

RESIDENTIAL ENERGY STORAGE SYSTEMS (ESS)

(BASED ON THE 2020 NEC AND THE 2021 IRC/IFC)

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West Coast Code Consultants

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Doug Smith, MCP/CBO

- Inspector/Plan Reviewer for over 20 years
- 19 ICC certifications
- Certified ICC Master Code Professional and CBO
- Taught electrical, solar PV, and ESS classes for over 14 years
- Performed well over ten-thousand electrical, solar PV, and ESS plan reviews
- Serve on NEC CMP 10 representing IAEI
- 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 residential energy storage systems (ESS). This presentation is based on the 2020/2023 NEC and 2021 IRC/IFC.
- 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

- Requirements for Residential ESS:
 - UL 9540 and UL 9540A – brief explanation
 - IRC/IFC Requirements for Energy Storage Systems
 - NEC Requirements for ESS
 - Example ESS Plans and System Layouts

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Requirements for Energy Storage Systems (ESS)



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Image from simplhipower.com

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Key Provisions of UL 9540: Energy Storage Systems and Equipment



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UL 9540 – Edition 3

UL 9540 – Edition 3:

- ❑ Published June 28, 2023.
- ❑ Effective Date is September 2024.

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UL 9540 Scope (continued)

Section 1.2:

- ❑ The systems covered under the UL 9540 standard include standalone systems, electric grid-tied systems, and systems used as ancillary equipment for other power generation systems.

Stand-alone and/or grid-tied ESS must comply with UL 9540.

Section 1.4:

- ❑ Both indoor and outdoor systems are included.

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UL 9540 Scope (continued)

Section 1.5:

- ❑ Outside the scope of the UL 9540 standard are systems utilizing lead acid or Ni-cad batteries and the system falls within the scope of UL 1778 for uninterruptable power systems (UPS).



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UL 9540 Scope (continued)

UL 9540 – Figure 6.1 (updated)

- ❑ AC ESS – includes energy storage capability, protective features, and power conversion.



- ❑ DC ESS – only includes energy storage capability and protective features.



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UL 9540, Compatibility

Section 15.2:

- ❑ Cannot assume that equipment is compatible with other equipment even though the equipment may be individually listed (and deemed safe individually).



Example of older battery backup PV system (does NOT have the UL 9540 listing)

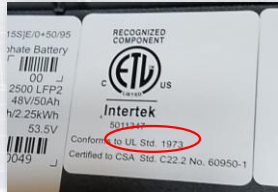
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UL 9540, listing of individual equipment

Section 24.1.1:

- ❑ Inverters, chargers, and charge control equipment must be evaluated per **UL 1741**, **UL 62109-1**, **UL 1012**, or **UL 1564** as applicable per its intended application in the system.
- ❑ Electrochemical batteries must be listed per **UL 1973** (except lead acid or Ni-cad batteries can follow Appendix D in UL 9540).



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UL 9540, ESS in Residential Living Space

Section 26.2.2:

- ESS installed in the living or habitable space of a residential dwelling unit (where permitted) must meet the **cell-level** performance requirements of UL 9540A, and such ESS must be marked per section 45.3(e)(1).
- 45.3(e)(1) requires that such systems meeting the above noted criteria must be marked as "Suitable For Use in Residential Habitable Spaces." (note: the 2021 IRC R328.1 exception instead says "For Use In Residential Dwelling Units")

Residential ESS must at least meet the **Unit-Level** criteria of UL 9540A




Thus far, NO ESS is permitted to be located in the living or habitable space of a dwelling.

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Overview of UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems



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UL 9540A, Large-Scale Fire Testing

ESS MUST achieve (pass) cell-level test to be allowed in the habitable space of a dwelling!

Cell Level Testing	If thermal runaway cannot be induced in the cell and any vented gas does not present a flammability hazard.	No further testing required
Module Level Testing	Any effects of thermal runaway are contained by the module design, and any vented gasses are nonflammable.	No further testing required
Unit Level Testing	Temp of modules is less than cell surface temperature at gas venting, and meets heat flux limits for means of egress. Temp increase of target walls less than 175°F. No explosion hazards. No flames extending beyond outer dimensions of BESS unit.	No further testing required
Installation level testing (includes fire protection equipment and does NOT apply to residential BESS)		

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UL 9540A



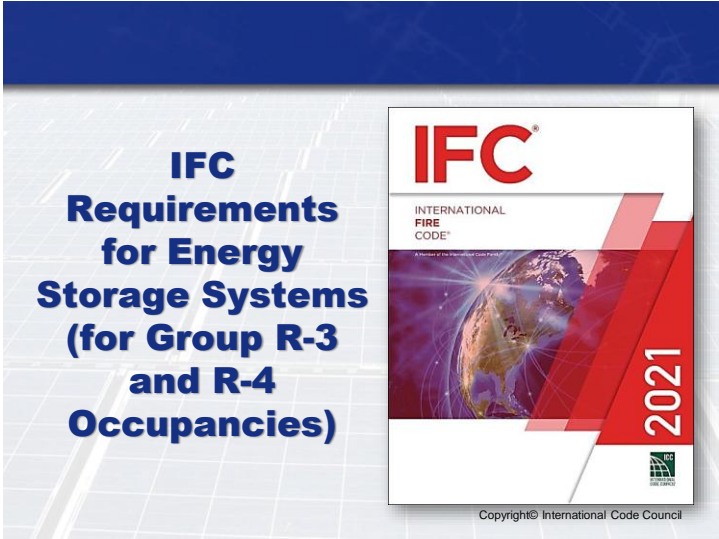
Highlighted area is a "module"

Multiple cells make up a "module" (cells not visible in this image)

"Unit"

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IFC Requirements for ESS

IFC R1207.11:

- ❑ Energy storage systems (ESS) in Group R-3 and R-4 occupancies must comply with the provisions of 1207.11.1 through 1207.11.9.
- ❑ Note, the only way an ESS can be installed in the living or habitable space of a dwelling unit is if the system has achieved the cell-level test of UL 9540A AND the equipment has the following marking "Suitable For Use in Residential Habitable Spaces". See UL 9540 Section 45.3(e)(1).

ESS can't be located in the living space of the home, but other spaces such as garages, outdoors, storage rooms, etc are often permitted (if provisions of IFC are met)

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IFC Requirements for ESS

IFC 1207.11.1 – Equipment Listings:

- ❑ ESS shall be listed and labeled in accordance with **UL 9540**. ESS listed only for commercial or utility use cannot be installed at residential occupancy.
- Exceptions:
 - Where approved, repurposed unlisted battery systems from electric vehicles are allowed to be installed outdoors or in detached sheds located not less than 5 feet (1524 mm) from exterior walls, property lines and public ways.
 - ESS less than 1 kWh (3.6 megajoules)

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Many violations!



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Example of older battery backup PV system
(does NOT have the UL 9540 listing)

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IFC Requirements for ESS

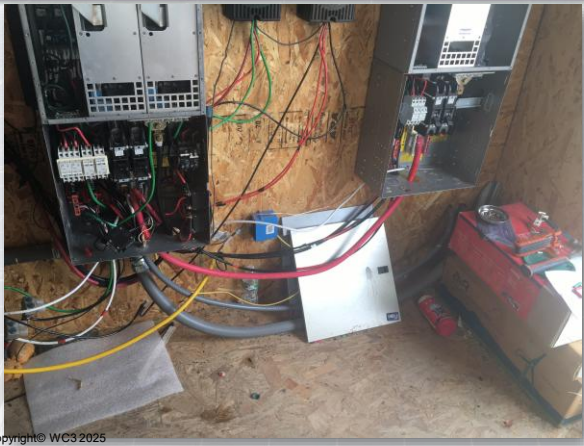
IFC 1207.11.2 – Installation:

- ❑ ESS shall be installed in accordance with the manufacturer's instructions and their listing.



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Lots of Violations!!!



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IFC Requirements for ESS

IFC 1207.11.2.1 – Spacing:

- ❑ Individual units (see also 1207.11.4) shall be separated from each other by not less than **three feet** except where smaller separation distances are documented to be adequate based on large scale fire testing complying with Section 1207.1.5 of the International Fire Code.

“Large-scale fire” testing is referring to testing in accordance with UL 9540A



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Violations?



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Violations?



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Example of a Good Install

The Enphase® ESS has been tested per UL 9540A and is permitted to have units spaced less than 36" (but still must follow installation instructions).



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Example of a Good Install

The SolarEdge® ESS has been tested per UL 9540A and is permitted to have units spaced less than 36" (but still must follow installation instructions).



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IFC Requirements for ESS

IFC 1207.11.3 – Location:

❑ ESS shall be installed only in the following locations:

- 1. Detached garages and detached accessory structures.
- 2. Attached garages separated from the dwelling unit living space in accordance with Section 406.3.2 of the IBC.
- 3. Outdoors or on the exterior side of exterior walls located not less than 3 feet from doors and windows directly entering the dwelling unit.
- 4. Utility closets and storage or utility spaces within dwelling units and sleeping units.

NOTE: R328.4 of the IRC also requires any utility rooms or storage spaces to have finished or noncombustible walls and ceilings. But walls and ceilings of unfinished wood-framed construction shall be provided with not less than 5/8-inch Type X gypsum wallboard. Also, the IRC specifies that ESS shall not be installed in sleeping rooms, or closets or spaces opening directly into sleeping rooms.

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Violations!!!



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Violations?



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IFC Requirements for ESS

IFC 1207.11.4 – Energy Ratings:

- ❑ Individual ESS units shall have a maximum rating of **20 kWh**. The aggregate rating of the ESS shall not exceed:
 1. 40 kWh within utility closets, basements, and storage or utility spaces.
 2. 80 kWh in attached or detached garages and detached accessory structures.
 3. 80 kWh on exterior walls.
 4. 80 kWh outdoors on the ground.

Note, at R328.5 in the IRC it says that ESS installations exceeding the permitted individual or aggregate ratings shall be installed in accordance with Section 1207 the International Fire Code.

