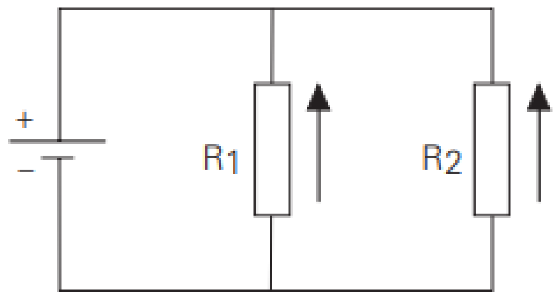
12- DC Parallel Circuit

12- 1 Resistance in a Parallel Circuit:

A parallel circuit is formed when two or more resistances are placed in a circuit side-by-side so that current can flow through more than one path. The illustration shows two resistors placed side-by-side. There are two paths of current flow. One path is from the negative terminal of the battery through R_1 returning to the positive terminal. The second path is from the negative terminal of the battery through R_2 returning to the positive terminal of the battery.

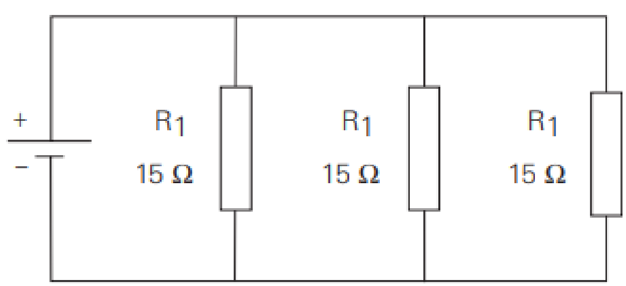


12-1-1 Formula for Equal Value Resistors in a Parallel Circuit:

To determine the total resistance when resistors are of equal value in a parallel circuit, use the following formula:

$$R_t = \frac{\text{Value of any one Resistor}}{\text{Number of Resistors}}$$

In the following illustration there are three 15 Ω resistors. The total resistance is:



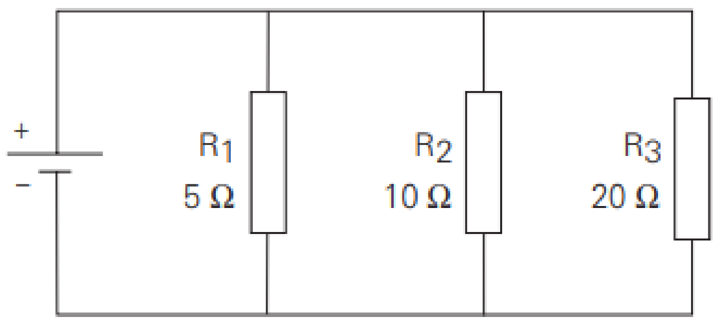
$$R_t = \frac{15}{3} = 5\ \Omega$$

12-1-2 Formula for Unequal Value Resistors in a Parallel Circuit:

There are two formulas to determine total resistance for unequal value resistors in a parallel circuit. **The first** formula is used when there are three or more resistors. The formula can be extended for any number of resistors.

$$\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

- In the following illustration there are three resistors, each of different value. The total resistance is:



$$\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

$$\frac{1}{Rt} = \frac{1}{5} + \frac{1}{10} + \frac{1}{20}$$ Insert Value of the Resistors

$$\frac{1}{Rt} = \frac{4}{5} + \frac{2}{10} + \frac{1}{20}$$ Find Lowest Common Denominator

$$\frac{1}{Rt} = \frac{7}{20}$$ Add the Numerators

$$\frac{Rt}{1} = \frac{20}{7}$$ Invert Both Sides of the Equation $\rightarrow$ $Rt = 2.86\ \Omega$

The second formula is used when there are only two resistors.

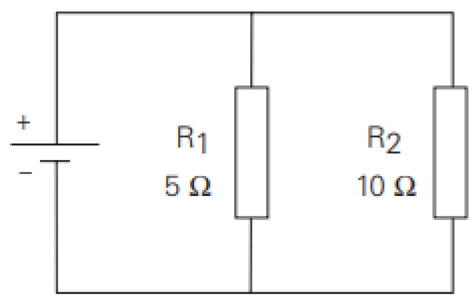
$$Rt = \frac{R1 \times R2}{R1+R2}$$

In the following illustration there are two resistors, each of different value. The total resistance is:

$$Rt = \frac{R1 \times R2}{R1+R2}$$

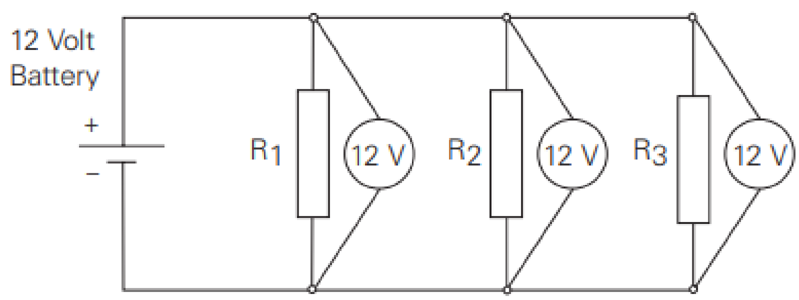
$$Rt = \frac{5 \times 10}{5+10}$$

$$Rt = \frac{50}{15} = 3.33\ \Omega$$

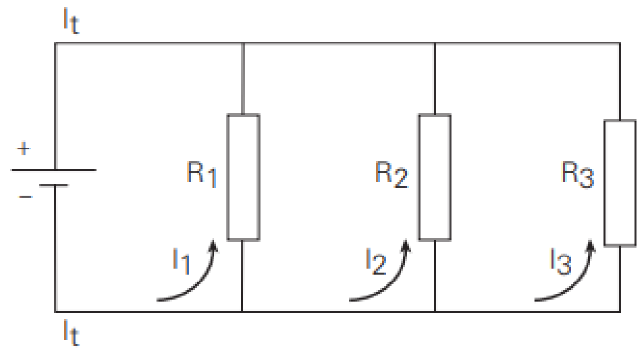


12- 2 Voltage in a Parallel Circuit:

When resistors are placed in parallel across a voltage source, <u>the voltage is the same across each resistor</u>. In the following illustration three resistors are placed in parallel across a 12volt battery. Each resistor has 12volts available to it.



12-3 Current in a Parallel Circuit:



Total current in a parallel circuit is equal to the sum of the current in each branch. The following formula applies to current in a parallel circuit.

$I_t = I_1 + I_2 + I_3$

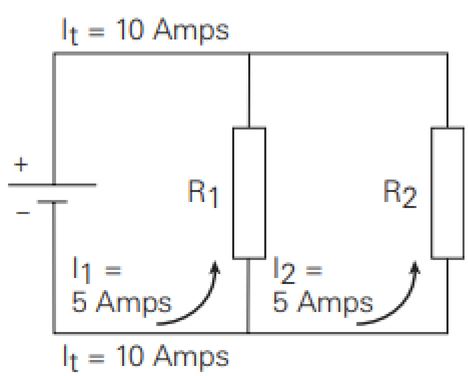
12-3-1Current Flow with Equal Value Resistors in a Parallel Circuit:

When equal resistances are placed in a parallel circuit, opposition to current flow is the same in each branch. In the following circuit R1 and R2 are of equal value. If total current (It) is 10 amps, then 5 amps would flow through R1 and 5 amps would flow through R2.

$I_t = I_1 + I_2$

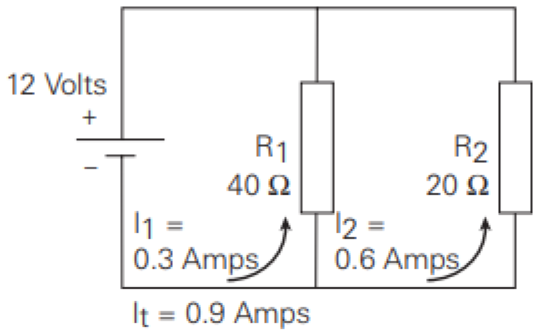
$I_t = 5$ Amps + 5 Amps

$I_t = 10$ Amps



12-3-2 Current Flow with Unequal Value Resistors in a Parallel Circuit:

When unequal value resistors are placed in a parallel circuit, opposition to current flow is not the same in every circuit branch. Current is greater through the path of least resistance. In the following circuit R1 is 40 Ω and R2 is 20 Ω. Small values of resistance means less opposition to current flow. More current will flow through R2 than R1.



Using Ohm's Law, the total current for each circuit can be calculated

$I_1 = \frac{E}{R1}$

$I_1 = \frac{12 \text{ volts}}{40\ \Omega} \rightarrow I_1 = 0.3$ Amps.

$I_2 = \frac{E}{R2}$

$I_2 = \frac{12 \text{ volts}}{20\ \Omega} \rightarrow I_2 = 0.6$ Amps.

