BRAC UNIVERSITY

Inspiring Excellence

CSE 460

VLSI DESIGN

Lab Assignment 4

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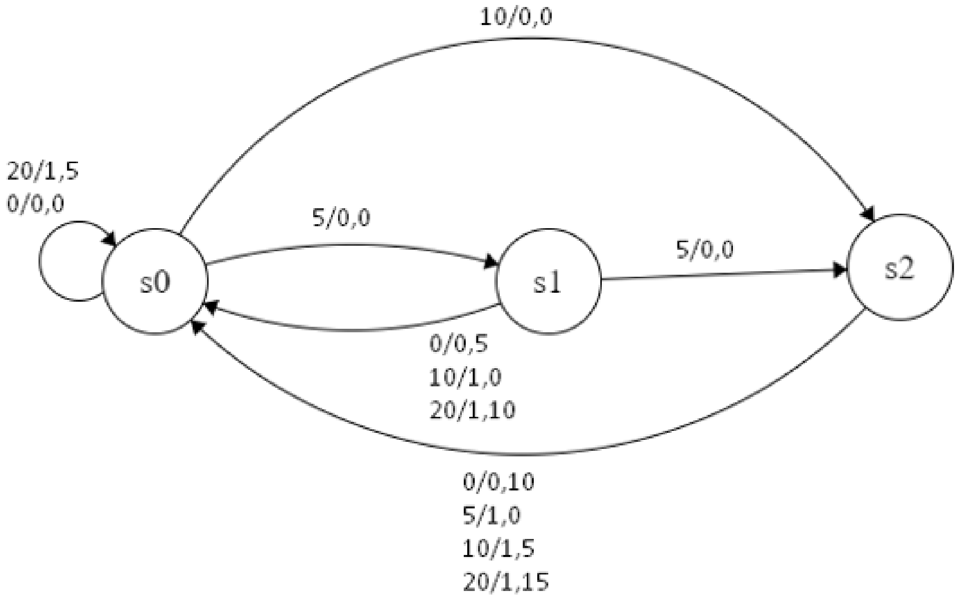
Problem: You have to design a vending machine in Quartus for a 15 Tk product. User's money, returned money by the machine, and product bought condition is represented as cash_in (2-bit input), chg (output), and buy respectively. The vending machine can only accept three inputs: no money (cash_in = 00), Tk 10 (cash_in = 01), and Tk 20 (cash_in = 10). Once an acceptable input is more than or equal to 15 Tk, the machine immediately generates an output (buy=1), goes back to the initial state, and gives back the change (if required).

1)State Diagram:



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2) How many types of changes (return) will the machine produce? How many bit/bits should 'chg' output have to represent the returned money in the code?

Ans. The machine will give back 0, 5, 10, and 15 Taka. For the returned money to be represented in the code, the chg output will require 2 bit. Binary representations of the return money are 0tk=00, 5tk=01, 10tk=10, and 15tk=11

3) State-assigned table:

Present state	Next State				Output				Change			
	0	5	10	20	0	5	10	20	0	5	10	2
S0	S0	S1	S2	S0	0	0	0	1	0	0	0	5
S1	S0	S2	S0	S0	0	0	1	1	5	0	0	10
S2	S0	S0	S0	S0	0	1	1	1	10	0	5	15 (11)

4) Verilog Code:

```
module lab4(cash_in, rst, clk, purchase, cash_return);
/*
cash_in=0,5,10,20 TK
price = 15 TK
*/
input [1:0] cash_in;
input rst, clk;
output reg purchase;
output reg [1:0] cash_return;

reg [1:0]current_state,next_state;

parameter state0 = 2'b00, state1 = 2'b01, state2 = 2'b10;

always @(current_state, cash_in)
```

```
case (current_state)
state0: if (cash_in == 2'b00)
begin
next_state = state0;
purchase = 0;
cash_return = 0;
end
else if (cash_in ==2'b01)
begin
next_state = state1;
purchase = 0;
cash_return = 0;
end
else if (cash_in ==2'b10)
begin
next_state = state2;
purchase = 0;
cash_return = 0;
end
else if (cash_in ==2'b11)
begin
next_state = state0;
purchase = 1;
cash_return = 2'b01;
end
state1: if (cash_in == 2'b00)
begin
next_state = state0;
```

```
purchase = 0;
cash_return = 2'b01;
end
else if (cash_in ==2'b01)
begin
next_state = state2;
purchase = 0;
cash_return = 0;
end
else if (cash_in ==2'b10)
begin
next_state = state0;
purchase = 1;
cash_return = 2'b00;
end
else if (cash_in ==2'b11)
begin
next_state = state0;
purchase = 1;
cash_return = 2'b10;
end
state2: if (cash_in == 2'b00)
begin
next_state = state0;
purchase = 0;
cash_return = 2'b10;
end
else if (cash_in ==2'b01)
```

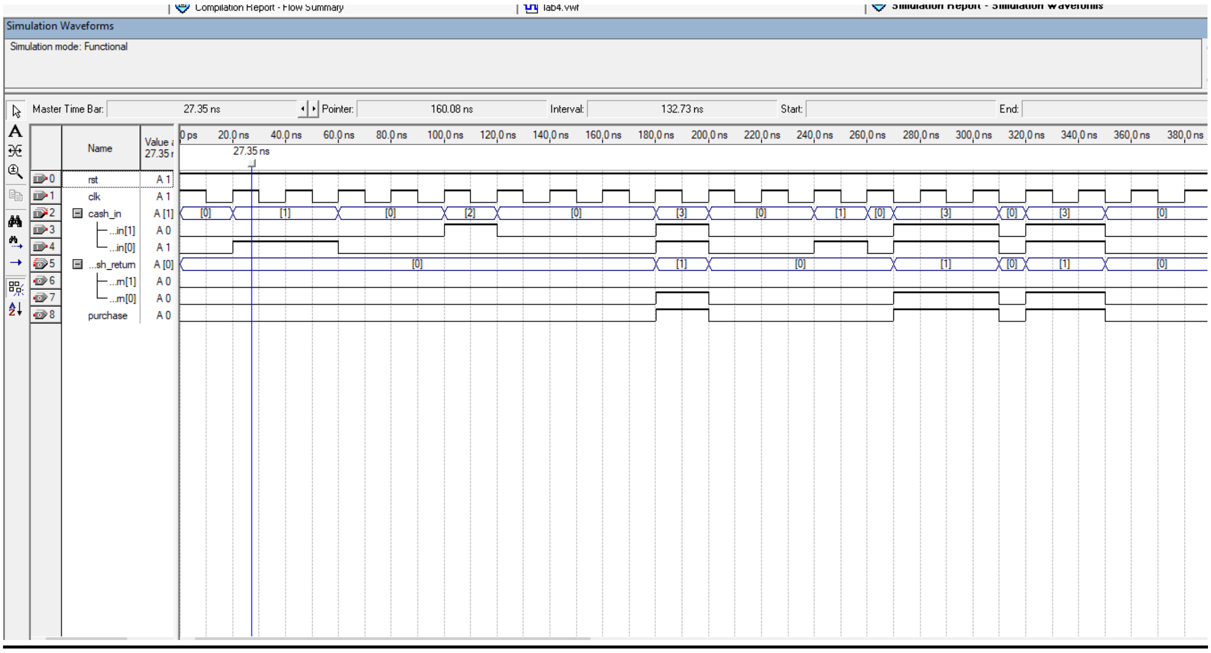
```
begin
next_state = state0;
purchase = 1;
cash_return = 0;
end
else if (cash_in ==2'b10)
begin
next_state = state0;
purchase = 1;
cash_return = 2'b01;
end
else if (cash_in ==2'b11)
begin
next_state = state0;
purchase = 1;
cash_return = 2'b11;
end


endcase

always @(posedge rst, posedge clk)
if (rst == 1)
current_state <= state0;
else
current_state <= next_state;

endmodule
```

5) Simulation:


Compilation Report - Flow Summary
lab4.vwf
Simulation Report - Simulation Waveforms
Simulation Waveforms

Simulation mode: Functional

Master Time Bar: 27.35 ns Pointer: 160.08 ns Interval: 132.73 ns Start: End:

Explanation: In this experiment, we created a vending machine that only accepts 0 tk, 5tk,10 tk, and 20 tk as input and will offer us a product worth 15 tk while giving us the additional money back. Here, if we insert 10TK, the machine will wait till we insert another 10TK,20TK or 5TK; otherwise, it will refund the 15/10TK/5TK. Nevertheless, if we add an additional 10 or 20 taka, it will save the first 15 taka and return us remaining taka 5TK or 10 TK or 20tk.