Department of Electrical and Computer Engineering

University of Victoria

ELEC 300 - Linear Circuits II

Laboratory Report

Experiment No.:	2
Title:	Frequency response of linear systems
Date of experiment:	19 February, 2016
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1 Objective

This experiment will create a type of RC circuit called a *phase lag circuit*. The circuit's transfer function will be used to determine the component values in the circuit for pre-defined frequency responses. The magnitude and phase responses of the circuit will be examined for a range of input frequencies.

2 Introduction

$$H(s) = K\frac{s-z}{s-p} \tag{1}$$

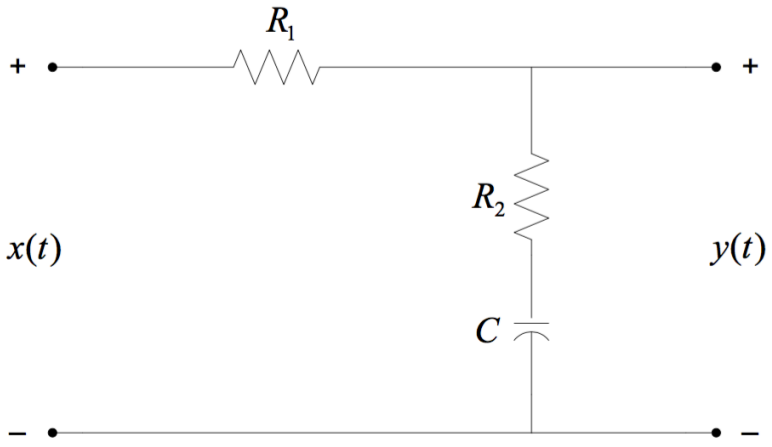

Figure 1: Schematic of a phase lag circuit

For the circuit in Fig. 1, the transfer function is:

$$H(s) = \frac{R_2 + \frac{1}{sC}}{R_1 + R_2 + \frac{1}{sC}} = \frac{R_2}{R_1 + R_2}\frac{s + \frac{1}{CR_2}}{s + \frac{1}{C(R_1+R_2)}}. \tag{2}$$

Comparing (1) with (2) gives:

$$\begin{aligned} K &= \frac{R_2}{R_1 + R_2} \\ |z| &= \frac{1}{CR_2} \\ |p| &= \frac{1}{C(R_1 + R_2)}. \end{aligned}$$

3 Results

$$|H(j\omega)|_{dB} = 20 \times \log\left(\frac{V_y}{V_x}\right)$$

$$\phi_{lag} = \phi_x - \phi_y$$

3.1 Raw Measurements

f (kHz)	V_y (V)	$\lvert H(j\omega)\rvert_{dB}$	ϕ_{lag} (°)
0.5	0.882	−1.065	−22.6
1.0	0.708	−2.973	−38
2.0	0.46	−6.719	−50.4
3.0	0.337	−9.421	−53.4
4.0	0.267	−11.444	−53
5.0	0.224	−12.969	−51.1
6.0	0.196	−14.129	−48.4
7.0	0.178	−14.966	−45.6
8.0	0.166	−15.572	−43
9.0	0.156	−16.111	−41
10.0	0.147	−16.628	−38
11.0	0.141	−16.990	−36
12.0	0.136	−17.303	−33

Table 1: Response of Fig. 1 to frequency change ($V_x = 1\,\text{V}$)

3.2 Analysis

Table 1 shows the response of the phase lag circuit to a range of frequencies, starting at 500Hz then 1kHz steps from 1kHz to 12kHz. Fig. 2 shows a visual representation of the magnitude and phase shift of the output over the range of 500Hz to 12kHz. The measured frequency response shown in Fig. 2 closely resembles the predicted, simulated response shown in Fig. 3.

The waveforms in Fig. 4, show the phase offset of the 2 waveforms, visible by the offset in vertical cursors demonstrating a time shift.

