NAND Logic

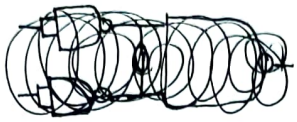
$\overline{AB} = \bar{A} + \bar{B}$

$A + B = \overline{\bar{A}\bar{B}}$

$AB =$

$\bar{A}\bar{B} =$

$\bar{A}B = \overline{A\bar{B}} =$



NOR Logic

$\bar{A}\bar{B} = \overline{A+B}$

$S_1 S_0$
0 0
0 1
1 0
1 1

ABS$_1$S$_0$	FG
0 0 0 0	0 0
0 0 0 1	0 0
0 0 1 0	0 0
0 0 1 1	0 0
0 1 0 0	1 0
0 1 0 1	1 0
0 1 1 0	1 0
0 1 1 1	1 0
1 0 0 0	0 0
1 0 0 1	0 0
1 0 1 0	0 0
1 0 1 1	0 0
1 1 0 0	1 0
1 1 0 1	1 0
1 1 1 0	1 0
1 1 1 1	1 0

$\overline{A+B}$	A	B	$\bar{A}$	$\bar{B}$	A+B	AB	$\bar{A}B$	$A\bar{B}$	$\bar{A}\bar{B}$	$\overline{AB}$	$\bar{A}+B$	$A+\bar{B}$	$\bar{A}+\bar{B}$
1	0	0	1	1	0	0	0	0	1	1	1	1	1
0	0	1	1	0	1	0	1	0	0	1	1	0	1
0	1	0	0	1	1	0	0	1	0	1	0	1	1
0	1	1	0	0	1	1	0	0	0	1	1	1	0

Clz-1

ABCD	fgh	E
0 0 0 0	1 0 0	0
0 0 0 1	0 1 1	1
0 0 1 0	0 1 0	1
0 0 1 1	0 1 0	1
0 1 0 0	0 0 1	
0 1 0 1	0 0 1	
0 1 1 0	0 0 1	
0 1 1 1	0 0 0	1
1 0 0 0		
1 0 0 1		
1 0 1 0		
1 0 1 1		
1 1 0 0		
1 1 0 1		
1 1 1 0		
1 1 1 1		

$F = \bar{A}\bar{B}\bar{C}\bar{D}$

$g = \bar{A}\bar{B}\bar{C}D + \bar{A}B\bar{C}\bar{D} + \bar{A}\bar{B}CD = \bar{A}\bar{B}D + \bar{A}BC$

$h = \bar{A}\bar{C}D + \bar{A}B$

ABC	FGE
0 0 0	1 0 0
0 0 1	1 0 0
0 1 0	0 1 1
0 1 1	0 0 1
1 0 0	0 0 1
1 0 1	1 0 1
1 1 0	0 0 1
1 1 1	1 0 1

$F = \bar{A}\bar{B} + AB + C$

$A \odot B + C$

$G = \bar{A}B\bar{C}$

$E = C + B + A = \overline{\bar{A}\bar{B}\bar{C}}$

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ABC	FG	C_2
000	00	0
001	01	0
010	10	0
011	11	0
100	00	1
101	01	1
110	10	1
111	11	1

C_{in}	AB	FG	C_{out}
0	00	00	0
1	00	01	0
0	01	10	0
1	01	11	0
0	10	00	1
1	10	01	1
0	11	10	1
1	11	11	1

$lb(x+1)$

C_{in}	AB	CD	FG	C_{out}
0	00	00	00	0
0	00	01	01	0
0	00	10	10	0
0	00	11	11	0
0	01	00	00	0
0	01	01	01	0
0	01	10	10	0
0	01	11	11	0
1	00	00	01	0
1	00	01	10	0
1	00	10	11	0
1	00	11	00	1
1	01	00	01	1
1	01	01	10	1
1	01	10	11	1
1	01	11	00	1

$F = \bar{A}B\bar{C} + \bar{A}BC + AB\bar{C} + ABC$

$= \bar{A}B + AB = B$

$G = \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}C + ABC$

$= \bar{A}C + AC = C_{in}$

$C_{out} = A$

ABC	FG	C_{out}
000	00	0
001	01	0
010	01	0
011	10	0
100	10	0
101	10	0
110	10	0
111	00	1

$\rightarrow \log_2(x+1)$

$\log_2(0+1) = 0$

$\log_2(1+1) = 1$

$\log_2(2+1) = 1.\sim$

$\log_2(3+1) = 2$

$\log_2(7+1) = 3$

AB	F	C_{out}
00	0	0
01	1	0
10	1	0
11	0	1

$= \log_2(x+1)$

$= \log_2(0+1) = 0$

$= lb(2) = 1$

$= lb(3) = 1$

$= lb(4) = 2$

$lb(x+1)$

ABCD	FG	C_{out}
0000	00	0
0001	01	0
0010	01	0
0011	10	0
0100	10	0
0101	10	0
0110	10	0
0111	00	1
1000	01	1
1001	10	1
1010	10	1
1011	10	1
1100	10	1
1101	10	1
1110	10	1
1111	00	1
10000	01	1

AB	FG buffer
00	00
01	01
10	10
11	11

ABCD

CAB	FG	C_{out}
000	00	0
001	00	0
010	10	0
011	10	0
100	11	
101	11	
110	11	
111	11	

$\bar{A}\bar{B}+\bar{A}B+A\bar{B}+AB$

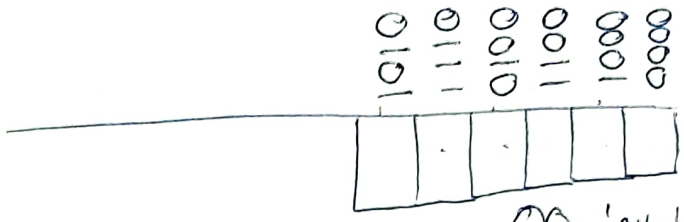
$\bar{A}+A=1$

1 2 3 ABC	S_1S_0	F
000	00	0
001	01	0
010	10	
011	11	
100	00	0
101	01	1
110	10	1
111	11	1

3-1 MUX

$\rightarrow BS_1\bar{S}_0+A\bar{S}_1S_0+$ [illegible] S_1S_0C

abcd



00 - invalid
01 - circle
10 - cross

A	B	F
0	0	0
0	1	1
1	0	0
1	1	1

$\bar{A}B+AB=B$

A	B	F
XOR 0	0	~~0~~ 1
OR 0	1	1
1	0	
1	1	

0	1	2
3	4	5
6	7	8

A	X	Y
0	0	1
1	1	0

$\bar{A}=\bar{X}Y$

$A=X\bar{Y}$

1	2	3
4	5	6
7	8	9

AB

01 - 0100|11110

10 - 0101|1000x

A B	X	Y
0 0	0	0
0 1	1	0
1 0	0	1
1 1	0	0

SQ3 SQ2 SQ1 ABC | $M_2M_1M_0$ XYZ

ABC	XYZ
000	000
001	001
010	010
011	011
100	100
101	101
110	110
111	111

$M_0=\bar{A}\bar{B}C+\bar{A}BC+A\bar{B}C+ABC$

$\bar{A}C+AC=C$

ABS	F
000	0
001	0
010	~~0~~
011	~~1~~
100	1
101	0
110	1
111	1

F= ~~$\bar{A}\bar{B}\bar{S}+\bar{A}B\bar{S}+AB\bar{S}$~~

~~$+AB\bar{S}$~~

= ~~$A\bar{S}+A\bar{S}+AB$~~

$F=\bar{A}BS+A\bar{B}\bar{S}+AB\bar{S}+ABS$

$=BS+A\bar{S}$

ABC	F
000	
001	
010	
011	
100	
101	
110	
111	

$A\bar{B}=X\bar{Y}$

$\bar{A}\bar{B}=\bar{X}Y$

AB	X	Y
00	0	0
01	0	1
10	1	0
11	0	0

$\bar{A}B=\bar{X}Y$

$A\bar{B}=X\bar{Y}$

ABC	FG
000	00
001	11
010	10
011	00
100	01
101	00
110	00
111	00

$F = \bar{A}\bar{B}C + \bar{A}B\bar{C} = \bar{A}\,\&\,(B \oplus C)$

$G = \bar{A}\bar{B}C + A\bar{B}\bar{C} = \bar{B}\,\&\,(A \oplus C)$

A	S	F	g
0	0	0	0
0	1	0	0
1	0	1	0
1	1	0	1

$F = A\bar{S}$

$g = AS$

ABC	FG
000	00
001	01
010	10
011	00
100	11
101	00
110	00
111	00

$F = \bar{A}B\bar{C} + A\bar{B}\bar{C} = \bar{C}\,\&\,(A \oplus B)$

$G = \bar{A}\bar{B}C + A\bar{B}\bar{C} = \bar{B}\,\&\,(A \oplus C)$

ABCD	FGH = $\log_2(x+1)$
0000	000
0001	001
0010	001
0011	010
0100	010
0101	010
0110	010
0111	011
1000	011
1001	011
1010	011
1011	011
1100	011
1101	011
1110	011
1111	100

$H = \bar{A}BCD + \bar{B}\bar{C}D + \bar{B}C\bar{D} + A\bar{B} + A\bar{C} + A\bar{D}$

$G = \bar{B}CD + \bar{A}B + A\bar{C} + A\bar{D}$

$F = ABCD$

AND 0	0000
OR 1	001
XOR 2	010
NAND 3	011
NOR 4	100
XNOR 5	101
6	110
7	111

AND	001
OR	000
XOR	

A	B	$S_2S_1S_0$
0	0	000
		001
		010
		011
		100
		101
		110
		111

1010 1111 0000 0010 0100

Exam 3 notes

~~$f'(c) = \frac{f(b)-f(a)}{b-a}$~~ ~~$F'(g(x)) \cdot g'(x)$~~

$g = \bar{A}B\bar{C}D + \bar{A}BC\bar{D} + \bar{A}BCD + A\bar{B}\bar{C}D + AB\bar{C}D + ABCD$
$= \bar{A}BD(\bar{C}+C) + \bar{A}BC\bar{D} + A\bar{B}\bar{C}D + ABD(\bar{C}+C)$
$= \bar{A}BD + \bar{A}BC\bar{D} + A\bar{B}\bar{C}D + ABD$
$= BD + \bar{A}BC\bar{D} + A\bar{B}\bar{C}D$
$= \bar{A}BC + BD + AD\bar{C}$

$f = A\bar{B}C\bar{D} + A\bar{B}CD + ABC\bar{D} + ABCD$
$= A\bar{B}C + ABC$
$= AC = \bar{A}\bar{C}$

$\bar{A}+\bar{B} = \overline{AB}$, $\bar{A} = \overline{AA} = \bar{A}+0$
$A+\bar{B} = \overline{\bar{A}B}$, $\bar{A}+B = \overline{A\bar{B}}$
$A+B = \overline{\bar{A}\bar{B}}$

$AA = A$
$\overline{AA} = \bar{A}$

$\bar{A}+\bar{B}+\bar{C} = \overline{AB}+\bar{C} = \bar{A}+\overline{BC} = \overline{ABC}$
$\bar{A}+\bar{B}+C = \overline{AB\bar{C}}$
$A+\bar{B}+\bar{C} = \overline{\bar{A}BC}$
$\bar{A}+B+\bar{C} = A\bar{B}C$

AND & NAND table

A+B	A	B	AB	$\overline{AB}$	$\bar{A}$	$\bar{B}$	$\overline{\bar{A}\bar{B}}$ (NOR)	$\bar{A}\bar{B}$
0	0	0	0	1	1	1	1	0
1	0	1	0	1	1	0	0	1
1	1	0	0	1	0	1	0	1
1	1	1	1	0	0	0	0	1

