Experiment T2

The common-emitter and common-collector amplifiers with Bipolar Junction Transistor

Before you start to perform an experiment you are obliged to have mastered to the following theoretical subjects:

1. Bipolar junction transistor (BJT) in common-emitter circuit – how it works. [1] and [4].
2. Common-emitter BJT amplifier with voltage-divider bias – how it works. [2] and [3].
3. Properties and characteristics of common-emitter and common-collector amplifiers. [2] and [3].

Purpose

To understand and analyze the principle of configuration and operation of the common-emitter and common-collector BJT amplifiers.

Description of the measurement method for BJT amplifiers

The n-p-n bipolar junction transistor (BJT) is tested both in common-emitter and in common-collector circuits. The Power Supply DF1731SB3A or MPS-3003L-3 together with Adjustable Voltage Regulator (ZN) enable biasing of the transistor and allow to establish the quiescent point (Q-point) around which the current and voltage variations can occur as the response to an AC input signal.

The sinusoidal input signal from Function Generator (DF1641A) causes the base-emitter voltage to vary sinusoidally above and below its DC offset level. The resulting variation in base current produces a larger variation in collector current because of the current gain of transistor and variation of collector-emitter voltage.

To enable the estimation of the input signal amplification the oscilloscope has to work in the dual channel operation mode to display both the input and output signals at the same time.

Tables of resistor's values:

Position	Resistance of $\mathbf{R_1}$
1	22 kΩ
2	30 kΩ
3	39 kΩ
4	47 kΩ
5	56 kΩ
6	68 kΩ
7	82 kΩ
8	100 kΩ
9	220 kΩ
10	430 kΩ
11	1000 kΩ
∞	∞

Position	Resistance of $\mathbf{R_2}$
0	0
1	5.6 kΩ
2	6.8 kΩ
3	7.5 kΩ
4	8.2 kΩ
5	9.1 kΩ
6	10 kΩ
7	15 kΩ
8	22 kΩ
9	30 kΩ
10	47 kΩ
∞	∞

$\mathbf{R_S}$	2.4 kΩ
$\mathbf{R_R}$	24 kΩ

Position	Resistance of $\mathbf{R_E}$
0	0
1	0.10 kΩ
2	0.22 kΩ
3	0.43 kΩ
4	0.82 kΩ
5	1.20 kΩ

Position	Resistance of $\mathbf{R_C}$
1	0.56 kΩ
2	1.20 kΩ
3	2.40 kΩ
4	4.70 kΩ
5	6.80 kΩ
6	9.10 kΩ

Position	Resistance of $\mathbf{R_L}$
1	0.51 kΩ
2	2 kΩ
3	10 kΩ
∞	∞

Experimental procedure

A. The common-emitter amplifier with dc base current

(The schematic setup is presented in Fig. M1a)

1. Connect the circuit according to the diagrams presented in Figs. M1a and M1b. Set the switch R_1 to the "11" position, switch R_2 to the "∞" position, switch R_C to the "3", switch R_L to the "∞" position, and switch R_E to the "0" position.
2. Connect the Power Supply with $+U_{CC}$ and $-U_{CC}$ terminals and set the voltage to 10 ÷ 12 V.
3. Watch the shape and amplitude of the output signal following the change of R_1 resistance (turn left or right the resistance R_1 knob). Observations should be performed both for small (20 mV) and great (500 mV) amplitude of input signal. For 20 mV signal level use 40 dB attenuator in the Function Generator. In order to estimate the Q-point position record the obtained results on the data sheet in the Table 1a. Describe the output signal as "sinusoidal with amplitude ……" or "non-sinusoidal with amplitude ……..".
4. Determine the value of R_1 resistance for the best choice of the Q-point on the basis of the lower deformation of the output signal and the best amplification of the input signal at the same time.
5. Estimate the input impedance of the amplifier for optimal Q-point. For this purpose apply the input signal to U_{IG} terminal and follow the instructions presented in 12-th point of experimental procedure in "Metrology" considering the amplifier as four terminal network. Record the obtained results on the data sheet in the Table 1b.
6. Estimate the output impedance of the amplifier. For this purpose set the lower value of R_L resistance. Record the obtained results on the data sheet in the Table 1c.

Table 1a.

#	Input signal				Output signal				Gain	collector -ground voltage
	Amplitude [V]	Resistance R_1		Description	Amplitude [V]	Resistance R_C		Description		
		[Ω]	Pos.			[Ω]	Pos.			
1										
2										
3										

Table 1b.

