STATE AND EXPLAIN THEVENIN'S THEOREM :

Thevenin's Theorem — State and Explain

Statement:
Thevenin's theorem states that *any linear, bilateral two-terminal electrical network containing sources and impedances can be replaced, as seen from its terminals, by an equivalent circuit consisting of a single ideal voltage source V_{th} in series with a resistance R_{th}.*
This equivalent circuit produces the **same voltage and current** in the external load as the original network.

Explanation

According to Thevenin's theorem, a complex network can be simplified into:

- **Thevenin voltage V_{th}:**
  The **open-circuit voltage** across the two terminals (load removed).
- **Thevenin resistance R_{th}:**
  The **equivalent resistance** seen from the terminals when:
  - All **independent voltage sources** are replaced by short circuits
  - All **independent current sources** are replaced by open circuits
    (Dependent sources, if any, are left unchanged)

Steps to Apply Thevenin's Theorem

1. **Remove the load resistance R_L** from the circuit.
2. **Find V_{th}:**
   Calculate the voltage across the open terminals.
3. **Find R_{th}:**
   Deactivate all independent sources and determine the resistance seen from the terminals.
4. **Draw the Thevenin equivalent circuit:**
   A voltage source V_{th} in series with resistance R_{th}.
5. **Reconnect the load R_L** and find the required current or voltage using simple circuit analysis.

Thevenin Equivalent Circuit

Vth

──(⊕ ⊖)── Rth ── RL ──

Advantages of Thevenin's Theorem

- Simplifies complex circuits
- Easy analysis when the load changes
- Reduces calculations in power system and network analysis

Limitations

- Applicable only to **linear, bilateral networks**
- Not valid for **non-linear elements** like diodes (unless linearized)

Norton's Theorem — State and Explain

Statement

Norton's theorem states that *any linear, bilateral electrical network containing voltage sources, current sources, and resistances can be replaced by an equivalent circuit consisting of a single current source* I_N *in parallel with a single resistance* R_N*, as seen from the load terminals.*

Explanation / Procedure

To find the Norton equivalent of a network across two terminals:

1. **Remove the Load Resistance**
   Disconnect the load from the circuit.
2. **Find Norton Current (I_N)**
   Short-circuit the load terminals and calculate the **short-circuit current** flowing between them. This current is the Norton current.
3. **Find Norton Resistance (R_N)**
   - Deactivate all independent sources:
     - Replace voltage sources with short circuits.
     - Replace current sources with open circuits.

- Find the equivalent resistance seen from the open terminals. This resistance is R_N.

4. **Draw Norton Equivalent Circuit**
   Replace the original network with a current source I_N in parallel with resistance R_N.

5. **Reconnect the Load**
   Connect the load resistance in parallel with the Norton equivalent circuit to easily calculate load current.

Applications of Norton's Theorem

1. **Simplification of Complex Circuits**
   Converts complicated electrical networks into a simple **current source in parallel with resistance**, making analysis easier.

2. **Easy Load Current Calculation**
   Useful for quickly finding current through different load resistances without re-analyzing the entire circuit.

3. **Analysis of Parallel Networks**
   Especially helpful in circuits where **parallel connections** are dominant.

4. **Power System Analysis**
   Used in fault analysis and short-circuit current calculations in power systems.

5. **Electronic Circuit Design**
   Helps in designing and analyzing amplifier and electronic circuits.

Limitations of Norton's Theorem

1. **Applicable Only to Linear Networks**
   Cannot be used for **non-linear elements** like diodes, transistors, or magnetic saturation.

2. **Not Valid for Unilateral Networks**
   The theorem applies only to **bilateral networks**.

3. **Not Directly Applicable with Dependent Sources Alone**
   Special methods are required if the circuit contains only dependent sources.

4. **Less Convenient for Voltage Analysis**
   Not ideal when the main requirement is to find **voltage across the load**.

5. **Requires Source Transformation**
   Source deactivation may not always be simple in practical circuits.

Maximum Power Transfer Theorem — State and Explain

Statement

Maximum Power Transfer Theorem states that *maximum power is transferred from a source to the load when the load resistance is equal to the internal (Thevenin) resistance of the source network.*

$$\boxed{R_L = R_{th}}$$

Explanation

Consider a network replaced by its **Thevenin equivalent** consisting of a voltage source V_{th} and resistance R_{th} supplying a load R_L.

- The power delivered to the load is

$$P_L = \frac{V_{th}^2 R_L}{(R_{th}+R_L)^2}$$

- By differentiating the power expression with respect to R_L and equating to zero, it can be shown that **maximum power occurs when**:

$$R_L = R_{th}$$

- Under this condition, the maximum power delivered to the load is:

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

For AC Circuits

In AC circuits, maximum power is transferred when the **load impedance is the complex conjugate of the source impedance**:

$$Z_L = Z_{th}^*$$

Key Points

- At maximum power transfer, **efficiency is 50%**
- Half of the power is dissipated in the source resistance

Applications

- Audio and communication systems
- Impedance matching circuits
- Electronic amplifiers

Limitations

- Low efficiency (50%)
- Not suitable for power transmission systems

PROBLEMS ARE DONE IN NOTES (REFER NOTES)