In an AC-coupled system, a grid-tied inverter can work with certain battery based inverters to supply electricity for critical loads when the grid is down.

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An Introduction to AC coupling

Through AC coupling, a grid-tied inverter can continue to operate when the grid goes down by syncing with the output of a battery based inverter - when both are connected to the same "critical loads" sub-panel. This luxury is especially useful in areas with an unstable grid, such as developing nations, or in areas prone to blackouts. In an AC-coupled system, the battery bank will supply electricity to critical loads when the grid is down. AC coupling is much more efficient in feeding the grid than DC coupling

because the PV array is connected to the utility grid through the grid-tie inverter without first passing through the battery. In Joe Schwartz's recent SolarPro article, "AC Coupling in Utility-Interactive and Stand-Alone Applications" (SolarPro 5.5)[1], he compiled articles submitted from Magnum Energy, Outback Power, Schneider Electric, and SMA on their inverters' AC-coupled solutions. A summary of Schwartz's article with examples from a completed CivicSolar project will provide a good understanding of AC coupling.

Magnum Energy

The Magnum Energy MS-PAE (MS4024PAE and MS4448PAE) series inverter/chargers can be used in AC-coupled applications. "Magnum Energy permits and supports ac-coupled system designs that synchronize the ac output of utility interactive string inverters from various manufacturers with its battery-based inverter/chargers."[1] In choosing a Magnum inverter, the inverter must be rated to handle the Pmax of the solar array and 111% of the maximum output power of the string inverter. When the grid is operational, the Magnum battery-based inverter is in Standby mode. The Magnum inverter will use both the utility grid and the AC output of the string inverter to maintain charge on the battery bank and to power the critical loads. When the grid goes down, the two inverters disconnect from the grid and the battery bank begins supplying power to the critical loads on the subpanel. After a 5 minute required disconnect, called the 5-minute sledgehammer, the grid-tie inverter will sync with the Magnum inverter's voltage and frequency and begin supplying energy from the PV array. Excess energy not consumed by the subpanel will return to the Magnum inverter and to the battery banks. The PAE inverters with firmware revision 4.1 and higher have an AC-Coupled Support mode that is controlled via the battery charge voltage setting. In AC-Coupled Support mode, the inverter will shift its frequency to 60.6 Hz to unsynchronize with the grid-tie inverter or back to 60.0 Hz to resynchronize. The battery will resync and charge when the voltage falls too low, and unsync when the voltage rises too high to prevent overcharging. Overcharging occurs when too much unused AC power returns to the battery banks. The constant on/off cycling method of overcharge protection described above is not ideal as it does not follow the three-stage charging method. In most cases, Magnum recommends a diversion load such as water heaters to minimize the amount of on/off cycling. Magnum recommends a diversion load as the primary battery-management system and its frequency-shifting second.

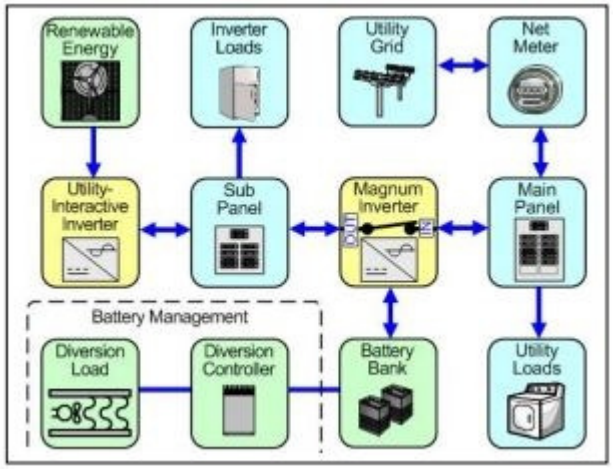

Figure 1a: Block Diagram of Utility-interactive AC Coupled to Backup Inverter – Normal Operation[2]

