BIRLA VISHVAKARMA MAHAVIDYALAYA

(An Autonomous Institution)

Electronics Engineering Department

A.Y. 2023-2024

Title: Assignment 3

Course Title: Digital System Design

Name: Monpara Om Rameshbhai

ID No.: 21EL034

Batch: A04B

Course Code: 3EL42

Course Coordinator: Prof. Chintan Patel

Q1. CLOCK DIVIDER

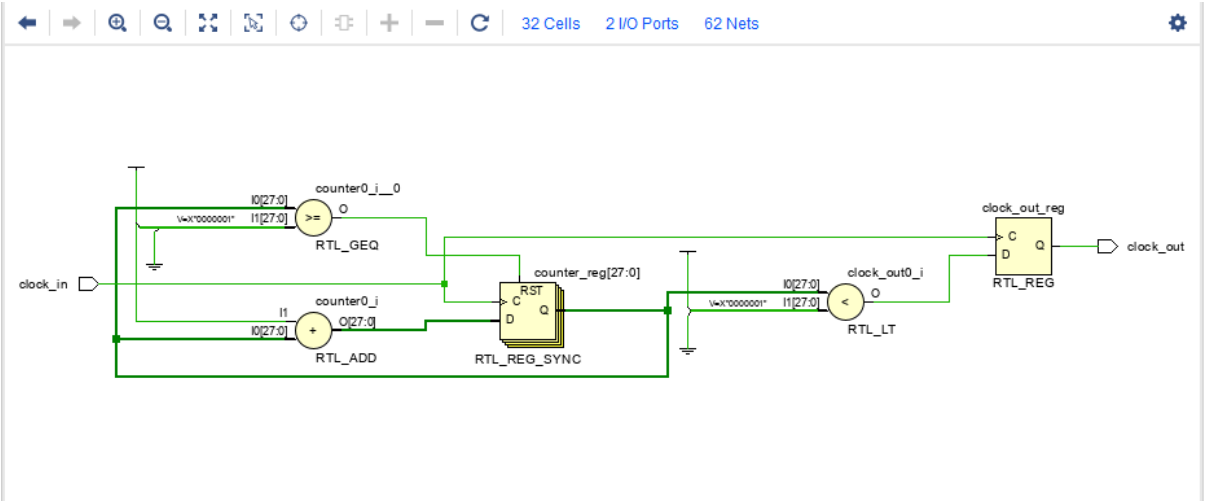
VERILOG CODE: -

```
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/ne
    Parameter DIVISOR bound to: 28'b0000000000000000000000000010
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     |IBUF   |     1|
```

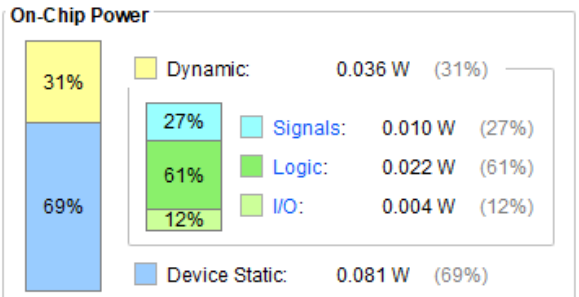
```
|3     |LUT1   |     1|
|4     |LUT4   |     1|
|5     |LUT5   |     2|
|6     |LUT6   |     8|
|7     |FDRE   |    29|
|8     |IBUF   |     1|
|9     |OBUF   |     1|
+------+-------+------+

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)



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 ϑJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

69%
27%
61%
12%
Signals: 0.010 W (27%)
Logic: 0.022 W (61%)
I/O: 0.004 W (12%)
Device Static: 0.081 W (69%)

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];
```

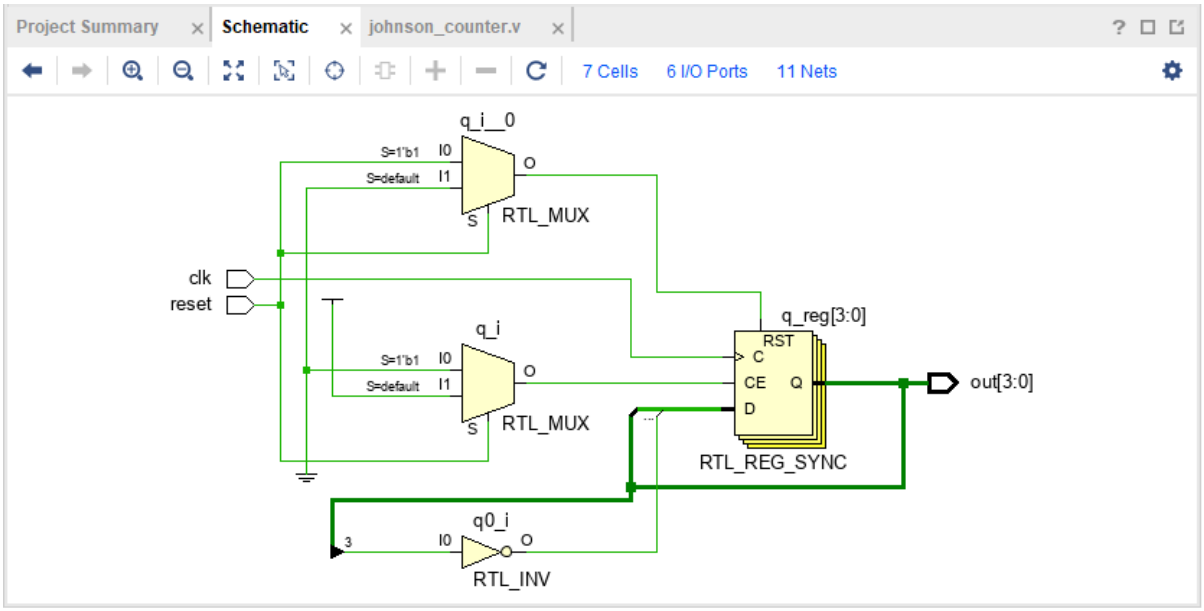
```
always @(posedge clk)
begin
if(reset)
 q=4'd0;
 else
    begin
        q[3]<=q[2];
        q[2]<=q[1];
        q[1]<=q[0];
        q[0]<=(~q[3]);
    end
 end

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

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
---------------------------------------------------------------------------------
```

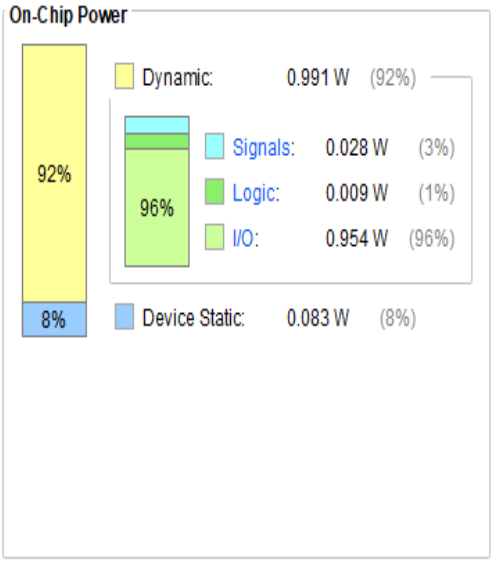
POWER REPORT: -

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 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



Q3. RING COUNTER

VERILOG CODE: -

ring_counter.v

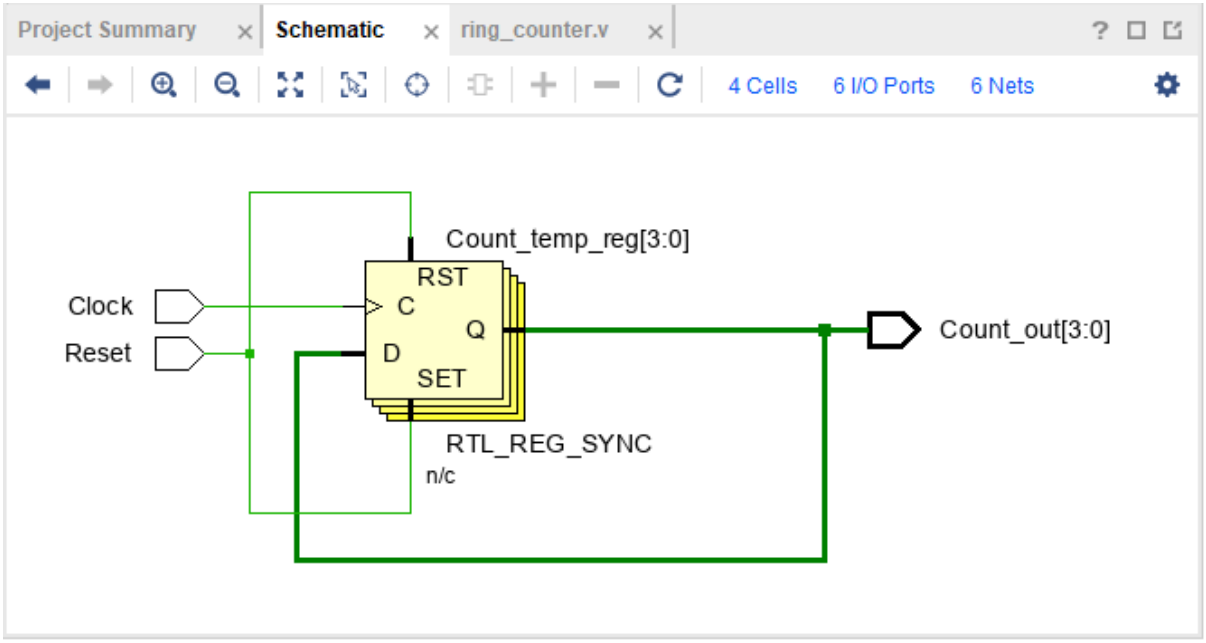
E:/projects dsd/RING COUNTER/ring counter.srcs/sources_1/new/ring_counter.v

```
1   `timescale 1ns / 1ps
2   module ring_counter(
3       input Clock,
4       input Reset,
5       output [3:0] Count_out
6       );
7       reg [3:0] Count_temp;
8       always @(posedge(Clock),Reset)
9       begin
10          if(Reset == 1'b1)   begin
11              Count_temp = 4'b0001;   end
12          else if(Clock == 1'b1)  begin
13
14              Count_temp = {Count_temp[2:0],Count_temp[3]};   end
15      end
16      assign Count_out = Count_temp;
17  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
```

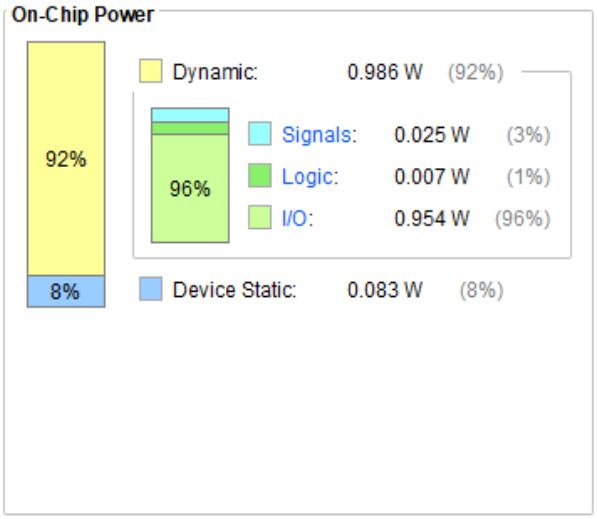
POWER REPORT: -

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 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



