Lab Exercise No. 12
Inductive Reactance

Vaun Michael Pace, Paul Andrew Parras

Department of Electrical and Computer Engineering
School of Engineering, University of San Carlos
Nasipit, Talamban Cebu City, Philippines
pacevaun@gmail.com parraspau13874@gmail.com

Abstract—**Inductive reactance, or the resistance an inductor produces to alternating current, is investigated in this experiment. We tested the changes in voltage and current at various frequencies using a circuit that had an inductor and an AC power source. The findings demonstrated that the inductive reactance rose in tandem with the frequency. This helps to clarify the function of inductors in AC circuits and validates their frequency-dependent behavior.**

Keywords-component; Inductive Reactance, Alternating Current, Inductor, Frequency, Circuit, Voltage, Current, Resistance, Impedance, Electrical Resistance, Electromagnetic Induction

I. Introduction

An **inductor's resistance** to the flow of alternating current (AC) is known as **inductive reactance**, and it is a basic idea in electrical engineering and circuit theory. Inductive reactance results from the magnetic field produced around an inductor as current passes through it, as opposed to resistance, which releases energy as heat. Both the component's inductance and the AC signal's frequency affect this opposition.

Inductive reactance is dependent on the frequency of the AC signal, in contrast to pure resistance, which is constant, It results from the Inductor's capacity to resist changes in current flow and store energy in a magnetic field, a property based on Faraday's law of electromagnetic induction.

Inductive reactance has been studied since the 19th century, when electromagnetism first emerged. The foundation for comprehending inductors and their behavior was established by early pioneers such as Joesph Henry and Michael Faraday. These ideas were later codified in James Clerk Maxwell's equations, which established the function of inductance in circuit theory.

Modern Technology relies heavily on inductive reactance, especially when designing electronic circuit filters, power supply, motors, and transformers. Because of its frequency dependence, it is crucial for alternating current systems, impacting communication, signal processing, and power distribution. Engineers may study and build effective circuits with the aid of an understanding of inductive reactance, guaranteeing peak performance in a wide range of applications.

II. Procedure

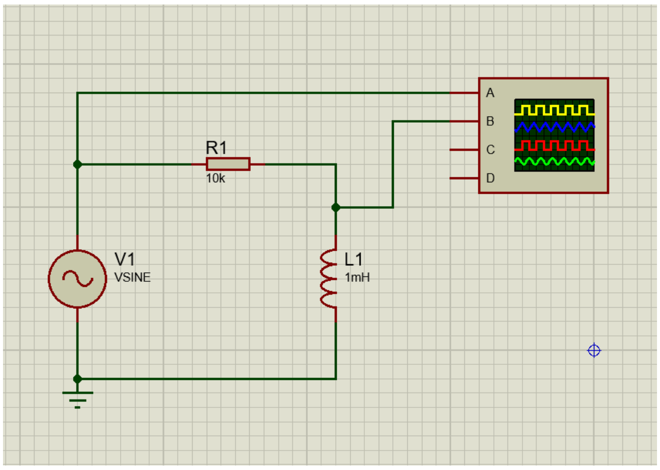

Figure 2.1: 1mH Inductor Circuit

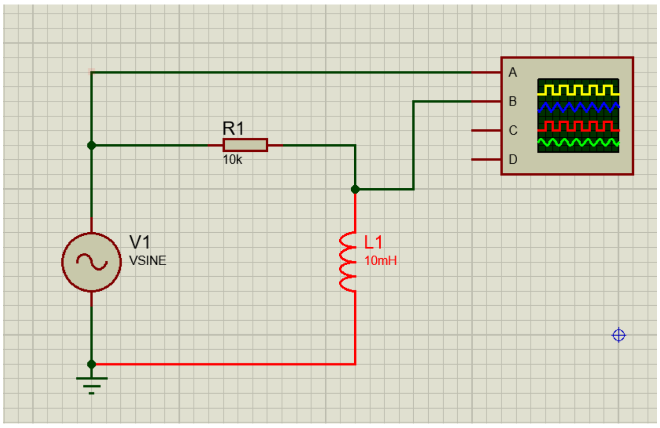

Figure 2.2: 10mH Indcutor Circuit

To start this experiment, we should build both circuits above with a 10V p-p and a 10kΩ resistor. After building the circuits, measure the circulating current using a DMM and record it in the data table. Also measure the DC resistance of the inductors using the DMM as well and record the values.

After recording those values, build the circuit with the 10mH inductor. Connect the oscilloscope to measure the voltage across the generator and the inductor. Set the frequency to 1000Hz sine wave with a 10V p-p.

After that, calculate the theoretical inductive reactance for the inductor and record it. Measure the peak-to-peak voltage across the inductor and record it as well. Using the source current and measured voltage, compute the experimental reactance and record it along with the percentage deviation. Repeat these steps while gradually increasing the frequency and writing down the results in the table. After, measuring values for the circuit with a 10mH inductor, replace the inductor with a 1mH inductor, and repeat the same steps done with the 10mH inductor.

III. RESULTS AND ANALYSIS

After performing the experiment, the following are the result tables.

A. *Peak to peak current source*

I_{Source}(p-p)(A)	1mA
R_{coil} of 1mH	337mΩ
R_{coil} of 10mH	11.99Ω

Table 3.1

B. *10mH Inductor Circuit Data Table*

Frequency	XL Theory	VL(p-p) Exp	XL Exp	Deviation %
1kHz	62.83	0.0632118	63.21	0.60%
2kHz	125.66	0.126478	126.48	0.65%
3kHz	188.50	0.189768	189.77	0.67%
4kHz	251.33	0.253056	253.06	0.68%
5kHz	314.16	0.316319	316.32	0.69%
6kHz	377	0.379534	379.53	0.67%
8kHz	502.65	0.505743	505.74	0.62%
10kHz	628.31	0.631586	631.59	0.52%

Table 3.2

This table shows the data gathered as well as the data calculated for the circuit with the 10mH inductor circuit.

C. *1mH Inductor Circuit Data Table*

Frequency	XL Theory	VL(p-p) Exp	XL Exp	Deviation %
1kHz	62.83	0.0615	63.15	0.51%
2kHz	125.66	0.126722	126.722	0.84%
3kHz	188.50	0.190676	189.676	1.16%
4kHz	251.33	0.226103	253.103	10.04%
5kHz	314.16	0.311747	316.747	0.77%
6kHz	377	0.382078	379.078	1.35%
8kHz	502.65	0.508172	505.172	1.1%
10kHz	628.31	0.562568	631.568	10.46%

Table 3.3

This table shows the data gathered as well as the data calculated for the circuit with the 1mH inductor circuit.

Questions:

1. **What is the relationship between inductive reactance and frequency?**
   - From the data gathered, we can say that **Inductive Reactance** increases as frequency increases. This confirms the theoretical relationship where inductive reactance is directly proportional to frequency. In both cases (with the 1mH and 10mH inductors), the experimental values align closely with the theoretical values, demonstrating this linear relationship.
2. **What is the relationship between inductive reactance and inductance?**
   - Inductive reactance is proportional to both inductance and Frequenct. If we compare tables 3.2 and 3.3, at the same frequencies, the values for X_L are 10 times higher with 10mH inductor, confirming that reactance increases with higher inductance.
3. **If the 10 mH trial had been repeated with frequencies 10 times higher than those in Table 12.2(3.2), what effect would that have on the experiment?**
   - If The Frequencies were increased 10 times, the inductive reactance would also increase 10 times since as stated before, the reactance directly correlate to the frequency. This would also result in larger voltages across the inductor, requiring careful adjustment of the measurement setup to avoid errors or exceeding the equipment limits.
4. **Do the coil resistances have any effect on the plots?**
   - Yes, the resistances have a slight effect on the plots. The experimental values include the effects of the inductor's internal resistance, which adds to the total impedance. This may cause some minor deviations between the theoretical and experimental values of $\mathbf{X_L}$**,** as seen in the deviation columns on the tables. This suggests that the coil's resistance has a more pronounced effect at higher frequencies.

IV. DISCUSSION AND CONCLUSIONS

We were able to effectively illustrate the connection between inductive reactance, frequency, and inductance with this experiment. As expected by theory, data gathered from both circuits verified that the inductive reactance was directly proportional to both inductance and frequency. The internal resistance of the inductor and small measurement errors were the main causes of the experimental readings' close resemblance to the theoretical computations.

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Notably, the inductors' internal resistances caused minor variations in the experimental outcomes. These resistances increased the total impedance, which had an impact on the calculated inductive reactance and voltage readings. The data from the 1mH inductors showed that this effect was more noticeable at higher frequencies, with variances as high as 10.46%. These variations draw attention to the idealized circuit models' practical limits and stress how crucial it is to take real-world component characteristics into account.

This experiment showed how inductive reactance depends on both frequency and inductance, confirming its theoretical underpinnings. With only slight variations due to inductor resistance and measurement errors, the results were in line with theoretical predictions. The results highlight the importance of inductive reactance in AC circuits as well as its usefulness in electrical system design and optimization.

References

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