**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 ↬

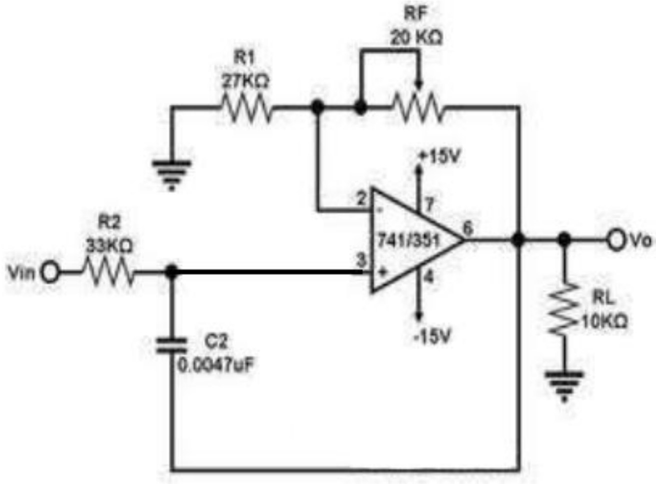


Fig. i) First Order Low Pass Filter

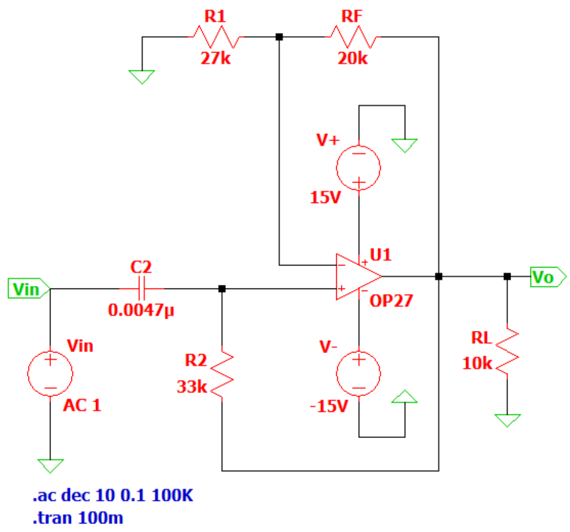


Fig. ii) LTSpice Implementation

## 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 ↬

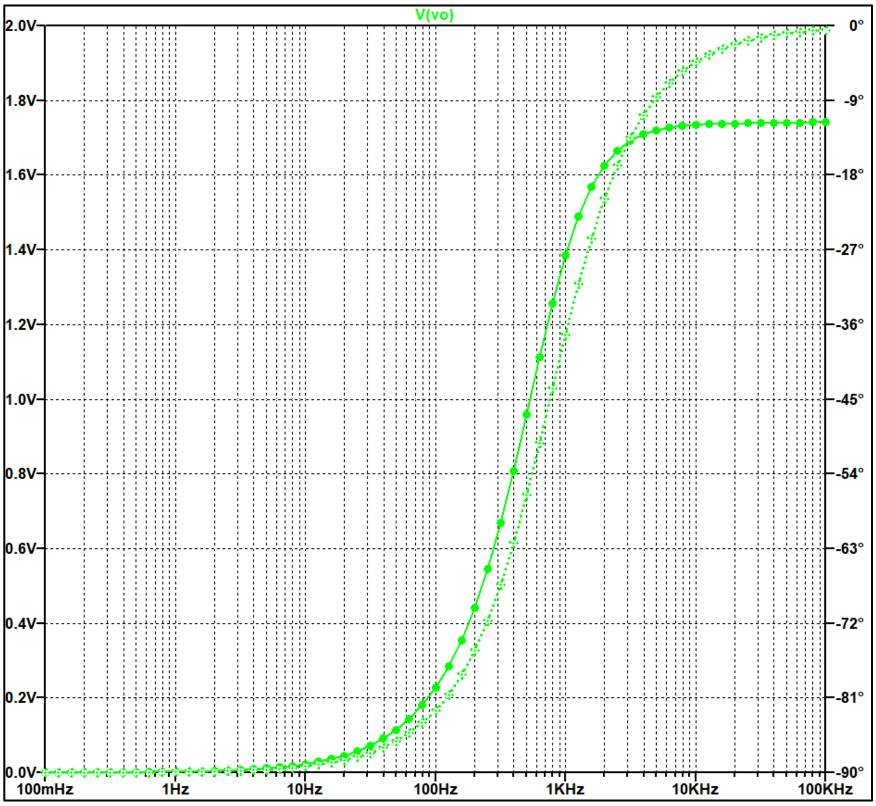


Fig. iii) Frequency Response [Linear]

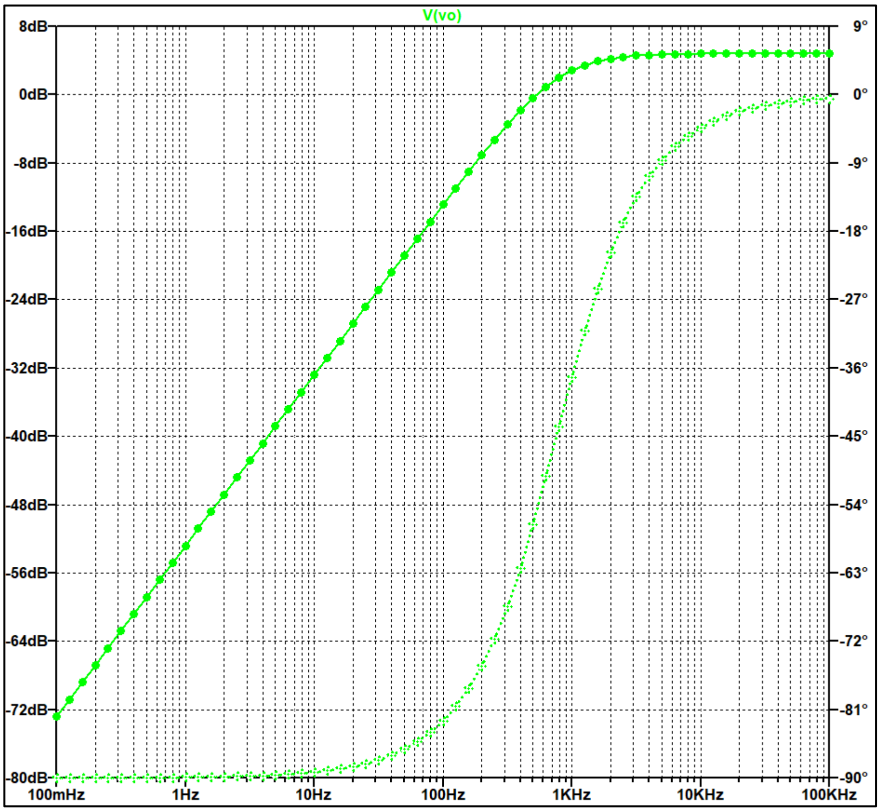


Fig. iv) Frequency Response [Decibel]

## Output ↬


Fig. v) DSO Output with increasing frequency

## 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.