AVAILABLE CIRCUITS

ANALOG ELECTRONIC

REMOTE LAB

Content

1. Circuits with resistors

The analog electronic remote lab has a set of 4 resistors (2 resistor of 1kΩ y 2 resistor of 10kΩ) to build all the available conFiguretions.

The election of these two values has not done under special criteria. The lab uses real components that are placed on the switching matrix, the instrument which is in charge of implementing the physical connections between the components and with the instruments, so it has a limited available space. Therefore, it is not possible to provide all the resistors' values available on the market.

Even so, the learning outcome of these circuits is to experiment with different conFiguretions (serial, parallel) and experiment with the Ohm Law.

Considerations to experiment with the Ohm Law:

1. In this circuits, the only available power supply is +25VDC
2. The maximum power supply value is +20VDC
3. The circuit always must be connected to ground.
4. Power supply always must be connected to ground.
5. Voltage measurements are available in all the nodes of the circuits.
6. Current measurements: due to a limited space on the switching matrix and the nature of this measure, current measurements are only allowed at the beginning of each branch in the circuit and in front of the first component of this branch[1].

1.1 Experiments with resistance associations

As it is indicated above, the following considerations must be taken into account when we work with resistances:

1. Only 2 resistances of 1k and 2 resistances of 10k can be used simultaneously
2. Any possible combination can be made. The circuits given below are only a set of examples.

Serial Associations
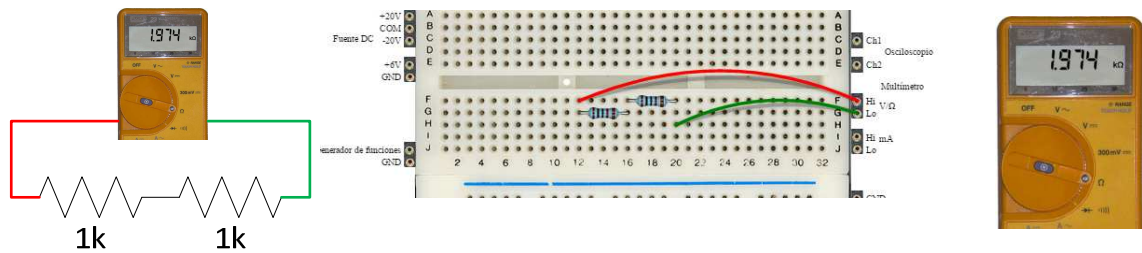
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[1] Check the lab user manual. Section 5

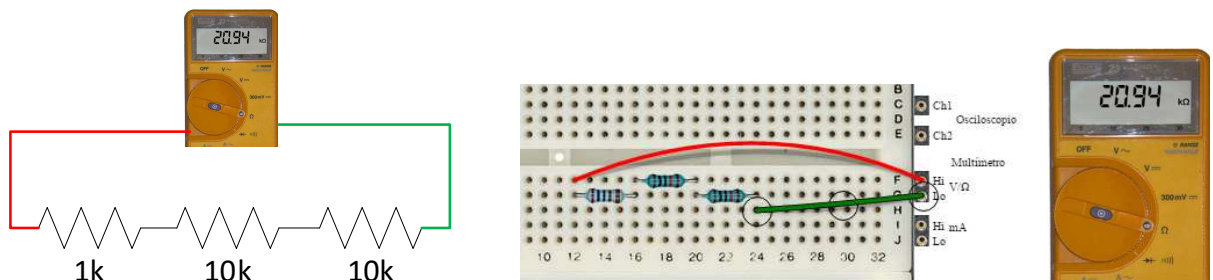Figure 1. 2 resistors of 1kΩ in serial. Circuit and implementation

Figure 2. 1 resistor of 1kΩ in serial with 2 resistors of 10kΩ. Circuit and implementation
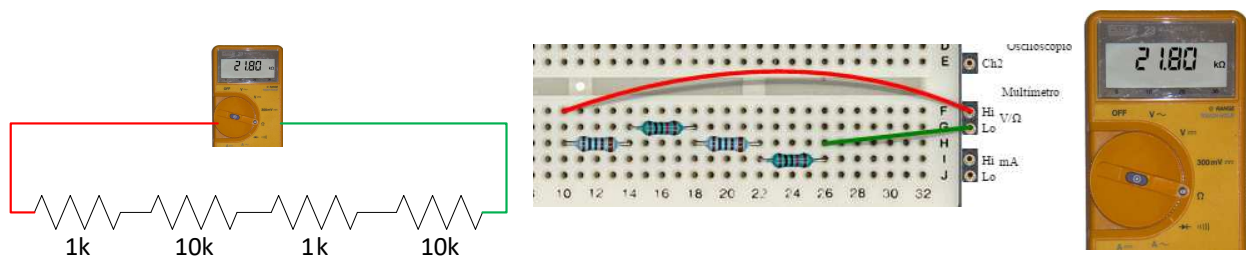

Figure 3. 2 resistors of 1kΩ in serial with 2 resistors of 1kΩ. Circuit and implementation

Remember that the components are real, so their values, according to the manufacturer have some tolerance. That is why, for example, in the circuit described at Figure 1, the measured value is not exactly 2kΩ but 1,974kΩ. If the values of the available 1k resist resistors are measured, their values are approximately 986.5Ω and 988.2Ω, hence the parallel equivalent is not exactly 2kΩ.
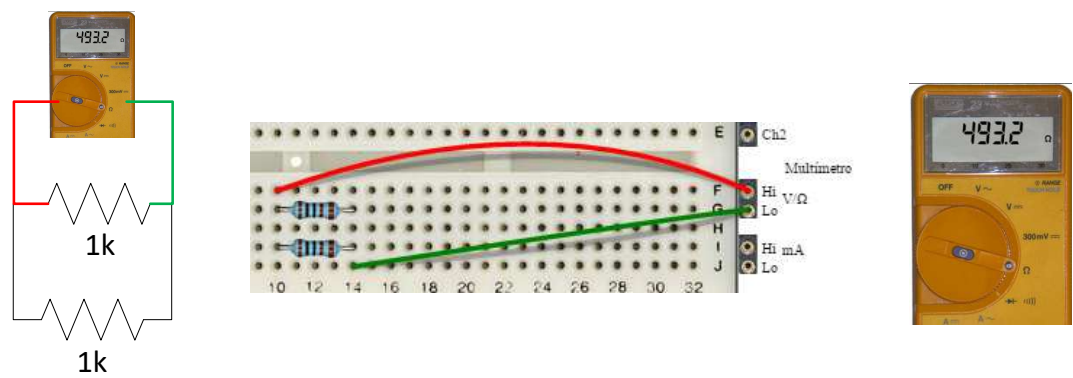
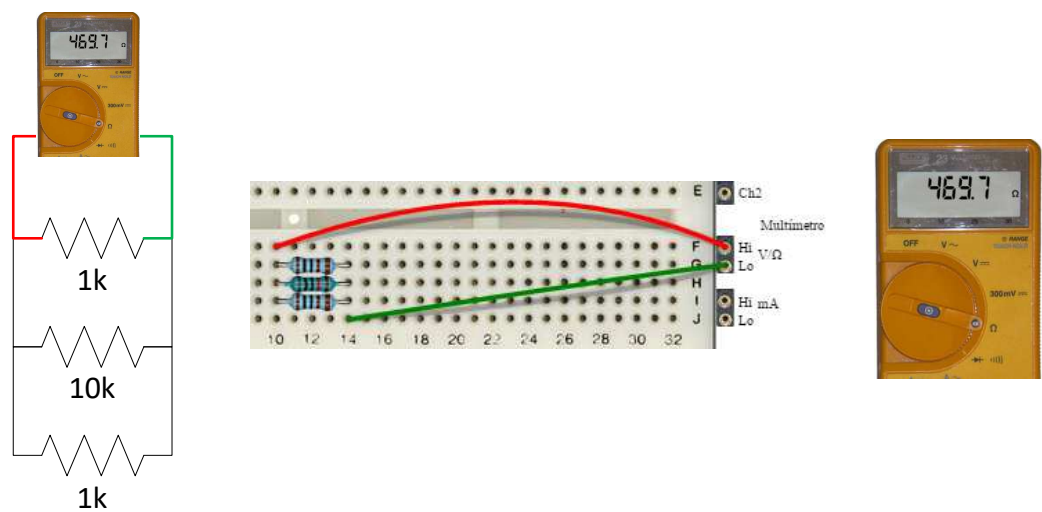## Parallel Associations
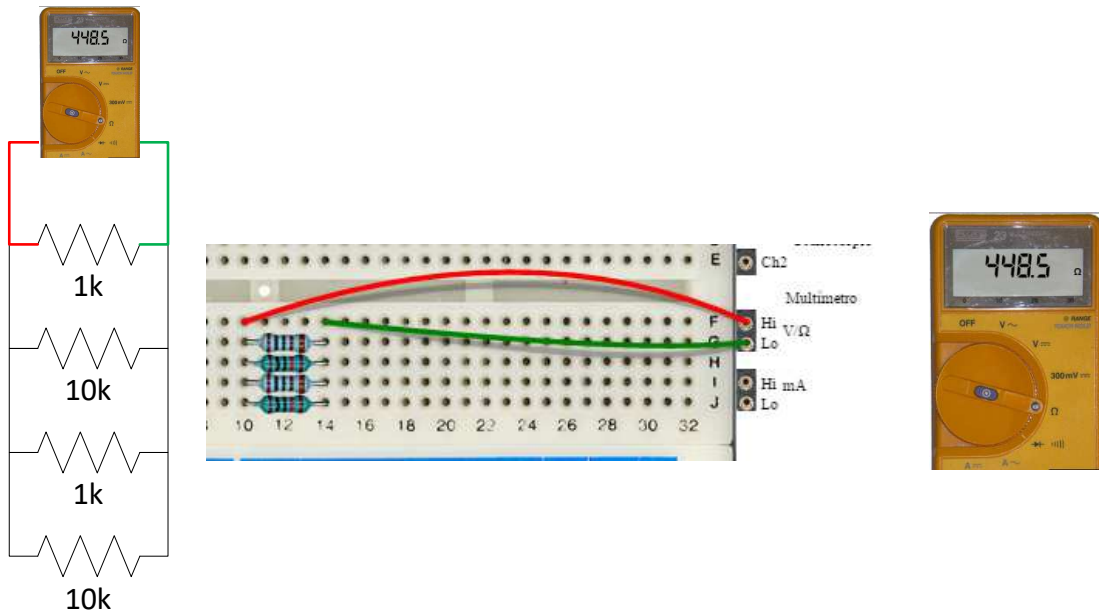

