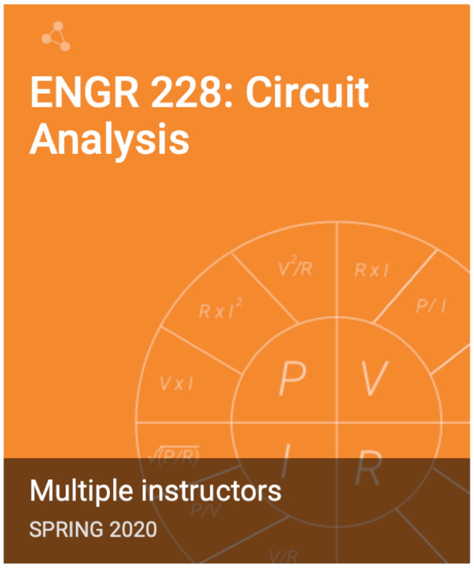


Chapter 3.10

Analysis Techniques

Maximum Power Transfer

Engr228 - Circuit Analysis

Spring 2020

Dr Curtis Nelson

Section 3.10 Objective

- Learn to establish the conditions for maximum transfer of current, voltage, or power from an input circuit to an external load.

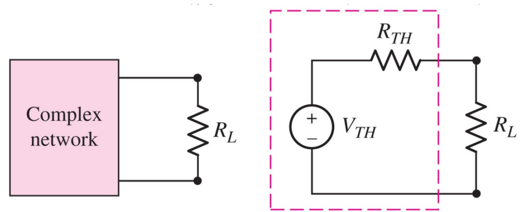
Finding the Thévenin Equivalent

- Disconnect the load;
- Find the open circuit voltage v_{oc};
- Find the equivalent resistance R_{eq} of the network with all independent sources turned off.
  - Set voltage sources to zero volts → short circuit
  - Set current sources to zero amps → open circuit

Then:

$V_{TH} = v_{oc}$ and

$R_{TH} = R_{eq}$

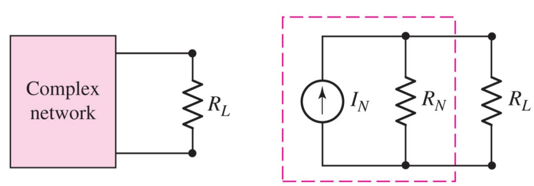


Finding the Norton Equivalent

- Replace the load with a short circuit;
- Find the short circuit current i_{sc};
- Find the equivalent resistance R_{eq} of the network with all independent sources turned off (same as Thévenin)
  - Set voltage sources to zero volts → short circuit;
  - Set current sources to zero amps → open circuit.

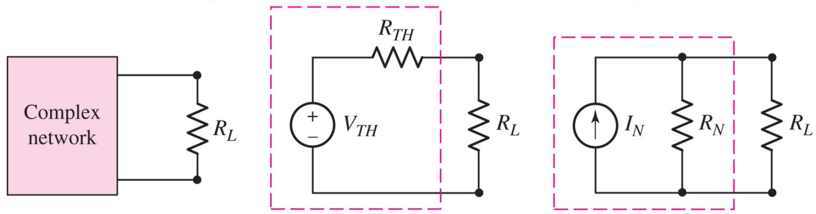
Then:

$I_N = i_{sc}$ and $R_N = R_{eq}$



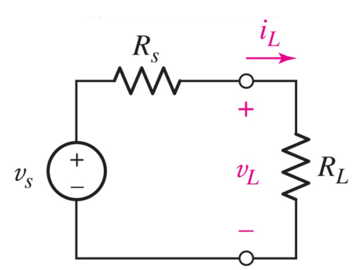
Source Transformation: Norton and Thévenin

The Thévenin and Norton equivalents are source transformations of each other.

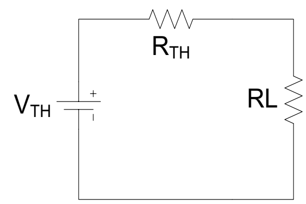


Maximum Power Transfer

Thévenin's or Norton's equivalent circuit delivers a maximum power to the load R_L for which $R_{TH} = R_L$



Maximum Power Theorem Proof



$P = I^2 R_L$ and $I = \dfrac{V_{TH}}{R_{TH} + R_L}$

Plug it in $P = \left(\dfrac{V_{TH}}{R_{TH} + R_L}\right)^2 \cdot R_L = \dfrac{V_{TH}{}^2 R_L}{(R_{TH} + R_L)^2}$

$$\frac{dP}{dR_L} = \frac{(R_{TH} + R_L)^2 V_{TH}{}^2 - V_{TH}{}^2 R_L \cdot 2(R_{TH} + R_L)}{(R_{TH} + R_L)^4} = 0$$

Maximum Power Theorem Proof - continued

$$\frac{dP}{dR_L} = \frac{(R_{TH} + R_L)^2 V_{TH}{}^2 - V_{TH}{}^2 R_L \cdot 2(R_{TH} + R_L)}{(R_{TH} + R_L)^4} = 0$$

$$(R_{TH} + R_L)^2 V_{TH}{}^2 = V_{TH}{}^2 R_L \cdot 2(R_{TH} + R_L)$$

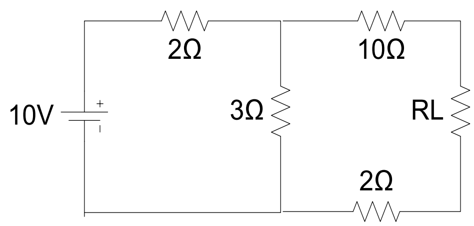
$$(R_{TH} + R_L) = 2R_L$$

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

For maximum power transfer

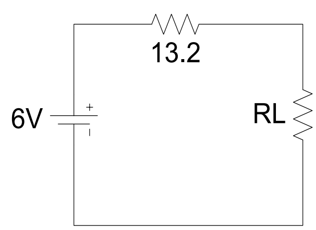
Maximum Power Example

Evaluate RL for maximum power transfer and find the power.



Maximum Power Example - continued

Thévenin's equivalent circuit



RL should be set to 13.2Ω to get maximum power transfer.

Max. power is $\dfrac{V^2}{R} = \dfrac{(6/2)^2}{13.2} = 0.68W$

Section 3.10 Summary

- You learned to establish the conditions for maximum transfer of current, voltage, or power from an input circuit to an external load.