ElecEng 2CF4
Assignment 3 Report 1

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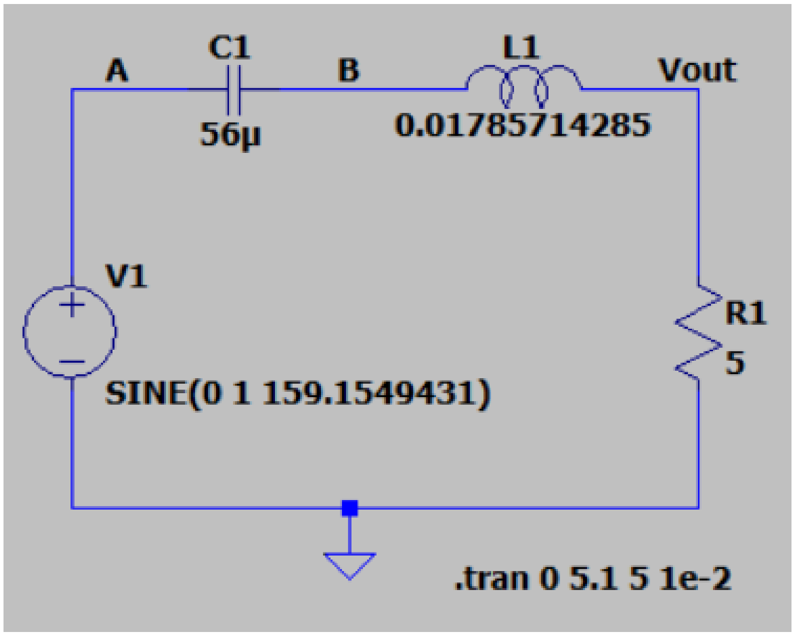
EXERCISE #1: RLC SERIES NETWORK AT RESONANCE

1. **Schematic**



2. **Spice Netlist**

* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment3\q1.asc
V1 A 0 SINE(0 1 159.1549431)
C1 B A 56µ
L1 B Vout 0.01785714285
R1 Vout 0 5
.tran 0 5.1 5 1e-2
.backanno
.end

3. **Calculations for R, C, L, Q, f_0, and the phasors V_L and V_C**

Calculating for R:

When in resonance, $Z_C + Z_L = 0$, thus, $Z(W_0) = Z_R = R = 5\Omega$

Calculating for C:

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Calculating for L:

$$W_0 = \frac{1}{\sqrt{LC}}$$

$$1000 = \frac{1}{L(56\mu F)}$$

$$L = \frac{1}{56}H = 0.01785714285H$$

Calculating for Q:

$$Q = \frac{W_0 L}{R}$$

$$Q = \frac{1000 \times \left(\frac{1}{56}\right)}{5}$$

$$Q = 3.57142857143$$

Calculating for V_L and V_C:

$$X_C = \frac{1}{\omega C} = 17.857$$

$$X_L = \omega L = 17.857$$

$$I = \frac{1\angle 0^\circ}{5} = 0.2\angle 0^\circ \text{ A}$$

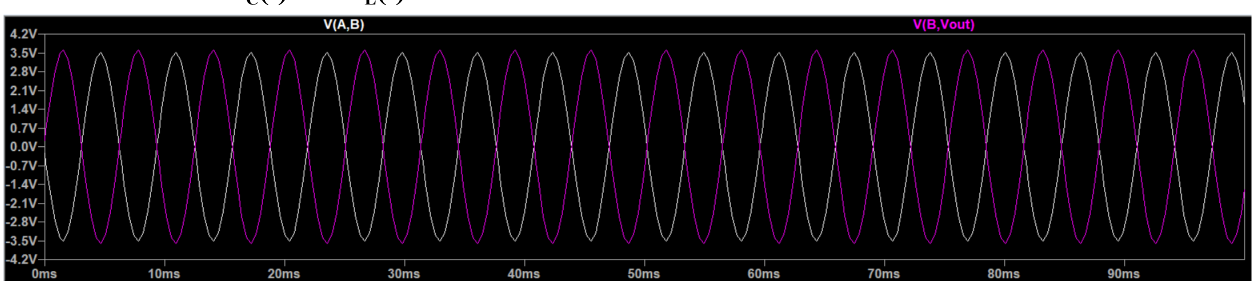
$$V_L = 17.857 \times (0.2\angle 0^\circ \text{ A}) = 3.571428572$$

- Inductor voltage leads current by 90°
- $V_L = 3.57\angle 90^\circ$ V

$$V_C = 17.857 \times (0.2\angle 0^\circ \text{ A}) = 3.571428572$$

- Capacitor voltage lags current by 90°
- $V_C = 3.57\angle -90^\circ$ V

4. **Plot of the $v_C(t)$ and $v_L(t)$ waveforms from the simulation**

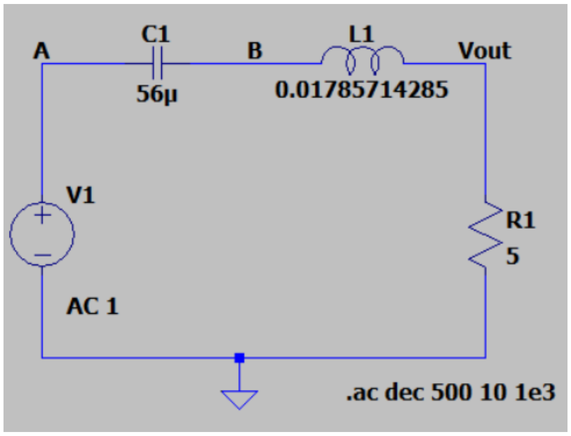


5. **Do the simulation results for $v_C(t)$ and $v_L(t)$ at the resonant frequency confirm the magnitude and phase calculation for the phasors V_L and V_C in part 4? Justify your answer.**

The simulation matches the two voltage phasors $V_C = 3.57\angle -90^\circ$ V and $V_L = 3.57\angle 90^\circ$ V. It can be seen that the amplitude of the voltage reaches 3.57V and the two waveforms are 180 degrees out of phase.

EXERCISE #2: RLC SERIES NETWORK AS A BANDPASS FILTER

1. **Schematic**



2. **Spice Netlist**

```
* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment3\q2.asc
V1 A 0 AC 1
C1 B A 56µ
L1 B Vout 0.01785714285
R1 Vout 0 5
.ac dec 500 10 1e3
.backanno
.end
```

3. **Calculation of the 3-dB BW, f_{LO} and f_{HI}**

$Q = 3.57142857143$

$W_0 = 1000 \text{ rad/s}$

$$\omega_{\text{LO}} = \omega_0 \left[-\frac{1}{2Q} + \sqrt{\left(\frac{1}{2Q}\right)^2 + 1} \right]$$

$\omega_{\text{LO}} = 869.7524449 \text{ rad/s}$

$f_{\text{LO}} = 138.425\text{Hz}$

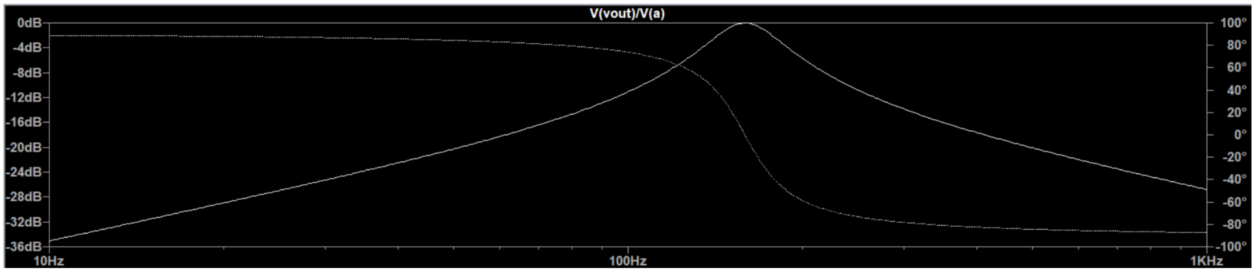
$$\omega_{\text{HI}} = \omega_0 \left[\frac{1}{2Q} + \sqrt{\left(\frac{1}{2Q}\right)^2 + 1} \right]$$

$\omega_{\text{HI}} = 1149.752445 \text{ rad/s}$

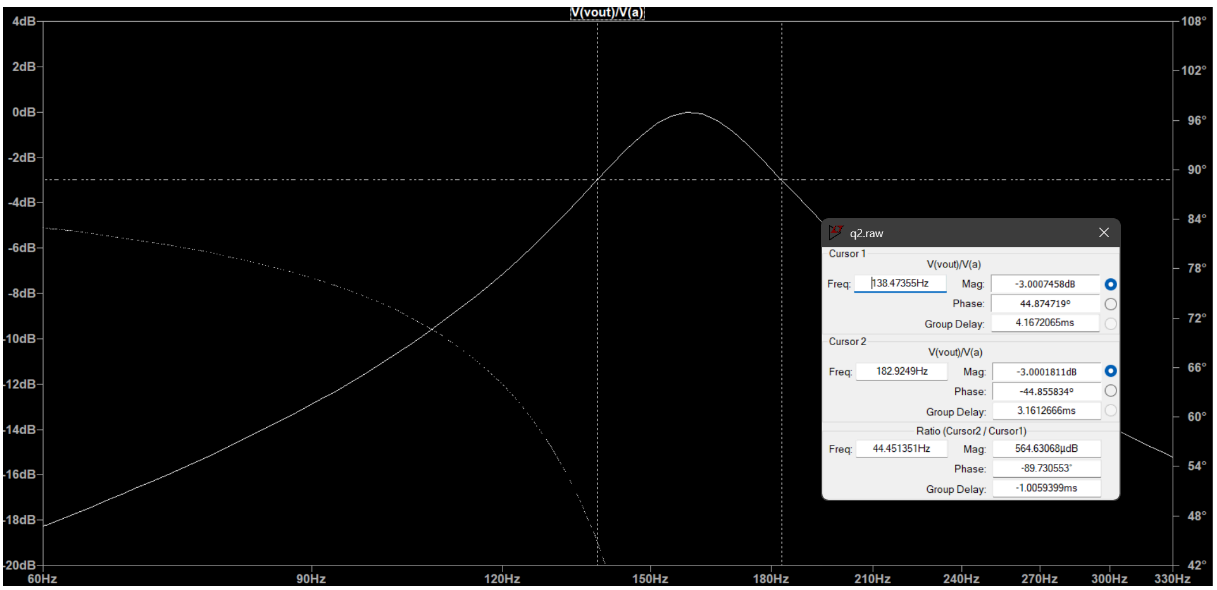
$f_{\text{HI}} = 182.989\text{Hz}$

$\text{BW} = f_{\text{HI}} - f_{\text{LO}} = 44.563 \text{ Hz}$

4. **Magnitude (in dB) and phase (in degrees) plot of G_v versus frequency from the simulation**



5. **Does the magnitude-dB plot of vG versus frequency confirm your calculations for BW, f_{LO}, and f_{HI}? To answer this question, you need to read the values of LOf and HIf from the plot.**



The cursors on the graph above show that the calculated values of 138.4Hz and 182.8Hz correspond to the 3dB frequency cutoffs.

6. **What are the values of the phase of vG at the resonant frequency 0f as well as the cut-off frequencies, f_{LO} and f_{HI} , according to the simulation plot? What are these values according to theory? Is there an agreement?**

Phase at f_{Res}: 47.257mdeg = 0deg
Phase at f_{LO}: 44.87deg = 45deg
Phase at f_{HI}: -44.85deg = -45deg

The voltage gain $VG(jw) = \frac{Vout}{Vs}$ where Vout is taken across the resistor R. In a series RLC circuit, the total impedance is $Ztotal = R + j(wL - \frac{1}{wC})$ and the voltage across the resistor is $VR = IR = \frac{VsR}{Ztotal}$. The phase shift out of the output voltage V_G(jw) depends on the reactance. When $X_L > X_C$ (inductive dominance), the circuit behaves inductively, and the current lags voltage. When $X_C >$

X_L (capacitive dominance), the circuit behaves capacitively, and the current leads the voltage. At resonance (w_0), $X_L = X_C$, meaning the impedance is purely resistive, and there is no phase shift (0deg).

At f_{LO} (lower cutoff frequency):

- The circuit is still capacitive ($X_C > X_L$), meaning the output voltage lags the input current and the phase shift is +45deg

At f_{HI} (higher cutoff frequency):

- The circuit becomes inductive ($X_L > X_C$), meaning the output voltage leads the input current and the phase shift is -45deg

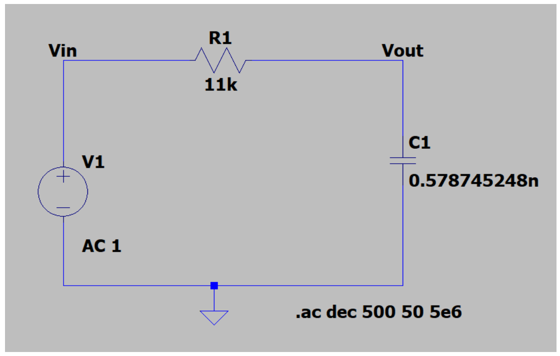
At resonance:

- $X_L = X_C$ and the phase shift is 0deg

Thus, the values are in agreement with the observations from the simulation.

