

ES 330: Electronics II

Laboratory Experiment No. 3**Title: Active Filter Design**

Objective: The main objectives of this lab session will be

- 1) Study low-pass and high-pass active filters
- 2) Design a bandpass filter

N. B. This lab experiment will be a part of your **project 2**. SO YOU MUST SAVE YOUR DESIGN.

Introduction:

Filters are widely used in communication system to attenuate any unwanted signal. Filter circuits get benefits of the frequency dependency property of reactive components (capacitor or inductor). Due to the bulky size of inductors, inductors are usually not preferred for filter design. Filter can be classified into two categories

- (a) Passive filter – uses resistors and capacitors, signal attenuation
- (b) Active filter – uses active device (transistor or opamp) along with resistors and capacitors

In this lab we will test three types of active filters – low pass, high pass and band pass.

Low-pass Filter:

Low pass filter only allows to pass from DC to a certain frequency (usually called *cut-off*, f_c , frequency) and attenuate all the frequencies above the f_c value. The frequency response of a low pass filter is shown in fig 1. The cut-off frequency is defined where the gain of the filter has been reduced by 3 dB from the maximum gain value.

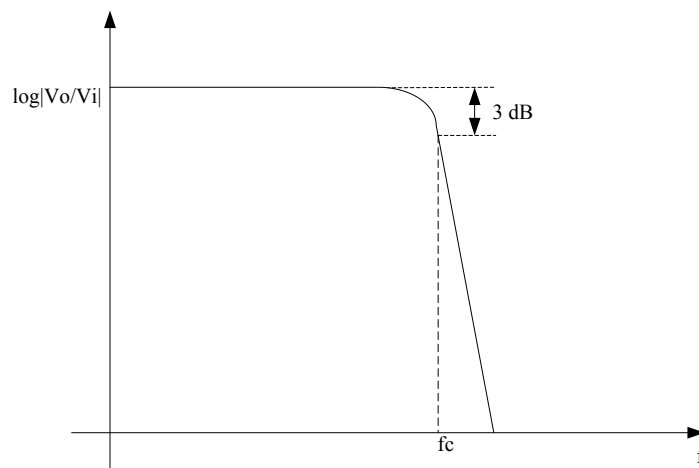


Fig 1: Frequency response curve of low-pass filter

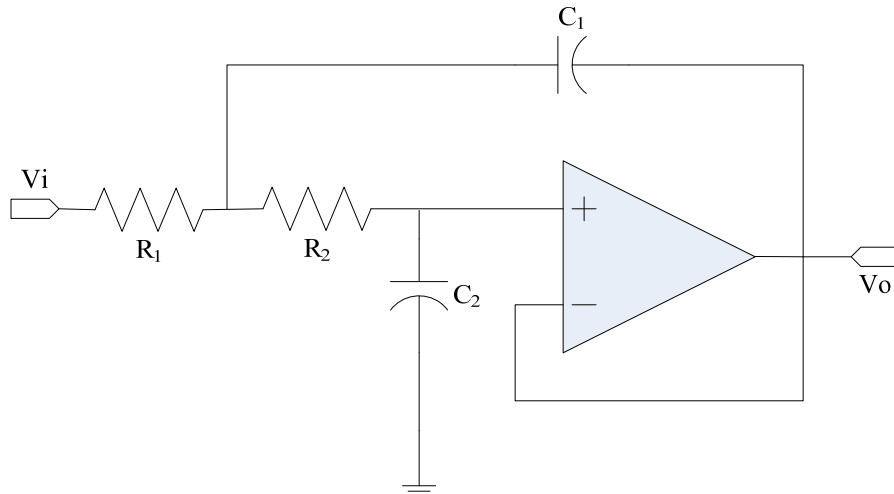


Fig 2: Circuit schematic of an active low-pass filter

Design:

Fig 2 shows the circuit schematic of a low-pass filter. You need to find out all the components values to meet the design specification.

1. First select a cut-off frequency for the filter. For your design use a cut-off frequency $f_c = 25\text{KHz}$
2. Select a capacitance value that will give you appreciable reactance ($X_c = 1/\omega_0 C$). for this design select a capacitance value of $C = 0.01 \mu\text{F}$.
3. Use $C_1 = 2C_2 = 2C$ and $R_1 = R_2 = R = 1/(\sqrt{2} * \omega_0 C)$. You may not get the correct value components in the lab. Try to use a value close to your calculated one.
4. Draw the circuit in PSPICE and simulate the frequency response.
5. Build the circuit in proto-board and measure frequency response. Compare the result with the simulated one.

High pass filter:

High pass filter allows to pass from a certain frequency (usually called *cut-off*, f_c , frequency) to any frequency above the f_c value but attenuate all the frequencies below the f_c value. The frequency response of a high pass filter is shown in fig 3.

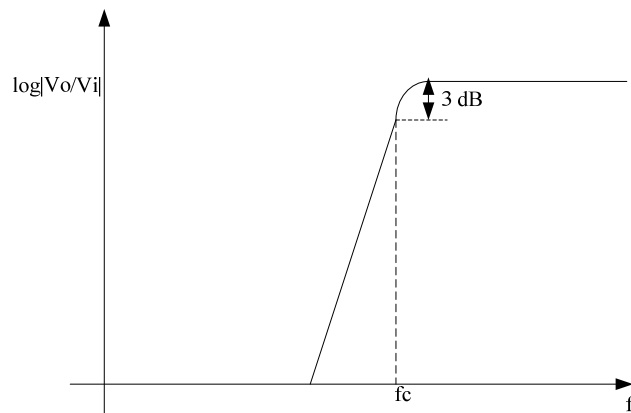


Fig 3: Frequency response of high-pass filter

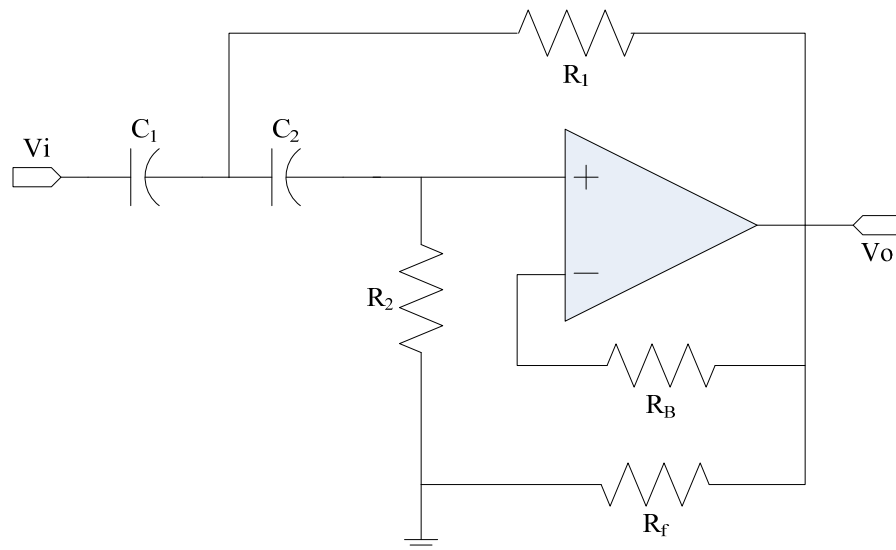


Fig 4: Schematic of high-pass filter

Design:

Fig 4 shows the circuit schematic of a low-pass filter. You need to find out all the components values to meet the design specification.

1. First select a cut-off frequency for the filter. For your design use a cut-off frequency $f_c = 5\text{KHz}$
2. Select a capacitance value that will give you appreciable reactance ($X_c = 1/(\omega_o C)$). for this design select a capacitance value of $C = 0.01 \mu\text{F}$.
3. Use $C_1 = C_2 = C$ and $R_1 = R_2 = R = 1/(\omega_o C)$
4. Use a Q value of 1. Find the value of K from the relationship $Q = 1/(3 - K)$.
5. Set $R_f = R$ and $R_B = (K-1)*R$.
6. Draw the circuit in PSPICE and simulate the frequency response.
7. Build the circuit in proto-board and measure frequency response. Compare the result with the simulated one.
8. Remove the input signal source and short the input terminal to ground. Vary the R_B value and find the condition where the output of the filter starts oscillating.

Band-pass Filter:

Bandpass filter allows to pass a band of frequencies. It has two cut-off frequencies – lower cut-off frequency, f_{c1} and higher cut-off frequency, f_{c2} . The bandwidth of the filter is defined as $BW = f_{c2} - f_{c1}$.

You can actually build a bandpass filter by cascading low-pass and high-pass filters. Now connect the output of the high-pass filter to the input of the low-pass filter. Simulate the circuit first and then measure the frequency response.

Question: If you connect the output of low-pass filter to the input of high-pass filter, can you predict what will be frequency response?