

## 01.4 fun.eq Thevenin's and Norton's theorems

Thévenin's and Norton's theorems yield ways to simplify our models of circuits.

### Thévenin's theorem

The following remarkable theorem has been proven.

#### Theorem 01 fun.9: Thévenin's theorem

Given a linear network of voltage sources, current sources, and resistors, the behavior at the network's output terminals can be reproduced exactly by a single *voltage source*  $V_e$  in series with a resistor  $R_e$ .

The equivalent circuit has two quantities to determine:  $V_e$  and  $R_e$ .

#### Determining $R_e$

The **equivalent resistance**  $R_e$  of a circuit is the resistance between the output terminals with all inputs set to zero. Setting a voltage source to zero means the voltage on both its terminals are equal, which is equivalent to treating it as a short or wire. Setting a current source to zero means the current through it is zero, which is equivalent to treating it as an open circuit.

#### Determining $V_e$

The **equivalent voltage source**  $V_e$  is the voltage at the output terminals of the circuit when they are left open (disconnected from a load).

Determining this value typically requires some circuit analysis with the laws of Ohm and Kirchhoff.

### Norton's theorem

Similarly, the following remarkable theorem has been proven.

**Theorem 01 fun.10: Norton's theorem**

Given a linear network of voltage sources, current sources, and resistors, the behavior at the network's output terminals can be reproduced exactly by a single *current source*  $I_e$  in parallel with a resistor  $R_e$ .

The equivalent circuit has two quantities to determine:  $I_e$  and  $R_e$ . The equivalent resistance  $R_e$  is identical to that of Thévenin's theorem, which leaves the equivalent current source  $I_e$  to be determined.

*Determining  $I_e$* 

The **equivalent current source**  $I_e$  is the current through the output terminals of the circuit when they are shorted (connected by a wire).

Determining this value typically requires some circuit analysis with the laws of Ohm and Kirchhoff.

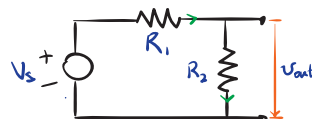
**Converting between Thévenin and Norton equivalents**

There is an equivalence between the two equivalent circuit models that allows one to convert from one to another with ease. The equivalent resistance  $R_e$  is identical in each and provides the following equation for converting between the two representations:

**Equation 1 converting between Thévenin and Norton equivalents**

**Example 01.4 fun.eq-1**

- For the circuit shown, find a Thévenin and a Norton equivalent.



re: Thévenin and Norton equivalents

