BEE1133 Circuit Analysis

Chapter 2B
Methods of Analysis (DC Circuits)

by
Nor Rul Hasma Abdullah
Faculty of Electrical & Electronics Engineering
hasma@ump.edu.my

Chapter Description

Aims

This chapter is aimed to:

1. Explain the Mesh Analysis technique in solving problem related to electric circuit

Expected Outcomes

Student should be able to

1. Identify the loop for circuit
2. Identify the supermesh in the circuit
3. Determine the equation of ohm’s law
4. Determine the KVL equation for each loop for solving the electric circuit problem.

References

1. C. Alexander and M. Sadiku, “Fundamentals of Electric Circuits”, 4th ed., McGraw-Hill, 2008.
2. J. Nilsson and S. Riedel, “Electric Circuits”, 8th ed., Prentice Hall, 2008.

Basic Concept

5.1 Mesh Analysis

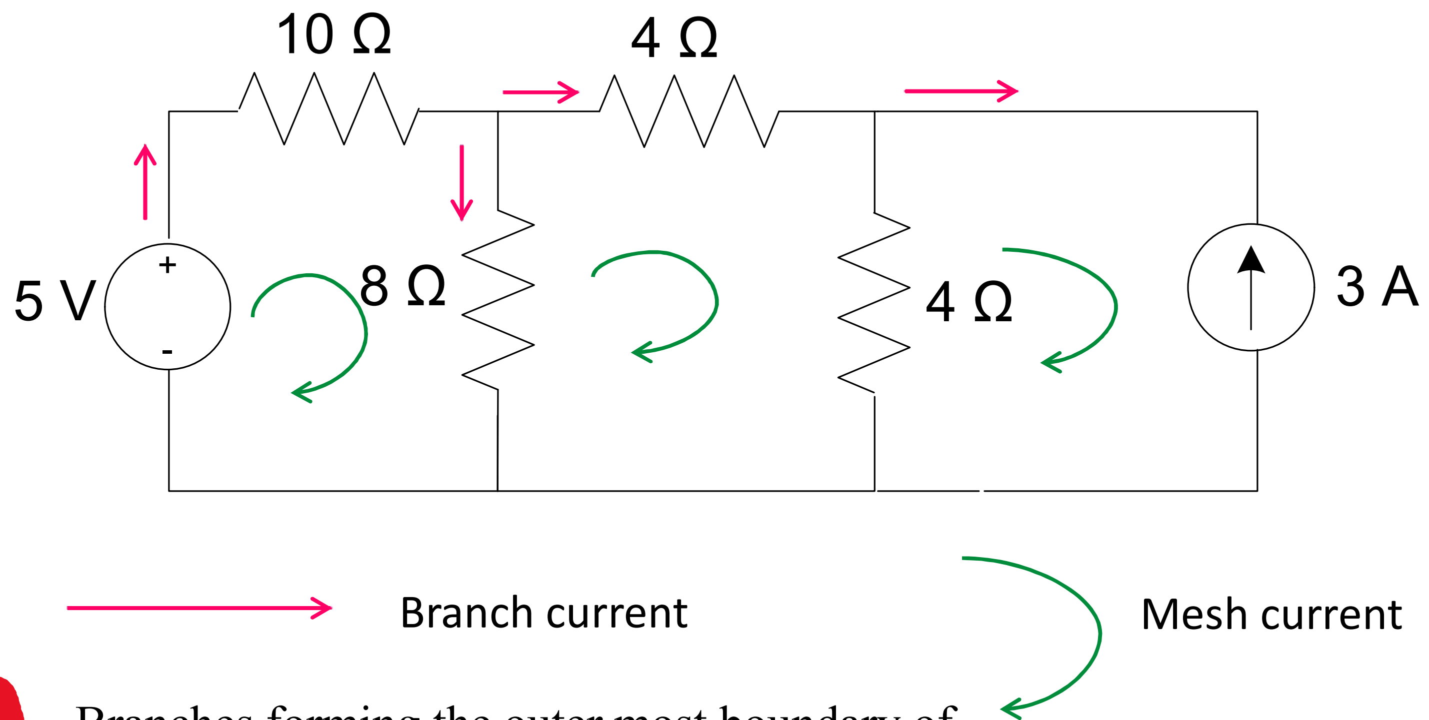
5.2 Mesh Analysis with current source: Supernode

5.3 Nodal versus mesh analysis

Mesh Analysis

- Mesh Analysis assigns **UNKNOWN MESH CURRENTS** to all the meshes in the circuit
- Finds the **UNKNOWN MESH CURRENTS** by performing KVL around all meshes.
- KVL: Summation of voltage in close loop equal to zero
- We can find any **BRANCH CURRENTS** passing through any element in the circuit after finding the **UNKNOWN MESH CURRENTS** .

