EE LAB REPORT-4

Kolluru Suraj
EE24BTECH11033
Department of EE

M.B.S Aravind
EE24BTECH11038
Department of EE

logo.jpg

CONTENTS

A. Aim

To study and analyse the transient response of an LC circuit, determine the natural frequency (Ω_n), and calculate the damping ratio (ξ) using theoretical and experimental methods.

B. Appratus used

- 580 pF capacitor
- Inductor of inductance 2.2mH
- DC power supply
- Oscilloscope

C. Theory

LC-circuit

1) 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 the inductor's magnetic field.
   - **Transient Response -** The transient response refers to the behavior of the circuit immediately after a change in input (e.g., switching ON or OFF).

Natural Frequency(Ω_n) - The frequency at which the LC circuit oscillates in the absence of any damping or external excitation.

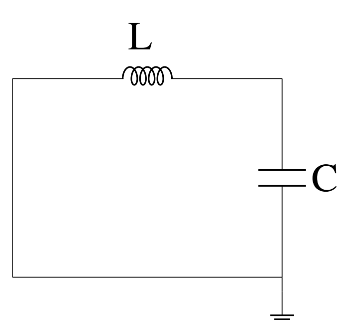

Fig. 1: LC Circuit

$$V_L + V_c = 0$$
$$V_L = L\frac{di}{dt}$$
$$V_c = \frac{1}{I}\int T dt$$

Taking derivative on both sides

$$\frac{d^2 I}{dt^2} + \frac{1}{LC} I = 0$$

An SHM equation

$$I(t) = I_o \cos\left(\frac{1}{\sqrt{LC}} t + \phi\right)$$
$$\Omega_n = \frac{1}{2\pi\sqrt{LC}}$$

Damping ratio (ξ)- A parameter that describes how quickly oscillations decay due to resistance in the circuit
Consider the LCR circuit shown below.

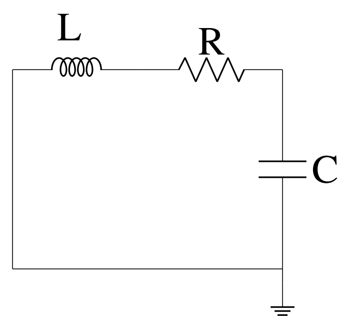

Fig. 2: Series RLC Circuit

current is given by

$$L\frac{d^2 I}{dt^2} + R\frac{dI}{dt} + \frac{I}{C} = 0$$
$$\frac{d^2 I}{dt^2} + \frac{R}{L}\frac{dI}{dt} + \frac{I}{CR} = 0$$

General form of 2nd order differential equation is

$$\frac{d^2x}{dt^2} + 2\xi\Omega_n\frac{dx}{dt} + \Omega_n^2 x = 0$$

Comparing both the equations gives the ξ = $\frac{R}{2}\sqrt{\frac{C}{L}}$
Therefore, natural frequency in damping condition is

$$\Omega_d = \Omega_n\sqrt{1-\xi^2} \tag{1}$$

Types of damping

1) **Underdamped**($\xi < 1$)
   - Oscillatory response with decreasing amplitude.
   - The system oscillates, but gradually loses energy.
2) **Critically Damped**($\xi = 1$)
   - Fastest return to equilibrium without oscillations.
3) **Overdamped**($\xi > 1$)
   - There is no oscillation, but the system takes a long time to reach equilibrium.

D. Procedure/Experiment

1) Charge the 580 pF capacitor using a 5V DC source
2) After charging carefully disconnect it without discharging
3) Construct a simple LC circuit
4) Capture the transient response by using oscilloscope

E. Experimental data

The transient response obtained is as shown

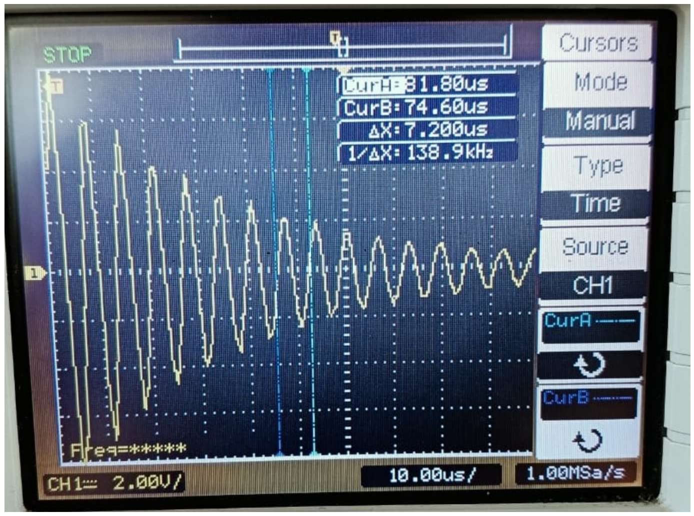

Fig. 3: Transient response for the LC circuit

Theoretical calculations

$$\Omega_n(\text{Natural frequency}) = \frac{1}{2\pi\sqrt{LC}} \tag{2}$$

$$\implies \Omega_n = 140.894KHz \tag{3}$$

However, when calculated using the oscilloscope's cursors, the frequency is shown as 138.9 kHz. This discrepancy is due to the internal resistance of the inductor, which also causes damping.
The internal resistance of inductor can be calculated using multimeter
In our case the internal impedance arising from the resistive components of the wiring and the intrinsic resistance of the inductor is given as 50Ω

$$\xi(\text{Damping factor}) = \frac{R}{2}\sqrt{\frac{C}{L}} \tag{4}$$

$$\implies \xi \approx 0.0122 \tag{5}$$

$$\Omega_d(\text{Damping frequency}) = \Omega_n\sqrt{1-\xi^2} \tag{6}$$

$$\implies \Omega_d = 140.85KHz \tag{7}$$

There will be capacitance in the oscilloscope probes and resistance parallel to capacitor we cannot get exact value of frequency