Electronic Devices and Circuits Lab : Report-1

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Contents

1 Aim :

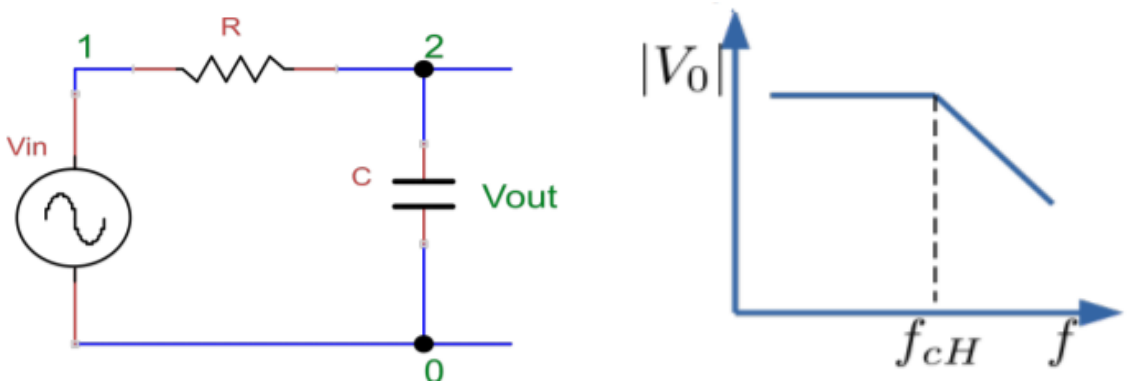
The aim of the experiment was to to understand the behaviour of filters (Low Pass, High Pass ,Band Pass) and simulate them using Ngspice.

2 Procedure :

Filters are the circuits that can be used to allow/reject certain components (frequency range) in a signal.There 3 filters to be studied,

- Low Pass Filter
- High Pass Filter
- Band Pass Filter

2.1 Low Pass Filter



(a) Circuit diagram (b) Output graph

Figure 1: Low Pass Filter

For the LPF, the cut off frequency is the frequency at which the output power is 1/2 of the input power which corresponds to -3dB in decibel scale and is given by

$$f_{cL} = \frac{1}{2\pi RC}$$

In the experiment,the cut-off frequency is given 50,000Hz. So we can take

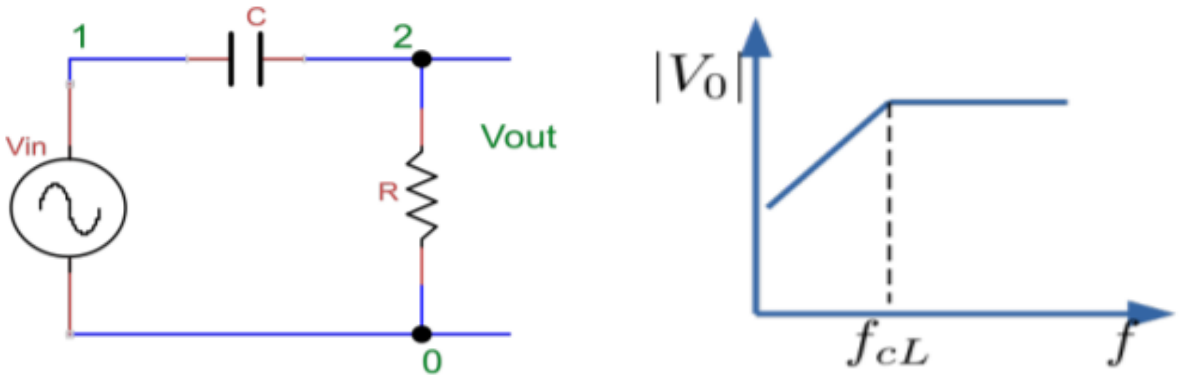
$$R = \frac{10}{\pi} = 3.183\Omega$$

$$C = 1\mu F$$

Now simulation of the LPF is done in Ngspice using the parameter equations and fitting in the nodes as shown in figure. By running AC analysis in frequency range of 1Hz to 1M Hz and plotting it, we can observe the output graph with lower frequencies dominating.