Mesh Current and Branch Current



Branches forming the outer most boundary of the circuit will have its **BRANCH CURRENT** the same as its **MESH CURRENT**

Remember!

Please understand on how to write the equation of voltage, V for each close loop

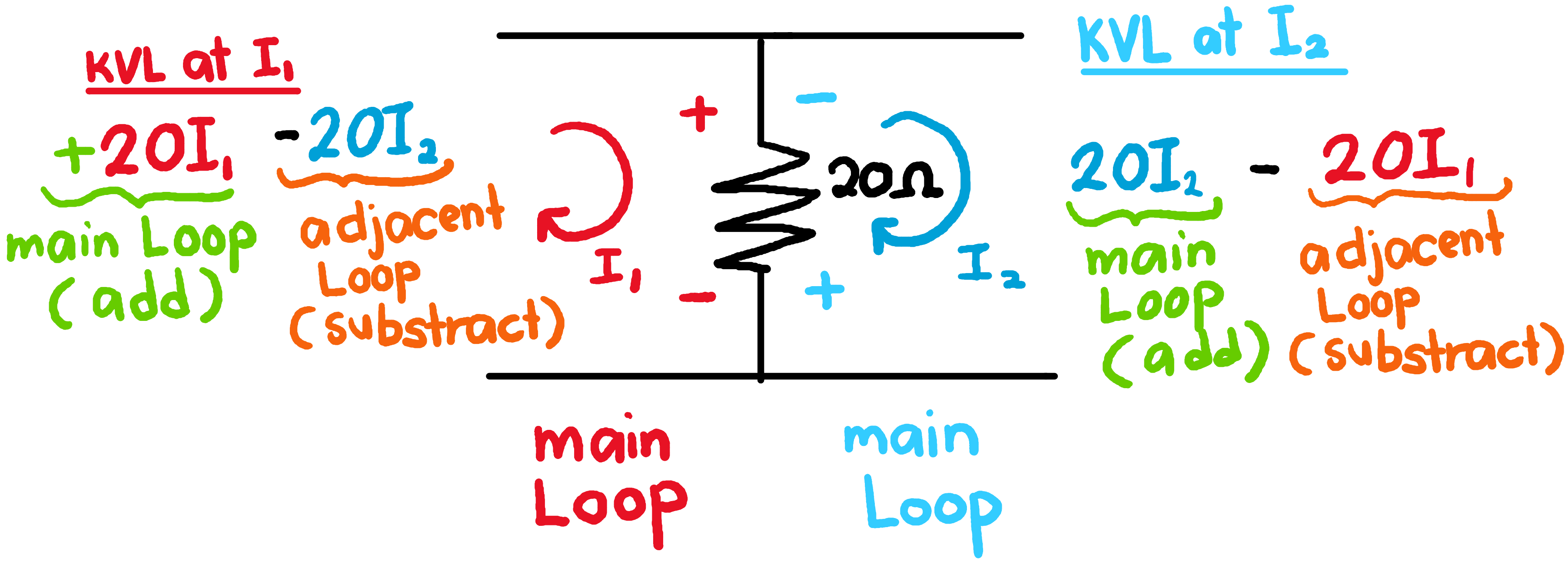
General Step For Using Mesh Analysis

Step 1	**Step 2**	**Step 3**	**Step 4**
Assign loop for each meshes in clockwise	Decide the number of equation The circuit **ONLY** consist of **R** and **dependent source** **No. of loop=no. of KVL** If the current source exist at the outer branch = No. of KVL -1 , no need to write the KVL equation, since the mesh current already given.	Apply KVL for each mesh in the circuit. The main loop voltage drops, **ADDED** and the voltage at the adjacent loop, **SUBTRACTED.**	Calculate the mesh current using Cramer/Calculator

Reminder!

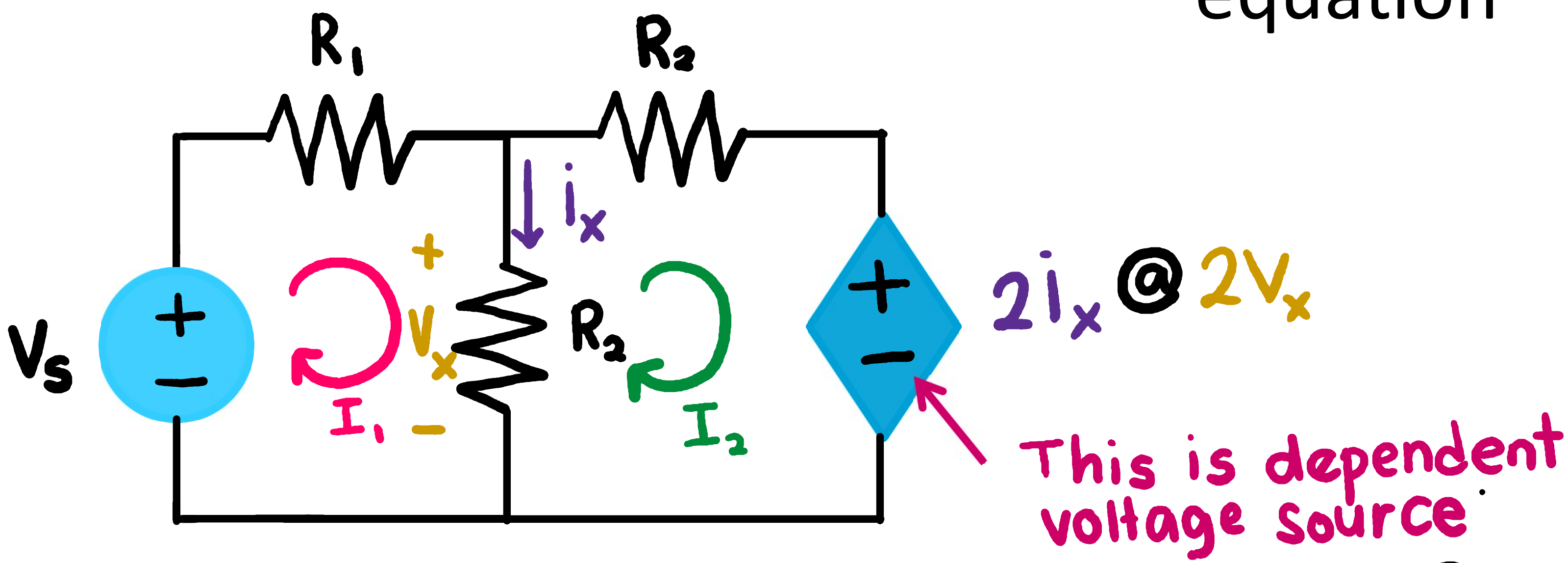
Finding the voltage

Current entering the resistor, the polarity setting is always positive



Circuit with dependent source

1 dependent source =additional 1 constraint equation



additional eq → constraint equation →

$i_x = I_1 - I_2$ @

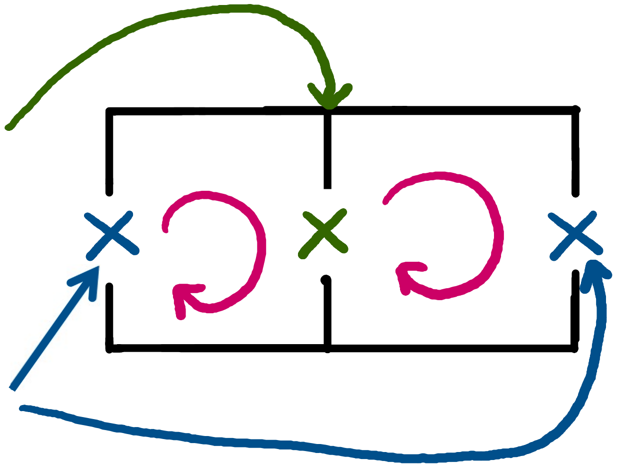
$V_x = (I_1 - I_2) R_2$

Circuit with current source

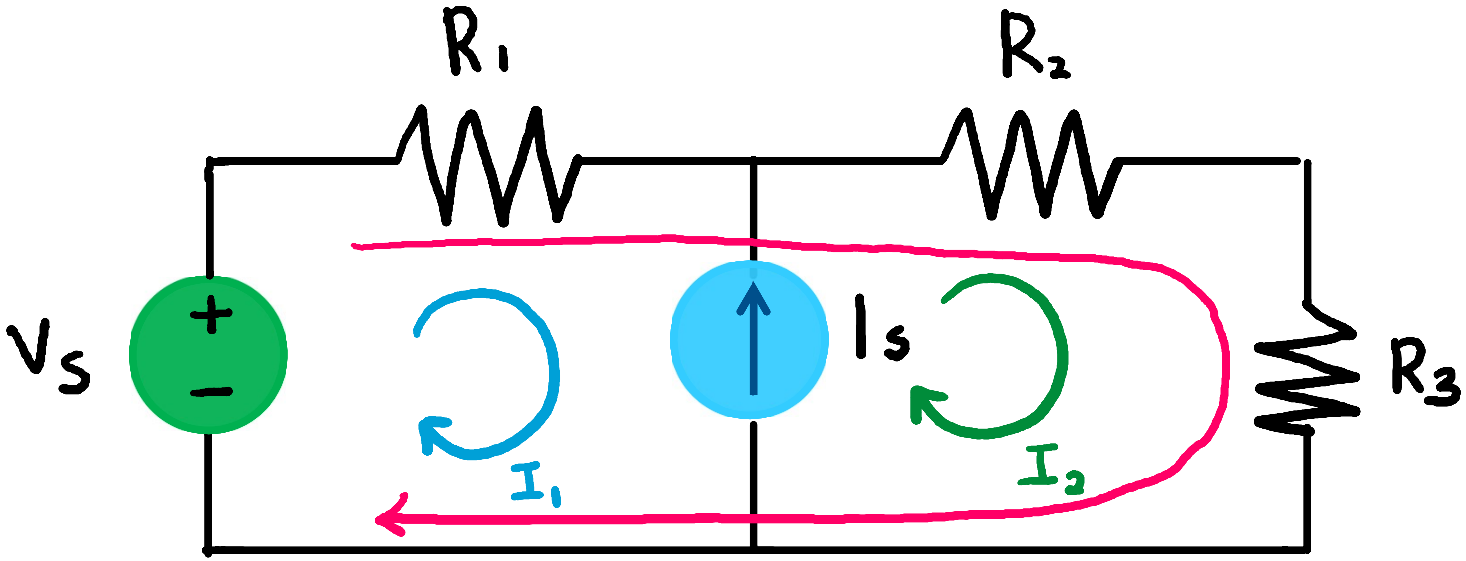
Current Source

On the branch

- the boundary between two meshes. ⇒ SUPERMESH
  - KCL = combine 2 meshes eq.
  - Eq → KCL at supermesh
  - Eq → Supermesh eq.
- the outer most boundary of the circuit. ⇒ The mesh current = the branch current



