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Division: - 04

Year: - 2023-24

Subject: - Digital System Design (3EL42)

Branch: - Electronics (EL)

# Q1. CLOCK DIVIDER

## VERILOG CODE: -

```verilog
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: -

```verilog
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: -
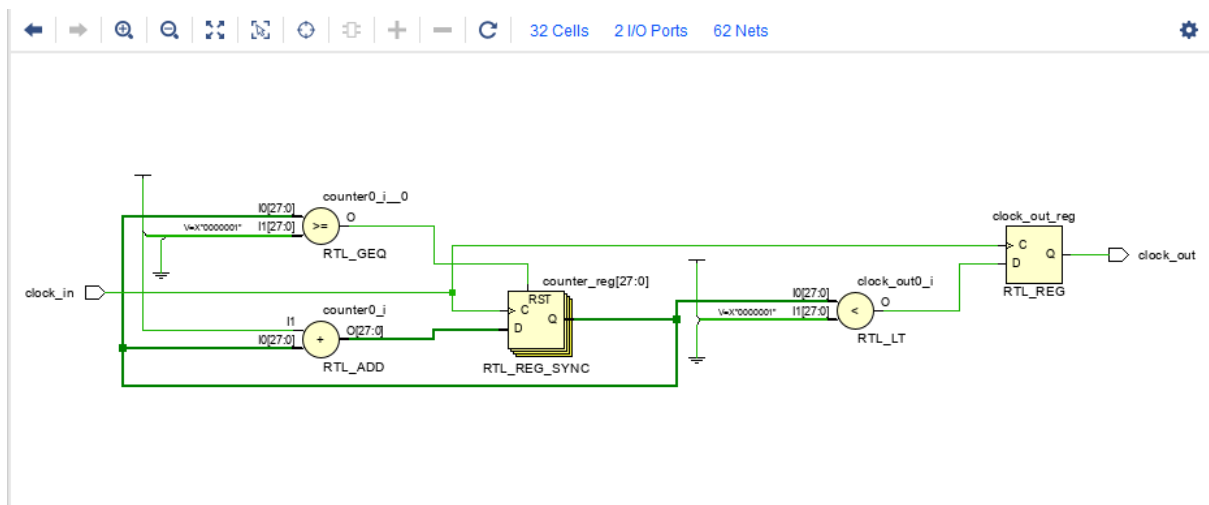


# SYNTHESIS REPORT: -

```
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'b0000000000000000000000000010
INFO: [Synth 8-6155] done synthesizing module 'clock_divider' (1#1) [E:/projects dsd/clock_divider 1/clock_divider 1.srcs/so
--------------------------------------------------------------------------------
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
----------------------------------------------------------------------
```
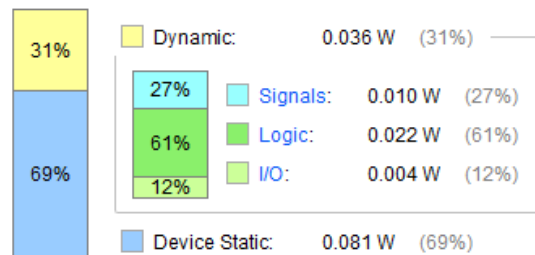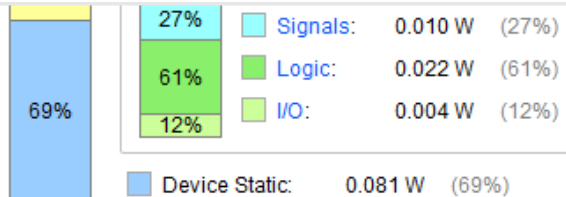
# POWER REPORT: -

## 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) |

On-Chip Power

- Dynamic: 0.036 W (31%)
  - Signals: 0.010 W (27%)
  - Logic: 0.022 W (61%)
  - I/O: 0.004 W (12%)
- Device Static: 0.081 W (69%)

| | |
|---|---|
| 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 |

- 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: -

```verilog
`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];
```

```verilog
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: -

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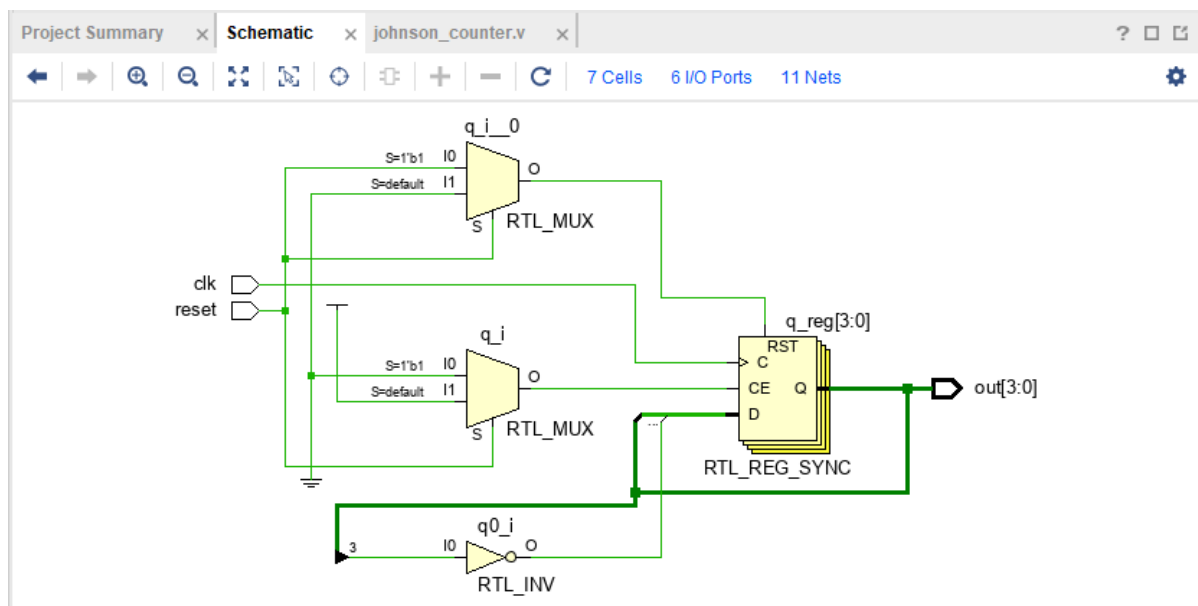
```verilog
  johnson_counter dut (.out(out), .reset(reset), .clk(clk));

  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

### On-Chip Power

| | | |
|---|---|---|
| Dynamic: | 0.991 W | (92%) |
| Signals: | 0.028 W | (3%) |
| Logic: | 0.009 W | (1%) |
| I/O: | 0.954 W | (96%) |
| Device Static: | 0.083 W | (8%) |

