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BAKU HIGHER OIL SCHOOL

Baku Higher Oil School

Course: ANALOG ELECTRONICS

LABORATORY REPORT

Experiment Title: **FET Amplifiers**

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Introduction

The primary objective of this report is to provide information about lab work namely “FET Amplifiers”. The major aim of the experiment carried out by me is to understand the FET amplification using different amplifier circuits (common-source amplifier and common-drain amplifier) and JFET transistor (n-channel BF256A JFET). I build these circuits and measure some parameters such as $V_G, V_S, V_D, V_{in}, V_{out}$ and calculate I_D and A_v. We carried out this experiment via help of different equipment and devices (n-channel BF256A JFET, resistors and capacitors) and they should be as accurate as possible. By doing this experiment, we will create different JFET amplifiers.

Transistor amplifier circuits such as the common emitter amplifier are made using Bipolar Transistors, but small signal amplifiers can also be made using Field Effect Transistors. These devices have the advantage over bipolar transistors of having an extremely high input impedance along with a low noise output making them ideal for use in amplifier circuits that have very small input signals. The design of an amplifier circuit based around a junction field effect transistor or “JFET”, (N-channel FET for this report) or even a metal oxide silicon FET or “MOSFET” is exactly the same principle as that for the bipolar transistor circuit used for amplifier circuit.

Generally, a suitable quiescent point or “Q-point” needs to be found for the correct biasing of the JFET amplifier circuit with single amplifier configurations of Common-source (CS), Common-drain (CD) or Source-follower (SF) and the Common-gate (CG) available for most FET devices. However, in this laboratory work, we will discuss about Common-source (CS), Common-drain (CD) amplifiers.

In this report, I will introduce how experiment is carried out. Additionally, some issues and problems will be considered in the report. There are some errors in measurements because of the non-ideal condition, however we try to understand how all changes happen. At the end, there will be some discussions about values, in order to provide report with more accurate information.

Theory

Let's start looking at two possible (but generally three with Common Gate JFET Amplifier) different JFET amplifiers:

- Common Source JFET Amplifier
- Common Drain JFET Amplifier

Common Source JFET Amplifier is one of the possible three configurations of JFET amplifiers, common source (CS) configuration is mostly used. A common-source JFET amplifier is one in which the AC input signal is applied to the gate and the AC output signal is taken from the drain. The source terminal is common to both the input and output signal. A common-source amplifier either has no source resistor or has a bypassed source resistor, so the source is connected to AC ground. A self-biased common-source n-channel JFET amplifier with an AC source capacitively coupled to the gate. The resistor, RG, serves two purposes: It keeps the gate at approximately 0 V DC, and its large value prevents loading of the AC signal source. A bias voltage is produced by the drop across RS. The bypass capacitor, C2, keeps the source of the JFET at AC ground. The input signal voltage causes the gate-to-source voltage to swing above and below its Q-point value, causing a corresponding swing in drain current. As the drain current increases, the voltage drop across RD also increases, causing the drain voltage to decrease. The drain current swings above and below its Q-point value in phase with the gate-to-source voltage. The drain-to-source voltage swings above and below its Q-point value and is 180° out of phase with the gate-to-source voltage.

The like the transistor emitter follower, the FET source follower configuration itself provides a high level of buffering and a high input impedance. The actual input resistance of the FET itself is very high as it is a field effect device. This means that the source follower circuit is able to provide excellent performance as a buffer. The voltage gain is unity, although current gain is high. The input and output signals are in phase. The capacitors C1 and C2 are used to couple the AC signal between stages and block the DC elements. The resistor RG provides the gate bias, holding he gate at ground potential. The source circuit shows the resistor RS to ground - its value is determined by the channel current that is required. The source follower circuit presents a very high impedance to the preceding stage and it is for this reason that the source follower is an ideal format for use as a buffer.

