- Enclosure Rating: NEMA 4 (IP20)
- Coating: Natural Connection - No Fans

FEATURES & COMPLIANCE

- Wireless ZigBee
- Transformer Design: High-Frequency Transformer, Galvanic Isolation
- Non-Islanding Protection: Yes (IEEE 1547-2018)
- FCC PART 15, ANSI C84.4, IEC-60335
- EMissions & Immunity (EMC) Compliance: Yes
- Safety & Grid Connection Compliance: UL1741, IEC 62109-1, IEC 62109-2, IEC 62109-3, IEC 62109-4, IEC 62109-5, IEC 62109-6, IEC 62109-7, IEC 62109-8, IEC 62109-9, IEC 62109-10, IEC 62109-11, IEC 62109-12, IEC 62109-13, IEC 62109-14, IEC 62109-15, IEC 62109-16, IEC 62109-17, IEC 62109-18, IEC 62109-19, IEC 62109-20, IEC 62109-21, IEC 62109-22, IEC 62109-23, IEC 62109-24, IEC 62109-25, IEC 62109-26, IEC 62109-27, IEC 62109-28, IEC 62109-29, IEC 62109-30, IEC 62109-31, IEC 62109-32, IEC 62109-33, IEC 62109-34, IEC 62109-35, IEC 62109-36, IEC 62109-37, IEC 62109-38, IEC 62109-39, IEC 62109-40, IEC 62109-41, IEC 62109-42, IEC 62109-43, IEC 62109-44, IEC 62109-45, IEC 62109-46, IEC 62109-47, IEC 62109-48, IEC 62109-49, IEC 62109-50, IEC 62109-51, IEC 62109-52, IEC 62109-53, IEC 62109-54, IEC 62109-55, IEC 62109-56, IEC 62109-57, IEC 62109-58, IEC 62109-59, IEC 62109-60, IEC 62109-61, IEC 62109-62, IEC 62109-63, IEC 62109-64, IEC 62109-65, IEC 62109-66, IEC 62109-67, IEC 62109-68, IEC 62109-69, IEC 62109-70, IEC 62109-71, IEC 62109-72, IEC 62109-73, IEC 62109-74, IEC 62109-75, IEC 62109-76, IEC 62109-77, IEC 62109-78, IEC 62109-79, IEC 62109-80, IEC 62109-81, IEC 62109-82, IEC 62109-83, IEC 62109-84, IEC 62109-85, IEC 62109-86, IEC 62109-87, IEC 62109-88, IEC 62109-89, IEC 62109-90, IEC 62109-91, IEC 62109-92, IEC 62109-93, IEC 62109-94, IEC 62109-95, IEC 62109-96, IEC 62109-97, IEC 62109-98, IEC 62109-99, IEC 62109-100

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Conductor And OCPD Sizing

Example Sys. #1

1. Max current
NEC 690.8(A)(3)

2. Breaker or fuse rating, and wire size
NEC 690.8(B) and 690.9(B)

AC Circuit Wiring Between AC combiner Panel and Service (inverters combined max output amps)

$2.28 \text{ amps} \times 19 \text{ micro inverters} = 43.3 \text{ A}$

AC Circuit Wiring Between AC combiner Panel and Service (inverters max output × 125%)

$43.3 \text{ A} \times 1.25 = 54.1 \text{ A}$

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Example System (for an AP Systems® YC600 micro inverter system)

Example Sys. #1

(14) 290W Jinko® Modules, with every two connecting to an AP Systems® YC600 micro inverter.

(14) 290W Jinko® Modules, with every two connecting to an AP Systems® YC600 micro inverter.

(10) 290W Jinko® Modules, with every two connecting to an AP Systems® YC600 micro inverter.

#12 AWG TCER trunk cable which includes a #12 AWG Cu EGC.

Three separate #12 AWG Cu, 2-wire NM cable ran through attic.

60A rated AC combiner panelboard (dedicated only for solar PV)

SolaDeck® J-box for transition of trunk cable to NM cable.

J-box mounted at roof eave for transition of NM cable to THWN-2 wire in conduit.

(3) #6 AWG THWN-2 Cu, with #10 AWG Cu EGC, 1/4" EMT

(9) #12 AWG Cu THWN-2 with #12 AWG EGC, in 3/4" EMT leading from roof eave down to AC combiner.

Existing Service panelboard

60A

Existing Loads

AC disconnect (as shown) is not required per the NEC (for this particular system), but may be required per the utility.

Service conductors extending to utility

Type of roof racking used: IronRidge®

AP Systems® YC600 Micro Inverter

Note: this wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS and APPLICABLE CODES.

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Jinko® solar PV module specs (jinkosolar.com)

Example Sys. #1

Eagle MP 60B
270-290 Watt
MONOCRYSTALLINE MODULE

KEY FEATURES

- High Efficiency (20% higher efficiency: 21.5% with Heterojunction Back Contact)
- High Voltage (150V module - 100V system increases cable and inverter ETC)
- Monocrystalline Solar Cells (For higher cell efficiency and module efficiency)
- FD-Box (More than 140 Watt module at 600V DC)
- Low Light Performance (Advanced anti-reflective and anti-dust coating technology better for low light)
- Strength and Durability (High-strength steel frame and 3000HRS salt test and 4000hrs humidity test)

LINEAR PERFORMANCE WARRANTY
30 Year Product Warranty - 10 Year System Power Warranty

Technical Performance & Temperature Dependent

Electrical Characteristics

| Module | Max Power (Wp) | Max Power (Wp) | Max Power (Wp) | Max Power (Wp) | Max Power (Wp) |
|-----------|----------------|----------------|----------------|----------------|----------------|
| JKM60-270 | 270 | 270 | 270 | 270 | 270 |
| JKM60-275 | 275 | 275 | 275 | 275 | 275 |
| JKM60-280 | 280 | 280 | 280 | 280 | 280 |
| JKM60-285 | 285 | 285 | 285 | 285 | 285 |
| JKM60-290 | 290 | 290 | 290 | 290 | 290 |

PACKAGING CONFIGURATIONS

Package Type: 60 cells, 60 cells, 60 cells, 60 cells, 60 cells, 60 cells

SPECIFICATIONS

Module Type: JKM60-270, JKM60-275, JKM60-280, JKM60-285, JKM60-290

Dimensions (mm): 2150 x 1300 x 30

Weight (kg): 18.5

Temperature Coefficient of Pmax: -0.45%/°C

Temperature Coefficient of Voc: -0.33%/°C

Temperature Coefficient of Isc: 0.05%/°C

STC: Irradiance 1000W/m², Cell Temperature 25°C, AM1.5

NOCT: Irradiance 800W/m², Ambient Temperature 20°C, AM1.5

Wired Splice Kits

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Jinko® UL 1703 Certification (jinkosolar.com)

Example Sys. #1

CERTIFICATE OF COMPLIANCE

Certificate Number: 20170424-E362479
Report Reference: E362479-201703203
Issue Date: 2017-APRIL-24

Issued to: JINKO SOLAR CO LTD
NO.1 JINKO RD
SHANGHAI ECONOMIC DEVELOPMENT ZONE
SHANGHAI
JIAOJIAO 201400 CHINA

This is to certify that representative samples of PHOTOVOLTAIC MODULES AND PANELS WITH SYSTEM VOLTAGE RATINGS OVER 600 VOLTS (See Addendum Pages)

Have been investigated by UL in accordance with the Standards indicated on this Certificate.

Standard(s) for Safety: Standard for Safety: Flat Plate Photovoltaic Modules and Panels (UL 1703)

Additional Information: See the UL Online Certifications Directory at www.ul.com/certifications for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification Mark in the U.S.

Look for the UL Certification Mark on the product.

CERTIFICATE OF COMPLIANCE

Certificate Number: 20170424-E362479
Report Reference: E362479-201703203
Issue Date: 2017-APRIL-24

JKM60-270-W, JKM60-275-W, JKM60-280-W, JKM60-285-W, JKM60-290-W
JKM60-270-B, JKM60-275-B, JKM60-280-B, JKM60-285-B, JKM60-290-B
JKM60-270-T, JKM60-275-T, JKM60-280-T, JKM60-285-T, JKM60-290-T
JKM60-270-L, JKM60-275-L, JKM60-280-L, JKM60-285-L, JKM60-290-L
JKM60-270-R, JKM60-275-R, JKM60-280-R, JKM60-285-R, JKM60-290-R
JKM60-270-M, JKM60-275-M, JKM60-280-M, JKM60-285-M, JKM60-290-M
JKM60-270-N, JKM60-275-N, JKM60-280-N, JKM60-285-N, JKM60-290-N
JKM60-270-O, JKM60-275-O, JKM60-280-O, JKM60-285-O, JKM60-290-O
JKM60-270-P, JKM60-275-P, JKM60-280-P, JKM60-285-P, JKM60-290-P
JKM60-270-Q, JKM60-275-Q, JKM60-280-Q, JKM60-285-Q, JKM60-290-Q
JKM60-270-S, JKM60-275-S, JKM60-280-S, JKM60-285-S, JKM60-290-S
JKM60-270-U, JKM60-275-U, JKM60-280-U, JKM60-285-U, JKM60-290-U
JKM60-270-V, JKM60-275-V, JKM60-280-V, JKM60-285-V, JKM60-290-V
JKM60-270-W, JKM60-275-W, JKM60-280-W, JKM60-285-W, JKM60-290-W
JKM60-270-X, JKM60-275-X, JKM60-280-X, JKM60-285-X, JKM60-290-X
JKM60-270-Y, JKM60-275-Y, JKM60-280-Y, JKM60-285-Y, JKM60-290-Y
JKM60-270-Z, JKM60-275-Z, JKM60-280-Z, JKM60-285-Z, JKM60-290-Z

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IronRidge® Racking Specs (Ironridge.com)

Example Sys. #1

IRONRIDGE Integrated Grounding System

Simplified Grounding
For Greater Safety & Lower Cost

Traditionally, solar modules are grounded by attaching lugs, bolts or clips to the module frame, then connecting these to a copper conductor that runs throughout the array. This process adds time and cost to the installation, and often results in improper grounding, creating significant long-term safety risks.

The IronRidge Integrated Grounding System solves these challenges by bonding modules directly to the mounting rails. This approach eliminates separate module grounding hardware, and creates many parallel grounding paths throughout the array, providing greater safety for system owners.

Grounding Mid Clamp
Each Grounding Mid Clamp connects through the end-module contacts on the module frame and other modules in the array to provide parallel grounding paths throughout the array.

Bonding Strap
Bonding Straps are used to bond the rails to the array. They are easy to install and provide a secure connection.

Grounding Lug
A single Grounding Lug connects the rail to the array. It is easy to install and provides a secure connection.

Installation Overview

- Install Roof Attachments**
 - Install appropriate roof flashing and/or standoff for roof type.
 - Attach L-Foot to flashing or standoff.
- Pressure Rail Connections**
 - Insert splice into first rail, then secure with Bonding Strap and self-drilling screw.
 - Slide second rail over splice, then secure with opposite end of Grounding Strap and self-drilling screw.
- Mount & Ground Rails**
 - Attach rails to L-Foot and level rails.
 - Connect Grounding Lug to grounding conductor.
- Install Modules & Clamps**
 - Install first module using End Clamps and Grounding Mid Clamps.
 - Install additional modules using Grounding Mid Clamps.
 - Finish row with a second pair of End Clamps.

Testing & Certification

The IronRidge Integrated Grounding System has been tested and certified to UL 2703 by Intertek Group plc.

UL 2703 is a proposed U.S. standard for evaluating solar module mounting and clamping devices. It ensures these devices will maintain strong electrical and mechanical connections over an extended period of time in extreme outdoor environments.

The testing process closely mirrors that of UL 1703, the solar module testing standard, including temperature and handling cycling, electrical and mechanical load testing, and manufacturing quality testing.

The Grounding Mid Clamp has proven robust in ground solar modules with a box frame construction, a range of panel thicknesses and racking lengths of 7.62' x 6' rails.

All solar modules listed to UL 1703 and with frame construction similar to the premium panel above are compatible with the IronRidge Integrated Grounding System.

Go to ironridge.com/ig

Module Frame Compatibility

| Dimension | Range |
|-----------|------------------|
| A | 31.0mm - 61.0mm |
| B | 5.08mm (maximum) |

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IronRidge® Racking Specs (Ironridge.com)

Example Sys. #1

XR Rail Family

The XR Rail Family offers the strength of a curved rail in three targeted sizes. Each size supports specific design loads, while minimizing material costs. Depending on your location, there is an XR Rail to match.

XR100 Rail

A low-profile mounting rail for agrivoltaics with light snow.

- 8' spacing capability
- Heavy load capability
- Clear & black anod. finish

XR1000 Rail

The ultimate residential solar mounting rail.

- 8' spacing capability
- Heavy load capability
- Clear & black anod. finish

XR1020 Rail

A heavyweight mounting rail for commercial projects.

- 12' spacing capability
- Extreme load capability
- Clear anodized finish

Internal Splices

All rails use internal splices for seamless connections.

- Self-healing anodized
- Varying versions for rails
- Grounding Straps attached

Attachments

- Flashed Foot**: Anchor, flash, and mount with all-in-one attachment.
- Shelfed L-Foot**: Design for rapid rail attachment.
- Standoffs**: Flange bolt or flange systems to various heights.
- T8 Legs**: T8 assembly to desired angle, up to 60 degrees.

Clamps & Grounding

- End Clamps**: Slide in clamp and secure modules at ends of rails.
- Grounding Mid Clamps**: Attach and ground modules in the middle of the rail.
- T-Bolt Grounding Lugs**: Ground system using the rail top rail.
- Accessories**: Provides a finished and organized look for rails.

Free Resources

- Design Assistant**: Go from rough notes to fully engineering system. For free.
- NABCEP Certified Training**: Earn free continuing education credits while learning more about our systems.

Rail Selection

The following table was prepared in compliance with applicable engineering codes and standards. Values are based on the following criteria: ASCE 7-16, Roof Zone 1, Exposure B, Roof Slope of 7 to 27 degrees and Mean Building Height of 30 ft. Visit IronRidge.com for detailed span tables and certifications.

| Snow (PSF) | Wind (MPH) | Rail Span | | | | | |
|------------|------------|-----------|----|-----|-----|-----|-----|
| | | 6' | 8' | 10' | 12' | 14' | 16' |
| None | 100 | | | | | | |
| | 140 | | | | | | |
| | 180 | | | | | | |
| 10-20 | 100 | | | | | | |
| | 140 | | | | | | |
| | 180 | | | | | | |
| 30 | 100 | | | | | | |
| | 140 | | | | | | |
| | 180 | | | | | | |
| 40 | 100 | | | | | | |
| | 140 | | | | | | |
| | 180 | | | | | | |
| 50-70 | 100 | | | | | | |
| | 140 | | | | | | |
| | 180 | | | | | | |

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Signage

Example Sys. #1

All signage must be permanently attached and be able to withstand the environment they are installed. Signage also cannot be hand-written. NEC 110.21(B).

Parallel Generation On Site. Second Source is Solar PV

A sign is required at the service panel stating that the home has a solar PV system as an additional power source. NEC 705.10. Warning could vary.

Warning, Inverter Output Connection, Do Not Relocate This Overcurrent Device

This sign is required to be located next to the PV backed breaker(s) ONLY if the 120% allowance of NEC 705.12(B)(3)(2) is being utilized.

Power Source

PV System: AC Current = 40A AC Volts = 240V

This sign is required to be located at the backed panelboard. NEC 690.54.

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN SWITCH TO THE OFF POSITION TO SHUTDOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY.

This sign to be located on the outside of, and within 3' of the service equipment. NEC 690.56(C).

