Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research
Vol. 07, Issue, 11, pp.16850-16854, November, 2017

ORIGINAL RESEARCH ARTICLE **OPEN ACCESS**

APPLICATION OF MESH FOR A SUPERMESH ANALYSIS METHOD

Mohan, B.S., Sharanya, K.B. Sindu, N., *Hemanth Kumar, N. G. and Shamanth G Bharadwaj

Electrical & Electronics Engineering, New Horizon College of Engineering, Bangalore

ARTICLE INFO

Article History:
Received 12th August 2017
Received in revised form
07th September, 2017
Accepted 15th October, 2017
Published online 29th November, 2017

Key Words:

KCL,
KVL,
Supermesh,
Mesh,
Current,
Voltage.

***Corresponding author:**

ABSTRACT

Any circuit however big or small, liner or non-linear, ohmic or non-ohmic follow Kirchhoff's current law (KCL) and Kirchhoff's voltage law (KVL), using these laws along with some other techniques to determine the currents and voltages in a given circuit. Supermesh is applied, if current source is common to more than one mesh current. In this paper, for a given circuit, suggesting an alternative method for supermesh. The alternative method is applicable for planar circuit. The circuit is redrawn such that the current source is not being common for more than one mesh current .i.e. in altered circuit one among the mesh current is equal the magnitude to current source (based on direction the value is assigned). Circuit unknowns, branch currents and Vx at first are found using any one these laws seconded by redrawing the given circuit and applying mesh analysis rather than supermesh. The number of equations to solve will reduce. For given circuit theoretical calculations are carried out and validated by simulating for both methods over pspice9.1 student version environment. Comparing the result, the alternative method can be used instead of supermesh provided the circuit is redrawn in planar form.

Citation: Mohan, B.S., Sharanya, K.B. Sindu, N., Hemanth Kumar, N. G. and Shamanth G Bharadwaj. 2017. "Application of Mesh for a Supermesh Analysis Method", *International Journal of Development Research*, 7, (11), 16850-16854.

INTRODUCTION

KCL and KVL laws are simply restatements of charge and energy conservation, respectively. Using ohm's and Kirchhoff's laws, to analysis a linear circuit to obtain the unknown such as voltage (with particular polarity), current (in particular direction) or power associated with particular element (resistance, voltage, current source). Two basic circuit analysis techniques are nodal analysis and mesh analysis [William, 2015]. In this paper, two problems have been taken to compare the results for unknowns using supermesh and alternative method. The unknowns at first, theoretical calculations are carried seconded by simulation [Channa]. The first circuit is solved by nodal analysis (a supermesh problem) then redrawing the circuit such that the current source is not common to more than one mesh current, tabulating the theoretical calculations by applying mesh analysis. These two circuits are simulated for comparing the results, in section II. The second circuit is solved by applying supermesh, redrawing the circuit such that mesh analysis can be applied for calculations. These two circuits are simulated for comparing the results, in section III. The results for nodal analysis, supermesh analysis are compared against alternative method for conclusion under section IV.

First Circuit

Theretical calculation

The unknowns (current in all branch, Vx and i_1)are solved by applying nodal analysis method for circuit shown in fig.1.

At node V1

$$\frac{V1 - V2}{1} + \frac{V1}{2} - 15 = 0$$

$$V1\left[1+\frac{1}{2}\right] - V2 = 15 \qquad (1)$$

At node V2

$$\frac{V2 - V1}{1} + \frac{V2}{3} - 3i = 0$$

$$i = \frac{V1}{2} \text{ sub in above equation}$$

$$\frac{V2 - V1}{1} + \frac{V2}{3} - \frac{3V1}{3} = 0$$

$$V1\left[-1 - \frac{3}{2}\right] + V2\left[1 + \frac{1}{3}\right] = 0 \quad (2)$$

Solving eq 1and 2, we get

$$V1 = -40V \quad (3)$$

$$V2 = -75V \quad (4)$$

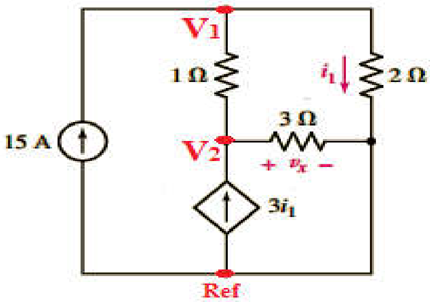

Fig.1 . Circuit 1

Currents in all branches, Vx and i_1 are calculated and tabulated in table.1.

