

# IE1204 Digital Design Answer Form 2021-05-17

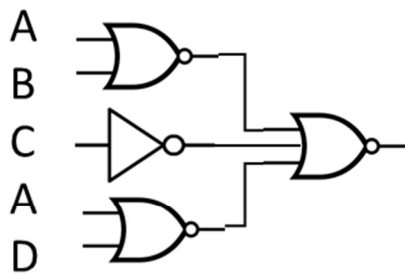
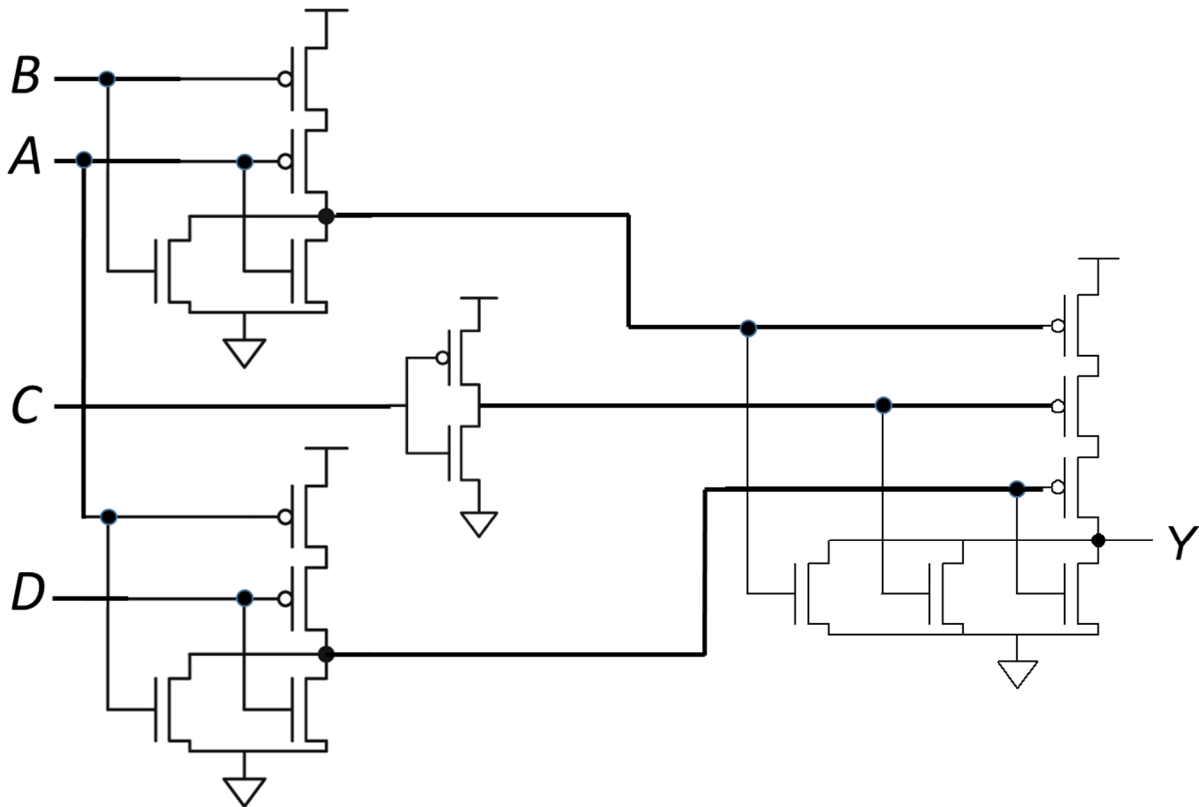
Full Name		Personal Number		Program		
Exam Answers 2021-05-17		00000000 = 0		NN		
#	Answer with	Answer				Points
1	Decimal number	-113				1
2	8 bit two's complement binary number	0	1	1	1	1
3	8 bit two's complement binary number	1	1	0	0	0
4	Boolean expression, Y =	$(A+BD)C$				1
5	Boolean expression, Y = $Y = (A + \bar{B} + C)(\bar{A} + \bar{B} + C)(\bar{A} + \bar{B} + \bar{C}) = (\bar{B} + C)(\bar{A} + \bar{B})$					1
6	Boolean expression, Y = OR	$Y = \bar{A} \cdot \bar{C} + C \cdot \bar{D} + B \cdot \bar{C}$ $Y = (\bar{C} + \bar{D})(\bar{A} + B + C)$				1
7	MUX connections	$0$				1
	CD = 00	$AB$				
	CD = 01	$A + B$				
	CD = 10	$A$				
8	Timing diagram					1
9	Timing diagram					1
10	Setup condition	<input type="checkbox"/> Yes		<input checked="" type="checkbox"/> No		1
	Hold condition	<input type="checkbox"/> Yes		<input checked="" type="checkbox"/> No		
11	Boolean expression (Hazard fix only)	$CD$				1
12	16 bit two's complement binary number, MSB	1	1	1	1	1
	LSB	0	1	1	1	0
13	8 bit two's complement binary number	1	1	1	0	1
14	Number interval	-8 to 7.9375				1
15	5 result bits (S4 S3 S2 S1 S0)	1	0	0	0	0
16	4 flag bits (V C N Z)	0	0	0	1	1
TOTAL POINTS		Examiner sign CMZ				16