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

This sign must be reflective and is required to be located next to the disconnect switch which activates rapid shutdown. NEC 690.56(C)(2) (for this system, it could be at any outdoor AC breaker or AC disconnect that isolates the micro inverters from the utility grid when such breaker or disconnect is shut off)

WARNING ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

This sign is required at disconnects where terminals can be energized even when the disconnect is shut off. NEC 690.13(B).

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AC disconnects

Here is an example of an AC disconnect switch (used for a PV system) that would require the following sign:

WARNING ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

NOTE: It's STRONGLY recommended that only AC disconnects with dead-fronts be used for a PV system!

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Plan Review Example System #2

Enphase® IQ7+™ Micro Inverter System

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Example System (for an Enphase® IQ7+™ micro inverter system)

Example Sys. #2

Type of roof racking used: Everest®

(13) 285W Hyundai® Modules each connecting to its own Enphase® IQ7+™ micro inverter.

#12 AWG Enphase® cable which does NOT include an EGC, therefore a separate solid #6 cu EGC must be provided from the roof J-box to the racking.

Two separate #12 AWG cu, 2-wire NM cable run through garage attic. White wires to be taped as ungrounded conductors at all terminations.

(3) #8 AWG THWN-2 Cu, with #10 AWG Cu EGC, 1/2" EMT (buried portion of conduit to be PVC & min of 18" deep)

Existing Service panelboard

Existing 200A

Existing 40 alum. Feeders extending to existing sub-panel in home.

Service conductors extending to utility

60A rated AC combiner panelboard (dedicated only for solar PV) located at detached bid.

AC disconnect (as shown is not required per the NEC for this particular system, but may be required per the utility for solar PV)

175A main breaker for existing sub-panel.

(4) #12 AWG Cu THWN-2 with #12 AWG EGC, in 1/2" EMT leading from roof eave down to AC combiner.

J-box mounted at roof eave (for transition of NM cable to THWN-2 wire in conduit).

J-box (for transition of trunk cable to NM cable).

The detached structure is required to have a grounding electrode system, per NEC 690.47 and 250.32(A).

Note: This wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS AND APPLICABLE CODES.

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Enphase® IQ6™ Micro Inverters

Example Sys. #2

Copyright© WC3 2024 Install by Intermountain Wind and Solar

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Site plan

Example Sys. #2

Location of service panelboard

Location of AC Combiner Panel

Flashed roof J-boxes

New PVC conduit, trenched 18" deep

Note: fire spacing clearances are not required on non-habitable detached structures, per IRC 324.6.

All roof penetrations must be properly flashed. IRC R903.2

Solar PV modules (panels) cannot be installed over or block any attic vents, plumbing vents*, furnace or water heater vents etc.

***Covered plumbing vents in accordance with the 2018 IRC, Section P3103.1.3, are permitted as long as approved by jurisdiction.**

All wiring must be properly supported by devices or mechanical means designed and listed for such use and wiring must be permanently and completely held off of the roof surface. See NEC 110.2, 110.3(A), 110.3(B), and 300.4.

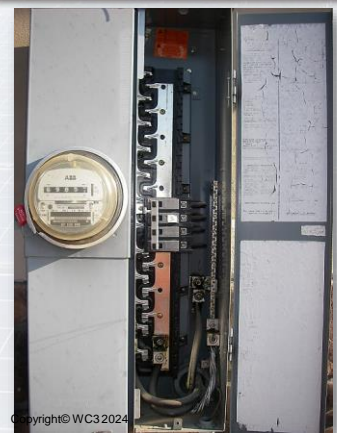
The detached structure is required to have a grounding electrode system, per NEC 690.47 and 250.32(A).

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Photo of Service Panel

Example Sys. #2



Typically, photos of the service panel label are needed in order to show the rating of the service (and rating of breaker slots).

Also, a clear photo showing the rating of the main service breaker(s) is usually required (in order to determine load-side connection rules).

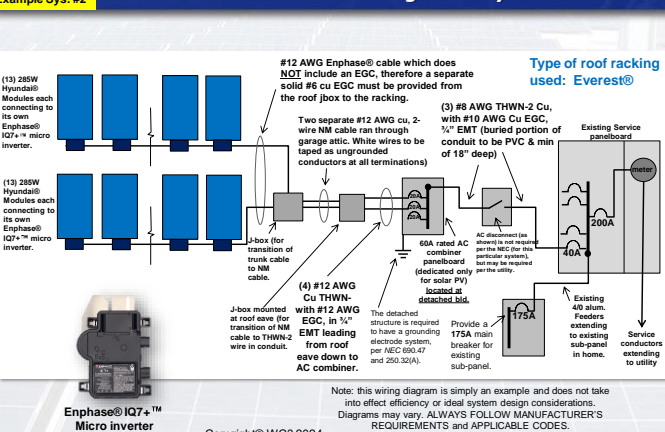
For this example, we are assuming that the service panel is rated for **200A** since the main service breaker is rated **200A**.

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Example System (for an Enphase® IQ7+™ micro inverter system)

Example Sys. #2



Type of roof racking used: Everest®

(13) 285W Hyundai® Modules each connecting to its own Enphase® IQ7+™ micro inverter.

#12 AWG Enphase® cable which does **NOT** include an EGC, therefore a separate solid #6 cu EGC must be provided from the roof J-box to the racking.

Two separate #12 AWG cu, 2-wire NM cable run through garage attic. White wires to be taped as ungrounded conductors at all terminations)

(3) #8 AWG THWN-2 Cu, with #10 AWG Cu EGC, 1/2" EMT (buried portion of conduit to be PVC & min of 18" deep)

Existing Service panelboard

Existing 200A

Existing 40 alum. Feeders extending to existing sub-panel in home.

Service conductors extending to utility

60A rated AC combiner panelboard (dedicated only for solar PV) located at detached bid.

AC disconnect (as shown is not required per the NEC for this particular system), but may be required per the utility for solar PV)

J-box (for transition of trunk cable to NM cable)

J-box mounted at roof eave (for transition of NM cable to THWN-2 wire in conduit).

(4) #12 AWG Cu THWN-2 with #12 AWG EGC, in 1/2" EMT leading from roof eave down to AC combiner.

The detached structure is required to have a grounding electrode system, per NEC 690.47 and 250.32(A).

Provide a 175A main breaker for existing sub-panel.

Note: This wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS AND APPLICABLE CODES.

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Enphase® IQ7+™ Specs

Example Sys. #2

| Enphase IQ7 and IQ7+ Microinverters | |
|--|---|
| INPUT RATING | 80-160 V AC |
| Commonly used module pairing ¹ | 240 W / 30 W + 180 W / 40 W |
| Maximum compatibility | 40-watt PV modules only |
| Maximum input DC voltage | 48 V |
| Peak power tracking voltage | 22.5 V |
| Operating range | 16 V - 48 V |
| Maximum input voltage | 22.5 V - 48 V |
| Maximum DC short-circuit current (module in) | 15 A |
| Overvoltage class (UL cert) | III |
| DC port backed current | 0.4 A |
| IP rating | IP 67 |
| EMC | 1.1: 1 impounded area, no additional CE side protection required |
| IP array configuration | AC only protection required max 250 amp branch circuit |
| SUPPORT DATA | |
| Peak output power | 280 W |
| Maximum continuous output power | 280 W |
| Maximum continuous output current | 240 V 280 V 240 V 280 V |
| Maximum DC voltage range | 21.0-48 V 36.0-50 V 21.0-48 V 36.0-50 V |
| Maximum continuous output current | 1.0 A @ 40 V 1.33 A @ 288 V <u>1.21 A @ 261 V</u> 1.39 A @ 208 V |
| Rated frequency | 60 Hz |
| Rated frequency range | 47 - 63 Hz |
| AC short-circuit fault current (over 3 cycles) | 5.4 kA rms |
| Maximum surge per 25 kVA (1/3 branch circuit) | 16 (240 V AC) 13 (208 V AC) <u>13.2 (200 V AC)</u> 11 (208 V AC) |
| Overvoltage class (UL cert) | II |
| AC port backed current | 16 mA |
| Power factor | 1.0 |
| Power factor (inverter) | 0.85 leading - 0.85 lagging |
| Efficiency | 92.8% - 95.5% |
| Peak efficiency | 97.5% |
| Efficiency at 50% load | 97.5% |
| Efficiency at 25% load | 97.5% |
| Efficiency at 10% load | 97.5% |
| MECHANICAL DATA | |
| Operating temperature range | -40°C to 140°C |
| Relative humidity range | 4% to 100% (condensing) |
| Dimensional type | Metric (or Imperial with 0.125" additional O.D. per adapter) |
| Dimensions (inches) | 112 mm x 175 mm x 30.2 mm (depth bracket) |
| Weight | 1.89 kg (4.16 lbs) |
| Coating | None (anodized aluminum) |
| Approved for wet locations | Yes |
| Flammable group | FD0 |
| Flammable liquid | Class I, Division 2 (Group C) |
| Environmental category (UV exposure rating) | NEMA Type 1 outdoor |
| FEATURES | |
| Communication | Power Line Communication (PLC) |
| Monitoring | Enphase Manager and Enphase web portal |
| Disconnecting means | Built options require installation of an Enphase IQ Disconnect |
| Compliance | The AC disconnect (shown in not required per the NEC for this particular system), but may be required per the utility for solar PV) |

1. See page 12 of the Enphase IQ7 and IQ7+ Technical Specification. 2. See page 13 of the Enphase IQ7 and IQ7+ Technical Specification. 3. See page 14 of the Enphase IQ7 and IQ7+ Technical Specification. 4. See page 15 of the Enphase IQ7 and IQ7+ Technical Specification.

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Conductor Ampacity and OCPD Sizing

Example Sys. #2

1. Max current
NEC 690.8(A)(1)(c)
2. Breaker or fuse rating, and wire ampacity
NEC 690.8(B) and 690.9(B)

AC Circuit Wiring Between AC combiner Panel and Service

(inverters combined max output amps)
1.21 amps × 26 micro inverters

→ (inverters max output × 125%)
31.5A × 1.25 = 39.4 A

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Example System (for an Enphase® IQ7+™ micro inverter system)

Example Sys. #2

Type of roof racking used: Everest®

Note: This wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS AND APPLICABLE CODES.

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Enphase® AC Combiner Panel (Enphase.com)

Example Sys. #2

Enphase IQ Combiner 3
(XIQ-AM1-240-3)

The Enphase IQ Combiner 3™ with Enphase IQ Energy™ consolidates interconnection equipment into a single enclosure and streamlines PV and storage installations by providing a consistent, pre-wired solution for residential applications. It offers up to four 2-pole input circuits and Export Bus breaker assembly.

Smart

- Includes IQ Energy for communication and monitoring
- Flexible mounting supports 48 in. frames available
- Custom AC terminals available for PV, storage
- Provides production warning and electrical communication

Simple

- Industrial case for protection
- Central disconnect breaker support angle and mounting
- Support back and side conduit entry
- 1/2 in. NPT back panel break for 1/2 in. NPT piping (breaker not included)
- 1/2 in. NPT for storage breaker entry

Available

- Square D® MET-SEL 160A type 2B breakers
- 2-pole main breaker
- 1-pole

Enphase IQ Combiner 3

MODEL NUMBER

REQUIREMENTS & REPLACEMENT PARTS

TECHNICAL SPECIFICATIONS

INSTALLATION OPTIONS

COMPATIBLE

COMPLIANCE

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Hyundai PV Module Specs (hhi-green.com/solar)

Example Sys. #2

Hyundai Solar Module

PERL - Passivated Emitter Rear Locality (Doped Cell)

Higher Cell Efficiency

Higher Module Output

Lower Temperature Coefficient

Affordable Price

Electrical Characteristics

| Parameter | 100 | 150 | 200 | 300 |
|---|-------|-------|-------|-------|
| Module Power (P _{max}) | 10.0 | 15.0 | 20.0 | 30.0 |
| Module Voltage (V _{oc}) | 37.1 | 37.1 | 37.1 | 37.1 |
| Module Current (I _{sc}) | 0.27 | 0.27 | 0.27 | 0.27 |
| Open Circuit Voltage (V _{oc}) | 37.1 | 37.1 | 37.1 | 37.1 |
| Short Circuit Current (I _{sc}) | 0.27 | 0.27 | 0.27 | 0.27 |
| Temperature Coefficient (P _{max}) | -0.40 | -0.40 | -0.40 | -0.40 |
| Temperature Coefficient (V _{oc}) | -0.23 | -0.23 | -0.23 | -0.23 |
| Temperature Coefficient (I _{sc}) | 0.002 | 0.002 | 0.002 | 0.002 |

Module Diagram

Installation Safety Guide

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Everest® Racking Specs (Everest-solarsystems.com)

Example Sys. #2

Everest Solar Systems CrossRail 48-S

Everest Solar Systems CrossRail 48-S

Technical data

88-S Rail Connector

88-S Rail Profile

Table 1: Rail Selection Chart

Table 1: Rail Selection Chart

| Height | 100 | 150 | 200 | 300 |
|--------|-----|-----|-----|-----|
| 10 | 10 | 10 | 10 | 10 |
| 15 | 10 | 10 | 10 | 10 |
| 20 | 10 | 10 | 10 | 10 |
| 30 | 10 | 10 | 10 | 10 |
| 40 | 10 | 10 | 10 | 10 |
| 50 | 10 | 10 | 10 | 10 |

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Everest® Racking Specs (Everest-solarsystems.com)

Example Sys. #2

Everest Solar Systems
Bonding Mid Clamp Spec Sheet

1. Integrated bonding
2. 3/8" 304 stainless steel bolt
3. 3/8" 304 stainless steel nut
4. 3/8" 304 stainless steel washer
5. 3/8" 304 stainless steel mid clamp

Sub-MID Components

| | | | |
|------------------|---|------------------|---|
| MID_CLAMP | MID Clamp (1) 3/8" 304 SS Bolt, 3/8" Washer | MID_CLAMP | MID Clamp (1) 3/8" 304 SS Bolt, 3/8" Washer |
| BOLT | 3/8" 304 SS Bolt | NUT | 3/8" 304 SS Nut |
| WASHER | 3/8" 304 SS Washer | CLAMP | 3/8" 304 SS Mid Clamp |
| WASHER | 3/8" 304 SS Washer | CLAMP | 3/8" 304 SS Mid Clamp |

BONDING AND GROUNDING:
Appropriate means of bonding and grounding are required by regulation. The information provided in this manual shall always be verified with local and interconnecting codes.

Everest Solar Systems has obtained a U.S. 2703 system listing from Underwriter's Laboratories (UL).

A sample bonding path diagram is shown in Figure 1 below. Your specific installation may vary, based upon site conditions and panel wattage requirements.

Each material connection has been tested in a maximum line voltage of 20kV. An hour size grounding must be used for ground of strings within each cell array, although additional may be used for redundancy. When installed per these installation instructions, all connections meet the requirements of NEC 480.43.

Everest CriticalPath cables are tested with the following UL, Suncoast, Suncoast/Listing of modules:
- PSC2000 200Wp (6-cell string)
- PSC2000 300Wp (6-cell string)

This racking system may be used to ground and/or mount a PV module complying with UL 1703 only when the specific model has been evaluated for grounding and/or mounting in compliance with the included instructions.

Figure 1: Bonding connection shown in cut.

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Signage

Example Sys. #2

All signage must be permanently attached and be able to withstand the environment they are installed. Signage also cannot be hand-written. **NEC 110.21(B).**

CAUTION: MULTIPLE SOURCES OF POWER

The above shown sign is required at the service disconnect. **NEC 705.10.**

WARNING: POWER SOURCE OUTPUT DO NOT RELOCATE THIS OVERCURRENT DEVICE.

This sign is required to be located next to the PV backed breaker(s) **ONLY** if the 120% allowance of **NEC 705.12(B)(3)(2)** is being utilized.

