Basic Electrical Engineering (TEE 101)

Lecture 11 (b): Superposition Theorem

Content

This lecture covers:

- **Introduction to Superposition Theorem (SPT)**
- **Procedure to solve an Electrical Circuit using SPT**

Introduction to Superposition Theorem (SPT)

The SPT is used to simplify a complex electrical circuit and helps in understanding its response in convenient way.

SPT is only applicable to the linear electrical circuits

Linear Electrical circuits are those which obey principle of superposition and homogeneity

This theorem states that: *In a linear, bilateral d.c. network containing more than one energy source, the resultant potential difference across or current through any element is equal to the algebraic sum of potential differences or currents for that element produced by each source acting alone with all other independent ideal voltage sources replaced by short circuits and all other independent ideal current sources replaced by open circuits (non- deal sources are replaced by their internal resistances).*

Procedure to solve an electrical network using SPT

Procedure. The procedure for using this theorem to solve d.c. networks is as under :

(*i*) Select one source in the circuit and replace all other energy sources with their internal resistances **(i.e. ideal voltage sources by short circuits and ideal current sources by open circuits)**

(*ii*) Determine the voltage across or current through the desired element/branch due to single source selected in step (*i*). **{To avoid confusion re-label the voltage and current notations suitably}**

(*iii*) Repeat the above two steps for each of the remaining sources.

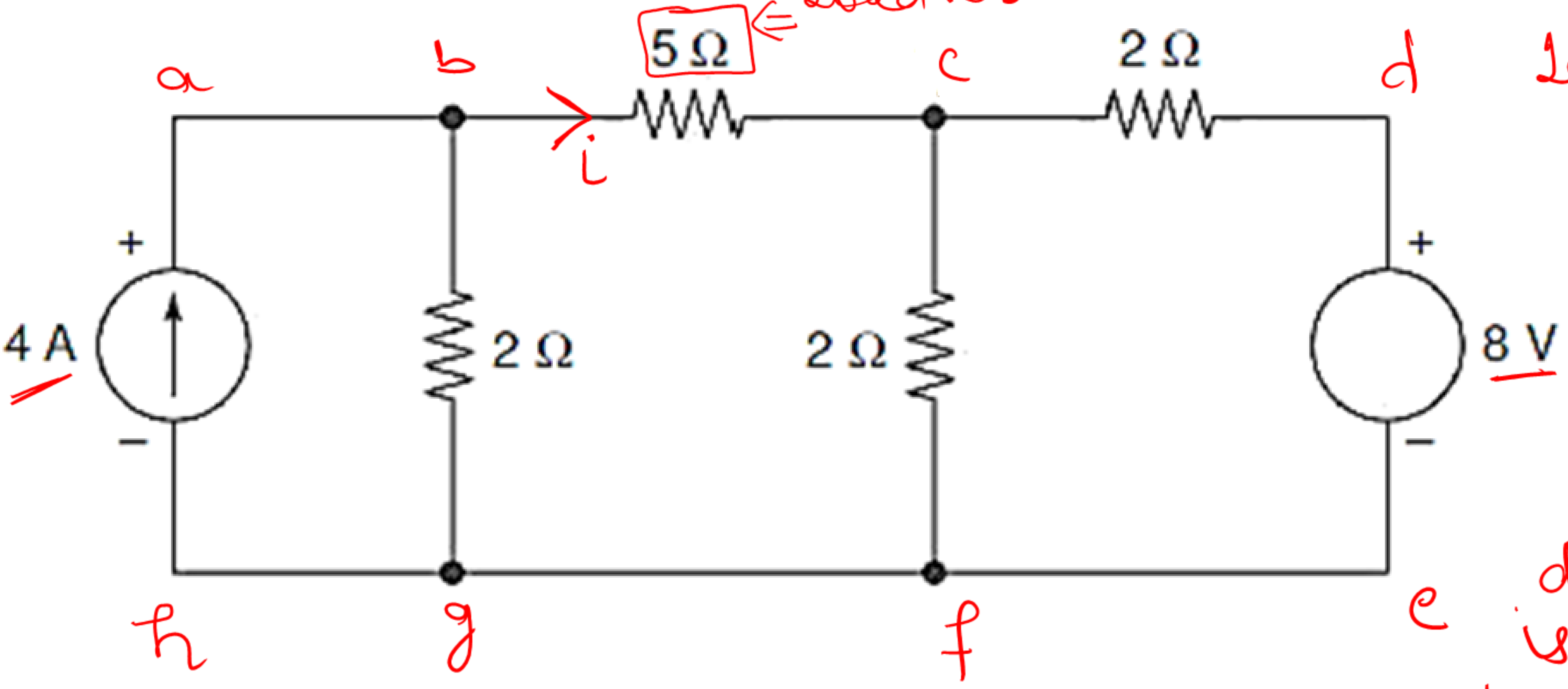
(*iv*) *Algebraically* add all the voltages across or currents through the element/branch under consideration. The sum is the actual voltage across or current through that element/branch when all the sources are acting simultaneously.

