Electrical Circuits (2)

Section (6)

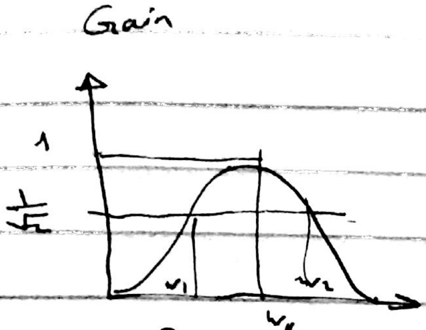
إضافي

17/3/2015

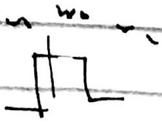
18/3/2015

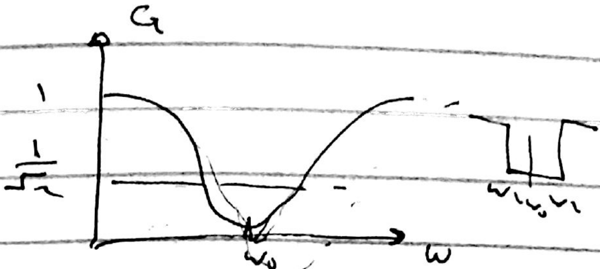
$\omega_0 = \frac{1}{\sqrt{LC}}$

Filters

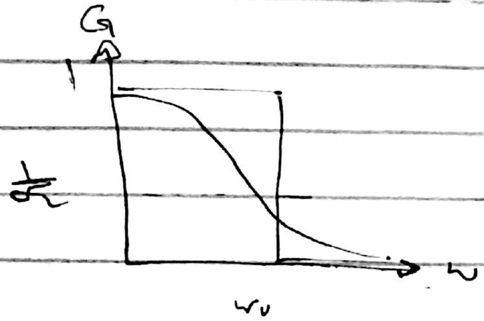


BPF

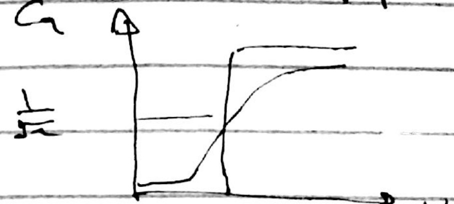




Band Reject filter.
(Notch)
(Band stop filter)



LPF



HPF

Circuits

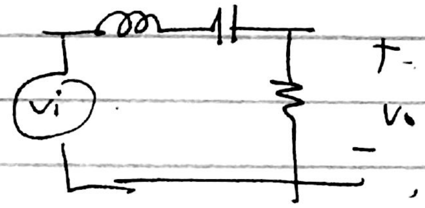
(1) passive BPF

a- O/p From Resistance

series Res.

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

$\left.\begin{matrix}\omega_1\\ \omega_2\end{matrix}\right\} \mp \frac{R}{2L}$



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

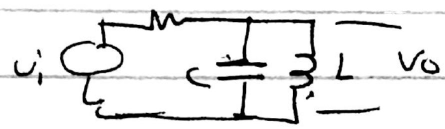
$$\omega_1 = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

$$\omega_2 = +\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

$$BW = R/L = \omega_2 - \omega_1$$

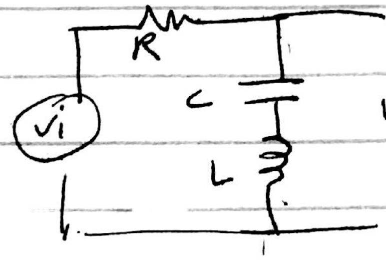
$H(f) = V_0/V_i$, $H(\omega) = \frac{1}{\sqrt{2}} H(\omega_{max})$

OR Parallel Res



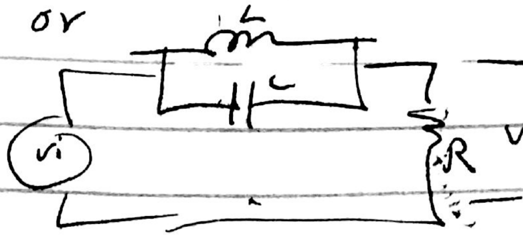
(2) Band Stop Filter (notch) (Reject)

(a)



Series Res

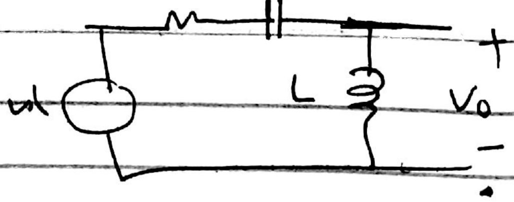
or



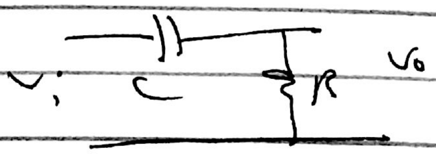
(b)

(2)

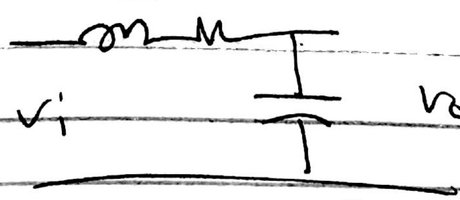
(3) HPF



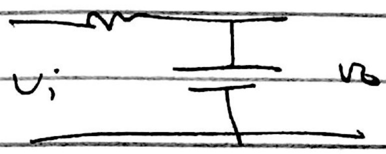
OR RC



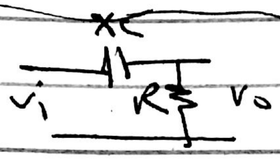
(4) LPF



OR RC



$H(f) = \frac{V_o}{V_i}$ ex



$V_o = V_i \frac{(R)}{R + X_c}$

$\frac{V_o}{V_i} = H(f) = \frac{R}{R + jwc}$ at $w=0$ $H(f) = 1$, at $w=\infty$ $H(f)=0$

$|H(f)| = \frac{R\angle 0}{\sqrt{R^2+w^2c^2}\angle\theta}$ ∴ $|H(f)| = \frac{R}{\sqrt{R^2+w^2c^2}}$ or $\frac{1}{\sqrt{1+(\frac{wc}{R})^2}}$ *

Self Study الـ مشابهات

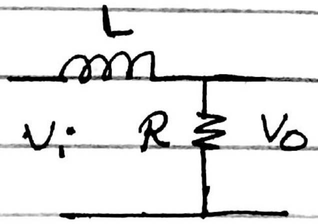
Seris يتواتير w_1 , w_2 تكون Series Res ملحوظة الـ
Parallel ———— Parallel ————

Sheet (5)

(1) Show That a series LR circuit is a lpF if o/p taken across a resistor & calc. Corner Freq f_c if $L = 2mH$ & $R = 10k$

((Solution))

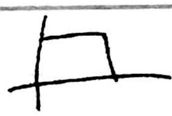
$$v_o = v_i \frac{R}{R + j\omega L}$$



$$\frac{v_o}{v_i} = H(f) = \frac{R}{R + j\omega L}$$

at $\omega = 0 \rightarrow H(f) = 1$

$\omega = \infty \rightarrow H(f) = 0$



(LPF)

Corner Freq. at $|H(f)| = \frac{1}{\sqrt{2}} H(0)$

$$H(f) = \frac{R}{R + j\omega L} = \frac{1}{1 + j\frac{\omega L}{R}}$$

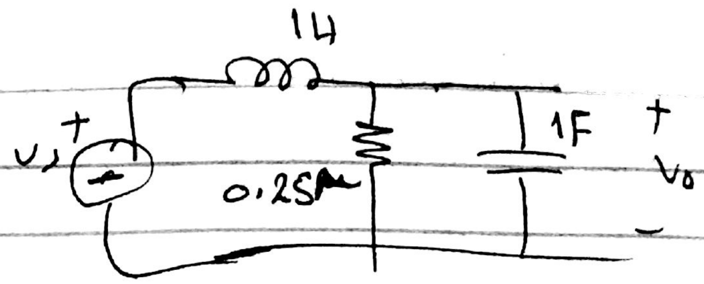
$$|H(f)| = \frac{1\angle 0}{\sqrt{1 + (\frac{\omega L}{R})^2}\angle\theta} = \frac{1}{\sqrt{1 + (\frac{\omega L}{R})^2}} = \frac{1}{\sqrt{2}}$$

$\therefore\ 1 + (\frac{\omega L}{R})^2 = 2$ or $\frac{\omega L}{R} = 1$ $\therefore\ \omega = \frac{R}{L}$

$\therefore\ 2\pi f = \frac{R}{L}$ $\therefore\ f = \frac{1}{2\pi}\frac{R}{L} = 796\ KHz$

