Physics 2. Electrical Engineering

Week 5 Network Analysis 3

Kirill Poletkin and Igor Gaponov

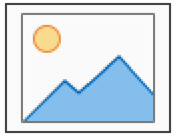
Institute of Robotics and Computer Vision

INNOPOLIS UNIVERSITY

Objectives

The main objectives of today's lecture are:

Picture



- Review the principle of superposition
- Learn Thevenin equivalent circuit
- Learn Norton equivalent circuit

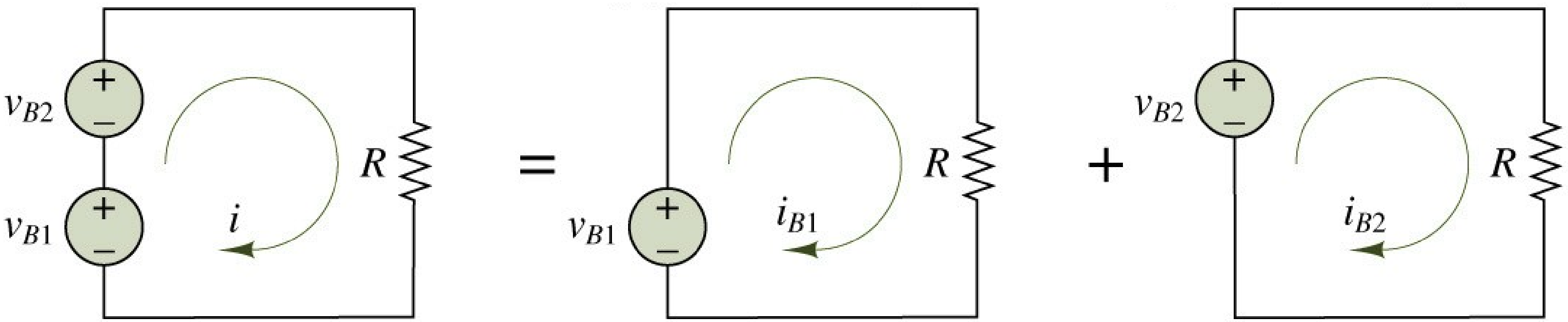
Last Week’s Review

The Principle of Superposition (1)

Unlike precise analysis technique, like the mesh current and node voltage methods, the principle of superposition is a conceptual aid that can be very useful in visualizing the behavior of a circuit containing multiple sources.

In a circuit containing sources,

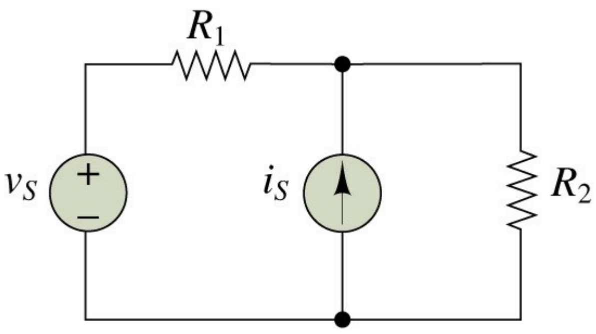
- each branch voltage and current is the sum of voltages and currents, each of which may be computed by setting all but one source equal to zero and solving the circuit containing that single source.



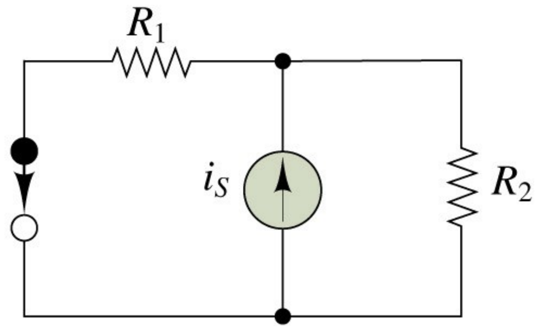
$$i = i_{B1} + i_{B2} = \frac{v_{B1}}{R} + \frac{v_{B2}}{R} = \frac{v_{B1} + v_{B2}}{R}$$

The Principle of Superposition (2)

- In order to set a voltage source equal to zero, we replace it with a short circuit

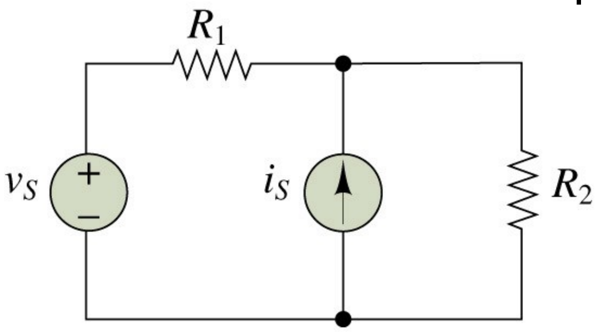


A circuit

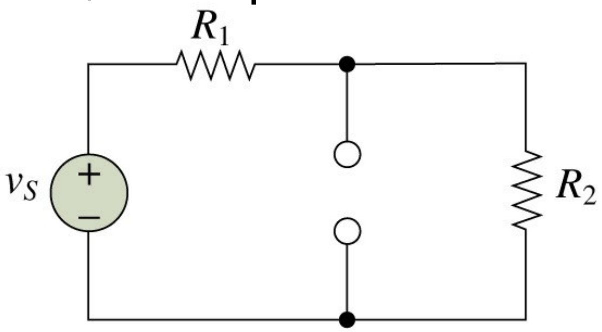


The same circuit with $v_S = 0$

- In order to set a current source equal to zero, we replace it with an open circuit



