



**Birla Vishvakarma Mahavidyalaya
Engineering Collage (An Autonomous Institution)
Vallabh Vidyanagar - 388 120
Affiliated to Gujarat Technological University**

A.Y. 2023

Assignment : III

Course Title: Digital System Design

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Batch: C04

Course Code: 3EL42

Q1. CLOCK DIVIDER

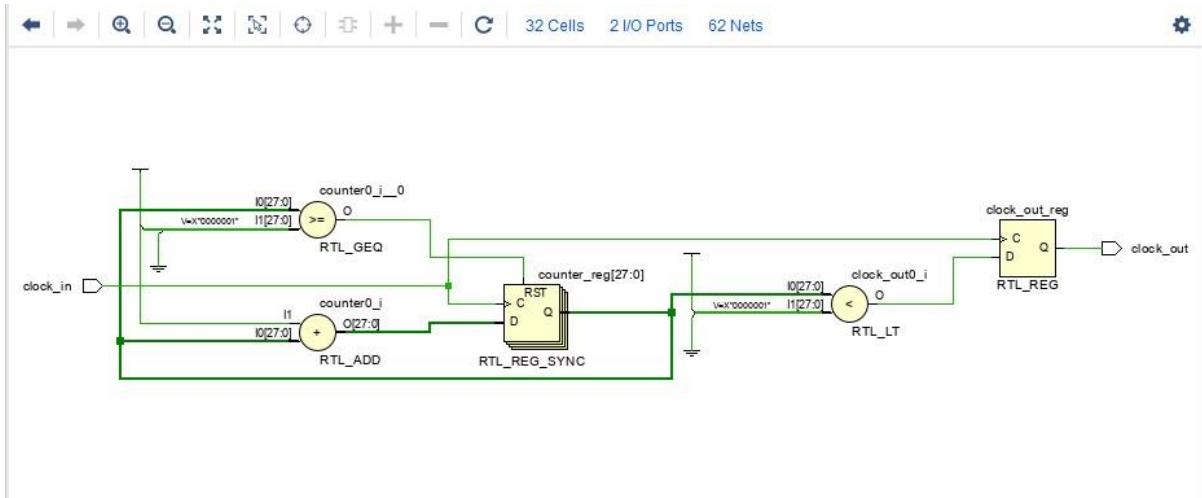
VERILOG CODE: -

```
module Clock_divider(
    input clock_in,
    output reg clock_out
);
reg[27:0] counter=28'd0;
parameter DIVISOR = 28'd2;
always @(posedge clock_in)
begin
    counter <= counter + 28'd1;
    if(counter>=(DIVISOR-1))
        counter <= 28'd0;
    clock_out <= (counter<DIVISOR/2)?1'b1:1'b0;
end
endmodule
```

TEST BENCH: -

```
module tb_clock_divider;
reg clock_in;
wire clock_out;
clock_divider uut (
    .clock_in(clock_in),
    .clock_out(clock_out)
);
initial begin
    clock_in = 0;
    forever #10 clock_in = ~clock_in;
end
endmodule
```

RTL SCHEMATIC: -



SYNTHESIS REPORT: -

```

source clock_divider.tcl -notrace
Command: synth_design -top clock_divider -part xc7k70tfbv676-1
Starting synth_design
Attempting to get a license for feature 'Synthesis' and/or device 'xc7k70t'
INFO: [Common 17-349] Got license for feature 'Synthesis' and/or device 'xc7k70t'
INFO: [Synth 8-7079] Multithreading enabled for synth_design using a maximum of 2 processes.
INFO: [Synth 8-7078] Launching helper process for spawning children vivado processes
INFO: [Synth 8-7075] Helper process launched with PID 11392
-----
Starting Synthesize : Time (s): cpu = 00:00:04 ; elapsed = 00:00:07 . Memory (MB): peak = 1046.367 ; gain = 0.000
-----
INFO: [Synth 8-6157] synthesizing module 'clock_divider' [E:/projects/dsd/clock_divider 1/clock_divider 1.srcs/sources_1/net
Parameter DIVISOR bound to: 28'b00000000000000000000000000000010
INFO: [Synth 8-6155] done synthesizing module 'clock_divider' (1#1) [E:/projects/dsd/clock_divider 1/clock_divider 1.srcs/s
-----
Finished Synthesize : Time (s): cpu = 00:00:05 ; elapsed = 00:00:08 . Memory (MB): peak = 1046.367 ; gain = 0.000

```

Report BlackBoxes:

+-----+	+-----+
BlackBox name Instances	
+-----+-----+	
+-----+-----+	

Report Cell Usage:

+-----+	+-----+
Cell Count	
+-----+-----+	
1 BUFG 1	
2 CARRY4 7	
3 LUT1 1	
4 LUT4 1	
5 LUT5 2	
6 LUT6 8	
7 FDRE 29	
8 TRUF 1	

```
| 3  |LUT1   |    1|
| 4  |LUT4   |    1|
| 5  |LUT5   |    2|
| 6  |LUT6   |    8|
| 7  |FDRE   |   29|
| 8  |IBUF   |    1|
| 9  |OBUF   |    1|
+----+-----+-----+
```

Report Instance Areas:

	Instance	Module	Cells
1	top		51

Finished Writing Synthesis Report : Time (s): cpu = 00:00:15 ; elapsed = 00:00:29 . Memory (MB): peak = 1046.367 ; gain = 0

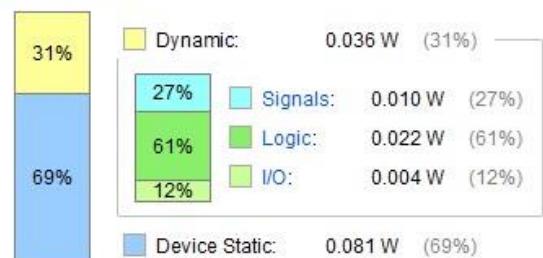
POWER REPORT: -

Summary

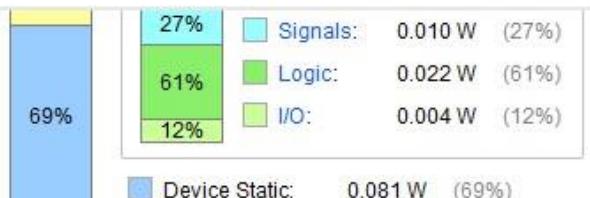
Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power: 0.117 W
Design Power Budget: Not Specified
Power Budget Margin: N/A
Junction Temperature: 25.2°C
Thermal Margin: 59.8°C (31.5 W)

On-Chip Power



Total On-Chip Power: 0.117 W
Design Power Budget: Not Specified
Power Budget Margin: N/A
Junction Temperature: 25.2°C
Thermal Margin: 59.8°C (31.5 W)
Effective 9JA: 1.9°C/W
Power supplied to off-chip devices: 0 W
Confidence level: Low



Q2. JOHNSON COUNTER

VERILOG CODE: -

```

`timescale 1ns / 1ps

module johnson_counter(
    input clk,
    input reset,
    output [3:0] out
);
    reg [3:0] q;

    always @(posedge clk)
    begin
        if(reset)
            q=4'd0;
        else
            begin
                q[3]<=q[2];
                q[2]<=q[1];
                q[1]<=q[0];
                q[0]<=(~q[3]);
            end
    end
end

assign out=q;
endmodule

```

TEST BENCH: -

```
`timescale 1ns / 1ps

module jc_tb;
    reg clk,reset;
    wire [3:0] out;

    johnson_counter dut (.out(out), .reset(reset), .clk(clk));

    always
        #5 clk =~clk;

    initial begin
        reset=1'b1; clk=1'b0;
        #20 reset= 1'b0;
    end

    initial
    begin

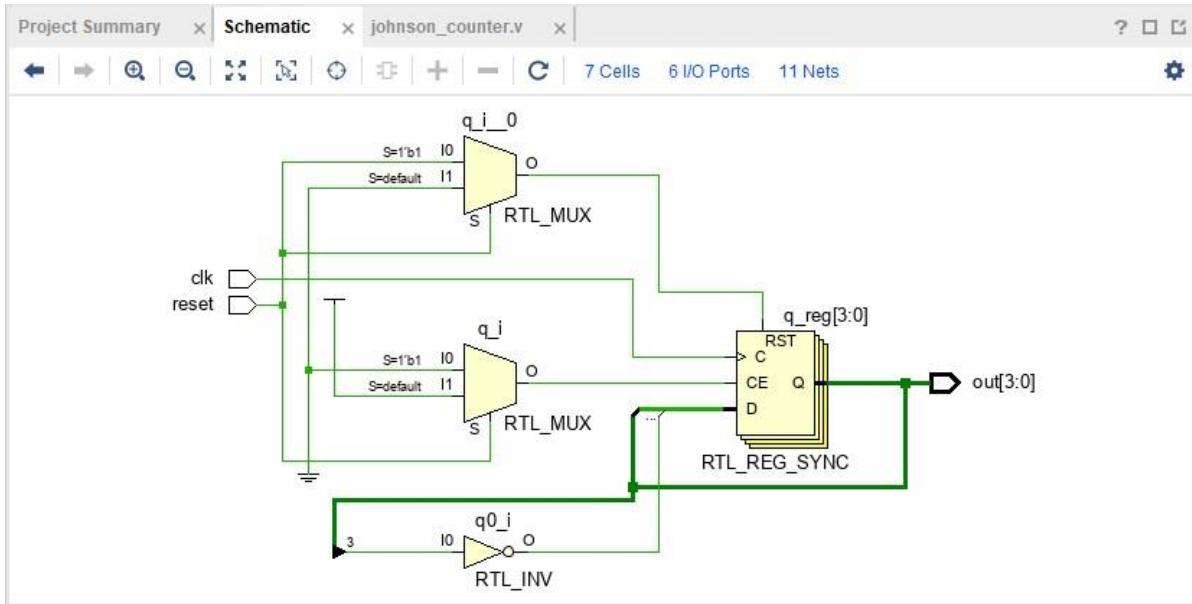
        johnson_counter dut (.out(out), .reset(reset), .clk(clk));

        always
            #5 clk =~clk;

        initial begin
            reset=1'b1; clk=1'b0;
            #20 reset= 1'b0;
        end

        initial
        begin
            $monitor( $time, " clk=%b, out= %b, reset=%b", clk,out,reset);
            #105 $stop;
        end
    end
endmodule
```

RTL SCHEMATIC: -



SYNTHESIS REPORT: -

```
Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
| |BlackBox name |Instances |
+-----+-----+
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
|     |Cell |Count |
+-----+-----+
|1    |BUFG |    1|
|2    |LUT1 |    1|
|3    |FDRE |    4|
|4    |IBUF |    2|
|5    |OBUF |    4|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
|     |Instance |Module |Cells |
+-----+-----+-----+
|1    |top      |      |    12|
+-----+-----+-----+
-----
Finished Writing Synthesis Report : Time (s): cpu = 00:00:16 ; elapsed = 00:00:30 . Memory (MB): peak = 1018.973 ; gain = 0.000
```

POWER REPORT: -

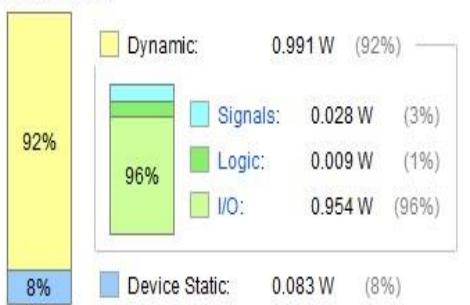
Summary

Power analysis from implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	1.074 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	27.0°C
Thermal Margin:	58.0°C (30.6 W)
Effective θ _{JA} :	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

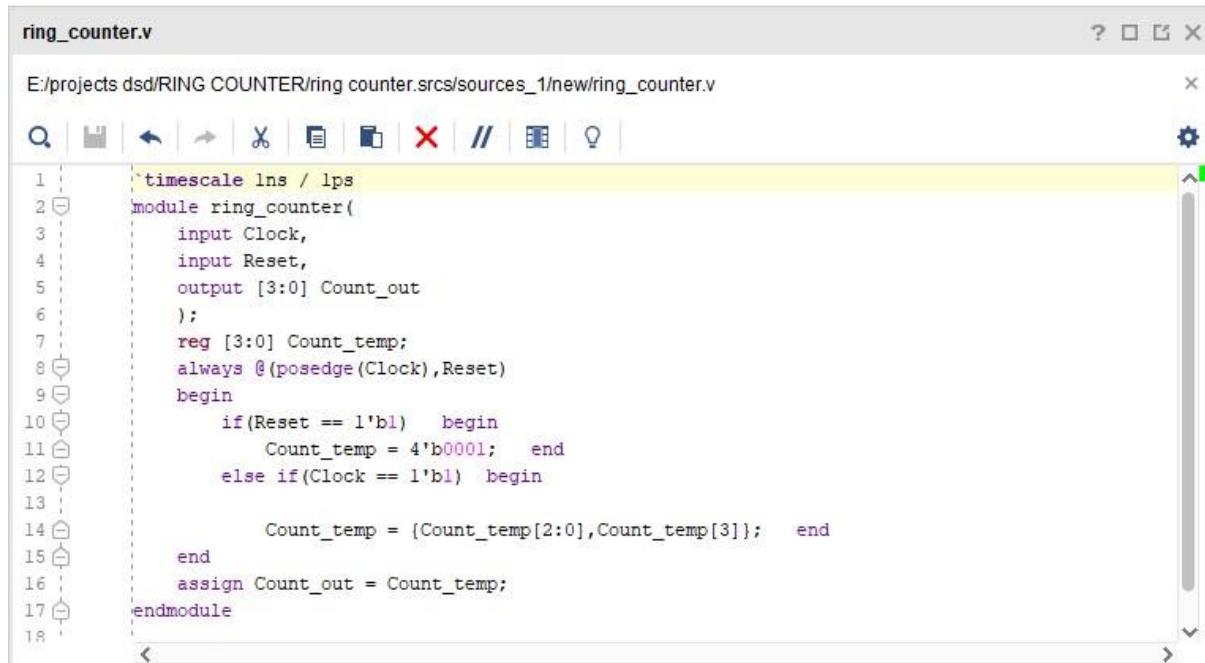
[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q3. RING COUNTER

VERILOG CODE: -



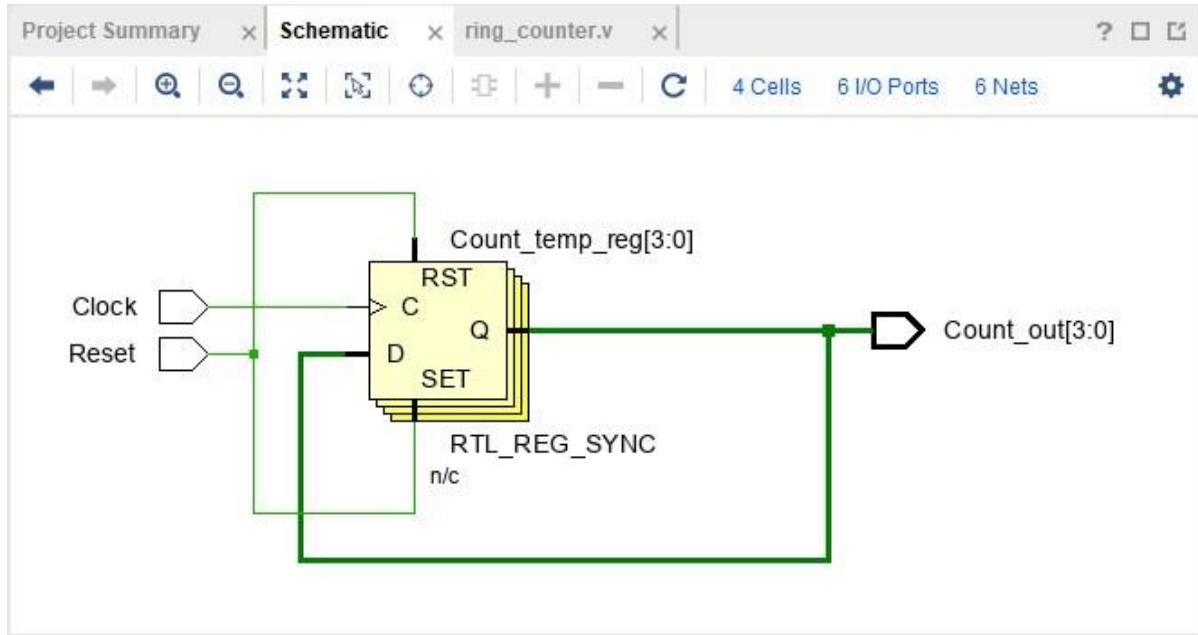
The screenshot shows a Verilog code editor window titled "ring_counter.v". The code is a module named "ring_counter" with the following structure:

```
timescale 1ns / 1ps
module ring_counter(
    input Clock,
    input Reset,
    output [3:0] Count_out
);
reg [3:0] Count_temp;
always @(posedge(Clock),Reset)
begin
    if(Reset == 1'b1) begin
        Count_temp = 4'b0001; end
    else if(Clock == 1'b1) begin
        Count_temp = {Count_temp[2:0],Count_temp[3]}; end
    end
    assign Count_out = Count_temp;
endmodule
```

