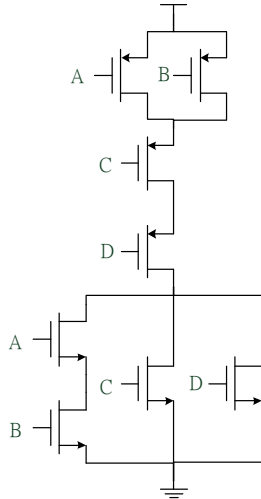


# VLSI 2012 Midterm Solution

1.

(a)

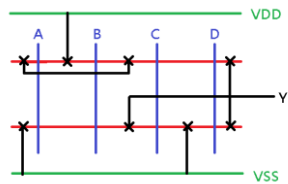


有多種答案，畫對任一種就算對，不用標示 size。

(b)  $g_A = g_B = (6+2)/3$

$g_C = g_D = (6+1)/3$

(c)



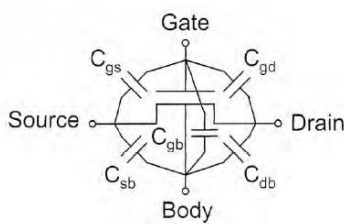
有多種答案，畫對任一種就算對，要有正確標示 VDD、VSS、A~D、Y(out)

(d)  $P_{max} = (6+6+2+1+1)/3 = 16/3$

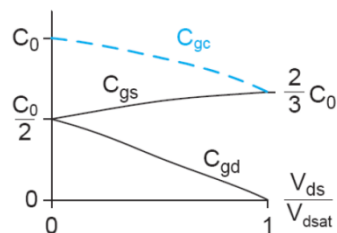
$P_{min} = (6+2+1+1)/3 = 10/3$

2. 兩小題,各 2.5 分,第一小題少畫兩個電容以上扣 2.5 分

(a)



(b)



3.

(a) 由題目可知，PMOS 為 2/3，所以 NMOS 為 12/3 如圖

$$g_u = 12/3 = 4$$

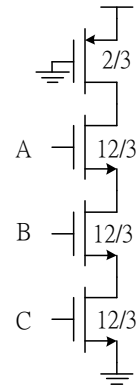
$$g_d = 12/9 = 4/3$$

$$g_{avg} = (g_u + g_d)/2 = 8/3$$

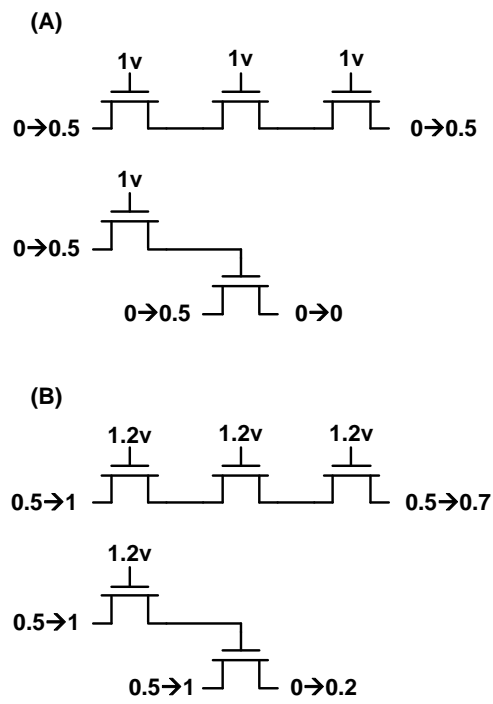
(b)  $p_u = 2/3 + 12/3 = 14/3$

$$p_d = (2/3 + 12/3)/3 = 14/9$$

$$p_{avg} = (p_u + p_d)/2 = 28/9$$

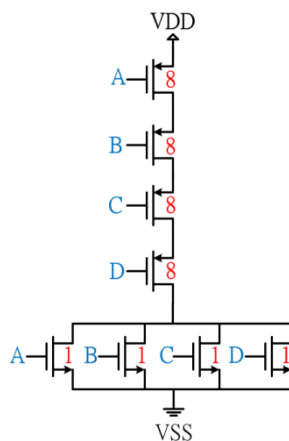


4. 每一小題 2.5 分，內有兩組答案，錯一個得 1.5 分，全錯 0 分

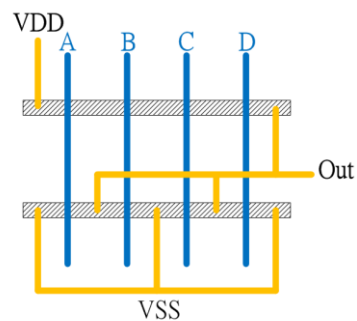


5. 兩小題,各 2.5 分,第二小題題目要求 smallest parasitic cap 因此沒有照解答畫法則扣 2.5 分

(a)

