Indian Institute of Information Technology, Allahabad
ELECTRONICS AND COMMUNICATION ENGINEERING DEPARTMENT

Course Name: Analog Electronics Laboratory

EXPERIMENT NO: 5

Objective:

To design and implement the (a) Low-Pass Filter and (b) High-Pass Filter using UA741 Op-Amp IC.

Materials/ Component Required:

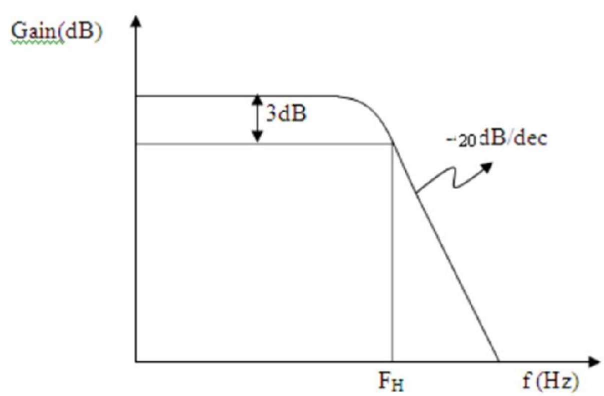
Resistance	4	15k, 15k, 15k and 12k
Capacitor	1	0.01μF
Op-Amp IC	1	741
Supply	DC	±15V
Function Generator		
Multimeter		

Theory:
A Low Pass Filter is a circuit that can be designed to modify, reshape or reject all unwanted high frequencies of an electrical signal and accept or pass only those signals wanted by the circuit's designer.

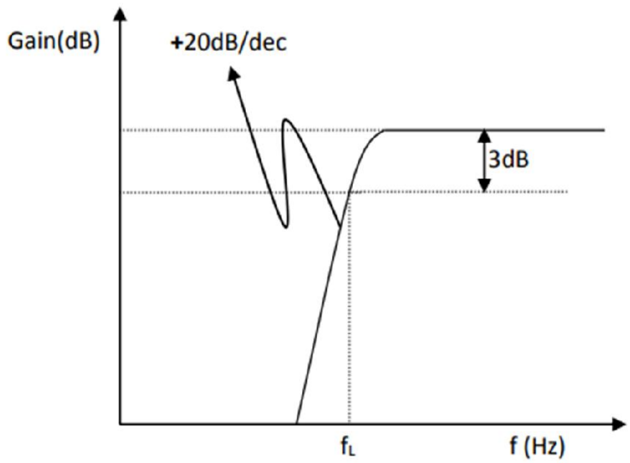
Filters are so named according to the frequency range of signals that they allow to pass through them, while blocking or "attenuating" the rest. The most commonly used filter designs are the:

The Low Pass Filter – the low pass filter only allows low frequency signals from 0Hz to its cut-off frequency, f_c point to pass while blocking those any higher.
The High Pass Filter – the high pass filter only allows high frequency signals from its cut-off frequency, f_c point and higher to infinity to pass through while blocking those any lower.
The Band Pass Filter – the band pass filter allows signals falling within a certain frequency band setup between two points to pass through while blocking both the lower and higher frequencies either side of this frequency band.

Expected Outcomes:

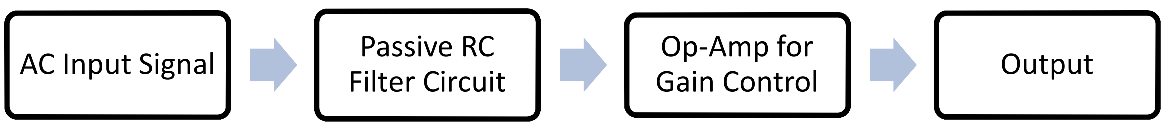


Response of Low-Pass filter



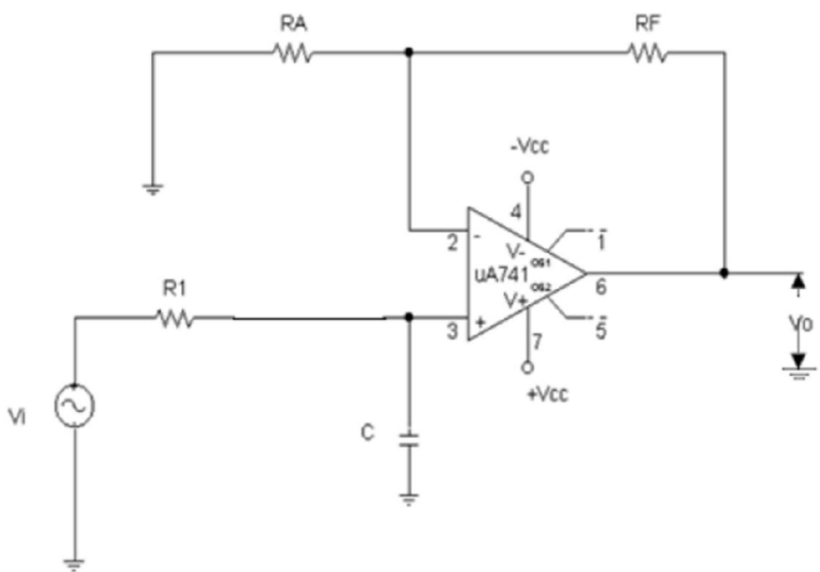
Response of High-Pass filter

Block Diagram:

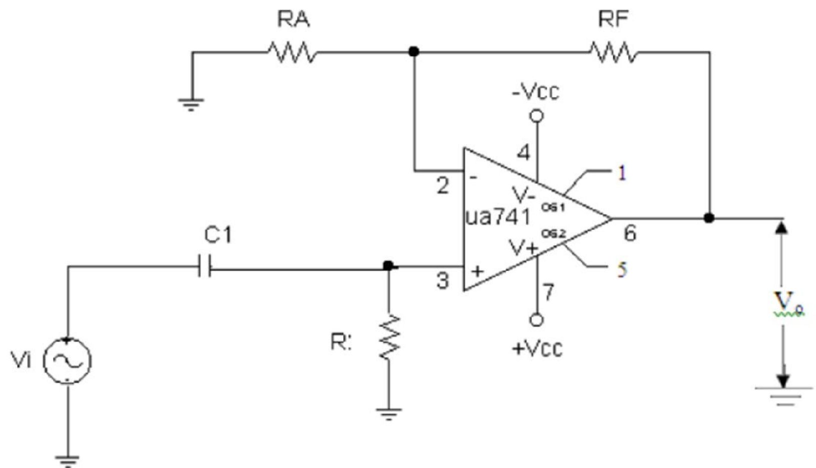


Circuit Diagram

Low Pass Filter



High-Pass Filter:



Design and Calculations:

DC Voltage Gain through Op-Amp: $A_f = 1 + \frac{R_F}{R_A}$ (Here R_F=R_A, hence A_f= 2)

Cut-off frequency: $f_C = \frac{1}{2\pi R_1 C}$ (for R_1=12k and C=0.01µC, f_c=1.32kHz)

Output Voltage Gain of Low-Pass Filter: $A_v = \frac{V_{out}}{V_{in}} = \frac{A_f}{\sqrt{1+\left(\frac{f}{f_C}\right)^2}}$

1. At very low frequencies, f<f_c: $A_v \sim A_f$
2. At the cut-off frequency, f=f_c: $A_v = A_f/\sqrt{2}$
3. At very high frequencies, f>f_c: $A_v < A_f$

Output Voltage Gain of High-Pass Filter: $A_v = \frac{V_{out}}{V_{in}} = \frac{A_f\left(\frac{f}{f_C}\right)}{\sqrt{1+\left(\frac{f}{f_C}\right)^2}}$

1. At very low frequencies, f<f_c: $A_v < A_f$
2. At the cut-off frequency, f=f_c: $A_v = A_f/\sqrt{2}$
3. At very high frequencies, f>f_c: $A_v \sim A_f$

Gain in dB: $A_v(dB) = 20\log_{10} A_v$

Observation Table:

V_{in}=……………. V

f (Hz)	V_{out} (V)	A_v	A_v (dB)

Report:

a) Explain how an op-amp can improve the passive filtering process.
b) What is the significance of 3dB attenuation?
c) What are the applications of filters?
d) What is difference between Active and Passive filters?
e) What are the advantages & disadvantages of Active filters?
f) Define cut-off frequencies?

Graph:

Result:

The filtering application using op-amp has been observed.

Precautions:

a) Connections should be verified before switching on the supply.
b) The resistance to be chosen should be in proper range and of calculated values.

References:

1. https://www.electronics-tutorials.ws/filter/filter_6.html
2. R.A. Gayakward, "Op-Amps and Linear Integrated Circuits" 4th Ed. Pearson-Prentice Hall