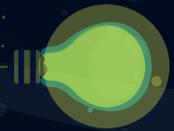


Eletricista de Sistemas de Energias Renováveis

Módulo I

Na aula anterior vimos:

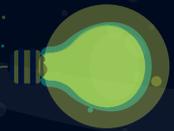
Lei de Ohm



Cálculo da Tensão

$$V = I \times R$$

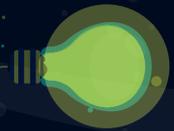
The equation is presented with three large circles containing the variables V, I, and R. Below each large circle is a smaller circle containing the unit for that variable: V (Volts) under the first V, A (Amperes) under the I, and Ω (Ohms) under the R.



Cálculo da Corrente:

$$I = \frac{V}{R}$$

The equation is represented by large, semi-transparent circles. The letter 'I' is in a large teal circle on the left. The letter 'V' is in a large olive-green circle at the top of the fraction. The letter 'R' is in a large grey circle at the bottom of the fraction. Below 'I' is a smaller teal circle with the letter 'A'. Below 'V' is a smaller olive-green circle with the letter 'V'. Below 'R' is a smaller grey circle with the Greek letter 'Ω'. A white horizontal line with a double underline is positioned between the top and bottom circles of the fraction.

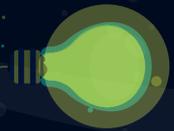


Cálculo da Resistência:

$$R = \frac{V}{I}$$

The equation is presented with large, semi-transparent circles for the variables: a grey circle for 'R', a large green circle for 'V', a smaller green circle for 'V', a large cyan circle for 'I', and a smaller cyan circle for 'A'. A white horizontal line is drawn under the denominator 'I'. Below the 'R' circle is a smaller grey circle containing the Greek letter Ω .

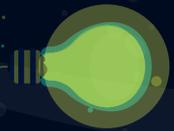
Lei de Ohm e Potência



Cálculo da Potência

$$P = V \times I$$

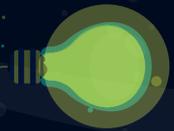
W V A



Cálculo da Corrente:

$$I = \frac{P}{V}$$

The equation is represented by large circles: a teal circle for 'I', a white circle for 'P', a teal circle for 'A', a large white circle for 'P', a small white circle for 'W', a large olive circle for 'V', and a small olive circle for 'V'. The letters are arranged to form the formula I = P/W and I = P/V.

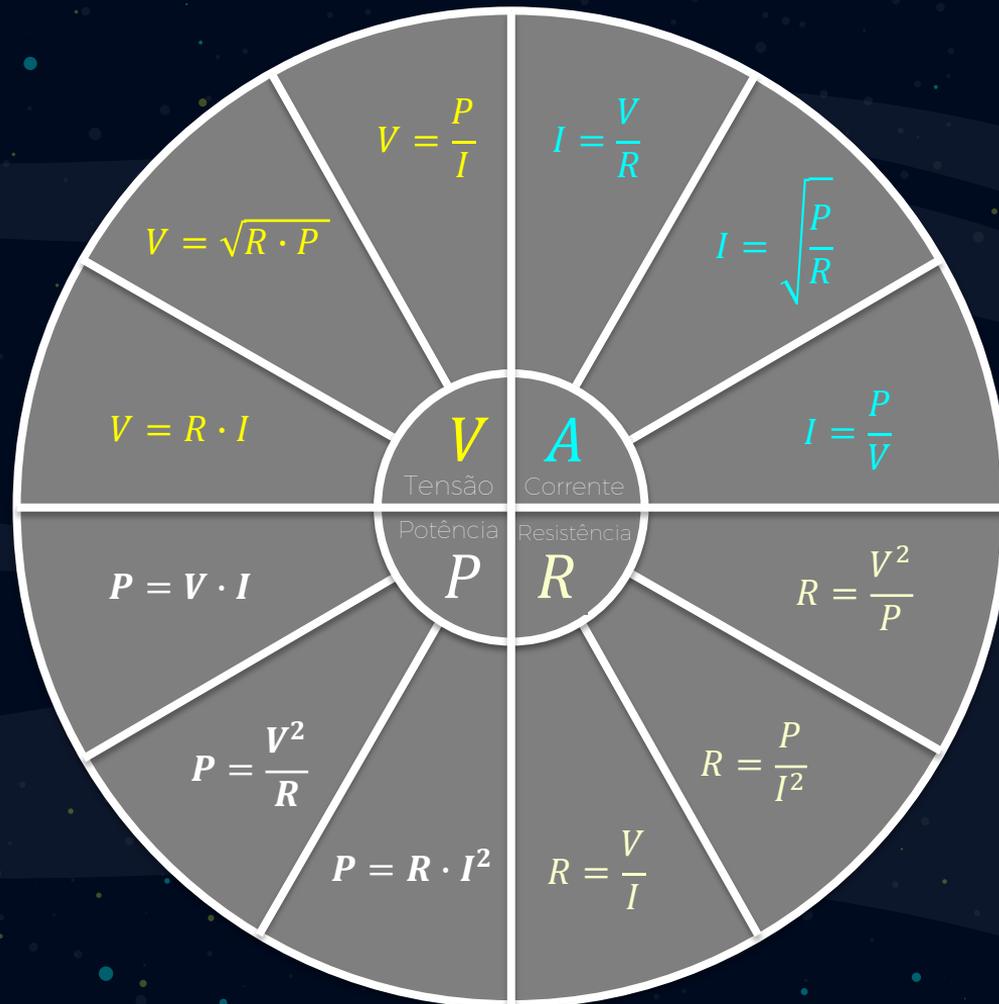


Cálculo da Tensão:

$$V = \frac{P}{I}$$

The diagram illustrates the calculation of voltage (V) using power (P) and current (I). The voltage (V) is represented by a large green circle on the left. The power (P) is represented by a large white circle on the right, with a smaller white circle containing 'W' (Watts) to its right. The current (I) is represented by a large teal circle on the right, with a smaller teal circle containing 'A' (Amperes) to its right. An equals sign (=) is placed between the voltage circle and a horizontal line. The power and current circles are positioned above and below this line, respectively, indicating the formula V = P / I.

Formulário





Preencha os valores na tabela:

V (Volts)	I (Ampère)	R (Ohms)	P (Watts)
100 m	-----	5 k	-----
-----	1,5	8 k	-----
-----	-----	10	100 m
25	5 m	-----	-----
-----	10	25	-----
12 k	-----	-----	150
-----	2 μ	-----	80 k
24	-----	100 k	-----
36 k	6 m	-----	-----
-----	12 μ	-----	600 m



Preencha os valores na tabela:

V (Volts)	I (Ampère)	R (Ohms)	P (Watts)
100 m	20 μ	5 k	2 μ
12 k	1,5	8 k	18 k
1	0,1	10	100 m
25	5 m	5 k	75 m
250	10	25	2,5 k
12 k	12,5 m	960 k	150
40 G (giga)	2 μ	0,2 P (peta)	80 k
24	240 m	100 k	5,76 m
36 k	6 m	6 M (mega)	216
50 k	12 μ	4,16 G (giga)	600 m

Na aula de hoje:

Aula 3

Circuitos Elétricos Simples

Circuito Série

Divisor de Tensão

Circuito Paralelo

Divisor de Corrente

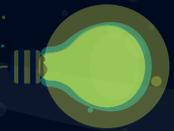
Exemplos

Revisão

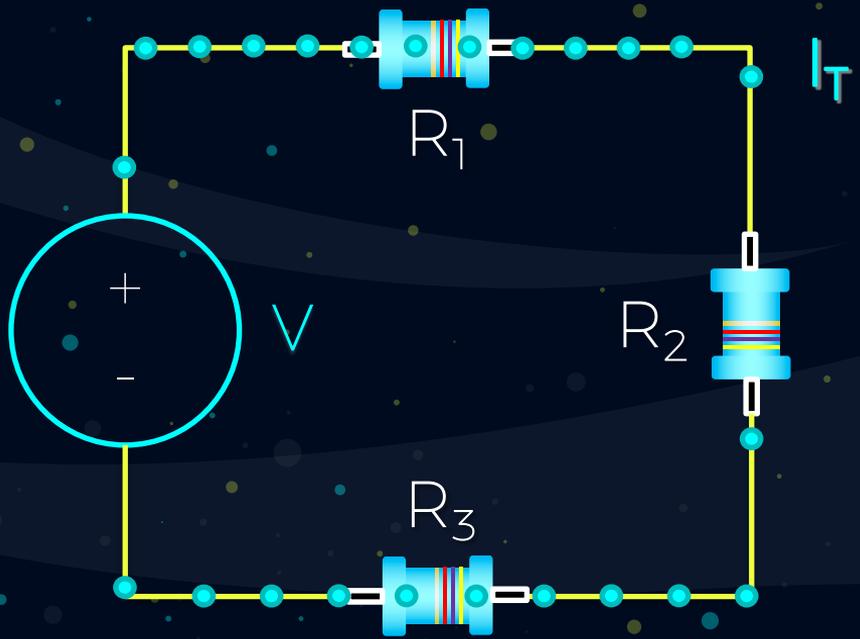
Quiz - Casa

Exercícios - Casa

Circuito Série

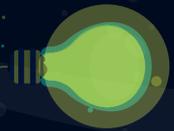


Circuito Série: Corrente

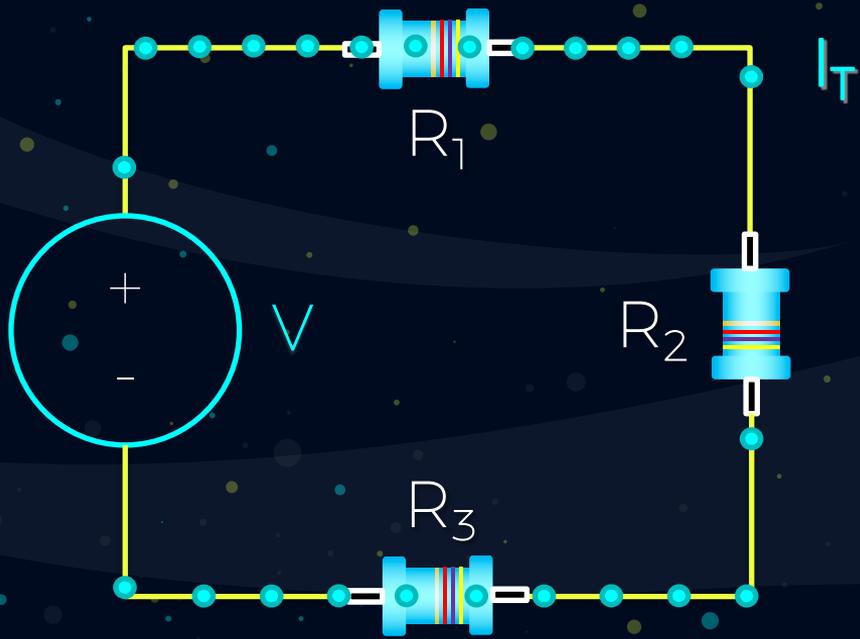


Existe um fluxo ÚNICO de corrente através de todos os resistores.

Portanto, podemos dizer que a Corrente que circula é a mesma em todos os resistores

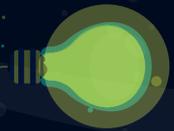


Circuito Série: Corrente

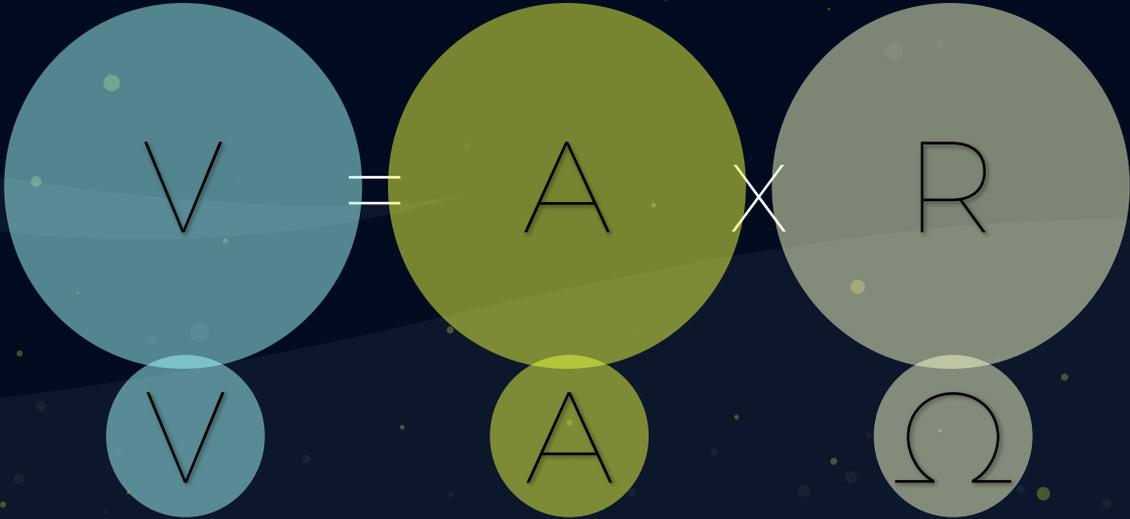


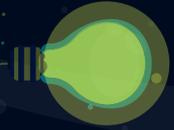
Assim:

$$I_T = I_1 = I_2 = I_3$$

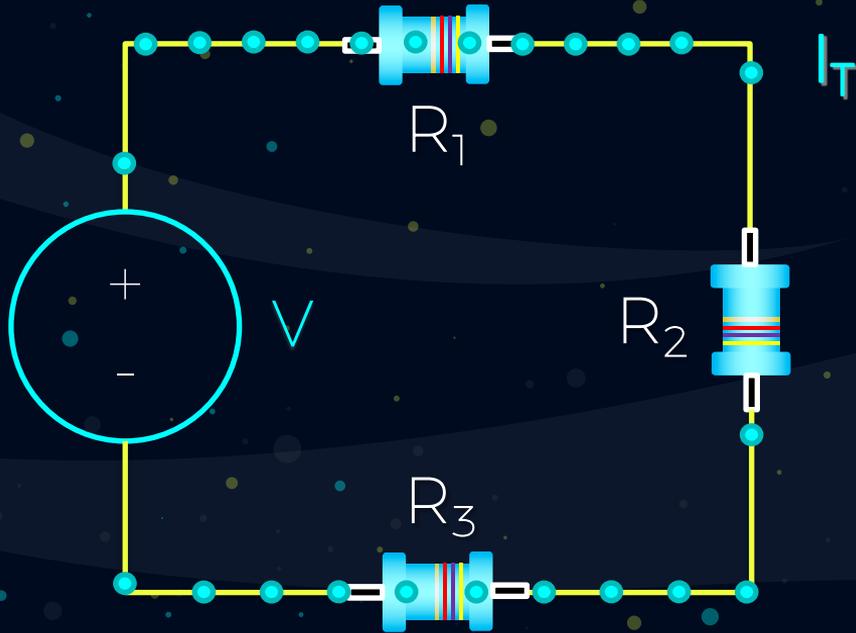


Da Lei de Ohm: lembramos!



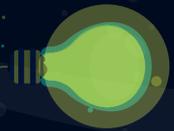


Circuito S rie: Tens o

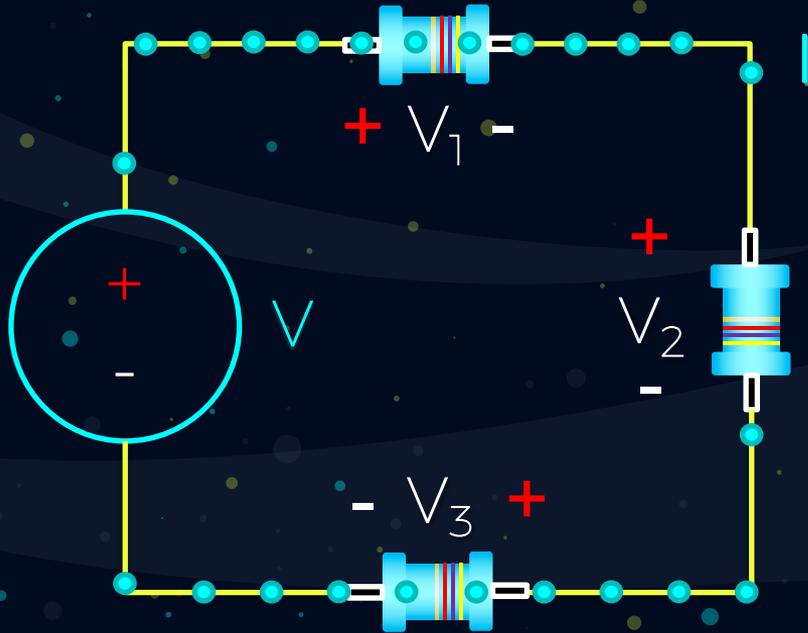


Isto  , se temos resist ncia e corrente, temos uma diferen a de potencial naquele ponto!

Assim, uma corrente vezes uma resist ncia, provoca a uma tens o sobre o resistor!

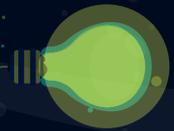


Circuito S rie: Tens o

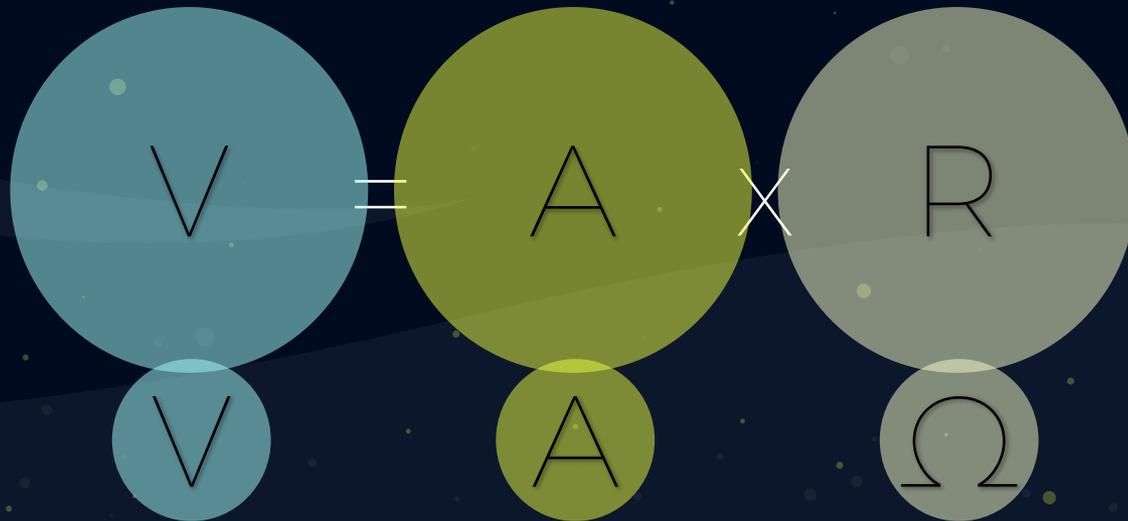


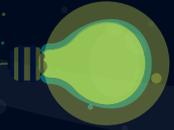
Assim:

$$V = V_1 + V_2 + V_3$$

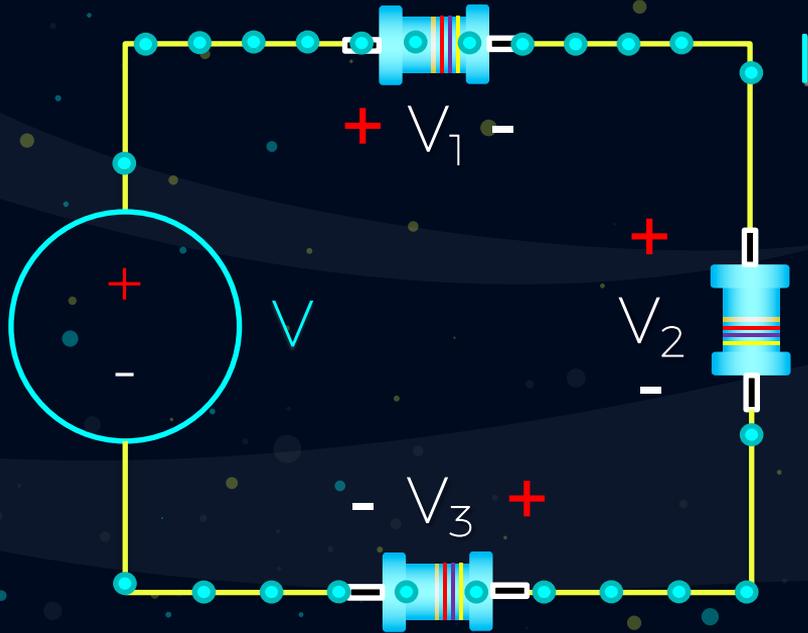


Lembrando de novo!





Circuito Série: Resistência

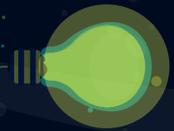


$$V = V_1 + V_2 + V_3$$

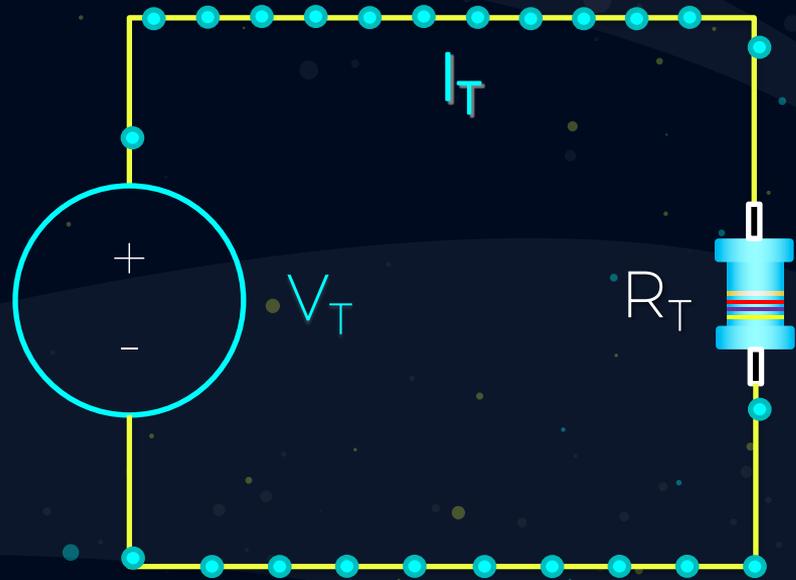
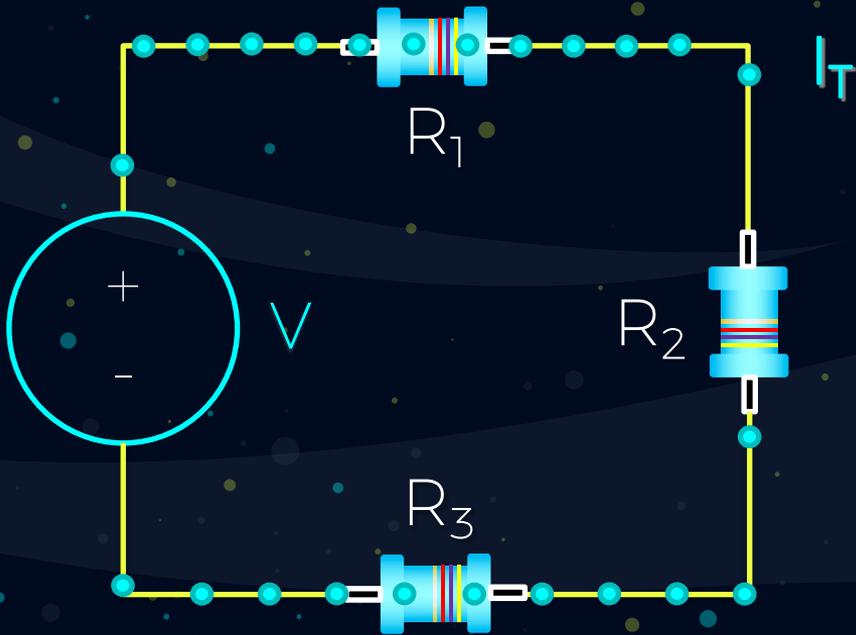
$$V = R_1 \times I_T + R_2 \times I_T + R_3 \times I_T$$

$$V = I_T \times (R_1 + R_2 + R_3)$$

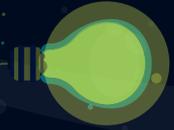
$$V = V_T = I_T \times (R_T)$$



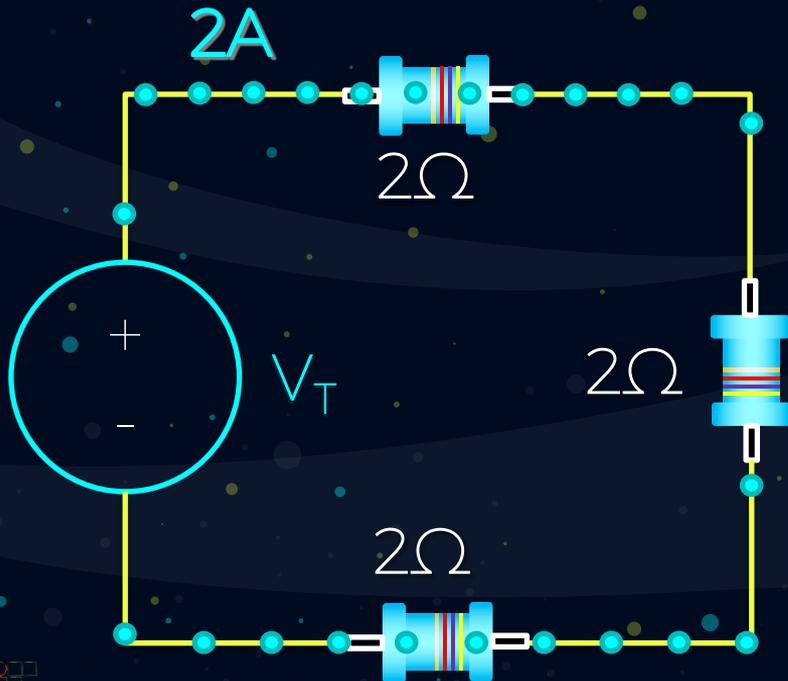
Na prática isso significa...



Exemplos

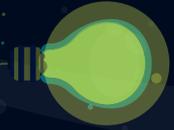


Exemplo 1:

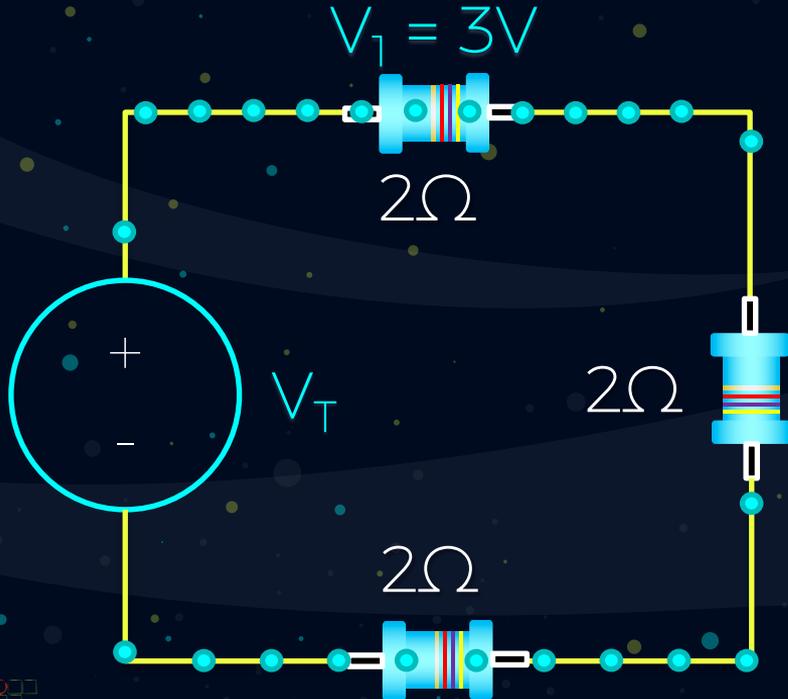


$$V_1 = I_T \times R_1$$
$$V_1 = 2A \times 2\Omega$$
$$V_1 = 4V$$

$$V_1 = V_2 = V_3$$
$$V_T = V_1 + V_2 + V_3$$
$$V_T = 4V + 4V + 4V$$
$$V_T = 12V$$



Exemplo 2:



$$V_1 = 3V \text{ e } R_1 = 2\Omega$$

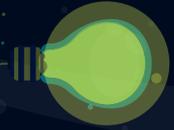
$$V_1 = V_2 = V_3$$

Porque todos os resistores tem o mesmo valor!

