Bilkent University

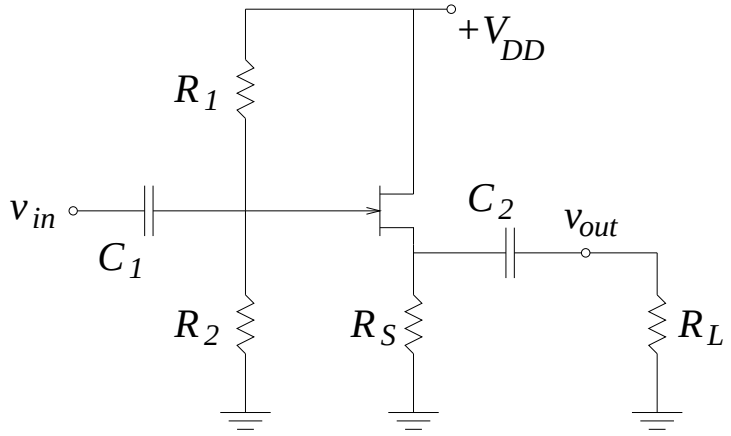
Department of Electrical and Electronics Engineering

EEE 313 Electronic Circuit Design

Experiment 6
JFET Source-Follower Amplifier Design

Introduction

The aim of this experiment is to design and construct a single-stage JFET source-follower amplifier using the circuit topology shown in the figure. Such an amplifier may be used as the output stage of a multistage amplifier to achieve a low output resistance.



During the experiment, you will also generate the i_D *vs* v_{DS} curve of a JFET for various values of v_{GS}, and measure the transistor parameters I_{DSS} and V_p.

Preliminary work

Review Section 6.9 in the textbook.

In the preliminary work section, you will design a JFET source-follower based on the given circuit topology. The DC supply voltage, the load resistance and the coupling capacitors are given as:

V_{DD}	R_L	C_1	C_2
15 V	330 Ω	0.1 μF	10 μF

The transistor that you will use is BF245C. This transistor has the following parameters:

	min	max
I_{DSS}	15 mA	17 mA
$\|V_P\|$	5.0 V	6.5 V

You are asked to design this amplifier and specify the values of R_1, R_2, and R_S. The design requirements are listed in the following table.

	min	max
Output resistance R_{out}		200 Ω
Voltage gain A_v	0.40	
Input resistance R_{in}	200 kΩ	
Peak-to-peak undistorted output voltage swing	3.0 V	

1. Design the amplifier and determine the values of R_1, R_2, and R_S. Show all your work clearly. **Write the values of these resistors in the provided boxes after finishing your design:**

R_1	R_2	R_S

Use only standard values: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 ($\times 10^n$ Ω)

2. Analyze your circuit for four different JFET parameter combinations using the resistor values found in the previous part. Show all your work clearly. Fill out the following table with the values found in your analysis.

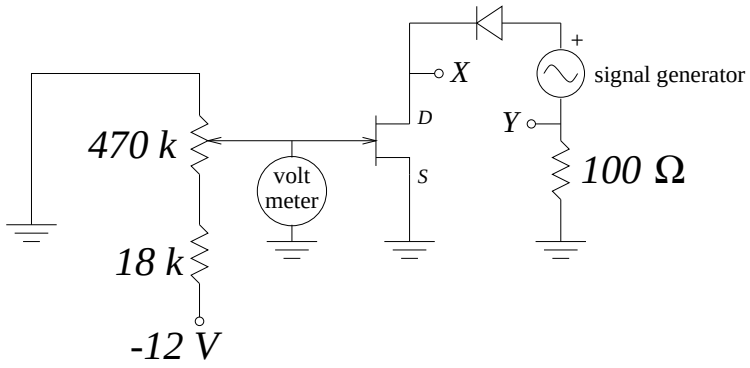
I_{DSS}	15 mA	15 mA	17 mA	17 mA
$\|V_P\|$	5 V	6.5 V	5 V	6.5 V
V_{GSQ}				
V_{DSQ}				
g_m				
R_{out}				
R_{in}				
A_v				
V_{pp}				

Experimental work

Before constructing your circuit, verify the values of the resistors that you are going to use by measuring their resistances with a multimeter. Make sure that all resistors are within 2% of their marked values. This will assure that your current measurements are accurate.

