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LAB 5 PRELIMINARY REPORT

1-Introduction

Lab 5 focuses on inductors in general. In preliminary work, connection types of inductances and mutual induction were studied. The working principle of the inductance was clearly understood.

2. Analysis

Step.1: Serial Connection, Positive Coupling

$$L_{total} = L_1 + L_2 + 2M$$

Step.2: Serial Connection, Negative Coupling

$$L_{total} = L_1 + L_2 - 2M$$

Step.3: Calculation method for mutual inductance M

Let us think about two sets of inductors. Setup A consists of two inductors (inductor a & inductor b) positively coupled. Setup B consists of two ***same*** inductors (inductor a & inductor b) negatively coupled. Difference between these two setups gives us only M.

$$L_A = L_1 + L_2 + 2M$$

$$L_B = L_1 + L_2 - 2M$$

$$L_A - L_B = 4M$$

$$M = \frac{L_A - L_B}{4}$$

$$M = \frac{L_A - L_B}{4}$$

This equation basically show that mutual inductance can be found by subtracting one inductor from another and divide this subtraction by 4.

Alternative method:

$$M = k\sqrt{L_1 L_2}$$

where $0 \le k \le 1$

Step.4:

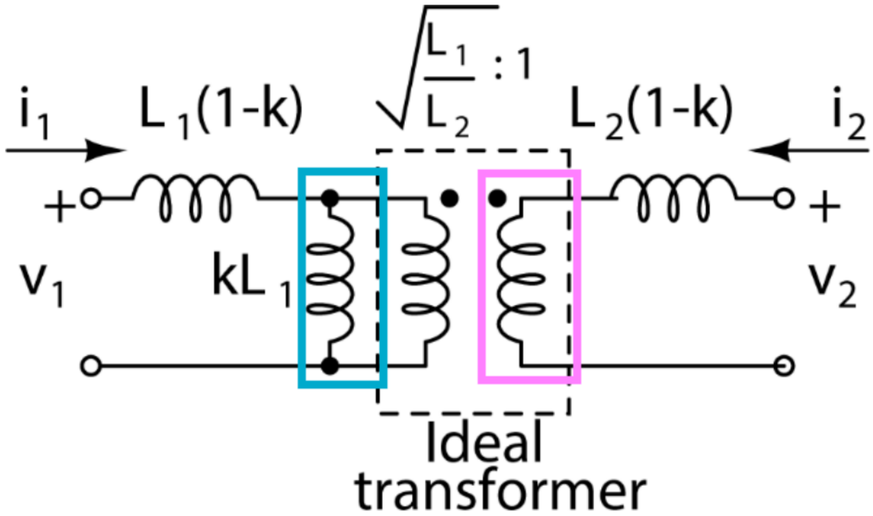

Figure.1: Transformer Voltage Division

$$v_{coupling}(v_{kL_1}) = v_1 \cdot \frac{kL_1}{(1-k)L_1 + kL_1} = \frac{kL_1}{L_1} = k$$

$$Since\ i_2 = 0,$$

$$v_2 = v_{kL_1} \cdot \sqrt{\frac{L_1}{L_2}} = k\sqrt{\frac{L_1}{L_2}}$$

Step.5 & Step.6:

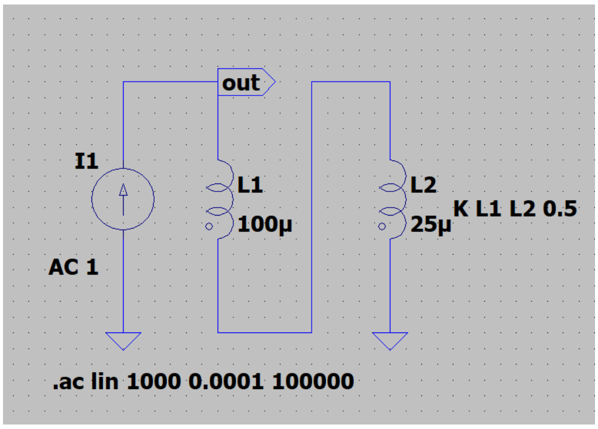

Figure.2: Series Connected Inductors

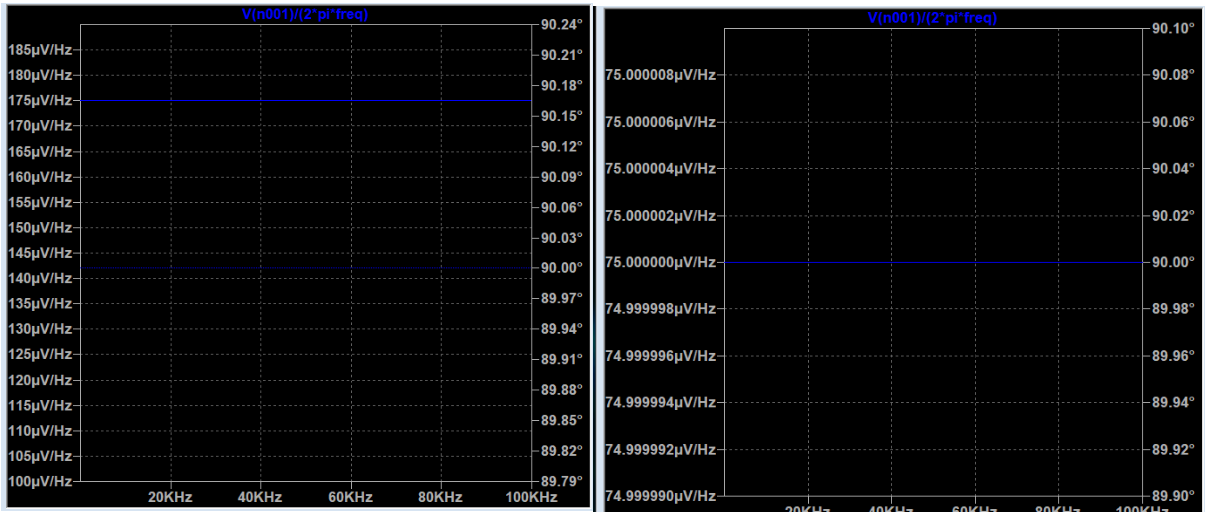

Figure.3: Series Inductors, Normal Direction (Case-1) & Reverse Direction (Case-2) Responses

Verifying the results using equations from Step.1,

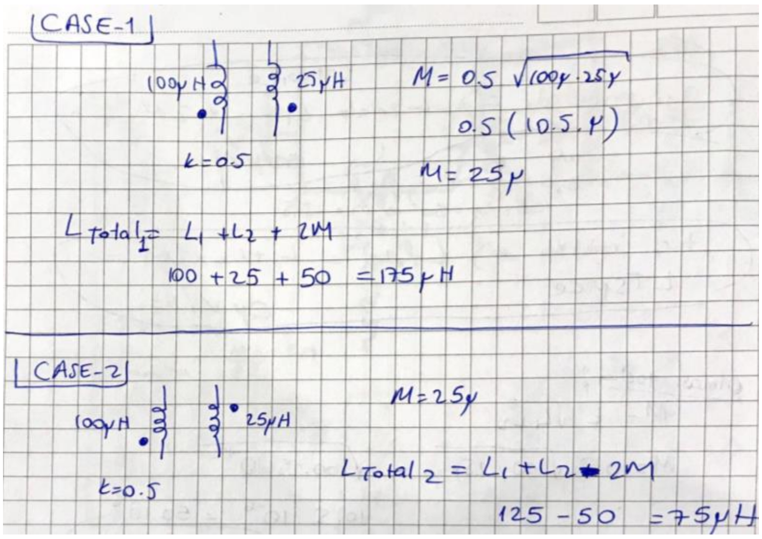

Figure.4: Verifying results for Normal Direction & Reverse Direction Responses

Step.7:

