EE 205 Circuit Theory

Lab 6

Passive Filter Analysis by Laplace Transform

The aim of this lab is to use analyze passive filters through their transfer function. Simulate the results using Proteus.

Low Pass Filter (LPF):

Consider the example circuit given in Fig.1. We have already studied this circuit in the lecture. Here, we want to verify the calculated results with the Proteus simulations.

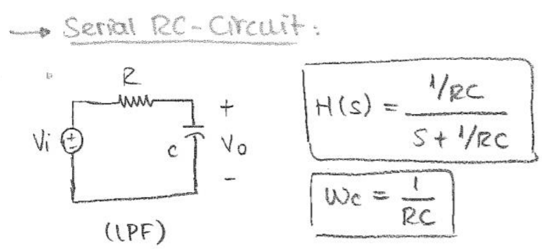


Fig.1. LPF circuit and its transfer function.

Suppose that the cut-off frequency $f_c = 10\ kHz$ is desired. Then, let $R = 1k$ gives $C \approx 16\ nF$.

Procedure:

1. Implement the following LPF circuit in Proteus.

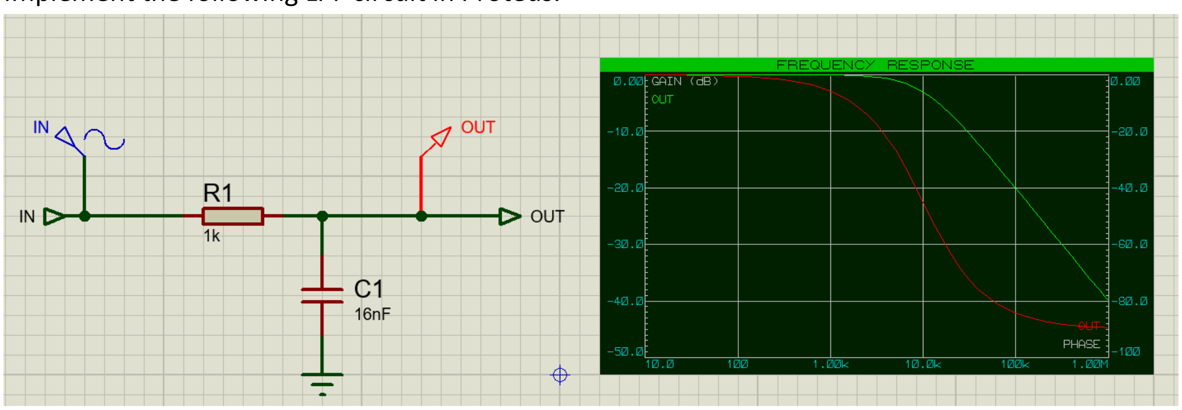


Fig.2. LPF proteus implementation

2. Connect ports “IN” and “OUT”.
3. Connect a sin input as a voltage source with 1V amplitude and 100Hz frequency.
4. From the graphs, select frequency graph and place it on the page.
5. Double click the graph and set the “reference” value as “IN”.
6. Then run the graph.
7. Fill the table below.

Table 1.

fc (calculated)	fc (measured) in dB	Roll-off (dB/dec)	Phase at fc in degrees.

High Pass Filter (HPF):

Consider the example circuit given in Fig.3. We have already studied this circuit in the lecture. Here, we want to verify the calculated results with the Proteus simulations.

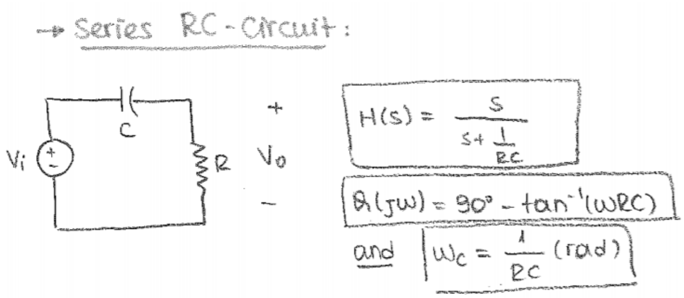


Fig.3. HPF circuit and its transfer function.

Suppose that the cut-off frequency $f_c = 10\ kHz$ is desired. Then, let $R = 1k$ gives $C \approx 16\ nF$.

Procedure:

1. Implement the following HPF circuit in Proteus.

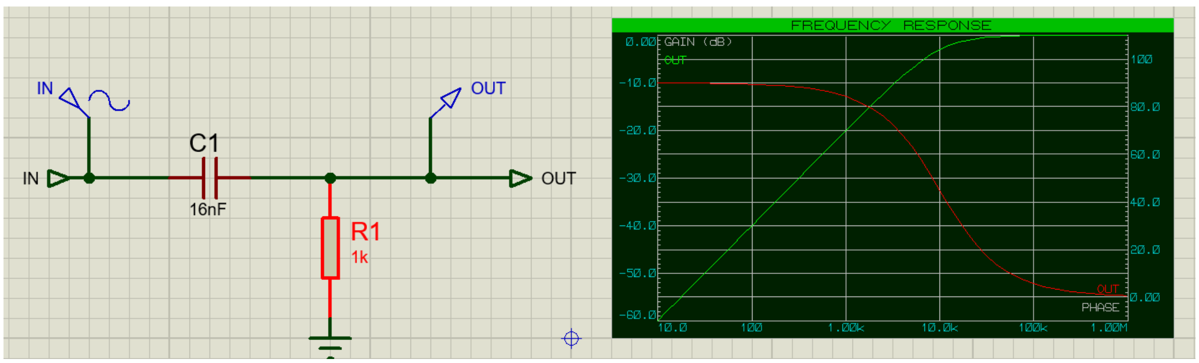


Fig.4. HPF Proteus implementation

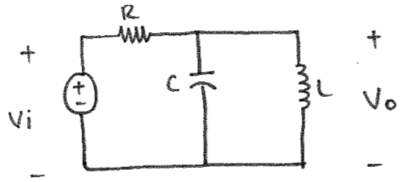
2. Fill the table below.

Table 2.

fc (calculated)	fc (measured) in dB	Roll-off (dB/dec)	Phase at fc in degrees.

Band Pass Filter (BPF):

Consider the example circuit given in Fig.5. We have already studied this circuit in the lecture. Here, we want to verify the calculated results with the Proteus simulations.



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

$|H(j\omega)|$ is max when $\left(\frac{1}{LC} - \omega^2\right)^2 = 0$ which gives; $\omega_0 = \sqrt{\frac{1}{LC}}$ and $|H(j\omega)| = 1 = \max$. To find ω_{c_1} and ω_{c_2} $\longrightarrow$ $\frac{1}{\sqrt{2}} = |H(j\omega_{c_1})|$ which gives;

$\omega_{c_1} = -\frac{1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \left(\frac{1}{LC}\right)}$, $\omega_2 = \frac{1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \left(\frac{1}{LC}\right)}$

and $B = \omega_{c_2} - \omega_{c_1} = \frac{1}{RC}$ and $Q = \frac{\omega_0}{B} = \sqrt{\frac{R^2C}{L}}$

so; $\omega_{c_1} = -\frac{B}{2} + \sqrt{\left(\frac{B}{2}\right)^2 + \omega_0^2}$ and $\omega_{c_2} = \frac{B}{2} + \sqrt{\left(\frac{B}{2}\right)^2 + \omega_0^2}$

Fig.5. BPF circuit and its transfer function.

Suppose that the cut-off frequencies $f_{c1} = 100\ kHz$ and $f_{c2} = 300\ kHz$ are desired. Then, the center frequency is $f_0 = 200kHz$ or $\omega_0 = 400\pi \times 10^3$ rad/sec.

Let $L = 100uH$, then from

$$\omega_0 = 400\pi \times 10^3 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(0.01)C}}$$

gives $C \approx 6.33nF$.

Since the bandwidth $B = (300kHz - 100kHz) = 200kHz,$ from

$$B = 2\pi \times 200kHz = \frac{1}{RC} = \frac{1}{R(6.33 \times 10^{-9})}$$

Gives $R = 126\ \Omega$. The $Q = \frac{\omega_0}{B} = \frac{2\pi \times 200 \times 10^3}{2\pi \times 200 \times 10^3} = 1$. Then we expect a “low Q” BPF.

Procedure:

3. Implement the following HPF circuit in Proteus.

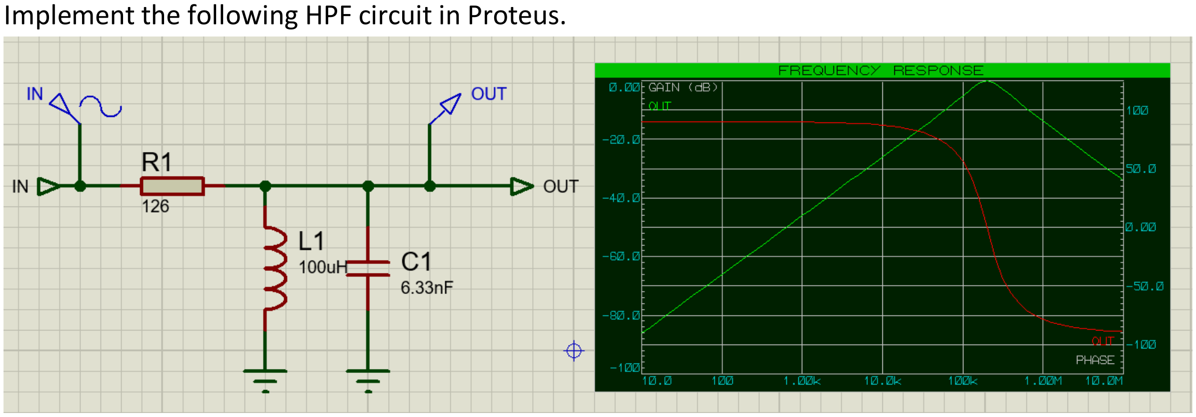


Fig.6. BPF Proteus implementation

4. Fill the table below.

Table 2.

f_{c1} (calculated)	f_{c1} (measured) in dB	Roll-off (dB/dec)	B (calculated)	B (measured)

Conclusion:

1. If calculated and measured values are different, what do you think causes this?
2. If you connect a LPF in series with a HPF each having corresponding w_{c1} and w_{c2} as in BPF, does this circuit work correctly?