

Homework 2

(Lecture 2 and Lecture 3)

Question 1

Given this P channel MOSFET, find the I_D and V_{SD}

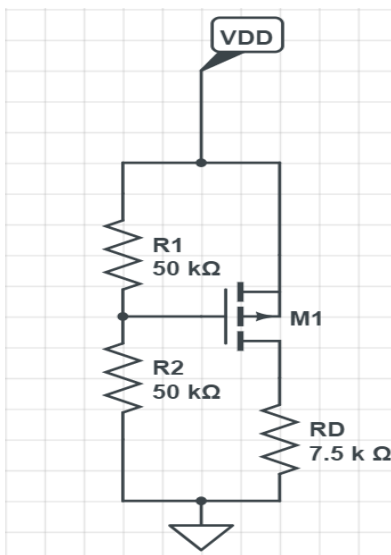
Assume, $R_1=R_2=50\text{ K ohm}$

$$K_p = 0.2\text{ mA/V}^2$$

$$V_{DD} = 5\text{v}$$

$$R_D = 7.5\text{ K ohm}$$

$$V_T = -0.8\text{v}$$



$$I_D \text{ is the linear region (P channel)} = K_p [2(V_{SG} + V_T)V_{SD} - V_{SD}^2]$$

$$I_D \text{ is the saturation region (P channel)} = K_p (V_{SG} + V_T)^2$$

Solution:

By DC voltage division, we get $V_g = 2.5V$, so $V_{SG} = 5 - 2.5 = \underline{2.5V}$

Since $V_{SG} > |V_T| \Rightarrow 2.5 > 0.8 \checkmark$, the transistor is active.

1) Assume saturation $\Rightarrow I_D = 0.2mA (2.5 - 0.8)^2 = 0.578mA$

$$V_D = I_D R_D = 0.578mA \cdot 7.5k\Omega = 4.335V \Rightarrow V_{SD} = .665V$$

CHECK $\rightarrow V_{SD} > V_{SD(sat)} = V_{SG} + V_T = 2.5 - 0.8 = 1.7V$ ($0.665V < 1.7V$)

\hookrightarrow transistor is NOT in saturation, so it must be in linear region.

$$2) I_D = 0.2 [2(2.5 - 0.8)(5 - V_D) - (5 - V_D)^2] = 0.2 [3.4(5 - V_D) - 25 + 10V_D - V_D^2]$$
$$0.2 [17 - 3.4V_D - 25 + 10V_D - V_D^2] = 0.2 [-V_D^2 + 6.6V_D - 8] = 0.2V_D^2 + 1.32V_D - 1.6 = I_D$$

$$3) \text{Sub in } I_D \rightarrow 0.2(7.5I_D)^2 + 1.32(7.5I_D) - 1.6 = I_D \rightarrow 11.25I_D^2 + 9.9I_D - 1.6 = I_D$$

$$\hookrightarrow 11.25I_D^2 + 8.9I_D - 1.6 = 0 \quad \begin{cases} \rightarrow I_D = 0.21mA \rightarrow V_D = 0.21mA(7.5k\Omega) = 1.5V \\ \rightarrow I_D = 0.61mA \rightarrow V_D = 0.61mA(7.5k\Omega) = 4.57V \end{cases}$$

4) V_{SD} must be $\leq 1.7V$, so $\boxed{I_D = 0.61mA \text{ and } V_{SD} = 33mV}$

Question 2

Sketch a stick diagram for the circuit below

$$Y = (A + B + C) \cdot D$$

Solution:

$$Y = \overline{(A + B + C)} \cdot D$$

