# University of Jordan
# School of Engineering
# Electrical Engineering Department

# EE 219
# Electrical Circuits Lab

## EXPERIMENT 6 REPORT & PRE-LAB
## INDUCTIVE REACTANCE

**Section # ____________ Group # ____________**

| | Student Name | ID |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |

# EXPERIMENT 6
# INDUCTIVE REACTANCE

***Note**: Use MATLAB to quickly perform theoretical calculations by defining a vector of frequencies then using array arithmetic.*

## PROCEDURE A – AC-EXCITED SERIES RL CIRCUIT

6. Which of the above two methods did you decide to use to measure $\boldsymbol{V_R}$?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

7. Can we just subtract the magnitudes of $|\boldsymbol{V_S}| - |\boldsymbol{V_L}|$ to obtain the magnitude $|\boldsymbol{V_R}|$? Why or why not?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

9. What is the relationship between the periods $T$ of the two signals $\boldsymbol{V_S}$ and $\boldsymbol{V_R}$?

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**Table 1**

| AC Source Frequency (Hz) | $\boldsymbol{V_S}$ (peak) (V) | | $\boldsymbol{V_S}$ period $\boldsymbol{T}$ (ms) | | $\boldsymbol{V_L}$ (peak) (V) | | $\measuredangle \boldsymbol{V_L}$ with $\boldsymbol{V_s}$ (Lead = positive) | |
|---|---|---|---|---|---|---|---|---|
| | **Theory** | **Meas.** | **Theory** | **Meas.** | **Theory** | **Meas.** | **Theory** | **Meas.** |
| **700** | 2 | | | | | | | |
| **1300** | 2 | | | | | | | |
| **2600** | 2 | | | | | | | |
| **5200** | 2 | | | | | | | |
| **9100** | 2 | | | | | | | |
| **14400** | 2 | | | | | | | |
| **22200** | 2 | | | | | | | |
| **39200** | 2 | | | | | | | |

**Table 2**

| AC Source Frequency (Hz) | $\boldsymbol{V_R}$ (peak) (V) | | $\measuredangle \boldsymbol{V_R}$ with $\boldsymbol{V_s}$ (Lag = negative) | | $\boldsymbol{V_R}$ period $\boldsymbol{T}$ (ms) | | $\boldsymbol{I}$ and $\measuredangle \boldsymbol{I}$ (mA) $= \boldsymbol{V_R}/R$ | |
|---|---|---|---|---|---|---|---|---|
| | **Theory** | **Meas.** | **Theory** | **Meas.** | **Theory** | **Meas.** | **Theory** | **Meas.** |
| **700** | | | | | | | | |
| **1300** | | | | | | | | |
| **2600** | | | | | | | | |
| **5200** | | | | | | | | |
| **9100** | | | | | | | | |
| **14400** | | | | | | | | |
| **22200** | | | | | | | | |
| **39200** | | | | | | | | |

10. You might have noticed some discrepancies between theoretical and measured values in Tables 1 and 2 for $\boldsymbol{V_L}$ and $\boldsymbol{V_R}$ values at some frequencies. Why do you think this happened?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

11. Use theoretical analysis to determine the voltages $\boldsymbol{V_L}$ and $\boldsymbol{V_R}$ in the following circuit at frequency **700 Hz**. The circuit shows a more realistic model for the inductor you used (which has an internal resistance for the long wound wire and another resistance representing low power core losses in the inductor). Assume $R_{DC}$ = 57 Ω and $R_P$ = 4677 Ω. Make sure to evaluate both magnitude and phase for each complex quantity.

$\boldsymbol{V_L}$ =  $\boldsymbol{V_R}$ =

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

12. Are the above values closer to your measured values for the same frequency or not?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

13. Use theoretical analysis again for the above circuit to determine the voltages $\boldsymbol{V_L}$ and $\boldsymbol{V_R}$ at frequency **1300 Hz**. Make sure to evaluate both magnitude and phase for each complex quantity.

$\boldsymbol{V_L}$ =  $\boldsymbol{V_R}$ =

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

14. Are the above values closer to your measured values for the same frequency or not?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

**Table 3**

| AC Source Frequency (Hz) | $\boldsymbol{X_L = \lvert V_L \rvert / \lvert I \rvert}$ (peak/peak) (kΩ) | | $\boldsymbol{\lvert Z \rvert = \lvert V_S \rvert / \lvert I \rvert}$ (peak/peak) (kΩ) | | $\boldsymbol{\measuredangle Z = \measuredangle V_S - \measuredangle I}$ (degrees) | |
|---|---|---|---|---|---|---|
| | **Theory** | **Meas.** | **Theory** | **Meas.** | **Theory** | **Meas.** |
| **700** | | | | | | |
| **1300** | | | | | | |
| **2600** | | | | | | |
| **5200** | | | | | | |
| **9100** | | | | | | |
| **14400** | | | | | | |
| **22200** | | | | | | |
| **39200** | | | | | | |

16. Using the *measured* values in Table 3, plot (**by hand**) the following figures using the graph paper attached at the end of the report: (1) $\boldsymbol{X_L}$ and $\boldsymbol{\lvert Z \rvert}$ on the same plot versus source frequency; (2) $\boldsymbol{\measuredangle Z}$ versus source frequency; (3) $\boldsymbol{V_L}$ and $\boldsymbol{V_R}$ on the same plot versus source frequency.

17. For the above plots, state your conclusions under the plot?

19. Using the values in Table 4, plot (**by hand**) the following figure using the graph paper attached at the end of the report: $\boldsymbol{P}$ and $\boldsymbol{Q}$ on the same plot versus source frequency.

