National University

Int. to Electrical Eng.

Circuit Theorem

Thevenin's Theorem

Introduction:

- The theorem was independently derived in 1853 by the German scientist Hermann von Helmholtz and in 1883 by Léon Charles Thevenin's (1857–1926), an electrical engineer with France's national Postes et Télégraphes telecommunications organization.

Thevenin's theorem holds that:

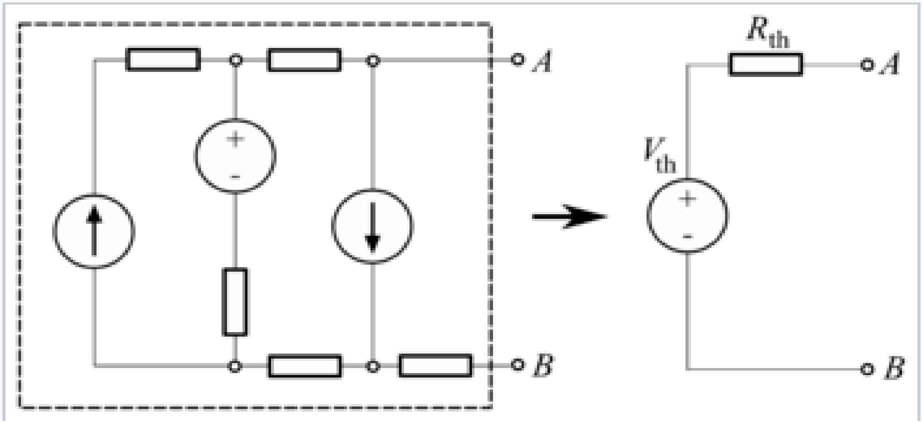
- Any linear electrical network containing only voltage sources, current sources and resistances can be replaced at terminals A-B by an equivalent combination of a voltage source V_{th} in a series connection with a resistance R_{th}.

- The equivalent voltage V_{th} is the voltage obtained at terminals A-B of the network with terminals A-B open circuited.

- The equivalent resistance R_{th} is the resistance that the circuit between terminals A and B would have if all ideal voltage sources in the circuit were replaced by a short circuit and all ideal current sources were replaced by an open circuit.

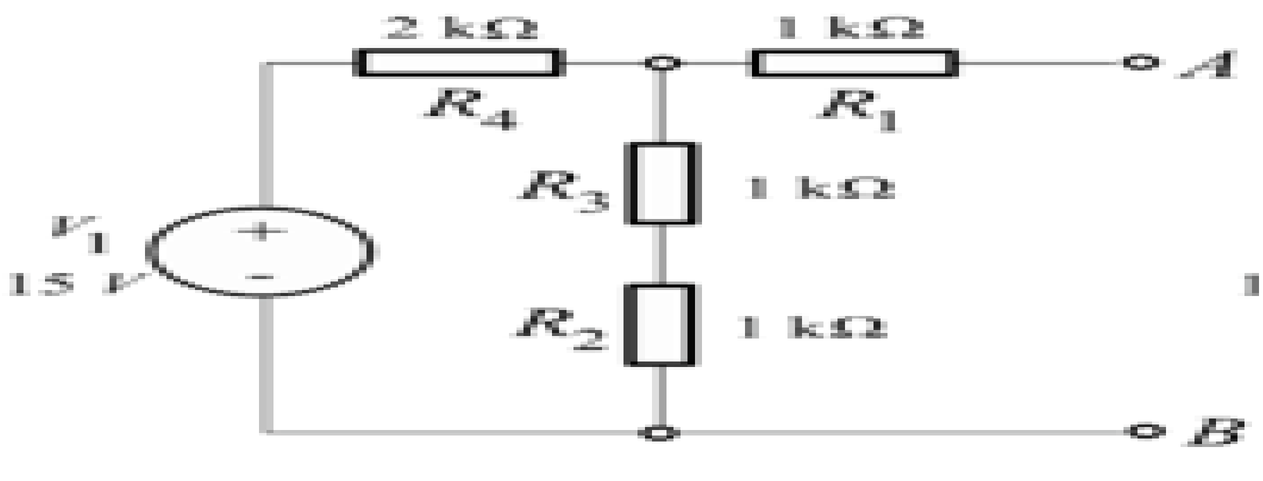
Continued:

- If terminals A and B are connected to one another, the current flowing from A to B will be V_{th}/R_{th}. This means that R_{th} could alternatively be calculated as V_{th} divided by the short-circuit current between A and B when they are connected together.



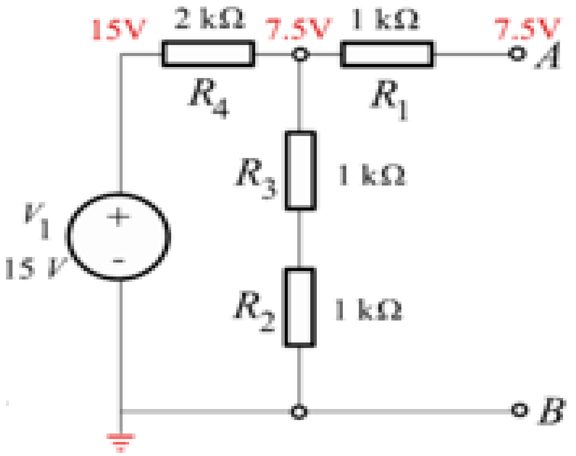
Example:

- Find Thevenin's equivalent circuit for the circuit below:



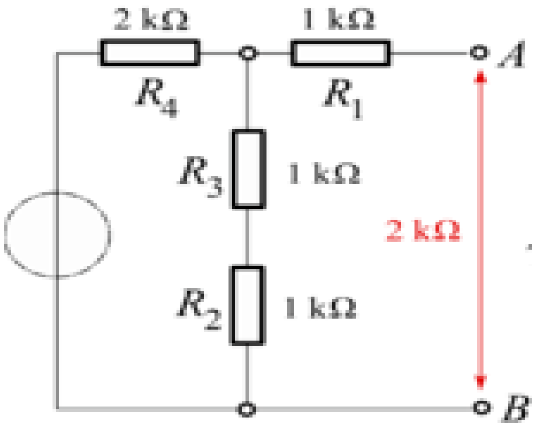
Solution:

- calculating the equivalent voltage:



$$V_{\mathrm{Th}} = \frac{R_2 + R_3}{(R_2 + R_3) + R_4} \cdot V_1$$
$$= \frac{1\,\mathrm{k\Omega} + 1\,\mathrm{k\Omega}}{(1\,\mathrm{k\Omega} + 1\,\mathrm{k\Omega}) + 2\,\mathrm{k\Omega}} \cdot 15\,\mathrm{V}$$
$$= \frac{1}{2} \cdot 15\,\mathrm{V} = 7.5\,\mathrm{V}$$

- Calculating equivalent resistance:



$$
\begin{aligned}
R_{\mathrm{Th}} &= R_1 + \left[(R_2 + R_3) \,\|\, R_4\right] \\
&= 1\,\mathrm{k}\Omega + \left[(1\,\mathrm{k}\Omega + 1\,\mathrm{k}\Omega) \,\|\, 2\,\mathrm{k}\Omega\right] \\
&= 1\,\mathrm{k}\Omega + \left(\frac{1}{(1\,\mathrm{k}\Omega + 1\,\mathrm{k}\Omega)} + \frac{1}{(2\,\mathrm{k}\Omega)}\right)^{-1} = 2\,\mathrm{k}\Omega.
\end{aligned}
$$

Thevenin’s equivalent circuit: