Superposition Theorem - GATE Study Material in PDF

In these free GATE 2018 Preparation Notes, we will discuss several more theorems such as Superposition Theorem and Maximum Power Transfer Theorem. According to the Superposition Theorem, in any linear directional circuit having more than one independent source, the response in any one of the element is equal to algebraic sum of the response caused by individual source while rest of the sources are replaced by their internal resistances. This method helps in simplifying networks.

Use these GATE Study Material to prepare for GATE EE, EC, IES, DRDO, BARC, BSNL and other exams. You can download in PDF all the GATE Notes to help you learn and revise at your convenience.

But before you start with this lesson, you are advised to go through previous notes to help you fix your basics.

Recommended Reading –

Basic Network Theory Concepts

Source Transformation & Reciprocity Theorem

Kirchhoff's Laws, Node and Mesh Analysis

Voltage Division, Current Division, Star-Delta Conversion

Thevenin & Norton's Theorems

Superposition Theorem

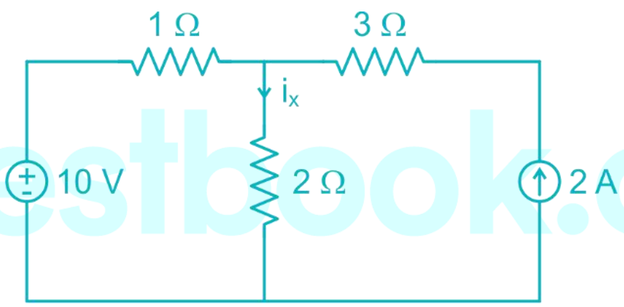
Steps for solution of a network using Superposition theorem:

1. Take only one independent source and deactivate the other independent sources (Replace voltage sources with short circuit and current sources with open circuit).

2. Repeat the above step for each of the indecent sources.

3. To determine the net value, just add the values obtained in step 1 and step 2.

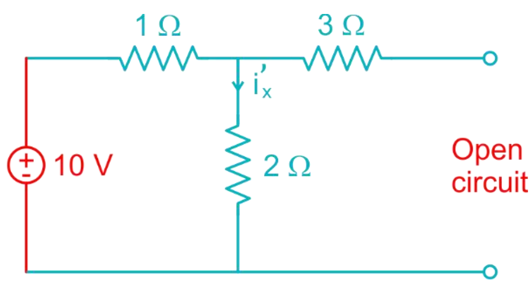
Example 1:



Find the value of i_x

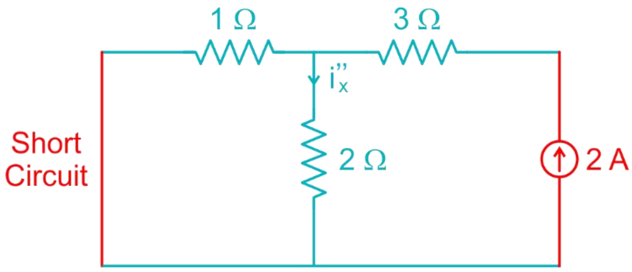
Solution: There are two independent sources

Step 1: Only voltage source is active



$\Rightarrow i'_x = \frac{10}{3}\text{A}$

Step 2: Only current source is active



$$\Rightarrow i_x'' = 2\left(\frac{1}{3}\right) = \frac{2}{3}A$$

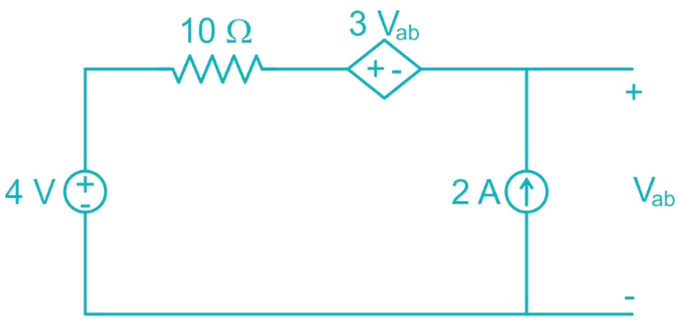
Step 3:

$$i_x = i_x' + i_x'' = \frac{10}{3} + \frac{2}{3} = 4A$$

Note: Dependent sources can't be suppressed since we don't know their internal resistances.

