Basic Electrical Engineering (TEE 101)

Lecture 4: Analysis of Voltage, current sources and Resistances in series and parallel

Content

This lecture covers the analysis of :

- Voltages sources in series
- Current sources in parallel
- Resistances in Series and Parallel

Voltage Sources Connected in Series

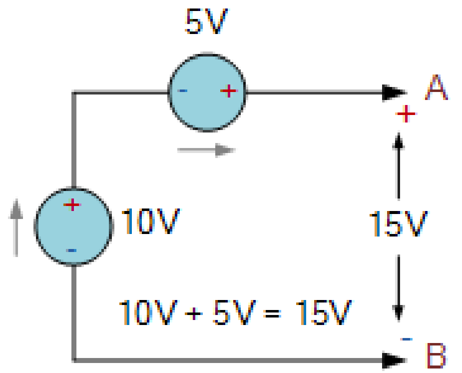
Voltage sources when connected in series either aid each other or oppose each other.

It depends on the direction of the polarities of the voltage sources, Or, we can say on the direction of the electric field

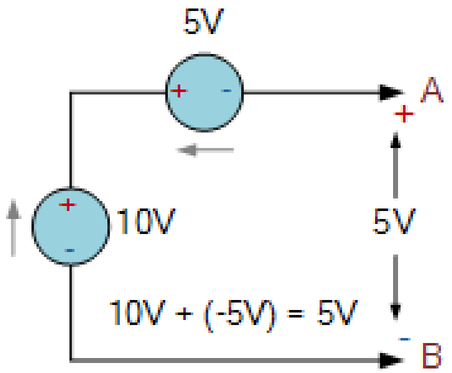
If the polarities of two voltage sources (V_1 and V_2) connected in series are same, then the total voltage (V) is the sum of two voltages (V_1 and V_2), i.e. $V = V_1 + V_2$

If the polarities of both voltage sources is opposite to each other, then the net voltage is the difference of the two voltages (i.e. $V = V_1 – V_2$)

This is illustrated in the diagrams below:



Series Aiding Voltages
(Voltage Addition)



Series Opposing Voltages
(Voltage Subtraction)

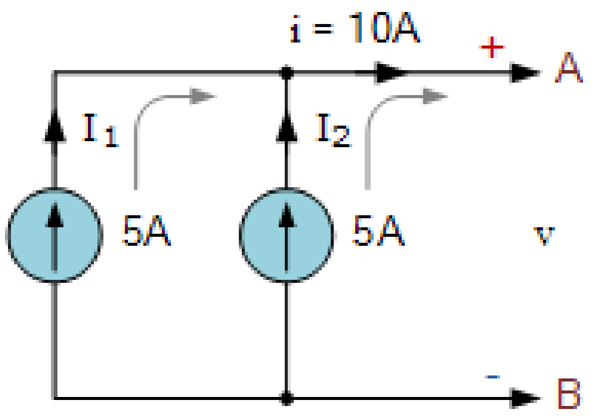
Current Source in Parallel

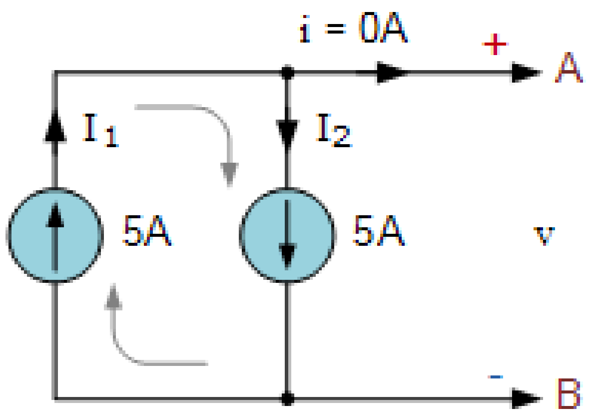
Just like voltage sources, ideal current sources can also be connected together to increase (or decrease) the available current.