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IFC Requirements for ESS

IFC 1207.11.5 – Electrical Installation:

- ❑ ESS shall be installed in accordance with NFPA 70 (*National Electrical Code*). Inverters shall be listed and labeled in accordance with UL 1741 or provided as part of the UL 9540 listing. Systems connected to the utility grid shall use inverters listed for utility interaction.



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IFC Requirements for ESS

IFC 1207.11.6 – Fire Detection:

- ❑ Rooms and areas within dwelling units, sleeping units, and attached garages in which ESS are installed shall be protected by smoke alarms in accordance with Section 907.2.10. (in the IRC the references section is R314)
- ❑ A heat detector (heat ALARM), listed and interconnected to the smoke alarms, shall be installed in locations within dwelling units, sleeping units, and attached garages where smoke alarms cannot be installed based on their listing.



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Heat alarm



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IRC Section R314

R314.4 Interconnection. Where more than one smoke alarm is required to be installed within an individual dwelling unit in accordance with Section R314.3, the alarm devices shall be interconnected in such a manner that the actuation of one alarm will activate all of the alarms in the individual dwelling unit.

Physical interconnection of smoke alarms shall not be required where listed wireless alarms are installed and all alarms sound upon activation of one alarm.

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IRC Section R314 (continued)

R314.6 Power Source. Smoke alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source and, where primary power is interrupted, shall receive power from a battery. Wiring shall be permanent and without a disconnecting switch other than those required for overcurrent protection.

Exceptions:

- 1. Smoke alarms shall be permitted to be battery operated where installed in buildings without commercial power.
- 2. Smoke alarms installed in accordance with Section R314.2.2 shall be permitted to be battery powered.

R314.7 also allows the use of a full fire alarm system.

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IFC Requirements for ESS

IFC 1207.11.7 – Protection from Impact:

- ❑ ESS installed in a location subject to vehicle damage shall be protected by approved barriers.



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Violations!!!

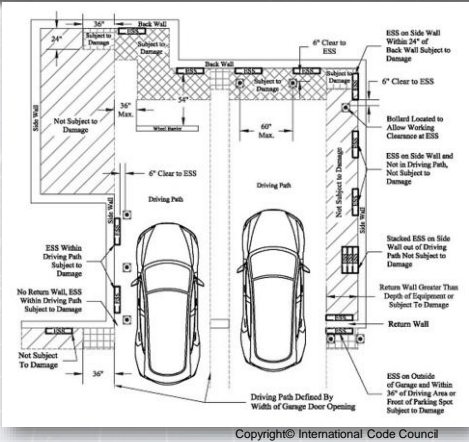


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Protection from Vehicle Damage

Figure 1207.11.7.1 of the 2024 IFC (or R328.8.1 from the 2024 IRC) helps provide guidance on what locations in a garage could be considered as subject to damage.

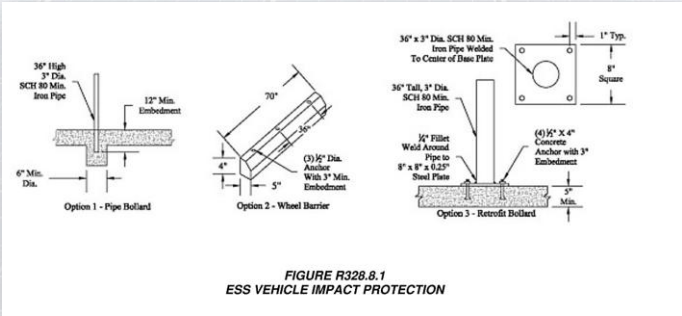


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Protection from Vehicle Damage

Figure 1207.11.7.1 of the 2024 IFC (or R328.8.1 from the 2024 IRC) also helps provide guidance on how to protect equipment from physical damage.



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IFC Requirements for ESS

IFC 1207.11.8 – Equipment Listings:

- Indoor installation of ESS that include batteries that produce hydrogen or other flammable gases during charging shall be provided with mechanical ventilation in accordance with Section 1207.6.1.

Note: most sealed batteries do not require ventilation per manufacturer's requirements.

IFC 1207.11.9 – Toxic & highly toxic gas:

- ESS that under normal charging and normal use that can produce toxic gases cannot be installed in a Group R-3 or R-4 occupancy.

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IFC Requirements for ESS

IFC 1207.11.19 – Electric Vehicle Use:

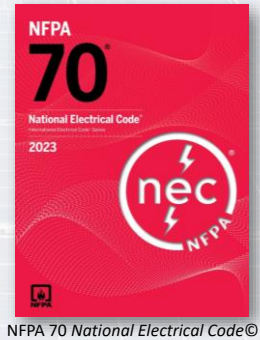
- The temporary use of an owner or occupant's electric powered vehicle to power a dwelling unit or sleeping unit while parked in an attached or detached garage or outdoors shall comply with the vehicle manufacturer's instructions and NFPA 70 (NEC).



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Key Energy Storage System (ESS) Requirements per the 2023 NEC



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NEC 706.5 – Listing

Energy storage systems (ESS) are required to be listed.

- ❑ Per informational note #3 of 706.1 and per Annex A in the NEC, the following standards apply:
 - UL 1973 for non-lead acid batteries
 - UL 1741 for inverters, converters and controllers
 - Inverters that are also utility interactive must be listed as such [see NEC 706.16(B) and (C)].
 - UL 9540 for ESS



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NEC 706.15 – Disconnecting Means

- 706.15(A):
- ❑ There must be a disconnect for all ungrounded (hot) conductors derived from an ESS.
 - ❑ The disconnect is permitted to be integral to listed ESS equipment.



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NEC 706.15(A) – Continued

The required disconnect must be readily accessible and must comply with one or more of the following:

- Be within the ESS (part of the ESS).
- Within sight and within 10 feet of the ESS.
- When the disconnect is not within sight of the ESS, the disconnect, or the enclosure of the disconnect, must be capable of being locked per NEC 110.25.

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[illegible]

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**ENERGY STORAGE
SYSTEM DISCONNECT**

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**ENERGY STORAGE
SYSTEM DISCONNECT**

NOMINAL ESS AC VOLTAGE:

MAXIMUM ESS DC VOLTAGE:

AVAILABLE FAULT CURRENT
DERIVED FROM THE ESS:

DATE CALCULATION PERFORMED:

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NEC 706.15(C) – Disconnect Marking Continued...

- 706.15(C) continued:
- ❑ Where the line and load terminals of an ESS disconnect can be energized when in the off (open) position, there must be a sign on the disconnect(s) with the following words:
“Warning Electric Shock Hazard Terminals on the Line and Load Sides May be Energized in the Open Position.”



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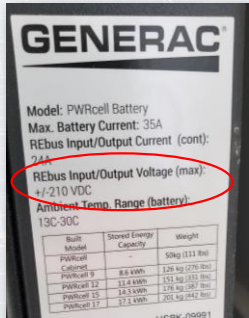
NEC 706.16 – Continued

- 706.16(F):
- ❑ When an ESS is capable of operating in stand-alone mode, the requirements of NEC 710.15 also apply.
 - Note: 710.15(A) states that a stand-alone system is permitted to have a capacity less than the calculated load.
 - The capacity of all combined sources of the stand-alone supply must be equal to or greater than the load of the largest single utilization equipment connected to the system.

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NEC 706.20 – General Installation Req.

- 706.20(B):
- ❑ The voltage for a one- and two-family dwelling cannot exceed 100V.
 - Exception says that up to 600V is permitted when live parts are not accessible during routine ESS maintenance.



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NEC 706.20 – Continued

- 706.20(C):
- ❑ Working space is required in front of equipment per NEC 110.26 and 110.34.
 - ❑ Spacing in between ESS components is permitted to be in accordance with the manufacturer's instructions and listing.
 - However, more restrictive spacing requirements may be required per Section 1207 of the IFC, or Section R328 of the IRC.



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Violations!



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NEC 706.21 – Identification of Power Sources

706.21:

- ❑ Marking or labels for ESS must be per NEC 110.21(B).
- ❑ “Plaques or directories” are required per 705.10 and 710.10.

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NEC 706.31 – OCPD Rating

706.31(B):

- ❑ Overcurrent protection devices (where required) for circuits serving an ESS must be rated not less **125%** of the current ratings per NEC 706.30(A).
 - The exception to the rule is assemblies with overcurrent devices which are rated for 100% continuous operation, in which case the overcurrent protection rating cannot be less than the current rating per NEC 706.30(**B**).

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Example Plan and System Layouts of Energy Storage Systems (ESS)



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ESS Example System #1

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. #1

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. #1

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

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Photo of Service Panel

ESS Example Sys. #1

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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ESS Example Sys. #1

SolarEdge Home Backup Interface for North America

BI-EUSGN-02 / BI-NUSGN-02

12-25 year warranty

(specs from solaredge.com)

