DG0849
Demo Guide
PolarFire 4K Dual Camera Video Kit

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1 Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

1.1 Revision 5.0

The following is a summary of the changes made in this revision.

- Added Gamma correction and Histogram plot feature to the design along with the GUI support.
- Updated section Running the Demo, page 8.

1.2 Revision 4.0

- Added clocking and reset structure, refer to Clocking Structure, page 5 and Reset Structure, page 6.
- The demo was updated to support 1080p video input through HDMI 2.0 Rx port.

1.3 Revision 3.0

The demo was updated to support 4K resolution HDMI output.

1.4 Revision 2.0

Added the image panning feature in Running the Demo, page 8.

1.5 Revision 1.0

The first publication of this document.

2 PolarFire 4K Dual Camera Video Kit

This document describes how to run the imaging and video demo using the PolarFire® Video Kit, Dual Camera sensor module, and a HDMI monitor. The demo design features a fully integrated solution developed using Microsemi Libero® System-on-Chip (SoC) software to help customers evaluate PolarFire in smart embedded vision applications and to build prototypes quickly. For more information, refer to *Smart Embedded Vision page*.

The demo demonstrates the following functions:

- MIPI CSI-2 RX to read the 4K dual camera input
- CFA (Color filter array) to RGB (Red, Green, Blue) conversion
- Display controller
- Picture in Picture (PIP)
- 4K image panning through 1920x1080 output via HDMI 1.4 TX port
- 1080p video input through HDMI 2.0 RX port
- 4K video output via HDMI 2.0 TX port
- Edge detection
- Image enhancements such as contrast, brightness, color balance, and gamma correction
- Histogram plot of live video

Note: The solution includes a user-friendly GUI to control these image/video settings.

The PolarFire Video Kit (DVP-102-000512-001) features:

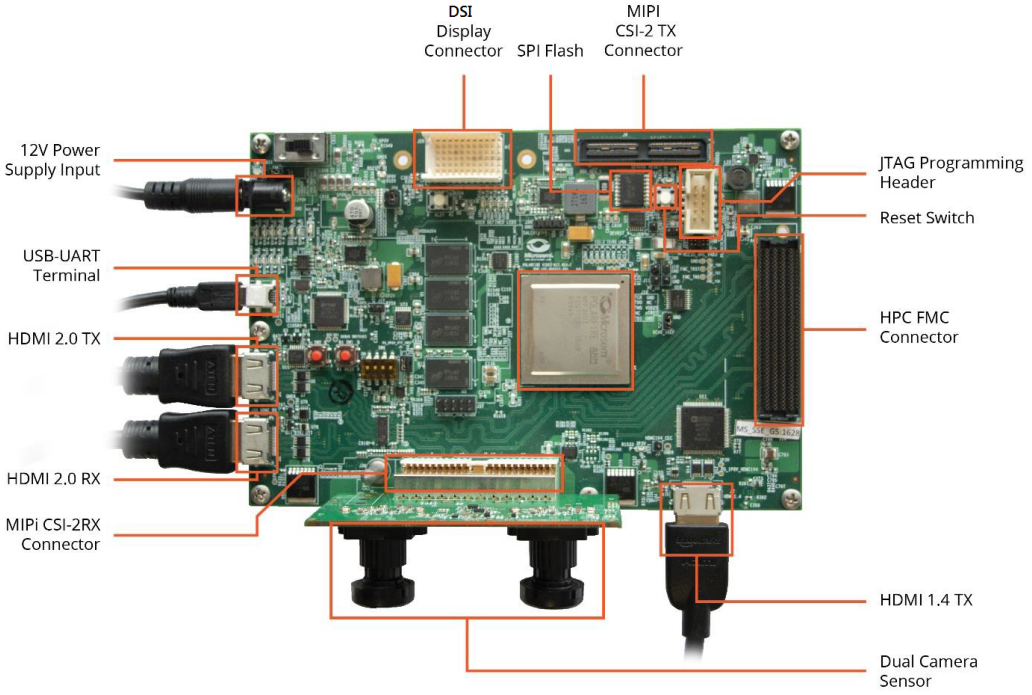
- A 300K LE FPGA (MPF300T, FCG1152)
- HDMI 1.4 transmitter (ADV7511) chipset and corresponding connector
- HDMI 2.0 with rail clamps, ReDrivers and corresponding connectors
- Dual camera sensor featuring IMX334 Sony image sensor
- Image sensor interface to support up to two MIPI CSI-2 cameras
- DSI Interface
- NVIDIA Jetson Interface (MIPI CSI-2 TX connector)
- A High Pin Count (HPC) FMC connector to connect to high-speed interfaces (like 12G-SDI and USXGMII)

For more information about this video kit, refer to https://www.microsemi.com/existing-parts/parts/150747.

For more information about Histogram, refer to *UG0944: Histogram User Guide*.

The following figure highlights the PolarFire Video Kit features:

Figure 1 • **PolarFire Video Kit (DVP-102-000512-001)**



2.1 Design Requirements

The following table lists the hardware and software required to run the demo.

