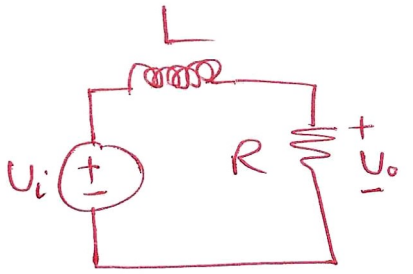
Chapter 14 :- Introduction to frequency selective circuits

14.2 Low-pass filters (LPF)

① RL

$$V_o(s) = \frac{R\,(V_i(s))}{sL + R} \quad \div \frac{L}{L}$$



$$\frac{V_o(s)}{V_i(s)} = H(s) = \frac{R/L}{s + R/L}$$

$s = j\omega$

$$H(j\omega) = \frac{R/L}{j\omega + R/L}$$

$$|H(j\omega)|^2 = \frac{R/L}{j\omega + R/L} \cdot \frac{R/L}{-j\omega + R/L}$$

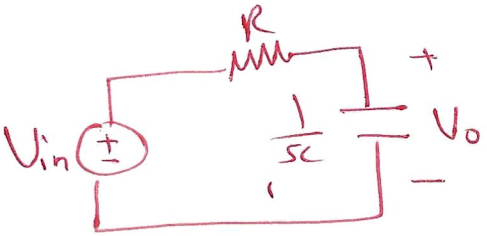
$$= \frac{(R/L)^2}{\omega^2 + (R/L)^2}$$

$$\therefore |H(j\omega)| = \sqrt{\frac{(R/L)^2}{\omega^2 + (R/L)^2}} = \frac{\overbrace{(R/L)}^{\omega_c}}{\sqrt{\omega^2 + (R/L)^2}}$$

$$\omega_c = \frac{R}{L} = 2\pi f_c$$

② RC (LPF)

$$H(s) = \frac{\frac{1}{sC}}{\frac{1}{sC} + R} = \frac{\overbrace{\frac{1}{RC}}^{\omega_c}}{s + \frac{1}{RC}}$$

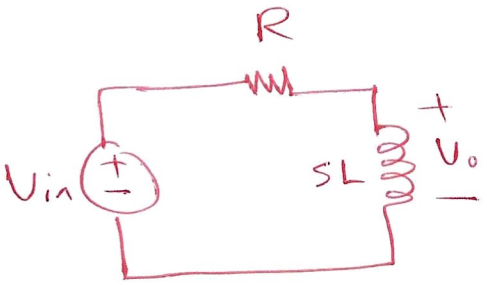


$$\omega_c = \frac{1}{RC}$$

14.3 High-pass filters

① RL (HPF)

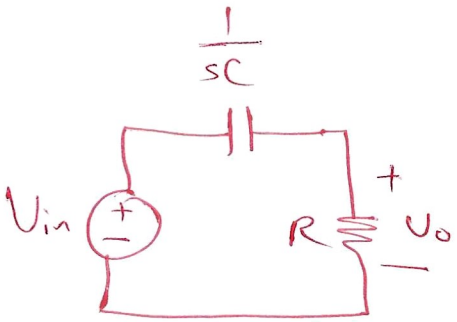
$$H(s) = \frac{sL}{sL+R} = \frac{s}{s+R/L} \qquad w_c$$



$$w_c = \frac{R}{L}$$

② RC (HPF)

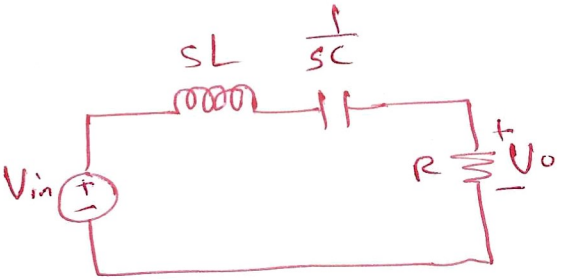
$$H(s) = \frac{R}{R+\frac{1}{sC}} = \frac{s}{s+\frac{1}{RC}}$$



$$w_c = \frac{1}{RC}$$

14.4 Band-pass filters (BPF)

① series RLC (BPF)



