Aim ↬ To study the NMOS & PMOS drain and gate characteristics.

Software Required ↬ OrCAD PSpice.

Circuit Elements ↬ PMOS, NMOS, Voltage sources, connecting wires.

Theory ↬

NMOS (N-type Metal-Oxide-Semiconductor) and PMOS (P-type Metal-Oxide-Semiconductor) are fundamental components of MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) technology used in digital and analog circuit design. The NMOS transistor conducts when a positive voltage is applied to the gate terminal, whereas the PMOS transistor conducts when a negative voltage is applied to the gate.

A MOSFET operates as a voltage-controlled device. The gate voltage [V_{GS}] controls the current flow between the drain and source terminals [I_D]. NMOS transistors typically use electrons as charge carriers, while PMOS transistors use holes. This makes NMOS faster due to higher electron mobility than hole mobility in PMOS.

The behavior of the MOSFET can be divided into three regions:

1. **Cutoff Region [$V_{GS} < V_{th}$]**: No current flows through the transistor [$I_D = 0$], as V_{GS} is below the threshold voltage [V_{th}].

$$I_D = 0$$

2. **Ohmic Region [$V_{GS} > V_{th}$ & $V_{DS} < V_{GS} - V_{th}$]**: The MOSFET operates like a resistor and the current increases linearly with V_{DS} for a fixed V_{GS}.

$$I_D = k.[2(V_{GS} - V_{th})V_{DS} - {V_{DS}}^2]$$

where, $k = \frac{\mu C_{ox} W}{L}$

3. **Saturation Region [$V_{DS} \geq V_{GS} - V_{th}$]** : The MOSFET operates as a current source, and I_D becomes constant irrespective of V_{DS} beyond a certain point.

$$I_D = k.(V_{GS} - V_{th})^2$$

Drain Characteristics [I_D vs. V_{DS}]:

- For a constant V_{GS}, I_D increases linearly in the linear region and saturates in the saturation region.
- The graph exhibits a family of curves, one for each V_{GS} value.

Transfer Characteristics [I_D vs. V_{GS}]:

- I_D increases quadratically with V_{GS} in the saturation region.
- Below the threshold voltage V_{th}, $I_D = 0$.

Circuit Diagram ↬

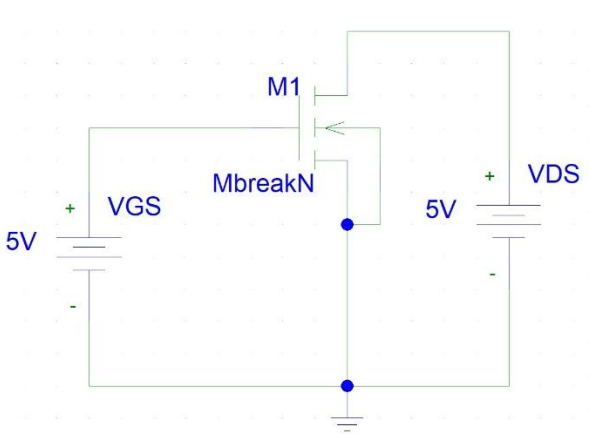

Fig. i) NMOS circuit

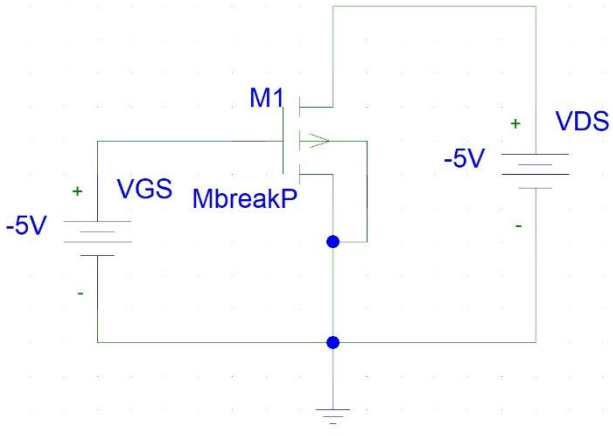

Fig. ii) PMOS circuit

Graphs ↬

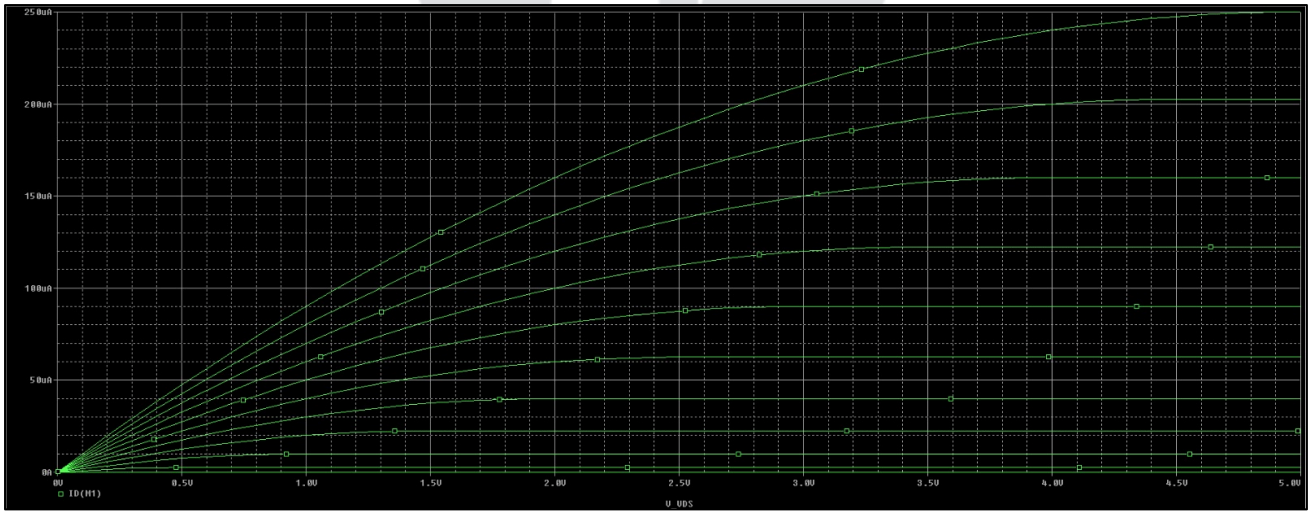

Fig. iii) Drain characteristics of NMOS circuit

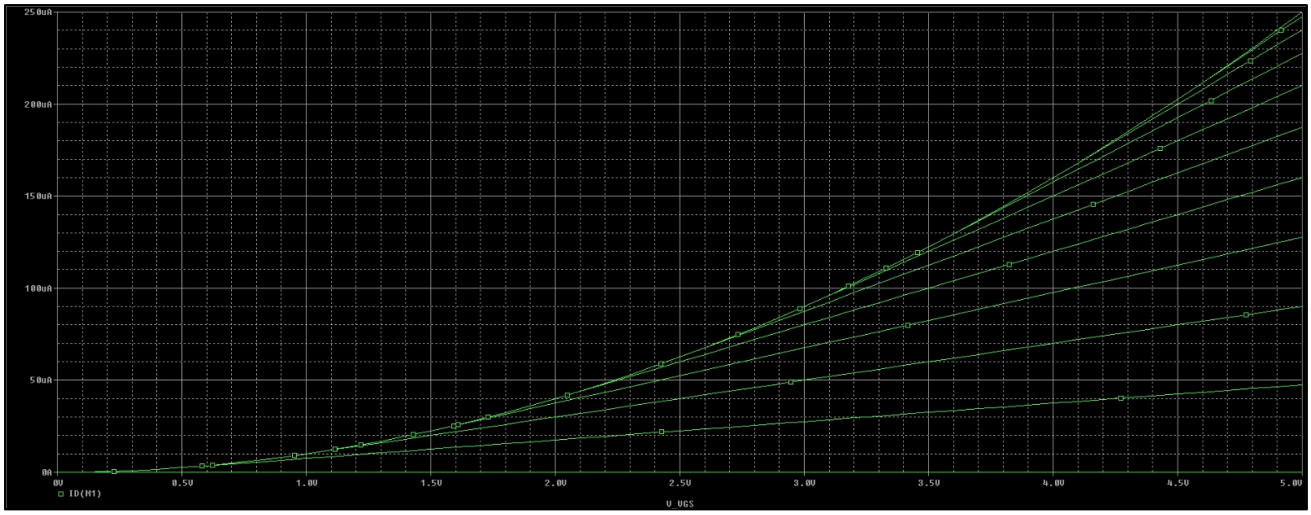

Fig. iv) Transfer characteristics of NMOS circuit

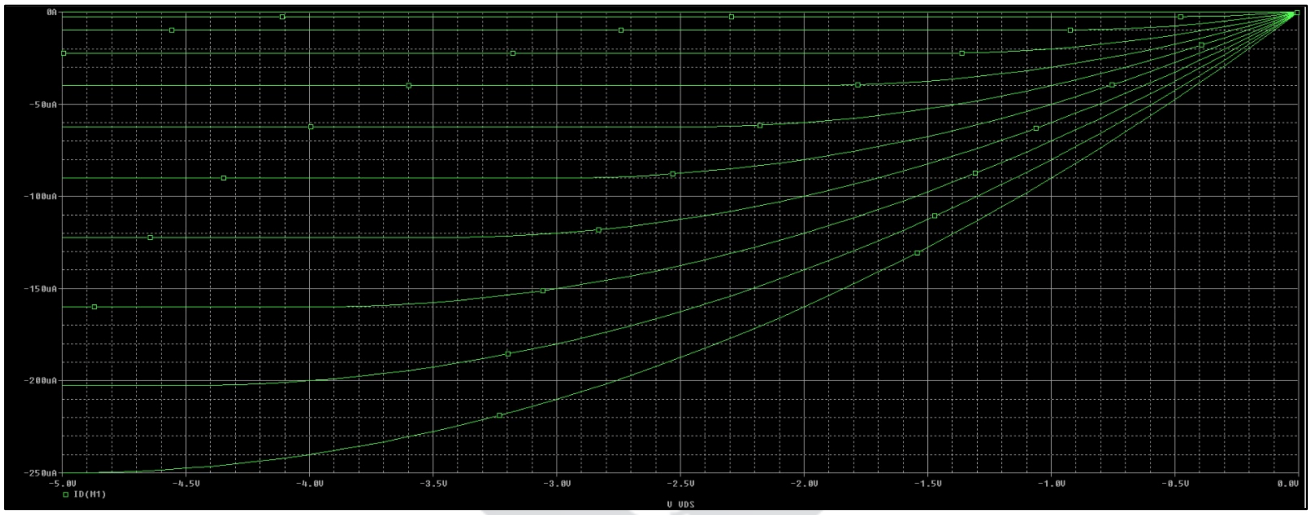

Fig. v) Drain characteristics of PMOS circuit

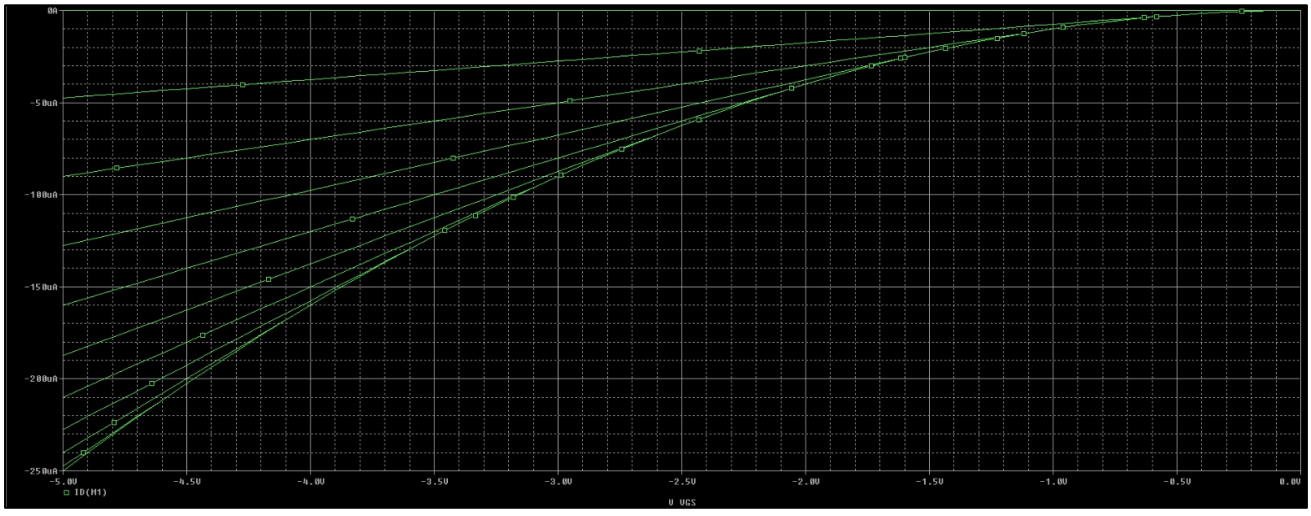

Fig. vi) Transfer characteristics of PMOS circuit

Result ↬

The experiment successfully demonstrated the drain and gate characteristics of NMOS and PMOS transistors. The simulation results aligned with theoretical expectations, showcasing the relationship between drain current and gate voltage under various conditions.

Conclusion ↬

The NMOS and PMOS characteristics were studied and analyzed using OrCAD PSpice. The simulation accurately captured the expected behavior, including the operation's linear, saturation, and cutoff regions. These results validate the theoretical models and provide insights into transistor behavior.

Precautions ↬

- Double-check the orientation of NMOS and PMOS transistors in the circuit.
- Ensure all connections are correct and components are securely placed.
- Do not exceed the voltage ratings of components.