Figure 4. 2

Figure 5.

Figure 6.

As in the case of the serial association of resistors, they can be connected in the desired order, remembering that a maximum of 2 resistances of 1kΩ and 2 resistors of 10k can be used at the same time.

Asociaciones en serie y paralelo

The remote analog electronics lab also allows you to create circuits combining serial and parallel associations. Here are some examples.
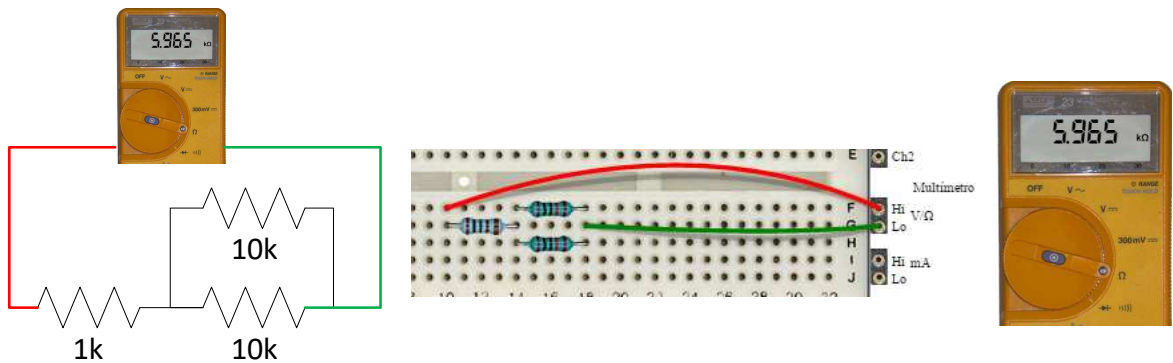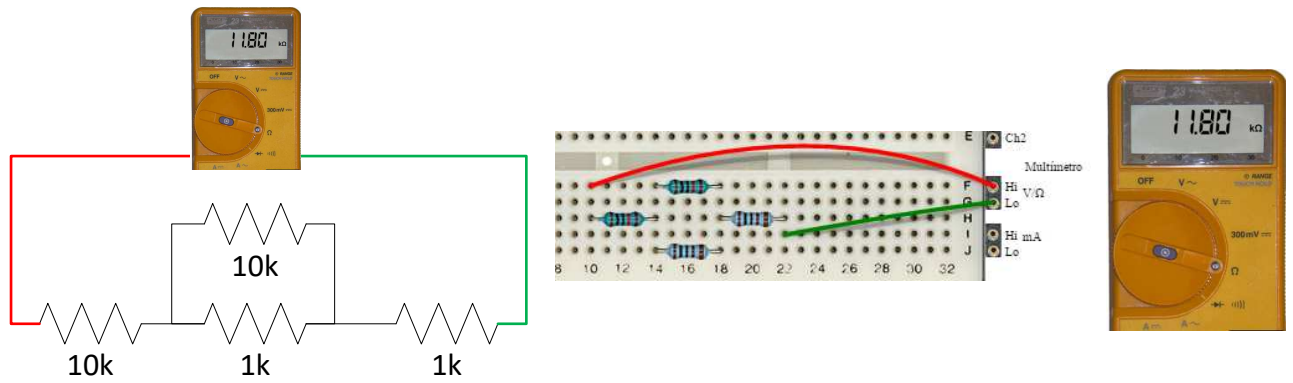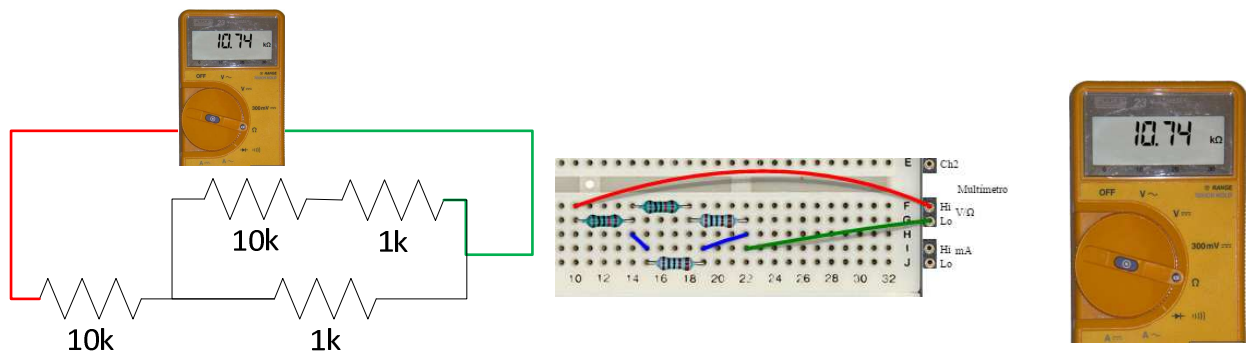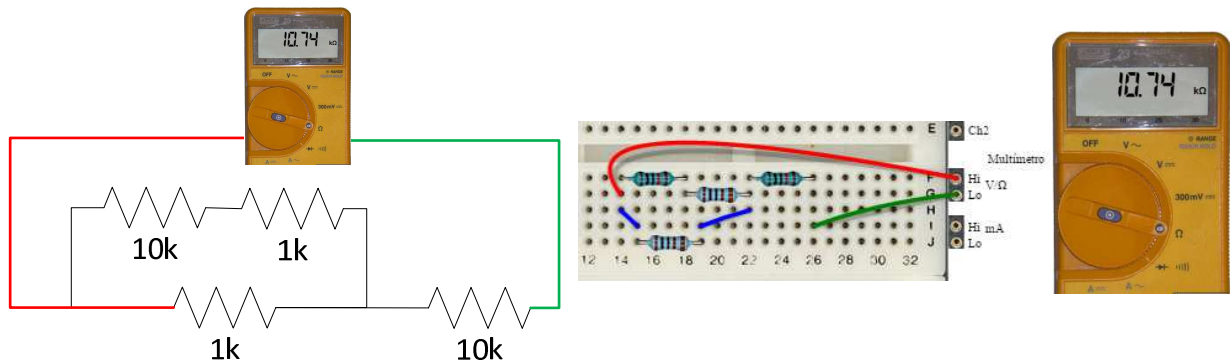

Figure 7

Figure 8.

Figure 9.

Figure 10.

1.1 Experiments with the Ohm's Law

In this set of experiments, we can use the same circuits built in the previous section, feeding them with a DC voltage and then, we can measure the voltage drop anywhere in the circuit. That is, you can create circuits with combinations up to 4 resistors (2 of 1kΩ and 2 of 10kΩ) as you want.

We will also be able to measure on the circuit the currents that flows by each branch. Remember that to perform this measurement the multimeter must be

placed at the beginning of each branch to be measured, in front of the first branch component as shown by the example in Figure 11.
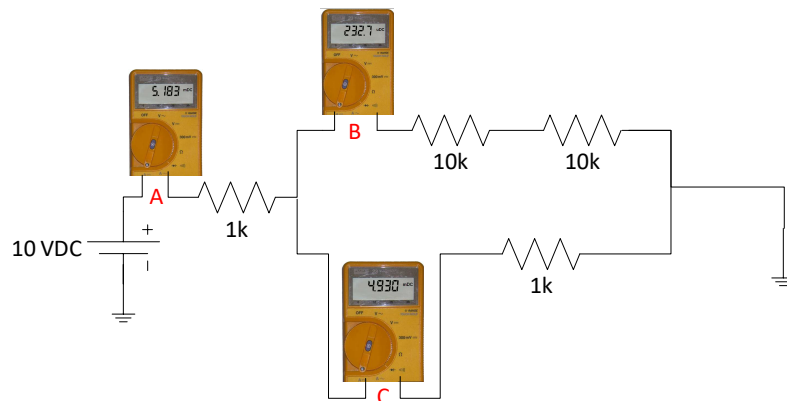

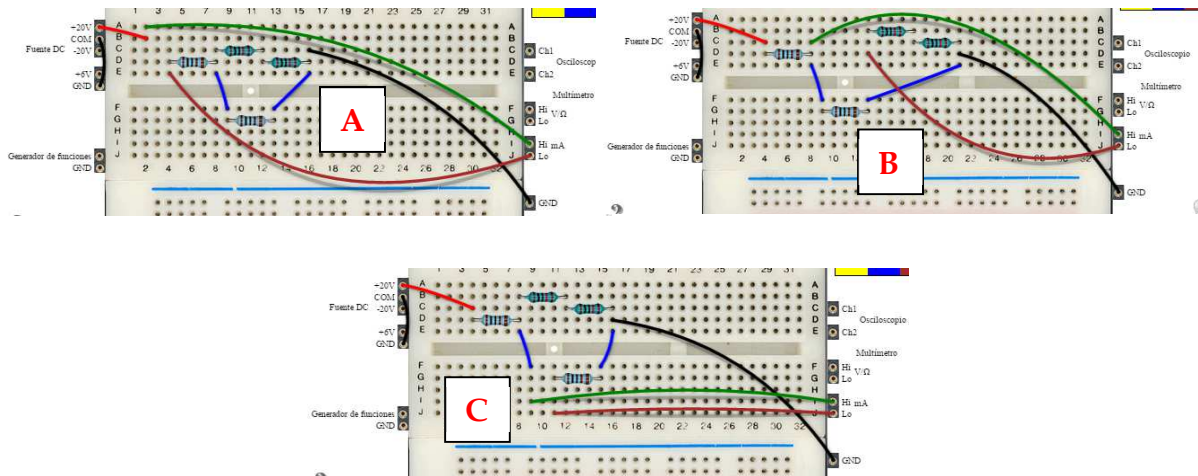Figure 11. Example for current measurement

Figure 12. Implementation of the measures at points A, B and C of Figure 11

2. Circuits with diodes

The components available for experimenting with diodes are:

- 1 1N4007
- 1 Zener 5.1V
- Resistors of 1kΩ y 10kΩ
- Capacitors of 1uF, 10uF y 0.1uF

2.1 Diode characteristic curve

The VISIR remote laboratory can be used to obtain the diode characteristic curve. In this experience it can be verified what it happens when the diode is polarized in direct and in reverse. For that:

1. Carry out the following assembly
2. Set the supply voltage. Use the + 25VDC source.
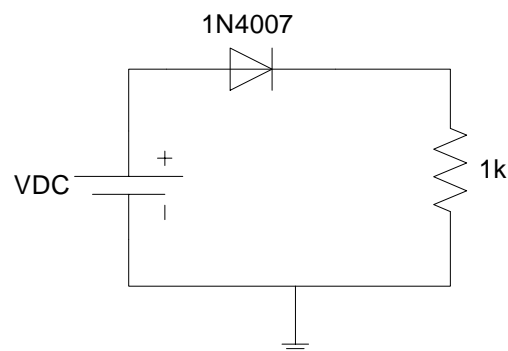3. Measure the voltage drop on the diode

Figure 13. Circuit to obtain the characteristic curve of the diode
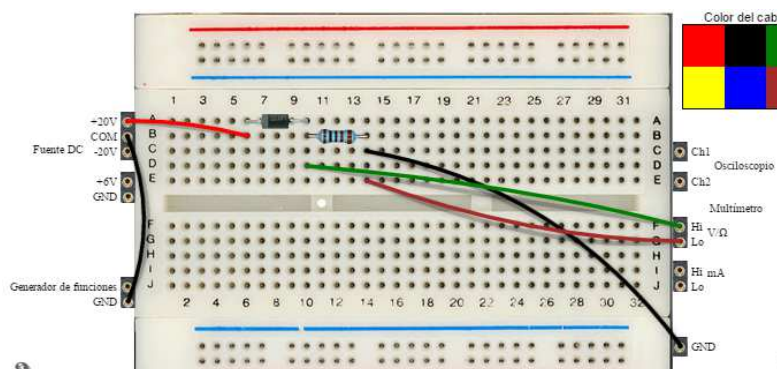
Implementation on the remote lab

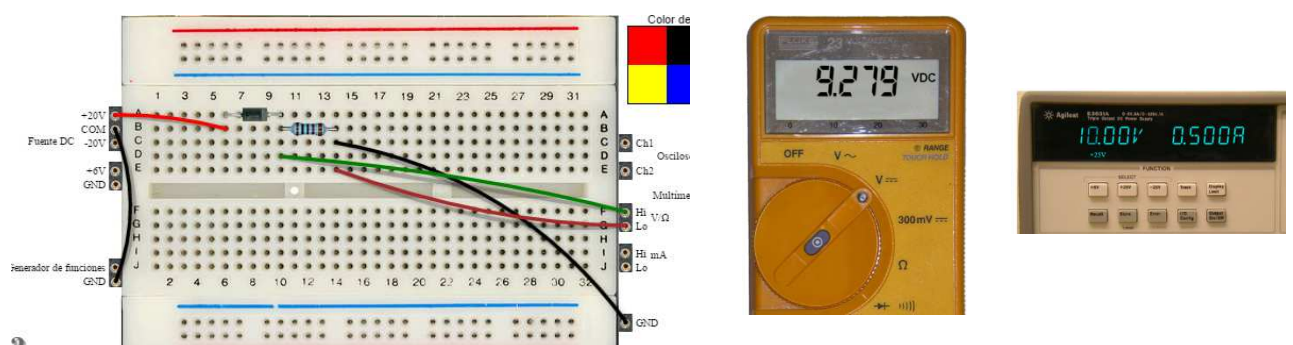Figure 14. Implementation on the remote lab. Diode in reverse

Figure 15. Implementation on the remote lab. Diode in direct possition

In this circuit it is also possible to measure the current flowing through the diode. To do this, connect the multimeter between the diode and the resistor or before the diode.
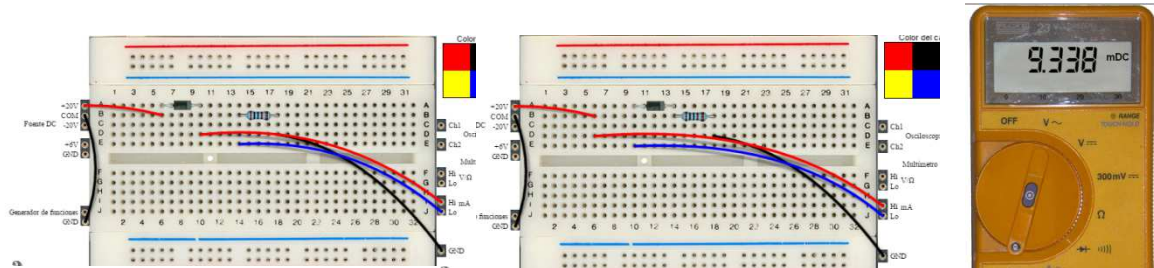

Figure 16. Measuring the current ton the diode. VDC=+10V

2.1 Half-wave rectifier

If, in the previous circuit, the DC source is replaced by the function generator and the circuit is supplied with a sinusoidal signal, we can observe the operation as a half-wave rectifier.
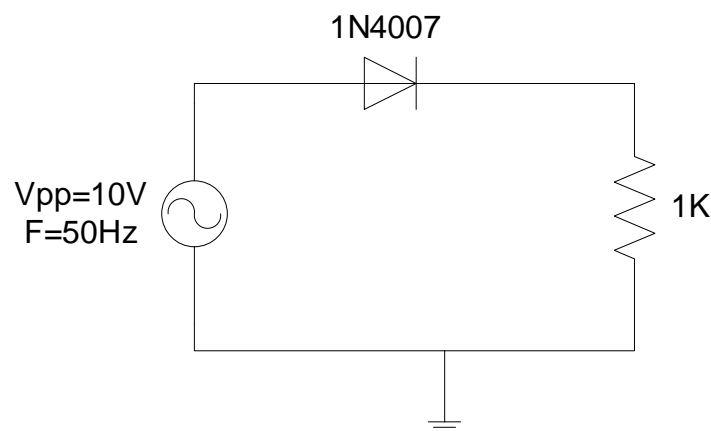

Figure 17. Half-wave rectifier

In the above circuit, the diode can be connected in direct or inverse and observe how the diode rectifies the positive or negative half-cycle of the input signal in each case.
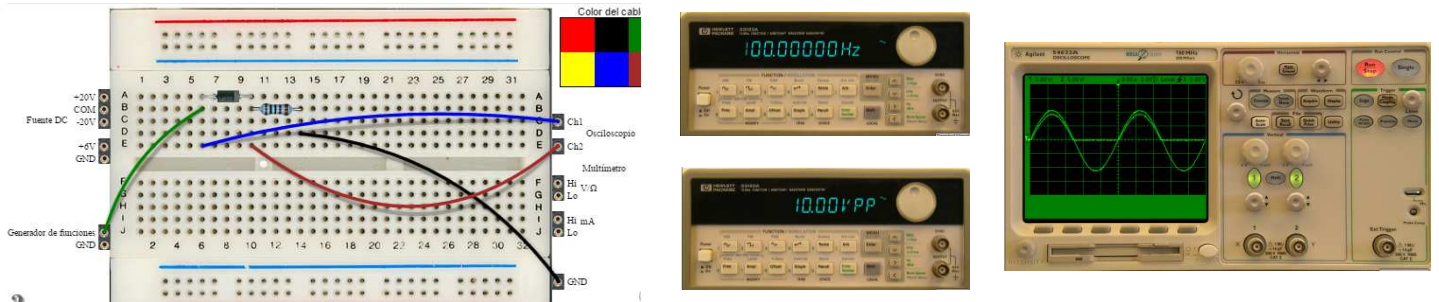
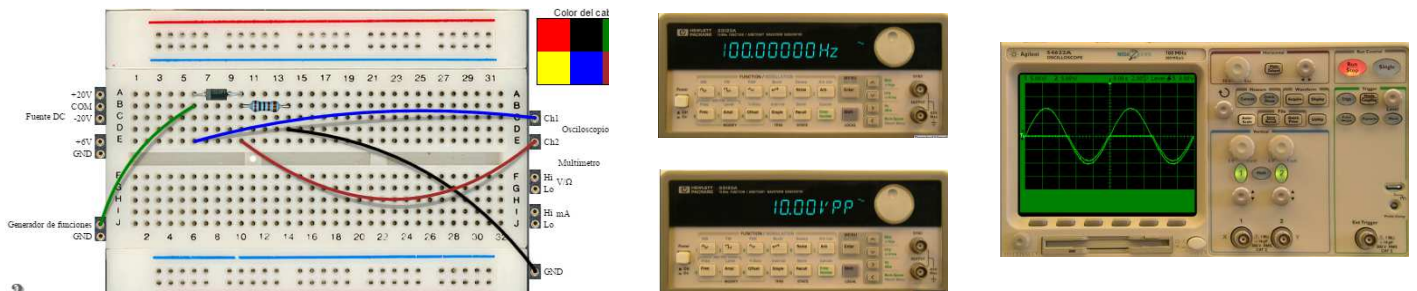Figure 18. Implementation on the remote lab of the positive half-wave rectifier.

Figure 19. Implementation on the remote lab of the negative half-wave rectifier.

2.2 Half-wave rectifier with output filter

A low-pass filter can be added to the previous circuit at the output to obtain a continuous signal. To do this, simply add a capacitor in parallel to the 1kΩ resistor. The available capacitor values are 1uF, 10uF and 0.1uF.
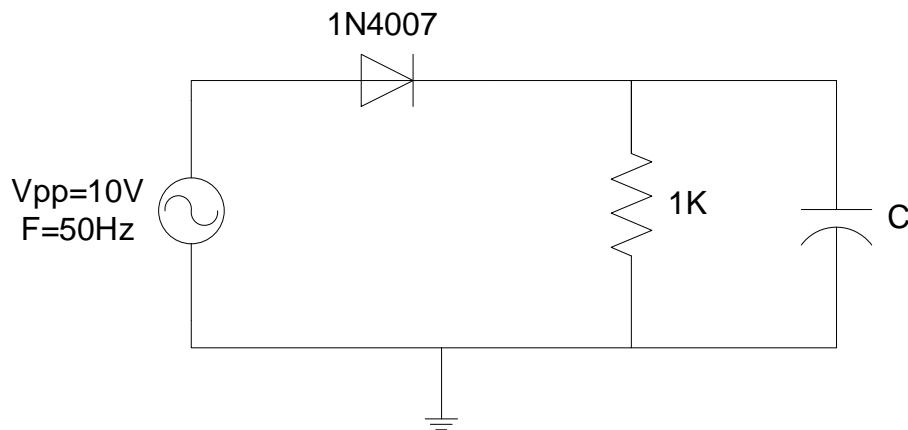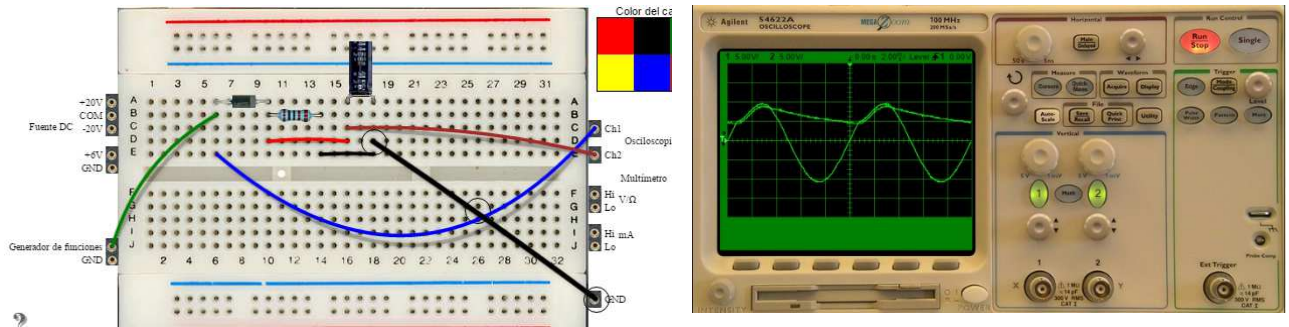

Figure 20. Half-wave rectifier with output filter circuit
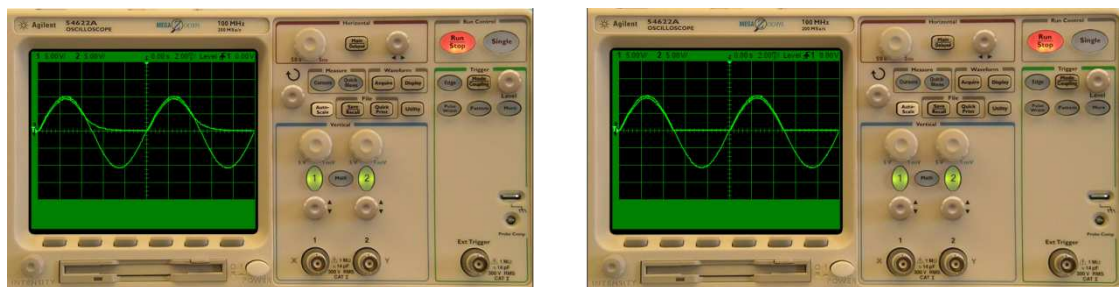
Figure 21. Implementation on the remote lab. C=10uF

Figure 22. Circuit outputs with C=1uF and C=0.1uF

2.3 Zener diode voltage regulator

Through this experiment the operation of a Zener diode can be analysed, either with forward or reverse polarization. For this, the remote laboratory has a 5.1V Zener diode, a 470Ohms resistor and a 1k resistor, which can be connected to the conFiguretion shown at Figure 11, in which the diode can be removed and see how it affects the voltage drop between both resistors.
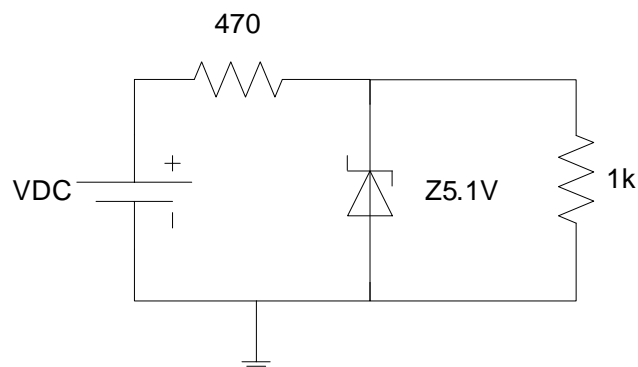

Figure 23. Circuit with Zener diode
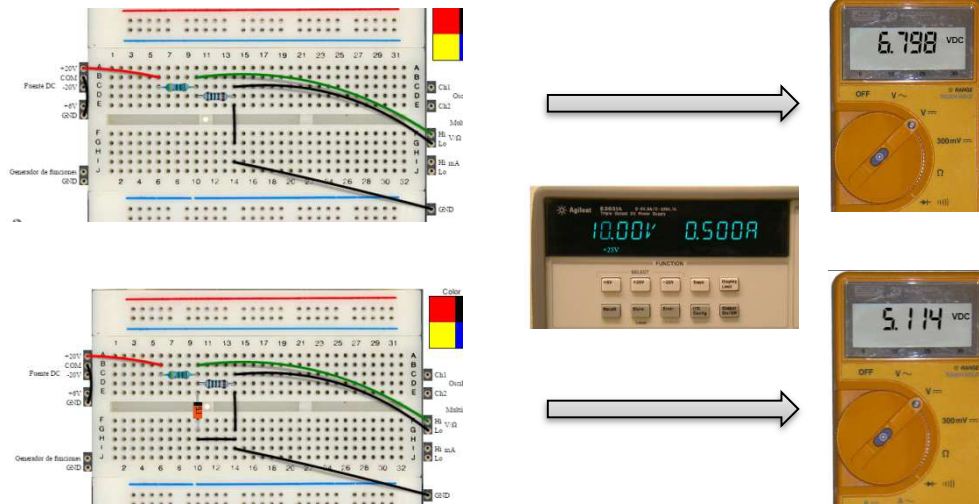
Figure 24. Implementation on the remote lab

In the previous circuit it is also possible to connect the multimeter before the 470 ohms resistor and in front of the Zener diode to obtain its characteristic I-V curve varying the value of the supply voltage VDC and taking measures of voltage and intensity on the circuit.
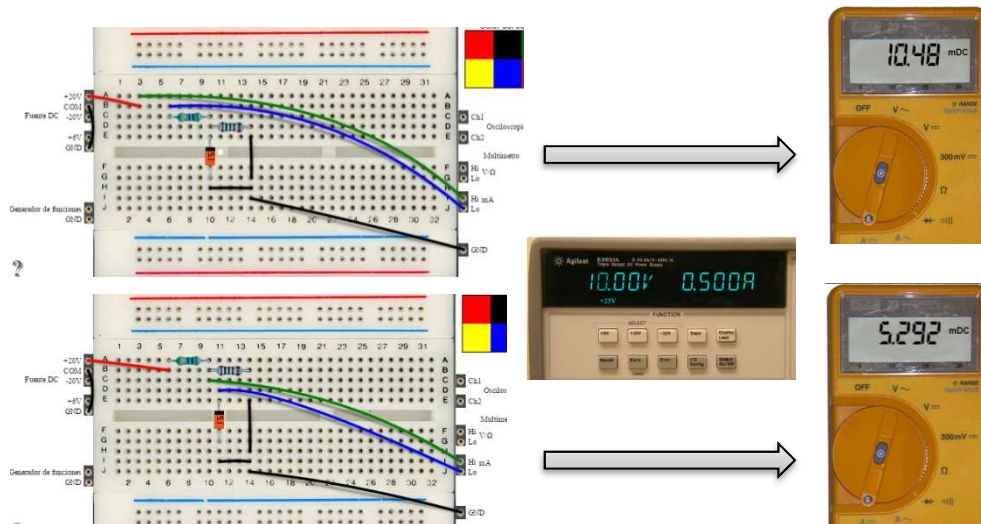

Figure 25. Measure of the currents on the Zener circuit

3. RC Circuits

3.1 Analysis of capacitor charge and discharge

The Analog Electronic remote lab allows to analyse and calculate the charge and discharge times of a capacitor (constant τ). The available components are:

- 1 resistor of 1Ω and other of 10kΩ
- Capacitors of 1uF, 10uF and 0.1uF

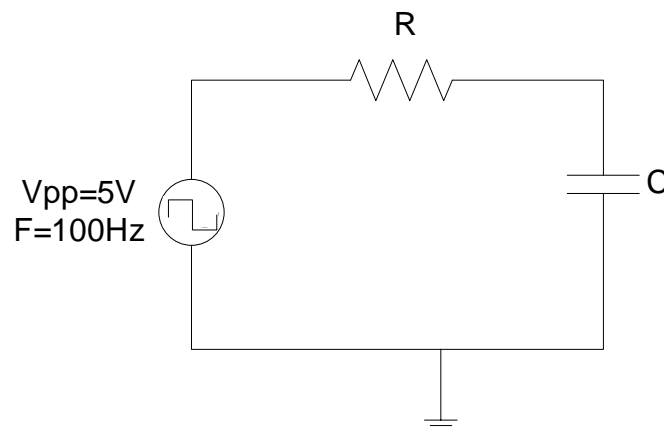To carry out the experiment, components can be connected as follows:

Figure 26. Circuit to analyse the charge and discharge of the capacitor.

By connecting the function generation to the input of the circuit and setting up to generate a square signal of 5Vpp and F = 100Hz, it is possible to observe signals at the input and at the output on the oscilloscope. Assuming 1kΩ and 1uF, the capacitor charge constant will be $\tau = R \cdot C = 1$ ms.

It is considered that the capacitor is charged when the voltage dropped in the capacitor is equal to 63% of the final value. If the signal is 10Vpp, this value will be 6.3V. As the generated signal goes from -5V to + 5V, this value measured on the oscilloscope will be 1.3V. Analogously, its discharge value will be -1.3V.
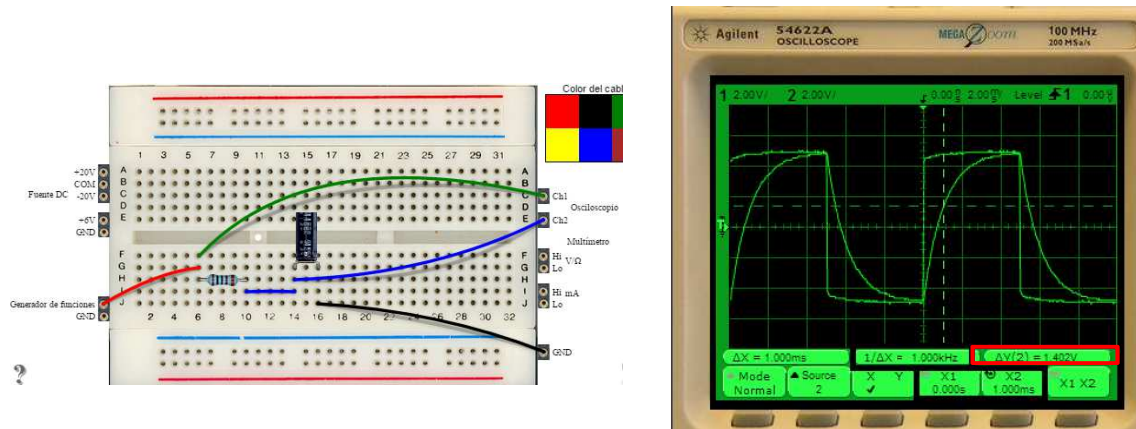
Figure 27. Implementation and measurement on the remote lab

3.2 Low pass and high pass RC filters.

Using the remote laboratory, it is possible to check the operation of low pass and high pass RC filters. To this end the remote laboratory has of:

- 1 resistor of 1Ω and other of 10kΩ
- Capacitors of 1uF, 10uF and 0.1uF

In order to perform the experiment, the components can be connected as shown in the Figure 28.
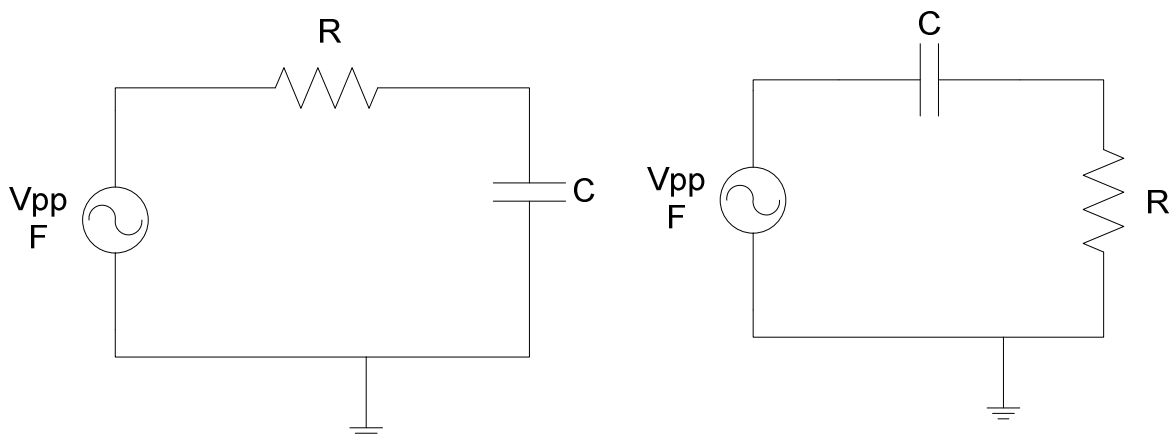

Figure 28. Low pass and high pass filters

Los valores de R y C pueden ser combinados como se quiera, dando lugar a hasta 6 filtros paso bajo diferentes, cada uno con una frecuencia de corte distinta. Manteniendo la tensión Vpp de la señal de entrada y variando su

frecuencia, se podrá comprobar la respuesta en frecuencia del filtro, calculando por ejemplo, su frecuencia de corte.

