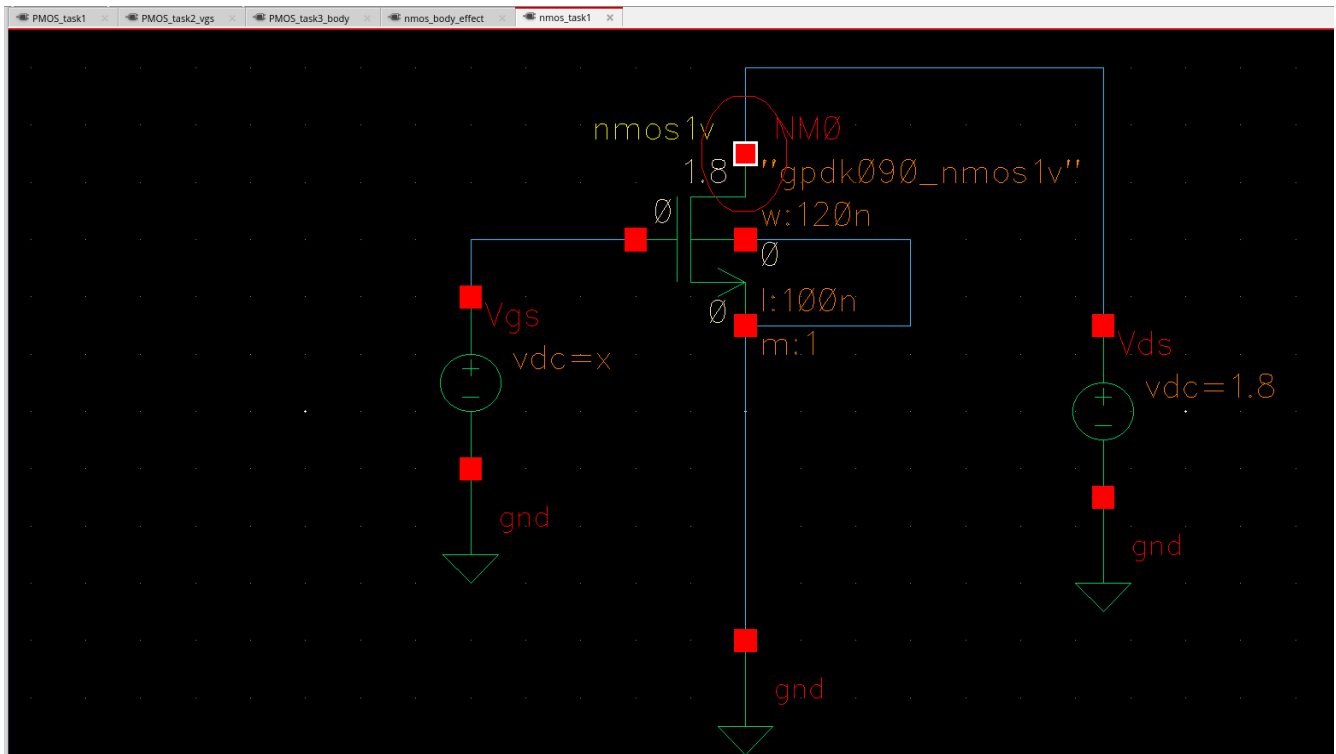


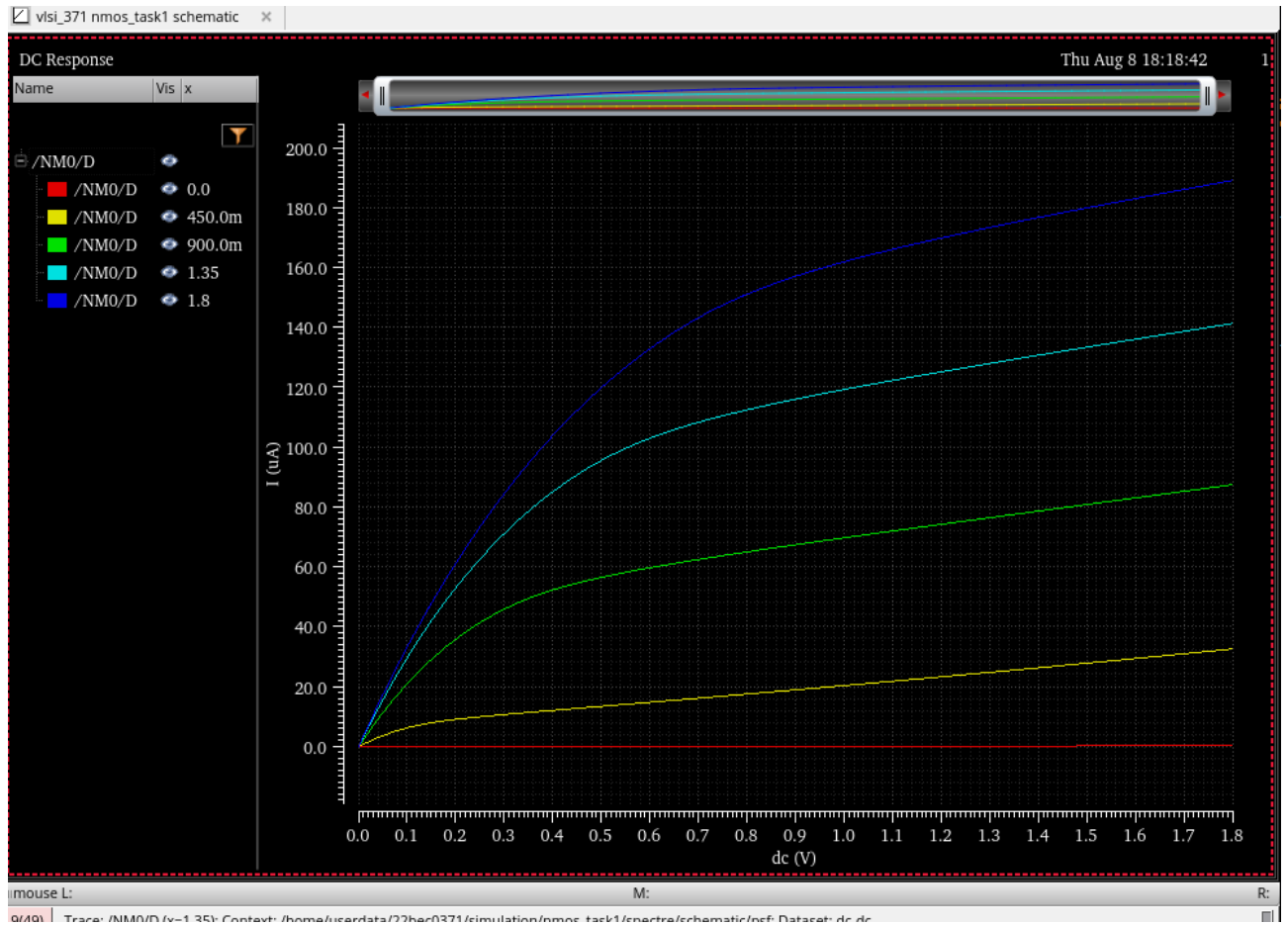
EXPERIMENT -1 N- MOSFET Characteristics

Objectives:

1. To plot the V_{ds} - I_{ds} (output) characteristics of NMOS transistor as a function of V_{gs} by parametric analysis.
 - a. Circuit diagram for obtaining output characteristics of an NMOS:

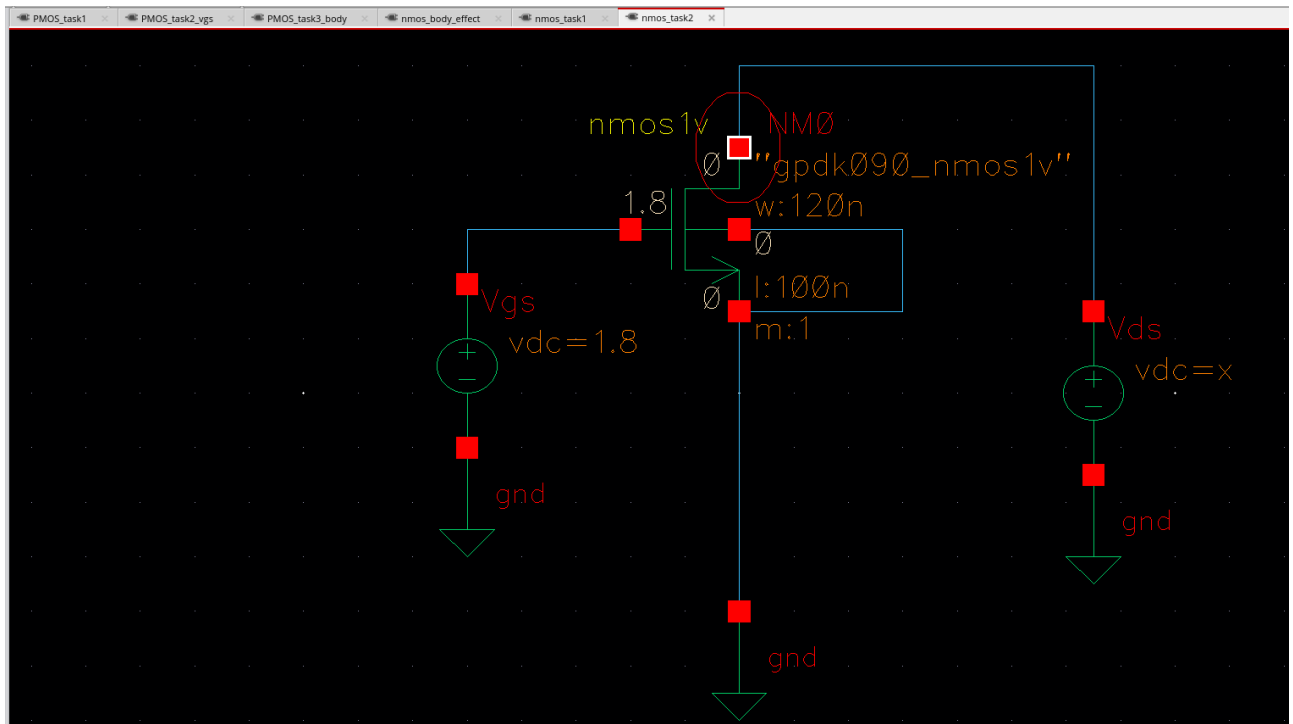


b. Plot of I_{ds} vs V_{ds} for change in V_{gs} :

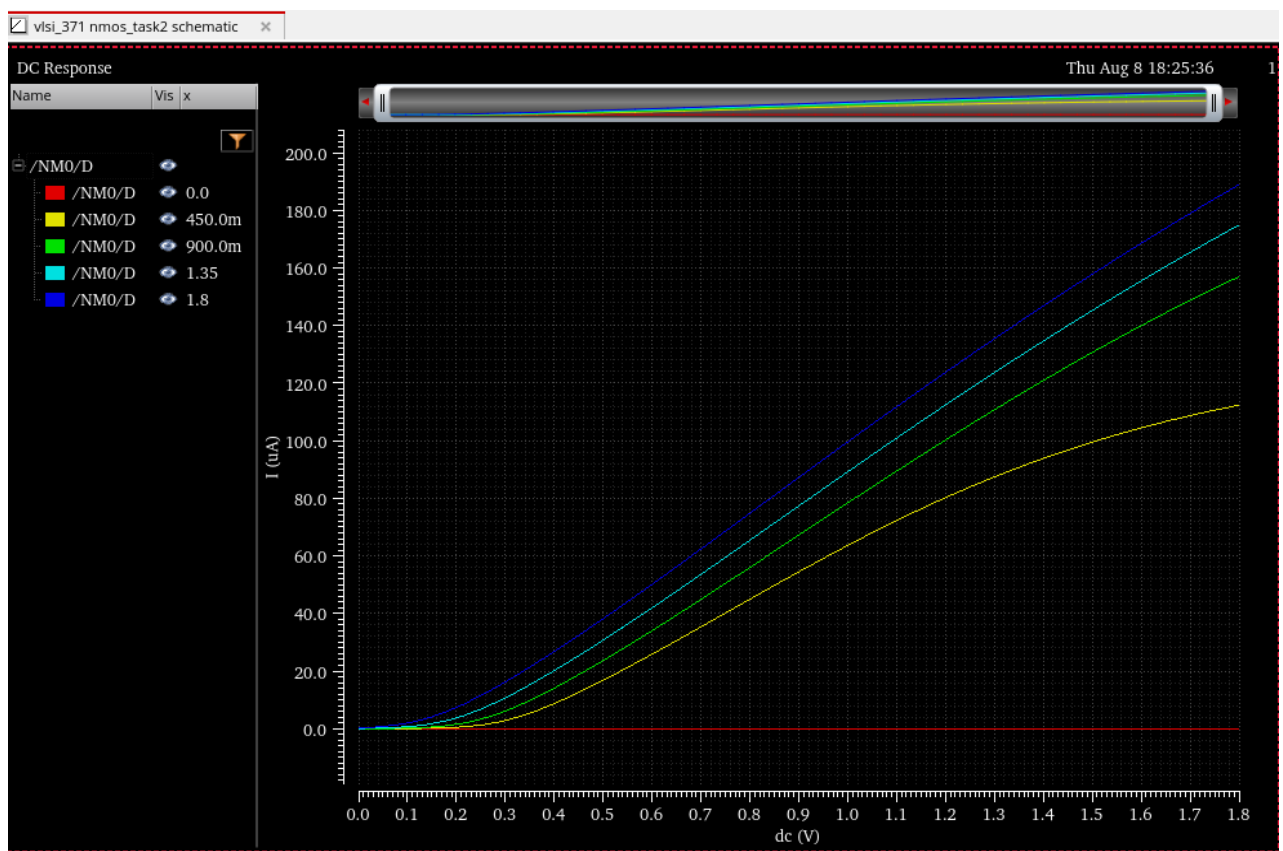


2. To plot the I_D Vs V_{GS} (input) characteristics as a function of V_{ds} through parametric analysis.

a. Circuit diagram for obtaining input characteristics of an NMOS:

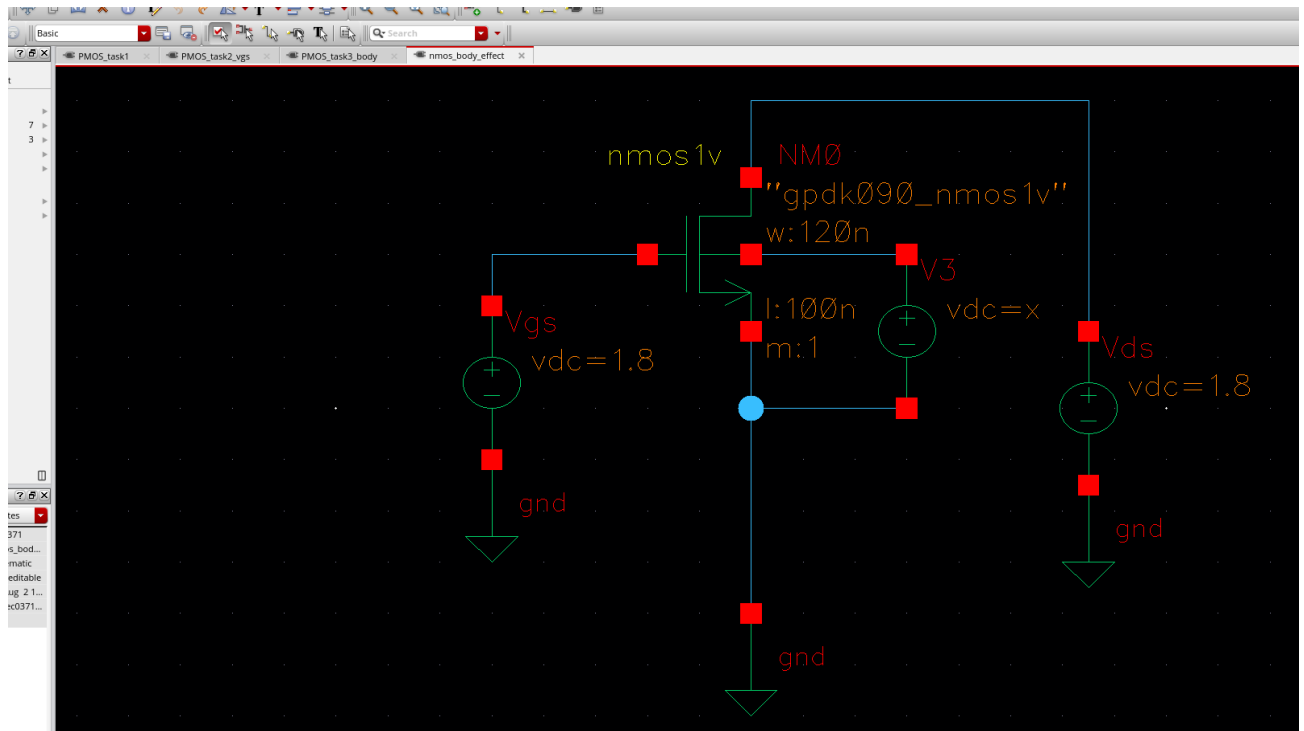


b. Plot of I_{ds} vs V_{gs} for change in V_{ds} :

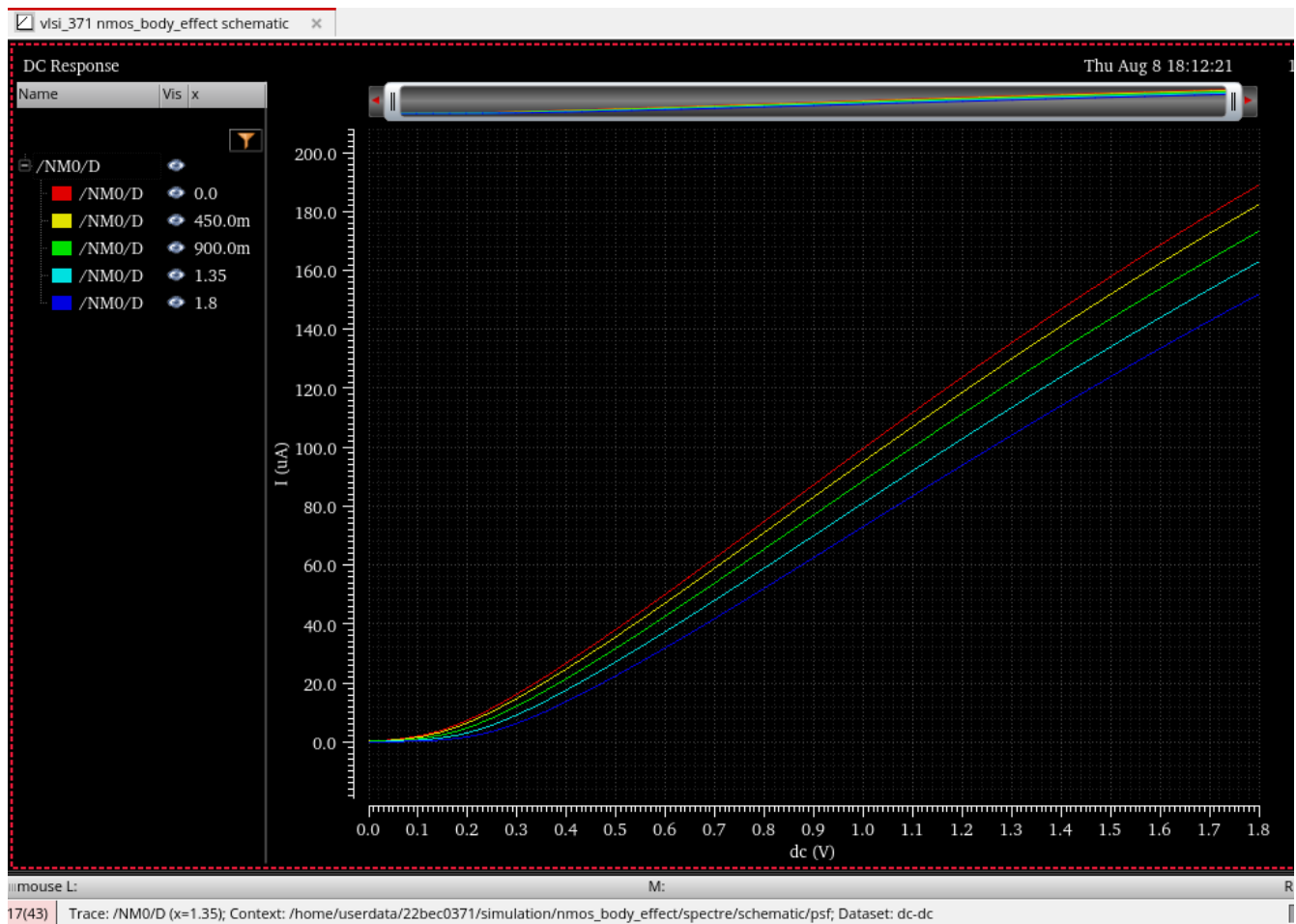


3. To plot the I_D Vs V_{GS} curves as a function of V_{SB} and show the body effect on threshold voltage.

a. Circuit diagram for finding the body effect of an NMOS:



b. Plot of I_{ds} vs V_{gs} for change in V_{bs} with constant $V_{ds}=1.8\text{v}$:



| Results Display Window (on cadence-server) | | | | | | | | | | | | | | | | |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Window Expressions Info Help | | | | | | | | | | | | | | | | cad |
| OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? | OP("NMOS" ??? |
| betaeff | gmbs | gds | gm | vtbeff | vdsat | vth | vgs | vds | vgs | vds | vgs | vds | vgs | isub | ids | trise |
| 278.793u | -10.5801u | 29.7583u | 98.4186u | -939.604m | 703.774m | 29.4249m | 0 | 1.8 | 1.8 | 0 | 1.8 | 1.8 | 1.8 | 11.8598m | 189.092u | NaN |
| 269.447u | -18.1508u | 24.8965u | 96.5317u | -940.461m | 704.047m | 37.4871m | 0 | 1.35 | 1.35 | 450m | 1.8 | 1.8 | 1.8 | 11.4226m | 182.464u | NaN |
| 258.615u | -21.9507u | 19.9621u | 94.4005u | -940.976m | 703.582m | 58.6933m | 0 | 900m | 900m | 900m | 1.8 | 1.8 | 1.8 | 10.8826m | 173.381u | NaN |
| 247.322u | -23.917u | 15.0274u | 92.166u | -941.319m | 701.488m | 87.3891m | 0 | 450m | 450m | 1.35 | 1.8 | 1.8 | 1.8 | 10.362m | 163.038u | NaN |
| 236.056u | -24.8475u | 10.1601u | 89.8671u | -941.564m | 697.231m | 120.772m | 0 | 0 | 0 | 1.8 | 1.8 | 1.8 | 1.8 | 9.91328m | 152.06u | NaN |

