EE 2245 Microelectronics Labs

Lab 3: Passive Filters

實驗室：______組別________Names and ID Numbers: ____

Objectives：

(1) Become familiar with the characteristics of passive low-pass and high-pass filters.

(2) Plot the phase response for low-pass and high-pass filters.

(3) Analyze the frequency response of tuned band-pass and band-stop filters.

(4) Become adept in the use of semilog graph paper.

Equipment Required :

Resistors: 300 Ω, 1 kΩ

Capacitors: 0.1 μF

Inductors: 10 mH

Instruments: Digital multimeter (DMM), digital oscilloscope, function generator.

注意：填寫實驗數據時如有『單位』請記得填入。

Procedure :

Part 1: Low-Pass R-C Filter Design

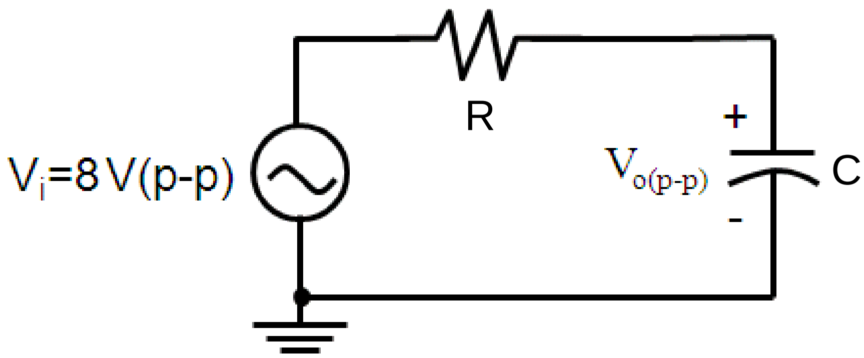


Figure 1-1

You are required to design a low-pass filter, as shown in Fig. 1-1, with a –3-dB frequency at 20 kHz (with tolerance of ±2%, i.e. 19.6 – 20.4 kHz). <u>Please demonstrate your result to a teaching assistant or teacher.</u>

(a) Please show your analysis, and write down the resistor and capacitor values of your choice. Please also record the measured values.

<u>Analysis:</u>

R = ______________; C= _______________

$R_{measured}$ = _______________; $C_{measured}$ = _______________;

(b) Write down the magnitude and phase of $V_o(j\omega)/V_i(j\omega)$ in terms of R and C.

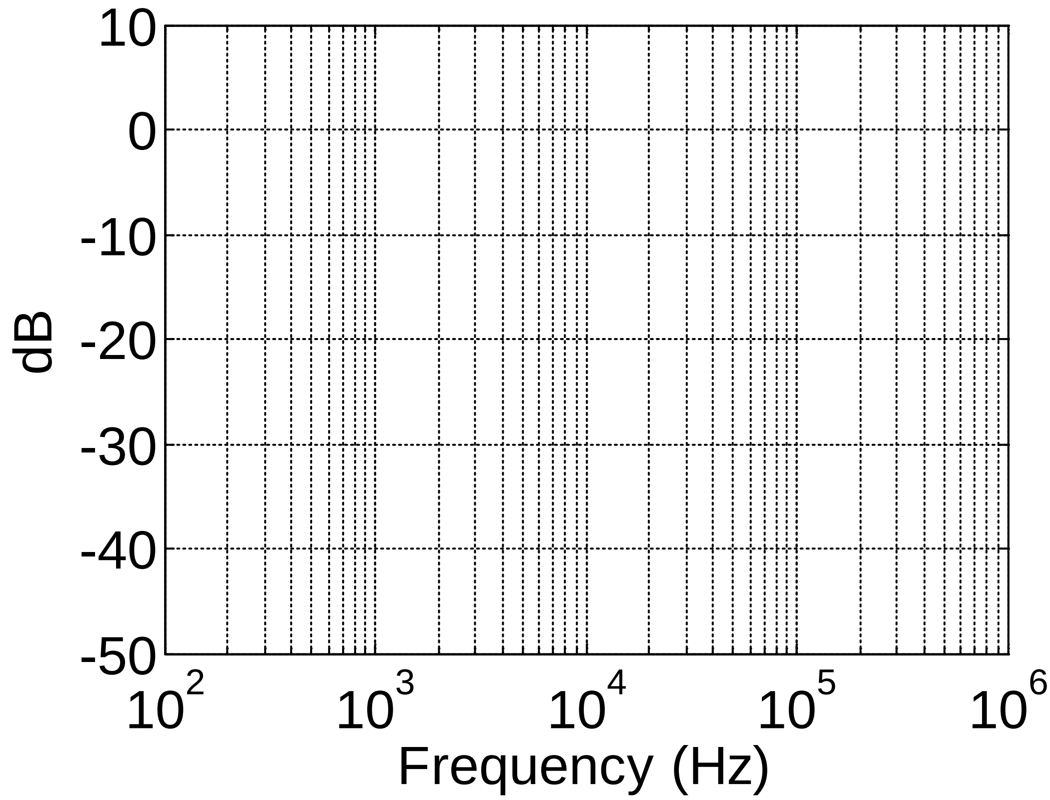
Analysis:

$|V_o(j\omega)/V_i(j\omega)|$ = ______________________; $\angle(V_o(j\omega)/V_i(j\omega))$ = ______________________

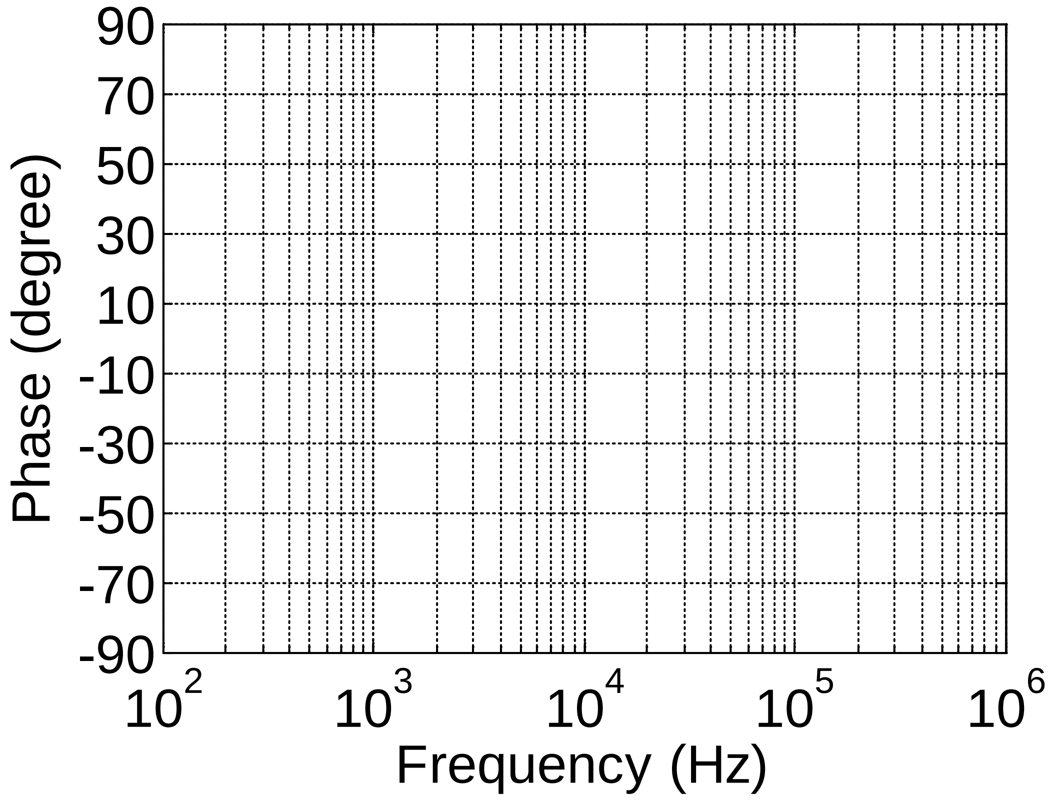
(c) Please complete Table 1-1. The angle θ is the angle by which V_o leads the input voltage V_i, related to the measured difference in time (Δt) between V_o and V_i. The sign of θ is minus when V_o lags the input voltage V_i. Please use the measured and calculated gains and phases in Table 1-1 to complete Graph 1-1 and 1-2.

Table 1-1

Frequency (kHz)	**measured $V_{o(p\text{-}p)}$ (V)**	**$A_v = V_{o(p\text{-}p)}/V_{i(p\text{-}p)}$ (measured, dB)**	**$A_v = V_{o(p\text{-}p)}/V_{i(p\text{-}p)}$ (calculated, dB)**	**measured Δt (sec)**	**θ (degree) (measured)**	**θ (degree) (calculated)**
0.05						
0.1						
0.5						
1						
5						
10						
15						
20						
30						
40						
70						
100						
200						
500						
1000						



Graph 1-1



Graph 1-2

(d) Please determine the frequency of the measured curve at which the angle is -45° from Graph 1-2.

f = ______________ Hz

How does it compare with the measured –3-dB frequency? Are they the same?

Comment:

Part 2: Band-Pass Filter

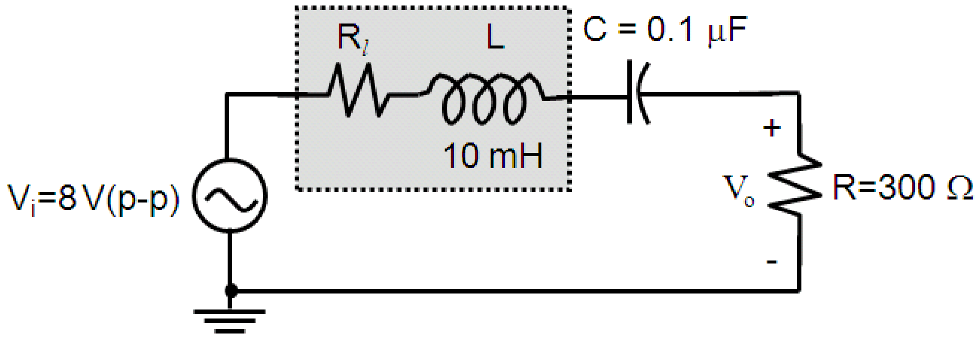


Figure 2-1

(a) Construct the network of Fig. 2-1. Fill in the measured resistor value and R_l for the inductor.

$R_{measured}$ = _______________, $R_{l\ measured}$ = _______________, $L_{measured}$ = _______________, $C_{measured}$ = _______________

(b) Write down the transfer function of $V_o(s)/V_i(s)$ without considering R_l. By replacing s = $j\omega$ into $V_o(s)/V_i(s)$, what is the dc gain (at $\omega = 0$) of $|V_o(j\omega)/V_i(j\omega)|$?

Calculation:

$V_o(s)/V_i(s)$ = ________________, $|V_o(j\omega)/V_i(j\omega)|_{\omega=0}$ = ______________

The natural frequency of the series LRC circuit is $f_n = \frac{1}{2\pi\sqrt{LC}}$ (Hz). By neglecting R_l, what is the gain of $|V_o(j\omega)/V_i(j\omega)|$ at the natural frequency ω_n?

Calculation:

$f_n = \dfrac{1}{2\pi\sqrt{LC}}$ = ________________ Hz, $|V_o(j\omega_n)/V_i(j\omega_n)|$ = ________________

(c) Please calculate the ratio of V_o/V_i at the natural frequency using the measured resistor values (including that of the inductor). Please also calculate the gain at other frequencies listed in Table 2-1 and fill in the values.

Calculation:

$|V_o(j\omega_n)/V_i(j\omega_n)|$ = ________________

(d) Energize the network of Fig. 2-1 and set the function generator to each of the frequencies appearing in Table 2-1. Make sure V_i = 8 $V_{(p\text{-}p)}$ on the scope before you apply to the circuit. **You may observe the loading effect of the 300-Ω resistor at some frequencies such that V_i will not be 8 $V_{(p\text{-}p)}$, since the function generator has an impedance of 50 Ω.** Please complete Table 2-1.

(e) Plot the measured and calculated A_v vs. frequency on Graph 2-1. Find the maximum value of A_v and compare to the calculated value in part (c). Please comment accordingly.

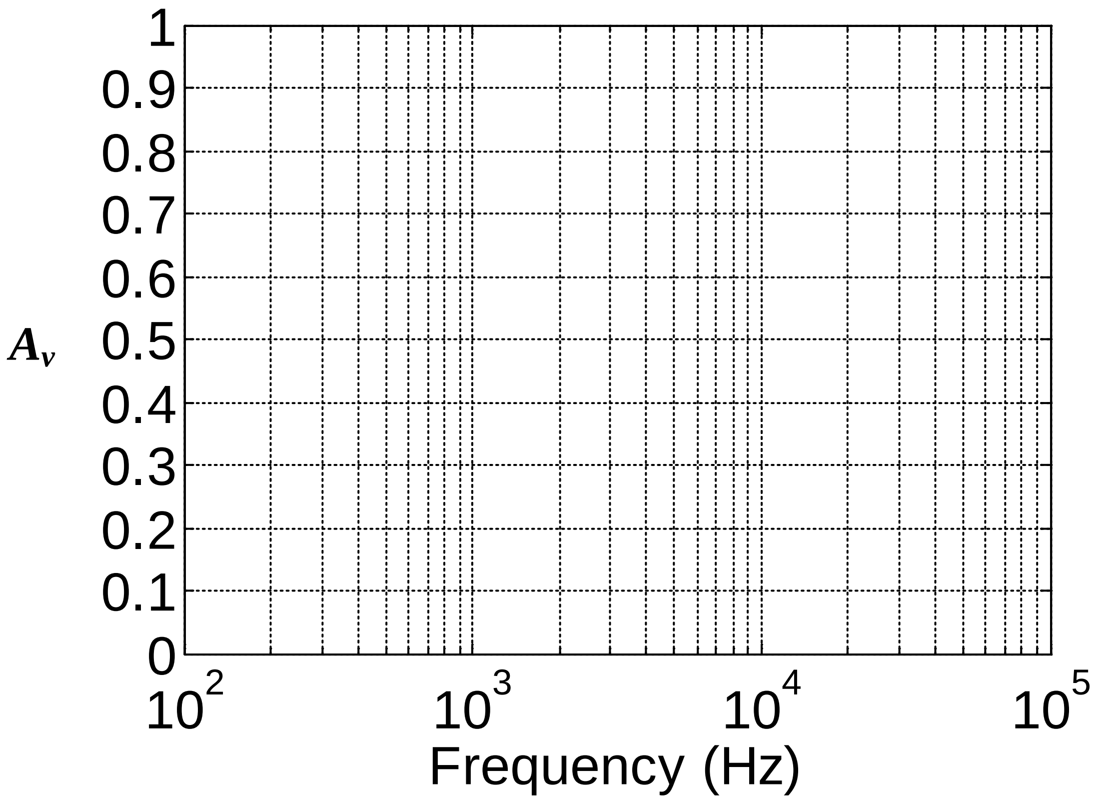
$A_{v,\,max}$ = ________________

Comment:

Table 2-1

Frequency (kHz)	$V_{o(p\text{-}p)}$ (measured)	$A_v = V_{o(p\text{-}p)}/V_{i(p\text{-}p)}$ (measured)	$A_v = V_{o(p\text{-}p)}/V_{i(p\text{-}p)}$ (calculated)
0.1			
0.2			
0.4			
0.6			
0.8			
1.0			
1.2			

1.4			
1.6			
1.8			
2.0			
3.0			
4.0			
5.0			
6.0			
8.0			
10.0			
12.0			
14.0			
16.0			
18.0			
20.0			
40.0			
60.0			
100.0			



Graph 2-1

Part 3: Band-Stop Filter Design

You are required to design a band-stop filter, as shown in Fig. 3-1, with a band-stop frequency at 1 kHz with a tolerance of ±10% (i.e. 0.9 to 1.1 kHz), and a corresponding lowest gain less than -15 dB (i.e. 0.178) at that frequency. Please demonstrate your result to a teaching assistant or teacher.

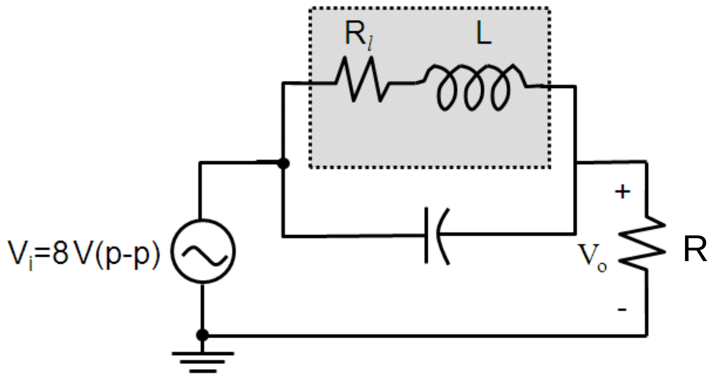


Figure 3-1

(a) Write down the transfer function of $V_o(s)/V_i(s)$ without considering R_l. By replacing s = $j\omega$ into $V_o(s)/V_i(s)$, what is the dc gain (at ω = 0) of | $V_o(j\omega)/V_i(j\omega)$|?

Calculation:

$V_o(s)/V_i(s)$ = ________________, | $V_o(j\omega)/V_i(j\omega)$| $_{\omega = 0}$ = ______________

The natural frequency of the parallel LC network is $f_n = \frac{1}{2\pi\sqrt{LC}}$ (Hz). By neglecting R_l, what is the gain of |$V_o(j\omega)/V_i(j\omega)$| at f_n?

Calculation:

$f_n = \frac{1}{2\pi\sqrt{LC}}$ = ________________ Hz, |$V_o(j\omega_n)/V_i(j\omega_n)$| = _______________

(b) By considering R_l, please determine the ratio |$V_o(j\omega_n)/V_i(j\omega_n)$|.

Calculation:

$|V_o(j\omega_n)/V_i(j\omega_n)|$ = ________________

(c) Please write down the inductor, capacitor, and resistor values of your choice, and the measured values.

R = ________________, L = ________________, C = ________________

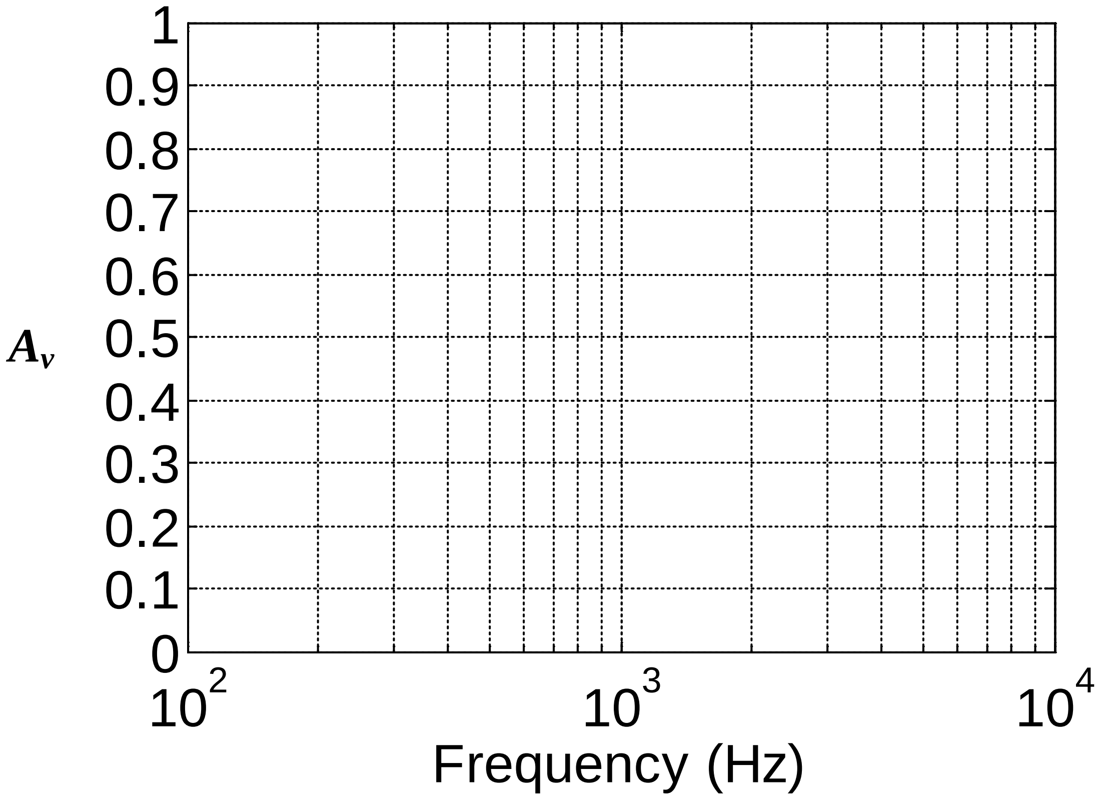
$R_{measured}$ = ________________, $R_{l\ measured}$ = ________________, $L_{measured}$ = ________________, $C_{measured}$ = ________________

(d) Energize the network of Fig. 3-1 and set the function generator to each of the frequencies appearing in Table 3-1. Make sure that V_i = 8 $V_{(p\text{-}p)}$ is on the scope first. Please complete Table 3-1. R_l should be considered when calculating A_v.

(e) Plot the measured and calculated A_v vs. frequency on Graph 3-1.

Table 3-1

Frequency (kHz)	$V_{o(p\text{-}p)}$ (measured)	$A_v = V_{o(p\text{-}p)}/V_{i(p\text{-}p)}$ (measured)	$A_v = V_{o(p\text{-}p)}/V_{i(p\text{-}p)}$ (calculated)
0.1			
0.2			
0.3			
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



Graph 3-1