AA 652 : Astronomy Lab II

End-Semester Exam - Part I

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LIST OF FIGURES

1 Band Pass Filter using R,L and C

Band Pass Filter circuit design by using inductor, capacitor and resistor is given as below.

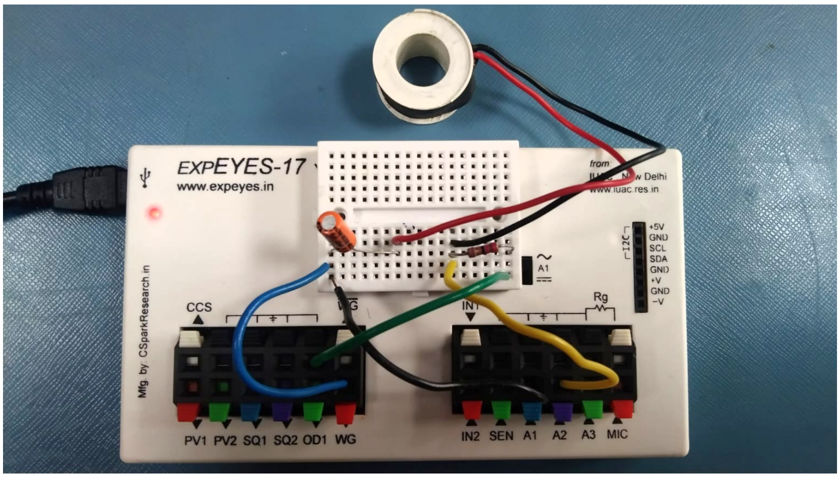


Figure 1.1: Band pass filter

1.1 Formula used

The centre frequency of the band pass filter which is also termed as 'resonant peak' can be formulated by using the below equation -

$$f_c = \frac{1}{2\pi\sqrt{LC}}\text{Hz}$$

The output voltage across R will be -

$$V_o = \frac{j\frac{R\omega}{L}}{-\omega^2 + j\frac{R\omega}{L} + \frac{1}{LC}} V_{in}$$

The Magnitude of the output voltage will be -

$$\left|\frac{V_o}{V_{in}}\right| = \frac{\frac{R\omega}{L}}{\sqrt{\left(\frac{1}{LC} - \omega^2\right)^2 + \left(\frac{R\omega}{L}\right)^2}} = \frac{R}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}}$$

The Phase response of the output voltage -

$$\theta(\omega) = 90^o - \tan^{-1}\left(\frac{\omega R/L}{\frac{1}{LC} - \omega^2}\right)$$

Resonance Frequency :- The frequency at which the output is maximum.

To obtain maximum output , the required condition is - $X_L = X_C$.

$$\omega_o L = \frac{1}{\omega_o C} \Rightarrow \omega_o = \sqrt{\frac{1}{LC}}$$

Cut off Frequency :- The frequency at which the the output falls down to the $\frac{1}{\sqrt{2}}$ of the maximum output($i.e.$ output at resonance frequency). $i.e. \left|\frac{V_o}{V_{in}}\right| = \frac{1}{\sqrt{2}}$

$$\frac{1}{\sqrt{2}} = \frac{\frac{R\omega}{L}}{\sqrt{\left(\frac{1}{LC} - \omega^2\right)^2 + \left(\frac{R\omega}{L}\right)^2}}$$

On solving this equation, we get

$$\omega_1 = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

$$\omega_2 = \frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

Bandwidth (β) **:-**

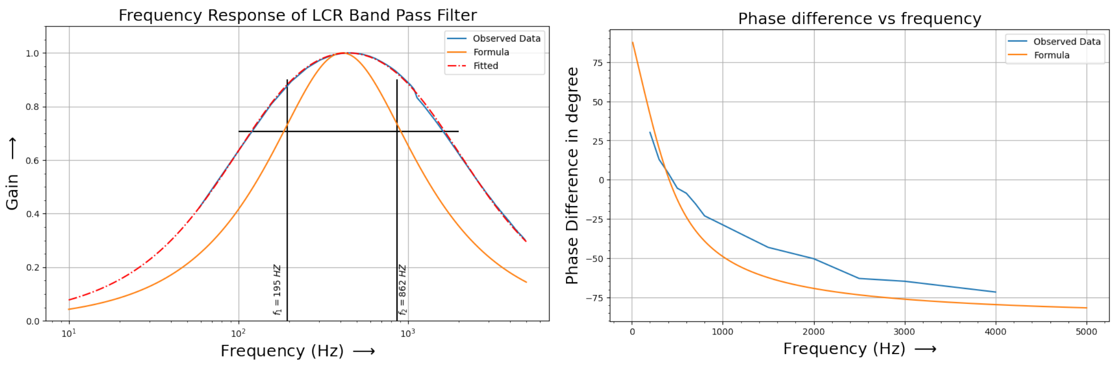
$$\beta = \omega_2 - \omega_1 = \frac{R}{L}$$

Quality Factor (Q) **:-** It is defined as -

$$Q = \frac{\omega_o}{\beta} = \sqrt{\frac{L}{CR^2}}$$

or,

$$Q = \frac{\omega_o}{\beta} = \frac{\omega_o}{\omega_2 - \omega_1} = \frac{f_o}{f_2 - f_1}$$



(a) Frequency v/s gain

(b) Frequency v/s Phase Difference

Figure 1.2: Fitted curves for the Band Pass filter

1.2 Problems

1.2.1 Draw the circuit diagram for a band-pass filter using resistor, capacitor, and an inductor.

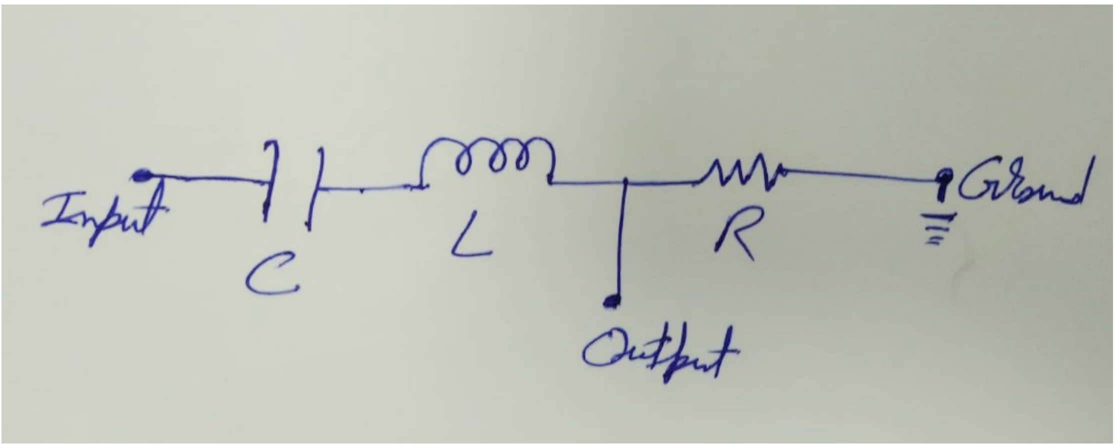


Figure 1.3: Circuit Diagram

1.2.2 Assuming the frequency limitation of the function up to 5KHz, choose suitable capacitor and resistor to investigate the frequency response of the filter.

$$\text{Resistance, R } = 612 \text{ Ohm}$$

$$\text{Capacitance, C } = 0.000001 \text{ Farad}$$

1.2.3 Using expEYES, perform an experiment to determine the frequency response of the band-pass filter.

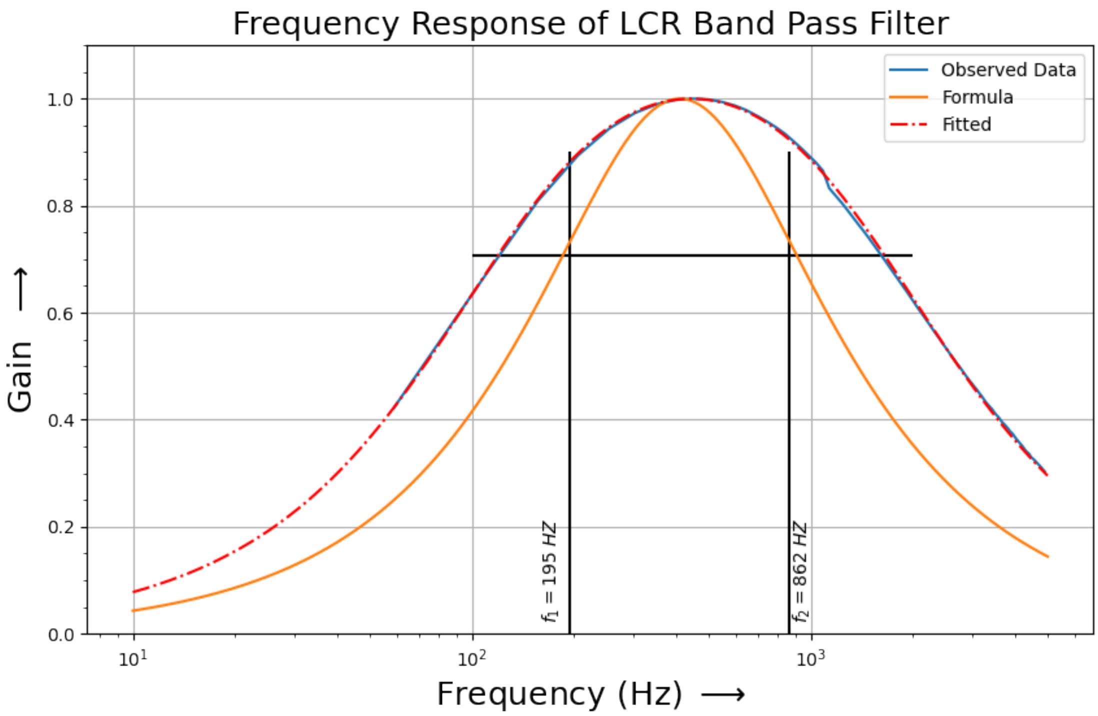


Figure 1.4: Frequency v/s gain

1.2.4 Find out the cutoff frequency and bandwidth of a Band-pass filter-

Cut off Frequency

$$\omega_1 = 195\ Hz$$

$$\omega_1 = 862\ Hz$$

Bandwidth

$$\beta = 862 - 195 = 667\ Hz$$

1.2.5 Measure the phase difference between input and output of the signal and make a plot to show how it varies with frequency.

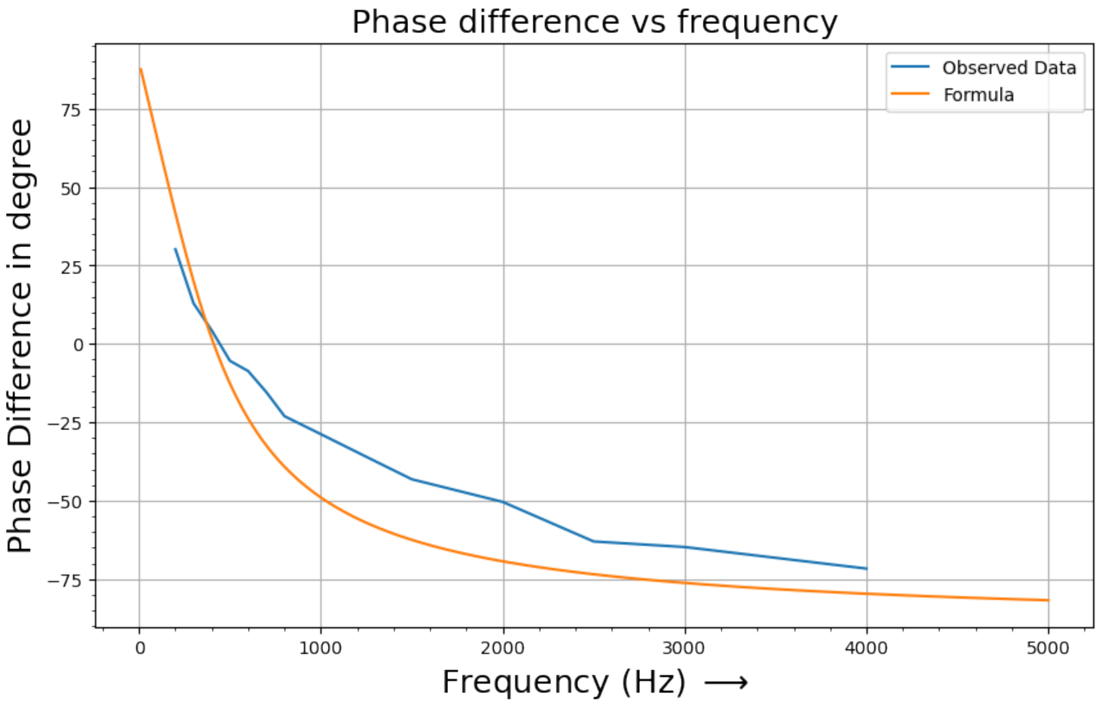


Figure 1.5: Frequency v/s Phase Difference