Ahmet Faruk Çolak
22102104
2024-2025 Fall

1-Introduction

This lab explores the design, implementation, and analysis of both passive and active filters. The passive low-pass filter, constructed using two capacitors and an inductor. The active band-pass filter design incorporates an operational amplifier (op-amp), introducing gain into the circuit—the defining characteristic of an "active" filter. Filters play critical roles in various applications, including audio engineering and music production, where they refine soundscapes by selectively attenuating or boosting frequency components to enhance the clarity and quality of musical instruments and vocals. This experiment provides practical experience in filter design principles and their real-world implications.

2. Analysis

A- Low Pass Filter (Passive)

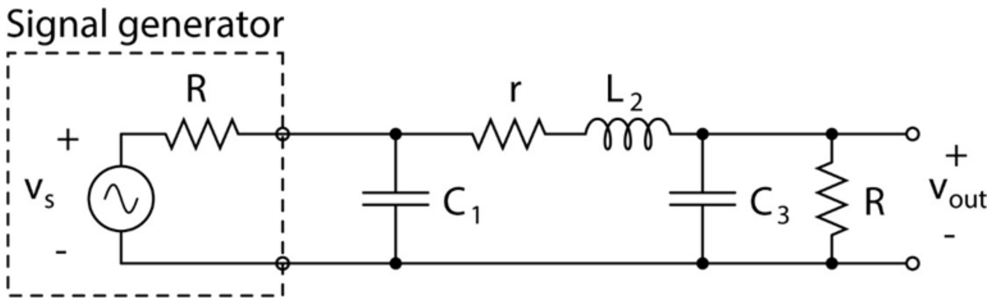

Figure.1: Low Pass Filter

Required Values:

$$C_1 = \frac{b_1}{2\pi f_0 R}, \quad L_2 = \frac{b_2 R}{2\pi f_0}, \quad C_3 = \frac{b_3}{2\pi f_0 R}, \qquad b_1 = 1.00, b_2 = 2.00, b_3 = 1.00$$

$$r = \frac{2\pi f L_{nom}}{Q}, \qquad L_{nom} = 15\mu H, \;\; Q = 25$$

$ID: 22102104$

$f = 1065kHz$

$C1 = C3 = 2.7nF$

$L2 = 15\mu H$
$r = 10\ \Omega$

$R = 50\ \Omega$

From shielded inductor box, slot ten – 3- 09 white inductor was chosen.