TEST BENCH: -

```
module tb_ring;
reg Clock;
reg Reset;
wire [3:0] Count_out;
ring_counter uut (
    .Clock(Clock),
    .Reset(Reset),
    .Count_out(Count_out)
);
initial Clock = 0;
always #10 Clock = ~Clock;
initial begin
    Reset = 1;
    #50;
    Reset = 0;
end
endmodule
```

RTL SCHEMATIC: -



SYNTHESIS REPORT: -

```
Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
| |BlackBox name |Instances |
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
| |Cell |Count |
+-----+-----+
|1 |BUFG | 1|
|2 |FDRE | 3|
|3 |FDSE | 1|
|4 |IBUF | 2|
|5 |OBUF | 4|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
| |Instance |Module |Cells |
+-----+-----+-----+
|1 |top | | 11|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:17 ; elapsed = 00:00:31 , Memory (MB): peak = 1019.336 ; gain = 0.000
```

POWER REPORT:

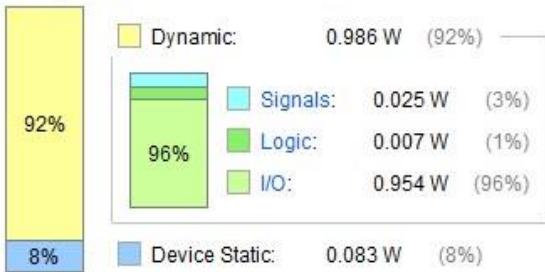
Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	1.069 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	27.0°C
Thermal Margin:	58.0°C (30.6 W)
Effective gJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q4. 5 INPUT MAJORITY CIRCUIT

VERILOG CODE: -

```

module majority_of_five(
    input [4:0] sw,
    output led
);
assign led =(sw[0] & sw[1] & sw[2]) |
            (sw[0] & sw[1] & sw[3]) |
            (sw[0] & sw[1] & sw[4]) |
            (sw[0] & sw[2] & sw[3]) |
            (sw[0] & sw[2] & sw[4]) |
            (sw[0] & sw[3] & sw[4]) |
            (sw[1] & sw[2] & sw[3]) |
            (sw[1] & sw[2] & sw[4]) |
            (sw[1] & sw[3] & sw[4]) |
            (sw[2] & sw[3] & sw[4]);
endmodule

```

TEST BENCH:-

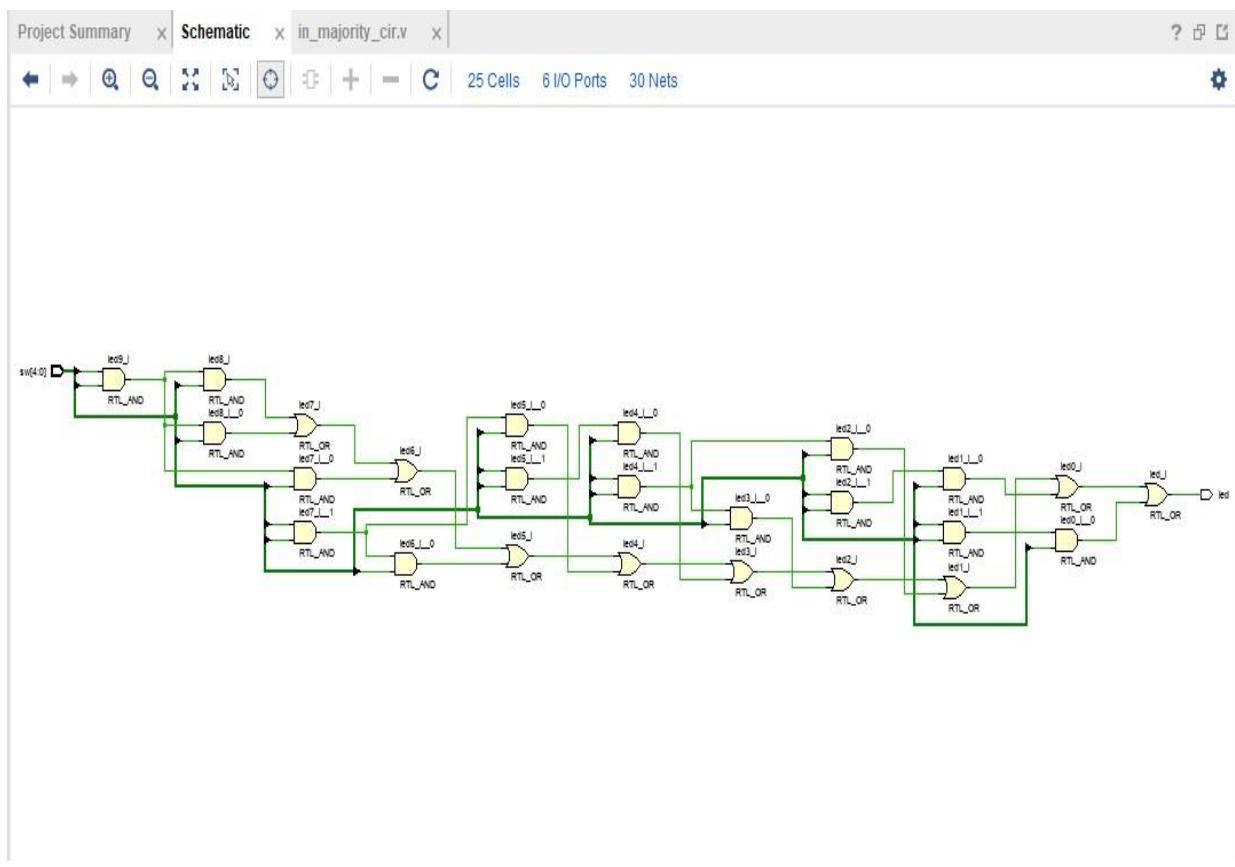
```

module majority_of_five_tb;
reg [4:0] sw;
wire led;
majority_of_five cut (.sw(sw),.led(led));
integer k;

initial
begin
    sw = 0;
    for (k=0; k<32; k=k+1)
        #20 sw = k;
    #20 $finish;
end
endmodule

```

RTL SCHEMATIC:



SYNTHESIS REPORT:-

```
-----  
Start Writing Synthesis Report  
-----
```

Report BlackBoxes:

BlackBox name	Instances

Report Cell Usage:

Cell	Count
LUT5	1
IBUF	5
OBUF	1

Report Instance Areas:

Instance	Module	Cells
top		7

```
-----  
Finished Writing Synthesis Report : Time (s): cpu = 00:00:16 ; elapsed = 00:00:27 . Memory (MB): peak = 1018.273 ; gain = 0.000  
-----
```

POWER REPORT:

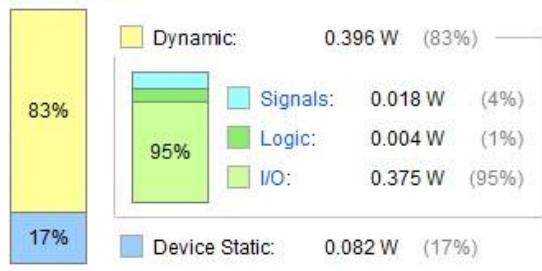
Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	0.478 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	25.9°C
Thermal Margin:	59.1°C (31.2 W)
Effective θ _{JA} :	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

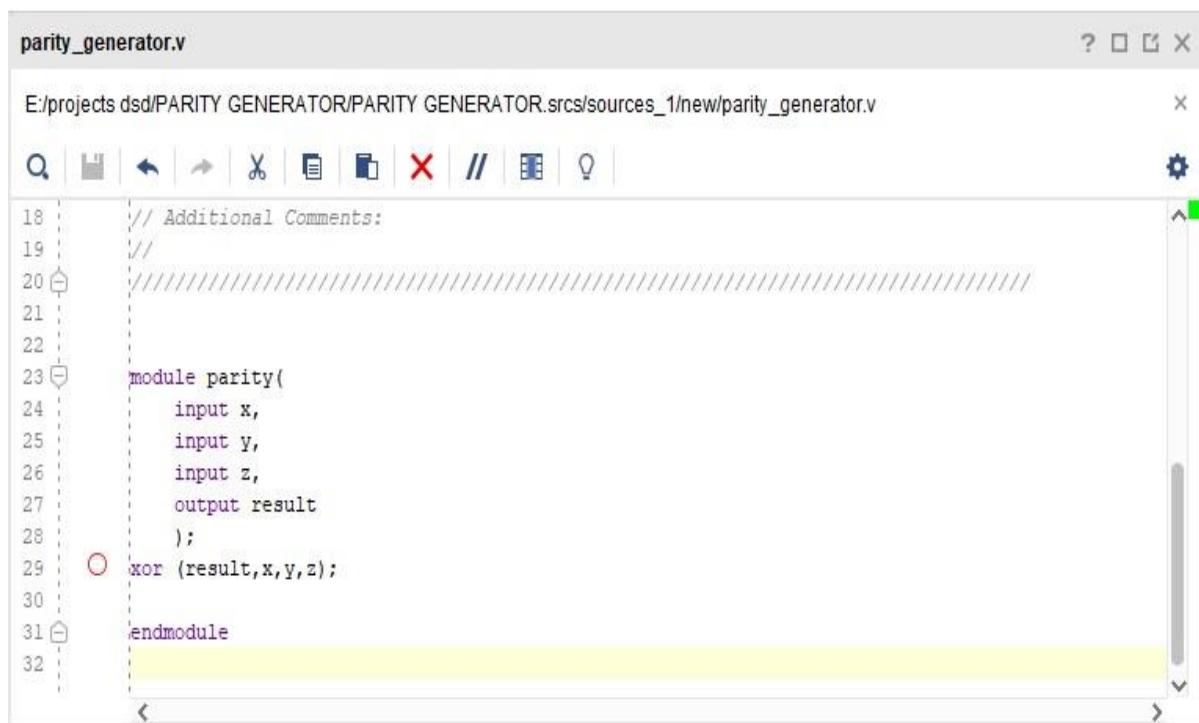
[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q5. PARITY GENERATOR

VERILOG CODE:-



The screenshot shows a Verilog code editor window titled "parity_generator.v". The code is as follows:

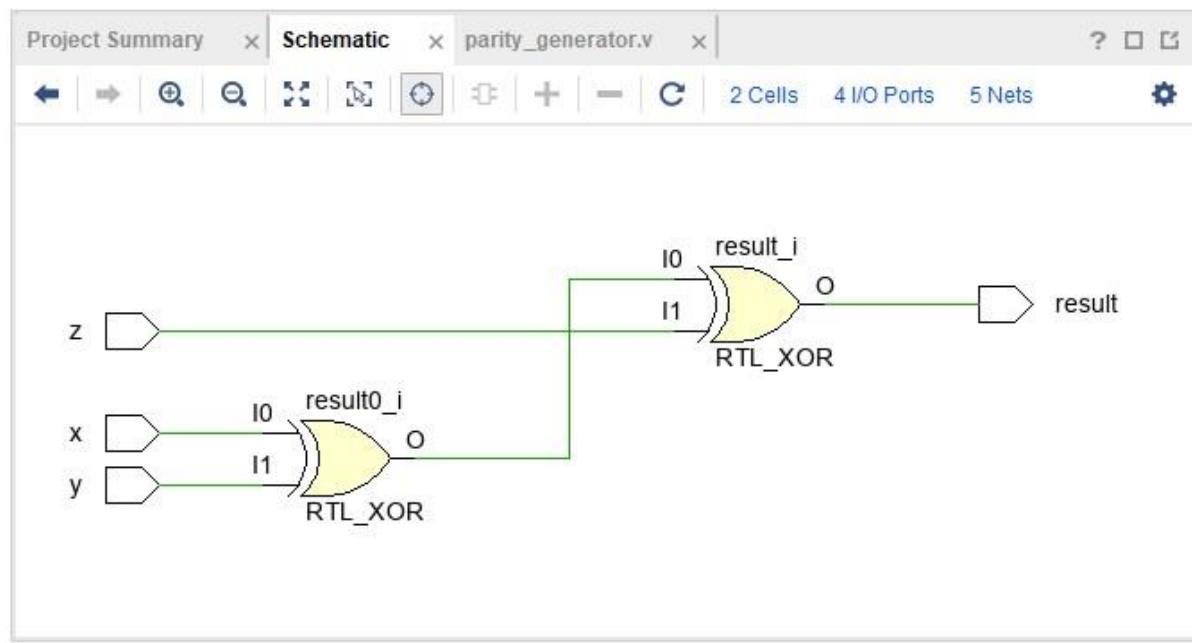
```
// Additional Comments:  
//  
module parity(  
    input x,  
    input y,  
    input z,  
    output result  
);  
    xor (result,x,y,z);  
endmodule
```

TEST BENCH:-

```
module parity_tb;  
reg x,y,z;  
wire result;  
  
initial begin  
x = 0;  
y = 0;  
z = 0;  
  
#100;  
x = 0;  
y = 0;  
z = 1;  
  
#100;  
x = 0;  
y = 1;  
z = 0;  
  
#100;  
x = 0;  
y = 1;  
z = 1;  
  
#100;  
x = 1;  
y = 0;  
z = 0;  
  
#100;  
x = 1;  
y = 0;  
z = 1;
```

```
#100;  
x = 1;  
y = 0;  
z = 1;  
  
#100;  
  
x = 1;  
y = 1;  
z = 0;  
  
#100;  
  
x = 1;  
y = 1;  
z = 1;  
  
#100;  
end  
endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

Start Writing Synthesis Report

Report BlackBoxes:

```
+---+-----+
| |BlackBox name |Instances |
+---+-----+
+---+-----+
```

Report Cell Usage:

```
+----+-----+
| |Cell |Count |
+----+-----+
|1 |LUT3 | 1|
|2 |IBUF | 3|
|3 |OBUF | 1|
+----+-----+
```

Report Instance Areas:

```
+----+-----+-----+
| |Instance |Module |Cells |
+----+-----+-----+
|1 |top | | 5|
+----+-----+
```

Finished Writing Synthesis Report : Time (s): cpu = 00:00:16 ; elapsed = 00:13:45 . Memory (MB): peak = 1014.574 ; gain = 0.000

POWER REPORT:-

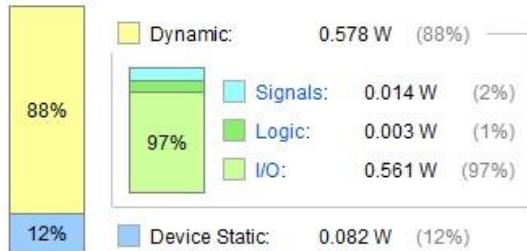
Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	0.661 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	26.2°C
Thermal Margin:	58.8°C (31.0 W)
Effective θ _{JA} :	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

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On-Chip Power



Q6. BINARY TO ONE HOT ENCODER

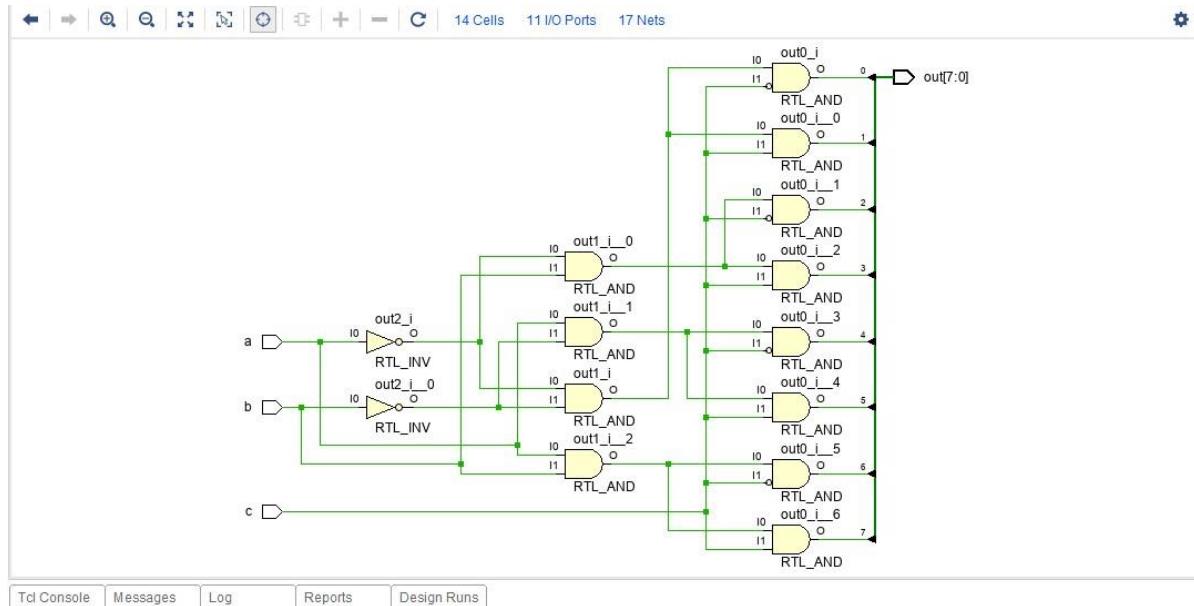
VERILOG CODE:-

```
module decoder_3_8(a, b, c, out);
    input a,b,c;
    output [7:0] out ;
    assign out [0] = (~a&~b&~c) ;
    assign out [1] = (~a&~b&c) ;
    assign out [2] = (~a&b&~c);
    assign out [3] = (~a&b&c);
    assign out [4] = (a&~b&~c);
    assign out [5] = (a&~b&c);
    assign out [6] = (a&b&~c);
    assign out [7] = (a&b&c);
endmodule
```

TEST BENCH:-

```
module test_decoder;
reg a, b,c;
wire [7:0] out;
decoder_3_8 DUT(a,b,c,out);
initial
begin
$monitor($time,"a=%b , b=%b , c=%b , out = %b" , a,b,c,out);
a=0 ; b=0 ;c=0 ;
# 100
a=0 ; b=0 ;c=1 ;
#100
a=0 ; b=1 ;c=0 ;
#100
a=1 ; b=1 ;c=1 ;
#100 $finish;
end
endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
++-----+-----+
| |BlackBox name |Instances |
++-----+-----+
++-----+-----+
Report Cell Usage:
+-----+-----+
|   |Cell |Count |
+-----+-----+
|1  |LUT3 |    8|
|2  |IBUF |    3|
|3  |OBUF |    8|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
|   |Instance |Module |Cells |
+-----+-----+-----+
|1  |top     |      |  19|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:17 ; elapsed = 00:00:30 . Memory (MB): peak = 1019.449 ; gain = 0.000
-----
```

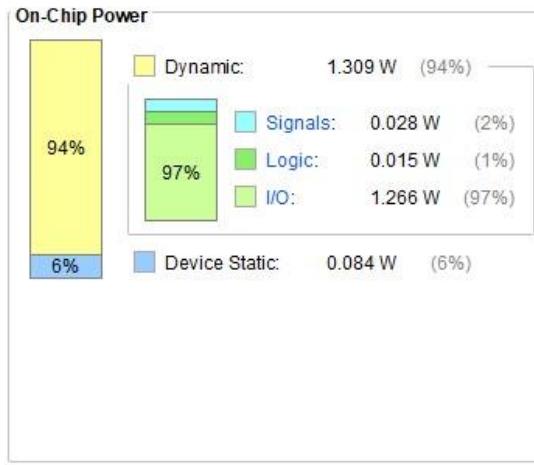
POWER REPORT:-

Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

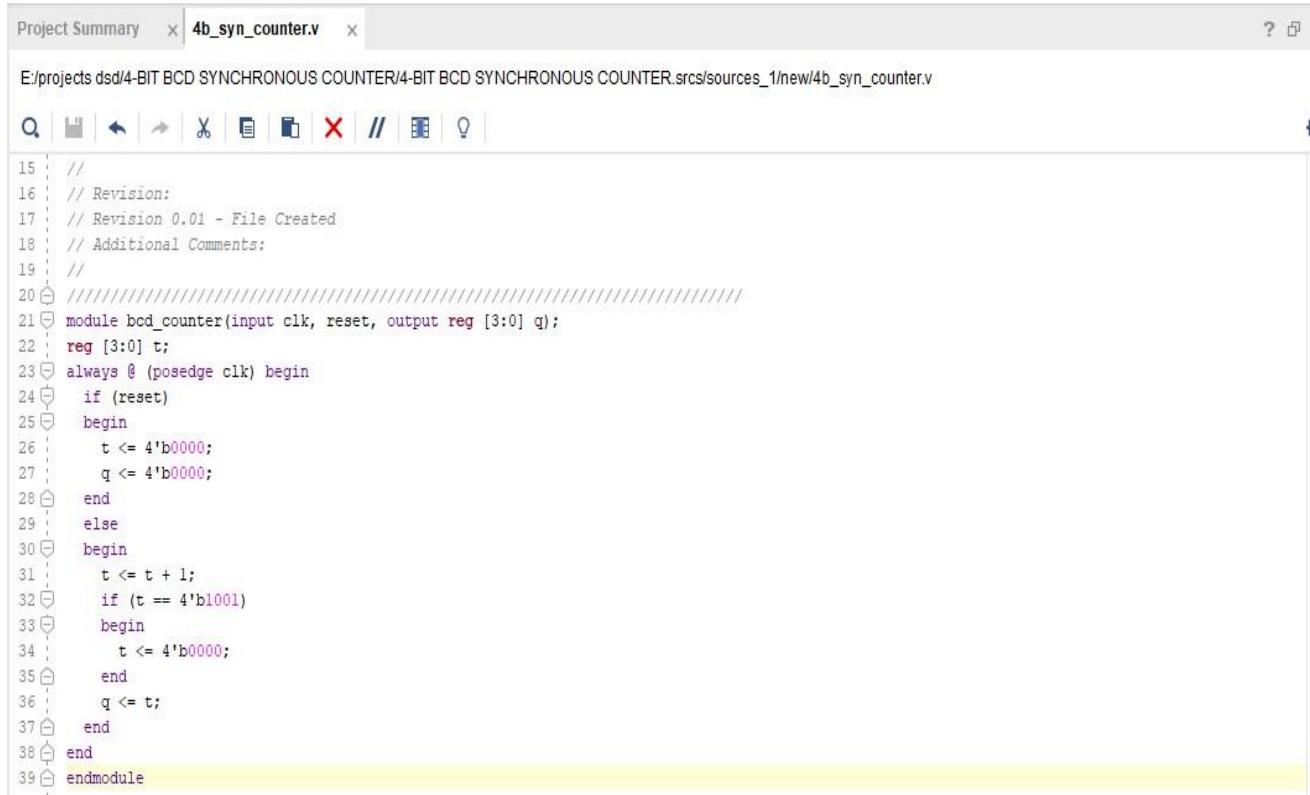
Total On-Chip Power:	1.393 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	27.6°C
Thermal Margin:	57.4°C (30.3 W)
Effective θJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q7. 4-BIT BCD SYNCHRONOUS COUNTER

VERILOG CODE:-



```

Project Summary  x 4b_syn_counter.v  x
E:/projects/dsd/4-BIT BCD SYNCHRONOUS COUNTER/4-BIT BCD SYNCHRONOUS COUNTER.srs/sources_1/new/4b_syn_counter.v

Q | H | ← | → | X | D | F | X | // | E | ? | I |
15 // 
16 // Revision: 
17 // Revision 0.01 - File Created 
18 // Additional Comments: 
19 // 
20 /////////////////////////////////////////////////////////////////// 
21 module bcd_counter(input clk, reset, output reg [3:0] q); 
22   reg [3:0] t; 
23   always @ (posedge clk) begin 
24     if (reset) 
25       begin 
26         t <= 4'b0000; 
27         q <= 4'b0000; 
28       end 
29     else 
30       begin 
31         t <= t + 1; 
32         if (t == 4'b1001) 
33           begin 
34             t <= 4'b0000; 
35           end 
36         q <= t; 
37       end 
38   end 
39 endmodule 

```

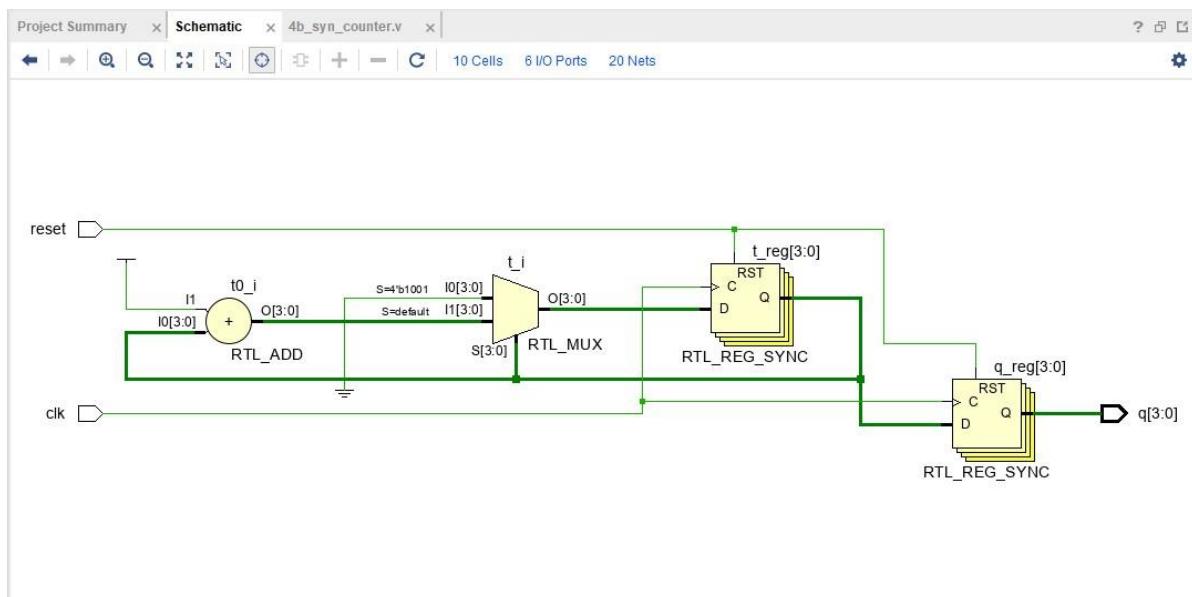
TEST BENCH:-

```

40 
41 
42 
43 //testbench 
44 module bcd_counter_tb; 
45   reg clk; 
46   reg reset; 
47   wire [3:0] q; 
48 
49 bcd_counter DUT(.clk(clk), .reset(reset), .q(q)); 
50 initial begin 
51   clk = 0; 
52   forever #5 clk = ~clk; 
53 end 
54 
55 initial begin 
56   reset = 1; 
57   #10 reset = 0; 
58   $monitor ("T=%0t out=%b", $time, q); 
59   #150 reset = 1; 
60   #10 reset = 0; 
61   #200 
62   $finish; 
63 end 
64 endmodule 

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
| !BlackBox name | Instances |
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
| Cell | Count |
+-----+-----+
| 1 |BUFG | 1|
| 2 |LUT1 | 1|
| 3 |LUT3 | 1|
| 4 |LUT4 | 2|
| 5 |FDRE | 8|
| 6 |IBUF | 2|
| 7 |OBUF | 4|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
| Instance |Module |Cells |
+-----+-----+-----+
| 1 |top | 19|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:14 ; elapsed = 00:00:26 . Memory (MB): peak = 1018.500 ; gain = 0.000
-----
```

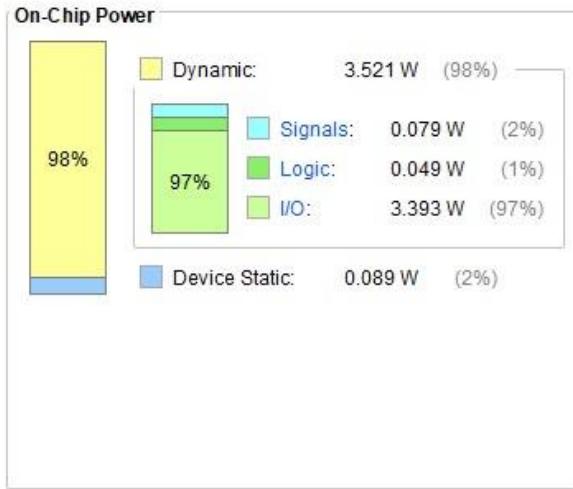
POWER REPORT:-

Summary

Power analysis from implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	3.609 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	31.8°C
Thermal Margin:	53.2°C (28.1 W)
Effective SJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q8. 4-BIT CARRY LOOKAHEAD ADDER

VERILOG CODE:-

```

Q | H | ← | → | X | ☐ | ☒ | // | ☓ | ? |
1 module CLA_Adder(a,b,cin,sum,cout);
2   input[3:0] a,b;
3   input cin;
4   output [3:0] sum;
5   output cout;
6   wire p0,p1,p2,p3,g0,g1,g2,g3,c1,c2,c3,c4;
7   assign p0=(a[0]^b[0]),
8     p1=(a[1]^b[1]),
9     p2=(a[2]^b[2]),
10    p3=(a[3]^b[3]);
11   assign g0=(a[0]&b[0]),
12     g1=(a[1]&b[1]),
13     g2=(a[2]&b[2]),
14     g3=(a[3]&b[3]);
15   assign c0=cin,
16     c1=g0|(p0&cin),
17     c2=g1|(p1&p0&cin),
18     c3=g2|(p2&p1&g0)|(p1&p0&cin),
19     c4=g3|(p3&g2)|(p3&p2&g1)|(p3&p2&p1&g0)|(p3&p2&p1&cin);
20   assign sum[0]=p0^c0,
21     sum[1]=p1^c1,
22     sum[2]=p2^c2,
23     sum[3]=p3^c3;
24   assign cout=c4;
25 endmodule

```

TEST BENCH:-

```

module TestModule;
reg [3:0] a;
reg [3:0] b;
reg cin;

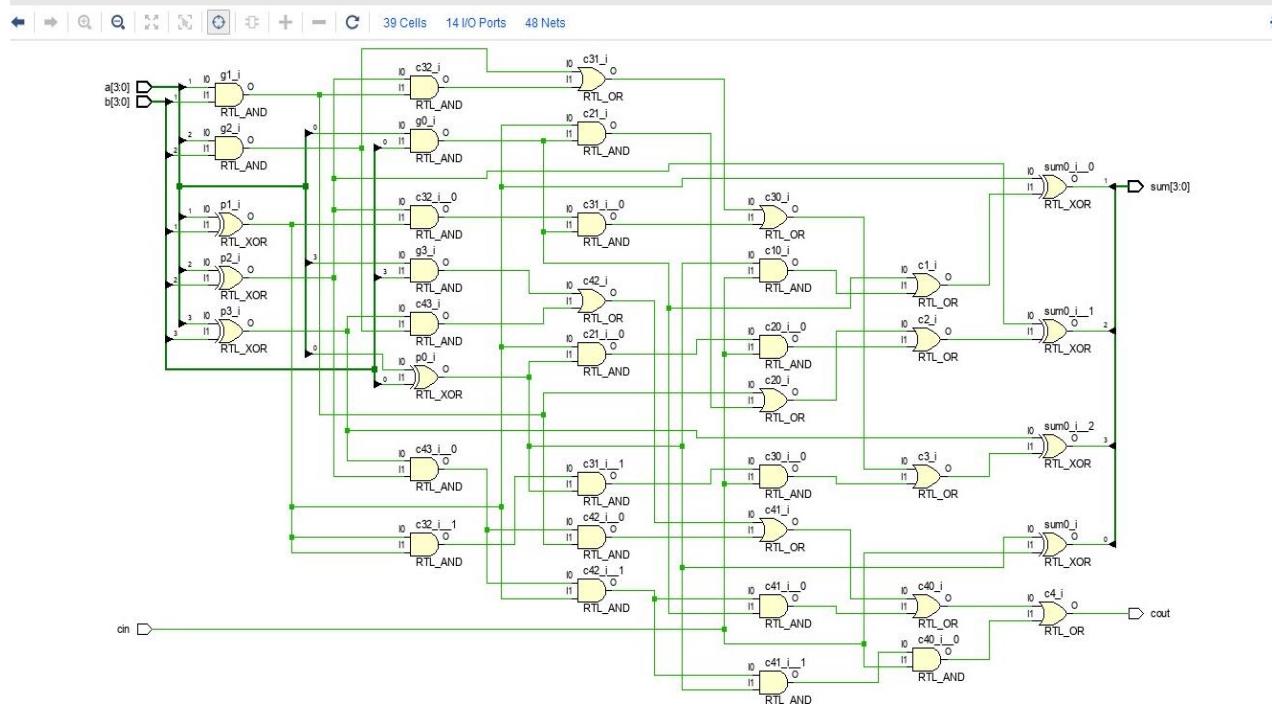
wire [3:0] sum;
wire cout;

CLA_Adder uut (
.a(a),
.b(b),
.cin(cin),
.sum(sum),
.cout(cout)
);
initial begin
a = 0;
b = 0;
cin = 0;

#100;
a = 5;
b = 6;
cin = 1;
#100;
end
endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+
| BlackBox name | Instances |
+-----+
+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
| Cell | Count |
+-----+-----+
| 1 | LUT2 | 1 |
| 2 | LUT3 | 1 |
| 3 | LUT4 | 1 |
| 4 | LUT5 | 4 |
| 5 | LUT6 | 2 |
| 6 | IBUF | 9 |
| 7 | OBUF | 5 |
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
| Instance | Module | Cells |
+-----+-----+-----+
| 1 | top | 23 |
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:18 ; elapsed = 00:00:32 . Memory (MB): peak = 1015.535 ; gain = 0.000

```

POWER REPORT:-

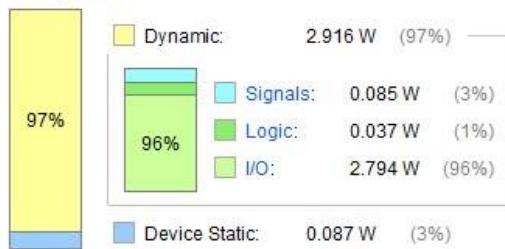
Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	3.003 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	30.7°C
Thermal Margin:	54.3°C (28.7 W)
Effective θ _{JA} :	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q9.N-BIT COMPARATOR

VERILOG CODE:-

```

> module comparator (
  input wire [3:0] a,
  input wire [3:0] b,
  output reg equal,
  output reg lower,
  output reg greater
);

  always @* begin
    if (a < b) begin
      equal = 0;
      lower = 1;
      greater = 0;
    end
    else if (a == b) begin
      equal = 1;
      lower = 0;
      greater = 0;
    end
    else begin
      equal = 0;
      lower = 0;
      greater = 1;
    end
  end
endmodule

```

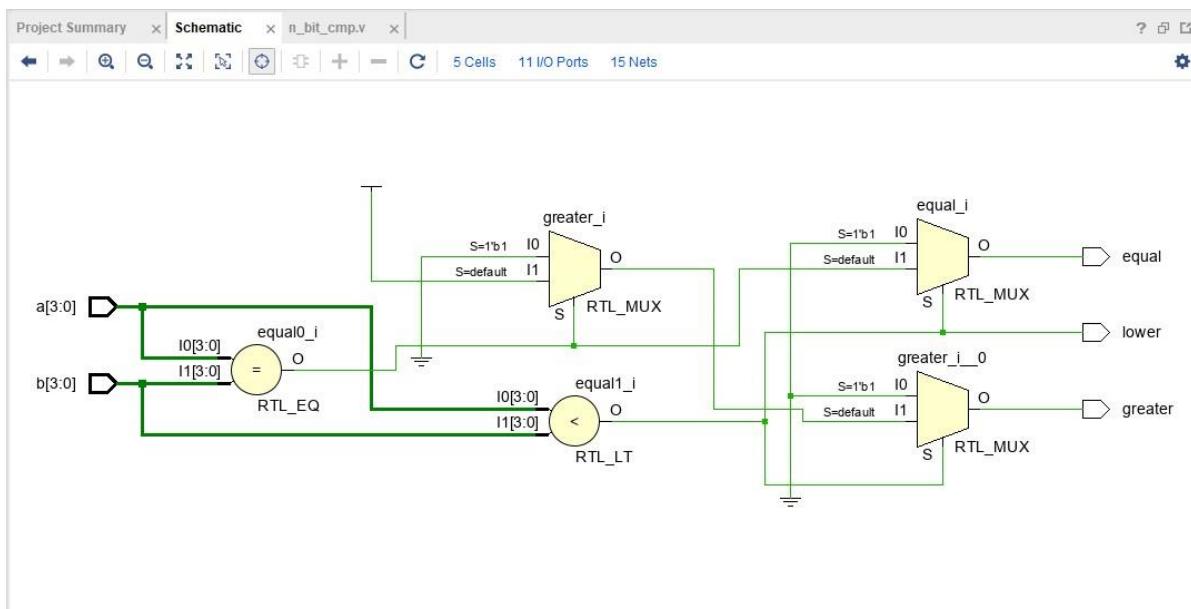
TEST BENCH:-

```

module testcomp;
reg [3:0] a, b;
wire eq, lw, gr;
comparator uut (
  .a(a),
  .b(b),
  .equal(eq),
  .lower(lw),
  .greater(gr)
);
initial begin
  a = 0;
  repeat (16) begin
    b = 0;
    repeat (16) begin
      #10;
      $display ("TESTING %d and %d yields eq=%d lw=%d gr=%d", a, b, eq, lw, gr);
      if (a==b && eq!=1'b1 && gr!=1'b0 && lw!=1'b0) begin
        $display ("ERROR!");
        $finish;
      end
      if (a>b && eq!=1'b0 && gr!=1'b1 && lw!=1'b0) begin
        $display ("ERROR!");
        $finish;
      end
      if (a<b && eq!=1'b1 && gr!=1'b0 && lw!=1'b1) begin
        $display ("ERROR!");
        $finish;
      end
      b = b + 1;
    end
    a = a + 1;
  end
  $display ("PASSED!");
  $finish;
  $display ("PASSED!");
  $finish;
end
endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
| !BlackBox name | Instances |
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
|     |Cell |Count |
+-----+-----+
| 1  |LUT3 |    1|
| 2  |LUT4 |    2|
| 3  |LUT6 |    2|
| 4  |IBUF |    8|
| 5  |OBUF |    3|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
|     |Instance |Module |Cells |
+-----+-----+-----+
| 1  |top      |       |   16|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:17 ; elapsed = 00:00:29 . Memory (MB): peak = 1015.203 ; gain = 0.000
-----
```

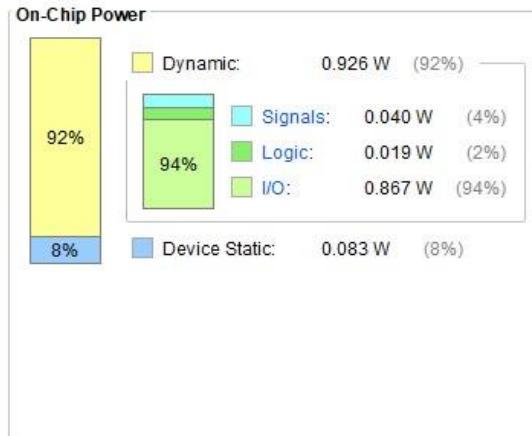
POWER REPORT:-

Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	1.009 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	26.9°C
Thermal Margin:	58.1°C (30.7 W)
Effective SJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q10. SERIAL IN SERIAL OUT SHIFT REGISTER

VERILOG CODE:-

```
module siso_design(input clk,b,output q);
wire w1,w2,w3;

d_ff dut1(.clk(clk),.d(b),.q(w1),.rst());
d_ff dut2(.clk(clk),.d(w1),.q(w2),.rst());
d_ff dut3(.clk(clk),.d(w2),.q(w3),.rst());
d_ff dut4(.clk(clk),.d(w3),.q(q),.rst());

endmodule

// d flip flop
module d_ff (
  input clk,
  input d,
  input rst,
  output reg q);

  always @ (posedge clk)
begin
  if (rst)
    q <= 1'b0;
  else
    q <= d;
end

endmodule
```

TEST BENCH:-

```
// testbench
`module siso_tb();

reg clk,b;
wire q;

siso_design uut(.clk(clk),.b(b),.q(q));

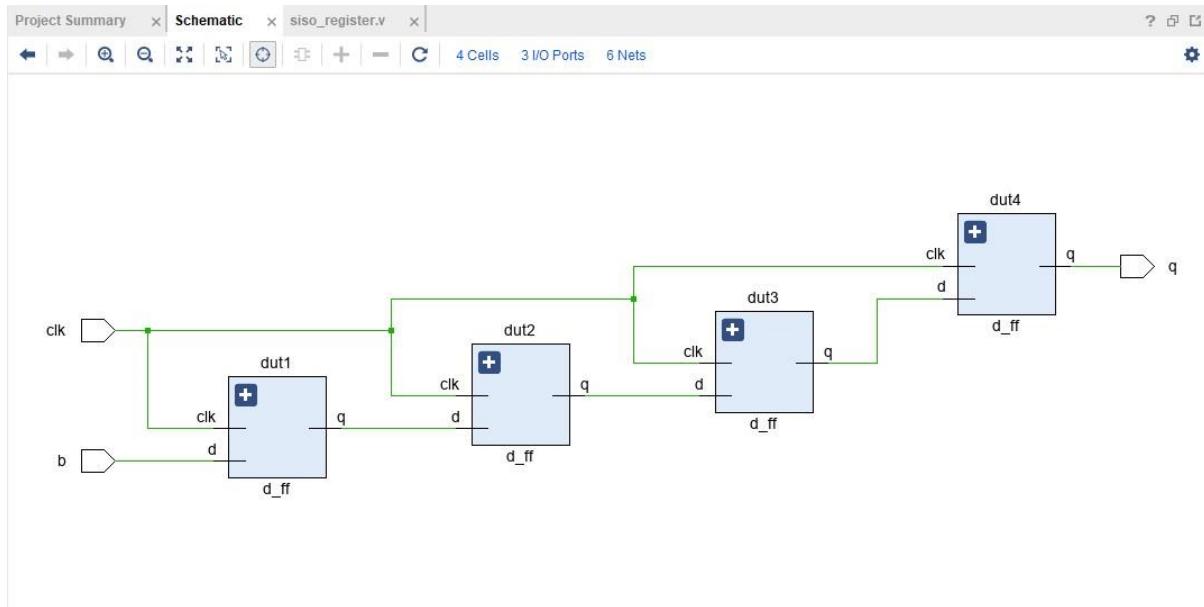
`initial
`begin
clk=1'b0;
forever #5clk=~clk;
`end

`initial
`begin
$monitor("clk=%d,b=%d,q=%d",clk,b,q);
`end

`initial
`begin
b=1;
#10;
b=1;
#10;
b=1;
#10;
b=0;

#50;
$finish;
`end
`endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

-----
Start Writing Synthesis Report
-----

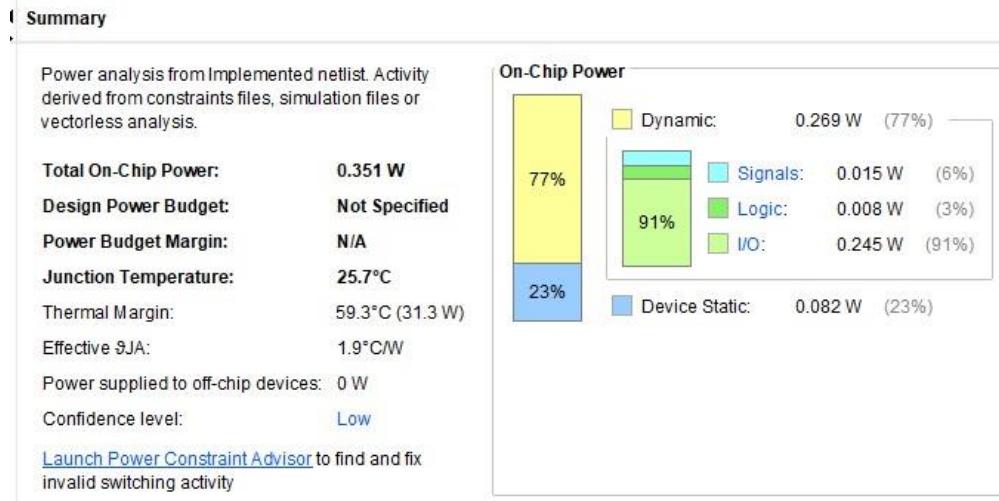
Report BlackBoxes:
++-----+-----+
| |BlackBox name |Instances |
++-----+-----+
++-----+-----+
| |           |           |
++-----+-----+


Report Cell Usage:
++-----+-----+
| |Cell |Count |
++-----+-----+
|1|BUFG | 1 |
|2|ISRL16E | 1 |
|3|FDRE | 2 |
|4|IBUF | 2 |
|5|OBUF | 1 |
++-----+-----+


Report Instance Areas:
++-----+-----+-----+
| |Instance |Module |Cells |
++-----+-----+-----+
|1|top | | 7 |
|2|dut1 |d_ff | 1 |
|3|dut3 |d_ff_0 | 1 |
|4|dut4 |d_ff_1 | 1 |
++-----+-----+-----+


Finished Writing Synthesis Report : Time (s): cpu = 00:00:17 ; elapsed = 00:00:31 . Memory (MB): peak = 1018.820 ; gain = 0.000
-----
```

POWER REPORT:-



Q11. SERIAL IN PARALLEL OUT SHIFT REGISTER

VERILOG CODE:-

```

E:/projects/dsd/SIPO REGISTER/SIPO REGISTER.srscs/sources_1/new/siso_register.v

1 module sipo_shift_register_design(input clk,b,output[3:0]q);
2
3   d_ff dut1(.clk(clk),.d(b),.q(q[3]),.rst());
4   d_ff dut2(.clk(clk),.d(q[3]),.q(q[2]),.rst());
5   d_ff dut3(.clk(clk),.d(q[2]),.q(q[1]),.rst());
6   d_ff dut4(.clk(clk),.d(q[1]),.q(q[0]),.rst());
7
8 endmodule
9 // d flip flop
10
11 module d_ff (
12   input clk,
13   input d,
14   input rst,
15   output reg q);
16
17 always @(posedge clk)
18 begin
19   if (rst)
20     q <= 1'b0;
21   else
22     q <= d;
23 end
24
25 endmodule

```

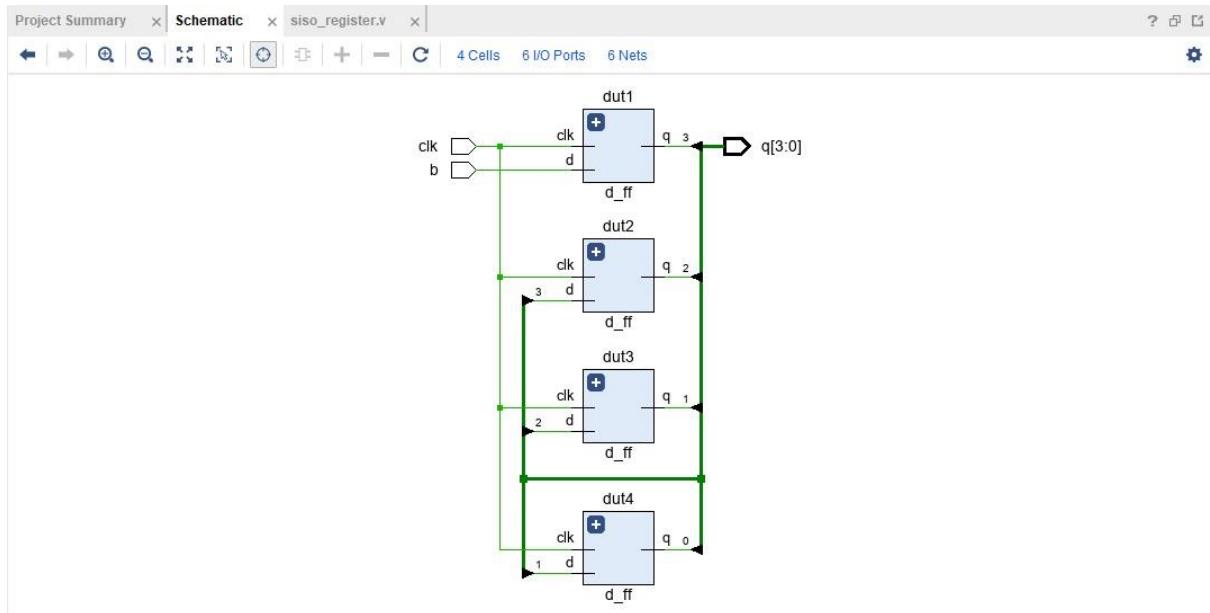
TEST BENCH:-

```

2 // testbench
3 module sipo_tb();
4
5 reg clk;
6 wire [3:0]q;
7
8 sipo_shift_register_design uut(.clk(clk),.b(b),.q(q));
9
10 initial
11 begin
12   clk=1'b0;
13   forever #5clk=~clk;
14 end
15
16 initial
17 begin
18   $monitor("clk=%d,b=%d,q=%d",clk,b,q);
19 end
20
21 initial
22 begin
23   b=1;
24   #10;
25   b=0;
26   #10;
27   b=1;
28   #10;
29   b=0;
30
31   #50;
32   $finish;
33
34 end
35
36 endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
++-----+-----+
| |BlackBox name |Instances |
++-----+-----+
++-----+-----+
Report Cell Usage:
-----+-----+
| |Cell |Count |
-----+-----+
|1 |BUFGE | 1|
|2 |FDRE | 4|
|3 |IBUF | 2|
|4 |OBUF | 4|
-----+-----+
Report Instance Areas:
-----+-----+-----+
| |Instance |Module |Cells |
-----+-----+-----+
|1 |top | | 11|
|2 | dut1 | d_ff | 1|
|3 | dut2 | d_ff_0 | 1|
|4 | dut3 | d_ff_1 | 1|
|5 | dut4 | d_ff_2 | 1|
-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:18 ; elapsed = 00:00:32 . Memory (MB): peak = 1041.301 ; gain = 0.000
-----+

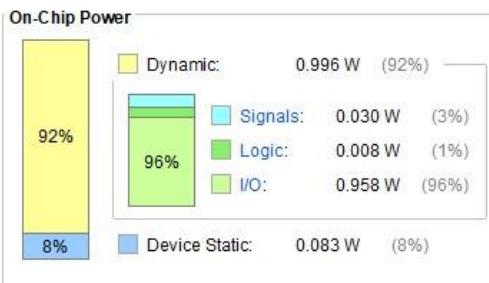
```

POWER REPORT:-

Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power: **1.079 W**
Design Power Budget: **Not Specified**
Power Budget Margin: **N/A**
Junction Temperature: **27.0°C**
Thermal Margin: **58.0°C (30.6 W)**
Effective TJA: **1.9°C/W**
Power supplied to off-chip devices: **0 W**
Confidence level: **Low**



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Q12. PARALLEL IN PARALLEL OUT REGISTER

VERILOG CODE:-

```

`timescale 1ns / 1ps
module pipo_design(input clk,input [3:0]b,output[3:0]a;
d_ff d1(.clk(clk),.d(b[3]),.q(a[3]),.rst());
d_ff d2(.clk(clk),.d(b[2]),.q(a[2]),.rst());
d_ff d3(.clk(clk),.d(b[1]),.q(a[1]),.rst());
d_ff d4(.clk(clk),.d(b[0]),.q(a[0]),.rst());
endmodule

// d flip flop

module d_ff (
    input clk,    // clock input
    input d,      // data input
    input rst,    // asynchronous reset input
    output reg q // output
);
    always @ (posedge clk) begin
        if (rst) // asynchronous reset
            q <= 1'b0;
        else // normal operation
            q <= d;
    end
endmodule

```

TEST BENCH:-

```

// test bench
module pipo_tb();
reg clk;
reg [3:0]b;
wire [3:0]a;

