



MANIPAL INSTITUTE OF TECHNOLOGY

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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

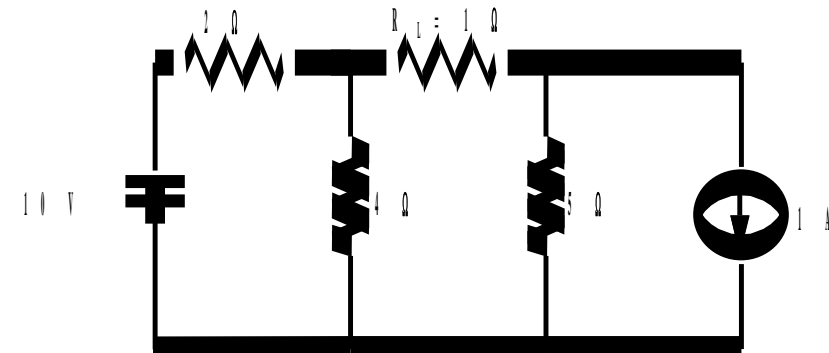
- In **any linear, bi-lateral** network, **total response** is the **sum** of partial responses.
- In any linear, bilateral network, the total response may be determined by adding the responses due to individual sources, considering one source at a time and replacing the other sources by their internal 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.
 - a. Ideal **voltage** source by **short** circuit,
 - b. 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 $1\ \Omega$ resistor using Superposition theorem



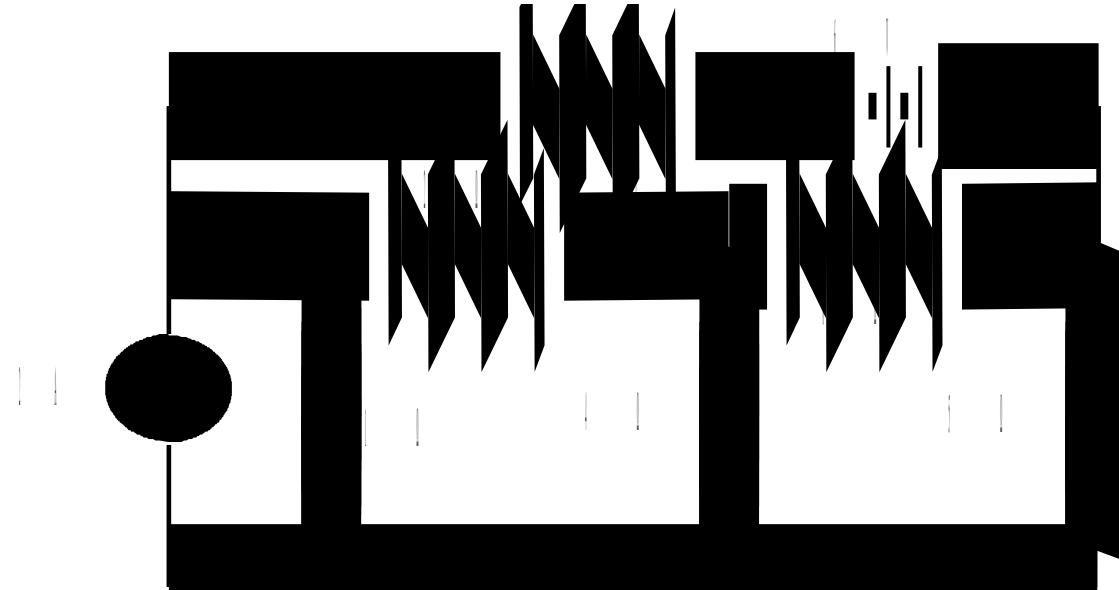
Ans: $I_{1\Omega} = 1.59\text{ A}$

Limitations of superposition Theorem

- **Doesn't work for power calculation**
 - Involves product of voltage and current,
 - the square of current or
 - the square of the voltage,
 - which are **non-linear** operations
- **cannot be applied for nonlinear circuit**

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, $R_L = R_{Th}$

Maximum Power,

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

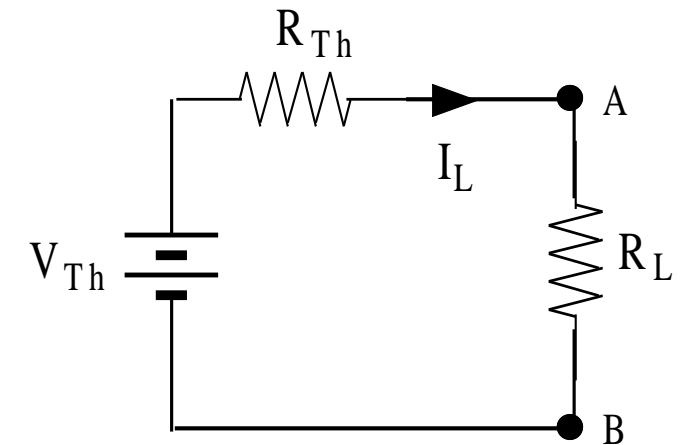
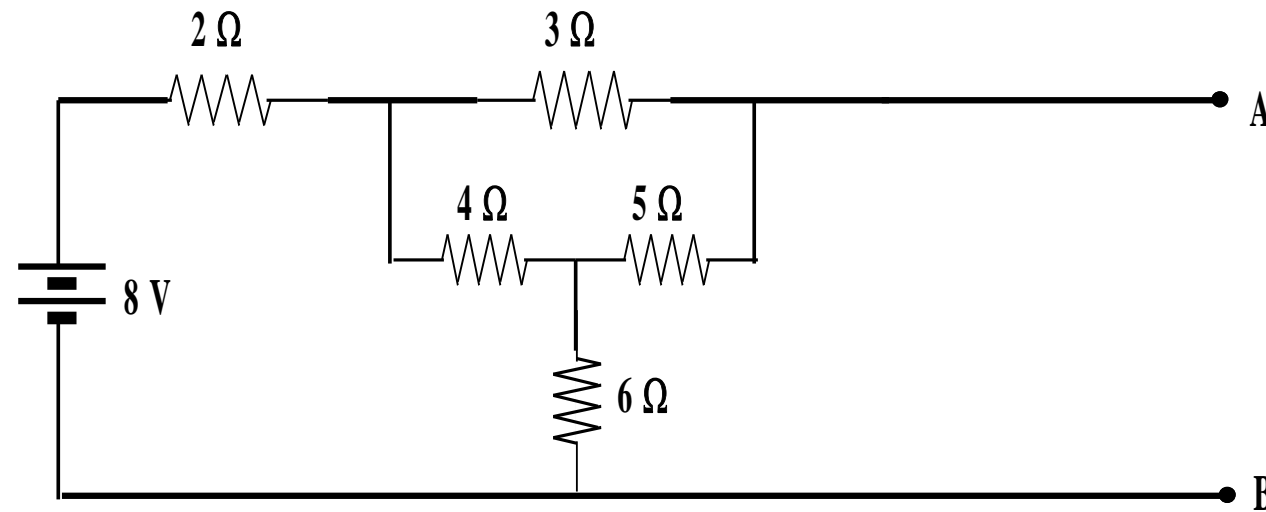


Illustration 3

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: $3.41\ \Omega$, $2.43\ \text{W}$