ELECTRONICS

Practical work 1

BIPOLAR TRANSISTOR AMPLIFIERS

1. Study of bipolar transistor amplifiers.

1.1. Compose the CE amplifier as in Fig. 1.

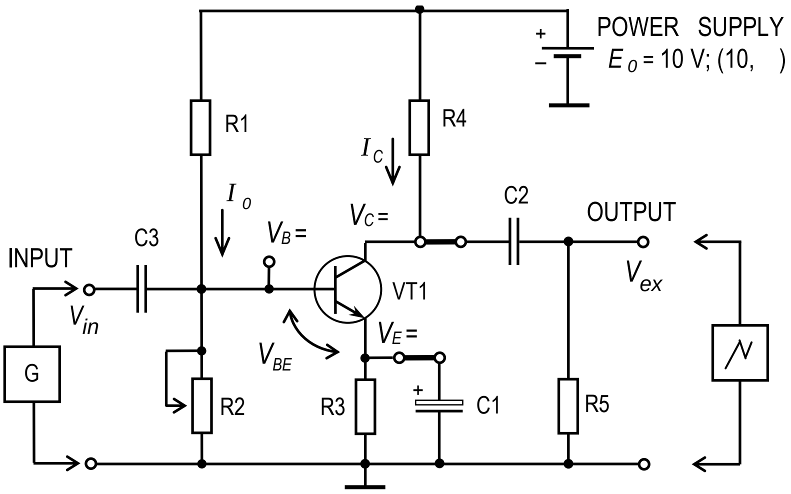

Fig. 1 Diagram of the CE transistor amplifier.

Connect the function generator at f = 400 Hz and adjust the level of the sine wave input for a maximum undistorted signal at the output.
Measure the following voltages:

V_C = [V];
V_B = [V];
V_E = [V];

Calculate: current through resistor R1: I_0 = ……………..... = ……..………..... = …….[μA] ;

collector current of transistor: I_C = ………… = ...…..… = ...[mA] ;

voltage drop V_{BE} = ………………… = ...……....= ....[V] ;

1.2. Take the relationship $V_{ex\,m} = f\,(\,V_{in\,m}\,)$ for amplifier by voltmeter and write the results into the Table 1 and Fig. 2.
Find the voltage gain A_v for the circuit from Table 1:

$$A_v = \frac{V_{ex}}{V_{in}} = \frac{\qquad}{\qquad} = \qquad ;$$

Calculate theoretical voltage gain $A_{v\,th}$ for the circuit:

$$A_{v\,th} = -\frac{h_{21}}{h_{11}} \cdot R_4 \parallel R_5 = \frac{\qquad}{\qquad} = \qquad ,$$

where: h_{21} is the current gain for transistor in common emitter (CE) configuration (a value between 30 and 200; use in the following calculations $h_{21} = 100$);
h_{11} is the input impedance for transistor in CE configuration and calculates as

$$h_{11} = V_T / I_B = V_T\, h_{21} / I_E = \qquad = \qquad [\Omega],$$

where emitter current $I_E =$ = = [mA].

and V_T is the thermal voltage: $V_T =$ [mV].

Table 1

V_{in} [V]	V_{ex} [V]	$V_{in}\sqrt{2}$ [V]	$V_{ex}\sqrt{2}$ [V]	$A_v = \frac{V_{ex}\cdot\sqrt{2}}{V_{in}\cdot\sqrt{2}}$