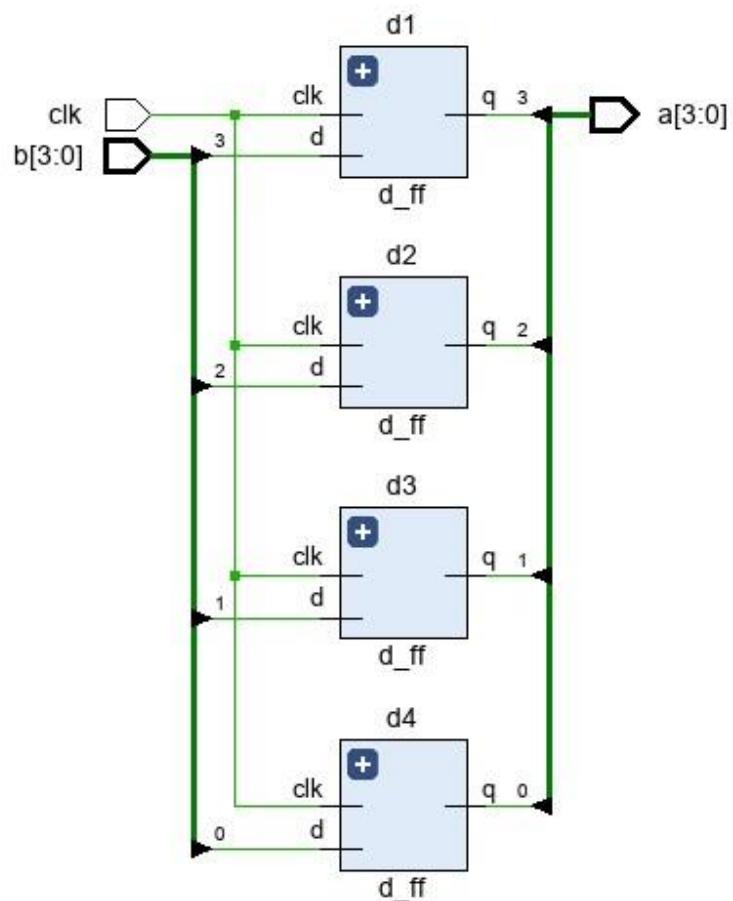
piopo_design uut(.clk(clk),.b(b),.a(a));

initial
begin
clk=0;
forever #10clk=~clk;
end

initial
begin
#10;
b=4'b1000;
#10;
b=4'b0101;
#10;
$display("clk=%d,b=%d,a=%d",clk,b,a);
#100 $finish;
end
endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```
-----  
Start Writing Synthesis Report  
-----  
  
Report BlackBoxes:  
+---+---+  
| BlackBox name | Instances |  
+---+---+  
+---+---+  
  
Report Cell Usage:  
+---+---+  
| Cell | Count |  
+---+---+  
|1 |BUFG | 1|  
|2 |FDRE | 4|  
|3 |IBUF | 5|  
|4 |OBUF | 4|  
+---+---+  
  
Report Instance Areas:  
+---+---+---+  
| Instance | Module | Cells |  
+---+---+---+  
|1 |top | 14| |
|2 | d1 | d_ff | 1|  
|3 | d2 | d_ff_0 | 1|  
|4 | d3 | d_ff_1 | 1|  
|5 | d4 | d_ff_2 | 1|  
+---+---+---+  
-----  
Finished Writing Synthesis Report : Time (s): cpu = 00:00:09 ; elapsed = 00:00:17 . Memory (MB): peak = 1017.965 ; gain = 0.000
```

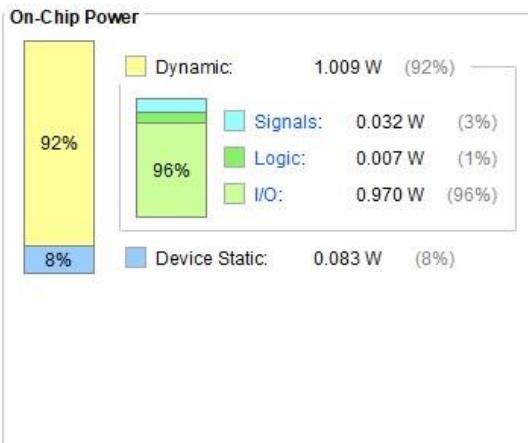
POWER REPORT:-

Summary

Power analysis from implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	1.092 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	27.1°C
Thermal Margin:	57.9°C (30.6 W)
Effective gJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q13. PARALLEL IN SERIAL OUT REGISTER

VERILOG CODE:-



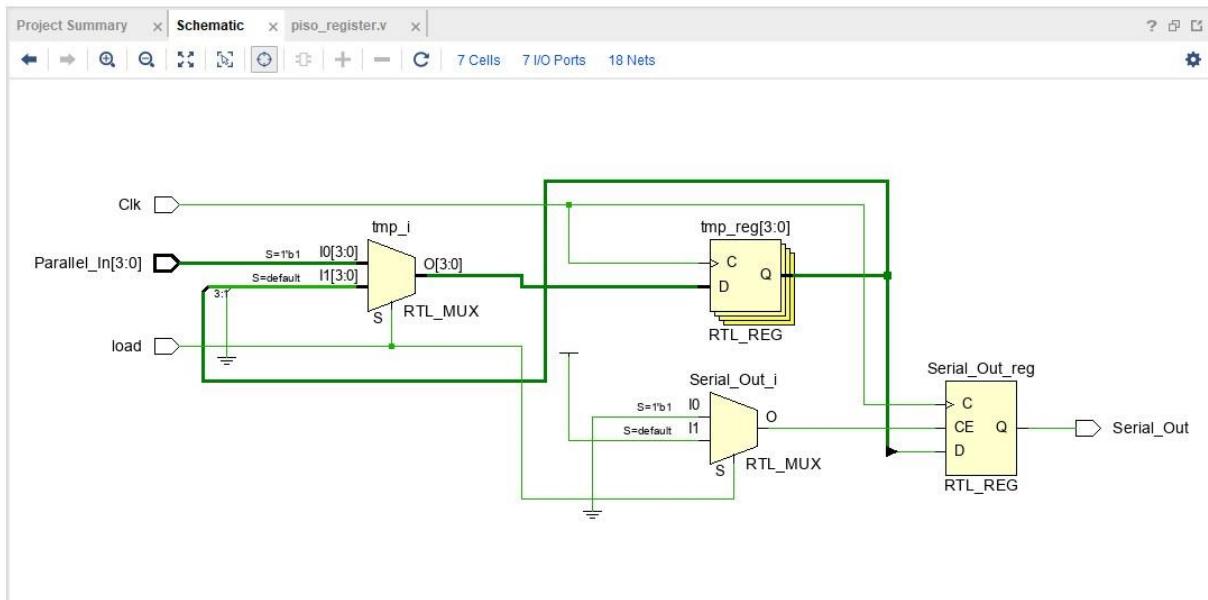
The screenshot shows a Verilog code editor window with the following code:

```
1 module Shiftregister_PISO(Clk, Parallel_In,load, Serial_Out);
2   input Clk,load;
3   input [3:0]Parallel_In;
4   output reg Serial_Out;
5   reg [3:0]tmp;
6   always @(posedge Clk)
7     begin
8       if(load)
9         tmp<=Parallel_In;
10      else
11        begin
12          Serial_Out<=tmp[3];
13          tmp<=(tmp[2:0],1'b0);
14        end
15      end
16   endmodule
```

TEST BENCH:-

```
module Shiftregister_PISO_tb();
reg [3:0]Parallel_in
reg Clk,load;
wire Serial_out;
piso_design dut(Clk,load,Parallel_in,Serial_out);
initial begin
Clk=l'b0;
forever #5 Clk=~Clk;
end
initial begin
load=0;b4'b0101;
#20 load=1;
#20 load=1;
#10 load=0;
#10 load=0;
#100 $finish;
end
endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
++-----+-----+
| |BlackBox name |Instances |
++-----+-----+
++-----+-----+
Report Cell Usage:
++-----+-----+
| |Cell |Count |
++-----+-----+
|1 |BUFGE | 1|
|2 |LUT1 | 1|
|3 |LUT2 | 1|
|4 |LUT3 | 3|
|5 |FDRE | 5|
|6 |IBUF | 6|
|7 |OBUF | 1|
++-----+-----+
Report Instance Areas:
++-----+-----+-----+
| |Instance |Module |Cells |
++-----+-----+-----+
|1 |top | | 18|
++-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:15 ; elapsed = 00:00:51 . Memory (MB): peak = 1015.211 ; gain = 0.000
-----
```

POWER REPORT:-

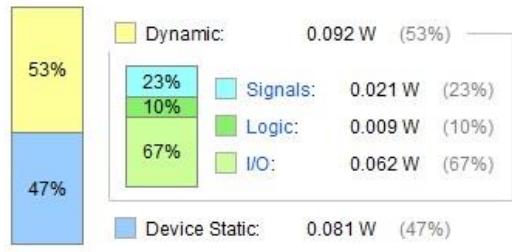
Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	0.173 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	25.3°C
Thermal Margin:	59.7°C (31.5 W)
Effective 8JA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q14. BIDIRECTION SHIFT REGISTER

VERILOG CODE:-

```

Project Summary  x | Schematic  x | bi_directional_register.v  x
E:/projects/dsd/BIDIRECTIONAL REGISTER/BIDIRECTIONAL REGISTER.srsc/sources_1/new/bi_directional_register.v
? ⓘ

17 // Revision 0.01 - File Created
18 // Additional Comments:
19 //
20 ///////////////////////////////////////////////////////////////////
21 module shift_reg #(parameter MSB = 8) (input d,
22   input clk,
23   input en,
24   input dir,
25   input rstn,
26   output reg [MSB-1:0] out);
27   always @ (posedge clk)
28     if (!rstn)
29       out <= 0;
30     else begin
31       if (en)
32         case (dir)
33           0 : out <= {out[MSB-2:0], d};
34           1 : out <= {d, out[MSB-1:1]};
35     endcase
36   else
37     out <= out;
38   end
39 endmodule

```

TEST BENCH:-

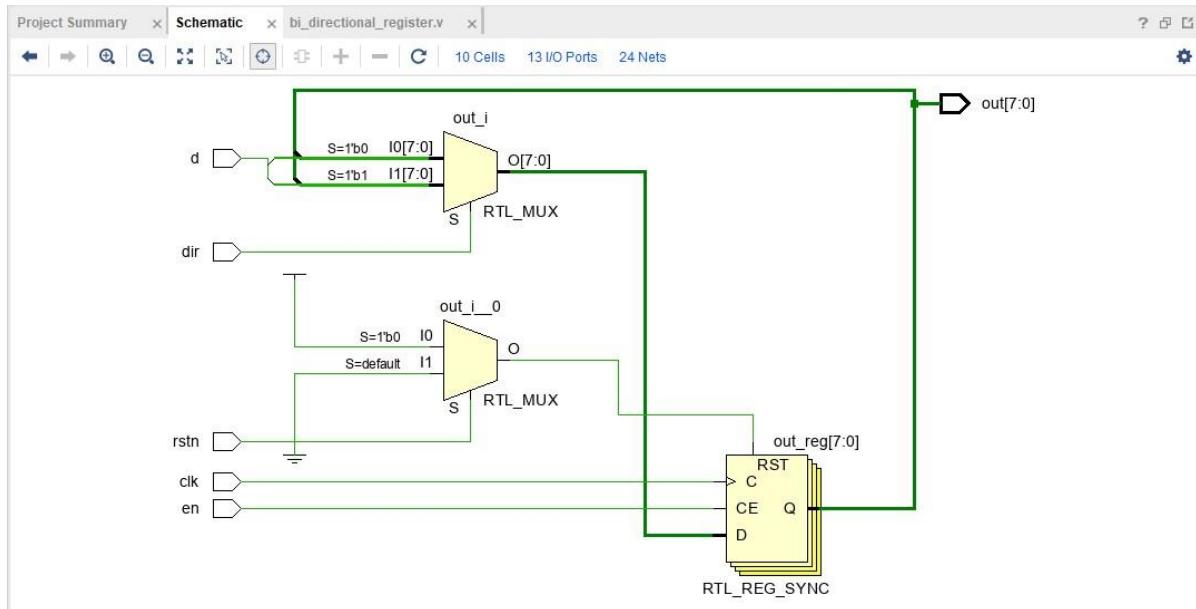
```

module tb_sr;
  parameter MSB = 16;
  reg data;
  reg clk;
  reg en;
  reg dir;
  reg rstn;
  wire [MSB-1:0] out;
  shift_reg #(MSB) sr0 (.d (data),
                        .clk (clk),
                        .en (en),
                        .dir (dir),
                        .rstn (rstn),
                        .out (out));

  always #10 clk = ~clk;
  initial begin
    clk <= 0;
    en <= 0;
    dir <= 0;
    rstn <= 0;
    data <= 'h1;
  end
  initial begin
    rstn <= 0;
    #20 rstn <= 1;
    en <= 1;
    repeat (7) @ (posedge clk)
      data <= ~data;
    #10 dir <= 1;
    repeat (7) @ (posedge clk)
      data <= ~data;
    repeat (7) @ (posedge clk);
    $finish;
  end
endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
++-----+-----+
| |BlackBox name |Instances |
++-----+-----+
++-----+-----+
++-----+-----+
Report Cell Usage:
++-----+-----+
| |Cell |Count |
++-----+-----+
|1 |IBUFG | 1|
|2 |LUT1 | 1|
|3 |LUT3 | 8|
|4 |FDRE | 8|
|5 |IBUF | 5|
|6 |OBUF | 8|
++-----+-----+
Report Instance Areas:
++-----+-----+-----+
| |Instance |Module |Cells |
++-----+-----+-----+
|1 |top | | 31|
++-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:09 ; elapsed = 00:00:17 . Memory (MB): peak = 1014.953 ; gain = 0.000
-----
```

POWER REPORT:-

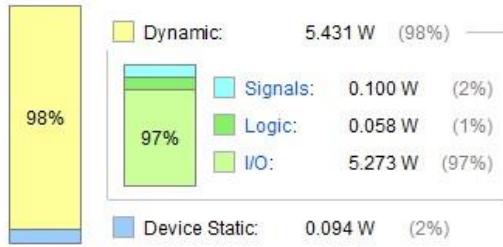
Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	5.524 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	35.4°C
Thermal Margin:	49.6°C (26.1 W)
Effective θJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q15. PRBS SEQUENCE GENERATOR

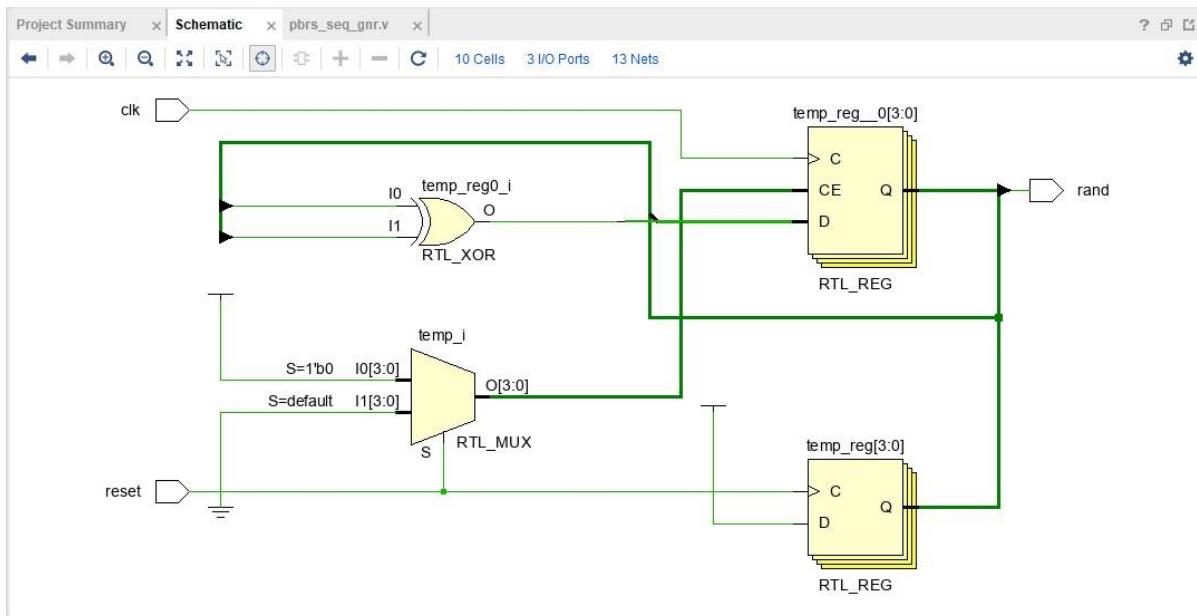
VERILOG CODE:-

```
module prbs (rand, clk, reset);
    input clk, reset;
    output rand;
    wire rand;
    reg [3:0] temp;
    always @ (posedge reset) begin
        temp <= 4'hf;
    end
    always @ (posedge clk) begin
        if (~reset) begin
            temp <= {temp[0]^temp[1],temp[3],temp[2],temp[1]};
        end
    end
    assign rand = temp[0];
endmodule
```

TEST BENCH:-