92%
96%
8%
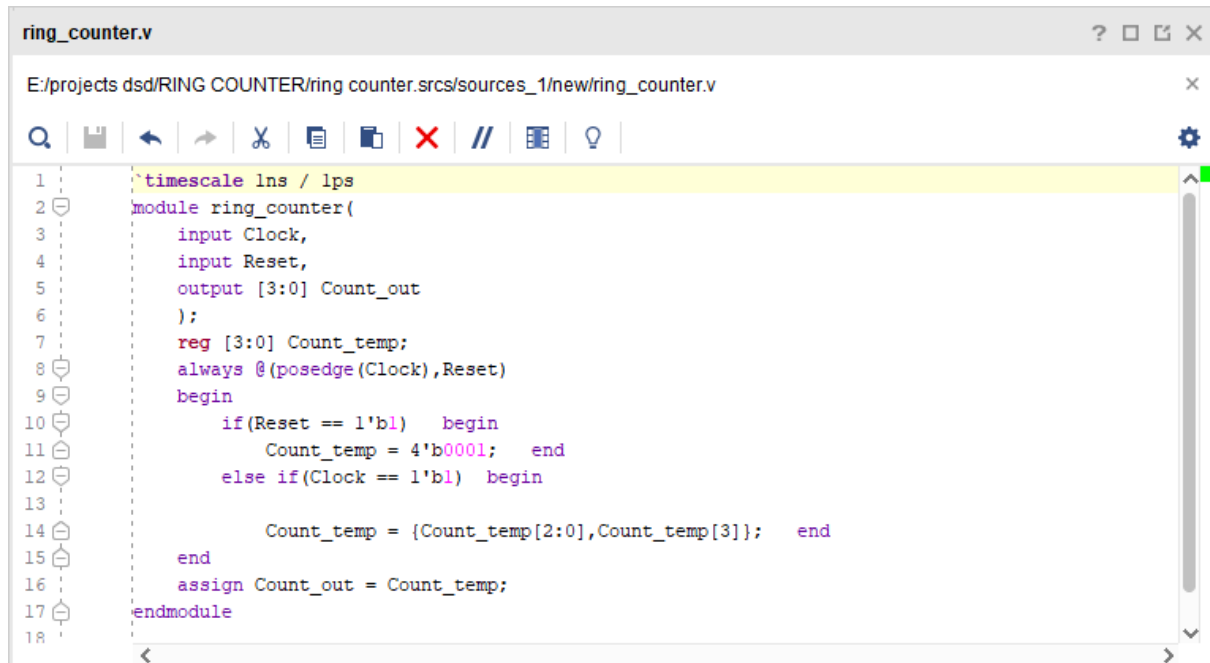
# Q3. RING COUNTER

## VERILOG CODE: -

```
ring_counter.v                                                    ? □ ⬚ ✕

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

Q  💾  ↰  ↱  ✂  📋  📋  ✕  //  📰  ♀                                      ✿

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
18
```
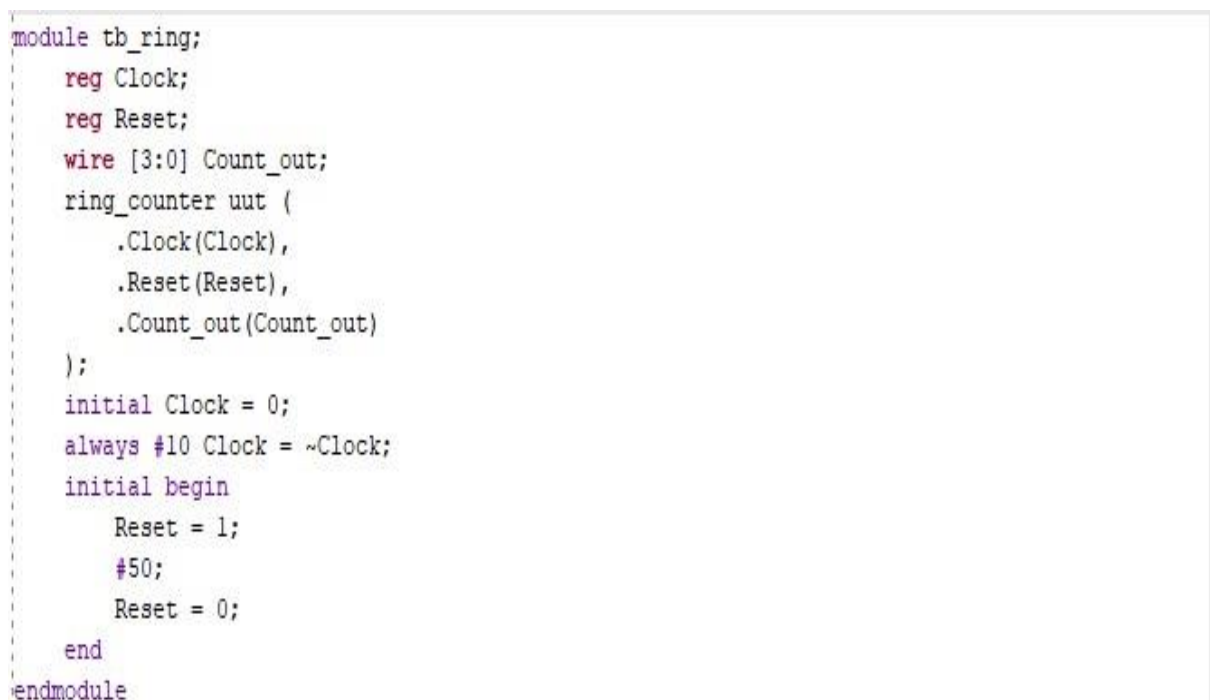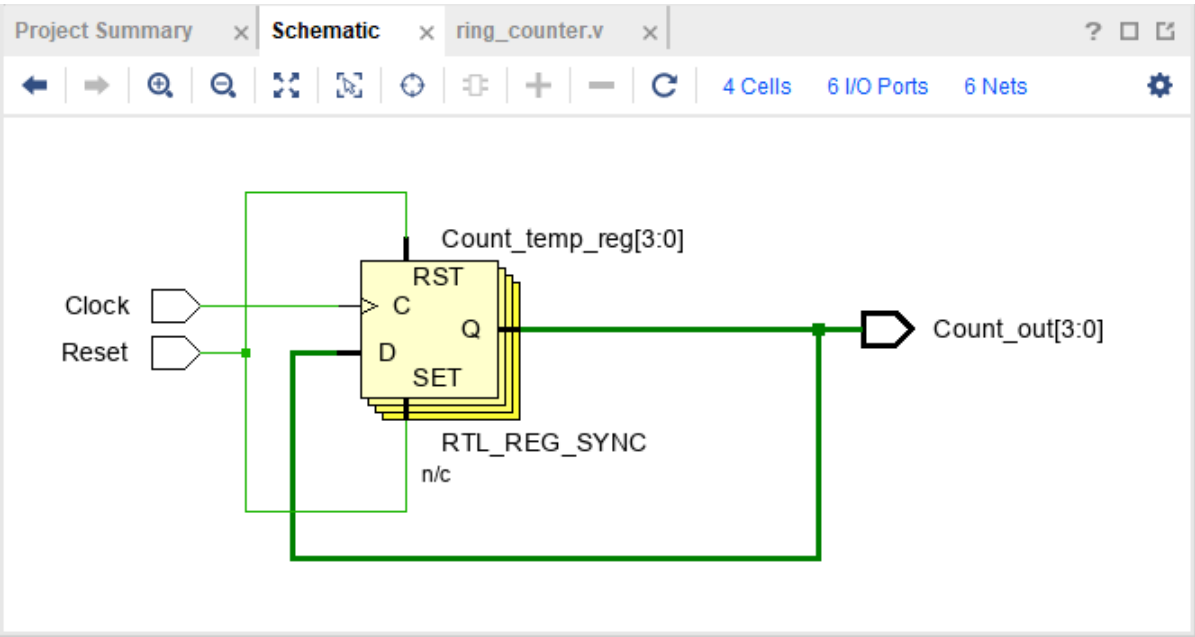
## TEST BENCH: -

```
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     |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

### On-Chip Power

| | | |
|---|---|---|
| Dynamic: | 0.986 W | (92%) |
| Signals: | 0.025 W | (3%) |
| Logic: | 0.007 W | (1%) |
| I/O: | 0.954 W | (96%) |
| Device Static: | 0.083 W | (8%) |

92%
96%
8%

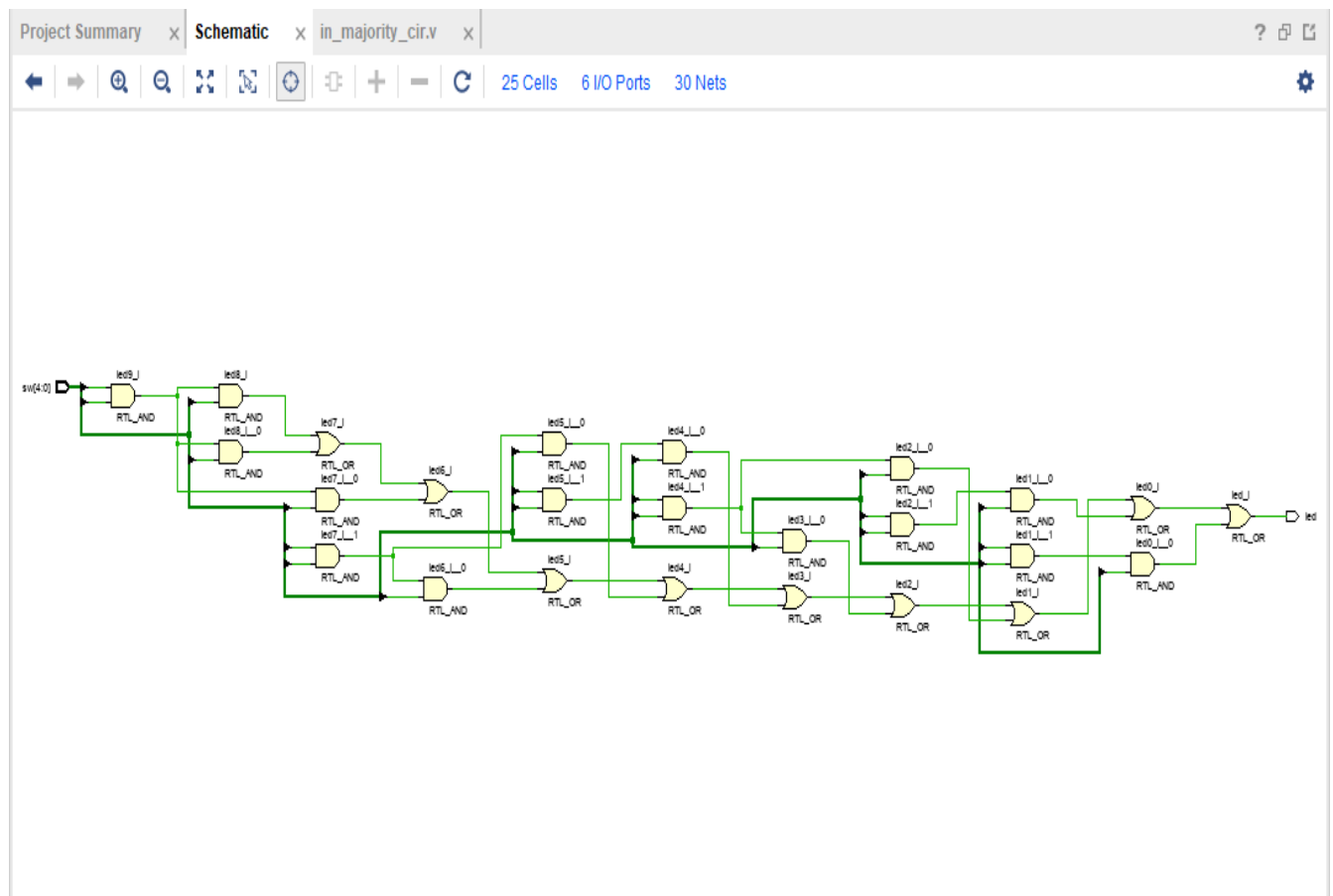## Q4. 5 INPUT MAJORITY CIRCUIT

## VERILOG CODE: -

```verilog
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:-

```verilog
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:-

← → ⊕ ⊖ ⤢ ◩ ◎ | ⬦ + − C | 25 Cells    6 I/O Ports    30 Nets                        ⚙

# 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

**On-Chip Power**

| Dynamic: | 0.396 W | (83%) |
|---|---|---|
| Signals: | 0.018 W | (4%) |
| Logic: | 0.004 W | (1%) |
| I/O: | 0.375 W | (95%) |
| Device Static: | 0.082 W | (17%) |

83%

17%

95%

# Q5.PARITY GENERATOR

## VERILOG CODE:-

