$$H(s) = \frac{k b_0}{s^4 + b_3 s^3 + b_2 s^2 + b_1 s + b_0}$$

$n=4$

Chebyshev,

$$\frac{1}{s^4 + 0.582 s^3 + 1.169 s^2 + 0.405 s + 0.172}$$

Bessel,

$$= \frac{1}{(s^2 + 0.411 s + 0.196)(s^2 + 0.170 s + 0.903)}$$

Bessel;

$$= \frac{1}{s^4 + 10 s^3 + 45 b_2 + 105 s + 105 S}$$

$$= \frac{1}{(s^2 + 4.208 s + 11.488)(s^2 + 5.792 s + 9.140)}$$

Butterworth,

$$= \frac{1}{s^4 + 2.613 s^3 + 3.414 s^2 + 2.613 s + 1}$$

$$= \frac{1}{(s^2 + 1.848 s + 1)(s^2 + 0.765 s + 1)}$$

for normalised filter,

$$H(s) = \frac{b}{s^2 + as + b}$$ with gain = 1,

We define $FSF = \frac{\omega_1}{\omega_n}$

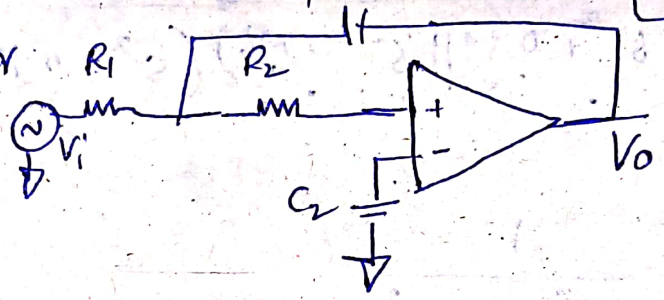
$$j\omega_n = \frac{j\omega_1}{FSF}$$ so

so

$$s_n \equiv \frac{s}{FSF}$$

$\boxed{\text{for cutoff } \omega_n = 1, \; FSF = \omega_1}$

For



$$\frac{V_o(s)}{V_i(s)} = \frac{\frac{1}{R_1R_2C_1C_2}}{s^2 + \left(\frac{1}{R_1} + \frac{1}{R_2}\right)\frac{1}{C_1}s + \frac{1}{R_1R_2C_1C_2}}$$

to convert $H(s)$ compatible for the above eqn.

replace $H(s) \longleftrightarrow H\left(\frac{s}{FSF}\right)$

so

$$H\left(\frac{s}{FSF}\right) = \frac{V_o(s)}{V_i(s)}$$

$$\frac{bFSF^2}{s^2 + aFSF\,s + bFSF^2} = \frac{\frac{1}{R_1R_2C_1C_2}}{s^2 + \left(\frac{1}{R_1} + \frac{1}{R_2}\right)\frac{1}{C_1}s + \frac{1}{R_1R_2C_1C_2}}$$

Equating both,

$$bFSF^2 = \frac{1}{R_1R_2C_1C_2} \rightarrow (1) \quad \& \quad \left(\frac{1}{R_1} + \frac{1}{R_2}\right)\frac{1}{C_1} = aFSF \rightarrow (2)$$

For LPF filter, we get

$$(R_1+R_2)C_2 = \frac{a}{bFSF} = \frac{a}{b\omega_1}$$

& $bFSF^2 = b\omega_1^2 = \frac{1}{R_1R_2C_1C_2}$

We fix $C_2 = 10nF$ in eq^{n}s and either of R_1, R_2

2 eq^n, 2 unknown when C_2 & R_1 fixed..

Similarly for HPF;

on getting LPF: R_1, R_2, C_1, C_2 for a particular ω as LPF

The values for HPF are

$$C_1, \text{highpass} = \frac{1}{R_1, \text{Lowpass}}$$

$$C_2, \text{high pass} = \frac{1}{R_2, \text{lowpass}}$$

$$R_1, \text{highpass} = \frac{1}{C_1, \text{lowpass}}$$

$$R_2, \text{highpass} = \frac{1}{C_2, \text{lowpass}}.$$