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Objectives

- To examine the Inductive reactance.
- To analyze its relationship between inductance and frequency
- To observe the plot of inductive reactance versus frequency.

Theory Overview

On contrary to resistance of a resistor which shows a constant resistor over a wide range of frequencies, the equivalent ohmic value for a inductor known as reactance of inductor is changed with change in frequency. The reactance of inductor is directly proportional to the frequency and measured through the formula:

$$X_L = 2\pi f L$$

Where:
XL = Inductive Reactance in Ohms, (Ω)
π (pi) = 3.142 (decimal) or as 22÷7 (fraction)
f = Frequency in Hertz, (Hz)
L = Inductance in Henry, (H)

To get more accurate results and plot a better frequency vs inductive reactance, feeding inductor a known current, measuring the resulting voltage, and dividing the two, following Ohm's Law The process should be repeated across a range of frequencies and then the experimental data recorded in table should be plotted.

To determine the AC source current flowing in the circuit, a large resistance should be placed in the circuit in series, so that the reactance of inductor can be ignored due to negligible drop across it. Using ohms law, we can find the current.

Equipment

1. AC Function Generator
2. Oscilloscope DMM

Component

1. 1mH actual: 1mH
2. 10 mH actual: 10 mH
3. 10 kΩ actual: 10 kΩ

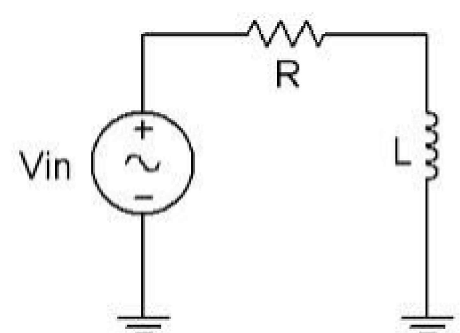


Figure 1: Circuit Schematics

Procedure

Current Source

1. Using Figure 1 with Vin=10 Vp-p and R=10 kΩ, and assuming that the reactance of the inductor is much smaller than 10k and can be ignored, determine the circulating current using measured component values and record in Table 1.

Measuring Reactance

2. Build the circuit of Figure 1 using R=10 kΩ, and L=10 mH. Place one probe across the generator and another across the inductor. Set the generator to a 1000 Hz sine wave and 10Vp-p. Make sure that the Bandwidth Limit of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.
3. Calculate the theoretical value of XL using the measured inductor value and record in Table2.
4. Record the peak-to-peak inductor voltage and record in Table 2
5. Using the source current from Table 1 and the measured inductor voltage, determine the experimental reactance and record it in Table 2. Also compute and record the deviation.
6. Repeat steps three through five for the remaining frequencies of Table 2.
7. Replace the 10 mH inductor with the 1mH unit and repeat steps two through six, recording results in Table 3.
8. Using the data of Tables 2 and 3, create plots of inductive reactance versus frequency.

Table 1

$I_{source(p-p)}$	1mA

Tables

Table 2: Values recorded with 10mH Inductor and 10k Ohm Resistor.