```
parity_generator.v                                                    ? □ ⌐ X

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
```
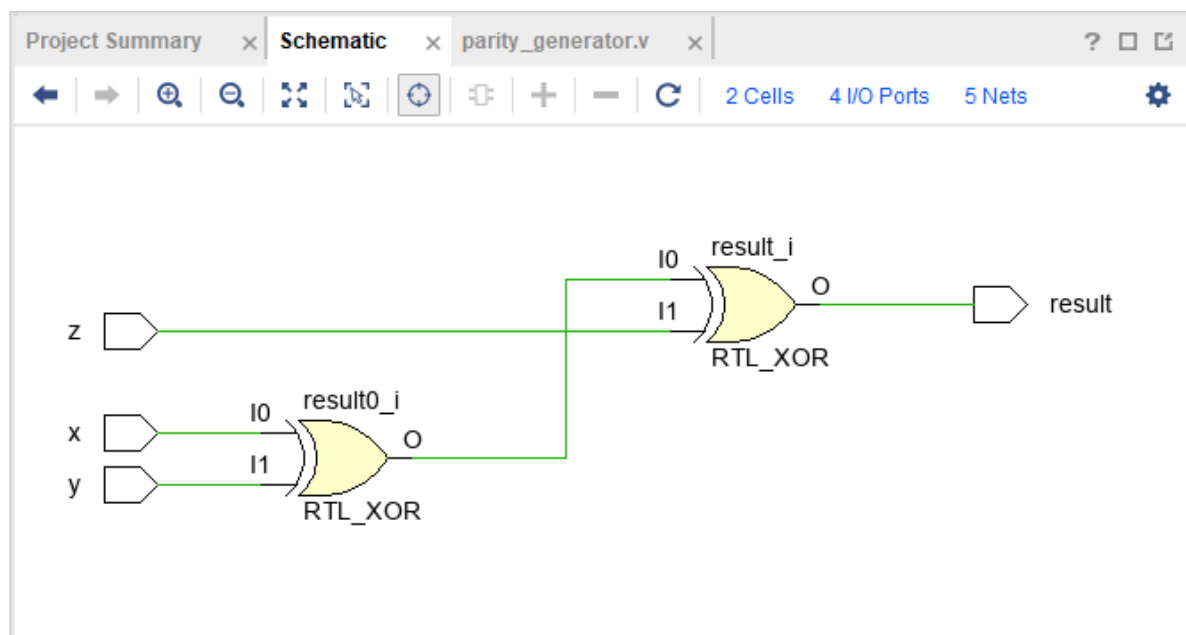
# RTL SCHEMATIC:-

# 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

### On-Chip Power

| | | |
|---|---|---|
| Dynamic: | 0.578 W | (88%) |
| Signals: | 0.014 W | (2%) |
| Logic: | 0.003 W | (1%) |
| I/O: | 0.561 W | (97%) |
| Device Static: | 0.082 W | (12%) |

88%
97%
12%

# Q6. BINARY TO ONE HOT ENCODER

## VERILOG CODE:-

```verilog
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:-

```verilog
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
```
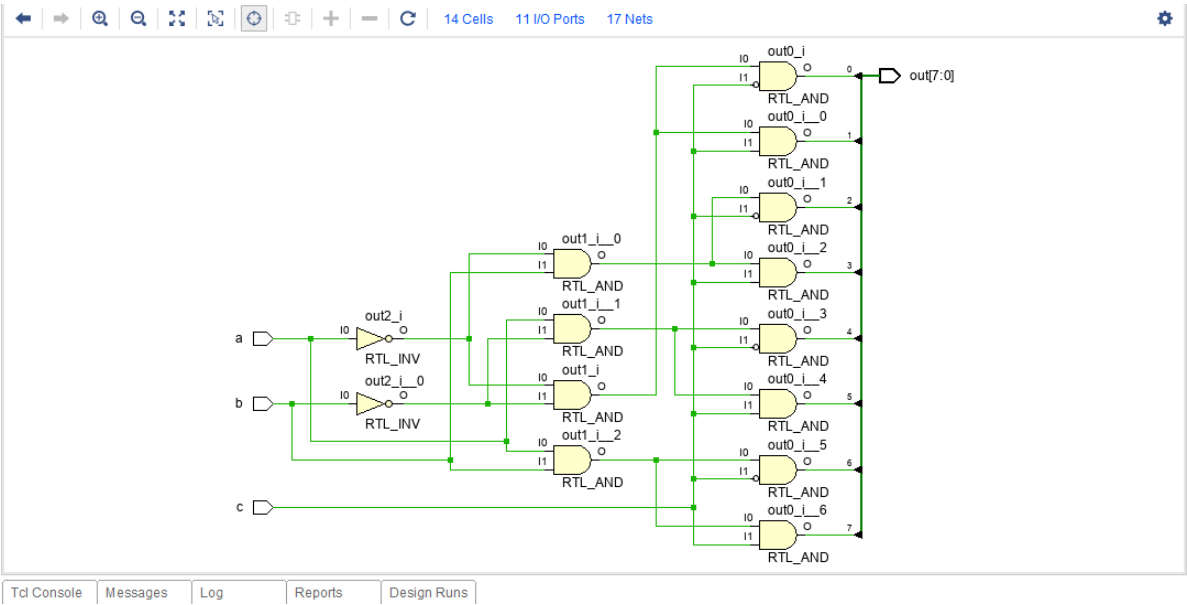
# RTL SCHEMATIC:-



# 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**

| | | |
|---|---|---|
| Dynamic: | 1.309 W | (94%) |
| Signals: | 0.028 W | (2%) |
| Logic: | 0.015 W | (1%) |
| I/O: | 1.266 W | (97%) |
| Device Static: | 0.084 W | (6%) |

94%
97%
6%

# Q7. 4-BIT BCD SYNCHRONOUS COUNTER

## VERILOG CODE:-

```
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:-
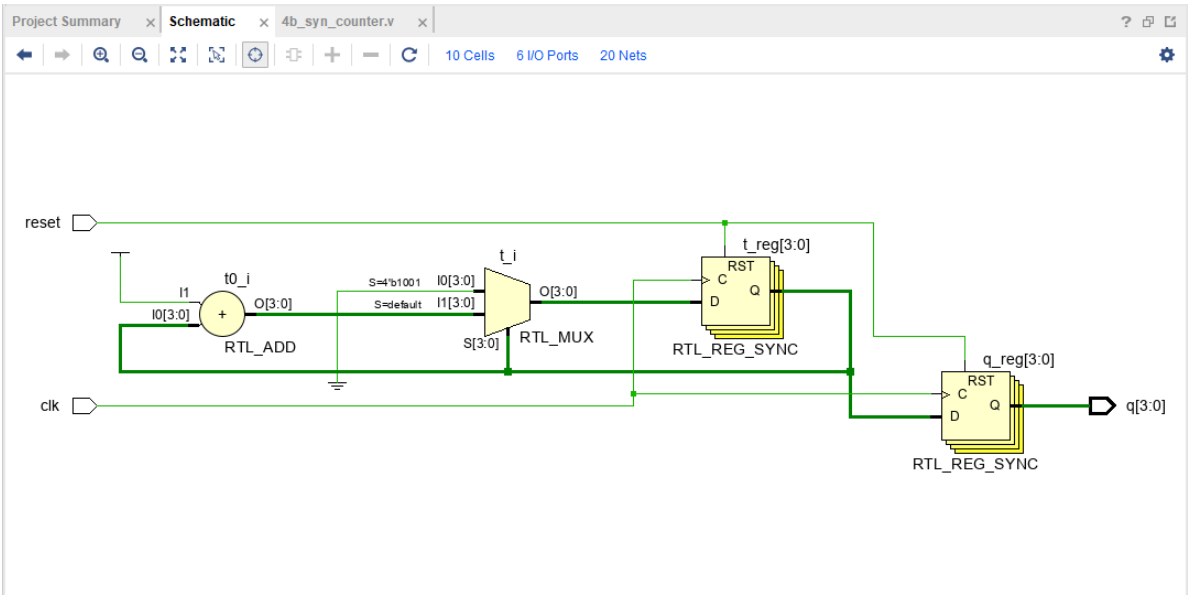


# SYNTHESIS REPORT:-

```
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

**On-Chip Power**

| | | |
|---|---|---|
| Dynamic: | 3.521 W | (98%) |
| Signals: | 0.079 W | (2%) |
| Logic: | 0.049 W | (1%) |
| I/O: | 3.393 W | (97%) |
| Device Static: | 0.089 W | (2%) |

98%

97%
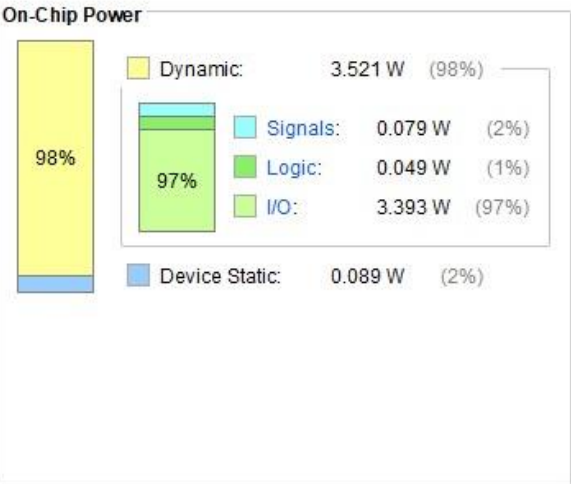
# Q8. 4-BIT CARRY LOOKAHEAD ADDER

## VERILOG CODE:-

```
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&g0)|(p1&p0&cin),
38    c3=g2|(p2&g1)|(p2&p1&g0)|(p2&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 |
+-+--------------+----------+
+-+--------------+----------+

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

**On-Chip Power**

97%

96%

| Dynamic: | 2.916 W | (97%) |
|---|---|---|
| Signals: | 0.085 W | (3%) |
| Logic: | 0.037 W | (1%) |
| I/O: | 2.794 W | (96%) |
| Device Static: | 0.087 W | (3%) |

# Q9.N-BIT COMPARATOR

## VERILOG  CODE:-