Q4. 5 INPUT MAJORITY CIRCUIT

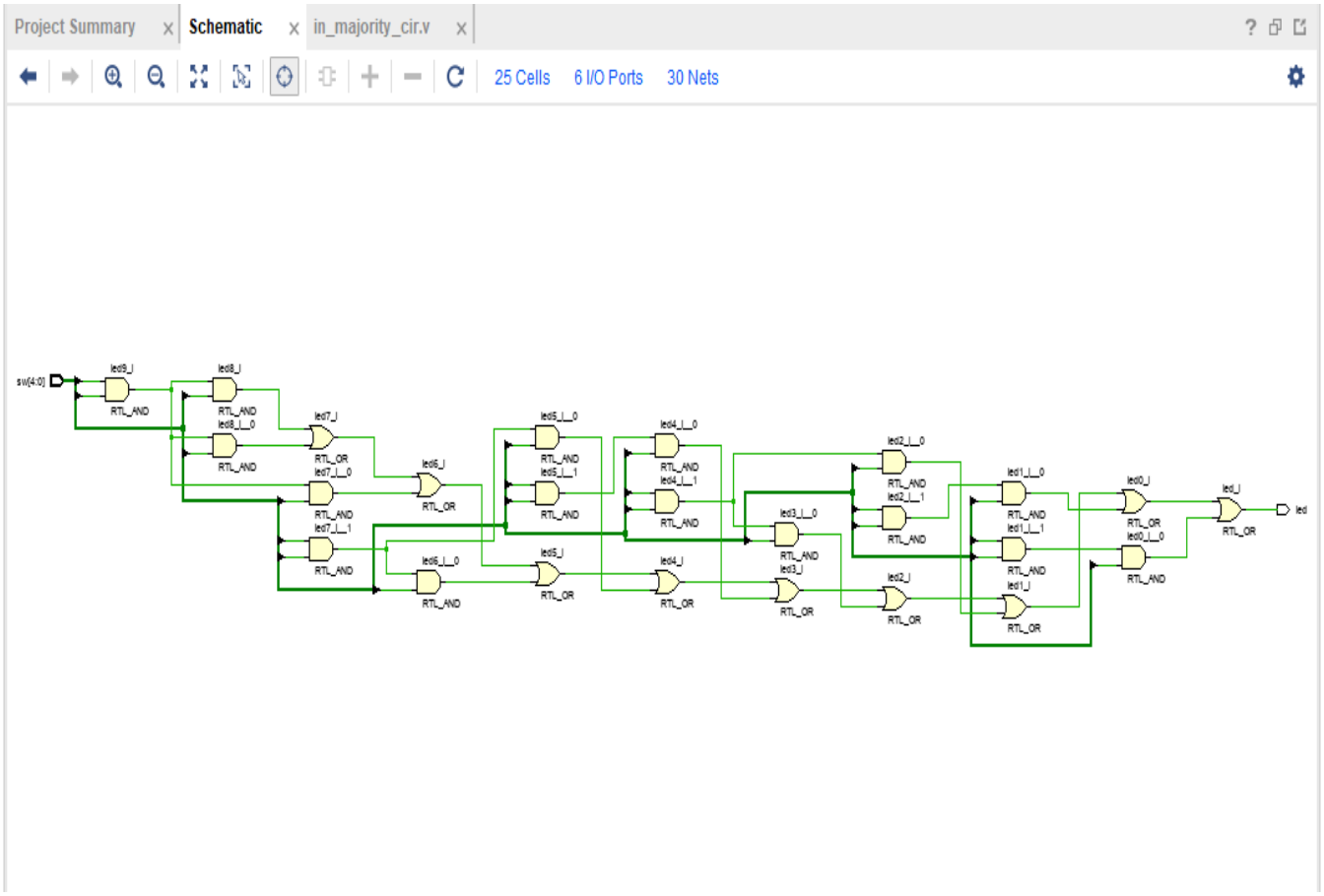
VERILOG CODE: -

```
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 |
+------+-----+------+
|1     |LUT5 |     1|
|2     |IBUF |     5|
|3     |OBUF |     1|
+------+-----+------+

Report Instance Areas:
+------+---------+-------+------+
|      |Instance |Module |Cells |
+------+---------+-------+------+
|1     |top      |       |     7|
+------+---------+-------+------+
---------------------------------------------------------------------------------
Finished Writing Synthesis Report : Time (s): cpu = 00:00:16 ; elapsed = 00:00:27 . Memory (MB): peak = 1018.273 ; gain = 0.000
---------------------------------------------------------------------------------
```

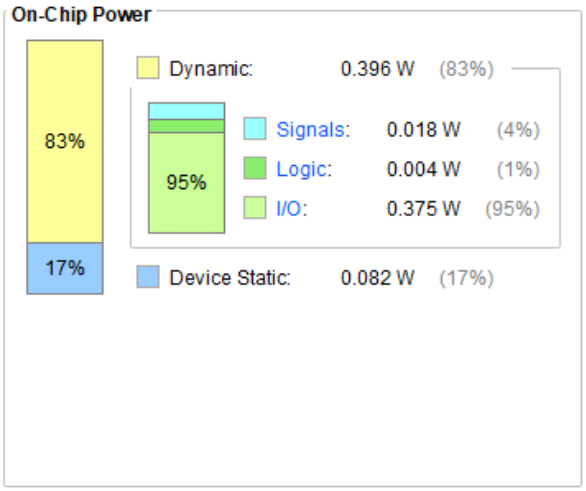
POWER REPORT:-

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 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



Q5.PARITY GENERATOR

VERILOG CODE:-

parity_generator.v

E:/projects dsd/PARITY GENERATOR/PARITY GENERATOR.srcs/sources_1/new/parity_generator.v

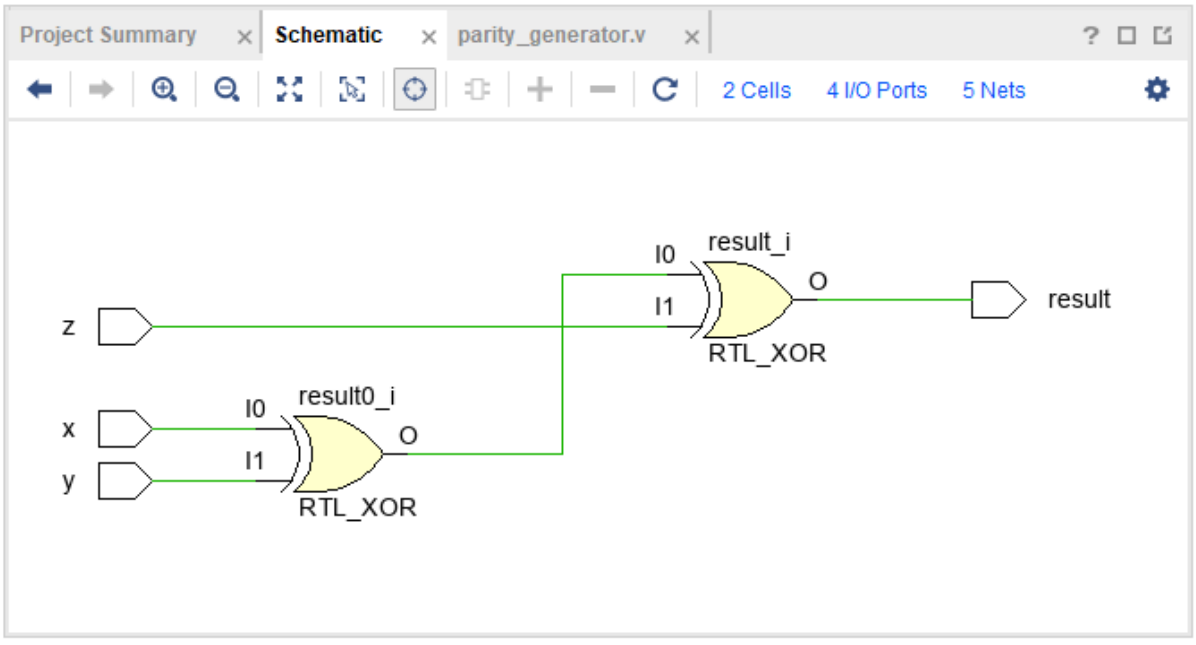
```
18      // Additional Comments:
19      //
20      //////////////////////////////////////////////////////////////////////////////////
21
22
23      module parity(
24          input x,
25          input y,
26          input z,
27          output result
28          );
29      xor (result,x,y,z);
30
31      endmodule
32
```

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
```

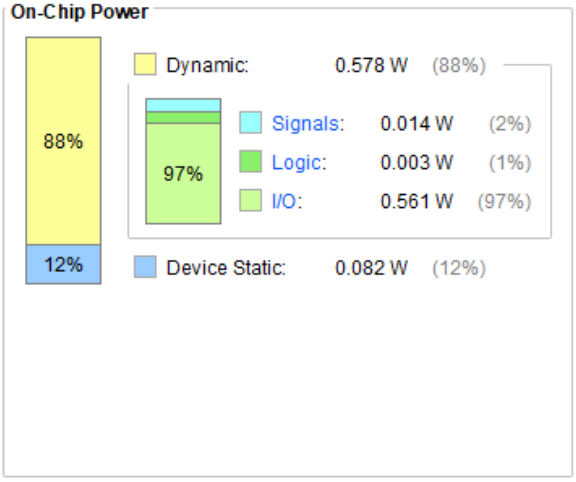
POWER REPORT:-

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 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



Q6. BINARY TO ONE HOT ENCODER

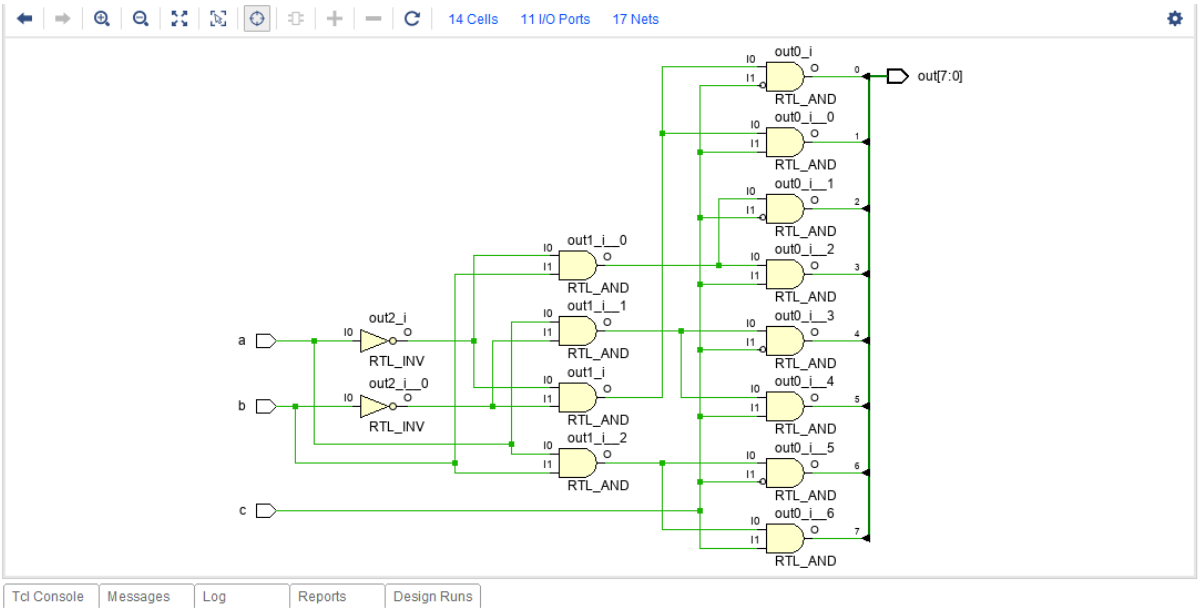
VERILOG CODE:-

