

Norton's Theorem

Elementrix Classes

Norton's Theorem

- Any linear electric network or complex circuit with current and voltage sources can be replaced by an equivalent circuit containing a single independent current source I_N and a parallel resistance R_N .

The main difference between Thevenin's theorem and Norton's theorem is that, Thevenin's theorem provides an equivalent voltage source and an equivalent series resistance, while Norton's theorem provides an equivalent Current source and an equivalent parallel resistance.

Steps to Analyze an Electric Circuit using Norton's Theorem:

1. Short the load resistor.
1. Calculate / measure the Short Circuit Current. This is the Norton Current (I_N).
1. Open Current Sources, Short Voltage Sources and Open Load Resistor.
1. Calculate /measure the Open Circuit Resistance. This is the Norton Resistance (R_N).

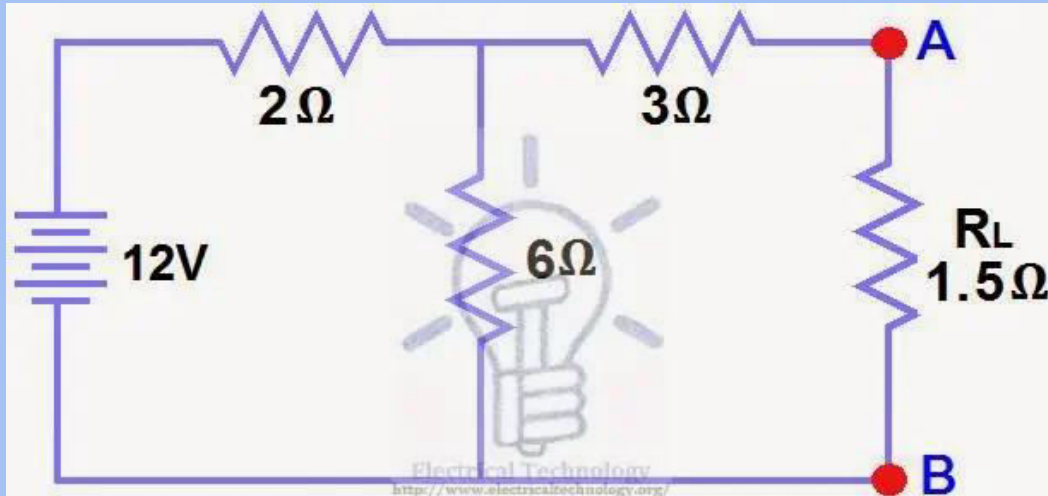
5. Now, Redraw the circuit with measured short circuit Current (I_N) in Step (2) as Current Source and measured open circuit resistance (R_N) in step (4) as a parallel resistance and connect the load resistor which we had removed in Step (3). This is the Equivalent Norton Circuit of that Linear Electric Network or Complex circuit which had to be simplified and analyzed. You have done it.

6. Now find the Load current flowing through and Load Voltage across Load Resistor by using the Current divider rule.

$$I_L = I_N \times \frac{R_N}{(R_N + R_L)}$$

Example:

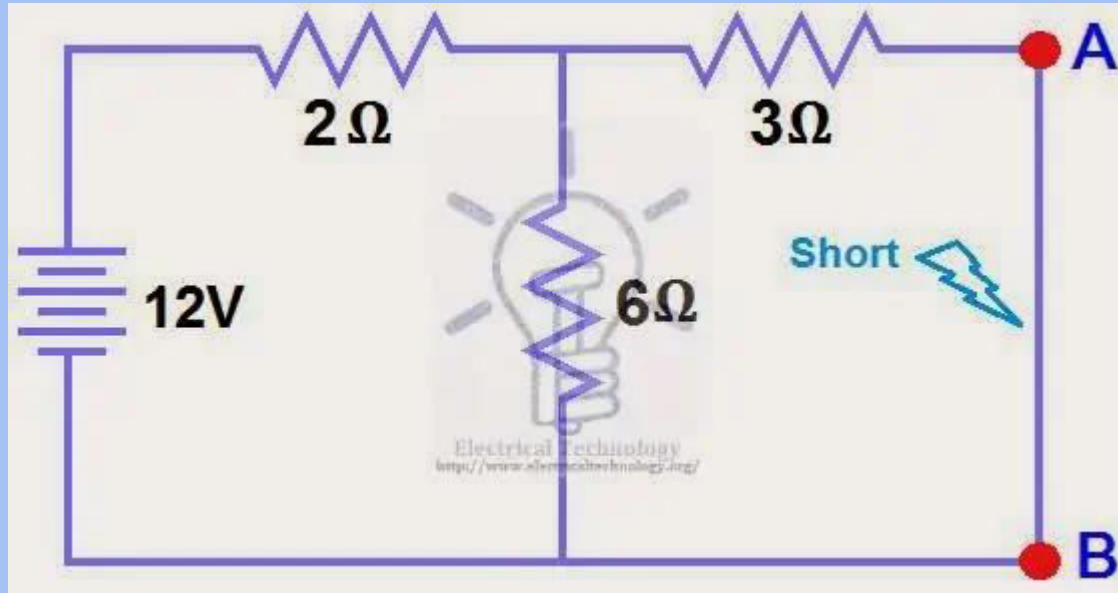
Find R_N , I_N , the current flowing through and Load Voltage across the load resistor in fig (1) by using Norton's Theorem.



Norton's Theorem. Easy Step by Step Procedure with Example (Pictorial Views)

STEP 1.

Short the 1.5Ω load resistor as shown in (Fig 2).



STEP 2.

Calculate / measure the Short Circuit Current. This is the Norton Current (I_N).

We have shorted the AB terminals to determine the Norton current, I_N . The 6Ω and 3Ω are then in parallel and this parallel combination of 6Ω and 3Ω are then in series with 2Ω .

So the total resistance of the circuit to the Source is:-

$2\Omega + (6\Omega \parallel 3\Omega) \dots\dots$ (\parallel = in parallel with).

$$R_T = 2\Omega + \left[\frac{(3\Omega \times 6\Omega)}{(3\Omega + 6\Omega)} \right]$$

$$I_T = 2\Omega + 2\Omega = 4\Omega.$$

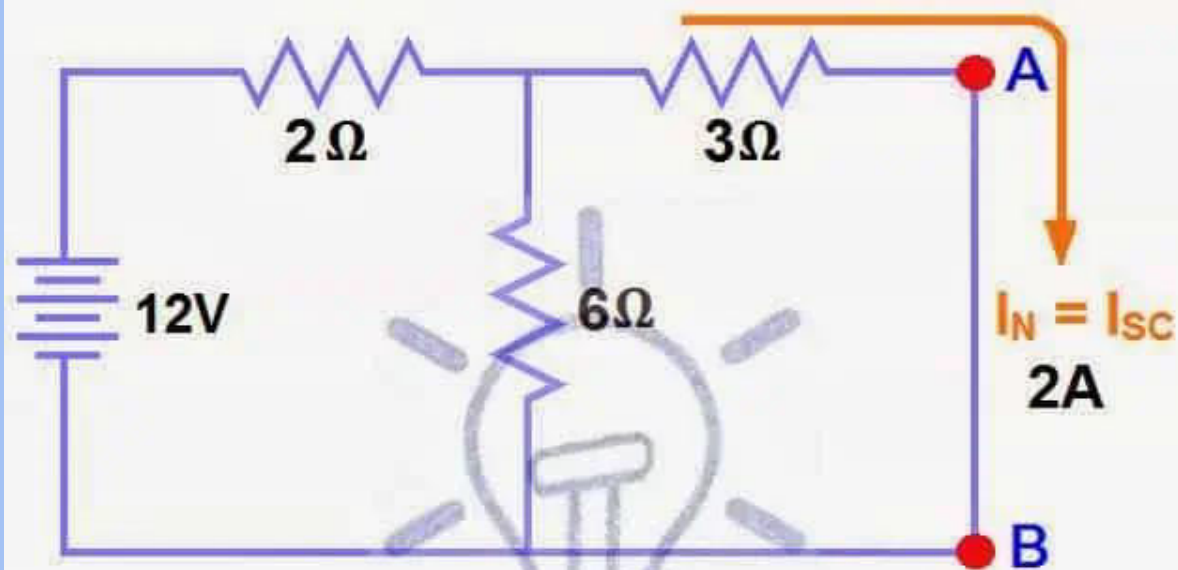
$$\mathbf{R_T = 4\Omega}$$

$$I_T = \frac{V}{R_T} = \frac{12V}{4\Omega} = 3A$$

Now we have to find $I_{sc} = I_N$... Apply CDR... (Current Divider Rule)...

$$I_{SC} = I_N = 3A \times \frac{6\Omega}{(3\Omega + 6\Omega)} = 2A$$

$$\mathbf{I_{sc} = I_N = 2A}$$



$$R_T = 2\Omega + \frac{3\Omega \times 6\Omega}{3\Omega + 6\Omega} \rightarrow 2\Omega + 2\Omega = 4\Omega$$

