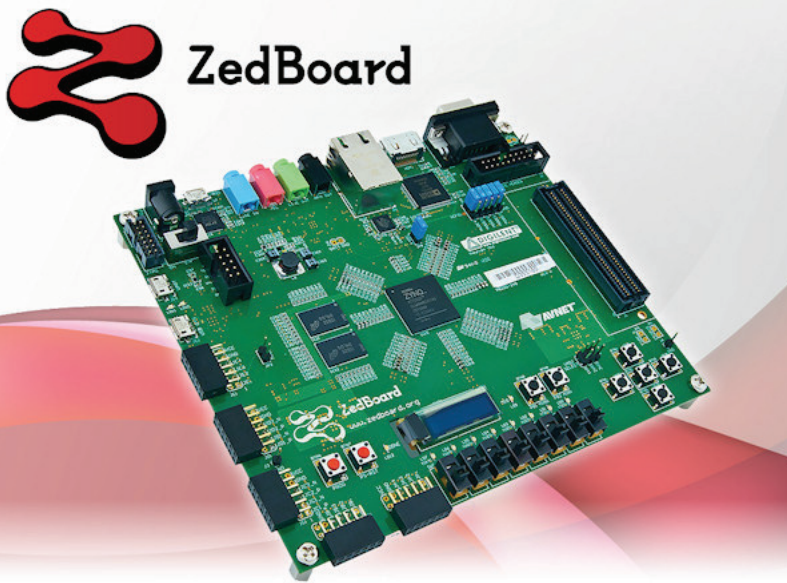


Zedboard LED Demo



([https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-](https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/zedboard-obl-bg-600.jpg?tid=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[started-with-zynq/zedboard-obl-bg-600.jpg?tid=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/zedboard-obl-bg-600.jpg?tid=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart))

Overview

This guide will provide a step by step walk-through of importing a custom IP into Vivado and getting started in Xilinx SDK.

At the end of this tutorial you will have:

- Imported and implemented a custom DigiLEDs IP block into the design.
- Created .C Project in Xilinx Vivado SDK (Software Development Kit) to interface with the Zedboard.

Prerequisites

Skills

- **Familiarity with Vivado**
- **Block Design Experience**

Hardware

- **Digilent Zedboard Board**
- **Micro USB Cable**
 - Used for UART communication and JTAG programming
- **Programmable RGB LEDs (WS2812, Neopixels)**
 - Data-in Signal wire connected to Zedboard's JB1

Software

- **Xilinx Vivado 2016.2 with the SDK package.**
 - Follow this Wiki guide ([Installing Vivado \(https://reference.digilentinc.com/vivado/installation\)](https://reference.digilentinc.com/vivado/installation)) on how to install and activate Vivado

Board Support Files

- **Zedboard Support Files**
 - These files will describe GPIO () interfaces on your board and make it easier to select your FPGA board and add GPIO () IP blocks.
 - Follow this Wiki guide ([Vivado Board Files for Digilent 7-Series FPGA Boards \(https://reference.digilentinc.com/vivado/boardfiles\)](https://reference.digilentinc.com/vivado/boardfiles)) on how to install Board Support Files for Vivado.

Project Files

- **DigiLED Custom IP** : ZIP (<https://reference.digilentinc.com/lib/exe/fetch.php?tok=53d927&media=https%3A%2F%2Fgithub.com%2Fmwingerson%2FDigiLED%2Farchive%2Fmaster.zip>)
- **main.c file** : ZIP (https://reference.digilentinc.com/_media/zybo/main.zip)

Introduction

In this tutorial, we are going to add our own custom IP block into the base system design to be used with some programmable RGB LEDs.

General Design Flow

I. Vivado

- Open Vivado
- Create a new block design

- Add the Zynq core IP and automate it
- Add the DigiLEDs custom IP to the project's IP repository
- Add the DigiLEDs IP to the design and configure it.
- Validate and save block design
- Create HDL system wrapper
- Run design Synthesis and Implementation
- Generate Bit File
- Export Hardware Design including the generated bit stream file to SDK tool
- Launch SDK

Now the Hardware design is exported to the SDK tool. The Vivado to SDK hand-off is done internally through Vivado. We will use SDK to create a Software application that will use the customized board interface data and FPGA hardware configuration by importing the hardware design information from Vivado.

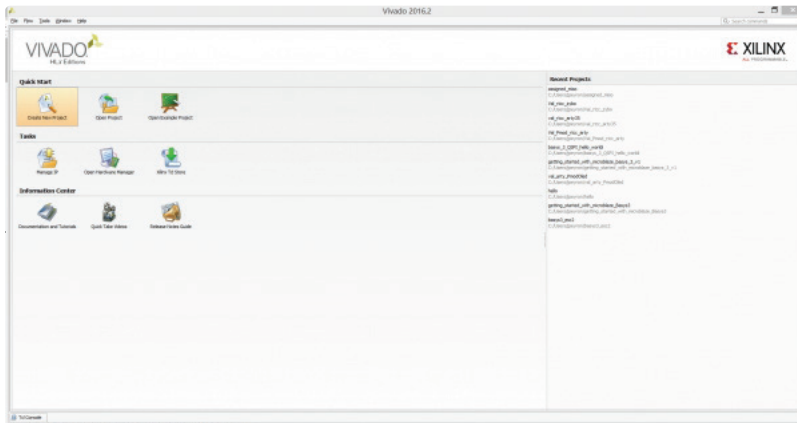
II. SDK

- Create new application project and select Empty Application template
- Import main.c
- Program FPGA

Tutorial

When you first run Vivado this will be the main start window where you can create a new project or open a recent one.

1.1) Click on **Create New Project**.



(https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/image_1.jpg?id=learn%3Aprogrammable-logic%3Atutorial%3Azedboard-led-demo%3Astart)

1.2) You will be presented with the project creation wizard. Click **Next**.



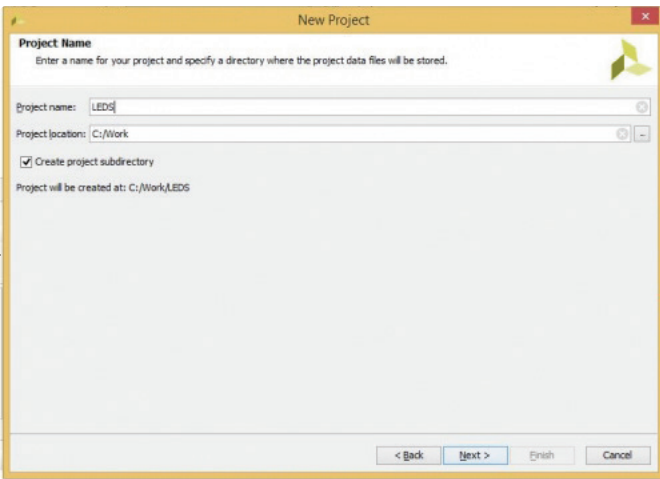
(https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/image_2.jpg?id=learn%3Aprogrammable-logic%3Atutorial%3Azedboard-led-demo%3Astart)

Next choose the Project Name and Location such that there are **no blank spaces**. This is an important naming convention to follow for project names, file names and location paths.

Underscore in a good substitute for empty spaces.

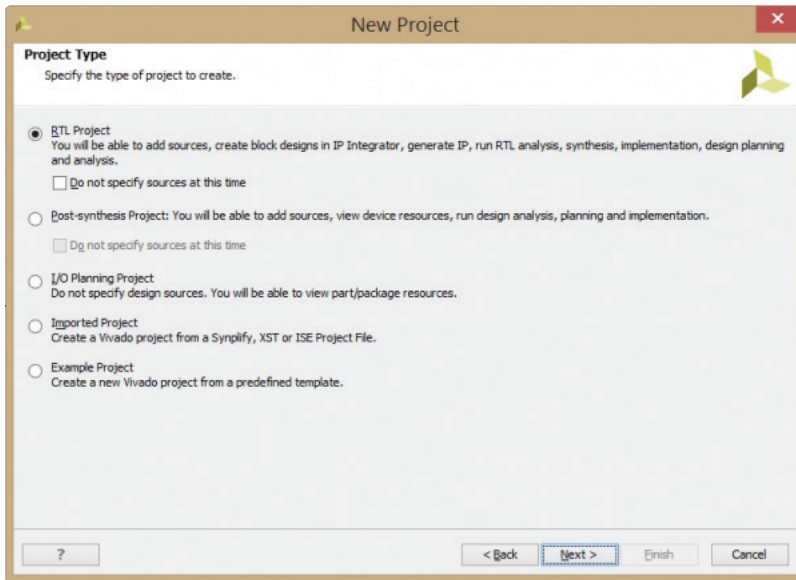
It is good practice to have a dedicated folder for Vivado Projects, preferably with the smallest possible path length. Example: C:/Vivado_Projects.

1.3) Name your Project and select the Project location and click **Next**.



https://reference.digilentinc.com/_media/zybo/new.jpg

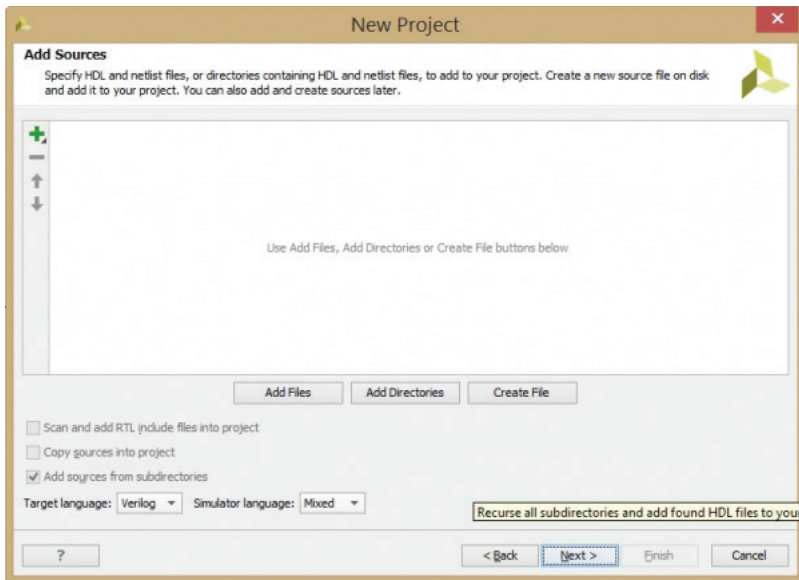
1.4) Select **RTL Project** and click **Next**.



[https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-](https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/image_4.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[started-with-zynq/image_4.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/image_4.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

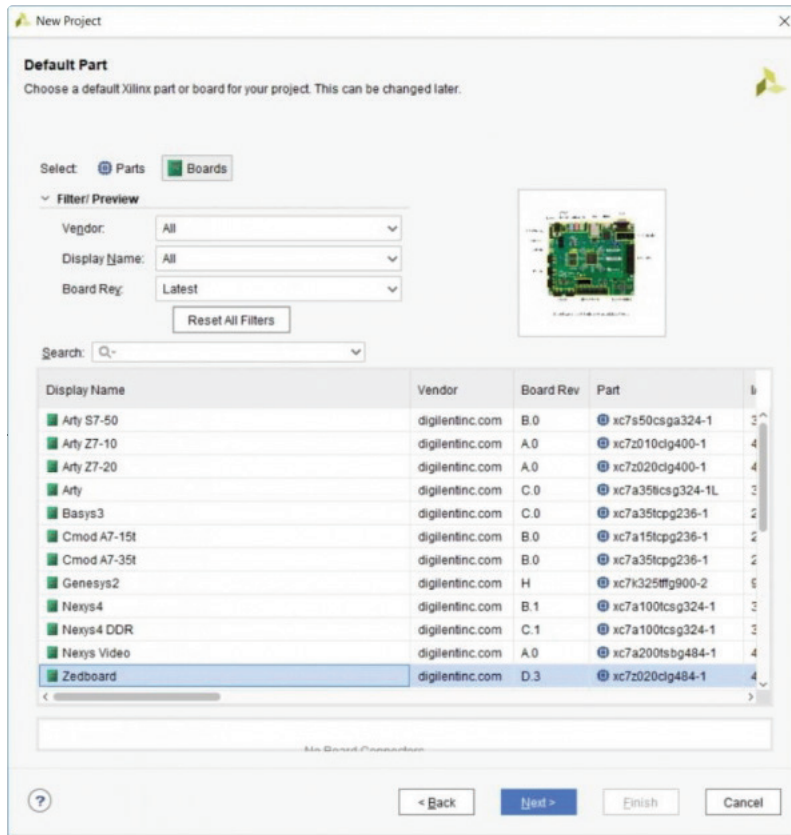
1.5) This demo does not use any existing sources, existing IP or constraints. Click through the next three screens.



