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Group Number: 7

In-Class Assignment 4

ELEN 21/COEN 21 – Fall 2022
Instructor: Maria Kyrarini
Date: 11/29/2022
Time: 1 hour and 20 minutes
Number of pages: 3

Important Notes:

- Be sure to read all the problems carefully and answer all questions.
- Be sure to answer all parts of each question.
- **Submit only one answer for each question.**
- Multiple solutions for one question will not be graded.
- **Clearly show all the steps of your work.**
- **Answers without explanation will not be graded.**
- The Engineering School Honor Code applies.

$32 + 25 + 32 = 89$

Problem 1 (35 points)

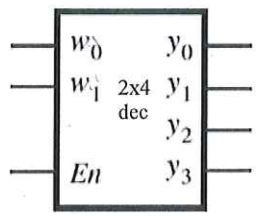
Implement the circuit that accepts two binary numbers A and B and performs the operation A^B using two 2-to-4 decoders with enable and a minimum network of OR, NOT, AND gates. The number A consists of 2 bits ($A = a_1a_0$) and B consists of 1 bit ($B = b_0$)

Reminder 1: $0^0 = 1$.

Reminder 2: Truth table and graphic symbol for 2-to-4 decoder with enable:

En	w_1	w_0	y_0	y_1	y_2	y_3
1	0	0	1	0	0	0
1	0	1	0	1	0	0
1	1	0	0	0	1	0
1	1	1	0	0	0	1
0	x	x	0	0	0	0

(a) Truth table



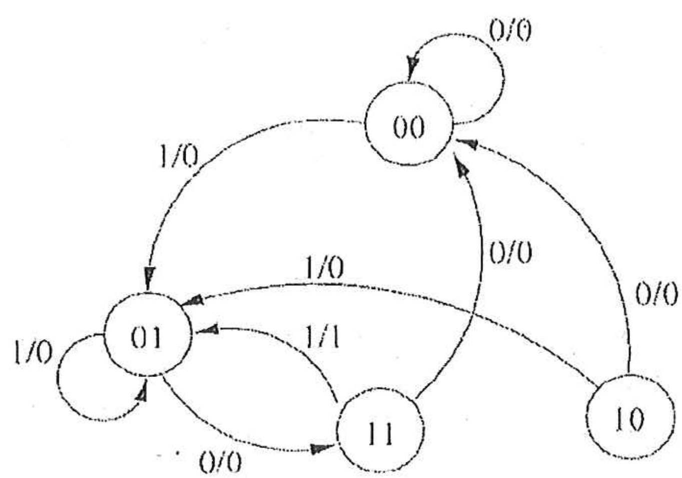
(b) Graphical symbol

Problem 2 (30 points)

A Mealy-style state machine has an input w and an output z. The machine is a sequence detector that produces z = 1 when it detects 1101; otherwise z = 0. Derive a circuit that realizes this state machine using one-hot encoding approach, T flip-flops and a network of AND-OR-NOT gates. **Note:** You do not need to draw the circuit – Show the Boolean expressions for the simplified circuit.

Problem 3 (35 points)

Consider the following state diagram for a circuit with one input X and one output Z. Draw the circuit implementation of this state diagram using JK positive-edge flip-flop (state Q_0), T positive-edge flip-flop (state Q_1), and a minimal AND-OR-NOT-XOR network. The states are in the form Q_1Q_0.



Boolean Algebra Properties

5*a*.	$x \cdot 0 = 0$	10*a*.	$x \cdot y = y \cdot x$	*Commutative*
5*b*.	$x + 1 = 1$	10*b*.	$x + y = y + x$	
6*a*.	$x \cdot 1 = x$	11*a*.	$x \cdot (y \cdot z) = (x \cdot y) \cdot z$	*Associative*
6*b*.	$x + 0 = x$	11*b*.	$x + (y + z) = (x + y) + z$	
7*a*.	$x \cdot x = x$	12*a*.	$x \cdot (y + z) = x \cdot y + x \cdot z$	*Distributive*
7*b*.	$x + x = x$	12*b*.	$x + y \cdot z = (x + y) \cdot (x + z)$	
8*a*.	$x \cdot \overline{x} = 0$	13*a*.	$x + x \cdot y = x$	*Absorption*
8*b*.	$x + \overline{x} = 1$	13*b*.	$x \cdot (x + y) = x$	
9.	$\overline{\overline{x}} = x$	14*a*.	$x \cdot y + x \cdot \overline{y} = x$	*Combining*
		14*b*.	$(x + y) \cdot (x + \overline{y}) = x$	
		15*a*.	$\overline{x \cdot y} = \overline{x} + \overline{y}$	*DeMorgan's theorem*
		15*b*.	$\overline{x + y} = \overline{x} \cdot \overline{y}$	
		16*a*.	$x + \overline{x} \cdot y = x + y$	
		16*b*.	$x \cdot (\overline{x} + y) = x \cdot y$	
		17*a*.	$x \cdot y + y \cdot z + \overline{x} \cdot z = x \cdot y + \overline{x} \cdot z$	*Consensus*
		17*b*.	$(x + y) \cdot (y + z) \cdot (\overline{x} + z) = (x + y) \cdot (\overline{x} + z)$	

In-class Assignment - Group 7

1. 2-to-4 decoder Behavior:

$y_0 = En\ \overline{W_1}\ \overline{W_0}$

$y_1 = En\ \overline{W_1}\ W_0$

$y_2 = En\ W_1\ \overline{W_0}$

$y_3 = En\ W_1\ W_0$

A^B Expr	Inputs a_1	a_0	b_0	Outputs X_3	X_2	X_1	X_0
$0^0 = 1$	0	0	0	0	0	0	1
$0^1 = 0$	0	0	1	0	0	0	0
$1^0 = 1$	0	1	0	0	0	0	1
$1^1 = 1$	0	1	1	0	0	0	1
$2^0 = 1$	1	0	0	0	0	0	1
$2^1 = 2$	1	0	1	0	0	1	0
$3^0 = 1$	1	1	0	0	0	0	1
$3^1 = 3$	1	1	1	0	0	1	1

By observation: $X_3 = 0$ & $X_2 = 0$

X_1 K-map:

b_0 \ $a_1 a_0$	00	01	11	10
0	0	0	0	0
1	0	0	1	1

$X_1 = a_1 b_0$

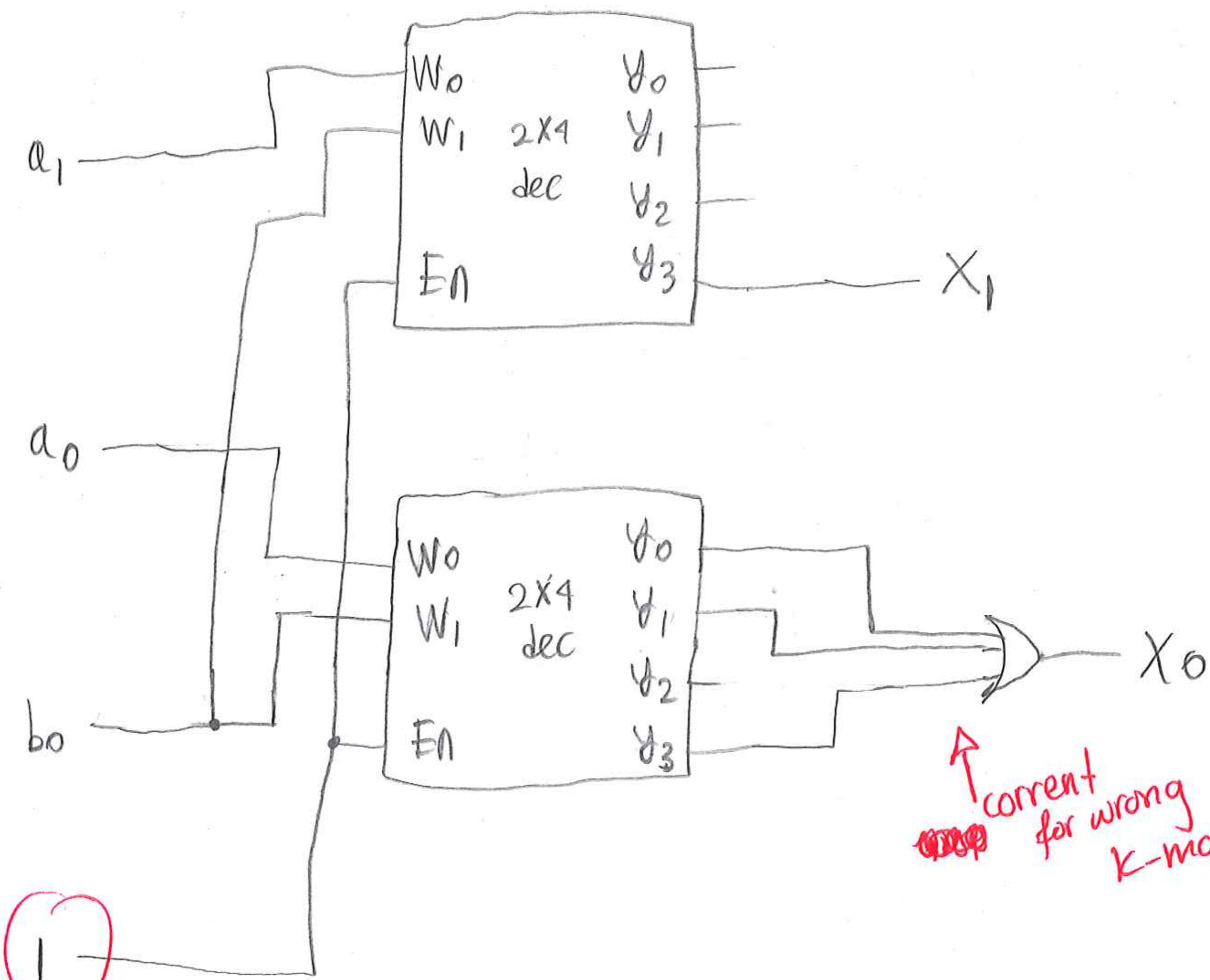
X_0 K-map:

b_0 \ $a_1 a_0$	00	01	11	10
0	1	1	1	1
1	0	1	1	0

Renew k-maps!

$X_0 = \overline{b_0} + a_0 \cancel{b_0}$

Question 1 cont.



correct for wrong k-map

1 not available as input

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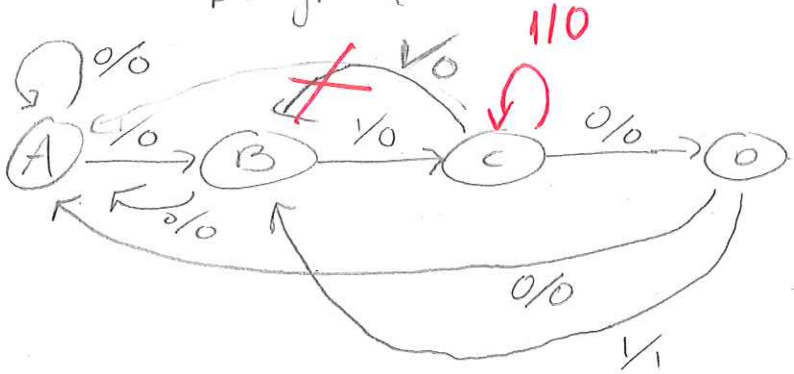
(2) State Diagram



when the state machine is in state "C" it has seen 11. So if it sees one more 1, then it should remain in "C".

