ABSTRACT
SYMPOSIUM POWER ELECTRONICS FOR ENERGY TRANSITION

30 Sept. & 1 Oct. 2025

Graz, Austria

Submission to the Call for Presentations and Posters

(please save as pdf and upload your document via the submission form by **12 May 2025**)

Corresponding topic (please tick)	☐ Power Electronics in Automotive & Charging Applications ☒ Power Electronics in Medium Voltage Applications ☐ DC Industry ☐ Sustainability & Circular Economy in Power Electronics
Proposed presentation title (you can indicate a preference for oral or poster presentation in the submission form)	Aspects of Solid State Transformers Employing Capacitive Coupling – A Serious Alternative to Inductively Coupled Approaches?
Authors (please highlight corresponding author / speaker)	**Daniel Neuner**, Michael Hartmann

Abstract (1,500 – 3,000 characters), you are encouraged to add graphs/images to highlight your research

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A huge variety of different concepts for solid state transformers (SSTs) has been proposed in recent years. The high potential to meet demands of future medium voltage grid connected converters and the high flexibility makes them suitable for a wide range of applications, e.g. high-power EV charging.

High insulation requirements between the medium voltage input and low voltage output draw focus on the SST's dc/dc converter stage. Beside inductively coupled approaches, where insulation is implemented employing medium frequency transformers, capacitively coupled structures implement capacitors to block the high dc common mode voltages of the series connected converter cells. The latter seem to be a serious alternative as they could score an efficiency improvement of up to 0.5 percentage points without an increase in size (cf. **Fig. 1**) compared to inductively coupled solutions. This is achieved by replacing the individual cell's coupling medium frequency transformer stage by polypropylene film capacitors. These capacitors show very low power losses while at the same time maintaining high voltage capability.

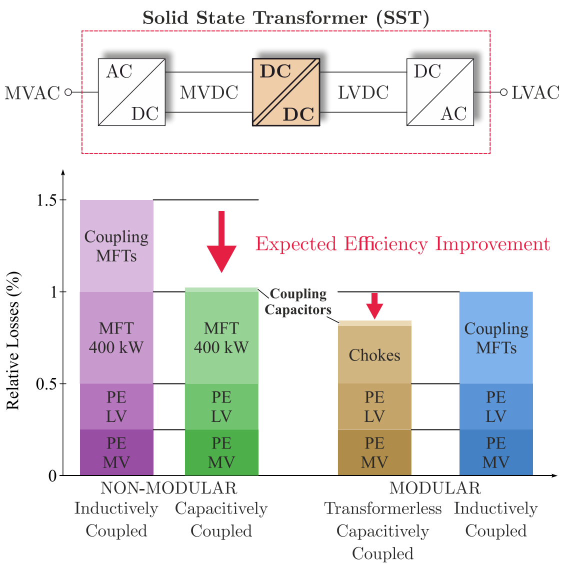

Fig. 1. Comparative evaluation on relative losses for capacitively coupled SST structures and inductively coupled approaches.

Switching time and component mismatches however cause circulating currents within the series connected converter cells which need to be suppressed. This challenging task is intensively investigated and solutions thereto are presented in the final presentation. In general, the capacitively coupled structures further explored in this work (see **Fig. 2**) will be explained in greater detail as well as design challenges and limitations will be highlighted.

A scaled down single cell prototype based on the CC-SST topology given in **Fig. 2(a)** has been designed and constructed (see **Fig. 3**).

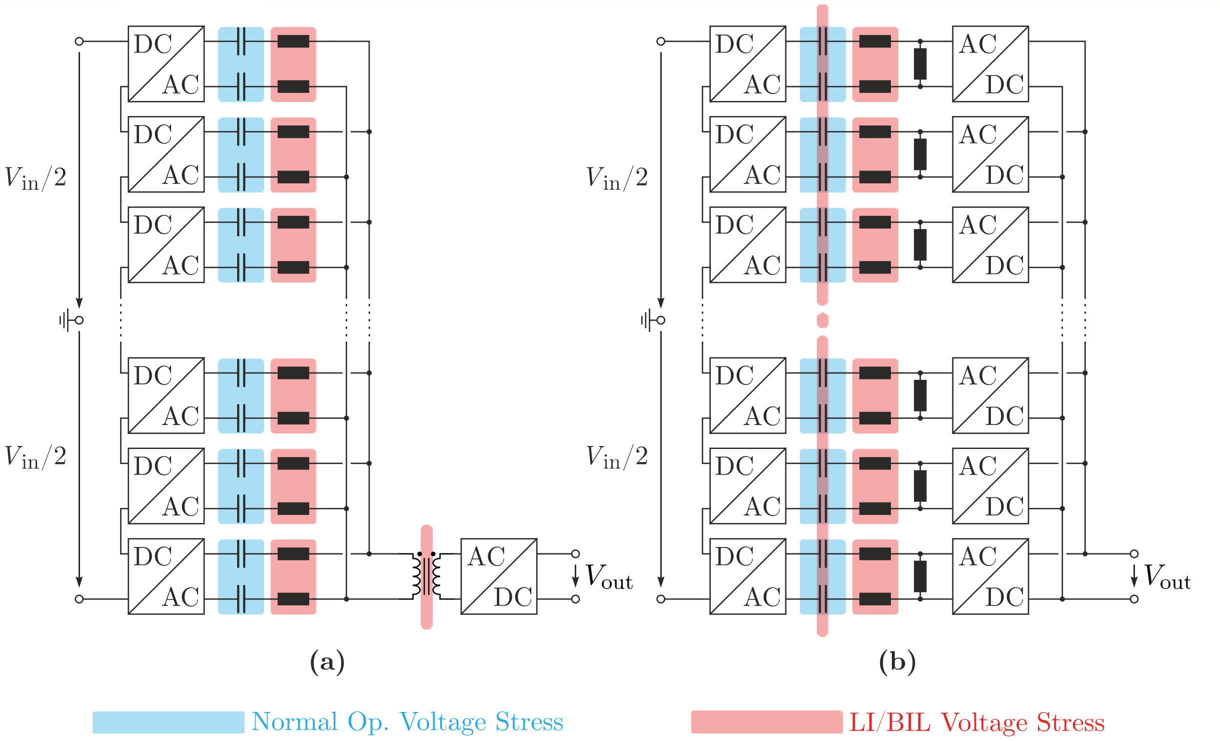

Fig. 2. Capacitively coupled SST topologies. (a) Non-modular capacitively coupled SST (CC-SST) [1] and (b) modular transformerless capacitively coupled SST (TLCC-SST).

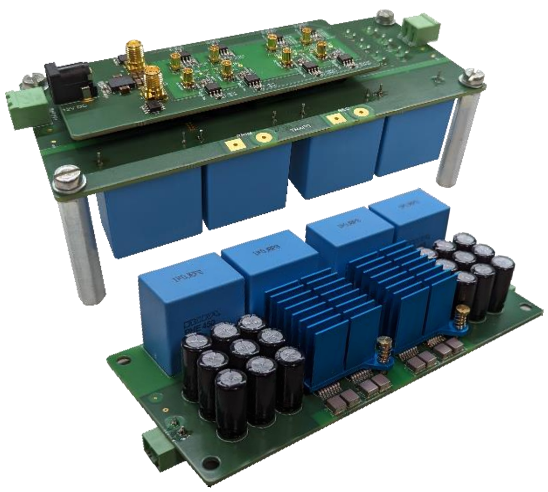

Fig. 3. Down-scaled single cell CC-SST prototype (200 V dc input, 200 V dc output, 2 kW).

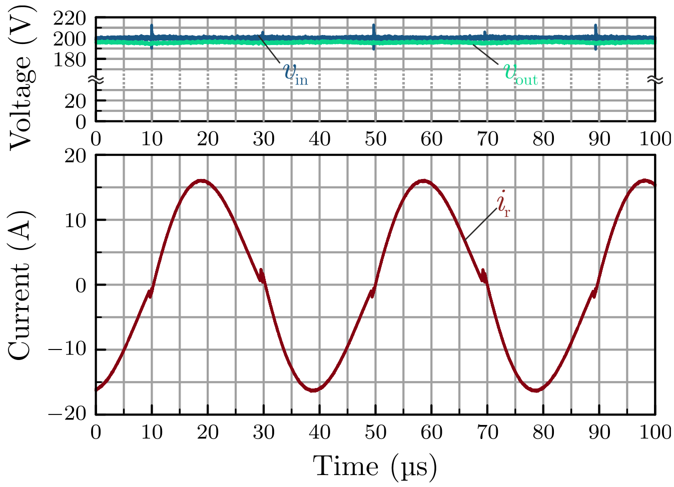

Fig. 4. Measured input voltage (v_{in}), output voltage (v_{out}) and resonant current (i_{r}) for the single cell CC-SST (cf. **Fig. 3**) in DCX operation at nominal load (2 kW).

Beside normal operation, the behavior of the addressed concepts in case of transient overvoltages is investigated in order to ensure proper insulation coordination of the converter. The apparent voltage distribution among the individual components in case of a lightning impulse event is thus analyzed based on derived common mode equivalent models and verified in the lab. Several aspects thereto will also be highlighted and discussed in the final presentation.

[1] K. Wallace, G. Mantov, and P. Jordanoff, “High voltage converter with switch modules parallel driving a single transformer primary,” U.S. Patent 11 463 011B1, Oct. 4, 2022.

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Short CV	Daniel Neuner received the BSc and the MSc degree (both with hons.) in electrical engineering from Graz University of Technology (TU Graz), Graz, Austria in 2019 and 2022, respectively. In February 2022, he joined the power electronics research group at the Electric Drives and Power Electronic Systems Institute (EALS), TU Graz, as a university assistant and PhD student. His research interests include resonant dc/dc converter design and control, Solid State Transformers with special focus on capacitively coupled topologies and insulation coordination of medium voltage grid connected dc/dc converter systems.	
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