


Introduction (Ask a Question)

This Application Note provides a comprehensive, hands-on demonstration, highlighting the video functionalities of the PolarFire® Video Kit. This demo outlines the following main functionalities:

- **Capture and Display Live Video:** This Video Kit captures and displays live videos from the camera sensor in resolutions up to 4K at 30 fps.
- **Utilize Picture-in-Picture (PIP) Mode:** PIP mode is used to view multiple video streams simultaneously.
- **Pass through HDMI Content:** The HDMI content is passed from an external device to the display of the kit.

This demo provides a foundation for understanding and leveraging the powerful features of the PolarFire Video Kit, and demonstrates the following functions:

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

 **Important:** The solution includes a user-friendly Graphic User Interface (GUI) to control the preceding image and video settings.

For more information about this video kit, see the [PolarFire FPGA Video and Imaging Kit with MPF300T Device](#) web page.

For more information about Histogram, see [UG0944: Histogram User Guide](#).

The following figure highlights the PolarFire Video Kit features.

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

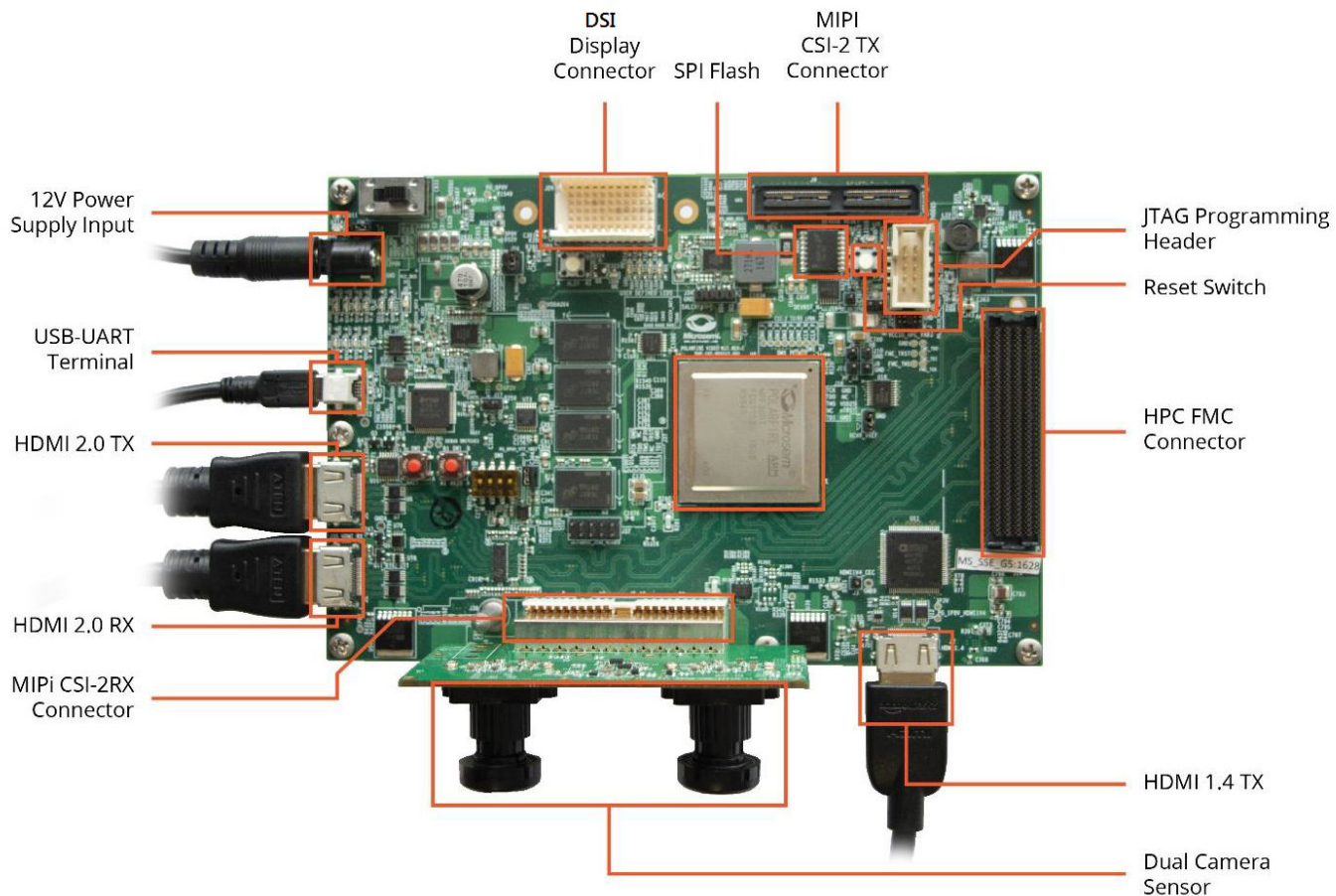


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1. Demo Requirements [\(Ask a Question\)](#)

The following table lists the hardware and software required for running the demo.