4

2



$$H(f) = \frac{R \parallel x_c}{x_L + R \parallel x_c}$$

$$= \frac{R\left(\frac{1}{j\omega C}\right) / \left(R + \frac{1}{j\omega C}\right)}{j\omega L + \frac{R\left(\frac{1}{j\omega C}\right)}{R + \frac{1}{j\omega C}}}$$

$$= \frac{R\left(\frac{1}{j\omega C}\right)}{\left(R + \frac{1}{j\omega C}\right)(j\omega L) + R\left(\frac{1}{j\omega C}\right)}$$

$$= \frac{R}{R + (j\omega C)(j\omega L)\left(R + \frac{1}{j\omega C}\right)}$$

$$= \frac{R}{R - \omega^2 LC\left(R + \frac{1}{j\omega C}\right)}$$

$$= \frac{R}{R - \omega^2 LRC - \frac{1}{j}\omega L} = \frac{R}{R - \omega^2 LRC + j\omega L}$$

at $\omega = 0 \rightarrow H(f) = 1$

$\omega = \infty \rightarrow H(f) = 0$

$\Rightarrow$ LPF

(3) Determine cutoff freq of LPF $H(\omega) = \dfrac{4}{2+j\,10\omega}$ & find gain in dB & phase of $H(\omega)$ at $\omega = 2$ rad/s

Sol: cutoff freq calculated when

$$|H(\omega)| = \frac{1}{\sqrt{2}}|H(\omega)|_{max}$$

$$H(0) = \frac{4}{2} = 2 \rightarrow \text{i.e. max}$$

$$H(\infty) = 0$$

∴ ~~Becaus~~ cutoff freq calculated when $|H(\omega)| = \frac{1}{\sqrt{2}}(2)$

But $$|H(\omega)| = \frac{4\angle 0}{\sqrt{2^2+(10\omega)^2}\ \angle\theta} = \frac{\cancel{4}\,2}{\sqrt{4+100\omega^2}} = \frac{\cancel{2}\,1}{\sqrt{2}}$$

i.e. $$\frac{4}{4+100\omega^2} = \frac{1}{2}$$ i.e. $100\omega^2 + 4 = 8$

or $\omega^2 = \frac{4}{100}$ $\boxed{\omega = 0.2}$ rad/s

$$H(2) = \frac{4}{2+j20} = \frac{2}{1+j10}$$

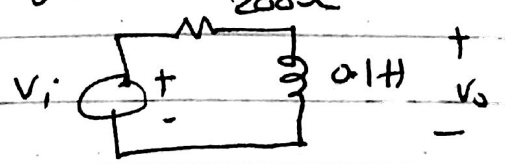
$$|H(2)| = \frac{2\angle 0}{\sqrt{101}\ \angle \tan^{-1}10} = \frac{2\angle 0}{\sqrt{101}\ \angle 84.3^\circ}$$

Phase $(0-\tan^{-1}10) = -84.3^\circ$

$$\text{Mag} = \frac{2}{\sqrt{101}} = 0.199$$

$$\text{Mag}_{dB} = 20\log 0.199 = -14.023$$

4) Determine what type of filter in figure, calc f_c



Sol//

$$V_o = V_i \left(\frac{\cancel{X}_L}{R + jX_L} \right)$$

$$H(f) = \frac{j\omega L}{R + j\omega L} = \frac{1}{1 + \frac{R}{j\omega L}}$$ at $\omega = 0 \rightarrow H(f) = 0$, $\omega = \infty \rightarrow H(f) = 1$

$\therefore$ HPF

$$\rightarrow |H(\omega)| = \frac{1}{\sqrt{2}} \text{ max} = \frac{1}{\sqrt{2}} H(\infty) = \frac{1}{\sqrt{2}}$$

$$= \left| \frac{1}{1 + \frac{R}{j\omega L}} \right| = \left| \frac{1}{1 - j\frac{R}{\omega L}} \right| = \frac{1}{\sqrt{1 + (\frac{R}{\omega L})^2}} = \frac{1}{\sqrt{2}}$$

or $1 + \left(\frac{R}{\omega L}\right)^2 = 2$ $\therefore$ $\boxed{\frac{R}{\omega L} = 1}$

