Stabilization of the operating object (Item No.: P1401600)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 16-19	Electricity	Electronics	Stabilization of the operating object

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Very difficult	10 Minutes	20 Minutes	1 Student

Additional Requirements:

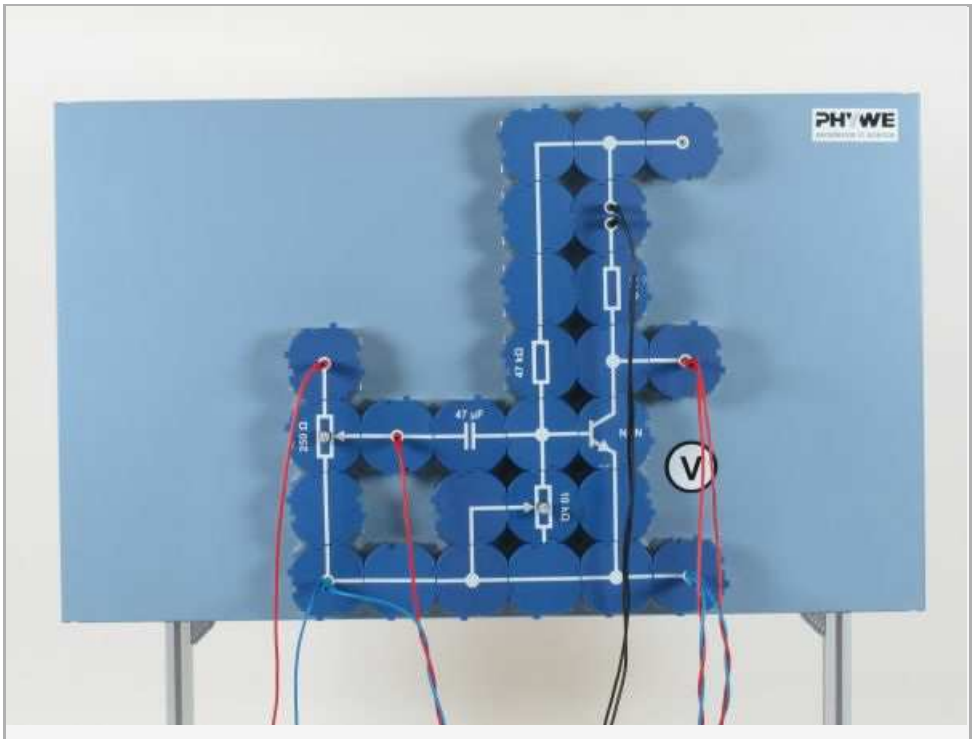
Experiment Variations:

Keywords:

Principle and equipment

Principle

The effect that an unfavourable position of the working point of a transistor amplification step has on the extent of amplification, and how the working point can be stabilised against changes in the operating voltage, are to be shown.



Experimental set-up

Equipment

Position No.	Material	Order No.	Quantity
1	Multimeter ADM2, demo., analogue	13820-01	1
2	PHYWE Digital Function Generator, USB, incl. Cobra4 software	13654-99	1
3	PHYWE power supply, universal DC: 0...18 V, 0...5 A / AC: 2/4/6/8/10/12/15 V, 5 A	13500-93	1
4	30 MHz digital storage oscilloscope with colour display,	11462-99	1
5	Demo Physics board with stand	02150-00	1
6	Loudspeaker,8 Ohm/5 kOhm	13765-00	1
7	Potentiometer 10 kOhm,module DB	09425-10	1
8	Potentiometer 250 Ohm, module DB	09423-25	1
9	Transistor BC337,module DB	09456-00	1
10	Connector interrupted, module DB	09401-04	1
11	Wire crossing,connected,module DB	09401-06	1
12	Junction, module DB	09401-10	4
13	Resistor 100 Ohm,module DB	09413-10	1
14	Resistor 1 kOhm,module DB	09414-10	1
15	Resistor 47 kOhm,module DB	09415-47	1
16	Capacitor(ELKO)0.047 mF,module DB	09445-47	1
17	Electr.symbols f.demo-board,12pcs	02154-03	1
18	Connector, straight, module DB	09401-01	6
19	Connector, angled, module DB	09401-02	2
20	Connector, T-shaped, module DB	09401-03	4
21	Connect.straight w.socket,mod. DB	09401-11	1
22	Adapter, BNC-plug/socket 4 mm	07542-26	2
23	Connecting cord, 32 A, 1000 mm, red	07363-01	5
24	Connecting cord, 32 A, 1000 mm, blue	07363-04	5
25	Connecting cord, 32 A, 750 mm, red	07362-01	1
26	Connecting cord, 32 A, 750 mm, blue	07362-04	1

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Set-up and procedure

1st. Experiment

- Set up the experiment as shown in Fig. 1; taking care that the earthing connections of the oscilloscope and function generator are connected together

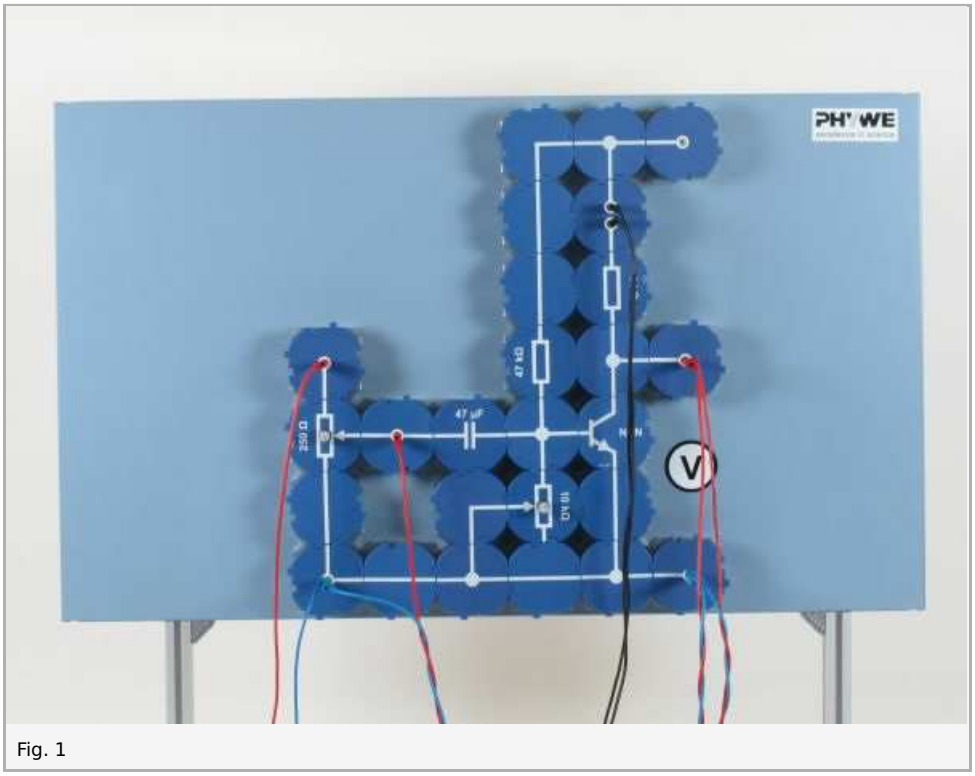

Fig. 1

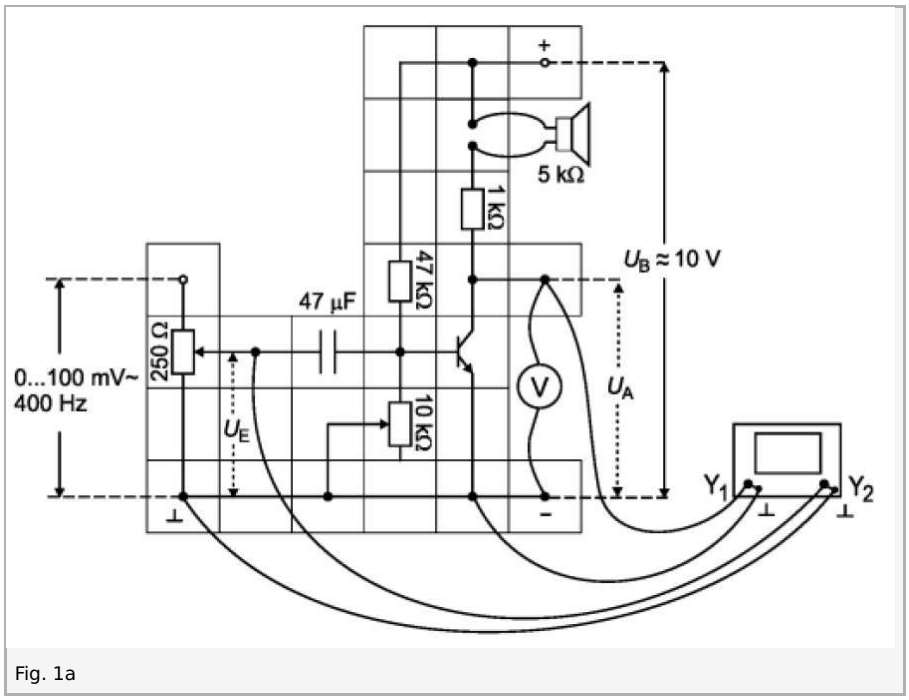

Fig. 1a

- Determine the collector voltage with the voltmeter, set 30 V- for this
- Set the power supply to a voltage of 10 V.
- Bring the collector-emitter voltage to 5 V- with the 10 kQ potentiometer
- Set the oscilloscope as follows:

  Channeli: Deflection coefficient $A\,Y1 = 2V/\mathrm{Div}$

Channel 2: Deflection coefficient $AY2 = 5mV/\mathrm{Div}$

Time deflection coefficient 1 ms/div; internal triggerung via channel 1

- Switch both channel inputs to alternating voltage input (AC)
- Switch on the function generator, set sinusoidal alternating voltage of 400 Hz and no amplitude if possible
- With the 250 n potentiometer, increase the input voltage U_{E} until the output voltage U_{A} just does not show any limitations on the oscilloscope screen
- Read off the peak values of the input and output voltages from the oscilloscope and enter them in Table 1
- First increase the operating voltage at the power supply U_{B} and then reduce it, thereby noting the operating voltage U_{max} at which distortion to the amplified output signal apear because of limitations (see Fig. 2), and the value of U_{min} at which the signal disappears (see Fig. 3)

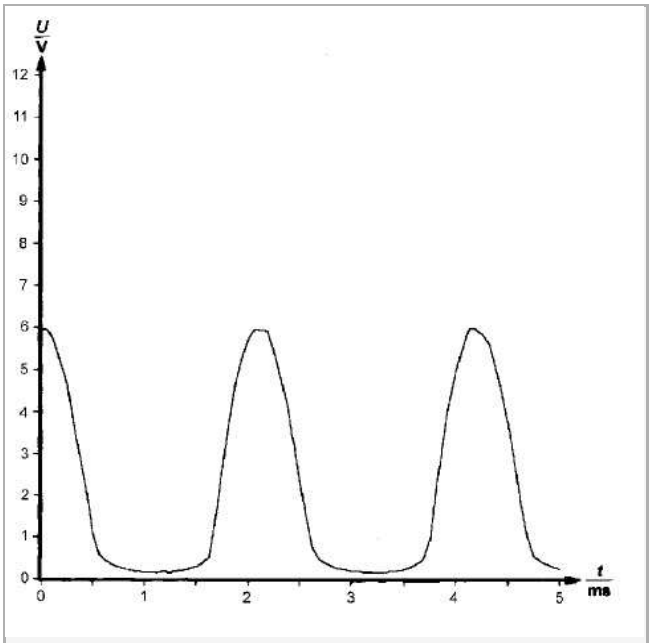

Fig. 2: Distortion of the output signal by limitations

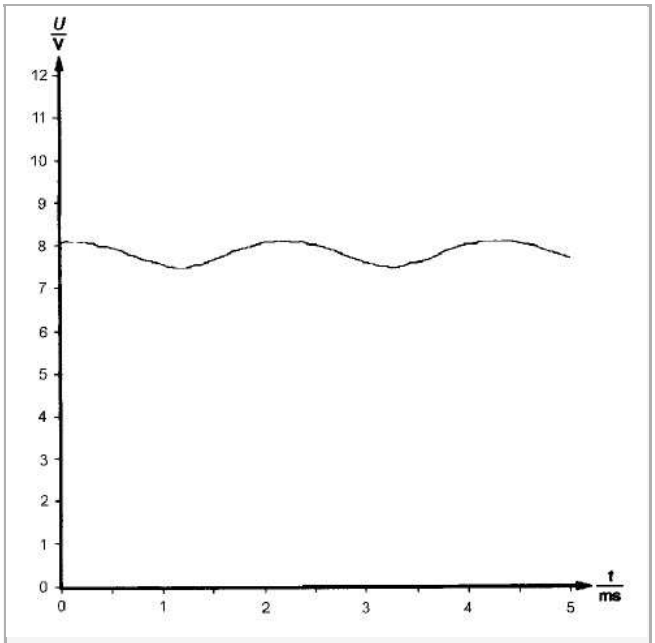

Fig. 3: Small output signal

2nd. Experiment

- Replace the straight connecting building block in the emitter circuit by the I 00 Q resistor: reset the operating voltage to I 0 V-; adjust the working point with the I 0 kQ potentiometer so that the collector voltage is about 5 V
- Increase the input voltage U E with the 250 Q potentiometer until the amplified output voltage just does not show any limitation
- Measure the peak values of the input and output voltages and note the measured values
- First increase the operating voltage and then reduce it, note the voltage values at which limitations of the output signal are recognisable

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Observation and evaluation

Observation

Table 1

	$\frac{U_E}{mV}$	$\frac{U_E}{V}$	$\frac{U_{max}}{V}$	$\frac{U_{min}}{V}$	Amplification
without R_E	7.5	5.2	11	7.6	693
with R_E	100	4.6	16	6.0	46

Evaluation

When the amplifier step is operated without emitter resistance, as in thelst. experiment, then distortion of the output signal occurs when the operating voltage is increased from 10 V to 11 V (U_{max}) The output voltage becomes very small, when the operating voltage is reduced to 7.6 V (U_{min}).

The voltage amplification is very high.

When a resistor is inserted in the emitter circuit, however, then distortion of the output voltage first appears when the operating voltage is increased to a value above 16 V, or is reduced to 6 V. The emitter resistor results in a stabilisation of the working point, whereby the influence of a change in the operating voltage is reduced. The amplification of the voltage is also reduced, from 693 to 46, however.

Remarks

The emitter resistor causes a current degeneration. The amplified emitter current generates a voltage drop at the emitter resistor, through which the base voltage is reduced. Both changes in the operating voltage and signal voltages lead therefore to small changes in the collector voltage.

To generate an undistorted output voltage of maximum amplitude, the working point must be set to a collector voltage approximately half the size of the operating voltage. It is thereby possible that the collector voltage, when controlled by a signal voltage to higher and lower voltages, can change in about the same proportion. When the working point is displaced, e.g. by changes in the operating voltage or the temperature, then the ouput voltage will be rather limited in the positive or negtive voltage area. The values given here are dependent on the characteristics of the transistor used.

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