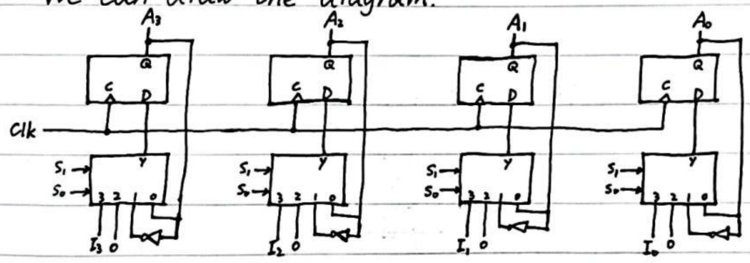
Assignment 4

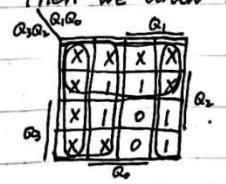
1. We need 4 DFF, suppose they're A_3、A_2、A_1、A_0.
   Analyze the 4×1 mux connected to A_3 as an example.
   When $S_1S_0 = 00$, means no change, so A_3 should connect to port 0.
   Similarly, $S_1S_0 = 01$, A_3' should be input into port 1.
   $S_1S_0 = 10$, 0 should be input of port 2.
   And $S_1S_0 = 11$, means parallel input, I_3 should connect to 3.
   We can draw the diagram.



2. length(1011110) = 7 ≤ 2^3-1, we should use at least 3 FF (choose DFF for easy). But in first 3 DFF, there're repeat state, so we add one DFF.

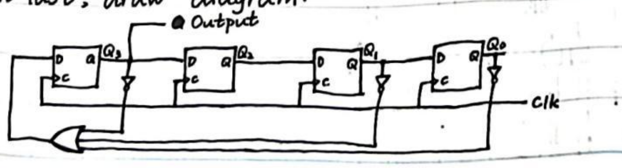
Clk	Z	Q_3	Q_2	Q_1	Q_0
↑	0	1	0	1	1
↑	1	0	1	0	1
↑	1	1	0	1	0
↑	1	1	1	0	1
↑	1	1	1	1	0
↑	0	1	1	1	1
↑	1	0	1	1	1

Then we draw K-map of Z:



$Z = Q_3' + Q_0' + Q_1'$

At last, draw diagram:



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3、Use 4 DFF to design. The state table is as follow.

Present State				Next State (DFF input)			
A	B	C	D	A (D_A)	B (D_B)	C (D_C)	D (D_D)
0	0	0	0	0	0	1	0
0	0	0	1	0	0	1	0
0	0	1	0	0	1	1	0
0	0	1	1	0	0	1	0
0	1	0	0	0	0	1	0
0	1	0	1	0	0	1	0
0	1	1	0	1	0	0	1
0	1	1	1	0	0	1	0
1	0	0	0	1	1	0	0
1	0	0	1	1	0	0	0
1	0	1	0	0	0	1	0
1	0	1	1	0	0	1	0
1	1	0	0	1	1	0	1
1	1	0	1	0	0	1	0
1	1	1	0	0	0	1	0
1	1	1	1	0	0	1	0

Use K-map get 4 DFFs' input equation:

D_A: AB\CD

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

D_B: AB\CD

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

$D_A = AC'D' + AB'C' + A'BCD'$

$D_B = AC'D' + A'B'CD'$

D_C: AB\CD

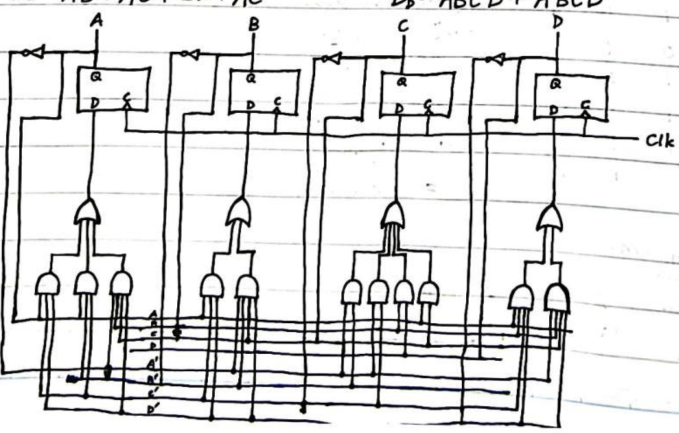
1	1	1	1
1	1	1	0
0	1	1	1
0	0	1	1

D_D: AB\CD

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

$D_C = A'B' + A'C' + BD + AC$

$D_D = ABC'D' + A'BCD'$



But we can also use only 3 DFFs to do the design.

