Transistor amplifier - part 2

1. Scope

- Determine the transistor characteristics in common emitter configuration (CE).
- Calculate parameters of the amplifier circuit to achieve reference gain.
- Determine frequency (amplitude and phase) characteristics.

2. Transistor amplifier in common emitter configuration.

Your goal is:

- build typical CE amplifier circuit,
- calculate element parameters to achieve reference parameters (gain, input resistance, etc),
- plot the frequency characteristics.

In order to achieve goals follow the further part of instruction.

Run Matlab and load file named LAB3.slx. Modify the simulation to build circuit presented in. Fig. 1.

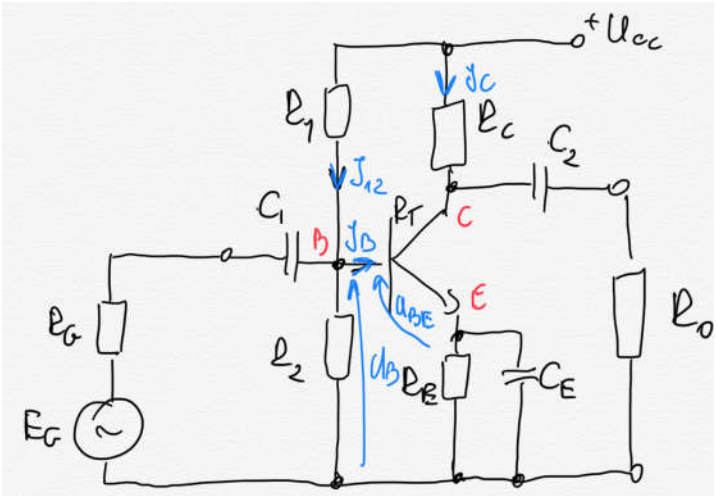


Fig. 1 Schematic of the amplifier circuit

Design parameters:

$K_U = 100 \frac{V}{V}$ $R_{IN} = 2\,k\Omega$ $U_{IN} = 1\,mV$

$R_O = 100\,k\Omega$ $f_L = 50\,Hz$ $E_G = 10\,V$ $R_G = 20\,\Omega$

Transistors parameters: I_C=2mA; U_{CE}=5V, β=150; U_{BE}=0.65V. In the report β parameter should be changed for each person

To analyze the amplifier hybrid π model of the bipolar transistor is used, presented in Fig. 2.

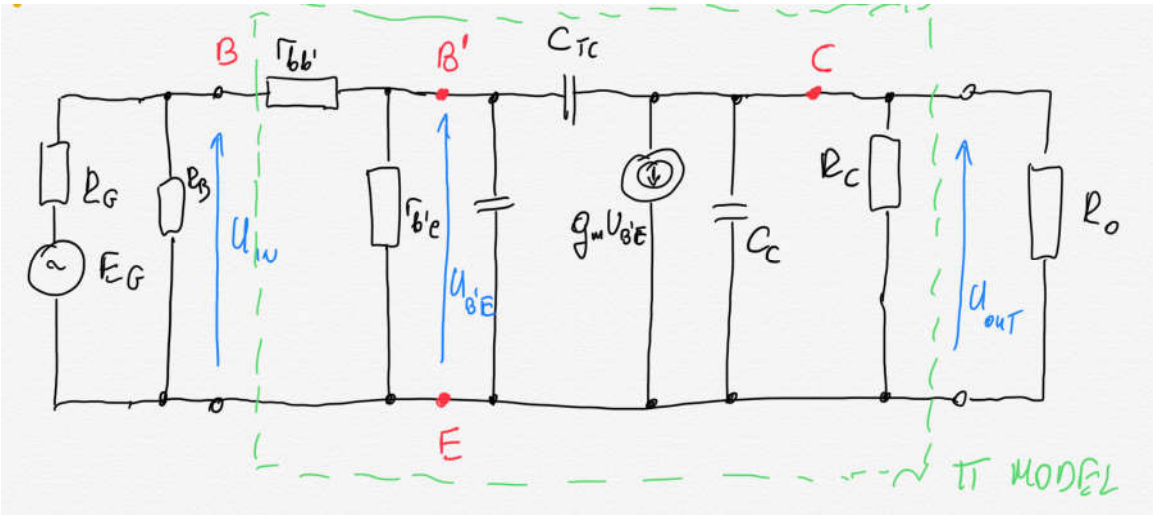


Fig. 2 Hybrid π model of the bipolar transistor - used for small signal analysis.

In order to perform small signal analysis it is necessary to transform amplifier circuit to form presented in Fig. 3.

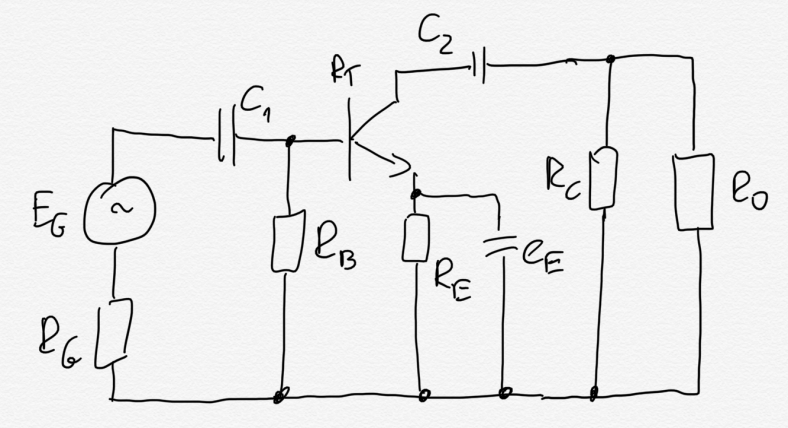


Fig. 3 Amplifier circuit used in small signal analysis.

According to design parameters choose the circuit parameters with following calculations.

$$R_T = r_{bb'} + r_{b'e} \qquad r_{bb'} \ll r_{b'e}$$

$$R_T \cong r_{b'e} = \beta \frac{U_T}{I_E} = \ldots \qquad U_T = 26\,mV$$

R_T - transistor resistance

$$k_u = \frac{R_C R_O}{R_C + R_O} \beta \frac{1}{R_T} \Rightarrow R_C = \text{A} \quad (1)$$

