LAB REPORT-8

Active filters

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Objective: To understand the characteristics of low-pass, high pass, band pass and band stop active filters.

Equipment/Components Required:

1. Op-Amp µA 741
2. Resistors – 8 kΩ,2.2 kΩ,1 kΩ,22 kΩ
3. Regulated Power Supply
4. Variable Power Supply
5. Capacitors – 10 nF
6. Digital Storage Oscilloscope
7. Arbitrary Function Generator

LPF, HPF and the band stop filter

1. Low pass filter:

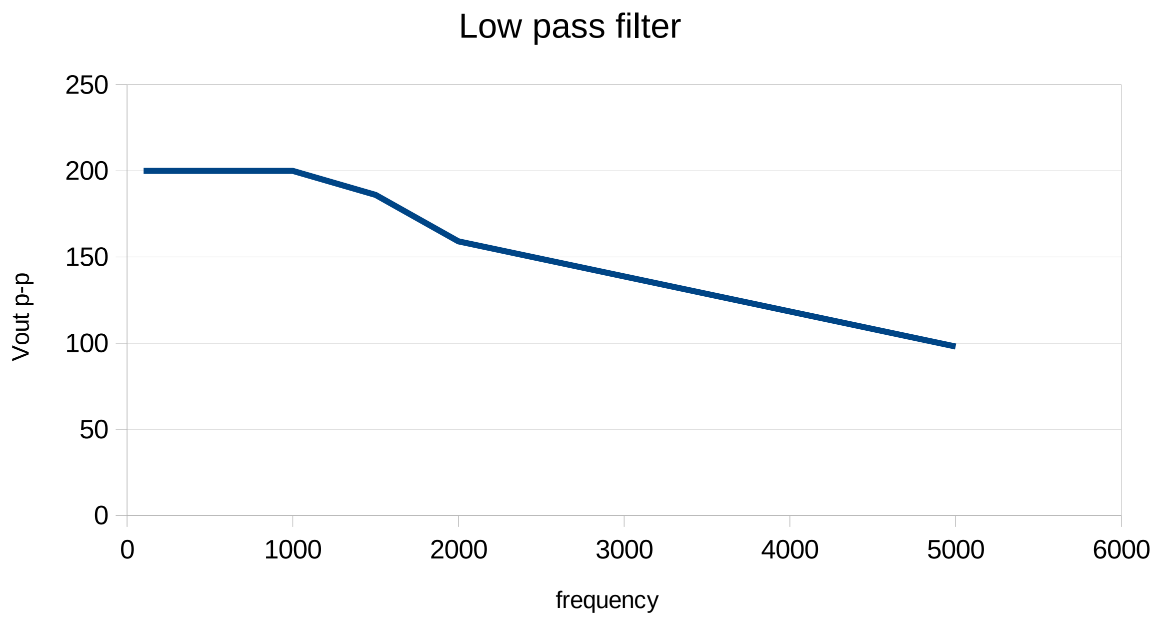
The cut-off frequency was calculated as,

$$f_c = \frac{1}{(2\pi\, Ra\, Ca)}$$

which turns out to be f_c = 1989.44 Hz, with Ra = 8 kΩ, Ca =10 nF.

Low pass filter

Frequency in Hz	V_i ($V_{p\text{-}p}$ in V)	V_o ($V_{p\text{-}p}$ in V)	Phase difference(ϕ)
100	200	200	3
200	200	200	5
300	200	200	9
400	200	200	11
500	200	200	14
600	200	200	17.5
700	200	200	20.3
1000	200	200	28
1500	200	186	38
2000	200	159	46
5000	200	98	-6750



We can see from the above frequency response plot, it behaves like a low-pass filter passing frequencies which are below cut-off frequency ~ 2 Khz.

2. High pass filter:

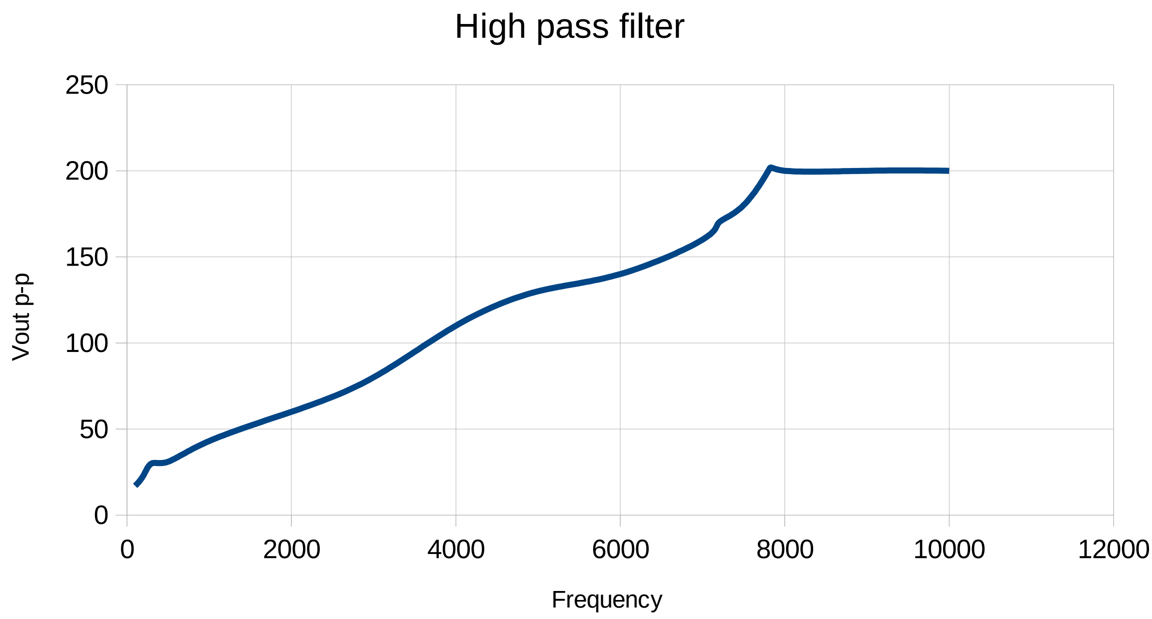
The cut-off frequency was calculated as,

$$f_c = \frac{1}{(2\pi\, Rb\, Cb)}$$

which turns out to be f_c = 7234.3 Hz, with R_b = 2.2 kΩ, C_b =10 nF.

High pass filter

Frequency in Hz	V_i ($V_{p\text{-}p}$ in V)	V_o ($V_{p\text{-}p}$ in V)	Phase difference(ϕ)
100	200	17	-30.4
200	200	23	-15.7
300	200	30	-11
500	200	31	-12
1000	200	43	-11
2000	200	60	-12
3000	200	80	-11
4000	200	110	-8
5000	200	130	-5
6000	200	140	-2
7000	200	160	-3
7200	200	170	-5
7500	200	180	-9
7800	200	200	-11
8000	200	200	-11
9000	200	200	-3
10000	200	200	-2



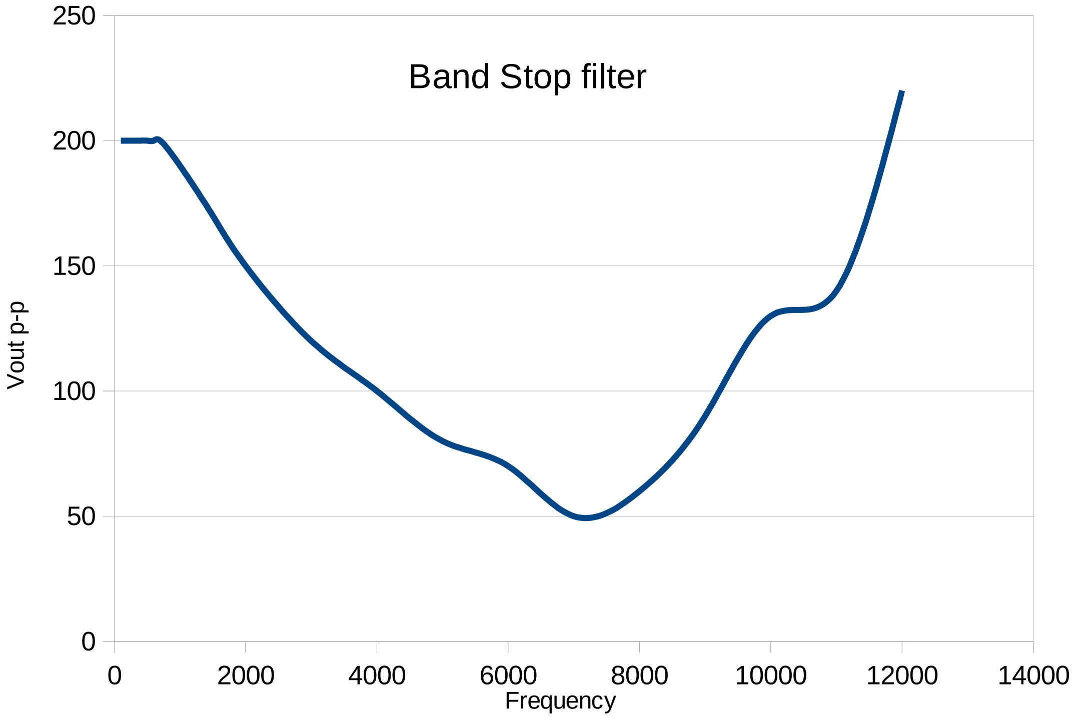
We can see from the above magnitude response plot, the filter is attenuating low frequencies and passing high frequencies which are above the cutoff frequency ~ 7.2 kHz.

3. Band stop filter:

Output of LPF and HPF are given to simple adder op-amp circuit with unity gain so that it attenuates the frequencies between the cut-off frequencies [2 kHz, 7.2 kHz].

Band stop filter

Frequency in Hz	V_i ($V_{p\text{-}p}$ in V)	V_o ($V_{p\text{-}p}$ in V)	Phase difference(ϕ)
100	200	200	-170
200	200	200	-165
300	200	200	-172
400	200	200	-169
500	200	200	-169
600	200	200	-167
700	200	200	-163
1000	200	190	-150
1500	200	170	-150
2000	200	150	-140
3000	200	120	-130
4000	200	100	-120
5000	200	80	-120
6000	200	70	-100
7000	200	50	-110
8000	200	60	-110
9000	200	90	-110
10000	200	130	-120
11000	200	140	-131
12000	200	220	-120



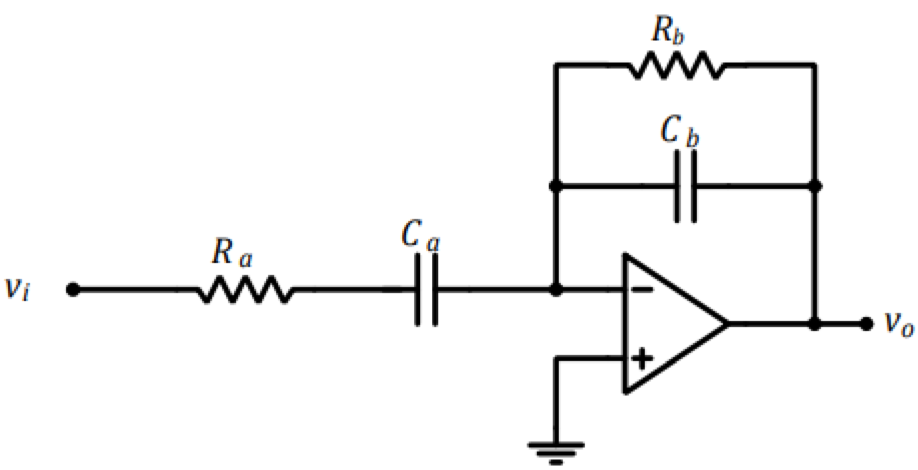
We can see from the above plot, it is attenuating frequencies between 2 kHz and 7.2 kHz and thus, it behaves like the band stop filter.

4. Band pass filter:

The lower cut-off frequency and upper cut-off frequency for pass band is,

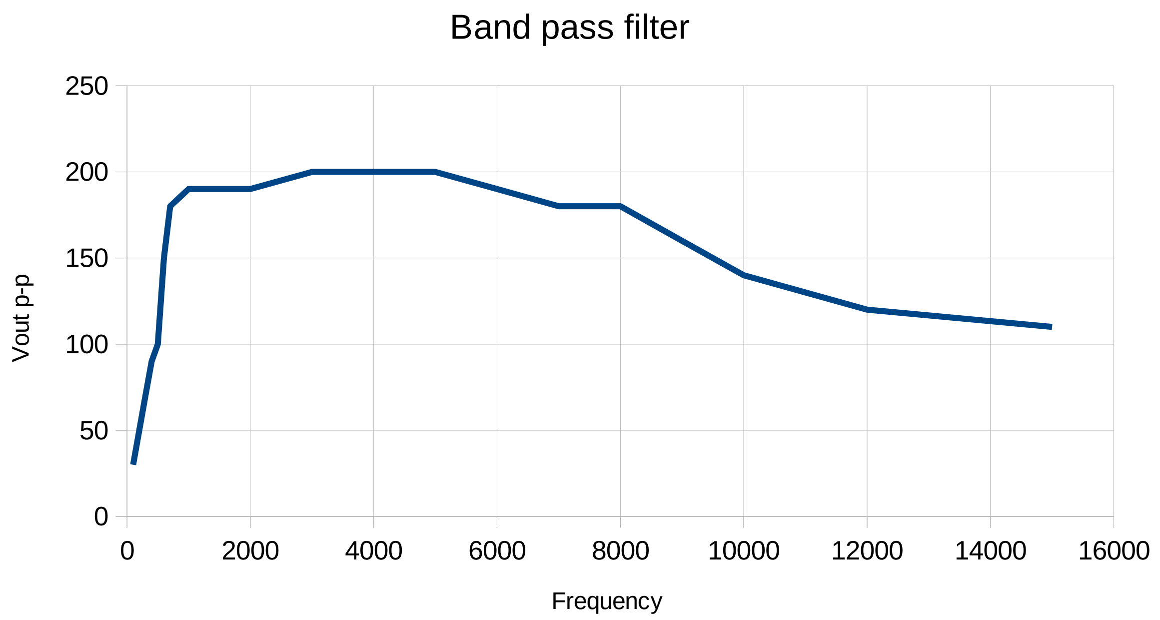
$$f_c = \frac{1}{(2\pi RC)}$$

and range for the band pass is [723.431 Hz, 7234.31 Hz], Given R_a=2.2 kΩ, R_b=22 kΩ and C_a=C_b=10 nF.



Band pass filter

Frequency in Hz	V_i (V_{p-p} in V)	V_o (V_{p-p} in V)	Phase difference(ϕ)
100	200	30	109
200	200	50	108
300	200	70	114
400	200	90	118
500	200	100	122
600	200	150	131
700	200	180	134
1000	200	190	140
1500	200	190	161
2000	200	190	171
3000	200	200	174
4000	200	200	157
5000	200	200	156
6000	200	190	153
7000	200	180	142
8000	200	180	141
9000	200	160	139
10000	200	140	140
11000	200	130	130
12000	200	120	140
15000	200	110	120
20000	200	90	100
50000	200	40	32000
100000	200	30	37000



We can see that the circuit behaves like a band pass filter allowing frequencies between nearly 0.7 kHz and 7 kHz and attenuating the frequencies outside this pass range.

Discussion

We got exposed to the different types of active filters in this lab using Operational Amplifiers. They are:

1. Low pass filter
2. High pass filter
3. Band stop filter
4. Band pass filter

We determined the cut-off frequencies using the given resistance and Capacitance values. The cut-off frequencies we computed theoretically matched with those experimentally when we applied a 100mV p-p sinusoid as input and varied it's frequency from 100 Hz to 100 kHz. The Low pass filter passed all the low frequencies while the High pass filter does the opposite.

As the cut-off frequencies were different for both LPF and HPF, we used an op-Amp adder circuit whose inputs were given from outputs of LPF and HPF and thus, were able to build a Band stop filter.

There are various applications of filters. In communication systems, LPF and HPF are used for demodulation of modulated signals in analog communication. Hence we were able to demonstrate the characteristics of filters of above kinds and implement them on the breadboards using Op-Amp.