Sequential logic design

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November 21, 2022

1 Objectives

1. Analyse and design both Mealy and Moore sequential circuits with multiple inputs and multiple outputs
2. Convert between Mealy and Moore designs

2 Mealy vs Moore Finite State Machines

Definition 1 (Finite State Machines (FSM))**.** *[1, Sec 3.4]*

FSM is another name for sequential circuits.
FSM is defined in opposition to Infinite State Machines (Turing Machines).

Definition 2 (Mealy FSM)**.** *[1, Sec 3.4.3]*

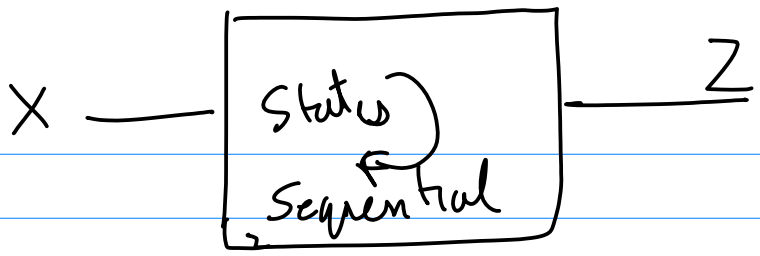
Mealy FSM have outputs that depend up on both inputs and the state of the circuit or the FSM.

Definition 3 (Moore FSM)**.** *[1, Sec 3.4.3]*

Moore FSM have outputs that depend only upon the states of the FSM.

seq detector

Example 1. *A sequential circuit has one input (X) and one output (Z). The circuit examines groups of four consecutive inputs and produces an output Z=1 if the input sequence 0010 or 0001 occurs. The sequences can overlap. Draw both Mealy and Moore timing diagrams. Find the Mealy and Moore state graph.*



0 0 1 0] Z = 1
0 0 0 1

otherwise Z = 0

X 0 0 0 1 0 0 1 1 0 0 1 0 ← Arbitrary example

Mealy output Z 0 0 0 1 1 0 0 0 0 0 0 1

(states)

Moore output Z 0 0 0 0 1 1 0 0 0 0 0 1

X 0 0 0 1 0 0 1 1 0 0 1 0

Mealy Z 0 0 0 1 1 0 0 0 0 0 1 1

Moore Z 0 0 0 0 1 1 0 0 0 0 1 1

Practice Problem 1. *A sequential circuit has one input (X) and one output (Z). The circuit examines groups of four consecutive inputs and produces an output Z=1 if the input sequence 0101 or 1001 occurs. The circuit resets after every four inputs. Draw both Mealy and Moore timing diagrams. Find the Mealy and Moore state graph.*

