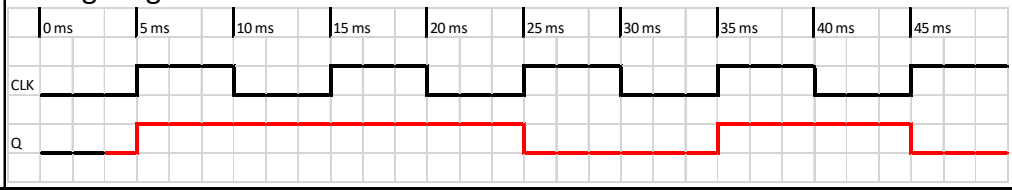
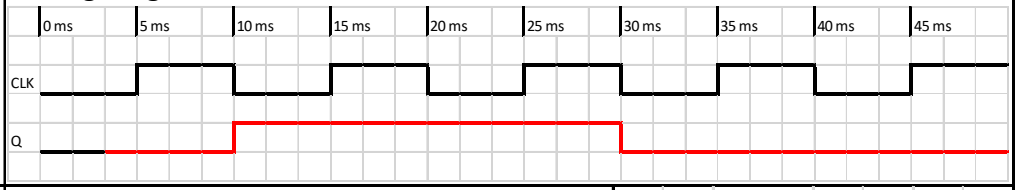
IE1204 Digital Design Answer Form 2021-01-12

Full Name	Personal Number	Program
Exam Answers 2021-01-12	YYYYMMDD-XXXX	NN

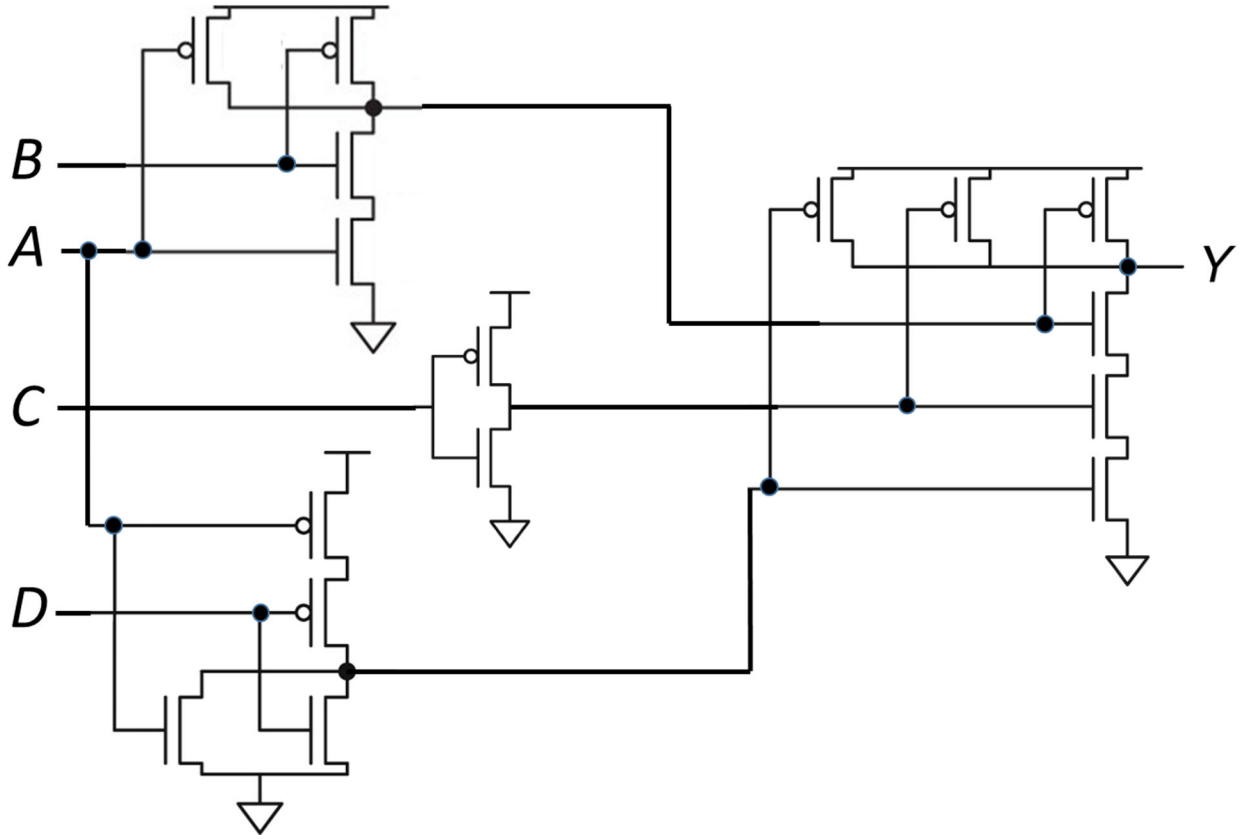
#	Answer with	Answer	Points
1	Decimal number	-42	1
2	8 bit two's complement binary number	0 1 1 1 0 1 0 1	1
3	8 bit two's complement binary number	1 1 0 1 1 0 0 1	1
4	Boolean expression, Y =	$A + C + D$	1
5	Boolean expression, Y = $(A+B+\overline{C})(\overline{A}+\overline{B}+C)(\overline{A}+B+\overline{C}) = (A+B+\overline{C})(\overline{B}+C)$		1
6	Boolean expression, Y = $(A+C)(\overline{B}+D)(\overline{A}+\overline{C}) = (\overline{B}+D)(A \oplus C)$ OR $\overline{A}\cdot\overline{B}\cdot C + \overline{A}\cdot C\cdot D + A\cdot\overline{B}\cdot\overline{C} + A\cdot\overline{C}\cdot D$		1
7	MUX connections Row CD = 00 Row CD = 01 Row CD = 10 Row CD = 11	$\overline{A\cdot B}$ $\overline{A}$ $\overline{A+B}$ $A \oplus B$	1
8	Timing diagram		1
9	Timing diagram		1
10	Setup condition Hold condition	☒ Yes ☐ No ☒ Yes ☐ No	1
11	Boolean expression	$\overline{A}\cdot\overline{C}$	1
12	16 bit two's complement binary number, MSB LSB	1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1	1
13	8 bit two's complement binary number	1 1 1 0 1 1 0 1	1
14	Number interval	-64 to 63.5	1
15	5 result bits (S4 S3 S2 S1 S0)	0 1 1 1 1	1
16	4 flag bits (V C N Z)	0 0 1 0	1
TOTAL POINTS	Examiner sign CMZ		16

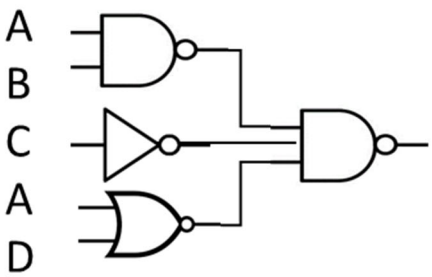
IE1204 Digital Design Exam 2021-01-12 K-maps

4 CMOS

Swedish: Bestäm den logiska funktionen Y = f(A, B, C, D) för CMOS-grindnätet.
Förenkla så långt som möjligt.

English: Determine the logic function Y = f(A, B, C, D) for the CMOS-circuit.
Simplify as much as possible.





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

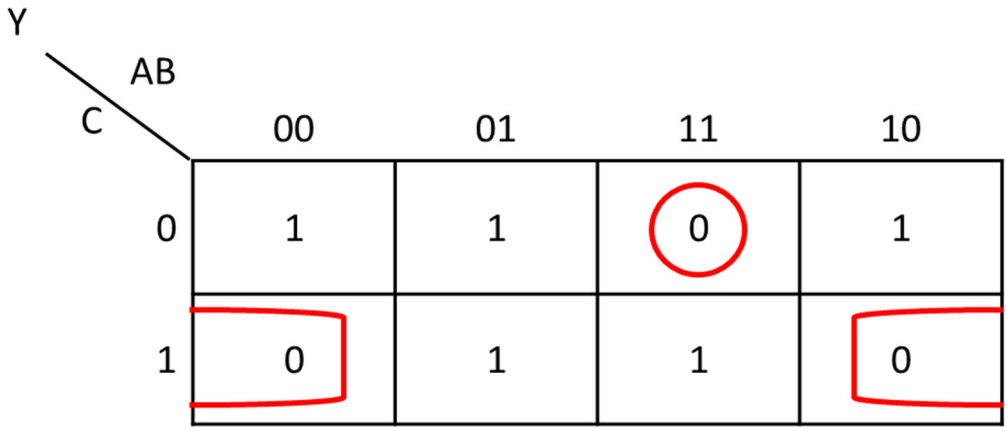
0.5 points if AB is included, 0 points if the expression has incorrect result
Only A + C + D received 1 point

5 SoP / PoS

Swedish: Ta fram booleskt uttryck på PoS form för sanningstabellen nedan.

English: Derive the Boolean expression in PoS form for the truth table below.

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



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

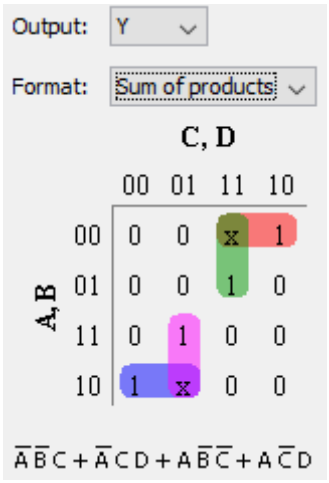
Either answer gives 1 point

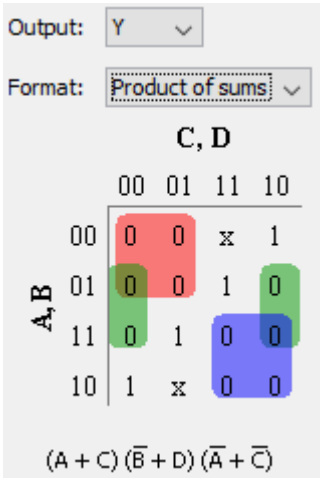
6 K-map

Swedish: Uttnyttja x = don't care.
Ta fram enklast möjliga booleska uttryck från K-map.

English: Use x = don't care.
Derive simplest possible Boolean expression from the K-map.

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





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

IE1204 Digital Design Exam 2021-01-12 Solutions

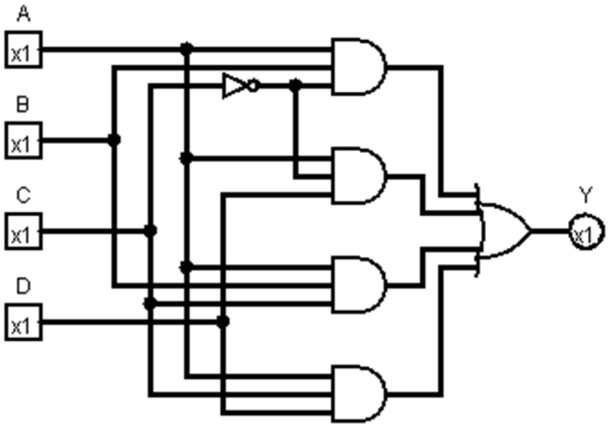
17 Analysis of Combinational Circuit

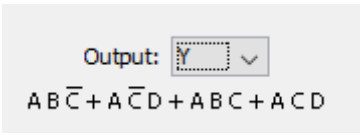
Swedish:

1. Ta fram booleskt uttryck för kretsen nedan.
2. Rita K-map för kretsen med variabelordning som i figuren.
3. Förenkla uttrycket med hjälp av K-map.
4. Rita ny krets med enbart 2- och 3-ingångars NOR-grindar.

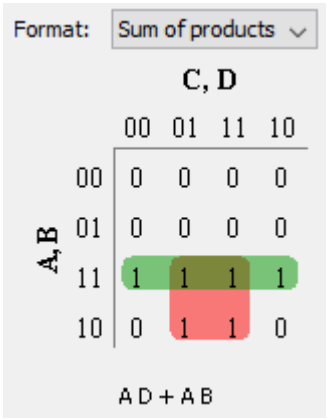
English:

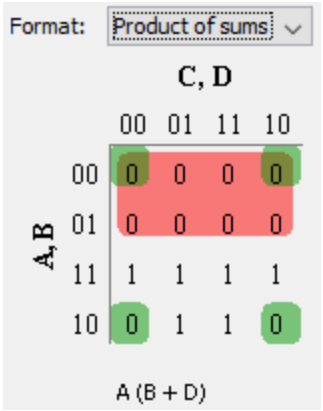
1. Derive the Boolean expression for the circuit below.
2. Draw a K-map for the circuit with variables as in the figure.
3. Simplify the expression using the K-map.
4. Draw a new circuit using only 2 and 3 input NOR gates.

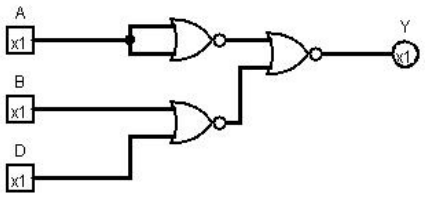




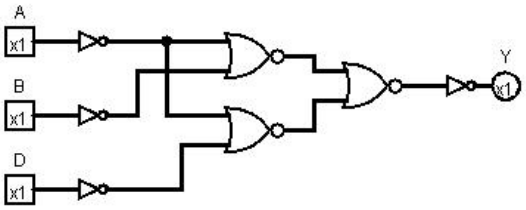
Use POS for NOR only (inverters are ok if you note that they can be made with a NOR)
No deductions if not simplest possible.







For POS, draw $Y = \overline{\overline{A} + \overline{B} + D}$ (See top figure)



For SOP, draw $Y = \overline{\overline{\overline{A} + \overline{D}} + \overline{\overline{A} + \overline{B}}}$
(Note the double inversion bars, an extra inverter/NOR is needed)

18 Design of Combinational Circuit

Swedish:
Designa en kombinatorisk krets för Y=f(Q3, Q2, Q1, Q0), Q3 = MSB där
Y = 1 för alla tal som är jämt delbara med 3
Y = x (don't care) för 7, 11, 13 och 14
Y = 0 för alla övriga tal

1. Rita sanningstabellen.
2. Rita K-map för sanningstabellen med variabelordning som i figuren.
3. Uttnyttja x = don't care. Ta fram enklast möjliga booleska uttryck från K-map.
4. Rita en krets för uttrycket med enbart NAND-grindar.

English:
Design a combinational circuit for Y=f(Q3, Q2, Q1, Q0), Q3 = MSB where
Y = 1 for all numbers evenly divisible by 3
Y = x (don't care) for 7, 11, 13, and 14
Y = 0 for all other numbers

1. Draw the truth table.
2. Draw a K-map for the truth table with variables as in the figure..
3. Use x = don't care. Derive simplest possible Boolean expression from the K-map.
4. Draw a circuit for the expression using only NAND-gates.

	Q_1Q_0 = 00	01	11	10
Q_3Q_2 = 00				
01				
11				
10				

Rita om K-map i dina inlämnade svar.

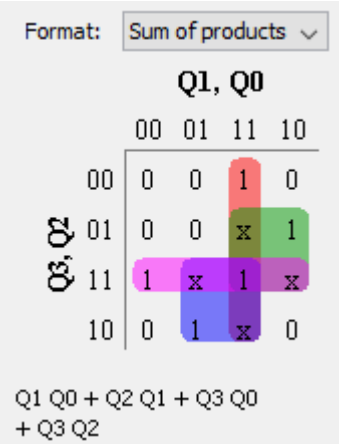
Redraw the K-map in your answer sheets.

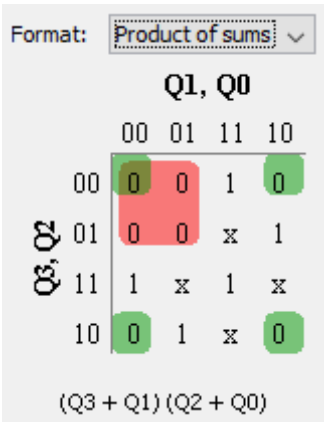
(Answer on next page)

18 Design of Combinational Circuit

Version A: Zero not divisible by 3

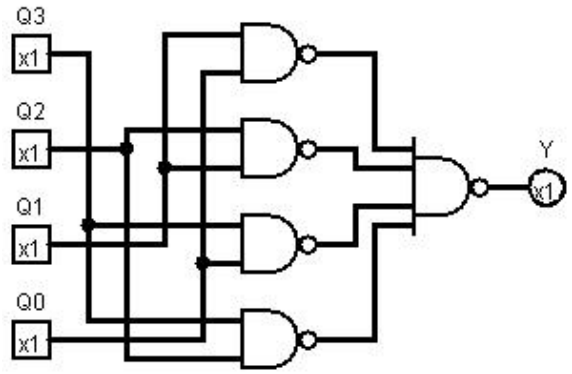
Q3	Q2	Q1	Q0	Y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	x
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	x
1	1	0	0	1
1	1	0	1	x
1	1	1	0	x
1	1	1	1	1



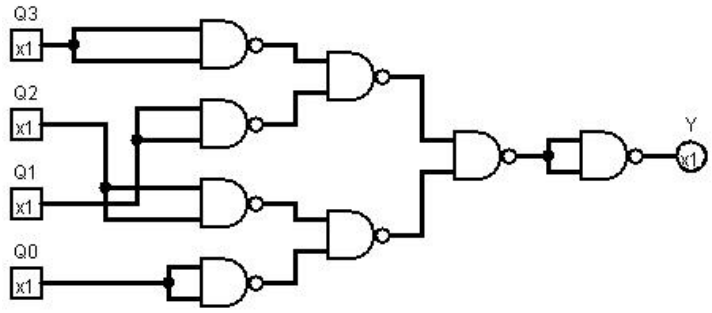


Use SOP for NAND only (inverters are ok if you note that they can be made with a NAND)
No deductions if not simplest possible.

For SOP draw $Y = \overline{\overline{Q1 \cdot Q0} \cdot \overline{Q2 \cdot Q1} \cdot \overline{Q3 \cdot Q0} \cdot \overline{Q3 \cdot Q2}}$ (see figure)



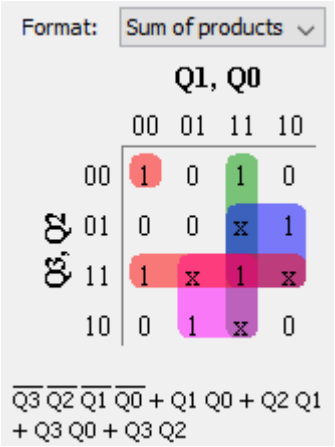
For POS draw $Y = \overline{\overline{\overline{Q3} \cdot \overline{Q1}} \cdot \overline{\overline{Q2} \cdot \overline{Q0}}}$

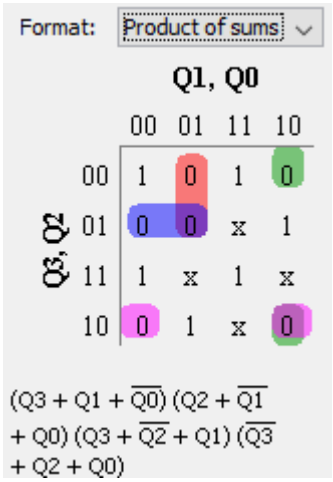


(Note the double inversion bars, an extra inverter/NAND is needed)

Version B: Zero divisible by 3

Q3	Q2	Q1	Q0	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	x
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	x
1	1	0	0	1
1	1	0	1	x
1	1	1	0	x
1	1	1	1	1

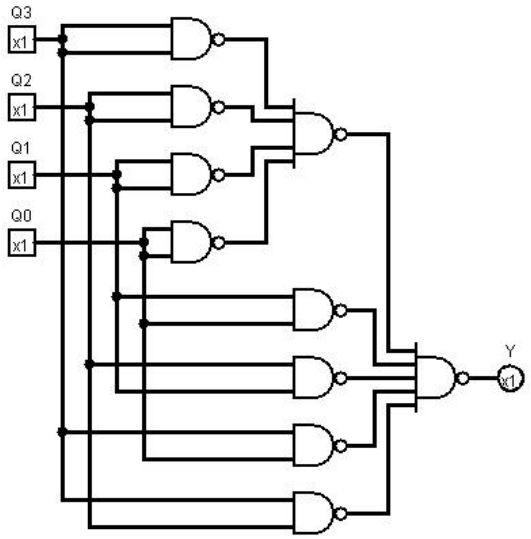


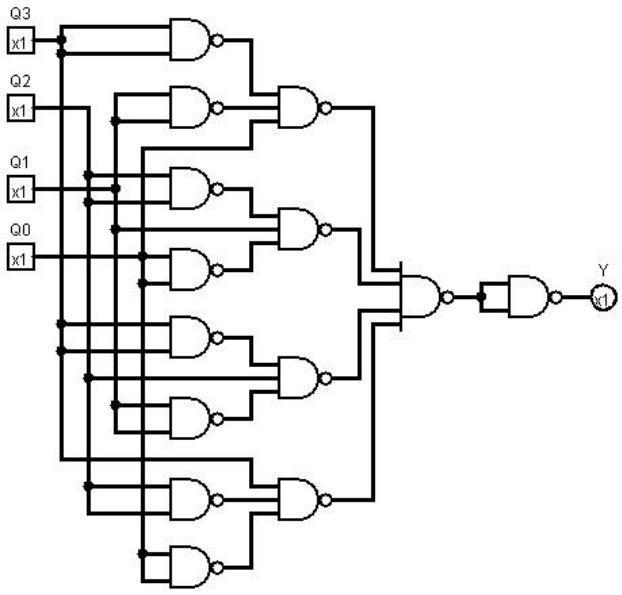


Use SOP for NAND only (inverters are ok if you note that they can be made with a NAND)
No deductions if not simplest possible.

For SOP draw $Y = \overline{\overline{Q3} \cdot \overline{Q2} \cdot \overline{Q1} \cdot \overline{Q0} \cdot \overline{Q1 \cdot Q0} \cdot \overline{Q2 \cdot Q1} \cdot \overline{Q3 \cdot Q0} \cdot \overline{Q3 \cdot Q2}}$ (see left figure)

For POS draw $Y = \overline{\overline{\overline{Q3} \cdot \overline{Q1} \cdot Q0} \cdot \overline{\overline{Q2} \cdot Q1 \cdot \overline{Q0}} \cdot \overline{\overline{Q3} \cdot Q2 \cdot \overline{Q1}} \cdot \overline{Q3 \cdot \overline{Q2} \cdot \overline{Q0}}}$ (see right figure)
(Note the double inversion bars, an extra inverter/NAND is needed)





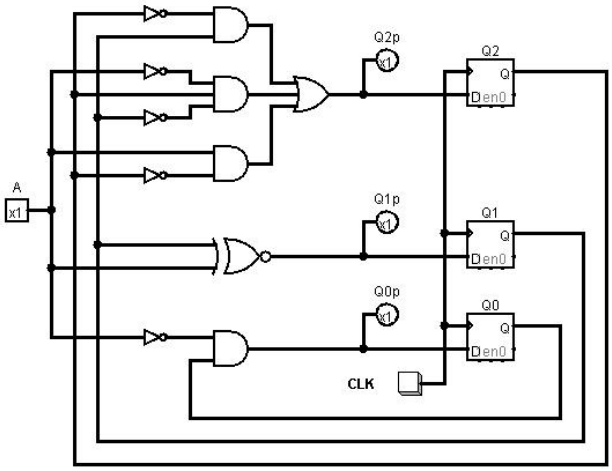
19 Analysis of FSM

Swedish: Analysera vad nedanstående tillståndsmaskin (FSM) utför.

1. Ta fram Boolska uttryck för nästa tillstånd.
2. Rita tillståndstabell.
3. Rita tillståndsdiagram.
   Använd ordningen $Q_{2:0}$

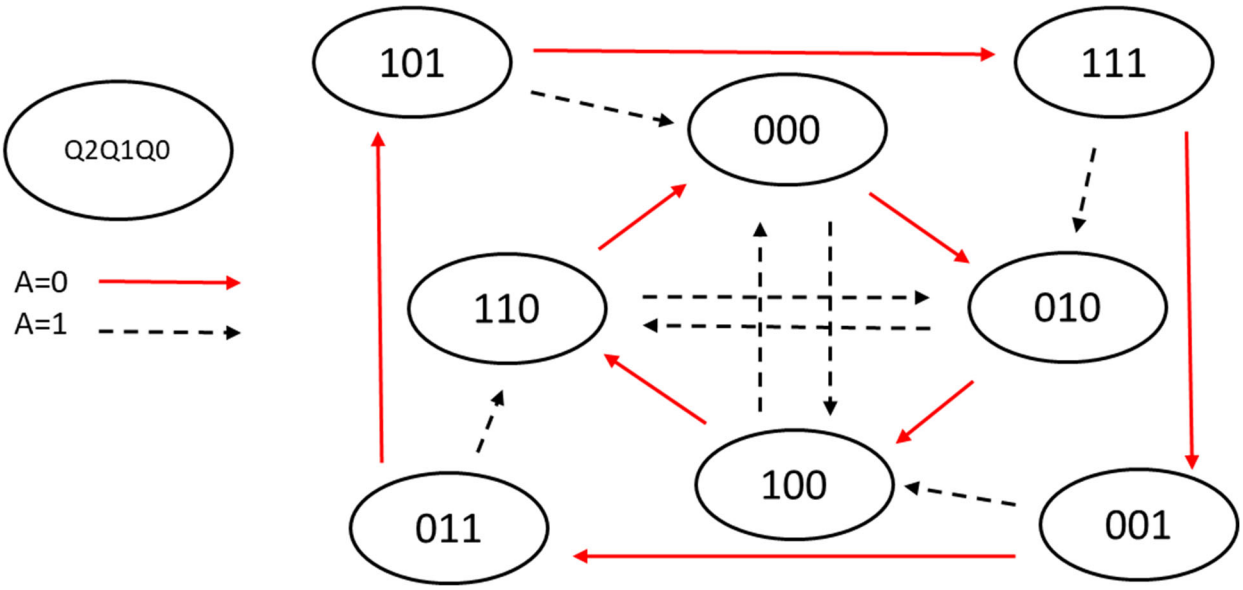
English: Analyze the state machine (FSM) below.

1. Derive Boolean expressions for next state.
2. Draw a state table.
3. Draw a state diagram.
   Use the order $Q_{2:0}$



$$Q2+= \overline{Q2} \cdot Q1 + \overline{A} \cdot Q2 \cdot \overline{Q1} + A \cdot \overline{Q2}$$
$$Q1+= A \cdot Q1 + \overline{A} \cdot \overline{Q1} = \overline{A \oplus Q1}$$
$$Q0+= \overline{A} \cdot Q0$$

Present state			Next state A = 0			Next state A = 1		
Q2	Q1	Q0	Q2+	Q1+	Q0+	Q2+	Q1+	Q0+
0	0	0	0	1	0	1	0	0
0	0	1	0	1	1	1	0	0
0	1	0	1	0	0	1	1	0
0	1	1	1	0	1	1	1	0
1	0	0	1	1	0	0	0	0
1	0	1	1	1	1	0	0	0
1	1	0	0	0	0	0	1	0
1	1	1	0	0	1	0	1	0



If A=0: +2
If A=1: +4 for even and +3 for odd numbers

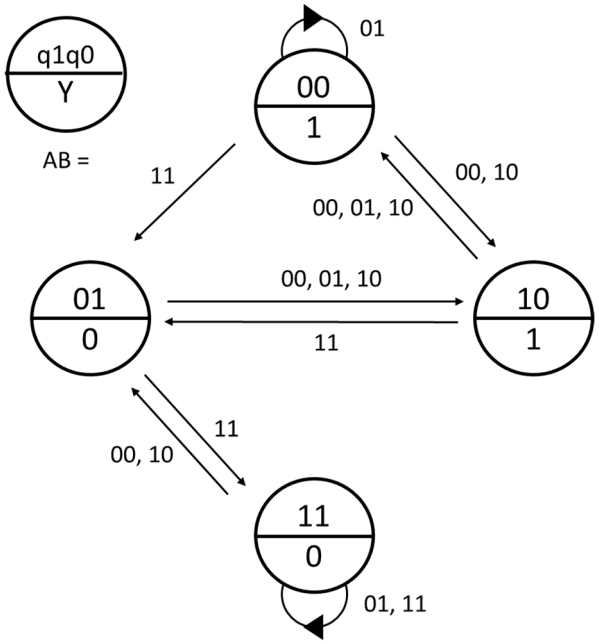
20 Design of FSM

Swedish: Konstruera en tillståndsmaskin (FSM) enligt tillståndsdiagrammet nedan.