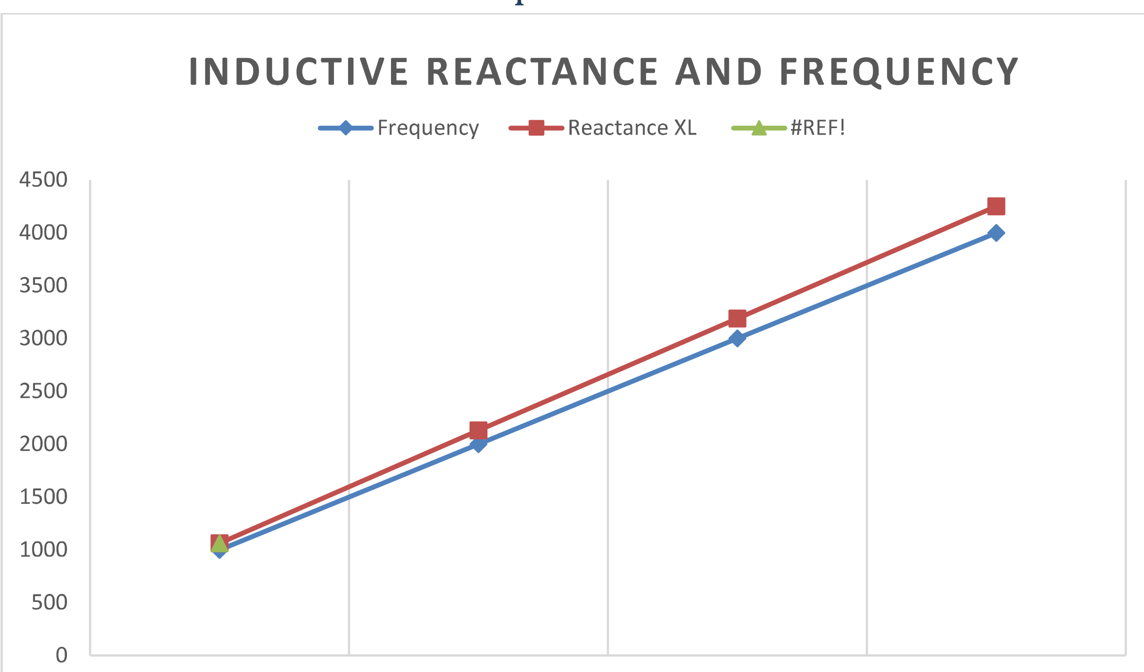
Frequency	X_L Theory	$V_{L(p-p)}$ Exp	X_L Exp	%Dev
1k	62.8 Ω	0.0628	62.8 Ω	±0
2k	125.6 Ω	0.13	130 Ω	±4
3k	188.4 Ω	0.19	190 Ω	±1
4k	251.2 Ω	0.25	250 Ω	±0
5k	314 Ω	0.33	330 Ω	±5
6k	376.8 Ω	0.38	380 Ω	±1
8k	502.4 Ω	0.51	510 Ω	±2
10k	628 Ω	0.63	630 Ω	±0

Table 3: Values recorded with 1mH Inductor and 10k Ohm Resistor.

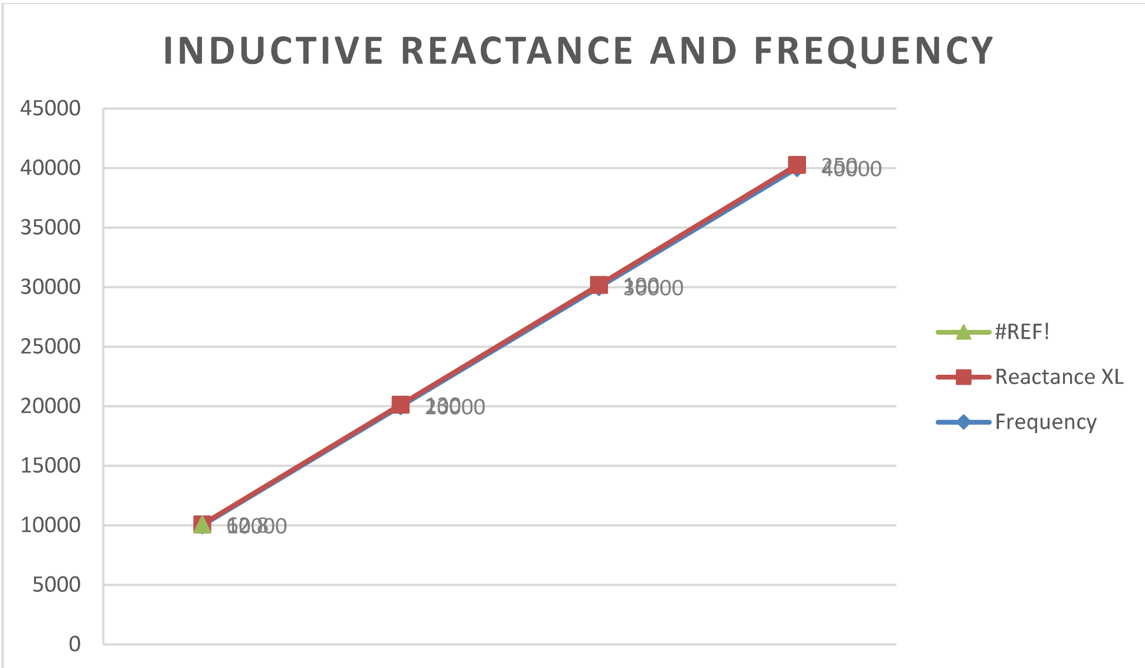
Frequency	X_L Theory	$V_{L(p-p)}$ Exp	X_L Exp	%Dev
10k	62.8 Ω	0.0628	62.8 Ω	±0
20k	125.6 Ω	0.13	130 Ω	±4
30k	188.4 Ω	0.19	190 Ω	±1
40k	251.2 Ω	0.25	250 Ω	±0
50k	314 Ω	0.33	330 Ω	±5
60k	376.8 Ω	0.38	380 Ω	±1
80k	502.4 Ω	0.51	510 Ω	±2
100k	628 Ω	0.63	630 Ω	±0

Graphs

Graph from Table 2



Graph from Table 3



Proteus Pictures

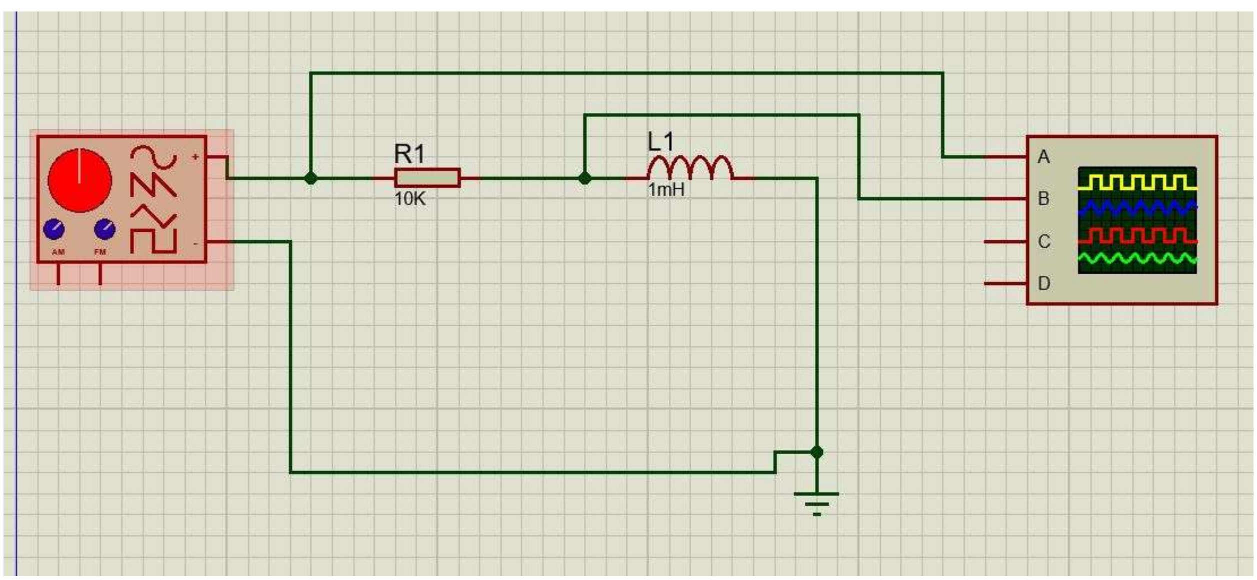
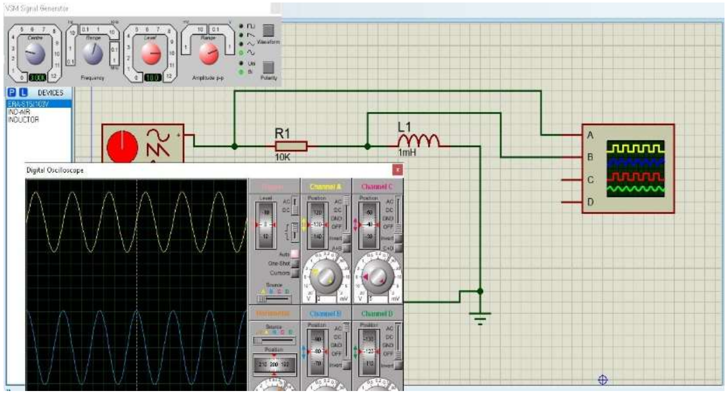
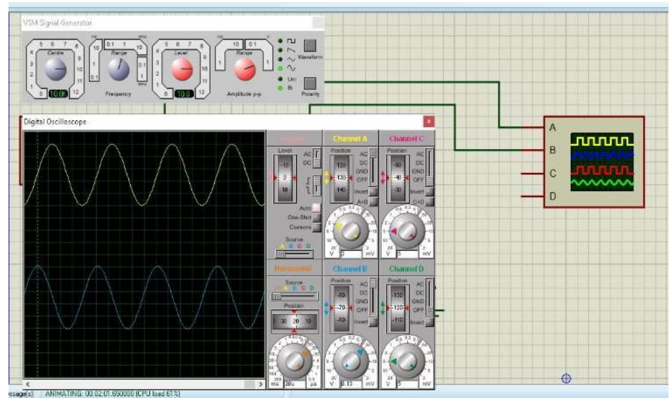
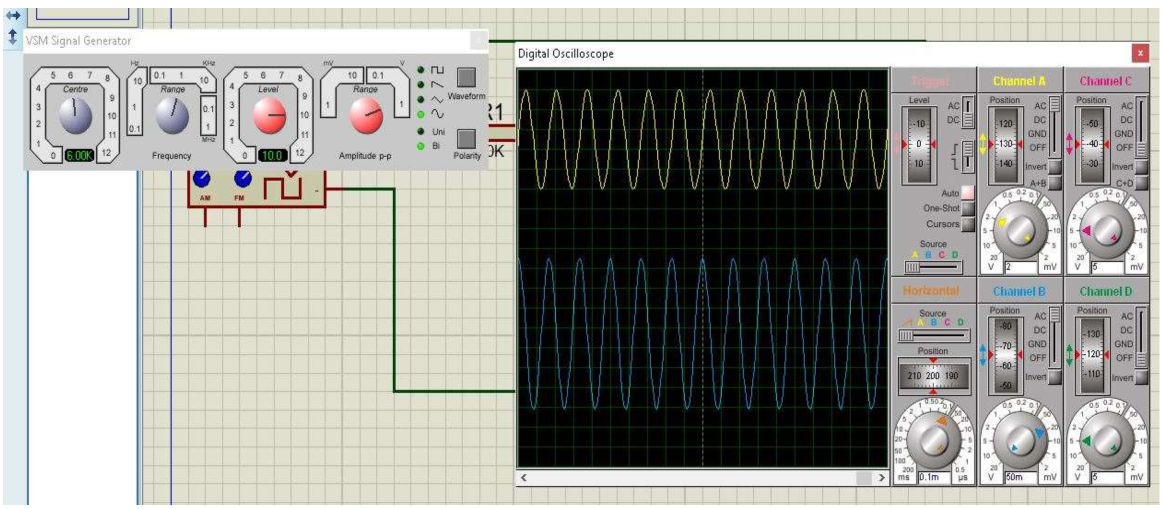
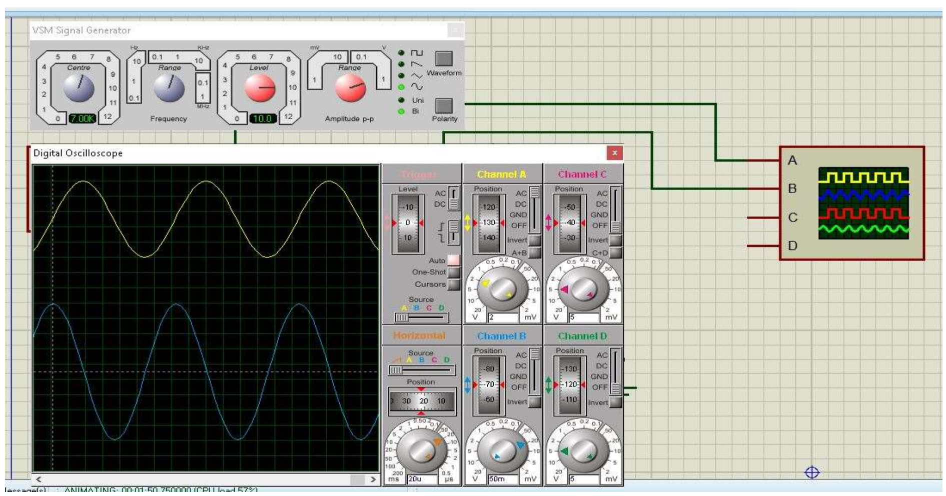


