(AC 2-5) Band Stop Filter

Aim of experiment

Verification of the operation and characteris-tics of band reject filter.

Apparatus

Cathode Ray Oscilloscope, CRO – AC Function Generator – Capacitors - Resistors - Inductor

Theory of experiment

A band reject-filter is a filter that pass all frequencies, but attenuates (or reduces) band of frequencies, it is also called band-stop filter. The actual amount of attenuation for each frequency varies from filter to filter..

By connecting or "parallel" together a single low pass filter circuit with a high pass filter circuit, we can produce another type of passive RC filter that rejects a selected range or "band" of frequencies that can be either narrow or wide while passing all those outside of this range.

The simplest form of band-reject filter is shown in *figure 1*. It consists of a resistor and a capacitor connected, across an input voltage V_{in}. The output voltage is determined across the capacitor and coil. Assume that the input voltage V_{in} has a fixed rms value but its frequency can be varied.

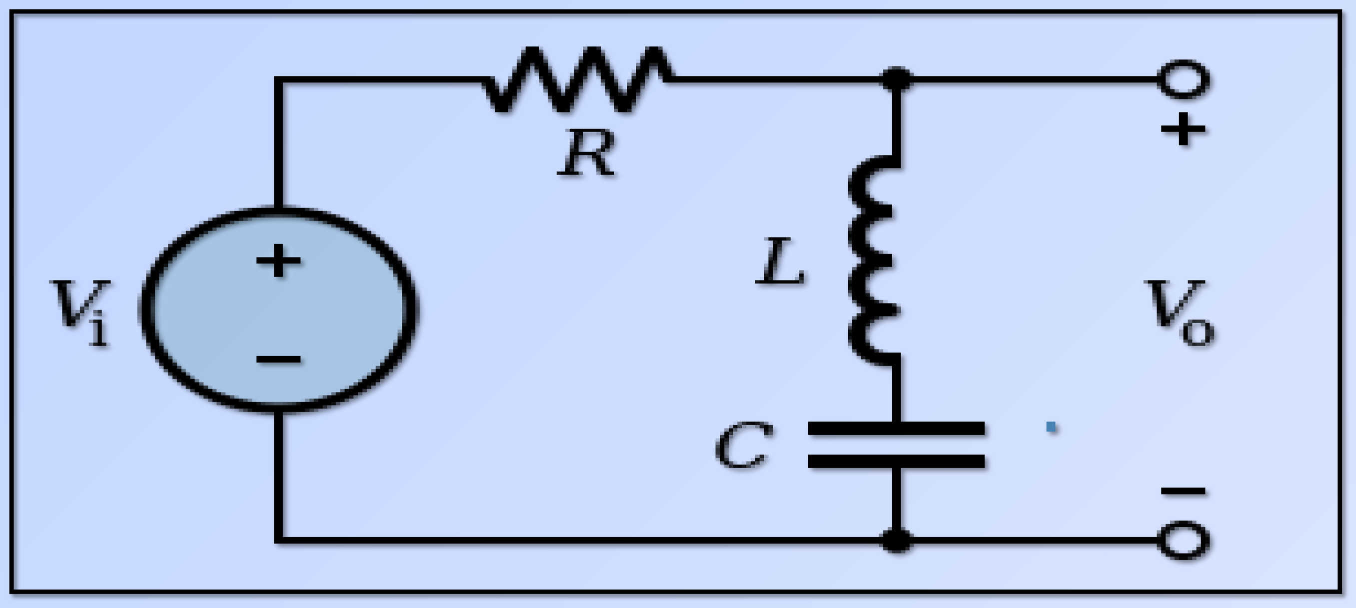

Figure 1 RC band-reject filter

Unlike a low pass filter that only passes signals of a low frequency range or a high pass filter which passes signals of a higher frequency range, a band reject filters reject signals within a certain "band" or "spread" of frequencies without distorting the input signal or introducing extra noise. This band of frequencies can be any width and is commonly known as the filters bandwidth. Bandwidth is defined as the frequency range between two specified frequency cut-off points (f_c), that are 3dB below the resonant peak while attenuating or weakening the others inside these two points.

Then for widely spread frequencies, we can simply define the term "bandwidth", BW as being the difference between the lower cut-off frequency ($f_{c\ lower}$) and the higher cut-off frequency ($f_{c\ higher}$) points.

