Network Theorems-3 (`EC_network_3.sqproj`)

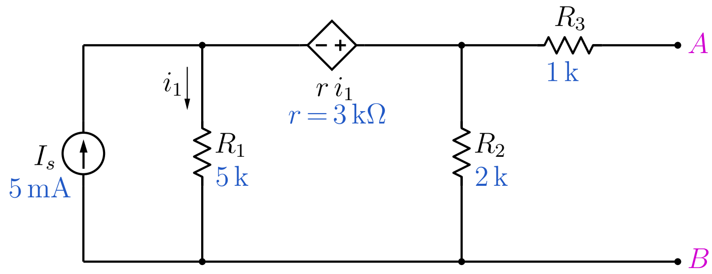

Figure 1: Thevenin theorem example.

Question: For the circuit shown in Fig. 1, find the Thevenin equivalent circuit as seen from AB.

Solution:

First, we find the open-circuit voltage V_{oc} (see Fig. 2). Using KCL, we know that the current through R_2 is $(I_s - i_1)$. We can now write the following KVL equation.

$$-R_1 i_1 - r\,i_1 + (I_s - i_1)R_2 = 0. \tag{1}$$

$$\rightarrow i_1 = I_s \times \frac{R_2}{R_1 + R_2 + r} = 5\,\mathrm{mA} \times \frac{2\,\mathrm{k\Omega}}{8\,\mathrm{k\Omega}} = 1\,\mathrm{mA}. \tag{2}$$

V_{oc} is the same as the drop across R_2 (since the current through R_3 is zero) and is given by

$$V_{oc} = (I_s - i_1) \times R_2 = (5-1)\,\mathrm{mA} \times 2\,\mathrm{k\Omega} = 8\,\mathrm{V}. \tag{3}$$

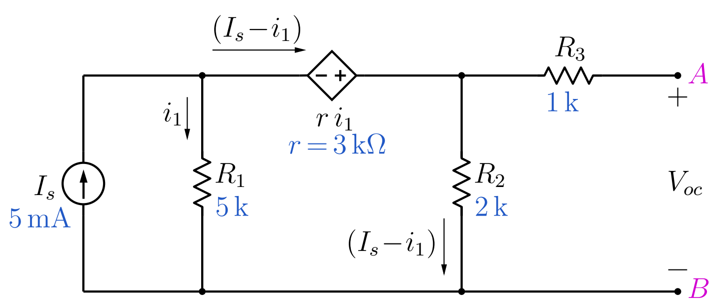

Figure 2: Calculation of V_{oc} for the circuit of Fig. 1.

Next, we find the short-circuit current I_{sc} (see Fig. 3). Since R_2 and R_3 have the same voltage drop, we have

$$\frac{i_{R2}}{i_{R3}} = \frac{R_3}{R_2} = \frac{1}{2} \rightarrow i_{R2} = \frac{I_{sc}}{2}, \tag{4}$$

as shown in the figure. Using KCL at nodes C and D, we get

$$i_1 = I_s - \frac{3\,I_{sc}}{2}. \tag{5}$$

KVL gives the following equation.

$$-i_1 R_1 - r\,i_1 + R_2 \frac{I_{sc}}{2} = 0. \tag{6}$$

Substituting for i_1 from Eq. 5, we get

$$-\left(I_s - \frac{3}{2}\,I_{sc}\right)(R_1 + r) + R_2 \frac{I_{sc}}{2} = 0, \tag{7}$$

which can be solved for I_{sc} to get

$$I_{sc} = I_s \times \frac{(R_1 + r)}{\frac{3}{2}(R_1 + r) + \frac{1}{2}R_2} \approx 3.08\,\text{mA}. \tag{8}$$

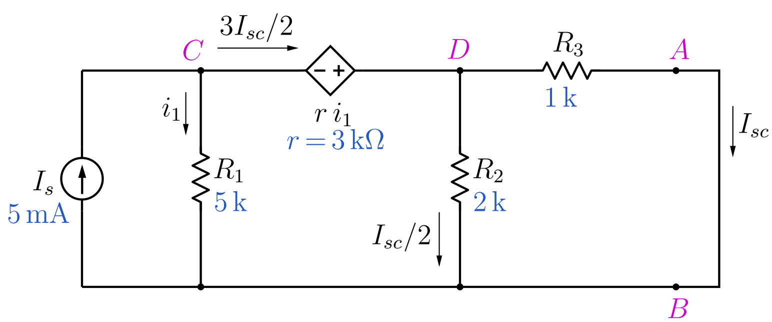

Figure 3: Calculation of I_{sc} for the circuit of Fig. 1.

The Thevenin equivalent circuit can now be specified as

$$V_{\text{Th}} = V_{oc} = 8\,\text{V}, \quad R_{\text{Th}} = \frac{V_{oc}}{I_{sc}} = \frac{8\,\text{V}}{3.08\,\text{mA}} = 2.6\,\text{k}\Omega. \tag{9}$$

SequelApp Exercises: Find V_{Th}, I_{sc}, R_{Th} for each of the following cases (with other component values as shown in Fig. 1). Verify your answers using SequelApp.

1. R_2 is changed from 2 k to 1 k.

2. I_s is changed from 5 mA to 2 mA.