

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 :

$$\begin{aligned}
 E &= \frac{1}{2} \cdot C \cdot U^2 = \frac{1}{2} \cdot 0.92\mu F \cdot (2V)^2 = 1.84\mu J \\
 E_c &= C \frac{u^2}{2} = 1.5nJ
 \end{aligned}$$

Q1b

Induction :

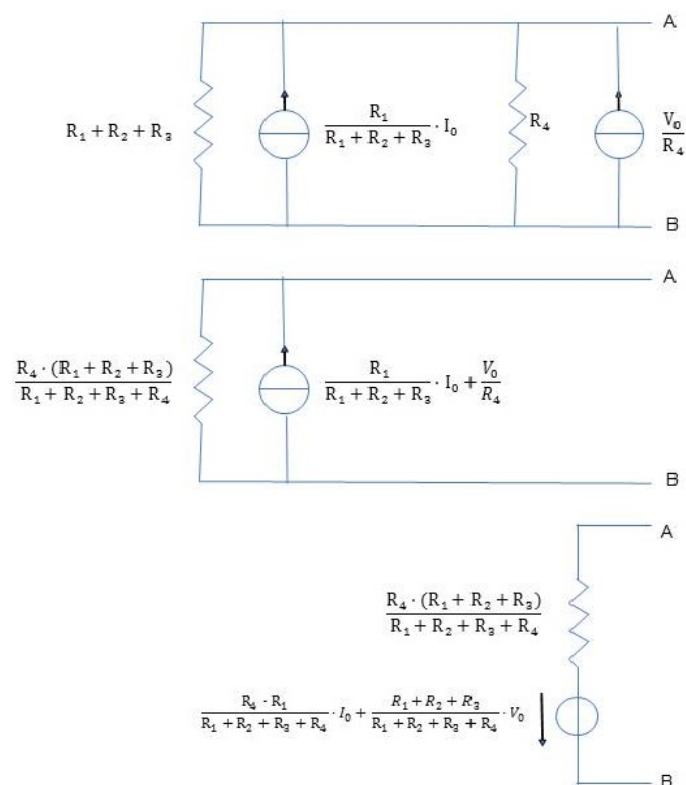
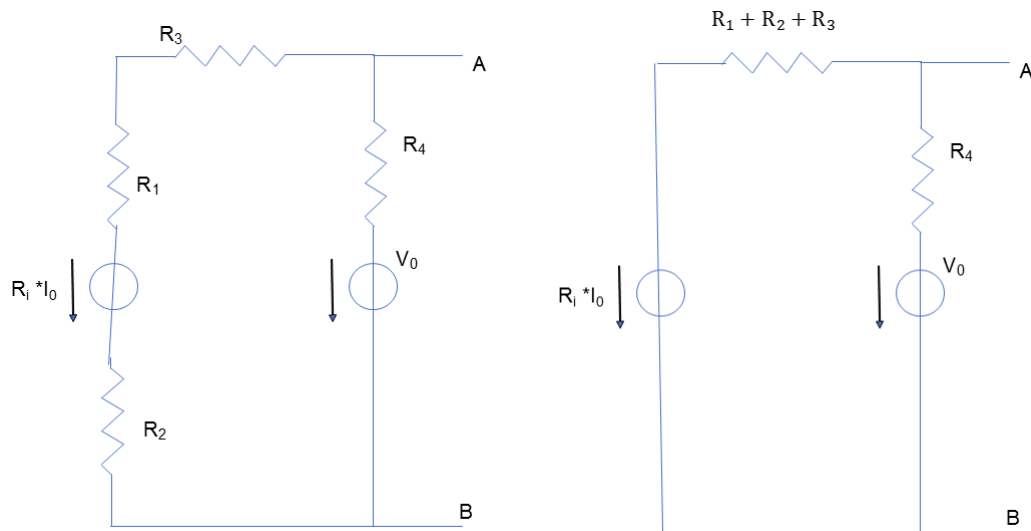
$$\begin{aligned}
 L_{tot} &= 1\mu H + \frac{1}{\frac{1}{5\mu H} + \frac{1}{3\mu H + 2\mu H} + \frac{1}{4\mu H}} \\
 &= 1\mu H + \frac{\frac{5}{2}\mu H \cdot 4\mu H}{\frac{5}{2}\mu H + 4\mu H} \\
 &= 1\mu H + \frac{20}{13}\mu H = \frac{33}{13}\mu H = 2.54\mu H
 \end{aligned}$$

Energie accumulée :

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

Solution : Exercice 2

Q2



Solution : Exercice 3

Q3a

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

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

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

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

Q3b

$t < 0$:

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

$t \geq 0$:

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

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

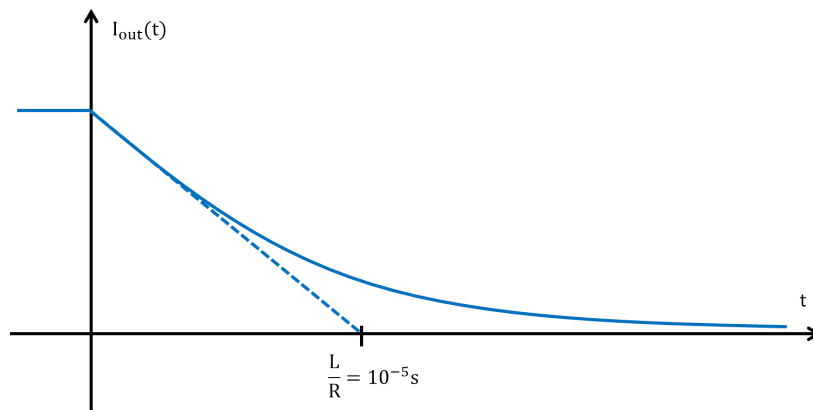
$$\Rightarrow -\left(\frac{L}{R} \ln(I_{OUT}(t)) - \frac{L}{R} \ln(I_{OUT}(t < 0))\right) = -\frac{L}{R} \ln\left(\frac{I_{OUT}(t)}{I(t < 0)}\right) = t - 0s = t$$

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

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

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

Q3c



Solution : Exercice 4

Q4

$$\underline{Z}_C = \frac{1}{j\omega C}$$

$$\underline{Z}_R = R$$

$$\underline{Z}_{R_L} = R_L$$

$$\underline{Z}_L = j\omega L$$

$$\underline{Z}_{tot} = \underline{Z}_L + \underline{Z}_R + \underline{Z}_C + \underline{Z}_{R_L} = j\omega L + R + \frac{1}{j\omega C} + R_L$$

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

$$\underline{I} = \frac{\underline{U}_{in}}{\underline{Z}_{tot}} = \underline{U}_{in} \cdot R_L \cdot \frac{1}{j\omega L + R + \frac{1}{j\omega C} + R_L}$$

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

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

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

Solution : Exercice 5

Q5

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

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

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

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

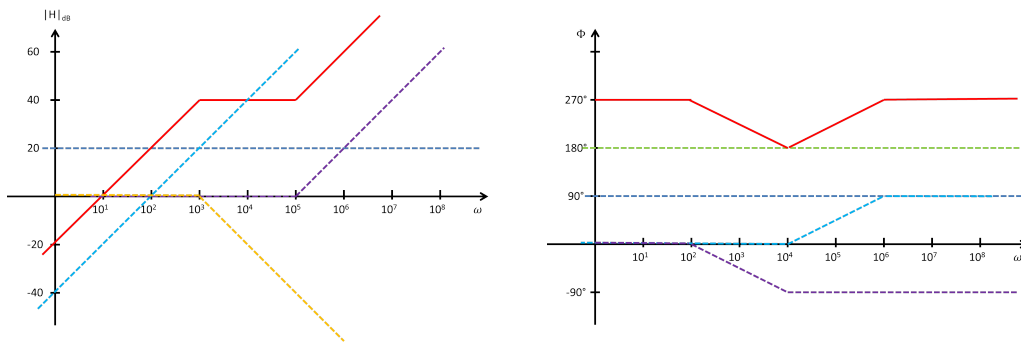
$$|H(j\omega_3)|_{dB} = 20dB + 60dB + 3.01dB - 40dB = 43.01dB$$

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

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

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

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



Solution : Exercice 6

Q6

