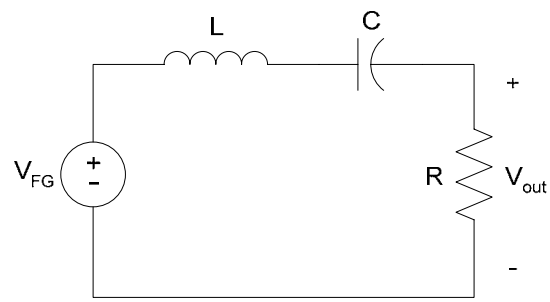
EE228 Spring 2007

LABORATORY EXPERIMENT #6

Engineering Problem: In many cases, we are tasked with synthesizing the frequency response characteristics for a given system, possibly to confirm whether or not certain specifications are being satisfied. We can do this analytically or experimentally in the laboratory. Further, for an analytical determination, you may use a straight-line approximation or you can generate a more detailed result using Matlab. We will explore all three approaches using the following RLC series circuit.



Part 1: Analytical Solution

1. Place the circuit above in the frequency domain and derive the transfer function $H(s) = \dfrac{V_{out}(s)}{V_{FG}(s)}$ in terms of the parameters R, L, and C.
2. Given nominal values of $L = 42mH$, $C = 0.001\mu F$, and $R = 13k\Omega$, substitute the component values into the above transfer function:
   a. Place the result in "normalized form"
   b. Identify the gain constant, zeros, and poles (use your calculator)
   c. Sketch the magnitude Bode plot on semilog paper (use 1000rad/s as the minimum frequency and sketch four decades). **Have the instructor verify your sketch.**
   d. From your sketch, what is the maximum value of the magnitude characteristic (in dB) and at what frequency (rad/s) does it occur?
   e. From your sketch, at what frequencies is the magnitude characteristic approximately -20dB down from the maximum value?
   f. Convert the three frequencies found above into Hz.

Part 2: Experimental Determination

1. Measure the actual component values in the laboratory using the DMM and LC-meter. The $13k\Omega$ can be implemented using $12k\Omega$ in series with $1k\Omega$. Note, the resistance of the inductor and the output resistance of the FG are much smaller than R and so we are comfortable with ignoring them.

2. Build the circuit above on your proto-board. Set the Function Generator (FG) output to a sine-wave with a peak value of 5V at a frequency close to the maximum value (in Hz) found above (ensure that the DC offset is zero).
3. Use one DMM to monitor the FG voltage (set to AC); use a second DMM to monitor the output voltage; use CH1 of the scope to also monitor the output voltage.
4. First, sweep the frequency from low frequency to high frequency and note how the amplitude of your output varies on the scope. Make sure that it follows the trend that you anticipate from your Bode plot approximation. If it doesn't, consult your instructor.
5. Next, collect input and output data (via the DMMs) adequate to compare with your straight-line theoretical approximation. Note gather more points near to where transitions occur. We gather both INPUT and OUTPUT values so that we can track any changes in the input voltage due to possible loading (current drawn from the FG). We can then form the ratio to find the frequency response magnitude and then convert the result into decibels. Your data chart should look like the following and should contain 10-15 data points. **Have the instructor verify your data.** At what frequencies is the data less reliable? Why? Make sure to collect a data point at the peak magnitude.

Frequency (Hz)	(rad/s)	Input (V)	Output (V)	$\lvert H \rvert$	H_{dB}

Part 3: Analytical Result Using Matlab

1. Create an M-file that will generate the magnitude Bode plot for your theoretical parameter values. The program should execute the following sequence
   a. Assign values to R, L, and C
   b. Assign a frequency range using the logspace command. The syntax for logspace is: w = logspace(n1, n2, pts) where you will create a logarithmically space frequency range from 10^{n1} to 10^{n2} containing pts elements. Use the same range as your straight-line approximation
   c. Assign the numerator and denominator polynomial vectors (in terms of R, L, and C)
   d. Use polyval (twice) to evaluate the two polynomial vectors at j*w
   e. Divide the resulting two vectors element-wise then take the absolute value (abs).
   f. Create the magnitude in dB using the log10 function
   g. Plot w versus your dB result using semilog paper by invoking the semilogx command
   h. Add an xlabel, ylabel, and grid
2. From your data, determine the frequencies at which your magnitude plot is closest to -20dB. How much is the input reduced by the system when the gain is -20dB?
3. Place your data points from Part 2 on your Matlab plot. Qualitatively compare the results.