Multidomain Design and Optimization Based on COMSOL Multiphysics® Software: Applications for Mechatronic Devices

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Abstract

In a very simplified manner, one typical mechatronic system integrated into ABB's Protection and Control systems consists of mainly two subsystems: the power topology and switching mechanism. This paper focuses on the development of design and optimization methodologies which can be applicable to a large spectrum of mechatronics devices.

A typical structure of such a system consists of a fully mechanical part, an electromagnetic actuator and an electronic control unit. COMSOL Multiphysics® software offers the possibility to analyze the different subsystems of such mechanism. The AC/DC Module is used in order to analyze the electromagnetic actuator. 2D and 3D transient FE electromagnetic simulations are performed in order to analyze the distribution of electromagnetic fields onto the ferromagnetic materials, the current distribution in the conductive materials as well as the electromagnetic forces.

A mathematics model is used in order to implement the differential equations describing the motion of the kinematic. The AC/DC Module and the Mathematics physics interfaces are coupled with the Moving Mesh interface which takes the state variable position to implement the motion of the actuator movable parts. In addition to this, the Structural Mechanics Module is used in order to assess the stress distribution on some critical components of the drive-chain mechanism. In order to damp the forces in the opening operation, an air damper could also be introduced in the system. The usage of the coupling with the CFD Module allows the study and the design of this part of the actuator. Finally, for the optimization of the complete simulation models, a coupling with MATLAB® software is realized.

This paper starts by describing the general context of ABB's Mechatronic Devices and the needs of developing highly advance multiphysics simulation and optimization platforms. The next section focuses on setup of the COMSOL simulation for a complete switching mechanics. The validation of the simulation models is also presented including different optimization case studies. The final part of the paper focused on the lessons learned as well as the foreseen next steps.

Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4