Experimental technique

For this experiment, I used JFET transistor namely BF256A, because I could not find BF244 type transistor in MultiSim catalog. $V_{GS_{(off)}}$ and I_{DSS} values for this device are changing between minimum and maximum, that is why I choose average values for BF256A as -6.5 V & 5 mA, respectively. The figure below shows the minimum and maximum $V_{GS_{(off)}}$ and I_{DSS} values for them in the conditions of

$$V_{DS} = 15V \; and \; I_D = 10nA$$

V_{GS}(off)	Gate-Source Cutoff Voltage	V_{DS} = 15V, I_D = 10nA	-0.5	-8	V
I_{GSS}	Gate Reverse Current	V_{GS} = -20V, V_{GS} = 0		-5	nA
On Characteristics					
I_{DSS}	Zero-Gate Voltage Drain Current BF256A	V_{GS} = 15V, V_{GS} = 0	3	7	mA

Fig.1: *$V_{GS_{(off)}}$ and I_{DSS} values for BF256A type JFET*

Apparatus

Resistors: one 560 Ω, one 1 kΩ, one 3.3 kΩ, one 10.0 kΩ, two 470 kΩ
Capacitors: one 0.1 uF, one 1.0 uF, one 10 uF
One BF256A n-channel JFET

In these circuits below, AC sources are presented in equivalent RMS values.

$$V_{pp} = 500mV \; for \; common - source \; amplifier \; V_{rms} = 176.8mV$$
$$V_{pp} = 2V \; for \; common - drain \; amplifier \; V_{rms} = 707.1mV$$

Setup

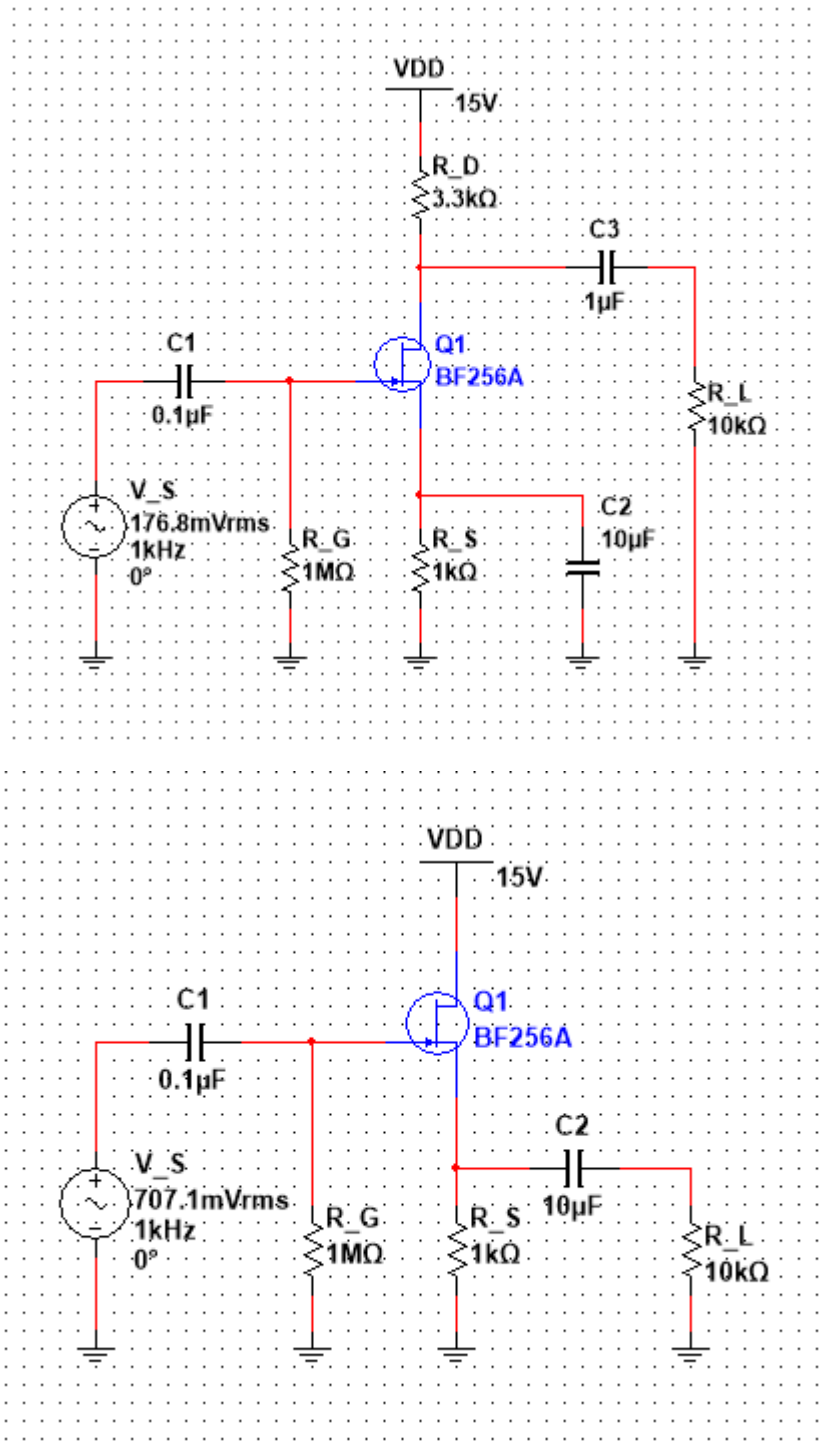


Fig.2: *Experimental setup for common-source and common-drain amplifier, respectively*

Results - Experimental and Derived

In this laboratory work, I could finish lab work successfully. Firstly, I want to write about Common-Source Amplifier analysis part. For calculation, I used the equations below and got the answers as shown in table 1.

$$I_D = I_{DSS}\left(1 - \frac{I_D * R_S}{V_{GS_{(off)}}}\right) \; ; \qquad A_v = \frac{V_{out}}{V_{in}} \; ;$$

Quantity	DC values	AC values
Gate voltage, V_G	0 V	
Source voltage, V_S	1.163 V	
Drain voltage, V_D	11.162 V	
Drain current, I_D	2.19 mA	
Input voltage, V_{in}		246.9 mV(peak)
Output voltage, V_{out}		1.274 V(peak)
Voltage gain, A_V		5.16
Phase difference		180 degree

Table.1: *Common-Source Amplifier analysis results*

Secondly, I want to write about Common-Drain Amplifier analysis part. For calculation, I used the equations below and got the answers as shown in the table 2.

$$I_D = I_{DSS}\left(1 - \frac{I_D * R_S}{V_{GS_{(off)}}}\right) \; ; \qquad A_v = \frac{V_{out}}{V_{in}} \; ;$$

Quantity	DC values	AC values
Gate voltage, V_G	0 V	
Source voltage, V_S	1.189 V	
Drain voltage, V_D	15 V	
Drain current, I_D	2.19 mA	
Input voltage, V_{in}		997.8 mV(peak)
Output voltage, V_{out}		689.8 mV(peak)
Voltage gain, A_V		0.691
Phase difference		0 degree

Table.2: *Common-Drain Amplifier analysis results*

I get the AC values (peak values for V_{in} V_{out}) based on the oscilloscope results below.