Result Analysis:

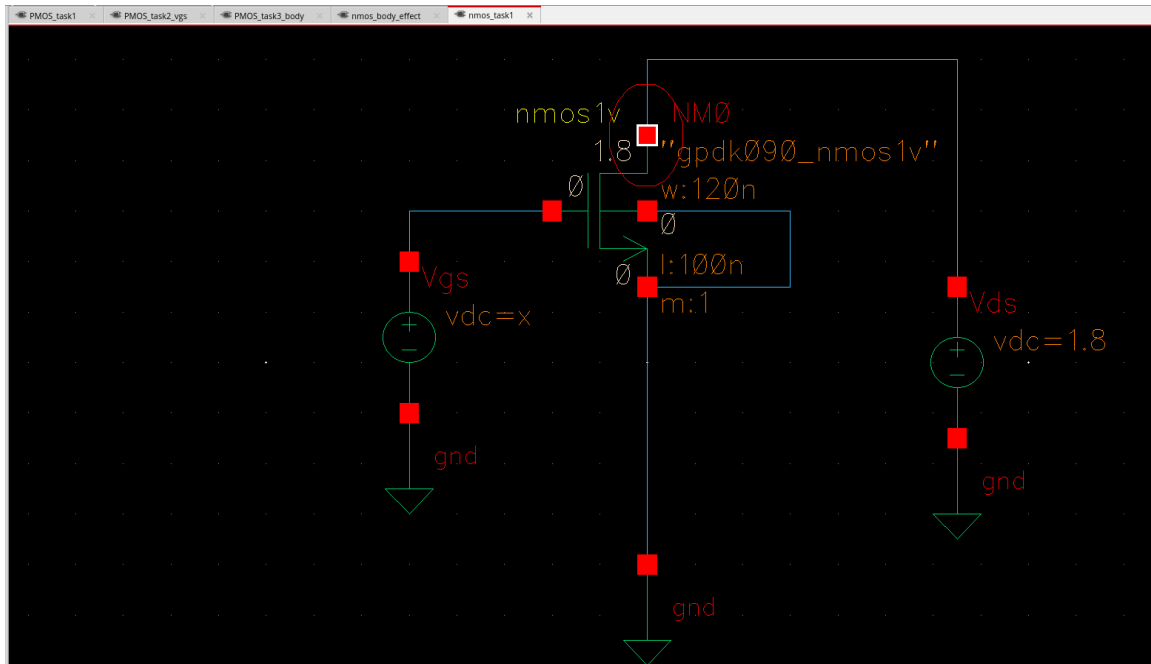
Table showing threshold voltage values for different of Vsb.

| S No | V _{SB} (V) | V _{TH} (mV) |
|------|---------------------|----------------------|
| 1. | 0 | 29.429m |
| 2. | 450m | 37.4871m |
| 3 | 900m | 58.6933m |
| 4 | 1.35 | 87.3891m |
| 5. | 1.8 | 120.722m |

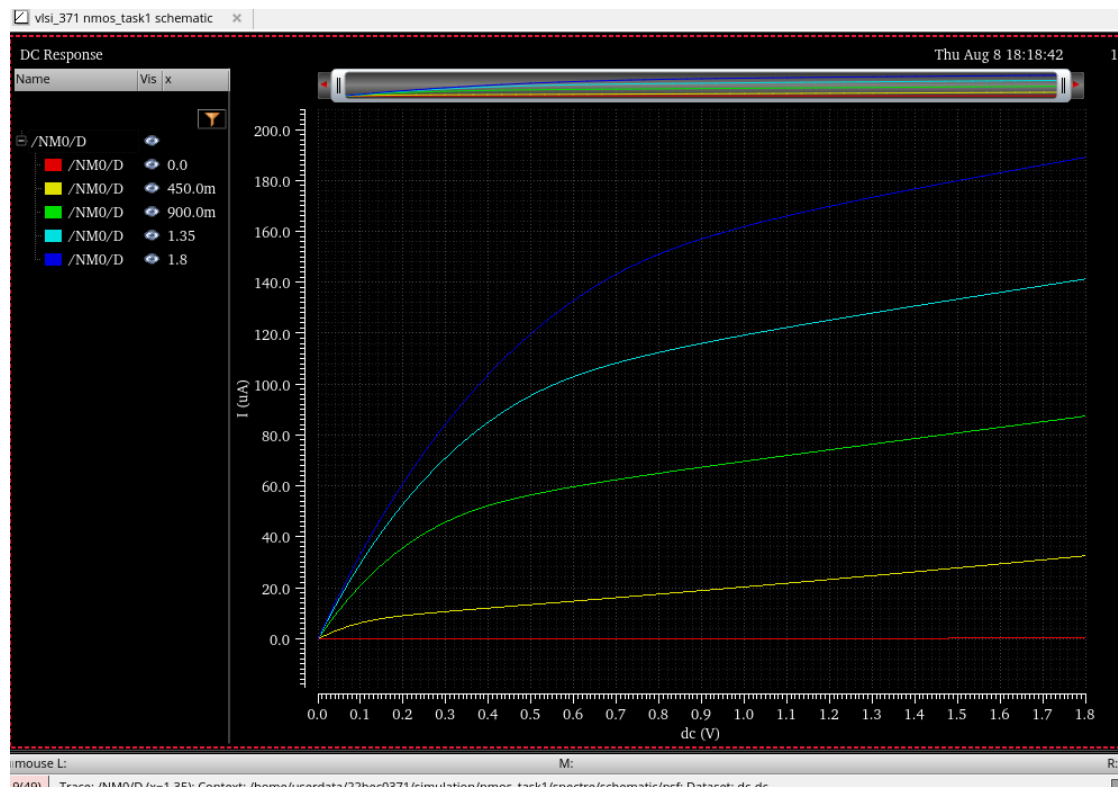
By observing the above plot and table, an increase in VSB results in an increase in the threshold voltage.