Backup Interface for Flexible Backup

- Automatically provides backup power to home loads in event of grid interruption
- Full flexibility in which loads to back up - the entire home or selected loads
- Scalable solution to support higher power and higher capacity
- Built-in Auto Transformer and Energy Meter for meter and faster installation
- Seamless integration with the SolarEdge Home Hub inverter to manage and monitor both PV generation and energy storage
- Generator connection support

solaredge.com

SolarEdge Home Backup Interface for North America

BI-EUSGN-02 / BI-NUSGN-02

	BI-EUSGN-02	BI-NUSGN-02	
INPUT FROM GRID			
AC Current Input	200		A
AC Output Voltage (Nominal)	200		VAC
AC Output Voltage Range	211 - 264		VAC
AC Frequency (Nominal)	60		Hz
AC Frequency Range	59.5 - 60.5		Hz
Maximum Interconnection Device Rated Current	200		A
Service Size AC Main Circuit Breaker Rated Current	200	N/A	A
Service Size AC Main Circuit Breaker Interrupt Current	1000	N/A	kA
Grid Disconnect Switching Time	<100		ms
OUTPUT TO MAIN DISTRIBUTION PANEL			
Maximum AC Current Output	200		A
AC L-L Output Voltage (Nominal)	200		VAC
AC L-L Output Voltage Range	211 - 264		VAC
AC Frequency (Nominal)	60		Hz
AC Frequency Range	59.5 - 60.5		Hz
Maximum Inverter AC Current Output in Backup Operation	100		A
Instantaneous Connection in Backup Operation	1000		A
AC L-L Output Voltage in Backup (Nominal)	200		V
AC L-L Output Voltage Range in Backup	195 - 195		V
AC Frequency Range in Backup	59 - 60		Hz
INPUT FROM INVERTER			
Maximum Inverter Power	Up to 3		kW
Maximum Rated AC Power in On-Grid and Backup Operation	10000		W
Maximum Continuous Current in On-Grid and Backup Operation	40		A
Factory Installed Inverter Input AC Circuit Breaker	Up to 10 kVA (30°)		
GENERATOR			
Maximum Rated AC Power	10000		W
Maximum Continuous Input Current	40		A
On-Grid Switch Voltage Rating	250/30		VAC/300
On-Grid Switch Current Rating	40		A
2-wire fan break	N/A		
ADDITIONAL FEATURES			
Installation Type	Suitable for use as service equipment		For main lug only
Number of Communication Inputs	2		
Communication	RS485		
Energy Meter (for required inputs)	Not required		
Manual Control Over Microgrid Interconnection Device	N/A		

BI-EUSGN-02 is suitable for use in 120/240V AC systems and BI-NUSGN-02 is suitable for use in 120/208V AC systems. The US version is suitable with the following part numbers: BI-EUSGN-02 for 120/240V AC, BI-NUSGN-02 for 120/208V AC. All units are UL listed and UL 1741 compliant. The US version is suitable with the following part numbers: BI-EUSGN-02 for 120/240V AC, BI-NUSGN-02 for 120/208V AC. All units are UL listed and UL 1741 compliant. The US version is suitable with the following part numbers: BI-EUSGN-02 for 120/240V AC, BI-NUSGN-02 for 120/208V AC. All units are UL listed and UL 1741 compliant.

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ESS Example Sys. #1

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ESS Example Sys. #1

Backup Interface for North America

BI-EUSGN-01 / BI-NUSGN-01

12-25 year warranty

StorEdge™ Specs (solaredge.com)

Backup Interface for Flexible Backup

- Automatically provides backup power to home loads in the event of grid interruption
- Full flexibility in which loads to back up - the entire home or selected loads
- Scalable solution to support higher power and higher capacity
- Built-in Auto Transformer and Energy Meter for meter and faster installation
- Seamless integration with the StorEdge™ inverter to manage and monitor both PV generation and energy storage
- Generator connection support

solaredge.com

Backup Interface for North America

BI-EUSGN-01 / BI-NUSGN-01

	BI-EUSGN-01	BI-NUSGN-01	
INPUT FROM GRID			
AC Current Input	200		A
AC Output Voltage (Nominal)	200		VAC
AC Output Voltage Range	211 - 264		VAC
AC Frequency (Nominal)	60		Hz
AC Frequency Range	59.5 - 60.5		Hz
Maximum Interconnection Device Rated Current	200		A
Service Size AC Main Circuit Breaker Rated Current	200	N/A	A
Service Size AC Main Circuit Breaker Interrupt Current	100	N/A	kA
Grid Disconnect Switching Time	<100		ms
OUTPUT TO MAIN DISTRIBUTION PANEL			
Maximum AC Current Output	200		A
AC L-L Output Voltage (Nominal)	200		VAC
AC L-L Output Voltage Range	211 - 264		VAC
AC Frequency (Nominal)	60		Hz
AC Frequency Range	59.5 - 60.5		Hz
Maximum Inverter AC Current Output in Backup Operation	100		A
Instantaneous Connection in Backup Operation	1000		A
AC L-L Output Voltage in Backup (Nominal)	200		V
AC L-L Output Voltage Range in Backup	195 - 195		V
AC Frequency Range in Backup	59 - 60		Hz
INPUT FROM INVERTER			
Maximum Inverter Power	3		kW
Maximum Rated AC Power	10000		W
Maximum Continuous Input Current	40		A
On-Grid Switch Voltage Rating	250/30		VAC/300
On-Grid Switch Current Rating	40		A
2-wire fan break	N/A		
ADDITIONAL FEATURES			
Installation Type	Suitable for use as service equipment		For main lug only
Number of Communication Inputs	2		
Communication	RS485		
Energy Meter (for required inputs)	Not required		
Manual Control Over Microgrid Interconnection Device	N/A		

BI-EUSGN-01 is suitable for use in 120/240V AC systems and BI-NUSGN-01 is suitable for use in 120/208V AC systems. The US version is suitable with the following part numbers: BI-EUSGN-01 for 120/240V AC, BI-NUSGN-01 for 120/208V AC. All units are UL listed and UL 1741 compliant. The US version is suitable with the following part numbers: BI-EUSGN-01 for 120/240V AC, BI-NUSGN-01 for 120/208V AC. All units are UL listed and UL 1741 compliant.

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ESS Example Sys. #1

StorEdge™ Specs (solaredge.com)

Backup Interface for North America

BI-EUSGN-01 / BI-NUSGN-01

	BI-EUSGN-01	BI-NUSGN-01	
STANDARD COMPLIANCE			
Safety	UL 1741, CSA 22.2 No. 107	N/A	
EMI/EMC	CE/ROHS	FCC part 15 class B	
INSTALLATION SPECIFICATIONS			
Supported Inverters	StorEdge single phase inverter, Single phase Energy Hub inverter with Prime technology		
AC from Grid Conduit Size / AWG Range	2" conduit / #6 - 4/0 AWG		
AC Inverter Conduit Size / AWG Range	1" conduit / #14 - 8 AWG		
AC Generator Input Conduit Size / AWG Range	1" conduit / #8 - 3 AWG		
Communication Conduit Size / AWG Range	3/4" / 24 - 10 AWG		
Weight	75 / 55		lb / kg
Cooling	Fan (user replaceable)		
Noise	< 50 dBA		
Operating Temperature Range	-40°F to +122°F / -40°C to +50°C		
Protection Rating	NEMA 3R, IP24		
Dimensions (WxHxD)	20.59 x 18.88 x 8.62 / 523.5 x 475.5 x 219		
	in / mm		

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ESS Example Sys. #1

Single Phase Energy Hub Inverter with Prism Technology for North America

SE3000H-US / SE3800H-US / SE6000H-US / SE7600H-US

Optimized battery storage with HD-Wave technology

- Record breaking 99% weighted efficiency with 200% DC overrating
- Multi-inverter, scalable StorEdge™ solution
- Modular design, fast and easy to install
- Integrated arc fault protection and rapid shutdown (NEC 2014 and 2017, per article 690.13 and 690.12)
- DC-coupled storage for full or partial home backup
- Built-in consumption monitoring
- Direct connection to the SolarEdge smart EV charger

solaredge.com

Single Phase Energy Hub Inverter with Prism Technology for North America

SE3000H-US / SE3800H-US / SE6000H-US / SE7600H-US

	SE3000H-US	SE3800H-US	SE6000H-US	SE7600H-US
OUTPUT - AC ON GRID				
Rated AC Power	3000	3800	6000	7600
Maximum AC Power Output	3000	3800	6000	7600
AC Output Voltage Range	120-240V	120-240V	120-240V	120-240V
AC Frequency Range (Hz)	50-60	50-60	50-60	50-60
Maximum Continuous Output Current	13.1	16	26	32
AC Voltage	120-240V	120-240V	120-240V	120-240V
Total Harmonic Distortion (THD)	<3%	<3%	<3%	<3%
UL954 Compliant	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-1)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-2)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-3)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-4)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-5)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-6)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-7)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-8)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-9)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-10)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-11)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-12)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-13)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-14)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-15)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-16)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-17)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-18)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-19)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-20)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-21)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-22)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-23)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-24)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-25)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-26)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-27)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-28)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-29)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-30)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-31)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-32)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-33)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-34)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-35)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-36)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-37)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-38)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-39)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-40)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-41)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-42)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-43)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-44)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-45)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-46)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-47)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-48)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-49)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-50)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-51)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-52)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-53)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-54)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-55)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-56)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-57)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-58)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-59)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-60)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-61)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-62)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-63)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-64)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-65)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-66)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-67)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-68)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-69)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-70)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-71)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-72)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-73)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-74)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-75)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-76)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-77)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-78)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-79)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-80)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-81)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-82)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-83)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-84)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-85)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-86)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-87)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-88)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-89)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-90)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-91)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-92)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-93)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-94)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-95)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-96)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-97)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-98)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-99)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-100)	Yes	Yes	Yes	Yes

