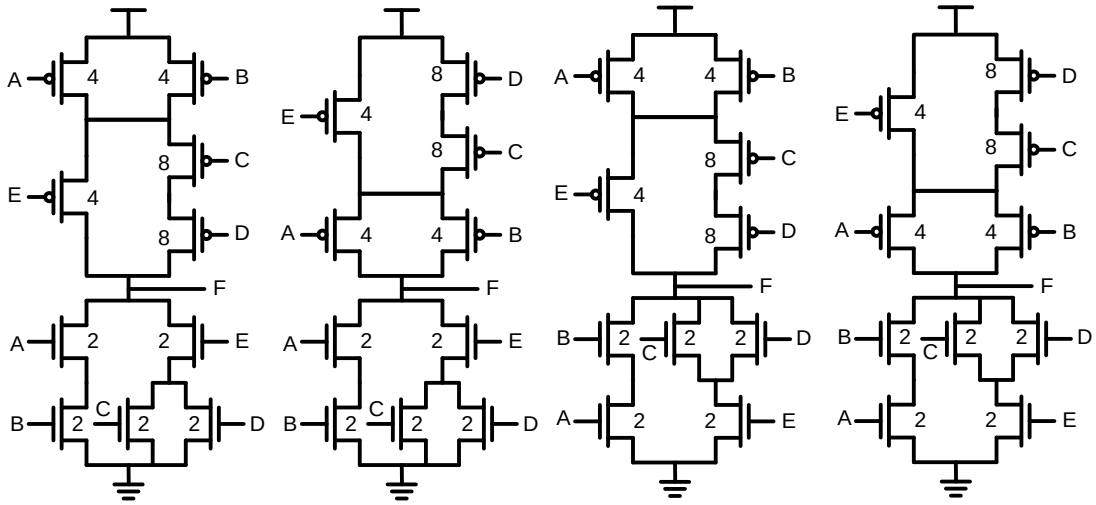
2011 VLSI Introduction Midterm Solution

2011/12/1

1.

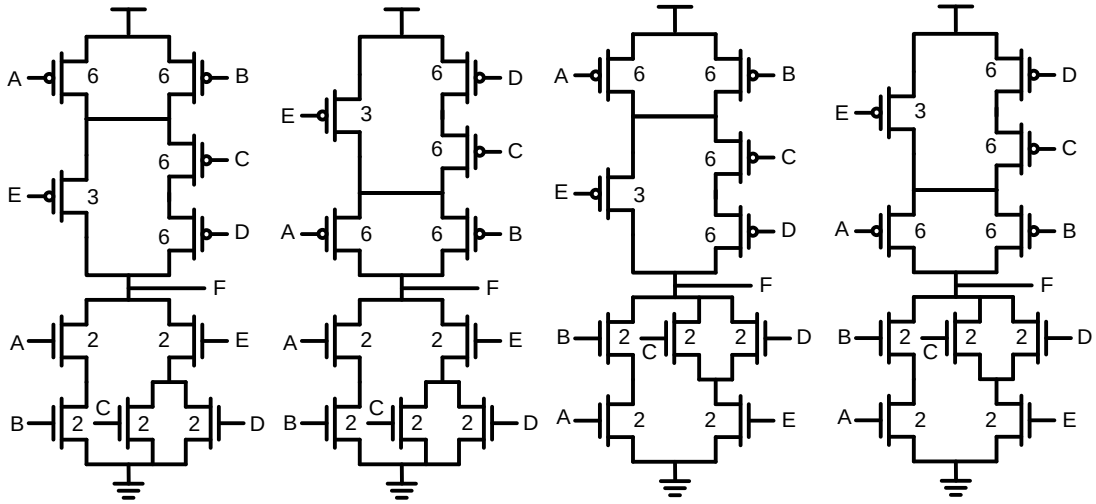
(a.) 2.5%

Case 1:



Case 2:

對 critical path 做最佳化



畫出以上任一種皆給分

(b.) 2.5% (no partial)

Case 1:

$$g_A = \frac{4+2}{3} = 2$$

$$g_C = \frac{8+2}{3} = \frac{10}{3}$$

$$g_E = \frac{4+2}{3} = 2$$

Case 2:

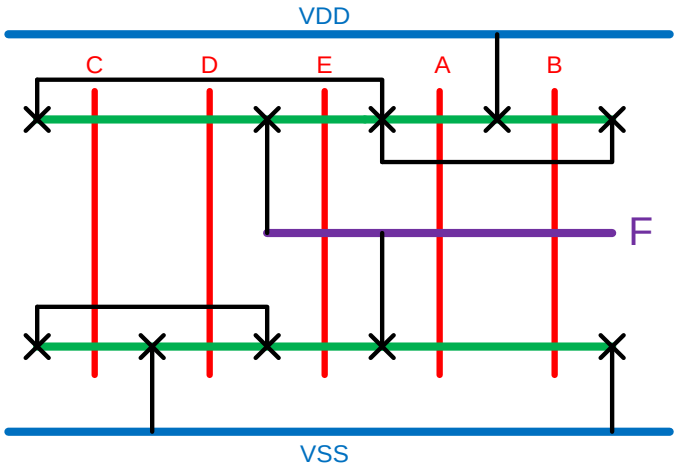
$$g_A = \frac{6+2}{3} = \frac{8}{3}$$

$$g_C = \frac{6+2}{3} = \frac{8}{3}$$

$$g_E = \frac{3+2}{3} = \frac{5}{3}$$

(c.) 2.5%

參考答案：(可分不同 diffusion，畫對就給分)



(d.) 2.5% (no partial)

Case 1:

$$p_{\max} = \frac{4+8+2+2+2}{3} = 6$$

$$p_{\min} = \frac{4+4+2+2}{3} = 4$$

Case 2:

$$p_{\max} = \frac{6+6+2+2+2}{3} = 6$$

$$p_{\min} = \frac{3+6+2+2}{3} = \frac{13}{3}$$

2.

(a)

$$g_u = 4$$

$$g_d = \frac{4}{3}$$

$$g_{avg} = \frac{8}{3}$$

(b)

$$P_u = \frac{14}{3}$$

$$P_d = \frac{14}{9}$$

$$P_{avg} = \frac{28}{9}$$

3.

(a) Vout = 0.7→0.5(V)

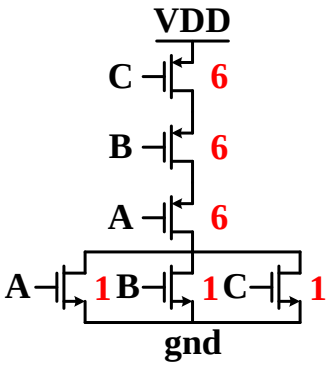
(b) (1) Vout = 0.5→0.7(V)

(2) Vout = X→0.5→0.7(V)

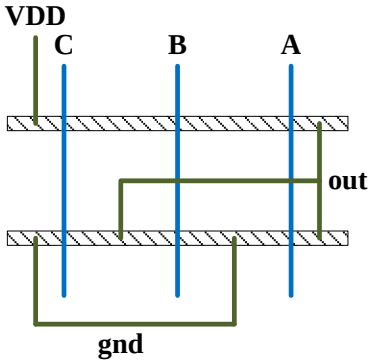
(1)(2)皆可

4.

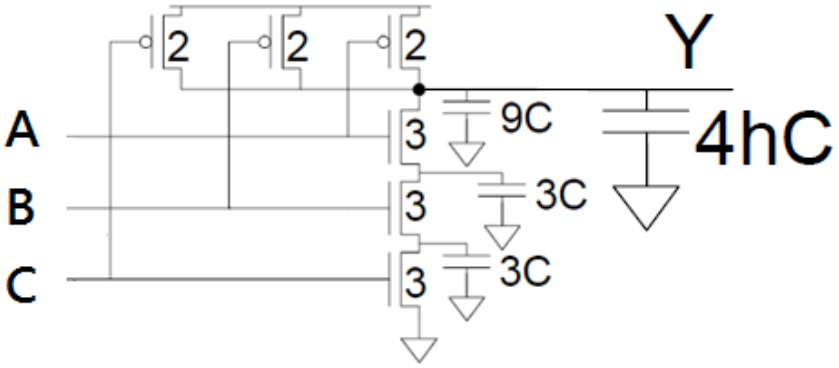
(a)



(b)



5.



(a.)

$$t_{pdr} = (9 + 4h)RC$$

$$t_{pdf} = (3C)\left(\frac{R}{3}\right) + (3C)\left(\frac{2R}{3}\right) + (9 + 4h)RC = (12 + 4h)RC$$

$$t_{pd} = \frac{t_{pdr} + t_{pdf}}{2} = \left(\frac{21}{2} + 4h\right)RC$$

(b.)

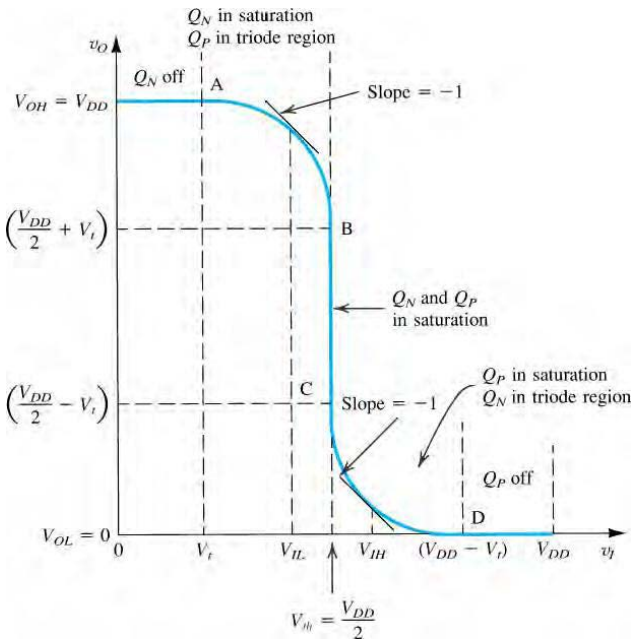
$$t_{cdr} = \frac{(9 + 4h)}{3}RC$$

$$t_{cdf} = (9 + 4h)RC$$

$$t_{cd} = \frac{t_{cdr} + t_{cdf}}{2} = \left(6 + \frac{8}{3}h\right)RC$$

6

(a)



(b)

$NM_H=V_{OH}-V_{IH}$

$NM_L=V_{IL}-V_{OL}$

(c)

High-skewed:

$NM_H\downarrow$ $NM_L\uparrow$

Low-skewed:

$NM_H\uparrow$ $NM_L\downarrow$

(d)

$$W_p/W_n = \mu_n/\mu_p = 3$$

(e)

$NM_H= V_{OH}-V_{TH} =V_{DD}-V_{TH}$

$NM_L=V_{TH}-V_{OL}=V_{TH}$

7.

(f) $D = N(128)^{\frac{1}{N}} + N$

N	1	2	3	4	5	6	7
F	128	11.3	5	3.4	2.6	2.2	2
D	129	24.6	18	17.6	18	19.2	21

N = 4

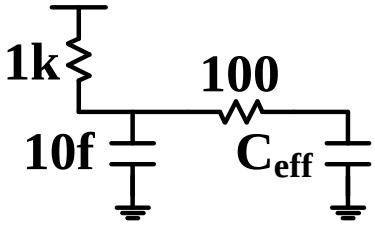
(g) f=3.4, D=17.6

8.

C_{wire} = 0.4*500 = 200 fF

C_{adj} = 0.2*500 = 100 fF

R_{wire} = 0.2*500 = 100 Ω



(a)

In this case, because the X and Y change in different direction, the C_{adj} should be multiplied by 2.

C_{eff} = 200f + 100f*2 = 400f

Propagation delay = 1k*10f + (1k + 100)*400f = 450000f = 450p (s)

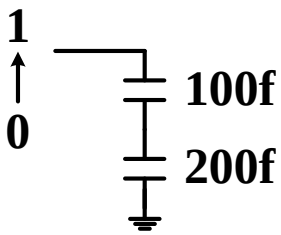
(b)

In this case, because only X changes, the C_{adj} is 100f.

C_{eff} = 200f + 100f = 300f

Propagation delay = 1k*10f + (1k + 100)*300f = 340000f = 340p (s)

(c)



$\Delta V_Y = \frac{100f}{200f+100f} \times 1 = \frac{1}{3}$ (V)

(d)

(1)Shielding.

(2)increasing the load capacitor of Y.

(3)put the two wire away.

9.

(a.)

$$d = gh + p = 2$$

$$f_{osc} = \frac{1}{2Nd} = \frac{1}{2 \times 7 \times 2 \times 0.5\text{k} \times 5\text{f}} = 14.286(\text{GHz})$$

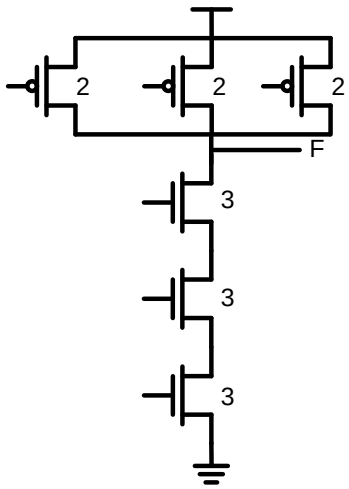
(b.)