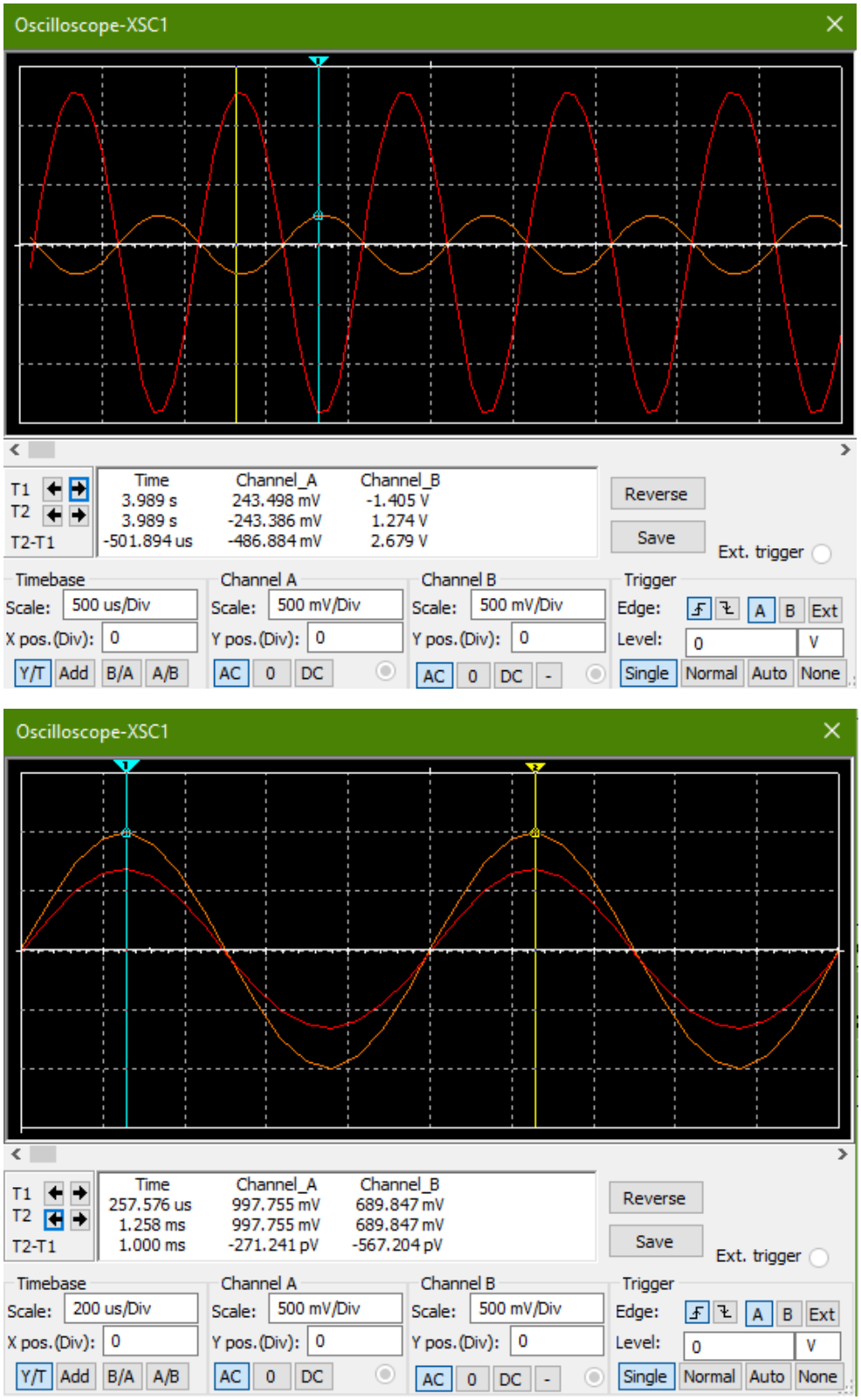


Fig.3: *Oscilloscope results for common-source and common-drain amplifier, respectively*