A circuit

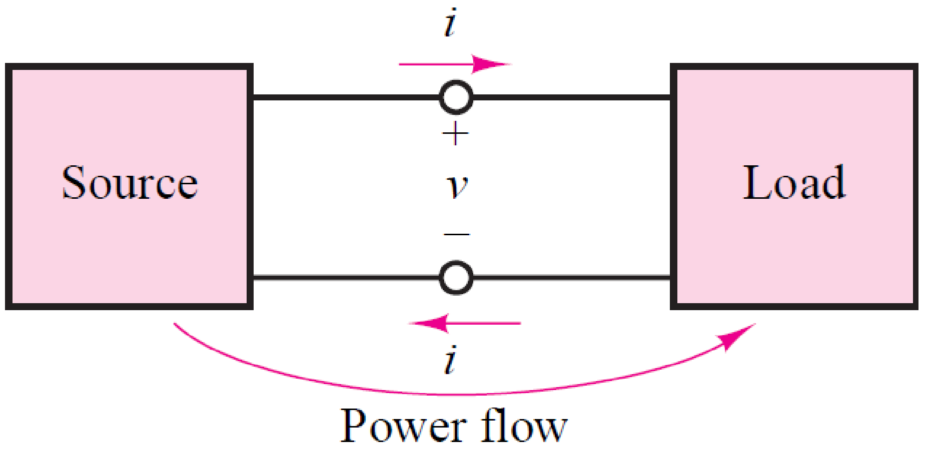


The same circuit with $i_S = 0$

One-Port Networks and Equivalent Circuits

One-Port Networks (1)

In our previous discussion of ideal power sources, we have described the flow of energy from a source to a load in a very general form, by showing the connection of two “black boxes” labeled source

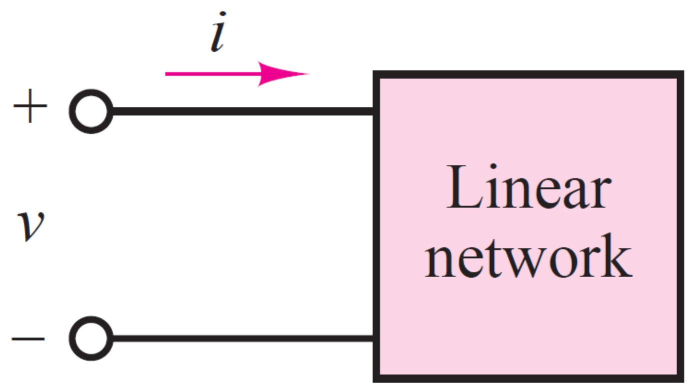


One-Port Networks (2)

Whatever the form chosen for source-load representation,

- each block (source or load) may be viewed as a two-terminal device, described by an characteristic.

- This configuration is called a one-port network and is particularly useful for introducing the notion of equivalent circuits.



One-Port Networks: Example

Determine the source (load) current in the circuit shown, using equivalent resistance

