AC-coupling Enphase IQ Microinverters with Victron battery inverters for on-grid residential systems with backup

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Purpose and scope

This technical brief provides guidance on how to combine Enphase IQ Series Microinverters with Victron battery inverters such as MultiPlus-II and Quattro. This guide is focused on on-grid systems for single-phase and three-phase installations.

The information shown in this document is only illustrative and may vary depending on local regulations. It is the responsibility of the installer to execute the correct installation following the correct regulations, codes, and standards.

Introduction to AC-coupled systems

In AC-coupled systems, IQ Series Microinverters and battery inverters are connected to a main AC line, where PV power is first used to power the loads, then to charge the batteries, and, lastly, any excess power is injected into the grid. When there is insufficient or no PV power available, power from the grid can be used to run the different loads and charge the batteries. Furthermore, an additional PV system can be connected to the DC side of the Victron inverter via a maximum power point tracking (MPPT) charge controller.

The main benefit of the system is the ability to work independently from the grid should it fail, powering the backup loads from the PV power and storage. To do so, the battery inverter creates a local grid, and the microinverters recognize this grid and therefore operate even during a power cut.

An important condition for this type of system is the presence of an automatic transfer switch, which will automatically isolate the system from the grid during a power cut. When doing so, no excess PV power can be fed into the grid, and the system operates in an off-grid mode until the grid power is restored. Both the MultiPlus and the Quattro battery inverters from Victron Energy have an embedded automatic transfer switch.

Here it is important to distinguish between nominal loads and backup loads. While backup loads can be powered through PV and storage during a power cut, nominal loads are located on the grid side of the system, and during a power cut, the automatic transfer switch will disconnect and leave them unpowered. Power for the backup loads is limited by the output of the battery inverter while power for the nominal loads is only limited by the grid supply.

Frequency shift control

As described previously, Victron MultiPlus and Quattro battery inverters allow the system to work in an off-grid mode, with microinverters producing power even when there is no mains grid available. When PV production is higher than the required power consumption, excess PV power is directed to the batteries. In this case, a way to control PV production is needed to manage the state of charge and avoid damage to the batteries.

Frequency shifting is the method most battery inverters use to control PV power. By changing the frequency of the AC wave, the MultiPlus or Quattro can control the power output from microinverters to prevent overcharging the batteries as well as overloading the inverter/charger at the input to the battery.

Victron considerations when installing an AC-coupled system

Factor 1.0 rule

The peak power of all the microinverters must be equal to or less than the VA rating of the inverter/charger. For example, for an 8000 VA Quattro, the peak power of all the microinverters must be under 8000 W; this is no more than 21 IQ7A units and no more than 27 IQ7+ units.

This Factor 1.0 rule does not apply to any additional PV installed on the DC side of the Victron inverter via the MPPT charge controller.

Minimum battery capacity

Another important consideration is to have installed a sufficiently sized battery. For lead batteries, 1 kWp of installed PV power requires approximately 4.8 kWh of battery capacity. For lithium batteries, 1.5 kWp of installed PV power requires 4.8 kWh of battery capacity.

For more information regarding the Factor 1.0 rule and the minimum battery capacity, refer to this Victron article: https://www.victronenergy.com/live/ac_coupling:start.

Integrating Enphase IQ Microinverters on the backup side of a Victron inverter

Victron inverters such as MultiPlus-II have one input for the grid and nominal loads and two outputs for the backup loads. In this technical brief, only one AC output is considered. During a power cut, the embedded automatic transfer switch will operate and disconnect the system from the mains grid and the nominal loads.

When the Enphase system is connected to the backup side, during its operation it will first power the backup loads, and then current will flow to the Victron inverter, which will determine whether to charge the batteries or feed the nominal loads/grid.

Even though the Enphase system is connected to the backup side of the Victron inverter, when the grid is available, Enphase IQ Microinverters will read the voltage and frequency of the grid, as the Victron inverter connects the input directly to the output. Therefore, Enphase IQ Microinverters have to be fully compliant with the grid code of the region, using a compliant grid profile and an IQ Relay if required by the local grid operator requirements.

Production CT(s) are recommended:

- Production CT(s) will be placed at the exit of the Enphase IQ Microinverter system and will measure PV production from microinverters. Where there is additional PV connected to the DC side of the Victron inverter, its production cannot be measured using the IQ Gateway.

Regarding the Consumption CTs, two options are available (single-phase cases):

- **Option A:** One Consumption CT installed at the grid side of the main electrical panel to monitor site power consumption. This Consumption CT must be configured in a "load + solar" configuration and will measure all energy imported from the grid. With this option, a Production CT is mandatory.

  With this configuration, if the grid fails, there will not be consumption measurements, even when the backup loads are on. Also, energy charged into the batteries will be considered as part of the consumption measurement, while energy discharged from the battery will not be measured. This option is recommended where power export limitation is required.

