Unit 4.2
Sequential Systems Design

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Bibliography

- Digital Design.
  M. Morris Mano. Prentice-Hall
- Introduction to Digital Logic Design.
  John P. Hayes. Addison-Wesley

Introduction

- Systematic way of designing any machine that passes through different states.

Examples: Counter, traffic lights, vending machine...

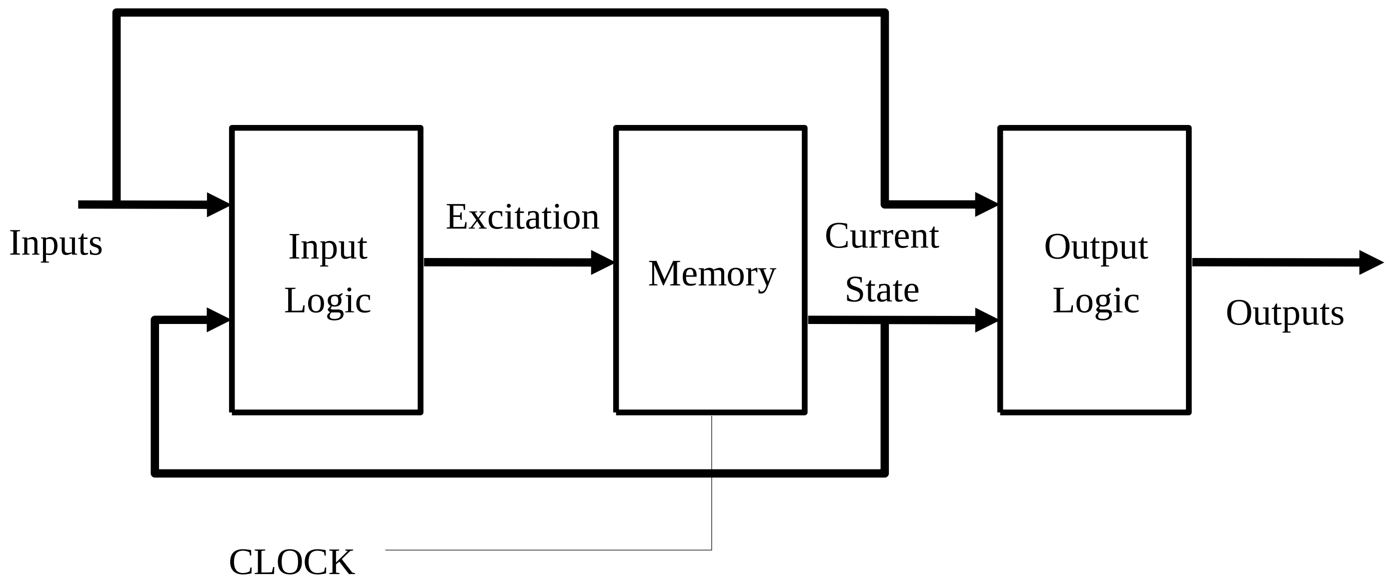
- Generally called ***Finite State Machines/Automatas***

- Two types:

Mealy Machines

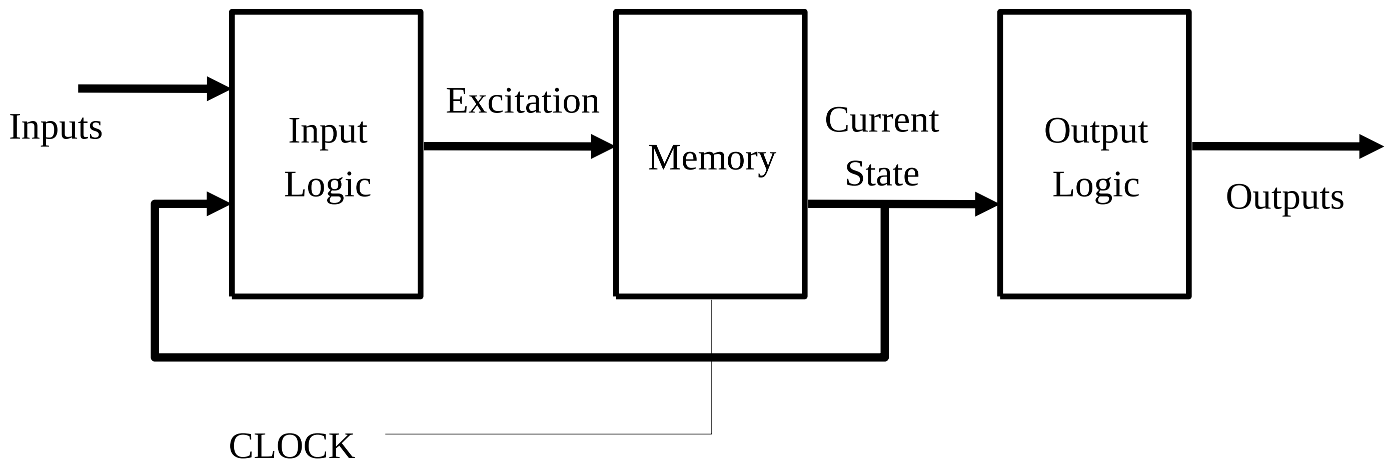
Moore Machines

Mealy Machine



Outputs are a function of both **inputs** and **current state**

Moore Machine



Outputs are a function of **current state only**

Steps to design

1- Understand specifications of the problem

2- Choose Mealy/Moore based on simplicity

3- Draw state diagram

4- Codify states and outputs and choose flip-flops

5- Obtain output function

6- Write transition and excitation table

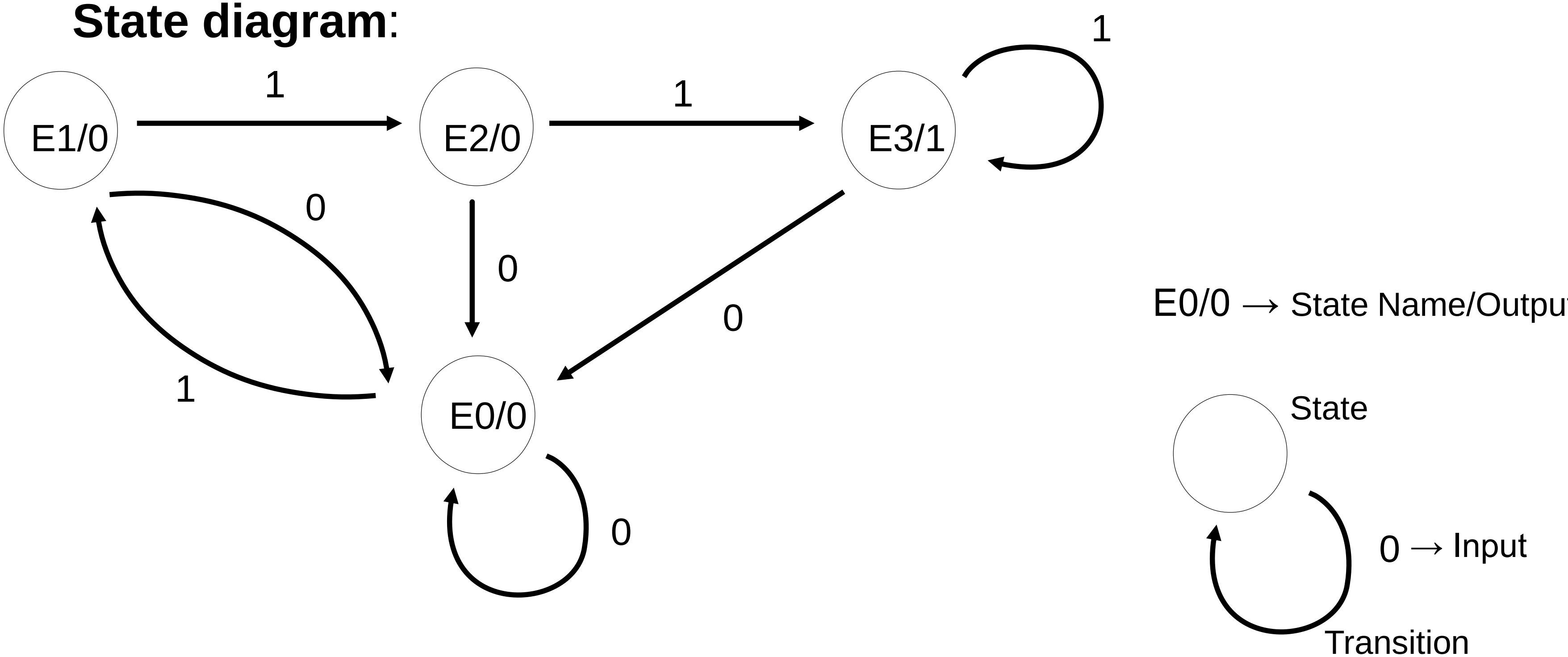
7- Obtain and simplify excitation functions

8- Implement the circuit

Example 1: Moore (I)

Design a Moore automata that detects a sequence of tree or more “1” in the input: ...111...

