Multi-Level Library of Electrical Machines for Aerospace Applications

P. Giangrande C.I. Hill C. Gerada S.V. Bozhko
University of Nottingham
PEMC Group, Nottingham, NG7 2RD, UK.
p.giangrande@nottingham.ac.uk c.hill@nottingham.ac.uk

An electrical machine library, developed within the framework of the European project *Actuation 2015*, is presented in this paper. The library has been developed adopting a multi-level approach, in order to minimize the models complexity and reduce the computational time. Multi-level approach consists in creating several models of the same electrical machine topology, with different levels of complexity. Indeed, model complexity increases at higher modelling levels and each model takes into account specific physical effects. In addition to the fundamental behavior, the presented models address physical effects such as losses, thermal behavior, magnetic saturation, torque ripple and fault conditions (i.e. short-circuits, open-circuits and permanent magnet demagnetization).

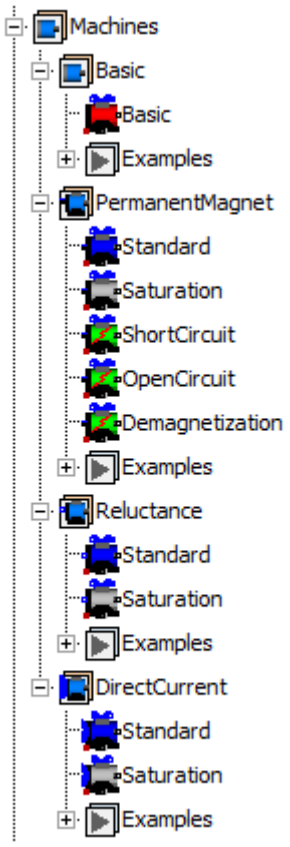

Figure 1: Structure of the `Electrical Machines` library as part of the *`Actuator`* library.

Considering that several models of the same machine topology are available within the library, the interchangeability among the model levels is crucial, in order to investigate different physical effects by simply replacing the model level. For this reason, the interchangeability has been ensured by using common interfaces among the different model levels. Moreover, all the developed models are power balanced and can work indifferently representing motor or generator.

The `Electrical Machines` library has been implemented using Modelica as modelling language. As reported in figure 1, the library is organized as three packages (one for each machine topology) plus the package `Basic`, which considers a generic alternating current electrical machine. The considered machine topologies are permanent magnet synchronous machine (package `PermanentMagnet`), synchronous reluctance machine (package `Reluctance`) and direct current machine (package `DirectCurrent`). Each package contains the sub-package `Examples`, which provides several study cases, helpful for highlighting the features of each modelling level.

The presented work is mainly focused on describing the package for permanent magnet synchronous machine because they are characterized by an excellent efficiency, together with a high power density. These features make permanent magnet synchronous machines very attractive for aerospace applications.

Physical effects included in the models are discussed and their implementation is detailed. In order to highlight the implemented physical effects and confirm the models effectiveness, Dymola simulation results are provided for several operating conditions.