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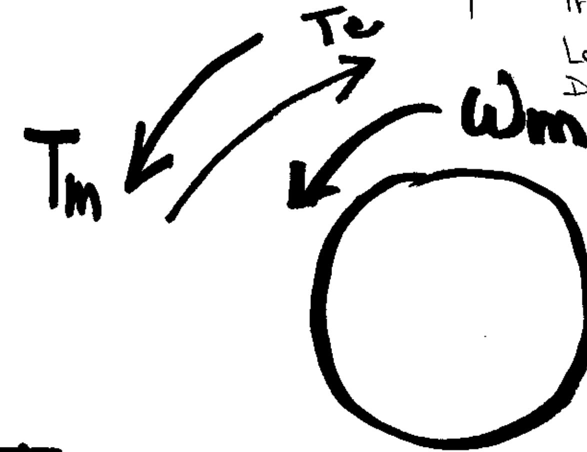
Lec. No. 13
Date :- 22/1/2010



$$J \frac{d\omega_m}{dt} = T_m - T_e$$

$$L = \begin{bmatrix} L_{ss} & L_{sr} \\ L_{rs} & L_{rr} \end{bmatrix}$$

$$T_e = - \frac{\partial W'}{\partial \theta_m}$$

$$W' = \frac{1}{2} \begin{bmatrix} i_s^T & i_r^T \end{bmatrix} L \begin{bmatrix} i_s \\ i_r \end{bmatrix}$$

$$T_e = -\frac{\partial W'}{\partial \theta_m} = -\frac{P}{2}\frac{\partial W'}{\partial \theta}$$

$$T_e' = -\frac{\partial W'}{\partial \theta}$$

$$T_e' = -\frac{1}{2}\left[i_s^T \frac{\partial L_{ss}}{\partial \theta} \cdot i_s + 2 i_s^T \frac{\partial L_{sr}}{\partial \theta} i_r \right]$$

$$J \cdot \frac{2}{p} \cdot \frac{d\omega}{dt} = T_m - \frac{p}{2} T_e'$$

H

$$\frac{1}{2}\omega_{mB}^2 \cdot J \cdot \frac{2}{p}\frac{d\omega}{dt} = \frac{1}{2}\omega_{mB}^2 \left(T_m - \frac{p}{2} T_e'\right)$$

$$\boxed{\frac{\frac{1}{2} J \omega_{mB}^2}{VA_{base}}} \cdot \frac{2}{p}\frac{d\omega}{dt} = \frac{\frac{1}{2}\omega_{mB}^2}{VA_{base}} \cdot \left(T_m - \frac{p}{2} T_e'\right)$$

$$\frac{2H}{\omega_{mB}} \cdot \frac{2}{P} \frac{d\omega}{dt} = \frac{\omega_{mB}}{VA_{base}} \left(T_m - \frac{P}{2} T_e' \right)$$

$$\therefore \frac{2H}{\omega_B} \cdot \frac{d\omega}{dt} = \frac{T_m}{T_{base}} - \frac{\omega_{mB}}{VA_{base}} \cdot \frac{P}{2} \cdot T_e'$$

$$2H \cdot \frac{d\left(\omega/\omega_B\right)}{dt} = T_{m_{pu}} - \left(\frac{T_e'(\theta)}{VA_{base}/\omega_B}\right)$$

$$\boxed{\frac{2H}{\omega_B} \cdot \frac{d\omega}{dt} = T_{m_{pu}} - \frac{T_e'(\theta)}{VA_{base}/\omega_B}}$$

- H → 2.5 – 6 MJ/MVA.
  (2 pole)

  4 – 10
  (4 pole)

hydro : 2 – 10.