Table.1 Current in all branches, Vx & i_1 for fig.1

Branch	Current Direction	Amperes
2Ω	Down	-20
1Ω	Down	35
3Ω	Right	-25
i_1	Down	-20

Voltage Vx across 3 ohms = V2 = -75 volts

Simulation

The unknowns are found over simulation to verify theoretical calculations. The circuit built over pspice is shown in fig.2. The simulated results for fig.2 is shown in fig.3

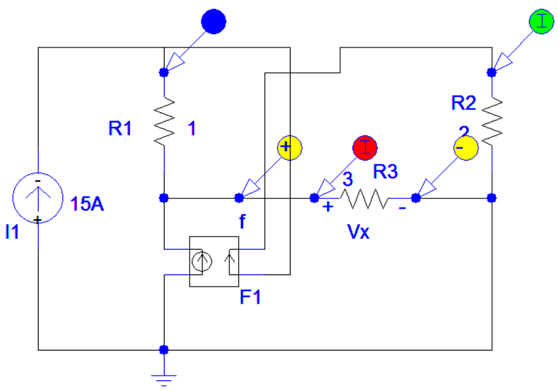

Fig.2 Simulated circuit for fig.1

The simulation output for current shows positive value. For example, in fig.3, current I_2 of 15A is flowing in upwards direction, this is indicated in simulation output at the bottom (positive value).

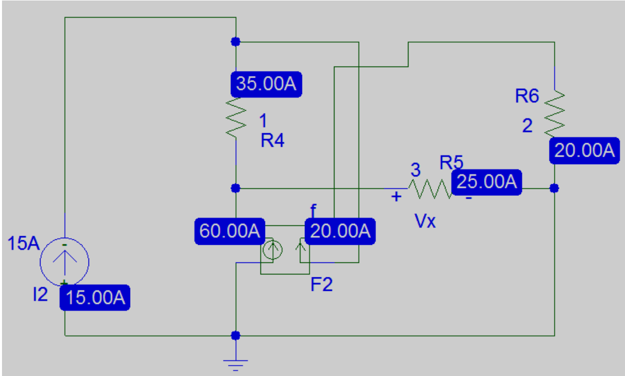

Fig. 3. Simulated output

For R4 (1Ω) the current in this branch is 35A flowing downwards, R6 (2Ω) it's 20A upward or -20A in downward direction. To find Vx with given polarity in R5 branch, the current should enter "+" terminal. The current entering "-" terminal is 25A, thus current entering "+" terminal is -25A. Thus Vx is equal to,

$$Vx = -25 * 3 = -75V \quad (5)$$

The simulated results are tabulated in table.2.

Table 2. Simulated current in all branches, Vx & i_1 for fig.1

Branch	Current Direction	Amperes
2Ω	Down	-20
1Ω	Down	35
3Ω	Right	-25
i_1	Down	-20

Voltage Vx across 3 ohms = V2 = -75 volts

Theretical calculation for redrawn circuit

The unknowns (current in all branch, Vx and i_1) are solved by applying mesh analysis method for circuit shown in fig.4. Currents in all branches, Vx and i_1 are calculated and tabulated in table.3.