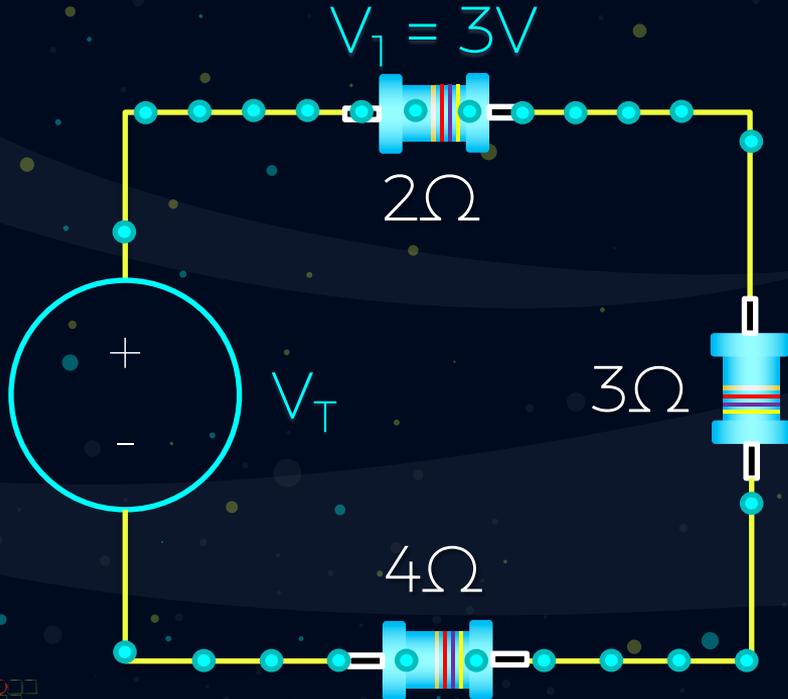
Portanto:

$$V_T = 3 \times (3V)$$

$$V_T = 9V$$



Exemplo 3:



$$V_1 = 3V \text{ e } R_1 = 2\Omega$$

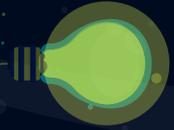
$$I_T = V_1 / R_1 = 3V / 2\Omega$$
$$I_T = 1,5A$$

$$V_T = I_T \times (R_T)$$

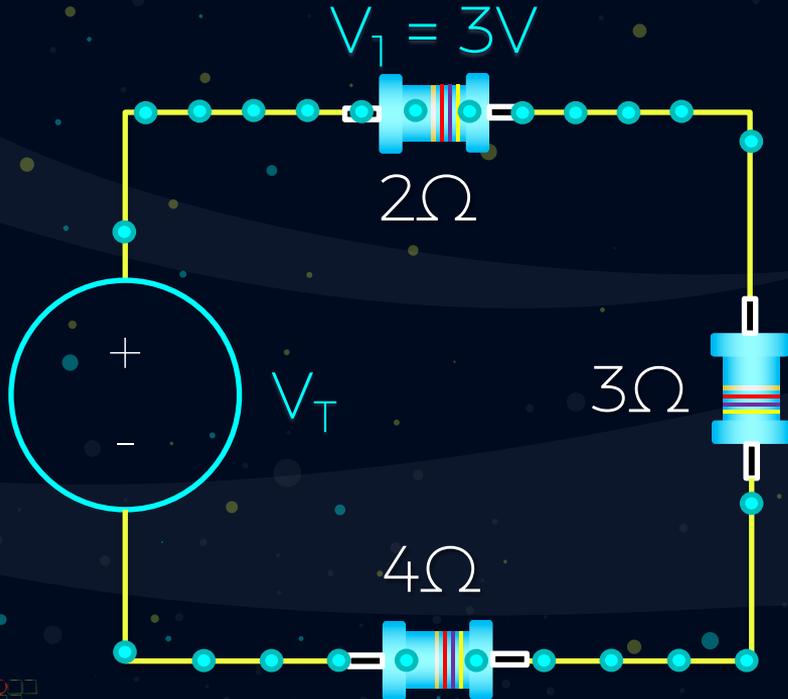
$$V_T = 1,5A \times (2\Omega + 3\Omega + 4\Omega)$$

$$V_T = 1,5A \times (9\Omega)$$

$$V_T = 13,5V$$



Exemplo 3:



$$V_1 = 3V \text{ e } R_1 = 2\Omega$$

$$I_T = V_1/R_1 = 3V/2\Omega$$

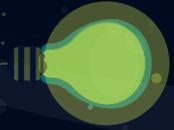
$$I_T = 1,5A$$

$$V_2 = 1,5A \times 3\Omega$$

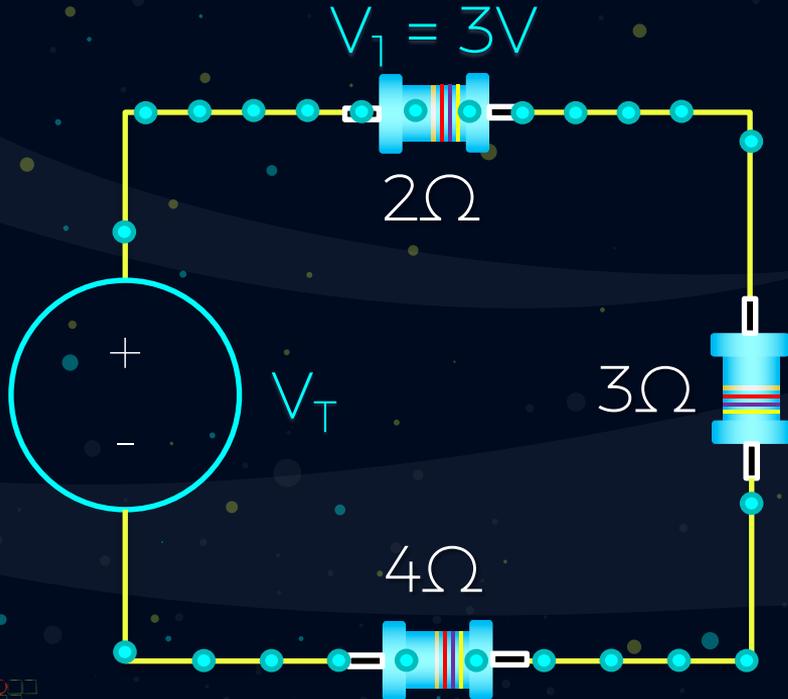
$$V_2 = 4,5V$$

$$V_3 = 1,5A \times 4\Omega$$

$$V_3 = 6V$$



Exemplo 3:

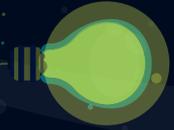


$$V_T = V_1 + V_2 + V_3$$

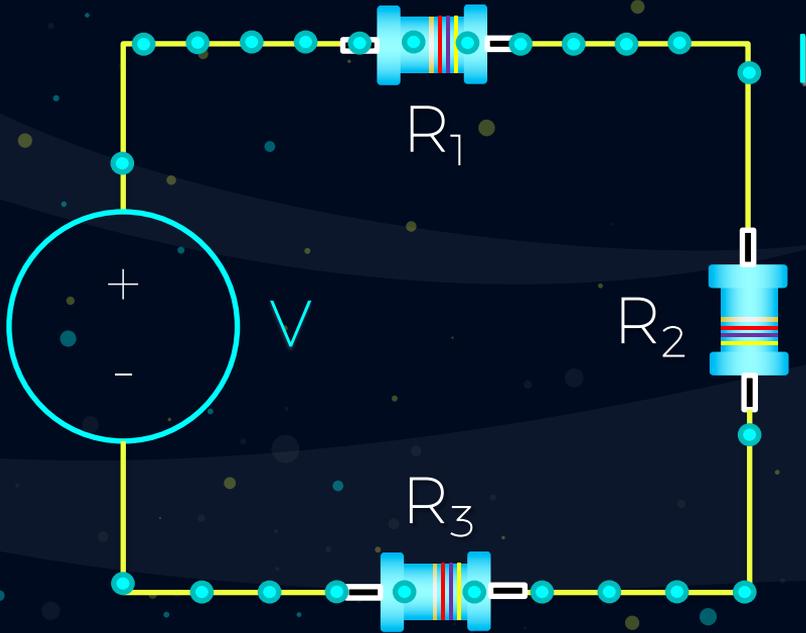
$$V_T = 3V + 4,5V + 6V$$

$$V_T = 13,5V$$

Resumindo...



Em um circuito Série

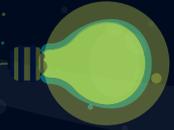


A corrente que circula é a mesma que passa em todos os resistores (Não se divide nunca!)

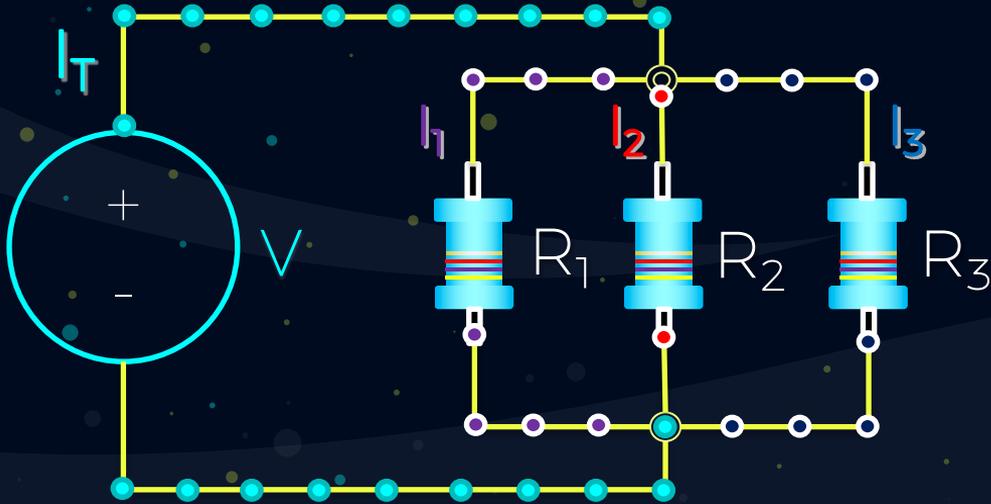
A tensão da fonte divide-se proporcionalmente ao valor da resistência (Conservação de Energia)

A Resistência total vista pela fonte, é a soma de todos os valores de resistência do circuito (Soma direta)

Circuito Paralelo

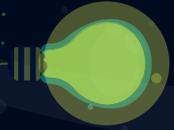


Circuito Paralelo: Corrente

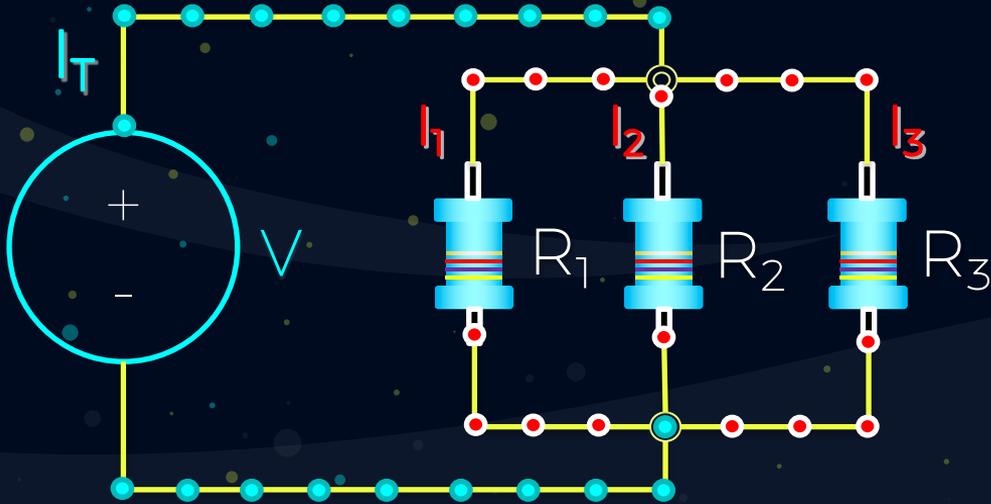


Não existe mais um único caminho de circulação no circuito.

Portanto, a corrente total do circuito se divide inversamente proporcional ao valor da Resistência

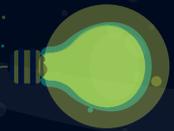


Circuito Paralelo: Corrente

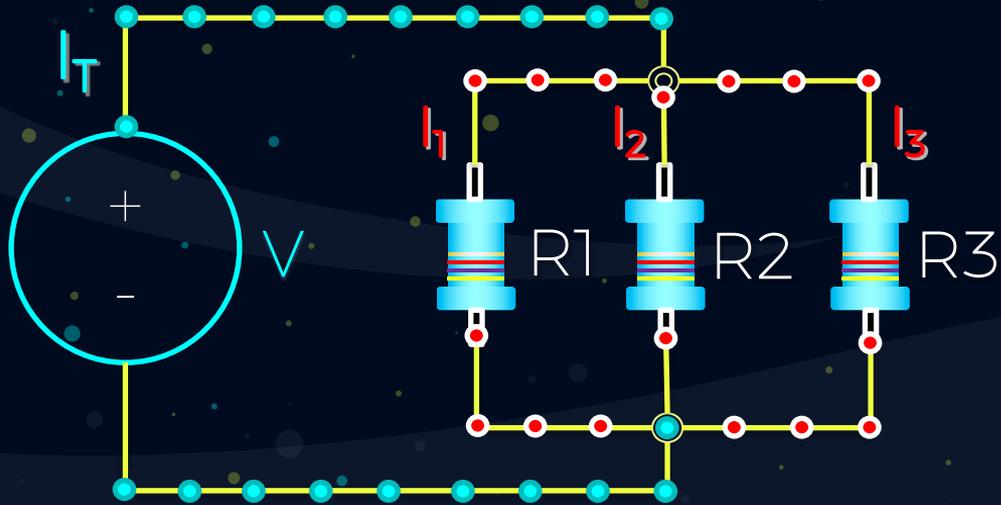


No caso particular de $R_1 = R_2 = R_3$, as três correntes terão o mesmo valor ao se dividirem.

