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EECS 170LC
Lab 1sim

Sim 1

a)

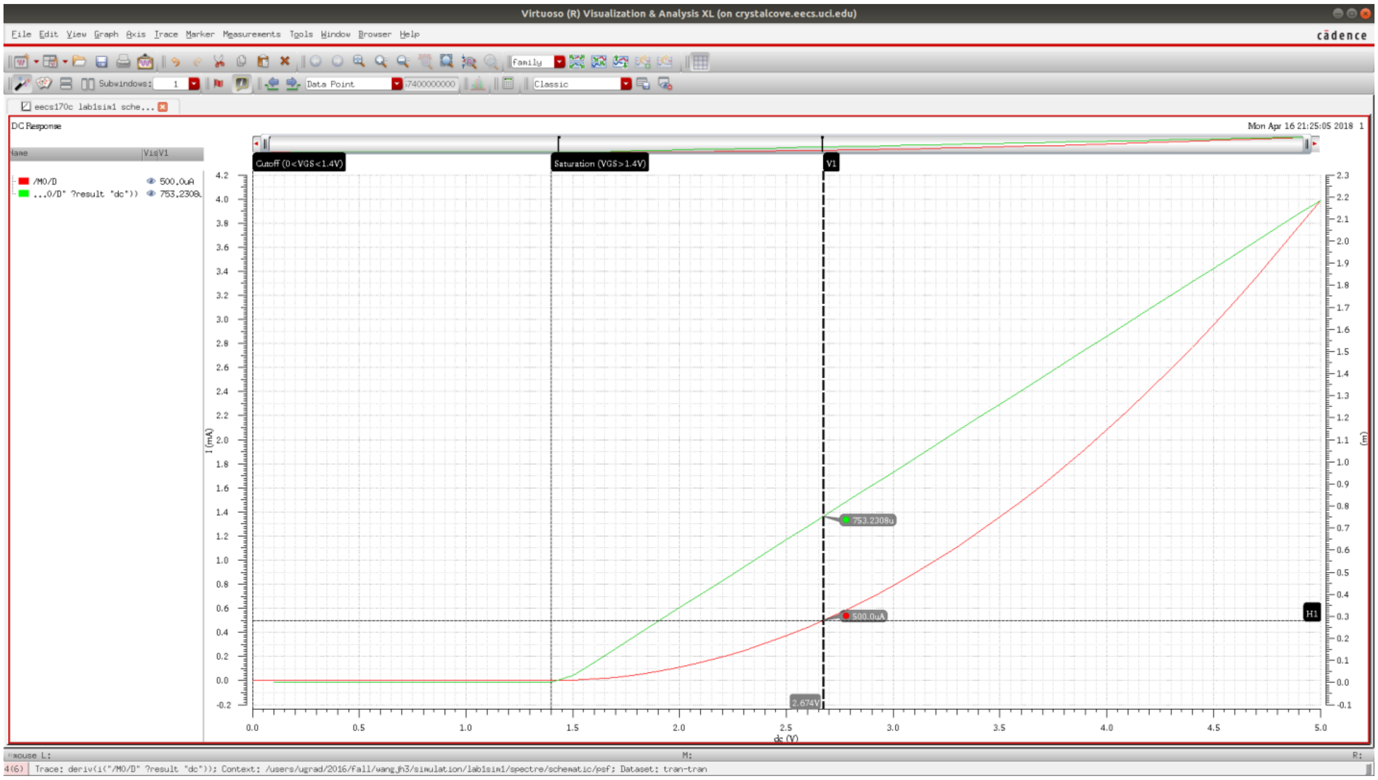

Figure 1 – NMOS CS Amplifier I_D vs. V_{GS} Plot and Derivative

b) When I_D = 500 uA, V_{GS} = 2.674 V. This V_{GS} value corresponds with g_m = **753.231 uS** from the derivative plot. The following is a hand calculation of transconductance.

$$g_m = \frac{2I_D}{V_{GS} - V_t} = \frac{2(500\ \mu A)}{2.674\ V - 1.4\ V} = \mathbf{784.929\ \mu S}$$

The hand calculated value of g_m above is reasonably close to the value found in the plot.
The value of g_m from the DC operating point simulation is **784 uS**, which is also close to the values above.