The values of R and C can be combined as you like, giving rise to up to 6 different filters, each with a different cut-off frequency. Keeping the input signal voltage Vpp and varying its frequency, you can check the frequency response of the filter, for example, calculating its cut-off frequency.
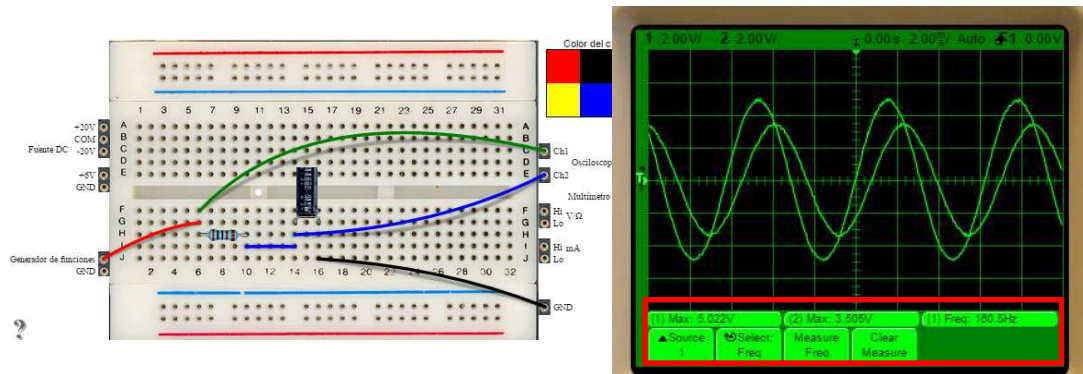

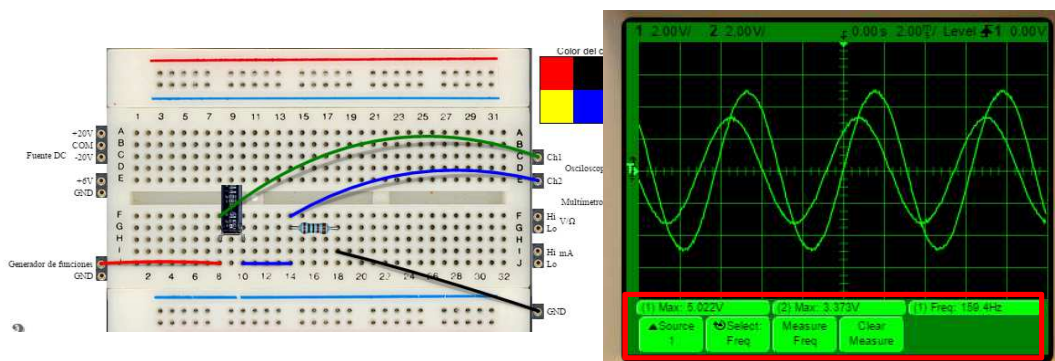Figure 29. Low pass filter implementation R=1kΩ y C=1uF. Input frequency = 160Hz.

Figure 30. High pass filter implementation R=1kΩ y C=1uF. Input frequency = 160Hz

4. RLC circuits

4.1 Basic LR circuit.

For this circuit we are going to use the following components:

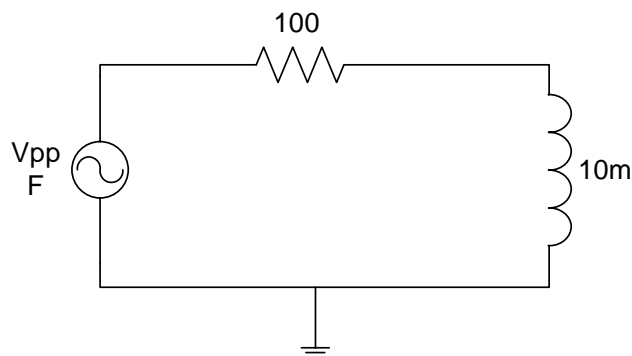- 100Ω resistor
- 10mH inductor

Figure 31. LR circuit

The voltage and the current in the coil can be analysed over the circuit. Both their amplitudes and the out-of-phase between them may be tested on this circuit. Remember that you can measure the current at the beginning of each branch, it is here, before the 10mH inductor.
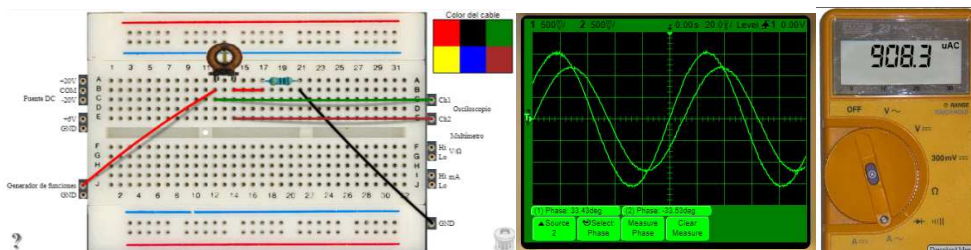

Figure 32. Implementation of the LR circuit. Input signal 9,109Hz @ 1,41Vpp. I$_{RMS}$ measurement on the DMM.

4.2 CRL circuit.

For this circuit we are going to use the following components:

- 2.2nF capacitor
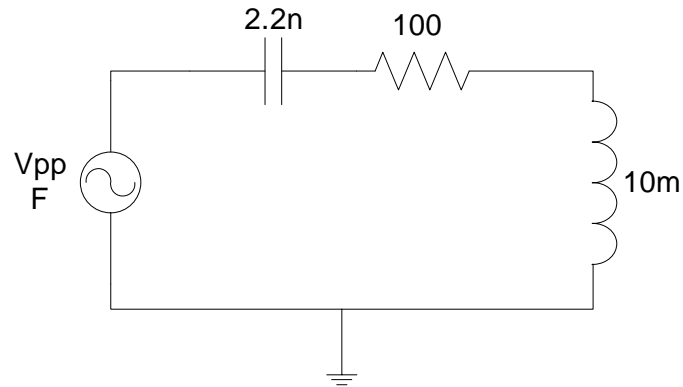- 100Ω resistor
- 10mH inductor

Figure 33. CRL circuit

On this circuit it can be analysed how are tensions both in the capacitor and inductor respect to the input signal, being able to analyse both their amplitudes and the existing out-of-phase.
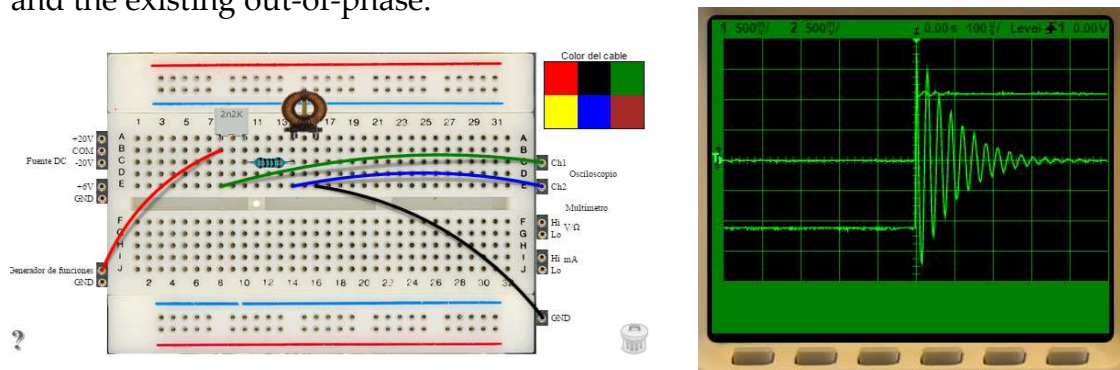

Figure 34. CRL circuit implementation. Input signal 500Hz@1Vpp

4.3 RLR Circuit.

For this circuit we are going to use the following components:
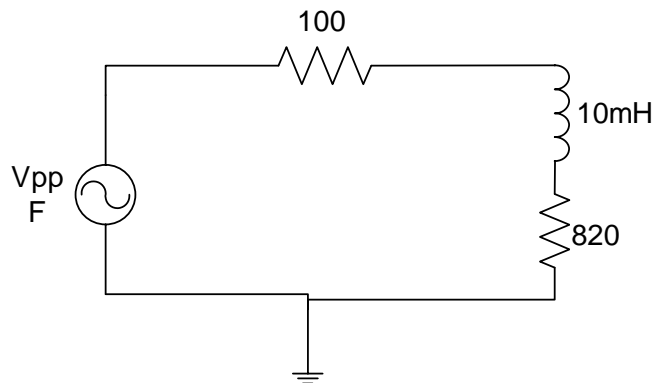
- 100Ω resistor
- 10mH inductor
- 820Ω resistor

Figure 35. RLR circuit

On this circuit it would be possible to measure the voltage and current in each of the elements, calculate the voltage out-of-phase between each of the elements, measuring RMS values of voltage and current. Remember that you can measure the current at the beginning of the branch with the multimeter. As reference the input Vpp can be 1, 41V and frequency 9, 109Hz
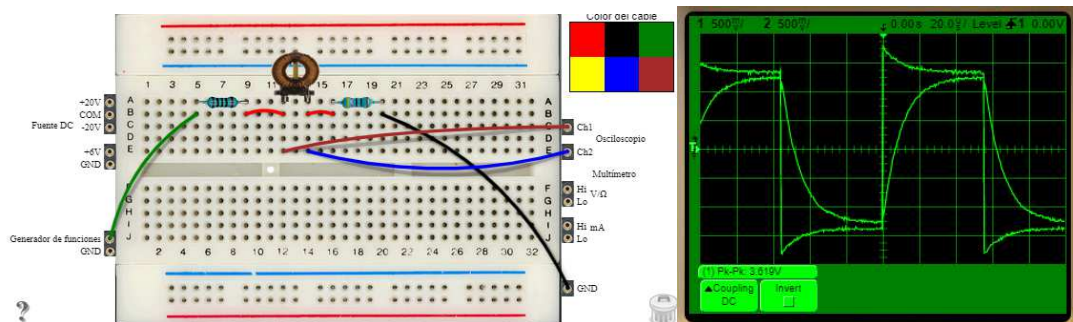

Figure 36. Implementation of RRL circuit. Input signal 9,109Hz@1,41Vpp

4.4   RLR and C in parallel.

For this circuit we are going to use the following components:

- 100Ω resistor
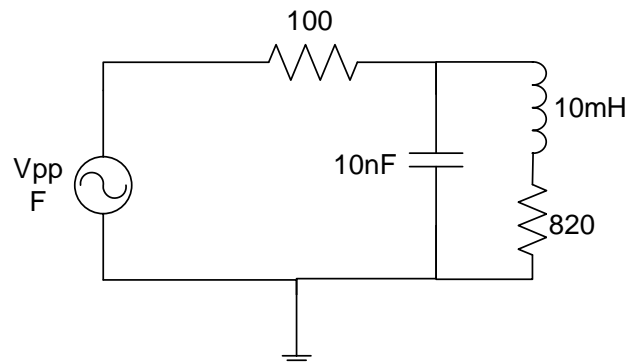- 10mH inductor
- 820Ω resistor
- 10nF capacitor

Figure 37. RLR circuit with a capacitor in parallel to the load.