[https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-](https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/image_5.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[started-with-zynq/image_5.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/image_5.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

1.6) Select **Boards** and select the **Zedboard** board file. Click **Next** and then **Finish**.



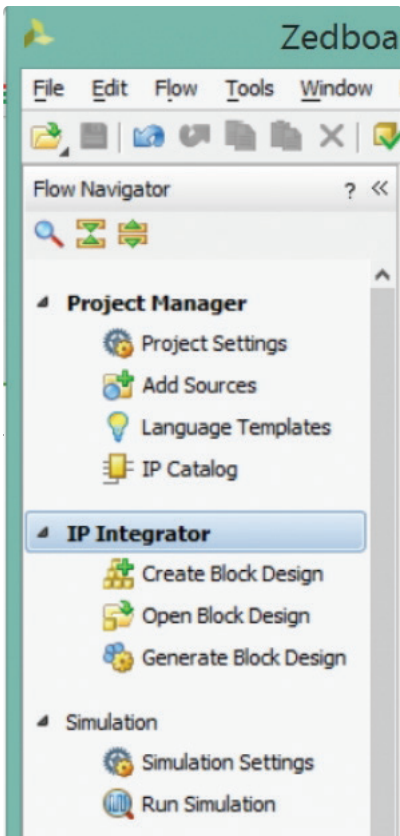
https://reference.digilentinc.com/_detail/learn/programmable-logic/tutorials/zedboard-

[getting-started-with-zynq/board_file_zedboard.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/learn/programmable-logic/tutorials/zedboard-)

Make sure to select the board file made by Digilent.

2. Creating a New Block Design

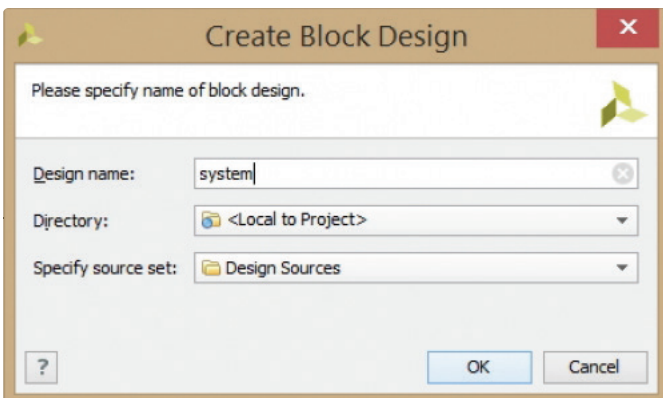
2.1) Once the process has completed, click **Create Block Design** in the flow navigator.



https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-zynq/image_7.jpg?

[id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart\)](#)

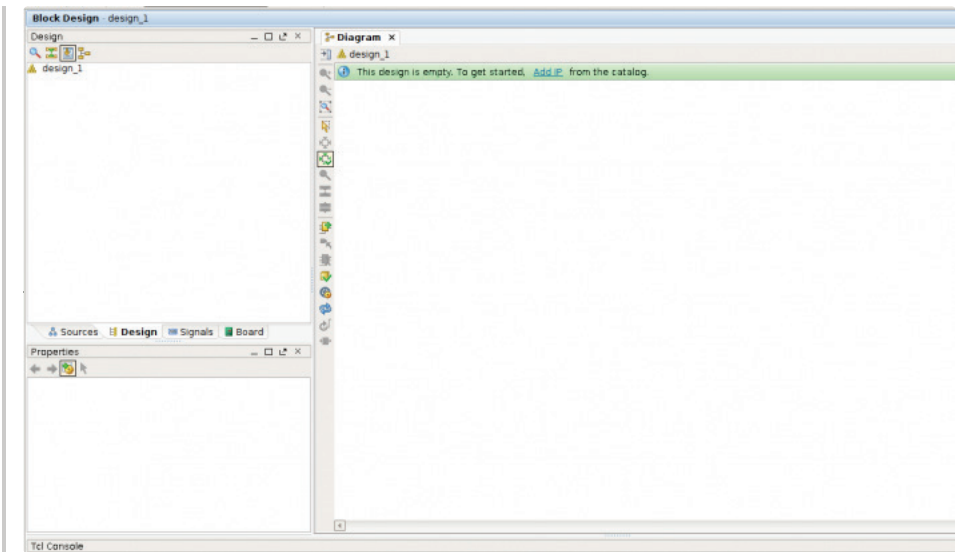
2.2) Click **OK**.



https://reference.digilentinc.com/_detail/reference/programmable-logic/zedboard-getting-started-with-

[zynq/image_8.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart\)](#)

2.3) A blank Block Design will open up.

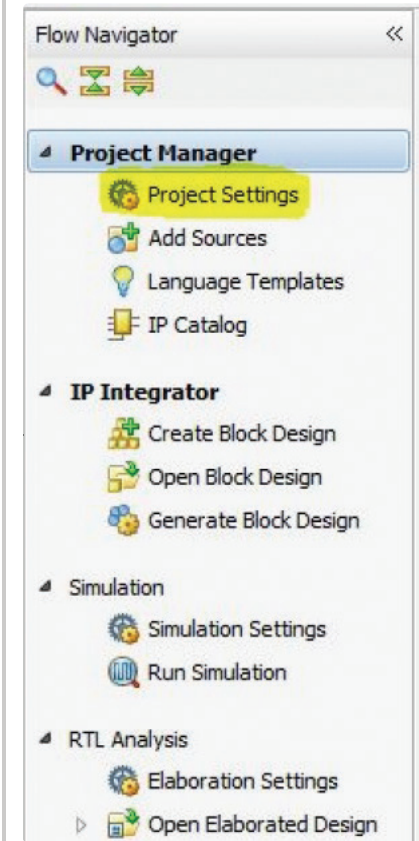


https://reference.digilentinc.com/_detail/zybo/blank_block_design.png?

[id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/zybo/blank_block_design.png?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

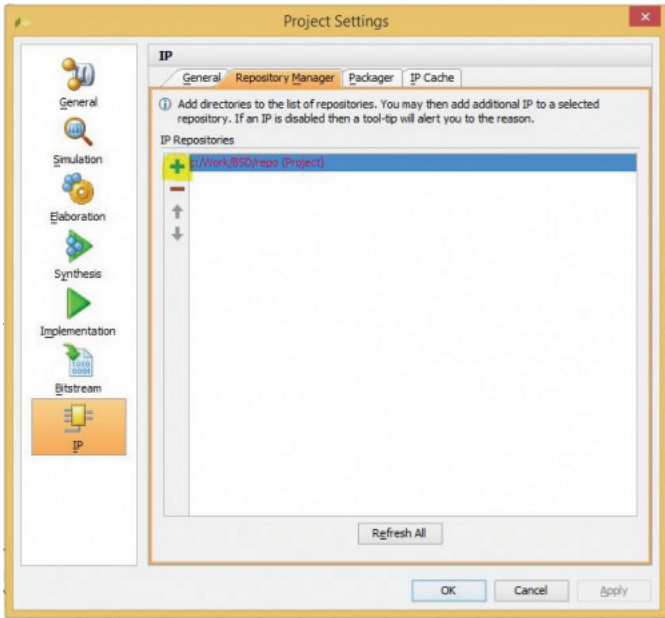
3. Adding Our Custom IP Repo

3.1) Find and click **“Project Settings”** under Project Manager on the left side of Vivado.



https://reference.digilentinc.com/_detail/artv/projsetting.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart

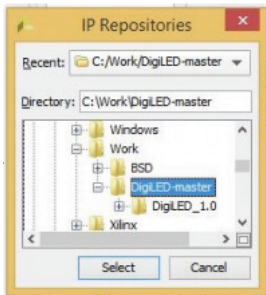
3.2) Within project settings, click “IP” on the left side. Then click the “Repository Manager” tab and click the + button (Highlighted below).



([https://reference.digilentinc.com/_detail/arty/iprepo.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/arty/iprepo.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

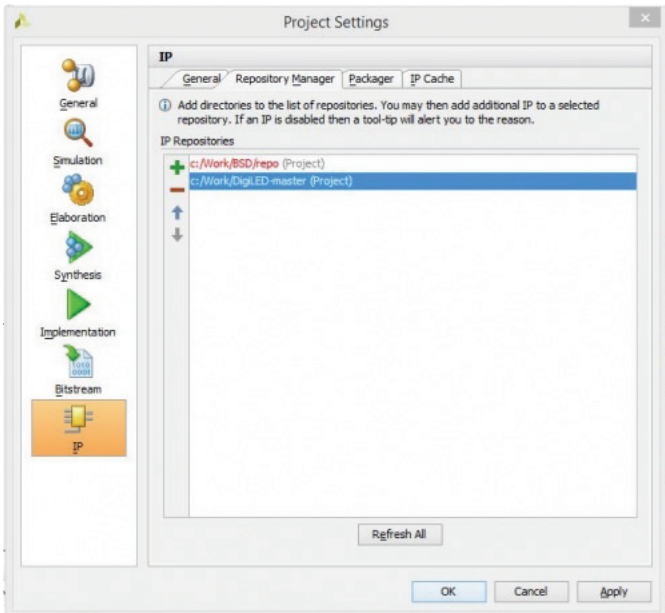
[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/arty/iprepo.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart))

3.3) Navigate to your projects folder and select the “DigiLED-master” folder.



(https://reference.digilentinc.com/_detail/arty/iprepo2.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

3.4) Verify that the new repo is in the list and click OK to exit project settings.



([https://reference.digilentinc.com/_detail/arty/iprepo3.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/arty/iprepo3.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/arty/iprepo3.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart))

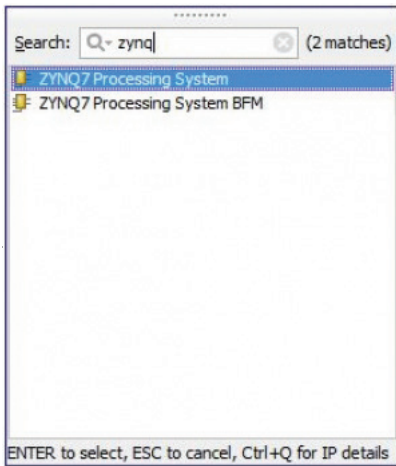
4. Adding Our Custom IP

4.1) Click the **“Add IP”** button. Type “DigiLED” in the search box and double click **“DigiLED_v1.0”**. This will add our custom IP to the block design.



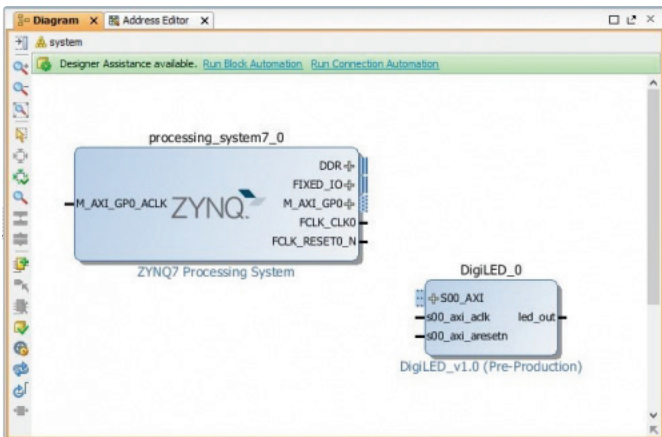
(https://reference.digilentinc.com/_detail/artv/addip2.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

4.2) Click **“Add IP”** button again. This time type “Zynq” in the search box and double click **ZYNQ7 Processing System**.



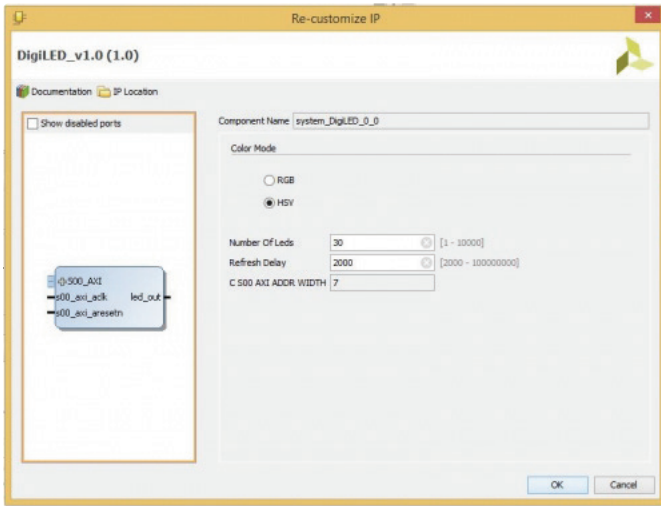
(https://reference.digilentinc.com/_media/zybo/2.jpg)

This will add the Zynq processor to our block design.



(https://reference.digilentinc.com/_media/zybo/3.jpg)

5.2) Select the **HSV** Bullet and change the Number of LEDs field to the number of LEDs on your RGB LED () strip before clicking OK.

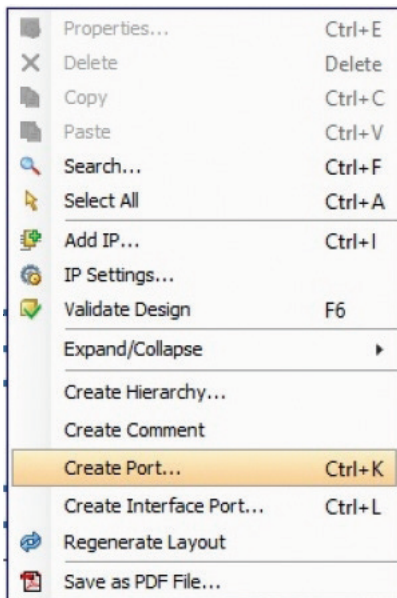


(https://reference.digilentinc.com/_detail/arty/custom.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

(https://reference.digilentinc.com/_detail/arty/custom.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

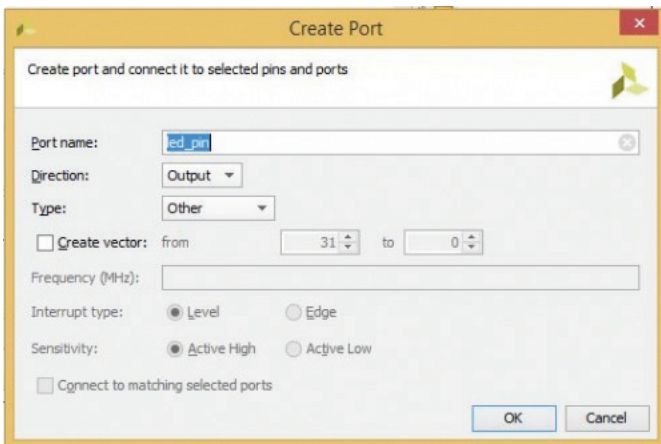
6. Adding the LED Signal Pin

6.1) Right click within your block design and click **“Create Port”**



(https://reference.digilentinc.com/_detail/arty/createport.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

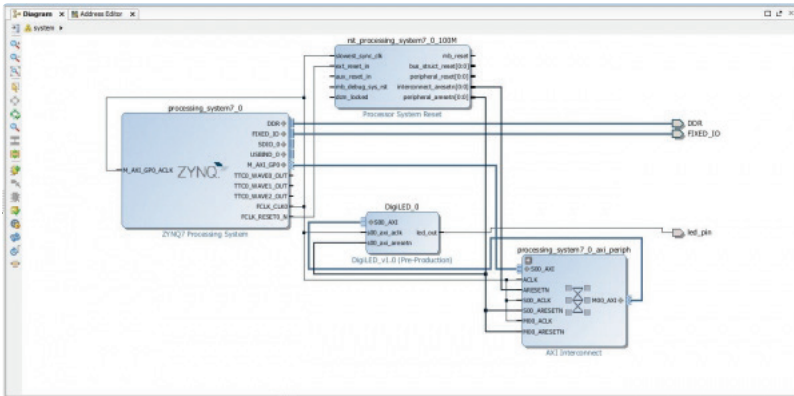
6.2) Name the port “led_pin” and set it as an **Output**. Click OK.



(https://reference.digilentinc.com/_detail/arty/led_pin.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

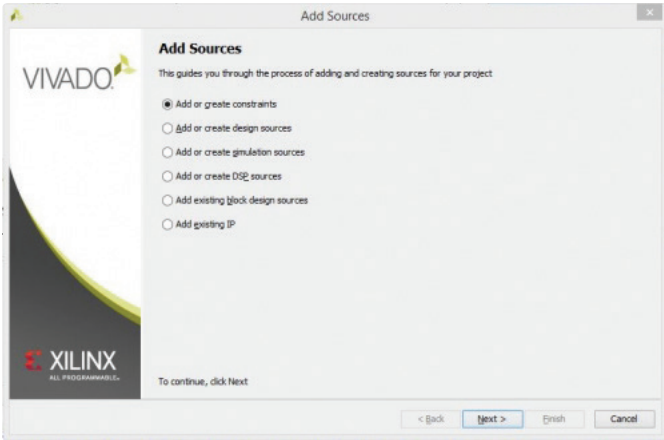
(https://reference.digilentinc.com/_detail/arty/led_pin.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

6.3) Connect the “led_pin” to “led_out” on the DigiLED_0 block using your cursor (It will look like a pencil).



(https://reference.digilentinc.com/_media/zybo/6.jpg)

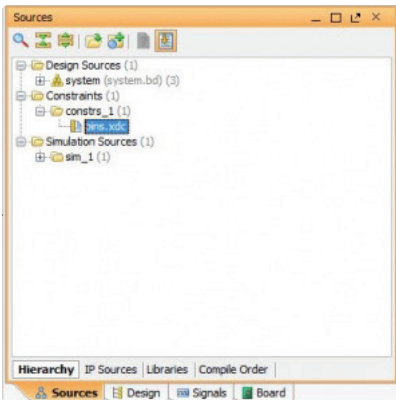
6.4) On the left of your block design, select the **Sources** tab, and right click in the window. Select **Add Sources...** and a window will open. Select **Add or create constraints** and click **Next**.



(https://reference.digilentinc.com/_media/zybo/7.jpg)

Create a new file, making sure the name has *no spaces*, and click **Finish**.

6.5) In the sources window, open the constraints folder to find your new .xdc file. Open it.



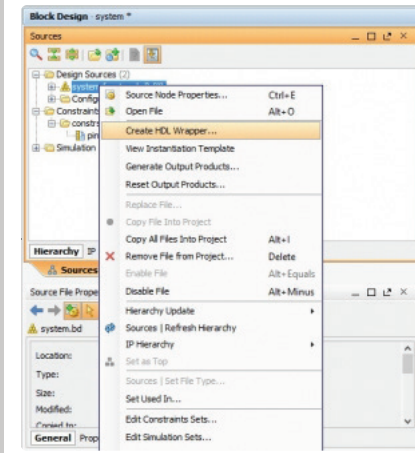
(https://reference.digilentinc.com/_media/zybo/8.jpg)

6.6) Copy the line below, and paste it within pins.xdc. This is the pin connected to Connector JB1.

```
set_property -dict { PACKAGE_PIN W12 IOSTANDARD LVCMOS33 } [get_ports { led_pin }];
```

6.7) Save pins.xdc and close it.

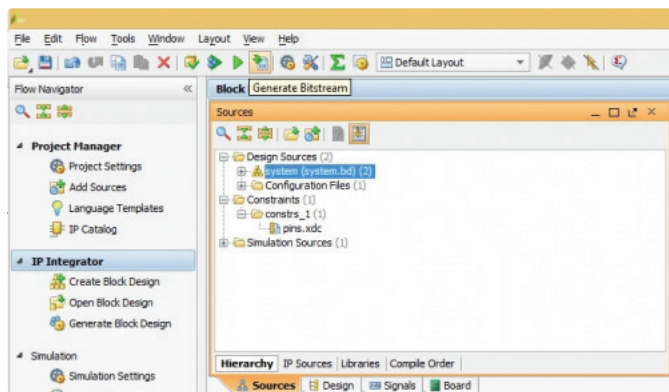
6.8) Right click **system.bd** and click **Create HDL Wrapper...**



(https://reference.digilentinc.com/_detail/arty/creathdl.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

7. Generating Bit File

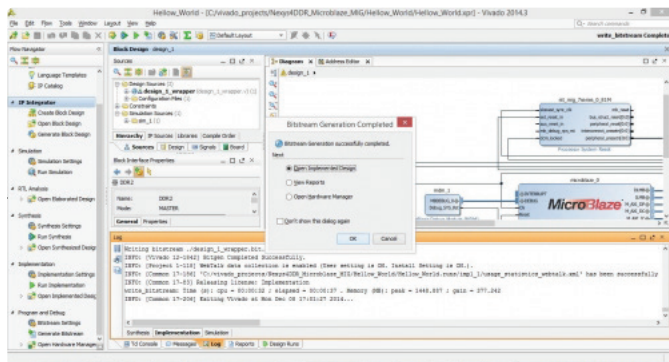
7.1) In the top toolbar, click **Generate Bitstream**. If you haven't already saved your design, you will get a prompt to save the block design.



([https://reference.digilentinc.com/_detail/arty/genbit.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/arty/genbit.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/arty/genbit.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart))

7.2) After the bitstream has been generated, a message prompt will pop-up on the screen. You don't have to open the Implemented Design for this demo. Just click on Cancel.



([https://reference.digilentinc.com/_detail/vivado/mig_42.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/vivado/mig_42.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

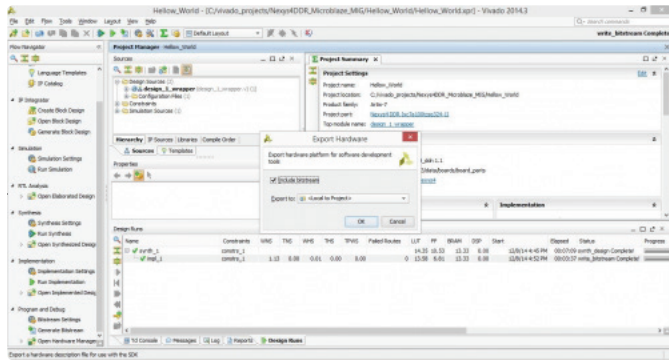
[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/vivado/mig_42.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart))

8. Exporting Hardware Design to SDK

8.1) On the top left corner of the window, from the tool bar click on **File** and select **Export Hardware**.

This will export the hardware design with system wrapper for the Software Development Tool - Vivado SDK.

Make sure the generated bitstream is included by checking the box.

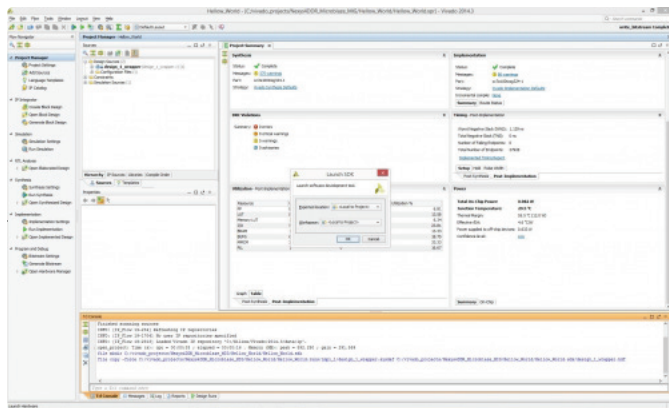


[https://reference.digilentinc.com/_detail/vivado/mig_43.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/vivado/mig_43.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/vivado/mig_43.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

9. Launching SDK

9.1) Go to *File* and select *Launch SDK* and click OK. The SDK file created local to the Vivado design project location will be launched. The hand-off to SDK from Vivado is complete.



[https://reference.digilentinc.com/_detail/vivado/mig_45.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/vivado/mig_45.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

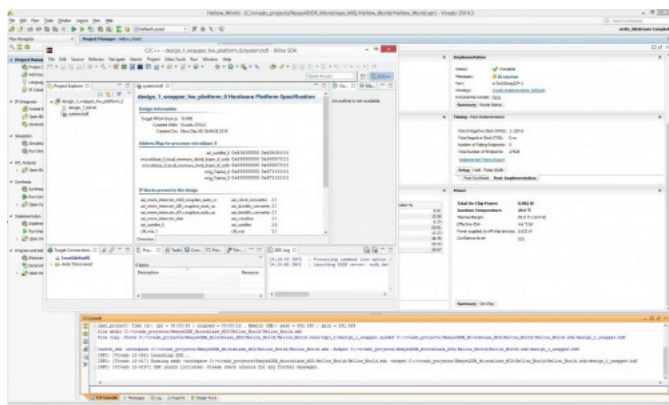
[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/vivado/mig_45.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

10. Inside SDK for Vivado

10.1) A new window for SDK will open. The HW design specification and included IP blocks are displayed in the *system.hdf* file. SDK tool is independent of Vivado, i.e. from this point, you can create your SW project in C/C++ on top of the exported HW design. If necessary, you can also launch SDK directly from the SDK folder created in the main Vivado Project directory.

Now, if you need to go back to Vivado and make changes to the HW design, then it is recommended to close the SDK window and make the required HW design edits in Vivado. After this you must follow the sequence of creating a new HDL wrapper, save design and bit file generation. This new bit file and system wrapper must then be exported to SDK.

Since we do not have any HW design edits at this point, we will proceed with creating a software application.



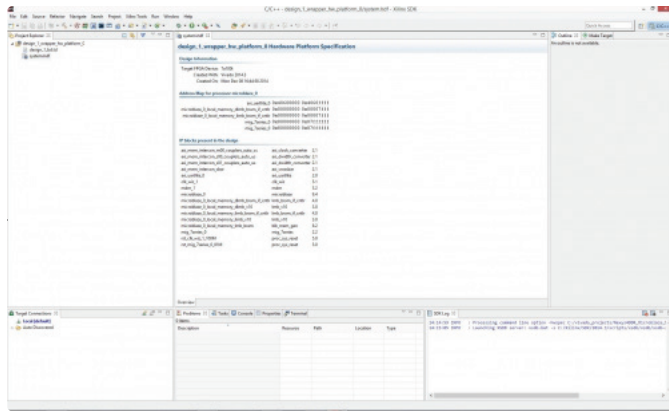
[https://reference.digilentinc.com/_detail/vivado/mig_46.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/vivado/mig_46.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/vivado/mig_46.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

10.2) On the left corner of the main SDK window, you will find the *Project Explorer* panel. Notice that there is a main project folder under the name **system_wrapper_hw_platform_0**.

system is the name of your block design created in Vivado. This hardware platform has all the HW design definitions, IP interfaces that have been added, external output signal information and local memory address information.

Say if at this point, you have closed SDK, made edits to your existing hardware design, and exported your design to SDK then after launching the SDK tool, you will find a new hardware platform called: **system_wrapper_hw_platform_1** in addition to the old HW design i.e. **system_wrapper_hw_platform_0**.



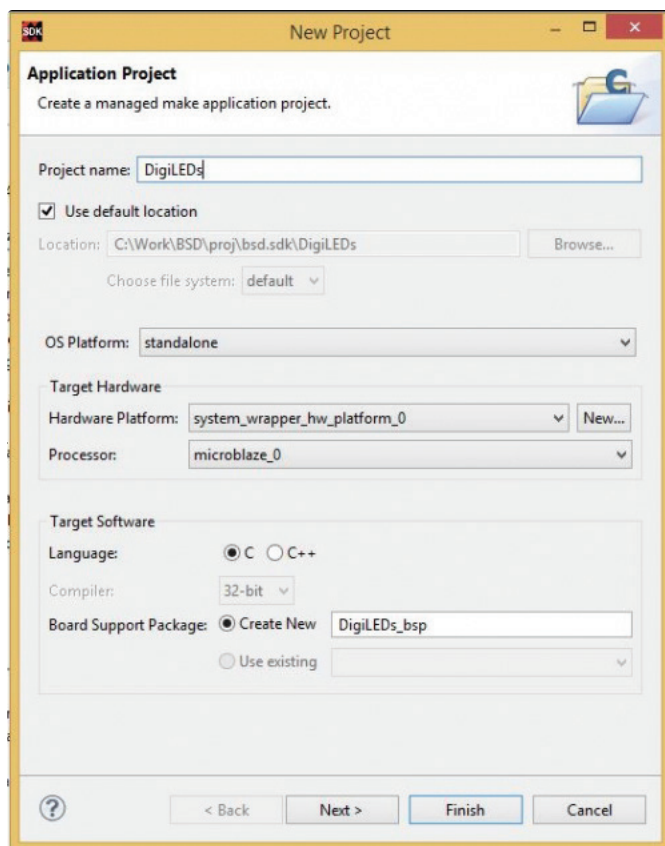
[https://reference.digilentinc.com/_detail/vivado/mig_47.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/vivado/mig_47.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/vivado/mig_47.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

11. Creating New Application Project in SDK

11.1) Go to *File* in the main tool bar and select **New Application Project**. A new project window will pop up.

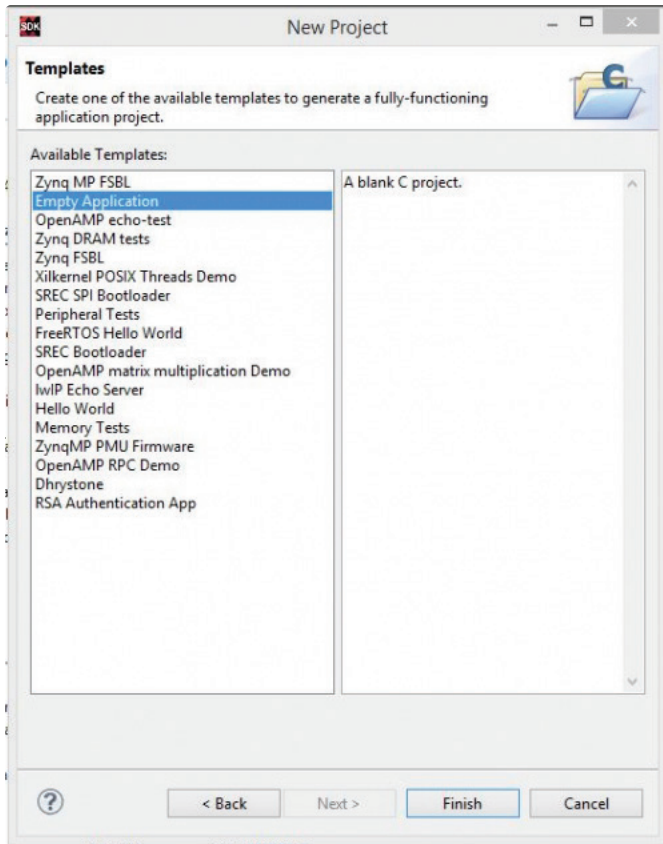
Give your SDK project a name that has no empty spaces such as "DigiLEDs". Make sure the *Target Hardware* is the correct hardware design. In our case, it will be "system_wrapper_hw_platform_0". Click "Next".



[https://reference.digilentinc.com/_detail/arty/digileds.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/arty/digileds.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/arty/digileds.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

11.2) Select **Empty Application** under *Available Templates* on the left panel and click Finish.



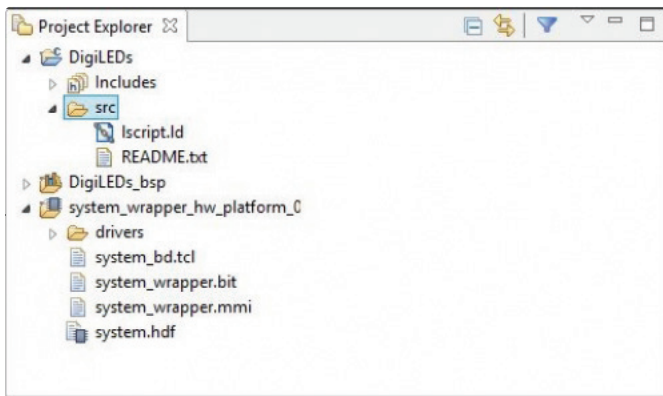
[https://reference.digilentinc.com/_detail/artyl/empty.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/artyl/empty.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

[logic%3Atutorials%3Azedboard-led-demo%3Astart](https://reference.digilentinc.com/_detail/artyl/empty.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

11.3) After completing the previous step, you will see two new folders in the *Project Explorer* panel.

****DigiLEDs**** which contains all the binaries, .C and .H (Header) files
****DigiLEDs_bsp**** which is the board support folder

DigiLEDs is our main working source folder. This also contains an important file shown here which is the "Iscript.ld". This is a Xilinx auto generated linker script file.



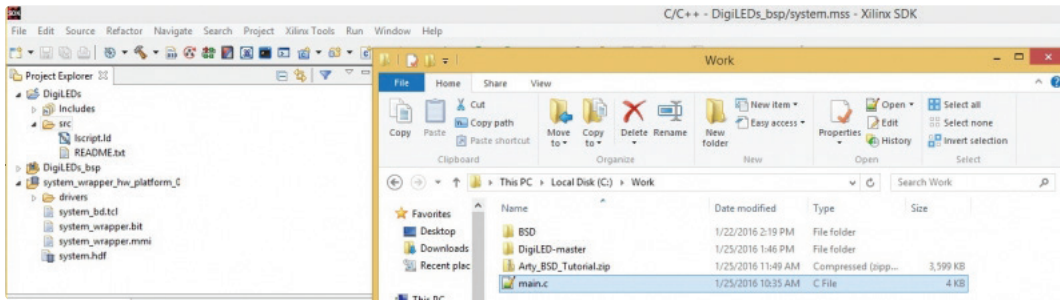
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12. Adding the Main Source File

12.1) Navigate to the "main.c" file.


12.2) Click and drag this main.c file into the **DigiLEDs/src** folder within Xilinx SDK. Choose to copy these source files into the project and click OK.



https://reference.digilentinc.com/_detail/artv/import.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart

13. Programming FPGA with Bit File

13.1) Make sure that the Zedboard is turned on and connected to the host PC with the provided micro USB cable.

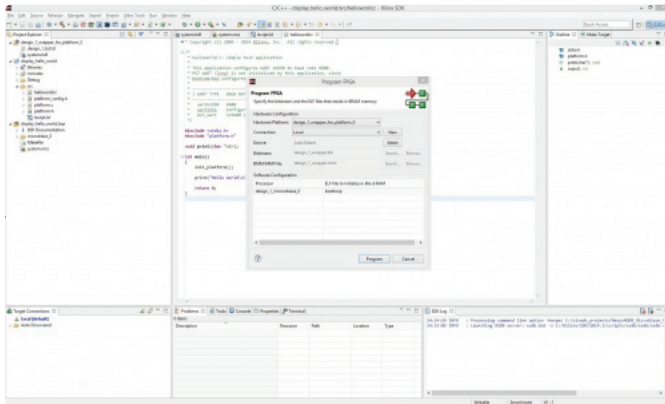
In the quick selection tool bar, you will find a symbol with a red arrow and three green square boxes.  https://reference.digilentinc.com/_detail/artv/programfpga.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart

Click on this symbol to open the Program FPGA window.

Make sure that the *Hardware Platform* is selected as **system_wrapper_hw_platform_0**.

In the software configuration box, under *ELF File to Initialize in Block RAM ()* column, the row option must read **bootloop**. If not, click on the row and select **bootloop**.

Now click on Program.

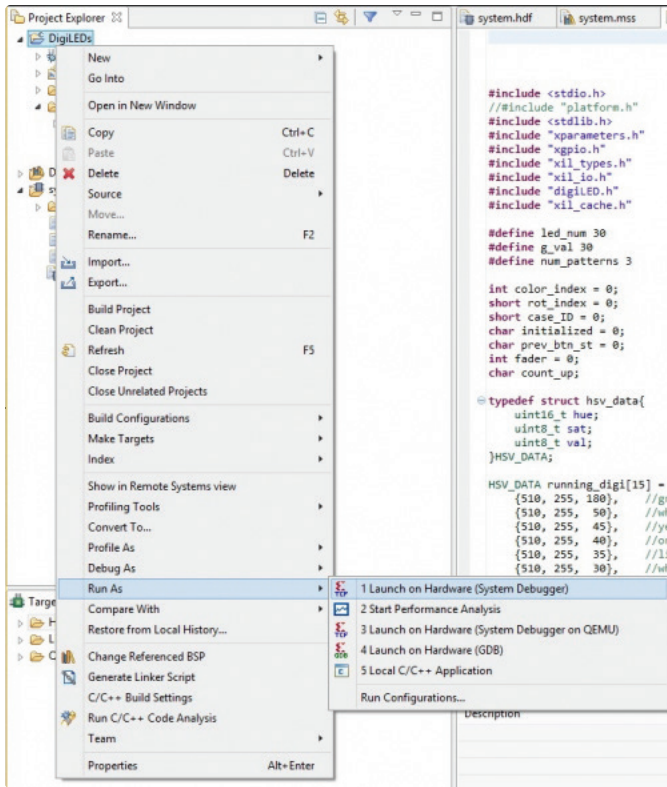


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14. Program the Zynq Processor

14.1) After the FPGA has been successfully programmed with the bit file, from the *Project Explorer* panel, right click on the “**DigiLEDs**” project folder. Go to “**Run As**” and select “**Launch on Hardware (System Debugger)**”



([https://reference.digilentinc.com/_detail/arty/program.jpg?id=learn%3Aprogrammable-](https://reference.digilentinc.com/_detail/arty/program.jpg?id=learn%3Aprogrammable-logic%3Atutorials%3Azedboard-led-demo%3Astart)

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Your Zedboard will then start the DigiLEDs Demo. Pressing Button 0 will cycle through three patterns on the RGB LED () strip.

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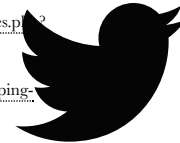
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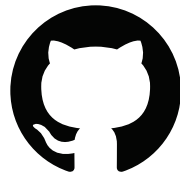
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