4. To find channel length modulation co-efficient (λ) of NMOS transistor by plotting I_{ds} vs V_{ds} .

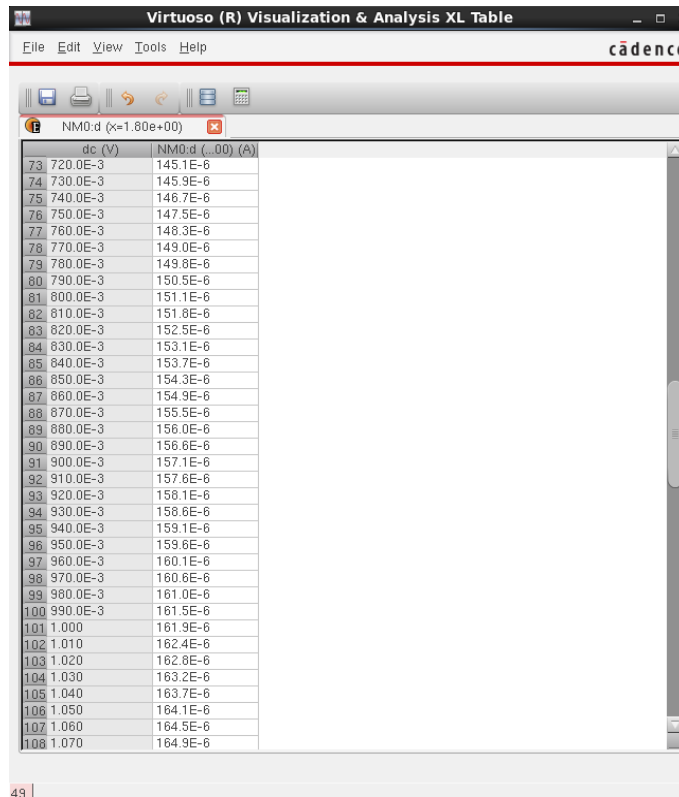
- a. Circuit diagram for obtaining output characteristics of an NMOS:



- b. Plot of I_{ds} vs V_{ds} for change in V_{gs}



- c. To find channel length modulation coefficient(λ) different values of I_{ds} and corresponding values of V_{ds} has been printed as shown.



The screenshot shows a window titled "Virtuoso (R) Visualization & Analysis XL Table" with a menu bar (File, Edit, View, Tools, Help) and a toolbar. The table is titled "NM0.d (λ=1.80e+00)". It contains two columns: "dc (V)" and "NM0.d (.00) (A)". The table lists 36 rows of data, with the last row (108) showing a value of 1.070 for dc (V) and 164.9E-6 for NM0.d (.00) (A).

| | dc (V) | NM0.d (.00) (A) |
|-----|----------|-----------------|
| 73 | 720.0E-3 | 145.1E-6 |
| 74 | 730.0E-3 | 145.9E-6 |
| 75 | 740.0E-3 | 146.7E-6 |
| 76 | 750.0E-3 | 147.5E-6 |
| 77 | 760.0E-3 | 148.3E-6 |
| 78 | 770.0E-3 | 149.0E-6 |
| 79 | 780.0E-3 | 149.8E-6 |
| 80 | 790.0E-3 | 150.5E-6 |
| 81 | 800.0E-3 | 151.1E-6 |
| 82 | 810.0E-3 | 151.8E-6 |
| 83 | 820.0E-3 | 152.5E-6 |
| 84 | 830.0E-3 | 153.1E-6 |
| 85 | 840.0E-3 | 153.7E-6 |
| 86 | 850.0E-3 | 154.3E-6 |
| 87 | 860.0E-3 | 154.9E-6 |
| 88 | 870.0E-3 | 155.5E-6 |
| 89 | 880.0E-3 | 156.0E-6 |
| 90 | 890.0E-3 | 156.6E-6 |
| 91 | 900.0E-3 | 157.1E-6 |
| 92 | 910.0E-3 | 157.6E-6 |
| 93 | 920.0E-3 | 158.1E-6 |
| 94 | 930.0E-3 | 158.6E-6 |
| 95 | 940.0E-3 | 159.1E-6 |
| 96 | 950.0E-3 | 159.6E-6 |
| 97 | 960.0E-3 | 160.1E-6 |
| 98 | 970.0E-3 | 160.6E-6 |
| 99 | 980.0E-3 | 161.0E-6 |
| 100 | 990.0E-3 | 161.5E-6 |
| 101 | 1.000 | 161.9E-6 |
| 102 | 1.010 | 162.4E-6 |
| 103 | 1.020 | 162.8E-6 |
| 104 | 1.030 | 163.2E-6 |
| 105 | 1.040 | 163.7E-6 |
| 106 | 1.050 | 164.1E-6 |
| 107 | 1.060 | 164.5E-6 |
| 108 | 1.070 | 164.9E-6 |

$$I_{ds} = \mu n C_{ox} \frac{W}{L} \frac{(V_{gs} - V_{th})^2}{2} (1 + \lambda V_{ds})$$

$$\frac{I_{ds1}}{I_{ds2}} = \frac{1 + \lambda V_{ds1}}{1 + \lambda V_{ds2}}$$

$$\frac{148.4092 \times 10^{-6}}{158.2982 \times 10^{-6}} = \frac{1 + \lambda 761.5854 \times 10^{-3}}{1 + \lambda 923.3846 \times 10^{-3}}$$

On calculating λ value $\rightarrow \lambda = 0.62908$ per volt

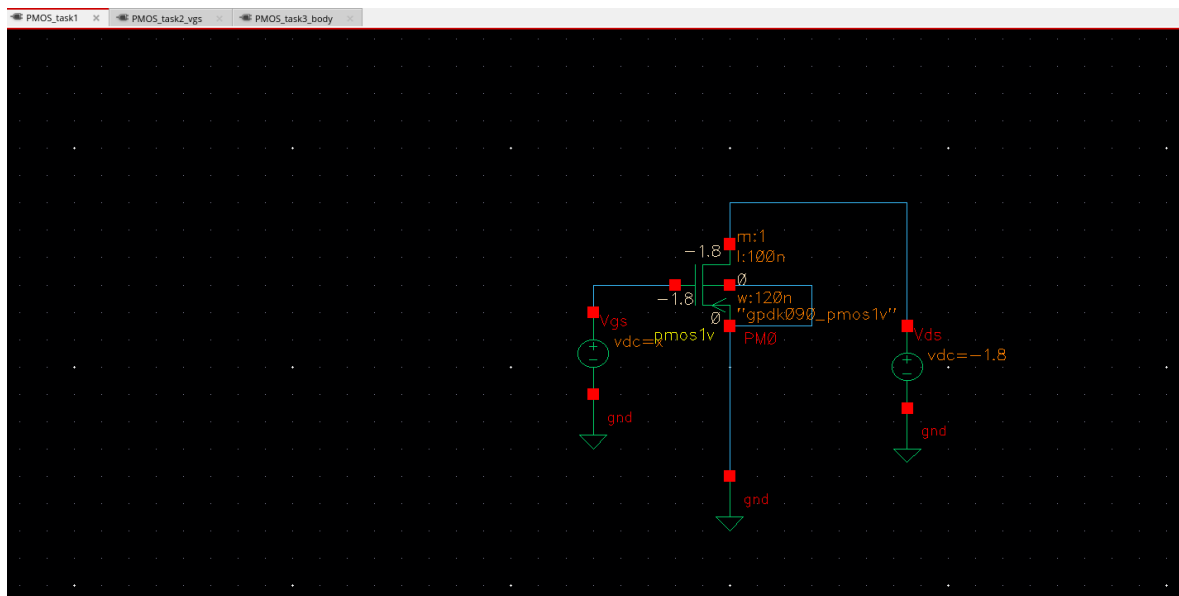
CONCLUSION OF NMOS I-V CHARACTERISTICS:

1. The output characteristics of NMOS was plotted
2. The input characteristics of NMOS was plotted.
3. The body effect of NMOS i.e. plot of I_G Vs V_{GS} as function of V_{SB} was also plotted and value of threshold voltage for different V_{SB} values were tabulated. The threshold value of NMOS FET at zero body bias is 29.429 mV
4. The channel length modulation co-efficient value (λ) for NMOS is 0.62908 **per volt**.

