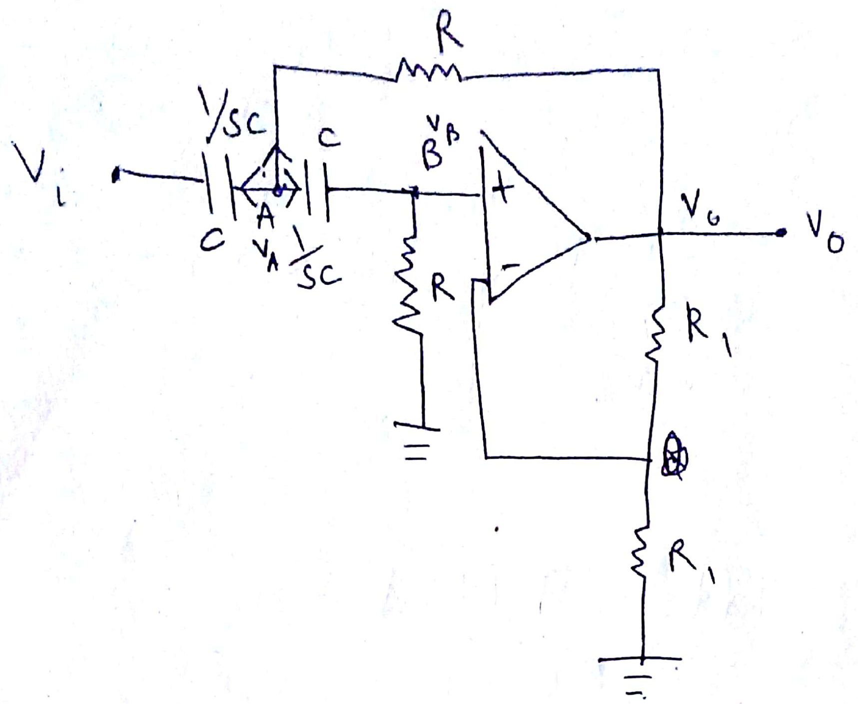
2nd Order HPF :-



2nd order HPF contain 2 storage elements like capacitor, It has a very high and constant gain where the signal level is very high compared to the 1st order HPF. When the frequency is low the gain of filter is very low compared to 1st order. The frequency response is better in second order HPF as compared to 1st order.

Apply KCL at node A,

[Assuming potential higher at A than other pts].

$$\frac{V_A - V_i}{\frac{1}{sC}} + \frac{V_A - V_0}{R} + \frac{V_A - V_B}{\frac{1}{sC}} = 0$$

$$\Rightarrow V_A\left(2SC + \frac{1}{R}\right) - SCV_i - SCV_B \quad \text{— (3)}$$

—

$$\frac{V_o - V_B}{R_1} = \frac{V_B - 0}{R_1}$$

$$\Rightarrow \quad V_B = \frac{V_o}{2} \quad \text{— (2)}$$

—

$$\frac{V_A - V_B}{\frac{1}{SC}} = \frac{V_B}{R}$$

$$\Rightarrow SCV_A = V_B\left(SC + \frac{1}{R}\right)$$

$$\Rightarrow SCV_A = \frac{V_o}{2}\left(SC + \frac{1}{R}\right)$$

$$\Rightarrow V_A = \frac{V_o}{2}\left(\frac{SCR+1}{SCR}\right) \quad \text{— (1)}$$

—

From 3

$$\frac{V_o}{2}\left(\frac{SCR+1}{SCR}\right)\left(\frac{2SCR+1}{R}\right) - SC\frac{V_i}{2} - SC\frac{V_o}{2} - \frac{V_o}{R} = 0$$