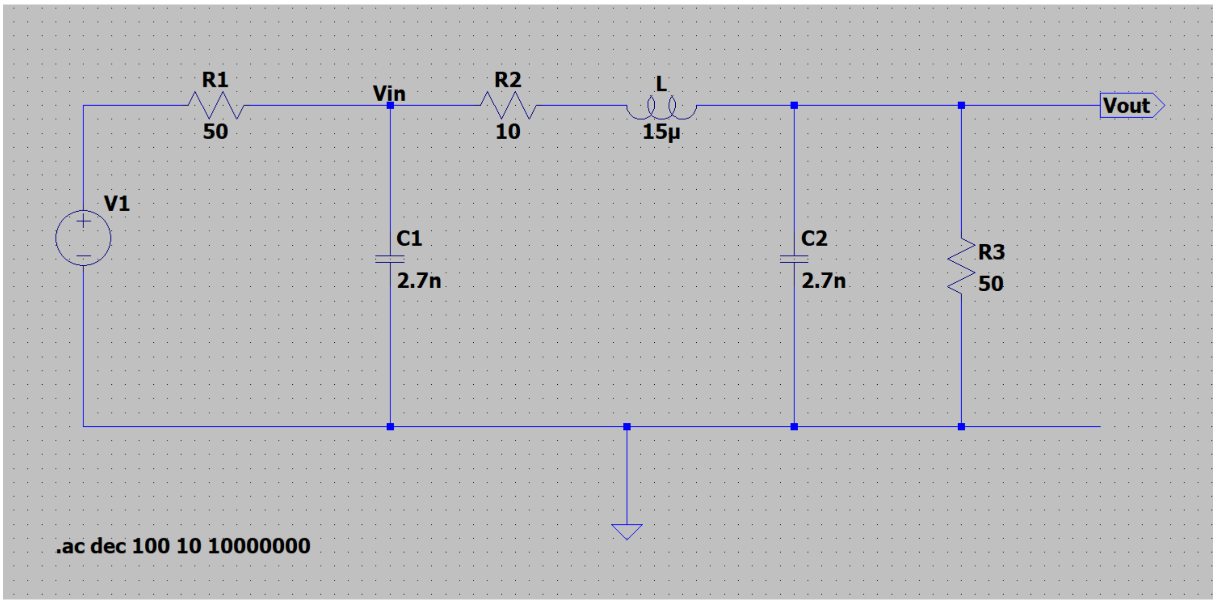

Figure.2: LTspice schematics for LPF

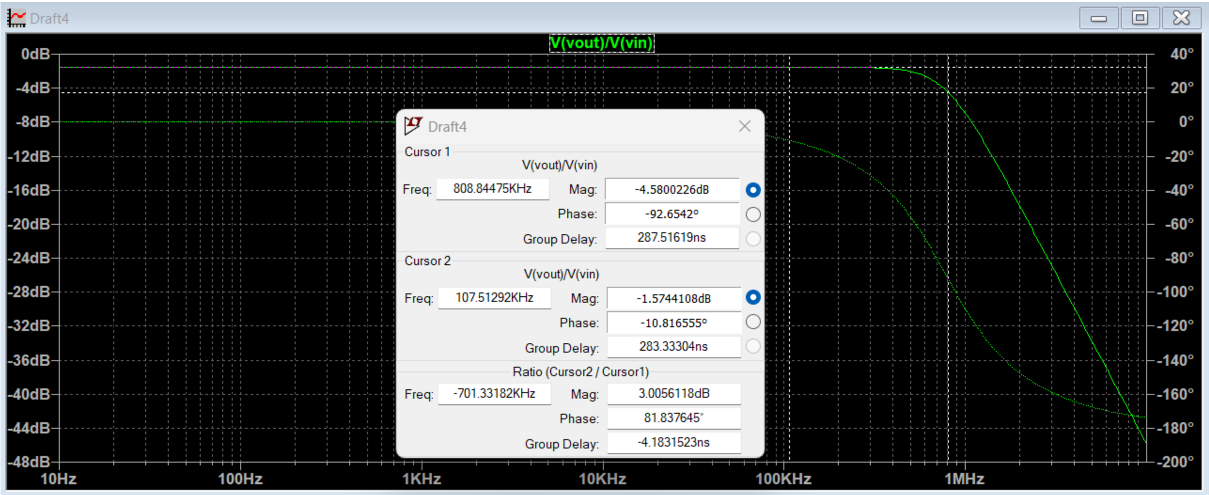

Figure.3: LTspice simulation for LPF

Cursor measurements revealed a 3dB cutoff frequency of 808KHz and an insertion loss of 1.57dB. The observed band reject rate of between-10dB/octave and -12dB/octave.

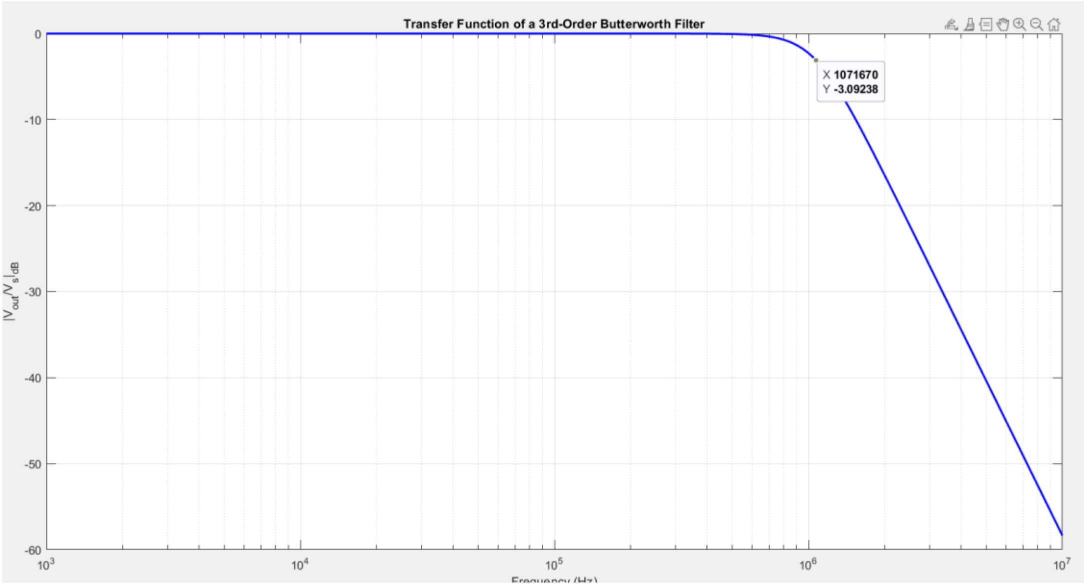

Figure.4: MATLAB simulation for LPF

According to simulation in MATLAB, f0 is approximately 1065.

```
f0 = 1065e3;
n = 3;
frequencies = logspace(3, 7, 500);

H_dB = -10 * log10(1 + (frequencies / f0).^(2 * n));

figure;
semilogx(frequencies, H_dB, 'b-', 'LineWidth', 1.5);
xlabel('Frequency (Hz)');
ylabel('|V_{out}/V_s|_{dB}');
title('Transfer Function of a 3rd-Order Butterworth Filter');
grid on;
```

