# FMC-IMAGEON
# HDMI Pass-Through
# Tutorial

Version 1.0

# Revision History

| Version | Description | Date |
|---|---|---|
| 1.0 | HDMI Pass-Through Tutorial<br>• Vivado 2013.3 version | Mar 06, 2014 |

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# About this Guide

This tutorial describes how to create a Vivado IP Integrator video design from scratch.

This manual contains the following chapters:

- Chapter "**Introduction**" provides an overview and features of the FMC-IMAGEON FMC module, as well as the hardware and software required for this tutorial.
- Chapter "**Tutorial Overview**" provides a general overview of this tutorial.
- Chapter "**Implement an HDMI Pass-Through**" describes the steps required to implement an Embedded System that implements an HDMI pass-through.
- Appendix "**References**" provides a list of references to documentation related to the FMC module.
- Appendix "**Known Issues and Limitations**" provides a list of known issues and limitations with the tools and/or IP used in this tutorial.
- Appendix "**Troubleshooting**" provides a list of troubleshooting suggestions for this tutorial.

## Additional Documentation

For more information on the VITA-2000 image sensor, please visit the following resources.


- **VITA2000: 2.3 Megapixel, 92 FPS, Global Shutter CMOS Image Sensor**
  - VITA-2000 Product Information
    http://www.onsemi.com/PowerSolutions/product.do?id=VITA2000

For more information on the Analog Devices HDMI devices, please visit the following resources.


- **ADV7511 HDMI Transmitter**
  - ADV7511 Product Information
    http://www.analog.com/adv7511
  - ADV7511 Technical Resources on EngineerZone
    http://ez.analog.com/docs/DOC-1740

- **ADV7611 HDMI Receiver**
  - ADV7611 Product Information
    http://www.analog.com/adv7611
  - ADV7611 Technical Resources on EngineerZone
    http://ez.analog.com/docs/DOC-1745

## Additional Support Resources

To access the most current collateral for the FMC-IMAGEON FMC module, please visit the product website at:

http://www.em.avnet.com/fmc-imageon

To access the most current collateral for the On Semi Image Sensor FMC bundle, which includes this FMC module, please visit the product website at:

http://www.em.avnet.com/fmc-imageon-v2000-c

Once on the product website:

To access the latest documentation and designs, click on the following link:


To access the commiunity forums, visit the following web link:

http://community.em.avnet.com/

To search the database of silicon and software questions and answers or to create a technical support case in WebCase, see the Xilinx website at:

http://www.xilinx.com/support

# Introduction

The ON Semiconductor Image Sensor FMC bundle provides several high-definition video interfaces for Xilinx® FMC-enabled baseboards. The FMC module has on-board HDMI input/output interfaces. The ON Semiconductor VITA-2000-color image sensor module provides a high definition camera supporting high frame rates and featuring a global shutter.

This FMC bundle is ideal for developing application for machine vision, motion monitoring, and high-end security and surveillance.

**Figure 1 – ON Semiconductor Image Sensor with HDMI Input/Output FMC Bundle**

As illustrated in Figure 2 and Figure 3, the FMC module connects to an FMC carrier, and provides the following interfaces:

- HDMI Input
- HDMI Output
- LCEDI Interface for VITA Image Sensor modules

The following block diagram illustrates how the connectivity of the FMC module.

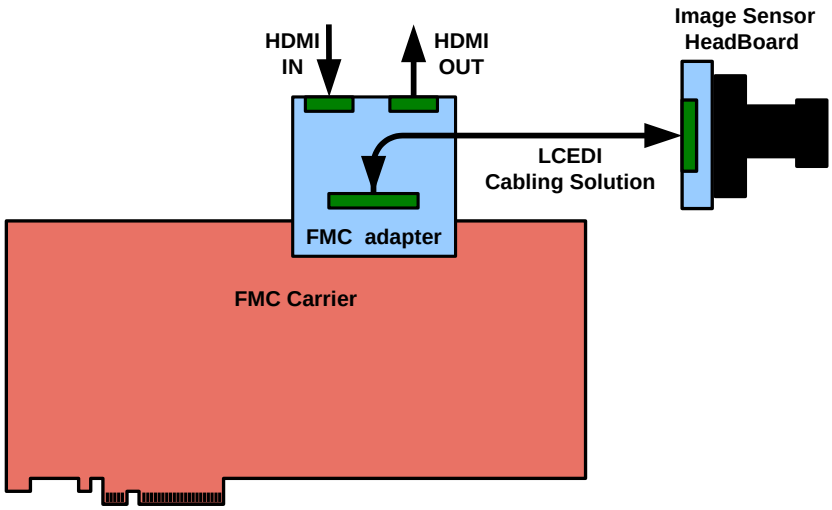



**Figure 2 – FMC-IMAGEON Hardware – Connectivity Diagram**

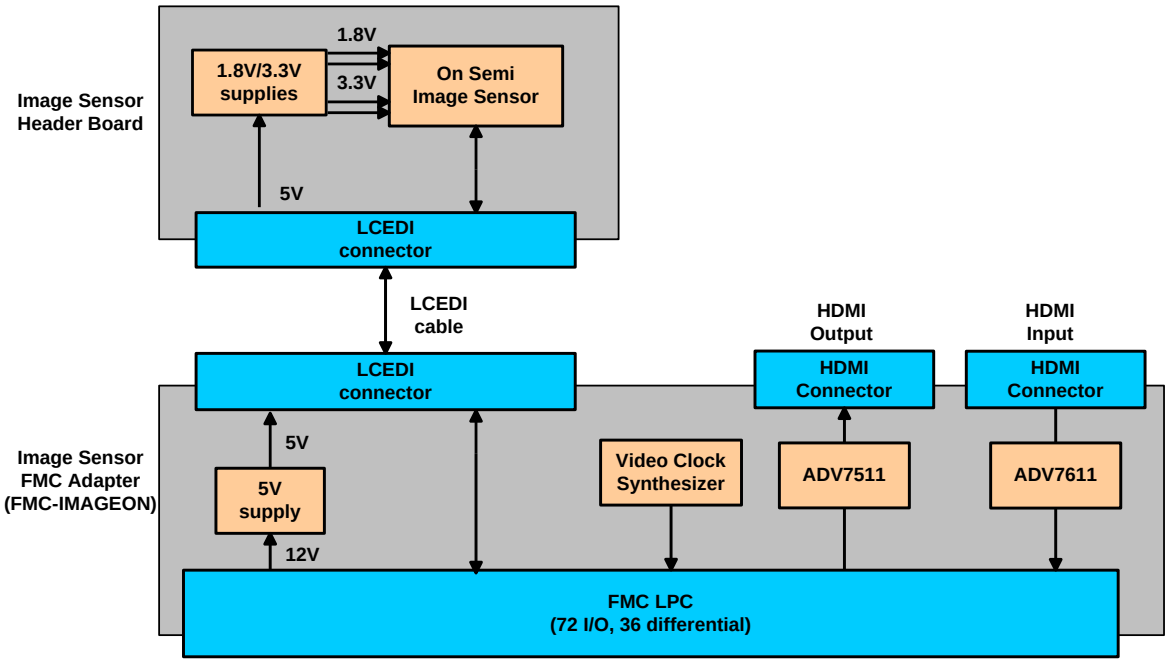



**Figure 3 – FMC-IMAGEON Hardware – Block Diagram**

## Requirements

The software and hardware requirements for this tutorial are described in the following sections.

### Software

The software required to build, and run the demonstrations is:

- Xilinx Vivado 2013.3
- Terminal Emulator (HyperTerminal or TeraTerm)

### Hardware

The bare minimum required to run this reference design is:

- Computer with a minimum of 4 GB to complete a design[1]
- One of the following Zynq carriers
    - ZC702 (including power supply and cables)
    - ZedBoard (including power supply and cables)
- The Avnet HDMI Input/Output FMC Module (FMC-IMAGEON)
- HDMI (or DVI-D) monitor, including HDMI cable
- HDMI source (non-encrypted content) or DVI-D source, including HDMI cable

### Zynq embedded design tools

This tutorial assumes that you have experience creating Zynq embedded designs. More specifically, it assumes a working knowledge of Vivado tools, including IPI (Vivado IP Integrator) and SDK.

If you do not have this experience, it is HIGHLY recommended that you follow the **Introduction to Zynq** on-line training course, available on zedboard.org.
http://www.zedboard.org/course/introduction-zynq

### Xilinx Video IP

This tutorial will make use of several of Xilinx's Video IP cores.

[1] Refer to http://www.xilinx.com/design-tools/vivado/memory.htm

Although it is possible to complete this tutorial without consulting the datasheets for these Video IP cores, it is strongly recommended to consult the datasheets for each Video IP core to fully understand and appreciate their potential.

**Video Timing Controller**
http://www.xilinx.com/products/intellectual-property/EF-DI-VID-TIMING.htm

**Video Input to AXI4-Stream**
http://www.xilinx.com/products/intellectual-property/video_in_to_axi4_stream.htm

**AXI4-Stream to Video Output**
http://www.xilinx.com/products/intellectual-property/axi4_stream_to_video_out.htm

**AXI Video DMA**
http://www.xilinx.com/products/intellectual-property/axi_video_dma.htm
In particular interest is the “Triple Frame Buffer Example” chapter

For the full list of Xilinx Video IP Cores, refer to the following web page:
http://www.xilinx.com/ipcenter/video/video_core_listing.htm

## Setup

Before you begin this tutorial, carefully read the following sections which will describe how to extract the tutorial archive and how to test your video equipment.

