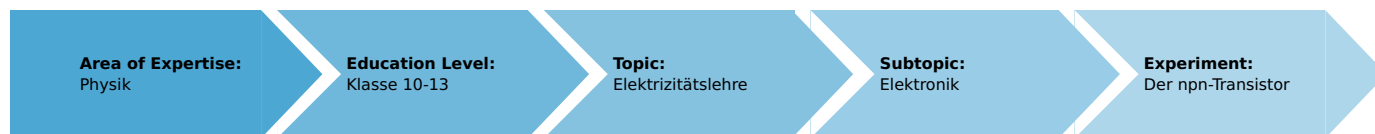


The npn transistor (Item No.: P1374200)

Curricular Relevance



Difficulty



Intermediate

Preparation Time



10 Minutes

Execution Time



10 Minutes

Recommended Group Size



2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional information

This experiment should impart the knowledge, that a collector current only flows through a transistor when the correct polarity of the collector voltage is chosen and a base voltage of correct polarity is applied. For an npn transistor, both the collector and base must be connected to the positive pole. The emitter is here in each case the reference electrode. Prior to carrying out the experiment, the students should be familiarised with the designations of transistor electrodes, as well as the meaning of the term npn transistor. The comparison of the base current, which can be estimated from the size of the base resistance and the applied voltage, with the collector current, which causes the lamp to light up, also leads to the conclusion that a minimal base current is sufficient to make the transistor conductive.

Notes on setup and procedure

The breakdown voltage of the transistor barrier layers is considerably lower with inverse operation. The operating voltage should therefore never be set higher than 6 V. It must be ensured that the transistor is operated either totally blocked or totally conductive, since in these cases either the current or the collector voltage are very small, so that the power dissipation is only very low. If this is not observed, then the transistor can be damaged by overheating.

Remarks

The model used in many pieces of literature represents a transistor as two diodes connected in opposition to each other. This is insufficient to describe the behaviour of a transistor, as it does not take the special property of the base-emitter barrier layer into account, and this is responsible for the actual transistor effect. The base layer is considerable thinner and more weakly doped than the emitter and collector. The barrier layer created by diffusion of the charge carriers, and consisting of donor and acceptor ions, generates a diffusion voltage which prevents charge carriers from penetrating the base layer. The charge carriers cannot flow from the emitter into the base until an external voltage with opposite polarity cancels the blocking effect of the diffusion voltage. Due to the minimal thickness and doping of the base, however, there is only very little recombination, i.e. the greater part of the charge carriers diffuse through the base layer and are whisked away into the collector by the applied voltage, since the collector-base junction is poled for these charge carriers (minority carriers) in the forward direction.

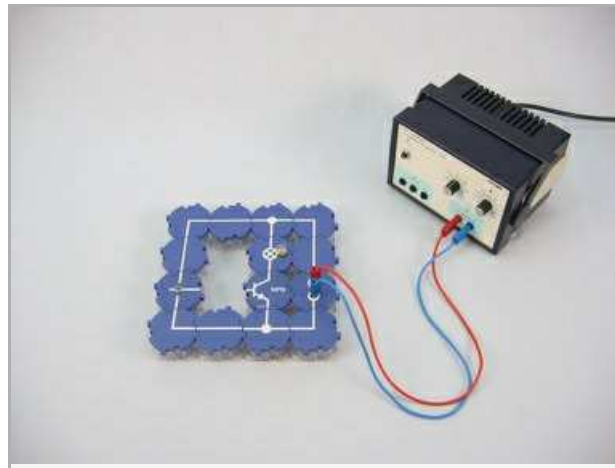
The npn transistor (Item No.: P1374200)

Task and equipment

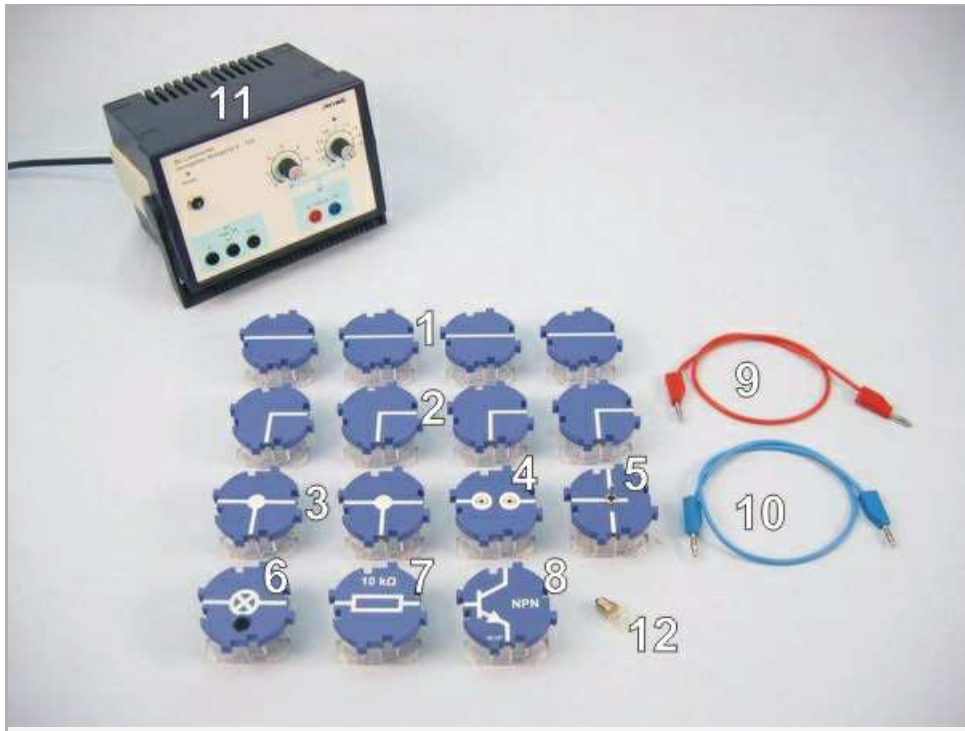
Task

With which voltage is an npn transistor to be operated?

Examine which polarity the collector voltage and the base voltage of an npn transistor must have for a collector current to flow.



Equipment



Position No.	Material	Order No.	Quantity
1	Straight connector module, SB	05601-01	4
2	Angled connector module, SB	05601-02	4
3	T-shaped connector module, SB	05601-03	2
4	Interrupted connector module, SB	05601-04	1
5	Change-over switch module, SB	05602-02	1
6	Socket module for incandescent lamp E10, SB	05604-00	1
7	Resistor module 10 kOhm, SB	05615-10	1
8	NPN transistor module BC337, SB	05656-00	1
9	Connecting cord, 32 A, 500 mm, red	07361-01	1
10	Connecting cord, 32 A, 500 mm, blue	07361-04	1
11	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13505-93	1
12	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, with the npn transistor, but first without the base resistor $R_B = 10\text{ k}\Omega$ (collector is connected to the positive terminal).

