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Division: - 04

Year: - 2023-24

Subject: - Digital System Design (3EL42)

Branch: - Electronics (EL)

Q1. CLOCK DIVIDER

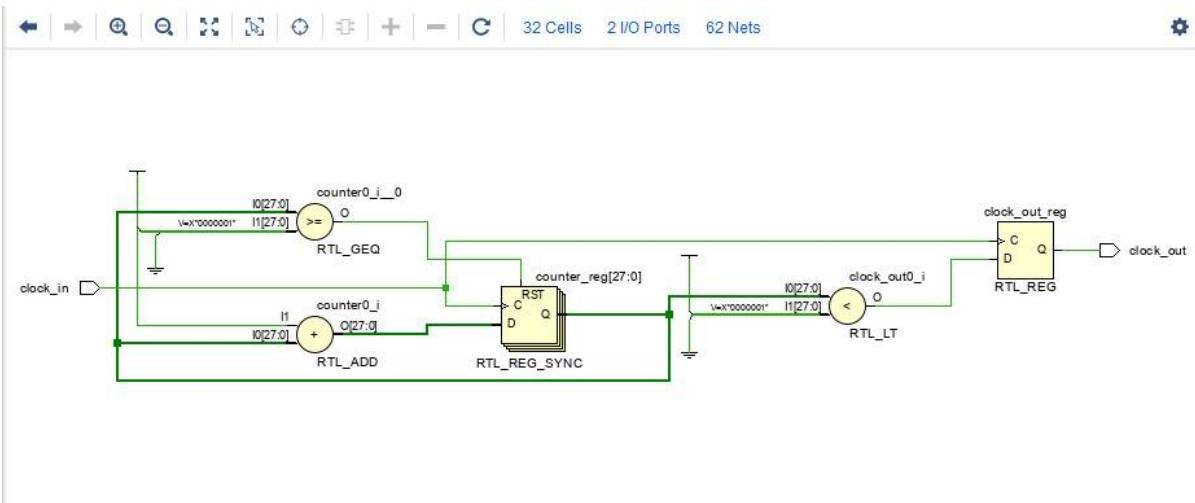
VERILOG CODE: -

```
) 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/new]
Parameter DIVISOR bound to: 28'b000000000000000000000000000000010
INFO: [Synth 8-6155] done synthesizing module 'clock_divider' (1#1) [E:/projects/dsd/clock_divider/1/clock_divider_1.srcs/sources_1/new]
-----
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
BUF	1
CARRY4	7
LUT1	1
LUT4	1
LUT5	2
LUT6	8
FDRE	29
TRUF	11

```

13 |LUT1   |    1|
14 |LUT4   |    1|
15 |LUT5   |    2|
16 |LUT6   |    8|
17 |FDRE   |   29|
18 |IBUF   |    1|
19 |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
-----
```

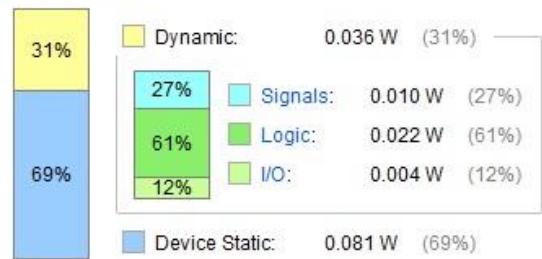
POWER REPORT: -

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 θJA:	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

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));

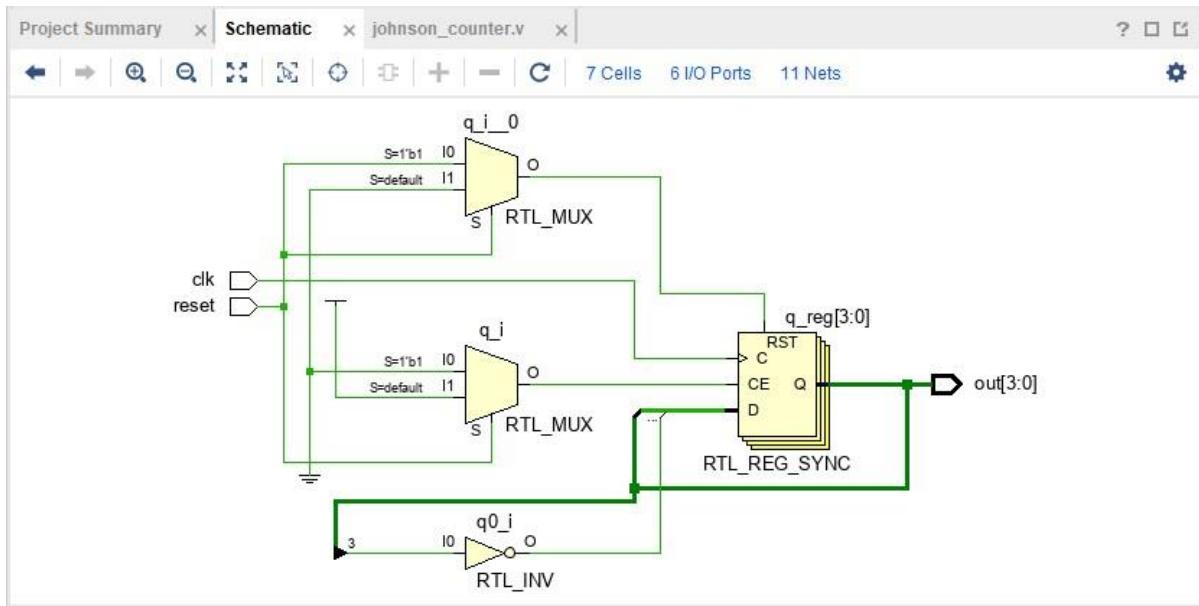
    always
      #5 clk =~clk;

    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 |
+-----+-----+
+-----+-----+
+-----+-----+
+-----+-----+
| |Cell |Count |
+-----+-----+
|1 |BUFGE | 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
-----+

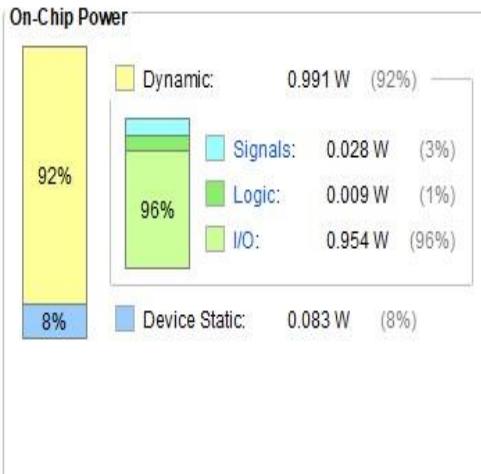
```

POWER REPORT: -

Summary

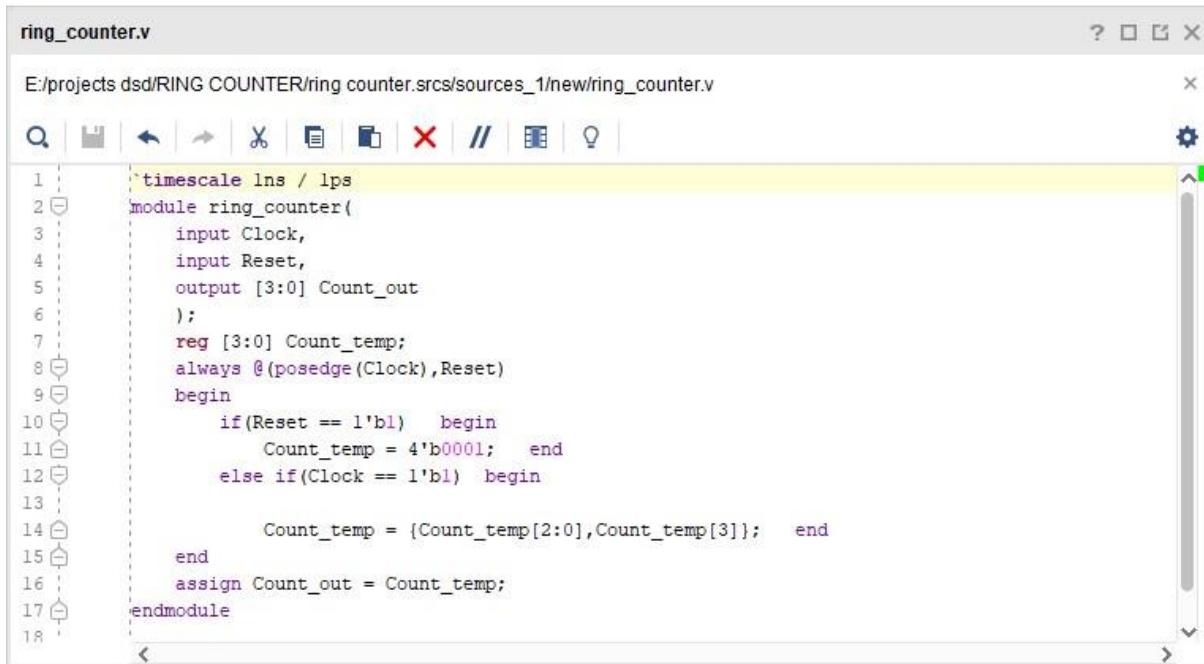
Power analysis from implemented netlist. Activity derived from constraints files, simulation files or vectorless analysis.

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**



Q3. RING COUNTER

VERILOG CODE: -



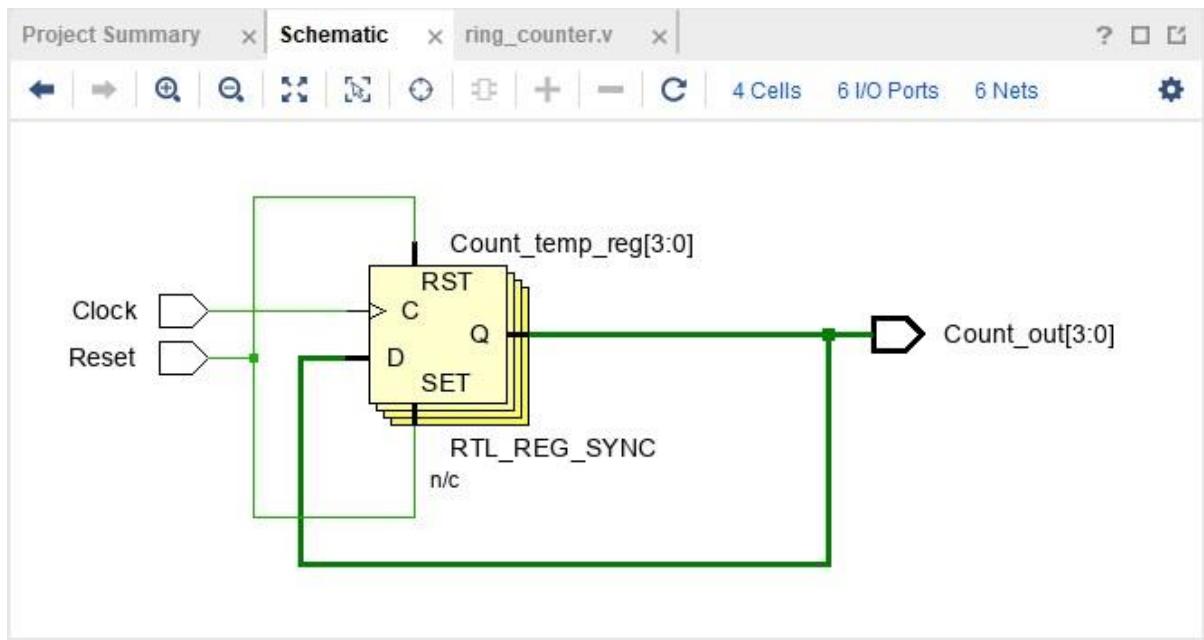
The screenshot shows a Verilog code editor window titled "ring_counter.v". The code is a module named "ring_counter" with the following structure:

```
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             Count_temp = {Count_temp[2:0],Count_temp[3]}; end
14         end
15         assign Count_out = Count_temp;
16     endmodule
17
18 
```

