

# **Laboratory 1.**

## **Introduction: laboratory thematic**

### **Aim of the laboratory**

- Getting accustomed with the security at work (fire preventing);
- Recognizing electrical symbols;
- Mathematical interpretation of electric circuit symbols;

### **Necessary equipment**

- Work stations with LTspice installed

### **Work security and fire preventing instructions**

To avoid electrical accidents when performing laboratory work the students must respect the following instructions:

1. Students will enter the laboratory only in the coordinator's presence ;
2. While working, students must respect a firm discipline in order to prevent any possible accidents ;
3. Changing seats and walking around is forbidden ;
4. Meaningless manipulation of buttons, switches from the devices and electrical installations in the laboratory are not allowed.

## Theoretical Approach

As you probably already know, in the electric schematics the physical properties of a circuit are replaced with equivalent circuit elements. The physical properties that may concern us are: the resistivity, the conductivity and the capacitance.

### 1. Passive Components

**The Resistor:** A resistor is a two-terminal electrical or electronic component that resists an electric current by producing a voltage drop between its terminals in accordance with Ohm's law:  $R = V/I$ . The electrical resistance is equal to the voltage drop across the resistor divided by the current through the resistor. Its symbol is R and it is measured in  $\Omega$  (ohms).

We will classify resistors in two categories: fixed and variable.

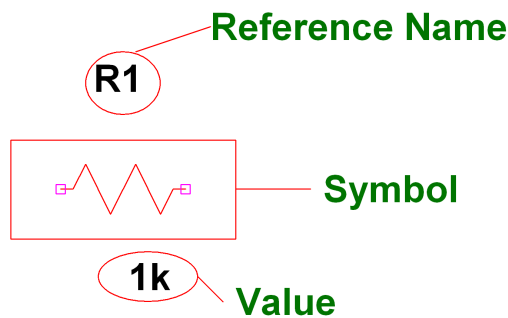


Figure 1. Symbol of the fixed resistor



Figure 2. . Main menu for changing resistor parameter values

**The Capacitor:** A capacitor is an electrical device that can store energy in the electric field between a pair of closely-spaced conductors (called 'plates'). When voltage is applied to the capacitor, electric charges of equal magnitude, but opposite polarity, build up on each plate.

Capacitors are used in electrical circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals and this makes them useful in electronic filters.

The capacitor's capacitance (C) is a measure of the amount of charge (Q) stored on each plate for a given potential difference or voltage (V) which appears between the plates:  $C = Q/V$

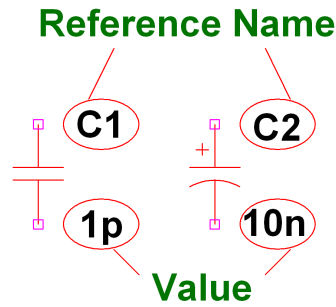


Figure 3. Symbol of the capacitor

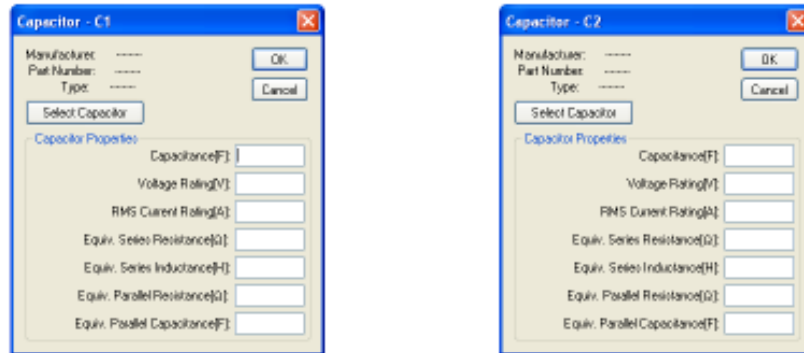


Figure 4. Main menu for changing capacitor parameter values

**The Inductor:** An inductor is a passive electrical device employed in electrical circuits for its property of inductance. An inductor can take many forms.

Inductance (measured in henries) is an effect which results from the magnetic field that forms around a current carrying conductor. Electrical current through the conductor creates a magnetic flux proportional to the current.

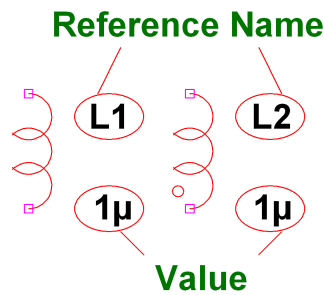


Figure 5. Symbols for an inductor

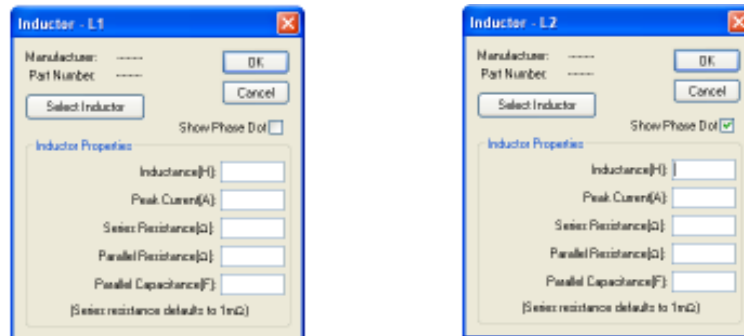


Figure 6. Main menu for changing inductor parameter values

**The transformer:** A transformer is a device that transfers electrical energy from one circuit to another by magnetic coupling without requiring relative motion between its parts. It usually contains two or more coupled windings, and, in most cases, a core to concentrate the magnetic flux.

Create symbol

**Figure 7. Symbol of a transformer with a primary and a secondary winding**

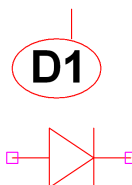
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**Figure 8. Transformer with median switch**

## 2. Active components

**The Diode:** A semiconductor diode's current-voltage, or I-V, characteristic curve is ascribed to the behavior of the so-called depletion layer or depletion zone which exists at the p-n junction between the different semiconductors.

### Reference Name



**Figure 9. Semiconductor diode**

**The bipolar junction transistor (BJT)** is a type of transistor. It is a three-terminal device constructed of doped semiconductor material and may be used in amplifying or switching applications. Bipolar transistors are so named because their operation involves both electrons and holes.

Although a small part of the transistor current is due to the flow of majority carriers, most of the transistor current is due to the flow of minority carriers and so BJTs are classified as 'minority-carrier' devices.

**The field-effect transistor (FET)** is a type of transistor that relies on an electric field to control the shape and hence the conductivity of a 'channel' in a semiconductor material. The concept of the field effect transistor predates the bipolar junction transistor (BJT), however FETs were implemented after BJTs due to the limitations of semiconductor materials and relative ease of manufacturing BJTs compared to FETs at the time.

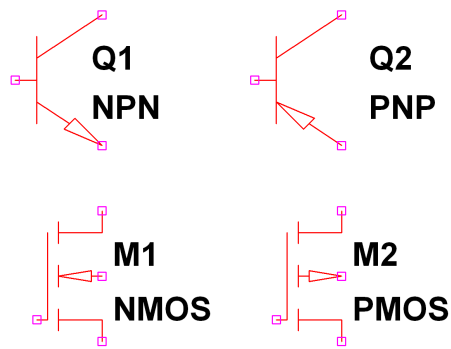


Figure 10. BJT and MOS transistors

**The mathematical interpretation of some symbols**

A resistor is a two-terminal electrical or electronic component that resists an electric current by producing a voltage drop between its terminals:

- Ohm's law

$$R = \frac{U}{I}$$

- Joule's law

$$Q = R I^2 t = P t$$

Where:

- U – voltage drop;
- I – electric current;
- Q- electric charge;
- t – time;
- P – power.

**Lab Activity:**

Search for an electric scheme with at least 30 components and implement it in LTspice.

**Homework:**

Write the relations that characterize the capacitance and inductance.