Getting Started with Embedded System Development using MicroBlaze processor & Spartan-3A FPGAs

This tutorial is an introduction to Embedded System development with the MicroBlaze soft processor and low cost Spartan-3 FPGAs. In this tutorial you will design a custom Embedded system and develop your application software.

First, you will get started with the Base System Builder (BSB) wizard in Xilinx Platform Studio (XPS). You will create a custom Embedded Processing system (a custom Microcontroller) targeted at the Spartan 1800A FPGA board. Then you will use the Xilinx Software Development Kit (SDK – an Eclipse-based IDE) to compile and debug some embedded software that runs on this system.

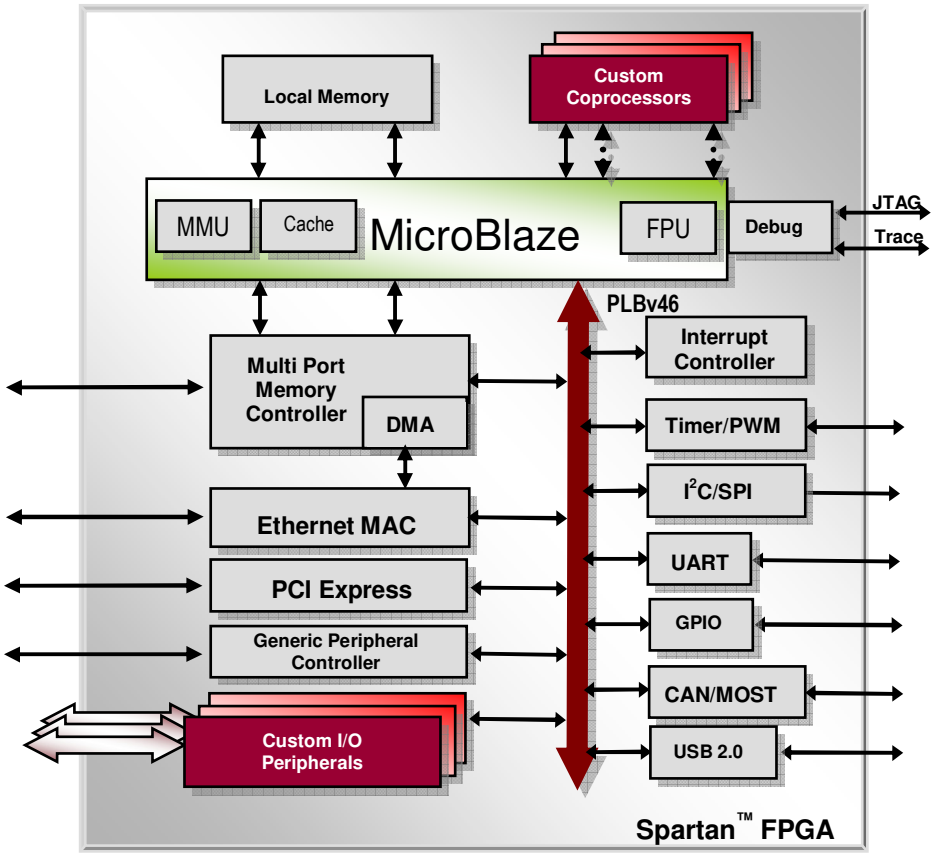


Figure 1 - MicroBlaze Processor System Architecture

Objectives

After completing this tutorial, you will be able to:

- Create an Embedded system with the MicroBlaze processor on Spartan-3 FPGA using Base System Builder (BSB) wizard
- Generate and Download the FPGA design bitstream on the board using Xilinx Platform Studio (XPS)
- Create a simple software application using Eclipse-based Platform Studio Software Development Kit (SDK)
- Debug the software application using the Eclipse IDE (SDK)

Requirements

Embedded Development HW/SW Kit – Spartan-3A DSP S3D1800A MicroBlaze Processor Edition

Hardware Requirements

- Xilinx MicroBlaze Development Kit (Spartan-3 1800A edition)
  - Spartan-3 1800A DSP FPGA board
  - Xilinx Platform Cable USB
  - RS232 cable

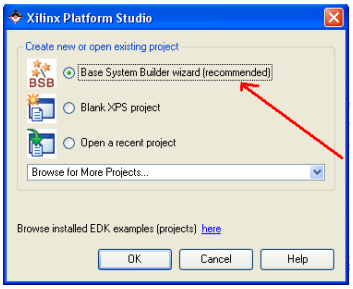
Software Requirements

- ISE Design Suite 10.1 (including EDK 10.1)
- HyperTerminal or Tera Term terminal program connecting the PC and the FPGA board at 115,200 baud

