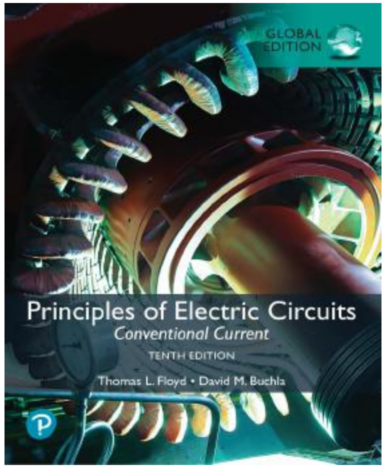
Principles of Electric Circuits: Conventional Current

Tenth Edition, Global Edition

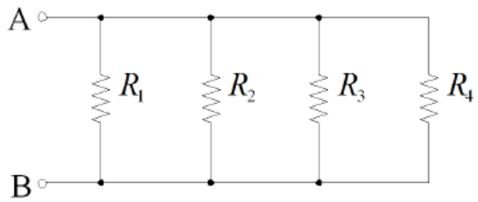


Chapter 6

Parallel Circuits

Summary: Resistors in parallel (1 of 3)

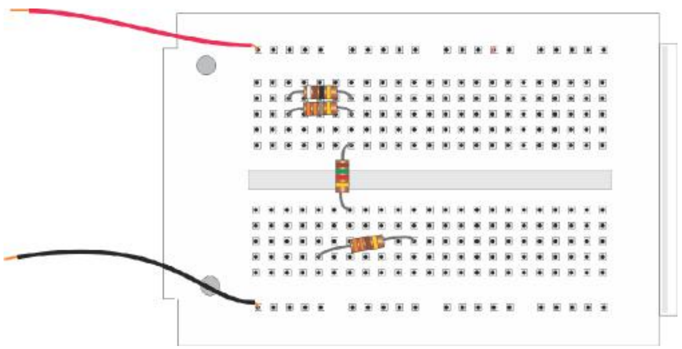
Resistors that are connected between the same two points are said to be in **parallel**. The two points (labeled A and B) are **nodes**. Sometimes a parallel connection is not as obvious as the drawing here.



Summary: Resistors in parallel (2 of 3)

Example:

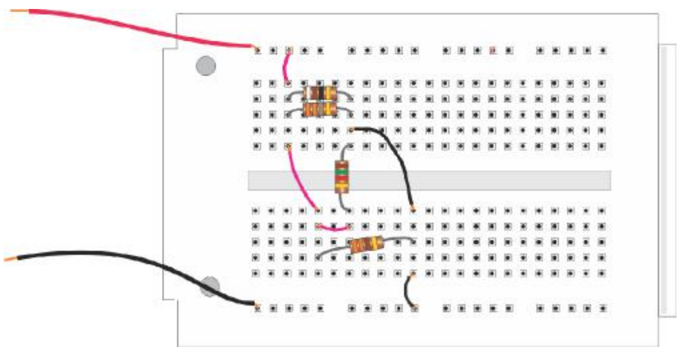
Show how to connect the resistors on the protoboard in parallel.



Summary: Resistors in parallel (3 of 3)

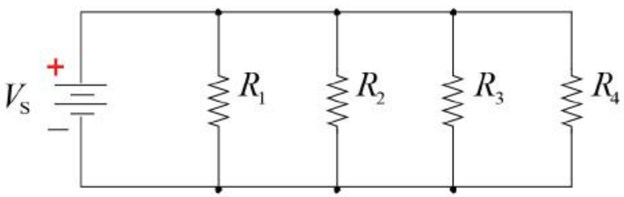
Solution:

This is one way. Notice that one node is colored in **red**; the other is **black** and *all* resistors are between these two nodes.



Summary: Parallel circuits

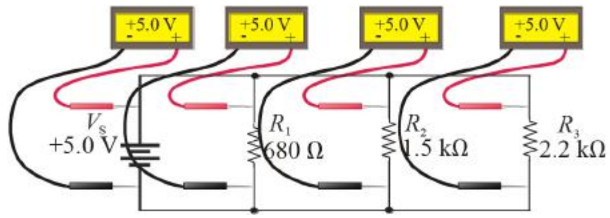
A ***parallel circuit*** is identified by the fact that it has includes a voltage source and more than one component between the two nodes.