ESS Example Sys. #1

Single Phase Energy Hub Inverter with Prism Technology for North America

SE3000H-US / SE3800H-US / SE6000H-US / SE7600H-US

Optimized battery storage with HD-Wave technology

- Record breaking 99% weighted efficiency with 200% DC overrating
- Multi-inverter, scalable StorEdge™ solution
- Modular design, fast and easy to install
- Integrated arc fault protection and rapid shutdown (NEC 2014 and 2017, per article 690.13 and 690.12)
- DC-coupled storage for full or partial home backup
- Built-in consumption monitoring
- Direct connection to the SolarEdge smart EV charger

solaredge.com

Single Phase Energy Hub Inverter with Prism Technology for North America

SE3000H-US / SE3800H-US / SE6000H-US / SE7600H-US

	SE3000H-US	SE3800H-US	SE6000H-US	SE7600H-US
OUTPUT - AC ON GRID				
Rated AC Power	3000	3800	6000	7600
Maximum AC Power Output	3000	3800	6000	7600
AC Output Voltage Range	120-240V	120-240V	120-240V	120-240V
AC Frequency Range (Hz)	50-60	50-60	50-60	50-60
Maximum Continuous Output Current	13.1	16	26	32
AC Voltage	120-240V	120-240V	120-240V	120-240V
Total Harmonic Distortion (THD)	<3%	<3%	<3%	<3%
UL954 Compliant	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-1)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-2)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-3)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-4)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-5)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-6)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-7)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-8)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-9)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-10)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-11)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-12)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-13)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-14)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-15)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-16)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-17)	Yes	Yes	Yes	Yes
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UL954 Compliant (UL954-20)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-21)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-22)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-23)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-24)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-25)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-26)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-27)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-28)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-29)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-30)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-31)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-32)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-33)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-34)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-35)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-36)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-37)	Yes	Yes	Yes	Yes
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UL954 Compliant (UL954-39)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-40)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-41)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-42)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-43)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-44)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-45)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-46)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-47)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-48)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-49)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-50)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-51)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-52)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-53)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-54)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-55)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-56)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-57)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-58)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-59)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-60)	Yes	Yes	Yes	Yes
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UL954 Compliant (UL954-62)	Yes	Yes	Yes	Yes
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UL954 Compliant (UL954-66)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-67)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-68)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-69)	Yes	Yes	Yes	Yes
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UL954 Compliant (UL954-73)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-74)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-75)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-76)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-77)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-78)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-79)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-80)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-81)	Yes	Yes	Yes	Yes
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UL954 Compliant (UL954-83)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-84)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-85)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-86)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-87)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-88)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-89)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-90)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-91)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-92)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-93)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-94)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-95)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-96)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-97)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-98)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-99)	Yes	Yes	Yes	Yes
UL954 Compliant (UL954-100)	Yes	Yes	Yes	Yes

ESS Example Sys. #1

SolarEdge® Power Optimizer™ Specs (solaredge.com)

P320 / P340 / P370 / P400 / P405 / P505

Power optimization at the module-level

- Specifically designed to work with SolarEdge inverters
- Up to 25% more energy
- Superior efficiency (99.5%)
- Minimizes 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
- Real-time generation monitoring with module-level monitoring
- Meets NEC requirements for arc fault protection (AFCP) and Photovoltaic Rapid Shutdown System (PRSS)
- Module-level voltage shutdown for inverter and lightning safety

solaredge.com

Power Optimizer for North America

P320 / P340 / P370 / P400 / P405 / P505

	P320	P340	P370	P400	P405	P505
System rated maximum power	320W	340W	370W	400W	405W	505W
Maximum power per module	320W	340W	370W	400W	405W	505W
Maximum power per module (at 1000W/m²)	320W	340W	370W	400W	405W	505W
Maximum power per module (at 1000W/m², 1000V)	320W	340W	370W	400W	405W	505W
Maximum power per module (at 1000W/m², 1000V, 1000Hz)	320W	340W	370W	400W	405W	505W
Maximum power per module (at 1000W/m², 1000V, 1000Hz, 1000W/m²)	320W	340W	370W	400W	405W	505W
Maximum power per module (at 1000W/m², 1000V, 1000Hz, 1000W/m², 1000W/m²)	320W	340W	370W	400W	405W	505W
Maximum power per module (at 1000W/m², 1000V, 1000Hz, 1000W/m², 1000W/m², 1000W/m²)	320W	340W	370W	400W	405W	505W
Maximum power per module (at 1000W/m², 1000V, 1000Hz, 1000W/m², 1000W/m², 1000						

ESS Example System #2

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

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Example System (for an Enphase® Encharge 10™ and IQ7+™ micro inverter system)

ESS Example Sys. #2

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

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Site Plan

ESS Example Sys. #2

Smoke or heat alarm must be in vicinity of the battery system and be interconnected with home's smoke alarm system. Such detector must be rated for the temperature of the environment it's installed. Must also follow installation instructions for the alarm. Utah IRC R328.7.

Heat or smoke alarms must be wired to receive power from the home (hard wired) with battery backup. Heat or smoke alarms are not allowed to be battery only (unless allowed by the AHJ). IRC R314

Location of service panelboard

Enphase® Enpower™ Smart Switch

Micro inverter AC combiner panel and PV AC disconnect switch (outside)

See floorplan layout of bsm storage room

Listed smoke alarm

New Enphase® Encharge 10™ battery backup system and battery AC combiner panel located in basement storage room inside of the home.

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Floorplan Layout

Hallway (or living room)

Listed smoke alarm

Enphase® Energy Storage System

3' clear space in front of equipment

Basement storage room

New AC combiner panel

ESS CANNOT BE LOCATED IN THE LIVING SPACE OF THE HOME AND CANNOT BE LOCATED IN A ROOM THAT OPENS UP INTO A BEDROOM! This is per UL 9540 requirements and R328.4 of the 2021 IRC.

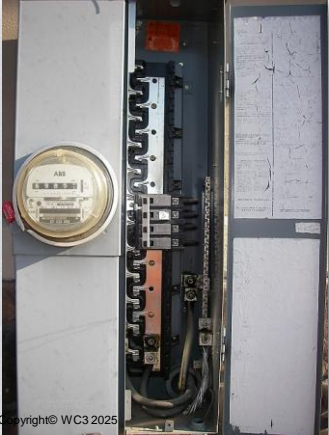
When an ESS is inside the home, the room must be finished on the walls and ceiling, or any unfinished walls and ceilings must have 5/8" Type X sheetrock installed on them. See IRC R328.4.

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Photo of Service Panel

ESS 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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ESS Example Sys. #2



The Enphase Charge 10™ all-in-one AC coupled storage system is reliable, smart, simple, and safe. It is comprised of three base Enphase IQ™ storage units that have a total usable energy capacity of 10.5 kWh and feature embedded grid-forming microinverters with 3.6A DC power output. It provides backup capability and enables you to quickly design the right system to meet the needs of both new and retrofit solar customers.

Reliable

- Proven high reliability IQ Series Microinverter
- Three-year limited warranty
- Three independent Enphase storage base units
- Weather-resistant, 48V microinverter technology
- Prevents cooking (see mounting guidelines)

Smart

- Grid-forming capability for backup operation
- Remote software and firmware upgrades
- Mobile app-based monitoring and control
- Support for self-consumption
- Utility-level low (700) optimization

Simple

- Fully integrated AC battery system
- Quick and easy plug-and-play installation
- Wired with standard household AC wiring

Safe

- UL safety tested
- UL954 fire-resistant UL954 chemistry for maximum safety and longevity

Enphase Charge 10

Model Number: ENCHARGE-10-1P-NA

Enphase Charge 10 battery storage system with integrated Enphase Microinverters and battery management system (BMS)

Three Enphase IQ 3.6A battery base units (B3-A1-0300-1-0)

One Enphase IQ 3.6A battery base unit with one and mounting bracket, watertight conduit tubes, and microinverter for wiring between batteries (B3-0-1000-0)

ACCESSORIES

ENCHARGE-10-01-01: One set of Enphase base unit installation hardware

TECHNICAL DATA

DC Input (VDC): 48V-150V

Rated (continuous) output power*: 3.6kW

Peak output power: 3.7kW (10 seconds)

Rated voltage / range: 240V (110V - 240V AC)

Rated frequency / range: 60 Hz (50 - 60 Hz)

Power factor (input/output): 0.98 leading, 0.98 lagging

Maximum DC voltage: 150V (150V AC)

Microinverter: Single phase

Maximum DC input rated (continuous) output: 3.6kW

Breaker type / efficiency: 80%

Total capacity: 10.5 kWh

Usable capacity: 10.5 kWh

Round-trip efficiency: 90%

Normal DC voltage: 47.2V

Maximum DC voltage: 150V

Ambient operating temperature range: -10°C to 50°C (-10°F to 122°F) non-condensing

Relative humidity: 5% to 95% (5% to 95% RH)

Chemistry: Lithium-ion phosphate (LiFePO4)

MECHANICAL DATA

Dimensions (height): 16.5" (418 mm) x 16.5" (418 mm) x 16.5" (418 mm)

Weight: 16.5 lbs (7.5 kg)

These dimensions are for the battery base unit plus 2.1 kg (4.6 lb) cover and mounting hardware (total 18.6 kg (41.3 lb))

Depth: 16.5" (418 mm)

Relative humidity: 5% to 95%

Up to 1000 meters (3280 feet)

Wiring: 10 AWG

FEATURES AND COMPLIANCE

Compatibility: Compatible with grid-tied PV systems. Compatible with Enphase IQ Series Micro, Enphase Bypass, and Enphase IQ Series for battery operation.

