

Embedded Systems (CSCE 313)

Project 5

Project Objective

In this project, we will cover two important tasks:

1. Execution image rotation on FPGA
2. Measurement of system performance

Rotation Requirements

- a. Use the platform designer from Project 4, but remove only the mode component.
- b. Use same test.v
- c. Remove the display and resize code from your application and include the rotation code which is provided in presentation in lecture 8.
- d. Rotate the image four times angles (0, 90, 180 and 270 degrees).

Performance Requirements

- a. In the platform designer, add **the interval timer and set its period to 100 and units to μ s**, and keep any other settings as default. Connect the component with the processor and clock sources as you connected the JTAG UART (including the interrupt IRQ signal).
- b. **Set the priority of the timer component as 0 and the priority of the JTAG UART as 16** as explained in the lecture.
- c. Add the **system ID peripheral** and keep its features as default. Connect the component to the processor and the clock sources as you connect the JTAG UART.
- d. Then, re-generate the system, recompile quartus project, and configure the board.
- e. Open the application project in eclipse. Right-click on the BSP directory, go to Nios II and select Nios II editor. Set the following features, then regenerate the BSP.

ys_clk_timer	Timestamp_timer	stdin	stdout	stderr
Timer_0	none	jtag	jtag	jtag

- f. In the application directory, open the main (or hello_world.c) program. Add the following header.

```
#include <sys/alt_alarm.h>
```

- g. Measure the time (number of ticks) required to execute the frame time. To do that you will need to use the code below.

```
int ticks_per_second, ticks_start, ticks_end, frame_ticks;
unsigned long long duration;
```

```
ticks_per_second = alt_ticks_per_second();
```

```
ticks_start = alt_ticks();
```

```
frame_function();
```

```
ticks_end = alt_ticks();
```

```
frame_ticks = ticks_end - ticks_start;
```

```
duration = (unsigned long long) ticks_total / (unsigned long long) ticks_per_second;
printf("Total duration %llu seconds \n\n", duration);
```

CPI-Calculation Requirements

- In the platform designer, **remove the timer component** and **add the performance counter**. Keep its features as default. Connect to the counter, as you connected the JTAG UART.
- Re-generate the system, recompile quartus project, and configure the board.
- Open the application project in eclipse. Right-click on the BSP directory, go to Nios II and select Nios II editor. Reset features, then regenerate the BSP.

Sys_clk_timer	Timestamp_timer	stdin	stdout	stderr
none	none	jtag	jtag	jtag

- In the application directory, open the main (or hello_world.c) program. Add the header.

```
#include <altera_avalon_performance_counter.h>
```
- Don't forget to remove `#include <sys/alt_alarm.h>` from your code.
- Measure the cycles required to execute the pixel code by using the following code. Also, use example_cycles posted in Module 5 as your reference.

```
unsigned long long start_cycles, end_cycles, total_cycles;
start_cycles = perf_get_total_time((void*) PERFORMANCE_COUNTER_0_BASE);
PERF_START_MEASURING(PERFORMANCE_COUNTER_0_BASE);
pixel_code();
```

```

end_cycles=perf_get_total_time ((void*) PERFORMANCE_COUNTER_0_BASE);
PERF_START_MEASURING(PERFORMANCE_COUNTER_0_BASE);
total_cycles = end_cycles - start_cycles;

printf("Estimate performance cycle = %llu \n", total_cycles);

```

Project Report (80%)

The project report will be graded out of 100, and the points will be distributed as following:

1. Your report should be written as a technical report. Please follow the following template:

1. **Presentation** (2.5 points)

- Script: The report must be printed single sided on white A4 paper.
- Margins: All margins must be at least 2.54cm
- Page numbers: Number all pages consecutively starting at 1

2. **Structure** (2.5 points):

- Start by writing the following in the top-middle first page of the report.

- Author (s)
- Title of the project
- Course
- Department
- University

- Summary** (5 points): brief description about the main objective of the project and outcomes.

3. **Discussion:** Answer the following questions:

- (10 points) what is the reason for calculating shift_row and shift_column in the rotation code?
- (10 points) You are given the image below. Find the new image after resizing (double) the given image by 2 (row and columns) based on finding the median approach.

150	120	120
200	250	260
210	210	210

- (10 points) Explain the main reason for using the performance counter in the project.
- (10 points) What is the difference between the timer component and the performance counter component?

4. Results (60 points)

- a. (5 points) After you compile and synthesize your system, read the summary report from Quartus, and fill out the below table with the numbers from the report.

<i>Logical Elements</i>	<i>Registers</i>	<i>Total Pins</i>	<i>Memory Bits</i>

- b. (5 points) Briefly compare the hardware results between the table above and Table.1 of project 4.
- c. (10 points) Run the application project on angles (0°, 45°, 90°). Then, add a picture of the monitor for each rotation.
- d. (10 points) Find the frame rate in seconds using the given equation:

$$\text{frame rate} = \frac{\text{number of frames}}{\text{frametime}}$$

- e. (10 points) Find the estimated number of cycles required to execute pixel code. The code will print the number of cycles in each pixel, you may select only one of them.
- f. (10 points) Find the number of instructions required to execute the pixel code by using the gdb.
- g. (10 points) Use the results that you got in d, e and f to find the total execution time.

Project demo (20%)

1. The main purpose of the demo is to test your project functionality and execution.
2. Demos will be checked and graded by the TA.
3. Demos will be graded out of 20. Below are how the demo points will be distributed.
4. Demos will be conducted during the lab time on the deadline day or before.
5. Both partners must show up on that day. If a member didn't show up, he/she receives 0 unless an excused absence was provided.

Tasks	Point
Rotation (0,90,180,270)	/5
Frame time	/5
Performance counter	/5
Questions	/5

Project Submission

- 1) Save the project report as r5_username1_username2.pdf, username of both students in the group.
- 2) Only one attempt is allowed.
- 3) Only one group member submits to the project.
- 4) Remember: Any grade dispute must be raised within one week of the grade posting.