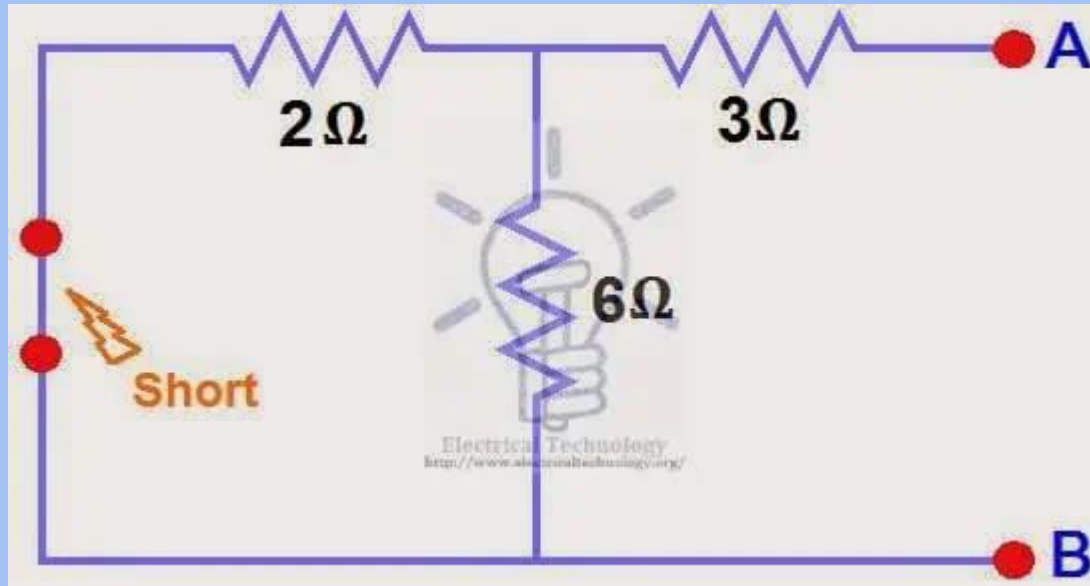
$$R_T = 4\Omega$$

$$I_T = V / R_T = 12/4 = 3A$$

$$I_N = I_{sc} = 3A \times \frac{6\Omega}{3\Omega + 6\Omega} = 2A \quad \text{.....Apply CDR}$$

STEP 3.

Open Current Sources, Short Voltage Sources and Open Load Resistor. Fig (4)



STEP 4.

Calculate /measure the Open Circuit Resistance. This is the Norton Resistance (R_N)

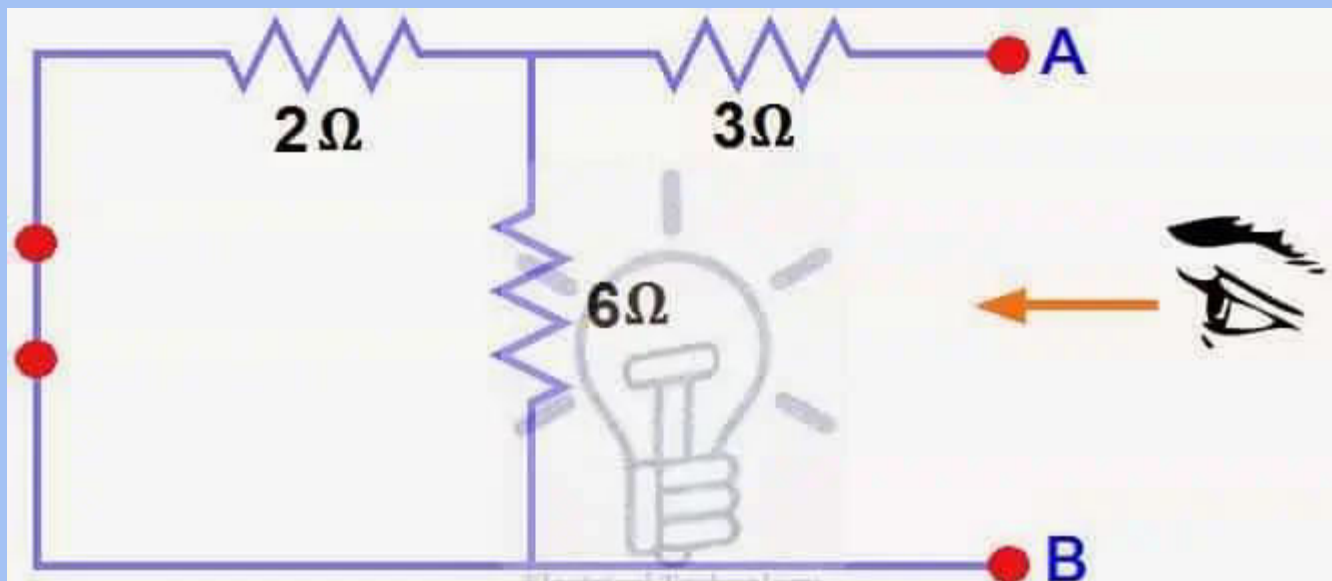
We have Reduced the 12V DC source to zero is equivalent to replace it with a short in step (3), as shown in figure (4) We can see that 3Ω resistor is in series with a parallel combination of 6Ω resistor and 2Ω resistor. I.e.:

$3\Omega + (6\Omega \parallel 2\Omega)$ (\parallel = in parallel with)

$$R_N = 3\Omega + \left(\frac{6\Omega \times 2\Omega}{6\Omega + 2\Omega} \right)$$

$$R_N = 3\Omega + 1.5\Omega$$

$$R_N = 4.5\Omega$$



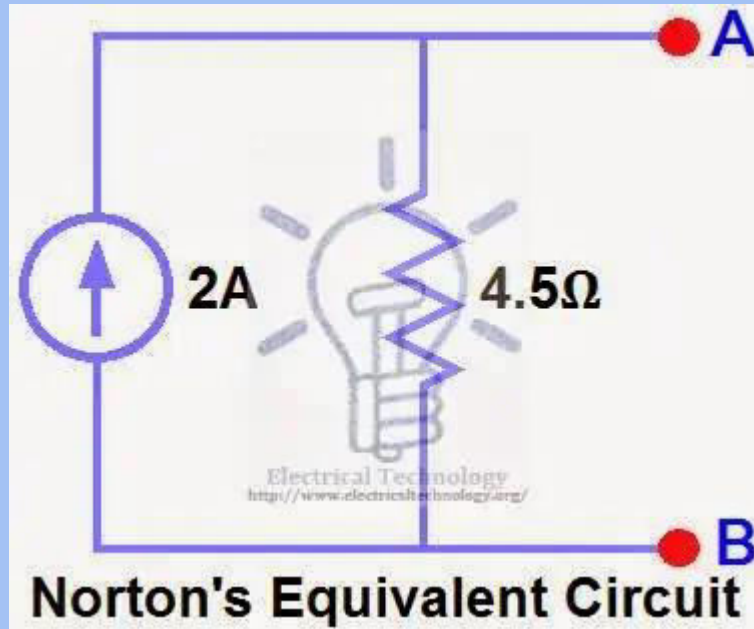
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$$= 3\Omega + (6\Omega \parallel 2\Omega) \rightarrow = 3\Omega + 1.5\Omega$$

$$R_N = 4.5\Omega$$

STEP 5.

Connect the R_N in Parallel with Current Source I_N and reconnect the load resistor. This is shown in fig (6) i.e. Norton Equivalent circuit with load resistor.



STEP 6.

Now apply the last step i.e. calculate the load current through and Load voltage across the load resistor by Ohm's Law as shown in fig 7.

Load Current through Load Resistor...

$$I_L = I_N \times \left(\frac{R_N}{R_N + R_L} \right) = 2A \times \left(\frac{4.5\Omega}{4.5\Omega + 1.5\Omega} \right) = 1.5A$$

$$I_L = 1.5A$$

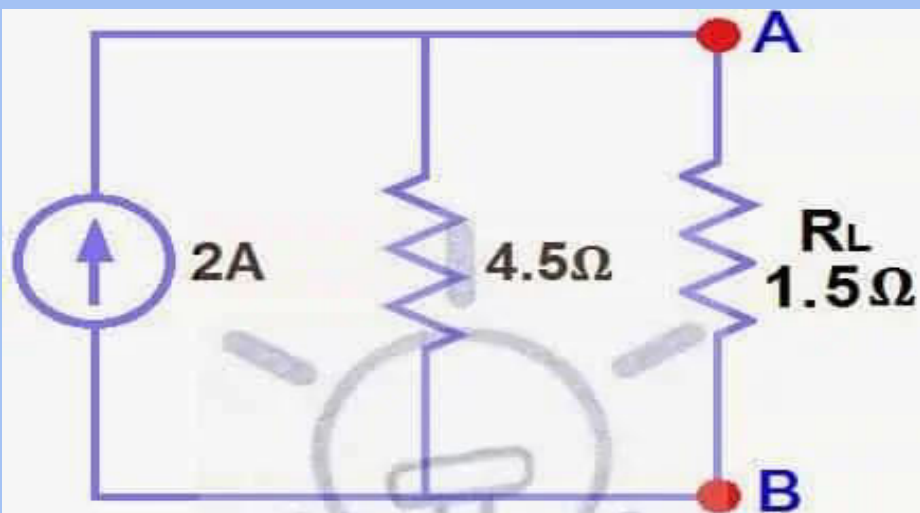
And

Load Voltage across Load Resistor...

$$V_L = I_L \times R_L$$

$$V_L = 1.5A \times 1.5\Omega$$

$$V_L = 2.25V$$



$$I_L = I_N \times \frac{R_N}{(R_N + R_L)} \text{CDR}$$

$$= 2A \times \frac{4.5\Omega}{(4.5\Omega + 1.5\Omega)} = I_L = 1.5A$$

$$V_L = I_L \times R_L$$

$$V_L = 1.5A \times 1.5\Omega$$

$$V_L = 2.25V$$

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