HW 2 Solutions Analog Filters.
E4215

Ans 2 (a)

Ckt 1 | Ckt 2
Series RLC | Parallel RLC

$\omega_0 = \frac{1}{\sqrt{LC}} = 2\pi \times 2.5 \times 10^9$

$C = 1\,pF$

$\Rightarrow L = 4\,nH$ | $L = 4\,nH$

$BW = R/L$ | $BW = 1/RC$

$\Rightarrow R = 12.7\,\Omega$ | $\Rightarrow R = 318.3\,\Omega$

(b) At 2.5 GHz i.e. at resonance frequency
C, L cancel each other.

$\therefore$ for ckt 1 (Series RLC) $i_s = \frac{1V}{R} = \frac{1}{12.7}\,A$ 78.7

for ckt 2 (|| RLC) $i_s = 1V/\infty = 0\,A$
(C, L cancel each other and effectively u have an open ckt at o/p)

(c) Ckt 1 $BW = (R + R_s)/L$

$\Rightarrow \left(\frac{R + R_s}{L}\right) = 1.1\, BW_0$ (where $BW_0$ is
BW of ~~previous~~ ckt
w/o $R_s$)

$$\frac{R+R_s}{L} = 1.1 \times BW_0 = 1.1\left(\frac{R}{L}\right)$$

$$\Rightarrow \frac{R_s}{L} = 0.1\left(\frac{R}{L}\right)$$

$$R_s = \frac{R}{10} = 1.92\,\Omega.$$

Ck 2 $\quad BW = \dfrac{1}{C(R+R_s)} = 0.9\, BW_0$

$$\frac{1}{C(R+R_s)} = 0.9 \frac{1}{CR} \quad \Rightarrow R+R_s = \frac{10}{9} R$$

$$\Rightarrow R_s = \frac{R}{9} = 35.3\,\Omega.$$

Ans 3 $\quad$ (a) $\quad \omega_B = \dfrac{1}{RC}$

b) for a low pass (secondorder) ckt BW↑ as Q↑ moreover it is clear that we require maximally flat response, or butterworth response.

$$\therefore Q = \frac{1}{\sqrt{2}}$$

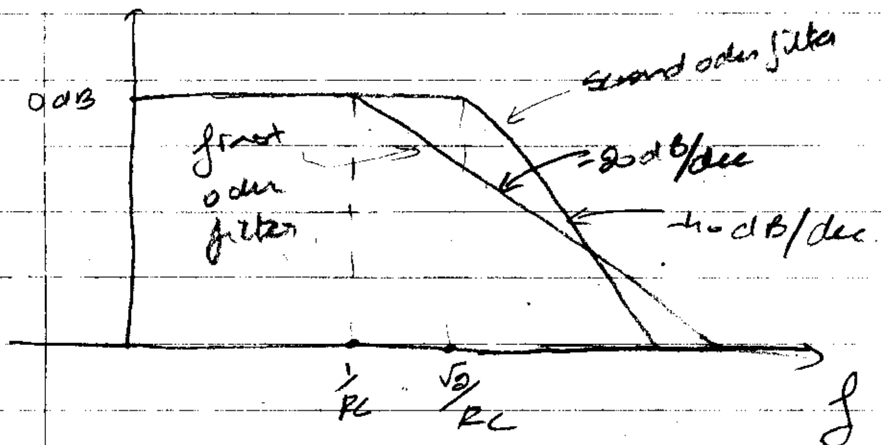
For series RLC $\quad Q = \dfrac{1}{R}\sqrt{\dfrac{L}{C}} = \dfrac{1}{\sqrt{2}}$

$$\Rightarrow L = \frac{R^2 C}{2}.$$

For second order Butterworth filter

$$BW = \omega_0 = \frac{1}{\sqrt{LC}}$$

in terms of $R, C$ $= \dfrac{1}{\sqrt{\frac{R^2C^2}{2}}} = \dfrac{\sqrt{2}}{RC}$




Ans 5

ckt 1

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

Ckt 2

$$V_0 = A(V_i - V_0)$$

$$V_0 + AV_0 = AV_i$$

$$\Rightarrow \frac{V_0(s)}{V_i(s)} = \frac{A}{1+A}$$

where $A = \dfrac{1}{\left(1 + s/\omega_p\right)^2}$

$$\therefore \quad H(s) = \frac{\dfrac{1}{(1+s/\omega_p)^2}}{1 + \dfrac{1}{(1+s/\omega_p)^2}} = \frac{1}{1 + \left(1 + \frac{s}{\omega_p}\right)^2}$$

(b)