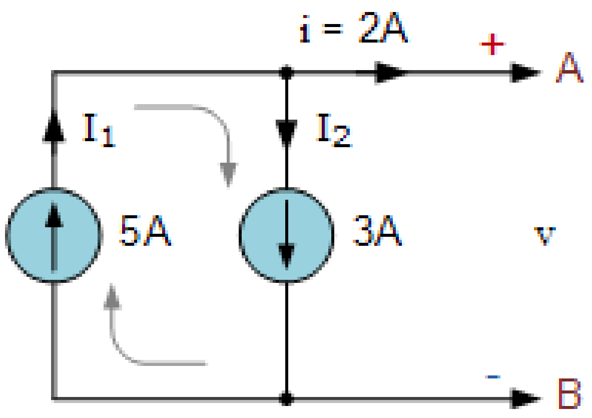
When two or more current sources connected in parallel to each other, the currents are added.

When current sources are connected anti parallel, then the net current is algebraic sum of all currents

Connecting two or more current sources in parallel is equivalent to one current source whose total current output is given as the algebraic addition of the individual current source.







current sources in same direction

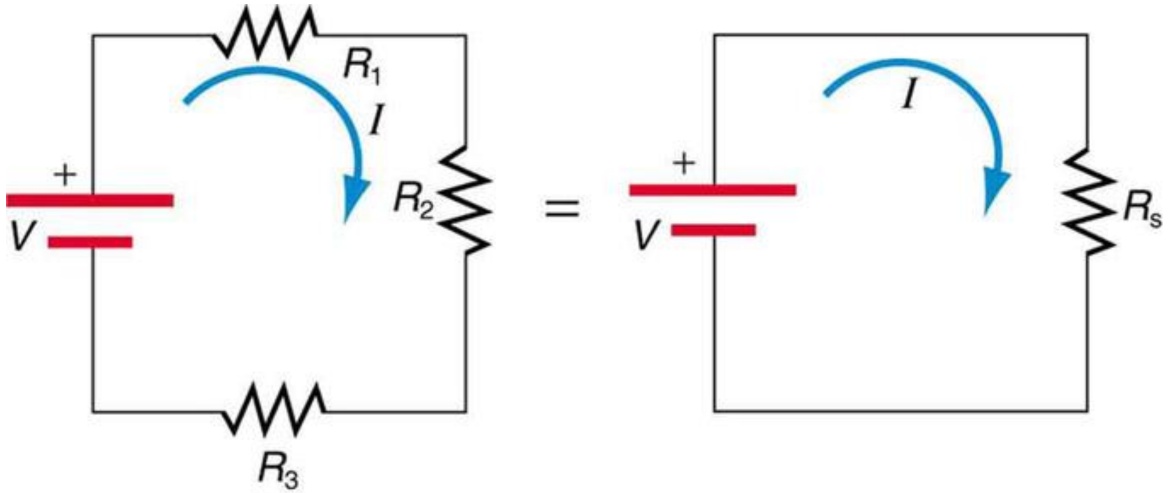
current sources in opposite direction

Resistances in Series

The total resistance in the circuit with resistors connected in series is equal to the sum of the individual resistances.

Consider a circuit as shown below. According to Ohm's law, the voltage drop, V, across a resistor when a current flows through it is calculated by using the equation **V=IR**,

- ***where V is in Volts, I is current in Amps (A) and R_S is the resistance in ohms (Ω).***



So the voltage drop across $\mathbf{R_1}$ **is:** $\mathbf{V_1=IR_1}$, across $\mathbf{R_2}$ **is** $\mathbf{V_2=IR_2}$, and across $\mathbf{R_3}$ **is** $\mathbf{V_3=IR_3}$.

The sum of the voltages would equal: $V=V_1+V_2+V_3$, based on the conservation of energy and charge.

