Prof A.M. Kaim
hi. Lec. 18.

$$\begin{bmatrix} \psi_d \\ \psi_f' \\ \psi_h' \end{bmatrix} = \begin{bmatrix} L_d & M_{df}' & M_{dh}' \\ M_{df}' & L_{ff}' & L_{fh}' \\ M_{dh}' & L_{fh}' & L_{hh}' \end{bmatrix} \begin{bmatrix} i_d \\ i_f' \\ i_h' \end{bmatrix}$$

$$\psi_f' = \psi_f \cdot \alpha_f \qquad \psi_h' = \psi_h' \alpha_h$$

$$i_f' = i_f / \alpha_f \qquad i_h' = i_h / \alpha_h .$$

$$M_{df}' = \alpha_f M_{df} \qquad L_{ff}' = \alpha_f^2 L_f$$

$$M_{dh}' = \alpha_h M_{dh} \qquad L_{hh}' = \alpha_h^2 L_h .$$

$$L_{fh}' = \alpha_f \alpha_h L_{fh}$$

$$\boxed{\begin{aligned} R_f' &= \alpha_f^2 R_f \\ R_h' &= \alpha_h^2 R_h \end{aligned}}$$

$$\begin{cases} \dfrac{d\psi_h'}{dt} + R_h' i_h' = 0 \\ \dfrac{d\psi_f'}{dt} + R_f' i_f' = V_f' = \alpha_f V_f \end{cases}$$

$$\frac{\psi_d(s)}{I_d(s)} \text{ is unchanged}$$

$$\frac{\psi_d(s)}{I_d(s)} = \frac{L_d\left(1 + B_N s + A_N s^2\right)}{1 + B_D s + A_D s^2}$$

$$\frac{\tau_d(s)}{\left[\frac{M_{af}}{R_f}\cdot V_f(s)\right]}$$ is unchanged.

$\rightarrow$ choose $\underline{\underline{\alpha_h}}$ $M_{dh}' = M_{df}'$ ✓

$\rightarrow$ $L_d - L_e = M_{df}'$ ✓

$\rightarrow$ $L_{fh}' = M_{df}'$ $\leftarrow$

L_l, L_d, T_d', T_d'', T_{do}', T_{do}'

R_f', R_h', L_{ff}', L_{hh}', M_{df}', L_d

MODEL I Ψ_d, Ψ_h', Ψ_f' $\rightarrow$ $\alpha_f \cdot \Psi_f$.

$\underbrace{\Psi_h'}_{} \rightarrow \alpha_h \Psi_h$

Assume $T''_{dc} = T''_d$ ←

(M)ODEL 2

$$\frac{\psi_d(s)}{V_f(s)} = \frac{M_{df}}{R_f} \frac{(1 + sT''_{dc})}{1 + B_D s + A_D s^2}$$

$$T''_{dc} = \left[\frac{L_{hh}}{R_h} - \frac{M_{dh} \cdot L_{fh}}{M_{df}}\right]$$

$$\frac{d\psi_H}{dt} = \frac{1}{T_d''}\left[-\psi_H + \psi_d\right]$$

$$\beta' \cdot E_{fd}$$

$$\frac{d\psi_F}{dt} = \frac{1}{T_d'}\left[-\psi_F + \psi_d + \beta V_f\right]$$

$$\psi_d = L_d'' i_d + \frac{(L_d' - L_d'')}{L_d'} \cdot \psi_H + (L_d - L_d')/L_d \cdot \frac{L_d''}{L_d} \psi_F .$$

$$\beta = \left\{ \frac{L_d'}{L_d - L_d'} \cdot \frac{M_{df}}{R_f} \right\} \qquad \beta' = \frac{L_d'}{L_d - L_d'} \cdot \frac{1}{\omega_B}$$

$$v_f \longrightarrow \underbrace{\omega_B \cdot \frac{M_{df}}{R_f}}_{E_{fd}} \cdot v_f$$

$$\cancel{\beta =}$$

$$\psi_d = L_d'' i_d + \frac{(L_d' - L_d'')}{L_d'} \psi_H$$

$$+ \frac{(L_d - L_d')}{L_d} \cdot \frac{L_d''}{L_d'} \psi_F$$

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

$$\frac{d\psi_G}{dt} = \frac{1}{T_q'}\left[-\psi_G + \psi_q\right] \quad \underline{\text{Q-AXIS}}$$

$$\frac{d\psi_K}{dt} = \frac{1}{T_q''}\left[-\psi_K + \psi_q\right]$$

$$\psi_q = L_q'' i_q + \frac{(L_q' - L_q'')}{L_q'}\psi_K +$$

$$\frac{L_q - L_q'}{L_q} \cdot \frac{L_q''}{L_q'} \cdot \psi_q$$

$$\frac{d\psi_q}{dt} = \omega \psi_d - R_a i_d - V_q .$$

$$V_{BASE} = V_{LL\,rms}.$$

$$MVA_{BASE} = \text{rated MVA}$$

$$I_{BASE} = \frac{MVA_{BASE}}{V_{BASE}}$$

$$Z_{BASE} = V_{BASE}^2 / MVA_{BASE}.$$

$$\omega_B = \text{rated E speed rad/s}$$

$$\psi_{BASE} = \frac{V_{BASE}}{\omega_B} \qquad L_{base} = \frac{Z_{base}}{\omega_B}.$$

$$T_{BASE} = \frac{MVA_{base}}{\omega_{Br}}$$

$$\omega_{Br} = \frac{2}{P} \cdot \omega_B$$

$$\frac{\dfrac{\bar{L}'_d}{\bar{L}_d - \bar{L}'_d} \cdot \dfrac{E_{fd}}{\omega_B}}{\psi_{BASE}}$$

$$V_{BASE} = \omega_B \cdot \psi_{BASE}$$

$$\frac{\frac{d\psi_d}{dt}}{\psi_{base}} = \frac{-\omega \psi_q}{\psi_{BASE}} - \frac{R_a i_d}{\psi_{BASE}} - \frac{V_d}{\psi_{BASE}}$$

$$\frac{d\bar{\psi}_d}{dt} = -\omega \bar{\psi}_q - \omega_B \bar{R}_a \bar{i}_d - \omega_B \bar{V}_d$$

$$\frac{2H}{\omega_B}\frac{d\omega}{dt} = 2H\cdot\frac{d\left(\frac{\omega}{\omega_B}\right)}{dt}$$

$$= \bar{T}_m - \frac{T_e'}{MVA_{BASE}/\omega_B}$$

$$= \bar{T}_m - \frac{(\psi_d i_q - \psi_q i_d)}{MVA_{BASE}/\omega_B}$$

$$\frac{MVA_{base}}{\omega_B} = \frac{V_{base} \times I_{base}}{\omega_B}$$

$$= \psi_{BASE} \cdot I_{base}.$$

$$\frac{d\bar{\psi}_H}{dt} = \frac{1}{T_d''}\left[-\bar{\psi}_h + \bar{\psi}_d\right]$$

$$\frac{d\bar{\psi}_F}{dt} = \frac{1}{T_d'}\left[-\bar{\psi}_F + \bar{\psi}_d + \frac{\bar{L}_d'}{\bar{L}_d - \bar{L}_d'} \cdot \cancel{\omega_B} \times \bar{E}_{fd}\right]$$

$\boxed{\text{D-AXIS}}$

$$T_{dc}'' = T_d''$$

$$\boxed{\frac{1}{\omega_B}\frac{d\bar{\psi}_d}{dt} = -\frac{\omega}{\omega_B}\bar{\psi}_q - \bar{R}_a\,\bar{i}_d - \bar{V}_d}$$

$$2H \frac{d}{\bar{d}t}\left(\frac{\omega}{\omega_B}\right) = \bar{T}_m - \left(\bar{\psi}_d \bar{i}_q - \bar{\psi}_q \bar{i}_d\right)$$

$$\bar{L}_d \leftrightarrow \bar{x}_d$$

$$\bar{L}_d = \bar{x}_d$$

$$\frac{\omega_B \cdot L_d}{} \cdot$$

$$\frac{L_d}{L_{base}} = \frac{x_d}{Z_{base}}$$

$$x_d > x_q > x_q' > x_d' > x_q'' > x_d''$$

$$T_{do}' > T_d' > T_{do}'' > T_d'' > \underline{\underline{T_{de}''}}$$

$$T_{qo}' > T_q' > T_{qo}'' > T_q''.$$