Proposed Commutation Method for Performance Improvement of Brushless DC Motor

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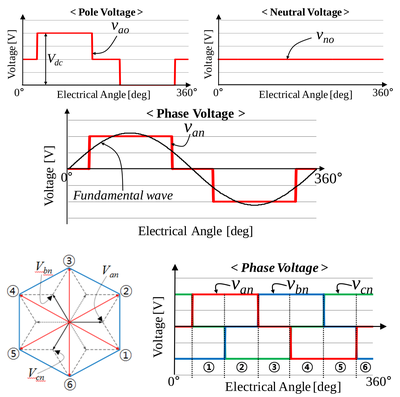
Background

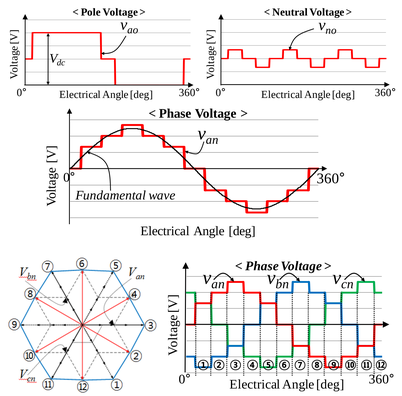
This study focused on efficiency improvement of BLDC motors via reduction of torque ripple, core loss, and permanent magnet loss. To achieve this objective, we proposed an improved 150° commutation method for three-phase permanent magnet brushless DC (BLDC) motors to improve the current waveform. Although the 120° commutation method is generally employed for a BLDC motor, the 150° commutation method is introduced in order to operate the BLDC with the same efficiency as a brushless AC (BLAC) motor. Moreover, an improved 150° commutation is proposed to reduce the phase current harmonics. The study investigates the attributes of different commutation methods analytically and experimentally in order to determine the optimal commutation method. The result of this study indicates that the improved 150° commutation method is optimum in terms of harmonic attributes, and reduced torque ripple, thereby improving the motor's efficiency.

Comparison of Commutation Method

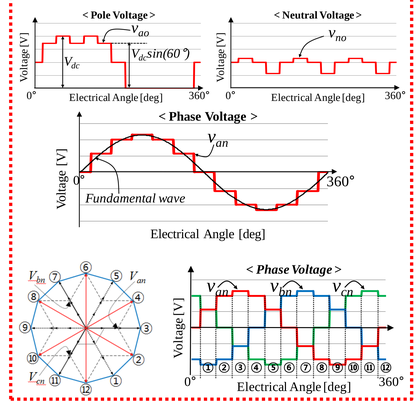
✓ 120^0 commutation



✓ 150^0 commutation



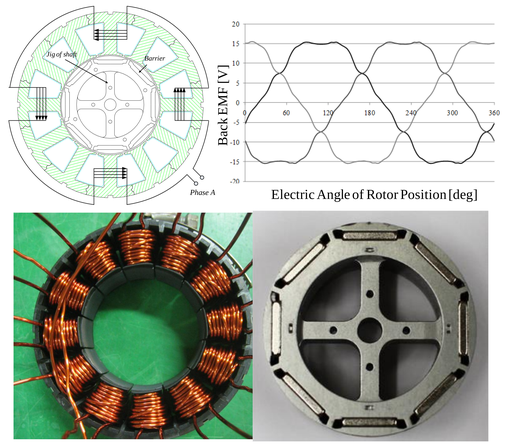
✓ Improved 150^0 commutation



Conclusion

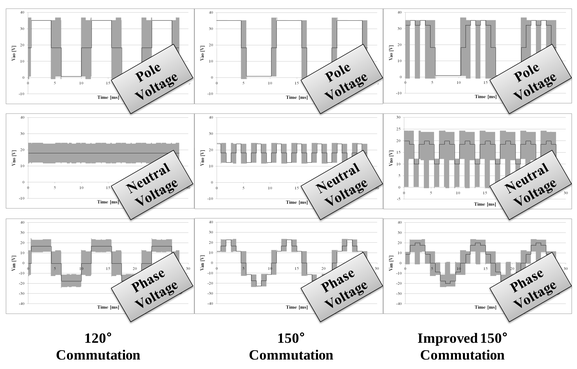
- The research conducted in this paper was based on BLDC motor characteristics for different commutation methods. Analysis was conducted using the co-simulation of the control circuit and the magnetic field FEM. The analytical method presented in this paper realizes near-reality input current waveform. In particular, it is important to minimize the current harmonics since it is significantly related to core loss, permanent magnet loss, and torque ripple.
- Our study was able to conclude that the improved 150° commutation method reduced current harmonics, thereby significantly improving the performance. Therefore, the improved 150° commutation method is ideal in fields where efficiency, torque ripple, and cost are important.

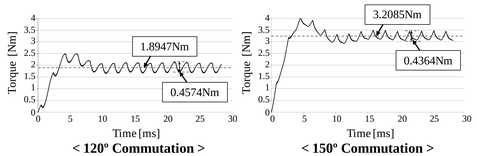
Studied Model and Specifications

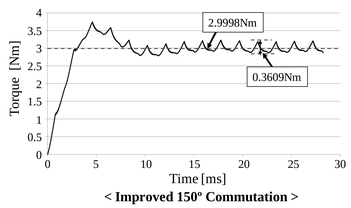


Parameters	Value	Unit
Base Speed / Max. Speed	1325 / 3930	rpm / rpm
Torque @ Base / Max. Speed	2.45 / 0.45	Nm / Nm
Continuous Power	340	W
Poles/Slots	8/12	-
Outer Diameter	110	mm
Stack Length	24.5	mm
Air Gap Length	0.5	Mm
Permanent Magnet(NdFeB)	1.25	T (@20℃)
Operating Temp.	100	℃

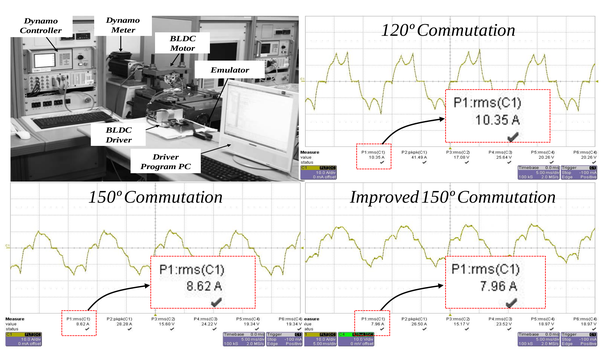
Analysis Results of Co-Simulation

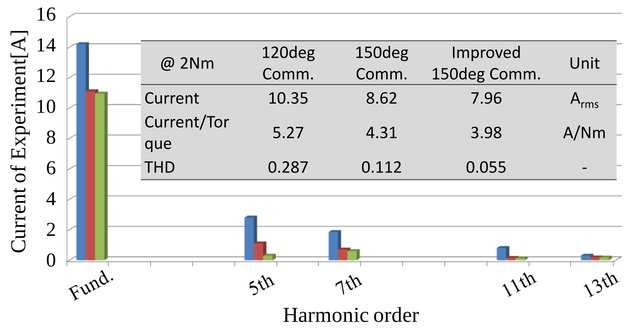






Experiment Results





@ 2Nm	120deg Comm.	150deg Comm.	Improved 150deg Comm.	Unit
Current	10.35	8.62	7.96	A_{rms}
Current/Torque	5.27	4.31	3.98	A/Nm
THD	0.287	0.112	0.055	-

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