SiC Based Modular Transformer-less MW-Scale Power Conditioning System and Control for Flexible Manufacturing Plants

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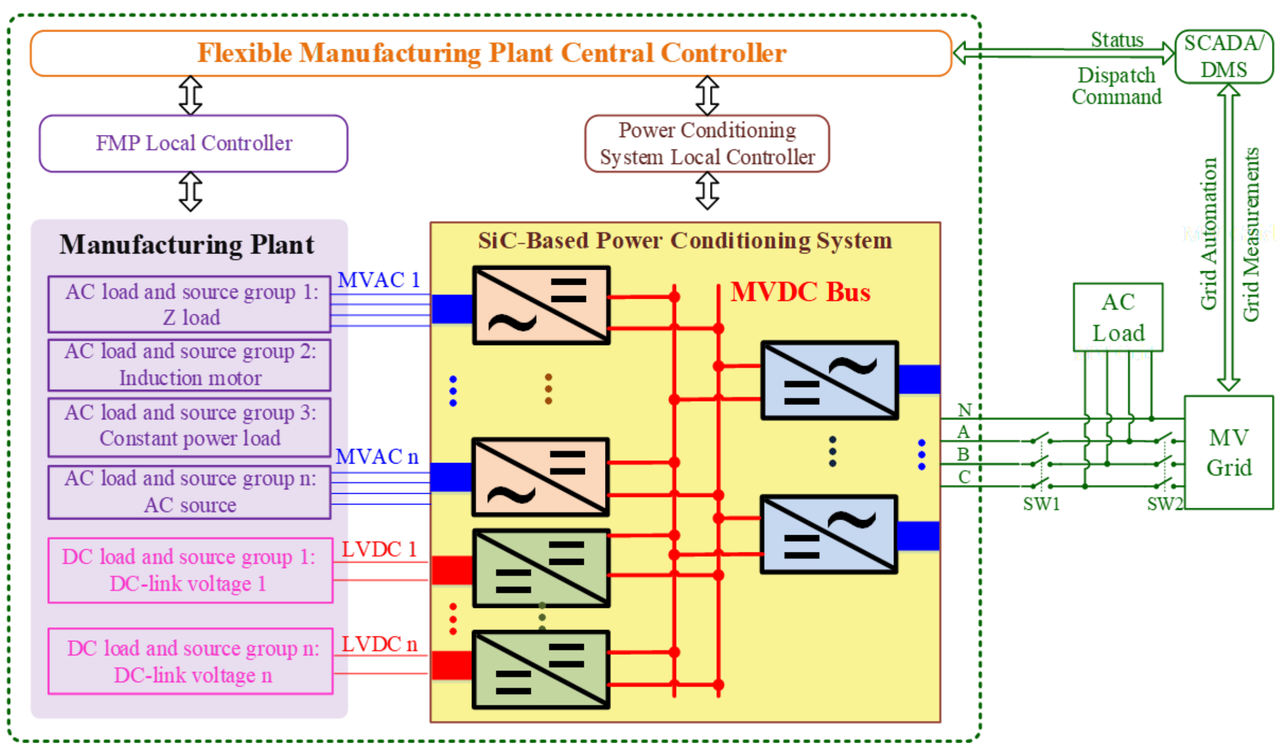
Introduction

- Medium voltage power conditioning system (PCS) is a key enabler to achieve grid-dispatchable and resilient manufacturing facilities.
- A 10 kV SiC power module based transformer-less MW-scale PCS is proposed for the flexible manufacturing plants (FMP). The proposed PCS architecture is capable of multiple asynchronous AC and DC ports, and support flexible and economic loads and source, and enables increased dispatchability and resiliency of the FMP. The PCS also functions as the power/energy flow controller/router, like the solid-state transformer.

