The MOS Differential Pair

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All experiments were conducted in LTspice.

Experiment 1: Differential Pair Current-Voltage Characteristics

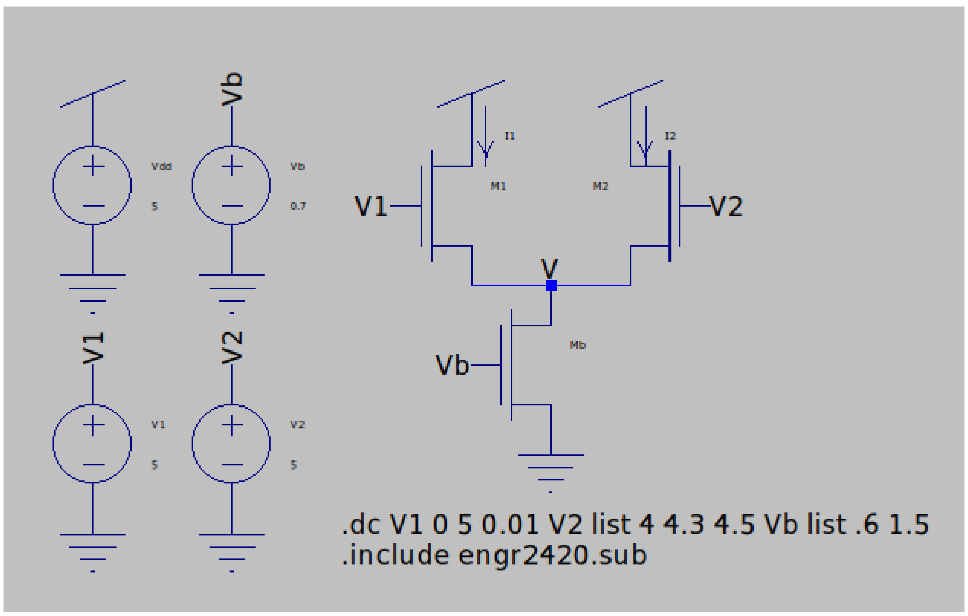

Figure 1: Schematic for Experiment 1

In Weak and Moderate Inversion

As seen on Figure 2, the current-voltage characteristics are almost identical for changing values of V2. There is no significant change in these characteristics as V2 changes.

As seen in Figure 3, the voltage seen on the common source node of the bias transistor is constant for values when V_1 is less than V_2, expressed as values under 0V on our plot. At $V_2 - V_1 = 0V$ there is an slope on the graph and the voltage measured on the common source node of the bias transistor climbs linearly as V_1 becomes greater than V_2.

The transconductance gain G_{dm} does not change significantly with changes in V_2. In the weak inversion case, the change has a magnitude on the order of 10^{-8}, which is insignificant.

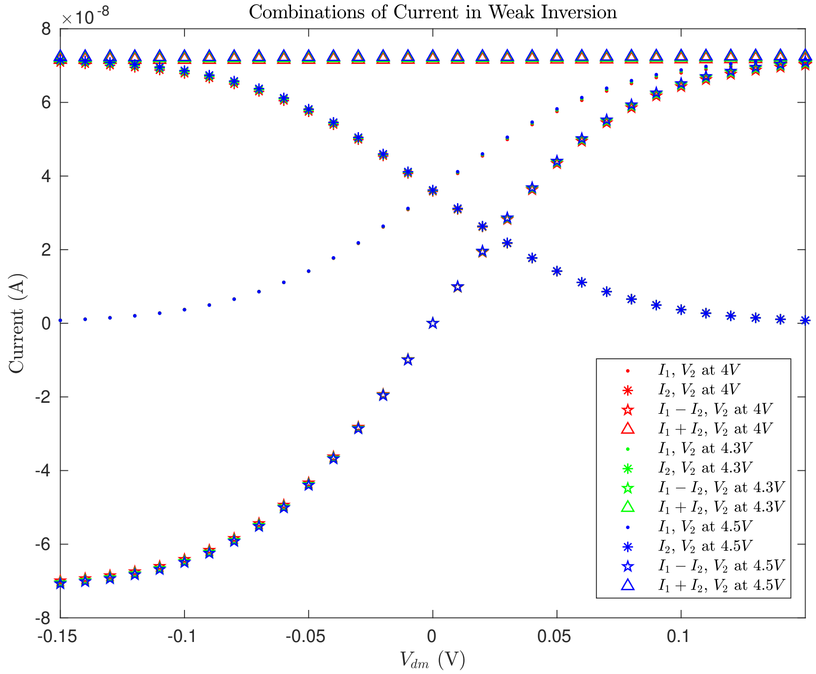

Figure 2: $I_1, I_2, I_1 - I_2$, and $I_1 + I_2$ as a function of $V_1 - V_2$ for V_2 @ 4V, 4.3V, 4.5V

V_2	WI
4V	$968.8n\mho$
4.3V	$978.1n\mho$
4.5V	$984.2n\mho$

Table 1: Extracted G_{dm} values for Weak Inversion modes for different V_2 values

In Strong Inversion

As seen on Figure 4, the current-voltage characteristics are almost identical for changing values of V_2. There is no significant change in these characteristics as V_2 changes.

As seen in Figure 5, the voltage seen on the common source node of the bias transistor is constant for values when V_1 - V_2 is less than -0.75V on our plot. At $V_2 - V_1 = 0.75V$ there is a change in slope on the graph and the voltage measured on the common source node of the bias transistor climbs linearly as V_1 becomes greater than V_2.

The transconductance gain G_{dm} does not change significantly with changes in V_2. In strong inversion, the change has a magnitude of 10^{-7}, which is insignificant compared to the change in V_2.

V_2	SI
4V	$44.97\mu\mho$
4.3V	$44.90\mu\mho$
4.5V	$44.84\mu\mho$

Table 2: Extracted G_{dm} values for Strong Inversion region for different V_2 values

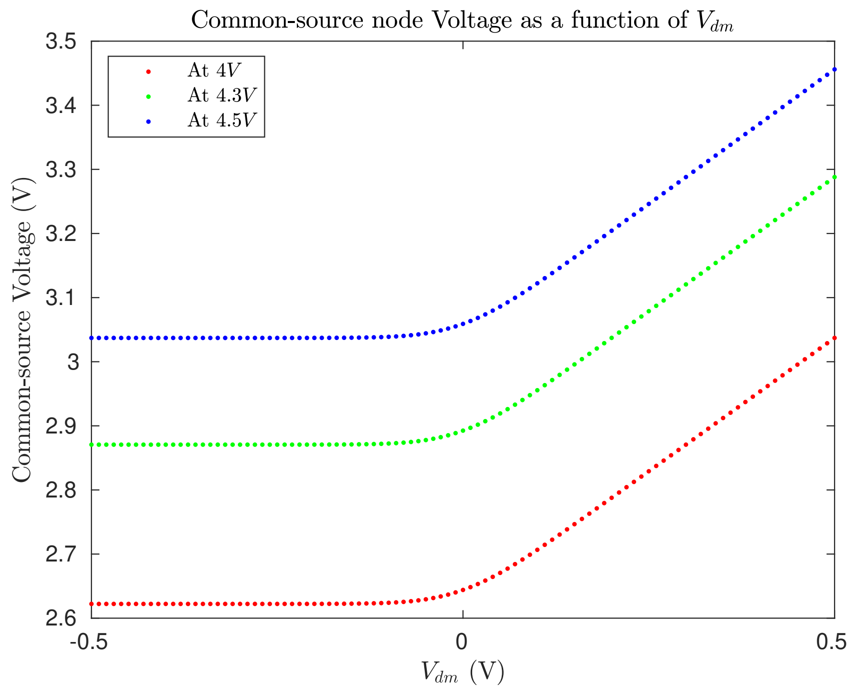

Figure 3: Voltage at the source of the bias transistor as a function of $V_1 - V_2$

Comparing the Response to Different Levels of Inversion

G_{dm} is much larger in strong inversion than in the weak and moderate inversion levels. This means that the circuit takes more time to become a source follower for either transistor. It's evidenced in the graph of the response - the circuit takes $\pm 1V$ from $V_{dm} = 0$ to settle into a source follower case for strong inversion, compared to $\pm 0.2V$ in the weak and moderate inversion cases. Additionally, the range of current spanned by the circuit's response in the strong inversion case is about 3 orders of magnitude greater than that of the circuit's response in the weak and moderate inversion cases.

Finally, the common-source node voltage V is also affected by the inversion case. It has larger values for the same values of V_2 in weak and moderate inversion than it does in strong inversion. It switches from a constant value to a steadily increasing value at an earlier point ($V_{dm} \approx -0.75V$) in strong inversion than in weak and moderate inversion ($V_{dm} \approx 0V$). The increasing behavior of V past this switch point looks more linear in the weak and moderate inversion cases than in the strong inversion case.

