Parallel and Series Resistors

Resistors in series

Consider the single-loop circuit to the right in which a voltage source vs is connected in series with five resistors. The KVL equation is given by :

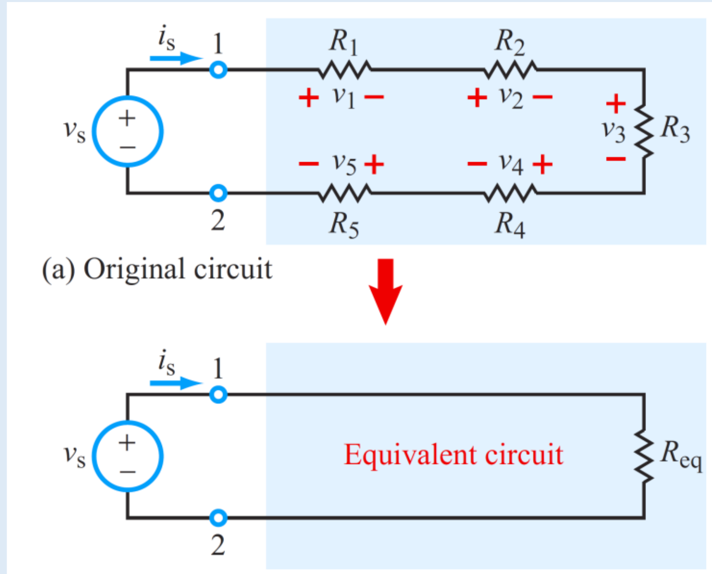
$$-v_s + i_sR_1 + i_sR_2 + i_sR_3 + i_sR_4 + i_sR_5 = 0$$

This can be cleaned up,

$$v_s = i_s(R_1 + R_2 + R_3 + R_4 + R_5)$$
$$v_s = i_sR_{eq}$$
$$\boldsymbol{R_{eq} = R_1 + R_2 + R_3 + R_4 + R_5}$$

From the perspective of the rest of the circuit:

multiple resistors connected in series (experiencing the same current) can be combined into a single equivalent resistor R_{eq} whose resistance is equal to the sum of all of their individual resistances



(a) Original circuit

(b) $R_{eq} = R_1 + R_2 + R_3 + R_4 + R_5$

Resistors in parallel

Consider the multi-branch circuit to the right in which a voltage source vs is connected in parallel with three resistors. From KCL we know :

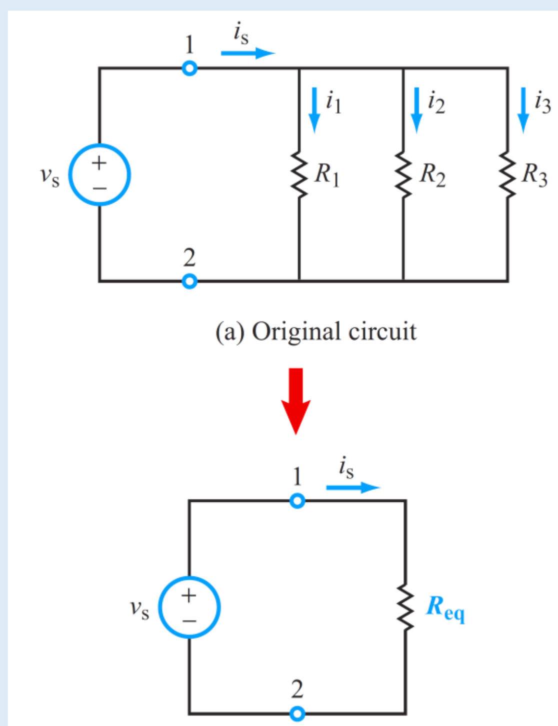
$$i_s = i_1 + i_2 + i_3$$

Applying Ohm's Law for each resistor,

$$i_s = \frac{v_s}{R_1} + \frac{v_s}{R_2} + \frac{v_s}{R_3}$$
$$i_s = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)v_s$$
$$\boldsymbol{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

From the perspective of the rest of the circuit:

multiple resistors connected in parallel (experiencing the same voltage) can be combined into a single equivalent resistor R_{eq} whose resistance is equal to the reciprocal of the sum of the reciprocal individual resistances



(a) Original circuit

(b) Equivalent circuit

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