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3CS - 1690
Computer Architecture
Assignment I

1. let $X(x_1 x_0)$ be the first 2 bit binary number.
let $Y(y_1 y_0)$ be the second 2 bit binary number.
The summation of x_0 and y_0 can be done using half adder circuit because there is no carry input.

inputs		outputs	
x_0	y_0	s_0	c_0
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

$$s_0 = \overline{x_0} y_0 + x_0 \overline{y_0}$$

$$c_0 = x_0 y_0$$

The summation of x_1 and y_1 must be the full adder circuit because there is carry input.

inputs			outputs	
x_1	y_1	c_0	s_1	c_1
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
1	0	0	1	0
0	1	1	0	1
1	1	0	0	1
1	0	1	0	1
1	1	1	1	1

$$\begin{aligned} s_1 &= \overline{x_1}\,\overline{y_1} c_0 + \overline{x_1} y_1 \overline{c_0} + x_1 \overline{y_1}\,\overline{c_0} + x_1 y_1 c_0 \\ &= \overline{x_1}\,\overline{y_1} x_0 y_0 + \overline{x_1} y_1 \overline{x_0 y_0} + x_1 \overline{y_1}\,\overline{x_0 y_0} + x_1 y_1 x_0 y_0 \\ &= \overline{x_1}\,\overline{y_1} x_0 y_0 + \overline{x_1} y_1 (\overline{x_0} + \overline{y_0}) + x_1 \overline{y_1} (\overline{x_0} + \overline{y_0}) \\ &\quad + x_1 y_1 x_0 y_0 \\ &= \overline{x_1}\,\overline{y_1} x_0 y_0 + \overline{x_1} y_1 \overline{x_0} + \overline{x_1} y_1 \overline{y_0} + x_1 \overline{y_1}\,\overline{x_0} + \\ &\quad x_1 \overline{y_1}\,\overline{y_0} + x_1 y_1 x_0 y_0 \end{aligned}$$

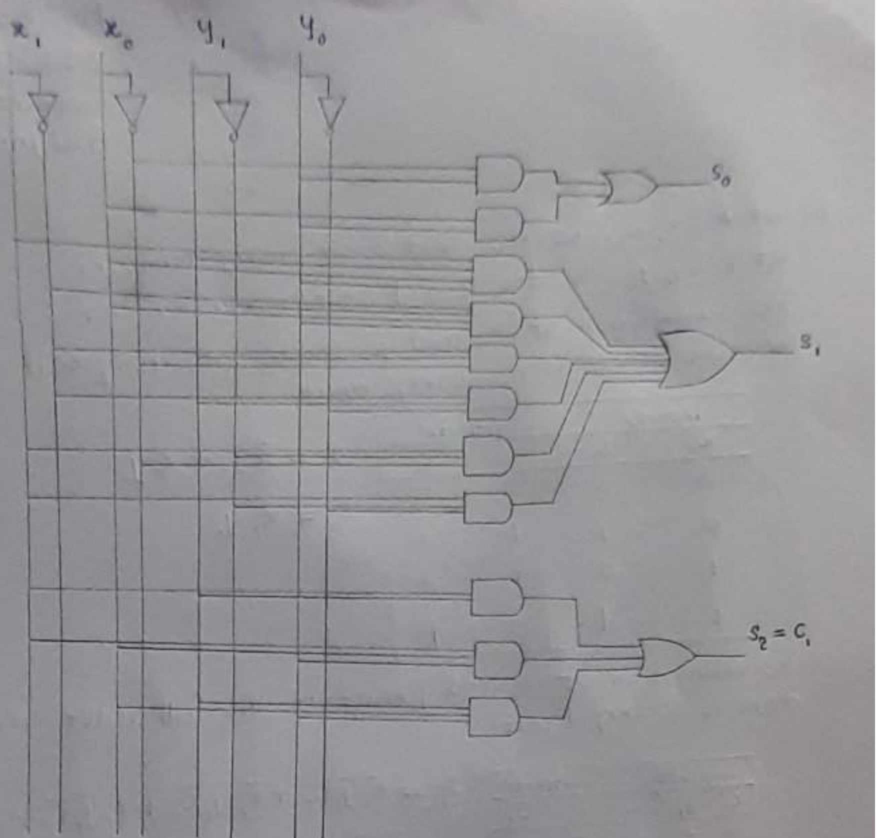
for s_1

$x_1 y_1$ \ c_0	0	1
00		1
01	1	
11		1
10	1	

for c_1

$x_1 y_1$ \ c_0	0	1
00		
01		1
11	1	1
10		1

$$\begin{aligned} c_1 &= x_1 y_1 + y_1 c_0 + x_1 c_0 \\ &= x_1 y_1 + y_1 x_0 y_0 + x_1 x_0 y_0 \end{aligned}$$



A two level combinational circuit ~~design~~ in SOP that computes the 3 bit sum of two 2 bit binary numbers using AND and OR gate

2.(a) $f_1(a,b,c,d) = a(b+\bar c)d + \bar a(b+d)(b+c)(c+d) + \bar b \bar c \bar d$

$= abd + a\bar c d + (\bar a b + \bar a d)(bc + bd + c + cd) + \bar b \bar c \bar d$

$= abd + a\bar c d + \bar a bc + \bar a bd + \bar a bc + \bar a bcd + \bar a bcd + \bar a bd + \bar a cd + \bar a cd + \bar b \bar c \bar d$

$= abd + \bar a cd + \bar a bc + \bar a bd + \bar b \bar c \bar d + \bar a bcd + a\bar c d$

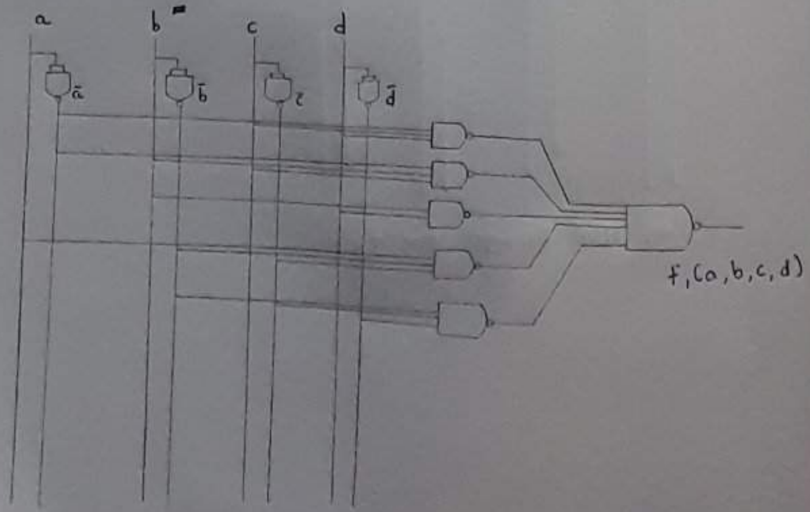
ab \ cd	00	01	11	10
00	1		1	
01		1	1	1
11		1	1	
10	1	1		

$\bar a cd$, $\bar a bc$, bd, $a\bar b \bar c$, $\bar b \bar c \bar d$

$f_1(a,b,c,d) = \bar a cd + \bar a bc + bd + a\bar b \bar c + \bar b \bar c \bar d$

$= \overline{\overline{\bar a cd + \bar a bc + bd + a\bar b \bar c + \bar b \bar c \bar d}}$

$= \overline{\overline{\bar a cd} \cdot \overline{\bar a bc} \cdot \overline{bd} \cdot \overline{a\bar b \bar c} \cdot \overline{\bar b \bar c \bar d}}$



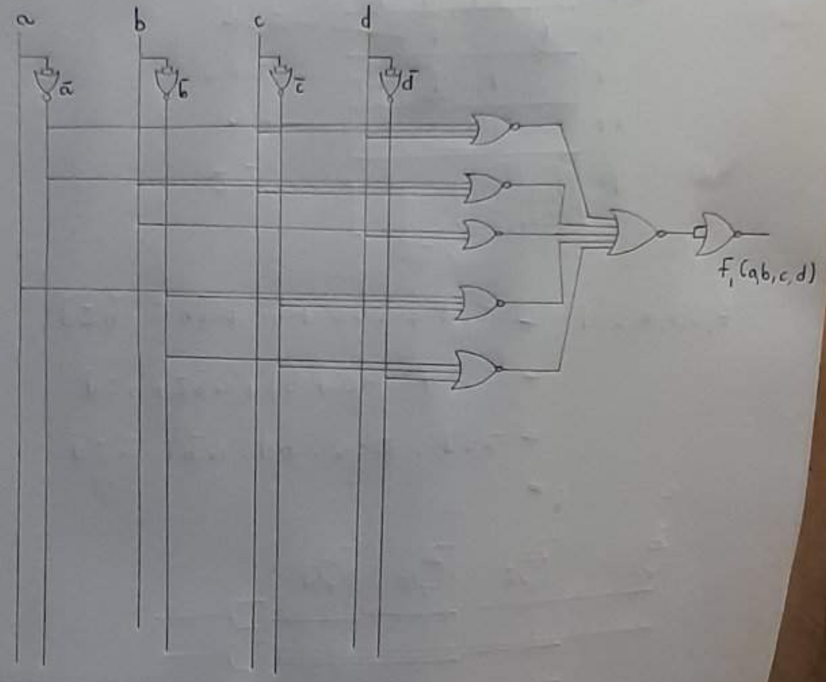
All NAND realization for f_1

(b) $f_1(a,b,c,d) = \overline{\overline{\bar{a} c d + \bar{a} b c + b d + a \bar{b} \bar{c} + \bar{b} \bar{c} \bar{d}}}$

$= \overline{\overline{\bar{a} c d} \cdot \overline{\bar{a} b c} \cdot \overline{b d} \cdot \overline{a \bar{b} \bar{c}} \cdot \overline{\bar{b} \bar{c} \bar{d}}}$

$= \overline{\overline{(\bar{a}+c+d)(\bar{a}+b+c)(b+d)(a+\bar{b}+\bar{c})(\bar{b}+\bar{c}+\bar{d})}}$

$= \overline{\overline{(\bar{a}+c+d)} + \overline{(\bar{a}+b+c)} + \overline{(b+d)} + \overline{(a+\bar{b}+\bar{c})} + \overline{(\bar{b}+\bar{c}+\bar{d})}}$



All NOR Design for f_1