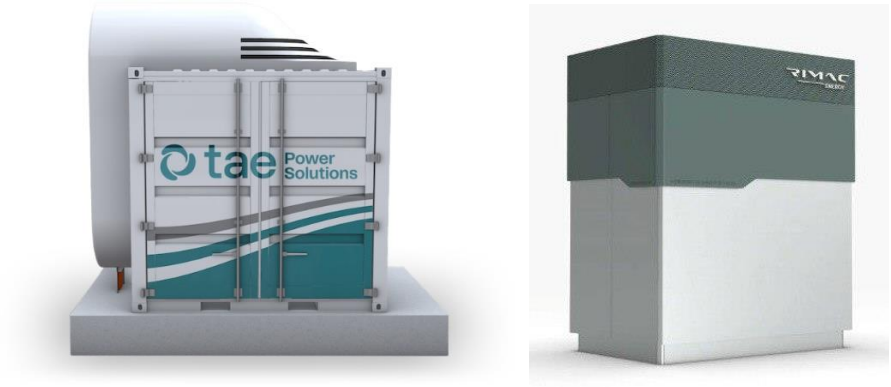
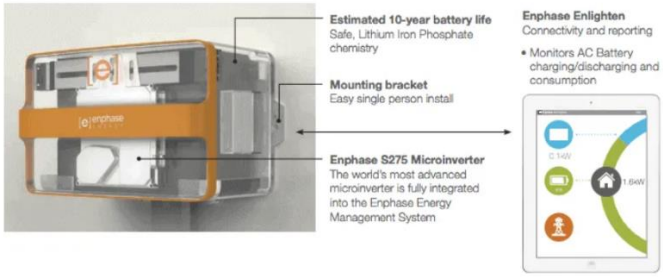
Distributed DC-DC converters for AC split batteries

Master thesis project



The tae power solutions and Rimac company's new BESS called SineStack

An AC Battery : Enphase manufactured



Summary:
The objective of this project is to look into distributed DC-DC converters that can be added to AC split battery sub-units. AC split batteries are integrated battery modules within modular multilevel inverters with a multilevel AC output. However, these battery subunits can be affected by the low-frequency ripple of the AC side, DC-DC converters can be used at the output of the battery modules to eliminate these ripples and also adjust the output voltage to a fixed voltage in case of uneven module voltages or dropped voltage due to low state of charge (SoCs|)and/or bypassing faulty module.

Problem definition:
The voltage and current levels of battery cells are low, so they need to be connected in series and parallel to meet the voltage and power requirements of applications. Cells even with the same manufacturers and ratings show different characteristics such as different self-discharge rates and internal resistance; therefore, their SoC varies over time. Hard-wired battery packs charge/discharge all the battery cells/modules in series with the same current and this limits the capacity, lifetime, and reliability of this kind of battery pack to the weakest cell/module inside of it and it can also lead to battery fire and explosions if the balancing is not done well. Split batteries on the other side can take advantage of the many already existing modules/cells in the hard-wired battery packs to have a multilevel AC output with lower THD and smaller filter requirements and further charge/discharge the battery modules with different average current values according to the modulation technique and balancing algorithm so the battery capacity wouldn't be limited by the weakest module and also it can bypass a cell/module in between in case of faulty one. Moreover, it obviates the need for a central high-rated inverter or charger by using low-rated MOSFETs around each battery module.

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However, since the inverter is not a central separate stage, a central DC-DC stage can also not be added to adjust the voltage. The alternative is to add a low-stressed distributed DC-DC converter to every battery subunit to fix the voltage of every battery module to a constant value even in case of uneven voltage values of battery modules or dropped voltage of modules in case of low SoCs or bypassing a faulty module. Furthermore, it eliminates the problems associated with low-frequency ripple going to the battery modules.

Method:

First, a literature review on AC split batteries and suitable DC-DC converters for the application should be done. Furthermore, the chosen suitable DC-DC converter added to the AC split battery with the structure of conventional cascaded H-bridge and T-type based cascaded H-bridge should be simulated and tested experimentally. Note that the prototype of conventional cascaded H-bridge and T-type based cascaded H-bridge are already built and only the DC-DC converters need to be built and added to the prototype.

Research objectives:

- A report of literature review on AC split batteries and suitable DC-DC converters for them
- Simulation verification of the chosen DC-DC converter added to the conventional cascaded H-bridge and T-type based cascaded H-bridge integrated with battery modules.
- Experimental verification of dc-dc converter added to the already existing conventional cascaded H-bridge and T-type based cascaded H-bridge prototypes.
- Evaluation of merits of adding the dc-dc stage in terms of battery lifetime assessment and reliabilty

Courses and supervision:

This is a straightforward project and the student who has completed a BSc in Electrical Engineering.would follow standard courses. The research would be in support of a PhD project and the PhD students will be the daily supervisor.

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