

Formulation of Hamiltonian Model of an Electromechanical Actuator in a Dq0 Reference Frame

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Abstract

A mathematical model of electrical machine formulated using Hamilton formalism is well suited to describe machines with very nonlinear flux-current characteristic, e.g. Synchronous Reluctance Machine (SynRM) [1]. In the model this characteristic is required to be approximated. It can be done using simplicial approximation [2], which approximates the characteristic with a piecewise affine function, used in the modelling and control algorithms synthesis [3]. Simplicial approximation requires sets of corresponding points in the spaces of fluxes and currents. Methods for obtaining such sets, using finite element method model of the machine or results of measurements, were developed in the earlier work, but they assume fixed angular position of rotor during computations or measurements. Thus, the resulting approximation does not take into consideration the dependence of the characteristic on angular position of the rotor, so its use in the mathematical model of the machine formulated in natural reference frame is limited. This dependence can be omitted by formulation of the model in the dq0 reference frame. In the paper, the approximations of the flux-current characteristic described using natural and dq0 reference frame (with the use of modified Park transform [4]) are compared. Possible error in the electromagnetic torque calculations, caused by the transformation to dq0 reference frame is discussed and modification of the model included to eliminate it is proposed. Further approximation improvements can be made using data dependent triangulation (DDT) of the transformed sets of points in both spaces. In the paper, a DDT method based on computed magnetic field coenergy values is presented. In the end, mathematical models of an exemplary SynRM machine, formulated using both natural and dq0 reference frame are compared.

References

1. W. BURLIKOWSKI. Hamiltonian Model of Electromechanical Actuator in Natural Reference Frame, Part 1&2. Archives of Electrical Engineering, vol. 60(3) (2011), 317-348.
2. M. K. AGOSTON. Computer Graphics and Geometric Modeling - Mathematics. Springer (2005).
3. J. P. HOW AND L. RODRIGUES. Observer-Based Control of Piecewise-Affine Systems. International Journal of Control 76 (5) (2003), 459-477.
4. W. BURLIKOWSKI. Application of Hamiltonian Formalism in Description of Electromechanical Actuator for Exemplary Reluctance Motor. Silesian University of Technology Publishing (2012).