```
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:-

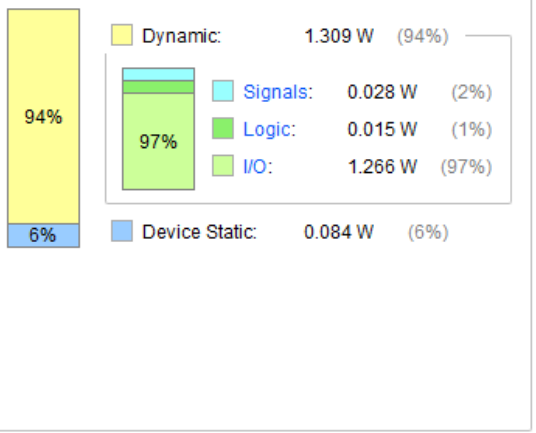
Summary

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

On-Chip Power



Q7. 4-BIT BCD SYNCHRONOUS COUNTER

VERILOG CODE:-

Project Summary | 4b_syn_counter.v

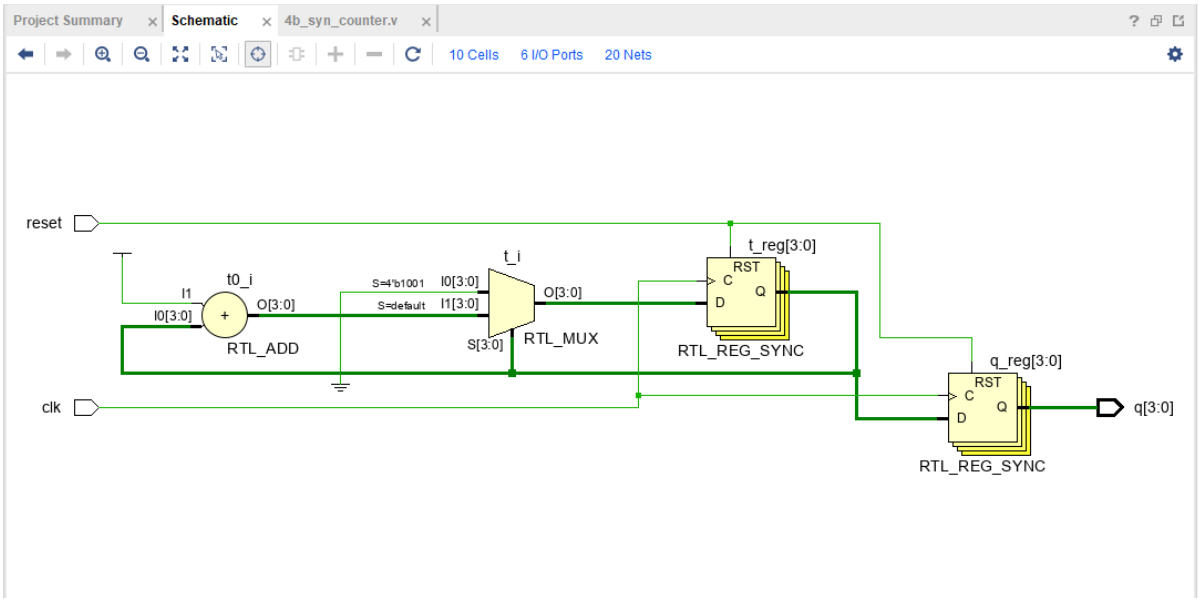
E:/projects dsd/4-BIT BCD SYNCHRONOUS COUNTER/4-BIT BCD SYNCHRONOUS COUNTER.srcs/sources_1/new/4b_syn_counter.v

```
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
-----------------------------------------------------------------------------
```

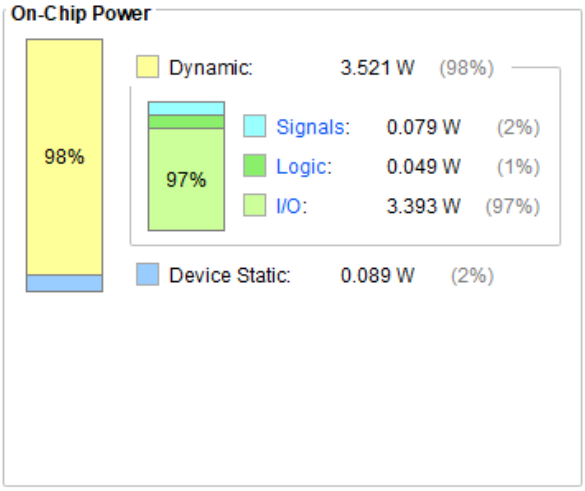
POWER REPORT:-

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 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



Q8. 4-BIT CARRY LOOKAHEAD ADDER

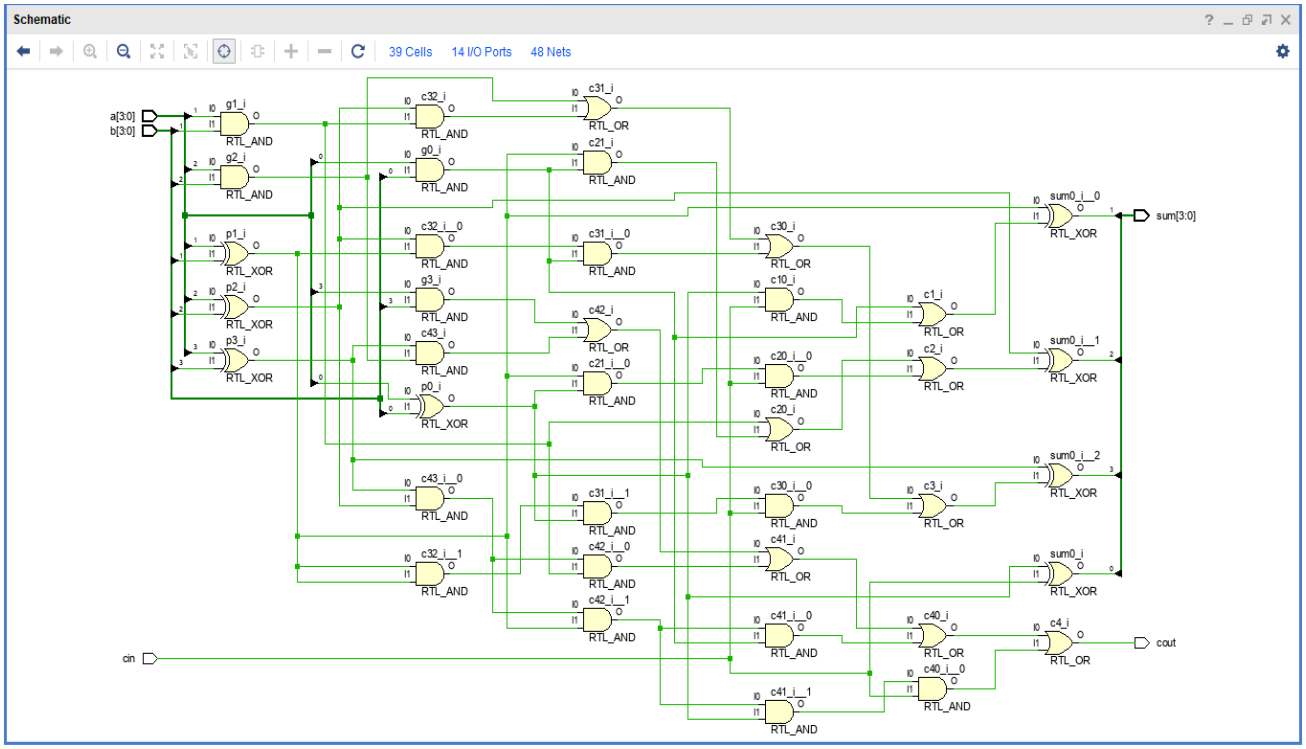
VERILOG CODE:-

```
module CLA_Adder(a,b,cin,sum,cout);
input[3:0] a,b;
input cin;
output [3:0] sum;
output cout;
wire p0,p1,p2,p3,g0,g1,g2,g3,c1,c2,c3,c4;
assign p0=(a[0]^b[0]),
p1=(a[1]^b[1]),
p2=(a[2]^b[2]),
p3=(a[3]^b[3]);
assign g0=(a[0]&b[0]),
g1=(a[1]&b[1]),
g2=(a[2]&b[2]),
g3=(a[3]&b[3]);
assign c0=cin,
c1=g0|(p0&cin),
c2=g1|(p1&g0)|(p1&p0&cin),
c3=g2|(p2&g1)|(p2&p1&g0)|(p1&p1&p0&cin),
c4=g3|(p3&g2)|(p3&p2&g1)|(p3&p2&p1&g0)|(p3&p2&p1&p0&cin);
assign sum[0]=p0^c0,
sum[1]=p1^c1,
sum[2]=p2^c2,
sum[3]=p3^c3;
assign cout=c4;
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
```

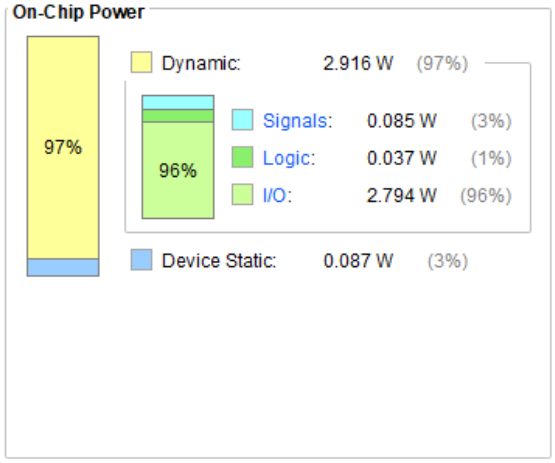
POWER REPORT:-

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 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



