Circuit, State Diagram, State Table

Circuits with Flip-Flop = Sequential Circuit

Circuit = State Diagram = State Table

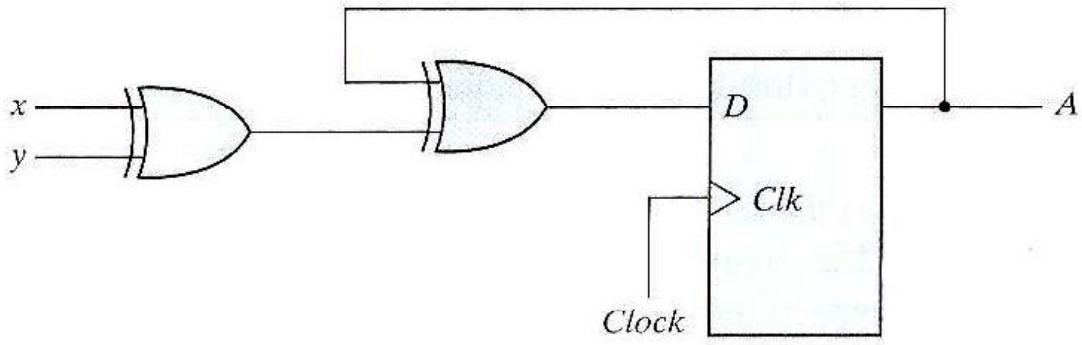
State Minimization

Sequential Circuit Design

Example: Sequence Detector

Example: Binary Counter

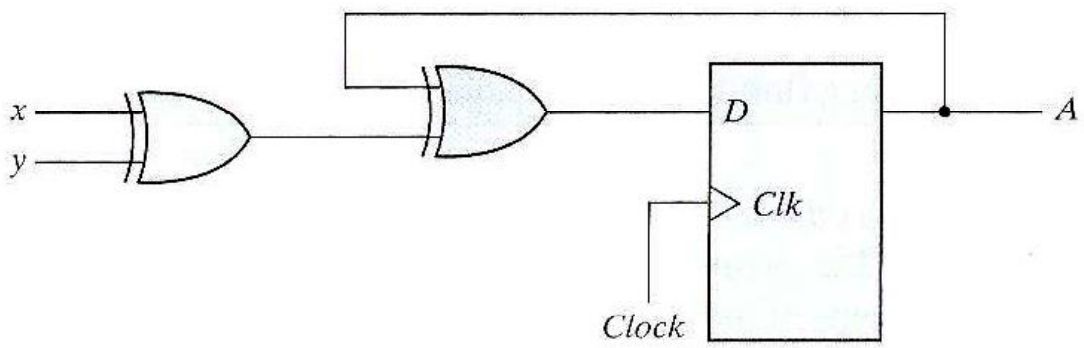
Circuit, State Diagram, State Table



(a) Circuit diagram

FIGURE 5.17
Sequential circuit with *D* flip-flop

Circuit, State Diagram, State Table



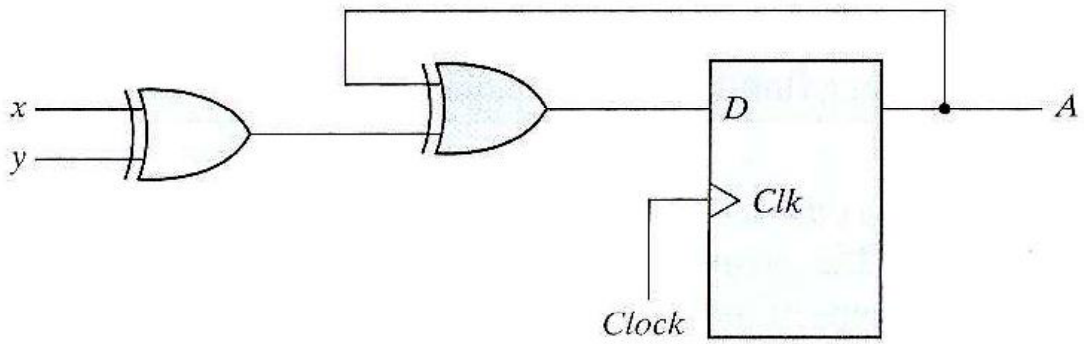
(a) Circuit diagram

Present state	Inputs		Next state
A	x	y	A
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

(b) State table

FIGURE 5.17
Sequential circuit with *D* flip-flop

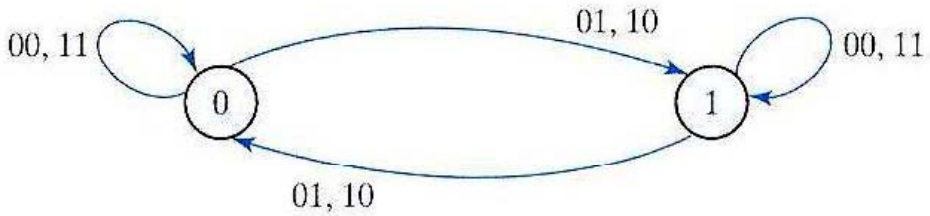
Circuit, State Diagram, State Table



(a) Circuit diagram

Present state	Inputs		Next state
A	*x*	*y*	*A*
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

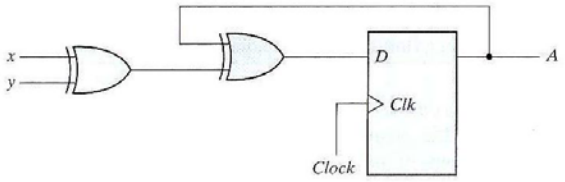
(b) State table



(c) State diagram

FIGURE 5.17
Sequential circuit with *D* flip-flop

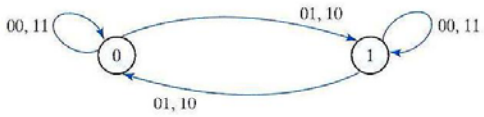
Circuit, State Diagram, State Table



(a) Circuit diagram

Present state	Inputs		Next state
A	x	y	A
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

(b) State table



(c) State diagram

FIGURE 5.17
Sequential circuit with *D* flip-flop

Terms:

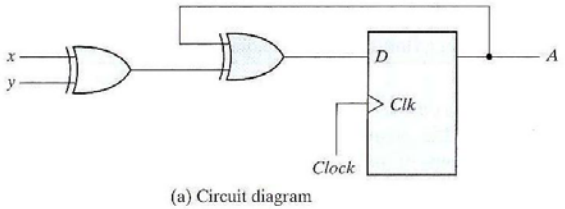
State: flip-flop output combination

Present state: before clock
Next state: after clock

State transition <= clock

1 flip-flop => 2 states
2 flip-flops => 4 states
3 flip-flops => 8 states
4 flip-flops => 16 states

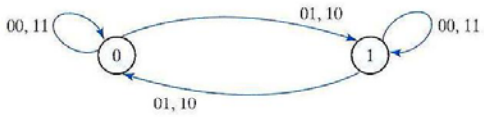
Circuit, State Diagram, State Table



(a) Circuit diagram

Present state	Inputs		Next state
A	*x*	*y*	*A*
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

(b) State table



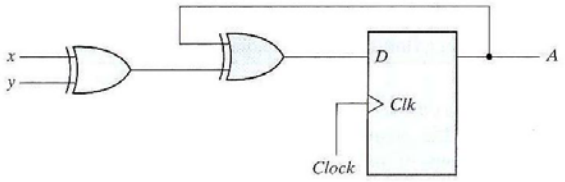
(c) State diagram

FIGURE 5.17
Sequential circuit with *D* flip-flop

Sequential circuit components:

Flip-flop(s)
Clock
Logic gates
Input
Output

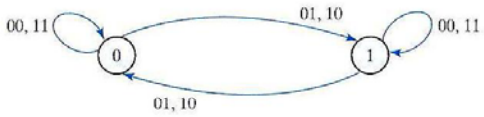
Circuit, State Diagram, State Table



(a) Circuit diagram

Present state	Inputs		Next state
A	*x*	*y*	*A*
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

(b) State table



(c) State diagram

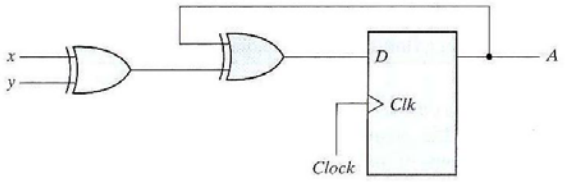
FIGURE 5.17
Sequential circuit with *D* flip-flop

State diagram:

Circle => state

Arrow => transition
input/output

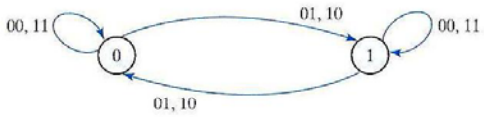
Circuit, State Diagram, State Table



(a) Circuit diagram

Present state	Inputs		Next state
A	*x*	*y*	*A*
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

(b) State table



(c) State diagram

FIGURE 5.17
Sequential circuit with *D* flip-flop

State table:

Left column => current state

Top row => input combination

Table entry => next state, output

Circuit, State Table, State Diagram

Example:

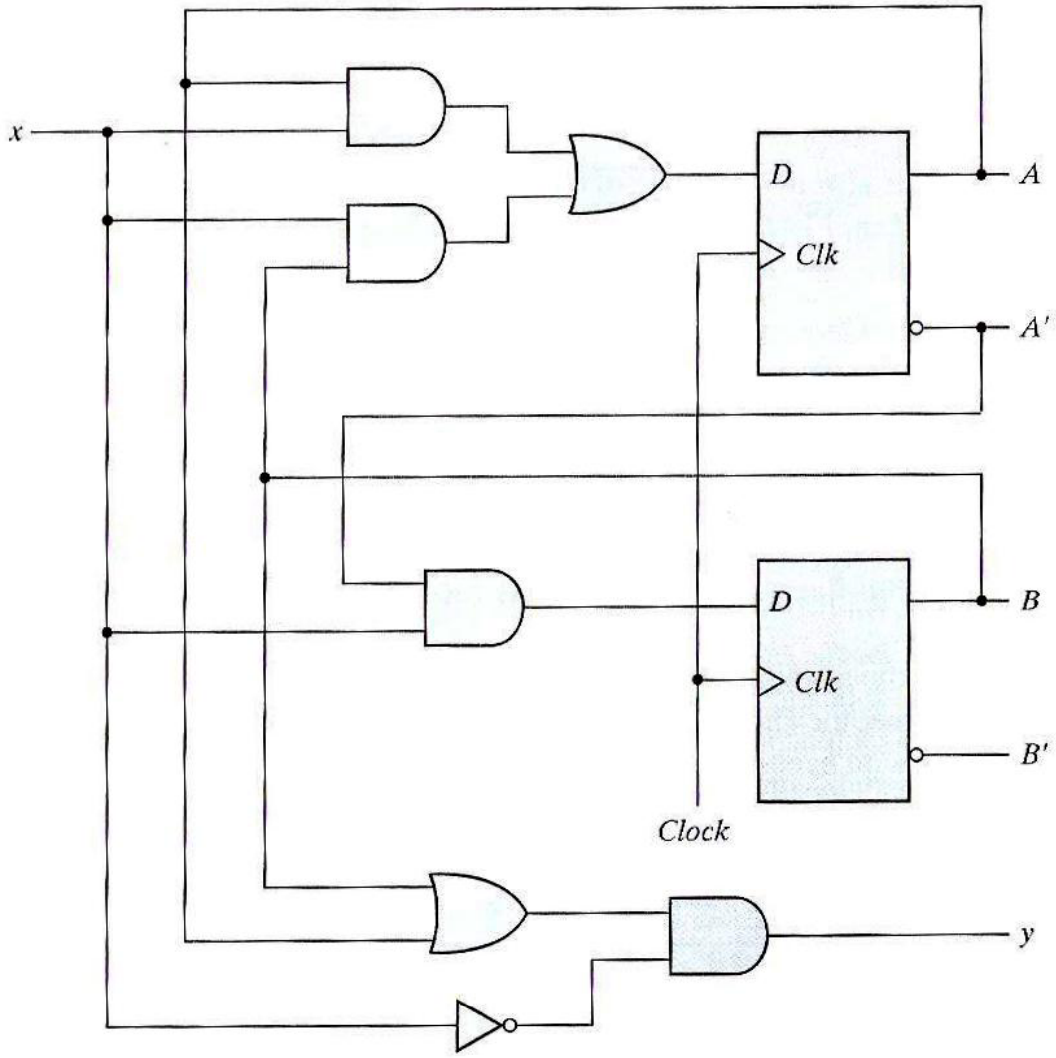


FIGURE 5.15
Example of sequential circuit

Circuit, State Table, State Diagram

Example:

Table 5.3
Second Form of the State Table

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

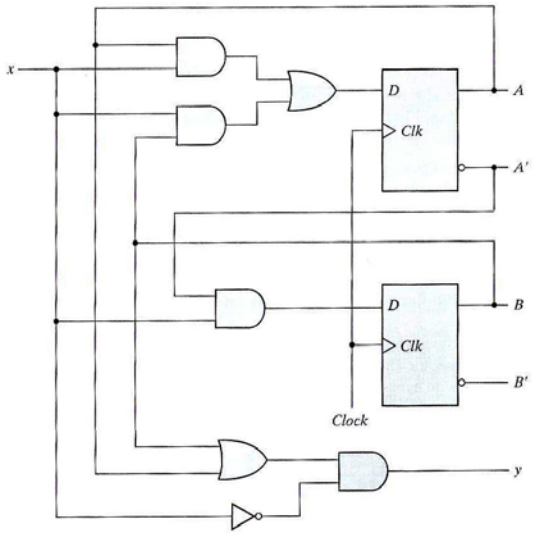


FIGURE 5.15
Example of sequential circuit

Circuit, State Table, State Diagram

Example:

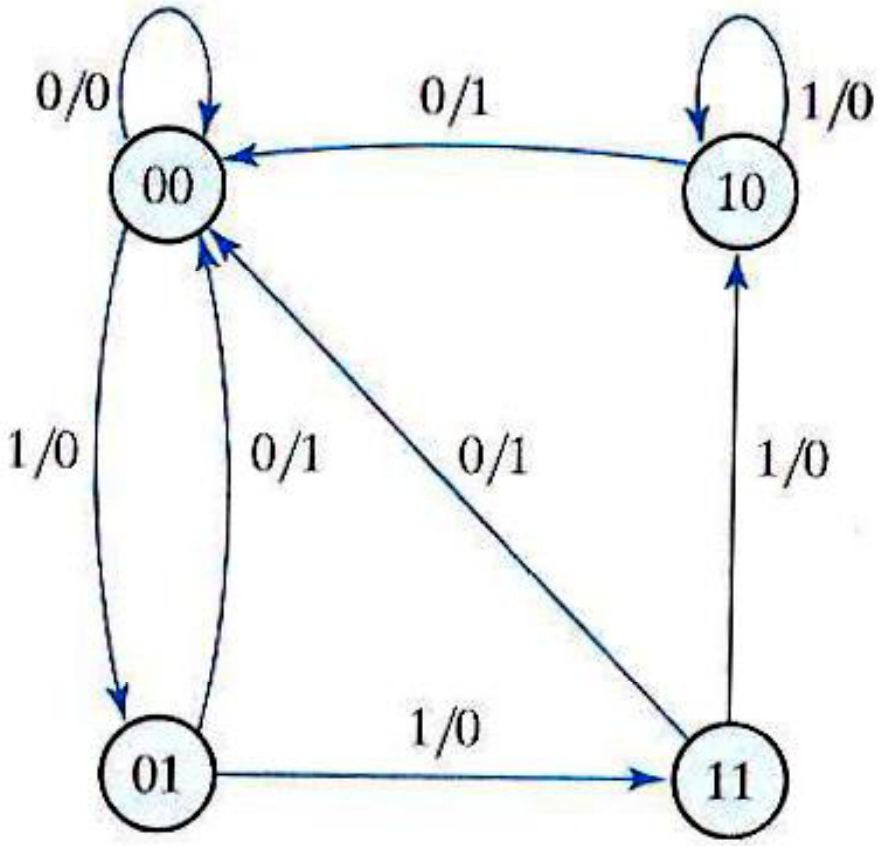


FIGURE 5.16
State diagram of the circuit of Fig. 5.15

Circuit, State Table, State Diagram

Example:

Table 5.3
Second Form of the State Table

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

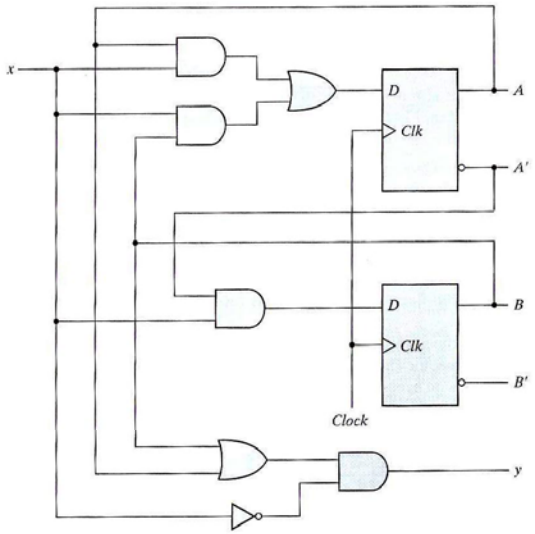


FIGURE 5.15
Example of sequential circuit

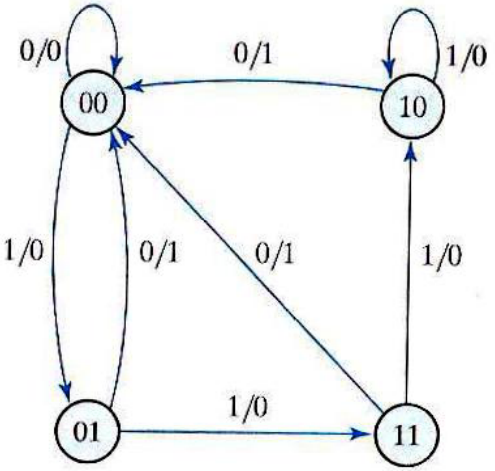
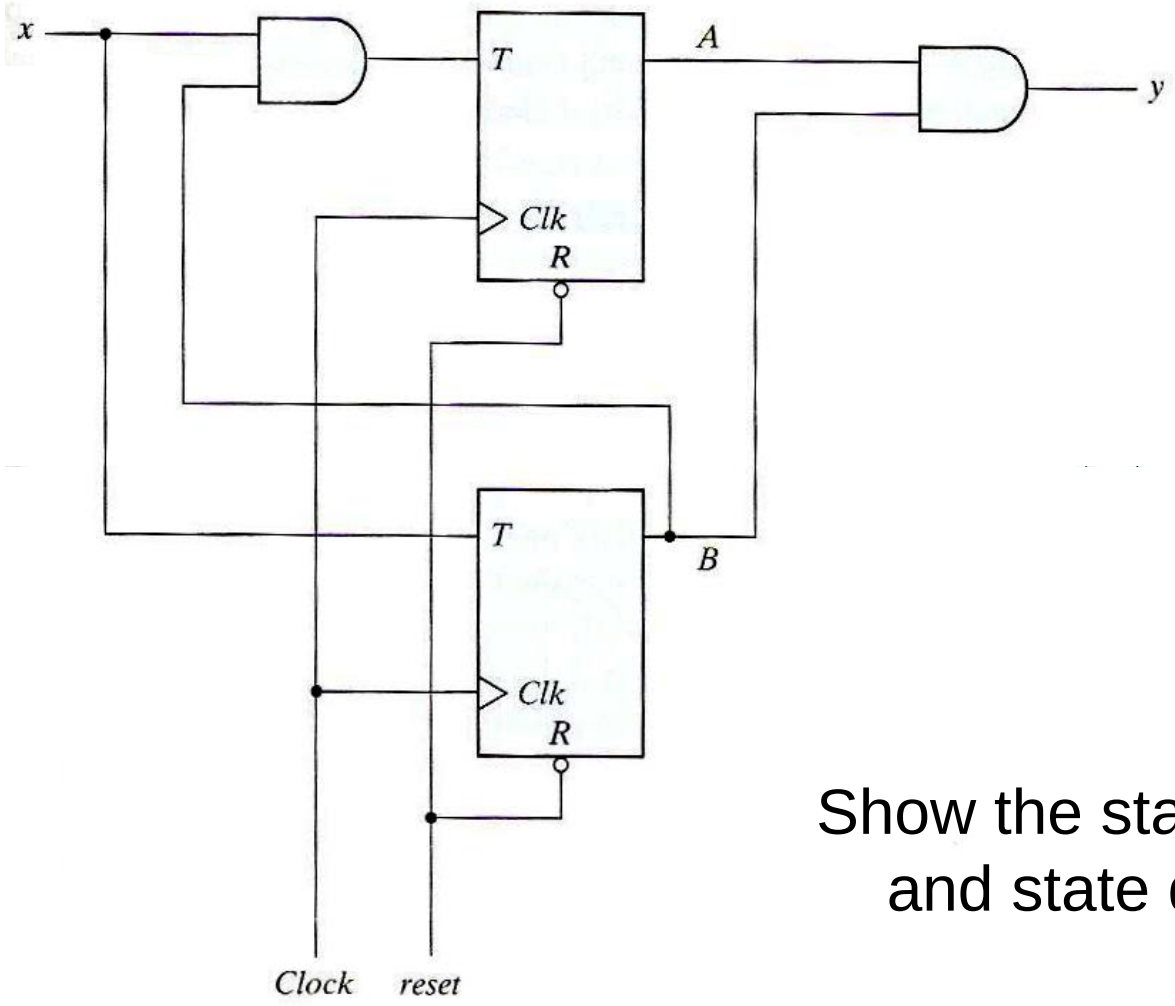


FIGURE 5.16
State diagram of the circuit of Fig. 5.15

Circuit, State Table, State Diagram

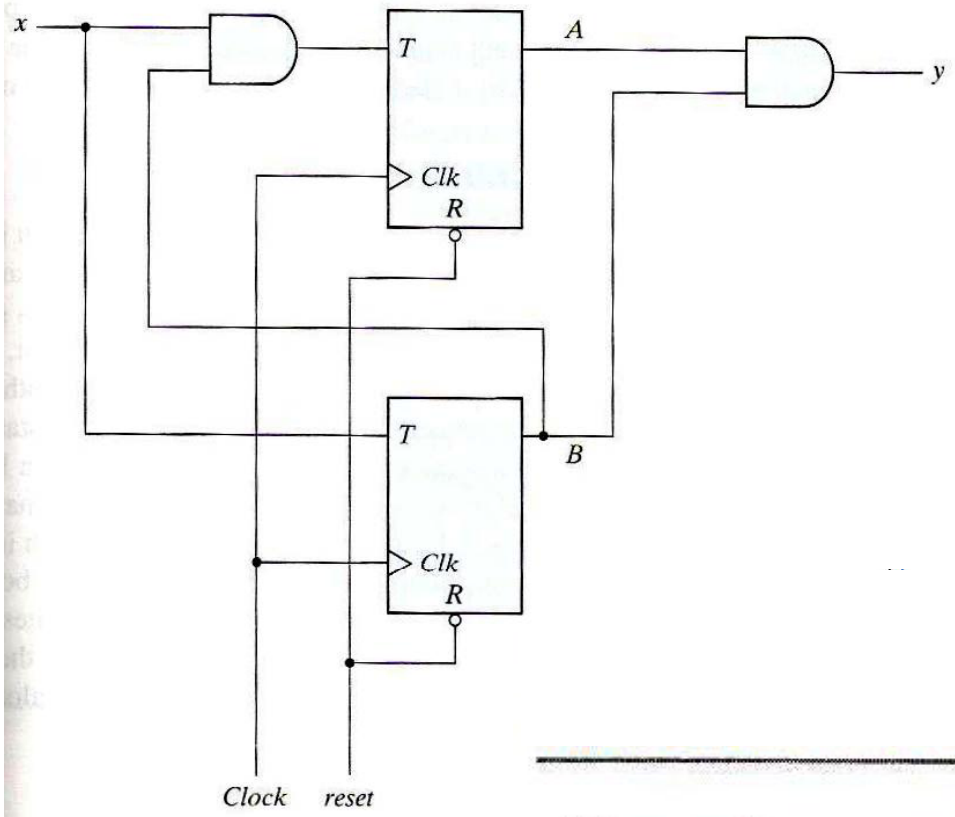
Example:



(a) Circuit diagram

FIGURE 5.20
Sequential circuit with *T* flip-flops

Show the state table and state diagram

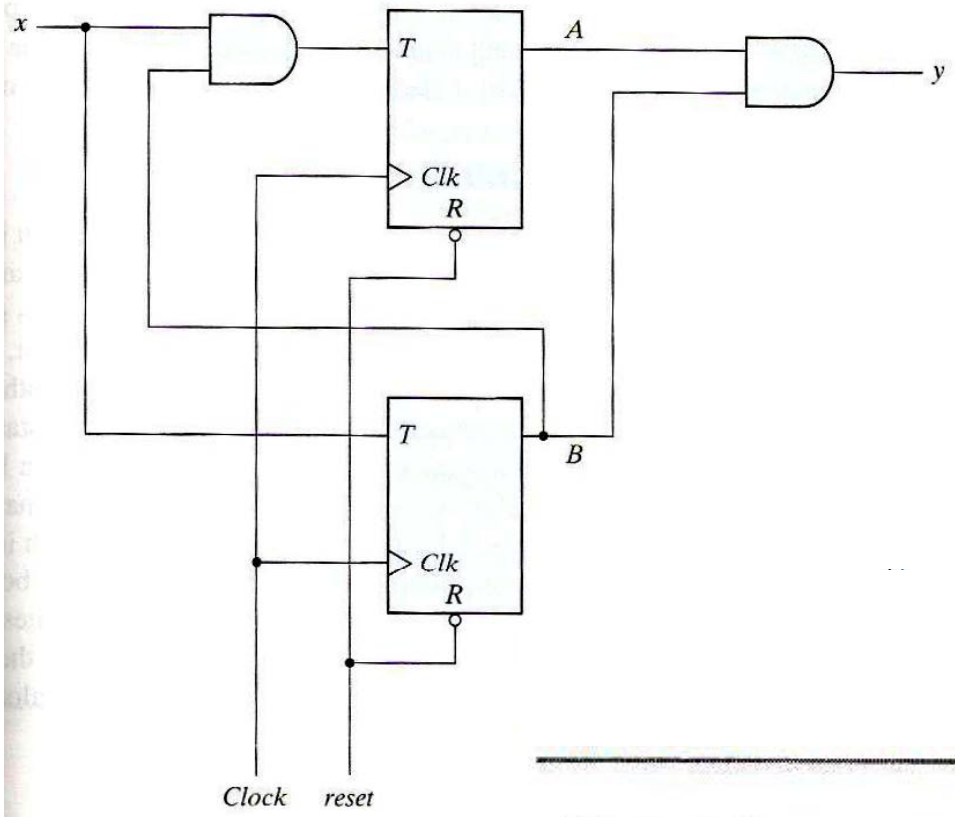


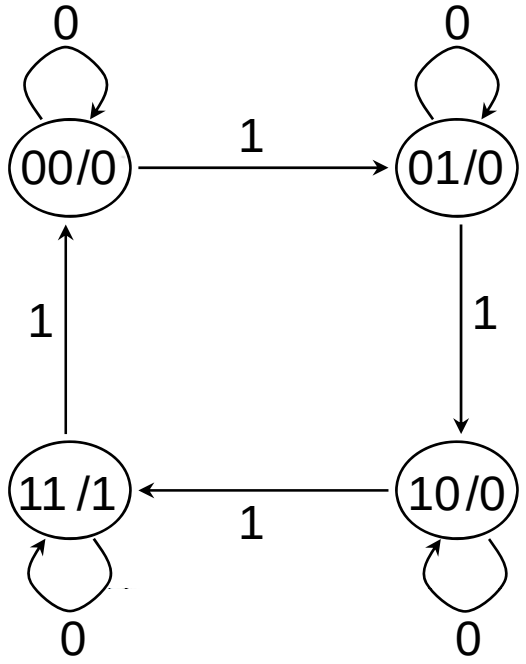
circuit

➔ state table

➔ state diagram

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



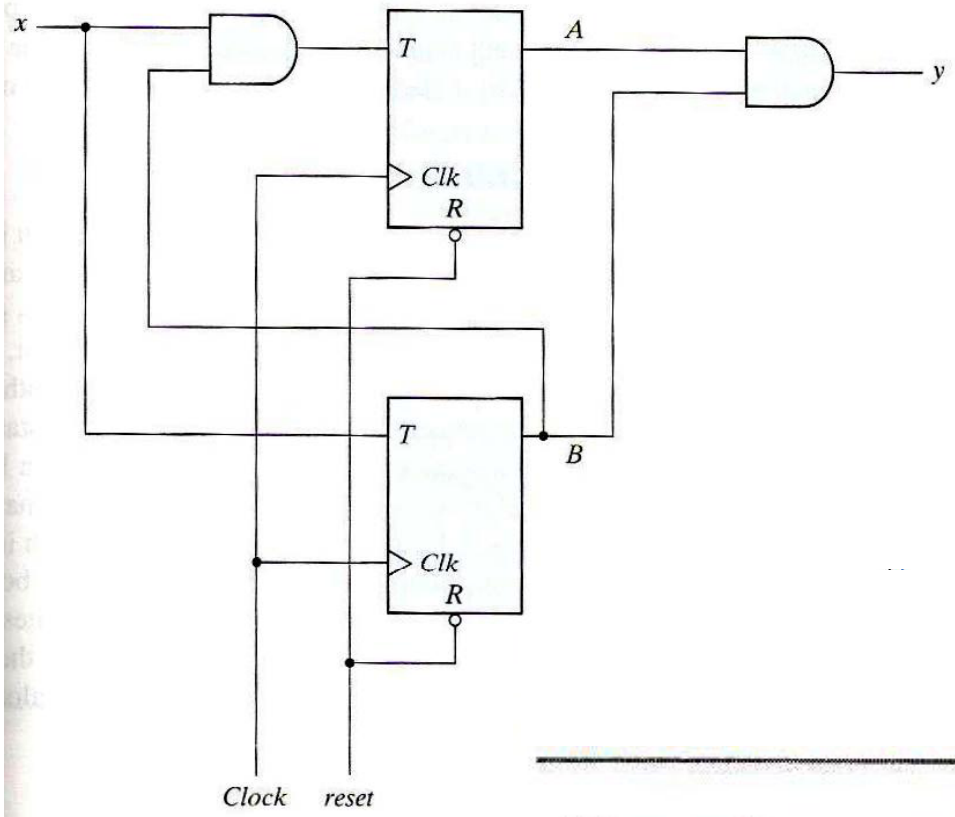


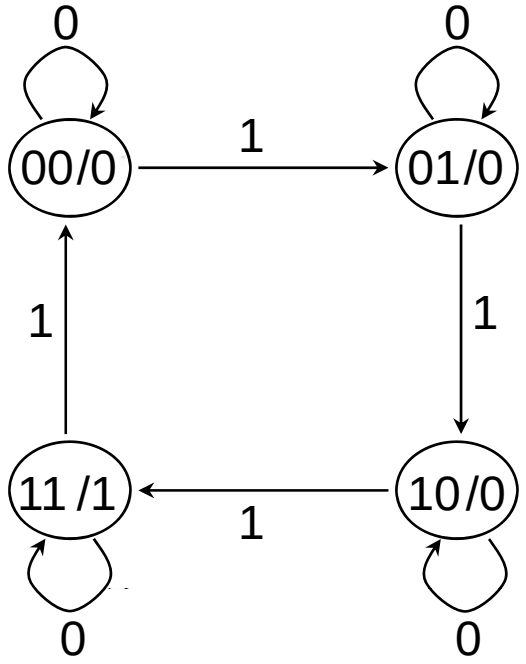
circuit

➔ state table

➔ state diagram

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





circuit

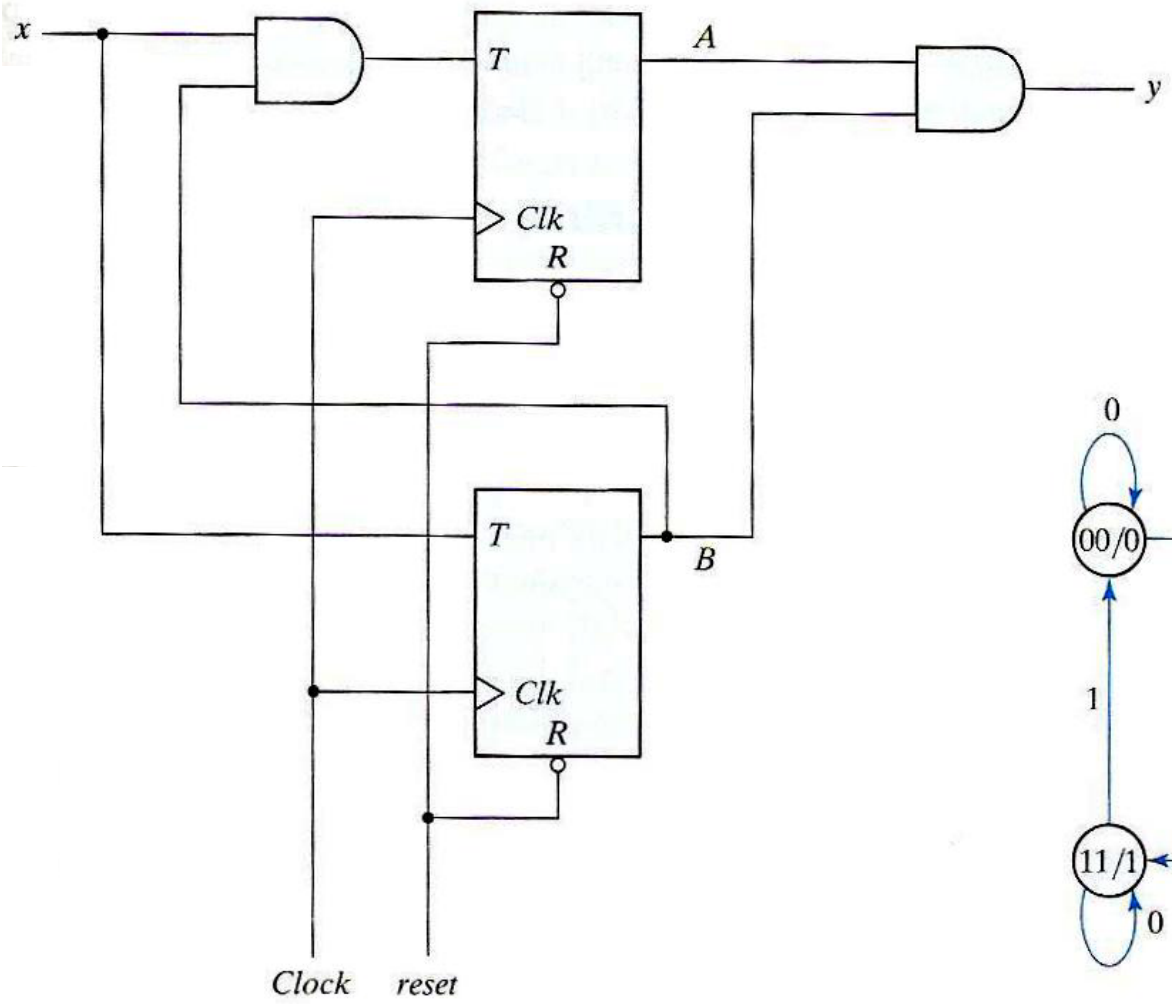
➔ state table

➔ state diagram

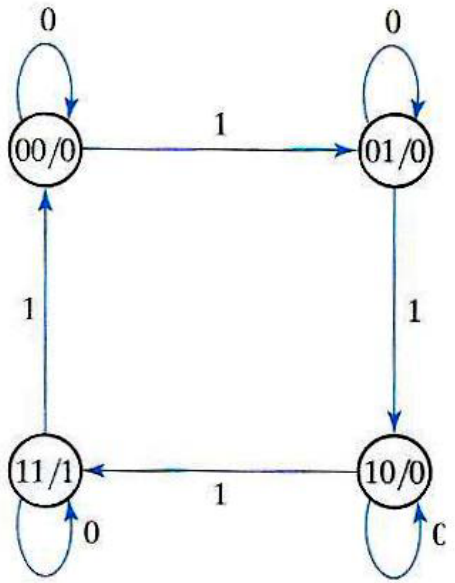
Present State		Next State				Output
		$x = 0$		$x = 1$		
A	B	A	B	A	B	y
0	0	0	1			0
0	1	1	0			0
1	0	1	1			0
1	1	0	0			1

Circuit, State Table, State Diagram

Example:



(a) Circuit diagram

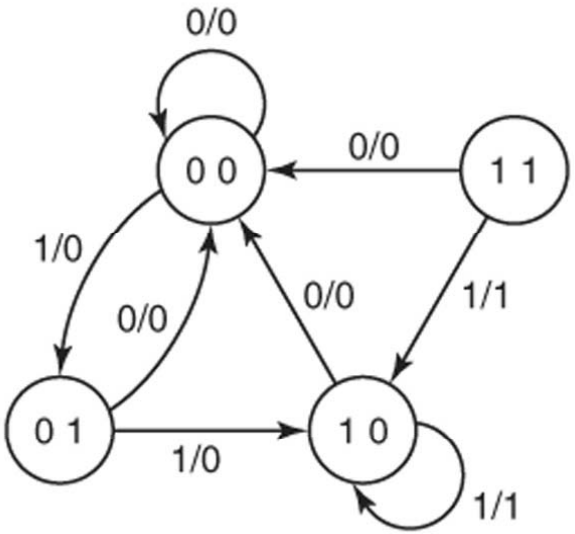


(b) State diagram

FIGURE 5.20
Sequential circuit with *T* flip-flops

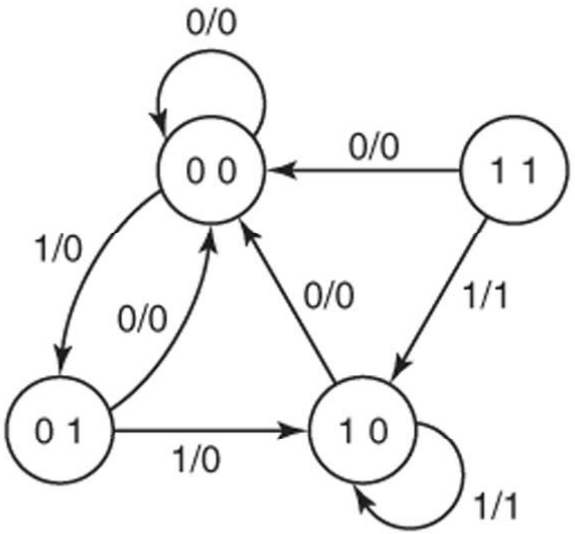
Circuit, State Diagram, State Table

Example: state diagram = state table



Circuit, State Diagram, State Table

Example: state diagram = state table



q	q^* $x=0$	q^* $x=1$	z $x=0$	z $x=1$
0 0	0 0	0 1	0	0
0 1	0 0	1 0	0	0
1 0	0 0	1 0	0	1
1 1	0 0	1 0	0	1

