EE236: Lab 8
p-Channel MOSFET I-V Characteristics

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1 Aim of the experiment

1. To measure output and transfer characteristics of a p-channel enhancement type MOSFET.
2. To investigate the effect of body bias on the characteristics of the pMOS.

2 Design & Working

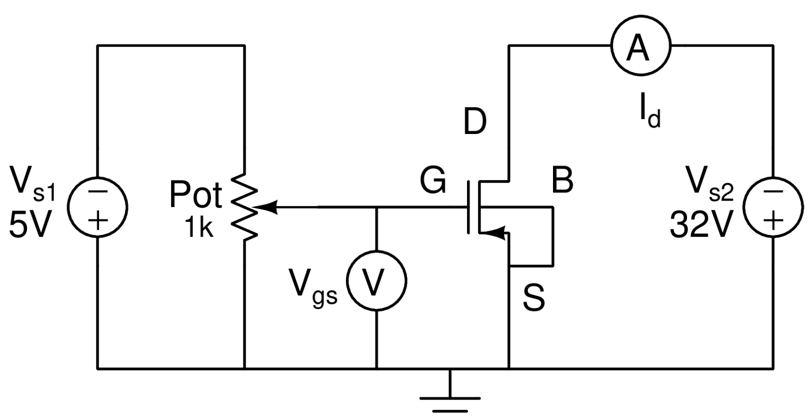

Fig. pMOS I-V Circuit

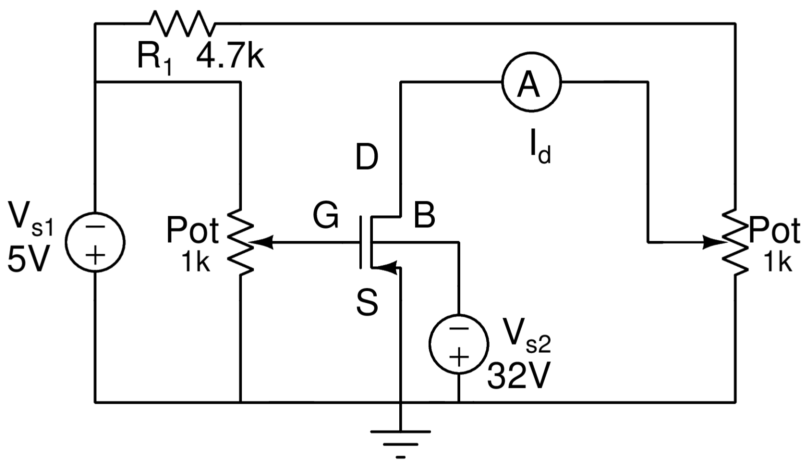

Fig. pMOS Body Effect Circuit

3 Experimental Results

For a pMOS to be "ON", the applied source-gate voltage must be greater than the threshold voltage (magnitude) i.e. $V_{SG} > |V_T|$. Otherwise it is said to be "OFF" (or in cut-off region).
The trans-conductance and the output resistance are respectively given by:

$$g_m = \left.\frac{\partial I_D}{\partial V_{SG}}\right|_{const\, V_{SD}} \qquad r_o = \left.\frac{\partial V_{SD}}{\partial I_D}\right|_{const\, V_{SG}} \tag{1}$$

3.1 Part-I

Given below are my readings for I_D and V_{SG} with the transistor biased in Linear region ($V_{SD} = 200mV$):

I_D (in mA)	V_{SG}
0	0
0	0.2
0	0.4
0	0.6
0.001	0.8
0.009	1
0.021	1.2
0.033	1.4
0.043	1.6
0.053	1.8
0.062	2
0.07	2.2
0.078	2.4

I_D (in mA)	V_{SG}
0.086	2.6
0.093	2.8
0.1	3
0.106	3.2
0.113	3.4
0.118	3.6
0.124	3.8
0.13	4
0.135	4.2
0.14	4.4
0.145	4.6
0.15	4.8
0.154	5

Given below is the plot for I_D vs V_{SG} for the given bias of $V_{SD} = 200mV$

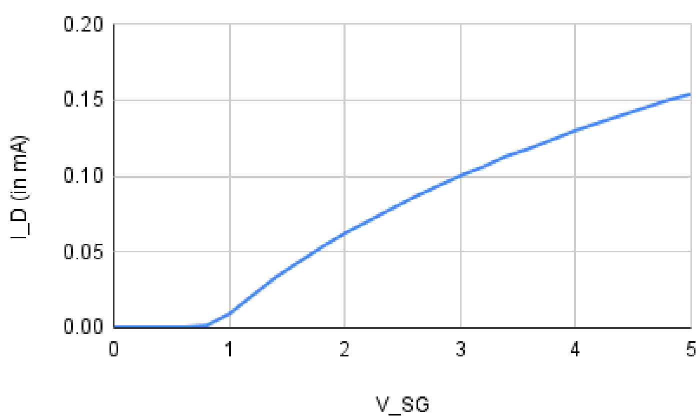

Fig. I_D vs V_{SG} Characteristics for Linear region

We obtain $g_m = 26.429mS$ and $V_T = 0.75V$.

Given below are my readings for I_D and V_{SG} with the transistor biased in Saturation region ($V_{SD} = 5V$):

I_D (in mA)	V_{SG}
0	0
0	0.2
0	0.4
0	0.6
0.001	0.8
0.013	1
0.038	1.2
0.072	1.4
0.12	1.6
0.18	1.8
0.239	2
0.317	2.2
0.399	2.4

I_D (in mA)	V_{SG}
0.48	2.6
0.577	2.8
0.671	3
0.771	3.2
0.877	3.4
0.997	3.6
1.112	3.8
1.23	4
1.356	4.2
1.487	4.4
1.618	4.6
1.749	4.8
1.887	5

Given below is the plot for I_D vs V_{SG} for the given bias of $V_{SD} = 5V$

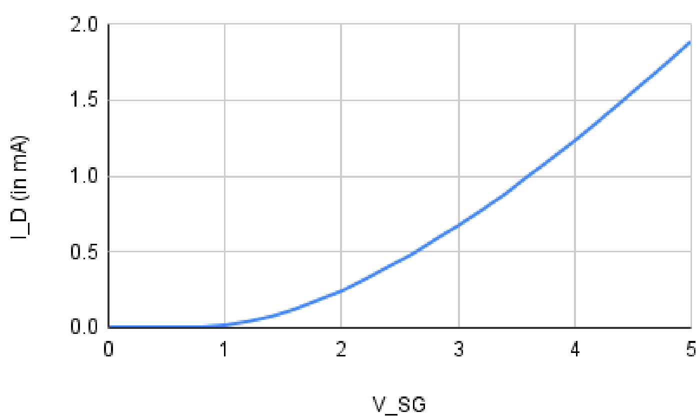

Fig. I_D vs V_{SG} Characteristics for Saturation region

We obtain $g_m = 635.714mS$ and $V_T = 0.85V$.

3.2 Part-II

Given below are my readings for I_D and V_{SD} with the transistor biased with V_{SG} = 1.5V, 2.5V, 3.5V:

V_{SD}	I_D (1.5V)	I_D (2.5V)	I_D (3.5V)
0	0	0	0
0.2	0.04	0.088	0.126
0.4	0.064	0.159	0.231
0.6	0.076	0.22	0.332
0.8	0.081	0.275	0.422
1	0.083	0.318	0.507
1.2	0.084	0.348	0.583
1.4	0.085	0.371	0.65
1.6	0.086	0.384	0.707
1.8	0.087	0.392	0.752
2	0.088	0.397	0.797
2.2	0.089	0.402	0.826
2.4	0.089	0.406	0.85
2.6	0.09	0.41	0.866
2.8	0.091	0.413	0.878
3	0.091	0.416	0.887
3.2	0.092	0.419	0.895
3.4	0.092	0.422	0.902
3.6	0.093	0.424	0.909
3.8	0.093	0.427	0.915
4	0.094	0.429	0.921
4.2	0.094	0.431	0.927
4.4	0.095	0.434	0.931
4.6	0.095	0.435	0.935
4.8	0.096	0.437	0.94
5	0.096	0.439	0.945

Given below is the plot for I_D vs V_{SD} for the given bias of $V_{SG} = 1.5\text{V}, 2.5\text{V}, 3.5\text{V}$:

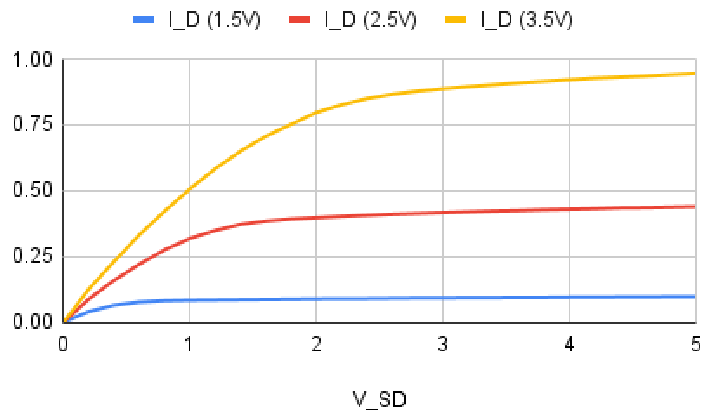

Fig. I_D vs V_{SD} Characteristics for varying V_{SG}

We obtain $r_o = 34.483\Omega$ for the case with $V_{SG} = 3.5V$.

3.2.1 Part-III

Given below are my readings for I_D and V_{SG} with the transistor biased with V_{SD} = 200mV for varying values of V_{SB}:

V_{SG}	I_D (-1V)	I_D (-2V)	I_D (-3V)
0	0	0	0
0.2	0	0	0
0.4	0	0	0
0.6	0	0	0
0.8	0	0	0
1	0.001	0	0
1.2	0.011	0.004	0.001
1.4	0.022	0.015	0.009
1.6	0.033	0.026	0.021
1.8	0.044	0.036	0.031
2	0.053	0.045	0.04
2.2	0.061	0.054	0.048
2.4	0.069	0.062	0.057

V_{SG}	I_D (-1V)	I_D (-2V)	I_D (-3V)
2.6	0.075	0.069	0.064
2.8	0.082	0.076	0.071
3	0.088	0.082	0.077
3.2	0.094	0.088	0.084
3.4	0.1	0.094	0.09
3.6	0.105	0.099	0.095
3.8	0.112	0.104	0.1
4	0.114	0.109	0.105
4.2	0.119	0.114	0.109
4.4	0.124	0.118	0.114
4.6	0.127	0.122	0.118
4.8	0.131	0.126	0.122
5	0.135	0.13	0.126

Given below is the plot for I_D vs V_{SG} for the given bias of $V_{SD} = 200\text{mV}$ and varying values of V_{SB}:

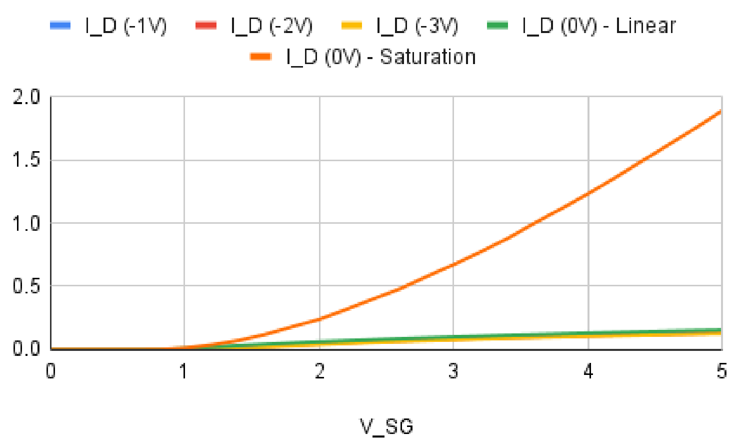

Fig. I_D vs V_{SG} Characteristics for varying V_{SB}

Given below are the observed values for the threshold voltage, V_T for different values of V_{SB}:

V_{SB}	V_T
0	0.85
-1	1
-2	1.1
-3	1.2

Given below is the plot for V_T vs V_{SB}:

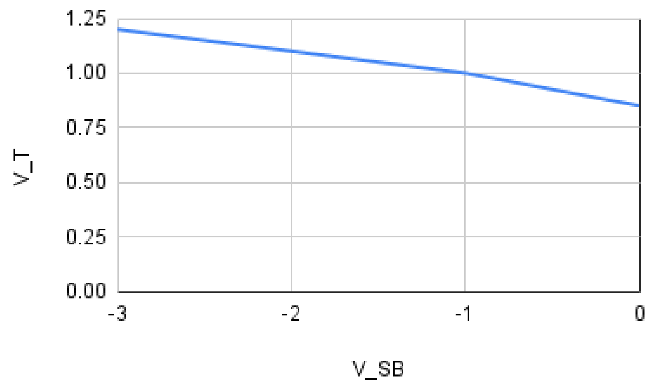

Fig. V_T vs V_{SB} Characteristics

The Body Effect coefficient can be calculated using the following equation:

$$V_T = V_{T_0} + \gamma(\sqrt{\phi_S - V_{SB}} - \sqrt{\phi_S}) \tag{2}$$

where $\phi_S = 0.8V$ is the Surface Potential and V_{T_0} is the threshold voltage when $V_{SB} = 0V$

Using the above equation, we get $\gamma = 0.3293\, V^{1/2}$