EE 221L Lab Experiment #8

**Topic:** Frequency response of first and second order circuits

**Date:**

**Purpose:** The purpose of this lab is to familiarize the student with the frequency response of circuits by plotting the response with a Bode plot by hand and with Matlab, a Spice program, and taking measurements.

**Preliminary:** In this lab, three circuits will be analyzed to determine the frequency response by hand. To begin, the transfer function and poles and zeros of the circuits will be found. This information will be used to plot both the magnitude and phase vs. frequency on a Bode plot by hand for circuits 1 and 2 and using Matlab for circuit 3. The calculations done by hand will be compared to the frequency response of the circuit simulated by a Spice program.

**Circuit 1**

![Circuit 1 Diagram]

**Circuit 2**

![Circuit 2 Diagram]

For the two circuits shown above, perform the following:

1. Based on the layout of the circuit, describe what you think the frequency response will be and why.

2. Compute the transfer function for the circuit $H(j\omega) = \frac{V_{out}}{V_{in}}$.

3. From the transfer function, determine the poles and zeros.

4. Plot the magnitude and phase vs. frequency on a Bode plot.

5. Plot the magnitude and phase vs. frequency using a Spice program. (see below for LTSpice information).

6. Compare your two plots. Do these plots match the estimated frequency response in part 1?

7. Determine the cutoff frequency, $\omega_c$, or the resonant frequency, $\omega_o$, of the circuit.

8. For Circuit 2 only, prepare Bode plots (magnitude only) for $R = 50\Omega, 200\Omega, 500\Omega$ and $2000\Omega$. 
For this circuit shown above, perform the following:

1. Based on the layout of the circuit, describe what you think the frequency response is and why.

2. Compute the transfer function for the circuit $H(j\omega) = \frac{V_{out}}{V_{in}}$.

3. From the transfer function, determine the poles and zeros.

4. Use the Matlab Bode function to plot the magnitude and phase. (see below for more information)

5. Plot the magnitude and phase vs. frequency using a Spice program.

6. Compare your two plots. Do these plots match the estimated frequency response in part 1?

7. Determine the resonant frequency, $\omega_0$, of the circuit.

**Matlab:** The transfer function is required to plot the magnitude and phase vs. frequency using Matlab. Convert the transfer function from $j\omega$ to $s$ and reduce to polynomial form; for example, $H(s) = \frac{s^2 + 6s + 8}{2s^3 + 4s^2 + 4s}$. Put the numerator and denominator coefficients in vector form. Using the above example, the numerator is [1, 6, 8] and the denominator is [2, 4, 4, 0]. Note the 0 term in the end of the denominator vector. In the Matlab workspace, type the bode command using the numerator and denominator vectors. This will generate plots of the magnitude and phase vs. frequency for the given transfer function.

\[ \text{bode([1, 6, 8], [2, 4, 4, 0]);} \]
The frequency range can also be controlled by entering the minimum and maximum frequency values after the denominator. Also, the grid on command is sometimes useful in determining specific frequencies.

\texttt{bode([1, 6, 8], [2, 4, 4, 0], [.1, 10000]);}
\texttt{grid on;}

\textbf{Lab:} The frequency response of the three circuits analyzed in the preliminary will be determined by taking measurements. In this lab, we will only be measuring the magnitude of the frequency response, not the phase. Use the function generator, oscilloscope and/or DMM from lab 6 to apply your signal and take measurements. Setup the function generator to provide a 5 volt peak sine wave as the input.

For the circuit shown above, perform the following:
1. Setup the circuit shown above using the function generator as your input.

2. Vary the frequency of the input from at least two decades below the cutoff or resonant frequency to at least two decades above. Record the measured input and output voltages and the frequency. Record enough data points so that you can sketch the magnitude of the response later. You will probably want to record more data points near the cutoff frequency.

3. Make a table showing the frequency, input voltage, output voltage, and gain/attenuation in dB.

4. Sketch the magnitude (dB) vs. frequency.

5. What is the measured cutoff or resonant frequency?

6. Compare the calculated and measured results. Discuss any differences that may occur between these results.