

Design and Simulation of Second order Active Band-Pass Filters

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Abstract

This project focuses on designing and simulating a second-order active band-pass filter (BPF) using the eSim software. The circuit incorporates the LM741 operational amplifier along with resistors and capacitors to achieve a resonant frequency of approximately 2.5 kHz and a bandwidth of 499.08 Hz. This document outlines the purpose, working principles, and simulation results, showcasing the performance and efficiency of the designed filter.

Keywords—Band-pass filter, Butterworth response, Circuit Maker, eSim 2.4.

Introduction: Filters are fundamental components in signal processing, used to allow signals of desired frequencies while attenuating others. Band-pass filters (BPFs) combine high-pass and low-pass characteristics to permit only a specific frequency range. This project utilizes an active BPF circuit, leveraging the LM741 operational amplifier, to achieve precise filtering with minimal signal loss. The circuit design and simulation were conducted using eSim , ensuring accuracy and reliability in the design process.

Purpose: The primary objective of this project is to design and simulate a second-order active BPF that meets the following specifications:

- **Center frequency (f_0):** 2.5 kHz
- **Pass band Frequency (BW):** 499.08 Hz
- **Quality factor ($Q=f/BW$)** ≈ 5

This filter aims to demonstrate the effectiveness of using active components like op-amps to achieve a practical and efficient frequency response.

Working Principle:

The second-order active band-pass filter is designed by cascading high-pass and low-pass filter stages with an operational amplifier to enhance signal gain and quality.

1. **High-Pass Filter (HPF):**

- Blocks low-frequency signals below the cut-off frequency and allows higher frequencies to pass.
- Designed using resistors (R1) and capacitors (C1).

2. Low-Pass Filter (LPF):

- Blocks high-frequency signals above the cut-off frequency and allows lower frequencies to pass.
- Designed using resistors (R2) and capacitors (C2).

3. Operational Amplifier (Op-Amp):

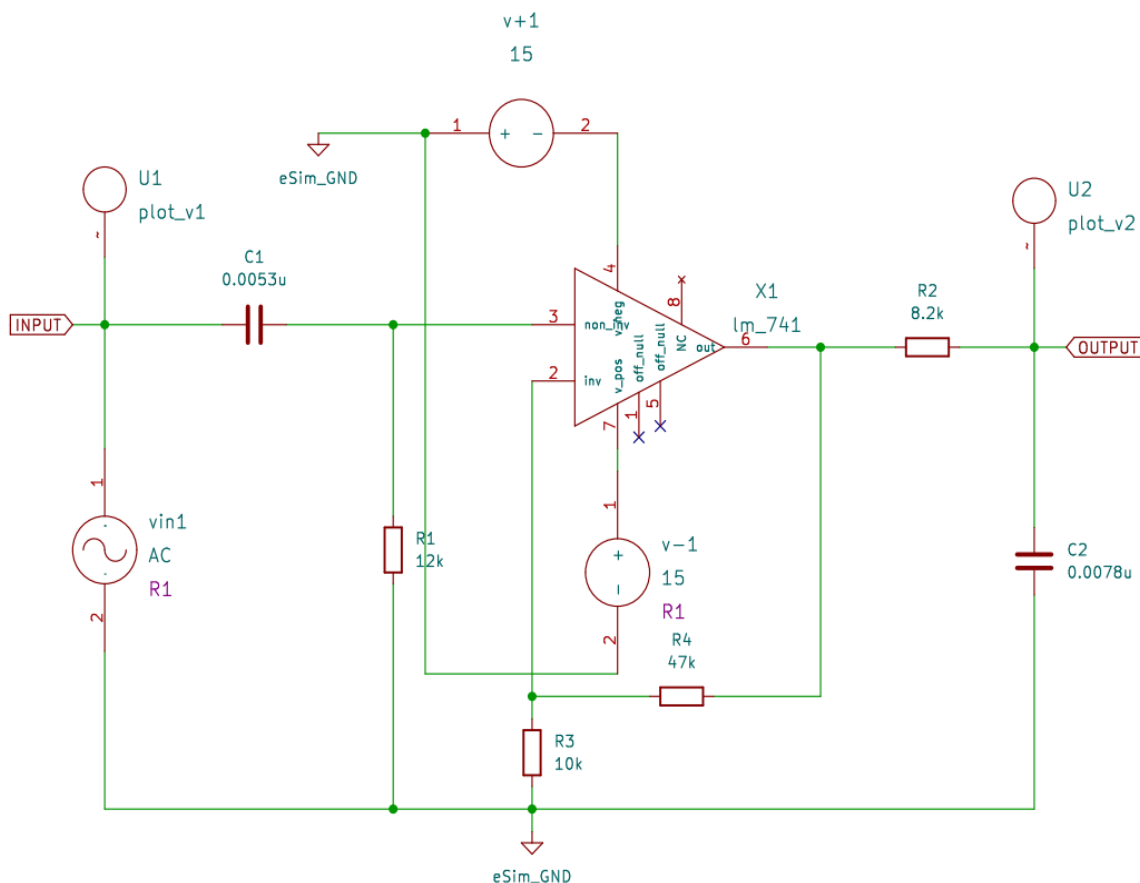
- The LM741 op-amp provides amplification and stabilization for the desired frequency range, ensuring minimal attenuation at the resonant frequency.