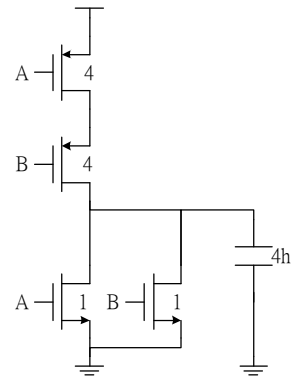


(b)



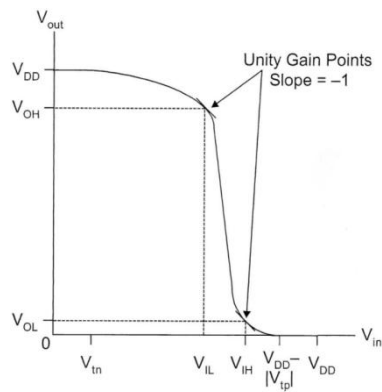
6.

$$\begin{aligned}
 \text{(a) } t_{pdf} &= (6+4h)RC \\
 t_{pdr} &= 4C \cdot R/2 + (6+4h)RC = (8+4h)RC \\
 t_{pd} &= (t_{pdf} + t_{pdr})/2 = (7+4h)RC \\
 \text{(b) } t_{cdf} &= (3+2h)RC \\
 t_{cdr} &= (6+4h)RC \\
 t_{cd} &= (t_{cdf} + t_{cdr})/2 = (9/2+3h)RC
 \end{aligned}$$



7. 五小題,各 2 分, (e)小題沒有分五個 region 討論則少一個或是錯一個 region 扣一分

(a)



(b)

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

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

(c)

$\beta$  ratio  $> 1$ :

$NM_H \downarrow$ ,  $NM_L \uparrow$

$\beta$  ratio  $< 1$ :

$NM_H \uparrow$ ,  $NM_L \downarrow$

$\beta$  ratio = 1:

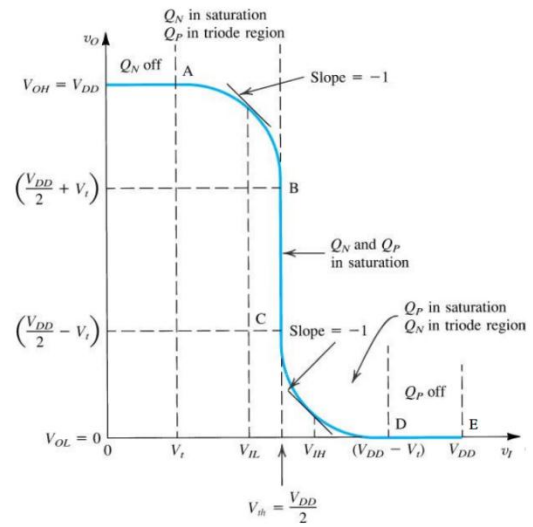
$NM_H = NM_L$

(d)

$$\frac{W_P}{W_N} = \frac{\mu_N}{\mu_P} = 4$$

(e)

Region	nMOS	pMOS
A	Cut-off	Linear
B	Saturation	Linear
C	Saturation	Saturation
D	Linear	Saturation
E	Linear	Cut-off



8. 每一小題 2.5 分，內有兩組答案，錯一個得 1.5 分，全錯 0 分

(A)

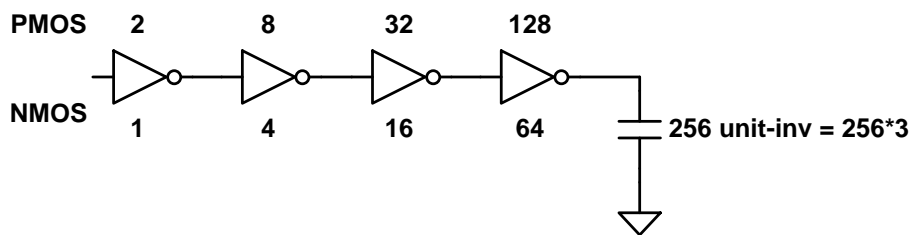
$$D = NF^{\frac{1}{N}} + N$$

$N$	1	2	3	4	5	6	7	8
$f_i$	256	16	6.35	4	3.03	2.52	2.2	2
$D$	257	34	22.05	20	20.15	21.12	22.4	24

$$N=4; D=20$$

(B)

$$f_i=4$$



9.

