

#1

$$(a) A_{\text{initial}} = NL^2$$

$$A_{\text{one-year}} = N_1 L_1^2 = A_{\text{initial}}$$

(assume that $A_{\text{one-year}}$ denotes the total chip area, which is fixed, N_1 : number of transistors after 1 year in the total area, L_1 : length of each transistor)

Given that # of transistors per unit area doubles per two years. Assume every year the growth rate in number is the same, then

$$\left(\frac{N_1}{N}\right)^2 = 2 \Rightarrow N_1 = N\sqrt{2}$$

↑
rate of growth in 2 years

$$N_1 L_1^2 = NL^2 \Rightarrow L_1^2 = \frac{N}{N_1} L^2 \Rightarrow L_1/L = \sqrt{\frac{N}{N_1}} = 1/2^{1/4}$$

the annual scaling factor is $S = L_1/L = 1/2^{1/4}$

$$(b) L_{2014} = 18.4\text{nm}, \text{ so } L_{2021} = L_{2014} S^{(2021-2014)} = L_{2014} \times 1/2^{7/4} \\ = 5.47\text{nm}$$

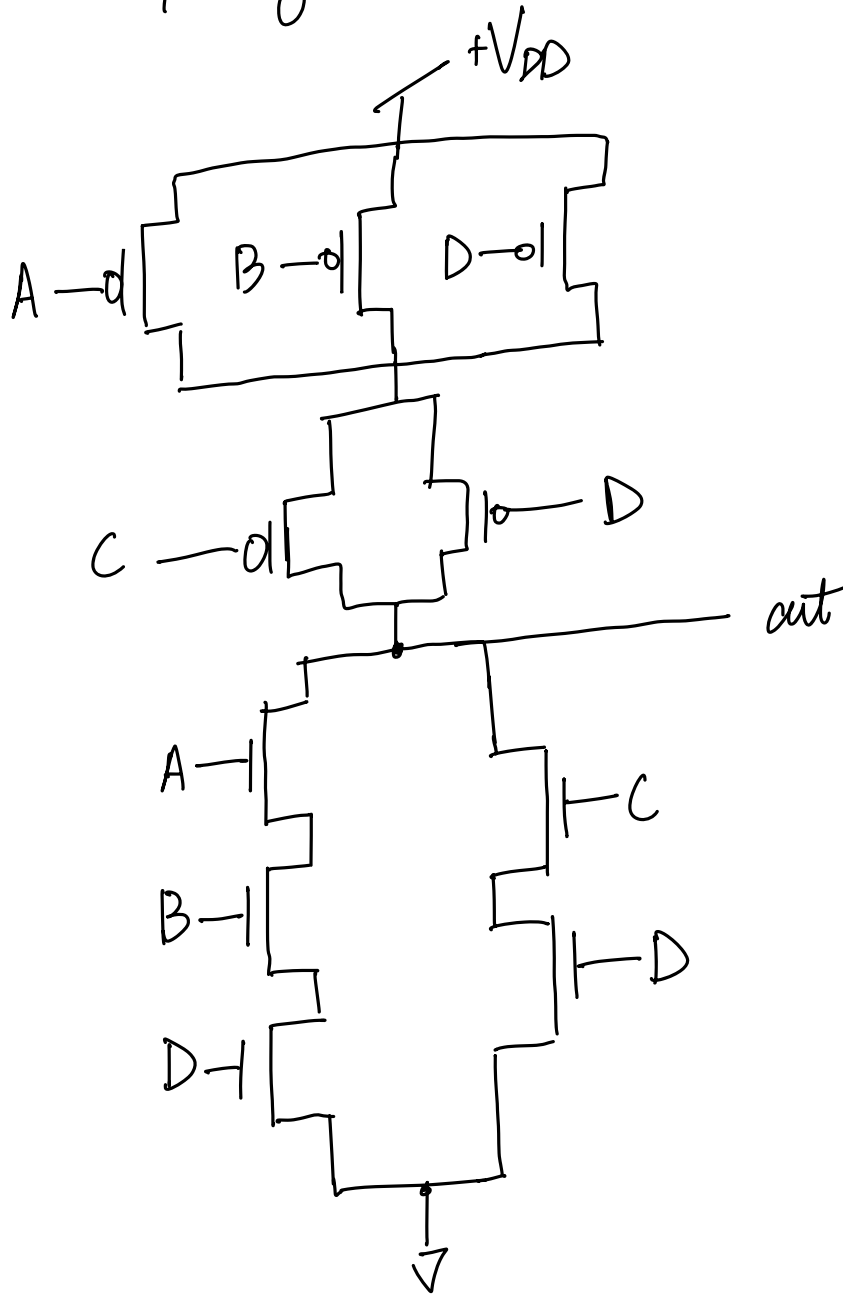
this predicted gate length is much shorter than the number in the report.