$I_t = I_1 + I_2$

$I_t = 0.3$ Amps + 0.6 Amps

$I_t = 0.9$ Amps

Total current can also be calculated by first calculating total resistance, then applying the formula for Ohm's Law.

$Rt = \frac{R1 \times R2}{R1 + R2}$

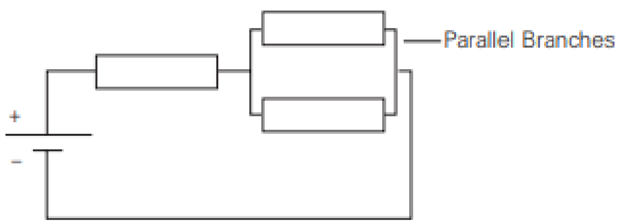
$Rt = \frac{40\ \Omega \times 20 \Omega}{40\Omega + 20\Omega} \rightarrow Rt = 13.333\ \Omega$

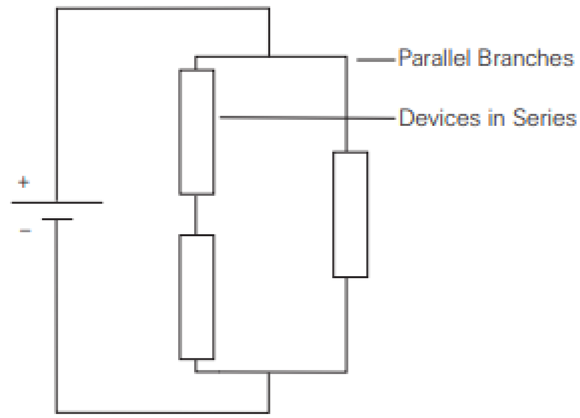
$I_t = \frac{E}{Rt} = \frac{12 \text{volts}}{13.333\ \Omega} = 0.9$ Amps

Series-Parallel Circuits

12-4 Series-Parallel Circuits:

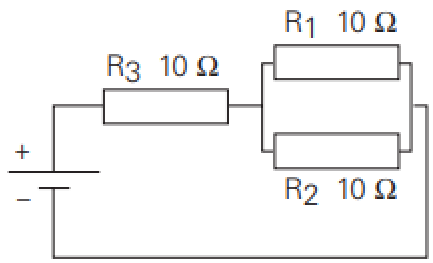
Series-parallel circuits are also known as compound circuits. At least three resistors are required to form a series-parallel circuit. The following illustrations show two ways a series-parallel combination could be found.





12-4-1Simplifying a Series-Parallel:

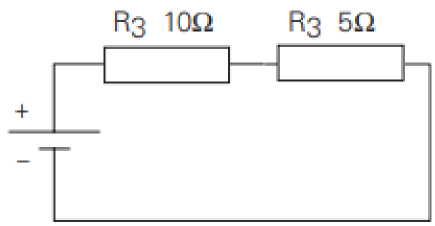
The formulas required for solving current, voltage and resistance problems have already been defined. To solve a series-parallel circuit, reduce the compound circuits to equivalent simple circuits. In the following illustration R1 and R2 are parallel with each other. R3 is in series with the parallel circuit of R1 and R2.



First, use the formula to determine total resistance of a parallel circuit to find the total resistance of R1 and R2. When the resistors in a parallel circuit are equal, the following formula is used

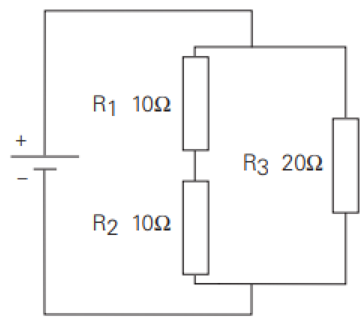
$$R = \frac{\text{Value of any one Resistor}}{\text{Number of Resistors}} = \frac{10\Omega}{2} = 5\ \Omega$$

Second, redraw the circuit showing the equivalent values. The result is a simple series circuit which uses already learned equations and methods of problem solving.



12-4-3 Simplifying a Series-Parallel Circuit to a Parallel Circuit:

In the following illustration R1 and R2 are in series with each other. R3 is in parallel with the series circuit of R1 and R2.



First, use the formula to determine total resistance of a series circuit to find the total resistance of R1 and R2. The following formula is used:

$R = R_1 + R_2$

$R = 10\ \Omega + 10\ \Omega \rightarrow R = 20\ \Omega$

Second, redraw the circuit showing the equivalent values. The result is a simple parallel circuit which uses already learned equations and methods of problem solving.