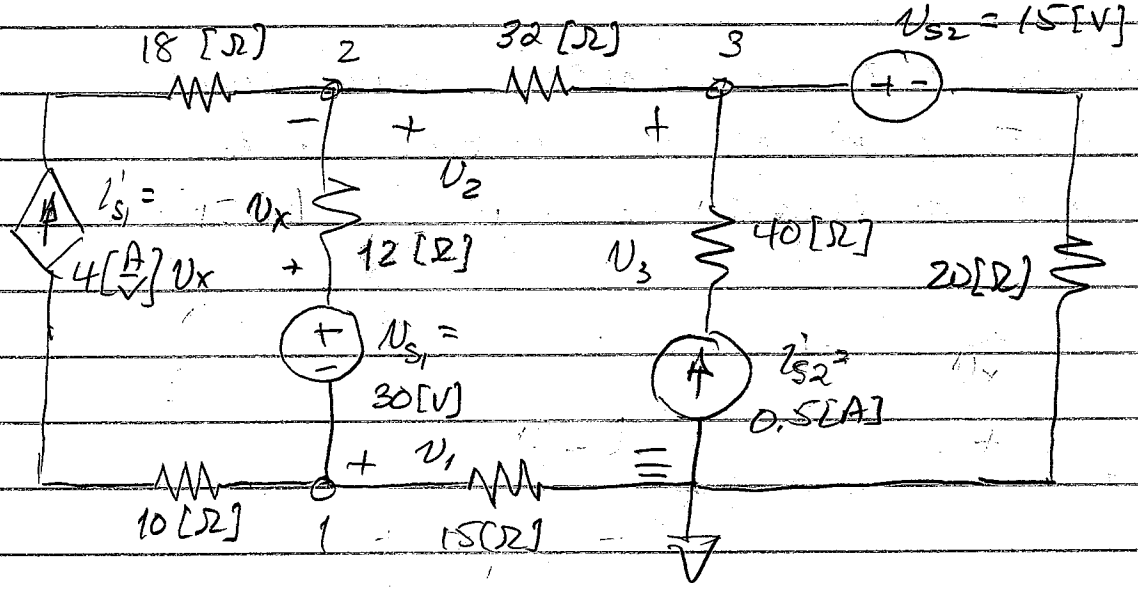
Example 1. NVM

We will write the node voltage equations for the circuit without attempting to solve them.



Our reference nodes, and node voltages v_1, v_2, v_3 are indicated. All four essential nodes have three branches attached, so in terms of number of connections, all choices are equivalent. I chose the one I did simply because I prefer it there.

Node-Voltage Equations

(1) $$\frac{v_1}{15} + \frac{v_1 - v_2 + 30}{12} + 4\left[\frac{A}{V}\right] v_x = 0$$

(2) $$\frac{v_2 - v_1 - 30}{12} - 4\left[\frac{A}{V}\right] v_x + \frac{v_2 - v_3}{32} = 0$$

(3) $\frac{v_3 - v_2}{32} + \frac{v_3 - 15}{20} - 0.5 = 0$

auxiliary: by KVL, $v_x + v_2 - v_1 - 30 = 0$,

We could solve these equations, and from there get any voltage or current in the circuit with a single equation.

Note: we could write, at node 1:

$$\frac{v_1}{15} + \frac{v_1 - v_2 + v_{s1}}{12} + i_{s1} = 0$$

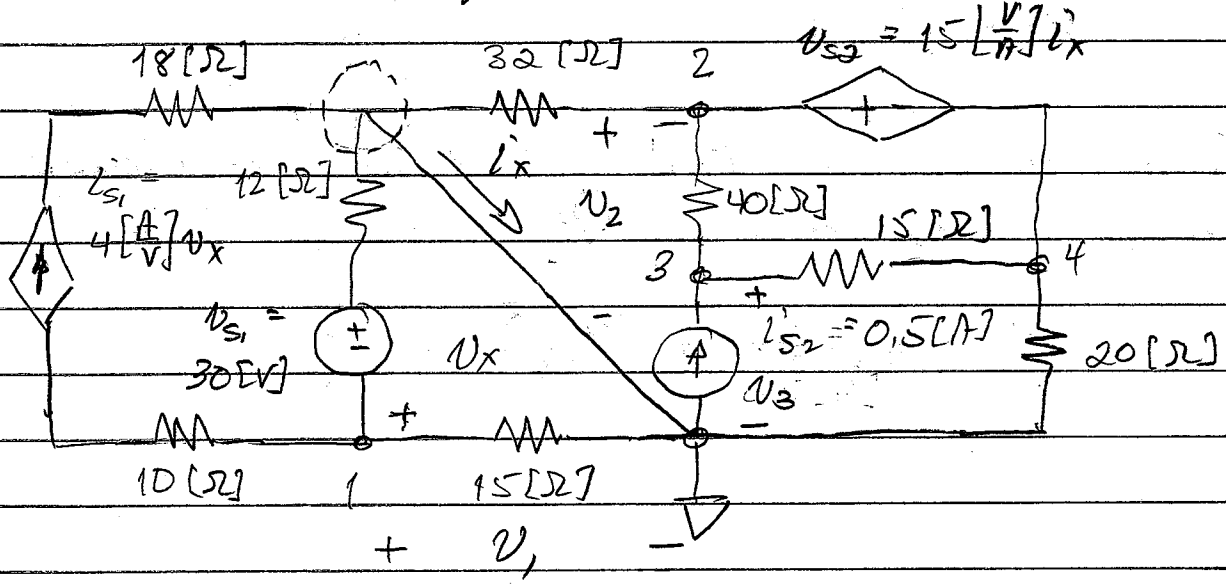
... but then we would need to also write:

$$v_{s1} = 30\ [V] \qquad i'_{s1} = 4\left[\frac{A}{V}\right] v_x$$

If we didn't do that, we could not solve the equations.

Example 2 NVM

We will write NV equations without solving...



(These diagrams can get messy, so be neat!!)

① $\frac{v_1}{15} + \frac{v_1 + 30}{12} + 4\left[\frac{A}{V}\right] v_x = 0$

② + ④ $\frac{v_2 - v_3}{40} + \frac{v_2}{32} + \frac{v_4 - v_3}{15} + \frac{v_4}{20} = 0$ } SUPERNODE

constraint: $v_2 - v_4 = 15\left[\frac{V}{A}\right] i_x$

③ $-0.5 + \frac{v_3 - v_4}{15} + \frac{v_3 - v_2}{40} = 0$

We need auxiliary equations for i_x and v_x:

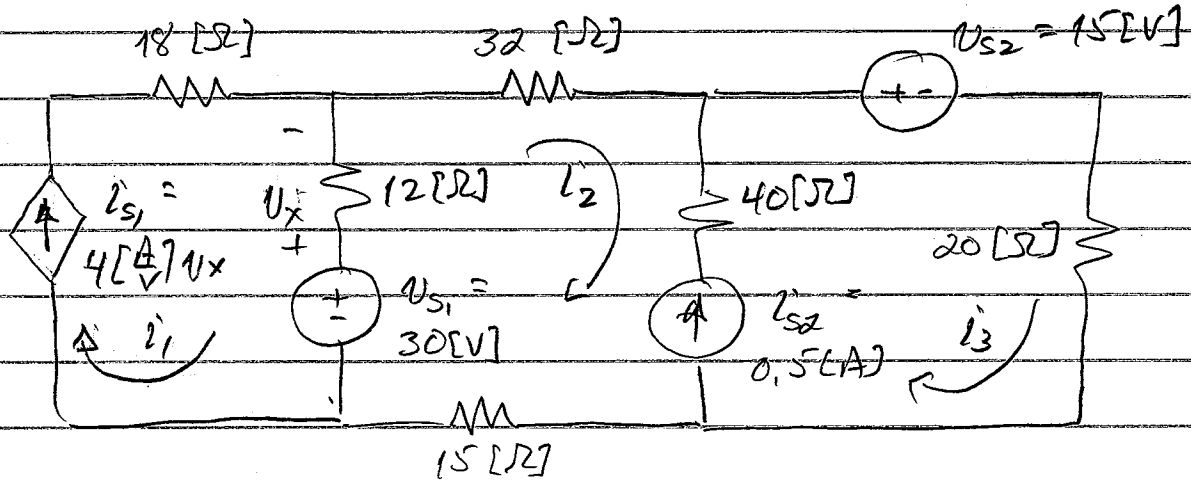
$$v_x = v_1 - v_2$$

i_x is found using KCL applied to the closed surface indicated by the dashed line.

$$i_x = 4\left[\frac{A}{V}\right]v_x + \frac{v_1 + 30}{12} + \frac{v_2}{32}$$

Example 3 MCM

Let's write mesh current equations for the circuit we solved in Example 1.



