

EXPERIMENT 7:

Resonance in RLC Circuits

Objectives:

- Study the phenomenon of resonance in RLC circuits.
- Determine the resonant frequency and bandwidth of the given network using a sinusoidal response.

Equipment:

- NI – ELVIS
- Resistors (1 K Ω)
- Capacitors (1 μ F, 0.01 μ F)
- Inductors (33mH)

Theory:

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 its many forms, allows us to select a desired radio or television signal 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.

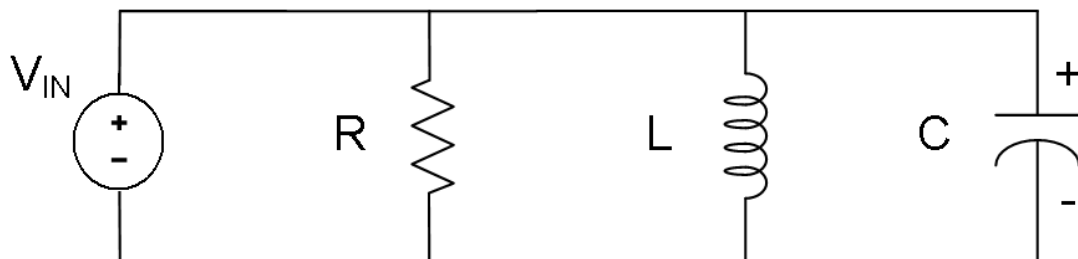


Figure 1: Parallel Resonance Circuit

Consider the Parallel RLC circuit of figure 1. The steady-state admittance offered by the circuit is:

$$Y = 1/R + j(\omega C - 1/\omega L)$$

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

$$\omega C - 1/\omega L = 0$$

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:

$$\omega_0 = \frac{1}{\sqrt{LC}} \quad \text{rad/s} \quad (1)$$

OR

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \quad \text{Hertz} \quad (2)$$

Frequency Response: It is a plot of the magnitude of 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 ω becomes infinite. The frequency response is shown in figure 2.

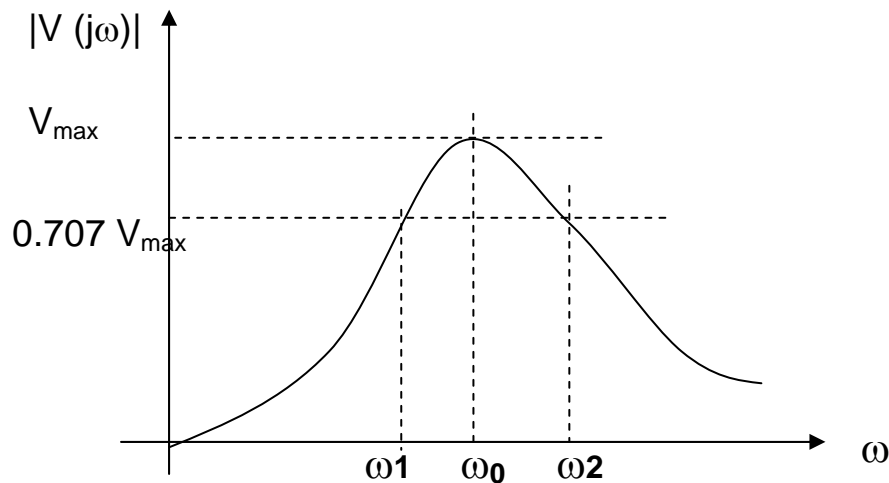


Figure 2: Frequency Response of Parallel Resonant Circuit

The two additional frequencies ω_1 and ω_2 are also indicated which are called *half-power frequencies*. These frequencies locate those points on the curve at which the voltage response is $1/\sqrt{2}$ or 0.707 times 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:

$$\beta = \omega_2 - \omega_1 \quad (3)$$

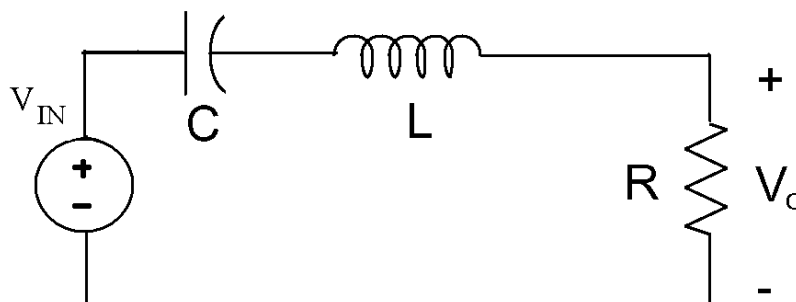


Figure 3: Series Resonance Circuit

Procedure:

1. Set up the RLC circuit as shown in Figure 4, with the component values $R = 1\text{ K}\Omega$, $C = 1\text{ }\mu\text{F}$ and $L = 33\text{ mH}$. and switch on the ELVIS board power supply.

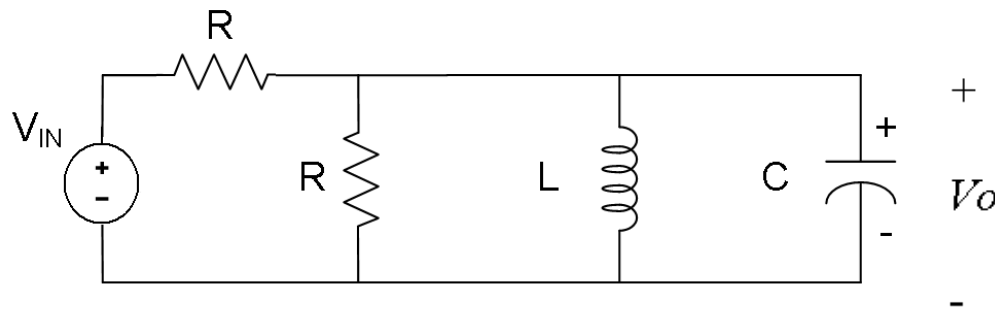


Figure 4: Parallel Resonance Circuit with a series resistance connected to a source

2. Select the Function Generator from the NI - ELVIS Menu and apply a $4V_{p-p}$ Sinusoidal wave as input voltage to the circuit.
3. Select the Oscilloscope from the NI - ELVIS Menu. Set the Source on Channel A, Source on Channel B, Trigger and Time base input boxes as shown in figure below.
4. Vary the frequency of the sine-wave on the FGEN panel from 500Hz to 2 KHz in small steps, until at a certain frequency the output of the circuit on Channel B, is maximum. This gives the resonant frequency of the circuit.
5. Repeat the experiment using for the series resonant circuitry in Figure 3, and use $L = 33\text{mH}$ and $C = 0.01\mu\text{F}$ and $R = 1\text{ K}\Omega$. The V_o voltage on the resistor is proportional to the series RLC circuit current.

Questions for Lab Report:

1. Find the resonant frequency, ω_o using equation (1) 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 (3).