Lattice mVision ISP Reference Design Quick Start Guide

Application Note

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Acronyms in This Document

A list of acronyms used in this document.

Acronym	Definition
AE	Auto Exposure
AWB	Auto White Balance
BLC	Black Level Correction
CCM	Color Correction Matrix
CFI	Color Filter Array Interpolation
DPC	Defective Pixel Correction
EVDK	Embedded Vision Development Kit
GAMMA	Gamma Correction
ISP	Image Signal Processing
TMAP	Tone Mapping
VIP	Video Interface Protocol

1. Overview

This document is intended to show you the hardware setup and operation procedures so as to demonstrate the Image Signal Processing (ISP) reference design features. It is assumed that you are familiar with the basic Lattice FPGA design flow.

This reference design is comprised of both Lattice Embedded Vision Development Kit (EVDK) and the sensor bridge board.

- Lattice Embedded Vision Development Kit (EVDK) is comprised of (Figure 1.1):
  - CrossLink™ Video Interface Protocol (VIP) Input Bridge Board
  - ECP5 VIP Processor Board
  - HDMI VIP Output Bridge Board
- Sensor bridge board is comprised of (Figure 1.2):
  - AR0234 Sensor Bridge Board

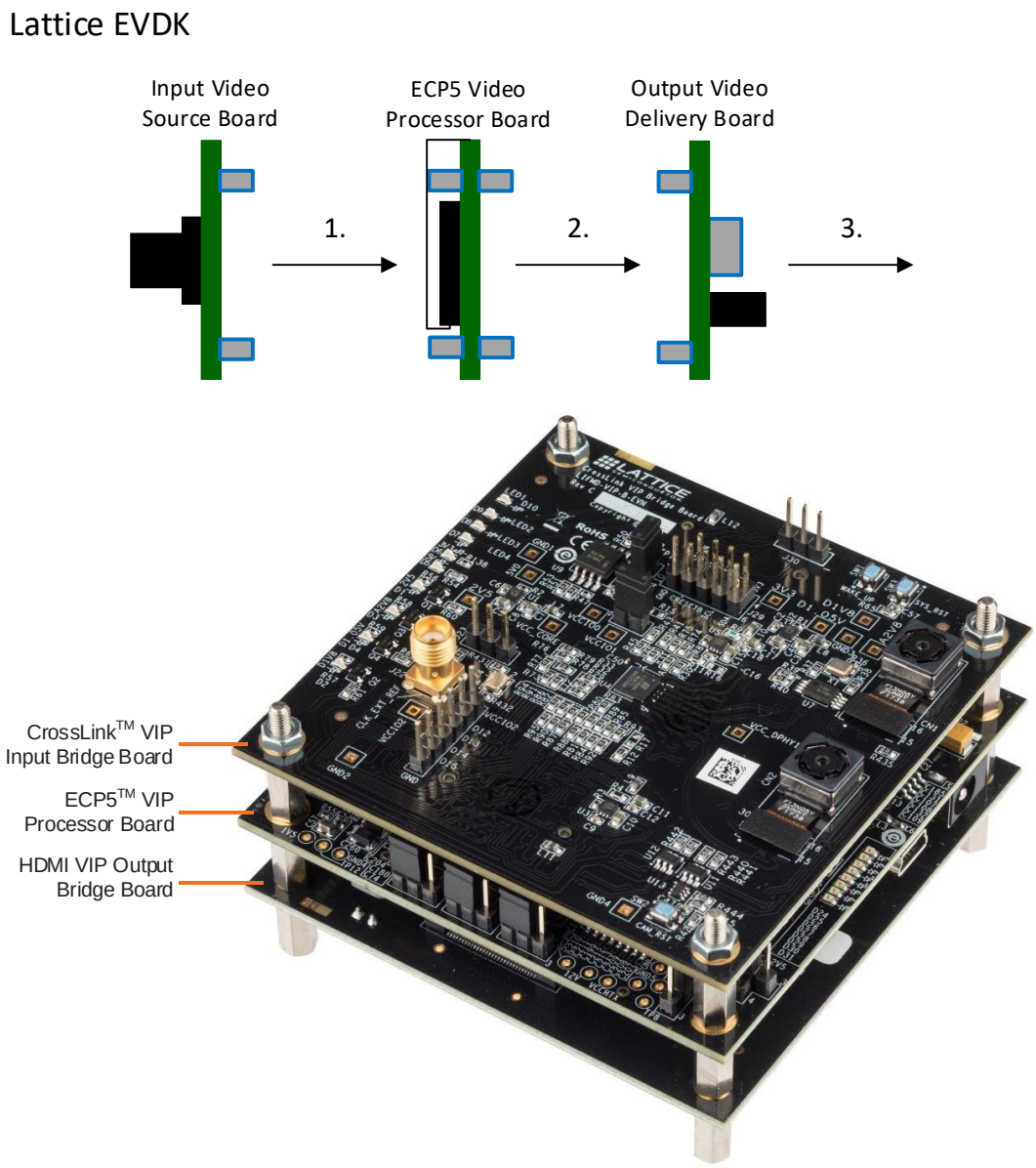

Figure 1.1. Lattice EVDK Components

Figure 1.2. AR0234 Sensor Bridge Board

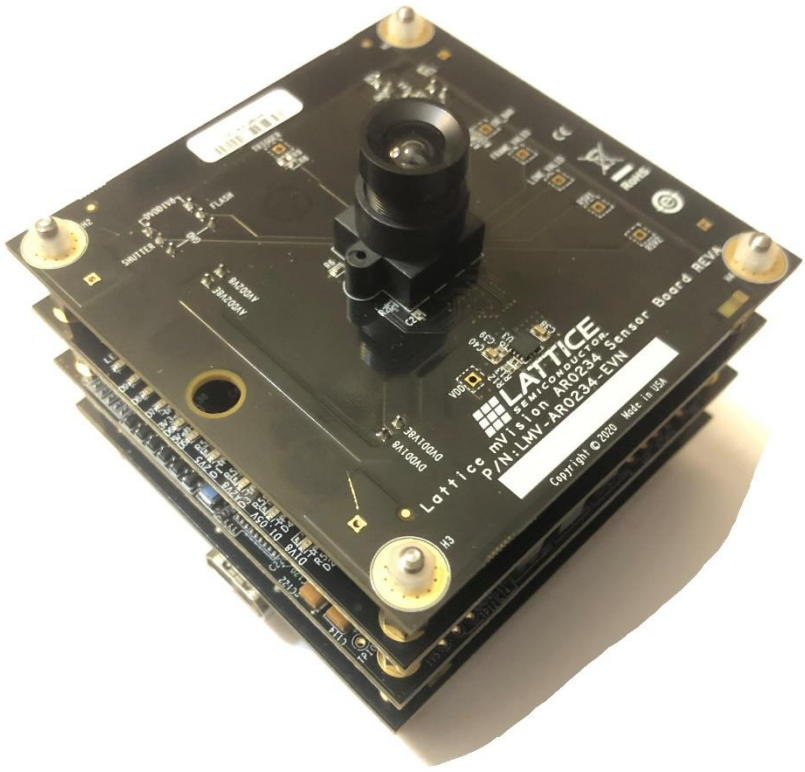

Figure 1.3. Assembled EVDK and AR0234 Sensor Bridge Board

For more details regarding Lattice EVDK, refer to Lattice Embedded Vision Development Kit User Guide (FPGA-UG-02015).

For more details regarding Lattice AR0234 Sensor Bridge Board, refer to Lattice mVision AR0234 Sensor Board User Guide (FPGA-UG-02124).

2. ISP Reference Design Block Diagram

The ISP reference design captures sensor data, converts its interfaces, implements ISP pipelines, and finally displays the video on the HDMI monitor. The following Figure 2.1 shows the whole ISP reference design architecture and data flow.

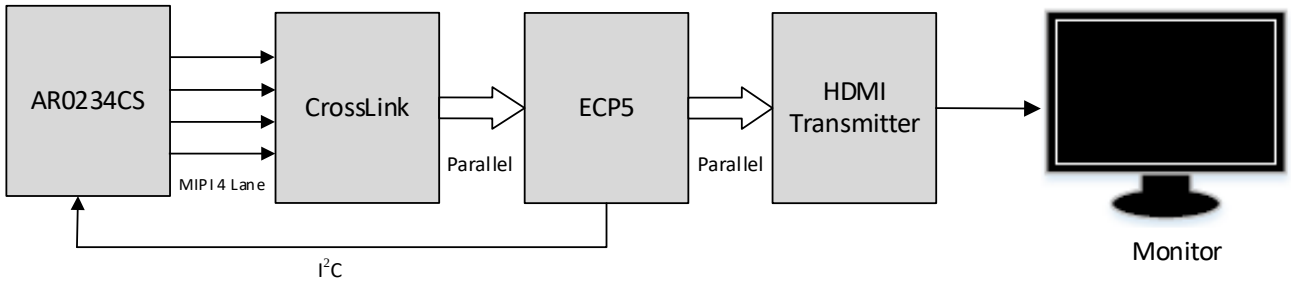

Figure 2.1. ISP Reference Design Architecture and Data Flow

The ISP core is implemented in the ECP5 device. The ECP5 device receives the parallel input sensor data from the CrossLink device, and transmits the video to the HDMI transmitter. The following Figure 2.2 shows the ECP5 ISP block diagram.

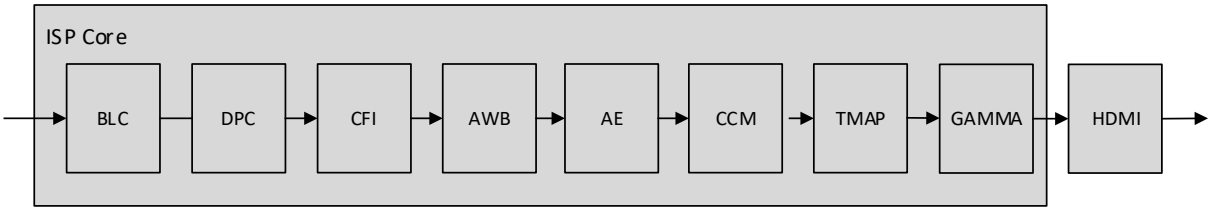

Figure 2.2. ECP5 ISP Block Diagram

3. ISP Reference Design Jumper Settings

Following jumper settings for CrossLink (Table 3.1) and ECP5 (Table 3.2) boards are required to enable the ISP function correctly.

Table 3.1. CrossLink VIP Input Bridge Board Jumper Settings

Serial Number	Jumper Name	Description
1	J4	Short
2	J30	Open
3	J2	Short
4	—	All other headers should be kept open.

Table 3.2. ECP5 VIP Input Bridge Board Jumper Settings

Serial Number	Jumper Name	Description
1	J55	Connect 1 and 2.
2	J51	Connect 1 and 2.
3	J5	Connect 1 and 2.
4	J9	Connect 1 and 2.
6	J6	Connect 1 and 2.
7	J3	Connect 1 and 2, also 5 and 6.
8	J50	Connect 1 and 2, also 3 and 5.
9	J7	Connect 2 and 3.
10	J52	Connect 1 and 2 for SPI 2, 2 and 3 for JTAG.
11	J53	Connect 1 and 2.
12	—	All other headers should be kept open.

4. ISP Reference Design Requirements

Following items are required for this reference design:

- LF-EVDK1-EVN
- AR0234 sensor bridge board
- HDMI monitor
- HDMI cable
- DC power adapter (12 V)
- Laptop/PC
- Bit/JED file
- USB 2.0 Type A to Mini-B cable*
- Lattice Diamond Programmer version 3.10 or higher*

*__Note__: Required only in the re-programming process.

5. Program CrossLink/ECP5 Board

The following steps show you how to download the bitstream to CrossLink/ECP5 board.

1. Connect the LF-EVDK1-EVN board to DC power adapter (12V).
2. Connect the board to PC via USB mini port.
3. Start Diamond Programmer, Version 3.10 or a later version.
4. The Diamond Programmer - Getting Started dialog box pops up (Figure 5.1). By default, the *Create a new project from a JTAG scan* option is selected. Check and confirm other settings are correctly reflected the real components connected (Figure 5.1). Click OK, if everything is correct.

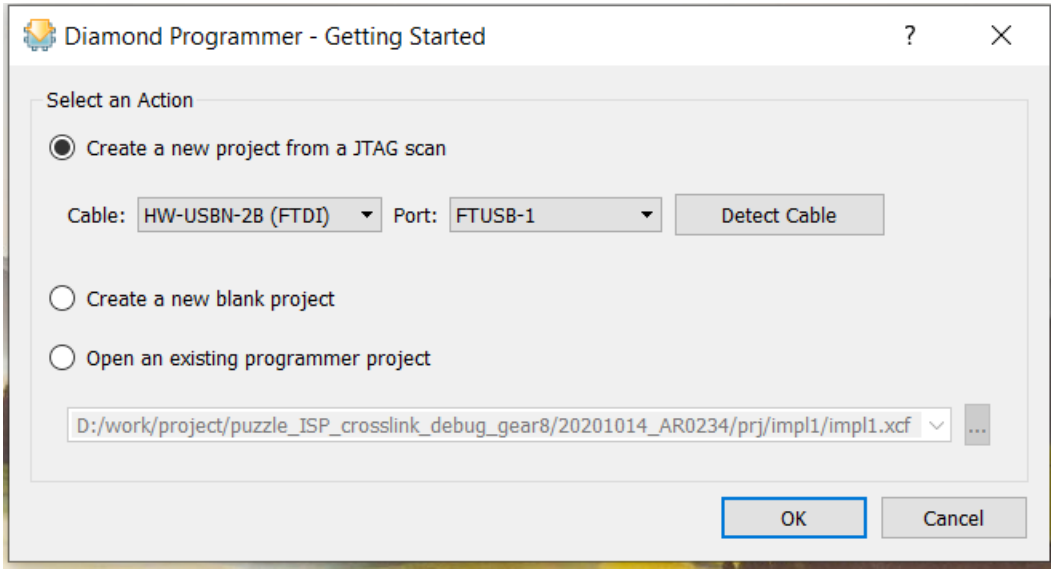

Figure 5.1. Getting Started dialog in Lattice Diamond Programmer

5. A new window pops up (Figure 5.2). Make sure the configuration settings for the CrossLink Board are the same as those shown in Figure 5.2.

   Device Family: LIFMD

   Device: LIF-MD6000

   Operation: Fast Program

   File Name: \\rel_mvision\V1.0\Bitstream\mVision_CSI2_2_parallel_impl1.bit

   ...

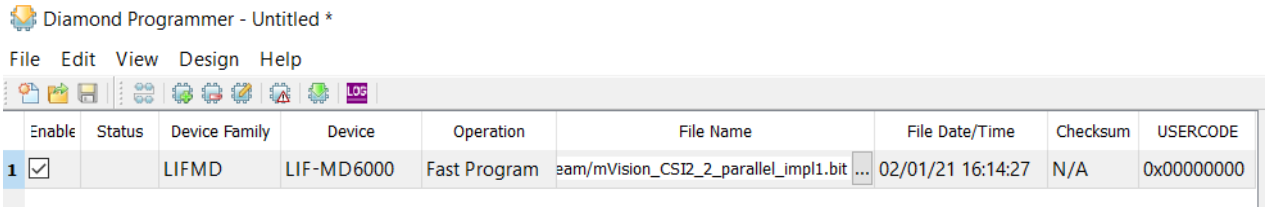

Figure 5.2. Set up Configuration Settings for CrossLink Board

6. Click the Program icon  from the toolbar, or choose the Design > Program menu item from Diamond Programmer, to program the CrossLink board. Check the programming status and result (Figure 5.3).

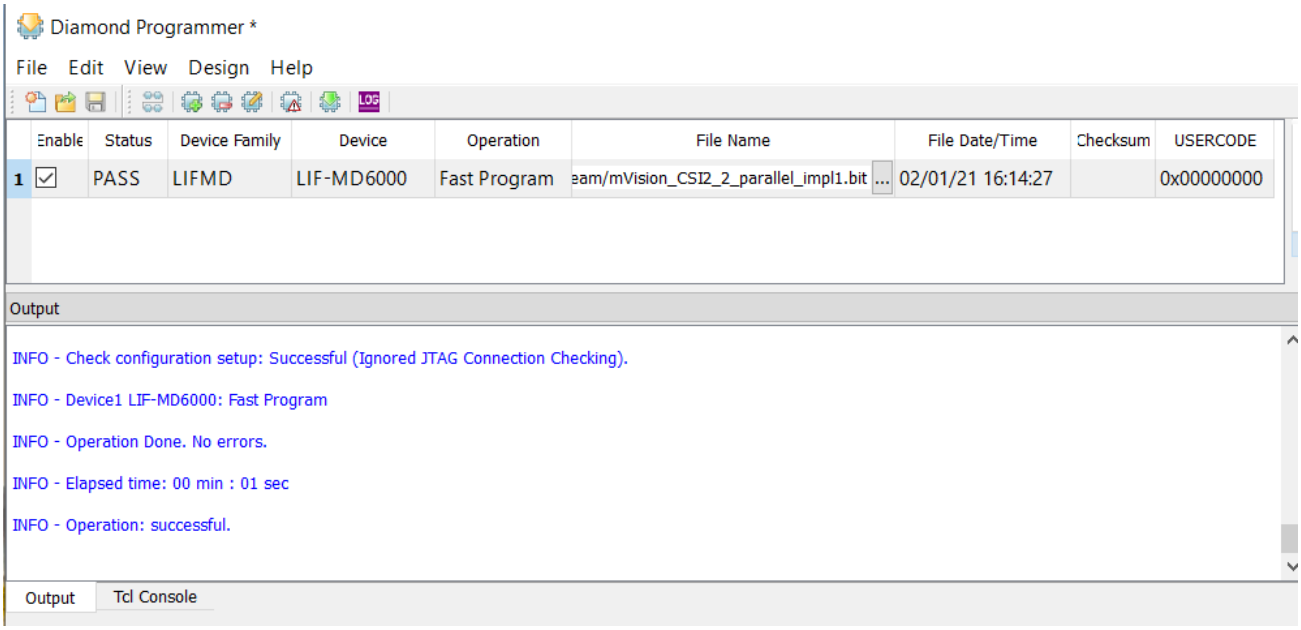

Figure 5.3 CrossLink Board Programming Status and Result

7. Make sure the configuration settings for the ECP5 Board are the same as those shown in Figure 5.4.
   Device Family: ECP5UM Device: LFE5UM-85F
   Operation: Fast Program
   File Name: \\rel_mvision\V1.0\Bitstream\mVision_ISP_1080p_impl1.bit
   ...

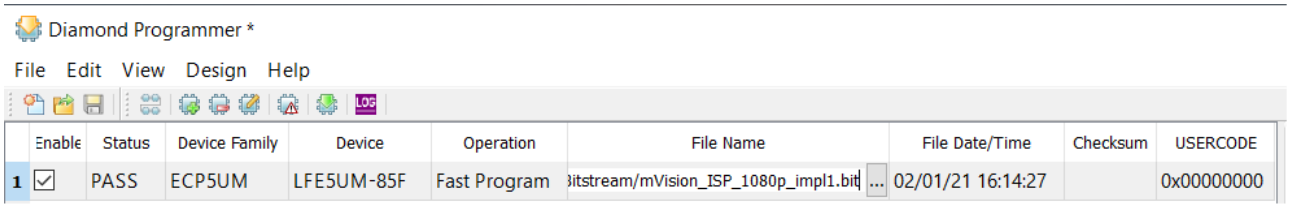

Figure 5.4. Set Up Configuration Settings for ECP5 Board

8. Click the Program icon  from the toolbar, or choose the Design > Program menu item from Diamond Programmer, to program the ECP5 board. Check the programming status and result (Figure 5.5).

