BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Electrical and Computer Engineering Department

ENEE2110

ELECTRIC CIRCUITS LAB

Experiment.10 Prelab

Frequency selective circuits

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Teacher assistance:

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1. Calculate the cut-off frequency (f_c) for the high pass and low pass filters shown in Figures 10.13 and 10.14.

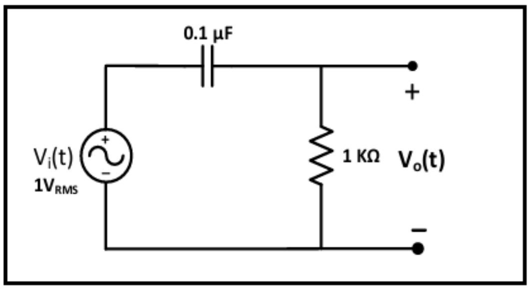

Figure 10.13

Figure 1: First-order RC High Pass Filter

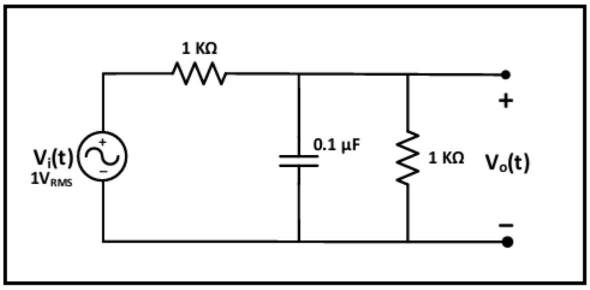

Figure 10.14

Figure 2: First-order RC Loaded Low Pass Filter

- ❖ **First-order RC High Pass Filter**

$$\mathrm{w_c} = \frac{1}{\mathrm{R} \times \mathrm{C}} = \frac{1}{1 \times 10^3 \times 0.1 \times 10^{-6}} = 10000\mathrm{rad/s}$$

- ❖ $\mathrm{f_c} = \frac{\mathrm{w_c}}{2\times\pi} = \frac{10000}{2\times\pi} = 1592.356\mathrm{Hz}$

- ❖ **First-order RC Loaded Low Pass Filter**

$$w_c = \frac{1}{\left(\frac{R_s \times R_l}{R_s + R_l}\right) \times C} = \frac{1}{\left(\frac{1 \times 10^3 \times 1 \times 10^3}{1 \times 10^3 + 1 \times 10^3}\right) \times 0.1 \times 10^{-6}} = 20000 rad/s$$

- ❖ $\mathrm{f_c} = \frac{\mathrm{w_c}}{2\times\pi} = \frac{20000}{2\times\pi} = 3184.71337\mathrm{Hz}$

2. Simulate the circuits mentioned in step 1 using ac sweep with a Vac source at 1 V amplitude, for each of the circuits plot the magnitude in decibel scale (dB (Vo)) and phase p(Vo).

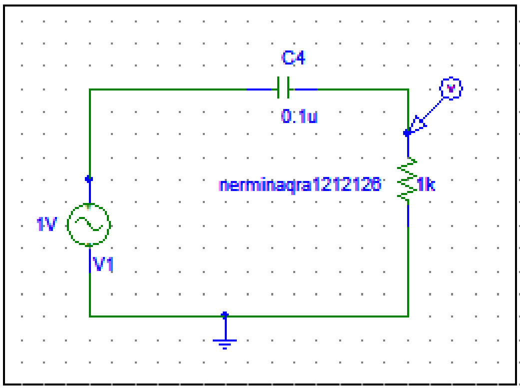

Figure 3:First-order RC High Pass Filter

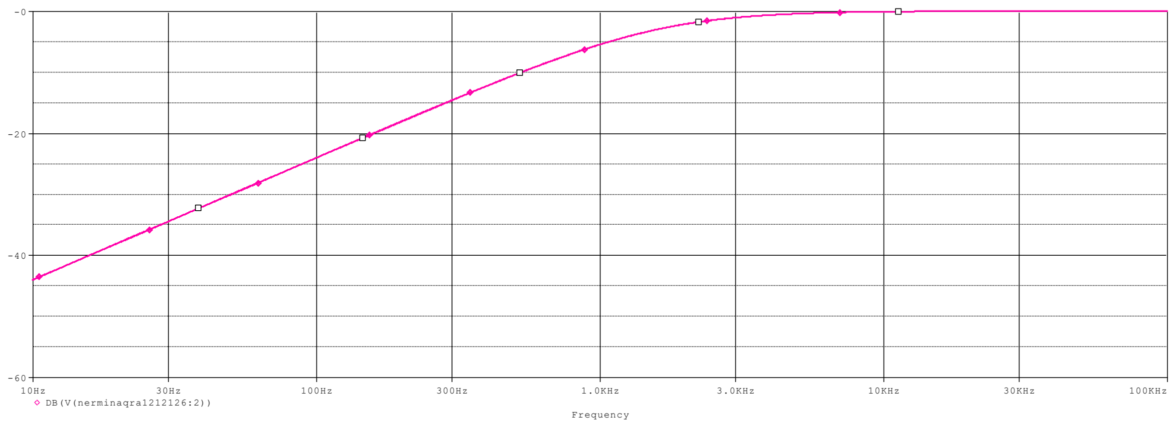

Figure 4: the magnitude in decibel scale (dB (Vo))

