LAB Experiment 7
MOSFET Charecteristics

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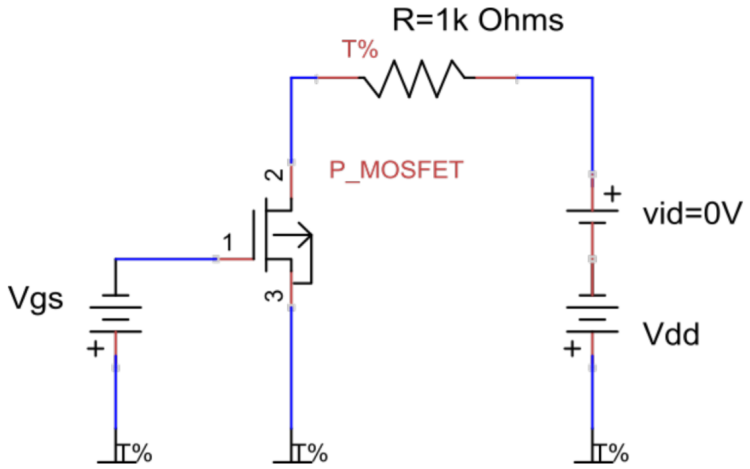
1 Aim

- Plot the $I_D - V_D$ output characteristics (-V_G = 1, 2, 3, 4, 5 V) and mark the important regions of operation.
- Plot the $I_D - V_G$ transfer characteristics for (-V_D = 1, 2, 3, 4, 5 V).
- Explain the working of the PMOSFET and the nature of the characteristics.

2 Procedure

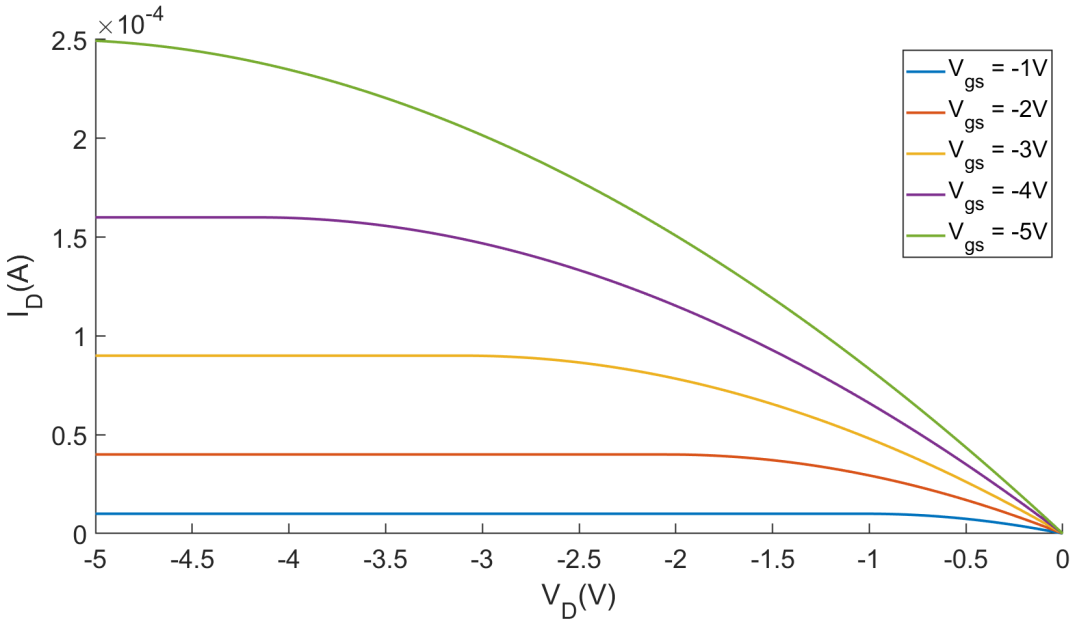


- Write the script in NGspice for the above circuit.
- For output characteristics vary the value of V_{dd} between 0 to 5 and plot different plots for different values of V_{gs}(1, 2, 3, 4, 5 V respectively)
- For transfer characteristics vary the value of V_{gs} between 0 to 5 and plot different plots for different values of V_{dd}(1, 2, 3, 4, 5 V respectively)

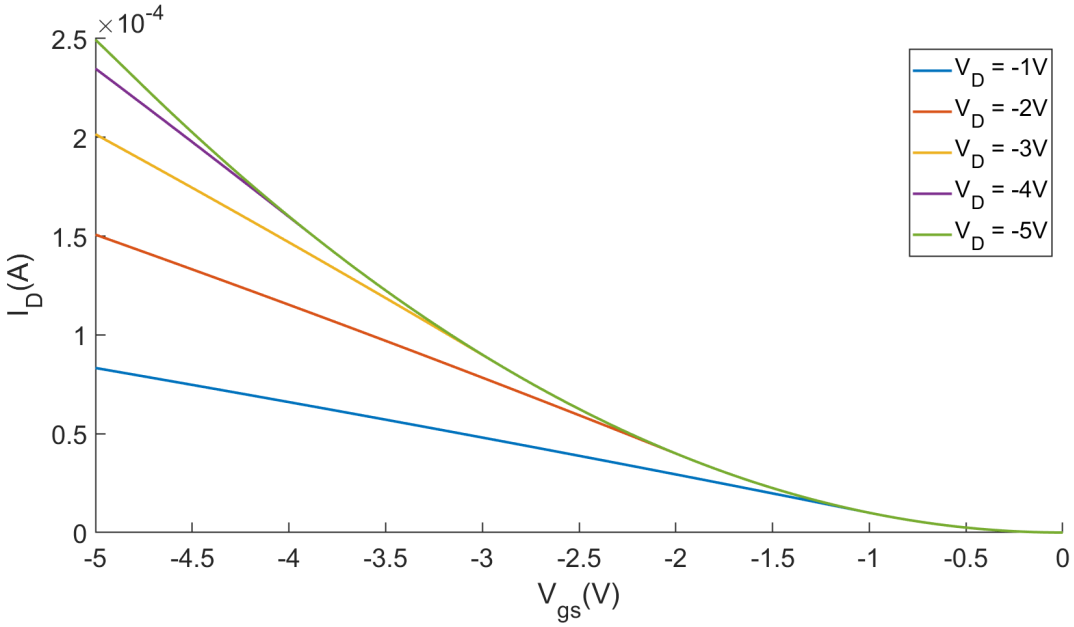
3 Results

3.1 Output characteristics

After printing the values from NGspice and using MatLab to plot we get the following graphs



3.2 Transfer characteristics



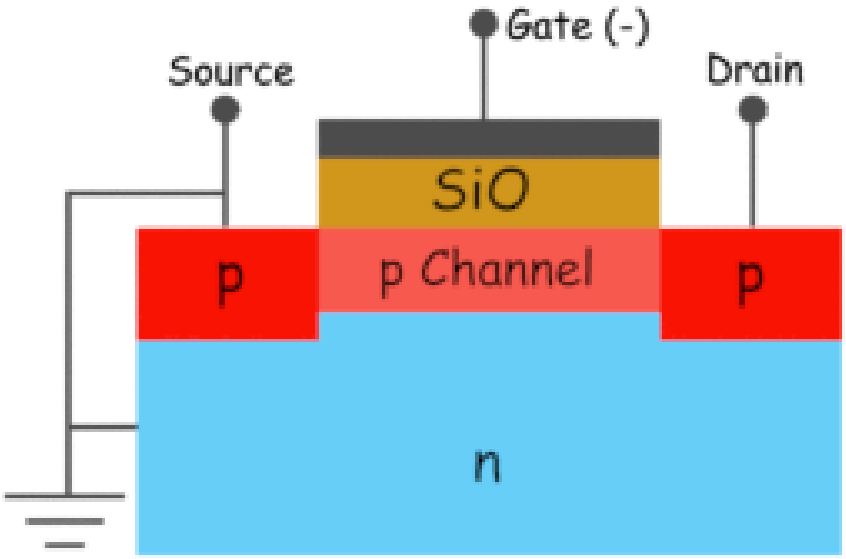
4 Understanding

- P channel MOSFET contains a substrate of lightly doped n-type semiconductor as the main body of the device.Two heavily doped p-type regions are there in the body separated by a certain distance.There is a thin layer of silicon dioxide (SiO_2) on the top of the substrate.This layer on the substrate behaves as a dielectric.There is an aluminum plate fitted on the top of this SiO_2 dielectric layer.The aluminum plate, dielectric and semiconductor substrate form a capacitor on the device.

- The terminals connected to two p-type regions are the source (S) and drain (D) of the device respectively. The terminal connected to the aluminum plate of the capacitor is the gate (G) of the device.

- When we apply the negative voltage to gate, the electrons present under the oxide layer are pushed downward into the substrate due to the repulsive force. Now this region is filled by the bound positive charges which are allied with the donor atoms. The negative voltage also attracts holes from from both heavily doped p-type source and drain region.

- After the voltage reaches a certain threshold voltage(V_T) electron-hole pairs get generated there. In this way, the concentration of holes increases here and a channel of holes from source to drain region is created. Due to the concentration of holes in the channel it becomes conductive in nature through which electric current can pass.



- If we further make the voltage more negative and it reaches a voltage called pinch-off voltage(V_P) the current stops increasing since most of the holes move towards drain and the p-channel is pinched off at source, so the current is saturated.

- From the transfer characteristics, we can see that I_D remains zero (cutoff state) until V_{gs} becomes equal to -V_T. This is because, only then the channel will be formed to connect the drain terminal with the source. After this, I_D increases as V_D becomes more negative(Ohmic region).
  However as V_D becomes equal to $-V_P$, the device enters into saturation during which a saturated amount of current (I_{Dss}) flows through the device, and from the output characteristics we can see that the value of saturation current flowing through the device increases as V_{gs} becomes more and more negative.

5 Conclusion

A MOSFET can act as a switching circuit since at the start it is in cut-off region(OFF state) and then goes into saturation region(ON state) at the end.
When the MOSFET is operated in the ohmic region we can see that its resistance changes slowly from the output characteristics plot, so it can be used as voltage controlled resistor.