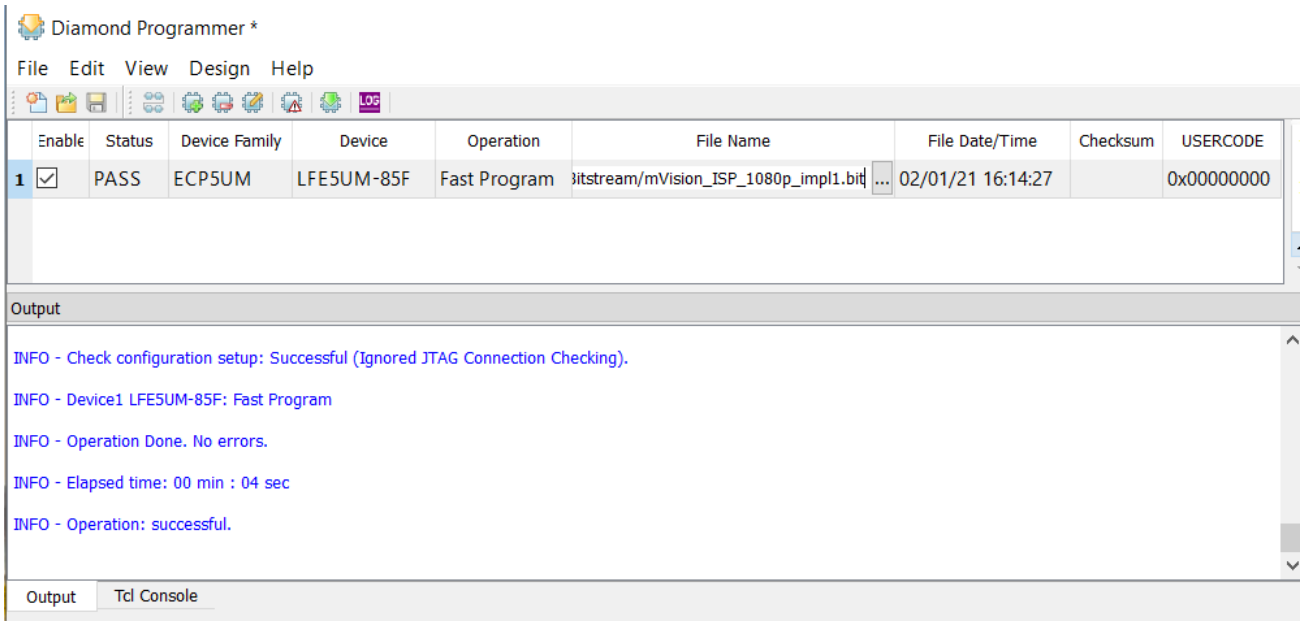

Figure 5.5. ECP5 Board Programming Status and Result

6. Display the Image Signal Processing Results

After programming the CrossLink and the ECP5 boards successfully, follow the steps below to display the Image Signal Processing (ISP) results, the video of the camera, on the monitor.

1. Connect the HDMI monitor to the EVDK components via the HDMI cable.
2. Toggle the button “SW3 (SYS_RST)” on the CrossLink VIP Bridge Board.
3. The video of the camera captured by the sensor can be displayed on the HDMI monitor.

7. Advanced Features and Tools

Beside those basic features of the ISP reference design discussed in the previous sections, some advanced features can also be accessed using SSP tools and running scripts.

7.1. Dynamic ISP Parameters Setup Using SSP Tools

Many registers are implemented in the ISP reference design to provide a dynamic way to control the logic and to setup ISP parameters. These registers can be accessed through the SSP tool.

Follow steps below to install and use the SSP tool in the ISP reference design.

1. Install the “mini-ssp” tool on PC.
   - Double click <*Drive*>:\\rel_mvision\V1.0\Tools\LSCC_SSP.msi. The SSP tool can be installed on your PC.
   - Once the tool is installed successfully, the following six documents can be found in <*Drive*>:\<install_folder>\<*Default_Company_Name*>\LSCC_SSP\doc\.
     - SSP Demo Quick Start.pdf
     - SSP Installation and Deployment Usage Guide.pdf
     - SSP Operation Tool Kits Usage Guide.pdf
     - SSP Register Mapping Interface Specifiction.pdf
     - SSP RTL Generator Usage Guide.pdf
     - SSP Simulation Platform Usage Guide.pdf

     Refer to these documents for the SSP tool usage accordingly.
2. Connect Lattice HW-USBN-2B cable with J14 of the ECP5 Video Processor Board, as shown in Figure 7.1. Refer to Table 7.1 for the pin connection details between the HW-USBN-2B cable and J14.

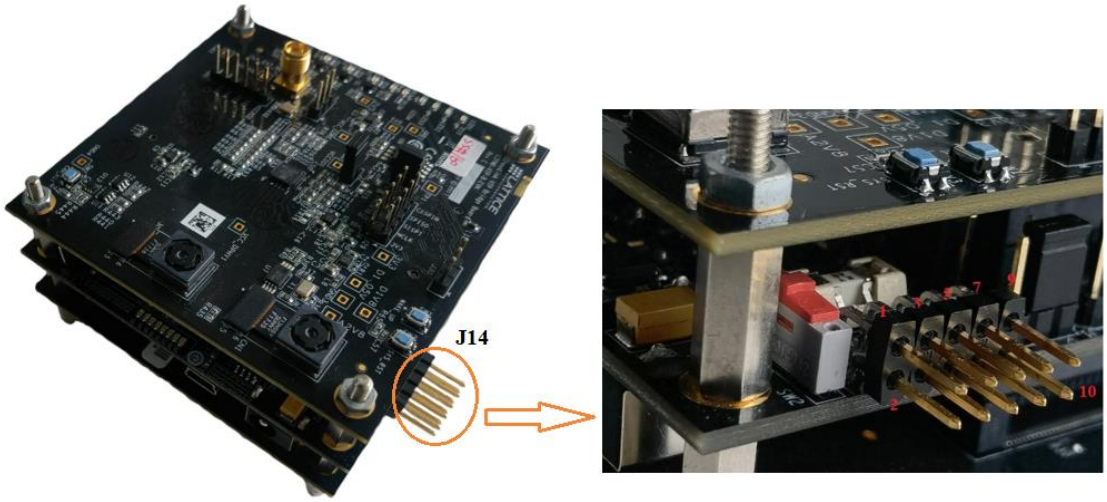

Figure 7.1. J14 Pin on ECP5 Video Processor Board

Table 7.1. J14 and HW-USBN-2B Cable Pin Connection

Number Pins on EVDK Board	USBN-2B Cable
1	VCC
3	SCLK
5	SI
7	S0
9	ISPEN
2	N/A
4	N/A
6	N/A
8	N/A
10	GND

3. After the configuration of the CrossLink and ECP5 boards done, run RMI-based command to access registers. Four types of command are supported:

   rmi_write addr (16-bit Hex) data (32-bit Hex)

   rmi_read addr (16-bit Hex) data_len (4x Decimal)

   cam_write addr (16-bit Hex) data (several bytes Hex)

   cam_read addr (16-bit Hex) data_len (Decimal)

   Examples:

   rmi_write 0x0000 0x11223344

   rmi_read 0x0000 4 (0x11223344 can be read out)

   cam_write 0x0204 0x0128

   0x0204 is the sensor register address

   The command writes 0x01 => 0x0204,

   0x28 => 0x0205 into the sensor registers

   cam_read 0x0204 2 (0x0204/0x0205 sensor register values will be read out)

Refer to the file (\\rel_mvision\V1.0\DOC\mVision_ISP_register_map.xlsx) for the detailed register map table.

By configuring different registers, you can modify desired ISP parameters. After that, you can verify the configuration result by checking the image from the HDMI monitor.

7.2. Easy Senor Frame Data Capturing via Running Scripts

Image capture scripts are provided to help you get sensor frame data and save it on your PC. The scripts can be found in the <*Drive*:> \\rel_mvision\V1.0\WorkSpace\ directory.

By following the steps below, you can capture the sensor frame data from sensor_cap.txt.

1. Follow Step 1 discussed in the previous Dynamic ISP Parameters Setup Using SSP Tools section to install the “mini-ssp” tool on your PC.
2. Go to the <*Drive*:> \\rel_mvision\V1.0\WorkSpace\ directory WorkSpace directory. Double-click “raw_capture.bat” file. Data capturing starts. During the capturing process, the frame sensor pixel data is saved in a text file, default name of which is sensor_cap.txt (Figure 7.2). Once the process is finished, this sensor_cap.txt can be found in the same directory.

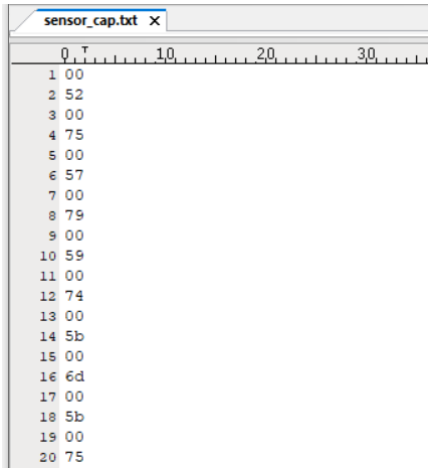

Figure 7.2. Sample sensor_cap.txt

Notes:

- The sensor frame data is for debugging only.
- The sensor frame data captured does not affect the current image displayed on the HDMI monitor.
- This sensor frame data capturing process does not affect the current image displayed on the HDMI monitor.

You can now get the frame data of the sensor from sensor_cap.txt, which is saved on your PC.

7.3. Flexible CCM-related Registers Configuring via Running Scripts

Color Correction Matrix (CCM) parameter configuration scripts are provided to help you configure the CCM-related registers conveniently. The scripts can also be found in the <*Drive*>: \\rel_mvision\V1.0\WorkSpace\ directory.

By following the steps below, you can configure the CCM-related registers and see the changes from the video displayed on the HDMI monitor.

1. Follow Step 1 discussed in the previous Dynamic ISP Parameters Setup Using SSP Tools section to install the “mini-ssp” tool on your PC.
2. Go to the <*Drive*:> \\rel_mvision\V1.0\WorkSpace\ directory WorkSpace directory. Open ccm_matrix_update.rmi in any text editor. Change the values of the desired CCM-related registers, and save the changes.
3. Under the same directory, double-click ccm_config.bat. The modified CCM-related registers can thus be written into the ISP modules.
4. Check the video from the HDMI monitor to see the modification results of the CCM-related registers.

Different CCM-related registers can control and affect the colors of the image on the HDMI monitor. Refer to the file (\\rel_mvision\V1.0\DOC\mVision_ISP_register_map.xlsx) for detailed CCM-related register definition. Contact Lattice Semiconductor for the color correction matrix generation of your main application scenarios.

References

- Lattice Embedded Vision Development Kit User Guide (FPGA-UG-02015)
- Lattice mVision AR0234 Sensor Board User Guide (FPGA-UG-02124)

Technical Support Assistance

Submit a technical support case through www.latticesemi.com/techsupport.

Revision History

Revision 1.0, March 2021

Section	Change Summary
All	Production release.

www.latticesemi.com