Q9.N-BIT COMPARATOR

VERILOG CODE:-

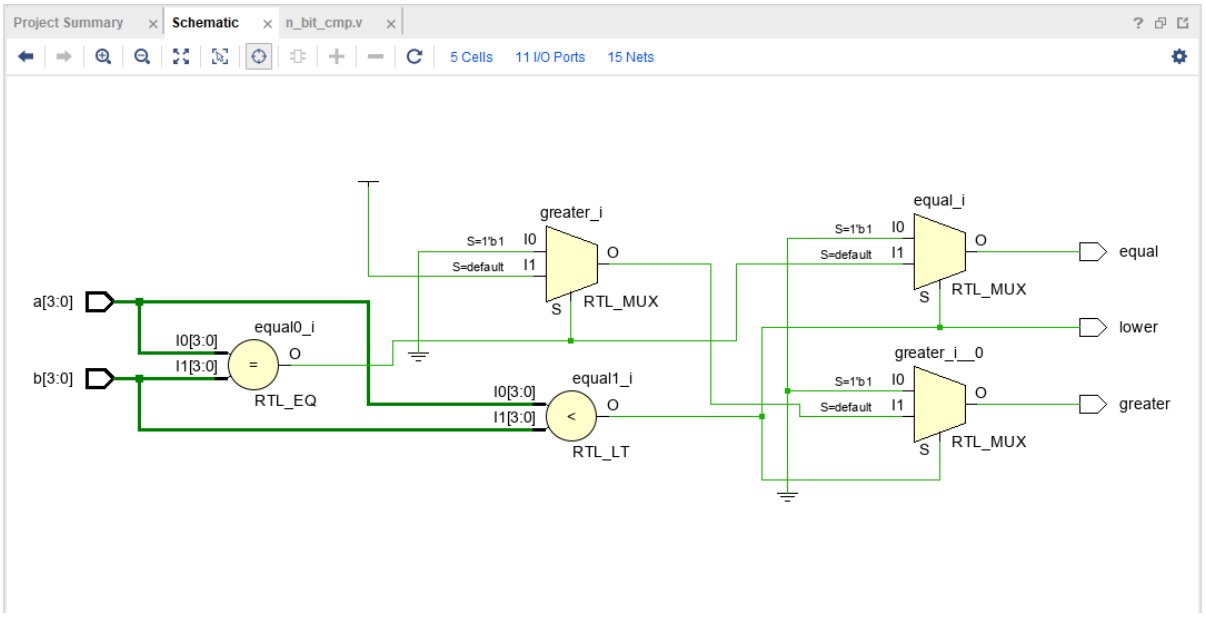
```
module comparator (
    input wire [3:0] a,
    input wire [3:0] b,
    output reg equal,
    output reg lower,
    output reg greater
    );

    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
---------------------------------------------------------------------------------
```

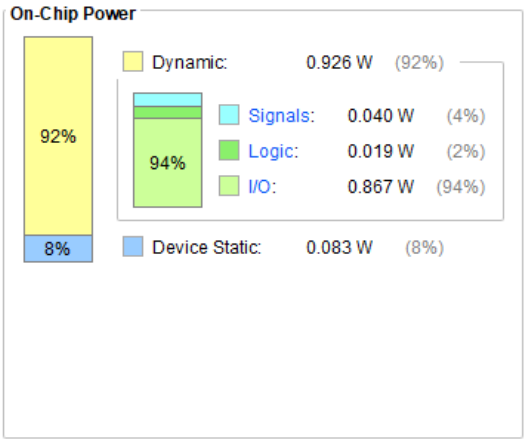
POWER REPORT:-

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 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



Q10. SERIAL IN SERIAL OUT SHIFT REGISTER

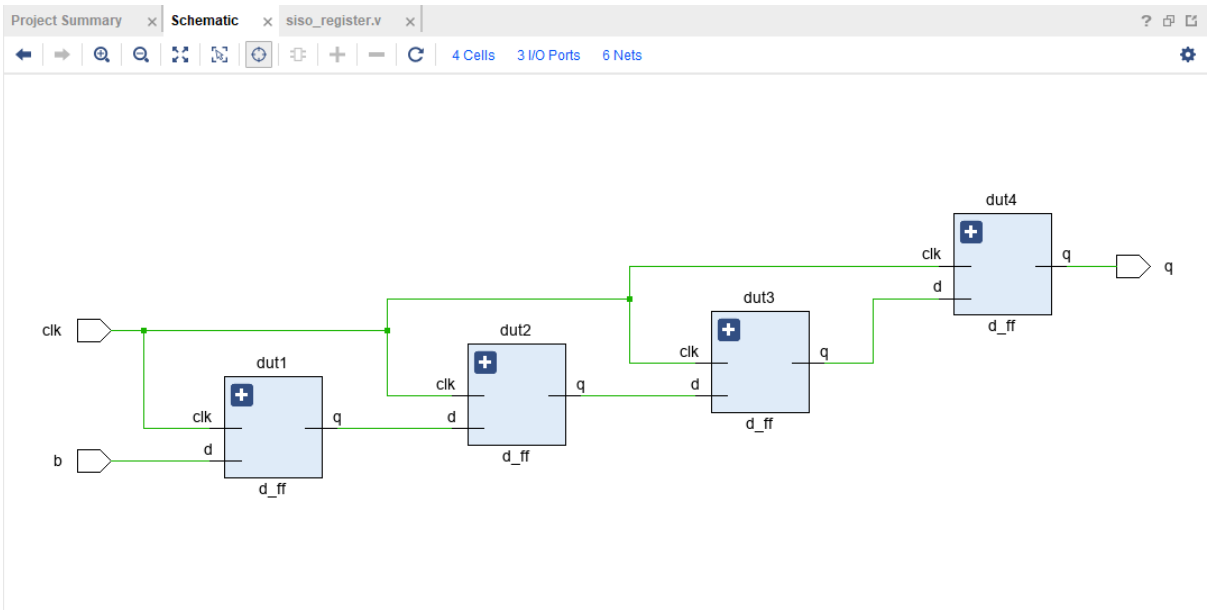
VERILOG CODE:-

```
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     |SRL16E |     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:-

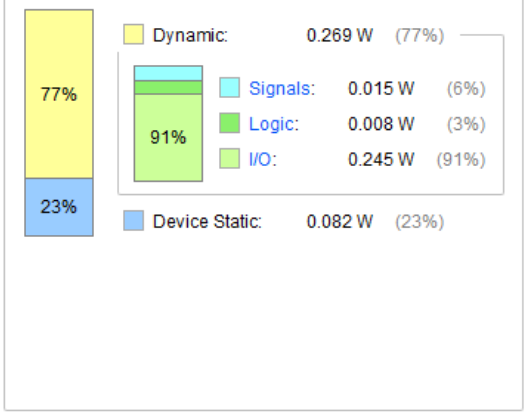
Summary

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

Total On-Chip Power:	**0.351 W**
Design Power Budget:	**Not Specified**
Power Budget Margin:	**N/A**
Junction Temperature:	**25.7°C**
Thermal Margin:	59.3°C (31.3 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

On-Chip Power



Q11. SERIAL IN PARALLEL OUT SHIFT REGISTER

VERILOG CODE:-

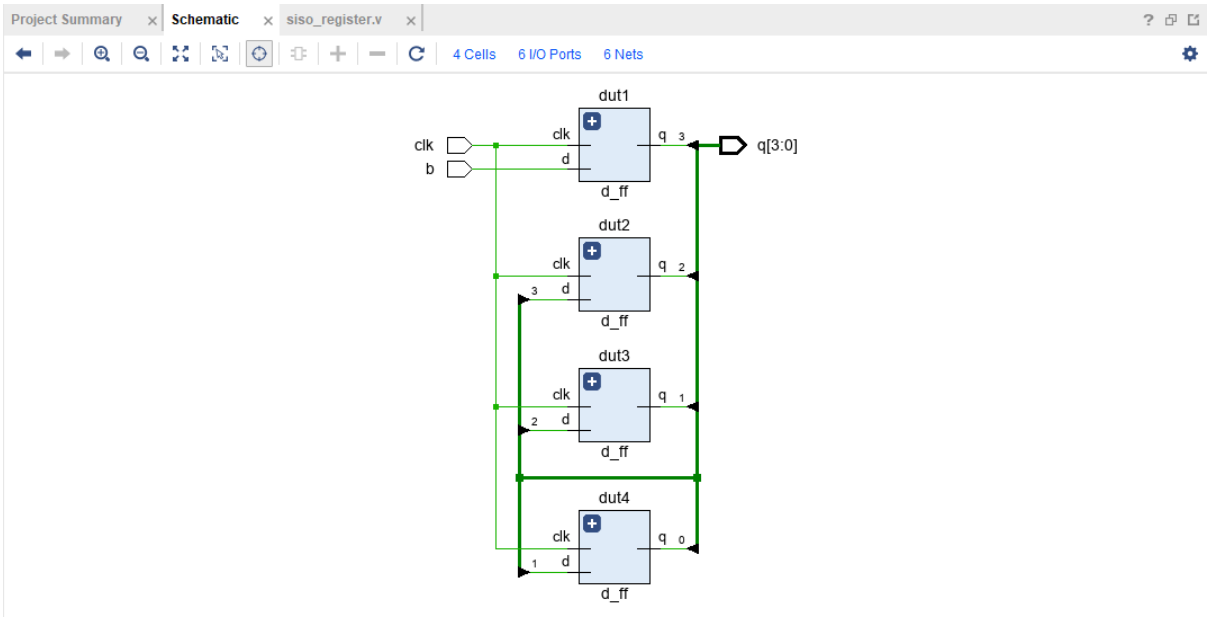
E:/projects dsd/SIPO REGISTER/SIPO REGISTER.srcs/sources_1/new/siso_register.v

```
module sipo_shift_register_design(input clk,b,output[3:0]q);

d_ff dut1(.clk(clk),.d(b),.q(q[3]),.rst());
d_ff dut2(.clk(clk),.d(q[3]),.q(q[2]),.rst());
d_ff dut3(.clk(clk),.d(q[2]),.q(q[1]),.rst());
d_ff dut4(.clk(clk),.d(q[1]),.q(q[0]),.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 sipo_tb();

reg clk,b;
wire [3:0]q;

sipo_shift_register_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=0;
#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     |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
------------------------------------------------------------------------------
```

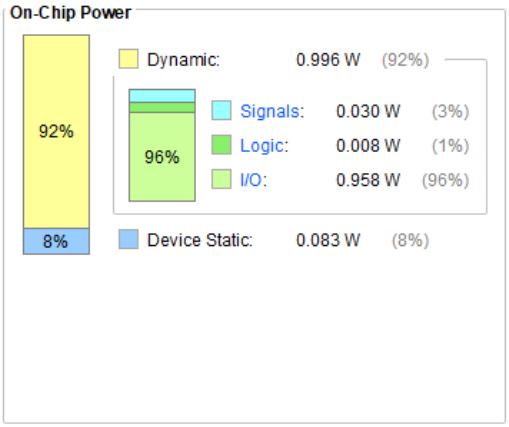
POWER REPORT:-

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 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



Q12. PARALLEL IN PARALLEL OUT REGISTER

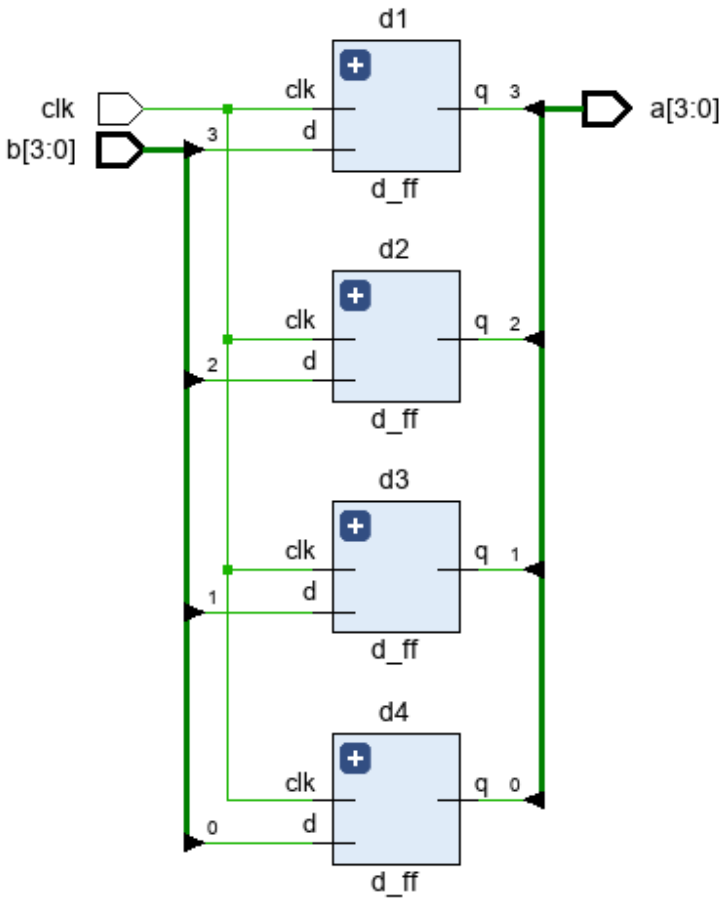
VERILOG CODE:-

