Excitation Tables

$Q(t)$	$Q(t+1)$	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

(a) JK Flip-Flop

J	K	Qt+1
0	0	Qt
0	1	0
1	0	1
1	1	Qt’

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

(b) T Flip-Flop

T	Qt+1
0	Qt
1	Qt’

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

(c) D

D	Qt+1
0	0
1	1

$Q(t)$	$Q(t+1)$	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

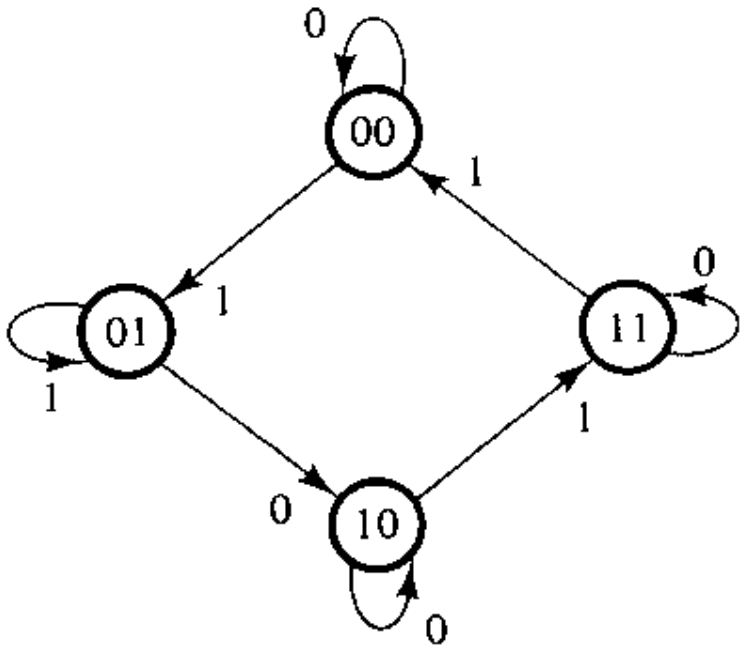
(d) SR FF

S	R	Qt+1
0	0	Qt
0	1	0
1	0	1
1	1	?

DESIGN PROCEDURE

1. The problem may be given by the word description or state diagram or state table
2. From the given information obtain the state table
3. Reduce the number of states if necessary.
4. Assign binary values to the states.
5. Determine the number of FFs needed and assign a letter symbol to each
6. Choose the type of flip-flops to be used.
7. Derive the circuit excitation and output tables
8. Derive the simplified flip-flop input equations and output equations.
9. Draw the logic diagram.

Example 1: Design the synchronous sequential circuit for the following state diagram using JK FF



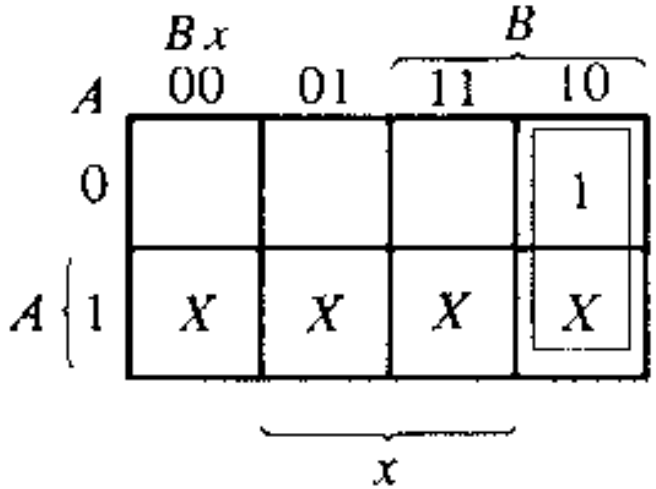
Solution:

State Table

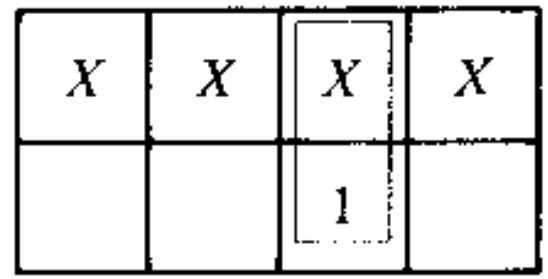
Present State		Next State			
		$x = 0$		$x = 1$	
A	B	A	B	A	B
0	0	0	0	0	1
0	1	1	0	0	1
1	0	1	0	1	1
1	1	1	1	0	0

Excitation Table

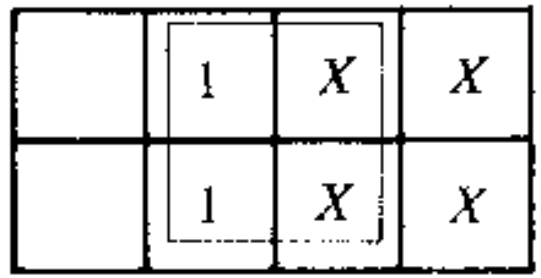
Inputs of Combinational Circuit			Next State		Outputs of Combinational Circuit			
Present State		Input			Flip-Flop Inputs			
A	*B*	*x*	*A*	*B*	*JA*	*KA*	*JB*	*KB*
0	0	0	0	0	0	*X*	0	*X*
0	0	1	0	1	0	*X*	1	*X*
0	1	0	1	0	1	*X*	*X*	1
0	1	1	0	1	0	*X*	*X*	0
1	0	0	1	0	*X*	0	0	*X*
1	0	1	1	1	*X*	0	1	*X*
1	1	0	1	1	*X*	0	*X*	0
1	1	1	0	0	*X*	1	*X*	1



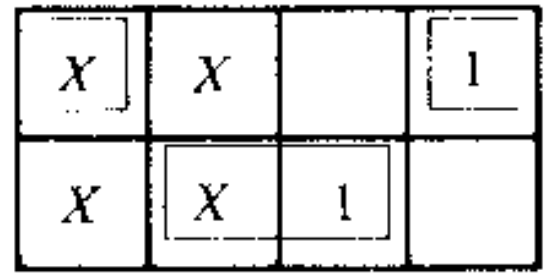
$JA = Bx'$



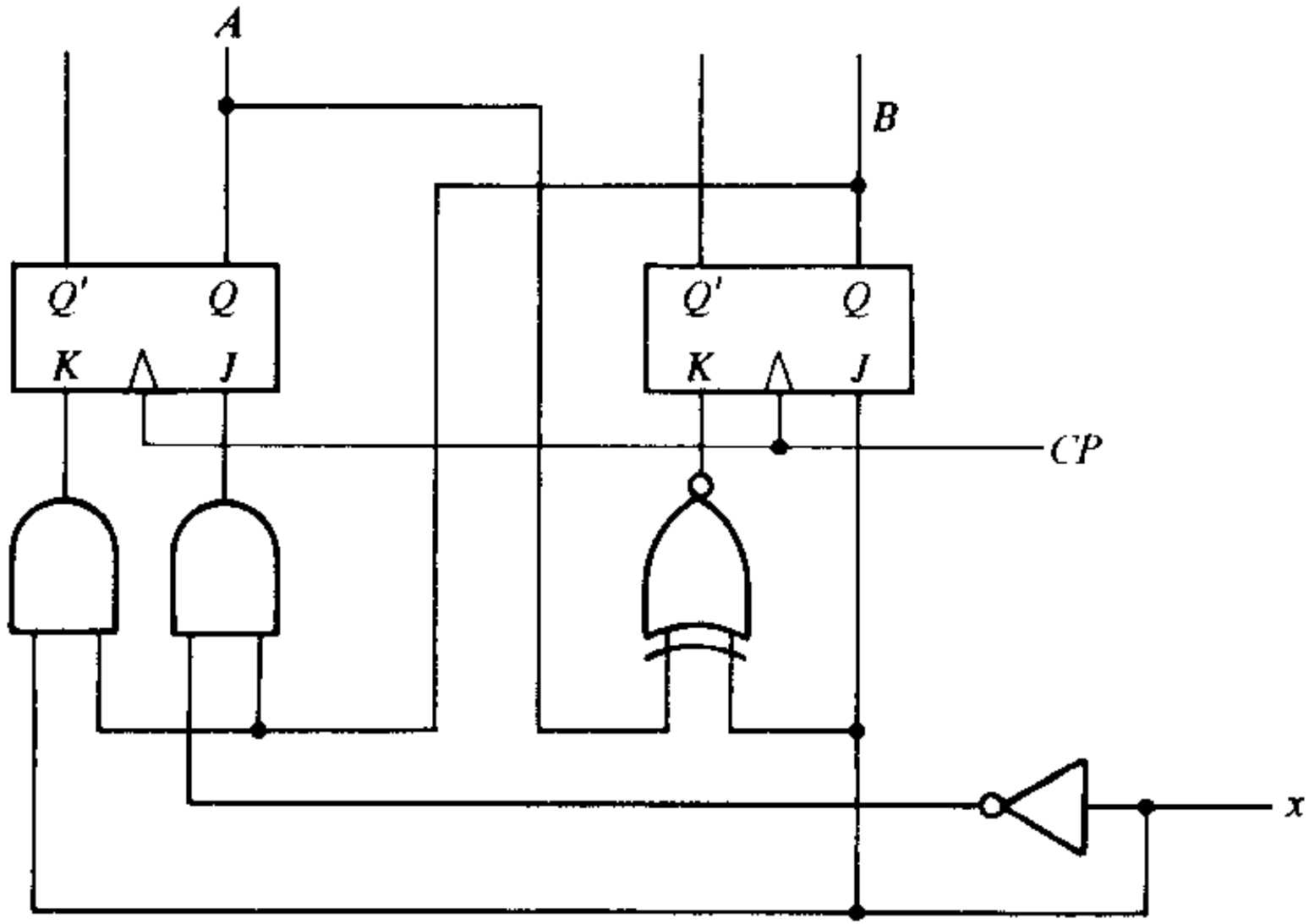
$KA = Bx$



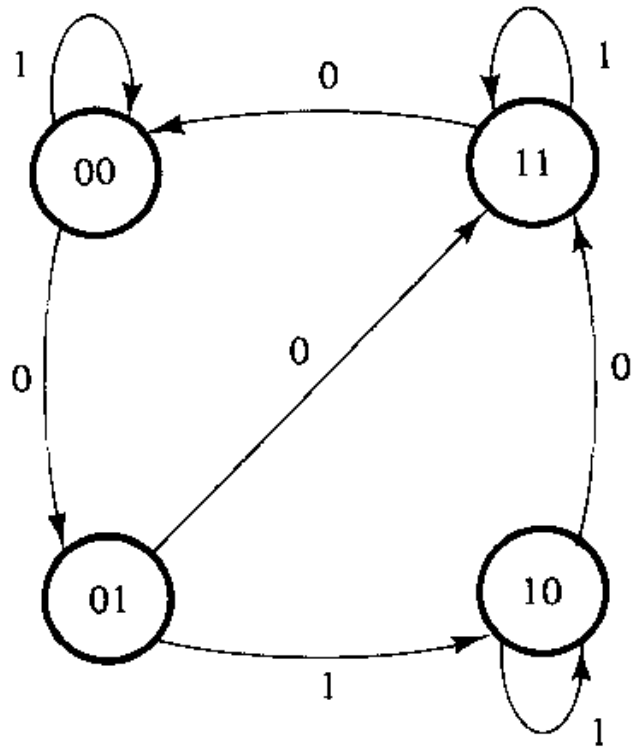
$JB = x$



$KB = (A \oplus x)'$


A
B
Q'
Q
K
J
Q'
Q
K
J
CP
x

Example 2: Design the synchronous sequential circuit for the following state diagram using T FF-(Exercise for the students to solve)



Solution:

Ta = A’B +Bx’

Tb = B’x’ + Ax’ + A’Bx

Design with D FFs

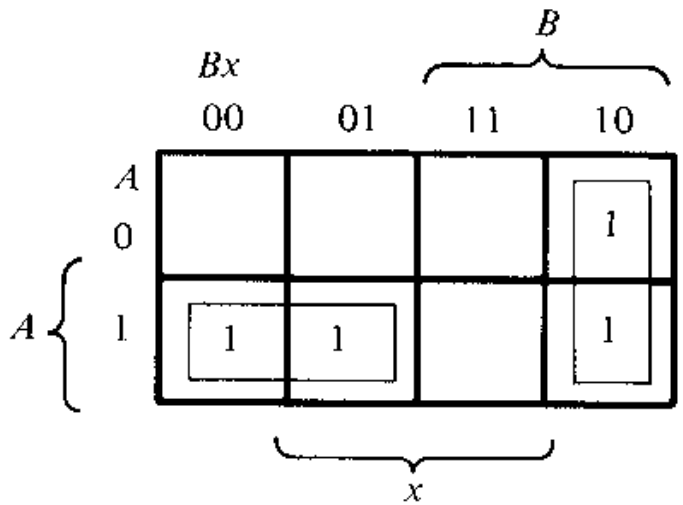
- Design if

A(t+1)= $DA(A, B, x) = \Sigma\,(2, 4, 5, 6)$

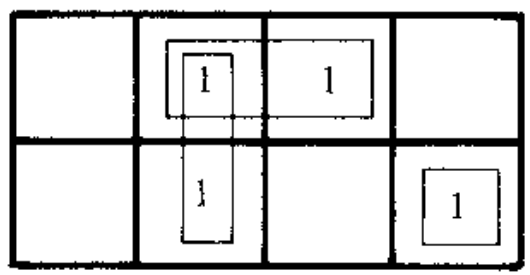
B(t+1)= $DB(A, B, x) = \Sigma\,(1, 3, 5, 6)$

$y(A, B, x) = \Sigma\,(1, 5)$

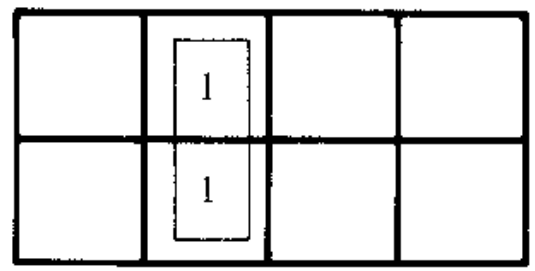
Solution:



$DA = AB' + Bx'$



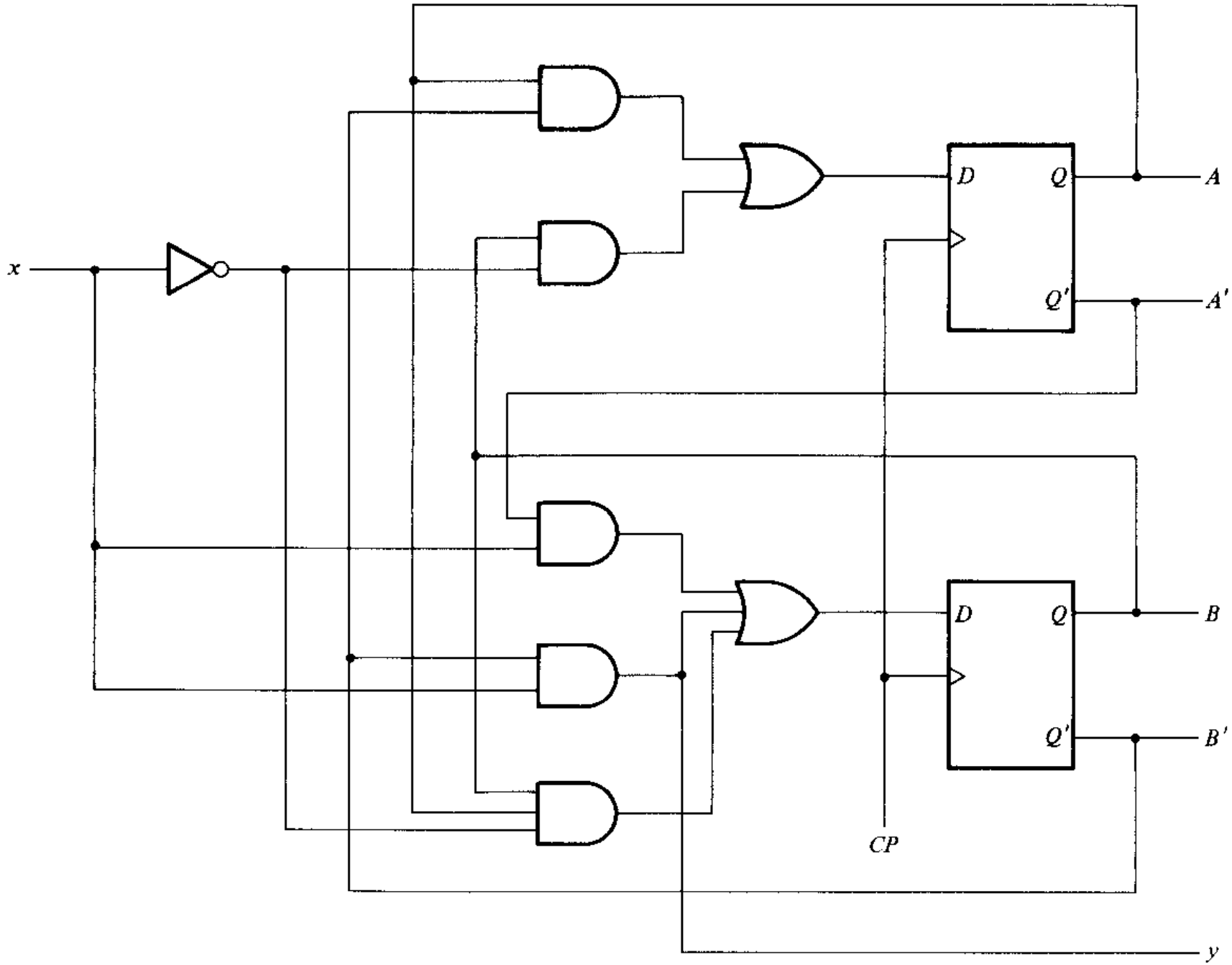
$DB = A'x + B'x + ABx'$



$y = B'x$

State Table for Design with *D* Flip-Flops

Present State		Input	Next State		Output
A	*B*	*x*	*A*	*B*	*y*
0	0	0	0	0	0
0	0	1	0	1	1
0	1	0	1	0	0
0	1	1	0	1	0
1	0	0	1	0	0
1	0	1	1	1	1
1	1	0	1	1	0
1	1	1	0	0	0


x
D
Q
A
Q'
A'
D
Q
B
Q'
B'
CP
y

Design with Unused States

Design the synchronous sequential circuit for the following state table:

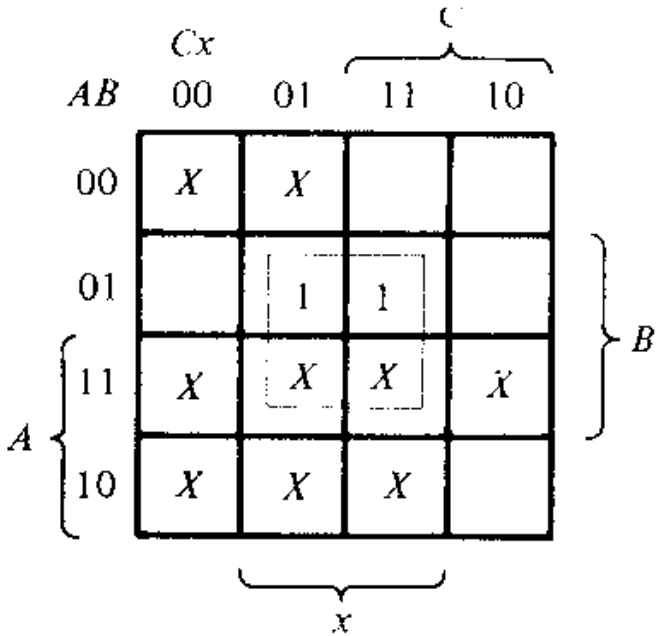
State Table with Unused States

Present State			Input	Next State			Output
A	*B*	*C*	*x*	*A*	*B*	*C*	*y*
0	0	1	0	0	0	1	0
0	0	1	1	0	1	0	0
0	1	0	0	0	1	1	0
0	1	0	1	1	0	0	0
0	1	1	0	0	0	1	0
0	1	1	1	1	0	0	0
1	0	0	0	1	0	1	0
1	0	0	1	1	0	0	1
1	0	1	0	0	0	1	0
1	0	1	1	1	0	0	1

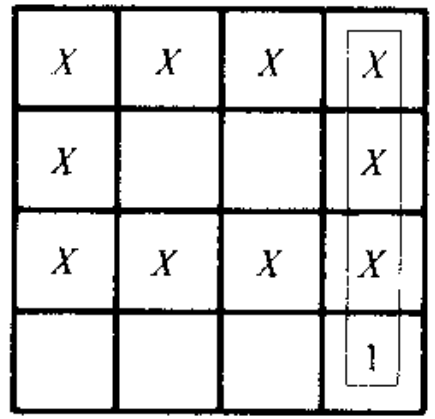
Present State			Input	Next State			Flip-Flop Inputs						Output
A	B	C	x	A	B	C	SA	RA	SB	RB	SC	RC	y
0	0	1	0	0	0	1							0
0	0	1	1	0	1	0							0
0	1	0	0	0	1	1							0
0	1	0	1	1	0	0							0
0	1	1	0	0	0	1							0
0	1	1	1	1	0	0							0
1	0	0	0	1	0	1							0
1	0	0	1	1	0	0							1
1	0	1	0	0	0	1							0
1	0	1	1	1	0	0							1

Q(t)	Q(t + 1)	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

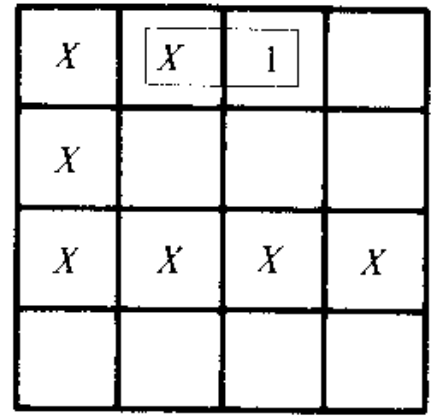
Present State			Input	Next State			Flip-Flop Inputs						Output
A	*B*	*C*	*x*	*A*	*B*	*C*	*SA*	*RA*	*SB*	*RB*	*SC*	*RC*	*y*
0	0	1	0	0	0	1	0	X	0	X	X	0	0
0	0	1	1	0	1	0	0	X	1	0	0	1	0
0	1	0	0	0	1	1	0	X	X	0	1	0	0
0	1	0	1	1	0	0	1	0	0	1	0	X	0
0	1	1	0	0	0	1	0	X	0	1	X	0	0
0	1	1	1	1	0	0	1	0	0	1	0	1	0
1	0	0	0	1	0	1	X	0	0	X	1	0	0
1	0	0	1	1	0	0	X	0	0	X	0	X	1
1	0	1	0	0	0	1	0	1	0	X	X	0	0
1	0	1	1	1	0	0	X	0	0	X	0	1	1



