IE1204 Exam 20200114 Answers

Part 1

1

A = $54_{10} = 00110110_2 = 36_{16}$
B = $31_{10} = 00011111_2 = 1F_{16}$
A + B = $01010101_2 = 55_{16} = 85_{10}$

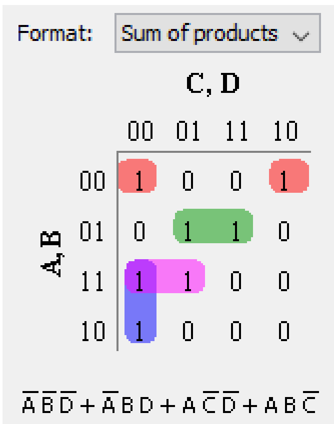
2

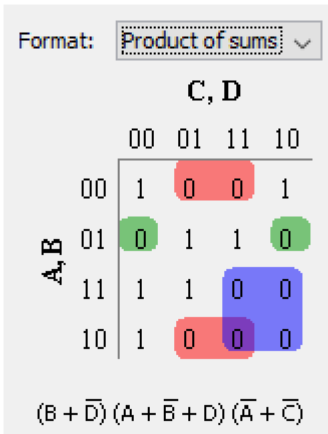
C = $01011101_2 = 93_{10} = 5D_{16}$
D = $10100011_2 = -93_{10} = A3_{16}$
-D = $01011101_2 = 93_{10} = 5D_{16}$
C - D = $10111010_2 = BA_{16} = 186_{10} = -70_{10}$
Calculation is correct if you realize that an overflow occurs since the result is greater than 127

3

$$Y = \overline{(A \oplus B) + (C + D)} + \overline{B \oplus D} \cdot \overline{A \cdot C} = \overline{A \oplus B} \cdot \overline{C + D} + \overline{B \oplus D} \cdot (\overline{A} + \overline{C})$$
$$= (A \cdot B + \overline{A} \cdot \overline{B}) \cdot \overline{C} \cdot \overline{D} + (B \cdot D + \overline{B} \cdot \overline{D})(\overline{A} + \overline{C})$$
$$= A \cdot B \cdot \overline{C} \cdot \overline{D} + \overline{A} \cdot \overline{B} \cdot \overline{C} \cdot \overline{D} + \overline{A} \cdot B \cdot D + \overline{A} \cdot \overline{B} \cdot \overline{D} + B \cdot \overline{C} \cdot D + \overline{B} \cdot \overline{C} \cdot \overline{D}$$

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0



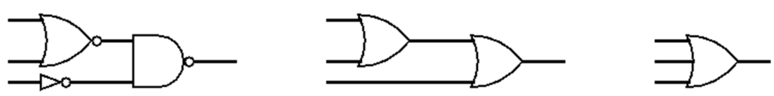


Several simplified solutions can be made

4

$Y1 = \overline{A + B} = \overline{A} \cdot \overline{B}$

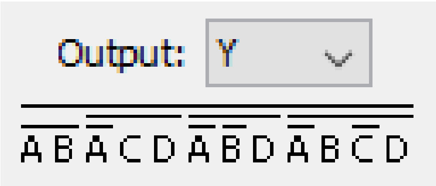
$Y = \overline{Y1 \cdot \overline{C}} = \overline{\overline{A} \cdot \overline{B} \cdot \overline{C}} = A + B + C$



Or use bubble pushing

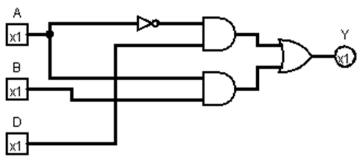
Part 2

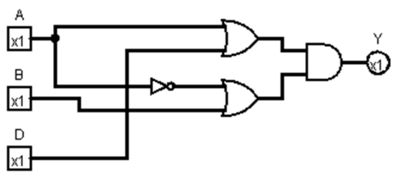
5

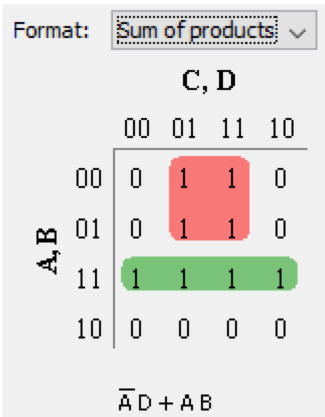


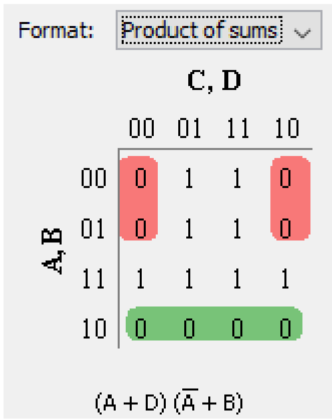
$$Y = A \cdot B + \overline{A} \cdot C \cdot D + \overline{A} \cdot \overline{B} \cdot D + \overline{A} \cdot B \cdot \overline{C} \cdot D$$

A	B	C	D	Y
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

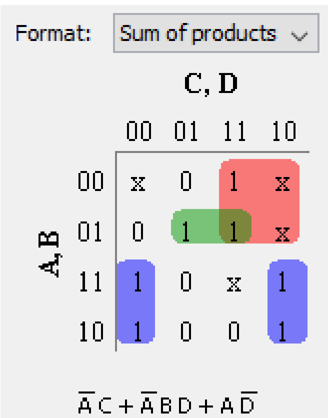


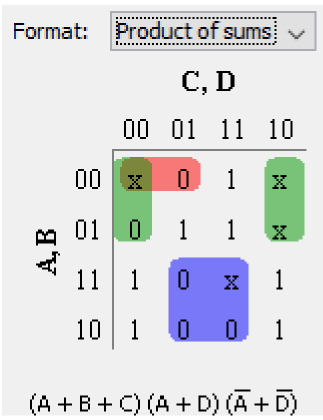






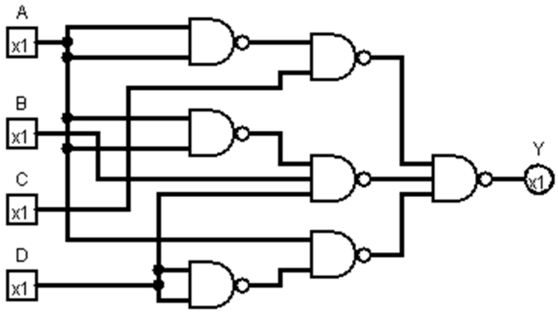
6

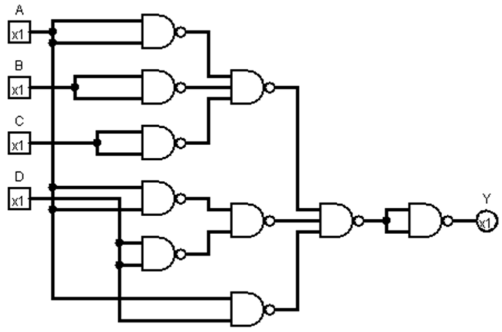




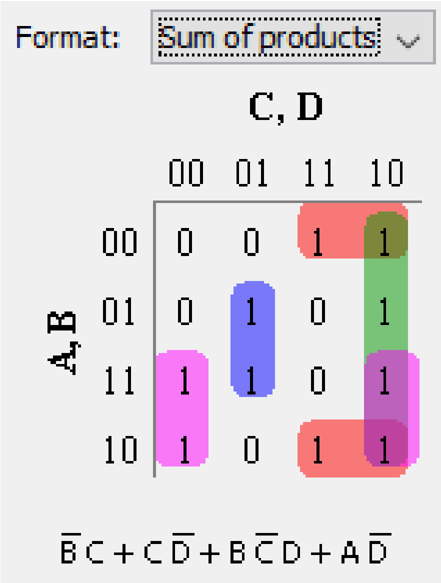
SOP is better for only NAND gates, use Bubble-pushing

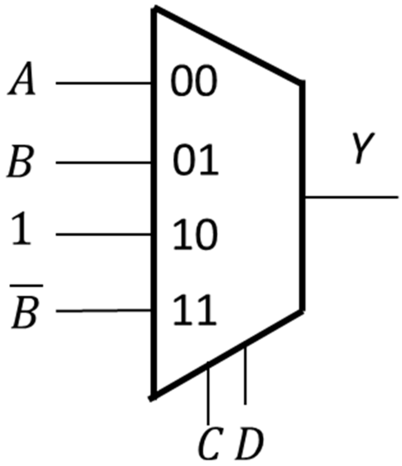
One point was deducted if the expression was not simplest possible. $\overline{B} \cdot \overline{D}$ should not be included.





7



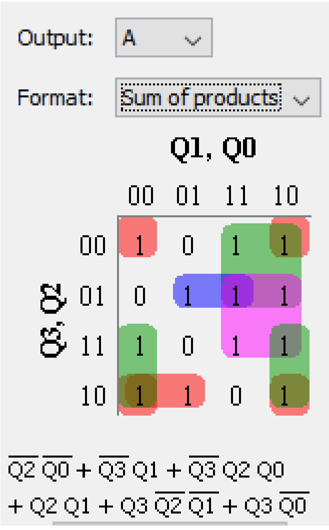


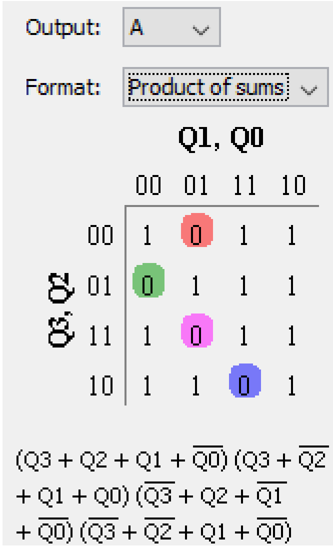
(Boolean expression not needed for full points)

