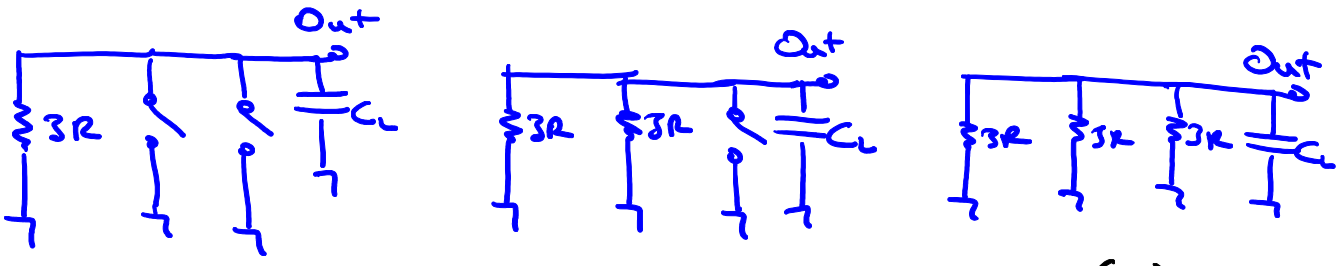
EECS 251 - Homework 7 Solutions

1

1)



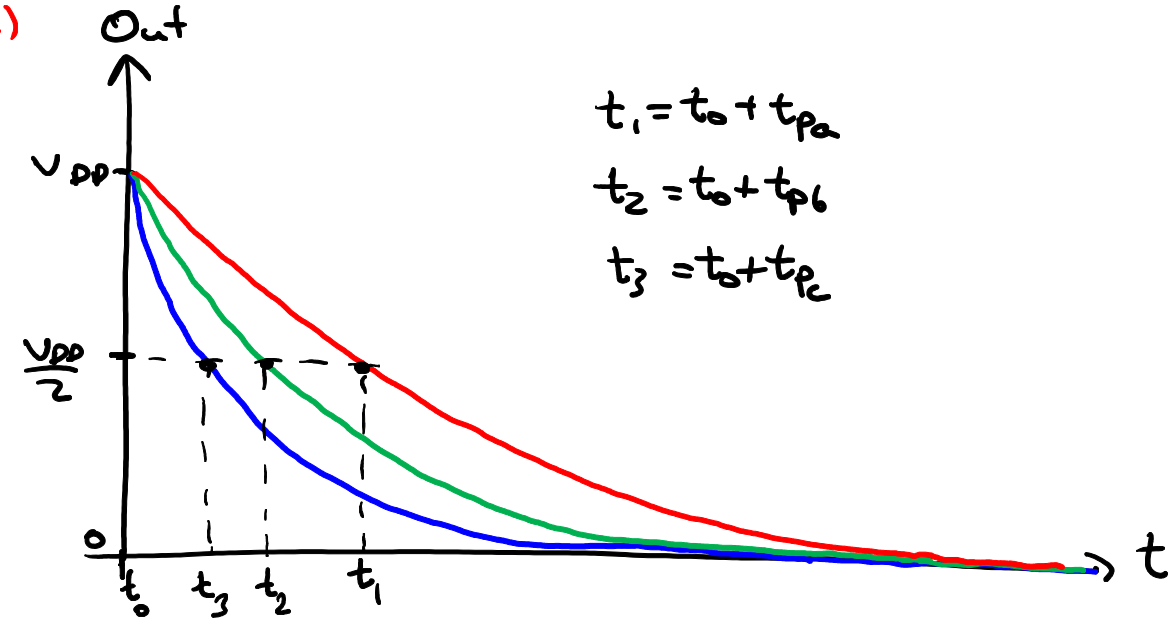
(a) (b) (c)

$$t_{p_a} = \ln(2) \cdot 3R \cdot C_L = 3 \cdot \ln(2) \cdot RC_L$$

$$t_{p_b} = \ln(2) \cdot \frac{3R}{2} \cdot C_L = 1.5 \cdot \ln(2) \cdot RC_L$$

$$t_{p_c} = \ln(2) \cdot \frac{3R}{3} \cdot C_L = \ln(2) \cdot RC_L$$

2)



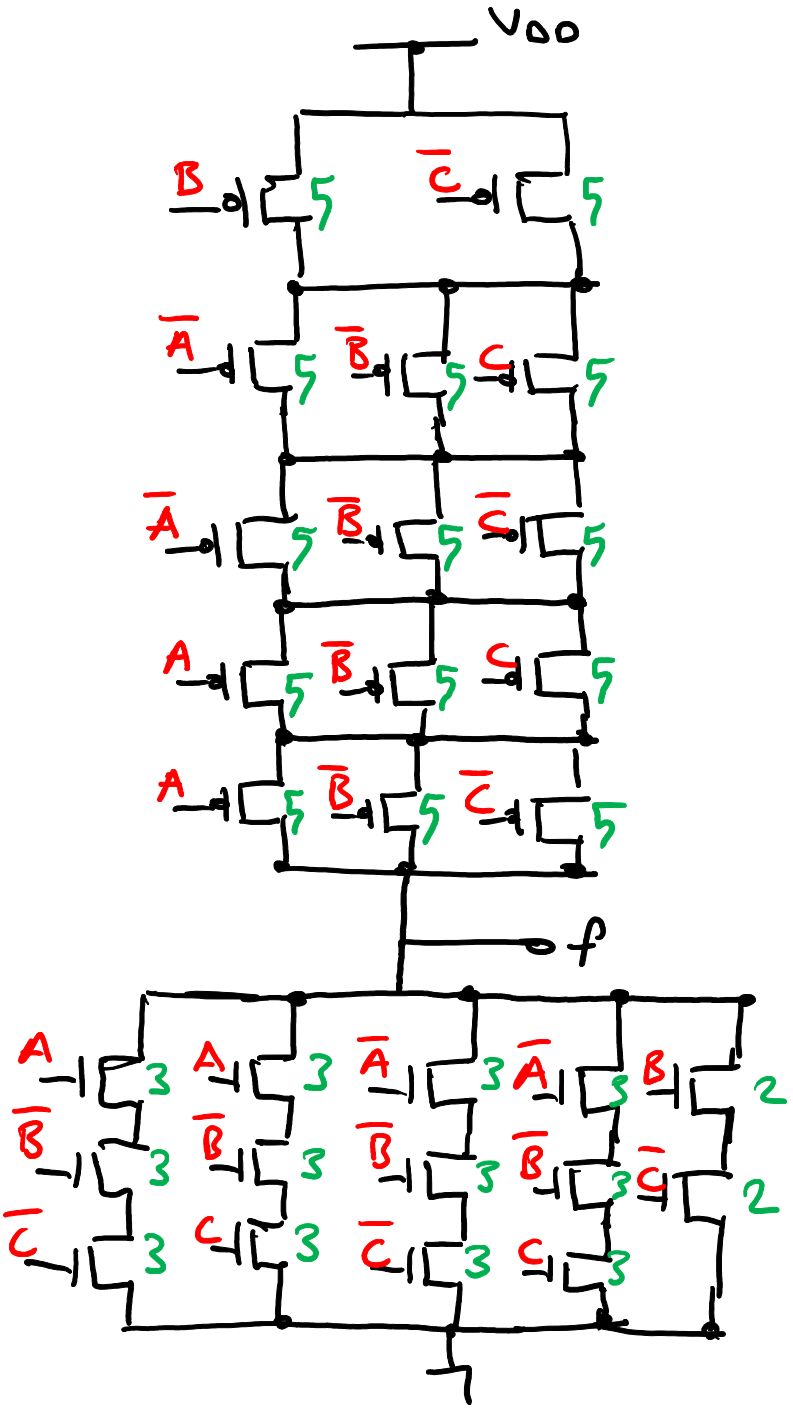
$$t_1 = t_0 + t_{p_a}$$

$$t_2 = t_0 + t_{p_b}$$

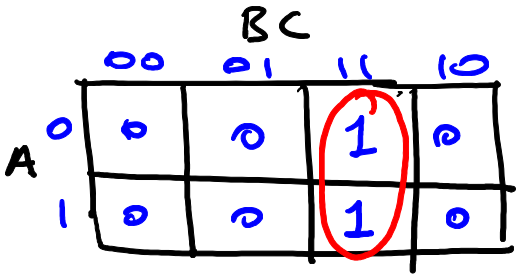
$$t_3 = t_0 + t_{p_c}$$

(2)

1)



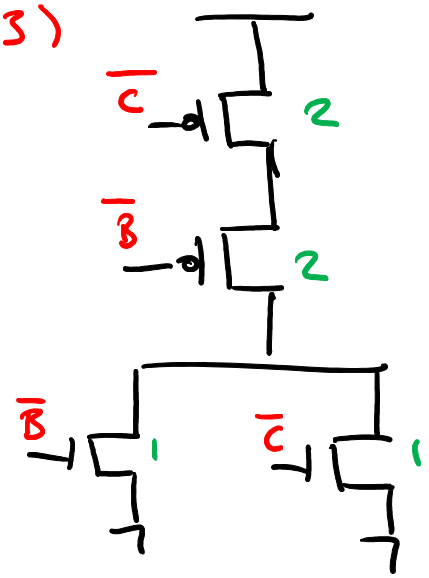
2)



