2.2

$$s P_A = \left(\frac{1}{C_L} + \frac{1}{C_W}\right) Q_A$$

$$\frac{1}{C_S} Q - \frac{1}{C_S} Q_A = L_p s^2 Q_A + R_p s Q_A + \frac{1}{C_L} Q_A + \frac{1}{C_W} Q_A$$

$$\frac{1}{C_S} Q = \left(L_p s^2 + R_p s\right) Q_A + \left(\frac{1}{C_L} + \frac{1}{C_W} + \frac{1}{C_S}\right) Q_A$$

$$\frac{1}{C_S} Q = \left(L_p s^2 + R_p s\right) Q_A + \frac{1}{C_T} Q_A$$

$$s P_{a_0} = L_c s^2 Q + R_c s Q + \frac{1}{C_S} Q - \frac{1}{C_S} Q_A$$

$$s P_{a_0} = \left(L_c s^2 + R_c s + \frac{1}{C_S}\right) \cdot C_S \left(L_p s^2 + R_p s + \frac{1}{C_T}\right) Q_A - \frac{1}{C_S} Q_A$$

$$s P_{a_0} = \left\{ C_S \left[L_c L_p s^4 + \left(L_c R_p + L_p R_c\right) s^3 + \left(\frac{L_c}{C_T} + R_c R_p + \frac{L_p}{C_S}\right) s^2 + \left(\frac{R_c}{C_T} + \frac{R_p}{C_S}\right) s + \frac{1}{C_S C_T} \right] - \frac{1}{C_S} \right\} Q_A$$

$$P_{a_0} = \left[C_S L_c L_p s^4 + \left(C_S L_c R_p + C_S L_p R_c\right) s^3 + \left(\frac{L_c C_S}{C_T} + R_c R_p C_S + L_p\right) s^2 + \left(R_c \frac{C_S}{C_T} + R_p\right) s + \underbrace{\frac{1}{C_T} - \frac{1}{C_S}}_{= \frac{1}{C_L} + \frac{1}{C_W}} \right] \frac{C_L C_W}{C_L + C_W} P_A$$

$$\frac{P_A}{P_{A0}} = \frac{\dfrac{C_L C_W}{C_L + C_W}}{C_S L_c L_p s^4 + \left(C_S L_c R_p + C_S L_p R_c\right) s^3 + \left(\frac{L_c C_S}{C} + R_c R_p C_S + L_p\right) s^2 + \left(R_c \frac{C_S}{C_T} + R_p\right) s + \dfrac{C_L + C_W}{C_L C_W}}$$

d'où : $a_0 = \dfrac{C_L + C_W}{C_L C_W} \Big/ C_S L_c L_p = \dfrac{C_L + C_W}{C_L C_W C_S L_c L_p}$

$$a_1 = \left[\frac{R_c C_S}{C_T} + R_p\right] \Big/ C_S L_c L_p = \frac{R_c}{C_T L_c L_p} + \frac{R_p}{C_S L_c L_p}$$

$$a_2 = \frac{\cancel{L_c}\cancel{C_S}}{C_T \cancel{C_S} \cancel{L_c} L_p} + \frac{R_c R_p \cancel{C_S}}{\cancel{C_S} L_c L_p} + \frac{L_p}{C_S L_c L_p}$$

$$a_2 = \frac{1}{C_T L_p} + \frac{R_c R_p}{L_c L_p} + \frac{1}{C_s L_c}$$

$$a_3 = \frac{C_s L_c R_p + C_s L_p R_c}{C_s L_c L_p}$$

$$a_3 = \frac{R_p}{L_p} + \frac{R_c}{L_c}$$

2.3 Modèle d'état

1) $$\frac{dQ}{dt} = \frac{P_{a_0} - \cancel{P_0}}{L_c} - \frac{R_c}{L_c} Q - \frac{1}{C_s L_c} \int_0^t (Q - Q_A)\, d\tau$$

$$\frac{dQ_A}{dt} = \frac{1}{C_s L_p} \int_0^t (Q - Q_A)\, d\tau - \frac{R_p}{L_p} Q_A - \frac{1}{C_c L_p} \int_0^t Q_A d\tau + \frac{1}{C_w L_p} \int_0^t Q_A d\tau$$

$$P_A - \cancel{P_0} = \frac{1}{C_w} \int_0^t Q_A\, d\tau$$

$$\dot{Q} = -\frac{1}{C_s L_c} \int Q - \frac{R_c}{L_c} Q - \frac{1}{C_s L_c} \int Q_A + \frac{P_{a_0}}{L_c}$$

$$\dot{Q}_A = \frac{1}{C_s L_p} \int Q - \left(\frac{1}{C_s L_p} + \frac{1}{C_c L_p} - \frac{1}{C_w L_p} \right) \int Q_A - \frac{R_p}{L_p} Q_A$$

$$y = P_A = \frac{1}{C_w} \int Q_A$$

$u = P_{a_0}$

$y = P_A$

$x = \left[\int Q \quad Q \quad \int Q_A \quad Q_A \right]^T$

$\dot{x} = \left[Q \quad \frac{dQ}{dt} \quad Q_A \quad \frac{dQ_A}{dt} \right]^T$

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -\frac{1}{C_s L_c} & -\frac{R_c}{L_c} & -\frac{1}{C_s L_c} & 0 \\ 0 & 0 & 0 & 1 \\ \frac{1}{C_s L_p} & 0 & -\frac{1}{L_p}\left(\frac{1}{C_s} + \frac{1}{C_c} - \frac{1}{C_w}\right) & -\frac{R_p}{L_p} \end{bmatrix}$$

$$B = \begin{bmatrix} 0 \\ 1/L_c \\ 0 \\ 0 \end{bmatrix}$$

$$C = \begin{bmatrix} 0 & 0 & 0 & \frac{1}{C_w} \end{bmatrix}$$

$$D = 0$$