ICRERA Paris 2018, October 14 – 17, 2018

Keynote Speech, Professor J.W. Kolar (Abstract)

The Essence of Solid-State Transformers

Solid-State Transformers (SSTs) are power electronic interfaces between medium-voltage AC or DC grids and low-voltage AC or DC grids, which employ medium-frequency transformers to provide galvanic isolation, and which offer a high degree of controllability of active and reactive power flows.

Early concepts date back to the 1970s, where research was mainly driven by the aim to reduce volume and weight of rail vehicles' isolated AC/DC input stages. Later, possible applications in the context of Smart Grids shifted into focus, where the main drivers were enhanced power routing functionalities of power electronic systems compared to passive low-frequency transformers. Current megatrends, such as Smart Cities, Electric Mobility and Clean Energy, open many new and interesting future applications for SST systems, especially in the context of future DC microgrids or DC applications in general, e.g., datacenters, larger EV charging facilities, DC collector grids for high-power off-shore wind parks, or even future hybrid propulsion aircraft.

After showcasing these motivators of SST research, the talk covers key concepts for the realization of SST systems. These key concepts include the scaling of magnetic components with operating frequency, basic isolated DC/DC converter topologies (dual active bridge, series-resonant DC transformer), multi-cell converter structures with input-series output-parallel (ISOP) configuration to achieve modularity and high reliability through redundancy, structural options for realizing three-phase connectivity, and hybrid transformers, amongst others. Industrial SST prototype systems are discussed to illustrate their application in practice.

Finally, the talk concludes with an overview on recent developments in the field, such as highly compact and efficient SST systems based on 10kV SiC power semiconductors.