PHYS143

Physics for Engineers

Lab Report - 6

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Instructor

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Experiment 1: Faraday’s Law

Purpose:

To understand Faraday’s Law and the working of a motor and a generator using this law.

Conclusion:

Faraday's law of electromagnetic induction, named after Michael Faraday, states that a changing magnetic field induces an electromotive force in a closed circuit. This E.M.F generates an electric current in the wire, which can be used to power devices. The magnitude of the induced E.M.F is proportional to the rate of change of the magnetic flux through the circuit.

This is given by the formula emf = $-N\Delta\phi/\Delta t$, where:

N = Number of turns

$\Delta\phi$ = change in magnetic flux

Δt = change in time

This law is common and usually used in many modern devices and technologies including, power generation, electric motors, transformers, and communication systems. It is also the basis of electromagnetic induction, which is fundamental in physics and electrical engineering.

Experiment 2: RL Circuit

Purpose

To experiment and understand an RL circuit connected to DC voltage by measuring the voltages across the inductor and resistor using an oscilloscope.

Hypothesis

As the current increases exponentially, the voltage across the resistor increases and the voltage across the inductor decreases.

Procedure

- Using Multisim, we created a circuit using a 400μH inductor, 150Ω resistor, two channel oscillator and a pulse voltage of 9V with a frequency of 0.033Hz
- Channel 1 was connected across the resistor and channel 2 across the inductor to measure the voltage for each component
- The frequency of the input signal is set to be: $\frac{1}{f} = T > \tau = \frac{L}{R}$ to allow for better observation of charging and discharging