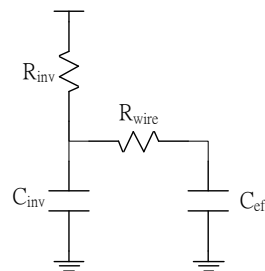
$$R_{inv} = 1k\Omega$$

$$C_{inv} = 40fF$$

$$R_{wire} = 150\Omega$$

$$C_{gnd} = 0.3pF$$

$$C_{adj} = 0.2pF$$



(a) 反向 couple  $\rightarrow C_{eff} = C_{gnd} + 2 * C_{adj}$

$$T_{pd} = R_{inv} * C_{inv} + (R_{wire} + R_{inv}) * C_{eff}$$

$$= 40p + 805p = 845ps$$

(b) 單向 couple  $\rightarrow C_{eff} = C_{gnd} + C_{adj}$

$$T_{pd} = R_{inv} * C_{inv} + (R_{wire} + R_{inv}) * C_{eff}$$

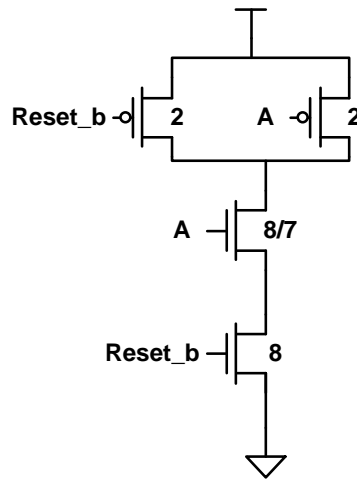
$$= 40p + 575p = 615ps$$

(c)  $1V * C_{adj} / (C_{adj} + C_{gnd}) = 0.4V$

(d) Shielding or separating 不能寫 guard-ring

(guard-ring 是指利用連結 substrate 或 n,p-well 的 via 包覆電路)

10. 每一小題 2.5 分，第 A 小題錯全錯，B 小題錯一得 1.5 分



(A)

Pull down path: resistance =  $1 - 1/8 = 7/8$ ; size\_A =  $8/7$

Pull up path unchanged: sizes = 2

(B)

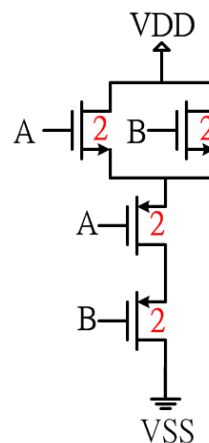
$$g_A = \frac{2 + \frac{8}{7}}{3} = \frac{22}{21}, g_B = \frac{2 + 8}{3} = \frac{10}{3}$$

11. 每一小題 2.5 分；每小題兩個答案  $g_{avg}, p$  錯一個扣 1 分, 錯兩個全錯

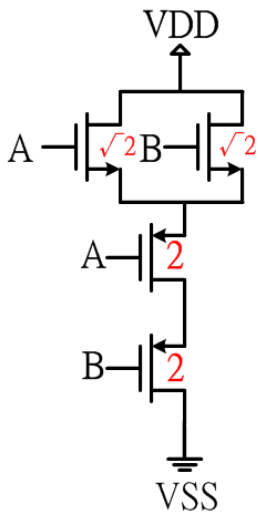
(a)

$$g_{avg} = \frac{2+2}{3} = \frac{4}{3}$$

$$p = \frac{2+2+2}{3} = 2$$



(b)



$$g_u = \frac{2+\sqrt{2}}{\sqrt{2}+\frac{\sqrt{2}}{2}} = 1.6095$$

$$g_d = \frac{2+\sqrt{2}}{2+1} = 1.13807$$

$$g_{\text{avg}} = \frac{g_u + g_d}{2} = 1.3738$$

$$p_u = \frac{2\sqrt{2}+2}{\sqrt{2}+\frac{\sqrt{2}}{2}} = 2.27614$$

$$p_d = \frac{2\sqrt{2}+2}{2+1} = 1.6095$$

$$p_{\text{avg}} = \frac{p_u + p_d}{2} = 1.9428$$

12. 每一小題 2.5 分；A 小題錯全錯，B 小題錯一扣 1 分

(a)

$$F = GBH = \left(1 \times \frac{5}{3} \times \frac{5}{3} \times 1\right) (2 \times 2) \left(\frac{100}{2}\right) = \frac{5000}{9}$$

$$N = 4, \quad P = 1 + 3 + 2 + 1 = 7$$

$$D = NF^{\frac{1}{N}} + P = 26.42$$

(b)