PV System: AC Current = 30A AC Volts = 240V

This sign is required to be located at the backed panelboard. **NEC 690.54** (of the 2020 NEC).

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SWITCH OFF THE PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY

This sign to be located on the outside of, and within 3' of the service equipment. **NEC 690.56(C).**

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

This sign must be reflective and is required to be located next to the disconnect switch which activates rapid shutdown. **NEC 690.56(C)(2)** (for this system, it could be at any AC breaker or AC disconnect that isolates the micro inverters from the utility grid when such breaker or disconnect is shut off).

WARNING ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

This sign is required at disconnects where terminals can be energized even when the disconnect is shut off. **NEC 690.13(B).**

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Plan Review Example System #3

SMA® Sunny Boy™ String Inverter System

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Example Single-Line Diagram (for an SMA® string inverter system)

Example Sys. #3

Type of roof racking used: SnapNrack®

(12) 280W SolarWorld® modules, each with a Tigo® TS4-R-S DC to DC converter in series.

(12) 280W SolarWorld® modules, each with a Tigo® TS4-R-S DC to DC converter in series.

(12) 280W SolarWorld® modules, each with a Tigo® TS4-R-S DC to DC converter in series.

(6) #10 AWG Cu PV Wire, and a solid #6 copper EGC extending from each roof J-box to roof racking/modules, wiring in free-air under modules

(2) #10 AWG THWN-2 Cu, with #10 AWG Cu EGC, 1/2" EMT, wiring in attic

(3) #8 AWG THWN-2 Cu, with #10 AWG Cu EGC, 1/2" EMT

Existing Service panelboard

Existing loads

Existing 20 amp. Feeder

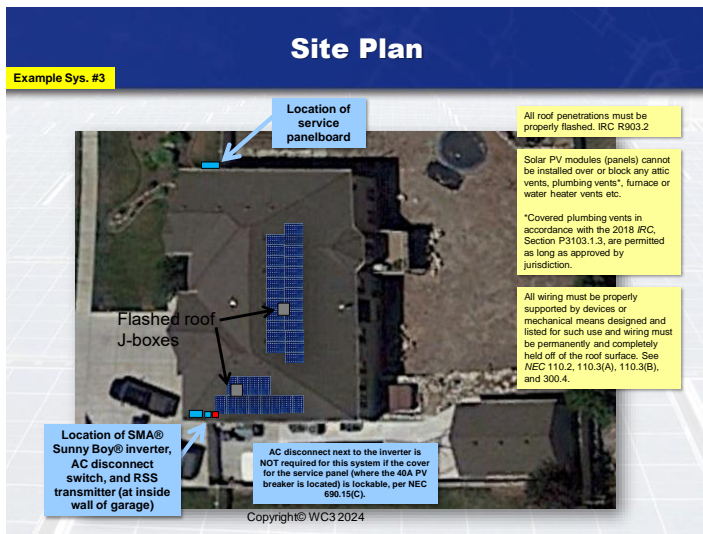
Service conductors extending to utility

AC disconnect next to the inverter is NOT required for this system if the cover for the service panel (where the 40A PV breaker is located) is lockable, per **NEC 690.15(C)**.

Note: this wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS AND APPLICABLE CODES.

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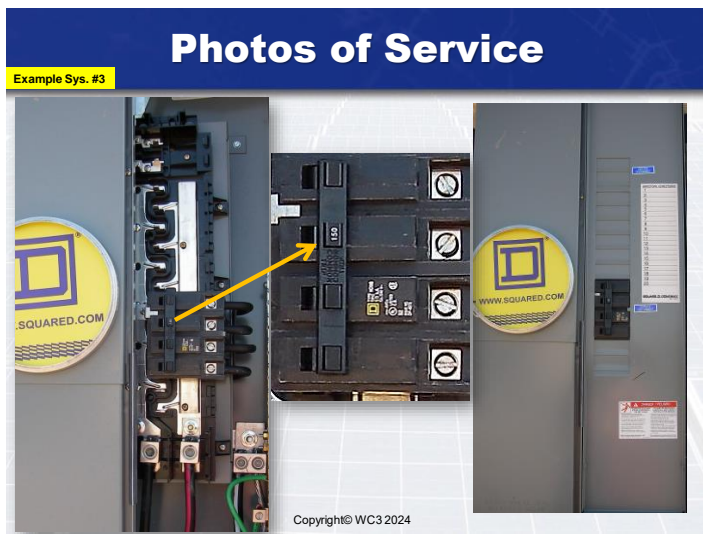
160



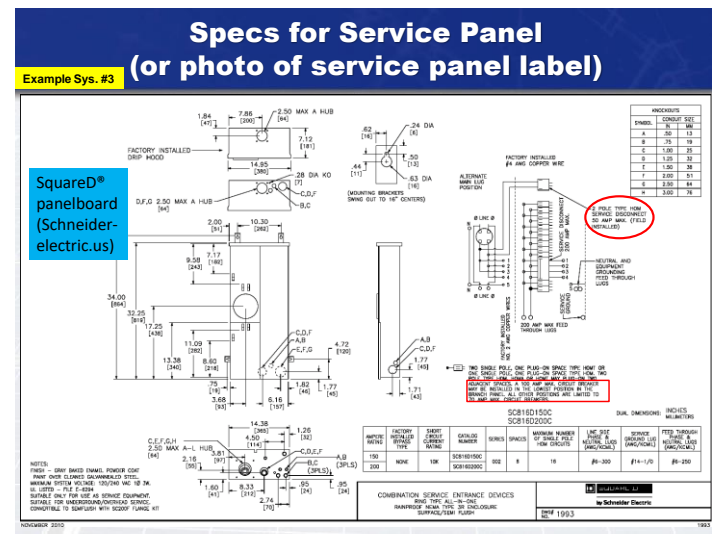
161



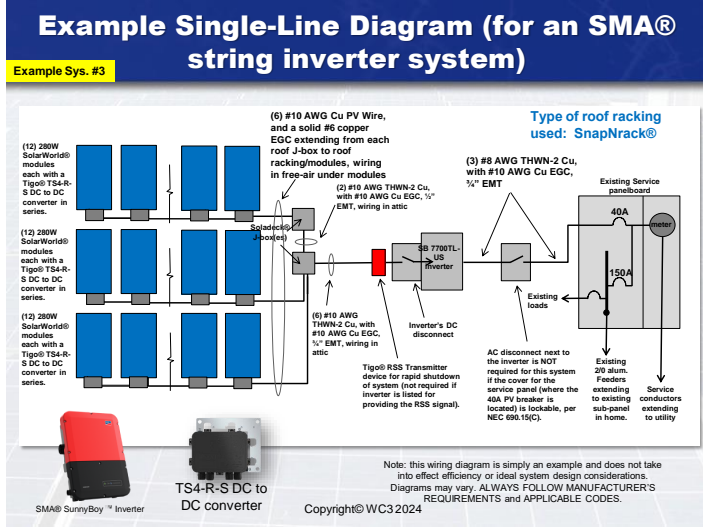
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SMA® Spec Sheets (sma-America.com)

Example Sys. #3

| Technical data | Sunny Boy 6.0-US | Sunny Boy 7.0-US | Sunny Boy 7.7-US |
|---|--------------------------------------|--------------------------------------|--------------------------------------|
| Input (DC) | | | |
| Max. PV power | 9600 Wp | 9940 Wp | 10905 Wp |
| Max. DC Voltage | 600 V | 600 V | 600 V |
| Rated MPPT Voltage range | 220 - 480 V | 245 - 480 V | 270 - 480 V |
| MPPT operating voltage range | 100 - 550 V | 100 - 550 V | 100 V / 125 V |
| Max. operating input current per MPPT | 18 A | 18 A | 18 A |
| Max. short circuit current per MPPT | 31 A | 31 A | 31 A |
| Number of MPPT tracker / string per MPPT tracker | 3 / 1 | 3 / 1 | 3 / 1 |
| Output (AC) | | | |
| AC nominal power | 5200 W | 6000 W | 6660 W |
| Max. AC apparent power | 5200 VA | 6000 VA | 6660 VA |
| Max. DC voltage / start voltage | 208 V / ● | 240 V / ● | 240 V / ● |
| AC voltage range | 183 - 229 V | 211 - 264 V | 183 - 229 V |
| AC grid frequency | 50 Hz / 50 Hz | 50 Hz / 50 Hz | 50 Hz / 50 Hz |
| Max. output current | 25.0 A | 25.0 A | 32.0 A |
| Power factor (cos φ) | 1 | 1 | 1 |
| Output phases / line connections | 1 / 2 | 1 / 2 | 1 / 2 |
| Harmonics | < 4% | < 4% | < 4% |
| Efficiency | | | |
| Max. efficiency | 97.3% | 97.7% | 97.3% |
| CEC efficiency | 96.7% | 96.9% | 96.8% |
| Protection devices | | | |
| DC disconnect device / DC reverse polarity protection | ● / ● | ● / ● | ● / ● |
| Ground fault monitoring / Grid monitoring | ● | ● | ● |
| AC short-circuit protection | ● | ● | ● |
| Algebra sensitive residual current monitoring (RCMUS) | ● | ● | ● |
| Arc fault circuit interrupter (AFCI) | ● | ● | ● |
| Protection class / overvoltage category | 1 / IV | 1 / IV | 1 / IV |
| General data | | | |
| Dimensions (W / H / D) in mm (in) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) |
| Packaging Dimensions (W / H / D) in mm (in) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) |
| Weight / packaging weight | 26 kg (57.8 lb) / 30 kg (66 lb) | 26 kg (57.8 lb) / 30 kg (66 lb) | 26 kg (57.8 lb) / 30 kg (66 lb) |
| Temperature range: operating / nonoperating | -25°C - +60°C (-13°F - +142°F) | -25°C - +60°C (-13°F - +142°F) | -25°C - +60°C (-13°F - +142°F) |
| Environmental protection rating | IP65 | IP65 | IP65 |
| Noise emission (typical) | 39 dB(A) | 39 dB(A) | 45 dB(A) |
| Internal power consumption at night | < 5 W | < 5 W | < 5 W |

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SMA® Spec Sheets (sma-America.com)

Example Sys. #3

| Technical data | Sunny Boy 6.0-US | Sunny Boy 7.0-US | Sunny Boy 7.7-US |
|---|--------------------------------------|--------------------------------------|--------------------------------------|
| Input (DC) | | | |
| Max. PV power | 9600 Wp | 9940 Wp | 10905 Wp |
| Max. DC Voltage | 600 V | 600 V | 600 V |
| Rated MPPT Voltage range | 220 - 480 V | 245 - 480 V | 270 - 480 V |
| MPPT operating voltage range | 100 - 550 V | 100 - 550 V | 100 V / 125 V |
| Max. operating input current per MPPT | 18 A | 18 A | 18 A |
| Max. short circuit current per MPPT | 31 A | 31 A | 31 A |
| Number of MPPT tracker / string per MPPT tracker | 3 / 1 | 3 / 1 | 3 / 1 |
| Output (AC) | | | |
| AC nominal power | 5200 W | 6000 W | 6660 W |
| Max. AC apparent power | 5200 VA | 6000 VA | 6660 VA |
| Max. DC voltage / start voltage | 208 V / ● | 240 V / ● | 240 V / ● |
| AC voltage range | 183 - 229 V | 211 - 264 V | 183 - 229 V |
| AC grid frequency | 50 Hz / 50 Hz | 50 Hz / 50 Hz | 50 Hz / 50 Hz |
| Max. output current | 25.0 A | 25.0 A | 32.0 A |
| Power factor (cos φ) | 1 | 1 | 1 |
| Output phases / line connections | 1 / 2 | 1 / 2 | 1 / 2 |
| Harmonics | < 4% | < 4% | < 4% |
| Efficiency | | | |
| Max. efficiency | 97.3% | 97.7% | 97.3% |
| CEC efficiency | 96.7% | 96.9% | 96.8% |
| Protection devices | | | |
| DC disconnect device / DC reverse polarity protection | ● / ● | ● / ● | ● / ● |
| Ground fault monitoring / Grid monitoring | ● | ● | ● |
| AC short-circuit protection | ● | ● | ● |
| Algebra sensitive residual current monitoring (RCMUS) | ● | ● | ● |
| Arc fault circuit interrupter (AFCI) | ● | ● | ● |
| Protection class / overvoltage category | 1 / IV | 1 / IV | 1 / IV |
| General data | | | |
| Dimensions (W / H / D) in mm (in) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) |
| Packaging Dimensions (W / H / D) in mm (in) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) |
| Weight / packaging weight | 26 kg (57.8 lb) / 30 kg (66 lb) | 26 kg (57.8 lb) / 30 kg (66 lb) | 26 kg (57.8 lb) / 30 kg (66 lb) |
| Temperature range: operating / nonoperating | -25°C - +60°C (-13°F - +142°F) | -25°C - +60°C (-13°F - +142°F) | -25°C - +60°C (-13°F - +142°F) |
| Environmental protection rating | IP65 | IP65 | IP65 |
| Noise emission (typical) | 39 dB(A) | 39 dB(A) | 45 dB(A) |
| Internal power consumption at night | < 5 W | < 5 W | < 5 W |

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SolarWorld® PV Module Specs (solarworld-usa.com)

Example Sys. #3

| Technical data | Sunny Boy 6.0-US | Sunny Boy 7.0-US | Sunny Boy 7.7-US |
|---|--------------------------------------|--------------------------------------|--------------------------------------|
| Input (DC) | | | |
| Max. PV power | 9600 Wp | 9940 Wp | 10905 Wp |
| Max. DC Voltage | 600 V | 600 V | 600 V |
| Rated MPPT Voltage range | 220 - 480 V | 245 - 480 V | 270 - 480 V |
| MPPT operating voltage range | 100 - 550 V | 100 - 550 V | 100 V / 125 V |
| Max. operating input current per MPPT | 18 A | 18 A | 18 A |
| Max. short circuit current per MPPT | 31 A | 31 A | 31 A |
| Number of MPPT tracker / string per MPPT tracker | 3 / 1 | 3 / 1 | 3 / 1 |
| Output (AC) | | | |
| AC nominal power | 5200 W | 6000 W | 6660 W |
| Max. AC apparent power | 5200 VA | 6000 VA | 6660 VA |
| Max. DC voltage / start voltage | 208 V / ● | 240 V / ● | 240 V / ● |
| AC voltage range | 183 - 229 V | 211 - 264 V | 183 - 229 V |
| AC grid frequency | 50 Hz / 50 Hz | 50 Hz / 50 Hz | 50 Hz / 50 Hz |
| Max. output current | 25.0 A | 25.0 A | 32.0 A |
| Power factor (cos φ) | 1 | 1 | 1 |
| Output phases / line connections | 1 / 2 | 1 / 2 | 1 / 2 |
| Harmonics | < 4% | < 4% | < 4% |
| Efficiency | | | |
| Max. efficiency | 97.3% | 97.7% | 97.3% |
| CEC efficiency | 96.7% | 96.9% | 96.8% |
| Protection devices | | | |
| DC disconnect device / DC reverse polarity protection | ● / ● | ● / ● | ● / ● |
| Ground fault monitoring / Grid monitoring | ● | ● | ● |
| AC short-circuit protection | ● | ● | ● |
| Algebra sensitive residual current monitoring (RCMUS) | ● | ● | ● |
| Arc fault circuit interrupter (AFCI) | ● | ● | ● |
| Protection class / overvoltage category | 1 / IV | 1 / IV | 1 / IV |
| General data | | | |
| Dimensions (W / H / D) in mm (in) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) | 535 x 720 x 198 (21.1 x 28.3 x 7.8) |
| Packaging Dimensions (W / H / D) in mm (in) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) | 600 x 800 x 300 (23.6 x 31.5 x 11.8) |
| Weight / packaging weight | 26 kg (57.8 lb) / 30 kg (66 lb) | 26 kg (57.8 lb) / 30 kg (66 lb) | 26 kg (57.8 lb) / 30 kg (66 lb) |
| Temperature range: operating / nonoperating | -25°C - +60°C (-13°F - +142°F) | -25°C - +60°C (-13°F - +142°F) | -25°C - +60°C (-13°F - +142°F) |
| Environmental protection rating | IP65 | IP65 | IP65 |
| Noise emission (typical) | 39 dB(A) | 39 dB(A) | 45 dB(A) |
| Internal power consumption at night | < 5 W | < 5 W | < 5 W |

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Cold Temperature DC Voltage

Example Sys. #3

Maximum system DC voltage calculation:

Open Circuit Voltage (Voc) of modules= 39.5V DC (at 25 C or 77 F)

39.5V x 12 modules= **474V** (at 77 F)

If we use -20° C for our coldest temperature (which is noted in the ASHRAE Fundamentals Handbook for the SLC valley):

The difference in temperature drop from 25 C to -20 C is **45 C**.

