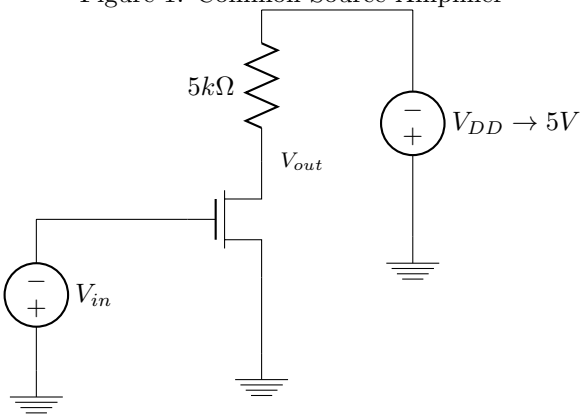
0.1 Theory and Procedure

Figure 1: Common-Source Amplifier



The common-source amplifier pictured above is then constructed. V_{in} is again swept from 0V to 5V. In the common-source arrangement, the NMOS transistor has the following condition for saturation:

$$V_{DS} > V_{GS} - V_T \rightarrow V_{out} = 5V - I_D R > V_{in} - V_T \rightarrow V_{in} < 5V - I_D R + V_T \quad (1)$$

In the common-source arrangement, V_{in} is equivalent to V_{GS}. So, when V_{in} is less than the threshold voltage, the transistor operates in the cutoff region and no current is passed through the transistor and consequently, the resistor. Because the transistor effectively acts as an open circuit, V_{out} is equivalent to V_{DD} for the entirety of the cutoff region. When V_{in} begins to overtake the threshold voltage, the transistor immediately operates in the saturation region. This is because small values of V_{GS} yield small I_D and thus, the condition in equation (1) is met. As V_{in} gets larger, I_D will also increase and V_{out} will decrease as a result. When V_{in} becomes sufficiently large, I_D will be large enough to violate the saturation condition and the transistor will then operate in triode mode. In triode region, V_{out} is expected to be very small because of the large I_D.

0.2 Results

`./data/common_source_edited.png`

Figure 2: Common Source Amplifier Voltage Transfer Characteristic

The threshold voltage V_T is again taken to be 1.7V. So, the NMOS transistor operates in the cutoff region when $V_{in} < 1.7$V and $V_{out} = 5$V for the majority of this range. When $V_{in} > 1.7$V, the transistor enters saturation mode and V_O sharply decreases.
Then, the bias point occurs when the following condition is met:

$$V_{DS} = V_{DD} - I_D R \rightarrow V_{in} = 5V - I_D R = V_{out} \tag{2}$$

Following the condition above, the bias point occurs at $V_{in} = V_{out} \approx 2.2V$ according to results shown in Figure (2). This voltage corresponds to the bias current $I_D = \frac{V_{out}}{5k\Omega} \approx \frac{2.2V}{5k\Omega} = 0.44$mA. The transistor enters triode mode when V_{in} exceeds $5V - I_D R + V_T$, which is beyond the bias point. With the assumption that the bias point occurs at the midpoint between the saturation and triode boundaries, V_{in} at triode region can be approximated to be $2.2V + (2.2V - 1.7V) \approx 2.7V$.