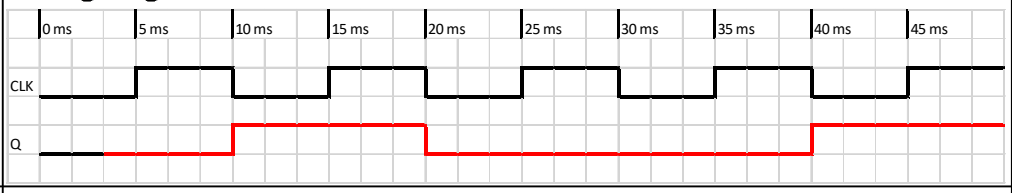
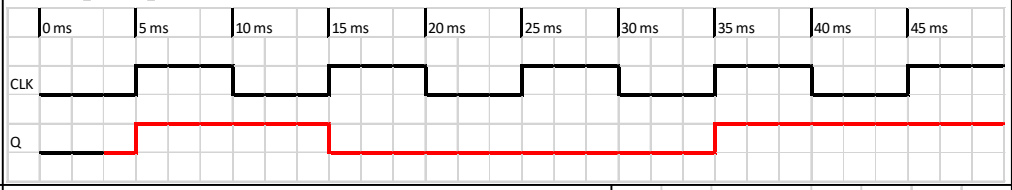
IE1204 Digital Design Answer Form 2021-04-07

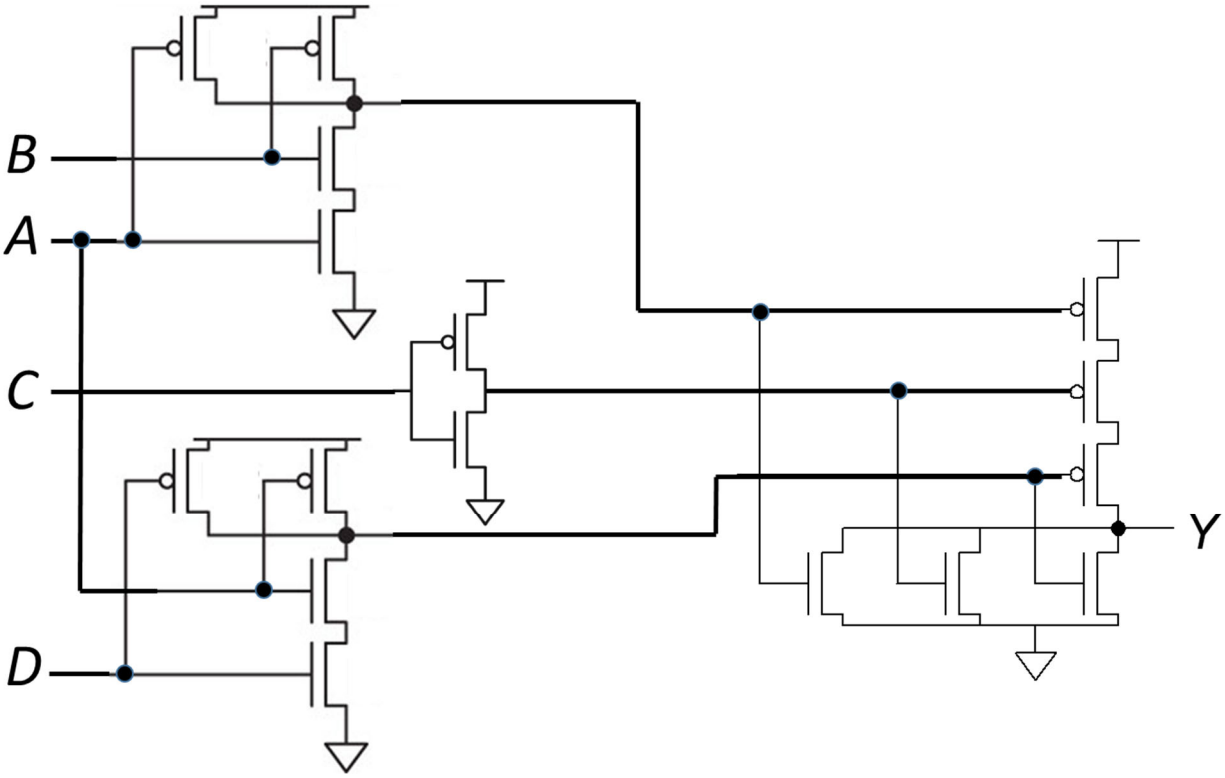
Full Name		Personal Number								Program
Exam Answers 2021-04-07		YYYYMMDD-XXXX								NN
#	Answer with	Answer								Points
1	Decimal number	-57								1
2	8 bit two's complement binary number	0	1	1	1	0	1	0	1	1
3	8 bit two's complement binary number	1	0	1	0	1	0	1	1	1
4	Boolean expression, Y =	$A \cdot B \cdot C \cdot D$								1
5	Boolean expression, Y =	$(A + B + \overline{C})(\overline{A} + B + C)\ (\overline{A} + \overline{B} + \overline{C})$								1
6	Boolean expression, Y =	$\overline{B} \cdot \overline{D} + A \cdot B \cdot D$								1
	OR $(B + \overline{D})(A + \overline{B})(\overline{B} + D)$									
7	MUX connections									1
	Row CD = 00	$\overline{A + B}$								
	Row CD = 01	$\overline{A \oplus B}$								
	Row CD = 10	$A \cdot B$								
	Row CD = 11	B								
8	Timing diagram									1
9	Timing diagram									1
10	Setup condition	☒ Yes ☐ No								1
	Hold condition	☐ Yes ☒ No								
11	Boolean expression (Hazard fix only)	$\overline{B} \cdot C$								1
12	16 bit two's complement binary number, MSB	1	1	1	1	1	1	1	0	1
	LSB	1	1	0	1	1	0	1	0	
13	8 bit two's complement binary number	1	1	1	0	1	0	0	1	1
14	Number interval	-8 to 7.9375								1
15	5 result bits (S4 S3 S2 S1 S0)	1	0	0	0	1				1
16	4 flag bits (V C N Z)	0	0	1	0					1
TOTAL POINTS		Examiner sign CMZ								16

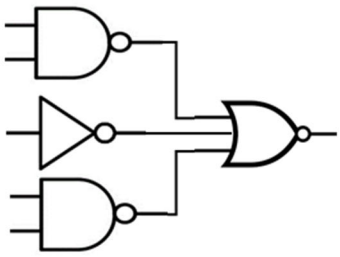
IE1204 Digital Design Exam 2021-04-07 K-maps

4 CMOS

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

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





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

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	0
1	0	1	1
1	1	0	1
1	1	1	0

Y \ AB / C	00	01	11	10
0	1	1	1	0
1	0	1	0	1

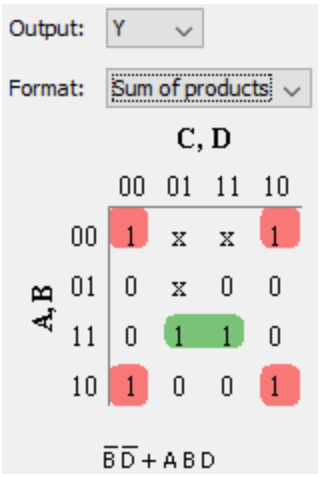
$$Y = (A + B + \overline{C})(\overline{A} + B + C)\ (\overline{A} + \overline{B} + \overline{C})$$

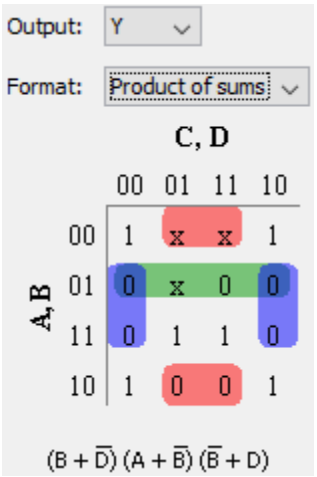
6 K-map

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	1	X	X	1
AB 01	0	X	0	0
AB 11	0	1	1	0
AB 10	1	0	0	1





IE1204 Digital Design Exam 2021-04-07 Solutions

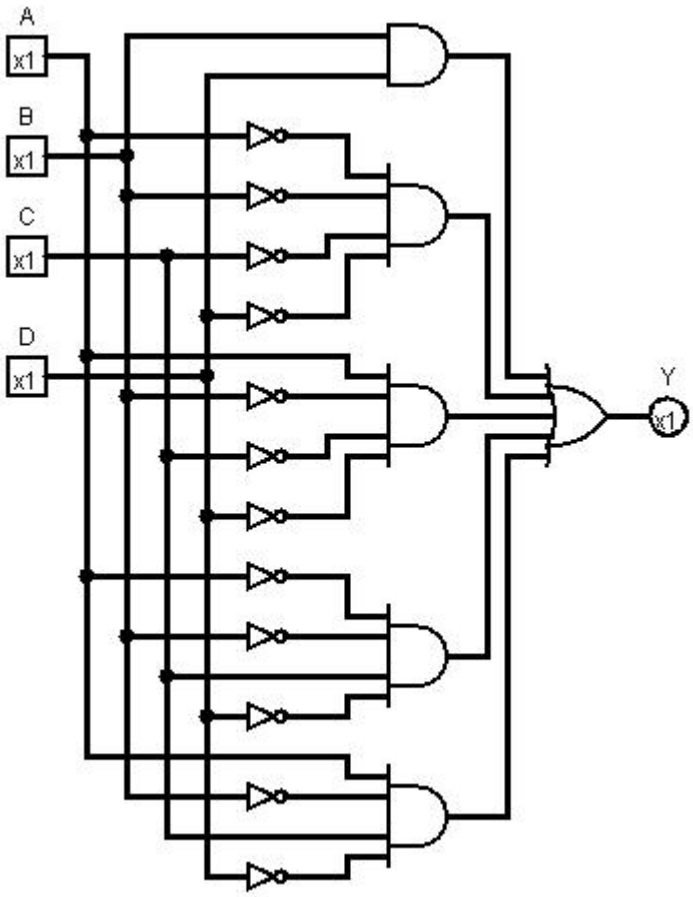
17 Analysis of Combinational Circuit

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.

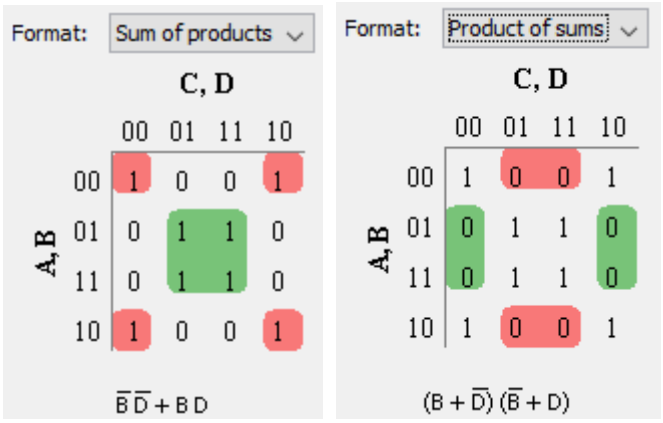


(Answer on next page)

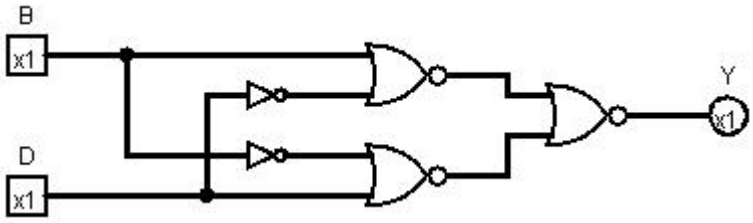
Use POS for NOR only (inverters are ok if you note that they can be made with a NOR)
No deductions if not simplest possible.

$$B\,D + \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + A\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}\,\overline{B}\,C\,\overline{D} + A\,\overline{B}\,C\,\overline{D}$$

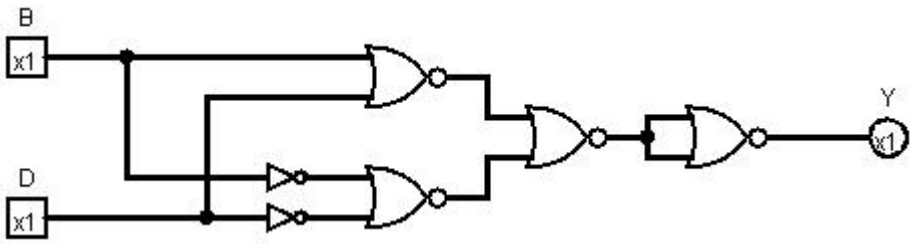
AB \ CD =	00	01	11	10
00	1	0	0	1
01	0	1	1	0
11	0	1	1	0
10	1	0	0	1



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



For SOP, draw $Y = \overline{\overline{\overline{B} \cdot \overline{D}} + \overline{B \cdot D}} = \overline{\overline{B + D} + \overline{\overline{B} + \overline{D}}}$
(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 0, 5, 10, 15
Y = x (don't care) för 2, 7, 8, 13
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 0, 5, 10, and 15
Y = x (don't care) for 2, 7, 8, and 13
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				

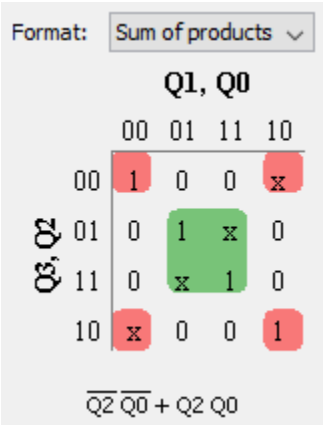
Rita om K-map i dina inlämnade svar.

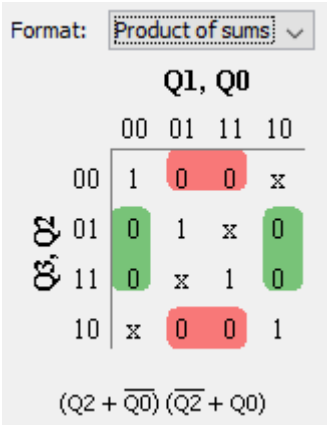
Redraw the K-map in your answer sheets.

(Answer on next page)

18 Design of Combinational Circuit

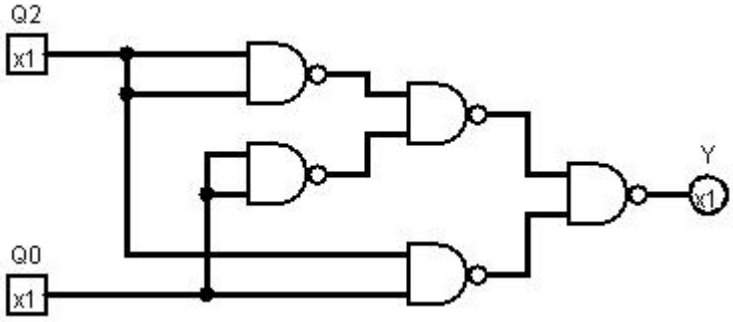
Q3	Q2	Q1	Q0	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	x
0	0	1	1	0
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	x
1	0	0	0	x
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	x
1	1	1	0	0
1	1	1	1	1



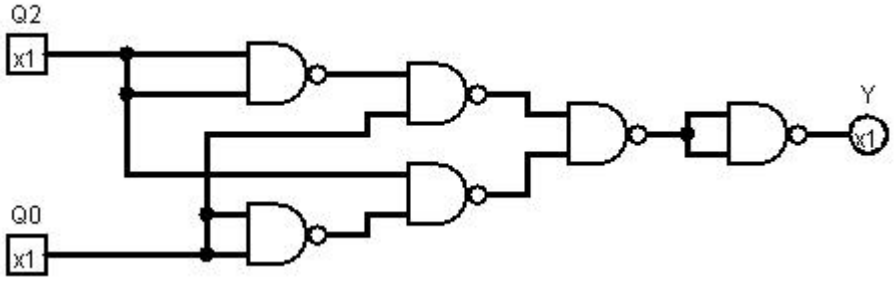


Use SOP for NAND only (inverters are ok if you note that they can be made with a NAND)
No deductions if not simplest possible.

For SOP draw $Y = \overline{\overline{Q2} \cdot \overline{Q0} + Q2 \cdot Q0} = \overline{\overline{\overline{Q2} \cdot \overline{Q0}} \cdot \overline{Q2 \cdot Q0}}$



For POS draw $Y = \overline{(Q2 + \overline{Q0}) \cdot (\overline{Q2} + Q0)} = \overline{\overline{Q2} \cdot Q0 \cdot Q2 \cdot \overline{Q0}}$



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

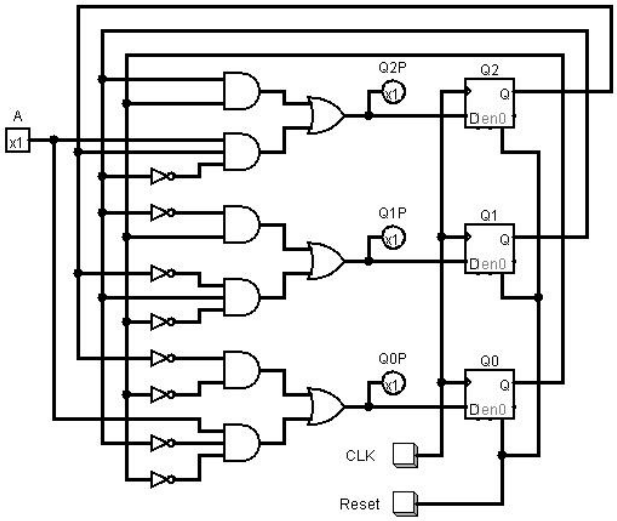
19 Analysis of FSM

Swedish: Analysera vad nedanstående tillståndsmaskin (FSM) utför.