Per the modules specs, the voltage of the modules increases by .30% for every 1° C.

Take 45° C x .30 = a voltage increase of 13.5% at -20° C.

474V x 1.135= a cold temperature voltage of **538V**.

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Conductor Ampacity and OCPD Sizing

Example Sys. #3

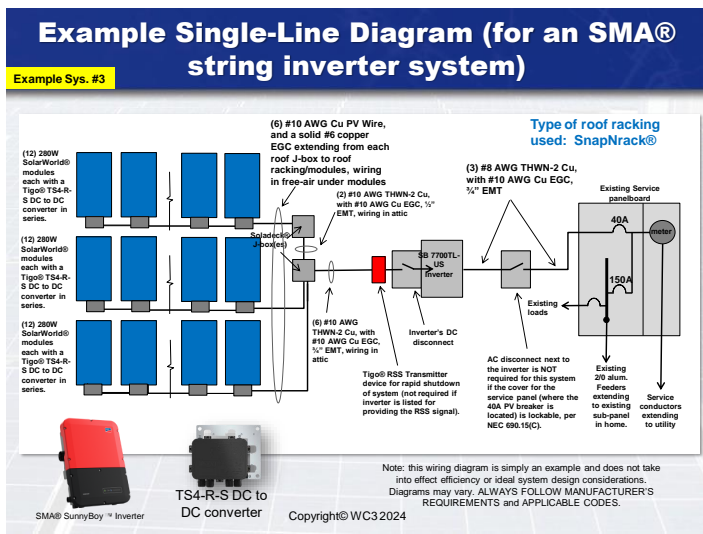
| | 1. Max current NEC 690.8(A)(1)(a-c) | 2. Breaker or fuse rating, and wire ampacity NEC 690.8(B) and 690.9(B) |
|--|--|--|
| String circuit (source circuit) | (string Isc x 125%) 9.71 x 1.25= 12.14 A | (string max current x 125% again) 12.14 x 1.25= 15.2 A |
| PV output Circuit (circuit between DC combiner box and inverter) | (each strings' max DC current combined together) x (# of strings) = ___ A | (Total combined strings' max current x 125%) x 1.25= ___ A |
| Inverter AC Output Circuit | (inverter max output) 32 amps | (inverter max output x 125%) 32 x 1.25= 40 A |

Use the max amps in this column when starting the adjustment of wires for temp. and conduit fill. Take the larger of either the final adjusted ampacity from this column or the final amps in column 2 to size the conductors, NEC 690.8(B)(2).

If deration or adjustment of wires is needed then use this column to size wire ampacity. Always use this column to size the breaker or fuses (use next size up breaker or fuse if between ratings).

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SMA® Rapid Shutdown Specs for Tigo® Optimizers (sma-America.com)

Example Sys. #3

TS4-A-F
PV Module Advanced Add-On

The TS4-A-F (Fire Safety) is the advanced add-on rapid shutdown solution that brings smart module functionality to standard PV modules for higher reliability. Ensure safety by upgrading existing PV systems or by adding safety features to new installations.

The TS4-A-F complies with NEC 2017 690.12 Rapid Shutdown specifications when installed with the Tigo RS5 Transmitter or an inverter with built-in Tigo certified transmitter.

Included Features

- Enhanced safety per NEC 690.12 rapid shutdown compliance
- Easy installation: Snap to standard module frame or remove brackets for rack mounting
- PLC Signaling: Control rapid shutdown with the Tigo RS5 Transmitter
- Automatic Shutdown: PV array enters rapid shutdown in event of AC grid loss

TS4-A-F SPECIFICATIONS

| | |
|-----------------------------|----------------------------------|
| Operating Temperature Range | -40°C to +85°C (-40°F to +185°F) |
| Outdoor Rating | IP68, NEMA 3R |
| Dimensions | 138 mm x 139 mm x 22 mm |
| Weight | 490g |
| Rated Voltage Range | 18 - 70V |
| Maximum Current | 1.5A |
| Maximum Power | 50W |
| Output Cable Length | 1.2m (standard) |
| Connectors | MC4 (standard) |
| Communication Type | PLC |
| Rapid Shutdown (V) Listed | Yes |
| NEC 2017 690.12 | Yes |

ORDERING INFORMATION

| | |
|------------|---|
| 4880020-02 | 1800V UL / 1000V PV, 1.2m cable, MC4 |
| 4880020-12 | 1800V UL / 700V, 1.2m cable, MC4 compatible |
| 4880020-02 | 1800V UL / 700V, 1.2m cable, PV02 |

For sales info: sales@sma-america.com | 1-888-453-8883

For product info: www.sma-america.com

For technical info: www.sma-america.com


Tigo

Tigo Energy, Inc. 453 Campbell Technology Pkwy Suite 100, Campbell, California 95008 USA
www.tigoenergy.com | 1-888-453-8883 | 1-408-358-6279 | info@tigoenergy.com

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SMA® Rapid Shutdown Specs for Tigo® Optimizers (sma-America.com)

Example Sys. #3



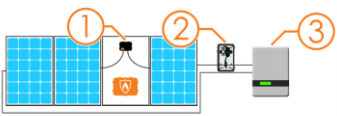
RSS TRANSMITTER - OUTDOOR KIT

Rapid Shutdown Activator for TS4-F

The Tigo Rapid Shutdown System (RSS) Transmitter is part of a rapid shutdown solution when paired with Tigo TS4-F (Free Safety), or PV module rapid shutdown unit. While powered on, the RSS Transmitter sends a signal to the TS4-F units to keep their PV modules connected and supplying energy.

TS4-F units automatically enter rapid shutdown mode when the RSS Transmitter is switched off and resume energy production when power is restored to the RSS Transmitter. This solution complies with NEC 490.12 specifications for 2014 and 2017 and is compatible with SunSpec signaling for rapid shutdown. The RSS Transmitter and TS4-F are compatible with many inverters and modules.

The RSS Transmitter Outdoor Kit includes an RSS Transmitter, outdoor enclosure, 120VAC~ power supply, and one or two RSS Cores.



1. Modules equipped with Tigo TS4-F (Free Safety)
2. Tigo RSS Transmitter with Outdoor Kit
3. Inverter

Specifications:

- Meets NEC 490.12 requirements
- Module-level disconnection with TS4-F
- Automatic or manual shutdown
- Weatherproof outdoor enclosure
- Includes one or two RSS Cores
- Includes 120VAC~ power supply

Input:

- Transmitter Input Voltage: 120V~
- Transmitter Input Current: 1A

Output:

- Max Current (in Outdoor Kit): 100A per RSS Core (Single Core: 100A, Dual Core: 200A)
- Max Voltage: 100V~
- Max Number of Strings per Core: 10
- Max Supported PV Module per String: 40

Operating Temperature Range: -20°C to 50°C (in Outdoor Enclosure)

Enclosure: #18, NEMA 4

ORDERING OPTIONS

#120000-01 Single Core RSS DIN Rail Transmitter Kit, 120VAC~ Power Supply, Outdoor Enclosure
#120000-02 Dual Core RSS DIN Rail Transmitter Kit, 120VAC~ Power Supply, Outdoor Enclosure

For sales info: sales@tigoenergy.com or 1-888-452-0802
For technical information: tiro.support@tigoenergy.com

For product info: www.tigoenergy.com/products
For technical info: tiro.tigoenergy.com

For additional info and product selection assistance, use Tigo's online design tool at www.tigoenergy.com/design

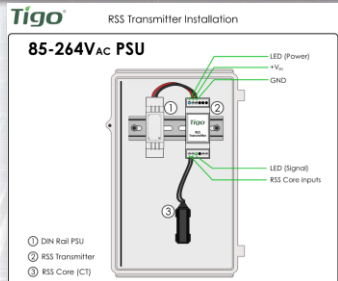
UL 1741 Photovoltaic Inverter System Equipment, 50W

Tigo Energy, Inc. 885 Conquistador Technology Drive Suite 120, Campbell, California 95008 USA
www.tigoenergy.com P: +1-888-452-0802 F: +1-408-358-2279 | sales@tigoenergy.com

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SMA® Rapid Shutdown Specs for Tigo® Optimizers (sma-America.com)

Example Sys. #3



RSS Transmitter Installation

85-264VAC PSU

1. DIN Rail PSU
2. RSS Transmitter
3. RSS Core (CT)

LED (Power)
+V_{DC}
GND

LED (Signal)
RSS Core Input

Transmitter power supply must be on same AC branch circuit as inverter to meet rapid shutdown requirements.

Note: Install TS4-F before powering on RSS Transmitter

- Drill holes in enclosure for conduit (see drilling guide for placement)
- Mount RSS Transmitter and power supply on DIN rail
- Connect DC leads from power supply ① to transmitter ②
- Connect RSS Core ③ to transmitter

Place rapid shutdown system label no more than 1m (3ft) from RSS Transmitter or AC disconnect if not at same location.

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SnapRack® Specs (snaprack.com)

Example Sys. #3



Ultra Rail

UR-40
UR-60

A sleek, straightforward rail solution for mounting solar modules on all roof types. Ultra Rail features two rail profiles: UR-40 is a lightweight rail profile that is suitable for most geographic regions and maintains all the great features of SnapRack rail, while UR-60 is a heavier duty rail profile that provides a larger rail channel and increased span capabilities. Both are compatible with all existing mounts, module clamps, and accessories for ease of install.

The Entire System is a Snap to Install

- New Ultra Rail Mounts include snap-in brackets for attaching rail
- Compatible with all the SnapRack Mid Clamps and End Clamps customers love
- Universal End Clamps and snap-in End Caps provide a clean look to the array edge

Unparalleled Wire Management

- Open rail channel provides room for running wires resulting in a long-lasting quality install
- Industry best wire management offering includes Junction Boxes, Universal Wire Clamps, MLPE Attachment Kits, and Conduit Clamps
- System is fully bonded and listed to UL 2703

Heavy Duty UR-60 Rail

- UR-60 rail profile provides increased span capabilities for high-wind speeds and snow loads
- Sturdy, stronger rail profile includes profile-specific rail splice and end cap
- All ending mounts, module clamps, and accessories are retained for the same great install experience

Quality, Innovative, Superior.

SnapRack Solar Mounting Solutions are engineered to optimize material use and labor resources and improve overall installation quality and safety.

877-732-2860 www.snaprack.com contact@snaprack.com

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SnapRack® Wind Loading Tables (snaprack.com)

Example Sys. #3



SnapRack Umbrella Sealing Technology

Featuring New Innovative Flashing

- Smaller 9"X12" size allows for easier insertion under shingles
- Alignment markers make it easy to locate pilot holes
- Rounded corners make for easier insertion & eliminate corner points from folding up

- Innovative Flashing Elevates Protection.** New Flashing uses a fully formed raised cone to prevent any potential water from getting into penetration. Seal secure as the flashing is one piece and doesn't rely on multiple parts sealing together.
- Mechanical Design Creates a Lifelong Seal.** Patented Umbrella technology utilizes unique Umbrella Washer to seal lag bolts. Test without a rubber seal, however rubber gasket is included for extra peace of mind.
- Single Fastener Eliminates Extra Steps.** Utilize one lag bolt with Umbrella Washer to secure the entire mount assembly and flashing. No longer necessary to attach a base, then a flashing, then a mount as all are secured in one step.
- Single Tool Installation.** SnapRack was the first in the industry to develop a complete system that only requires a single tool. That tradition is continued as a "1" socket is still the only tool necessary to secure the mount as well as all other parts of the system.

Industry Leading Spans for a Light Rail Solution

This table was prepared in compliance with applicable engineering codes and standards. Values are based on the following:

- ASCE 7-10
- Chapter 30 Wind Loads & Chapter 7 Snow Loads
- Roof Slope: 7-27 deg
- Roof Height: 0-30 ft
- Exposure: B
- Roof Zone: 1
- Module Orientation: Portrait
- Module Type: 60 Cell Modules
- Roof Type: Comp

Certifications

SnapRack Ultra Rail System has been evaluated by Underwriters Laboratories (UL) and Listed to UL/ANSI Standard 2703 for Mechanical Loading and Fire. Additionally it is listed to UL 2182 for wind-driven rain.

877-732-2860 www.snaprack.com contact@snaprack.com

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Signage

Example Sys. #3

All signage must be permanently attached and be able to withstand the environment they are installed. Signage also cannot be hand-written. **NEC 110.21(B).**

CAUTION: MULTIPLE SOURCES OF POWER

The above shown sign is required at the service disconnect. *NEC 705.10.*

PV System: AC Current = 32A AC Volts = 240V

This sign is required to be located at the backed panelboard. *NEC 690.54* (per the 2020 *NEC*).

Maximum DC Voltage = 310V

This sign is required to be mounted on the string inverter. *NEC 690.54*

WARNING: POWER SOURCE OUTPUT DO NOT RELOCATE THIS OVERCURRENT DEVICE.

This sign is required to be located next to the AC PV backed breaker(s) **ONLY** if the 120% allowance of *NEC 705.12(B)(3)(2)* is being utilized.

