

Analog IC Design: Assignment-2

Spring 2026, IIIT Hyderabad

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Due Date: February 23, 2026 (18:00 hrs)

Question 1: n-channel MOSFET Characteristics

Considering $V_{DS} = 1V$ and $\frac{W}{L} = \frac{500n}{180n}$:

(a) I_D vs V_{GS} and g_m vs V_{GS} Plots

Cases: (i) $V_{SB} = 0V$, (ii) $V_{SB} = 0.9V$, (iii) $V_{SB} = -0.9V$.

Schematic and Simulation Setup

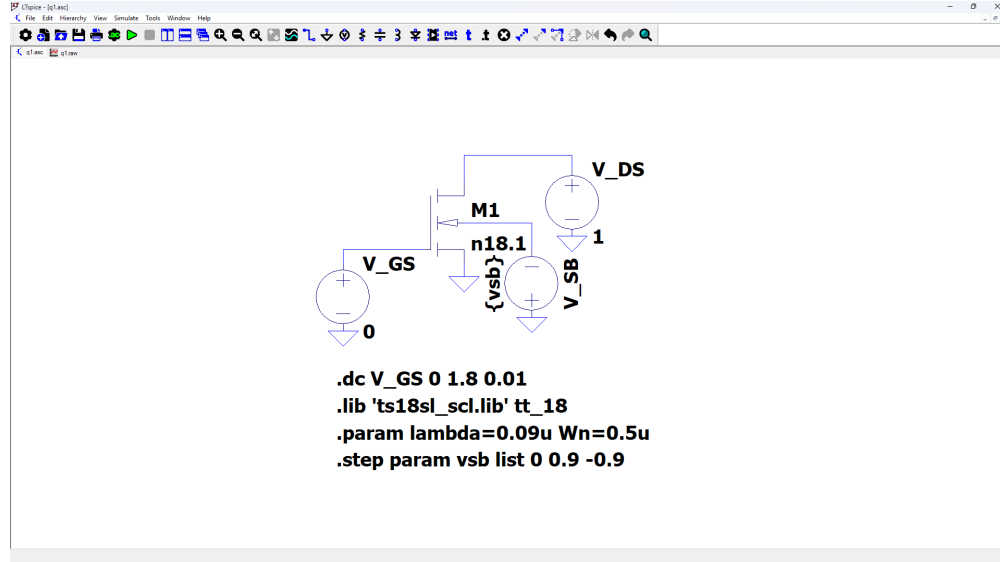


Figure 1: Schematic for I_D vs V_{GS} and g_m vs V_{GS} simulations.

Simulation Results (Plots)

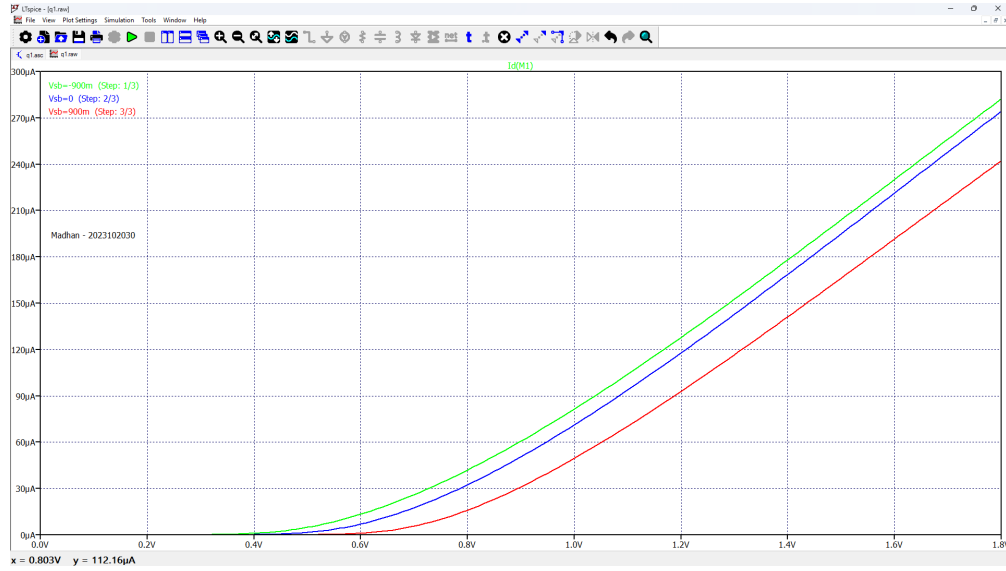


Figure 2: Simulated I_D vs V_{GS} for different V_{SB} values.

