2.3 Thevenin's and Norton's Theorems
The equivalent output resistance of an actual network can be found similarly as follows:

1. Set all independent sources inside the network to zero by replacing voltage sources with short circuits and current sources with open circuits. (Do working to independent sources.)

2. Then determine the effective resistance seen at the terminals. The most general method for doing this is to drive a 1-A current source into the network by connecting a 1-A current source at the terminals. Determine the resulting voltage at the terminals. This voltage is numerically equal to the resistance.

In other words, $R_{eq}$ is found as follows (see Figure 2.3.3):

$$V_{eq} = R_{eq} \times 1 \text{A}$$

Therefore one way to find $R_{eq}$ after setting all independent sources to 0, is to insert a 1-A current back into the network’s output terminal and then solve for $V_{eq}$ numerically. This method will also work if $R_{eq}$.

We can use the method as a check on our calculations of $R_{eq}$ and $I_{eq}$ by setting $R_{eq} = V_{eq}/I_{eq}$. In general, in order to find either the Thévenin or the Norton terminal equivalent circuit of any actual circuit that contains only linear resistors, one needs any two of the following (see Figure 2.3.3): the open-circuit voltage, the short-circuit current, or the equivalent resistance.

### Table 2.3.3

<table>
<thead>
<tr>
<th>Thevenin</th>
<th>Norton</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{eq} = 0$ when $I = 0$</td>
<td>$V_{eq} = 0$</td>
</tr>
<tr>
<td>$I_{eq} = 0$ when $V = 0$</td>
<td>$I_{eq} = 0$</td>
</tr>
<tr>
<td>$R_{eq} = \frac{V}{I_{eq}}$</td>
<td>$R_{eq} = \frac{V}{I}$</td>
</tr>
<tr>
<td>$V = V_{eq}$ when $I = 0$</td>
<td>$I = I_{eq}$ when $V = 0$</td>
</tr>
</tbody>
</table>

Therefore, $R_{eq} = R_{eq}$.

**WARNING** It should be carefully noted that the Thévenin and Norton circuits are terminal equivalent of some other (usually larger and more complicated) network.

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Find a Thévenin and a Norton terminal equivalent circuit for the circuit shown in Figure 2.3.3a.

**Figure 2.3.3**

(A) an arbitrary network (B) Setting for $V_{eq}$ (C) Setting for $R_{eq} = R_{eq}$

**ANS.** Solve for the open-circuit voltage by voltage division for $V_{eq}$.

$$V_{eq} = \frac{R_1}{R_1 + R_2} \times V_1$$

**ANS.** Solve for the short-circuit current. In Figure 2.3.3b no current will flow in the 3-Ω resistor. Thus, $I = I_{eq} = \frac{V}{R_{eq}}$.

The output resistance ($R_{eq} = R_{eq}$) is found by replacing the 10-V source by a piece of wire, as in Figure 2.3.3c.

Whence in we see that.