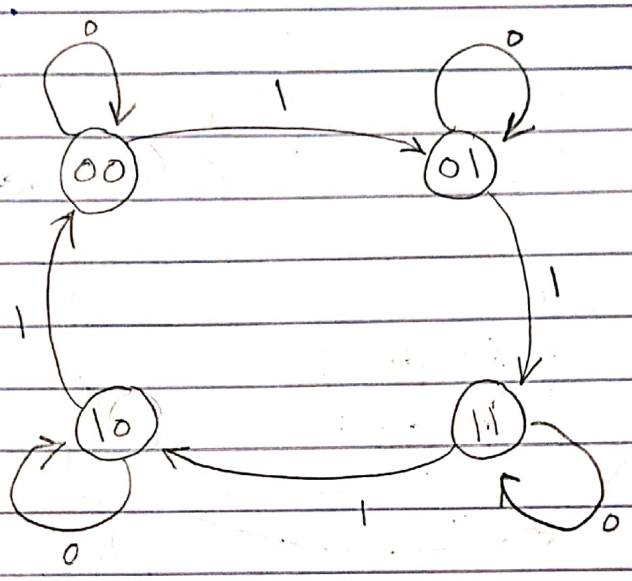
Exercise Seven

5.16 Design a sequential circuit with two D-FF A and B, and one input-x.

(a) When x_in = 0, the state of the circuit remains the same. When x_in = 1, the circuit goes through the state transitions from 00 → 01 → 11 → 10 back to 00, and repeats.

1- State diagram



2- State and assignment table

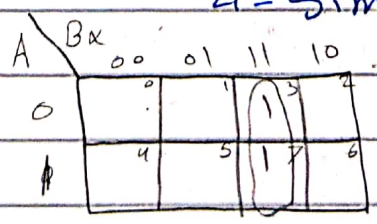
P.S	N.S x=0	N.S x=1
00	00	01
01	00	11
10	00	00
11	00	10

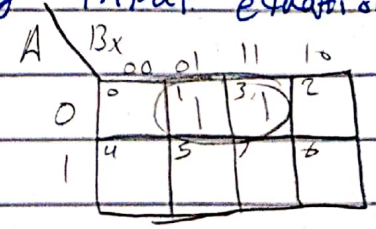
P.S A	P.S B	input x	N.S A	N.S B	D_A	D_B
0	0	0	0	0	0	0
0	0	1	0	1	0	1
0	1	0	0	0	0	0
0	1	1	1	1	1	1
1	0	0	0	0	0	0
1	0	1	0	0	0	0
1	1	0	0	0	0	0
1	1	1	1	0	1	0

