Analog Electronics I
Laboratory
Exercise 2
FET Amplifier

Aim of the exercise

The aim of this laboratory exercise is to become familiar with operation of simple single FET transistor amplifier. Exercise illustrates transistor polarization, frequency characteristics and nonlinear distortions of the amplifier.

Control questions

1. Explain the role of C_1, C_2, C_S capacitors and R_S resistor in the amplifier circuit.
2. How would the amplifier voltage gain change if R_1 is increased?
3. Explain the role of R_G resistor.
4. Write the DC parameters (voltages, currents) of FET transistor.
5. If a signal peak-to-peak voltage is 2V, what is the amplitude of the signal?
6. If a signal amplitude is 2V, what is the peak-to-peak voltage of the signal?
7. In the amplifier input voltage is 2V and output voltage is 4V. What is the voltage gain?
8. In the amplifier input voltage is 2V and output voltage is 1V. What is the voltage gain?
9. What can be the reason of nonlinear distorion?

Equipment

- Oscilloscope;
- Measurement set: function generator, digital multimeter, frequency meter, power supply;
- Soldering toolbox;
- Measurement toolbox;
- Soldering station;
- Prototype board.

Before the exercise please check the contents of the toolbox with the checklist on the box. If anything is missing report it to your teacher.

Warning! Soldering iron is heated to the temperature above 300ºC. Please use it carefully in order to prevent getting burn.

Amplifier Circuit

The FET amplifier with input voltage divider (resistors R_1 and R_2) and load R_L=10kΩ is presented in fig. 2. The resistors R_G, R_S and R_D are used for transistor polarization and the Q-point setting.

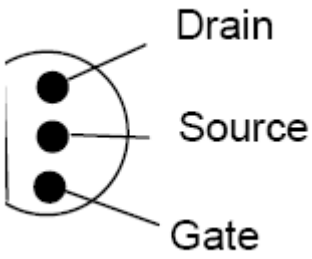

Fig. 1 Transistor spinning – bottom view.

Tasks

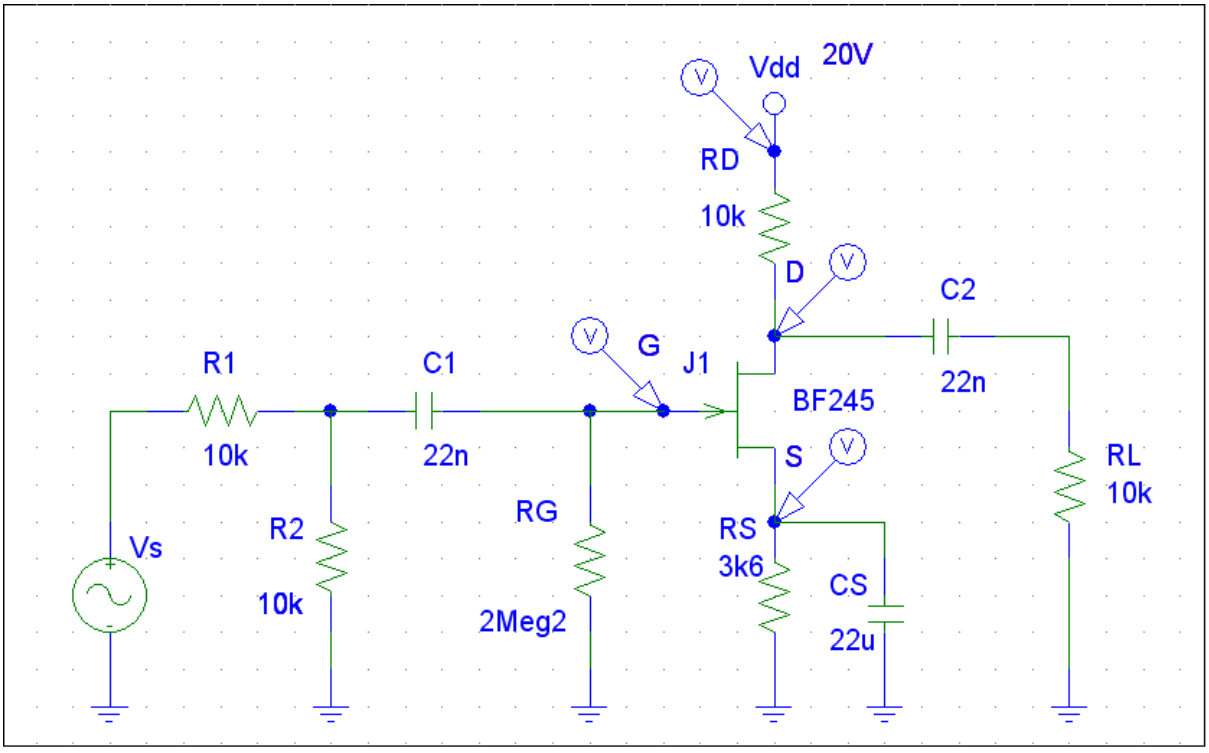

Fig. 2 Schematics of FET amplifier. 2Meg2 means 2.2MΩ and 3k6 means 3.6kΩ as well.

Warning! Capacitor CS is of electrolytic type and has positive and negative pins (the negative pin is shorter than the positive pin and marked on enclosure of the capacitor by the minus symbol). <u>Connect the minus pin to the ground!</u> Improper connection of the capacitor can cause its explosion.

1. DC measurements

1. Using digital multimeter measure the following DC voltages with regard to ground: V_G, V_D, V_S and V_{DD}. The measurement points are marked by voltage markers. **Remember to measure the voltages with the generator turned off.**
2. Calculate: V_{GS}, V_{DS}, V_{RD} (voltage drop on resistor R_D) and i_D current. Notice that the DC drain current flows through R_D and can be calculated on the basis of the Ohm's rule.

2. Frequency characteristics

1. Set the following parameters of the signal generator:
    a. Frequency = 100kHz
    b. Signal shape – sine
    c. Signal peak-to-peak voltage $V_{p\text{-}p}$=1V
    d. Output resistance of the generator R_{OUT}=50Ω
2. Press button "F/G" in order to measure the signal frequency using the frequency counter.
3. Connect the signal from the generator to the amplifier input.
4. Measure the amplifier peak-to-peak output voltage $V_{OUTp\text{-}p}$ (i.e. voltage on the load resistor R_L.
5. Calculate the voltage gain A_v of the amplifier.
6. Measure voltage gain vs. frequency. Remember to keep the input signal level constant during this measurement. Note the results in the table like the one below:

Table 1.

Frequency	**$V_{OUTp\text{-}p}$**
200Hz	
500Hz	
1kHz	
2kHz	
5kHz	
100kHz	
500kHz	
1MHz	
2MHz	

3. Nonlinear distortions

1. Set the frequency of the signal to 100kHz.
2. Measure peak-to-peak values of the output signal for the following input signal amplitudes:

Table 2.

V_{INp-p} [V]	V_{OUTp-p} [V]	Describe distortions if noticed
1		
1.5		
2		
2.5		
3		
3.5		
4		

3. Observe the waveform of the output signal. Describe the type of the nonlinear distortions if they occur.
4. Save in the program the obtained output signal plot for input peak-to-peak voltage equal to $V_{INp-p} = 4V$.
5. Draw the transfer characteristics of the amplifier ($V_{out} = f(V_{in})$) and determine maximum non-distorted amplitude (or peak-to-peak value) of the output signal. What is the input signal that corresponds to this output signal?

Additional information

BF245 transistor data site (parameters, data sheet, spice model, etc.):
http://www.semiconductors.philips.com/cgi-bin/pldb/pip/bf245a

Transistor data sheet (PDF):
http://www.semiconductors.philips.com/acrobat/datasheets/BF245A-B-C_2.pdf

Report preparation

The report must be delivered in electronic form to your teacher. Each page in header should have named and id numbers of persons carried out the exercise.. Each report should include:

- schematics of the examined circuit (e.g. prepared in SPICE);
- values of the DC voltages measured in task 1;
- values of amplifier gain for 100kHz frequency of the input signal;
- voltage gain frequency characteristics of the amplifier. Determine the -3dB bandwidth for this amplifier. Use logarithmic scale for the frequency axis and dB scale for amplifier gain;
- the plot of the distorted output signal;
- the plot of the amplifier transfer characteristics. Mark the linear region of the characteristics;
- simulation results;
- comparison of the obtained measurement results and oscilloscope plots with SPICE simulation results;
- comments and conclusions;
- answers to control questions.