Note. This theorem is called *superposition* because we superpose or algebraically add the components (currents or voltages) due to each independent source acting alone to obtain the total current in or voltage across a circuit element.

This will be illustrated with the help of an example.

Que. In the circuit as shown below, find the through 5 ohm resistance using the superposition theorem.

Load Resistance



Let us assume that the net current in 5 Ω is "i" and its direction is from b → c

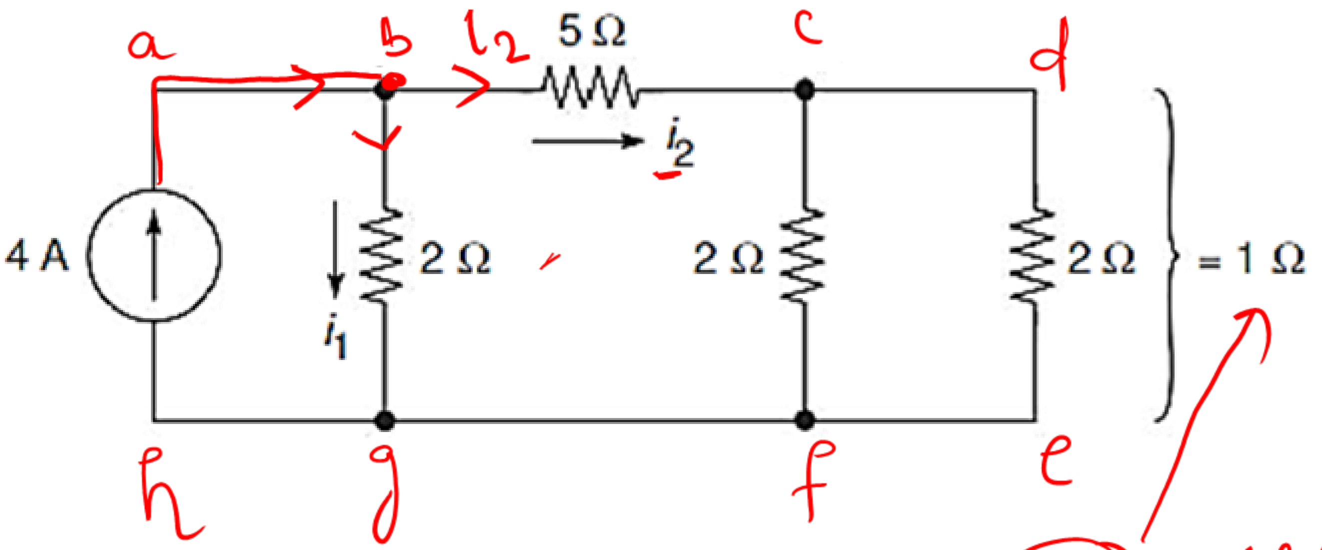
Step 1:

Let us calculate the current through 5 ohm resistance due to the available current source (4A).

So, we will replace the available voltage source in the circuit with its resistance.

Assuming all sources to be ideal, the resistance of an ideal voltage source is ZERO.

Hence, the voltage source will be replaced with a short branch/path.



bg ∥ bcf

$\frac{1}{2} \parallel \frac{1}{2} = \frac{4}{4} = 1\Omega$

Let us assume that the current due to 4A source in 5Ω is i_2. and the direction is from b → c.

So, i_2 can be obtained by apply current division rule at junction "b".

$$\boxed{i_2 = \frac{4 \times 2}{2+5+1} = \frac{8}{8} = 1\,A} \quad \text{——— (1)}$$

That means the current in $5\,\Omega$ Resistance due to the 4A current source is 1A

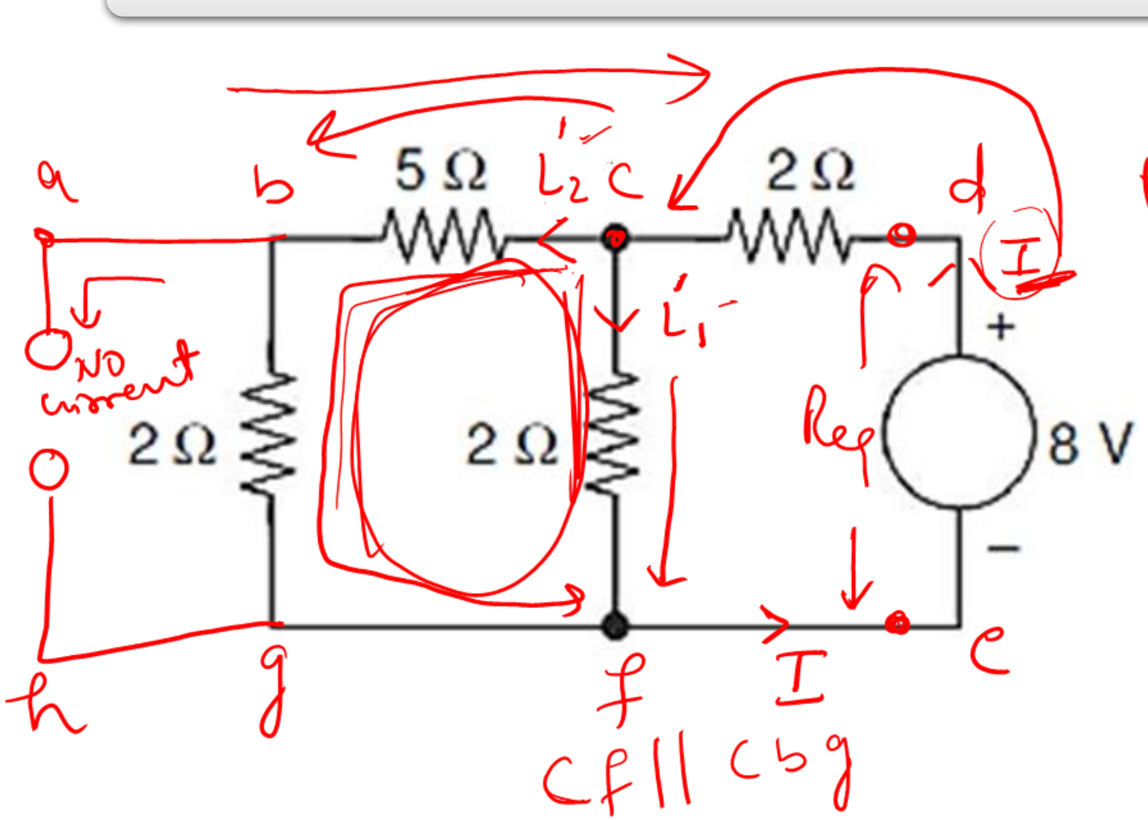
Step 2:

Let us calculate the current through 5 ohm resistance due to the available voltage source (8V).

So, we will replace the available current source in the circuit with its resistance.

Assuming all sources to be ideal, the resistance of an ideal current source is INFINITE.

Hence, the current source will be replaced with an open branch/path.



Let us assume that the current through 5 Ω resistance due to 8V source is i_2' and the direction is from c ⟶ b.

we can use Mesh, Nodal, C.D.R etc

whichever you find easy.

Let us try to solve the network for i_2' using C.D.R.

$$i_2' = \frac{I \times 2}{5+2+2} \quad \text{--- (2)}$$

Now, to calculate i_2' we need I.

I is the total current in this circuit due to 8 V source

hence,

$$I = \frac{8}{R_{eq}}$$

Now R_{eq} is calculated across the terminal d-c

$$R_{eq} = [(5+2) \| 2] + 2$$

$$R_{eq} = [7 \| 2] + 2 = \frac{14}{9} + 2 = \frac{32}{9}\,\Omega$$

hence; $I = \frac{8}{32/9} = \frac{9}{4}\,A$ --- (3)

hence, $i_2' = \frac{(9/4) \times 2}{9} = \frac{1}{2} = 0.5\,A$

So, the current in 5Ω resistance due to 8V source is $i_2' = 0.5\,A$

So, The net current in 5Ω as per SPT is : $i_2 \pm i_2' = 1A + (-0.5) = \underline{\underline{0.5A}}$

Limitations of Superposition Theorem

- This theorem cannot be applied on the electrical circuits with single energy source.
- This theorem cannot be applied to non-linear networks
- This theorem cannot be used to calculate power in electrical circuits as this theorem is based on the concept of linearity
- To analyze highly complex electrical circuits, this theorem is not convenient

Thank You