

Magnum Inverters Connected with Utility-Interactive Inverters

With more homes utilizing renewable energy and installing utility-interactive inverter systems to offset their power consumption from the utility grid, it would be prudent to understand the advantages of installing a battery-based inverter that can connect in parallel with the house wiring circuits.

Most of the utility-interactive inverter systems installed do not require batteries to operate. The main reason for this is the perceived lower install costs, lower maintenance, and higher conversion and operating efficiency. However, the homeowner soon learns that when a utility power outage occurs, these batteryless inverters are required to shut down. This can cause considerable frustration as the homeowner realizes that the essential loads in the home (refrigerator, lights, water pump, etc.) are no longer powered; and all the energy that the renewable energy system could be generating is being wasted.

To overcome some of the disadvantages of batteryless utility-interactive inverters, homeowners can add a battery-based backup inverter along with a backup load panel to provide power to essential loads during a power outage. However, the generated power continues to be wasted until the utility power returns.

Using Magnum battery-based inverters¹ will allow the home's essential loads to continue to be powered; and, they can be installed in a way to utilize the power that is being wasted during a power outage. On a Magnum inverter, the AC input and output circuits can be connected in parallel with the home's AC wiring without damaging the inverter. The ability to connect both of the inverter's AC circuits in parallel, and use utility power to continue powering loads and charge the batteries from the AC side is a concept referred to as *AC Coupling*.

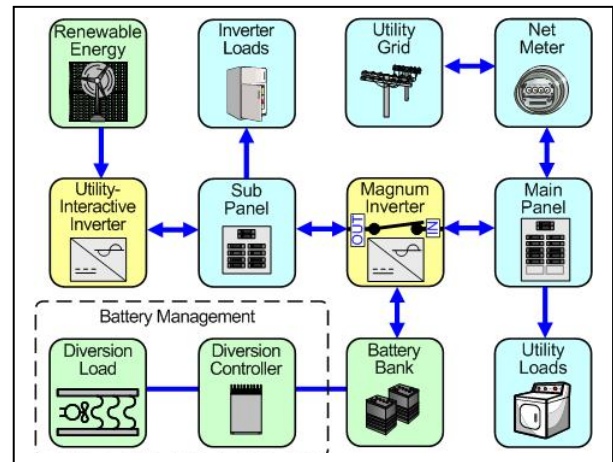
Battery-based inverters that can be AC coupled into existing utility-interactive inverter systems provide the following convenient and efficient advantages:

- The connection from the renewable energy source (i.e., solar array) to the utility-interactive inverter doesn't require any rewiring (this is typically required with standard back-up inverters to provide the battery charging requirements).
- Connects in parallel with the utility circuit to provide charging to the inverter's battery bank.
- If there is a utility failure, the inverter's transfer switch will de-couple from the utility circuit (so not to energize the grid and create a safety hazard).

- Provides the AC voltage and frequency reference needed for the utility-interactive inverter to continue to operate while using the renewable energy to provide power to the home during a power outage.
- Capable of operating as a standalone inverter or Standby mode (battery charging with AC transfer), with automatic transition from one state to the other.

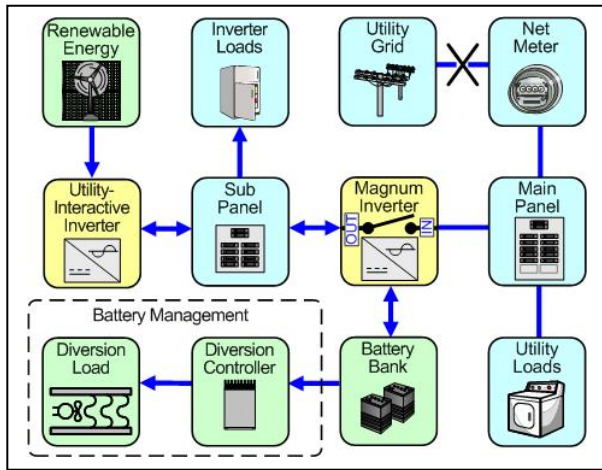
Considering all the advantages of installing a battery based backup inverter that can be AC coupled, it is beneficial to understand how the inverter operates before and during a power outage.

The diagram below is a typical example of a utility-interactive inverter system that is AC coupled with a battery-based Magnum inverter and sub-panel. Normally, with the utility power present, the energy from the renewable energy source is converted by the utility-interactive inverter and is used to power the loads in the home, to charge the inverter's battery system, and to feed any surplus energy back into the utility grid.



