C E B E K ®
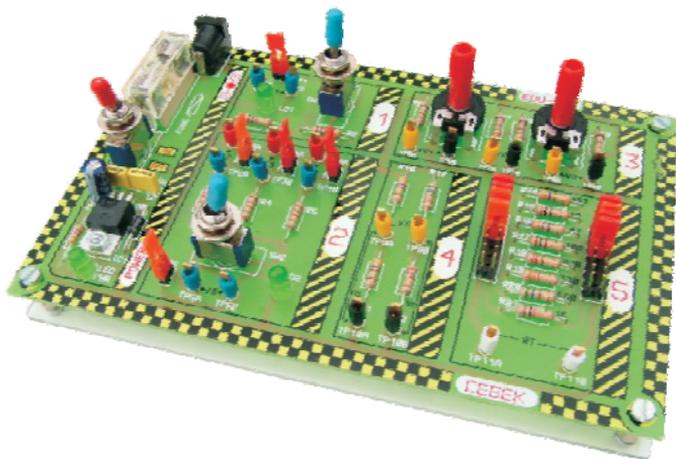
EDUCATIONAL MODULES

For LEARNING and to PRACTISE the ELECTRONICS

www.cebek.com

EDU-003. The Resistor.

The EDU-003 module introduce 5 practices; principles, characteristics and code for the carbon resistor, the electrical result of its application in different configurations and finally the omnipresent Thevenin theorem.

To make the introduced different practices, the module only requires a power supply and a multimeter. The rest of operations are done with elements supplied wit the circuit. Technical differences will allow to the student to go more deeply into each experimental field.

Practice 1. Resistor definition. Serial behaviour.

Practice 2. Resistors´ behaviour in parallel, voltage and current.

Practice 3. The voltage Divider. Behaviour and Formula.

Practice 4. Thévenin´s theorem, Thévenin´resistor.

Practice 5. Norton´s theorem.

Practice 6. Auto configuration in Serial - in Parallel. Voltage and Current control.

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⬡ Warranty and Do not forget.

Cebek educational modules included in the EDU serial offer several practices to analyse, experiment and to learn basic knowledge on the studied theme. Nevertheless, their function is not to make a mini-class on each theme, but to complete and to be used as basis, as well as to allow to experiment on the theoretical theme evocated by the teacher. For this reason, we suggest you to use modules form the EDU serial under the supervision and the direction of a teacher.

Cebek doesn't offer a consulting service as concern the theoretical or the operating principles concerning the theme deal with the module. It only offers a technical assistance regarding questions and problems coming from the circuit's internal operating mode.

All Cebek modules included in the EDU serial have a warranty of 3 years as concerning components and labour man. All damages provoked by external causes (from the circuit), as well as wrong connections or installations or due to an operating mode no indicated into the module's documentation won't be covered by the warranty. More over, all wrong or incorrect handling won't be excluded from the warranty. For any claim, you have to present the corresponding invoice.

To contact our technical department, you can send a message to sat@cebek.com, or a fax :Nº+34.93.432.29.95 or a mail to the following address: CEBEK, c/Quetzal, 17-21, 08014 Barcelona (SPAIN).

⬡ Rules and Identification of the EDU serial elements.

To make easier the identification and for a single rule as concern different practices and educational Cebek modules, all common elements will answer to colour code and to a shape.

Test Point. (TP).

It allows to connect oscilloscope's or multimeter extremities to read parameters relating to the practice. According to its colour, it will indicate that the Test Point (TP) is connected to the positive or to the negative of the circuit, as well as reads concerning current, voltage, load, etc….

TP. ➕ circuit Red   **TP. ➖ circuit** Black   **TP. Tension** Yellow   **TP. Courant** Blue

TP Without current or TP AC. White

Conmutator / Switch.

According to the colour of the switch, you can control the voltage, the current

Power supply Red   **Current** Blue   **Voltage** Yellow   **Logical** Green

Jumper.

It allows to close or open a signal or an electrical circuit

Important Point

Important Point: Part to remind.

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◑ Before to start...

Before to start a practice, it is very important to carefully read its instruction manual as well as corresponding indications.

You have to do correctly connections in indicated contact points, otherwise measures depending on these connections will be confuses or wrong.

Do not make connections not indicated in the instruction manual to avoid to damage the circuit.
If the Led of the power supply "PWR" doesn't light on or if its function suddenly stops, you have to quickly disconnect the power supply for the device and check there is any short-circuit as well as the fuse's status.

Even if described practices can be done following instruction manual, we recommend you to use it under the supervision of a teacher who can advise and bring you a support (an help) concerning described concepts.

In the circuit, each practice will be delimited by a rectangle with the corresponding number. One or several experiment(s) can be reported and referenced to this practice.

◑ Module's power supply.