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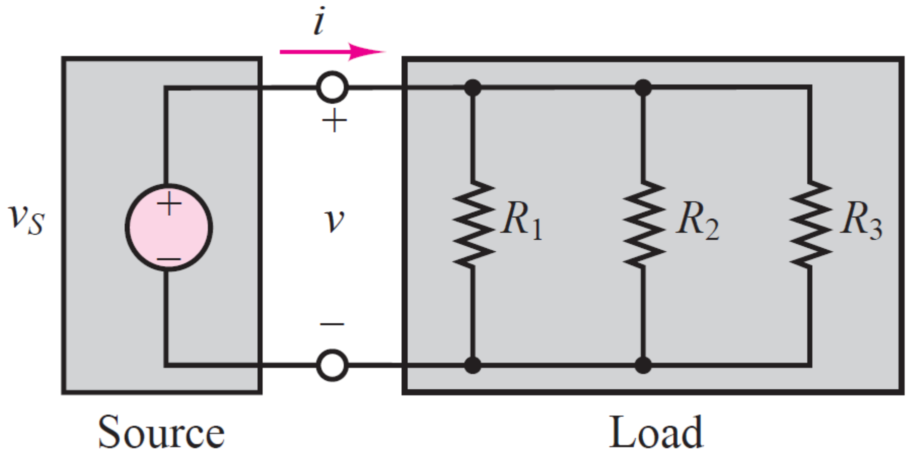
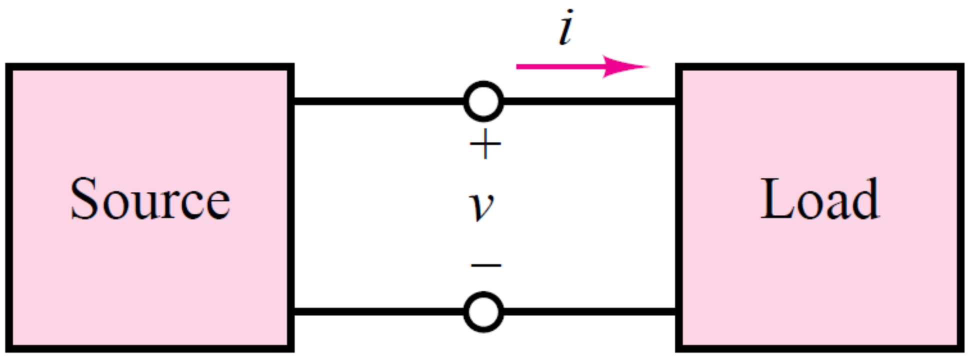
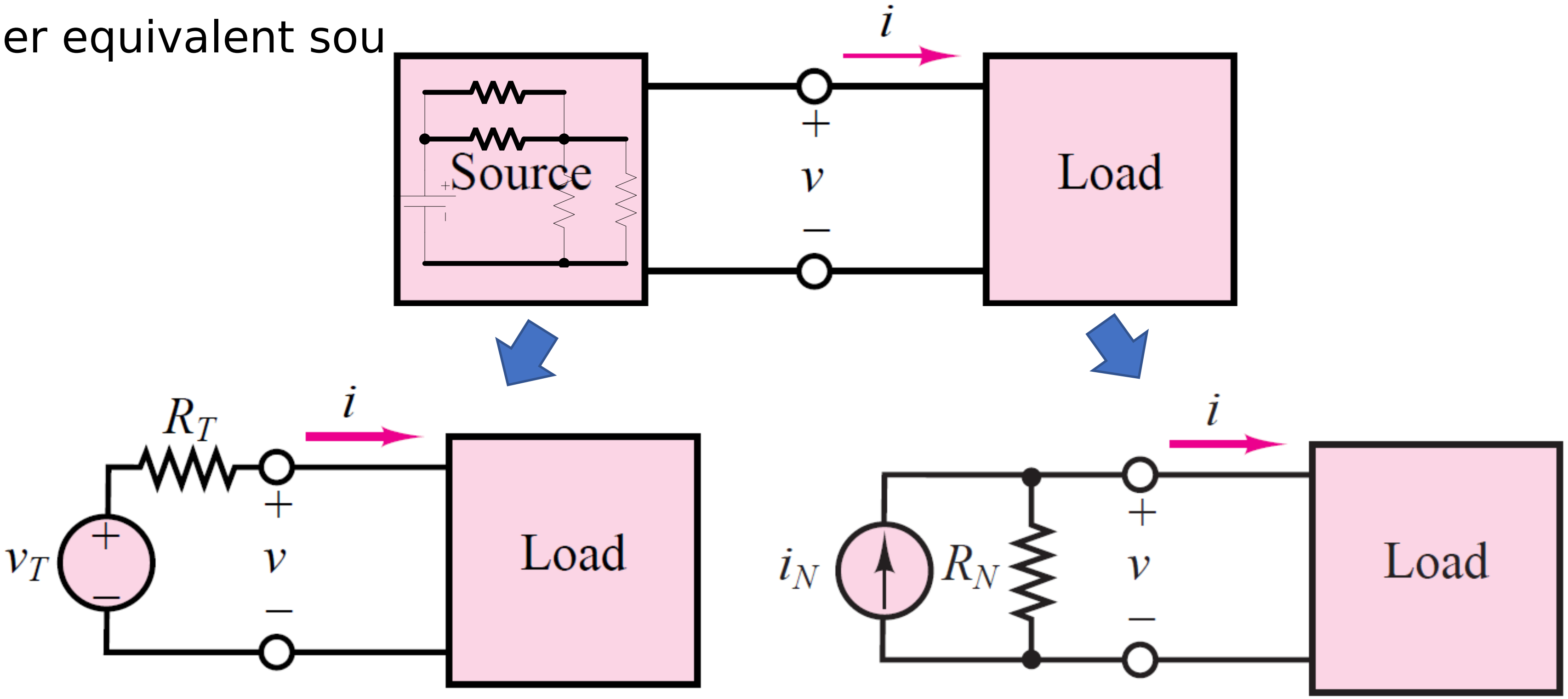




Equivalent Circuits (1)

When viewed from the load, any network composed of ideal voltage and current sources, and of linear resistors, may be represented by an equivalent circuit – a much simpler equivalent sou

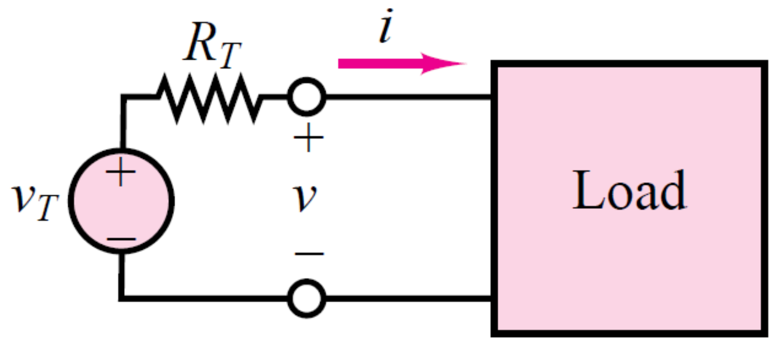


Equivalent Circuits (2)

The discussion of equivalent circuits begins with the statement of two very important theorems.

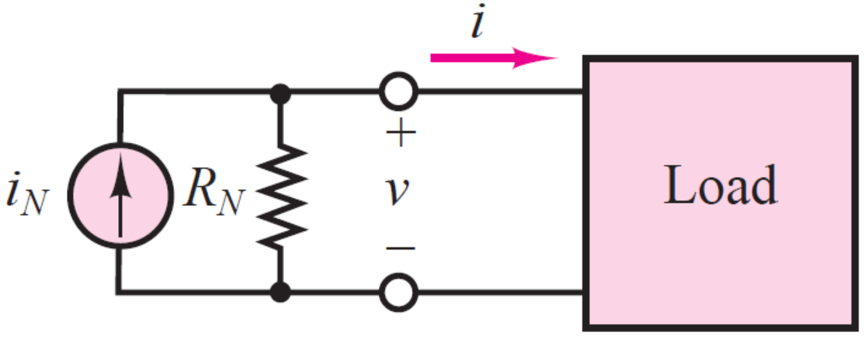
- The Thévenin Theorem:

When viewed from the load, any network composed of ideal voltage and current sources, and of linear resistors, may be represented by an equivalent circuit consisting of an ideal voltage source in series with an equivalent resistance .

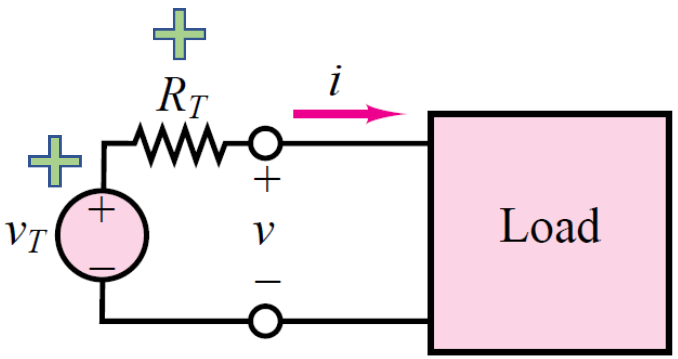


- The Norton Theorem:

When viewed from the load, any network composed of ideal voltage and current sources, and of linear resistors, may be represented by an equivalent circuit consisting of an ideal current source in parallel with an equivalent resistance .

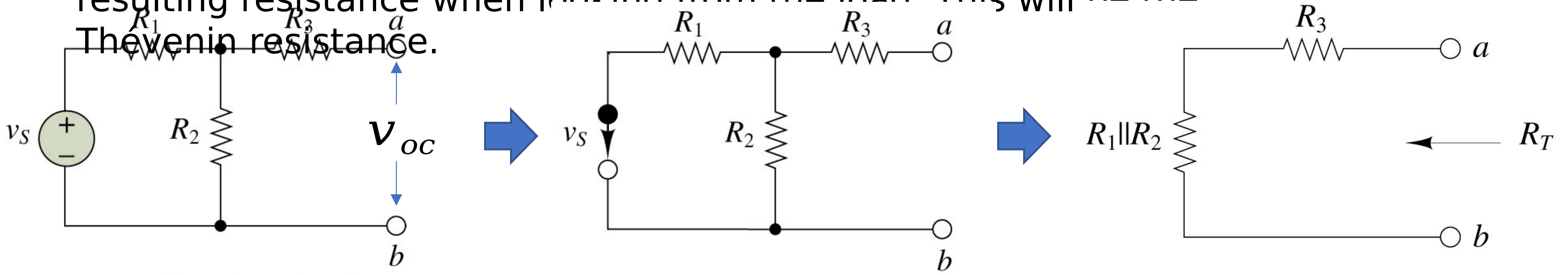


Thévenin Equivalent Circuit (1)



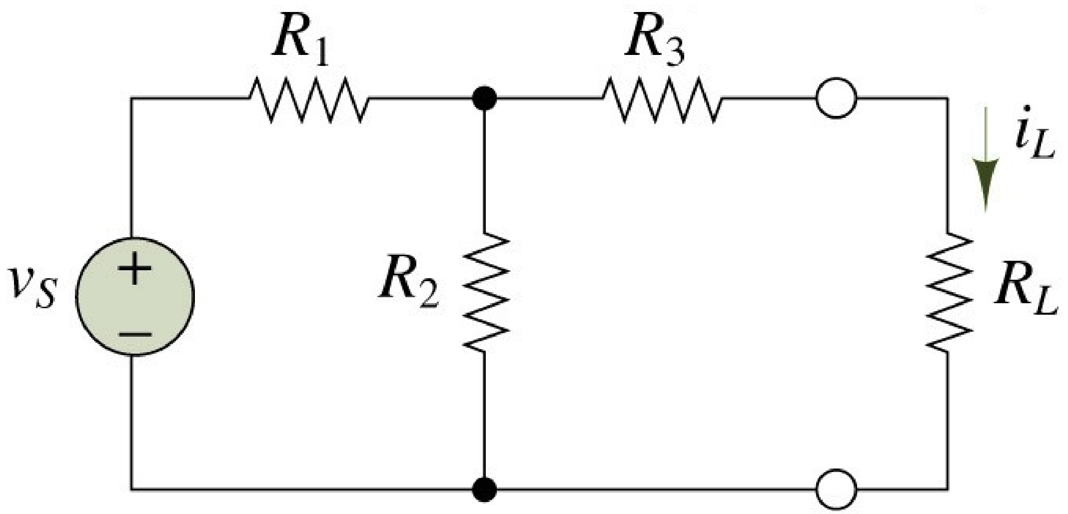
In order to compute the Thévenin voltage:

1. Remove the load, leaving the terminals open-circuited.
2. Define the open-circuit voltage across the open load terminals.
3. Apply any preferred method (e.g. node voltage analysis) to solve for .
4. The Thévenin voltage is = .
5. Next, disconnect all voltage and current sources and find the resulting resistance when looking from the load. This will be the Thévenin resistance.

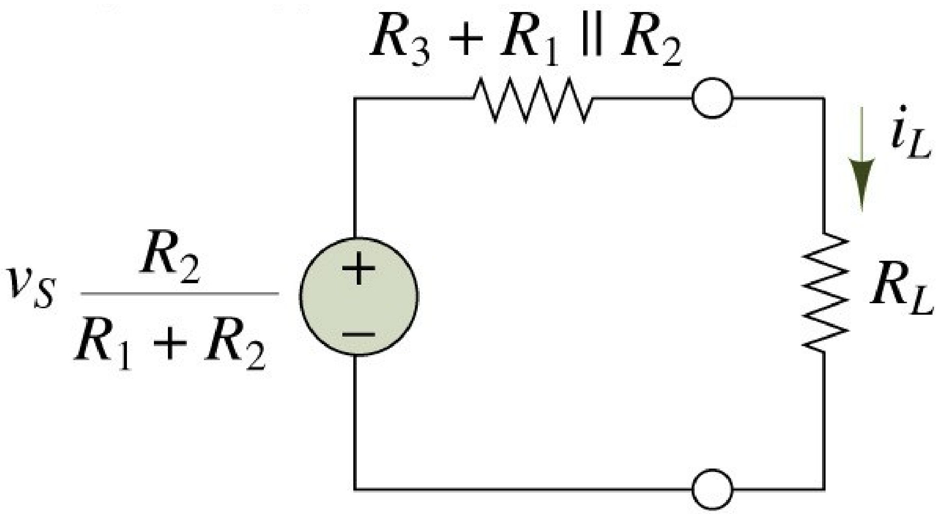


Thévenin Equivalent Circuit (2)

For the previous example,



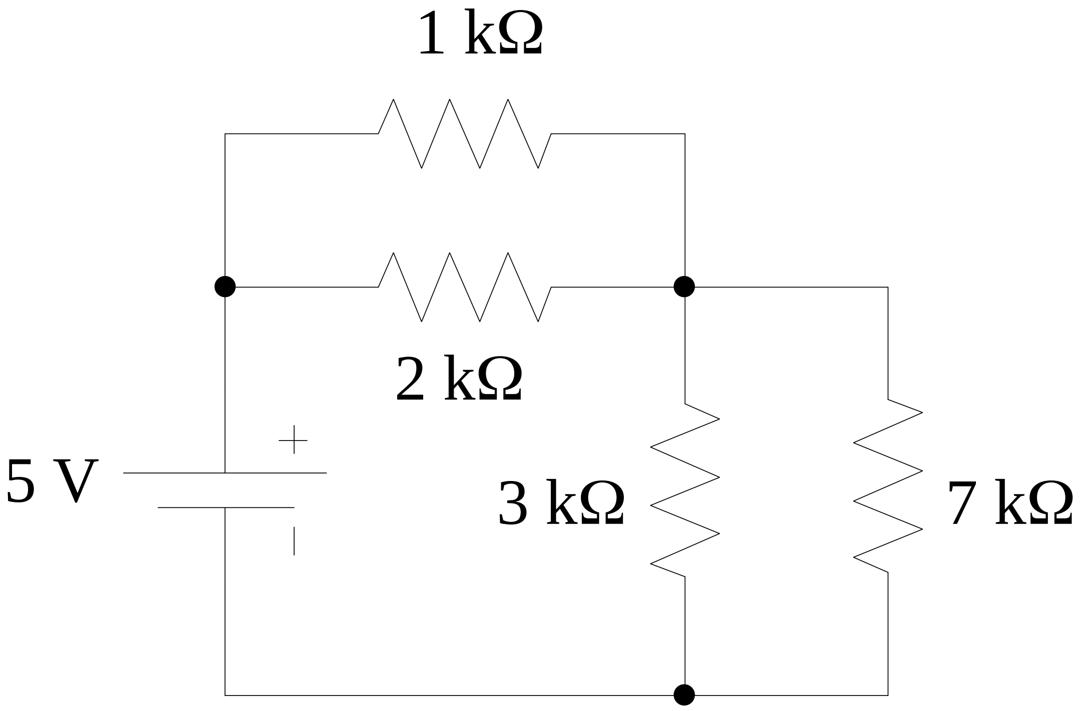
A circuit



Its Thévenin equivalent

Thévenin Equivalent Circuit: Example

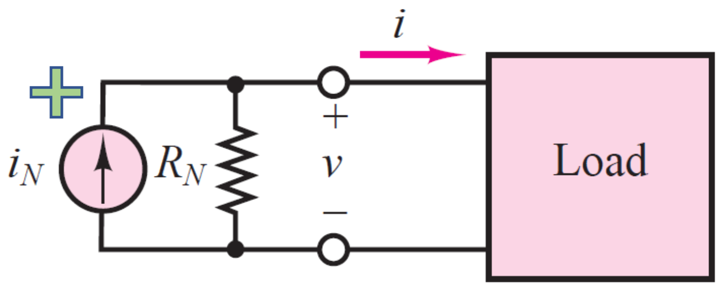
Compute the Thévenin equivalent circuit as seen from the 7 kΩ resistor.

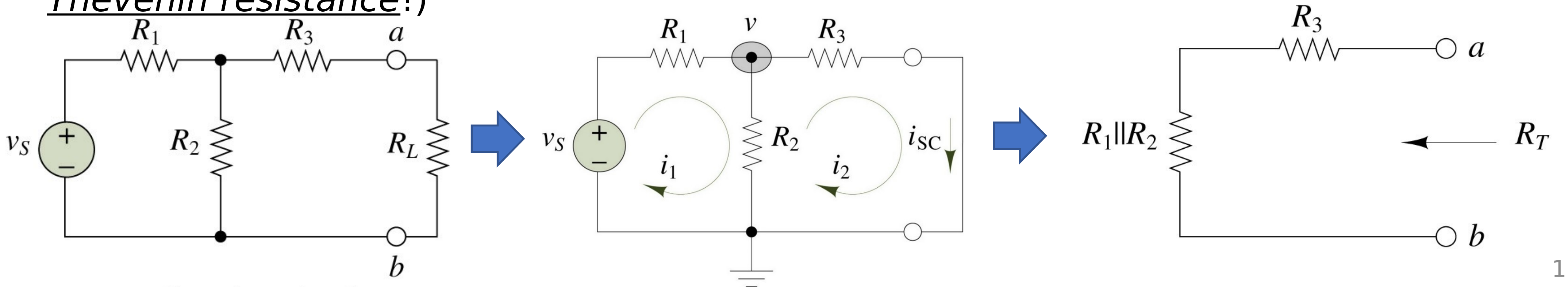


Norton Equivalent Circuit (1)

The Norton equivalent current is equal to the short-circuited current that would flow if the load were replaced by a short circuit. In order to compute the Norton circuit:

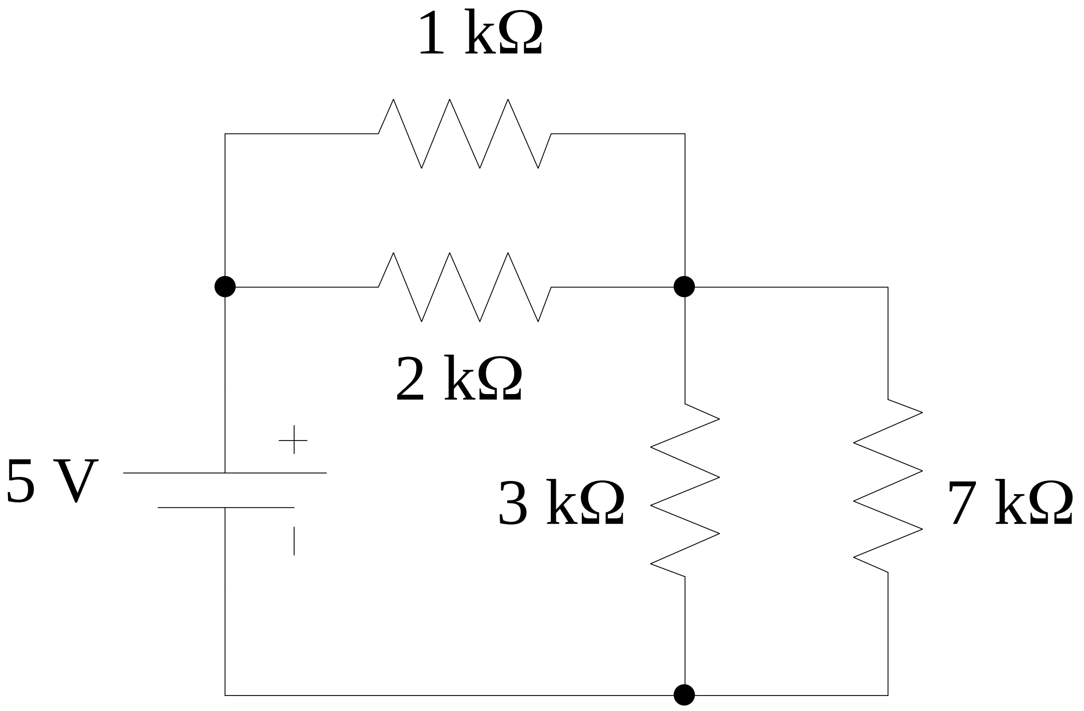
1. Replace the load with a short circuit.
2. Define the short-circuit current to be the Norton equivalent curr
3. Apply any preferred method (e.g. node analysis) to solve for .
4. The Norton current is = .
5. Next, disconnect all voltage and current sources and find the resulting resistance when looking from the load. This will be the Norton resistance (*<u>same with the Thévenin resistance</u>*!)





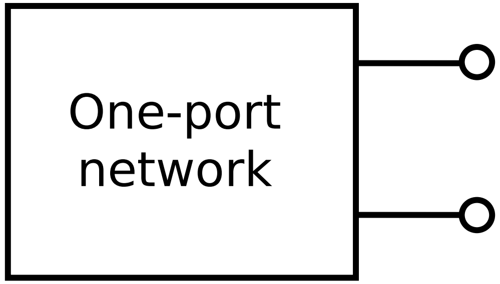
Norton Equivalent Circuit: Example

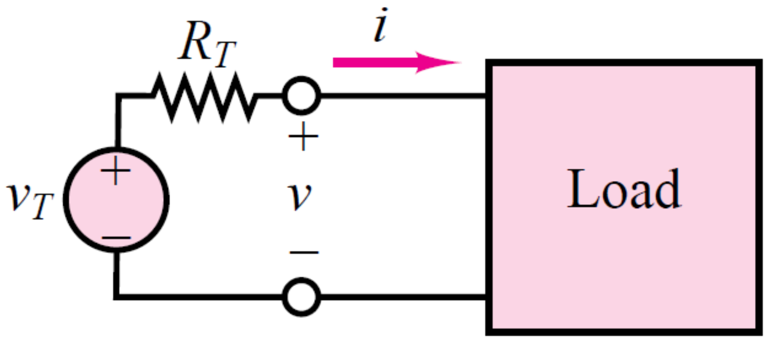
Compute the Norton equivalent circuit as seen from the 7 kΩ resistor.



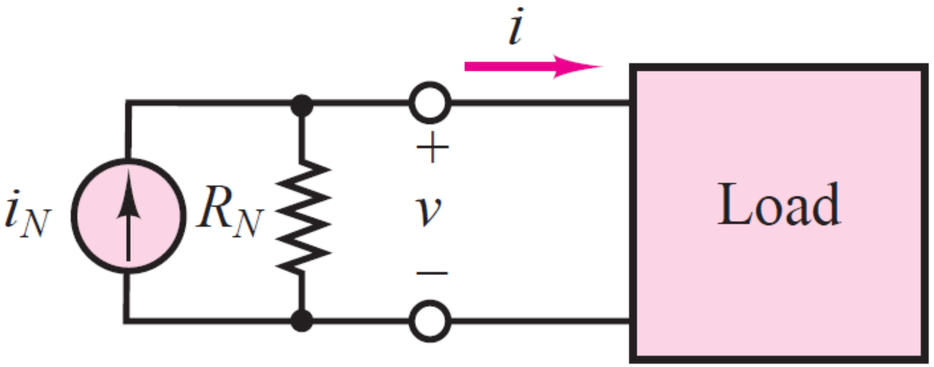
Source Transform

One can easily transform between Thévenin and Norton equivalent circuits with the help of... Ohm’s law.