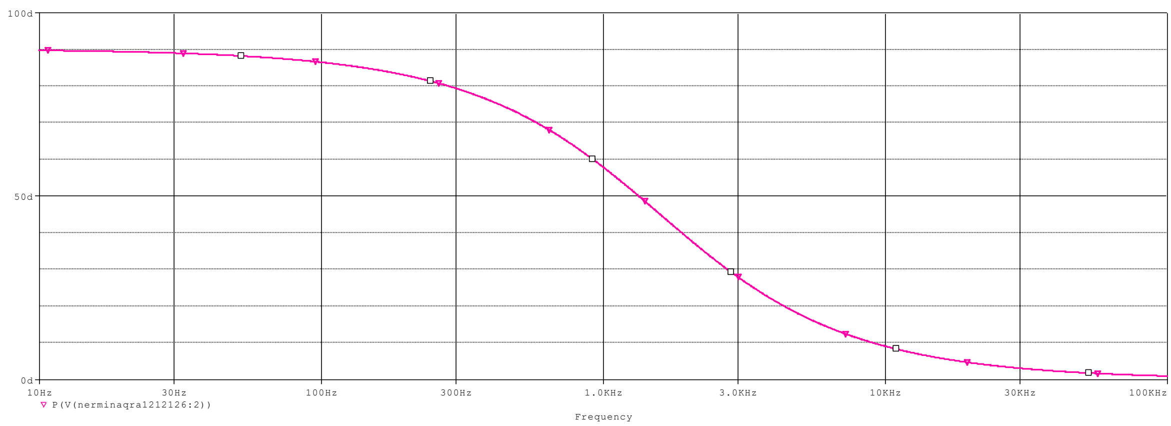

Figure 5: the magnitude phase p(Vo)

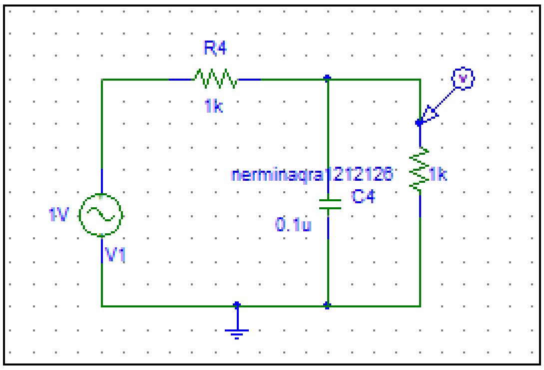

Figure 6: First-order RC Loaded Low Pass Filter

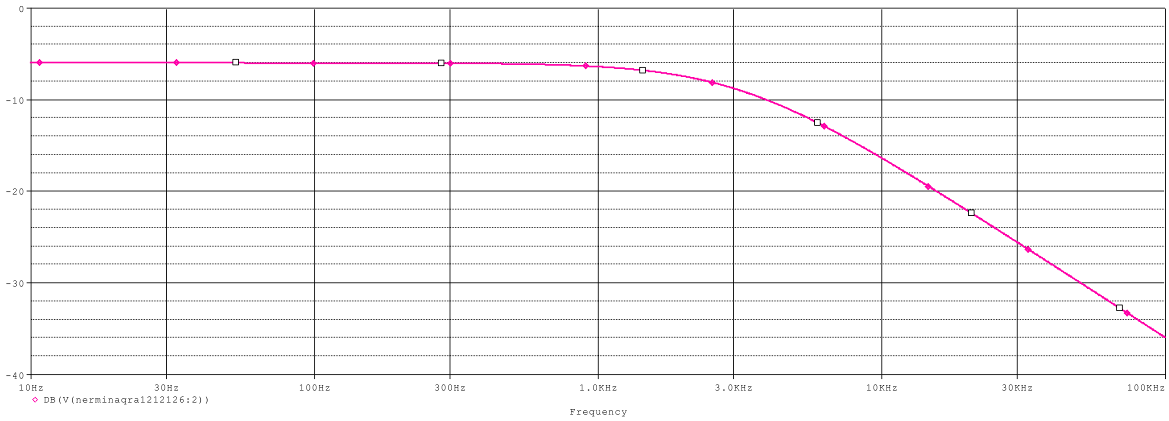

Figure 7:the magnitude in decibel scale (dB (Vo))

