Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Title:	ELE302 Electric Networks
Course Number:	ELE302
Semester/Year (e.g.F2016)	F2024

Instructor:	S. Jassar

Assignment/Lab Number:	4
Assignment/Lab Title:	Filters post Lab

Submission Date:	
Due Date:	

Student LAST Name	Student FIRST Name	Student Number	Section	Signature*
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*By signing above you attest that you have contributed to this written lab report and confirm that all work you have contributed to this lab report is your own work. Any suspicion of copying or plagiarism in this work will result in an investigation of Academic Misconduct and may result in a "0" on the work, an "F" in the course, or possibly more severe penalties, as well as a Disciplinary Notice on your academic record under the Student Code of Academic Conduct, which can be found online at: http://www.ryerson.ca/senate/current/pol60.pdf

5.0 IN-LAB IMPEMENTATION & MEASUREMENTS (5 marks in total):

Part I: The Frequency Responses of the Lowpass Passive Filters

(a) Step 1: Construct the circuit shown in **Figure 1.0**: Set L = 0.1H, C = 0.01μF, and R = 4kΩ [note that the internal resistance of the inductor in addition to the value of R is the total resistance value that should be used to design a Butterworth (Q = 0.707) lowpass filter]. You can use the Potentiometer for the resistance.

Connect Channels (1) and (2) of the oscilloscope to display the input voltage and output voltage respectively, with the trigger source at Channel (1). Set both channels to AC coupling. Set the controls of the function generator to provide a **sinusoidal** input voltage of 6V (peak) at a frequency of 5kHz.

(b) Step 2: Use the oscilloscope displays to measure the phase angle $\angle H(\omega)$ in degrees, and use DMM to measure the dB-values of the input and output voltage, and evaluate the magnitude $|H(\omega)|$ in dB as:

$$|H(\omega)|_{dB} = |V_o|_{dB} - |V_i|_{dB}$$

Record your results in **Table 1.0**.

(c) Step 3: Repeat as in Step 2 for each frequency setting in **Table 1.0**. Use **Graph 1.0** to plot the magnitude $|H(\omega)|$ in dB and phase $\angle H(\omega)$ in degrees versus frequency in Hz.

Note: Make sure you re-adjust the input voltage to 6V (peak) when you change the frequency.

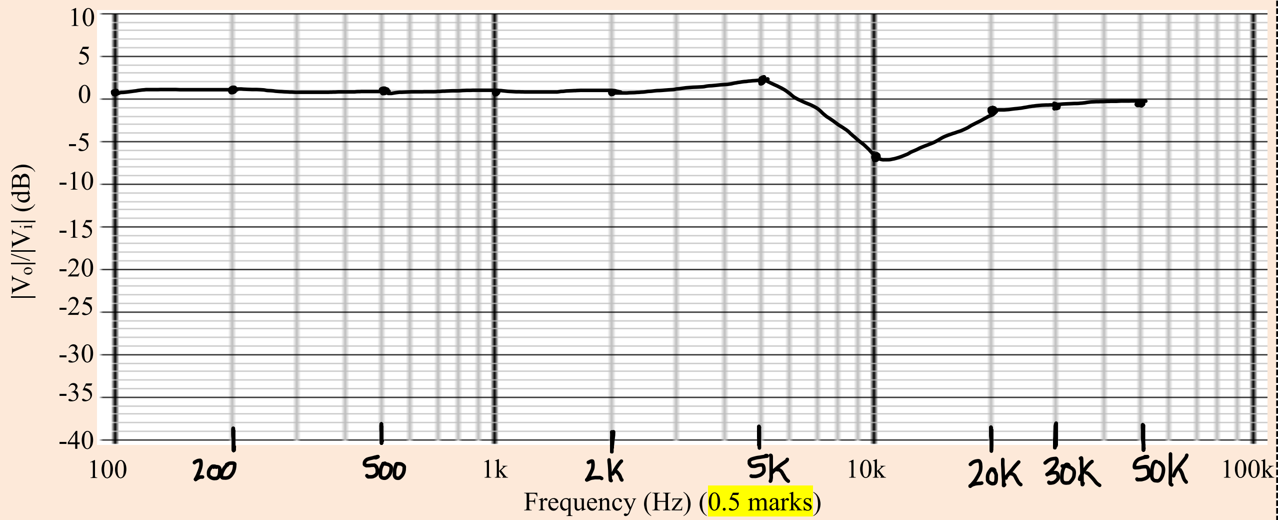
Use your plots to find the location of the low-cutoff frequency f_o. Fill in the corresponding entry for f_o in **Table 1.0**.

(d) Step 4: Demonstrate the correct operation of your experiment setup to your TA. (1 mark)\

Table 1.0 (0.5 marks)

Frequency (Hz)	$\lvert V_o \rvert$ (dB)	$\lvert V_i \rvert$ (dB)	$\lvert H(\omega) \rvert$ (dB)	$\angle H(\omega)$ (degrees)
f_o =	Convert to DB			
100	20 log(6.0) = 15.563	20 log(6.2) = 15.847	−0.284	−2.0°
200	20 log(6.1) = 15.706	20 log(6.1) = 15.706	0	−3.8°
500	20 log(6.2) = 15.847	20 log(6.2) = 15.847	0	−4.5°
1k	20 log(6.2) = 15.847	20 log(6.3) = 15.986	−0.139	−9.0°
2k	20 log(6.2) = 15.847	20 log(6.7) = 16.521	−0.674	−19°
5k	20 log(6.0) = 15.563	20 log(8.4) = 18.485	−2.922	−88°
10k	20 log(6.0) = 15.563	20 log(2.1) = 6.444	9.119	−154°
20k	20 log(6.0) = 15.563	20 log(0.450) = −6.935	22.498	−170°
30k	20 log(6.0) = 15.563	20 log(0.195) = −14.199	29.762	−177°
50k	20 log(6.0) = 15.563	20 log(0.064) = −23.876	39.439	−178°

Vo/Vi dB



Graph 1.0

Part II: The Frequency Responses of the Bandpass Active Filters

(e) Step 5: Connect the circuit shown in **Figure 2.0**, with $R_1 = 470\Omega$, $R_2 = 27k\Omega$ and $C = 0.01\mu F$. Please use the resistors and capacitors from your lab kit.

Connect Channels (1) and (2) of the oscilloscope to display the input and output voltage respectively with the trigger source at Channel (1). Set both channels to AC coupling. Set Channel (2) on inv, as the polarity of the output voltage in **Figure 2.0** is inverted w.r.t. that of the input voltage. Set the controls of the function generator to provide a sinusoidal input voltage of 0.5V (peak-to-peak) at a frequency of 5kHz.

(f) Step 6: Use the oscilloscope displays to measure the phase angle $\angle H(\omega)$ in degrees, and use DMM to measure the dB-values of the input and output voltages, and evaluate the magnitude $|H(\omega)|$ in dB. Record your results in **Table 2.0**.

