# Assignment on passive filters

(1) Design a constant K-low pass filter having $f_c = 2KHZ$ and design impedance $R_0 = 600\Omega$. Obtain the value of attenuation at 4KHZ.
page No-762. (A. Chakrabarty)

(2) Design a constant K-high pass filter, having $f_c = 4KHZ$ and design impedance $R_0 = 600\Omega$.

(3) Design an R-L HP filter with $f_c = 2KHZ$ and having $R = 2K\Omega$

(4) In a series LCR type BPF, $L = 50mH$, $C = 127\mu F$ and $R_F = 63\Omega$. Determine
(i) the resonance frequency
(ii) the band width.
(iii) the cut-off frequencies.

(5) In a LCR type band stop filter $R = 1K\Omega$, $L = 115mH$, $C = 400pF$, Determine (i) the bandwidth (ii) cutoff frequency (iii) output voltage at $f_r$, $f_1$ and $f_2$.

(6) In a series resonance type BFF, $C = 1.8pF$, $L = 25mH$, $R_F = 52\Omega$ and $R_L = 9K\Omega$. Find $f_r$ and BW.

Solution:

(2)

(1) The values of the elements of constant-K-low pass filter are:

The series arm inductance:

$$L = \frac{R_0}{\pi f_c} = \frac{600}{\pi \times 2\times 10^3} H = 95.493 mH$$

The shunt capacitance,

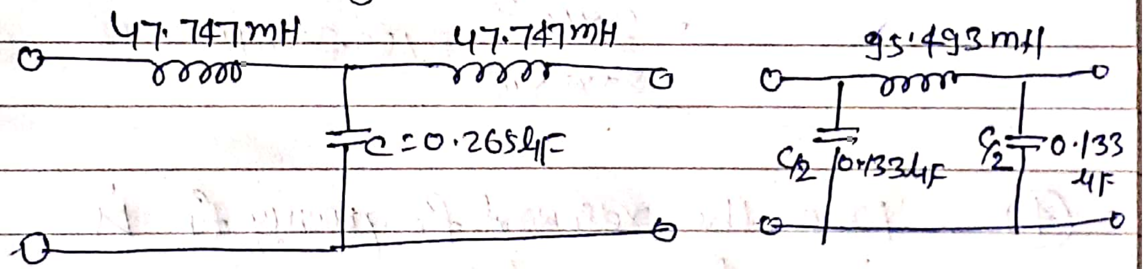
$$C = \frac{1}{\pi f_c R_0} = \frac{1}{\pi \times 2\times 10^3 \times 600} F = 0.265 \mu F$$

Let attenuation at 4KHZ be $\alpha$, where $\alpha$ is given by relation,

$$\alpha = 2\cosh^{-1}\left(\frac{f_x}{f_c}\right)$$

$$= 2\cosh^{-1}\left(\frac{4000}{2000}\right) \text{nepers} = 2.634 \text{ nepers}$$

The required T and $\pi$-section low pass filters are shown in fig. below.




(2) From the theory of high pass filter, the series arm capacitance (C) and shunt arm inductance (L) are given by

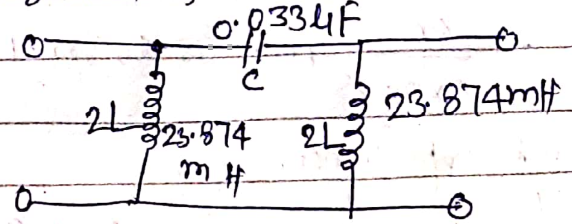
$$C = \frac{1}{4\pi R_0 f_c} = \frac{1}{4\times\pi\times 600\times 4000} F$$

$$= 0.033 \mu F$$

and $$L = \frac{R_0}{4\pi f_c} = \frac{600}{4\times\pi\times 4000} H = 11.937 mH$$

P.T.O

The required constant K π-section high pass filter is shown as below




Constant K π - section HPF

(3) From the equation of R-L HP filter

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

$$= \frac{2\times10^3}{2\pi\times2\times10^3}$$

$$= \frac{2\times10^3}{2\pi\times2\times10^3} = 159.25 mH$$

(4) From the resonant frequency $f_r$ is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}} \text{ HZ}$$

$$= \frac{1}{2\pi\sqrt{50\times10^{-3}\times127\times10^{-9}}} = 2 KHZ$$

Again, $R = \frac{R_F \times R_L}{R_F + R_L} = \frac{63\times600}{63+600} = 57\Omega$

$\therefore$ BW(band width) $= \frac{f_r}{Q} = \frac{2\times10^3}{11} = 181.8 HZ$

$$\left[ Q = \frac{\omega_r L}{R} = \frac{2\pi\times0.05}{57} = 11 \right]$$

$f_1$ = lower cut-off frequency

$= f_r - \frac{BW}{2}$

$= 2\times10^3 - \frac{182}{2} = 1909\ HZ$

$\therefore f_2$ = Higher cut-off frequency

$= f_r + \frac{BW}{2}$

$= 2\times10^3 + \frac{182}{2} = 2091\ HZ$

5

We know that

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.155\times400\times10^{-12}}}$$

$$= 20.50 KZ$$

However, $Q = \frac{W_r L}{R}$

$$= \frac{2\pi(20.55\times10^2)\times0.155}{1\times10^3} = 20 HZ$$

But it is evident that $Q = \frac{f_r}{BW}$

$$\therefore BW = \frac{f_r}{Q} = \frac{20.50\times10^3}{20} = 1025 HZ$$

Also, $f_1 = f_r - \frac{BW}{2} = 20\times10^3 - \frac{1025}{2}$

$= 19.49\ KHZ$

~~The requi~~

and $f_2 = f_r + \frac{BW}{2} = 20\times10^3 + \frac{1025}{2}$

$= 20.51\,KHZ.$

We observe that for the BSF given in the question

$|Z| = |X_L - X_C|$

& $|Z_T| = \sqrt{R^2 + (X_L - X_C)^2}$

at $f_r$, $X_L = X_C$

$|Z| = 0$ & $|Z_T| = R$

This gives $V_o = V_i\,\frac{0}{R} = 0$ at $f_r$

i.e. at $f = f_r$ the signal is completely attenuated

at $f = f_1$

∴ $X_L = 2\pi \times 19.49\times10^3 \times 0.0155 = 18.97\,K\Omega$

$X_C = \frac{1}{2\pi \times 19.49\times10^3 \times 400\times10^{-12}}$

$= 20.4\,K\Omega$

∴ $|X_L - X_C| = -1410\,\Omega$

$V_o = V_i \frac{\sqrt{(-1410)^2}}{\sqrt{(1000)^2 + (-1410)^2}} = 0.81\,V_i$ volts

at $f = f_2$

$X_L = 2\pi \times 20.51\times10^3 \times 0.155 = 19.97\,K\Omega$

(6)

$$X_C = \frac{1}{2\pi \times 20.51 \times 10^3 \times 400 \times 10^{-12}} = 19.45\Omega$$

$$\therefore |X_L - X_C| = 1150\Omega$$

$\therefore$ $V_o$ at $f = f_2$ is $V_i \dfrac{\sqrt{(1150)^2}}{\sqrt{(1000)^2 + (1150)^2}}$

$$= 0.75 V_i \text{ volts}$$

i.e. 75% of the signal will pass at $f = f_2$.

Idealy 70.7% signal should have passed through for $f = f_1$ or $f_2$. The error has come due to negligence of resistance in the inductance coil which should be taken into account for all accurate calculations.

~~$R + jX$~~

~~$Z = R + jX$~~

~~$Z = R + jX_L$~~

~~$Z = R - jX_C$~~

(6) We know that

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.025 \times 1.8 \times 10^{-12}}} = 751 KZ$$

$$\text{and } R = \frac{R_F * R_L}{R_F + R_L} = \frac{52 \times 9000}{52 + 9000} = 52\Omega$$

$$\therefore Q_{factor} = \frac{W_r L}{R} = \frac{2\pi \times 751 \times 25 \times 10^{-3}}{52} = 2270$$

$$\text{Thus } BW = \frac{f_r}{Q} = \frac{751 \times 10^3}{2270} = 331 HZ$$

$f_1$ and $f_2$ can also be found out as

$$f_1 = f_r - \frac{BW}{2} = 751 \times 10^3 - \frac{331}{2}$$

$$= 750.849 \text{ KHZ}$$

and $$f_2 = f_r + \frac{BW}{2} = 751.162 \text{ KHZ}$$

Scanned with CamScanner