If we substitute the values for individual voltages, we get: $\mathbf{V=IR_1+IR_2+IR_3}$

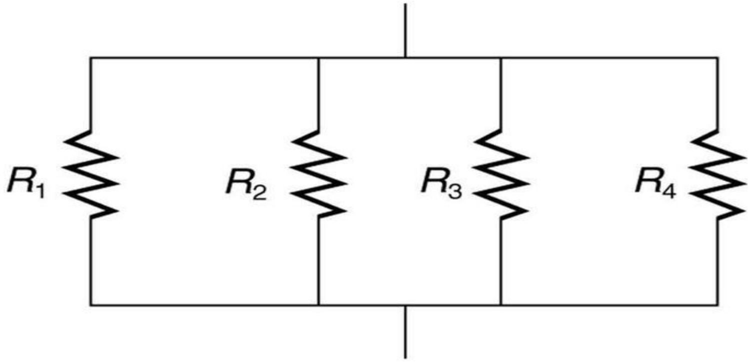
- **Or, $V=I(R_1+R_2+R_3)$**
- **Or, $V/I = R_1+R_2+R_3$**
- **$V/I = R_S$, Hence: $R_S = R_1+R_2+R_3$**

This implies that the total resistance in a series is equal to the sum of the individual resistances.

Therefore, for every circuit with N number of resistors connected in series:

$R_S=R_1+R_2+R_3+\ldots+R_N$

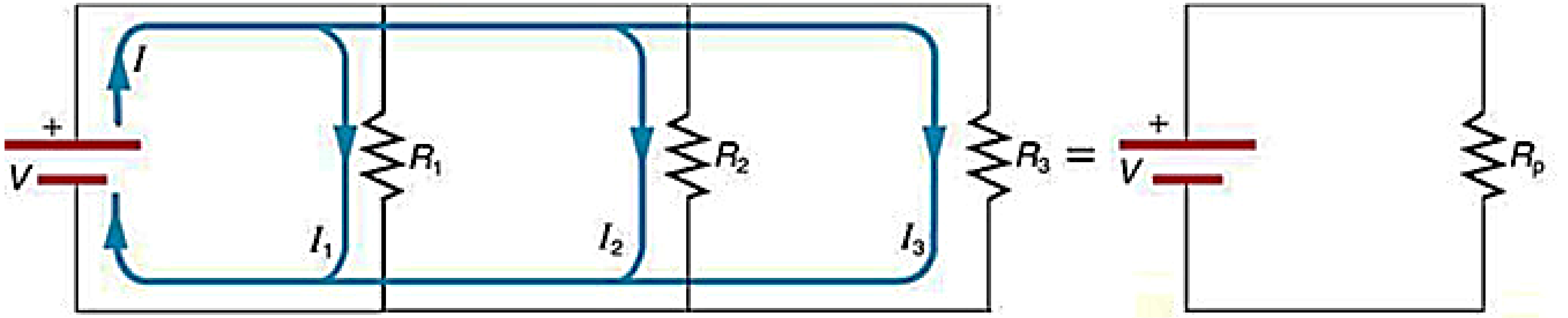
Resistances in Parallel



Resistors are in parallel when each resistor is connected directly to the voltage source by connecting wires having negligible resistance.

Consider a circuit as shown below. According to Ohm's law, the currents flowing through the individual resistors are $I_1 = \frac{V}{R_1}$ $I_2 = \frac{V}{R_2}$ $I_3 = \frac{V}{R_3}$

- ***where V is in Volts (V), I is current in amps (A) and R_P is the resistance in ohms (Ω).***



Conservation of charge implies that the total current is the sum of these currents: $I = I_1 + I_2 + I_3$.

Substituting the expressions for individual currents gives:

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Or, $$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

Or, $$\frac{I}{V} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

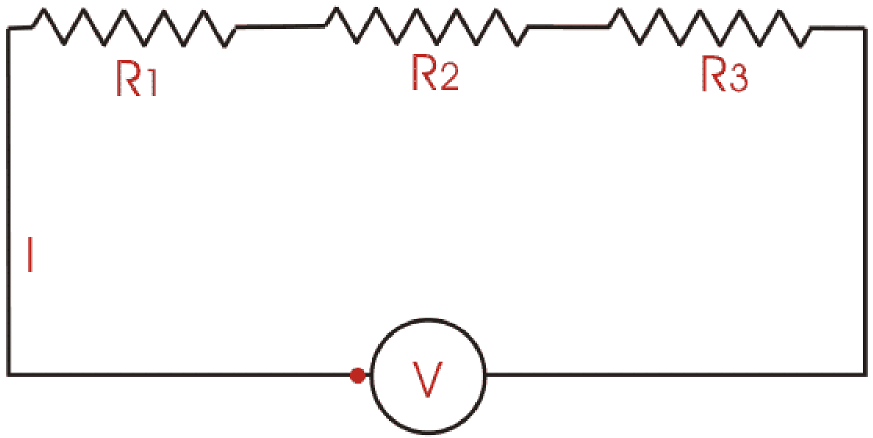
Or, $$\frac{1}{R_P} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

