Engr228 Lab #6 Spring, 2020

Forced Response of a Series RLC Circuit

Name ______________________________

Introduction

This experiment investigates a series RLC circuit driven by an AC Voltage. The relationship of the output voltage (V_O) with the input voltage (V_I) exhibits the characteristics of a band-pass filter which means that it passes a selective band of frequencies and blocks frequencies outside of this band. To learn how this works, you will explore the frequency response, both magnitude and phase, of a series RLC circuit.

Lab Objectives

- Continue developing proficiency with the function generator and oscilloscope;
- Understand magnitude and phase relationships in series RLC circuits;
- Understand the VI characteristics of capacitors, inductors, and resistors.

Equipment

- Waveforms software;
- Digilent Analog Discovery 2 Module;
- Breadboard;
- Assorted components and wires.

References

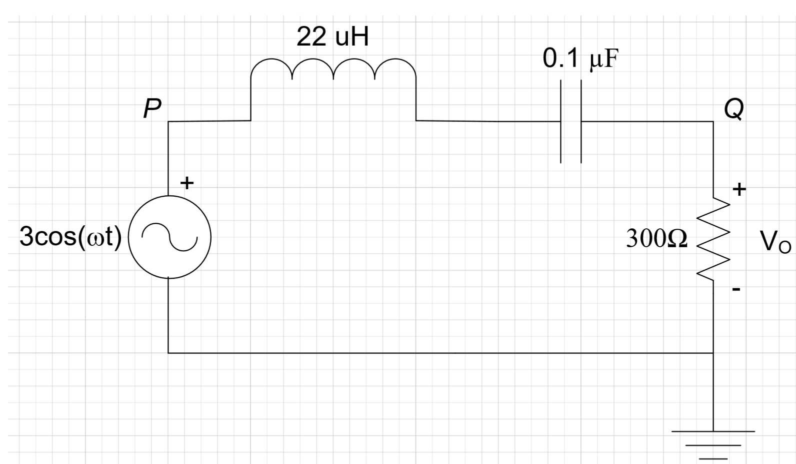
- Zybooks text book;
- Course web site;
- Resistor color-code chart.

Procedure

1. Measure and record the values of the components shown in the schematic. Note you can't measure the inductance.

   C = __________ nF

   R = __________ Ω



2. Using your breadboard, connect the circuit shown. Connect the channel 1 oscilloscope probe between points *P* and ground and the channel 2 oscilloscope probe between points *Q* and ground.

3. Measure the voltages at points *P* and *Q* for the frequencies shown in the table below. This must be done carefully to ensure reliable data.

   Relating to the function generator:
   - Select a sine wave output and set the initial frequency to 500 Hz;
   - Set the magnitude of the voltage at point *P* to $6.0V_{peak\text{-}to\text{-}peak}$.

   Relating to the oscilloscope:
   - Use the *Measurement* function so you can directly read the *P* and *Q* peak-to-peak voltages and the frequency;
   - You will likely have to adjust the sensitivity of channel 2 as frequency changes (necessary if measurements appear in red).
   - For each frequency setting, you must also take a measurement of the phase difference by using the method demonstrated in the lab lecture. Note that θ **is positive for frequencies that occur before the peak voltage (around 107,000Hz) and negative for frequencies that occur after the peak voltage.**

F (kHz)	**P (v_{pp})**	**Q (v_{pp})**	**θ (degrees) Time Method**
1			
2			
5			
10			
20			
50			
100			
200			
500			
1000			
2000			
5000			

4. We haven't yet covered a concept called phasors so I won't have you derive the input/output equations for the series RLC circuit. I have derived the equations for the magnitude and phase of (V_Q/V_P). The equations below are general in terms of R, L, and C. Fill out the equations below using your actual values for R and C that you measured in step 1. Use the nominal value for the inductor. Your results for magnitude and phase will be functions of ω.

$$\left|\frac{V_Q}{V_P}\right| = \sqrt{\frac{C^2R^2\omega^2}{C^2L^2\omega^4 + C^2R^2\omega^2 - 2CL\omega^2 + 1}}$$

$$\theta = -\tan^{-1}\left(\frac{CL\omega^2 - 1}{CR\omega}\right)$$

5. From the equations in step 4 above calculate:

   a) The center frequency f_0, which is the frequency where the response is maximum. To find this number, differentiate the magnitude equation from step 4 with respect to ω, set the resulting equation equal to zero, and solve for ω. (Use any tool you wish to help you do this).

   b) Compare your result in step 5a with that of a series RLC circuit:

$$f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$$

c) Solve for the bandwidth (BW) of your circuit. BW is the frequency difference between the two points on the magnitude plot that are 0.707 times the peak magnitude. To calculate BW, set your magnitude equation from step 4 equal to 1 divided by the square root of 2 and solve for the two values of ω. BW is the difference between these two values.

BW = ____________ Hz

6. Using Excel, plot magnitude vs. frequency (Hz) from your equation in step 4. On the same graph, plot experimental data (V_Q/V_P) vs. frequency (Hz) from step 3.

7. Also in Excel, plot phase vs. frequency (Hz) from your equation in step 4. On the same graph, plot phase vs. frequency (Hz) from step 3.

8. From the graph in step 6, eyeball the center frequency (f_O) and bandwidth (BW) of the circuit and compare to the calculated values from step 5.

	Experimental	**Theoretical**	**% Difference**
f_O (Hz)			
BW (Hz)			

9. Turn in this report and your plots from steps 6 and 7.