$$U_{CE} \approx U_{CC} - I_C (R_C + R_E) \Rightarrow R_E = \text{B} \quad (2)$$

$$I_{12} \gtrsim 10 \cdot I_B \quad (3)$$

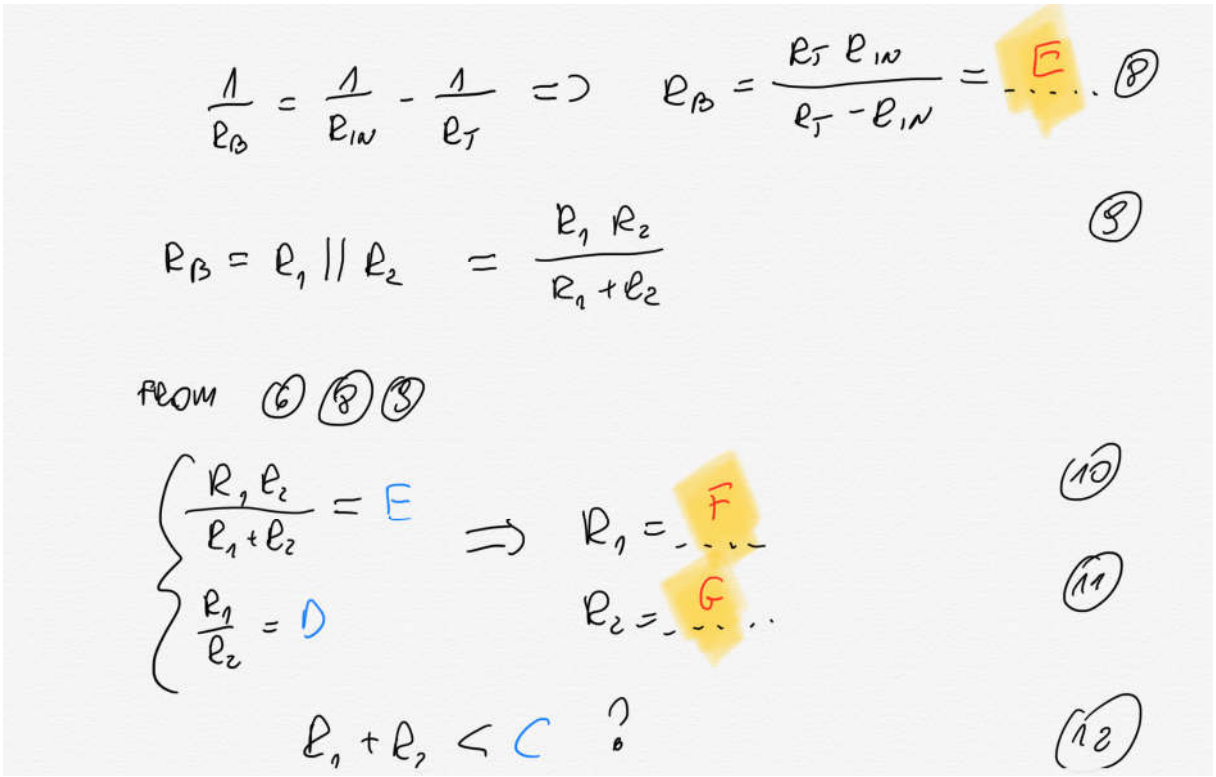
$$\frac{U_{CC}}{R_1 + R_2} \approx 10 \cdot \frac{I_C}{\beta} \Rightarrow R_1 + R_2 \lesssim \frac{\beta U_{CC}}{10 I_C} = \text{C} \quad (4)$$

$$U_B \cong I_C R_E + U_{BE} = \frac{U_{CC} R_2}{R_1 + R_2} = \frac{U_{CC}}{\frac{R_1}{R_2} + 1} \quad (5)$$

$$\frac{R_1}{R_2} = \frac{U_{CC}}{I_C R_E + U_{BE}} - 1 = \text{D} \quad (6)$$

$$R_{IN} = R_B \parallel R_T \Rightarrow \frac{1}{R_{IN}} = \frac{1}{R_B} + \frac{1}{R_T} \quad (7)$$

$$\frac{1}{R_B} = \frac{1}{R_{IN}} - \frac{1}{R_T} \Rightarrow R_B = \frac{R_T R_{IN}}{R_T - R_{IN}} = \text{E} \quad (8)$$



To calculate capacitors value the amplifier is treated as three independent high pass filters. The others capacitors are bypassed during analysis (red line in the schematic). The most important filter is consist of C_E.

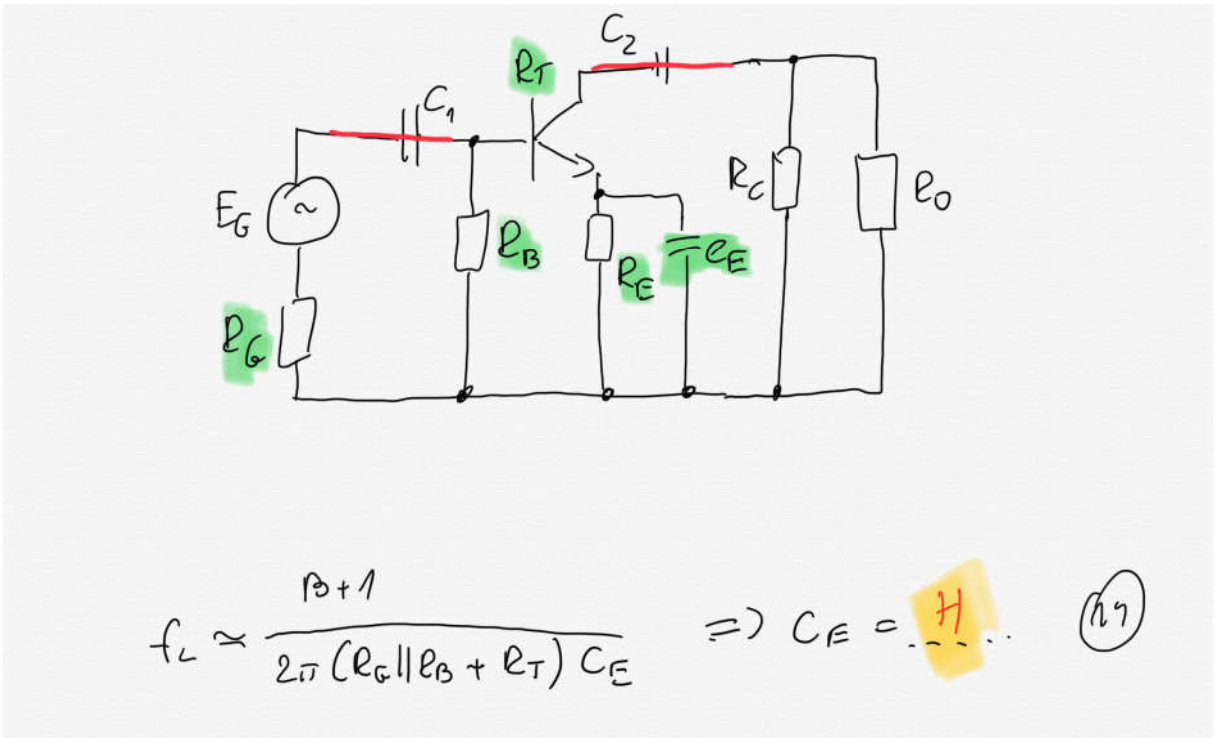


Fig. 4 Schematic of the amplifier circuit with bypassed C1 and C2 (for frequency analysis)

The other filters frequency should be lower than $0.1f_L$.

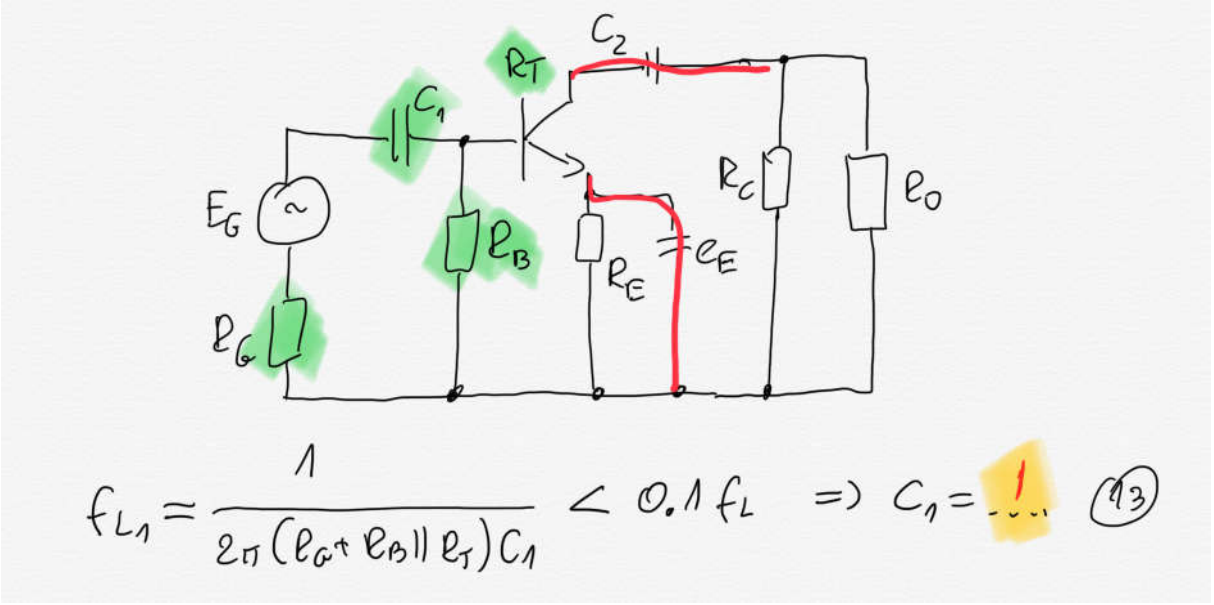


Fig. 5 Schematic of the amplifier circuit with bypassed C2 and C_E (for frequency analysis)

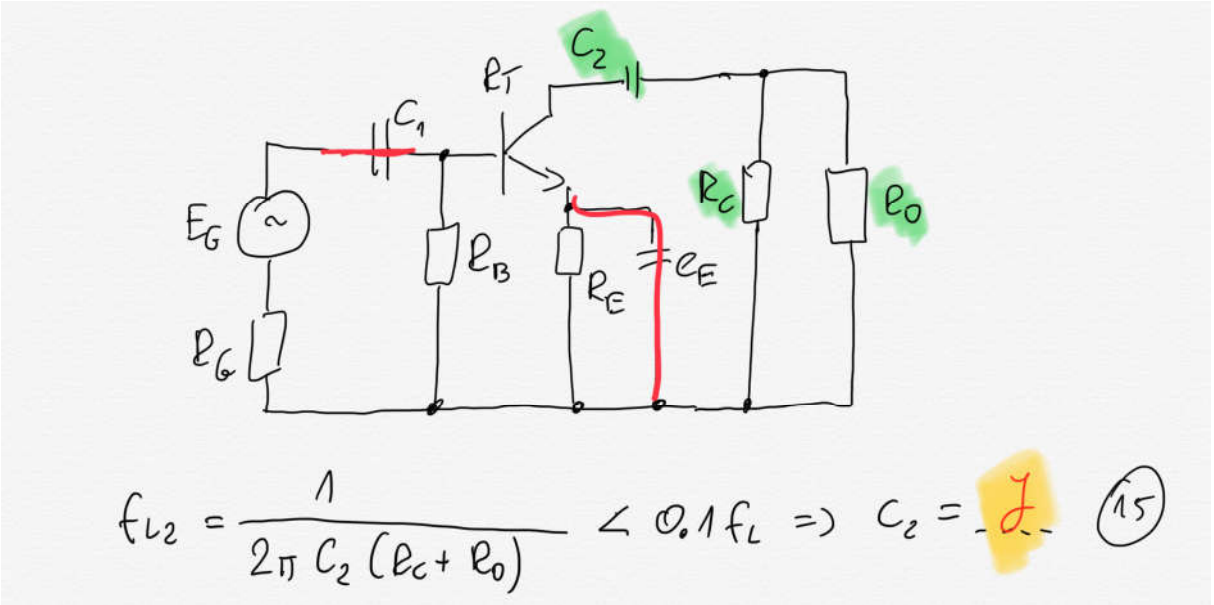


Fig. 6 Schematic of the amplifier circuit with bypassed C1 and C_E (for frequency analysis)

In the matlab modify the resistance and capacitance values according to your calculations. Start simulation and check results. Determine the current and voltage gain.

k_u=.....

k_I= .....

Determine the phase and amplitude characteristics by change the frequency of the source voltage and observe input and output voltage in one plot.
Present results in Fig. 7 and Fig. 8.

Fig. 7 5 Phase-frequency characteristic of the designed amplifier

Fig. 8 5 Phase-frequency characteristic of the designed amplifier

Comment your results:
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