```
module pbrs_tb;
    reg clk, reset;
    wire rand;
    prbs pr (rand, clk, reset);
    initial begin
        forever begin
            clk <= 0;
            #5
            clk <= 1;
            #5
            clk <= 0;
        end
    end
    initial begin
        reset = 1;
        #12
        reset = 0;
        #90
        reset = 1;
        #12
        reset = 0;
    end
endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
++-----+-----+
| BlackBox name | Instances |
++-----+-----+
++-----+-----+
Report Cell Usage:
++-----+-----+
|   Cell   | Count |
++-----+-----+
|1| BUFG | 2|
|2| LUT1 | 2|
|3| LUT2 | 1|
|4| FDRE | 8|
|5| IBUF | 2|
|6| OBUF | 1|
++-----+-----+
Report Instance Areas:
++-----+-----+-----+
|   Instance   |Module|Cells |
++-----+-----+-----+
|1| ltop | | 16|
++-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:09 ; elapsed = 00:00:16 . Memory (MB): peak = 1018.242 ; gain = 0.000
-----
```

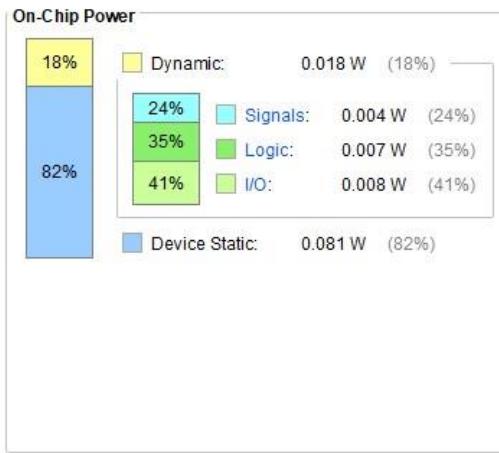
POWER REPORT:-

Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power:	0.1 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	25.2°C
Thermal Margin:	59.8°C (31.6 W)
Effective SJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q16 & 17. 8-BIT ADDER/SUBTRACTOR

VERILOG CODE:-

```
| module par_sub(a,b,cin,diff,bout);
|   input [7:0] a;
|   input [7:0] b;
|   input cin;
|   output reg [7:0] diff;
|   output reg bout;
|   reg [8:0] c;
|   integer i;
|   always @ (a or b or cin)
|   begin
|     c[0]=cin;
|     if (cin == 0) begin
|       for ( i=0; i<8 ; i=i+1)
|       begin
|         diff[i]= a[i]^b[i]^c[i];
|         c[i+1]= (a[i]&b[i])|(a[i]&c[i])|(b[i]&c[i]);
|       end
|     end
|     else if (cin == 1) begin
|       for ( i=0; i<8 ; i=i+1)
|       begin
|         diff[i]= a[i]^(~ b[i])^c[i];
|         c[i+1]= (a[i]&(~b[i]))|(a[i]&c[i])|((~b[i])&c[i]);
|       end
|     end
|     bout=c[8];
|   end
| endmodule
```

TEST BENCH:-

```
module par_sub_tb
reg [7:0] a;
reg [7:0] b;
reg cin;
wire [7:0] diff;
wire bout;

par_sub_uut (.a(a), .b(b), .cin(cin), .diff(diff), .bout(bout) );

initial begin

#10 a=8'b00000001; b=8'b00000001; cin=l'b0;

#10 a=8'b00000001; b=8'b00000001; cin=l'b1;

#10 a=8'b00000010; b=8'b00000011; cin=l'b0;

#10 a=8'b10000001; b=8'b10000001; cin=l'b0;

#10 a=8'b00011001; b=8'b00110001; cin=l'b0;

#10 a=8'b00000011; b=8'b00000011; cin=l'b1;

#10 a=8'b11111111; b=8'b00000001; cin=l'b0;

#10 a=8'b11111111; b=8'b00000000; cin=l'b1;

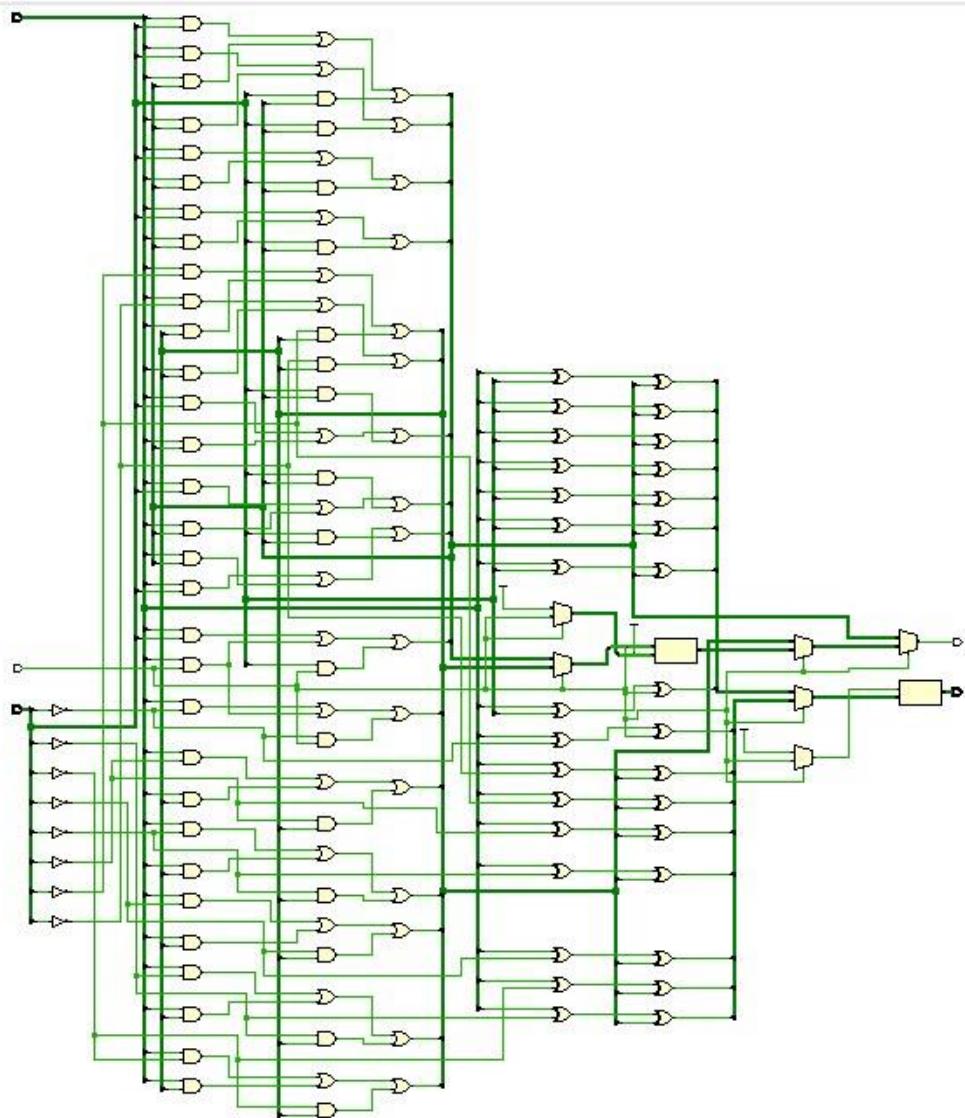
#10 a=8'b11111111; b=8'b11111111; cin=l'b0;

#10 $stop;

end

endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

Start Writing Synthesis Report

Report BlackBoxes:

BlackBox name	Instances
I	1
I	6
I	14
I	17
I	9

Report Cell Usage:

Cell	Count
LUT2	1
LUT3	6
LUT5	14
IBUF	17
OBUF	9

Report Instance Areas:

Instance	Module	Cells
top		47

Finished Writing Synthesis Report : Time (s): cpu = 00:00:09 ; elapsed = 00:00:27 . Memory (MB): peak = 1017.555 ; gain = 0.000

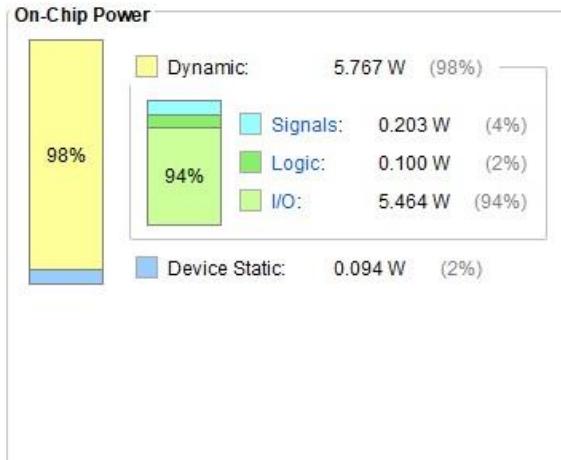
POWER REPORT:-

Summary

Power analysis from Implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

Total On-Chip Power:	5.862 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	36.0°C
Thermal Margin:	49.0°C (25.8 W)
Effective gJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q18. 4-BIT MULTIPLIER

VERILOG CODE:-

```

`timescale 1ns / 1ps
`module multiplier_4_x_4(product,inpl,inp2);

    output [7:0]product;
    input [3:0]inpl;
    input [3:0]inp2;

    assign product[0]=(inpl[0]&inp2[0]);

    wire x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14,x15,x16,x17;

    HA HA1(product[1],x1,(inpl[1]&inp2[0]),(inpl[0]&inp2[1]));
    FA FA1(x2,x3,inpl[1]&inp2[1],(inpl[0]&inp2[2]),x1);
    FA FA2(x4,x5,(inpl[1]&inp2[2]),(inpl[0]&inp2[3]),x3);
    HA HA2(x6,x7,(inpl[1]&inp2[3]),x5);

    HA HA3(product[2],x15,x2,(inpl[2]&inp2[0]));
    FA FA5(x14,x16,x4,(inpl[2]&inp2[1]),x15);
    FA FA4(x13,x17,x6,(inpl[2]&inp2[2]),x16);
    FA FA3(x9,x8,x7,(inpl[2]&inp2[3]),x17);

    HA HA4(product[3],x12,x14,(inpl[3]&inp2[0]));
    FA FA8(product[4],x11,x13,(inpl[3]&inp2[1]),x12);
    FA FA7(product[5],x10,x9,(inpl[3]&inp2[2]),x11);
    FA FA6(product[6],product[7],x8,(inpl[3]&inp2[3]),x10);

` endmodule

` module HA(sout,cout,a,b);
    output sout,cout;
    input a,b;
    assign sout=a^b;
    assign cout=(a&b);
` endmodule

` module HA(sout,cout,a,b);
    output sout,cout;
    input a,b;
    assign sout=a^b;
    assign cout=(a&b);
` endmodule

` module FA(sout,cout,a,b,cin);
    output sout,cout;
    input a,b,cin;
    assign sout=(a^b^cin);
    assign cout=((a&b)|(a&cin)|(b&cin));
` endmodule

```

TEST BENCH:-

```
) module tb;

    reg [3:0]inpl;
    reg [3:0]inp2;
    wire [7:0]product;

    multiplier_4_x_4 uut(.inpl(inpl),.inp2(inp2),.product(product));

) initial
) begin
    inpl=10;
    inp2=12;
    #30 ;

    inpl=13;
    inp2=12;
    #30 ;

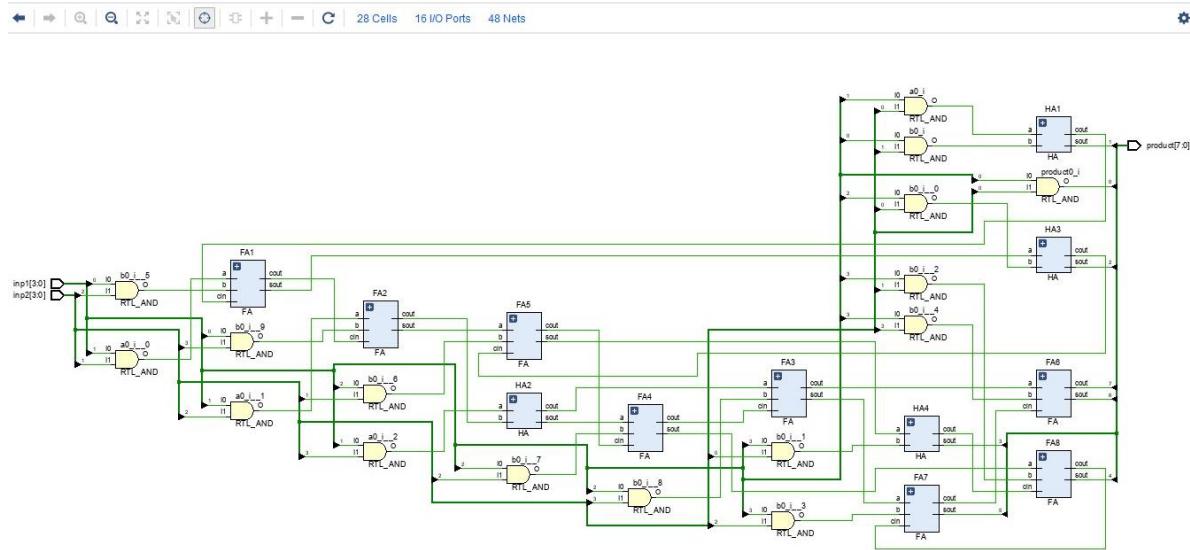
    inpl=10;
    inp2=22;
    #30 ;

    inpl=11;
    inp2=22;
    #30 ;

    inpl=12;
    inp2=15;
    #30 ;

    $finish;
) end
) endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

Start Writing Synthesis Report

Report BlackBoxes:

BlackBox name	Instances

Report Cell Usage:

Cell	Count
1 LUT2	11
2 LUT4	6
3 LUT6	11
4 IBUF	8
5 OBUF	8

Report Instance Areas:

Instance	Module	Cells
1 top		34

Finished Writing Synthesis Report : Time (s): cpu = 00:00:15 ; elapsed = 00:00:30 . Memory (MB): peak = 1014.992 ; gain = 0.000

POWER REPORT:-

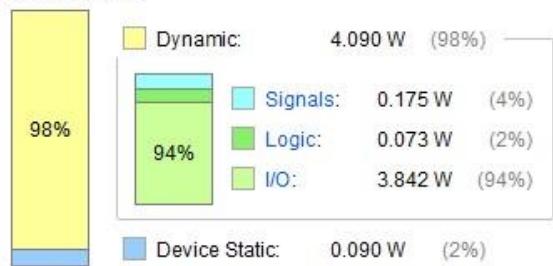
Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power:	4.18 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	32.9°C
Thermal Margin:	52.1°C (27.5 W)
Effective θJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q19. FIXED POINT DIVISION

VERILOG CODE:-

```

fixed_p_div.v
E:/projects/dsd/Fixed point division/Fixed point division.scs/sources_1/newfixed_p_div.v

module qdiv #(
    //Parameterized values
    parameter Q = 15,
    parameter N = 32
)
(
    input  [N-1:0] i_dividend,
    input  [N-1:0] i_divisor,
    input  i_start,
    input  i_clk,
    output [N-1:0] o_quotient_out,
    output o_complete,
    output o_overflow
);

reg [2*N+Q-3:0] reg_working_quotient;
reg [N-1:0] reg_quotient;
reg [N+2:Q:0] reg_working_dividend;
reg [2*N+Q-3:0] reg_working_divisor;
reg [N-1:0] reg_count;

reg reg_done;
reg reg_sign;
reg reg_overflow;

initial reg_done = 1'b0;
initial reg_overflow = 1'b0;
initial reg_sign = 1'b0;

initial reg_working_quotient = 0;
initial reg_quotient = 0;
initial reg_working_dividend = 0;
initial reg_working_divisor = 0;

initial reg_count = 0;

initial reg_quotient = 0;
initial reg_working_dividend = 0;
initial reg_working_divisor = 0;
initial reg_count = 0;

assign o_quotient_out[N-2:0] = reg_quotient[N-2:0];
assign o_quotient_out[N-1] = reg_sign;
assign o_complete = reg_done;
assign o_overflow = reg_overflow;

always @(`posedge i_clk`) begin
    if( reg_done && i_start ) begin
        reg_done <= 1'b0;
        reg_count <= N+Q-1;
        reg_working_quotient <= 0;
        reg_working_dividend <= 0;
        reg_working_divisor <= 0;
        reg_overflow <= 1'b0;

        reg_working_dividend[N+Q-2:Q] <= i_dividend[N-2:0];
        reg_working_divisor[2*N+Q-3:N+Q-1] <= i_divisor[N-2:0];

        reg_sign <= i_dividend[N-1] ^ i_divisor[N-1];
        end
    else if(!reg_done) begin
        reg_working_divisor <= reg_working_divisor >> 1;
        reg_count <= reg_count - 1;

        // If the dividend is greater than the divisor
        if(reg_working_dividend >= reg_working_divisor) begin
            reg_working_quotient[reg_count] <= 1'b1;
            reg_working_dividend <= reg_working_dividend - reg_working_divisor;
        end
    end
end

```

```

//stop condition
if(reg_count == 0) begin
    reg_done <= 1'b1;
    reg_quotient <= reg_working_quotient;
    if (reg_working_quotient[2*N+Q-3:N]>0)
        reg_overflow <= 1'b1;
    end
else
    reg_count <= reg_count - 1;
end
end
endmodule

```

TEST BENCH:-

```

module Test_Div;

// Inputs
reg [31:0] i_dividend;
reg [31:0] i_divisor;
reg i_start;
reg i_clk;

