

Planning a Commercial IQ Microinverter System

The Enphase IQ Microinverter™ system is inexpensive to install and provides a wide range of new installation options to solar professionals. The IQ Microinverter system is available for single-phase and three-phase applications. New components available as part of this system provide additional options for reducing Balance of System (BOS) costs and installation complexity. This planning brief introduces solar installation professionals to the new components, provides guidance on component selection, and gives tips for various system design and installation scenarios.



The Enphase Commercial IQ Microinverter system includes the following:

- Enphase IQ Series Micros™: IQ 6, IQ 6+, IQ 7, IQ 7+ and IQ 7X
- Enphase IQ Commercial Envoy™ or IQ Envoy™
- Enphase Q Cable™ and accessories
- Enphase Enlighten™ and apps

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IQ Micros on a Three Phase System

IQ micros connect line to line, with each microinverter branch circuit connecting into a two-pole 20A circuit breaker. Balanced three phase generation is achieved by connecting the same number of microinverters between phase pairs (L1-L2, L2-L3 and L1-L3) with three two-pole circuits into a three-phase configuration. System capacity can be increased by adding additional groups of three two-pole 20A circuits.

IMPORTANT: Design recommendation: Maintain generation imbalance within 10%.

IQ 6 and IQ 6+ Micros

The IQ 6 and IQ 6+ Microinverters have a 97% CEC efficiency for split phase applications and are available at maximum continuous output power ratings of 230 watts and 280 watts respectively. The maximum number of microinverters per 2P 20A branch circuit is detailed in the table below. See the IQ product data sheets for complete product specifications at Enphase.com.

Maximum IQ Microinverters per 20A AC branch circuit	IQ 6 Microinverters (single-phase 240 VAC)	IQ 6+ Microinverters (single-phase 240 VAC)
	16	13
	IQ 6 Microinverters (single-phase 208 VAC)	IQ 6+ Microinverters (single-phase 208 VAC)
	14	11

IQ 7 and IQ 7+ Micros

The IQ 7 and IQ 7+ Micros have a 97% CEC efficiency for split phase applications and are available at maximum continuous output power ratings of 240 watts and 290 watts respectively. The maximum number of microinverters per 2P20A branch circuit is detailed in the below. See the IQ product data sheets for complete product specifications at Enphase.com.

Maximum IQ Micros per 20A AC branch circuit	IQ 7 Micros (single-phase 240 VAC)	IQ 7+ Micros (single-phase 240 VAC)
	16	13
	IQ 7 Micros (single-phase 208 VAC)	IQ 7+ Micros (single-phase 208 VAC)
	13	11

IQ 7X Micros

The IQ 7X Micros have a 97.5% CEC efficiency for split phase applications and are available at maximum continuous output power ratings of 315 watts. The maximum number of microinverters per 2P20A branch circuit is detailed in the table below. See the IQ product data sheets for complete product specifications at Enphase.com.

Maximum IQ Micros per 20A AC branch circuit	IQ 7X Micros (single-phase 240 VAC)
	12
	IQ 7X Micros (single-phase 208 VAC)
	10

IMPORTANT: The Enphase IQ Envoy and IQ Series Micros do not communicate with, and should not be used with, previous generation Enphase Microinverters, AC Batteries, and Envoys. The Q accessories work only with Enphase IQ Series Micros.

IQ Envoy and IQ Commercial Envoy

When designing a three-phase, commercial-scale system, it is critical to install a single-phase IQ Envoy (model ENV-IQ-AM1-240) or a three-phase IQ Commercial Envoy (model ENV-IQ-AM3-3P). Although the single-phase IQ Envoy is intended for use with single-phase systems, it can be used with three-phase systems for monitoring microinverters in a single communications domain. The production CT included with the IQ Envoy is not used when installed on a three-phase system.

Design recommendations for good PLC communications between the Envoy and Enphase Microinverters:

1. Do not exceed 300 IQ Microinverters per Envoy. Consult Enphase if this limit needs to be exceeded.
2. Install the Envoy as close as possible to the microinverters. Consult Enphase if you need to exceed 75 meters (246 feet) conductor length between the Envoy and the last microinverter in the circuit.
3. Install a line communication filter or use a delta-wye isolation transformer(s) to isolate Envoy domains. Filtering is mandatory when multiple Envoys are installed to separate communication domains.
4. Do not mix Envoy domain circuits when distributing power. Keep parallel circuit runs of different communication domains physically separated by at least 12 inches.

The IQ Commercial Envoy is to be used solely for 208Y/120V three phase applications and provides integrated PV production metering (+/- 0.5%) via three 200A continuous rated production CTs (included), and optional consumption monitoring (+/- 2.5%). The IQ Commercial Envoy is required to use Power Export Limiting (PEL) but PEL works only in systems that have a single IQ Commercial Envoy. The maximum consumption CT capacity of a single IQ Envoy is 400A (paralleling two 200A CTs per phase).

Do not install the Enphase IQ Combiner, IQ Combiner+ or IQ Combiner 3 in three phase applications; these are only for single-phase applications.



Select the IQ Envoy model for your system depending on metering requirement and on voltage configuration at the solar subpanel:

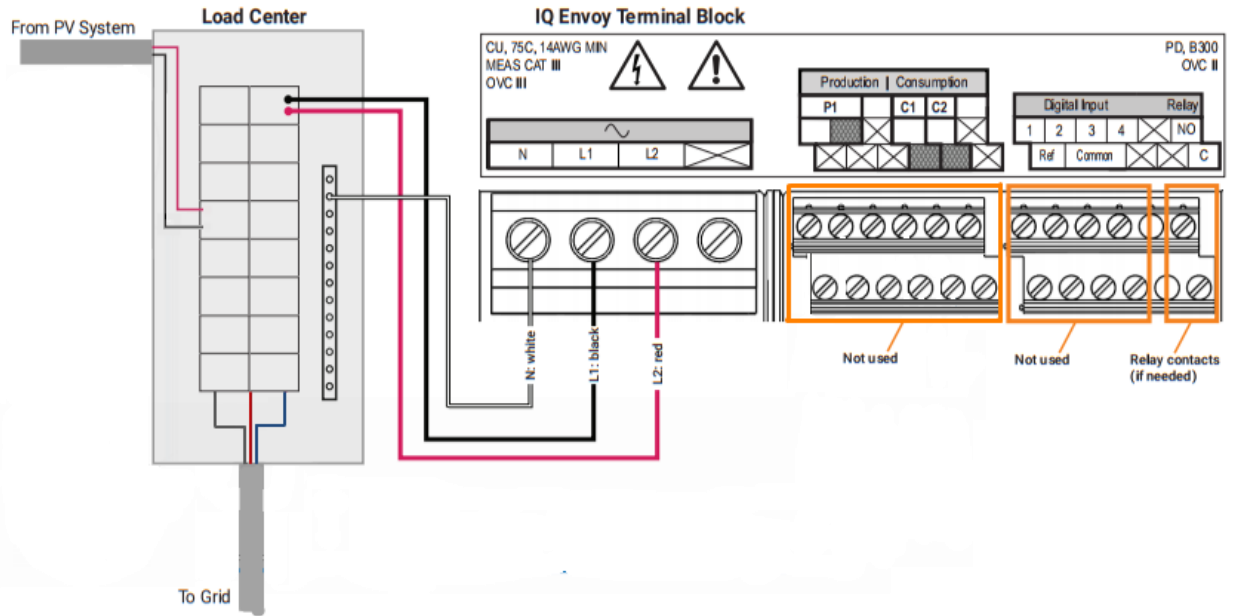
Voltage Configuration (at Solar Subpanel)	Envoy Type	Envoy SKU	3 -Phase Metering
208Y/120	IQ Commercial Envoy	ENV-IQ-AM3-3P	Available
	IQ Envoy	ENV-IQ-AM1-240	Not Available
240 high-leg delta	IQ Envoy	ENV-IQ-AM1-240	Not Available
240 delta*	IQ Envoy	ENV-IQ-AM1-240	Not Available

*Install a 240V to 120/240V auto-transformer to provide neutral for powering the IQ Envoy.

Wiring the IQ Envoy ENV-IQ-AM1-240 for Three-Phase Applications

When installing the single-phase IQ Envoy, the production and consumption CTs do not support three-phase applications, so the CTs should not be installed and production or consumption metering should not be enabled. The IQ Micros do not use a neutral, and a neutral is not required on the roof. However, a neutral is required for operation of the IQ Envoy. In addition, L1 and L2 conductors must be terminated at the IQ Envoy for communicating with the microinverters.

The diagram below shows how to properly wire an IQ Envoy ENV-IQ-AM1-240 into a three-phase system.



Wiring the IQ Commercial Envoy ENV-IQ-AM3-3P for Three-Phase Applications

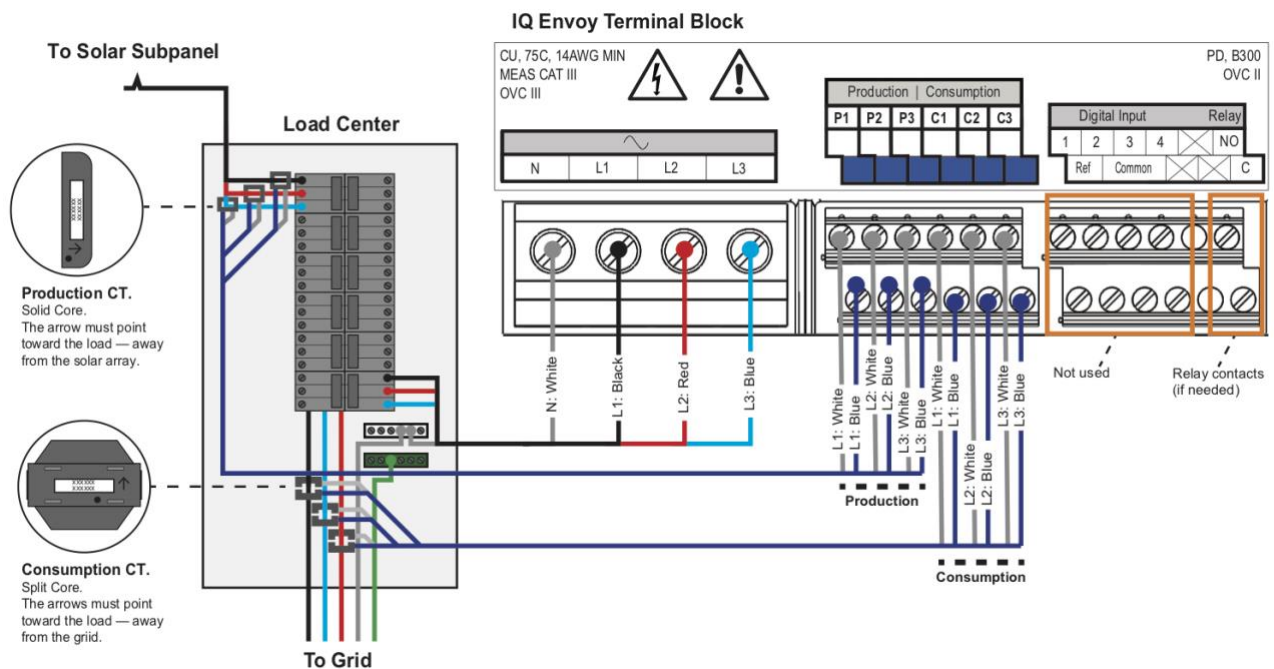
When installing the three-phase IQ Commercial Envoy (model ENV-IQ-AM3-3P), make sure the voltage configuration is 208Y/120 three-phase at the solar subpanel. Do not use the IQ Commercial Envoy for 240 high-leg delta or 240 delta configurations. For such cases, use the single-phase IQ Envoy (ENV-IQ-AM1-240).

The production CTs and optional consumption CTs may be installed if the following criteria can be met.

- **Production** CTs are limited to 200A of continuous current / 250A OCPD – 72kW AC. Using parallel connected CTs for up to 500A – 144kW AC is allowed if your system AC wiring makes this possible. The internal aperture of the solid core production CTs measures 19.36mm to support 250MCM THWN conductors (max).
- **Consumption** CTs are limited for electrical services up to 250A with parallel runs up to 500A. The internal aperture of the split core CTs measures 0.84" x 0.96" (21.33mm x 24.38mm) to support 3/0 THWN conductor. CT wire insulation has a 600V rating and may be run alongside other current carrying conductors.

The IQ Microinverter system does not use a neutral, and a neutral is not required on the roof. However, a neutral is required for operation of the IQ Commercial Envoy.

The diagram below shows how to properly wire an IQ Commercial Envoy (model ENV-IQ-AM3-3P) into a 208Y/120V three-phase system.

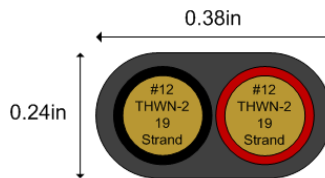


Q Cable and IQ Microinverter Accessories

The IQ Microinverter system uses a new and improved cabling system. Q Cable is lighter than previous generation cabling systems and easier to manage, thus driving down overall system costs. Q Cable is a purpose-built single-phase cable containing two 12 AWG conductors with integrated AC connectors. You can use the cable in single-phase or three-phase applications. The Q Cable male connectors plug directly into the IQ Microinverters, whose double insulated rating requires no neutral or ground conductors.

Q CABLE SPECIFICATIONS	
Voltage rating	600V (connector rating 250 V)
Cable temperature rating	90° C (194° F)
Certification	UL3003, DG cable
Flame test rating	FT4
Compliance	RoHS, OIL RES I, CE, UV resistant, combined UL for Canada and United States
Conductor rating	THHN/THWN-2 dry/wet

Q Cable is a UL3003 DG (Distributed Generation) listed cabling system. The DG cable standard UL3003 is based upon the construction specifications (wet rated) of TC-ER cable, which may be installed in raceway as per NEC 336.10(3). The Q Cable and raw Q Cable are manufactured with DG cable to the specifications in the *Q Cable Specifications* Table.



Refer to the UL guide card for DG cable: http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=QHZR.GuideInfo&ccnshorttitle=Distributed+Generation+Cable&objid=1085285873&cfqid=1073741824&version=versionless&parent_id=1085285872&sequence=1

Q Cable is available in three connector-spacing options:

- 1.0m portrait module pitch (connector pitch is 1.3m) to accommodate modules in portrait orientation
- 1.7m landscape module pitch (connector pitch is 2.0m) to accommodate 60-cell modules in landscape orientation
- 2.0m landscape module pitch (connector pitch is 2.3m) to accommodate 72-cell modules in landscape orientation





Raw Q Cable without integrated AC connectors may be used for runs between separated arrays or to a junction box located some distance away from an array.

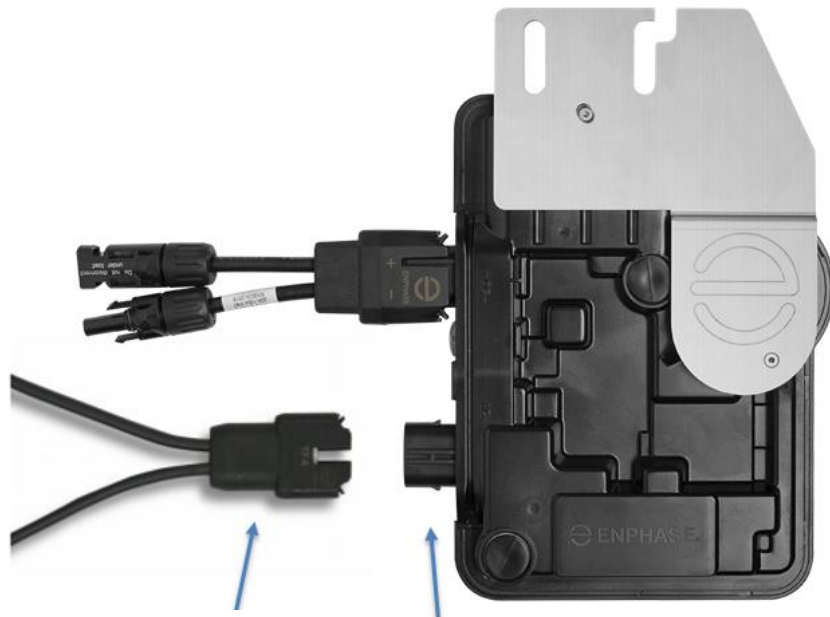
Install supports (clips, etc.) for the Q Cable and raw Q Cable at six-foot intervals or less. Installation requirements for wet-rated cable allow Q Cable and raw Q Cable to be installed in conduits, cable trays, and other raceways.

Q CABLE TYPES / ORDERING OPTIONS				
Model Number	Description	Connector spacing	PV module orientation	Connector count per box
Q-12-10-240	Q Cable for 60/72 cell 1.0m portrait module	1.3 m (4.2 ft.)	Portrait	240
Q-12-17-240	Q Cable for 60-cell 1.7m landscape module	2.0 m (6.5 ft.)	Landscape (60-cell)	240
Q-12-20-200	Q Cable for 72-cell 2.0m landscape module	2.3 m (7.5 ft.)	Landscape (72-cell)	200
Q-12-RAW-300	Q Cable, 12 AWG, no connectors, 300m length	N o t a p p l i c a b l e		

ENPHASE Q CABLE ACCESSORIES

Name	Model Number	Description
Field Wireable Q Connector (male)	Q-CONN-10M	Make Q Cable connections to any Q Aggregator open connector or female Field Wireable Q Connector
Field Wireable Q Connector (female)	Q-CONN-10F	Make Q Cable connections to any Q Cable open connector or male Field Wireable Q Connector
Q Clip	Q-CLIP-100	Used to fasten cabling to the racking or to secure looped cabling
Q Cable Disconnect Tool	Q-DISC-10	Disconnect tool for Q Cable connectors, DC connectors, and AC module mount
Q Sealing Caps (female)	Q-SEAL-10	Female sealing cap for unused Q Cable connectors
Q Cable Terminator	Q-TERM-10	Terminator for unused Q Cable ends
IQ Replacement DC Adapter (MC4)	Q-DCC-2	IQ Microinverter replacement adaptor for MC4 DC connector
IQ Replacement DC Adapter (UTX)	Q-DCC-5	IQ Microinverter replacement adaptor for UTX DC connector

	Q Cable Terminator Terminator for unused cable ends, sold in packs of ten (Q-TERM-10)		Q Sealing Caps Sealing caps for unused aggregator and cable connections (Q-BA-CAP-10 and Q-SEAL-10)
	Q Cable Disconnect Tool Plan to use at least one per installation, sold in packs of ten (Q-DISC-10)		Q Clip Used to fasten cabling to the racking or to secure looped cabling, sold in packs of one hundred (Q-CLIP-100)



Male connector on Q Cable

Female connector on IQ Microinverter

Field Wireable Q Connectors

You can use the male or female Field Wireable Q Connectors to extend the Q Cable (with connectors) or the raw Q Cable (without connectors). Installers assemble the Field Wireable Q Connectors using a crimp tool and the provided terminals.

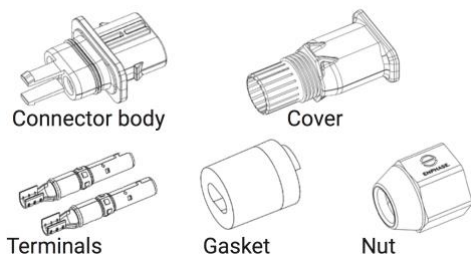
Enphase recommends the Multi-Contact PV-CZM-18100, -19100, or -22100 crimp tools.

Each male or female Field Wireable Q Connector includes the corresponding male or female terminals, so be sure to keep the terminals separate, as they are not interchangeable.

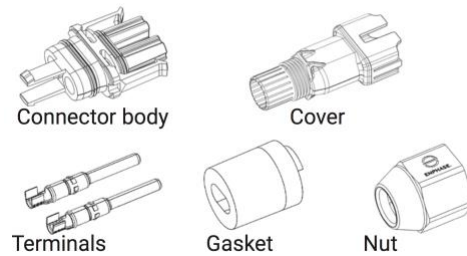
Note:

- Use only the provided terminals, and do NOT use the Field Wireable Q Connectors with other types of terminals.
- Use the Field Wireable Q Connectors only with Enphase Q Cable, and do NOT use other types of cables or conductors.

FEMALE CONNECTOR PARTS

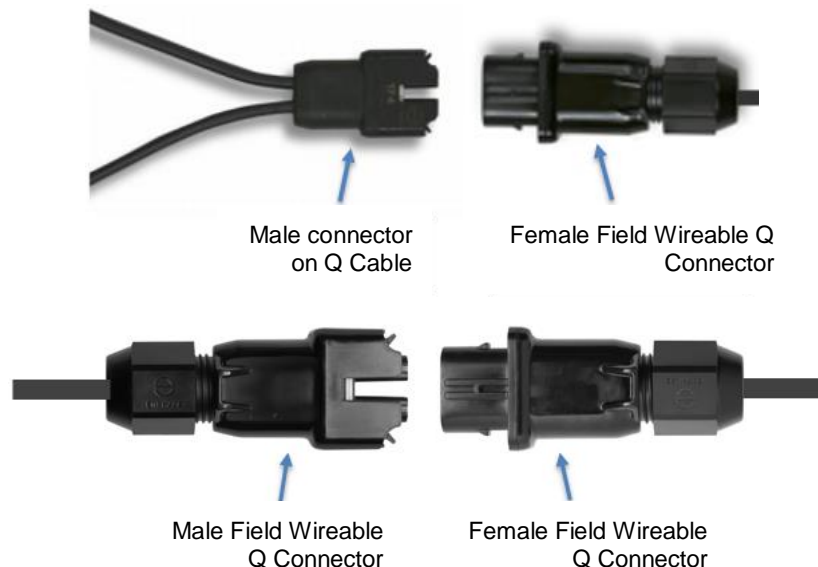


MALE CONNECTOR PARTS



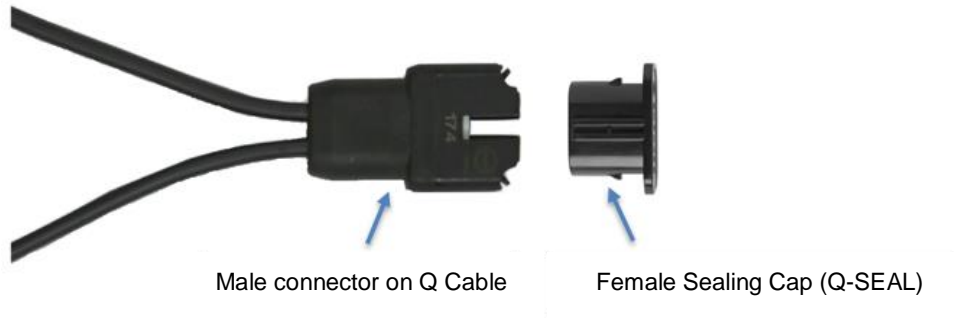
Connector Type	Will connect to
Field Wireable Q Connectors (Male)	IQ Microinverter, or a female Field Wireable Q Connector
Field Wireable Q Connectors (Female)	Q Cable connector or a male Field Wireable Q Connector

When the microinverters are located some distance from the roof top junction box, it may be most economical to use raw Q Cable (without connectors) to run across an array or to run through raceway, conduit or a chase to another array.

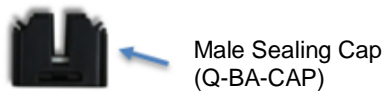


Sealing Caps

Unused Q Cable connectors must be sealed with a watertight sealing cap (Q-SEAL).



Use male sealing caps to temporarily seal any exposed IQ Microinverter connectors not connected to the Q Cable to protect against moisture or water damage at the exposed connector during construction.



Q Terminator

Install a terminator on any cut end of Q Cable that is not terminated with a Field Wireable Q Connector.



Commercial IQ System Design

The new IQ system provides the lowest installed cost of any three-phase microinverter system. The IQ system can be interconnected to a three-phase, 208Y/120V utility service or to a 240 high-leg delta (with stinger) without any transformers. Other utility voltages are supported with the installation of a transformer.

Each IQ Envoy or IQ Commercial Envoy can support up to 300 Enphase Microinverters communicating over power line communication for systems with common net metering functionality.

More than one IQ Envoy may be installed on a site, reporting into the same system into Enlighten. For systems larger than 300 microinverters, or for systems with multiple IQ Envoys on a common transformer, it is important to provide line communication filtering for electrical isolation between each IQ Envoy powerline communication domain. The communication domain is the fundamental building block in an Enphase Microinverter system, and the maximum number of microinverters per communication domain is 300 for systems with common net metering functionality. Consult Enphase if you must exceed 300 micros per IQ Envoy.

In systems where an electric utility interconnection requires advanced grid functionality, e.g., California Rule 21, Enphase requires a limit of 300 Enphase Microinverters on each IQ Envoy.

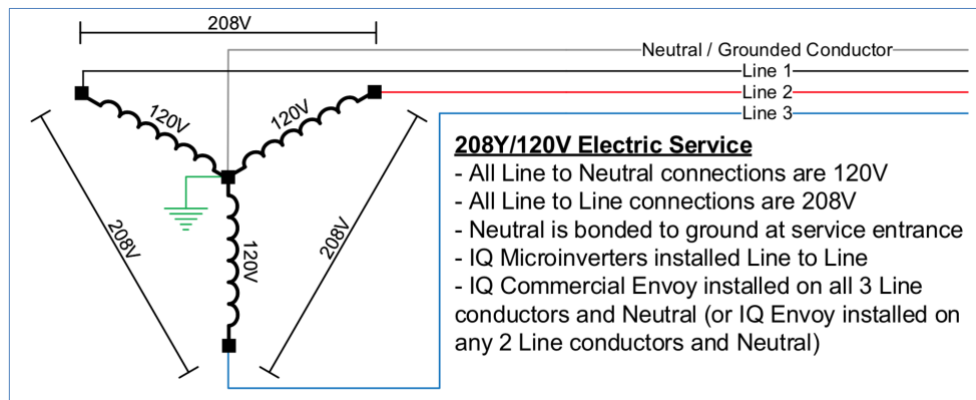
Three-phase, 208Y/120V System Design

Designing a three-phase, 208Y/120V system is straight-forward and simple. Design the system much like you would design a residential system, using two-pole circuit breakers. The two-pole circuit breakers are installed in a three-phase, 208Y/120V panel board. Take care to balance the number of microinverters across the three phases.

A neutral is not required to the roof with the microinverter branch circuits, and the IQ Micros do not have a neutral connection. However, a 120V line to neutral connection is required to power the IQ Envoy. Therefore, it makes sense to install a neutral conductor at the solar subpanel and to power the Envoy from a branch circuit breaker wired directly off the solar subpanel. Wire the IQ Envoy with two hot conductors and a neutral.

A 208Y/120V interconnection is a Wye type interconnection. A Wye utility service requires a neutral ground bond at the center point of the transformer.

208Y/120V Electrical Service Conceptual Schematic



Ampacity Calculations for 208V Branch Circuits on Two-Pole Circuit Breakers

Calculate the ampacity of a two-pole branch circuit as follows:

$$\# \text{ of Microinverters} * \text{Inverter Continuous Output Current Rating} = \text{Branch Circuit Output Current}$$

	IQ 6 (208V)	IQ 6+ (208V)	IQ 7 (208V)	IQ 7+ (208V)	IQ 7X (208V)
Maximum Continuous Output Current Rating	1.11A	1.35A	1.15A	1.39A	1.51A

For a fully populated branch circuit of 11 IQ 7+ Microinverters, the continuous output current rating is:

$$11 * 1.39A = 15.29A$$

NEC Article 690.9(B) requires a 125% factor be applied to the continuous output current for sizing overcurrent protection of the branch circuit:

$$15.29A * 1.25 \text{ safety factor} = 19.1A$$

A 20A branch circuit overcurrent protection device (OCPD) is required for 11 IQ 7+ Microinverters at 208V.

