Electronic Devices and Circuits Lab (EE2301)
Experiment 1 : Filters

EE19BTECH11041,
Srijith Reddy Pakala
Department of Electrical Engineering
IIT Hyderabad

September 16, 2020

1 Aim

Our aim is to design Filters using resistors and capacitors with ng spice.

Filters: A filter is a Circuit that can allow or reject a certain frequency range in a signal.
In this experiment we are going to design 3 types of filters i.e. Low pass filter,High pass filter,and Band pass filter.

Low pass filter:
A low-pass filter (LPF) is a filter that passes signals with a frequency lower than a selected cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency.

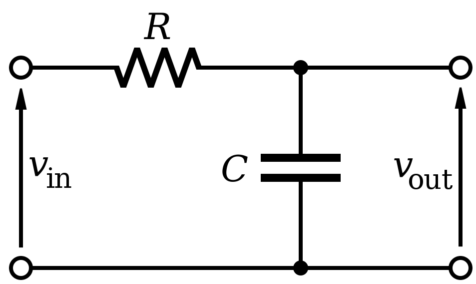
High pass Filter:
A high-pass filter (HPF) is an electronic filter that passes signals with a frequency higher than a certain cutoff frequency and attenuates signals with frequencies lower than the cutoff frequency.

Band pass filter:
A band-pass filter or band pass filter (BPF) is a device that passes frequencies within a certain range and rejects (attenuates) frequencies outside that range.

2 Procedure

Low pass filter

To make a low pass filter we need to design the circuit shown below.

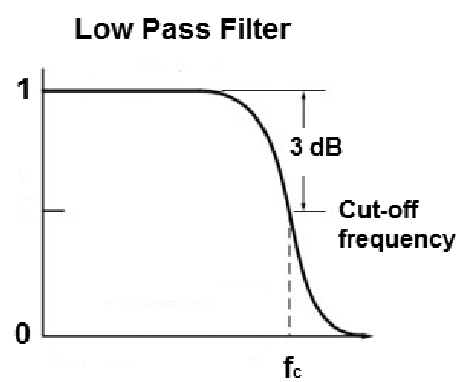


Low pass filter

and now we need to decide the cutoff frequency of the filter by adjusting the values of resistance R and capacitance C with reference to the equation given below

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

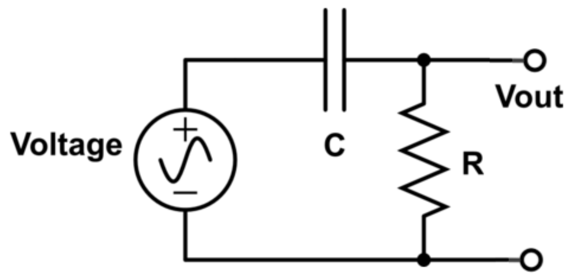
Now we should apply the input voltage V_{in} which is an AC voltage and note down the output voltage i.e. voltage across the capacitor and by changing the AC voltage frequency we need to plot the gain in (db) Vs frequency . Now to verify the cutoff frequency we need to find the point we gain in (db) is -3db i.e. when the ouput power is $\frac{1}{2}$ of the input power. Expected plot is shown below.



gain Vs frequency

High pass filter

To make a high pass filter we need to design the circuit shown below.

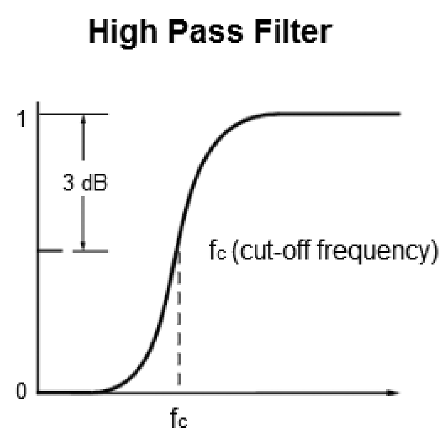


High pass filter

and now we need to decide the cutoff frequency of the filter by adjusting the values of resistance R and capacitance C with reference to the equation given below