```
`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;

pipo_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
---------------------------------------------------------------------------------
```

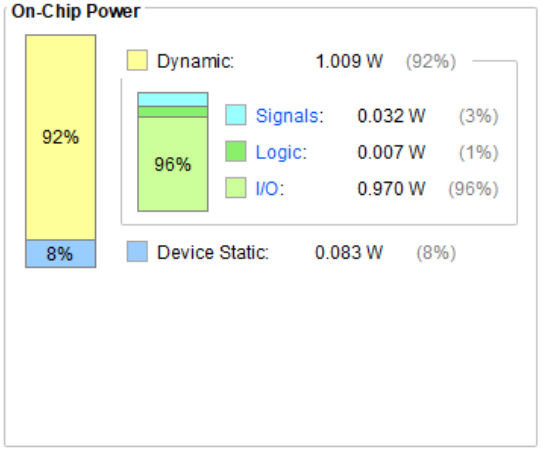
POWER REPORT:-

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 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



Q13. PARALLEL IN SERIAL OUT REGISTER

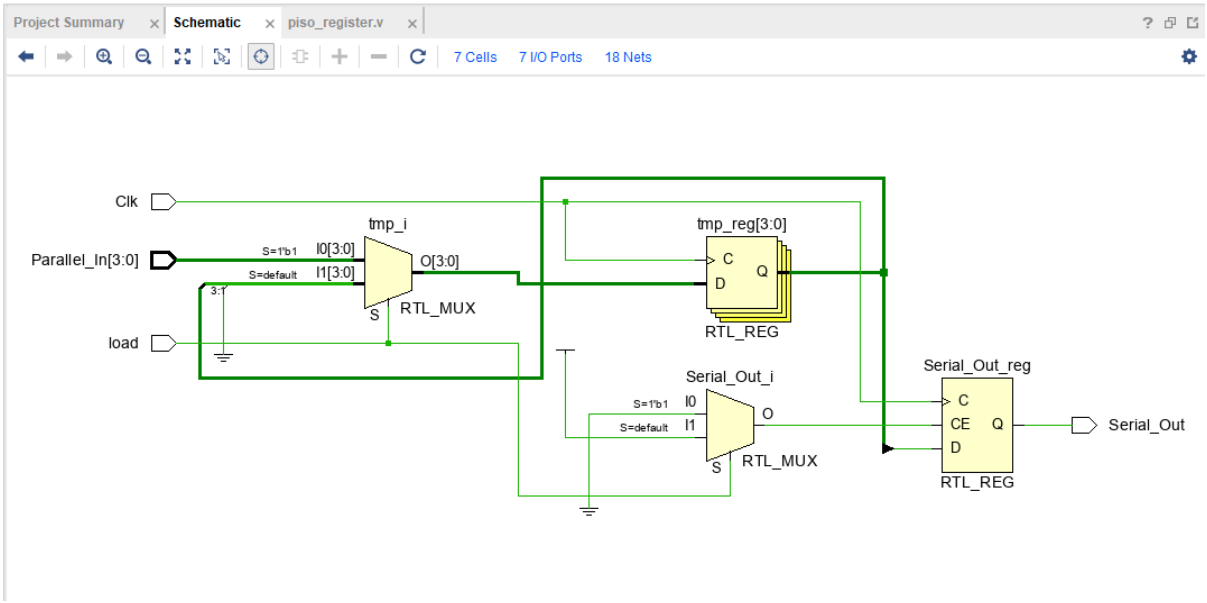
VERILOG CODE:-

```
module Shiftregister_PISO(Clk, Parallel_In,load, Serial_Out);
input Clk,load;
input [3:0]Parallel_In;
output reg Serial_Out;
reg [3:0]tmp;
always @(posedge Clk)
begin
if(load)
tmp<=Parallel_In;
else
begin
Serial_Out<=tmp[3];
tmp<={tmp[2:0],1'b0};
end
end
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=1'b0;
forever #5 Clk=~Clk;
end
initial begin
load=0;b=4'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     |BUFG |     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
---------------------------------------------------------------------------------
```

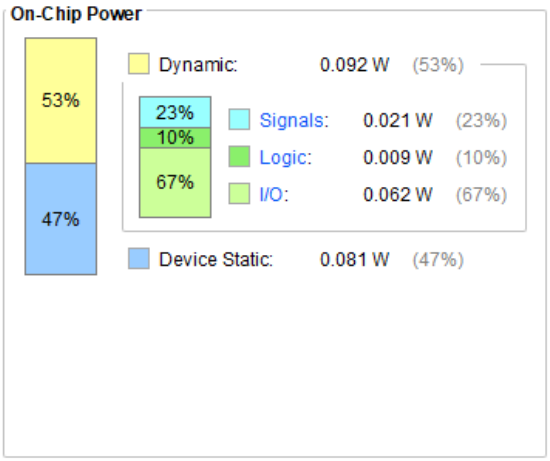
POWER REPORT:-

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 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



Q14. BIDIRECTION SHIFT REGISTER

VERILOG CODE:-

Project Summary | Schematic | bi_directional_register.v

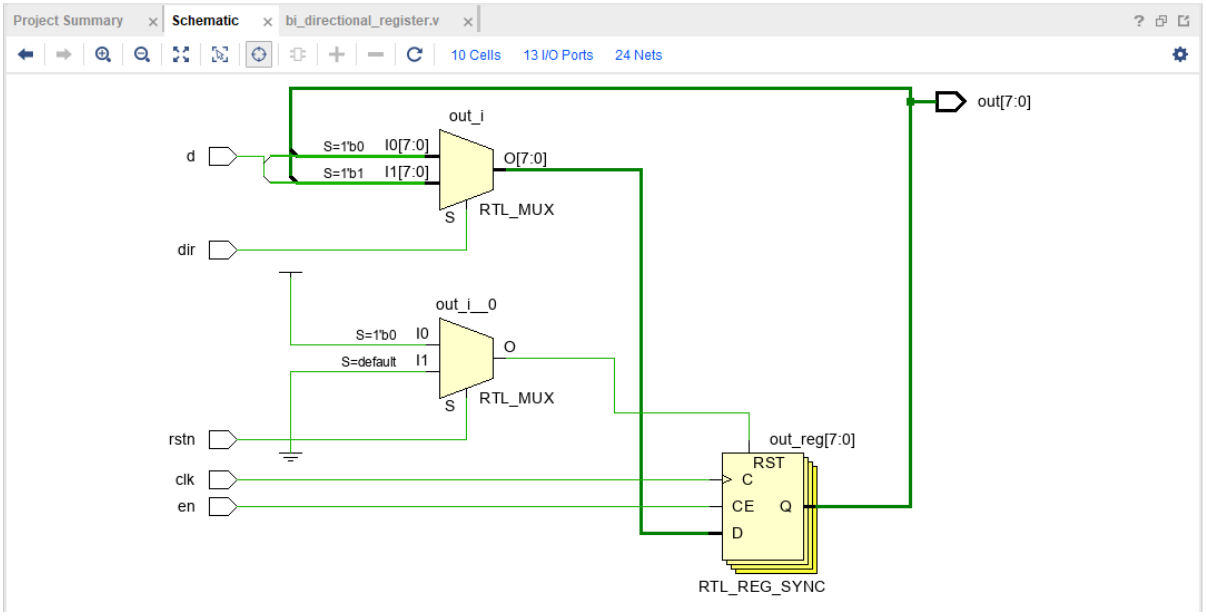
E:/projects dsd/BIDIRECTIONAL REGISTER/BIDIRECTIONAL REGISTER.srcs/sources_1/new/bi_directional_register.v

```
// Revision 0.01 - File Created
// Additional Comments:
//
//////////////////////////////////////////////////////////////////////////////////
module shift_reg #(parameter MSB = 8)(input d,
input clk,
input en,
input dir,
input rstn,
output reg [MSB-1:0] out);
always @ (posedge clk)
if (!rstn)
out <= 0;
else begin
if (en)
case (dir)
0 : out <= {out[MSB-2:0], d};
1 : out <= {d, out[MSB-1:1]};
endcase
else
out <= out;
end
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     |BUFG |     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
--------------------------------------------------------------------------------
```

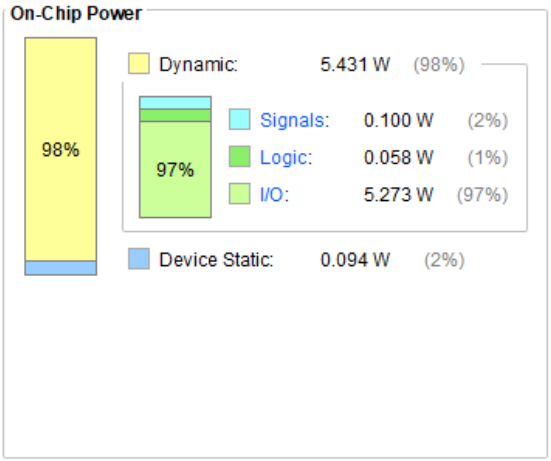
POWER REPORT:-

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



Q15. PRBS SEQUENCE GENERATOR

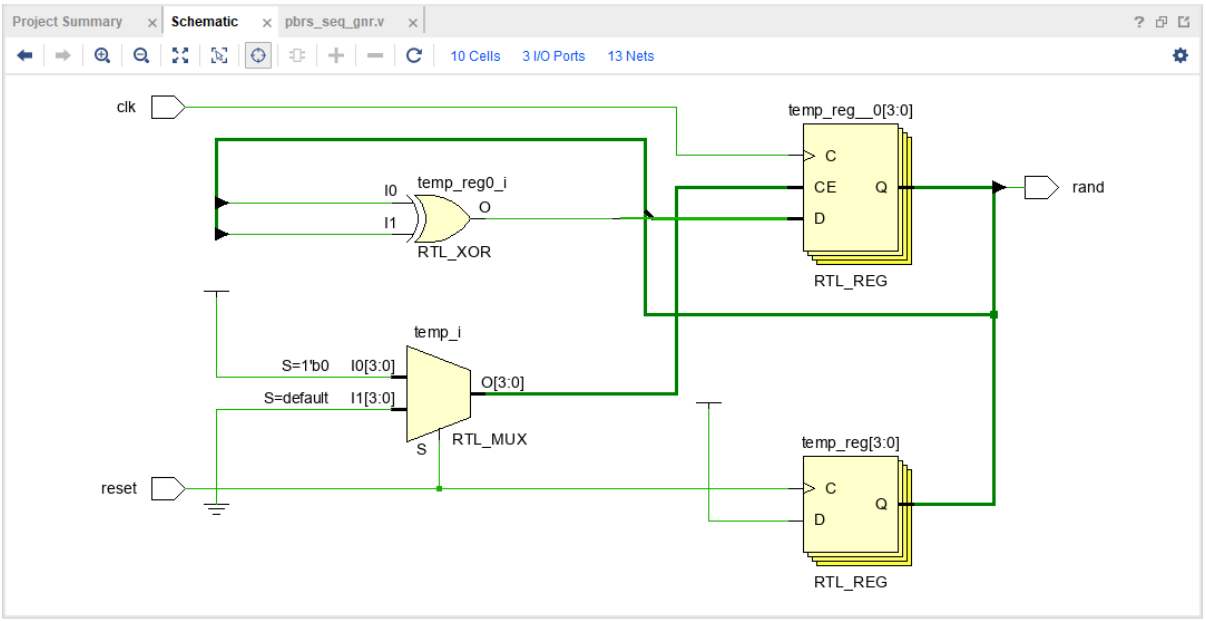
VERILOG CODE:-

```
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     |top      |       |    16|
+------+---------+-------+------+
---------------------------------------------------------------------------------
Finished Writing Synthesis Report : Time (s): cpu = 00:00:09 ; elapsed = 00:00:16 . Memory (MB): peak = 1018.242 ; gain = 0.000
---------------------------------------------------------------------------------
```

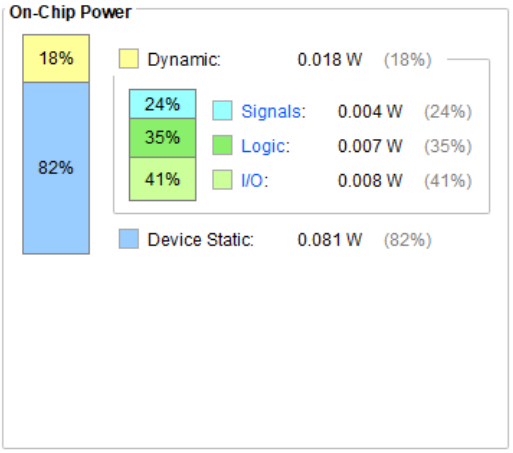
POWER REPORT:-

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 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



Q16 & 17. 8-BIT ADDER/SUBTRACTOR

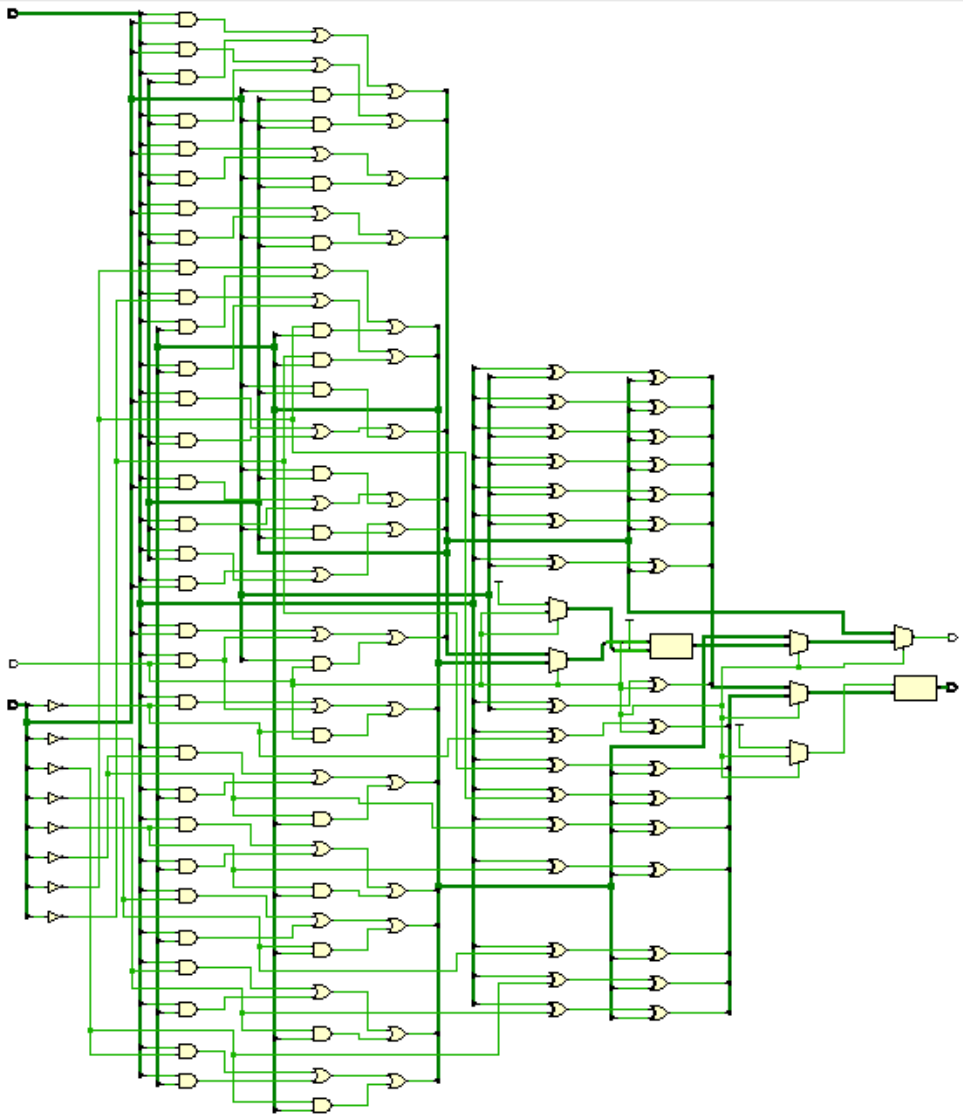
VERILOG CODE:-

```
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=1'b0;

#10 a=8'b00000001;b=8'b00000001;cin=1'b1;

#10 a=8'b00000010;b=8'b00000011;cin=1'b0;

#10 a=8'b10000001;b=8'b10000001;cin=1'b0;

#10 a=8'b00011001;b=8'b00110001;cin=1'b0;

#10 a=8'b00000011;b=8'b00000011;cin=1'b1;

#10 a=8'b11111111;b=8'b00000001;cin=1'b0;

#10 a=8'b11111111;b=8'b00000000;cin=1'b1;

#10 a=8'b11111111;b=8'b11111111;cin=1'b0;

#10 $stop;

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 |     6|
|3     |LUT5 |    14|
|4     |IBUF |    17|
|5     |OBUF |     9|
+------+-----+------+

Report Instance Areas:
+------+---------+-------+------+
|      |Instance |Module |Cells |
+------+---------+-------+------+
|1     |top      |       |    47|
+------+---------+-------+------+
---------------------------------------------------------------------------------
Finished Writing Synthesis Report : Time (s): cpu = 00:00:09 ; elapsed = 00:00:27 . Memory (MB): peak = 1017.555 ; gain = 0.000
---------------------------------------------------------------------------------
```

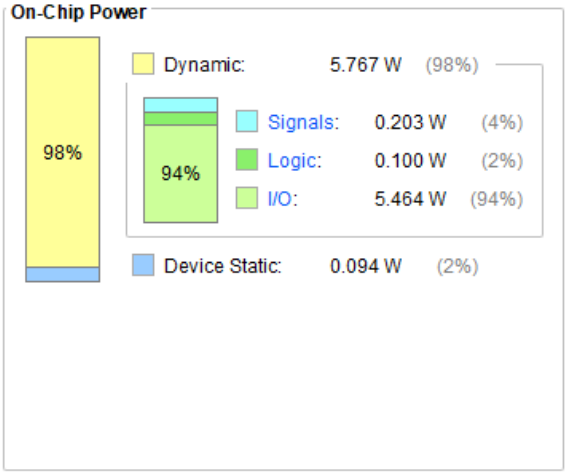
POWER REPORT:-

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 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



Q18. 4-BIT MULTIPLIER

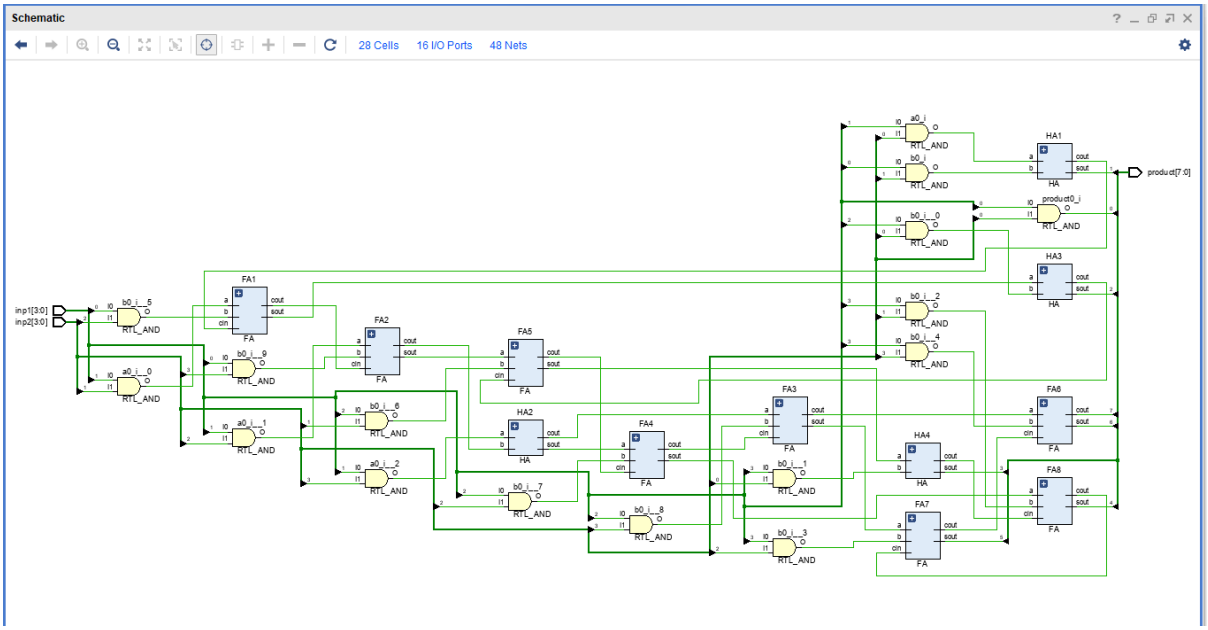
VERILOG CODE:-

```
`timescale 1ns / 1ps
module multiplier_4_x_4(product,inp1,inp2);

    output [7:0]product;
    input [3:0]inp1;
    input [3:0]inp2;

    assign product[0]=(inp1[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,(inp1[1]&inp2[0]),(inp1[0]&inp2[1]));
    FA FA1(x2,x3,inp1[1]&inp2[1],(inp1[0]&inp2[2]),x1);
    FA FA2(x4,x5,(inp1[1]&inp2[2]),(inp1[0]&inp2[3]),x3);
    HA HA2(x6,x7,(inp1[1]&inp2[3]),x5);

    HA HA3(product[2],x15,x2,(inp1[2]&inp2[0]));
    FA FA5(x14,x16,x4,(inp1[2]&inp2[1]),x15);
    FA FA4(x13,x17,x6,(inp1[2]&inp2[2]),x16);
    FA FA3(x9,x8,x7,(inp1[2]&inp2[3]),x17);

    HA HA4(product[3],x12,x14,(inp1[3]&inp2[0]));
    FA FA8(product[4],x11,x13,(inp1[3]&inp2[1]),x12);
    FA FA7(product[5],x10,x9,(inp1[3]&inp2[2]),x11);
    FA FA6(product[6],product[7],x8,(inp1[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]inp1;
  reg [3:0]inp2;
  wire [7:0]product;

  multiplier_4_x_4 uut(.inp1(inp1),.inp2(inp2),.product(product));

  initial
  begin
    inp1=10;
    inp2=12;
    #30 ;

    inp1=13;
    inp2=12;
    #30 ;

    inp1=10;
    inp2=22;
    #30 ;

    inp1=11;
    inp2=22;
    #30 ;

    inp1=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 |     1|
|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
---------------------------------------------------------------------------------
```

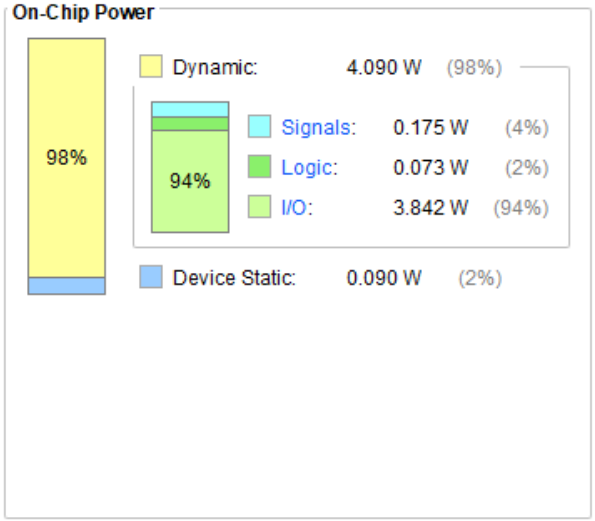
POWER REPORT:-

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



Q19. FIXED POINT DIVISION

VERILOG CODE:-

fixed_p_div.v

E:/projects dsd/Fixed point division/Fixed point division.srcs/sources_1/new/fixed_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'b1;
    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_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
```

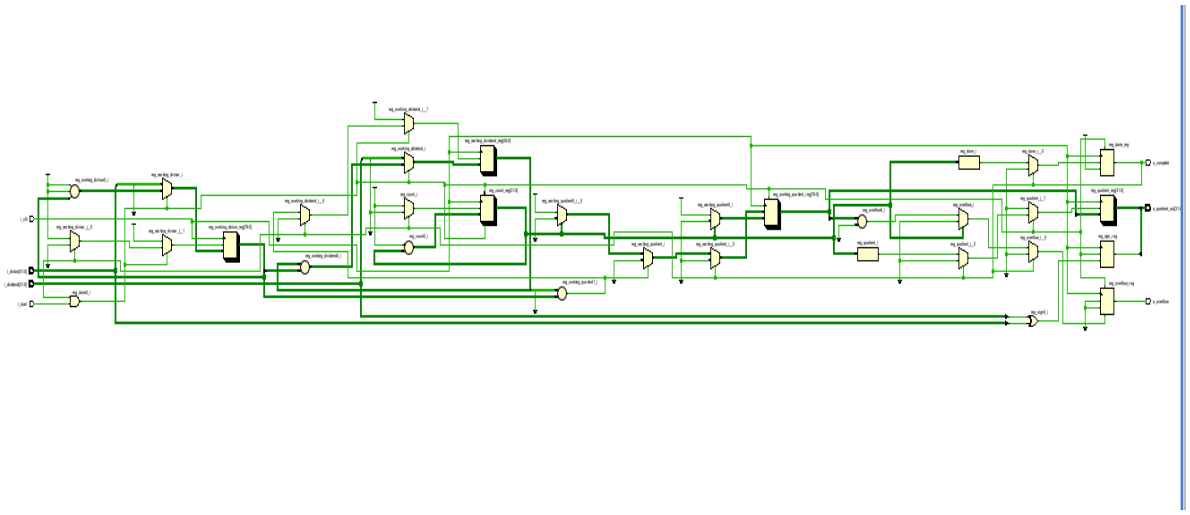
```
            //stop condition
            if(reg_count == 0) begin
                reg_done <= 1'b1;
                reg_quotient <= reg_working_quotient;
                if (reg_working_quotient[2*N+Q-3:N]>0)
                    reg_overflow <= 1'b1;
                    end
            else
    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

    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
```

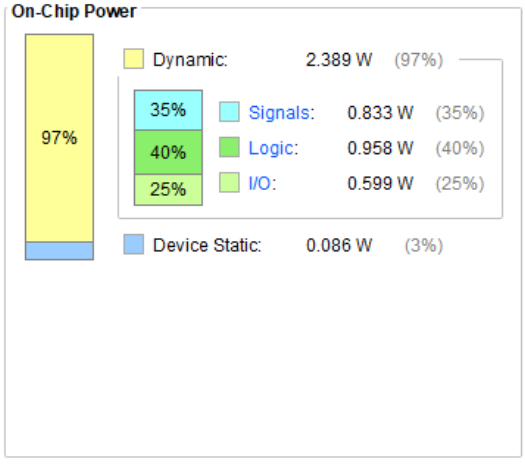
POWER REPORT:-

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 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



Q20. MASTER SLAVE JK FLIP FLOP

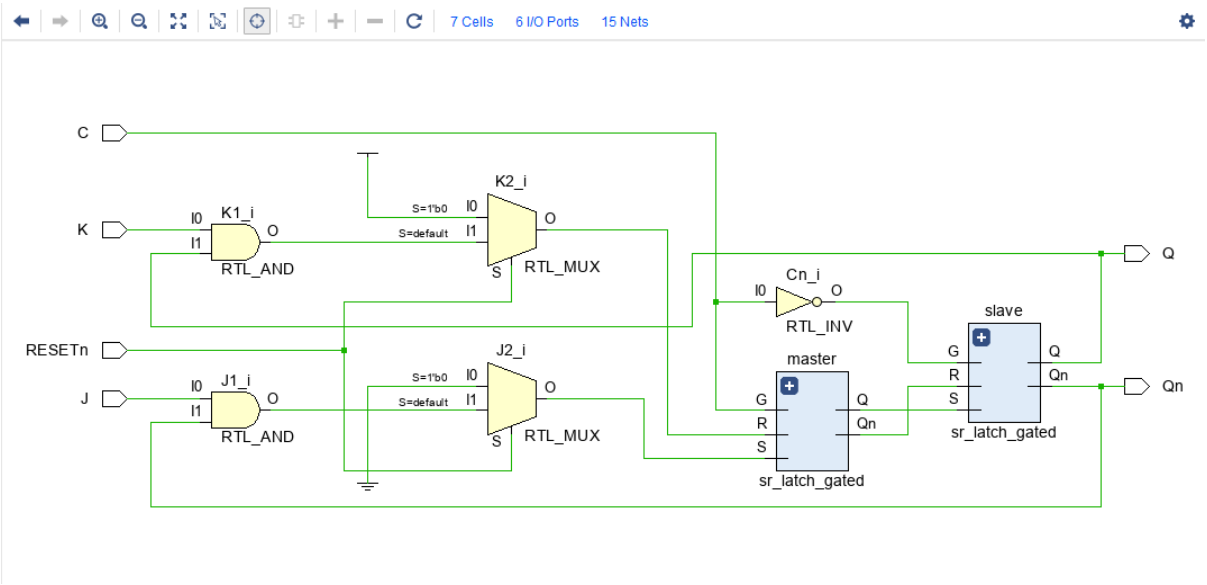
VERILOG CODE:-

```
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,K,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;

 #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 |
+------+-----+------+
|1     |LUT3 |     2|
|2     |LUT6 |     2|
|3     |IBUF |     4|
|4     |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
---------------------------------------------------------------------------------
```

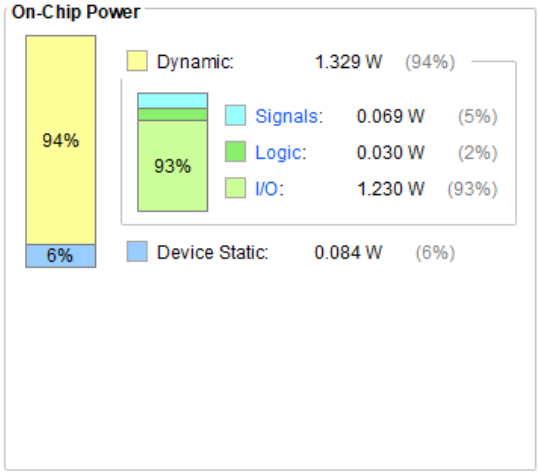
POWER REPORT:-

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

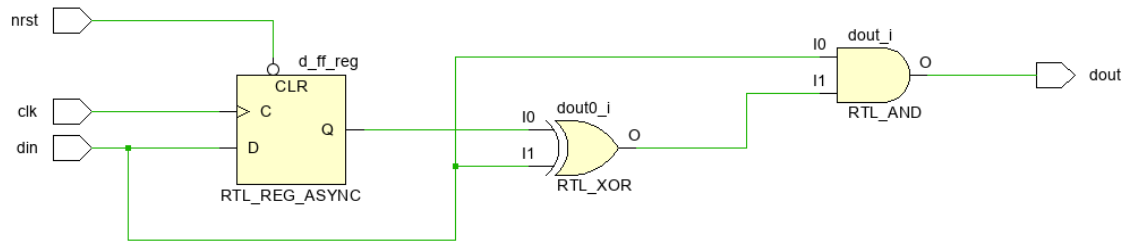
VERILOG CODE:-

```
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:-

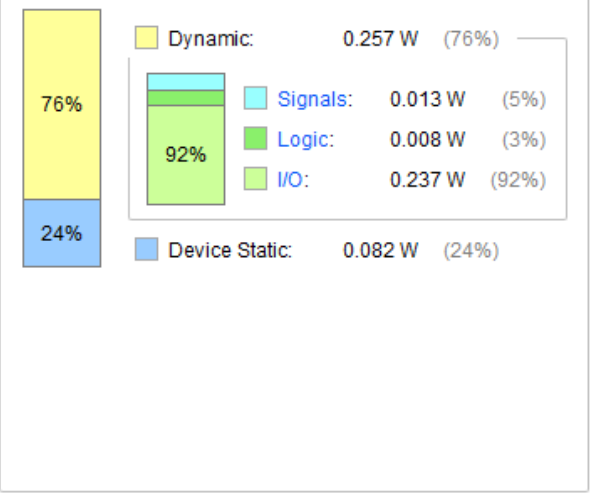
Summary

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 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



Q22. BCD ADDER

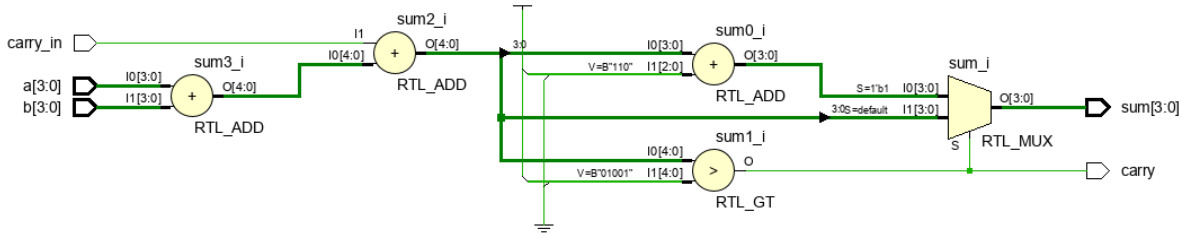
VERILOG CODE:-

