Network Theorems-2 (`EC_network_2.sqproj`)

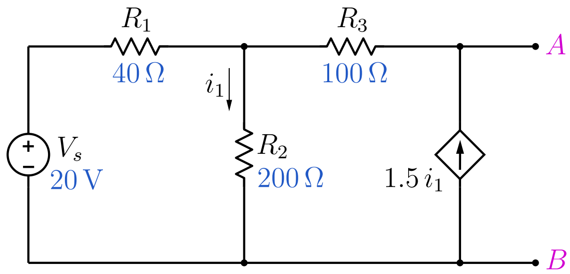

Figure 1: Thevenin theorem example.

Question: For the circuit shown in Fig. 1,

(a) Find the Thevenin equivalent circuit as seen from AB.

(b) Find the power absorbed by a resistance $R_L = 100\,\Omega$ connected between A and B.

(Reference: "Engineering Circuit Analysis," by W.H. Hayt and J.E. Kemmerly)

Solution:

Let us first find V_{oc}, the open-circuit voltage between A and B (see Fig. 2 (a)). Using KCL,

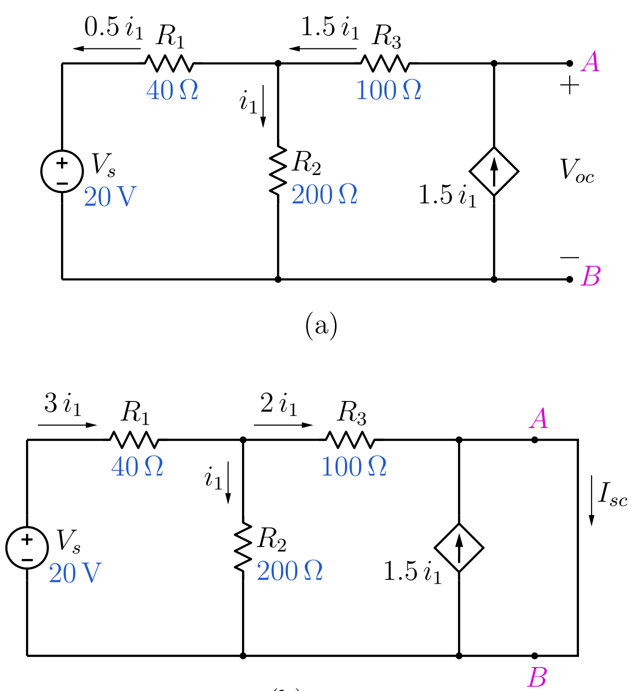

Figure 2: Calculation of (a) V_{oc}, (b) I_{sc} for the circuit of Fig. 1.

we find the current through R_1 to be $0.5\,i_1$. KVL for the loop involving V_s, R_2, and R_1 gives

$$V_s - R_2 i_1 + R_1 \times 0.5\,i_1 = 0, \tag{1}$$

from which we get $i_1 = 1/9\,\text{A}$. V_{oc} can then be found as

$$V_{oc} = 1.5\,i_1 R_3 + i_1 R_2 = 38.9\,\text{V}. \tag{2}$$

Next, we find the short-circuit current I_{sc} (see Fig. 2 (b)). Since the voltage drops across R_2 and R_3 are equal, the current through R_3 must be $2\,i_1$, as shown in the figure. Using KCL, we find the current through R_1 to be $3\,i_1$. KVL gives

$$-V_s + 3\,i_1 R_1 + i_1 R_2 = 0. \tag{3}$$

Solving this equation, we obtain $i_1 = 1/16\,\text{A}$. The short-circuit current can now be obtained using KCL as

$$I_{sc} = 2\,i_1 + 1.5\,i_1 = 3.5\,i_1 = 0.219\,\text{A}. \tag{4}$$

The Thevenin equivalent circuit is therefore given by

$$V_{\text{Th}} = V_{oc} = 38.9\,\text{V}, \quad R_{\text{Th}} = \frac{V_{\text{Th}}}{I_{sc}} = \frac{38.9}{0.219} \approx 178\,\Omega. \tag{5}$$

When $R_L = 100\,\Omega$ is connected (see Fig. 3), the power absorbed by it is

$$P_L = I_L^2 R_L = \left(\frac{V_{\text{Th}}}{R_{\text{Th}} + R_L}\right)^2 R_L = 1.96\,\text{W}. \tag{6}$$

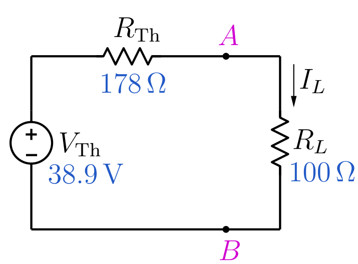

Figure 3: Thevenin equivalent circuit with R_L connected between A and B.

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

1. The CCCS current is given by $3\,i_1$ (instead of $1.5\,i_1$).

2. V_s is changed from 20 V to 10 V.