# EE4C10 Analog Circuit Design Fundamentals
## Homework Assignment I

Tzong Lin Chua

August 31, 2021

## Contents

## Problem 1

For $I_D = 40\mu A$:

$$I_D = \frac{1.8V - V_D}{R}$$
$$V_D = 1.8V - I_D R$$
$$\underline{V_D = 1.0V}$$

Saturation region:

$$V_{GS} = 1.0V > V_{TH}$$
$$V_{GS} - V_{TH} = 0.4V < V_{DS}$$

1. $\lambda = 0V^{-1}$

$$I_D = \frac{\mu_n C_{OX}}{2}\frac{W}{L}(V_{GS} - V_{TH})^2$$
$$L = \frac{\mu_n C_{OX}}{2}\frac{W}{I_D}(V_{GS} - V_{TH})^2$$
$$\underline{L = 0.39\mu m}$$

2. $\lambda = 0.06V^{-1}$

$$I_D = \frac{\mu_n C_{OX}}{2}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$$
$$L = \frac{\mu_n C_{OX}}{2}\frac{W}{I_D}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$$
$$\underline{L = 0.41\mu m}$$

## Problem 2

$W = \frac{2LI_D}{\mu_p C_{OX}}\frac{1}{(V_{SG} - V_{TH})^2}$

1. Bulk of the transistors are connected to the source, $V_B = V_S$

$$V_{TH} = V_{TH0} + \gamma(\sqrt{2\varphi_F + V_{SB}} - \sqrt{|2\varphi_F|})$$
$$V_{TH} = V_{TH0} = 0.33V$$

(a) Transistor $M_1$

$$V_{SG} = 2.5V - 1.7V = 0.8V$$

$$I_D = \frac{\mu_p C_{OX}}{2} \frac{W}{L}(V_{SG} - V_{TH})^2$$
$$W = \frac{2LI_D}{\mu_p C_{OX}} \frac{1}{(V_{SG} - V_{TH})^2}$$
$$W_1 = 2.72\mu m$$

(b) Transistor $M_2$

$$V_{SG} = 1.7V - 1V = 0.7V$$

$$W = \frac{2LI_D}{\mu_p C_{OX}} \frac{1}{(V_{SG} - V_{TH})^2}$$
$$W_2 = 4.38\mu m$$

(c) Transistor $M_3$

$$V_{SG} = 1V$$

$$W = \frac{2LI_D}{\mu_p C_{OX}} \frac{1}{(V_{SG} - V_{TH})^2}$$
$$W_3 = 1.37\mu m$$

2. Bulk terminals are attached to the $V_{DD}$, $V_B = V_{DD}$.

(a) Transistor $M_1$

$$V_{SB} = 2.5V - 2.5V = 0V$$

$$V_{TH} = V_{TH0} + \gamma(\sqrt{2\varphi_F + V_{SB}} - \sqrt{|2\varphi_F|})$$
$$V_{TH} = V_{TH0} = 0.33V$$
$$W = \frac{2LI_D}{\mu_p C_{OX}} \frac{1}{(V_{SG} - V_{TH})^2}$$
$$W_1 = 2.72\mu m$$

(b) Transistor $M_2$

(c) Transistor $M_3$

# Problem 3

# Problem 4

# Problem 5

# Problem 6

# Problem 7