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DC COUPLING: THE EFFICIENT WAY OF CONNECTING STORAGE AND PV

Abstract

With the decreasing cost of energy storage, PV-coupled storage applications are becoming more and more attractive for a broad range of applications. Further drivers for this development are the termination of subsidies for PV-produced energy in Germany and other countries and the replacement of diesel generators with renewables within self-supporting microgrids for regions with weak grid infrastructures.

The modular TRUMPF TruConvert product family combined with Ampt string optimizers offers a cost-effective, energy-efficient, flexible solution for DC-coupled solar energy storage systems.

Introduction

In general, there are two ways to connect PV and storage systems: AC-coupled or DC-coupled. AC-coupled systems have one inverter for the PV array and one inverter for the battery. Usually easy to install, they are flexible and highly efficient if most of the PV energy is delivered directly into the grid. DC-coupled approaches are usually based on a single hybrid inverter that offers both PV and battery inputs and can boost system efficiency by avoiding unnecessary AC conversion stages – especially if a significant part of the PV energy needs to be transferred into the battery. One downside of hybrid inverters compared to AC-coupled systems is the loss of flexibility, as the PV and battery inputs are usually fixed in terms of PV-to-battery power ratio or the supported input voltage windows. Especially in terms of growing microgrid applications or system integrators that need to support a wide range of different storage applications, the task of finding a suitable DC-coupled solution for every use case can be a real challenge.

The modular TRUMPF TruConvert system, combined with Ampt string optimizers, delivers the benefits of both DC- and AC-coupled approaches to energy storage. The TruConvert system provides a flexible, scalable battery-to-PV power ratio and wide PV input voltage range, while staying energy efficient and cost effective. The

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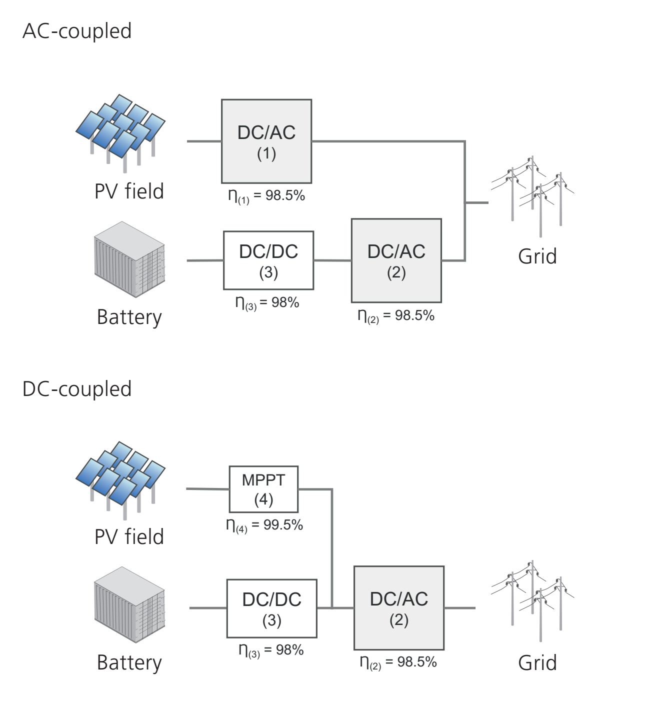

Figure 1: Power electronic components involved in AC- and DC-coupled PV storage systems

TruConvert product family is highly optimized for low voltage battery applications; Ampt string optimizers are designed to maximize the production and value of PV installations. The combined solution uses a higher, fixed DC-link voltage to achieve the ideal power electronics solution for PV-coupled storage systems.

DC coupling as an alternative to AC coupling

Figure 1 illustrates the different power electronic components used for AC- and DC-coupled PV storage systems.

The components involved in the AC-coupled setup are (1) a DC/AC inverter for the PV grid connection, (2) a DC/AC inverter for connecting the battery to the grid and (3) a DC/DC converter to adapt the battery voltage window to the DC input range of the AC/DC inverter. In the DC-coupled setup, the PV inverter (1) is replaced by a lower-cost and higher-efficiency DC/DC converter that performs Maximum Power Point Tracking (MPPT) (4).

Taking typical efficiency values for the components of both approaches (as shown in Figure 1), the DC-coupled solution has a significantly higher round-trip efficiency when charging the battery with PV energy since two of the AC conversion stages are eliminated. When feeding the PV energy directly into the grid, the AC-coupled solution has a slightly higher efficiency by avoiding the extra MPPT; however, this advantage is offset by the DC-coupled system's increase in PV utilization over the complete operation range.

The silicon effort needed for MPPT is significantly less than for a complete DC/AC inverter stage of the same power level – especially in light of the fact that some PV inverters include additional MPPTs to maximize the efficiency over the complete panel operation range. This makes the DC-coupled approach more cost effective than an AC-coupled solution, especially if the ratio of storage power to PV power is increasing.

Assuming a simplified island application with 50 kWp PV, 25 kW storage and 25 kW AC loads, during the day the battery would be charged with 25 kW of the PV power and the loads would consume the other 25 kW on the AC side. During the night the loads would be supplied by the battery. To realize this system with an AC-coupled approach, it would be necessary to install DC/AC inverters for both PV (1) and storage (2) with a total power of 75 kW, even if the AC loads are only rated at 25 kW.

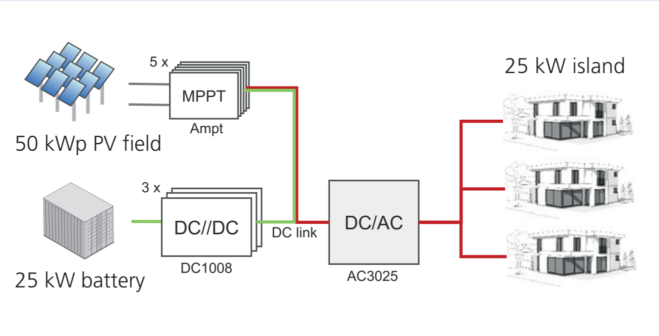

Figure 2: TruConvert system for a 25 kW island application with 25 kW storage and 50 kWp PV

Figure 2 shows this scenario for a 48V battery realized as a DC-coupled solution using the TruConvert family and Ampt string optimizers. Instead of using two 75 kW DC/AC inverters, the TruConvert solution uses only one 25 kW inverter and five 10 kW string optimizers. This lowers the overall costs and increases round-trip energy storage efficiency. In addition, the string optimizers provide MPPT for every string of PV modules rather than on every two to four strings as is typical of inverters in an AC-coupled system. This increase in MPPT granularity increases the lifetime performance of the PV array by eliminating energy losses from built-in or environmental sources of voltage mismatch as well as from degradation as the PV modules age. The wide input voltage range of 400 to 1000V per string, and the ability of the string optimizers to combine voltages from the two input strings, reduces clipping in the morning and evening hours to further increase the overall production of the installed PV system.

Summary

In terms of cost and energy efficiency, a DC-coupling approach is increasingly being recognized as a way to enhance energy storage for a broad range of scenarios. In addition to those benefits, the modular TRUMPF TruConvert system combined with Ampt string optimizers enables even greater flexibility and performance optimization compared to other DC- and AC-coupled solutions.

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