### Extract the tutorial archive on your computer

Extract the tutorial archive in the root of your C:\ drive. It will contain the following directories

C:\FMC_IMAGEON\2013_3\avnet_fmc_imageon_cores
C:\FMC_IMAGEON\2013_3\constraints
C:\FMC_IMAGEON\2013_3\code
C:\FMC_IMAGEON\2013_3\scritps

### Test your DVI-D or HDMI equipment

Before going through this tutorial, test your DVI-D and/or HDMI equipment:

1. Connect your DVI-D or HDMI source to your DVI-D or HDMI monitor
2. Verify that you can see the video source on your monitor
3. Using the menu settings on your DVI-D or HDMI monitor to validate the video resolution of your DVI-D or HDMI source. Make sure that it is generating one of the following supported video resolutions

| Resolution | Pixel Rate (MHz) | Frame Dimensions | Frame Rate |
|---|---|---|---|
| 1080P60 | 148.5 MHz | 1920 x 1080 | 60 Hz |
| SXGA | 110 MHz | 1280 x 1024 | 60 Hz |
| 720P60 | 74.25 MHz | 1280 x 720 | 60 Hz |
| XGA | 65 MHz | 1024 x 768 | 60 Hz |
| SVGA | 40 MHz | 800 x 600 | 60 Hz |
| 576P50 | 27 MHz | 720 x 576 | 50 Hz |
| 480P60 | 27 MHz | 720 x 480 | 60 Hz |
| VGA | 25.175 MHz | 640 x 480 | 60 Hz |

**Table 1 – Supported Video Resolutions**

# Tutorial Overview

This tutorial will guide you in creating a video design that implements an HDMI pass-through for the Avnet HDMI Input/Output FMC module.

## Reusable Components

The tutorial will make use of reuseable components for the video input and video output interfaces:

- IP Cores, for each of the video interfaces on the FMC-IMAGEON module
  - FMC-IMAGEON – HDMI Input
  - FMC-IMAGEON – HDMI Output
  - FMC-IMAGEON – VITA Receiver

- TCL scripts, which automatically create IP Integrator sub-modules

  For a 16 bits YUV 4:2:2 pass-through design:
  - **fmc_imageon_hdmii_yuv422.tcl** : video input path, 16 bits YUV 4:2:2 format
  - **fmc_imageon_hdmio_yuv422.tcl** : video output path, 16 bits YUV 4:2:2 format

  For a 24 bits RGB pass-through design:
  - **fmc_imageon_hdmii_rgb.tcl** : video input path, 24 bits RGB format
  - **fmc_imageon_hdmio_rgb.tcl** : video output path, 24 bits RGB format

- XDC constraints, which define pinout and constraints for various carriers
  - **zc702_fmc_imageon_hdmi_pasthrough.xdc** : constraints for ZC702
  - **zedboad_fmc_imageon_hdmi_pasthrough.xdc** : constraints for ZedBoard

- C source code, which provides example initialization code
  - **fmc_imageon_hdmi_passthrough.c/.h** : initi code for HDMI pass-through

For more information on these reusable components, refer to the **FMC-IMAGEON - IP CORES for Vivado** document.

## HDMI Pass-Through Overview

The user may choose to implement a video pass-through for two video formats.

One pass-through will make the 16 bits YUV 4:4:2 video format available for the user, which corresponds to the video format of the external HDMI input (ADI ADV7611) and HDMI output (ADI ADV7511) devices

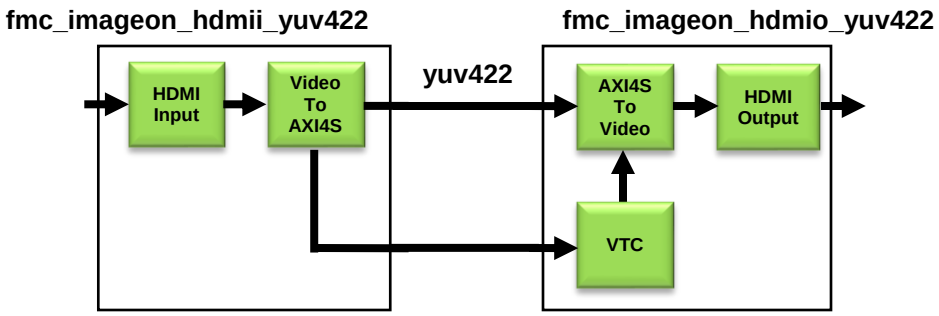



**Figure 4 –HDMI Pass-Through – 16 bits YUV 4:2:2**

An alternate pass-through makes us of the Chroma Resample (422 To 444 / 444 To 422) and Color Space Conversion (YUV to RGB / RGB to YUV) cores to make the 24 bits RGB video format available to the user.

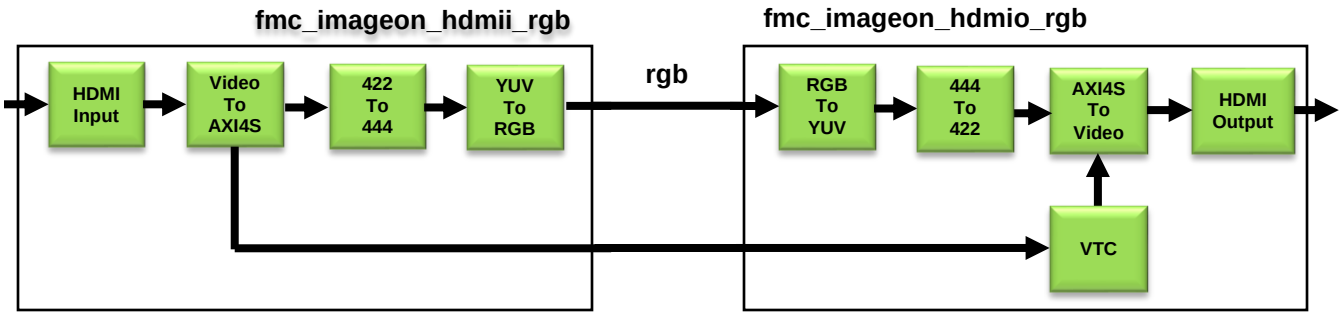



**Figure 5 –HDMI Pass-Through – 24 bits RGB**

## Embedded Design with Processor

This design requires an embedded design that contains a processor, as well as the following peripherals:

- external memory
- serial port (UART or USB-UART)

This tutorial will create a Zynq based embedded design.

Alternatively, for non-Zynq based carriers, a MicroBlaze based embedded design can also be created. However, this is not described in this tutorial, and left as an exercise to the user.

## FMC-IMAGEON - I2C Controller

Once the embedded processor design is created, an I2C controller is implemented with the following Xilinx IP core:

- AXI I2C Controller
  - not shown in the previous block diagram, this core will allow the processor to configure the FMC-IMAGEON hardware peripherals, including:
    - ADV7611 : HDMI input device
    - ADV7511 : HDMI output device
    - CDCE913 : video clock synthesizer

## FMC-IMAGEON – Video Interfaces

The following cores, provided with the tutorial, will be used to interface to the ADV7611 and ADV7511 devices on the FMC-IMAGEON module. It is important to note that, on the FMC-IMAGEON module, these devices are used in 16 bits YCbCr 4:2:2 with “embedded sync” mode.

- FMC-IMAGEON HDMI Input
  - this core contains logic that will extract the embedded synchronization signals from the 16 bit video data received from the ADV7611 HDMI input device.
- FMC-IMAGEON HDMI Output
  - this core contains logic that will embed the synchronization signals in the 16 bit video data sent to the ADV7511 HDMI output device.

The HDMI Input and HDMI Output IP cores make a generic parallel video interface available to the design.

## AXI4-Stream Bridges

The following cores, are used to bridge between the HDMI interfaces and the AXI4-Stream protocol.

- Video Timing Controller
  - this core is capable of:
    - detecting the video timing on a video input interface
    - (re)generating video timing for a video output interface
  - a single VTC core will be used:
    - the video timing of the video input will be detected by the detector portion of the VTC core
    - the generator portion of the VTC core will be synchronized to the detector, thus re-generating the same video timing on the output
- Video Input to AXI4-Stream
  - this core converts a generic parallel video interface (ie. DVI/HDMI) to the AXI4-Stream for Video protocol
  - the core includes a FIFO allowing the AXI4-Stream for Video interface to run on a different clock

- AXI4-Stream to Video Output
    - this core generates a generic parallel video interface (ie. DVI/HDMI) from a AXI4-Stream for Video interface
    - the core includes a FIFO allowing the AXI4-Stream for Video interface to run on a different clock

To illustrate the back-pressure capability of the AXI4-Stream interface, this video pipeline will be implemented with two separate clock domains. The input and output interfaces will be running on the HDMI input interface's video clock. The AXI4-Stream interface will be running on a separate clock.

# Implement an HDMI Pass-Through

In this section, a new Vivado project will be created, implementing the HDMI pass-through design for the Avnet FMC-IMAGEON module.

## Licensing the Video and Image Processing Pack IP Cores

This design uses several of the Xilinx Video and Image Processing Pack IP cores that must be licensed prior to use. Follow these steps to request an evaluation license:

1. Go to:
   www.xilinx.com/products/intellectual-property/EF-DI-VID-IMG-IP-PACK

2. Click the Evaluate link located on the upper-left of the web page,
   and follow the online instructions


3. The generated license file is sent by email. Follow the enclosed instructions to add the evaluation license features for the Video and Image Processing Pack.

## Create a new Vivado project

To create a new project, start the Vivado™ design and analysis software and create a project with an embedded processor system as the top level.

1. Start the Vivado 2013.3 software.
2. Select **Create New Project** to open the New Project wizard
3. Use the information in the table below to make your selections in the wizard screen

| Wizard Screen | System Property | Setting or Command to Use |
|---|---|---|
| Project Name | Project name | Specify the project name, such as:<br>**tutorial** |

| | | |
|---|---|---|
| | Project location | Specify the directory in which to store the project files: **C:\FMC_IMAGEON\2013_3** |
| | Create Project Subdirectory | Leave this checked. |
| Project Type | Specify the type of project to create | Use the default selection, specify **RTL Project**. |
| Add Sources | | Do not make any changes on this screen. |
| Add Existing IP | | Do not make any changes on this screen. |
| Add Constraints | | Do not make any changes on this screen. |
| Default Part | Specify | Select **Boards**. |
| | Filter | In the Family list, select **Zynq-7000** |
| | Board list | Select one of the following board: **Zynq-7 ZC702 Evaluation Board** or **ZedBoard Zynq Evaluation and Development Kit** |
| New Project Summary | Project summary | Review the project summary before clicking **Finish** to create the project. |

**Table 2 – New Project Settings**

When you click **Finish**, the New Project wizard closes and the project you just created opens in Vivado.

## Create the Embedded Hardware Design with IP Integrator

This section will guide you on how to create a basic embedded hardware design. This section may differ slightly for different carriers.

Create a new Vivado IP Integrator block diagram.

1. Click **Create Block Design** in the **IP Integrator** flow navigator.
   The Create Block Design dialog opens.
2. Specify a design name for the block diagram and click **OK**.
3. Click **Next**.

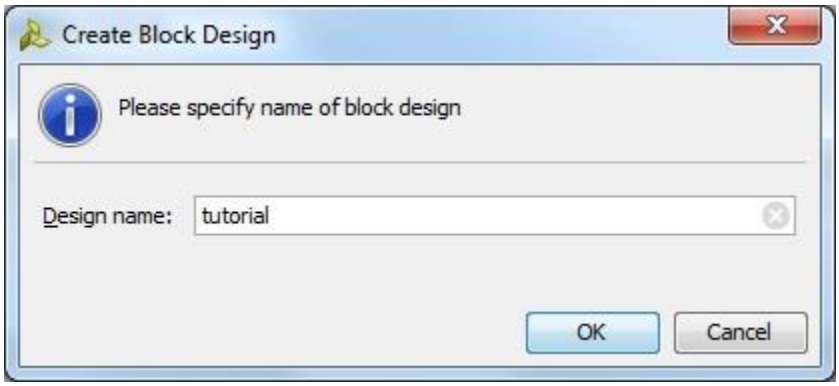


**Figure 6 – Create Block Design**

Notice that Vivado IP Integrator provides design assistance:


**Figure 7 – Designer Assistance – Add IP**

Add the ZYNQ7 Processing System core to the block design.

4. Click **Add IP** in the design assistance
   or
   **Right-click** in the block design, then select **Add IP**.
5. Select the **ZYNQ7 Processing System** core,
   then click **ENTER** (or double-click selection)

Notice that Vivado IP Integrator provides additional design assistance:

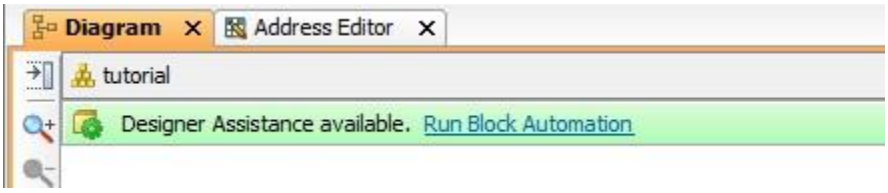



**Figure 8 – Designer Assistance – Run Block Automation**

Configure the ZYNQ7 Processing System core using the designer assistance:

6. Click **Run Block Automation** in the design assistance
7. Select **/processing_system7_0**
8. Make sure the **Apply Board Preset** option is selected.
9. Click **OK**.

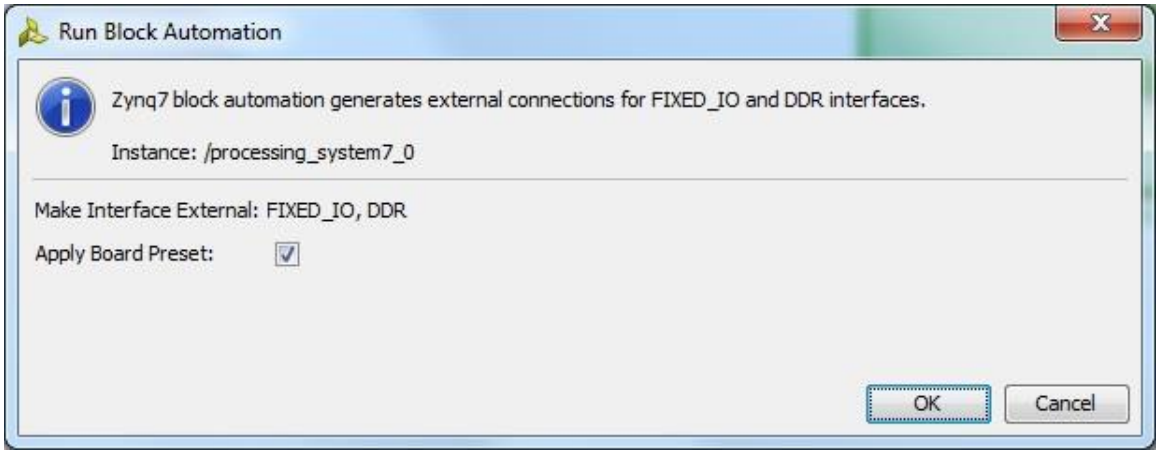



**Figure 9 –Run Block Automation**

## Add the I2C Controller

Add the **AXI IIC** IP core to the design, which will be used to configure the I2C peripherals on the FMC module.

1. **Right-click** in a blank portion of the block design, then select **Add IP**.
2. Select the **AXI IIC** core,
   then click **ENTER** (or double-click selection)

Rename the IIC controller to fmc_imageon_iic_0.

3. Select the **AXI IIC** core in the block diagram.
4. In the **Block Properties** dialog,
   modify the **Name** of the block to **fmc_imageon_iic_0**

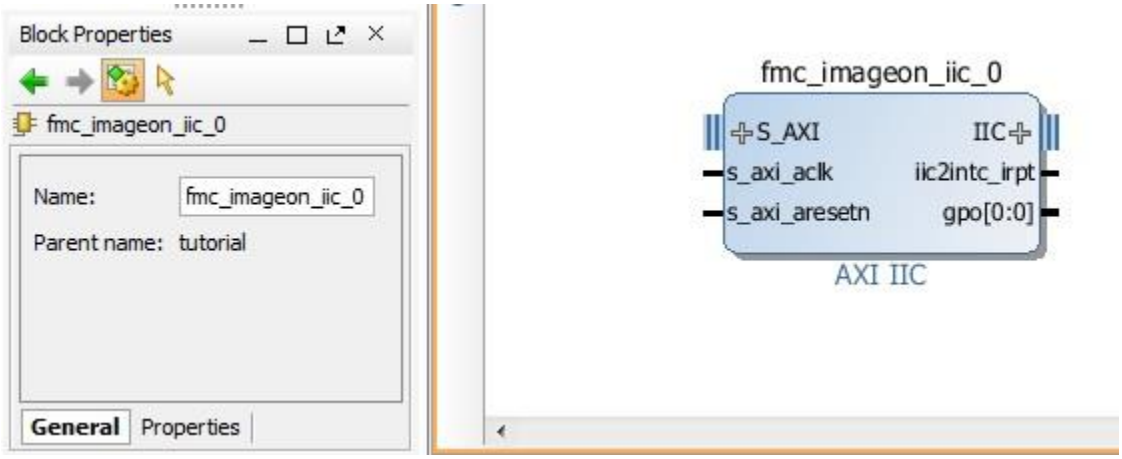



**Figure 10 – AXI IIC - Block Properties**

Use the designer assistance to connect the AXI IIC core to the ZYNQ7 Processing System's GP0 port.

5. Click **Run Connection Automation** in the design assistance
6. Select **/fmc_imageon_iic_0/S_AXI**
7. Click **OK**.

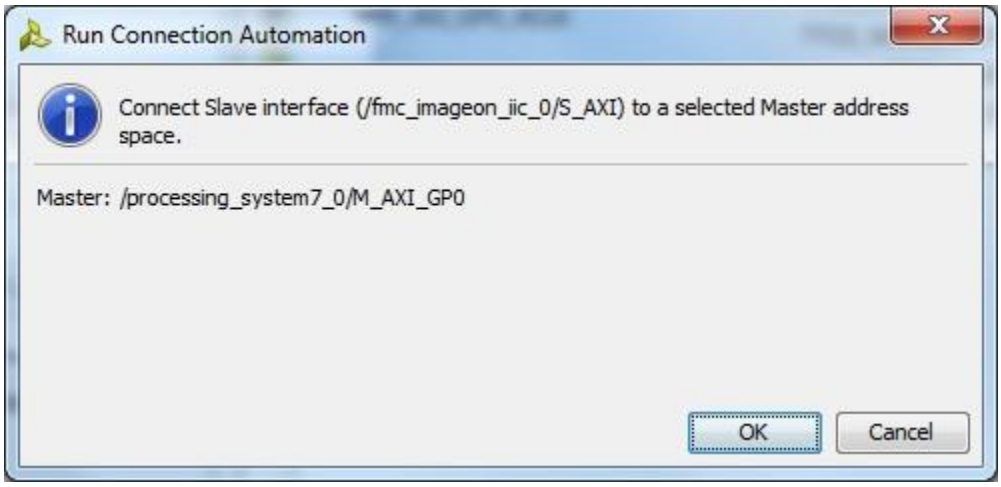



**Figure 11 – Run Connection Automation – /fmc_imageon_iic_0/S_AXI**

Use the designer assistance to connect the AXI IIC core's external I/O

8. Click **Run Connection Automation** in the design assistance
9. Select **/fmc_imageon_iic_0/IIC**
10. [If the **Select Board Interface** drop down list appears, specify **Custom**]
11. Click **OK**.

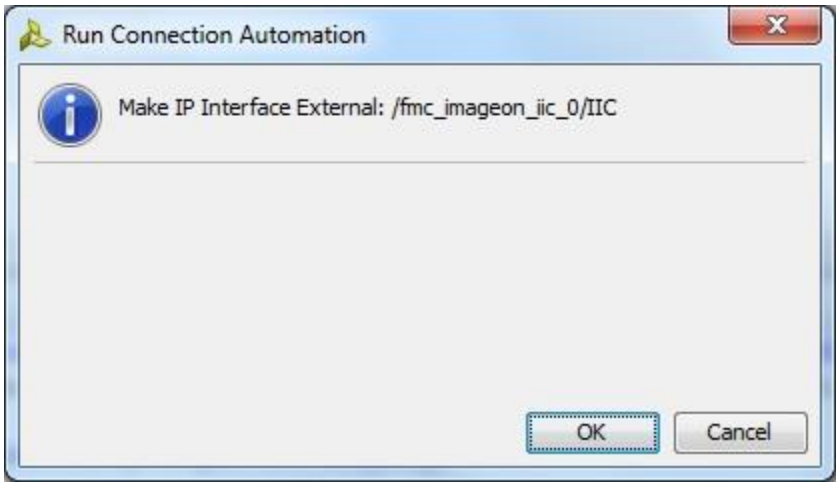



**Figure 12 – Run Connection Automation – /fmc_imageon_iic_0/IIC**

Rename the external iic_rtl port to fmc_imageon_iic

12. Select the **iic_rtl** external port in the block diagram.
13. In the **External Interface Properties** dialog, modify the **Name** of the block to **fmc_imageon_iic**

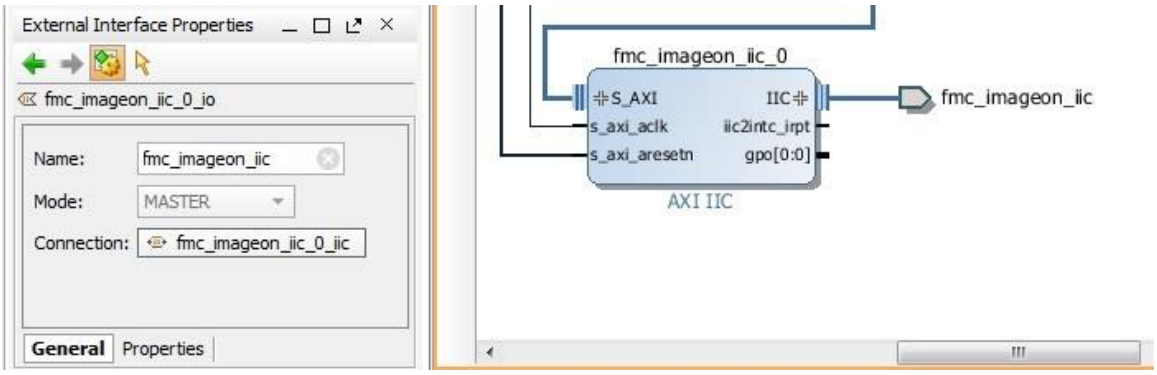



**Figure 13 – External Interface Properties – fmc_imageon_iic**

Connect the AXI IIC core's gpo[0:0] port to an external port

14. Select the **gpo[0:0]** port on the AXI IIC core
15. **Right-click**, then select **Make External**

Rename the external gpo[0:0] port to fmc_imageon_iic_rst_n

16. Select the **gpo[0:0]** external port in the block diagram.
17. In the **External Interface Properties** dialog, modify the **Name** of the block to **fmc_imageon_iic_rst_n**

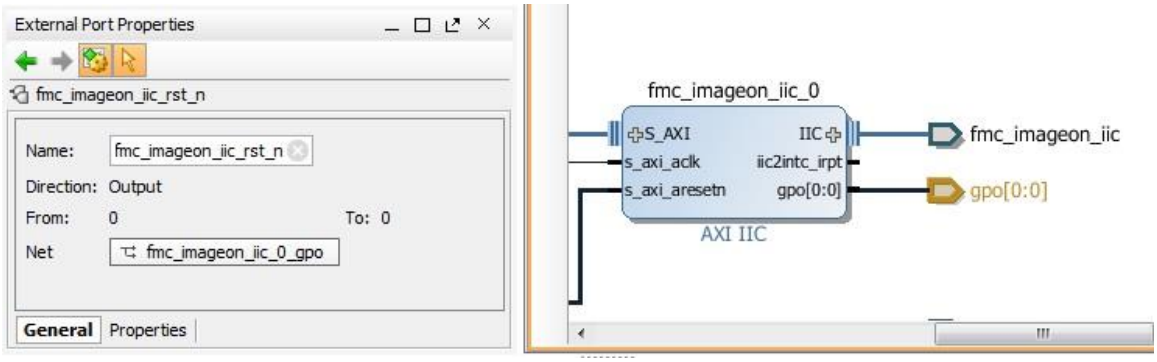



**Figure 14 – External Interface Properties – fmc_imageon_iic_rst_n**

At this point, validate that you have a correct design.

18. **Right-click** in a blank portion of the block design, then select **Validate Design**

19. If successful, Click **OK** and proceed with the next section.
    Otherwise, fix any errors in the design before proceeding.


**Figure 15 – Validate Design**

## Add the Video Pipeline

The video pipeline will make use of Avnet provided IP cores. In order for Vivado Design Suite to recognize these cores, we need to add the location of the Avnet FMC-IMAGEON cores to the repository path.

1. In the Vivado menu, select **Tools** => **Project Settings**.
   The Project Settings dialog opens.
2. Click on the IP icon on the left.
3. In the **Repository Manager** tab, click the **Add Repository** button.
4. Specify the "**C:\FMC_IMAGEON\2013_3\avnet_fmc_imageon_cores**" directory, then click the **Select** button.

The following three IP cores should be detected and appear in the **IP in Selected Repository** window:

- FMC-IMAGEON - HDMI Input
- FMC-IMAGEON - HDMI Output
- FMC-IMAGEON - VITA Receiver

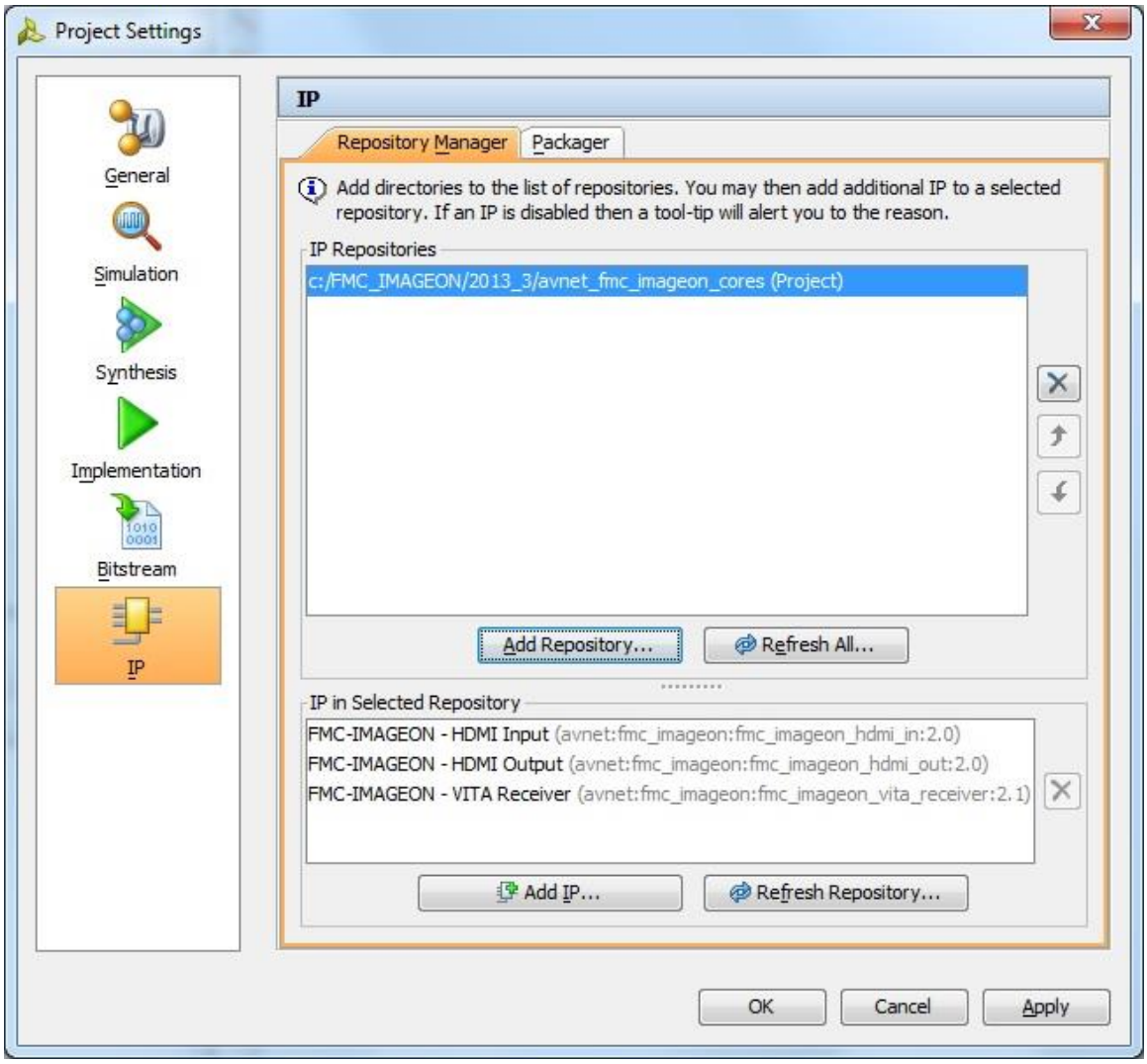



**Figure 16 – IP Repository Manager**

5. Click **OK**.

The HDMI input and output interfaces will be created with TCL scripts.

If you want the 16 bits YUV 4:2:2 video format to be made available in your design, run the following two TCL scripts:

- **fmc_imageon_hdmii_yuv422.tcl** : video input path, 16 bits YUV 4:2:2 format
- **fmc_imageon_hdmio_yuv422.tcl** : video output path, 16 bits YUV 4:2:2 format

If you want the 24 bits RGB video format to be made available in your design, run the following two TCL scripts:

- **fmc_imageon_hdmii_rgb.tcl** : video input path, 24 bits RGB format
- **fmc_imageon_hdmio_rgb.tcl** : video output path, 24 bits RGB format

Use the TCL console to run the two TCL scripts you have chosen. This tutorial will make use of the 16 bits YUV 4:2:2 video format, but the tutorial instructions can also be applied when making use of the 24 bits RGB 4:4:4 video format.

6. In the **Tcl Console**, type the following command to generate the video input path
   **source C:/FMC_IMAGEON/2013_3/scripts/fmc_imageon_hdmii_yuv422.tcl**
   then press {ENTER}
7. In the **Tcl Console**, press {UP ARROW} to repeat the previous command,
   edit the command to generate the video output path.
   **source C:/FMC_IMAGEON/2013_3/scripts/fmc_imageon_hdmio_yuv422.tcl**
   then press {ENTER}

This will create two new video sub-modules in your block diagram.

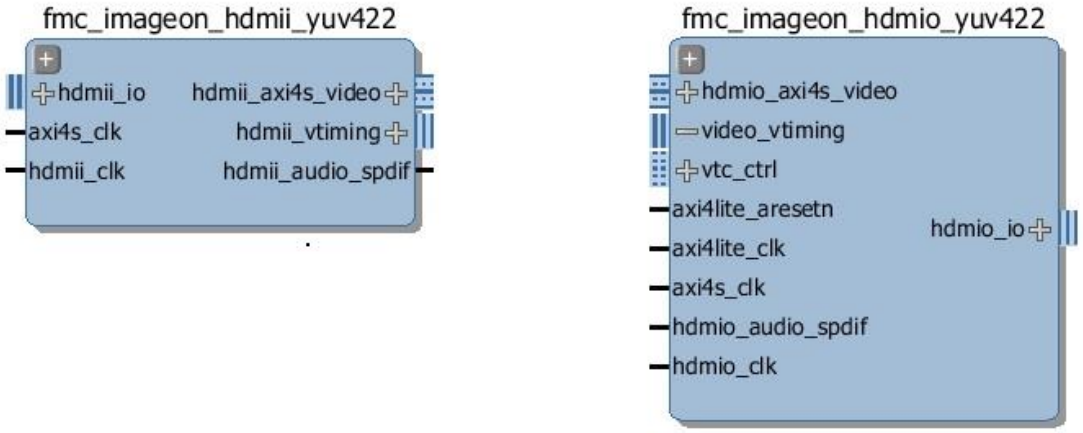



**Figure 17 – HDMI input/output sub-modules**

Connect the AXI4-Lite clock to the ZYNQ7 Processing System's FCLK_CLK0 port.

1. Select the fmc_imageon_hdmio_yuv422 sub-module's **axi4lite_clk** port
2. Click and hold the left mouse button, then drag to the ZYNQ7's **FCLK_CLK0** port.
3. Release the mouse button to make the connection

Connect the AXI4-Lite resets to the proc_sys_reset core's peripheral_aresetn port.

4. Select the fmc_imageon_hdmio_yuv422 sub-module's **axi4lite_aresetn** port
5. Click and hold the left mouse button, then drag to the proc_sys_reset core's **peripheral_aresetn[0:0]** port.
6. Release the mouse button to make the connection

Use the designer assistance to connect the VTC core's control port (vtc_ctrl) to the ZYNQ7 Processing System's GP0 port.

7. Click **Run Connection Automation** in the design assistance
8. Select **/fmc_imageon_hdmio_yuv422/vtc_ctrl**
9. Click **OK**.

Configure the ZYNQ7 Processing System to generate a 150MHz clock on its FCLK_CLK1 port, which will be used for the AXI4-Stream based interconnect and cores.

10. Double-click on the ZYNQ7 Processing System core.
11. Click on the **Clock Generation** block
12. Expand the **PL Fabric Clocks** section
13. Select the **FCLK_CLK1** clock
14. Specify a **Requested Frequency** of **150MHz**.
15. Click **OK**.

Connect the AXI4-Stream clocks to the ZYNQ7 Processing System's FCLK_CLK1 port.

16. Select the fmc_imageon_hdmii_yuv422 sub-module's **axi4s_clk** port
17. Click and hold the left mouse button, then drag to the ZYNQ7's **FCLK_CLK1** port.
18. Release the mouse button to make the connection.

19. Select the fmc_imageon_hdmio_yuv422 sub-module's **axi4s_clk** port
20. Click and hold the left mouse button, , then drag to the ZYNQ7's **FCLK_CLK1** port.
21. Release the mouse button to make the connection.

Create an external port for the HDMI input clock in the block diagram.

22. **Select** the fmc_imageon_hdmii_yuv422 sub-module's **hdmii_clk** port
23. **Right-click**, then select **Make External**

Connect the HDMI output clock to the HDMI input clock.

24. Select the fmc_imageon_hdmio_yuv422 sub-module's **hdmio_clk** port
25. Click and hold the left mouse button, then drag to the **hdmii_clk** net.
26. Release the mouse button to make the connection.

Connect the HDMI I/O ports (hdmii_io & hdmio_io) to external ports

27. **Select** the fmc_imageon_hdmii_yuv422 sub-module's **hdmii_io** port
28. **Right-click**, then select **Make External**

29. **Select** the fmc_imageon_hdmio_yuv422 sub-module's **hdmio_io** port
30. **Right-click**, then select **Make External**

Connect the HDMI input and HDMI output sub-modules together, implementing a video pass-through.

31. **Select** the fmc_imageon_hdmii_yuv422 sub-module's **hdmii_axi4s_video** port
32. Click and hold the left mouse button,
    then drag to the fmc_imageon_hdmio_yuv422 sub-module's **hdmio_axi4s_video**
33. Release the mouse button to make the connection.

34. **Select** the fmc_imageon_hdmii_yuv422 sub-module's **hdmii_audio_spdif** port
35. Click and hold the left mouse button,
    then drag to the fmc_imageon_hdmio_yuv422 sub-module's **hdmio_audio_spdif**
36. Release the mouse button to make the connection.

37. **Select** the fmc_imageon_hdmii_yuv422 sub-module's **hdmii_vtiming** port
38. Click and hold the left mouse button,
    then drag to the fmc_imageon_hdmio_yuv422 sub-module's **video_vtiming**
39. Release the mouse button to make the connection.

At this point, validate that you have a correct design.

40. **Right-click** in a blank portion of the block design, then select **Validate Design**
41. If successful, Click **OK** and proceed with the next section.
    Otherwise, fix any errors in the design before proceeding.


**Figure 18 – Validate Design**

Save the block diagram

42. In the menu, select **File** => **Save Block Design**

## Build the hardware with Vivado Design Suite

Create the top level HDL file.

1. In the **Sources** tab, select the block diagram
2. **Right-click**, then select **Create HDL Wrapper**

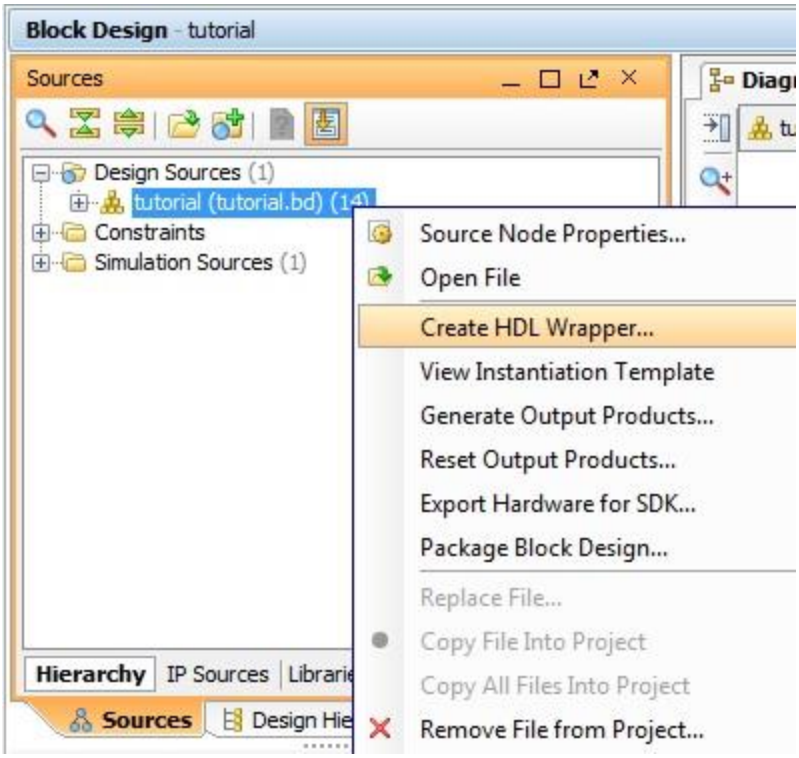



**Figure 19 – Create HDL Wrapper**

3. When asked whether to add or copy the HDL wrapper, select **Let Vivado manage wrapper and auto-update**.

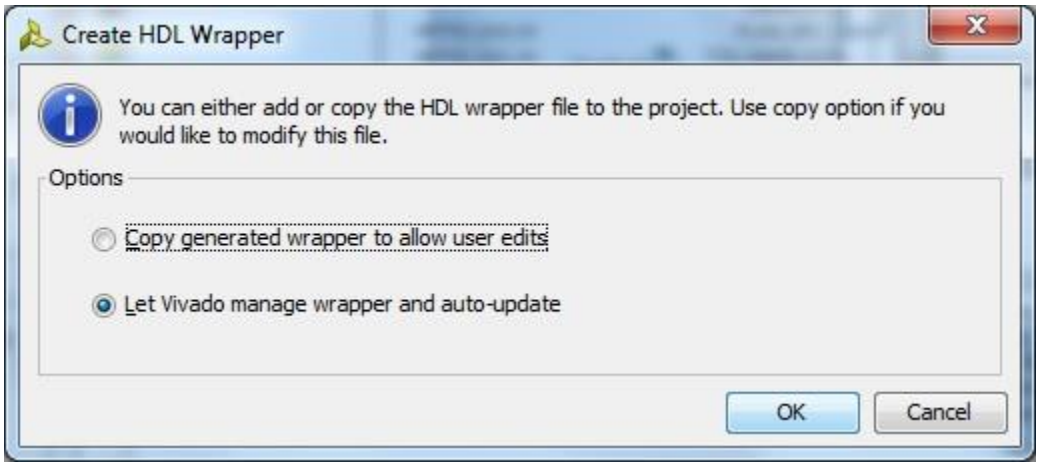



**Figure 20 – Let Vivado manage wrapper and auto-update**

Add the XDC constraints file.

4. In the Flow Navigator, under the Project Manager section, click **Add Sources**.
5. Select the **Add or Create Constraints** option
6. Click **Next**
7. In the dialog box that opens, click the **Add Files …** button to add an existing XDC file
8. Select one of the following XDC files, depending on your hardware:
    a. For the ZC702:
        ..\constraints\zc702_fmc_imageon_hdmi_passthrough.xdc
    b. For the ZedBoard:
        ..\constraints\zedboard_fmc_imageon_hdmi_passthrough.xdc

    Once selected, click **OK**
9. Click **Finish**.

Build the bitstream.

10. In the Flow Navigator, under the Program and Debug section, click **Generate Bitstream**. A dialog box appears asking whether all the processes starting for synthesis should be done.
11. Click **Yes**.

The “Bitstream Generation Completed” dialog box will open, asking what to do Next.

12. Select **Open Implemented Design**
13. Click **OK**.

The resource utilization and power estimation for this design can be seen in the Project Summary. Note that results may be different depending on the video format chosen, and for different carriers.