On this circuit it would be possible to measure the voltage and current in each of the elements, calculate the voltage out-of-phase between each of the elements, measuring effective values of voltage and current. Remember that you can measure the current at the beginning of the branch with the multimeter, e.g. in front of resistance of 100Ω and in front of 10nF capacitor. As reference the input signal Vpp can be 1, 41V and frequency 9, 109Hz.
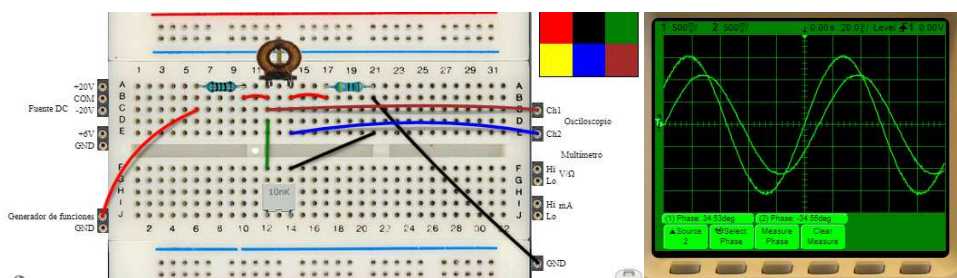

Figure 38. Implementation of RRL circuit with capacitor in parallel to the load. Input signal 9,109Hz@1,41Vpp

5. Circuits with operational amplifiers

A través del laboratorio remoto de electrónica analógica también se puede experimentar con circuitos más complejos, incluyendo incluso circuitos integrados. A modo de demostración se incluyen algunos ejemplos posibles a implementar empleando amplificadores operacionales, en concreto el U741, cuyo esquema aparece en la Figure 39

Thanks to the Analog Electronics remote laboratory also it can be experienced with circuits more complex, including integrated circuits. They are listed some examples that can be implemented using operational amplifiers, specifically the U741, whose scheme appears at Figure 39
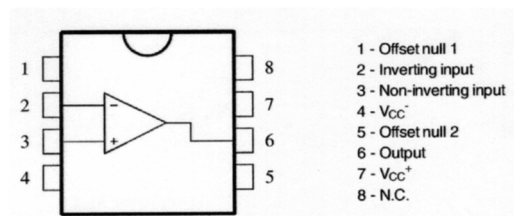

Figure 39. UA741 integrated circuit

5.1 Non-inverting Operational Amplifier Configuration

Figure 40 shows the electronic scheme of the UA741 op-amp operating as non-inverter amplifier. To check the effect of amplification, it is possible to change the resistance placed in the branch of feedback to take the values shown in Figure 40
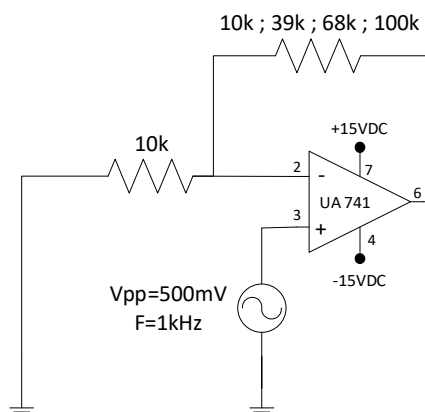

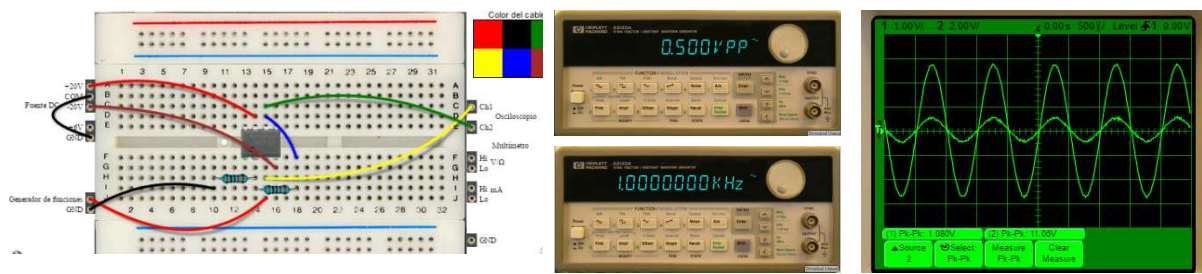Figure 40. Op-amp operating as non-inverter amplifier

Figure 41Implementation of op-amp operating as non-inverter amplifier, being R$_{feedback}$=100kΩ

Remember that the function generator generates a signal of double amplitude that sets it in its front panel[2].

Very important: feed the circuit with + 15VDC -15VDC for correct operation.

5.2 Inverting amplifier

Figure 42 shows the UA741 op amp electronic scheme working as inverter amplifier. To check the effect of amplification, it is possible to change the resistance placed in the branch of feedback to take the values shown in Figure 42.
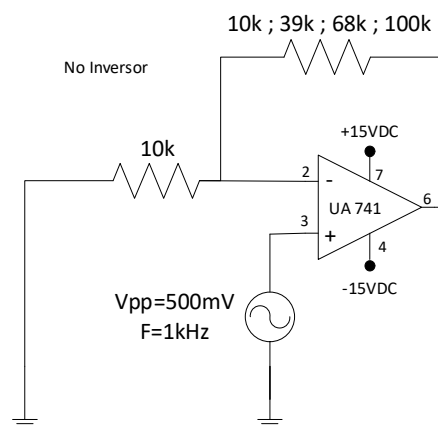

Figure 42. Amplificador operacional funcionando como inversor

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[2] Complete information can be consulted at section 4.1 of the remote lab user manual.

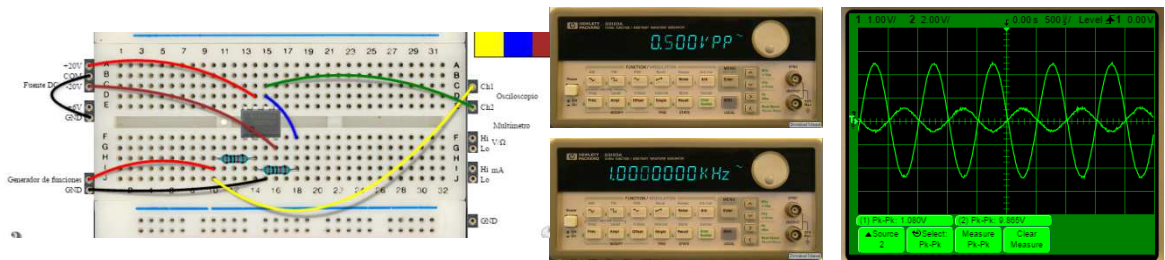Figure 43. Implementación del circuito inversor, siendo R_realimentación=100kΩ

5.3 Op-amp Differentiator circuit

Next figure shows the UA741 working as differentiator amplifier. As in the previous circuits, the resistor connected on the feedback branch, can adopt the values shown at Figure 42.
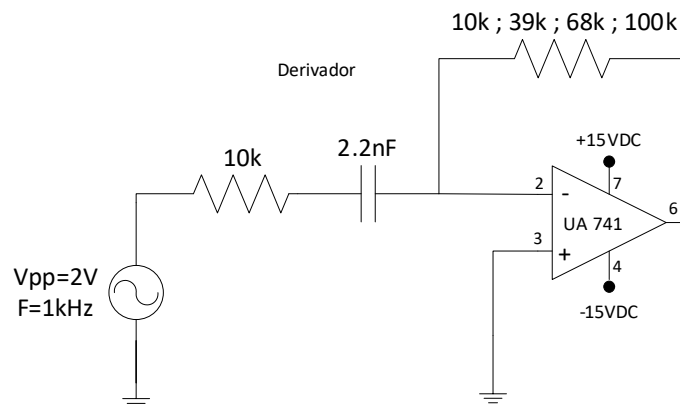

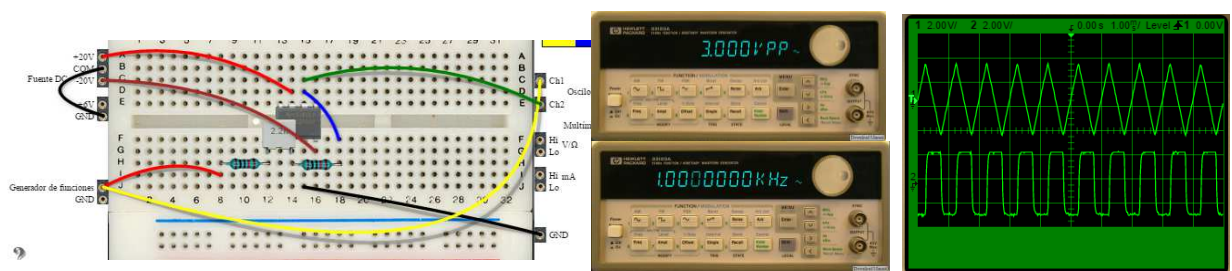Figure 44. 5.3   Op-amp Differentiator circuit

Figure 45. Op-amp Differentiator circuit implementation, being R_feedback=100kΩ and a triangle inmput signal

5.4 Op-amp Integrator circuit

Next figure shows the UA741 working as integrator amplifier. As in the previous circuits, the resistor connected on the feedback branch, can adopt the values shown at Figure 46.
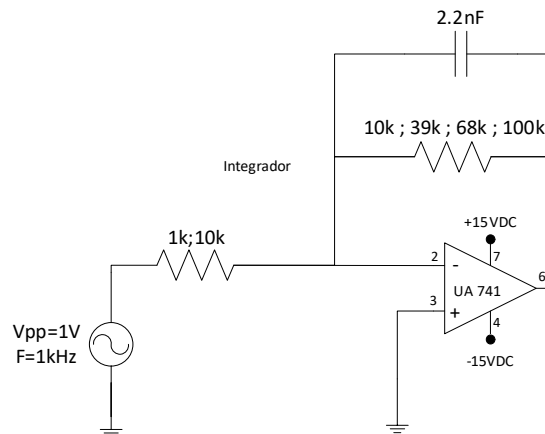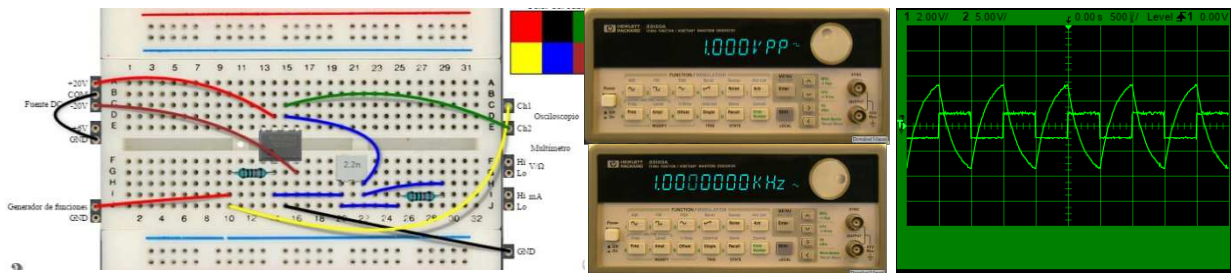

Figure 46. Op-amp Integrator circuit

Figure 47. Op-amp integrator circuit implementation, being Rfeedback=100kΩ and a square input signal

5.5 Op-amp comparator circuit

Next figure shows the UA741 working as comparator. As in the previous circuits, the resistor connected on the feedback branch, can adopt the values shown at Figure 48.
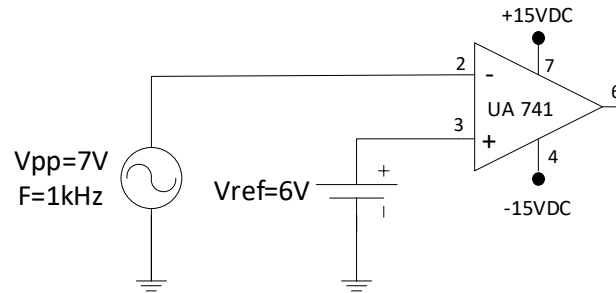
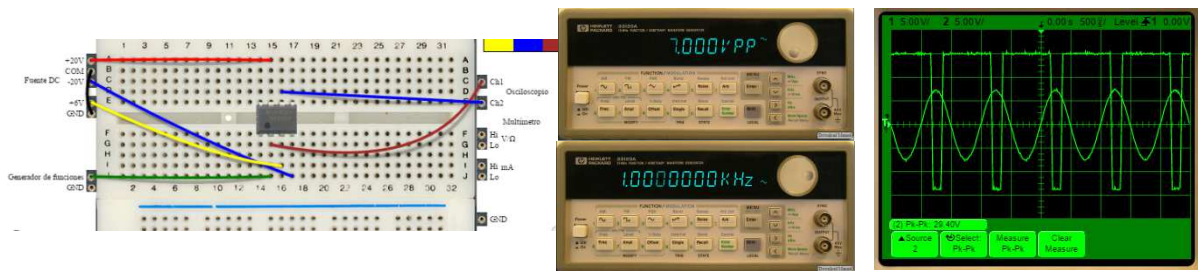Figure 48. Op-amp comparator circuit

Figure 49. Op-amp comparator circuit implementation, being the input a sinusoidal signal of 14Vpp and the reference equals to 6VDC

6. Circuits with transistors

In the remote laboratory, it is also possible to implement circuits with transistors, as it picks up the example of the Figure 50
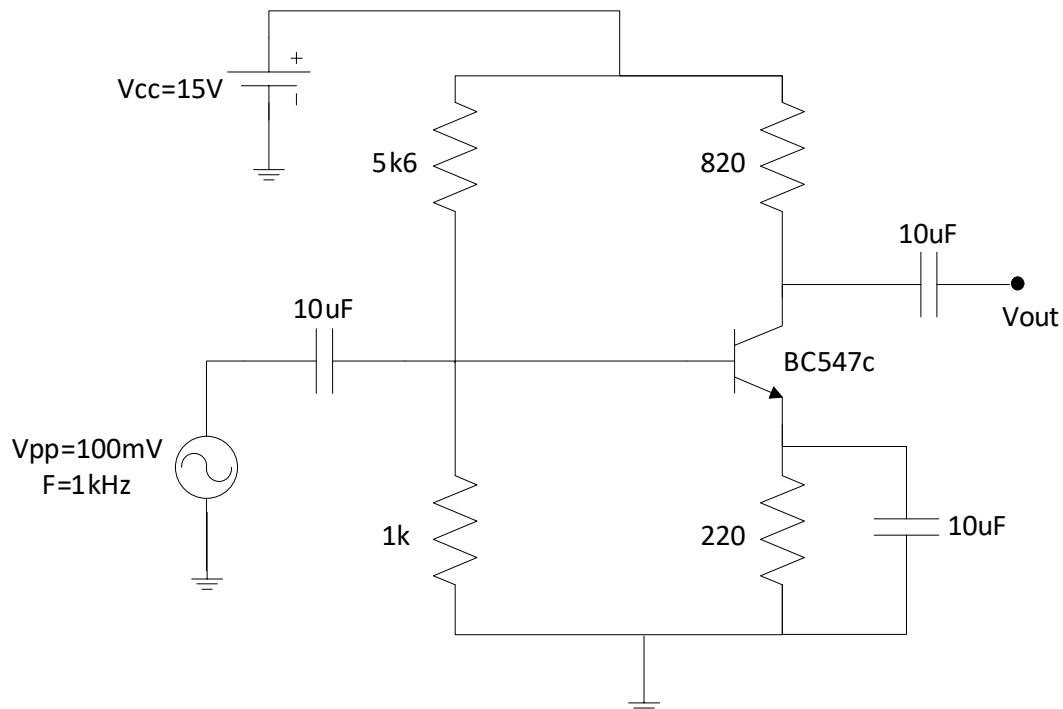

Figure 50. BJT in common emitter configuration

The implementation of the circuit in the remote laboratory is shown in Figure 51. Voltage measurements can be performed in all the nodes of the circuit, as well as obtain the output signal with respect to the input signal, as it is shown in Figure 51.
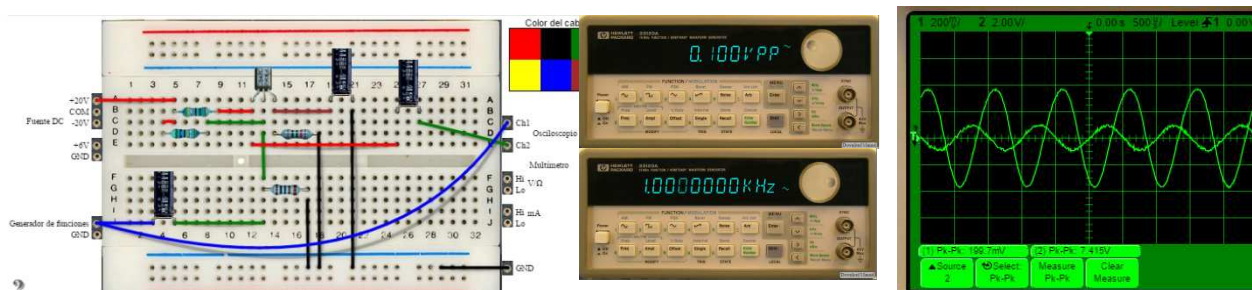

Figure 51. Implementation of the BJT common emitter circuit