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

Equipment Required ↬

Resistance, Potentiometer, Capacitor, IC 741 OP-AMP, Function Generator, CRO, Breadboard & connecting wires.

Theory ↬

A high-pass filter allows signals with frequencies higher than a specified cut-off frequency f_L to pass through while attenuating frequencies lower than f_L. At the cut-off frequency, the gain of the HPF is reduced to 70.7% (or -3 dB) of its maximum value, marking the transition point between blocking and passing signals. HPFs are widely used to eliminate low-frequency noise, DC offsets, and other unwanted components from a signal.

Roll-off Rate and Filter Order ↴

A First Order HPF exhibits a roll-off rate of 20 dB/decade or 6 dB/octave below the cut-off frequency. This means that for every tenfold decrease in frequency, the gain decreases by 20 dB, or for every halving of frequency, the gain decreases by 6 dB. First-order filters have a gradual roll-off, making them suitable for applications where moderate attenuation of lower frequencies is acceptable.

Higher-order filters provide steeper roll-off rates, resulting in sharper cutoffs and better noise suppression but require more components and increased complexity.

Mathematical Expression ↴

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

This formula derives from the basic principles of filter design, where the cut-off frequency is inversely proportional to the product of resistance and capacitance.

Practical Considerations ↴

The cut-off frequency is also known as the -3 dB frequency, break frequency, or corner frequency. It is a critical parameter in determining how effectively the filter can separate desired signals from unwanted low-frequency noise.

In practical applications, HPFs are used to filter out low-frequency noise from signals, ensuring that only the relevant higher-frequency components are processed. This is essential in audio processing, signal conditioning, and many other electronic applications.

Circuit Diagram ↬

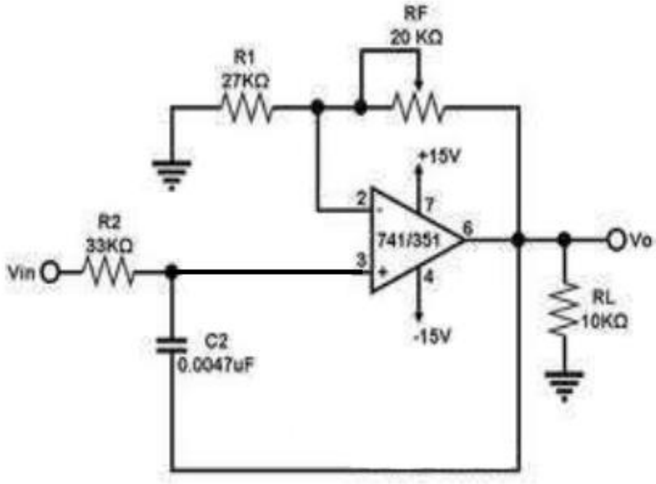

Fig. i) First Order Low Pass Filter

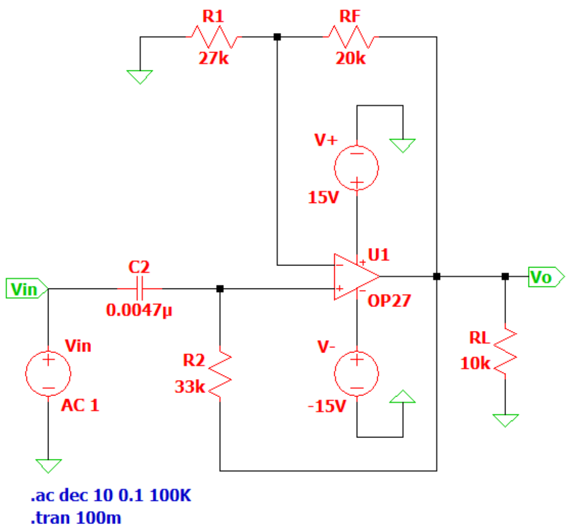

Fig. ii) LTSpice Implementation

Observation Table ↬

- **Simulation Data ↪**

S.No.	Input Freq f [Hz]	Gain Magnitude $\left\|\frac{V_0}{V_i}\right\|$	Magnitude in dB $20log\left\|\frac{V_0}{V_i}\right\|$
1	0.1	226µ	-72.91
2	1	2.25m	-52.96
3	10	23m	-32.78
4	100	228m	-12.83
5	1K	1.39	2.87
6	10K	1.74	4.83
7	100K	1.74	4.83

Graphs ↬

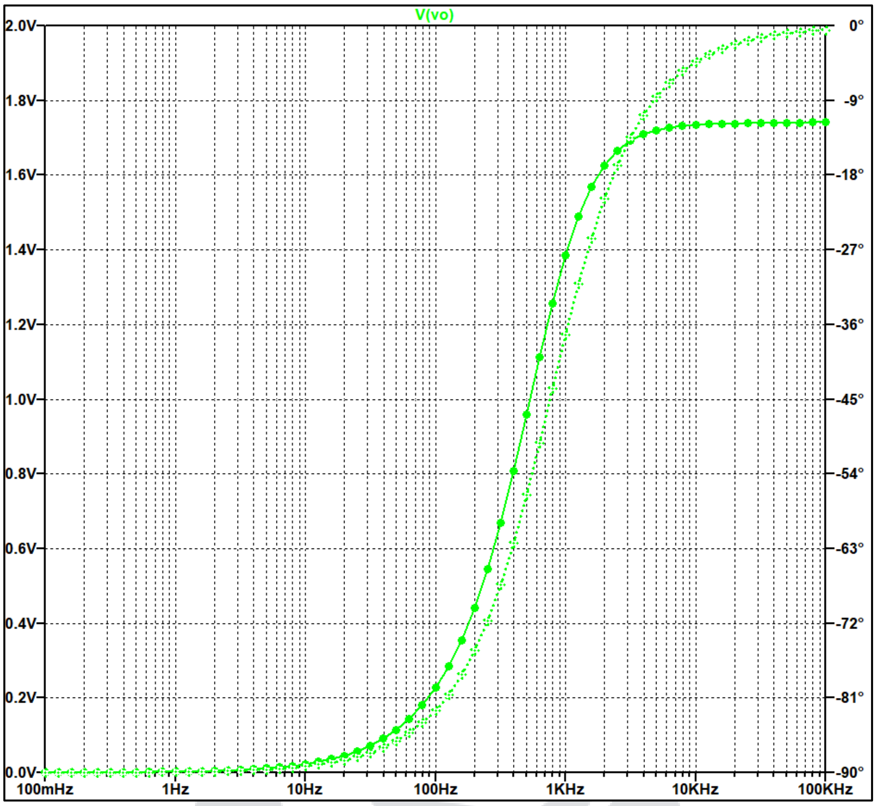

Fig. iii) Frequency Response [Linear]

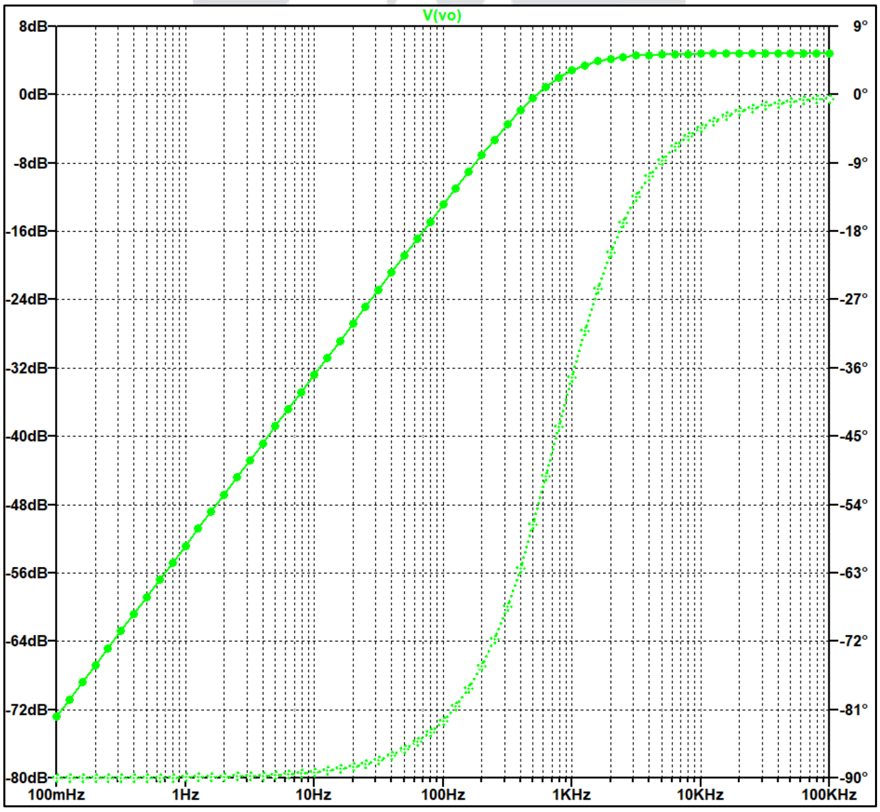

Fig. iv) Frequency Response [Decibel]

Result ↬

The experiment demonstrated the design and frequency response of a first-order high-pass filter. The filter passed signals above the cut-off frequency f_L and attenuated lower frequencies at 20 dB/decade, as expected.

Conclusion ↬

The first-order high-pass filter was designed and tested successfully, matching 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.