Table 1 • **Design Requirements**

Design Requirement	Description
Hardware	
-PolarFire VIDEO KIT	DVP-102-000512-001 REV 1.0
-Image Sensor module	LI-IMX334-MIPI-MICRO v1.0
-USB A to mini-B cable	Required for: -FPGA programming -UART interface with the Video Control GUI
-HDMI cable	HDMI A Male to Male cable
-HDMI monitor	2 HDMI monitors are required: -A 1920 x1080 60 Hz resolution monitor for the HDMI 1.4 TX port. -A 4K resolution monitor for the HDMI 2.0 TX port.
-Power Adapter	12 V, 5 A
-Host PC	A host PC with USB port
Software	
-Program_Debug_v12.6_win.exe	This executable file installs FlashPro Express, used to program the FPGA.

2.2 Prerequisites

Before you start:

1. Download the programming job file from:
   http://soc.microsemi.com/download/rsc/?f=mpf_dg0849_liberosoc_jb
2. Download the GUI from:
   http://soc.microsemi.com/download/rsc/?f=mpf_dg0849_liberosoc_gui
3. Download and install the Program and Debug software from:
   https://soc.microsemi.com/portal/default.aspx?r=3&p=f=ProgramDebug_v12_6_WIN

Note: On this web page, download the `Program_Debug_v12.6_win.exe` binary file. Installation of this executable file installs FlashPro Express and SmartDebug used for FPGA programming and debugging. FlashPro Express is used in this demo.

Note: The **Program and Debug** Software also installs the drivers on the host PC to detect the COM port for running the demo. Install this software whenever the demo is run on a different host PC.

2.3 Demo Resources

The `mpf_dg0849_liberosoc_jb` folder contains the following resources:

- **A job file (JOB file)**: This file includes the FPGA bitstream and the SPI Flash image to be programmed.

For programming the FPGA using the job file, refer to Programming the Device, page 8.

2.4 Clocking Structure

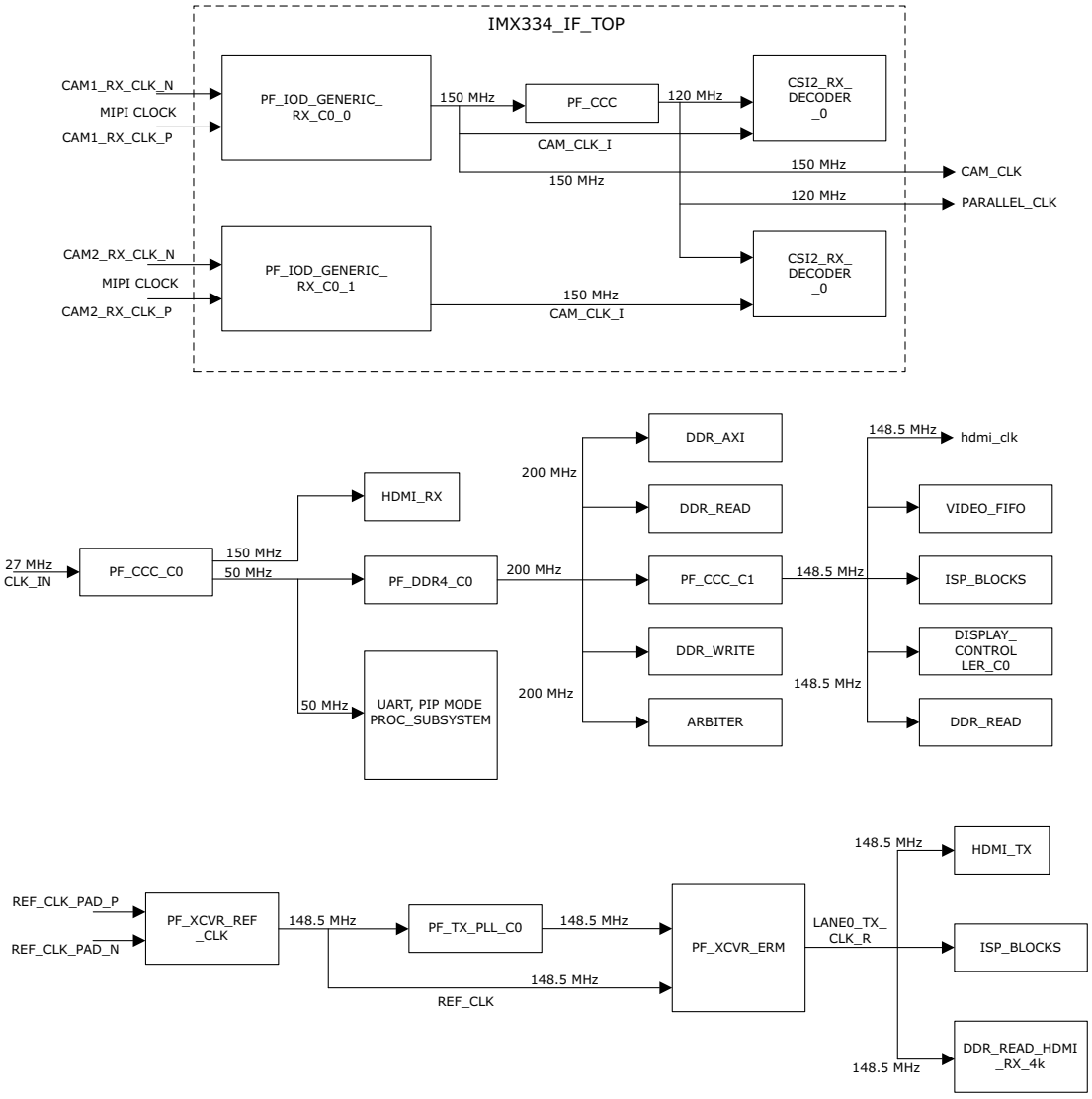
The clocks generated from the onboard oscillator are used in the demo design. Using the 27 MHz reference frequency from the onboard oscillator, PF_CCC_C0 generates a 150 MHz clock for the HDMI_RX, and a 50 MHz clock for the Mi-V processor subsystem and DDR Controller. Using the reference frequency of 200 MHz (DDR System clock), PF_CCC_C1 generates a 148.5 MHz clock for XCVR_ERM_C0 (HDMI) and Display Controller. Using the 148.5 MHz onboard oscillators, PF_XCVR_REF_CLK generates the following clocks:

