Electric Circuits

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Lecture 7 (Thevenin's Theorem)
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Overview

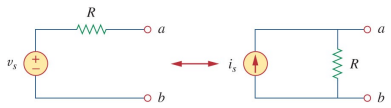
- In this chapter, the concept of superposition will be introduced.
- Source transformation will also be covered.
- Thevenin and Norton's theorems will be covered.
- Examples of applications for these concepts will be presented.

Source Transformation

- It is possible to transform a source from one form to another
- This can be useful for simplifying circuits
- The principle behind all of these transformations is equivalence

Source Transformation II

- A source transformation is the process of replacing a voltage source v_s in series with a resistor R by a current source i_s in parallel with a resistor R, or vice versa.



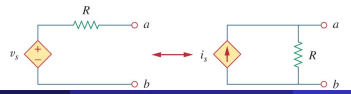
Terminal Equivalency

- These transformations work because the two sources have equivalent behavior at their terminals
- If the sources are turned off the resistance at the terminals are both R
- If the terminals are short circuited, the currents need to be the same
- From this we get the following requirement:

$$v_s = i_s R \quad \text{or} \quad i_s = \frac{v_s}{R}$$

Dependent Sources

- Source transformation also applies to dependent sources
- But, the dependent variable must be handled carefully
- The same relationship between the voltage and current holds here:



Source transformation rules

- Note that the arrow of the current source is directed towards the positive terminal of the voltage source
- Source transformation is not possible when R=0 for an ideal voltage source
- For a realistic source, R≠0
- For an ideal current source, R=∞ also prevents the use of source transformation

Solved Problem

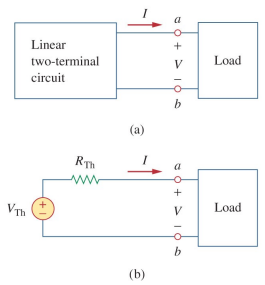
Solved Problem

Thevenin's Theorem

- In many circuits, one element will be variable
- An example of this is household outlet; many different appliances may be plugged into the outlet, each presenting a different resistance
- This variable element is called the load
- Ordinarily one would have to reanalyze the circuit for each change in the load

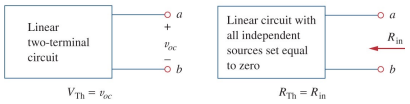
Thevenin's Theorem II

- Thevenin's theorem states that a linear two terminal circuit may be replaced with a voltage source and resistor
- The voltage source's value is equal to the open circuit voltage at the terminals
- The resistance is equal to the resistance measured at the terminals when the independent sources are turned off.



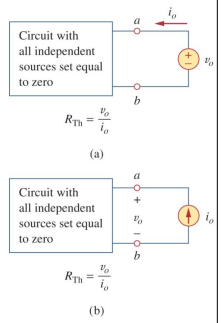
Thevenin's Theorem III

- There are two cases to consider when finding the equivalent resistance
- Case 1: If there are no dependent sources, then the resistance may be found by simply turning off all the sources



Thevenin's Theorem IV

- Case 2: If there are dependent sources, we still turn off all the independent sources.
- Now apply a voltage v_0 (or current i_0) to the terminals and determine the current i_0 (voltage v_0).



Thevenin's Theorem V

- Thevenin's theorem is very powerful in circuit analysis.
- It allows one to simplify a circuit
- A large circuit may be replaced by a single independent voltage source and a single resistor.
- The equivalent circuit behaves externally exactly the same as the original circuit.

Negative Resistance?

- It is possible for the result of this analysis to end up with a negative resistance.
- This implies the circuit is supplying power
- This is reasonable with dependent sources
- Note that in the end, the Thevenin equivalent makes working with variable loads much easier.
- Load current can be calculated with a voltage source and two series resistors
- Load voltages use the voltage divider rule.

Solved Problem

Solved Problem

Solved Problem