Example 2:

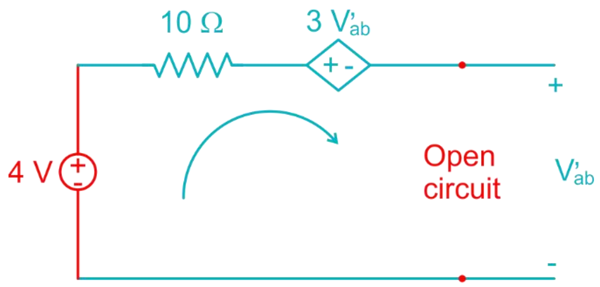
Find V_{ab} using Superposition theorem



Solution:

There are two independent sources.

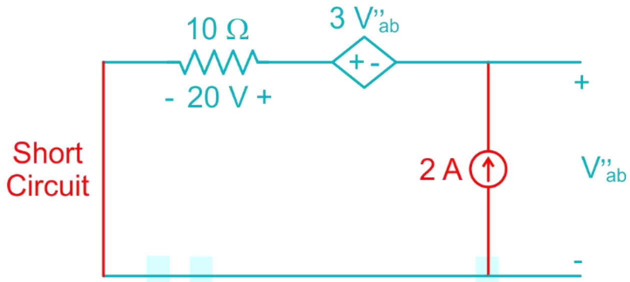
Step 1: Only voltage source is active



By KVL

$\Rightarrow -4 + 3V_{ab} + V_{ab} = 0 \Rightarrow V'_{ab} = 1V$

Step 2:



By KVL,

$\Rightarrow -20 + 3V''_{ab} + V''_{ab} = 0$

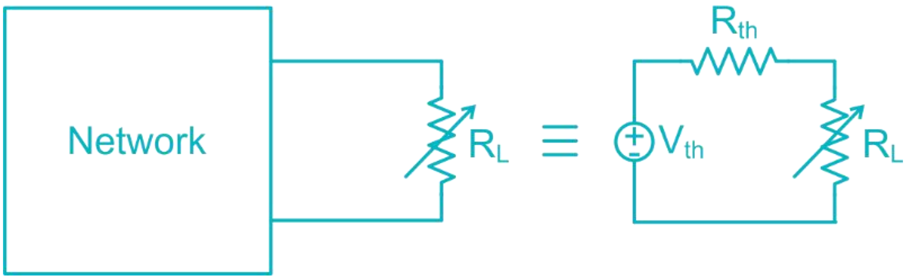
$\Rightarrow V''_{ab} = 5V$

Step 3:

$V_{ab} = V'_{ab} + V''_{ab} = 1 + 5 = 6V$

Maximum Power Transfer Theorem

A resistance load, being connected to a dc network, receives maximum power when the load resistance is equal to internal resistance (Thevenin's equivalent resistance) of the source network as seen from the load terminals.



Maximum transferred to R_L when $R_L = R_{th}$

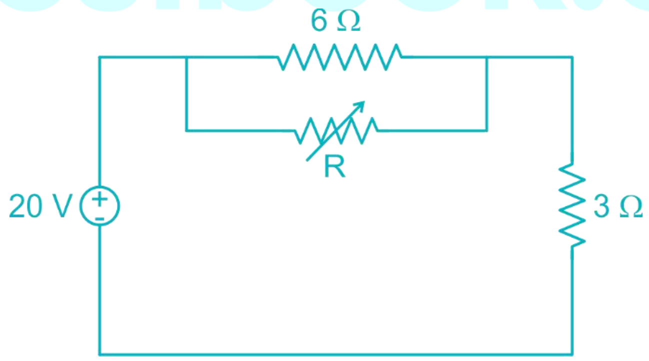
Where R_{th} is Thevenin's resistance of the given network.