- 148.5 MHz clock (LANE0_TX_CLK_R) for the 4K User Logic.

Using the reference frequency of 150 MHz, PF_CCC generates a 120 MHz clock for MIPI_RX_DECODER.

The following figure shows the clocking structure.

Figure 2 • **Clocking Structure**



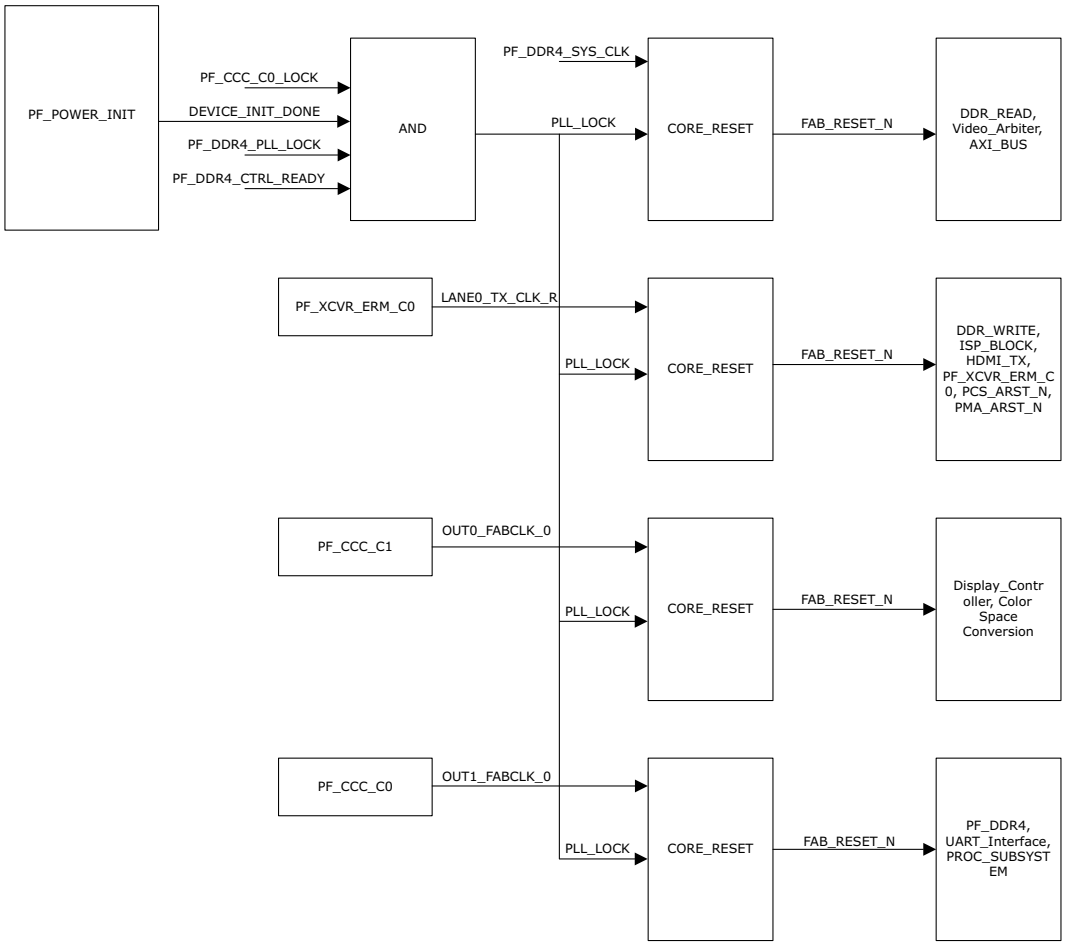
2.5 Reset Structure

The Mi-V processor subsystem, XCVR, UART, ISP, and all other blocks are reset when the following signals are asserted:

- DEVICE_INIT_DONE from PF_INIT_MONITOR
- DDR_CTRL_RDY from DDR Controller
- DDR PLL_LOCK
- PLL_LOCK of PF_CCC_C0

The following figure shows the reset structure.

Figure 3 • **Reset Structure**



2.6 Installing the Demo GUI

To install the GUI:

1. Extract the contents of the **mpf_dg0849_liberosoc_gui.rar** file and run the **setup.exe** file.
2. Click Yes for any message from User Account Control.
   The **Video Control GUI** installation wizard is displayed.
3. Confirm the installation directory locations for the GUI and the National Instruments products and click **Next**.
4. Accept the license agreement and click **Next**.
5. Review the summary and click **Next**.
   The installation proceeds with a progress bar. After the installation, a confirmation message is displayed.
6. Click **Next** to exit the installation wizard.
7. Restart the host PC when prompted.

The Video_Control GUI is installed.

2.7 Setting Up the Demo

Setting up the demo involves the following steps:

1. Setting Up the Hardware, page 7
2. Programming the Device, page 8

2.7.1 Setting Up the Hardware

Setting up the hardware involves interfacing the dual camera sensor module and the HDMI monitor with the PolarFire Video Kit and verifying the jumper settings.

Follow these steps:

1. Connect the **J1** connector of the dual camera sensor module to **J38** interface of the video kit.
2. Connect the Full HD HDMI monitor to **J2** (HDMI 1.4 TX port) of the video kit using the HDMI cable.
3. Connect the 4K HDMI monitor to **J1** (HDMI 2.0 TX port) of the video kit.
4. Connect the host PC and the video kit through **J12** of the video kit using the USB mini cable.
5. Connect the power supply cable to **J20** of the video kit.
6. Ensure that the following jumper settings are set on the video kit.

Table 2 • **Jumper and Switch Settings**

Jumper	Default Position	Functionality
J15	Open	SPI Slave and Master mode selection. By default, SPI master
J17	Open	100K PD for TRSTn. By default,1K PD is connected
J19	Pin 1 and 2	Default: XCVR_VREF is connected to GND
J28	Pin 1 and 2	Default: Programming through the FTDI
J24	Pin 2 and 4	Default: VDDAUX4 voltage is set to 3V3
J25	Pin 5 and 6	Default: Bank4 voltage is set to 1V8
J36	Pin 1 and 2	Default: Board power up through the SW4
SW6	ON	User DIP switch
SW4	OFF	Power ON/OFF switch
J20	12 Volts Input	12 V input to the board

7. Power-up the HDMI monitor.
8. Power-up the board using the **SW4** slide switch.

The PolarFire dual camera video and imaging hardware is set up. Refer to the following section to program the PolarFire device.

9. Connect the HDMI port of a HDMI output device such as laptop to the HDMI 2.0 RX port J35 connector on the video kit through an additional HDMI male to male cable. Make sure the HDMI output device uses a resolution of 1920 x1080p 60 Hz.
10. The video in the HDMI monitor is automatically switched to the video from HDMI input source.
11. Disconnect the HDMI RX cable to switch back to camera video.

2.7.2 Programming the Device

To program the PolarFire device with the job file provided as part of the design files using FlashPro Express software, refer to Appendix: Programming the Device Using FlashPro Express, page 12.

2.8 Running the Demo

The demo features receiving the MIPI Rx data from the two cameras with 4K resolution at 30 Frames Per Second (FPS). The frames from camera are stored in DDR and passed on to the display as per the display controller timing parameters. The image processing pipeline on the display side uses bayer interpolation, gamma correction, histogram, and image enhancement IPs to enhance the raw image from the camera. Also, the demo uses automatic camera exposure control based on the lighting conditions.

The demo also features HDMI Rx input at a resolution of 1920 x1080p 60 Hz. The HDMI input video is displayed on the HDMI monitor upon connecting a HDMI source at the RX port.

In the demo design, two display controllers are used to provide two video outputs:

- Full HD output (1920x1080 60 Hz resolution)
- 4K output (3840x2160 30 Hz resolution)

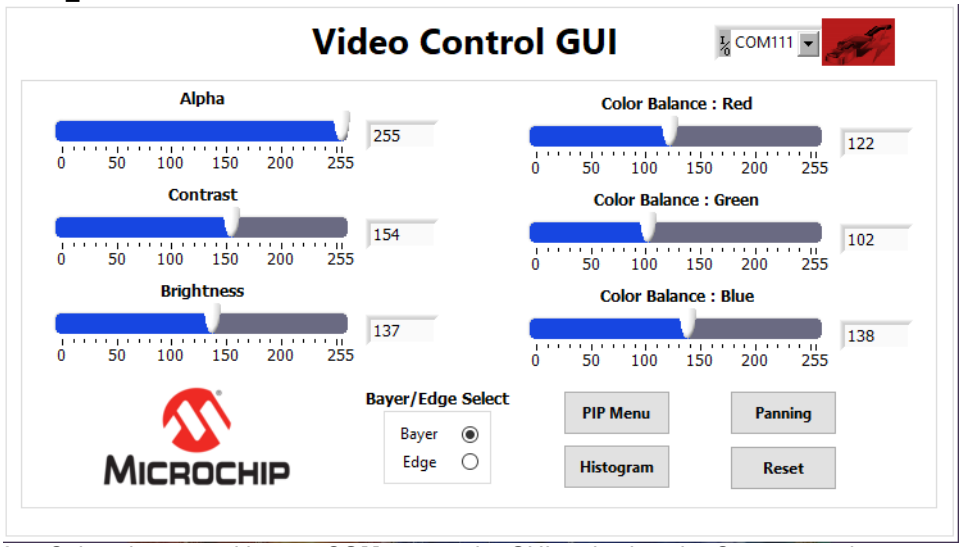
The Full HD output supports PIP, panning, Edge Detection, and Image enhancements such as contrast, brightness, color balance, and alpha blending. The 4K output supports Image enhancements. The GUI control for image enhancements is common for both the video outputs.

Running the demo involves verifying the imaging and video settings using the Video_Control GUI and then observing the result on the HDMI monitor.

To use the demo GUI:

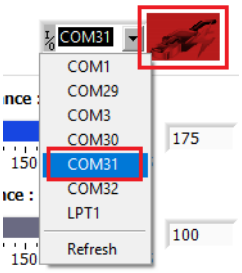
1. Start the **Video_Control GUI** from the installation directory.
   The GUI is displayed as shown in the following figure.

Figure 4 • **Video_Contol GUI**



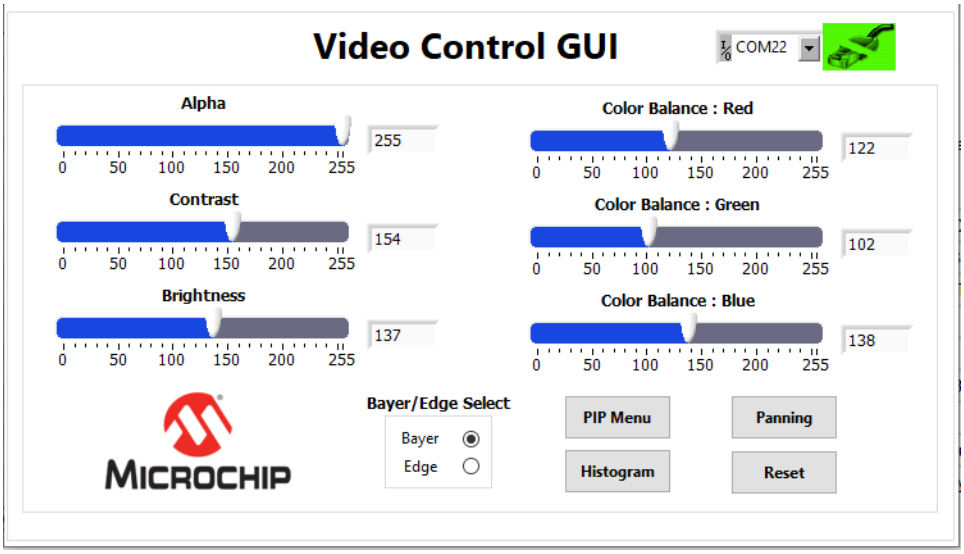
2. Select the second largest **COM** port on the GUI and select the **Connect** option.

Figure 5 • **Connecting the GUI and Video kit**



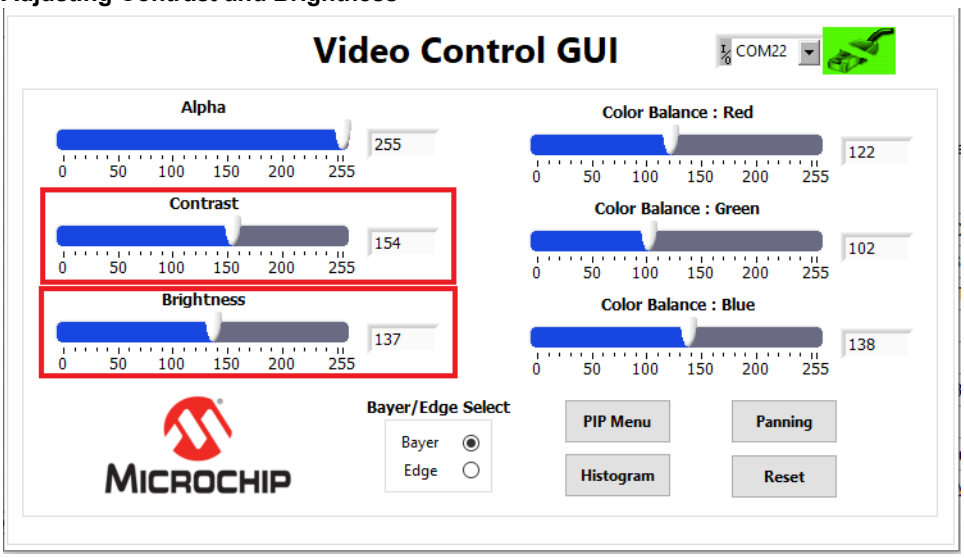
3. The Connect button turns green indicating a successful connection.

Figure 6 • **Connection Successful**



4. Use the **Contrast** and **Brightness** sliders to adjust the contrast and brightness and observe the change on the HDMI monitor. The sliders are highlighted in the following figure.

