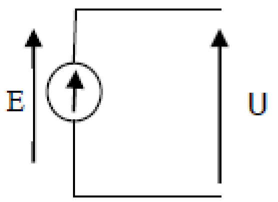
Exercise 1:

Give (trace) the symbols of the sources (generators) of voltage (ideal and real). What is the difference between the two types. The same question applies to power sources (generators).

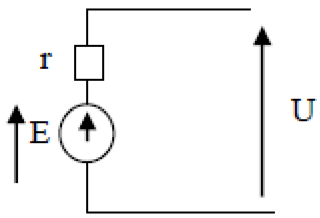
Answers 1 :

Voltage Source Ideal



$U = E$

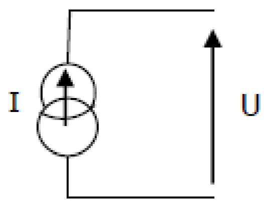
Actual voltage source



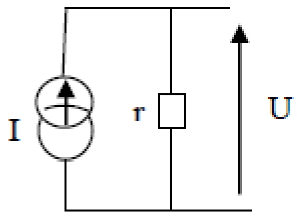
$U = E - r.I$

The difference between the two types is that the actual source contains an internal resistance, whereas the ideal does not contain contains.

Ideal power supply



Actual power source



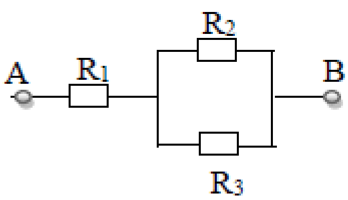
For the difference same answer as that of the voltage source.

Exercise 2 :

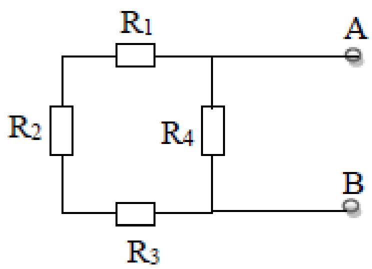
Determine and calculate the equivalent resistance between the two points for each assembly below :

R1 = 1KΩ, R2 = R3 = 2 KΩ, R4 = 3 KΩ .

Setup 1:

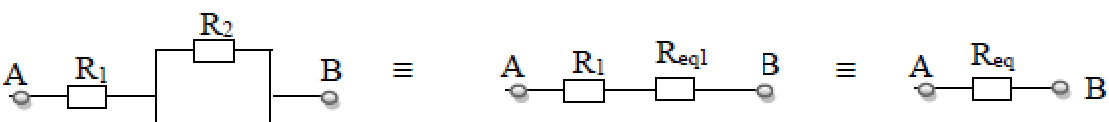


Setup 2:



Correction 2 :

Setup 1:

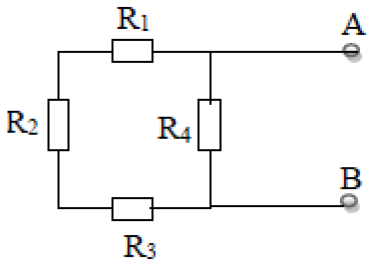


$R_{eq1} = R_2 // R_3$

$R_{eq} = R1 + R_{eq1}$

$R_{eq1} = R_2//R_3 = (R_2xR_3)/(R_2+R_3) = (2x2)/(2+2) = 1K\Omega$, $Req = R_1+R_{eq1} = 1+1 = 2K\Omega$

Setup 2:



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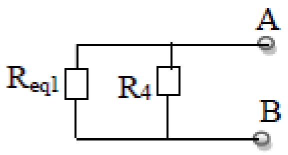
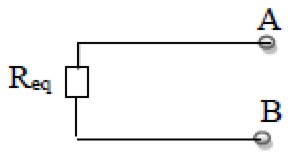