#	Resistance [Ω]		U_{OUT} (amplitude) [mV] [V]
1	R_S =	0	
2	R_S =		

Table 1c.

#	Resistance [Ω]		U_{OUT} (amplitude) [mV] [V]
1	R_L =	∞	
2	R_L =		

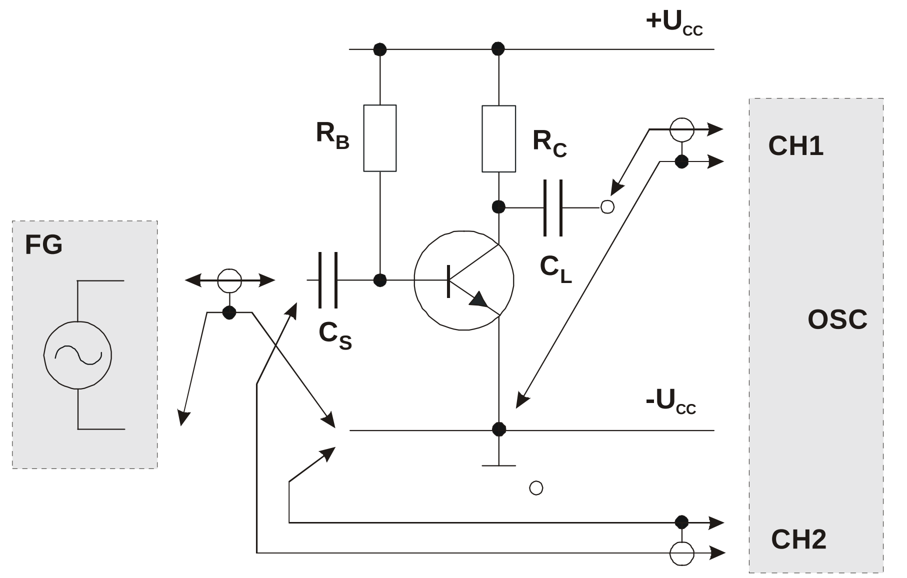

Fig. M1a.