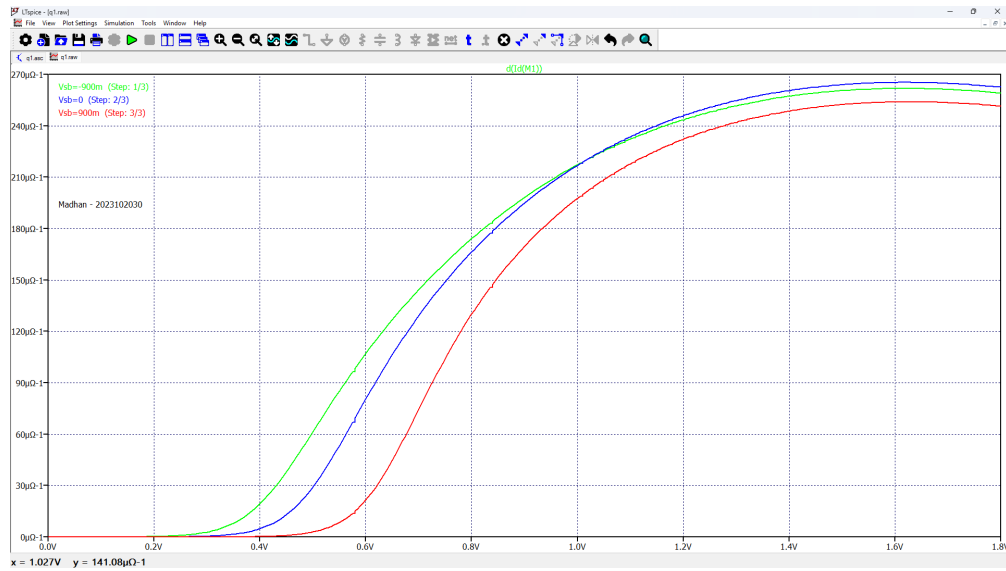


Figure 3: Simulated g_m vs V_{GS} for different V_{SB} values.

Discussion

Discussion:

(b) Reference Current I_{D0}

For $V_{SB} = 0V$ and $V_{GS} = 0.9V$:

- $I_{D0} = \underline{\hspace{2cm}}$

• $g_{m0} =$ _____

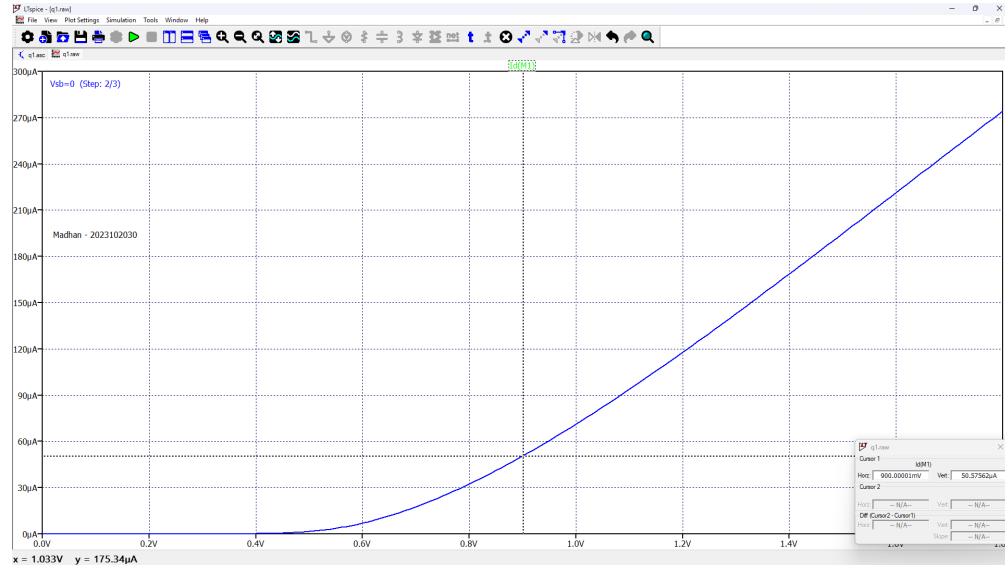


Figure 4: I_{D0} value at $V_{GS} = 0.9V$ and $V_{SB} = 0V$.