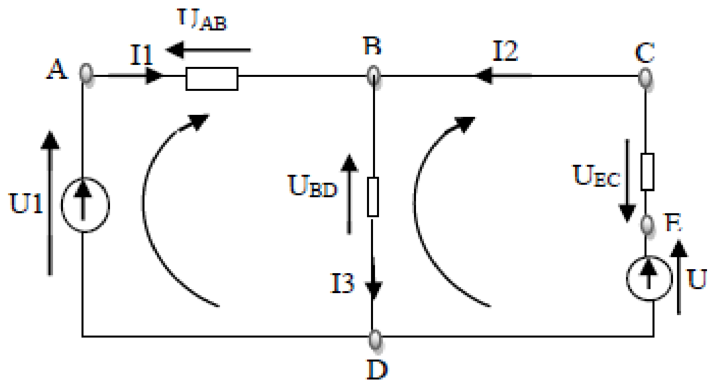


$R_{eq1}= R_1+R_2+R_3$ $\qquad$ $R_{eq} = R_{eq1}//R_4$

$Req = 1+2+2 = 5K\Omega$, $\qquad$ $R_{eq} = (R_{eq1}xR_4)/(R_{eq1}+R_4)=15/8=1.87K\Omega$

<u>Exercise</u> 3 :

Let be the following electrical circuit :



We give :

$U_1 = 120$ V, $I_1 = 8$ A.
$U_2 = 50$ V, $I_3 = 5$ A, $U_{BD} = 80$ V.

1) Calculate I_2.

2) Calculate U_{AB} and U_{EC}.

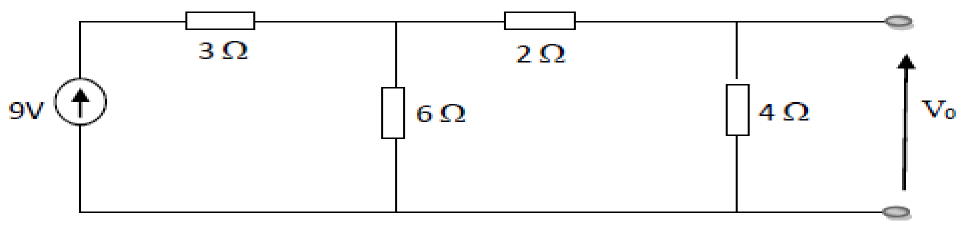
<u>Correction</u> 3 :

1) **I_2 = ?,**
Law of knots at point A : $I_1 + I_2 = I3 \Rightarrow I_2 = I_3 – I_1 = 5 – 8 = -3V$.
$I2 = -3$ A, $I2 < 0 \Rightarrow$ The true direction of the current is the reverse of the one indicated.

2) **U_{AB} = ?,**
Law of ABDA meshes.
$U_1 - U_{AB} -U_{BD} = 0 \Rightarrow U_{AB} = U_1 - U_{BD} \quad \Rightarrow U_{BD} = U_1 – U_{AB} = 120 – 80 = 40$ V.

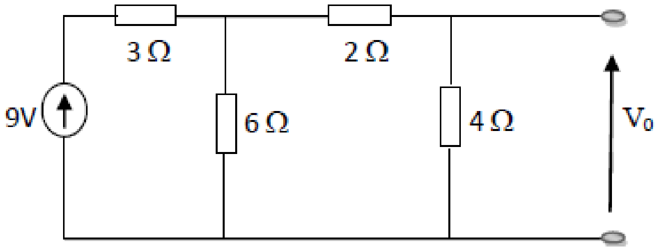
U_{EC} = ?,
The law of meshes is applied along the BCDB branches
$U_{BD} + U_{EC} – U_2 = 0 \Rightarrow U_{EC} = U_2 – U_{BD} = 50 – 80 = -30V$.

