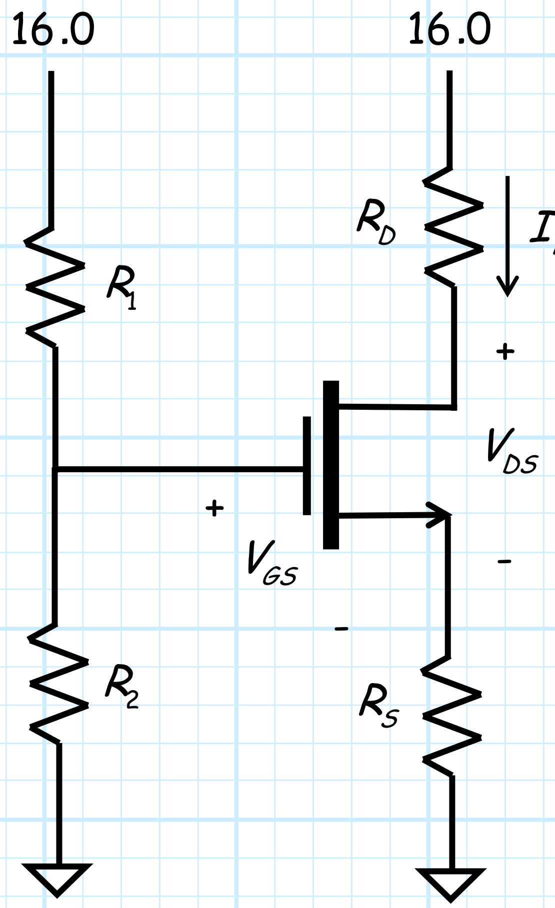
Example: Biasing of Discrete MOSFET Amplifiers



If the MOSFET has device values $K = 1.0 \text{ mA/V}^2$ and $V_t = 1.0 \text{ V}$, determine the resistor values to bias this MOSFET with a DC drain current of:

$$I_D = 4 \text{ mA}$$

1. Given the desired value of I_D, make **source voltage** $V_s = V_{DD}/4 = 4.0 \text{ V}$, i.e. set the source resistor R_S to:

$$R_S = \frac{V_s}{I_D} = \frac{4.0}{4.0} = 1 \text{ K}\Omega$$

2. Now determine the required value of V_{GS}. Since $I_D = K(V_{GS} - V_t)^2$, we find that V_{GS} should be:

$$\begin{aligned} V_{GS} &= \sqrt{\frac{I_D}{K}} + V_t \\ &= \sqrt{\frac{4.0}{1.0}} + 1.0 \\ &= 3.0 \text{ V} \end{aligned}$$

3. Set the required value of **gate voltage** V_G.

$$\begin{aligned} V_G &= V_{GS} + V_S \\ &= 3.0 + 4.0 \\ &= 7.0 \text{ V} \end{aligned}$$

Since the gate current is **zero** ($i_G = 0$), we find from voltage division that:

$$V_G = \frac{V_{DD}}{\left(R_1 / R_2\right) + 1}$$

Therefore:

$$\begin{aligned} R_1 / R_2 &= \frac{V_{DD}}{V_G} - 1 \\ &= \frac{16.0}{7.0} - 1 \\ &= \frac{9}{7} \end{aligned}$$

We need a **second** equation to explicitly determine the resistors values—the **sum** of the two resistances, for example.

We make the resistors as large a practicable. For **example**:

$$R_1 + R_2 = 240 \text{ K}$$

Therefore:

$$\frac{9}{7}R_2 + R_2 = 240$$

$$\frac{16}{7}R_2 = 240$$

and thus:

$$R_1 = 135 \text{ K}\Omega \qquad \text{and} \qquad R_2 = 105 \text{ K}\Omega$$

4. Set the required value of DC **drain voltage** V_D.

Set the drain voltage V_D to a value **half-way** between V_{DD} and $V_G - V_t$!

In other words, set the DC **drain voltage** to be:

$$\begin{aligned} V_D &= \frac{V_{DD} + (V_G - V_t)}{2} \\ &= \frac{16 + (7.0 - 1.0)}{2} \\ &= 11.0 \text{ V} \end{aligned}$$

To achieve this, we must select the drain **resistor** R_D so that:

$$\begin{aligned} R_D &= \frac{V_{DD} - V_D}{I_D} \\ &= \frac{16.0 - 11.0}{4.0} \\ &= 1.25\ \text{K}\Omega \end{aligned}$$