Lecture 14: Mesh Analysis with current sources

Mesh Analysis (with Current Sources):

When the circuit contains current sources, the above procedure is modified.

Example 4:

Calculate the mesh currents i_1 & i_2 & i_3

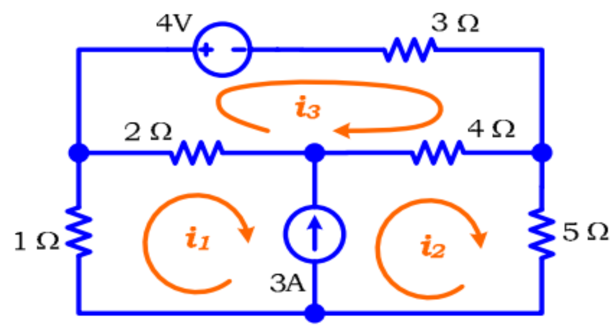

Figure 10

Solution:

KVL around mesh 1 $\Rightarrow$ $1i_1 + 2(i_1 - i_3) + V_x = 0$ (problem!)

We *cannot directly* replace V_x by mesh currents, because Ohm's Law *does not* apply to current sources.

KVL around mesh 2 $\Rightarrow$ $-V_x + 4(i_2 - i_3) + 5i_2 = 0$ (similar problem!)

Mesh 1 & 2 contain a current source (they *share* the $3A$ source)

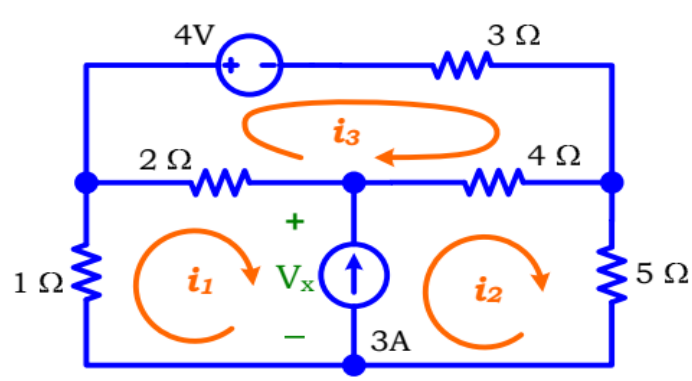

Figure 11

Lecture 14: Mesh Analysis with current sources

What to do in this case? $\Rightarrow$ Combine mesh 1 & 2 $\Rightarrow$ Super Mesh (SM)

To avoid V_x $\Rightarrow$ Apply KVL around SM

$\Downarrow$

$$1i_1 + 2(i_1 - i_3) + 4(i_2 - i_3) + 5i_2 = 0$$

$\Downarrow$

$$3i_1 + 11i_2 - 6i_3 = 0 \quad (1)$$

We need one more equation!

Apply KCL $\Rightarrow$ $i_2 - i_1 = 3 \quad (2)$

Mesh 3 *does not contain a current source* $\Rightarrow$ no special treatment

KVL around mesh 3 $\Rightarrow$ $4 + 3i_3 + 4(i_3 - i_2) + 2(i_3 - i_1) = 0$

$\Downarrow$

$$-2i_1 - 4i_2 + 9i_3 = -4 \quad (3)$$

Solving (1) & (2) & (3) $\Rightarrow$ $i_1 = -2.767A$ & $i_2 = 0.233A$ & $i_3 = -0.956A$

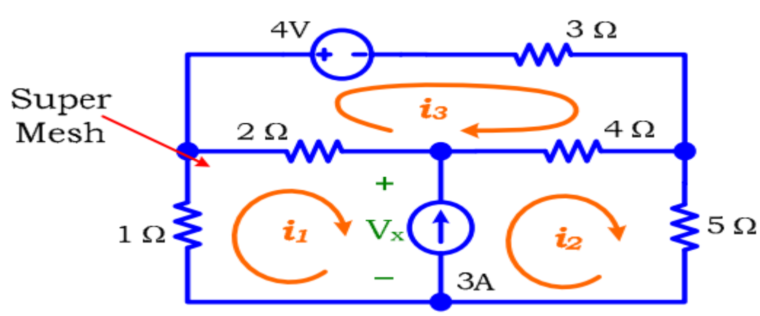

Figure 12

Current source *shared* by two meshes

$\Downarrow$

1) Combine the two meshes into a SM

2) Apply KVL around the SM

3) Apply KCL

Example 5:

Calculate the mesh currents i_1 & i_2 & i_3

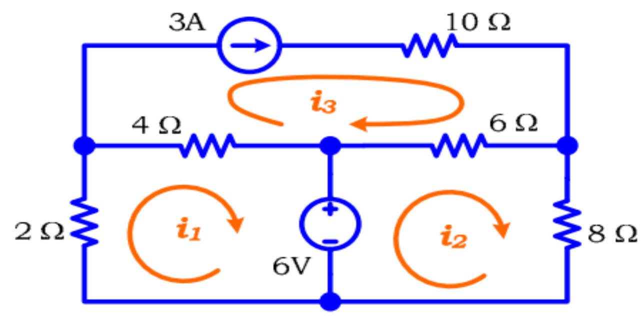

Figure 13

Solution:

Mesh 1 & 2 *do not* contain *current* sources $\Rightarrow$ Just Apply KVL around mesh (1) & (2)

KVL around mesh 1 $\Rightarrow$ $2i_1 + 4(i_1 - i_3) + 6 = 0$ $\Rightarrow$ $6i_1 - 4i_3 = -6$ (1)

KVL around mesh 2 $\Rightarrow$ $-6 + 6(i_2 - i_3) + 8i_2 = 0$ $\Rightarrow$ $14i_2 - 6i_3 = 6$ (2)

Mesh 3 contains $3A$ current source (*not shared by another mesh*)

$\Downarrow$

Do not apply KVL (because KVL *involves voltage* across the *current source*)

$\Downarrow$

Apply KCL Only

$\Downarrow$

$$i_3 = 3 \qquad (3)$$

[Note: Since we need *just* one equation from mesh 3, KCL provides it in this case]

Solving (1) & (2) & (3) $\Rightarrow$ $i_1 = 1.000A$ & $i_2 = 1.714A$ & $i_3 = 3.000A$

Lecture 14: Mesh Analysis with current sources

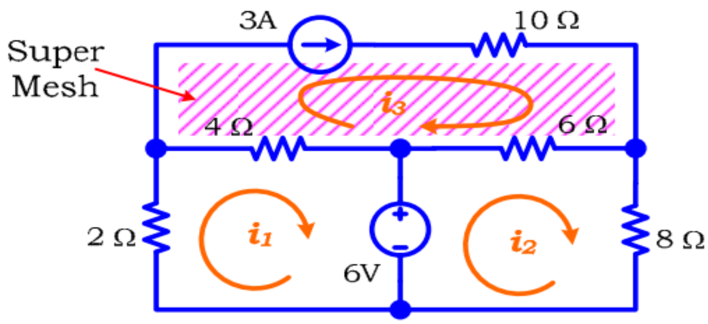

Figure 14

Current source in *one mesh only* (*not shared*) $\Rightarrow$ No KVL $\Rightarrow$ Only KCL

Nodal Vs Mesh Analysis

Which method is more efficient, the nodal or the mesh analysis?

The answer depends on the circuit under consideration. The method that results in the *least* number of *actual* unknowns is generally more efficient.

Example 4:

Calculate the power absorbed by the 4Ω resistor.

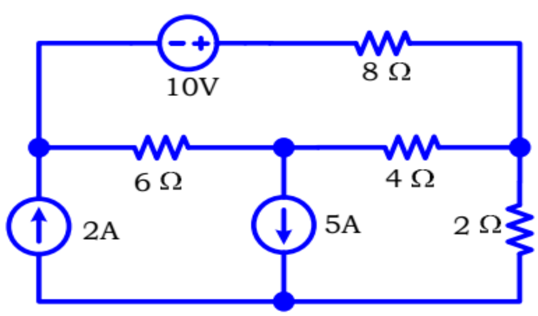

Figure 7

Using nodal analysis:

There are 5 essential nodes in the circuit.

Choose the reference node on one side of the $10V$ source.

$\therefore$ Number of *actual* unknowns is 3 (only v_2 & v_3 & v_4 are unknown, since $v_1 = 10V$)

Lecture 14: Mesh Analysis with current sources

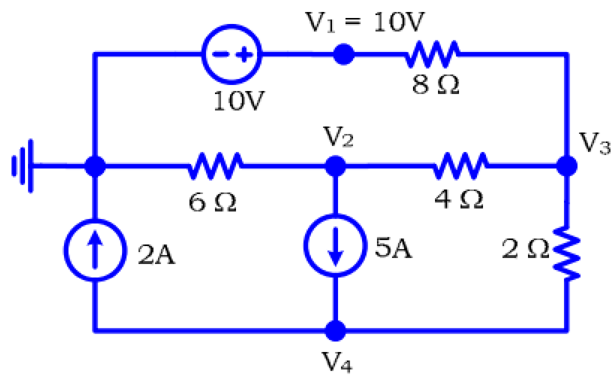

Figure 8

Using mesh analysis:

Number of actual unknowns is only 2 (only i_2 & i_3 are unknown, since $i_1 = 2A$)

$\therefore$ Use the mesh analysis to solve this problem:

KCL $\Rightarrow$ $i_1 - i_2 = 5$ $\Rightarrow$ $2 - i_2 = 5$ $\Rightarrow$ $i_2 = -3A$

KVL around mesh 3 $\Rightarrow$ $-10 + 4(i_3 - (-3)) + 6(i_3 - 2) = 0$ $\Rightarrow$ $i_3 = 1A$

$\therefore p_{4\Omega} = 4(i_2 - i_3)^2 = 4(-3-1)^2 = 16W$

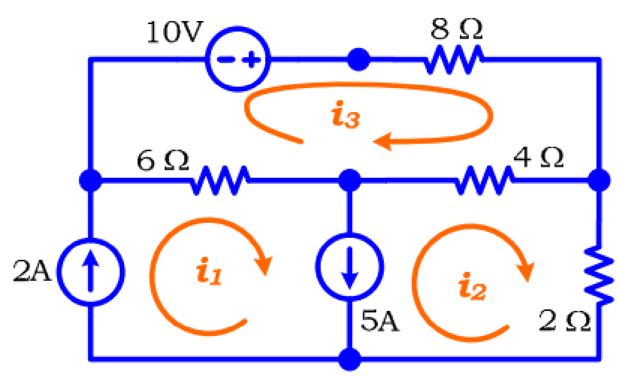

Figure 9