National University

Int. to Electrical Eng.

Circuit Theorem

Norton's Theorem

Introduction:

- Norton's theorem was independently derived in 1926 by Siemens & Halske researcher Hans Ferdinand Mayer (1895–1980) and Bell Labs engineer Edward Lawry Norton (1898–1983).

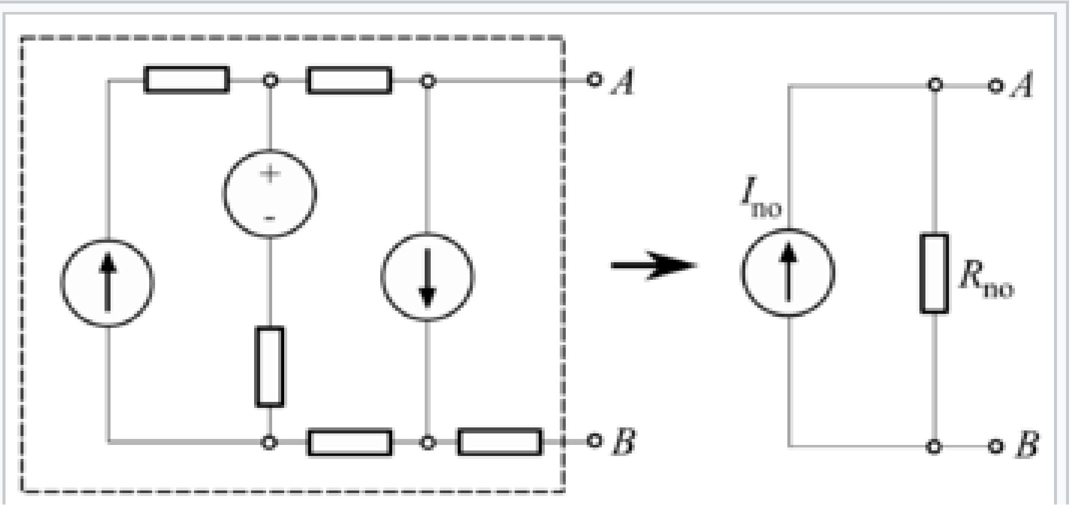
Norton theory hold that:

- Any linear electrical network with current sources and only resistances can be replaced at terminals *A*–*B* by an equivalent current source I_{no} in parallel connection with an equivalent resistance R_{no}.

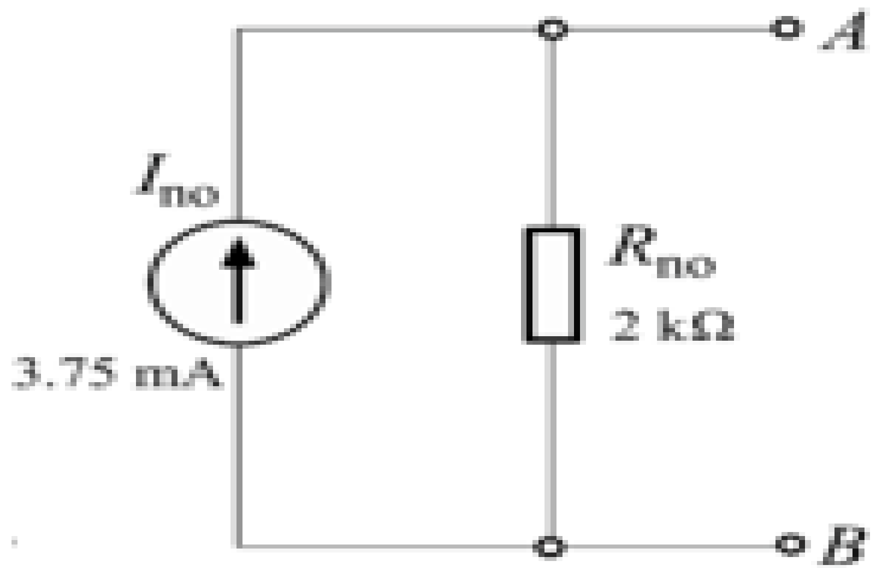
- This equivalent current I_{no} is the current obtained at terminals *A*-*B* of the network with terminals *A*-*B* short circuited.