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

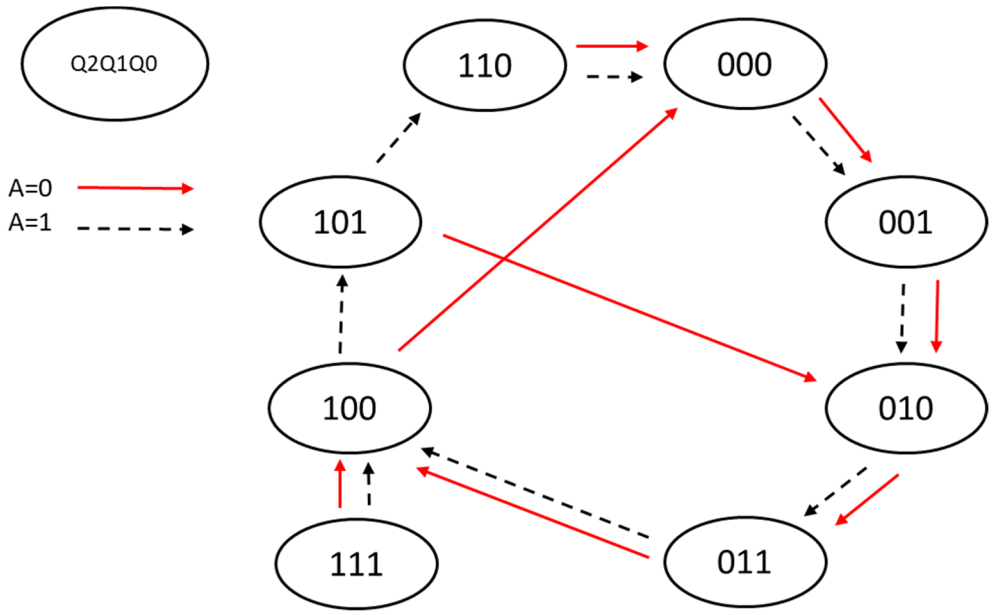
English: Analyze the state machine (FSM) below.

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



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

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



If A=0: divide by 5
If A=1: divide by 7

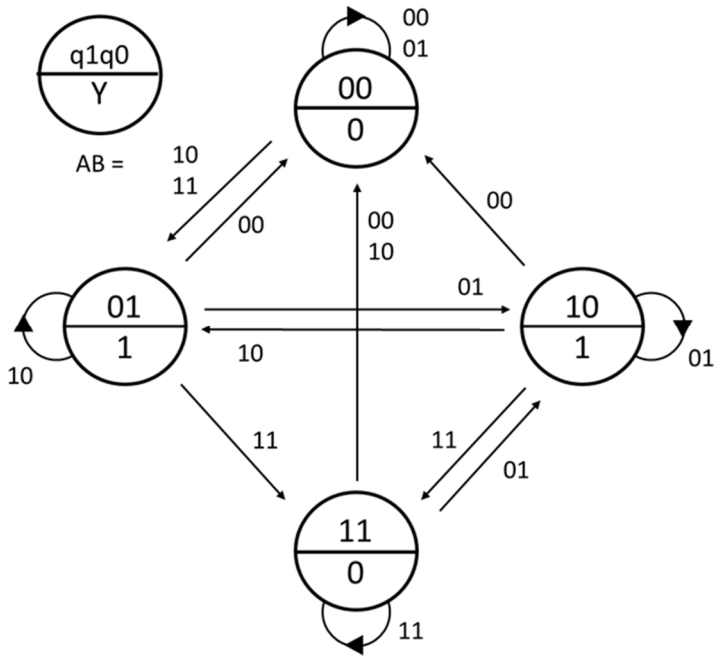
20 Design of FSM

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	0	0	0	0	0	1	0	1	0
0	1	0	0	1	0	1	1	0	1	1
1	1	0	0	1	0	1	1	0	0	0
1	0	0	0	1	0	1	1	0	1	1

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

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

K-map not needed for Y, $Y = q1 \oplus q0$

Continues on next page

Output: q1p

Format: Sum of products

q1, q0 \ A, B	00	01	11	10
00	0	0	0	0
01	0	1	1	0
11	0	1	1	0
10	0	1	1	0

$q0\,B + q1\,B$

Output: q1p

Format: Product of sums

q1, q0 \ A, B	00	01	11	10
00	0	0	0	0
01	0	1	1	0
11	0	1	1	0
10	0	1	1	0

$(q1 + q0)\,B$

Output: q0p

Format: Sum of products

q1, q0 \ A, B	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	0	0	1	0
10	0	0	1	1

$\overline{q1}\,A + \overline{q0}\,A + A\,B$

Output: q0p

Format: Product of sums

q1, q0 \ A, B	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	0	0	1	0
10	0	0	1	1

$A\,(\overline{q1} + \overline{q0} + B)$