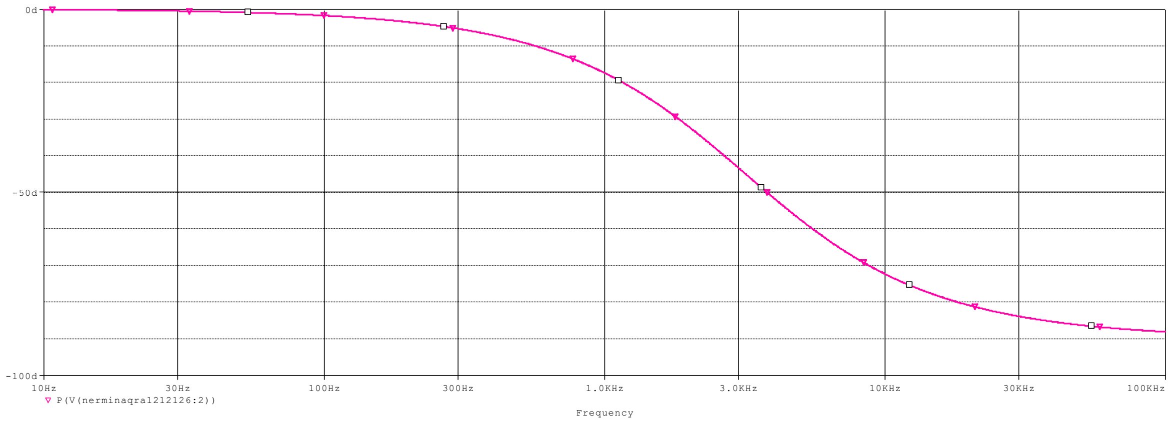

Figure 8:the magnitude phase p(Vo)

3. Calculate the center frequency (f_0), two cut-off frequencies (f_{c1} and f_{c2}),and bandwidth (β) in Hertz for the circuit in Figure 10.15 with two values of R (3.2 kΩ and 1.6 kΩ).

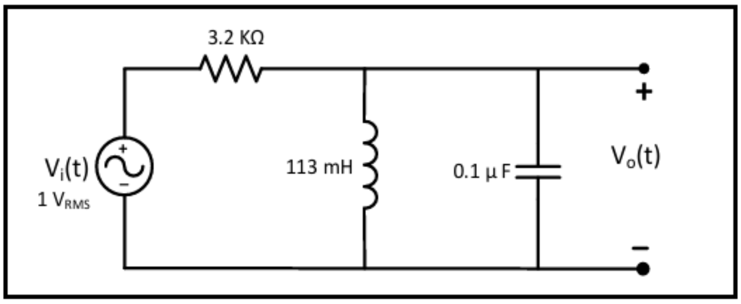

Figure 10.15

Figure 9: Parallel RLC Band Pass Filter

$$w_0 = \frac{1}{\sqrt{L \times C}} = \frac{1}{\sqrt{113 \times 10^{-3} \times 0.1 \times 10^{-6}}} = 9407.2086 rad/s$$

❖ $f_0 = \frac{w_0}{2\times\pi} = \frac{9407.2086}{2\times\pi} = 1497.963\text{Hz}$

When R=3.2KΩ

$$w_{c1,c2} = \pm\frac{1}{2 \times R \times c} + \sqrt{\left(\frac{1}{2 \times R \times C}\right)^2 + \left(\frac{1}{L \times C}\right)}$$

$$w_{c1,c2} = \pm\frac{1}{2\times3.2\times10^3\times0.1\times10^{-6}} + \sqrt{\left(\frac{1}{2\times3.2\times10^3\times0.1\times10^{-6}}\right)^2 + \left(\frac{1}{113\times10^{-3}\times0.1\times10^{-6}}\right)}$$

$$w_{c1} = 7973.58837 rad/s \quad \&\& \; w_{c2} = 11098.58837 rad/s$$

❖ $f_1 = \frac{w_{c1}}{2\times\pi} = \frac{7973.58837}{2\times\pi} = 1269.6796\text{Hz}$

❖ $f_2 = \frac{w_{c2}}{2\times\pi} = \frac{11098.58837}{2\times\pi} = 1767.2911\text{Hz}$

❖ Bandwidth→ $\beta = w_{c2} - w_{c1} = 11098.58837 - 7973.58837$

$$\beta = 3125 rad/s \; \rightarrow \beta = 497.611 Hz$$

❖ $f_0 = \frac{w_0}{2\times\pi} = \frac{9407.2086}{2\times\pi} = 1497.963\text{Hz}$