$$\Rightarrow \frac{V_o}{SCR}(SCR+1)(2SCR+1)$$

$$-2CRV_i - SCRV_o - 2V_o = 0.$$

$$\Rightarrow \frac{V_o}{SCR}(2S^2C^2R^2 + 3SCR + 1)$$

$$-2SCRV_i - SCRV_o - 2V_o = 0,$$

$$\Rightarrow V_o(2S^2C^2R^2 + 3SCR + 1)$$

$$-2S^2C^2R^2V_i - S^2C^2R^2V_o - 2V_oSCR$$

$$= 0.$$

$$\Rightarrow S^2C^2R^2V_o + V_oSCR + V_o$$

$$-2S^2C^2R^2V_i = 0.$$

$$\Rightarrow \frac{V_o}{V_i} = \frac{2S^2C^2R^2}{S^2C^2R^2 + SCR + 1}$$

$$H(s) = \frac{2S^2C^2R^2}{S^2C^2R^2}$$

$$= \frac{2s^2}{s^2 + \frac{s}{RC} + \left(\frac{1}{RC}\right)^2}$$

$$H(s) = \frac{2s^2}{s^2 + \frac{s}{RC} + \left(\frac{1}{RC}\right)^2}$$

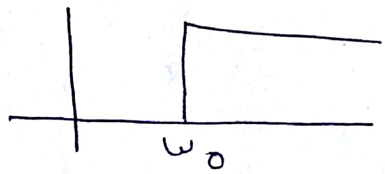
$$= \frac{K s^2}{s^2 + \left(\frac{\omega_0}{2}\right) s + (\omega_0)^2}$$

$K = 2$

$Q \rightarrow$ quality factor or fig. of merit.

$$\frac{V_o}{V_i} = \frac{k}{1 + \frac{\omega_0}{Q s} + \left(\frac{\omega_0}{s}\right)^2}$$

Case 1 :- $\omega << \omega_0$



$$\frac{V_o}{V_i} = \frac{k}{1 + \frac{\omega_0}{j\omega} + \left(\frac{\omega_0}{j\omega}\right)^2} \rightarrow 0.$$

Case 2 : $\omega_0 << \omega$

$$\frac{V_o}{V_i} = k \Rightarrow V_o = k V_i.$$

Conclusion - (i) From this experiment, it is said that the presence of s^2 in numerator, makes the active filter very high & const gain at very high frequency.

(ii) At low frequency, $\omega \ll \omega_o$,

$V_o \rightarrow 0$, $\frac{V_o}{V_i} \rightarrow 0$.

i.e. filter drops low frequency signal to reach output.

(iii) Cut off frequency ω_o depends on R & C values. By varying R & C ω_o can be changed.

Q in this exp = 1

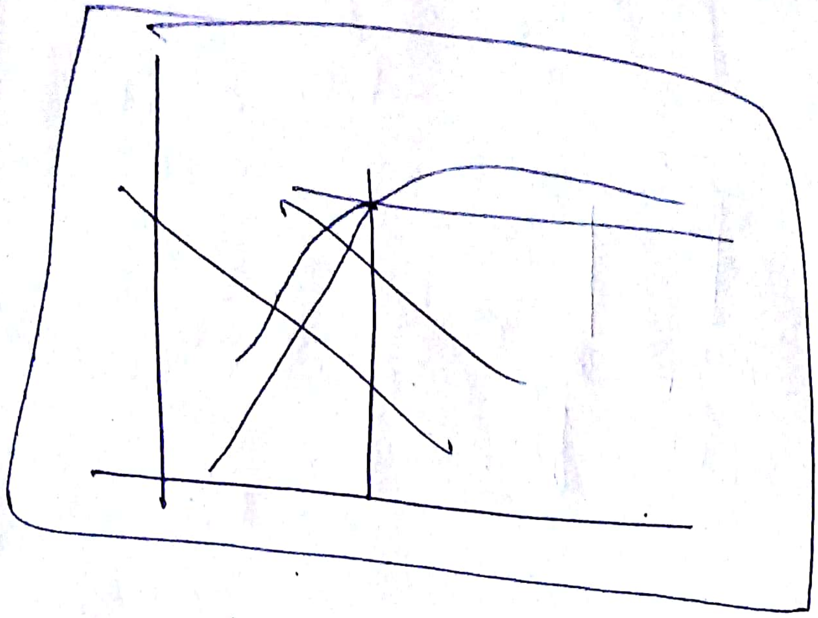
as here resistor & capacitor are chosen with identical values

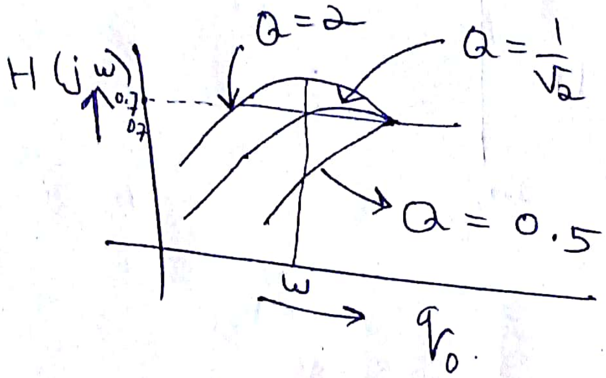
Q depends on R & C values

While changing R & C, Q can be chaged.

Scanned by CamScanner

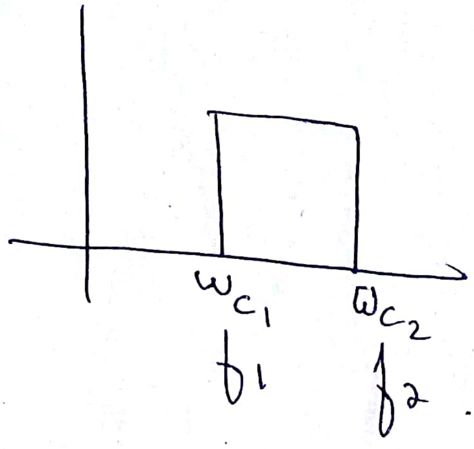
Pattern of Response :-

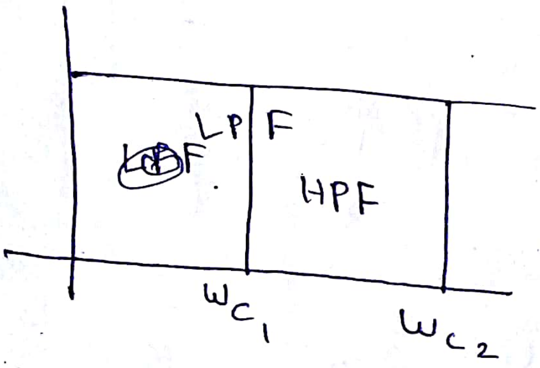


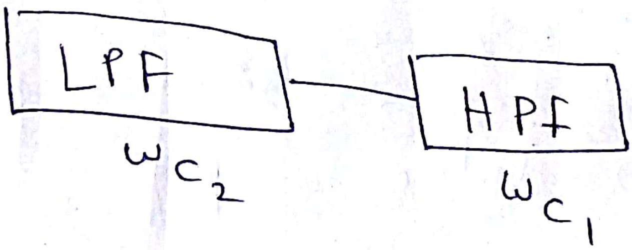


By adjusting value of R & C value of Q can be adjusted to have different pattern of response At $Q = \frac{1}{\sqrt{2}}$ i.e 0.707 the extension of the horizontal portion of response towards cut off is max flat which is most desired response of the second order H.P.F.

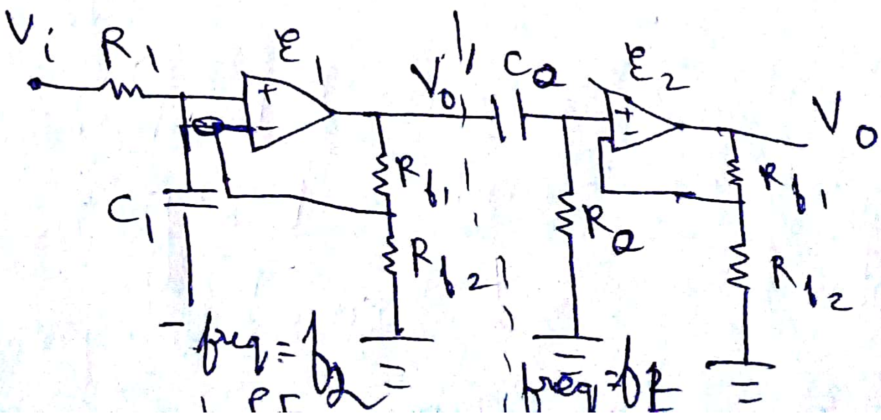
1st order BPF







$$\omega_{c_1} < \omega_{c_2}$$



$f_2 > f_1$

$f_2 - f_1 =$ Bandwidth :-

$$f_2 = \frac{1}{2\pi R_1 C_1}$$

$$f_1 = \frac{1}{2\pi R_0 C_0}.$$

$$\frac{V_0}{V_i} = \frac{V_0}{V_0'} \times \frac{V_0'}{V_i}$$

$$\boxed{\cancel{= A\left[\frac{1}{\sqrt{1+\left(\frac{\omega_0}{\omega}\right)^2}}\right] \times A\left[\frac{1}{\sqrt{\ }}\right]}}$$

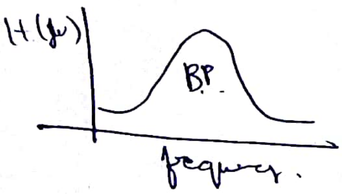
$$= \frac{sC_0R_0}{1+sC_0R_0} \times \frac{1}{1+sC_1R_1}$$

$$= \frac{sC_0R_0}{1+s(R_0C_0+R_1C_1)+s^2R_1C_1R_0C_0}$$

$$= \frac{s\cancel{C_0}\cancel{R_0}}{\cancel{R_0}\cancel{C_0}R_1C_1\left[s^2+\frac{s}{R_1C_1}+\frac{s}{R_0C_0}+\frac{1}{R_1C_1R_0C_0}\right]}$$

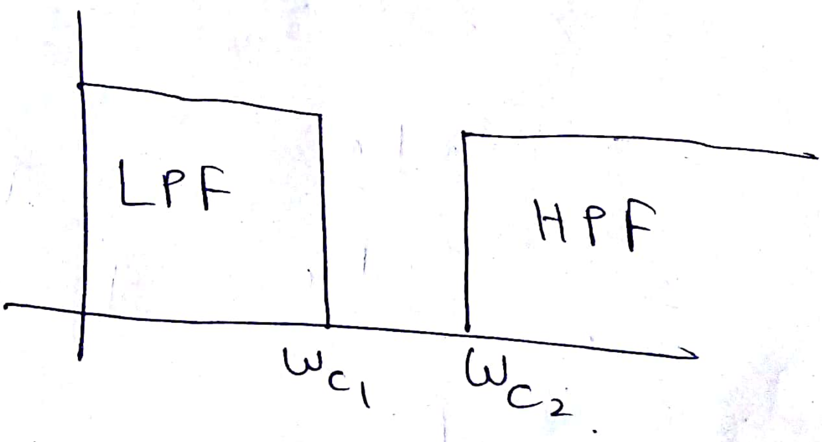
$$\Rightarrow \frac{V_o}{V_i} = \frac{S}{R_1 C_1 \left[S^2 + \frac{S}{R_1 C_1} + \frac{S}{R_o C_o} + \frac{1}{R_1 C_1 R_o C_o} \right]}$$

$$H(j\omega) = \frac{S \omega_{c_2}}{s^2 + s(\omega_{c_2} + \omega_{c_1}) + \omega_{c_2}\omega_{c_1}}$$



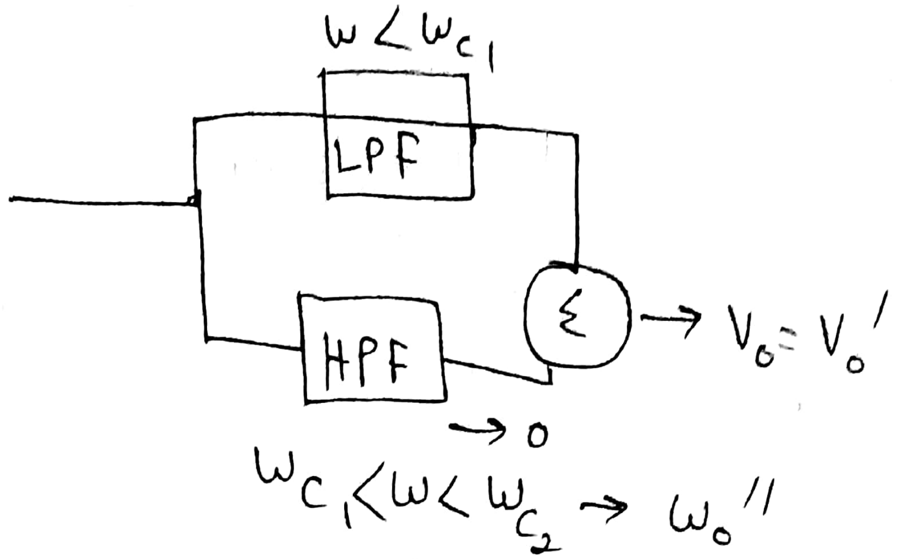
$$\frac{1}{R_1 C_1} = \omega_{c_2}$$

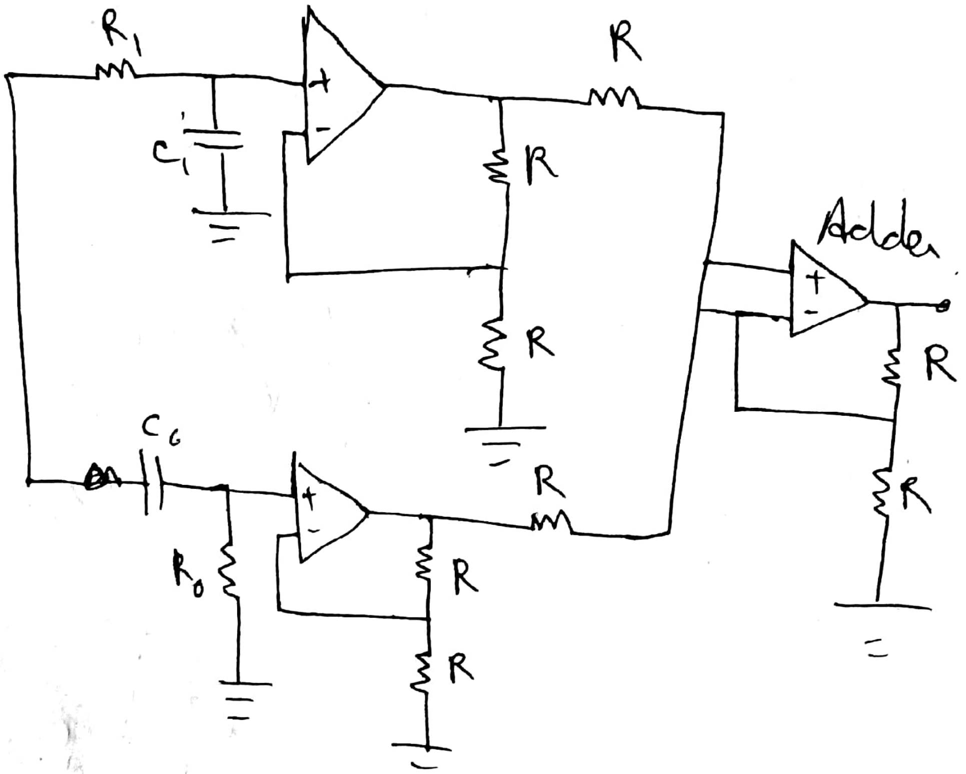
Band Reject Filter -

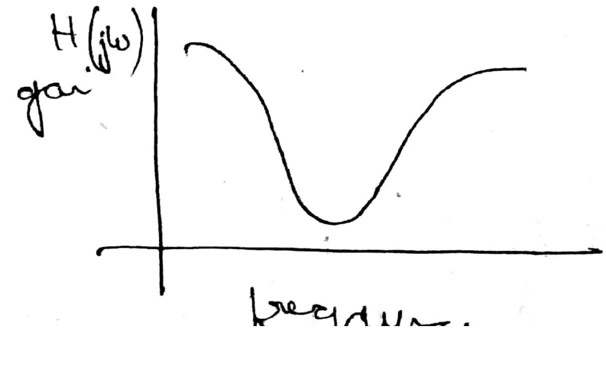


$\omega_{c_2} > \omega_{c_1}$

cutoff freq. of HPF > cut off freq. of LPF


w < wc1
LPF
HPF
Σ
→ V0 = V0'
→ 0
wc1 < w < wc2 → w0''


R1
C1
R
R
R
Adder
R
R
C0
R
R0
R
R


H(jw)
gain