Lecture 19 – Sequential circuits 5

Dr. Aftab M. Hussain,

Assistant Professor, PATRIoT Lab, CVEST

Chapter 5

Design procedure

- The procedure for designing synchronous sequential circuits can be summarized by a list of recommended steps:

1. Derive a state diagram for the circuit
2. Assign binary values to the states
3. Obtain the binary-coded state table
4. Derive the simplified flip-flop input equations and output equations
5. Draw the logic diagram

The sequence of three detector

Sequence of three

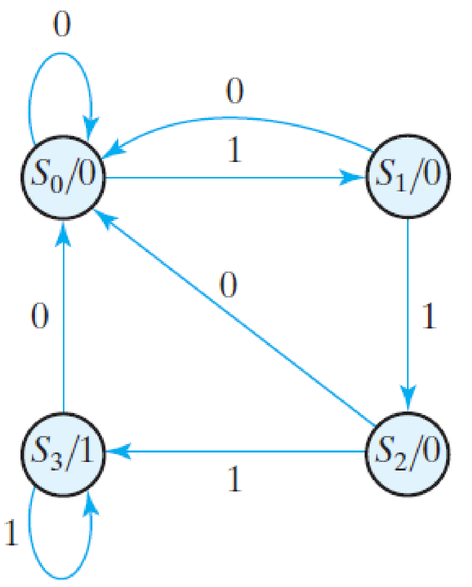
- Suppose we wish to design a circuit that detects a sequence of three or more consecutive 1’s in a string of bits coming through an input line (i.e., the input is a *serial bit stream*
- We start with state S_0, the reset state
- If the input is 0, the circuit stays in S_0, but if the input is 1, it goes to state S_1 to indicate that a 1 was detected
- If the next input is 1, the change is to state S_2 to indicate the arrival of two consecutive 1’s, but if the input is 0, the state goes back to S_0

Sequence of three

- The third consecutive 1 sends the circuit to state S_3
- If more 1's are detected, the circuit stays in S_3
- Thus, the circuit stays in S_3 as long as there are three or more consecutive 1's received
- The output is 1 when the circuit is in state S_3 and is 0 otherwise

Sequence of three

- To design the circuit, we need to assign binary codes to the states and list the state table
- The table is derived from the state diagram with a sequential binary assignment
- We choose two *D* flip-flops to represent the four states, and we label their outputs *A* and *B*
- There is one input *x* and one output *y*



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

Sequence of three

- The flip-flop input equations can be obtained directly from the next-state columns of *A* and *B* and expressed in sum-of-minterms form as:

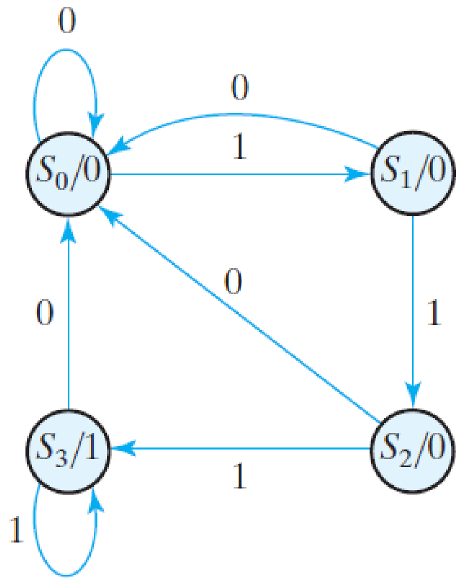
$$A(t + 1) = D_A(A, B, x) = \sum(3, 5, 7)$$

$$B(t + 1) = D_B(A, B, x) = \sum(1, 5, 7)$$

$$y(A, B, x) = \sum(6, 7)$$

- Using K-maps, we can find the expressions for D_A, D_B and y as:

$$D_A = Ax + Bx$$
$$D_B = Ax + B'x$$
$$y = AB$$



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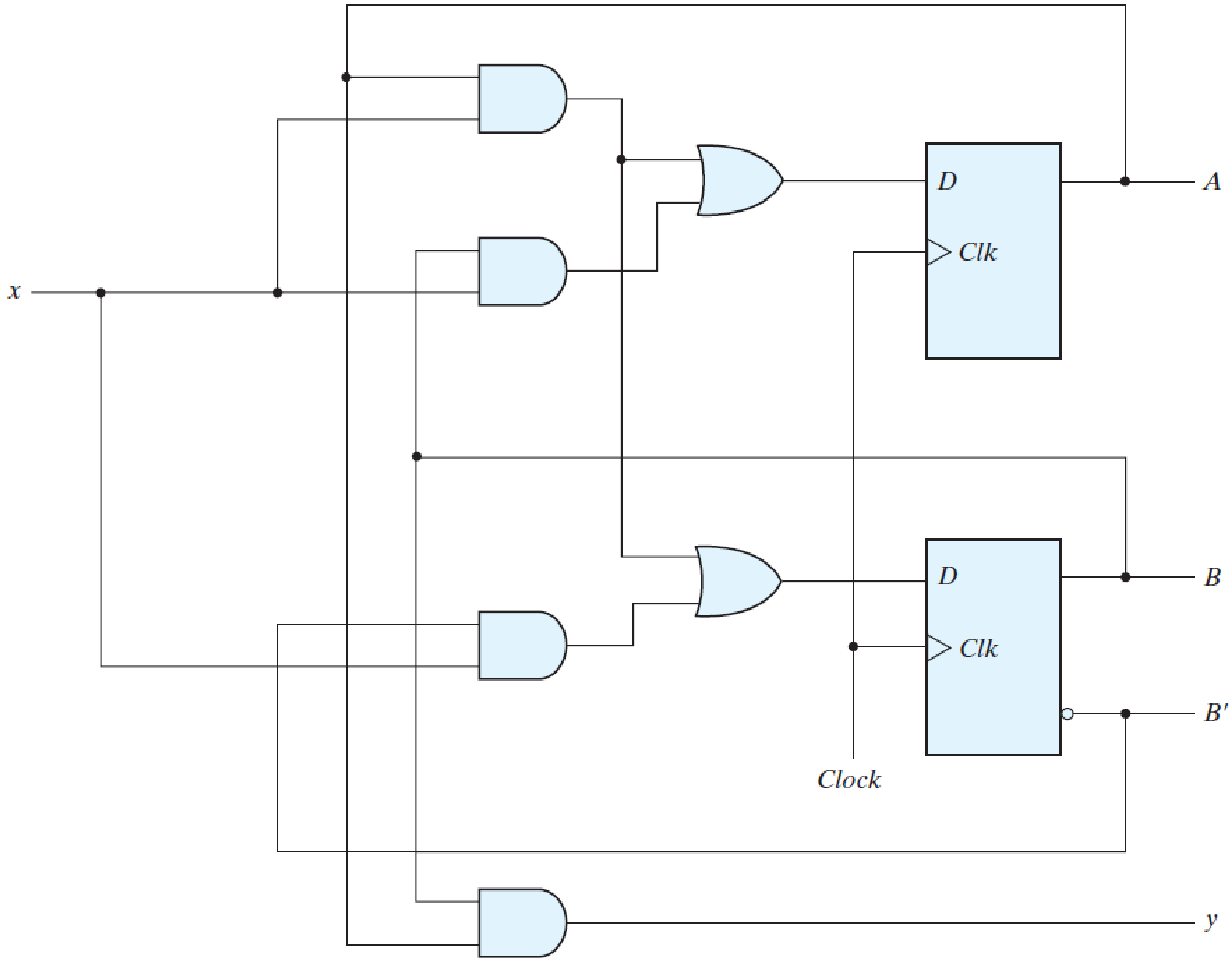
Sequence of three



The vending machine

The vending machine

- Lets say we are asked to design a circuit for a vending machine that dispenses candy for Rs. 3
- The input consists of a coin slot that can accept Rs. 1 and Rs. 2 coins
- The deposit of these coins by the user is detected by a circuit that gives out two outputs x and y – when Rs. 1 is inserted, y goes to one, and when Rs. 2 is inserted, x goes to one, for one clock cycle. x and y are at zero by default
- Only one coin can be entered at once
- We need to design a circuit that takes x and y as inputs and outputs 1 if the sum is ≥ 3, so that the machine can dispense the candy

