99% Efficient Isolated Three-Phase PFC Rectifier

spotlight-esc.ethz.ch/2018/10/17/99-efficient-isolated-three-phase-pfc-rectifier

Data centers, which are key elements of the worldwide information processing and communication infrastructure are estimated to consume 300 TWh annually, which equals a continuous dissipation of 34 GW. Accordingly, DC power distribution systems with a bus voltage of 400 V are introduced in next generation datacenters to provide significant improvements in terms of efficiency, reliability and cost. However, these systems require rectifiers to supply the dc load from the existing three-phase mains when local generation from renewable sources is not sufficient.

In a research project carried out at the Power Electronic Systems Laboratory, D-ITET, concepts for ultra-efficient three-phase rectifiers are analyzed and a 99% efficient, isolated three-phase rectifier has been built and tested. The prototype shown in Figure 1 is designed for a nominal three-phase input voltage of 230 V rms and an output voltage of 400 V dc. Using a matrix converter topology that enables to integrate the required inductor into the isolation transformer, an exceptionally high power density of 4 kW/liter is achieved. By analytical modeling and optimization of the rectifier's modulation scheme, losses in the semiconductors and the transformer are minimized. Combined with latest SiC MOSFETs this enables an ultra-high peak efficiency of 99.1% at 6.7kW output power and nominal AC input voltage, as can be seen in the measurement results plotted in Figure 2. Compared to best-in-class state-of-the-art systems, this represents a reduction of losses and related energy costs by a factor of two, while maintaining a very high power density.

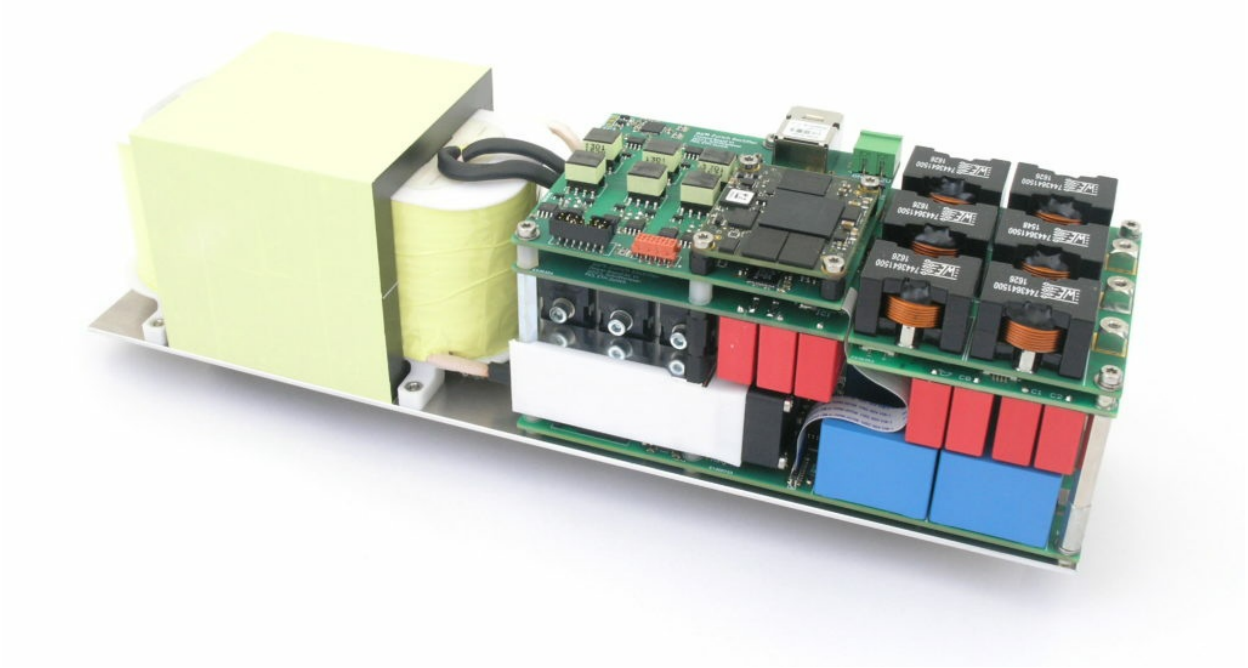

Abbildung 1: Isolated three-phase PFC rectifier prototype, achieving 99% efficiency and 4kW/liter power density

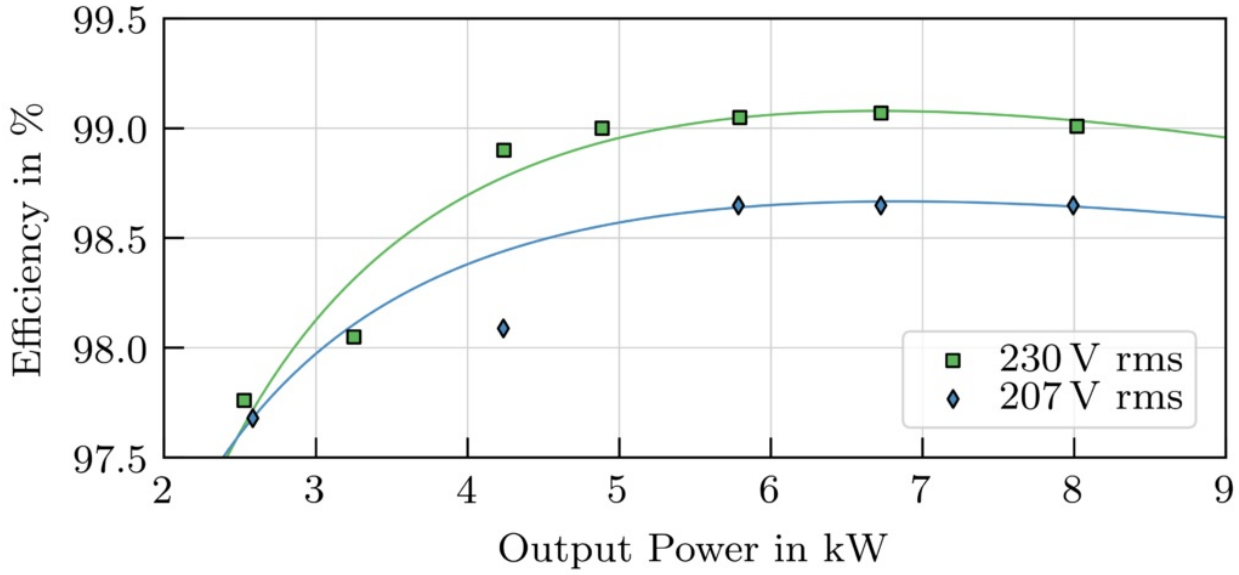

Abbildung 2: Measured efficiencies for two different AC input voltages and various output power levels.

The people involved in this project are Lukas Schrittwieser, Michael Leibl and ESC Member, Professor Johan W. Kolar.

Prof. Kolar is head of the Power Electronic Systems Laboratory (PES). The research at PES opens up new fields of applications and drives the innovation of power electronics systems in close partnership with both Swiss and international industry. In line with the focus areas of ETH Zurich, fundamentally new concepts, e.g., for sustainable energy systems, sustainable mobility, future datacenters, and medical applications, are of primary interest, along with general scientific challenges and the pursuit of excellence and an internationally leading reputation.

Tweet: 99% Efficient Isolated Three-Phase PFC Rectifier