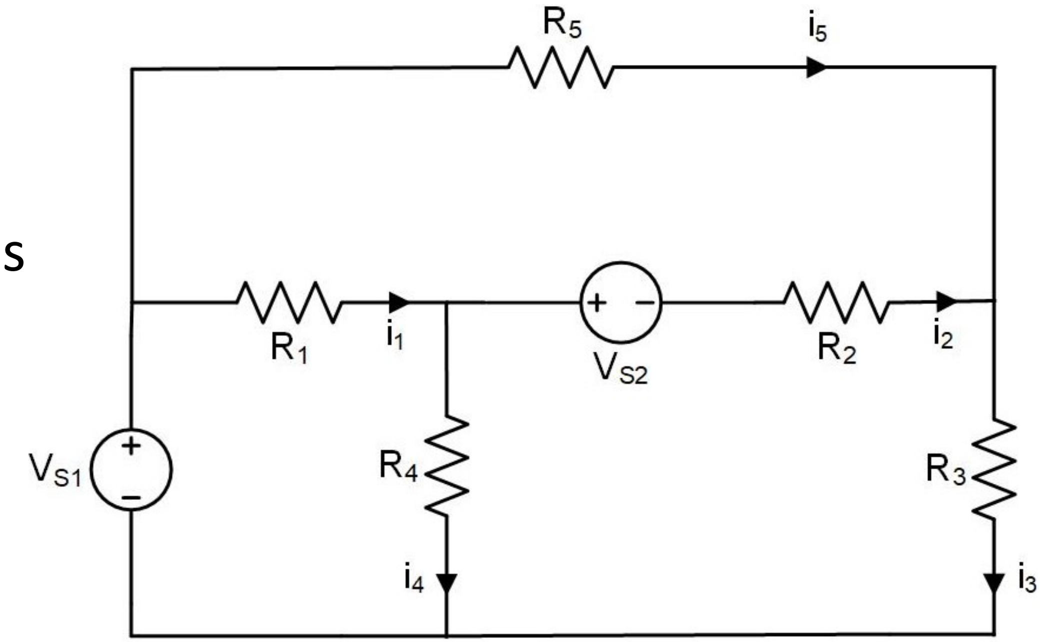
Mesh Analysis

A mesh is defined as a loop which does not contain any other loops.

Assumption: the elements are i-controlled

1. Write voltage equation in the mesh (KVL)
2. Write element (branch) voltages in terms of element currents
3. Replace element (branch) currents with mesh currents



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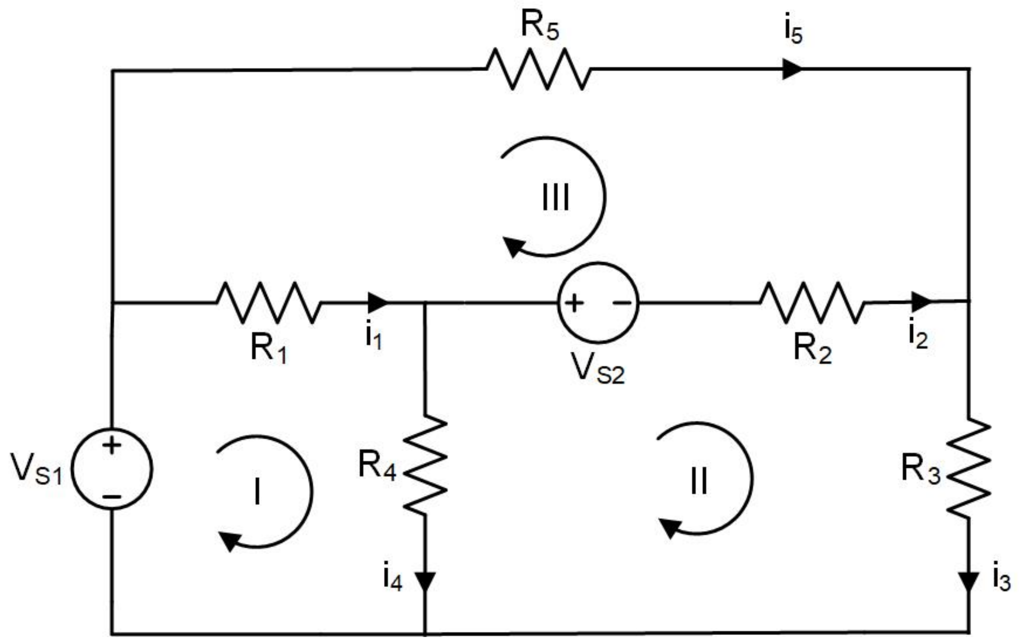


I) $V_1 + V_4 - V_{S1} = 0$

II) $V_2 + V_3 - V_4 + V_{S2} = 0$

III) $V_5 - V_2 - V_{S2} - V_1 = 0$

I) $i_1R_1 + i_4R_4 = V_{S1}$

II) $i_2R_2 + \ldots = \ldots$

III) $-R_1i_1 - \ldots = \ldots$

I) $R_1(I_{m1} - I_{m3}) + R_4(I_{m1} - I_{m2}) = V_{S1}$

II) $R_2(I_{m2} - I_{m3}) + \ldots = \ldots$

III) $-R_1(I_{m1} - I_{m3}) - \ldots = \ldots$

$$\underbrace{\begin{bmatrix} R_1 + R_4 & -R_4 & -R_1 \\ -R_4 & R_2 + R_3 + R_4 & -R_2 \\ -R_1 & -R_2 & R_1 + R_2 + R_5 \end{bmatrix}}_{z_m} \begin{bmatrix} I_{m1} \\ I_{m2} \\ I_{m3} \end{bmatrix} = \begin{bmatrix} V_{S1} \\ -V_{S2} \\ V_{S2} \end{bmatrix}$$

Z_m: mesh impedance matrix

1. z_{kk} is the sum of impedances of the elements in mesh *k*.
2. For i ≠ j, $z_{ik} = z_{ki}$ if a circuit consists of two-terminal elements only.
3. z_{ik} is either the sum or the negative sum of the impedances of elements which are common to the two meshes.
   If in the element common to the two meshes the reference directions of the two meshes are the same z_{ik} is the sum; otherwise z_{ik} is the negative sum.

4. V_S^k is the algebraic sum of voltage sources in the *k*th mesh. It is positive if the direction of the mesh is opposite to the direction of the voltage source.

Modified mesh analysis

If there are also elements which are not i-controlled.

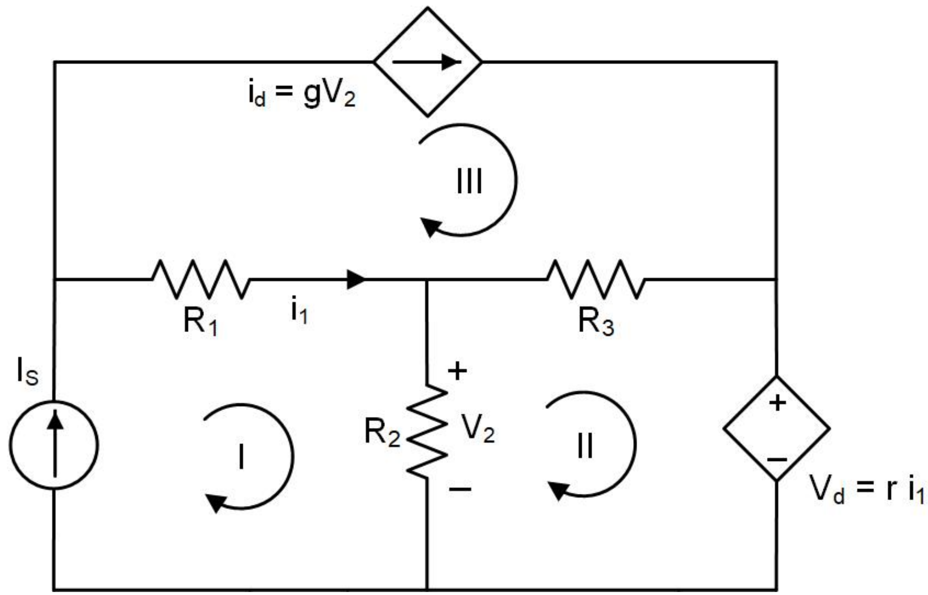
1. Write mesh equations using mesh currents as variables.
2. Whenever an element is encountered that is not i-controlled, introduce in the mesh equation the corresponding branch voltage as a new variable.
3. Add the branch equation of that element as a new equation in terms of mesh currents and voltages of the elements which are not i-controlled.

I) $(R_1 + R_2)I_{m1} - R_2 I_{m2} - R_1 I_{m3} + V_{Is} = 0$

II) $- R_2 I_{m1} + \ldots$

$V_d = ri_1 = \ldots$

III) $- R_1 I_{m1} + \ldots$



Extra equations:

$I_{m1} = \ldots$

$i_d = gV_2 = \ldots$

$$\begin{bmatrix} R_1 + R_2 & -R_2 & -R_1 & 1 & 0 \\ r - R_2 & R_2 + R_3 & -R_3 - r & 0 & 0 \\ -R_1 & -R_3 & R_1 + R_3 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 \\ gR_2 & -gR_2 & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_{m1} \\ I_{m2} \\ I_{m3} \\ \mathrm{V}_{\mathrm{ls}} \\ V_{i_d} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ I_s \\ 0 \end{bmatrix}$$