Band Pass Filter

AIM: To design and implement band pass filter in the range 400Hz-1KHz by cascading a low pass filter and a high pass filter, obtain the frequency response of the filter and plot the relevant graph.

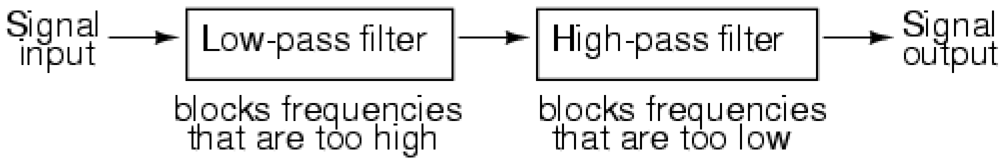
EQUIPMENT REQUIRED

Equipment	Range	Quantity
CRO	(0-20)MHz	1
Function Generator	(0-1)MHz	1
Experiment Kit		1
Power Supply	(0-30)V	2

COMPONENTS REQUIRED

Components	Value	Quantity
OP-AMP	IC 741	2
Capacitor	0.01µF	2
Resistor	10kΩ	5
Potentiometer	9-15KΩ	2

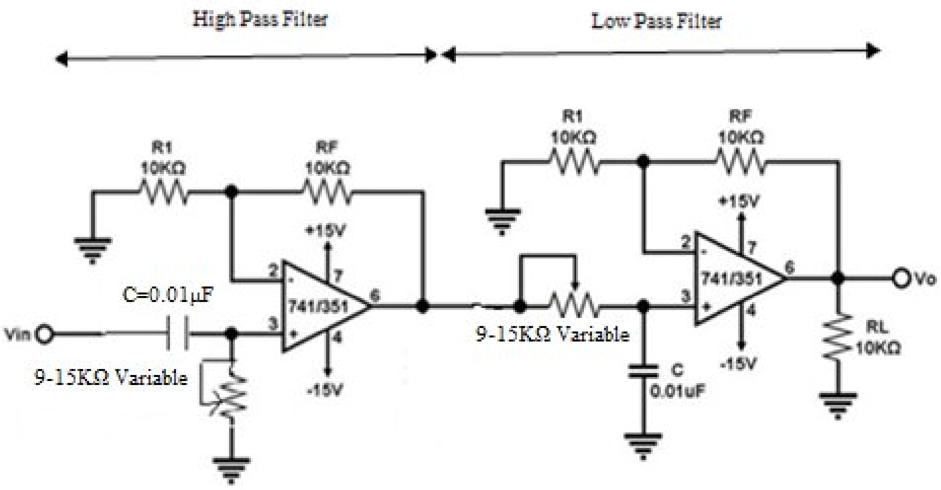
THEORY: A band pass filter passes a range of frequencies while rejecting frequencies outside the upper and lower limits of the pass band. The range of frequencies to be passed is called the pass band and extends from a point below the centre frequency to a point above the centre frequency where the output voltage falls about 70% of the output voltage at the centre frequency. These two points are not equally spaced above and below the centre frequency but will look equally spaced if plotted on a log graph. The percentage change from the lower point to the centre will be the same as from the centre to the upper, but not the absolute amount. The filter bandwidth (BW) is the difference between the upper and lower pass band frequencies. A *band-pass* filter works to screen out frequencies that are too low or too high, giving easy passage only to frequencies within a certain range.



PROCEDURE

1. Connections are made as shown in the circuit diagram.
2. Apply a $5V_{(p-p)}$ sinusoidal wave as input voltage to the circuit.
3. Take reading after adjusting resistance such that it behaves as a band pass filter.
4. Vary the frequency for different range of values and note the corresponding values of $V_{out.}$
5. Calculate the Gain ($A=V_o/V_{in}$) and plot graph between Gain in dB and frequency.

CIRCUIT DIAGRAM



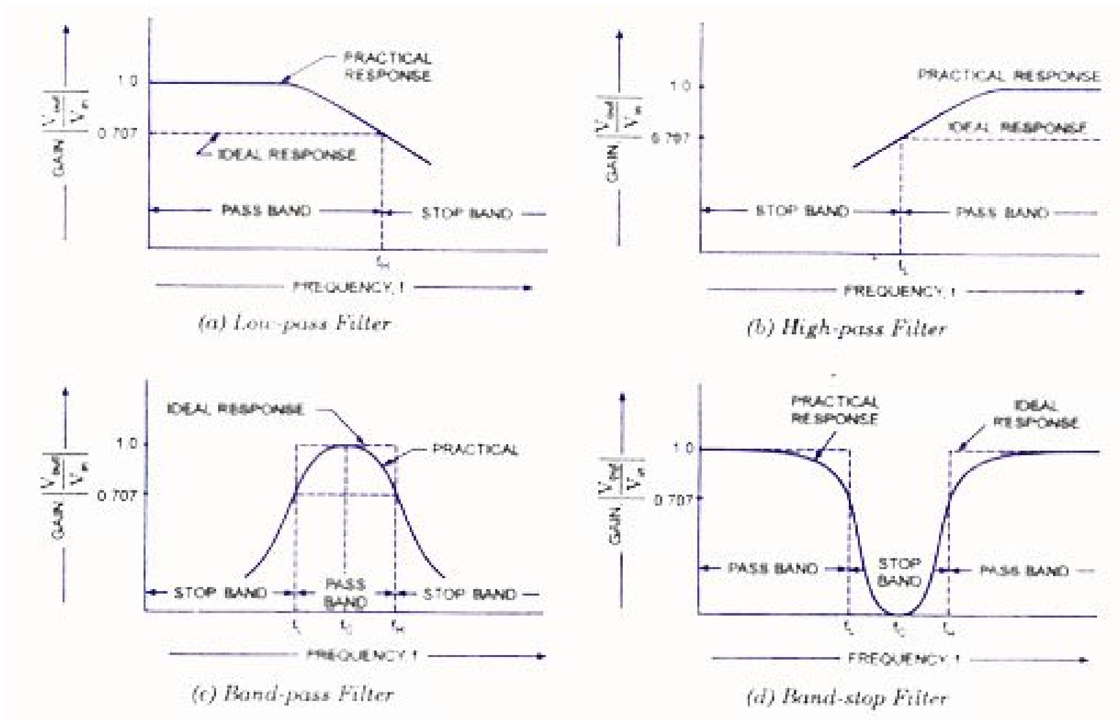
Description: A low-pass filter is a circuit that blocks signals with frequencies greater than a cut-off frequency f_c.

The Lower cut-off frequency is given as: $f_L = R/2\pi L$ (1)

It uses an op-amp configured as a non-inverting amplifier, with an RC circuit at the non-inverting input to do the filtering of the high-frequency signals. Similarly, a high-pass filter is a circuit that blocks signals with frequencies lower than a cut-off frequency f_c.

The higher cut-off frequency is given as: $f_H = 1/2\pi RC$ (2)

WAVEFORMS:



(a) Low-pass Filter (b) High-pass Filter (c) Band-pass Filter (d) Band-stop Filter

All of these filters use op-amps as the active elements and R-C networks. Although the 741 type op-amp operates satisfactorily in these filter circuits, high-speed op-amps like the LM 318 or ICL 8017 improve the performance of the filter circuits through their increased slew rates and higher unity GBW.

Low Pass Filter:
A low-pass filter has a constant gain from 0 Hz to a high cut-off frequency f_H. Therefore the bandwidth is also f_H. At high cut-off frequency f_H the gain is reduced by 3 db and for $f > f_H$ it decreases with the increase in input frequency. The frequencies between 0 and $/_H$ are known as pass band frequencies while the range of frequencies beyond f_H are attenuated and are therefore called the stop-band frequencies.

High Pass Filter:
A high-pass filter with a stop band $0 < f < f_L$ and a pass band $f > f_L$ is shown in figure. Here $/_L$ is the lower cut-off frequency and / is the operating frequency.

Band Pass Filter:
A band pass filter has a pass band between two cut-off frequencies f_H and f_L where $f_H > f_L$ and two stop bands at $0 < f < f_L$ and $f > f_H$. The bandwidth of the band pass filter is, therefore, equal to $f_H - f_L$. All these are obvious from the frequency response of a band pass filter as shown if figure.

Band Stop Filter:
Band-stop filter is exactly opposite to the band pass filter in performance i.e., it has a band stop between two cut-off frequencies f_H and f_L and two pass bands, $0 < f < f_L$ and $f > f_H$.

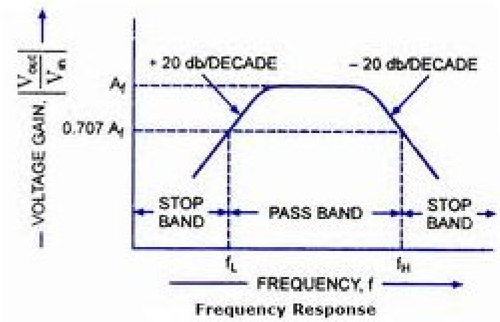
Frequency Response: It is a graph of magnitude of the output voltage of the filter as a function of the frequency. It is generally used to characterize the range of frequencies in which the filter is designed to operate. A band pass filter may be constructed by cascading a High Pass RL filter with a roll-off frequency f_L and a Low Pass RC filter with a roll-off frequency f_H, such that

$$f_L < f_H$$

The Band Width of frequencies passed is given by

$$BW = f_H - f_L$$

Thus, all the frequencies below f_L and above f_H are attenuated and those in between are passed by the filter.



Frequency Response wide bandpass filter

Lab Report

- Compute the cut-off frequencies for each Band Pass filter constructed using the formulae in equations (1) and (2) above. Compare these theoretical values to the ones obtained from the experiment and provide suitable explanation for any differences.
- Graph the Frequency Response for each filter built in the lab. (Use the values recorded in the tabular column and graph with the frequency on a logarithmic scale). Compare this to the response obtained from the Bode Plot and comment.