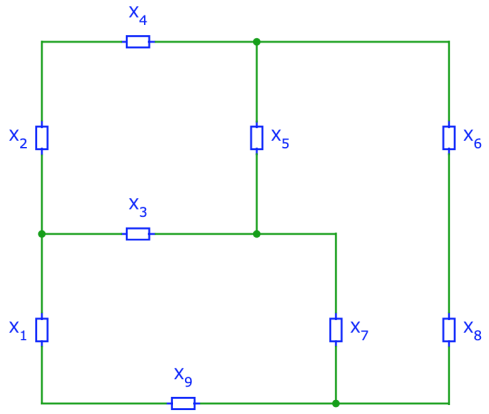
EECS 16A Designing Information Devices and Systems I
Fall 2019 Discussion 6B

1. Nodes and Branches

In the circuit shown below, identify and count all nodes and branches.



Answer: There are seven nodes and nine branches.

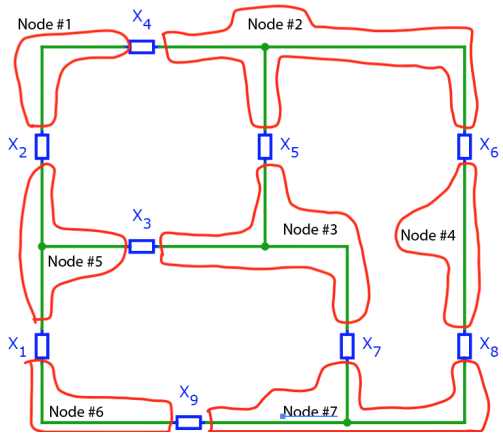


Figure 1: Labeled Nodes

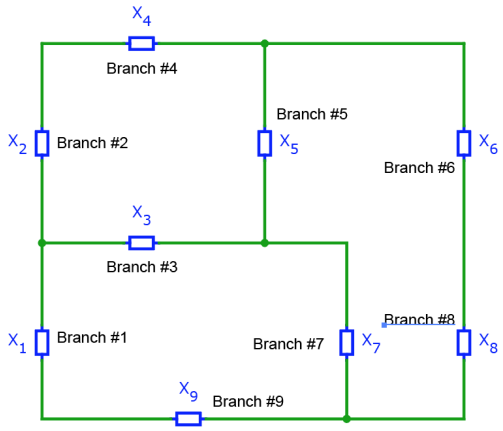
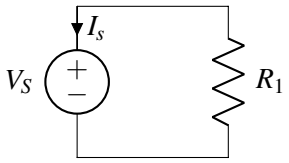


Figure 2: Labeled branches

2. A Simple Circuit

(a) For this problem assume $V_S = 1V$ and $R_1 = 1k\Omega$. Find the current flowing through the voltage source, I_s.



Answer:

Based on Ohms law,

$$I_1 = \frac{V_S}{R_1} \tag{1}$$

Then based on KCL at the top node,

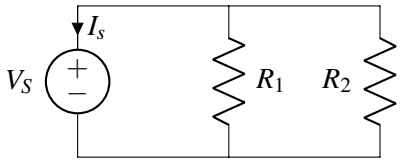
$$I_1 + I_S = 0 \tag{2}$$

$$I_S = -\frac{V_S}{R_1} \tag{3}$$

Plugging in,

$$I_S = -1mA \tag{4}$$

(b) For this problem assume $V_S = 1V$, $R_1 = 2k\Omega$, and $R_2 = 2k\Omega$. Find the current flowing through the voltage source, I_s.



Answer:

Based on Ohms law,

$$I_1 = \frac{V_S}{R_1} \tag{5}$$

$$I_2 = \frac{V_S}{R_2} \tag{6}$$

$$\tag{7}$$

Then based on KCL at the top node,

$$I_1 + I_2 + I_S = 0 \tag{8}$$

$$\frac{V_s}{R_1} + \frac{V_s}{R_2} + I_S = 0 \tag{9}$$

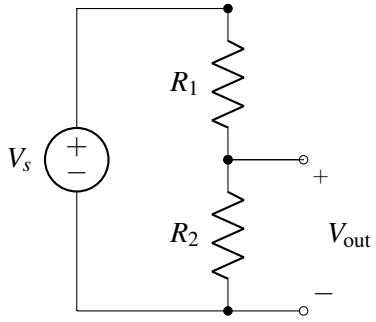
$$I_S = -\left(\frac{V_s}{R_1} + \frac{V_s}{R_2}\right) \tag{10}$$

Plugging in,

$$I_S = -1mA \tag{11}$$

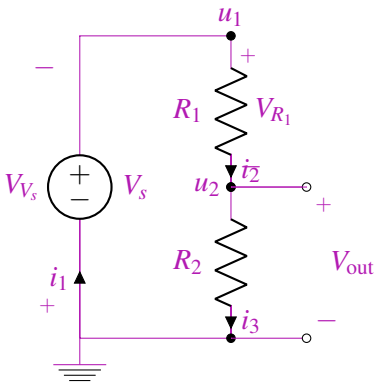
3. (Optional) Divider

For the circuit below, find the voltage V_{out} in terms of the resistances R_1, R_2, and V_s.



Answer:

We start by selecting a ground node and labeling all the node potentials and branch currents.



Next we write KCL equations for all the nodes, except for the ground node:

$$\begin{aligned} i_1 - i_2 &= 0 \\ i_2 - i_3 &= 0 \\ i_3 - i_1 &= 0 \end{aligned}$$

Notice the above equations imply that $i_1 = i_2 = i_3$. We will remove some of the variables and just set $i_x = i_1 = i_2 = i_3$.

Next we write element equations:

$$\begin{aligned} 0 - u_1 = V_{V_s} = -V_s \\ u_1 - u_2 = V_{R_1}, V_{R_1} = i_x R_1 \implies u_1 - u_2 = i_x R_1 \\ u_2 - 0 = V_{R_2}, V_{R_2} = i_x R_2 \implies u_2 - u_0 = i_x R_2 \end{aligned}$$

We can again remove an extra variable by setting u_1 to V_s. The above equations then become:

$$\begin{aligned} V_s - u_2 &= i_x R_1 \\ u_2 &= i_x R_2 \end{aligned}$$

Now we have two unknowns, i_x and u_2, and two equations. We can solve them directly for u_2. Notice that $V_{\text{out}} = u_2 - 0 = u_2$

$$V_{\text{out}} = u_2 = \frac{R_2}{R_1 + R_2} V_s$$