Network Theorems

4.1 Superposition Theorem and Reciprocity

4.2 Source Transformation, Thevenin's and Norton's Theorem

4.3 Millman's Theorem

4.3 Maximum Power Transfer Theorem

4.4 Substitution Theorem

4.5 Compensation Theorem

SUPERPOSITION THEOREM

Superposition Theorem

Superposition : the voltage across (or current through) an element in a linear circuits is the algebraic sum of the voltage across (or current through) that element due to each independent source acting alone.

Current Source → open circuit(0 A)

Voltage Source → short circuit (0 V)

Superposition Theorem

Step to apply:

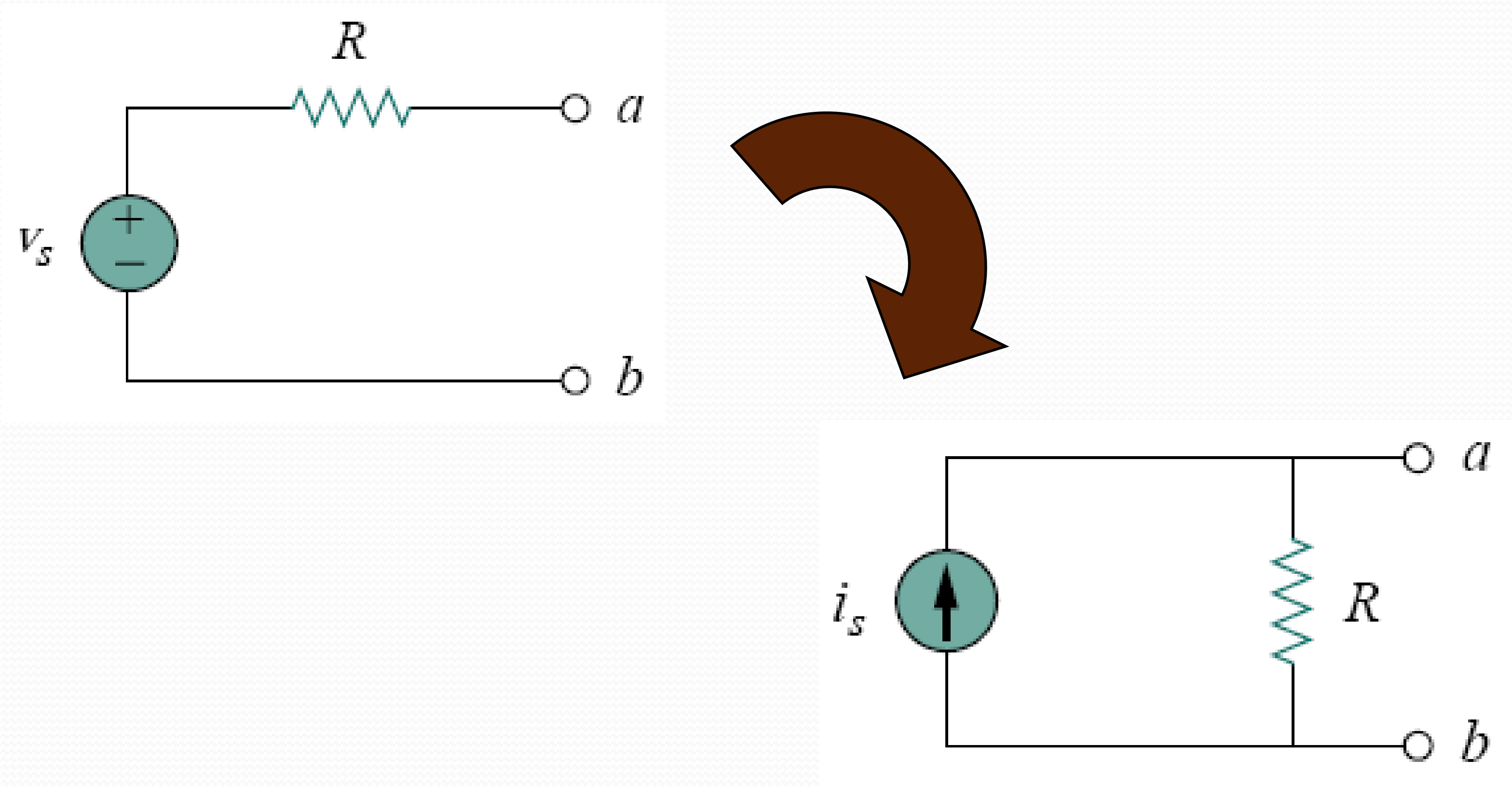
1. Turn off all independent sources except one source. Find the output (voltage or current) due to that active source.
2. Repeat step 1 for each other independent sources.
3. Find the total contribution by adding algebraically all the contribution due to the independent source.

SOURCE TRANSFORMATION

Source Transformation

Source transformation : replacing a voltage source v_s in series with a impedance Z by a current source i_s in parallel with a impedance Z, or vice versa.

Source Transformation

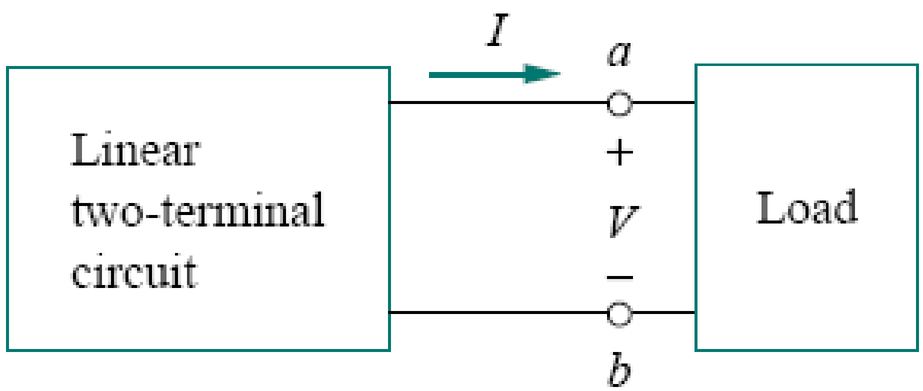


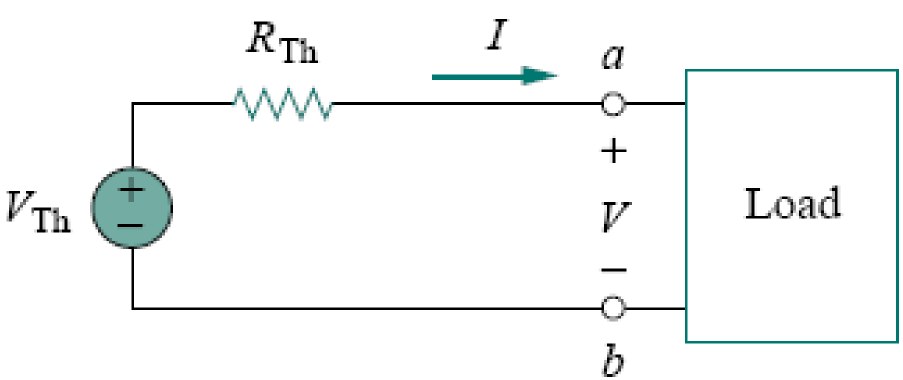
THEVENIN’S THEOREM

Thevenin's Theorem

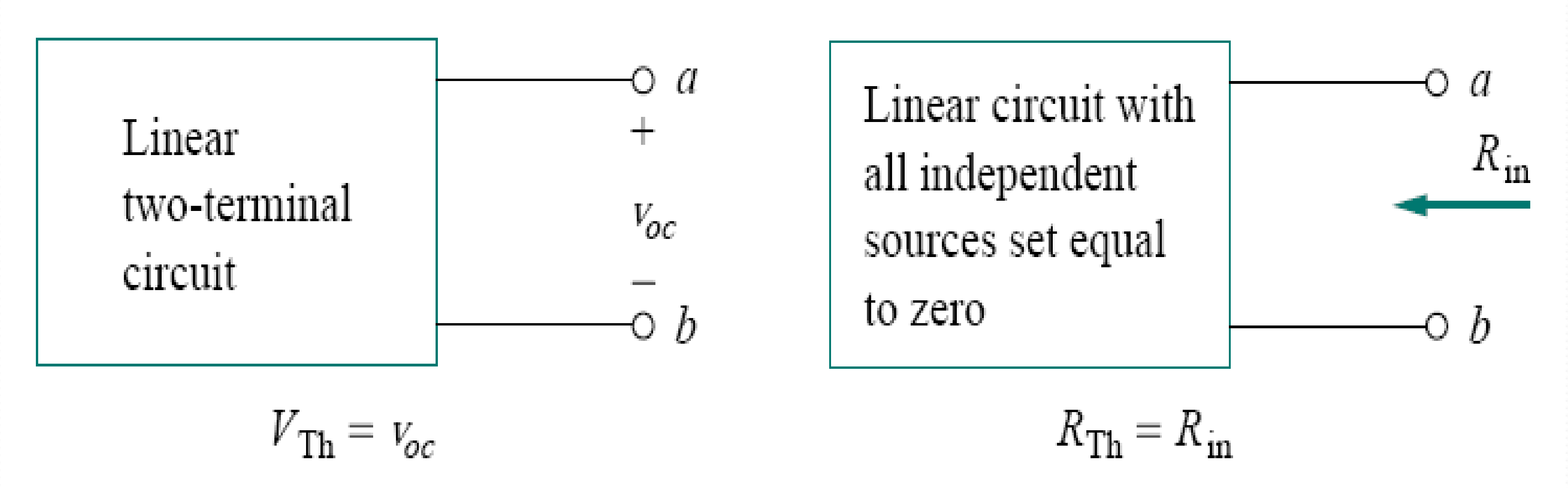
Thevenin's theorem : a linear two terminal circuit can be replaced by an equivalent circuit consisting of a voltage V_{Th} in series with an impedance Z_{Th} , where V_{Th} is the open circuit voltage at the terminals and Z_{Th} is the input or equivalent impedance at the terminals when the independent source are turned off.