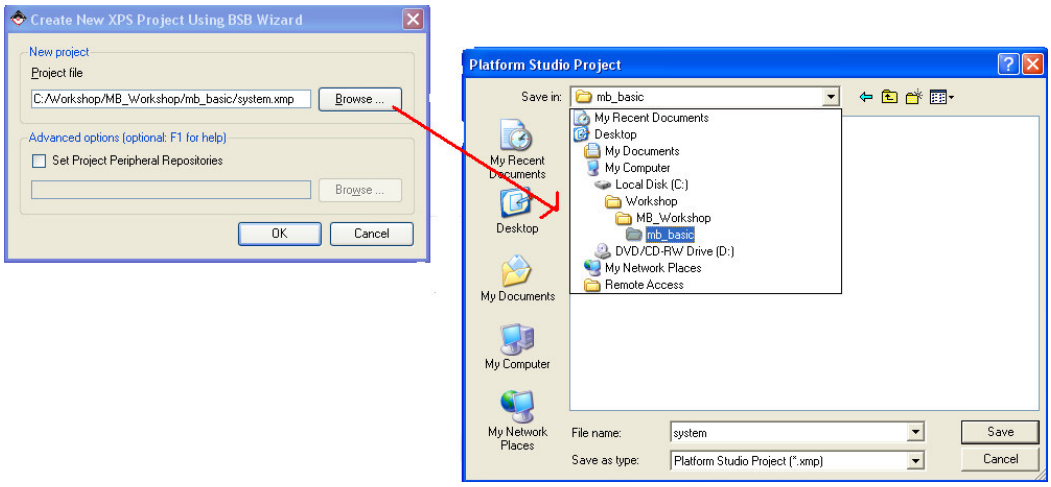
Step 1 – Create Custom Embedded System

1. Open Xilinx Platform Studio:

2. You will create a new project:
   - Select **"Base System Builder wizard"** and Click **OK**

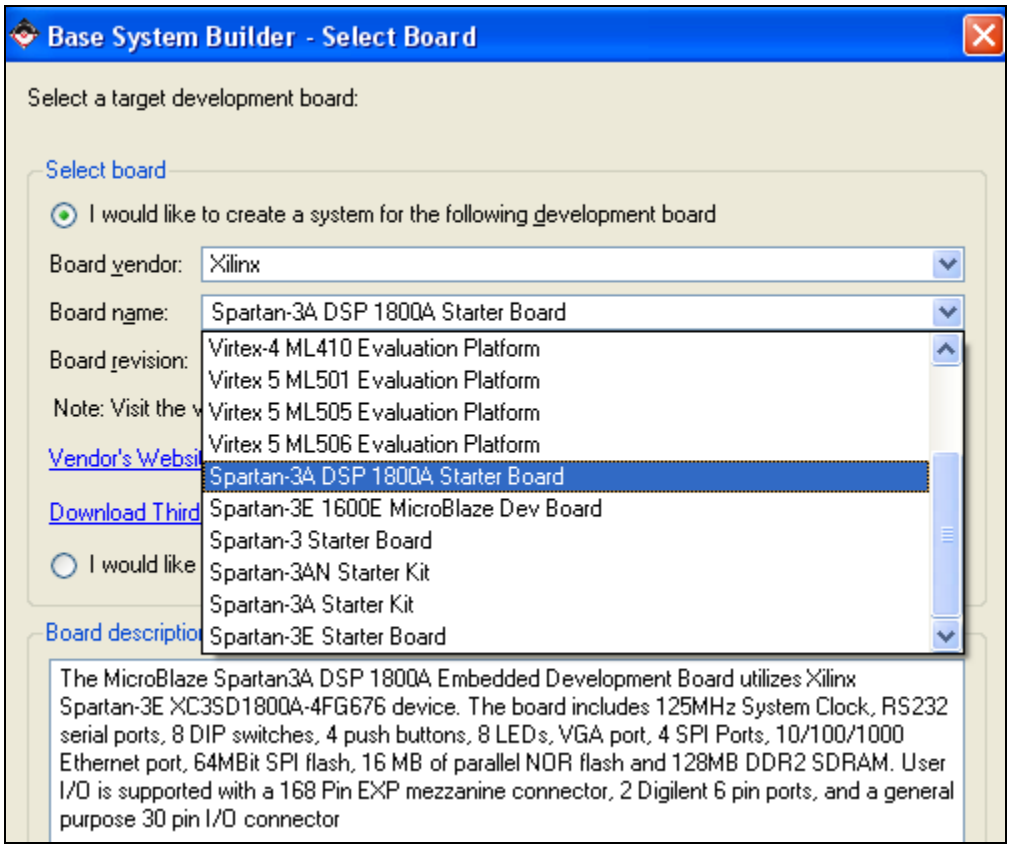


3. Select the design directory for new project:
   - Click the **Browse** button and browse to the following location: **C:\Workshop\MB_Workshop\mb_basic**
   - The file name should be: **system**
   - Click **Save**
   - Click **OK**



4. Next the Wizard will give options on how to create the system:
   - Select "**I would like to create a new design**"
   - Click **"Next"**