$\overline{\bar{A}+\bar{B}}$

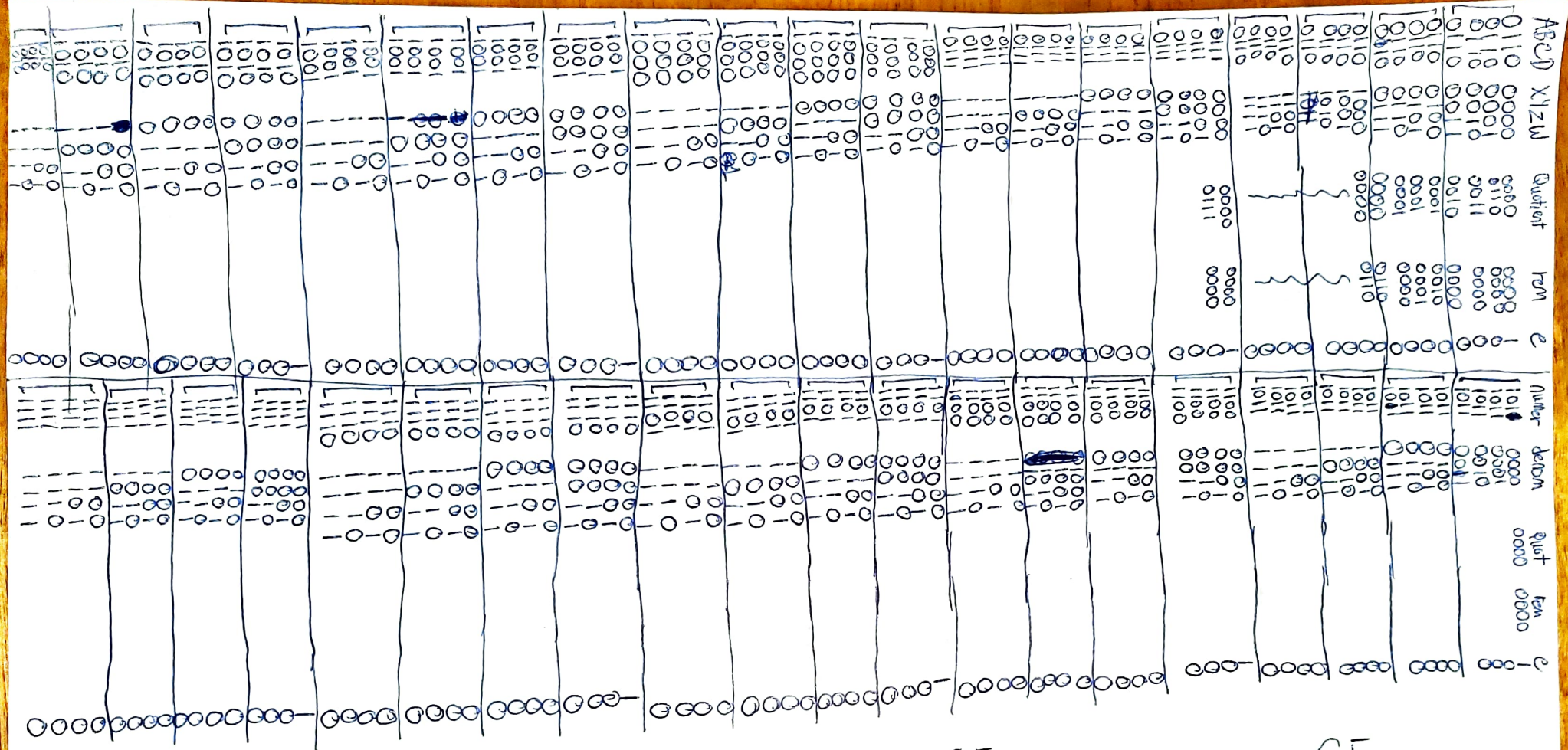
1
1
1
0

$\bar{A}\bar{B} = \overline{A+B}$

$ABC = \overline{\bar{A}\bar{B}\bar{C}}$, $AB = \overline{\bar{A}\bar{B}}$
$AB\bar{C} = \overline{\bar{A}\bar{B}C}$
$A\bar{B}C = \overline{\bar{A}BC}$

$\bar{A}B + A\bar{B} = A \oplus B = \overline{\bar{A}\bar{B}} + \overline{AB} = \overline{(\bar{A}\bar{B})(AB)}$ XOR
$\bar{A}\bar{B} + AB = A \odot B = \overline{A \oplus B} = \overline{(\bar{A}B)(A\bar{B})} = \overline{(\bar{A}B)}\,\overline{(A\bar{B})} = (\overline{\bar{A}B})(\overline{A\bar{B}}) = (\overline{AB})(\overline{\bar{A}\bar{B}})$ XNOR

A	B	$A \oplus B$	$A \odot B$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	0	1



Min → &

AB	F
00	0
01	0
10	0
11	1

AND

Max → +

AB	F
00	0
01	1
10	1
11	1

OR

ABC	F

Min ABCD	Fg

LT

AB	A<B
00	0
01	1
10	0
11	0

$\bar{A}B$

GT

AB	A>B
00	0
01	0
10	1
11	0

$A\bar{B}$

eQ XNOR

GE

AB	A>=B
00	1
01	0
10	1
11	1

$\bar{A}\bar{B} + A\bar{B} + AB$

$= \bar{B}(\bar{A}+A) + AB$

$= \bar{B} + AB = (\bar{B}+B)(\bar{B}+A)$

$= \bar{B} + A = \overline{\bar{A}B}$

$\bar{A}+B = \overline{\bar{B}A}$ $\quad \bar{A}+\bar{B} = \overline{AB}$, $AB = \overline{\overline{AB}}$

ABCD	EFGH	XYZW	MNOP	C_I
0000	0000	0000	0000	0
0000	0001	0000	0000	0
0000	0010	0000	0000	0
0000	0011	0000	0000	0
0000	0100	0000	0000	0
0000	0101	0000	0000	0
0000	0110	0000	0000	0
0000	0111	0000	0000	0
0000	1000	0000	0000	0
0000	1001	0000	0000	0
0000	1010	0000	0000	0
0000	1011	0000	0000	0
0000	1100	0000	0000	0
0000	1101	0000	0000	0
0000	1110	0000	0000	0
0000	1111	0000	0000	0
0001	0000	0000	0000	1
0001	0001	0001	0000	0
0001	0010	0000	0001	0
0001	0011	0000	0000	0
0001	0100	0000	0001	0
0001	0101	0000	0001	0
0001	0110	0000	0001	0
0001	0111	0000	0001	0
0001	1000	0000	0001	0
0001	1001	0000	0001	0
0001	1010	0000	0001	0
0001	1011	0000	0001	0
0001	1100	0000	0001	0
0001	1101	0000	0001	0
0001	1110	0000	0001	0
0001	1111	0000	0001	0
0010	0000	0000	0000	1
0010	0001	0010	0000	0
0010	0010	0001	0000	0
0010	0011	0000	0010	0
0010	0100	0000	0010	0
0010	0101	0000	0010	0
0010	0110	0000	0010	0
0010	0111	0000	0010	0
0010	1000	0000	0010	0
0010	1001	0000	0010	0
0010	1010	0000	0010	0
0010	1011	0000	0010	0
0010	1100	0000	0010	0
0010	1101	0000	0010	0
0010	1110	0000	0010	0
0010	1111	0000	0010	0
0011	0000	0000	0000	1
0011	0001	0011	0000	0
0011	0010	0001	0001	0
0011	0011	0001	0000	0
0011	0100	0000	0011	0
0011	0101	0000	0011	0
0011	0110	0000	0011	0
0011	0111	0000	0011	0
0011	1000	0000	0011	0
0011	1001	0000	0011	0
0011	1010	0000	0011	0
0011	1011	0000	0011	0
0011	1100	0000	0011	0
0011	1101	0000	0011	0
0011	1110	0000	0011	0
0011	1111	0000	0011	0
0100	0000	0000	0000	1
0100	0001	0100	0000	0
0100	0010	0010	0000	0
0100	0011	0001	0001	0
0100	0100	0000	0100	0
0100	0101	0000	0100	0
0100	0110	0000	0100	0
0100	0111	0000	0100	0
0100	1000	0000	0100	0
0100	1001	0000	0100	0
0100	1010	0000	0100	0
0100	1011	0000	0100	0
0100	1100	0000	0100	0
0100	1101	0000	0100	0
0100	1110	0000	0100	0
0100	1111	0000	0100	
0101	0000	0		1
0101	0001	0101	0000	0
0101	0010	0010	0001	0
0101	0011	0001	0010	0
0101	0100	0001	0001	0
0101	0101	0001	0000	0
0101	0110	0000	0101	0
0101	0111	0000	0101	0
0101	1000	0000	0101	0
0101	1001			0
0101	1010			0
0101	1011			0
0101	1100			0
0101	1101			0
0101	1110			0
0101	1111	0000	0101	0