The maximum power is given by

$$P_{max} = \frac{V_{th}^2}{4R_{th}}$$

Example 3:

Find the value of 'R' so that maximum power occurs in it.



Solution: As per the maximum power condition

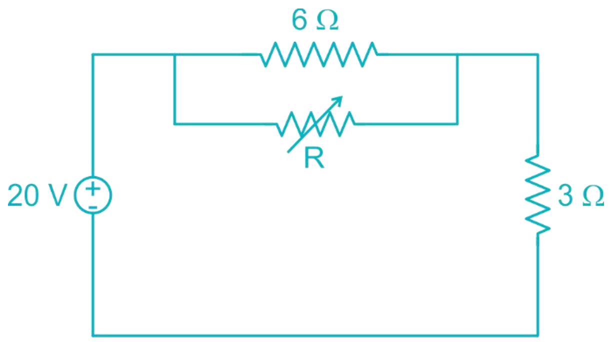
$R = R_{th}$

Here $R_{th} = 6||3 = 2\Omega$

$\Rightarrow R = 2\Omega$

Example 4:

Find the value of 'R' so that maximum power in 3 Ω resistor



Solution: Maximum current will flow through 3 Ω resistor, when R=0. Hence maximum power occurs in 3 Ω resistor at R=0 Ω

Maximum Power Transfer Theorem in AC Circuits

Maximum power is transferred tom load impedance when load impedance is complex conjugate Source impedance.

$Z_L = Z_{th}^*$

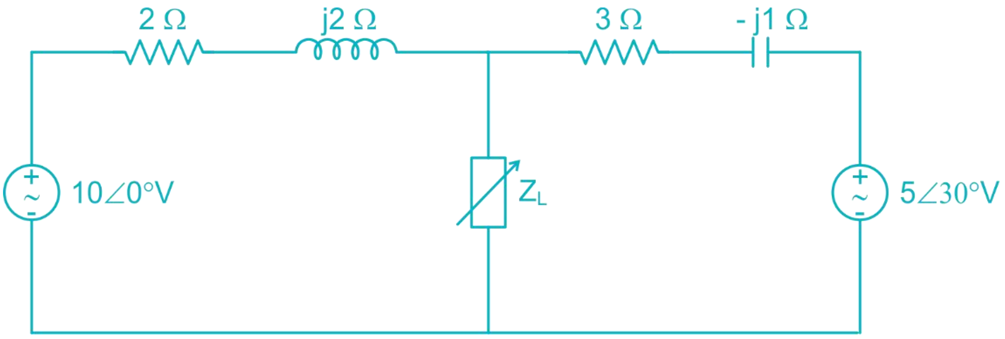
And the maximum power is given by

$P_{max} = \frac{V_S^2}{4R_S}$

Where $R_S = Re[Z_S]$

Example 5:

Find the value of Z_L so that maximum power occurs in it



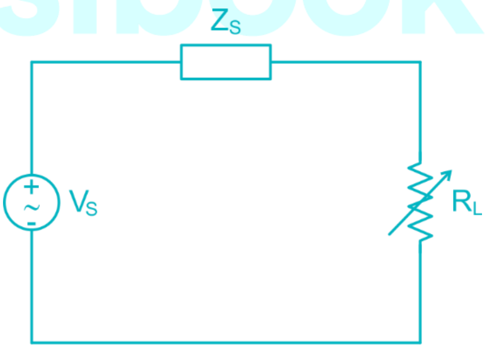
Solution:

$Z_{th} = (2 + j2)||(3 - j1)$

$Z_{th} = (1.69 + j0.46)\Omega$

$\Rightarrow Z_L = Z_{th}^* = (1.69 - j0.46)\Omega$

Special Case:



Here phase balancing is not possible. So at least magnitude must be equal in order to get maximum power transferred through R_L.

$\Rightarrow R_L = |Z_s|$

Example 6:

A voltage source having an internal impedance of (8+j6) ohms supplies power to a resistance load. What should be the load resistance for maximum power transferred to it?

Solution:

$R_L = |Z_s| = |8 + j6|$

$= \sqrt{64 + 36} = 10\Omega$

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