Figure 7 • **Adjusting Contrast and Brightness**

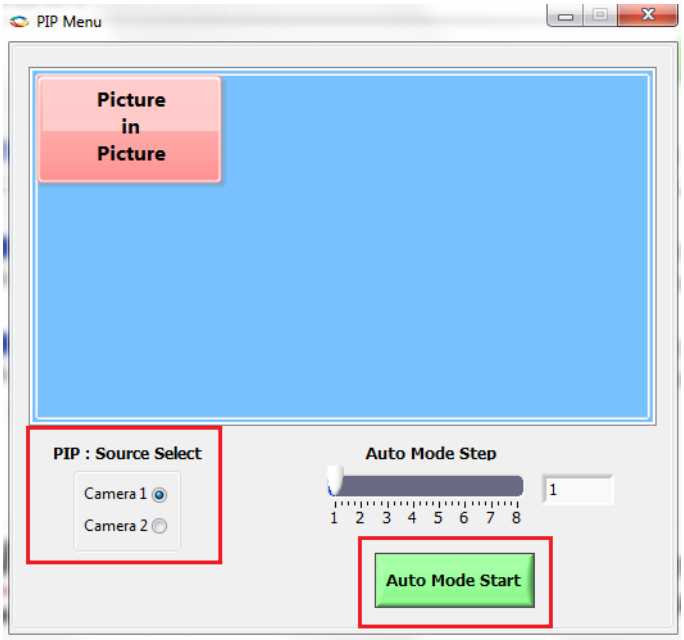


5. Similarly, adjust the color balance of the image using the color balance sliders.
6. Adjust the Alpha slider. The alpha blending feature enables adjusting the transparency of the PIP image. When the alpha value is adjusted to minimum (0), the image disappears.

Note: Default image settings can be reverted by using the **Reset** option.

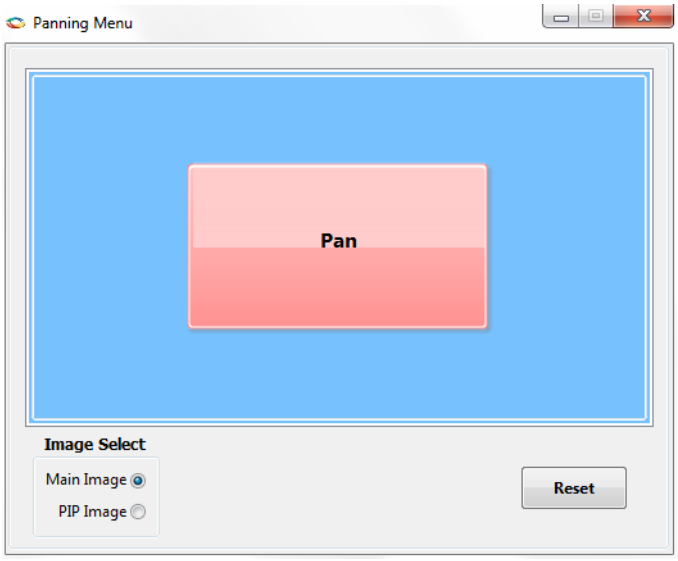
7. Switch to **Edge Detection** mode using the **Edge** option.
8. Select the **PIP Menu** to change the PIP settings.
9. Select the source of the PIP window between Camera 1 and Camera 2 using **PIP: Source Select**. The position of the PIP window can be moved anywhere within the screen by dragging the pink **Picture In Picture** box. The **Auto Mode Start** option moves the PIP window automatically. The speed of this movement can be controlled using the **Auto Mode Step** slider.

Figure 8 • **PIP Menu**



10. Close the **PIP Menu**.
11. In the main video control GUI window, select the **Panning** option to view a particular area of the main or the PIP image within a 4K image.
12. In the **Panning** Menu, use **Image Select** to select the image to be panned (Main image or PIP image). Any area of the 4K camera feed can be viewed by dragging the pink box horizontally or vertically. The **Reset** option sets the view of the **Main image** and **PIP image** to its default center position.

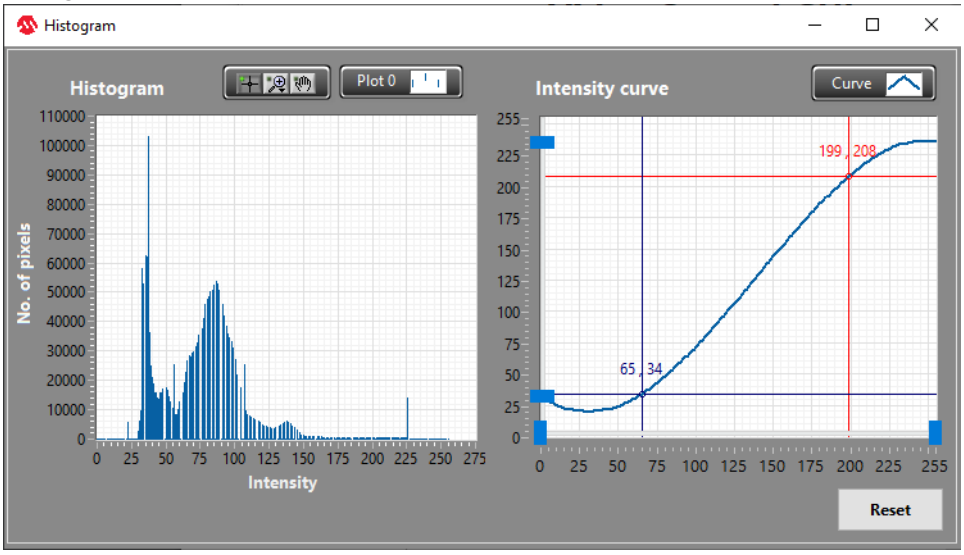
Figure 9 • **Panning Menu**



13. Close the **Panning Menu** to return to the main GUI.

14. In the main video control GUI window, select the **Histogram** option to view the Histogram plot of the live video. The plot on the right side is the intensity curve which can be modified to adjust the intensity of various pixel values are as shown in the following figure.