```verilog
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:-

```verilog
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;
```

```verilog
        $display ("PASSED!");
        $finish;
    end
endmodule
```
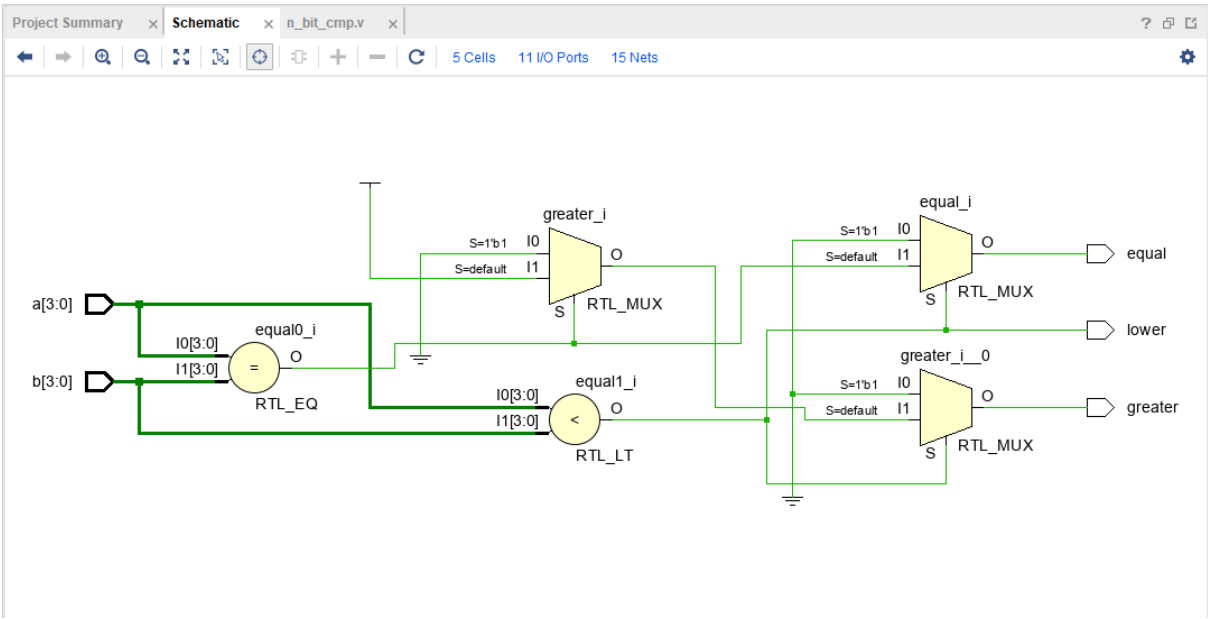
# RTL SCHEMATIC:-



# 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
-------------------------------------------------------------------------------
```
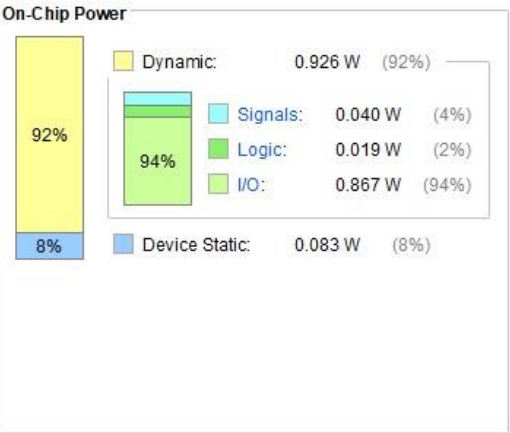
# POWER REPORT:-

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

**On-Chip Power**

| | | | |
|---|---|---|---|
| | Dynamic: | 0.926 W | (92%) |
| | Signals: | 0.040 W | (4%) |
| | Logic: | 0.019 W | (2%) |
| | I/O: | 0.867 W | (94%) |
| | Device Static: | 0.083 W | (8%) |

92%

94%

8%

## 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:-

```verilog
// 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
```
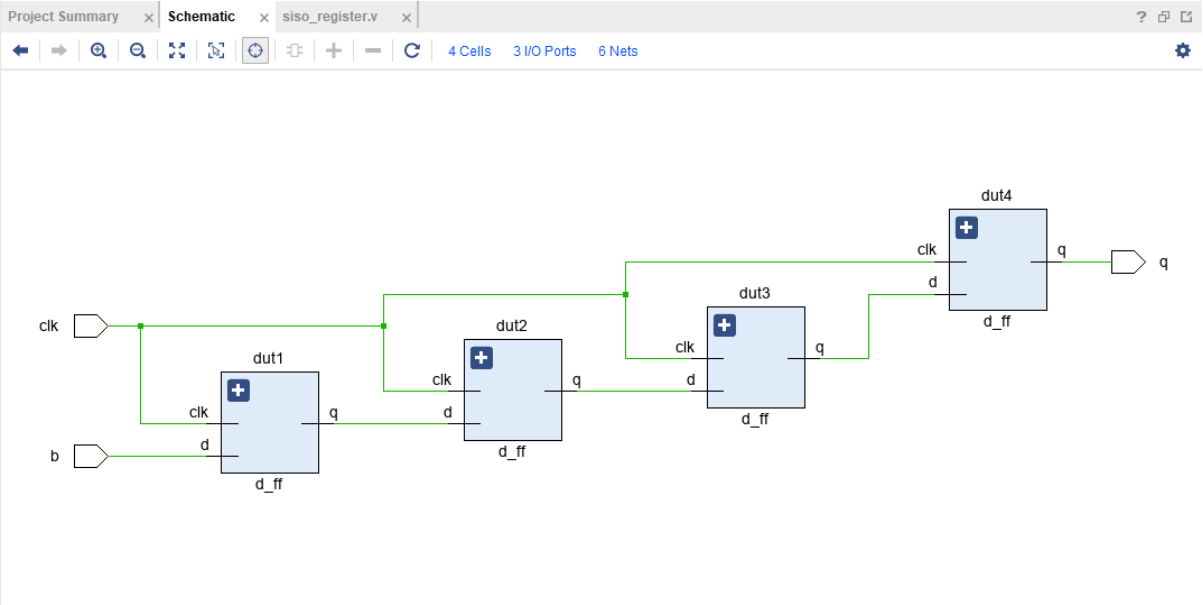
# RTL SCHEMATIC:-

← → ⊕ ⊖ ⤢ ⬚ ⊙ ⊟ ＋ － C   4 Cells   3 I/O Ports   6 Nets                    ⚙

# 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
--------------------------------------------------------------------------------
```
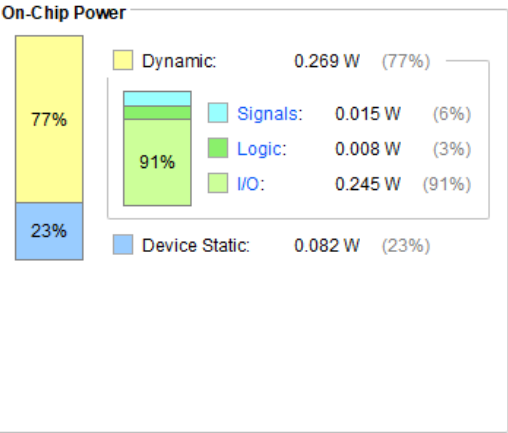
# POWER REPORT:-

**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**

| | | |
|---|---|---|
| Dynamic: | 0.269 W | (77%) |
| Signals: | 0.015 W | (6%) |
| Logic: | 0.008 W | (3%) |
| I/O: | 0.245 W | (91%) |
| Device Static: | 0.082 W | (23%) |

77%
23%
91%

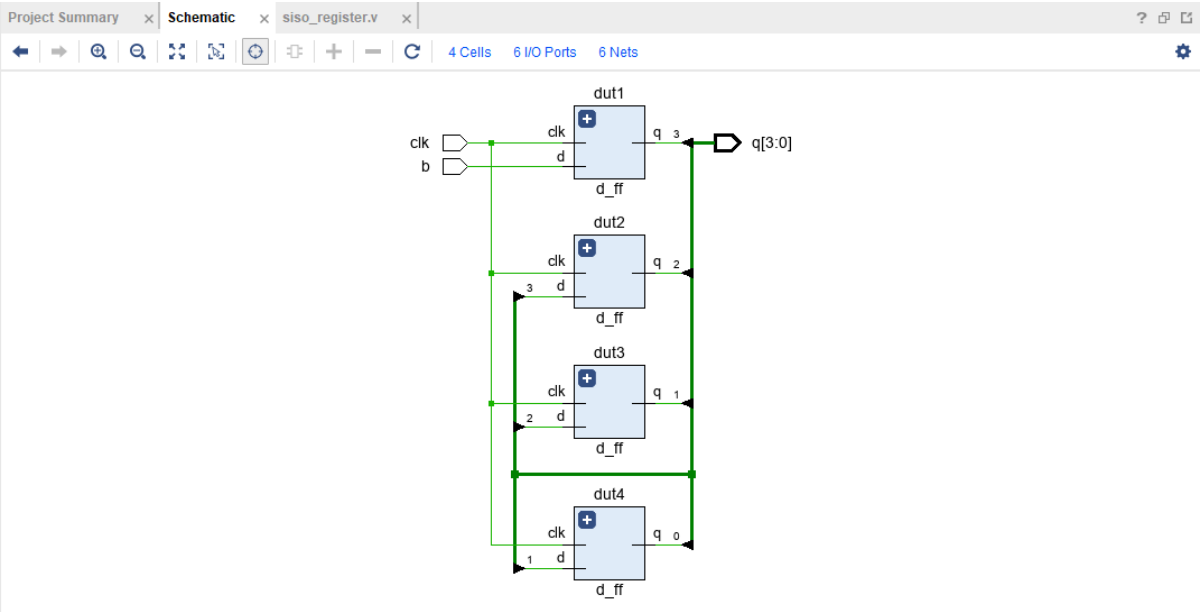# Q11. SERIAL IN PARALLEL OUT SHIFT REGISTER

## VERILOG CODE:-

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

```verilog
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:-

```verilog
// 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 $\vartheta$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**

| | | | |
|---|---|---|---|
| Dynamic: | 0.996 W | (92%) | |
| Signals: | 0.030 W | (3%) | |
| Logic: | 0.008 W | (1%) | |
| I/O: | 0.958 W | (96%) | |
| Device Static: | 0.083 W | (8%) | |

92%

96%

8%

# 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
```
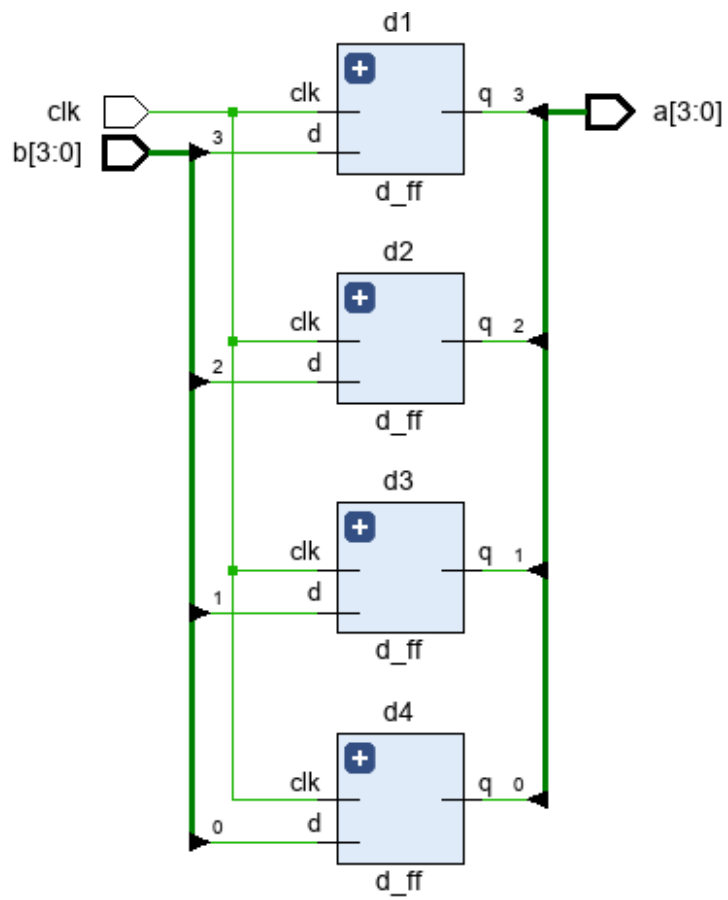
## TEST BENCH:-

```
// 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

**On-Chip Power**

| | | |
|---|---|---|
| Dynamic: | 1.009 W | (92%) |
| Signals: | 0.032 W | (3%) |
| Logic: | 0.007 W | (1%) |
| I/O: | 0.970 W | (96%) |
| Device Static: | 0.083 W | (8%) |

92%
96%
8%

# Q13. PARALLEL IN SERIAL OUT REGISTER

## VERILOG CODE:-

```verilog
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:-

```verilog
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
```
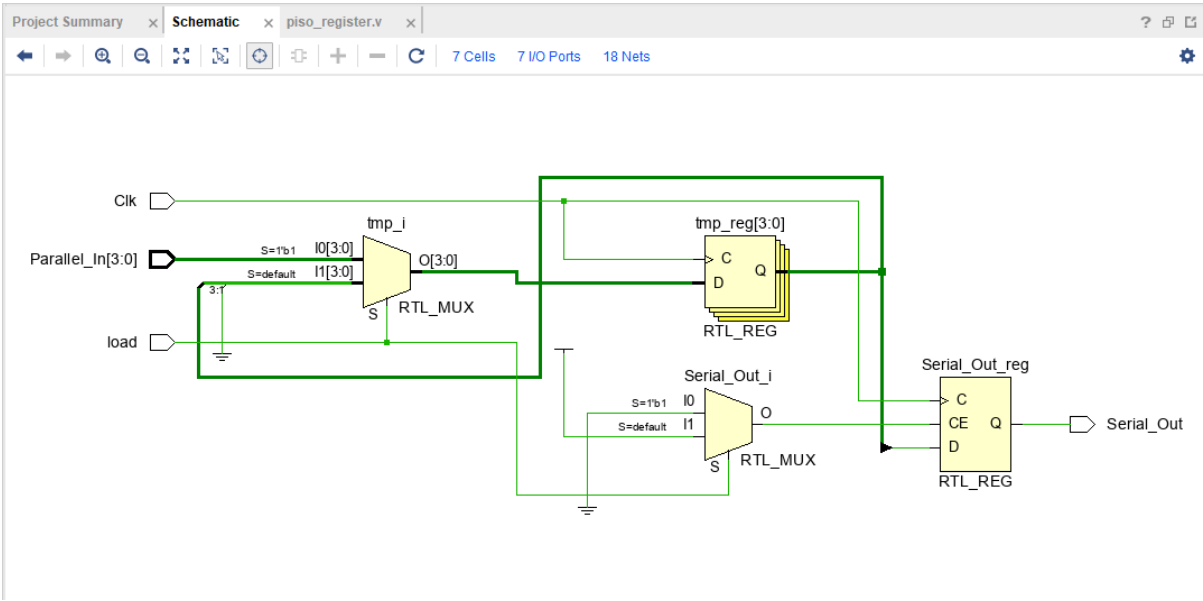
# RTL SCHEMATIC:-



# 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

**On-Chip Power**

| | | | |
|---|---|---|---|
| Dynamic: | 0.092 W | (53%) | |
| 53% | Signals: | 0.021 W | (23%) |
| | Logic: | 0.009 W | (10%) |
| 47% | I/O: | 0.062 W | (67%) |
| Device Static: | 0.081 W | (47%) | |

23%
10%
67%
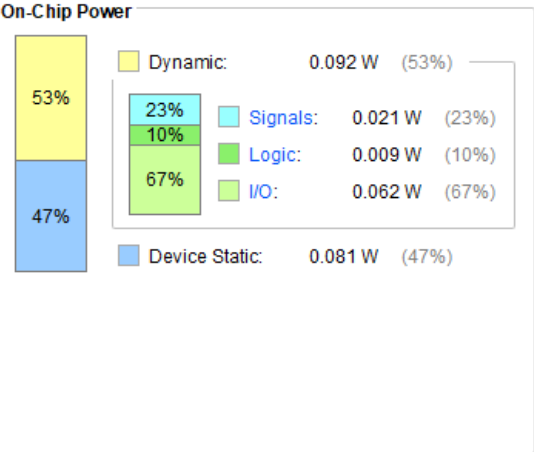
# Q14. BIDIRECTION SHIFT REGISTER

## VERILOG CODE:-

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

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

## TEST BENCH:-

```verilog
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
```
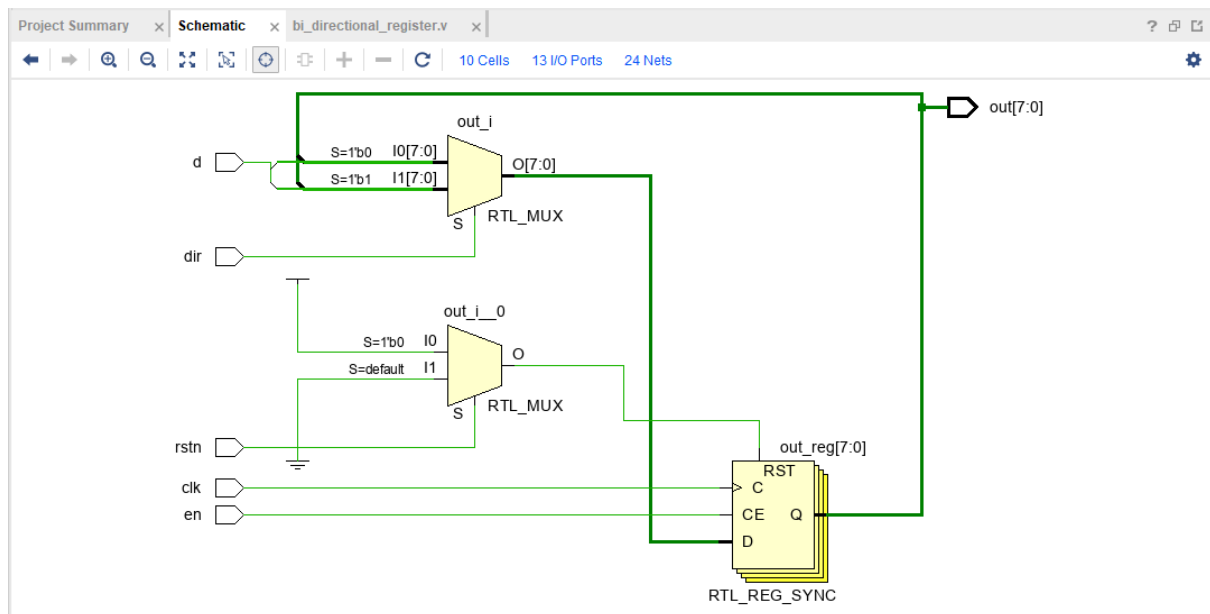
# RTL SCHEMATIC:-



# 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

**On-Chip Power**

| | | |
|---|---|---|
| Dynamic: | 5.431 W | (98%) |
| Signals: | 0.100 W | (2%) |
| Logic: | 0.058 W | (1%) |
| I/O: | 5.273 W | (97%) |
| Device Static: | 0.094 W | (2%) |

98%

97%

# Q15. PRBS SEQUENCE GENERATOR

## VERILOG CODE:-

```verilog
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:-

```verilog
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
```
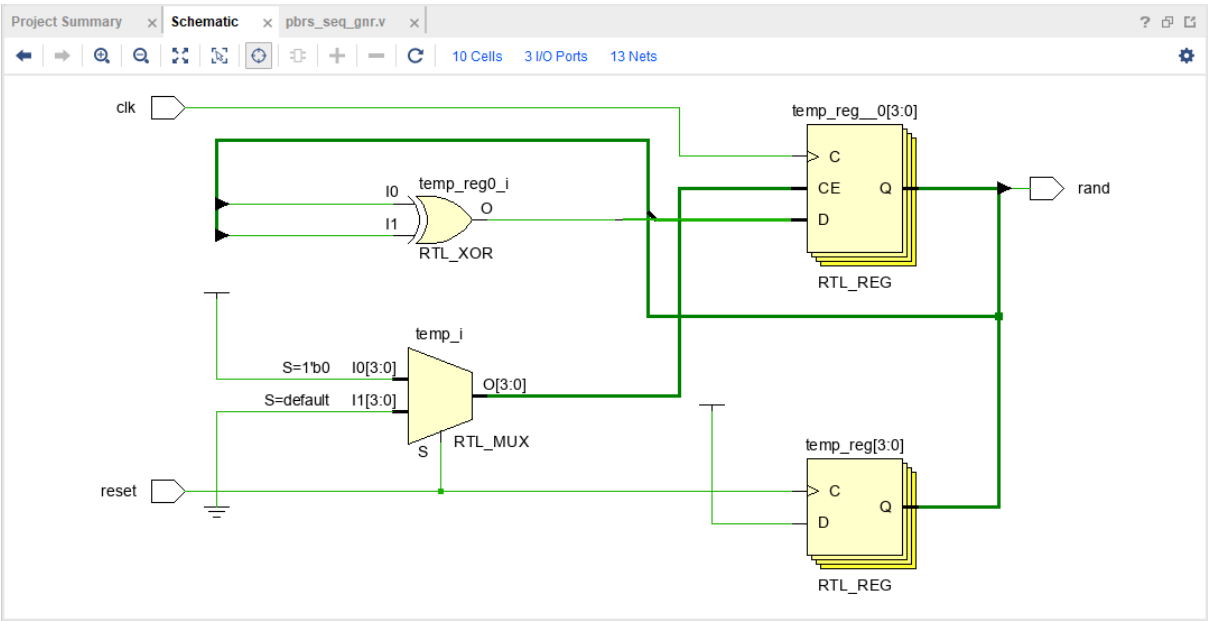
# RTL SCHEMATIC:-



# 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

**On-Chip Power**

| | | | | |
|---|---|---|---|---|
| 18% | Dynamic: | 0.018 W | (18%) | |
| 24% | Signals: | 0.004 W | (24%) | |
| 35% | Logic: | 0.007 W | (35%) | |
| 41% | I/O: | 0.008 W | (41%) | |
| 82% | Device Static: | 0.081 W | (82%) | |

# Q16 & 17. 8-BIT ADDER/SUBTRACTOR

## VERILOG CODE:-

```verilog
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:-

```verilog
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
```
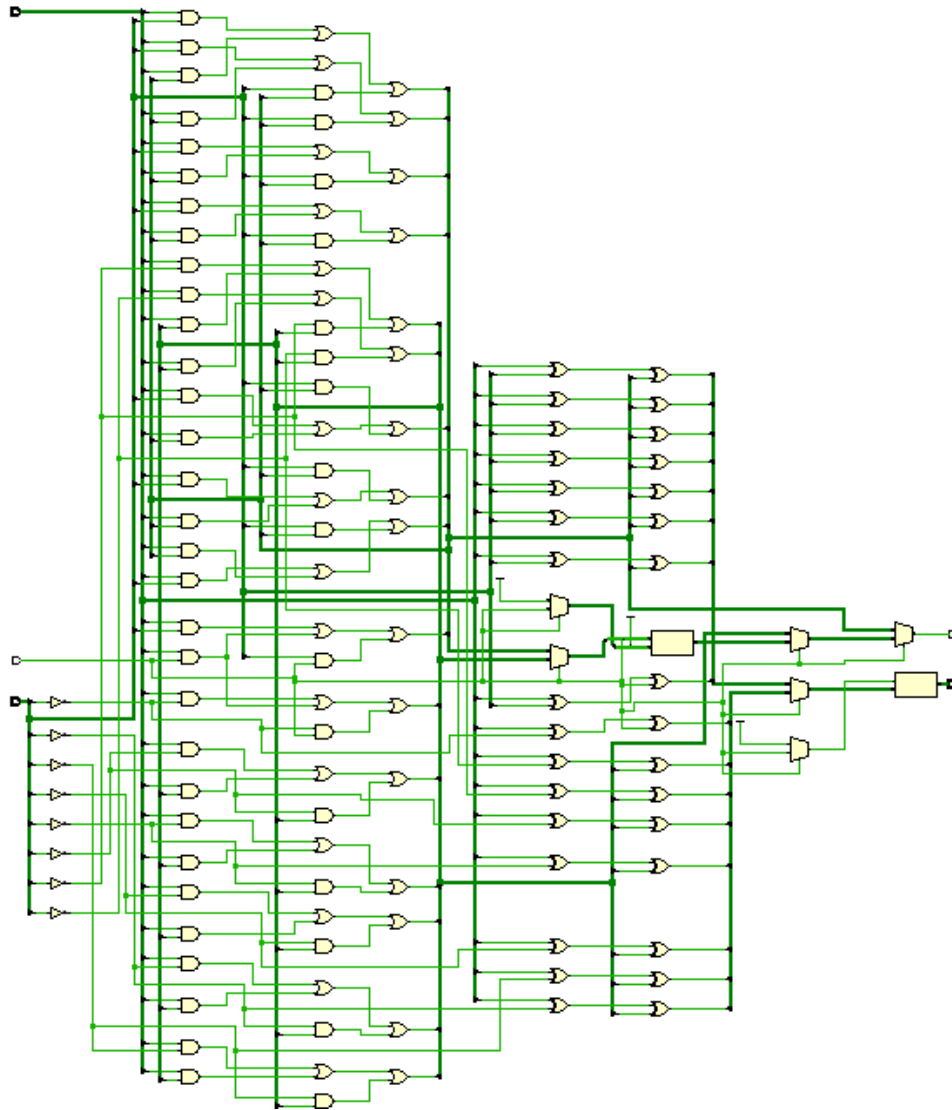
RTL SCHEMATIC:-

# 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
---------------------------------------------------------------------
```
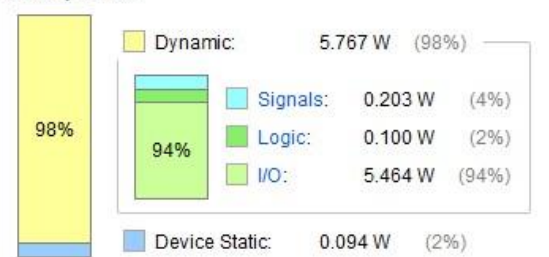
# POWER REPORT:-

## 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

**On-Chip Power**

| | | |
|---|---|---|
| Dynamic: | 5.767 W | (98%) |
| Signals: | 0.203 W | (4%) |
| Logic: | 0.100 W | (2%) |
| I/O: | 5.464 W | (94%) |
| Device Static: | 0.094 W | (2%) |

98%
94%

# Q18. 4-BIT MULTIPLIER

## VERILOG CODE:-

```verilog
`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:-

```verilog
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
```
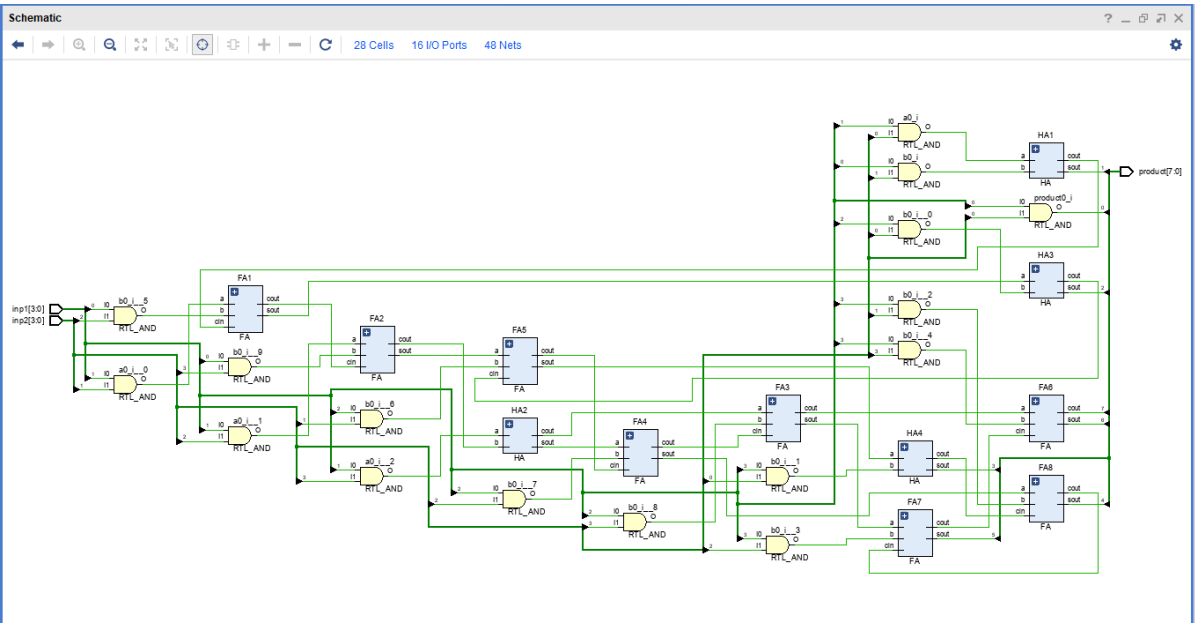
# RTL SCHEMATIC:-



# 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
-------------------------------------------------------------------------------
```
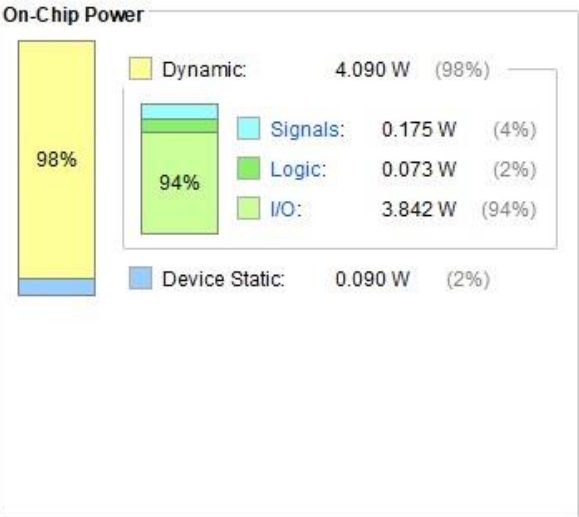
# POWER REPORT:-

## 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

**On-Chip Power**

| | | | |
|---|---|---|---|
| Dynamic: | 4.090 W | (98%) | |
| Signals: | 0.175 W | (4%) | |
| Logic: | 0.073 W | (2%) | |
| I/O: | 3.842 W | (94%) | |
| Device Static: | 0.090 W | (2%) | |

98%

94%

# Q19. FIXED POINT DIVISION

## VERILOG CODE:-

```verilog
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-2+Q: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;
```

```verilog
    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;
```

```verilog
        // 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:-
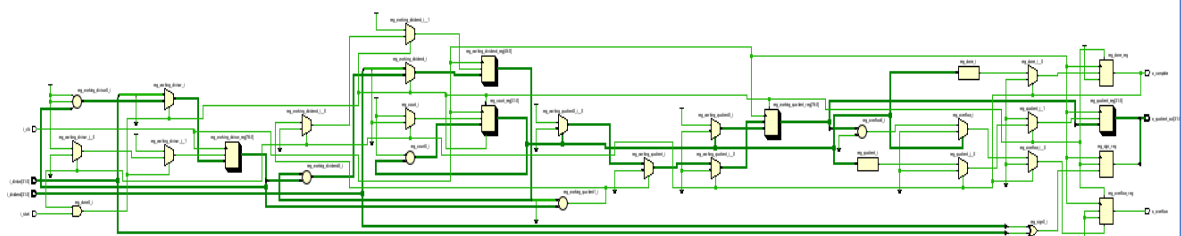
# SYNTHESIS REPORT:-

```
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

**On-Chip Power**

97%

| | | | |
|---|---|---|---|
| 35% | Signals: | 0.833 W | (35%) |
| 40% | Logic: | 0.958 W | (40%) |
| 25% | I/O: | 0.599 W | (25%) |

Dynamic: 2.389 W (97%)

Device Static: 0.086 W (3%)

# Q20. MASTER SLAVE JK FLIP FLOP

## VERILOG CODE:-

```verilog
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:-

```verilog
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
```
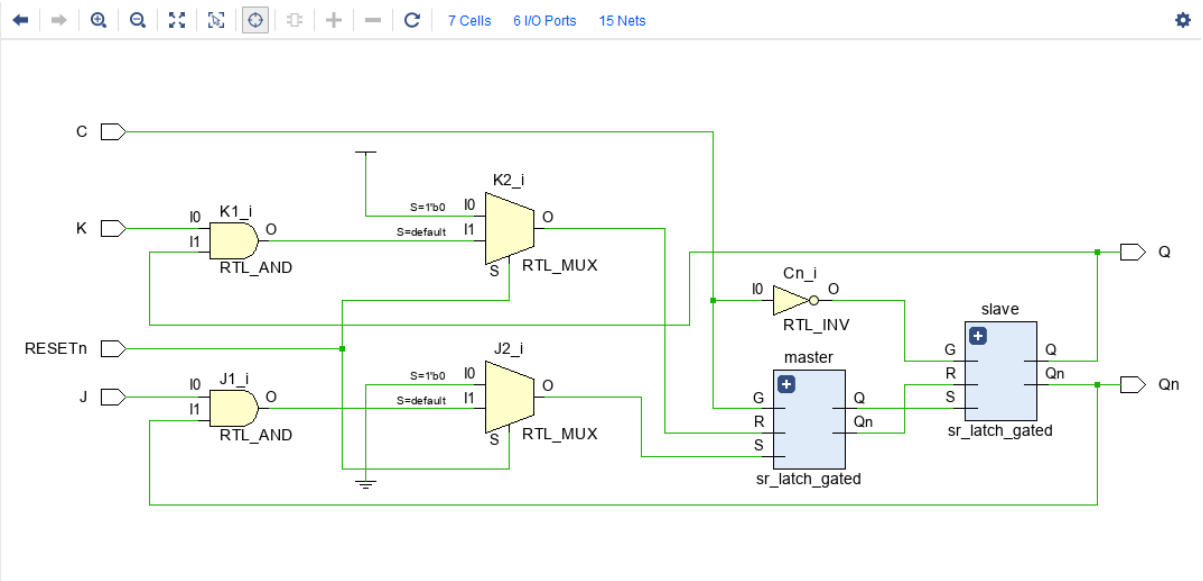
# RTL SCHEMATIC:-

# 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**

| | | | |
|---|---|---|---|
| Dynamic: | 1.329 W | (94%) | |
| ■ Signals: | 0.069 W | (5%) | |
| ■ Logic: | 0.030 W | (2%) | |
| ■ I/O: | 1.230 W | (93%) | |
| Device Static: | 0.084 W | (6%) | |

94%
93%
6%

## Q21. POSITIVE EDGE DETECTOR

## VERILOG CODE:-

```verilog
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:-

```verilog
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
```
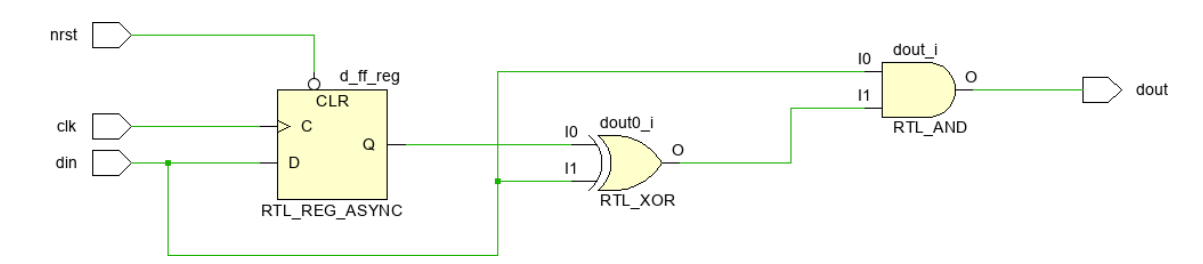
# RTL SCHEMATIC:-



# 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**

| | | |
|---|---|---|
| Dynamic: | 0.257 W | (76%) |
| Signals: | 0.013 W | (5%) |
| Logic: | 0.008 W | (3%) |
| I/O: | 0.237 W | (92%) |
| Device Static: | 0.082 W | (24%) |

76%
92%
24%

# Q22. BCD ADDER

## VERILOG CODE:-

```verilog
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:-

```verilog
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
```
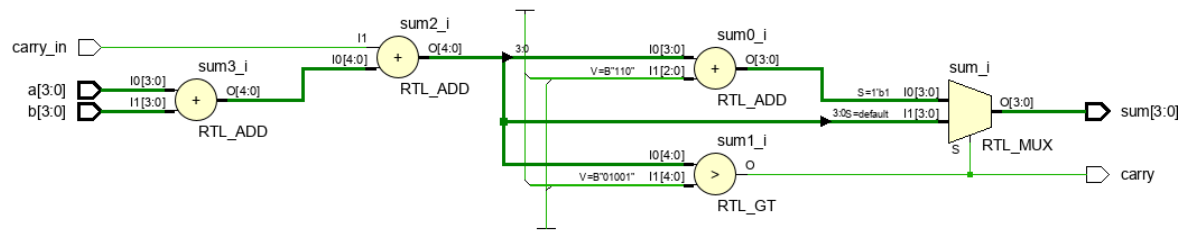
## RTL SCHEMATIC:-

# 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

**On-Chip Power**

| | | |
|---|---|---|
| Dynamic: | 3.187 W | (97%) |
| Signals: | 0.217 W | (7%) |
| Logic: | 0.038 W | (1%) |
| I/O: | 2.933 W | (92%) |
| Device Static: | 0.088 W | (3%) |

97%

92%

# Q23. 4-BIT CARRY SELECT ADDER

## VERILOG CODE:-