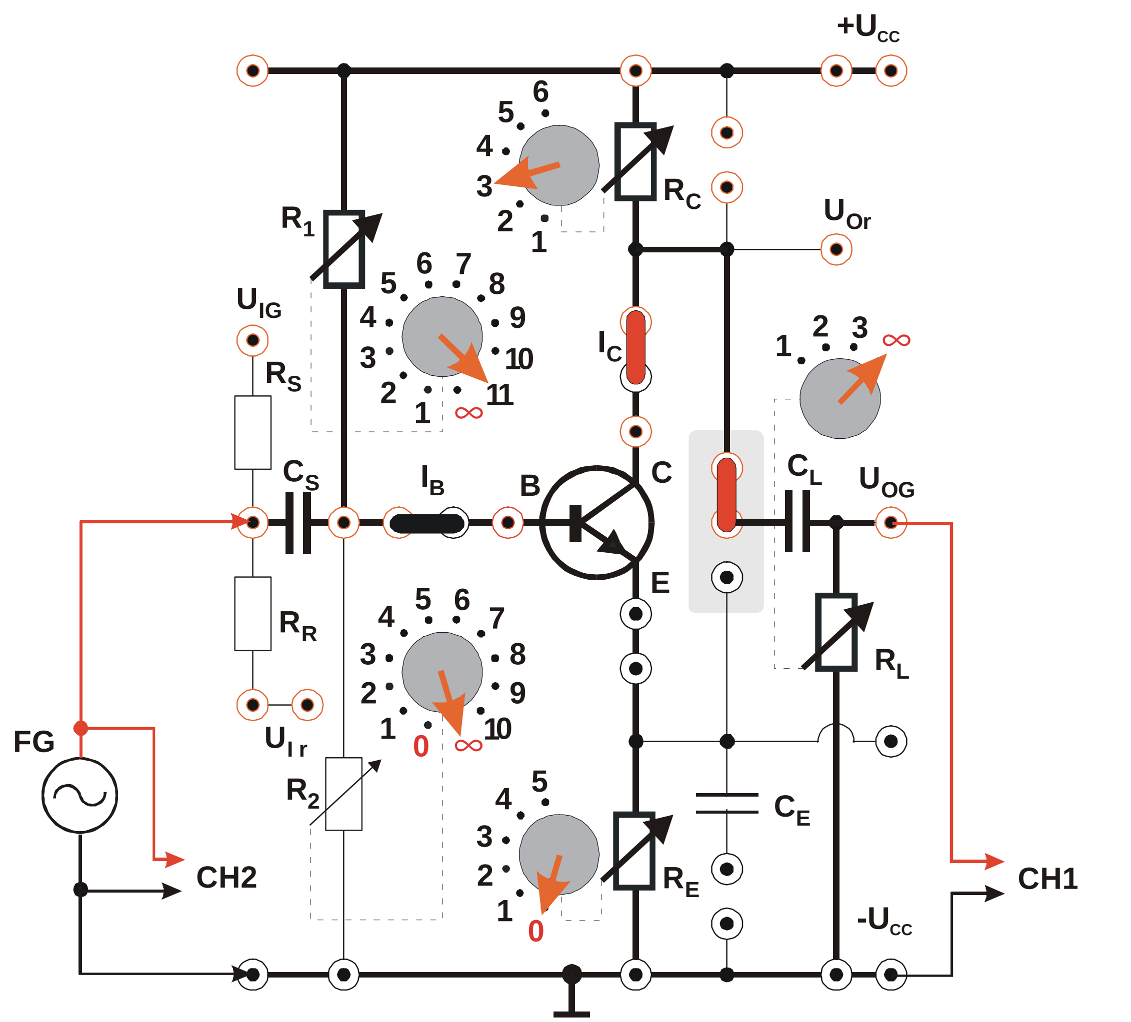

Fig. M1b.

B. The common-emitter amplifier with dc base current and stabilization of the emitter current

(The schematic setup is presented in Fig. M2a)

1. Connect the circuit according to the diagrams presented in Figs. M2a and M2b. Set the switch R_1 to the “11” position, switch R_2 to the “∞” position, switch R_C to the “3”, switch R_L to the “∞” position, and switch R_E to the “4” position.
2. Connect the Power Supply with $+U_{CC}$ and $-U_{CC}$ terminals and set the voltage to 10 ÷ 12 V.
3. Watch the shape and the amplitude of the output signal following the change of R_1 resistance (turn left or right the resistance R_1 knob). Observations should be performed both for small (20 mV) and great (500 mV) amplitude of the input signal. For 20 mV signal level use 40 dB attenuator in the Function Generator. Record the obtained results on the data sheet in the Table 2a. Describe the output signal as “sinusoidal with amplitude ……” or “non-sinusoidal with amplitude …….”.
4. Find the optimal position of the Q-point on the basis of the lower deformation of the output signal and the best amplification of the input signal at the same time. Estimate the input and the output impedance. Record the obtained results on the data sheet in the Table 2b and Table 2c.
5. For the optimal position of the Q-point estimate the gain of the amplifier following the change of the R_E resistance (set the R_E switch on the relevant positions from “1” to “5”). Record the obtained results on the data sheet in the Table 2d.

Table 2a.

#	Input signal ; R_E = ... [Ω]				Output signal				Gain
	Amplitude [V]	Resistance R_1		Description	Amplitude [V]	Resistance R_C		Description	
		[Ω]	Pos.			[Ω]	Pos.		
1									
2									
3									

Table 2b.

#	Resistance [Ω]		U_{OUT} (amplitude) [mV] [V]
1	R_S =	0	
2	R_S =		

Table 2c.

#	Resistance [Ω]		U_{OUT} (amplitude) [mV] [V]
1	R_L =	∞	
2	R_L =		

Table 2d.

#	Input signal ; R_C = ... [Ω]				Output signal				Gain
	Amplitude [V]	Resistance R_1		Description	Amplitude [V]	Resistance R_E		Description	
		[Ω]	Pos.			[Ω]	Pos.		
1									
2									
3									

