Experimental Result of Flux Linkage Identification of IPM Motor by Focusing on Current Norm

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1. Introduction

Magnetic flux linkage is one of the main parameters of an interior permanent magnet (IPM) motor. A novel parameter identification technique has been proposed by the authors [1]. To confirm effectiveness of the flux linkage identification proposed in the past work, this paper presents the experiment result and evaluates the identification error.

2. Flux Linkage Identification Technique and Result

Figure 1 shows the configuration of the proposed identification technique. The q-axis current control loop employs a P regulator instead of a PI regulator and d-axis inherently does the PI regulator. Therefore, the q-axis current is influenced by the mismatches of the flux linkage Ψ and the d-axis inductance L_d. The d-axis current follows to its command with no steady state error because of the PI regulator. To separate the effect of Ψ from influence of mismatch of L_d, the d-axis current command is set to zero. According to this situation, the system can perfectly eliminate the effect of the detuned L_d. Mathematical expressions of i_d and i_q can be derived from Fig. 1 as shown in (1) and (2).

$$i_d = i_d^* = 0 \tag{1}$$

$$i_q = \frac{\omega_c(\hat{\psi} - \psi)}{K_{Pq} + R} + \frac{i_q^* K_{Pq}}{K_{Pq+R}} \tag{2}$$

The second term of (2) disturbs identification of Ψ indicated in the first term. To obtain only the first term of (2), it is necessary to eliminate the value of the second term by means of the following scheme.

Figure 2 shows the simulator of the second term in (2) after L_q identification. By giving the same values as i_q^* and K_{pq} to the d-axis current control loop, the second term of (2) can be known and be recoded by the d-axis loop. Equation (3) shows this calculation.

$$i_{d\_rec} = \frac{i_d^* K_{Pd}}{K_{Pd+R}} = \frac{i_q^* K_{Pq}}{K_{Pq+R}} \tag{3}$$

The current norm characteristic modified by eliminating the second term in (2). is shown in Fig. 3, and experimental result is also compared with the simulation result. The two curves show similar properties and reach the minimum when Ψ in the controller is equal to the true value.

Figure 4 shows an experimental result of the Ψ identification. The identification result converges to 0.0680Wb by hill-climbing method whereas the true value is 0.0674Wb whose identification error is 1.0 %.

Table 1. Experimental test conditions.

Ψ	0.0674 Wb
L_d	0.013 H
$\hat{L}_d$	0.0 H
K_{pq}	1.0 V/A
K_{pd}	1.0 V/A
ω	300 r/min

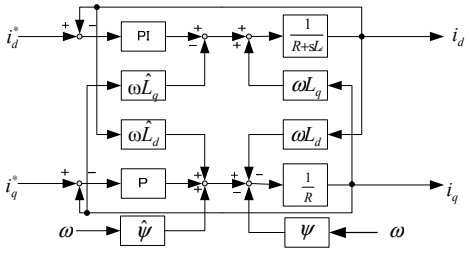

Fig. 1. Proposed identification system.

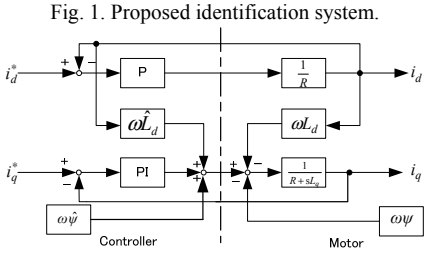

Fig. 2. Second term simulator after L_q identification.

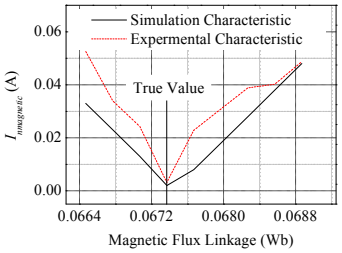

Fig. 3. Current norm characteristic of Ψ.

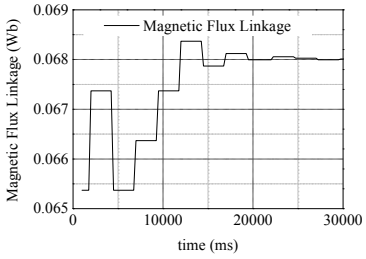

Fig. 4. Ψ identification result.

3. Conclusion

This paper has discussed the off-line Ψ identification technique and presented the experimental result. The proposed technique can identify Ψ within the error of approximately $\pm$1.0 %.

References

(1) X. Ji, T. Noguchi: "Off-line Parameter Identification of Interior Permanent Magnet Motor by Searching Minimum Point of Current Norm Characteristics," IEEE SPEEDAM, EMD0064, 2014 (Italy).