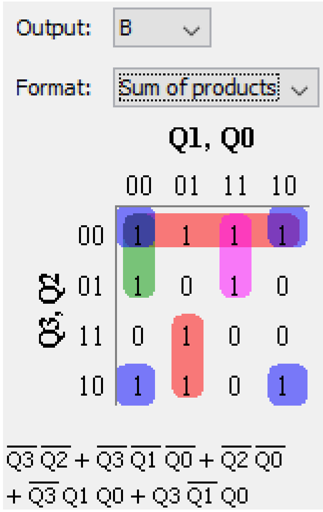
8

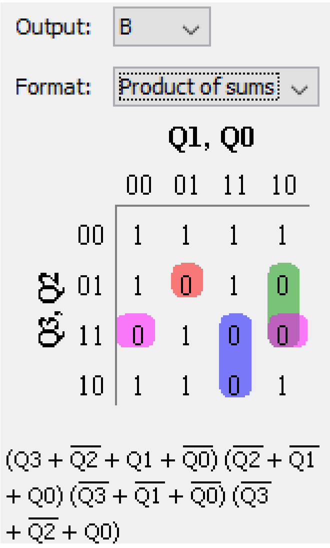
Q3	Q2	Q1	Q0	A	B	C	D	E	F	G
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1
1	0	1	0	1	1	1	0	1	1	1
1	0	1	1	0	0	1	1	1	1	1
1	1	0	0	1	0	0	1	1	1	0
1	1	0	1	0	1	1	1	1	0	1
1	1	1	0	1	0	0	1	1	1	1
1	1	1	1	1	0	0	0	1	1	1

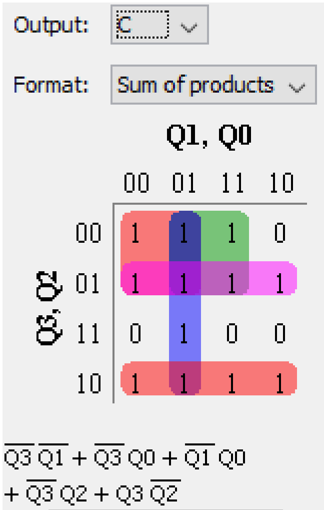
Three segments of seven (A-G) for full points

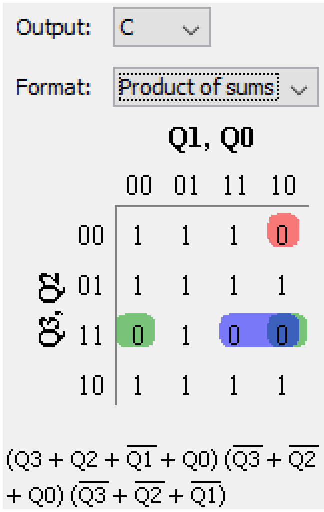


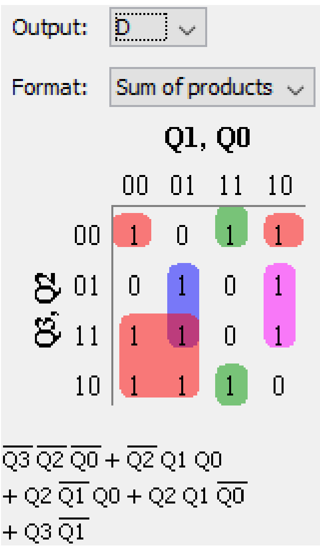


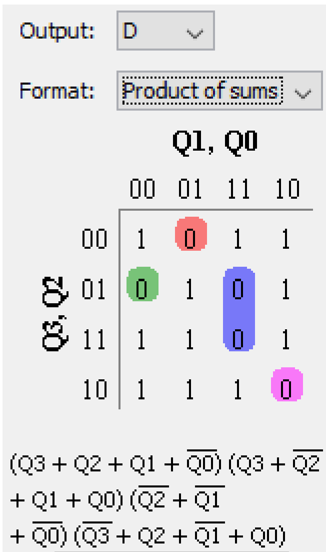


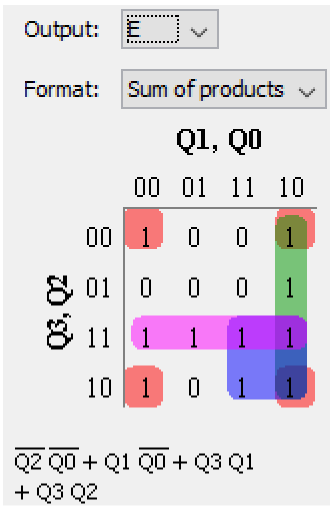


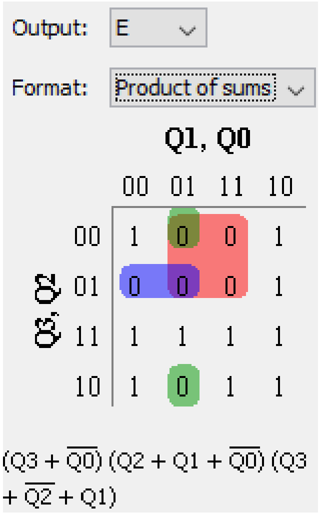


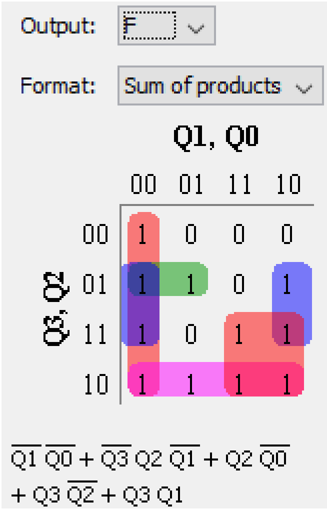


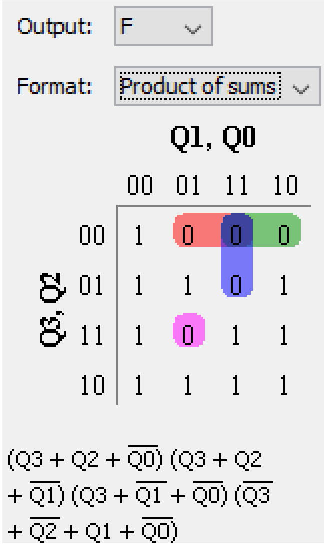


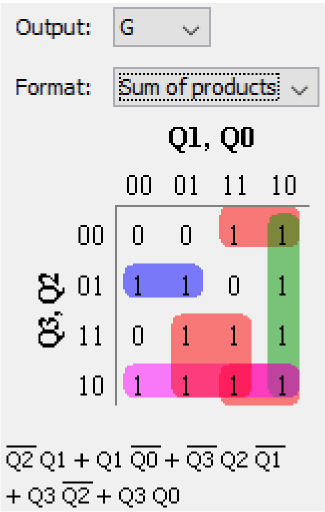


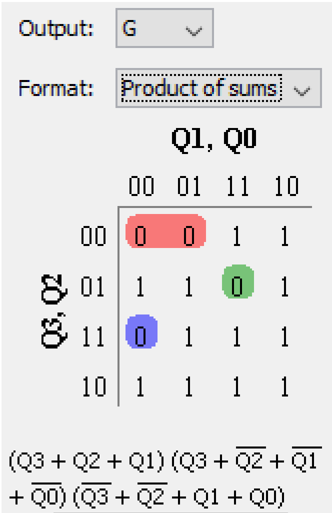



Output: E
Format: Product of sums
Q1, Q0
Q3, Q2
00 01 11 10
00 1 0 0 1
01 0 0 0 1
11 1 1 1 1
10 1 0 1 1
$(Q3 + \overline{Q0})\ (Q2 + Q1 + \overline{Q0})\ (Q3 + \overline{Q2} + Q1)$


Output: F
Format: Sum of products
Q1, Q0
Q3, Q2
00 01 11 10
00 1 0 0 0
01 1 1 0 1
11 1 0 1 1
10 1 1 1 1
$\overline{Q1}\ \overline{Q0} + \overline{Q3}\ Q2\ \overline{Q1} + Q2\ \overline{Q0} + Q3\ \overline{Q2} + Q3\ Q1$

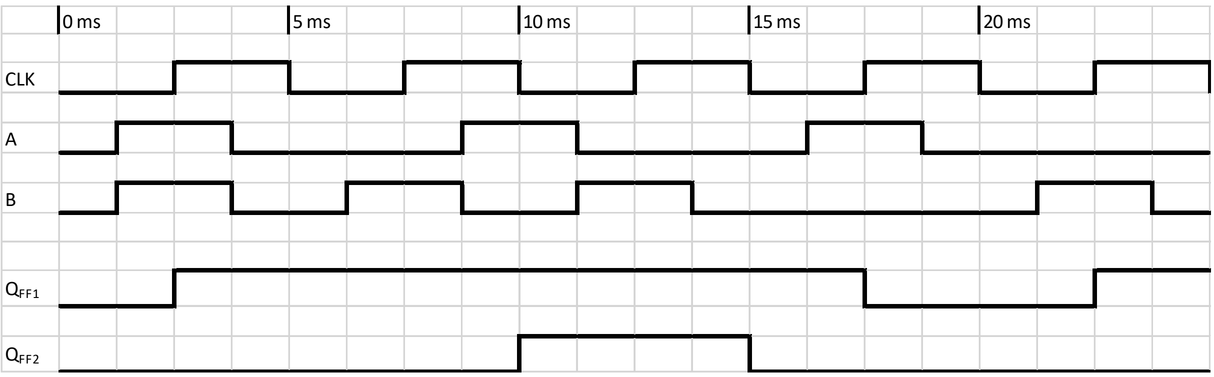

Output: F
Format: Product of sums
Q1, Q0
Q3, Q2
00 01 11 10
00 1 0 0 0
01 1 1 0 1
11 1 0 1 1
10 1 1 1 1
$(Q3 + Q2 + \overline{Q0})\ (Q3 + Q2 + \overline{Q1})\ (Q3 + \overline{Q1} + \overline{Q0})\ (\overline{Q3} + \overline{Q2} + Q1 + \overline{Q0})$