Summary: Parallel circuit rule for voltage

Because all components are connected across the same voltage source, the voltage across each component is the same.

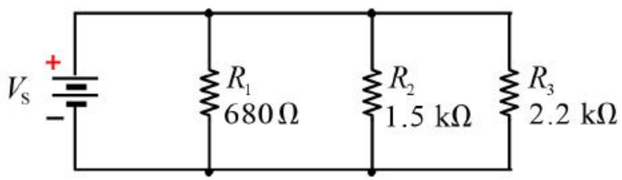
For example, the source voltage is 5.0 V. What will a voltmeter read if it is placed across each of the resistors?



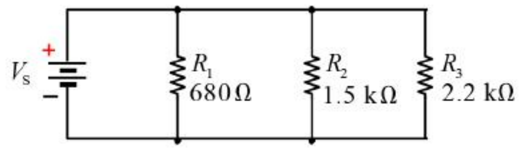
Summary: Parallel circuit rule for resistance

The total resistance of resistors in parallel is the reciprocal of the sum of the reciprocals of the individual resistors.

For example, the resistors in a parallel circuit are 680 Ω, 1.5 k Ω, and 2.2 k Ω. What is the total resistance? 386 Ω



Summary: Parallel circuit



Tabulating current, resistance, voltage and power is a useful way to summarize parameters in a parallel circuit. Continuing with the previous example, complete the parameters listed in the Table.

I_1= 7.4 mA	R_1= 0.68 kΩ	V_1= 5.0 V	P_1= 36.8 mW
I_2= 3.3 mA	R_2= 1.50 kΩ	V_2= 5.0 V	P_2= 16.7 mW
I_3= 2.3 mA	R_3= 2.20 kΩ	V_3= 5.0 V	P_3= 11.4 mW
I_T= 13.0 mA	R_T= 386 Ω	V_S= 5.0 V	P_T= 64.8 mW

Summary: Kirchhoff's Current Law (KCL)

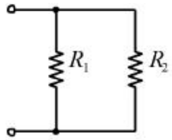
KCL is generally stated as:

The sum of the currents entering a node is equal to the sum of the currents leaving the node.

Notice in the previous example that the current from the source is equal to the sum of the branch currents.

I_1 = 7.4 mA	R_1 = 0.68 kΩ	V_1 = 5.0 V	P_1 = 36.8 mW
I_2 = 3.3 mA	R_2 = 1.50 kΩ	V_2 = 5.0 V	P_2 = 16.7 mW
I_3 = 2.3 mA	R_3 = 2.20 kΩ	V_3 = 5.0 V	P_3 = 11.4 mW
I_T = 13.0 mA	R_T = 386 Ω	V_S = 5.0 V	P_T = 64.8 mW

Summary: Special case for resistance of two parallel resistors



The resistance of two parallel resistors can be found by

either: $R_T = \dfrac{1}{\dfrac{1}{R_1} + \dfrac{1}{R_2}}$ or $R_T = \dfrac{R_1 R_2}{R_1 + R_2}$

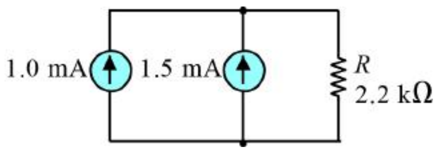
This is known as the product-over-sum rule.

Question:

What is the total resistance if R_1 = 27 kΩ and R_2 = 56 kΩ?

18.2 kΩ

Summary: Parallel current sources



Current sources in parallel can be combined algebraically into a single equivalent source.
The two current sources shown are aiding, so the net current in the resistor is their sum (2.5 mA).

Question:

(a) What is the current in *R* if the 1.5 mA source is reversed?

0.5 mA

(b) Which end of *R* will be positive? The bottom

Summary: Current divider

When current enters a junction it divides with current values that are inversely proportional to the resistance values.

The most widely used formula for the current divider is the two-resistor equation. For resistors R_1 and R_2,

$$I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I_T \quad \text{and} \quad I_2 = \left(\frac{R_1}{R_1 + R_2}\right) I_T$$

Notice the highlighted subscripts. The resistor in the numerator is not the same as the one for which current is found.

