Electric Circuits

Hani Mehrpouyan,

Department of Electrical and Computer Engineering,
Boise State University
Lecture 8 (Norton's Theorem)
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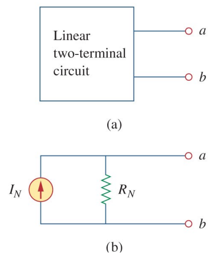
Overview

- In this chapter, the concept of superposition will be introduced.
- Source transformation will also be covered.
- Thevenin and Norton's theorems will be covered.
- Examples of applications for these concepts will be presented.

Norton's Theorem

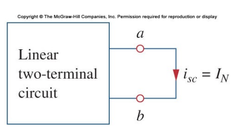
- Similar to Thevenin's theorem, Norton's theorem states that a linear two terminal circuit may be replaced with an equivalent circuit containing a resistor and a current source
- The Norton resistance will be exactly the same as the Thevenin



Norton's Theorem II

- The Norton current I_N is found by short circuiting the circuit's terminals and measuring the resulting current

$$I_N = i_{sc}$$



Norton vs. Thevenin

- These two equivalent circuits can be related to each other
- One need only look at source transformation to understand this
- The Norton current and Thevenin voltage are related to each other as follows:

$$I_N = \frac{V_{Th}}{R_{Th}}$$

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Norton vs. Thevenin II

- With V_{TH}, I_N, and (R_{TH}=R_N) related, finding the Thevenin or Norton equivalent circuit requires that we find:
- The open-circuit voltage across terminals *a and b.*
- The short-circuit current at terminals *a and b.*
- The equivalent or input resistance at terminals *a and b when* all independent sources are turned off.

Solved Problem

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Solved Problem

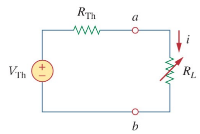
Solved Problem

Maximum Power Transfer

- In many applications, a circuit is designed to power a load
- Among those applications there are many cases where we wish to maximize the power transferred to the load
- Unlike an ideal source, internal resistance will restrict the conditions where maximum power is transferred.

Maximum Power Transfer II

- We can use the Thevenin equivalent circuit for finding the maximum power in a linear circuit
- We will assume that the load resistance can be varied
- Looking at the equivalent circuit with load included, the power transferred is:



$$p = \left(\frac{V_{Th}}{R_{Th} + R_L} \right)^2 R_L$$

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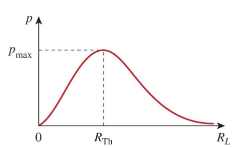
Maximum Power Transfer III

- For a given circuit, V_{TH} and R_{TH} are fixed. By varying the load resistance R_L, the power delivered to the load varies as shown
- You can see that as R_L approaches 0 and ∞ the power transferred goes to zero.
- In fact the maximum power

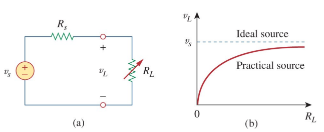


Pspice?

- The Thevenin and Norton equivalent circuits are useful in understanding the behavior of realistic sources
- Ideal voltage sources have no internal resistance
- Ideal current sources have infinite internal resistance
- The Thevenin and Norton circuits introduce deviations from these ideals

Source Modeling

- Take the Thevenin circuit with load resistor:
- The internal resistor and the load act a voltage divider.
- The lower the load resistance, the more voltage drop that occurs in the source

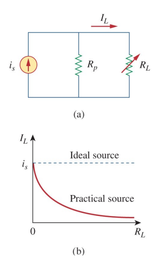


Source Modeling II

- This means that as the load resistance increases, the voltage source comes closer to operating like the ideal source.
- Similarly, with a realistic current source, the internal resistor in parallel with the ideal source acts to siphon away current that would otherwise go to the load.

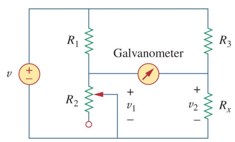
Source Modeling III

- Here, the load and the internal resistor act as a current divider.
- From that perspective, the lower the load resistance, the more current passes through it.
- Thus lower load resistance leads to behavior closer to the ideal source.



Resistance Measurement

- Although the ohmmeter is the most common method for measuring resistance, there is a more accurate method
- It is called the Wheatstone bridge
- It is based on the principle of the voltage divider



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Resistance Measurement

- Using three known resistors and a galvanometer, an unknown resistor can be tested
- The unknown resistor is placed at the position R_4
- The variable resistor R_2 is adjusted until the galvanometer shows zero current
- At this point, the bridge is "balanced" and the voltages from the two dividers are equal

Balanced Bridge

- When balanced, the unknown resistor's value is
$$R_x = \frac{R_3}{R_1} R_2$$
- The key to the high accuracy lies in the fact that any slight difference in the voltage dividers will lead to a current flow

$$I = \frac{V_{Th}}{R_{Th} + R_m}$$

Solved Problem

Solved Problem

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Solved Problem