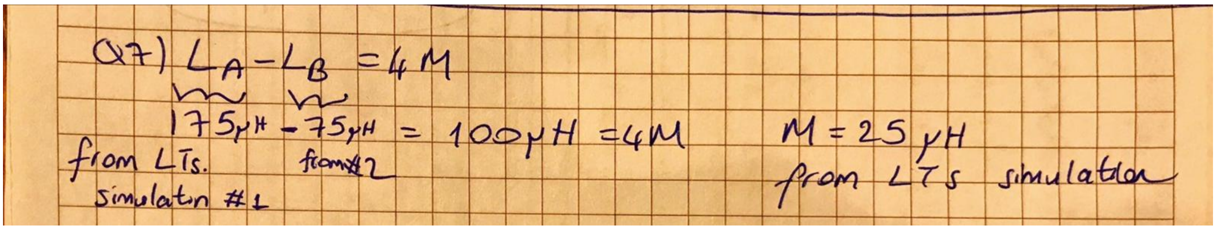

Figure.5: Finding M using LTspice data

From LTspice simulation, we know that $L_A = 175\mu H \ and \ L_B = 75\mu H$

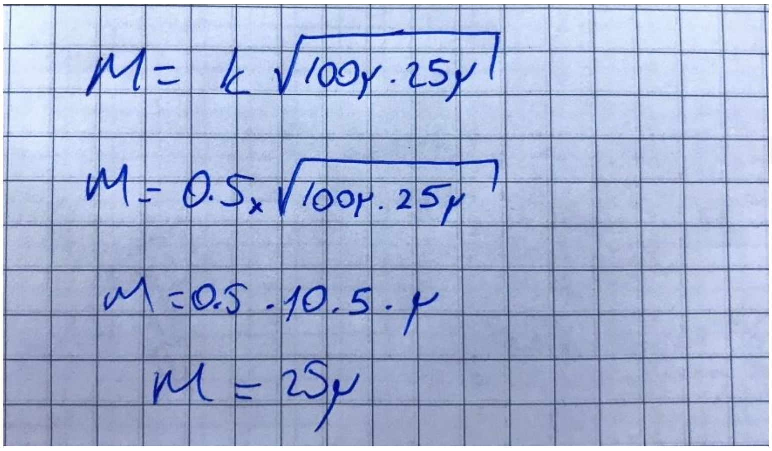

Figure.6: Finding M using inductor values

Step.8:

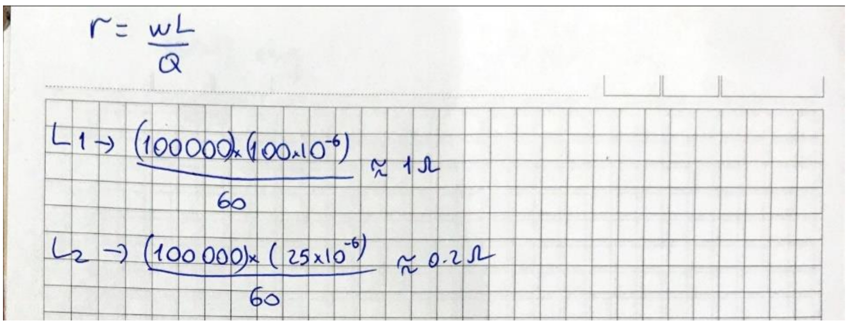

Figure.7: Finding r, resistance of inductors and v_2

Series resistances included into both inductors by right clicking to the inductor and adding series resistance value.