During your measurements, make sure that your oscilloscope is DC-coupled. This will make it easier for you to note asymmetric waveforms.

1. Determine the transistor characteristics. This can be done using the following circuit.



   At the gate side, the -12 V DC supply together with the 18 kΩ resistor and the 470 kΩ pot are used to set V_{GS} to a desired value, which can be measured using a DC volt meter. A signal generator (with a floating output) is connected to the drain to sweep the drain-to-source voltage v_{DS} approximately in the 0 to 10 V range. The diode assures that v_{DS} is always positive. The voltage drop across the 100 Ω resistor is used to measure the drain current. In this circuit, the voltage at point X is v_{DS} and the voltage at point Y is proportional to i_D. If you use the oscilloscope in the X-Y mode, the i_D–v_{DS} characteristics can be obtained on the screen.

   Construct this circuit and set the signal generator to a triangular wave with $f = 1$ kHz and 20 V peak-to-peak output. Generate and plot (print) the i_D–v_{DS} curve for $V_{GS} = 0$, -1, -2, -3, -4, -5, -6, -7 V. Measure I_{DSS} by noting the saturation current when $V_{GS} = 0$ V. To measure V_p, set V_{GS} close to where $I_D \simeq 0$ and change the 100 Ω resistor with a 10 KΩ resistor. Then slowly adjust V_{GS} to determine when I_D becomes exactly zero to find V_p. (Changing the resistor is necessary to be able to measure small currents.)

2. Construct the amplifier circuit using the values indicated in the preliminary work section.

   Determine the Q-point: Before connecting the signal generator, measure V_{GSQ}, I_{DQ}, and V_{DSQ}, and compare these with your calculations. Calculate the maximum peak-to-peak undistorted (unclipped) output voltage swing that you can expect for this Q-point.

3. Measure the voltage gain of your amplifier: Set the input voltage signal to a sinusoid with 5 kHz frequency and 500 mV peak-to-peak amplitude. Observe the input and output voltage waveforms on the oscilloscope. Measure the voltage gain of the amplifier and compare with your calculations.
4. Determine the maximum peak-to-peak undistorted (unclipped) output voltage swing: Gradually increase the input signal amplitude and observe the onset of distortion (clipping) at the output. Set the signal generator to a triangular wave output; this will make it easier to observe clipping. Gradually vary the input signal amplitude and determine the onset of distortion (clipping) at the output. Measure the peak-to-peak maximum undistorted output voltage swing. Compare this with your calculations and comment on how this value is related to the location of the Q-point on the AC load line.
5. Observe the linearity of your amplifier: Set the signal generator back to a sinusoidal wave output. Set the input signal amplitude to a value such that the output peak-to-peak voltage swing is 1 V. Compare the input and output waveforms on the oscilloscope to get a qualitative feel for the linearity of your amplifier. Put the oscilloscope into the $X-Y$ mode to obtain an input–output curve. Increase the input voltage to observe the full input–output relationship with distortion visible at both ends of the linear region.
6. Measure the output resistance of your amplifier: To do this, set the input voltage signal to a sinusoid with 1 V peak-to-peak amplitude. Measure the output voltage with and without the load resistor, and deduce R_{out}.
7. Measure the input resistance of your amplifier: To do this, connect a 220 kΩ resistor between the signal generator and the input of your amplifier, thereby making a voltage divider between R_{in} and the 220 kΩ resistor. By measuring the voltage waveform on either side of the 220 kΩ resistor, you can deduce the value of R_{in}. Compare this value with your calculations. In this measurement, set the input voltage signal to a sinusoid with 1 V peak-to-peak amplitude.

Measurement results: Fill out the following table based on your measurements.

I_{DSS}	$\lvert V_P \rvert$	V_{GSQ}	I_{DQ}	V_{DSQ}

A_v	V_{pp}	R_{out}	R_{in}