```verilog
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
```

```verilog
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:-

```verilog
) 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
```
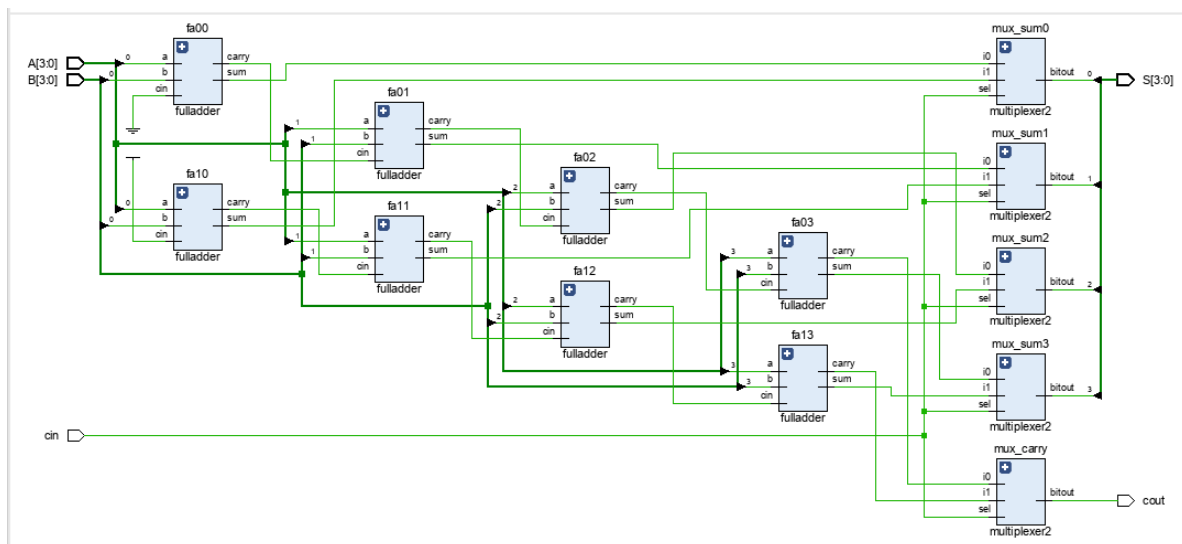
## RTL SCHEMATIC:-

# 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

**On-Chip Power**

| | | |
|---|---|---|
| Dynamic: | 2.970 W | (97%) |
| Signals: | 0.152 W | (5%) |
| Logic: | 0.024 W | (1%) |
| I/O: | 2.795 W | (94%) |
| Device Static: | 0.087 W | (3%) |

97% — 94%

## Q24. MOORE FSM 1010 SEQUENCE DETECTOR

## VERILOG CODE:-

```verilog
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
          end
```

```verilog
   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
```
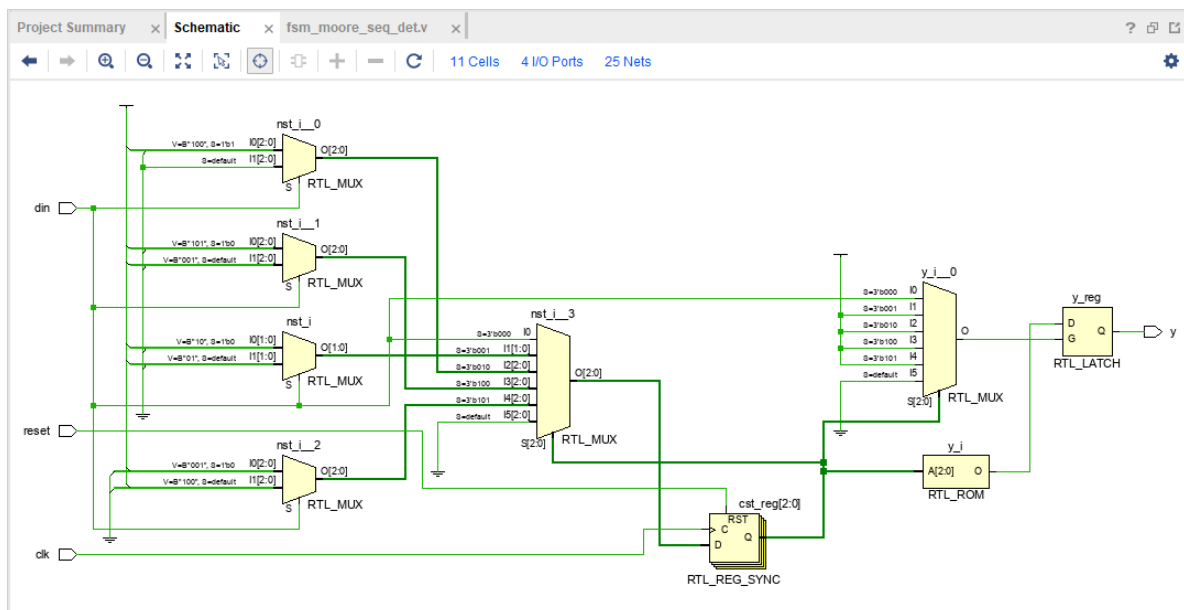
## TEST BENCH:-

```
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

**On-Chip Power**

| | | | |
|---|---|---|---|
| Dynamic: | 0.090 W | (53%) | |
| 53% | | | |
| | Signals: | 0.021 W | (23%) |
| | Logic: | 0.021 W | (23%) |
| | I/O: | 0.049 W | (54%) |
| 47% | | | |
| Device Static: | 0.081 W | (47%) | |

# Q25. N:1 MUX

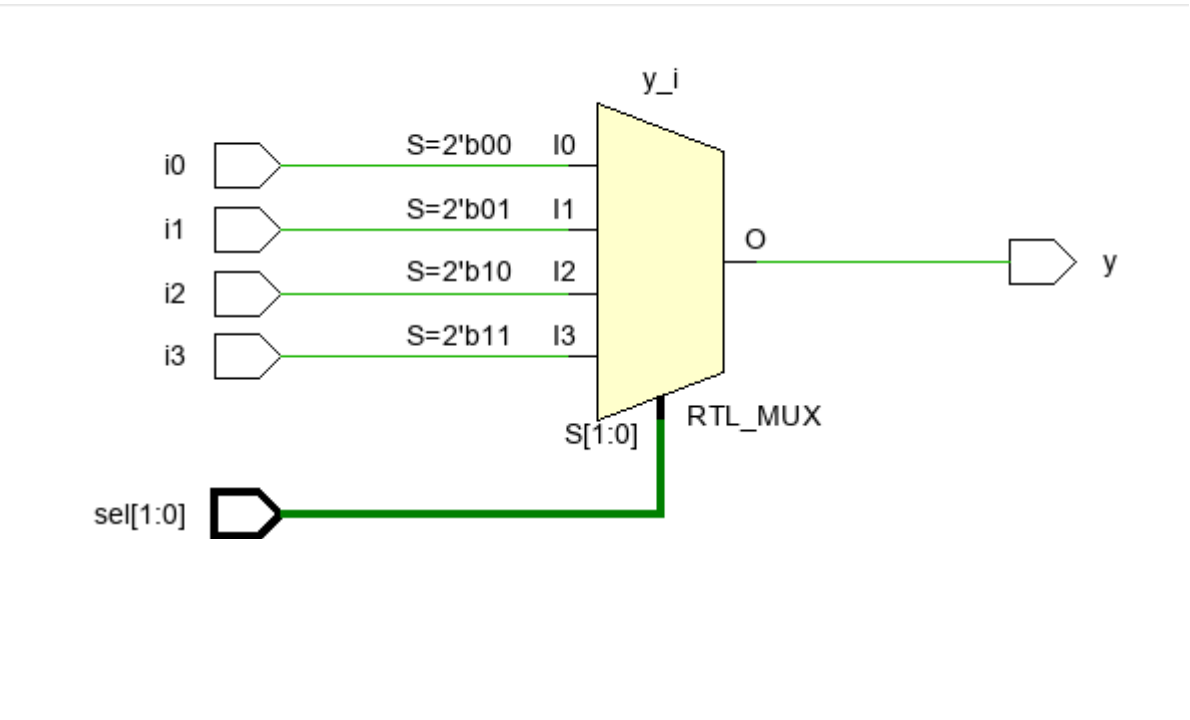## VERILOG CODE:-

```verilog
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:-

```verilog
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:-

```
                                    y_i
                    S=2'b00   I0  ┌──────┐
         i0  ───────────────────→ │      │
                    S=2'b01   I1  │      │
         i1  ───────────────────→ │      │  O
                    S=2'b10   I2  │      ├───────→  y
         i2  ───────────────────→ │      │
                    S=2'b11   I3  │      │
         i3  ───────────────────→ │      │
                                  └──┬───┘  RTL_MUX
                               S[1:0]│
                                     │
         sel[1:0] ────────────────────┘
```

# 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**

| | | |
|---|---|---|
| Dynamic: | 0.462 W | (85%) |
| Signals: | 0.012 W | (3%) |
| Logic: | 0.004 W | (1%) |
| I/O: | 0.446 W | (96%) |
| Device Static: | 0.082 W | (15%) |

85%

96%

15%