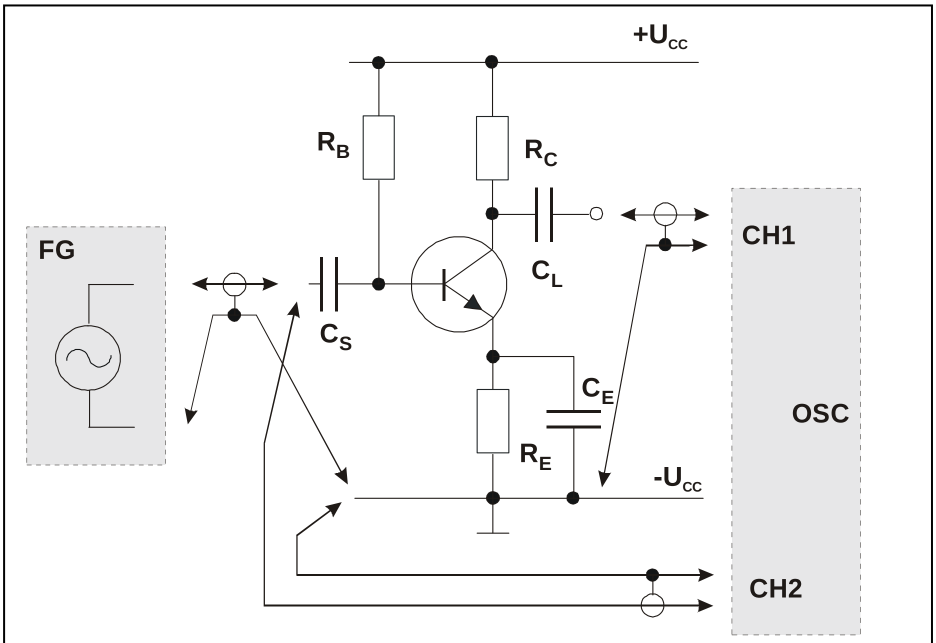

Fig. M2a.

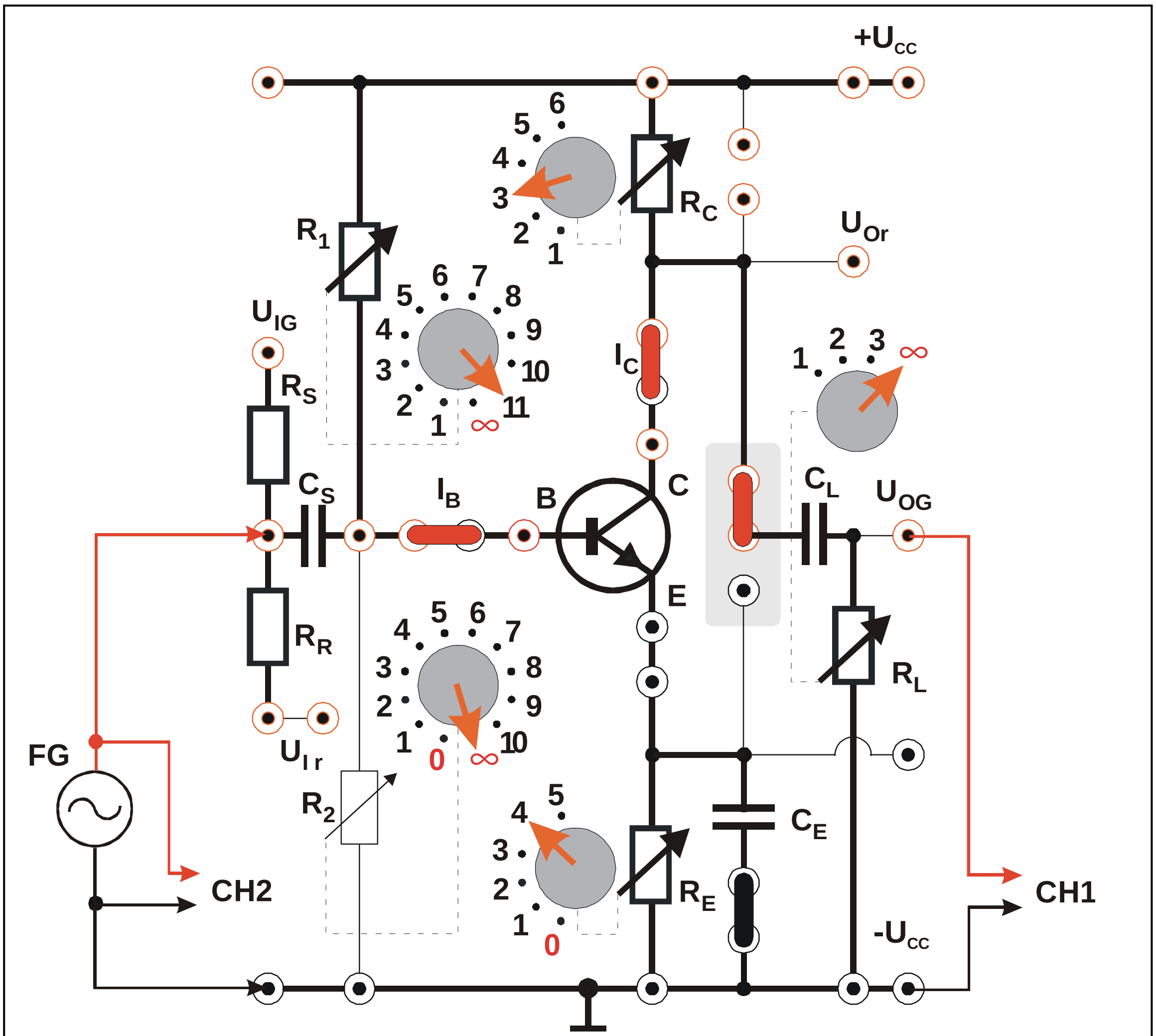

Fig. M2b.

