

# VISIR REMOTE LAB: Ohm and Kirchhoff Laws

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## 1 Objectives and complexity level

Through the practical sessions presented in this document and using the remote analogue electronics laboratory provided by the University of Deusto, the following objectives can be met:

1. Observe and assimilate the implications of the resistance, voltage and current on a branch that is, understand the operation of the Ohm's Law.
2. Understand the implication of having different branches in an electronic circuit, therefore, understand Kirchhoff's Laws.

The use and use of this remote laboratory has a level of complexity that depends directly on the teacher, since the laboratory allows starting from circuits already made by the teacher and that he/she can share with the students, or the teacher can propose experiments where the students have to build the circuit from the beginning and connect the instruments to check the behaviour of the circuit.

In addition, the circuits can be allowed a mixed variant in which starting from a circuit predefined by the teacher, the student has to modify it according to some requirements in order to obtain certain results.

## 2 The Lab

Using the VISIR remote analog electronics laboratory, we will be able to measure the equivalent resistance of different resistor associations.

This remote lab allows to create physically the circuit that you implement on the user interface. This is thanks to a switching matrix that creates the connections between the components. In addition, on the built circuit with real components, we can connect different instruments to check and characterize their behaviour: a power supply, a function generator, an oscilloscope and a multimeter. In this case, to measure the equivalent resistance of different resistor associations, we will use the multimeter provided by the VISIR laboratory

In this case, to experiment with both Ohm's Law and Kirchhoff's Law, we can use the breadboard, the digital multimeter as well as the power supply to define the input voltage of the circuit.

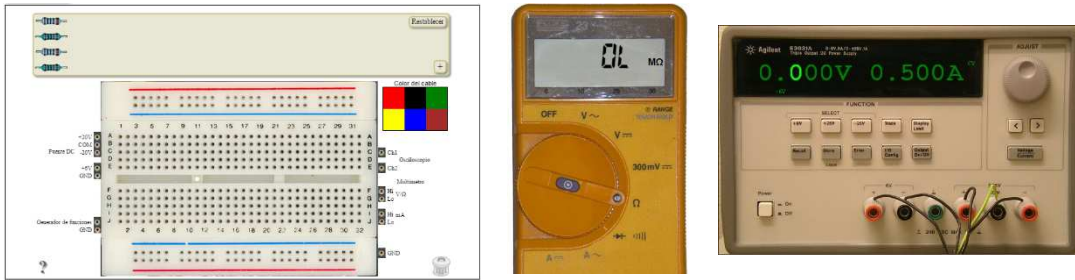


Figure 1. Breadboard and instruments

In this experiment on the VISIR remote laboratory it is possible to control the following parameters:

1. We have four resistors: 2 resistors of  $1\text{k}\Omega$  and 2 resistors of  $10\text{k}\Omega$
2. With a maximum of these 4 resistors in the circuit, we can create any possible association and obtain its equivalent resistance value (as we explained in other didactic material dedicated exclusively to the measurement of resistance associations).
3. Power the circuit with the power supply by selecting a voltage up to  $+20\text{VDC}$ .
4. Place the multimeter in any node of the circuit created and measure at that point the voltage drop.
5. Place the multimeter at the beginning of any branch of the circuit created and measure the current flowing through said branch<sup>1</sup>.

Although the complexity of the circuits that can be implemented in this remote laboratory can be high, the construction of them is quite simple. We only have to remember the following points:

1. In the breadboard, the two zones (lower and upper) delimited by a blue and red line, the connection holes are linked together in rows.
2. In the breadboard, in the central zone, the connection holes are connected to each other in columns. If we click the question mark to the left of the prototype board, a help will appear on how the holes are interconnected.
3. On the left and right of the breadboard are located the connectors where we will carry the cables from the circuit to connect the available

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<sup>1</sup> Due to the real nature of the laboratory and the hardware configuration needed to make possible to interconnect the components with each other and to connect the instruments to the circuit, during its design it was determined that only current measurements can be made at the beginning of each branch. Introduce the multimeter is not possible at all points of the created circuit.

instruments: power supply, function generator, oscilloscope and multimeter.

4. In case of powering the circuit with the voltage output of + 20VDC, the maximum allowable voltage, for safety, will be + 20VDC
5. When the power supply is connected to the circuit, it must have a grounding connection (there must be a wire connecting the circuit to one of the GND sockets around the prototype board) and the power supply you must also connect to one of these jacks. That is, the same procedure as in manual construction in a face-to-face laboratory.
6. As in a traditional laboratory, to perform current measurement on a branch, we must "open" the circuit and connect the multimeter to the branch in series, properly selecting the test points we are going to use (Hi-Lo mA) and placing the multimeter selection wheel in the appropriate option.

Therefore, on this laboratory we can modify practically all possible variables: the resistance values of each branch, ie the topology of the circuit, the supply voltage, as well as the points where we want to measure the voltage and current for check the mathematical models of the laws of Ohm and Kirchhoff.

## 3 Examples of experiments

As you can imagine, there are many questions that we can try to solve using the VISIR remote lab. Below, we present several experiments to serve as a basis for others that you can raise.

### 3.1 *Experiment 1. Ohm's Law*

Here are the steps to experiment with the Ohm Law in the remote lab:

1. We will access the Labsland portal with our username and password.
2. Access the remote electronics lab and follow the steps indicated

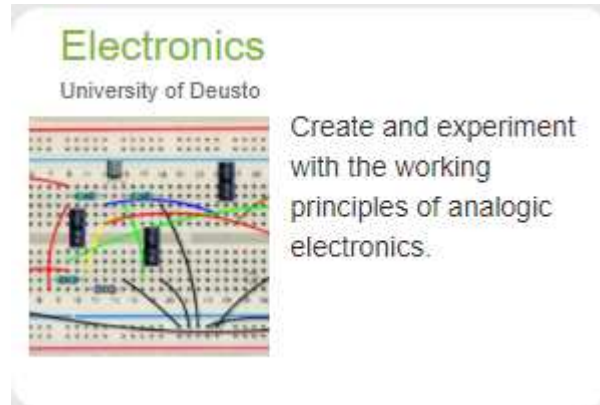


Figure 2. Access to the VISIR remote lab

- To see a very simple example of applying Ohm's Law, let's build the next circuit. Remember that this is just an example and that you can combine up to two resistors of  $1k\Omega$  and other two of  $10k\Omega$  as you like. In addition, the versatility of this laboratory allows you to verify that happens when adding or removing resistances in the branches of the circuit.

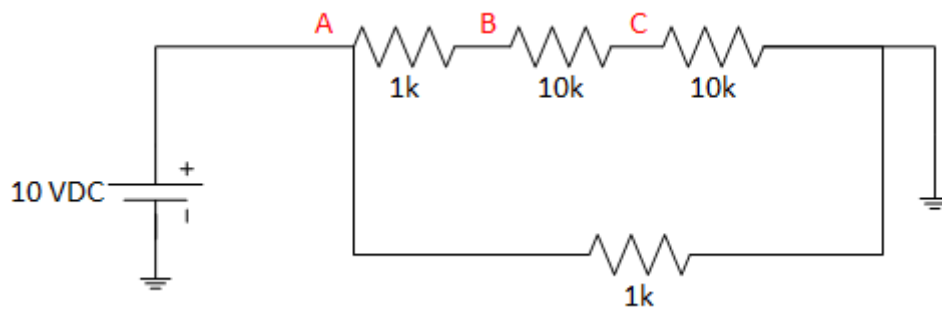


Figure 3. Electrical schema

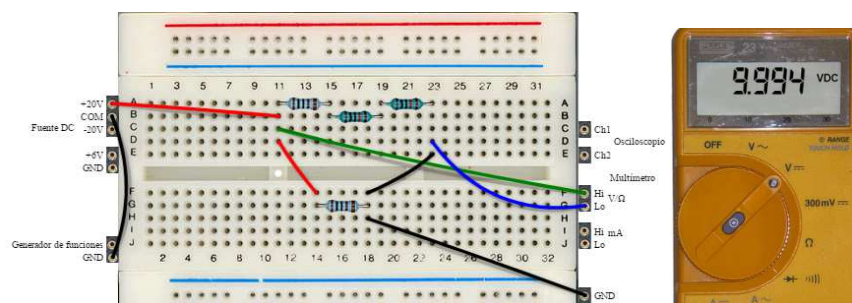


Figure 4. Voltage measure at A

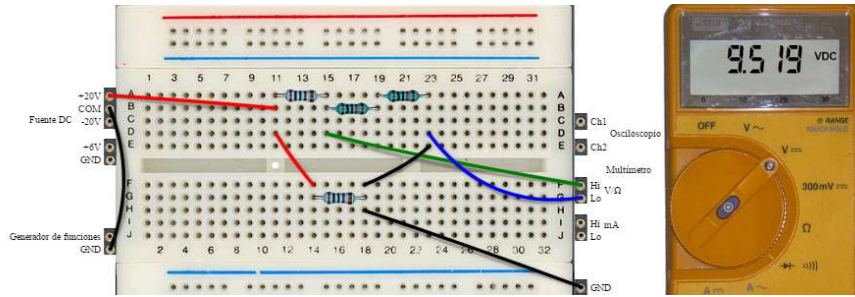


Figure 5. Voltage measure at B

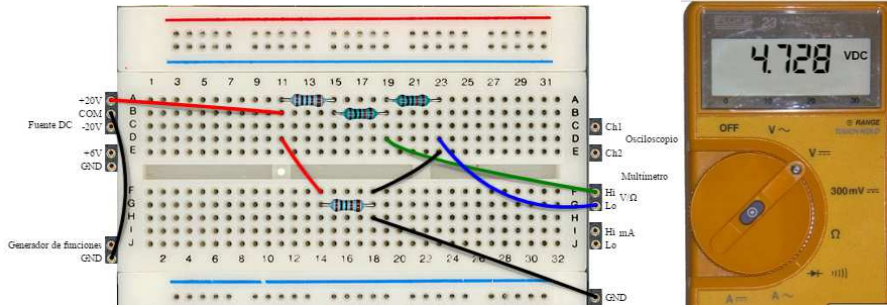


Figure 6. Voltage measure at C

8. We see that, once the circuit is built, it is very easy to place the multimeter at the different points A, B or C to measure the corresponding voltage, as indicated in the previous figures.
9. We can now modify the circuit to see what happens if we move the resistance of 1k and put it in series with the other three, and re-measure the voltages at the same points in the circuit. We will observe how when modifying the total resistance of the branch, the tension in each one of the points will also be affected.

