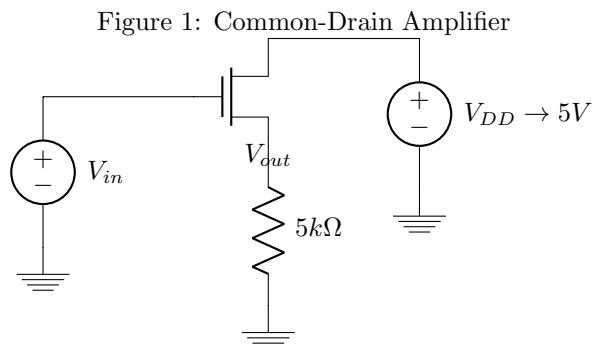


0.1 Theory and Procedure



A common-drain amplifier is to be constructed. V_{in} is swept from 0V to 5V. The following is the saturation condition for the NMOS transistor:

$$V_{DS} > V_{GS} - V_T \rightarrow V_D > V_G - V_T \rightarrow V_{in} < 5V + V_T \quad (1)$$

So long as V_{in} stays below 5V and high enough that the MOSFET does not enter the cutoff region, it remains in saturation. So, for small values of V_{in} , the transistor operates in the cutoff region because a current-enabling channel cannot form. Once V_{in} is high enough that the channel can form, the transistor operates in the saturation region due to the high drain voltage "pinching-off" the channel. By design, V_{in} never exceeds 5V. So, the transistor transitions from cutoff to saturation during the DC sweep.

0.2 Results

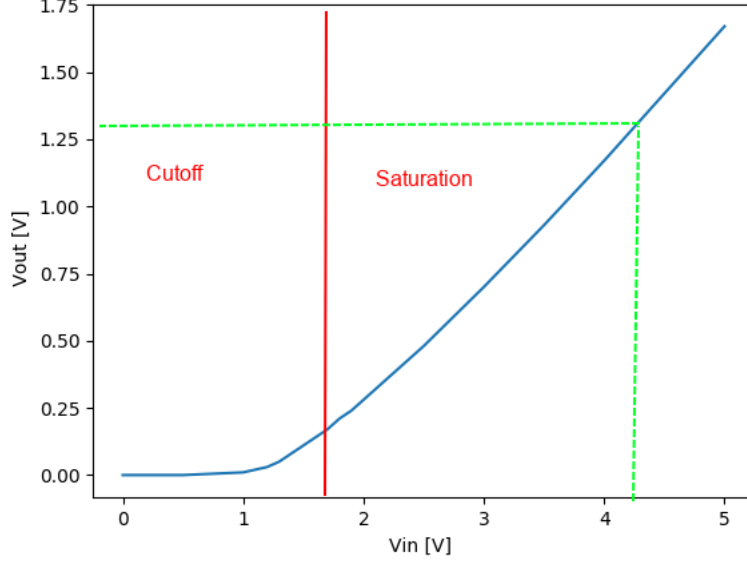


Figure 2: Common Drain Amplifier Voltage Transfer Characteristic

The amplifier should be biased in the middle of the saturation region. Using the characteristics of the NMOS determined earlier (and not what figure (2) may present), the threshold voltage is taken to be $V_T = 1.7\text{V}$. Suppose the transistor exits the cutoff region for some $V_{in} > V_T$. Then, no current flows through the resistor. Therefore, the source voltage becomes 0V , meaning that $V_{GS} = V_{in} > V_T$. This is a contradiction. Thus, transistor cannot begin to exit cutoff at a voltage above V_T . For a voltage $V_{in} < V_T$, assume the transistor is not in cutoff. Then, current flows through the resistor. Therefore, the source voltage is above ground, meaning that $V_{GS} = V_{in} - V_S < V_T$. This is a contradiction. So, the transistor exits cutoff mode when $V_{in} = V_T = 1.7\text{V}$. This value is to be used instead of the value in figure (2) because subthreshold current can flow even though the transistor is still in cutoff. The transistor exits saturation when $V_{in} = 5\text{V} + V_T = 5\text{V} + 1.7\text{V} = 6.7\text{V}$. So, the midpoint of the saturation region occurs when $V_{in} = \frac{1.7\text{V} + 6.7\text{V}}{2} = 4.2\text{V}$, which corresponds to a bias current of $\frac{V_{out}}{5k\Omega} \approx \frac{1.3\text{V}}{5k\Omega} = 0.26\text{mA}$.