Sensor Lab Report
Experiment No: 1

Course Code: EEP304

Name: Aditya Pramod Rehpade
ID Number: 1240120

Aim:

Study the frequency response of different filters using op-amp.

Objective:

- Study the frequency response of Low-Pass filter.
- Study the frequency response of High-Pass filter.

Components:

S.No.	Components Required	Quantity
1	Signal Generator	1
2	DC Power Supply	-
3	Capacitor	5.6nF -2
4	Resistor	5.6k -2
5	Bread Board	1
6	Wires	-

Table 1: Apparatus used

IC OP07CP

The OP07CP is a precision op-amp with low offset voltage and noise, ideal for high- accuracy applications like instrumentation and signal processing. It is used in circuits for operations such as addition, subtraction, integration, and differentiation. The IC operates with a dual power supply and comes in an 8-pin DIP package, with configurable functions using external resistors and capacitors.

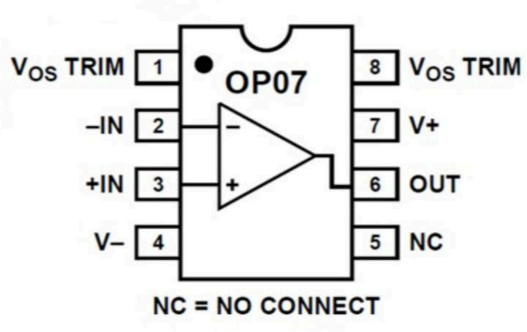

Figure 1: Pin Diagram of OP07CP

Filter Design

Low Pass Filter

A low-pass filter (LPF) is an electronic circuit that allows signals with frequencies lower than a specified cutoff frequency to pass while attenuating higher frequencies. The trans- fer function of an op-amp-based LPF is given by:

$$H(s) = -\frac{R_2}{R_1} \cdot \frac{1}{1 + R_2 C s}$$

$$= A_f \cdot \frac{1}{1 + sR_f C_f} \quad \text{where} \quad A_f = -\frac{R_2}{R_1},\ R_f = R_2,\ C_f = C$$

$$= |A_f| \cdot \left|\frac{1}{1 + j\omega R_f C_f}\right|$$

$$= |A_f| \cdot \frac{1}{\sqrt{1 + \omega^2 R_f^2 C_f^2}}$$

$$= |A_f| \cdot \frac{1}{\sqrt{2}} \quad \text{at} \quad \omega = \frac{1}{R_f C_f}$$

where R_1 and R_2 are resistances, C is the capacitance, and s is the complex frequency variable. This function describes the filter's ability to reduce high-frequency components of the input signal.

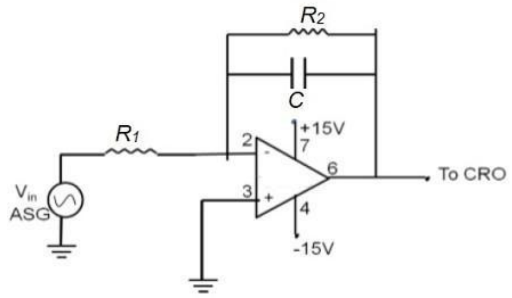

Fig:Circuit Diagram of Low-Pass Filter

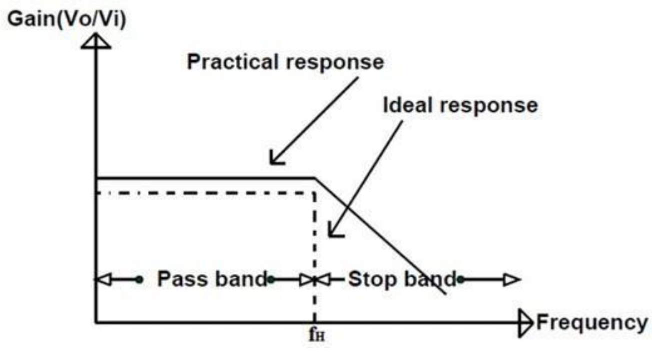

Fig:Frequency Response of Low-Pass Filter

The circuit shown in Fig is designed using resistors R_1 = 5.6 kΩ and R_2 = 56 kΩ to achieve a gain of 10. Given the cutoff frequency f_{cutoff} = 1 kHz, the required capacitance is calculated using the equations:

$$H(s) = \frac{R_2}{R_1} \cdot \frac{1}{1 + R_2 C s}, \quad f_{\text{cutoff}} = \frac{1}{2\pi RC}$$

The resulting capacitance is found to be C = 2.6 nF. nF.Using two 5.6nF in series. A peak-to-peak (Vp-p) AC sinusoidal input is used. The frequency response is analyzed from 1 Hz to 1 MHz, showing attenuation beyond the cutoff frequency.

The DSO Images Are as follows:

image 1

image 2

High Pass Filter

A high-pass filter (HPF) is an electronic circuit that allows signals with frequencies higher than a specified cutoff frequency to pass while attenuating lower frequencies. The transfer function of an op-amp-based HPF is given by:

$$H(s) = -\frac{R_2}{R_1} \cdot \frac{R_1 C s}{1 + R_1 C s} = |A_f| \cdot \frac{1}{\sqrt{2}}$$

$$= A_f \cdot \frac{j\omega}{j\omega + \omega_c} \quad \text{where} \quad A_f = -\frac{R_2}{R_1}, \quad \omega_c = \frac{1}{R_1 C}$$

$$= |A_f| \cdot \left| \frac{j\omega_c}{j\omega_c + \omega_c} \right| = |A_f| \cdot \left| \frac{j}{1 + j} \right|$$

$$= |A_f| \cdot \frac{1}{\sqrt{2}} H(s) = -\frac{R_2}{R_1} \cdot \frac{R_1 C s}{1 + R_1 C s}$$

where R_1 and R_2 are resistances, C is the capacitance, and s is the complex frequency variable. This function describes the filter's ability to reduce low-frequency components of the input signal.

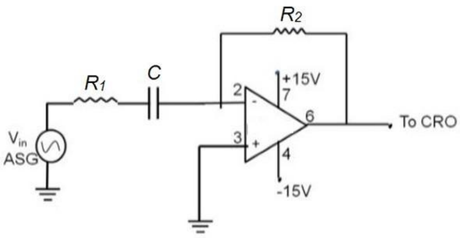

Fig:Circuit Diagram of High-Pass Filter

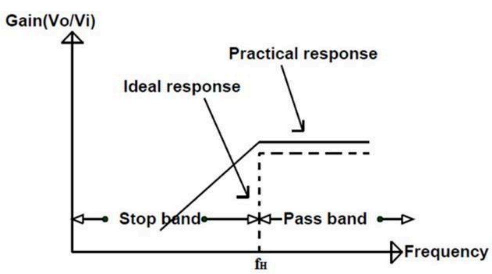

Fig:Frequency Response of Low-Pass Filter

The circuit shown in the figure is designed using resistors R_1 = 1.6 kΩ and R_2 = 16 kΩ to obtain a gain of 10. Given a cutoff frequency of f_c = 10 kHz, the required capacitance is calculated using the following expressions:

$$H(s) = \frac{R_2}{R_1} \cdot \frac{R_1 C s}{1 + R_1 C s}, \quad f_c = \frac{1}{2\pi RC}$$

Substituting the values, the calculated capacitance is approximately:

C ≈ 2.6 nF

Using two 5.6nF in series.

A peak-to-peak (Vp-p) AC sinusoidal input is used. The frequency response is analyzed from 1 Hz to 1 MHz, showing attenuation below the cutoff frequency.

The DSO Images Are as follows:

image 1

image 2

Conclusion

In this experiment, we successfully implemented low-pass, high-pass filters as per the given specifications. We measured the output voltages and corresponding gains for each filter across a range of frequencies. The frequency responses were also analyzed to validate the accuracy of our results. While the responses slightly deviate from the ideal behavior, they align well with expected practical outcomes when accounting for possible sources of error.