ECE 303L Signals and Systems Lab
Experiment #8: Butterworth Filters

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Date Assigned: Novemeber 13, 2025 **Date of Submission:** Novemeber 28, 2025 **Instructor:** Dr. Rashedul Islam

1 Introduction

In this experiment, the student was expected to closely observe the class of Butterworth filters. Butterworth filters are a type of frequency-selective filter that can be implemented using op-amps, resistors, and capacitors to create second-order filter stages. To understand Butterworth filters, one should recognize that they belong to a broader class of frequency-selective filters. In general, filters can be classified as high-pass or low-pass, and they can be constructed by cascading stages with buffers or by combining circuits in parallel.

Through exposure to these different variations of filters, the student was able to examine the behavior of Butterworth filters more closely. Butterworth filters are designed to have a smooth magnitude response with no ripple in either the passband or stopband. This smooth response is what makes Butterworth filters widely used and effective in many electronic applications.

1.1 Circuit Construction

- Components Used: Op-amp(Operational amplifier), resistors, and capacitors.
- Configuration: The componemts were configured to achieve smooth maginitude to fit the butterworth thesis.Below is figure of the intented achieved circuit one had to construct.
- Connections: Oscilloscope channels for output connections. Waveform generatior to connect input connections.

1.2 Measurement Procedure

- Oscilloscope: Put on DC coupling, High-Z mocde, and FFT mode to observe behaviors of the filter.
- Waveform Generator:COnnectioned for sinusiodal inputs to sweeep in a range of frequencies.

1.3 Theory and Equations

The theory and math that was behind butterworth filters is that they used the Laplace transfer function for the low-pass filter:

$$H(s) = \prod_{k=1}^{n} \frac{\omega_c}{s - p_k} \tag{1}$$

where the poles lie evenly spaced on a semicircle in the left half of the s-plane:

$$p_k = \omega_c e^{j\left(\frac{2k-1}{2n}\pi\right)}, \quad k = 1, 2, ..., n \tag{2}$$

For a second-order Butterworth filter, the magnitude response becomes:

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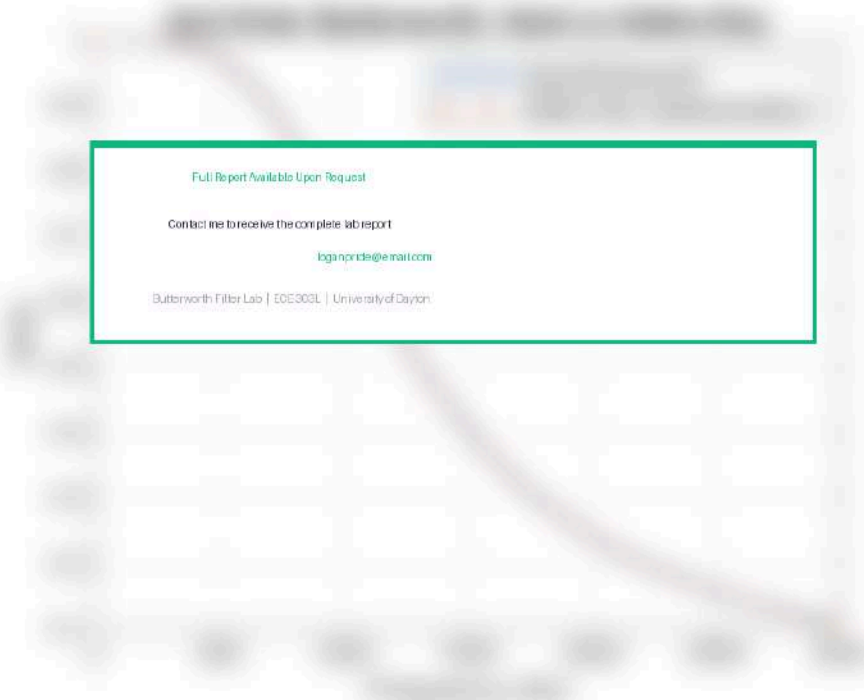

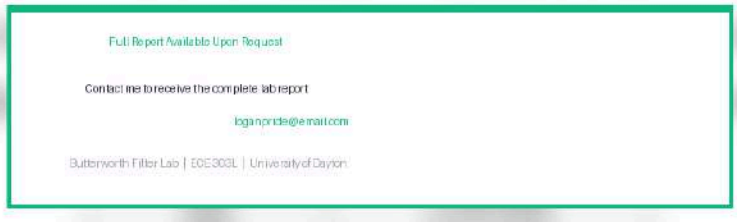
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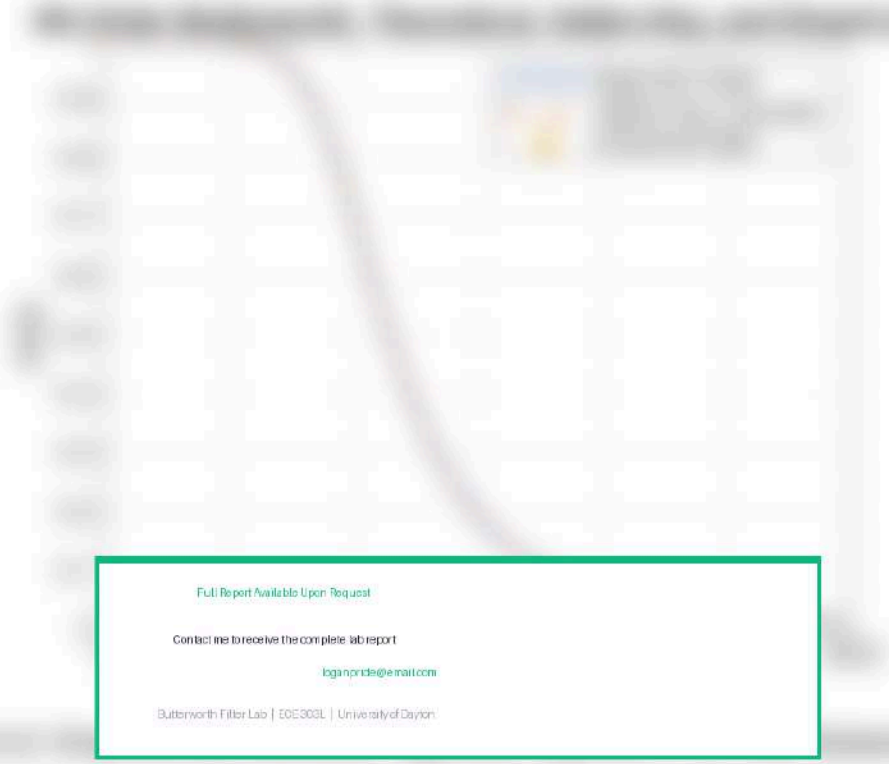
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