<u>Exercise</u> 4 :
Let us consider the following assembly :



Using Thevenin's Theorem to Determine V_0

<u>Correction</u> 4 :



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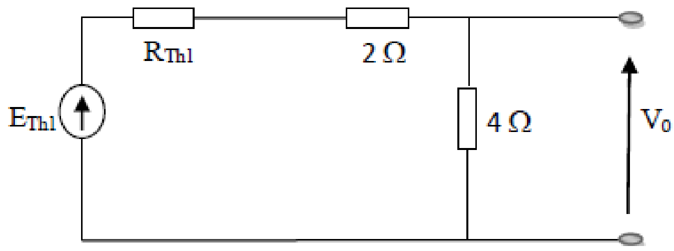
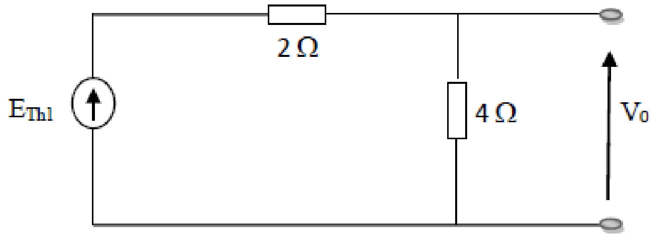


E_{Th1} = (6/9).9 = 6 V

R_{Th1} = (18/9) = 2Ω

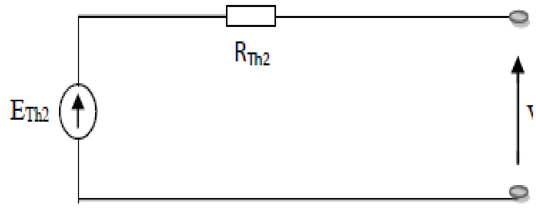
≡



E_{Th2} = (4/8).6 = 3 V
E_{Th2} = V0 = 3V

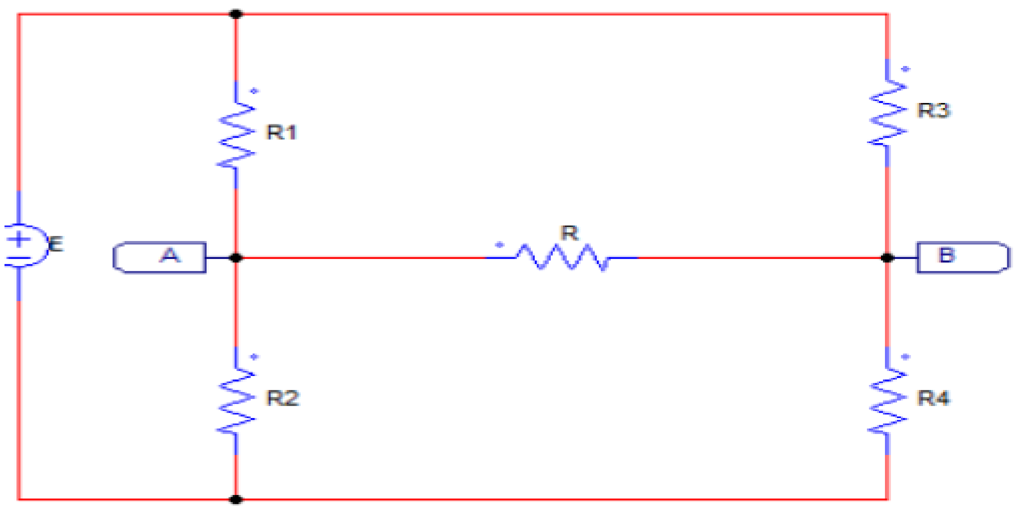
R_{Th2} = (4x4/(4+4) = 2Ω

≡



<u>Exercise</u> 5 :

Let us consider the circuit below



We give : E = 240 V, R_1= 40 Ω, R_2= 160 Ω, R_3= 60 Ω, R_4= 100 Ω, R = 10,5Ω.

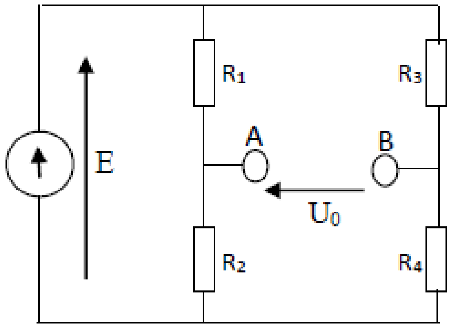
1 – Determine the equivalent Thevenin model seen from points A and B.

2 – Deduce the value of the current I flowing through the resistor R, as well as the voltage U across its terminals.

3 – Determine the equivalent Norton model seen from points A and B.

4 – Find the value of the current I and the voltage U across the resistor R.

<u>Correction</u> 5 :



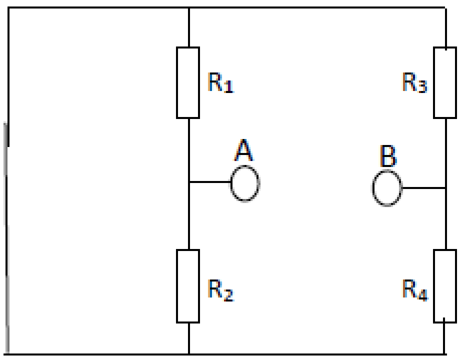
1) On calcule la tension U_0 vue des points A et B.

$$U_0 = U_A - U_B, \text{ tel que } \begin{cases} U_A = \frac{R_2}{R_1+R_2}E \\ U_A = \frac{R_4}{R_3+R_4}E \end{cases}$$

$$U_A = \frac{240x160}{40+160} = \frac{38400}{200} = 192\ V, U_A = \frac{240x100}{100+60} = \frac{24000}{160} = 150\ V$$

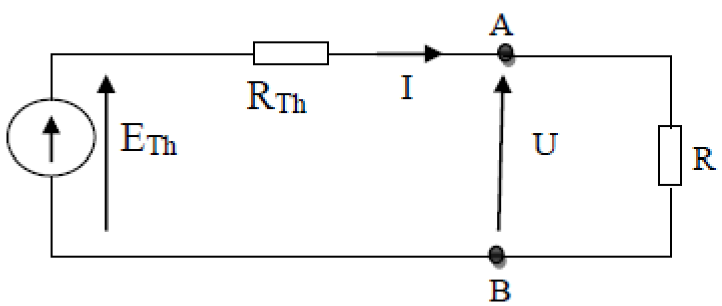
Therefore, $U_0 = 192 - 150 = 42$ V et $E_{Th} = 42$ V

Calculate the equivalent resistance seen from points A and B: By replacing the generator E with a short circuit, the following arrangement will be obtained :



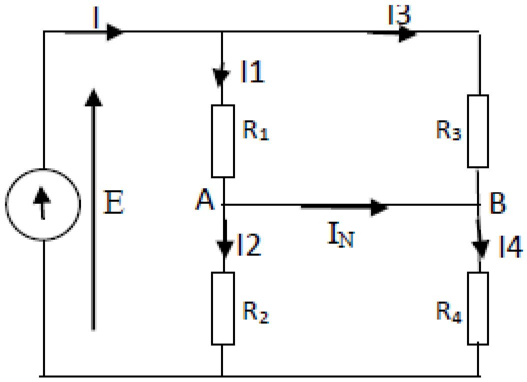
$$R_{AB} = \frac{R_1.R_2}{R_1+R_2} + \frac{R_3.R_4}{R_3+R_4} = \frac{40.160}{40+160} + \frac{100.60}{100+60}$$
$$= \frac{6400}{200} + \frac{6000}{160} = 32 + 37{,}5 = 69.5\ \Omega$$

Thevenin's equivalent model



$$2)\ I = \frac{E_{Th}}{R_{Th}+R} = \frac{42}{69.5+10.5} = \frac{42}{80} = 0.525\ A.$$

The Norton current is calculated by replacing the resistor R with a single wire (short circuit).



