$$f_L = \frac{1}{2\pi\sqrt{R_2 R_3 C_2 C_3}}$$

$= R, \quad C_2 = C_3 = C$

... Response.

III Order $A_{f_1} = 1, A_{f_2} = 2$

IV Order
$A_{f_1} = 1.152, A_{f_2} 2.235$
..., and

$5) = 2.57 = A_f$

Band Pass

$$Q = \frac{f_c}{BW} = \frac{f_c}{f_H - f_L}$$ → Narrow Band $Q > 10$ figure of merit

$$f_c = \sqrt{f_H f_L}$$ → Wide Band $Q < 10$

Higher Q → More Selective

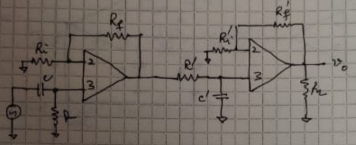
1st Order → ± 20dB

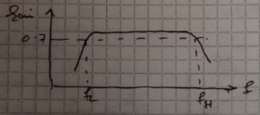
2nd Order → ± 40 dB

UNIT 3

(1)

Wide Band Pass



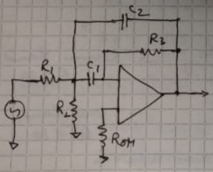


$$f_L = \frac{1}{2\pi RC}$$

$$f_H = \frac{1}{2\pi R'C'}$$

Design Low Pass & High Pass filters & combine.

Narrow Band Pass



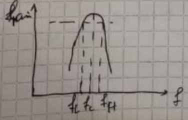
$$C = C_1 = C_2$$

$$R_1 = \frac{Q}{2\pi f_c C A_f}$$

$$R_2 = \frac{Q}{2\pi f_c C (2Q^2 - A_f)}$$

$$R_3 = \frac{Q}{\pi f_c C}$$

$$A_f = \frac{R_3}{2R_1} \qquad A_f < 2Q^2$$

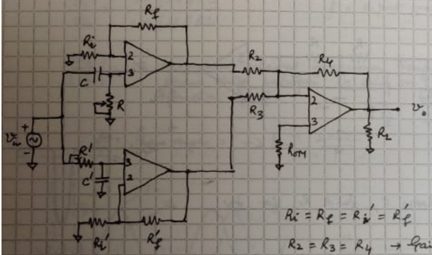


Band Reject filters:

Band stop or Band elimination

WIDE-BAND Reject : Low pass filter + High pass filter + Summing amplifier

- f_L of High pass filter > f_H of low pass pass filter
- Passband gain of both filters should be same



$R_i = R_f = R_i' = R_f'$

$R_2 = R_3 = R_4$ → Gain = 1

$R_{OM} = R_2 \parallel R_3 \parallel R_4$

$f_c = \sqrt{f_H f_L}$

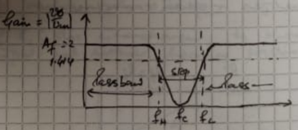
= Max. attenuation frequency

Voltage gain changes @ 20 dB/decade above f_H and below f_L

Passband Gain : 2 each

where $f_H = \frac{1}{2\pi R'C'}$

$f_L = \frac{1}{2\pi RC}$



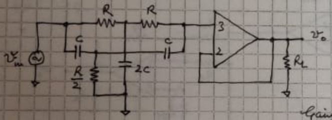
Narrow-Band-Reject

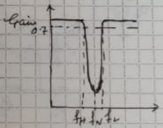
Generally known as Notch-filter commonly used to reject line frequency of 50Hz - power line frequency hum.

Twin-T-passive filter — low figure of merit Q

Q can be increased by using it with voltage follower:

$$f_N = \frac{1}{2\pi RC}$$



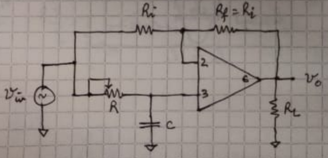


Choose C, find R for f_N

All Pass filter

Allows all frequencies, introduces known phase change.

Phase change is introduced when signals transmitted over transmission lines like telephone lines. To compensate these phase changes, all pass filters are used. Known as delay equalizers or phase correctors.



Using superposition theorem

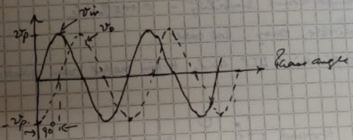
$$v_0 = -v_{in} + \frac{-jX_c}{R - jX_c} v_{in} \cdot 2 \qquad X_C = \frac{1}{2\pi f C}$$

$$= v_{in}\left(-1 + \frac{2}{j2\pi f RC + 1}\right)$$

$$\frac{v_0}{v_{in}} = \frac{1 - j2\pi f RC}{1 + j2\pi f RC} \qquad f = \text{input frequency}$$

$\left|\frac{v_0}{v_{in}}\right| = 1 \rightarrow$ throughout useful frequency response and phase shift between v_0 and v_{in} is a function of f.

$$\phi = \text{Phase angle} = -2\tan^{-1}\left(\frac{2\pi f RC}{1}\right)$$



In this case v_0 lags v_{in} by 90°.

For fixed R, C, ϕ changes from $0^\circ \rightarrow (-180^\circ)$ as f varies from $0 \rightarrow \infty$

If R, C are interchanged, the phase shift between input and output becomes positive, i.e. v_0 leads v_{in}