Parameter Identification of IPM Motor Focusing on Current Norm

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1. Introduction

This paper proposes a new approach to identify the q-axis inductance L_q of an interior permanent magnet synchronous motor (IPMSM) focusing on the current norm characteristic. The current norm depends on the mismatch of L_q, and the minimum or the maximum value of the current norm is obtained when the parameter is properly tuned. Using a simple method to search the minimum point of the current norm, it is possible to achieve the off-line parameter identification. This paper describes an improved technique to identify L_q of the motor, which introduces a P controller and a PI controller to the current loop of the field-oriented controller. The current norm characteristic is examined through computer simulations and experimental tests.

2. Identification System

Fig.1 presents the proposed L_q identification technique. This identification system tunes $\hat{L}_q$ in the decoupling controller. The P controller with a small gain is employed in the d-axis loop to get the current variation caused by the mismatch between $\hat{L}_q$ and L_q. On the other hand, the PI control is used in the q-axis loop to reduce interference by the unidentified $\hat{L}_d$ and $\hat{\Psi}$. The PI controller has the following time constant and loop gain to obtain the optimum response:

$$\tau_q = \frac{L_q}{R} \quad (1)$$

$$K_q = \omega_{cq} L_q \quad (2)$$

Setting $i_d^* = 0$, i_d , i_q and the current norm can be obtained as follows:

$$i_d = \frac{i_q^* K_q (1 + s\tau_q)\omega(L_q - \hat{L}_q)}{(K_q + R)(K_d + R)\tau_q s} \quad (3)$$

$$i_q = \frac{i_q^* K_q (1 + s\tau_q)(R + K_d)}{(K_q + R)(K_d + R)\tau_q s} \quad (4)$$

$$i_n = \sqrt{i_d^2 + i_q^2} = \frac{i_q^* K_q (1 + \tau_q s)\sqrt{\omega^2 (L_q - \hat{L}_q)^2 + (R + K_d)^2}}{(K_q + R)(K_d + R)\tau_q s} \quad (5)$$

From (5), it is found that the current norm is varied by the mismatch between $\hat{L}_q$ and L_q. The current norm has a convex parabola characteristic and has the minimum value when $\hat{L}_q = L_q$.

3. Simulation and Experimental Results

The proposed technique is tested through computer simulations using PSIM software and experimental tests with a real IPMSM shown in the Table1. It can be seen in Fig. 2 that when the speed is stable and $\hat{L}_q$ is equal to a real value of L_q, the current norm becomes the minimum. While the mismatch between $\hat{L}_q$ and L_q is observed, the current norm is greater than the minimum value.

Table 1. Parameters of IPMSM.

Number of poles	6
Winding resistance	0.48 Ω
Rated output power	1.5 kW
Rated rotation speed	3000 r/min
Damping coefficient	0.00019 Ns/rad
q-axis inductance	24.5 mH
Range of q-axis inductance	22.5mH~36.0mH
d-axis inductance	13.0 mH
Setup d-axis inductance	10.0 mH
Field flux linkage	0.06737 Wb
Setup field flux linkage	0.0 Wb
Rotation speed	320 r/min

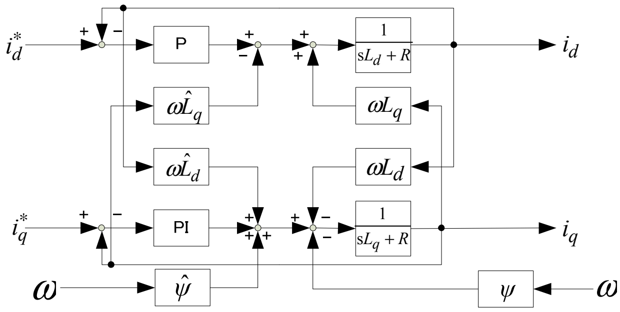

Fig. 1. Proposed L_q identification technique.

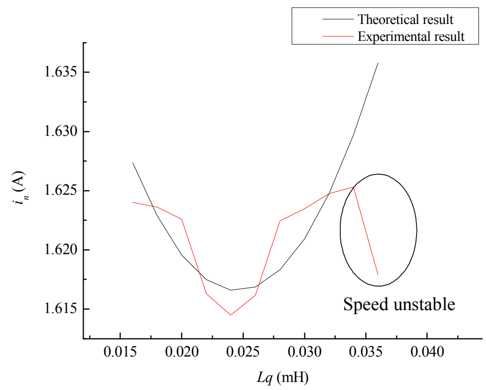

Fig. 2. Current norm characteristics with respect to L_q mismatch.

4. Conclusion

The current norm characteristic with respect to L_q mismatch has been confirmed. The experimental and simulation results show that the identification of L_q can be achieved by using the current norm characteristic.

References

(1) Ji Xiang and T. Noguchi, "Off-Line Parameter Identification of Permanent Magnet Synchronous Motor Based on Current Norm," IEEJ IAS Conference Proceedings No. 3,70, pp. 315-318, Aug. 2012(in Japanese).

(2) Ji Xiang and T. Noguchi, "Offline Identification of q-axis Inductance in Interior Permanent Magnet Synchronous Motor Based on Relationship between Its Parameter Mismatch and Current Norm," IEEJ Conference Proceedings No. 4,129, pp. 225-226, Mar. 2013(in Japanese).