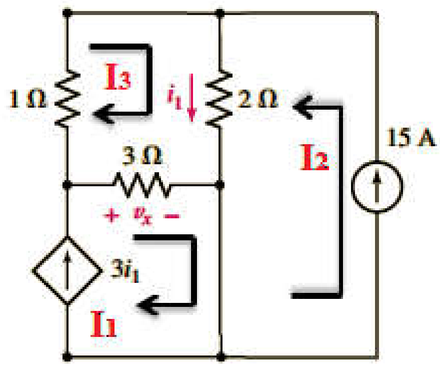

Fig. 4. Redrawn circuit for circuit-1

$$Vx = 3(I1 - I3)$$
$$I1 = 3i \quad (5)$$

$$\text{where, } i = I3 - I2$$
$$\text{Thus, } I1 = 3(I3 - I2) \quad (6)$$

$$I2 = 15A \quad (7)$$

Applying KVL to mesh 3, we get

$$2I3 + 30 + 3I3 - 3I1 + I3 = 0$$

Substituting the values of I2, and I1 we ger

$$6I3 - 9(I3 + 15) = -30$$

$$I3 = -35A \quad (8)$$

$$I1 = 3(-35 - 15) = -60A \quad (9)$$

$$Vx = 3(-60 + 35) = -75V \quad (10)$$

Currents in all branches, Vx and i_1 are calculated and tabulated in table.3.

Table 3. Current in all branches, Vx & i_1 for fig.3

Branch	Current Direction	Amperes
2Ω	Down	-20
1Ω	Down	35
3Ω	Right	-25
i_1	Down	-20

Voltage Vx across 3 ohms = -75 volts

Simulation for redrawn circuit

The unknowns are found over simulation to verify theoretical calculations. The circuit built over pspice is shown in fig.5.

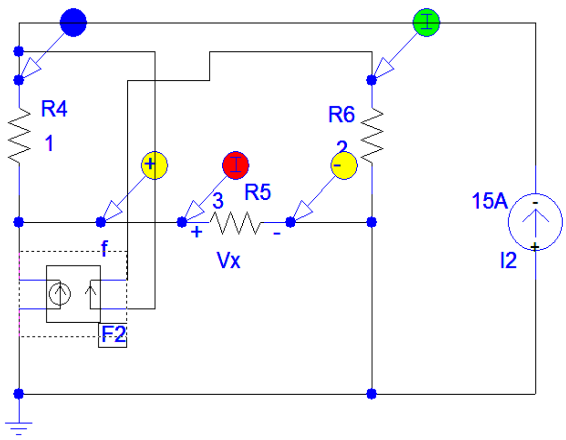

Fig. 5. Simulation circuit for redrawn circuit-1

The simulated result for fig.5 is shown in fig.6 and tabulated in table.4.

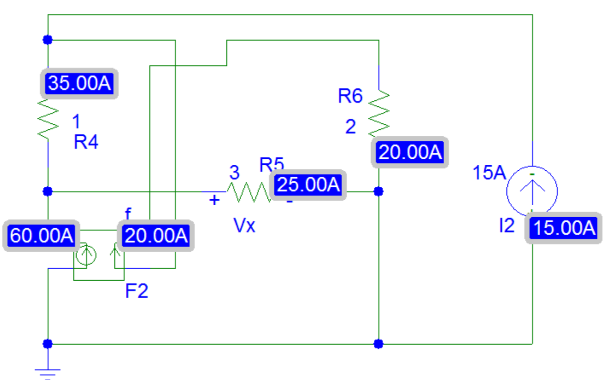

Fig. 6. Simulated output for redrawn circuit-1

Simulated output for current shown positive values as expressed in section II, B. The output for various branch currents and Vx are tabulated in table.4.