The module is supplied at 12 V DC. You have to use a stabilized power supplied or our Cebek FE-113 power supply. The circuit's supply is only do through male connector inserted on the PCB, **do not inject signal on any other terminal of the circuit.** Once supplied, the circuit offers voltages necessary to experiment with each practice. For the power supply connection, the module includes a cable with a male connector at an extremity and wires at the other extremity.
Connect each terminal respecting the connector polarity to the corresponding output of the power supply. Then you could insert it on the module.
Note: The circuit's fuse is 200 mA.

Female Connector

Male Connector
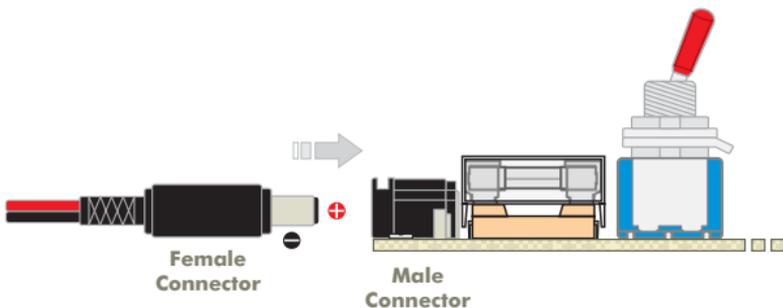
◑ Required Material.

You won't need any other material or additional component to experiment with this module. You will only need basic measure instruments to obtain and to compare values of practices. For this module, you will need one or several multimeters with their voltmeter, ampermeter or ohmmeter functions. If you have an oscilloscope, you also could use it to substitute the voltmeter.

◑ Bibliography.

.- Electronics principles E. McGraw-Hill. Author: Albert Paul Malvino.
.- With Google: Resistors.

EDU-003

EDU-003. The Resistor.

◐ The resistor. Definition and types.

In electricity, materials can be conductors, insulators, or partially conductors. Materials partially conductors offer an opposition to electrical flows, their average will determine the materials' resistive value. These elements are known as passive electrical components. One of them is the resistor; that means an electrical component which offers a resistance with a concrete value when the current pass.

Resistors are basically divided in three groups:

.- Fix linear resistors, or common resistors, with a concrete value determined by the manufacturer.
.- Variable resistors, with a value which can be externally adjusted between two margins established by the manufacturer.
.- No linear resistors, like NTC, LDR, etc…which value will change according to the submitted temperature, luminosity, etc….
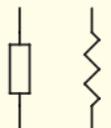
Electrical symbol
for the fix resistor

Electrical symbol
for the variable resistor
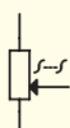
Electrical symbol
for a NTC

◐ Resistors read

There is a colour code, common for all manufacturers which allows to visually identify the resistance's value.
Placing the resistor with the tolerance band oriented to the right side, the two first bands at the left will indicate their ohm value. The third band will indicate the number of zero and the fourth the tolerance of the global value.

The resistor of the example = 560K (+/- 5%).

Value
Number of zero
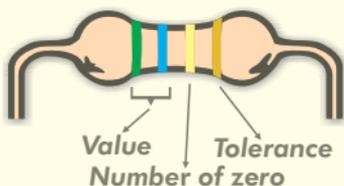
Tolerance

◐ Equivalence between Value-Colour:

0 *black*	*1* *brown*	*2* *red*	*3* *orange*	*4* *yellow*
5 *green*	*6* *blue*	*7* *violet*	*8* *grey*	*9* *white*

◐ Tolerance:

± 5% (Gold Colour).   ± 2% (Yellow Colour).
± 1% (Black Colour).

EDU-003. The Resistor.

⬤ Practice 1. Behaviour in serial configuration.

The resistor, as opposition element to the electrons pass, will proportionally and directly limit the current that cross it, regarding to the applied voltage. This principle is known under the following name: Ohm law. For this law, we can establish the following formula:

> Ohm´s law: **V= R . I** V= Voltage R = Resistance I = Intensity

⬤

The practice N°1 allows to verify the Ohm law as well as the principle of the resistors' behaviour, placed in serial (serial configuration).

Firstly, you have to place an ammeter between TP1A and TP1B tips test and remove the JP1 jumper to allow its connection in serial. If the SW1 switch is connected to R1, the consumption will be approximately 7mA. At the opposite, if you connect the SW2 switch to the R2, the current will pass through both resistors, then
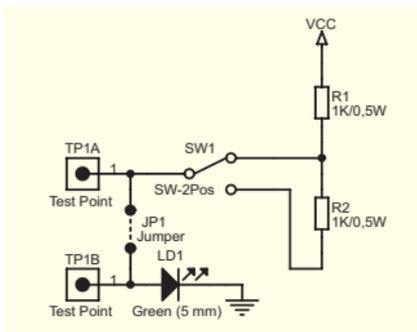

Electrical drawing for the practice 1

their opposition will be double and the consumption is reduced to 3.6 mA. As you can see, the luminosity of the Led decreases when the current's limitation, determined by R1 + R2, increases.

If we compare the value obtained by the Ohm law's formula I=V/R.

.- Removing both V absorbed by the Led (7/1000) = 0.007A.

.- But connecting R1 and R2 in serial (7/2000) = 0.0036A.

Therefore, we can deduce that total impedance or ohm resistance in a configuration of resistors in serial, is equal to the sum of their values.

> **Resistor in Serial:** The impedance or total ohm resistance for resistors in serial configuration **is equal to the sum of their total values.**

⬤ Practice 2. Behaviour in Parallel.

If you add more resistors, you don't obligatory increase the ohm capacity of the obtained circuit. The following practice lesson shows several applications of different resistors in parallel, as well as the current's and voltage's behaviour.

Before to start this practice, the SW2 switch has to be in open position. Then, you have to place an ammeter between TP2A and TP2B test tips; removing JP2 jumper to allow the connection in serial. With the obtained measure, you have to do the same read operation on TP5A and TP5B. If you don't have two ammeters, you can install again the JP2 jumper and remove only the JP5 jumper.

You can verify that the obtained current is exactly the same before and after the resistor's installation (approximately 5,6 mA). Indeed, in a circuit in serial, the current's value which crosses it is the same in all points of the circuit.

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◍ **Practice 2. Parallel configuration,** (2nd part)

If we maintain the SW2 switch in closed position, as well as all jumpers inserted, R3, R4 and R5 resistors will remain connected in parallel.
Placing a voltmeter tips test between TP2B and TP3B as well as between TP4B and TP5B, you can read the voltage fall corresponding to each resistor. Then, the obtained result will be approximately 6,8 V; same matter for each resistor. Therefore, in a configuration of resistors in parallel, the voltage fall is not affected, but determined by the individual resistance which composes it, contrary to a configuration of resistors in serial where the voltage is shared out or divided. (See the practice N°3, where it is explained).

◍ To check the intensity behaviour, you have to remove the JP5 jumper and to place again an ammeter between TP5A and TP5B test tips. The obtained current (coming from the Led) is approximately 17mA, and it is divided into three different currents: one for each parallel circuit, and proportionally to the resistance of each one. In this practice, as all resistors have the same value, the current will divide into three equal parts of 5,7 mA approximately.

Then, each circuit add its intensity to the common point identified by TP5A, and the led luminosity will be more intense according to the addition of three circuits in parallel.

Applying the Ohm law' formula, if V=(Vcc-VLed), (9-2=7V) as well as 17 mA corresponding to the obtained current read, the total resistance of the circuit will be 411 Ohms. Nevertheless, when it is necessary to obtain the total value of different resistors placed in parallel, through the theoretical formula, you can use the following formula:

Electrical Drawing Pratice 2

$$Rtotal = \cfrac{1}{\cfrac{1}{R1} + \cfrac{1}{R2} + \cfrac{1}{R3} + \cdots}$$ **To calculate Resistances in parallel.**
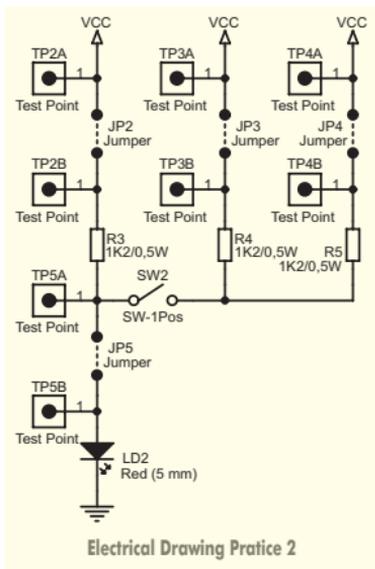
Applying values of the practice, (1K2 for each resistor), the result would be 400 Ohms. You can note that it is practically the same result that you obtained through voltage registers and real currents of the practice lesson.

There are simplest and different methods for the calculation of resistors in parallel, as for instance to use resistors with equal values. In such case, the value is equal to the division of the ohm value by the number of resistors placed in parallel.
For resistors with different values, and placed in parallel, the value result is always inferior to the value of the smallest resistor used.

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Practice 3. The voltage divider.

In a drawing of resistors placed in serial, the voltage supplied is shared out between them, the voltage is constantly used in different configurations and circuits; and from this one, you can obtain a concrete voltage value on a determined point.

Applying the Ohm law, you obtain the formula to obtain the specific voltage divider for each application.
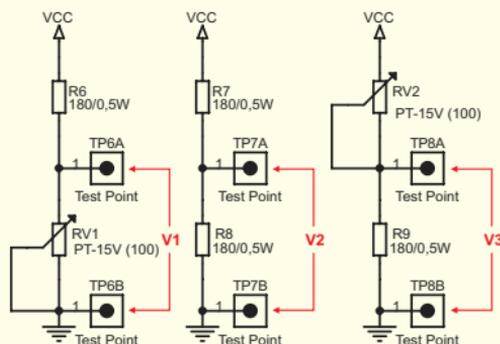
Voltage divider:

$$Va = \frac{Vcc \cdot R2}{R1 + R2} - Vss$$
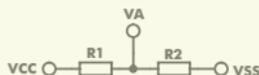
The practice n°3 allows to experiment, with three different voltage dividers, the three most frequent cases being: To divide fix voltage, variable regarding to V DC, or variable regarding to the ground.

The exercise has to start obtaining theoretical values of V1, V2 and V3, through the voltage divides formula. Then, we will place a voltmeter between tips test TP6A and TP6B, TP7A and TP7B as well as TP8A and TP8B.

On TP6, V1 is established between 0 and 3 V. In a voltage divider, when the potentiometer or the variable resistor are referred to the ground, the minimum adjustment will be always zero. Instead of the ground, if you inject a voltage different to zero (Vss in the formula), the minimum value will be always Vss.

Electrical Drawing Practice 3

This one is due to the inevitable short circuit situation obtained by the variable resistor when it is placed at an extremity, appearing then the integral value of Vss or ground in V1.

On TP7, the voltage divider is composed by two fix or equal resistors, therefore the voltage in V2 is always the same (the half of Vcc). In a configuration in serial with successive resistors having the same value, the resulting voltage in each obtained voltage divider, is always equal to Vcc divided by the number of resistors placed till this divider.

For instance, for five resistors assembled in serial, voltage dividers will follow one other: Vcc/2, Vcc/3, Vcc/4 andVcc/5.

On TP8, V3 remains established between 6 and 9 V approximately Contrary to the first divider, when the variable resistor is referred to vcc, the minimum adjustment will be always the Vc value. Indeed, this condition is due to the same phenomenon produces by the potentiometer's short circuit situation, when it is placed at an extremity.

EDU-003. The Resistor.

Practice 4. Thévenin´s theorem.

The Thevenin theorem determines that all multiples net diagrams can be resumed to a simple net, converting the analyse of a complicated circuit in a simple circuit. This capability offers to the theorem many applications and make it indispensable to solve damage, to conceive or to analyse electronic circuits.

The practice N°4, simulate the connection of an undetermined load between TP9A and TP9B. To find the Thevenin voltage (THV), you have to visualize obtained circuits during the imaginary opening of the load resistor (RL). Then, you will obtain two simple voltage dividers. One with a 4,5V voltage and the other with a voltage of 3V. The THV will be equal to the difference between these two voltages (1,5V). The Thevenin resistance from the practice, THR is solved visualizing the power supply of the diagram as a short circuit. Then, the result will reflect two serial circuits placed in parallel, to easily indicate the formula: 417 Ohms.

Electrical Drawing Practice 4
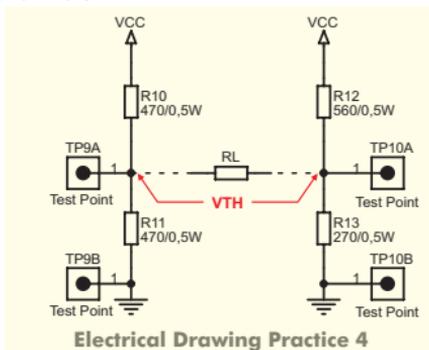
Once the Thevenin resistance and voltage obtained, the equivalent Thevenin circuit for this practice is completely defined.

To calculate the Thevenin´s resistance

Equivalent Thévenin circuit
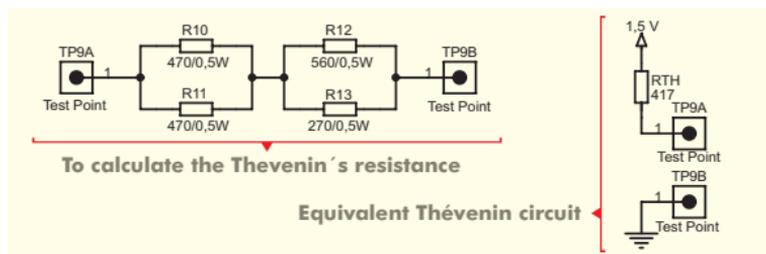
The practice n°5 includes eight resistors that you can connect in parallel between them according to your needs, through the corresponding jumpers' closure. The experiment consists of previously calculate the resulting value from resistors that you wish to connect in parallel. Then, installing an ohmmeter between tips test TP11A and TP11B you can compare the obtained value with the calculated value applying the theoretical.

Practice 5

EDU-002