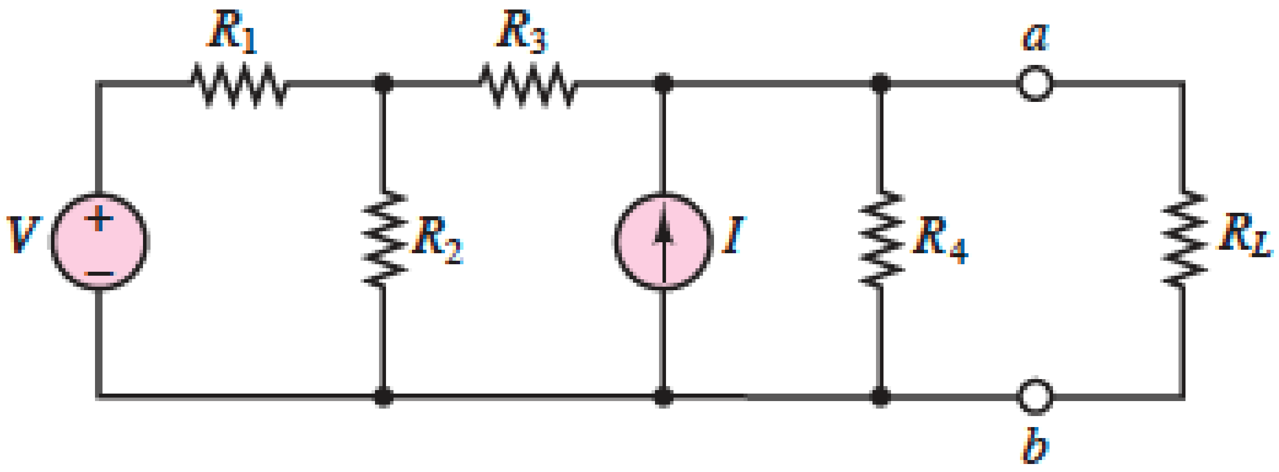




$$v_T = R_T i_N$$

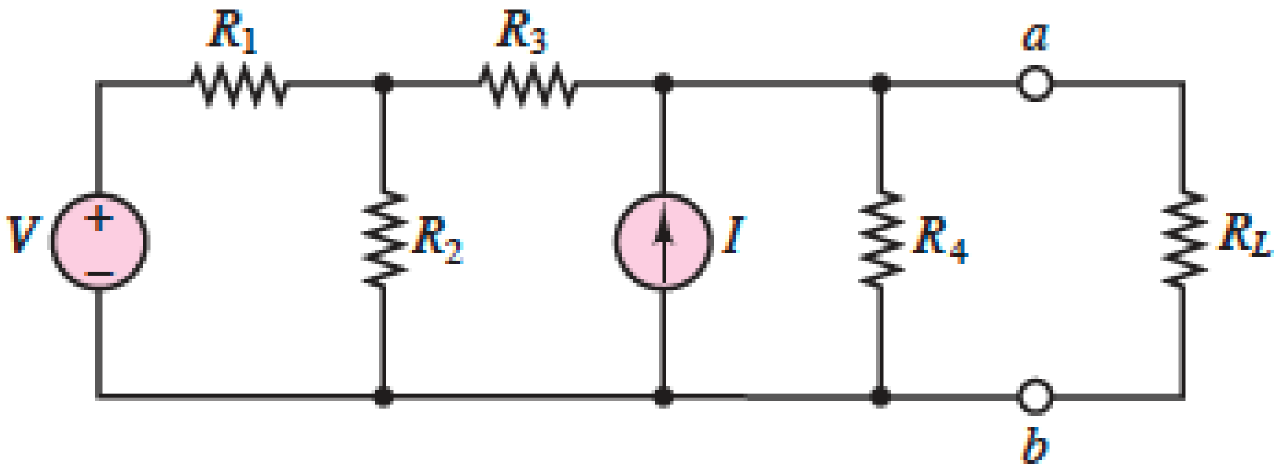


Thévenin Equivalent Circuit: Other Example



$V = 5V$; $R_1 = 2\Omega$; $R_2 = 2\ \Omega$; $R_3 = 1\ \Omega$; $I = 1A$, $R_4 = 2\Omega$.

Norton Equivalent Circuit: Other Example



$V = 5V; R_1 = 2\Omega \; ; R_2 = 2 \; \Omega; R_3 = 1$
$\Omega; I = 1A, R_4 = 2\Omega.$

Thank you for your attention!

Igor Gaponov

i.gaponov@innopolis.ru