EE315 - Electronics Laboratory

Experiment - 5

MOSFET Characteristics and Small Signal Amplifier

Preliminary Work

1. The inverter in Figure **1** utilizes an N-channel enhancement-mode MOSFET with the parameters $\mathbf{K_n = 1\ mA/V^2}$ and $\mathbf{V_{TN} = 2\ V}$. Find the inverter output at v_{out} when $v_{in} = 3$ V and $v_{in} = 4$ V. Plot the v_{in}-v_{out} transfer characteristics of the inverter.

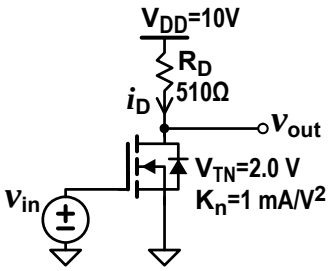

Figure 1

Equations for the N-channel MOSFET are given below.

$$i_D = K_n(v_{GS} - V_{TN})^2 \quad \text{(in SAT region: } v_{DS} \geq v_{GS} - V_{TN}\text{)}$$

$$i_D = K_n[2(v_{GS} - V_{TN})v_{DS} - v_{DS}^2] \quad \text{(in triode=non-SAT region: } v_{DS} < v_{GS} - V_{TN}\text{)}$$

2. Consider the MOSFET amplifier in Figure **2** with the parameters $\mathbf{K_n = 1\ mA/V^2}$ and $\mathbf{V_{TN} = 2\ V}$. Determine the resistor values to obtain roughly $\mathbf{I_D = 1\ mA}$ and to set $\mathbf{V_D}$ approximately midway between $\mathbf{V_{DD}}$ and $\mathbf{V_G}$.

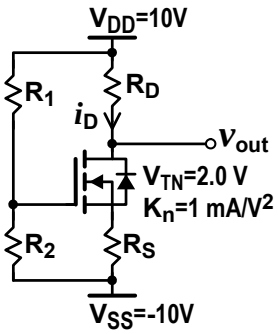

Figure 2

Procedure

1.a) Build the inverter circuit given in Figure **1** using $\mathbf{R_D = 510\ \Omega}$ and $\mathbf{V_{DD} = 10\ V}$. Initially set $\boldsymbol{v_{in}}$ **= 0 V**.

1.b) Increase $\boldsymbol{v_{in}}$ gradually until the point $\boldsymbol{v_{out}}$ becomes constant. Record the $\boldsymbol{v_{in}}$ and $\boldsymbol{v_{out}}$ values to identify significant changes in the inverter response.

2.a) Build the circuit in Figure **3**. Apply an input voltage varying between **0 V** and **10 V** setting $\boldsymbol{v_{in}}$ **= 5V +5V** $sin(2000\,\pi\,t)$.

2.b) Connect the oscilloscope probes as shown in Figure 3. Observe and record the $\boldsymbol{i_D}$ versus $\boldsymbol{v_{GS}}$ plot using the oscilloscope in X-Y mode. Note that, polarities of $\boldsymbol{v_{GS}}$ and $\boldsymbol{i_D}$ are reversed on the oscilloscope screen.

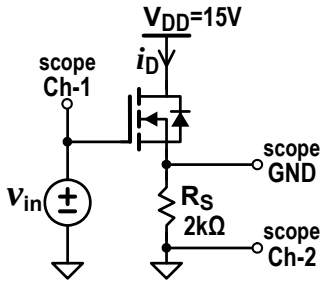

Figure 3

3.a) Build the circuit in Figure **4** using the resistor values you calculated in the preliminary work. Set $\boldsymbol{v_{in}}$ frequency to **10 kHz** and amplitude to **10 mV**. You may need a higher amplitude to obtain significant results when you begin the measurements.

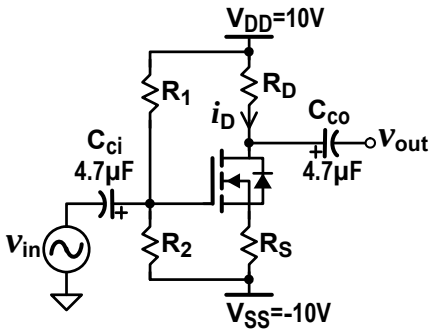

Figure 4

3.b) Display input and output signals on the oscilloscope and observe the phase shift. Measure the output voltage, phase shift and calculate the voltage gain.

3.c) Connect a **100 kΩ** resistor between the input voltage source and the coupling capacitor, $\mathbf{C_{ci}}$. Measure the voltage gain and use the results from step **3.b** to deduce the amplifier input resistance, $\mathbf{R_{in}}$.

3.d) Measure the output resistance, $\mathbf{R_o}$, of the amplifier.