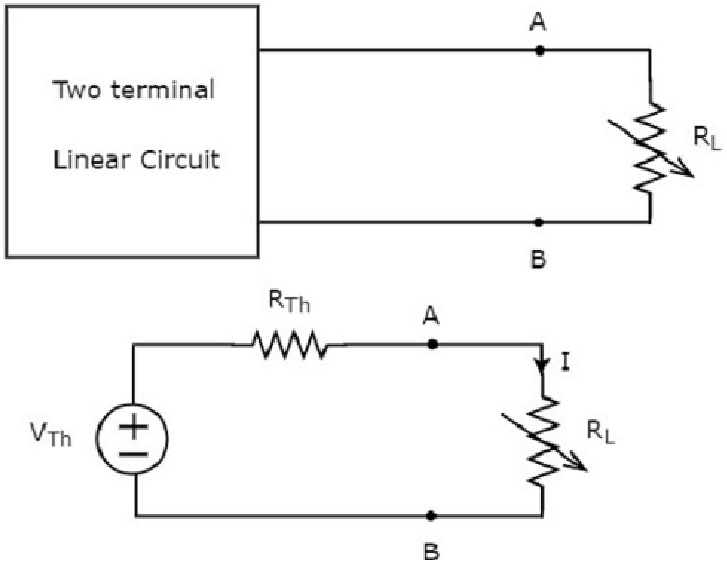
Maximum power transfer theorem

Maximum Power Transfer Theorem

- DC voltage source will deliver maximum power to the variable load resistor only when the load resistance is equal to the source resistance.
- AC voltage source will deliver maximum power to the variable complex load only when the load impedance is equal to the complex conjugate of source impedance.

Proof of Maximum Power Transfer Theorem



- Transform any linear network or circuit to the *two parts.*
  - *Equivalent source (use Thevenin's theorem/Norton's theorem)*
  - *Load* R_L

Proof of Maximum Power Transfer Theorem

- The amount of power dissipated across the load resistor is $P_L = I^2 R_L$
- Substitute $I = \frac{V_{TH}}{R_{TH}+R_L}$ $(from\ thevenin's\ theorem)$
- Then $P_L = \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 R_L$
- For maximum or minimum, first derivative will be zero. So, differentiate above equation with respect to R_L and make it equal to zero.
- We get a condition that $R_{L=}R_{TH}$
- That means, if the value of load resistance is equal to the value of source resistance. i.e., Thevenin's resistance, then the power dissipated across the load will be of maximum value.

The value of Maximum Power Transfer

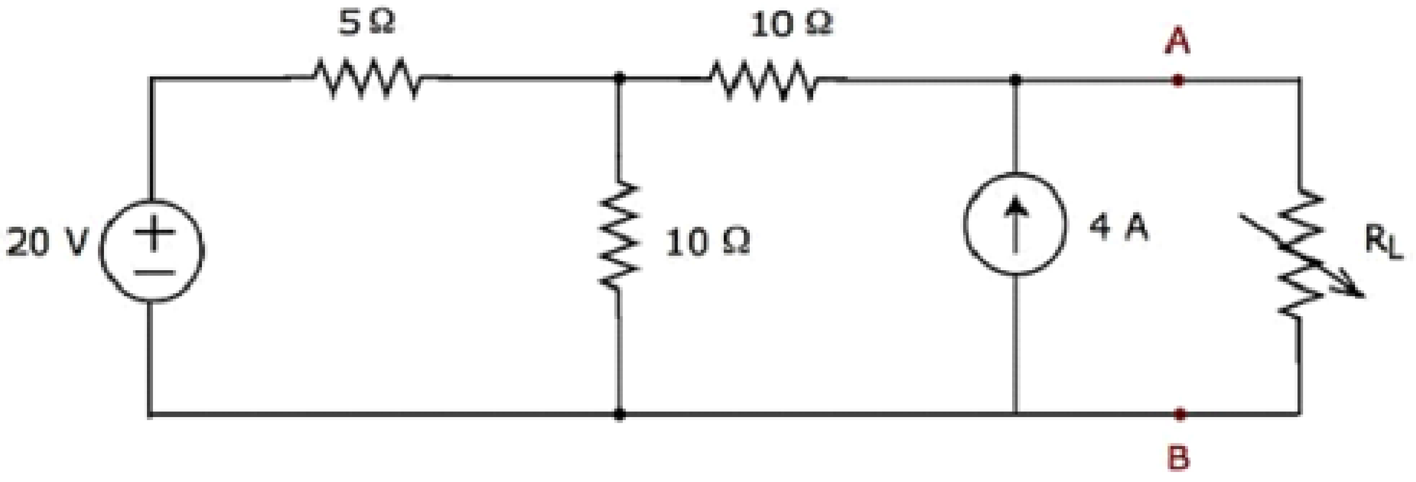
- Substitute $R_L = R_{TH}$ and $P_L = P_{MAX}$ in $P_L = \left(\frac{V_{TH}}{R_{TH}+R_L}\right)^2 R_L$
- We get, $P_{MAX} = \frac{{V_{TH}}^2}{4R_{TH}} = \frac{{V_{TH}}^2}{4R_L}$

