Winding Current Reconstruction of Brushless Permanent Magnet Motor

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Abstract

Brushless Permanent Magnet (BLPM) motors have many benefits, such as high efficiency and high power density, which make them a popular choice in advance motor drive systems. However, the values of the three-phase currents of the motor are required to control the torque of the motor, which has to be measured using multiple current sensors. The current sensors are expensive and reduce the reliability of the system. In addition to this, current sensors may degrade the signal and introduce errors, which may results in torque ripple in a practical motor drive.

Several researchers have proposed various methods to reduce the number of current sensors. One of those methods suggested using a single current sensor to measure the DC link current and using the switching signals to reconstruct the three-phase currents of the motor. Although this was possible, it should be emphasised that in some instances of the switching state, the motor current does not flow through the DC link, but it circulates inside the inverter circuit. In several articles, the method to find the three-phase currents using a similar method was explained. However, none of these studies considered the circulating inverter current in the reconstruction of the phase currents.

This thesis provides a comprehensive motor simulation program that can be used to study a number of operating modes of the motor drive, and can introduce artificial faults and noises that may appear in the real drive. The thesis also provides a detailed analysis of the DC link current and inverter switching states. The current reconstruction algorithm and a compensation routine are given in the thesis. The practical data from the real motor drive are obtained, the simulation studies are verified, and the limitations of the method are highlighted. It is demonstrated that a single current sensor on the DC link and the switching signals can be used to reconstruct the three-phase currents of the BLPM motor. However, a real-time implementation of such a method requires a noise-free measurement and further improvements on the current compensation technique, which can be investigated in the future.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Libraries, being available for photocopying and loan.

Signature:...   **Date:** 2/4/01

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Abbreviations

Abbreviation	Variable Name	Units
θ_e	Electrical position	rad
Δerror	DC link current error = real DC link current - simulated DC link current	A
Δh	Hysteresis bandwidth for current	A
ω_e	Electrical velocity of the motor	rad/s
ω_r	Angular speed of the rotor	rad/s
Δt	Sampling interval	sec
AC	Alternating current	
B	Damping coefficient	Nm·s
BLDC	Brushless DC	
BLPM	Brushless Permanent Magnet	
CSI	Current Source Inverter	
DC	Direct current	
$e_{1,2,3}$	Instantaneous back emf voltages of phase1, 2 and 3 respectively	V
$i_{1,2,3}$	Instantaneous phase currents of phase1, 2 and 3 respectively	A
$I_{compensate1,2,3}$	The phase currents of the simulator after compensating	A
I_{dc} or i_{dc}	DC link current, average or instantaneous values respectively	A
$I_{dcphase}$	The current of a phase of which the absolute amplitude of the current is equal to the absolute amplitude of the DC link current	A
$I_{model1,2,3}$	The phase currents of the simulator	A
$I_{motor1,2,3}$	The phase currents of the real motor	A
J	Moment of inertia	kg·m^2
k_e	Maximum back emf constant	V·sec/rad
L	Inductance of the motor winding	H

Abbreviation	Variable Name	Units
n	The number of step of the integration	
PID	Proportional Integral Differential	
PWM	Pulse Width Modulation	
R	Resistance of the motor winding	Ω
rpm	Revolutions per minute	
T_e	Electromagnetic torque	N·m
T_L	Load torque	Nm
$v_{1,2,3}$	Instantaneous phase voltage	V
$v_{a,b,c}$	Instantaneous terminal voltage	V
V_{dc}	Voltage between the positive and the negative DC rail	V
v_s	Voltage at the star point in the motor circuit	V
VSI	Voltage Source Inverter	

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