Network Theorems

Chapter 04

Circuit analysis techniques

A direct application of Kirchhoff 's current and voltage laws using the principles discussed in Chapter 3 can solve many circuit problems.

There are a techniques, based on these two laws, that can simplify circuit analysis.

The main techniques are:

- Mesh analysis.
- Nodal analysis.
- Thévenin's theorem.
- Norton's theorem.

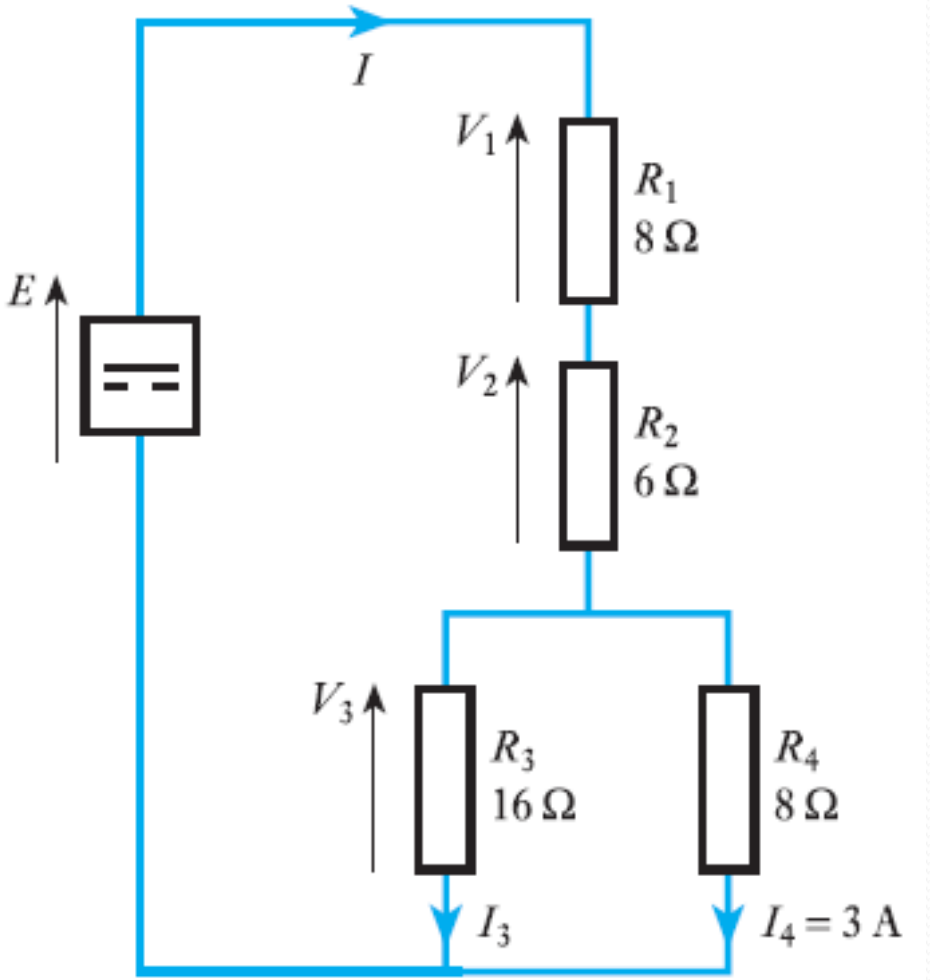
Kirchhoff's laws & network solution

- Kirchhoff's laws can be applied to networks in any of the following ways:
  - By direct application to the network using Ohm's law
  - By indirect application to the network
  - By direct application to the network solving simultaneous equations.

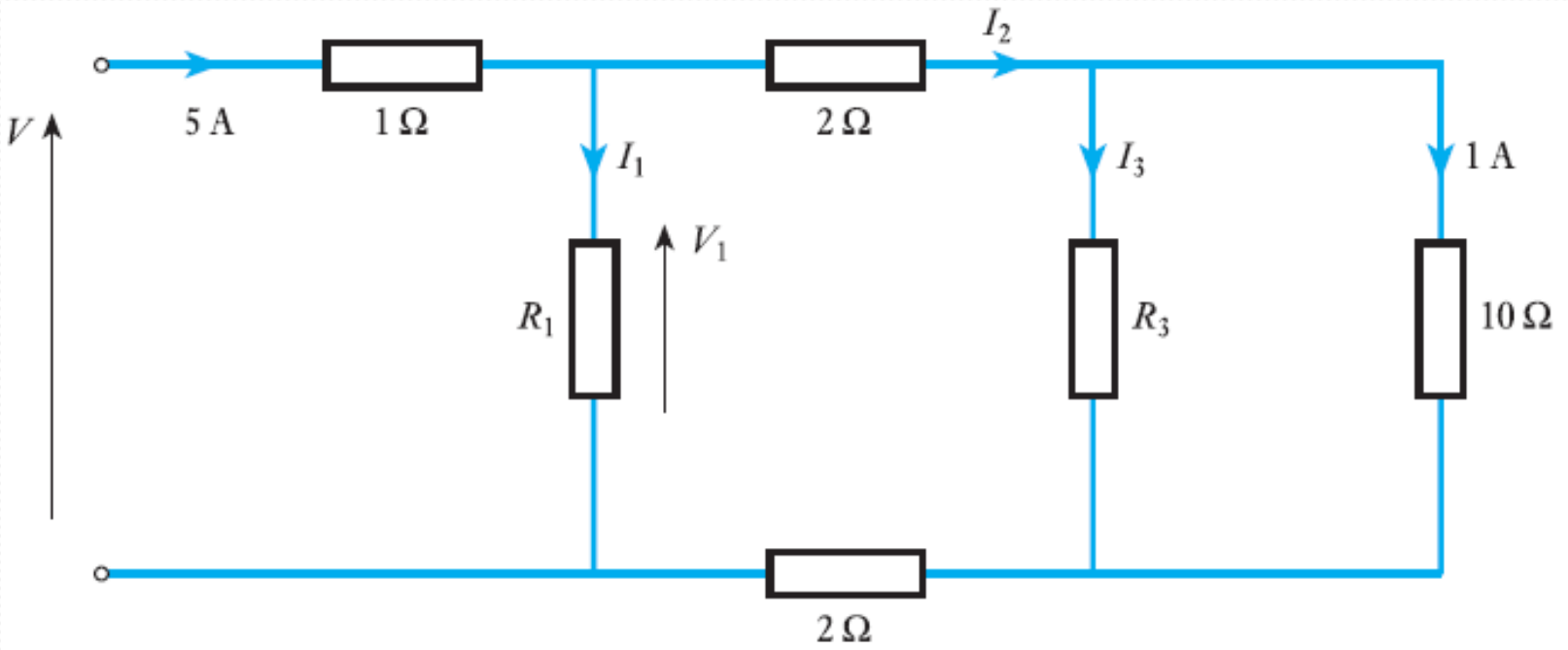
It is very easy and systematic !

Direct application of Kirchhoff's laws

For the network shown, determine the supply current and the source e.m.f.



Direct application of Kirchhoff's laws



For the network shown, the power dissipated in *R*3 is 20 W. Calculate the current *I*3 and hence evaluate *R*1, *R*3, *I*1, *I*2 and *V*.

Superposition theorem

- The Superposition theorem states that:

In any network containing more than one source, the current in, or the potential difference across, any branch can be found by considering each source separately and adding their effects. omitted sources

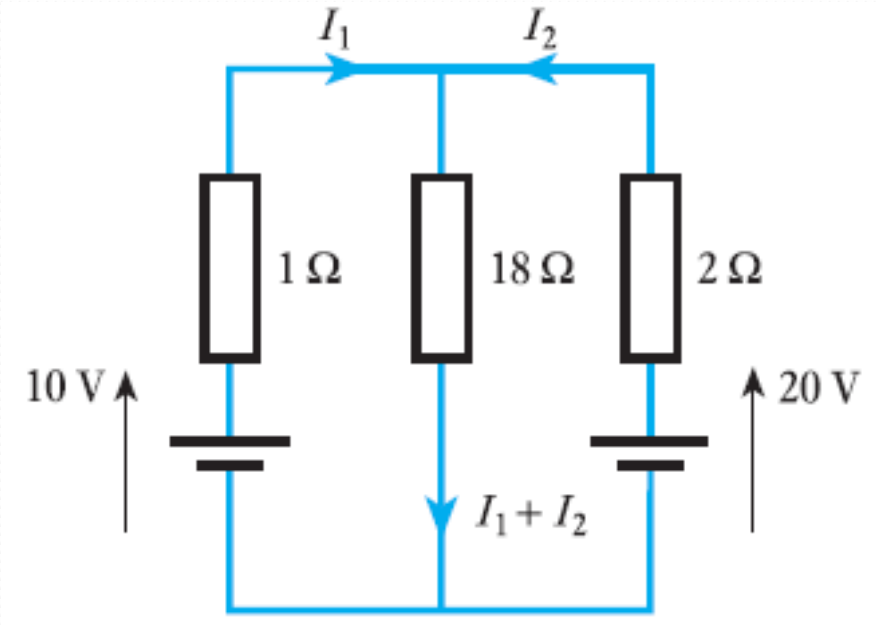
- Omitted sources are set to zero.

Omitted voltage source = 0 V Short circuit.

Omitted current source = 0 A open circuit.

Example

By means of the superposition theorem, calculate the currents in the network shown

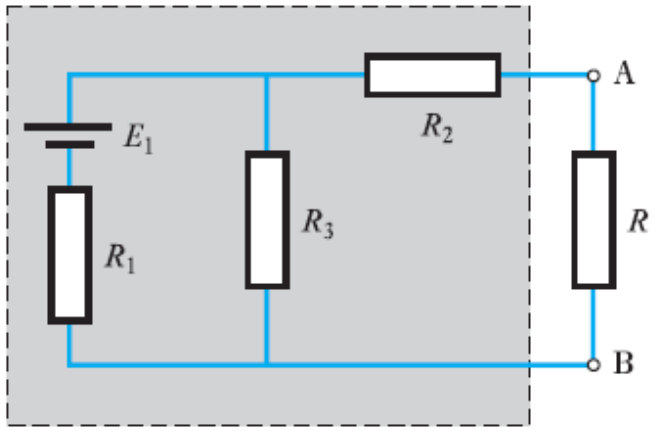


Thévenin's theorem

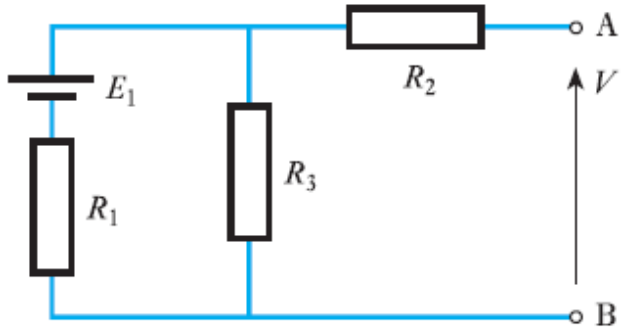
- Thévenin's theorem states that:

  An active network having two terminals A *and* B *can be replaced by a constant-voltage source having an e.m.f. E and an internal resistance r.*
  The value of E is equal to the open-circuit p.d. between A *and* B*, and r is the resistance of the network measured between* A *and* B *with the load disconnected and the sources of e.m.f. replaced by their internal resistances.*

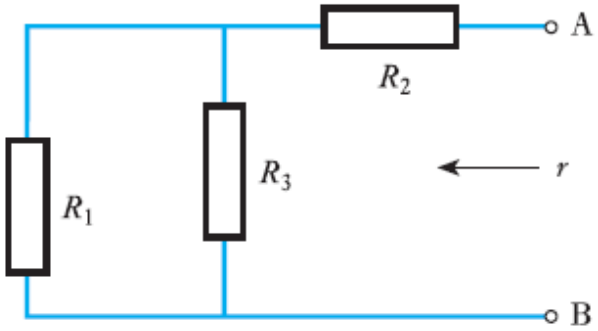
Thévenin's theorem 2

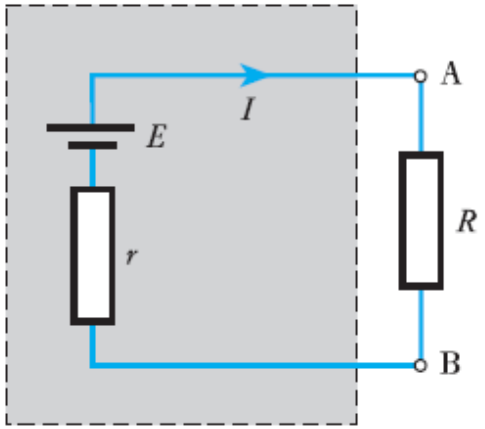


(a)



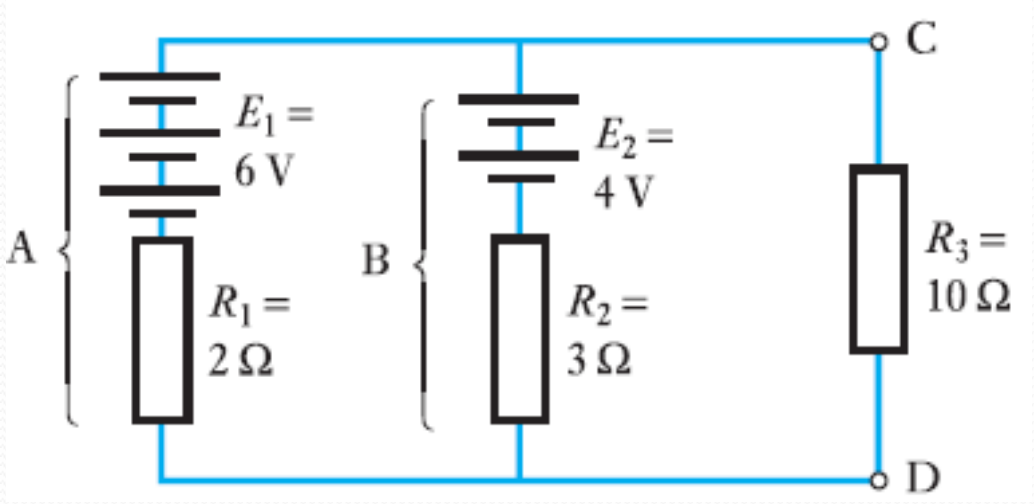
(b)



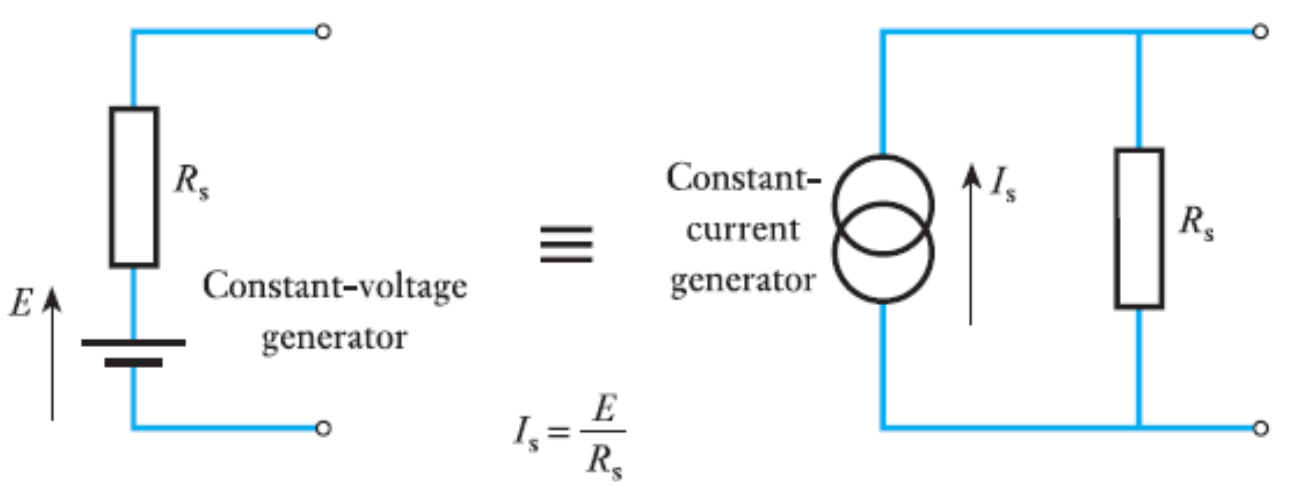


Example

In the shown circuit, C and D represent the two terminals of an active network.
Calculate the current through *R*3.

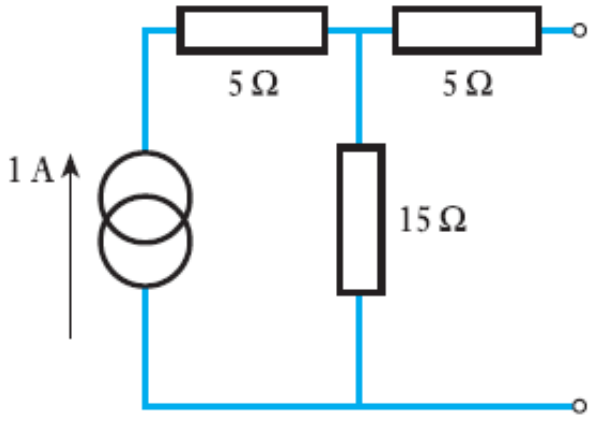


The constant current generator

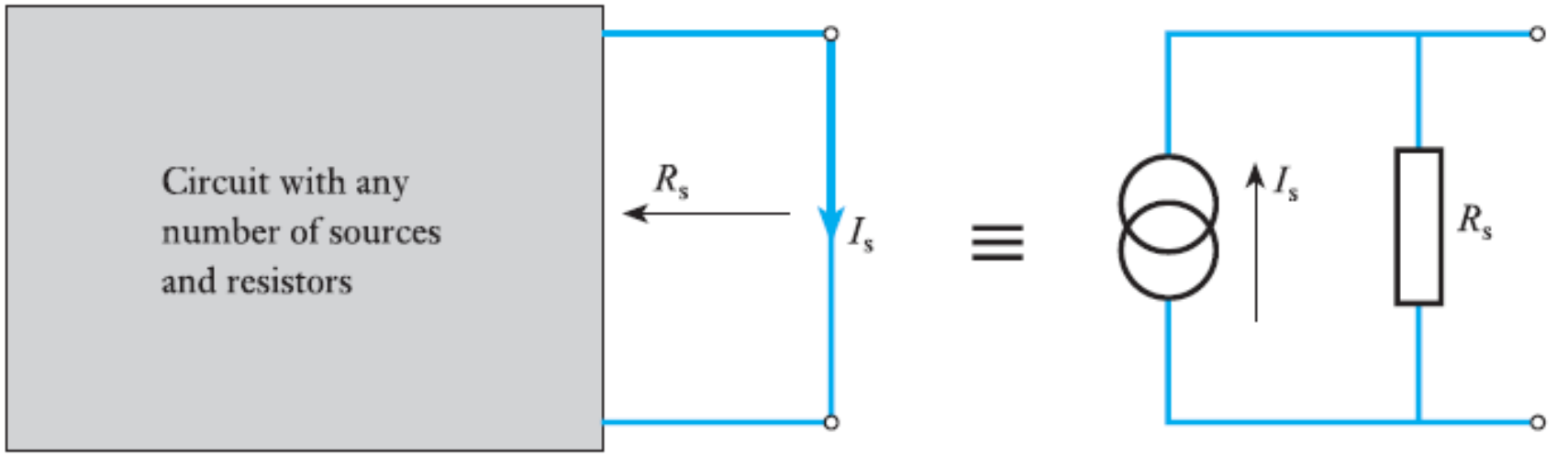


Source transformation

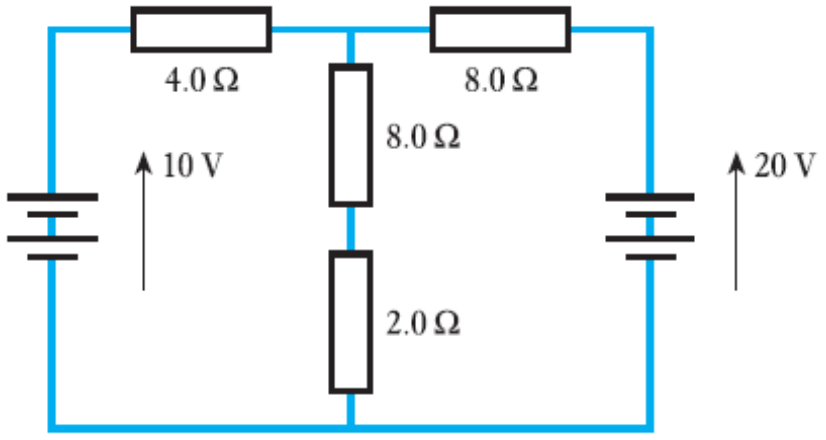
Example: Represent the network shown by one source of e.m.f. in series with a resistance.



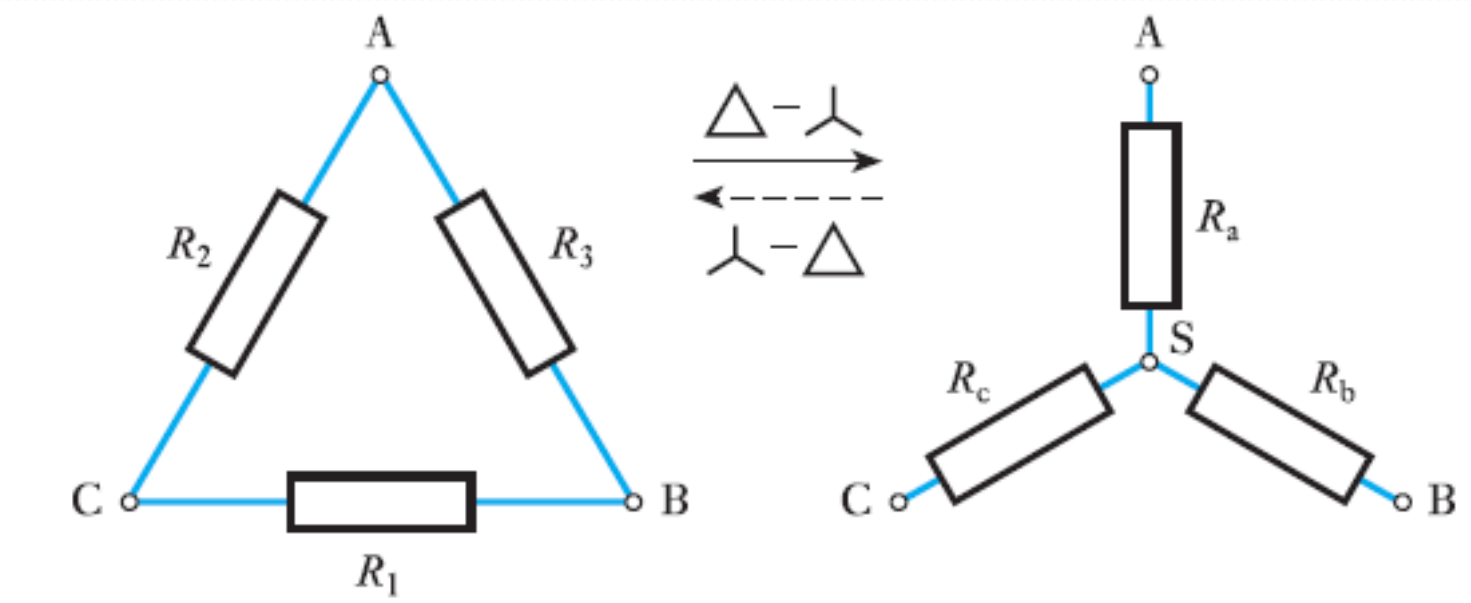
Norton's theorem



Example: Calculate the potential difference across the 2.0 Ω resistor in the network shown



Delta–star transformation



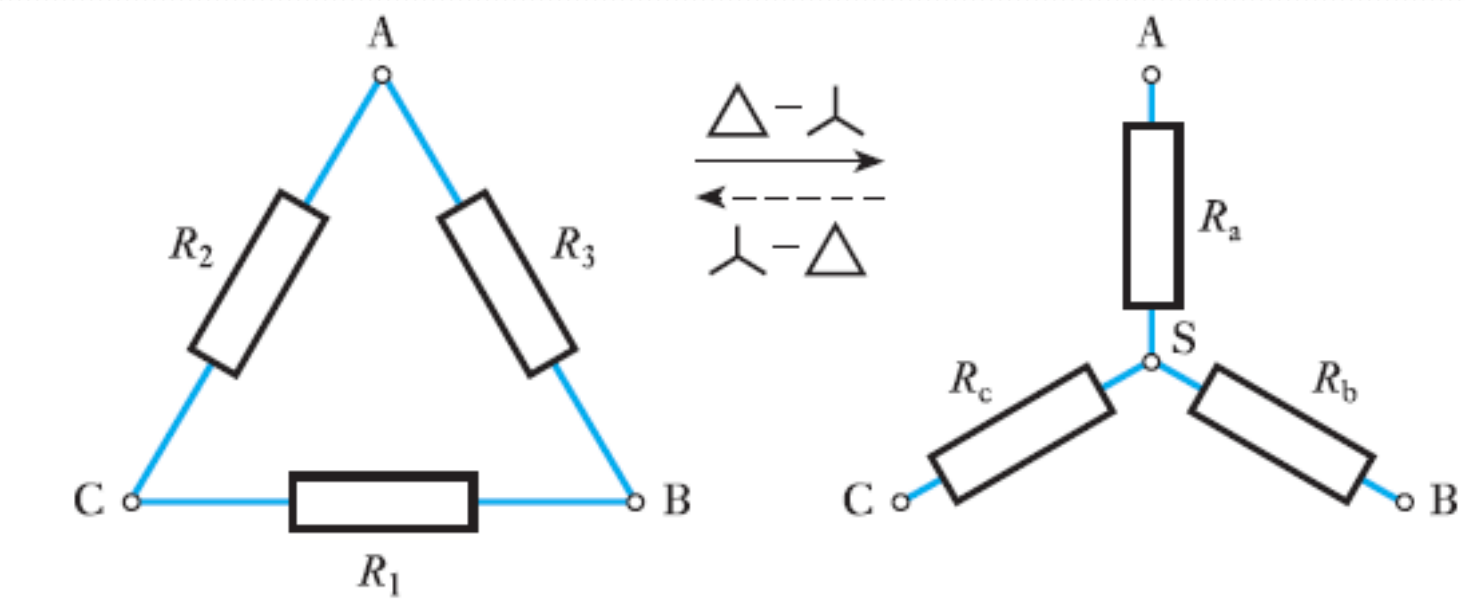
the equivalent star resistance connected to a given terminal is equal to the product of the two delta resistances connected to the same terminal divided by the sum of the delta resistances

$$R_a = \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

$$R_b = \frac{R_3 R_1}{R_1 + R_2 + R_3}$$

$$R_c = \frac{R_1 R_2}{R_1 + R_2 + R_3}$$

Star–delta transformation



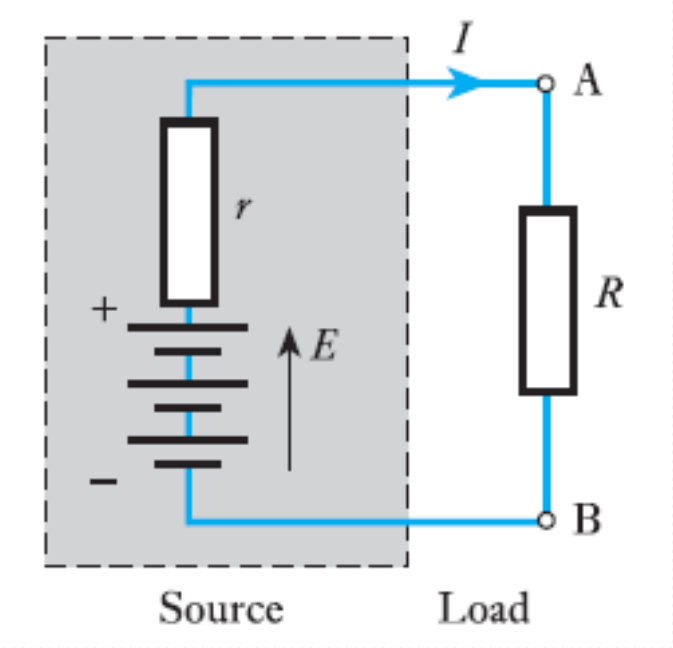
the equivalent delta resistance between two terminals is the sum of the two star resistances connected to those terminals plus the product of the same two star resistances divided by the third star resistance

$$R_1 = R_b + R_c + \frac{R_b R_c}{R_a}$$

$$R_2 = R_c + R_a + \frac{R_c R_a}{R_b}$$

$$R_3 = R_a + R_b + \frac{R_a R_b}{R_c}$$

Maximum power transfer



Please find the Value of R that receives the maximum possible power from the source in the shown circuit.

$$R = r$$

Hence: power transferred from the source to load is maximum when the resistance of the load is equal to the internal resistance of the source.

This is "*resistance matching*"

Very important in: communications and electronics to transfer max possible power from source to load