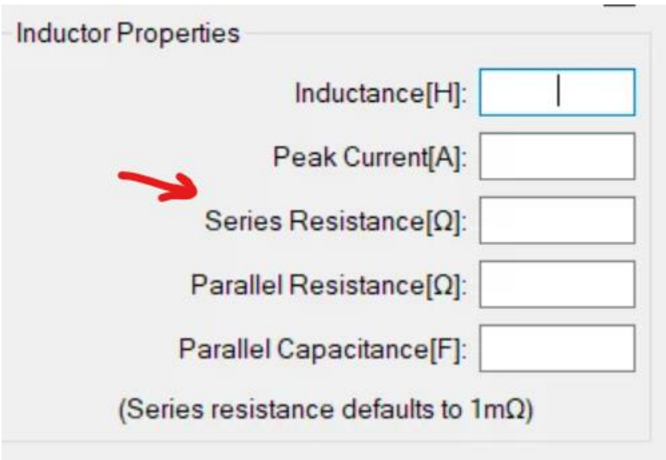

Figure.8: Adding series resistance

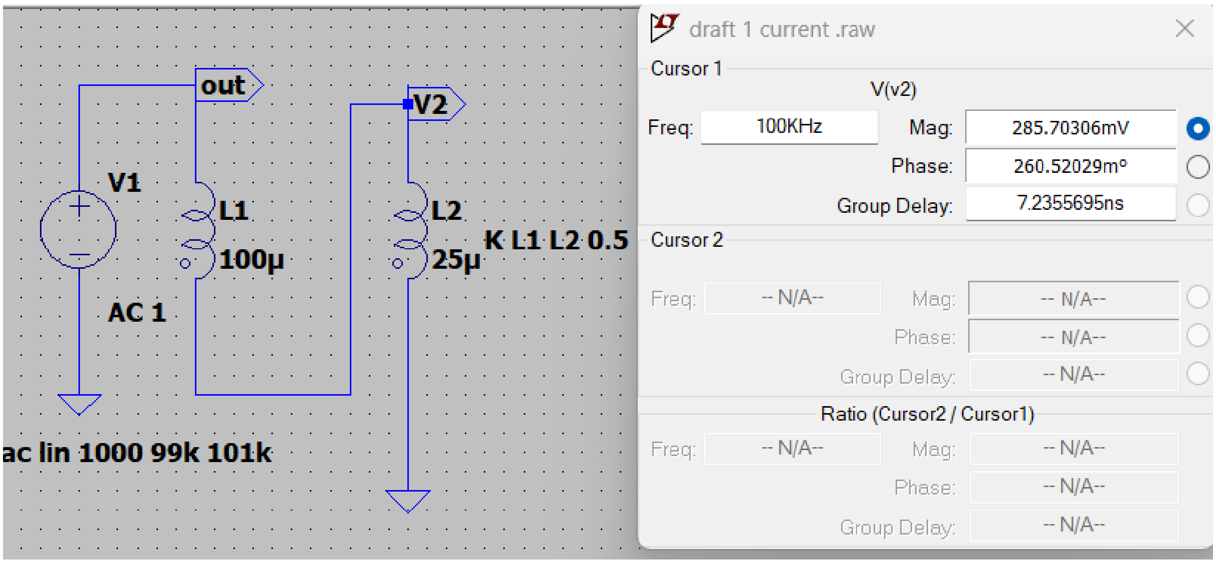

Figure.9: Included internal resistances of inductors

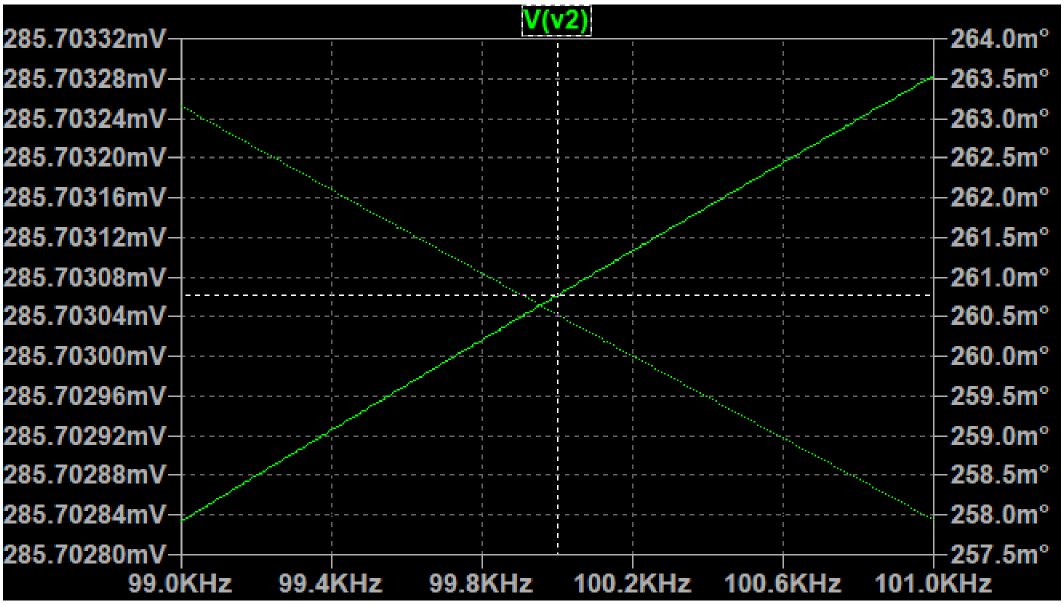

Figure.10: Graph of internal resistances included

	Frequency (Hz)	Magnitude (V)	Phase (Degree)
v_2	100 kHz	0.285 V	0.26°

Table.1: Values for v_2

Step.9:

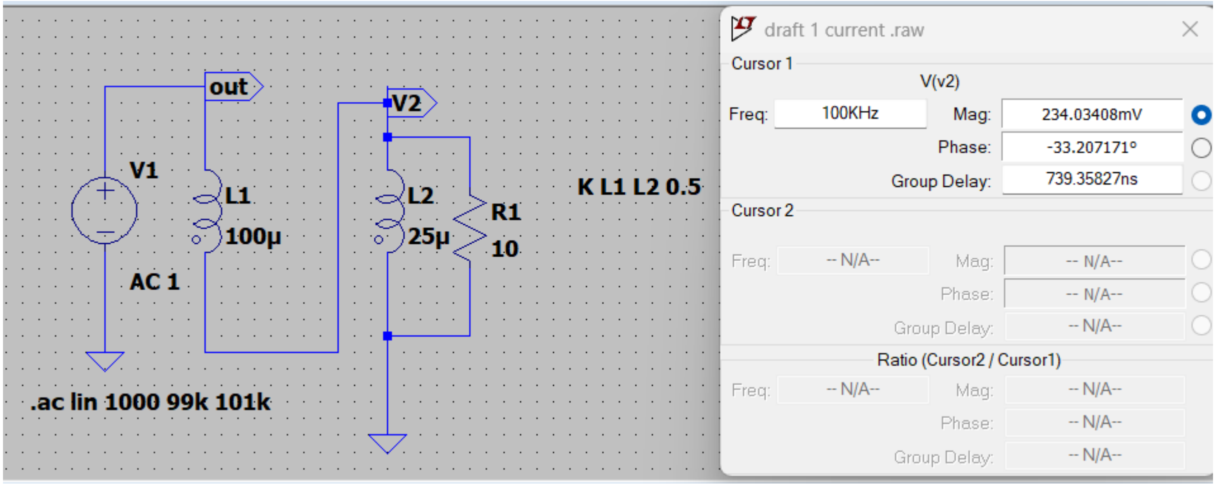

Figure.11: Schematics and values for the case included 10 Ω internal resistance for L_2

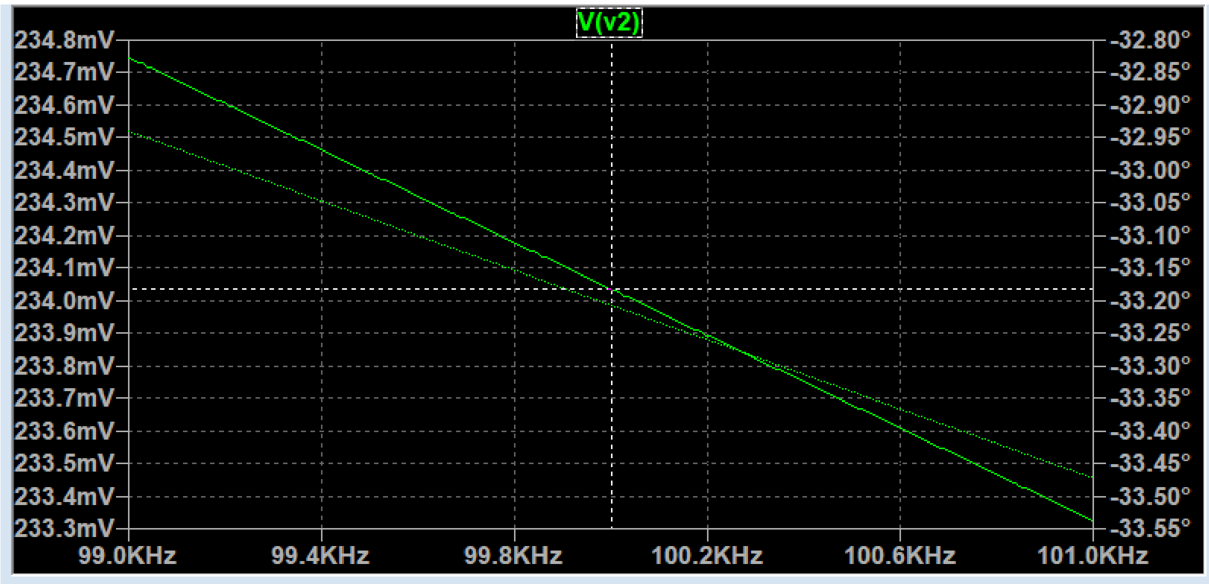

Figure.12: Graph of the case included 10 Ω internal resistance for L_2

	Frequency (Hz)	Magnitude (V)	Phase (Degree)
v_2	$\sim 100\ kHz$	0.234 V	$-33.2°$

Table.2: Values for v_2, 10 Ω internal resistance for L_2

3. Conclusion

Essential concepts about inductors and transformers were explored in this lab, including their connections, positive and negative coupling, and methods to measure mutual inductance. Understanding was significantly enhanced through the use of LTspice simulations, which provided practical insights into these concepts.

The preliminary work established the theoretical background, such as the impact of coupling dots on total inductance and the role of the coupling coefficient (kk). Mutual inductance was calculated and simulated under various conditions to reinforce these principles.

Overall, this lab effectively bridged theoretical knowledge with practical applications, providing a deeper understanding of inductor behavior and transformer modeling.