When R=1.6KΩ

$$w_{c1,c2} = \pm\frac{1}{2\times R\times c} + \sqrt{\left(\frac{1}{2\times R\times C}\right)^2 + \left(\frac{1}{L\times C}\right)}$$

$$w_{c1} = \pm\frac{1}{2\times 1.6\times 10^3\times 0.1\times 10^{-6}}\sqrt{\left(\frac{1}{2\times 1.6\times 10^3\times 0.1\times 10^{-6}}\right)^2 + \left(\frac{1}{113\times 10^{-3}\times 0.1\times 10^{-6}}\right)}$$

$$w_{c1} = 6787.67876rad/s \quad \&\& \; w_{c2} = 13037.67876rad/s$$

- $f_1 = \frac{w_{c1}}{2\times\pi} = \frac{6787.67876}{2\times\pi} = 1080.8405Hz$
- $f_2 = \frac{w_{c2}}{2\times\pi} = \frac{13037.67876}{2\times\pi} = 2076.0634Hz$
- Bandwidth→ $\beta = w_{c2} - w_{c1} = 13037.67876 - 6787.67876$

$$\beta = 6250rad/s \;\rightarrow \beta = 995.2229Hz$$

- $f_0 = \frac{w_0}{2\times\pi} = \frac{9407.2086}{2\times\pi} = 1497.963Hz$

4. Calculate the center frequency (f_0), two cut-off frequencies (f_{c1} and f_{c2}), and bandwidth (β) in Hertz for the circuit in Figure 10.15 with R = 3.2 kΩ and with another value of L = 60mH.

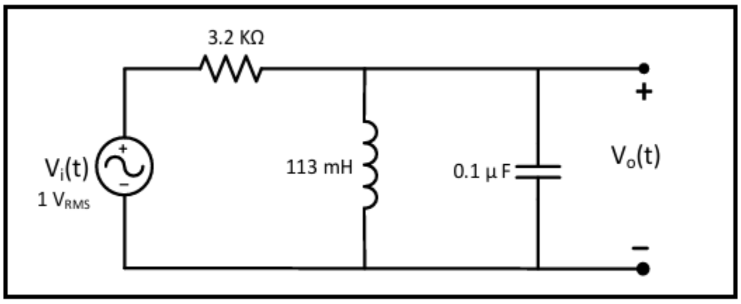

Figure 10.15

Figure 10:Figure 9: Parallel RLC Band Pass Filter

$$w_0 = \frac{1}{\sqrt{L \times C}} = \frac{1}{\sqrt{60 \times 10^{-3} \times 0.1 \times 10^{-6}}} = 12909.9444 rad/s$$

❖ $f_0 = \frac{w_0}{2\times\pi} = \frac{12909.9444}{2\times\pi} = 2055.7236\text{Hz}$

$$w_{c1,c2} = \pm\frac{1}{2 \times R \times c} + \sqrt{\left(\frac{1}{2 \times R \times C}\right)^2 + \left(\frac{1}{L \times C}\right)}$$

$$w_{c1,c2} = \pm\frac{1}{2\times3.2\times10^3\times0.1\times10^{-6}} + \sqrt{\left(\frac{1}{2\times3.2\times10^3\times0.1\times10^{-6}}\right)^2 + \left(\frac{1}{60\times10^{-3}\times0.1\times10^{-6}}\right)}$$

$$w_{c1} = 11441.65599 rad/s \quad \&\& \; w_{c2} = 14566.65599 rad/s$$

❖ $f_1 = \frac{w_{c1}}{2\times\pi} = \frac{11441.65599}{2\times\pi} = 1821.91974\text{Hz}$

❖ $f_2 = \frac{w_{c2}}{2\times\pi} = \frac{14566.65599}{2\times\pi} = 2319.531209\text{Hz}$

❖ Bandwidth→ $\beta = w_{c2} - w_{c1} = 14566.65599 - 11441.65599$

$$\beta = 3125 rad/s \; \rightarrow \beta = 497.611 Hz$$

5. Repeat step 2 for the circuits mentioned in step 3.

➢ **When R = 3.2 kΩ**

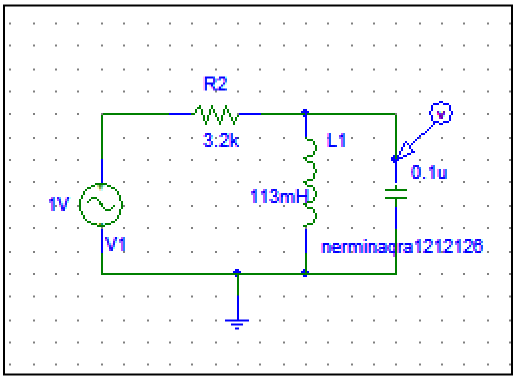

Figure 11: Parallel RLC Band Pass Filter

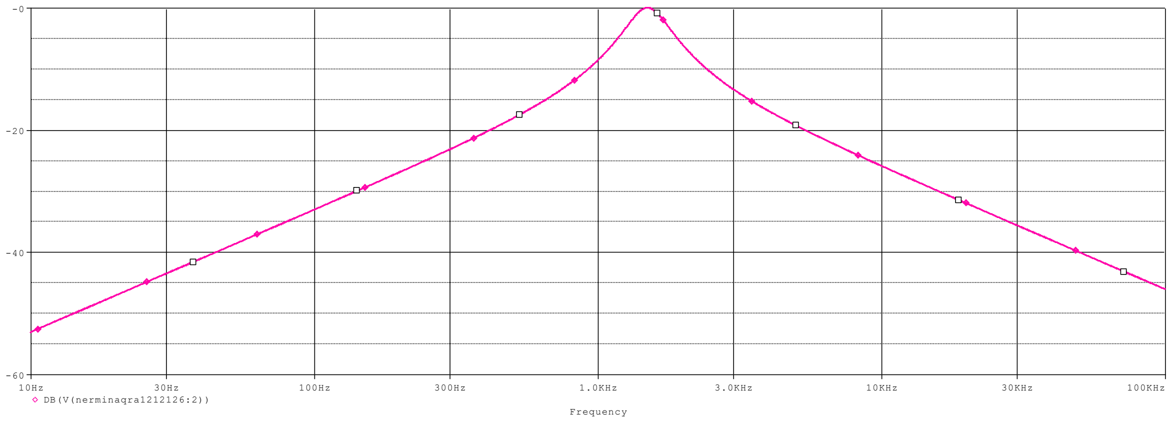

Figure 12:the magnitude in decibel scale (dB (Vo))

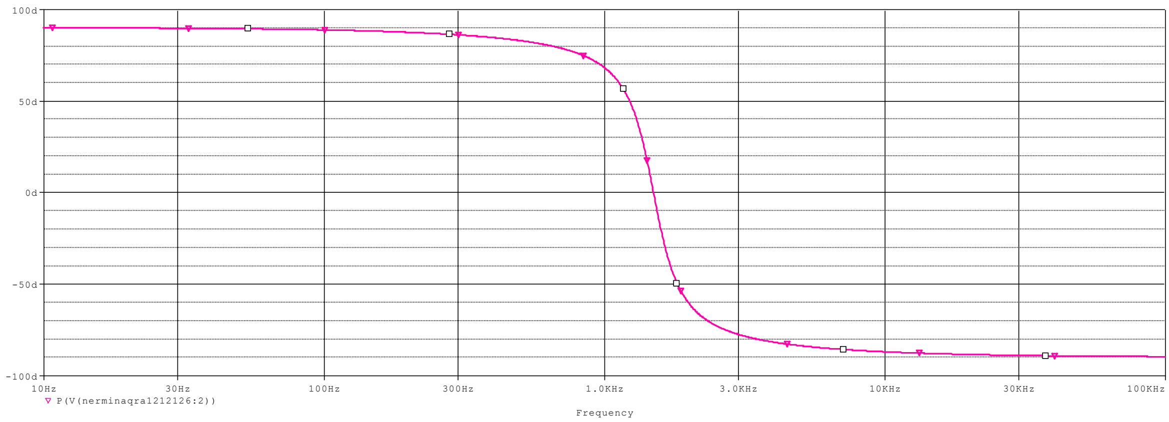

Figure 13:the magnitude phase p(Vo)

➢ **When R = 1.6 kΩ**

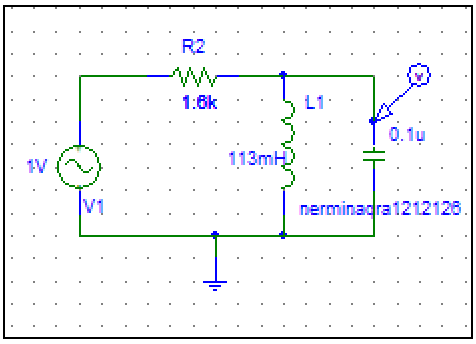

Figure 14:Parallel RLC Band Pass Filter

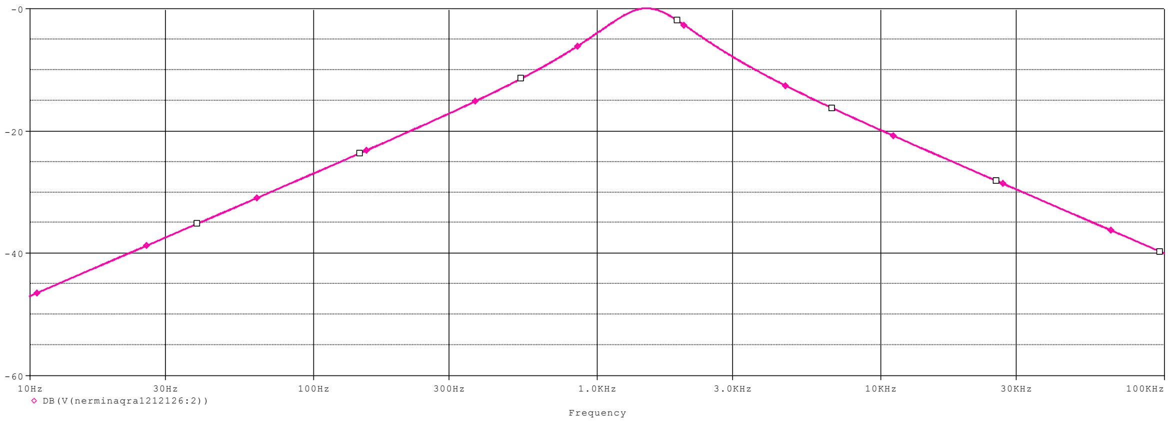

Figure 15:the magnitude in decibel scale (dB (Vo))