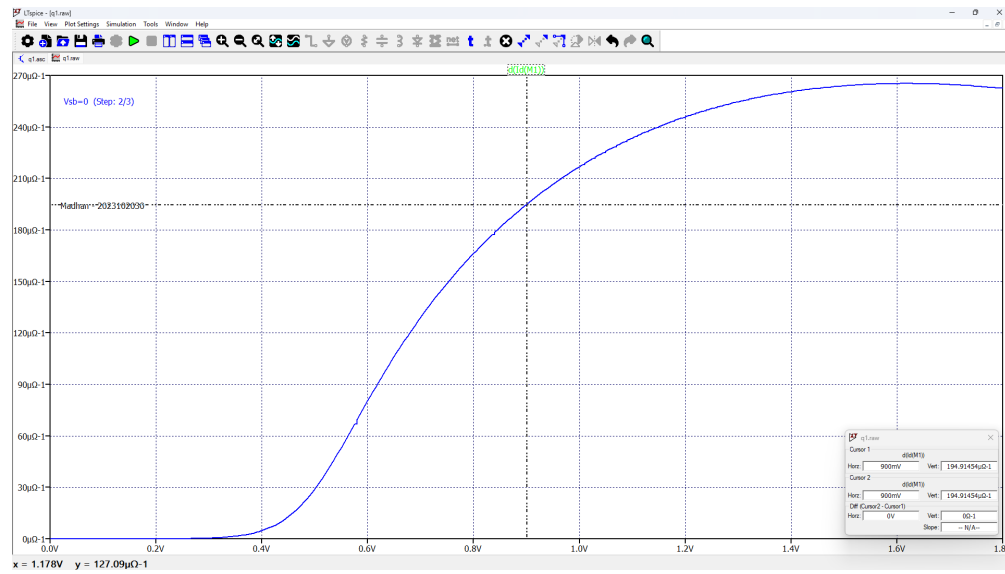


Figure 5: g_{m0} value at $V_{GS} = 0.9V$ and $V_{SB} = 0V$.

(c) g_m Variation for $V_{GS} = 0.9V$

- Case $V_{SB} = 0.9V$: Variation =
- Case $V_{SB} = -0.9V$: Variation =

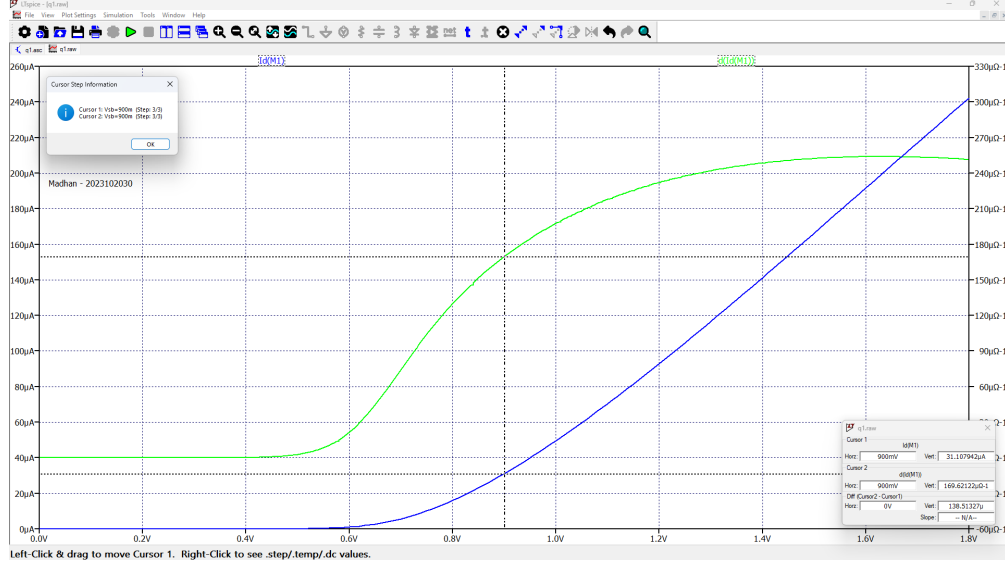


Figure 6: g_m variation at $V_{GS} = 0.9V$ for different $V_{SB} = 0.9$.

