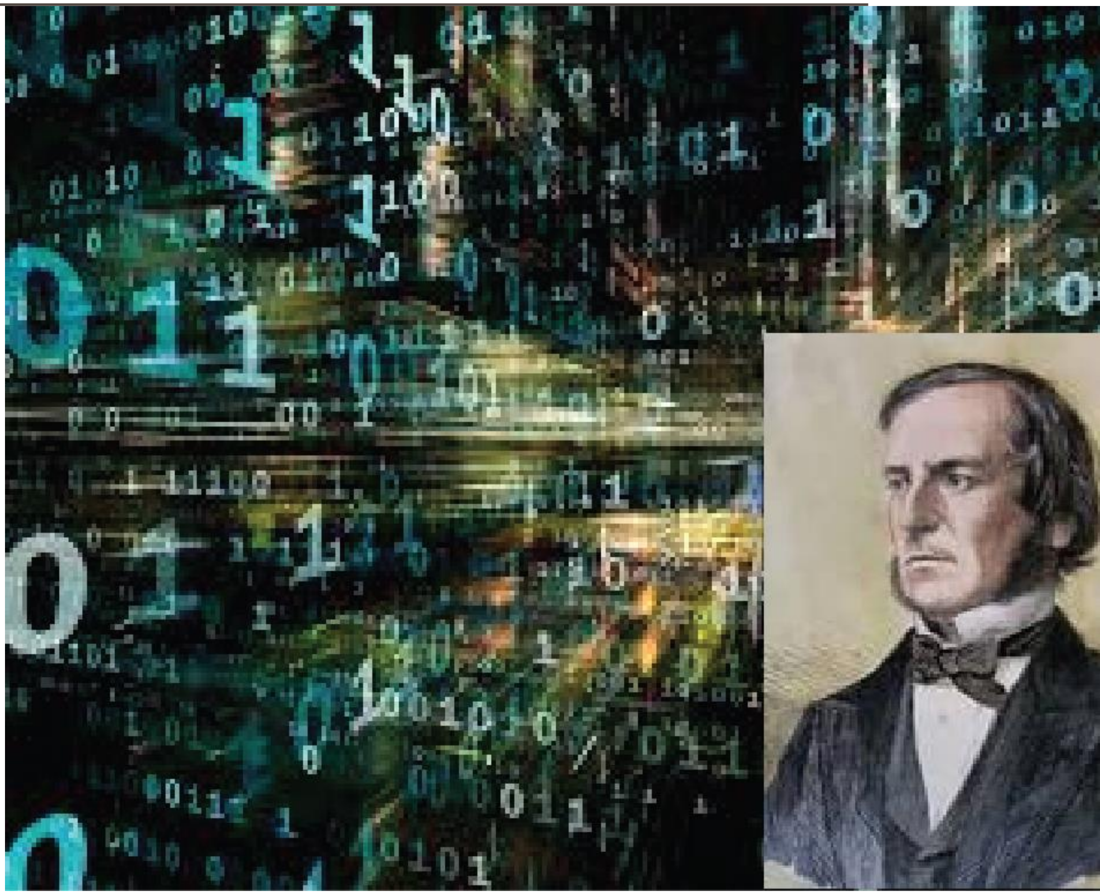
DIGITAL CIRCUITS

Week-12, Lecture-3
Sequential Circuits



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2nd November, 2018

Digital Circuits: Announcements/Revision

Sequential Circuits

Design

Sequential Circuit: Design

Sequential Circuit Design:

- Given a behavior, find a suitable hardware (a sequential circuit)
- Behaviour: Word Problem or State Diagram or State Table
- Hardware: Flip-flops (D, JK or T type) and combinational circuit elements

Sequential Circuit: Steps

Sequential Circuit Design:

1. From the word description and specifications of the desired operation, derive a state diagram for the circuit.
2. Reduce the number of states if necessary.
3. Assign binary values to the states.
4. Obtain the binary-coded state table.
5. Choose the type of flip-flops to be used.
6. Derive the simplified flip-flop input equations and output equations.
7. Draw the logic diagram.

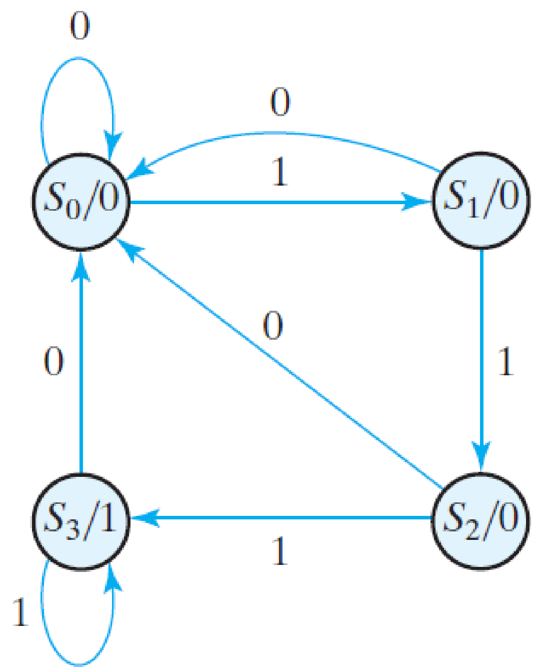
Sequential Circuit Design: Example (1)

Problem 1:

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).

Sequential Circuit Design:

1. From the word description and specifications of the desired operation, derive a state diagram for the circuit.



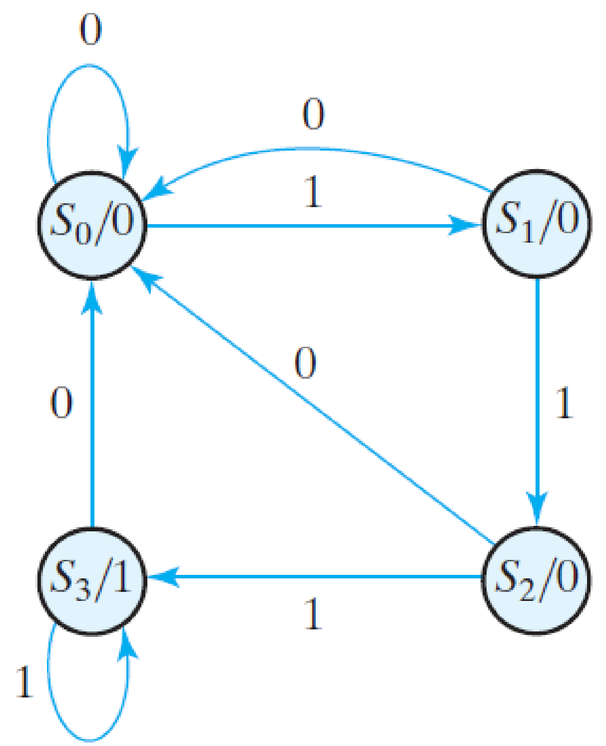
- S_0 is the initial (reset) state
- Moore model: Output is 1 when the state is S_3 else it is 0.

Sequential Circuit Design: Example (2)

Sequential Circuit Design:

2. Reduce the number of states if necessary.
3. Assign binary values to the states.

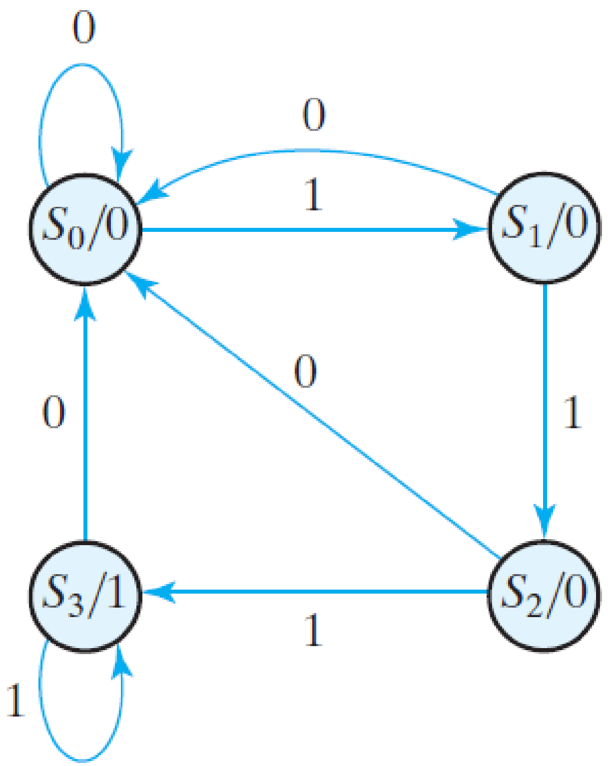
- Assign states as follows:
  - S_0 is 00, S_1 is 01, S_2 is 10 and S_3 is 11
- Each state is represented using 2 bits
  - Two flip-flops are required (lets call them as A and B)



Sequential Circuit Design: Example (3)

Sequential Circuit Design:

4. Obtain the binary-coded state table.



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

Sequential Circuit Design: Example (4)

Sequential Circuit Design:

5. Choose the type of flip-flops to be used.

6. Derive the simplified flip-flop input equations and output equations.

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

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

$$\mathrm{y(t)} = \mathrm{y}(A, B, x) = \Sigma(6, 7)$$

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

Sequential Circuit Design: Example (5)

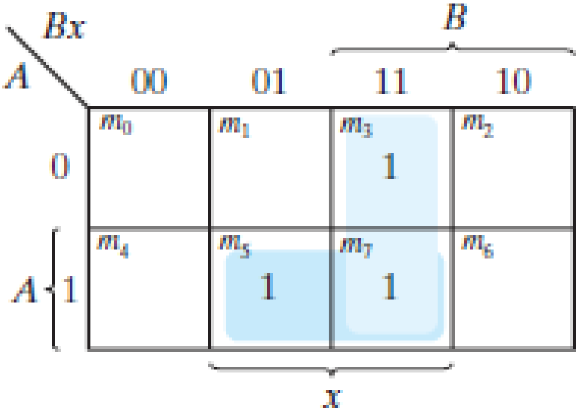
Sequential Circuit Design:

6. Derive the simplified flip-flop input equations and output equations.

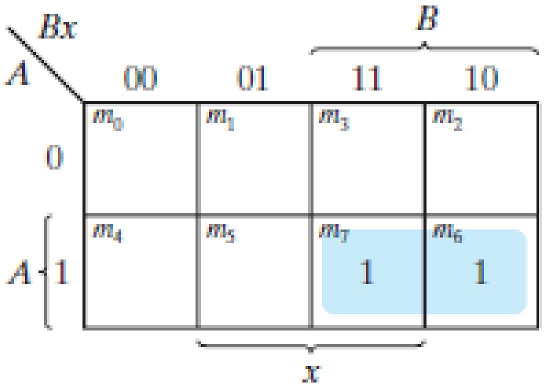
$A(t+1) = D_A(A,B,x) = \Sigma(3,5,7)$

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

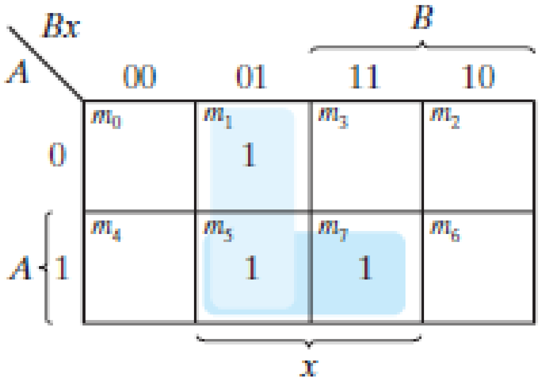
$y(t) = y(A,B,x) = \Sigma(6,7)$



$D_A = Ax + Bx$



$y = AB$



$D_B = Ax + B'x$

$D_A(A,B,x) = Ax + Bx$

$D_B(A,B,x) = Ax + B'x$

$y(A,B,x) = AB$

Sequential Circuit Design: Example (6)

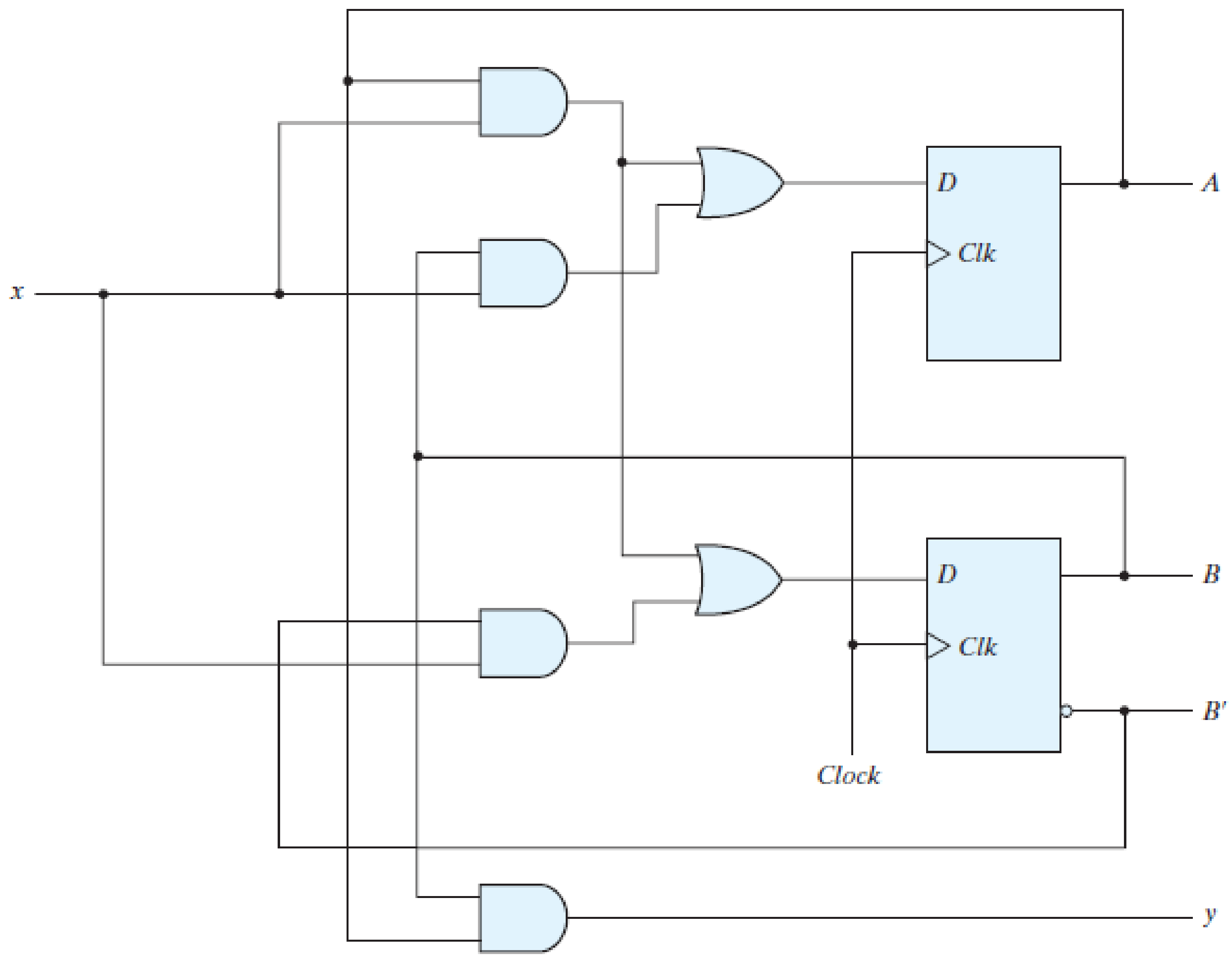
Sequential Circuit Design:

7. Draw the logic diagram

$D_A(A, B, x) = Ax + Bx$

$D_B(A, B, x) = Ax + B'x$

$y(A, B, x) = AB$



Sequential Circuit Design: Excitation Table

Characteristics Table/Function:

- Given a current state and the inputs, what would be the next state
- Useful for Analysis

Excitation Table/Function:

- Given a current state and the next state, what are the required inputs
- Useful for Synthesis

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

(a) *JK* Flip-Flop

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

(b) *T* Flip-Flop

Digital Circuits: Practice Problems

Problems 5.9-5.10, 5.16-5.19

from “Digital Design”– M. Morris Mano & Michael D. Ciletti, Ed-5, Pearson (Prentice-Hall).