3- D-FF Excitation table

Q	Q(t+1)	D
0	0	0
0	1	1
1	0	0
1	1	1

4- Simplified input equations

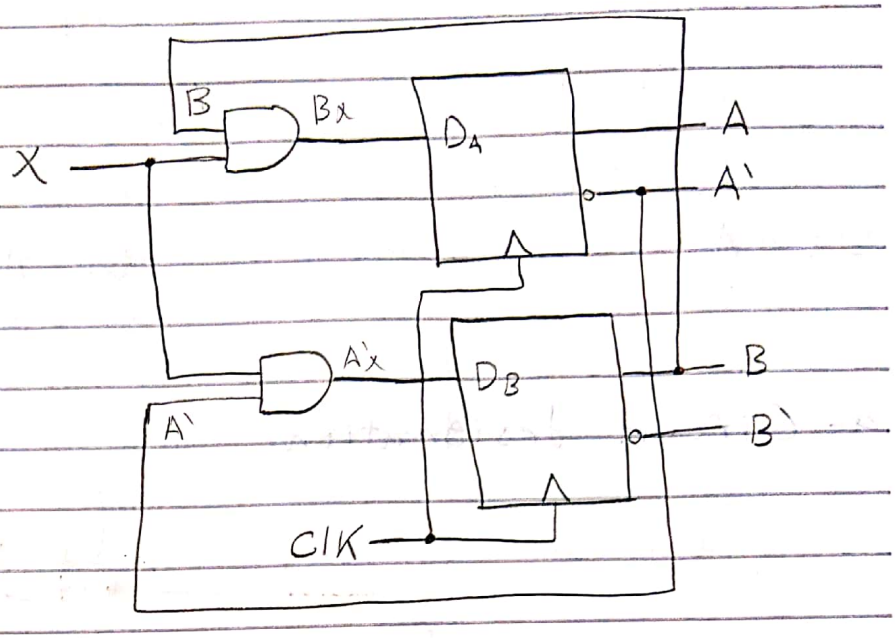




$D_A = Bx$

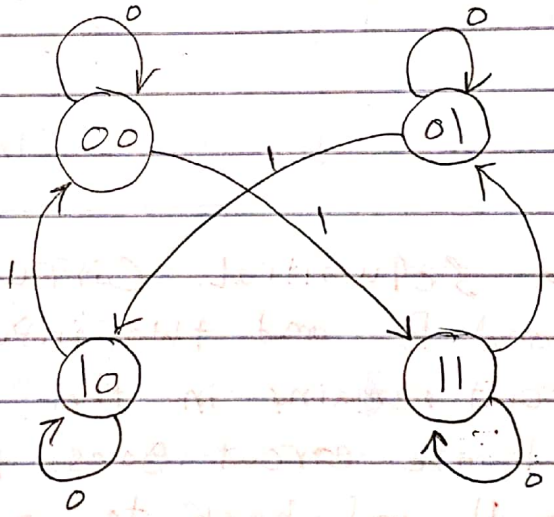
$D_B = A'x$

5- The Design



(B) When x_in = 0, the state remains the same and When x_in = 1, the circuit goes through the state transitions from 00 → 11 → 01 → 10, back to 00 ....

1- State diagram



2- State table

P.S	N.S	
	X=0	X=1
00	00	11
01	00	10
10	00	00
11	00	01

P.S		input	N.S			
A	B	X	A	B	D_A	D_B
0	0	0	0	0	0	0
0	0	1	1	1	1	1
0	1	0	0	0	0	0
0	1	1	1	0	1	0
1	0	0	0	0	0	0
1	0	1	0	0	0	0
1	1	0	0	0	0	0
1	1	1	0	1	0	1

