NIRMA UNIVERSITY
INSTITUTE OF TECHNOLOGY
B. Tech. Semester - III (Electrical), July 2010
2EE209: NETWORK ANALYSIS & SYNTHESIS

HANDOUT 2
NETWORK EQUATIONS

Session: 1

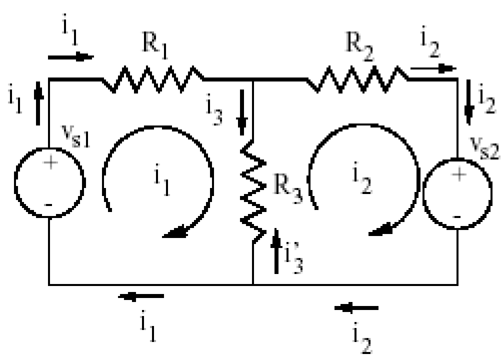
Contents

1. Introduction to mesh
2. Mesh current analysis
3. Concepts of super mesh.

Mesh-Current Method

A mesh is defined as a closed path (a loop) that contains no closed path within it.

The mesh analysis is applicable only to those networks which are plannar.



Mesh current is the current that circulates in the mesh i.e.,

a) if an element is located on a single mesh (such as R1, R2, vs1, and vs2) it carries the same current as the mesh current,

b) If an element is located on the boundary of two meshes (such as R3), it will carry a current that is the algebraic sum of the the two mesh currents:

i3 = i1 - i2

i'3 = i2 - i1

In the circuit above, KVLs give:

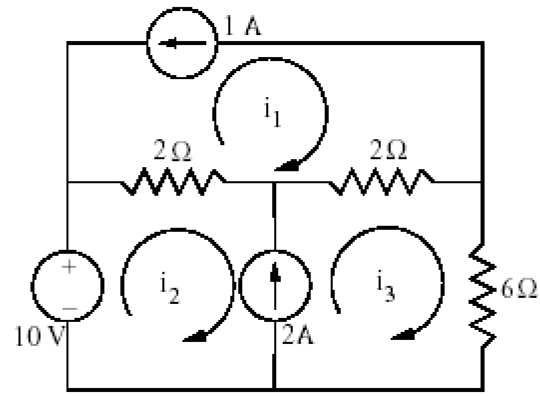
Mesh 1: $R_1 i_1 + R_3(i_1 - i_2) - v_{s1} = 0 \quad \rightarrow \quad (R_1 + R_3)i_1 - R_3 i_2 = v_{s1}$

Mesh 2: $R_3(i_2 - i_1) + R_2 i_2 + v_{s1} = 0 \quad \rightarrow \quad -R_3 i_1 + (R_2 + R_3)i_2 = -v_{s2}$

or in matrix form,

$$\begin{bmatrix} R_1 + R_3 & -R_3 \\ -R_3 & R_2 + R_3 \end{bmatrix} \bullet \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} v_{s1} \\ -v_{s2} \end{bmatrix} \qquad \rightarrow \qquad \mathbf{R} \bullet \mathbf{i} = \mathbf{v_s}$$

If network has one or more current sources in the network KVL equations as such cannot be applied to the meshes. In that case we can assume the current source to be open circuited and create a new mesh called the **super mesh**. A super mesh is constituted by two adjacent meshes that have common current source. We can apply KVL only to those meshes in the modified network.



From the circuit, we note:

- If a current source is located on only one mesh (1-A) the mesh current can be directly found from the current source and we do not need to write any KVL:

  i1 = -1 A

- If a current source is located on the boundary between two meshes (2-A) We need two equations to substitue for the two KVLs on meshes 2 and 3 that are not useful now.

  The first one is found from the i-v characteristics of the current source (its current should be 2 A):

  i3 - i2 = 2 A

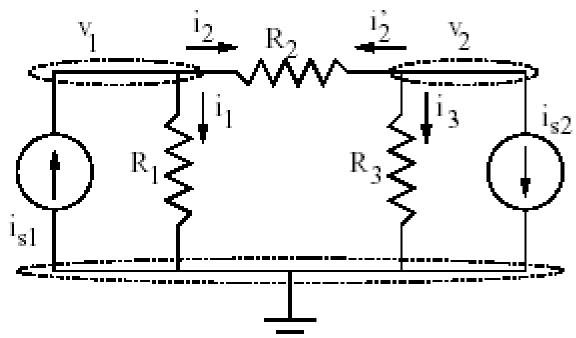
  The second equation can be found by noting that KVL can be written over any closed loop. We define a **super mesh a**s the combination of two meshes which have a current source on their boundary as shown in fig.

Session: 2

Contents:

1. Introduction to node
2. Node voltage analysis
3. Concepts of super node.

A node is a point in a network common to two or more circuit element. Each node is identified by a number or a letter. Then we associate a voltage with each node. Select one node as a reference node and then define a voltage between each remaining node and the reference node. There will be only (N-1) voltages defined in an N-node circuit.

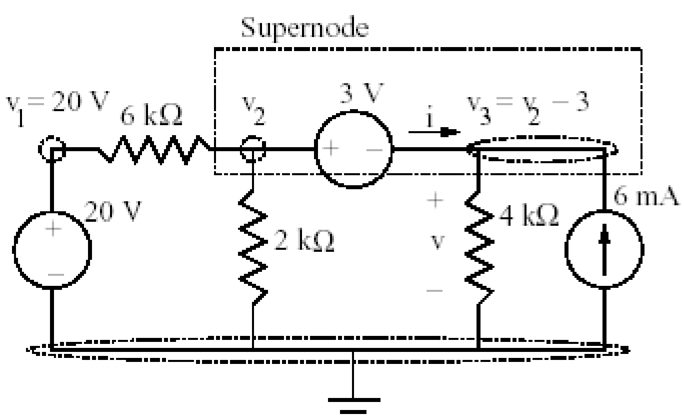


For above network there are three nodes and node 3 is selected as reference node. Apply KCL to two nodes 1 and 2 and two equations in the unknown's V_1 and V_2 are obtained. Assume that all branch current are leaving the node and algebraic sum of currents leaving the junctions is zero.

$$\text{KCL 1:} \qquad i_2 + i_1 - i_{s1} = 0 \qquad \rightarrow \qquad \frac{v_1 - v_2}{R_2} + \frac{v_1 - 0}{R_1} = i_{s1}$$

$$\text{KCL 2:} \qquad i_{s2} + i_3 + i_2' = 0 \qquad \rightarrow \qquad \frac{v_2 - 0}{R_3} + \frac{v_2 - v_1}{R_2} = -i_{s2}$$

If network has one or more voltage sources in the network KCL equations as such cannot be applied to the nodes. In that case we can assume the voltage source to be short circuited and create a **super node**. Thus each voltage source effectively reduces the number of non reference nodes by one at which we may apply KCL.



KCL for super node 2&3: $$-6 \times 10^{-3} + \frac{v_2 - 3}{4 \times 10^3} + \frac{v_2}{2 \times 10^3} + \frac{v_2 - 20}{6^3} = 0$$

The above is one equation in one unknown which can be solved rapidly.

<u>Session: 3</u>

Contents:

1. Dot convention

When the magnetic field produced by varying current in one coil induces a voltage in other coil, then the coils are said to be magnetically coupled or simply coupled coils. A transformer is an example of couple coils. Fig shows two windings wound over a common magnetic core. When coil 1 is energized with v_1, current i_1 will passed from coil 1 and produce a flux Φ_1. Part of flux Φ_1 will interact with coil 2 also and it will produce mutual inductance between two coils. It will induce voltage in coil 2. The polarity of this induced voltage can be decided by dot convention. The direction of this induced voltage v_2 is given by Lenz's law which states that the voltage induced in a coil by a change of flux tends to establish a current in coil in a direction to oppose the change in flux that has induced the voltage.

The dot convention is very useful in deciding the sign of the coefficient of mutual inductance (M) in formulating the circuit equilibrium equations.