國 立 臺 北 科 技 大 學

106 學年第一學期電機系博士班資格考試

交 流 電 機 控 制 試 題

注意事項：

1. 本試題共【4】題，配分共 100 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間：二小時。
5. 可以使用計算器。

(1) *(25%)* A 1 kW, 220 V, 6-pole, 60 Hz three-phase induction motor has a full-load slip frequency of 0.04. What is the full-load speed (rpm)? What is the rated output torque (Nm)?

(2) *(25%)* Consider a vector controlled permanent magnet synchronous motor (PMSM) running at steady state. If the rotor frame *q*-axis and *d*-axis currents are 5 A and 2 A, respectively. What is the line current of the motor? (Note: all the currents are expressed in peak value)

(3) *(25%)* The parameters of a 4-pole IPM-PMSM are: λ_m = 0.3 wb, L_{qs} = 40 mH, L_{ds} = 20 mH, and r_s = 1Ω. The motor is vector controlled, and its currents are regulated in the rotor frame with negligible error. The motor is running at 1000 rpm, the *d*-axis current command is set to -1 A, and the motor phase current is 2 A. Calculate motor output torque? (Note: all the currents are expressed in peak value)

(4) *(25%)* A 4-pole, IPM-PMSM motor is driven by the external load at a fix speed ω_o. The terminals of the motor are open. What is the **peak line to line** voltage between any of the two motor terminals?

Reference: (參考方程式)

(a) Three-phase and stationary dq frame conversions:

$$f_{as} = f_{qs}$$
$$f_{bs} = -\frac{1}{2} f_{qs} - \frac{\sqrt{3}}{2} f_{ds} ,$$
$$f_{cs} = -f_{as} - f_{bs}$$

$$f_{qs} = f_{as}$$
$$f_{ds} = -\frac{1}{\sqrt{3}} f_{as} - \frac{2}{\sqrt{3}} f_{bs}$$

(b) Stationary dq frame and rotor dq frame conversions:

$$\begin{bmatrix} f_{qs}^r \\ f_{ds}^r \end{bmatrix} = \begin{bmatrix} \cos\theta_r & -\sin\theta_r \\ \sin\theta_r & \cos\theta_r \end{bmatrix} \begin{bmatrix} f_{qs}^s \\ f_{ds}^s \end{bmatrix}, \quad \begin{bmatrix} f_{qs}^s \\ f_{ds}^s \end{bmatrix} = \begin{bmatrix} \cos\theta_r & \sin\theta_r \\ -\sin\theta_r & \cos\theta_r \end{bmatrix} \begin{bmatrix} f_{qs}^r \\ f_{ds}^r \end{bmatrix}$$

(c) Voltage equations for IPM-PMSM:

Rotor frame:
$$\begin{cases} v_{qs}^r = (r_s + L_{qs}s)i_{qs}^r + \omega_r L_{ds} \cdot i_{ds}^r + \omega_r \lambda_m \\ v_{ds}^r = (r_s + L_{ds}s)i_{ds}^r - \omega_r L_{qs} \cdot i_{qs}^r \end{cases}$$

λ_m: flux linkage from PM, L_{qs}, L_{ds}: q and d-axis inductance, r_s: phase resistance.

$$T_e = \frac{3}{2}\frac{P}{2}\left[\lambda_m i_{qs}^r + (L_{ds} - L_{qs})i_{qs}^r i_{ds}^r\right]$$