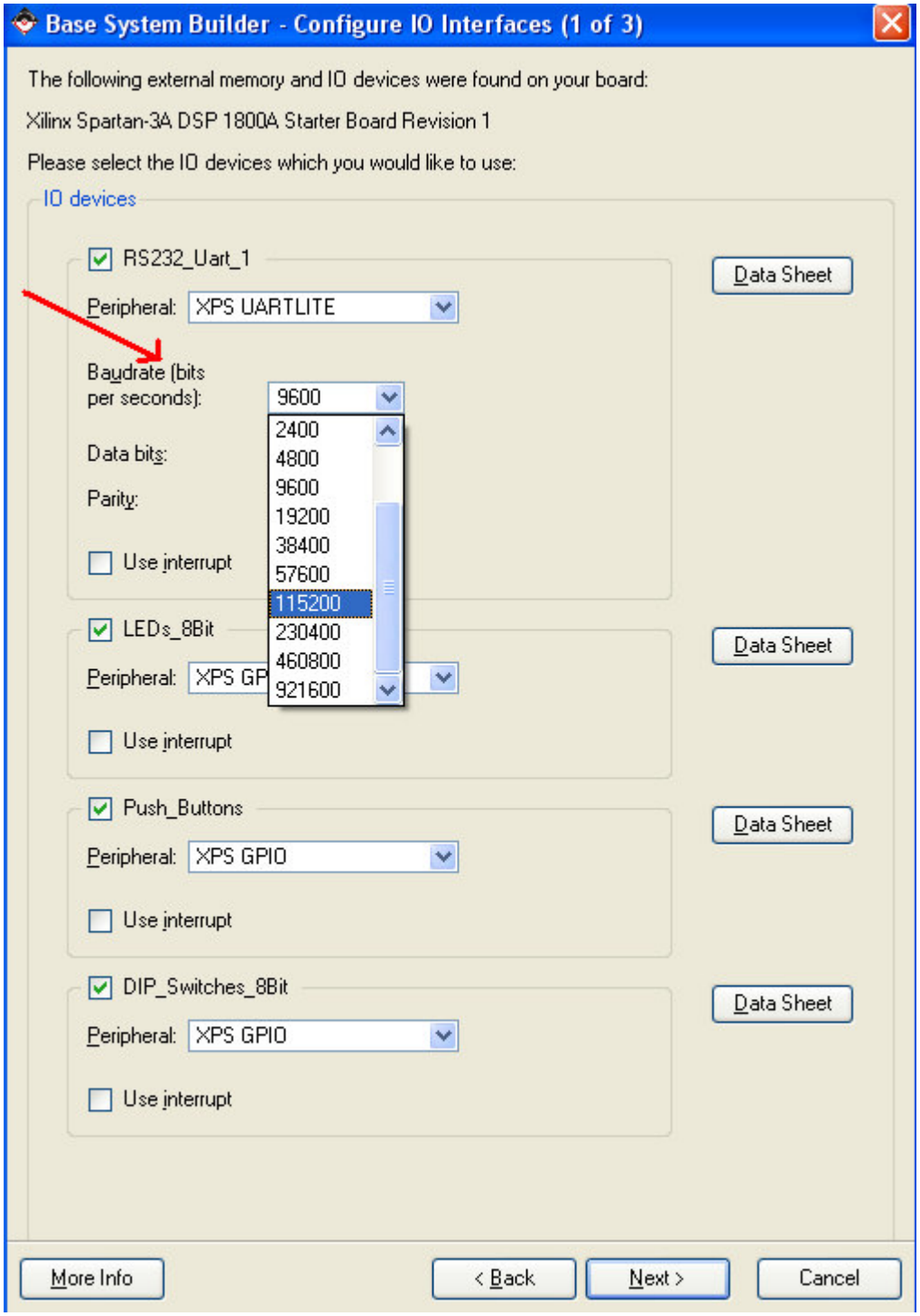
5. Select the target development board:
   - Select Board vendor:"**Xilinx**"
   - Select Board name: **"Spartan-3A DSP 1800A Starter Board"**
   - Click **"Next"**



6. Select the processor. *(Here you have no other option – only the Virtex-5 FXT FPGA has a PowerPC processor)*:
   - Click **"Next"**

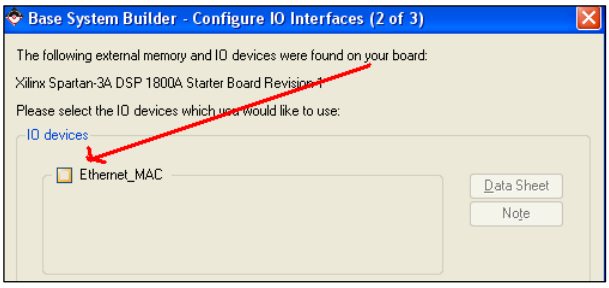
7. Configure the processor options. You can modify options like local on-chip memory size, caches, FPU, etc. For now, you will leave the defaults and modify the system later.
   - Click **"Next"**

8. Configure the I/O interfaces of your embedded system. Here you can select the right set of Peripherals you need for your target system or microcontroller and also customize each peripheral:
   - Select the drop down for **"Baudrate"** and choose **"115200"**
   - Click **"Next"**

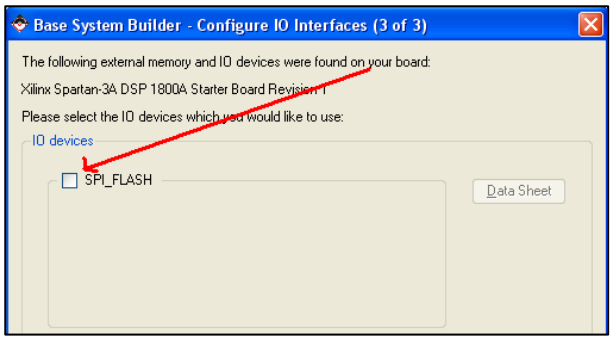


9. Continue configuring the I/O interfaces. For now, you will unselect the Ethernet MAC and SPI Flash peripherals as we will not be using it in this tutorial. This will make the design smaller and also save some time when we create the FPGA netlist/bitstream for this tutorial:

   - **Unselect Ethernet MAC peripheral**
   - Click **"Next"**

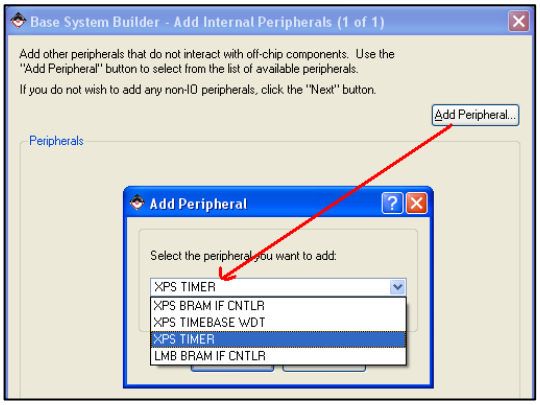


   - **Unselect SPI Flash peripheral**
   - Click **"Next"**



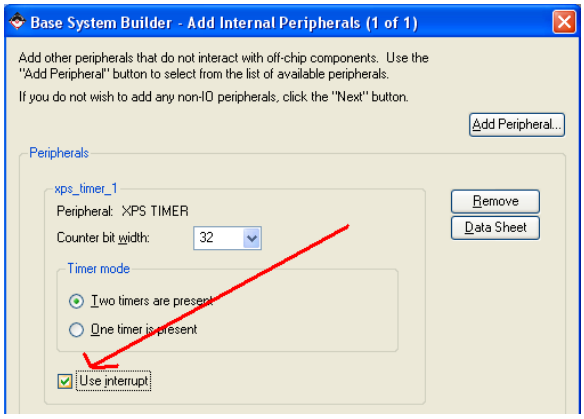
10. Add some internal on-chip peripherals:

    - Click **"Add Peripheral"**
    - Select **"XPS Timer"**
    - Click **"Ok"**



11. Customize the Timer by enabling Interrupts:

    - Click **"Use Interrupt"** for the timer peripheral
    - Click **"Ok"**

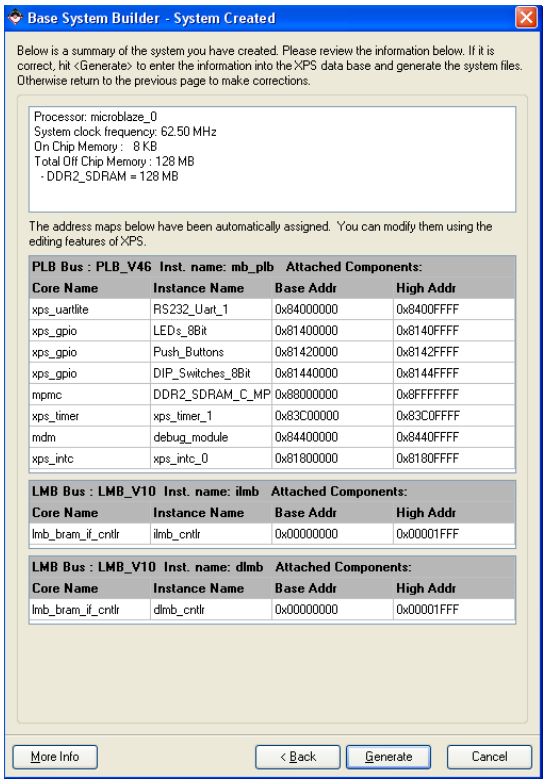


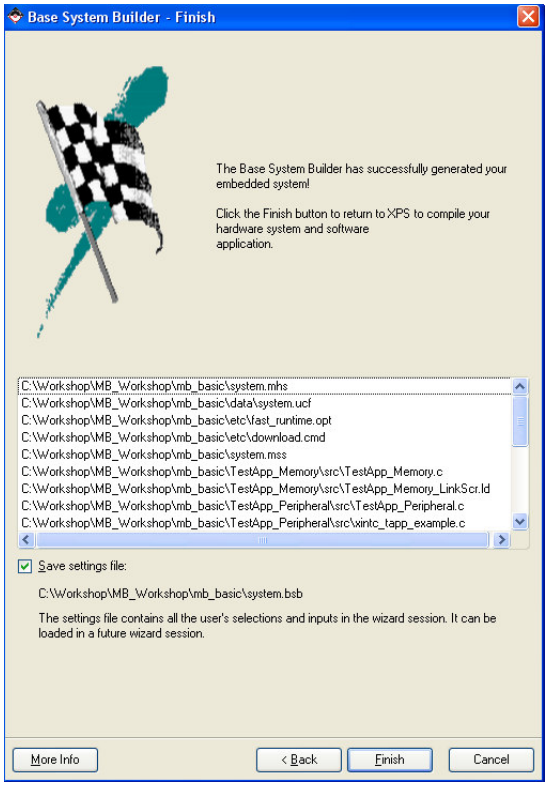
12. Next the wizard will help you create some sample programs that will do some diagnostics on your custom embedded system.