$$f = \left(\frac{5000}{9}\right)^{\frac{1}{4}} = 4.85$$

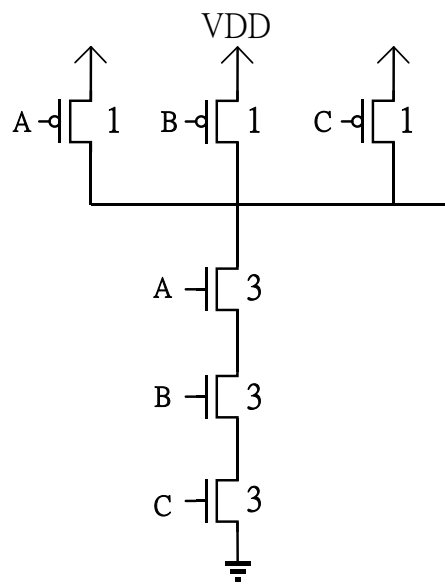
$$C_{\text{in}} = \frac{g \times C_{\text{out}}}{f}$$

$$\Rightarrow \begin{cases} z = \frac{1 \times 100}{4.85} = 20.6 \\ y = \frac{5/3 \times 20.6}{4.85} = 7.1 \text{ 在這裡鍵入方程式。} \\ x = \frac{5/3 \times 7.1 \times 2}{4.85} = 4.87 \end{cases}$$

13. 每一小題 2 分，依正確性酌量扣 1 分或全錯

- (a) 請參考講義 4-14
- (b) 請參考講義 3-11
- (c) 請參考講義 4-15
- (d) 請參考講義 3-11
- (e) 請參考講義 4-12

14. 每一小題 2.5 分；A 小題圖畫錯全錯，圖畫對 SIZE 錯一個扣 1 分，SIZE 全錯則扣光，B 小題  $g_{avg}$  佔 0.5 分，另兩個各佔 1 分



(b)

$$g_u = \frac{1 + 3}{1 + \frac{1}{2}} = \frac{8}{3}, \quad g_d = \frac{1 + 3}{1 + 2} = \frac{4}{3}$$

$$g_{avg} = \frac{1}{2}(g_u + g_d) = 2$$

15. 每一小題 2.5 分；A 小題錯全錯，B 小題圖畫錯全錯，圖畫對 NMOS 的 SIZE 錯扣 1 分，SIZE 全錯則扣光

(a)

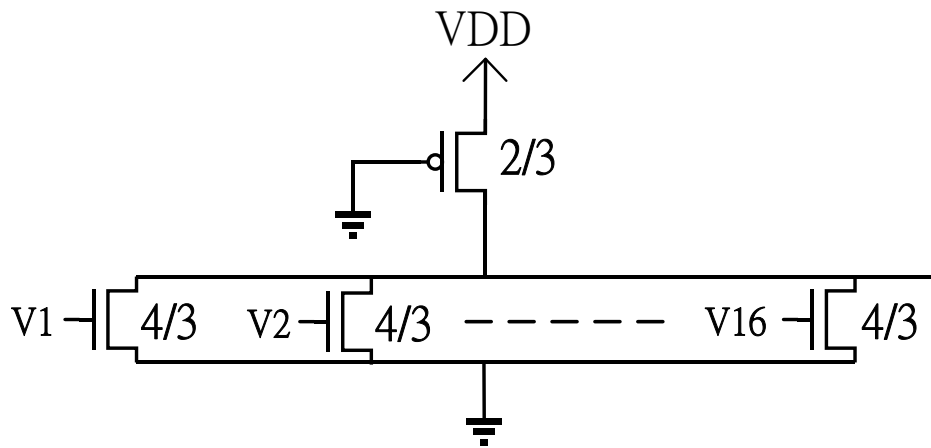
$$G = 1 \times \frac{8}{9} = \frac{8}{9}, \quad H = \frac{64}{2} = 32, \quad N = 2$$

$$F = GBH = \frac{8}{9} \times 1 \times 32 = \frac{256}{9}$$

$$P = 1 + \frac{4 + 8 \times 16}{9} = \frac{141}{9}$$

$$D = NF^{\frac{1}{N}} + P = \frac{79}{3} = 26.33$$

(b)



16. 總共 5 分，錯一個順序位置扣一分，扣到 0 分為止

D → C → I → B → H → F → L → K → G → E → J → A

17.

(a)F (b)F (c)F (d)T (e)F

(f)T (g)T (h)T (i)T (j)F