$\Rightarrow f = B \cdot C$

$f = \overline{\bar{B} + \bar{C}}$

3)



4)

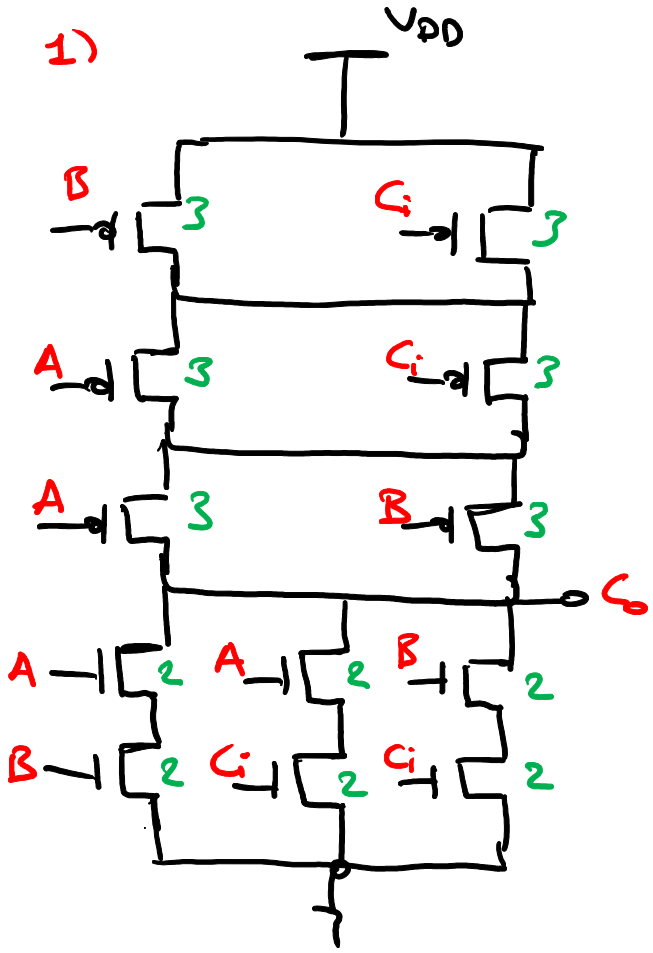
PMOS ↑ NMOS ↑

$A_{total_1} = 70 + 40 = 110$

$A_{total_2} = 4 + 2 = 6$

(3)

1)



2) Yes, it is equivalent. It uses less transistors and utilizes smaller transistors, reducing the input capacitances.

3) It is a static CMOS gate. It does not have complementary PU/PD networks, but the two networks operate as if they are complementary. This property (that only some logical functions have) is called "self-duality".

(4) For PMOS weaker than NMOS (2:1)

$$TLE = \frac{4}{3} \times \frac{5}{3} \times \frac{5}{3} \times \frac{7}{3}$$

$B = 4$

$F = 200$

$PE = 6914 \Rightarrow EF = \sqrt[7]{PE} \cong 3.54$

$$f = \frac{C_L}{EF} = 56.5$$

$$e = \frac{f}{EF} \cdot LE_e = 37.2$$

$$d = \frac{e}{EF} \cdot LE_d = 17.52$$

$$c = \frac{d}{EF} = 4.95$$

$$b = B_b \cdot \frac{c}{EF} \cdot LE_b = 9.33$$

$$a = \frac{b}{EF} \cdot LE_a = 3.52$$

The fact that a is not exactly 3.52 is due to rounding errors.

For PMOS equal to NMOS

$$\pi LE = \frac{3}{2} \cdot \frac{3}{2} \cdot 2.2 = 9$$

$$B = 4$$

$$F = 200$$

$$PE = 7200 \Rightarrow EF = \sqrt[7]{PE} \cong 3.56$$

$$f = \frac{C_L}{EF} = 56$$

$$e = \frac{f}{EF} \cdot LE_e = 31.46$$

$$d = \frac{e}{EF} \cdot LE_d = 17.67$$

$$c = \frac{d}{EF} = 4.96$$

$$b = B_b \cdot \frac{c}{EF} \cdot LE_b = 8.36$$

$$a = \frac{b}{EF} \cdot LE_a = 3.52$$

The fact that a is not exactly 3.52 is due to rounding errors.