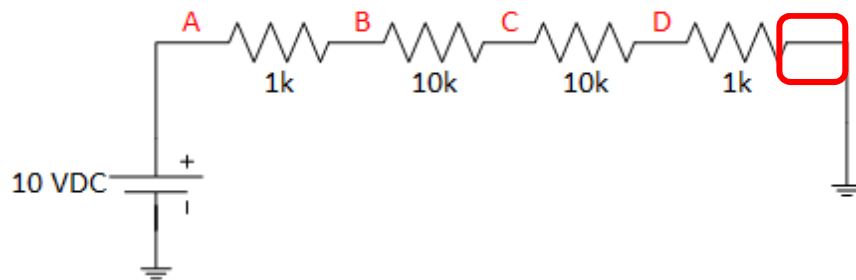


Figure 7. Modified schema

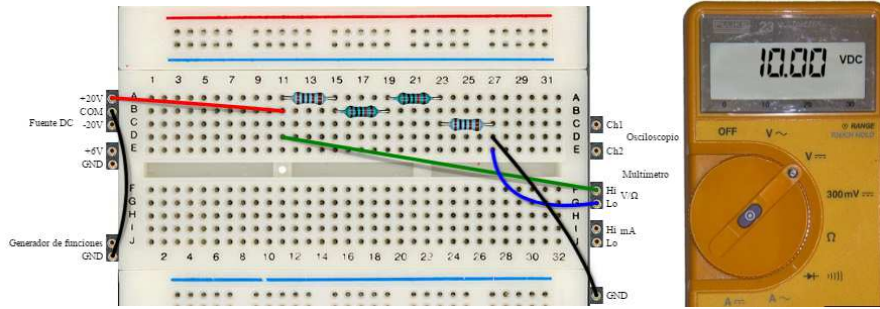


Figure 8. Voltage measure at A

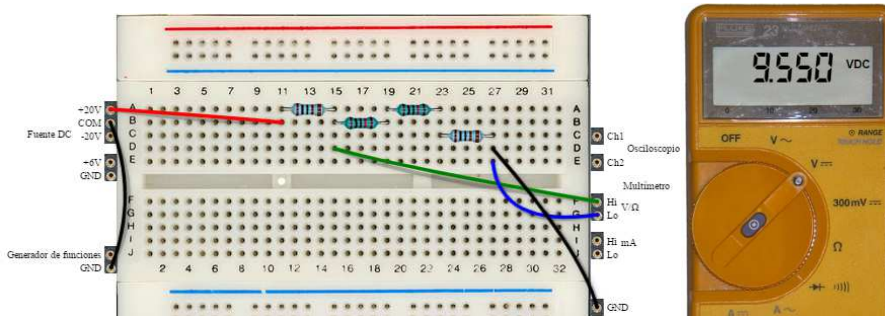


Figure 9. Voltage measure at B

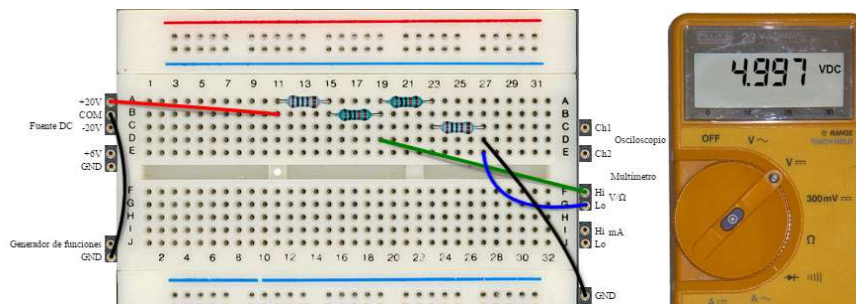


Figure 10. Voltage measure at C

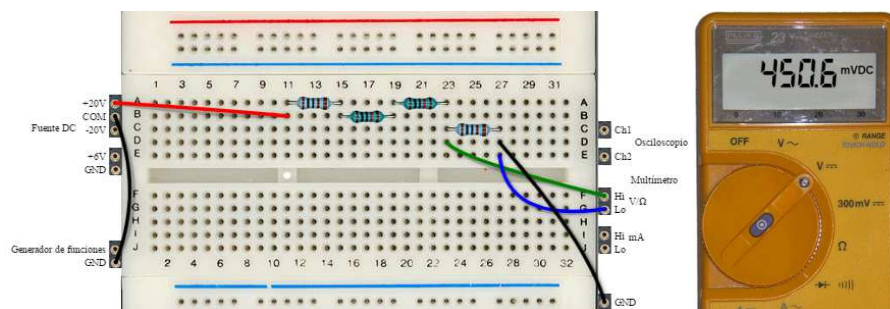


Figure 11. Voltage measure at D

Just as we have done this simple modification, we could make different combinations with the resistors and see how the value of the resistance in each of the branches of a circuit affects the value of the voltage measured. It is very interesting to make several examples combining resistors in series with resistors in parallel.

### 3.2 Experiment 2. Kirchhoff's Laws

Once experienced with Ohm's Law, let's look at an example to analyse Kirchhoff's Law and see how it affects several branches in a circuit. For this we will follow the following steps:

1. Repeating steps 1 and 2 of the previous experiment, we come back to the interface with which we can control the DC Panel. To experiment with Kirchhoff's Law, let's set up the next circuit.

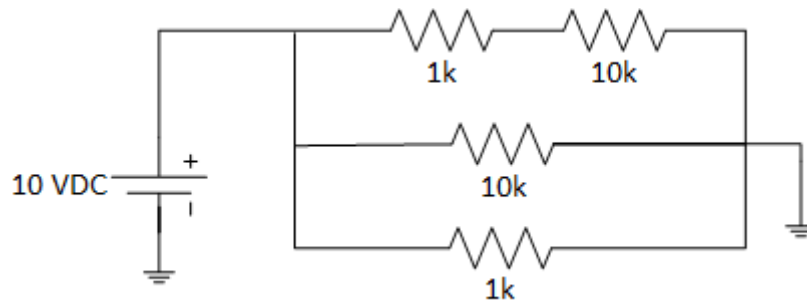


Figure 12. Electrical schema

2. Then we can proceed to measure the current in each of the branches. Remember to place the multimeter at the beginning of each branch, choose the appropriate probes on the board and select the DC current measurement on the multimeter.

