

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
Report submitted on:	26 February, 2016
To:	TA, B07
Names:	M. Drinnan (V00755525) T. Mulligan (V00819591) T. Stephen (V00812021)

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

The transfer function of an electric circuit holds important information about the circuit's response to excitation by different frequencies. A transfer function has the form of:

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

where the values of K , p and z are determined the the circuit configuration. The values of $s = z$ and $s = p$ are the *poles* and *zeros* of the transfer function and correspond to frequencies that will alter the frequency response of the circuit.

This experiment examines the frequency response of the circuit shown in Fig. 1

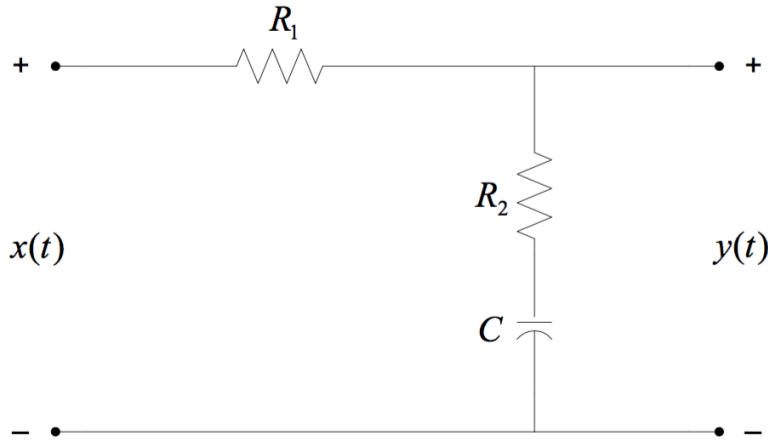


Figure 1: Schematic of a phase lag circuit

The transfer function of this circuit is:

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

Comparing (1) with (2) gives:

$$K = \frac{R_2}{R_1 + R_2}$$

$$|z| = \frac{1}{CR_2} \quad (3)$$

$$|p| = \frac{1}{C(R_1 + R_2)}. \quad (4)$$

The lab manual specified that the circuit would be designed such that there was a pole at $f = 1000$ Hz and a zero at $f = 10\,000$ Hz. Using these values and the constraint $C = 0.01$ nF, (3) and (4) yield $R_1 = 1.591$ k Ω and $R_2 = 14.324$ k Ω . R_1 can be realized with a standard 1.6 k Ω resistor and R_2 can be realized from a 10 k Ω resistor in series with a 10 k Ω potentiometer tuned to 4324 Ω .

3 Results

The circuit from Fig. 1 was constructed using R_1 and R_2 as determined in Section 2. The voltages were recorded for 500 Hz to 12.5 kHz and are recorded in Table 1.

f (kHz)	V_y (V)	$ H(j\omega) _{dB}$	ϕ_{lag} ($^\circ$)
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 ($V_x = 1$ V)

The magnitude of the frequency response is given by:

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

The phase response is given by:

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

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

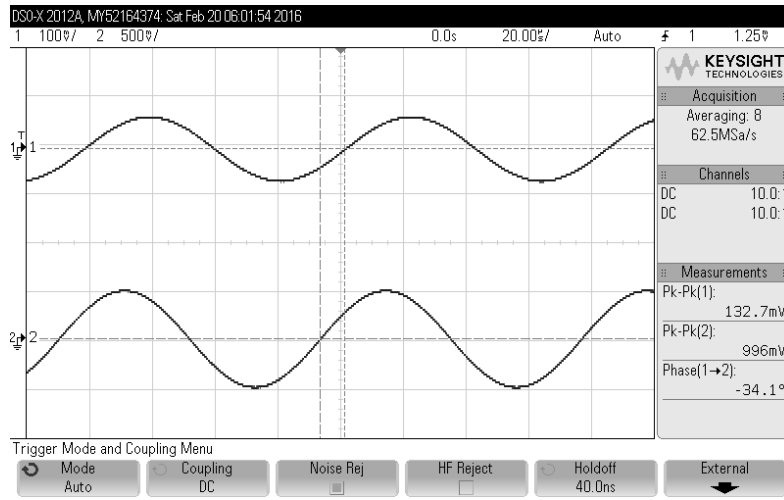
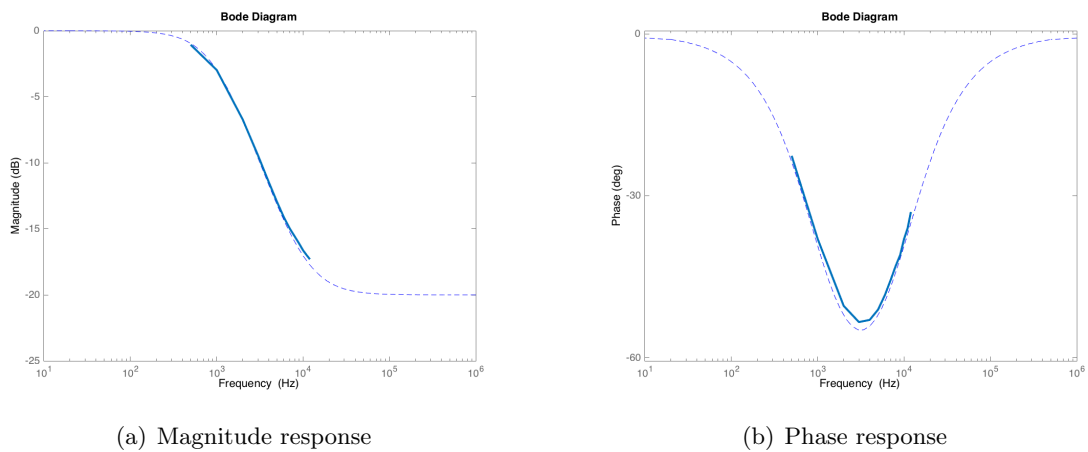


Figure 2: $V_y(t)$ (top) lags $V_x(t)$ (bottom) by 34.1° at 12 kHz

3.1 Analysis

Fig. 3.1 shows the data from Table 1 overlaying the ideal frequency response as predicted by (2).



(a) Magnitude response

(b) Phase response

Figure 3: Experimental data overlaying the ideal response

4 Discussion

5 Conclusion

Justify conclusions and results.