Summary: Power in parallel circuits

Power in each resistor can be calculated with any of the standard power formulas. Most of the time, the voltage is known, so the equation $P = \frac{V^2}{R}$ is most convenient.

As in the series case, the total power is the sum of the powers dissipated in each resistor.

Question:

What is the total power if 10 V is applied to the parallel combination of R_1 = 270 Ω and R_2 = 150 Ω? 1.04 W

Key Terms

Branch One current path in a parallel circuit.

Current divider A parallel circuit in which the division of branch currents is inversely proportional to the parallel branch resistances.

Junction A point at which two or more components are connected. Also known as a node.

Kirchhoff's current law A law stating the total current into a junction equals the total current out of the junction.

Parallel The relationship in electric circuits in which two or more current paths are connected between two separate points (nodes).

Quiz (1 of 11)

1. The total resistance of parallel resistors is equal to
   - a. the sum of the resistances
   - b. the sum of the reciprocals of the resistances
   - c. the sum of the conductances
   - d. none of the above

Quiz (2 of 11)

2. The number of nodes in a parallel circuit is
   - a. one
   - b. two
   - c. Three
   - d. can be any number

Quiz (3 of 11)

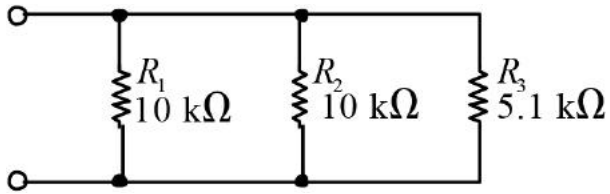
3. The total resistance of the parallel resistors is

   a. 2.52 kΩ

   b. 3.35 kΩ

   c. 5.1 k Ω

   d. 25.1 kΩ



Quiz (4 of 11)

4. If three equal resistors are in parallel, the total resistance is

   a. one third the value of one resistor

   b. the same as one resistor

   c. three times the value of one resistor

   d. there is not enough information to say

Quiz (5 of 11)

5. In any circuit the total current entering a junction is

   a. less than the total current leaving the junction

   b. equal to the total current leaving the junction

   c. greater than the total current leaving the junction

   d. can be any of the above, depending on the circuit

Quiz (6 of 11)

6. The current divider formula to find I_1 for the special case of two resistors is

   a. $I_1 = \left(\frac{R_1}{R_T}\right) I_T$

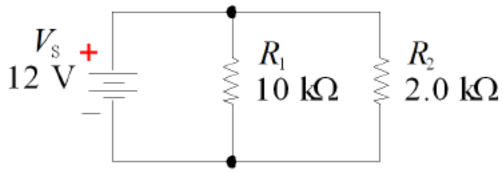
   b. $I_1 = \left(\frac{R_2}{R_T}\right) I_T$

   c. $I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I_T$

   d. $I_1 = \left(\frac{R_1}{R_1 + R_2}\right) I_T$

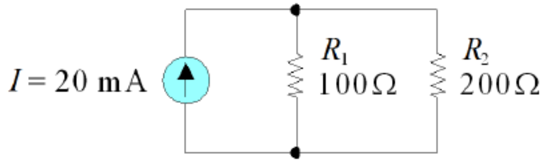
Quiz (7 of 11)

7. The total current leaving the source is
   a. 1.0 mA
   b. 1.2 mA
   c. 6.0 mA
   d. 7.2 mA



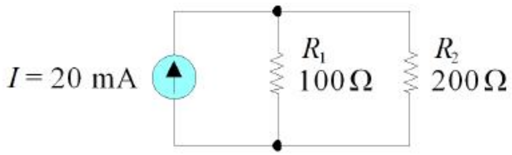
Quiz (8 of 11)

8. The current in R_1 is
   a. 6.7 mA
   b. 13.3 mA
   c. 20 mA
   d. 26.7 mA



Quiz (9 of 11)

9. The voltage across R_2 is
   a. 0 V
   b. 0.67 V
   c. 1.33 V
   d. 4.0 V



Quiz (10 of 11)

10. The total power dissipated in a parallel circuit is equal to the
    a. power in the largest resistor
    b. power in the smallest resistor
    c. average of the power in all resistors
    d. sum of the power in all resistors

Quiz (11 of 11)

Answers:

1. d
2. b
3. a
4. a
5. b
6. c
7. d
8. b
9. c
10. d

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