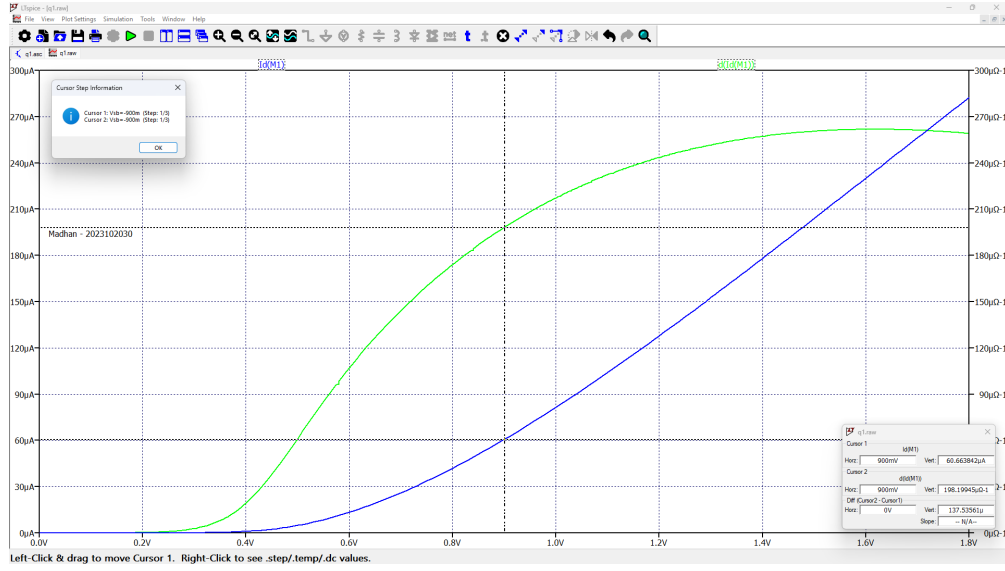


Figure 7: g_m variation at $V_{GS} = 0.9V$ for different $V_{SB} = -0.9$.

(d) g_m Variation for $I_D = I_{D0}$

- Case $V_{SB} = 0.9V$: Variation =
- Case $V_{SB} = -0.9V$: Variation =

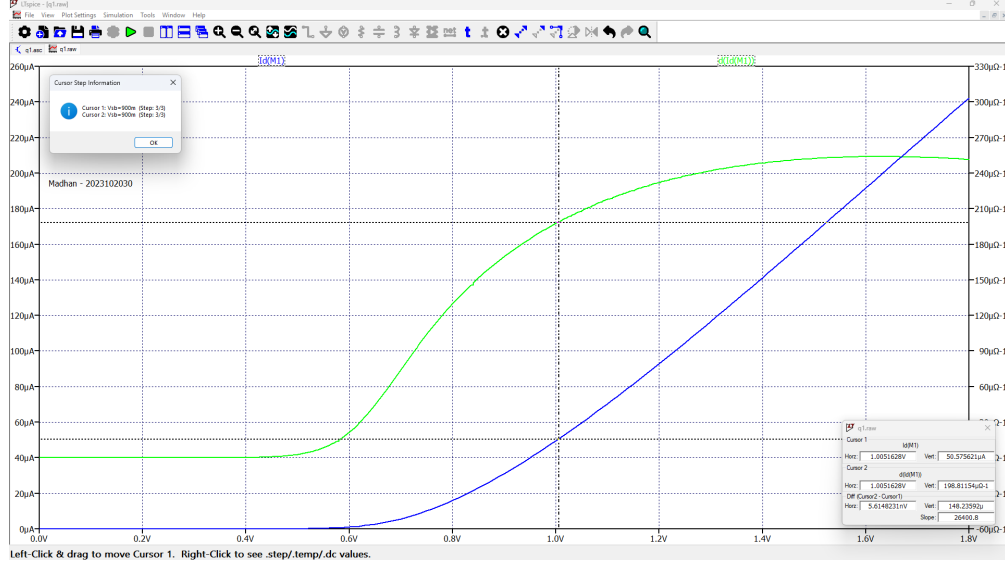


Figure 8: g_m variation at $I_D = I_{D0}$ for different $V_{SB} = 0.9$.

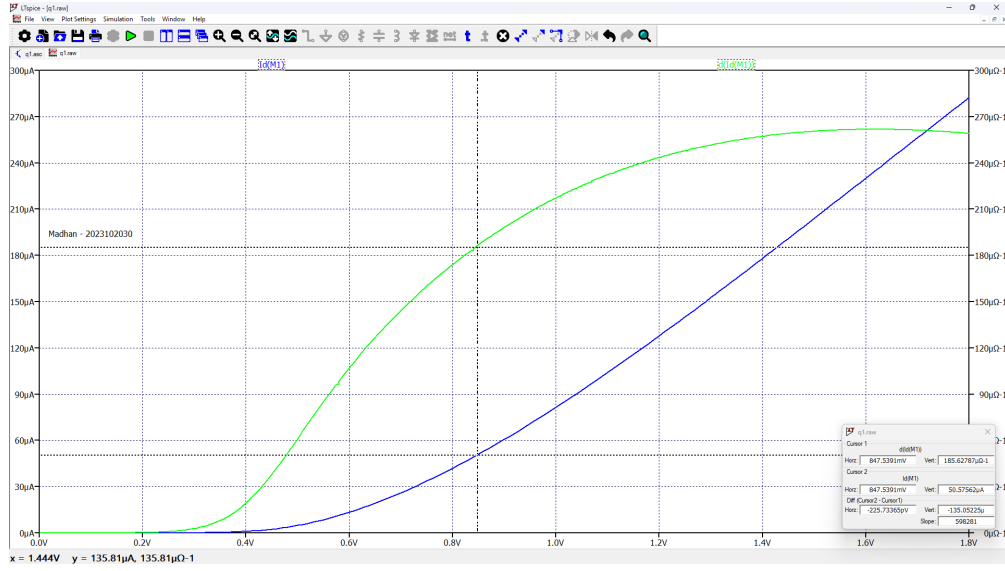


Figure 9: g_m variation at $I_D = I_{D0}$ for different $V_{SB} = -0.9$.