*The scripts are written and explained in separate text files and is considered that f_{cL} is the cutoff frequency for low pass filter.

2.2 High Pass Filter



(a) Circuit diagram (b) Output graph

Figure 2: High Pass Filter

For the HPF, the cut off frequency is the frequency at which the output power is 1/2 of the input power which corresponds to -3dB in decibel scale and is given by

$$f_{cH} = \frac{1}{2\pi RC}$$

In the experiment,the cut-off frequency is given 50Hz. So we can take

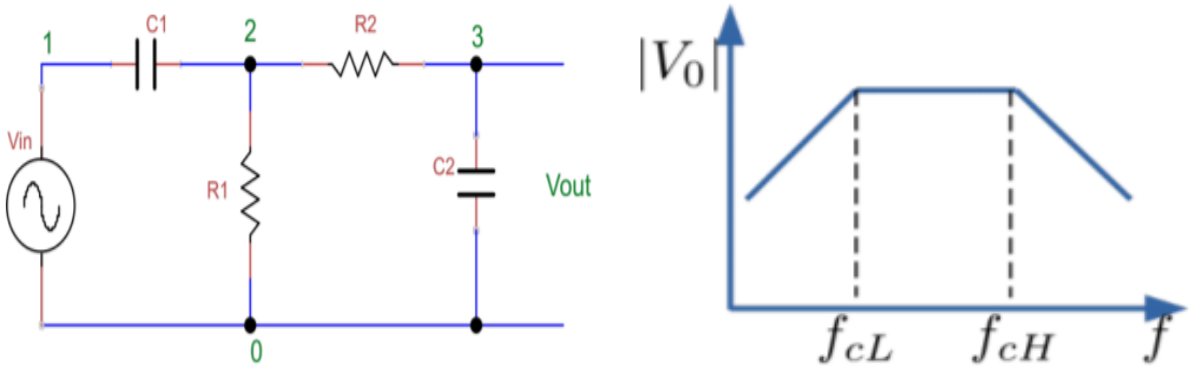
$$R = \frac{10}{\pi} = 3.183\Omega$$

$$C = 1mF$$

Now simulation of the HPF is done in Ngspice using the parameter equations and fitting in the nodes as shown in figure. By running AC analysis in frequency range of 1Hz to 1M Hz and plotting it, we can observe the output graph with higher frequencies dominating .

*The scripts are written and explained in separate text files and is considered that f_{cH} is the cutoff frequency for high pass filter..

2.3 Band Pass Filter



(a) Circuit diagram (b) Output graph

Figure 3: Band Pass Filter

A band pass filter is a filter which allows those frequency components within specific range of frequencies. It is obtained by cascading a high pass filter with a low pass filter (as shown) or vice-versa.
From cascading the previous LPF and HPF, we get the cut-off range as $[f_{cH}, f_{cL}]$ where

$$f_{cL} = 50,000Hz; f_{cH} = 50Hz$$

Hence in the given circuit diagram we have

$$C1 = 1mF; R1 = 10/\pi = 3.183\Omega$$

$$C2 = 1\mu F; R2 = 10/\pi = 3.183\Omega$$

Now simulation of the BPF is done in Ngspice using the parameter equations and fitting in the nodes as shown in figure. By running AC analysis in frequency range of 1Hz to 1M Hz and plotting it, we can observe the output graph with a band of frequencies dominating .

*The scripts are written and explained in separate text files where f_{cL} is the cutoff frequency for low pass filter and f_{cH} is the cutoff frequency for high pass filter.

3 Results

3.1 Low Pass Filter Simulation

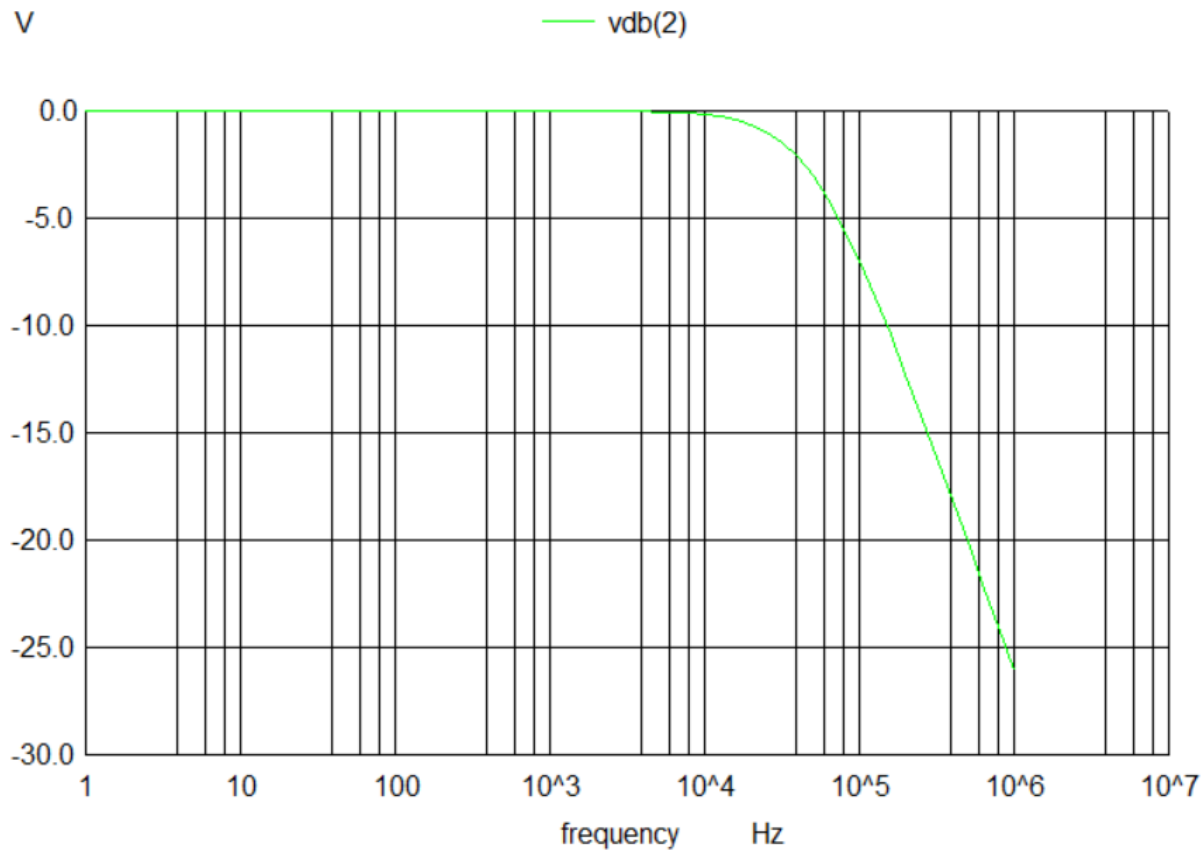


Figure 4: LPF Simulation output

The graph above tells us that the lower frequencies remain and the higher frequencies die down gradually with increasing frequency. And at the point of -3dB, we approximately get our corresponding cut-off frequency i.e., 50,000 Hz.
We can also observe that the lower frequency signal have almost 0 dB saying that maximum power is transferred into the resistor, suggesting large impedance of capacitor.
And even the adjacent frequencies higher than the cut-off have some power, inferring that the filter is not ideal.