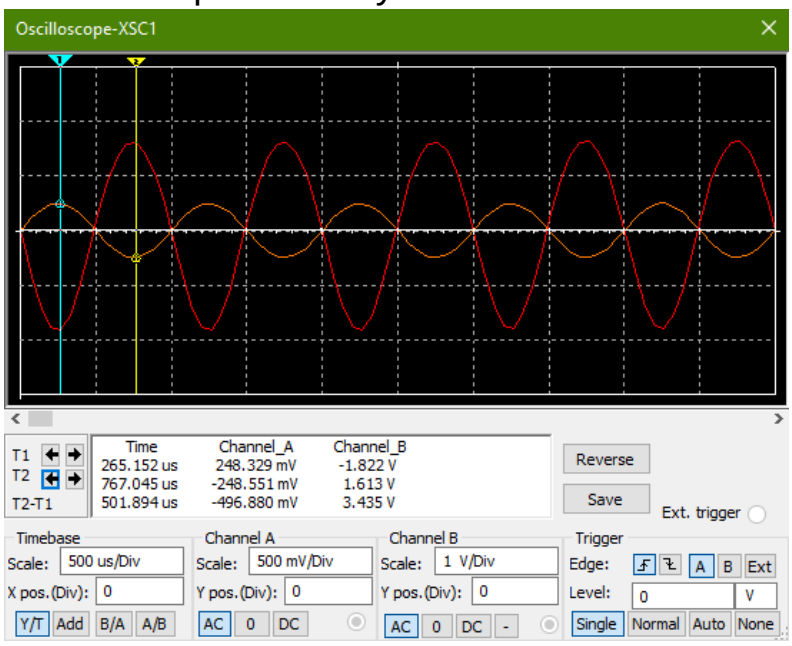
Discussion of the results

Firstly, I want to write about the similarities (or similar results) between common-drain amplifier and common-source amplifier circuits. In DC part, the values of V_G, I_D, V_S are the same or similar. In both cases V_G is 0 because in both circuit design the DC gate are grounded. I_D is the same because we used the same type transistor in both circuit (BF256A) and the calculation technique (or formula) are the same. In both circuit, R_S values are the same (1 kOhm), that is why the V_S values are similar. About V_D, they are different because in common-drain amplifier circuit, V_{DD} is directly connected to drain, however there is R_D (3.3 kOhm) in the common-source amplifier design.

In AC part, we used oscilloscope to measure some values. We get different $V_{in}\ and\ V_{out}$ values, because we used different source voltages. For obtaining voltage gain, I divide the peak values of output to input. From the graph which is obtained using oscilloscope, I also define the shift for common-drain amplifier and common-source amplifier as 0 & 180 degree, accordingly. The voltage gain for common-source amplifier is 5.16, but for common-drain amplifier this value is 0.691 which is near to 1.

- **In common-source amplifier, change the load resistor from 10 kΩ to 100 kΩ. Does the gain change?**

Gain will change, theoretically, based on the equations below.
$R_d = R_D||R_L$; $A_V = g_m * R_d$;
Also I proved this fact experimentally.



As it is shown in the graph above $A_V = \frac{1.613\ V}{248\ mV} = 6.5$ which is different from previous value of 5.16.

- **Compare common-drain amplifier with common-source amplifier. Explain your answer.**

As we get values from the tables above and from the background knowledge from Theory part, it is indisputable fact that the phase shift values are the main difference between common-drain amplifier and common-source amplifier with the values of 0 & 180 degree, respectively. Another difference is the voltage gain, while the voltage gain of common-source amplifier is high (can be very high), the voltage gain of common-drain amplifier is approximately 1 (which means no gain). Additionally, if we talk about the DC values, V_D values are different because in common-drain amplifier circuit, V_{DD} is directly connected to drain, however there is R_D (3.3 kOhm) in the common-source amplifier design. To sum up, these gaps between some figures are the main results of different design.

Questions

There was no question (more accurately under the “Questions” title) to answer (I answered 2 questions in Discussion part).

Conclusion

Briefly, I want to add my personal feelings about the experiment carried out by me and have to express that such kinds of experimentations make us learn more profoundly, deep dive the corresponding subject and do some research in order to grasp what is going on behind the process. Furthermore, the most important factors in carrying out this experiment is that depending on the circuit design we can get different acting amplifiers in result. However their main purpose is to amplify the signal, they are acting differently in the same situations. Although I used the same type JFET transistor, I could not avoid the differences between these two different circuit design, called common-drain amplifier and common-source amplifier. They have different phase shift and voltage gain (which are the main characteristics of every amplifier). The major thing that is derived from this experiment for us is that whenever we take shortages and errors into account we get our results more or less the same as we expected.

Reference

Leaflet of the Laboratory experiment
Electronic devices (Floyd 9th edition), page 452-504
https://www.electronics-tutorials.ws