Output: G
Format: Sum of products
Q1, Q0
Q3, Q2
00 01 11 10
00 0 0 1 1
01 1 1 0 1
11 0 1 1 1
10 1 1 1 1
$\overline{Q2}\ Q1 + Q1\ \overline{Q0} + \overline{Q3}\ Q2\ \overline{Q1} + Q3\ \overline{Q2} + Q3\ Q0$


Output: G
Format: Product of sums
Q1, Q0
Q3, Q2
00 01 11 10
00 0 0 1 1
01 1 1 0 1
11 0 1 1 1
10 1 1 1 1
$(Q3 + Q2 + Q1)\ (Q3 + \overline{Q2} + \overline{Q1} + \overline{Q0})\ (\overline{Q3} + \overline{Q2} + Q1 + Q0)$

Part 3

9

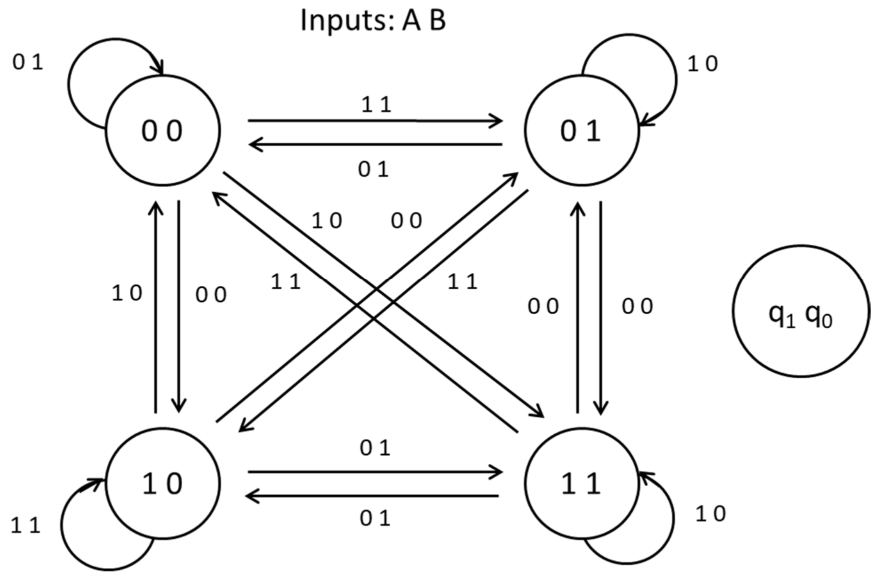

0 ms
5 ms
10 ms
15 ms
20 ms
CLK
A
B
Q_{FF1}
Q_{FF2}

10

q1+ \ A B =	00	01	11	10
q1q0 = 00	1	0	0	1
01	1	0	1	0
11	0	1	0	1
10	0	1	1	0

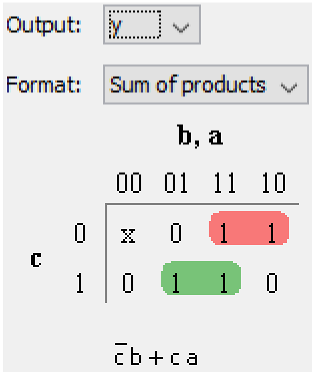
q0+ \ A B =	00	01	11	10
q1q0 = 00	0	0	1	1
01	1	0	0	1
11	1	0	0	1
10	1	1	0	0

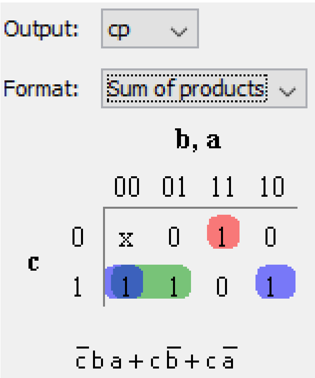
		Next state							
Present state		A B = 0 0		A B = 0 1		A B = 1 1		A B = 1 0	
q1	q0	q1+	q0+	q1+	q0+	q1+	q0+	q1+	q0+
0	0	1	0	0	0	0	1	1	1
0	1	1	1	0	0	1	0	0	1
1	1	0	1	1	0	0	0	1	1
1	0	0	1	1	1	1	0	0	0

