

# Introduction to Hardware/Software Co-Design on Zynq SoC

## OBJECTIVES

- Create a Hardware/Software System using the ZYBO Board.
- Create a Block Based Design in Vivado.
- Use of the AXI GPIO peripheral to control LEDs.
- Creating a software application in SDK.

## ZYBO BOARD SETUP FOR HARDWARE/SOFTWARE CO-DESIGN

- The current Zynq Book Tutorials (Aug 15<sup>th</sup>, 2015) includes a procedure that requires copying definition files into the Vivado installation directory. This helps when setting up the ZYBO Board.
- In this tutorial, we will manually indicate the Zynq device, the LED ports, and the Processing System (PS) definition file.
- The procedure described here follows closely that of the Zynq Book Tutorials found in [www.zynqbook.com](http://www.zynqbook.com). Some modifications were made due to the use of the ZYBO Board.

## CREATING A BLOCK DESIGN PROJECT IN VIVADO FOR THE ZYBO BOARD

- Create new project (`first_zynq_design_zybo`) in Vivado. Select the **ZYNQ XC7Z010-1CLG400** device.
- Make sure the default language in VHDL, so that the system wrapper is created in VHDL.
- Once created, add the `ZYBO_Master.xdc` file into the project.
- Click on 'Create Block Design'.
- Instantiate the Zynq PS and the AXI GPIO peripheral (right click on the canvas and select 'Add IP').
- Click on 'Run Block Automation'. This will create the external connections for the DDR and FIXED\_IO interfaces.
- Click on 'Run Connection Automation'. Check both S\_AXI and GPIO.
- Configure AXI\_GPIO: Double-click on it, select 'All Outputs', and set GPIO Width to 4.
- Double click on ZYNQ PS: Load the `ZYBO_zynq_def.xml` file (Import XPS Settings). This will indicate which peripherals are used by the PS. If this file is not loaded, the software application on the 'ddr' or other peripherals (e.g. UART) might not work as expected.
- Create the VHDL wrapper (Sources Window → right-click on the top-level system design)
- We included 4 output ports, which now we need to manually indicate:
  - ✓ Open the VHDL wrapper and modify the name of the 4-bit output port (usually name `gpio_rtl_tri_o`) to 'led'. Do the same in the port map statement.
  - ✓ Open the XDC file and uncomment the lines for the LEDs (name the port as 'led'). The name of the LED ports must match the name given in the top VHDL wrapper file.
- Synthesize your design. The first time, Vivado will undo your modifications to the VHDL wrapper file. So, modify it for a second time and Synthesize again.
- Implement and generate the bitstream.
- Export hardware (with bitstream) and launch SDK (Software Development Kit).

## CREATING A SOFTWARE APPLICATION IN SDK

- Select File -> New -> Application project.
- Enter `LED_test` in the Project Name field. Keep Target Software -> Language -> C.
- Select Empty Application.
- Copy the `LED_test_tut_1C.c` (obtained from the [www.zynqbook.com](http://www.zynqbook.com) website) on the folder: `first_zynq_design_zybo/first_zynq_design_zybo.sdk/LED_test/src`
- Right-click on the `LED_test` project and select 'Refresh' to update the files.
- The software routine controls the LEDs using software instructions by writing on a particular peripheral register (refer to the Zynq Book Tutorials for a comprehensive explanation).
- UART: This peripheral is connected to the PS. We can use the `xil_printf` instruction to print out messages. Feel free to modify the software by printing out messages. These messages will appear in the Terminal: you need to configure it to 11500 Baud Rate and with the proper COM port.
- By default, SDK will build the software project and create an output `.elf` file. This is the file that needs to be loaded into the instruction memory.
- Connect your ZYBO Board to the USB port of your computer.
- Download the bitstream on the PL: Xilinx Tools -> Program FPGA.
- Select the project `LED_test`. Right click and select Run As -> Launch on Hardware (GDB). You will see the LEDs blinking.
- Sometimes, when trying the software for the first time, it might not work. Go to Run -> Run Configurations: `LEDtest.elf` and uncheck: `Run ps7_nit`, `ps7_post_config`. Then select run the software again.