LAB-2

TRANSIENT RESPONSE OF SERIES LCR CIRCUIT

|Tejas Kaushik | GUID- 3049840K|

Objective

To study and analyze the transient response of a series LCR circuit, determine the damping constant (α), natural frequency (ω_0), inductance (L), and coil resistance ($R_{(coil)}$), and compare experimental and simulated results for under-damped and critically damped conditions.

Milestone 1 – Measurement of Damped Oscillation Period

With Rpot = 0 Ω and an input of 3 V p-p, the period of the damped oscillations ($T_{(d)}$) was measured using cursors on the oscilloscope. After verifying that the period does not depend on amplitude, the amplitude was reduced to 0.3 V p-p for the rest of the experiment. The average period obtained was:

$T_{(d)}$ = 17 ms

Observation: The oscillation period remained constant across different amplitudes, confirming that the frequency depends on L and C only.

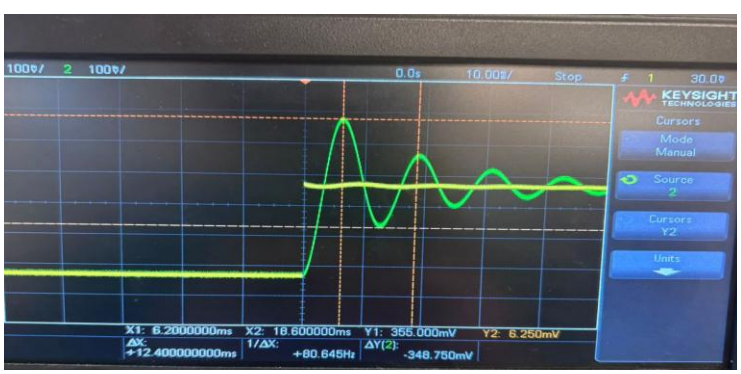
Milestone 2 – Determination of Damping Constant (α), Inductance (L), and Coil Resistance ($R_{(coil)}$)

Using 0.3 V p-p input and Rpot = 0 Ω, the first two peak amplitudes (O_1 and O_2) of the capacitor voltage were measured from Channel 2 on the oscilloscope.

Measured values: O_1 = 111.25 mV, O_2 = 43.7 mV, $T_{(d)}$ = 12.4 ms.

The damping constant (α) was calculated using the relation: $\alpha = (1/T_{(d)}) \ln(O_1 / O_2) = 75$ s^{-1}. From $T_{(d)}$, the damped and natural frequencies were found as $\omega_{(d)}$ = 506 rad/s and $\omega_{(0)}$ = 511 rad/s respectively. The inductance and coil resistance were then calculated as L = 3.8 H and $R_{(coil)}$ = 580 Ω.

Observation: The calculated values confirm that the circuit is under-damped since $\alpha < \omega_0$.