EXERCISE #3: LOW-PASS FILTER

1. **Include the complete schematic (screenshot or image export).**



2. **Include the complete netlist (View→SPICE Netlist).**

```
* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment3\q3.asc
V1 Vin 0 AC 1
R1 Vout Vin 11k
C1 Vout 0 0.578745248n
.ac dec 500 50 5e6
.backanno
.end
```

3. **Include the values of R and C. Show the calculation for C.**

$R = 11k$

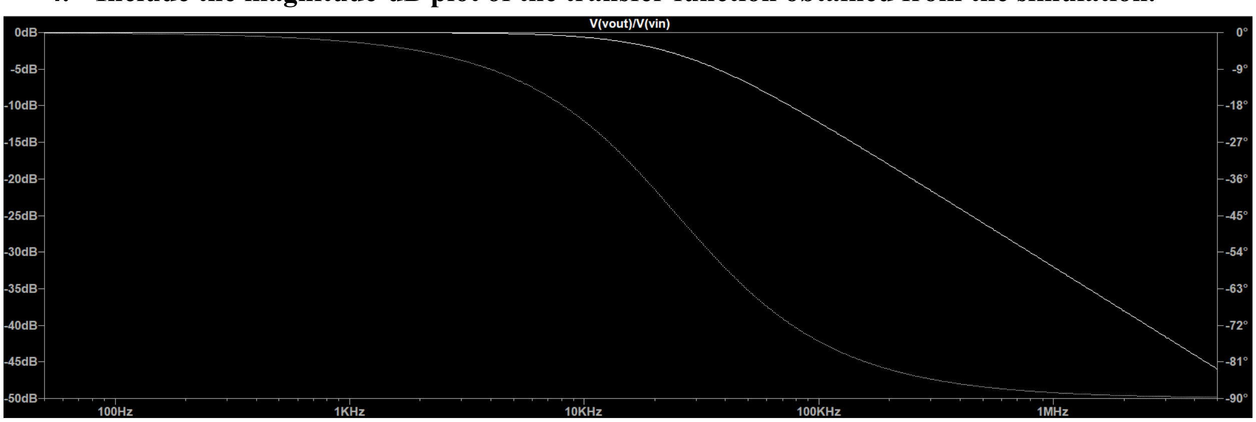
$$W_0 = \frac{1}{RC}$$

$$C = \frac{1}{2\pi f_0 R}$$

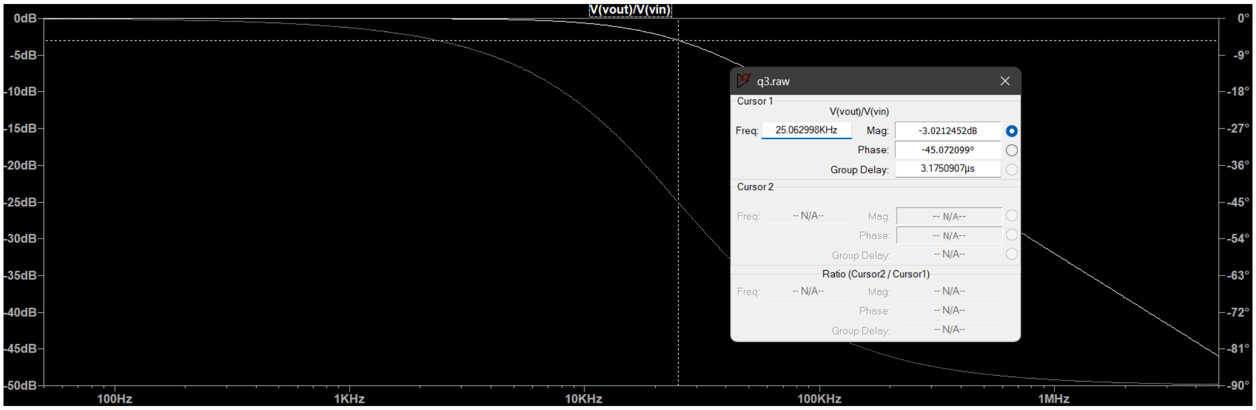
$C = 5.78745248 \times 10^{-10}\ \mathrm{F}$

$C = 0.578745248\ \mathrm{nF}$

4. **Include the magnitude-dB plot of the transfer function obtained from the simulation.**



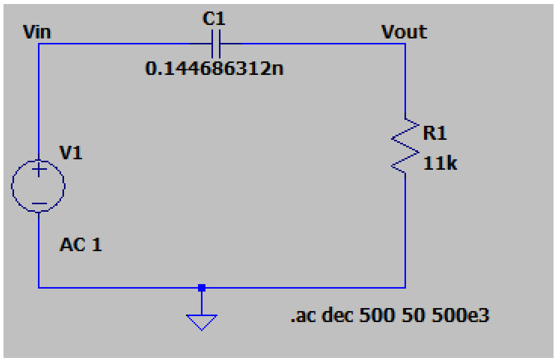
5. **From the magnitude-dB plot of the transfer function, determine the cut-off frequency. Is it in agreement with the required value of 25 kHz?**



As seen by the cursor placed at the 3dB cutoff frequency, the filter is in agreement with the required value of 25 kHz.

