EXPERIMENT 4

MOS FIELD-EFFECT TRANSISTORS AND AMPLIFIERS

1. OBJECTIVES

- To conduct a DC analysis and compare the theoretical values with the values after the implementation of the circuit.
- To examine the performance of Common Source MOSFET Single stage amplifiers.

Laboratory dressing requirements: shoes must hold the ankle. It means no flip flops

2. THEORY – In order to appreciate how these circuits amplify an input, you should know the small signal models for MOSFET. See the text book, Sedra and Smith for details.

3. Prelab:-

1. Draw the hybrid – π model for the MOSFET and explain the terms.
2. Write the condition when a MOSFET transistor is in the saturation region of its operation.

4. EXPERIMENTAL PROCEDURE

Required components

Transistors	**Resistors**	**Capacitors**
VN2222LL N-Channel	1, 4.7, 10, 90, 30 KΩ	10, 47 μ*F*

The picture below shows the appearance of the MOSFET that you will find in the lab. The pins are described in the table below. It would be useful to mount the devices on the long-legged holders before you put together your circuit on the breadboard.

Pin No.	**VN2222LL MOSFET**
1	Source
2	Gate
3	Drain

Figure 1

4.1 Quiescent (Q) point measurement

Assemble the circuit below and measure the quiescent point (I_{DS}, V_{DS}, and V_{GS}). From these values calculate the power dissipation in the transistor.

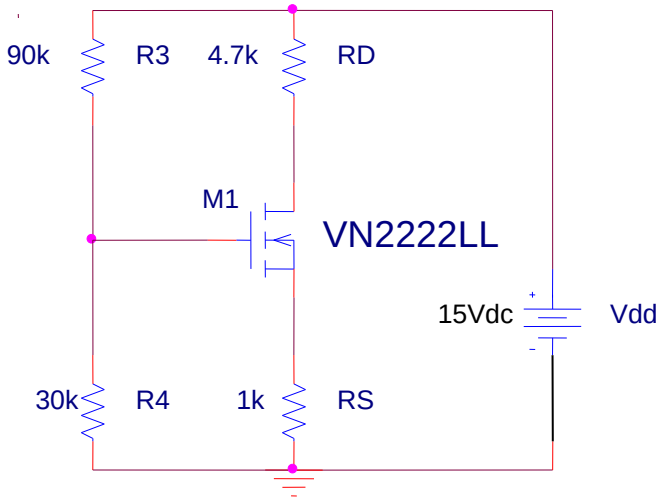

Fig. 2

4.2 AC MEASUREMENT FOR COMMON SOURCE AMPLIFIER

The amplifier bandwidth (operating frequency range) is defined as the difference in Hz between the upper and lower 3dB points. The 3dB point is known as the point where the amplifier gain falls below the mid-band gain by the factor $\frac{1}{\sqrt{2}}$ i.e. $G_{out} = \frac{G_{MID-BAND}}{\sqrt{2}}$. The following equation is used as a formal definition for the 3dB point.

$$-3dB = 10 * \log(\frac{G_{out}}{G_{MID-Band}}) = 20 * \log(\frac{1}{\sqrt{2}})$$

Add to circuit shown in Fig.2, several components to make it a common-source (CS) amplifier as shown in Fig.3.

1- Apply a sinusoidal input signal with 100 mV peak-peak and 4 KHz.
2- Use the oscilloscope to measure the following peak-peak values: v_{in} and v_{out}. Be ready to adjust input amplitude if v_{out} saturates or the output is too small.
3- Display Vin on CH1 and v_{out} on CH2, then change the frequency (if needed) and measure the peak-to-peak value of the maximum output voltage that is, $v_{out} = v_{MID-BAND}$. Now decrease the frequency and observe the peak-peak values of the output signal v_{out}, when $v_{OUT} = \frac{v_{MID-BAND}}{\sqrt{2}}$ record the frequency of the input signal. This is the frequency at the lower 3dB point.
4- Set the input frequency to the mid-band value and slowly increase the frequency till the output peak-peak equals $\frac{v_{MID-BAND}}{\sqrt{2}}$. Determine this frequency at the upper 3dB point.
5- From the above readings compute the following: the mid-band gain (v_{out}/v_{in}), and the bandwidth of the CS amplifier.

6- Remove the 47μF capacitor from the circuit and obtain the maximum gain (v_{out}/v_{in}) and the bandwidth.

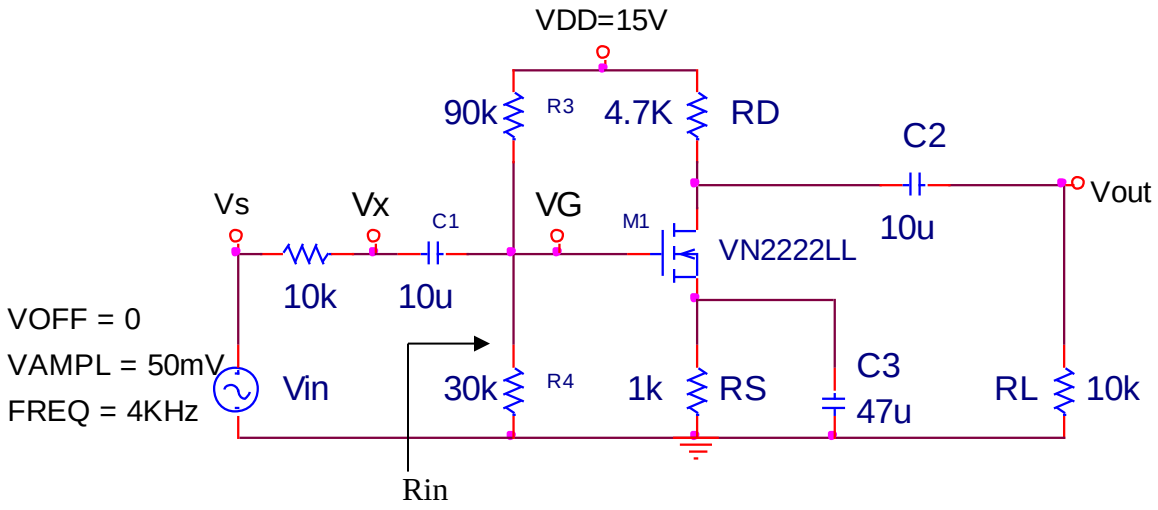

Figure 3

5. QUESTIONS AND DISCUSSION

1. Explain how the Source resistor RS (1 KΩ) stabilizes the *Q* point.
2. Which of the 3 capacitors in Fig.3 is the bypass capacitor? What is its role? What is the role of other two 10 μF capacitors?
3. Compare the voltage gain obtained for the circuit in figure 3, with, and without 47μF capacitor. Discuss the influence of the bypass capacitor on these values.
4. If the small-signal model for MOSFET has been covered by your professor then using theoretical analysis, show that the presence of bypass capacitor in Fig 3 significantly enhances the gain in the mid-band region. In answering you may assume that the bypass capacitor creates a virtual ground at the capacitor. You may also ignore the coupling capacitors and the biasing resistors. In the small signal model, assume that $g_m = 0.5 \times 10^{-3}$ S.
5. Compare the bandwidth obtained for the circuit in figure 3 with, and without 47μF capacitor. Discuss the influence of the bypass capacitor on these values. Can you explain the sizable difference in the bandwidth?
6. Explain how you would measure Rin (See Fig. 3).
7. By looking at the data-sheet for VN2222LL, state the maximum allowed Drain-Source voltage for this transistor.