CPCS-211

Digital Logic Design (10%)

Xerox machine

CS3 - Dr. Asaad Ahmed – CPCS-211

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Table of content

Input specification

- On/Off switch.
- 32-bit password inputted as 8 decimal numbers.
- Inputting 1 or 2 for both printing properties.
- Number of copies wanted.

Determination of System components

- (4) 1-bit input switches.
- (9) 4-bit 7-segment encoders.
- (8) 4-bit 7-segment decoders.
- (9) 4-bit comparators.
- (2) 2x1 multiplexer.
- (2) 1x2 demultiplexer.
- (3) JK flip flops.
- (1) Clock.
- 4x4 bit multiplier.
- Costume 2-digit 7-segment display encoders.

Determination of truth tables, state/characteristic tables, characteristic equations

4-bit 7-segment encoder

Truth table

N	a	b	c	d	e	f	g	b3	b2	b1	b0
0	1	1	1	1	1	1	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	1
2	1	1	0	1	1	0	1	0	0	1	0
3	1	1	1	1	0	0	1	0	0	1	1
4	0	1	1	0	0	1	1	0	1	0	0
5	1	0	1	1	0	1	1	0	1	0	1
6	1	0	1	1	1	1	1	0	1	1	0
7	1	1	1	0	0	0	0	0	1	1	1
8	1	1	1	1	1	1	1	1	0	0	0
9	1	1	1	1	0	1	1	1	0	0	1
10	x	x	x	x	x	x	x	x	x	x	x
11	x	x	x	x	x	x	x	x	x	x	x
12	x	x	x	x	x	x	x	x	x	x	x
13	x	x	x	x	x	x	x	x	x	x	x
14	x	x	x	x	x	x	x	x	x	x	x
15	x	x	x	x	x	x	x	x	x	x	x

4-bit 7-segment decoders

Truth table

N	b3	b2	b1	b0	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1
10	x	x	x	x	x	x	x	x	x	x	x
11	x	x	x	x	x	x	x	x	x	x	x
12	x	x	x	x	x	x	x	x	x	x	x
13	x	x	x	x	x	x	x	x	x	x	x
14	x	x	x	x	x	x	x	x	x	x	x
15	x	x	x	x	x	x	x	x	x	x	x

4-bit comparator

Truth table

A1	A0	B1	B0	A > B	A = B	A < B
0	0	0	0	0	1	0
0	0	0	1	0	0	1
0	0	1	0	0	0	1
0	0	1	1	0	0	1
0	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	1
1	0	0	0	1	0	0
1	0	0	1	1	0	0
1	0	1	0	0	1	0
1	0	1	1	0	0	1
1	1	0	0	1	0	0
1	1	0	1	1	0	0
1	1	1	0	1	0	0
1	1	1	1	0	1	0

The truth should be for 4x4 comparator bit but doing that table will take 256 rows so I will do the truth table of 2x2 bit comparator.

K-maps

A>B	00	01	11	10
00	0	0	0	0
01	1	0	0	0
11	1	1	0	1
10	1	1	0	0

A>B = A1B1’ + A0B1’B0’ + A1A0B0’

A=B	00	01	11	10
00	1	0	0	0
01	0	1	0	0
11	0	0	1	0
10	0	0	0	1

A=B = (A1 (+) B1) (A0 (+) B0)

A<B	00	01	11	10
00	0	1	1	1
01	0	0	1	1
11	0	0	0	0
10	0	0	1	0

A<B = A1’B1 + A1’A0’B0 + A0’B1B0

2x1 multiplexer

Truth table

S	Y
0	I_0
1	I_1

1x2 demultiplexer

Truth table

S	Y0	Y1
0	1	0
1	0	1

JK flip flop

Truth table

ClK	J	K	Qn+1
0	x	x	Qn
1	0	0	Qn
1	0	1	0
1	1	0	1
1	1	1	Qn’

Characteristic table

Qn	J	K	Qn+1
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Excitation table

Qn	Qn+1	J	K
0	0	0	X
0	1	1	x
1	0	X	1
1	1	x	0

K-maps

J	0	1
0	0	1
1	x	x

J = Qn+1

K	0	1
0	x	x
1	1	0

K = Qn’+1

Qn+1	00	01	11	10
0	0	0	1	1
1	1	0	0	1

Qn+1 = Qn’J + QnK’

4x4 bit multiplier

Is not included in the lectures but I used it.

Costume 2-digit 7-segment display encoders

Truth table

Hex	A	B	C	D	d1	a1	b1	c1	d1	e1	f1	g1	d2	a2	b2	c2	d2	e2	f2	g2	N
00	0	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	00
01	0	0	0	1	0	1	1	1	1	1	1	0	1	0	1	1	0	0	0	0	01
02	0	0	1	0	0	1	1	1	1	1	1	0	2	1	1	0	1	1	0	1	02
03	0	0	1	1	0	1	1	1	1	1	1	0	3	1	1	1	1	0	0	1	03
04	0	1	0	0	0	1	1	1	1	1	1	0	4	0	1	1	0	0	1	1	04
05	0	1	0	1	0	1	1	1	1	1	1	0	5	1	0	1	1	0	1	1	05
06	0	1	1	0	0	1	1	1	1	1	1	0	6	1	0	1	1	1	1	1	06
07	0	1	1	1	0	1	1	1	1	1	1	0	7	1	1	1	0	0	0	0	07
08	1	0	0	0	0	1	1	1	1	1	1	0	8	1	1	1	1	1	1	1	08
09	1	0	0	1	0	1	1	1	1	1	1	0	9	1	1	1	1	0	1	1	09
10	1	0	1	0	1	0	1	1	0	0	0	0	0	1	1	1	1	1	1	0	10
11	1	0	1	1	1	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	11
12	1	1	0	0	1	0	1	1	0	0	0	0	2	1	1	0	1	1	0	1	12
13	1	1	0	1	1	0	1	1	0	0	0	0	3	1	1	1	1	0	0	1	13
14	1	1	1	0	1	0	1	1	0	0	0	0	4	0	1	1	0	0	1	1	14
15	1	1	1	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15

K-maps

a1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	0	x	0
10	1	1	0	0

a1 = A’ + AB’C’

b1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	x	1
10	1	1	1	1

b1 = A’ + A

c1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	x	1
10	1	1	1	1

c1 = A’ + A

d1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	0	x	0
10	1	1	0	0

d1 = A’ + AB’C’

e1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	0	x	0
10	1	1	0	0

e1 = A’ + AB’C’

f1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	0	x	0
10	1	1	0	0

f1 = A’ + AB’C’

g1	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	0	0	x	0
10	0	0	0	0

g1 = 0

a2	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	1	1	x	0
10	1	1	0	1

a2 = AC’ + A’C + BD + B’D’

b2	00	01	11	10
00	1	1	1	1
01	1	0	1	0
11	1	1	x	1
10	1	1	1	1

b2 = A’B’ + A + C’D’ + CD

c2	00	01	11	10
00	1	1	1	0
01	1	1	1	1
11	0	1	x	1
10	1	1	1	1

c2 = A’C’ + CD + A’B + AB’ + BC + AD

d2	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	1	1	x	0
10	1	1	0	1

d2 = A’B’C + AC’ + BC’D + A’CD’ + B’D’

e2	00	01	11	10
00	1	0	0	1
01	0	0	0	1
11	1	0	x	0
10	1	0	0	1

e2 = AC’D’ + A’CD’ + B’D’

f2	00	01	11	10
00	1	0	0	0
01	1	1	0	1
11	0	0	x	1
10	1	1	0	1

f2 = A’C’D’ + AB’C’ + BCD’ +A’BC’ + AB’D’

g2	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	1	1	x	1
10	1	1	0	0

g2 = BC’ +A’B’C + BCD’ +AC’

Implementation of state diagrams, time tracing, timing diagrams

Implementation for the 3-bit KJ flip flop counter

State table

A	B	C	A*	B*	C*	J_A	K_A	J_B	K_B	J_C	K_C
0	0	0	0	0	1	0	x	0	x	1	x
0	0	1	0	1	0	0	x	1	x	x	1
0	1	0	0	1	1	0	x	x	0	1	x
0	1	1	1	0	0	1	x	x	1	x	1
1	0	0	1	0	1	x	0	0	x	1	x
1	0	1	1	1	0	x	0	1	x	x	1
1	1	0	1	1	1	x	0	x	0	1	x
1	1	1	0	0	0	x	1	x	1	x	1