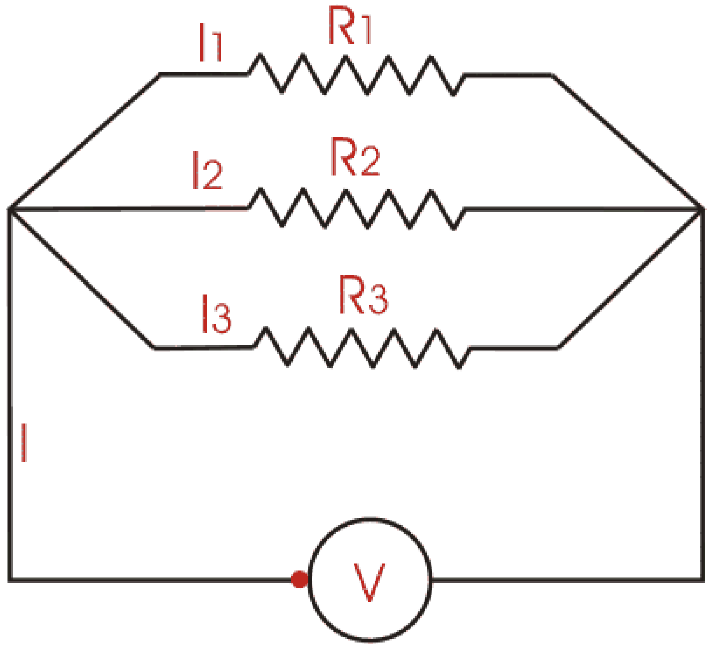
Where, $$R_P = \frac{V}{I}$$

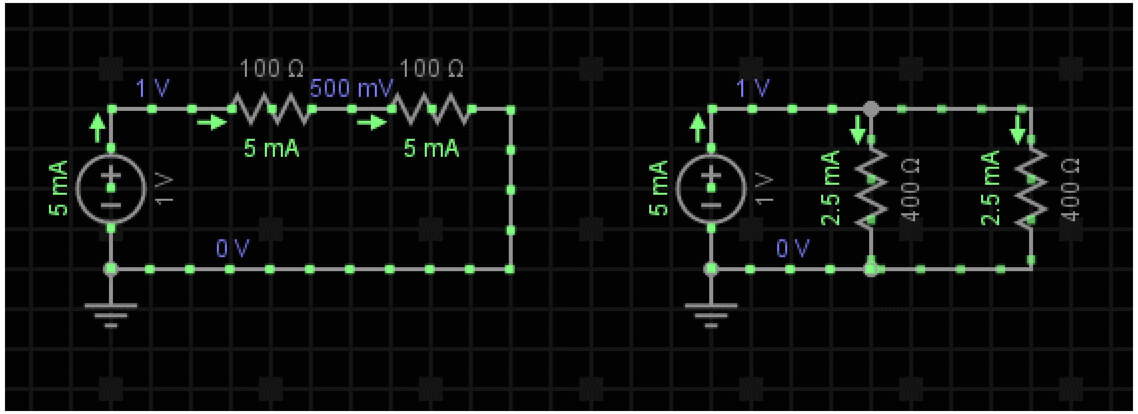
This implies that the total resistance in a parallel circuit is equal to the sum of the inverse of each individual resistances.

