The transistor as a switch (Item No.: P1374500)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 10-13
Topic: Elektrizitätslehre
Subtopic: Elektronik
Experiment: Der Transistor als Schalter

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional information

The development of computer engineering and the increasing digitalisation in the transmitting and processing of information are accompanied by an increasing use of transistors for switching functions.
This experiment is designed to demonstrate the basic principles of how a transistor functions as an electronic switch. We recommend that the differences between mechanical and electronic switches, and the benefits of electronic switches, be worked out with the students. The benefits of electronic switches include the low control power required, the absence of contacts (which tend to wear out in time), switching times so rapid that they are in the nanosecond range, and the small size which enables them to be fitted into integrated circuits.

Notes on setup and procedure

The base current is reduced by the 1 kΩ resistor to a level that allows safe switching in the conductive state, even with a small current amplification factor. If only one multi range meter is available for each group of students, then the individual measurements can be carried out one after the other, whereby the ammeter must be replaced by a connector module.

Remark

Electronic switches are also used in great numbers in the transmission of audio and video signals, an area of increasing digitalisation.

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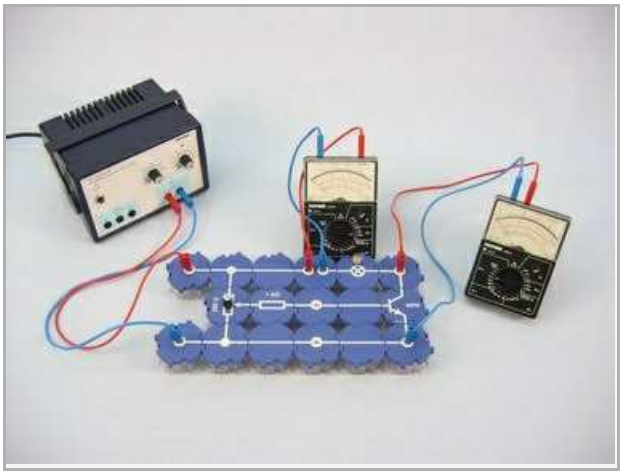
Task and equipment

Task

How can a transistor be used as a switch?

Investigate how the two switching conditions of a switch can be realised with a transistor.



Equipment

Position No.	Material	Order No.	Quantity
1	Straight connector module, SB	05601-01	4
2	T-shaped connector module, SB	05601-03	2
3	Interrupted connector module, SB	05601-04	1
4	Junction module, SB	05601-10	2
5	Straight connector module with socket, SB	05601-11	2
6	Angled connector module with socket, SB	05601-12	2
7	Socket module for incandescent lamp E10, SB	05604-00	1
8	Resistor module 1 kOhm, SB	05614-10	1
9	Potentiometer module 250 Ohm, SB	05623-25	1
10	NPN transistor module BC337, SB	05656-00	1
11	Connecting cord, 32 A, 250 mm, red	07360-01	1
12	Connecting cord, 32 A, 250 mm, blue	07360-04	1
13	Connecting cord, 32 A, 500 mm, red	07361-01	2
14	Connecting cord, 32 A, 500 mm, blue	07361-04	2
15	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
16	Multi-range meter, analogue	07028-01	2
17	Filament lamps 4V/0.04A, E10, 10	06154-03	1 piece

Set-up and procedure

Set-up

Set up the circuit as shown in Fig. 1 and Fig. 2.

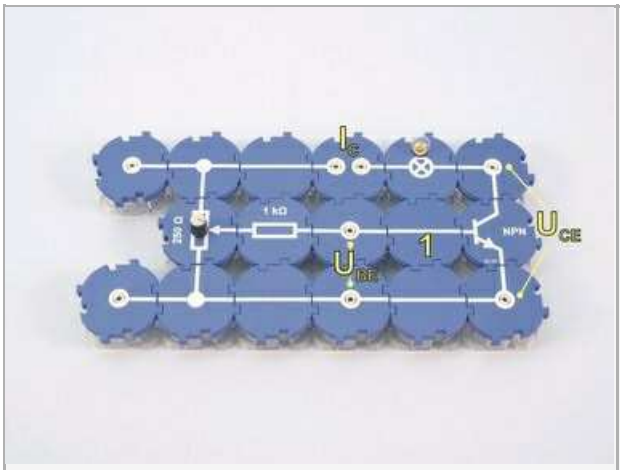


Fig. 1

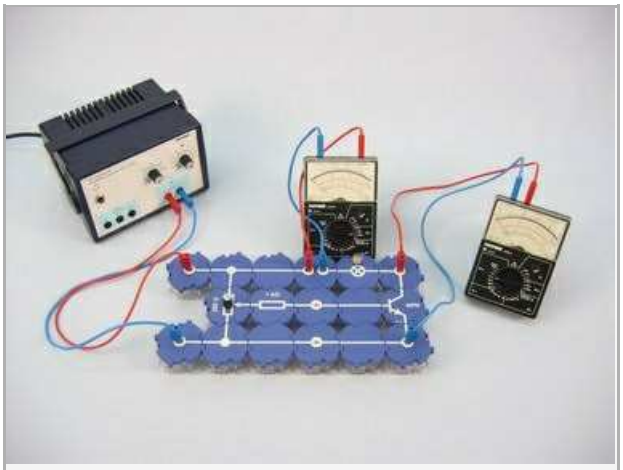


Fig. 2

Procedure

- Switch on the power supply; set the voltage to 4 V−.
- First observe the experiment qualitatively; to do this, while observing the lamp, turn the potentiometer from the left stop to the right stop and back again.
- Turn the potentiometer to the left stop, measure the collector current I_C and the collector-emitter voltage U_{CE} and enter the values in Table 1 in the report.
- Turn the potentiometer so far that the filament lamp begins to light up, again measure I_C and U_{CE} and enter the values in Table 1.
- Turn the potentiometer to the right stop and record the measured values.
- Turn the potentiometer back to the left stop.
- Switch off the power supply.
- Change the connections of the voltmeter so that voltage U_{BE} can be measured.
- Exchange the positions of the ammeter and connector module 1, as shown in Fig. 3 and Fig. 4.

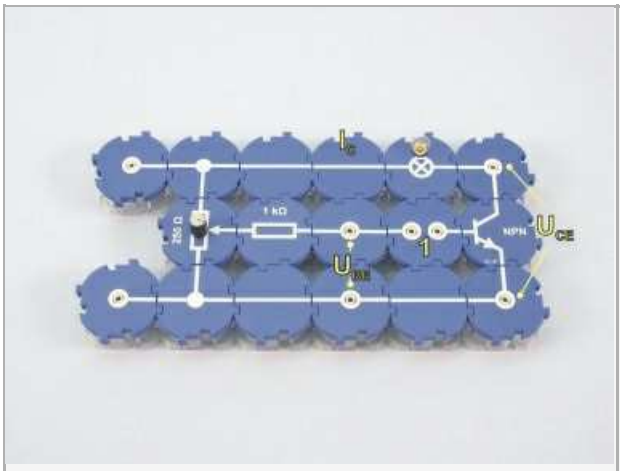


Fig. 3

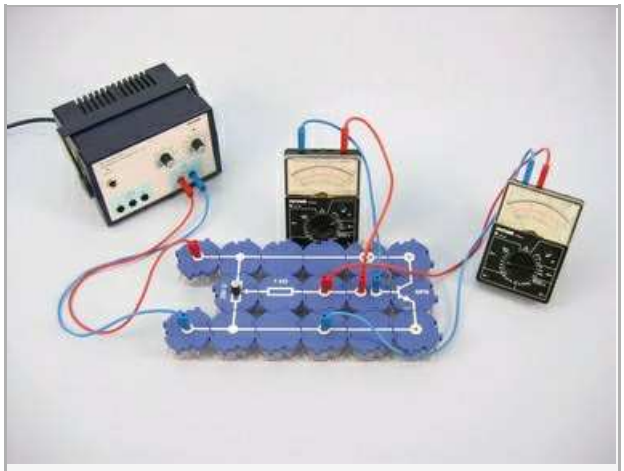


Fig. 4

- Switch on the power supply.
- Measure the base current I_B and the base-emitter voltage U_{BE}, enter the values in Table 1.
- Slowly turn the potentiometer to the right and take measurements as above.
- Switch off the power supply.

Report: The transistor as a switch

Result - Table 1

Record your measured values in the table.

	Potentiometer at left Lamp does not light up	Lamp begins to light up	Potentiometer at right Lamp lights up brightly
Collector current I_C in mA	1 ±0	1 ±0	1 ±0
Collector-emitter voltage U_{CE} in V	1 ±0	1 ±0	1 ±0
Base-emitter voltage U_{BE} in V	1 ±0	1 ±0	1 ±0
Base current I_B in mA	1 ±0	1 ±0	1 ±0

Evaluation - Question 1

State the conditions which must be fulfilled for the transistor to close a circuit.

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Evaluation - Question 2

State the conditions which must be fulfilled for the transistor to interrupt a circuit.

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Evaluation - Question 3

When the lamp lights up at maximum brightness, the power switched on and off by the transistor in this experiment is approximately equal to the product of the applied operating voltage $U_B = 4$ V and the collector current: $P_S \approx U_B \cdot I_C$.

Compare this switching power with the control power necessary to trigger the switching effect: $P_{con} = U_{BE} \cdot I_B$.

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Evaluation - Question 4

How does a transistor switch differ from a mechanical switch?

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Evaluation - Question 5

Where could transistor switches be used to advantage in practice?

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