Aim ↬ To design and obtain the frequency response of Second Order High Pass Filter [HPF].

Equipment Required ↬

Resistors, Potentiometer, Capacitors, IC 741 OP-AMP, Function Generator, CRO, Breadboard & connecting wires.

Theory ↬

A second-order high-pass filter allows signals with frequencies higher than a specified cut-off frequency f_L to pass while attenuating frequencies lower than f_L. The gain of the HPF at the cut-off frequency is reduced to 70.7% [or -3 dB] of its maximum value, indicating the transition between blocking and passing signals. Compared to first-order filters, second-order HPFs provide a steeper roll-off rate, allowing for better noise suppression and sharper cutoffs, making them ideal for applications requiring significant attenuation of low-frequency components.

Roll-off Rate and Filter Order ↴

A second-order HPF exhibits a roll-off rate of 40 dB/decade [or 12 dB/octave] below the cut-off frequency. This means that for every tenfold decrease in frequency, the gain decreases by 40 dB. Second-order filters achieve a sharper cutoff than first-order filters, which is beneficial in filtering out unwanted low-frequency noise and improving signal quality in various applications.

Mathematical Expression ↴

$$f_L = \frac{1}{2\pi\sqrt{R_2 R_3 C_2 C_3}}$$

For simplicity, in a circuit where $R_2 = R_3 = R$ and $C_2 = C_3 = C$, the cut-off frequency is given by:

$$f_L = \frac{1}{2\pi RC}$$

This formula, derived from filter design principles, indicates that the cut-off frequency is inversely proportional to the product of resistance and capacitance.

Practical Considerations ↴

The cut-off frequency, also known as the -3 dB frequency, is essential for determining the filter's effectiveness in separating desired high-frequency signals from unwanted low-frequency noise. In practical applications, second-order HPFs are commonly used in audio processing, signal conditioning, and various electronic applications to enhance the quality of processed signals.

Circuit Diagram ↬

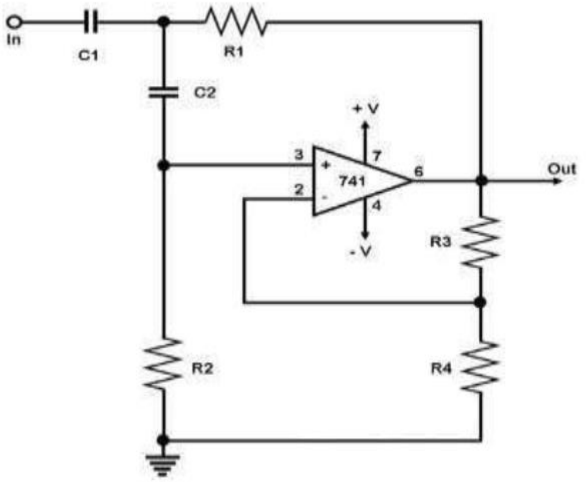

Fig. i) Second Order High Pass Filter

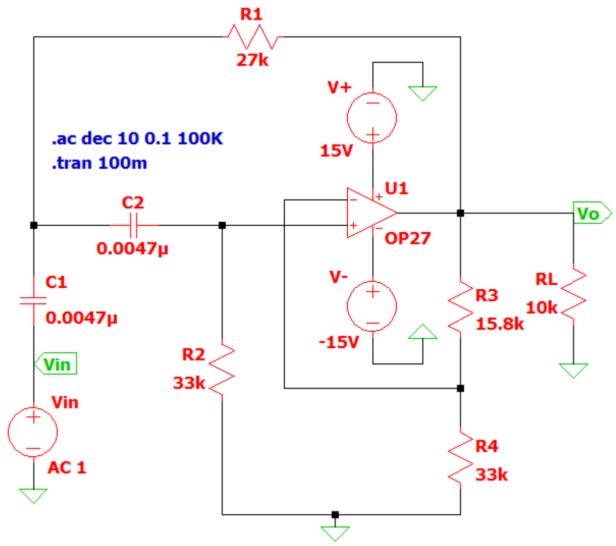

Fig. ii) LTSpice Implementation

Observation Table ↬

- **Simulation Data ↪**

S.No.	Input Freq f [Hz]	Gain Magnitude $\left\lvert\frac{V_0}{V_i}\right\rvert$	Magnitude in dB $20log\left\lvert\frac{V_0}{V_i}\right\rvert$
1	0.1	11.48n	-158.8
2	1	1.15µ	-118.8
3	10	114m	-78.8
4	100	11.48m	-38.8
5	1K	0.998	-0.009
6	10K	1.48	3.41
7	100K	1.48	3.40

Graphs ↬

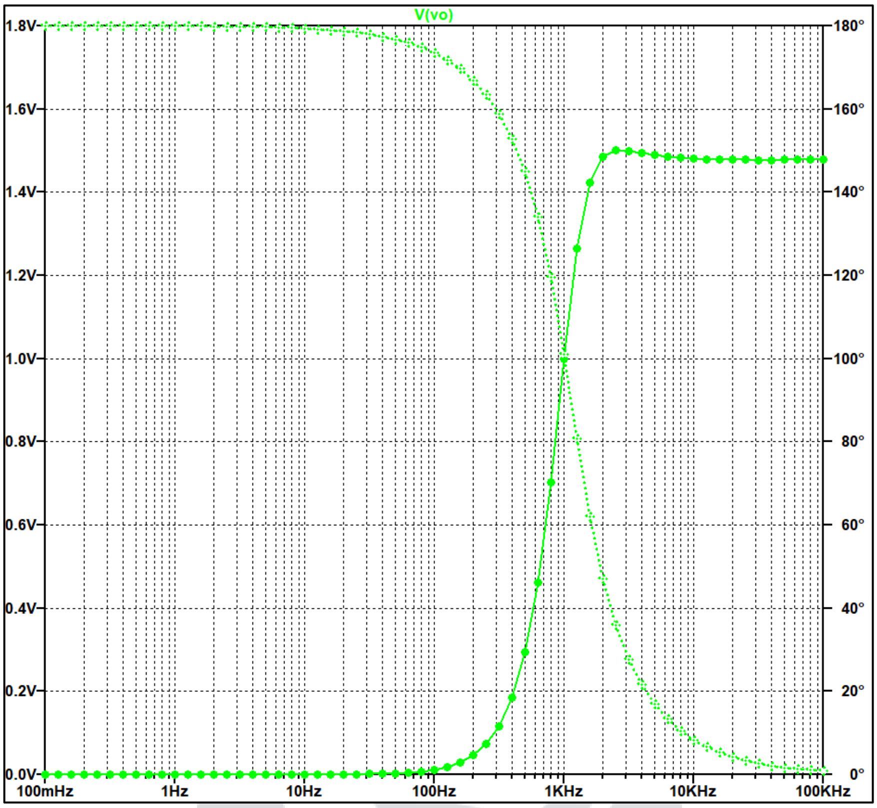

Fig. iii) Frequency Response [Linear]

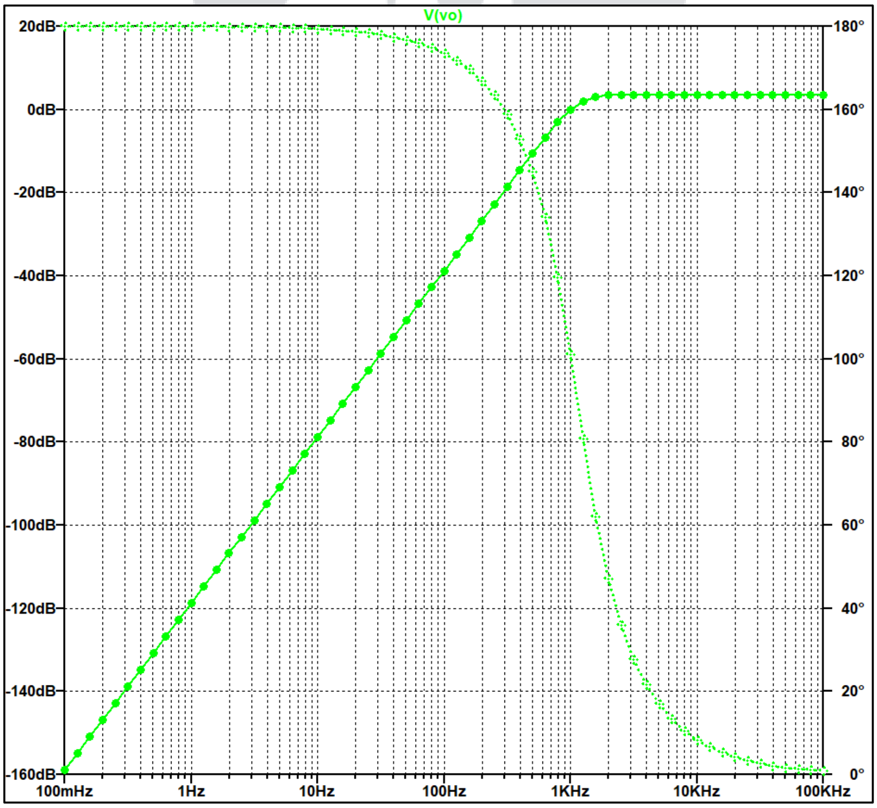

Fig. iv) Frequency Response [Decibel]

Result ↬

The experiment demonstrated the design and frequency response of a second-order high-pass filter. The filter successfully passed signals above the cut-off frequency f_L and attenuated lower frequencies at 40 dB/decade, confirming the expected behavior.

Conclusion ↬

The second-order high-pass filter was designed and tested successfully, aligning with the expected theoretical and simulation results. The filter exhibited the correct frequency response with the predicted roll-off rate below the cut-off frequency.

Precautions ↬

- Ensure all connections are correct and components are securely placed.
- Do not exceed the voltage ratings of components, especially the op-amp.
- Verify capacitor polarity and op-amp orientation.
- Double-check the circuit setup before powering on the equipment.