Therefore, for every circuit with "N" number of resistors connected in parallel,

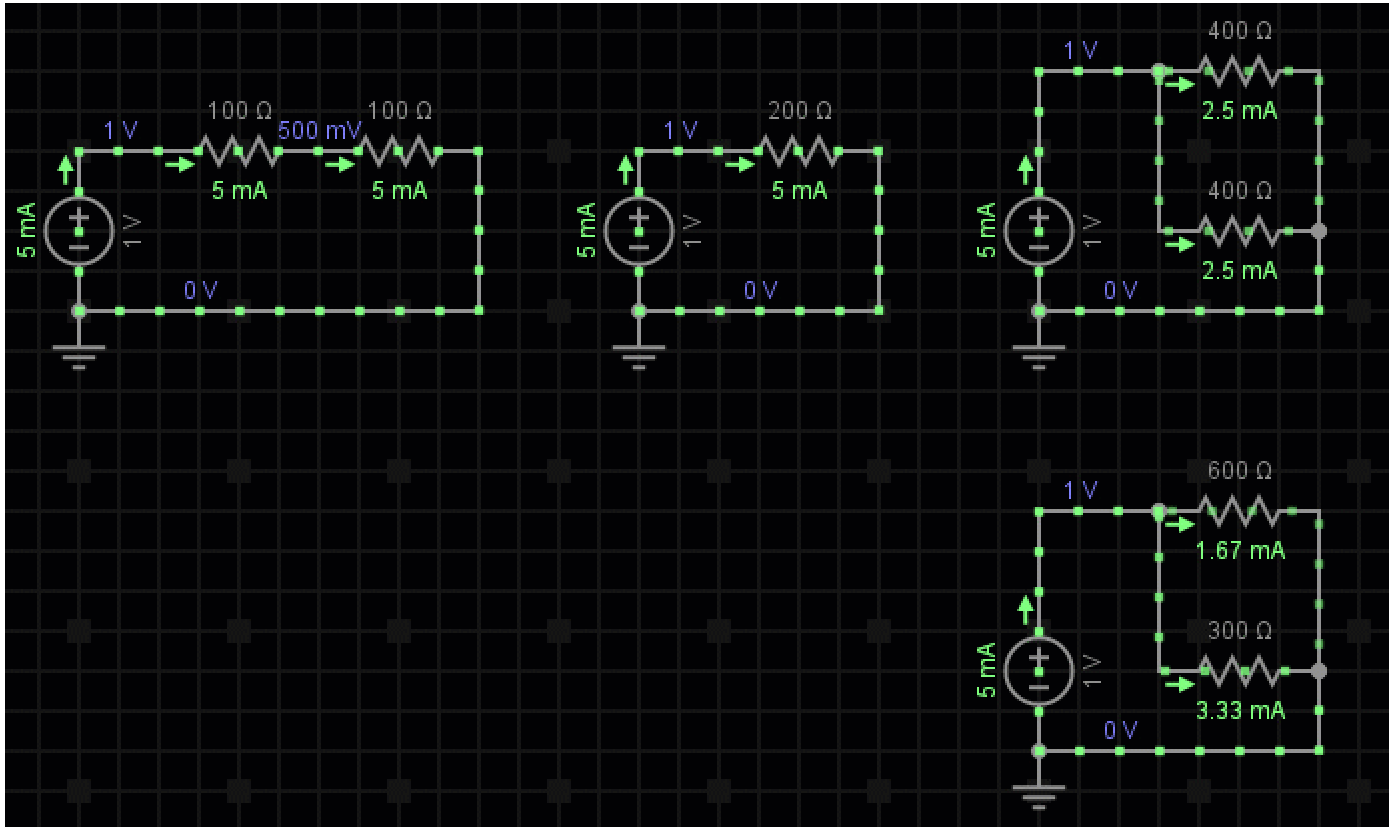
$$\frac{1}{R_P} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots + \frac{1}{R_N}\right)$$


R1
R2
R3
I
V


I1
R1
I2
R2
I3
R3
I
V



1 V
100 Ω
500 mV
100 Ω
5 mA
5 mA
5 mA
1 V
0 V
1 V
2.5 mA
400 Ω
2.5 mA
400 Ω
5 mA
1 V
0 V



1 V
100 Ω
500 mV
100 Ω
5 mA
5 mA
5 mA
1 V
0 V
1 V
200 Ω
5 mA
5 mA
1 V
0 V
1 V
400 Ω
2.5 mA
400 Ω
2.5 mA
5 mA
1 V
0 V
1 V
600 Ω
1.67 mA
300 Ω
3.33 mA
5 mA
1 V
0 V

Thank You