Figure 2: Circuit


VSM Signal Generator
Digital Oscilloscope
R1
10K
L1
1mH


VSM Signal Generator
Digital Oscilloscope


VSM Signal Generator
Centre
Range
Frequency
Level
Amplitude p-p
Waveform
Uni
Bi
Polarity
Digital Oscilloscope
Trigger
Channel A
Channel C
Horizontal
Channel B
Channel D
AM
FM


VSM Signal Generator
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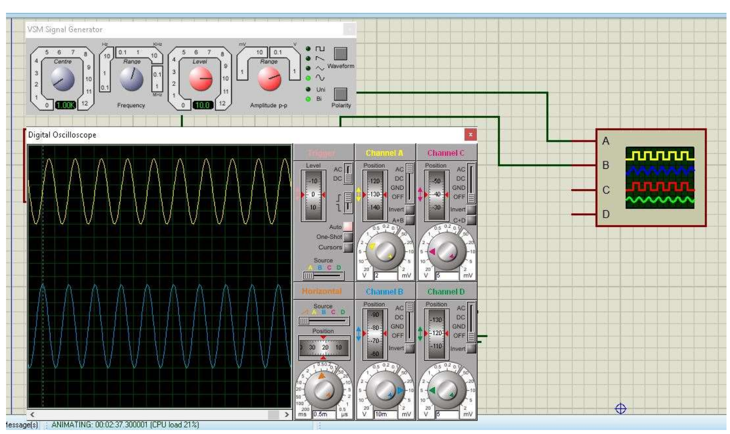
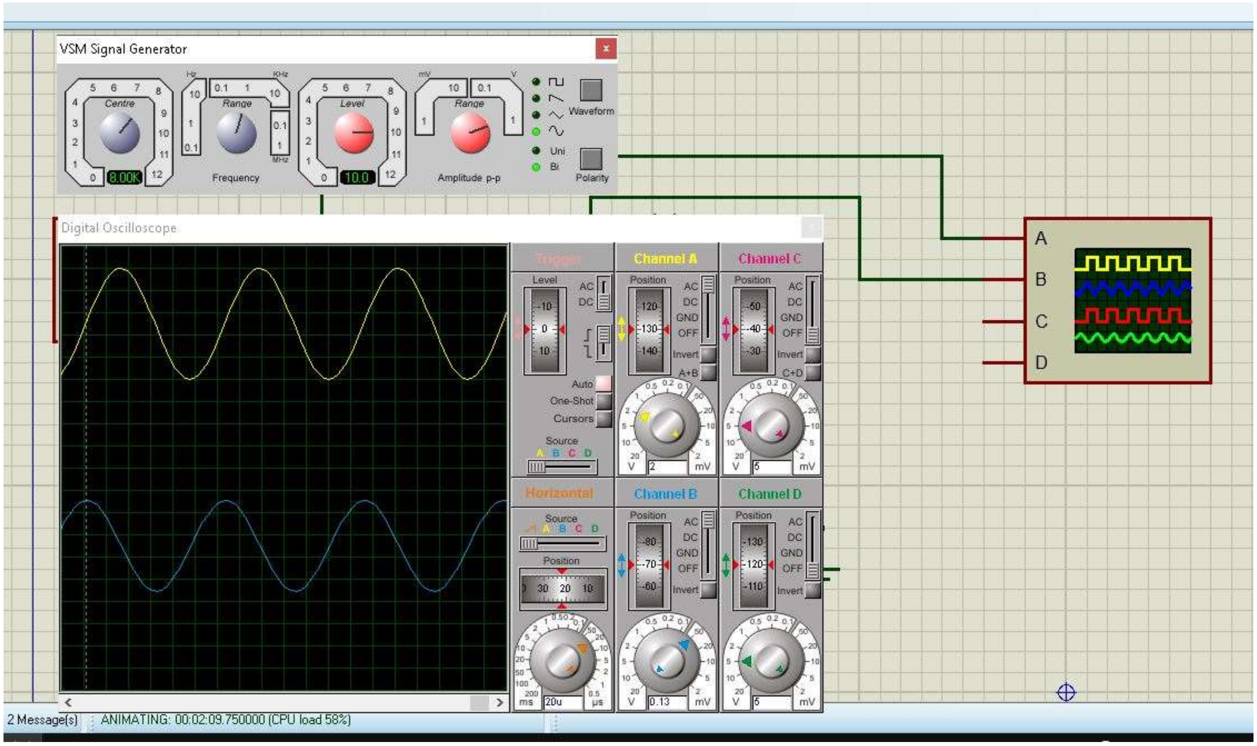
Trigger
Channel A
Channel C
Horizontal
Channel B
Channel D


