Chapter 5 - Methods of Analysis of Resistive Circuits

Lecture 15
Sections 5.2-5.3

MEMS 0031 Electrical Circuits

Mechanical Engineering and Materials Science Department
University of Pittsburgh

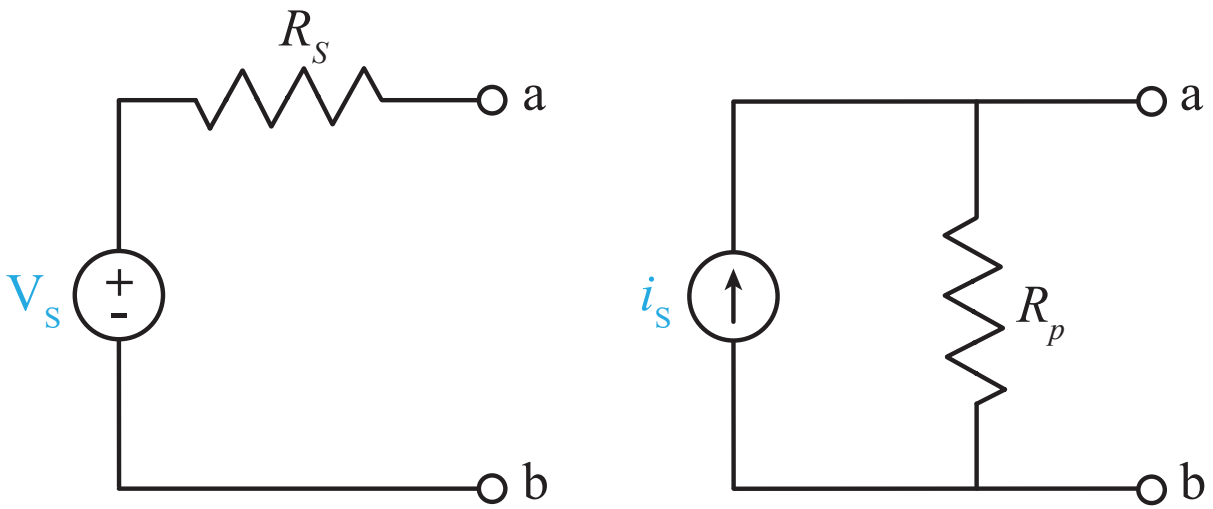
Student Learning Objectives

At the end of the lecture, students should be able to:

- Able to transform voltage and current sources to current and voltage sources, respectively
- Apply the superposition principle to sources to analyze the behavior of circuits

