Solution : Exercice 1

Q1a

Capacitor en serie :

$$\begin{aligned}
C_{tot} &= \frac{1}{1/1\mu F + \frac{1}{5\mu F + \frac{1}{1/3\mu F + 1/2\mu F} + 4\mu F}} \\
&= \frac{1}{1/1\mu F + \frac{1}{5\mu F + \frac{3\mu F \cdot 2\mu F}{3\mu F + 2\mu F} + 4\mu F}} \\
&= \frac{1}{1/1\mu F + \frac{1}{5\mu F + 6/5\mu F + 4\mu F}} \\
&= \frac{1}{1/1\mu F + \frac{1}{10.2\mu F}} \\
&= \frac{1\mu F \cdot 10.2\mu F}{1\mu F + 10.2\mu F} \\
&= \frac{10.2}{11.2}\mu F = 0.92\mu F
\end{aligned}$$

Energie accumulée :

$$E = \frac{1}{2} \cdot C \cdot U^2 = \frac{1}{2} \cdot 0.92\mu F \cdot (2V)^2 = 1.84\mu J$$

Q1b

Induction :

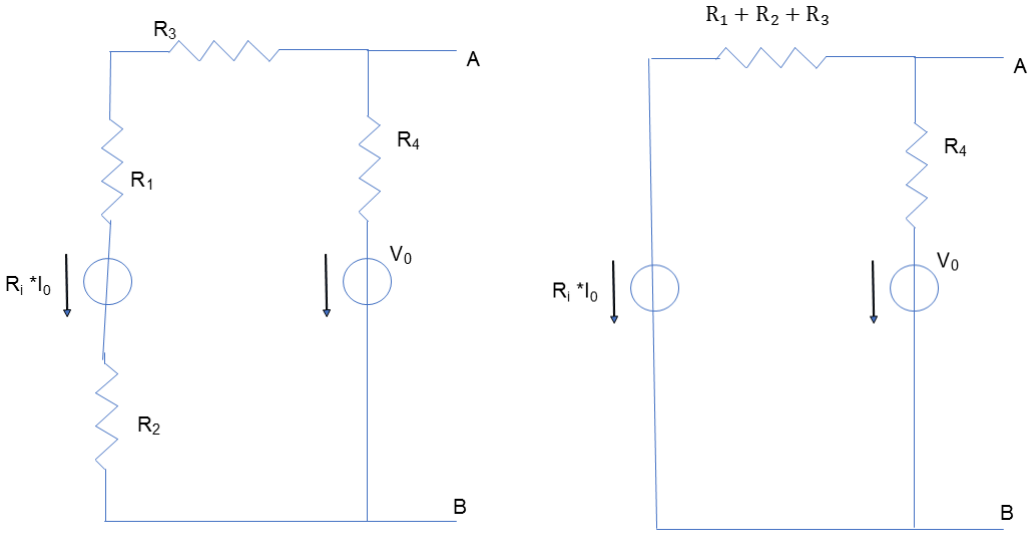
$$\begin{aligned}
L_{tot} &= 1\mu H + \frac{1}{\frac{1}{5\mu H} + \frac{1}{3\mu H + 2\mu H} + \frac{1}{4\mu H}} \\
&= 1\mu H + \frac{\frac{5}{2}\mu H \cdot 4\mu H}{\frac{5}{2}\mu H + 4\mu H} \\
&= 1\mu H + \frac{20}{13}\mu H = \frac{33}{13}\mu H = 2.54\mu H
\end{aligned}$$

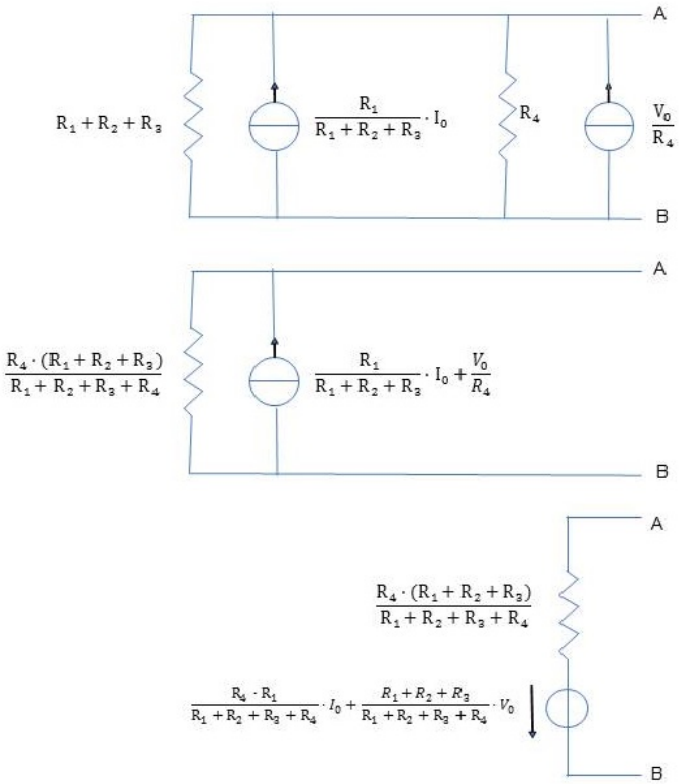
Energie accumulée :

$$E = \frac{1}{2} \cdot L \cdot I^2 = 31.75\mu J$$

Solution : Exercice 2

Q2





Solution : Exercice 3

Q3a

$$U_R(t) = R \cdot I_{OUT}(t)$$

$$U_L(t) = L \cdot \frac{dI_{OUT}(t)}{dt}$$

$$V_{in} - U_R(t) - U_L(t) = 0$$

$$=> V_{in} = U_R(t) + U_L(t) = R \cdot I_{OUT}(t) + L \cdot \frac{dI_{OUT}(t)}{dt}$$

Q3b

t<0 :

$$I = const. => \frac{dI(t)}{dt} = 0 => I_{OUT}(t < 0) = \frac{V_{in}(t < 0)}{R} = \frac{2V}{10\Omega} = 0.2A$$

t $\geq$ 0 :

$$V_{in}(t \geq 0) = 0 => 0 = R \cdot I_{OUT}(t) + L \cdot \frac{dI_{OUT}(t)}{dt} <=> -L \cdot \frac{dI_{OUT}(t)}{dt} = R \cdot I_{OUT}(t)$$

$$=> -\frac{L}{R} dI \cdot \frac{1}{I_{OUT}} = dt$$

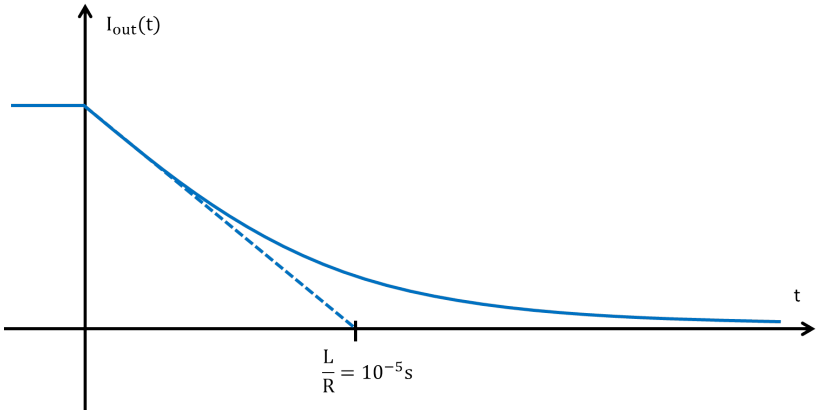
$$=> -\left(\frac{L}{R} ln\left(I_{OUT}(t)\right) - \frac{L}{R} ln\left(I_{OUT}(t < 0)\right)\right) = -\frac{L}{R} ln\left(\frac{I_{OUT}(t)}{I(t < 0)}\right) = t - 0s = t$$

$$=> I(t) = e^{-\frac{R}{L} \cdot t}$$

$$=> I(t > 0) = 0.2A \cdot e^{-\frac{R}{L} \cdot t} = 0.2A \cdot e^{-\frac{10^5}{s} \cdot t}$$

$$\frac{dI_{OUT}(t)}{dt}(t = 0) = I_{OUT}(t = 0 =) \cdot \left(-\frac{R}{L}\right) \cdot e^{-\frac{10^5}{s} \cdot 0s} = -I_{OUT}(t = 0) \cdot \frac{R}{L}$$