Figure.5: MATLAB code for LPF

B- Band Pass Filter (Active)

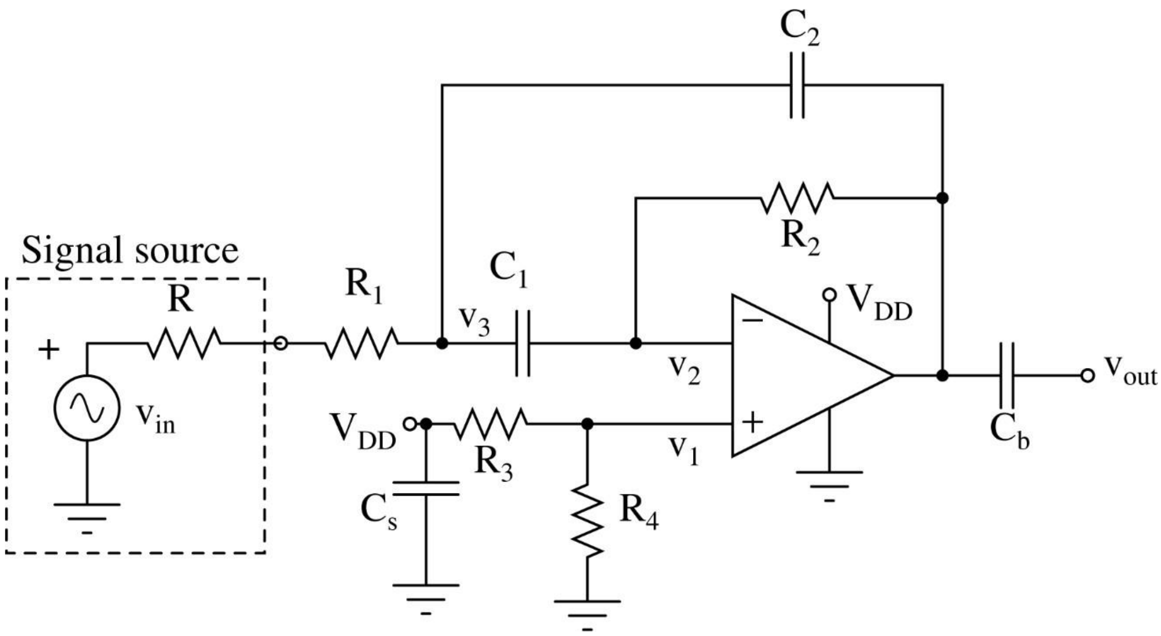

Figure.6: Band Pass Filter

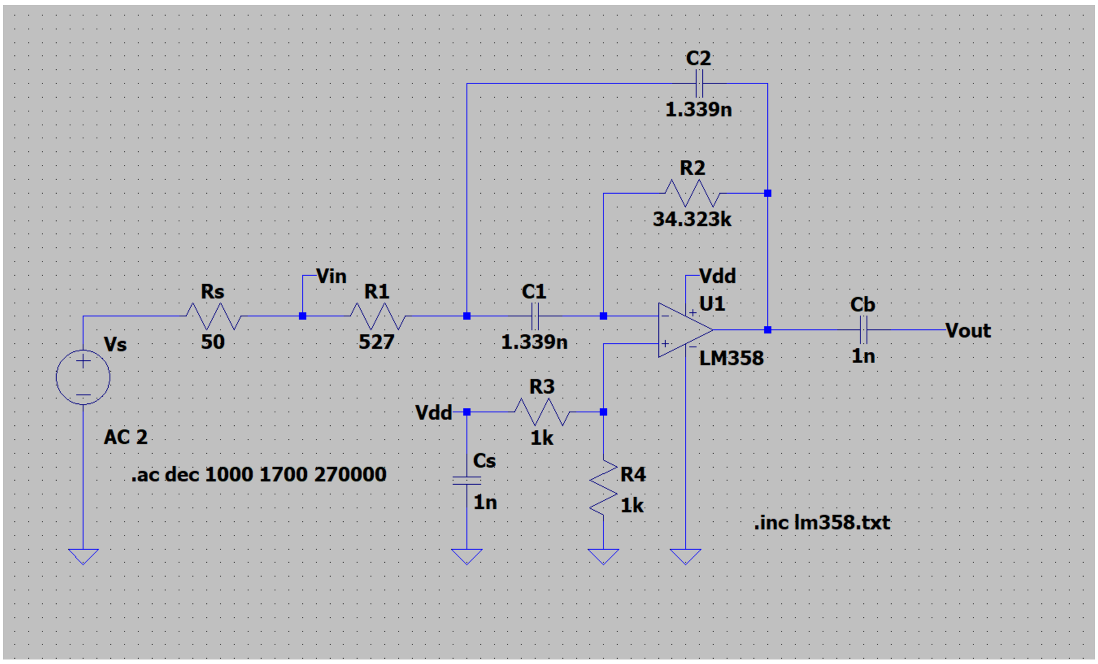

Figure.7: LTspice schematics of Band Pass Filter

Where gain function come from is:

$$KCL\ at\ V_{3:}$$

$$\frac{V_3 - V_{in}}{R_1} + V_3 \cdot \frac{1}{j\omega C} + (V_3 - V_{out}) \cdot \frac{1}{j\omega C} = 0$$

$$KCL\ at\ V_{2:}$$

$$-V_3 \cdot \frac{1}{j\omega C} - \frac{V_{out}}{R_2} = 0$$

$$Using\ these\ 2\ equations:$$

$$V_3 = -\frac{V_{out}}{R_2 \cdot \frac{1}{j\omega C}}$$

$$solving\ for(\frac{V_{out}}{V_{in}}):$$

$$\frac{V_{out}}{V_{in}} = \frac{1}{\frac{1}{j\omega L \cdot R_2} - \frac{2R_1'}{R_2} + R_1' \cdot \frac{1}{j\omega C}}$$

$$at\ a\ resonance\ frequency:$$