Communication: Wireless 2.4 GHz and 915 MHz

Standard: Backed-up and supported by the National Charge, NEMA 1000

Monitoring: Enphase Manager and Monitoring monitoring system, with integration

Compliance (pending): UL 954, UL 954A, UL 954B, UL 954C, UL 954D, UL 954E, UL 954F, UL 954G, UL 954H, UL 954I, UL 954J, UL 954K, UL 954L, UL 954M, UL 954N, UL 954O, UL 954P, UL 954Q, UL 954R, UL 954S, UL 954T, UL 954U, UL 954V, UL 954W, UL 954X, UL 954Y, UL 954Z, UL 954AA, UL 954AB, UL 954AC, UL 954AD, UL 954AE, UL 954AF, UL 954AG, UL 954AH, UL 954AI, UL 954AJ, UL 954AK, UL 954AL, UL 954AM, UL 954AN, UL 954AO, UL 954AP, UL 954AQ, UL 954AR, UL 954AS, UL 954AT, UL 954AU, UL 954AV, UL 954AW, UL 954AX, UL 954AY, UL 954AZ, UL 954BA, UL 954BB, UL 954BC, UL 954BD, UL 954BE, UL 954BF, UL 954BG, UL 954BH, UL 954BI, UL 954BJ, UL 954BK, UL 954BL, UL 954BM, UL 954BN, UL 954BO, UL 954BP, UL 954BQ, UL 954BR, UL 954BS, UL 954BT, UL 954BU, UL 954BV, UL 954BW, UL 954BX, UL 954BY, UL 954BZ, UL 954CA, UL 954CB, UL 954CC, UL 954CD, UL 954CE, UL 954CF, UL 954CG, UL 954CH, UL 954CI, UL 954CJ, UL 954CK, UL 954CL, UL 954CM, UL 954CN, UL 954CO, UL 954CP, UL 954CQ, UL 954CR, UL 954CS, UL 954CT, UL 954CU, UL 954CV, UL 954CW, UL 954CX, UL 954CY, UL 954CZ, UL 954DA, UL 954DB, UL 954DC, UL 954DD, UL 954DE, UL 954DF, UL 954DG, UL 954DH, UL 954DI, UL 954DJ, UL 954DK, UL 954DL, UL 954DM, UL 954DN, UL 954DO, UL 954DP, UL 954DQ, UL 954DR, UL 954DS, UL 954DT, UL 954DU, UL 954DV, UL 954DW, UL 954DX, UL 954DY, UL 954DZ, UL 954EA, UL 954EB, UL 954EC, UL 954ED, UL 954EE, UL 954EF, UL 954EG, UL 954EH, UL 954EI, UL 954EJ, UL 954EK, UL 954EL, UL 954EM, UL 954EN, UL 954EO, UL 954EP, UL 954EQ, UL 954ER, UL 954ES, UL 954ET, UL 954EU, UL 954EV, UL 954EW, UL 954EX, UL 954EY, UL 954EZ, UL 954FA, UL 954FB, UL 954FC, UL 954FD, UL 954FE, UL 954FF, UL 954FG, UL 954FH, UL 954FI, UL 954FJ, UL 954FK, UL 954FL, UL 954FM, UL 954FN, UL 954FO, UL 954FP, UL 954FQ, UL 954FR, UL 954FS, UL 954FT, UL 954FU, UL 954FV, UL 954FW, UL 954FX, UL 954FY, UL 954FZ, UL 954GA, UL 954GB, UL 954GC, UL 954GD, UL 954GE, UL 954GF, UL 954GG, UL 954GH, UL 954GI, UL 954GJ, UL 954GK, UL 954GL, UL 954GM, UL 954GN, UL 954GO, UL 954GP, UL 954GQ, UL 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954ZY, UL 954ZZ

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ESS Example Sys. #2



CERTIFICATE OF COMPLIANCE

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

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

This certificate confirms that representative samples 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.

Standard(s) for Safety: ANSI/CAN/UL 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://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. #2



The Enphase Enpower™ smart switch connects the home to grid power, the Enphase storage system, and solar PV. It provides integrated interconnection device (MIC) 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 and storage installations by providing a consistent, pre-wired solution for residential applications.

Reliable

- UL954 fire-resistant UL954 chemistry for maximum safety and longevity
- Two-year limited warranty

Smart

- Connects safely to the grid
- Automatically detects and manages
- Provides seamless transition to backup

Simple

- Connects to the load or service entrance side of the main load panel
- Centralized monitoring and control
- Supports central entry from the bottom, bottom left side, and bottom right side
- Supports whole home and partial home backup and islanded backup
- Up to 2000 meters (6560 feet)
- Up to 1000 meters (3280 feet)

Enphase Enpower

Model Number: EP2000-10-1P-NA

Enphase Enpower smart switch with optional forming transformer (PFT) Managed PV and storage applications

Three Enphase IQ 3.6A battery base units (B3-A1-0300-1-0)

One Enphase IQ 3.6A battery base unit with one and mounting bracket, watertight conduit tubes, and microinverter for wiring between batteries (B3-0-1000-0)

ACCESSORIES

ENCHARGE-10-01-01: One set of Enphase base unit installation hardware

TECHNICAL DATA

DC Input (VDC): 48V-150V

Rated (continuous) output power*: 3.6kW

Peak output power: 3.7kW (10 seconds)

Rated voltage / range: 240V (110V - 240V AC)

Rated frequency / range: 60 Hz (50 - 60 Hz)

Power factor (input/output): 0.98 leading, 0.98 lagging

Maximum DC voltage: 150V (150V AC)

Microinverter: Single phase

Maximum DC input rated (continuous) output: 3.6kW

Breaker type / efficiency: 80%

Total capacity: 10.5 kWh

Usable capacity: 10.5 kWh

Round-trip efficiency: 90%

Normal DC voltage: 47.2V

Maximum DC voltage: 150V

Ambient operating temperature range: -10°C to 50°C (-10°F to 122°F) non-condensing

Relative humidity: 5% to 95% (5% to 95% RH)

Chemistry: Lithium-ion phosphate (LiFePO4)

MECHANICAL DATA

Dimensions (height): 16.5" (418 mm) x 16.5" (418 mm) x 16.5" (418 mm)

Weight: 16.5 lbs (7.5 kg)

These dimensions are for the battery base unit plus 2.1 kg (4.6 lb) cover and mounting hardware (total 18.6 kg (41.3 lb))

Depth: 16.5" (418 mm)

Relative humidity: 5% to 95%

Up to 1000 meters (3280 feet)

Wiring: 10 AWG

FEATURES AND COMPLIANCE

Compatibility: Compatible with grid-tied PV systems. Compatible with Enphase IQ Series Micro, Enphase Bypass, and Enphase IQ Series for battery operation.

Communication: Wireless 2.4 GHz and 915 MHz

Standard: Backed-up and supported by the National Charge, NEMA 1000

Monitoring: Enphase Manager and Monitoring monitoring system, with integration

Compliance (pending): UL 954, UL 954A, UL 954B, UL 954C, UL 954D, UL 954E, UL 954F, UL 954G, UL 954H, UL 954I, UL 954J, UL 954K, UL 954L, UL 954M, UL 954N, UL 954O, UL 954P, UL 954Q, UL 954R, UL 954S, UL 954T, UL 954U, UL 954V, UL 954W, UL 954X, UL 954Y, UL 954Z, UL 954AA, UL 954AB, UL 954AC, UL 954AD, UL 954AE, UL 954AF, UL 954AG, UL 954AH, UL 954AI, UL 954AJ, UL 954AK, UL 954AL, UL 954AM, UL 954AN, UL 954AO, UL 954AP, UL 954AQ, UL 954AR, UL 954AS, UL 954AT, UL 954AU, UL 954AV, UL 954AW, UL 954AX, UL 954AY, UL 954AZ, UL 954BA, UL 954BB, UL 954BC, UL 954BD, UL 954BE, UL 954BF, UL 954BG, UL 954BH, UL 954BI, UL 954BJ, UL 954BK, UL 954BL, UL 954BM, UL 954BN, UL 954BO, UL 954BP, UL 954BQ, UL 954BR, UL 954BS, UL 954BT, UL 954BU, UL 954BV, UL 954BW, UL 954BX, UL 954BY, UL 954BZ, UL 954CA, UL 954CB, UL 954CC, UL 954CD, UL 954CE, UL 954CF, UL 954CG, UL 954CH, UL 954CI, UL 954CJ, UL 954CK, UL 954CL, UL 954CM, UL 954CN, UL 954CO, UL 954CP, UL 954CQ, UL 954CR, UL 954CS, UL 954CT, UL 954CU, UL 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Signage

ESS 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).

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 690.56(B) and 706.10. Wording could vary.

Note: Battery System is mounted at West wall, inside of garage.

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), 706.21, and 705.10. Wording 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.

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

This sign is required to be located at the backed panelboard and AC disconnect switch. 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)(1).

ENERGY STORAGE SYSTEM DISCONNECT Maximum DC Voltage = 240V Nominal AC Voltage = 240V

This sign is required to be mounted on the ESS disconnect (for this system could be the Enphase Smart Switch shutoff). NEC 706.15(C)

Battery chemistry is lithium

Battery chemistry sign required per Utah Amendments

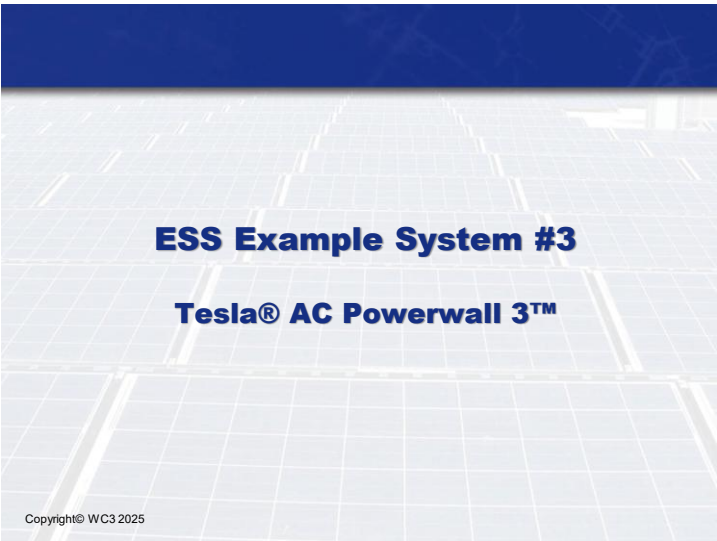
WARNING ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

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

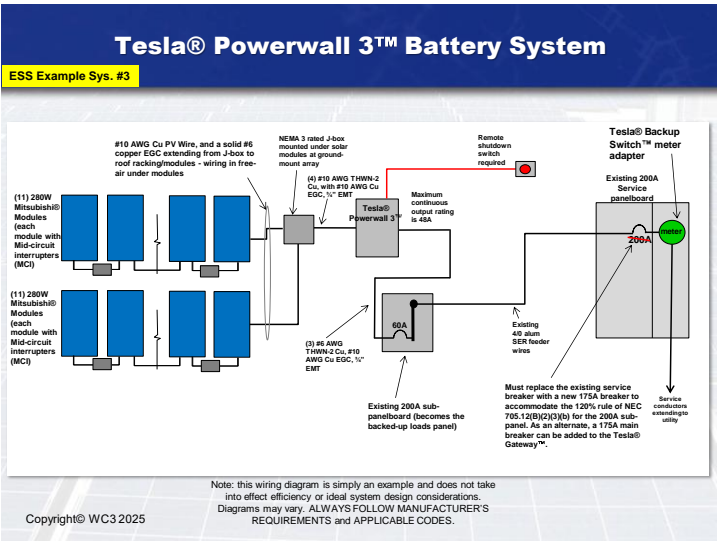
RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

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)

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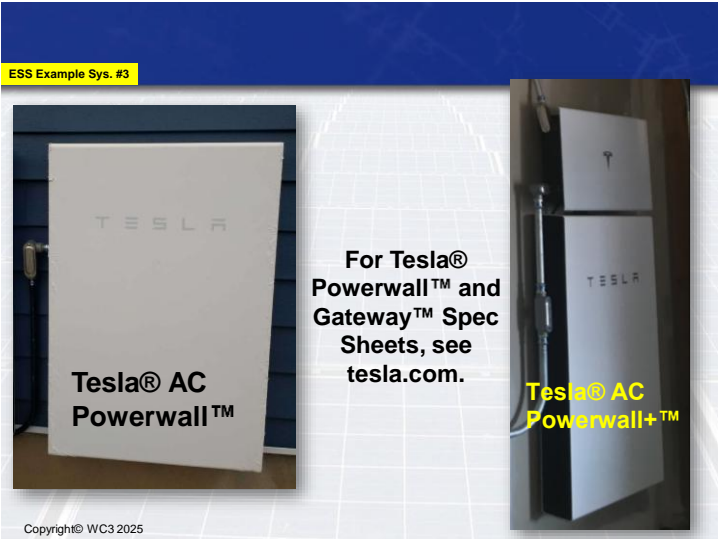
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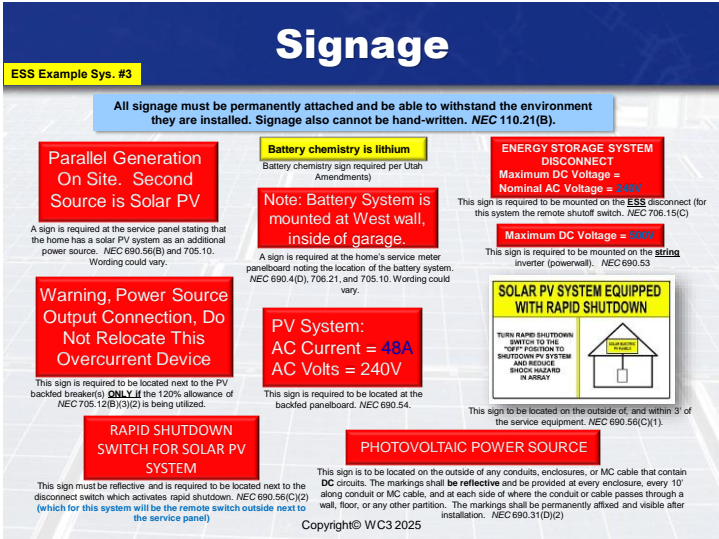
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ESS Example System #4

Tesla® AC Powerwall™ with a SolarEdge® String Inverter System

ALTERNATE LAYOUT

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SolarEdge® String inverter with a Tesla® AC Powerwall™ Battery System

ESS Example Sys. #4

Note: For the existing service meter panelboard, the sum of all breakers therein (not counting the 200A main service breaker) cannot exceed 100% of the rating of the service panel. This is permitted per NEC 705.12(B)(3)(3) instead of using the 120% allowance of NEC 705.12(B)(3)(2).

OR as an alternate the PCS setting can be set to a maximum of 32A.

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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Pictures of Service Panel

ESS Example Sys. #4

200A main service breaker

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SolarEdge® String inverter with a Tesla® AC Powerwall™ Battery System

ESS Example Sys. #4

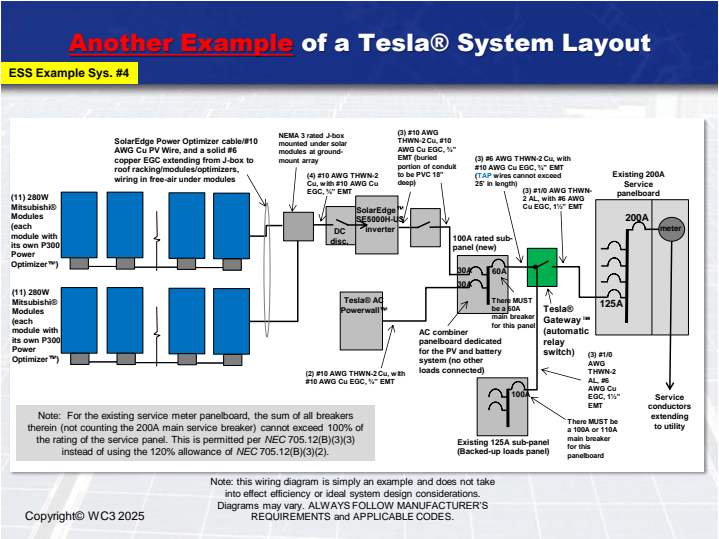
Note: For the existing service meter panelboard, the sum of all breakers therein (not counting the 200A main service breaker) cannot exceed 100% of the rating of the service panel. This is permitted per NEC 705.12(B)(3)(3) instead of using the 120% allowance of NEC 705.12(B)(3)(2).

OR as an alternate the PCS setting can be set to a maximum of 32A.

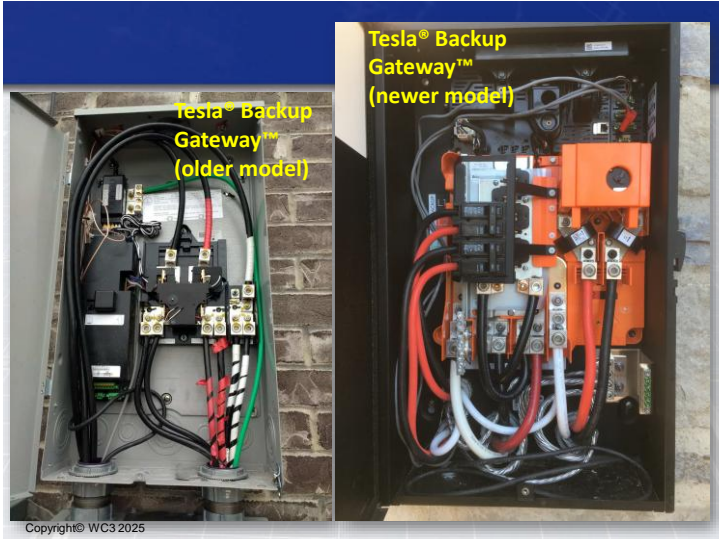
Note: this wiring diagram is simply an example and does not take into effect efficiency or ideal system design considerations. Diagrams may vary. ALWAYS FOLLOW MANUFACTURER'S REQUIREMENTS AND APPLICABLE CODES.

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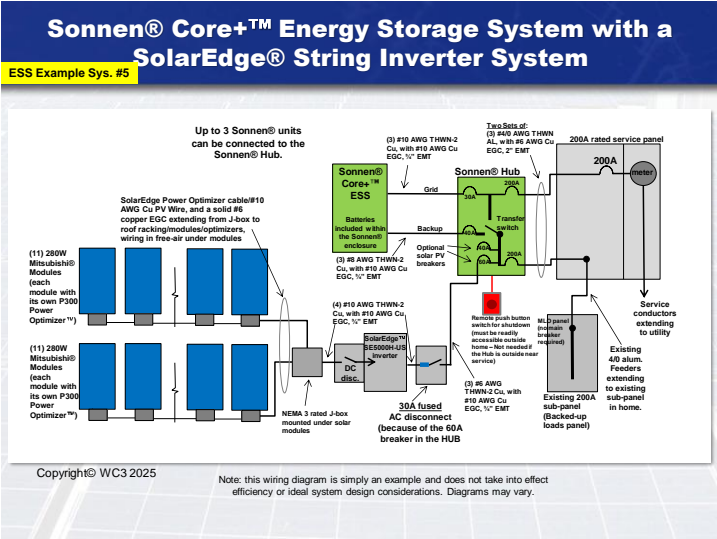
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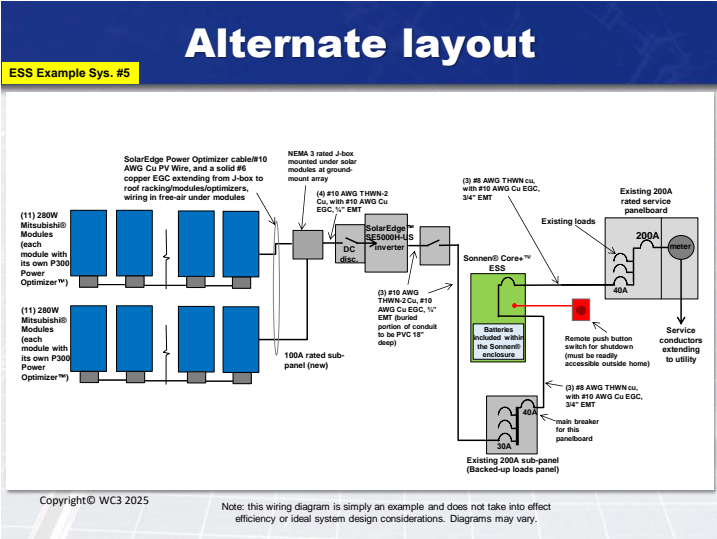
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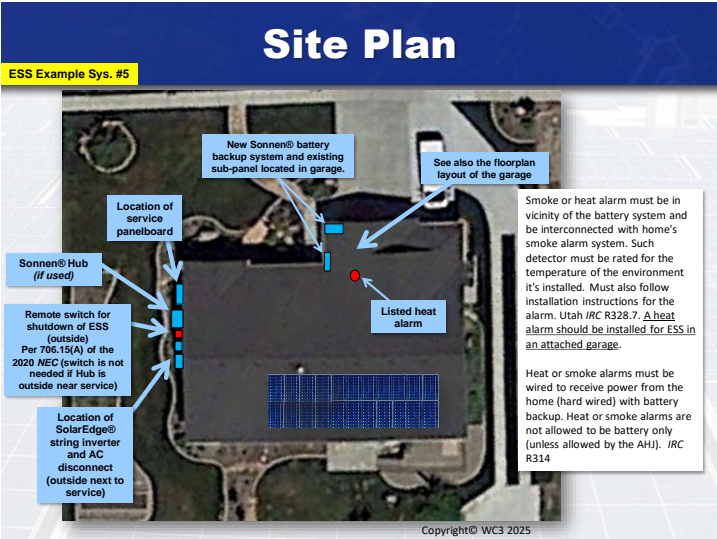
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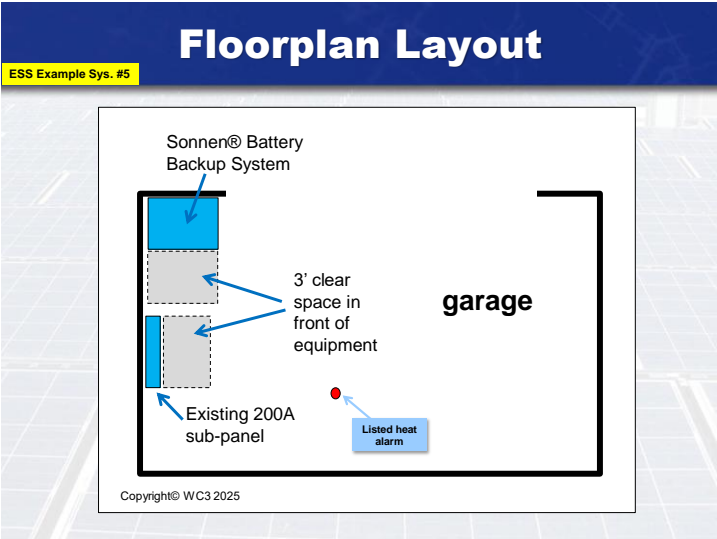
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ESS Example Sys. #5



