Instituto Politécnico Nacional

ESCOM “Escuela Superior de Cómputo”

INGENIERÍA EN SISTEMAS COMPUTACIONALES

Análisis Fundamental de Circuitos

Práctica Teorema de Thevenin

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Objective

It is sought that the student demonstrates in a practical way the circuits proposed for the theorem of Thévenin applying other theorems as a subject of superposition in obtaining the circuit equivalent also the transformation method to obtain the equivalent circuit. As well as the Kirchhoff laws of current and voltage, as the case may be. The voltages and currents will be measured to check the calculations. Y You will find the value of the power delivered by the equivalent circuit and, therefore, the original circuit.

Material

- Resistors (1/4 watt with practice values).
- Conection wires (protoboard).
- Tongs.
- 1 potentiometer 2.5 Ohm.

Equipment

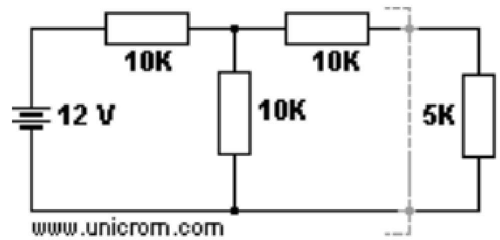
- 1 Analogical multimeter.
- 1 Digital multimeter.
- 1 Variable voltage source.
- 4 points banana – banana.
- 10 points caiman-caimán.
- Breadboard

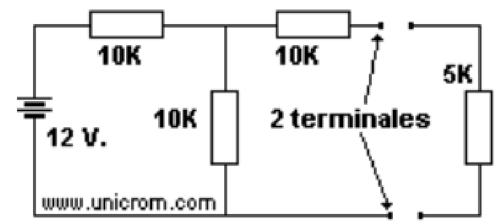
Theoric introduction

In very large circuits, with a large number of meshes and nodes it would be very difficult, if not impossible, to find branch currents or node voltages by mesh analysis techniques or node analysis. However, when it is desired to analyze the voltage, current and power in some particular element, a method that is very powerful in very complex linear circuits is the method based on Thévenin's theorem.

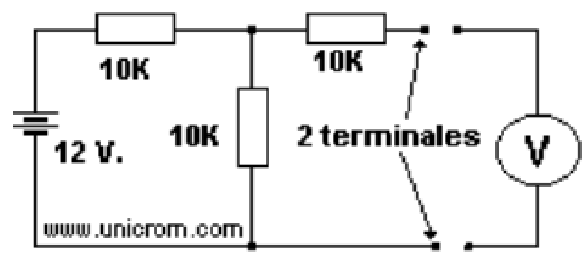
The equivalent circuit will have a source and a resistance in series as already said, in series with the resistance that from its terminals observes the conversion.

This voltage is called VTh and the resistance is called RTh.



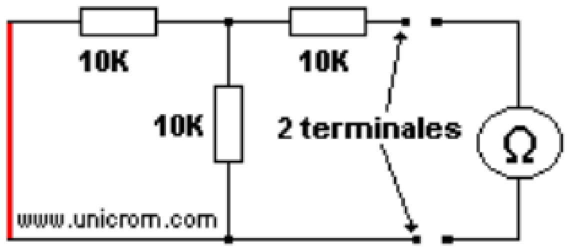


To obtain VTh (Thevenin Voltage), the voltage in the two terminals mentioned above is measured and that voltage will be the Thevenin voltage. Or theoretically you can apply the methods of meshes, nodes, voltage divider to know the thevenin voltage

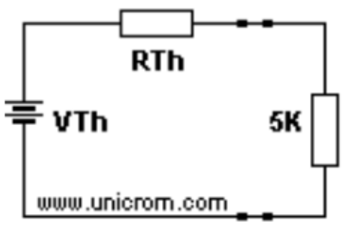


To obtain RTh (Thevenin Resistance), all voltage sources are replaced by short circuits and the resistance from the two terminals mentioned above is measured.

Theoretically, the resistance reduction is made until reaching the R equivalent to what we will call RTH (Resistance e thevenin).