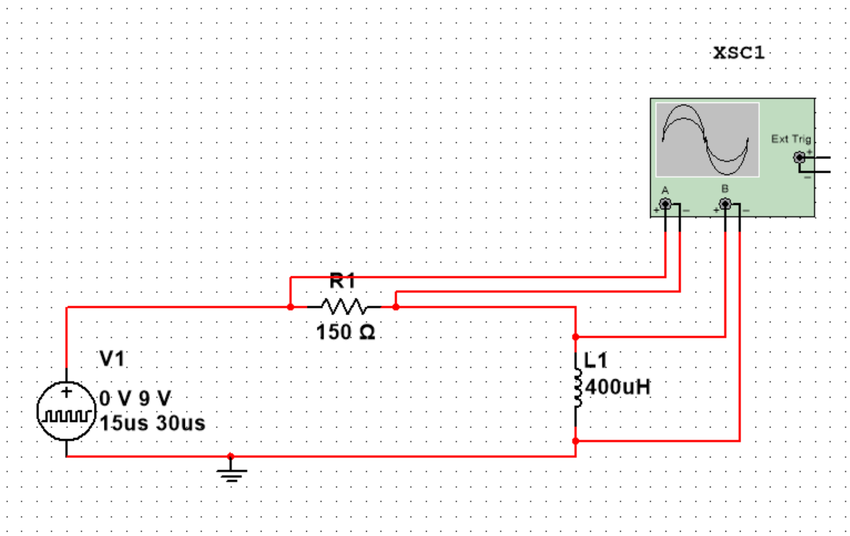

Fig. 1: Multisim circuit diagram

Data and Observations

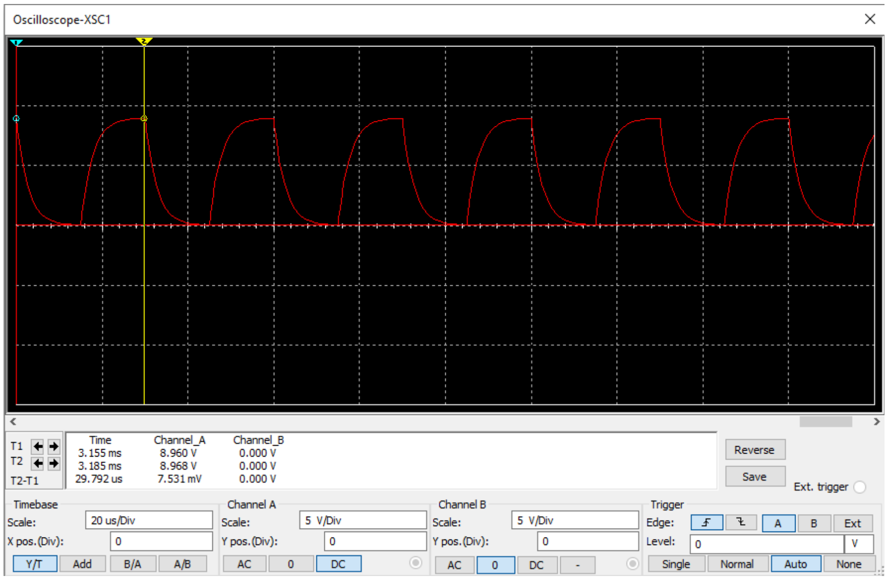

Fig. 2: Oscillator output across channel 1 (V_R)

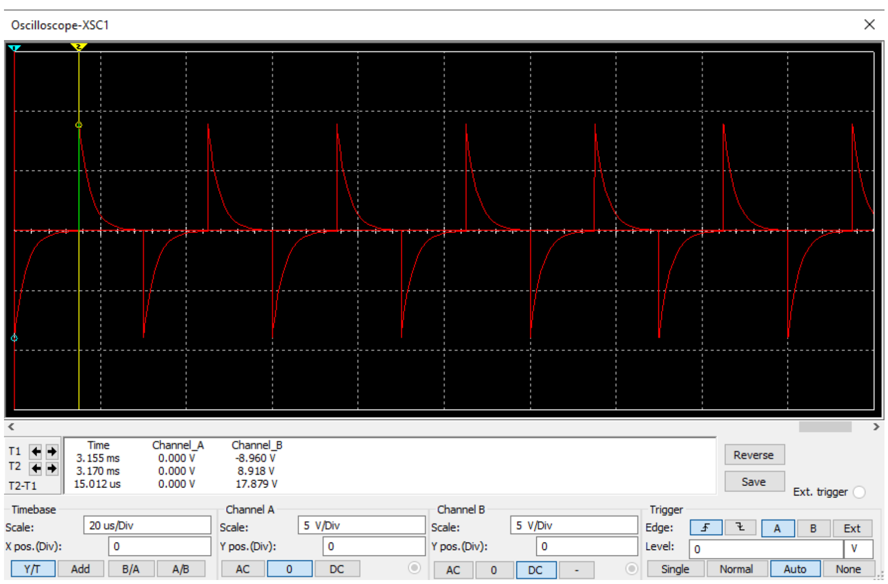

Fig. 3: Oscillator output across channel 2 (V_L)

From the given output of the oscillator across the two components, we can observe that as voltage across the resistor increases over time, the voltage of the inductor decreases. When V_R is maximum, V_L is zero and vice versa. However, V_L experiences a curve much more like a sine wave with alternating positive and negative amplitudes.

R (Ω)	L (μH)	τ (μs)	V_{max} (V)	f (Hz)	T (s)	V_R (V)	V_L (V)	V_{max} - V_R (V)	V_{max} - V_L (V)
150	400	2.67	9.00	0.033	30.0	8.968	8.918	0.032	0.082

Table 1: Recorded values from the experiment

To compare the measured values with theoretical values, we can calculate the expected values of voltage across each component using the formulas:

$$V_L = LI_{max}(e^{-t/\tau})$$

$$V_R = V_{max}(1 - e^{-t/\tau})$$

Conclusion

In conclusion, this experiment helped us understand the variation of voltage across a resistor and an inductor in an RL circuit. We were able to accurately predict the output values received on the oscillator at a given time using the time constant and the theoretical formulas. According to the lectures the time constant in an RL circuit is defined as the time taken for the current to reach its maximum steady state value and we were able to observe this through the experiment that we successfully performed.

Experiment 3: RLC Circuit

Purpose

To understand RLC circuit resonance and observe underdamped and overdamped oscillations in RLC circuits.