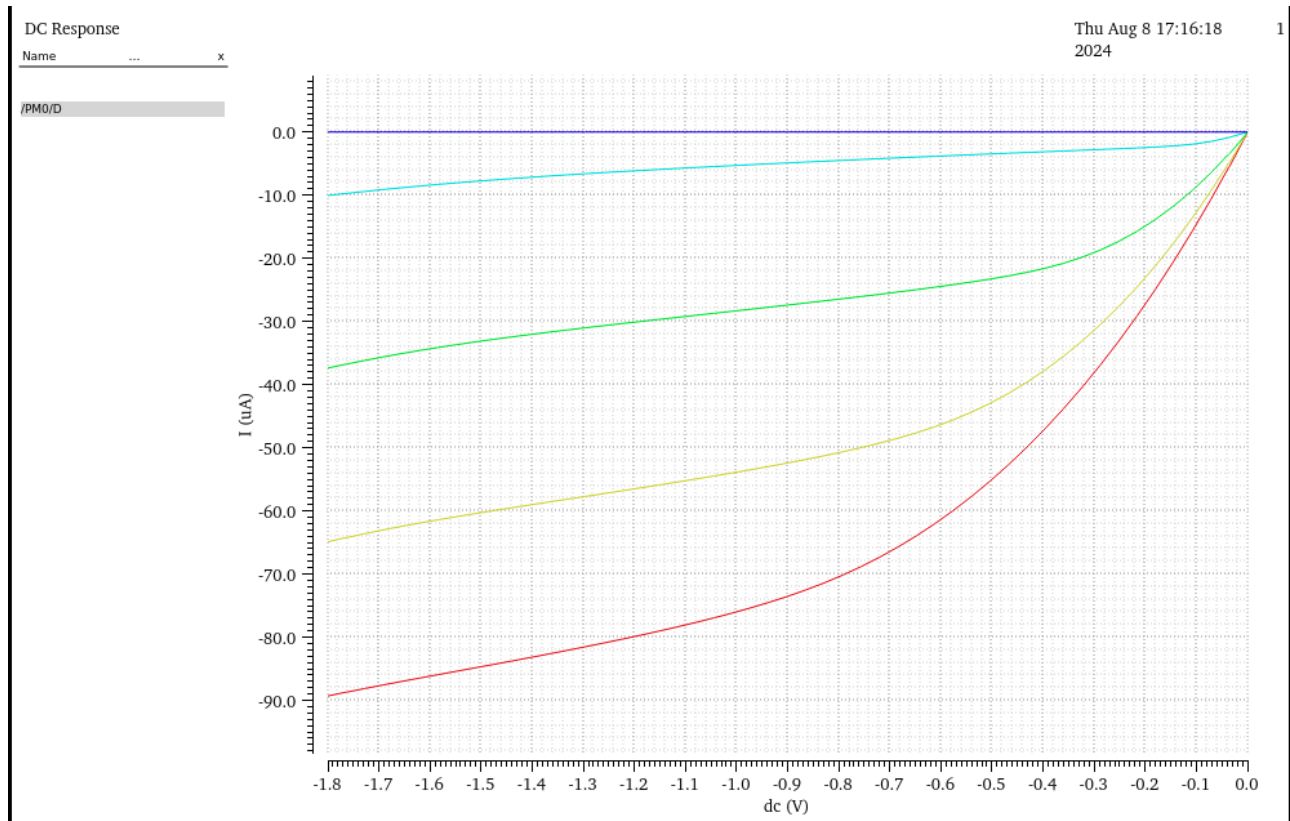
TASK -1 P- MOSFET Characteristics

1. To plot the V_{ds} - I_{ds} (output) characteristics of PMOS transistor as a function of V_{gs} by parametric analysis.

a. Circuit diagram for obtaining output characteristics of an PMOS:

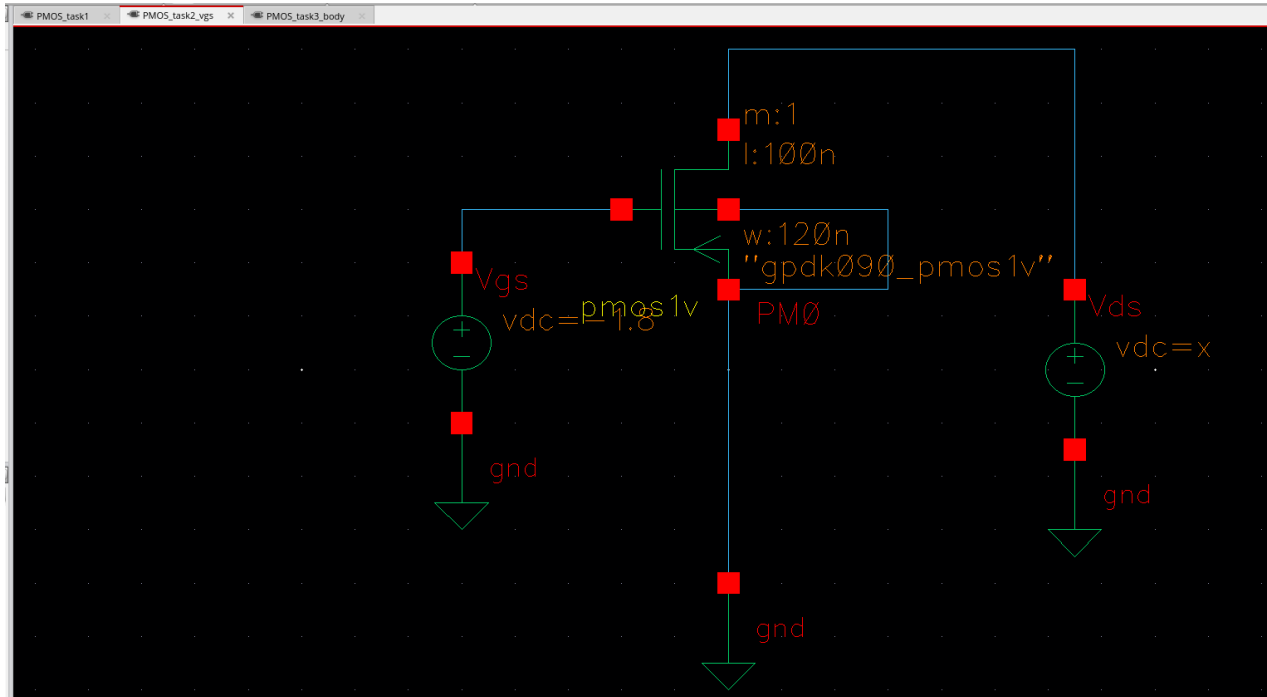


b. Plot of I_{ds} vs V_{ds} for change in V_{gs} :



2. To plot the I_D Vs V_{GS} (input) characteristics as a function of V_{ds} through parametric analysis.

a. Circuit diagram for obtaining input characteristics of an PMOS:



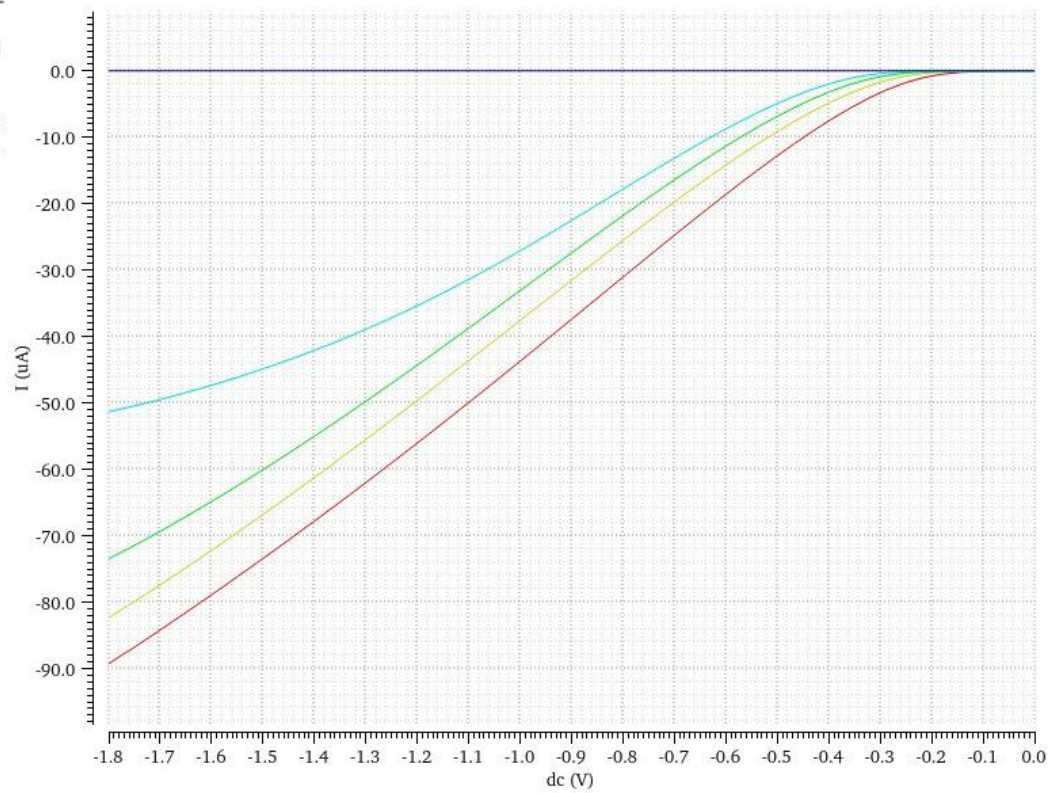
b. Plot of I_{ds} vs V_{gs} for change in V_{ds} :

DC Response

Thu Aug 8 17:25:03
2024

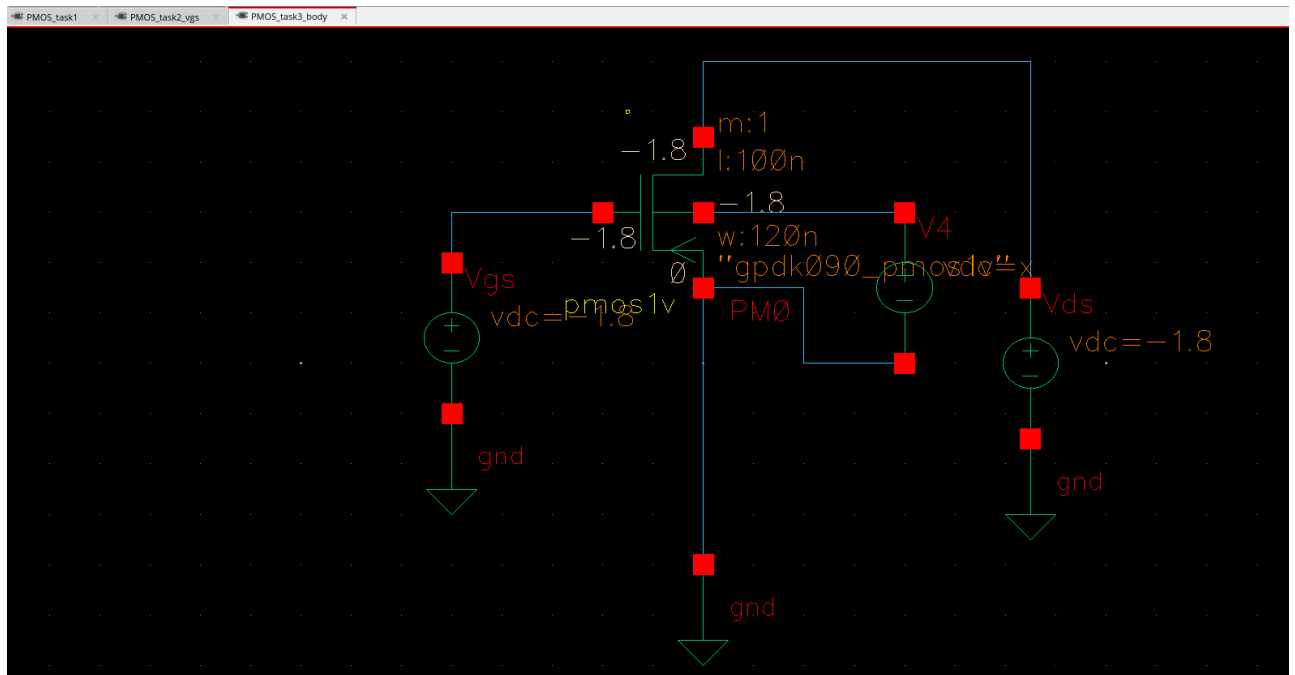
Name ... x

| /PM0/D | | |
|--|--|---------|
| ■ /PM0/D | | -1.8 |
| ■ /PM0/D | | -1.35 |
| ■ /PM0/D | | -900.0m |
| ■ /PM0/D | | -450.0m |
| ■ /PM0/D | | 0.0 |



3. To plot the I_D Vs V_{GS} curves as a function of V_{SB} and show the body effect on threshold voltage.

a. Circuit diagram for finding the body effect of an PMOS:



b. Plot of I_{ds} vs V_{gs} for change in V_{bs} with constant $V_{ds}=-1.8v$:



| Results Display Window (on cadence-server) | | | | | | | | | | | | | | | | |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Window | Expressions | Info | Help | | | | | | | | | | | | | |
| OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" | OP("PMO") "??" |
| staeff | gmbs | gds | gn | vbeff | vsat | vth | vgd | vdb | vgb | vbs | vds | vgs | isub | ids | trise | |
| 125.513u | -6.79879u | 16.9033u | 46.6187u | -789.83m | -763.287m | -86.7571m | 0 | 0 | 0 | -1.8 | -1.8 | -1.8 | -57.9496p | -81.1266u | NaN | |
| 127.63u | -6.50392u | 17.0357u | 47.5885u | -789.594m | -785.913m | -98.991m | 0 | -450m | -450m | -1.35 | -1.8 | -1.8 | -50.2985p | -84.1912u | NaN | |
| 129.543u | -5.31408u | 17.1835u | 48.5689u | -789.252m | -808.033m | -115.256m | 0 | -900m | -900m | -900m | -1.8 | -1.8 | -43.2652p | -86.8719u | NaN | |
| 131.053u | -3.10568u | 17.2859u | 49.5572u | -788.733m | -829.443m | -137.973m | 0 | -1.35 | -1.35 | -450m | -1.8 | -1.8 | -36.8205p | -88.8123u | NaN | |
| 131.752u | 1.29971u | 17.2867u | 50.48u | -787.853m | -849.532m | -172.073m | 0 | -1.8 | -1.8 | 0 | -1.8 | -1.8 | -30.9674p | -89.3286u | NaN | |

Result Analysis:

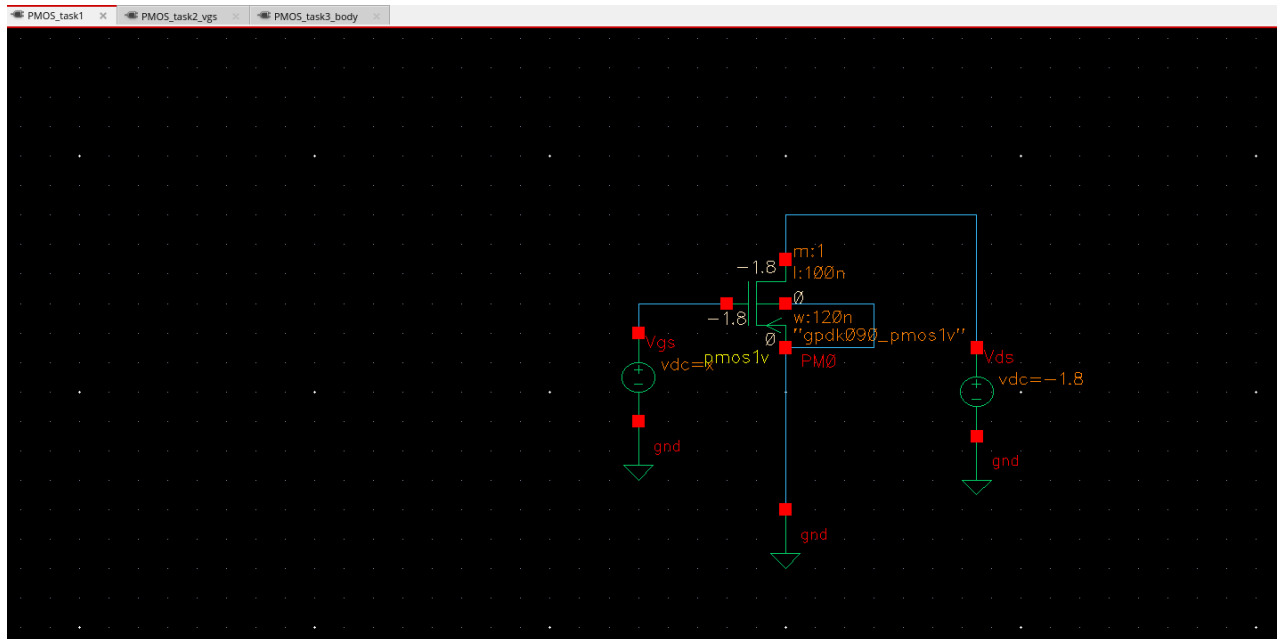
Table showing threshold voltage values for different of V_{sb} .

| S No | V_{SB} (V) | $V_{TH}(mV)$ |
|------|--------------|--------------|
| 1. | 0 | -86.7571m |
| 2. | -450m | -98.991m |
| 3 | -900m | -115.256m |
| 4 | -1.35 | -137.973m |
| 5. | -1.8 | -172.073m |

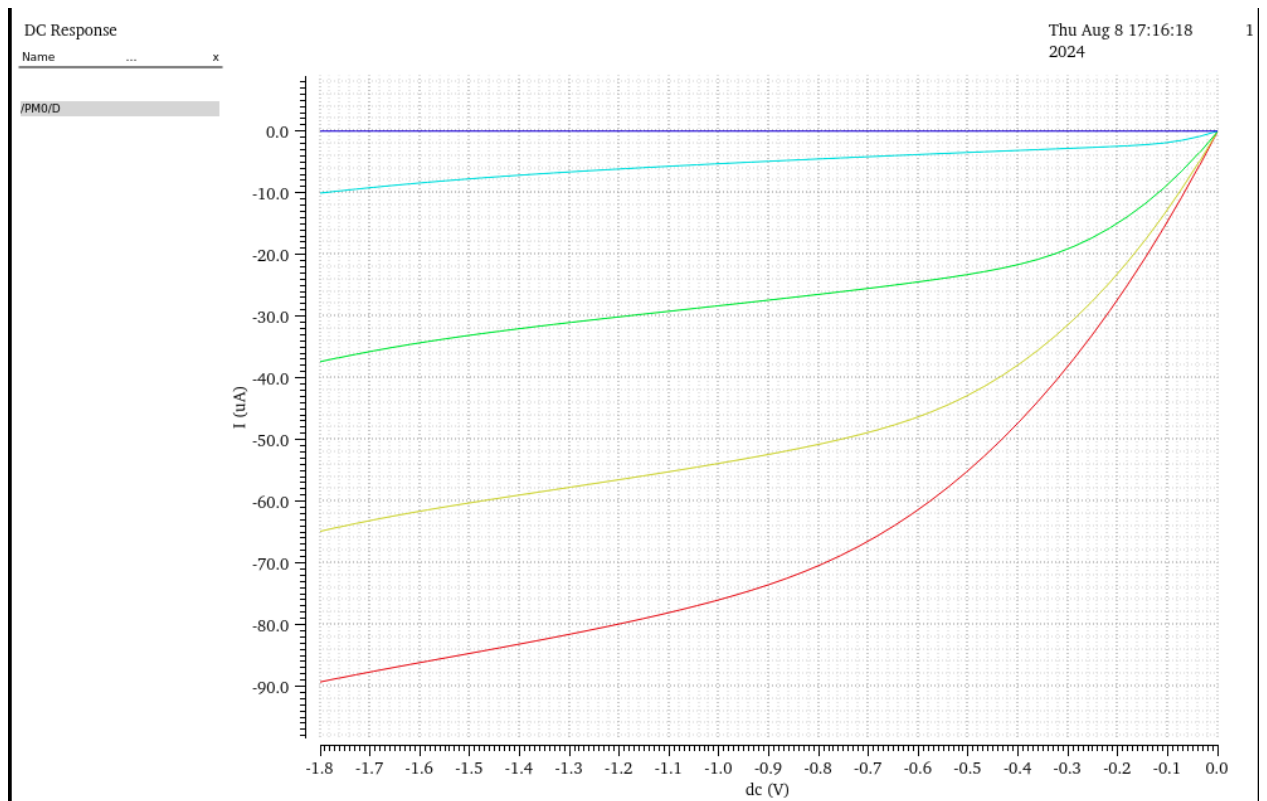
By observing the above plot and table, an increase in V_{SB} results in an increase in the threshold voltage.

4. To find channel length modulation co-efficient (λ) of PMOS transistor by plotting I_{ds} vs V_{gs} .

a. Circuit diagram for obtaining output characteristics of an PMOS:



b. Plot of I_{ds} vs V_{ds} for change in V_{gs} :



$$I_{ds} = \mu_n C_{ox} \frac{W}{L} \frac{(V_{gs} - V_{th})^2}{2} (1 + \lambda V_{ds})$$

$$\frac{I_{ds1}}{I_{ds2}} = \frac{1 + \lambda V_{ds1}}{1 + \lambda V_{ds2}}$$

$$\frac{-83.78 \times 10^{-6}}{-88.72 \times 10^{-6}} = \frac{1 + \lambda (-1.440)}{1 + \lambda (-1.764)}$$

$$\lambda = -0.2466 \text{ per volt}$$

CONCLUSION OF PMOS I-V CHARACTERISTICS:

1. The output characteristics of PMOS was plotted
2. The input characteristics of PMOS was plotted.
3. The body effect of PMOS i.e. plot of I_G Vs V_{GS} as function of V_{SB} was also plotted and value of threshold voltage for different V_{SB} values were tabulated. The threshold value of PMOS FET at zero body bias is -86.429 mV
4. The channel length modulation co-efficient value (λ) for PMOS is - 0.2466 **per volt**.

THANK YOU