

# HLS-Assignment 9 PART-1

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VITIS-HLS

## 1 Problem Statement

Problem Statemt

## 2 Header File

```
//header.h
#ifndef _HEADER_H_
#define _HEADER_H_

#include <hls_stream.h>
#include "ap_int.h"
using namespace std;

#define N 8          //length of input message
#define y 25         //length of divisor (parity)
#define x N+y-1     //length of crc (len of input+divisor-1)

typedef ap_uint<N> data;

void crc24a(hls::stream<data>& input, hls::stream<data>& output, ap_uint<1> last)

#endif
```

### 3 CRC bits Generator Code

```
// crc.cpp
#include "header.h"

void crc24a(hls::stream<data>& input, hls::stream<data>& output, ap_uint<1> last)

#pragma HLS INTERFACE mode=axis register_mode=both port=input register
#pragma HLS INTERFACE mode=axis register_mode=both port=output register
#pragma HLS INTERFACE mode=ap_none port=last

    ap_uint<1> crc[x];
    ap_uint<1> divisor[y] = {1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 1, 0, 0,
1, 1, 1, 1, 0, 1, 1};

// Read input stream a
    data d = input.read();
    for (int j = 0; j < N; j++) {
#pragma HLS PIPELINE II=1
        crc[j] = d[j];
    }
// Add padding zeros to message
    for (int i = 8; i < x; i++) {
#pragma HLS PIPELINE II=1
        crc[i] = 0;
    }

// Division is performed only when last is high
    for (int i = 0; i <= x - y; i++) {
#pragma HLS PIPELINE II=1
        if (crc[i] == 1 && last == 1) {
            for (int j = 0; j < y; j++) {
#pragma HLS UNROLL
                crc[i + j] = crc[i+j] ^ divisor[j];
            }
        }
    }

// Find start index of nonzero bits in crc
    int startIdx = 0;
    while (startIdx < x && crc[startIdx] == 0) {
        startIdx++;
    }
```

```

// Store nonzero values into another array and minimum length will be length of
    ap_uint<1> temp[y-1];

    for (int i = 0; i < y-1; i++) {
#pragma HLS PIPELINE II=1
        temp[i] = (startIdx == x) ? crc[i] : crc[startIdx + i];
    }

// Write the result to output stream c
    data o1,o2,o3,o4;

    for (int i = 0; i < y-1; i++) {
#pragma HLS PIPELINE II=1
        if (i < N) {
            o1(i, i) = d(i, i);
            o2(i, i) = temp[i];
        } else if (i < N*2) {
            o3(i%N, i%N) = temp[i];
        } else {
            o4(i%N, i%N) = temp[i];
        }
    }

    output.write(o1);
    output.write(o2);
    output.write(o3);
    output.write(o4);
}

```

## 4 Test Bench Code

```
// crc_tb.cpp
#include "header.h"

int main() {
    hls::stream<data> a,b;
    data w, z;
    ap_uint<1> last;

    w=0b00010110;
    //msbtolsb

    /* ap_uint<1> dividend[8] = {0, 1, 1, 0, 1, 0, 0, 0};
    //lsbtomsb
        for (int i = 0; i < 8; i++) {

            w(i,i) = dividend[i];

        }

    */

    a.write(w);
    last=1;

    // Perform binary divison
    crc24a(a, b, last);

    // Read the result from the output stream out1
    cout << "CRC generator output : ";
    ap_uint<1> p[32];

    for (int i = 0; i < 4; i++) {
        z = b.read();
        for (int j = 0; j < 8; j++) {
            p[i * 8 + j] = z(j, j);
        }
    }

    for (int i = 0; i < 32; i++) {
        cout << p[i];
    }
```

```

        cout<<endl;

// Checking if output is valid or not
ap_uint<1> comp[32]; bool flag=0;
ap_uint<1> divisor[y] = {1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 1, 0, 0,
1, 1, 1, 1, 0, 1, 1};

//Output is valid only when remainder division of output with divisor is 0
for (int i = 0; i <= x - y; i++) {
    if (p[i] == 1) {
        for (int j = 0; j < y; j++) {
            p[i + j] = p[i+j] ^ divisor[j];
        }
    }
}
cout<<"CRC detector output : ";
for (int i = 0; i < 32; i++) {
    cout<<p[i];
    if (p[i]==1){
        flag=1;
    }
}
cout<<endl;
if ( flag==0) {
    cout << "!PASS!CRC Check at detector is Success" << std::endl;
}
else {
    cout << "!ERROR!CRC Check at detector has Failed" << std::endl;
}
return 0;
}

```

## 5 C simulation Output

```
INFO: [SIM 2] ***** CSIM start *****
INFO: [SIM 4] CSIM will launch GCC as the compiler.
    Compiling ../../../../codes/crc_tb.cpp in debug mode
    Compiling ../../../../codes/crc.cpp in debug mode
    Generating csim.exe
CRC generator output : 01101000101101001111001100000010
CRC detector output : 00000000000000000000000000000000
!PASS!CRC Check at detector is Success
INFO [HLS SIM]: The maximum depth reached by any hls::stream() instance in the
design is 4
INFO: [SIM 1] CSim done with 0 errors.
INFO: [SIM 3] ***** CSIM finish *****
```

## 6 HLS Resource Consumption Report

Utilization Estimates					
Summary					
Name	BRAM_18K	DSP	FF	LUT	URAM
DSP	-	-	-	-	-
Expression	-	-	0	8	-
FIFO	-	-	-	-	-
Instance	-	-	121	1415	-
Memory	0	-	1	1	0
Multiplexer	-	-	-	146	-
Register	-	-	69	-	-
Total	0	0	191	1570	0
Available	624	1728	460800	230400	96
Utilization (%)	0	0	~0	~0	0

Figure 1: Resource Consumption

## 7 HLS Timing and Fmax Report

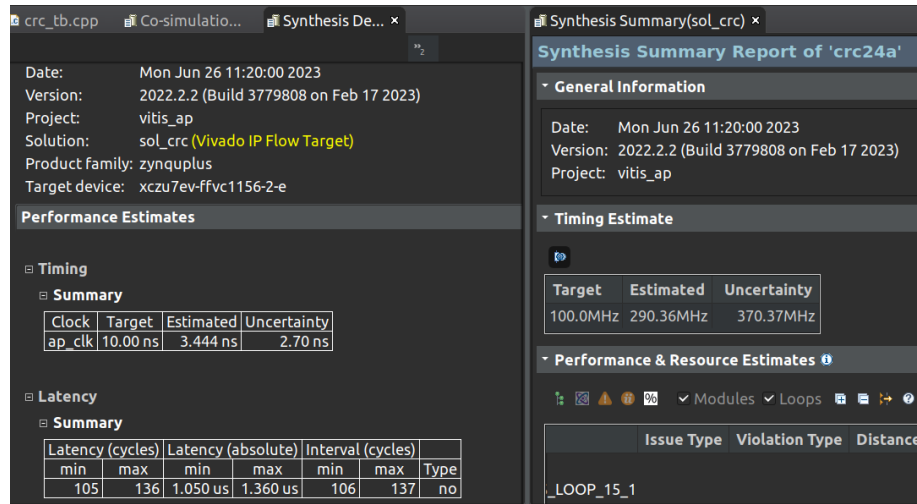


Figure 2: Timing and Fmax



## 8 CoSimulation Report

Cosimulation Report for 'crc24a'

General Information

Date: Mon Jun 26 11:21:04 AM IST 2023

Version: 2022.2.2 (Build 3779808 on Feb 17 2023)

Project: vitis\_ap

Status: Pass

Solution: sol\_crc (Vivado IP Flow Target)

Product family: zynqplus

Target device: xczu7ev-ffvc1156-2-e

Cosim Options

Tool: Vivado XSIM

RTL: Verilog

Performance Estimates

Modules & Loops	Avg II	Max II	Min II	Avg Latency	Max Latency	Min Latency
▼ crc24a				103	103	103
> crc24a_Pipeline_VITIS_LOOP_15_1			8	8	8	8
> crc24a_Pipeline_VITIS_LOOP_20_2			24	24	24	24
> crc24a_Pipeline_VITIS_LOOP_27_3			8	8	8	8
> crc24a_Pipeline_VITIS_LOOP_39_5			8	8	8	8
> crc24a_Pipeline_VITIS_LOOP_46_6			24	24	24	24
> crc24a_Pipeline_VITIS_LOOP_54_7			24	24	24	24

Figure 3: Cosimulation

## 9 Block Design

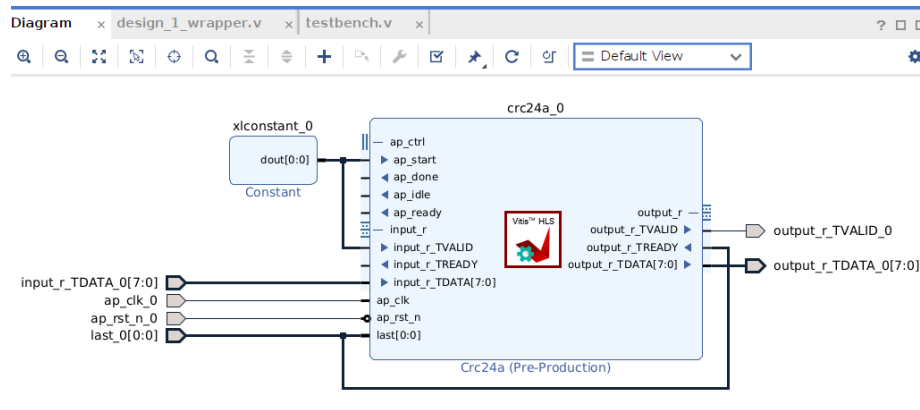


Figure 4: Block Diagram

## 10 Verilog Testbench

```
//testbench.v
`timescale 1ns / 1ps
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
// Company:
// Engineer:
//
// Create Date: 06/26/2023 11:35:30 AM
// Design Name:
// Module Name: testbench
// Project Name:
// Target Devices:
```

```

// Tool Versions:
// Description:
//
// Dependencies:
//
// Revision:
// Revision 0.01 -- File Created
// Additional Comments:
//
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////

module testbench();
    reg ap_clk_0;
    reg ap_rst_n_0;
    always #5 ap_clk_0=~ap_clk_0;

    reg [7:0] ip;
    reg last_0;
    wire [7:0] op;
    wire output_r_TVALID_0;

    initial begin
        ap_clk_0=0;ap_rst_n_0=0;
        #10
        ap_rst_n_0=1;
        #10
        ip=16'b00010110;// ascii "h"

        #1 last_0=1;
        #2000
        $finish;
    end

    design_1_wrapper
    uut(.ap_clk_0(ap_clk_0), .ap_rst_n_0(ap_rst_n_0),.input_r_TDATA_0(ip),
        .last_0(last_0),.output_r_TDATA_0(op),.output_r_TVALID_0(output_r_TVALID_0)

endmodule

```

## 11 Output Waveform

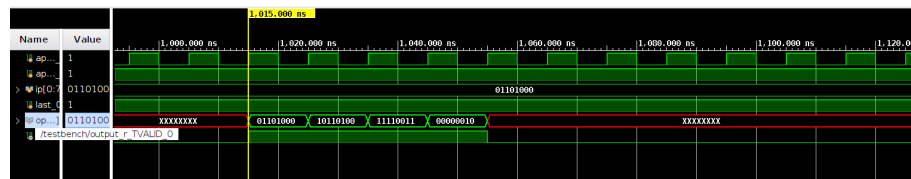


Figure 5: Output Waveform

## 12 Matlab Reference



```

1 % divisor polynomial
2 Polynomial = 2^24 + 2^23 + 2^18 + 2^17 + 2^14 + 2^11 + 2^10 + 2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2 + 1;
3
4 %built function for CRC from sg toolbox
5 crc24a = comm.CRCGenerator(Polynomial);
6
7 %input message
8 x = [0 1 1 0 1 0 0 0]';
9
10 %expected output
11 expectedcrc = [0 1 1 0 1 0 0 0 1 0 1 1 0 1 0 0 1 1 1 0 0 1 1 0 0 0 0 0 1 0]';
12 len = length(expectedcrc);
13
14 %actual output
15 crc = crc24a(x);
16 actualcrc = crc(end-len+1:end);
17
18 %checking whether actual output and expected output are same
19 isequal(actualcrc, expectedcrc)
20 %displaying actual output
21 disp(actualcrc)

```

Command Window

```

>> crcgenerator
ans =
    logical
     1
Columns 1 through 30
 0     1     1     0     0     0     1     0     1     1     0     1     0     0     1     1     1     1     0     0     0     0     0     0     0     0     0     0
Columns 31 through 32
 1     0
>>

```

Figure 6: Matlab Reference

## 13 Conclusion

The Output of HLS\_IP is matching with Output of reference Matlab code and also using this floating Point Converter Online :

<https://www.h-schmidt.net/FloatConverter/IEEE754.html>

GITHUB : <https://github.com/dk-425/Training.git>