EXERCISE #4: HIGH-PASS FILTER

1. **Include the complete schematic (screenshot or image export).**



2. **Include the complete netlist (View→SPICE Netlist).**

```
* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment3\q4.asc
V1 Vin 0 AC 1
R1 Vout 0 11k
C1 Vout Vin 0.144686312n
.ac dec 500 50 500e3
.backanno
.end
```

3. **Include the values of R and C. Show the calculation for C.**

$R = 11k$

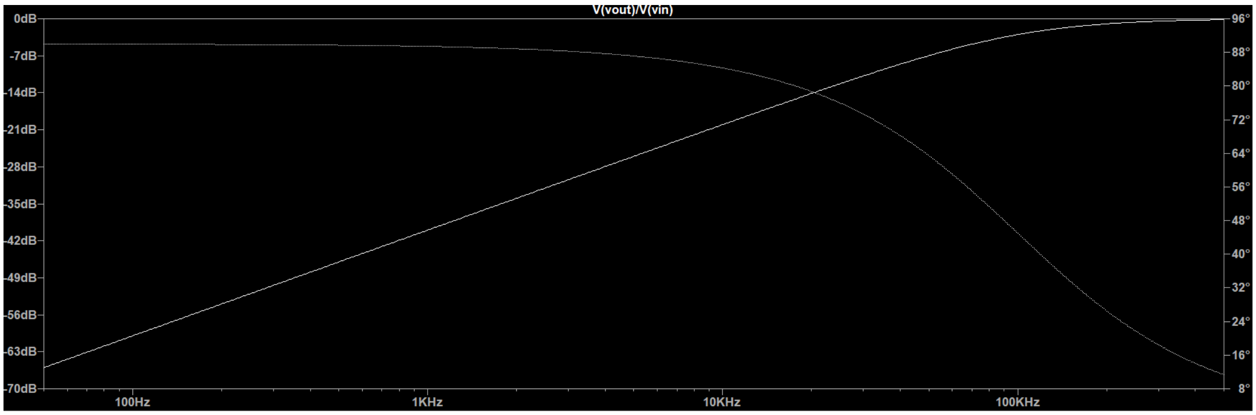
$W_0 = \frac{1}{RC}$

$C = \frac{1}{2\pi f_0 R}$

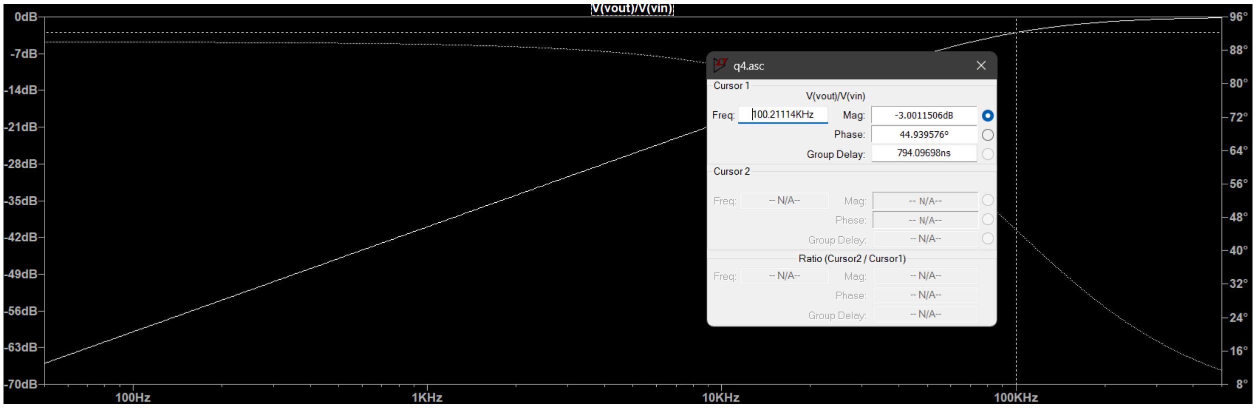
$C = 1.44686312 \times 10^{-10}$ F

$C = 0.144686312$ nF

4. **Include the magnitude-dB plot of the transfer function versus frequency.**



5. **From the magnitude-dB plot of the transfer function, determine the cut-off frequency. Is it in agreement with the required value of 100 kHz?**



As seen by the cursor placed at the 3dB cutoff frequency, the filter is in agreement with the required value of 100 kHz.