Question 2: Transconductance Analysis

Using the circuit in Figure 1 with $V_{DD} = 1.8V$.

(a) g_m vs I_D Curve

Sweep I_D from $10\mu A$ to $1mA$ for: 1. $(W/L) = \frac{3\mu m}{1\mu m}$ 2. $(W/L) = \frac{0.45\mu m}{0.18\mu m}$

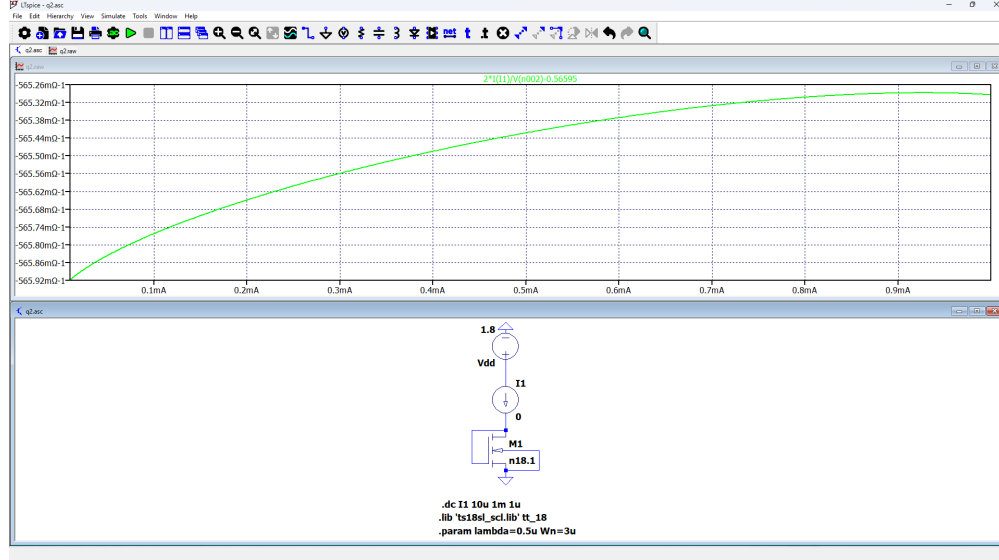


Figure 10: Schematic for g_m vs I_D simulation for $(W/L) = 3u/1u$.

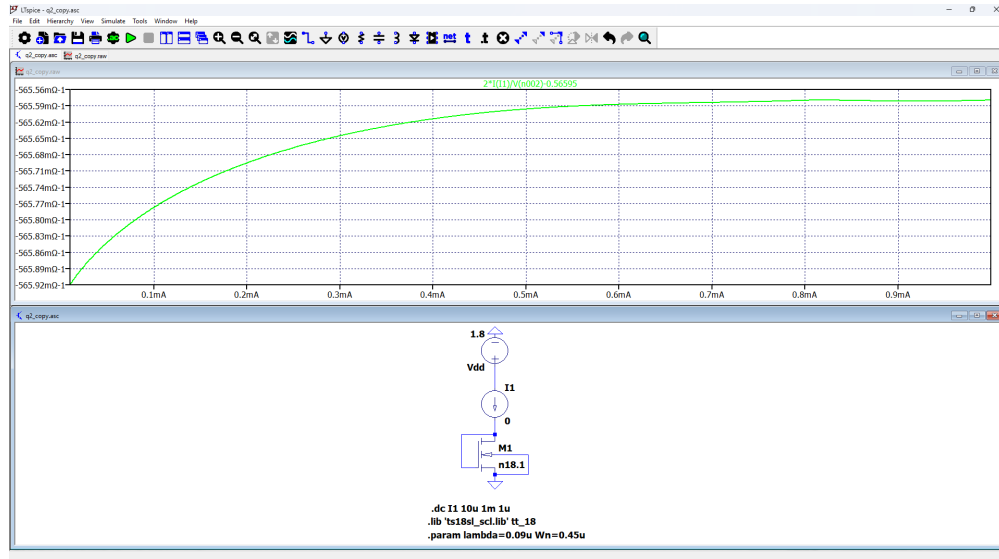


Figure 11: Simulated g_m vs I_D for $(W/L) = 0.45u/0.18u$.

Inference: Which case is closer to the expected form $g_m = \frac{2I_D}{V_{GS} - V_T}$ and why?