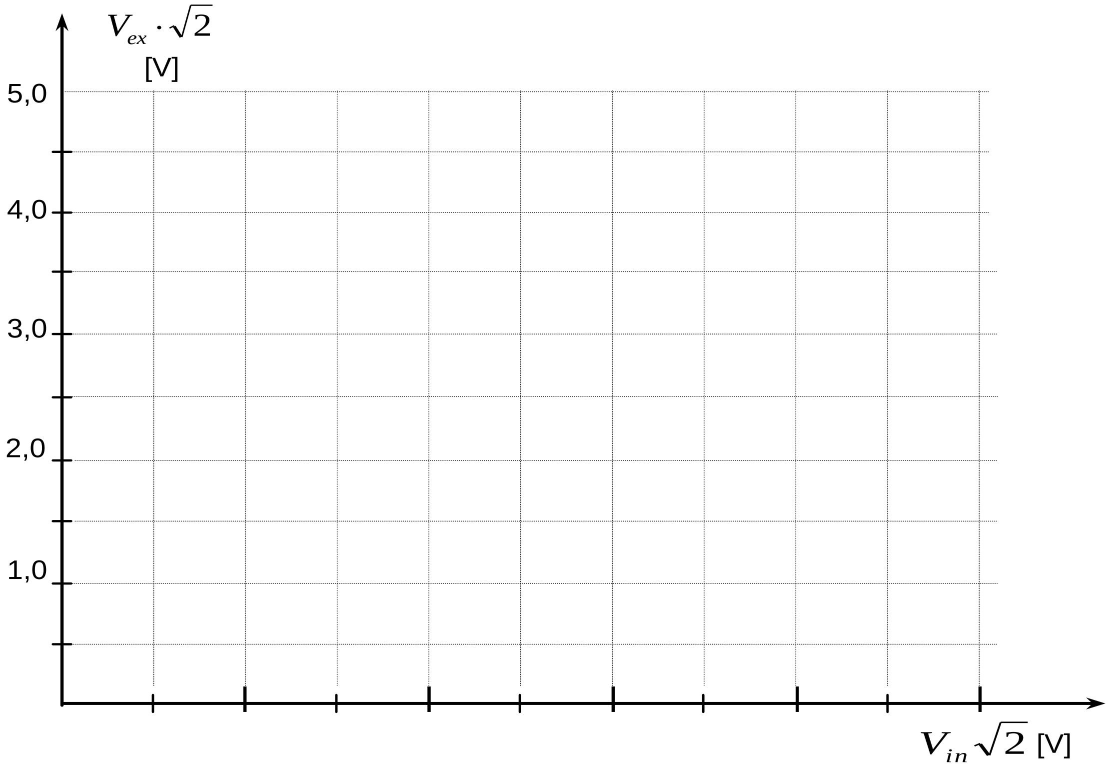

Fig. 2 Transfer relationship $V_{ex\,m} = f\,(V_{in\,m})$ for CE amplifier.

1.3. Find the logarithmic gain - frequency response.
For it calculate:
- voltage gain A_o for passband frequencies (e.g. at 400 Hz)

$$A_o = 20\ lg\ V_{ex\ m} / V_{in\ m} = 20\ lg\ \ldots\ldots\ldots\ldots/\ldots\ldots\ldots\ldots.. = \ldots\ldots\ldots.[dB]$$, and

- lower cutoff frequency (by multimeter) : f_b = ……….[Hz]; lg f_b = ……….[Hz];
- upper cutoff frequency (by oscilloscope): f_h = ………[kHz]; lg f_h = ………[kHz]; where:
f_b and f_h are - 3 dB frequencies for amplifier.
Write the results into the Table 2 and use for Fig. 3.
Construct the straight-line approximation and corrected smooth curve for logarithmic gain - frequency relationship.

Table 2

f [Hz]	V_{in} [dB]	V_{ex} [dB]	A_v [dB] = V_{ex} [dB] – V_{in}[dB]
f_b =			
400			A_0 [dB] =
f_h =			

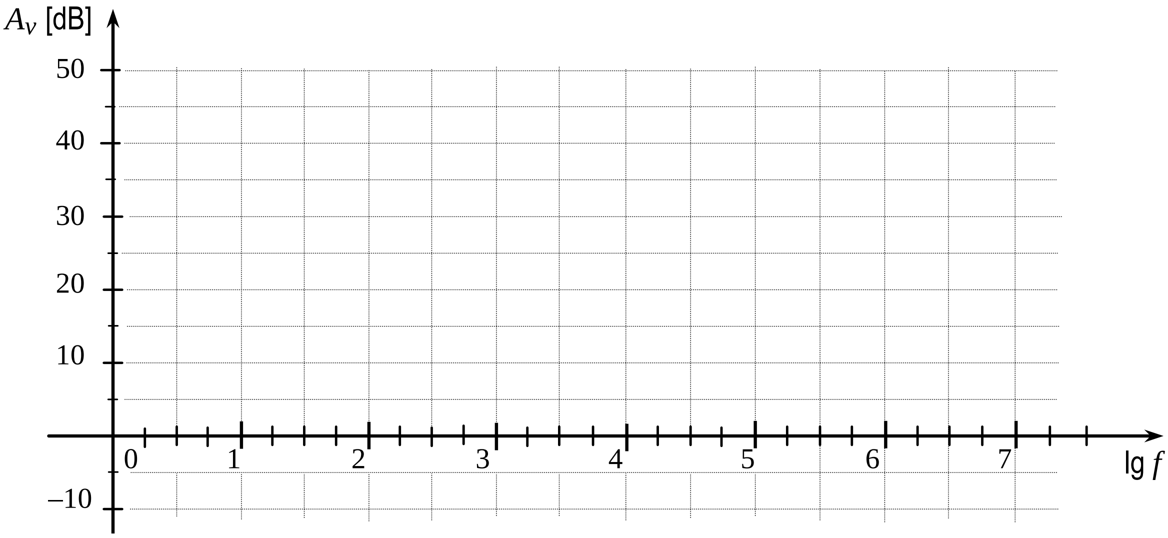

Fig. 3 Logarithmic gain - frequency relationship for CE amplifier.

