Modeling and System Identification of a Variable Excited Linear Direct Drive

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Abstract : Linear actuators are deployed in a wide range of applications. This paper presents the modeling and system identification of a variable excited linear direct drive (LDD). The LDD is designed based on linear hybrid stepper technology exhibiting the characteristic tooth structure of mover and stator. A three-phase topology provides the thrust force caused by alternating strengthening and weakening of the flux of the legs. To achieve best possible synchronous operation, the phases are commutated sinusoidal. Despite the fact that these LDDs provide high dynamics and drive forces, noise emission limits their operation in calm workspaces. To overcome this drawback an additional excitation of the magnetic circuit is introduced to LDD using additional enabling coils instead of permanent magnets. The new degree of freedom can be used to reduce force variations and related noise by varying the excitation flux that is usually generated by permanent magnets. Hence, an identified simulation model is necessary to analyze the effects of this modification. Especially the force variations must be modeled well in order to reduce them sufficiently. The model can be divided into three parts: the current dynamics, the mechanics and the force functions. These subsystems are described with differential equations or nonlinear analytic functions, respectively. Ordinary nonlinear differential equations are derived and transformed into state space representation. Experiments have been carried out on a test rig to identify the system parameters of the complete model. Static and dynamic simulation based optimizations are utilized for identification. The results are verified in time and frequency domain. Finally, the identified model provides a basis for later design of control strategies to reduce existing force variations.

Keywords : force variations, linear direct drive, modeling and system identification, variable excitation flux
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