Table 4. Current in all branches, Vx & i_1 for fig.5

Branch	Current Direction	Amperes
2Ω	Down	-20
1Ω	Down	35
3Ω	Right	-25
i_1	Down	-20

Voltage Vx across 3 ohms = -75 volts

Theretical calculation

The unknowns (current in all branch, Vx and i_1)are solved by applying supermesh analysis method for circuit shown in fig.7

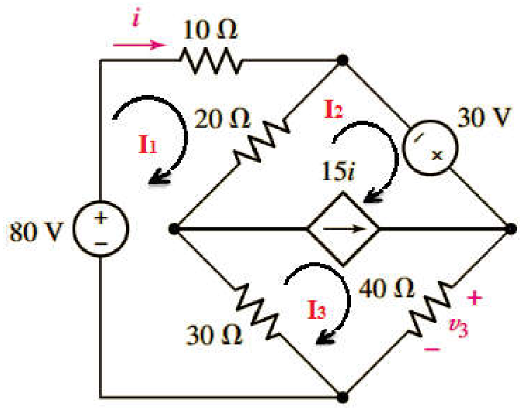

Fig.7. Circuit-2

Constrain Equation

$$I3 - I2 = 15i \quad (11)$$

I= I1 sub in eq 1 we get,

$$-15I1 - I2 + I3 = 0 \quad (12)$$

SUPER MESH

$$-30 + 4040I3 + 30I3 - 30I1 + 20I2 - 20I1 = 0$$

$$-50I1 + 20I2 + 70I3 = 30 \quad (13)$$

KVL to mesh 1, we get

$$10I1 + 20I1 - 20I2 + 30I1 - 30I3 - 80 = 0$$

$$60I1 - 20I2 - 30I3 = 80 \quad (14)$$

Solving above equation, we get

$$I1 = 0.5839A \quad (15)$$

$$I2 = -6.1544A \quad (16)$$

$$I3 = 2.60403A \quad (17)$$

$$i = I1 = 0.5839A \quad (18)$$

$$Vx = 40(I3) = 104.1612V \quad (19)$$

Currents in all branches, Vx and i1 are calculated and tabulated in table 5

Table 5. Current in all branches, Vx & i_1 for fig.7

Branch	Direction of current flow	Amperes
30Ω	Down	-2.02
20Ω	Down	6.7383
40Ω	Down	2.6041
10Ω	Right	0.5839
30V	Down	-6.1544

Simulation

The unknowns are found over simulation to verify theoretical calculations. The circuit built over pspice is shown in fig.8.