Portanto, $I_1 = I_2 = I_3$, e assim, a soma das correntes em cada resistor deverá ser igual à I_T



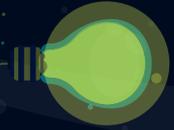
Circuito Paralelo: Corrente



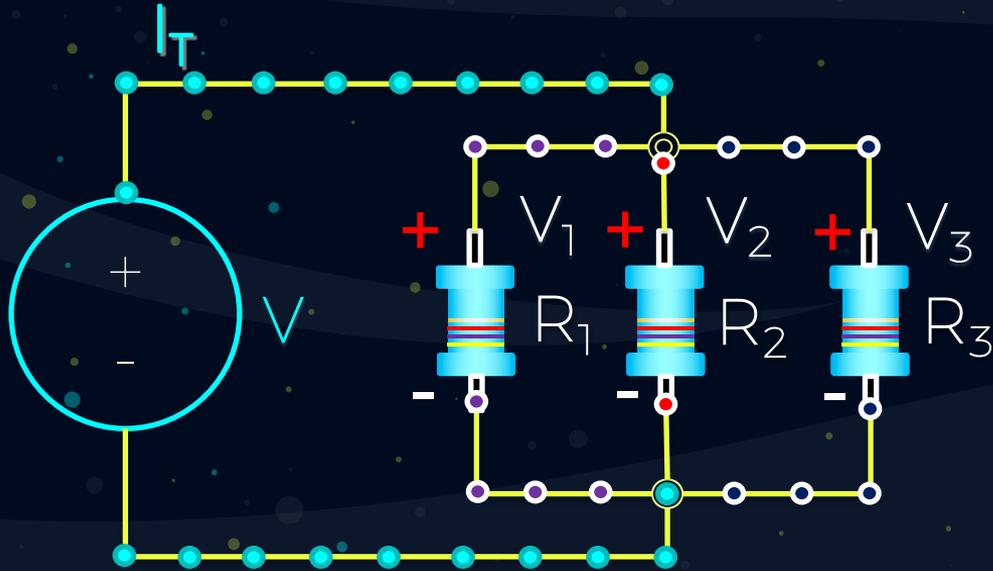
$$I_T = I_1 + I_2 + I_3$$

ou

$$I_T = 3 \times I_1$$

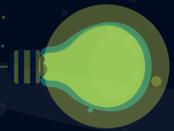


Circuito Paralelo: Tensão

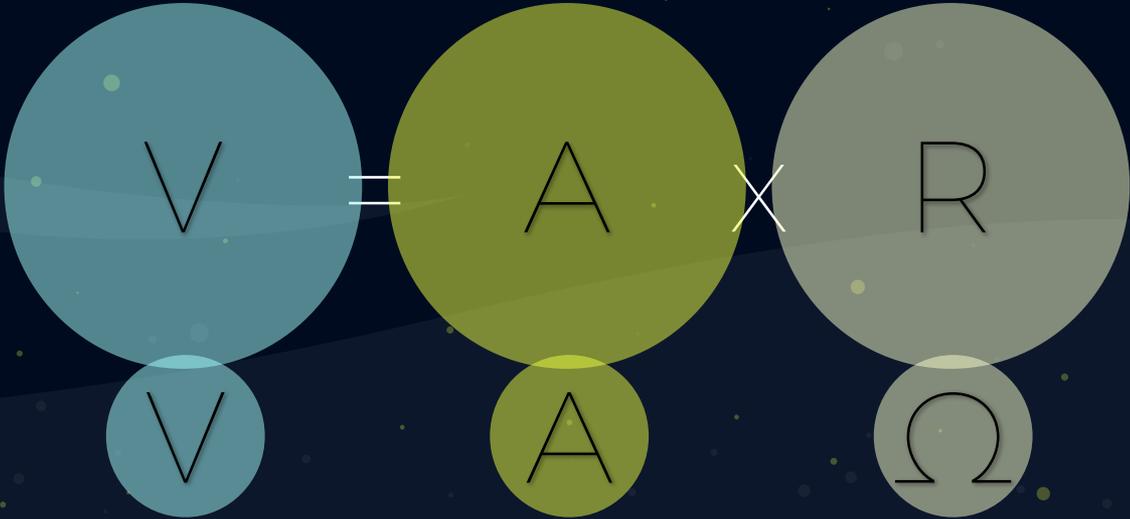


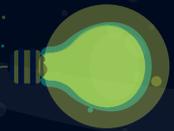
Como no caso do Circuito Série, havendo passagem de corrente através de um resistor, haverá uma d.d.p sobre o mesmo (Lei de Ôhm)

Desta forma, neste circuito, **V₁**, **V₂** e **V₃**. Lembrando que a polarização da d.d.p. é definida pela circulação da corrente no circuito.

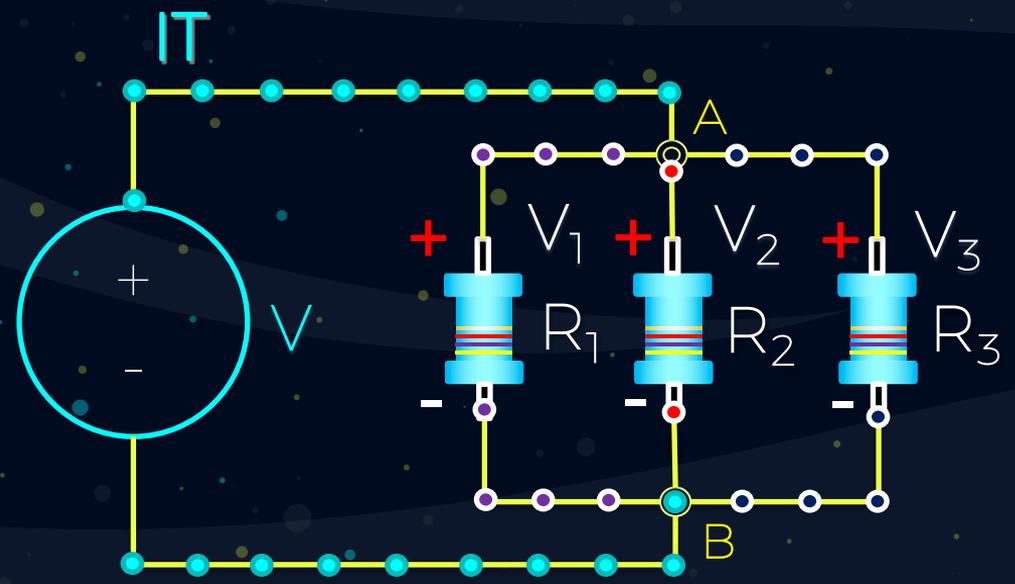


Da Lei de Ohm:

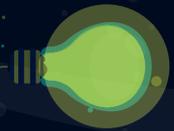




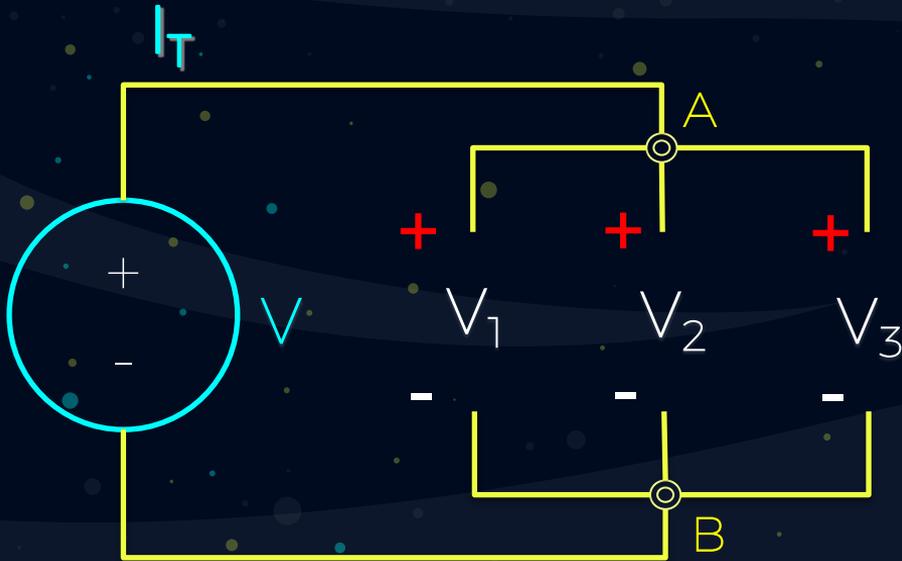
Circuito Paralelo: Tensão



Observa-se que os 3 Resistores possuem dois pontos de ligação em comum, os pontos A e B.

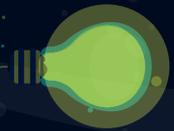


Circuito Paralelo: Tensão

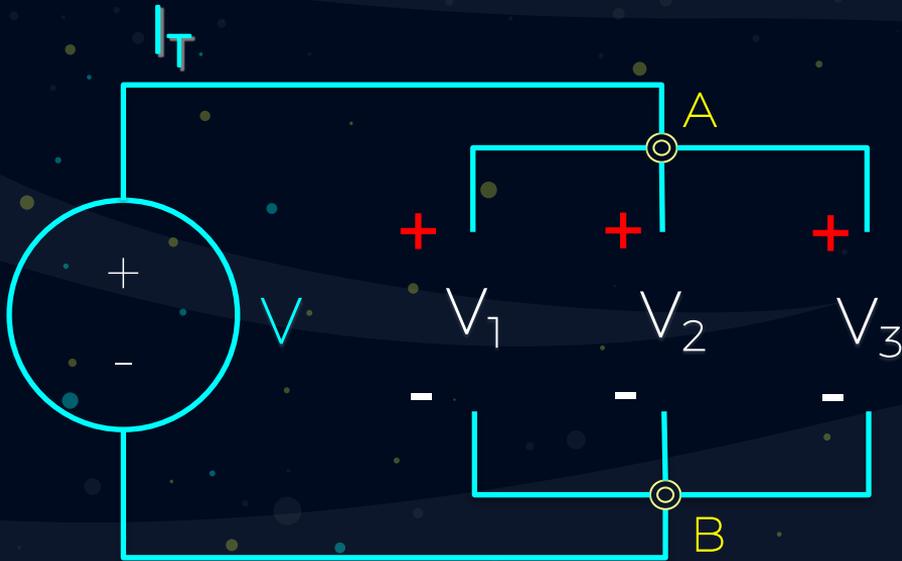


Imagine-se que os resistores estão danificados, e portanto, nestes pontos o circuito está interrompido.

Portanto, não se tem circulação de corrente no circuito, isto é **$I_T = 0A$**

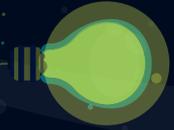


Circuito Paralelo: Tensão

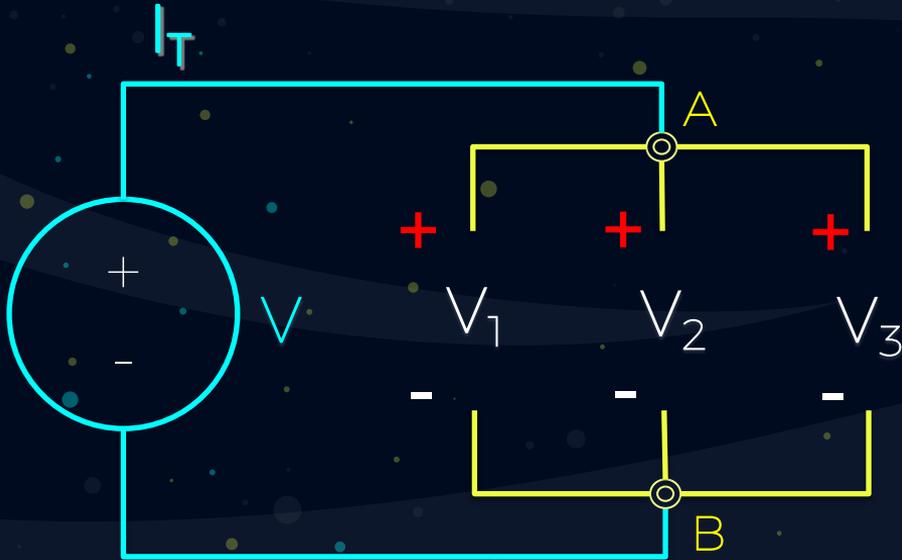


Observando com atenção, verifica-se que o ponto A está ligado no terminal positivo da fonte.

Do mesmo modo, o ponto B está ligado no terminal negativo da fonte.