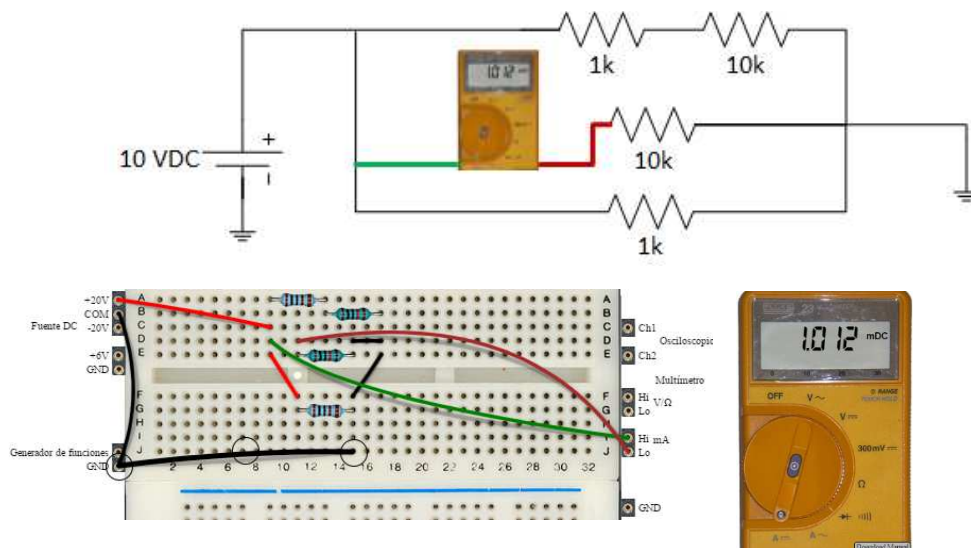


Figure 13. Example of measuring

3. As an example, we can see in the previous figure how to proceed to measure the current in the intermediate branch of the circuit under test. In an analogous way, we can measure the current in the other two



branches. Obviously, since the resistance is different in each branch, the current will also be different.

- Now we can move the 1k resistance from the lower branch and place it on the intermediate branch, to see how the current is modified by this branch.

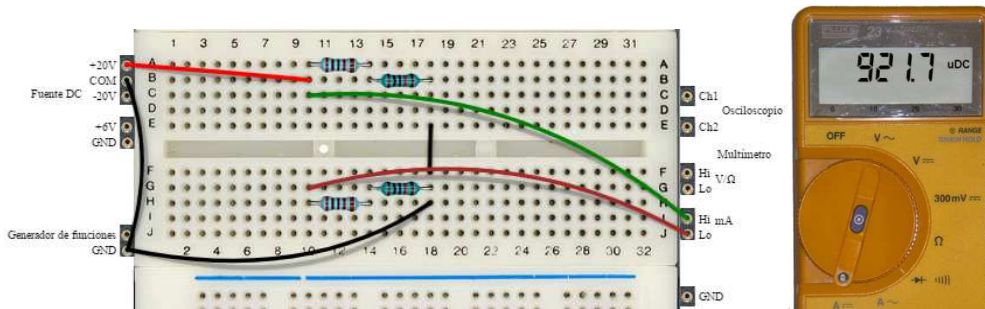


Figure 14. Measure of the current in the new branch

- On the same schema on Figure 14, we can measure the current in the upper branch of the circuit. As the equivalent resistance of that branch is the same as in the lower branch ( $10k + 1k = 11k$ ), the current is the same
- What we can also verify is whether Kirchhoff's Law is satisfied. To do this, if the current in each branch is about  $921\mu A$ , the current at the input of the circuit should be  $921\mu A + 921\mu A = 1,842mA$

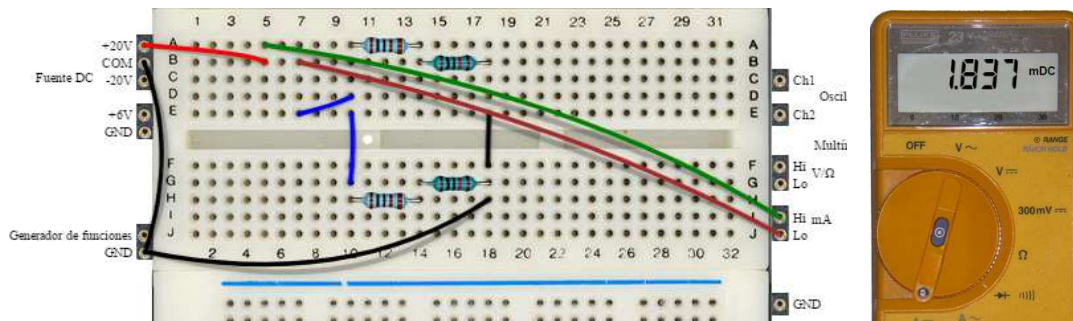


Figure 15. Input current measurement

- With the configuration shown at Figure 15 we can verify perfectly how the input current is equal to the sum of the current that flows through each of the other two branches of the circuit

We can repeat this example (or others) with any circuit that you want to create using up to two resistances of 1k and two of 10k.