Labs 4 and 5

RLC Resonant Circuits

Purpose

Highly tuned RLC tank circuits play a major role in electronics and communications. In these experiments you will investigate the frequency response of two RLC circuits that produce a low-pass and a bandpass filter. Through PSPICE simulation and actual laboratory experimentation, you will determine the natural frequency, damping ratio, 3-dB bandwidth, and quality factor of the circuits in terms of the circuit parameters.

Skills to develop

After completing this lab you should be able to:

- Choose the resistor value in a series or parallel RLC circuit to achieve a specified *BW* or *Q* value
- Use Pspice to simulate series or parallel RLC circuits in the frequency domain, determining ω_o, *BW* and *Q* from your plots
- Measure the resonance properties of RLC series and parallel circuits in the lab, including determination of the resonance frequency, bandwidth and *Q*

Equipment

For the laboratory experimentation, the standard laboratory equipment (function generator, oscilloscope, multimeter) will be used along with a capacitor (0.027 μF), an inductor (10 mH for the series RLC circuit and 1 mH for the parallel RLC circuit), and a resistor (to be determined in your prelab work).

Prelab work and PSpice simulations were done in Lab 4

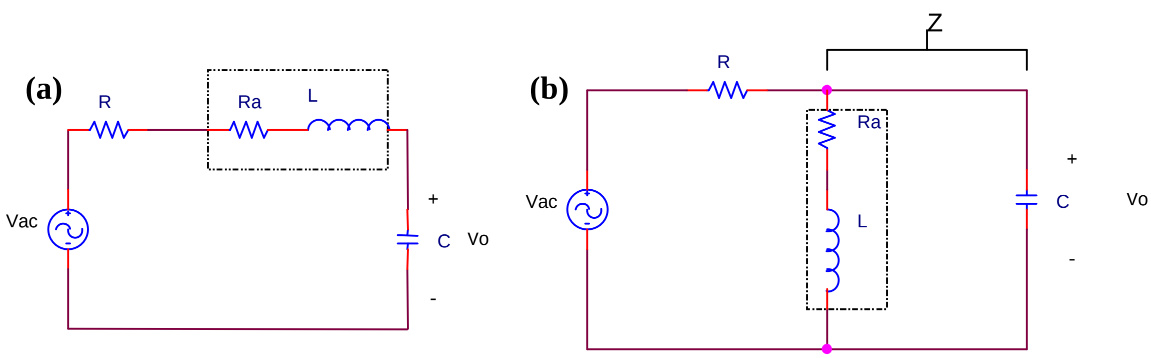

Fig. 1. RLC lowpass (a) and bandpass (b) filter circuits.

Lab No. 5 Laboratory Investigation:

1. Measure the resistance (R_a) of the inductors you are going to use in your experiments.

Lowpass Circuit

Note: You may choose to use this lab to construct the lowpass circuit you designed for the RLC Design Problem, *instead of circuit (a)*. Be sure to indicate which circuit you are building in your notebook, and take data according to the Design problem requirements if you choose to use that circuit. Otherwise, take data according to the lab instructions below if you are building the RLC circuit you simulated last week in Lab 4.

2. Breadboard circuit (a); Use a value of R, as close as you can, to the value you determined in your prelab minus the internal impedance of the signal generator. You measured this impedance in your earlier experiments to be about 50 Ω.

3. With the signal generator disconnected from your circuit, adjust its frequency to be close to the natural frequency of your circuit. Also, adjust the unloaded generator output voltage to a sinusoid with a peak-to-peak amplitude of one volt (unloaded means just connected to the oscilloscope, and not to the rest of the circuit).

4. Connect the signal generator to your circuit. Vary the frequency setting of the signal generator slightly to find the frequency at which the voltage across the capacitor (V_0) is at its maximum. Note the function generator frequency, which we will call f_{peak}, and its corresponding radian frequency ω_{peak}. Also note the maximum signal amplitude. Decrease the frequency by two orders of magnitude and measure the output voltage amplitude to determine your low frequency gain. Is this as you expect, considering the function generator output resistance and the inductor resistance?

5. Increase the frequency of the signal generator slightly to find the frequency, f_H, at which the voltage output of the circuit is reduced by a factor of 0.707 from the peak voltage. Note this frequency.

6. Decrease the frequency of the signal generator to a frequency f_L, ($f_L < f_o$), at which the circuit output voltage is reduced by a factor of 0.707 from the peak voltage. Note this frequency. Calculate the bandwidth and Q of your circuit.

7. Using the technique from Lab 3 in which we used the sync output from the function generator for a phase reference, measure the phase angle difference between the output voltage of the circuit and that of the signal generator at frequency f_{peak}. By how many degrees does the circuit output voltage lead or lag the circuit input voltage at f_{peak}? Adjust for a 90^o phase lag, and note the frequency f_o at which this occurs. Measure the output voltage amplitude at f_o. For the low-pass series RLC circuit, this should be Q times the low frequency voltage amplitude.

8. Measure the output voltage gain and phase at $10f_o$ and at $20f_o$. You may need to increase the input amplitude to make these measurements. How does the amplitude decrease as a function of frequency, in dB/octave or dB/decade, well beyond resonance?

Bandpass Circuit

9. Repeat steps 2-8 above for the parallel RLC bandpass circuit (b). In step 7, adjust for a 0^o phase lag, which should occur at $f_o = f_{peak}$.