Engineering Design Tech Specs - sonnenCore+

The sonnenCore+ is an intelligent energy storage solution that is safe, long lasting and offers up to 20kWh of battery capacity. The sleek design combines smart energy management software with the safest and longest lasting batteries to efficiently manage home energy usage throughout the day, store excess solar power for use at night and provide reliable backup power during power outages.

Model number	SCORE P10	SCORE P20
Usable capacity	10 kWh	20 kWh
Weight (approximate)	428 lbs	514 lbs
Rated power rating (50% test output at 40°C)	-	8.8 kW
Dimensions W*H*D* (adjustable height from ground)	27.7/31.1/14	27.7/31.1/14 (with top extended)
Grid integration	4C inverter	-
Applications	- Time of use - Virtual Power Plant - Solar self-consumption - Emergency backup power	-
Usable capacity*	5 kWh per battery module	-
Inverter efficiency	94.4% peak	-
On-Grid pass-through	25A	-
Max round trip efficiency*	91.6%	-
Operation temperature range	32°F - 104°F (3000 power)	-
System cooling	NAT - 100°F	-
Cable ports	External	-
Communication protocols / Control	Surge, Modbus / J1939 (optional to select)	-
Harmonization	<20.0%	-
Total harmonic distortion	<5%	-
Maximum compatible PV inverter	6.6kW	-

Sonnen® Core+™ Specs (sonnen-batterie.com)

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ESS Example Sys. #5

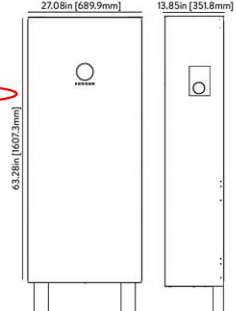
Sonnen® Core+™ Specs (sonnen-batterie.com)

Off-grid specifications	
Nominal Off-Grid current (Continuous)	20 A / 4.8 kVA
Max AC Off-Grid current (Max 30min)	25 A / 5.52 kVA
Max AC Off-Grid current (Max 5s)	30 A / 7.2 kVA
Max AC Off-Grid current (Max 100ms)	36 A / 8.64 kVA

Measurements	
27.08in (689.9mm)	13.85in (351.8mm)

Compliance information	
Certifications	UL1741, UL1973, UL9540, UL9540.3
Grid Connections	IEEE 1547, IEEE 2030.5, Rule 21
Emissions	FCC Part 15 Class B (Inverter)
Transient protection	IEEE C62.41 Class B
Warranty*	10 year or 10,000 cycle system warranty - includes inverter, battery modules, cabinet and components
Enclosure rating	Type 12

Battery specification	
Nominal DC voltage	102 VDC
DC battery input voltage	95 - 112 VDC
Max charge current	19 A per module
Cell discharge	5 kWh with 100% DoD
Cell chemistry	Lithium iron phosphate
Over-current Protection	Fuse protection



Sonnen® Core+™ Specs (sonnen-batterie.com)

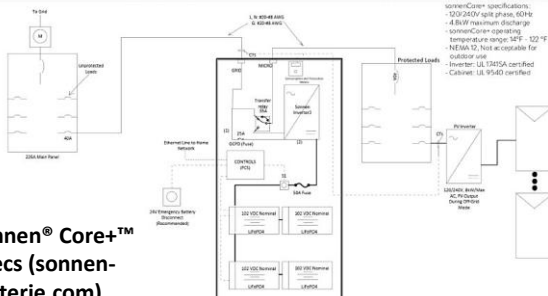
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ESS Example Sys. #5

Sonnen® Core+™ Specs (sonnen-batterie.com)

Single Line Diagram for System Design

Below is an overview of the design layout for a single sonnenCore+ system with a protected loads panel for backup power. Specific project design consultation for custom installations is available through sonnen Applications Engineering at design@sonnen-batterie.com.



sonnenCore+ specifications:

- 120/240V split phase, 60Hz
- 4.8kW maximum discharge
- sonnenCore+ operating temperature range: 32°F - 104°F
- NEMA 12, Not accessible for outdoor use
- Inverter: UL 1741/5A certified
- Cabinet: UL 9540 certified


3 P10 connected conductor
2 P10 connected device

Sonnen® Core+™ Specs (sonnen-batterie.com)

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ESS Example Sys. #5

Sonnen® Battery-Backup System



Sonnen® Battery-Backup System

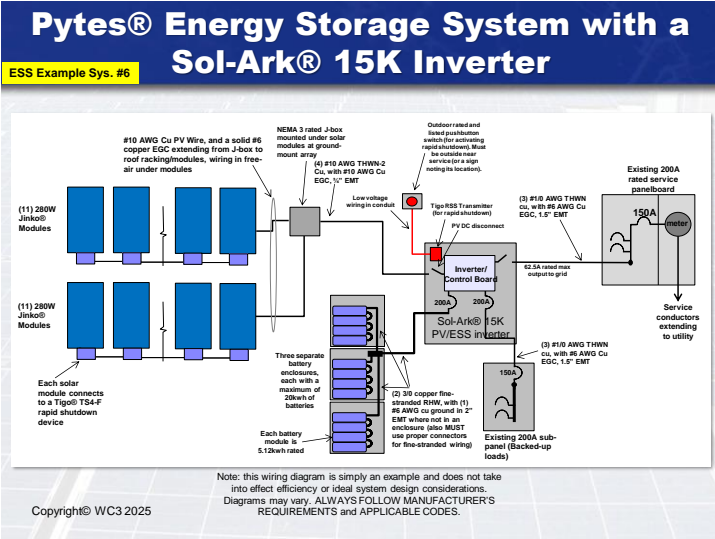
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ESS Example System #6

Pytes® Energy Storage System with a Sol-Ark® 15K Inverter

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Specs from Pytesusa.com

ESS Example Sys. #6



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Specs from Pytesusa.com

ESS Example Sys. #6

Technical Specifications			
Battery Model	E-BOX-48100R	E-BOX-4850	E-BOX-48100C
Chemistry	LFP	LFP	LFP
Nominal Voltage	51.2V	48V	51.2V
Voltage Range	47.5V-58V	45V-54V	47.5V-58V
Nominal Capacity	100Ah	50Ah	100Ah
Nominal Energy	5.12kWh	2.4kWh	5.12kWh
Unit Dimension	440mm* 620mm *117mm 17.32in * 24.41in * 4.61in 51kg/ 112.44lbs	440mm* 420mm * 89mm 17.32in * 16.54in * 3.50in 25kg/ 55.12lbs	440mm* 480mm * 200mm 17.32in * 18.90in * 7.87in 50.6kg/ 111.55lbs
Unit Weight			
Standard Charge Current	50A	50A	50A
Maximum Charge Current	50A	50A	50A
Standard Discharge	50A	50A	50A
Maximum Discharge Rate	50A	50A	50A
Round-Trip Efficiency	≥95%	≥95%	≥95%
Communication Protocol	RS232, RS485, CAN	RS232, RS485, CAN	RS232, RS485, CAN
Cycle Life	≥6000cycles	≥8000cycles	≥8000cycles
Calendar Life	≥10years	≥10years	≥10years
Operating Temperature	-10°C~50°C/ 14°F~122°F	-10°C~50°C/ 14°F~122°F	-10°C~50°C/ 14°F~122°F
Connect style	Parallel	Parallel	Parallel
Storage Temperature	< 1month: -20~55°C/ -4°F~131°F 1-3months: 0~35°C/ 32°F~95°F 3-12months: 20~25°C/ 68°F~77°F		

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Specs from Sol-Ark.com

ESS Example Sys. #6

North America: 15K-2P-N

Datasheet

UL: Limitless 15K-LV

Input Data (PV)

Max. Allowed PV Power (STC)	19,500W
Nominal Voltage Range	175 - 425V
Startup Voltage	125V
Max. Input Voltage	500V
Max. Input Current per MPPT	26A (self-limiting)
No. of MPPT Trackers	3
No. of PV Strings per MPPT	2
Max. AC Coupled Input	19,200W

Output Data (AC)

Nominal AC Voltage	120/240V, 120/208V, 220V
Grid Frequency	50 / 60Hz
Real Power, max continuous	15,000W
Max. Output Current	62.5A
Real Power, max continuous (batteries only, no PV)	12,000W (50A @ 240V)
Peak Apparent Power (10s, off-grid)	24,000VA @ 240V
Peak Apparent Power (100ms, off-grid)	30,000VA @ 240V
Max. Output Fault Current (5s)	94A with PV, 75A (batteries only, no PV)
Max. Output Fault Current (100ms)	120A
Max. Grid Passthrough Current	200A
Power Factor Output Range	+/- 0.9 adjustable
Backup Transfer Time	5ms
CEC Efficiency	96.5%
Max. Efficiency	97.5%
Design (DC to AC)	Transformerless DC
Stackable	Up to 12 in parallel

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Specs from Sol-Ark.com

ESS Example Sys. #6

Battery Input Data (DC)

Battery Technologies	Lithium / Lead Acid
Nominal DC Voltage	48V
Operating Voltage Range	43 - 63V
Capacity	50 - 9900Ah
Max. Battery Charge / Discharge Current	275A
Charging Controller	3 Stage with Equalization
Grid to Battery Charging Efficiency	94.0%
External Temperature Sensor	Included
Current Shunt for Accurate % SOC	Integrated
Automatic Generator Start	Integrated
Communication to Lithium	CANBus & RS485

General Data

Dimensions (H x W x D)	807 x 494 x 306 mm / 31.8 x 19.4 x 12 in
Weight	61.2 Kg / 135 lb.
Enclosure	IP65 / NEMA 3R
Ambient Temperature	-25 ~ 55°C, > 45°C Derating
Noise	< 30 dB
Idle consumption - No Load	90W
Wi-Fi & LAN Communication	Included
Standard Warranty	10 Years

Protection and Certifications

Electronics Certified Safety by SGS Labs to NEC & UL Specs - NEC 490.48 & NEC 705.4/6	Yes
Grid Sell Back - UL1741-2010/2018, IEEE1547a 2003/2014, FCC 15 Class B, UL1741SB, CA Rule 21, NERC Rule 14H	Yes
PV DC Disconnect Switch - NEC 240.15	Integrated
Ground Fault Detection - NEC 690.5	Integrated
PV Rapid Shutdown Control - NEC 690.12	Integrated
PV Arc Fault Detection - NEC 690.11	Integrated
PV Input Lightning Protection	Integrated
PV String Input Reverse Polarity Protection	Integrated
AC Output Breaker - 200A	Integrated
200A x 2 Battery Breaker / Disconnect	Integrated
Surge Protection	DC Type II / AC Type II

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Jinko® PV Module Specs (example) – Cold Temp dc voltages

Specifications

Module Type	JKM210M-60-V	JKM210M-60-V	JKM210M-60-V
STC	NOCT	STC	NOCT
Maximum Power (Pmax)	290Wp	210Wp	290Wp
Maximum Power Voltage (Vmp)	38.2V	36.2V	38.2V
Maximum Power Current (Imp)	7.61A	5.81A	7.61A
Open Circuit Voltage (Voc)	45.5V	43.5V	45.5V
Short Circuit Current (Isc)	8.55A	7.81A	8.55A
Module Efficiency STC (%)	17.72%	16.02%	18.33%
Operating Temperature (°C)	-40°C ~ 85°C		
Maximum System Voltage	1000VDC (UL and IEC)		
Maximum System Fuse Rating	25A		
Power Tolerance	±0.5%		
Temperature Coefficient of Pmax	-0.38%/°C		
Temperature Coefficient of Voc	-0.29%/°C		
Temperature Coefficient of Isc	0.064%/°C		
Nominal Operating Cell Temperature (NOCT)	45±2°C		

Linear Performance Warranty

Linear Performance Warranty: 30 Years

Power Output Guarantee: 90% at 30 Years

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Cold Temperature DC Voltage

Example

Maximum dc voltage of a solar PV system on residential premises cannot exceed 600V (NEC 690.7)

Maximum system DC voltage calculation:

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

39.5V x 11 modules on a dc string = 434.5V (at 77°F)

If we use -28°C for our coldest temperature (which is noted in the ASHRAE Fundamentals Handbook for Bozeman, MT):

The difference in temperature drop from 25°C to -28°C is 53°C.

Per the module's specs, the voltage of the modules increases by .29% for every 1°C drop in temperature.

Take 53°C x .29 = a voltage increase of 15.37% at -28°C.

434.5V x 1.1537 = a cold temperature voltage of 501V.


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Tigo® Rapid Shutdown Devices

ESS Example Sys. #6



RSS TRANSMITTER

Meets NEC 480.12 requirements
Module-level deactivation with TS4-F
Automatic or manual shutdown
Includes one or two RSS Cores
Optional 120V/240V_{ac} power supply

Product
Transmitter input voltage: 120V/120-270V
Transmitter input current: 1A
Max Current: 10A per RSS Core (Single Core: 150A, Dual Core: 300A)
Max String Voltage: 1520Vdc
Max Number of Strings per Core: 10
Max Supported PV Modules per String: 30
Communication: RS-485
Operating Temperature Range: -40°C to 85°C

For Tigo RSS Transmitter integration inside an inverter, be able to provide the following power profile:

- Voltage: 27Vdc (V_{in} 25V)
- Power Average: 0.85W
- Power Standby: 0.50W
- Duty Cycle: 10%
- Max Power: 0.3W

ORDERING OPTIONS

480-0000-10 Single Core (150A) RSS Core Kit transmitter (no power supply)
480-0000-20 Dual Core (300A) RSS Core Kit transmitter (no power supply)
980-0112-00 DIN Rail Power Supply, 12Vdc, 1.25A

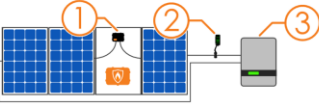
For sales info:
sales@tigoenergy.com or 1.408.402.0802

For technical information:
http://support.tigoenergy.com

For product info:
Visit www.tigoenergy.com/products

For technical info:
http://support.tigoenergy.com

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



1. Modules installed with Tigo TS4-F (Fire Safety)
2. Tigo RSS Transmitter and RSS Core
3. Inverter

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Tigo® Rapid Shutdown Devices

ESS Example Sys. #6



TS4-F

Fire Safety

TS4-F is a rapid shutdown solution that pairs with an integrated modular junction box base (TS4-F), install with Tigo RSS Transmitter for rapid shutdown activation.

Features

- Meets NEC 480.12 rapid shutdown requirements
- Module-level deactivation
- Automatic or manual shutdown
- PFC signaling

Protect your investment by enhancing safety with TS4-F

- UL Certified for TS4-F (integrations)
- Uses Tigo's (Line-Voltage) (LVS) Core technology for superior performance
- Refer to www.tigoenergy.com/design for rapid shutdown system listed inverters



Deploy TS4-F to prevent fire damage caused by faulty installation, defective equipment, or other environmental hazards.

Meet rapid shutdown specifications with TS4-F

Tigo has further expanded its smart module platform with the TS4-F Fire Safety cover. TS4 increases your freedom of choice by allowing you to select the right features for each project and budget.

Parameter	Value
Voltage Range	1A - 10V
Maximum Current	1A
Maximum Power	475W
Communication Type	PFC
Impedance Matching Function	No
Output Voltage Limit	No
Rapid Shutdown is Listed	Yes
UL: 2014 & 2017 ENEC	Yes

TS4-F

Parameter	Value
Operating Temperature Range	-40°C to +85°C (-40°F to +185°F), RH = 95%
Storage Temperature Range	-40°C to +85°C (-40°F to +185°F), RH = 95%
Coating method	Natural Coating
Dimensions (base unit cover)	150.0mm x 108mm x 25.0mm
Weight (base unit cover)	475g
Outdoor Rating	IP67/IP68, NEMA 3R

Options

Option	Value
Type	Fire Safe
Output Cable Length	1.0m (standard), 1.2m (optional)
Rating Options	1000V (standard), 1500V (optional)
Cable Core Section	6.3 (3.0mm)
Connections	MC4, MC4 compatible, EV02
Maximum String Voltage	1500V UL/IEC

Notes

All TS4 covers are 1500V compatible. Specify max system voltage when ordering modules with TS4 covers for appropriate ratings & connections.
Rapid shutdown activation of TS4-F requires RSS Transmitter.

For sales info:
sales@tigoenergy.com or 1.408.402.0802

For product info:
Visit www.tigoenergy.com/products

For technical info:
Visit support.tigoenergy.com

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

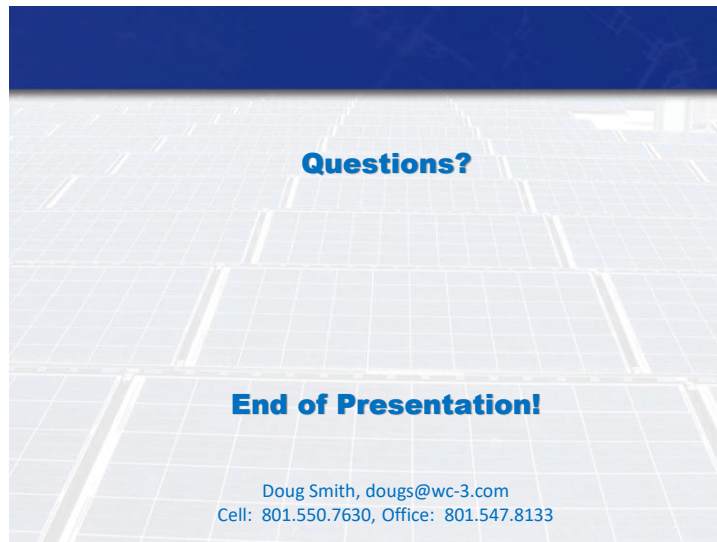
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