Post-Lab Questions

1. In checkpoint 1 of the lab, you printed simulation results from “Behavior Simulation” and “Post-Implementation Timing Sim ulation”. List three differences that you observe between the re sults from the “Behavior Simulation” and “Post-Implementation Timing Simulation”? What are the reasons for these differences between the two simulations? Use the zoom button to help you find these differences in the simulation windows. (15 pts).

One clear difference is that the Behavioral Simulation’s timed events hap pen on integer multiples of the clock period, but the Post-Implementation Timing Simulation’s events happen at timing intervals that aren’t inte ger multiples of the clock period. Moreover, the Behavioral Simulation doesn’t show interconnect delay or propogation delay, it only takes into account gate delay. This can be seen by the Post-Implementation timing taking a bit longer for events to happen as compared to the Behavorial Simulation. A final distinct difference between the two is that the Be havioral simulation doesn’t show phenomena like meta-stability. You can see this phenomona in the Post-Implementation Timing Simulation, some states go through multiple changes before settling to a final values.

2. In checkpoint 1 of the lab, look at the waveform results at time 220ns from the start of the simulation. This is the time when the buttons change from state 4b’1111 to 4b’1011. Use the zoom in button to closely examine the results. How long does it take for the LEDs to change its output state measured from the time the buttons change from state 4b’1111 to 4b’1011? Do you see any erroneous states that the LEDs transition through? Use the zoom button and take a snapshot of these states. Include them in the report. Why do you have these erroneous states? (10 points)

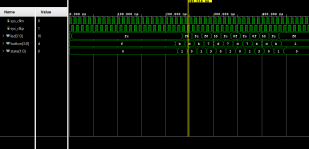
It takes 25 ns from when the button is pressed for the LED’s to finally change to their next value. There are erronous states, which can be seen in Figure 5. These are characterized by the different LED states stuttering through incorrect states before coming across the final state. This could

1

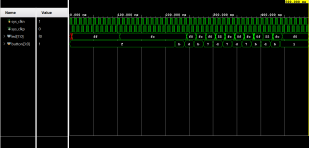
be due to physical behavior in the FPGA, since Post-Implementation takes into account the physical fitting and routing of elements.

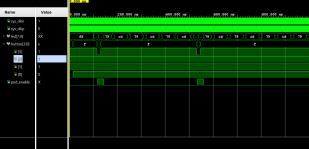
3. Compare the timing results from question 2 to the ones from the “Behavioral simulation”. Report the time it takes for the LEDs to change its output measured from the onset the buttons change from state 4b’1111 to 4b’1011. Why is this time different compared to the one from the “Post-Implementation Timing Simulation”? (10 points)

It takes 15 ns from when the button is pressed for the LED’s to finally change to their next value. This difference between the two simulations is probably due to the different considerations taken in each simulation. The behavioral simulation seems to only take into account gate delay/logical delay, however, in the post implementation timing simulation, propagation delay and fanout is also taken into effect. This is most likely the cause between the differences in the times.

Figure 1: Milestone 1 Behavioral Simulation

2

Figure 2: Milestone 1 Post-Implementation Timing Simulation Figure 3: Milestone 2 Behavioral Simulation

Figure 4: Milestone 2 Post Implementation Timing Simulation

3

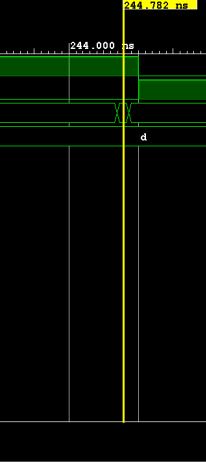


Figure 5: Erroneous Behavior in Post Implementation Timing Simulation 4

Include a printout of both codes with the final report.

