$\underline{\omega = 0}$

$V_f = 0$

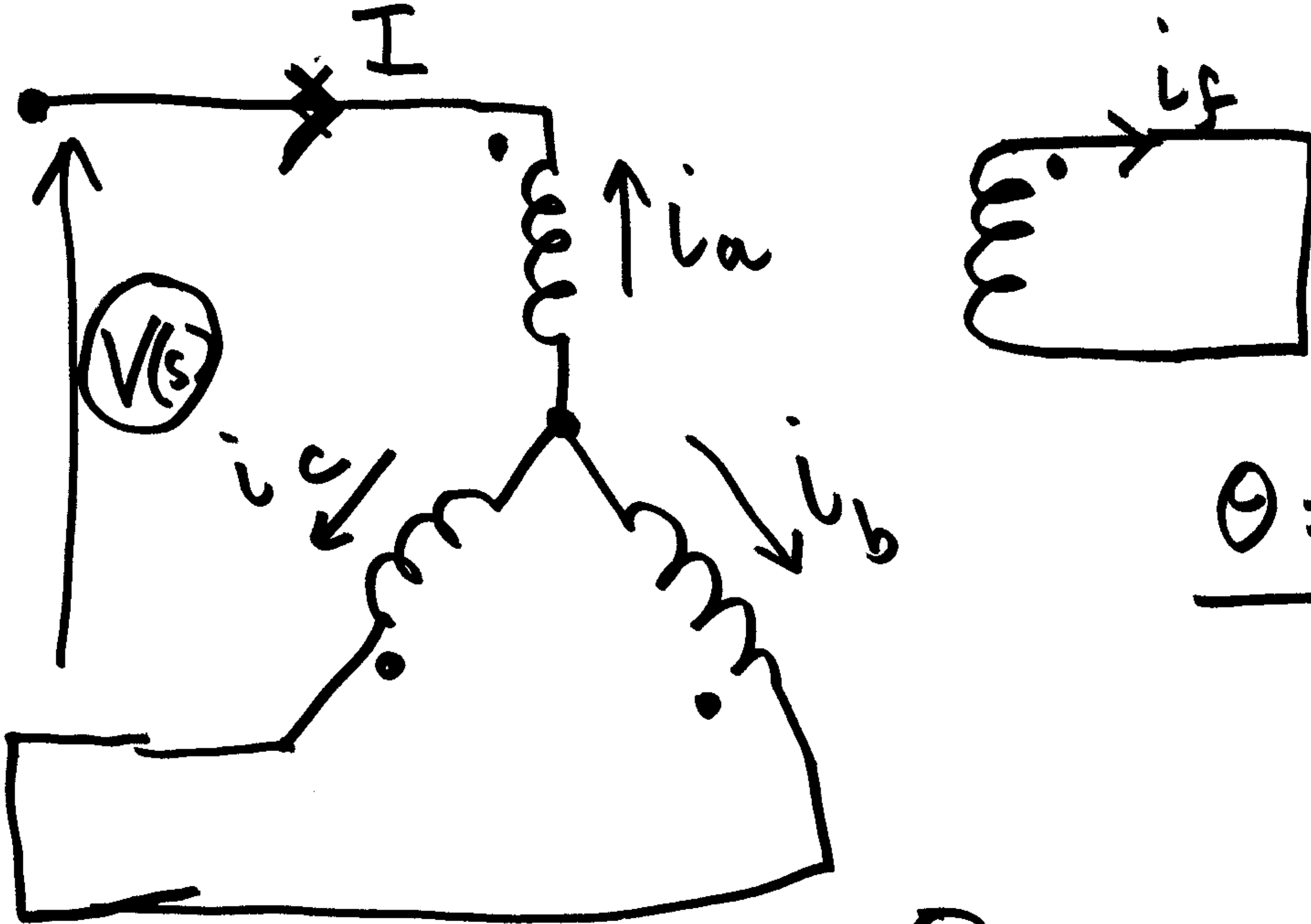
Prof. A M Kulkarni
Lec. 16 - 17/2/10

$$-\frac{d\psi_d}{dt} - \cancel{R_a i_d} = V_d$$

$$-\frac{d\psi_q}{dt} - \cancel{R_a i_q} = V_q$$

$\psi_0 \; , \; i_0$

$$\frac{V_d(s)}{I_d(s)} = \frac{-s}{\omega_B} X_d(s)$$



$\underline{\theta = 0}$

$V_b = V_c$ (1)

$V(s) = V_a(s) - V_b(s)$ (2)

$$I_a(s) = -I(s) \quad - ③$$

$$I_b(s) = I_c(s) = \frac{1}{2} I(s) \quad - ④$$

$$\theta = 0$$

$$I_d = \sqrt{\frac{2}{3}}\left[-I\cos 0 + \frac{I}{2}\cos(-120^\circ) + \frac{I}{2}\cos(+120^\circ)\right]$$

$$= -\sqrt{3/2}\cdot I$$

$$\boxed{I_d(s) = -\sqrt{\frac{3}{2}}\, I(s)}$$

$$I_q = \sqrt{\frac{2}{3}}\left[-I \sin 0 + \frac{I}{2}\sin 120 + \frac{I}{2}\sin(-120)\right]$$

$$= 0$$

$$V_d = \sqrt{\frac{2}{3}}\left[V_a \cos 0 + V_b \cos(-120) + V_c \cos(+120)\right]$$

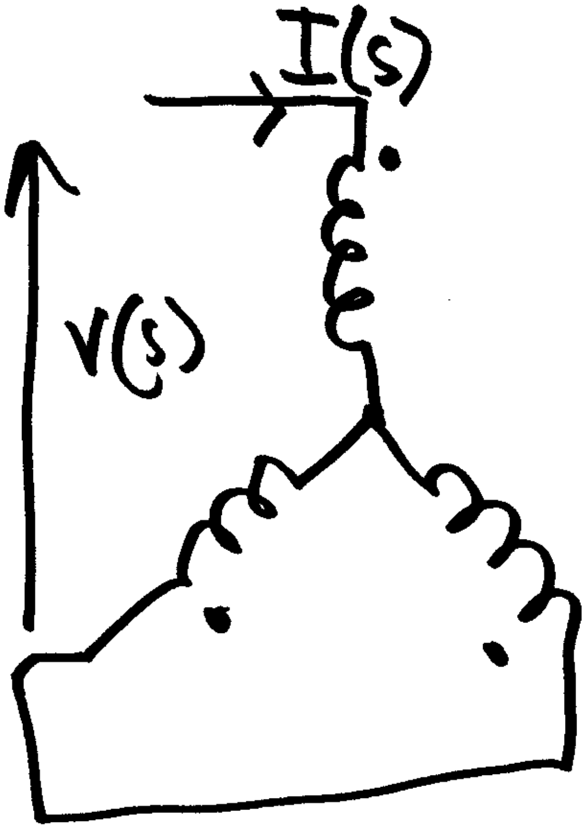
$$\boxed{V_d(s) = \sqrt{\frac{2}{3}}\, V(s)}$$

$$\frac{V_d(s)}{I_d(s)} = -\frac{2}{3}\frac{V(s)}{I(s)}. \qquad \underline{V_q = 0}$$

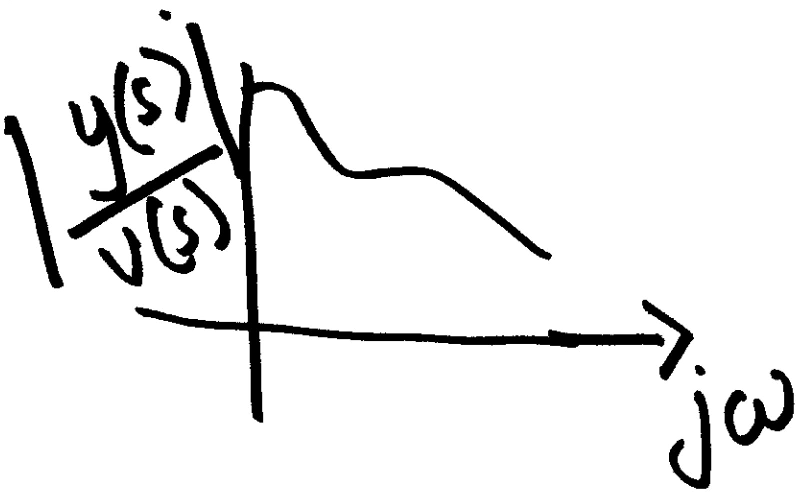
$$\frac{V(s)}{I(s)} \rightarrow \frac{\psi_d(s)}{I_d(s)}$$

