\[ \frac{J \, \text{d}w_m}{\text{d}t} = T_m - T_e \]

\[ T_e = - \frac{\partial W'}{\partial \Theta_m} \]

\[ W' = \frac{1}{2} \begin{bmatrix} i_s^T & i_r^T \end{bmatrix} L \begin{bmatrix} i_s \\ i_r \end{bmatrix} \]
\[ T_e = -\frac{\partial W'}{\partial \Theta_m} = -\frac{P}{2} \frac{\partial W'}{\partial \Theta} \]

\[ T_e' = -\frac{\partial W'}{\partial \Theta} \]

\[ T_e' = -\frac{1}{2} \left[ i_s^T \frac{\partial L_{ss}}{\partial \Theta} i_s + 2i_s^T \frac{\partial L_{strir}}{\partial \Theta} \right] \]
$$J \cdot \frac{2}{P} \cdot \frac{d\omega}{dt} = T_m - \frac{P}{2} T_e'$$

$$\frac{1}{2} \omega_{mb}^2 \cdot J \cdot \frac{2}{P} \frac{d\omega}{dt} = \frac{1}{2} \omega_{mb}^2 (T_m - \frac{P}{2} T_e')$$

$$\frac{1}{2} J \omega_{mb}^2 \cdot \frac{2}{P} \frac{d\omega}{dt} = \frac{1}{2} \omega_{mb}^2 \cdot \frac{2}{P} \left( T_m - \frac{P}{2} T_e' \right)$$
\[
\frac{2H}{\omega_B} \cdot \frac{2}{P} \frac{dw}{dt} = \frac{W_{mb}(T_m - \frac{P}{2} T_e)}{\sqrt{V_{A_{base}}}^2} \\
\frac{2H}{\omega_B} \cdot \frac{dw}{dt} = \frac{T_m}{T_{base}} - \frac{W_{mb} \cdot P \cdot T_e}{\sqrt{V_{A_{base}}}^2}
\]
\[ 2H \cdot \frac{\text{d}(w/w_B)}{\text{d}t} = T_{m_{pu}} - \left( \frac{T_{e'}(\theta)}{\sqrt{V_{A_{one}}}/w_B} \right) \]
\[ H \rightarrow 2.5 - 6 \text{ (2 pole)} \]
\[ 4 - 10 \text{ (4 pole)} \]

\text{hydro} : 2-10
\[
\begin{bmatrix}
fa \\
fb \\
fc
\end{bmatrix}
= \begin{pmatrix}
C_p(\theta)
\end{pmatrix}
\begin{bmatrix}
fd \\
fq \\
fo
\end{bmatrix}
\]

\[
\begin{bmatrix}
fd \\
fq \\
fo
\end{bmatrix}
= \begin{pmatrix}
C_p^{-1}(\theta)
\end{pmatrix}
\begin{bmatrix}
fa \\
fb \\
fq \\
foc
\end{bmatrix}
\]
\[ C_p = \begin{bmatrix} K_d \cos \theta & K_q \sin \theta & K_0 \\
K_d \cos \left( \theta - \frac{2\pi}{3} \right) & K_q \sin \left( \theta - \frac{2\pi}{3} \right) & K_0 \\
K_d \cos \left( \theta + \frac{2\pi}{3} \right) & K_q \sin \left( \theta + \frac{2\pi}{3} \right) & K_0 \end{bmatrix}. \]
\[ \mathbf{C}_p^{-1} = \begin{bmatrix} k_1 \cos \theta & k_1 \cos (\theta - \frac{2\pi}{3}) & k_1 \cos (\theta + \frac{2\pi}{3}) \\ k_2 \sin \theta & k_2 \sin (\theta - \frac{2\pi}{3}) & k_2 \sin (\theta + \frac{2\pi}{3}) \\ k_3 & k_3 & k_3 \end{bmatrix} \]

\[ k_1 = \frac{2}{3K_a} \quad k_2 = \frac{2}{3K_v} \quad k_3 = \frac{1}{3K_0}. \]
\[
\begin{bmatrix}
4s \\
4r
\end{bmatrix} = 
\begin{bmatrix}
L_{ss} & L_{sr} \\
L_{rs} & L_{rr}
\end{bmatrix}
\begin{bmatrix}
is. \\
ir.
\end{bmatrix}
\]

\[
\begin{bmatrix}
4s \\
4r
\end{bmatrix} = 
\begin{bmatrix}
C_p & 0 & 0 \\
0 & I_{xy} & 0
\end{bmatrix}
\begin{bmatrix}
4dq,0 \\
4r
\end{bmatrix}
\]
\[
\begin{bmatrix}
  y \\
  x
\end{bmatrix} = \begin{bmatrix}
  I_{4 \times 4} & 0 \\
  0 & 0
\end{bmatrix}
\begin{bmatrix}
  p_{1} & p_{2} & p_{3} & p_{4} \\
  L_{1} & L_{2} & L_{3} & L_{4}
\end{bmatrix}
\begin{bmatrix}
  1 \\
  0 \\
  0 \\
  0
\end{bmatrix}
\]
\[ C_p^{-1} L_{sr} = C_p^{-1} \begin{bmatrix} L_{sr} & L_{3r} \end{bmatrix} \]

\[ d. \quad L_{sr} = \begin{bmatrix} \text{Maf } \cos \theta \\ \text{Maf } G_0 (\theta - 2\pi) / 3 \\ \text{Maf } G_0 (\theta + 2\pi / 3) \end{bmatrix} \]
\[ C_p^{-1} L_{5Y} \begin{pmatrix} 1, 1 \end{pmatrix} = \begin{bmatrix} k_1 \cos \theta & k_1 \cos (\theta - 2\pi/3) & k_1 \cos (\theta + 2\pi) \\ k_1 \cos \theta & k_1 \cos (\theta - 2\pi/3) & k_1 \cos (\theta + 2\pi) \\ \end{bmatrix} \]
\[ C_p^{-1} L_{5y} (1, 1) = K_1 \text{Maf} \left[ G_2^2 \Theta + G_2^2 \left( \Theta - 2 \pi \right) \right. \]
\[ \left. + G_3^2 \left( \Theta + 2 \pi \right) \right] \frac{3}{3} \]
\[ = K_1 \text{Maf} \times \frac{3}{2} \cdot \frac{2}{3Kd} \cdot \frac{3}{2} \]
\[ = \text{Maf} / Kd. \]
\[
\mathbf{L}_{ss} = \begin{bmatrix}
L_d & 0 & 0 \\
0 & L_q & 0 \\
0 & 0 & L_o
\end{bmatrix}
\]

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

\[
L_q = L_{aa0} - L_{ab0} - \frac{3}{2} L_{aa2}
\]

\[
L_o = L_{aa0} + 2 L_{ab0}
\]
$L_{sr}' = \begin{bmatrix} \frac{Maf}{Kd} & \frac{Mar}{Kd} & 0 & 0 \\ 0 & Kd \frac{Mar}{Kd} & 0 & 0 \\ 0 & 0 & \frac{Mar}{Kq} & \frac{Mar}{Kq} \end{bmatrix}$

$L_{rs}' \neq (L_{sr}')^T$ in general.
\[ L_{rs} = \begin{bmatrix}
\frac{3}{2} M_a k d & 0 & 0 \\
\frac{3}{2} M_h k d & 0 & 0 \\
0 & \frac{3}{2} M_a k v & 0
\end{bmatrix} \]

\[ k_d = \frac{2}{3} \quad k_v = \frac{2}{3} \quad L_{rs}^{T} = L_{rs}^{T} \]
\[ \cos \theta + \cos \left( \theta - \frac{2\pi}{3} \right) + \cos \left( \theta + \frac{2\pi}{3} \right) = 0 \]

\[ \cos^2 \theta + \cos^2 \left( \theta - \frac{2\pi}{3} \right) + \cos^2 \left( \theta + \frac{2\pi}{3} \right) = \frac{3}{2} \]
\[
\frac{d\mathbf{y}}{dt} = -RL^{-1}\mathbf{y} - \mathbf{u}.
\]

\[
\mathbf{y} = L\mathbf{i}
\]

\[
\mathbf{y} = \begin{bmatrix} y_s \\ y_r \end{bmatrix}, \quad \mathbf{i} = \begin{bmatrix} i_s \\ i_r \end{bmatrix}
\]

\[
\mathbf{u} = \begin{bmatrix} v_a \\ v_b \\ v_c \\ v_f \end{bmatrix}
\]
\[
\frac{d\mathbf{y}_s}{dt} = -R_s i_s - v_s.
\]

\[
\begin{bmatrix}
4_s \\
4_r
\end{bmatrix}
\]

\[
\begin{bmatrix}
4_s \\
4_r
\end{bmatrix} \rightarrow \begin{bmatrix}
4_a \\
4_b \\
4_c
\end{bmatrix}
\]

\[
\begin{bmatrix}
R_s \\
0 \\
0 \\
R_r
\end{bmatrix}
\]
\[-\frac{d\psi_s}{dt} - R_s i_s = v_s - \]
\[- \frac{d}{dt} \left[ C_p V d\psi_{dq0} \right] - R_s C_p i d\psi_{dq0} = C_p V d\psi_{dq0} \]
What is

\[ - \frac{d}{dt} (C_p \Delta q_{\text{vo}}) \quad = \quad - C_p \frac{d}{dt} \Delta q_{\text{vo}} \]

\[ + \quad - \frac{d}{dt} C_p \cdot \Delta q_{\text{vo}} \]

\[ 23 \]
\[- \frac{d}{dt} \left[ C_p \, dq_0 \right] = - C_p \, d \frac{dq_0}{dt} - \frac{dC_p}{d\theta} \cdot \frac{dq_0}{dt} \]

"extra"