(b) Max Transconductance and Saturation

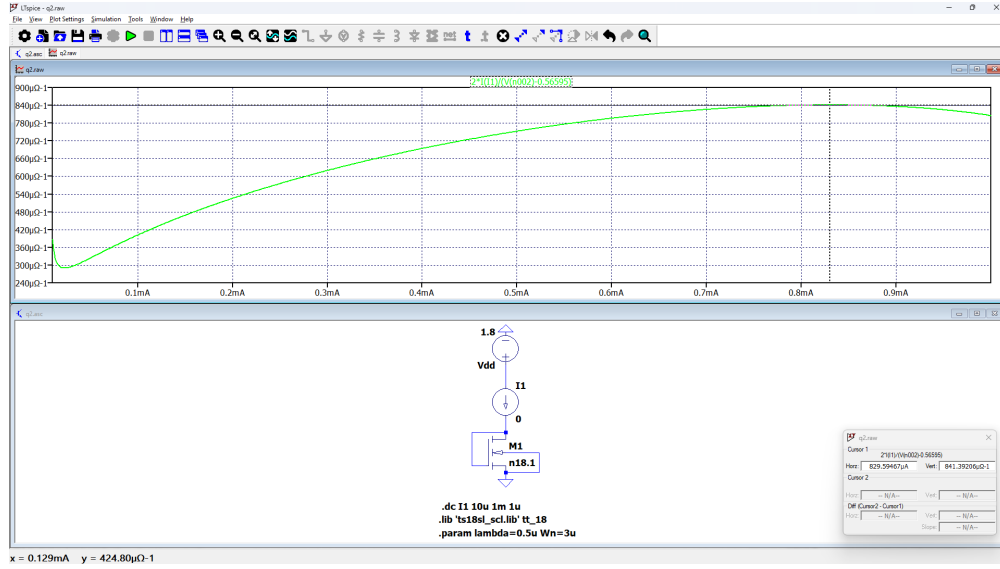


Figure 12: $g_{m,max}$ for $(W/L) = 3u/1u$.

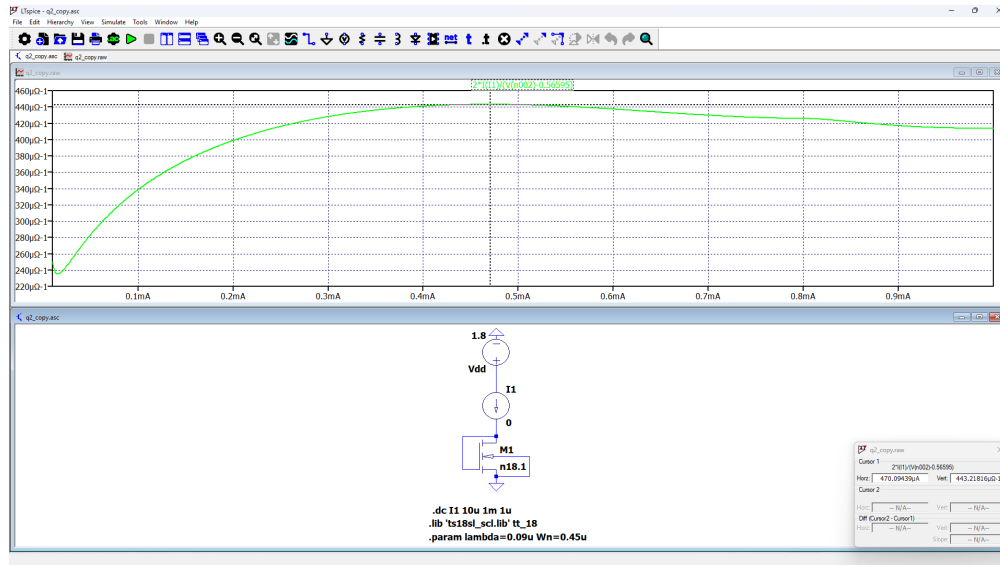


Figure 13: $g_{m,max}$ for $(W/L) = 0.45u/0.18u$.

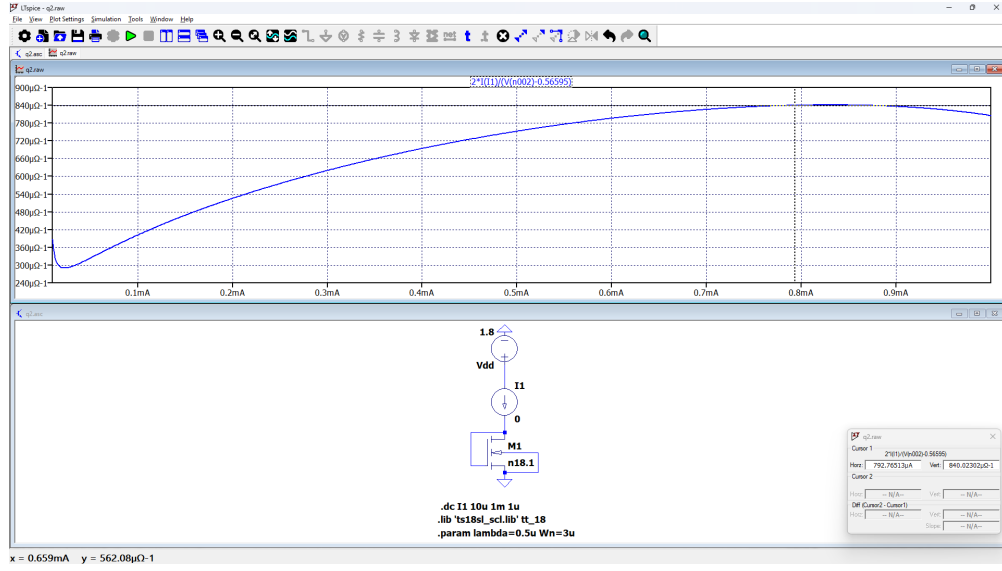


Figure 14: Saturation of g_m for $(W/L) = 3u/1u$.

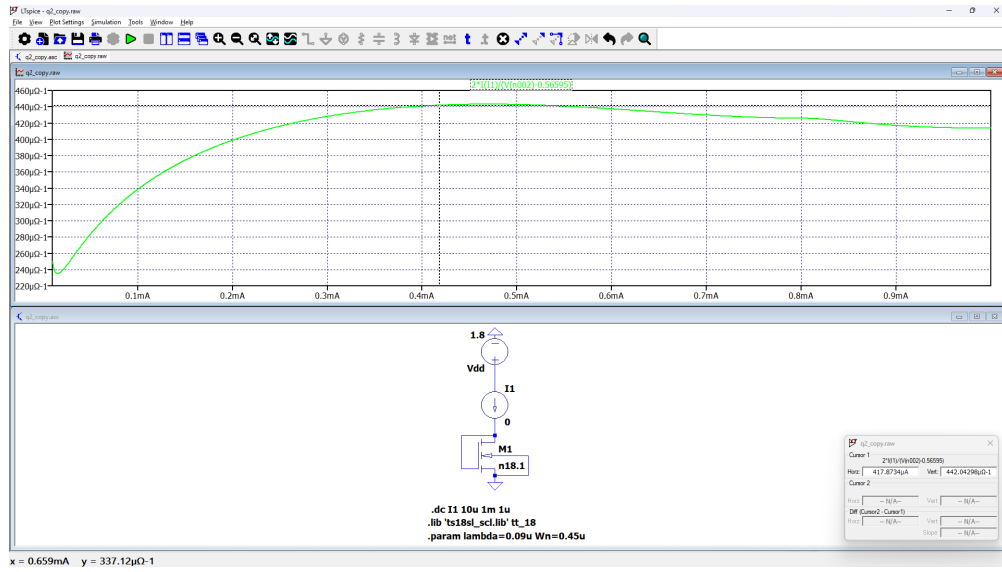


Figure 15: Saturation of g_m for $(W/L) = 0.45u/0.18u$.

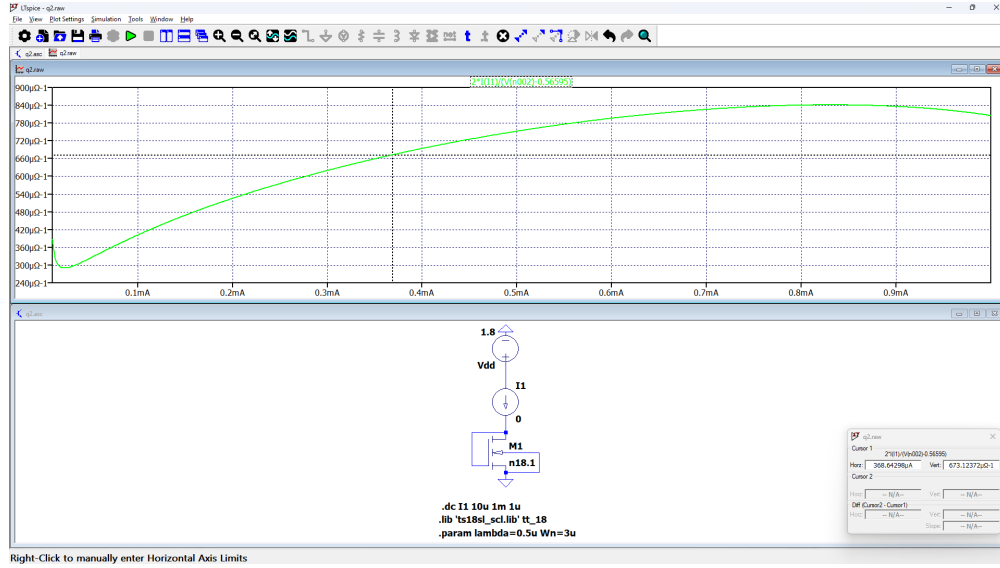


Figure 16: Determining I_D for $g_{m,use} = 0.8 \times g_{m,max}$ for $(W/L) = 3u/1u$.