```
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;


    always @(a,b,carry_in)
    begin
        sum_temp = a+b+carry_in;
        if(sum_temp > 9)    begin
            sum_temp = sum_temp+6;
            carry = 1;
            sum = sum_temp[3:0];    end
        else    begin
            carry = 0;
            sum = sum_temp[3:0];
        end
    end

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:
+-+--------------+----------+
| |BlackBox 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
---------------------------------------------------------------------------------
```

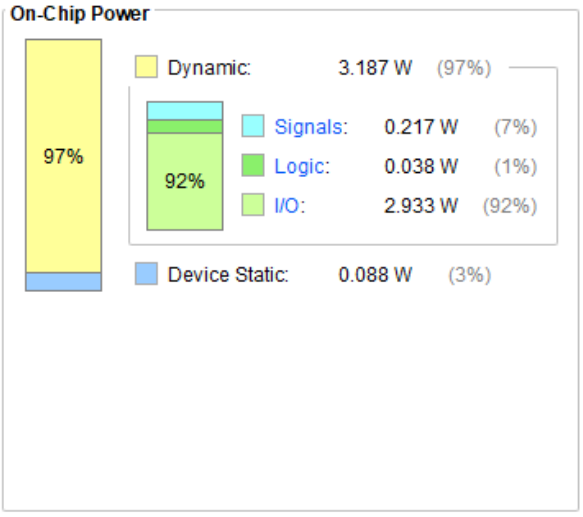
POWER REPORT:-

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:	**3.275 W**
Design Power Budget:	**Not Specified**
Power Budget Margin:	**N/A**
Junction Temperature:	**31.2°C**
Thermal Margin:	53.8°C (28.4 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



Q23. 4-BIT CARRY SELECT ADDER

VERILOG CODE:-

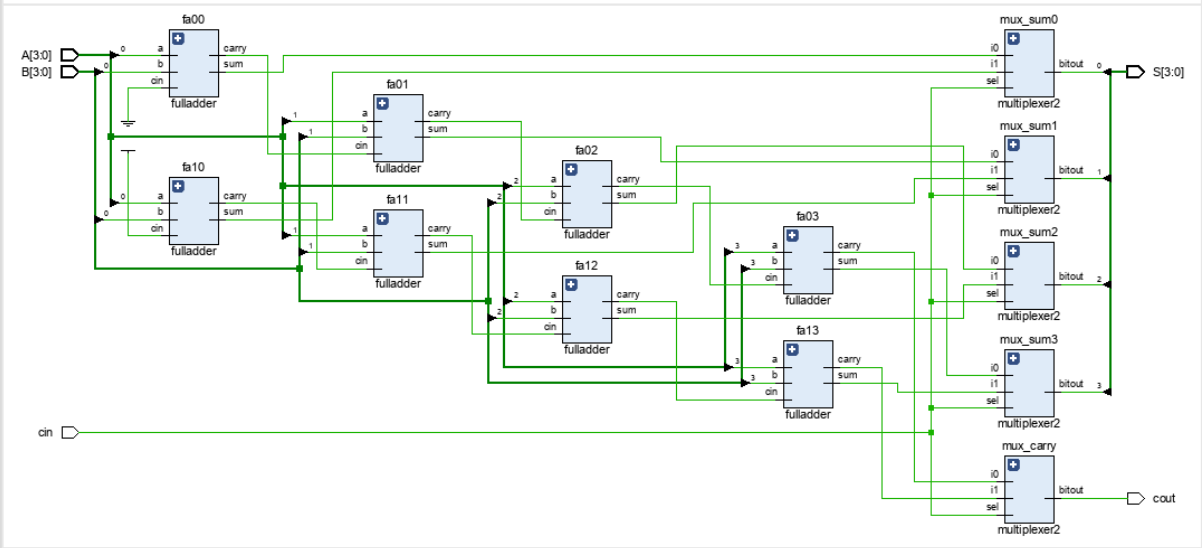
```
module carry_select_adder
        (   input [3:0] A,B,
            input cin,
            output [3:0] S,
            output cout
            );


  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 fa11(A[1],B[1],carry1[0],temp1[1],carry1[1]);
  fulladder fa12(A[2],B[2],carry1[1],temp1[2],carry1[2]);
  fulladder fa13(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
------------------------------------------------------------------------------
```

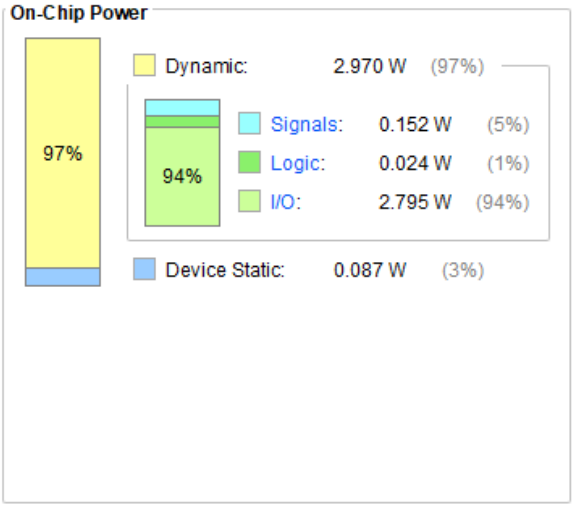
POWER REPORT:-

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 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



Q24. MOORE FSM 1010 SEQUENCE DETECTOR

VERILOG CODE:-

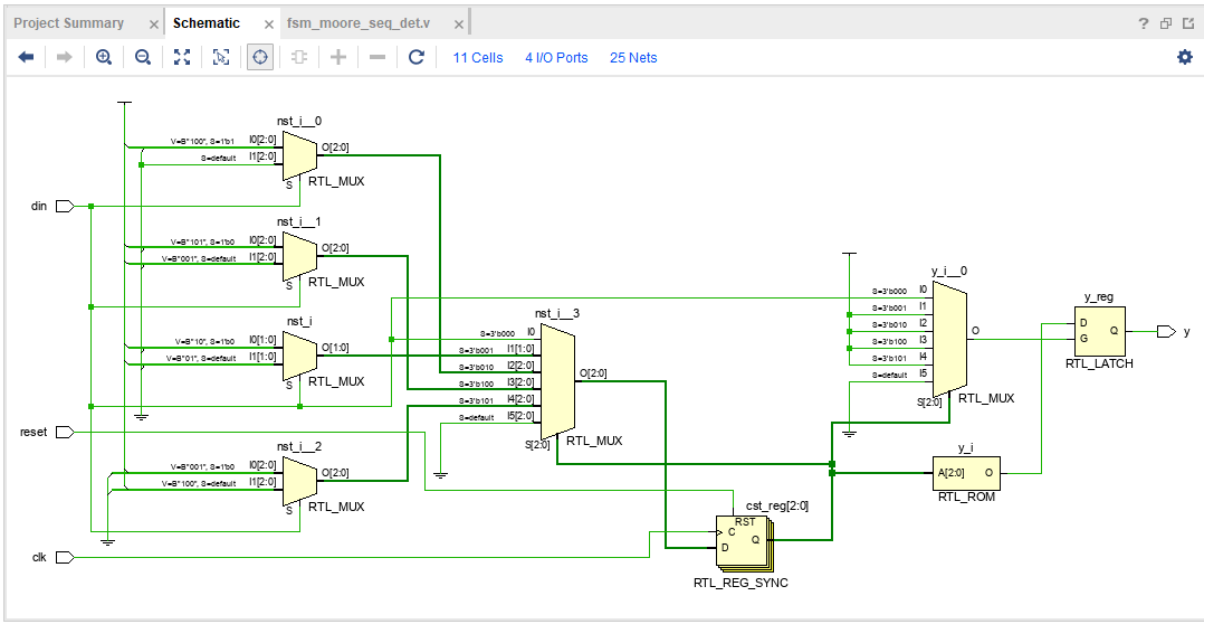
```
module morfsmolp(din, reset, clk, y);
input din;
input clk;
input reset;
output reg y;
reg [2:0] cst, nst;
parameter S0 = 3'b000,
          S1 = 3'b001,
          S2 = 3'b010,
          S3 = 3'b100,
            S4 = 3'b101;
always @(cst or din)
 begin
 case (cst)
   S0: if (din == 1'b1)
        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

```
   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'b1;
          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 m1(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
--------------------------------------------------------------------------------
```

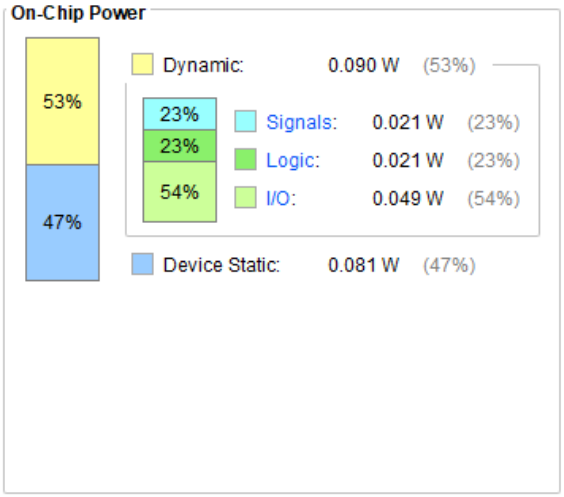
POWER REPORT:-

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



Q25. N:1 MUX

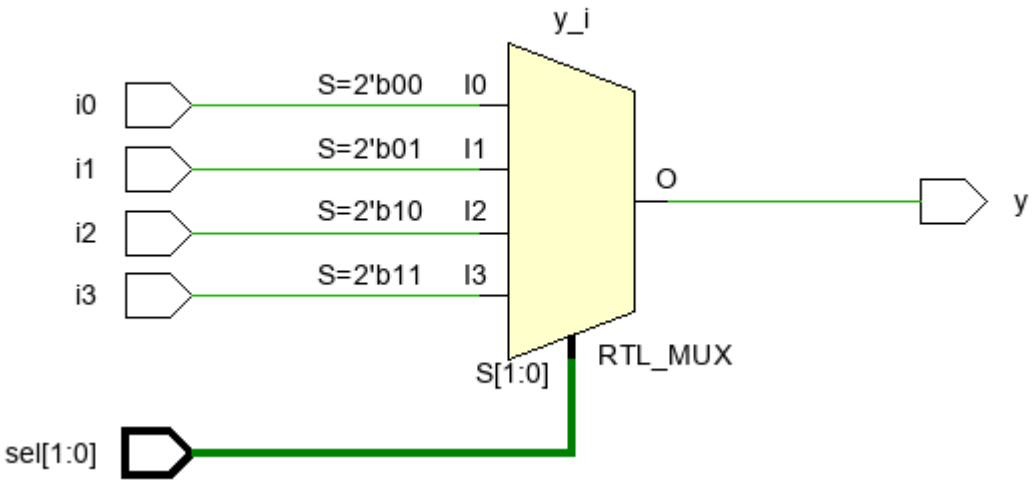
VERILOG CODE:-

```
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 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