State diagram:



Example 1: Moore (II)

Codify states and outputs:

-There are 4 states so we need two bits to codify them

-We use two JK flip-flops

-Codification:

States	JKs	Output
	Q1 Q0	Z
E0	0 0	0
E1	0 1	0
E2	1 0	0
E3	1 1	1

Obtain output function:

Z = Q1 Q0

Example 1: Moore (III)

Write transition and excitation table:

Current state	Input	Next state	JK excitation	
$Q1^t$ $Q0^t$	Y	$Q1^{t+1}Q0^{t+1}$	J1 K1	J0 K0
E0: 0 0	0	0 0	0 X	0 X
E0: 0 0	1	0 1	0 X	1 X
E1: 0 1	0	0 0	0 X	X 1
E1: 0 1	1	1 0	1 X	X 1
E2: 1 0	0	0 0	X 1	0 X
E2: 1 0	1	1 1	X 0	1 X
E3: 1 1	0	0 0	X 1	X 1
E3: 1 1	1	1 1	X 0	X 0

JK Excitation table

Q^t Q^{t+1}	J K
0 0	0 X
0 1	1 X
1 0	X 1
1 1	X 0

Example 1: Moore (IV)

Obtain and simplify excitation function:

-Obtain J1, K1, J0 and K0 in terms of $Q1^{t+1}$, $Q0^{t+1}$ and Y using Karnaugh

-Example

J1 = Q0 Y

Q1 \ Q0Y	00	01	11	10
0			1	
1	X	X	X	X

Doing the other Karnaugh Maps:

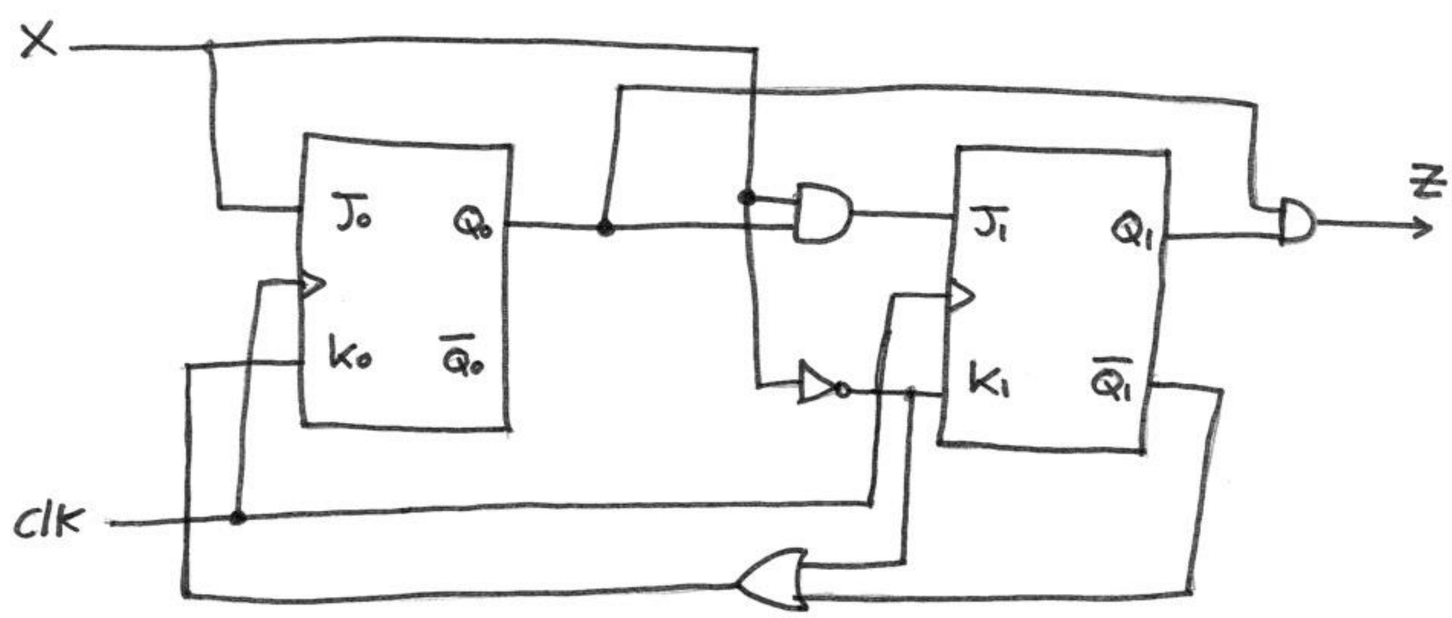
K1 = Y!

J0 = Y

K0 = Q1! + Y!

Example 1: Moore (V)

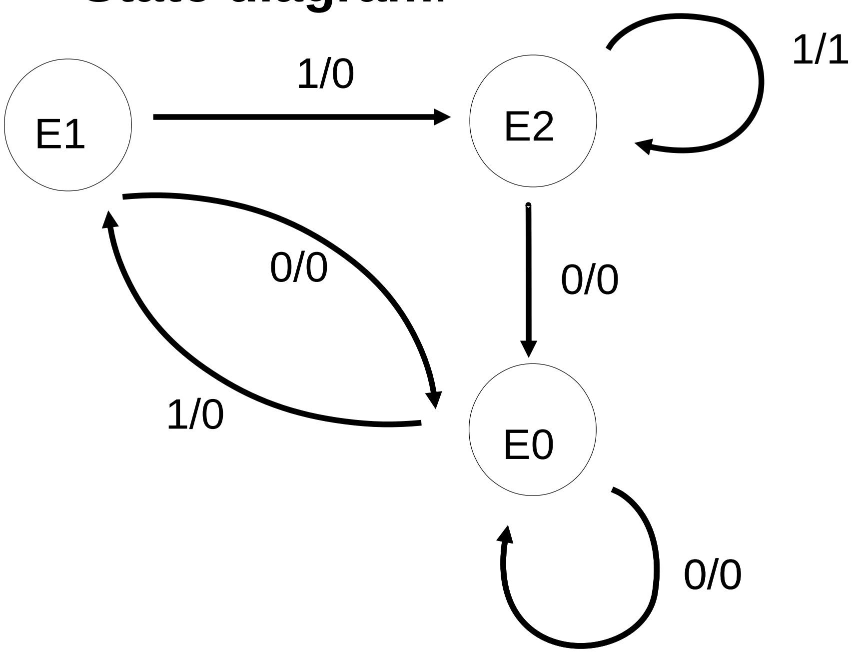
Implement the circuit:

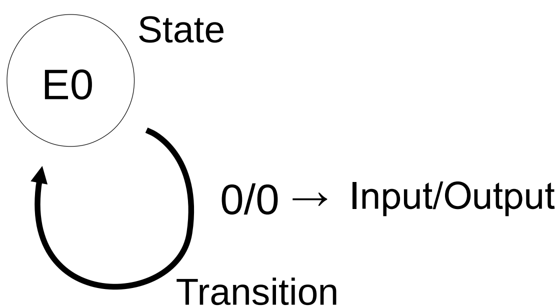


Example 2: Mealy (I)

Design a Mealy automata that detects a sequence of tree or more “1” in the input: ...111...

State diagram:





Example 2: Mealy (II)

Codify states and outputs:

-There are 3 states so we need two bits to codify them

-We use two JK flip-flops

-Codification:

States	JKs		Input	Output
	Q1	Q0	Y	Z
E0	0	0	0	0
E0	0	0	1	0
E1	0	1	0	0
E1	0	1	1	0
E2	1	0	0	0
E2	1	0	1	1
E3	1	1	0	X
E3	1	1	1	X

Obtain output function:

Q1 \ Q0Y	00	01	11	10
0				
1		1	X	X

Z = Y Q1

Example 2: Meally (III)

Write transition and excitation table:

Current state	Input	Next state	JK excitation	
$Q1^t$ $Q0^t$	Y	$Q1^{t+1}Q0^{t+1}$	J1 K1	J0 K0
E0: 0 0	0	0 0	0 X	0 X
E0: 0 0	1	0 1	0 X	1 X
E1: 0 1	0	0 0	0 X	X 1
E1: 0 1	1	1 0	1 X	X 1
E2: 1 0	0	0 0	X 1	0 X
E2: 1 0	1	1 0	X 0	0 X
E3: 1 1	0	X X	X X	X X
E3: 1 1	1	X X	X X	X X

JK Excitation table

Q^t Q^{t+1}	J K
0 0	0 X
0 1	1 X
1 0	X 1
1 1	X 0

Example 2: Mealy (IV)

Obtain and simplify excitation function:

-Obtain J1, K1, J0 and K0 in terms of $Q1^{t+1}$, $Q0^{t+1}$ and Y using Karnaugh

-Example

J1 = Q0 Y

Q1 \ Q0Y	00	01	11	10
0			1	
1	X	X	X	X

Doing the other Karnaugh Maps:

K1 = Y!

J0 = Y Q1!

K0 = 1

Example 2: Mealy (V)

Implement the circuit: