Multiport Modular Multilevel Converter for DC Systems

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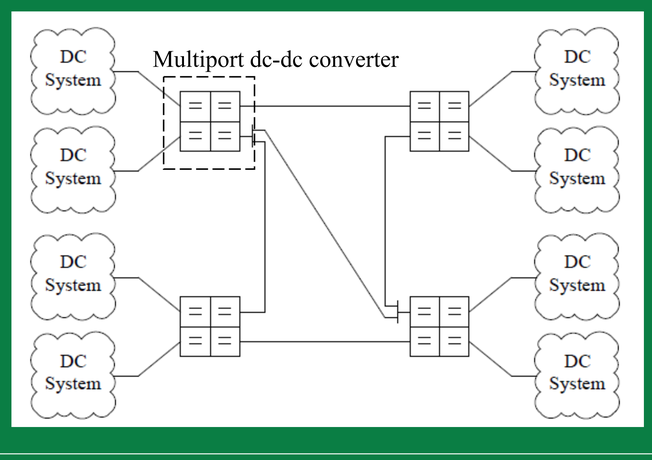
BACKGROUND

High voltage dc (HVDC) transmission has higher transmission capacity and efficiency than ac transmission over long distances. With the existing ac grid becoming overburdened, and the increasing need to interconnect dispersed renewable energy sources, a backbone HVDC grid is an integral part to the next generation of power systems.

To interconnect multiple dc systems, multiport dc-dc converters are required to achieve voltage conversion and power flow control between the connected dc systems in a dc network.



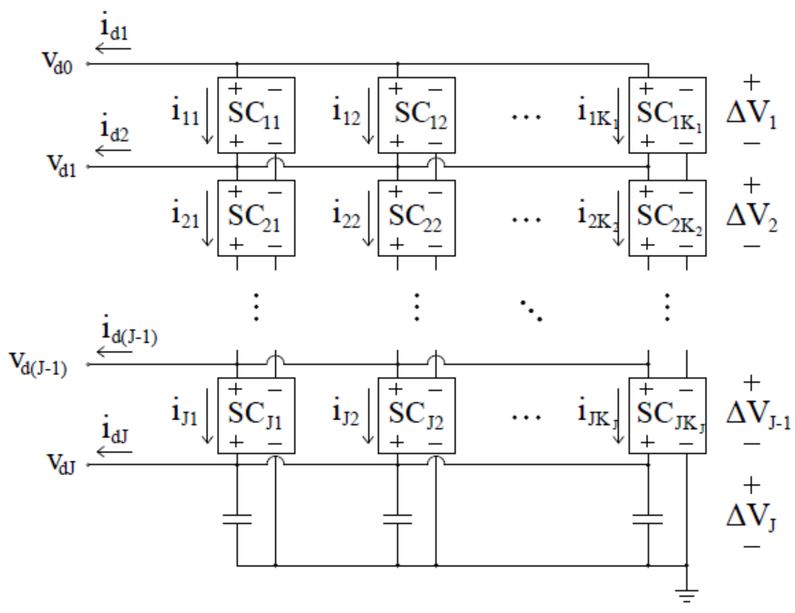
OBJECTIVE

This research proposes a modular multiport dc-dc converter, termed multiport dc-dc modular multilevel converter (MP-DCMMC), for dc system interconnections in MVDC and HVDC networks.

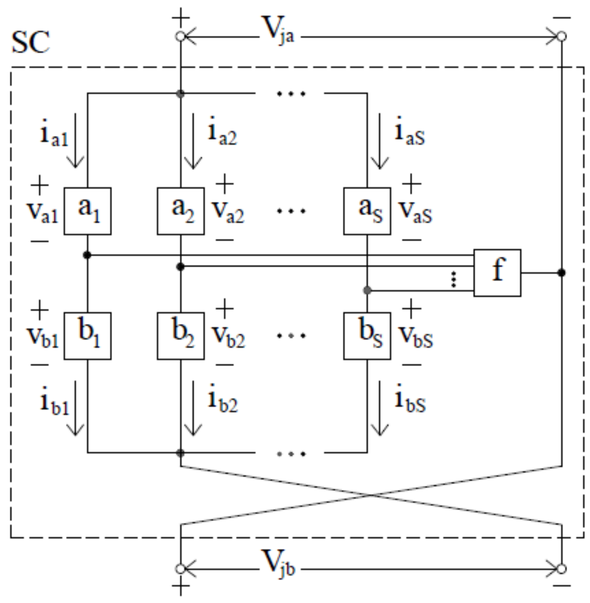
The MP-DCMMC consists of multiple subconverters (SCs), which are based on dc-dc modular multilevel converters (MMCs) to allow voltage conversion at MV and HV levels. When compared with existing multiport HV dc-dc converters, the MP-DCMMC has higher modularity and reliability, and can more easily accommodate additional ports for future expansions to the system.

This work develops the general structure, subconverter design, analytical model and control strategy of the MP-DCMMC. The operation and control of the MP-DCMMC is verified through time-domain simulation in PLECS.

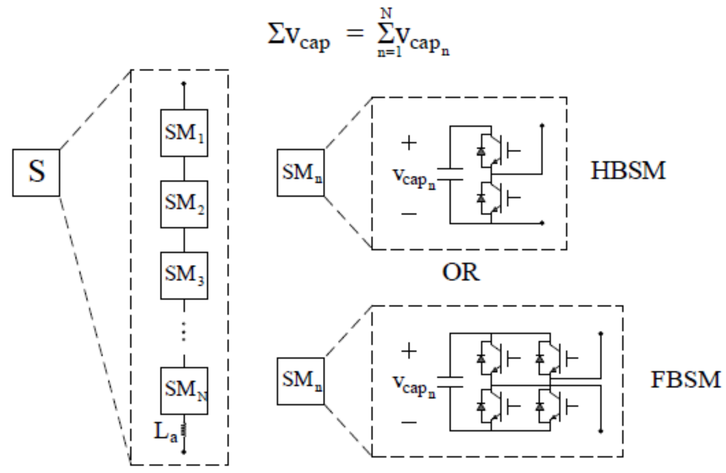
MP-DCMMC Structure



(a) MP-DCMMC general structure



(b) Inverting buck-boost DCMMC



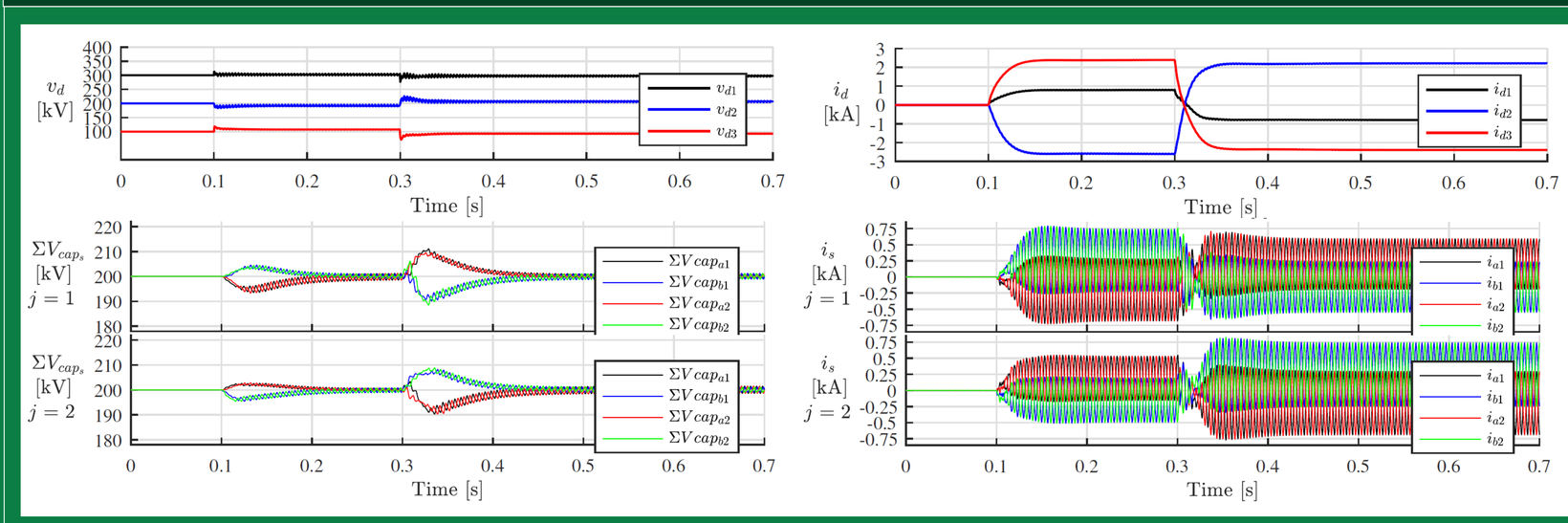
(c) Submodule in an arm

Control Strategy

Two-layer Cascaded Control

The MP-DCMMC utilizes two layers of controls. Each SC has its own inner layer SC controller internal to regulate the power balance between capacitors within itself. An outer layer controller regulates the port voltages and power flow by generating the set-points for the inner layer SC controllers and passing them to each SC.

PLECS Simulation



Contribution and Future Works

The contribution of this work:

- Developing the MP-DCMMC, a truly modular solution for interconnecting multiple dc systems with full voltage conversion and power control abilities.
- Developing the buck-boost DCMMC, which is suitable for two-port dc-dc conversion and can be used as a SC for the MP-DCMMC.

This work provides the foundation for future work in:

- Experimental validation of MP-DCMMC operation and features
- Real-time simulation of multiport dc-dc converters deployed in a multi-terminal dc grid

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