Figure 10 • **Histogram Plot**



15. Close the Histogram window to return to the main GUI.
16. Close the GUI to exit from the demo.

This concludes the demo.

3 Appendix: Programming the Device Using FlashPro Express

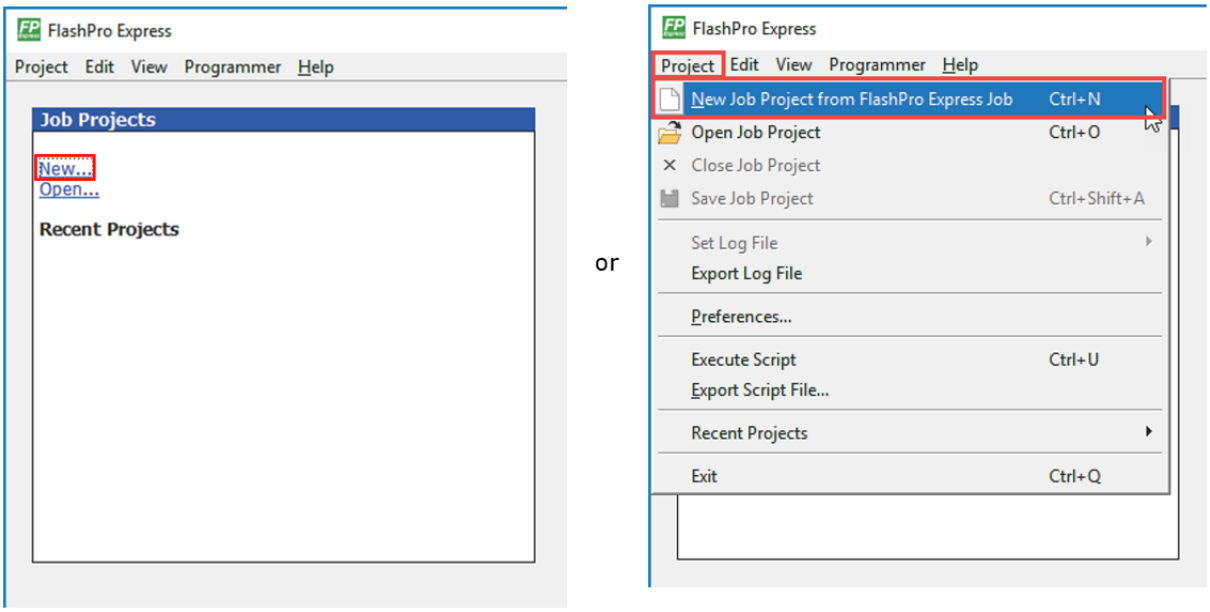
This chapter describes how to program the PolarFire device with the job file using FlashPro Express. The job file is available at the following design files folder location:

`<$Download_Directory>\mpf_dg0849_liberosoc_jb`

Follow these steps:

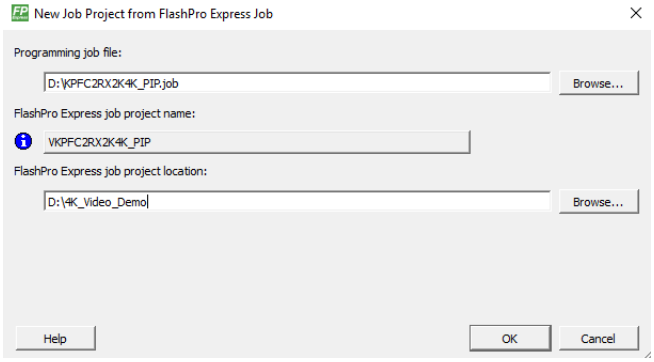
1. On the host PC, start the FlashPro Express software from its installation directory.
2. Select **New** or **New Job Project from FlashPro Express Job** from Project menu to create a new job project, as shown in the following figure.