$\therefore \omega = R/L$, $2\pi f = R/L \rightarrow f = 318.3\ Hz$

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5) in HPF with cutoff Freq 100KHZ, L = 40mH, find R

Sol// So it is RL

$$\omega = \frac{R}{\underbrace{L}_{40mH}} = 2\pi \underbrace{f}_{100K}$$

$R = 25.13\ K\Omega$

(6) Design a Series RLC type BPF with cutoff Freq. 10KHz, 11KHz, assuming $C = 80pF$, find R, L, and Q

Sol

$$\omega_1 = 2\pi f_1 = 20\pi \times 10^3$$
$$\omega_2 = 2\pi f_2 = 22\pi \times 10^3$$
$$B = \omega_2 - \omega_1 = 2\pi \times 10^3$$
$$\omega_0 = \frac{\omega_1 + \omega_2}{2} = 21\pi \times 10^3$$
$$Q = \frac{\omega_0}{B} = 10.5$$

Series RLC as series Resonance

$$\rightarrow \omega_0 = \frac{1}{\sqrt{LC}} \quad \therefore L = 2.87H$$

$$B = R/L \Rightarrow R = BL = 18\,K\Omega$$

(7) Determine The range of frequencies That will be passed By a series RLC BPF, $R = 10\Omega$, $L = 25mH$, $C = 0.4\mu F$ find Q

Sol/ series RLC $\Rightarrow \omega_0 = \frac{1}{\sqrt{LC}} = 10\,Krad/s$

$$B = R/L = 0.4\,Krad/s$$
$$Q = \omega/B = 25$$

$\rightarrow$ range of Freq ω_1, ω_2

$$\omega_1 = \omega_0 - B/2 = 9.8\,Krad/s, \quad f_1 = 1.56\,kHz$$
$$\omega_2 = \omega_0 + B/2 = 10.2\,Krad/s, \quad f_2 = 1.62\,kHz$$

$$f_1 < f < f_2$$

(8) a series parameter for series RLC bandstop filter are $R = 2K$, $L = 0.1H$, $C = 40PF$ calc
a) center Freq b) half Power freq c) Quality factor

Sol a- $w_0 = \frac{1}{\sqrt{LC}} = 0.5\times10^6$ rad/s

b- $w_1 = w_0 - B/2$
$w_2 = w_0 + B/2$ } $B = R/L = 2\times10^4$
$\therefore w_1 = 490$ krad/s
$w_2 = 510$ krad/s

c- $Q = w_0/B = 25$

(Assignment)

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[9] find BW & center freq. of Bandstop filter

a - sol for BW: Img(Z) = 0

b - " " BW $H(f) = \frac{1}{\sqrt{2}} H(max)$

a $Z = 6 + 4 \,//\, (x_L + x_C)$

$= 6 + 4 \,//\, (jwL + \frac{1}{jwC})$

$= 6 + 4 \,//\, (\frac{1 - w^2LC}{jwC})$

$= 6 + \frac{\frac{4(1-w^2LC)}{jwC}}{4 + \frac{1-w^2LC}{jwC}}$

$= 6 + \frac{4(1-w^2LC)}{4jwC + (1-w^2LC)}$

$= 6 + \frac{4(1-w^2LC)\big((1-w^2LC) - 4jwC\big)}{(1-w^2LC)^2 + (4wC)^2}$

Img(Z) = 0

$\therefore \frac{(4jwC)(4)(1-w^2LC)}{(1-w^2LC)^2 + (4wC)^2} = 0$

$\therefore w = 0$ Refused

$1 - w^2LC = 0$ or $w = \frac{1}{\sqrt{LC}}$

$\therefore w = 15.8$ krad/s

→ center freq $f_C = w/2\pi$

b- $H(f) = \frac{4 \,//\, (X_L + x_C)}{6 + 4 \,//\, (x_L + x_C)}$

$= \frac{\frac{4(1-w^2LC)\left[(1-w^2LC) - 4jwC\right]}{(1-w^2LC)^2 + (4wC)^2}}{6 + \ldots}$!!?

at $A(0)$ = max

$H(0) = \frac{4}{6+4}$

at w_1, w_2 $|H(f)| = \frac{1}{\sqrt{2}} \times \frac{4}{6+4}$

14.65 krad/s $= w_1$ تحلها ← w^4 في معادلة تطلع

17.06 krad/s w_2

$\therefore BW = w_2 - w_1 = 2.408$ krad/s

B =