Continued:

- This equivalent resistance R_{no} is the resistance obtained at terminals *A*-*B* of the network with all its voltage sources short circuited and all its current sources open circuited



Norton equivalent circuit:



To find the equivalent:

1. Find the Norton current I_{no}. Calculate the output current, I_{AB}, with a short circuit as the load (meaning 0 resistance between *A* and *B*). This is I_{no}.

2. Find the Norton resistance R_{no}. When there are no dependent sources

Continued:

there are two methods of determining the Norton impedance R_{no}:

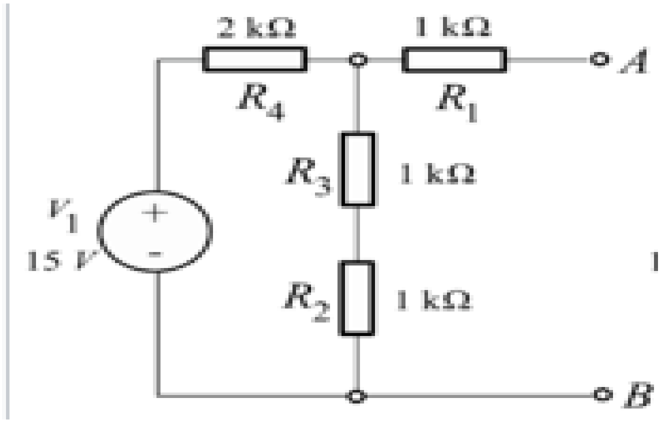
- Calculate the output voltage, V_{AB}, when in open circuit condition). R_{no} equals this V_{AB} divided by I_{no}.

- Or replace independent voltage sources with short circuits and independent current sources with open circuits. The total resistance across the output port is the Norton impedance R_{no}.

This is equivalent to calculating the Thevenin's resistance.

Example:

- Find Norton equivalent circuit for the circuit below:



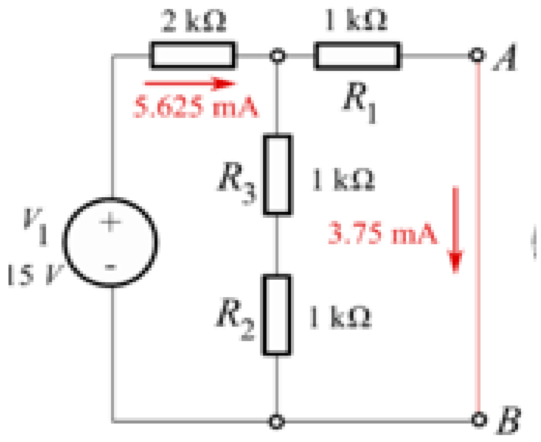
Solution:

- *the total current* I_{total} *is given by:*

$$I_{\text{total}} = \frac{15\text{V}}{2\,\text{k}\Omega + 1\text{k}\Omega \| (1\,\text{k}\Omega + 1\,\text{k}\Omega)} = 5.625\text{mA}.$$

The current through the load is then, using the current divider rule:

$$I_{\text{no}} = \frac{1\,\text{k}\Omega + 1\,\text{k}\Omega}{(1\,\text{k}\Omega + 1\,\text{k}\Omega + 1\,\text{k}\Omega)} \cdot I_{\text{total}}$$
$$= 2/3 \cdot 5.625\text{mA} = 3.75\text{mA}.$$

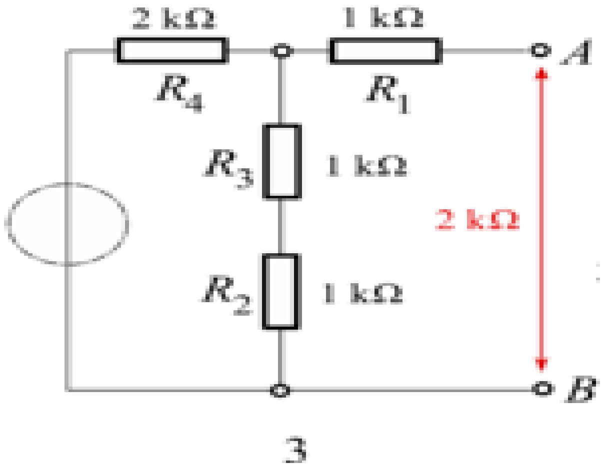


Continued:

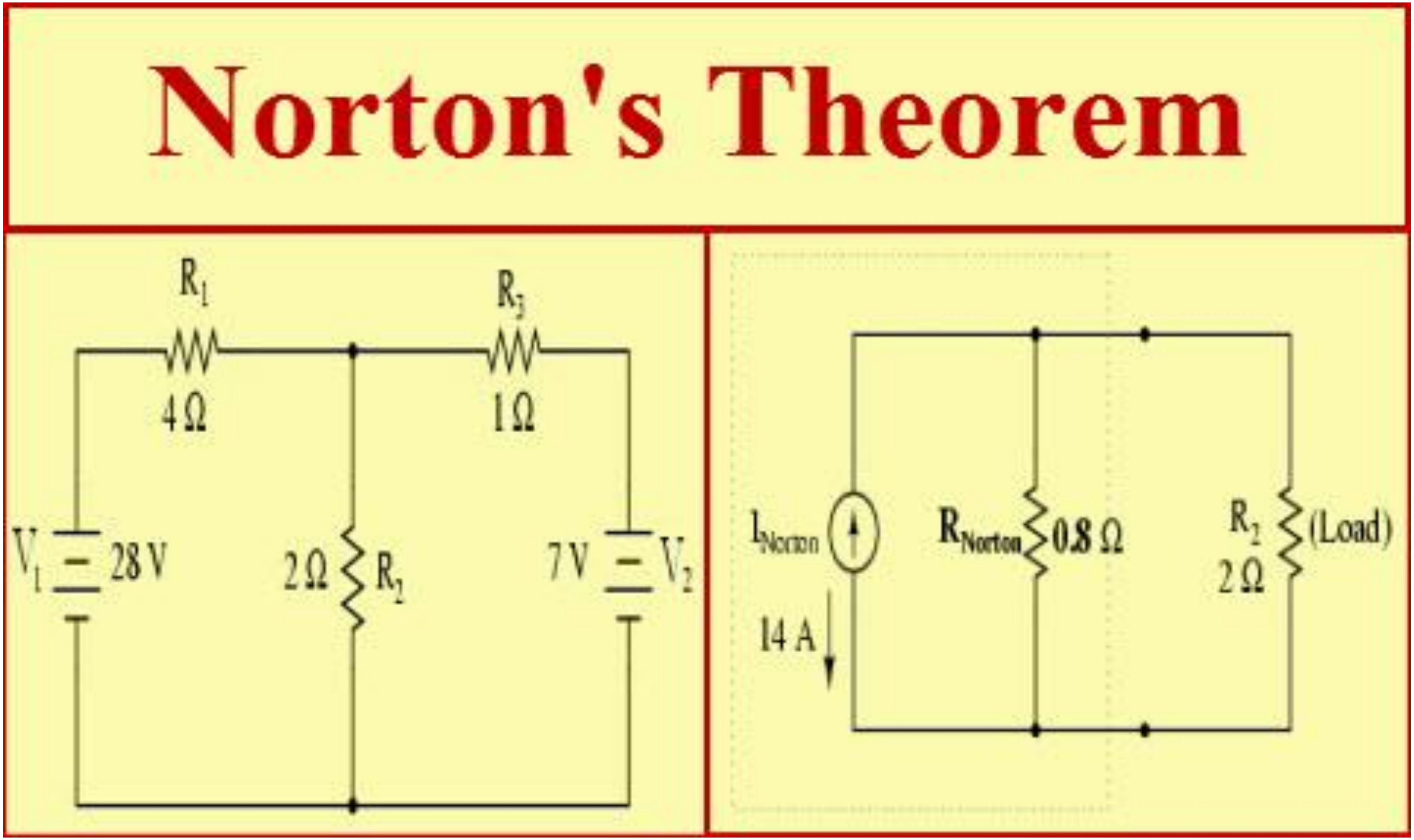
And the equivalent resistance looking back into the circuit is:

$$R_{no} = 1\,k\Omega + \left(2\,k\Omega \| (1\,k\Omega + 1\,k\Omega)\right) = 2\,k\Omega.$$

So the equivalent circuit is a 3.75 mA current source in parallel with a 2 kΩ resistor.



Example:



Norton's Theorem
R1
4 Ω
R3
1 Ω
V1
28 V
2 Ω
R2
7 V
V2
INorton
14 A
RNorton
0.8 Ω
R2
2 Ω
(Load)

Example: