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 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.

equivalent resistance R_e

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.

equivalent voltage source V_e

Norton's theorem

Similarly, the following remarkable theorem has been proven.

Theorem 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

equivalent current source 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 fun.eq−1

re: Thévenin and Norton equivalents

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