IE1204 Exam 20191021 Answers

Part 1

1

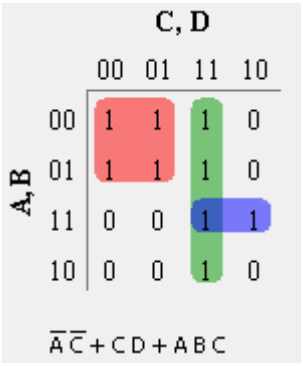
A = $93_{10} = 01011101_2 = 5D_{16}$
B = $-42_{10} = 11010110_2 = D6_{16}$
A + B = $00110011_2 = 51_{10}$

2

C = $01011010_2 = 90_{10} = 5A_{16}$
D = $00110011_2 = 51_{10} = 33_{16}$
-D = $11001101_2 = -51_{10} = CD_{16}$
C - D = $00100111_2 = 39_{10}$

3

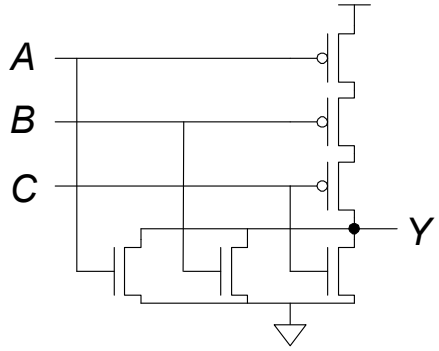
A	B	C	D	Y
0	0	0	0	1
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	1



Can't be further simplified!

4

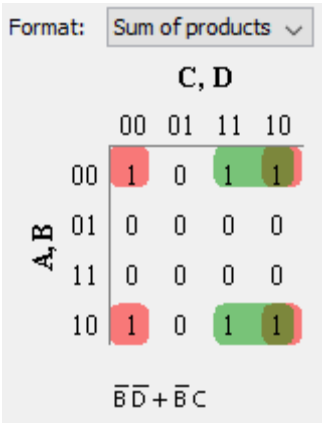
$Z = \overline{A} \cdot \overline{B} \cdot \overline{C} = \overline{A + B + C}$ (three input NOR)

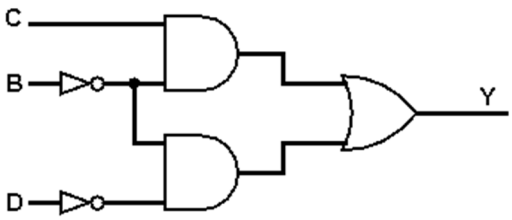


Part 2

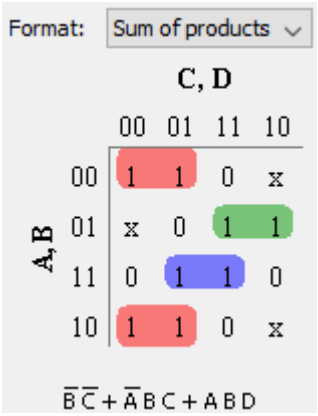
5

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

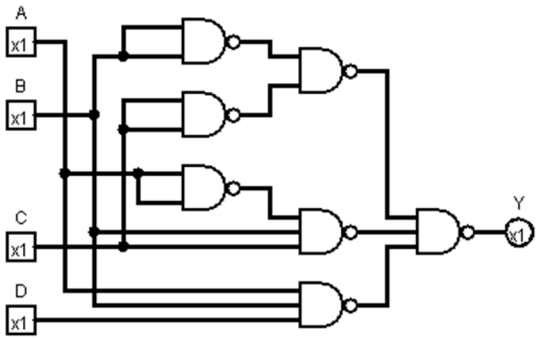




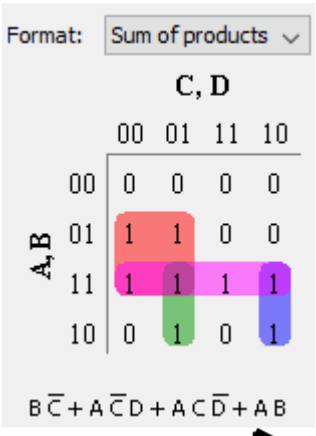
6

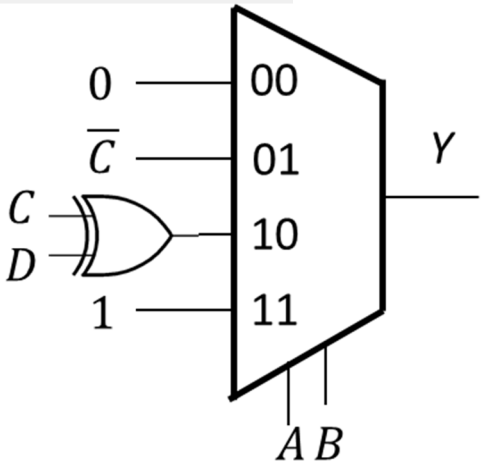


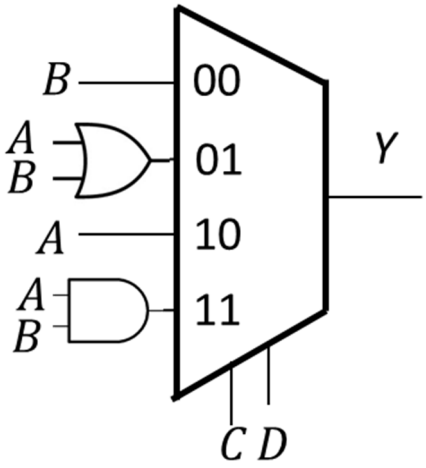
$Y = \overline{B} \cdot \overline{C} + \overline{A} \cdot B \cdot C + A \cdot B \cdot D = \overline{\overline{B} \cdot \overline{C} + \overline{A} \cdot B \cdot C + A \cdot B \cdot D} = \overline{\overline{\overline{B} \cdot \overline{C}} \cdot \overline{\overline{A} \cdot B \cdot C} \cdot \overline{A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



7

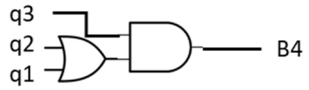


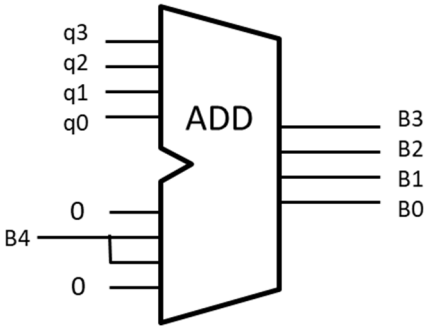




8

q3	q2	q1	q0	B4	B3	B2	B1	B0
0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	1
0	0	1	0	0	0	0	1	0
0	0	1	1	0	0	0	1	1
0	1	0	0	0	0	1	0	0
0	1	0	1	0	0	1	0	1
0	1	1	0	0	0	1	1	0
0	1	1	1	0	0	1	1	1
1	0	0	0	0	1	0	0	0
1	0	0	1	0	1	0	0	1
1	0	1	0	1	0	0	0	0
1	0	1	1	1	0	0	0	1
1	1	0	0	1	0	0	1	0
1	1	0	1	1	0	0	1	1
1	1	1	0	1	0	1	0	0
1	1	1	1	1	0	1	0	1





$B4 = q3 \cdot q2 + q3 \cdot q1 = q3(q2 + q1)$
$B3 = q3 \cdot \overline{B4}$
$B2 = q2 \cdot \overline{B4} + q3 \cdot q2 \cdot q1 = \overline{q3} \cdot q2 + q3 \cdot q2 \cdot q1$
$B1 = q1 \oplus B4$
$B0 = q0$

Or use the first expression plus an ADDER: add 6 if the value is 10 or higher (has the same effect as subtracting 10 when the carry is not used)

Part 3

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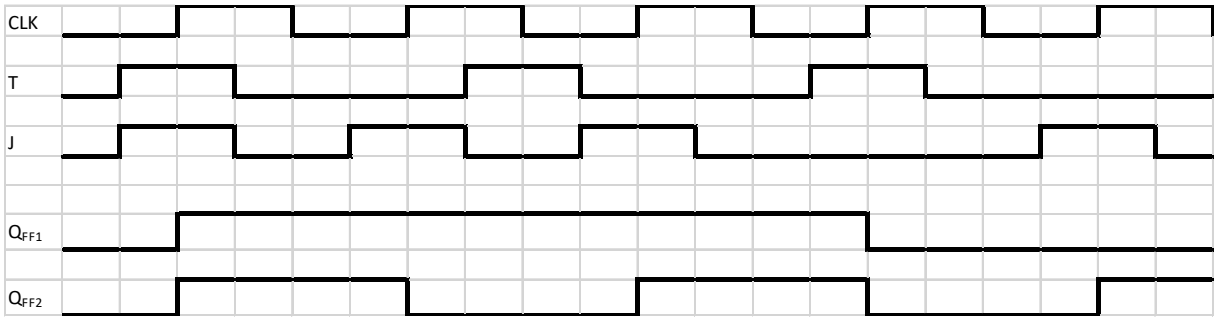


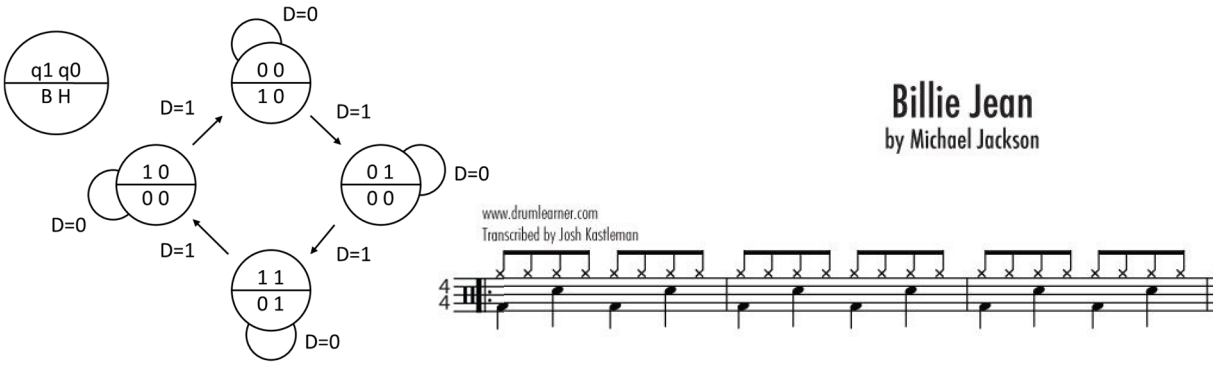
10

$if\ D = 0: q_1^+ = q_1$
$q_0^+ = q_0$

$if\ D = 1: q_1^+ = q_0$
$q_0^+ = \overline{q_1}$

$B = \overline{q_1 + q_0} = \overline{q_1} \cdot \overline{q_0}$
$H = q_1 \cdot q_0$

Present state		Next state				Out	
		D=0		D=1			
q1	q0	q1+	q0+	q1+	q0+	B	H
0	0	0	0	0	1	1	0
0	1	0	1	1	1	0	0
1	1	1	1	1	0	0	1
1	0	1	0	0	0	0	0



The FSM can be used as a drum machine: B = Base, H = Hi-hat, clk = Snare, D=1 drum, D=0 pause

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

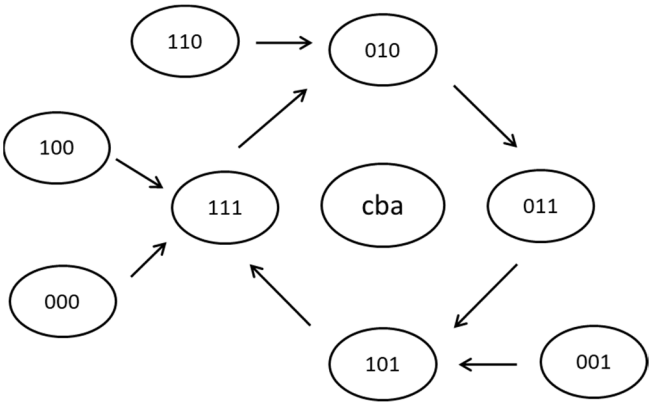
c+ \ ba	00	01	11	10
c = 0	x	x	1	0
1	x	1	0	x

