

1. Detailed Description of the Structure of the Co-Simulation

The first model, which is built in Matlab/Simulink, contains the control system. Simulink enables modelling using simple signal flow diagrams and is therefore ideally suited for the implementation of control structures. The second model is the electromagnetic FEM model of the electrical machine. The Maxwell model is used to precisely determine the reaction of the electrical machine to the currents specified by the control algorithm. The third model, built in Ansys TwinBuilder, contains a mechanical model. In Ansys Twinbuilder, physical networks can be built and simulated, which makes it very easy to implement mechanical or electrical networks. In addition, TwinBuilder offers suitable interfaces to Simulink and Maxwell, which makes it a good framework for co-simulation.

For each time step, the setpoints of the control are generated in Simulink, which are transferred to TwinBuilder. In TwinBuilder, the currents are generated, which are transferred to Maxwell. In addition, the mechanical network in Twinbuilder is used to calculate the current speed, which is also transferred to Maxwell. With the help of the speed and the currents in the coils, the electromagnetic torque is calculated in Maxwell, which is again transferred to TwinBuilder. This torque provides the basis for calculating the speed for the next time step. Together with the phase currents, the actual speed and the actual angle of rotation are transferred to Simulink so that the control system can determine the setpoints for the next time step.

2. Additional Simulation Results

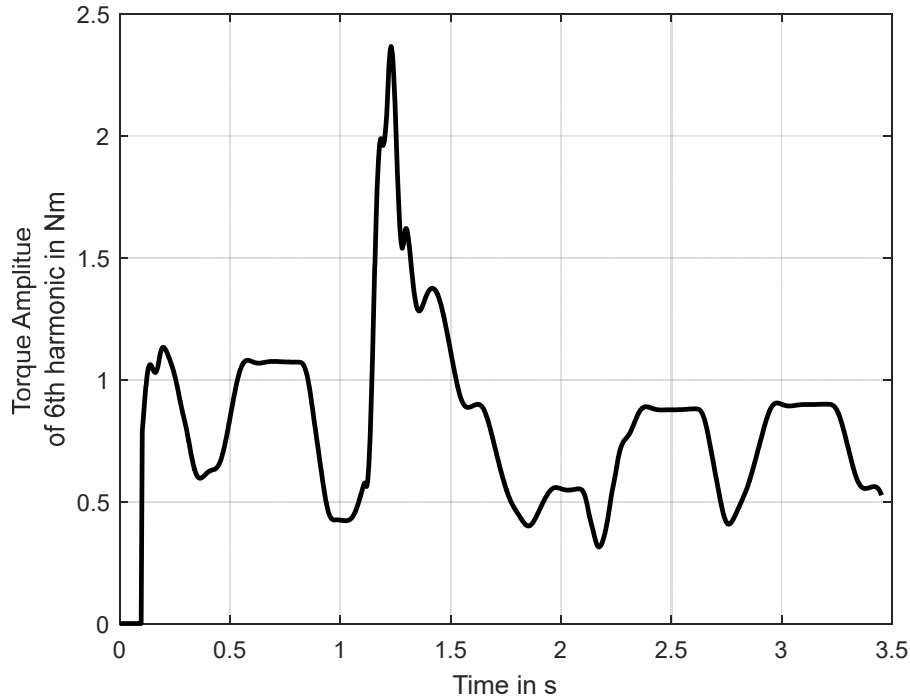


Figure S1. Amplitude of the 6th harmonic in the torque over the step of the general conditions.

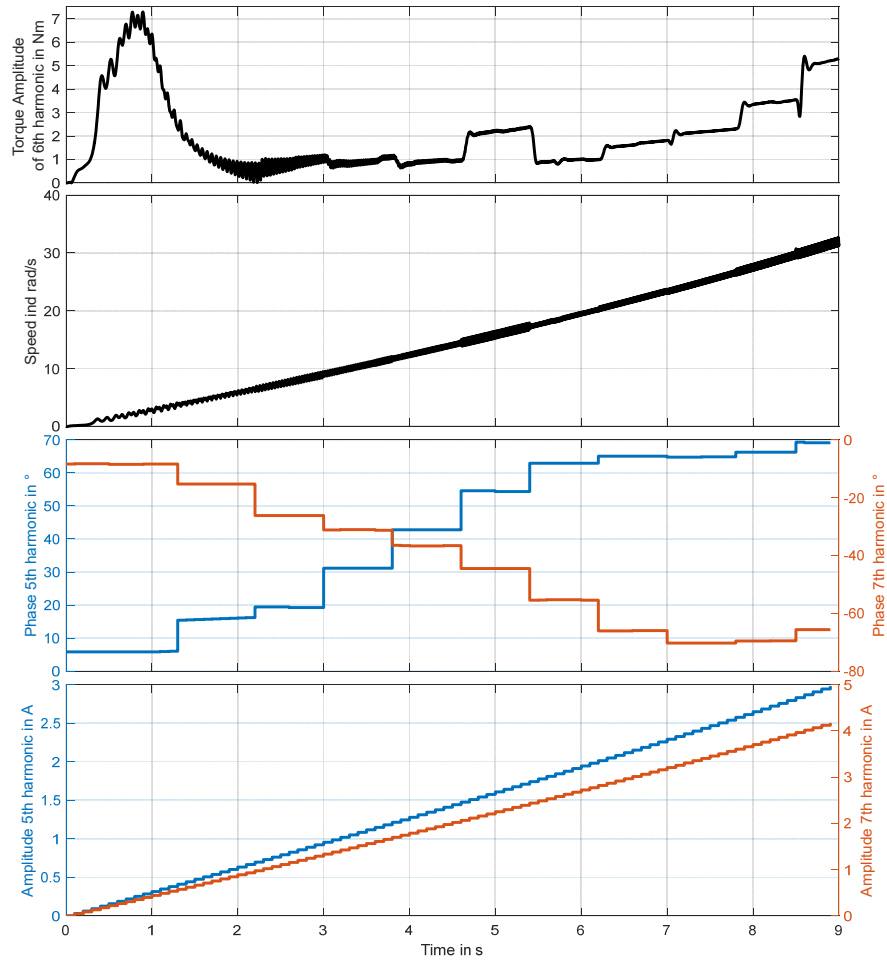


Figure S2. Top: Amplitude of the 6th harmonic in the torque. 2nd: Speed of the rotor. 3rd: Phase angle of the 5th and 7th harmonics in the current. Bottom: Amplitudes of the 5th and 7th harmonics in the current.

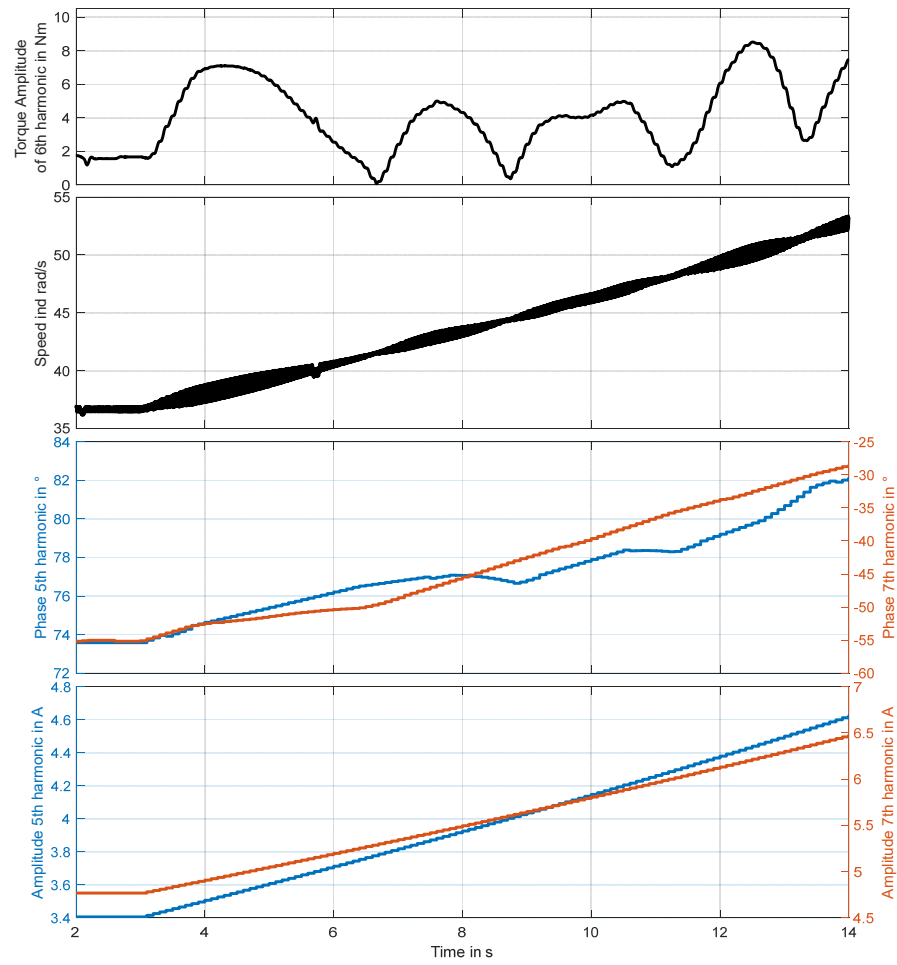


Figure S3. Top: Amplitude of the 6th harmonic in the torque. 2nd: Speed of the rotor. 3rd: Phase angle of the 5th and 7th harmonics in the current. Bottom: Amplitudes of the 5th and 7th harmonics in the current.