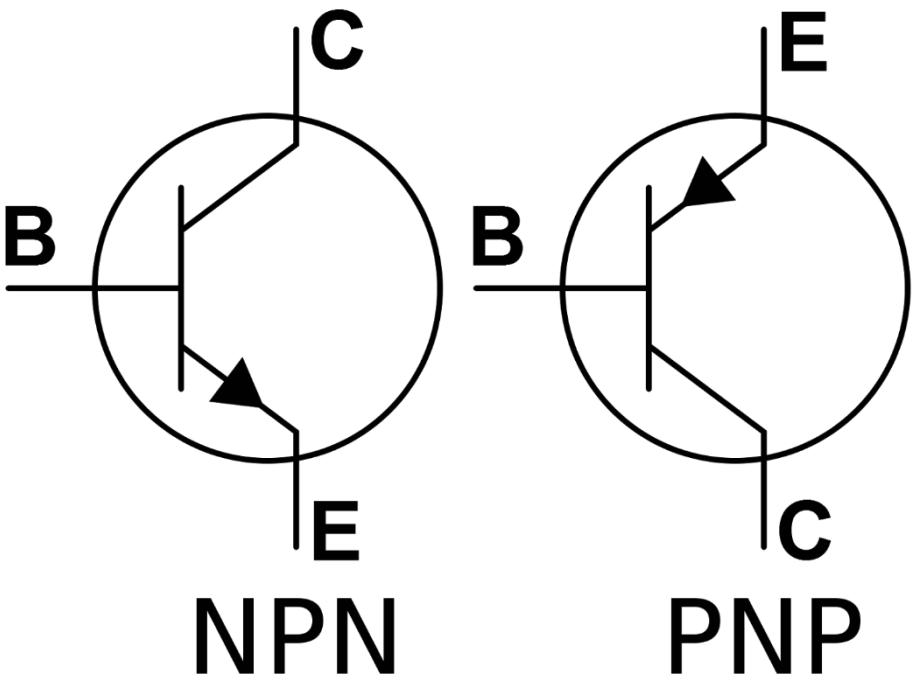
Hand-on Semiconductors

Topic 2: Transistor



Transistors

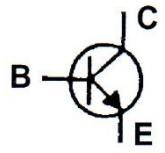
Basics:

The transistor, like a diode, can conduct the current in one direction. It regulates whether a current can flow and how strong the current is. This is why you can use it as a **switch** or as an **amplifier**.

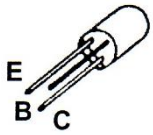
Before transistors were developed, tubes were used to switch and amplify in electrical appliances. These were not only very large, but also expensive and they needed an electric heater. The transistors were therefore a significant step forward and in 1956 three Americans were awarded the Nobel Prize for the development of the transistor. Small, handy devices such as calculators, digital clocks or computers would be unthinkable today without transistors.

Looking more closely at a transistor, you will first realise that it has three connections. As well, one side of the transistor is flat with information printed on it.

In order to be able to distinguish the three connections, you can familiarise yourself with the symbol used in circuit diagrams:



E = Emitter (emits electrons)
B = Base (controls the flow of the electrons)
C = Collector (collects the electrons)



There are two types of transistors, depending on the combination of p- and n-doted components. We use an NPN Transistor. If the transistor we use is lying flat side down, so that the connections point towards you, the left terminal is the emitter, the middle terminal the base and the right terminal the collector. The vertical bar in the symbol indicates the flat side of the transistor.

When connecting the transistor, make sure not to reverse the connections! A reverse polarity leads to the destruction of the component. Have your teacher check your circuit before you connect it to the battery!

V1: Material:

- 1 wooden Plate
- 10 Thumbtacks
- 10 springs
- 1 transistor
- 1 LED
- 2 resistors (130Ω; 6,8 kΩ)
- 1 pair of alligator clips
- 1 4.5V battery

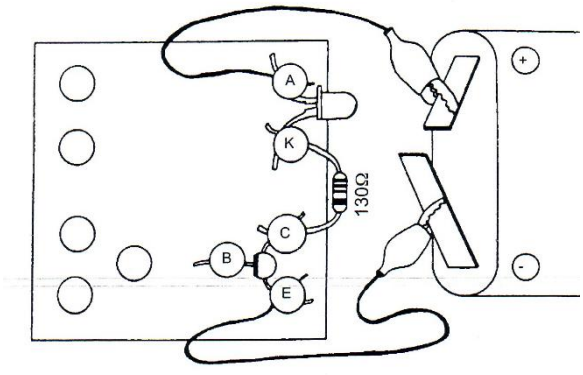


Figure 1

Build the circuit as shown in Figure 1 using the thumbtacks and springs. Does the LED light up? Explain the reason for your observation!

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Now complete the circuit as shown in Figure 2. What happens? Explain your observation.

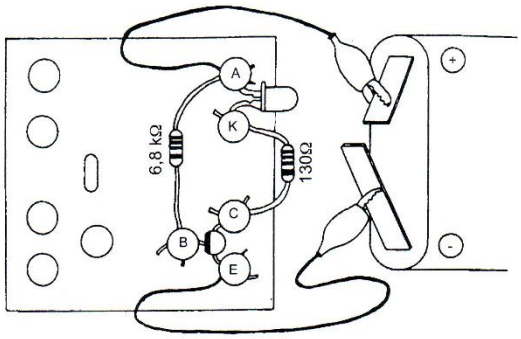

Figure 2

This circuit is called emitter circuit. What could be the reason for this naming? (Hint: follow the current flow, what is required to "enable" the transistor!)

Applications of the transistor

Alarm system:
Additional Material: 1 piece of wire

Add a thin fuse wire between base and emitter to the emitter circuit of Experiment 1 (see Figure 16). When is the alarm triggered in this circuit and why? Try your prediction.

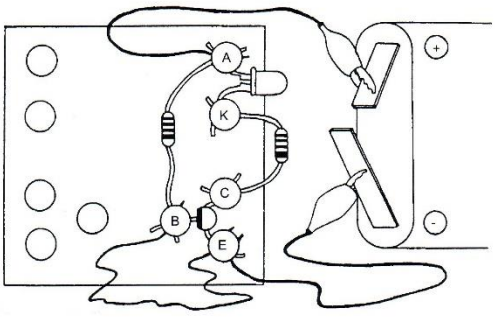

Figure 3

How could this circuit be incorporated in everyday life?

What is the function of the transistor in this circuit?

Humidity sensor

Material: - wooden board with thumbtacks and springs
- 2 resistors (130Ω; 1,8 kΩ)
- 1 LED
- 1 transistor
- 2 pair of alligator clips
- 1 4.5V battery
- 1 Glas filled with water
- 2 sensor wires

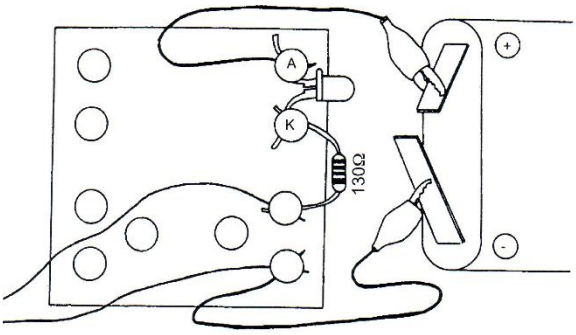

Figure 4

Build the circuit shown in Figure 4 on the wooden board. The two sensor wires must not touch. Fill the cup with water until it is half filled. Dip the two sensor wires at a distance of about 1 cm from each other into the water. Is the LED illuminated? Explain your observation using physics.

Now add a transistor and a 1.8 kΩ resistor to the circuit as shown in Figure 5. Repeat the experiment.
What are you observing now concerning the LED? What is the function of the transistor in this circuit?

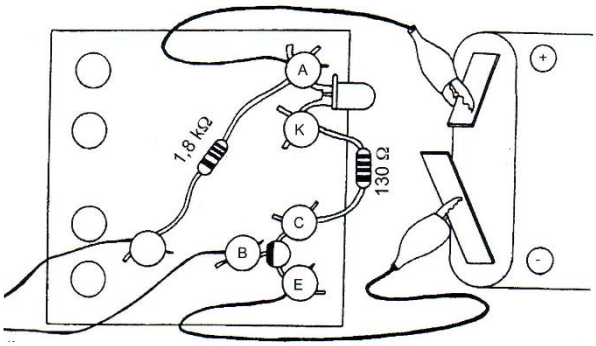

Figure 5

Think about different applications you could use this circuit for.

Sensor switch

Sensor switches, as they are used e.g. on screens, have to illuminate an LED with even weaker signals than those used for the humidity sensor. For this purpose, a coupling of two transistors is used.

Additional material: - 1 resistor (6,8 kΩ)
- 1 transistor

Add a second transistor and a 6.8 kΩ resistor to the circuit in Figure 5. The 1.8 kΩ resistor that was already in the circuit must now be attached to another location (see Figure 6).
Now touch both sensor wires with one finger. The wires should not touch each other. What do you observe?

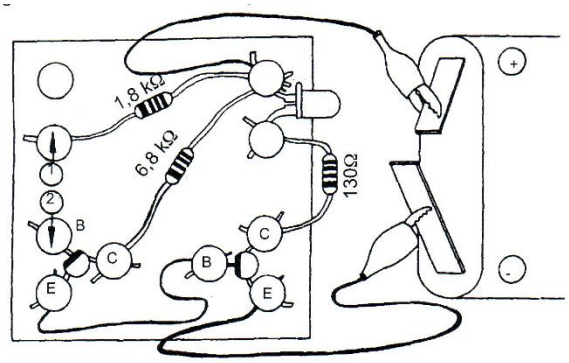

Figure 6

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Such a combination of two transistors is called a ***Darlington circuit***.

Explain in detail the physical processes in this circuit. In doing so, refer to the individual functions of the components.

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Homework: *Design a twilight switch from the components you know, as it is used, for example, as emergency lighting in the hospital. A small lamp should turn on as the circuit no longer receives enough light.*