Comparison, Simulation and Analytical Examination of the Currents of Four Different Combination Coupled Circuits with Different Solution Method

M. Salih Taci,
Dept. of Electrical Engineering,
Yildiz Technical University, Istanbul, Turkey

Abstract:- This article investigates different currents of four different coupled circuit fed sinusoidally for analytical and simulation conditions.

In this paper, analytical modeling and equations for four different coupled circuit based on current point signal is presented.

A discussion based on their theoretical use is then presented in the simulation along with calculations regarding their currents performances.

These models are also validated by simulation results of current waveforms for each analytical case. PSpice program is used for this simulation.

It has been confirmed that the analytical calculation values obtained in the analysis of the coupled circuits and the simulation plot values obtained in the Pspice analysis are the same.

Keywords:- *Coupled Circuit, Coupling Coefficient (K), Mutual Inductance (M). Polarity. Self Inductances, Sşmulation, Analytical Calculation, Pspice.*

I. INTRODUCTION

When two or more than two inductors are connected together by electromagnetic induction and alternating current flows through a coil, the magnetic field passes from the first coil to the second coil and this magnetic field induces a voltage in the coil. [1,2].

The solution of coupled circuits is available in many electrical circuit analysis books. [3]

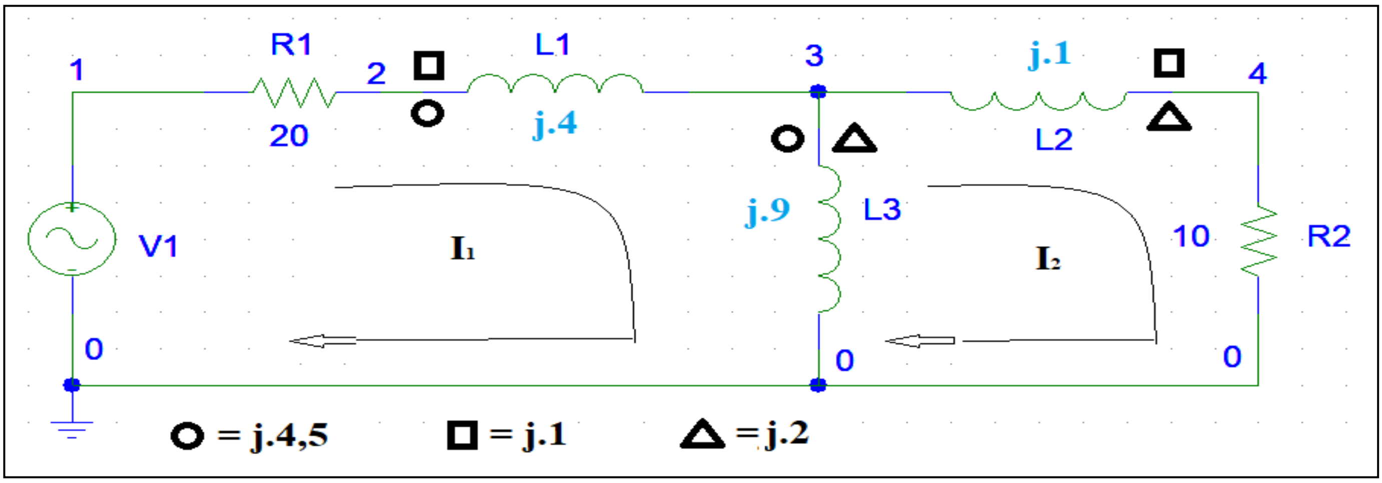

Fig 1a: The Circuit of Coupled

II. SOLUTION DIFFERENT SOLUTION METHOD

Fig. 3. a) The circuit of coupled j.4,5 j.1 j.2 j.4,5 j.1 j.2 Ø ■ Δ Ø ■ Δ (11) 11 11 (21) (21) (21) (12) (12) (12) 22 22 (22) 1.mesh 2.mesh

In the first mesh, $(20 + j.4).I_1 + j.9.(I_1 - I_2)$ and for coupled circuit first meshcalculation

$\emptyset_{11}$ There are two dotted point terminal in both first mesh. The current enters the dotted point terminal in both two coils, hence current direction sign is pozitive (+). also because they are in the same mesh,we multiply by 2. (2.j.4,5.I1)

$\emptyset_{12}$ There is point in both first and second mesh. The current enters the first dotted point pozitive terminal and enters in the second dotted point negative terminal, therefore, negative (-) sign is used. (-j. 4,5.I2)

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■ 12 In both meshes there is a square. Current in mesh 1 enters the pozitive square point terminal, while in mesh number 2 it enters the negative square point terminal, therefore negative (-) sign is used. (- j.1.I2)

Δ 12 In both meshes there is a triangle point. in mesh number 1 current enters the pozitive triangle point terminal, while in mesh number 2 it enters the negative triangle point terminal therefore negative (-) signis used. (- j.2.I2)$(20+j.4).I_1+j.9(I_1-I_2)+2.j.4{,}5.I_1-j.4{,}5.I_2-j.1.I_2-j.2.I_2=100$

In the second mesh, $j.9(I_2-I_1)+(10+j.1).I_2$ and for coupled circuit second mesh calculation

∅ 21 There are dotted point in both second and first mesh.The current enters the second mesh dotted negative terminal and enters in the first mesh dotted pozitive terminal, therefore, negative (-) sign is used. (- j.4,5.I1)