3- Simplified input equations

$D_A = \Sigma m(1,3)$

A \ Bx	00	01	11	10
0	0	1	3	2
1	4	5	7	6

$D_A = A'x$

$D_B = \Sigma m(1,7)$

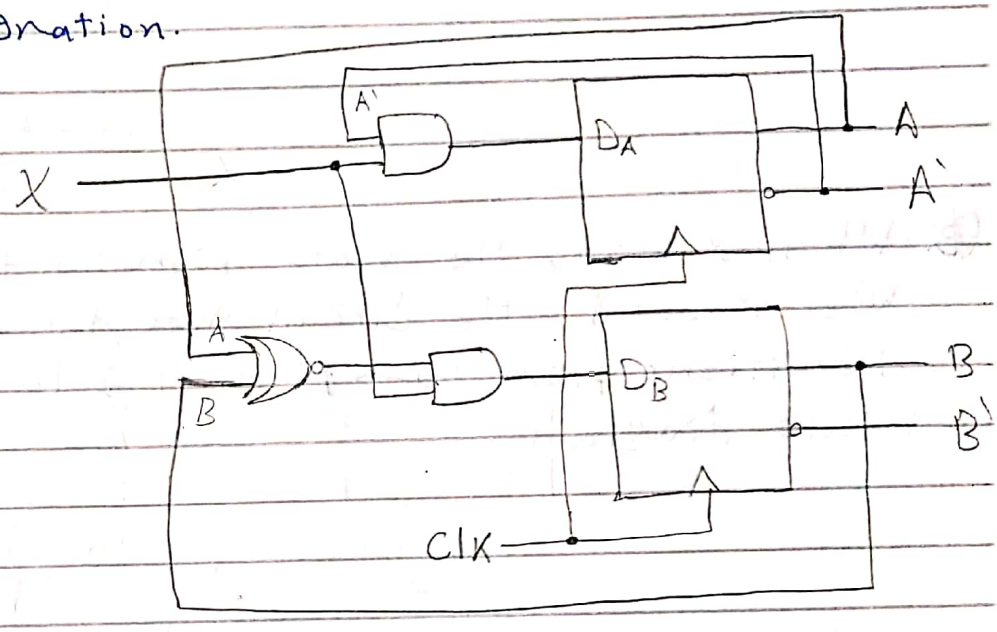
A \ Bx	00	01	11	10
0	0	1	3	2
1	4	5	7	6

$D_B = A'B'x + ABx$

$= x(A'B' + AB)$

$= x(A \oplus B)'$

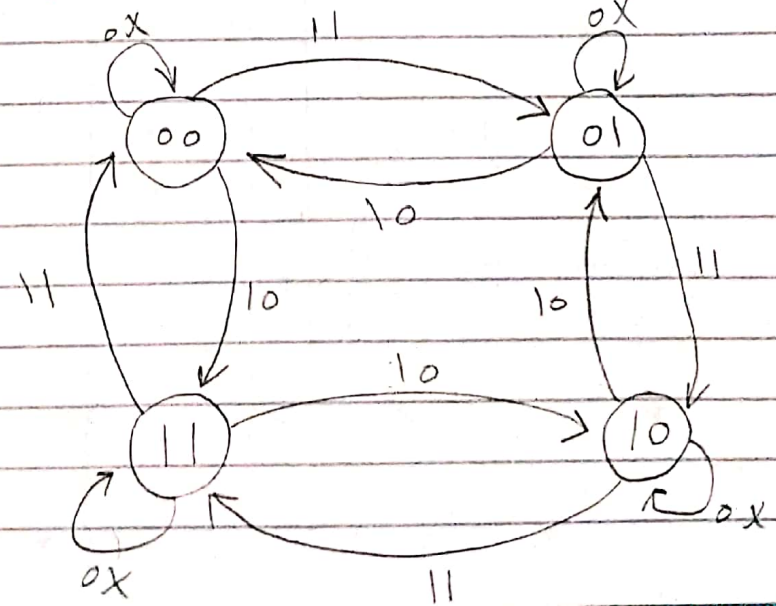
4- Circuit designation.



5.18 Design a sequential circuit with two JK flip-flops A and B and two inputs E and F. If E=0 the circuit remains in the same state, When E=1 & F=1 the circuit goes through from 00 → 01 → 10 → 11, and back to 00.

When E=1 and F=0 it goes through 00 → 11 → 10 → 01 back to 00.

1- State diagram



2- State table,

P.S A	P.S B	input E	input F	N.S A	N.S B	J_A	K_A	J_B	K_B
0	0	0	X	0	0	0	X 0	0	X 0
0	0	0	X	0	0	0	X 1	0	X 1
0	0	1	0	1	1	1 2	X 2	1 2	X 2
0	0	1	1	0	1	0	X 3	1 3	X 3
0	1	0	X	0	1	0	X 4	X 4	0
0	1	0	X	0	1	0	X 5	X 5	0
0	1	1	0	0	0	0	X 6	X 6	1 6
0	1	1	1	1	0	1 7	X 7	X 7	1 7
1	0	0	X	1	0	X 8	0	0	X 8
1	0	0	X	1	0	X 9	0	0	X 9
1	0	1	0	0	1	X 10	1 10	1 10	X 10
1	0	1	1	1	1	X 11	0	1 11	X 11
1	1	0	X	1	1	X 12	0	X 12	0
1	1	0	X	1	1	X 13	0	X 13	0
1	1	1	0	1	0	X 14	0	X 14	1 14
1	1	1	1	0	0	X 15	1 15	X 15	1 15

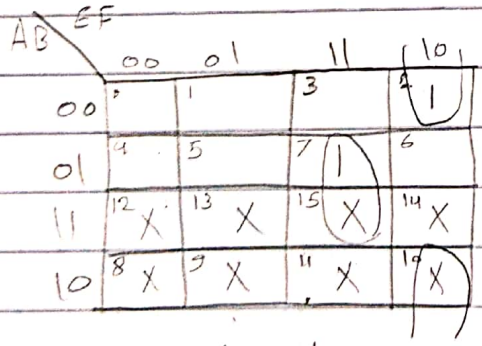
3- JK-FF Excitation Table

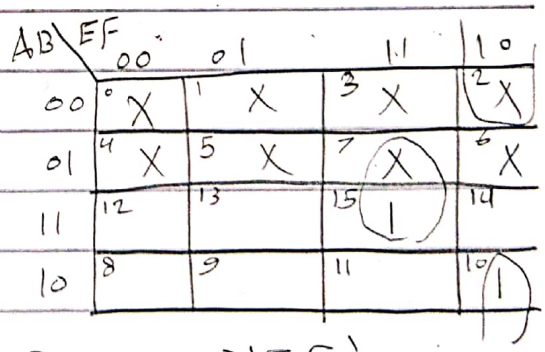
Q	$Q_{(t+1)}$	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

