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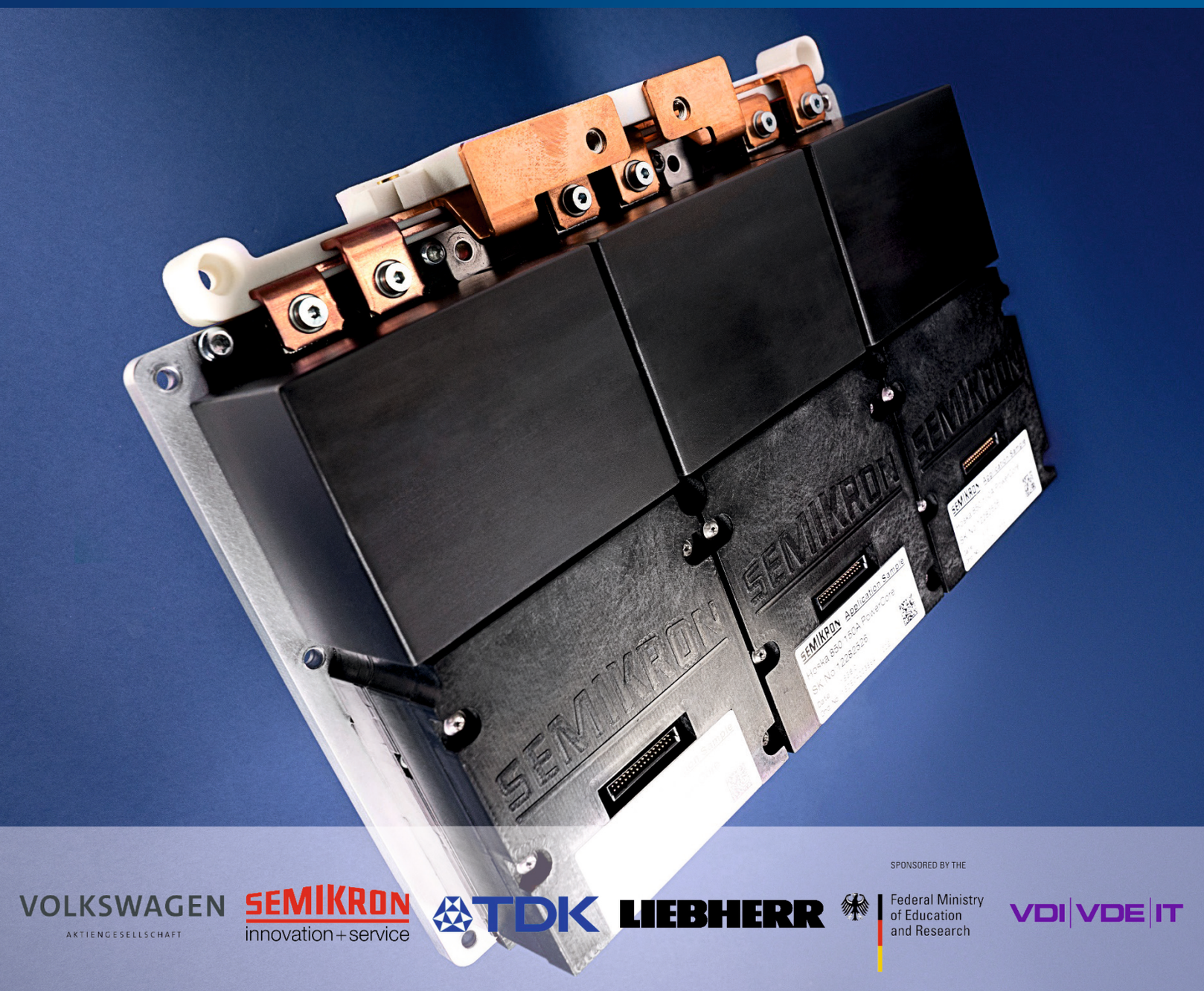
HoskA: 9-PHASE AUTOMOTIVE SIC-INVERTER

Based on three modular 50 kW B6-Inverter-Building-Blocks



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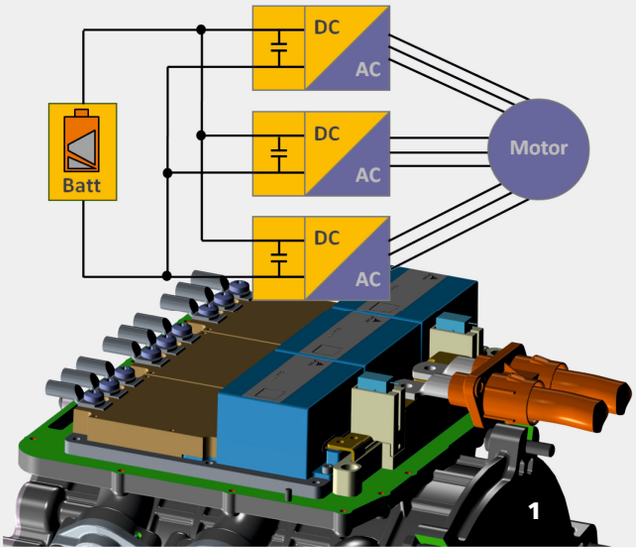

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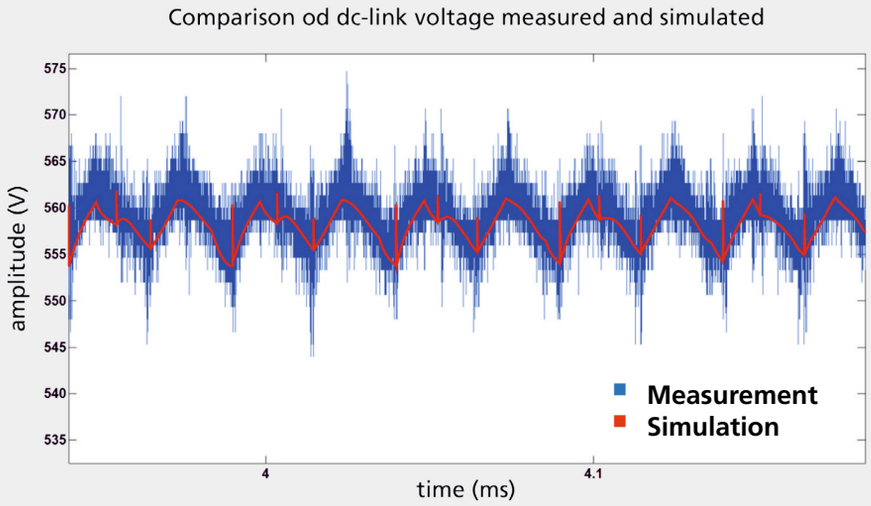

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Modular 9-phase SiC-inverter

Within the project *HoskA,* a SiC-based 9-phase automotive inverter based on B6-powercores was developed. The powercores include the DCB-based powermodules with SiC-MOSFETs and SEMIKRON SKiN technology, the gate driver, the DC-link capacitor as well as current and temperature sensors (Fig.1) .

Using three B6 powercores in parallel, a symmetrical 9-phase 150 kW electric drive with a phase displacement of 40 degree of the PMSM was realized. The modularization concept allows also the realization of 50 kW (3-phase) and 100 kW (6-phase) drive systems using one or two identical powercores.

Simulation based inverter design

A simulation based design approach was used to calculate the losses of the SiC-MOSFETs during operation and to optimize the overall thermal management in Ansys .

A design tool for the dimensioning of the required DC-link capacitance in multiphase inverter systems was implemented in PLECS and Matlab Simulink and verified with test-bench measurements. Fig. 2 shows the comparison of the DC-link voltage ripple measurement (red) and simulations (blue). Within the project, the potential to reduce the total DC-link capacitance in 6- or 9-phase electric drives could be shown.

Technical data 150 kW SiC-drive

DC-Link voltage	650 - 850 V
Max. phase current	100 A_{rms}
Max. output power	3 x 50 kW
Topology	3 x B6
Semiconductor	1200 V SiC
Max. coolant temperature	90 °C
Max. switching speed	40 kV/µs
Powercore dimensions	79 x 171 x 51 mm^3
Commutation loop inductance	< 5 nH

9-phase motor control (FOC)

For operating the HoskA system on the test bench, a 9-phase field-oriented-control (FOC) software was developed in Matlab Simulink and implemented on a dSPACE platform. It includes a novel pulse width modulation (PWM) algorithm with arbitrary variable phase shift and a current control for the fifth and seventh harmonics (Fig. 3) for multiphase drives.

Feature summary

- Highly integrated 9-phase inverter based on 1200 V SiC MOSFETs
- Modular and scalable inverter architecture (50, 100 and 150 kW)
- Highest inverter switching speed and efficiency
- Low commutation loop inductance
- Reduced DC-link capacitance in comparison with 3-phase 150 kW drive train (Fig. 3)
- Integrated passive discharge of the DC-link capacitance
- Increased PMSM torque density [1]
- Improved magnet material utilization because of winding factor effect [1]
- Field-oriented control for 9-phase electric machines
- Further details and advantages of the HoskA 9-phase drive train are summarized in [1]

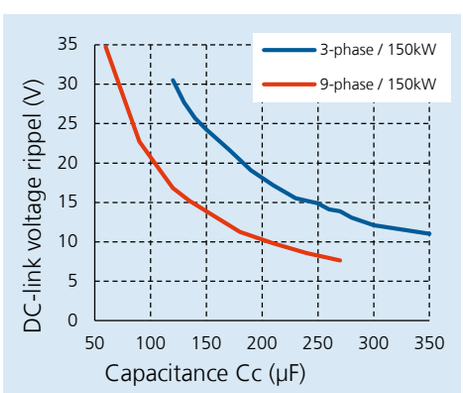

Fig. 3: DC-link voltage ripple as a function of the DC-link capacitance for a three-phase reference and the nine-phase HoskA drive system [1]

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[1] S. Piepenbreier, J. Berlinecke, N. Burani, R. Bittner, S. Matichyn, F. Streit, M. Hofmann, R. Plikat: Analysis of a multiphase multi-star PMSM drive system with SiC-based inverter for an automotive application. PCIM Europe 2018, International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management; Nuremberg; 5-7 June 2018; Germany