<u>Ckt 1</u>

$$H(s) = \frac{1}{1 + \frac{2s}{\omega_p} + \frac{s^2}{\omega_p^2}}$$

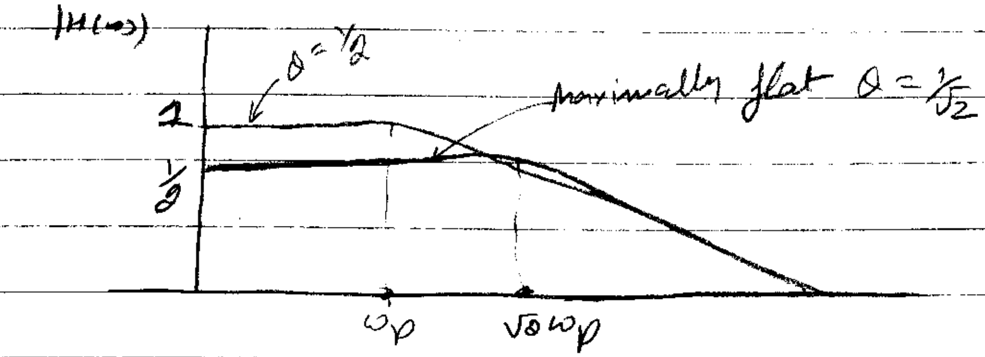
$\omega_0 = \omega_p \quad Q = \frac{1}{2}$

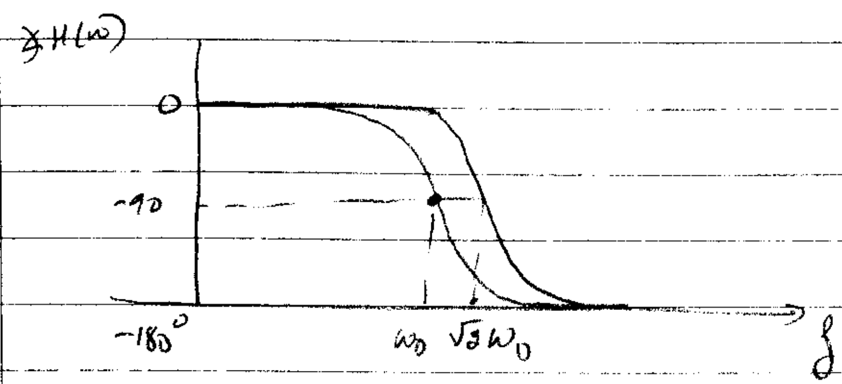
<u>Ckt 2</u>

$$H(s) = \frac{1}{2 + \frac{2s}{\omega_p} + \frac{s^2}{\omega_p^2}}$$

$$= \frac{1}{2} \frac{1}{1 + s/\omega_0 + \frac{s^2}{2\omega_0}}$$

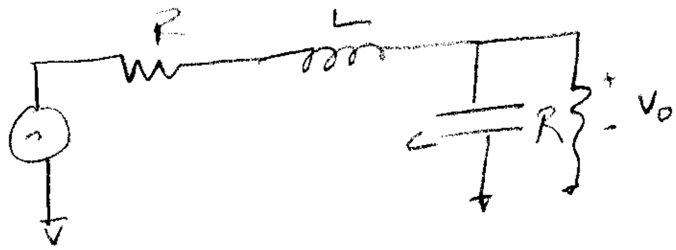
$\omega_0 = \sqrt{2}\,\omega_p \quad Q = \frac{1}{\sqrt{2}}$



HW 9 **Problem 1** 

Analog Filters




$$\frac{V_o}{V_i} = \frac{R_L \| C}{(R_L \| C) + (R_L + L)}$$

Voltage Divider

$$= \frac{\frac{R}{1+sRC}}{\frac{R}{1+sRC} + R + sL} = \frac{R}{s^2 CLR + s(CR^2+L) + 2R}$$

$$\therefore \omega_0^2 = \frac{2R}{CLR} = \frac{2}{CL} \text{ (constant)}$$

$$BW = \frac{1}{CR} + R/L$$

$$Q = \frac{\omega_0}{BW}$$

$$\frac{\partial Q}{\partial R} = \omega_0 \frac{\partial}{\partial R}\left(\frac{1}{CR} + R/L\right)$$

$$= \omega_0\left(-\frac{1}{CR^2} + 1/L\right)$$

$$\partial Q/\partial R = 0$$

$$\Rightarrow R = \sqrt{L/C}$$

$$\therefore \text{Max } Q = 1/\sqrt{2}$$

$$\& \ \omega_p = \text{constant} = \sqrt{2/LC}$$