Ampacity Calculations for Three-Phase Feeders to 208Y/120V Solar Subpanel

Calculate the ampacity of the three-phase, 208Y/120V solar subpanel feeders from the continuous output power rating as follows:

$$\# \text{ of Microinverters} * \text{Inverter Continuous Output Power Rating} = \text{Total Continuous Output Power}$$

$$\text{Total Continuous Output Power} / 208V / 1.732 = \text{Solar Subpanel Continuous Ampacity}$$

	IQ 6 (208V)	IQ 6+ (208V)	IQ 7 (208V)	IQ 7+ (208V)	IQ 7X (208V)
Maximum Continuous Output Power Rating	230VA	280VA	240VA	290VA	315VA

For a solar subpanel with balanced 219 IQ 7+ Microinverters, the continuous output current rating is:

$$219 * 290VA = 63,510VA$$

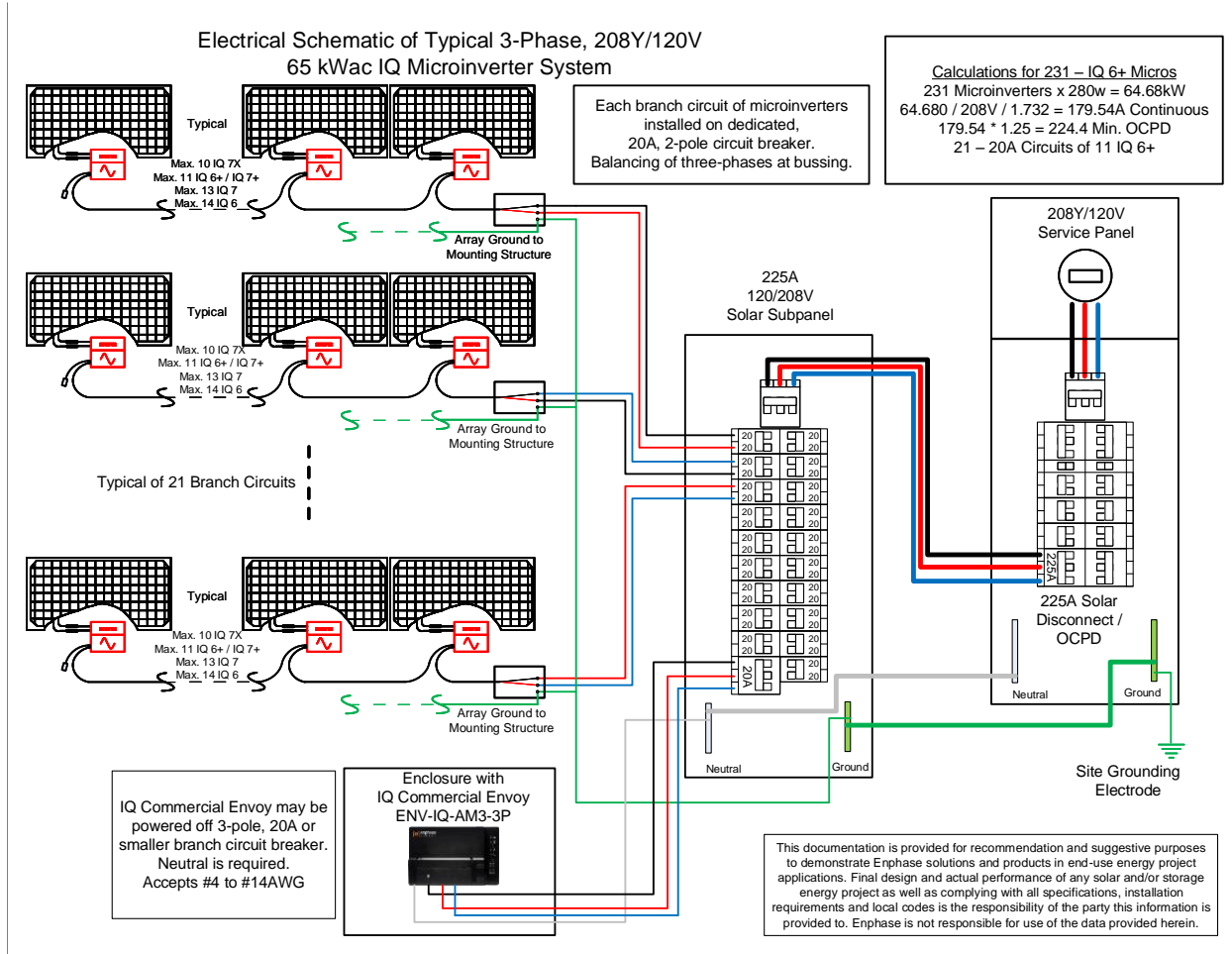
$$63,510VA / 208V / 1.732 = 176.29A$$

NEC Article 690.9(B) requires a 125% factor be applied to the continuous output current for sizing overcurrent protection of the branch circuit:

$$176.29A * 1.25 \text{ safety factor} = 220.4A$$

A 225A overcurrent protection device (OCPD) is required for 219 - IQ 7+ Microinverters at 208Y/120V.

Example 208Y/120V Electrical Schematic



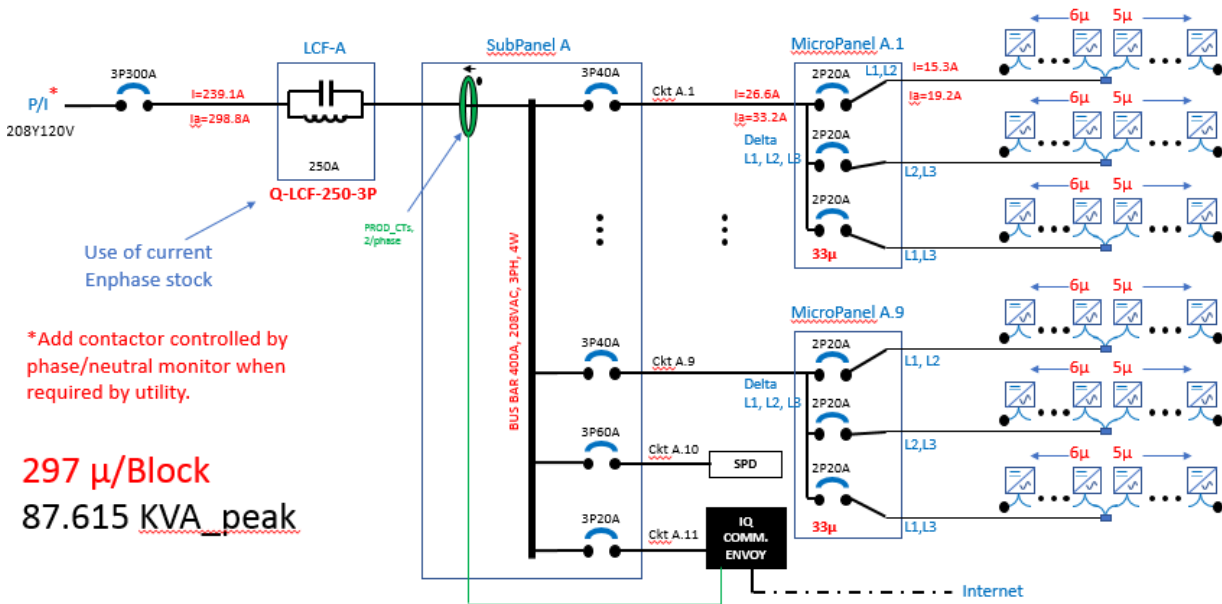
The following Example C&I Single Line Diagram (SLD) represents the recommended (300 microinverters per IQ Envoy) communication domain building block for designing large systems. The number of microinverters can be adjusted down depending on actual system size.

In cases where the subpanel feeder exceeds 200A and IQ Commercial Envoy production metering is required, the feeder must be two parallel conductors to accommodate a second set of production CTs in parallel per phase, since the maximum capacity for a single production CT is 200A. In this case, you will need three additional Enphase Production CTs in addition to the three included with the IQ Commercial Envoy.

Example 208Y/120V Basic Building Block Diagram

The following shows an example 208Y/120V basic building block single line diagram for IQ 7+ with optional field-assembled MicroPanel, keeping within maximum 300 microinverters per IQ Envoy recommendation.

C&I Block SLD for IQ7PLUS-72-2, 60Hz



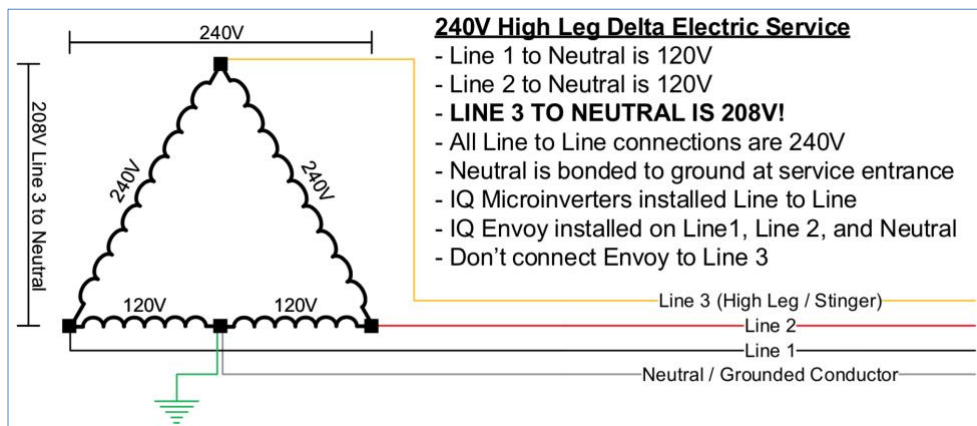
Three-phase, 240V High-Leg Delta System Design

Designing a three-phase, 240V high-leg delta (also known as 240V delta with stinger) system is very simple with Enphase IQ Microinverters and does not require a transformer. IQ Microinverters do not require a neutral connection, so can be installed on all three phases in a 240V system.

When interconnecting an IQ Microinverter system to a 240V high-leg delta system, the IQ Envoy (Model ENV-IQ-AM1-240 M) must be connected to the two hot conductors that are 120V line to neutral. The high-leg (or stinger leg) will measure 208V from line to neutral. That stinger leg can damage sensitive electronics and should not be connected to the IQ Envoy.

For 240V delta systems without a neutral, use an inexpensive (~\$40) auto-transformer to generate a neutral to power the IQ Envoy. Follow the installation recommendations for interconnecting to a 240V delta system.