Thevenin’s Theorem



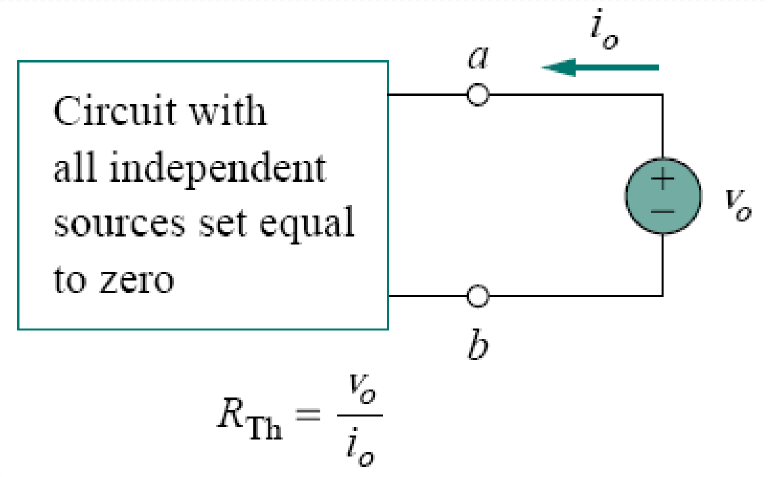


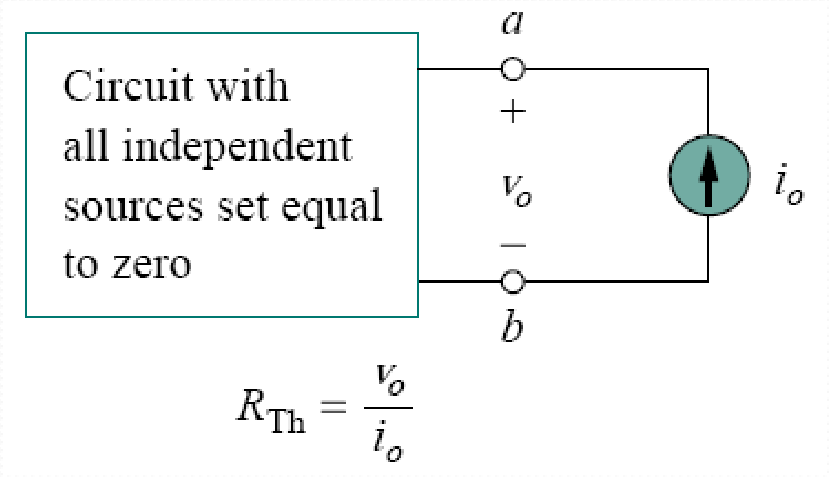
Thevenin's Theorem



Finding V_{Th} and Z_{Th}

Thevenin's Theorem

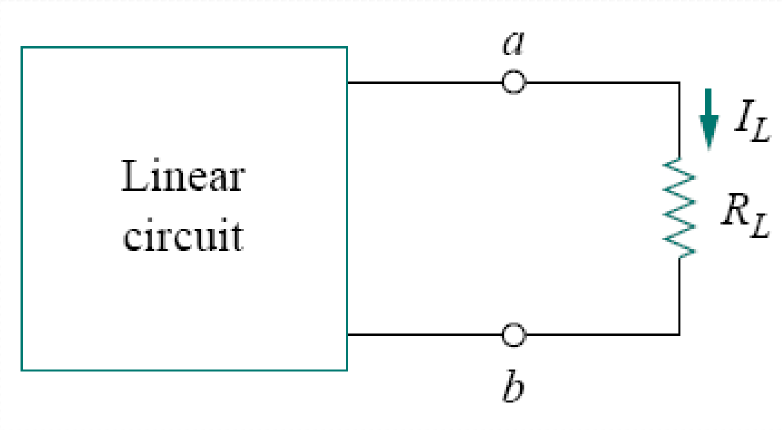


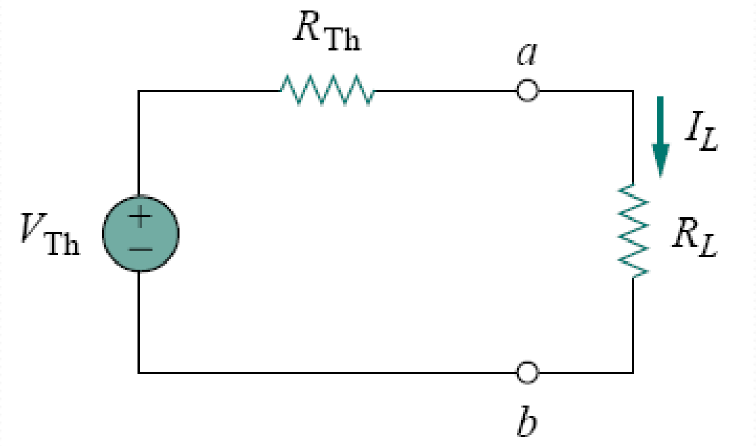


Finding Z_{Th} when circuit has dependent sources

Thevenin's Theorem

Circuit with load





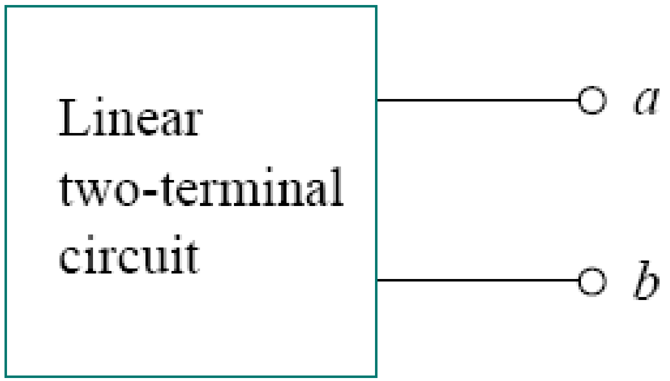
$$I_L = \frac{V_{Th}}{R_{Th} + R_L} \qquad V_L = R_L I_L = \frac{R_L}{R_{Th} + R_L} V_{Th}$$

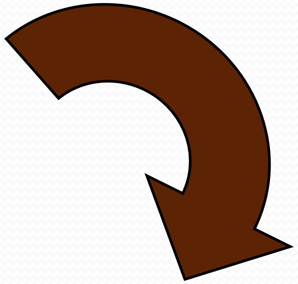
NORTON’S THEOREM

Norton’s Theorem

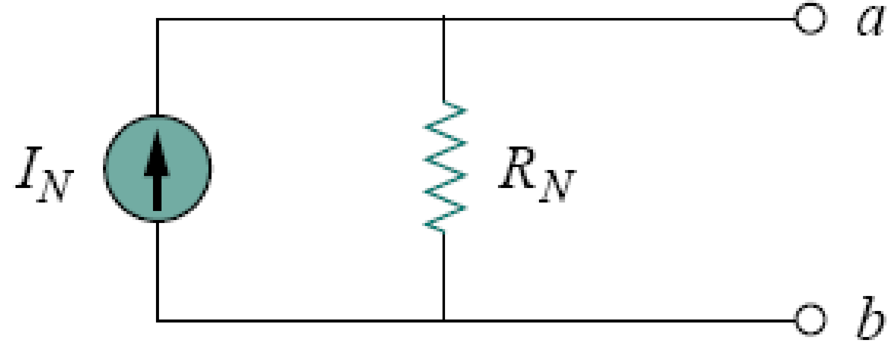
Norton’s Theorem : a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a current source I_N in parallel with an impendence Z_N, where I_N is the short circuit current through the terminals and Z_N is the input or equivalent impedance at the terminals when the independent source are turned off.

Norton's Theorem



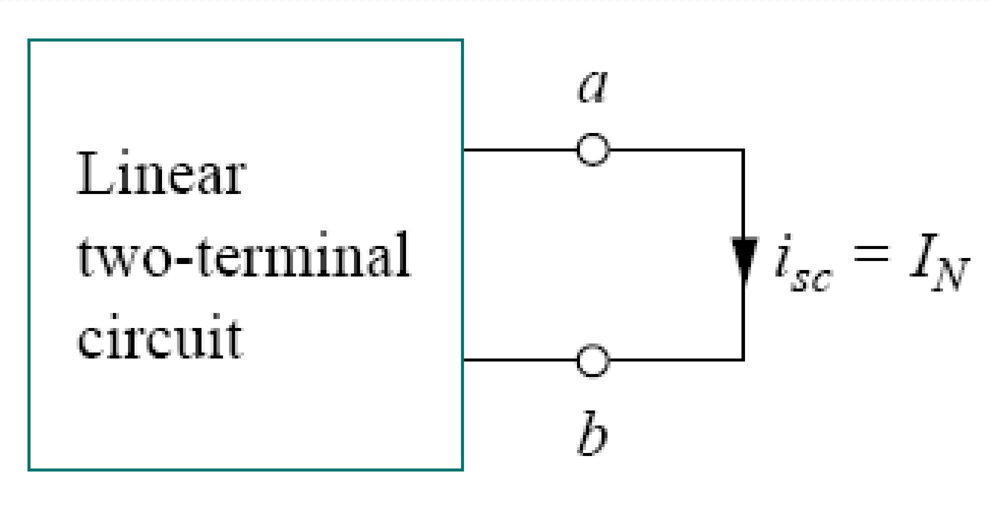


$$R_N = R_{Th}$$



Norton's Theorem

Finding Norton current I_N.



$$I_N = i_{sc}$$

$$I_N = \frac{V_{Th}}{R_{Th}}$$

Thevenin and Norton Equivalent

$$V_{Th} = v_{oc}$$

$$I_N = i_{sc}$$

$$R_{Th} = \frac{v_{oc}}{i_{sc}} = \frac{V_{Th}}{I_N} = R_N$$

Millman's Theorem

- A number of voltage sources in parallel can be replaced by a single ideal voltage source V in series with an impedance Z where

$$V = \frac{\sum_{i=1}^{n} V_i Y_i}{\sum_{i=1}^{n} Y_i}$$

$$Z = \frac{1}{\sum_{i=1}^{n} Y_i}$$

Millman's Theorem

- A number of current sources in series can be replaced by a single ideal current source I in parallel with an impedance Z where

$$I = \frac{\sum_{i=1}^{n} (I_i / Y_i)}{\sum_{i=1}^{n} (1/Y_i)} \qquad Y = \frac{1}{\sum_{i=1}^{n} (1/Y_i)}$$

MAXIMUM POWER TRANSFER THEOREM

Maximum Power Transfer Theorem

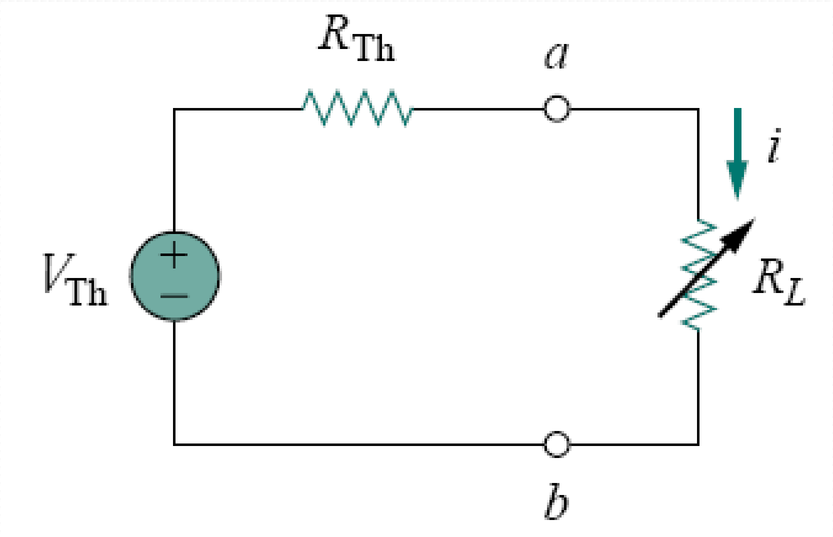
Maximum power : transferred to the load when the load resistance equals the Thevenin resistance as seen from the load

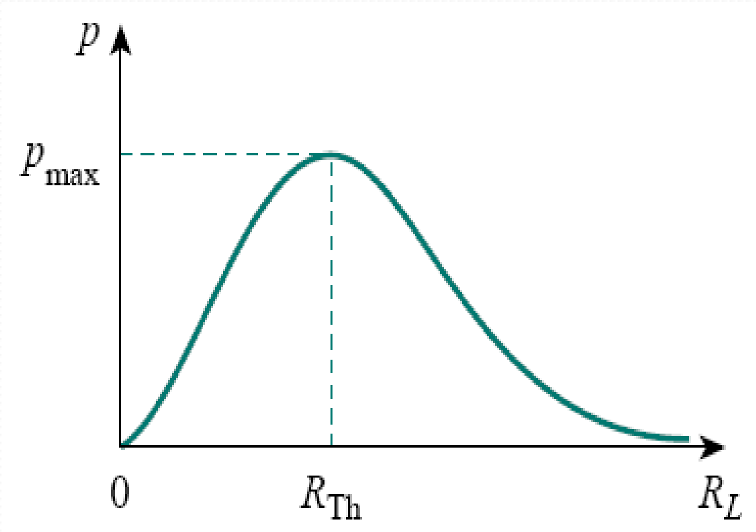
$$R_L = R_{Th}$$

Maximum power : transferred to the load when the load impedance equals the conjugate of the Thevenin impedance as seen from the load

$$Z_L = Z^*_{Th}$$

Maximum Power Transfer





$$R_L = R_{Th}$$

$$p_{max} = \frac{V_{Th}^2}{4R_{Th}}$$