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

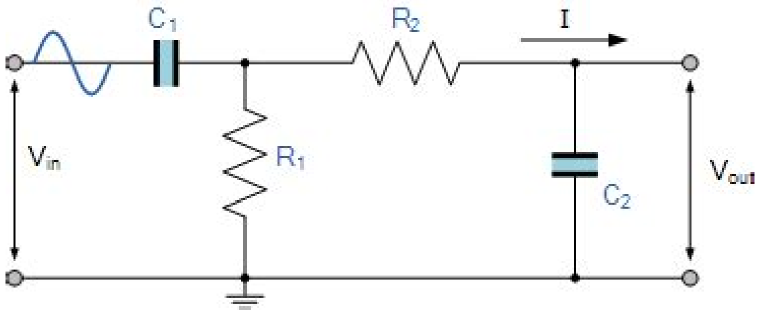
Now we need to do the same as in low pass filters but the only difference is we should take output across the resistance instead of capacitance and plot the gain in (db) Vs frequency . Now to verify the cutoff frequency we need to find the point we gain in (db) is -3db i.e. when the ouput power is $\frac{1}{2}$ of the input power.
Expected plot is shown below.



gain Vs frequency

Band pass filter

To make a Band pass filter we need to design the circuit shown below.



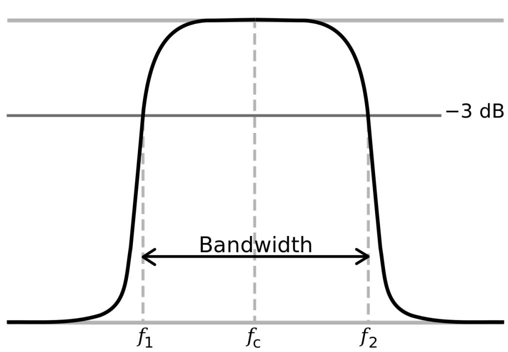
Band pass filter

and now we need to decide the cutoff frequencies of the filter by adjusting the values of resistances R_1,R_2 and capacitances C_1,C_2 with reference to the equations given below

$$f_{cL} = \frac{1}{2\pi R_2 C_2} \tag{3}$$

$$f_{cH} = \frac{1}{2\pi R_1 C_1} \tag{4}$$

Now we need to do the same as in low pass and high pass filters and take the output across the capacitance (C_2)and plot the gain in (db) Vs frequency .
Now to verify the cutoff frequency we need to find the point we gain in (db) is -3 db i.e. when the ouput power is $\frac{1}{2}$ of the input power on the both sides of the plot.
Expected plot is shown below.

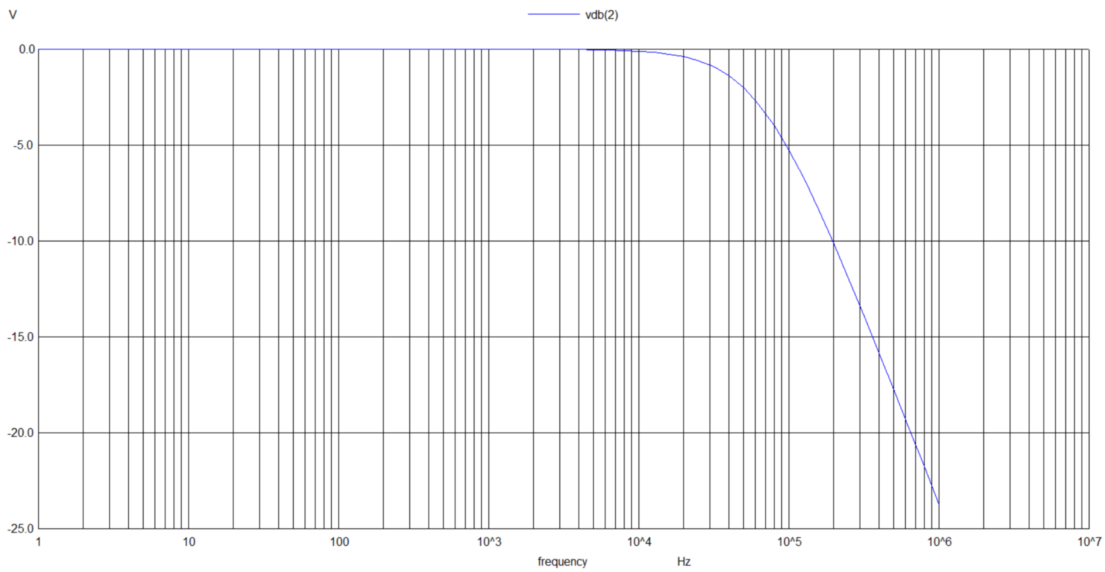


gain Vs frequency

3 Results

Low pass filter

Required cutoff frequency f_{cL}= 65 KHz.
Based on the equation (1). we chose R= 816 Ω ,C= 3nF such that cutoff frequency is 65 KHz. Below figure represents the plot of Gain in (db) Vs frequency.



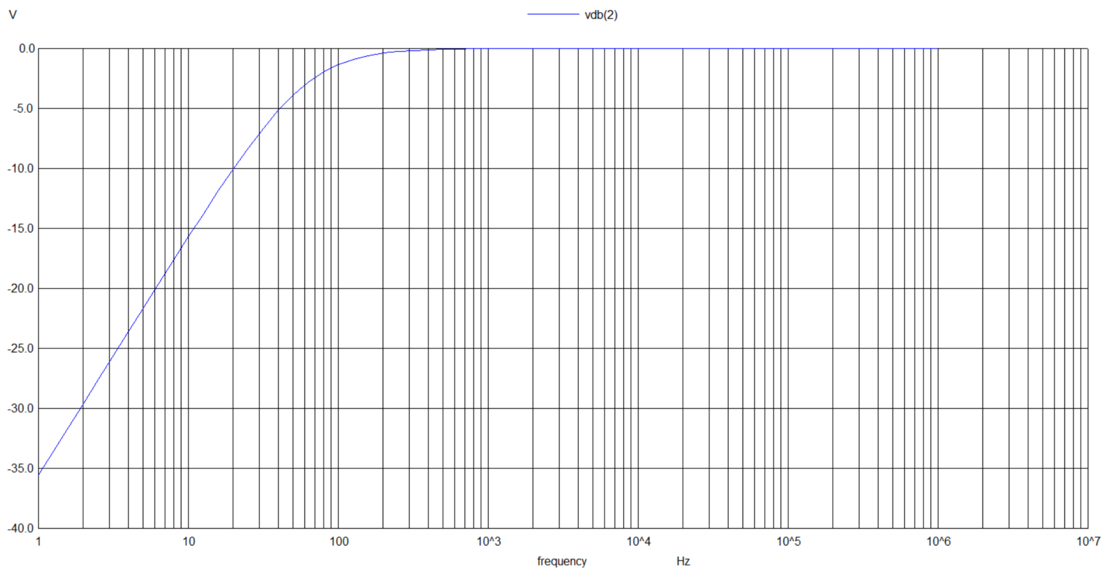
Plot: Gain in (db) Vs Frequency

And we also wrote a table depicting gain in (db) at different frequencies.

S No	Gain in (db)	Frequency
1	0 db	40 Hz
2	0 db	400 Hz
3	0 db	1400 Hz
4	0 db	2500 Hz
5	0 db	5000 Hz
6	-0.13 db	13000 Hz
7	-1.01 db	32500 Hz
8	-2.09 db	52000 Hz
9	-3.17 db	65700 Hz
10	-4.18 db	79000 Hz
11	-5.6 db	105000 Hz

High pass filter

Required cutoff frequency f_{cH}= 60 Hz.
Based on the equation (2). we chose R= 1326 Ω ,C= 2uF such that cutoff frequency is 60 Hz. Below figure represents the plot of Gain in (db) Vs frequency.



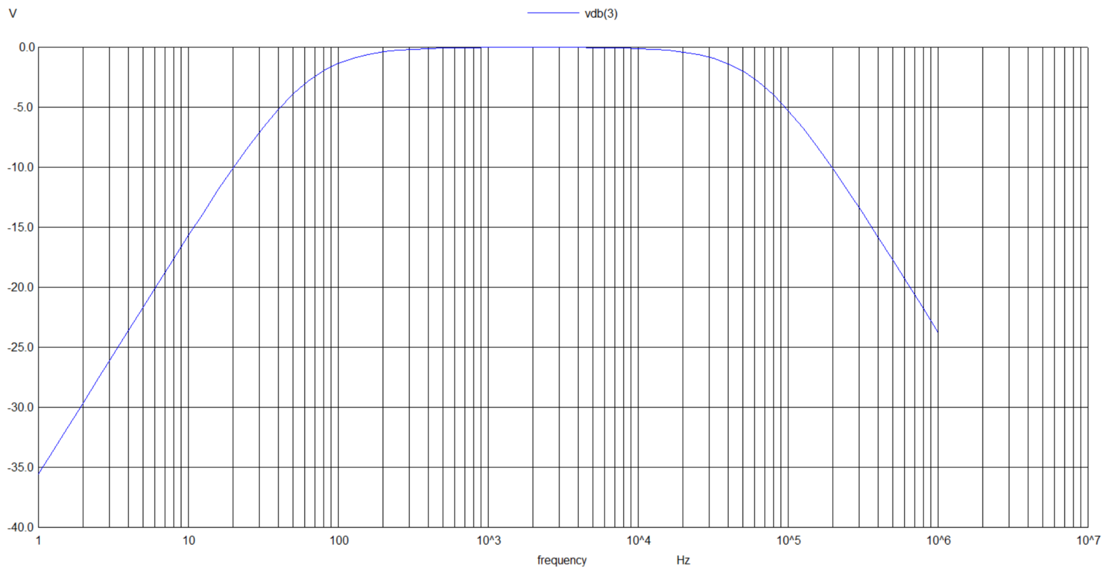
Plot: Gain in (db) Vs Frequency

And we also wrote a table depicting gain in (db) at different frequencies.

S No	Gain in (db)	Frequency
1	-35.1 db	1 Hz
2	-22 db	5 Hz
3	-15.65 db	10 Hz
4	-6.7 db	30 Hz
5	-3 db	60 Hz
6	-1.08 db	100 Hz
7	-0.1 db	225 Hz
8	0 db	800 Hz
9	0 db	4500 Hz
10	0 db	15000 Hz
11	0 db	95000 Hz

Band pass filter

Required cutoff frequencies f_{cH}= 60 Hz,f_{cL}= 65 KHz.
Based on the equations (3,4). we chose R_1= 1326 Ω , R_2= 816 Ω, C_1= 2uF ,C_2= 3nF .
Below figure represents the plot of Gain in (db) Vs frequency.



Plot: Gain in (db) Vs Frequency

And we also wrote a table depicting gain in (db) at different frequencies.

S No	Gain in (db)	Frequency
1	-35.5 db	1 Hz
2	-22 db	5 Hz
3	-15.8 db	10 Hz
4	-3 db	60 Hz
5	-3 db	60 Hz
6	-0.86 db	140 Hz
7	-0.1 db	335 Hz
8	0 db	950 Hz
9	0 db	5500 Hz
10	-0.86 db	30000 Hz
11	-3 db	65000 Hz
12	-7.6 db	151000 Hz

4 Understandings/Observations

• Although in an ideal case of filters the gain dies down to -∞,but here in the simulation we didn't really obtain ideal conditions.

• The cutoff frequency is the frequency in the simulation where power is 1/2 i.e gain is -3db.

• The Band pass filter is basically the combination of Low pass and High pass filters.

• Although we got nearly ideal cutoff frequency in the simulation i don't think we can achieve that close results in all the practical cases due to many factors like heating,etc.

• we can use ngspice for various simulations but here we used ac decade analysis with 10 points for decade.
• The simulation plot after/before cutoff frequency looks like a straight line for low pass and high pass filters respectively.

5 Conclusions

• The cutoff frequencies observed in the simulation match the ideal cutoff frequencies in all 3 filters to high precision.

• The maximum gain achieved by the filter circuits is 0 db.

• since P_{in} $\geq$P$_{out}$ the filters are passive.

• The expected plot mostly matches the simulation plot except at the very end.

Thank you