20. For the above plot, state your conclusions under the plot?

21. At what frequency the real power $\boldsymbol{P}$ is maximum? Why?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

22. At what frequency the magnitude of the reactive power $|\boldsymbol{Q}|$ is maximum? Why?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

**Table 4**

| AC Source Frequency (Hz) | $\|S\|$ (mVA) | $\measuredangle S$ (degrees) | $P$ (mW) | $Q$ (mVAR) | $PF$ value | $PF$ lead or lag |
|---|---|---|---|---|---|---|
| | Measured | Measured | Measured | Measured | Measured | Measured |
| 700 | | | | | | |
| 1300 | | | | | | |
| 2600 | | | | | | |
| 5200 | | | | | | |
| 9100 | | | | | | |
| 14400 | | | | | | |
| 22200 | | | | | | |
| 39200 | | | | | | |

## PROCEDURE B – AC-EXCITED PARALLEL RL CIRCUIT

**Table 5**

| AC Source Frequency (Hz) | $V_{R'}$ (peak) (V) | | $\measuredangle V_{R'}$ with $V_s$ (Lag = negative) | | $V_R = V_L \approx V_S$ (peak) (V) | | $\measuredangle V_R$ with $V_s$ (degrees) | |
|---|---|---|---|---|---|---|---|---|
| | Theory | Meas. | Theory | Meas. | Theory | Meas. | Theory | Meas. |
| 810 | | | | | 2 | | 0° | 0° |
| 1620 | | | | | 2 | | 0° | 0° |
| 4100 | | | | | 2 | | 0° | 0° |
| 5700 | | | | | 2 | | 0° | 0° |
| 8100 | | | | | 2 | | 0° | 0° |
| 11400 | | | | | 2 | | 0° | 0° |
| 17900 | | | | | 2 | | 0° | 0° |
| 30000 | | | | | 2 | | 0° | 0° |

**Table 6**

| AC Source Frequency (Hz) | $I$ (peak) (mA) $= V_{R'}/R'$ | | $\measuredangle I$ with $V_s$ (Lag = negative) | | $I_R$ (peak) (mA) $= V_R/R$ | | $\measuredangle I_R$ with $V_s$ (degrees) | |
|---|---|---|---|---|---|---|---|---|
| | Theory | Meas. | Theory | Meas. | Theory | Meas. | Theory | Meas. |
| 810 | | | | | | | 0° | 0° |
| 1620 | | | | | | | 0° | 0° |
| 4100 | | | | | | | 0° | 0° |
| 5700 | | | | | | | 0° | 0° |
| 8100 | | | | | | | 0° | 0° |
| 11400 | | | | | | | 0° | 0° |
| 17900 | | | | | | | 0° | 0° |
| 30000 | | | | | | | 0° | 0° |

**Table 7**

| AC Source Frequency (Hz) | $I_L = I - I_R$ (mA) (magnitude (peak) and phase (degrees)) (phasor subtraction) | |
|---|---|---|
| | Theory | Measured |
| 810 | | |
| 1620 | | |
| 4100 | | |
| 5700 | | |
| 8100 | | |
| 11400 | | |
| 17900 | | |
| 30000 | | |

8. Can we just subtract the magnitudes of $|I| - |I_R|$ to obtain the magnitude $|I_L|$? Why or why not?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

**Table 8**

| AC Source Frequency (Hz) | $B_L = |I_L|/|V_L|$ (peak/peak) (mS) | | $|Y| = |I|/|V_S|$ (peak/peak) (mS) | | $\measuredangle Y = \measuredangle I - \measuredangle V_S$ (degrees) | |
|---|---|---|---|---|---|---|
| | Theory | Meas. | Theory | Meas. | Theory | Meas. |
| 810 | | | | | | |
| 1620 | | | | | | |
| 4100 | | | | | | |
| 5700 | | | | | | |
| 8100 | | | | | | |
| 11400 | | | | | | |
| 17900 | | | | | | |
| 30000 | | | | | | |

10. Using the *measured* values in Table 8, plot (**by hand**) the following figures using the graph paper attached at the end of the report: (1) $\boldsymbol{B_L}$ and $|\boldsymbol{Y}|$ on the same plot versus source frequency; (2) $\measuredangle \boldsymbol{Y}$ versus source frequency; (3) $\boldsymbol{I_L}$ and $\boldsymbol{I_R}$ on the same plot versus source frequency.

11. For the above plots, state your conclusions under the plot?

**Table 9**

| **AC Source Frequency (Hz)** | $\boldsymbol{|S|}$ **(mVA)** | $\measuredangle \boldsymbol{S}$ **(degrees)** | $\boldsymbol{P}$ **(mW)** | $\boldsymbol{Q}$ **(mVAR)** | $\boldsymbol{PF}$ **value** | $\boldsymbol{PF}$ **lead or lag** |
|---|---|---|---|---|---|---|
| | **Measured** | **Measured** | **Measured** | **Measured** | **Measured** | **Measured** |
| **810** | | | | | | |
| **1620** | | | | | | |
| **4100** | | | | | | |
| **5700** | | | | | | |
| **8100** | | | | | | |
| **11400** | | | | | | |
| **17900** | | | | | | |
| **30000** | | | | | | |

13. Using the values in Table 9, plot (**by hand**) the following figure using the graph paper attached at the end of the report: $\boldsymbol{P}$ and $\boldsymbol{Q}$ on the same plot versus source frequency.

14. For the above plot, state your conclusions under the plot?

15. At what frequency the real power $\boldsymbol{P}$ is maximum? Why?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

16. At what frequency the magnitude of the reactive power $|\boldsymbol{Q}|$ is maximum? Why?

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

**<u>CONCLUSIONS</u>**

Summarize in clear but concise format what you learned from this experiment:

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**** End ****