4- Simplified functions

$J_A = \Sigma m(2,7) + d\Sigma(8,9,10,11,12,13,14,15)$

$K_A = \Sigma m(10,15) + d\Sigma m(0,1,2,3,4,5,6,7)$





$J_A = BEF + B'EF'$

$= E(BF + B'F')$

$= E(B \oplus F)'$

$K_A = BEF + B'EF'$

$= E(BF + B'F')$

$= E(B \oplus F)'$

$J_B = \Sigma m(2,3,10,11) + d\Sigma m(4,5,6,7,12,13,14,15)$

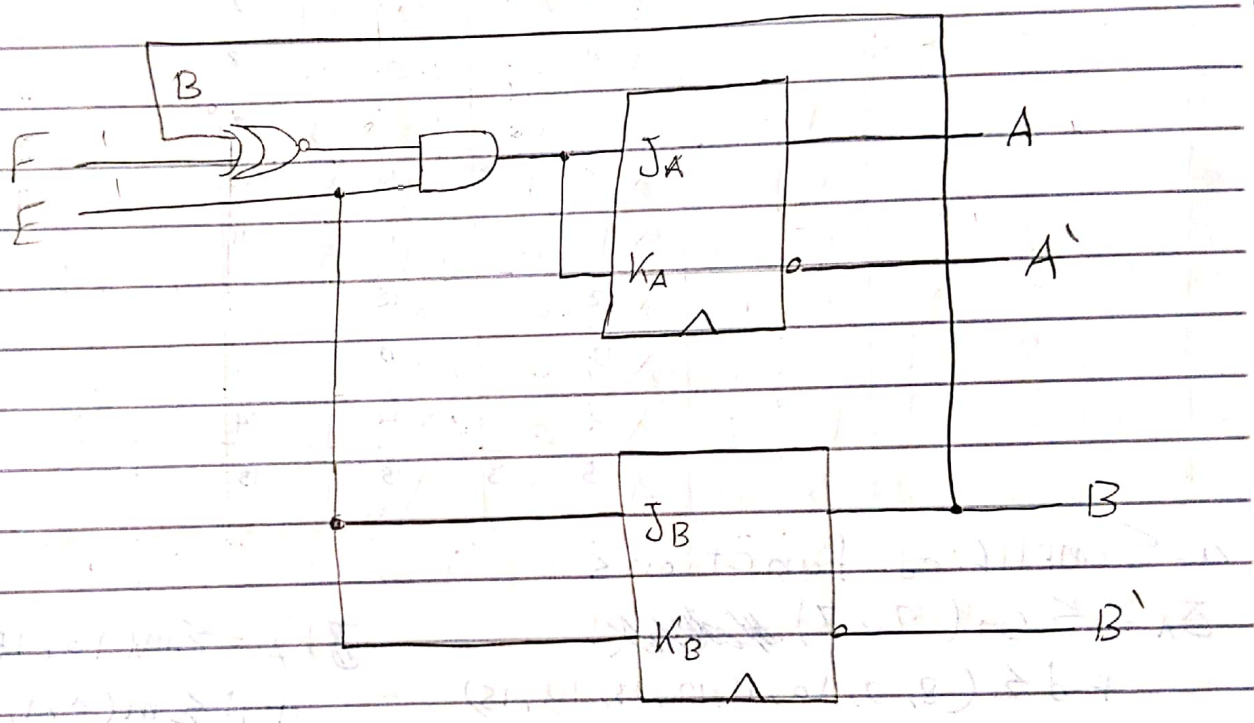
AB \ EF	00	01	11	10
00	0	1	3 1	2 1
01	4 X	5 X	7 X	6 X
11	12 X	13 X	15 X	14 X
10	8	9	11 1	10 1

$J_B = E$

$K_B = \Sigma m(6,7,14,15) + d\Sigma m(0,1,2,3,8,9,10,11)$

AB \ EF	00	01	11	10
00	0 X	1 X	3 X	2 X
01	4	5	7 1	6 1
11	12	13	15 1	14 1
10	8 X	9 X	11 X	10 X

$K_B = E$



5.19 A Sequential Circuit has three flip-flops A, B, C; one input x-in; and one output y-out. The State diagram is shown in Fig. P.5.19. Analyze the circuit obtained from the design to determine the effect of the unused state.

(a) Use D-FFs in the design.

1) State table:-

P.S	Next State x=0	Next State x=1	output x=0	output x=1
000	011	100	0	1
001	001	100	0	1
010	010	000	0	1
011	001	010	0	1
100	010	011	0	0

JK excitation table

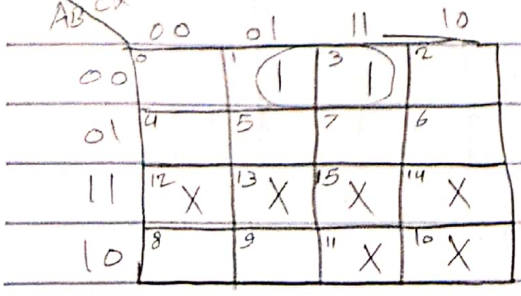
Q	$Q_{(t+1)}$	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

P.S	x-in	N.S	y-out	J_A	K_A	J_B	K_B	J_C	K_C	D_A	D_B	D_C
000	0	011	0	0	X	1	X	1	X	0	1	1
000	1	100	1	1	X	0	X	0	X	1	0	0
001	0	001	0	0	X	0	X	X	0	0	0	1
001	1	100	1	1	X	0	X	X	1	1	0	0
010	0	010	0	0	X	X	0	0	X	0	1	0
010	1	000	1	0	X	X	1	0	X	0	0	0
011	0	001	0	0	X	X	1	X	0	0	0	1
011	1	010	1	0	X	X	0	X	1	0	1	0
100	0	010	0	X	1	1	X	0	X	0	1	0
100	1	011	0	X	1	1	X	1	X	0	1	1

Simplified functions:-

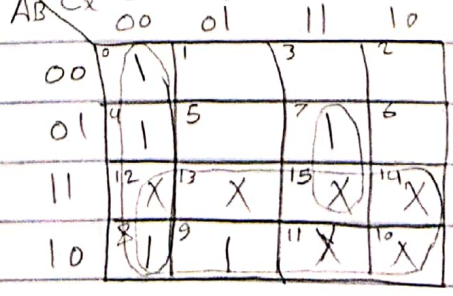
don't care = $\Sigma m(10, 11, 12, 13, 14, 15)$

$D_A = \Sigma m(1, 3)$



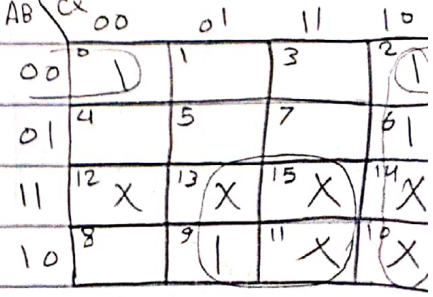
$D_A = A'B'x$

$D_B = \Sigma(0, 4, 7, 8, 9)$



$D_B = C'x' + A + BCx$

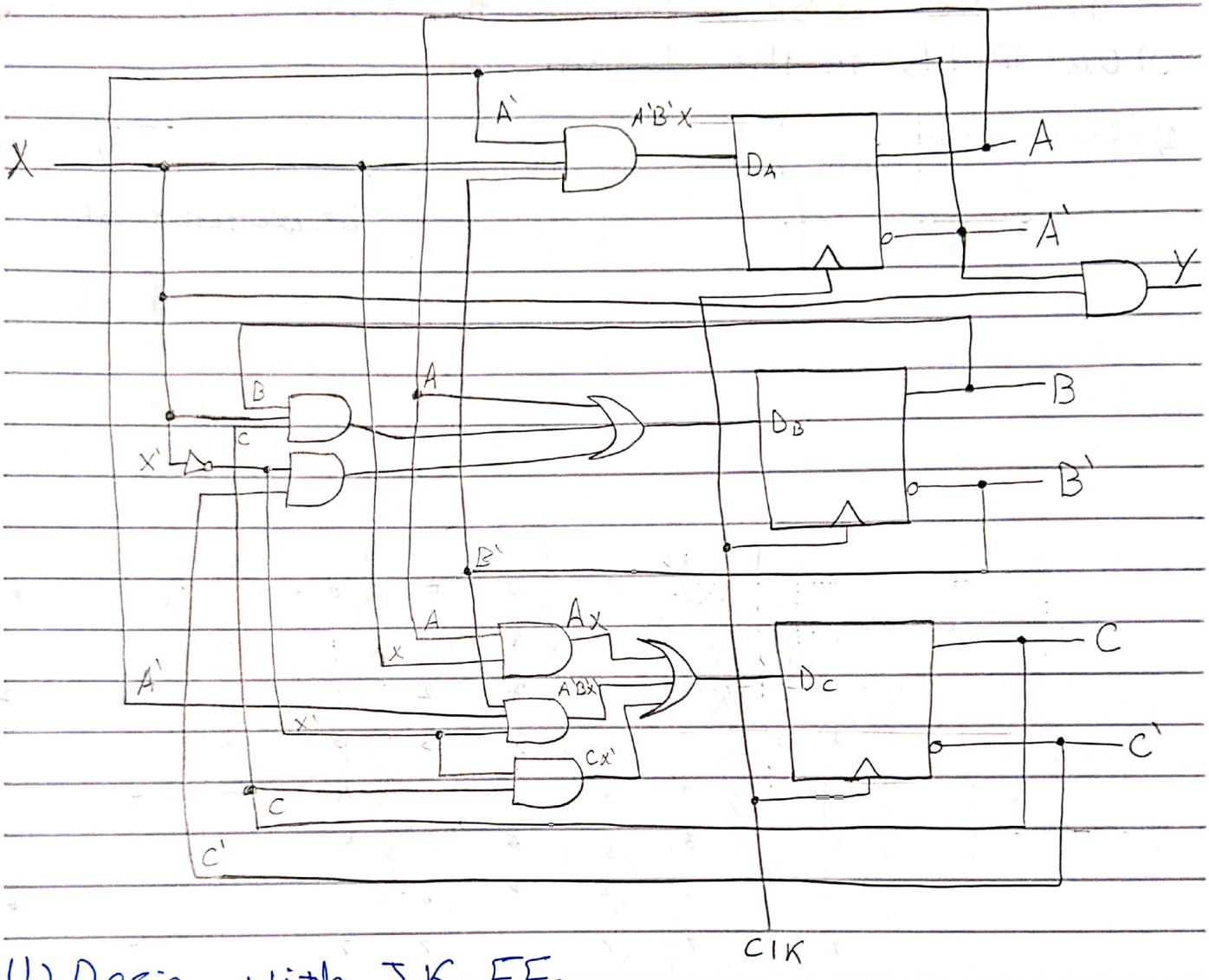
$D_C = \Sigma m(0, 2, 6, 9)$



$D_C = A'B'x' + Ax + Cx'$

Designation with D-FFs

$D_A = A'B'x$ $D_B = A + Bx + C'x'$ $D_C = Ax + A'B'x' + Cx'$



(b) Design with JK-FFs

$J_A = \Sigma m(1,3)$

$+d = \Sigma m(8,9,10,11,12,13,14,15)$

AB \ Cx	00	01	11	10
00	0	1 1	3 1	2
01	4	5	7	6
11	12 X	13 X	15 X	14 X
10	8 X	9 X	11 X	10 X

$J_A = B'x$

$K_A = \Sigma m(8,9)$

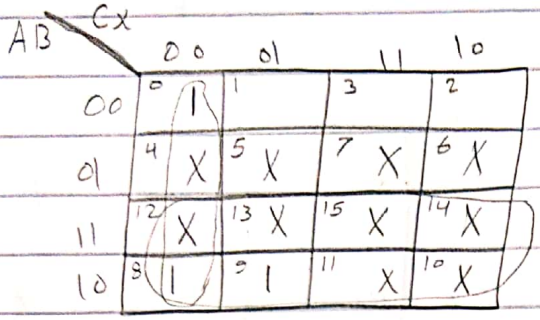
$+d = \Sigma m(0,1,2,3,4,5,6,7,10,11,12,13,14,15)$

AB \ Cx	00	01	11	10
00	0 X	1 X	3 X	2 X
01	4 X	5 X	7 X	6 X
11	12 X	13 X	15 X	14 X
10	8 1	9 1	11 X	10 X

$K_A = 1$

$J_B = \Sigma m(0, 8, 9)$

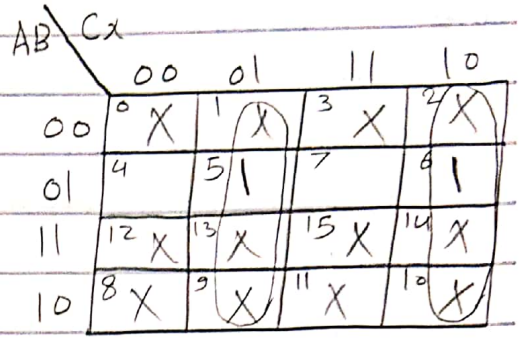
$+ d \Sigma m(4, 5, 6, 7, 10, 11, 12, 13, 14, 15)$



$J_B = C'x' + A$

$K_B = \Sigma m(5, 6)$

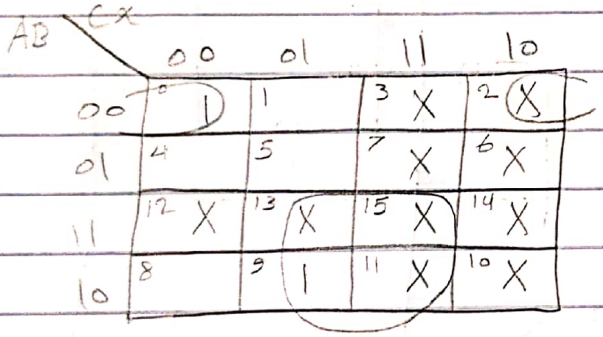
$+ d = \Sigma m(0, 1, 2, 3, 8, 9, 10, 11, \ldots)$



$K_B = C'x + Cx' = C \oplus x$

$J_C = \Sigma m(0, 9)$

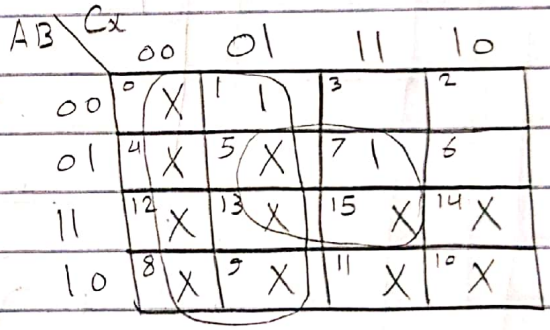
$+ d + \Sigma m(2, 3, 6, 7, 10, 11 \ldots)$



$J_C = A'B'x' + Ax$

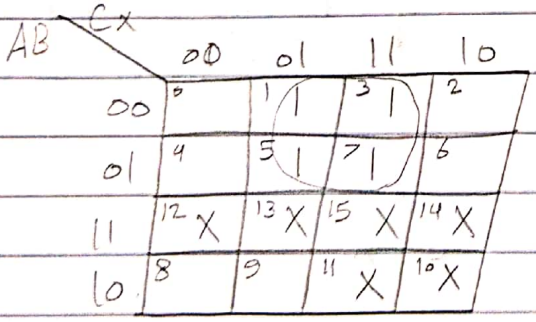
$K_B = \Sigma m(1, 7)$

$+ d \Sigma m(0, 1, 4, 5, 8, 9, \ldots)$



$K_C = C' + Bx$

$out\_y = \Sigma m(1, 3, 5, 7) + d = \Sigma m(10, 11, 12, 13, 14, 15)$

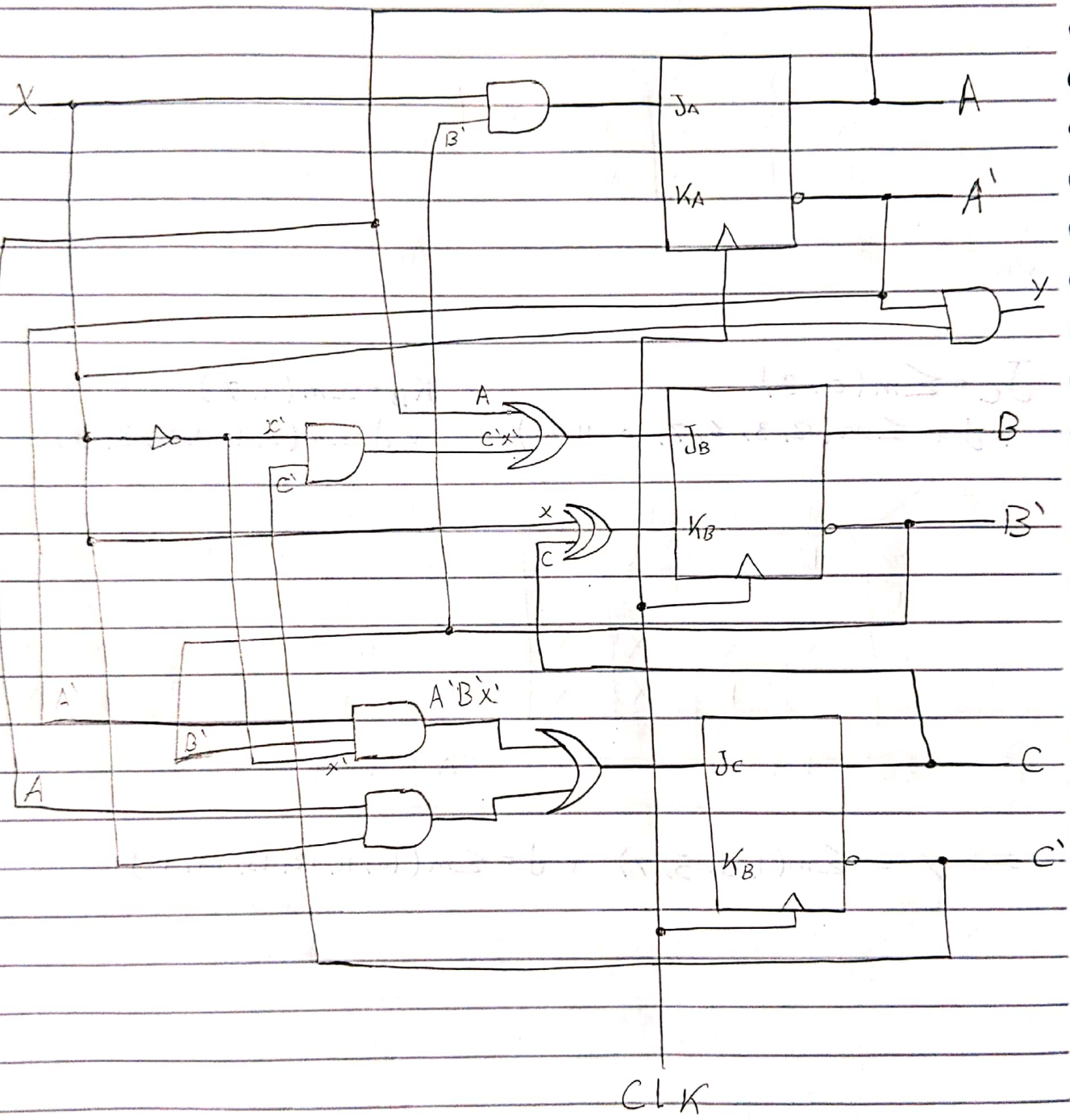


$Y = A'x$

$J_A = B'x$ $J_B = A + C'x'$ $J_C = A'B'x' + Ax$

$K_A = 1$ $K_B = C \oplus x$ $K_C = Bx + C'$

$y =$



5.20 Design the sequential circuit specified by the state diagram of Fig. 5.19, using T-FFs

1- State table

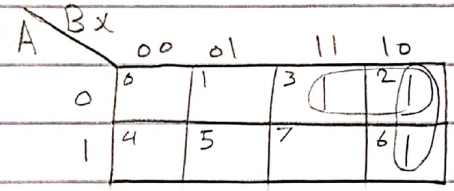
P.S	Next State x=0	Next State x=1
S_0	S_1	S_0
S_1	S_3	S_2
S_2	S_3	S_3
S_3	S_0	S_3

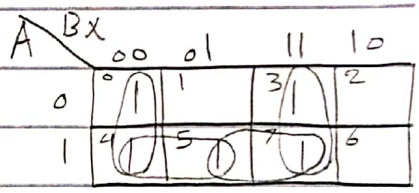
Present State A	Present State B	Input x	Next State A	Next State B	T_A	T_B
0	0	0	0	1	0	1 (0)
0	0	1	0	0	0	0
0	1	0	1	1	1 (2)	0
0	1	1	1	0	1 (3)	1 (3)
1	0	0	1	1	0	1 (4)
1	0	1	1	1	0	1 (5)
1	1	0	0	0	1 (6)	0
1	1	1	1	1	0	1 (7)

T-FF Excitation table

Q	Q(t+1)	T
0	0	0
0	1	1
1	0	1
1	1	0

$T_A = \Sigma m(2,3,6)$ $\quad T_B = \Sigma m(0,3,4,5,7)$





$T_A = A'B + Bx'$

$T_B = B'x' + AB' + \cancel{Ax} + Bx$
$= AB' + Bx + B'x'$
$= AB' + (B \oplus x)'$