Block Diagram of Utility-interactive Inverter AC Coupled To Backup Inverter – Normal Operation

During a utility power interruption, both the battery-based inverter and the utility-interactive inverter disconnect. Once this occurs, the battery-based inverter automatically starts inverting and momentarily uses battery power to continue powering the essential loads. Because the AC output of the battery-based inverter is connected to the same circuit as the utility-interactive inverter, the utility-interactive inverter will synchronize with the battery-based inverter's AC output. After a minimum 5 minute disconnect period, the utility-interactive inverter reconnects and starts inverting the energy from the renewable energy source.



Block Diagram of Utility-interactive Inverter AC Coupled To Backup Inverter – Utility Power Outage

The utility-interactive inverter - now reconnected by using the battery-based inverter's AC output - is responsible for converting as much of the available renewable energy as possible. This energy is normally used by all the loads in the home and any excess is pushed into the utility grid. However, during a power outage the non-essential loads (i.e., main panel) and the utility grid are no longer connected. This means any excess energy that is not used by the home's essential loads will be pushed back thru the AC output of the battery-based inverter into the battery system. Since this is not the normal path for the battery-based inverter to sense incoming current, it can't regulate the current or control the battery voltage, so the inverter must be rated to handle the full power output of the renewable energy source².

Some Magnum battery-based inverters also have a feature that allows the AC output frequency to shift when the battery voltage rises to a high level³, causing the utility-interactive inverter to disconnect, which helps prevent battery overcharging. However, this protection feature that disconnects the utility-interactive inverter does not ensure effective battery charging and should only be used as a backup to a primary battery management system⁴.

Magnum Inverters in Micro-Grid Applications

Drawing on similar technology that is used for utility-interactive systems in single homes, inverters that are able to AC couple can also be easily expanded to multiple homes and/or use multiple AC sources as part of a self-sufficient subsystem or "micro-grid".

The ability to use inverters in a multiple system approach and combine AC sources and loads as a micro-grid means the AC generation (i.e., battery-

based inverter) and corresponding loads can be separated from the main power distribution network (i.e., utility grid) during a power interruption and continue to provide backup power. Being isolated from the main power distribution and continuing to power the coupled loads (known as "islanding") at a local level has the possibility of providing better reliability than that available from the main power distribution network.

Micro-grids that include energy storage and multiple, on-site power sources, means increased flexibility to provide power. The micro-grid can use stored power or power supplied by the main power distribution network, or even power from another micro-grid that could be connected. These systems can also be designed to store enough energy to keep power flowing during blackouts, making them ideal for emergency "standalone" systems.

Using Magnum's inverters with renewable energy sources offers power independence with better reliability and increased flexibility in either single home or micro-grid system applications.

Note 1: The Magnum inverters referred to in this paper are listed to UL1741 as standalone inverters, not as utility-interactive inverters. Therefore, as an inverter, the output of the inverter should not be connected directly to the utility power distribution circuits. These inverters can parallel (or AC couple) to the AC wiring circuits only when the utility power is connected to the input of the inverter and the inverter is in Standby mode (charging with AC passing thru).

Note 2: The maximum power rating of the renewable energy source must be no greater than 90% of the continuous power rating of the Magnum inverter.

Note 3: The MS-PAE Series (≥Rev 4.1) inverter/chargers have the AC Coupled Support mode. This mode, when activated, causes the inverter output frequency to change to 60.6Hz. This mode is enabled using an optional remote that allows the Battery Type to be set to "Custom", and activates when the battery voltage increases 2-volts (24-volt units) or 4-volts (for 48v units) above the Absorb Voltage setting. The frequency returns to 60.0Hz when the battery voltage falls 2-volts (24-volt units) or 4-volts (for 48v units) below the Absorb Voltage setting.

Note 4: The battery bank voltage can be managed by installing a diversion controller and load capable of absorbing the majority of the expected surplus energy, using: 1. DC diversion controller and DC resistance loads; 2. AC diversion using AC resistance loads driven by DC controlled relays; or 3. Magnum's AC Load Diversion Controller. Now in development, Magnum's AC Load Diversion Controller will allow customers the ability to maximize the use of onsite generated renewable power and provide multiple-stage battery charging with temperature compensation using AC loads. For more information on the release of this AC Load Diversion Controller, continue to monitor our website at www.magnumenergy.com.