Nodal Analysis-1 (`EC_nodal_1.sqproj`)

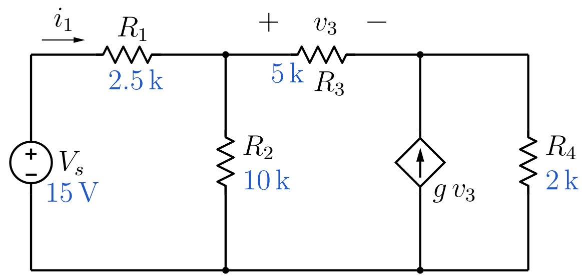

Figure 1: Nodal analysis example.

Question: In the circuit shown in Fig. 1, find the voltage v_3 using nodal analysis with $g = 0.3\,\mathrm{m℧}$.

Solution:

To begin with, we define one of the circuit nodes as the reference node (ground) and mark node voltages with respect to that node, as shown in Fig. 2. The KCL equations at nodes B and C

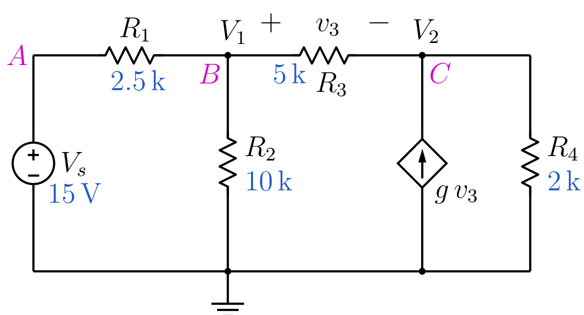

Figure 2: Circuit of Fig. 1 with reference node and node voltages marked.

in Fig. 2 can be written in terms of the node voltages V_1 and V_2 as

$$\frac{V_1 - V_s}{R_1} + \frac{V_1}{R_2} + \frac{V_1 - V_2}{R_3} = 0, \tag{1}$$

$$\frac{V_2 - V_1}{R_3} + \frac{V_2}{R_4} - g(V_1 - V_2) = 0. \tag{2}$$

Collecting terms in V_1 and V_2, we get

$$V_1\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) + V_2\left(-\frac{1}{R_3}\right) = \frac{V_s}{R_1}, \tag{3}$$

$$V_1\left(-\frac{1}{R_3} - g\right) + V_2\left(\frac{1}{R_3} + \frac{1}{R_4} + g\right) = 0. \tag{4}$$

With resistances in kΩ and g in m℧, we can rewrite the above equations as

$$V_1 \left(\frac{1}{2.5} + \frac{1}{10} + \frac{1}{5} \right) + V_2 \left(-\frac{1}{5} \right) = \frac{15}{2.5}, \tag{5}$$

$$V_1 \left(-\frac{1}{5} - 0.3 \right) + V_2 \left(\frac{1}{5} + \frac{1}{2} + 0.3 \right) = 0. \tag{6}$$

Solving Eqs. 5 and 6, we obtain $V_1 = 10\,\text{V}$, $V_2 = 5\,\text{V}$. The voltage v_3 in Fig. 1 is therefore $v_3 = V_1 - V_2 = 10 - 5 = 5\,\text{V}$.

SequelApp Exercises:

1. Find v_3 in the circuit of Fig. 1 for the following component values: $R_1 = 3\,\text{k}$, $R_2 = 16\,\text{k}$, $R_3 = 5\,\text{k}$, $R_4 = 2\,\text{k}$, $g = 0.1\,\text{m℧}$, $V_s = 10\,\text{V}$.

2. For the circuit of Fig. 1, find the value of g for which the current i_1 is $1.6\,\text{mA}$, assuming all other component values to be the same as those shown in the figure.

Verify your answers using SequelApp.