C. The common-emitter amplifier with voltage-divider bias and stabilization of the emitter current

(The schematic setup is presented in Fig. M3a)

1. Connect the circuit according to the diagrams presented in Figs. M3a and M3b. Set the switch R_1 to the “11” position, switch R_2 to the “10” position, switch R_C to the “3”, switch R_L to the “∞” position, and switch R_E to the “4” position.
2. Connect the Power Supply with $+U_{CC}$ and $-U_{CC}$ terminals and set the voltage to 10 ÷ 12 V.
3. Watch the shape and amplitude of the output signal following the change of R_1 and R_2 resistances (turn left or right the resistance R_1 and R_2 knobs). Observations should be performed both for small (20 mV) and great (500 mV) amplitude of input signal. For 20 mV signal level use 40 dB attenuator in the Function Generator. Record the obtained results on the data sheet in the Table 3a. Describe the output signal as “sinusoidal with amplitude ……” or “non-sinusoidal with amplitude ………”.
4. Find the optimal position of the Q-point on the basis of the lower deformation of output signal and the best amplification of the input signal at the same time. Estimate the input and output impedances. Record the obtained results on the data sheet in the Table 3b and Table 3c.
5. For the optimal position of the Q-point estimate the gain of the amplifier following the change of the R_E resistance (set the R_E switch on the relevant positions from “1” to “5”). Record the obtained results on the data sheet in the Table 3d.

Table 3a.

#	Input signal ; R_E = ... [Ω]						Output signal				Gain
	Ampl. [V]	R_1		R_2		Description	Ampl. [V]	R_C		Description	
		[Ω]	Pos.	[Ω]	Pos.			[Ω]	Pos.		
1											
2											
3											

Table 3b.

#	Resistance [Ω]		U_{OUT} (amplitude) [mV] [V]
1	R_S =	0	
2	R_S =		

Table 3c.

#	Resistance [Ω]		U_{OUT} (amplitude) [mV] [V]
1	R_L =	∞	
2	R_L =		

Table 3d.

#	Input signal ; R_C= .... [Ω]						Output signal				Gain
	Ampl. [V]	R_1		R_2		Description	Ampl. [V]	R_E		Description	
		[Ω]	Pos.	[Ω]	Pos.			[Ω]	Pos.		
1											
2											
3											

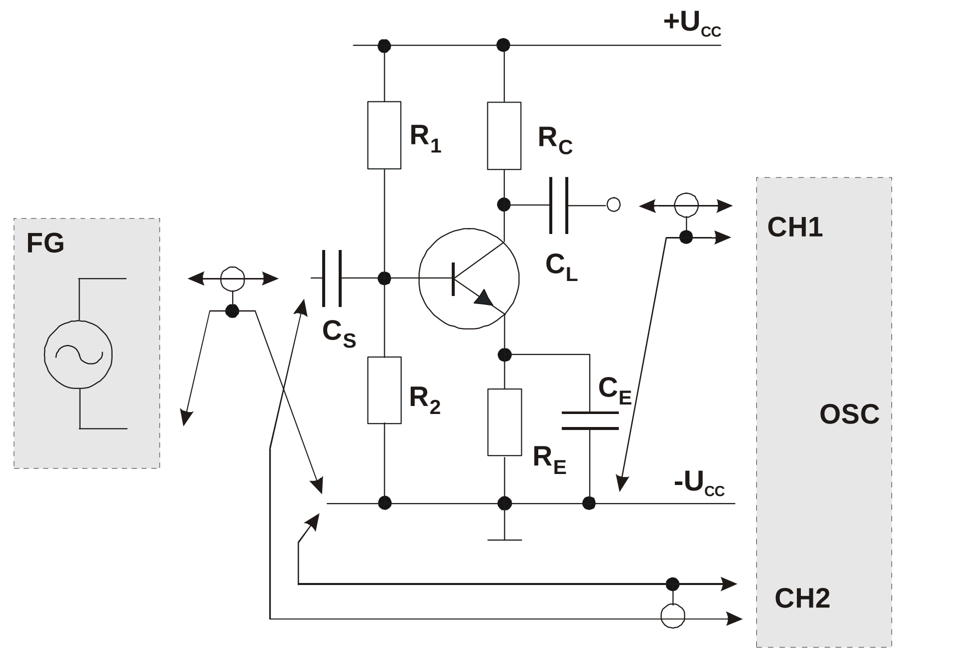

Fig. M3a.

