

Simplified Circuit and Switching Device Modeling Approach for Bidirectional CLLC Resonant Converter

A model-based design process is presented for a generic power converter (NiPEBB) for Navy ship electrification under the power corridor concept.

The converter topology is presented and design tradeoffs are discussed. The NiPEBB is designed around a bidirectional resonant CLLC (Fig. 1), utilizing a 500 kHz split-core transformer, 1.7 kV Gen3 SiC dies, and high-power resonant capacitors. The components are integrated on connectorless multilayer organic direct bond copper (ODBC) substrates for thermal management and power density. A common-mode (CM) screen in the ODBC layers is used to mitigate electromagnetic interference (EMI), with the cost of increased parasitic capacitance.

Models are developed in LT Spice for device-level studies and in PLECS for converter- and system-level studies (Fig. 2). The PLECS model is validated by establishing its alignment with LT Spice and with physical hardware, including switching behaviors.

The PLECS model is leveraged for a parametric study to identify a NiPEBB design space where soft-switching can be maintained. Tradeoffs are explored (e.g. load current, switching frequency, deadtime, transformer design, device paralleling) with a goal to minimally compromise all aspects of the NiPEBB design from their nominal targets. Areas of flexibility are identified and their contribution to a realizable design are explored utilizing the PLECS model.

PLECS modeling is used to analyze converter behavior as a hardware demonstrator is incrementally tested.

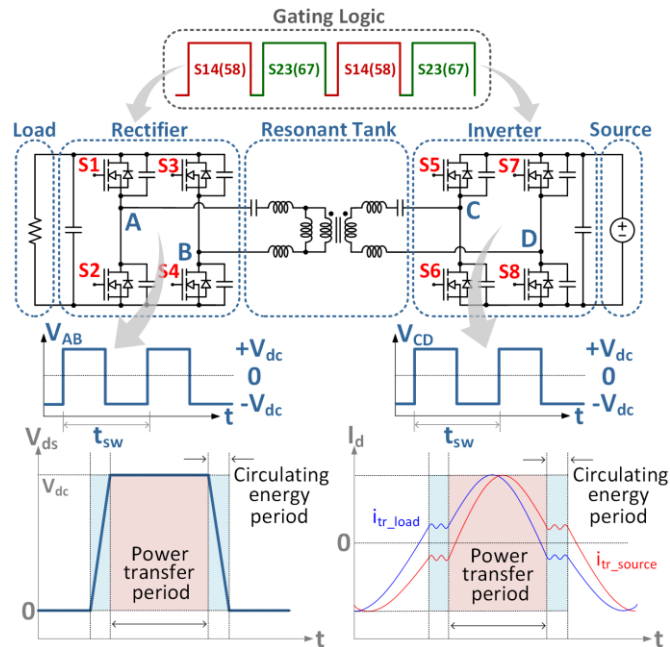


Fig. 1. Resonant converter to be modeled

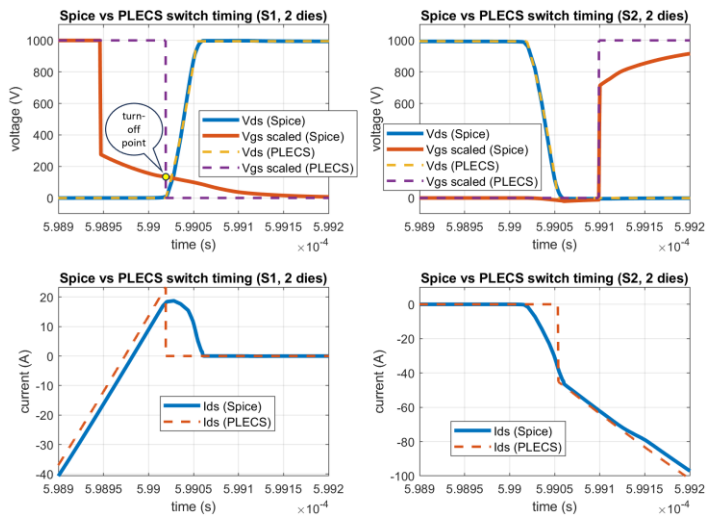


Fig. 2. Switching behavior: LT Spice vs PLECS

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