APPLICATION NOTE

AC Coupling of Enphase Microinverters to Battery Based Systems

AC Coupling allows use of Enphase Microinverters with off-grid and battery-based photovoltaic systems. These applications require a battery-based inverter to create a "micro grid" that the microinverters can then be connected to. This is generally referred to as AC coupling because the Enphase Microinverters and the battery-based inverters are "coupled" on their AC outputs.

While these systems are more complicated than traditional grid interconnected systems, they can provide power during power outages, in emergency situations, and to remote locations. Enphase Microinverters, when AC coupled to a battery-based inverter system, offer advantages over other inverter technologies. This is because a microinverter system is divided into branch circuits to provide a tapered charge to the batteries. Offering more flexibility than string inverters, Enphase Microinverter systems can be AC coupled to a battery-based inverter system after installation, and the production capacity and critical loads can be increased or reconfigured to fit storage needs. Enphase Microinverters also offer the design flexibility, increased safety, and increased performance that come with module level maximum power point tracking and monitoring.

A battery-based application is generally much more complicated than a utility-interactive system and requires special knowledge to be implemented successfully. Installers and designers must be qualified experts before working with battery-based systems and AC coupled systems. This document does not list all of the requirements and qualifications required, but it does provide guidelines for designing AC-coupled systems with Enphase Microinverters.

In all battery-based systems, there are requirements for safe and reliable operation. Additional safeguards when AC coupling Enphase Microinverter systems include:

- Do not allow the batteries to overcharge. Overcharging batteries can damage the batteries and can potentially cause fires and catastrophic meltdowns. It is smart to provide redundant methods to regulate the charge to the battery.
- Do not connect the Enphase Microinverters to the output of an engine generator. This can cause damage to the microinverters and the generator.
- Design the Enphase Microinverter system so that it does not exceed the pass-through capabilities of the battery-based inverter's charging system.

Whenever working with batteries, take precautions to ensure safety. This is particularly true for AC coupled systems because traditional inverter chargers and charge controllers are not designed to regulate the charge from an AC coupled system. Therefore, take precautions to ensure that the batteries are not overcharged. The best practice is to shut off the microinverter system when the batteries are charged. To accomplish this, you can use a voltage-controlled relay to shut off the Enphase Microinverter system when the battery reaches a voltage within the manufacturer's limit. For more complicated systems, use a series of relays to taper the charge to the batteries.

For additional battery protection, use a dump load to drain excess power out of the batteries in the case of overcharging. Do this by using some of the stored power to heat water or air with a listed and approved heating element.

Some battery-based inverters use "frequency shifting" to regulate the charge on batteries. These inverters shift the frequency to a range outside of the utility-interactive inverters' UL1741 frequency settings. Do not rely on this method of charge regulation alone! An Enphase Microinverter system's grid parameter settings can be adjusted remotely, and they may be set outside of the window being used by the battery-based inverter. For this reason, use an additional voltage-controlled relay.

If an engine generator is present, do not connect the Enphase Microinverters to the same load panel as the generator. When using a generator to charge batteries in a battery-based inverter system, the battery-based inverter also internally bypasses the generator's output to the back-up / emergency load panel that the Enphase microinverters are feeding. Allowing this connection can damage the generator and microinverters. Therefore, if using a generator to charge batteries, ensure that the Enphase Microinverters are shut-off when the generator is running. The best method is to use a voltage controlled relay that is activated by the generator panel. Use a transfer switch to ensure that the generator is always isolated from the Enphase Microinverters.