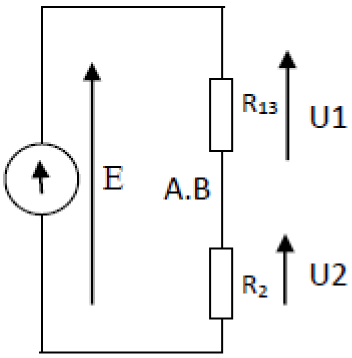
$I_N = I_1 - I_2$, $I_N = I_4 - I_3$

$$R_{13} = \frac{R_1 . R_3}{R_1 + R_3} = \frac{40x60}{40 + 60} = \frac{2400}{100} = 24\Omega$$

$$R_{24} = \frac{R_2 . R_4}{R_2 + R_4} = \frac{160x100}{160 + 100} = \frac{16000}{260} = 61{,}54\Omega$$

Donc, on peut calculer U_1 et U_2

$$U_1 = Ex\frac{R_{13}}{R_{13} + R_{24}} = \frac{240x24}{24 + 61.54} = \frac{5760}{85{,}54} = 67.33V$$



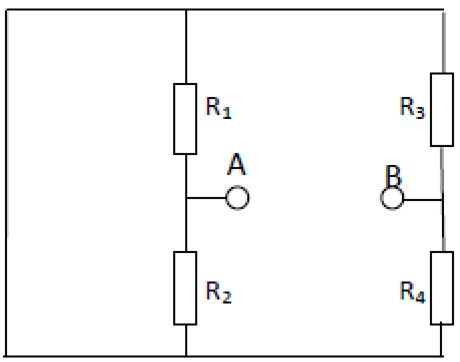
$$U_2 = Ex\frac{R_{24}}{R_{13} + R_{24}} = \frac{240x61.54}{24 + 61.54} = \frac{14769.6}{85{,}54} = 172{,}66V$$

3) Law of knots at point A

$I_1 = I_2 + I_N \Rightarrow I_N = I_1 - I_2$ ou $I_1 = U_1/R_1 = 67.4/40 = 1{,}685A$

$I_2 = U_2/R_2 = 172.6/160 = 1.08A$. Finally $I_N = 1.685 - 1.08 = 0.605A$.

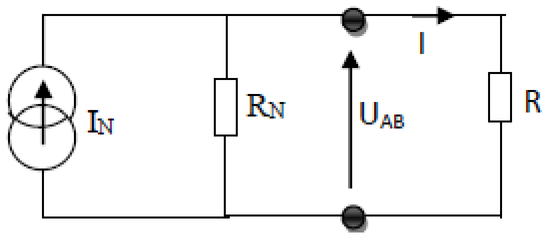
It remains to calculate the Norton resistance as seen from points A and B (by replacing the voltage sources with short circuits)



$$R_{AB} = \frac{R_1 x R_2}{R_1 + R_2} + \frac{R_3 x R_4}{R_3 + R_4} = \frac{40x160}{40 + 160} + \frac{60x100}{60 + 100}$$
$$= \frac{6400}{200} + \frac{6000}{160} = 32 + 37.5 = 69.5\Omega$$

Donc $R_N = 69.5\Omega$

Norton's equivalent model

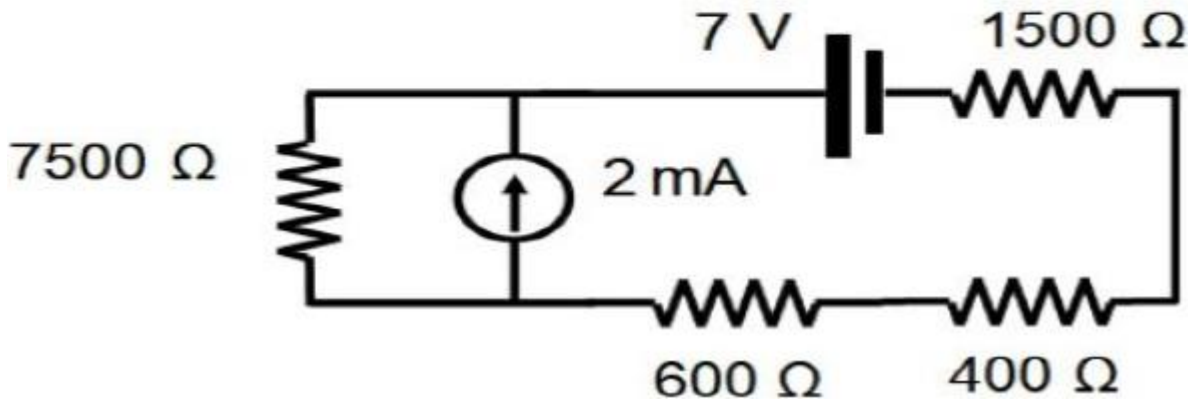


4) $I = \frac{I_N R_N}{R_N + R} = \frac{0.605x69.5}{69.5+10.5} = 0.526A$ et

U = RxI = 10.5 x 0.526 = 5.52V

<u>Exercise</u> 6 :