Sim 2

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a)

Figure 2 - NMOS CS Amplifier I_D vs. V_{DS} Plot and Derivative, V_{GS} = 0 V

For the entire range of V_{DS} (0 V ≤ V_{DS} ≤ 5 V), the NMOS is in cutoff region for V_{GS} = 0 V.

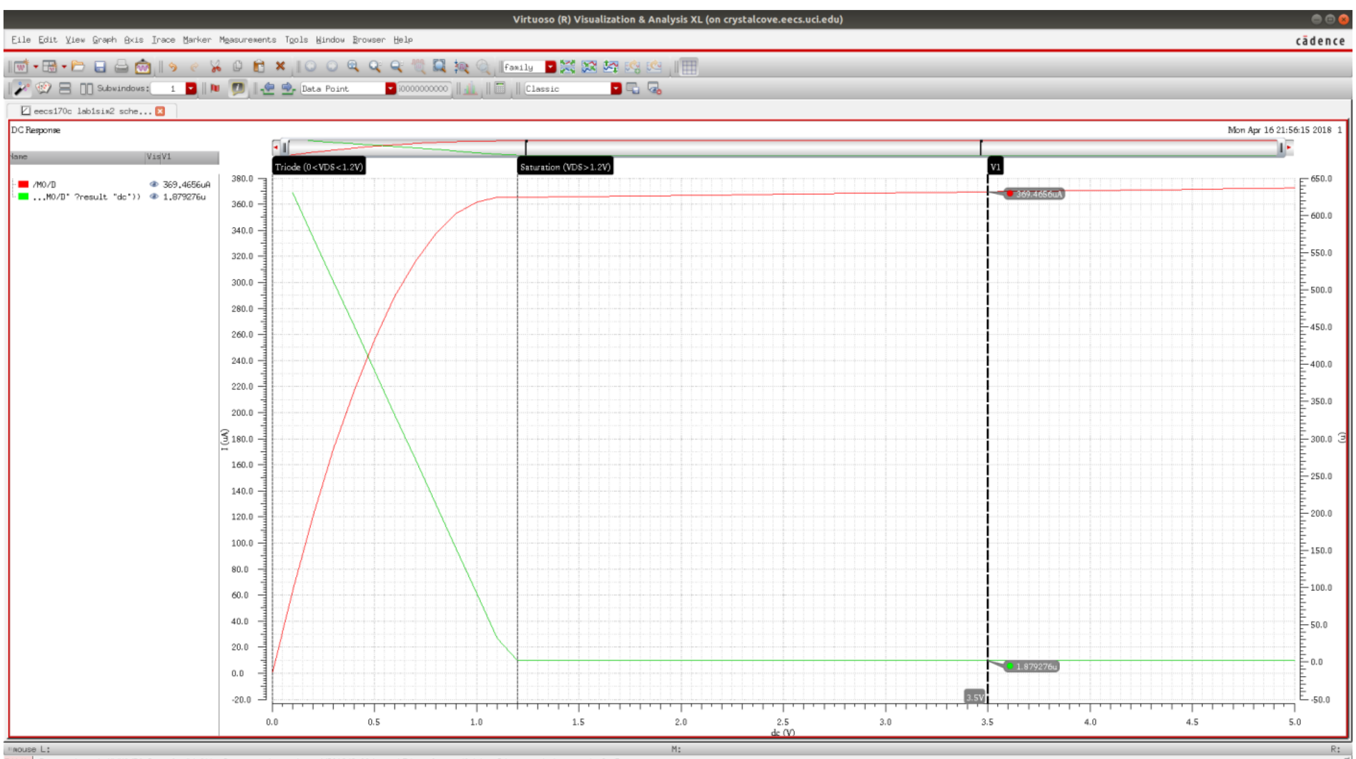

Figure 3 - NMOS CS Amplifier I_D vs. V_{DS} Plot and Derivative, V_{GS} = 2.5 V

From V_{DS} = 0 to 1.2 V, the NMOS is in triode region. From V_{DS} = 1.2 to 5 V, the NMOS is in saturation region.

