

Intro to Measurement Systems - Practice 1

Resonance in RLC circuits

LA-CoNGA physics

January 28, 2022

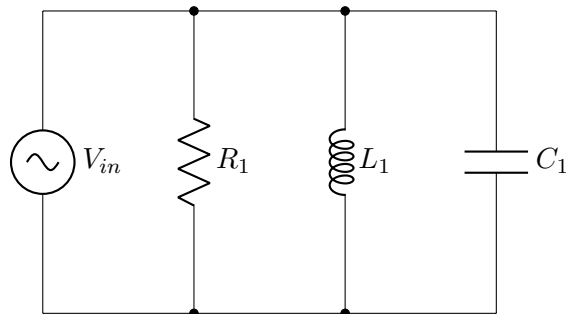
1 Objective:

The objective of this Lab activity is to study the phenomenon of resonance in RLC circuits. Determine the resonant frequency and bandwidth of the given network using the amplitude response to a sinusoidal source.

2 Background:

A resonant circuit, also called a tuned circuit consists of an inductor and a capacitor together with a voltage or current source. It is one of the most important circuits used in electronics. For example, a resonant circuit, in one of many forms, allows us to tune into a desired radio or television station from the vast number of signals that are around us at any time.

A network is in resonance when the voltage and current at the network input terminals are in phase and the input impedance of the network is purely resistive.



Consider the Parallel RLC circuit of figure. The steady-state admittance (the reciprocal of impedance) offered by the circuit is:

$$\gamma = \frac{1}{R} + j \left(\omega C - \frac{1}{\omega L} \right) \quad (1)$$

Resonance occurs when the voltage and current at the input terminals are in phase. This corresponds to a purely real admittance, so that the necessary condition is given by:

$$\omega C - \frac{1}{\omega L} = 0 \quad (2)$$

The resonant condition may be achieved by adjusting L , C , or ω . Keeping L and C constant, the resonant frequency ω_0 is given by:

$$f_0 = \frac{1}{(2\pi\sqrt{LC})} \quad [Hz] \quad (3)$$

Frequency Response: It is a plot of the magnitude of the output Voltage of a resonance circuit as function of frequency. The response of course starts at zero, reaches a maximum value in the vicinity of the natural resonant frequency, and then drops again to zero as f becomes infinite. The frequency response is shown in figure 1 .

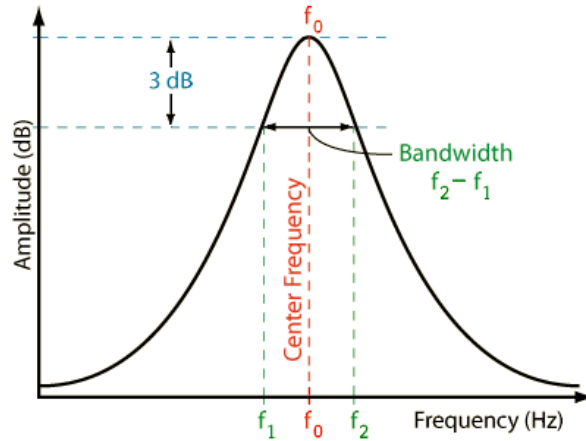


Figure 1: Frequency Response of Parallel Resonant Circuit

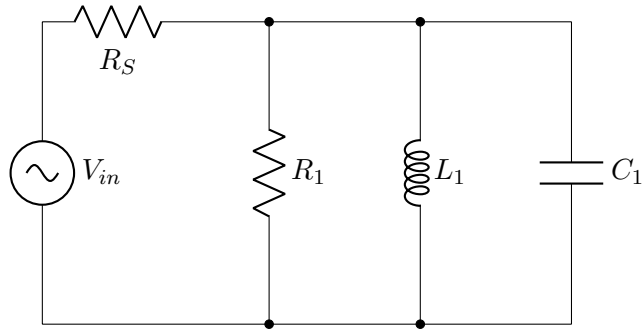
The two additional frequencies f_1 and f_2 are also indicated which are called half-power frequencies. These frequencies locate those points on the curve at which the amplitude is $3dB$ lower than the maximum value. They are used to measure the band-width of the response curve. This is called the half-power bandwidth of the resonant circuit and is defined as:

$$\beta = f_2 - f_1 \quad (4)$$

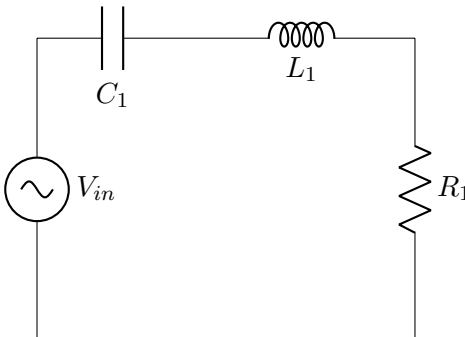
3 Procedure

3.1 Simulating

1. Simulate the RLC circuit asSet up the RLC circuit as shown in the following figure on LTSpice, with the component values $R_S = 100\Omega$, $R_1 = 1K\Omega$, $C_1 = 1\mu F$ and $L_1 = 20mH$.



2. Perform an AC analysis with the following parameters
 - Type of sweep: Decade
 - Number of points per decade: 100
 - Start frequency 10 Hz
 - Stop frequency 10kHz
3. Calculate the resonance frequency and the bandwidth of the circuit using eq.(3) and (4) and compare with the simulated values
4. Repeat the experiment using for the series resonant circuitry (see figure below, and use $L_1 = 20mH$ and $C_1 = 0.01\mu F$ and $R_1 = 1K\Omega$. The voltage V_0 on the resistor is proportional to the series RLC circuit current.



5. Compare the results of both experiments and draw your conclusions

3.2 Measuring

3.2.1 Parallel RLC

1. Set up the RLC circuit as shown in figure 3 on your solderless breadboard, with the component values $R_S = 100\Omega$, $R_1 = 1K\Omega$, $C_1 = 1\mu F$ and $L_1 = 20mH$.
2. Set the signal generator to generate a signal with Min value to 0.5 and Max value to 4.5V to apply a $4V_{pp}$ sine wave centered on 2.5V with 500Hz of frequency as the input voltage to the circuit.
3. Connect channel A of the oscilloscope to the first terminal of R_S resistor and set the voltage and time scale to display 2 periods of the signal
4. Connect the channel B of the oscilloscope to the second terminal of R_S
5. Vary the frequency of the sinewave on the input from 500Hz to 2.5KHz in 100Hz steps. For each frequency write down the peak to peak voltage for channel A and channel B and the A-B phase. Note at what frequency the voltage seen at the output of the circuit on Channel B, is maximum. This will be near the resonant frequency of the circuit. Note the phase should be nearly zero degrees at this frequency. Adjust the frequency in 10Hz increments around where you see a maximum for channel B voltage until the A-B phase is exactly zero.

3.2.2 Series RLC

1. Repeat the experiment using for the series resonant circuitry in figure 4, and use $L_1 = 20mH$ and $C_1 = 0.01\mu F$ and $R_1 = 1K\Omega$. The V_o voltage on the resistor is proportional to the series RLC circuit current.

4 Questions

1. Find the resonant frequency, f_0 using equation (3) and compare it to the experimental value in both cases.
2. Plot the voltage response of the circuit and obtain the bandwidth from the half-power frequencies using equation (4).

4.1 Analyzing

1. Compute the attenuation of the input vs output using dB units.
2. Graph the attenuation against frequency using logarithm scale.
3. Compare your results with simulations.