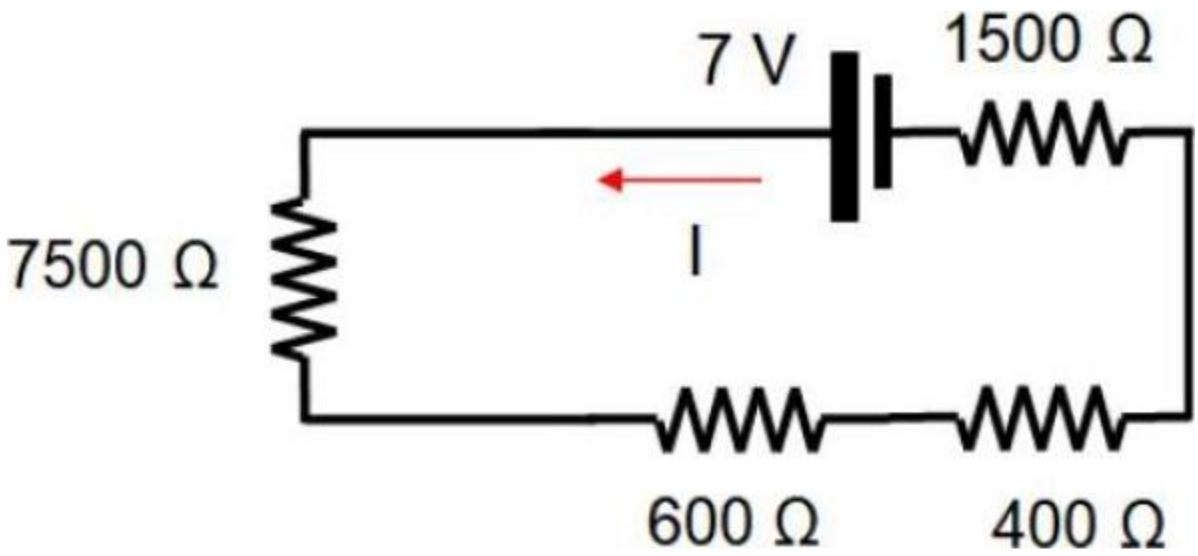
In the circuit shown in the following figure, find the current flowing through each resistor using the superposition theorem. In the circuit shown in the following figure, find the current flowing through each resistor using the superposition theorem.



<u>Solution</u> 6

Contribution of the voltage source

To begin with, the current source is eliminated, making the circuit look like this :



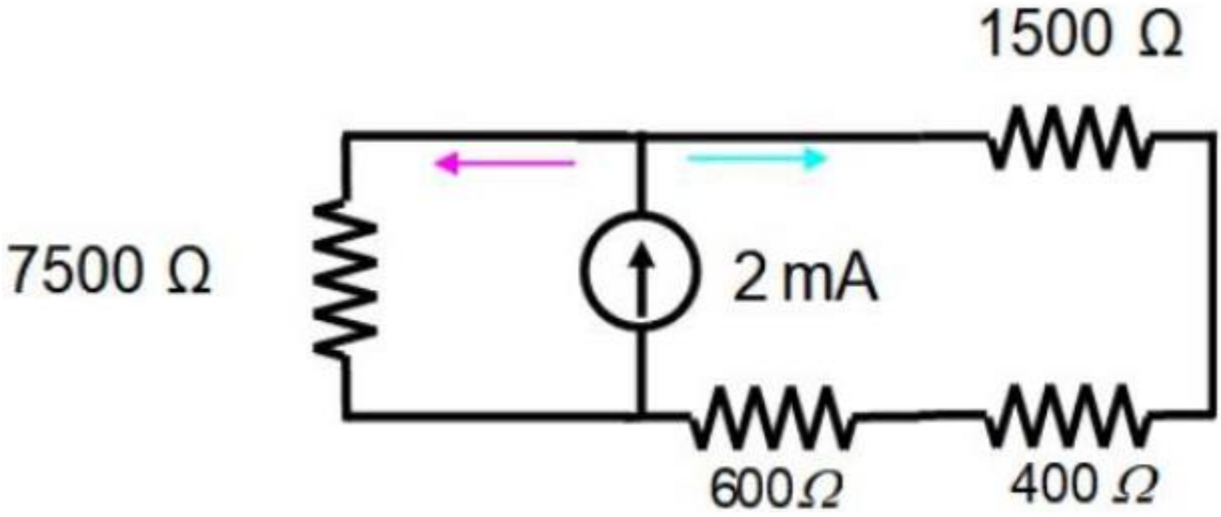
The equivalent resistance is found by adding the value of each resistor, since they are all in series :