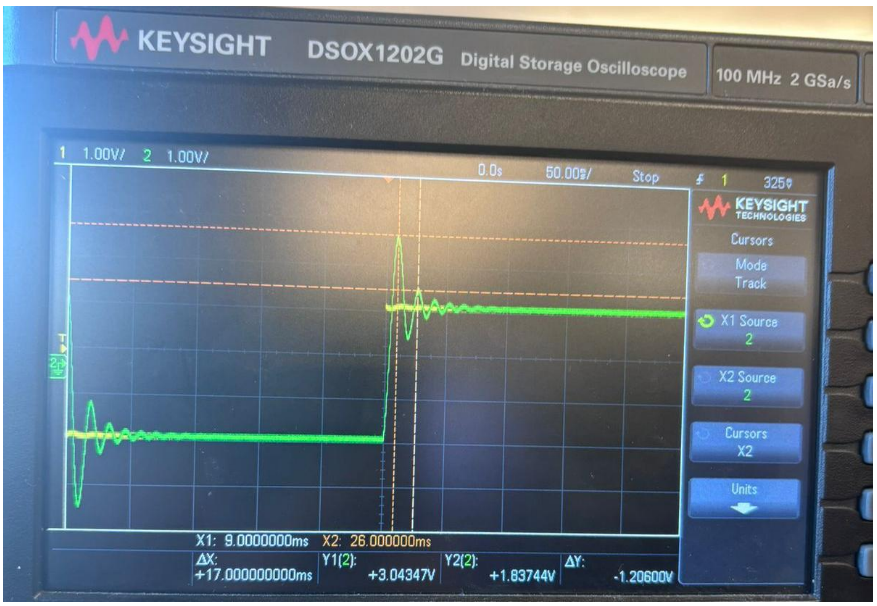


Oscilloscope waveforms showing O_1 and O_2.

Milestone 3 – Critical Damping

The potentiometer (Rpot) was increased gradually until oscillations just disappeared and the output returned to equilibrium without overshoot. This setting represents the critical damping condition.

The critical resistance was measured as $R_{c} = R_{pot,crit} + R_{coil} \approx 3.9\ k\Omega$, which matches the theoretical value $R_{c,theory} = 2\sqrt{(L/C)} \approx 3.9\ k\Omega$.



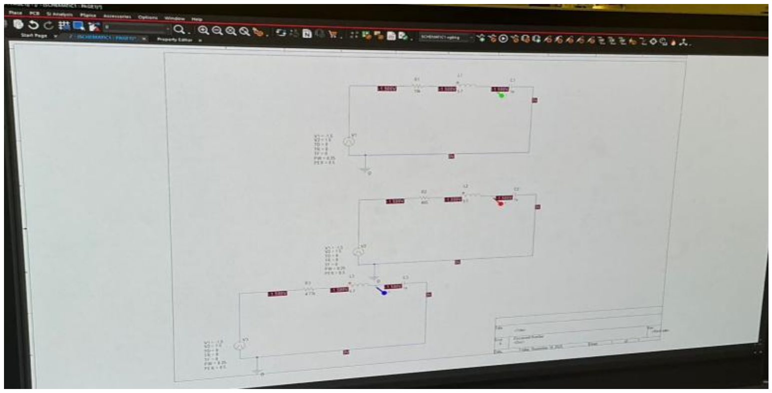
Oscilloscope waveform showing critically damped response.

Milestone 4 – PSpice Simulation

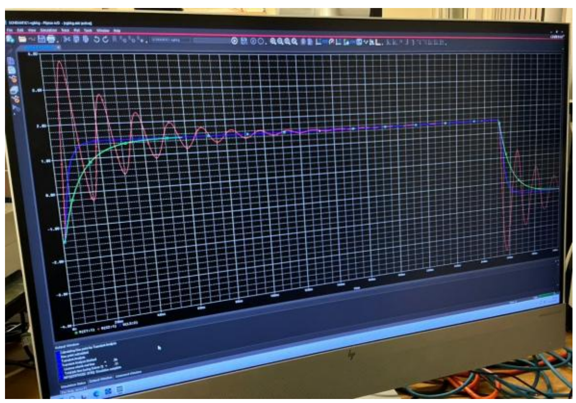
The circuit was simulated in OrCAD/PSpice using VPULSE, R, L, and C components with parameters matching the measured values. Simulations were run for both under-damped (R = 160 Ω) and critically damped (R = 3.9 kΩ) cases.

Results:
- R = 160 Ω → Under-damped oscillation observed.
- R = 3.9 kΩ → Critically damped response with no overshoot.

The simulated waveforms matched the experimental data closely, confirming theoretical predictions.



PSpice schematic of LCR circuit.



Simulation waveform (under-damped and critically damped).

Conclusion

The transient response of a series LCR circuit was successfully studied. Experimental and simulated results were consistent with theoretical expectations. For $R < R_{(C)}$, the circuit was under-damped and exhibited decaying oscillations, while at $R \approx R_{(C)}$ the system achieved critical damping. The experiment verified the relationship $R_{(C)} = 2\sqrt{(L/C)}$ and demonstrated how resistance controls the damping behaviour of an LCR circuit.