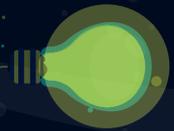


Circuito Paralelo: Tensão

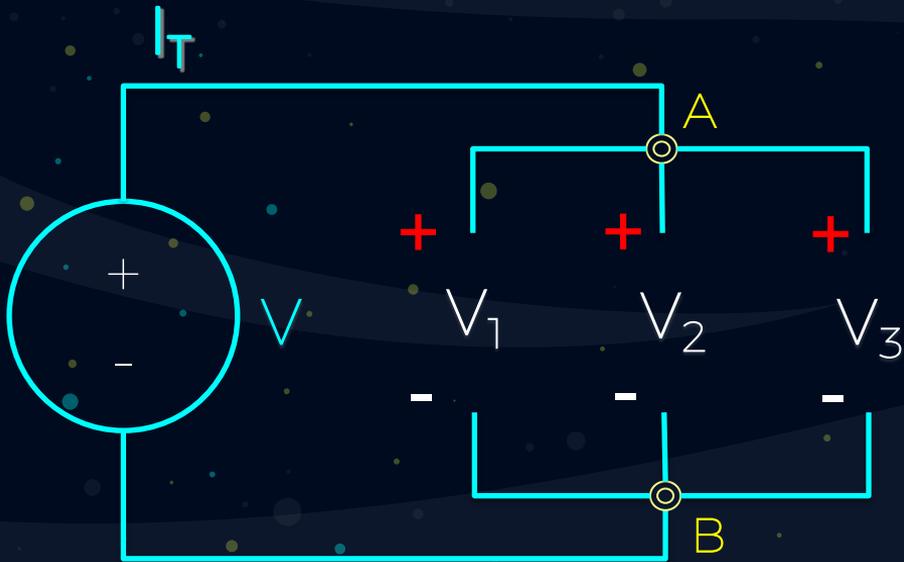


Se fosse medida a tensão no ponto A com relação ao Ponto B (V_{AB}), o valor da Tensão seria igual ao próprio valor da Fonte.:

Isto quer dizer que o ponto A e o ponto B são extensões dos terminais da fonte de alimentação.

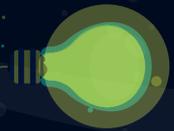


Circuito Paralelo: Tensão

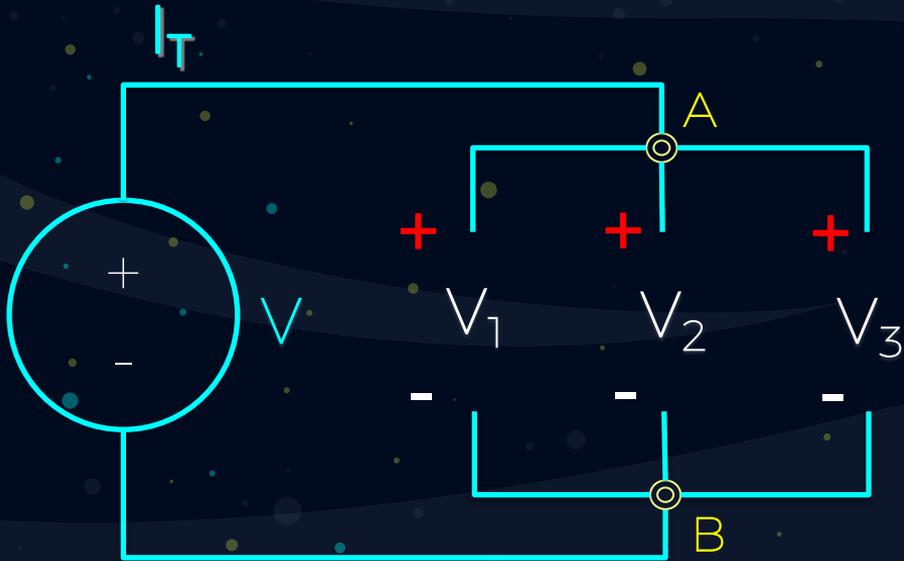


Como cada resistor está ligado no ponto A e no ponto B, é como se cada resistor estivesse diretamente conectado à fonte de alimentação.

$$V_1 = V_2 = V_3 = V_{AB}$$

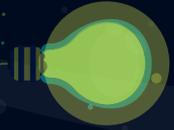


Circuito Paralelo: Tensão

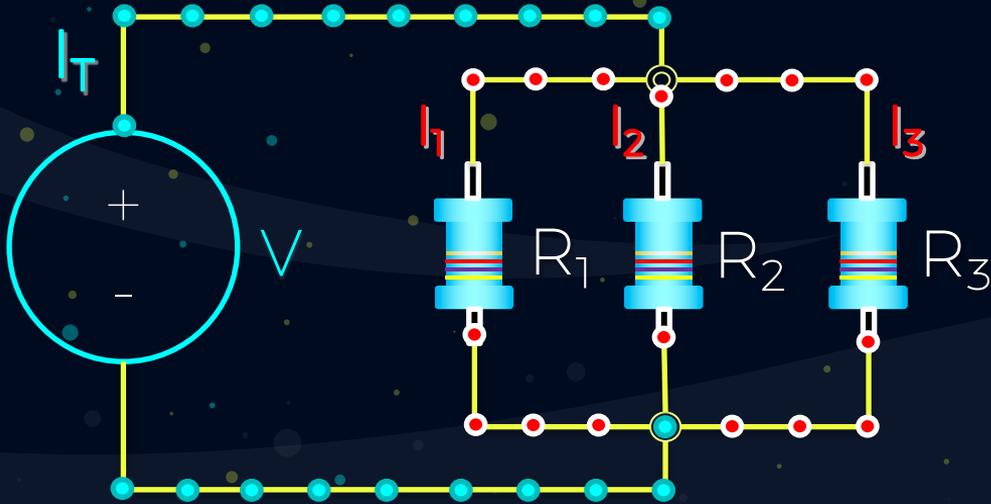


Portanto, em Circuitos Paralelos, a tensão medida sobre cada resistor, é a própria tensão da Fonte.

$$V_1 = V_2 = V_3 = V_{AB} = V$$

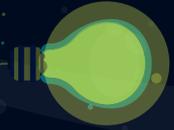


Circuito Paralelo: Resistência

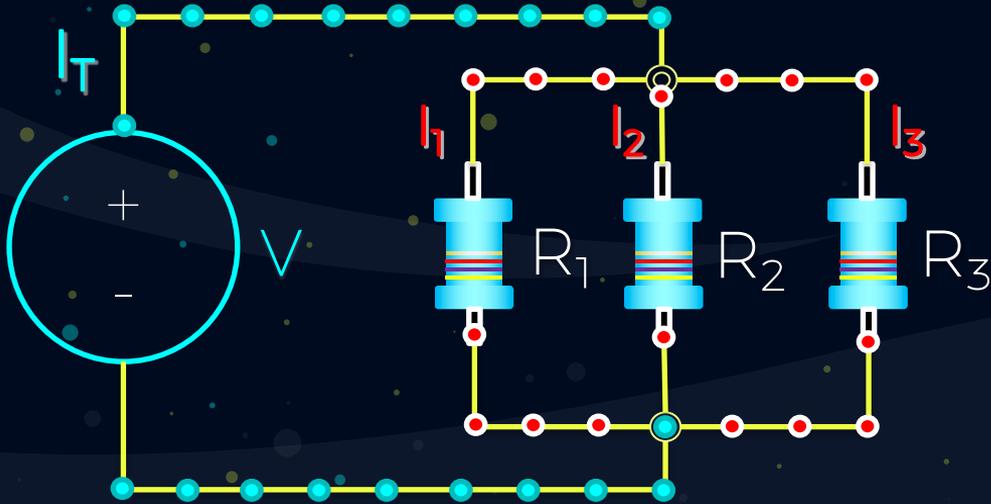


Da mesma forma que no Circuito Série, no Circuito Paralelo, a fonte não sabe quantos resistores estão ligados no circuito.

Para a Fonte, todos os resistores ligados podem ser representados por um único resistor equivalente a todos (R_T)

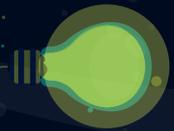


Circuito Paralelo: Resistência

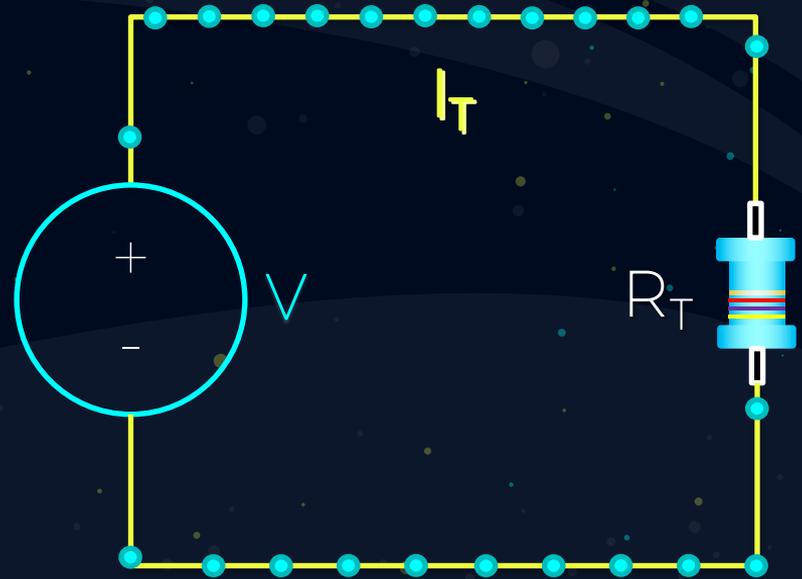
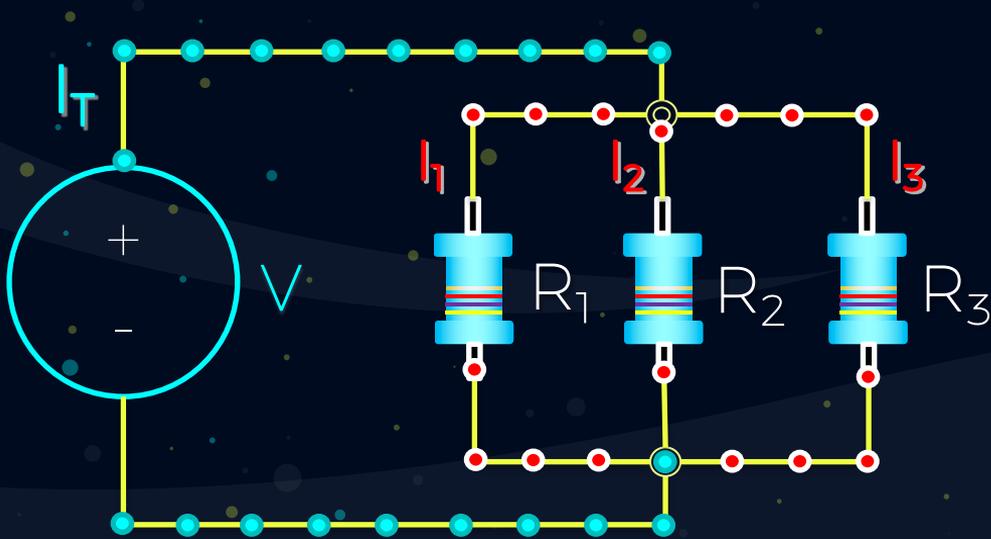


No Circuito Paralelo, não pode ser obtido a R_T da mesma forma que no Circuito Série, visto que um circuito é inverso do outro.

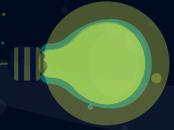
Para tanto existem 4 métodos distintos para calcular a R_T em Circuitos Paralelos de acordo com algumas situações.



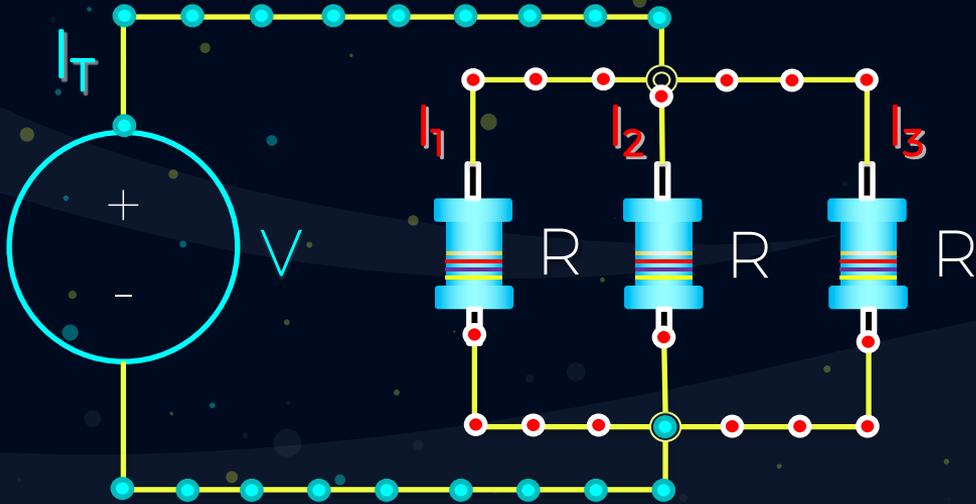
Na prática, isto significa...



Métodos de Cálculo de R_T



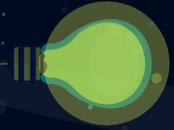
Circuito Paralelo: Resistência #1



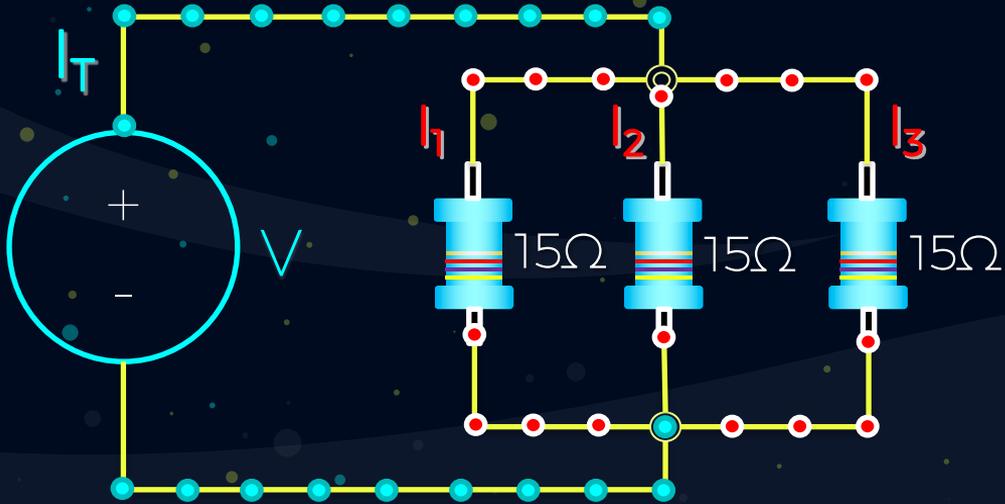
Método 1: Quando todos os resistores ligados em paralelo possuem o mesmo valor.

$$R_T = \frac{R}{n}$$

Onde R é o valor de um dos resistores e n é a quantidade deles no circuito.