You can leave the defaults and modify the software later:

- Click **"Next"**
- Click **"Next"**
- Click **"Next"**

13. Now you have finished creating a basic system. The wizard will let you review your selections and generate the system:
    - Click **"Generate"**
    - Click **"Finish"**



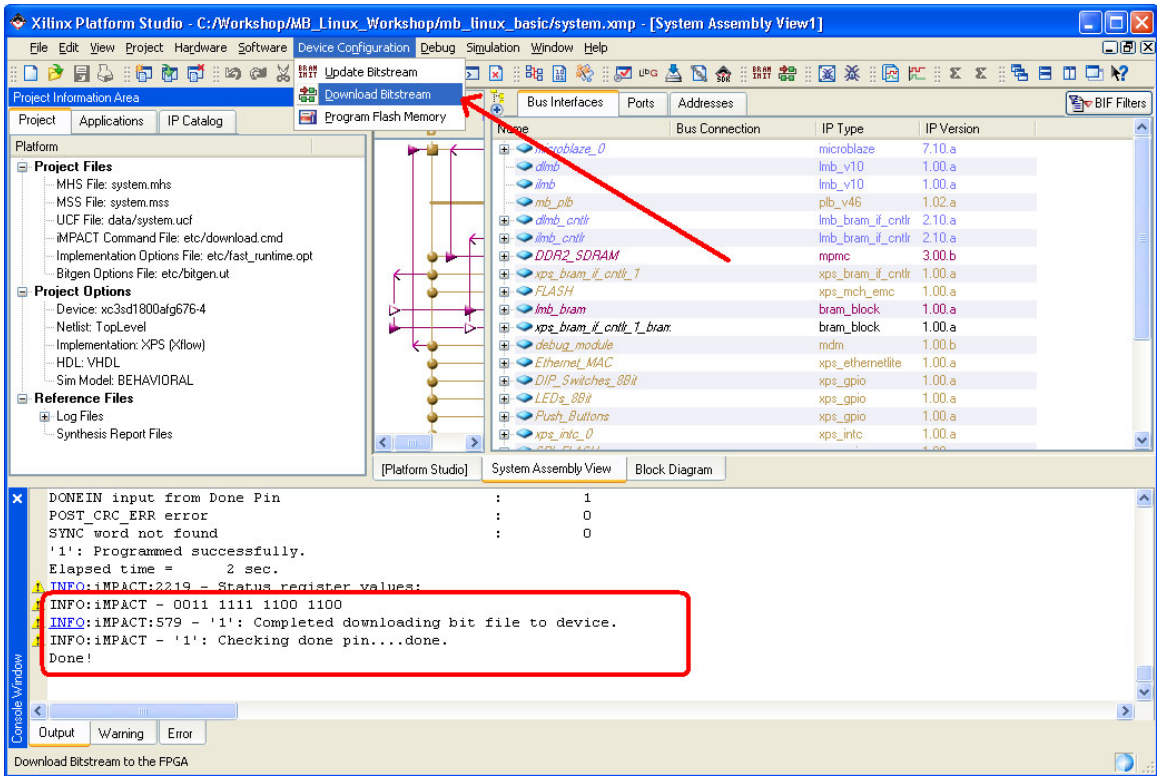


Step 2 – Build and Download the Hardware system

1. From the Xilinx Platform Studio (XPS) IDE, create the FPGA bitstream and download the hardware design onto the Spartan FPGA board as follows:

   - Select the menu "**Device Configuration-> Download Bitstream**"

NOTE: This step will take almost 30 minutes. Do not close the window !



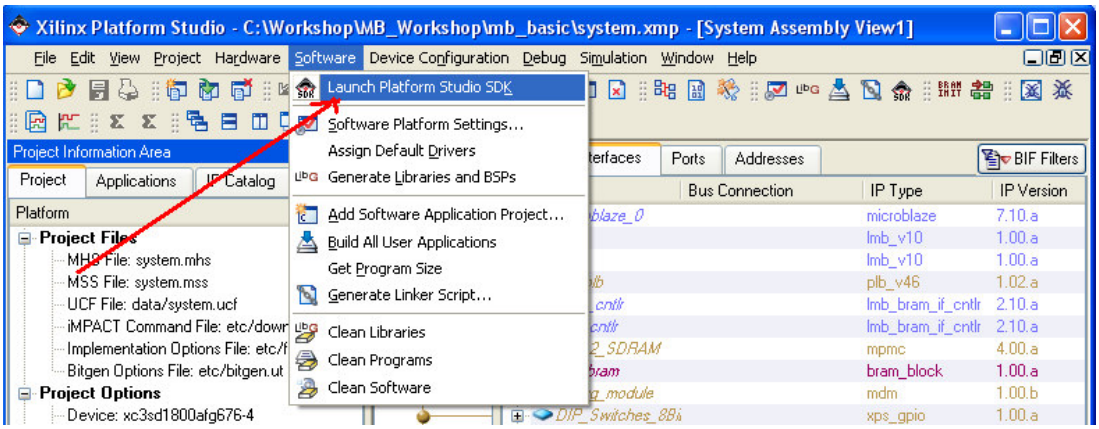
This will create the FPGA design files, synthesize the netlist and also place and route the design creating the bitstream. The FPGA on the board will also be configured with this new bitstream containing your custom embedded system.

Your custom hardware is now ready. Next will write and program some software.

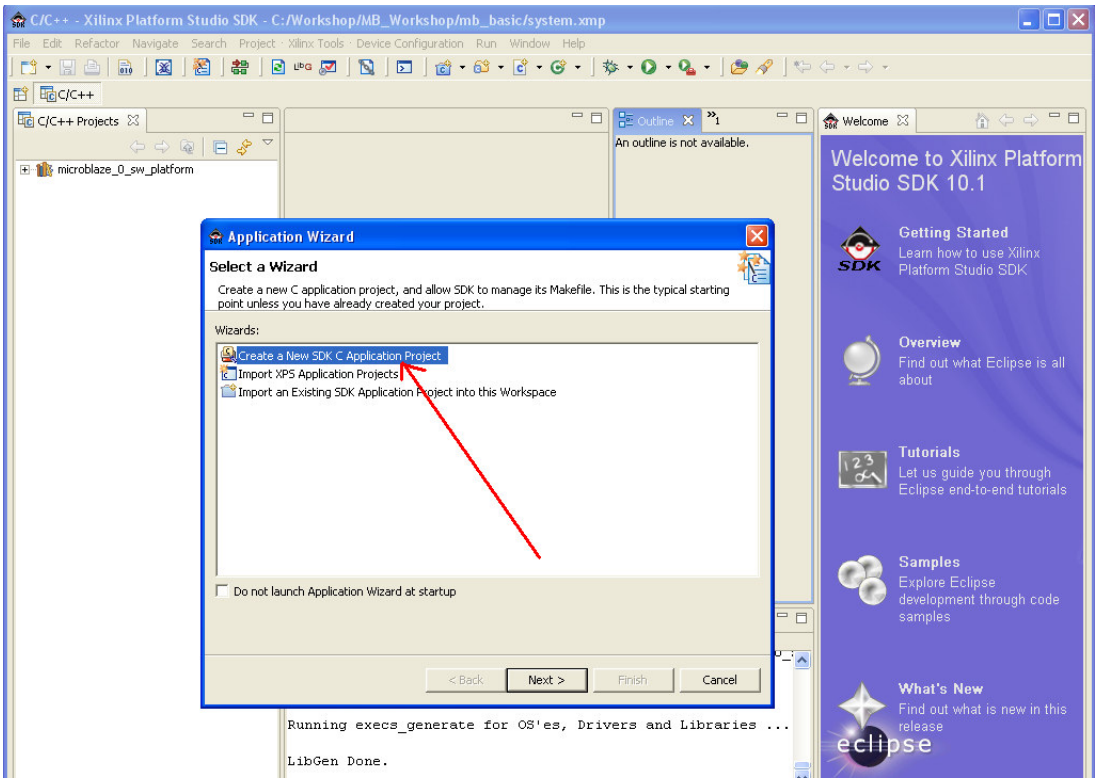
Step 3 – Develop Embedded software

1. From the Platform Studio IDE, launch Eclipse IDE for software development:

   - Select the menu **"Software->Launch Platform Studio SDK"**

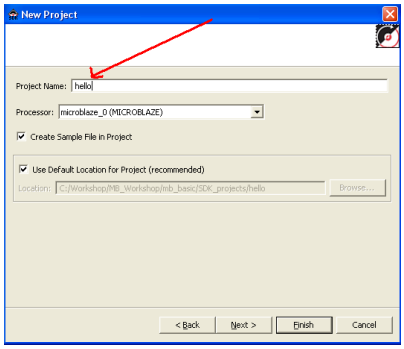


2. In SDK, start creating a new software application using the Application Wizard:
   - Select **"Create a New SDK C Application Project"**
   - Click **"Next"**



3. Provide a name to the new project

- Type **"hello"**
- Click **"Next"**



Use the rest of the project defaults

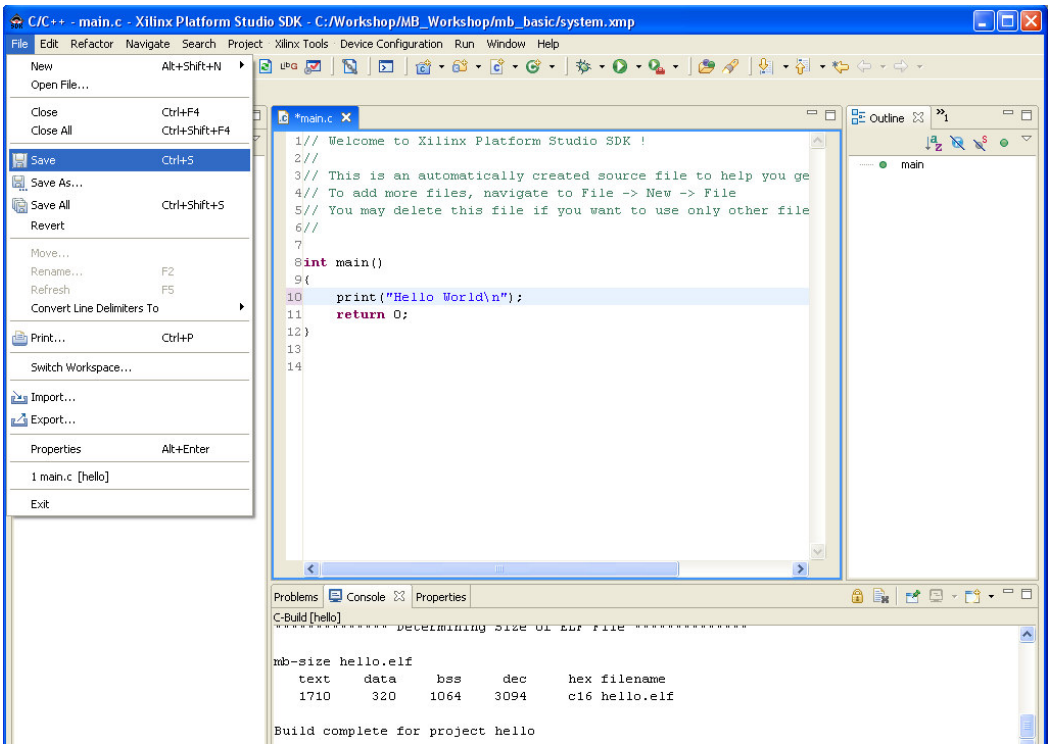
- Click **"Next"**
- Click **"Finish"**

4. In the Editor view, edit the default program "main.c" and save it:
   - Insert the following line after main() {

```
print("Hello World");
```

NOTE: It is print() and not printf().

- Select the menu **"File-> Save"**



Saving the program will also compile it and result in "hello.elf" as you see in the console view.

Now you are ready to download and debug the program on the board.

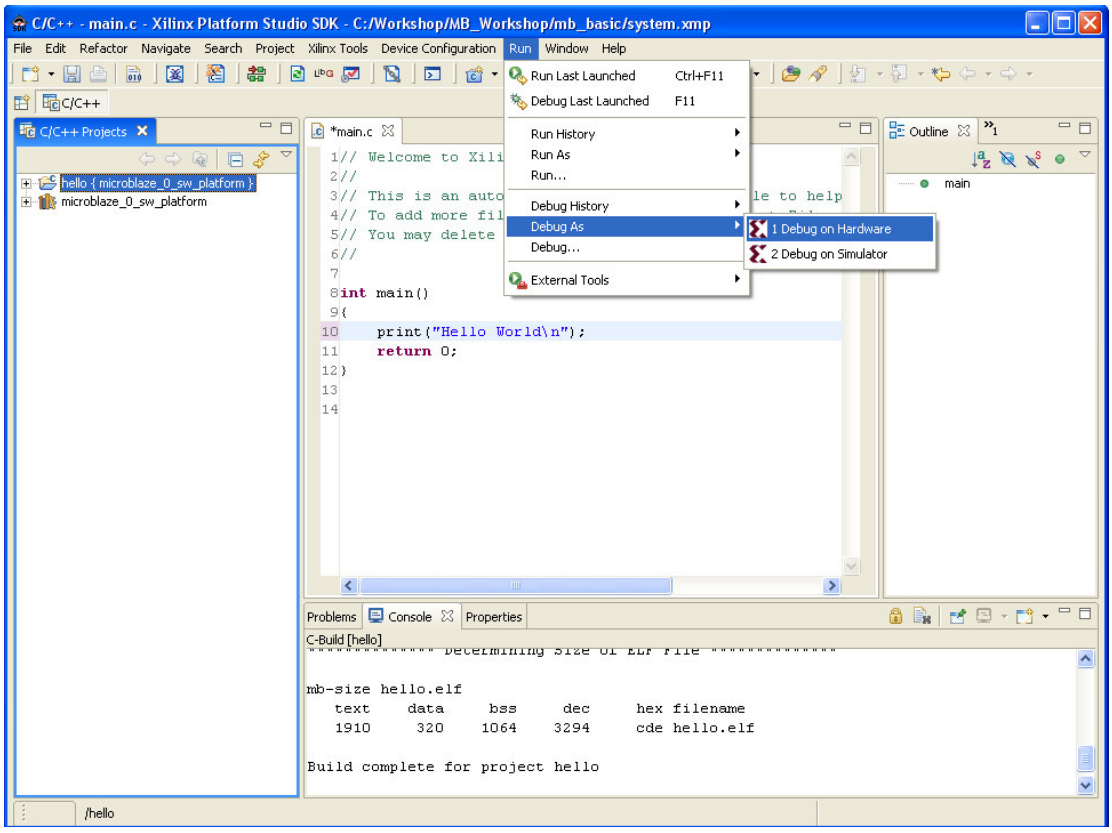
Step 4 – Debugging software program

1. Before debugging the Hello world program, you have to open the RS-232 serial communication with the board using the Tera Term console program.

   - **Double Click on the Tera Term Icon** on the Windows Desktop

The output of your Hello world program can be seen in this console.

