Basic Electrical Technology

Superposition & Maximum Power Transfer Theorems

Terminologies Used

- **Linear element:** V-I characteristics is linear. E.g: R, L, C
- **Non-linear element:** V-I characteristics is non-linear. E.g: Diode
- **Unilateral element:** Property changes with the direction of operation. E.g: Diode
- **Bi-lateral element:** Property does not change with direction of operation. E.g: R, L, C
- **Linear Circuit:** Circuit with linear elements only
- **Bi-lateral circuit:** Circuit with bi-lateral elements only.
- **Response:** The output of the network. E.g: current, voltage

Superposition Theorem

Definition

- In **any linear, bi-lateral** network, **total response** is the **sum** of partial responses.

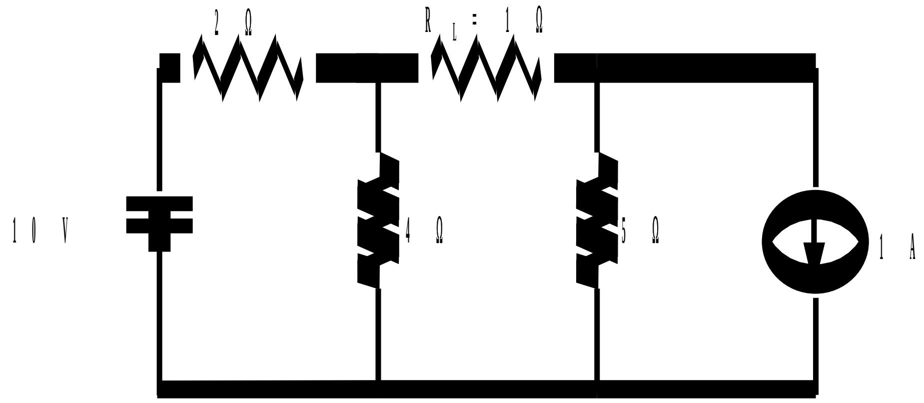
- In any linear, bilateral network, the total response may be determined by adding the responses due to individual sources, considering one source at a time and replacing the other sources by their internal resistances.

Procedure

1. Draw the circuit with passive elements only.
2. Place one of the sources in its position.
3. Replace the other sources by their internal resistances. Ex: Ideal voltage source by short circuit, ideal current source by open circuit.
4. Find the response using one of the methods, i.e., network reduction, mesh current, node voltage methods.
5. Repeat the procedure for all the sources.
6. Add the responses due to individual sources.

Illustration 1

Find the current through 1 Ω resistor using Superposition theorem



Ans: $I_{1\Omega}$ = 1.59 A

Illustration 2

Find the current I_0 using Superposition theorem

Ans: I_0 = -0.105 A

Maximum Power Transfer Theorem

Definition

In **any linear, bi-lateral network**, maximum power will be transferred to the load from the network when the load resistance is equal to the internal resistance of the network.

Proof

Consider the Thevenin's equivalent circuit of a network

$$I_L = \frac{V_{Th}}{R_{Th}+R_L}$$

$$P_L = \left(\frac{V_{Th}}{R_{Th}+R_L}\right)^2 R_L$$

$$For P_L \ to \ be \ maximum, \frac{dP_L}{dR_L} = 0$$

$$which \ yields, \boldsymbol{R_L = R_{Th}}$$

$$Maximum \ Power,$$

$$P_{L-max} = \left(\frac{V_{Th}}{R_{Th}+R_{Th}}\right)^2 R_{Th} = \frac{V_{Th}^2}{4R_{Th}}$$

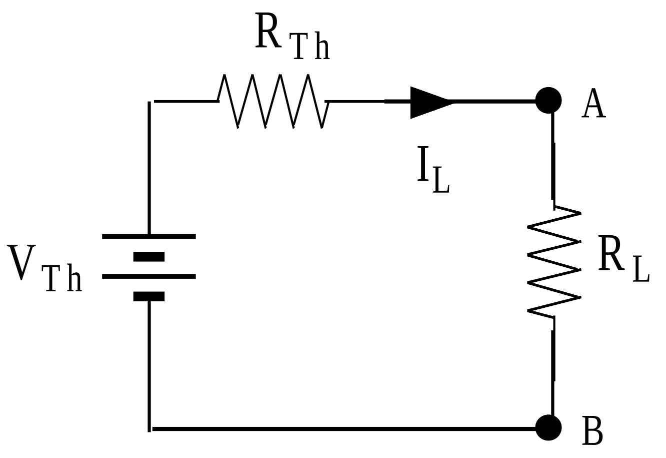
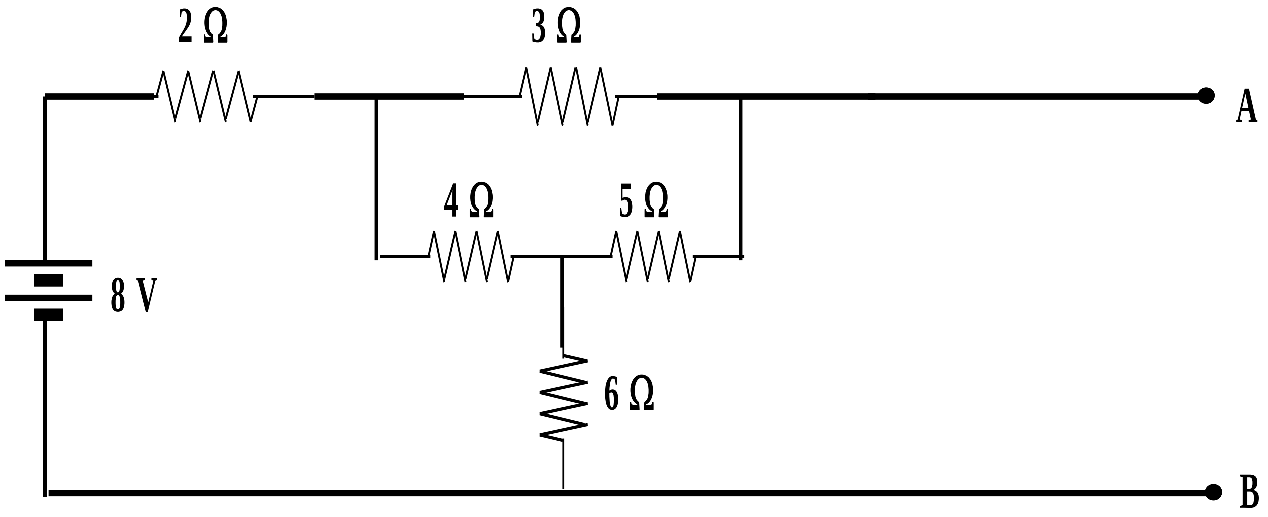


Illustration 3

Determine the value of resistor to be connected across the terminals A & B such that maximum power is transferred to the that resistor. Also, find the value of maximum power.



Ans: 3.41 Ω, 2.43 W