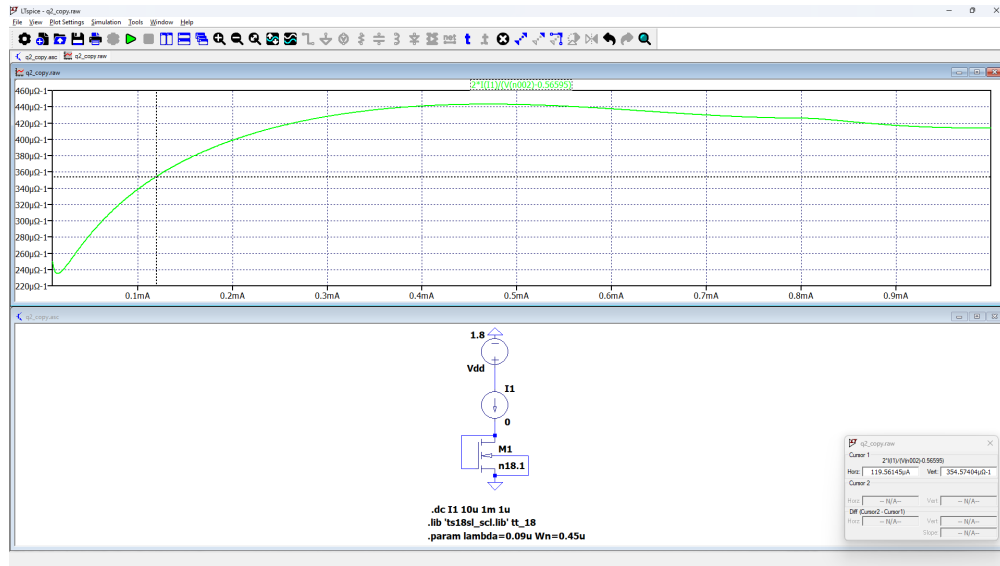


Figure 17: Determining I_D for $g_{m,use} = 0.8 \times g_{m,max}$ for $(W/L) = 0.45u/0.18u$.

- $g_{m,max}$ observed: _____
- I_D at which g_m saturates: _____
- I_D for $g_{m,use} = 0.8 \times g_{m,max}$: _____

(c) Scaling Parameters

To obtain $g_{m,req} = 4 \times g_{m,use}$ while ensuring the same speed:

Question 3: CS Amplifier Design (g_m/I_D Approach)

Specifications: $A_v > 60$, $f_u = 100\text{MHz}$, $C_L = 1\text{pF}$, $V_{DD} = 1.8\text{V}$, $V^* = \frac{2I_D}{g_m} = 200\text{mV}$.

(a) Channel Length Selection

[Insert plot of $g_m r_o$ vs V_{DS} for different L] **Chosen L :** _____ **Output Swing Range:** _____

(b) Process and Temperature Variations

[Insert $g_m r_o$ vs V_{DS} plot for corners: tt, ff, ss and temps: -40, 25, 80, 125 °C]

(c) Design Calculations

- Calculated g_m :
- Calculated I_D :
- Calculated W :

(d) Transient Analysis and THD

[Insert annotated transient plots] **THD for maximum input swing:** _____

(e) AC Analysis

[Insert AC Response plots]

- Verified f_u :
- f_{-3dB} :
- AC Gain:

Question 4: Common Source Amplifier Variants

$R_L = 10\text{k}\Omega$, $V_{DD} = 1.8\text{V}$, $A_v > 5$, Overdrive = 200mV, $f_{min} = 100\text{Hz}$.

(a) Design Procedure (Resistive Load)

Total Power Consumption: _____

(b) Transient Simulation

[Insert transient plots for $v_{in} = 10 \sin(2\pi \cdot 1000t)\text{mV}$]

(c) AC Response

[Insert AC plots 1Hz to 1GHz] Unity Bandwidth f_u : _____

(d) PMOS Current Source Load

[Insert design procedure, Transient, and AC plots for $A_v > 15$]

(e) Cascode Amplifier Design

[Insert design procedure, Transient, and AC plots] Observed Gain: _____ Comparison with Hand Calculations:

(f) Comparison Table

Table 1: Comparison of Amplifier Topologies

Topology	Gain	Power	Output Swing	Remarks
Resistive Load				
PMOS Load				
Cascode				

References

1. Lookup table based systematic design of analog circuits (gm/Id based design) <https://youtu.be/8sbxbeduIoM>