ECE 3723 - Electric Circuits II - Fall 2021
Project 6: Two-Port Networks

Due: 12/02/21 in Canvas by 11:59pm

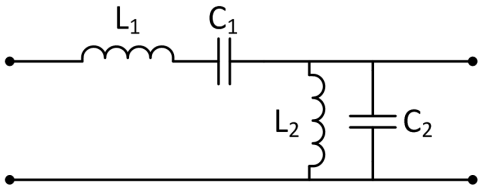
Introduction

As discussed in class, two-port networks are very useful for circuit and systems analysis. These two-port networks can be constructed by analyzing the circuit directly or by breaking the circuit into basic elements, finding the two-port network for each, and then combining them to form the overall circuit. This method of representing circuits by block diagrams -black boxes- and combining them in various configurations greatly simplifies system design. A wide variety of performance parameters can be easily calculated for any system represented by a two-port network.

In this project a second-order Butterworth bandpass filter will be investigated and represented by a two-port network that will be formed by connecting several two-port networks, where each network contains a single component. This will clearly demonstrate how immensely useful two-port networks are for circuit analysis.

1 Two-Port Network

You are given the second-order Butterworth bandpass filter using passive components below.



The component values are $L_1 = 112.54$ nH, $C_1 = 37.806$ fF, $L_2 = 94.514$ pH, and $C_2 = 45.016$ pF.

What is the center frequency of this filter (in Hz)? Note, this can be solved without finding the cutoff frequencies, just think about what needs to happen at resonance (hint: it's similar to two BPFs cascaded). (10 points)

Find the a-parameters by hand. (15 points)

Now split the circuit into four separate blocks (two-port networks containing one component each) and find the a-parameters for each. Hint: do it for a generic impedance or admittance to see the trend. (20 points)

Create a MATLAB code that calculates the a-parameter matrices as a function of frequency from 1 GHz to 3.5 GHz. Then cascade them at each point in frequency. Finally, assume that the filter is terminated by a 50 Ω load and is excited by a source with a 50 Ω source load. The voltage transfer function is:

$$H(\omega) = \frac{V_2}{V_g}$$

Find the transfer function and plot it in dB versus frequency. (20 points)
Remember the dB scale represents power, so you need to use $20\log_{10}(H)$.

What is the maximum amplitude? Explain why the amplitude is what it is. (10 points)

2 Deliverables

This project should be written up in a neatly organized report that includes the results from all the sections, answers to all the questions, and all plots that are generated.

All calculations and derivations must be typed up, no credit will be given for handwritten solutions.

3 Grading

- **The report itself is worth 15 points, which will be given based on the structure of the report, grammar, clarity, and formatting.**
- **Answering the questions listed in the handout in the main body of the report is worth 75 points.**
- **Turning in the code in an appendix is worth 10 points.**