UNIT-1

D C Circuit Analysis and Network Theorems:

- Circuit Concepts: Concepts of network, Active and passive elements, voltage and current
- sources, source transformation, unilateral and bilateral elements,
- Kirchhoff's laws; loop and nodal methods of analysis; star-delta transformation; Network
- Theorems: Superposition Theorem, Thevenin's Theorem, Maximum Power Transfer Theorem.

Introduction

- This chapter introduces important fundamental theorems of network analysis. They are the
  - **Superposition theorem**
  - **Thévenin's theorem**
  - **Norton's theorem**
  - **Maximum power transfer theorem**

Superposition Theorem

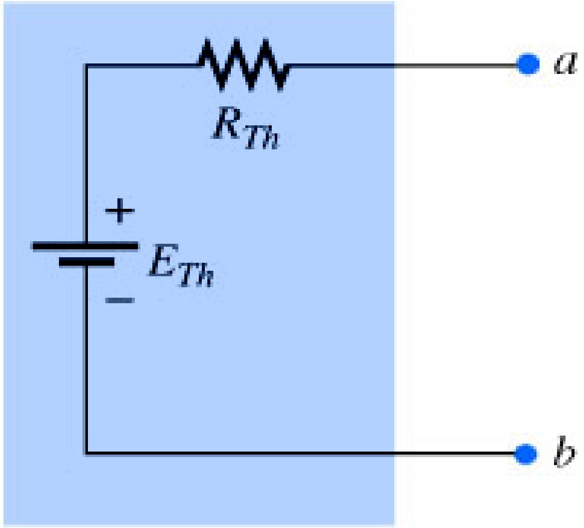
- Used to find the solution to networks with two or more sources that are not in series or parallel.
- The current through, or voltage across, an element in a network is equal to the algebraic sum of the currents or voltages produced independently by each source.
- Since the effect of each source will be determined independently, the number of networks to be analyzed will equal the number of sources.

Superposition Theorem

- The total power delivered to a resistive element must be determined using the total current through or the total voltage across the element and cannot be determined by a simple sum of the power levels established by each source.

Thévenin's Theorem

- Any two-terminal dc network can be replaced by an equivalent circuit consisting of a voltage source and a series resistor.



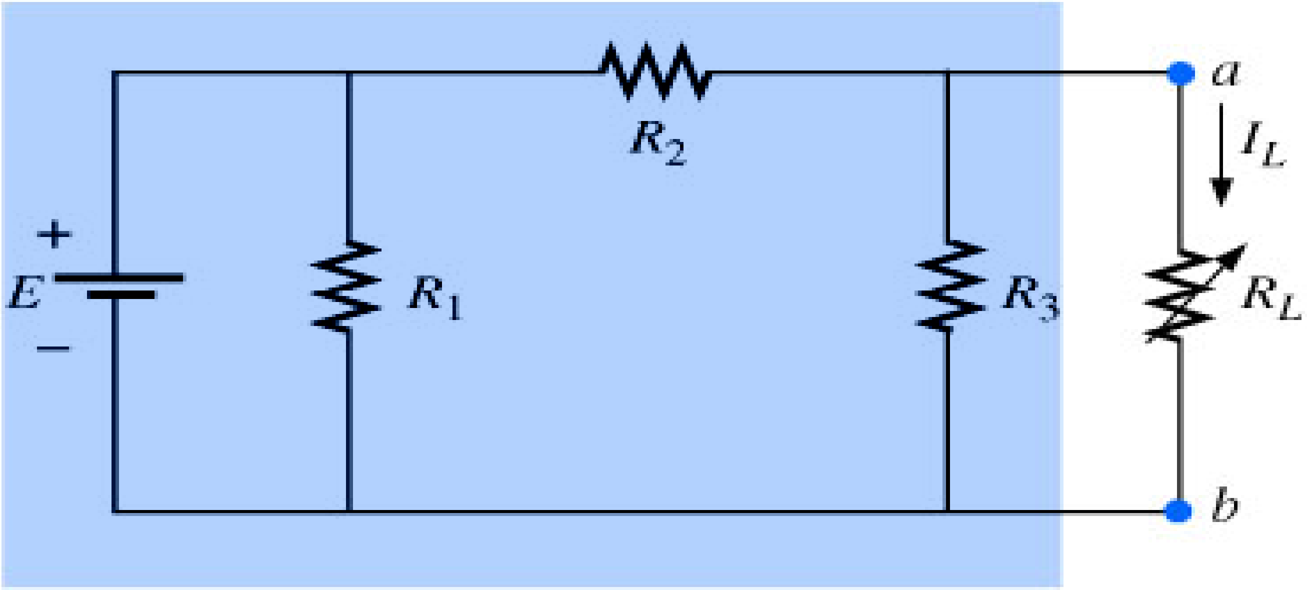
Thévenin's Theorem

- Thévenin's theorem can be used to:
  - Analyze networks with sources that are not in series or parallel.
  - Reduce the number of components required to establish the same characteristics at the output terminals.
  - Investigate the effect of changing a particular component on the behavior of a network without having to analyze the entire network after each change.