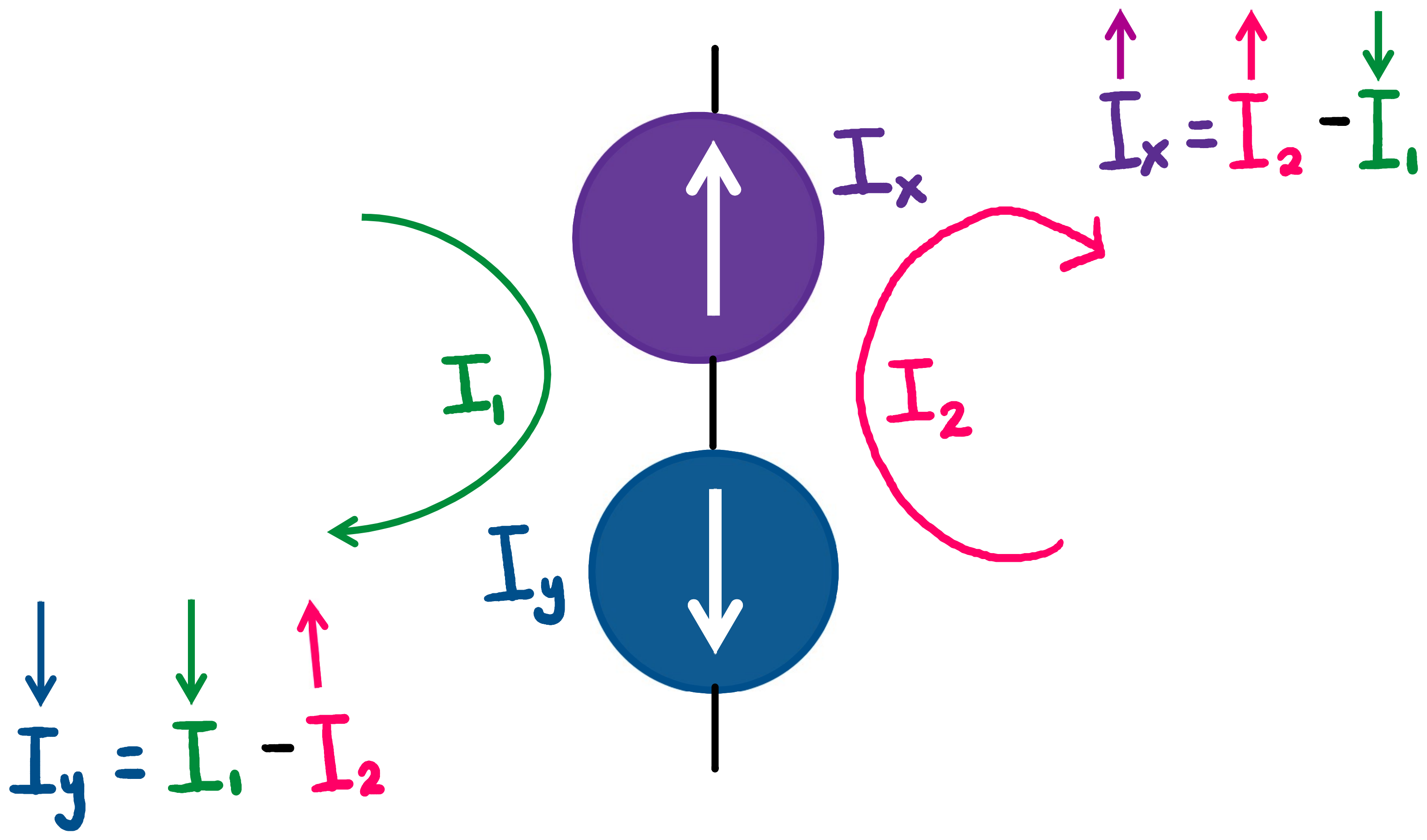
SUPERMESH



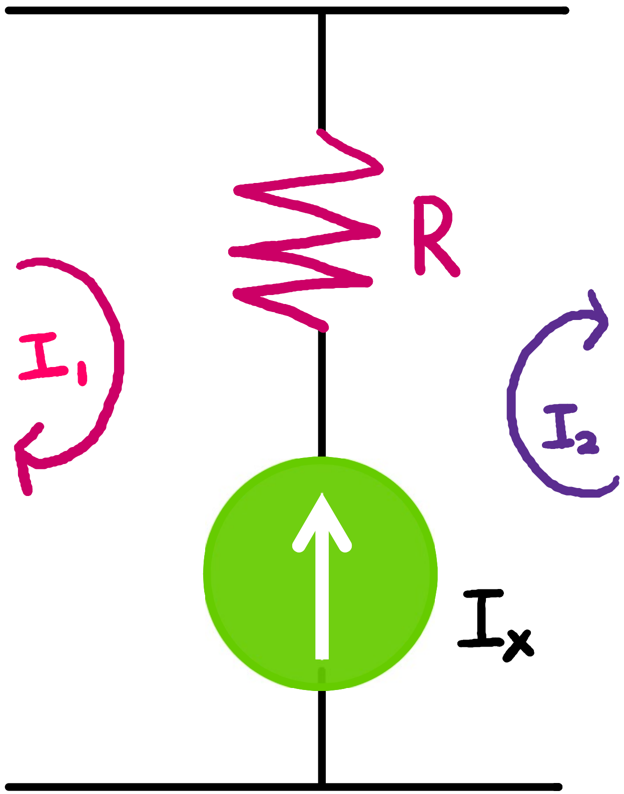
KVL at Supernode : $-V_s + I_1R_1 + I_2R_2 + I_2R_3 = 0$

Supernode : $I_s = I_2 - I_1$

SUPERMESH



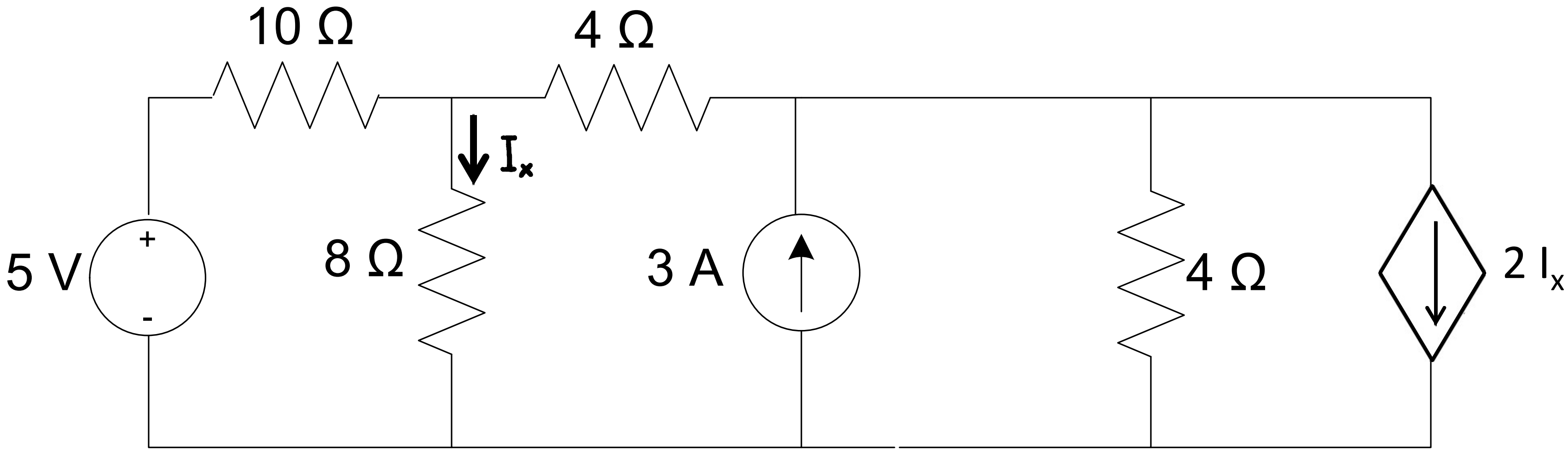
TIPS



$I_x = I_2 - I_1$

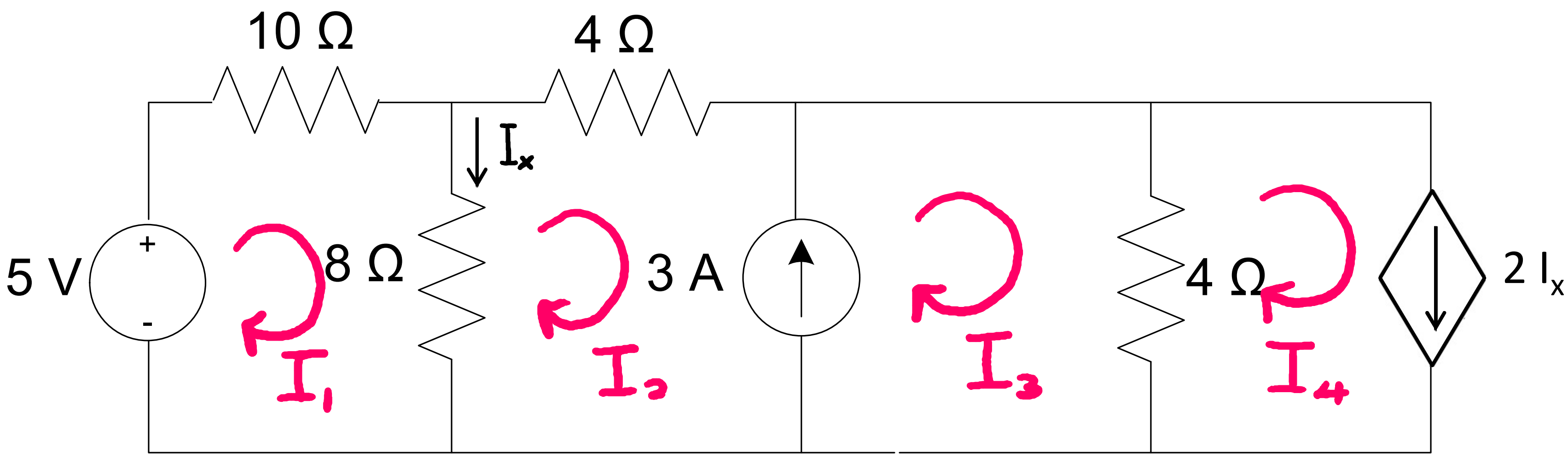
The current flow through the branch is I_x.
Therefore, R is ignored or act as short circuit

BASIC STEP

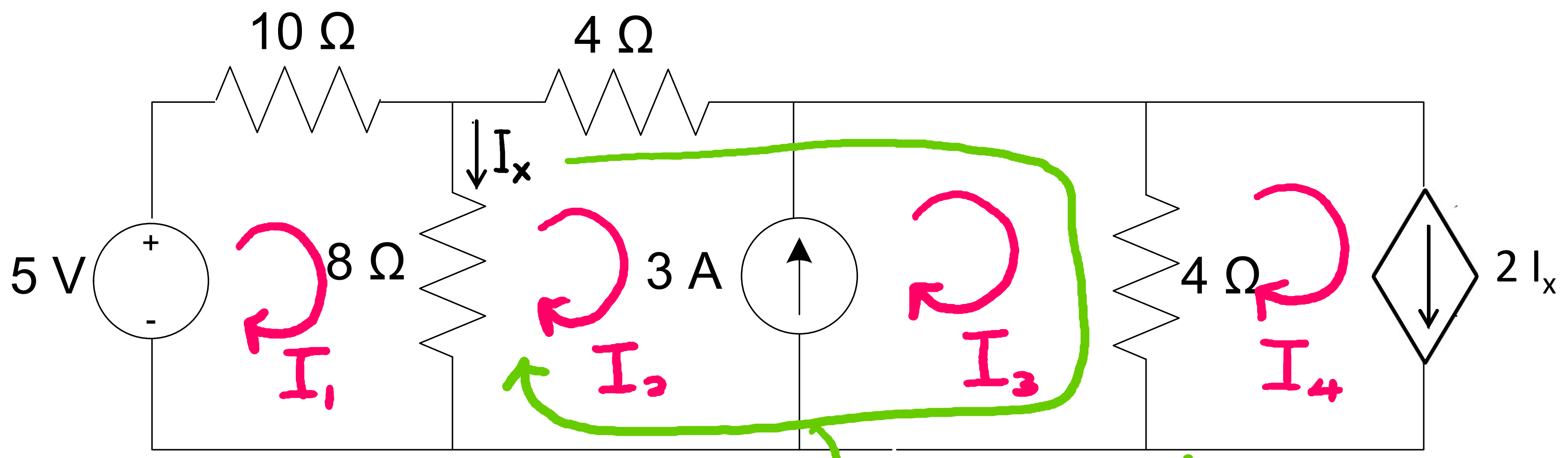


Assume that we are trying to find the voltage across and the current through all the elements

Step 1: Assign loop (clock wise)



Step 2: Decide no. of equation



No. of loop = 4

Supermesh = 4 − 1 (supermesh) + 1 (supermesh eq.)

Loop 4 = already know the current value. (no need to do KVL)

Dependent source = + 1 constraint eq

Step 3: Decide no. of equation

- 3 KVL Equations
  - ✓ Loop 1
  - ✓ Loop Supermesh(combine loop 2 and loop 3)
  - ✓ Loop 4

- 1 Supermesh Equation

- 1 Constraint Equation

Total = 5 Equations

Step 3: Deside no. of equation (cont)

- 3 KVL equation
  - ✓ Loop 1

    $$-5 + 10I_1 + 8(I_1 - I_2)=0$$

  - ✓ Loop Supermesh(combine loop 2 and loop 3)

    $$8(I_2 - I_1) + 4\ I_2 + 4\ (I_3\text{-}I_4)=0$$

  - ✓ Loop 4

    $$I_4 = 2\ I_x$$

- 1 Supermesh Equation

  $$I_3 - I_2 = 3$$

- 1 Constraint Equation

  $$I_x = I_1 - I_2$$

Step 4: Calculate the mesh currents

Solving the simultaneous equation by applying Cramer's Rule or using calculator

KVL at Loop 1

$$-5+10I_1+8(I_1-I_2)=0$$
$$I_1(10+8)-I_2(8)=5$$
$$I_1(18)-I_2(8)=5 \quad \text{--- (1)}$$

KVL at Supermesh

$$8(I_2-I_1)+4I_2+4(I_3-I_4)=0$$
$$I_1(-8)+I_2(8+4)+4I_3+I_4(-4)=0$$
$$I_1(-8)+I_2(12)+4I_3+I_4(-4)=0 \quad \text{--- (2)}$$

At Loop 4

$$I_4=2I_x \quad \text{--- (3)}$$

Supermesh Eq.

$$I_3-I_2=3 \quad \text{--- (4)}$$

Constraint Eq.

$$I_x=I_1-I_2 \quad \text{--- (5)}$$

Substitute (5) –(3)

$$I_4 = 2(I_1 - I_2)$$

$$2I_1 - 2I_2 - I_4 = 0 \quad \text{———— (6)}$$

From 4

$$I_3 = 3 + I_2 \quad \text{———— (7)}$$

Substitute (7) –(2)

$$-8I_1 + 12I_2 + 4(3 + I_2) - 4I_4 = 0$$

$$-8I_1 + 12I_2 + 12 + 4I_2 - 4I_4 = 0$$

$$-8I_1 + 16I_2 - 4I_4 = -12 \quad \text{———— (8)}$$

Rearrange Eq. (1), (6), (8)

$$\begin{bmatrix} 18 & -8 & 0 \\ 2 & -2 & -1 \\ -8 & 16 & -4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_4 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ -12 \end{bmatrix}$$

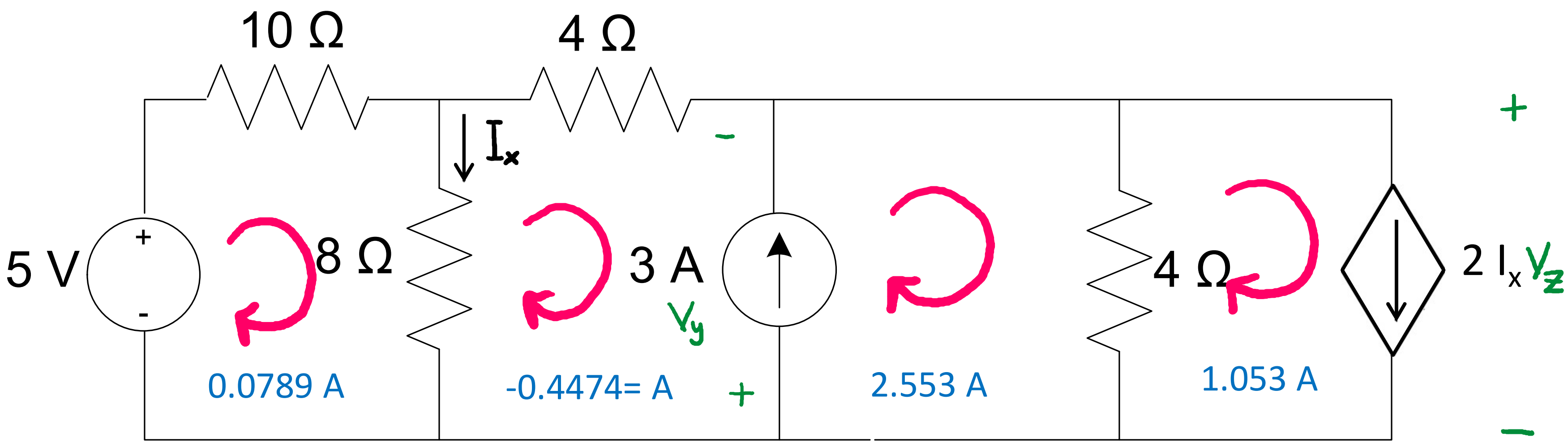
$$I_1 = \frac{3}{38} = 0.0789A$$

$$I_2 = -\frac{17}{38} = -0.4474A$$

$$I_4 = \frac{20}{19} = 1.053A$$

$$I_3 = 3 + I_2 = 3 - 0.4474 = 2.553A$$

Answer



Additional Question (Discuss with friend)

1. Find the voltage at current source, V_y and V_z.
2. Determine the power deliver by **ALL** source.

Nodal VS Mesh

Compare the number of Nodal equations to the number of Mesh equations required.

- ✓ **Choose the less equation would be the better choice.**

Author Information

Nor Rul Hasma Abdullah (Ph. D)
Senior Lecturer
Email:
hasma@ump.edu.my
Google Scholar:
Nor Rul Hasma
Scopus ID :
35791718100