Chapter 4 — Circuit Theorems: Norton's Theorem & Maximum Power Transfer

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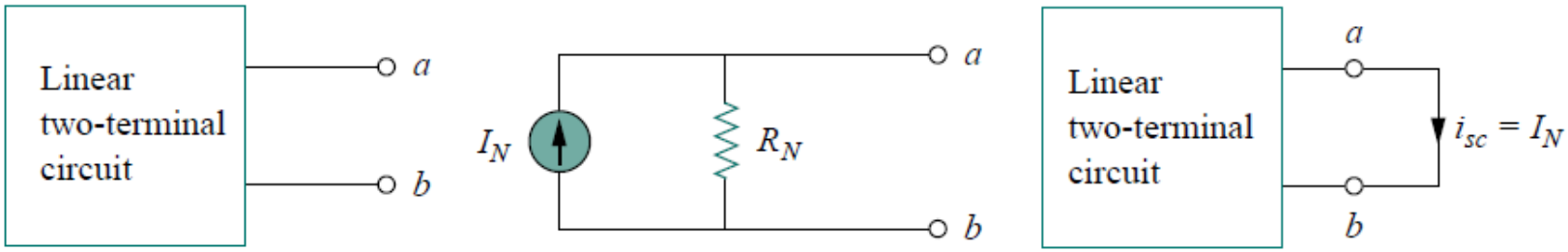
Overview

Reference:

[1] Alexander Sadiku, Fundamentals of Electric Circuits, 4th ed. McGraw-Hill, 2009.

Norton's Theorem

Norton's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a current source I_N in parallel with a resistor R_N, where I_N is the short-circuit current through the terminals and R_N is the input or equivalent resistance at the terminals when the independent sources are turned off.

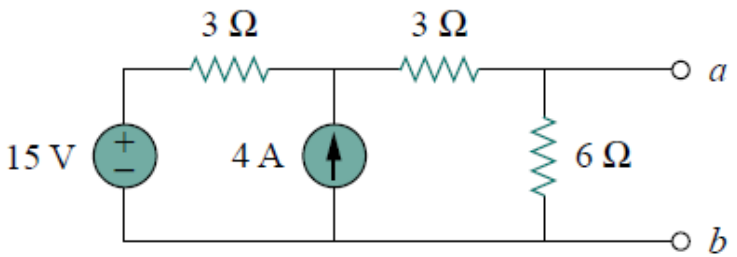


$$R_N = R_{Th}, \qquad I_N = I_{sc} = \frac{V_{Th}}{R_{Th}}$$

Example

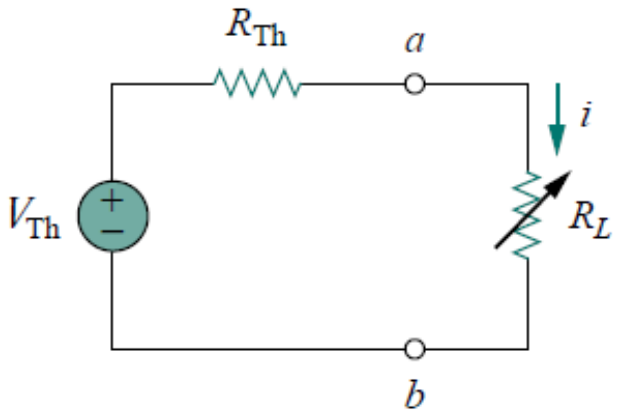
Find the Norton equivalent circuit for the circuit shown.

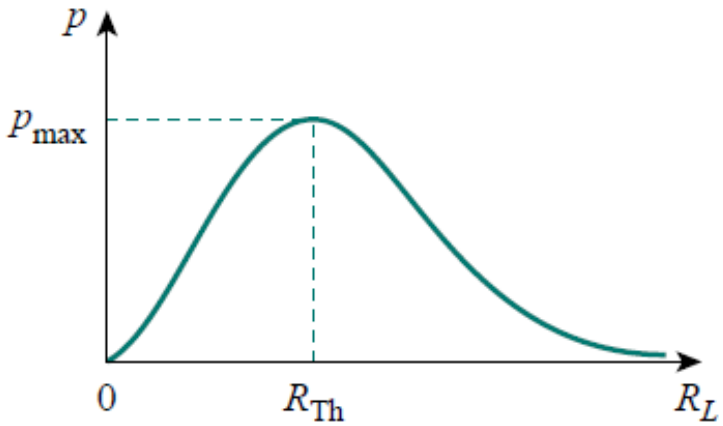
Answer: $R_N = 3\Omega$, $I_N = 4.5$ A



Maximum Power Transfer

Maximum power is transferred to the load when the load resistance equals the Thevenin resistance as seen from the load ($R_L = R_{Th}$).





Maximum Power Transfer (cont'd)

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

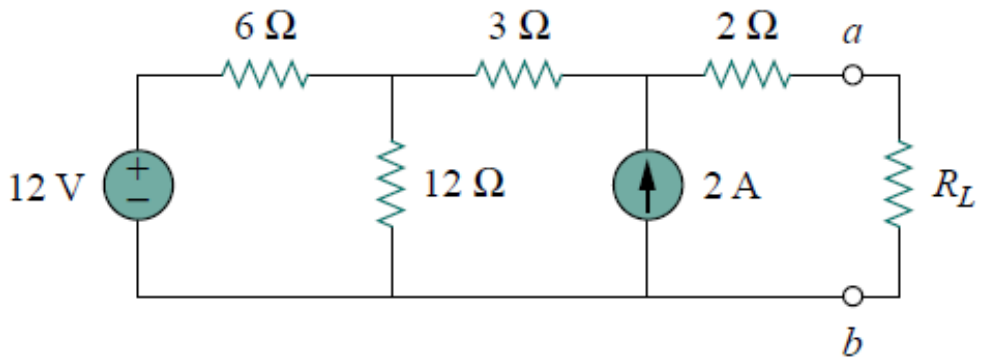
$$\begin{aligned} \frac{dp}{dR_L} &= V_{Th}^2 \left[\frac{(R_{Th}+R_L)^2 - 2R_L(R_{Th}+R_L)}{(R_{Th}+R_L)^4} \right] \\ &= V_{Th}^2 \left[\frac{R_{Th}-R_L}{(R_{Th}+R_L)^3} \right] \end{aligned}$$

$$\text{for max. power} \quad \frac{dp}{dR_L} = 0 \quad \Rightarrow R_{Th} = R_L$$

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

Example

Find the value of R_L for maximum power transfer in the circuit shown. Find the maximum power.
Answer: 9Ω and 13.44 W



Conclusions

Concluding remarks

- Norton's Theorem has been studied highlighted by some examples
- The condition for maximum power transfer has been addressed with an example