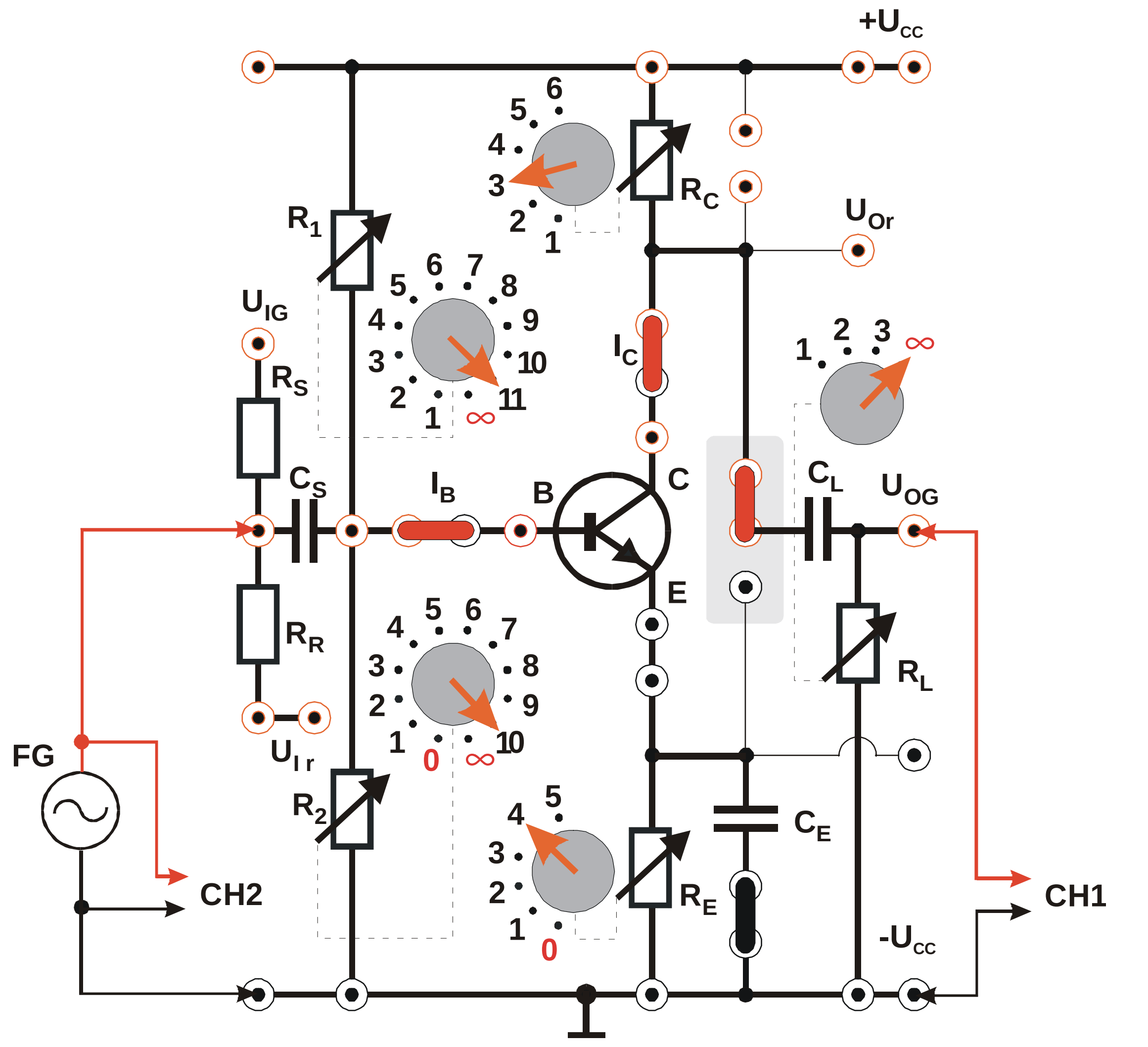

Fig. M3b.

D. The common-collector amplifier with voltage-divider bias

(The schematic setup is presented in Fig. M4a)

1. Connect the circuit according to the diagrams presented in Figs. M4a and M4b. Set the rotary function switch of the DMM ammeter to the 200 mA range (measurement of I_C) and rotary function switch of the DMM ammeter to the 2 mA range (measurement of I_B). Set the switch R_1 to the “11” position, switch R_2 to the “10” position, switch R_L to the “∞” position, and switch R_E to the “5” position.
2. Connect the Power Supply with $+U_{CC}$ and $-U_{CC}$ terminals and set the voltage to 10 ÷ 12 V.
3. Watch the shape and amplitude of the output signal following the change of R_1 and R_2 resistances (turn left or right the resistance R_1 and R_2 knobs). Observations should be performed both for small (20 mV) and great (500 mV) amplitude of input signal. For 20 mV signal level use 40 dB attenuator in the Function Generator. Record the obtained results on the data sheet in the Table 4a. Describe the output signal as “sinusoidal with amplitude ……” or “non-sinusoidal with amplitude ………”.
4. Find the optimal position of the Q-point on the basis of the lower deformation of output signal and the best amplification of the input signal at the same time. Estimate the input and output impedances. For this purpose apply the input signal to U_{IR} terminal. Record the obtained results on the data sheet in the Table 4b.
5. For the optimal position of the Q-point estimate the gain of the amplifier following the change of the R_E resistance (set the R_E switch on the relevant positions from “2” to “5”). **Warning!!!. Do not select the position “1” nor “0”.** Record the obtained results on the data sheet in the Table 4b.

Table 4a.

#	Input signal						Output signal				Gain
	Ampl. [V]	R_1		R_2		Description	Ampl. [V]	R_E		Description	
		[Ω]	Pos.	[Ω]	Pos.			[Ω]	Pos.		
1											
2											
3											

Table 4b.

#	Resistance [Ω]		U_{OUT} (amplitude) [mV] [V]
1	R_S =	0	
2	R_S =		
3	R_L =	∞	
4	R_L =		

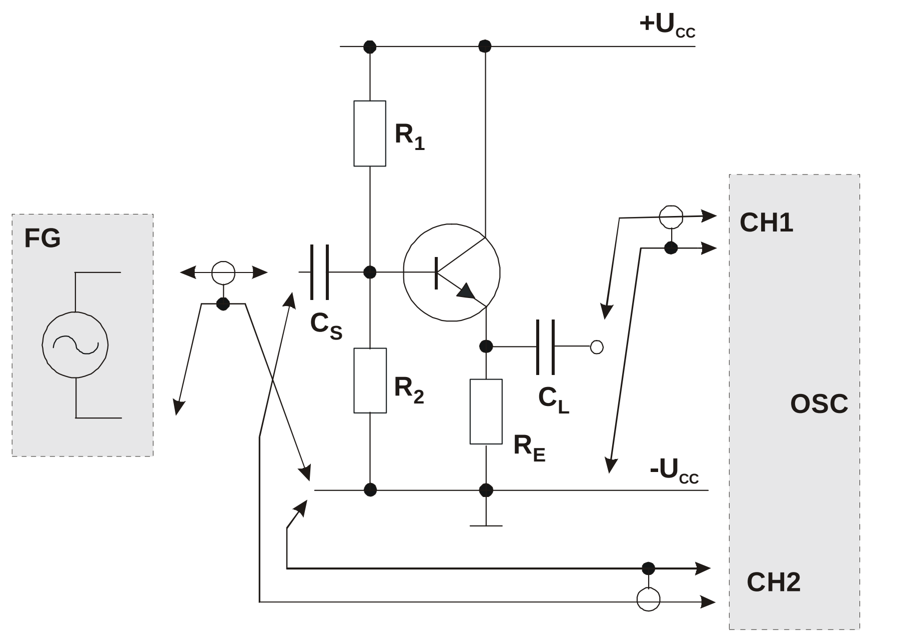

Fig. M4a.

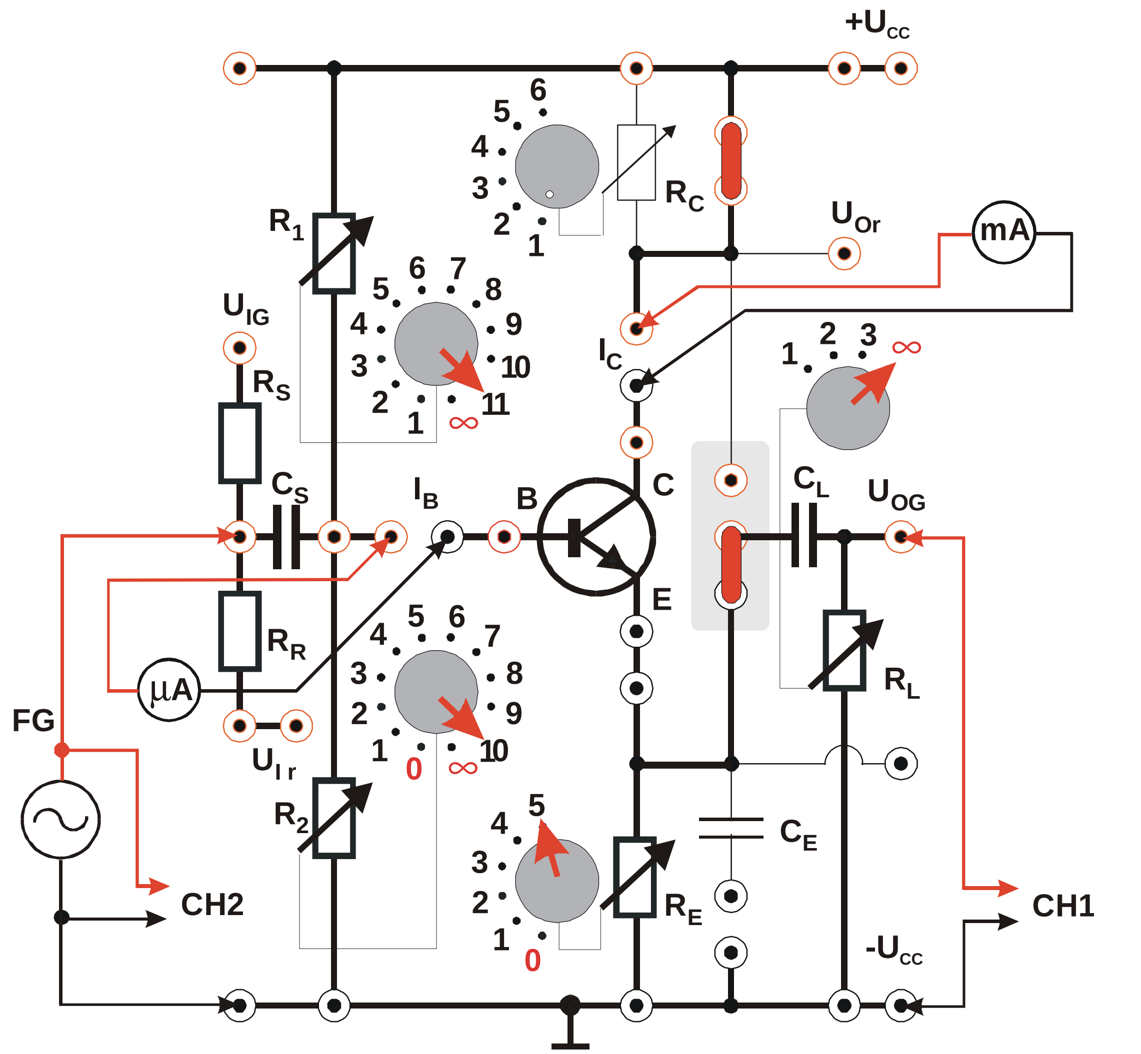

Fig. M4b.

Report elaboration

Report has to be composed of:

1. Front page (by using a pattern),
2. Description of experiment purposes,
3. Schematic diagrams of tested circuits,
4. List of the used instruments and devices (id number, type, settings and rang values),
5. Results of measurements (including oscillograms and tables),
6. Drawings and analysis of obtained results,
7. Final remarks and conclusions.

On the basis of the obtained results one should:

1. Assess the influence of R_1 or R_2 on the shape of amplified signal and on the choice of the optimal Q-point,
2. Estimate the input and the output impedance each of amplifiers (without error calculations),
3. Compare the properties of common-emitter and common-collector amplifiers,
4. Evaluate the influence of input signal amplitude on the gain level for the optimal Q-point of amplifiers under investigation.

References

[1] M. Rusek, J. Pasierbiński, *Elementy i układy elektroniczne w pytaniach i odpowiedziach*, WNT, Warszawa, 1999.
[2] Z. Nosal, J.Baranowski, *Układy elektroniczne. Cz. I. Układy analogowe liniowe*, Seria Podręczniki Akademickie, (Elektronika, Informatyka, Telekomunikacja), WNT, Warszawa, 2003.
[3] A. Filipowski, *Układy elektroniczne analogowe i cyfrowe*, Seria Podręczniki Akademickie, (Elektronika, Informatyka, Telekomunikacja), WNT, Warszawa, 2005.
[4] P. Horowitz, W. Hill, *Sztuka elektroniki. Cz. 1.*, (tłum. ang.), WKiŁ, Warszawa, 2003.