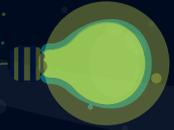
Circuito Paralelo: Resistência #1



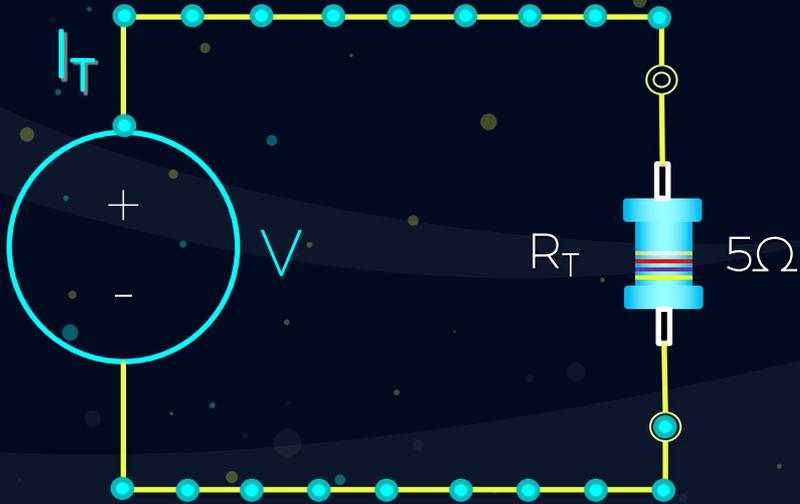
Método 1: Quando todos os resistores ligados em paralelo possuem o mesmo valor.

$$R_T = \frac{15\Omega}{3}$$

$$R_T = 5\Omega$$



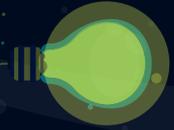
Circuito Paralelo: Resistência #1



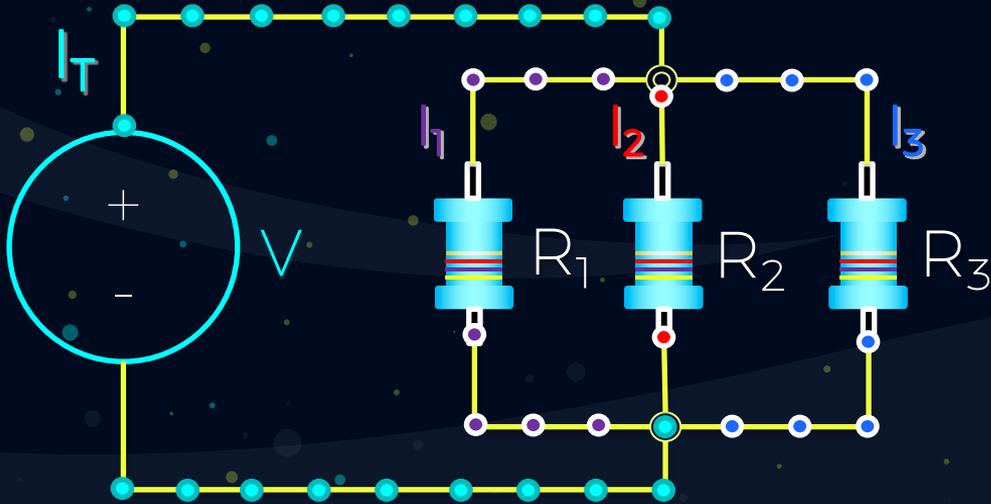
Método 1: Quando todos os resistores ligados em paralelo possuem o mesmo valor.

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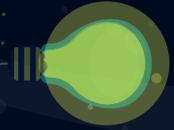
Circuito Paralelo: Resistência #1



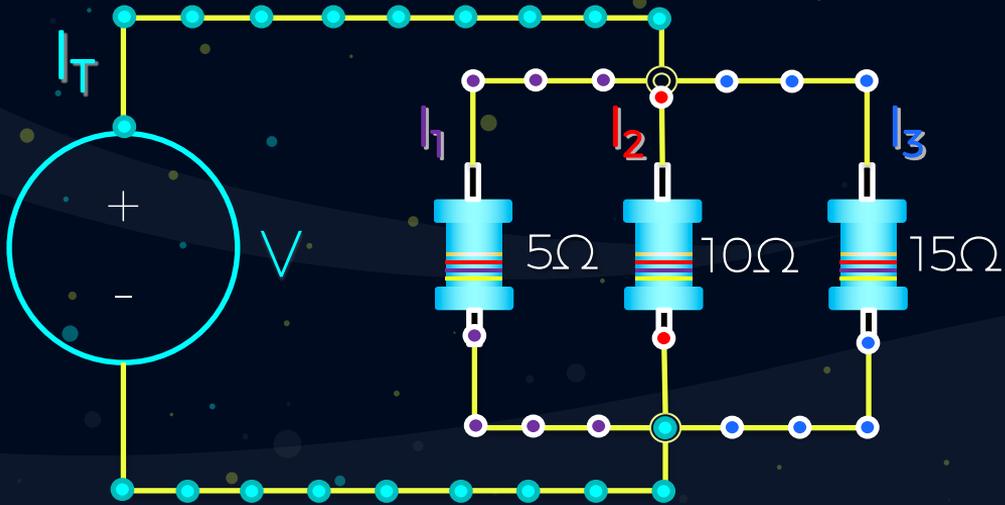
Método 2: Quando os resistores tem valores distintos

$$R_T = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

Este método é válido para o cálculo em duplas de resistores.



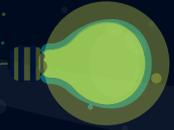
Circuito Paralelo: Resistência #2



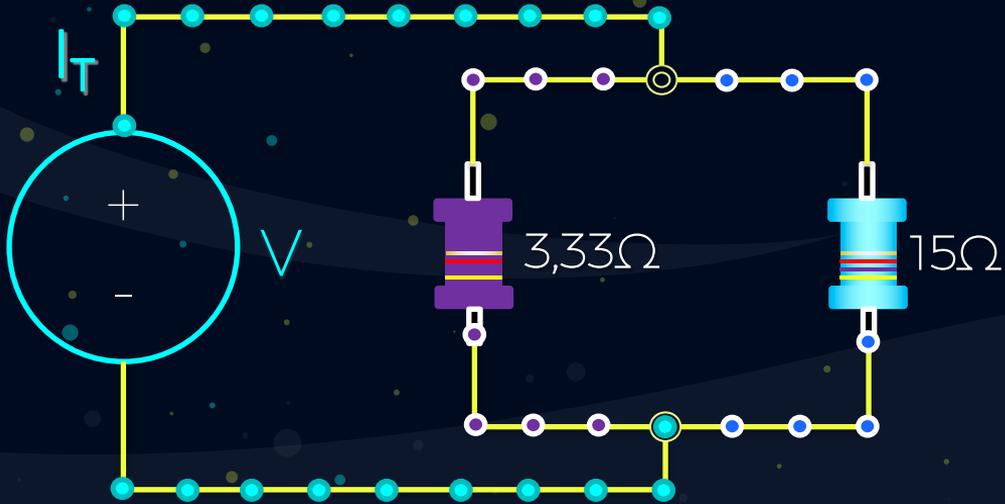
Vamos iniciar o processo de cálculo primeiramente para R_1 e R_2 .

$$R_{1,2} = \frac{5\Omega \cdot 10\Omega}{5\Omega + 10\Omega} = \frac{50\Omega^2}{15\Omega}$$

$$R_{1,2} = 3,33\Omega$$



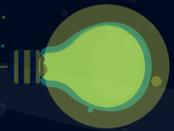
Circuito Paralelo: Resistência #2



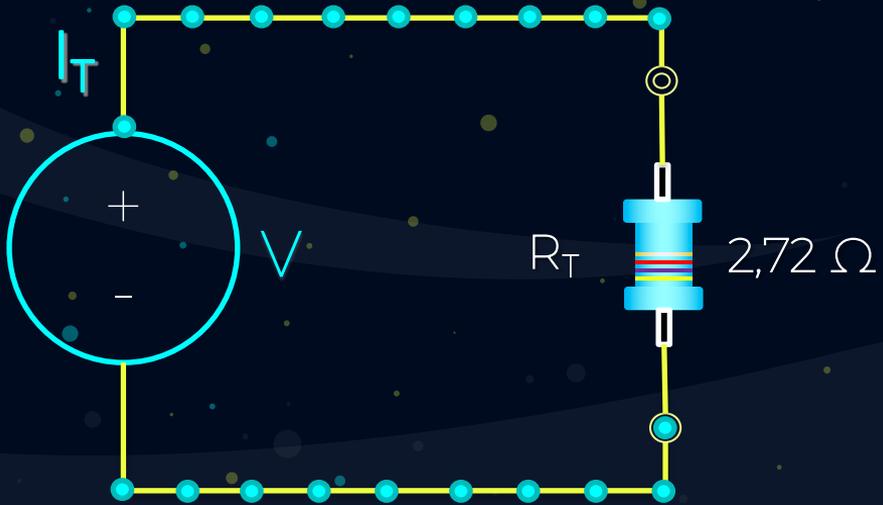
Vamos iniciar o processo de cálculo primeiramente para $R_{1,2}$ e R_3 .

$$R_T = \frac{3,33\Omega \cdot 15\Omega}{3,33\Omega + 15\Omega} = \frac{49,95\Omega^2}{18,33\Omega}$$

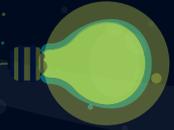
$$R_T = 2,72\Omega$$



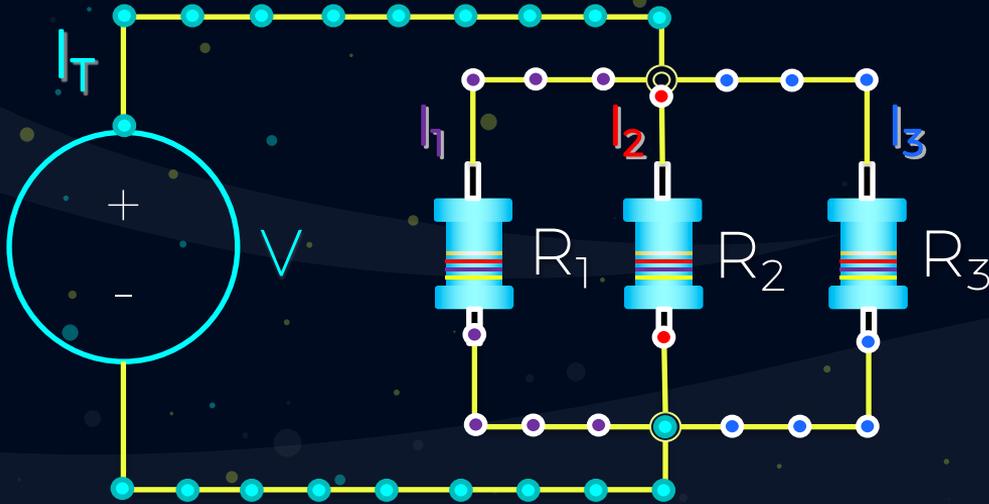
Circuito Paralelo: Resistência #3



$$R_T = 2,72\Omega$$



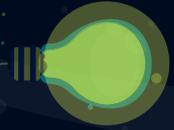
Circuito Paralelo: Resistência #3



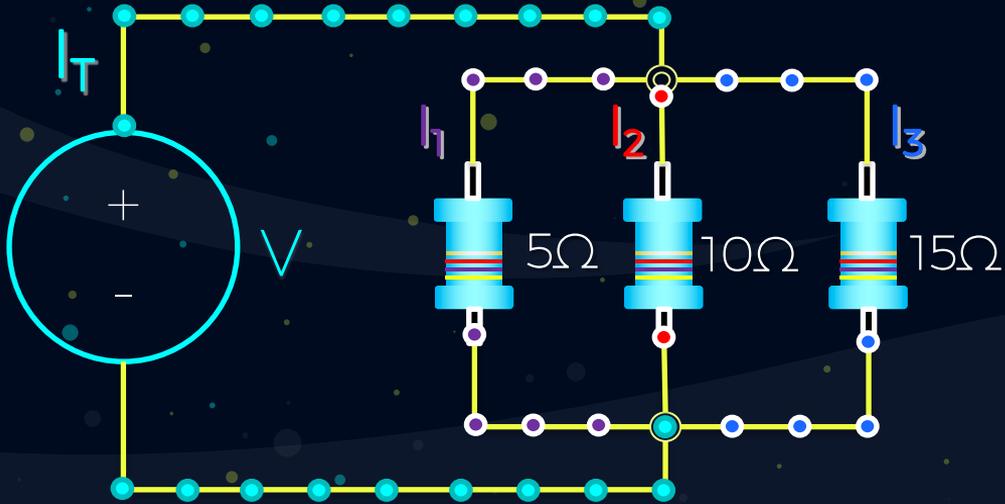
Método 3: Quando todos os resistores ligados em paralelo possuem valores distintos.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Este método utiliza o MCM, e consiste na soma de frações.



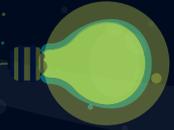
Circuito Paralelo: Resistência #3



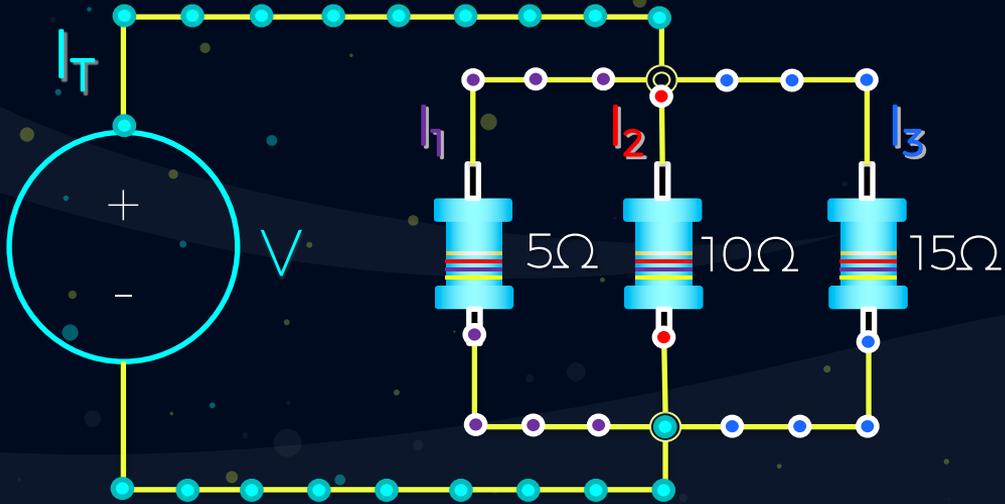
Utilizando os valores do exemplo anterior:

$$\frac{1}{R_T} = \frac{1}{5\Omega} + \frac{1}{10\Omega} + \frac{1}{15\Omega}$$

Calculando o MCM dos três valores (5-10-15), obtém-se o denominador: 30



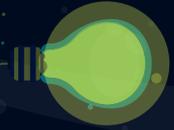
Circuito Paralelo: Resistência #3



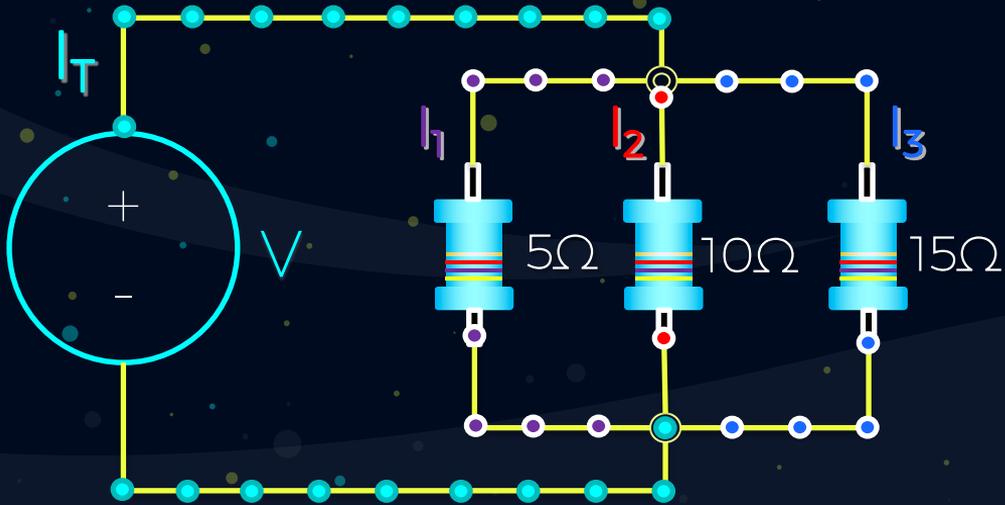
Realizando a soma de frações, obtém-se:

$$\frac{1}{R_T} = \frac{1}{5} + \frac{1}{10} + \frac{1}{15} = \frac{6+3+2}{30}$$

$$\frac{1}{R_T} = \frac{6+3+2}{30} = \frac{11}{30}$$



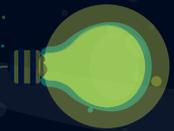
Circuito Paralelo: Resistência #3



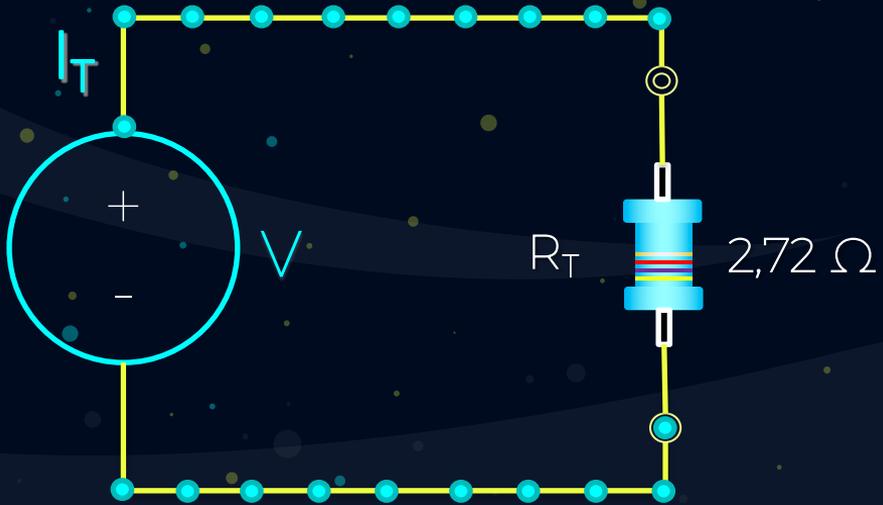
Lembrando que o valor calculado é o inverso de R_T e não R_T . Portanto, a fração deverá ser o inverso de $1/R_T$.

$$\frac{1}{R_T} = \frac{1}{11} \therefore R_T = \frac{30}{11}$$

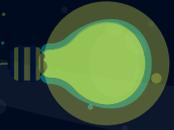
$$R_T = 2,72\Omega$$



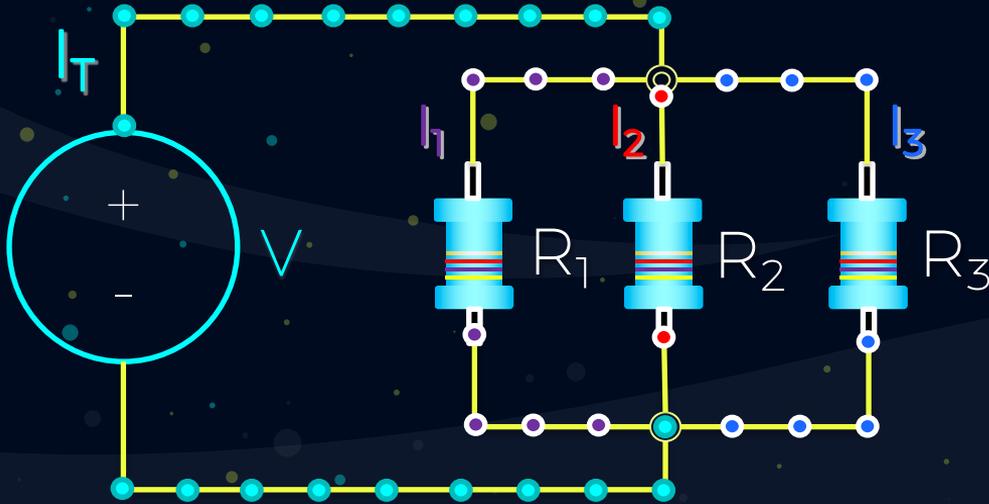
Circuito Paralelo: Resistência #3



$$R_T = 2,72\Omega$$



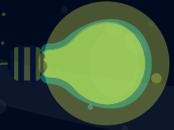
Circuito Paralelo: Resistência #4



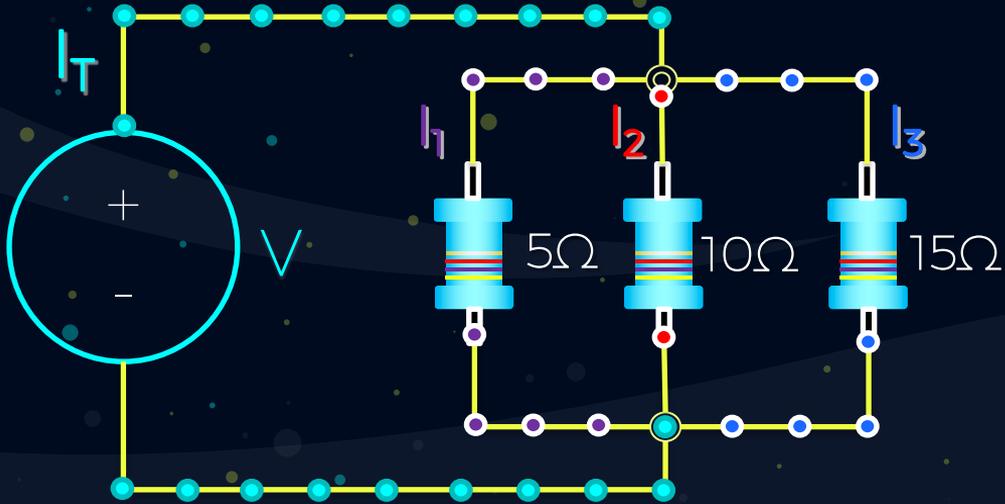
Método 4: Quando todos os resistores ligados em paralelo possuem valores distintos.

$$C_T = \frac{1}{R_T} \text{ (Siemens)}$$

Este método é chamado também de método da Condutância (Inverso da Resistência)



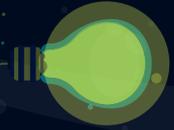
Circuito Paralelo: Resistência #4



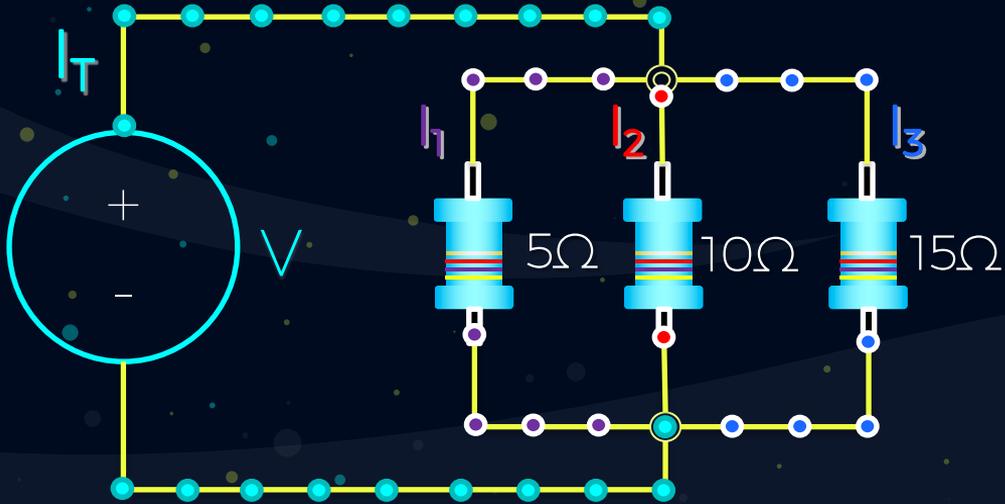
Utilizando os valores do exemplo anterior:

$$\frac{1}{R_T} = \frac{1}{5\Omega} + \frac{1}{10\Omega} + \frac{1}{15\Omega}$$

$$C_T = C_1 + C_2 + C_3$$



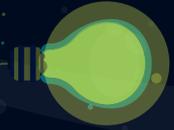
Circuito Paralelo: Resistência #4



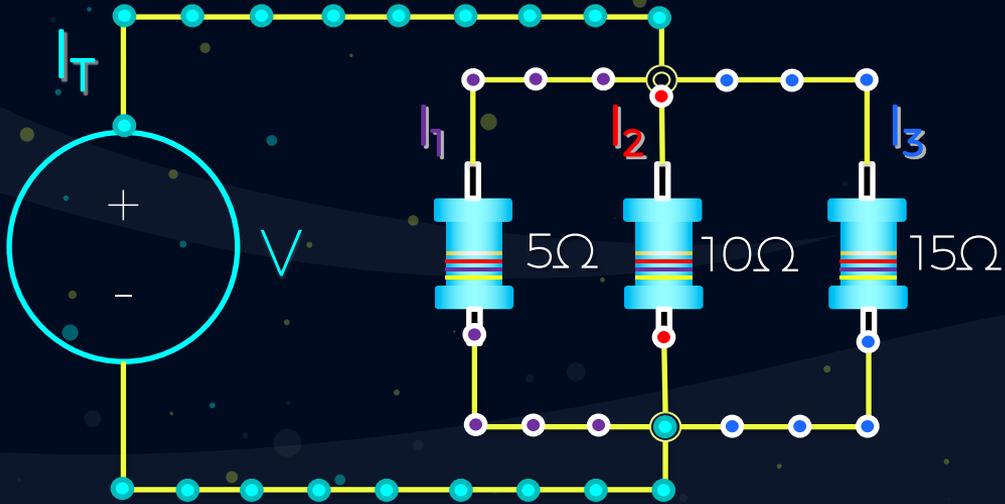
Calculando os valores de forma direta, obtém-se que:

$$\frac{1}{R_T} = \frac{1}{5\Omega} + \frac{1}{10\Omega} + \frac{1}{15\Omega}$$

$$C_T = 0,2S + 0,1S + 0,067S$$



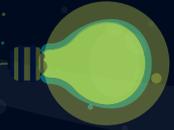
Circuito Paralelo: Resistência #4



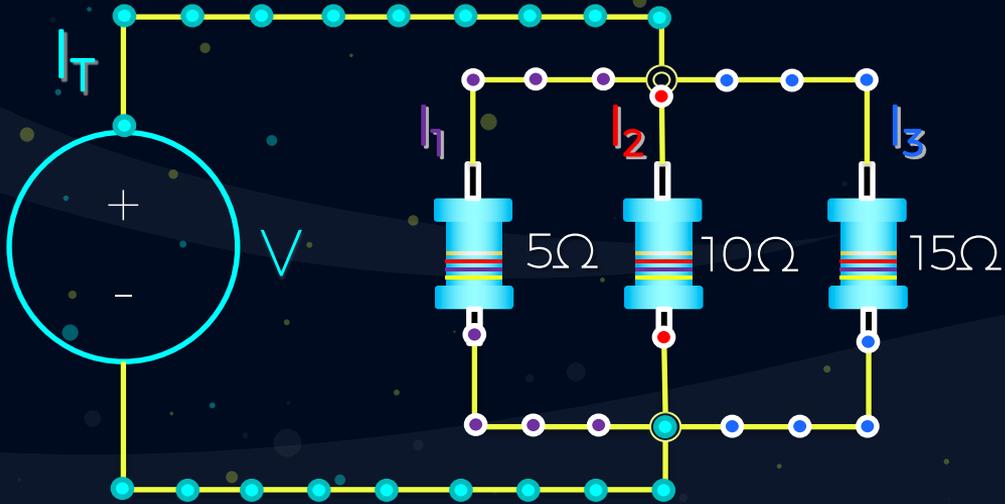
Somando os valores de condutância calculados, obtém-se a Condutância Total do Circuito

$$C_T = 0,367 S$$

Lembrando que a Condutância Total é o inverso da Resistência Total.



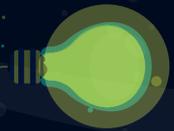
Circuito Paralelo: Resistência #4



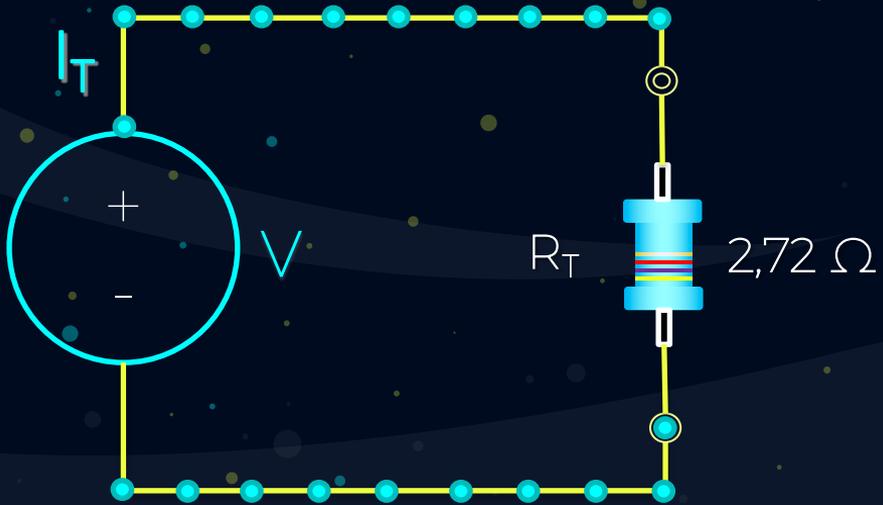
Portanto, invertendo o valor da Condutância Total, obtém-se o Valor da R_T

$$R_T = \frac{1}{C_T} = \frac{1}{0,367 S}$$

$$R_T = 2,72\Omega$$



Circuito Paralelo: Resistência #4



$$R_T = 2,72\Omega$$

Resumindo:

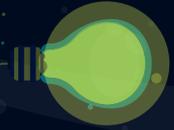
#método 1: Somente se todos os valores de resistores forem iguais.

#método 2: Para valores diferentes. Uso em pares! Pode ser utilizado para mais de 2 resistores, porém terá mais interações.

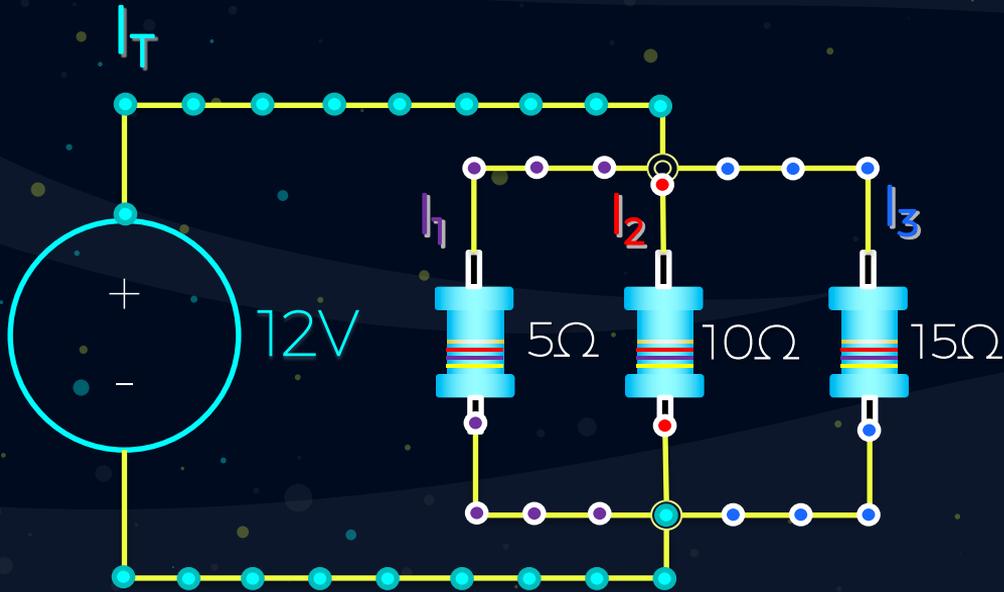
#método 3: Para valores diferentes e qualquer número de resistores. Requer MCM e inversão do resultado final.

#método 4: Para valores diferentes e qualquer número de resistores. Recomendado pela simplicidade e rapidez de cálculo.

Exemplos



Exemplo 1:



$$V_1 = V_2 = V_3 = V = 12V$$

$$I_1 = 12V/5\Omega = 2,4A$$

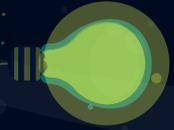
$$I_2 = 12V/10\Omega = 1,2A$$

$$I_3 = 12V/15\Omega = 0,8A$$

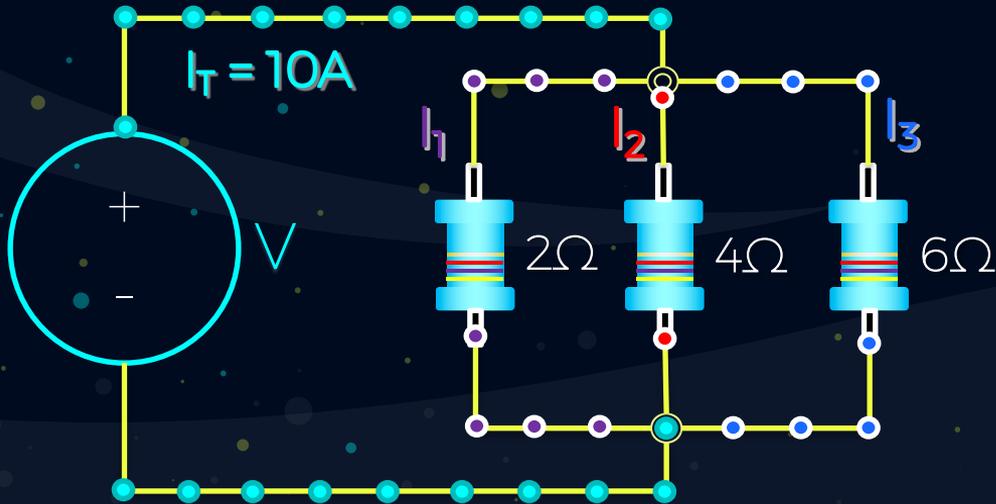
$$I_T = I_1 + I_2 + I_3$$

$$I_T = 2,4A + 1,2A + 0,8A$$

$$I_T = 4,4A$$



Exemplo 2:



$$I_T = 10A$$

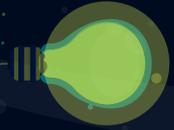
$$C_T = C_1 + C_2 + C_3$$

$$C_T = 0,5S + 0,25S + 0,167S$$

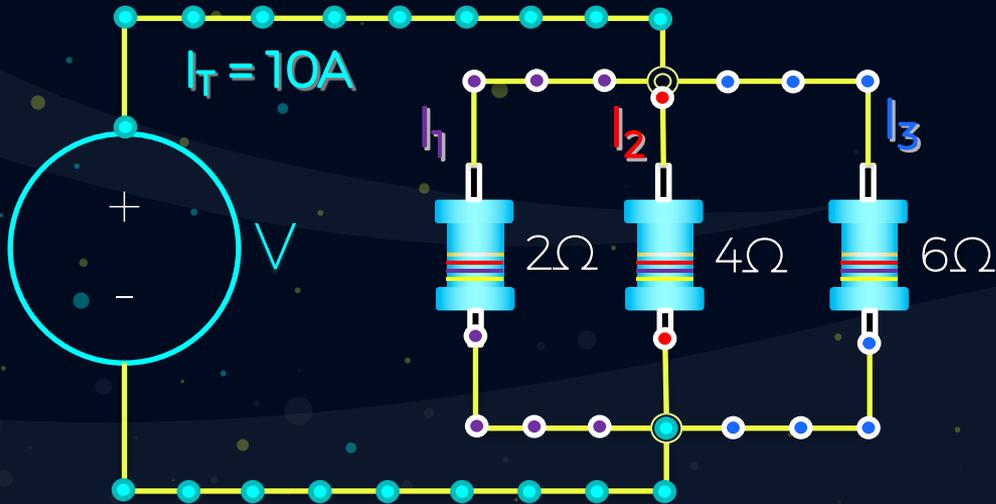
$$C_T = 0,917S$$

$$R_T = 1 / C_T = 1 / 0,917S$$

$$R_T = 1,09\Omega$$



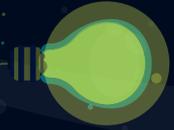
Exemplo 2:



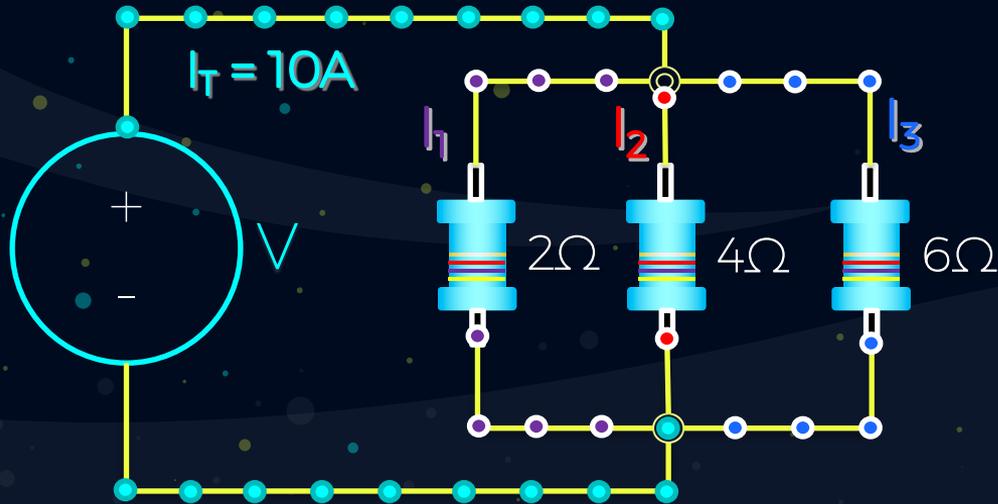
$$V_T = I_T \times R_T$$

$$V_T = 10A \times 1,09\Omega$$

$$V_T = 10,9V$$



Exemplo 2:



$$V_T = 10,9 \text{ V}$$

$$V_T = V_1 = V_2 = V_3$$

$$I_1 = 10,9\text{V}/2\Omega = 5,45\text{A}$$

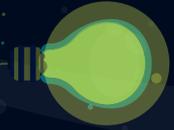
$$I_2 = 10,9\text{V}/4\Omega = 2,725\text{A}$$

$$I_3 = 10,9\text{V}/6\Omega = 1,817\text{A}$$

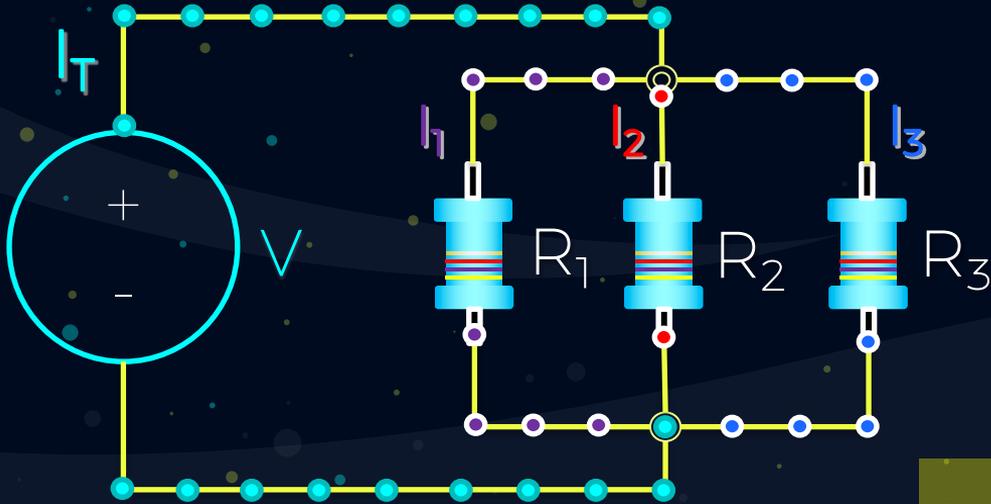
$$I_T = I_1 + I_2 + I_3$$

$$I_T = 9,992 \text{ A} = 10 \text{ A}$$

Resumindo...



Em um Circuito Paralelo



A corrente total se divide inversamente proporcional ao valor do Resistor

A tensão sobre qualquer resistor é o mesmo em todos os resistores em paralelo.

A Resistência Total não pode ser calculada diretamente como no Circuito Série, existem 4 métodos de cálculo.

Dúvidas?

raul.sales@passofundo.ifsul.edu.br