The current-voltage characteristic of an NPN transistor (Item No.: P1374400)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 10-13
Topic: Elektrizitätslehre
Subtopic: Elektronik
Experiment: Strom-Spannungs-Kennlinie eines npn-Transistors

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 knowledge of the characteristics of a transistor is a prerequisite for a deeper understanding of the processes related to a transistor amplifying or switching stage. Of the four characteristics (the output, control, input and reverse voltage transfer ratio characteristics), the output and control characteristics are particularly important. This experiment is therefore limited to the recording of the characteristic curves for control and output. The other characteristic curves can be determined by slightly altering the experimental setup.
We recommend some class time to be spent after the experiment going over the characteristic curves that the students recorded. The operating lines graphed in the output characteristic field can be used to deepen their understanding of the control process. For example, you can explain voltage gain as a function of load resistance, the oppositional nature of output and input voltage, the output power achievable, and the influence of the position of the operating point on signal clippings.

Notes on setup and procedure

When care is taken that the polarity of the connections to the measuring instruments and the diode is correct, no great difficulty should be experienced in setting up the circuit.
As changes in the collector voltages influence the strength of the base current, the collector voltage is held constant and the collector current measured in dependence on the base current. Take care that the maximum power dissipation of the transistors P_D = 600 mW is not exceeded. This is ensured when the collector current is kept below 50 mA.

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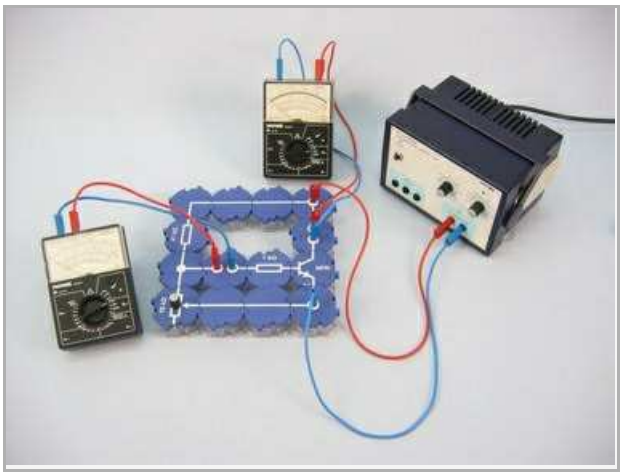
Task and equipment

Task

How does the collector current of a transistor depend on the base current and collector voltage?

Examine the dependence of the collector current of an npn transistor on the base current at various collector voltages.



Equipment

Position No.	Material	Order No.	Quantity
1	Straight connector module, SB	05601-01	4
2	Angled connector module, SB	05601-02	1
3	T-shaped connector module, SB	05601-03	1
4	Interrupted connector module, SB	05601-04	2
5	Angled connector module with socket, SB	05601-12	2
6	Resistor module 47 kOhm, SB	05615-47	1
7	Resistor module 10 kOhm, SB	05615-10	1
8	Resistor module 1 kOhm, SB	05614-10	1
9	Potentiometer module 10 kOhm, SB	05625-10	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

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Set-up and procedure

Set-up

Set up the circuit as shown in Fig. 1 and Fig. 2, ensure that the measurement ranges and polarity of the measuring instruments are correctly chosen (measurement range 50 µA for the base current, 30 mA for the collector current).

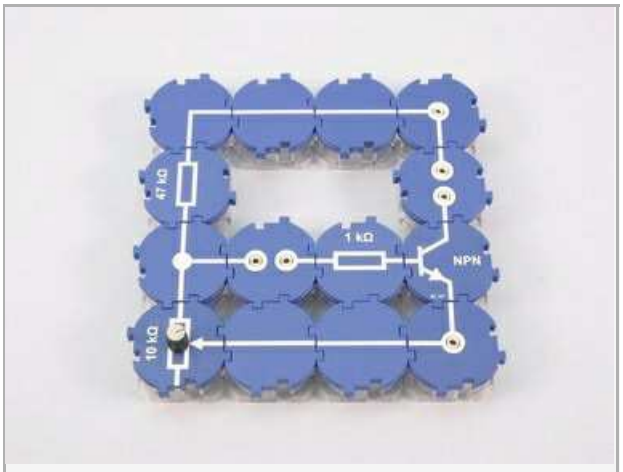

Fig. 1

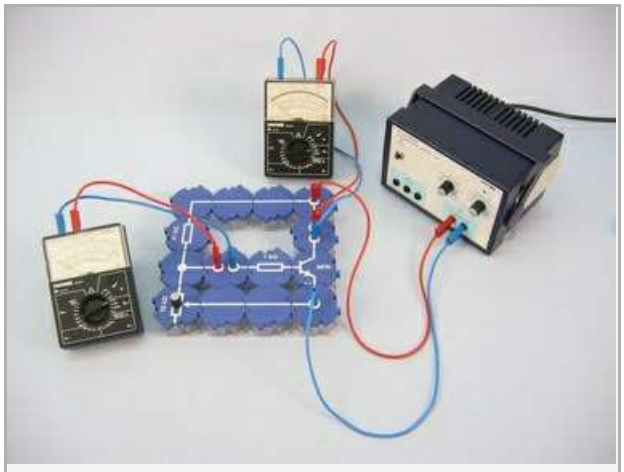
Fig. 2

Procedure

- Turn the potentiometer to the right stop.
- Switch on the power supply; set the voltage on the power supply to U_{CE} = 12 V.
- Use the potentiometer to increase the base current in steps of I_B = 10 µA (wait until the base current is constant, correct if necessary) and enter the values for the collector current I_C in the appropriate boxes in Table 1 in the report.
- Reduce the collector voltage in steps of 1 V; carry out the measurements and enter the results in Table 1.
- With voltages of U_{CE} = 6 V to U_{CE} = 2 V, replace the 47 kΩ resistor with a 10 kΩ resistor (Fig. 3).
- Finally set U_{CE} = 0 V and carry out the measurements.
- Switch off the power supply.

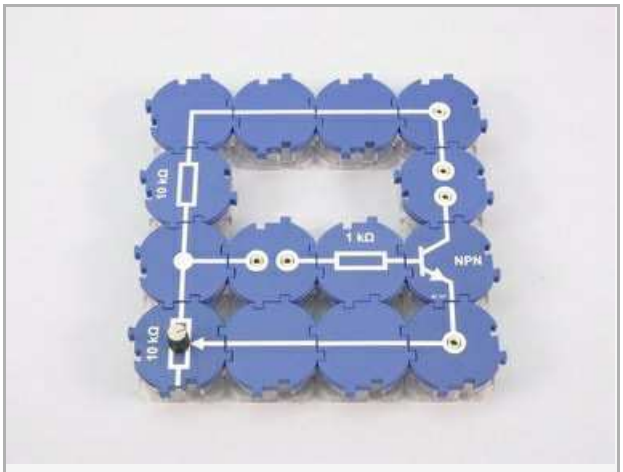

Fig. 3

Report: The current-voltage characteristic of an NPN transistor

Result - Table 1

Record the collector current I_C in dependence on the voltage U_{CE} at different base currents I_B.

	I_B in µA:				
U_{CE} in V	10	20	30	40	50
12	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
11	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
10	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
9	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
8	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
7	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
6	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
5	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
4	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
3	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
2	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0
0	1 ±0	1 ±0	1 ±0	1 ±0	1 ±0

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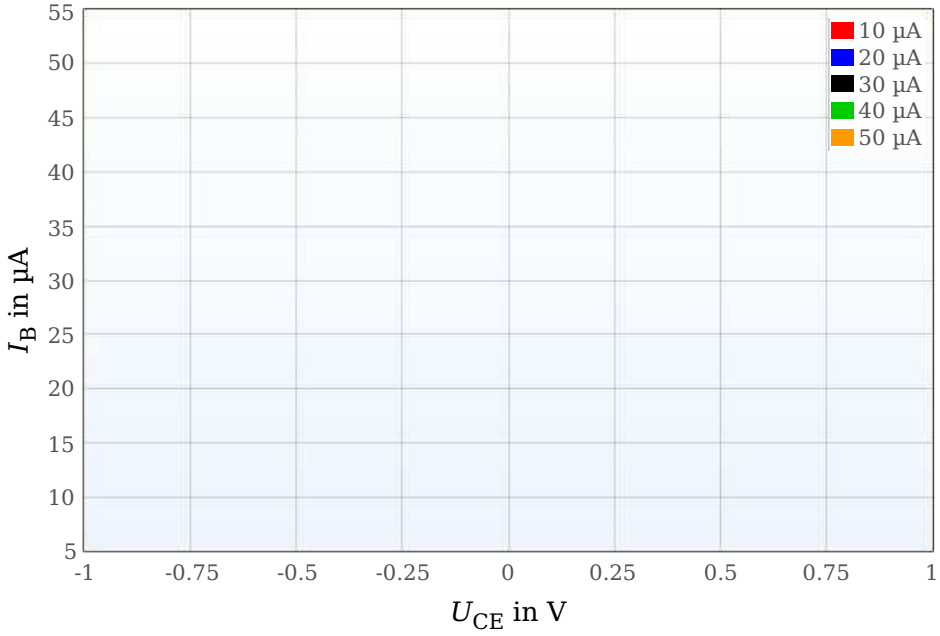
Number1



Evaluation - Question 1

The product of the collector voltage and collector current is the power dissipation $P_D = U_C \cdot I_C$. This is converted to heat by the transistor. Its maximal permissible value for the transistor used is 600 mW. Calculate the power dissipation of the transistor at a collector voltage of 5 V and a base current of 30 µA, and check if the result lies below the maximal permissible value for P_D.

Evaluation - Question 2

The ratio $\Delta U_{CE} / \Delta I_C$ is the output resistance of the transistor for a certain operating point.

Use the characteristic curve for a base current of 30 µA to determine the change in the collector current ΔI_C when the collector voltage ΔU_{CE} is increased from 5 V to 10 V, and calculate the value of the output resistance of the transistor.

ΔI_C = ... mA

R = $\Delta U_{CE} / \Delta I_C$ = ... kΩ