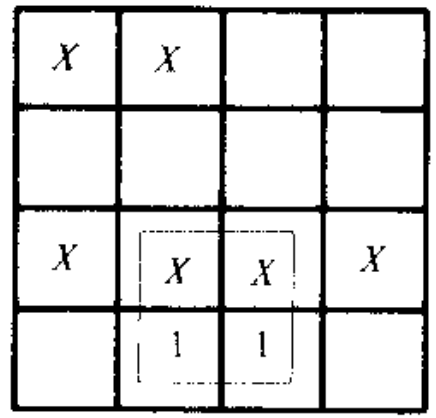
$SA = Bx$



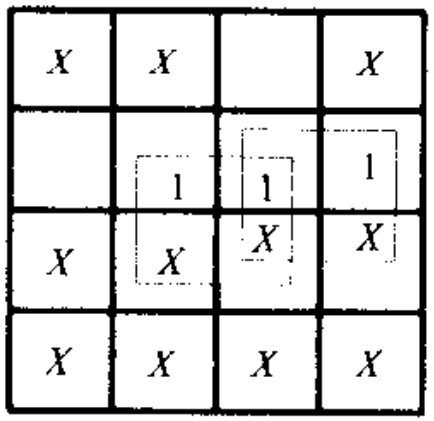
$RA = Cx'$



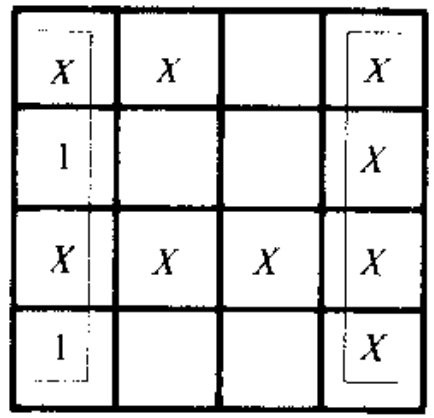
$SB = A'B'x$



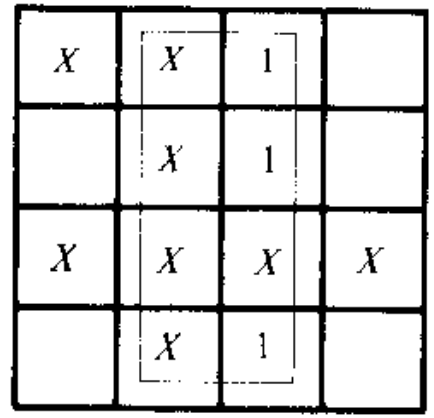
$y = Ax$



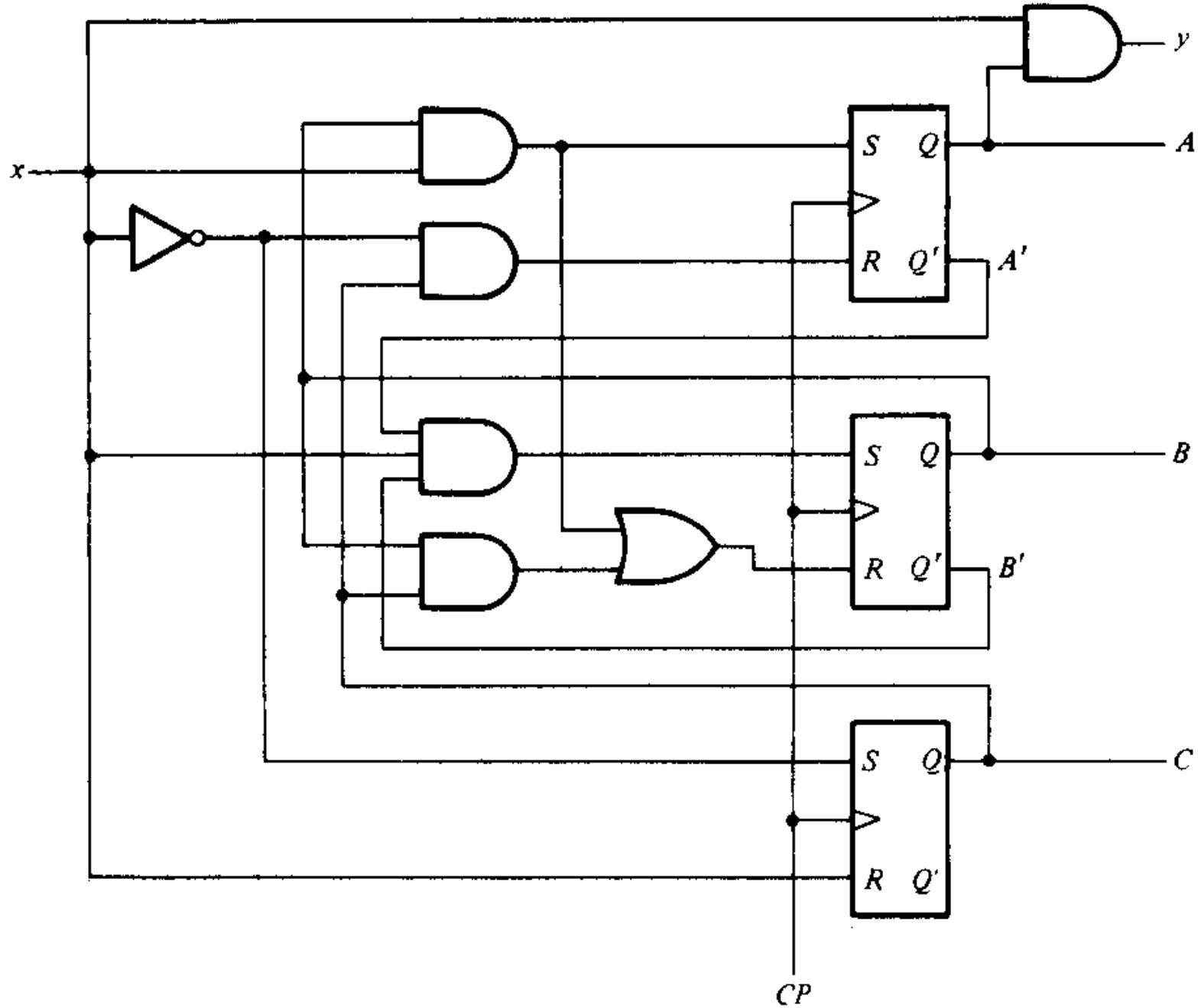
$RB = BC + Bx$



$SC = x'$



$RC = x$


x
y
A
A'
B
B'
C
CP
S
Q
R
Q'
S
Q
R
Q'
S
Q
R
Q'

Example: 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 regardless of the value of *F* . When $E = 1$ and $F = 1$, the circuit goes through the state transitions from 00 to 01, to 10, to 11, back to 00, and repeats.

When $E = 1$ and $F = 0$, the circuit goes through the state transitions from 00 to 11, to 10, to 01, back to 00, and repeats

Solution: $JA = KA = (B'F' + BF)E$

$JB = KB = E$

2 Design a sequential circuit with two D flip-flops, A and B, and one input, x. When $x = 0$, the state of the circuit remains the same. When $x = 1$, the circuit goes through the state transitions from 00 to 01 to 11 to 10 back to 00, and repeats.

3. Design the sequential circuit for the following state diagram

(a) Use D flip-flops in the design.
(b) Use JK flip-flops in the design.