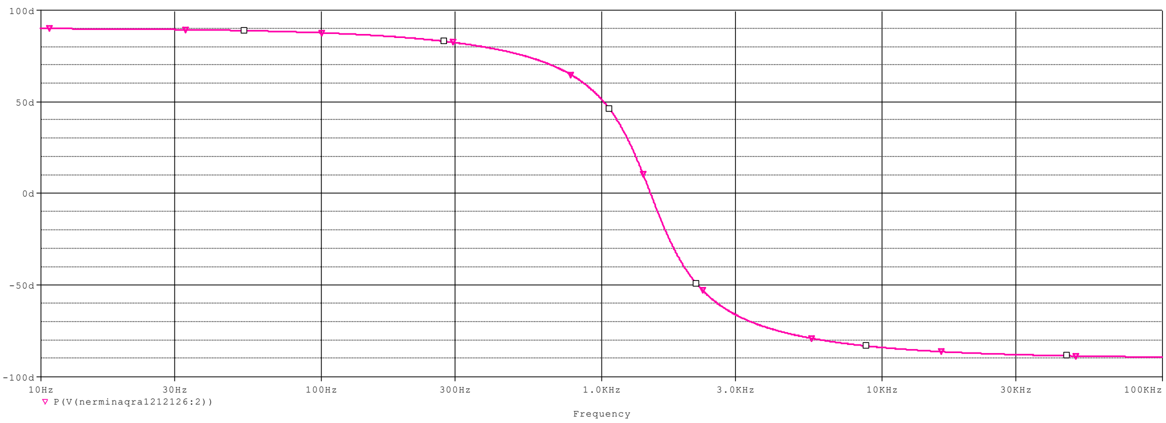

Figure 16:the magnitude phase p(Vo)

6. Calculate the center frequency (f0), two cut-off frequencies (fC1 and fC2), and bandwidth (β) in Hertz for the circuit in Figure 10.16 with two values of R (3.5 kΩ and 7.1 kΩ).

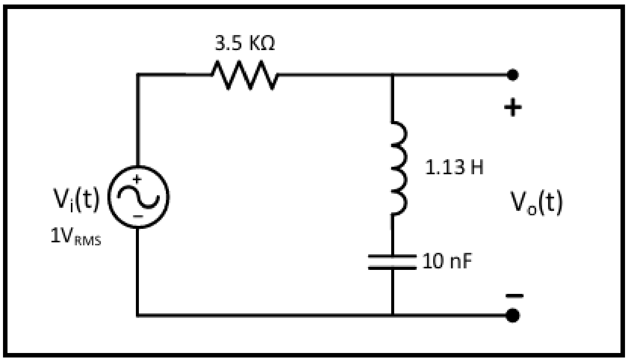

Figure 10.16

Figure 17:Series RLC Band Reject Filter

$$w_0 = \sqrt{\frac{1}{L \times C}} = 9407.208684 rad/s$$

❖ $f_0 = \frac{w_0}{2\times\pi} = \frac{9407.2086}{2\times\pi} = 1497.963Hz$

When R=3.5KΩ

$$w_{c1,c2} = \pm\frac{R}{2 \times L} + \sqrt{\left(\frac{R}{2 \times L}\right)^2 + \left(\frac{1}{L \times C}\right)}$$

$$w_{c1,c2} = \pm\frac{3.5\times10^3}{2\times1.13} + \sqrt{\left(\frac{3.5\times10^3}{2\times1.13}\right)^2 + \left(\frac{1}{1.13\times10\times10^{-9}}\right)}$$

$$w_{c1} = 7985.15992 rad/s \quad \&\& \; w_{c2} = 11082.50506 rad/s$$

❖ $f_1 = \frac{w_{c1}}{2\times\pi} = \frac{7985.15992}{2\times\pi} = 1271.52228Hz$

❖ $f_2 = \frac{w_{c2}}{2\times\pi} = \frac{11082.5056}{2\times\pi} = 1764.730191Hz$

❖ Bandwidth→ $\beta = w_{c2} - w_{c1} = 11082.50506 - 7985.15992$

$$\beta = 3097.34 rad/s \rightarrow \beta = 493.20782 Hz$$

❖ $f_0 = \frac{w_0}{2\times\pi} = \frac{9407.2086}{2\times\pi} = 1497.963Hz$

When R=7.1KΩ

$$w_{c1,c2} = \pm\frac{R}{2\times L} + \sqrt{\left(\frac{R}{2\times L}\right)^2 + \left(\frac{1}{L\times C}\right)}$$

$$w_{c1,c2} = \pm\frac{7.1\times10^3}{2\times1.13} + \sqrt{\left(\frac{7.1\times10^3}{2\times1.13}\right)^2 + \left(\frac{1}{1.13\times10\times10^{-9}}\right)}$$

$$w_{c1} = 6776.329307 rad/s \quad \&\& \; w_{c2} = 13059.51515 rad/s$$

- $\mathrm{f}_1 = \frac{\mathrm{w}_{c1}}{2\times\pi} = \frac{6776.329307}{2\times\pi} = 1079.033329\mathrm{Hz}$
- $\mathrm{f}_2 = \frac{\mathrm{w}_{c2}}{2\times\pi} = \frac{13059.51515}{2\times\pi} = 2079.540629\mathrm{Hz}$
- Bandwidth→ $\beta = w_{c2} - w_{c1} = 13059.51515 - 6776.329307$

$$\beta = 6283.185843 rad/s \;\rightarrow \beta = Hz$$

- $\mathrm{f}_0 = \frac{\mathrm{w}_0}{2\times\pi} = \frac{9407.2086}{2\times\pi} = 1497.963\mathrm{Hz}$

7. Repeat step 2 for the circuits mentioned in step 6.

➢ **When R=3.5KΩ**

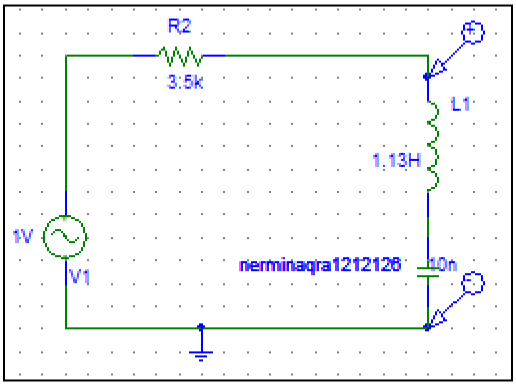

Figure 18:Series RLC Band Reject Filter

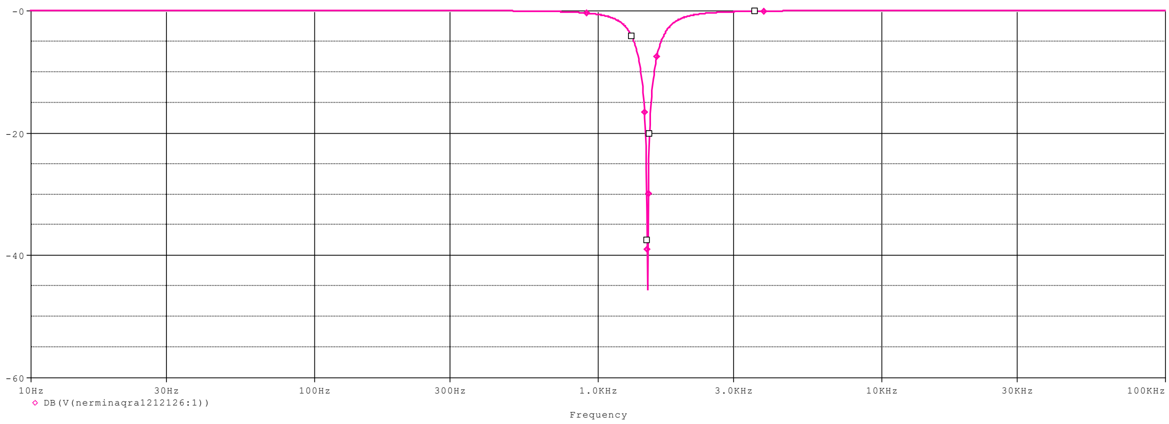

Figure 19:the magnitude in decibel scale (dB (Vo))

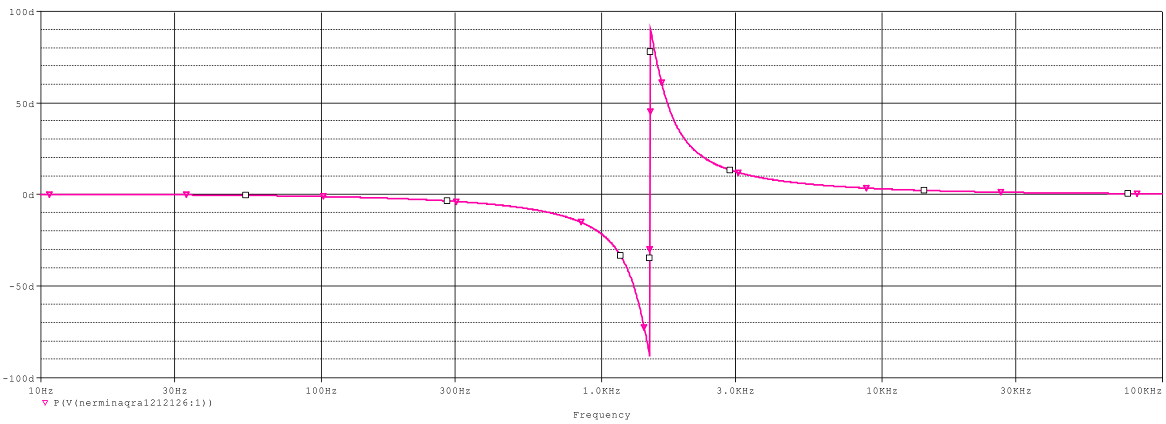

Figure 20:the magnitude phase p(Vo)