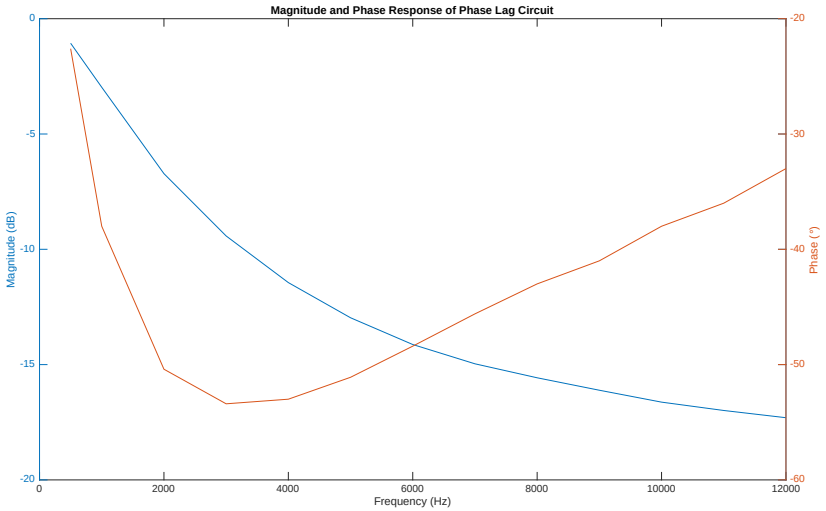

Figure 2: Response of Fig. 1 to frequency change ($V_x = 1\,\mathrm{V}$)

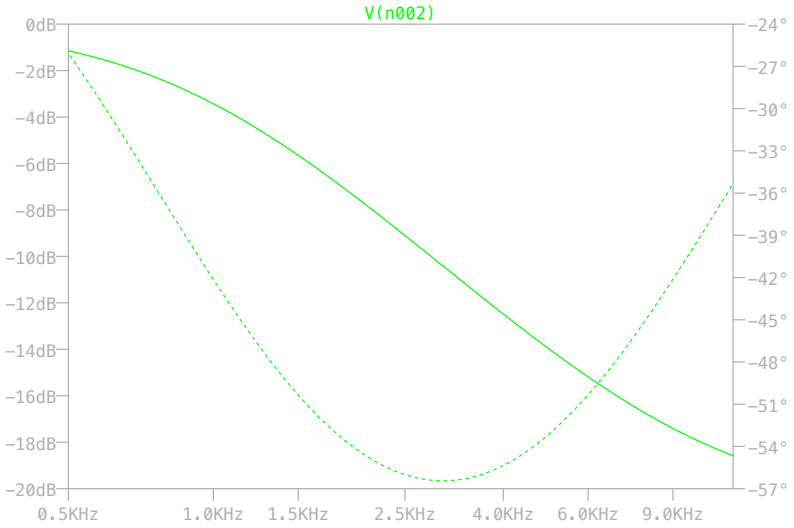

Figure 3: Simulation of Fig. 1's frequency response

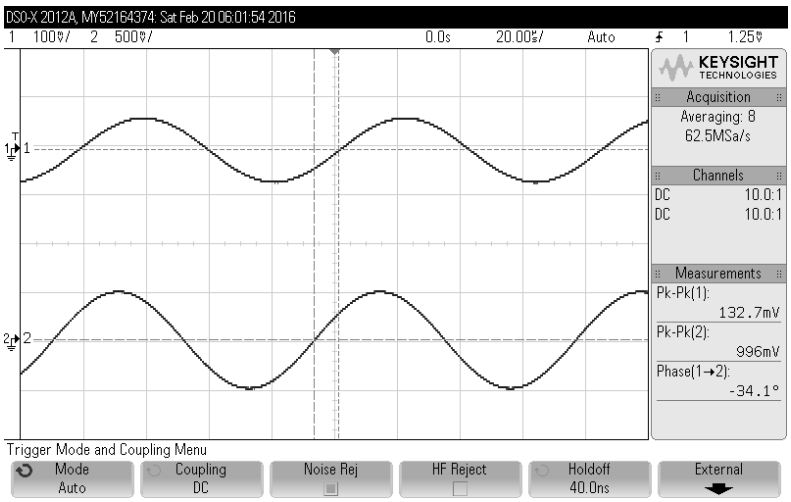

Figure 4: $V_y(t)$ (top) lags $V_x(t)$ (bottom) by 34.1° at 12 kHz

4 Discussion

5 Conclusion

Justify conclusions and results.