Diagram 1: Grid-Tied AC Coupled System

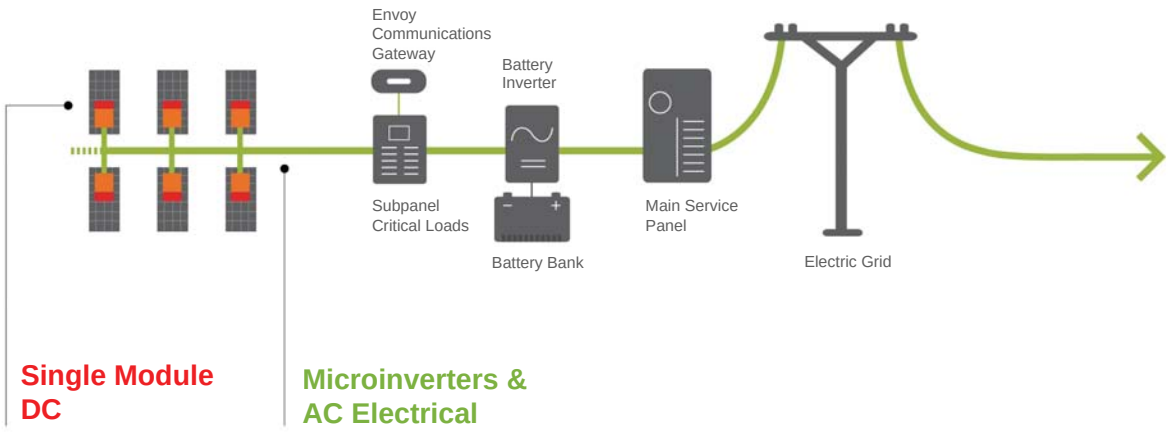


Diagram 2: Off-Grid AC Coupled System

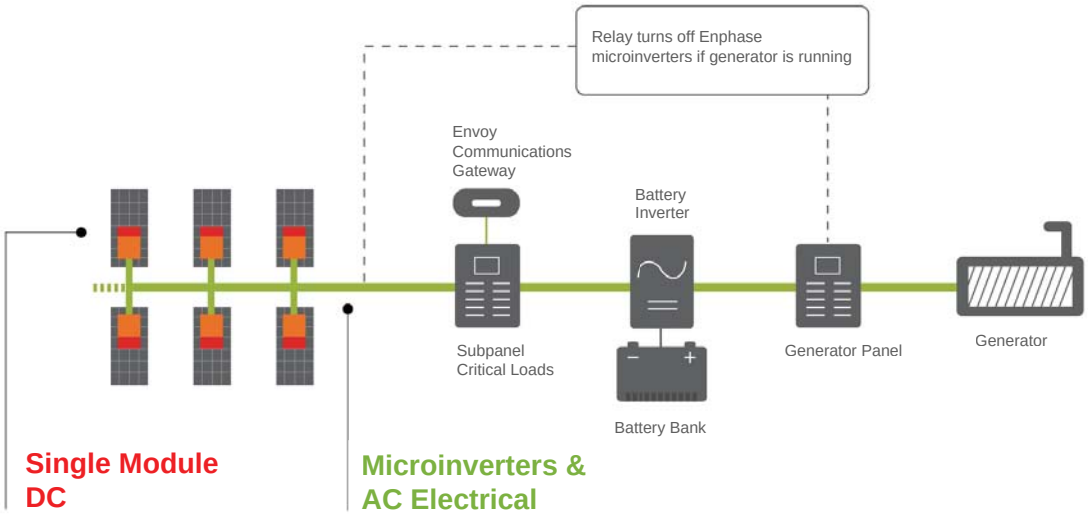
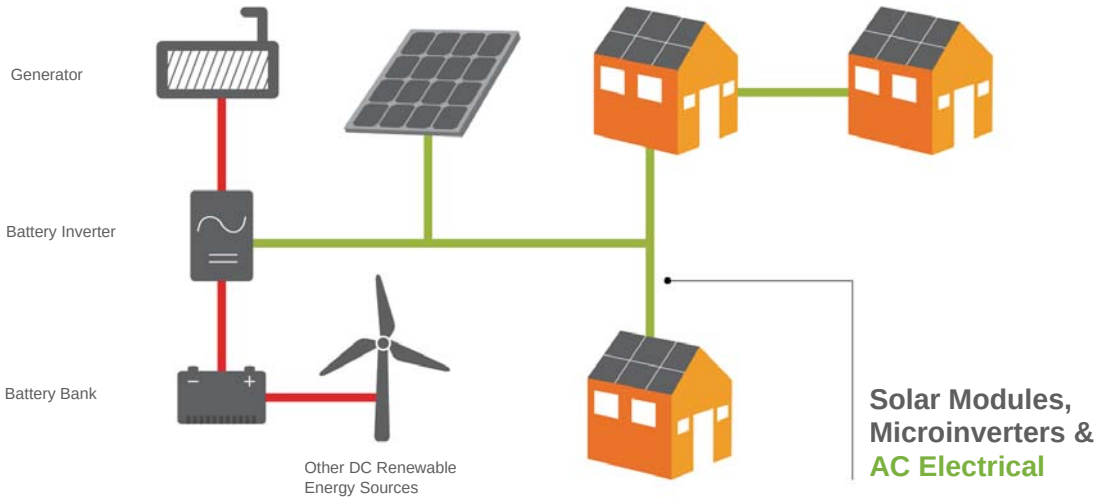


Diagram 3: Microgrid



The Power Room of an AC Coupled System with Enphase Microinverters, Courtesy of Magnum Energy

For additional resources on installing AC-Coupled systems, refer to the battery manufacturer's and battery- based inverter manufacturer's documentation. Enphase Microinverters work with a number of battery-based inverter manufacturers and component manufacturers, including Magnum Energy, Outback Power Systems, MidNite Solar, SMA, and Schneider Electric. You can find many other documents, application notes, and schematics on AC Coupling at the following websites.

Magnum Energy	http://www.magnumenergy.com/Documents/DocsFront.htm
Outback Power Systems	http://www.outbackpower.com/index.php/applications/ac-coupling
MidNite Solar	http://www.midnitesolar.com/index.php

Disclaimers

No Guaranty as to Content of Information - The information in this application note is provided for general information purposes only and may not apply to a specific or particular situation or circumstance. While Enphase has made reasonable efforts to ensure that the information is accurate at the time of publication, information is constantly evolving and the information provided does not purport to be correct, comprehensive or exhaustive. Enphase expressly disclaims any liability for any errors or omissions in any information published.

Information Provided "As-Is" - The information contained in this application note is provided "AS-IS" and any representations do not constitute an express or implied warranty of any kind. Enphase makes no representations as to the completeness or validity of any information contained herein or the consequences arising from the use of or reliance on this information, and Enphase expressly and specifically disclaims all warranties, whether express or implied, written or oral, including, without limitation, the warranty of merchantability and the warranty of fitness for a particular purpose, provided, however, that **nothing contained herein is intended to alter or revise limited warranties, if any, provided to purchasers of Enphase products or services at the time of purchase**.

Disclaimer of Liability - By accessing this application note, you acknowledge that you are accessing the information contained therein at YOUR OWN RISK and in your own discretion. Enphase disclaims all liability and shall not be liable to you for any damages to your person or property which may result from your use of this application note.

Under no circumstances shall Enphase be liable for any claim arising from the use or misuse of this application note or any reliance on any information contained herein, including without limitation any claims for direct, indirect, incidental, consequential, special, exemplary or punitive damages, as well as attorney's fees or costs, regardless of whether such claims arise out of negligence, gross negligence, carelessness, recklessness, wantonness, fraud, misrepresentation or contract. This disclaimer of liability also extends and includes any alleged damages incurred by user as a result of linking to a third party's website.

Links to Third Party Sites - This application note contains links to sites controlled and/or operated by a third party over which Enphase has no control. Enphase is not responsible for the contents of any linked site. Any link is provided only as a convenience and is not an endorsement by Enphase of the contents of any third party site or any product or service described on such site.