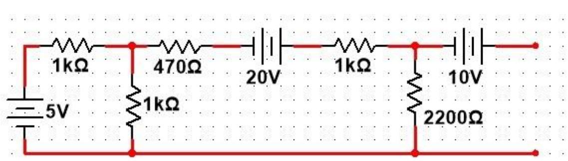
With the data found, a new circuit is created that is very easy to understand, which is called the Thevenin Equivalent circuit. With this last circuit it is very easy to obtain the voltage, current and power there is in the resistance of 5 K



Experimental progress

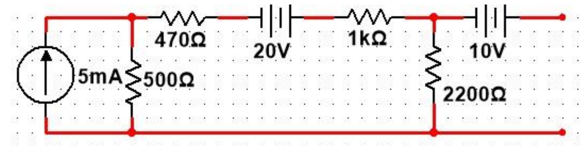
To start with the calculation we proceed to short-circuit the voltage source and disconnect RL from the circuit leaving it open. Then we proceed to calculate the resistance of thevenin and to obtain the voltage source of thevenin we will work on the network with the source on. Then we proceed to calculate the voltage using ohm law.

Calculations

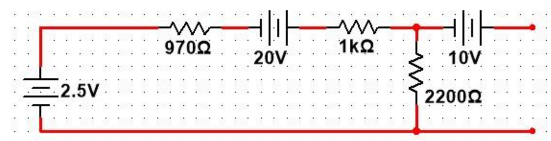


$$\mathrm{I} = \frac{5V}{1000\Omega} = 5mA$$

$$\mathrm{R} = \frac{1000 * 1000}{1000 + 1000} = 500\Omega$$



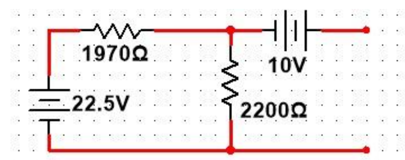
$$V = 5mA \times 500\Omega = 2.5V$$



$$R = 470 + 500 = 970\Omega$$

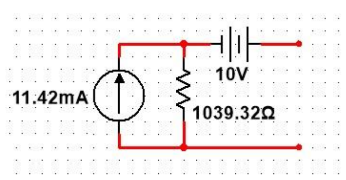
$$V = 20 + 2.5 = 22.5V$$

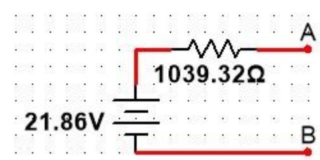
$$R = 1000 + 970 = 1970\Omega$$



$$I = \frac{22.5V}{1970\Omega} = 11.42mA$$

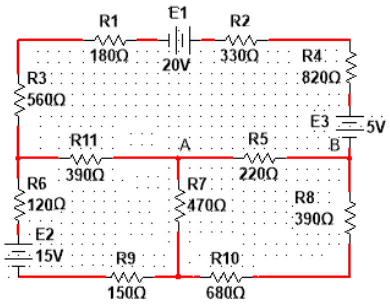
$$R = \frac{1970 * 2200}{4170} = 1039.32\Omega$$





$$V = 11.42mA * 1039.32\Omega = 11.86V$$

Circuit 2



$$V_{AB} = 11.42\text{mA} * 1039.32\Omega = 11.86V$$

$$I_{AB} = \frac{21.86V}{1039.32\Omega} = 21.03mA$$

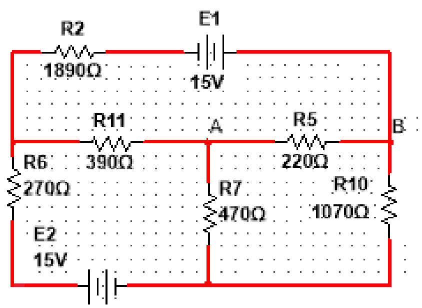
$$I_{AB} = \frac{21.86V}{1039.32\Omega} = 21.03mA$$

$R_{1234} = 180\Omega + 330\Omega + 560\Omega + 820\Omega = 1890\Omega$

$E_{13} = 20\text{V} - 5\text{V} = 15\text{V}$

$R_{69} = 120\Omega + 150\Omega = 270\Omega$

$R_{8\,10} = 390\Omega + 680\Omega = 1070\Omega$



Malla 1

$1890i_1 - 15 + 220(i_1 - i_2) + 390(i_1 - i_3) = 0$

$2500i_1 - 220i_2 - 390i_3 = 15$

Malla 2

$-220(i_1 - i_2) + 470(i_2 - i_3) + 1070i_2 = 0$

$-220i_1 + 1760i_2 - 470i_3 = 0$

Malla 3

$-390(i_1 - i_3) - 470(i_2 - i_3) - 15 + 270i_3 = 0$

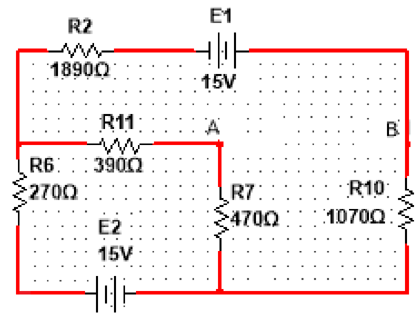
$-390i_1 - 470i_2 + 1130i_3 = 15$

$i_1 = 9.55mA$ $\qquad$ $i_2 = 6.32mA$ $\qquad$ $i_3 = 19.2mA$

$I_{AB} = 9.55mA - 6.32mA = 3.23mA$

$V_{AB} = (3.23mA)(220\Omega) = 0.71V$

$P_{R5} = (3.23mA)(0.71V) = 2.29mW$



Malla 1:

$1890\,i_1 + 1070i_1 + 470(i_1 - i_2) + 390(i_1 - i_2) = 15V$

$3820i_1 - 860i_2 = 15$

Malla 2:

$-390(i_1 - i_2) - 470(i_1 - i_2) + 270I2 = 15V$

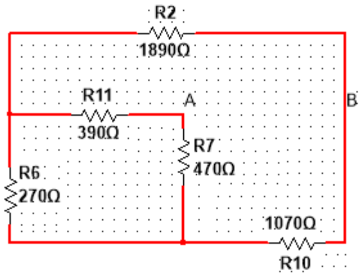
$-860i_1 + 1130i_2 = 15V$

$I1 = 8.34mA$ $\qquad$ $I_{AB} = 19.62\ mA$

$V_{R_{10}} = (8.34mA) * (1070\Omega) = 8.92V$

$V_{R_7} = (19.62mA - 8.34mA) * (470\Omega) = 5.30V$

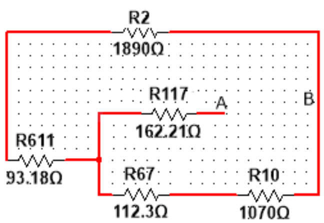
$$V_{AB} = 8.92V - 5.30V = 3.62V$$



$$R_{6\,11} = \frac{270 * 390}{270 + 390 + 470)} = 93.18\Omega$$

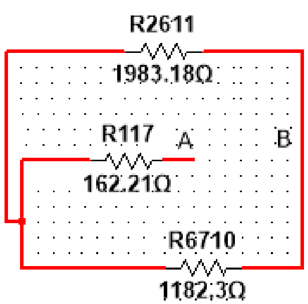
$$R_{11\,7} = \frac{390 * 470}{270 + 390 + 470} = 162.21\Omega$$

$$R_{67} = \frac{470 * 270}{270 + 390 + 470} = 112.3\Omega$$

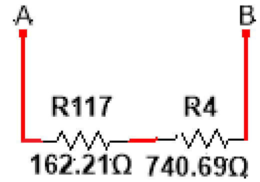


$$R_{2\,6\,11} = 93.18 + 1890 = 1983.18\Omega$$

$$R_{6\,7\,10} = 112.3 + 1070 = 1182.3\Omega$$

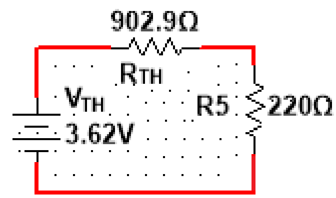


$$R_{eq} = \frac{1983.18 * 1182.3}{1983.18 + 1182.3} = 740.69\Omega$$



$$R_{TH} = 162.21 + 740.69 = 902.9\Omega$$

$$I_{AB} = \frac{3.62V}{902.9\Omega} = 4\text{mA}$$

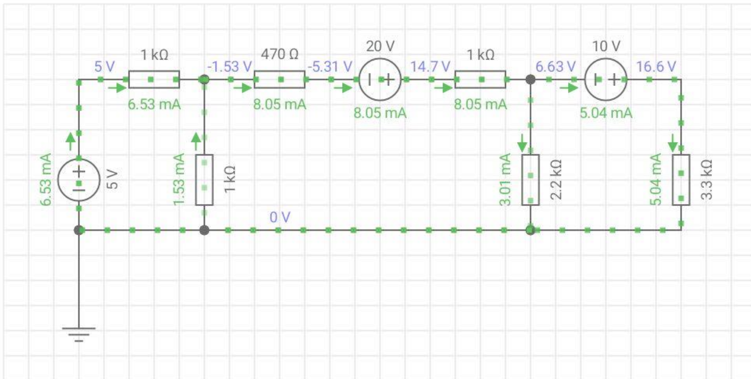


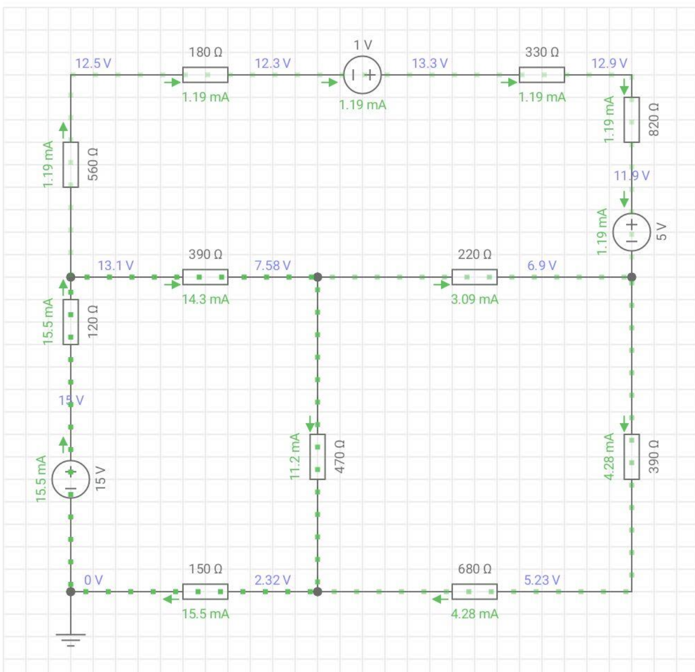
$$V_{R5} = \frac{3.62V * 220\Omega}{902.9 + 220} = 0.70V$$

$$I_{R5} = \frac{0.70V}{220\Omega} = 3.22mA$$

$$P_{R5} = (0.70\text{V}) * (3.22\text{mA}) = 2.25\text{mW}$$

Circuit simulations





Comparative of calculated, measured and simulated values

Table 1

Measurements	Theoric value	Simulated value	Measured value
Current	5 mA	5.04 mA	4.85 mA
Voltage	16.6 V	16.6 V	16.69 V
Power	87.66 mW	83.66 mW	82 mW

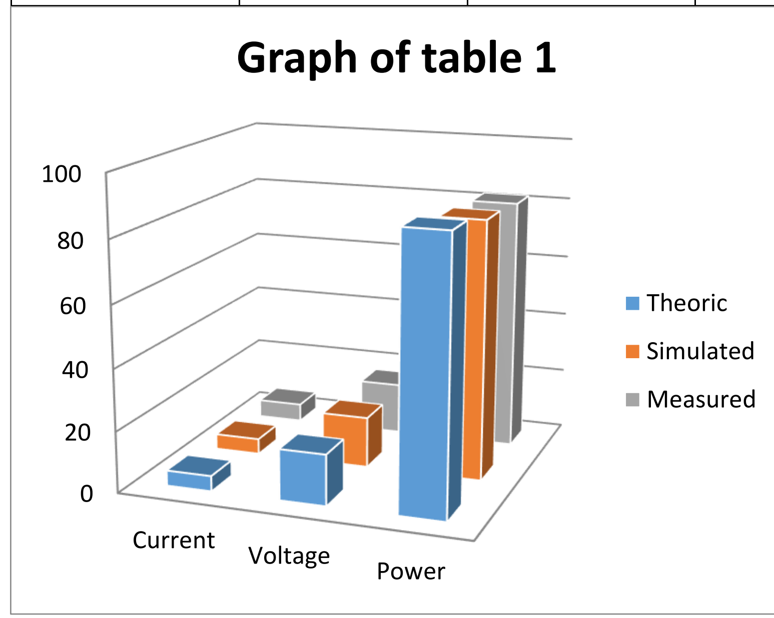


Table 2

Measurements	Theoric Value	Simulated value	Measured value
Current	20.8 mA	21 mA	21 mA
Voltage	21.4 V	21.8 V	21.8 V
Thevenin resistor	1.052 kΩ	1.048 kΩ	1.090 kΩ

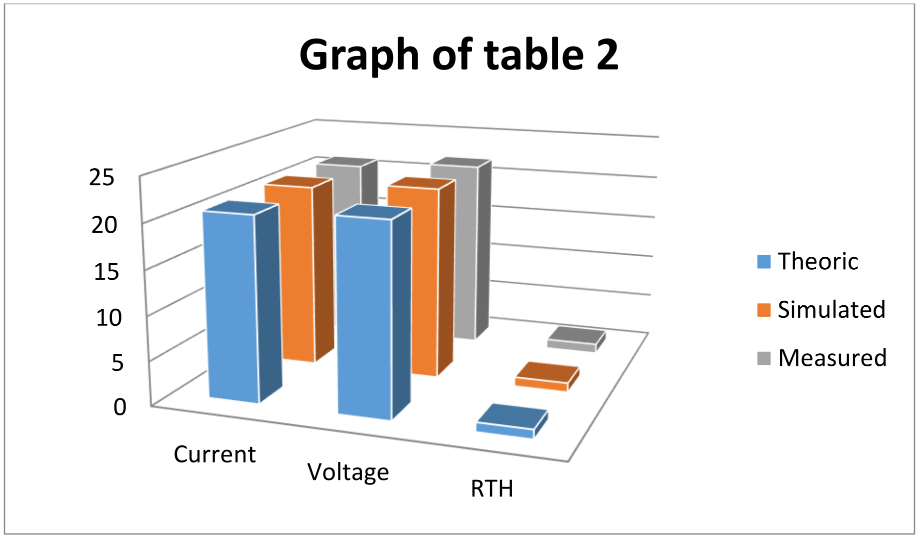


Table 3

Measurements	Theoric value	Simulated value	Measured value
Current	360 µA	360 µA	357 µA
Voltage	84 mV	84 mV	83 mV
Power	30.2 µW	30.29 µW	29.63 µW

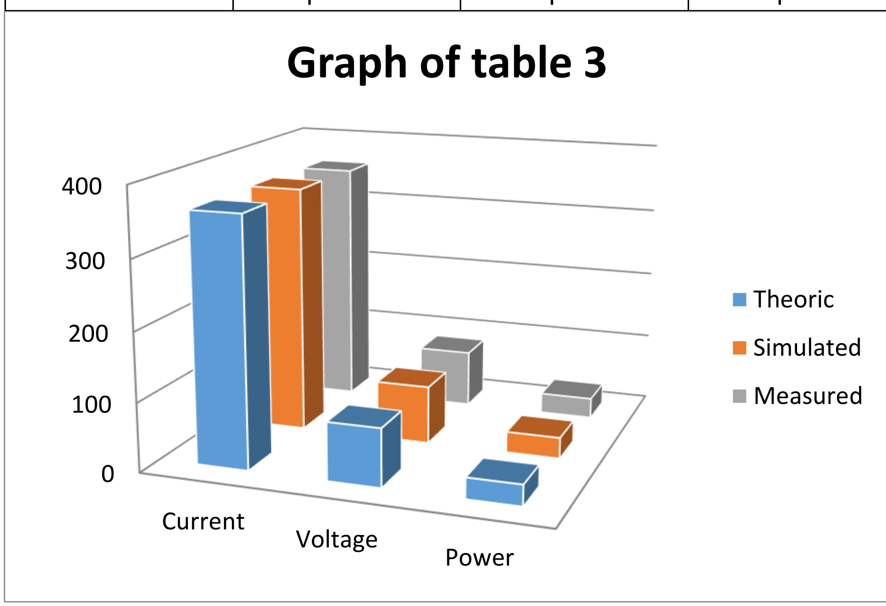


Table 4

Measurements	Theoric value	Simulated value	Measured value
Voltage (open circuit)	473.2 mV	473 mV	972 mV
Current (short circuit)	430 µA	430 µA	430.7 µA