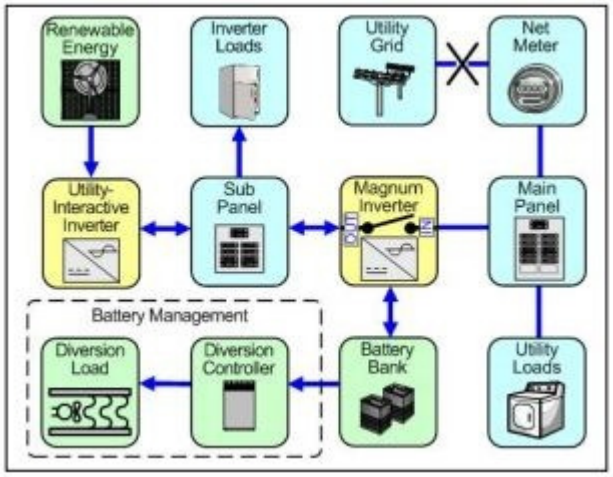

Figure 1b: Block Diagram of Utility-interactive AC Coupled to Backup Inverter – Utility Power Outage[2]

Outback Power Technologies

The Outback FX (FX, VFX, GVFX or GTFX) single-phase inverter/charger series and Radian series support AC coupling. Unlike their competing inverters, Outback Power inverter/chargers do not utilize frequency-shifting. The FX series inverter/chargers can be stacked in series and parallel in AC-coupled systems. When a single FX series inverter/charger with a 120 Vac output is AC-coupled to a 240 Vac string inverter, an Outback autotransformer can be used to step down the string inverter to 120 Vac.

The Outback Radian GS8048 is a grid-interactive 120/240 Vac inverter/charger that can be stacked in parallel. The Radian normally functions as the battery-based inverter in an AC-coupled minigrid, but has a Utility-Interactive mode that can feed excess power to the grid, but at a lower efficiency than a grid-tie inverter. The Outback inverter/charger is recommended to handle 125% of the maximum output of the string inverter.

Both Outback Radian and FX inverter/chargers do not have frequency-shift battery management capabilities. The Radian supports diversion loads and blackout relays, and the FX only supports blackout relays.

Outback Power maintains that AC coupling has trouble with systems involving backup-generators. For backup-generator-based system charging, the battery-based inverter will shift its frequency to synchronize with the generator and disconnect from the string inverter – at which point the generator becomes the voltage/frequency source for the system. This creates two problems. Firstly, most motor generators do not have sufficient voltage/frequency regulation for the grid-tie inverter to stably operate, so PV generation is lost. Secondly, the generator has to power all AC loads and charge the batteries because the string inverter is offline, which will require a larger generator that in AC-coupled systems.

Schneider Electric

Schneider Electric recommends pairing their TX grid-direct inverters with their XW battery-based inverters to avoid complications between inverters from different manufacturers in AC-coupled systems. Unlike Magnum Energy, Schneider does not support systems in which their battery-based inverter is AC-coupled to a grid-tie inverter of a different manufacturer. As a result, they only discuss the interaction between the TX and XW inverters in their contribution to this article.

Schneider XW inverter/chargers with firmware version 1.07 (downloadable here) include the AC-coupling feature. The Schneider XW uses frequency-shifting and on/off cycling to prevent overcharging similar to the Magnum inverters. The Schneider XW inverter is recommended to handle at least 100% of the grid-tie inverter power rating.

SMA

When one of CivicSolar's customers asked for help designing an AC coupled system for a client, all available solutions were analyzed - even coupling Enphase micro-inverters to a Xantrex XW 6048 inverter. While all the other components - Xantrex, Outback, Enphase and Magnum, are very high quality equipment, none of them offered as highly evolved a system as the SMA Sunny Island 5048 (SI) and Sunny Boy US (SB) inverter pair.

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The unique advantage of the native SMA setup is that the grid tied and battery inverters employ direct rs485 communications to regulate the grid tied inverter's output, rather than bringing it to a hard stop and then restarting it 'cold' with a five minute delay. No relays or diversion loads are specifically required to protect the batteries or send the AC charger into an on/off mode.

The customer wanted to minimize cost by only installing one SMA SI 5048 - requiring an autotransformer to generate the necessary 240Vac to sync with the SB inverter. An Outback 6kVa Autoformer was used, but SMA also offers a Smartformer product that could have done the job as well.

Sources

1. http://solarprofessional.com/article/?file=SP5_5_pg74_Schwartz

2. Images courtesy of Magnum Energy

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