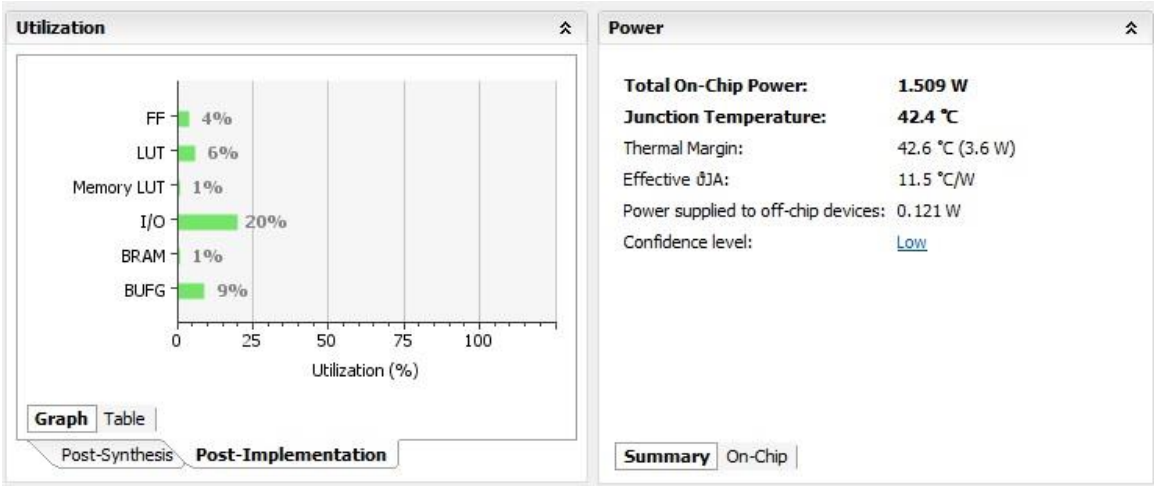



**Figure 21 – HDMI Pass-Through – Resource Utilization**

You have successfully created the hardware design !

## Create the Embedded Software Application with SDK

Launch SDK from Vivado Design Suite.

1. In the Vivado menu, Select **File > Export > Export Hardware for SDK**.
   The “Export Hardware for SDK” dialog box opens.
   By default, the “Include Bitstream” and “Export Hardware” check boxes are checked.
2. Check the **Launch SDK** check box.
3. Click **OK**. SDK opens.

Notice that when SDK launched, the hardware description file was automatically read in. The system.xml tab shows the address map for the entire Processing System.

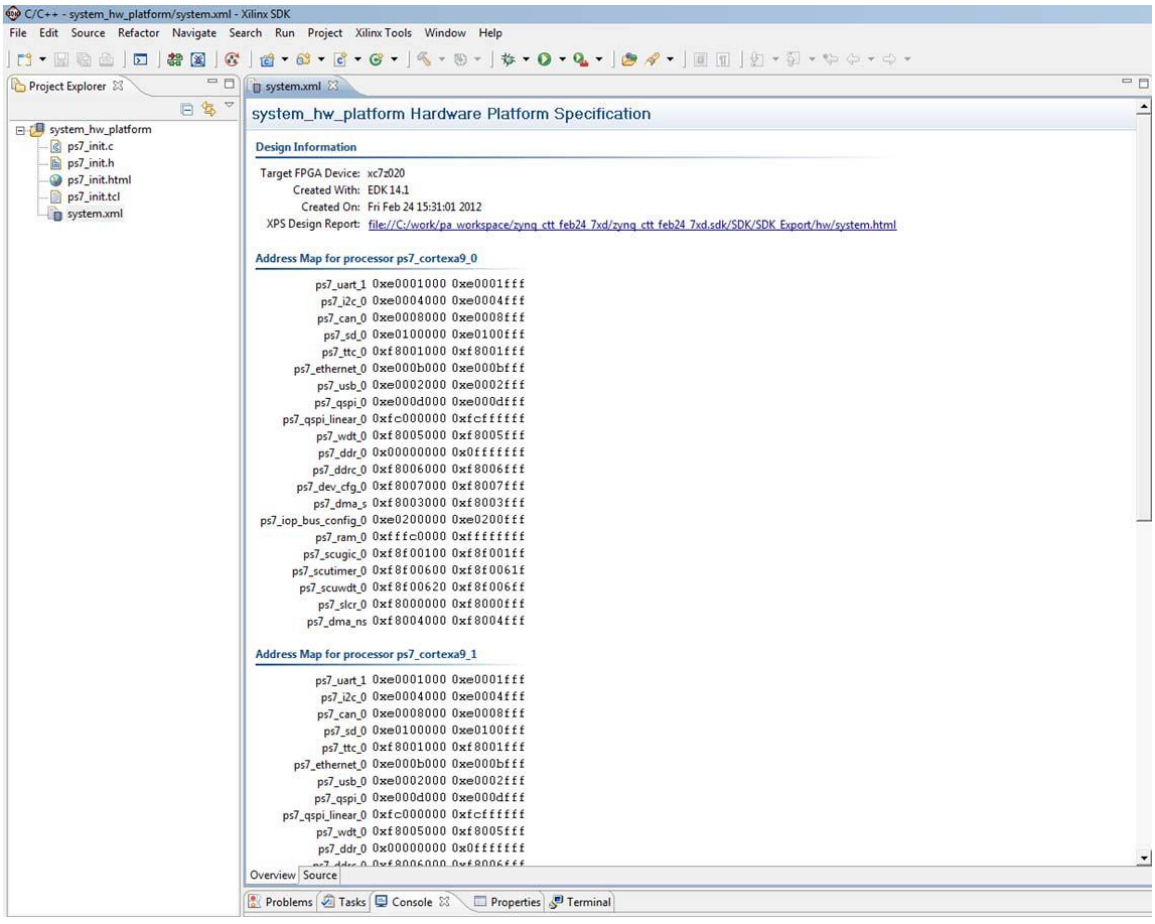



**Figure 22 – Address Map in SDK system.xml Tab**

The **avnet_fmc_imageon_cores** directory contains some software drivers that we will use in this design. In order for the project to recognize the contents of this directory, the path must be added to the project repositories, as described below.

4. In the SDK menu, select **Xilinx Tools** => **Repositories**
   The Preferences dialog box opens.

5. In the Local Repositories section, click on the **New …** button.
6. Select the **C:\FMC_IMAGEON\2013_3\avnet_fmc_imageon_cores** directory, then click **OK**
7. Click **OK** in the Preferences dialog box.

Create a standalone BSP (board support package).

8. In the SDK menu, select **File** => **New** => **Xilinx Board Support Package**.
   The New Board Support Package Project dialog box opens.
9. In the **Project name** field, type "**hdmi_passthrough_bsp**".
10. Keep the default settings, and click **Finish**.
    The Board Support Package Settings dialog box opens.
11. In the Supported Libraries, select the `fmc_iic_sw` and `fmc_imageon_sw` libraries.

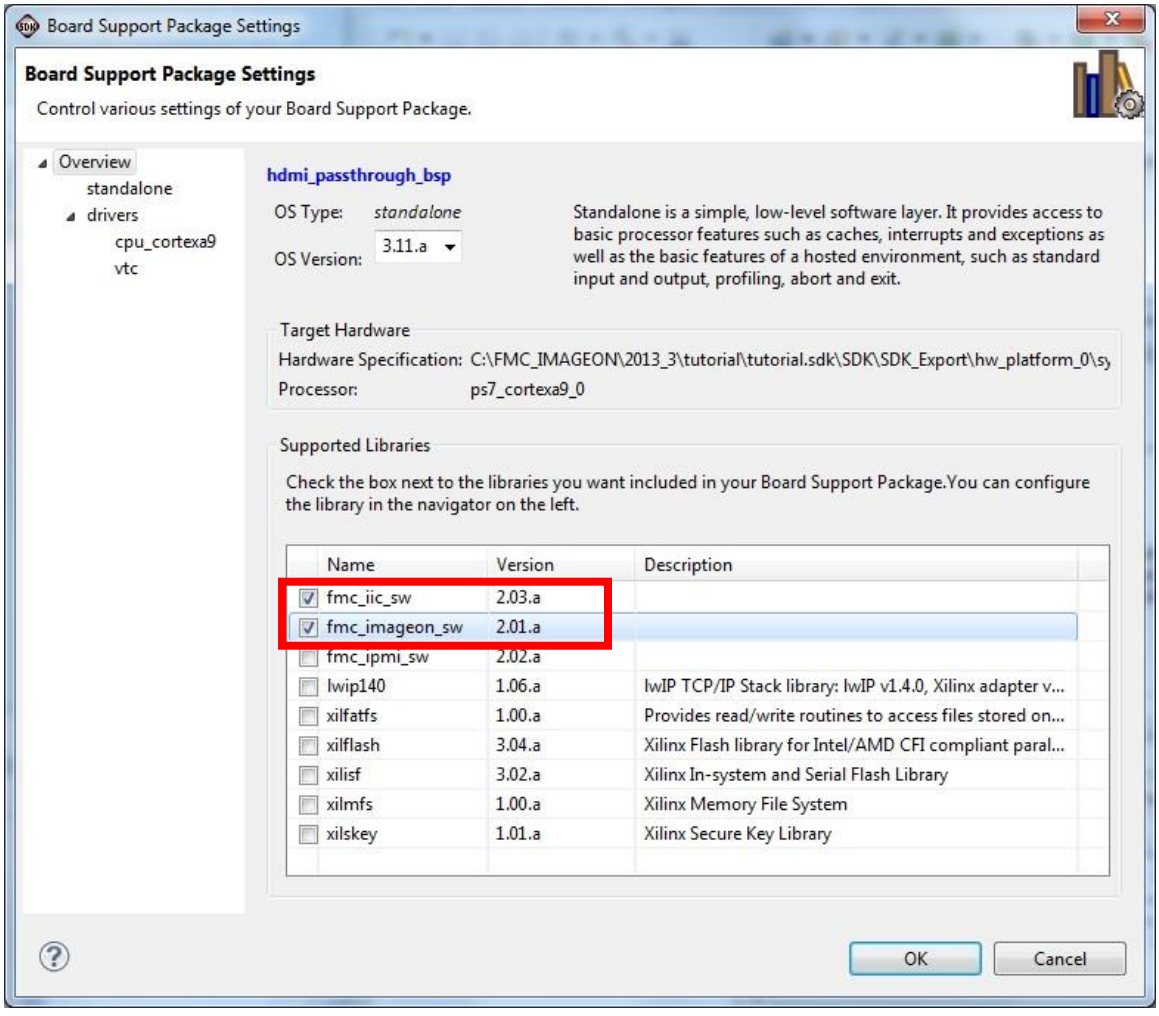



**Figure 23 – Board Support Package Settings**

12. Click **OK**.
    If the Build Automatically setting is enabled, SDK will automatically build the standalone BSP.

Create a new C project.