1. Rita tillståndstabell.
2. Ta fram K-map för nästa tillstånd.
3. Ta fram minimerade uttryck för nästa tillstånd och utsignal.
4. Rita kretsschema för en FSM med DFFs och vilka grindar som helst.

English: Design a state machine (FSM) according to the state diagram below.

1. Draw a state table.
2. Derive K-maps for next states.
3. Derive minimized expressions for next state and output.
4. Draw the FSM circuit diagram with DFFs and any gates.



	A B = 00	01	11	10
q1q0 = 00				
01				
11				
10				

Rita om K-map i dina inlämnade svar.

Redraw the K-map in your answer sheets.

					Next state					
Present state		AB = 00		AB = 01		AB = 11		AB = 10		Out
q1	q0	q1+	q0+	q1+	q0+	q1+	q0+	q1+	q0+	Y
0	0	1	0	0	0	0	1	1	0	1
0	1	1	0	1	0	1	1	1	0	0
1	1	0	1	1	1	1	1	0	1	0
1	0	0	0	0	0	0	1	0	0	1

q1+	AB=			
q1q0	00	01	11	10
00	1	0	0	1
01	1	1	1	1
11	0	1	1	0
10	0	0	0	0

q0+	AB=			
q1q0	00	01	11	10
00	0	0	1	0
01	0	0	1	0
11	1	1	1	1
10	0	0	1	0

K-map not needed for Y, $Y = \overline{q0}$

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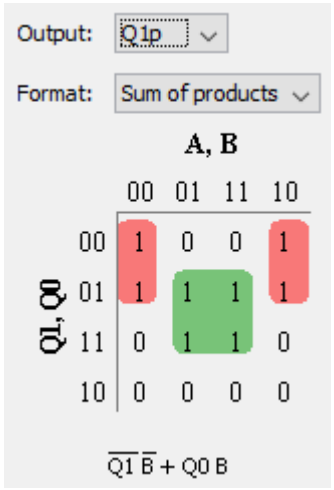

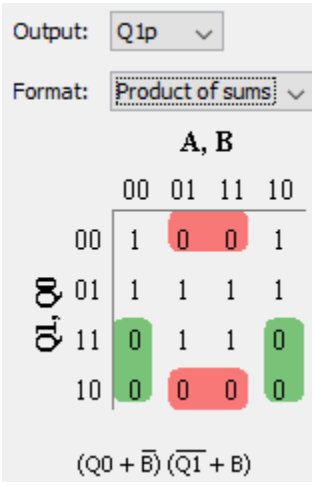

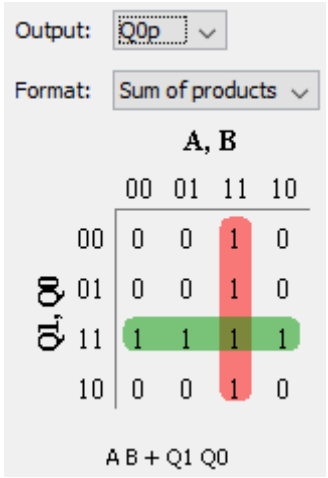

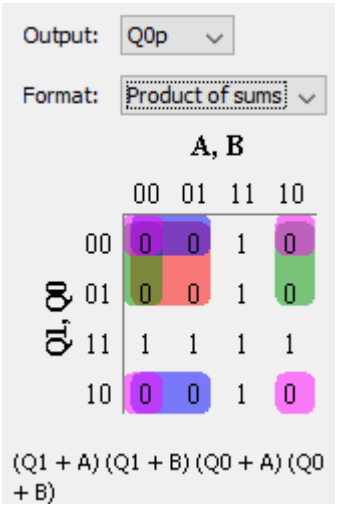

$Y = \overline{q0}$