$$-\frac{d\psi_d}{dt} = V_d \qquad -\frac{d\psi_q}{dt} = V_q$$

$$-\psi_d(s) = V_d(s)/s.$$



$$\boxed{\frac{\psi_q(s)}{I_q(s)}}$$



$$\boxed{\frac{\psi_d(s)}{I_d(s)}}$$

$$s = j\omega$$

$$\frac{(1+sT_1)}{(1+sT_2)}$$

$$\frac{Y_d(s)}{I_d(s)} \longrightarrow$$

V

EXPERIMENT

I

$$\frac{Y_d(j\omega)}{I_d(j\omega)}$$

$$\psi = L i$$

$$\frac{d\psi}{dt}$$

$$\frac{\Psi_d(s)}{I_d(s)}$$

$$s\,\Psi_f(s) + R_f\, I_f(s) = \underline{V_f(s) = 0}$$

$$\left.\begin{aligned} \Psi_f(s) &= -\frac{R_f}{s} I_f(s) \\ \Psi_h(s) &= -\frac{R_h}{s} I_h(s) \end{aligned}\right\}.$$

$$\begin{bmatrix} \psi_d(s) \\ \psi_f(s) \\ \psi_h(s) \end{bmatrix} = \begin{bmatrix} L_d & M_{df} & M_{dh} \\ M_{df} & L_{ff} & L_{fh} \\ M_{dh} & L_{fh} & L_{hh} \end{bmatrix} \begin{bmatrix} I_d(s) \\ I_f(s) \\ I_h(s) \end{bmatrix}$$

$$\Psi_d(s) = L_d I_d(s) + M_{df} I_f(s) + M_{dh} I_h(s).$$

$$\begin{bmatrix} 0 \\ 0 \end{bmatrix} = \begin{bmatrix} M_{df} \\ M_{dh} \end{bmatrix} I_d(s) + \begin{bmatrix} L_{ff} + \frac{R_f}{s} & L_{fh} \\ L_{fh} & L_{hh} + \frac{R_h}{s} \end{bmatrix} \times \begin{bmatrix} I_f(s) \\ I_h(s) \end{bmatrix}$$

$$\psi_d(s) = \frac{L_d\,(1+sT_d')(1+sT_d'')}{(1+sT_{do}')(1+sT_{do}'')}\, I_d(s)$$

$$= \frac{L_d\left(1+s(T_d'+T_d'')+T_d'\,T_d''s^2\right)}{1+s(T_{do}'+T_{do}'')+T_{do}'\cdot T_{do}''s^2}$$

$$= \frac{L_d\,(1+B_N s+A_N s^2)}{(1+B_D s+A_D s^2)}$$

L_d, M_{df}, M_{dh}, L_{ff}, L_{hh}

$L_{fh} = L_{hf}$, R_h, R_f

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$$\boxed{L_d\ ,\ T_d'\ ,\ T_d''\ ,\ T_{do}''\ ,\ T_{do}' \quad (5)}$$

Transfer function

"5"

STATE SPACE

"8"

STATE SPACE

"5"

$$\left.\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx \end{aligned}\right\}$$

$$\frac{Y(s)}{U(s)} = C\,(sI - A)^{-1} B.$$

$$x = Rz$$

$$\dot{z} = R^{-1}ARz + R^{-1}Bu$$

$$y = CRz$$

$$\frac{Y(s)}{U(s)} = CR\left(sI - R^{-1}AR\right)^{-1}R^{-1}B$$

$$= C\left(sRR^{-1} - R\left(R^{-1}AR\right)R^{-1}\right)^{-1}B$$

$$= \underline{C\left(sI - A\right)^{-1}B}$$

$$B_N = \frac{\left(L_d L_{ff} R_h + L_d R_f L_{hh} - M_{dh}^2 R_f - M_{df}^2 R_h\right)}{L_d R_f R_h}$$

$$A_D = \frac{L_{ff} L_{hh}}{R_f R_h} \qquad B_D = \frac{L_{ff} R_h + R_f L_{hh}}{R_f R_h}$$

$$A_N = \frac{1}{R_f R_h}\left(L_{ff} L_{hh} - L_{fh}^2 - \frac{M_{af}^2 \cdot L_{hh}}{L_d} + 2\,\frac{M_{af} M_{ah} L_{fh}}{L_d} - \frac{M_{ah}^2 \cdot L_{ff}}{L_d} \right)$$