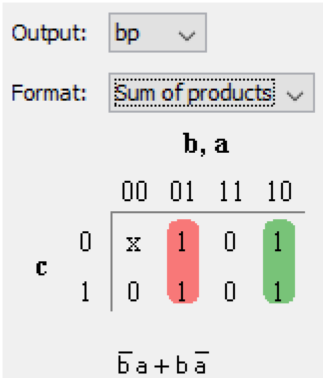


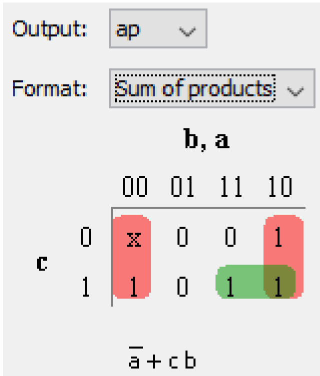
11

Present state			Next state			Output
c	b	a	c+	b+	a+	y
0	0	0	X	X	X	X
0	0	1	0	1	0	0
0	1	0	0	1	1	1
0	1	1	1	0	0	1
1	0	0	1	0	1	0
1	0	1	1	1	0	1
1	1	0	1	1	1	0
1	1	1	0	0	1	1

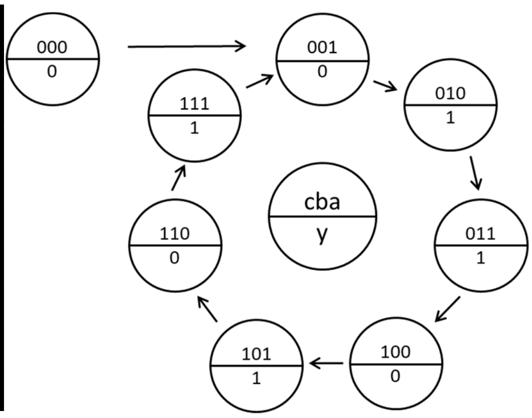


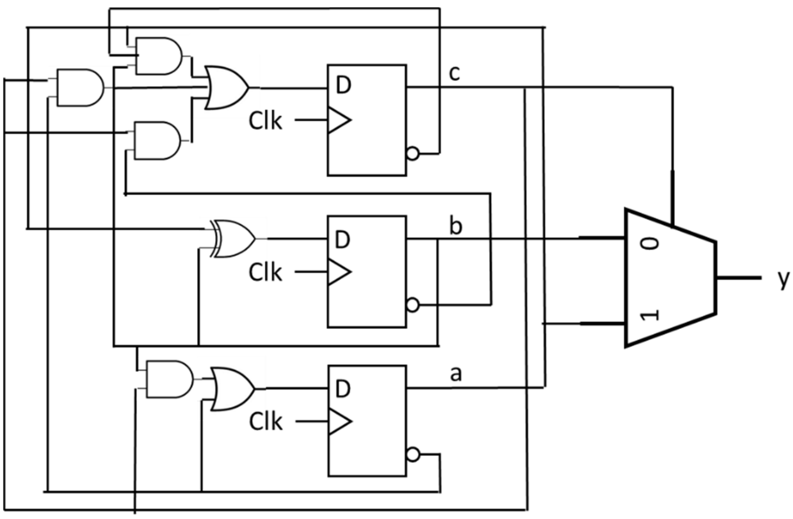






Present state			Next state			Output
c	b	a	c+	b+	a+	y
0	0	0	0	0	1	0
0	0	1	0	1	0	0
0	1	0	0	1	1	1
0	1	1	1	0	0	1
1	0	0	1	0	1	0
1	0	1	1	1	0	1
1	1	0	1	1	1	0
1	1	1	0	0	1	1

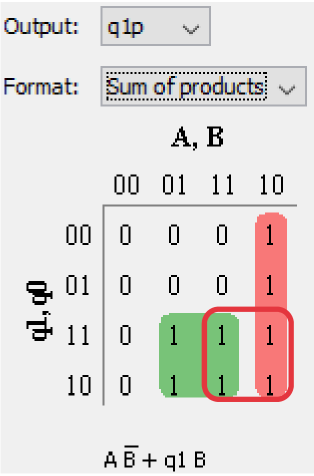


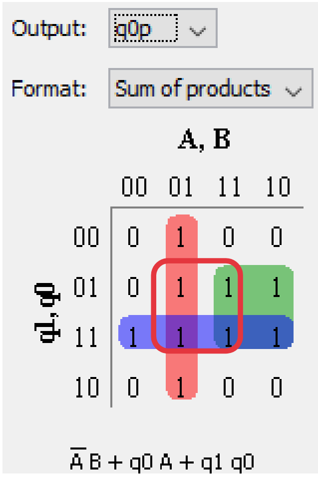


(not necessary to draw the FSM)