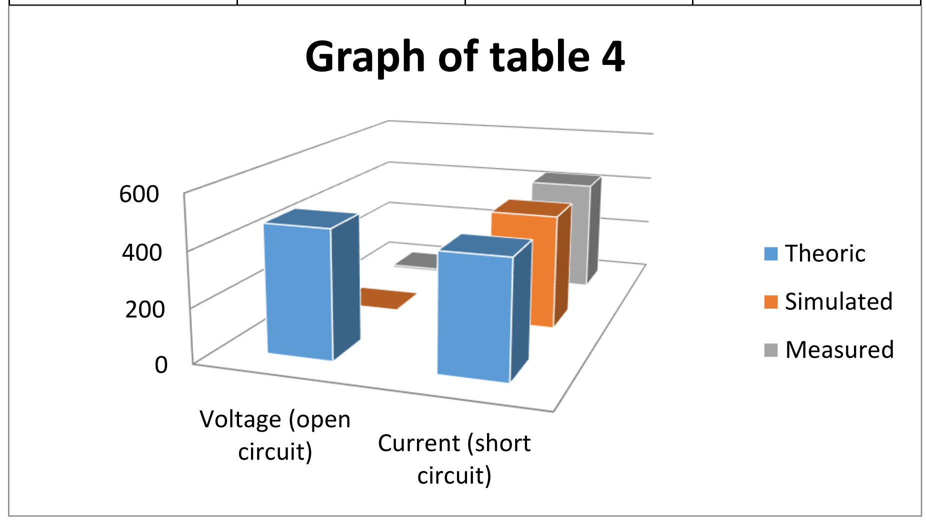
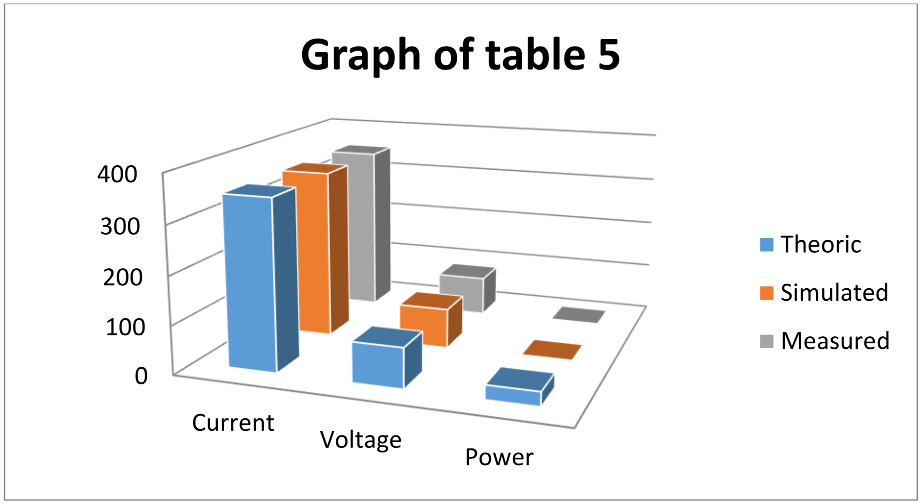


Table 5

Measurements	Theoric value	Simulated value	Measured value
Current	351 µA	351.3 µA	351 µA
Voltage	83 mV	83 mV	82 mV
Power	2.91 µW	2.91 µW	2.87 µW



Questionary

- Explain Thévenin's theorem with the support of some example.
    - To calculate the Thévenin voltage, Vth, the load is disconnected (ie, the load resistance) and VAB is calculated. When the load is disconnected, the intensity that Rth crosses in the equivalent circuit is zero and therefore the voltage of Rth is also zero, so now VAB = Vth by the second Kirchhoff law.
    Because the Thévenin voltage is defined as the voltage that appears between the load terminals when the load resistance is disconnected, it can also be called open-circuit voltage.
    To calculate the Thévenin resistance, the load resistance is disconnected, the voltage sources are short-circuited and the current sources are opened. The resistance seen from the terminals AB is calculated and that resistance RAB is the Thevenin resistance sought Rth = RAB
- Say from these experiments, what is the utility of Thévenin's theorem?
    - Thevenin's theorem is used to convert a complex circuit, which has two terminals into a very simple one that contains only one voltage or voltage source (VTh) in series with a resistor (RTh).
- Between what measurements does a greater difference exist? (Theoretical, simulated or measured) and why.
    - Between the measured and simulated because the simulator doesn't see the theorem and make another way to measured the values

Inferences

- Quintana Camacho Ruben Abiasaf:
    - Thanks to this practice we were able to solve a more complicated circuit with a fairly simple and easy to use method since in many other methods the process is a bit more complicated and long.
- Rojas Alvarado Luis Enrique:
    - In this practice we could see more thoroughly the analysis of a complex circuit and solve it both theoretically and physically, in physics it is much easier to give an answer to what they ask us whether current or voltage, since only with the multimeter we can do the measurement work and reach the result, but it is more difficult theoretically because you have to apply several methods to solve what is asked for.
- Rodríguez Hernández Aldo Hassan:
    - In practice Thevenin's theorem is used to deduce the value of Thevenin resistance and voltage, in all cases it was necessary to reduce the circuit to obtain those values, the practice was not very difficult

Bibliography

1) https://unicrom.com/el-teorema-de-thevenin-circuito-equivalente-vth-rth-simplificacion-de-circuitos/