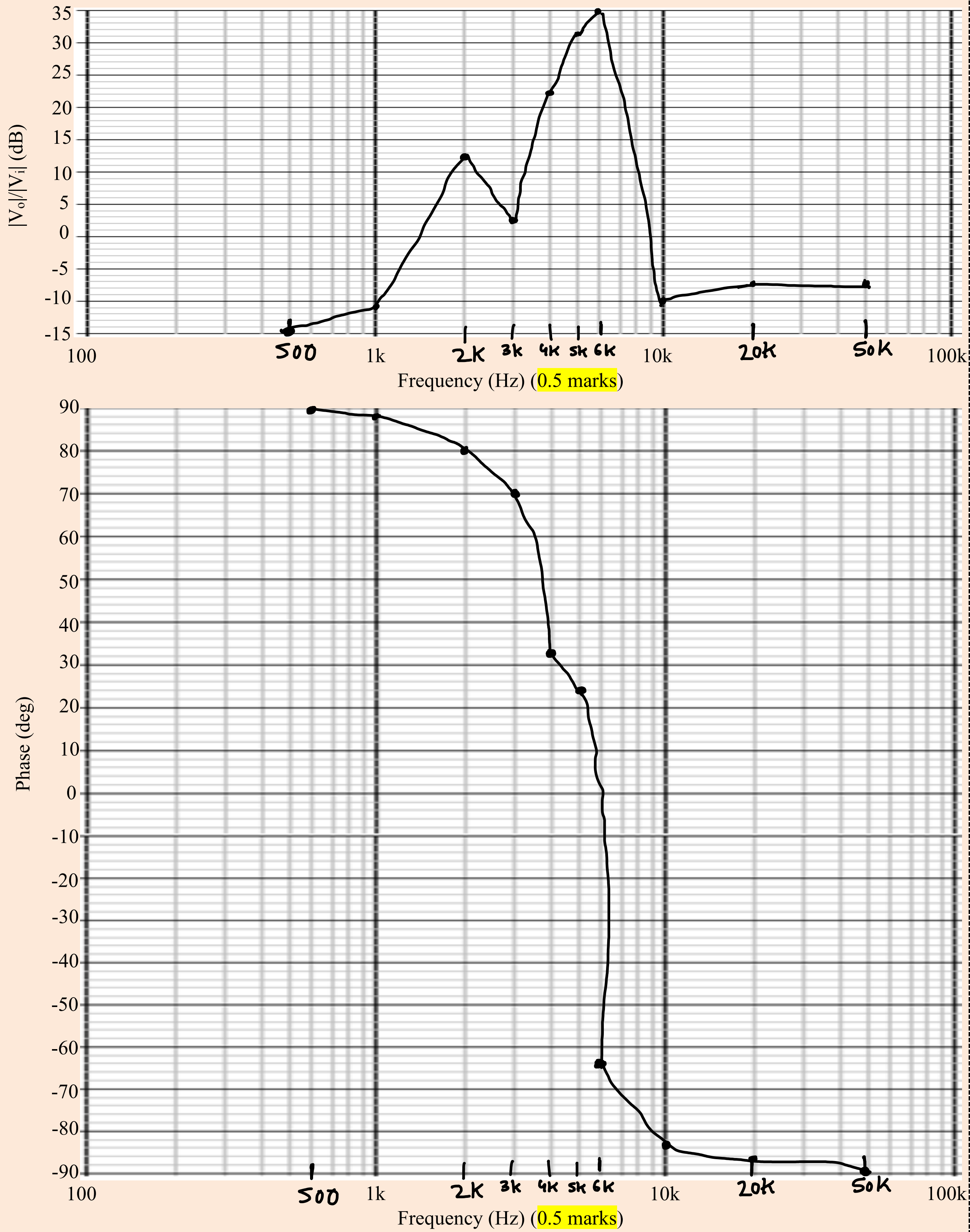
(g) Step 7: Scan the frequency spectrum to locate the central frequency f_o, the low-cutoff frequency f_L, and the high-cutoff frequency f_H, **as defined by their phase values in Table 2.0**. Record the corresponding voltages and $|H(\omega)|$.

(h) Step 8: Repeat Step 6 for each frequency setting in **Table 2.0**. Use **Graph 2.0** to plot the magnitude $|H(\omega)|$ in dB and phase $\angle H(\omega)$ in degrees versus frequency in Hz. Double check your input voltage when you change the frequency.

(i) Step 9: Demonstrate the correct operation of your experimental setup to your TA. (1 mark)

Table 2.0 (0.5 marks)

Frequency (Hz)	$\lvert V_o \rvert$ (dB)	$\lvert V_i \rvert$ (dB)	$\lvert H(\omega) \rvert$ (dB)	$\angle H(\omega)$ (degrees)
f_o =				0^o
f_L=				$+45^o$
f_H=				-45^o
500	-7.47	0.23	7.7	87°
1k	-2.43	0.21	2.64	71°
2k	4.1	0.30	3.8	60°
3k	7.94	0.46	7.48	43°
4k	11.3	0.51	10.29	21°
5k	17.5	0.56	16.94	-3°
6k	22.1	0.31	21.79	-56°
10k	14.9	-1.47	16.37	-78°
20k	5.3	-0.74	6.04	-87°
50k	-4.4	-0.63	-3.71	-90°


|Vo|/|Vi| (dB)
35
30
25
20
15
10
5
0
-5
-10
-15
100
500
1k
2K
3k
4k
5k
6k
10k
20K
50K
100k
Frequency (Hz) (0.5 marks)
Phase (deg)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
100
500
1k
2K
3k
4k
5k
6k
10k
20K
50K
100k
Frequency (Hz) (0.5 marks)

Graph 2.0

6.0 POST-LAB QUESTIONS (2 marks in total, 2/3 marks for each question):

(1) By considering your plots on **Graph 1.0** and the Multisim plots from prelab, answer the following:

a) How is the maximum rate of attenuation of $|H(\omega)|$ affected by Q?
b) What is so special about the magnitude response when $Q = 1/\sqrt{2}$?
c) How do the phase responses compare as a function of Q?

a) looking at the graphs the max rate of attenuation of $|H(\omega)|$ is as $|H(\omega)|$ increases Q will increases as well.

b) when $Q = \frac{1}{\sqrt{2}}$ this means that the filter is critical damped. This means the attenuation is accurate.

c) If Q is a low value the phase angle will be low as well. If Q is a high value then the phase angle will be high.