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 BUF_G	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:

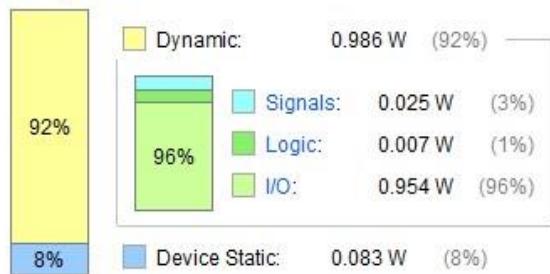
Summary

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

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On-Chip Power



Q4. 5 INPUT MAJORITY CIRCUIT

VERILOG CODE:-

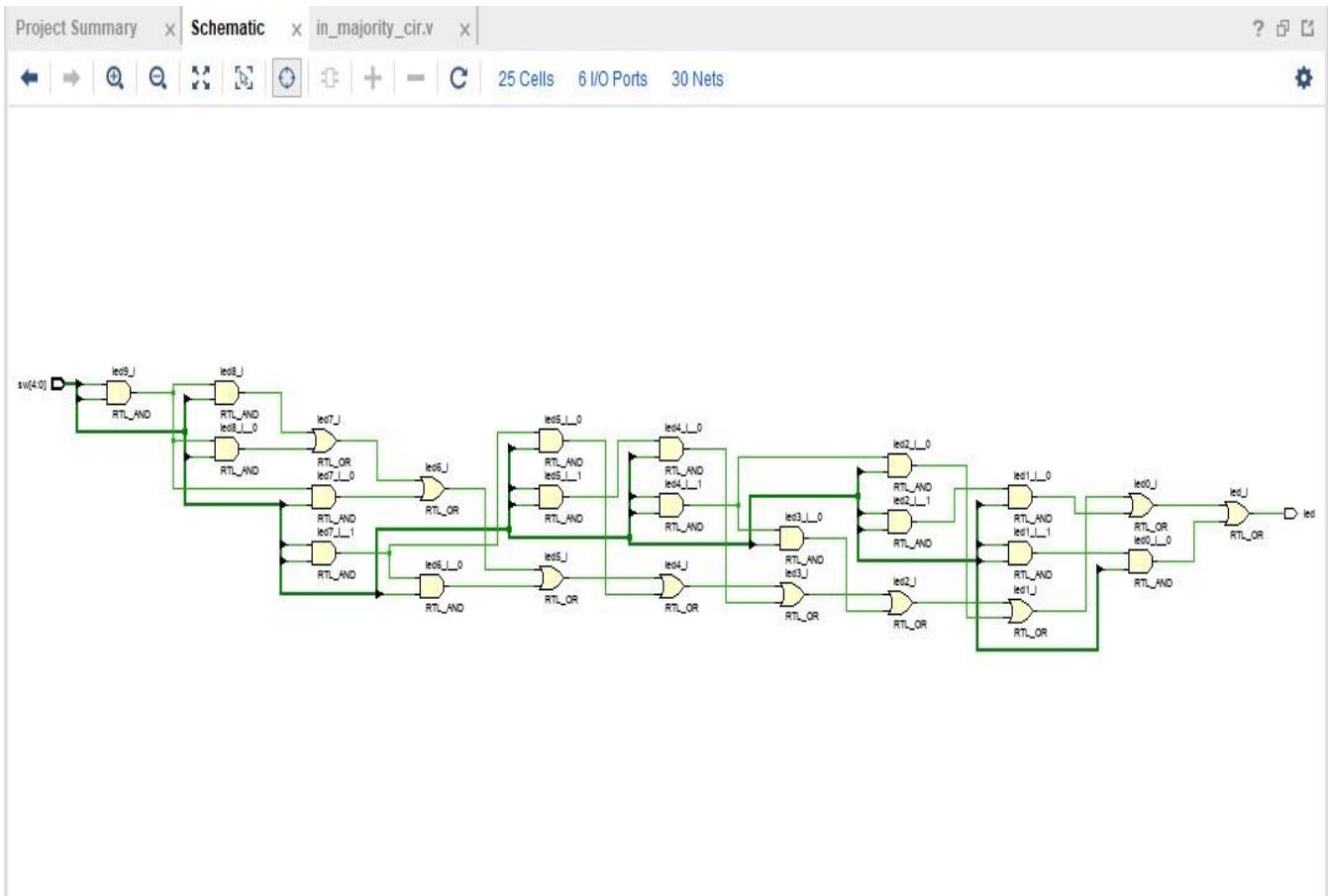
```
module majority_of_five(
    input [4:0] sw,
    output led
);
assign led =(sw[0] & sw[1] & sw[2]) |
            (sw[0] & sw[1] & sw[3]) |
            (sw[0] & sw[1] & sw[4]) |
            (sw[0] & sw[2] & sw[3]) |
            (sw[0] & sw[2] & sw[4]) |
            (sw[0] & sw[3] & sw[4]) |
            (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	
I1	LUT5	1
I2	IBUF	5
I3	OBUF	1

```
Report Instance Areas:
```

Instance	Module	Cells
I1	top	7

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

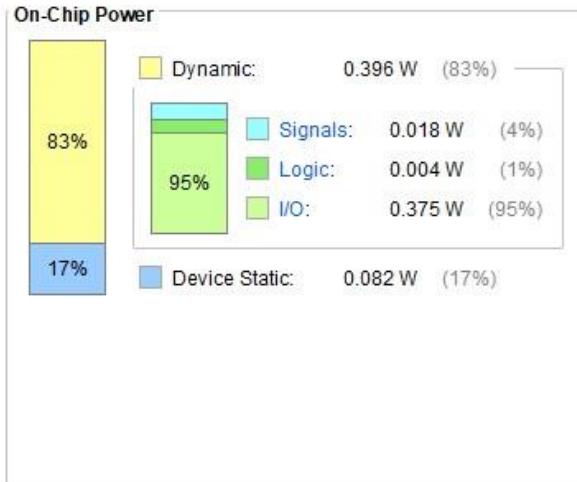
POWER REPORT:

Summary

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

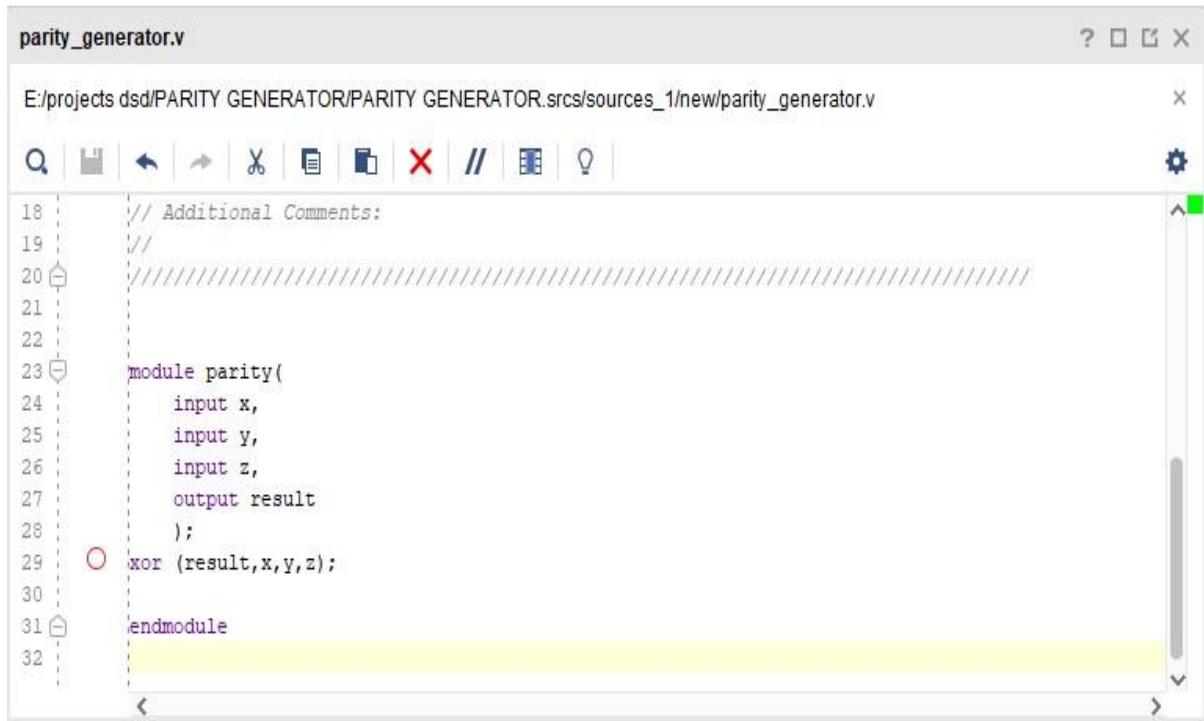
Total On-Chip Power:	0.478 W
Design Power Budget:	Not Specified
Power Budget Margin:	N/A
Junction Temperature:	25.9°C
Thermal Margin:	59.1°C (31.2 W)
Effective θJA:	1.9°C/W
Power supplied to off-chip devices:	0 W
Confidence level:	Low

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



Q5.PARITY GENERATOR

VERILOG CODE:-



The screenshot shows a Verilog code editor window titled "parity_generator.v". The code is a simple module definition for a parity generator. It includes comments, input ports (x, y, z), an output port (result), and a body containing an xor assignment. The code is syntax-highlighted with purple for keywords and red for operators.

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

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

TEST BENCH:-

```
module parity_tb
#(x=3,y=3,z=3)
wire result;

initial begin
    x = 0;
    y = 0;
    z = 0;

    #100;
    x = 0;
    y = 0;
    z = 1;

    #100;
    x = 0;
    y = 1;
    z = 0;

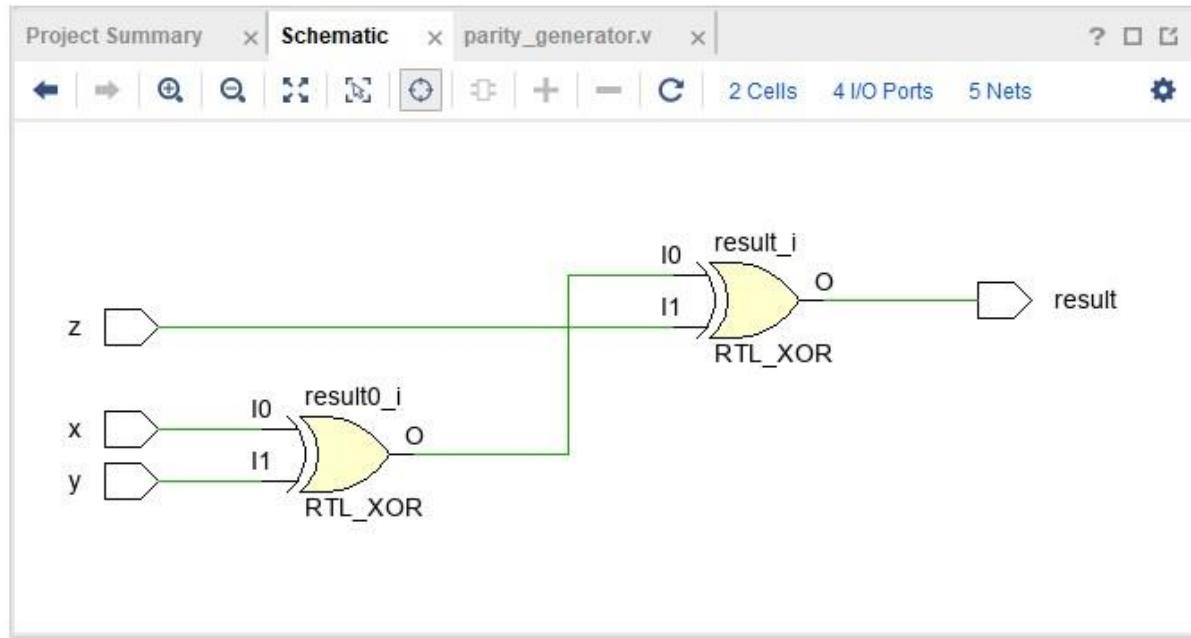
    #100;
    x = 0;
    y = 1;
    z = 1;