Hypothesis

At resonant frequency, the inductive reactance of the circuit becomes equal to the capacitive reactance which causes oscillations.

Procedure

1. Using Multisim, create a circuit with L=100mH, R=50Ω, C=10μF, a two channel oscillator and wave generator.
2. Channel 1 is connected across the capacitor and the wave generator is set to sin waves.
3. Note down the observations and waveform for different measurements for R.

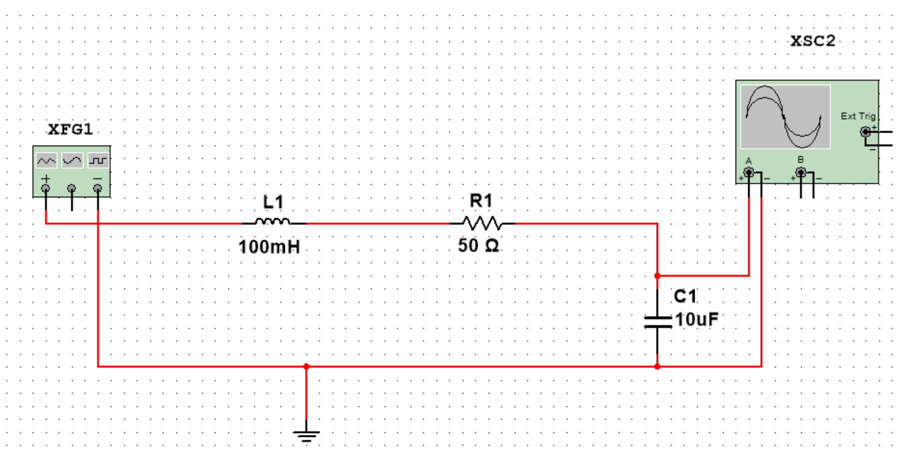

Fig. 4: Mulitsim circuit diagram

Data and Observations:

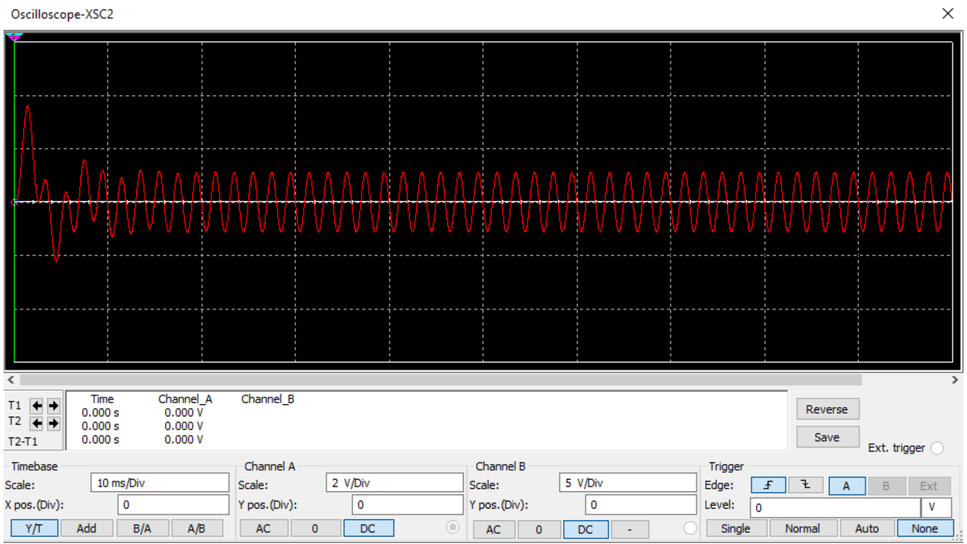

Fig. 5: Undamped oscillations

When $R=50\Omega$ ($R<2\sqrt{L/C}$), The signal slowly oscillates towards the permanent value of V_{in}

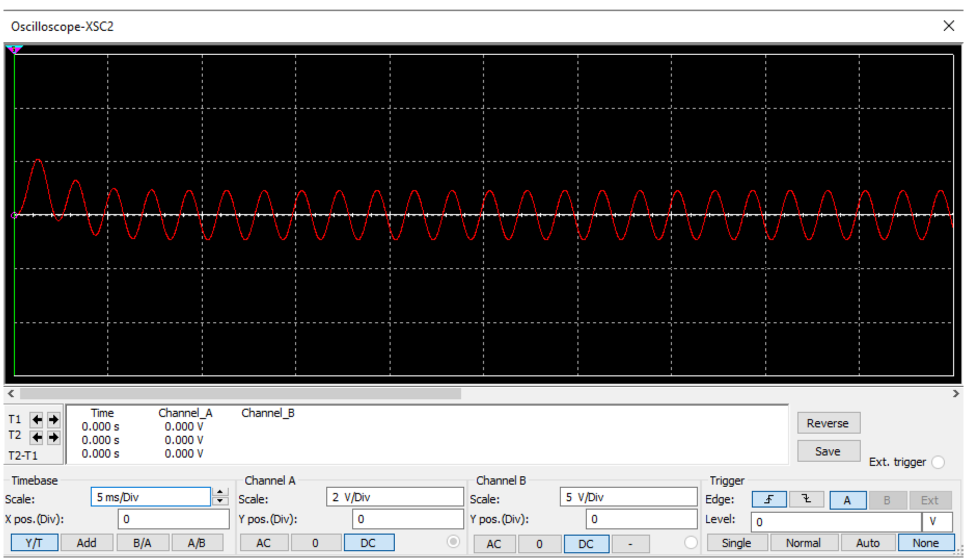

Fig. 6: Critical oscillations

When $R=200\Omega$ ($R=2\sqrt{L/C}$), the signal reaches V_{in} in the lowest period of time

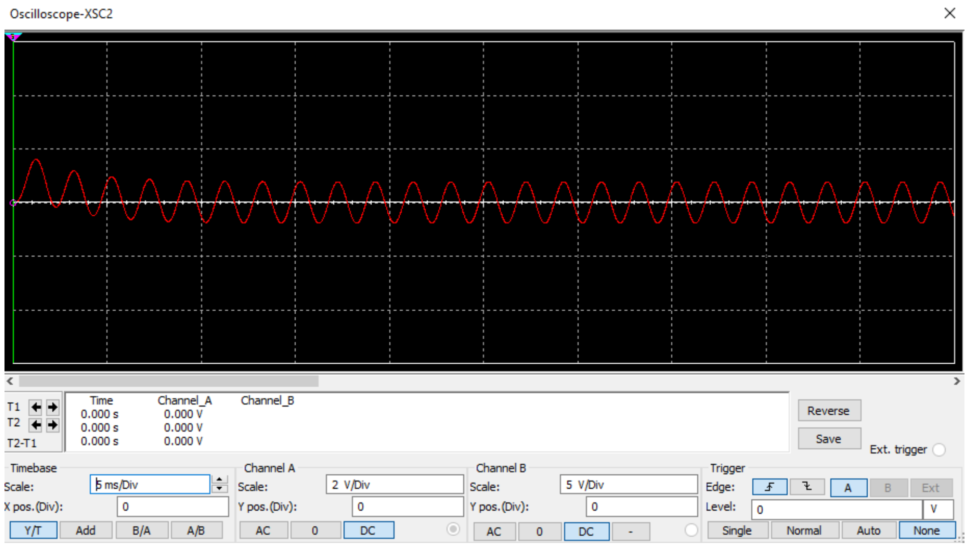

Fig. 7: Overdamped oscillations

When R=300Ω (R>2√L/C), the wave undergoes over-damping, it will not go through a complete oscillation initially and slowly increases to V_{in}

Conclusion:

This experiment showed the role of resistance in an RLC circuit and its effect on the oscillations formed. The amplitude's rate of decline is inversely related to its square. Underdamped, overdamped, and critically damped oscillation are the three different types of damped oscillation. Systems that are underdamped have a natural frequency that is higher than the damping factor. Systems that are overdamped have a natural frequency that is lower than the damping coefficient. Systems that have been critically damped have a natural frequency equal to the damping factor.