Analysis of I-V Characteristicsand Body Effect in NMOS

Keshav Samdani
22b3952

October 2024

1 Introduction

This report explores the I-V characteristics of an N-channel enhancement MOSFET (NMOS), focusing on its output and transfer characteristics. The body effect is analyzed to evaluate its impact on the device's performance. Essential parameters, such as threshold voltage, transconductance, and output resistance, are derived from the I-V curves and examined in detail.

2 Part 1: Transfer Characteristics

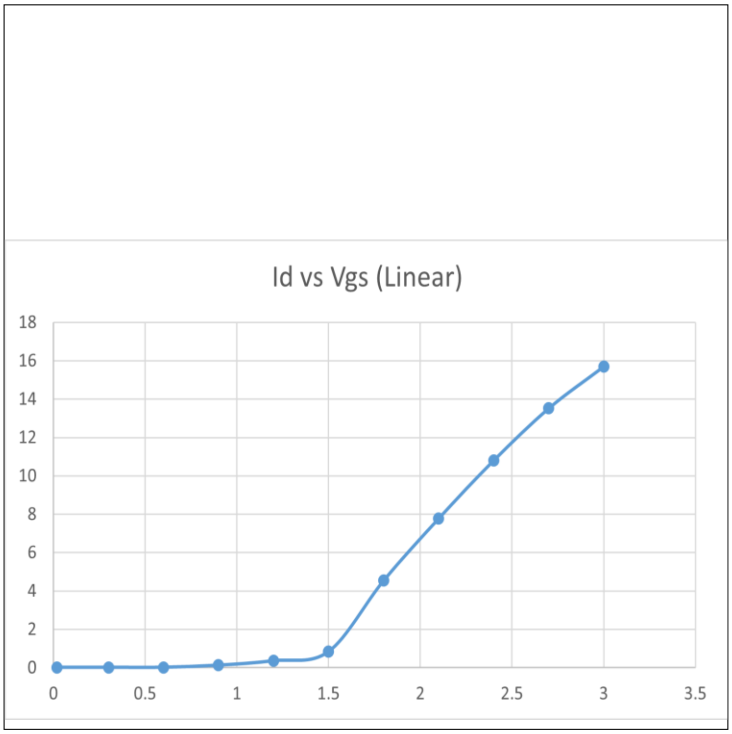

Figure 1: Schematic for Part-1 and Part-2 circuit configuration.

In this section, the NMOS is operated in both linear and saturation regions. The transfer characteristics, represented by I_D vs V_{GS}, are obtained by varying V_{GS} while keeping V_{DS} constant.

2.1 Linear Region ($V_{DS} = 0.2V$)

The results for the linear region are summarized in Table 1.

Table 1: Measured Transfer Characteristics in the Linear Region (V_{DS} = $0.2V$)

V_{GS} (V)	I_D (mA)
0.02	0.02
0.30	0.02
0.60	0.02
0.90	0.13
1.20	0.36
1.50	0.84
1.80	4.54
2.10	7.78
2.40	10.81
2.70	13.53
3.00	15.71

2.2 Saturation Region ($V_{DS} = 3V$)

The transfer characteristics in the saturation region are shown in Table 2.

Table 2: Measured Transfer Characteristics in the Saturation Region (V_{DS} = $3V$)

V_{GS} (V)	I_D (mA)
2.96	61.6
2.65	53.8
2.40	50.7
2.14	46.1
1.73	34.1
1.39	21.6
1.09	12.6
0.87	3.2
0.60	0.0
0.30	0.0
0.00	0.0

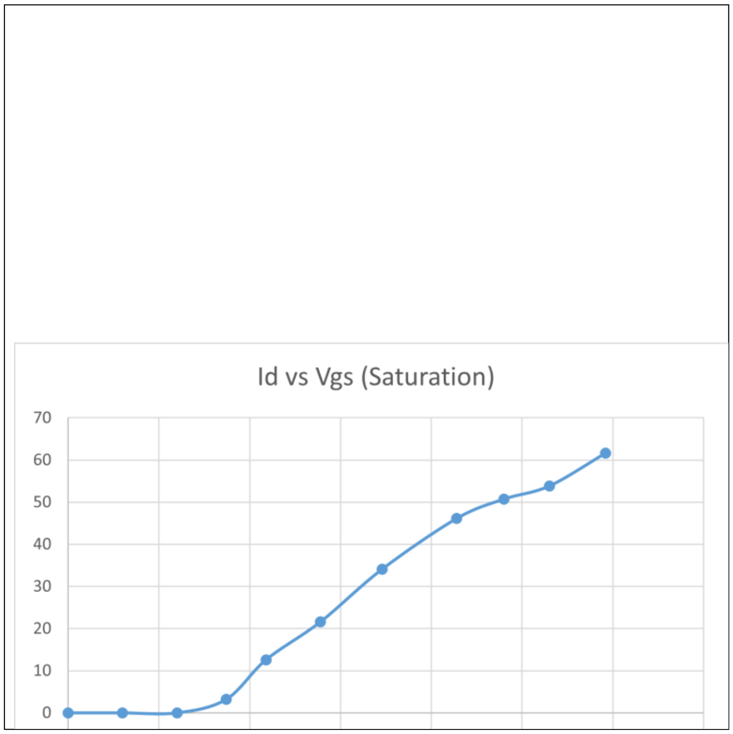

Figure 2: Schematic for $V_{DS} = 0.2V$ circuit.

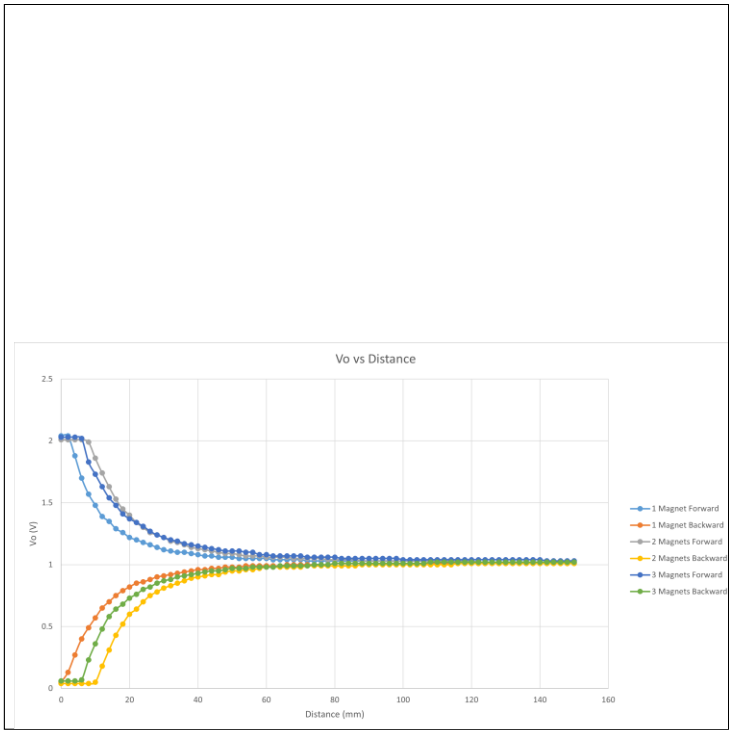

Figure 3: Schematic for $V_{DS} = 3V$ circuit.

3 Part 2: Drain Characteristics

The drain characteristics (I_D vs V_{DS}) are measured at three distinct gate voltages: $V_{GS} = 1.5V$, $V_{GS} = 2.5V$, and $V_{GS} = 3.5V$. The results for each case are presented in the following tables.