(2) What effect does the value of Q have on the frequency responses of the band-pass filter circuit?

The effect of the Q value has on the response frequency varies.
As Q increases the magnitude will increase. It will also have a Steep graph. However when Q decreases the graph will become less Steep and the magnitude will decrease.

(3) Is it practically feasible to realize a band-pass characteristic with f_o = 5kHz and Q = 100, using the active-filter circuit shown in **Figure 2.0** with C = 0.01 µF? Explain your answer.

$$f = \frac{1}{2\pi\sqrt{R_1 R_2 C^2}}$$

$$= \frac{1}{2\pi\sqrt{(470)(27000)(1\times10^{-8})^2}}$$

$$= 4467.755 \text{ Hz}$$

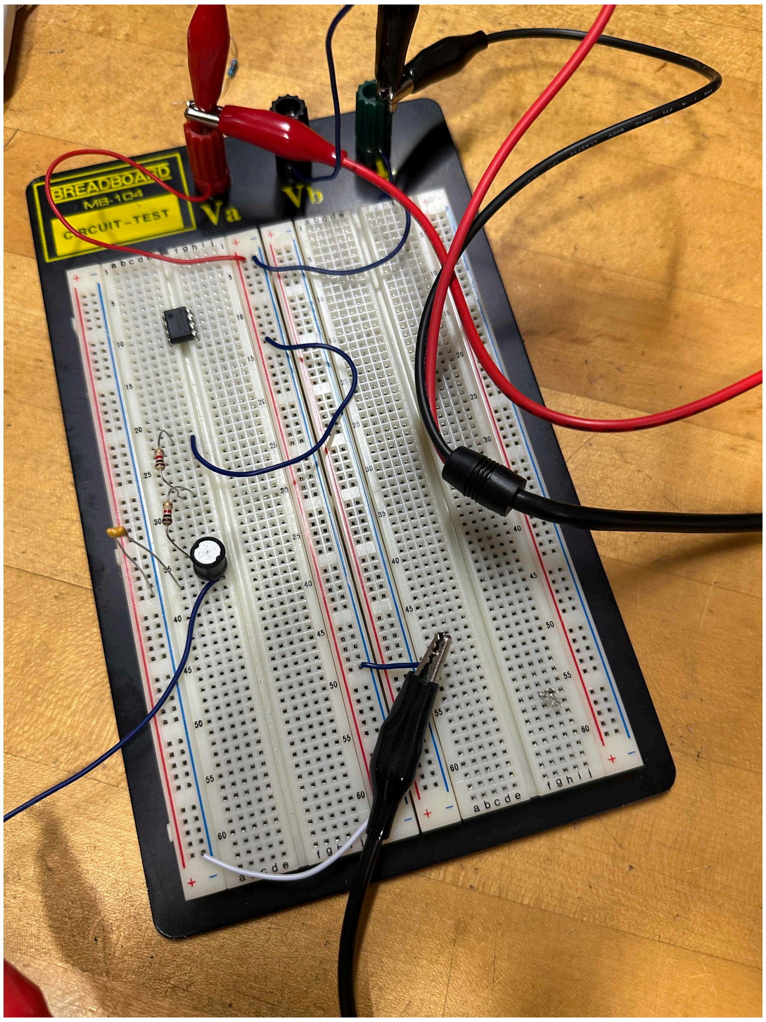
$$= 4.47 \text{kHz}$$

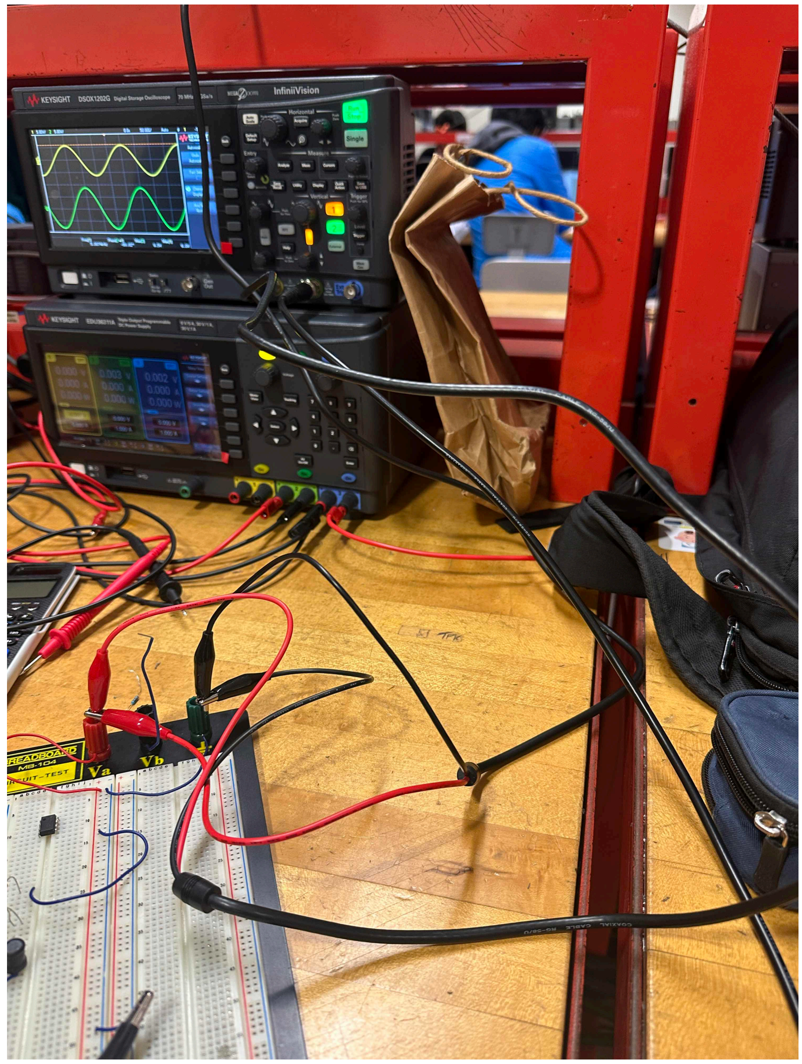
$$Q = \frac{1}{2}\sqrt{\frac{R_2}{R_1}}$$

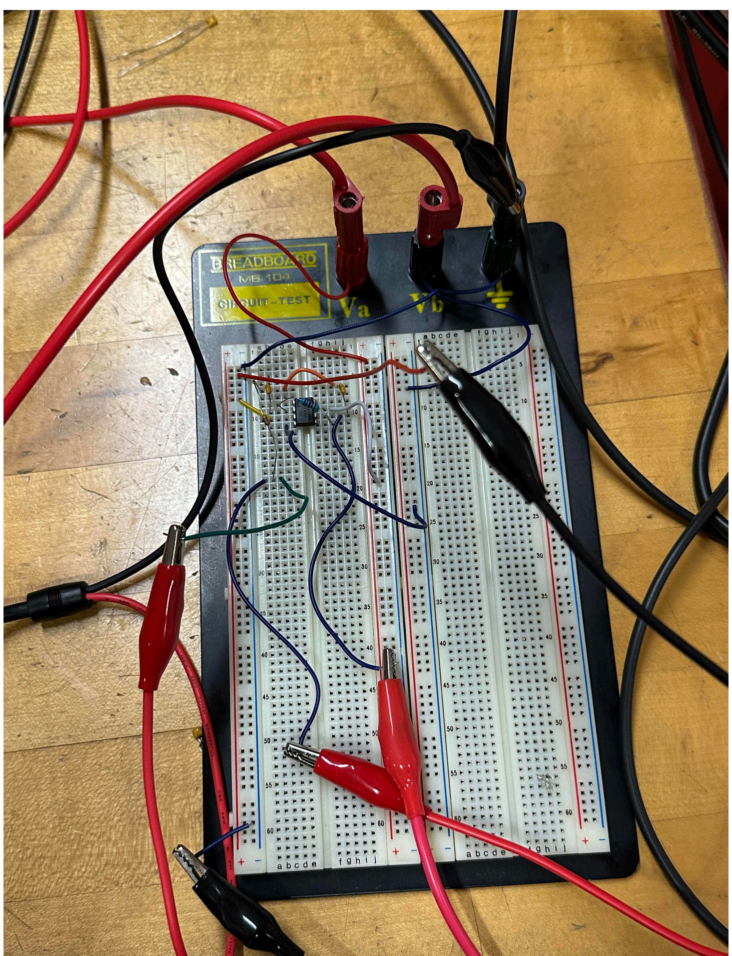
$$= \frac{1}{2}\sqrt{\frac{(27000)}{(470)}}$$

$$Q = 3.7897$$

∴ it is not feasible with the given values.


BREADBOARD
MB-104
CIRCUIT-TEST
Va
Vb


KEYSIGHT
InfiniiVision
BREADBOARD
Va
Vb


BREADBOARD
MB-104
CIRCUIT-TEST
Va
Vb