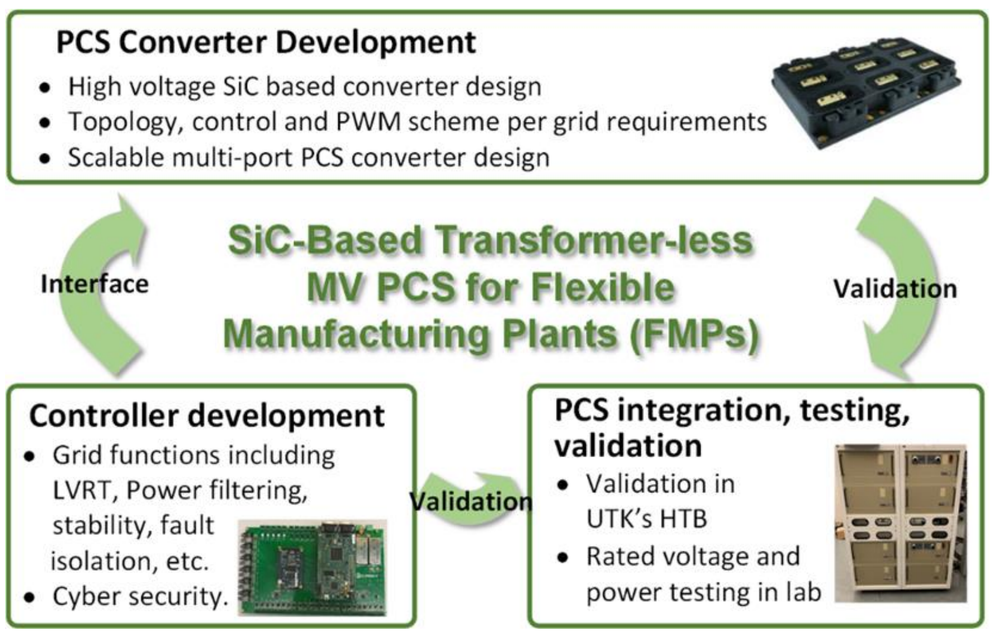
PCS Architecture



Technical Objectives

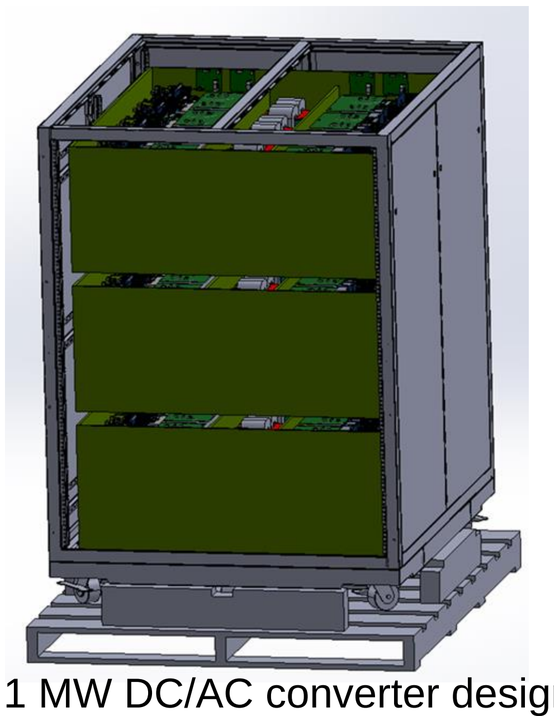
- Develop a 10 kV SiC MOSFET-based 1 MW bi-directional PCS for manufacturing plants, consisting of 1 MW back-to-back 13.8 kV AC/DC converter and a 200 kW isolated DC/DC converters connected to the PCS MV DC bus.
- The proposed PCS converter will meet performance targets including >99.4% power efficiency, <0.3 m3/MW volumetric density, >10% dispatchability, 300 Hz voltage control bandwidth and 1 kHz current control bandwidth, and grid supporting functions including 1) conform with IEEE 1547-2018 and IEEE 2030.7; 2) multiple grid support functions including frequency, var, etc.; 3) multiple operation modes including grid connected, islanded and stand-by; 4) unbalanced load (max 30%) and fault; 5) cyber security
- The PCS converter can also be scaled to >10 MW power and support multi-port operations.

Technical Approaches

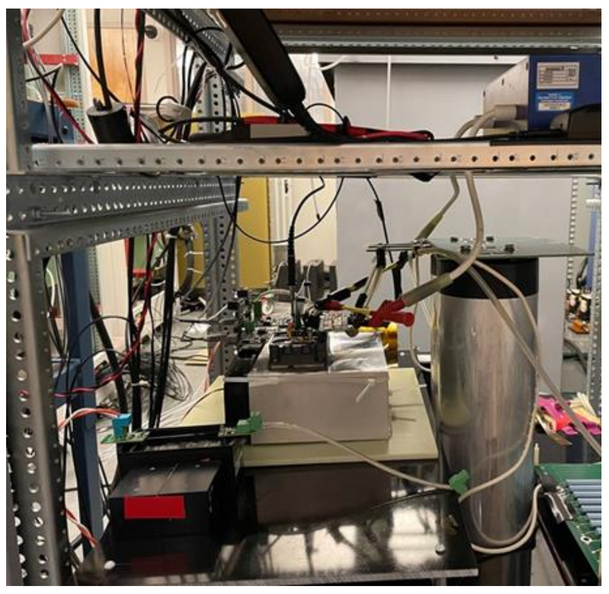


- BP1: Design of 1 MW AC/DC/AC converter and 200 kW DC/DC converter and FMP controller to meet all performance targets.
- BP2: Build the 1 MW AC/DC/AC converter and 200 kW DC/DC converter, and test one phase-leg of the DC/AC converter and one module of the DC/DC converter.
- BP3: Integrating and testing the PCS with FMP controller, demonstrating grid support functions.

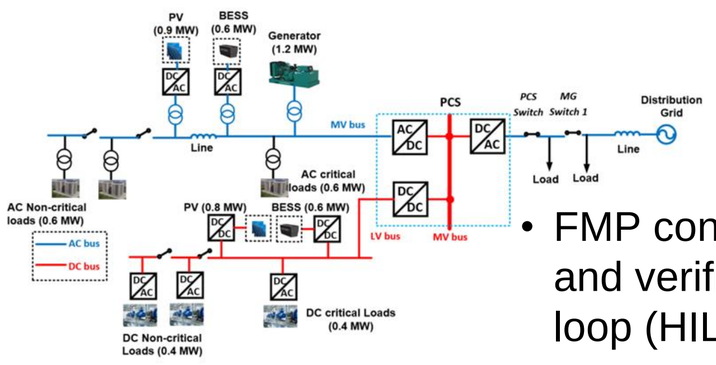
Results



- 1 MW DC/AC converter design



- 10 kV SiC power module HB testing platform



- FMP controller algorithms developed and verified in the hardware in the loop (HIL) simulation

Conclusion and Future Work

- A 10 kV SiC MOSFET based 1 MW PCS is designed meeting all design targets. A 10 kV SiC module based submodule is built and tested with key risks retired. The FMP controller is developed with control algorithms validated.
- Future work is to continue building and testing the 1 MW DC/AC converter and the 200 kW DC/DC converter and then integrating the PCS with FMP controller demonstrating grid support functions.