3.1 $V_{GS} = 1.5V$

Table 3: Drain Characteristics for $V_{GS} = 1.5V$

V_{DS} (V)	I_D (mA)
0.0	0.0
0.1	0.031
0.2	0.042
0.3	0.045
0.4	0.046
3.0	0.048
5.0	0.049

3.2 $V_{GS} = 2.5V$

Table 4: Drain Characteristics for V_{GS} = 2.5V

V_{DS} (V)	I_D (mA)
0.0	0.0
0.1	0.152
0.2	0.278
0.3	0.387
0.4	0.477
0.5	0.549
0.6	0.601
0.7	0.637
0.8	0.658
0.9	0.671
1.0	0.679
1.1	0.683
1.2	0.687
1.3	0.690
1.4	0.692
2.0	0.701
2.5	0.706
3.0	0.710
3.5	0.717
4.0	0.717
5.0	0.720

3.3 $V_{GS} = 3.5V$

Table 5: Drain Characteristics for $V_{GS} = 3.5V$

V_{DS} (V)	I_D (mA)
0.0	0.0
0.1	0.250
0.2	0.490
0.3	0.700
0.4	0.910
0.5	1.100
0.6	1.260
0.7	1.400
0.8	1.530
0.9	1.630
1.0	1.710
1.1	1.780
1.2	1.830
1.3	1.860
1.4	1.890
1.5	1.910
2.0	1.950
2.5	1.970
3.0	1.990
4.0	2.010
5.0	2.020

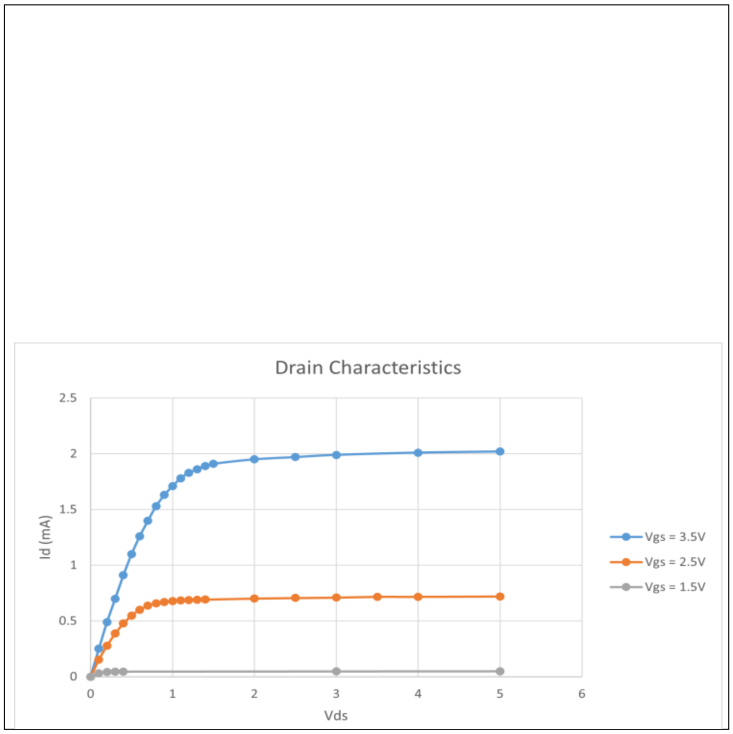

Figure 4: Schematic for Drain Characteristics Circuit.

4 Part 3: Body Effect Analysis

In this part, the threshold voltage is extracted under varying source-bulk voltages. The body effect is analyzed by evaluating the change in the threshold voltage.

4.1 Threshold Voltage Extraction

Table 6 provides the measured threshold voltages as a function of V_{SB}.

Table 6: Threshold Voltage (V_T) as a Function of Source-Bulk Voltage (V_{SB})

V_{SB} (V)	V_T (V)
0.0	0.8
1.0	0.9
2.0	1.0
3.0	1.1

5 Conclusion

This lab experiment offered an in-depth analysis of the I-V characteristics of an NMOS transistor, focusing on both its transfer and output characteristics. By collecting data at various gate-source and drain-source voltages, key device parameters such as threshold voltage and transconductance were extracted. The experiment also highlighted the body effect, as changes in the source-bulk voltage demonstrated its impact on threshold voltage. These findings are crucial for understanding the behavior of MOSFETs in real-world circuits.