Digital Logic IV: Finite State Machines

CMSC 313
Sections 01, 02

Sequential Circuits

2

TOPICS TODAY

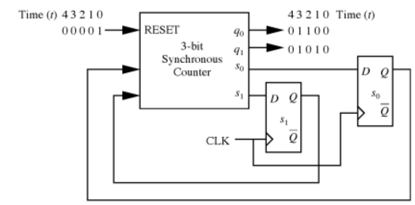
- Finite State Machines
- Example: Mod-4 Counter
- Example: Vending Machine

FINITE STATE MACHINES

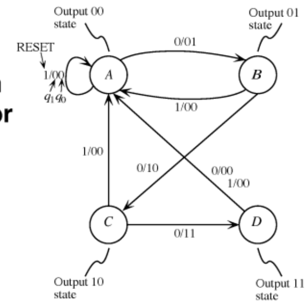
EXAMPLE: MOD 4 COUNTER

Example: Modulo-4 Counter

- Counter has a clock input (CLK) and a RESET input.
- Counter has two output lines, which take on values of 00, 01, 10, and 11 on subsequent clock cycles.



State Transition Diagram for Mod-4 Counter



State Table for Mod-4 Counter

Present state \ Input	*RESET* 0	*RESET* 1
A	*B*/01	*A*/00
B	*C*/10	*A*/00
C	*D*/11	*A*/00
D	*A*/00	*A*/00

Next state — Output

State Assignment for Mod-4 Counter

Present state (S_t) \ Input	*RESET* 0	*RESET* 1
A:00	01/01	00/00
B:01	10/10	00/00
C:10	11/11	00/00
D:11	00/00	00/00

Truth Table for Mod-4 Counter

RESET $r(t)$	$s_1(t)$	$s_0(t)$	$s_1s_0(t+1)$	$q_1q_0(t+1)$
0	0	0	01	01
0	0	1	10	10
0	1	0	11	11
0	1	1	00	00
1	0	0	00	00
1	0	1	00	00
1	1	0	00	00
1	1	1	00	00

$$s_0(t+1) = \overline{r(t)}\,\overline{s_1(t)}\,\overline{s_0(t)} + \overline{r(t)}s_1(t)\overline{s_0(t)}$$

$$s_1(t+1) = \overline{r(t)}\,\overline{s_1(t)}s_0(t) + \overline{r(t)}s_1(t)\overline{s_0(t)}$$

$$q_0(t+1) = \overline{r(t)}\,\overline{s_1(t)}\,\overline{s_0(t)} + \overline{r(t)}s_1(t)\overline{s_0(t)}$$

$$q_1(t+1) = \overline{r(t)}\,\overline{s_1(t)}s_0(t) + \overline{r(t)}s_1(t)\overline{s_0(t)}$$

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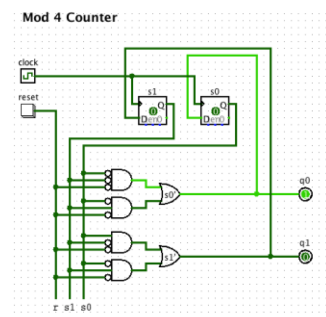
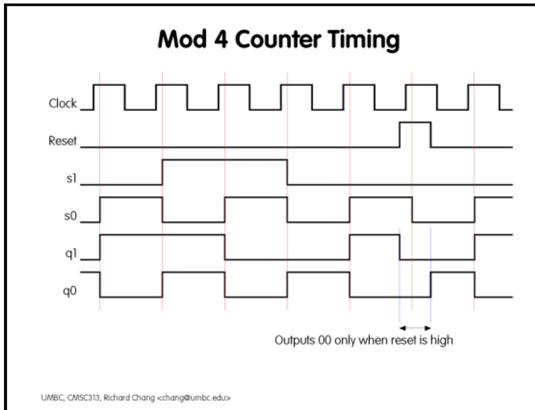
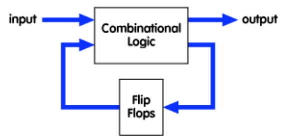


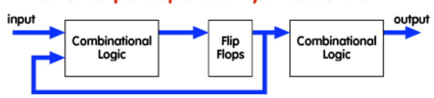


Mealy vs Moore Finite State Machines

- Mealy: output depends on input and state bits



- Moore: output depends only on state bits



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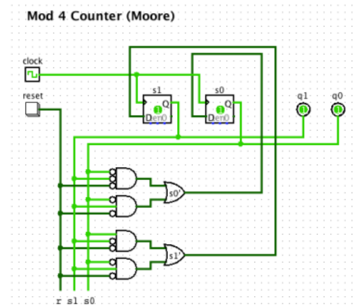
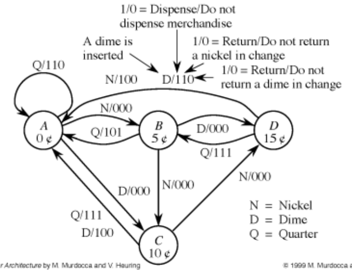


EXAMPLE: VENDING MACHINE

Example: A Vending Machine Controller

- Example: Design a finite state machine for a vending machine controller that accepts nickels (5 cents each), dimes (10 cents each), and quarters (25 cents each). When the value of the money inserted equals or exceeds twenty cents, the machine vends the item and returns change if any, and waits for next transaction.
- Implement with PLA and D flip-flops.

Vending Machine State Transition Diagram



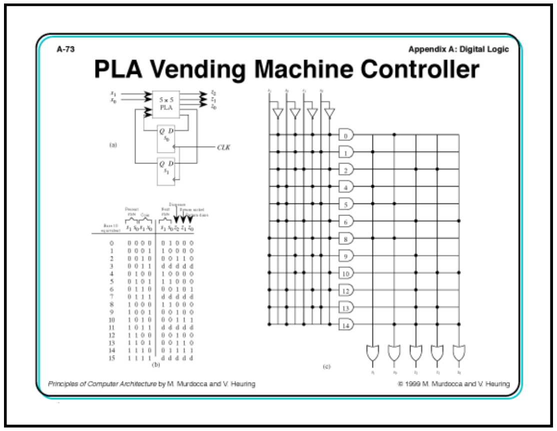
Vending Machine State Table and State Assignment

P.S. \ Input	N 00	D 01	Q 10
A	*B*/000	*C*/000	*A*/110
B	*C*/000	*D*/000	*A*/101
C	*D*/000	*A*/100	*A*/111
D	*A*/100	*A*/110	*B*/111

(a)

P.S. \ Input	N x_1x_0 00	D x_1x_0 01	Q x_1x_0 10
s_1s_0	s_1s_0 / $z_2z_1z_0$		
A:00	01/000	10/000	00/110
B:01	10/000	11/000	00/101
C:10	11/000	00/100	00/111
D:11	00/100	00/110	01/111

(b)


A-73
Appendix A: Digital Logic
PLA Vending Machine Controller
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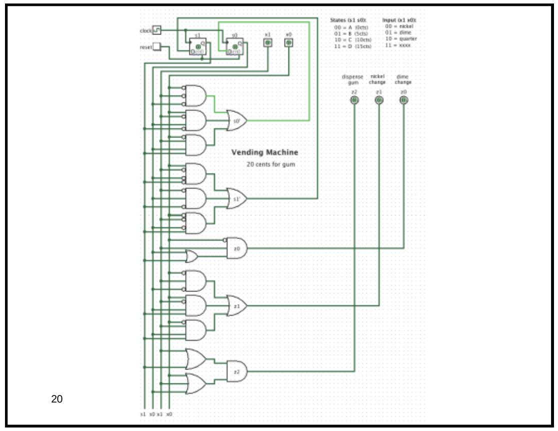
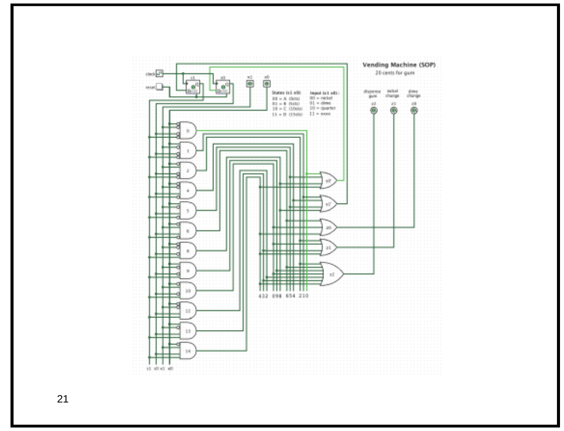

Vending Machine
20 cents for gum
20


Vending Machine (SOP)
20 cents for gum
21