Experiment 5: RLC Circuit Response Analysis

Arnav Kapoor (23060)

[Date of Experiment - 14/09/2025]

Objective

- **5.1:** For the given RLC circuit, apply input signals of different frequencies and vary the resistance values for a fixed value of L and C. Measure output voltage, $V_{out}(t)$.
- **5.2:** Measure V_{out} for these combinations to observe underdamped, overdamped, and critically damped behavior by adjusting the appropriate values of R, L, and C.

Circuit Details

- **Inductor (L)** [Value, 100 mH]
- **Capacitor (C)** [Value, 10 μF]
- **Resistor (R)** [Value, 1 kΩ]
- **Input Signal** Sine wave, [frequency range, 10 Hz – 10 kHz]

Experimental Procedure

1. Set up the RLC series circuit with fixed L and C values.
2. Apply input signals of different frequencies using a function generator.
3. Vary the resistance (R) and record the output voltage $V_{out}(t)$ for each combination.
4. For each R value, observe the circuit's response and classify it as underdamped, overdamped, or critically damped.
5. Record the time-domain response using an oscilloscope.

Experimental Setup

Below are images of the experimental setup used for the RLC circuit analysis:

Observations

The observation table is shown below:

LTspice Simulation Results

LTspice simulation results for the RLC circuit are shown below:

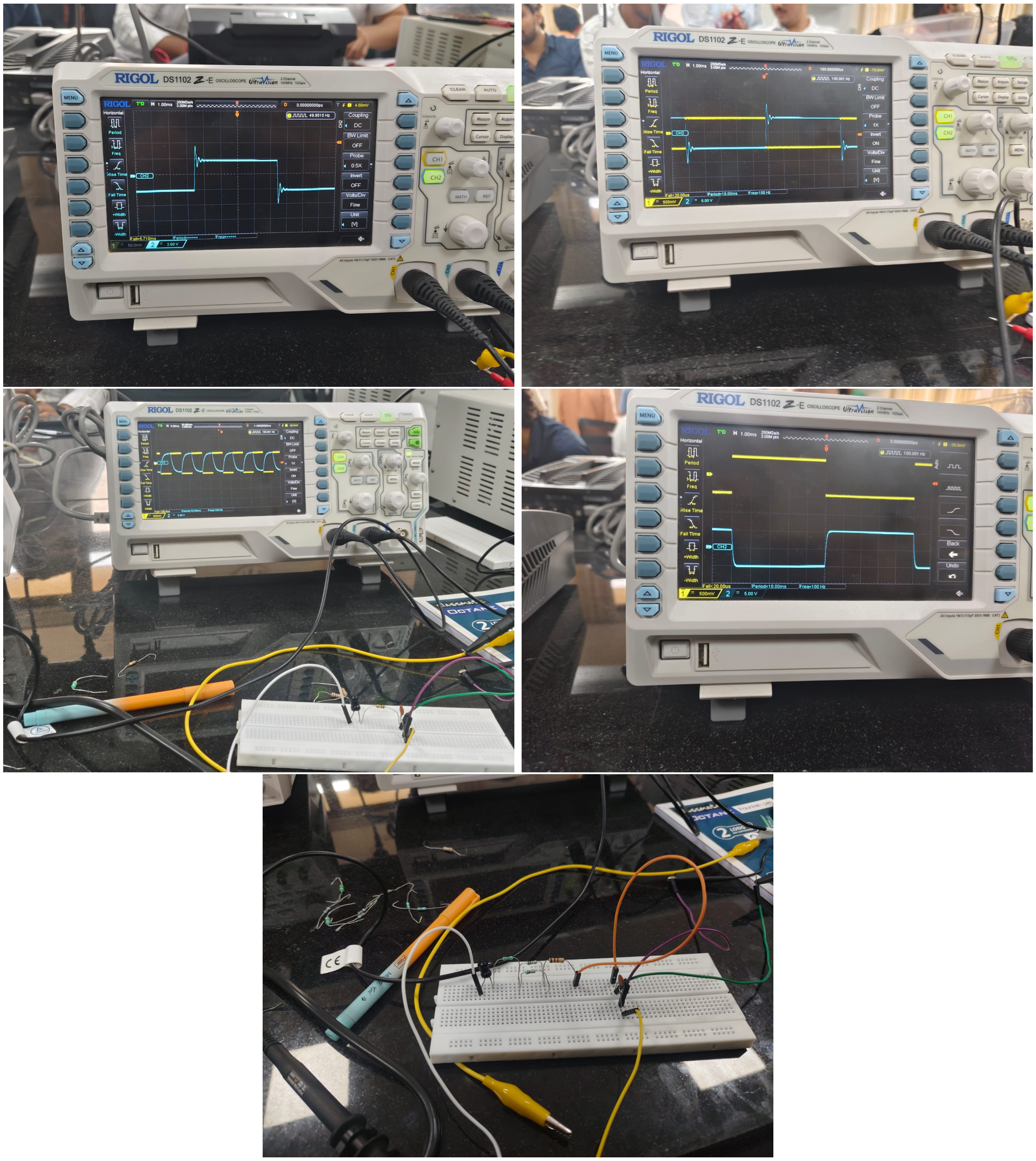

Figure 1: Experimental setup for RLC circuit analysis

Plots

- Output voltage $V_{out}(t)$ vs time for each damping case (underdamped, overdamped, critically damped)
- Output voltage vs frequency for different R values

frequency (=ω/2*pi) in KHz	I (µA)
0.5	106.2
1	217.4
1.5	340.5
2	480
2.5	643
3	827
3.5	1031
4	1233
4.5	1354
4.6	1358
5	1279
6	758
7	390
8	207.5
9	113.6
10	61.7

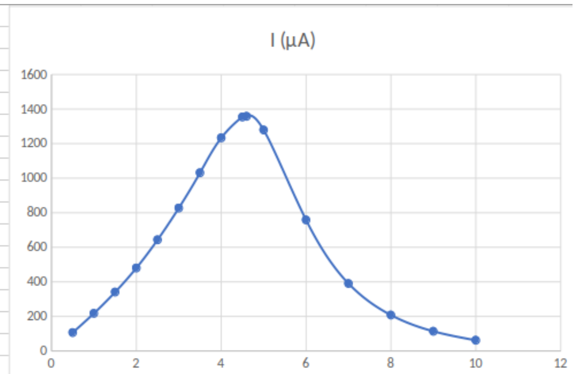

Figure 2: Observation Table for RLC Circuit

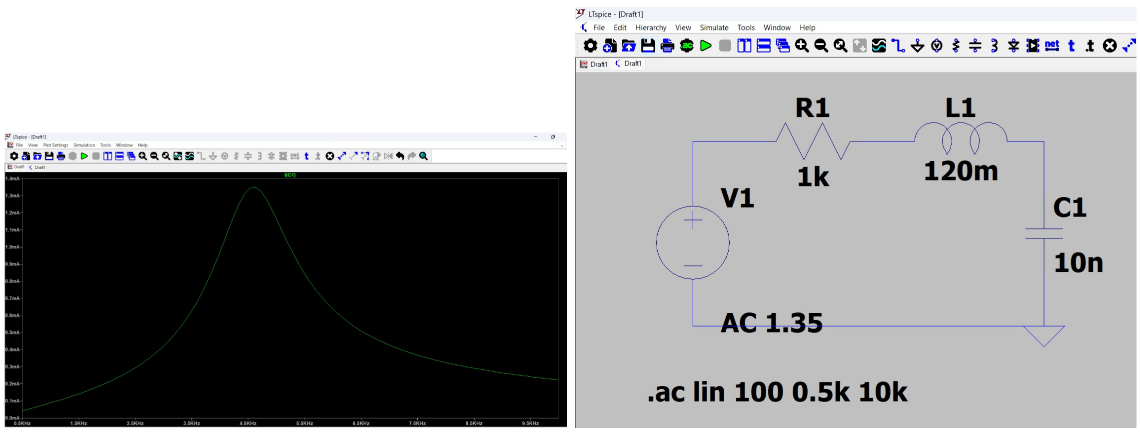

Figure 3: LTspice Simulation Results for RLC Circuit

Theoretical Background

The response of an RLC circuit to a step or sinusoidal input is governed by the second-order differential equation:

$$L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{1}{C}i = V_{in}(t)$$

The damping behavior depends on the damping factor $\zeta = \frac{R}{2}\sqrt{\frac{C}{L}}$:

- **Underdamped** ($\zeta < 1$): Oscillatory response
- **Critically damped** ($\zeta = 1$): Fastest non-oscillatory return to zero
- **Overdamped** ($\zeta > 1$): Slow, non-oscillatory response

Results & Discussion

Summarize the observed responses for each R value. Compare experimental results with theoretical predictions. Discuss any discrepancies (e.g., component tolerances, measurement errors).

Conclusion

The experiment successfully demonstrated the effect of resistance on the damping behavior of an RLC circuit. Underdamped, overdamped, and critically damped responses were observed and measured. The results align with theoretical expectations for second-order systems.