Optimization, Modulation and Advanced Control of Solid-State Transformers

Research Focus

This research project focuses on solid-state transformers (SST) and their interaction with the utility grid. By leveraging optimization methods, modulation strategies, and advanced controllers, it aims to achieve higher efficiency, faster dynamic performance, and smarter power routing.

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- Google scholar: https://scholar.google.com/citations?user=1Nqbdv8AAAAJ&hl=zh-CN&oi=ao

Short Description

With the integration of DC grid-tied devices (e.g., electrical vehicle chargers), distributed renewable energies, and V2G technologies, utility grids are becoming increasingly demanding in terms of distribution interface. SSTs are an emerging technology in utility networks. Compared with conventional line-frequency transformers, SSTs are more compact and offer smarter functionalities, making them a key enabling device for future smart grids.

However, SSTs still face challenges such as low efficiency, limited reliability, and high cost. In addition, intelligent features—such as advanced grid-interaction capabilities—remain to be further developed.

Therefore, this research project aims to comprehensively improve efficiency, reliability, cost-effectiveness, and intelligent functionalities through topology and parameter optimization, novel modulation schemes, and advanced control algorithms (e.g., predictive control).

Picture(s) (if available)

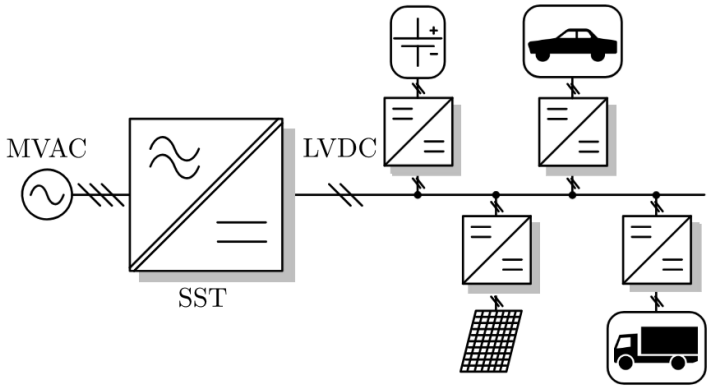

Fig. 1. Hybrid AC/DC interface based on SST.

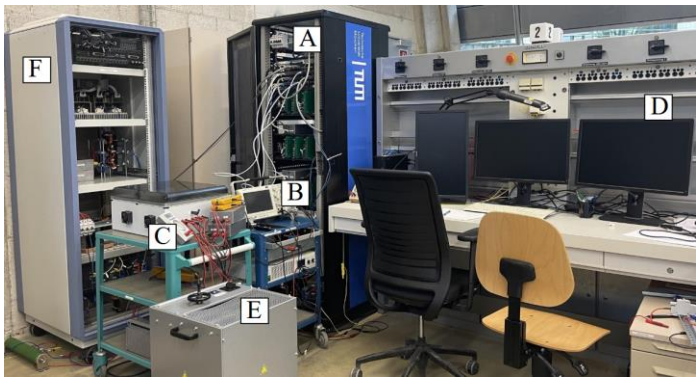

Fig. 2. SST prototype.

Publications (if available)

- D. Kong, T. Cao, R. Kennel and M. L. Heldwein, "Deadbeat Control of Dual Active Bridge Converters With Adaptive Noise Resistance Ability," in IEEE Transactions on Power Electronics, doi: 10.1109/TPEL.2025.3648175.
- T. Cao, D. Kong, C. Hu, B. Long and M. Lobo Heldwein, "Exploring the Inherent Fault-Tolerance of Model-Free Predictive Control in Three-Level T-Type Converters," in IEEE Transactions on Power Electronics, vol. 40, no. 12, pp. 18214-18225, Dec. 2025, doi: 10.1109/TPEL.2025.3594869.
- D. Kong, Y. Sun, Z. Zhang, H. Li, R. Kennel and M. L. Heldwein, "Integrated Model Predictive Control of Double-Stage Solid-State Transformers With Dynamic Reference," in *IEEE Transactions on Power Electronics*, vol. 40, no. 9, pp. 13965-13976, Sept. 2025, doi: 10.1109/TPEL.2025.3571305.

- D. Kong, Y. Wang, Z. Zhang, J. Rodriguez, R. Kennel and M. L. Heldwein, "Transient DC Offset Mitigation for Dual Active Bridge Converters Based on Model Predictive Control With Optimized Dynamic Performance," in *IEEE Transactions on Industrial Electronics*, vol. 72, no. 6, pp. 5906-5916, June 2025, doi: 10.1109/TIE.2024.3482096.
- D. Kong, X. Gao, Z. Zhang, C. Liu, M. L. Heldwein and R. Kennel, "Minimization of Current Stress for Dual Active Bridge Converters Based on Model Predictive Control With Enhanced ZVS Ability," in *IEEE Transactions on Industrial Electronics*, vol. 71, no. 8, pp. 8970-8980, Aug. 2024, doi: 10.1109/TIE.2023.3329229.