// Outputs
wire [31:0] o_quotient_out;
wire o_complete;
wire o_overflow;

// Instantiate the Unit Under Test (UUT)
qdiv uut (
    .i_dividend(i_dividend),
    .i_divisor(i_divisor),
    .i_start(i_start),
    .i_clk(i_clk),
    .o_quotient_out(o_quotient_out),
    .o_complete(o_complete),
    .o_overflow(o_overflow)
);

reg [10:0] count;

initial begin
    // Initialize Inputs
    i_dividend = 1;
    i_divisor = 1;
    i_start = 0;
    i_clk = 0;

    count <= 0;

```

```

// Wait 100 ns for global reset to finish
#100;

// Add stimulus here
forever #2 i_clk = ~i_clk;
end

always @(posedge i_clk) begin
    if (count == 47) begin
        count <= 0;
        i_start <= 1'b1;
        end
    else begin
        count <= count + 1;
        i_start <= 1'b0;
        end
    end

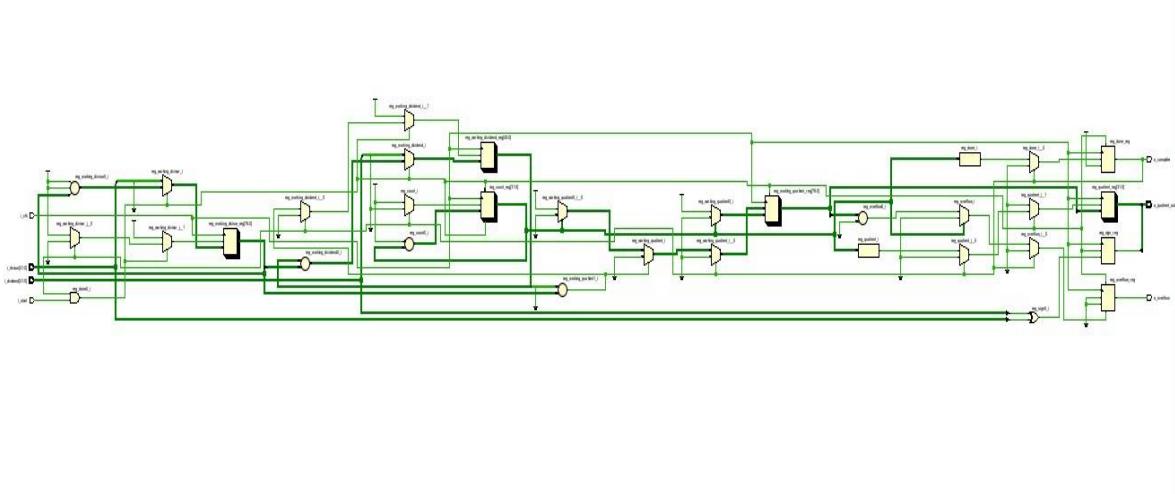
always @(count) begin
    if (count == 47) begin
        if ( i_divisor > 32'h1FFFFFFF ) begin
            i_divisor <= 1;
            i_dividend = (i_dividend << 1) + 3;
            end
        else
            i_divisor = (i_divisor << 1) + 1;
        end
    end
end

always @(posedge o_complete)
$display ("%b,%b,%b, %b", i_dividend, i_divisor, o_quotient_out, o_overflow);

endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
++-----+-----+
| |BlackBox name |Instances |
++-----+-----+
++-----+-----+
Report Cell Usage:
++-----+-----+
| |Cell |Count |
++-----+-----+
|1 |BUFG | 1|
|2 |CARRY4 | 30|
|3 |LUT1 | 34|
|4 |LUT2 | 20|
|5 |LUT3 | 121|
|6 |LUT4 | 102|
|7 |LUT5 | 39|
|8 |LUT6 | 27|
|9 |FDRE | 261|
|10 |FDSE | 4|
|11 |IBUF | 66|
|12 |OBUF | 34|
++-----+-----+
Report Instance Areas:
++-----+-----+
| |Instance |Module |Cells |
++-----+-----+
|1 |top | | 739|
++-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:17 ; elapsed = 00:00:30 . Memory (MB): peak = 1019.531 ; gain = 0.000

```

POWER REPORT:-

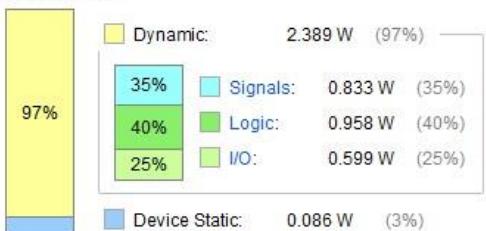
◀ Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power:	2.475 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	29.7°C
Thermal Margin:	55.3°C (29.2 W)
Effective QJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q20. MASTER SLAVE JK FLIP FLOP

VERILOG CODE:-

```

`module jk_flip_flop_master_slave(Q, Qn, C, J, K, RESETn);
    output Q;
    output Qn;
    input C;
    input J;
    input K;
    input RESETn;

    wire MQ;
    wire MQn;
    wire Cn;
    wire J1;
    wire K1;
    wire J2;
    wire K2;
    assign J2 = !RESETn ? 0 : J1;
    assign K2 = !RESETn ? 1 : K1;

    and(J1, J, Qn);
    and(K1, K, Q);
    not(Cn, C);
    sr_latch_gated master(MQ, MQn, C, J2, K2);
    sr_latch_gated slave(Q, Qn, Cn, MQ, MQn);
`endmodule
`


`module sr_latch_gated(Q, Qn, G, S, R);
    output Q;
    output Qn;
    input G;
    input S;
    input R;

    wire S1;
    wire R1;

    and(S1, G, S);
    and(R1, G, R);
    nor(Qn, S1, Q);
    nor(Q, R1, Qn);
`endmodule

```

TEST BENCH:-

```

) module JK_ff_tb;

reg C, J, K, RESETn;
wire Q;
wire Qn;

jk_flip_flop_master_slave jkflipflop( .C(C), .RESETn(RESETn), .J(J), .K(K), .Q(Q), .Qn(Qn) );

) initial begin
$dumpfile("dump.vcd"); $dumpvars;
$monitor(C,J,Q,Qn,RESETn);

J = 1'b0;
K = 1'b0;
RESETn = 1;
C=1;

#10
RESETn=0;
J=1'b1;
K=1'b0;

#100
RESETn=0;
J=1'b0;
K=1'b1;

#100
RESETn=0;
J=1'b1;
K=1'b1;

#100
RESETn=0;
J=1'b1;
K=1'b1;

#100
RESETn=0;
J=1'b0;
K=1'b0;

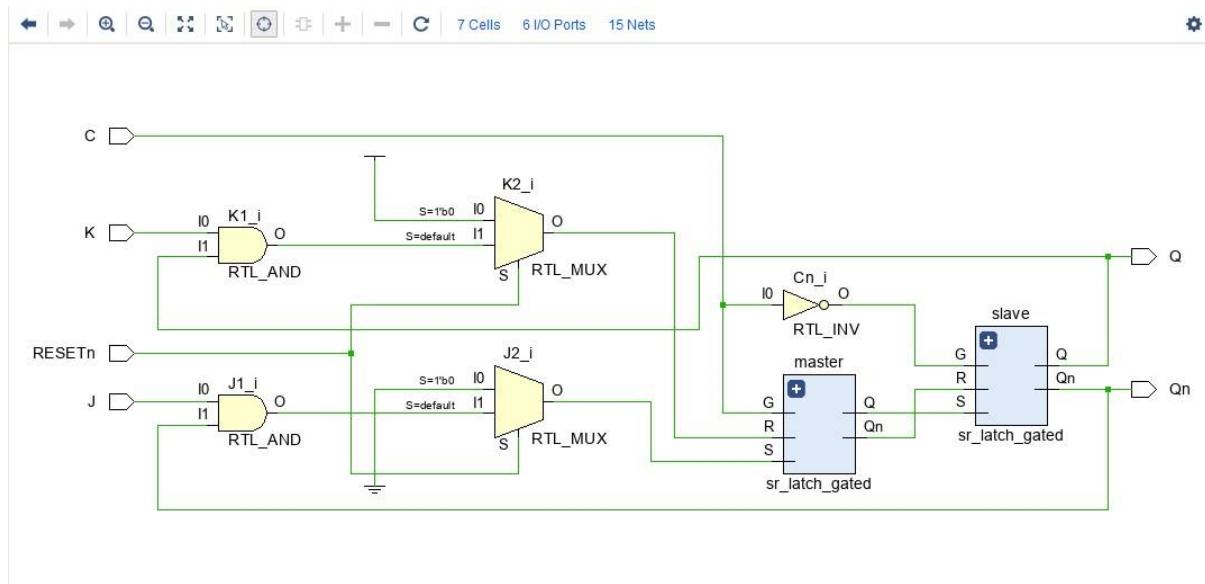
#100
RESETn=1;
J=1'b1;
K=1'b0;

) end
always #25 C <= ~C;

) endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

-----
Start Writing Synthesis Report
-----

Report BlackBoxes:
++-----+-----+
| !BlackBox name |Instances |
++-----+-----+
++-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
|     |Cell |Count |
+-----+-----+
|11   |LUT3  |    2|
|12   |LUT6  |    2|
|13   |IBUF  |    4|
|14   |OBUF  |    2|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
|     |Instance |Module |Cells |
+-----+-----+-----+
|1    |top      |        |    10|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:15 ; elapsed = 00:00:28 . Memory (MB): peak = 1015.500 ; gain = 0.000
-----
```

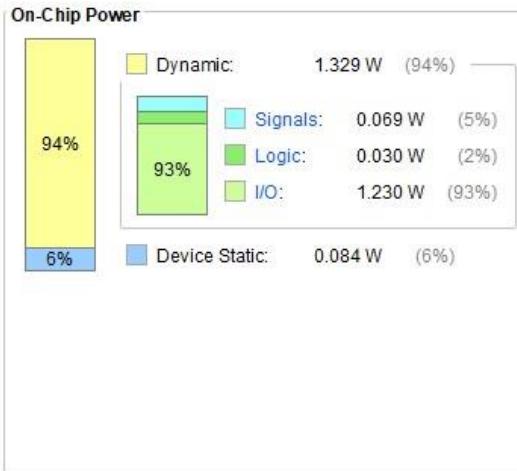
POWER REPORT:-

Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power:	1.413 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	27.7°C
Thermal Margin:	57.3°C (30.2 W)
Effective θJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q21. POSITIVE EDGE DETECTOR

VERILOG CODE:-

```
module pos_edge_detect(clk,nrst,din,dout);
    input clk;
    input nrst;
    input din;
    output dout;
    reg d_ff;

    always @(posedge clk or negedge nrst)
    begin
        if(!nrst)
            d_ff<=1'b0;
        else
            d_ff<=din;
    end
    assign dout=din&&(d_ff^din);
endmodule

module d_ff(D,C,a);
    input D;
    input C;
    output a;
    reg a;
    always @(posedge C)
    begin
        a <= D;
    end
endmodule
```

TEST BENCH:-

```
module tb;
    reg nrst;
    reg clk;
    reg din;
    wire dout;

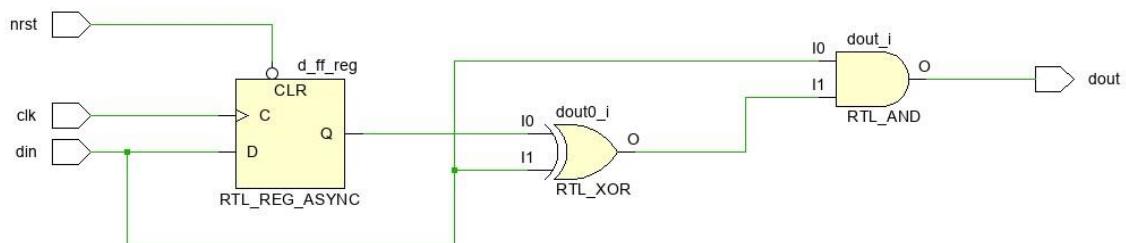
    pos_edge_det ped0 ( .nrst(nrst),
                        .clk(clk),
                        .din(din),.dout(dout));

    always #5 clk = ~clk;

    initial begin
        clk <= 0;
        nrst <= 0;
        #15 nrst<= 1;
        #20 nrst<= 0;
        #15 nrst<= 1;
        #10 nrst <= 0;
        #20 $finish;
    end

    initial begin
        $dumpvars;
        $dumpfile("dump.vcd");
    end
endmodule
```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
|  BlackBox name | Instances |
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
|      Cell | Count |
+-----+-----+
| 1  |BUFG |    1|
| 2  |LUT1 |    1|
| 3  |LUT2 |    1|
| 4  |FDCE |    1|
| 5  |IBUF |    3|
| 6  |OBUF |    1|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
|      Instance |Module |Cells |
+-----+-----+-----+
| 1  |top       |      |  8|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:20 ; elapsed = 00:00:41 . Memory (MB): peak = 1018.688 ; gain = 0.000
-----
```

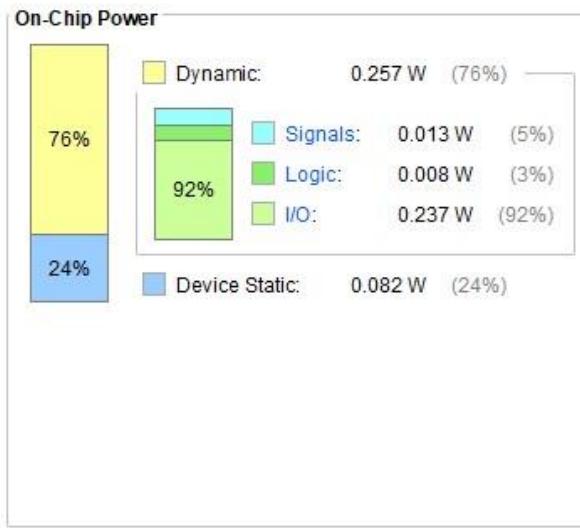
POWER REPORT:-

Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power:	0.339 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	25.6°C
Thermal Margin:	59.4°C (31.3 W)
Effective 3JA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q22. BCD ADDER

VERILOG CODE:-

```
1 module bcd_adder(a,b,carry_in,sum,carry);  
  
    input [3:0] a,b;  
    input carry_in;  
    output [3:0] sum;  
    output carry;  
  
    reg [4:0] sum_temp;  
    reg [3:0] sum;  
    reg carry;  
  
1 always @(a,b,carry_in)  
1 begin  
    sum_temp = a+b+carry_in;  
1 if(sum_temp > 9) begin  
    sum_temp = sum_temp+6;  
    carry = 1;  
1     sum = sum_temp[3:0];    end  
1 else begin  
    carry = 0;  
    sum = sum_temp[3:0];  
1 end  
1 end  
1  
1 endmodule
```

TEST BENCH:-

```

) module tb_bcdadder;

    reg [3:0] a;
    reg [3:0] b;
    reg carry_in;

    wire [3:0] sum;
    wire carry;

    bcd_adder uut (
        .a(a),
        .b(b),
        .carry_in(carry_in),
        .sum(sum),
        .carry(carry)
    );

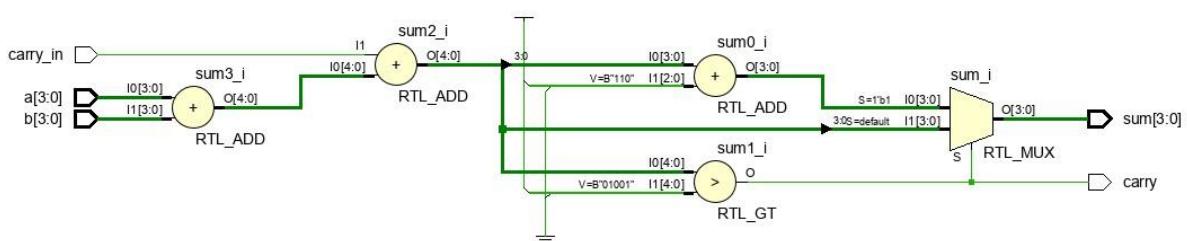
    ) initial begin

        a = 0;  b = 0;  carry_in = 0;  #100;
        a = 6;  b = 9;  carry_in = 0;  #100;
        a = 3;  b = 3;  carry_in = 1;  #100;
        a = 4;  b = 5;  carry_in = 0;  #100;
        a = 8;  b = 2;  carry_in = 0;  #100;
        a = 9;  b = 9;  carry_in = 1;  #100;
    end

) endmodule

```

RTL SCHEMATIC:-

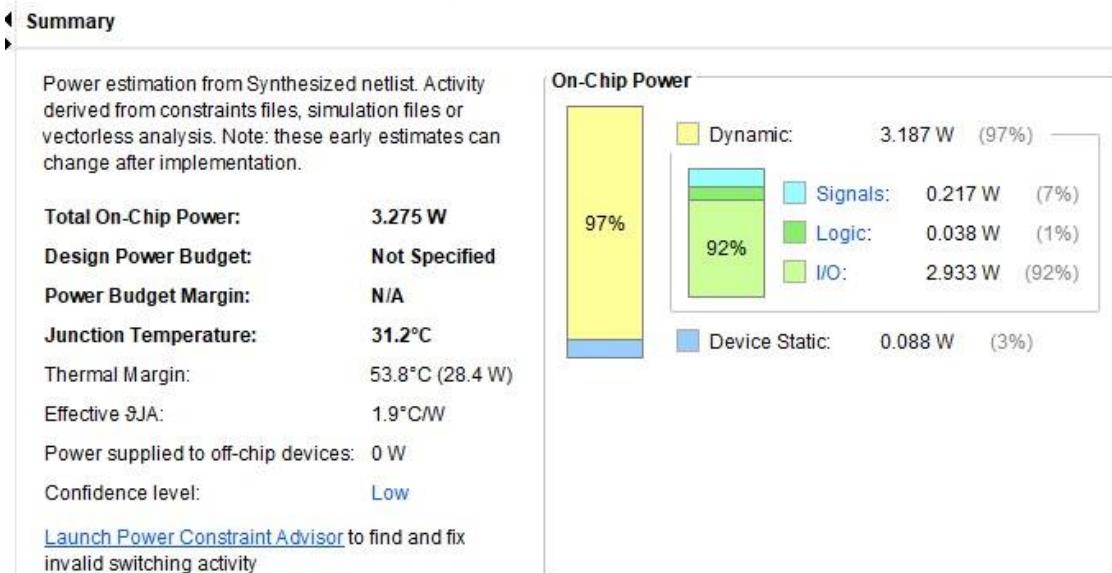


SYNTHESIS REPORT:-

```
-----
Start Writing Synthesis Report
-----

Report BlackBoxes:
+-----+-----+
| 1BlackBox name |Instances |
+-----+-----+
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
|     |Cell |Count |
+-----+-----+
|1   |LUT3 |    1|
|2   |LUT5 |    2|
|3   |LUT6 |    4|
|4   |IBUF |    9|
|5   |OBUF |    5|
+-----+-----+
Report Instance Areas:
+-----+-----+
|     |Instance |Module |Cells |
+-----+-----+
|1   |top      |       | 21|
+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:23 ; elapsed = 00:00:44 . Memory (MB): peak = 1016.285 ; gain = 0.000
-----
```

POWER REPORT:-



Q23. 4-BIT CARRY SELECT ADDER

VERILOG CODE:-

```

) module carry_select_adder
    (   input [3:0] A,B,
        input cin,
        output [3:0] S,
        output cout
    );

    wire [3:0] temp0,temp1,carry0,carry1;

    fulladder fa00(A[0],B[0],1'b0,temp0[0],carry0[0]);
    fulladder fa01(A[1],B[1],carry0[0],temp0[1],carry0[1]);
    fulladder fa02(A[2],B[2],carry0[1],temp0[2],carry0[2]);
    fulladder fa03(A[3],B[3],carry0[2],temp0[3],carry0[3]);

    fulladder fa10(A[0],B[0],1'b1,temp1[0],carry1[0]);
    fulladder fall(A[1],B[1],carry1[0],temp1[1],carry1[1]);
    fulladder fa12(A[2],B[2],carry1[1],temp1[2],carry1[2]);
    fulladder fal3(A[3],B[3],carry1[2],temp1[3],carry1[3]);

    multiplexer2 mux_carry(carry0[3],carry1[3],cin,cout);

    multiplexer2 mux_sum0(temp0[0],temp1[0],cin,S[0]);
    multiplexer2 mux_sum1(temp0[1],temp1[1],cin,S[1]);
    multiplexer2 mux_sum2(temp0[2],temp1[2],cin,S[2]);
    multiplexer2 mux_sum3(temp0[3],temp1[3],cin,S[3]);

) endmodule

```

```
) module fulladder
    (   input a,b,cin,
        output sum,carry
    );

    assign sum = a ^ b ^ cin;
    assign carry = (a & b) | (cin & b) | (a & cin);

) endmodule

) module multiplexer2
    (   input i0,i1,sel,
        output reg bitout
    );

    always@(i0,i1,sel)
    begin
    if(sel == 0)
        bitout = i0;
    else
        bitout = i1;
    end

) endmodule
```

TEST BENCH:-

```
) module tb_adder;

    reg [3:0] A;
    reg [3:0] B;
    reg cin;

    wire [3:0] S;
    wire cout;
    integer i,j,error;

    carry_select_adder uut (
        .A(A),
        .B(B),
        .cin(cin),
        .S(S),
        .cout(cout)
    );

    ) initial begin

        A = 0;
        B = 0;
        error = 0;

        cin = 0;
    ) for(i=0;i<16;i=i+1) begin
        ) for(j=0;j<16;j=j+1) begin
            A = i;
            B = j;
            #10;
        ) if({cout,S} != (i+j))
```

```

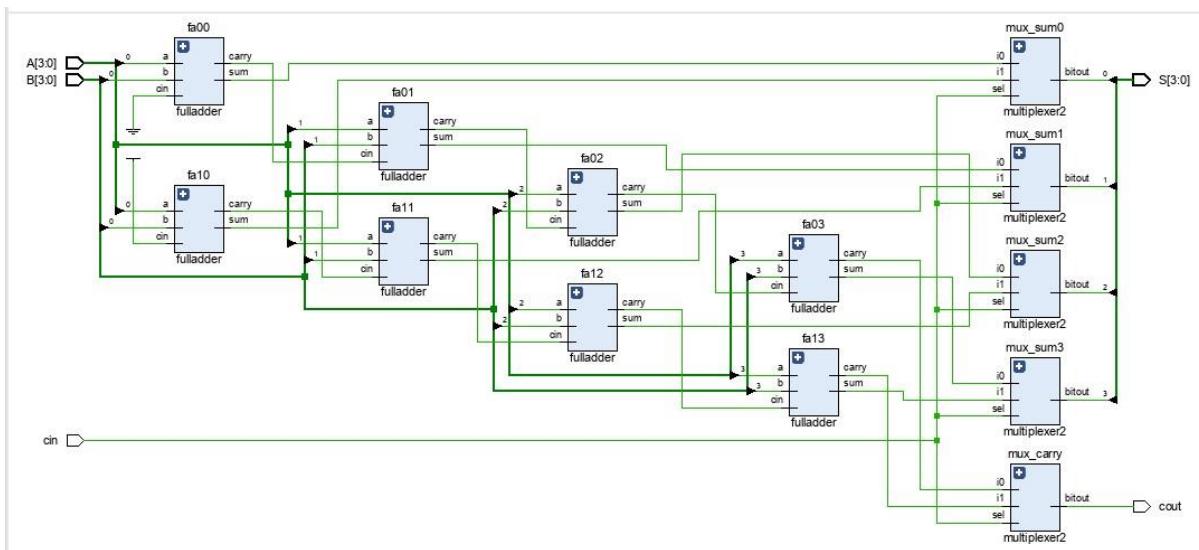
    end

    cin = 1;
    for(i=0;i<16;i=i+1) begin
        for(j=0;j<16;j=j+1) begin
            A = i;
            B = j;
            #10;
            if({cout,S} != (i+j+1))
                error <= error + 1;
        end
    end
end

endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```
Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
| BlackBox name | Instances |
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
| Cell | Count |
+-----+-----+
|1| LUT3 | 2|
|2| LUT5 | 4|
|3| IBUF | 9|
|4| OBUF | 5|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
| Instance | Module | Cells |
+-----+-----+-----+
|1| top | | 20|
+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:22 ; elapsed = 00:00:43 . Memory (MB): peak = 1017.844 ; gain = 0.000
```

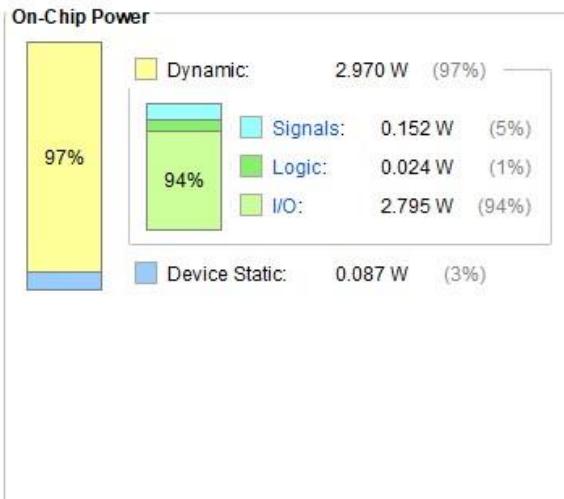
POWER REPORT:-

Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power:	3.058 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	30.8°C
Thermal Margin:	54.2°C (28.6 W)
Effective θ _{JA} :	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity



Q24. MOORE FSM 1010 SEQUENCE DETECTOR

VERILOG CODE:-

```
module morfsmolp(din, reset, clk, y);
    input din;
    input clk;
    input reset;
    output reg y;
    reg [2:0] cst, nst;
    parameter S0 = 3'b000,
              S1 = 3'b001,
              S2 = 3'b010,
              S3 = 3'b100,
              S4 = 3'b101;
    always @(cst or din)
        begin
            case (cst)
                S0: if (din == 1'b1)
                    begin
                        nst = S1;
                        y=1'b0;
                    end
                else nst = cst;
                S1: if (din == 1'b0)
                    begin
                        nst = S2;
                        y=1'b0;
                    end
                else
                    begin
                        nst = cst;
                        y=1'b0;
                    end
                S2: if (din == 1'b1)
                    begin
                        nst = S3;
                        y=1'b0;
                    end
            endcase
            if (reset)
                nst = S0;
            else
                nst = cst;
            y = nst[2];
        end
    endmodule
```

```
S3: if (din == 1'b0)
    begin
        nst = S4;
        y=1'b0;
    end
else
    begin
        nst = S1;
        y=1'b0;
    end
S4: if (din == 1'b0)
    begin
        nst = S1;
        y=1'b1;
    end
else
    begin
        nst = S3;
        y=1'bl;
    end
default: nst = S0;
endcase
end
always@(posedge clk)
begin
    if (reset)
        cst <= S0;
    else
        cst <= nst;
end
endmodule
```

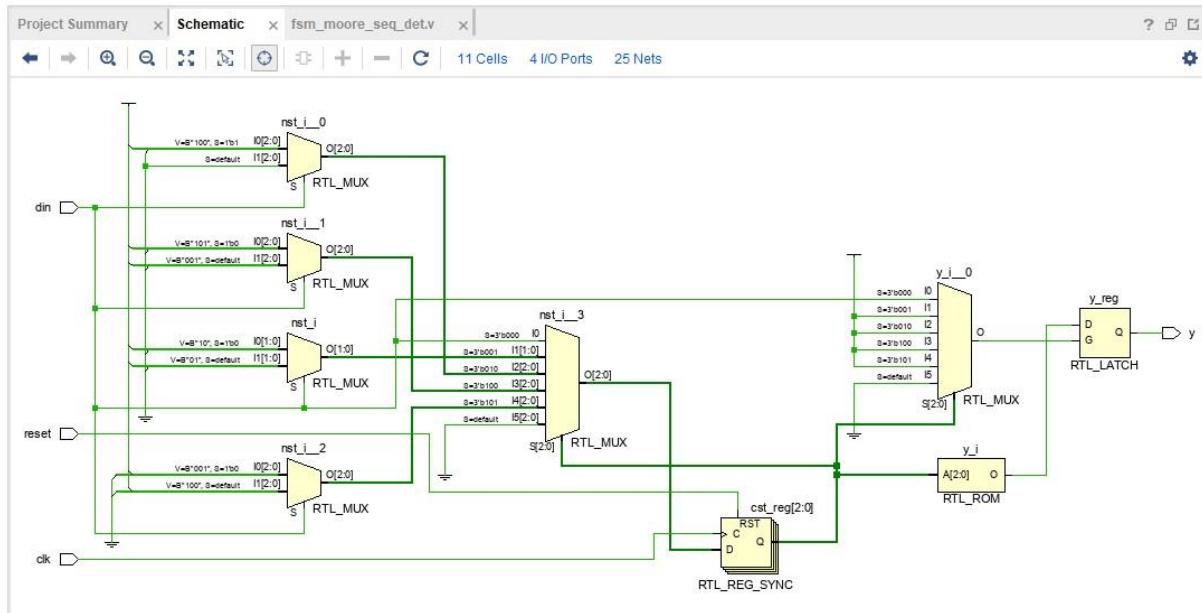
TEST BENCH:-

```

module morfsmolp_tb;
reg din,clk,reset;
wire y;
morfsmolp ml(din, reset, clk, y);
initial
begin
reset=0      ;clk=0;din=0;
$monitor($time, , "c=%b",clk,, "y=%b",y,, "r=%b",reset,, "d=%b",din);
#10 din=1;
#10 din=0;
#10 din=1;
#10 din=0;
end
always
#5 clk=~clk;
initial
#100 $finish ;
endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```
Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
| |BlackBox name |Instances |
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
| |Cell |Count |
+-----+-----+
|1 |BUFG | 1|
|2 |LUT2 | 2|
|3 |LUT3 | 2|
|4 |LUT5 | 1|
|5 |LUT6 | 1|
|6 |FDRE | 4|
|7 |FDSE | 1|
|8 |LD | 1|
|9 |IBUF | 3|
|10 |OBUF | 1|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
| |Instance |Module |Cells |
+-----+-----+-----+
|1 |top | | 17|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:10 ; elapsed = 00:00:17 . Memory (MB): peak = 1017.680 ; gain = 0.000
```

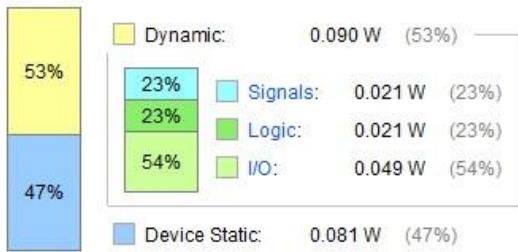
POWER REPORT:-

Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power: 0.172 W
Design Power Budget: Not Specified
Power Budget Margin: N/A
Junction Temperature: 25.3°C
 Thermal Margin: 59.7°C (31.5 W)
 Effective θJA: 1.9°C/W
 Power supplied to off-chip devices: 0 W
 Confidence level: Low
[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

On-Chip Power



Q25. N:1 MUX

VERILOG CODE:-

```

) module mux_4_1(
  input [1:0] sel,
  input i0,i1,i2,i3,
  output reg y);

) always @(*) begin
)   case(sel)
  2'h0: y = i0;
  2'h1: y = i1;
  2'h2: y = i2;
  2'h3: y = i3;
  default: $display("Invalid sel input");
) endcase
) end
) endmodule

```

TEST BENCH:-

```

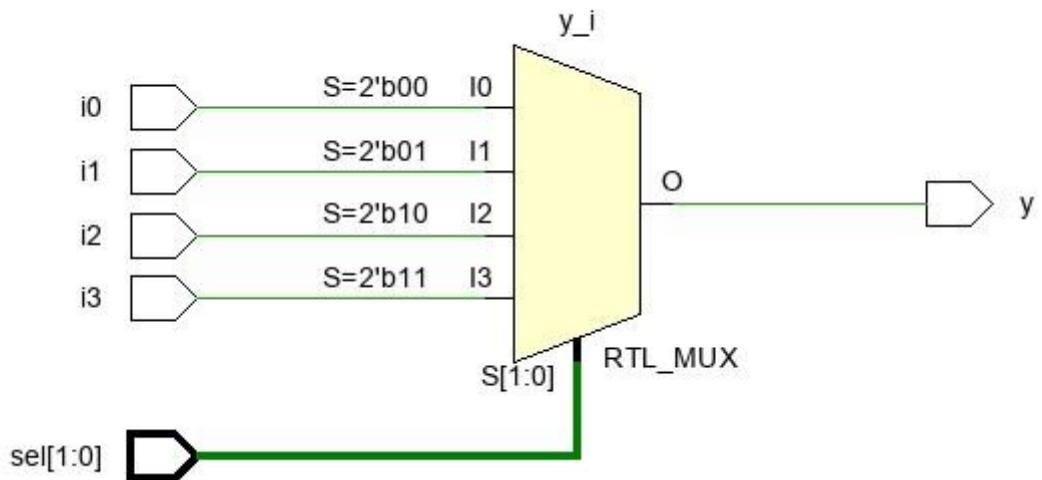
) module tb;
  reg [1:0] sel;
  reg i0,i1,i2,i3;
  wire y;

  mux_example mux(sel, i0, i1, i2, i3, y);

) initial begin
  $monitor("sel = %b -> i3 = %0b, i2 = %0b ,i1 = %0b, i0 = %0b -> y = %0b", sel,i3,i2,i1,i0, y);
  {i3,i2,i1,i0} = 4'h5;
) repeat(6) begin
  sel = $random;
  #5;
) end
) end
) endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
+-----+-----+
| BlackBox name | Instances |
+-----+-----+
+-----+-----+
Report Cell Usage:
+-----+-----+
|   |Cell |Count |
+-----+-----+
|1  |LUT6 |    1|
|2  |IBUF |     6|
|3  |OBUF |     1|
+-----+-----+
Report Instance Areas:
+-----+-----+-----+
|   |Instance |Module |Cells |
+-----+-----+-----+
|1  |top      |       |    8|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:11 ; elapsed = 00:00:20 . Memory (MB): peak = 1020.262 ; gain = 0.000
-----
```

POWER REPORT:-

Summary

Power estimation from Synthesized netlist. Activity derived from constraints files, simulation files or vectorless analysis. Note: these early estimates can change after implementation.

Total On-Chip Power:	0.544 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	26.0°C
Thermal Margin:	59.0°C (31.1 W)
Effective QJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

[Launch Power Constraint Advisor](#) to find and fix invalid switching activity