State Assignment Table

	$Q_3Q_2Q_1Q_0$	w = 0	w = 1	Z w = 0	Z w = 1
A)	1000	1000	0100	0	0
B)	0100	1000	0010	0	0
C)	0010	0001	$0\overset{01}{\cancel{10}}0$	0	0
	0001	1000	0100	0	1

	$Q_3Q_2Q_1Q_0$	Next state	T_3	T_2	T_1	T_0
	1000	1000	0	0	0	0
	0100	1000	1	1	0	0
w = 0	0010	0001	0	0	1	1
	0001	1000	1	0	0	1
	1000	0100	1	1	0	0
	0100	0010	0	1	1	0
w = 1	0010	$0\overset{01}{\cancel{10}}0$	0	$\overset{0}{\cancel{1}}$	$\overset{0}{\cancel{1}}$	0
	0001	0100	0	1	0	1

$$T_3 = (Q_2 + Q_0)\cdot\overline{w} + (Q_3 + Q_1)\cdot w \quad \cancel{= (Q_2 + Q_0) \oplus w}$$

$$T_2 = Q_2 \cdot \overline{w} + [illegible] \cdot w$$

$$T_1 = Q_1 + w \cdot Q_2$$

$$T_0 = Q_0 + \overline{w} \cdot Q_1$$

$$Z = Q_0 \cdot w$$

correct for wrong state machine

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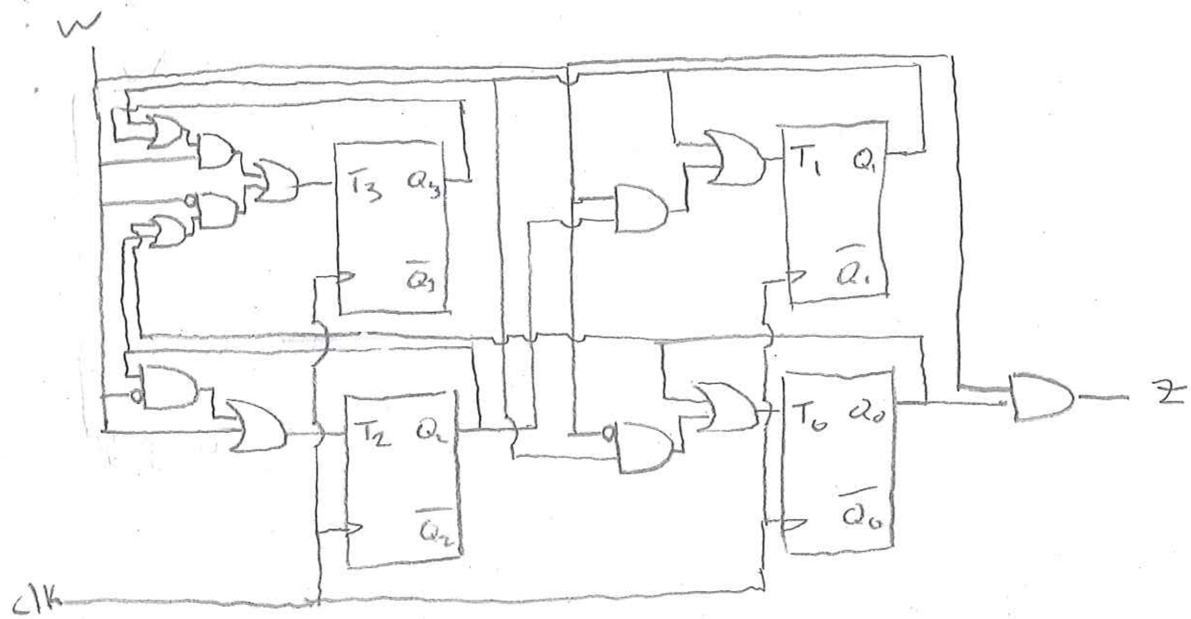
Circuit



W
T3 Q3
$\overline{Q_3}$
T2 Q2
$\overline{Q_2}$
T1 Q1
$\overline{Q_1}$
T0 Q0
$\overline{Q_0}$
Z
clk