$$\begin{bmatrix} f_a \\ f_b \\ f_c \end{bmatrix} = C_p(\theta) \begin{bmatrix} f_d \\ f_q \\ f_0 \end{bmatrix}$$

$$\begin{bmatrix} f_d \\ f_q \\ f_0 \end{bmatrix} = C_p^{-1}(\theta) \begin{bmatrix} f_a \\ f_b \\ f_c \end{bmatrix}$$

$$C_p = \begin{bmatrix} K_d \cos\theta & K_q \sin\theta & K_0 \\ K_d \cos\left(\theta - \frac{2\pi}{3}\right) & K_q \sin\left(\theta - \frac{2\pi}{3}\right) & K_0 \\ K_d \cos\left(\theta + \frac{2\pi}{3}\right) & K_q \sin\left(\theta + \frac{2\pi}{3}\right) & K_0 \end{bmatrix}.$$

$$C_p^{-1} = \begin{bmatrix} K_1 \cos\theta & K_1 \cos\left(\theta - \frac{2\pi}{3}\right) & K_1 \cos\left(\theta + \frac{2\pi}{3}\right) \\ K_2 \sin\theta & K_2 \sin\left(\theta - \frac{2\pi}{3}\right) & K_1 \sin\left(\theta + \frac{2\pi}{3}\right) \\ K_3 & K_3 & K_3. \end{bmatrix}$$

$$K_1 = \frac{2}{3K_d}. \quad K_2 = \frac{2}{3K_q} \quad K_3 = \frac{1}{3K_0}.$$

$$\begin{bmatrix} \psi_s \\ \psi_r \end{bmatrix} = \begin{bmatrix} L_{ss} & L_{sr} \\ L_{rs} & L_{rr} \end{bmatrix} \left[\begin{array}{c} i_s \\ \hline i_r \end{array}\right]$$

$$\begin{bmatrix} \psi_s \\ \psi_r \end{bmatrix} = \begin{bmatrix} C_p & 0 \\ 0 & I_{4\times 4} \end{bmatrix} \left[\begin{array}{c} \psi_{dq0} \\ \hdashline \psi_r \end{array}\right]$$

$$
\begin{bmatrix} \psi_{dq0} \\ \psi_r \end{bmatrix} = \begin{bmatrix} C_p^{-1} & 0 \\ 0 & I_{4\times4} \end{bmatrix} \times \begin{bmatrix} L_{ss} & L_{sr} \\ L_{rs} & L_{rr} \end{bmatrix}
$$

$$
\times \begin{bmatrix} C_p & 0 \\ 0 & I_{4\times n} \end{bmatrix} \begin{bmatrix} i_{dq0} \\ i_r \end{bmatrix}
$$

$$\begin{bmatrix}\psi_{dq0}\\ \psi_r\end{bmatrix} = \underbrace{\begin{bmatrix}C_p^{-1} L_{ss} C_p & C_p^{-1} L_{sr}\\ L_{rs} C_p & L_{rr}\end{bmatrix}}_{\begin{bmatrix}L_{ss}' & L_{sr}'\\ L_{rs}' & L_{rr}\end{bmatrix}} \times \begin{bmatrix} i_{dq0}\\ i_r\end{bmatrix}$$

$$C_p^{-1} L_{sr} = C_p^{-1} \left[L_{sr}^{d} \;\vdots\; L_{sr}^{q} \right]$$

$$L_{sr}^{d} = \begin{bmatrix} M_{af} \cos\theta & x \\ M_{af} \cos\left(\theta - \frac{2\pi}{3}\right) & x \\ M_{af} \cos\left(\theta + 2\pi/3\right) & x \end{bmatrix}$$

$$C_p^{-1} L_{sr}^{d} (1,1) =$$

$$\begin{bmatrix} K_1 \cos\theta & K_1 \cos(\theta - \frac{2\pi}{3}) & K_1 \cos(\theta + \frac{2\pi}{3}) \end{bmatrix}$$

$$\times \begin{bmatrix} M_{af} \cos\theta \\ M_{af} \cos(\theta - \frac{2\pi}{3}) \\ M_{af} \cos(\theta + \frac{2\pi}{3} \end{bmatrix}$$

$$C_p^{-1} L_{sr}^{d}(1,1)$$

$$= K_1 M_{af}\left[\cos^2\theta + \cos^2\left(\theta - \frac{2\pi}{3}\right) + \cos^2\left(\theta + \frac{2\pi}{3}\right)\right].$$

$$= K_1 M_{af} \times \frac{3}{2}. \quad = \frac{2}{3K_d} \cdot M_{af} \cdot \frac{3}{2}.$$

$$= M_{af}/K_d.$$

$$L_{ss}' = \begin{bmatrix} L_d & 0 & 0 \\ 0 & L_q & 0 \\ 0 & 0 & L_0 \end{bmatrix}$$

$$L_d = L_{aa0} - L_{ab0} + \frac{3}{2} L_{aa2}$$

$$L_q = L_{aa0} - L_{ab0} - \frac{3}{2} L_{aa2}.$$

$$L_0 = L_{aa0} + 2 L_{ab0}$$

$$L_{sr}' = \begin{bmatrix} M_{af}/K_d & \frac{M_{ah}}{K_d} & 0 & 0 \\ 0 & 0 & \frac{M_{ag}}{K_q} & \frac{M_{ak}}{K_q} \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$L_{rs}' \neq (L_{sr}')^T$ in general.

$$L'_{rs} = \begin{bmatrix} \frac{3}{2} M_{af} K_d & 0 & 0 \\ \frac{3}{2} M_{ah} K_d & 0 & 0 \\ 0 & \frac{3}{2} M_{ag} K_q & 0 \\ 0 & \frac{3}{2} M_{ak} K_q & 0 \end{bmatrix}$$

$$K_d^2 = \frac{2}{3} \quad K_q^2 = \frac{2}{3} \quad L'_{sr} = L'^{T}_{rs}$$

$$\cos\theta + \cos\left(\theta - \frac{2\pi}{3}\right) + \cos\left(\theta + \frac{2\pi}{3}\right)$$

$$= 0$$

$$\cos^2\theta + \cos^2\left(\theta - \frac{2\pi}{3}\right) + \cos^2\left(\theta + \frac{2\pi}{3}\right)$$

$$= \frac{3}{2}$$

$$= -RL^{-1}\psi - v.$$

$$\frac{d\psi}{dt} = -Ri - v.$$

$$v = \begin{bmatrix} v_a \\ v_b \\ v_c \\ -v_f \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\psi = Li$$

$$\psi = \begin{bmatrix} \psi_s \\ \psi_r \end{bmatrix} \qquad i = \begin{bmatrix} i_s \\ i_r \end{bmatrix}$$

$$\underbrace{\frac{d\psi}{dt}}_{\begin{bmatrix}\psi_s\\ \psi_r\end{bmatrix}} = -\overbrace{R}^{\left[\begin{array}{c|c} R_s & 0 \\ \hline 0 & R_r \end{array}\right]}\underbrace{i}_{\begin{bmatrix} i_s \\ i_r\end{bmatrix}} - \underbrace{v}_{\begin{bmatrix} v_s \\ v_r\end{bmatrix}}.$$

$$\frac{d\psi_s}{dt} = -R_s i_s - v_s. \checkmark$$

$$\psi_s \to \begin{bmatrix}\psi_a \\ \psi_b \\ \psi_c\end{bmatrix}$$

$$-\frac{d\psi_s}{dt} - R_s i_s = v_s. \checkmark$$

$$-\frac{d}{dt}\left[C_p \psi_{dq0}\right] - R_s C_p i_{dq0} = C_p v_{dq0}$$

$-$

what is

$$-\frac{d}{dt}\left(C_p\, \Psi_{dq0}\right) = \underbrace{-C_p \frac{d}{dt}\Psi_{dq0}}_{} + \left(-\frac{d}{dt}C_p \cdot \Psi_{dq0}\right)$$

$$-\frac{d}{dt}\left[C_p \Psi_{dq0}\right] = -C_p \frac{d\Psi_{dq0}}{dt}$$

$$\underbrace{-\frac{dC_p}{d\theta}\cdot\frac{d\theta}{dt}\cdot\Psi_{dq0}}_{\text{"extra"}}$$