13. In the SDK menu, select **File** => **New** => **Application Project**.
    The Application Project dialog box opens.
14. In the **Project Name** field, type "**hdmi_passthrough_app**".
15. For the **Board Support Package**, select **Use Existing**, then select the BSP that was created previously.
16. Click **Next**.
    The Templates dialog box opens.
17. Select the **Hello World** template.
18. Click **Finish**.

Configure the application's memory map to execute from external memory.

19. Right-click on the **hdmi_passthrough_app** application
20. Select **Generate Linker Script**
    This opens the Generate a linker script dialog box.

21. Select the **ps7_ddr_0** memory for each of the Code, Data, Heap and Stack sections.

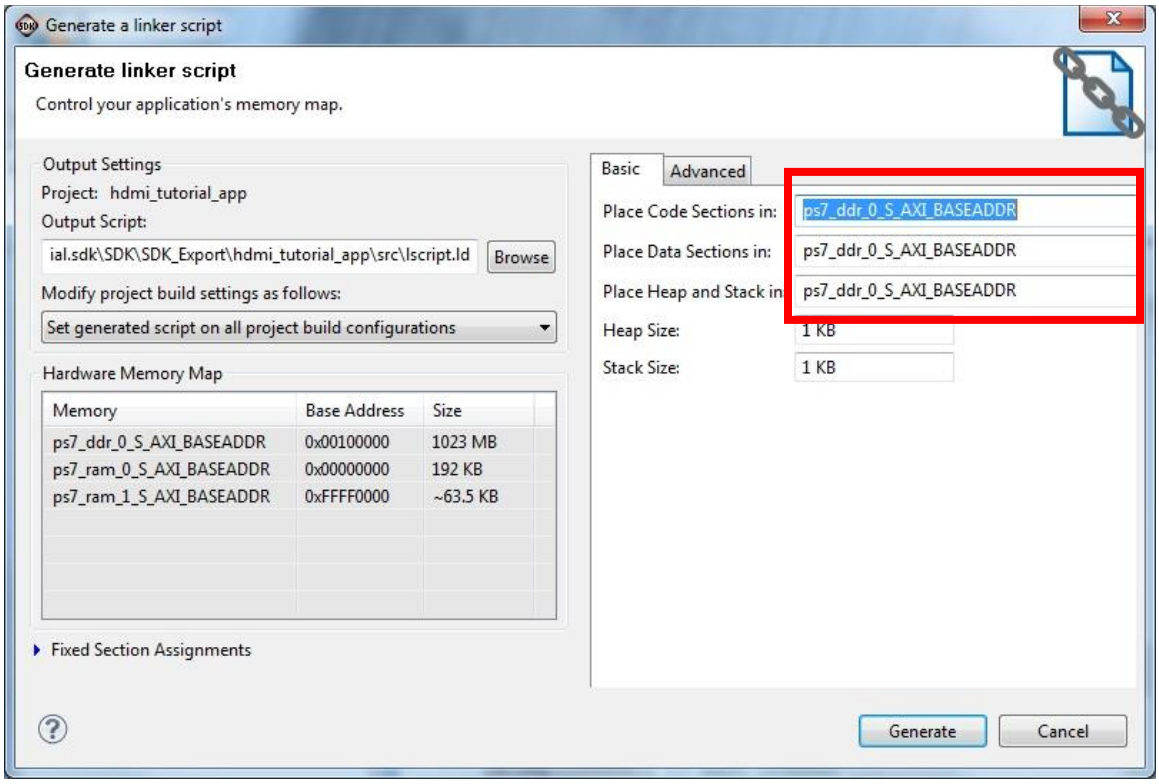



**Figure 24 – Generate a Linker Script**

22. Click **Generate**.
    A dialog box appears asking whether it is OK to overwrite the existing linker script file.
23. Click **Yes**

Copy the provided example C files to the new application.
Note that the source for the new application is placed in the following directory:
C:\FMC_IMAGEON_Tutorial\tutorial\tutorial.sdk\SDK\SDK_Export\hdmi_tutorial_app\src

24. From the following directory:
    C:\FMC_IMAGEON\2013_3**code\fmc_imageon_hdmi_passthrough**
    Copy the following files to the src directory of the new application.
    fmc_imageon_hdmi_passthrough.c
    fmc_imageon_hdmi_passthrough.h
    video_resolution.c
    video_resolution.h
25. In the Project Explorer window, select the **hdmi_passthrough_app** application
26. Right-click, then select **Refresh** from the pop-up menu.
    SDK will recognize the new source files.
    If the Build Automatically setting is enabled, SDK will automatically build the application.

Import the provided example source files for the hdmi passthrough

27. In the Project Explorer window, select the **hdmi_passthrough_app** application
28. Right-click, then select **Import** from the pop-up menu.
    The Import wizard appears.
29. Expand the **General** section
30. Select **File System**, then click **Next**.

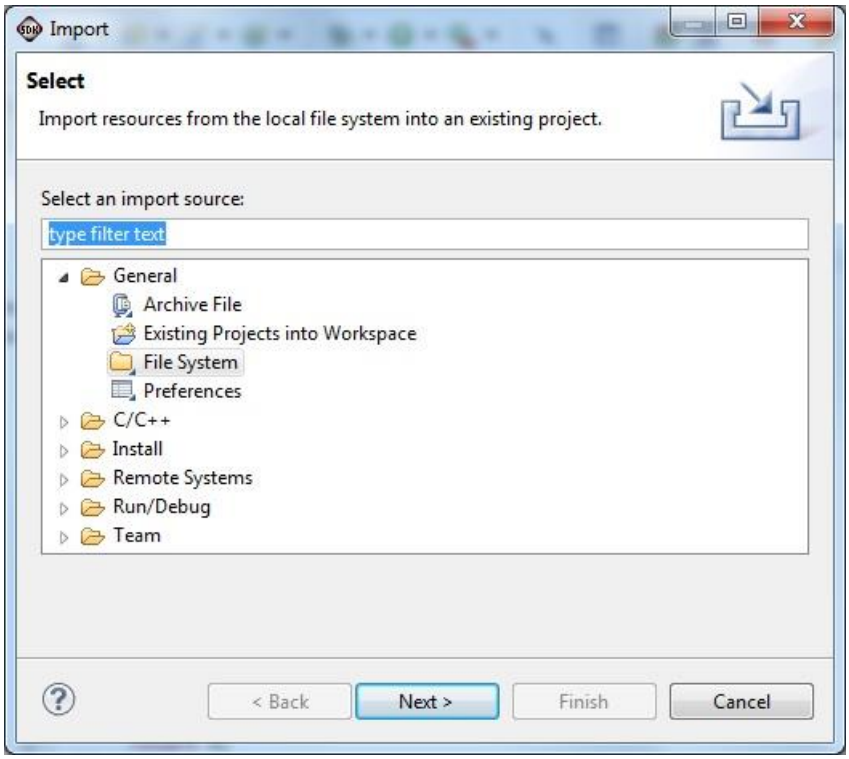



**Figure 25 – Import from File System – Dialog 1**

The next dialog of the Import wizard appears.

31. Next to the **From directory** field, click the **Browse** button
32. Specify the following directory:
    **C:\FMC_IMAGEON\2013_3\code\fmc_imageon_hdmi_passthrough**
33. Click **OK**

34. Select the following source files:
    fmc_imageon_hdmi_passthrough.c
    fmc_imageon_hdmi_passthrough.h
    video_resolution.c
    video_resolution.h
35. Next to the **Into directory** field, click the **Browse** button
36. Specify the following directory : **hdmi_passthrough_app\src**, then click **OK**

