

## Third harmonic utilization in permanent magnet machines

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### Abstrak

This book investigates the utilization of harmonics in the permanent magnet (PM) or rotor shape to improve the torque density of PM brushless AC machines including three-phase inner rotor and outer rotor machines, five-phase machines, dual three-phase machines, linear machines, by means of analytical, finite element analyses, and as well as experimental validation.

The torque density can be improved while the torque ripple remains low in PM shaping utilizing the 3rd harmonic. In this book, the analytical expression of output torque is derived for PM machines with rotor shape using the 3rd harmonic, and then the optimal 3rd harmonic for maximizing torque is analytically obtained.

The book compares the PM shape in surface-mounted PM (SPM) machines and the rotor lamination shape in interior PM (IPM) machines utilizing the 3rd harmonic, and it becomes clear that their shaping methods and amount of torque improvement are different.

In a five-phase PM machine, the 3rd harmonic can be utilized in both the current waveform and PM shapes to further improve the output torque. For the dual three-phase SPM machines without deteriorating the torque more than 30% when the optimal 3rd harmonic into both the current and PM shape are injected.

The harmonics in airgap flux density have significant influence on the cogging torque, stator iron flux distribution, and radial force between the rotor and stator. These effects has been investigated as well in this book.