$$H(s) = \frac{R}{R+sL+\frac{1}{sC}} = \frac{R}{\frac{sCR+s^2LC+1}{sC}}$$

$$= \frac{sRC/LC}{s^2+\frac{sRC}{LC}+\frac{1}{LC}}$$

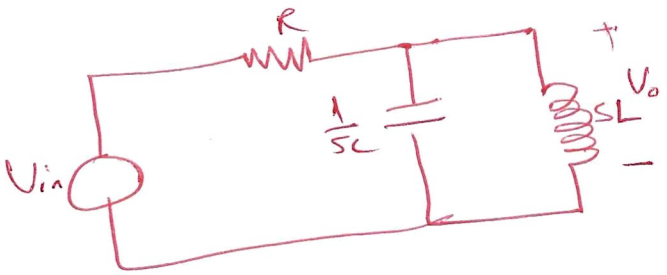
$$= \frac{s\left(\frac{R}{L}\right)}{s^2+s\left(\frac{R}{L}\right)+\frac{1}{LC}} = \frac{\beta s}{s^2+\beta s+w_o^2}$$

$$w_o = \frac{1}{\sqrt{LC}} \qquad \beta = \frac{R}{L} = w_{c2}-w_{c1} \qquad w_o = \sqrt{w_{c1}w_{c2}}$$

$$w_{c1} = -\frac{R}{2L}+\sqrt{\left(\frac{R}{2L}\right)^2+\frac{1}{LC}} \qquad Q = \frac{w_o}{\beta} = \sqrt{\frac{L}{CR^2}}$$

$$w_{c2} = \frac{R}{2L}+\sqrt{\left(\frac{R}{2L}\right)^2+\frac{1}{LC}}$$

② Parallel RLC – band pass filter (bpf)



$$H(s) = \frac{Z_{eq}}{Z_{eq} + R}$$

$$= \frac{\frac{s}{RC}}{s^2 + \frac{s}{RC} + \frac{1}{LC}} \equiv \frac{Bs}{s^2 + Bs + \omega_o^2}$$

$$\omega_{c1} = -\frac{1}{RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}}$$

$$\omega_{c2} = \frac{1}{RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}}$$

$$\omega_o = \sqrt{\omega_{c1}\omega_{c2}} = \frac{1}{\sqrt{LC}}$$

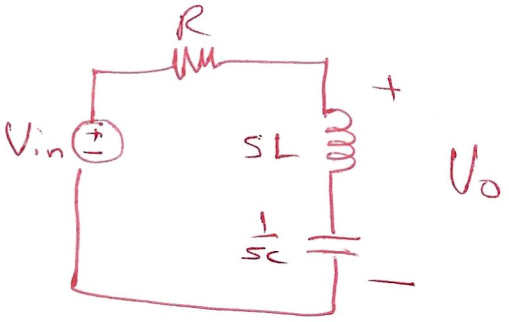
$$B = \omega_{c2} - \omega_{c1} = \frac{1}{RC}$$

$$Q = \frac{\omega_o}{B} = \frac{\frac{1}{\sqrt{LC}}}{\frac{1}{RC}} = \sqrt{\frac{R^2C}{L}}$$

14.5 Band-reject filters (BRF)

① Series RLC

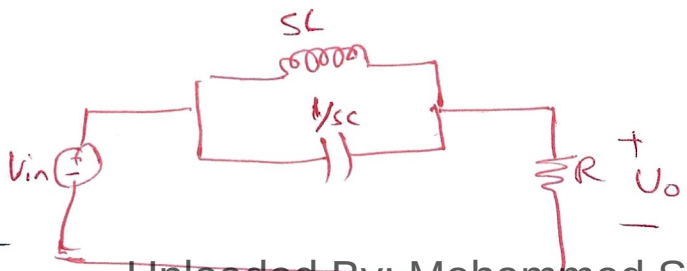
$$H(s) = \frac{s^2 + \left(\frac{1}{LC}\right)}{s^2 + s\left(\frac{R}{L}\right) + \frac{1}{LC}} \equiv \frac{s^2 + \omega_o^2}{s^2 + Bs + \omega_o^2}$$



ω_{c1}, ω_{c2}, ω_o, B and Q as in series RLC bandpass

② Parallel RLC BRF

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



ω_o, ω_{c1}, ω_{c2}, B and Q as in parallel RLC bpf