Electrical Ode of the PMSM

$$\begin{bmatrix} v_s^d \\ v_s^q \end{bmatrix} = R_s \begin{bmatrix} i_s^d \\ i_s^q \end{bmatrix} + \omega_{el} \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} \psi_{Pm} + L_s^d i_s^d \\ L_s^q i_s^q \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \frac{d}{dt}\left(\psi_{Pm} + L_s^d i_s^d\right) \\ \frac{d}{dt} L_s^q i_s^q \end{bmatrix}$$

i.e. $v_s^d = R_s i_s^d - \omega_{el} L_s^q i_s^q + \frac{d}{dt}\psi_{Pm} + L_s^d \frac{d}{dt} i_s^d$

or $L_s^d \frac{d}{dt} i_s^d = v_s^d - R_s i_s^d + \omega_{el} L_s^q i_s^q - \frac{d}{dt}\psi_{Pm}$.

or $\frac{d}{dt} i_s^d = \frac{1}{L_s^d}\left(v_s^d - R_s i_s^d + \omega_{el} L_s^q i_s^q - \frac{d}{dt}\psi_{Pm}\right)$ — (a)

$v_s^q = R_s i_s^q + \omega_{el}\left(\psi_{Pm} + L_s^d i_s^d\right) + \frac{d}{dt} L_s^q i_s^q$

or $L_s^q \frac{d}{dt} i_s^q = v_s^q - R_s i_s^q - \omega_{el}\left(\psi_{Pm} + L_s^d i_s^d\right)$

or $\frac{d}{dt} i_s^q = \frac{1}{L_s^q}\left(v_s^q - R_s i_s^q - \omega_{el}\left(\psi_{Pm} + L_s^d i_s^d\right)\right)$ — (b).

$$\begin{bmatrix} v_s^x \\ v_s^y \end{bmatrix} = R_s \begin{bmatrix} i_s^x \\ i_s^y \end{bmatrix} - \omega_{el} \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} L_s^x i_s^x \\ L_s^y i_s^y \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \frac{d}{dt} L_s^x i_s^x \\ \frac{d}{dt} L_s^y i_s^y \end{bmatrix}$$

$v_s^x = R_s i_s^x + \omega_{el} L_s^y i_s^y + L_s^x \frac{d}{dt} i_s^x$

or $L_s^x \frac{d}{dt} i_s^x = v_s^x - R_s i_s^x - \omega_{el} L_s^y i_s^y$

or $\frac{d}{dt} i_s^x = \frac{1}{L_s^x}\left[v_s^x - R_s i_s^x - \omega_{el} L_s^y i_s^y\right]$ — (c).

$v_s^y = R_s i_s^y - \omega_{el} L_s^x i_s^x + L_s^y \frac{d}{dt} i_s^y$

or $L_s^y \frac{d}{dt} i_s^y = v_s^y - R_s i_s^y + \omega_{el} L_s^x i_s^x$

or $\frac{d}{dt} i_s^y = \frac{1}{L_s^y}\left(v_s^y - R_s i_s^y + \omega_{el} L_s^x i_s^x\right)$ — (d).