Thévenin's Theorem

- Procedure to determine the proper values of R_{Th} and E_{Th}
- Preliminary

1. **Remove that portion of the network across which the Thévenin equation circuit is to be found. In the figure below, this requires that the load resistor R_L be temporarily removed from the network.**



Thévenin's Theorem

2. Mark the terminals of the remaining two-terminal network. (The importance of this step will become obvious as we progress through some complex networks.)

R_{Th}:

3. Calculate R_{Th} by first setting all sources to zero (voltage sources are replaced by short circuits, and current sources by open circuits) and then finding the resultant resistance between the two marked terminals. (If the internal resistance of the voltage and/or current sources is included in the original network, it must remain when the sources are set to zero.)

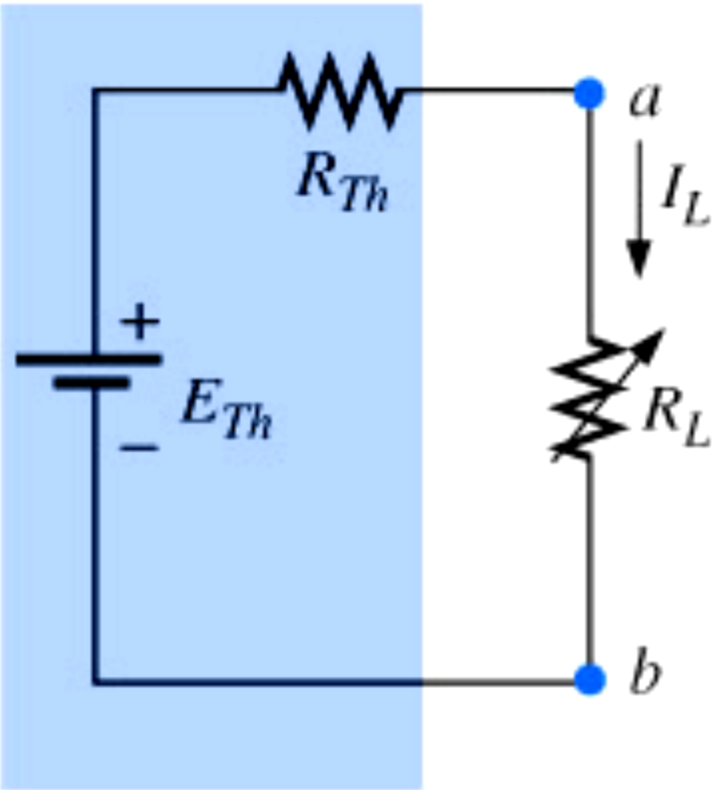
Thévenin's Theorem

E_{Th}:

4. Calculate E_{Th} by first returning all sources to their original position and finding the open-circuit voltage between the marked terminals. (This step is invariably the one that will lead to the most confusion and errors. In all cases, keep in mind that it is the open-circuit potential between the two terminals marked in step 2.)

Thévenin's Theorem

- Conclusion:
  5. Draw the Thévenin equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit. This step is indicated by the placement of the resistor R_L between the terminals of the Thévenin equivalent circuit.



Thévenin's Theorem

Experimental Procedures

- Two popular experimental procedures for determining the parameters of the Thévenin equivalent network:
  - Direct Measurement of E_{Th} and R_{Th}
    - For any physical network, the value of E_{Th} can be determined experimentally by measuring the open-circuit voltage across the load terminals.
    - The value of R_{Th} can then be determined by completing the network with a variable resistance R_L.

Thévenin's Theorem

- Measuring V_{OC} and I_{SC}
  - The Thévenin voltage is again determined by measuring the open-circuit voltage across the terminals of interest; that is, $E_{Th} = V_{OC}$. To determine R_{Th}, a short-circuit condition is established across the terminals of interest and the current through the short circuit (I_{sc}) is measured with an ammeter.
  - Using Ohm's law:

$$R_{Th} = V_{oc} / I_{sc}$$

Norton's Theorem

- Norton's theorem states the following:
  - Any two-terminal linear bilateral dc network can be replaced by an equivalent circuit consisting of a current and a parallel resistor.
- The steps leading to the proper values of I_N and R_N.
- Preliminary steps:
  1. Remove that portion of the network across which the Norton equivalent circuit is found.
  2. Mark the terminals of the remaining two-terminal network.

Norton's Theorem

- **Finding R_N:**

3. Calculate R_N by first setting all sources to zero (voltage sources are replaced with short circuits, and current sources with open circuits) and then finding the resultant resistance between the two marked terminals. (If the internal resistance of the voltage and/or current sources is included in the original network, it must remain when the sources are set to zero.) Since $R_N = R_{Th}$ the procedure and value obtained using the approach described for Thévenin's theorem will determine the proper value of R_N.

Norton's Theorem

- **Finding I_N :**

4. Calculate I_N by first returning all the sources to their original position and then finding the short-circuit current between the marked terminals. It is the same current that would be measured by an ammeter placed between the marked terminals.

- **Conclusion:**

5. Draw the Norton equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit.

Maximum Power Transfer Theorem

- The maximum power transfer theorem states the following:

  A load will receive maximum power from a network when its total resistive value is exactly equal to the Thévenin resistance of the network applied to the load. That is,

$$R_L = R_{Th}$$

Maximum Power Transfer Theorem

- For loads connected directly to a dc voltage supply, maximum power will be delivered to the load when the load resistance is equal to the internal resistance of the source; that is, when:

$$R_L = R_{int}$$