The horizontal axis is scaled logarithmically, in decades of frequency;
the dB gain is assigned to the vertical axis.
Explain the reasons for the frequency distortions of CE amplifier:
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1.4. Assume, you apply the incoming square-wave signal v_{IN} for frequency f_1 = 400 Hz. Draw the output voltage v_{EX} curves in Fig. 4.
Determine the phase shift φ for input and output voltages and explain it:

φ = …… °;………………………………………………………………………………

Explain the reasons for the output voltage distortion: …………………………………..

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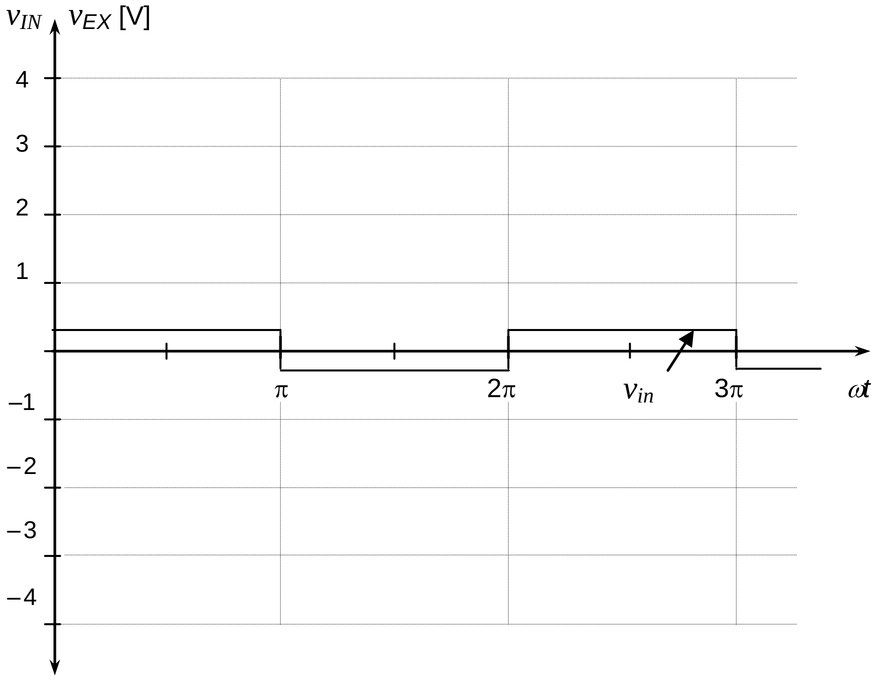

Fig. 4 Input voltage v_{IN} and output voltage v_{EX} curves.

1.5. Design the CE amplifier configuration without emitter capacitor and determine the voltage gain A_v for 400 Hz sine wave input:

$$A_v = \frac{V_{ex}}{V_{in}} = \frac{\qquad}{\qquad} = \qquad ;$$

Compare the result with the theoretical gain value $A_{v\,th}$:

$$A_{v\,th} \approx \frac{R_4 \parallel R_5}{R_3} \approx \frac{\qquad}{\qquad} \approx \qquad ;$$

1.6. Design the common collector (CC) configuration amplifier (emitter follower). The CC amplifier diagram is shown in Fig. 5.

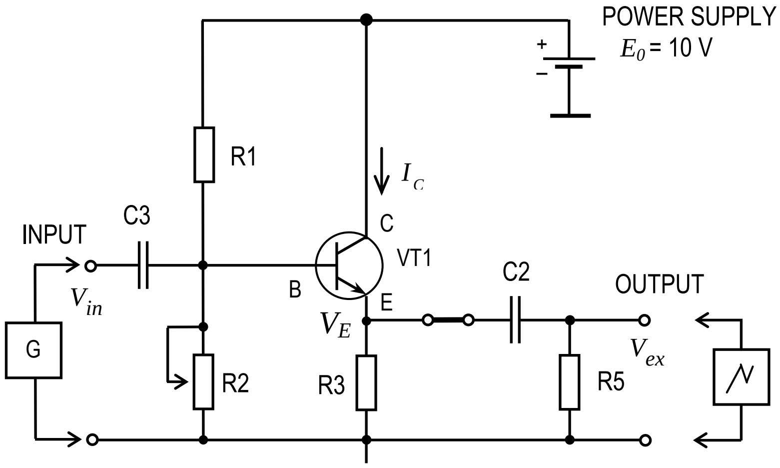

Fig. 5 Diagram of the CC amplifier (emitter follower).

Apply the 400 Hz sine wave input.

Adjust by input signal the maximum undistorted output signal.

Find the voltage gain for CC amplifier:

$$A_v = \frac{V_{ex}}{V_{in}} = \underline{\qquad\qquad\qquad} = \qquad ;$$

Measure the DC voltage:

V_E = ………..[V] ;

Calculate the following DC currents:

I_E =…………………… = ...…… = ……… [mA] ;

I_C =…………………… = ...…… = ……… [mA] .

Determine the phase shift φ for the input and output voltages and explain it:

$\varphi =$ °,………………………………………………………………………

Conclusions:…………………………………………………………………

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