Ministry of Higher Education and Scientific Research
Med Boudiaf University - M'sila
Department: Electrical Engineering
Module: Control Systems
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3rd Year Engineering

Lab Work No. 4

Frequency Analysis (Plotting Bode Diagrams)

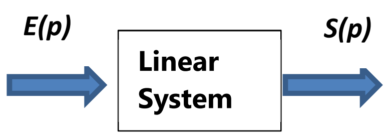
OBJECTIVE OF THE EXPERIMENT

The purpose is to study the frequency response of 1st and 2nd order passive circuits. The main focus of this practical work is to plot Bode plots (gain and phase) using the Tina simulation software, thereby familiarizing students with Bode diagrams and developing proficiency in measuring gain and phase shift.

II. THEORETICAL BACKGROUND

II.1 Transfer Function

$$F(p) = \frac{S(p)}{E(p)}$$



where:

$S(p)$: Laplace transform of the output signal,

$E(p)$: Laplace transform of the input signal,

$F(p)$: Transfer function.

II.2 Harmonic Analysis

The transfer function $F(j\omega)$ enables frequency analysis (or harmonic analysis) in steady-state sinusoidal regime.

$$F(j\omega) = \frac{S(j\omega)}{E(j\omega)} = |F(j\omega)|.e^{j\phi(\omega)} = A(\omega).e^{j\phi(\omega)}$$

$A(j\omega)=|F(j\omega)|$: $A(\omega) = \frac{|S(j\omega)|}{|E(j\omega)|}$: Amplitude gain of the filter (or system)

$\varphi(j\omega)=\arg(F(j\omega))$: $\phi(\omega)$ Phase shift between the input and output signal

a) Amplitude Plot:

This curve represents the gain in decibels (AdB) as a function of the decimal logarithm of the frequency (on semi-logarithmic paper).

$$A_{dB}=20\ LOG_{10}\,(|A(j\omega)|)$$

b) Phase Plot:

This curve represents the phase shift (in degrees) as a function of the decimal logarithm of the frequency (on semi-logarithmic paper).

III. Preparatory work

1. Using the values indicated in Figure 1 (below), determine the corresponding cutoff frequency f_c (knowing that $f_c=\omega/2\pi$).
2. Plot the theoretical asymptotic diagrams (Gain and Phase). The following scales are recommended:

- 4 dB per 1 cm (on the AdB axis)
- 10° per 1 cm (on the φ axis).

3. Identify the type of each filter.
4. Repeat the same work for the filters in Figures 2, 3, and 4.

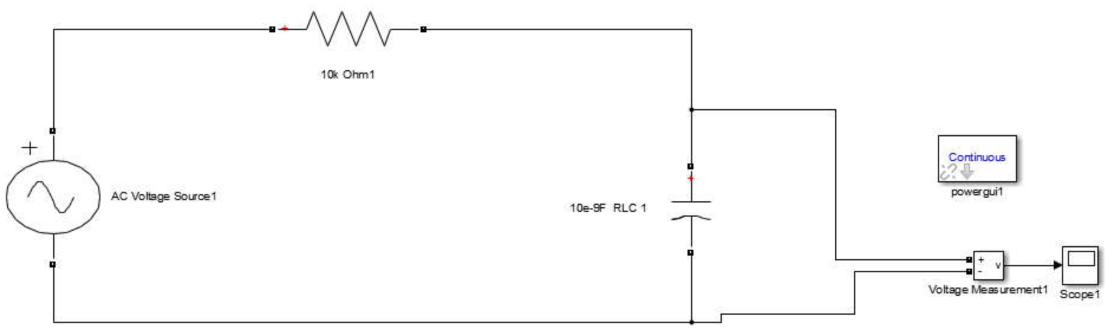


Fig. 1 *(Circuit diagram for passive filter)*

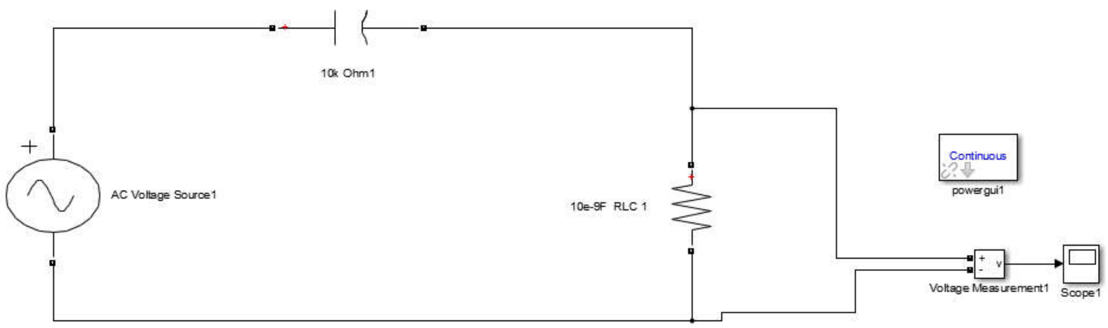


Fig. 2 *(Circuit diagram for another passive filter)*

IV. Simulation

1. Plot the Boode diagram using MATLAB with the following program:

```
R=1e-6
C=1e-9
RC=R*C
num=[1]
den=[RC,1]
F=tf(num,den)
bode(F)
```

2. determine the cutoff frequency fc
3. Construct the circuit in **Figure 1**. in SIMULINK
4. Apply the input signal (*Ve*) 2V peak-to-peak. This signal must remain fixed.
5. Vary the frequency, starting with $f1=fc/1000$ and ending with $f2=1000\times fc$ (take more points near *fc*).

6. For each frequency value f:

   a) Measure the amplitude of the output signal (Vs), calculate the gain $A=Vs/Ve$, convert this gain to decibels, and plot the graph $AdB=g(f)$.

   $AdB=20\log10(|A(j\omega)|)=20\log10(Vs/Ve)$

   b) Measure the phase shift between the input and output signals

   $\varphi=(T2-T1)\times f\times 360°$) and record this value in **Table 1**. Then plot the graph $\varphi=h(f)$.

Table 1

[f[Hz]	**fc/1000**	…	**....**	**fc**	….	**...**	**1000fc**
Vs[V]							
$20\log10(Vs/Ve)$[dB]							
$T2-T1$[s]							
$\varphi=(T2-T1)\times f\times 360°$							

5. Repeat the same procedure for the circuits in **Figures 2**

V. Required work

The report should be structured as follows:

1. **Objective of the Practical Work**
2. **Simulation Results**
3. **Plotted Graphs (Gain and Phase Diagrams)**
4. **Interpretation of the Results**
5. **Conclusion**