Circuit, State Diagram, State Table

Example: Show the state diagram of following circuit

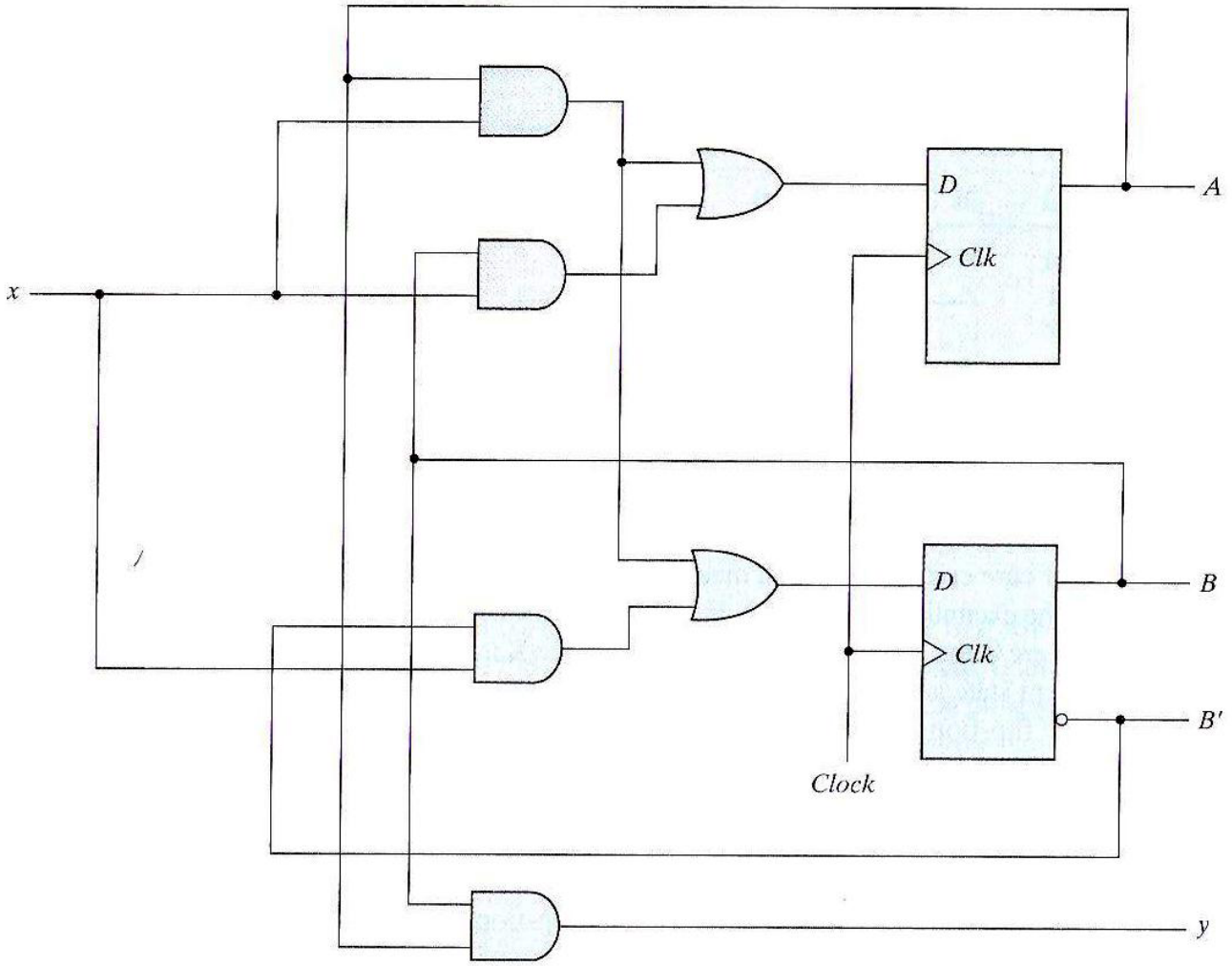


FIGURE 5.29
Logic diagram of sequence detector

Circuit, State Diagram, State Table

Example: Show the state diagram of following circuit

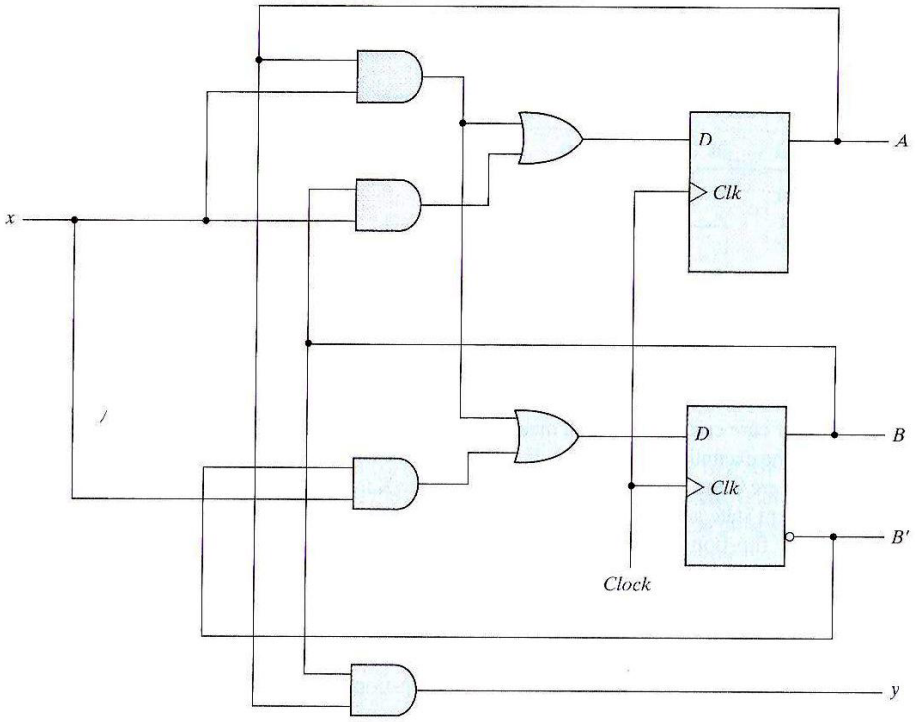


FIGURE 5.29
Logic diagram of sequence detector

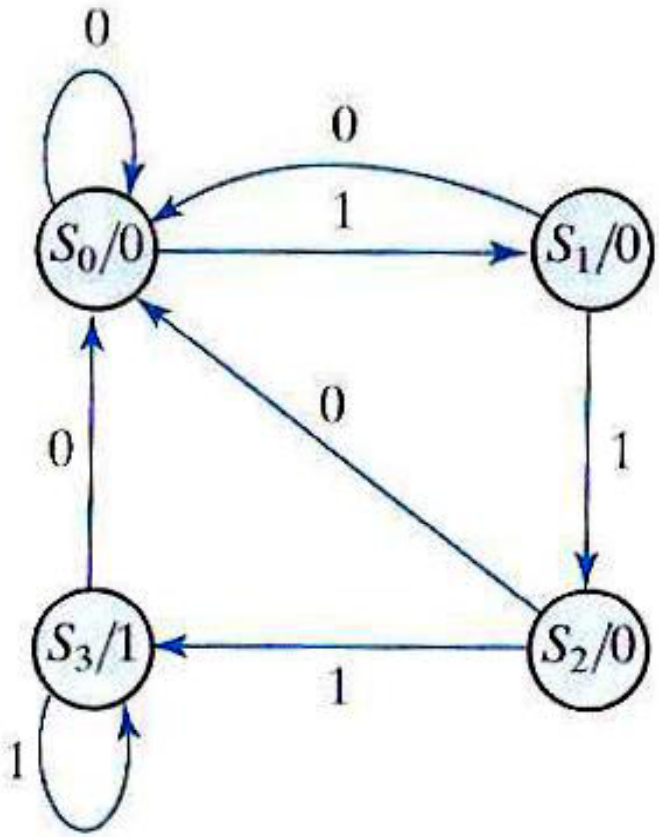


FIGURE 5.27
State diagram for sequence detector

Circuit, State Diagram, State Table

More Example: Binary Counter – show state diagram and table

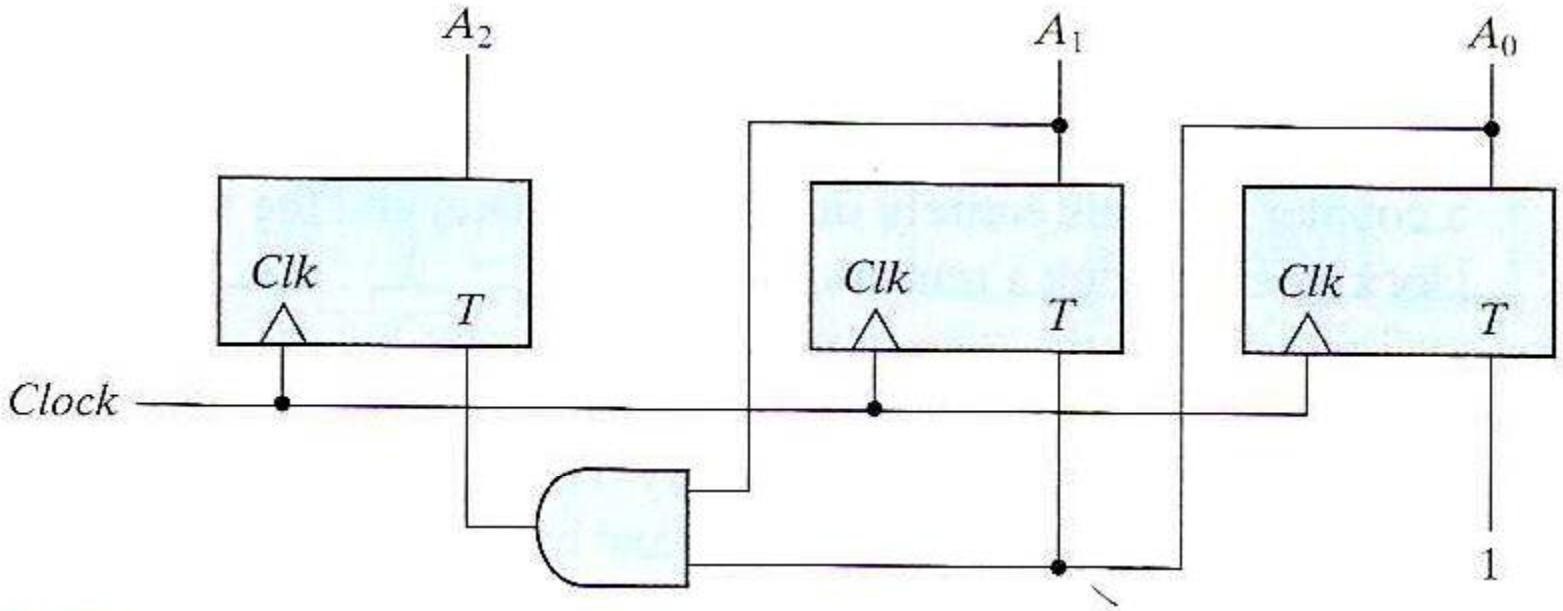


FIGURE 5.34
Logic diagram of three-bit binary counter

Circuit, State Diagram, State Table

More Example: Binary Counter – show state diagram and table

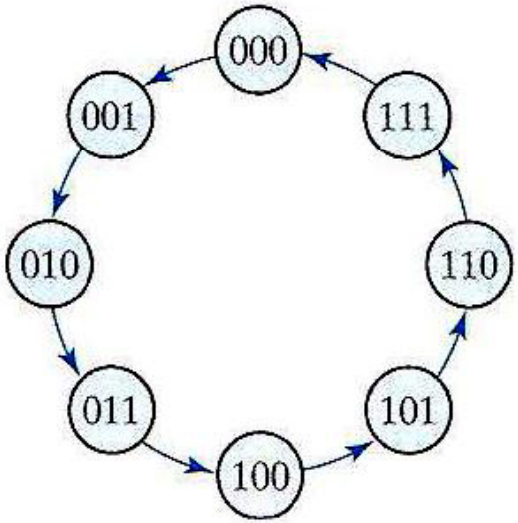


FIGURE 5.32
State diagram of three-bit binary counter

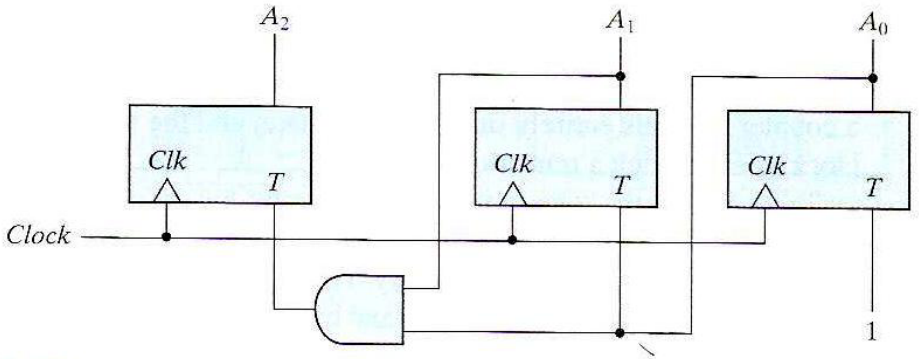


FIGURE 5.34
Logic diagram of three-bit binary counter

Circuit, State Diagram, State Table

Quiz:

http://www.eelab.usyd.edu.au/digital_tutorial/part3/t-diag.htm

Circuit, State Diagram, State Table

Quiz: solution

http://www.eelab.usyd.edu.au/digital_tutorial/part3/t-diag.htm

Circuit, State Diagram, State Table

More Example:

http://www.eelab.usyd.edu.au/digital_tutorial/part3/example1-1.htm