American International University- Bangladesh
Department of Electrical and Electronic Engineering
EEE2210: Analog Electronics 1 Laboratory

Title: Study of Active Filters.

Introduction:

A filter is a circuit that is designed to pass a specified band of frequencies while attenuating all signals outside this band. Filter networks may be either active or passive. Passive filter networks contain only resistors, inductors, and capacitors. Active *filters*, which are the only type covered in this experiment, employ transistors or op amps plus resistors, inductors, and capacitors. Inductors are not often used in active filters, because they are bulky and costly and may have large internal resistive component. The objective of this experiment is to observe the frequency response of low pass filters and high pass filters.

Theory and Methodology:

Most widely used active filters are-Low Pass Filter, High Pass Filter, Band Pass Filter and Band Reject Filter. Frequency response of each filter type is depicted in fig. 1.

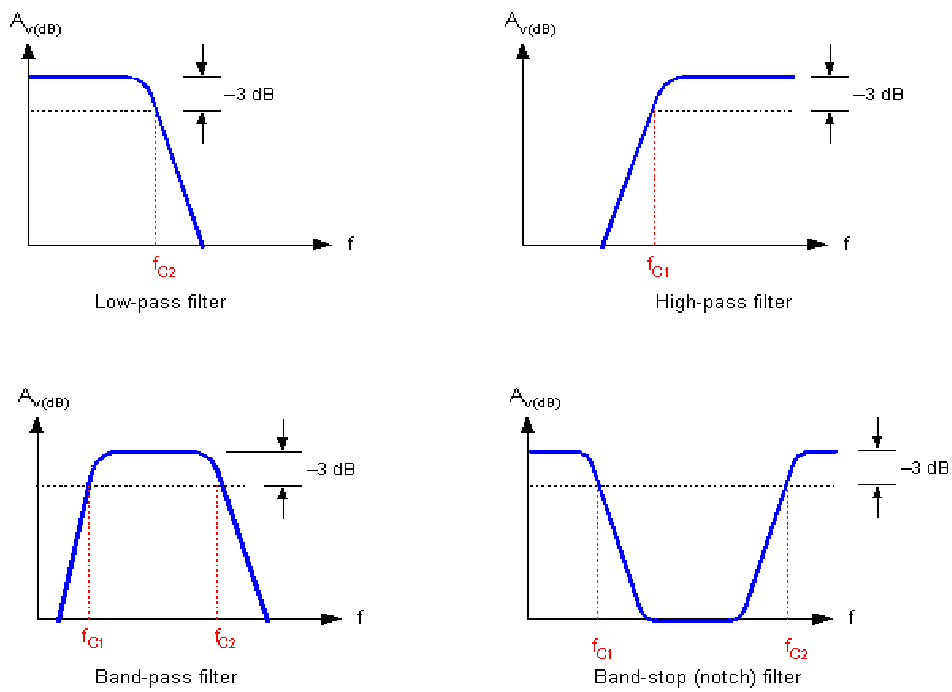

Fig. 1: Frequency Response of different filters

A **low-pass** filter has a constant gain from 0 Hz to a high cut-off frequency f_{c2}. Therefore the bandwidth is also f_{c1}. At high cut-off frequency f_{c1} the gain is reduced by 3dB and for $f > f_{c2}$ it decreases with the increase in input frequency. The frequencies between 0 and f_{c1} are known as passband frequencies while the range of frequencies beyond f_{c1} are attenuated and are therefore called the stop-band frequencies. Frequency response of a low-pass filter is illustrated in figure 1. As indicated by the dashed line, an ideal filter has no loss in the passband and infinite loss (or attenuation) in the stop-band. But ideal filter response is not practical because linear networks cannot produce the discontinuities.

In many low-pass filter applications it is necessary that the closed-loop gain is as close to unity as possible within the pass band. The Butterworth filter is best suited for such applications. This filter is also called a maximally flat or flat-flat filter. Ideal and the practical frequency responses of Butterworth filters are classified based on the roll-off beyond the cut-off frequency (-20dB/decade, -40dB/decade and -60 dB/decade). Fig. 2 and Fig. 3 show the -20dB/decade and -40dB/decade roll off low pass filter.

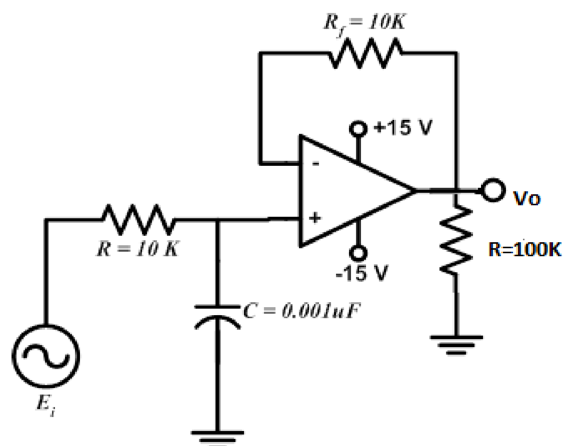

Fig. 2: Basic Low Pass Filter for -20dB/decade roll off.

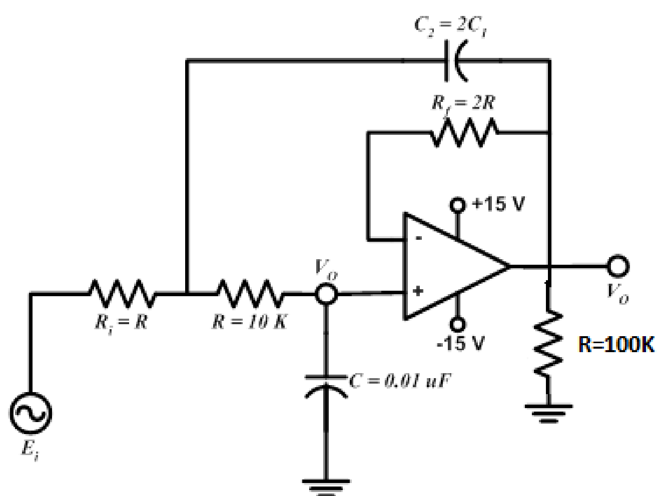

Fig. 3: Low Pass Filter for a roll-off of -40db/decade

A **high-pass** filter has stop band $0 < f < f_{c1}$ and a pass band $f > fc_1$ as shown in figure 1. A high pass filter of -40dB/decade is shown in Fig. 4.

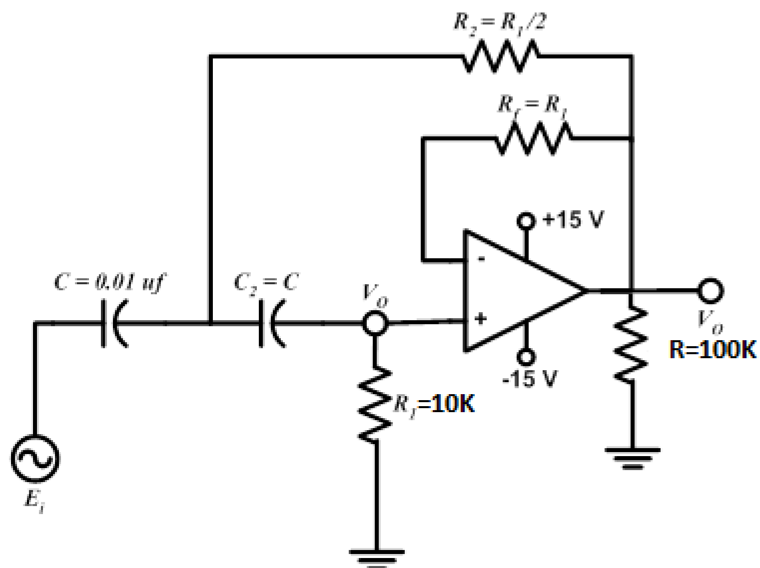

Fig. 4: High Pass Filter for a roll-off of 40db/decade

Pre-Lab Homework:

Read about different types of active filters from “Operational Amplifiers and Linear Integrated Circuits” by Robert F. Coughlin and use PSPICE_9.1_STUDENT_VERSION to generate the output of the circuits provided in this lab sheet. Compare the graphs given in the textbook with your results. Save the simulation results and bring it to the lab.

Apparatus:

1. IC-741(quantity:1)
2. Resistor 100K(quantity:1), 10K(quantity:2), 5k(quantity:1), 20K(quantity:1)
3. Bread Broad
4. DC power supply
5. Function Generator
6. Oscilloscope
7. Connecting wires

Precautions:

Biasing of the op-amps should be done carefully and oscilloscopes should be properly calibrated using the information provided at the calibration port before obtaining the wave shapes using the experimental set up.

Experimental Procedure:

1. Implement the circuit as shown in the figure 2.
2. Apply an input voltage of 5 V (p-p).

3. Vary the frequency and calculate gain, AV = $\frac{V_O}{E_i}$ for the range of frequencies.
4. Note the data in a data sheet given below
5. Draw the response curve (gain vs. frequency) in a semi log graph paper and find the 3-db frequency or cut-off frequency from the graph.
6. Calculate the cut-off frequency theoretically using the formula $f_C = \frac{1}{2\pi RC}$.
7. Repeat the steps 1-5 for -40dB/decade roll off low pass filter. Calculate the cut-off frequency theoretically using the formula $f_C = \frac{0.707}{2\pi RC_1}$.
8. Repeat the steps 1-5 for -40dB/decade roll off high pass filter. Calculate the cut-off frequency theoretically using the formula $f_C = \frac{1.414}{2\pi R_1 C}$.

Frequency (Hz)	Vi	Vo	Gain (Vo / Vi)	Gain (dB) = 20 Log (Vo/Vi)
10				
100				
1K				
10K				
100K				
1M				

Simulation and Measurement:

Compare the simulation results with your experimental data/ wave shapes and comment on the differences (if any).

Discussion and Conclusion:

Interpret the data/findings and determine the extent to which the experiment was successful in complying with the goal that was initially set. Discuss any mistake you might have made while conducting the investigation and describe ways the study could have been improved.