2. From SDK, start debugging the program as follows:
   - Select the Menu item **"Run->Debug As->Debug on Hardware"**

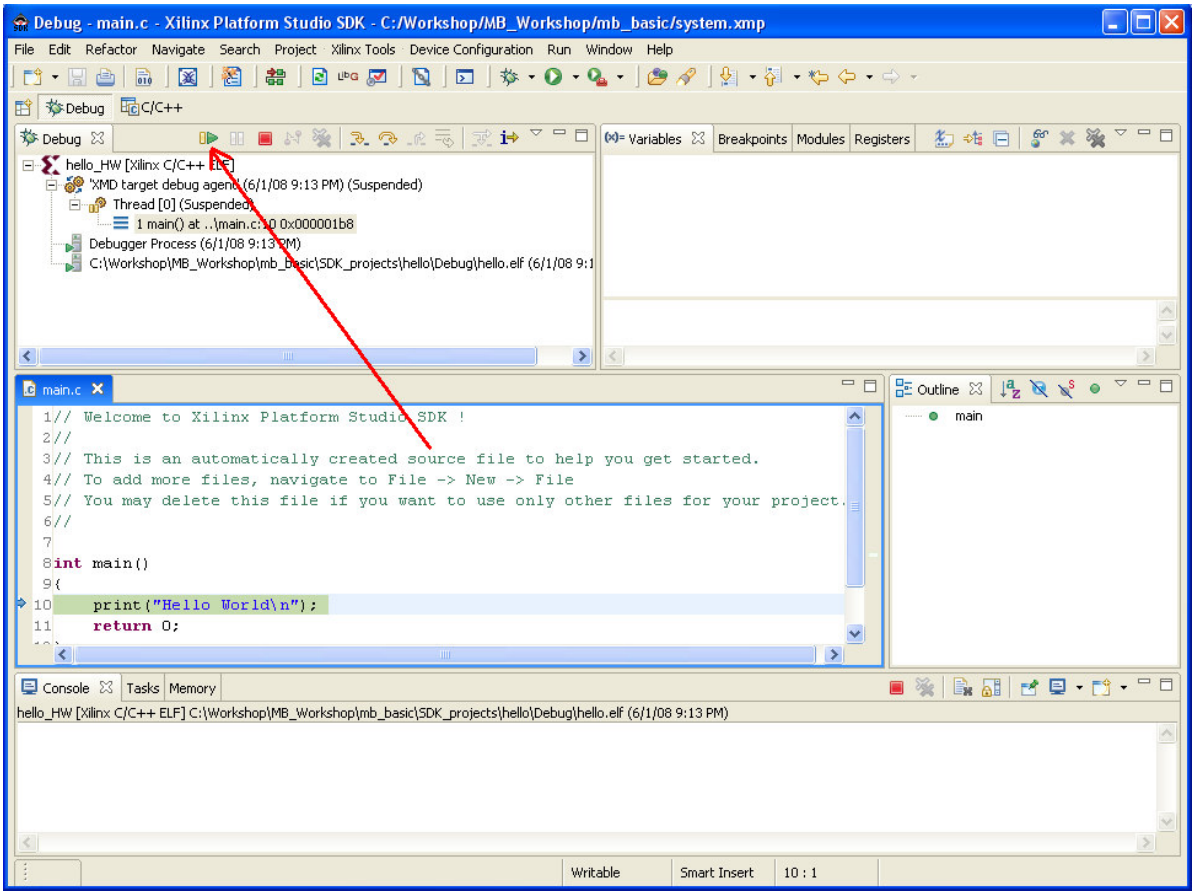


SDK will now change to the Debug Perspective. SDK will also connect to the FPGA board via the USB cable, connect to the MicroBlaze processor and download the program to memory.

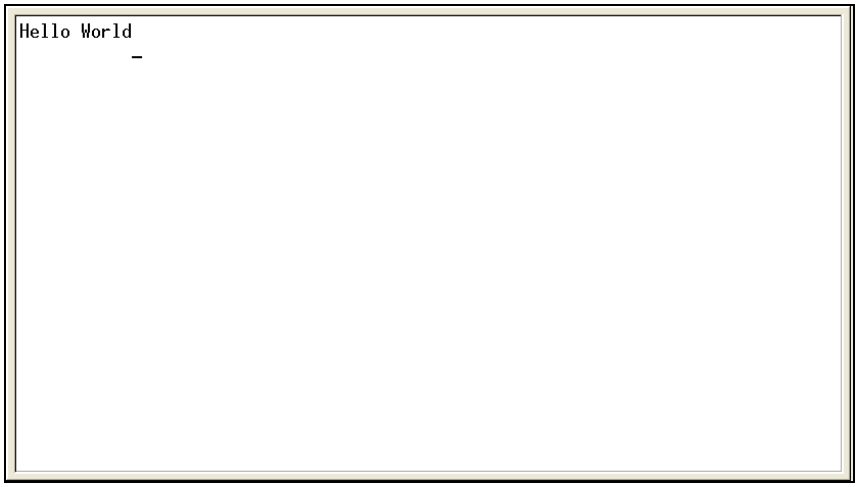
Now you are ready to debug the program using the Eclipse Debug perspective.

3. In the Debug perspective, click on the resume button (looks like ***Play*** button):
   - Click the "**Resume**" button

   NOTE: You can alternatively select ***"Run->Resume"***



You should now see the output of the program on the Serial console (TeraTerm program) as follows:



You can now use the Eclipse IDE to modify your program and debug it further. Here are some steps to try out on your own:

1. In the SDK IDE source code perspective,
    a. Use the Application Wizard to import Test_App_Memory and Test_App_Peripheral programs.

2. While debugging,
    a. View Registers, Memory
    b. Single Step through the program using Step, Next
    c. Toggle between assembly and source views

3. In the SDK IDE source code perspective,
    a. Modify the linker script and change the location where the program is running from