    #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:-



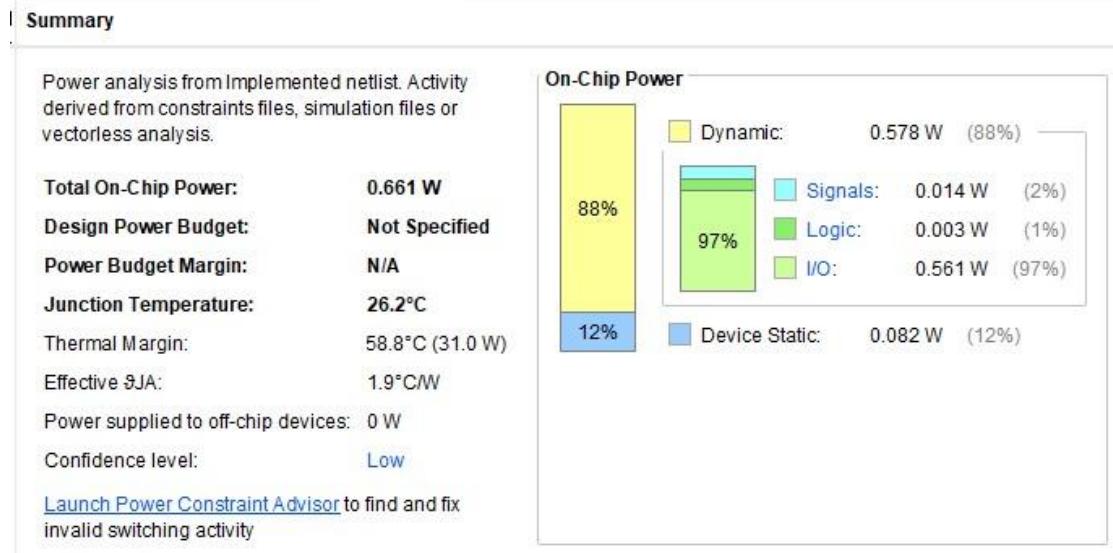
SYNTHESIS REPORT:-

```

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:-



Q6. BINARY TO ONE HOT ENCODER

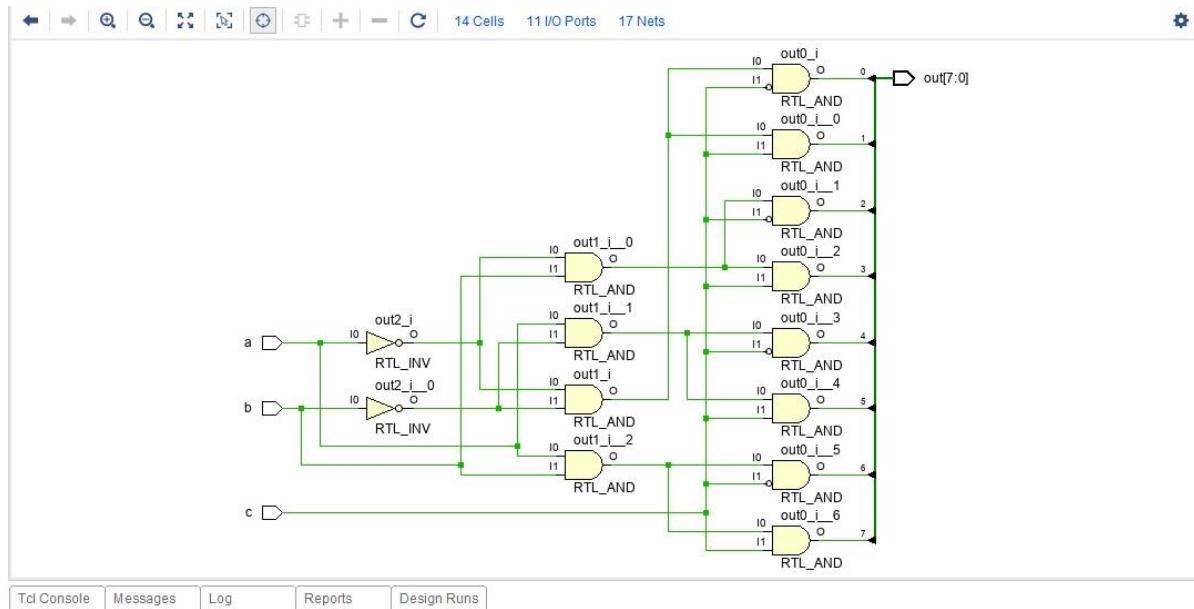
VERILOG CODE:-

```
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:-

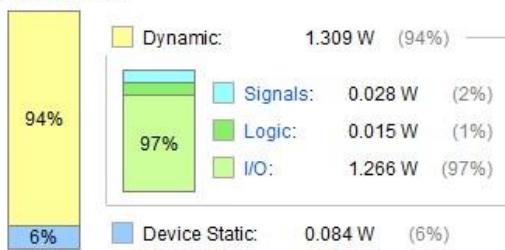
Summary

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 9JA: 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:-

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

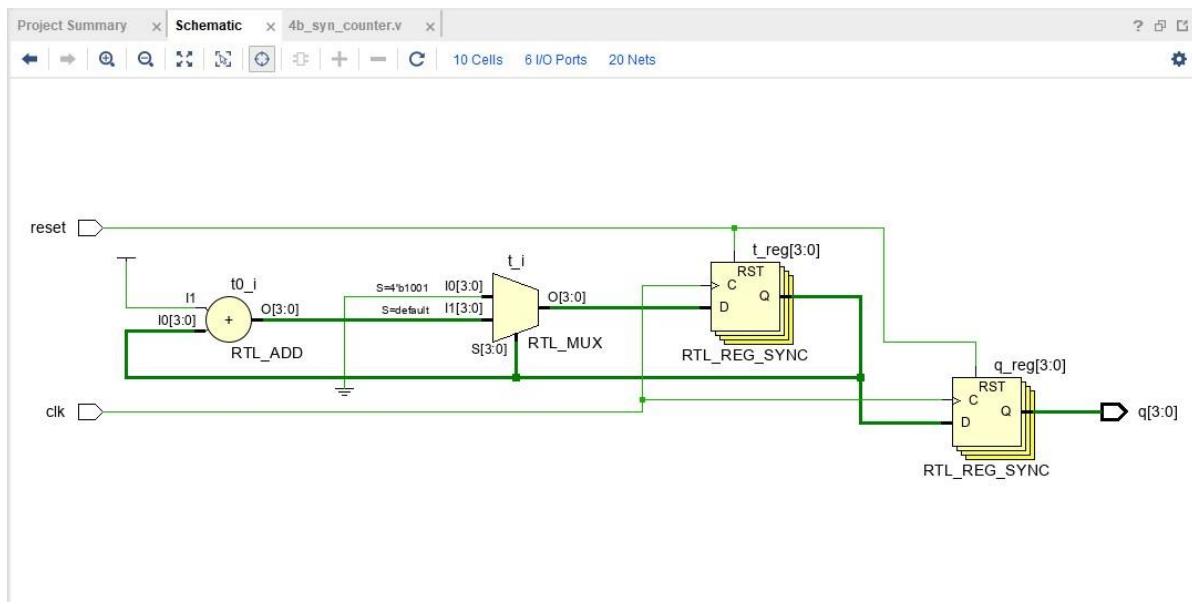
- Project Summary tab is selected.
- File name: 4b_syn_counter.v
- File path: E:/projects/dsd/4-BIT BCD SYNCHRONOUS COUNTER/4-BIT BCD SYNCHRONOUS COUNTER.srsc/sources_1/new/4b_syn_counter.v
- Toolbar icons include search, file operations, and code navigation.
- Code content:

```
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 |BUFGE | 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 | 1 | 19|
+-----+-----+-----+
Finished Writing Synthesis Report : Time (s): cpu = 00:00:14 ; elapsed = 00:00:26 . Memory (MB): peak = 1018.500 ; gain = 0.000

```

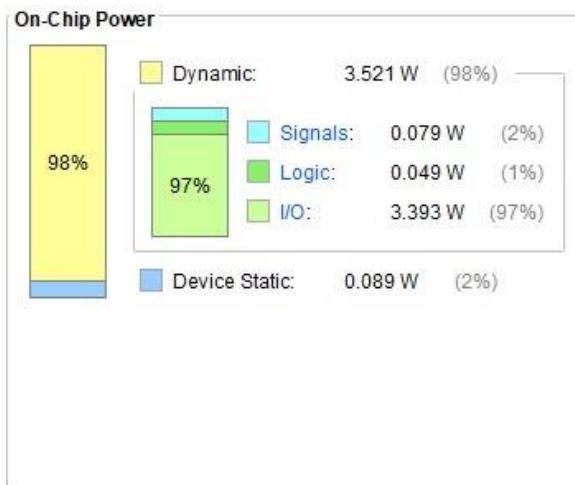
POWER REPORT:-

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 9JA:	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 | ☰ | ⌛ | ⌚ | X | ☰ | ⌛ | // | ☰ | ? |
21 module CLA_Adder(a,b,cin,sum,cout);
22   input[3:0] a,b;
23   input cin;
24   output [3:0] sum;
25   output cout;
26   wire p0,p1,p2,p3,g0,g1,g2,g3,c1,c2,c3,c4;
27   assign p0=(a[0]^b[0]),
28     p1=(a[1]^b[1]),
29     p2=(a[2]^b[2]),
30     p3=(a[3]^b[3]);
31   assign g0=(a[0]&b[0]),
32     g1=(a[1]&b[1]),
33     g2=(a[2]&b[2]),
34     g3=(a[3]&b[3]);
35   assign c0=cin,
36     c1=g0|(p0&cin),
37     c2=g1|(p1&p0&cin),
38     c3=g2|(p2&g1)|(p2&p1&g0)|(p1&p1&p0&cin),
39     c4=g3|(p3&g2)|(p3&p2&g1)|(p3&p2&p1&g0)|(p3&p2&p1&p0&cin);
40   assign sum[0]=p0^c0,
41   sum[1]=p1^c1,
42   sum[2]=p2^c2,
43   sum[3]=p3^c3;
44   assign cout=c4;
45 endmodule

```

TEST BENCH:-

```

module TestModule;

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

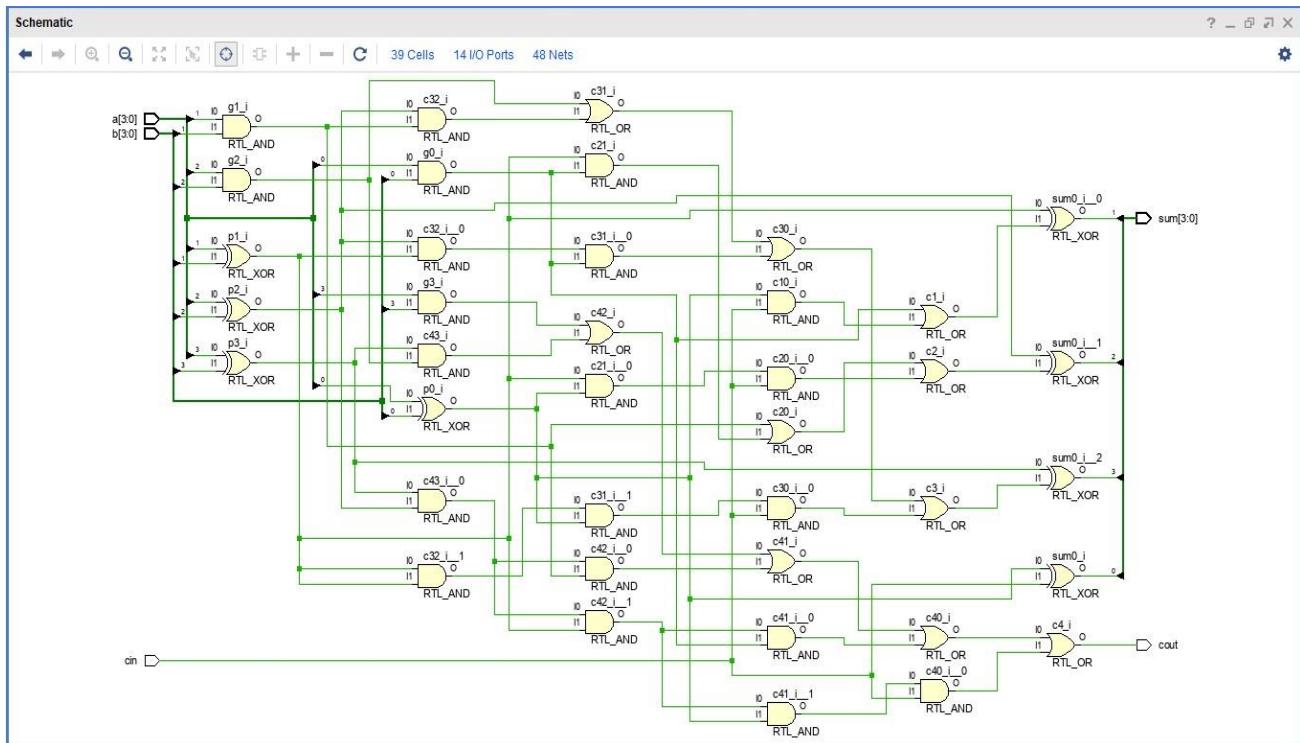
wire [3:0] sum;
wire cout;

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
LUT2	1
LUT3	1
LUT4	1
LUT5	4
LUT6	2
IBUF	9
OBUF	5

Report Cell Usage:

Cell	Count
LUT2	1
LUT3	1
LUT4	1
LUT5	4
LUT6	2
IBUF	9
OBUF	5

Report Instance Areas:

Instance	Module	Cells
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:-

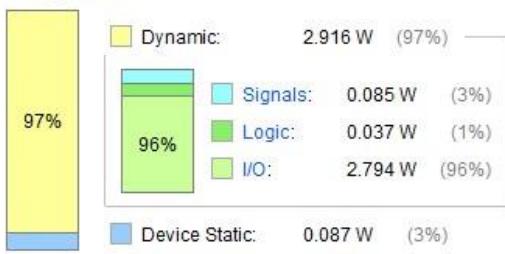
Summary

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 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



Q9.N-BIT COMPARATOR

VERILOG CODE:-

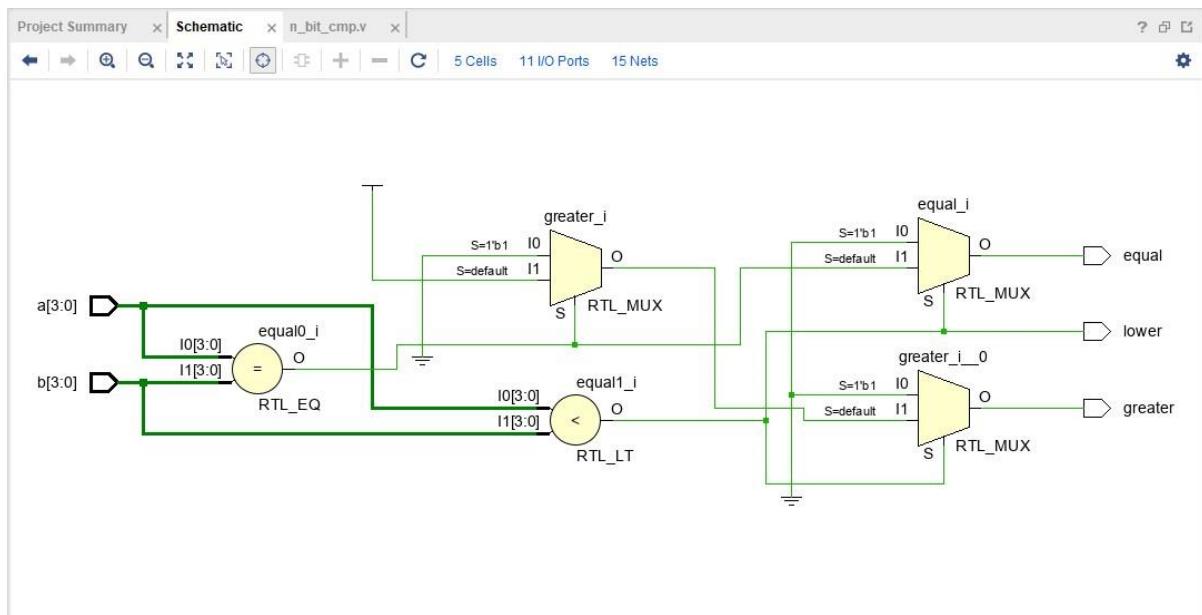
```
module comparator (
    input wire [3:0] a,
    input wire [3:0] b,
    output reg equal,
    output reg lower,
    output reg greater
);

    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
-----
```

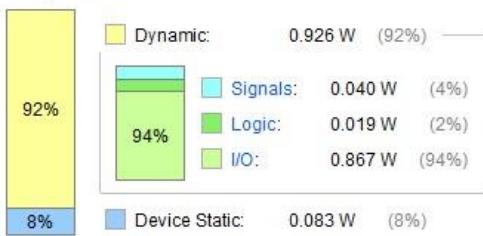
POWER REPORT:-

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

On-Chip Power



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));

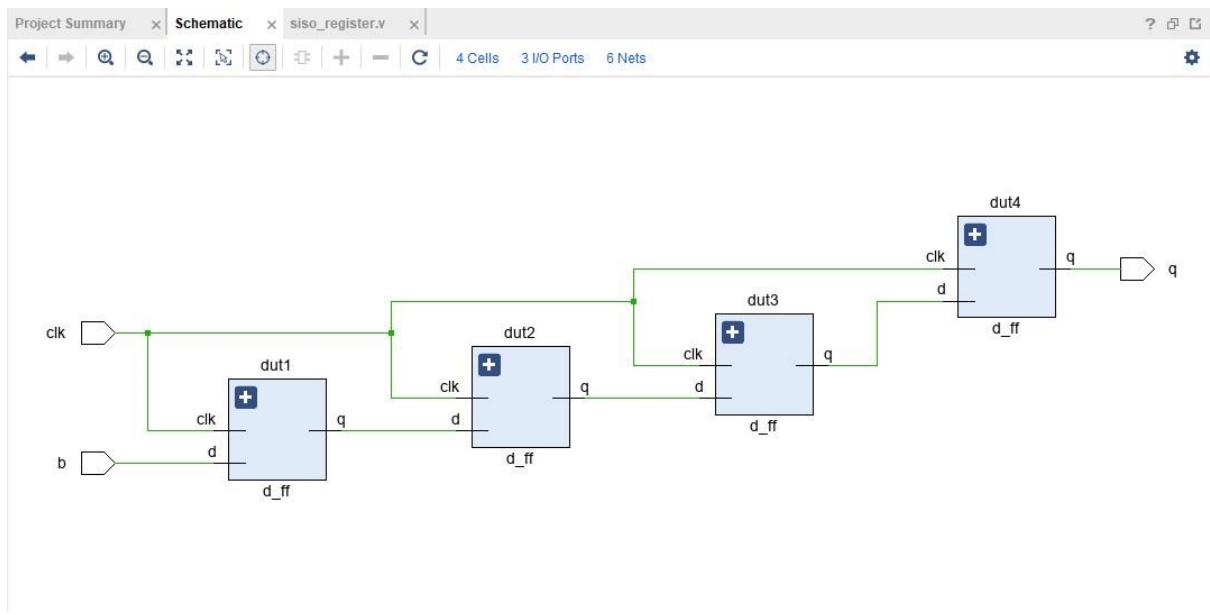
`initial
`begin
clk=1'b0;
forever #5clk=~clk;
end

`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 |IBUG | 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 SJA:

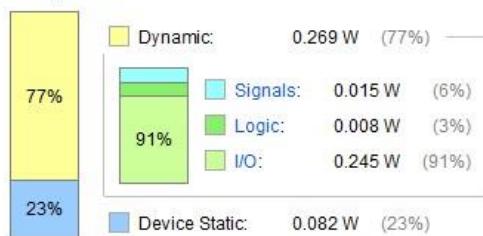
1.9°C/W

Power supplied to off-chip devices: **0 W**

Confidence level: **Low**

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

On-Chip Power



Q11. SERIAL IN PARALLEL OUT SHIFT REGISTER

VERILOG CODE:-

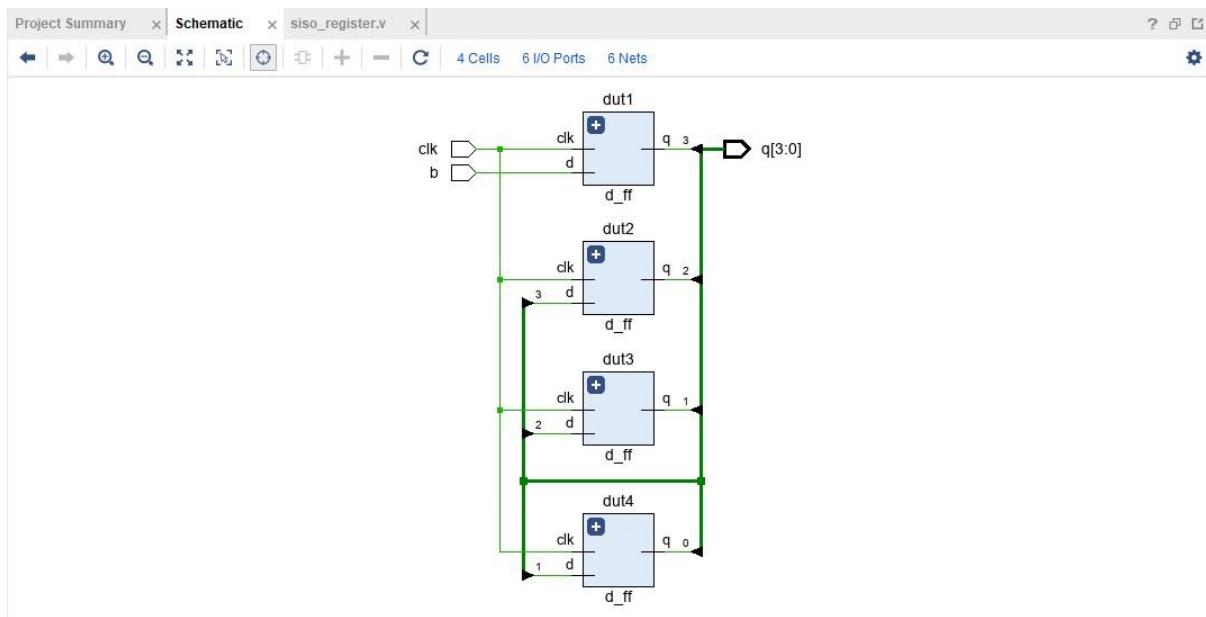
```
E:/projects/dsd/SIPO REGISTER/SIPO REGISTER.srzs/sources_1/new/siso_register.v

Q | H | ← | → | X | D | F | // | E | ? |
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,b;
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 |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:-

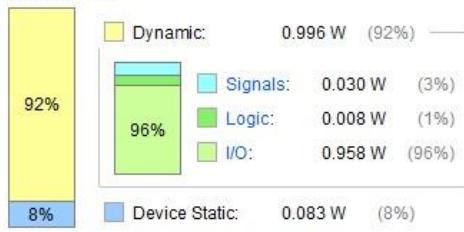
Summary

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 TJA: 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



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:-

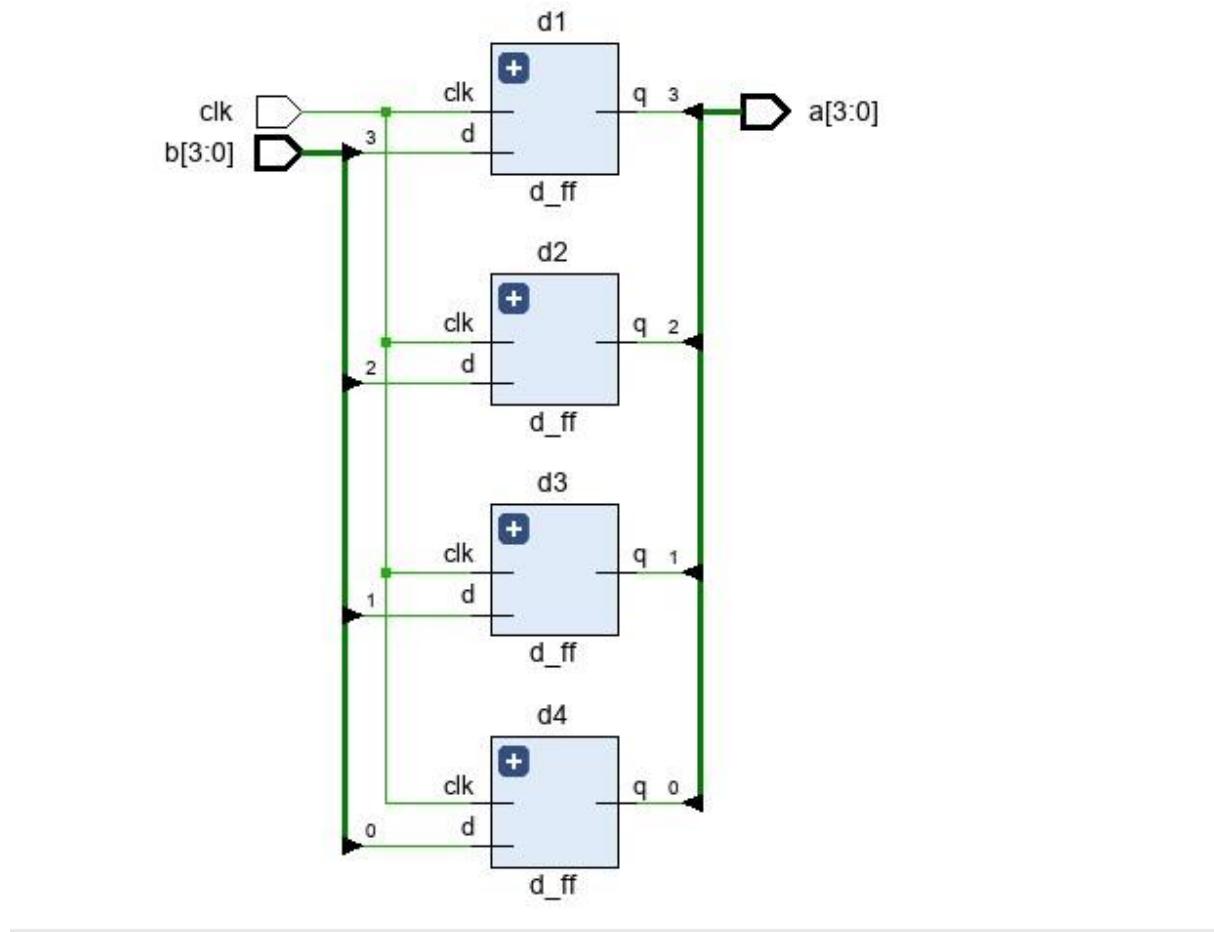
```
// test bench
module pipo_tb();
reg clk;
reg [3:0]b;
wire [3:0]a;

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
-----
```

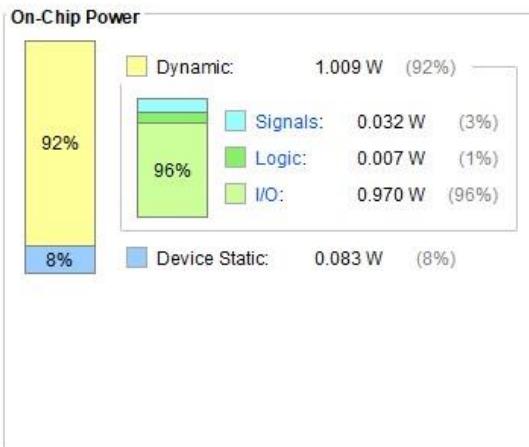
POWER REPORT:-

| 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 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:-

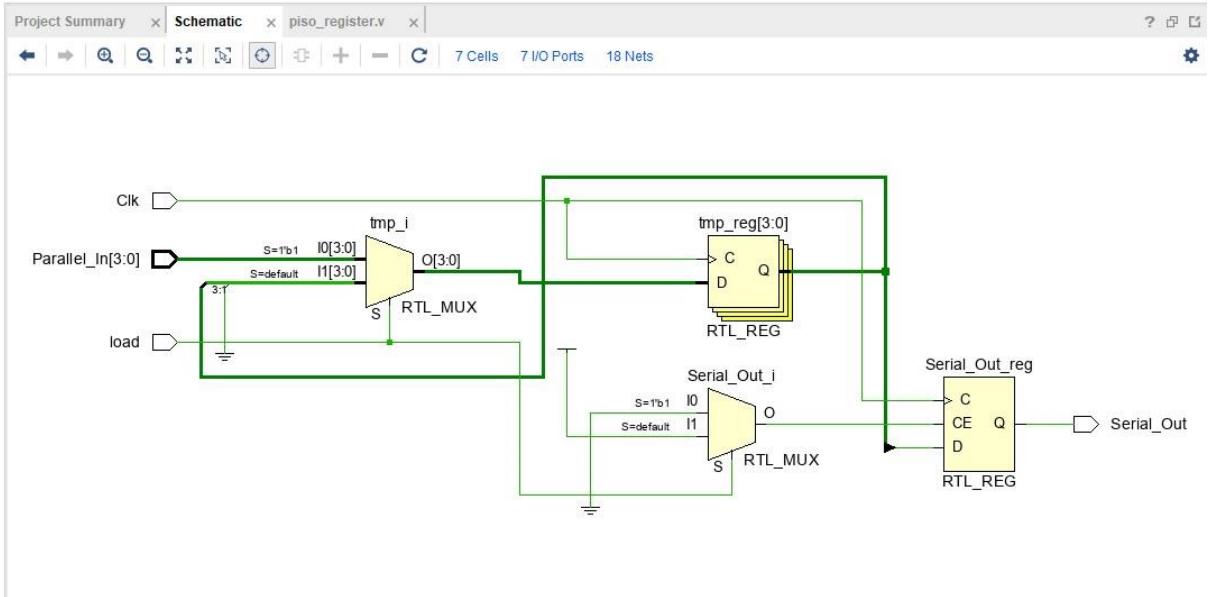


```
1 module Shiftregister_PISO(Clk, Parallel_In,load, Serial_Out);
2   input Clk,load;
3   input [3:0]Parallel_In;
4   output reg Serial_Out;
5   reg [3:0]tmp;
6   always @(posedge Clk)
7     begin
8       if(load)
9         tmp<=Parallel_In;
10      else
11        begin
12          Serial_Out<=tmp[3];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

TEST BENCH:-

```
1 module Shiftregister_PISO_tb();
2   reg [3:0]Parallel_in;
3   reg Clk,load;
4   wire Serial_out;
5   piso_design dut(Clk,load,Parallel_in,Serial_out);
6   initial begin
7     Clk=1'b0;
8     forever #5 Clk=~Clk;
9   end
10  initial begin
11    load=0;b=4'b0101;
12    #20 load=1;
13    #20 load=1;
14    #10 load=0;
15    #10 load=0;
16    #100 $finish;
17  end
18 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)

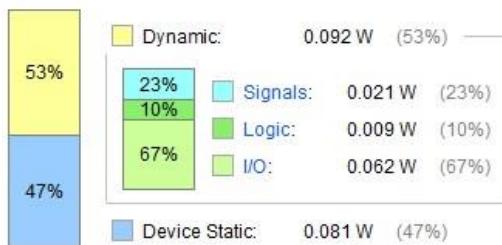
Effective 9JA: 1.9°C/W

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 Schematic bi_directional_register.v

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

Q | // | ? |

```

17 // Revision 0.01 - File Created
18 // Additional Comments:
19 //
20 module shift_reg #(parameter MSB = 8) (input d,
21   input clk,
22   input en,
23   input dir,
24   input rstn,
25   output reg [MSB-1:0] out);
26   always @ (posedge clk)
27     if (!rstn)
28       if (!en)
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:-

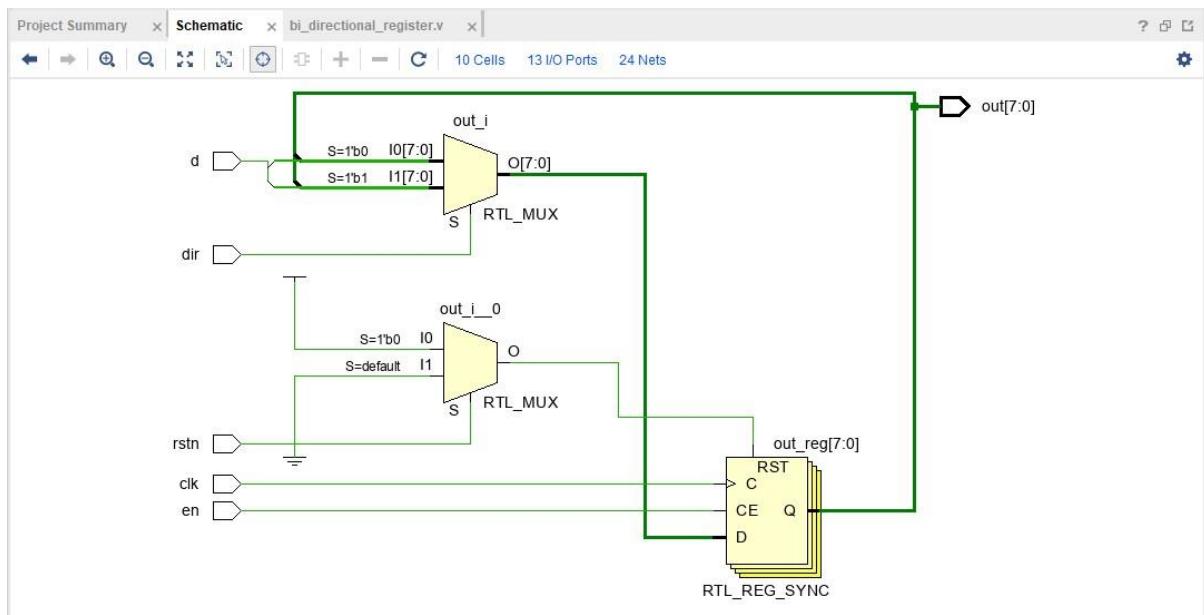
```

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|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:-

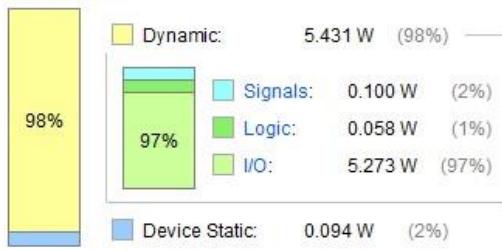
Summary

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 9JA: 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

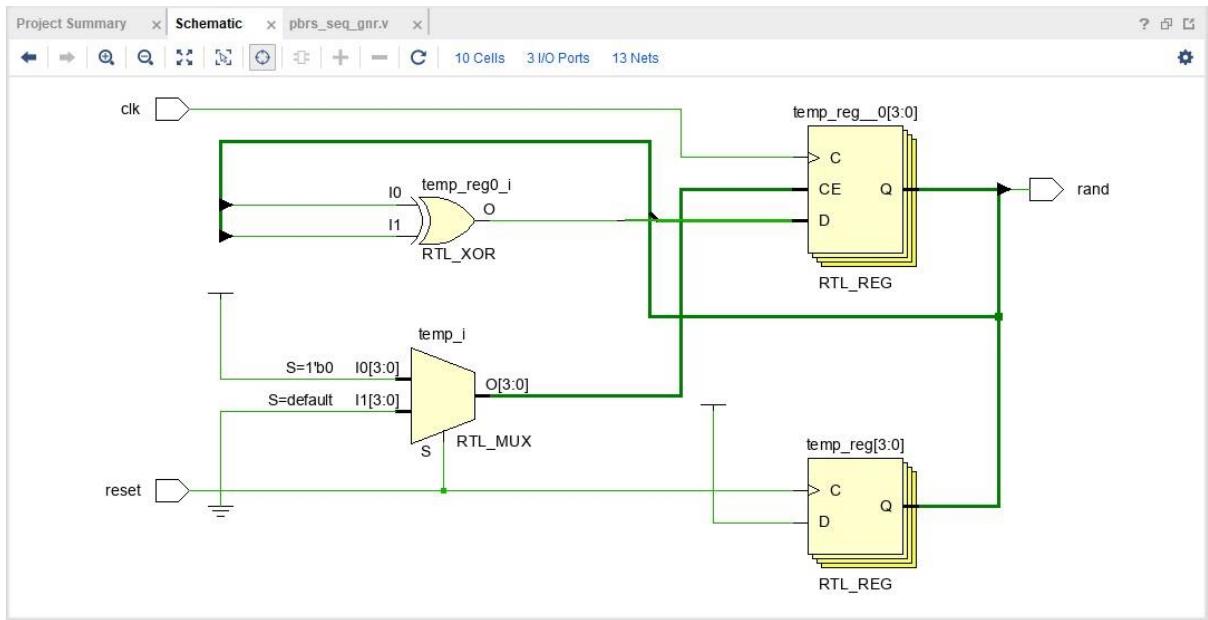
VERILOG CODE:-

```
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 pbris_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
-----
```

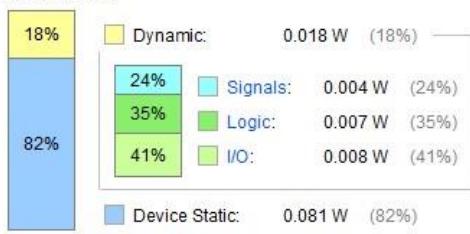
POWER REPORT:-

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

On-Chip Power



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;

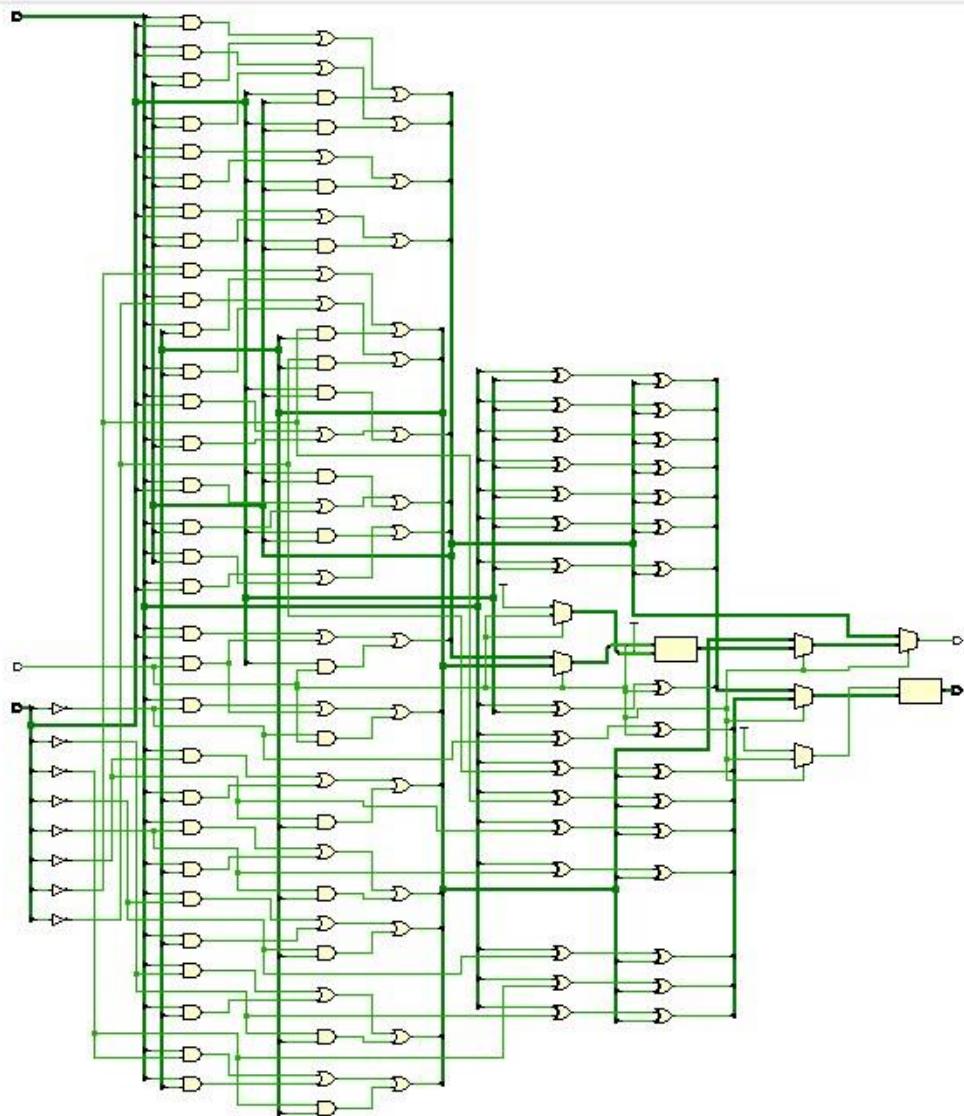
#10 $stop;

end

endmodule

```

RTL SCHEMATIC:-



SYNTHESIS REPORT:-

```

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

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

```

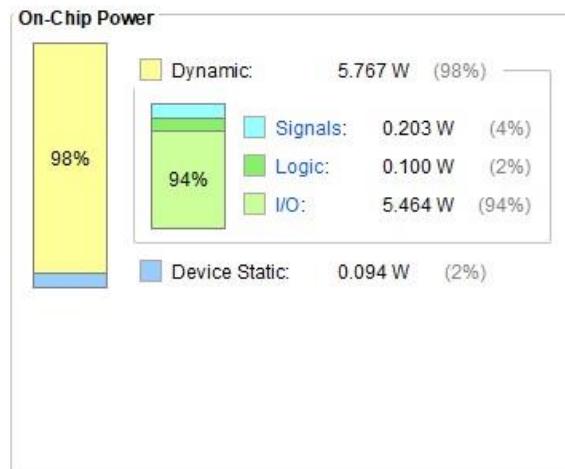
POWER REPORT:-

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 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 ;

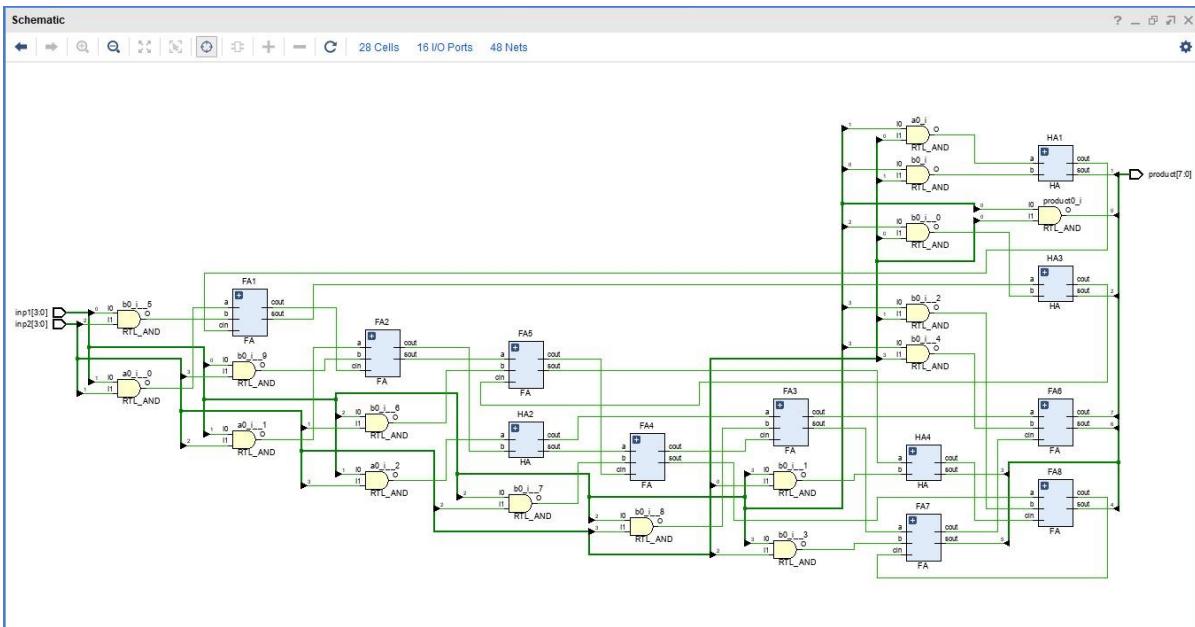
    inpl=11;
    inp2=22;
    #30 ;