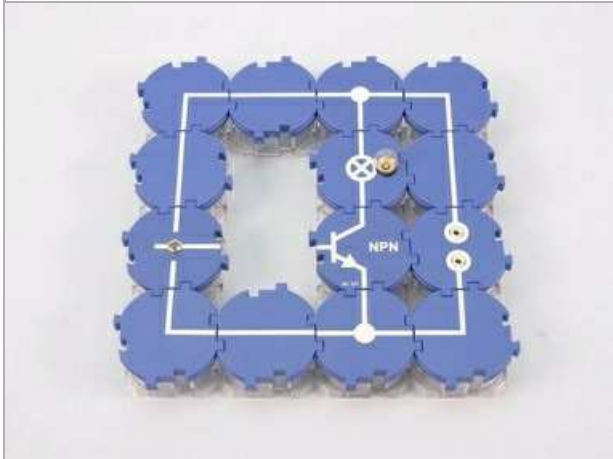


Fig. 1

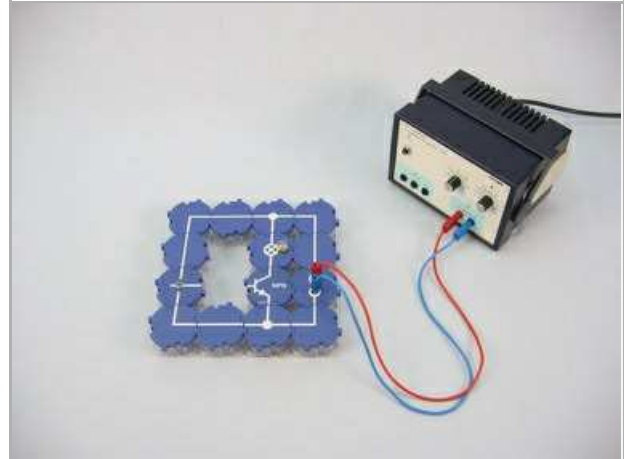


Fig. 2

Procedure

- Set the power supply to 6 V direct voltage; switch it on; observe the filament lamp; appropriately tick what you observe in Table 1 in the report.
- Switch over the connecting cables to the power supply, so that the collector is now connected to the negative terminal (Fig. 3); note what you observe.
- Insert the 10 kΩ base resistor (Fig. 4 and Fig. 5), operate the changeover switch several times; note what you observe.
- Change the connection to the power supply back again, so that the collector is again connected to the positive terminal (Fig. 6); operate the changeover switch and note what you observe.
- Switch off the power supply.

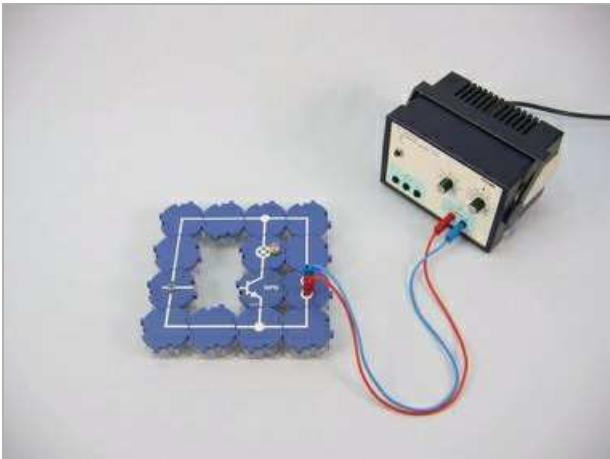


Fig. 3

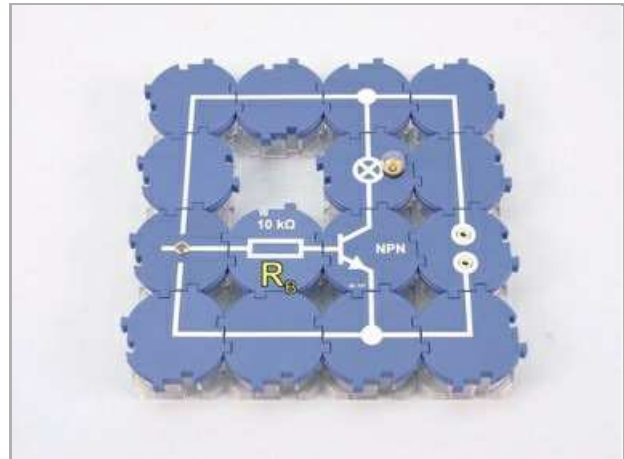


Fig. 4

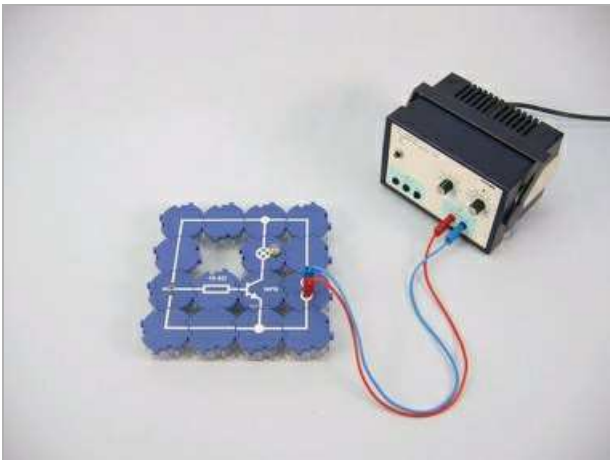


Fig. 5



Fig. 6

Report: The npn transistor

Result - Table 1

Write X for the correct case.

	Lamp lights up when at collector			
	positive terminal		negative terminal	
	Yes	No	Yes	No
without base resistor	1	X	1	1
base resistor at positive terminal	X	1	1	1
base resistor at negative terminal	1	X	1	1

Evaluation - Question 1

Explain with which terminal of a voltage source the collector and base of an npn transistor must be connected for a collector current to flow.

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Evaluation - Question 2

Estimate the size of the base current in your experimental setup. Compare the strength of the base current with that of the collector current.

Note: You can estimate the strength of the base current with the applied operating voltage (6 V) and the base resistor used. The base voltage (approx. 0.6 V) can be disregarded. The strength of the collector current is approximately given by the rated value of the current for the filament lamp.

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