Solid-state transformers

Energy routing for future trains, ships and smart grids

The next generation of high-speed trains, more-electric ships, and all-electric aircraft or medium-voltage DC collecting grids for offshore wind farms requires electrical isolation between medium-voltage systems and low-voltage systems in a very confined space. Compared to conventional solutions employing passive low-frequency transformers, new medium-frequency solid-state transformers (SSTs) based on highly scalable multi-cell converter systems and/or innovative silicon carbide (SiC) power semiconductors offer unprecedented performance in terms of efficiency and power density. The Power Electronic Systems Laboratory is driving the research in this area, taking a holistic approach based on multi-objective optimisation and considering a wide range of aspects – including, but not limited to, topologies (such as single-cell versus multi-cell approaches), efficiency, power density, isolation, protection, control, reliability, and costs, as well as the design and testing of hardware prototype systems.

www.pes.ee.ethz.ch

High Power Electronic Systems

Ultrafast charging station

Electric vehicles in combination with renewable energy sources have the potential to substantially reduce the greenhouse gas emissions caused by private methods of transport. However, the range of electric vehicles available is still limited due to the energy density of rechargeable batteries and long charging times. With the aim of drastically reducing recharging times, the High Power Electronic Systems Laboratory run by Prof. Jürgen Biela is working on concepts for ultrafast charging stations, which will make it possible to charge electric vehicles in a matter of minutes. To achieve such short recharging times, a high charging power of several hundred kilowatts is necessary. To avoid exposing the electrical grid to excessive stress or disturbance from the rapid charging process, a stationary battery is included in the fast charging station. This stationary energy storage system can also be used as an intermediate storage facility for smart grid applications, thus increasing the station's cost-effectiveness.

www.hpe.ee.ethz.ch

Power semiconductors

Multi-physics modelling of power modules

Designing power semiconductor devices and modules is a highly multi-disciplinary field that requires strong collaborations between material scientists, physicists and power electronics engineers. A goal of this research project, conducted by the Advanced Power Semiconductor Laboratory under Prof. Ulrike Grossner, is to create a computational core that will enable efficient multi-physics modelling of power modules during the design process, simultaneously taking into account the thermal, electrical and electromagnetic aspects. The first modelling examples demonstrate that the multi-domain modelling approach developed in the laboratory and the measurements match up extremely closely. The researchers are aiming to create a powerful tool for the virtual design of power modules, enabling engineers to gain a deep insight in the electrical, thermal and electromagnetic performance of advanced power semiconductor packages developed in the course of implementing wide-bandgap semiconductor devices in power electronic systems.

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