- **When R=7.1KΩ**

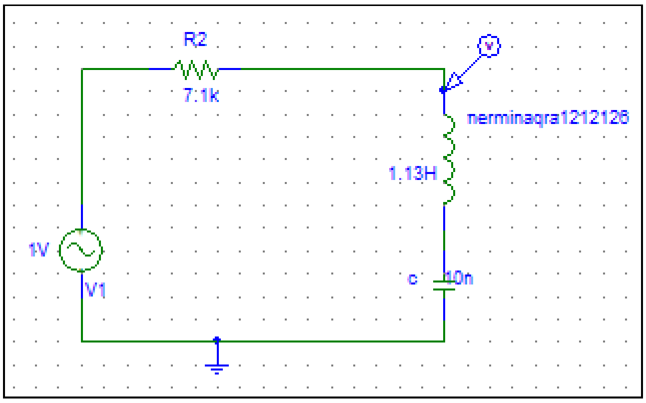

Figure 21:Series RLC Band Reject Filter

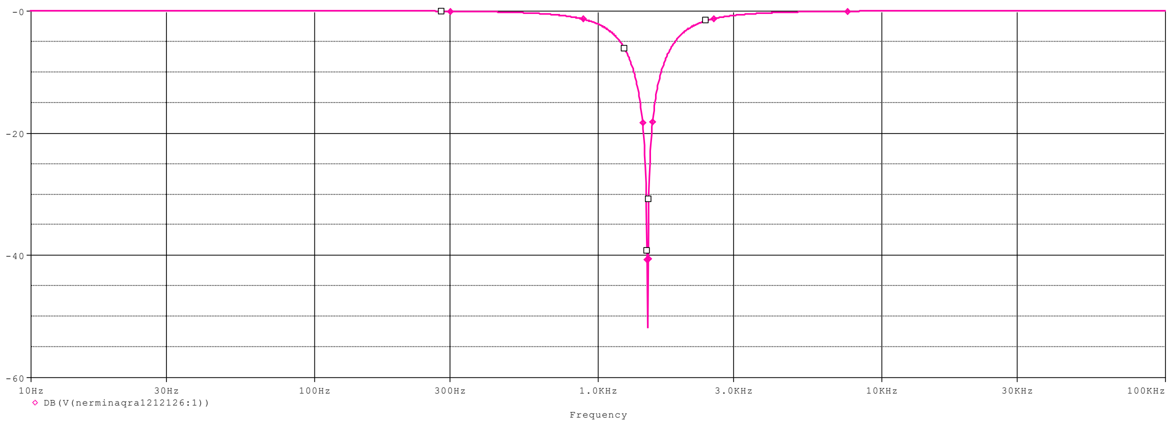

Figure 22:the magnitude in decibel scale (dB (Vo))

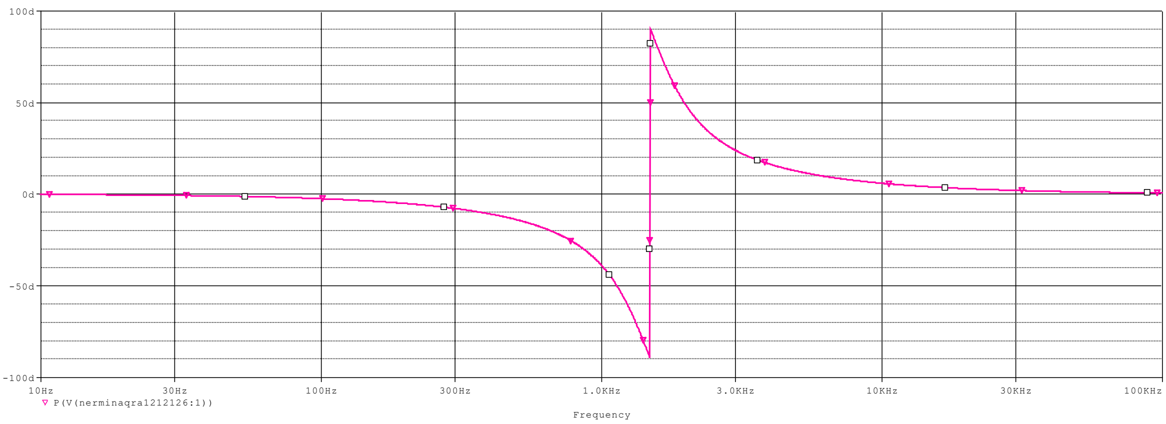

Figure 23:the magnitude phase p(Vo)