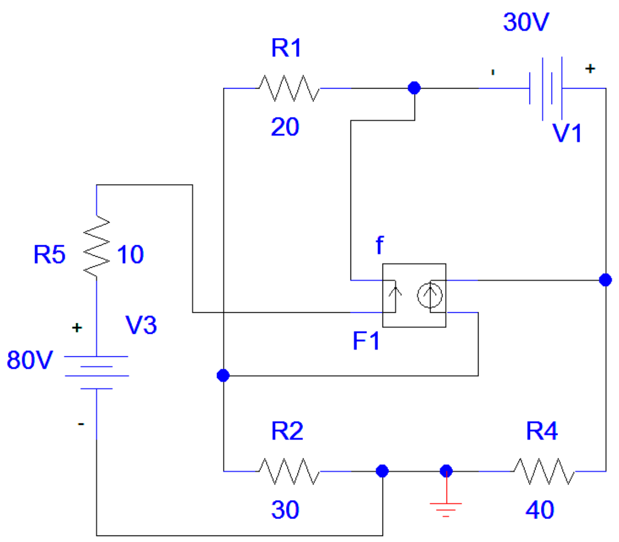

Fig. 8. Simulation for circuit-2

The simulated results for fig.8 is shown in fig.9

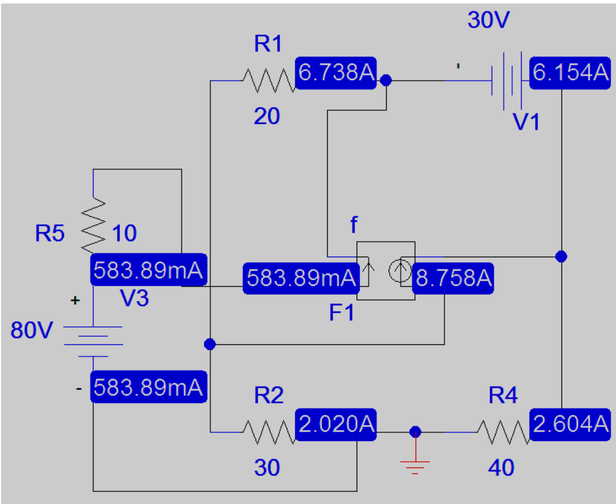

Fig.9. Simulated result for circuit-2

As expressed in section II wrt flow of positive current direction. The unknowns are tabulated under table.6.

Table 6. Current in all branches, Vx & i_1 for fig.8

Branch	Direction of current flow	Amperes
30Ω	Down	-2.02
20Ω	Down	6.7383
40Ω	Down	2.6041
10Ω	Right	0.5839
30V	Down	-6.1544

Theretical calculation for redrawn circuit

The unknowns (current in all branch, Vx and i_1) are solved by applying mesh analysis method for circuit shown in fig.10

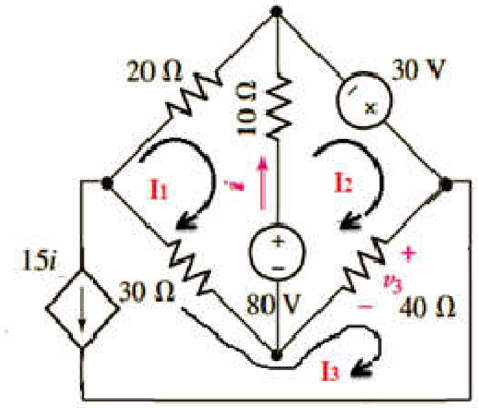

Fig.10. Redrawn for circuit-2

$$i = I2 - I1 \tag{20}$$

$$I3 = -15i = -15(I2 - I1) = 15I1 - 15I2 \tag{21}$$

KVL to Mesh 1, we get

$$10I1 + 80 + 30I1 - 30I3 + 20I1 - 10I2 = 0$$

$$60I1 - 10I2 - 30(15I1 - 15I) = -80$$

$$-390I1 + 440I2 = -80 \tag{22}$$

Mesh 2

$$-30 + 40I2 - 40I3 - 80 + 10I2 - 10I1 = 0$$

$$-10I1 + 40I2 - 50(15I1 - 15I2) = 110$$

$$-610I1 + 650I2 = 110 \tag{23}$$

solving equation, 22 and 23, we get

$$I1 = -6.7383A \tag{24}$$

$$I2 = -6.1544A \tag{25}$$

$$i = I2 - I1 = 0.5839A \tag{26}$$

$$I3 = -15i = -8.7383A \tag{27}$$

$$Vx = 40(I2 - I3) = 104.164V \tag{28}$$

Currents in all branches, Vx and i_1 are calculated and tabulated in table.7.

Table 7. Current in all branches, Vx & i_1 for fig.10

Branch	Direction of current flow	Amperes
30Ω	Down	-2.02
20Ω	Down	6.7383
40Ω	Down	2.6041
10Ω	Right	0.5839
30V	Down	-6.1544

Simulation for redrawn circuit

The unknowns are found over simulation to verify theoretical calculations. The circuit built over pspice is shown in fig.11. Simulated results for redrawn circuit is shown in fig.12 and tabulated in table.8.

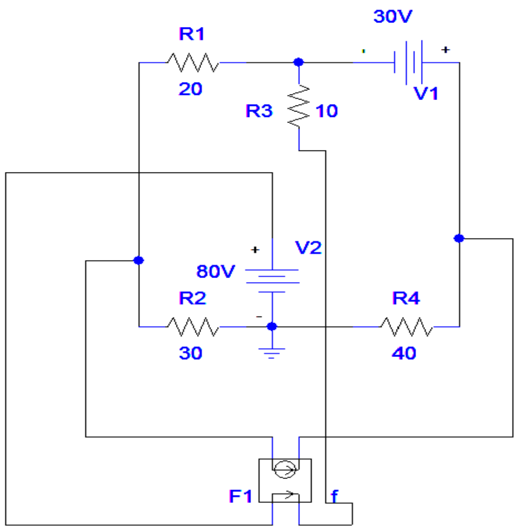

Fig. 11. Simulated for fig.10

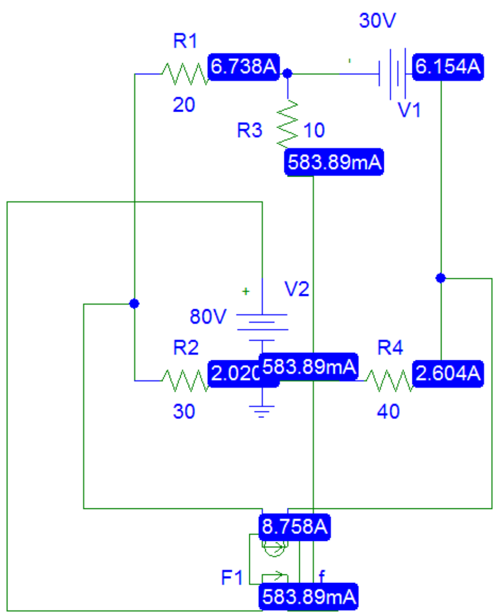

Fig.12. Simulated result for redrawn circuit.

Table 8. Current in all branches, Vx & i_1 for fig.12

Branch	Direction of current flow	Amperes
30Ω	Down	-2.02
20Ω	Down	6.7383
40Ω	Down	2.6041
10Ω	Right	0.5839
30V	Down	-6.1544

RESULT ANALYSIS AND CONCLUSION

Solving circuit-1using nodal analysis has two unknowns and when same is redrawn to avoid application of supermesh method, the number of unknown wrt mesh analysis is one. Thus the number of unknowns is reduced for same solution. In circuit-2, the number of equations to solve by application of supermesh is three. When the circuit is redrawn for application of alternative method, the number of equation to solve is two, thus reducing the number of equations to solve by one. Other unknowns in any case are found using other techniques. When circuit is redrawn the electrical characteristic of the original circuit is not changed .i.e. the circuit is still planar.

Circuit – 1

Branch currents, Vx and i_1 using nodal analysis for circuit-1 is tabulated in table.1. For the foresaid unknowns, the circuit is redrawn to solve using alternative method. The results for unknowns are same .i.e. all the values are same respectively.

- For nodal analysis, the number of equations to solve is two, whereas under alternative method it reduces to one.
- The results for nodal analysis, alternative method and simulation show the same values both in magnitude and direction/polarity as tabulated in table.1, table.3 & table.4 respectively.

Circuit – 2

Branch currents, Vx and i_1 using supermesh analysis for circuit-2 is tabulated in table.5. For the foresaid unknowns, the circuit is redrawn to solve using alternative method. The results for unknowns are same .i.e. all the values are same respectively.

- The number of steps the given circuit is less in alternative method.
- The results for supermesh analysis method, alternative method and simulation shows the same values both in magnitude and direction/polarity as tabulated in table.5, table.7 & table.8 respectively.

Thus by comparing the results for two circuits, an alternative method exists for any given circuit apart from supermesh analysis. For any given circuit (circuit which comes to supermesh analysis method) which can be redrawn in planar form such that the current source is not being common to more than one loop/mesh current path an alternative method exists giving same results validated by simulation results respectively.

REFERENCES

Channa Venkatesh, J. K. and Ganesh Roa, D. "Network Analysis", 1st chapter, 2nd edition.

William, G., Hayt, H., Jack E. 2015. Kemmerly & Steven M. Durbin, " Engineering Circuit Analysis",4th chapter, eighth edition.

****