00 invalid
01 rock
10 Paper
11 scissors

AB	CD	P_1 P_2	
		f g	
00	00	00	
01	01	00	
10	10	00	
11	11	00	
rock			
01	10	01	$\bar{A}BC\bar{D} = \bar{F}g$ 2
01	11	10	$\bar{A}BCD = F\bar{g}$ 1
paper			
10	01	10	$A\bar{B}\bar{C}D = F\bar{g}$ 1
10	11	01	$A\bar{B}CD = \bar{F}g$ 2
scissors			
11	01	01	$AB\bar{C}D = \bar{F}g$ 2
11	10	10	$ABC\bar{D} = F\bar{g}$ 1

$\bar{A}BCD + A\bar{B}\bar{C}D + ABC\bar{D} = F$

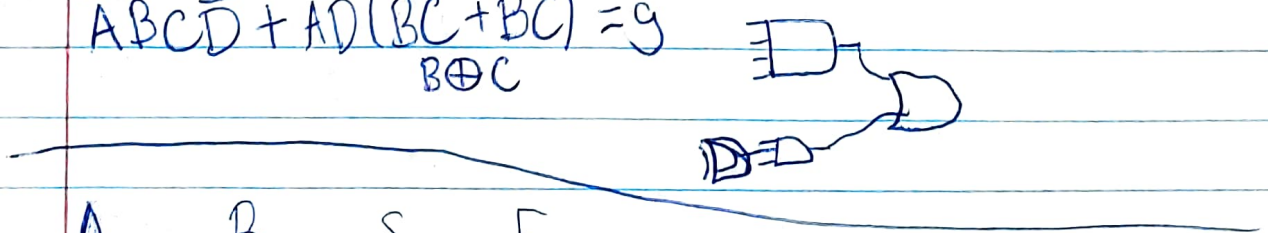
$BC(\bar{A}D + A\bar{D}) + A\bar{B}\bar{C}D$

$A \oplus D$

$\bar{A}BC\bar{D} + A\bar{B}CD + AB\bar{C}D = g$

$\bar{A}BC\bar{D} + AD(\bar{B}C + B\bar{C}) = g$

$B \oplus C$



A	B	S	F	
0	0	0	0	
0	1	0	1	$\bar{A}B\bar{S} + A\bar{B}S + ABS$
1	0	1	1	$\bar{A}B\bar{S} + AS$
1	1	1	1	

ABCD	EFGH	f: X	Y	Z	W	e
0000	0000	0	0	0	0	1
....	⋮					⋮
1111	0000	0	0	0	0	1
0000	0001	0	0	0	0	0
1111	⋮	A	B	C	D	
0001		0	0	0	1	
0010		0	0	1	0	
0011		0	0	1	1	
0100		0	1	0	0	
0101		0	1	0	1	
0110		0	1	1	0	
0111		0	1	1	1	
1000						
1001						
1010						
1011						
1100						
1101						
1110						
1111						

$e = \bar{E}\bar{F}\bar{G}\bar{H} = e$

$\bar{A}\bar{B}\bar{C}\bar{D} + E\bar{F}GH = f$

$ABCD = \bar{e}$

AB CD	FG E
00 00	0 0 1
00 01	0 0 0
00 10	0 0 0
00 11	0 0 0
01 00	0 0 1
01 01	0 1 0
01 10	0 0 0
01 11	0 0 0
10 00	0 0 1
10 01	1 0 0
10 10	0 1 0
10 11	0 0 0
11 00	0 0 1

ABCD	FGE
1101	110
1110	010
1111	010

$\bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}B\bar{C}\bar{D} + A\bar{B}\bar{C}\bar{D} + AB\bar{C}\bar{D} = E = \bar{C}\bar{D}$

$\bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}B\bar{C}\bar{D} + AB\bar{C}\bar{D} + ABCD + ABC\bar{D} = G = B\bar{C}D + AC\bar{D} + ABC$

$A\bar{B}\bar{C}D + AB\bar{C}\bar{D} = F = A\bar{C}D$