Efficiency of Maximum Power Transfer

- We can calculate the efficiency of maximum power transfer, η_{max} using formula $\eta_{max} = \frac{P_{MAX}}{P_S}$
- Where, P_{MAX} is the maximum amount of power transferred to the load and P_S is the amount of power generated by the source.
- Power generated by the source $P_S = I^2(R_{TH} + R_L)$
- Since $R_{TH} = R_L$ therefore $P_S = 2I^2R_{TH} = 2I^2R_L = \frac{V_{TH}^2}{2R_{TH}} = \frac{V_{TH}^2}{2R_L}$
- $\eta_{max} = \frac{P_{MAX}}{P_S} = \frac{\frac{{V_{TH}}^2}{4R_{TH}}}{\frac{V_{TH}^2}{2R_{TH}}} = \frac{1}{2}$
- Therefore, the efficiency of maximum power transfer is **50 %**.

Question-1

Find the **maximum power** that can be delivered to the load resistor R_L of the circuit shown in the following figure

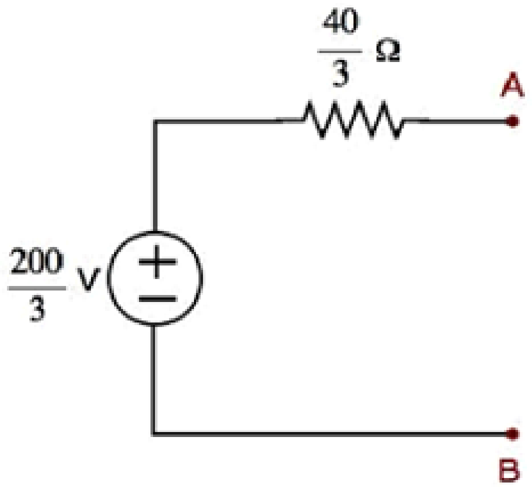


Solution

Step 1 – Using Thevenin's Theorem we calculated the Thevenin's equivalent circuit to the left side of terminals A & B. We can use this circuit now. It is shown in the following figure.

$$V_{TH} = \frac{200}{3} \text{volt}$$

$$R_{TH} = \frac{40}{3} \Omega$$



Step 2 − Replace the part of the circuit, which is left side of terminals A & B of the given circuit with the above Thevenin's equivalent circuit. The resultant circuit diagram is shown in the following figure.

Solution

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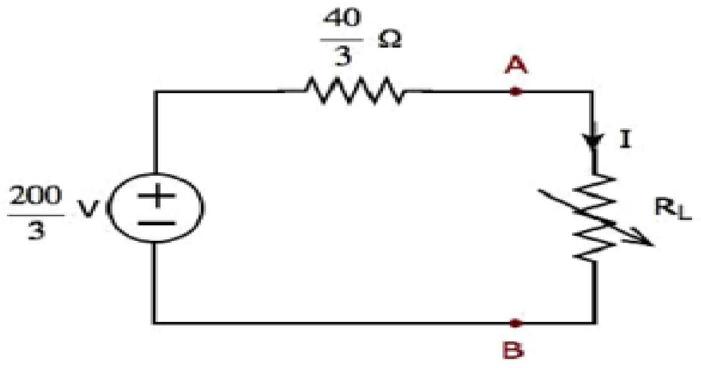

Step 3 − We can find the maximum power that will be delivered to the load resistor, R_L by using the following formula

$$P_{MAX} = \frac{{V_{TH}}^2}{4R_{TH}} = \frac{(\frac{200}{3})^2}{4 \times \frac{40}{3}} = \frac{250}{3} watts$$


Thank You!