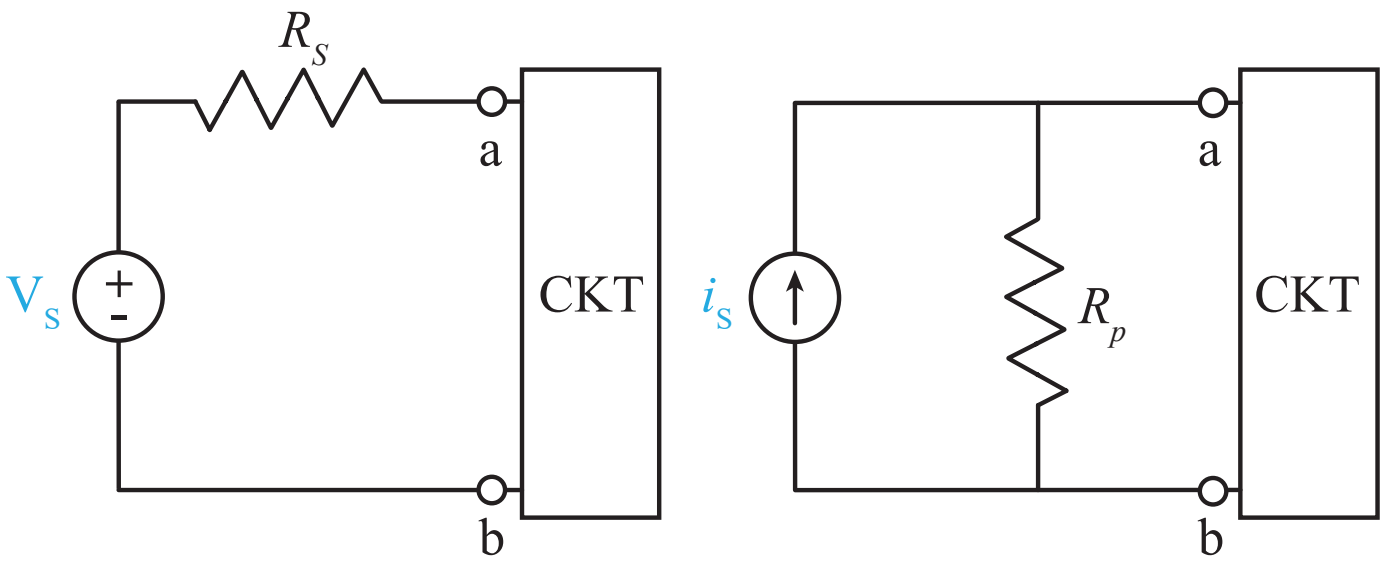
Ideal vs. Nonideal Sources

- A real, independent source exhibits a decrease in voltage or current as power drawn is increased
- This behavior can be represented by placing a resistor, R_s, in series with a V_S, or a resistor, R_p, in parallel with a current source



Source Transformation

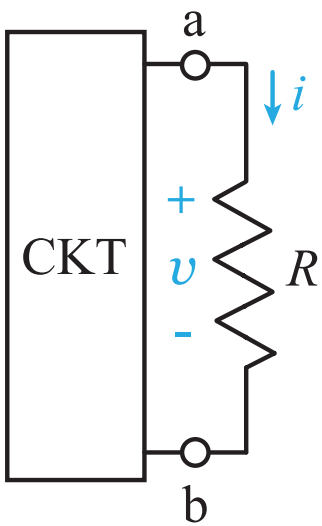
- Under some circumstances, the non-ideal V_S and i_s are equivalent



- When a "source transformation" occurs from one to another, CKT behaves exactly the same

Example #1

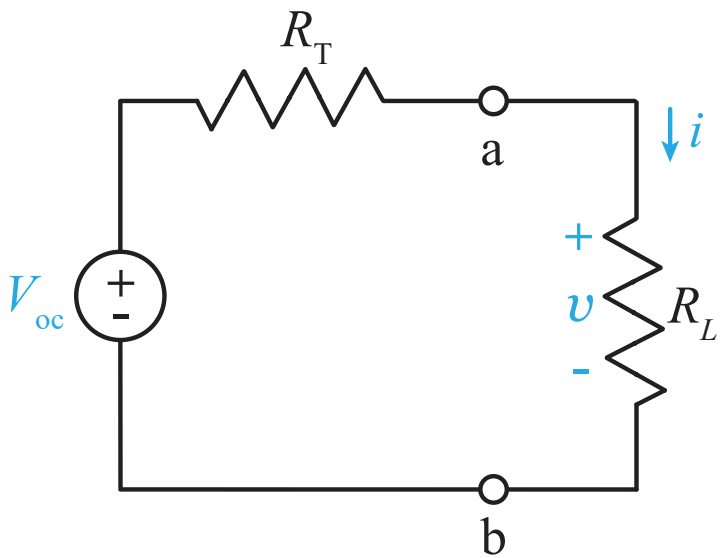
- Imagine you are analyzing the following circuit, with the following data. Can you construct an expression for the behavior?



R [kΩ]	0	1	2	5	10	20	50	∞
i [mA]	3	2.667	2.4	1.846	1.33	0.857	0.414	0
V [V]	0	2.667	4.8	9.231	13.33	17.143	20.69	24

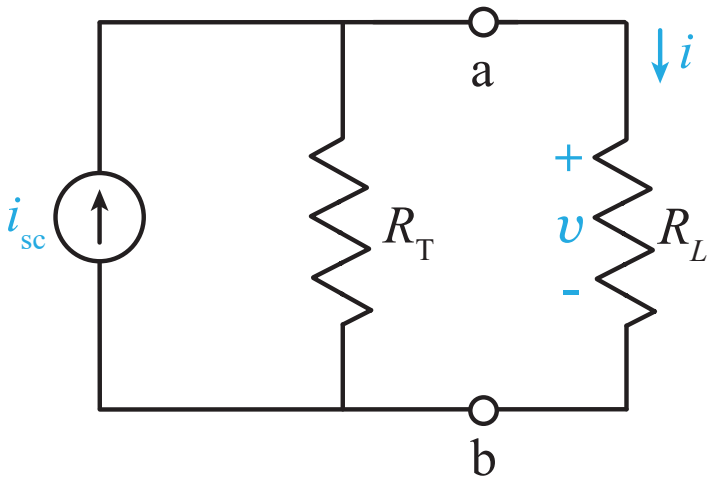
Thevenin Equivalent

- We can form an equivalent circuit with non-ideal $V_S = V_{oc}$ which is in series to R_T attached to a load R

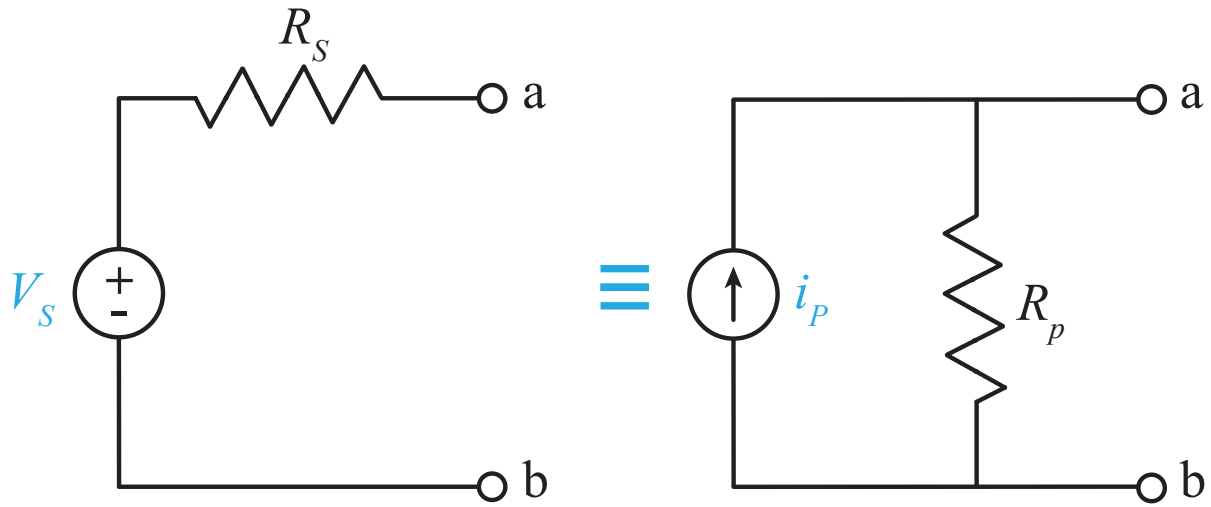


Norton Equivalent

- Alternatively, we could form an equivalent, non-ideal current source setting $i_s = i_{sc}$ in parallel with R_t attached to a load R



Source Equivalency

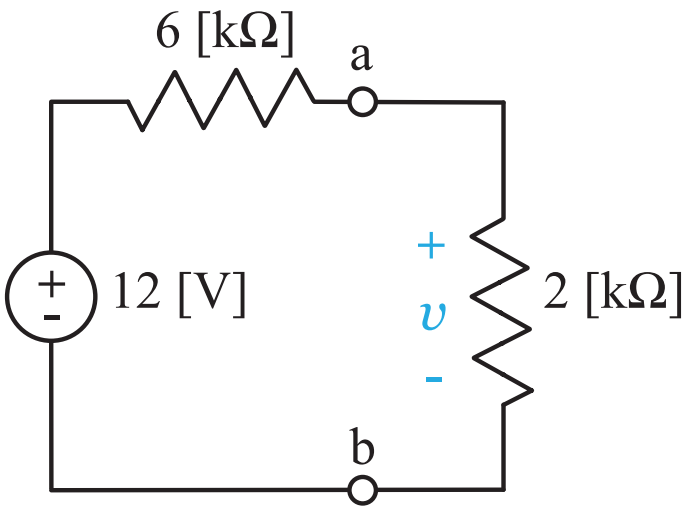


- When converting from i_P, R_P to V_S, R_S:

- When converting from V_S, R_S to i_P, R_P:

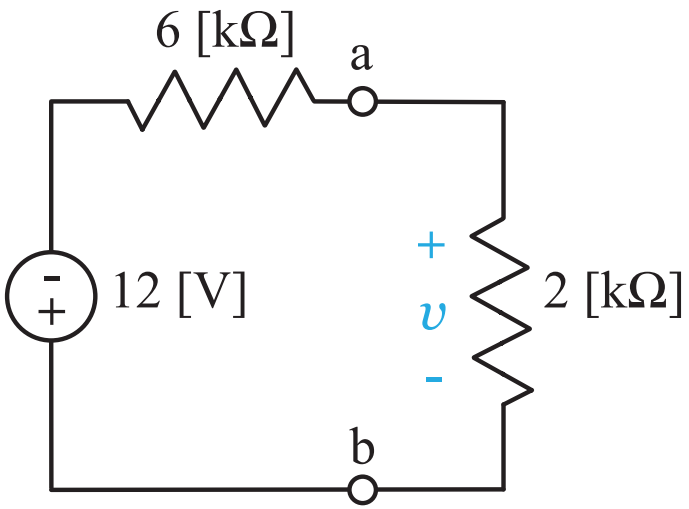
Example #2

- Determine the Norton equivalent and determine the voltage drop across the 2 [kΩ] resistor.



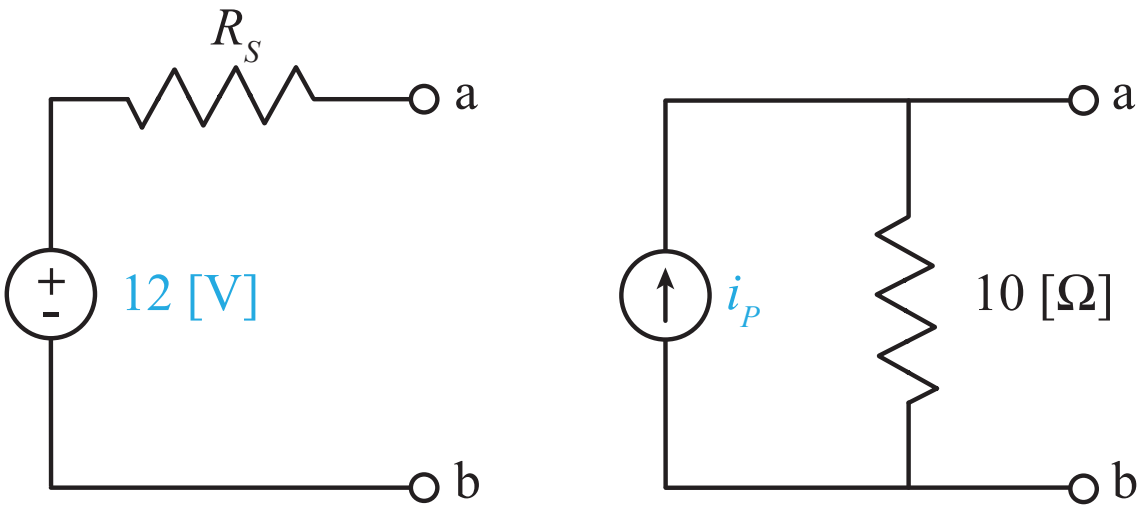
Example #3

- How does the solution change if the polarity of the voltage source is switched?



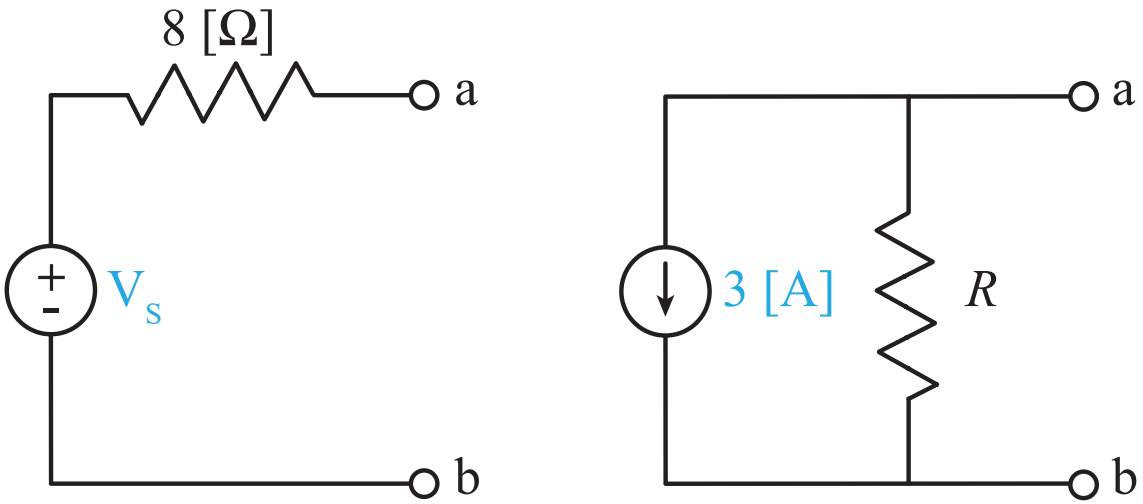
Example #4

- Solve for unknown parameters:



Example #5

- Solve for unknown parameters:

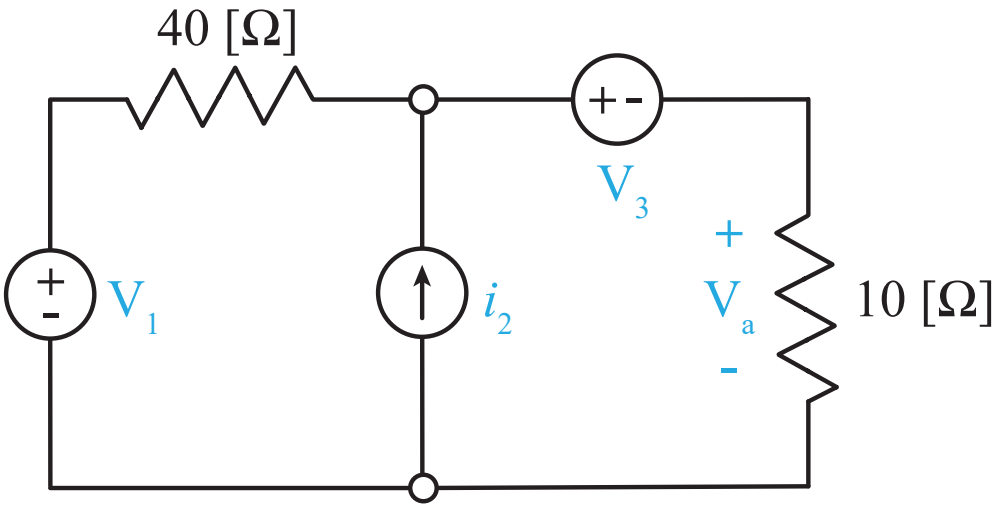


Superposition

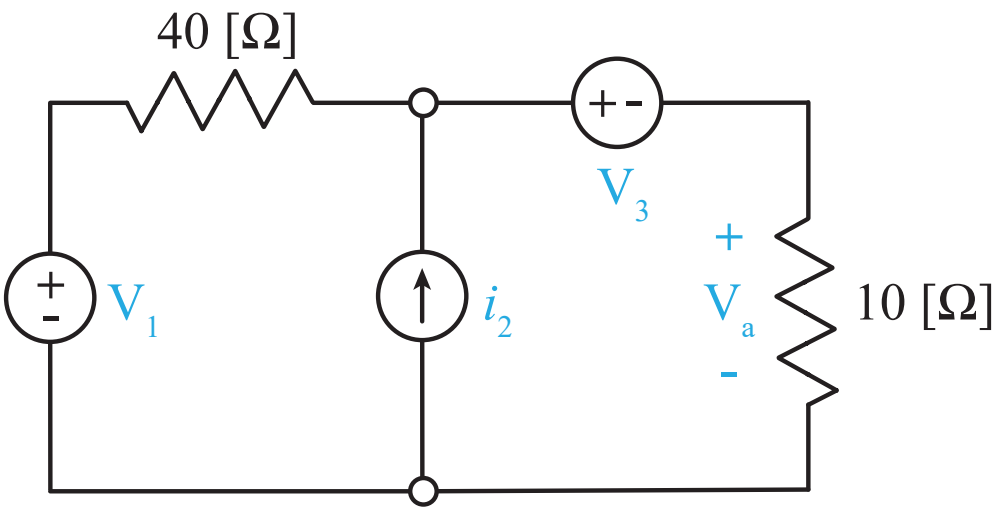
- The total response is the sum of the responses of each independent source
- Short-circuit voltage sources
- Open-circuit current sources

Example #6

- Find V_a



Example #6



Student Learning Objectives

At the end of the lecture, students should be able to:

- Able to transform voltage and current sources to current and voltage sources, respectively
  - We use Ohm's law to convert between a voltage and current source, or a current and voltage source, using the constant of proportionality, i.e. R, which is kept invariant
- Apply the superposition principle to sources to analyze the behavior of circuits
  - When determining the behavior of a circuit using superposition, we consider one independent source at a time. To do such, we short the voltage sources and open the current sources.

Suggested Problems

- 5.2-1, 5.2-2, 5.2-3, 5.2-4, 5.2-7, 5.3-1, 5.3-5, 5.3-7