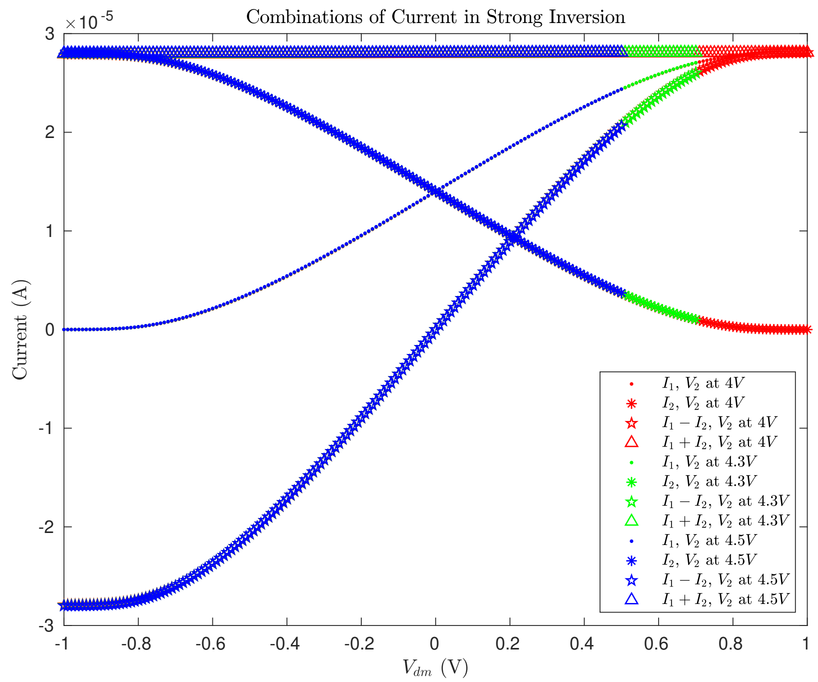

Figure 4: $I_1, I_2, I_1 - I_2$, and $I_1 + I_2$ as a function of $V_1 - V_2$ for V_2 @ 4V, 4.3V, 4.5

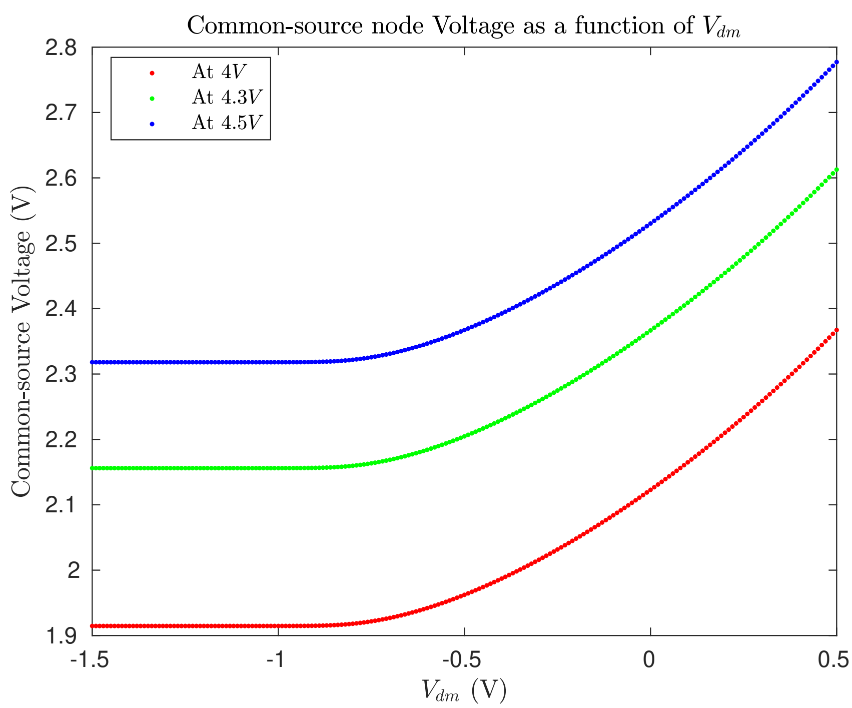

Figure 5: Voltage at the source of the bias transistor as a function of $V_1 - V_2$