

4-1. Example: How to use PLL-IP core in Quartus

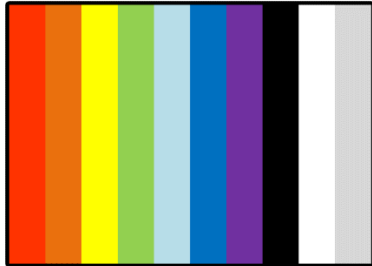
Follow “4-1 How to use PLL-IP core in Quartus.pdf” to study how to create and use PLL-IP core.

Requirements:

1. You do NOT need to include this example in your report.

4-2. Example: Simple VGA Display-1

Write a VGA driver and use the FPGA development board to drive the VGA display to display ten-color equal-width color bars. The VGA display mode is 640x480@60. The expected experimental result is the following figure.



Requirements:

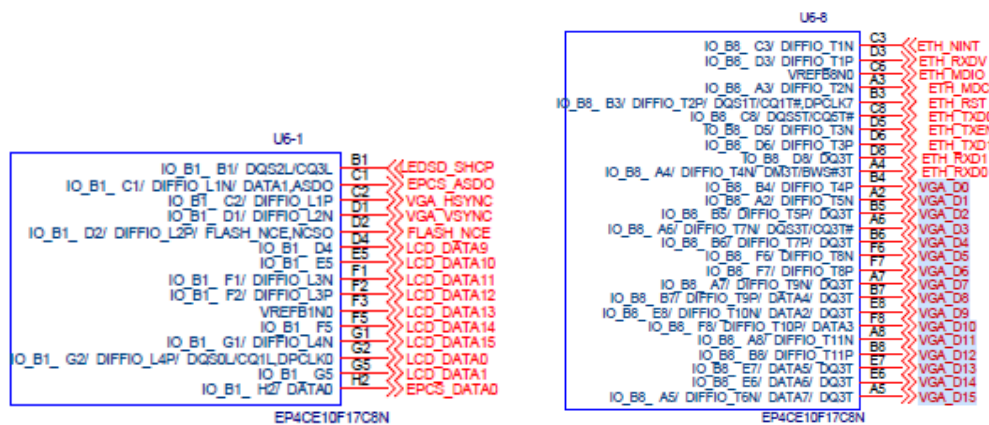
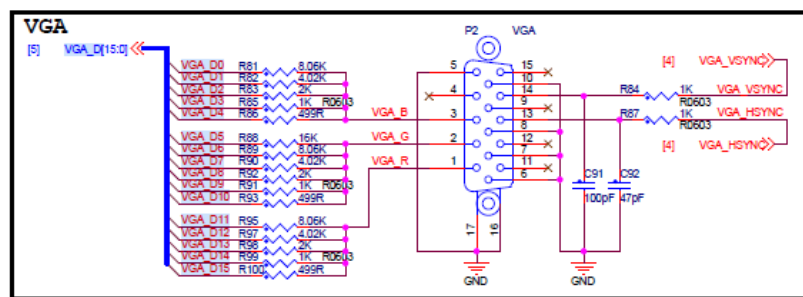
2. Write the Verilog codes to build the required circuit.
3. Do the simulation to verify whether your designs and codes satisfy the required functions.
4. You need to test your designs in the development board.
5. You do NOT need to include this example in your report.

4-3. Simple VGA Display-2

Following experiment 4-2, implement a VGA driver by using the FPGA to display “M”, “U”, “S”, and “T” on the VGA screen. The VGA display mode is 640x480@60.

Note:

- You may use some tools to generate the fonts in pixel, like “PCToLCD2002” or some online tools (https://hungtcs-lab.github.io/text-to-lcd/#/text_processor or <https://www.zhetao.com/fontarray.html>).
- Do NOT forget to plan pins before download your design to the development board



Requirements:

- Write the Verilog codes to build the required circuit.
- Do the simulation to verify whether your designs and codes satisfy the required functions.
- You need to test your designs in the development board
- You need to include this experiment in your report. In your report, you need to include:
 - Introduction:

- i. Introduce the background. For example, you can introduce
 - what is the VGA,
 - what are the VGA interface and pins
 - VGA display principle
 - VGA timing standards
 - ...
 - ii. Purpose of the experiment
 - iii. Brief introduce your designs and key results
 - iv. Contributions of your group members
 - v. ...
- b) Materials and Methods: Show your FPGA solution. You need to show
- i. Your designed structure block diagrams,
 - ii. Your designed signal waveforms,
 - iii. ...
- c) Results: Show your simulation and corresponding testing results. You need to show
- i. How you build the testbenches,
 - ii. Testing inputs,
 - iii. Expected outputs,
 - iv. Actual outputs,
 - v. Differences between the expected outputs and the actual outputs,
 - vi. Expected values, actual values, and their differences of the important internal variables
 - vii. Testing results in the development board
 - viii. ...
- a) Discussions. This part is not essential in this experiment, but you can show:
- i. If you find any bugs or problems that you can not solve in the given time, you can discuss them and show your possible solutions.
 - ii. If you find any interesting results, you can discuss them.
 - iii. ...
- d) Conclusion. You need to
- i. Summarize all your designs and simulation results,
 - ii. Summarize the key discussions if you have
 - iii. ...
- e) References. This is a list of all the sources cited in the report, formatted according to a specific citation style. You need to use the IEEE reference format [\(<http://journals.ieeeauthorcenter.ieee.org/wp->](http://journals.ieeeauthorcenter.ieee.org/wp-)

content/uploads/sites/7/IEEE_Reference_Guide.pdf).

- f) Appendices. This optional section can include codes, raw data, calculations, additional graphs, and other supplementary material that is relevant but not essential to the main report.