

PCS NOTICE OF COMPLETION

September 8, 2023
Mr. Travis Bizjak
Enphase Energy Inc.
1420 N. McDowell Blvd
Petaluma, CA 94954-6515

Our Reference: File E341165, Vol. (new) Sec. 1, Project 4790806693 and 4790898396

Project Scope: Evaluation of Enphase System 3.0 for Power Control System Functionality.

Dear Mr. Bizjak:

Congratulations! UL's investigation of your product has been completed under the above Reference Number and the product was determined to comply with the applicable requirements of the UL 1741 (3RD Edition CRD on Power Control Systems (PCS), issued on April 8, 2023 - (UL1741 3rd edition CRD is considered equivalent to the UL1741 2nd Edition CRD for PCS dated March 8th, 2019). Compliance with the CRD includes: a) protection of current overload for specific Enphase system circuits and busbars and b) management, control and limitation of power exchange between Energy Storage Systems and Area EPS/AC utility systems.

The PCS evaluation was conducted on a representative Enphase Energy System 3.0 and the certification applies to the following products which were part of the tested system in the PCS modes defined below.

This PCS supports up to 3 branch circuit inputs, two ESS and one PV input. each with up to 8 daisy-chained IQ Battery 5P units. Each branch's charge/discharge current can be limited from 64 Amps to 8 Amps continuous.

System backup protection from current overload with Listed branch circuit breakers is as defined below:

1. PV inverter breakers on the combiner box and system controller must be properly sized.
 - a. Maximum breaker size for the PV inverter branch in a combiner box is 20A.
 - b. Maximum breaker size for the PV inverter branch in the system controller is 80A.
2. Battery inverter breakers on the combiner box or system controller must be properly sized.
 - a. Maximum breaker size for the battery inverter branch in a combiner box is 20A
 - b. Maximum breaker size for the battery system controller input is 80A.
3. Main Panel breaker has to be sized properly based on the main panel busbar and grid breaker, maximum breaker size of 80A is tested with the test setup.
4. Please refer to the certification report and Enphase PCS installation instructions for system configuration details.

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Energy Storage System operating mode: Import Only

This PCS ensures the battery can import from the utility grid but does not export to the utility grid for both grid interactive and multi-mode systems. This is the only ESS operating mode supported by the Enphase IQ Battery 5P and is always enabled without any installer/user configuration.

A representative Enphase Energy System 3.0 was evaluated for PCS and the certification applies to the products listed below.

1. UL (Listed), Enphase IQ Battery 5P (Encharge battery 3rd generation) system.
 - a. Model numbers IQ BATTERY-5P-1P-NA, B05-T02-US00-1-3-RMA
2. UL (Listed) IQ8D-BAT Inverter(s) rated 120/240Vac, intended to be connected to a battery and will charge and discharge the battery.
 - a. Model Number IQ8D-BAT
3. UL (Listed), Enphase IQ Gateway (the PCS controller)
 - a. Model number X-IQ-AM1-240-5, X-IQ-AM1-240-5C
Firmware version v08.02.57, checksum 151122 with PCS-eSW v1.0.0, checksum f4d81573c3
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: ENV-IQ-AM1-240, ENV2-IQ-AM1-240, ENV-S-AM1-120, X-IQ-AM1-240-3, X-IQ-AM1-240-3C, X-IQ-AM1-240-3-ES, X-IQ-AM1-240-3C-ES, X-IQ-AM1-240-4, X-IQ-AM1-240-4C, X2-IQ-AM1-240-4, X2-IQ-AM1-240-4C
4. UL (Listed), Current Transformers, Enphase model numbers:
 - a. For solar production monitoring: At least 1 unit CT-200-SOLID
 - b. For consumption monitoring: At least 2 units of CT-200-SPLIT or CT-200-CLAMP
 - c. For battery monitoring: At least 1 unit of CT-200-SPLIT or CT-200-CLAMP
5. UL (Listed) PV Inverter (s) rated 120/240Vac. The Enphase Energy System 3.0 system was tested with 100 units Model IQ8H-240-72-2-US, each with 1.6A for a maximum current contribution of 160 Amps total. When used with the IQ System Controller, the current is limited by the PCS to 64A for use with an 80A breaker.
 - a. Enphase PCS for Energy Storage System: Import Only mode does not control PV current, and is not impacted by the presence of PV Inverters.
6. Optionally a UL (Listed), Enphase IQ System Controller 3/3G (Enpower smart switch), model numbers:
 - a. SC200D111C240US01 and SC200G111C240US01
 - i. (The “D” and “G” differences refer to the 3rd input which may be a DER or a Generator)
 1. Enphase PCS does not control generator current, and is not impacted by the presence of the generator.

