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EE1200 - ELECTRIC CIRCUITS LAB

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1 TRANSIENT RESPONSE OF AN LC CIRCUIT

1.1 AIM :

To study and analyze the transient response of an LC circuit, determine the natural frequency Ω_n, and calculate the damping ratio ζ using theoretical and experimental methods.

1.2 APPARATUS REQUIRED:

- A 1 nF capacitor
- A 2.2 mH inductor
- DC power supply
- An oscilloscope
- Connecting wires
- Probe

1.3 THEORY :

- An LC circuit consists of an inductor (L) and a capacitor (C) connected in parallel.
- When a charged capacitor is connected to an inductor, energy oscillates between the capacitor's electric field and inductor's magnetic field.
- But, in practicality, the components have their associated resistances, so the circuit essentially becomes an RLC circuit. Hence, the response eventually decays and becomes zero and becomes **damped oscillation** .

1.4 PROCEDURE :

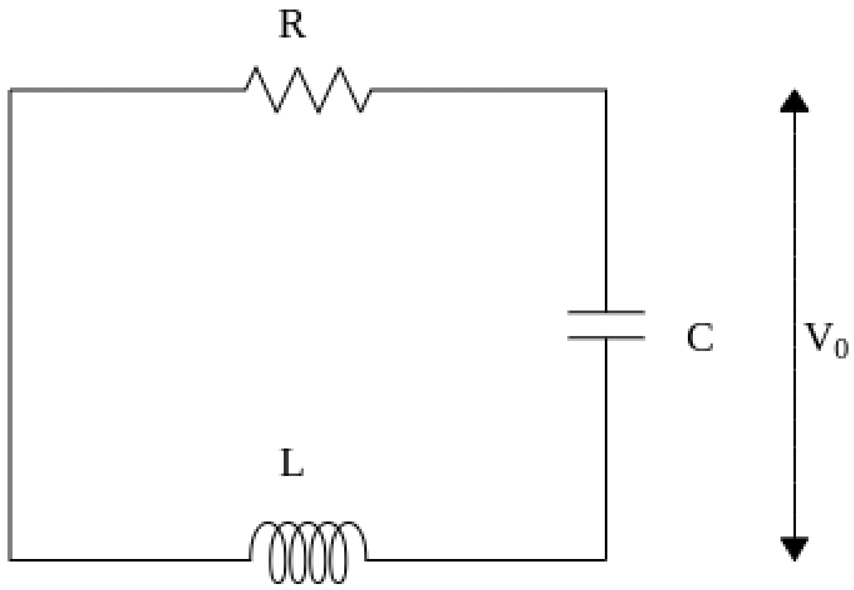
- Connect the capacitor to a 5 V DC power supply. Once charged, disconnect it carefully without discharging it.
- Connect the charged capacitor in parallel with the inductor. Ensure minimal resistance in the wiring.
- The oscilloscope is used to monitor the voltage across the capacitor, and the natural oscillations are observed.
- The natural frequency is calculated using theoretical method as given in the following section and the value is compared with the experimental value.
- The resistance across the inductor is found using a multimeter and the damping ratio ζ is estimated and compared with the observed value.

1.5 OBSERVATION :

- The waveform from the oscilloscope is recorded.
- The oscillation period is measured using cursors.
- The decay rate is measured.
- From the graph, it can be seen that the damping frequency is 60 kHz .

1.6 CALCULATION :

Consider the RLC circuit shown in Figure . The governing differential equation can be written as



$$\frac{d^2V}{dt^2} + \left(\frac{R}{L}\right)\frac{dV}{dt} + \frac{V}{LC} = 0 \tag{1}$$

The damping coefficient,

$$\zeta = \frac{R}{2}\sqrt{\frac{C}{L}} \tag{2}$$

Considering $\zeta < 1$, we have,

$$V = V_0 e^{\frac{-Rt}{L}} \left(cos(\Omega_n t) + sin(\Omega_n t)\right) \tag{3}$$

where,

$$\Omega_n = \frac{1}{\sqrt{LC}} \tag{4}$$

It can be seen that

$$\Omega_n = \frac{1}{\sqrt{2.2 \times 10^{-3} \times 10^{-9}}} \tag{5}$$

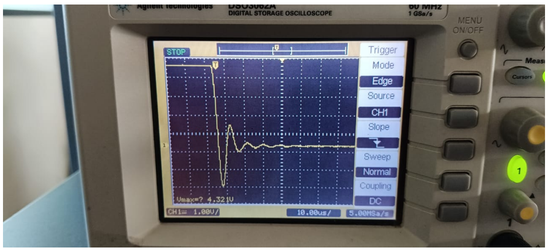
$$= 107 \text{ kHz} \tag{6}$$

$$\zeta = 12.5 \times \sqrt{\frac{10^{-9}}{2.2 \times 10^{-3}}} \tag{7}$$

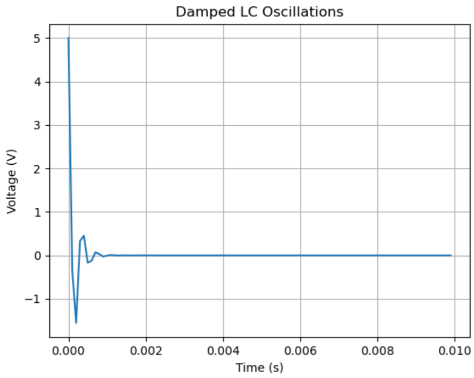
$$= 8.09 \times 10^{-3} \tag{8}$$

1.7 CONCLUSION :

- It can be seen that the observed and calculated values are matching under the limits of experimental errors.
- The dependence of Ω_n and ζ are established and explored.

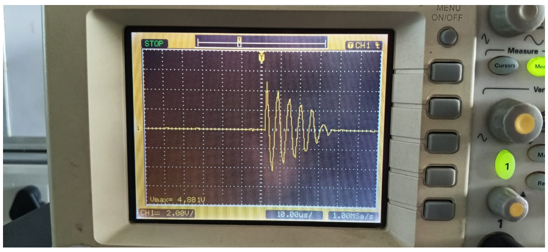


(a) Voltage across capacitor

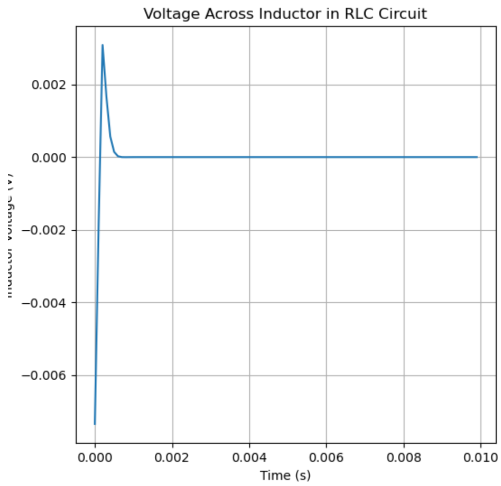


(b) Theoretical Result

Figure 1: Comparison of Experimental and Theoretical Results



(a) Voltage across inductor



(b) Theoretical Result