240V High Leg Delta Electrical Service Conceptual Schematic



Ampacity Calculations for 240V Branch Circuits on Two-Pole Circuit Breakers

Calculate the ampacity of a two-pole branch circuit as follows:

$$\# \text{ of Microinverters} * \text{Inverter Continuous Output Current Rating} = \text{Branch Circuit Output Current}$$

	IQ 6 (240V)	IQ 6+ (240V)	IQ 7 (240V)	IQ 7+ (240V)	IQ 7X (240V)
Maximum Continuous Output Current Rating	0.96A	1.17A	1.00A	1.21A	1.31A

For a fully populated branch circuit of 13 IQ 7+ Microinverters, the continuous output current rating is:

$$13 * 1.21A = 15.73A$$

NEC Article 690.9(B) requires a 125% factor be applied to the continuous output current for sizing overcurrent protection of the branch circuit:

$$15.73A * 1.25 \text{ safety factor} = 19.7A$$

A 20A two-pole branch circuit overcurrent protection device (OCPD) is required for 13 IQ 7+ Microinverters at 240V.

Ampacity Calculations for Three-Phase Feeders to 240V High-Leg Delta Solar Subpanel

Calculate the ampacity of the 240V high-leg delta three-phase solar subpanel feeders from the continuous output power rating as follows:

$$\# \text{ of Microinverters} * \text{Inverter Continuous Output Power Rating} = \text{Total Continuous Output Power}$$

$$\text{Total Continuous Output Power} / 240V / 1.732 = \text{Solar Subpanel Continuous Ampacity}$$

	IQ 6 (240V)	IQ 6+ (240V)	IQ 7 (240V)	IQ 7+ (240V)	IQ 7X (240V)
Maximum Continuous Output Power Rating	230VA	280VA	240VA	290VA	315VA

For a solar subpanel with 267 IQ 7+ Microinverters, the continuous output current rating is:

$$267 * 290VA = 77,430VA$$

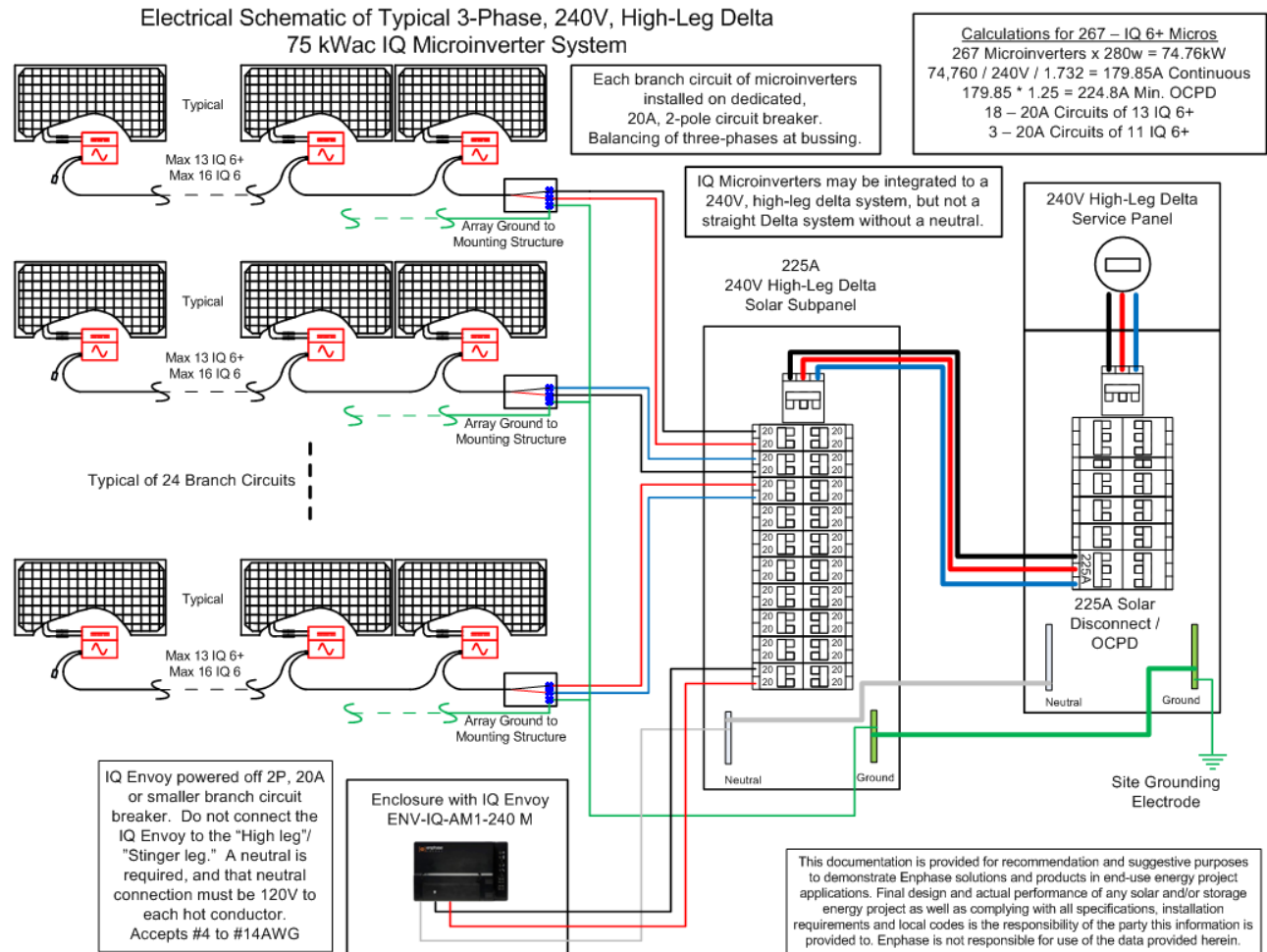
$$77430VA / 240V / 1.732 = 186.27A$$

NEC Article 690.9(B) requires a 125% factor be applied to the continuous output current for sizing overcurrent protection of the branch circuit:

$$186.27 * 1.25 \text{ safety factor} = 232.8A$$

A 250A overcurrent protection device (OCPD) is required for (267) IQ 7+ Microinverters.

Example 240V High-Leg Delta Electrical Schematic



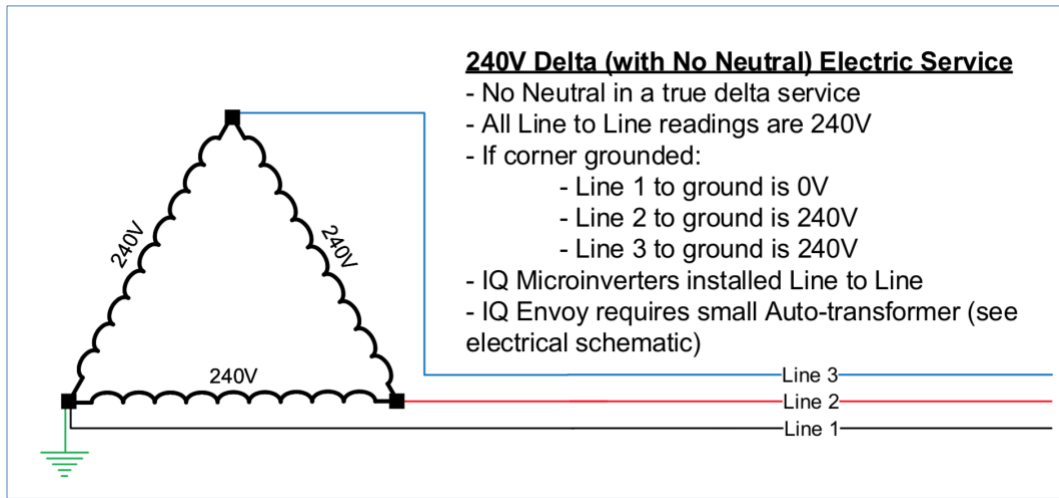
Three-Phase, 240V Delta with No Neutral

All of the recommendations related to a 240V system apply to a 240V delta, with the exception that you must use a small auto-transformer to provide a 120V connection to power the IQ Envoy.

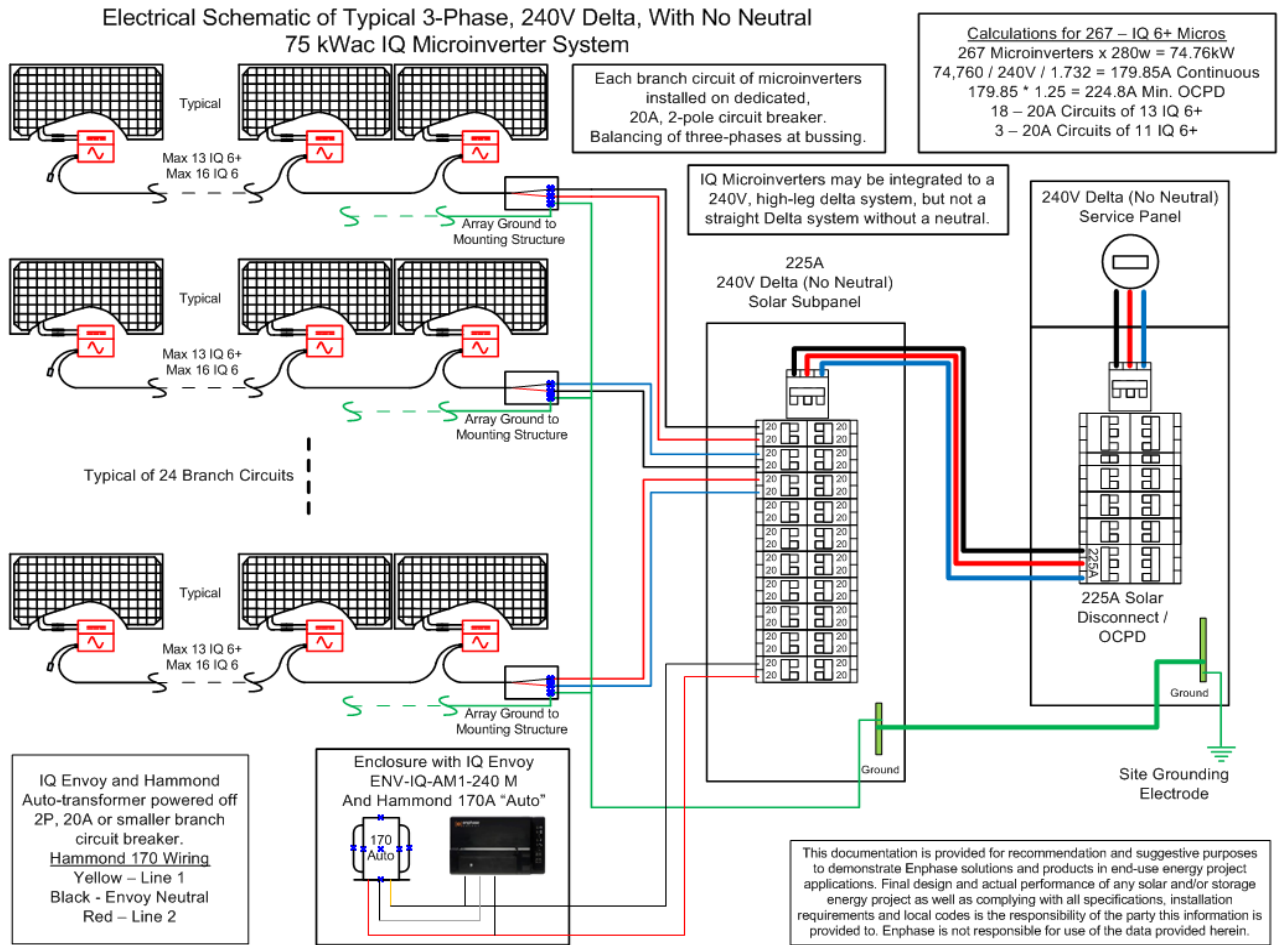
Generating a Neutral for 240V Delta Interconnections

When the site is 240V delta without a neutral, use an auto-transformer for generating a 120V connection to power the IQ Envoy. The Hammond 170 Auto line of auto-transformers is affordable and available in sizes starting at 50 watts. The 170A, 170B, and 170C are all listed by CSA. The IQ Envoy is less than three watts, so the smallest auto-transformer in the Hammond 170 Auto line is sufficient. More information is available at <http://www.hammondmfg.com/168.htm>.

240V Delta (with No Neutral) Electrical Service Conceptual Schematic



Example 240V Delta (With No Neutral) Electrical Schematic



Interconnecting IQ Microinverters to Other Voltages

For interconnection to system voltages other than 120/240V single-phase, 120/208 single-phase, 208Y/120V three-phase, and 240V high-leg delta three-phase, a transformer is required to interconnect to the grid.

While transformers interconnect Enphase Microinverter Systems to any utility power voltage, they also offer other benefits.

- For many projects, it is cost effective to distribute the power at the higher utility voltages and then step down the voltage to 208Y/120V or 240V high-leg delta at each sub-system. This practice results in more transformers but can be cost effective when wire runs are greater than 250 feet.
- Choose transformers with adjustable taps. Use the tap to make minor adjustments when the utility-provided voltage is high or when optimizing conductor sizing versus expected voltage rise for the value engineered PV system.

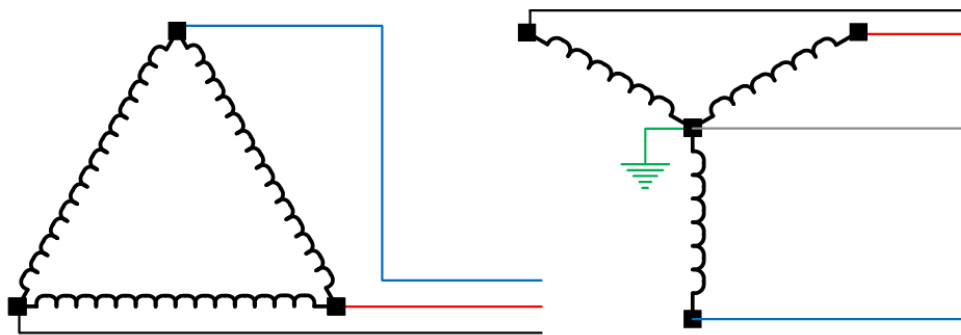
It is common to specify high-efficiency or ultra-high efficiency, general purpose, dry-type transformers for an Enphase Microinverter System. It is not necessary to specify power factor correcting transformers or K-factor transformers.

Specify the transformer kVA size to meet the inverter output in kW AC. Some additional deratings, such as adjustments for power factor and temperature may apply. Refer to the transformer manufacturer's specifications for transformer sizing.

Most transformers for Enphase systems are specified as delta on the primary/utility side and as 208/120 Wye or 240V high-leg delta on the secondary/PV side. Even if the utility voltage is Wye, such as a 480Y/277V service, it is still best to provide a delta configuration with no neutral to the primary/utility side of the transformer. This configuration works well, lowers wire costs, and is recommended by the manufacturers of transformers for improved performance and reduced harmonics.



Delta and Wye Wiring



The following table lists utility voltage values and transformer requirements.

Transformer Specification (Table of Various Voltage Configurations)

Utility voltage configurations	Nominal voltages between the lines and neutral/ground					
	L1 to L2	L2 to L3	L3 to L1	L1 to N/G	L2 to N/G	L3 to N/G
208Y/120V	208	208	208	120	120	120
No transformer would be specified for interconnection						
480Y/277V	480	480	480	277	277	277
Specify a 480 delta:208Y/120V transformer or 480 delta:240 high-leg delta transformer						
480 delta (*corner grounded)	480	480	480	-	-	-
Specify a 480 delta:208Y/120V transformer or 480 delta:240 high-leg delta transformer						
240 delta	240	240	240	-	-	-
Install a 240V to 120/240V auto-transformer for powering the Envoy (Hammond 170 "Auto")						
240 high-leg delta	240	240	240	120	120	208
No transformer would be required for interconnection of IQ System						
600Y/347V	600	600	600	347	347	347
Specify a 600 delta:208Y/120V transformer or 600 delta:240 high-leg delta transformer						

Multiple IQ Envoys on a Single Site — Filtering Communication Domains

Enphase IQ Microinverter systems use power line communications (PLC) to communicate module level data between the microinverters and the IQ Envoy. Each IQ Envoy can communicate with a maximum of 600 IQ Microinverters. The PLC signal is at 110kHz in an IQ System. In a commercial scale system, the IQ Envoy is continuously polling the microinverters for their recent power production, temperature, voltage, amperage, and frequency data. To ensure good communication between the IQ Microinverters and the IQ Envoy, install power line filters or isolation transformers to:

- Prevent cross-domain communications between multiple IQ Envoys.
- Minimize electrical noise at frequencies near 110kHz.
- Minimize the distances between the IQ Microinverters and the IQ Envoys.

When multiple IQ Envoys are on a single utility transformer, use a filter to isolate each IQ Envoy and its associated IQ Microinverters from the other IQ Envoys and IQ Microinverters. This is particularly important for large-scale projects.

In a large-scale project, each sub-system or communication domain generally consists of a single IQ Envoy, a single panel board, a power line filter, and the branch circuits off that panel board. A differential mode filter prevents power-line communication signals from one IQ Envoy communication domain from interfering with other communication domains. The filter also eliminates electrical noise from site loads.

With multiple communication domains, the total number of filters can be one less than the total number of communication domains. For example, if all other communication domains have filters, the last communication domain can be installed without a filter ($n - 1$).

If the system contains fewer than 600 IQ Microinverters with a single IQ Envoy on-site (a single communication domain), a filter is not required to isolate communication domains from each other but may be used to ensure a clean PLC environment free of electrical noise.

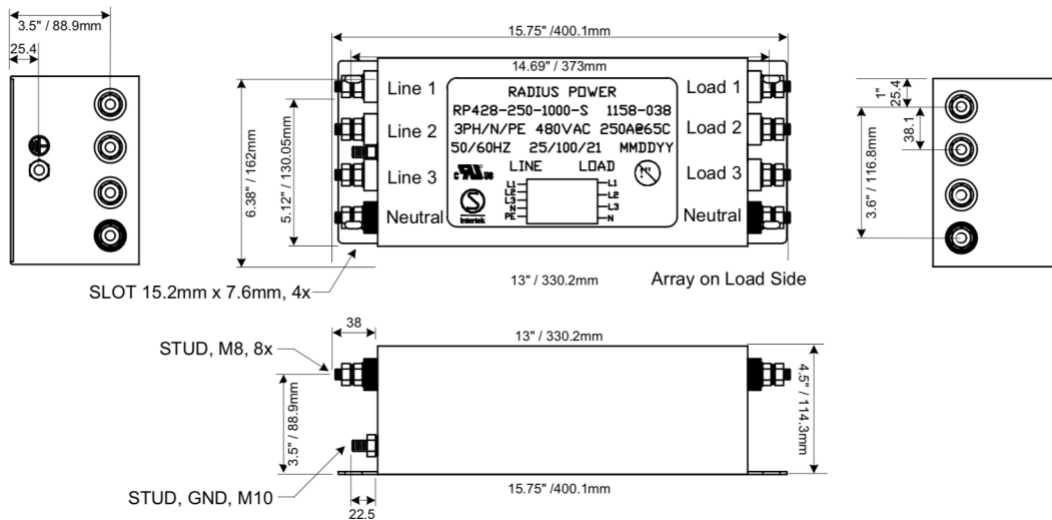
For sites with multiple IQ Envoys, the conductors and conduits of each communication domain must be kept physically separated from the conductors and wiring of other communications domains by at least 12 inches. Coupling of the signals can occur between the conductors and conduits when run together, especially on long conduit and wire runs.

Filtering with Enphase Q-LCF-250-3P

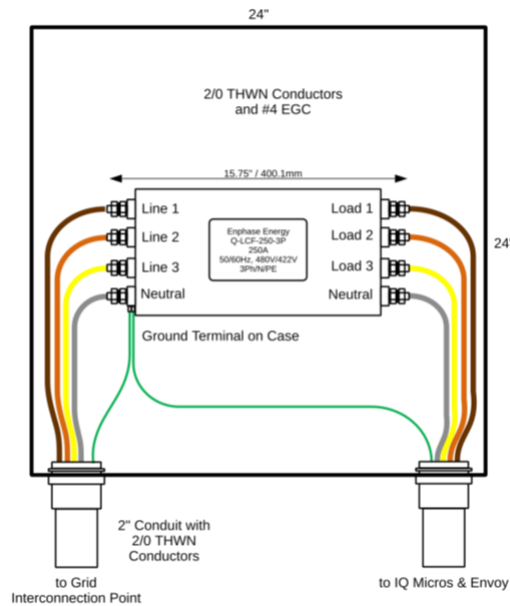
Enphase provides a 250A power line filter, the Q-LCF-250-3P specific for the IQ System Power Line Communication (PLC) frequency. You can use it to filter electrical noise or signals between multiple IQ Envoys and their respective communication domains, and/or noise sources from loads or other devices in commercial and industrial settings. The filter must be protected by a 250A or smaller OCPD. When installing a power line filter in an IQ System, the IQ Micros and the IQ Envoy must ALL be located on the load side of the filter. A 250A limit of the filter limits the communication domain to 72kW AC at 208Y/120V or 83kW AC at 240 delta. Do not cross filtered Load and Line connected conductors or run them in the same conduit; this would defeat the purpose of line filtering. Also, do not run filtered Load conductors from more than one IQ Envoy communication domain in the same conduit or cable tray.

For communication domains larger than this, use an isolation transformer to filter the communication domain.

Q-LCF-250-3P Line Communication Filter Mechanical Dimension



Q-LCF-250-3P Line Communication Filter Installation Recommendation



Filtering with transformers

Isolation transformers such as 480 wye to 240 high-leg delta transformers also provide noise filtering and signal filtering between IQ Envoy communication domains. For a system with multiple IQ Envoys, it may be most practical to distribute power at a higher voltage and then step down to the IQ System voltage at each communication domain.

IQ Envoy Installation Options

For three-phase applications, the IQ Envoy should be procured as a stand-alone component, model ENV-IQ-AM1-240. The IQ Envoy communicates with all of microinverters in a three-phase system. The production CT and consumption CTs must not be enabled or installed.

Locate the IQ Envoy adjacent to the solar subpanel and wire it directly off that solar subpanel. The IQ Envoy requires two hot conductors and one neutral conductor.

IQ Commercial Envoy Installation Options

The IQ Commercial Envoy is a three-phase device and should be procured as a stand-alone component, model ENV-IQ-AM3-3P. It communicates with all of the microinverters in a three-phase system connected to the same domain. The IQ Commercial Envoy ships with three solid-core 200A production CTs. Consumption measurement is optional and would require three split core consumption CT, model CT-200-SPLIT, sold separately. The IQ Commercial Envoy has the capacity of measuring up to 400A in both production and consumption by paralleling CTs. Extra CTs sold separately.

Locate the IQ Commercial Envoy adjacent to the solar subpanel and wire it directly to a 3P 20A breaker in that solar subpanel. The IQ Commercial Envoy requires three hot conductors and one neutral conductor.

Installing IQ Envoy/IQ Commercial Envoy in an Outdoor Enclosure

The IQ Envoy or IQ Commercial Envoy must be installed inside an electrical enclosure, keeping the operating temperature of the Envoy in mind. This enclosure must be large enough to house the IQ Envoy. If you use a power line bridge or other networking component, make sure the enclosure can accommodate a receptacle. The enclosure can be metal or non-metallic but should be non-metallic if Wi-Fi or cellular networks are used for the IQ Envoy Internet connection. You must meet the following requirements:

- Use a NEMA type 3R, 4, or better rated outdoor enclosure with hinged cover or screw cover of suitable dimensions. Typical enclosure dimensions are in the range of 10" x 10" x 4" to 12" x 12" x 6".
- Connect the IQ Envoy to two lines and a neutral. A neutral is required for powering the IQ Envoy. It does not ship with a plug-in style power cord, so a receptacle is not required in the enclosure for powering the IQ Envoy.
- Connect the IQ Commercial Envoy to three lines and a neutral. A neutral is required for powering the IQ Commercial Envoy and for metering. It does not ship with a plug-in style power cord, so a receptacle is not required in the enclosure for powering the IQ Commercial Envoy.
- Install a receptacle inside the enclosure if an Ethernet over power line communication (PLC) bridge is desired. The enclosures listed in the following section provide adequate room for a receptacle.
- Install the enclosure in a location that is shaded from extensive periods of direct sunlight. The IQ Envoy and IQ Commercial Envoy are rated for ambient temperatures of -40°F to 115°F when installed in an enclosure.
- **Do not drill holes on the top** of the enclosure or anywhere that allows moisture ingress, if the enclosure is outdoors. If top entry is performed, a water-tight conduit hub, like a Myers Hub or other suitable hub product must be used.
- Do not leave energized terminals or components accessible, and place the enclosure in a location that is accessible only to service personnel.

Enclosure Options for the IQ Envoy

Arlington EB1212-BP Enclosure with Back Plate

- Lockable unit dimensions are 12"x12"x4"
- Easily accommodates the addition of a field-wired receptacle, if needed
- Outdoor rated with hinged door opening upward, but indoor rated with hinge to side



Orbit 57905 Timer Cabinet

- Back plate included, NEMA3R, lockable
- Approximate dimensions are 11"x10"x5"
- Includes a receptacle pre-installed (not wired)
- Mounting plate and IQ Envoy must be removed to install back mounting screws
- Tight wiring space for IQ Envoy with PLC bridge



Integra H12104H* Enclosures**

- Strong metal or poly backplate options, NEMA4, lockable
- Approximate dimensions are 10"x12"x5"
- Easily accommodates addition of a field wired receptacle, if needed
- Manufacturer provides a wide variety of enclosure options, including mounting tabs, and vents



Attabox AH12106 Enclosure with BP1210A Back Plate

- Strong metal or poly backplate options, NEMA4, lockable
- Approximate dimensions are 10"x12"x5"
- Easily accommodates the addition of a field wired receptacle, if needed
- Manufacturer provides a wide variety of enclosure options, including mounting tabs, and vents

Cantex 5133714 Enclosure with Cover and Gasket

- NEMA4, PVC electrical enclosure
- Approximate dimensions are 12"x12"x6"
- Requires eight screws to install or remove cover and gasket

Splicing Q Cable and Raw Q Cable with Junction Boxes

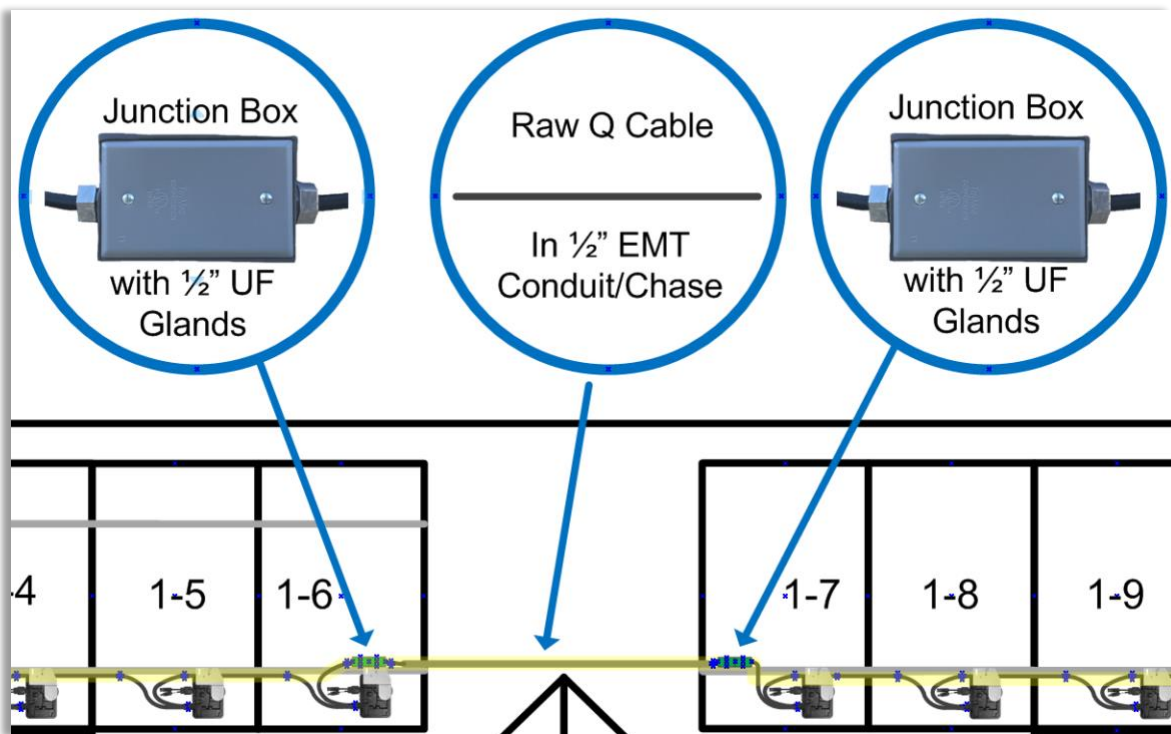
For complex installations that include multiple arrays, it is possible to use raw Q Cable (Q-12-RAW-300) to service the arrays and branch circuits that originate directly at the primary roof-mounted junction box. In the case that Field Wireable Q Connectors are not readily available, you can use a small junction box to splice two sections of Q Cable together or to splice Q Cable to raw Q Cable.



The raw Q Cable is available in 300m (984ft) cable rolls (Q-12-RAW-300).

Terminate the raw Q Cable in one of the following manners:

- Into a junction box using a ½” service entrance (SE) strain reliefs, UF cable glands, or Heyco® -Tite Liquid Tight Cordgrips for Enphase Q Cables
- With a Field Wireable Q Connector (male or female)



Wire Management of AC and DC Cables Under Array

Since the Q Cable contains only two conductors, it is smaller and lighter than the previous generation Engage Cable. For this reason, we use cable clips with a reduced wire retention area for the Q Cable. The outer dimensions of the Q Cable allow it to be supported by many of the existing PV cable clips and USE-2 cable clips that are frequently used for supporting the DC module leads today.

Enphase has evaluated and developed wire clips for a wide variety of applications, including rail based applications, rail-less applications, and AC module applications. These clips are listed later in this section.

DC Cable Adapters for IQ Microinverters

Some IQ Series Microinverters (IQ7-60-2-US, IQ7PLUS-72-2-US, and IQ7X-96-2-US) ship with MultiContact MC4 DC connectors. You can order Amphenol UTX DC connectors, if needed. To change out the adapters, remove the DC connector assembly on the microinverter and replace it using the Enphase Disconnect Tool for Q Cable connectors (Q-DISC). This tool can disconnect both the AC and DC connectors on the microinverter and disconnect MC4 and UTX connectors. For an AC Module with Enphase IQ Micro, the Disconnect Tool also provides a means to release the AC module latches to lower the microinverter into shipping position if needed.

Replacement DC adapters are also available for IQ Microinverters:

Q-DCC-2	IQ Microinverter Replacement Adaptor for MultiContact MC4 DC Connector
Q-DCC-5	IQ Microinverter Replacement Adaptor for Amphenol UTX DC Connector



Disconnect Tool



Wire Management Clips for Attaching Q Cable to Solar Mounting Rails


The Enphase Q Clip (Q-CLIP-100) can manage one or two Q Cables or raw Q Cables to a solar mounting rail. This clip has been evaluated with a large selection of racking systems and works with most available rail based racking systems. These clips support the cable along the rail and may be adequate for supporting the cabling during row to row transitions (depending on cable length), but additional support may be provided from module frame clips. Use at least one clip or other support for every six feet of cable.



Wire Management Clips for Attaching Q Cable to Module Frames for Rail-less and AC Module Applications

There are a variety of products available for supporting DC module leads off the roof. Most of the wire clips available for PV cable and for USE-2 cable can also be used to attach Q Cable to module frames. Attaching Q Cable to module frames is useful for rail-less racking systems since there is no rail on which to support the cabling. Also, for AC module installations, it is often more convenient to clip the Q Cable to the module frame than to clip the Q Cable to the racking system (if possible).

Q Cable and raw Q Cable must be supported at intervals not to exceed 6 feet. This helps to ensure that the cable does not touch the roof surface.

Manufacturer	Model	Image
Nine Fasteners	DCS-1307 PV cable clip DCS-1306 USE-2 cable clip	
Burndy / Wiley Electronics	ACME ACC-PV PV cable clip	
Heyco Products	SunRunner PV cable clip	

Supporting the DC Module Leads

Prepare the modules using clips on the DC module leads to prevent the leads from resting on the roof. It is best to prepare the modules on the ground before installation. Install the wire clips and DC module leads to allow for easy connection to the microinverter while also supporting the conductors off the roof.



Once the modules are prepared, install them on the racking. Secure any loose wires or cables to the module frames with properly sized wire clips. Ensure that all conductors are supported off the roof.

AC Wire Management at the Junction Box

Wire management practices at the junction box are critical to the long-term reliability of any PV system. Installers often install the roof-mounted junction box on the side of a rail.

For Junction Box Applications

Follow these recommendations to prevent moisture from accumulating in the junction box. This helps to improve system reliability while ensuring that the wiring connections last for the life of the system.

- Make sure that cables enter the junction box from the side or from the bottom, never from the top where water can enter the enclosure.
- Install cables with a drip loop. Secure the cable so that water drains away from the cable entry.
- Use properly sized strain reliefs and cord grips. Note that the Q Cable is elliptical, so the cable gland securing the Q Cable must contain an inner gland designed for elliptical cable. These cable glands are commonly available from electrical distributors or home improvement stores and are often available under the following names:
 - 1/2" Service Entrance (SE) watertight connectors
 - UF Cable Glands
 - Heyco® -Tite Liquid Tight Cordgrips for Enphase Q Cables
 - M3231GCZ (1/2" NPT) and M3234GDA-SM (3/4" NPT).
 - The 1/2" version provides liquid tight entry for one Enphase Q Cable – .24 x .38" (6,1 x 9,7 mm).
 - The 3/4" version provides liquid tight entry for up to two Enphase Q Cables – .24 x .38" (6,1 x 9,7 mm) and an additional .130" (3,3 mm) dia. hole for a #8 solid grounding cable.
 - The 3/4" version uses a skinned-over technology, so any unused holes will retain a liquid tight seal.
- Properly tighten the strain reliefs to prevent cable movement and to prevent water ingress.
- Install the junction box to meet the manufacturer's recommended mounting and orientation requirements. Use NEMA 4 enclosures. (NEMA 3 enclosures have a limited mounting orientation range and may not accommodate typical rooftop installations.)
- Consider drilling a small drain hole in the bottom, lowermost corners of the junction box, so that moisture or condensate can drain out of the junction box.

Installing IQ Microinverters with Frame Mount Bracket

The Enphase Frame Mount bracket attaches the Enphase Microinverters directly to module frames. This is an ideal solution for rail-less racking solutions, whether residential or commercial. When using the Enphase Frame Mount product, support the Q Cable to keep it off the roof by clipping it to the module frames using module edge wire clips that work with PV cable and USE-2 cable.



Appendix A: Lightning and Surge Suppression in Commercial Systems

Although not common, you must consider the possibility of lightning strikes. Also, surges can occur anywhere on the electrical grid. Enphase Microinverters, like all electrical components, can be damaged by lightning strikes or voltage surges from the electrical grid. The guidelines in this section help to minimize any lightning- or surge-related issues in your commercial installation.

Enphase suggests that you protect your system with lightning and surge suppression devices.

Enphase Microinverters have integral surge protection. However, if the surge has sufficient energy, the protection built into the microinverter can be exceeded and the equipment may be damaged.

There are a wide range of devices available from equipment manufacturers with a range of warranties. Enphase does not warrant or guarantee the performance of any of these products. In addition to having some level of surge suppression, it is important to have insurance that protects against lightning and electrical surges. Install protective devices per vendor instructions.

Examples

- Citel DS73RS-120 surge protector; [data sheet](#)
- Delta LA-303 lightning arrester; [website](#)

An inline surge protective device provides the greatest level of protection but is often more expensive than a surge protective device that is placed in parallel to the microinverter panel board and will likely filter the power line communications in a system.

If using an inline surge protective device, then the IQ Envoy and IQ Microinverters must be located together on the load side of this device.

Appendix B: Phase Loss Protection

For project success, you must consider phase balance when designing commercial PV systems using IQ Micros that interconnect to a three-phase service. You must also consider the possibility of phase loss.

This appendix provides details and recommends best practices for designing systems compatible with phase imbalance, phase loss, and neutral sense guidelines that may be required by some AHJs and/or utilities to meet recent IEEE requirements.

Phase Loss Scenarios

The Enphase IQ Series Microinverters connect to two of the three available phases of a three-phase 208V WYE service. Since the Q Cable is a two-wire line to line cable and branch circuits are connected to two-pole circuit breakers, system design should consider balancing the number of microinverters across all three phases in the panel board.

If a grid failure occurs on only one phase (ground fault or load rejection), then one third of the microinverters connected to the other two phases may be unable to detect the failure. These microinverters may continue to export power on those phases, contributing to a phase imbalance present on the local grid node.

Phase Loss Hardware Solution

In jurisdictions where the utility requires compliance to IEEE 1547, Enphase requires the use of a phase loss relay system (NPR-3P-208-NA) described in this section. A phase loss relay system is not required for the IQ Microinverter to function, but may be required by some AHJs and/or utilities to meet recent revisions to IEEE 1547 and/or local code requirements. In such instances, it is mandatory that the Enphase Three-Phase Network Protection Relay™ be specified to maintain UL listing of the IQ system.

A phase loss prevention relay system consists of:

- A phase loss relay that monitors the three-line voltages and detects loss of phase
- A contactor that opens all three lines of the circuit to disrupt the power flow
- A UPS to ensure the relay can reconnect after loss of power.

The Enphase Three-Phase Network Protection Relay includes an SEL-547 and an ABB 24V contactor. All of the components are available off the shelf. However, it will need to be assembled by Enphase to bear the UL mark. The device only supports 208V Wye connection since a neutral is required to power the IQ Envoy.

Install the combined relay-contactor system on the PV system side of the interconnection point and on the grid side of the power line filter. For systems with no power line filter, install the relay-contactor system on the grid side of the main PV load center, as shown in the following diagram.