Application of the law of Ohm V = IR and current resolution :

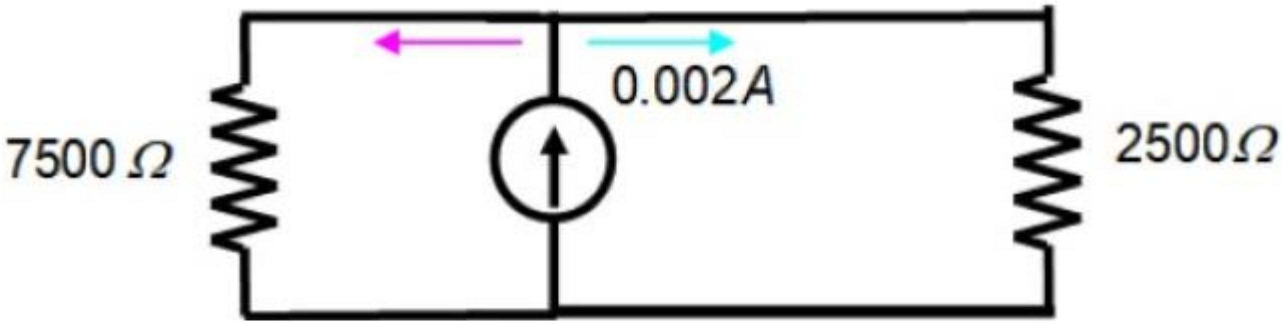
This current is the same for all resistors.

Contribution from Current Source

The voltage source is immediately eliminated, to work only with the current source. The resulting circuit is shown below.



The resistors of the straight mesh are in series and can be replaced by a single one: 600 + 400 + 1500 Ω = 2500 Ω The resulting circuit looks like this :



The current of 2 mA = 0.002 A is divided between the two resistors in the figure, so the equation of the current divider is valid:

Where I_x is the current in the resistor Rx, R_{eq} symbolizes the equivalent resistance, and I_T is the total current. We must find the equivalent resistance between the two, knowing that : So :

For this other circuit, the current flowing through the resistor of 7500 Ω is found by substituting values in the current divider equation :

While the one breaking through the 2500 Ω resistance is :

Application of the superposition theorem

Now, the superposition theorem is applied for each resistor, starting with the 400 Ω :

$I_{400\,\Omega}$ = 1,5 mA - 0,7 mA = 0,8 mA

Important: for this resistor, the currents are subtracted, because they flow in the opposite direction, as shown by a careful observation of the figures, in which the directions of the currents have different colors.

This same current also flows through the 1500 Ω and 600 Ω resistors, since they are all in series.

The theorem is then applied to find the current through the resistance of 7500 Ω :

$I_{7500\ \Omega}$ = 0,7 mA + 0,5 mA = 1,2 mA

Important: in the case of the 7500 Ω resistor, note that the currents add up, because in both circuits they flow in the same direction when passing through this resistor. Again, it is necessary to carefully observe the directions of the currents.