Suppose 8 states: 000 (output 0010), 001 (output 0110), 010 (output 1001), 011 (output 1000), 100 (output 1100), 101 (output 1101), 110 (output don't care), 111 (output don't care). State 110、111 must go to state 000.

Present State			Next State (DFF input)			Output			
L	M	N	D_L	D_M	D_N	A	B	C	D
0	0	0	0	0	1	0	0	1	0
0	0	1	0	1	0	0	1	1	0
0	1	0	0	1	1	1	0	0	1
0	1	1	1	0	0	1	0	0	0
1	0	0	1	0	1	1	1	0	0
1	0	1	0	0	0	1	1	0	1
1	1	0	0	0	0	X	X	X	X
1	1	1	0	0	0	X	X	X	X

Use K-map to get DFFs' input equation and output combination logic.

$D_L = L'MN + LM'N$ $\quad D_M = L'MN' + L'M'N$ $\quad D_N = M'N' + L'N'$

A:

L \ MN	00	01	11	10
0	0	0	1	1
1	1	1	X	X

B:

L \ MN	00	01	11	10
0	0	1	0	0
1	1	1	X	X

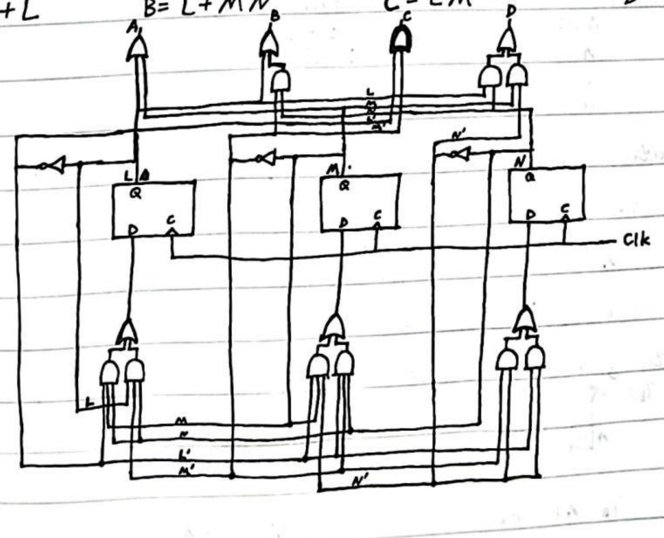
C:

L \ MN	00	01	11	10
0	1	1	0	0
1	0	0	X	X

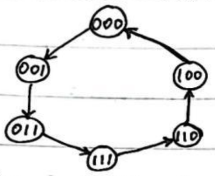
D:

L \ MN	00	01	11	10
0	0	0	0	1
1	0	1	X	X

$A = M + L$ $\quad B = L + M'N$ $\quad C = L'M'$ $\quad D = LN + MN'$



4、 The state machine like below.



Use 3 TFFs to design (suppose they're A、B、C)

Present State A	B	C	Next State A	B	C	TFF input T_A	T_B	T_C
0	0	0	0	0	1	0	0	1
0	0	1	0	1	1	0	1	0
0	1	0	X	X	X	X	X	X
0	1	1	1	1	1	1	0	0
1	0	0	0	0	0	1	0	0
1	0	1	X	X	X	X	X	X
1	1	0	1	0	0	0	1	0
1	1	1	1	1	0	0	0	1

T_A: (A\BC; B over the last two columns, C over the middle two)

	0	0	1	X
A	1	X	0	0

T_B: (A\BC; B over the last two columns, C over the middle two)

	0	1	0	X
A	0	X	0	1

T_C: (A\BC; B over the last two columns, C over the middle two)

	1	0	0	X
A	0	X	1	0

$T_A = A'B + AB'$ $T_B = B'C + BC'$ $T_C = AC + A'C'$

Then, the 'X' in state table is like this.

Present State A	B	C	Next State A	B	C	TFF input T_A	T_B	T_C
0	1	0	1	0	1	1	1	1
1	0	1	0	1	0	1	1	1

The extra 2 states will occur a lock out, so we correct the design by make 010 and 101 next state to 000.

Present State A	B	C	Next State A	B	C	TFF input T_A	T_B	T_C
0	1	0	0	0	0	0	1	0
1	0	1	0	0	0	1	0	1

Then used K-map to get input equations after correct the design.

T_A:

	0	0	1	0
A	1	1	0	0

T_B:

	0	1	0	1
A	0	0	0	1

T_C:

	1	0	0	0
A	0	1	1	0

$T_A = AB' + A'BC$ $T_B = A'B'C + BC'$ $T_C = A'B'C' + AC$

The block diagram: