Digital Logic and Design
CMPS4252
Final Project
Osborn Collins and Mark Pascual
15th November 2022

INSTRUCTIONS
==========

NOTE: This project can be done in PAIRS (both persons must present) or individually.

DUE DATE: November 21, 2022, by 11:30 pm
Note: Provide a link to your YouTube video and a link to your PowerPoint slides on GitHub

QUESTION:

You have been enlisted to design a soda machine dispenser for the IT department students' lounge. Sodas are partially subsidized by the student chapter of the ACM, so they cost only 25 cents each. The machine accepts 5 cents, 10 cents, and shillings. When enough coins have been inserted, it dispenses the soda and returns any necessary change. Design an FSM controller for the soda machine. The FSM inputs are 5 cents, 10 cents, and shilling, indicating which coin was inserted. Assume that exactly ONE coin is inserted on each cycle. The outputs are Dispense, Return5Cents, Return10Cents, and ReturnTwo10Cents. When the FSM reaches 25 cents, it asserts Dispense and the necessary Return outputs required to deliver the appropriate change. Then it should be ready to start accepting coins for another soda.

NOTE: I have given you the FSM except that it uses nickels (5), dimes (10), and quarters (25).

TASKS:

PART 1

Provide:

0. The modified FSM (showing 5 cents, 10 cents and shillings instead of nickels, dimes, and quarters)
1. The State Encoding table
[HINT: Use 10 bits to represent each of the 10 states (S0 - S45).
Use a one-hot encoding scheme with S0 = 0000000001 and S45 = 1000000000
2. The State Transition table and the resulting simplified equations
3. The Output table and the resulting simplified equations
4. The circuit

PART 2

Provide:

0. A PowerPoint presentation (between 25 - 30 minutes). This presentation will explain how the FSM works, how you arrived at the state transition equations, how you arrived at the output equations, and how the circuit works.

GRADING CRITERIA
==========
1. Clarity of explanation (conciseness)
2. Length of presentation (between 25 - 30 minutes)

FSM

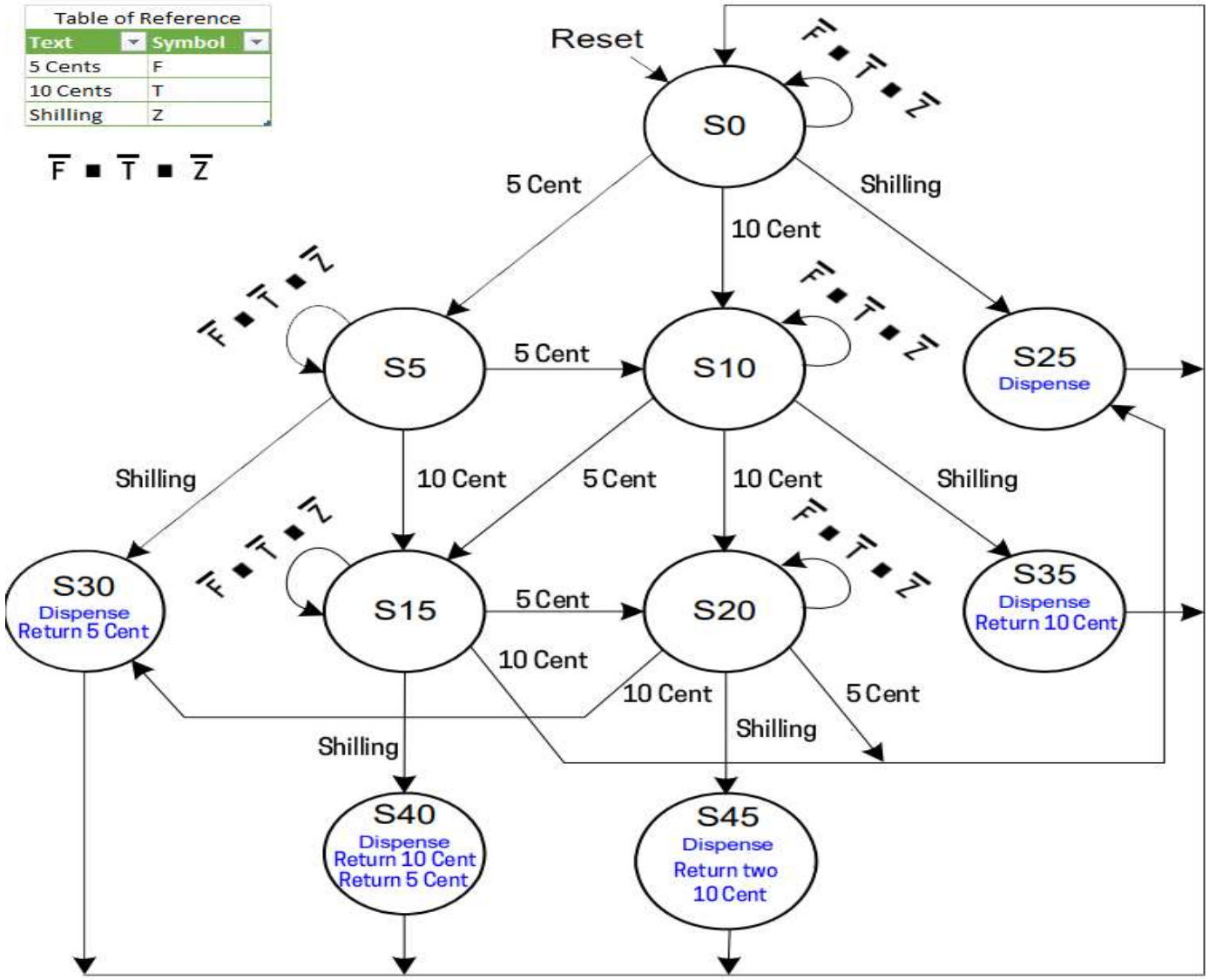
Table of Reference
Text
Symbol
5 Cents
F
10 Cents
T
Shilling
Z
F ■ T ■ Z
Reset
S0
5 Cent
10 Cent
Shilling
S5
S10
S25
Dispense
S30
Dispense
Return 5 Cent
S15
S20
S35
Dispense
Return 10 Cent
S40
Dispense
Return 10 Cent
Return 5 Cent
S45
Dispense
Return two
10 Cent

State encoding

State	Encoding $S_{9:0}$
S0	0000000001
S5	0000000010
S10	0000000100
S25	0000001000
S30	0000010000
S15	0000100000
S20	0001000000
S35	0010000000
S40	0100000000
S45	1000000000

Definitions:

5 cents – F

10 cents – T

Shilling – Z

State transition table

Current state	Inputs			Next state
S	F (five cent)	T (ten cent)	Z (shilling)	S’
S0	0	0	0	S0
S0	0	0	1	S25
S0	0	1	0	S10
S0	1	0	0	S5
S5	0	0	0	S5
S5	0	0	1	S30
S5	0	1	0	S15
S5	1	0	0	S10
S10	0	0	0	S10
S10	0	0	1	S35
S10	0	1	0	S20
S10	1	0	0	S15
S25	X	X	X	S0
S30	X	X	X	S0
S15	0	0	0	S15
S15	0	0	1	S40
S15	0	1	0	S25
S15	1	0	0	S20
S20	0	0	0	S20
S20	0	0	1	S45
S20	0	1	0	S30
S20	1	0	0	S25
S35	X	X	X	S0
S40	X	X	X	S0
S45	X	X	X	S0

State transition table with encoding

Current State S										Inputs			Next State S'									
S_9	S_8	S_7	S_6	S_5	S_4	S_3	S_2	S_1	S_0	F	T	Z	S'_9	S'_8	S'_7	S'_6	S'_5	S'_4	S'_3	S'_2	S'_1	S'_0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	X	X	X	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	1	0	0	0	0	X	X	X	0	0	0	0	0	0	0	0	0	1
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
0	0	1	0	0	0	0	0	0	0	X	X	X	0	0	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	0	0	X	X	X	0	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	X	X	X	0	0	0	0	0	0	0	0	0	1

Boolean Equations

$S'_9 = S_6Z$

$S'_8 = S_5Z$

$S'_7 = S_2Z$

$S'_6 = S_2T + S_5F + S_6\bar{F}\bar{T}\bar{Z}$

$S'_5 = S_1T + S_2F + S_5\bar{F}\bar{T}\bar{Z}$

$S'_4 = S_1Z + S_6T$

$S'_3 = S_0Z + S_5T + S_6F$

$S'_2 = S_0T + S_1F + S_2\bar{F}\bar{T}\bar{Z}$

$S'_1 = S_0F + S_1\bar{F}\bar{T}\bar{Z}$

$S'_0 = S_1\bar{F}\bar{T}\bar{Z} + S_3 + S_4 + S_7 + S_8 + S_9$

Definitions:

rF – Return 5 Cent

rT – Return 10 Cent

r2T – Return two 10 Cent

Output Table

Current State	Dispense	rF	rT	r2T
S25	1	X	X	X
S30	1	1	X	X
S35	1	X	1	X
S40	1	1	1	X
S45	1	X	X	1

Output Table with Encoding

Current State										Output			
S_9	S_8	S_7	S_6	S_5	S_4	S_3	S_2	S_1	S_0	Dispense	rF	rT	r2T
0	0	0	0	0	0	1	0	0	0	1	X	X	X
0	0	0	0	0	1	0	0	0	0	1	1	X	X
0	0	1	0	0	0	0	0	0	0	1	X	1	X
0	1	0	0	0	0	0	0	0	0	1	1	1	X
1	0	0	0	0	0	0	0	0	0	1	X	X	1

Boolean Equations for the Output

Dispense = $S_3 + S_4 + S_7 + S_8 + S_9$

rF = $S_4 + S_8$

rT = $S_7 + S_8$

r2T = S_9

Circuit Diagram