Q3c



Solution : Exercice 4

Q4

$$\underline{Z_C} = \frac{1}{j\omega C}$$

$$\underline{Z_R} = R$$

$$\underline{Z_{R_L}} = R_L$$

$$\underline{Z_L} = j\omega L$$

$$\underline{Z_{tot}} = \underline{Z_L} + \underline{Z_R} + \underline{Z_C} + \underline{Z_{R_L}} = j\omega L + R + \frac{1}{j\omega C} + R_L$$

$$\underline{U} = \underline{Z} \cdot \underline{I}$$

$$\underline{I} = \frac{\underline{U_{in}}}{\underline{Z_{tot}}} = \underline{U_{in}} \cdot R_L \cdot \frac{1}{j\omega L + R + \frac{1}{j\omega C} + R_L}$$

$$\frac{\underline{U_{out}}}{\underline{U_{in}}} = \frac{R_L}{j\omega L + R + \frac{1}{j\omega C} + R_L} = \frac{R_L}{R + R_L + j(\omega L - \frac{1}{\omega C})} = \frac{R_L \cdot (R + R_L - j \cdot R_L \cdot (\omega L - \frac{1}{\omega C})}{(R + R_L)^2 + (\omega L - \frac{1}{\omega C})^2}$$

$$=> Re\left(\frac{\underline{U_{out}}}{\underline{U_{in}}}\right) = \frac{R_L \cdot (R + R_L)}{(R + R_L)^2 + (\omega L - \frac{1}{\omega C})^2}$$

$$=> Im\left(\frac{\underline{U_{out}}}{\underline{U_{in}}}\right) = \frac{-R_L \cdot (\omega L - \frac{1}{\omega C})}{(R + R_L)^2 + (\omega L - \frac{1}{\omega C})^2}$$

Solution : Exercice 5

Q5

$$H(j\omega) = -10\frac{j\frac{\omega}{\omega_1}(1 + j\frac{\omega}{\omega_3})}{(1 + j\frac{\omega}{\omega_2})}$$

$$|H(j\omega)|_{dB} = 20dB + 20Log\left(\frac{\omega}{\omega_1}\right)dB + 20Log\left(\sqrt{1 + \left(\frac{\omega}{\omega_3}\right)^2}\right)dB - 20Log\left(\sqrt{1 + \left(\frac{\omega}{\omega_2}\right)^2}\right)dB$$

$$|H(j\omega_1)|_{dB} = 20dB + 0dB + 0dB - 0.04dB = 19.96dB$$

$$|H(j\omega_2)|_{dB} = 20dB + 20dB + 0dB - 3.01dB = 36.99dB$$

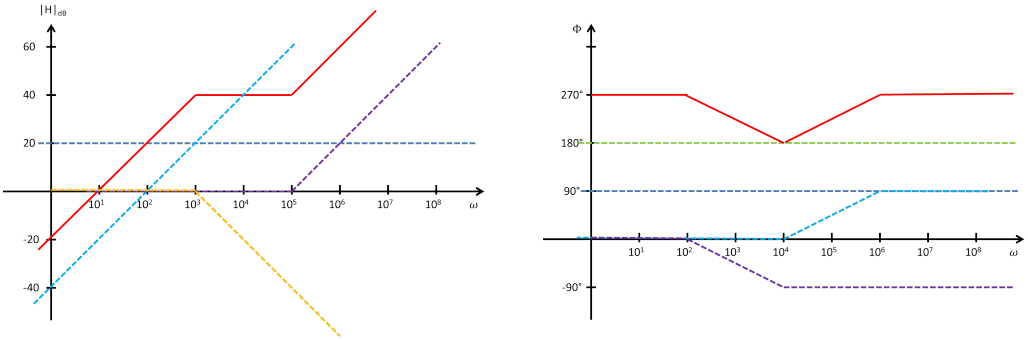
$$|H(j\omega_3)|_{dB} = 20dB + 60dB + 3.01dB - 40dB = 43.01dB$$

$$\Phi(H(j\omega) = 180^\circ + 90^\circ + arctan\left(\frac{\omega}{\omega_3}\right) - arctan\left(\frac{\omega}{\omega_2}\right)$$

$$\Phi(\omega = \omega_1) = 180^\circ + 90^\circ + 0.06^\circ - 5.71^\circ = 264.35^\circ$$

$$\Phi(\omega = \omega_1) = 180^\circ + 90^\circ + 0.57^\circ - 45^\circ = 225.57^\circ$$

$$\Phi(\omega = \omega_1) = 180^\circ + 90^\circ + 45^\circ - 89.43^\circ = 225.57^\circ$$



Solution : Exercice 6

Q6