$$\frac{1}{j\omega L \cdot R_2} = -R_1' \cdot \frac{1}{j\omega C} \Rightarrow \frac{1}{j\omega L \cdot R_2} = -j\omega C R_1'$$

$$\Rightarrow \omega_0 = \frac{1}{\sqrt{C \cdot R_1' \cdot R_2}}$$

$$\Rightarrow f_0 = \frac{1}{2\pi\sqrt{C \cdot R_1' \cdot R_2}}$$

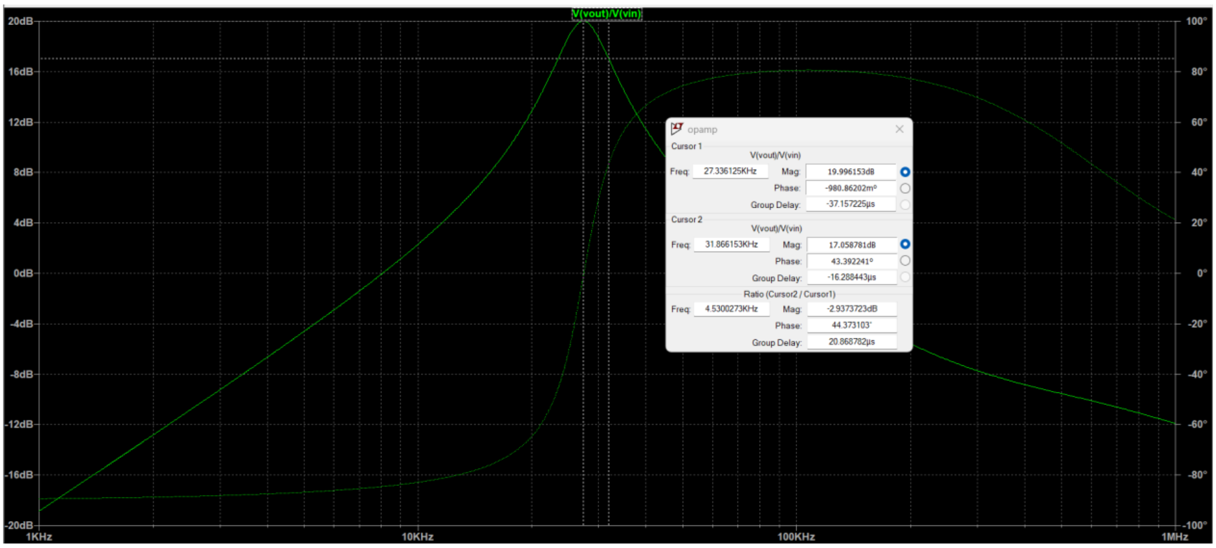

Figure.8: LTspice simulation of Band Pass Filter

3. Conclusion

This lab provided valuable hands-on experience with filter design and behavior. Combining theoretical calculations with practical adjustments led to more accurate filter implementations. Both active and passive filter circuits were explored, giving a deeper understanding of their different characteristics. Working with an op-amp in the active filter design improved familiarity with its operation.