In other words, $BW = f_{c\ lower} - f_{c\ higher}$ Clearly for a stop band filter to function correctly, the cut-off frequency of the low pass filter must be lower than the cut-off frequency for the high pass filter.

The ideal band pass filter graph, shown in *figure 2*, consists of a stop band and two pass bands but this not practical as the output drops to 0, in no time. On the other hand, in practice, filters get transition bands between (pass to stop band) and between (stop to pass band), which mean two transition bands as shown in *figure 3*.

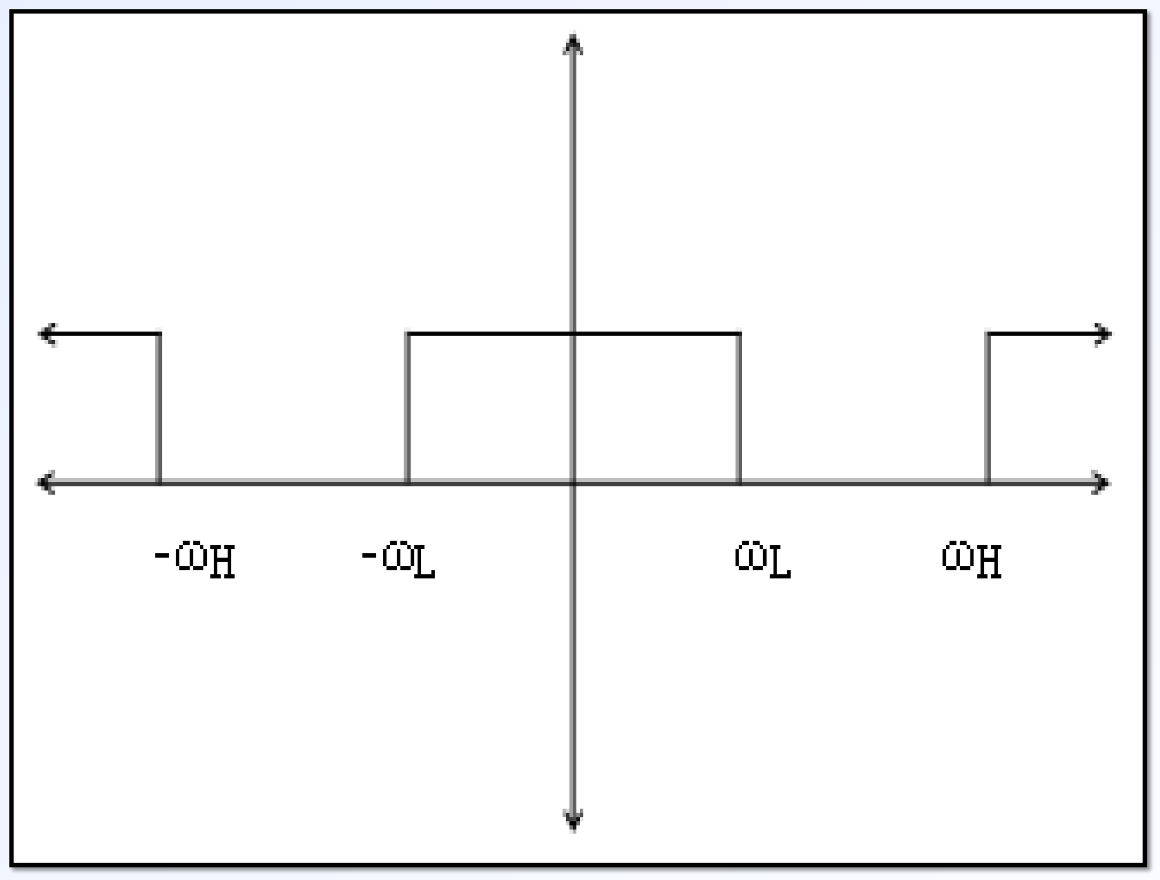

Figure 2 Ideal band reject filter

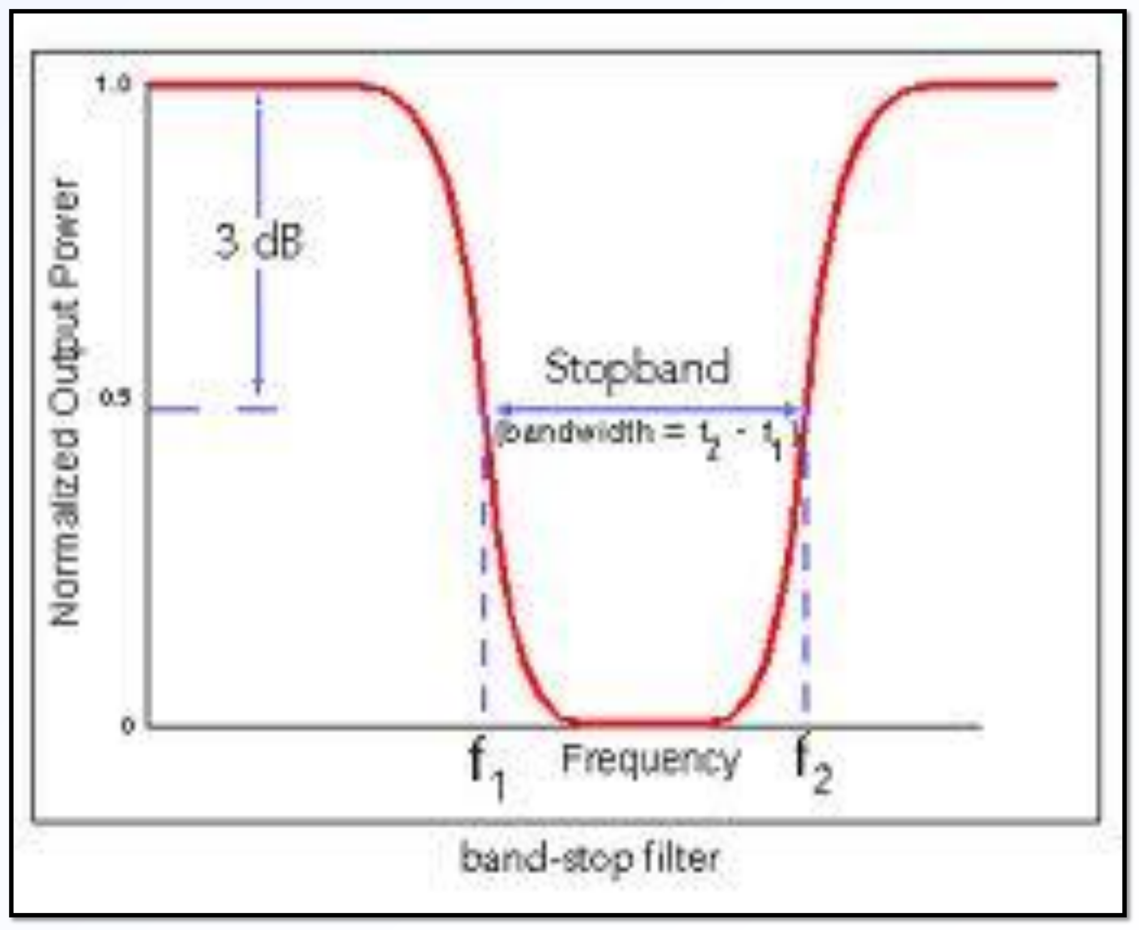

Figure 3 Practical band reject filter

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The frequency response of the filter is used to fully define the filter. It consists of amplitude (gain) response and phase response. Amplitude response indicates how filter affect the amplitude of input signal (decrease or increase or fixed) and it equals output amplitude divided by input amplitude (V_{out}/V_{in}), as shown in *figure 4*. Phase response indicates how shift filter causes and it equals phase shift between output and input (Φ_{out}- Φ_{in}), as shown in *figure 4.*

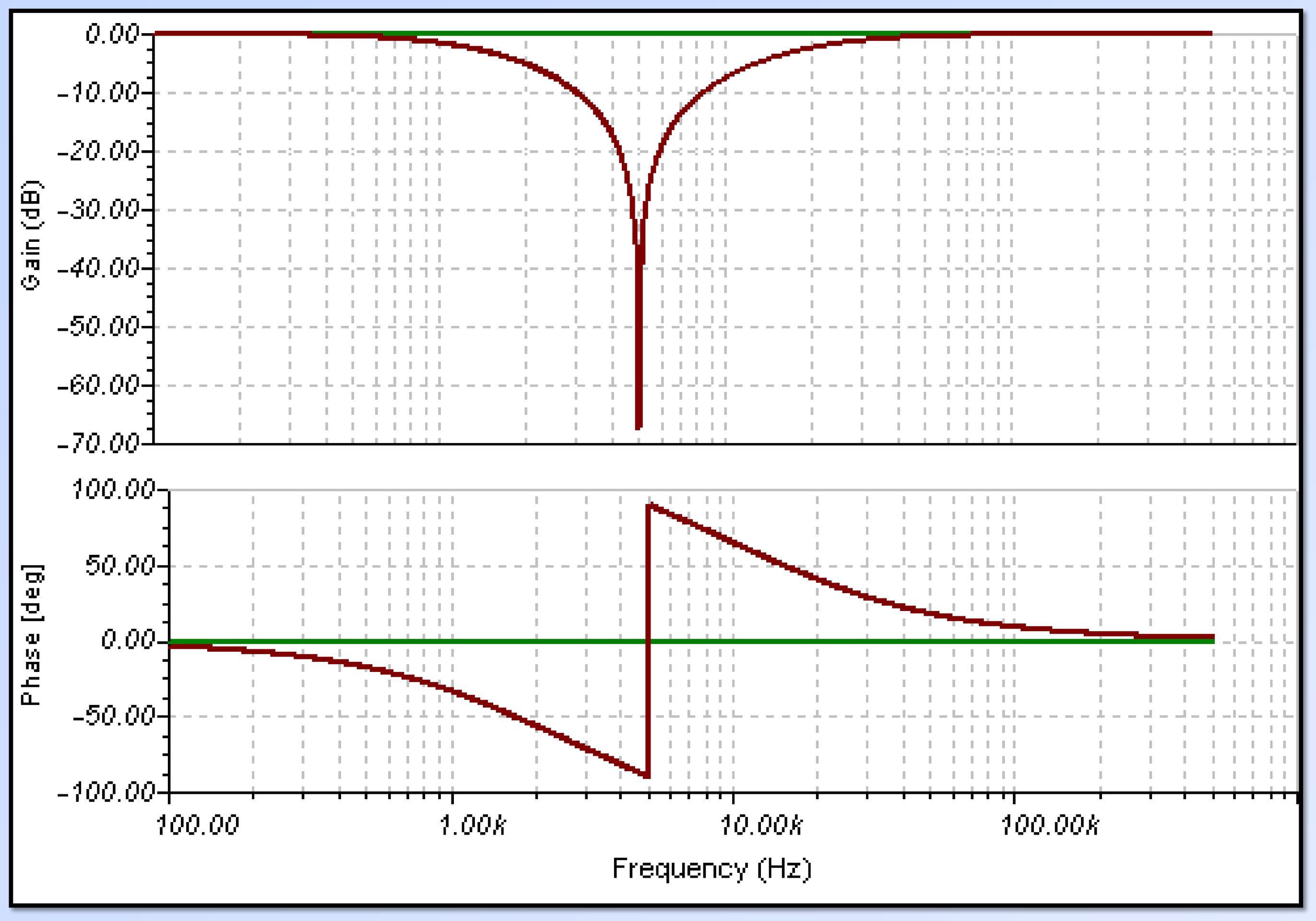

Figure 4 Frequency response of band-reject filter

The upper and lower cut-off frequency points for a band reject filter can be found using the same formula as that for both the low and high pass filters, For example.

$$f_c = \frac{1}{2\pi\tau} = \frac{1}{2\pi RC}$$

Then clearly, the width of the pass band of the filter can be controlled by the positioning of the two cut-off frequency points of the two filters.

Procedures

1. Connect the circuit as shown in *figure 1* such that the output of function generator is connected to channel 1 and the output of band pass filter is connected to channel 2.
2. Set the generator range to the LOW position and vary the frequency each 1Hz up to 10 kHz and record the corresponding output voltage amplitude (V_{out}).
3. Measure the phase difference (Φ_{out}- Φ_{in}.) in each case by measuring the periodic time of the input pulse, T, and the time difference, Δt, between the two signals from the relation:

   Φ_{out}- Φ_{in}. = (Δt x 360º)/T
4. Draw a graph between the frequency and V_{out}/V_{in}.
5. Draw a graph between the frequency and Φ_{out}- Φ_{in}.
6. Using the values of resistance and capacitance compute the cut-off frequencies ($f_{c\ lower}$= Hz and $f_{c\ higher}$ = Hz) then compute center frequency by $f_r^2 = f_{c\ upper} \times f_{c\ lower}$, compare this value with value from curve corresponding to minimum value in band stop region.

Results

V_{in}= V

f (Hz)	V_{out}	V_{out}/V_{in}	Φ_{out} - Φ_{in}