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Mon-Af-Po1.21-05 [92]: Design and Analysis of a Multi-Flux-Modulated Permanent Magnet Motor

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Flux-modulated permanent magnet (FMPM) motors have attracted widespread attention in many applications due to the superiority of low-speed large-torque, such as the electric vehicles. In the type of motors, the flux modulation effect is the key to obtain the excellent torque performances, which realize the electric gear operation by forming the matching between the magnetic fields with high PM pole-pairs and low winding one. So in previous studies, the flux modulation effect of the FMPM motor has been the main research subject, where the performance improvements are often realized by the single design of PMs, or modulator, or winding. It reveals that the highly efficient utilization of modulation effect is an effective path to deeply explore and develop the performance potential of the FMPM motors. It is worth noting that, in motor energy conversion, the motor flux is often modulated by one time, which is inferred that the increase design of modulation times may be another effective way to improve the modulation effect utilization. In this paper, a concept of multi-flux-modulation (MFM) is proposed, and a multi-flux-modulation flux-modulated permanent magnet (MFM-FMPM) motor is designed and investigated. It contains a stator, middle PM rotor, and inner PM rotor. And the halbach-array is applied in the inner rotor to increase the PMs utilization. The key of the MFM-FMPM motor is that the MFM can be divided into three modulation combinations. One of the magnetic fields generated by the PMs in the inner rotor is modulated by the modulator in the middle rotor. Simultaneously, the other two magnetic fields generated by the PMs in the middle rotor are modulated by the stator and the modulators on the inner rotor respectively. The main harmonics in the three magnetic fields are utilized by the armature windings on the stator. With the unique MFM effect, the performances of the motor are significantly improved. Finally, the prototype is manufactured to verify the effectiveness of the MFM design and the MFM-FMPM motor.

Primary authors: Mrs PU, Weiling (jiangsu univeristy school of electrical and information engineering); Prof. QUAN, Li (School of Electrical and Information Engineering, Jiangsu University, Zhenjiang, China); Prof. ZHU, Xiaoyong (School of Electrical and Information Engineering); XIANG, Zixuan; Mrs JIANG, Min (Jiangsu univeristy school of electrical and information engineering)

Presenter: Mrs PU, Weiling (jiangsu univeristy school of electrical and information engineering)

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