Verilog Code Milestone 1

`timescale 1ns / 1ps

module lab3\_example(

input [3:0] button,

output [7:0] led,

input sys\_clkn,

input sys\_clkp

);

reg [1:0] state = 0;

reg [7:0] led\_register = 0;

reg [3:0] button\_reg;

wire clk;

IBUFGDS osc\_clk(

.O(clk),

.I(sys\_clkp),

.IB(sys\_clkn)

);

assign led = ~led\_register; *//map led wire to led\_register* localparam STATE\_INIT = 2'd0;

localparam STATE\_ALPHA = 2'd1;

localparam STATE\_BRAVO = 2'd2;

localparam STATE\_CHARLIE = 2'd3;

always @(posedge clk)

begin

button\_reg = ~button;

if (button\_reg [3:0] == 4'b1110) state <= STATE\_INIT;

else

begin

case (state)

STATE\_INIT : begin

if (button\_reg == (4'b0100)) state <= STATE\_ALPHA;

else if (button\_reg == 4'b1000) state <= STATE\_BRAVO;

else led\_register <= 8'b00000011;

end

STATE\_ALPHA : begin

if (button\_reg == 4'b1000) state <= STATE\_CHARLIE;

else if (button\_reg == 4'b0010) state <= STATE\_INIT;

else led\_register <= 8'b00001111;

end

5

STATE\_BRAVO : begin

if (button\_reg == 4'b0100) state <= STATE\_CHARLIE;

else if (button\_reg == 4'b0010) state <= STATE\_INIT;

else led\_register <= 8'b11110000;

end

STATE\_CHARLIE : begin

if (button\_reg == 4'b0010) state <= STATE\_INIT;

else led\_register <= 8'b10101010;

end

default: state <= STATE\_INIT;

endcase

end

end

endmodule

Verilog Code Milestone 2

`timescale 1ns / 1ps

module lab3\_example(input wire [4:0] okUH,

output wire [2:0] okHU,

inout wire [31:0] okUHU,

inout wire okAA,

input [3:0] button,

output [7:0] led,

input sys\_clkn,

input sys\_clkp

);

*//Front Panel Stuff*

wire okClk; *//These are FrontPanel wires needed to IO communication* wire [112:0] okHE; *//These are FrontPanel wires needed to IO communication* wire [64:0] okEH; *//These are FrontPanel wires needed to IO communication* wire [31:0] ped\_but;

*//This is the OK host that allows data to be sent or recived*

okHost hostIF (

.okUH(okUH),

.okHU(okHU),

.okUHU(okUHU),

.okClk(okClk),

.okAA(okAA),

.okHE(okHE),

.okEH(okEH)

6

);

*//parameters*

localparam endPt\_count = 1;

wire [endPt\_count\*65-1:0] okEHx;

okWireOR # (.N(endPt\_count)) wireOR (okEH, okEHx);

okWireIn wire10 ( .okHE(okHE),

.ep\_addr(8'h00),

.ep\_dataout(ped\_enable));

reg [2:0] state = 0;

reg [7:0] led\_register = 0;

reg [3:0] button\_reg;

reg [31:0] count = 0;

reg [31:0] ped\_count = 0;

reg ped\_enable;

reg ped\_reset = 0;

wire clk;

IBUFGDS osc\_clk(

.O(clk),

.I(sys\_clkp),

.IB(sys\_clkn)

);

always @ ( posedge clk) begin

if (ped\_reset) begin

ped\_enable <= 1'b0;

end

else if (ped\_but == 32'hFFFF) begin

ped\_enable <= 1'b1;

end

end

assign led = ~led\_register; *//map led wire to led\_register* localparam R1 = 3'd0;

localparam Y1 = 3'd1;

localparam G1 = 3'd2;

localparam R2 = 3'd3;

localparam Y2 = 3'd4;

localparam G2 = 3'd5;

localparam C\_N\_S = 3'd6;

localparam C\_E\_W = 3'd7;

always @(posedge clk)

begin

button\_reg = ~button;

if (button\_reg == 4'b0001) begin

7

state <= G1;

count <= 32'd0;

ped\_reset <= 0;

end

else

begin

case (state)

