Exam Electronics

Study of Sinusoidal steady state [SI-S1-ELEC-2-ERS]

Calculators and documents are forbidden. Scoring scale is given as a guide

Answers exclusively on the subject. If you need more space, you can use the back of the pages.

Exercise 1. MCQ (4 points – No negative score)

For each of the questions below, circle around the correct answer(s).

Consider the sinusoidal voltage $u(t) = U.\sqrt{2}.sin\,(\omega t + \varphi)$.

1. What is the unit of U ?

   a. A
   b. $V.rad.s^{-1}$
   c. V
   d. U is unit less

2. $\underline{U}$, is the complex amplitude associated to $u(t)$. What is the argument of $\underline{U}$?

   a. $\omega t + \varphi$
   b. ωt
   c. φ
   d. U

3. Consider a dipole D. We set:

   - $u(t)$, the voltage between its terminals
   - $i(t)$, the current crossing it
   - $\underline{Z}$, its complex impedance.

   u and i are arrowed according to the receiver convention. (Q2&3)

   The argument of $\underline{Z}$ stands for?

   a. The phase of u at the time origin
   b. The phase of i at the time origin
   c. The phase shift of u with respect to i
   d. The answer depends on the dipole

4. What is the unit of the product $C\omega$?

   a. Siemens b. Hertz c. Amperes d. Ohms

Consider a filter of order 1. We set $\underline{T}(\omega)$ its tranfer function, $A(\omega)$, its amplification and $G(\omega)$, its gain in dB.

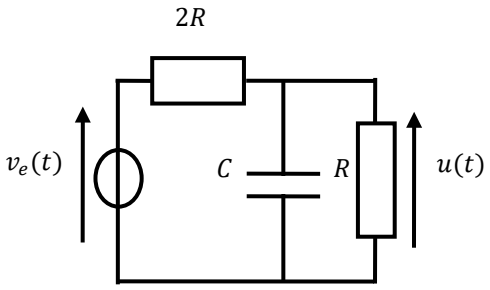
5. The ratio of the RMS value of the output voltage over the RMS value of the input voltage stands for?

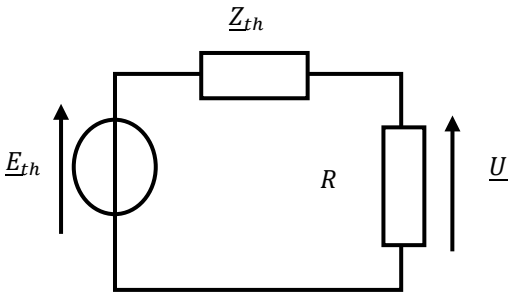
   a. The gain $G(\omega)$
   b. The amplification $A(\omega)$
   c. The transfer function $\underline{T}(\omega)$
   d. None of this

6. $arg\ (\underline{T}(\omega)$ stands for the phase shift of the output voltage with respect to the input voltage.

   a. TRUE
   b. FALSE

Consider the diagram on the left, where $e(t) = E.\sqrt{2}.\sin(\omega t)$. We want to determine the equivalent Thévenin generator seen by the resistor R. Therefore, we obtain the diagram on the left in complex representation. (Q7&8)





7. What is the expression of $\underline{\mathrm{E}}_{\mathrm{th}}$?

   a- $\underline{E_{th}} = \frac{1}{1+2jRC\omega}\underline{V_E}$
   b- $\underline{E_{th}} = \frac{jC\omega}{2R+jC\omega}\underline{V_E}$
   c- $\underline{E_{th}} = \frac{C}{2R+C}\underline{V_E}$
   d- $\underline{E_{th}} = \underline{V_E}$

8. What is the expression of $\underline{Z_{th}}$?

   a- $\underline{Z_{th}} = \frac{2RC}{2R+C}$
   b- $\underline{Z_{th}} = 2R + \frac{1}{jC\omega}$
   c- $\underline{Z_{th}} = \frac{2jRC\omega}{2R+jC\omega}$
   d- $\underline{Z_{th}} = \frac{2R}{1+2jRC\omega}$

Exercise 2. Sinusoidal steady state: Study of a filter (9 points)

Consider the following diagram:

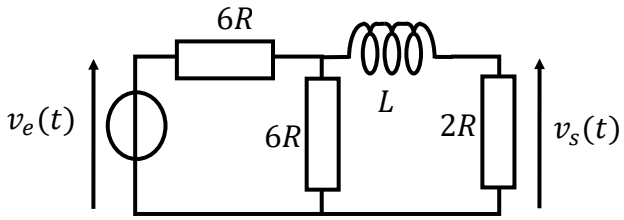


Figure 1

1. Qualitative study:

   a. Draw the equivalent scheme of the filter at Very Low Frequencies (VLF). Deduce the limit of filter amplification $A(\omega)$ at VLF.

   b. Draw the equivalent scheme of the filter at Very High Frequencies (VHF). Deduce the limit of filter amplification $A(\omega)$ at VHF.

   c. Conclude on the filter type.

d. What is the filter type if we substitute the coil with a capacitor? Justify your answer.

2. Quantitative study:

a- Determine $\underline{E_{th}}$ and $\underline{Z_{th}}$ so that the precedent diagram (figure 1) is equivalent to the diagram on the opposite (figure 2). Detail your arguments.

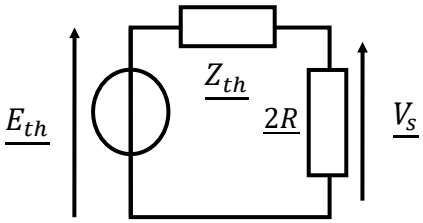


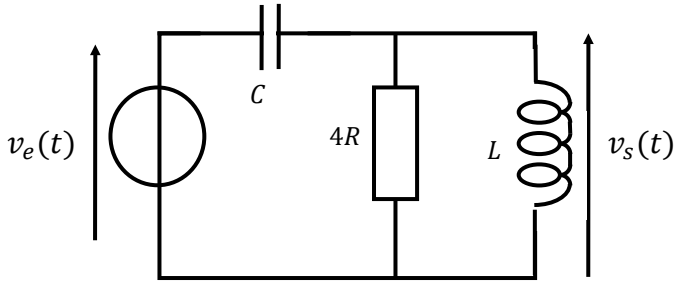
Figure 2

b- Using the diagram in la figure 2, give the expression of the complex amplitude $\underline{V_S}$ associated to the voltage $v_s(t)$ in terms of $\underline{E_{th}}$, $\underline{Z_{th}}$ and R, then, in terms of R, L, ω and $\underline{V_E}$.

Deduce the filter transfer function, then, the cutoff pulsation. If needed, you find in annex the standard forms of transfer functions.

Exercise 3. Steady sinusoidal state: Study of a filter (7 points)

Consider the diagram below:



1. Qualitative study:

a. Draw the equivalent scheme of the filter at Very Low Frequencies (VLF). Deduce the limit of filter amplification $A(\omega)$ at VLF.

b. Draw the equivalent scheme of the filter at Very High Frequencies (VHF). Deduce the limit of filter amplification $A(\omega)$ at VHF.

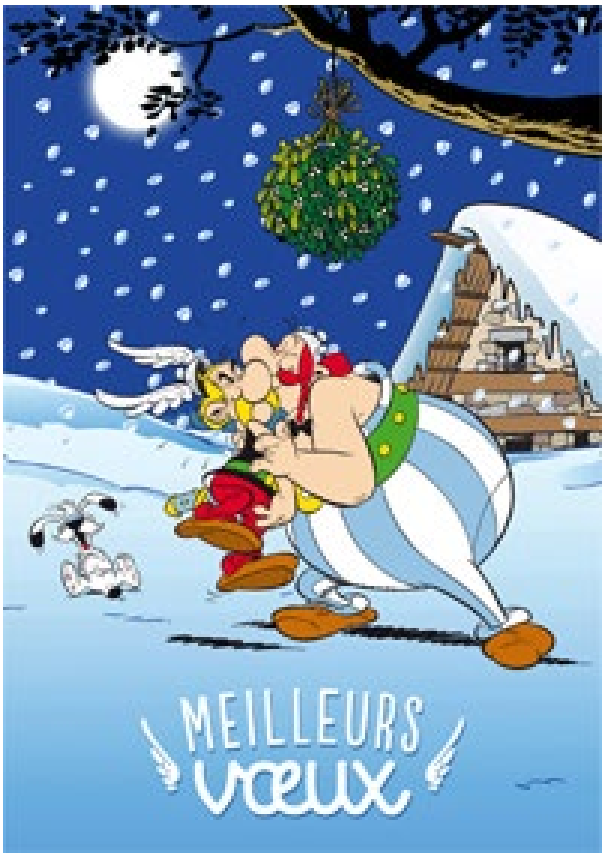
c. Conclude on the filter type and order.

d. What type of filter is obtained if the capacitor is replaced with a coil? Justify your answer

2. Quantitative study:

a. Determine the complex amplitude $\underline{V_S}$ associated to the voltage $v_s(t)$ in terms of R, L, C, ω and $\underline{V_E}$. Deduce the transfer function of this filter.

b. Put the transfer function under the standard form and deduce the tuning (central) pulsation ω_0 as well as the damping factor σ. You find in annex the standard forms of transfer functions. You can express σ in terms of ω_0.



Standard forms of transfer functions

Filter type	Order 1	Order 2
Low Pass	$\underline{T}(\omega) = A_{Max}.\frac{1}{1+j\frac{\omega}{\omega_c}}$ with: $A_{Max} = A_{VLF}$ $\omega_c =$ cutoff Pulsation	$\underline{T}(\omega) = A_0.\frac{1}{1+2j\sigma\frac{\omega}{\omega_0}-\left(\frac{\omega}{\omega_0}\right)^2}$ with: $A_0 = A_{VLF}$
High Pass	$\underline{T}(\omega) = A_{Max}.\frac{j\frac{\omega}{\omega_c}}{1+j\frac{\omega}{\omega_c}}$ with: $A_{Max} = A_{VHF}$ $\omega_c =$ cutoff Pulsation	$\underline{T}(\omega) = A_0.\frac{-\left(\frac{\omega}{\omega_0}\right)^2}{1+2j\sigma\frac{\omega}{\omega_0}-\left(\frac{\omega}{\omega_0}\right)^2}$ with: $A_0 = A_{VHF}$
Band Pass		$\underline{T}(\omega) = A_0.\frac{2j\sigma\frac{\omega}{\omega_0}}{1+2j\sigma\frac{\omega}{\omega_0}-\left(\frac{\omega}{\omega_0}\right)^2}$ with: $A_0 = A_{Max}$