3.2 High Pass Filter Simulation

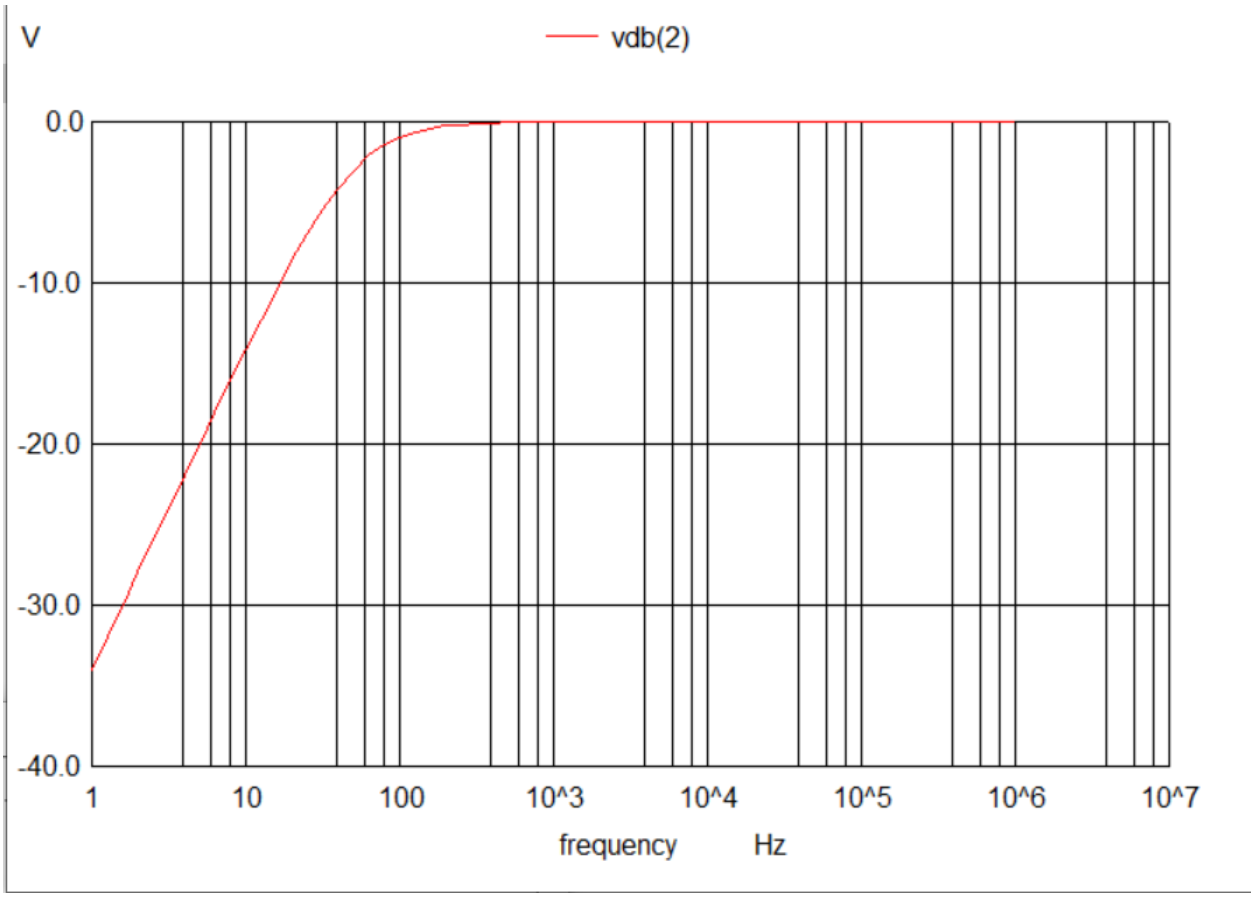


Figure 5: HPF Simulation output

The graph above tells us that the larger frequencies remain and the lower frequencies die down gradually with decreasing frequency. And at the point of -3dB, we approximately get our corresponding cut-off frequency i.e., 50 Hz.
We can also observe that the higher frequency signal have almost 0 dB saying that maximum power is transferred into the capacitor, suggesting smaller impedance of capacitor with increasing frequency.
And even the adjacent frequencies lower than the cut-off have some power, inferring that the filter is not ideal.

3.3 Band Pass Filter Simulation

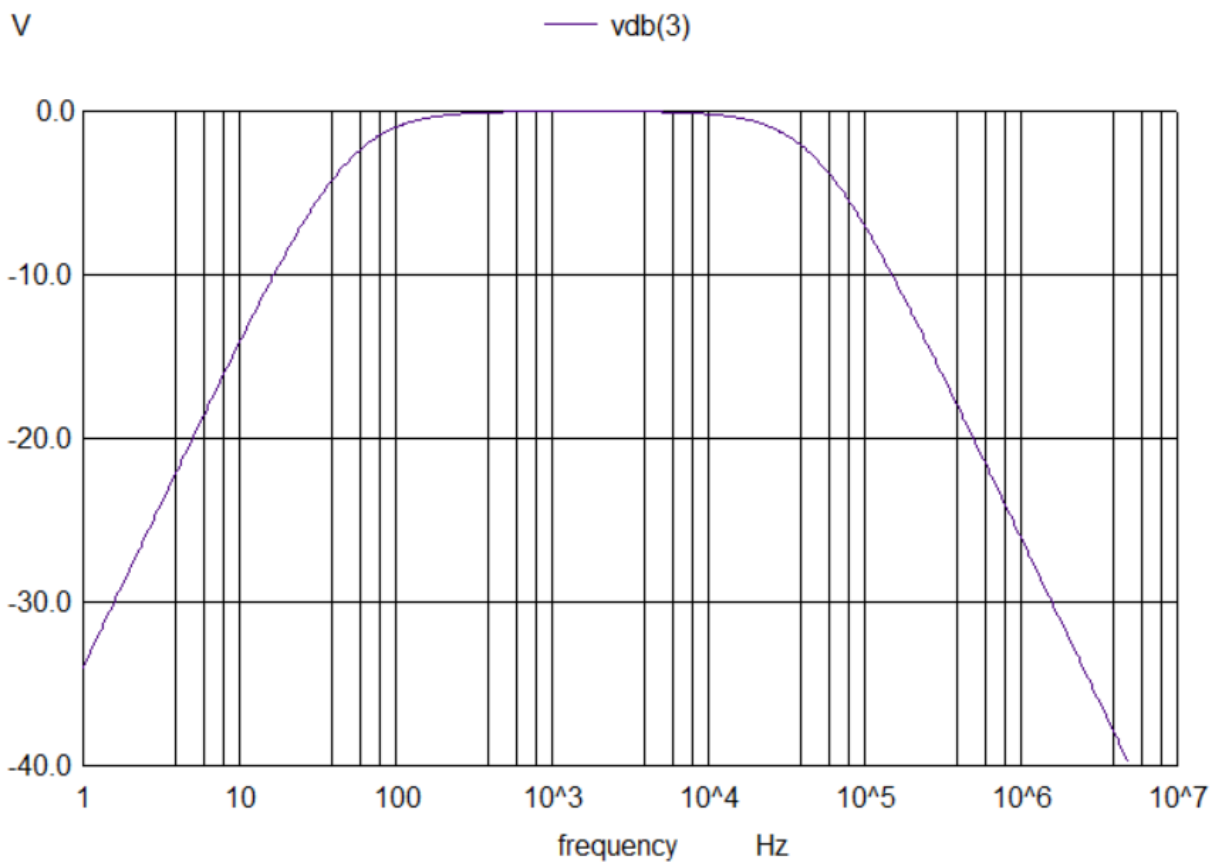


Figure 6: BPF Simulation output

The graph above tells us that the signal within the particular band of frequencies remain and the other frequency signals die down when moving away from the central band. And we get our cut-off frequencies on the -3dB line i.e., 50Hz and 50,000Hz corresponding to the lower and upper limits.

It can be seen that the initial lower frequencies have very less dB value, suggesting that the HPF in the cascade filters away the lower frequency signals and the LPF just passes it to the output. Similarly for the higher frequencies, the HPF passes them away where as the LPF in the cascade filters the high frequency signals. Hence allowing a central band of frequencies on a whole.

We can also find tails on either side off cut-offs suggesting the non-ideality of the filter on a whole.So even some tailing frequency have some unwanted power.

4 Conclusions

- We are able understand the purpose of filters.
- We are able construct the filters using simple passive elements like resistors and capacitors.
- We can fine tune the resistance and capacitance for a desired frequency cut-off.
- No filter is ideal,suggesting possibility of unwanted noise.
- Cascading low pass filter and high pass filter helps in building a band pass filter.
- Ngspice is an effective tool to comprehend the behaviour of the circuit systems.
- We have various types of analysis in Ngspice, which helps in understanding of behaviour of ciruits in both AC and DC realms.