Recording the characteristics of a transistor

Objects of the experiment

- Recording the characteristics of a NPN-transistor

  Input characteristic $I_B = f(U_{BE})$

  Control characteristic $I_C = f(I_B)$

  Output characteristic $I_C = f(U_{CE})$

Principles

Transistors are among the most important semiconductor components in electronic circuit technology. The electrodes of a bipolar transistor are called the emitter (E), the base (B) and the collector (C). Electrons and holes are both involved in conducting current. The transistor consists of a total of three n-conducting and p-conducting layers, in the order npn or pnp. The base layer, located in the middle, is so thin that charge carriers originating at one junction can cross to the other junction.

The experiment examines the properties of an npn-transistor on the basis of its characteristics. This experiment measures :

- the input characteristic
i.e. the base current I_B as a function of the base-emitter voltage U_{BE}

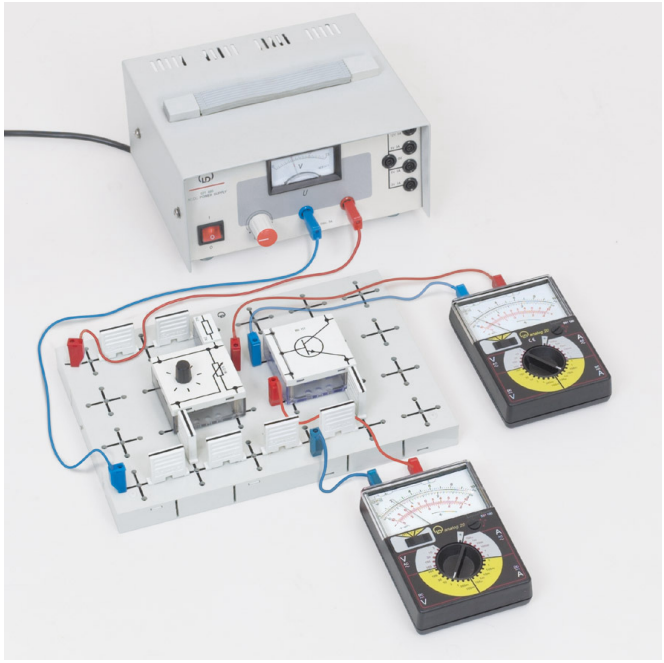
- the control characteristic
i.e. the collector current I_C as a function of the base current I_B at a constant collector-emitter voltage U_{CE}.

- the output characteristic
i.e. the collector current I_C as a function of the collector-emitter voltage U_{CE} at a constant base current I_B

Apparatus

1	Rastered socket panel, DIN A 4	576 74
1	Set of 10 bridge plugs	501 48
1	STE Resistor 1 kΩ	577 44
1	STE Resistor 47 kΩ	577 64
1	STE Potentiometer 220 Ω	577 90
1	STE Potentiometer 1 kΩ	577 92
1	STE Transistor BD 137, NPN	578 67
1	AC/DC power supply, 0...12 V	521 485
3	Multimeter LDanalog 20	531 120
4	Pair of cables, 50 cm, red/blue	501 45

Setup



Carrying out the experiment

- Set up the experiment as shown in the figure. Pay attention of the measuring range and polarity of the multimeters. The resistor 1 kΩ must be used in every circuit.
- Set the voltage of the power supply to 5 V.

KEM 0806

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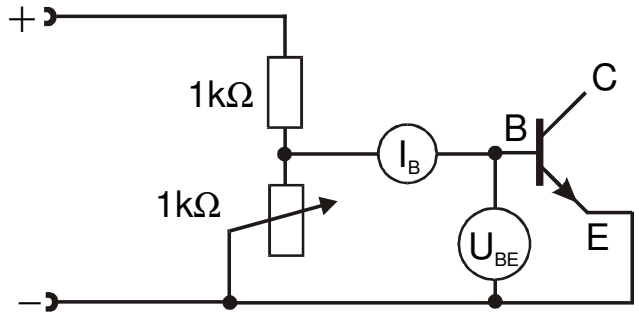
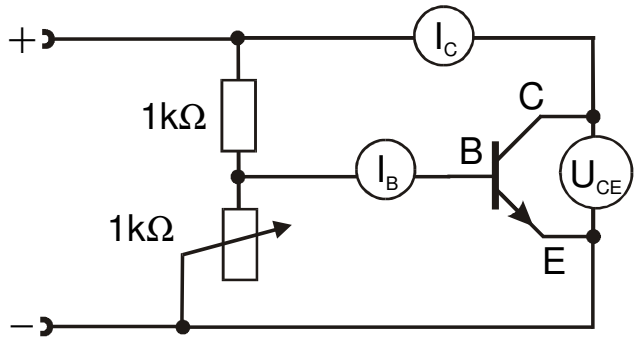
Input characteristic. Measuring I_B and U_{BE}



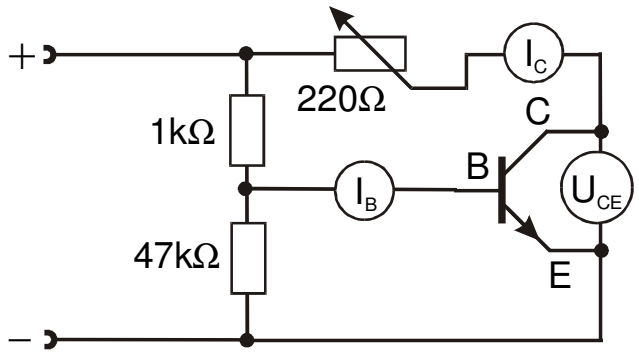
- Adjust the potentiometer 1 kΩ so that the base-emitter-voltage U_{BE} = 0 V.
- By turning potentiometer carefully increase voltage U_{BE}. Fill in pairs of voltage U_{BE} and current I_B in the table 1.

Control characteristic: measuring I_C and I_B , parameter U_{CE}



- Plug in the additional multimeter to measure the collector current I_C.
- Read the voltage U_{CE} (instead of voltage U_{BE}) and fill in the value as header of table 2.
- Adjust potentiometer 1 kΩ minimizing base current I_B.
- By turning potentiometer carefully increase current I_B. Fill in pairs of current I_B and current I_C in the table 2.

Output characteristic: measuring I_C and U_{CE} , parameter I_B



- Replace potentiometer 1 kΩ by resistor 47 kΩ and plug in the potentiometer 220 Ω in serie to the collector.
- Read current I_B and fill in the value as header of table 3.
- Adjust potentiometer 220 Ω minimizing collector-emitter voltage U_{CE}.
- By turning potentiometer carefully increase voltage U_{CE}. Fill in pairs of voltage U_{CE} and current I_C in the table 3.

Measuring example

Table 1: Input characteristic $I_B = f(U_{BE})$

$\frac{U_{BE}}{V}$	$\frac{I_B}{mA}$		$\frac{U_{BE}}{V}$	$\frac{I_B}{mA}$
0	0		0.63	0.3
0.10	0.0		0.66	0.9
0.20	0.0		0.68	1.4
0.30	0.0		0.69	1.9
0.40	0.0		0.70	2.6
0.50	0.0		0.71	3.4
0.59	0.1			

Table 2: Control characteristic: $I_C = f(I_B)$; $U_{CE} = 5\ V$

$\frac{I_B}{mA}$	$\frac{I_C}{mA}$		$\frac{I_B}{mA}$	$\frac{I_C}{mA}$
0.05	6.4		1.5	230
0.1	14		2.0	300
0.2	28		2.5	360
0.4	58		3.0	400
0.5	75		3.4	430
1.0	150			

Table 3: Output characteristic $I_C = f(U_{CE})$, $I_B = 4{,}6\ mA$

$\frac{U_{CE}}{V}$	$\frac{I_C}{mA}$		$\frac{U_{CE}}{V}$	$\frac{I_C}{mA}$
0.02	50		0.6	480
0.03	80		0.9	500
0.08	200		2.0	540
0.11	300		3.0	570
0.2	400		4.0	590
0.4	450		4.8	610

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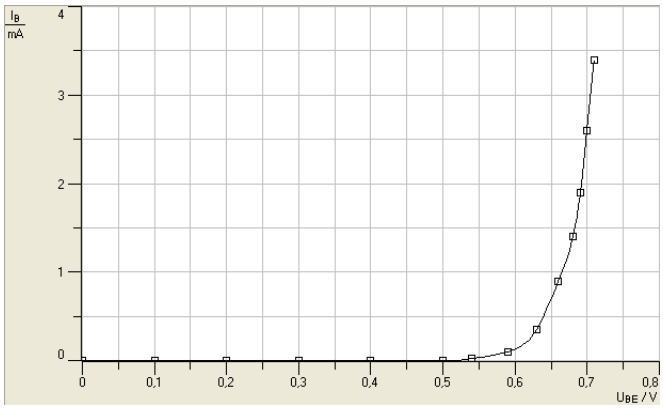
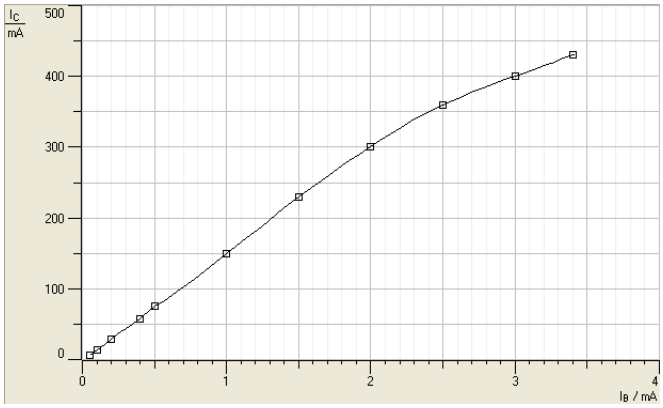
Evaluation and results

Input characteristic: $I_B = f(U_{BE})$



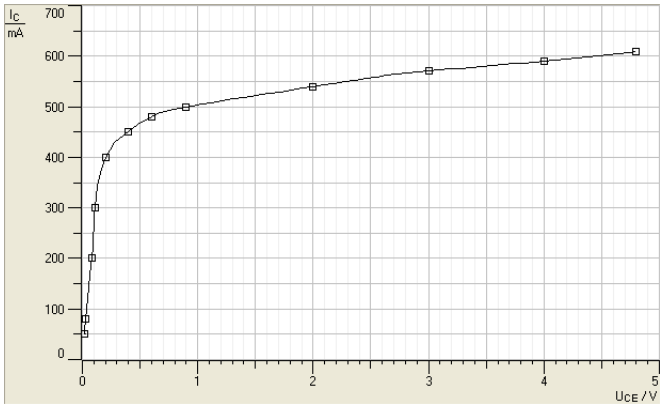
The pn-junction base to emitter behaves like a diode with a threshold voltage of about 0.6 V.

Control characteristic: $I_C = f(I_B), U_{CE} = 5\ \mathrm{V}$



Remark: The amplification of current is characterized by $B = \frac{I_C}{I_B}$. For the transistor BD 137 is β = 40 … 250

Output characteristic: $I_C = f(U_{CE}), I_B = 4{,}6\ \mathrm{mA}$



Remark: The main power losses are given by the collector emitter junction: $P = U_{CE} \cdot I_C$. For transistor BD 137 the maximum power losses are 8 VA.