K-maps

J_A	00	01	11	10
0	0	0	1	0
1	x	x	x	x

J_A = BC

K_A	00	01	11	10
0	x	x	x	X
1	0	0	1	0

K_A = BC

J_B	00	01	11	10
0	0	1	x	x
1	0	1	x	x

J_B = C

K_B	00	01	11	10
0	x	x	1	0
1	x	x	1	0

K_B = C

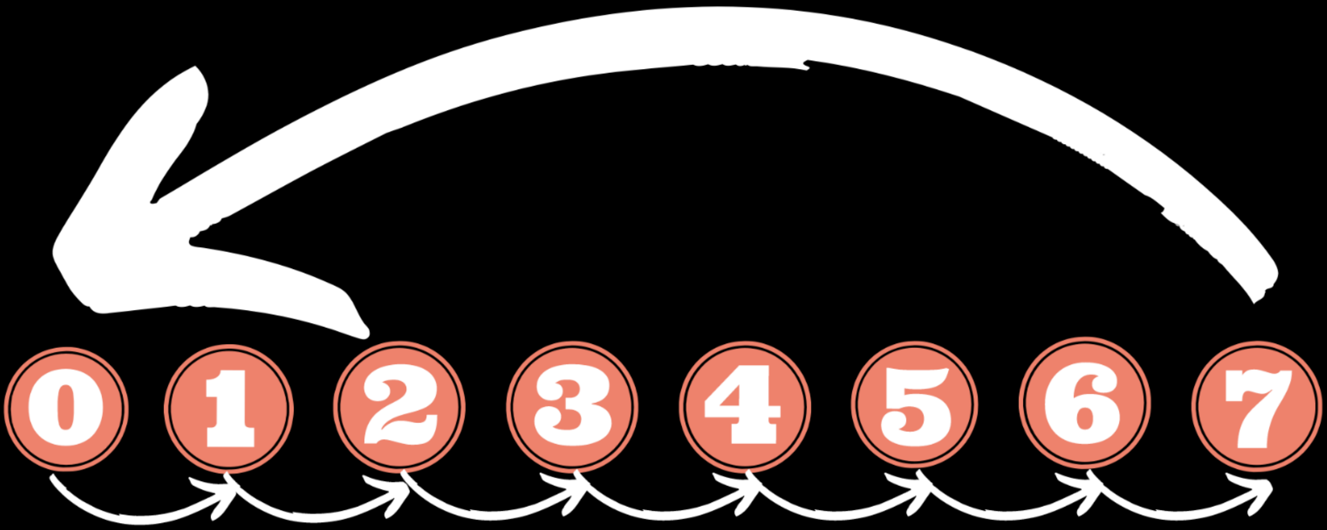
J_C	00	01	11	10
0	1	x	x	1
1	1	x	x	1

J_C = 1

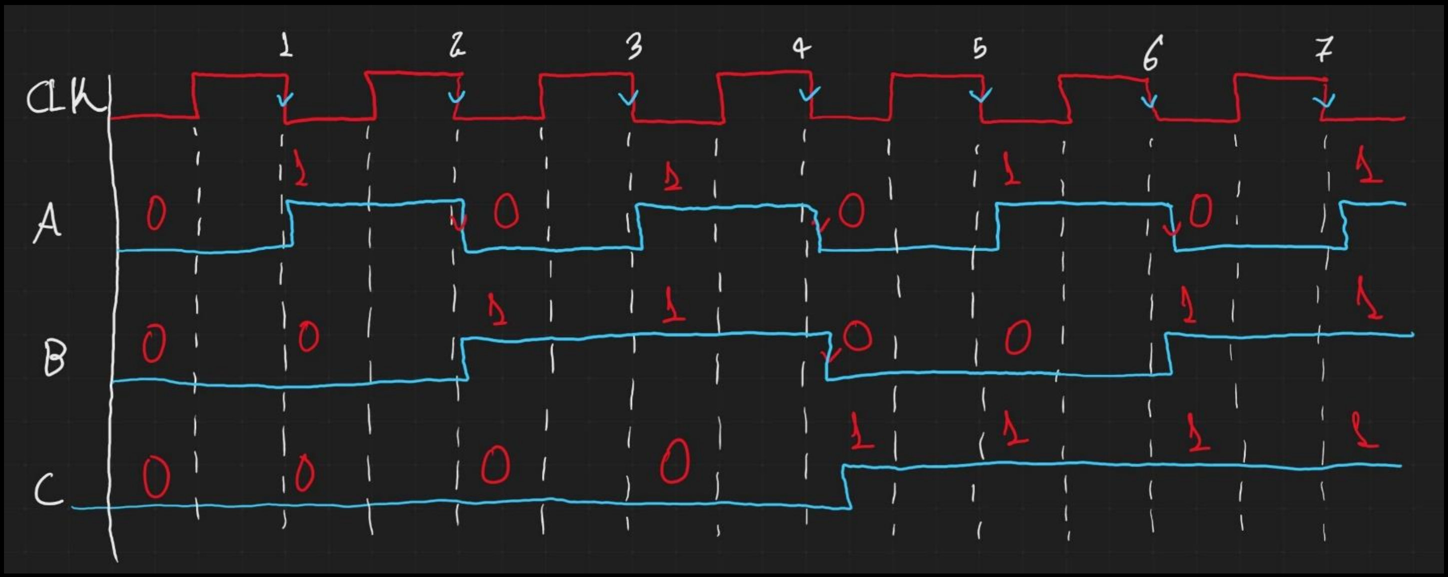
k_C	00	01	11	10
0	x	1	1	x
1	x	1	1	x

K_C = 1

State diagram



Time trace



Timing table

Clock	C	B	A	Decimal Eq
Initially	0	0	0	0
1	0	0	1	1
2	0	1	0	2
3	0	1	1	3
4	1	0	0	4
5	1	0	1	5
6	1	1	0	6
7	1	1	1	7

Output Specification

- LED lamps
- (8) 4-bit 7-segment decoders.
- Costume 2-digit 7-segment display encoders.

CONCLUSION

From this project I learnt a lot about combinational and sequential circuits and how to implement what I studies in real life. I will harness that new experience to something great In Shaa Allah.

Extra: there might be malfunction in the 2-digit 7-segment display and due to the shortage of time I was not unable to fix it so sorry for that. 😊

References

- https://youtu.be/s1DSZEaCX_g (Neso Academy)