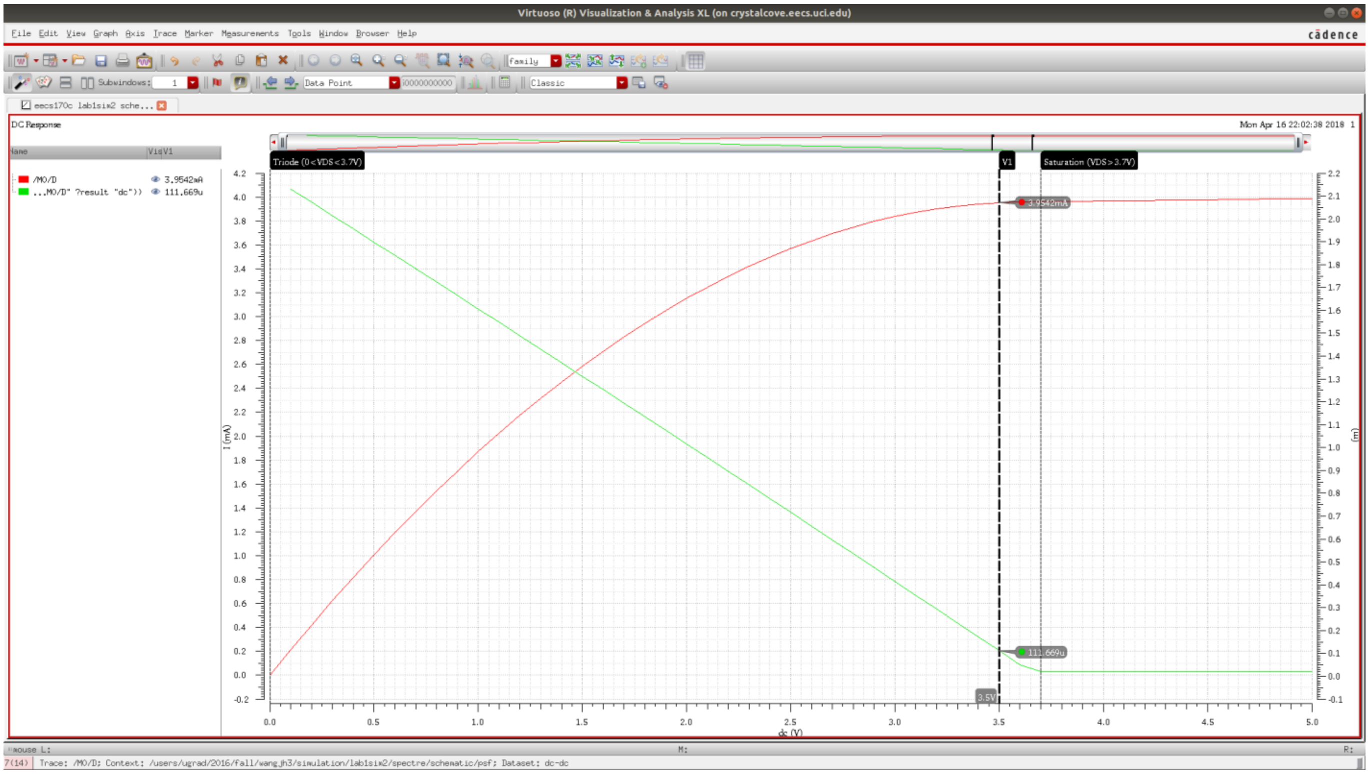

Figure 4 - NMOS CS Amplifier I_D vs. V_{DS} Plot and Derivative, V_{GS} = 5 V

From V_{DS} = 0 to 3.7 V, the NMOS is in triode region. From V_{DS} = 3.7 to 5 V, the NMOS is in saturation region.

b) For V_{GS} = 0 V and V_{DS} = 3.5 V, g_{ds} is graphically found to be **0 uS**. This g_{ds} value produces the following λ.

$$g_{ds} = \frac{1}{r_o} = \lambda I_D \rightarrow \lambda = \frac{g_{ds}}{I_D} = \frac{0\ S}{10\ fA} = 0\ V^{-1}$$

For V_{GS} = 2.5 V and V_{DS} = 3.5 V, g_{ds} is graphically found to be **1.87276 uS**. This g_{ds} value produces the following λ.

$$g_{ds} = \frac{1}{r_o} = \lambda I_D \rightarrow \lambda = \frac{g_{ds}}{I_D} = \frac{1.87276\ \mu S}{369.466\ \mu A} = 5.069\ m(V^{-1})$$

For V_{GS} = 5 V and V_{DS} = 3.5 V, g_{ds} is graphically found to be **111.67 uS**. This g_{ds} value produces the following λ.

$$g_{ds} = \frac{1}{r_o} = \lambda I_D \rightarrow \lambda = \frac{g_{ds}}{I_D} = \frac{111.67\ uS}{3954.2\ uA} = 28.240\ m(V^{-1})$$

The valid λ value from the above calculations is $\mathbf{5.069\ m(V^{-1})}$ because the NMOS is operating in saturation. From the DC operating point simulation, the g_{ds} values for V_{GS} = 0 V, 2.5 V, and 5 V are **0 uS**, **1.88 uS**, and **81.19 uS**, respectively. These values are close to the values found graphically except for the case in which V_{GS} = 5 V. This inconsistency may be because 3.5 V is very close to the edge of triode and saturation in the V_{GS} = 5 V case.

<u>Sim 3</u>

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a)

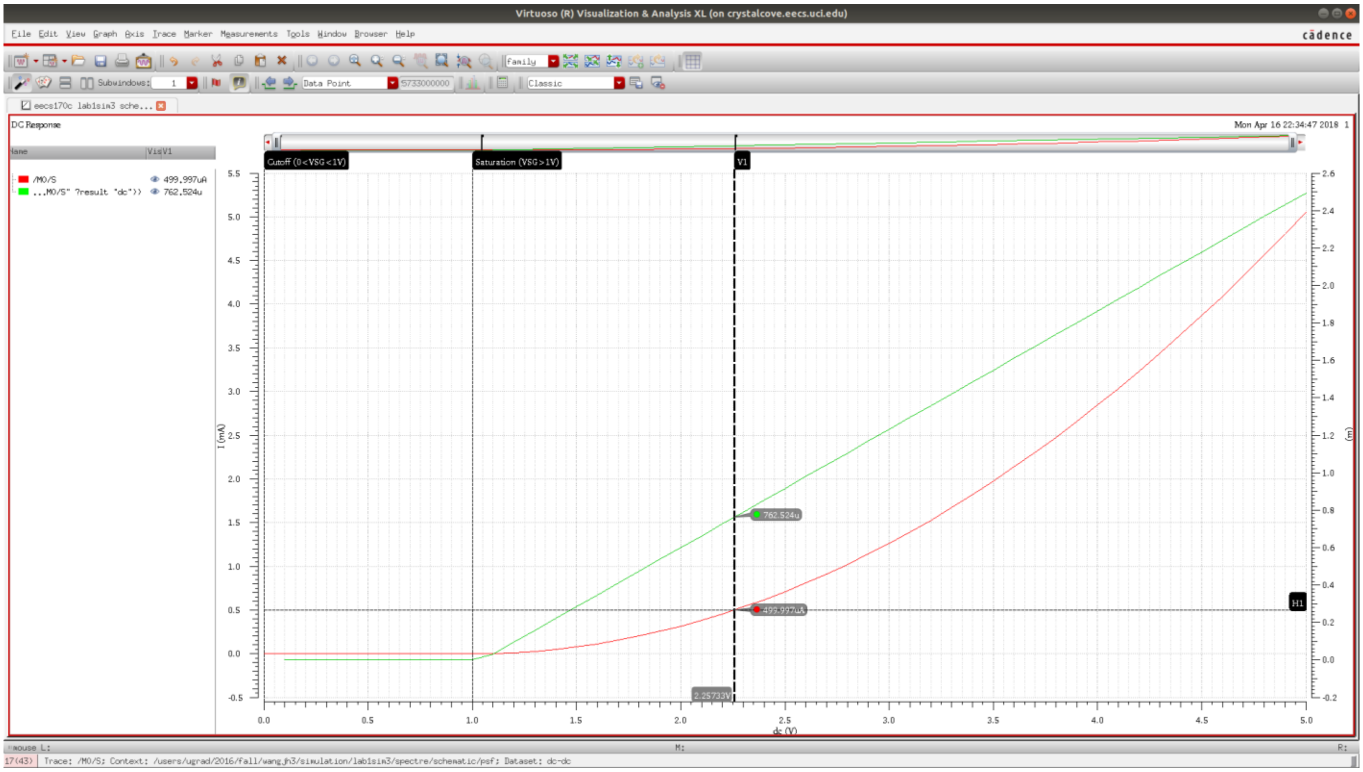

Figure 5 – PMOS CS Amplifier I_D vs. V_{SG} Plot and Derivative

b) When I_D = 500 uA, V_{SG} = 2.25733 V. This V_{GS} value corresponds with g_m = **762.524 uS**. The following is a hand calculation of transconductance.

$$g_m = \frac{2I_D}{V_{SG} - |V_t|} = \frac{2(500\ \mu A)}{2.25733\ V - 1.0\ V} = \mathbf{795.336\ \mu S}$$

The hand calculated value of g_m above is reasonably close to the value found in the plot.
The value of g_m from the DC operating point simulation is **794.1 uS**, which is also close to the values above.

Sim 4

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a)

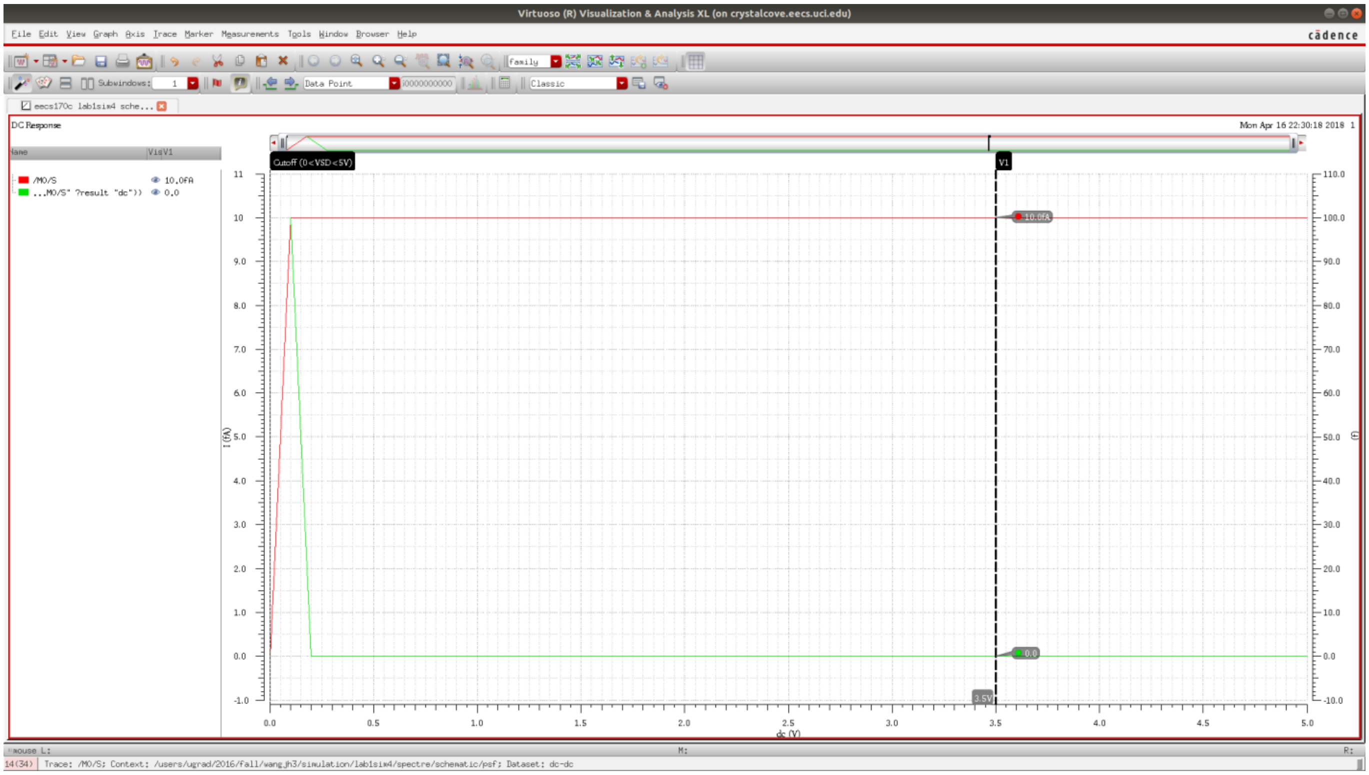

Figure 6 - PMOS CS Amplifier I_D vs. V_{SD} Plot and Derivative, V_{SG} = 0 V

For the entire range of V_{SD} (0 V ≤ V_{SD} ≤ 5 V), the PMOS is in cutoff region for V_{SG} = 0 V.

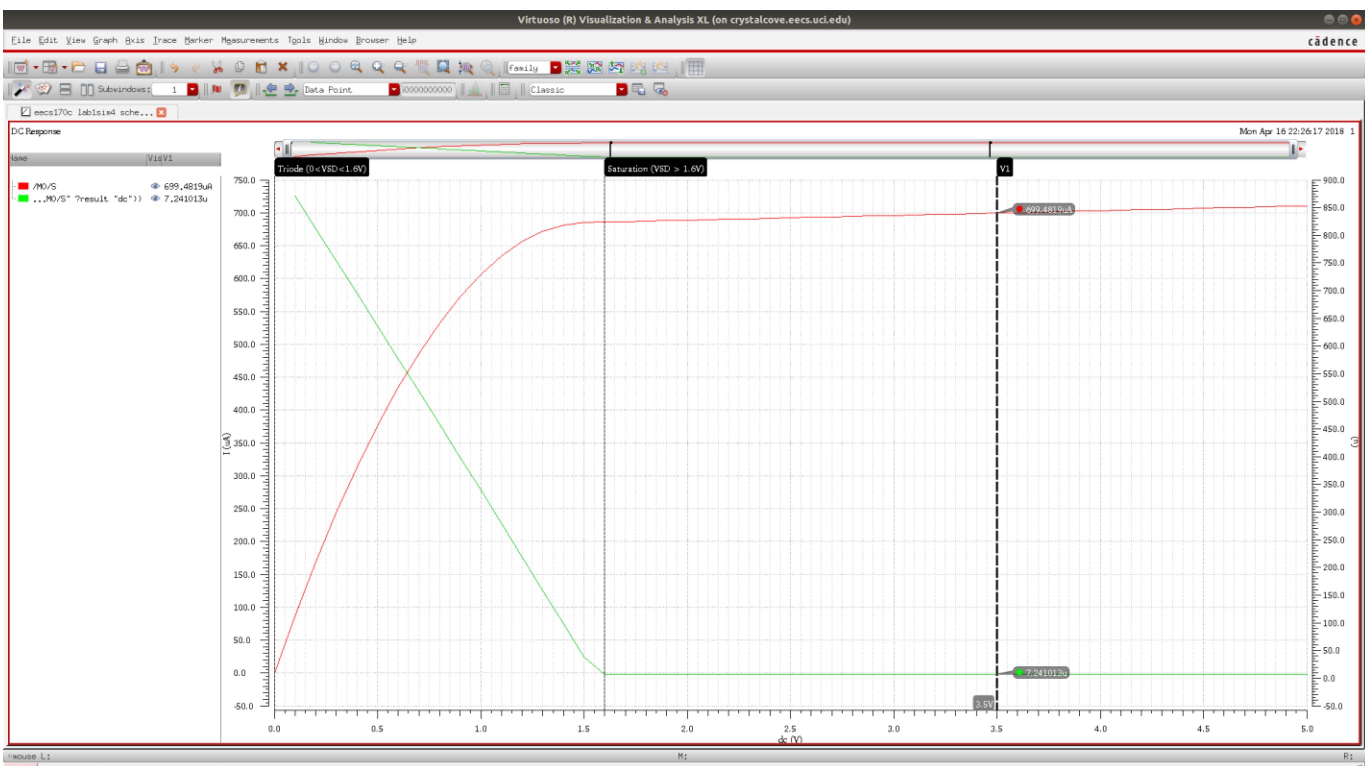

Figure 7 - PMOS CS Amplifier I_D vs. V_{SD} Plot and Derivative, V_{SG} = 2.5 V

From V_{SD} = 0 to 1.6 V, the PMOS is in triode region. From V_{SD} = 1.6 to 5 V, the PMOS is in saturation region.

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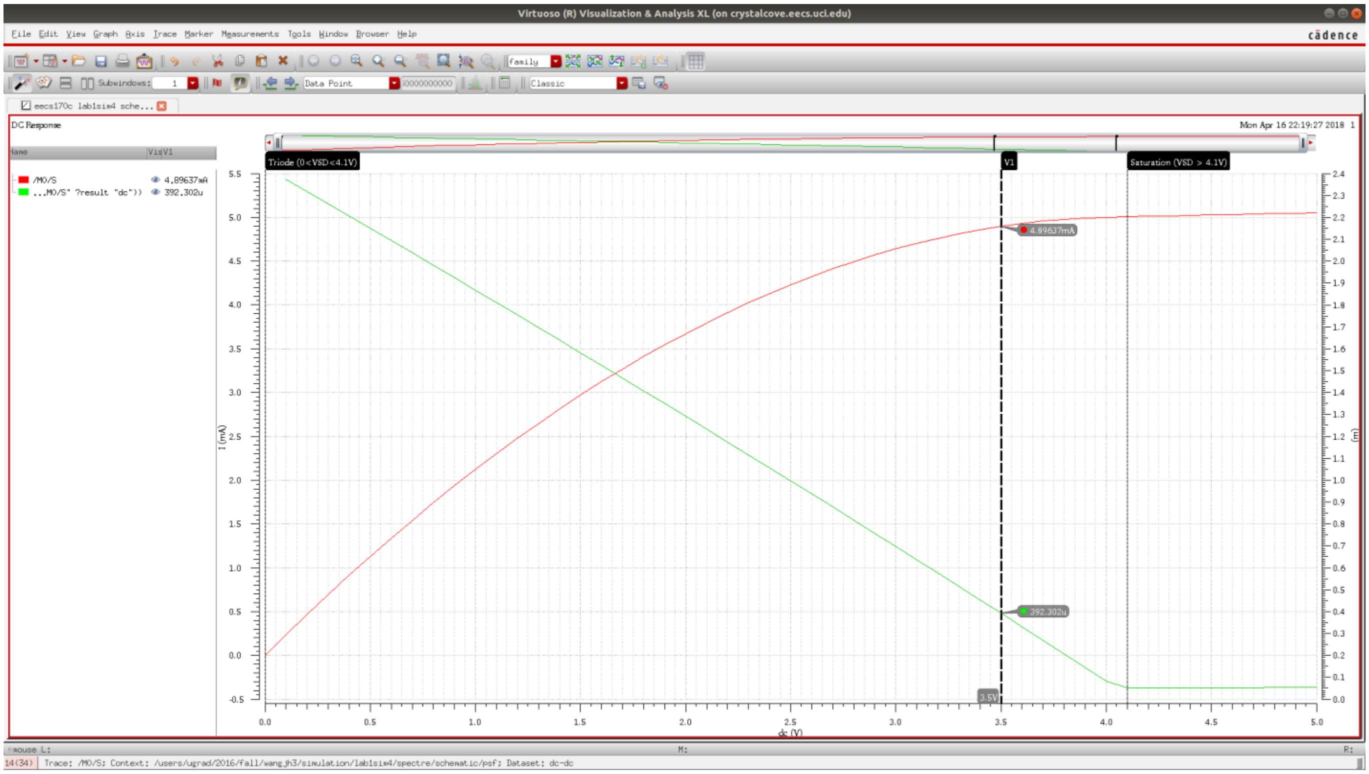

Figure 8 - PMOS CS Amplifier I_D vs. V_{SD} Plot and Derivative, V_{SG} = 5 V

From V_{SD} = 0 to 4.1 V, the PMOS is in triode region. From V_{SD} = 4.1 to 5 V, the PMOS is in saturation region.

b) For V_{SG} = 0 V and V_{SD} = 3.5 V, g_{sd} is graphically found to be **0 uS**. This g_{ds} value produces the following λ.

$$g_{sd} = \frac{1}{r_o} = \lambda I_D \rightarrow \lambda = \frac{g_{ds}}{I_D} = \frac{0\ S}{10\ fA} = 0\ V^{-1}$$

For V_{SG} = 2.5 V and V_{SD} = 3.5 V, g_{sd} is graphically found to be **7.241013 uS**. This g_{ds} value produces the following λ.

$$g_{sd} = \frac{1}{r_o} = \lambda I_D \rightarrow \lambda = \frac{g_{ds}}{I_D} = \frac{7.241013\ \mu S}{699.4819\ \mu A} = 10.352\ m(V^{-1})$$

For V_{SG} = 5 V and V_{SD} = 3.5 V, g_{sd} is graphically found to be **392.302 uS**. This g_{ds} value produces the following λ.

$$g_{sd} = \frac{1}{r_o} = \lambda I_D \rightarrow \lambda = \frac{g_{ds}}{I_D} = \frac{392.302\ uS}{4896.37\ uA} = 80.121\ m(V^{-1})$$

The valid λ value from the above calculations is $\mathbf{10.352\ m(V^{-1})}$ because the PMOS is operating in saturation. From the DC operating point simulation, the g_{ds} values for V_{GS} = 0 V, 2.5 V, and 5 V are **0 uS**, **7.249 uS**, and **361.6 uS**, respectively. These values are close to the values found graphically.