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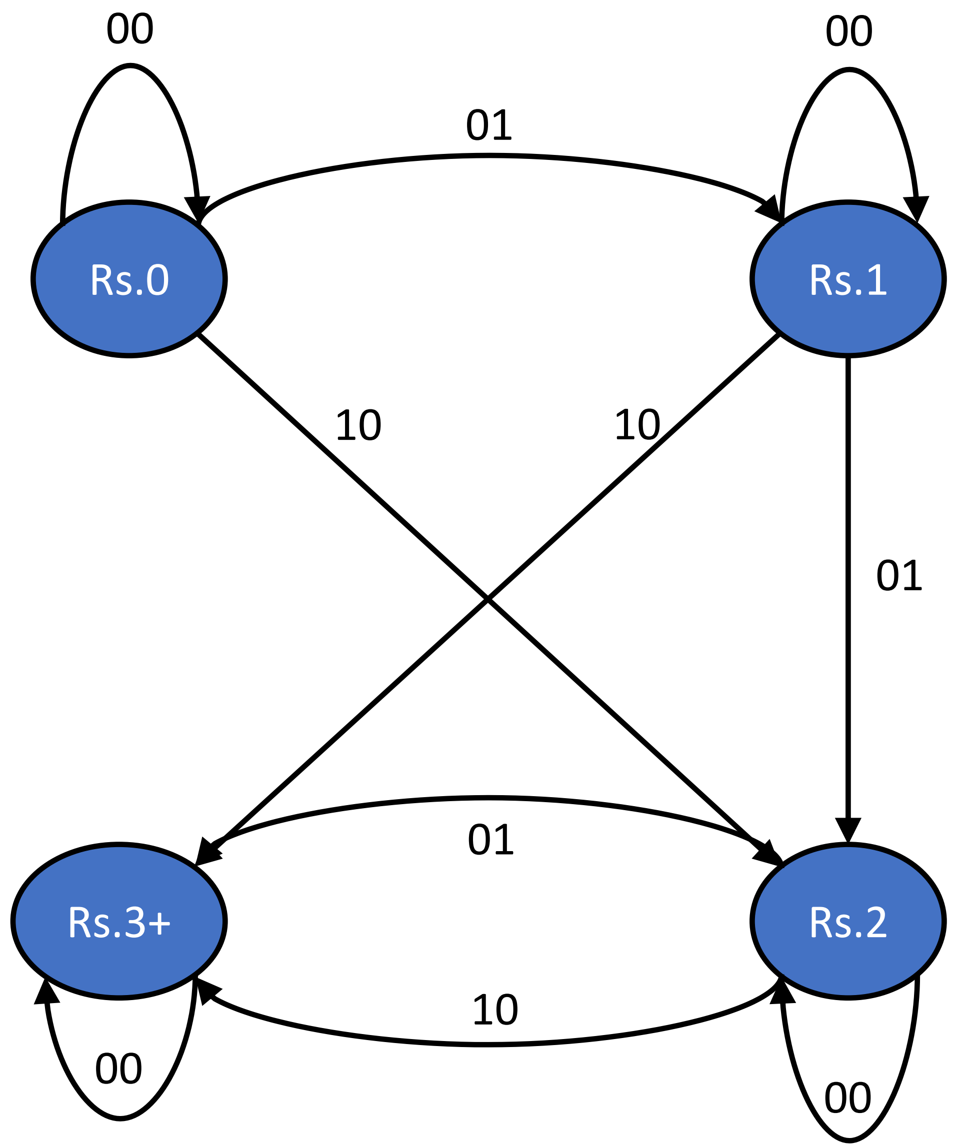
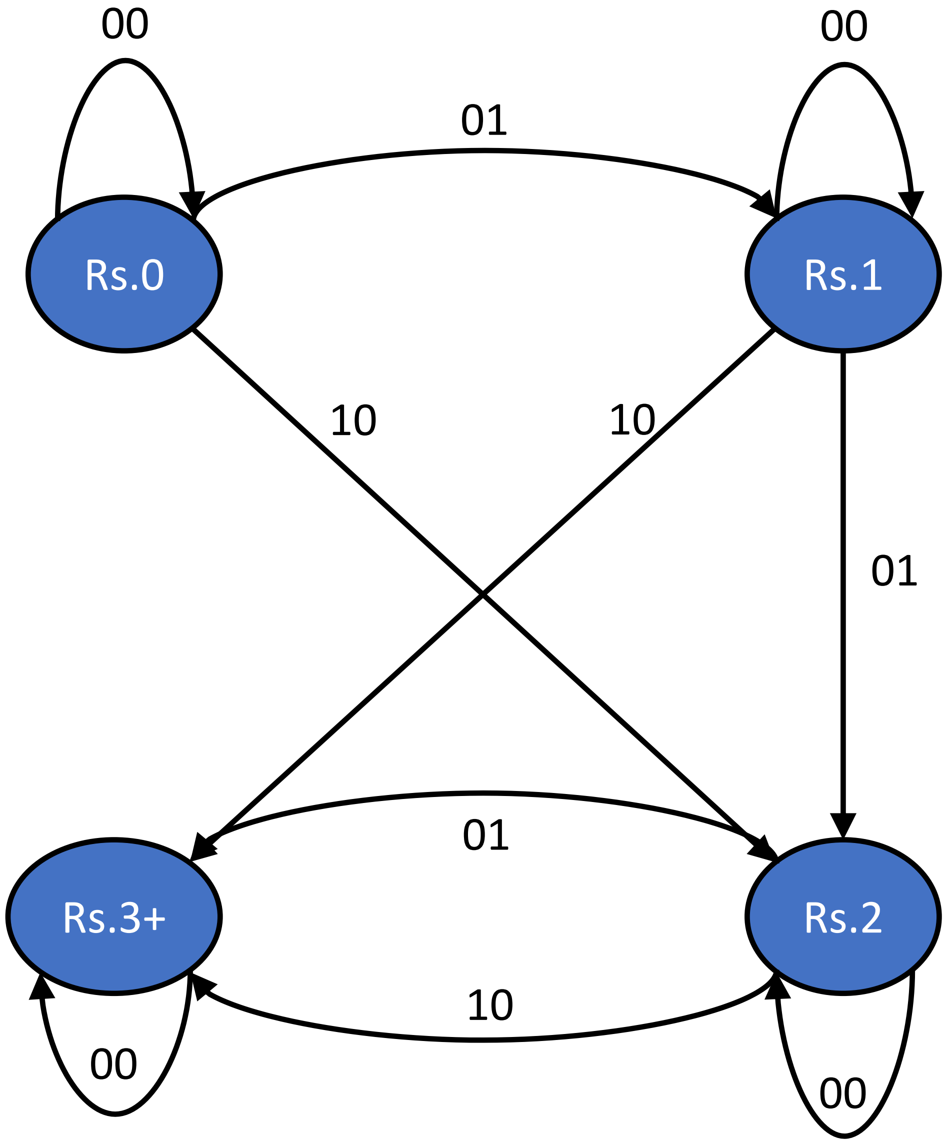
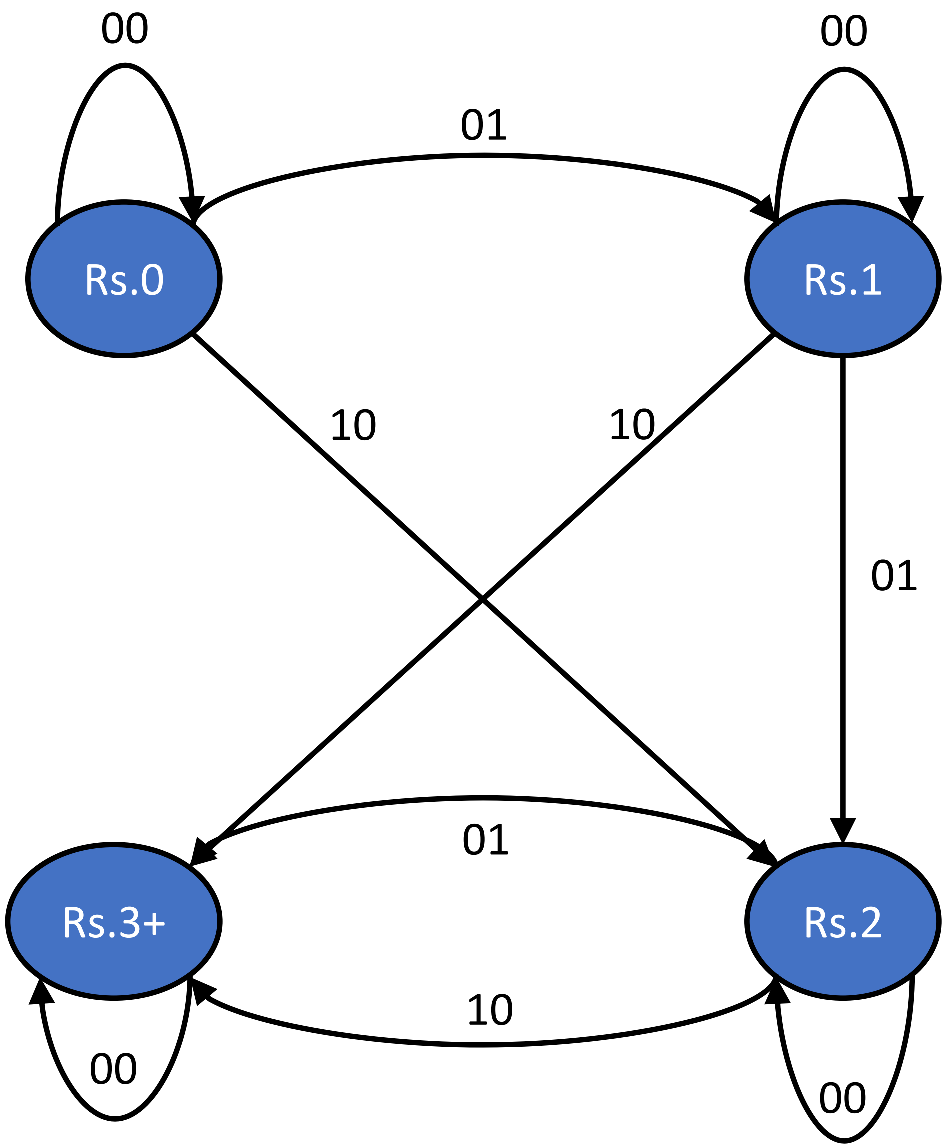


The vending machine



The vending machine

A	B	x	y	A(t+1)	B(t+1)	z
0	0	0	0	0	0	0
0	0	0	1	0	1	0
0	0	1	0	1	0	0
0	0	1	1	x	x	0
0	1	0	0	0	1	0
0	1	0	1	1	0	0
0	1	1	0	1	1	0
0	1	1	1	X	X	0
1	0	0	0	1	0	0
1	0	0	1	1	1	0
1	0	1	0	1	1	0
1	0	1	1	X	x	0
1	1	0	0	1	1	1
1	1	0	1	1	1	1
1	1	1	0	1	1	1
1	1	1	1	x	x	1



The vending machine

A(t+1)

AB \ xy	00	01	11	10
00	m_0 0	m_1 0	m_3 X	m_2 1
01	m_4 0	m_5 1	m_7 X	m_6 1
11	m_{12} 1	m_{13} 1	m_{15} X	m_{14} 1
10	m_8 1	m_9 1	m_{11} X	m_{10} 1

x, y, A, B

$$A(t+1) = A + x + By$$

The vending machine

B(t+1)

AB \ xy	00	01	11	10
00	m_0 0	m_1 1	m_3 X	m_2 0
01	m_4 1	m_5 0	m_7 X	m_6 1
11	m_{12} 1	m_{13} 1	m_{15} X	m_{14} 1
10	m_8 0	m_9 1	m_{11} X	m_{10} 1

x

B

A

y

$$B(t+1) = (B + y + Ax)(B' + y' + A)$$