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SHUTDOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY

This sign to be located on the outside of, and within 3' of the service equipment. *NEC 690.56(C).*

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

This sign must be reflective and is required to be located next to the disconnect switch which activates rapid shutdown. *NEC 690.56(C)(2)* (for this system, it would be the 40A solar PV breaker located in the service meter panelboard)

PHOTOVOLTAIC POWER SOURCE

This sign is to be located on the outside of any conduits, enclosures, or MC cable that contain DC circuits. The markings shall be reflective and be provided at every enclosure, every 10' along conduit or MC cable, and at each side of where the conduit or cable passes through a wall, floor, or any other partition. The markings shall be permanently affixed and visible after installation. *NEC 690.31(D)(2)*

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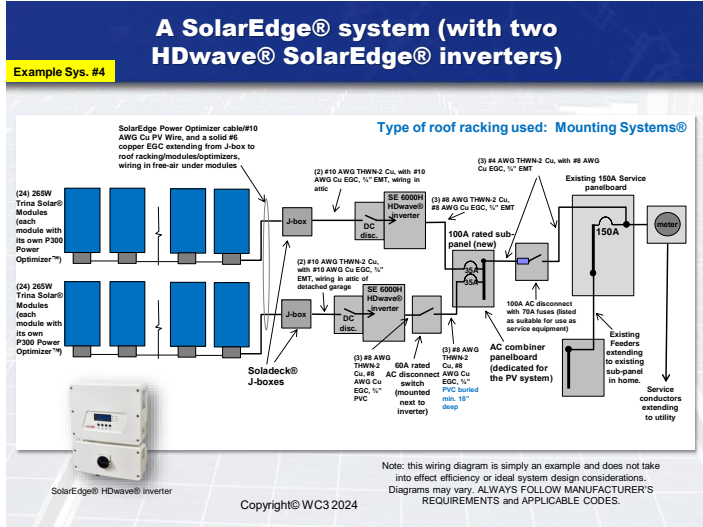
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Plan Review Example System #4

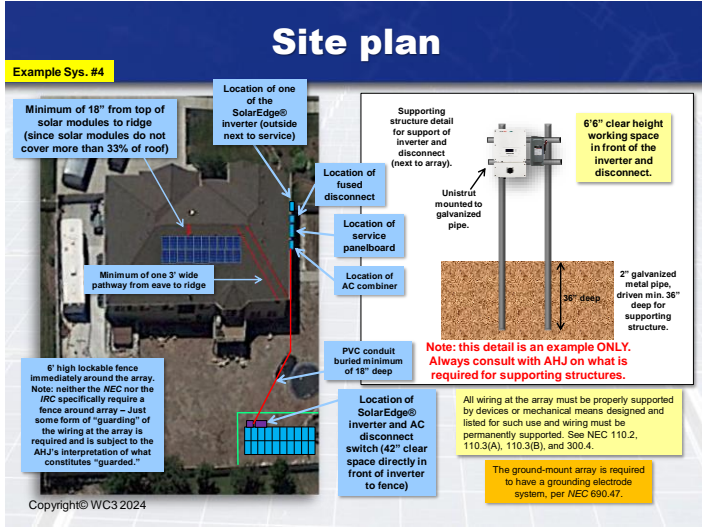
SolarEdge® HDwave™ String Inverter System – Ground Mounted PV

Copyright© WC3 2024

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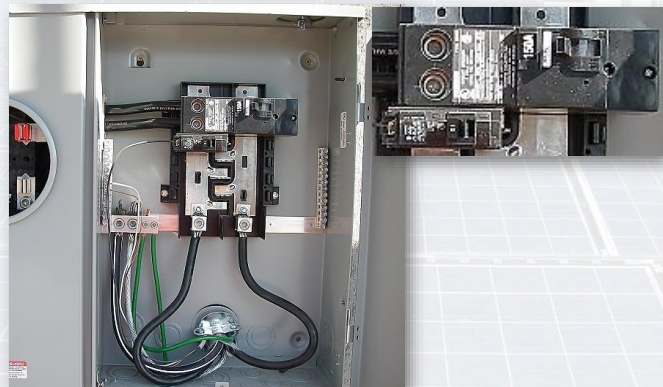
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Photos of Service Panel

Example Sys. #4

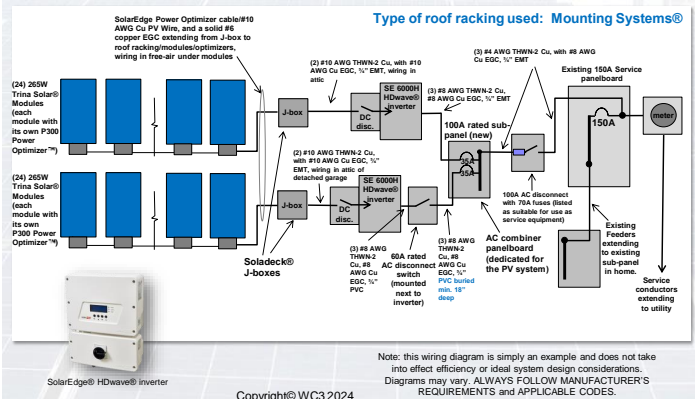


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A SolarEdge® system (with two HDwave® SolarEdge® inverters)

Example Sys. #4



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SIEMENS

Rainproof Combination Metering

Catalog Number: MC0816B1200TH

Enclosure: Type 3R

RATING: 200 AMP/240V AC, 1 PHASE, 3 WIRE, 3 WIRE 200/120 VOLTS AC, 1 PHASE, 3 WIRE, WHEN 5TH JAW IS INSTALLED. (DERIVED FROM 3-PHASE, 4-WIRE SYSTEM)

| Terminal | Wire Size | Termin. |
|----------|------------|---------|
| A1, B1 | 200mm² AWG | 275.1m |
| A2, B2 | 60-95 | 50.9m |
| A3, B3 | 46-95 | 68.8m |
| A4, B4 | 28-95 | 109.2m |
| A5, B5 | 10-95 | 316.3m |

METER SOCKET RATING: 200 AMP/240V AC

SUITABLE ONLY FOR USE AS SERVICE EQUIPMENT.

FOR OVERHEAD OR UNDERGROUND SERVICE: USE 80/75 COPPER OR ALUMINUM CONDUCTOR IN TERMINALS A1, B1, N1, N2, N3, G1, A2 AND B2.

GENERAL INFORMATION: REMOVE THIS COVER FROM SEARPOINT ONLY WHERE BREAKERS WILL BE INSTALLED. ALL OPENINGS MUST BE FILLED WITH BREAKERS OR FILLER PLATES.

ADDITIONS: FILLER PLATE - CAT. NO. DF3, 80 AMP ACCESSORY - CAT. NO. M3J1, LAMP LUG NEUTRAL KIT - CAT. NO. L31H

Specs for the Siemens® MC0816B1200TH service panelboard (Siemens.com)

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Inverter Specs (solaredge.com)

Example Sys. #4

Single Phase Inverter with HD-Wave Technology for North America

SE3000H-US / SE3800H-US / SE5000H-US / SE6000H-US / SE7600H-US / SE10000H-US / SE11400H-US

12-25 year warranty

Single Phase Inverter with HD-Wave Technology for North America

SE3000H-US / SE3800H-US / SE5000H-US / SE6000H-US / SE7600H-US / SE10000H-US / SE11400H-US

| MODEL NUMBER | SE3000H-US | SE3800H-US | SE5000H-US | SE6000H-US | SE7600H-US | SE10000H-US | SE11400H-US |
|-------------------------|--------------------|------------|------------|------------|------------|-------------|-------------|
| APPLICABLE TO INVERTERS | | | | | | | |
| WAVE NUMBER | SEXXXXX-XXXXXXBXX4 | | | | | | |
| OUTPUT | 3000 | 3800 | 5000 | 6000 | 7600 | 10000 | 11400 |
| Max. DC Power (kW) | 3000 | 3800 | 5000 | 6000 | 7600 | 10000 | 11400 |
| Max. AC Power (kW) | 3000 | 3800 | 5000 | 6000 | 7600 | 10000 | 11400 |
| Max. DC Voltage (V) | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 |
| Max. AC Voltage (V) | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| Max. DC Current (A) | 20 | 25 | 33 | 40 | 51 | 67 | 76 |
| Max. AC Current (A) | 16 | 20 | 27 | 33 | 42 | 55 | 63 |
| Weight (kg) | | | | | | | |
| Dimensions (mm) | | | | | | | |

Optimized installation with HD-Wave Technology

- Specifically designed to work with power optimizers
- Record-breaking 99% weighted efficiency
- Quick and easy inverter commissioning directly from a smartphone using the Solaredge mobile app
- UL1741 SA certified, for CPUC Rule 21 g in all states
- Small, lightweight, and easy to install in attics
- Built-in module-level monitoring
- Optional faster installation with both in-attic (0.5 ACW) and ground-mount (0.5W ACW) mounting (0.5W ACW)
- Optional faster installation with both in-attic (0.5 ACW) and ground-mount (0.5W ACW) mounting (0.5W ACW)

solaredge.com

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Inverter Specs (solaredge.com)

Example Sys. #4

Single Phase Inverter with HD-Wave Technology for North America

SE3000H-US / SE3800H-US / SE5000H-US / SE6000H-US / SE7600H-US / SE10000H-US / SE11400H-US

| MODEL NUMBER | SE3000H-US | SE3800H-US | SE5000H-US | SE6000H-US | SE7600H-US | SE10000H-US | SE11400H-US |
|---|---|------------|-------------------------------------|------------|-----------------------|-------------|-------------|
| ADDITIONAL FEATURES | | | | | | | |
| Supported Communication Interfaces | RS485, Ethernet, ZigBee (optional), Cellular (optional) | | | | | | |
| Revenue Grade Metering, ANSI C12.20 | Optional ¹ | | | | | | |
| Consumption Metering | Optional ¹ | | | | | | |
| Inverter Commissioning | With the SetApp mobile application using Built-in Wi-Fi Access Point for Local Connection | | | | | | |
| Rapid Shutdown - NEC 2014 and 2017 690.12 | Automatic Rapid Shutdown upon AC Grid Disconnect | | | | | | |
| STANDARD COMPLIANCE | | | | | | | |
| Safety | UL 1741, UL 1741 SA, UL 1998, CSA C22.2, Canadian AEG according to TLL M-07 | | | | | | |
| Grid Connection Standards | IEEE 1547, Rule 21, Rule 14 (H) | | | | | | |
| Emissions | FCC Part 15 Class B | | | | | | |
| INSTALLATION SPECIFICATIONS | | | | | | | |
| AC Output Conduit Size / AWG Range | 1" Maximum / 14-6 AWG | | | | 1" Maximum / 14-4 AWG | | |
| DC Input Conduit Size / AWG Range | 1" Maximum / 1-3 strings / 14-6 AWG | | 1" Maximum / 1-3 strings / 14-6 AWG | | | | |
| Dimensions with Safety Switch (HxWxD) | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 | | 21.3 x 14.6 x 7.3 / 540 x 370 x 185 | | 19 / 200L | | |
| Weights with Safety Switch | 22 / 10 | | 25.1 / 11.4 | | 26.2 / 11.9 | | 38.8 / 17.6 |
| Noise | < 25 | | | | | | < 50 |
| Coding | Natural Connection | | | | | | |
| Operating Temperature Range | -40°C to +60°C / -40°F to +140°F | | | | | | |
| Protection Rating | NEMA 4X (Inverter with Safety Switch) | | | | | | |

¹ Inverter with Revenue Grade Meter (P/N: SE444-02000R1C4, Inverter with Revenue Grade Production and Consumption Meter (P/N: SE444-02000R1C4). For consumption metering, current transformers should be ordered separately. (SAC70750-200M-20 or SAC70750-400M-20). (10000W only).
² Full power up to 45 °C (113 °F). For power derating information refer to: <https://www.solaredge.com/sites/default/files/inverter-temperature-derating-profile.pdf>

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Inverter Certification (SolarEdge.com and Intertek.com)

Example Sys. #4

intertek
intertek.com

Address: Irvine, CA 92618
Contact: 949.261.1300
Telephone: 607.759.4515
www.intertek.com

Subject: ETL Evaluation of SolarEdge Products to NEC 2017 Rapid Shutdown Requirements

To, whom it may concern:

This letter represents the testing results of the below listed products to the requirements contained in the following standards:

National Electric Code, 2017, Section 690.12 requirement for rapid shutdown.

UL 1741, UL 1741 CRD for rapid shutdown

The evaluation was done on the PV Rapid Shutdown System (PVRSS), and covers installations consisting of optimizers and inverters with part numbers listed below.

The testing done has verified that controlled conductors are limited to:

- Not more than 30 volts and 240 voltamperes within 30 seconds of rapid shutdown initiation outside the array.
- Not more than 30 volts and 240 voltamperes within 30 seconds of rapid shutdown initiation inside the array.

The rapid shutdown initiation is performed by either disconnecting the AC feed to the inverter, or - if the inverter DC Safety switch is readily accessible - by turning off the DC Safety switch.

Applicable products:

- Power optimizers:
 - PO followed by 001 to 350, followed by -40B or -7FL.
 - OP followed by 001 to 300, followed by -1V, -M1, -W or -EV.
 - P followed by 001 to 850.
 - SP followed by 001 to 350.
- Inverters:
 - Where optimizers are connected to 2 or more modules in series, the max input voltage may exceed 800V. Following the implementation of the NEC 2017 rapid shutdown value of 800V max inside of the array at the beginning of 2019, modules exceeding this combined input max voltage will be required to use optimizers with parallel inputs.

3-gt Inverters:

- SE1000A-US / SE3800A-US / SE5000A-US / SE6000A-US / SE7600A-US / SE10000A-US / SE11400A-US / SE3000H-US / SE3800H-US / SE5000H-US / SE6000H-US / SE7600H-US / SE10000H-US / SE11400H-US when the following label is labeled on the side of the inverter:

Inverter part number may be followed by a suffix

3-gt Inverters:

- SE6KUS / SE100KUS / SE4-KUS / SE20KUS / SE30KUS / SE33-KUS / SE43-KUS / SE66-KUS / SE100KUS ; when the following label is labeled on the side of the inverter:

Inverter part number may be followed by a suffix

If there are any questions regarding the results contained in this report, or any of the other services offered by Intertek, please do not hesitate to contact the undersigned.

Version: 8 September 2016 Page: 1 of 3

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SolarEdge® Power Optimizer™ Specs (solaredge.com)

Example Sys. #4

Power Optimizer For North America

P320 / P340 / P370 / P400 / P405 / P505

POWER OPTIMIZER

| Optimum input power (Wattage) | P320 (320W) | P340 (340W) | P370 (370W) | P400 (400W) | P405 (405W) | P505 (505W) |
|----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Maximum Power Point (Wattage) | 320 | 340 | 370 | 400 | 405 | 505 |
| Maximum Power Point (Voltage) | 32.0 | 34.0 | 37.0 | 40.0 | 40.5 | 50.5 |
| Maximum Power Point (Current) | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Maximum Power Point (Efficiency) | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 |

OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER)

| Output Voltage (V) | Output Current (A) | Output Power (W) |
|--------------------|--------------------|------------------|
| 32.0 | 10.0 | 320 |
| 34.0 | 10.0 | 340 |
| 37.0 | 10.0 | 370 |
| 40.0 | 10.0 | 400 |
| 40.5 | 10.0 | 405 |
| 50.5 | 10.0 | 505 |

INSTALLATION SPECIFICATIONS

| Parameter | Value |
|-----------------------------|-------------------------------------|
| Operating Temperature Range | -40°C to +60°C / -40°F to +140°F |
| Protection Rating | NEMA 4X |
| Dimensions (HxWxD) | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 |
| Weight | 22 / 10 |

PV power optimization at the module-level

- Specifically designed to work with SolarEdge inverters
- Up to 25% more energy
- Superior efficiency (98.0%)
- Integrates all types of module mismatch losses, from manufacturing tolerance to partial shading
- Flexible system design for maximum space utilization
- Fast installation with a single bolt inverter
- Next generation maintenance with module-level monitoring
- Meets NEC requirements for anti-back-feeding (ABFC) and Photovoltaic Rapid Shutdown System (PVRSS)
- Multiple level-voltage shutdowns for installer and firefighter safety

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Solar PV Module Specs (trinasolar.com)

Example Sys. #4

ALLMAX FRAMED 60-CELL MODULE

60 CELL ALLMAX FRAMED MODULE

260-280W POSITIVE VOLTAGE RANGE

17.1% MAXIMUM EFFICIENCY

0-+5W POSITIVE POWER TOLERANCE

Highly reliable due to stringent quality control

Certified to withstand the most challenging environmental conditions

Comprehensive Product Analysis

25-YEAR PERFORMANCE WARRANTY

| Electrical Data (STC) | 260 | 270 | 275 | 280 |
|--|------|------|------|------|
| Peak Power (Watt) | 260 | 270 | 275 | 280 |
| Maximum Power Voltage (V _{mp}) | 33.4 | 35.8 | 36.9 | 37.1 |
| Maximum Power Current (A _{mp}) | 8.10 | 8.41 | 8.72 | 8.84 |
| Open Circuit Voltage (V _{oc}) | 38.2 | 38.3 | 38.4 | 38.7 |
| Short Circuit Current (I _{sc}) | 9.00 | 9.10 | 9.18 | 9.25 |
| Module Efficiency (%) | 15.9 | 16.2 | 16.5 | 16.8 |

| Electrical Data (NOCT) | 193 | 197 | 200 | 204 |
|--|------|------|------|------|
| Maximum Power (Watt) | 193 | 197 | 200 | 204 |
| Maximum Power Voltage (V _{mp}) | 28.4 | 28.4 | 28.7 | 29.0 |
| Maximum Power Current (A _{mp}) | 6.81 | 6.93 | 6.97 | 7.03 |
| Open Circuit Voltage (V _{oc}) | 33.4 | 33.5 | 33.5 | 33.8 |
| Short Circuit Current (I _{sc}) | 7.27 | 7.35 | 7.41 | 7.47 |

Comprehensive Products And System Certificates

IEC61215/IEC61730/UL1703/IEC61701/IEC62716
ISO 9001: Quality Management System

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Example Sys. #4

IronRidge® Ground-Mount Racking Specifications (ironridge.com)

Doug Smith
GROUND-BASED

Project Details

| | |
|--|---------------------|
| NAME: Doug Smith | DATE: 2017-10-13 |
| LOCATION: Optima, UT, 84401 | TOTAL MODULES: 20 |
| MODULE: Mitsubishi PV M50E30H2 (60mm) | TOTAL WATTS: 5,800 |
| DIMENSIONS: 64'0" x 40'1" x 1'8" (Etron x Tron x 45mm) | TILT: 25 deg |
| | CONFIGURATION: #10p |

Load Assumptions

| |
|-------------------------|
| WIND EXPOSURE: 0 |
| WIND SPEED: 110 mph |
| GROUND SNOW LOAD: 0 psf |

Substructure Requirements

| |
|-----------------------|
| PIPE DIA: 2" |
| DIAGONAL BRACING: Yes |

3rd Party Substructure Materials

| |
|--------------------------------------|
| TOTAL PIPE: 124 5.0' |
| TOTAL CONCRETE: 1.16 yd ³ |

Array Details

| Count | Repeats | Modules Per Row | Total Pans | South Pans | North Pans | Cross Pipes | Centerline | Total Pipe Length |
|-------|---------|-----------------|------------|------------|------------|-------------|------------|-------------------|
| 4x6 | 1 | 2,00 | 10 | 5,07 23 | 5,07 83 | 2,077 7,91 | 0' 0" | 124 5.0' |

Foundation Requirements

| |
|------------------------|
| TYPE: Concrete |
| HOLE DIAMETER: 12 in. |
| MIN-HOLE DEPTH: 48 in. |

Foundation Loads

| |
|-------------------|
| SUCTION: 100 lbs. |
| MOMENT: 0.9 lbs. |
| UPLIFT: -620 lbs. |

Last updated by Doug Smith on 2017-10-13 10:46:44 -0700 Page 1 of 5

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Example Sys. #4

IronRidge® Ground-Mount Racking Specifications (ironridge.com)

Doug Smith
GROUND-BASED

Plan View

Side View

Last updated by Doug Smith on 2017-10-13 10:46:44 -0700 Page 2 of 5

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Example Sys. #4

IronRidge® Ground-Mount Racking Specifications (ironridge.com)

Doug Smith
GROUND-BASED

Pipe Fittings Detail

Clamp Detail

Last updated by Doug Smith on 2017-10-13 10:46:44 -0700 Page 3 of 5

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Example Sys. #4

IronRidge® Ground-Mount Racking Specifications (ironridge.com)

Doug Smith
GROUND-BASED

Grounding Diagram

Plan View

Side View

Last updated by Doug Smith on 2017-10-13 10:46:44 -0700 Page 4 of 5

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IronRidge® Ground-Mount Racking Specifications (Ironridge.com)

Example Sys. #4

Starling Madison Lofquist, Inc.
 5224 South 39th Street, Phoenix, Arizona 85040
 Tel: (602) 438-2500 Fax: (602) 438-2505 ROC#P21916 www.starling.com

Date: June 3, 2016
 Page 1 of 51

IronRidge
 1493 Zepher Ave
 Hayward, CA 94544

Attn: Mr. David F. Taggart, Vice President Products
 Subject: Ground Mounting System – Structural Analysis – 4 Module
 Dear Sir:

We have analyzed the subject ground mounted structure and determined that it is in compliance with the applicable sections of the following Reference Document:

Codes: ASCE 7-10 Min. Design Loads for Buildings & Other Structures
 International Building Code, 2015 Edition
 Other: AC408, Acceptance Criteria for Modular Framing Systems Used to Support PV Modules, dated Effective November 1, 2012 by ICC-ES
 Aluminum Design Manual, 2015 Edition
 IronRidge Exhibit EX-001

The structure is a simple column (pier) and beam (cross pipe) system. The pier and cross pipes are ASTM A53 Grade B standard weight (schedule 40) steel pipes or Allied Mechanical Tubing. Please refer to Exhibit EX-001 for approved pipe geometry and material properties. The tops of the piers are connected in the E-W direction by the cross pipes which cantilever over and extend past the end piers. The cross pipes are connected by proprietary IronRidge 2001600 rails spanning up and down the slope which cantilever over and extend past the top and bottom cross pipes. There are typically two rails per column of modules. The modules are clamped to the rails by the IronRidge Module Mounting Clamps as shown in the Attached Exhibit.

Gravity loads are transferred to the piers and foundations by the rails and cross pipes acting as simple beams. For lateral loads the system is either a cantilever structure or, when diagonal braces are provided, a braced frame. The effect of seismic loads (for all design categories A-F) have been determined to be less than the effect due to wind loads in all load conditions and combinations.

The pier spacing in the N-S direction is 7'-6". The pier spacing in the E-W direction is selected from load tables determined by the structural design for the specified slope, wind load, and snow load. The governing criteria for the pier spacing is either the spanning capacity of the cross pipes or the cantilever capacity of the pier. Simplified Load Tables 1 & 2, 4 & 24-F are included herein for reference.

More comprehensive information covering all load combinations is available at the IronRidge website, IronRidge.com.

Starling Madison Lofquist, Inc. Consulting Structural and Financial Engineers

June 3, 2016
 Page 1 of 51

IronRidge
 Mr. David F. Taggart
 Ground Mounting System – Structural Analysis – 4 Module

Notes for Tables 3 & 4:
 1. Concrete Strength = 145 pcf ($f'_c = 2500$ psi)
 2. Silt/Fraction per 2015 IRC 1810.3.1.4 & 5
 3. Top 1'-0" of soil regulated for Risk V/Extreme
 4. Snow Load = 0 pcf - substituted values are conservative for Snow Loads > 0 pcf
 5. * Indicates special foundation required. Contact IronRidge
 6. Resistance to corrosion and/or sulfate attack, along with possible adverse effects due to expansive soils has not been considered in these foundation recommendations. RSM Engineers assumes no liability with regard to these items.
 7. Soil classification is to be determined and verified by the end user of this certification letter.

The analysis assumes that the array, including the connections and associated hardware, are installed in a workmanlike manner in accordance with the IronRidge Ground Mount Installation Manual and generally accepted standards of construction practice. Verification of PV Module capacity to support the loads associated with the given array shall be the responsibility of the Contractor or Owner and not IronRidge or Starling Madison Lofquist.

Please feel free to contact me at your convenience if you have any questions.

Respectfully yours,

Trey Warner, P.E.
 Design Division Manager

Stamp: NO. 2024-0203
 TRES. WARNER
 STATE OF ARIZONA
 6-3-16
 Exp 3-31-19

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IronRidge® Ground-Mount Racking Specifications (ironridge.com)

Example Sys. #4

EXHIBIT: EX-0001 CONCRETE FOUNDATION DETAILS

IRONRIDGE
 GROUND MOUNT SYSTEM,
 4 SOLAR MODULE ROWS
 EX-0001

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IronRidge® Ground-Mount Racking Specifications (ironridge.com)

Example Sys. #4

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Signage

Example Sys. #4

All signage must be permanently attached and be able to withstand the environment they are installed. Signage also cannot be hand-written. NEC 110.21(B).

CAUTION: MULTIPLE SOURCES OF POWER

The above shown sign is required at the service disconnect. NEC 705.10.

Note: 2nd PV inverter is located at ground-mounted solar array behind home.

A sign is required at the home's service meter panelboard noting the location of the 2nd string inverter since it's not located next to the utility service panel. NEC 690.4(D). Warning could vary.

Maximum DC Voltage = 1000V

This sign is required to be mounted on the string inverter. NEC 690.53

WARNING: POWER SOURCE OUTPUT DO NOT RELOCATE THIS OVERCURRENT DEVICE.

This sign is required to be located next to the AC PV backed breaker(s) ONLY if the 120% allowance of NEC 705.12(B)(3)(2) is being utilized.

PV System: AC Current = 50A AC Volts = 240V

This sign is required to be located at the backed panelboard. NEC 690.54 (in the 2020 NEC).

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAISED SHUT-DOWN SWITCH TO THE OFF POSITION TO SHUT-DOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN EMERGENCY

This sign is required to be located on the outside of, and within 3' of the service equipment. NEC 690.56(C).

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

This sign must be reflective and is required to be located next to the disconnect switch which activates rapid shutdown. NEC 690.56(C)(2) (for this system, it would be at the TMS tie-in breaker in the service or the PV AC disconnect switch near service - if provided)

PHOTOVOLTAIC POWER SOURCE

This sign is to be located on the outside of any conduits, enclosures, or MC cable that contain DC circuits. The markings shall be reflective and be provided at every enclosure, every 10' along conduit or MC cable, and at each side of where the conduit or cable passes through a wall, floor, or any other partition. The markings shall be permanently affixed and visible after installation. NEC 690.31(D)(2)

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ESS Example System #5

SolarEdge® StorEdge HUB™ Battery Backup String Inverter with an LG Chem® DC Battery System

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Example System (for an SolarEdge® Hub™ battery system)

ESS Example Sys. #5

The diagram illustrates the electrical connections between 15x 290W solar modules, SolarEdge StorEdge HUB™ Hybrid Inverters, a SolarEdge Home Battery, and an existing service panel. Key components and labels include:

- 15x 290W Solar Modules with their own PS90 Power Optimizer™.
- SolarEdge StorEdge HUB™ Hybrid Inverters.
- SolarEdge Home Battery (up to 3 per inverter).
- Existing Service Panelboard with a 200A main breaker.
- AC disconnect and 175A main breaker in the interface panel.
- Wiring specifications for #10 AWG THWN-2 Cu, #12 AWG THWN-2 Cu, and #10 AWG THWN-2 Cu EMT.
- Labels for AC disconnect, EMT, and service conductors.

Note: This wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS and APPLICABLE CODES.

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Site Plan (gabled roof)

ESS Example Sys. #5

The site plan shows the placement of solar modules on a gabled roof. Key annotations include:

- Location of the LG Chem® battery system (inside of garage - East wall).
- Location of the SolarEdge™ inverter, and AC disconnect switch (on inside of garage wall).
- Location of service panelboard.
- Minimum of 36" from solar modules to ridge (since solar modules appear to cover more than 33% of roof).
- J-box (located under the PV modules).
- Location of existing sub-panel (at bsm of home).
- Minimum of one 3' wide pathway from eave to ridge.

Other notes:

- There must be a sign on the service panel noting the location of the inverter and LG Chem @ batteries.
- AC disconnect (required by RMP).
- Location of SolarEdge® Interface Panelboard.
- Rapid shutdown pushbutton switch.
- Note: the fire clearances are not required if waived by the Fire Department/Fire Marshall.
- All roof penetrations must be properly flashed. IRC R903.2.
- Solar PV modules (panels) cannot be installed over or block any attic vents, plumbing vents*, furnace or water heater vents etc.
- *Covered plumbing vents in accordance with the 2019 IRC, Section P3103.1.3, are permitted as long as approved by jurisdiction.
- All wiring must be properly supported by devices or mechanical means designed and listed for such use and wiring must be permanently and completely held off of the roof surface. See NEC 110.2, 110.3(A), 110.3(B), and 300.4.

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Photo of Service Panel

ESS Example Sys. #5

The photograph shows the interior of an electrical service panel. A 200A main breaker is clearly visible. The panel is labeled with a 200A rating.

For this example, we are assuming that the service panel is rated for 200A since the main service breaker is rated 200A.

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StorEdge™ Specs (solaredge.com)

**SolarEdge Energy Bank
10kWh Battery
For North America**

Optimized for SolarEdge Energy Hub Inverters*

- Maximized system performance, gaining more energy to store and use for the grid and backup power applications
- Requires only the standard long-life solar panel technology, providing a single point of common technology between inverter and battery
- Simple plug-and-play installation, with no wiring needed for energy storage, inverter, and battery
- Simple solution for increased power and safety with multiple battery inverters

**SolarEdge Energy Bank
10kWh Battery
For North America**

**SolarEdge Home Battery®
specification sheets
(SolarEdge.com)**

BAT-10KWH¹

| BATTERY SPECIFICATION | | |
|---|---------------------------------------|----------------|
| Line-to-Line Voltage (Nominal) | 512V | 48V |
| Continuous Output Power | 5000 | 60 |
| Max Output Power (for 20 minutes) | 10000 | 120 |
| Peak In-Rush Current (Nominal) | 120A | 7% |
| Charging Current | 50 | 100% |
| Voltage Range | 300-420 | 70% |
| Minimum State of Charge | 25% | 50% |
| Expansion Capacity | 160 kWh (8) | |
| STANDARD COMPLIANCE | | |
| UL 9540 (UL 9540-1, UL 9540-2) | UL 1973 | |
| MECHANICAL SPECIFICATIONS | | |
| Dimensions (H x W x D) | 61.4 x 84.4 x 81.4 (700 x 1700 x 200) | 41.7 (16.4) |
| Weight | 330 (122) | 56 (20) |
| Mounting | Front or wall mount* | |
| Operating Temperature | +100 to -10 (32 to 14) | 10 (-10 to 50) |
| Storage Temperature (Transient) | +130 to -40 (270 to 10) | 12 (5 to 60) |
| Storage Temperature (Max. for 2 months) | +20 to 40 (68 to 104) | 12 (5 to 60) |
| Shipping | 400 (143) | 5 (2) |
| Enclosure Protection | IP65 (NEMA 4X) | IP65 (NEMA 4X) |
| Cable | 40 (1.6) | 20 (0.8) |
| Note (for 10-inverter) | None | 800 |

* The SolarEdge Energy Bank is designed to be used with SolarEdge inverters for a seamless connection. The inverter requires an existing long-life solar panel technology for Plug & Store installation. (Energy Bank must not be used in utility areas.)
 † These units are designed for use in outdoor applications and are suitable for use in outdoor applications. The inverter requires an existing long-life solar panel technology for Plug & Store installation. (Energy Bank must not be used in utility areas.)
 ‡ The SolarEdge Energy Bank is designed to be used with SolarEdge inverters for a seamless connection. The inverter requires an existing long-life solar panel technology for Plug & Store installation. (Energy Bank must not be used in utility areas.)
 § The SolarEdge Energy Bank is designed to be used with SolarEdge inverters for a seamless connection. The inverter requires an existing long-life solar panel technology for Plug & Store installation. (Energy Bank must not be used in utility areas.)
 ¶ The SolarEdge Energy Bank is designed to be used with SolarEdge inverters for a seamless connection. The inverter requires an existing long-life solar panel technology for Plug & Store installation. (Energy Bank must not be used in utility areas.)
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solaredge.com

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Single Phase Energy Hub Inverter with Prism Technology For North America

SE3000H-US / SE3800H-US / SE6000H-US / SE7600H-US / SE10000H-US / SE11400H-US¹⁾

HOME BACKUP

(specs from solaredge.com)

Single Phase Energy Hub Inverter with Prism Technology For North America
SE3000H-US / SE3800H-US / SE6000H-US / SE7600H-US / SE10000H-US / SE11400H-US¹⁾

| OUTPUT: AC ON GRID | SE3000H-US | | SE3800H-US | | SE6000H-US | | SE7600H-US | | SE10000H-US | | SE11400H-US | |
|---|------------|-------------|------------|-------------|------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|
| | Power (kW) | Power (kVA) | Power (kW) | Power (kVA) | Power (kW) | Power (kVA) | Power (kW) | Power (kVA) | Power (kW) | Power (kVA) | Power (kW) | Power (kVA) |
| Max. Output Power (kW) | 3.0 | 3.8 | 6.0 | 7.6 | 12.0 | 15.5 | 20.0 | 26.0 | 30.0 | 39.0 | 51.0 | 66.0 |
| Max. Output Power (kVA) | 3.6 | 4.6 | 7.2 | 9.1 | 14.4 | 18.6 | 24.0 | 31.2 | 36.0 | 46.8 | 61.2 | 79.2 |
| Max. Output Current (A) | 14 | 18 | 28 | 36 | 48 | 62 | 80 | 104 | 120 | 156 | 204 | 264 |
| Max. Output Voltage (V) | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| Max. Output Frequency (Hz) | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Max. Output Power Factor | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Max. Output Voltage Unbalance (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Max. Output Voltage Harmonic Distortion (%) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Max. Output Current Unbalance (%) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Max. Output Current Harmonic Distortion (%) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Max. Output Power Factor (Lag) | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Max. Output Power Factor (Lead) | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |

Optimized battery storage with HD-Wave technology

- Revised inverter THD weighted efficiency with 200% DC overrating
- Small footprint, and easy to install
- Modular design, future ready with optional expansion
- Both in consumption metering
- Direct connection to the SolarEdge smart EV charger
- Multi-inverters: scalable storage solution
- With enhanced battery power up to 10kW
- Integrated fire-trap protection and rapid shutdown for NEC 690.6, NEC 601 and NEC 690.9 per article 690.11 and 690.12
- Embedded inverter grade production data, AMS C10.00 class 10

solaredge.com

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Single Phase Energy Hub Inverter with Prism Technology For North America

SE3000H-US / SE3800H-US / SE6000H-US / SE7600H-US / SE10000H-US / SE11400H-US¹⁾

| | SE3000H-US | SE3800H-US | SE6000H-US | SE7600H-US | SE10000H-US | SE11400H-US | UNITS |
|---|---|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---------|
| INPUT - DC (BATTERY) | | | | | | | |
| Supported Battery Types | SolarEdge Energy Bank, LG RESU Prime ¹⁾ | | | | | | |
| Number of Batteries per Inverter | Up to 2 SolarEdge Energy Bank up to 2 LG RESU Prime | | | | | | |
| Continuous Power ²⁾ | 6000 | 7600 | 15000 | 20000 | 30000 | 40000 | W |
| Peak Power ³⁾ | 6000 | 7600 | 15000 | 20000 | 30000 | 40000 | W |
| Max Input Current | 16 | 20 | | | | | Amps |
| 2-pole Disconnection | | | Yes | | | | |
| SMART ENERGY CAPABILITIES | | | | | | | |
| Consumption Metering | Built-in ⁴⁾ | | | | | | |
| Backup & Battery Storage | With Backup Interface (purchased separately) for service up to 200A, Up to 3 inverters | | | | | | |
| EV Charging | Direct connection to Smart EV charger | | | | | | |
| ADDITIONAL FEATURES | | | | | | | |
| Integrated Communication Channels | RS485, Ethernet, Cellular ⁵⁾ , Wi-Fi (optional), SolarEdge Energy Net (optional) | | | | | | |
| Revenue Grade Metering, ANSI C12.20 | Built-in ⁶⁾ | | | | | | |
| Integrated AC, DC and Communication Connection Unit | Yes | | | | | | |
| Inverter Communication | With the SetApp mobile application using built-in Wi-Fi Access Point for local connection | | | | | | |
| DC Voltage Rapid Shutdown (PV and Battery) | Yes, according to NEC 200.9AC, NEC 2017 and NEC 2020-690.12 | | | | | | |
| STANDARD COMPLIANCE | | | | | | | |
| Safety | UL 1741, UL 1741 SA, UL 1741 FCS, UL 1998, UL 1998-1, UL 9540, CSA 22.2 | | | | | | |
| Grid Connection Standards | IEEE 1547, IEEE 1547-2018, IEEE 1547-2018-1 | | | | | | |
| Enclosures | IP65 (NEMA 4X) | | | | | | |
| INSTALLATION SPECIFICATIONS | | | | | | | |
| AC Output and/or AC Output Conduct Size / AWG Range | 1" maximum / 14-6 AWG | | | | | | |
| DC Input (PV and Battery) Conduct Size / AWG Range | 1" maximum / 14-6 AWG | | | | | | |
| Dimensions with Connection Unit (H x W x D) | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 | 17.7 x 14.6 x 6.8 / 450 x 370 x 174 | in / mm |
| Weight with Connection Unit | 26 / 11.8 | | 28 / 11.8 | | 43.7 / 18.9 | | lb / kg |
| Noise | < 25 | < 25 | < 50 ⁷⁾ | | < 50 | | dBA |
| Cooling | Natural Convection | | | | | | |
| Operating Temperature Range | -40 to +140 / -40 to +100 ⁸⁾ | | | | | | |
| Protection Rating | NEMA 4 | | | | | | |

(specs from solaredge.com)

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StorEdge™ Specs (solaredge.com)

ESS Example Sys. #5

HOME BACKUP

(specs from solaredge.com)

SolarEdge Home Backup Interface For North America
BI-EUSGN-02 / BI-NUSGN-02

| INPUT FROM GRID | BI-EUSGN-02 | | BI-NUSGN-02 | |
|---|-------------|-------------|-------------|-------------|
| | Power (kW) | Power (kVA) | Power (kW) | Power (kVA) |
| Max. Output Power (kW) | 200 | 250 | 200 | 250 |
| Max. Output Power (kVA) | 240 | 300 | 240 | 300 |
| Max. Output Current (A) | 9.1 | 11.3 | 9.1 | 11.3 |
| Max. Output Voltage (V) | 120 | 120 | 120 | 120 |
| Max. Output Frequency (Hz) | 60 | 60 | 60 | 60 |
| Max. Output Power Factor | 0.95 | 0.95 | 0.95 | 0.95 |
| Max. Output Voltage Unbalance (%) | 1.0 | 1.0 | 1.0 | 1.0 |
| Max. Output Voltage Harmonic Distortion (%) | 3.0 | 3.0 | 3.0 | 3.0 |
| Max. Output Current Unbalance (%) | 1.0 | 1.0 | 1.0 | 1.0 |
| Max. Output Current Harmonic Distortion (%) | 3.0 | 3.0 | 3.0 | 3.0 |

Backup Interface for Flexible Backup

- Automatically provides backup power to home loads in the event of grid interruption
- Full backup in about half an hour - the entire home or selected loads
- Scalable solution to support higher power and higher energy
- Built-in Auto Transformer and Energy Meter for easier and faster installation
- Supports integration with the SolarEdge Home Hub Inverter for storage and monitor both PV generation and energy storage
- Generator connection supported¹⁾

solaredge.com

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StorEdge™ Specs (solaredge.com)

ESS Example Sys. #5

SolarEdge Home Backup Interface For North America

BI-EUSGN-02 / BI-NUSGN-02

| STANDARD COMPLIANCE | BI-EUSGN-02 | BI-NUSGN-02 |
|---------------------|-----------------------------|----------------------|
| Safety | UL 1741, UL 1741-2, NEC 690 | UL 1741, NEC 690 |
| EMC | FCC part 15, Class B | FCC part 15, Class B |

INSTALLATION SPECIFICATIONS

| Supported Inverters | Supported Batteries |
|--|--|
| SolarEdge single-phase inverter | SolarEdge Home Backup Interface |
| AC Input Voltage Range / AC Output Range | AC Input Voltage Range / AC Output Range |
| AC Input Current Range / AC Output Current Range | AC Input Current Range / AC Output Current Range |
| AC Input Power Range / AC Output Power Range | AC Input Power Range / AC Output Power Range |
| AC Input Frequency Range / AC Output Frequency Range | AC Input Frequency Range / AC Output Frequency Range |
| AC Input Power Factor Range / AC Output Power Factor Range | AC Input Power Factor Range / AC Output Power Factor Range |
| AC Input Voltage THD Range / AC Output Voltage THD Range | AC Input Voltage THD Range / AC Output Voltage THD Range |
| AC Input Current THD Range / AC Output Current THD Range | AC Input Current THD Range / AC Output Current THD Range |
| AC Input Power THD Range / AC Output Power THD Range | AC Input Power THD Range / AC Output Power THD Range |
| AC Input Frequency THD Range / AC Output Frequency THD Range | AC Input Frequency THD Range / AC Output Frequency THD Range |
| AC Input Power Factor THD Range / AC Output Power Factor THD Range | AC Input Power Factor THD Range / AC Output Power Factor THD Range |
| AC Input Voltage THD Range / AC Output Voltage THD Range | AC Input Voltage THD Range / AC Output Voltage THD Range |
| AC Input Current THD Range / AC Output Current THD Range | AC Input Current THD Range / AC Output Current THD Range |
| AC Input Power THD Range / AC Output Power THD Range | AC Input Power THD Range / AC Output Power THD Range |
| AC Input Frequency THD Range / AC Output Frequency THD Range | AC Input Frequency THD Range / AC Output Frequency THD Range |
| AC Input Power Factor THD Range / AC Output Power Factor THD Range | AC Input Power Factor THD Range / AC Output Power Factor THD Range |
| AC Input Voltage THD Range / AC Output Voltage THD Range | AC Input Voltage THD Range / AC Output Voltage THD Range |
| AC Input Current THD Range / AC Output Current THD Range | AC Input Current THD Range / AC Output Current THD Range |
| AC Input Power THD Range / AC Output Power THD Range | AC Input Power THD Range / AC Output Power THD Range |
| AC Input Frequency THD Range / AC Output Frequency THD Range | AC Input Frequency THD Range / AC Output Frequency THD Range |
| AC Input Power Factor THD Range / AC Output Power Factor THD Range | AC Input Power Factor THD Range / AC Output Power Factor THD Range |

(specs from solaredge.com)

The diagram illustrates the system architecture. Solar panels are connected to a Backup Interface. The Backup Interface is also connected to a Generator. Both the Backup Interface and the Generator are connected to a Monitoring Platform. The Backup Interface is also connected to a Battery bank.

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Power Optimizer

For North America
P320 / P340 / P370 / P400 / P405 / P505

(specs from solaredge.com)

PV power optimization at the module-level

- Specifically designed to work with SolarEdge inverters
- Up to 25% more energy
- Superior efficiency (99.5%)
- Mitigates all types of module mismatch losses, from manufacturing tolerance to partial shading
- Flexible system design for maximum space utilization
- Fast installation with a single bolt
- Next generation maintenance with module-level monitoring
- Meets NEC requirements for arc fault protection (AFP) and Photovoltaic Rapid Shutdown System (PRSS)
- Module-level voltage shutdown for installer and firefighter safety

Power Optimizer For North America

P320 / P340 / P370 / P400 / P405 / P505

| Optimizer model (typical module connectivity) | P320 (for 10-cell modules) | P340 (for high-power AC-coupled modules) | P370 (for 72-cell modules) | P400 (for 72-cell modules) | P405 (for thin film modules) | P505 (for larger current modules) |
|---|----------------------------|--|----------------------------|----------------------------|------------------------------|-----------------------------------|
| Module Max DC Power | 100 | 100 | 100 | 100 | 100 | 100 |
| Module Max DC Voltage | 60 | 60 | 60 | 60 | 60 | 60 |
| Module Max DC Current | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| Module Max DC Power Factor | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Module Max DC Voltage THD | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Current THD | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Power Factor THD | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Voltage THD Range | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Current THD Range | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Power Factor THD Range | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Voltage THD Range | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Current THD Range | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Module Max DC Power Factor THD Range | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |

STANDARD COMPLIANCE

UL 1741, UL 1741-2, NEC 690

INSTALLATION SPECIFICATIONS

| Parameter | Value |
|--------------------------------------|-------|
| Module Max DC Power | 100 |
| Module Max DC Voltage | 60 |
| Module Max DC Current | 1.7 |
| Module Max DC Power Factor | 0.95 |
| Module Max DC Voltage THD | 0.5% |
| Module Max DC Current THD | 0.5% |
| Module Max DC Power Factor THD | 0.5% |
| Module Max DC Voltage THD Range | 0.5% |
| Module Max DC Current THD Range | 0.5% |
| Module Max DC Power Factor THD Range | 0.5% |
| Module Max DC Voltage THD Range | 0.5% |
| Module Max DC Current THD Range | 0.5% |
| Module Max DC Power Factor THD Range | 0.5% |

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Signage

ESS Example Sys. #5

All signage must be permanently attached and be able to withstand the environment they are installed. Signage also cannot be hand-written. NEC 110.21(B).

Parallel Generation On Site. Second Source is Solar PV

A sign is required at the service panel stating that the home has a solar PV system as an additional power source. NEC 705.10. Wording could vary.

Note: Inverter and battery system is located inside of the garage (East wall).

A sign is required at the home's service meter panelboard noting the location of the string inverter and batteries since they're not located next to the utility service panel. NEC 690.4(D) and NEC 690.56(B). Wording could vary.

ENERGY STORAGE SYSTEM DISCONNECT

Maximum DC Voltage = 480V
Nominal AC Voltage = 240V

This sign is required to be mounted on the ESS disconnect (for this system the pushbutton switch). NEC 706.15(C)

Warning, Power Source Output Connection, Do Not Relocate This Overcurrent Device

This sign is required to be located next to the AC PV backfed breaker(s). ONLY if the 120% allowance of NEC 705.12(B)(3)(2) is being utilized.

PV System: AC Current = 32A AC Volts = 240V

This sign is required to be located at the backfed panelboard. NEC 690.54.

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN OFF TO THE "OFF" POSITION TO SHUTDOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN WET AREAS

This sign to be located on the outside of, and within 3' of the service equipment. NEC 690.56(C).

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

This sign must be reflective and is required to be located next to the disconnect switch which activates rapid shutdown. NEC 690.56(C)(2) (for this example system, it could be the pushbutton switch)

PHOTOVOLTAIC POWER SOURCE

This sign is to be located on the outside of any conduits, enclosures, or MC cable that contain DC circuits. The markings shall be reflective and be provided at every enclosure, every 10' along conduit or MC cable, and at each side of where the conduit or cable passes through a wall, floor, or any other partition. The markings shall be permanently affixed and visible after installation. NEC 690.31(D)(2)

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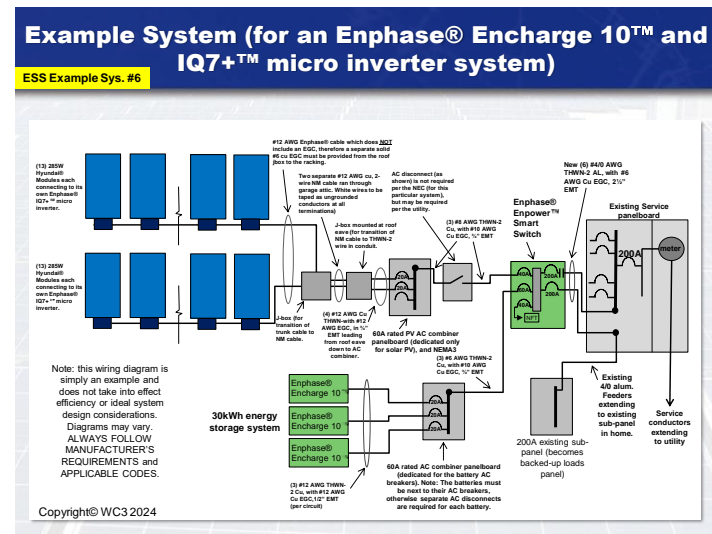
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ESS Example System #6

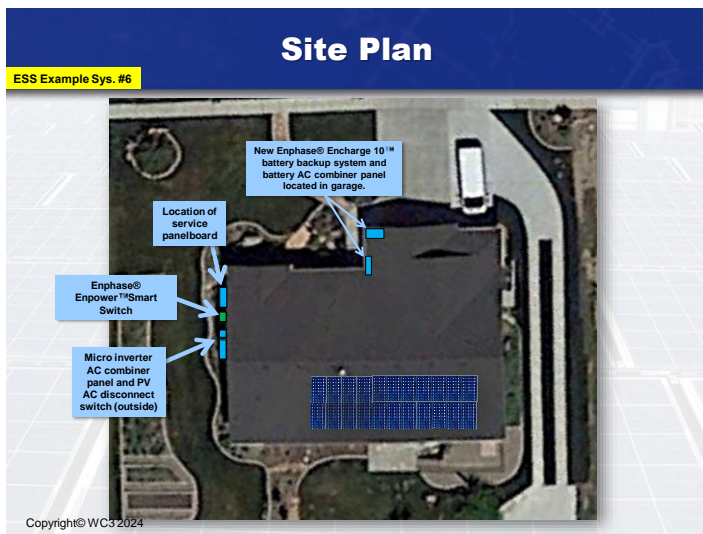
Enphase® Encharge 10™ Energy Storage System with Enphase® Micro Inverters

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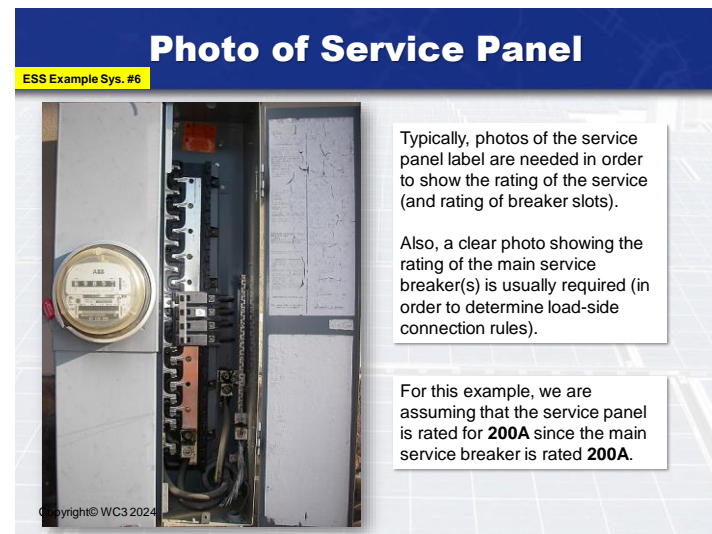
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ESS Example Sys. #6

Enphase Encharge 10

The Enphase Encharge 10™ all-in-one AC-coupled storage system is reliable, smart, simple, and safe. It is comprised of three base Encharge 10™ storage units, has a total usable energy capacity of 10.08 kWh and twice embedded grid-forming inverters with 3.84 kW power output. It provides backup capability and enables smart design for the right system size to meet the needs of both new and existing solar customers.

Reliable

- Proven light-weight 10 Series Microinverters
- No need for external wiring
- Three independent 10 Series inverters built into each Encharge 10™
- Tested and certified for 40,000 hours
- Includes monitoring for fire and safety

Smart

- Grid-forming capability for backup operation
- Remote software and firmware updates
- Includes app for monitoring and control
- Support for anti-islanding
- Only one set of AC breakers

Simple

- Fully integrated AC battery system
- Back-up inverter and battery protection
- Inverters with embedded AC-coupling

Safe

- Fully safety tested
- Includes pre-installed GFCI protection for maximum safety and longevity

Enphase Encharge 10 Specifications

| | |
|---|--|
| Model Number | ENCHARGE 10-1P-NA |
| Accessories | One set of Encharge base unit installation hardware |
| Efficiency (AC) | 97.5% VAD ¹ |
| Rated continuous output power | 3.84 kW |
| Peak output power | 7.68 kW (10 seconds) |
| Rated voltage (range) | 240 V (1) – 264 VAC |
| Rated frequency (range) | 60 Hz ± 1% Hz |
| Rated output current | 16 A |
| Power factor (range) | 0.95 leading, 0.91 lagging |
| Maximum cable per 10 Series circuit | 1.0 AWG THHN/THWN |
| Maximum AC input total fault current over 1 phase | 85 kA RMS |
| Rated efficiency | 97% |
| Grid frequency | 60 Hz |
| Grid capacity | 10.08 kWh |
| Rated DC voltage | 47.7 V |
| Maximum DC voltage | 73.5 V |
| Active operating temperature range | 10°F to 50° C (50° F to 122° F) non-condensing |
| Operation temperature range | 31° F to 50° F (0° F to 50° F) by IEC 61851-1 |
| Case name | Light gray, white, or black |
| Dimensions (height) | 10.08 inches x 6.69 inches x 10.08 inches (331.3 mm x 170.1 mm x 256.4 mm ± 1.3 mm) |
| Weight | Three individual 42.2 kg (93.1 lb) base units plus 21.1 kg (46.4 lb) cover and mounting hardware (59.4 kg/131.4 lbs) |
| UL ENEC environmental test | EN50538-1 |
| UL ENEC environmental test | EN50538-2 |
| Coating | Neutral corrosion – No film |
| Aluminum | 100% aluminum (3003 H14) |
| Mounting | Wall mount |
| Compliance | Compliant with grid-tied PV systems. Compliant with Enphase IQ Series Micro Inverter and Enphase Smart Meter for backup operation. |
| Communication | Wireless 2.4 GHz and 915 MHz |
| Monitoring | Enphase Enlighten™ monitoring system, Enphase Enlighten Manager and Enlighten monitoring system, A4I integration |
| Compliance (listing) | UL 1741, UL 1741-2, UL 1741-3, UL 1741-4, UL 1741-5, UL 1741-6, UL 1741-7, UL 1741-8, UL 1741-9, UL 1741-10, UL 1741-11, UL 1741-12, UL 1741-13, UL 1741-14, UL 1741-15, UL 1741-16, UL 1741-17, UL 1741-18, UL 1741-19, UL 1741-20, UL 1741-21, UL 1741-22, UL 1741-23, UL 1741-24, UL 1741-25, UL 1741-26, UL 1741-27, UL 1741-28, UL 1741-29, UL 1741-30, UL 1741-31, UL 1741-32, UL 1741-33, UL 1741-34, UL 1741-35, UL 1741-36, UL 1741-37, UL 1741-38, UL 1741-39, UL 1741-40, UL 1741-41, UL 1741-42, UL 1741-43, UL 1741-44, UL 1741-45, UL 1741-46, UL 1741-47, UL 1741-48, UL 1741-49, UL 1741-50, UL 1741-51, UL 1741-52, UL 1741-53, UL 1741-54, UL 1741-55, UL 1741-56, UL 1741-57, UL 1741-58, UL 1741-59, UL 1741-60, UL 1741-61, UL 1741-62, UL 1741-63, UL 1741-64, UL 1741-65, UL 1741-66, UL 1741-67, UL 1741-68, UL 1741-69, UL 1741-70, UL 1741-71, UL 1741-72, UL 1741-73, UL 1741-74, UL 1741-75, UL 1741-76, UL 1741-77, UL 1741-78, UL 1741-79, UL 1741-80, UL 1741-81, UL 1741-82, UL 1741-83, UL 1741-84, UL 1741-85, UL 1741-86, UL 1741-87, UL 1741-88, UL 1741-89, UL 1741-90, UL 1741-91, UL 1741-92, UL 1741-93, UL 1741-94, UL 1741-95, UL 1741-96, UL 1741-97, UL 1741-98, UL 1741-99, UL 1741-100 |
| Limited Warranty | 10-year warranty on battery and inverter, 5-year warranty on AC-coupling, 2-year warranty on AC-coupling, 2-year warranty on AC-coupling, 2-year warranty on AC-coupling |

To learn more about Enphase offerings, visit enphase.com

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ESS Example Sys. #6

CERTIFICATE OF COMPLIANCE

Certificate Number: E488100
Report Reference: E488100-20200514
Issue Date: 2020-MAY-18

Issued to: ENPHASE ENERGY INC
1420 N MacDowell Blvd
Petaluma CA 94954-6515

This certificate confirms that representative sample of ENERGY STORAGE SYSTEMS AND EQUIPMENT Utility Interactive Energy Storage System, Model: ENCHARGE-3-1P-NA and ENCHARGE-10-1P-NA Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.

Standards for Safety: ANSICANUL 9540, Energy Storage Systems and Equipment, UL 991, Tests for Safety-Related Controls Employing Solid-State Devices

Additional Information: See the UL Online Certifications Directory at <https://www.ul.com/certification> for additional information.

This Certificate of Compliance does not provide authorization to apply the UL Mark. Only the UL Follow-Up Service Procedure provides authorization to apply the UL Mark.

Only those products bearing the UL Mark should be considered as being UL Certified and covered under UL's Follow-Up Services.

Look for the UL Certification Mark on the product.

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ESS Example Sys. #6

Enphase Enpower

The Enphase Enpower™ smart switch connects the home to grid power, the Encharge storage system, and solar PV. It provides integrated interconnection device (IMD) functionality by automatically detecting and seamlessly transitioning the home energy system from grid power to backup power in the event of a grid failure. It consolidates interconnection equipment into a single enclosure and streamlines grid independent capabilities of PV, user energy installation by providing a compact, pre-wired solution for residential applications.

Reliable

- Durable NEMA type 3R enclosure
- No need for external wiring

Smart

- Connects safely to the grid
- Automatically detects grid outages
- Provides protection to the battery

Simple

- Connects to the load or service entrance side of the main breaker
- Compact mounting brackets support single rail mounting
- Supports central wiring from the bottom, bottom left side, or bottom right side
- Supports whole home and partial home backup and islanding
- Up to 100A main breaker support
- Includes mounting hardware for the main panel 100A or 125A backup operation

Enphase Enpower Specifications

| | |
|--|---|
| Model Number | EP20001-04040000 |
| Accessories and Replacement Parts | Enphase Enpower smart switch with neutral (Energy Transformer (NET), Manual Interconnect Device (MID), Inverter, and Inverter, Disconnect grid independent capabilities of the grid storage transformers) |
| Warranty | 10-year warranty on battery and inverter, 5-year warranty on AC-coupling, 2-year warranty on AC-coupling, 2-year warranty on AC-coupling |
| Assembly rating | Continuous operation at 100% of its rating |
| Rated voltage (range) | 240 VAC, 120 VAC |
| Rated frequency (range) | 60 Hz, 50 Hz |
| Rated output current | 100 A |
| Maximum continuous current rating | 100 A |
| Maximum continuous power rating | 24 kW |
| Maximum continuous power density rating | 240 W/in ³ |
| Maximum continuous power density rating for PV | 240 W/in ³ |
| Neutral Forming Transformer (NFT) | Neutral forming transformer, 100 between L1 and Neutral, 400 between L2 and Neutral, 400 between L3 and Neutral, 400 between L4 and Neutral, 400 between L5 and Neutral, 400 between L6 and Neutral, 400 between L7 and Neutral, 400 between L8 and Neutral, 400 between L9 and Neutral, 400 between L10 and Neutral, 400 between L11 and Neutral, 400 between L12 and Neutral, 400 between L13 and Neutral, 400 between L14 and Neutral, 400 between L15 and Neutral, 400 between L16 and Neutral, 400 between L17 and Neutral, 400 between L18 and Neutral, 400 between L19 and Neutral, 400 between L20 and Neutral, 400 between L21 and Neutral, 400 between L22 and Neutral, 400 between L23 and Neutral, 400 between L24 and Neutral, 400 between L25 and Neutral, 400 between L26 and Neutral, 400 between L27 and Neutral, 400 between L28 and Neutral, 400 between L29 and Neutral, 400 between L30 and Neutral, 400 between L31 and Neutral, 400 between L32 and Neutral, 400 between L33 and Neutral, 400 between L34 and Neutral, 400 between L35 and Neutral, 400 between L36 and Neutral, 400 between L37 and Neutral, 400 between L38 and Neutral, 400 between L39 and Neutral, 400 between L40 and Neutral, 400 between L41 and Neutral, 400 between L42 and Neutral, 400 between L43 and Neutral, 400 between L44 and Neutral, 400 between L45 and Neutral, 400 between L46 and Neutral, 400 between L47 and Neutral, 400 between L48 and Neutral, 400 between L49 and Neutral, 400 between L50 and Neutral, 400 between L51 and Neutral, 400 between L52 and Neutral, 400 between L53 and Neutral, 400 between L54 and Neutral, 400 between L55 and Neutral, 400 between L56 and Neutral, 400 between L57 and Neutral, 400 between L58 and Neutral, 400 between L59 and Neutral, 400 between L60 and Neutral, 400 between L61 and Neutral, 400 between L62 and Neutral, 400 between L63 and Neutral, 400 between L64 and Neutral, 400 between L65 and Neutral, 400 between L66 and Neutral, 400 between L67 and Neutral, 400 between L68 and Neutral, 400 between L69 and Neutral, 400 between L70 and Neutral, 400 between L71 and Neutral, 400 between L72 and Neutral, 400 between L73 and Neutral, 400 between L74 and Neutral, 400 between L75 and Neutral, 400 between L76 and Neutral, 400 between L77 and Neutral, 400 between L78 and Neutral, 400 between L79 and Neutral, 400 between L80 and Neutral, 400 between L81 and Neutral, 400 between L82 and Neutral, 400 between L83 and Neutral, 400 between L84 and Neutral, 400 between L85 and Neutral, 400 between L86 and Neutral, 400 between L87 and Neutral, 400 between L88 and Neutral, 400 between L89 and Neutral, 400 between L90 and Neutral, 400 between L91 and Neutral, 400 between L92 and Neutral, 400 between L93 and Neutral, 400 between L94 and Neutral, 400 between L95 and Neutral, 400 between L96 and Neutral, 400 between L97 and Neutral, 400 between L98 and Neutral, 400 between L99 and Neutral, 400 between L100 and Neutral |

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Signage

ESS Example Sys. #6

All signage must be permanently attached and be able to withstand the environment they are installed. Signage also cannot be hand-written. NEC 110.21(B).

Paralle Generation On Site. Second Source is Solar PV

A sign is required at the service panel stating that the home has a solar PV system as an additional power source. NEC 705.10. Wording could vary.

Warning Power Source Output Connection, Do Not Relocate This Overcurrent Device

A sign is required at the home's service meter panelboard noting the location of the **string** inverter and battery system. NEC 690.4(D), 708.21, and 705.10. Wording could vary.

ENERGY STORAGE SYSTEM DISCONNECT Maximum DC Voltage = Nominal AC Voltage

This sign is required to be located next to the PV backed breaker(s) **ONLY** if the 120% allowance of NEC 705.12(B)(3)(2) is being utilized.

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

This sign must be reflective and is required to be located next to the disconnect switch which activates rapid shutdown. NEC 690.56(C)(2) (for this system, it could be at any AC breaker or AC disconnect that isolates the micro inverters from the Enphase Smart Switch)

WARNING ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

This sign is required to be located at the terminals where disconnects are energized even when the disconnect is shut off. NEC 690.13(B).

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

This sign is located on the outside of, and within 3' of the equipment. NEC 690.56(C).

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