Figure 11 • **FlashPro Express Job Project**



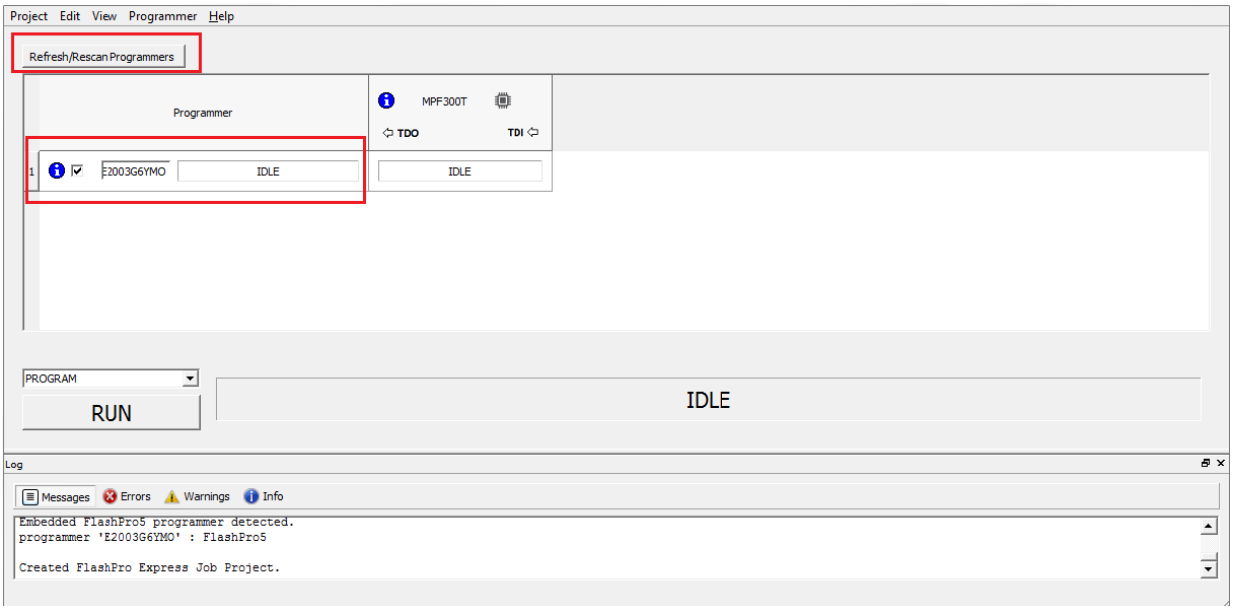
3. Enter the following in the New Job Project from FlashPro Express Job dialog box:
   - Programming job file: Click **Browse** and navigate to the location where the job file is located and select the file. The default location is:
     `<$Download_Directory>\mpf_dg0849_liberosoc_jb`
   - **FlashPro Express job project location**: Select **Browse** and navigate to the location where you want to save the project.

Figure 12 • **New Job Project from FlashPro Express Job**



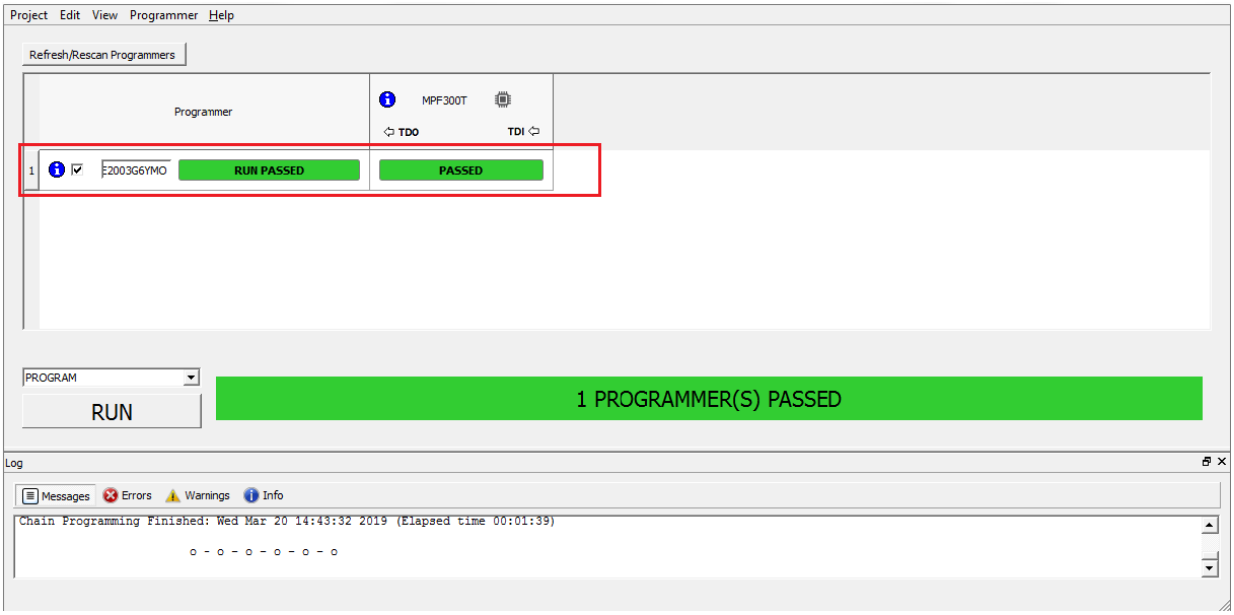
4. Click **OK**. The required programming file is selected and ready to be programmed in the device.
5. The FlashPro Express window appears as shown in the following figure. Confirm that a programmer number appears in the Programmer field. If it does not, confirm the board connections and click **Refresh/Rescan Programmers**.

Figure 13 • **Programming the Device**



6. Click **RUN** to program the device. When the device is programmed successfully, a **RUN PASSED** status is displayed as shown in the following figure. Refer to Running the Demo, page 8.

Figure 14 • **FlashPro Express—RUN PASSED**



7. Close FlashPro Express (**Project > Exit**).

The PolarFire device and SPI Flash are programmed.

Power cycle the board using switch SW4. After power cycling:

- The Full HD HDMI monitor displays the camera feed from the 2 cameras as Picture in Picture.
- The 4K HDMI monitor displays the camera feed from one of the cameras in 4K mode.