■ 21 In both meshes there is a square. Current in mesh 2 enters the negative square terminal, while in mesh 2 it enters the pozitive square terminal, therefore negative (-) sign is used. (- j.1.I1)

Δ 21 In both meshes there is a triangle. Current in mesh 2 it enters the negative triangle terminal, while in mesh 1 it enters the pozitive triangle terminal therefore negative (-) sign is used. (- j.2.I1)

Δ 22 There are two triangle terminal in both second mesh. The current enters the two square negative terminal in both two coils, hence pozitive (+) sign. And because they are in the same mesh, we multiply by 2. (+2.j.2.I2)

$$j.9(I_2-I_1)+(10+j.1).I_2-j.4{,}5.I_1-j.1.I_1$$
$$j.2.I_1+2.j2.I_2=0$$

➢ *Finding the k Coupling Coefficients for Simulation*

$M_1=1 \quad M_2=4{,}5 \quad M_3=2$

$$k_1=\frac{M_1}{\sqrt{L_1.L_2}}=\frac{1}{\sqrt{4x1}}=0{,}5$$

$$k_2=\frac{M_2}{\sqrt{L_1.L_3}}=\frac{4{,}5}{\sqrt{4x9}}=0{,}75$$

$$k_2=\frac{M_3}{\sqrt{L_2.L_3}}=\frac{2}{\sqrt{1x9}}=0{,}666$$

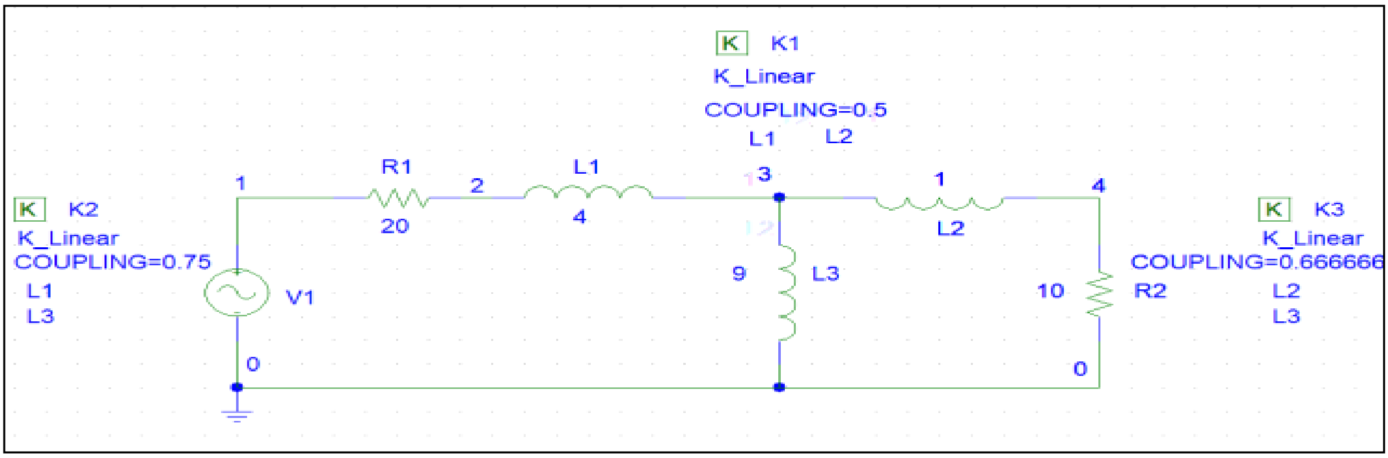

Fig 1b: The Circuit Diagram of Fig. 3.a has been Redrawn for PSpice schematic Analysis

III. RESULTS OBTAİNED FROM CALCULATİONS AND SİMULATİONS FOR EACH CİRCUİT

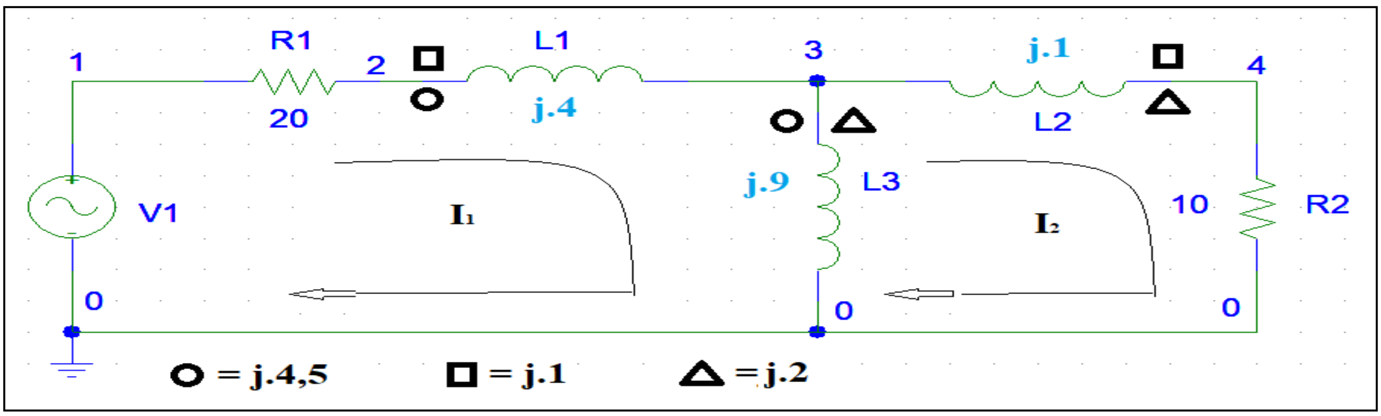

Fig 2a): The Circuit of Coupled

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j.4,5 j.1 j.2 j.4,5 j.1 j.2 Ø ■ Δ Ø ■ Δ (11) 11 11 (21) (21)

(21) (12) (12) (12) 22 22 (22) 1.mesh 2.mesh

$$(20 + j.4).I_1 + j.9.(I_1 - I_2) + 2.j.4{,}5.I_1 \quad - j.4{,}5.I_2 - j.1.I_2 - j.2.I_2 = 100$$

$$j.9.(I_2 - I_1) + (10 + j.1).I_2 - j.4{,}5.I_1 - j.1.I_1 - j.2.I_1 + 2.j2.I_2 = 0$$

$$\begin{vmatrix} 20 + j.22 & -j.16{,}5 \\ -j.16{,}5 & 10 + j.14 \end{vmatrix} \begin{vmatrix} I1 \\ I2 \end{vmatrix} = \begin{vmatrix} 100 \\ 0 \end{vmatrix}$$

$I_1 = 3{,}2677\angle - 17{,}32647\ A \quad I_2 = 3{,}1347\angle 18{,}211\ A \qquad I_{L3} = I_1 - I_2 = 1{,}958\angle - 85{,}85A$

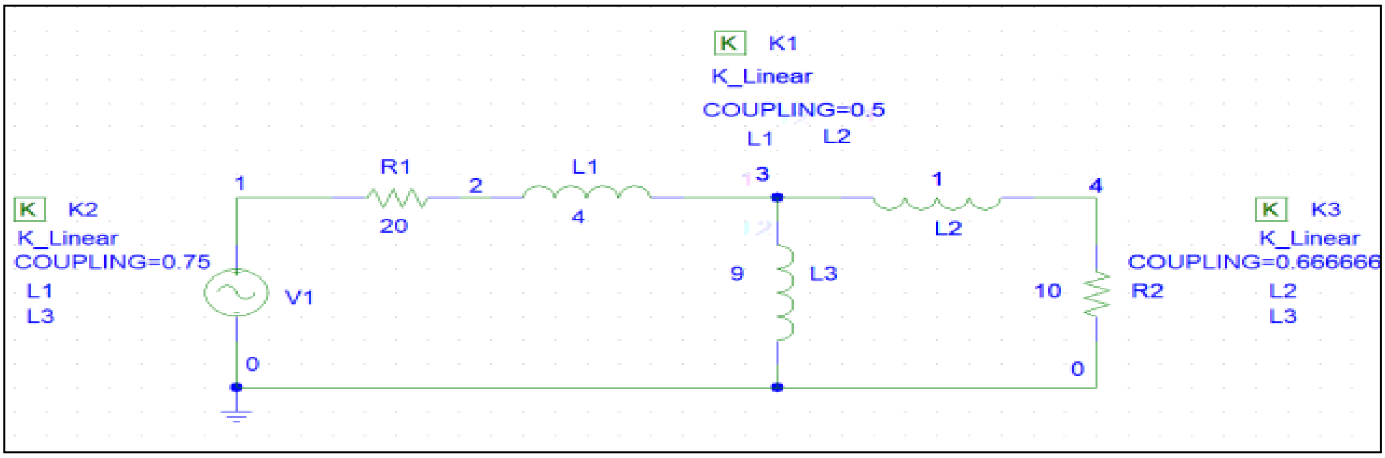

Fig 2b): The Circuit Diagram of Fig. 2.a has been Redrawn for PSpice Schematic Analysis

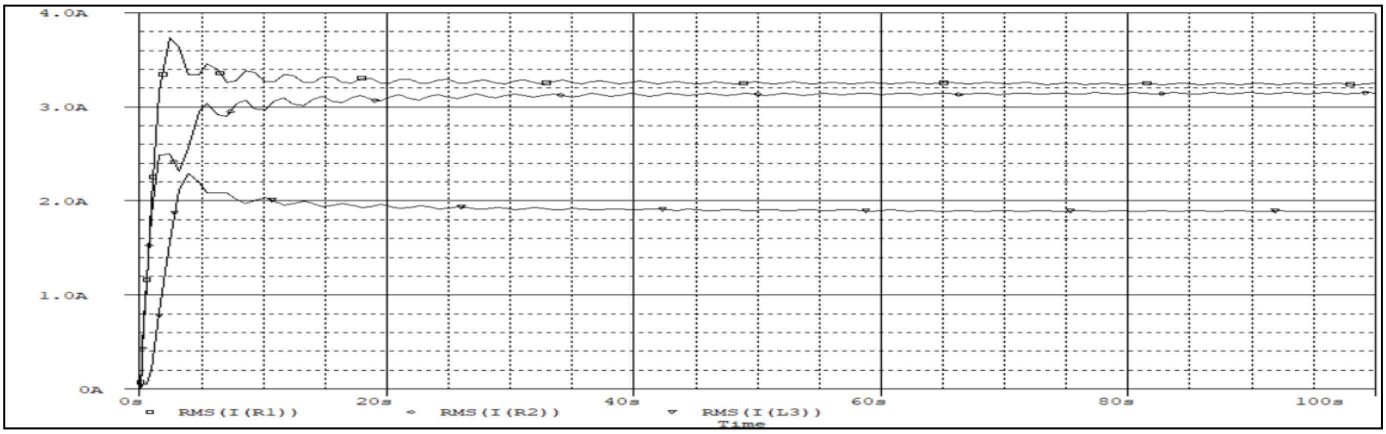

Fig 2c): PSpice plot of Currents Coupled Circuit Case for Fig. 2-b

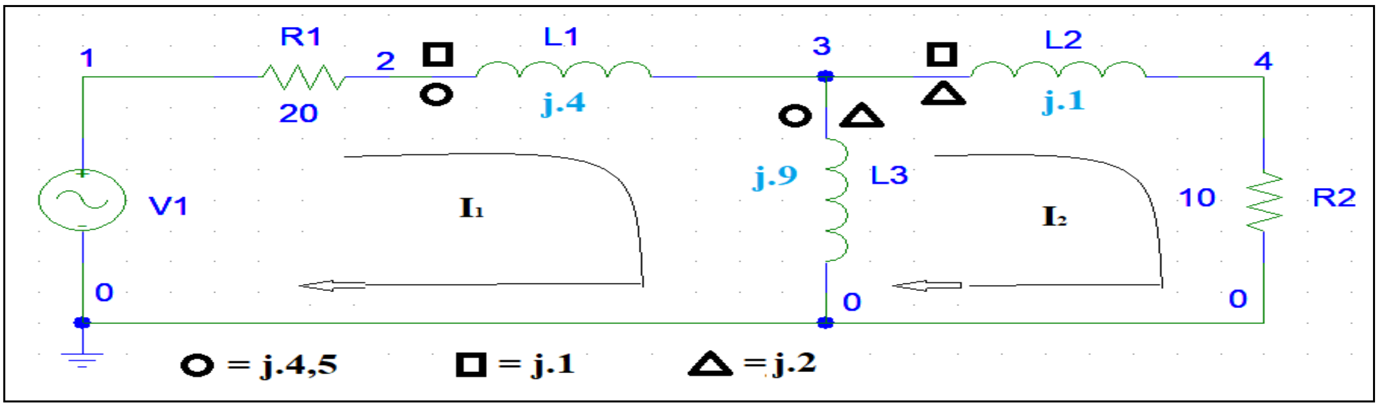

Fig 3a): The Circuit of Coupled j.4,5 j.1 j.2 j.4,5 j.1 j.2 Ø ■ Δ Ø ■ Δ (11) 11 11 (21) (21) (21) (12) (12) (12) 22 22 (22) 1.mesh 2.mesh

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$$(20+j.4).I_1 + j.9.(I_1 - I_2) + 2.j.4{,}5.I_1 \;- j.4{,}5.I_2 + j.1.I_2 + j.2.I_2 = 100$$

$$j.9.(I_2 - I_1) + (10+j.1).I_2 - j.4{,}5.I_1 + j.1.I_1 + j.2.I_1 - 2.j2.I_2 = 0$$

$$\begin{vmatrix} 20+j.22 & -j.10{,}5 \\ -j.10{,}5 & 10+j.6 \end{vmatrix} \begin{vmatrix} I1 \\ I2 \end{vmatrix} = \begin{vmatrix} 100 \\ 0 \end{vmatrix}$$

$I_1 = 3{,}037\angle -31{,}347\ A$ $\qquad I_2 = 2{,}735\angle\ 27{,}66A$ $\qquad I_{L3} = I_1 - I_2 = 2{,}864\ \angle 86{,}53A$

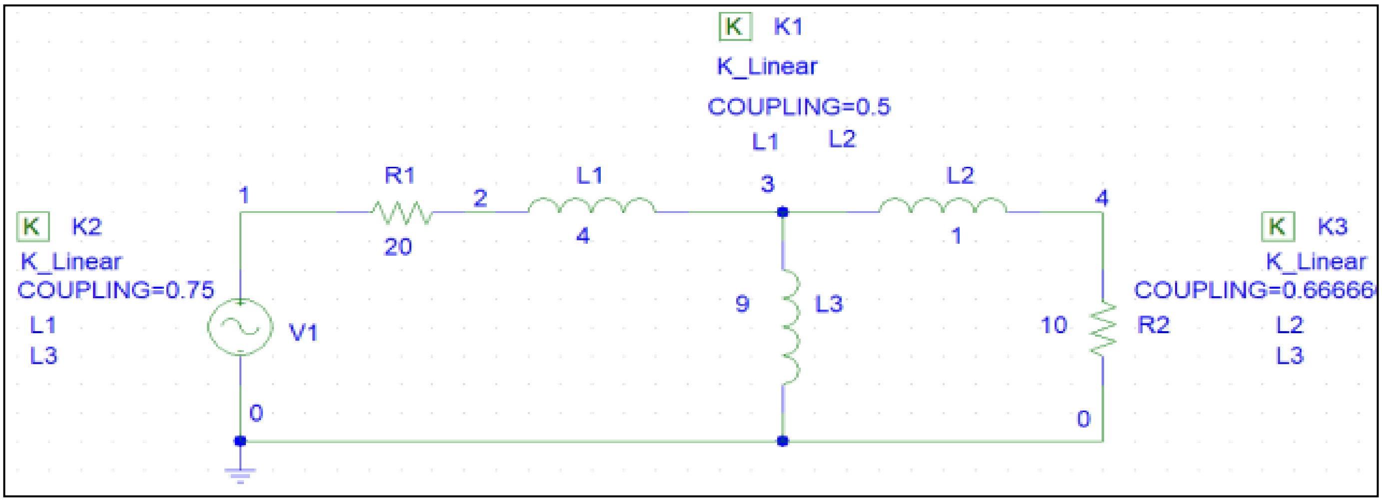

Fig 3b): The Circuit Diagram of Fig. 3a has been Redrawn for Pspice Schematic Analysis

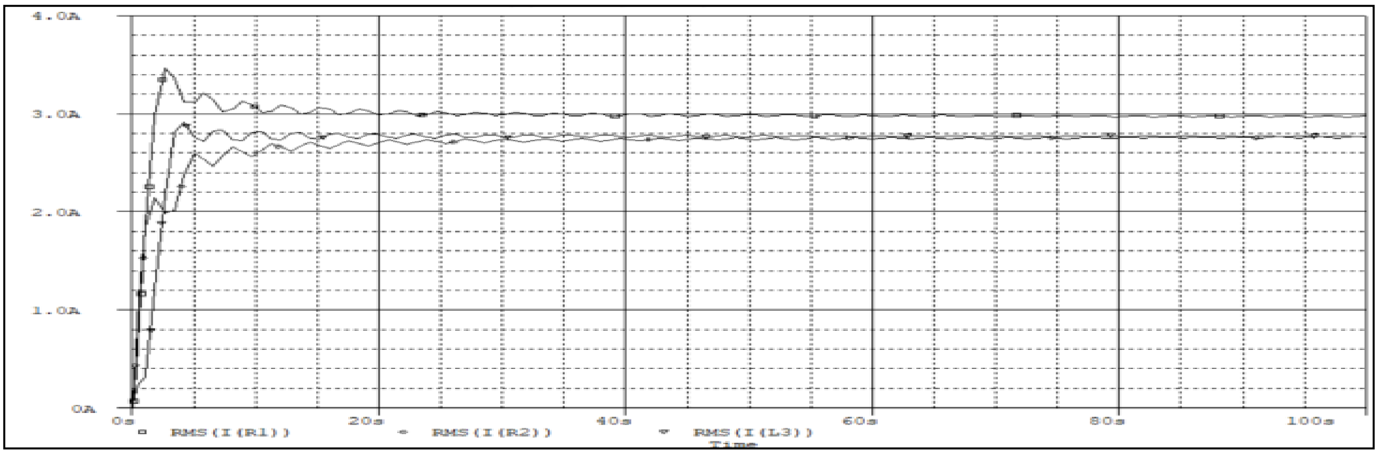

Fig 3c): PSpice Plot of Currents Coupled Circuit Case for Fig. 3-b

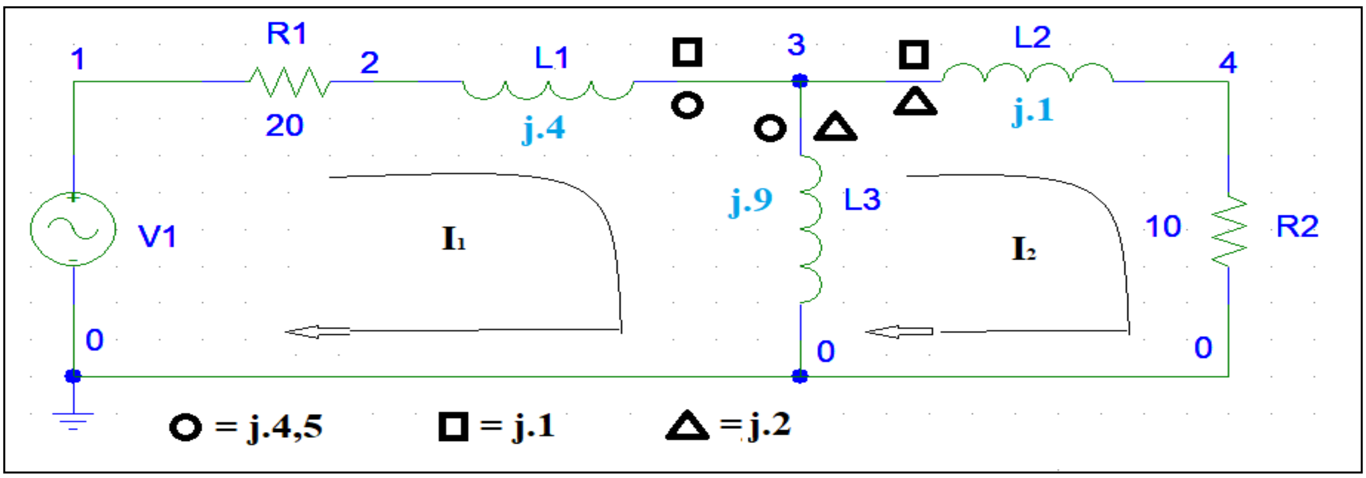

Fig 4a): The circuit of coupledj.4,5 j.1 j.2 j.4,5 j.1 j.2 ∅ ■ Δ ∅ ■ Δ (11) 11 11
(21) (21) (21) (12) (12) (12) 22 22 (22) 1.mesh 2.mesh

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$(20+j.4).I_1 + j.9.(I_1 - I_2) - 2.j.4{,}5.I_1 \quad + j.4{,}5.I_2 - j.1.I_2 + j.2.I_2 = 100$

$j.9.(I_2 - I_1) + (10+j.1).I_2 + j.4{,}5.I_1 - j.1.I_1 + j.2.I_1 - 2.j2.I_2 = 0$

$$\begin{vmatrix} 20+j.4 & -j.3{,}5 \\ -j.3{,}5 & 10+j.6 \end{vmatrix} \begin{vmatrix} I1 \\ I2 \end{vmatrix} = \begin{vmatrix} 100 \\ 0 \end{vmatrix}$$

$I_1 = 4{,}72\angle -9{,}388\ A$ $\qquad I_2 = 1{,}4157\angle 49{,}66\ A$ $\qquad I_{L3} = I_1 - I_2 \ = 4{,}172\angle -26{,}32A$

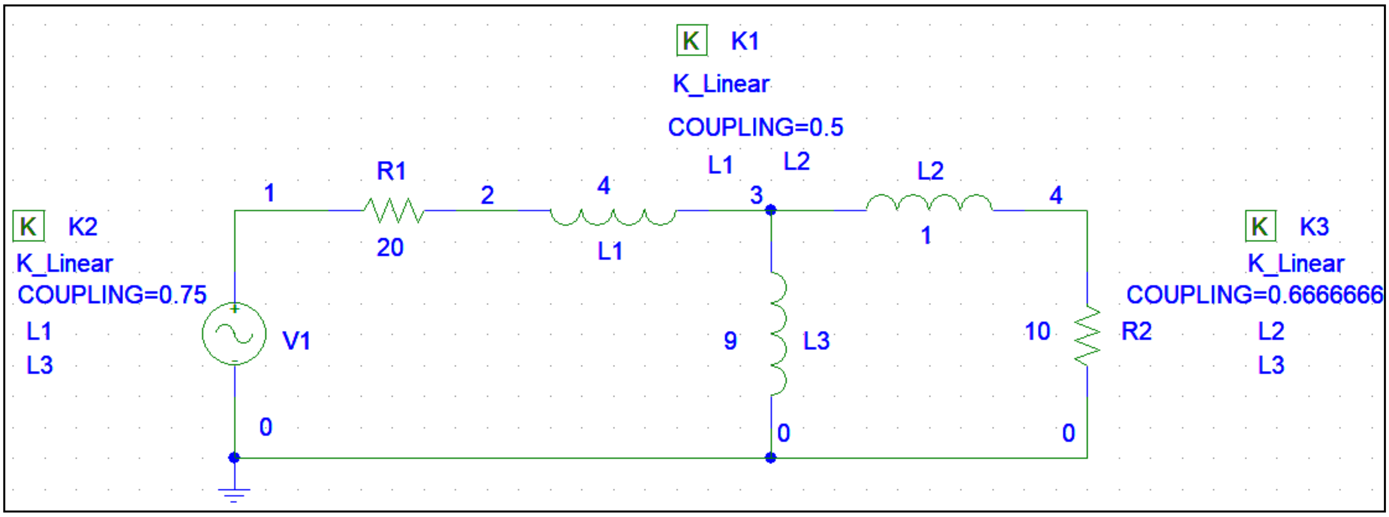

Fig 4b): The Circuit Diagram of Fig. 4.a has been Redrawn for PSpice Schematic Analysis

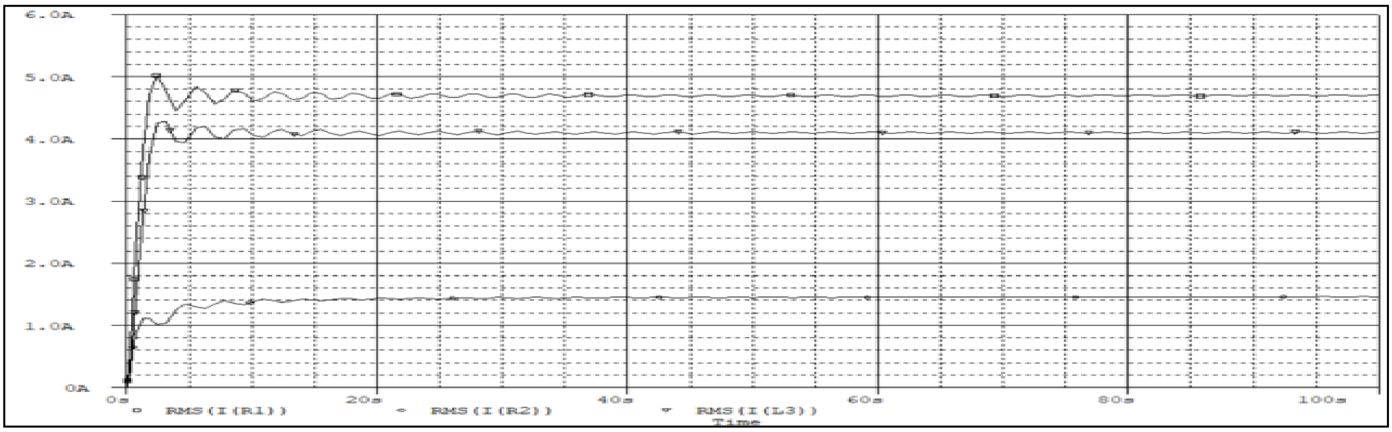

Fig 4c): PSpice Plot of Currents Coupled Circuit Case for Fig. 4-b

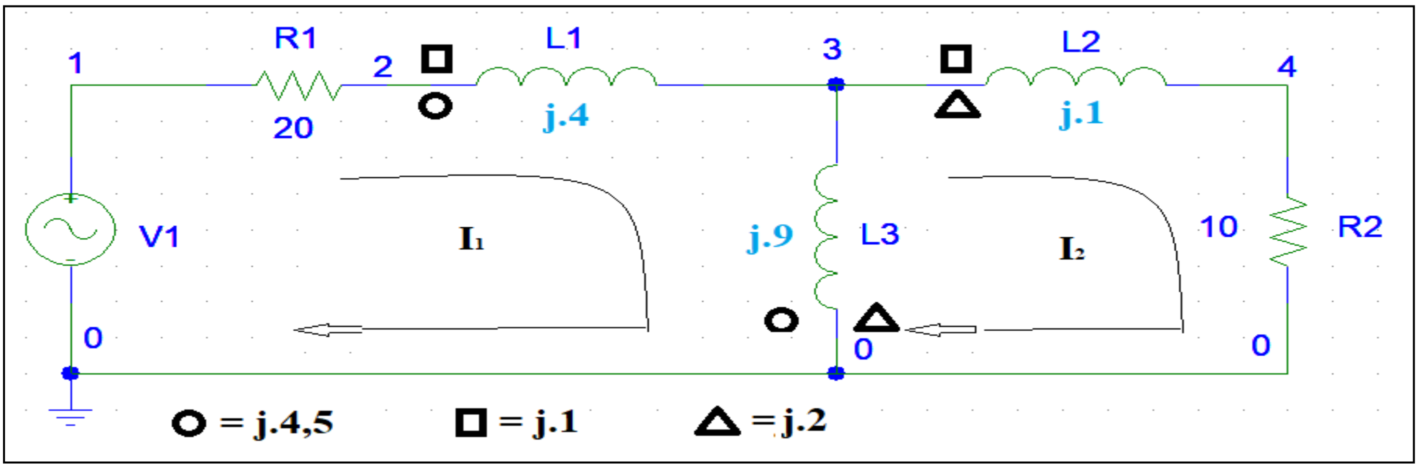

Fig 5a): The Circuit of Coupled j.4,5 j.1 j.2 j.4,5 j.1 j.2 Ø ■ Δ Ø ■ Δ
(11) 11 11 (21) (21) (21) (12) (12) (12) 22 22 (22) 1.mesh 2.mesh

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$(20 + j.4).I_1 + j.9.(I_1 - I_2) - 2.j.4{,}5.I_1 \quad + j.4{,}5.I_2 + j.1.I_2 - j.2.I_2 = 100$

$j.9.(I_2 - I_1) + (10 + j.1).I_2 + j.4{,}5.I_1 + j.1.I_1 - j.2.I_1 + 2.j2.I_2 = 0$

$$\begin{vmatrix} 20 + j.4 & -j.5{,}5 \\ -j.5{,}5 & 10 + j.15 \end{vmatrix} \begin{vmatrix} I1 \\ I2 \end{vmatrix} = \begin{vmatrix} 100 \\ 0 \end{vmatrix}$$

$I_1 = 4{,}7218\angle - 6{,}967\ A$ $\quad I_2 = 1{,}50943\angle 28{,}56\ A$ $\quad I_{L3} = I_1 - I_2 = 3{,}6\angle - 21{,}066A$

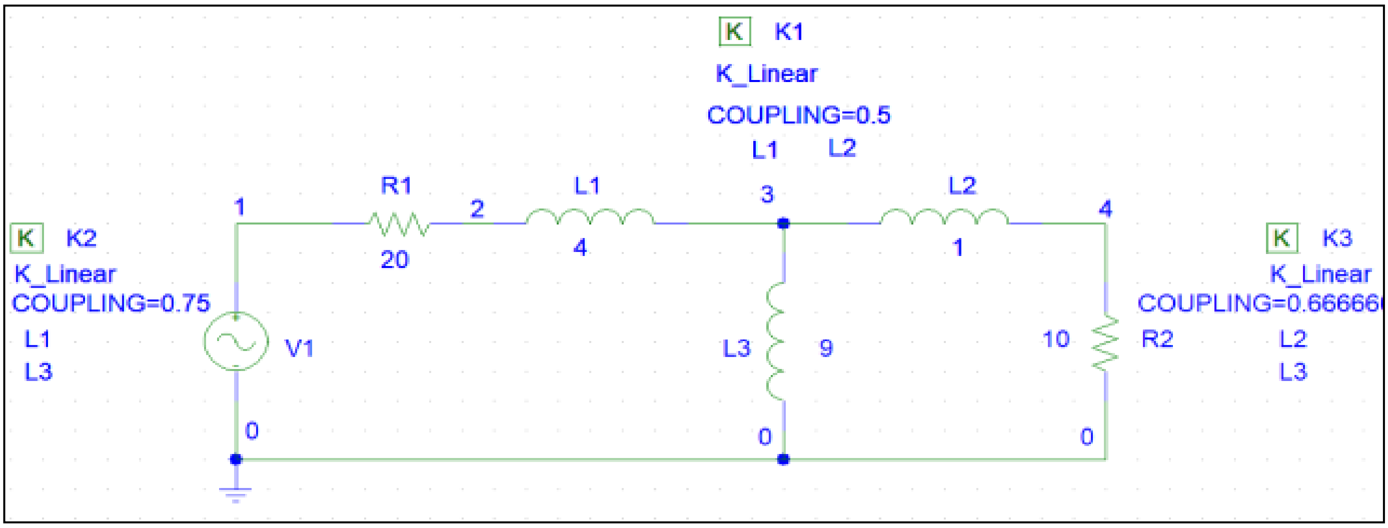

Fig 5b): The Circuit Diagram of Fig. 5.a has been Redrawn for PSpice Schematic Analysis.

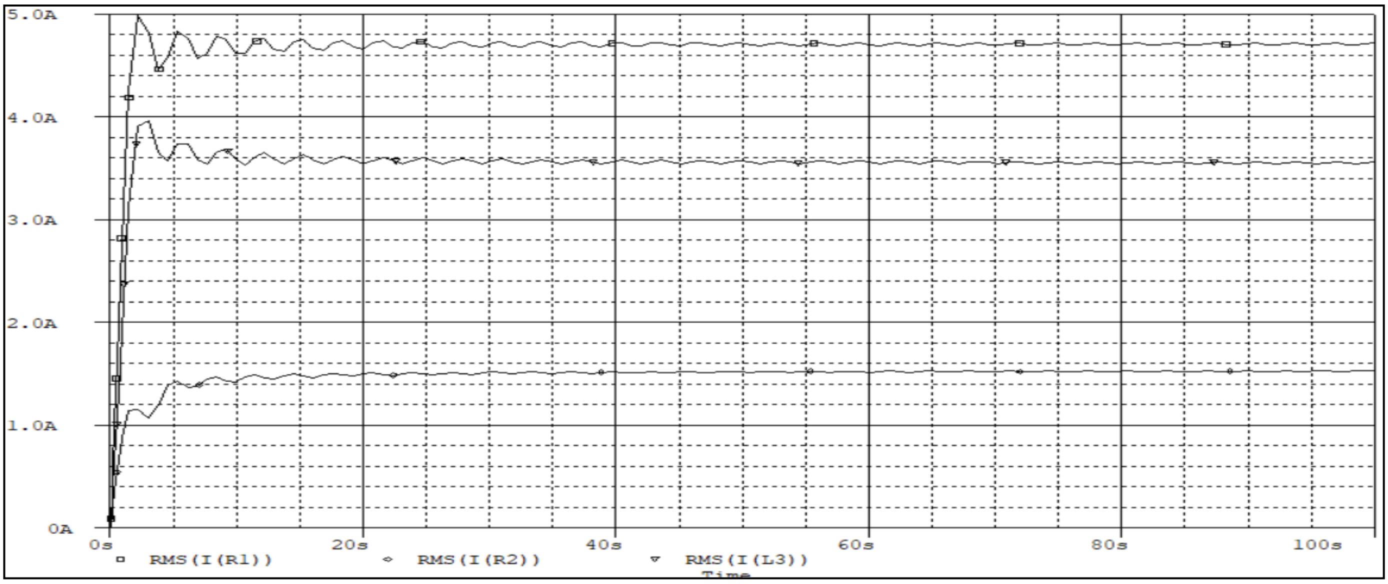

Fig 5c): P Spice Plot of Currents Coupled Circuit Case for Fig. 5-b

IV. CONCLUSION

Figure 2.a. Figure 3.a. Figure 4.a. and Figure 5.a. coupling circuits for analytical calculations of I1 , I2 and IL3 currents and Figure 2.b. Figure 3.b. Figure 4.b. and Figure 5.b. schematic circuits for analysis in Pspice and Figure 3.c. Figure 4.c. and Figure 5.c. show the simulation results obtained in the analysis of schematic circuits in Pspice. As is clearly seen from the analytical and simulation results, I1, I2 and IL3 currents for each circuit for four different types of coupling circuits;

It has been confirmed that the analytical calculation values obtained in the analysis of the coupled circuits and the simulation plot values obtained in the Pspice analysis are the same.

➢ *According to the Analysis and Simulation*

Fig 2 $I_1 = 3{,}2677\angle - 17{,}32647\ A$ $\quad I_2 = 3{,}1347\angle 18{,}211\ A$ $I_{L3} = I_1 - I_2 = 1{,}958\angle - 85{,}85A$

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➢ *According to the Analysis and Simulation*

Fig.3. $I_1 = 3{,}037\angle - 31{,}347\ A$ $\ I_2 = 2{,}735\angle\ 27{,}66A$; $I_{L3} = I_1 - I_2 = 2{,}864\ \angle 86{,}53A$

➢ *According to the Analysis and Simulation*

Fig.4. $I_1 = 4{,}72\angle - 9{,}388\ A$ $\qquad I_2 = 1{,}4157\angle 49{,}66\ A$
$I_{L3} = I_1 - I_2\ = 4{,}172\angle - 26{,}32A$

➢ *According to the Analysis and Simulation*

Fig.5. $I_1 = 4{,}7218\angle - 6{,}967\ A$ $\qquad I_2 = 1{,}50943\angle 28{,}56\ A$
$I_{L3} = I_1 - I_2 = 3{,}6\angle - 21{,}066A$

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