- **Option B:** Two Consumption CTs, one of them installed in the nominal loads and the other one in the backup loads. Both CTs must be connected in parallel in the IQ Gateway terminals and configured as "load only". With this option, a Production CT is not mandatory.

  With this configuration, energy charged into the batteries will not be measured as part of the consumption measurement, while energy discharged from the batteries into the loads is accounted for in the consumption measurement. However, this option is not recommended for sites where power export limitation is required, as batteries will not be charged from PV at any time (or just partially charged if the export limitation is not set to zero).

Steps to set up the Victron inverter

1. Load the Victron inverter (MultiPlus or Quattro) with the ESS Assistant. More information about ESS can be found in the following link: ESS design and installation manual.
2. Connect the Victron inverter to the battery bank.
3. Connect a computer through the VEBus to configure the system with the latest version of the software VEConfigure.
4. Go to the "Assistants" tab and load the Victron inverter with the ESS Assistant.
5. Depending on the region where you are located, you might need to change the default settings in the Assistant.
6. The table below shows the preferable Enphase grid profile and the corresponding Victron settings for different locations.

Table 1: Enphase grid profile and Victron settings

Region	Preferable grid profile	Start	Minimum	Disconnect
France	EN 50549-1:2019 VFR2019 France	50.2	51.2	51.5
Germany	VDE AR-N-4105:2018 Germany, PEL 70 %W, UE	50.2	51.5	51.5
Poland	EN 50549-1:2019 RfG Poland	50.2	51.7	52.0

Region	Preferable grid profile	Start	Minimum	Disconnect
South Africa	NERSA 3.0:2019/NRS 097-2-1:2017 ED2.1 South Africa	50.5	51.7	52.0
Spain	EN 50549-1:2019 Spain	50.2	51.7	52.0
United Kingdom	G98-1-4:2019 UK G99-1-6:2020 UK	50.4	51.7	52.0

NOTE: Even when using a grid profile with a higher start frequency (for instance, 50.5 Hz), there is no real drawback using the proposed value of 50.2 Hz. The system will just increase the frequency until the PV inverter regulation kicks in. The value of 50.2 Hz will work with a broader range of grid codes.

7. During the commissioning of the Enphase system, select the grid profile that corresponds to your location and site requirements.

Single-phase diagram Victron + Enphase, one Consumption CT, option A

This example shows a single-phase system with Victron and Enphase IQ Microinverters, where one Consumption CT is used for measuring energy imported from the grid, configured as “load + solar”. However, energy charged into the batteries will be considered part of the consumption measurements (while energy discharged from the battery will not be measured). Also, it will not measure the energy consumption of the backup loads when in backup operation. This configuration is preferred if a power export limiting, or zero export grid profile is chosen.

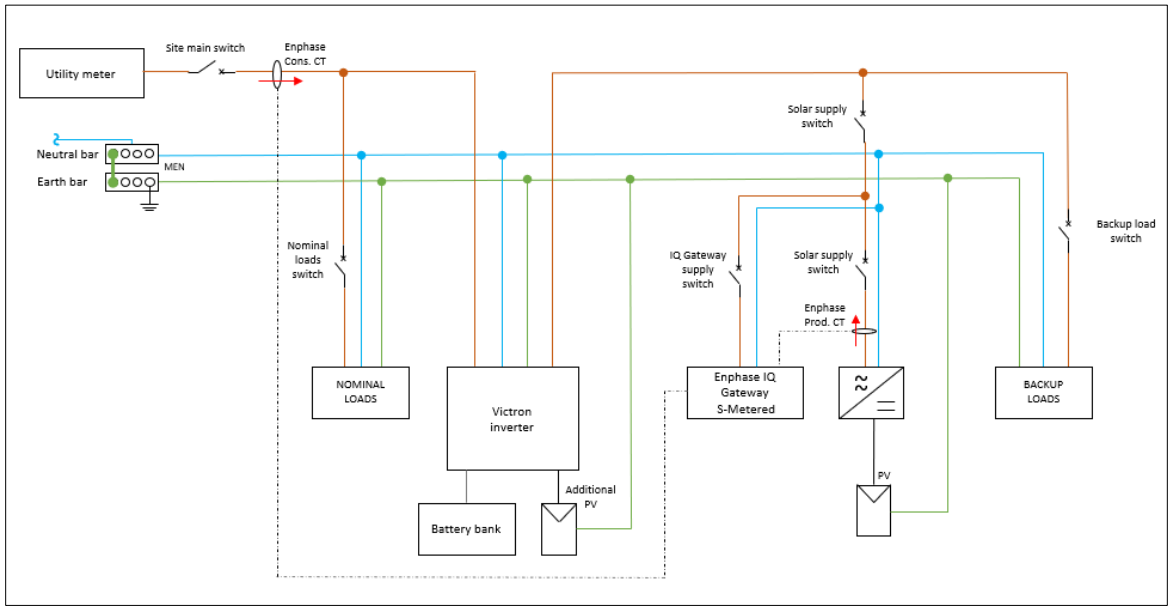

Figure 1: Single-phase system with Victron and Enphase

Single-phase diagram Victron + Enphase, two Consumption CTs, option B

This example shows a single-phase system with Victron and Enphase IQ Microinverters, where two Consumption CTs are used for monitoring both nominal and backup loads, configured as “load only”. Following this configuration, energy charged into the batteries will not be measured as part of the consumption measurement. If a power export limiting or zero export grid profile is used, do not use this configuration, as batteries will not be charged from PV at any time (or just partially charged if power export limiting is in place).

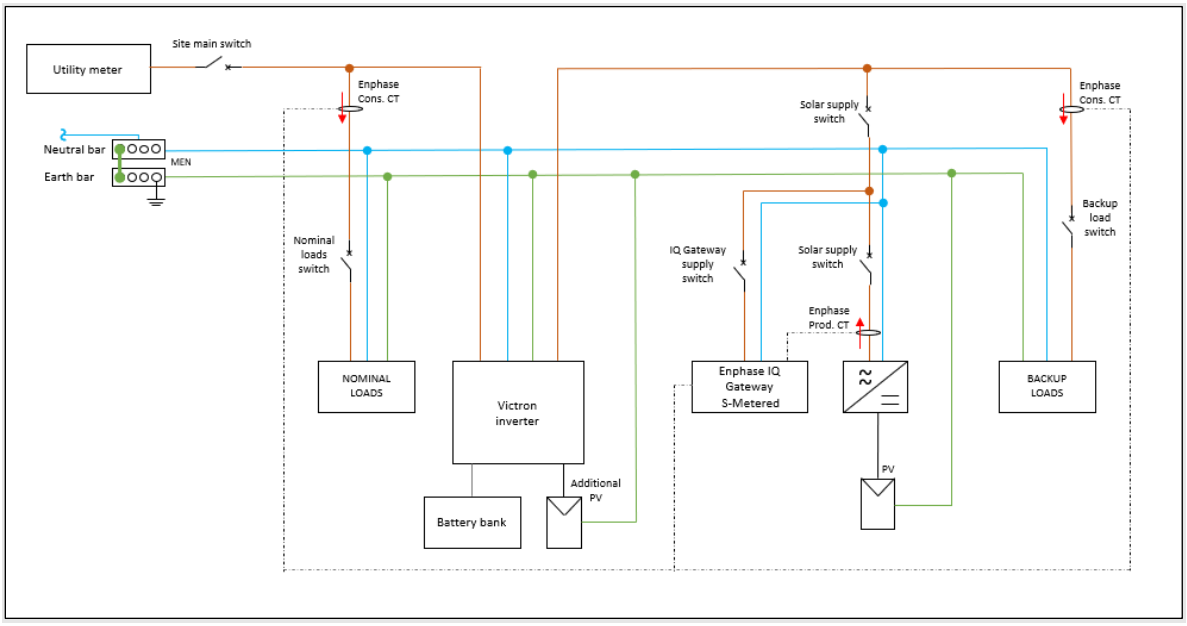

Figure 2: Single-phase system with Victron and Enphase IQ Microinverters

Three-phase diagram Victron + Enphase, three-phase backup

This example shows a three-phase Victron system with an Enphase IQ Microinverter system installed in a three-phase configuration on the backup side. In this case, an overall grid consumption reading is chosen, configured as “load + solar,” and energy charged into the battery will be considered in the consumption measurement (while energy discharged from the battery will not be measured). When the system operates in backup mode, the Enphase consumption measurement will be nil.