Skewed inverter gavg = 1,

$$f_{osc} = \frac{1}{2Nd} = \frac{1}{2 \times 7 \times 2 \times 0.5\text{k} \times 5\text{f}} = 14.286(\text{GHz})$$

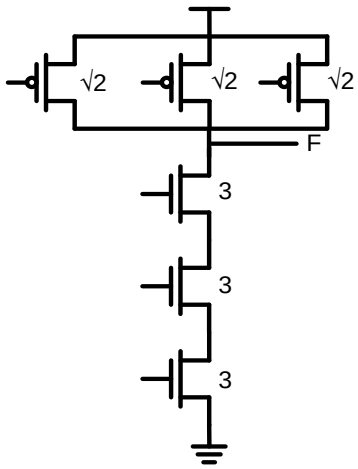
10

(a)



$g_{avg} = \frac{5}{3}$, p = 3

(b)



$$g_u = \frac{3+\sqrt{2}}{\sqrt{2}+\frac{\sqrt{2}}{2}} = 2.08 \quad , \quad g_d = \frac{3+\sqrt{2}}{2+1} = 1.471 \quad , \quad g_{avg} = 1.7755$$

$$p_u = \frac{3+3\sqrt{2}}{\sqrt{2}+\frac{\sqrt{2}}{2}} = 3.414 \quad , \quad p_u = \frac{3+3\sqrt{2}}{2+1} = 2.414 \quad , \quad p_{avg} = 2.914$$

11.

解釋和解決方法各一分

(a.) 參考講義 Chapter 5. Page 5-59~60

(b.) 參考講義 Chapter 5. Page 5-47~50

(c.) 參考講義 Chapter 5. Page 5-51~56

(d.) 參考講義 Chapter 5. Page 5-57~58

(e.) 參考講義 Chapter 5. Page 5-61~65

12.

(a)

$G = 1 \times \frac{4}{3} \times \frac{5}{3} \times 1 = \frac{20}{9}$

$H = \frac{60}{2} = 30$

$B = 2 \times 2 = 4$

$F = GBH = \frac{20}{9} \times 4 \times 80 = \frac{800}{3}$

$\hat{f} = \sqrt[4]{F} = \sqrt[4]{\frac{800}{3}} = 4.041$

$P = 1 + 2 + 2 + 1 = 6$

$D = 4 \times 4.041 + 6 = 22.164$

(b)

$$Z = \frac{60\times1}{4.041} = 14.85$$

$$Y = \frac{14.85\times\frac{5}{3}}{4.041} = 6.12$$

$$X = \frac{6.12\times2\times\frac{4}{3}}{4.041} = 4.04$$

13.

(a.) 參考講義 Chapter 4. Page 4-15

(b.) 參考講義 Chapter 4. Page 4-14

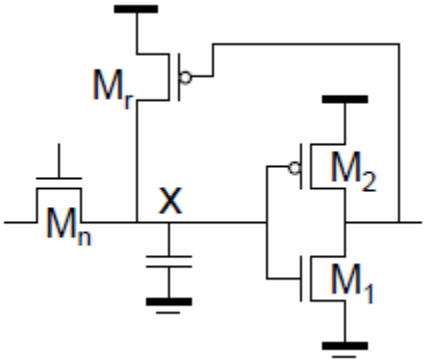
(c.) 參考講義 Chapter 4. Page 4-12

(d.) 參考講義 Chapter 4. Page 4-13

(e.) 參考講義 Chapter 4. Page 4-19

14.

(a)



(b)

$R_{on} \leq 100\Omega$ (若使用 V_{IL} 來算 R_{ON}，則扣一分!)

15.

$$P_{dynamic} = \left[0.1\left(20M \times 0.6um \times 2\,{}^{fF}/_{um}\right) + 0.05\left(80M \times 0.2um \times 2\,{}^{fF}/_{um}\right)\right] \times (0.8)^2 \times 1 \times 10^9 = 2.56W@1GHz$$

16.

(a) F

(b) F

(c) F

(d) F

(e) T

(f1) T

(g1) T

(f2) F

(g2) T

(h) F

(i) F

(j) T

(k) T

(l) T

(m) F

(n) T

(o) F