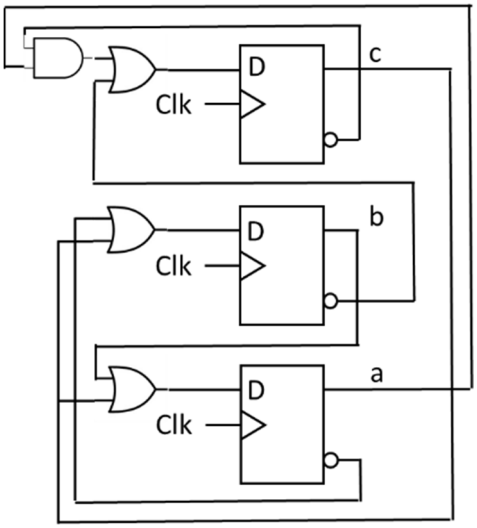
b+ \ ba	00	01	11	10
c = 0	x	x	0	1
1	x	1	1	x

a+ \ ba	00	01	11	10
c = 0	x	x	1	1
1	x	1	0	x

$c^+ = \overline{b} + \overline{c} \cdot a$
$b^+ = c + \overline{a}$
$a^+ = \overline{c} + \overline{b}$

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





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		Next state							
Present state		a b = 0 0		a b = 0 1		a b = 1 1		a b = 1 0	
q2	q1	q2+	q1+	q2+	q1+	q2+	q1+	q2+	q1+
0	0	0	0	1	0	—	—	0	1
0	1	0	0	0	1	1	1	0	1
1	1	—	—	0	1	1	1	0	1
1	0	0	0	1	0	1	1	—	—

q2+ \	a b = 00	01	11	10
q2q1 = 00	0	1	X	0
01	0	0	1	0
11	X	0	1	0
10	0	1	1	X

$q_2^+ = a \cdot b + \overline{q_1} \cdot b$

q1+ \	a b = 00	01	11	10
q2q1 = 00	0	0	X	1
01	0	1	1	1
11	X	1	1	1
10	0	0	1	X

$q_1^+ = q_1 \cdot b + a$

Part 4

13

Ripple carry critical path is 2 x 4 = 8 gates. t_{pd} = 8 x 40 = 320 ps
74hc283 critical path is 6 gates. t_{pd} = 6 x 40 = 240 ps (even though the carry-chain has 5)
$T_c \geq t_{pcq} + t_{pd} + t_{setup} = 40 + 320 + 50 = 410$ ps. $f_{clock} = 1 / T_c = 2{,}5$ GHz
$T_c \geq t_{pcq} + t_{pd} + t_{setup} = 40 + 240 + 50 = 330$ ps. $f_{clock} = 1 / T_c = 3{,}0$ GHz
Hold time does not affect max clock speed.

14

$E = 01010101_2 = 85_{10}$
$F = 00101010_2 = 42_{10}$
$G = 00010001_2 = 17_{10}$
$P = E \times F = 0000\ 1101\ 1111\ 0010_2 = 3570_{10} = 85 \times 42$
$K = E / G = 00000101_2 = 5_{10} = 85 / 17$

15

The opcodes for the ALU is as below (did not need to be shown).
First case A = 1010, B = 0011, S2 = 0, S1 = 1, S0 = 1: Y = A NOR B = 0100
Second case if S2 = 1: Y = A – B = 0111 (10 – 3 = 7, calculate decimal or binary with 2 complement)

S2	S1	S0	Operation
0	0	0	A AND B
0	0	1	A NAND B
0	1	0	A OR B
0	1	1	A NOR B
1	0	0	A + A = 2A
1	0	1	A - A = 0
1	1	0	A + B
1	1	1	A - B

16

$A_4A_3A_2A_1A_0 = 01001$
$D_3D_2D_1D_0 = 0101$ (diodes are zero, no inverters on this ROM)