(3)

present		input	next		output			
q_1	q_0	x	Q_1	Q_0	z	T_1	J_0	K_0
0	0	0	0	0	0	0	0	d
0	0	1	0	1	0	0	1	d
0	1	0	1	1	0	1	d	0
0	1	1	0	1	0	0	d	0
1	0	0	0	0	0	1	0	d
1	0	1	0	1	0	1	1	d
1	1	0	0	0	0	1	d	1
1	1	1	0	1	1	1	d	0

q_0	Q_0	J	K
0	0	0	d
0	1	1	d
1	0	d	1
1	1	d	0

q_1	Q_1	T_1
0	0	0
0	1	1
1	0	1
1	1	0

x \ q_1q_0	00	01	11	10
0	0	1	1	1
1	0	0	1	1

$T_1 = \bar{x} q_0 + q_1$ ✓

x \ q_1q_0	00	01	11	10
0	0	d	d	0
1	1	d	d	1

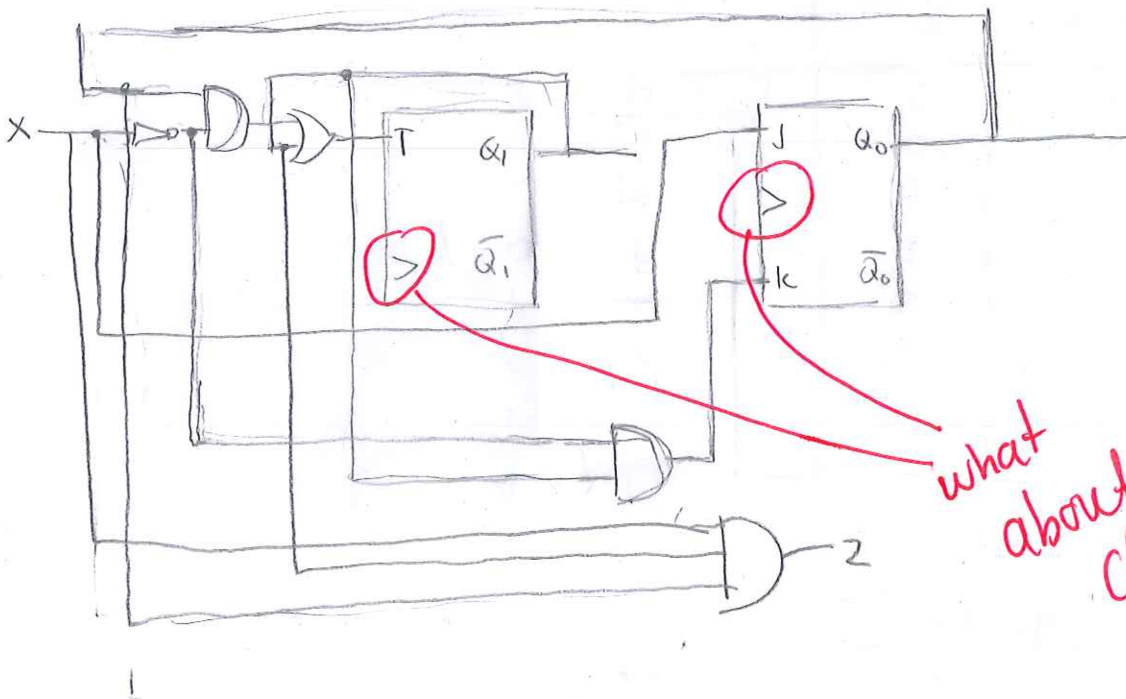
$J_0 = x$ ✓

x \ q_1q_0	00	01	11	10
0	d	0	1	d
1	d	0	0	d

$K_0 = \bar{x} q_1$ ✓

x \ q_1q_0	00	01	11	10
0	0	0	0	0
1	0	0	1	0

$z = x q_1 q_0$ ✓



what about the clock?

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2

$T_1 = \bar{x} q_0 + q_1$

$J_0 = x$

$K_0 = \bar{x} q_1$

$2 = x q_1 q_0$