12

$q_1^+ = q_1 \cdot B + A \cdot \overline{B}$
$q_0^+ = q_0 \cdot A + \overline{A} \cdot B + q_1 \cdot q_0$





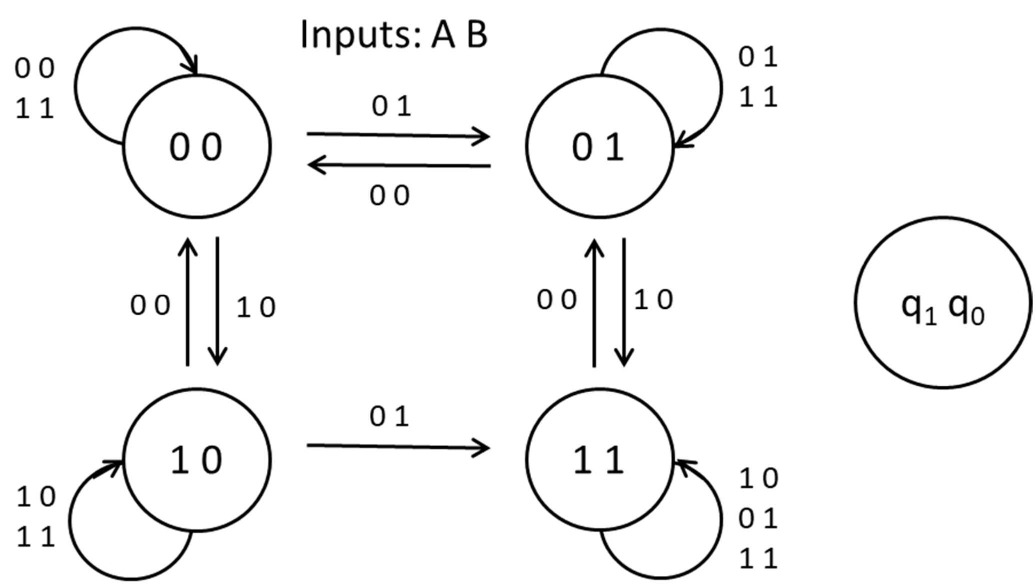
For glitch free expressions add one term each:

$q_1^+ = q_1 \cdot B + A \cdot \overline{B} + q_1 \cdot A$

$q_0^+ = q_0 \cdot A + \overline{A} \cdot B + q_1 \cdot q_0 + q_0 \cdot B$

		Next state							
Present state		A B = 0 0		A B = 0 1		A B = 1 1		A B = 1 0	
q1	q0	q1+	q0+	q1+	q0+	q1+	q0+	q1+	q0+
0	0	0	0	0	1	0	0	1	0
0	1	0	0	0	1	0	1	1	1
1	1	0	1	1	1	1	1	1	1
1	0	0	0	1	1	1	0	1	0

No forbidden states



Part 4

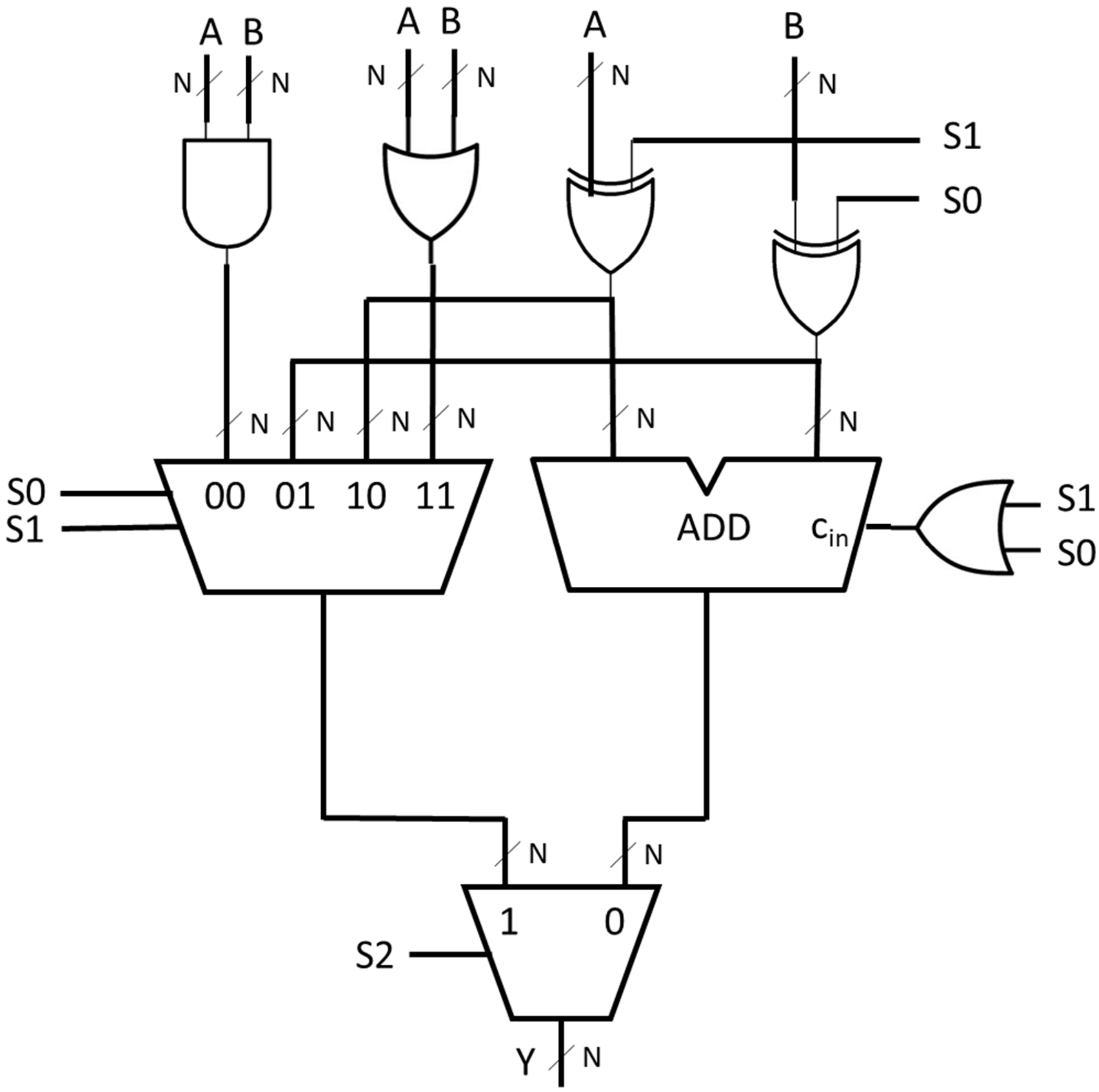
13

Add 4 1-bit full adders in each row, and add 4 rows.
In total 56 1-bit full adders and 64 AND gates.
The output will have 16 bits.

14

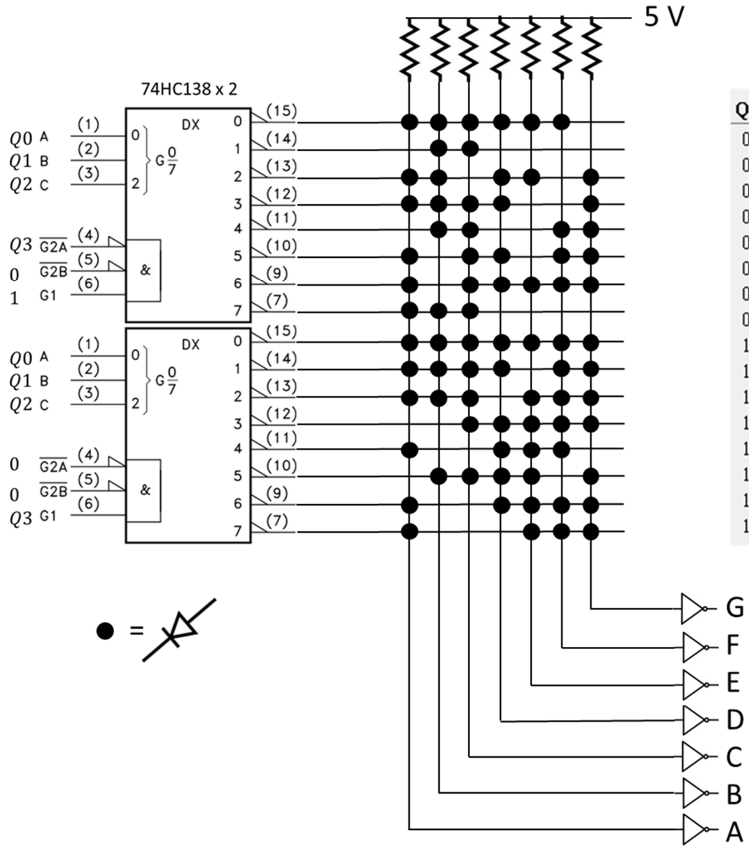
$E = 01100110_2 = 102_{10}$
$F = 00010001_2 = 17_{10}$
$P = E \times F = 0000\ 0110\ 1100\ 0110_2 = 6 \times 256 + 12 \times 16 + 6 = 1734_{10} = 102 \times 17$
$Q = E / F = 00000110_2 = 6_{10} = 102 / 17$

15



Other solutions are also possible

16



Q3	Q2	Q1	Q0	A	B	C	D	E	F	G
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1
1	0	1	0	1	1	1	0	1	1	1
1	0	1	1	0	0	1	1	1	1	1
1	1	0	0	1	0	0	1	1	1	0
1	1	0	1	0	1	1	1	1	0	1
1	1	1	0	1	0	0	1	1	1	1
1	1	1	1	1	0	0	0	1	1	1