    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 | 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 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



Q19. FIXED POINT DIVISION

VERILOG CODE:-

```

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

Q | I | < | > | X | S | D | X | // | B | ? |

1 module qdiv #((
2   //Parameterized values
3   parameter Q = 15,
4   parameter N = 32
5 )
6 (
7   input [N-1:0] i_dividend,
8   input [N-1:0] i_divisor,
9   input i_start,
10  input i_clk,
11  output [N-1:0] o_quotient_out,
12  output o_complete,
13  output o_overflow
14 );
15
16 reg [2^N+Q-3:0] reg_working_quotient;
17 reg [N-1:0] reg_quotient;
18 reg [N+2Q:0] reg_working_dividend;
19 reg [2^N+Q-3:0] reg_working_divisor;
20
21 reg [N-1:0] reg_count;
22
23
24 reg reg_done;
25 reg reg_sign;
26 reg reg_overflow;
27
28 initial reg_done = 1'b1;
29 initial reg_overflow = 1'b0;
30 initial reg_sign = 1'b0;
31
32 initial reg_working_quotient = 0;
33 initial reg_quotient = 0;
34 initial reg_working_dividend = 0;
35 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
  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

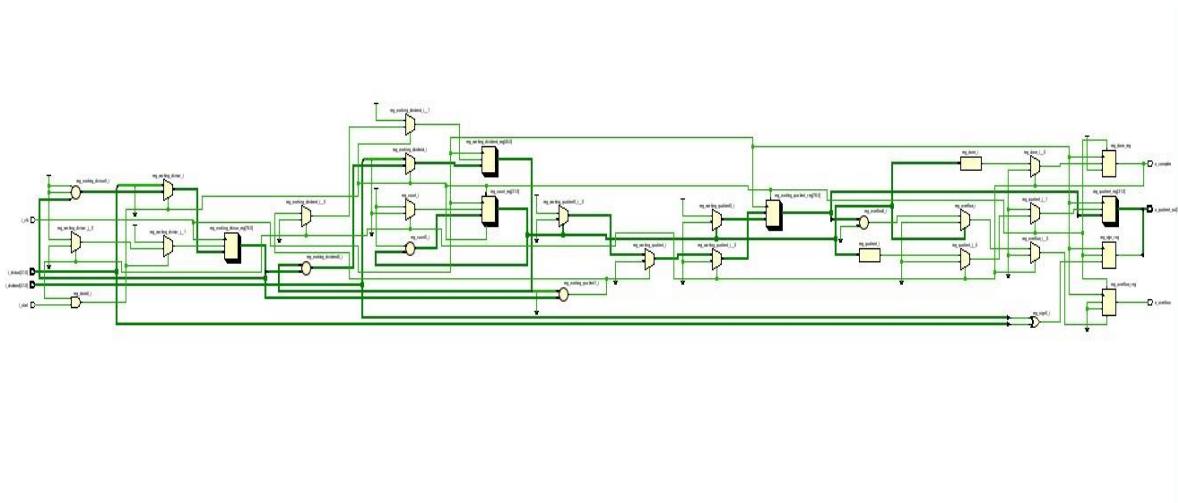
always @ (count) begin
    if (count == 47) begin
        if ( i_divisor > 32'h1FFFFFFF ) begin
            i_divisor <= 1;
            i_dividend = (i_dividend << 1) + 3;
            end
        else
            i_divisor = (i_divisor << 1) + 1;
        end
    end
end

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

endmodule

```

RTL SCHEMATIC:-



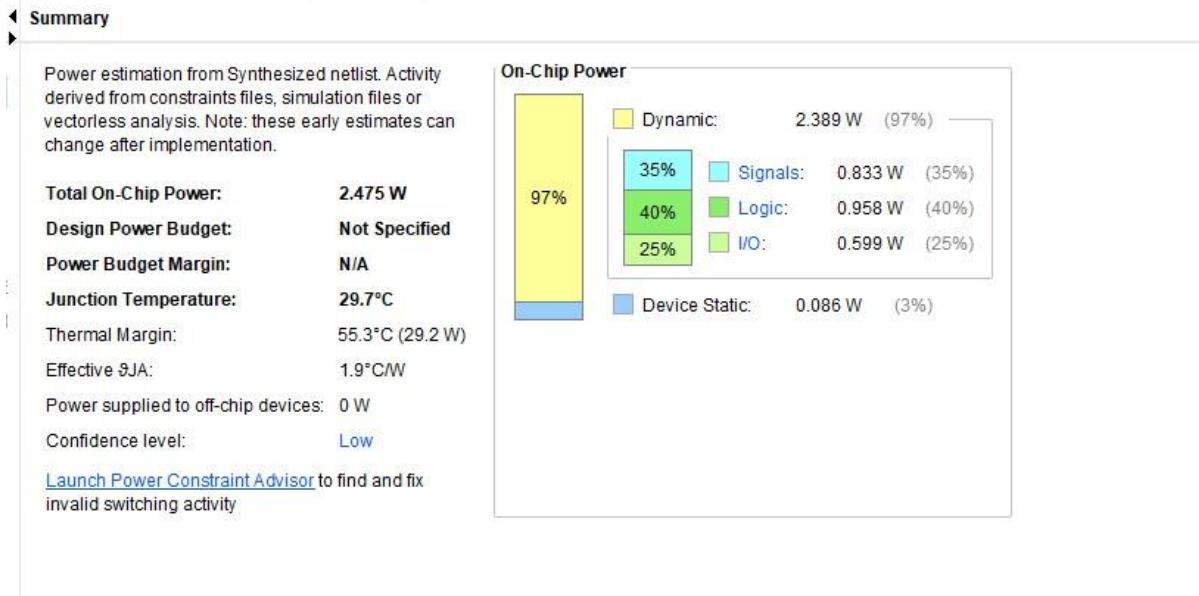
SYNTHESIS REPORT:-

```

Start Writing Synthesis Report
-----
Report BlackBoxes:
++-----+-----+
| |BlackBox name |Instances |
++-----+-----+
++-----+-----+
Report Cell Usage:
++-----+-----+
| |Cell |Count |
++-----+-----+
|1 |BUFGE | 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:-



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;

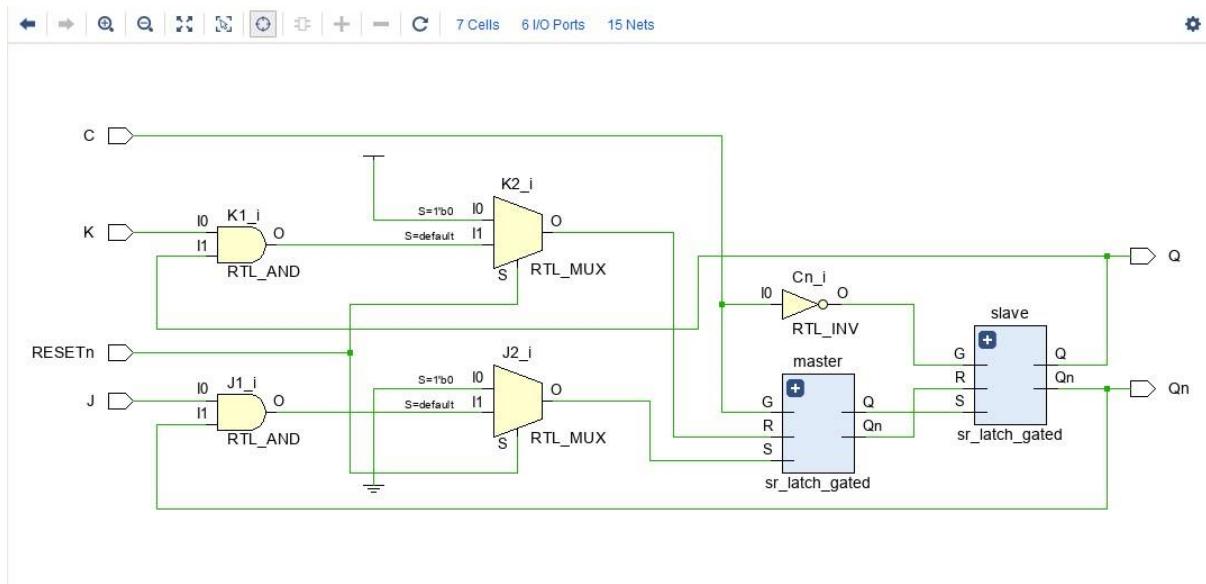
#100
RESETn=1;
J=1'b1;
K=1'b0;

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:-

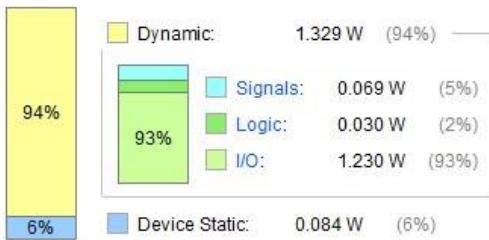
Summary

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

On-Chip Power



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));

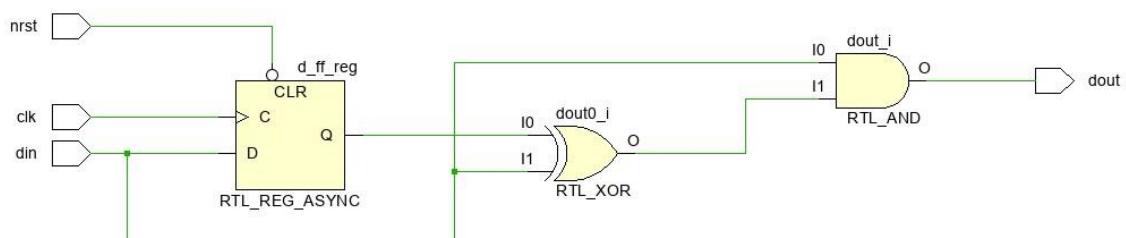
    always #5 clk = ~clk;

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

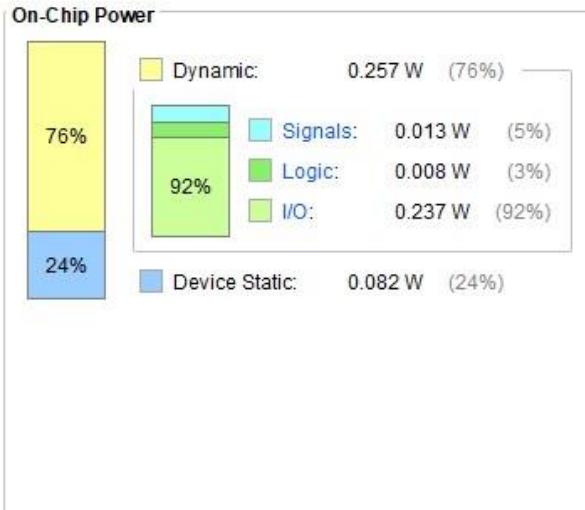
POWER REPORT:-

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 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



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)
    );

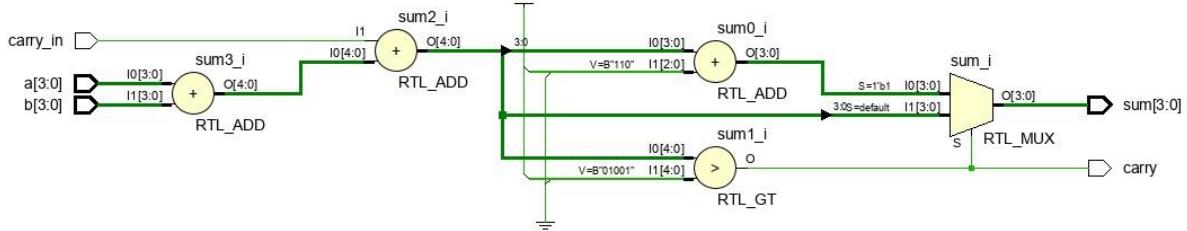
    initial begin

        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:-

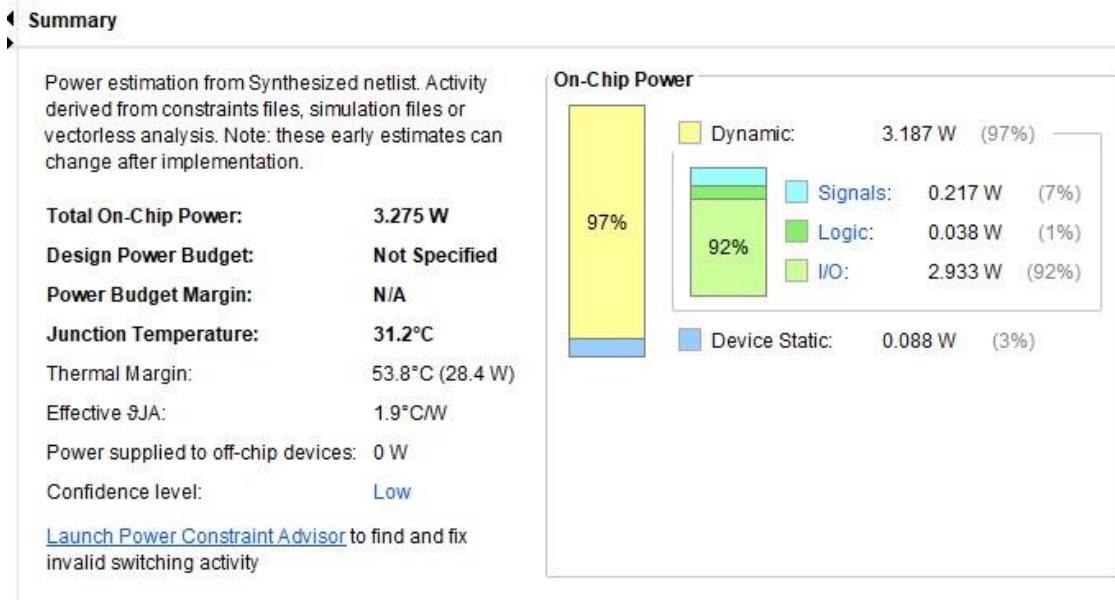
```

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

Report BlackBoxes:
+-----+-----+
| |BlackBox name |Instances |
+-----+-----+
+-----+-----+
+-----+-----+
+-----+-----+
|1 |LUT3 | 1|
|2 |LUT5 | 2|
|3 |LUT6 | 4|
|4 |IBUF | 9|
|5 |OBUF | 5|
+-----+-----+
+-----+-----+
+-----+-----+
+-----+-----+
| |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 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)
    );

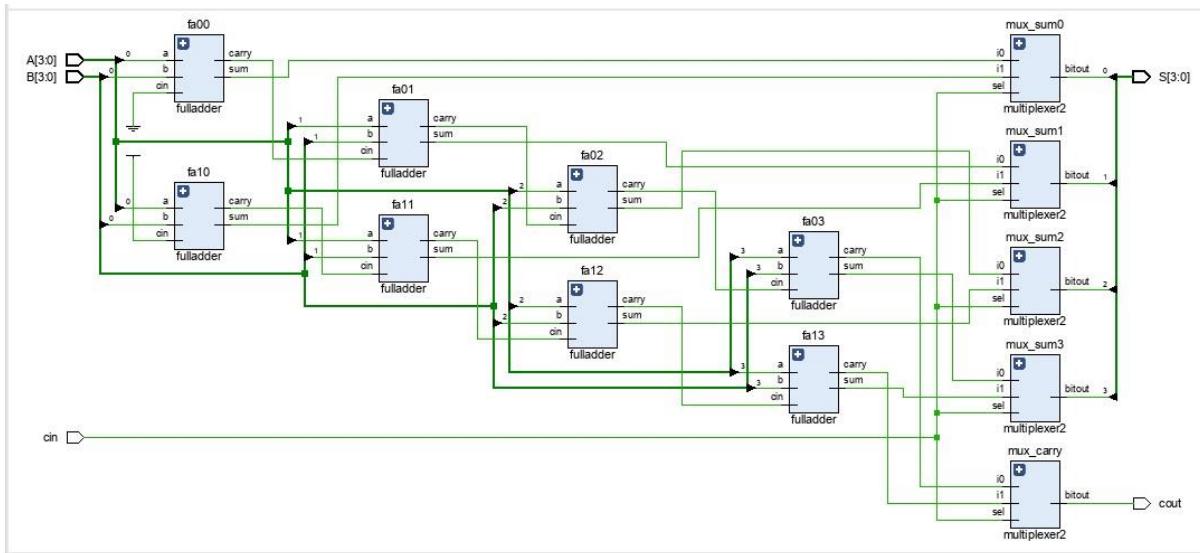
) initial begin

    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))
)                error <= error + 1;
        end
    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
LUT3	2
LUT5	4
IBUF	9
OBUF	5

Report Instance Areas:

Instance	Module	Cells
top		20

Finished Writing Synthesis Report : Time (s): cpu = 00:00:22 ; elapsed = 00:00:43 . Memory (MB): peak = 1017.844 ; gain = 0.000

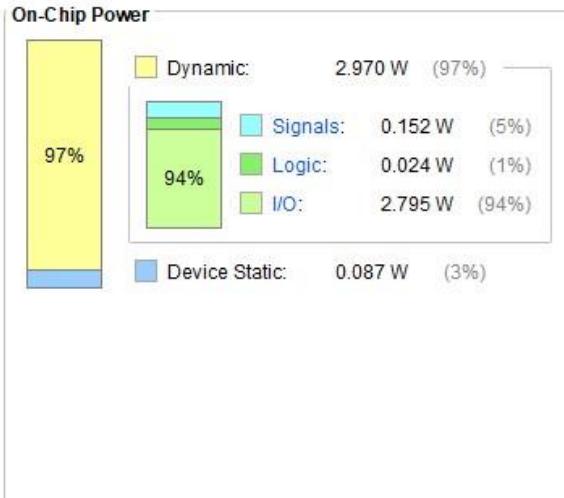
POWER REPORT:-

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:-

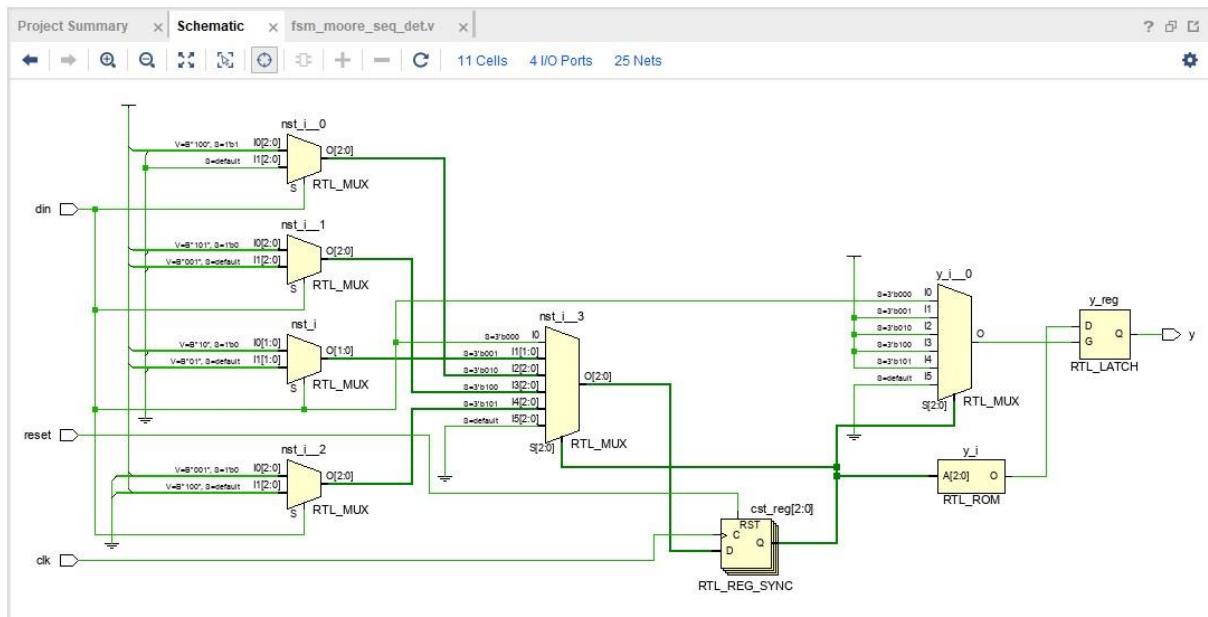
```
module morfsmolp(din, reset, clk, y);
    input din;
    input clk;
    input reset;
    output reg y;
    reg [2:0] cst, nst;
    parameter S0 = 3'b000,
              S1 = 3'b001,
              S2 = 3'b010,
              S3 = 3'b100,
              S4 = 3'b101;
    always @(cst or din)
    begin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

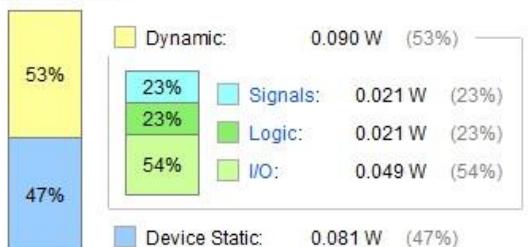
Summary

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 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



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
```

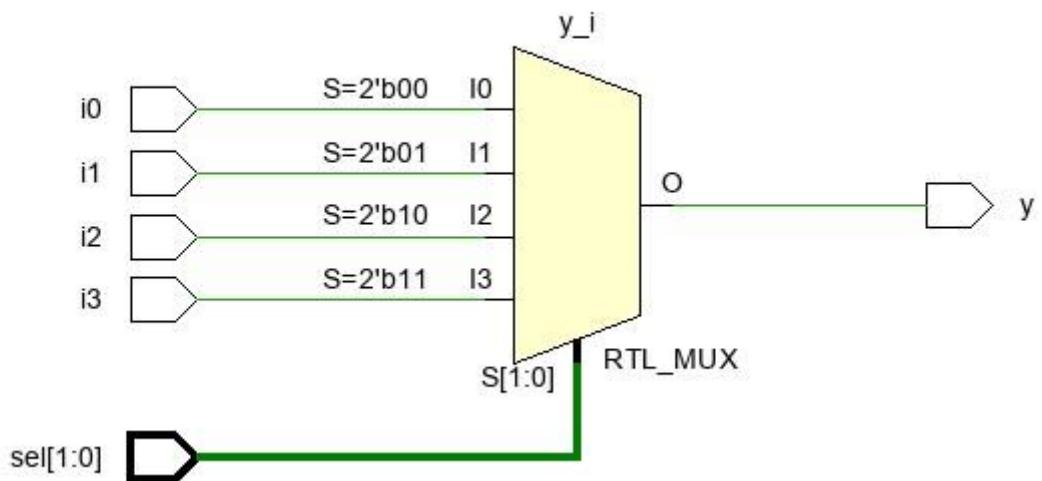
TEST BENCH:-

```
) 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 9JA:

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