We have identified 3 mesh currents. Meshes 2 and 3 will be a supermesh. We have one dependent source so there will be four equations.

Mesh Current Equations

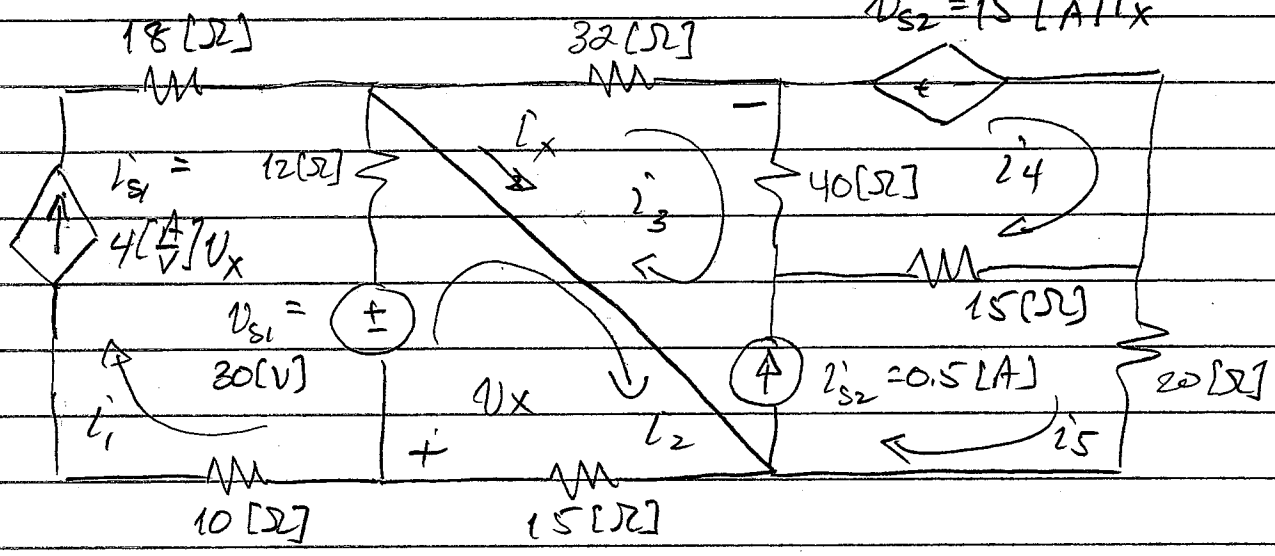
① $i_1' = 4\left[\frac{A}{V}\right] v_x$

②+③ $32 i_2' + 15 + 20 i_3' + 15 i_2' - 30 + 12(i_2' - i_1') = 0$

constraint: $i_3' - i_2' = 0.5\ [A]$

auxiliary: $v_x = 12(i_2' - i_1')$

Example 4 MCM



We will write the MC equations without solving...

① $i_1' = 4\left[\frac{A}{V}\right] v_x$

② $15\, i_2' - 30 + 12\,(i_2' - i_1') = 0$

③ + ⑤ Supermesh:

$$32\, i_3' + 40(i_3' - i_4') + 15\,(i_5' - i_4') + 20\, i_5' = 0$$

constraint: $i_5' - i_3' = 0.5\ [A]$

④ $15\left[\frac{V}{A}\right] i_x + 15\,(i_4' - i_5') + 40\,(i_4' - i_3') = 0$

auxiliary: $v_x - 32\, i_3' + 12\,(i_1' - i_2') + 30 = 0$

$i_x' = i_2' - i_3'$