R1 : begin

if (count == 32'd10) begin

count <= 32'd0;

state <= G2;

end

else if (ped\_enable == 1'b1) begin

count <= 32'd0;

ped\_count <= 32'd0;

state <= C\_N\_S;

end

else begin

led\_register <= 8'b10000110;

count <= count + 1;

end

end

Y1 : begin

if (count == 32'd5) begin

count <= 32'd0;

state <= R1;

end

else begin

led\_register <= 8'b01010010;

count <= count + 1;

end

end

G1 : begin

if (count == 32'd15) begin

count <= 32'd0;

state <= Y1;

ped\_reset <= 0;

end

else begin

8

led\_register <= 8'b00110010;

count <= count + 1;

end

end

R2 : begin

if (count == 32'd10) begin

count <= 32'd0;

state <= G1;

end

else if (ped\_enable == 1'b1) begin count <= 32'd0;

ped\_count <= 32'd0;

state <= C\_E\_W;

end

else begin

led\_register <= 8'b00110010;

count <= count + 1;

end

end

Y2 : begin

if (count == 32'd5) begin

count <= 32'd0;

state <= R2;

end

else begin

led\_register <= 8'b10001010;

count <= count + 1;

end

end

G2 : begin

if (count == 32'd15) begin

count <= 32'd0;

state <= Y2;

ped\_reset <= 0;

end

else begin

led\_register <= 8'b10000110;

count <= count + 1;

end

9

end

C\_N\_S : begin

if (ped\_count == 32'd10) begin

ped\_reset <= 1;

state <= G2;

ped\_count <= 32'd0;

end

else begin

led\_register <= 8'b10010001;

ped\_count <= ped\_count + 1;

end

end

C\_E\_W : begin

if (ped\_count == 32'd10) begin

ped\_reset <= 1;

state <= G1;

ped\_count <= 32'd0;

end

else begin

led\_register <= 8'b10010001;

ped\_count <= ped\_count + 1;

end

end

default: state <= G1;

endcase

end

end

endmodule

Python Code

*# -\*- coding: utf-8 -\*-*

*#%%*

*# import various libraries necessary to run your Python code* import time *# time related library*

import sys,os *# system related library*

ok\_sdk\_loc = "C:\\Program Files\\Opal Kelly\\FrontPanelUSB\\API\\Python\\x64" ok\_dll\_loc = "C:\\Program Files\\Opal Kelly\\FrontPanelUSB\\API\\lib\\x64"

10

sys.path.append(ok\_sdk\_loc) *# add the path of the OK library*

os.add\_dll\_directory(ok\_dll\_loc)

import ok *# OpalKelly library*

*# Define FrontPanel device variable, open USB communication and*

*# load the bit file in the FPGA*

dev = ok.okCFrontPanel() *# define a device for FrontPanel communication* SerialStatus=dev.OpenBySerial("") *# open USB communication with the OK board* ConfigStatus=dev.ConfigureFPGA("lab2\_example.bit"); *# Configure the FPGA with this bit file*

*# Check if FrontPanel is initialized correctly and if the bit file is loaded. # Otherwise terminate the program*

print("----------------------------------------------------")

if SerialStatus == 0:

print ("FrontPanel host interface was successfully initialized.")

else:

print ("FrontPanel host interface not detected. The error code number is:" + str(int(Seprint("Exiting the program.")

sys.exit ()

if ConfigStatus == 0:

print ("Your bit file is successfully loaded in the FPGA.")

else:

print ("Your bit file did not load. The error code number is:" + str(int(ConfigStatus))print ("Exiting the progam.")

sys.exit ()

print("----------------------------------------------------")

print("----------------------------------------------------")

*#%%*

*# Define the two variables that will send data to the FPGA*

*# We will use WireIn instructions to send data to the FPGA*

on = 4294967295

off = 0

dev.SetWireInValue(0x00, off) *#Input data*

dev.UpdateWireIns() *# Update the WireIns*

*#%%*

*# We will read data from the FPGA in two different variables*

*# Since we are using a slow clock on the FPGA to compute the results*

*# we need to wait for the result to be computed*

*# First receive data from the FPGA by using UpdateWireOuts*

while(1) :

time.sleep(.10)

11

dev.SetWireInValue(0x00, off)

dev.UpdateWireIns()

button = 0;

button = int(input('Input 1 to press walk')) print(result\_difference)

if (button == 1):

time.sleep(0.05)

dev.SetWireInValue(0x00, on)

dev.UpdateWireIns() *# Update the WireIns* else :

time.sleep(0.05)

dev.SetWireInValue(0x00, off)

dev.UpdateWireIns()

dev.Close

*#%%*

12