# IE1204 Digital Design Exam 2021-05-17 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.



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

## 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	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

Y

		AB			
		00	01	11	10
C	0	1	0	0	1
	1	1	1	0	1

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

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

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

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

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

Format:

		C, D			
		00	01	11	10
A, B	00	x	1	0	x
	01	1	1	0	1
	11	x	1	0	1
	10	0	0	x	1

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

Format:

		C, D			
		00	01	11	10
A, B	00	x	1	0	x
	01	1	1	0	1
	11	x	1	0	1
	10	0	0	x	1

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

# IE1204 Digital Design Exam 2021-05-17 Solutions

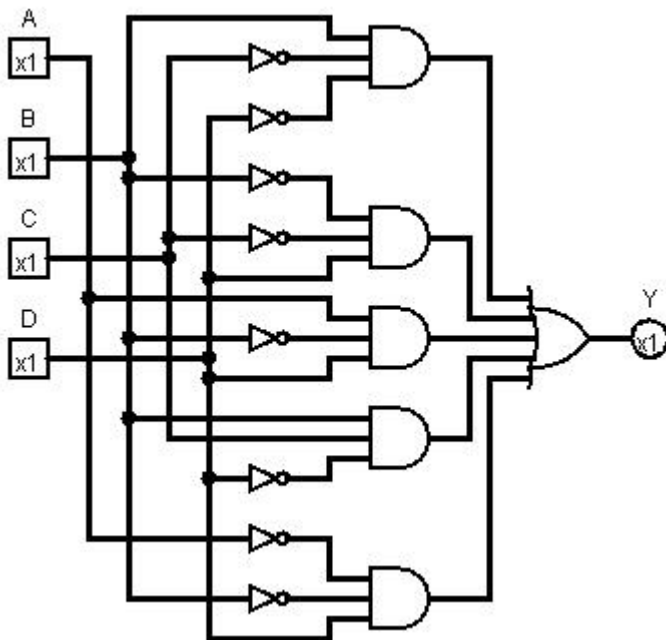
## 17 Analysis of Combinational Circuit

### 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.

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

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

Format: Sum of products

C, D

		00	01	11	10
00		0	1	1	0
01		1	0	0	1
11		1	0	0	1
10		0	1	1	0

$\bar{B}D + B\bar{D}$

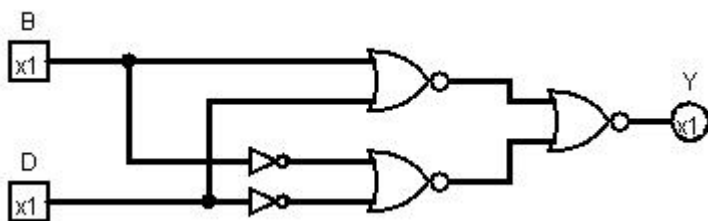
Format: Product of sums

C, D

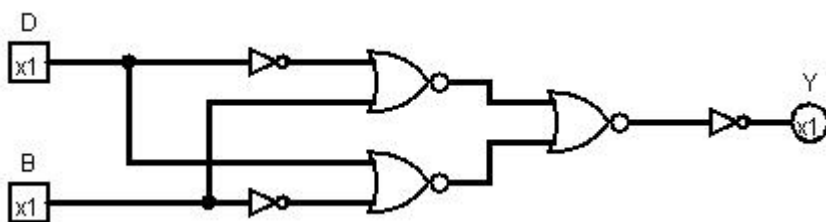
		00	01	11	10
00		0	1	1	0
01		1	0	0	1
11		1	0	0	1
10		0	1	1	0

$(B + D)(\bar{B} + \bar{D})$

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



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



## 18 Design of Combinational Circuit

### Swedish:

Designa en kombinatorisk krets för  $Y=f(Q_3, Q_2, Q_1, Q_0)$ ,  $Q_3 = \text{MSB}$  där

$Y = 1$  för 3, 4, 10, 13

$Y = x$  (don't care) för 1, 2, 5, 9, 11, 12

$Y = 0$  för alla övriga tal

1. Rita sanningstabellen.
2. Rita K-map för sanningstabellen med variabelordning som i figuren.
3. Utnyttja  $x = \text{don't care}$ . 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  $Y=f(Q_3, Q_2, Q_1, Q_0)$ ,  $Q_3 = \text{MSB}$  where

$Y = 1$  for 3, 4, 10, and 13

$Y = x$  (don't care) for 1, 2, 5, 9, 11, and 12

$Y = 0$  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  $x = \text{don't care}$ . 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	0
0	0	0	1	x
0	0	1	0	x
0	0	1	1	1
0	1	0	0	1
0	1	0	1	x
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	x
1	0	1	0	1
1	0	1	1	x
1	1	0	0	x
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

Format:

		Q1, Q0			
		00	01	11	10
Q3, Q2	00	0	x	1	x
	01	1	x	0	0
	11	x	1	0	0
	10	0	x	x	1

$\overline{Q2} \cdot Q1 + Q2 \cdot \overline{Q1}$

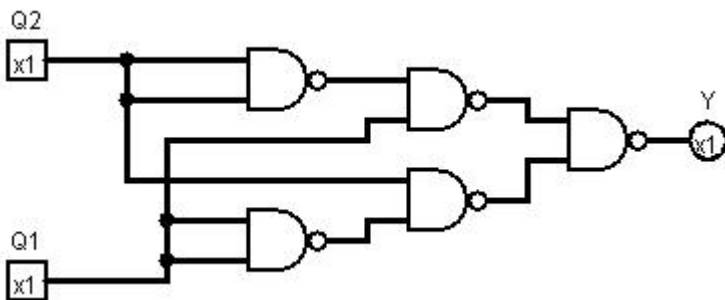
Format:

		Q1, Q0			
		00	01	11	10
Q3, Q2	00	0	x	1	x
	01	1	x	0	0
	11	x	1	0	0
	10	0	x	x	1

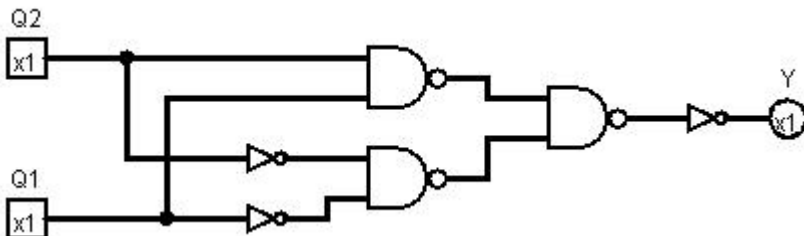
$(Q2 + Q1)(\overline{Q2} + \overline{Q1})$

**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  $Y = \overline{\overline{Q2}} \cdot Q1 + Q2 \cdot \overline{\overline{Q1}} = \overline{\overline{Q2}} \cdot Q1 \cdot \overline{\overline{Q2}} \cdot \overline{\overline{Q1}}$



For POS draw  $Y = \overline{\overline{(Q2 + Q1)}} \cdot \overline{\overline{(Q2 + Q1)}} = \overline{\overline{Q2}} \cdot \overline{\overline{Q1}} \cdot \overline{\overline{Q2}} \cdot \overline{\overline{Q1}}$



