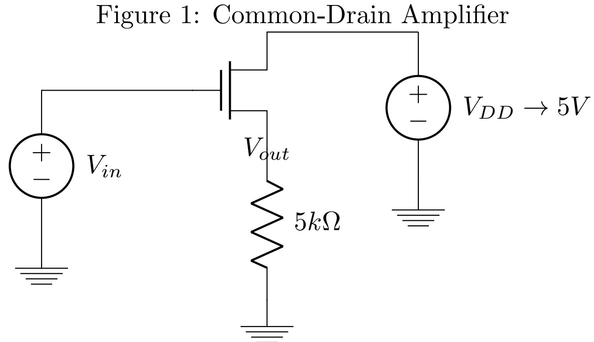
0.1 Theory and Procedure

Figure 1: Common-Drain Amplifier



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:

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

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

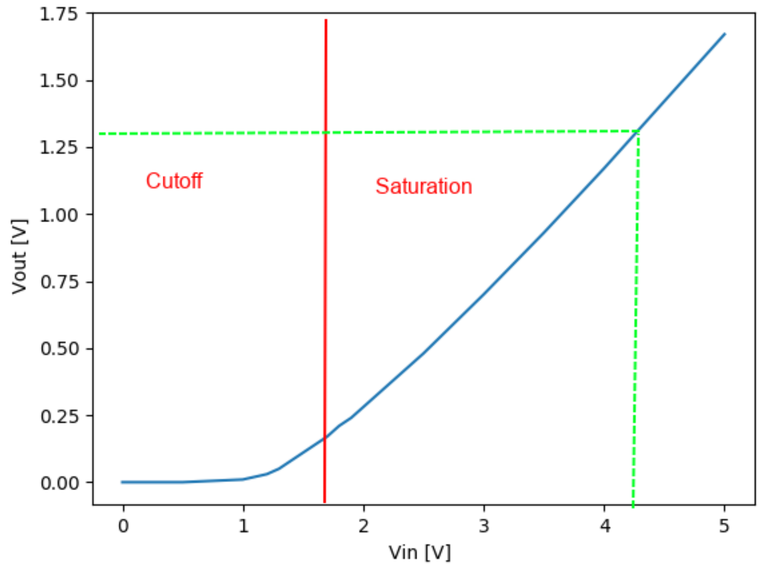


Figure 2: Common Drain Amplifier Voltage Transfer Characteristic

The amplifier should be biased in the middle of the saturation region. Using the characteristics of the NMOS determined earlier, the threshold voltage is taken to be $V_T = 1.7$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 $V_{in} = V_T = 1.7$V. The current begins to rise from 0mA before this point. However, $V_T = 1.7$V is used when calculating the edge between saturation and triode. For the sake of consistency, $V_T = 1.7$V is used for the edge between cutoff and saturation.

The transistor exits saturation when $V_{in} = 5V + V_T = 5V + 1.7V = 6.7V$. So, the midpoint of the saturation region occcurs when $V_{in} = \frac{1.7V+6.7V}{2} = 4.2$V, which corresponds to a bias current of $\frac{V_{out}}{5k\Omega} \approx \frac{1.3V}{5k\Omega} = 0.26$mA.