#2 (1) $F = \overline{(AB+C)D}$

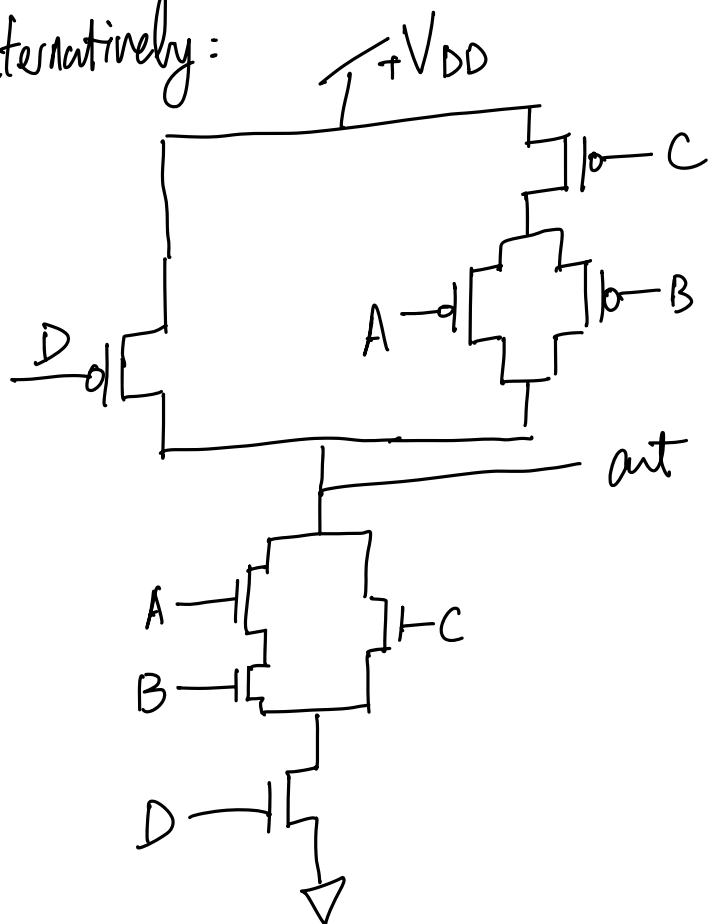
$\bar{F} = (AB+C)D \rightarrow$ to be realized with PDN

$= ABD + CD$

the corresponding CMOS circuit:



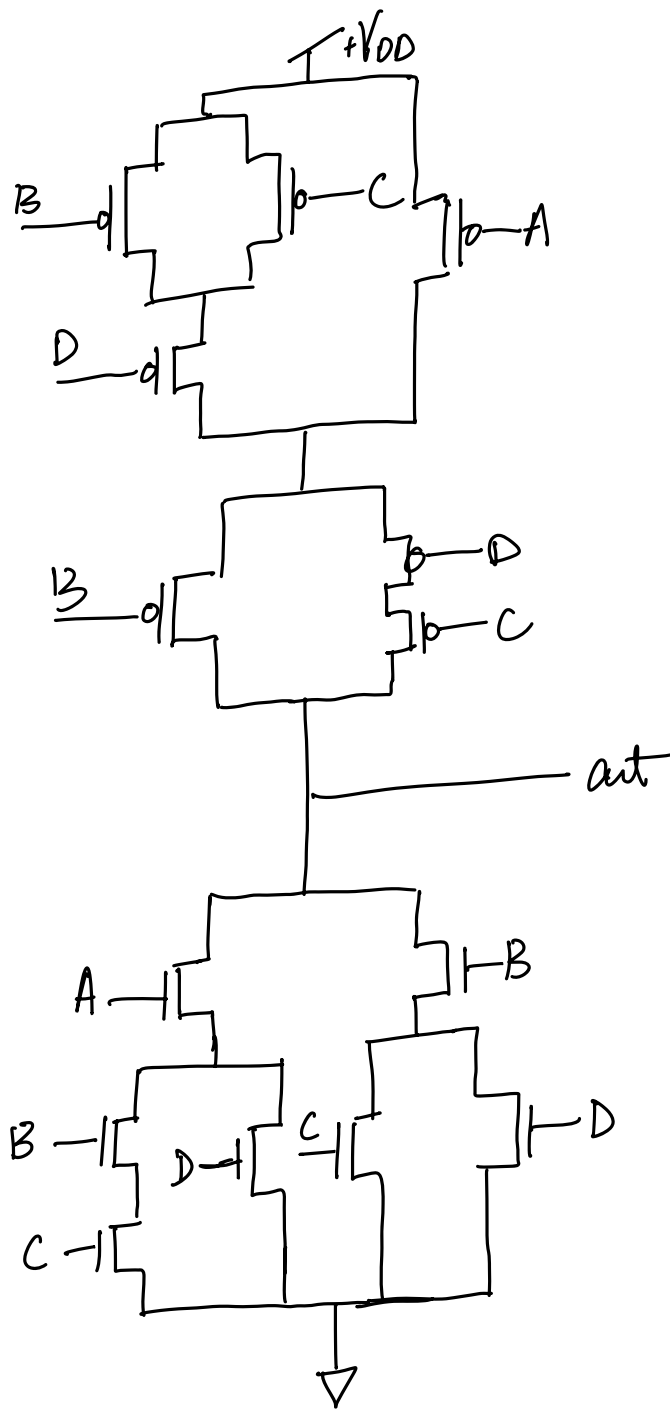
Alternatively:



$$(2) F = (A+B)(BC+D)$$

$$\begin{aligned} \bar{F} &= (A+B)(BC+D) \\ &= ABC + AD + \underbrace{BBC}_{=B} + BD = A(BC+D) + B(C+D) \end{aligned}$$

CMOS:



(3) Look at PDN: the function is

$$f_{PDN} = (A+B)(C+D)(E+F+GH)$$

$$\boxed{f = \bar{f}_{PDN} = \overline{(A+B)(C+D)(E+F+GH)}}$$

Verify: the PUN function is

$$f_{PUN} = \bar{A}\bar{B} + \bar{C}\bar{D} + \bar{E}\bar{F}(\bar{G} + \bar{H})$$

$$\begin{aligned}\text{Verify: } \bar{f}_{PDN} &= \overline{(A+B)} + \overline{(C+D)} + \overline{(E+F+GH)} \\ &= \bar{A}\bar{B} + \bar{C}\bar{D} + \bar{E}\bar{F}(\bar{G} + \bar{H}) \\ &= \bar{A}\bar{B} + \bar{C}\bar{D} + \bar{E}\bar{F}(\bar{G} + \bar{H}) \\ &= f_{PUN} \quad \checkmark\end{aligned}$$

#3

AB \ CD	00	01	11	10
00		1	1	
01		1		
11	1	1	1	1
10				

(a) prime implicants

AB \ CD	00	01	11	10
00		1	1	2
01		1	3	
11	1	1	1	1
10				

List of all prime implicants:

1: AB 2: $A'B'D$ 3: $A'C'D$ 4: $BC'D$

(b) Essential prime implicants are:

1: AB , and 2: $A'B'D$

#4

(a) map m0 - m15 to A, B, C, D:

M	ABCD	
1	0001	.
5	0101	.
7	0111	.
9	1001	.
11	1011	.
12	1100	.
14	1110	.
15	1111	.

group by number
of 1's

0001

0101

1001

1100

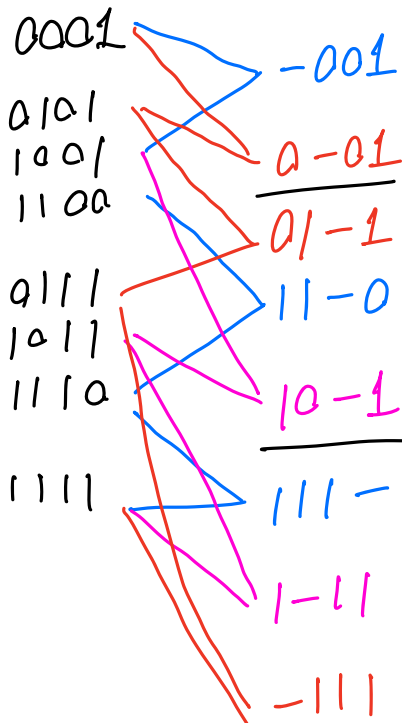
0111

1011

1110

1111

Find prime implicants



these are all prime implicants:

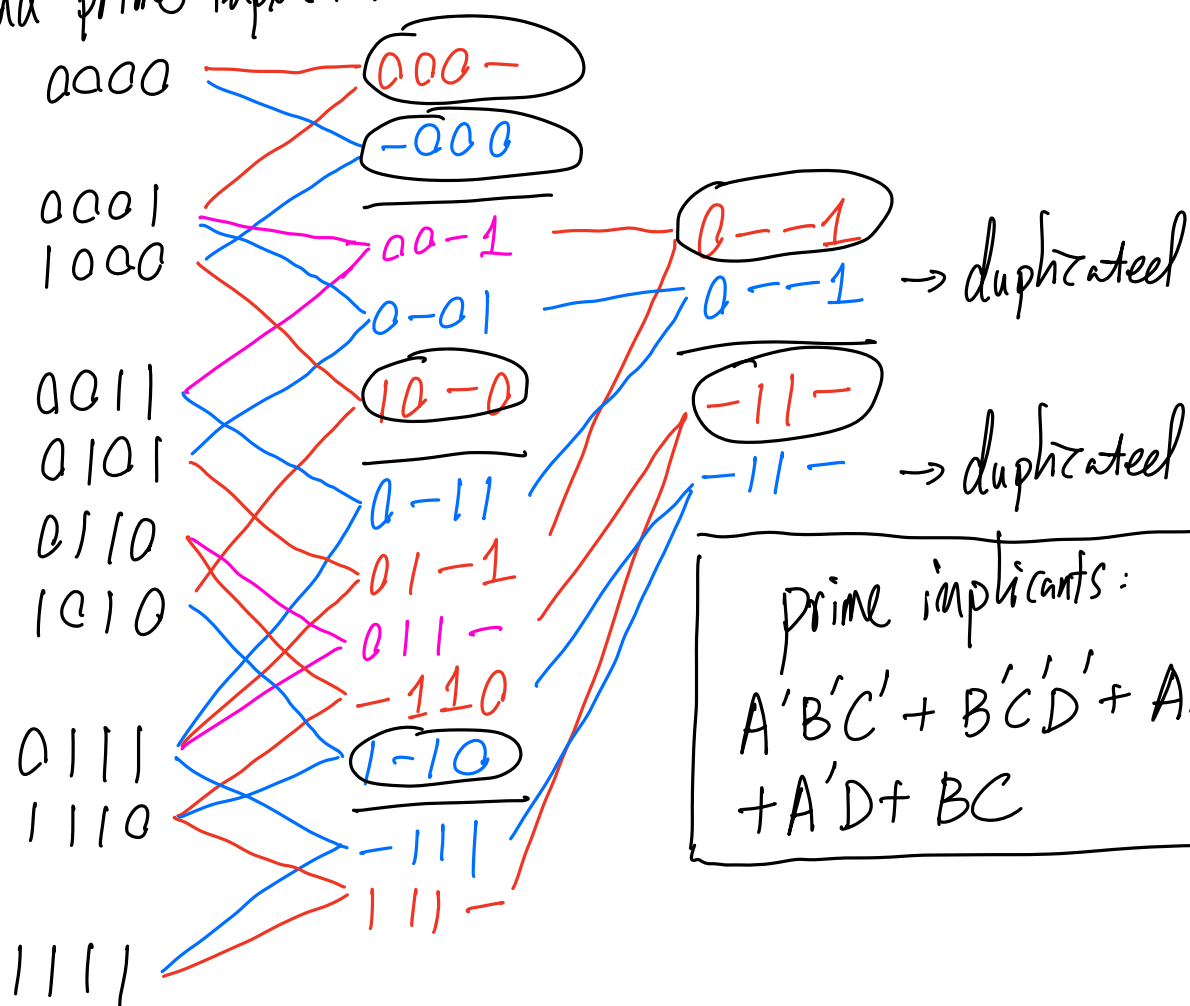
$$B'C'D + A'C'D + A'BD + ABD' + AB'D + ABC + ACD + BCD$$

(b)

M	ABCD		
0	0000	.	0000
1	0001	.	0001
3	0011	.	1000
5	0101	.	0011
6	0110	.	0101
7	0111	.	0110
8	1000	.	1010
10	1010	.	0111
14	1110	.	1110
15	1111	.	1111

grouping

Find prime implicants



prime implicants:

$$A'B'C' + B'C'D' + AB'D + ACD' + A'D + BC$$