Inputs

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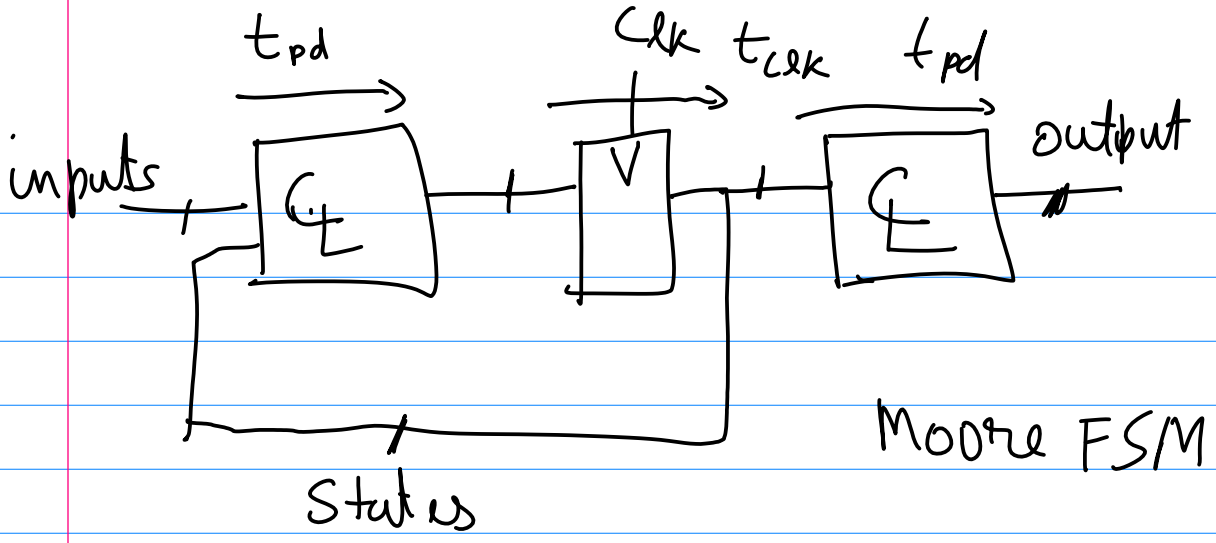
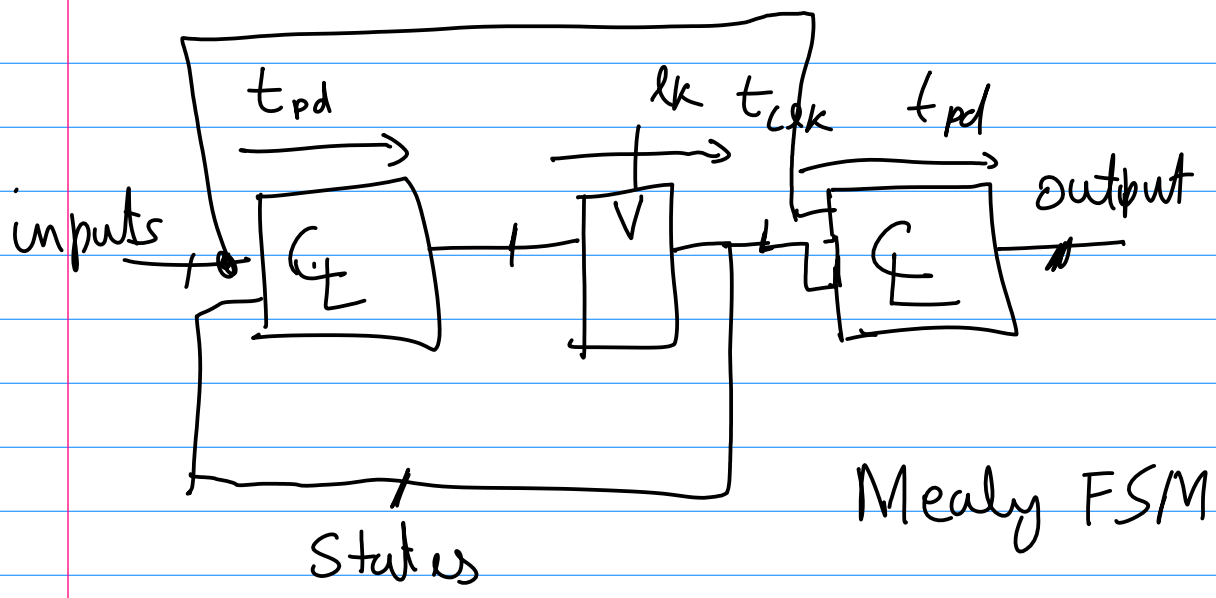
References

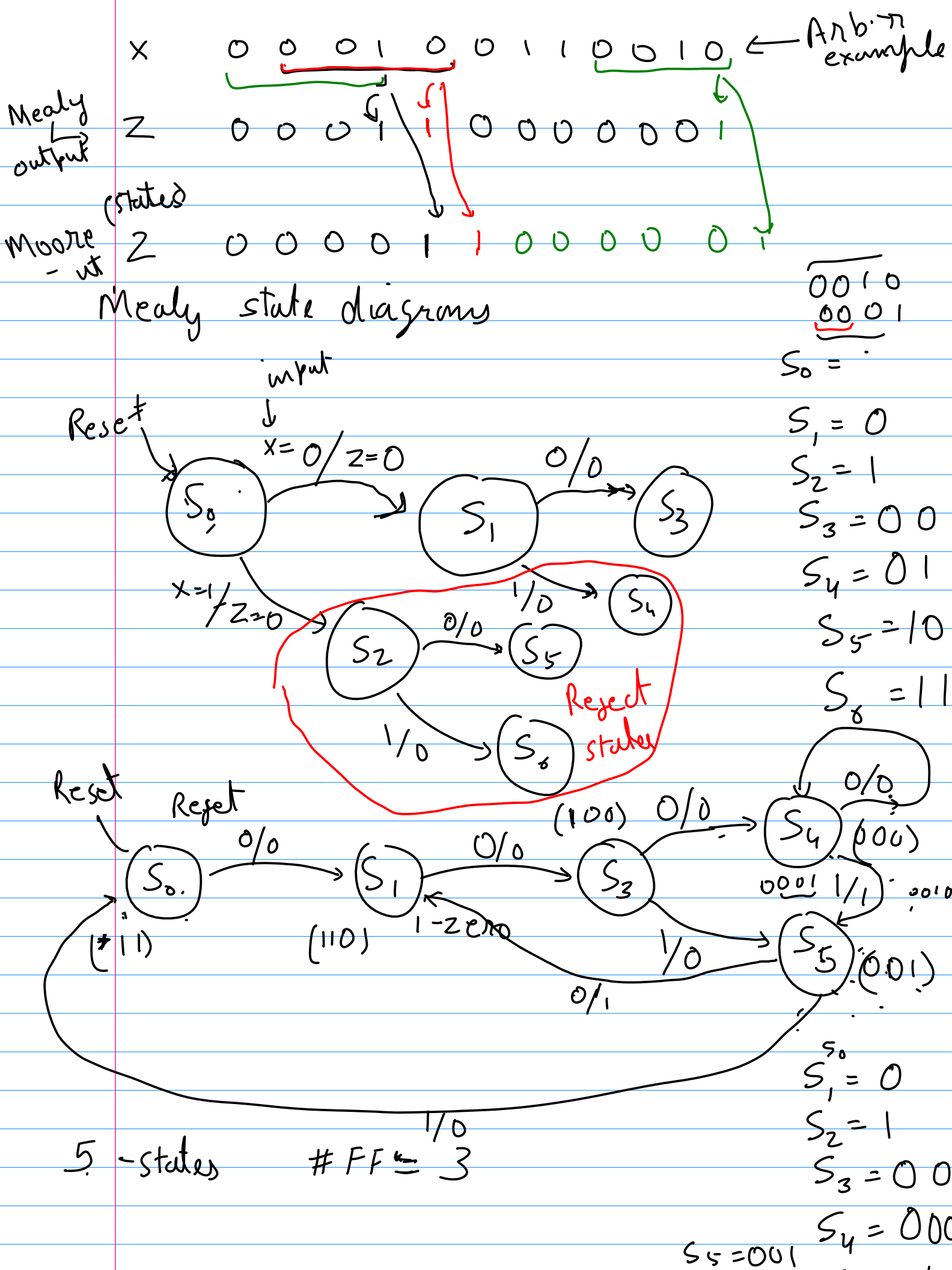
[1] Sarah L Harris and David Harris. *Digital design and computer architecture*. Morgan Kaufmann, 2022.



Moore FSM



Mealy FSM


X
0 0 0 1 0 0 1 1 0 0 1 0
Arb. → example
Mealy output
Z
0 0 0 1 1 0 0 0 0 0 0 1
(states)
Moore - ut
Z
0 0 0 0 1 1 0 0 0 0 0 1
Mealy state diagram
input
Reset
x=0/z=0
0/0
x=1/z=0
1/0
0/0
1/0
Reject states
Reset
Reset
0/0
0/0
(100)
0/0
0/0
(001)
001
1/1
010
(111)
(110)
1-zero
1/0
0/1
(001)
1/0
5 -states
FF = 3
0010
0001
S_0 =
S_1 = 0
S_2 = 1
S_3 = 0 0
S_4 = 0 1
S_5 = 10
S_6 = 11
S_0
S_1 = 0
S_2 = 1
S_3 = 0 0
S_4 = 000
S_5 = 001

$C_2\ C_1\ C_0$

$S_0 = 0\ 0\ 0$

$S_1 = 0\ 0\ 1$

$S_3 = 0\ 1\ 1$

$S_4 = 1\ 0\ 0$

$S_5 = 1\ 0\ 1$