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



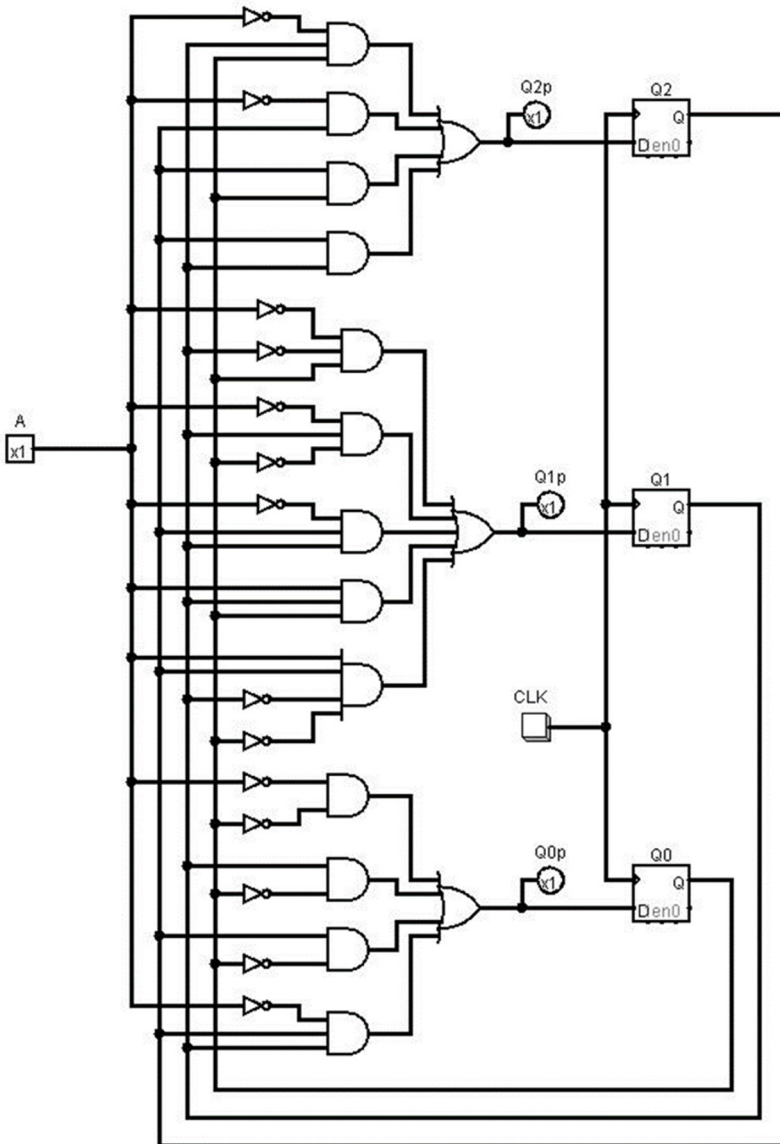
## 19 Analysis of FSM

**Swedish:** Analysera vad nedanstående tillståndsmaskin (FSM) utför.

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

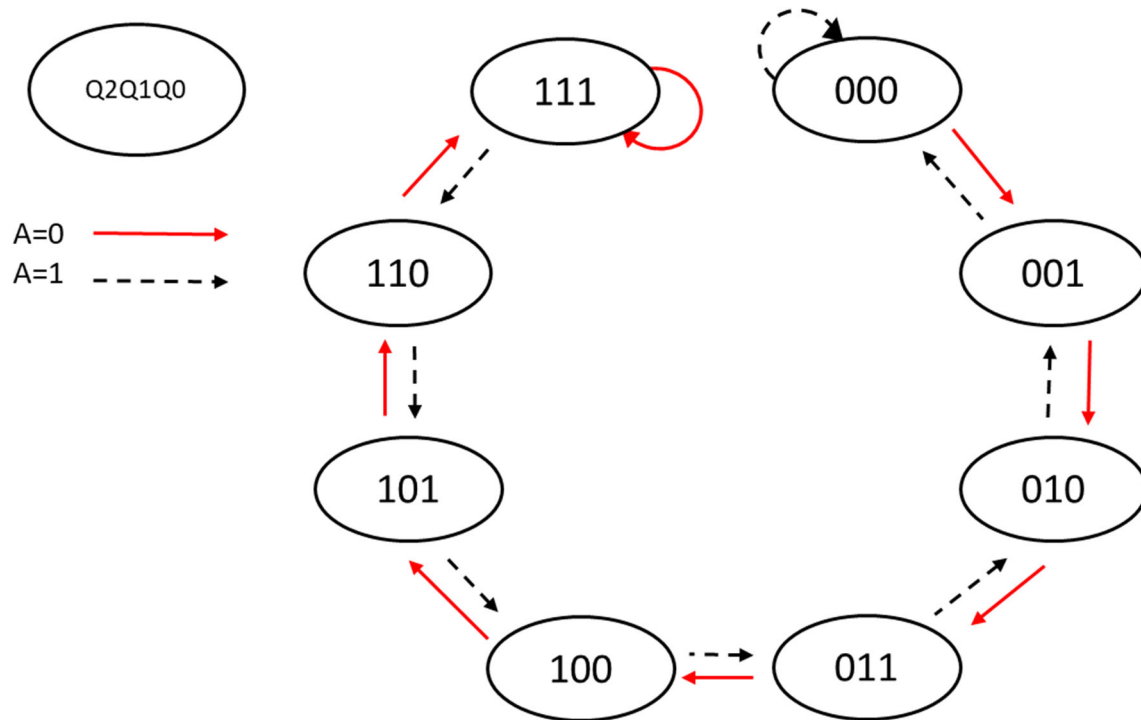
**English:** Analyze the state machine (FSM) below.

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



$$\begin{aligned}
 Q_{2+} &= \bar{A} \cdot Q_1 \cdot Q_0 + \bar{A} \cdot Q_2 + Q_2 \cdot Q_0 + Q_2 \cdot Q_1 \\
 Q_{1+} &= \bar{A} \cdot \bar{Q}_1 \cdot Q_0 + \bar{A} \cdot Q_1 \cdot \bar{Q}_0 + \bar{A} \cdot Q_2 \cdot Q_1 + A \cdot Q_1 \cdot Q_0 + A \cdot Q_2 \cdot \bar{Q}_1 \cdot \bar{Q}_0 \\
 Q_{0+} &= \bar{A} \cdot \bar{Q}_0 + Q_1 \cdot \bar{Q}_0 + Q_2 \cdot \bar{Q}_0 + \bar{A} \cdot Q_2 \cdot Q_1
 \end{aligned}$$

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



If A=0: count up and stop at 7  
 If A=1: count down and stop at 0

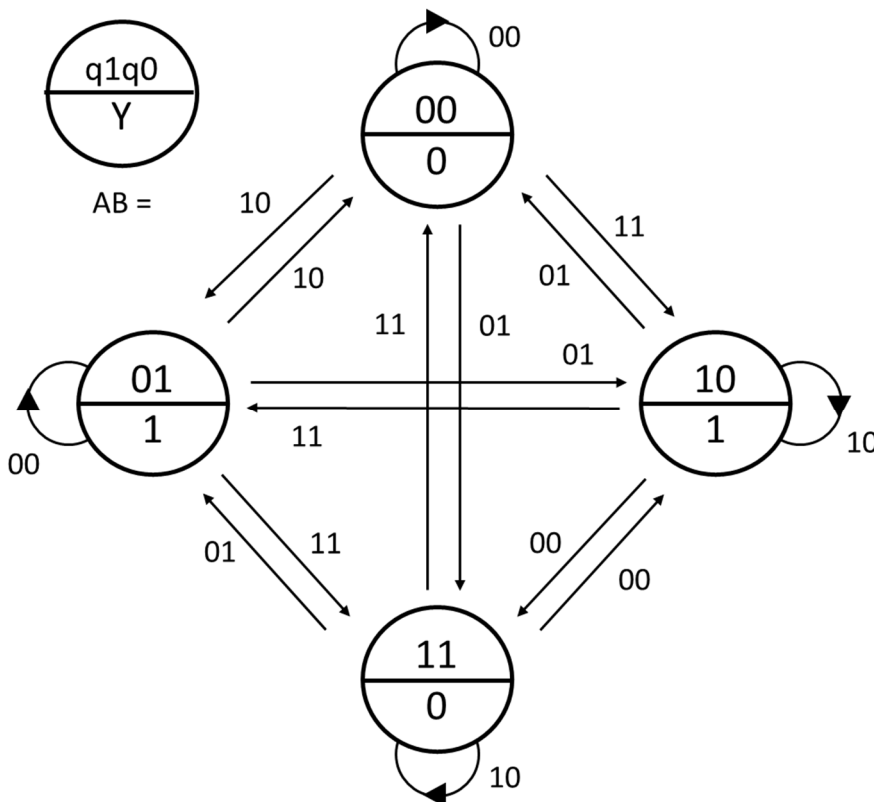
## 20 Design of FSM

**Swedish:** Konstruera en tillståndsmaskin (FSM) enligt tillståndsdigrammet 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.



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

Rita om K-map i dina inlämnade svar.

Redraw the K-map in your answer sheets.

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

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

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

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

Output:

Format:

A, B

	00	01	11	10
00	0	1	1	0
01	0	1	1	0
11	1	0	0	1
10	1	0	0	1

$\overline{Q1} B + Q1 \overline{B}$

Output:

Format:

A, B

	00	01	11	10
00	0	1	1	0
01	0	1	1	0
11	1	0	0	1
10	1	0	0	1

$(Q1 + B)(\overline{Q1} + \overline{B})$

Output:

Format:

A, B

	00	01	11	10
00	0	1	0	1
01	1	0	1	0
11	0	1	0	1
10	1	0	1	0

$\overline{Q1} \overline{Q0} \overline{A} B + \overline{Q1} \overline{Q0} A \overline{B}$   
 $+ \overline{Q1} Q0 \overline{A} \overline{B} + \overline{Q1} Q0 A B$   
 $+ Q1 \overline{Q0} \overline{A} \overline{B} + Q1 \overline{Q0} A B$   
 $+ Q1 Q0 \overline{A} B + Q1 Q0 A \overline{B}$

Output:

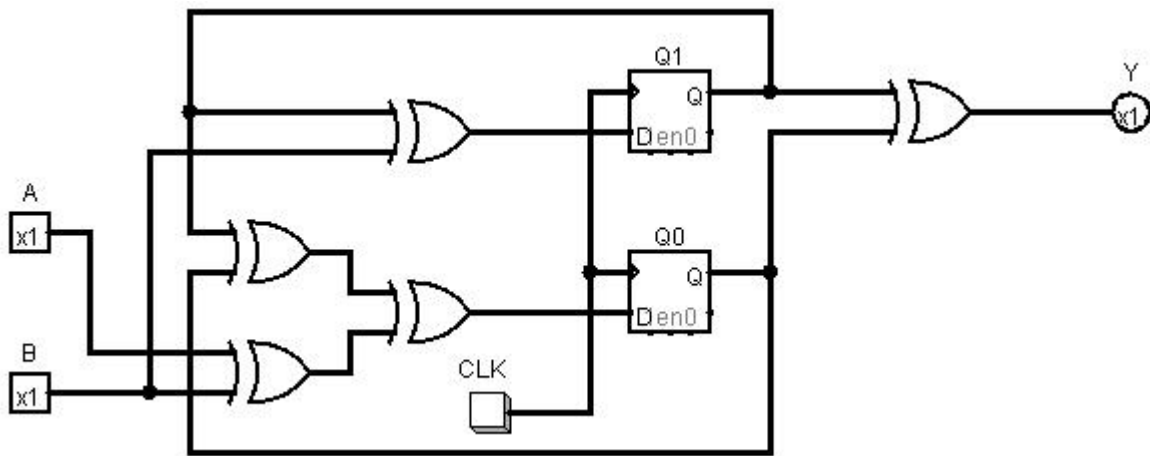
Format:

A, B

	00	01	11	10
00	0	1	0	1
01	1	0	1	0
11	0	1	0	1
10	1	0	1	0

$(Q1 + Q0 + A + B)(Q1 + Q0 + \overline{A} + \overline{B})(Q1 + \overline{Q0} + A + \overline{B})(Q1 + \overline{Q0} + \overline{A} + B)(\overline{Q1} + Q0 + A + \overline{B})(\overline{Q1} + Q0 + \overline{A} + B)(\overline{Q1} + Q0 + A + \overline{B})(\overline{Q1} + Q0 + \overline{A} + B)$

Admittedly horrible expressions for Q1+, unless you see that it is multiple XOR!  
 Continues on next page



Otherwise it is very complicated:

