

Machine integrated gearbox for electrical vehicles

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MACHINE INTEGRATED GEARBOX FOR ELECTRIC VEHICLES

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Keywords

Electric Vehicle; Actuation Concepts; Machine Integrated Gearbox; Modular Drive; EV Transmission

Research and/or Engineering Questions/Objective

The required electric machine (EM) power to propel an electric vehicle (EV) depends heavily on the speed ratio (SR) that can be obtained by the drive-line. An increased SR reduces the required EM power for a given vehicle weight and acceleration profile. A method is presented, capable of increasing the SR of an EM without the need for weakening the machine magnetic field, potentially improving the drive-line efficiency.

Methodology

To increase the speed ratio of an EM, a speed dependent reconfigurable stator winding structure is presented, named dynamic machine operation (DMO). With DMO, a high starting torque can be combined with a high final speed, as required for traction. Transitions between the different winding structures can be executed during acceleration, realizing a machine integrated gearbox as a result. An overview of existing transmission systems used for EVs, capable of increasing the speed range is presented. The advantages and disadvantages of these systems are weighted and compared with the DMO principle. The open-winding structure EM is powered by an unconventional modular power electronics (PE) system capable of driving each of the winding sections individually or in a per phase series connected manner.

Results

In the paper, simulation and measurement results of different operating modi will be presented and compared. The multi-phase test machine is coupled to a DC load machine, which is driven according to a speed profile or drive cycle. The control methods are tested and will be detailed. The implemented 12 leg voltage source inverter measurement setup has been tested successfully and its operation will be made clear. Efficiency plots of the PE, the EM and the complete drive system are presented for various torque levels.

Limitations of this study

The different operation modi of the DMO principle are demonstrated, however, no transitions between the modi are shown in this paper, due to the restricted number of pages.

What does the paper offer that is new in the field including in comparison to other work by the authors?

Compared to previously published work of the authors, the detailed simulations of the proposed DMO principle including a multiple-harmonics feed-forward controller executed in Matlab Simulink applying PLECS is new. Furthermore, the performed measurements proving the feasibility of the concept are also new.

Conclusions

A new EV propulsion system increasing the speed range of an EM is presented, explained, simulated, and measured. As a result, the machine power requirement for a given dynamical vehicle response can be reduced, potentially improving the drive-line efficiency.