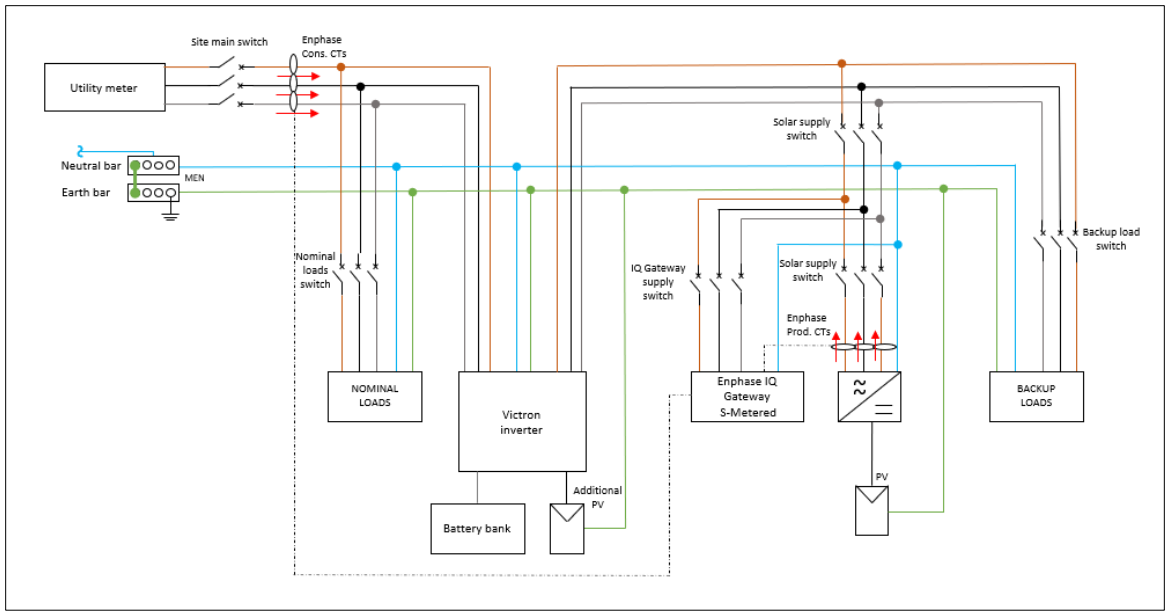

Figure 3: Three-phase Victron system with an Enphase IQ Microinverter system in three-phase configuration

However, reading the total consumption (grid + solar + storage) of nominal and backup loads is also possible. Six Consumption CTs should be used, three for nominal loads and three for backup loads (they must be installed in parallel in the consumption terminals of the IQ Gateway and configuration must be "load only"). This way, when the grid goes down, Enphase will still read consumption measurements.

Three-phase diagram Victron + Enphase, single-phase backup

This example shows a three-phase Victron system with an Enphase IQ Microinverter system installed in a single-phase configuration on the backup side.

In this case, the IQ Gateway is fed in a single-phase, and the consumption measurement cannot be made on the grid side of the system since it is three-phases. Hence, one Consumption CT must be installed on the backup side of the system. If it is placed at the input of the backup loads as shown in the diagram, it must be configured as "load only". Power export limiting and zero export are not possible for this type of configuration.

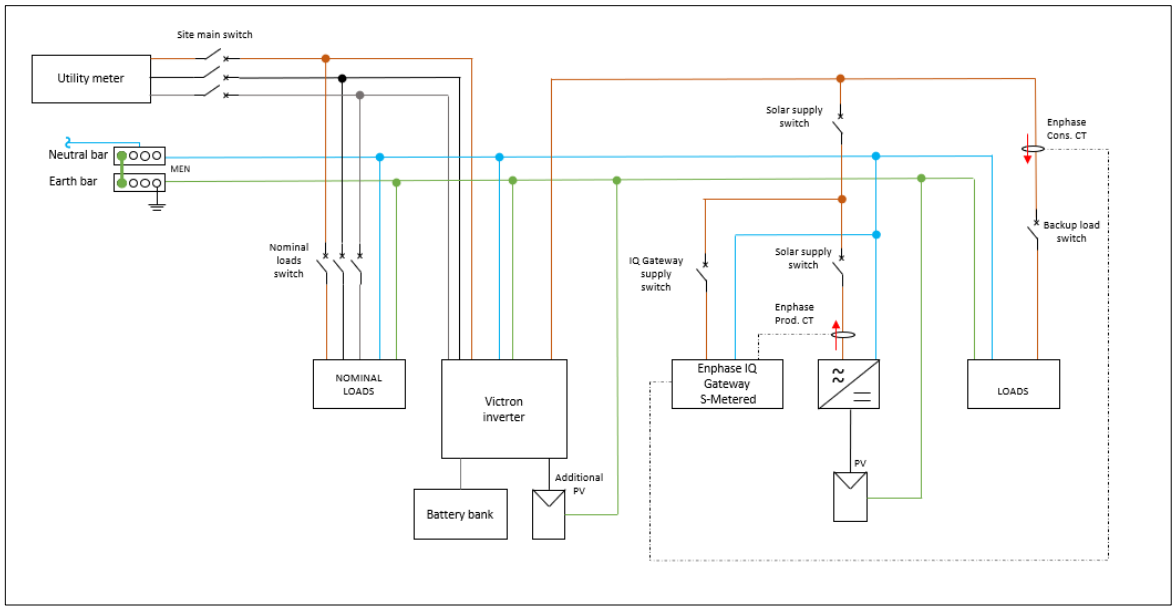

Figure 4: Three-phase Victron system with an Enphase IQ Microinverter system in a single-phase configuration

Revision history

Revision	Date	Description
1	May 2023	Initial release