VSM Signal Generator
Digital Oscilloscope



Questions

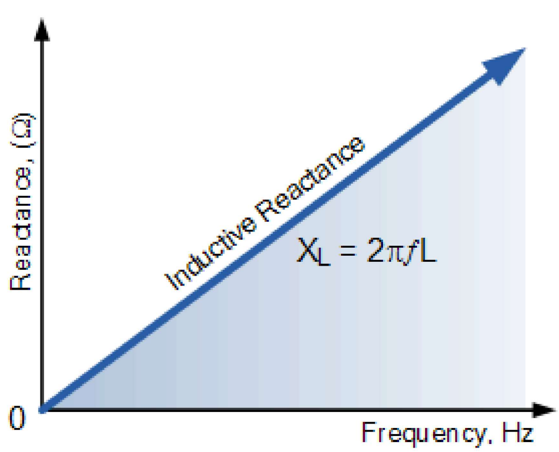
What is the relationship between inductive reactance and frequency?

Answer:

The frequency and inductive reactance are directly proportional. So, increase in frequency will result in increase in inductive reactance. If the frequency approaches infinity the inductors reactance would also increase to infinity acting like an open circuit. The direct relation can be seen from the graph plotted from experimental result and can also be seen from the formula.

$$X_L = 2\pi f L$$

Inductive Reactance against Frequency:



2. What is the relationship between inductive reactance and inductance?

Answer:

Inductive reactance is the name given to the opposition to a changing current flow. This inductive reactance (X_L) of a component is directly proportional to the inductance (L) of the component and the applied frequency to the circuit by the following formula:

$$X_L = 2\pi fL$$

This means that the increase in the inductance of an inductor will result in increase in the inductive reactance of that component. So, there will be more opposition to the current flow in the circuit with increased inductance.

3. If the 10mH trial had been repeated with frequencies 10 times higher than those in Table 2, what effect would that have on the experiment?

Answer:

The frequency and inductive reactance are directly proportional. So, increase in frequency will result in increase in inductive reactance. Since the frequency and inductive reactance are related to each other with the formula:

$$X_L = 2\pi fL$$

So, increasing the frequency 10 times will increase the inductive reactance 10 times. Same applies for the 10mH inductor. **Increasing the frequency 10 times will yield 10 times higher inductive reactance.** However, the increasing trend of reactance with increase in frequency will be same as it was for lower frequencies.

4. Do the coil resistances have any effect on the plots?

Answer:

The simple answer is NO. The plot will not be changed. Inductive reactance of the inductor was plotted against a range of frequencies. So, increase in frequency will result in increased inductive reactance. If 10K Ohm resistance in the circuit transformed to a coil resistance, the 1mH or 10mH inductor will still follow same rule-- that is, increase in frequency yields greater reactance.

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