The combination of these components creates a circuit that selectively passes signals within a specific frequency range, characterized by the resonant frequency and bandwidth

With the transfer function $H(s)$:

$$H(s) = \frac{sR1C1}{(1+sR1C1)(1+sR2C2)}$$

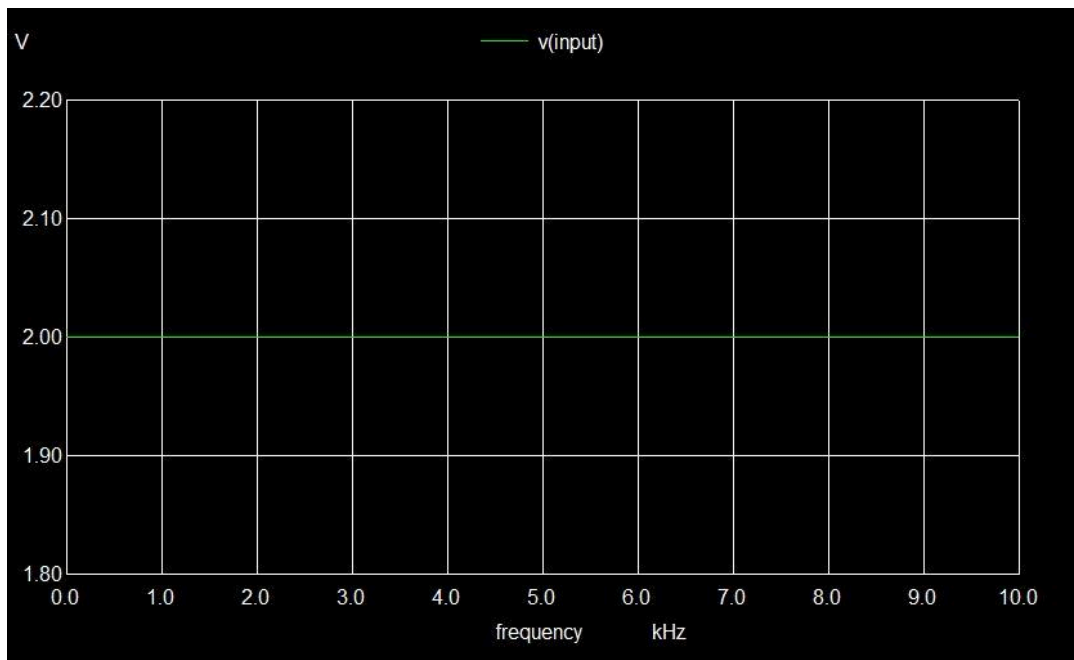
Implemented Circuit Diagram:



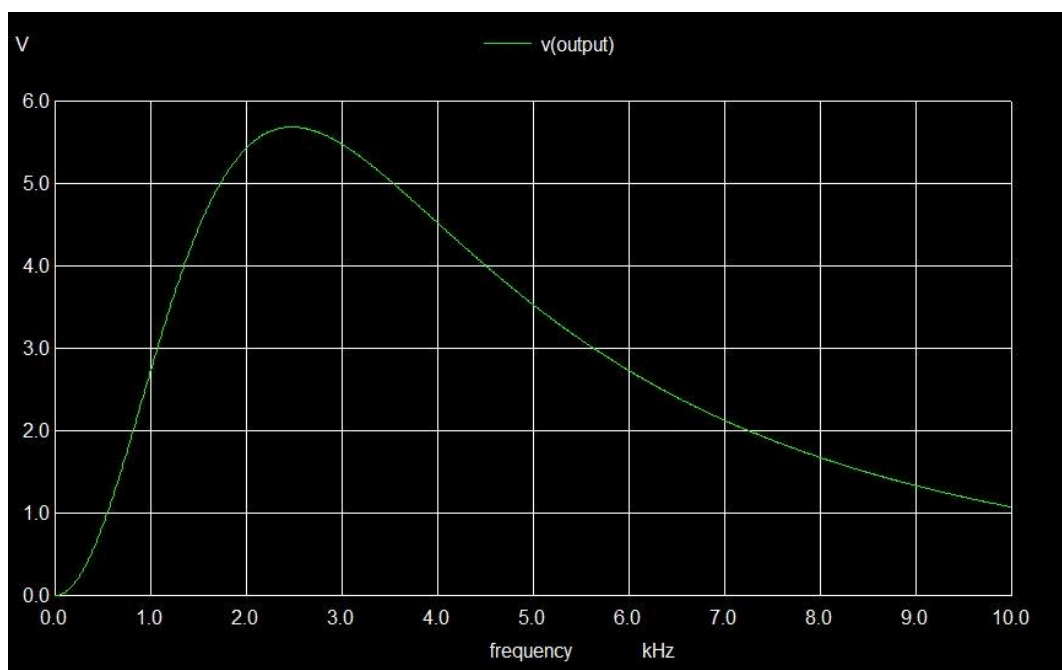
Simulation Results and Output:

- **Resonant Frequency (f_0):** Approximately 2.5 kHz
- **Bandwidth (BW):** 499.08 Hz
- The output waveform confirms the circuit's ability to filter signals within the specified frequency range, with minimal distortion and a clear peak at the resonant frequency.

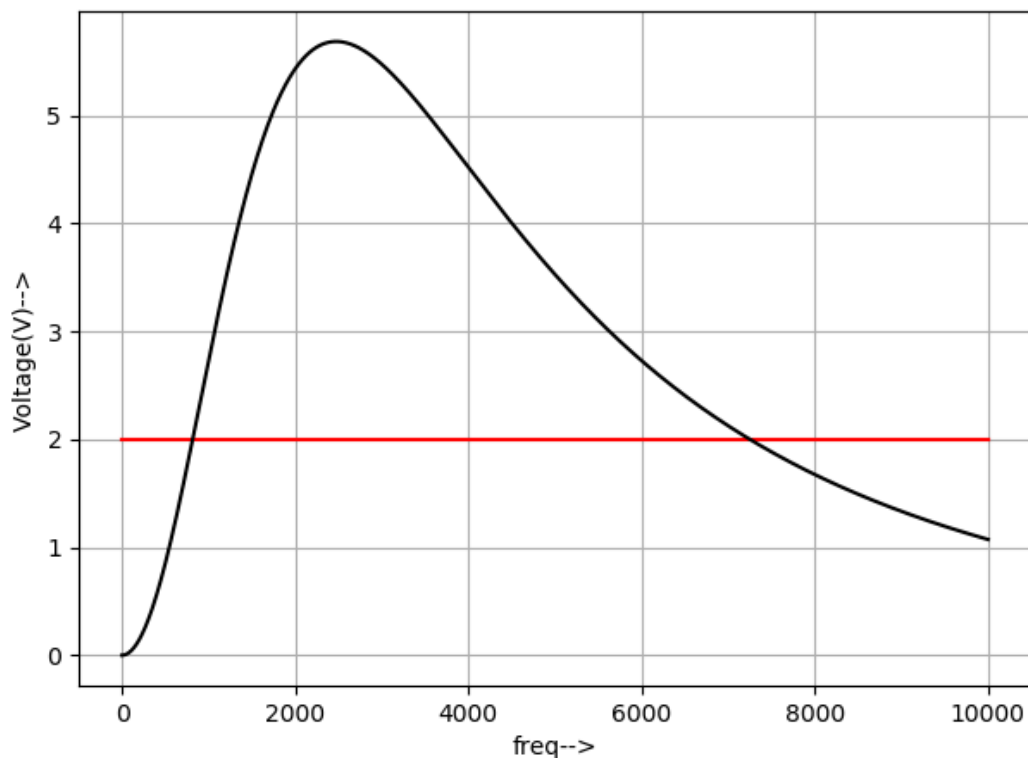
INPUT :



OUTPUT : FREQUENCY vs MAGNITUDE PLOT:



INPUT V/S OUTPUT:



Conclusion:

The design and simulation of the second-order active band-pass filter were successfully implemented using eSim. The circuit achieved the desired resonant frequency and bandwidth, validating its performance. This project highlights the practical application of active filters in signal processing, demonstrating their effectiveness in isolating specific frequency ranges with high precision and stability.

References: Design and Implementation of Active Band-Pass Filter for Low Frequency RFID (Radio Frequency Identification) System, Miss Zin Ma Ma Myo, Dr. Zaw Min Aung, Dr. Zaw Min Naing