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Energy Storage System operating mode: Import Only (continued from above)

The Enphase Energy System 3.0 system was evaluated for its ability to control export levels to the AC line (grid connection) when connected to sources mentioned in the above list.

Export levels and power output from the energy storage sub-system and PV were monitored. Tests verified that when system load levels were subjected to step changes, the ESS output level was adjusted by the PCS control system to cease the ESS output current flow to the AC line (utility grid connection), as such the PV inverter source was the only source of export.

The maximum open loop response time (OLRT) for the ESS response was verified to be less than 2 seconds. The PV input was controlled to a steady state value of 64 Amps.

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PCS for Energy Storage System Discharge/Charge Limiting

In this mode the PCS limits battery charge/discharge current and enables more battery capacity to be installed for both grid-interactive and multi-mode systems while not exceeding the charge and discharge limits of the circuits, busbars or Area EPS / grid connection. Enphase refers to this mode as “Battery Oversubscription”.

A representative Enphase Energy System 3.0 was evaluated for PCS and the certification applies to the products listed below.

1. UL (Listed), Enphase IQ Battery 5P (Encharge battery 3rd generation) system.
 - a. Model numbers IQ BATTERY-5P-1P-NA, B05-T02-US00-1-3-RMA
2. UL (Listed) IQ8D-BAT Inverter(s) intended to be connected to a battery and will charge and discharge the battery.
 - a. Model Number IQ8D-BAT
3. UL (Listed), Enphase IQ Gateway (the PCS controller)
 - a. Model number X-IQ-AM1-240-5, X-IQ-AM1-240-5C
Firmware version v08.02.57, checksum 151122 with PCS-eSW v1.0.0, checksum f4d81573c3
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: ENV-IQ-AM1-240, ENV2-IQ-AM1-240, ENV-S-AM1-120, X-IQ-AM1-240-3, X-IQ-AM1-240-3C, X-IQ-AM1-240-3-ES, X-IQ-AM1-240-3C-ES, X-IQ-AM1-240-4, X-IQ-AM1-240-4C, X2-IQ-AM1-240-4, X2-IQ-AM1-240-4C
4. UL (Listed), Current Transformers, Enphase model numbers:
 - a. For solar production monitoring: At least 1 unit CT-200-SOLID
 - b. For consumption monitoring: At least 2 units of CT-200-SPLIT or CT-200-CLAMP
 - c. For battery monitoring: At least 1 unit of CT-200-SPLIT or CT-200-CLAMP
5. UL (Listed) PV Inverter (s) rated 120/240Vac, maximum 160 Amps total continuous current. The Enphase Energy System 3.0 system was tested with 100 units of Model IQ8H-240-72-2-US, each with 1.6A for a maximum current contribution of 160 Amps total. When used with the IQ System Controller, the current is limited by the PCS to 64A for use with an 80A breaker.
 - a. Enphase PCS in this mode does not control PV current, and is not impacted by the presence of PV Inverters.
6. Optionally a UL (Listed), Enphase IQ System Controller 3/3G (Enpower smart switch), model numbers:
 - a. SC200D111C240US01 and SC200G111C240US01
 - i. (The “D” and “G” differences refer to the 3rd input which may be a DER or a Generator)
 1. Enphase PCS does not control generator current, and is not impacted by the presence of a generator input.

PCS for Energy Storage System Discharge/Charge Limiting (Continued from above)

The Enphase Energy System 3.0 system was evaluated for its ability to limit battery power levels (both charge and discharge) when connected to sources mentioned in the above list.

This PCS mode supports up to 2 ESS branch circuits, each with up to 8 daisy-chained IQ Battery 5P units. Each branch's charge/discharge current can be limited from 64 Amps to 8 Amps continuous.

The PV input was controlled to a steady state value of 64 Amps.

The maximum open loop response time (OLRT) for PCS for the ESS was verified to be less than 2 seconds.

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Supplemental PCS Overcurrent Protection - Power Limiting at Point of Common Coupling (PCC)

This PCS enables the per-phase back feed current to the main panelboard on the utility side of the system to be controlled for multi-mode PV and/or battery systems.

The Enphase Energy System 3.0 configured for this mode of operation includes the specific equipment listed below.

1. UL (Listed), Enphase IQ Gateway (the PCS controller)
 - a. Model number X-IQ-AM1-240-5, X-IQ-AM1-240-5C
Firmware version v08.02.57, checksum 151122 with PCS-eSW v1.0.0, checksum f4d81573c3
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: ENV-IQ-AM1-240, ENV2-IQ-AM1-240, X-IQ-AM1-240-3, X-IQ-AM1-240-3C, X-IQ-AM1-240-3-ES, X-IQ-AM1-240-3C-ES, X-IQ-AM1-240-4, X-IQ-AM1-240-4C, X2-IQ-AM1-240-4, X2-IQ-AM1-240-4C
2. UL (Listed) IQ8 Series PV Inverter(s) rated 120/240Vac, 1.6A per unit. PCS was tested with 100 units for a maximum current contribution of 160 Amps total. When used with the IQ System Controller, the current is limited by the PCS to 64A for use with an 80A breaker.
 - a. Model IQ8H-240-72-2-US,
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: IQ8-60-2-US, IQ8PLUS-72-2-US, IQ8M-72-2-US, IQ8A-72-2-US, IQ8-60-M-US, IQ8PLUS-72-M-US, IQ8M-72-M-US, IQ8A-72-M-US, IQ8H-240-72-M-US, IQ8MC-72-M-US, IQ8AC-72-M-US, IQ8HC-72-M-US
3. UL (Listed), Current Transformers, Enphase model numbers:
 - a. For solar production monitoring: At least 1 unit CT-200-SOLID
 - b. For consumption monitoring: At least 2 units of CT-200-SPLIT or CT-200-CLAMP
 - c. For battery monitoring: At least 1 unit of CT-200-SPLIT or CT-200-CLAMP
4. Optionally a UL(Listed) Enphase IQ Battery System:
 - a. UL (Listed), Enphase IQ Battery 5P (Encharge battery 3rd generation): IQ BATTERY-5P-1P-NA, B05-T02-US00-1-3-RMA
OR
 - b. UL (Listed), Enphase IQ Battery 3T/10T (Encharge battery 2nd generation): ENCHARGE-3T-1P-NA, ENCHARGE-10T-1P-NA. These batteries are protected with appropriately sized breakers and are not part of PCS functionality.
OR
 - c. UL (Listed), Enphase IQ Battery 3/10 (Encharge battery 1st generation): ENCHARGE-3-1P-NA, ENCHARGE-10-1P-NA. These batteries are protected with appropriately sized breakers and are not part of PCS functionality.

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Supplemental PCS Overcurrent Protection - Power Limiting at Point of Common Coupling (PCC) (Continued from above)

5. UL (Listed), Enphase IQ System Controller 3/3G (Enpower smart switch), model numbers:
 - a. SC200D111C240US01 and SC200G111C240US01
 - i. (The “D” and “G” differences refer to the 3rd input which may be a DER or a Generator)
 1. Generator Input is NOT included in PCS functionality.
 2. Enphase PCS does not control the generator current and is not impacted by the presence of the generator
 - ii. Based on similarity in construction and firmware versions, the following models are also considered covered: EP200G101-M240US01

The Enphase Energy System 3.0 system was evaluated for its ability to control up to 160 Amps of PV nameplate rated inverter output (as described in list above) to limit the per-phase back feed levels to the AC lines (grid connection) to a setting of up to a maximum of 64 Amps from the PV inverters.

Export levels and power output from the PV PCS input were monitored. Tests verified that when step changes in load or generation occurred, the output level was adjusted by the PCS to limit of 64 Amps or below.

This PCS mode limits the PV export current. The open loop response time was 10 seconds.

Supplemental PCS Overcurrent Protection with Power Limiting at Point of PV Connection (PoC)

PCS model Enphase Energy System 3.0 in this mode enables the per-phase back feed current to the panelboard on the non-utility side of the system to be controlled for both grid-interactive and multi-mode systems. This mode controls and limits current at the point of PV connection essentially oversubscribing the aggregate PV breaker (in the panel or in the IQ System Controller). Enphase refers to this feature as PV oversubscription.

The Enphase Energy System 3.0 configured for this mode of operation, includes the specific equipment listed below.

1. UL (Listed), Enphase IQ Gateway (the PCS controller)
 - a. Model number X-IQ-AM1-240-5, X-IQ-AM1-240-5C
Firmware version v08.02.57, checksum 151122 with PCS-eSW v1.0.0, checksum f4d81573c3
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: ENV-IQ-AM1-240, ENV2-IQ-AM1-240, X-IQ-AM1-240-3, X-IQ-AM1-240-3C, X-IQ-AM1-240-3-ES, X-IQ-AM1-240-3C-ES, X-IQ-AM1-240-4, X-IQ-AM1-240-4C, X2-IQ-AM1-240-4, X2-IQ-AM1-240-4C
2. UL (Listed) IQ8 Series PV Inverter(s) rated 120/240Vac, 1.6A per unit. PCS was tested with 100 units for a maximum current contribution of 160 Amps total. When used with the IQ System Controller, the current is limited by the PCS to 64A for use with an 80A breaker.
 - a. Model IQ8H-240-72-2-US
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: IQ8-60-2-US, IQ8PLUS-72-2-US, IQ8M-72-2-US, IQ8A-72-2-US, IQ8-60-M-US, IQ8PLUS-72-M-US, IQ8M-72-M-US, IQ8A-72-M-US, IQ8H-240-72-M-US
3. UL (Listed), Current Transformers, Enphase model numbers:
 - a. For solar production monitoring: At least 1 unit CT-200-SOLID
 - b. For consumption monitoring: At least 2 units of CT-200-SPLIT or CT-200-CLAMP
 - c. For battery monitoring: At least 1 unit of CT-200-SPLIT or CT-200-CLAMP
4. Optionally a UL(Listed) Enphase IQ Battery System:
 - a. UL (Listed), Enphase IQ Battery 5P (Encharge battery 3rd generation): IQ BATTERY-5P-1P-NA, B05-T02-US00-1-3-RMA
OR
 - b. UL (Listed), Enphase IQ Battery 3T/10T (Encharge battery 2nd generation): ENCHARGE-3T-1P-NA, ENCHARGE-10T-1P-NA. These batteries are protected with appropriately sized breakers and are not part of PCS functionality.
OR
 - c. UL (Listed), Enphase IQ Battery 3/10 (Encharge battery 1st generation): ENCHARGE-3-1P-NA, ENCHARGE-10-1P-NA. These batteries are protected with appropriately sized breakers and are not part of PCS functionality.

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Supplemental PCS Overcurrent Protection with Power Limiting at Point of PV Connection (PoC) (Continued from above)

5. Optionally a UL (Listed), Enphase IQ System Controller 3/3G (Enpower smart switch), model numbers:
 - a. SC200D111C240US01 and SC200G111C240US01
 - i. The “D” and “G” differences refer to the 3rd input which may be a DER or a Generator
 1. Generator Input is NOT included in PCS functionality.
 2. Enphase PCS does not control the generator current and is not impacted by the presence of the generator.
 - ii. Based on similarity in construction and firmware versions, the following models are also considered covered: EP200G101-M240US01

The Enphase Energy System 3.0 system was evaluated for its ability to control up to 160 Amps of PV nameplate rated inverter output (as described in list above) to limit the per-phase back feed levels to the AC lines (grid connection) to a setting of up to a maximum of 64 Amps from the PV inverters.

Export levels and power output from the PV PCS input were monitored. Tests verified that when step changes in load or generation occurred, the output level was adjusted by the PCS to limit of 64 Amps or below.

This PCS mode limits the PV export current. The open loop response time was 13 seconds.

Aggregate Power Export Limit (PEL)

This PCS mode limits the system export power to the area EPS / utility for both grid-interactive and multi-mode systems.

The Enphase Energy System 3.0 configured for this mode of operation, includes the specific equipment listed below.

1. UL (Listed), Enphase IQ Gateway (the PCS controller)
 - a. Model number X-IQ-AM1-240-5, X-IQ-AM1-240-5C
Firmware version v08.02.57, checksum 151122 with PCS-eSW v1.0.0, checksum f4d81573c3
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: ENV-IQ-AM1-240, ENV2-IQ-AM1-240, X-IQ-AM1-240-3, X-IQ-AM1-240-3C, X-IQ-AM1-240-3-ES, X-IQ-AM1-240-3C-ES, X-IQ-AM1-240-4, X-IQ-AM1-240-4C, X2-IQ-AM1-240-4, X2-IQ-AM1-240-4C
2. UL (Listed) IQ8 Series PV Inverter(s) rated 120/240Vac, 1.6A per unit. Enphase Energy System 3.0 was tested with 100 units for a maximum current contribution of 160 Amps total. When used with the IQ System Controller, the current is limited by the PCS to 64A for use with an 80A breaker.
 - a. Model IQ8H-240-72-2-US
 - i. Based on similarity in construction and firmware versions, the following models are also considered covered: IQ8-60-2-US, IQ8PLUS-72-2-US, IQ8M-72-2-US, IQ8A-72-2-US, IQ8-60-M-US, IQ8PLUS-72-M-US, IQ8M-72-M-US, IQ8A-72-M-US, IQ8H-240-72-M-US, IQ8MC-72-M-US, IQ8AC-72-M-US, IQ8HC-72-M-US
3. UL (Listed), Current Transformers, Enphase model numbers:
 - a. For solar production monitoring: At least 1 unit CT-200-SOLID
 - b. For consumption monitoring: At least 2 units of CT-200-SPLIT or CT-200-CLAMP
 - c. For battery monitoring: At least 1 unit of CT-200-SPLIT or CT-200-CLAMP
4. Optionally a UL(Listed) Enphase IQ Battery System:
 - b. UL (Listed), Enphase IQ Battery 5P (Encharge battery 3rd generation): IQ BATTERY-5P-1P-NA, B05-T02-US00-1-3-RMA
OR
 - a. UL (Listed), Enphase IQ Battery 3T/10T (Encharge battery 2nd generation): ENCHARGE-3T-1P-NA, ENCHARGE-10T-1P-NA. These batteries are protected with appropriately sized breakers and are not part of PCS functionality.
OR
 - b. UL (Listed), Enphase IQ Battery 3/10 (Encharge battery 1st generation): ENCHARGE-3-1P-NA, ENCHARGE-10-1P-NA. These batteries are protected with appropriately sized breakers and are not part of PCS functionality.

Aggregate Power Export Limit (PEL) (Continued from above)

5. Optionally a UL (Listed), Enphase IQ System Controller 3/3G (Enpower smart switch), model numbers:
 - a. SC200D111C240US01 and SC200G111C240US01
 - i. (The “D” and “G” differences refer to the 3rd input which may be a DER or a Generator)
 1. Generator Input is NOT included in PCS functionality
 2. Enphase does not control the generator current and is not impacted by the presence of the generator.
 - ii. Based on similarity in construction and firmware versions, the following models are also considered covered: EP200G101-M240US01

The Enphase Energy System 3.0 system of up to 160 Amps PV nameplate rating was evaluated for its ability to control export levels to the AC line (grid connection) from 64 Amps down to zero when connected to sources mentioned in the above list.

Export levels and power output from the energy storage sub-system and PV were monitored. Tests verified that when system load levels or PV power were subjected to step changes, power output from the PV source was the principal source of export power to the AC utility system

The Enphase Energy System 3.0 PCS was evaluated and found to comply with its ratings for each of the configurations and operation modes described in this letter and certification report. The testing under this project demonstrated that this PCS which was able to control, limit and or cease the current flow to the set level for the specific configuration and mode of operation before the rated open loop response time had expired.

A UL certification is a valuable marketing tool meaning your product or company has successfully met stringent requirements. We encourage you to use your product certification in your marketing activities. You can find information on how to accurately promote your UL certification at <https://www.ul.com/marketing>. If you have any questions, please contact me or any of our customer service representatives.

Sincerely,
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Reviewed by:
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