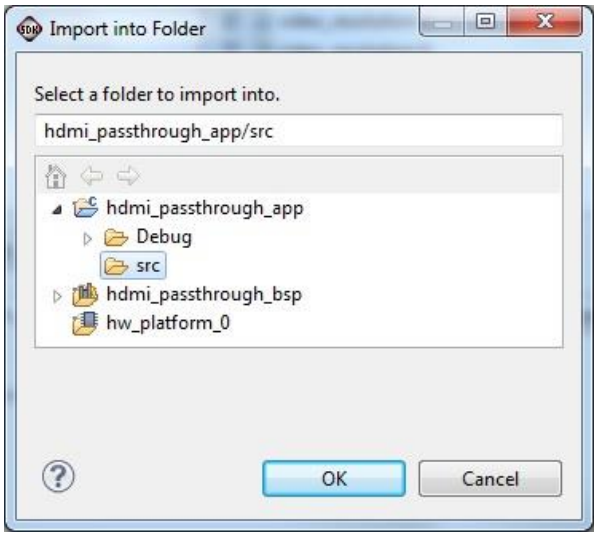



**Figure 26 – Import into Folder**

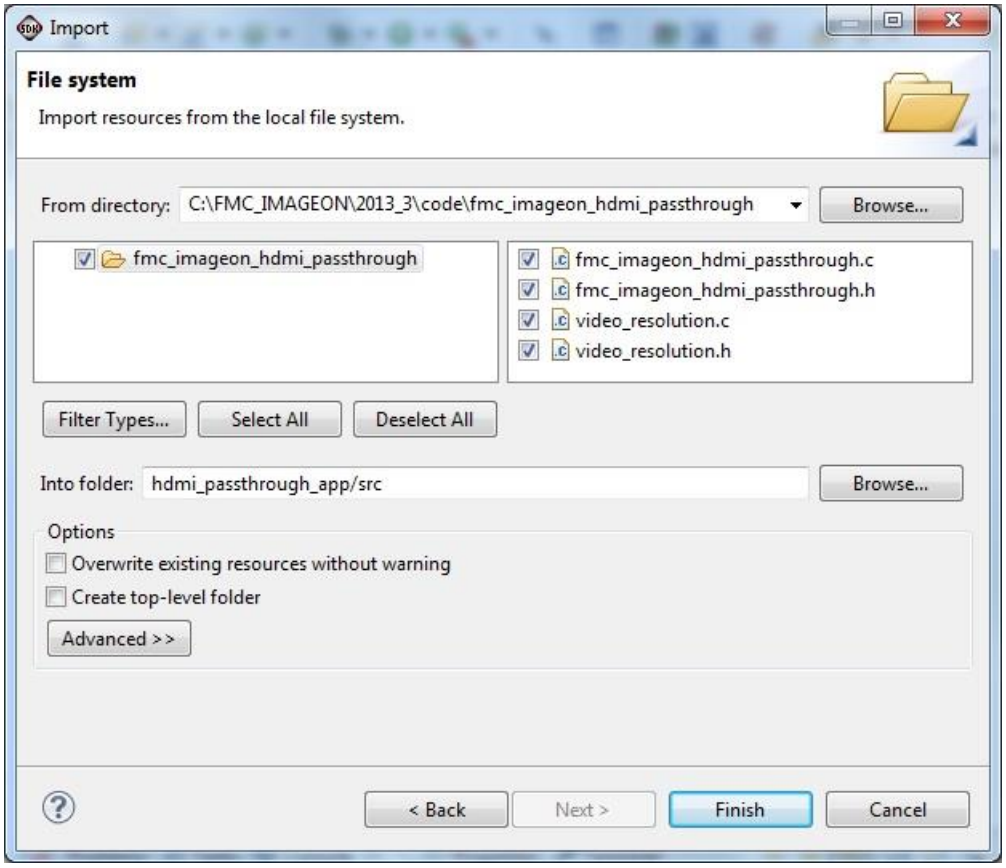



**Figure 27 – Import from File System – Dialog 2**

37. Click **Finish**.

Modify the hello world application

38. Open the helloworld.c file and edit the source code as follows:

```
/*
 * helloworld.c: simple test application
 */

#include <stdio.h>
#include "platform.h"

#include "fmc_imageon_hdmi_passthrough.h"
fmc_imageon_hdmi_passthrough_t demo;

//void print(char *str);
void print( const char *str);

int main()
{
    init_platform();

    print("Hello World\n\r");

    demo.uBaseAddr_IIC_FmcImageon = XPAR_FMC_IMAGEON_IIC_0_BASEADDR;
    demo.uBaseAddr_VTC_Axi4sTiming= XPAR_FMC_IMAGEON_HDMIO_YUV422_V_TC_0_BASEADDR;
    fmc_imageon_hdmi_passthrough_init( &demo );

    cleanup_platform();

    return 0;
}
```

**strange bug:**
**when vtc driver is active, need to modify print declaration to match the one in xil_printf.h**

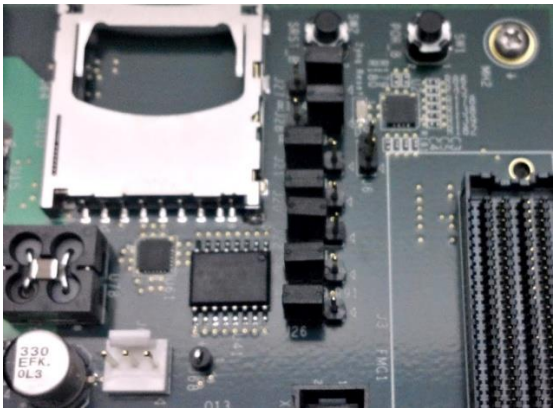
39. If the Build Automatically setting is enabled, SDK will automatically build the application. If not, right-click on the application and select **Build Project** to build the application.

You have successfully created the software application !

## Set up your ZC702 Hardware

Setup your ZC7020-based hardware, as described below.

1. Set the ZC702 board's boot mode to cascaded JTAG using jumpers
    a. J21,J20,J22,J25,J26 should all be set to '0'
    b. J27,J28 should be set to '1'



2. Connect a mini USB cable to the ZC702's USB-UART connector (J17)
3. Connect one of the following JTAG connections:
    a. Connect platform USB pod to the ZC702's JTAG header (J2) and set SW10 to '10'
    b. Connect a micro USB cable to the ZC702's on-board Digilent JTAG module and set SW10 to '01'
4. Populate the FMC-IMAGEON board on FMC Slot #2.
5. Connect a DVI or HDMI source to the FMC module's HDMI IN connector
6. Connect a DVI or HDMI monitor to the FMC module's HDMI OUT connector
7. Power on the ZC702 board
8. Open a serial communication utility for the COM port assigned on your system.
   ***Note:*** The standard configuration for Zynq Processing System is baud rate 115200, 8 bit, parity

## Set up your ZedBoard Hardware

Setup your ZedBoard hardware, as described below.

1. Set the ZedBoard's boot mode to cascaded JTAG using jumpers
    a. JP7, JP8, JP9, JP10, JP11 should all be set to '0'

2. Connect a micro USB cable to the ZedBoard's USB-UART connector (J14)
3. Connect one of the following JTAG connections:
    a. Connect platform USB pod to the ZedBoard's JTAG header (J15)
    b. Connect a micro USB cable to the ZedBoard's on-board Digilent JTAG connector (J17)

4. Populate the FMC-IMAGEON board on FMC Slot #1.
5. Connect a DVI or HDMI source to the FMC module's HDMI IN connector
6. Connect a DVI or HDMI monitor to the fMC module's HDMI OUT connector
7. Power on the ZedBoard board
8. Open a serial communication utility for the COM port assigned on your system.
   ***Note:*** The standard configuration for Zynq Processing System is baud rate 115200, 8 bit, parity

## Execute the HDMI Pass-Through Design on Hardware using SDK

From SDK, configure the FPGA bitstream and launch the application.

1. In the SDK menu, select **Xilinx Tools** => **Program FPGA**
   The "Program FPGA" dialog opens.
2. Make sure the path to the bitstream is valid
   *(HINT : If you moved the project, you will need to update the path to the bitstream file)*
3. Click **Program**.
   It will take approximately 10 seconds to program the bitstream to hardware
4. Right-click **hdmi_passthrough_app**
   and select **Run as > Run Configurations**
5. Click **Xilinx C/C++ ELF** and click **New launch configurations**.
6. The new run configuration is created named **hdmi_passthrough_app Debug**.
   The configurations associated with application are pre-populated in the main tab of these launch configurations.
7. Click the **Device Initialization** tab in the launch configurations and check the settings here.
   Notice that there is a configuration path to the initialization TCL file. The path of `ps7_init.tcl` is mentioned here. This is file that was exported when you exported your design to SDK; it contains the initialization information for the processing system.
   *(HINT : If you moved the project, you should delete the previous run configuration and create a new one)*
8. The STDIO Connection tab is available in the launch configurations settings. You can use this to have your STDIO connected to the console. We will not use this now because we have already launched a serial communication utility. There are more options in launch configurations but we will focus on them later.
9. Click **Apply** and then **Run**.
10. If you get a Reset Status dialog box indicating that the current launch will reset the entire system, click **OK**.
11. You should see something similar to the following on your serial console:

```
Hello World

------------------------------------------------------
--          FMC-IMAGEON HDMI Pass-Through           --
------------------------------------------------------

FMC-IMAGEON Initialization ...
HDMI Input Initialization ...
Waiting for ADV7611 to locked on incoming video ...
        ADV7611 Video Input LOCKED
ADV7611 Video Input Information
        Video Input      = HDMI, Progressive
        Color Depth      = 8 bits per channel
```

```
        HSYNC Timing     = hav=1920, hfp=88, hsw=44(hsp=1), hbp=148
        VSYNC Timing     = vav=1080, vfp=04, vsw=05(vsp=1), vbp=036
        Video Dimensions = 1920 x 1080
ADV7511 Video Output Information
        Video Output     = DVI, Progressive
        Color Depth      = 8 bits per channel
        HSYNC Timing     = hav=1920, hfp=88, hsw=44(hsp=1), hbp=148
        VSYNC Timing     = vav=1080, vfp=04, vsw=05(vsp=1), vbp=036
        Video Dimensions = 1920 x 1080
HDMI Output Initialization ...
Video Timing Controller Initialization …

Done


Press ENTER to re-start ...
```

To re-start the detection of the HDMI input source, press ENTER.

You have successfully executed the HDMI pass-through on hardware !

# References

All documentation supporting the ON Semiconductor Image Sensor with HDMI Input/Output FMC Bundle is available on the Avnet Design Resource Center (DRC):
http://www.em.avnet.com/fmc-imageon-v2000c

1. Getting Started with the HDMI Input/Output FMC Module
   http://www.em.avnet.com/fmc-imageon ➔ Support Files & Downloads
2. Avnet FMC-IMAGEON – Hardware User Guide
   http://www.em.avnet.com/fmc-imageon ➔ Support Files & Downloads

3. Getting Started with the ON Semiconductor Image Sensor with HDMI Input/output FMC Bundle
   http://www.em.avnet.com/fmc-imageon-v2000c ➔ Support Files & Downloads

The following reference provides links to documentation for video intellectual property (IP).

4. Video and Image Processing IP
   http://www.xilinx.com/ipcenter/video/video_core_listing.htm
5. Video Timing Controller
   http://www.xilinx.com/products/intellectual-property/EF-DI-VID-TIMING.htm
6. Video Input to AXI4-Stream
   http://www.xilinx.com/products/intellectual-property/video_in_to_axi4_stream.htm
7. AXI4-Stream to Video Output
   http://www.xilinx.com/products/intellectual-property/axi4_stream_to_video_out.htm
8. AXI Video DMA
   http://www.xilinx.com/products/intellectual-property/axi_video_dma.htm

The following reference provides links to documentation for AXI interconnect.

9. UG761 - AXI Reference Guide
10. PG065 – AXI4-Stream Infrastructure

# Known Issues and Limitations

The following issues are known to exist. When applicable, the workaround used is described.

## Hello World Template – error: conflicting types for 'print'

The "Hello World" C project template has an issue that may manifest itself depending on which drivers are included in the design.

The "print( …. )" declaration does not match the declaration in the xil_printf.h file and will result in the following error:

```
helloworld.c:29:6: error: conflicting types for 'print'
xil_printf.h:39:6: note: previous declaration of 'print' was here
```

The solution is to simply fix the "print( … )" declaration as shown below.

```
//void print(char *str);
void print( const char *ptr);
```

# Troubleshooting