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Application Note

Commercial System Design Guidelines

1. Introduction

When designing a large grid tied PV system using the Enphase Micro-Inverter system, there are a few recommendations to minimize costs and maximize performance. AC branch circuits can be combined using readily available components, saving material and labor costs, as well as reducing the energy lost to voltage drop. The circuits can also be arranged to ensure high quality transmission within the powerline communications domains. This document will outline the design flow and make best practice recommendations.

2. Determine the number of Modules/Inverters required.

The desired system size for this example is 250 kW STC
The chosen PV module is rated at 200 watts STC
The number of modules required would be:

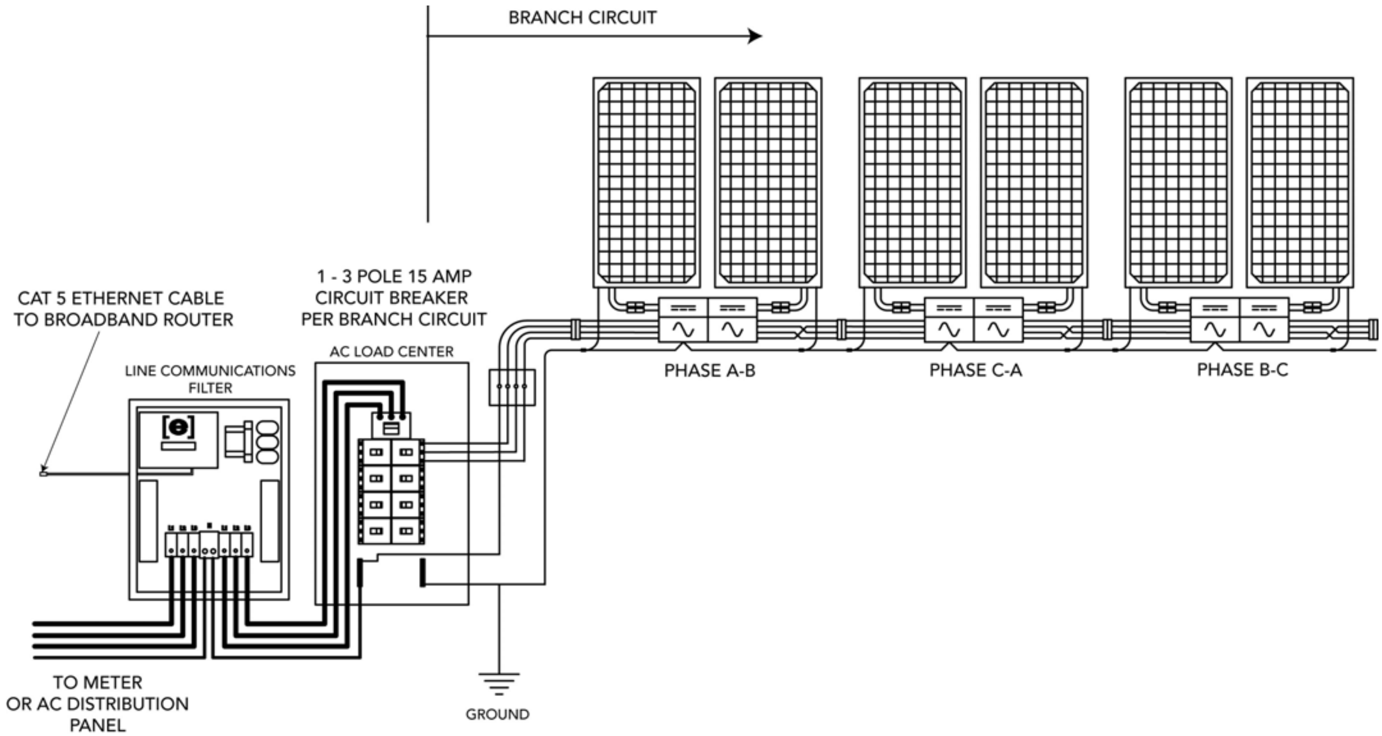
250,000 W ÷ 200 W/Module = 1250 modules

The recommended Enphase micro-inverter for commercial systems is the dual module micro-inverter. The dual module micro-inverter contains 2 inverters and is capable of independently managing 2 PV modules. For this example the required number of inverters would be:

1250 modules ÷ 2 = 625

3. Determining the number of Micro-Inverters per branch circuit

The National Electric Code defines a branch circuit as the circuit conductors between the final overcurrent device protecting the circuit and the devices. The micro-inverters connect end to end to create a chain. The beginning of this chain is wired to a circuit breaker in the main distribution panel or a local load center. This collection of micro-inverters and wiring make up the micro-inverter branch circuit. The maximum size of the circuit breaker protecting each micro-inverter branch circuits is 15 amps.



Since the power output of a photo-voltaic inverter is considered to be continuous, the conductors and overcurrent devices must be sized to carry not less than 125% of the inverter rated output.

15 amps ÷ 1.25 = 12 amps nominal current maximum per 15 amp circuit breaker

The maximum total micro-inverter power allowable on a 15 amp circuit breaker at 480 Vac would be:

12 amps nominal x √3 x 480 Vac = 9965 watts

The dual module micro inverter contains 2 inverters rated at 190 watts ac each for a total of 380 watts ac per micro-inverter.

9965 watts ÷ 380 watts = 26.2 micro-inverters per 15 amp circuit breaker

Conclusion:

For a 480/277 Vac 3 phase circuit the maximum number of micro-inverters allowed on a single branch circuits is 26.

4. Determine the number of Branch Circuits required

1250 modules ÷ 2 modules per micro-inverter = 625 dual module micro-inverters

625 micro-inverters ÷ 26 per branch = 24 branch circuits required

5. Determine the number of Communications Domains required

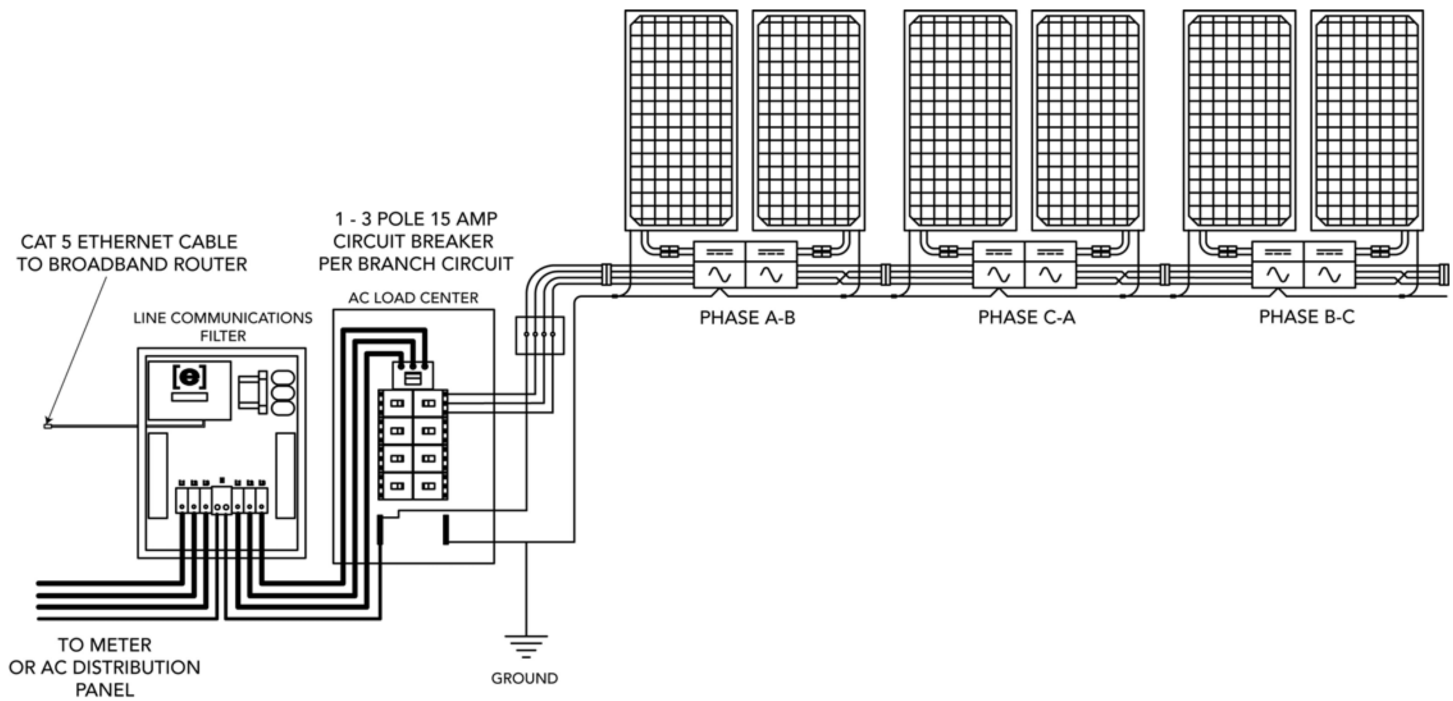
Line Communications Filter

The Enphase Envoy gateway is the data logger / internet gateway for the micro-inverters in the Enphase micro-inverter system. The micro-inverters communicate performance and production data over powerline to the Envoy. We refer to a grouping of one Envoy and the micro-inverters associated with it as a single communications domain. For systems larger than 208 dual micro-inverters or 79 kW, more than one Envoy is required. When multiple Envoy gateways are required, a Line Communications Filter is also required, to prevent communications data from one communications domain from cross-talking to another.

The Line communications filter has a maximum current rating of 125 amps. This rating works well with a 125 amp, 24 space main lug load center containing eight 3-pole 15 amp breakers. Eight branch circuits fully loaded with 26 dual module micro-inverters each, equals a total of 208 dual module micro-inverters. The output of the load center would pass through the Line Communications Filter enclosure on their way to the main power distribution panel.

The calculation for load center loading would be:

8 branch circuits x 26 micro-inverters each = 208 micro-inverters
208 micro-inverters x 380 watts each = 79,040 watts
79,040 watts ÷ 480 volts ÷ √3 = 95.18 amps
95.18 amps x 1.25 = 118.9 amps or a 125 amp load center

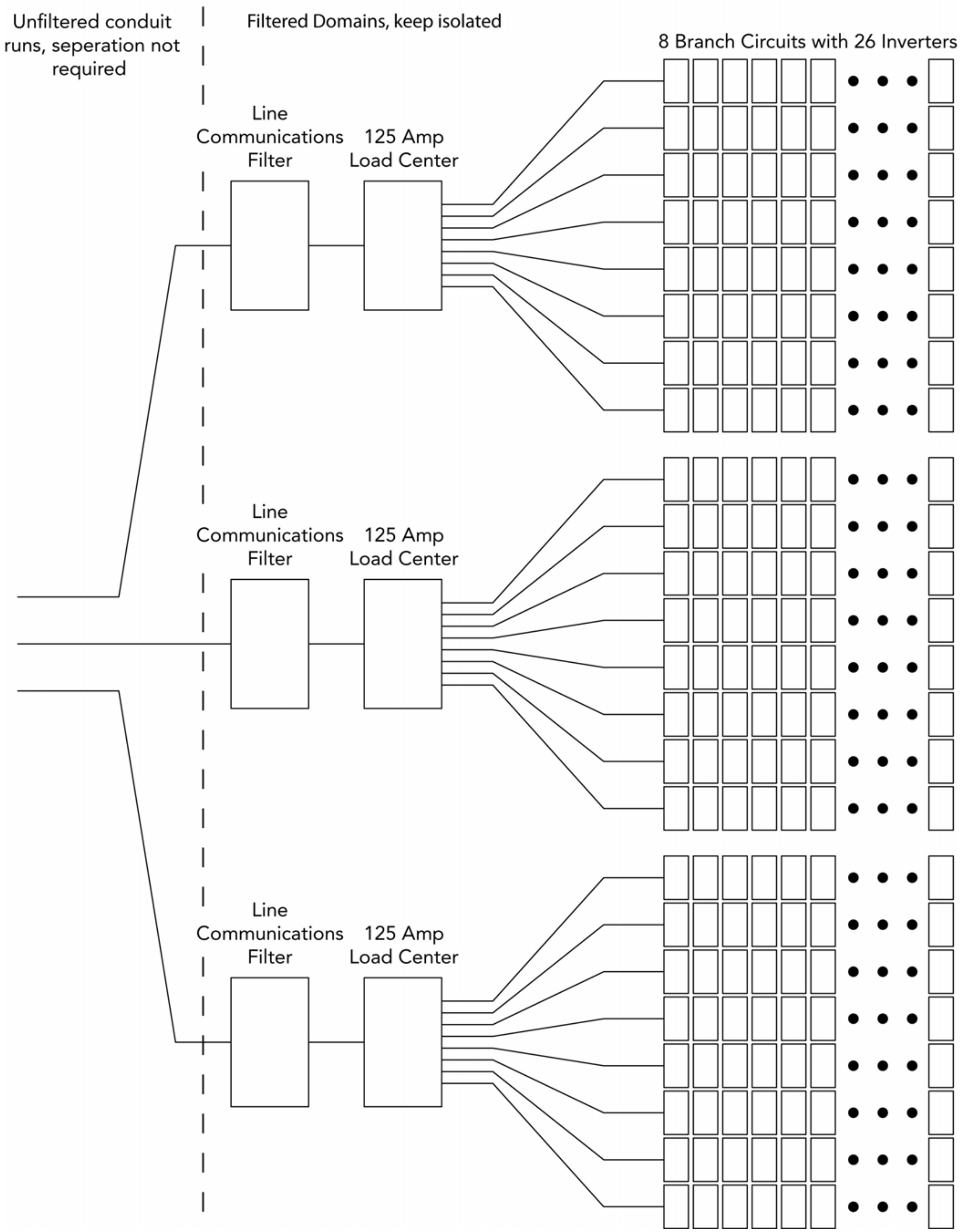


The line communication filter contains a filter network that prevents the powerline communications from exiting the communications domain. The line communications filter also contains an Envoy gateway that is connected to the micro-inverter side of the filter network.

Conclusion:

24 branch circuits required ÷ 8 branch circuits per load center =3

3 Communications domains are required



Unfiltered conduit runs, seperation not required
Filtered Domains, keep isolated
8 Branch Circuits with 26 Inverters
Line Communications Filter
125 Amp Load Center
Line Communications Filter
125 Amp Load Center
Line Communications Filter
125 Amp Load Center

6. Best Practices

Locating the Load Centers, Line Communications Filters

By locating the load centers close to the array, the branch circuit lengths are kept to a minimum. Consolidating the branch circuits into a single larger ampacity circuit will reduce material costs. Using a distance of 200 feet for example, installing a single 1 ½″ conduit with #1 AWG instead of installing 8 ¾″ conduits with #10 AWG would save 44% on material cost.
Locating the load center close to the array allows the Line Communications Filter to be located close to the array as well. If conduit runs from different communications domains are closely paralleled prior to the LCF, it is possible that the domains will cross talk. By containing the powerline communications close to the array, the possibility of cross talk will be greatly reduced.

Metal conduit is preferred for the shielding against induced signals that it provides. If PVC conduits are used Enphase recommends at least 12″ of separation if the conduits are from different communications domains.

Size Conductors for Voltage Drop

Installing the minimum allowable conductor size per NEC guidelines will be adequate for current flow requirements but is not always adequate to prevent excessive voltage drop in the branch and feeder circuits. The resistance in long circuit lengths can cause the circuit voltage to rise outside of IEEE allowable levels, causing the inverters to drop off line. The power consumed by this line loss is energy that is not delivered to the utility. Enphase recommends using the table in the support section on our website, enphaseenergy.com, to help determine the wire gauge based on the number of inverters per branch. The tables are separated by system voltage.

Isolate Neutrals

It is a requirement that the circuit feeding each Line Communications Filter as well as the individual branch circuits would contain a conductor for L1, L2, L3, and neutral. It is important that the conductors on the inverter side of the Line Communications Filter do not come in contact with conductors from other communications domains. Even though the neutral conductors meet at the point of interconnect to the utility, it is important that they are separated once they are on the inverter side of the Line Communications Filter.