Table 1-1. Demo Requirements

Requirement	Description
Hardware and Accessories	
PolarFire® video kit	MPF300-VIDEO-KIT-NS Kit contents: <ul style="list-style-type: none"> • PolarFire Video and Imaging board with MPF300T-1FCG1152E Device • Dual Camera Sensor board – VIDEO-DC-DUALCAM • 12V power pack/AC adapter • HDMI cable • USB 2.0 A male to mini-B
2x HDMI Monitor	<ul style="list-style-type: none"> • 1920 x 1080, 60 Hz resolution monitor for the HDMI 1.4 TX port • 4K resolution monitor for the HDMI 2.0 TX port
Software	
FlashPro Express	This software is used to program the FPGA.
Microchip FPGA_GUI_Pack	This pack includes the necessary run-time engine and drivers for the operation of the Microchip FPGA Demo GUIs.

2. Demo Prerequisites [\(Ask a Question\)](#)

For the best demo experience, ensure to perform the following steps:

1. Download the [PolarFire 4K Dual Camera Video Kit design files](#).
2. Program the FPGA using the job file.



Important: The `mpf_an5270_v2024p1_jb` folder contains a job file (JOB file) which includes the FPGA bitstream to be programmed. For programming FPGA using the job file, see [6.2. Programming the Device Using FlashPro Express](#).

3. From the [Libero SoC Software Downloads](#), download and install the Libero® SoC Design Suite.
4. Download and install the [Microchip FPGA_GUI_Pack](#).

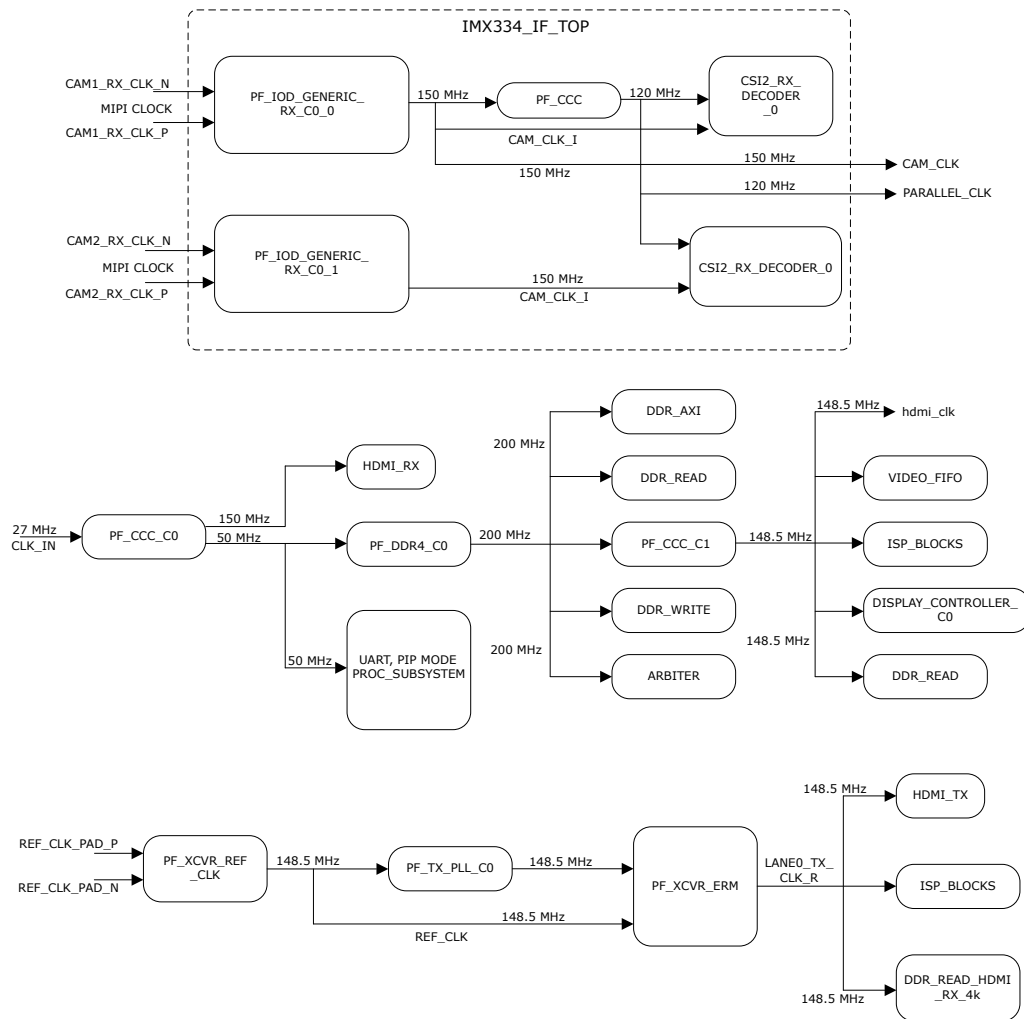
3. Clocking Structure (Ask a Question)

The clocks generated from the on-board oscillator are used in the demo design. Using the 27 MHz reference frequency from the on-board 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 on-board oscillators, PF_XCVR_REF_CLK generates a 148.5 MHz clock (LANE0_TX_CLK_R) for the 4K User Logic.

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

The following figure shows the clocking structure.

Figure 3-1. Clocking Structure



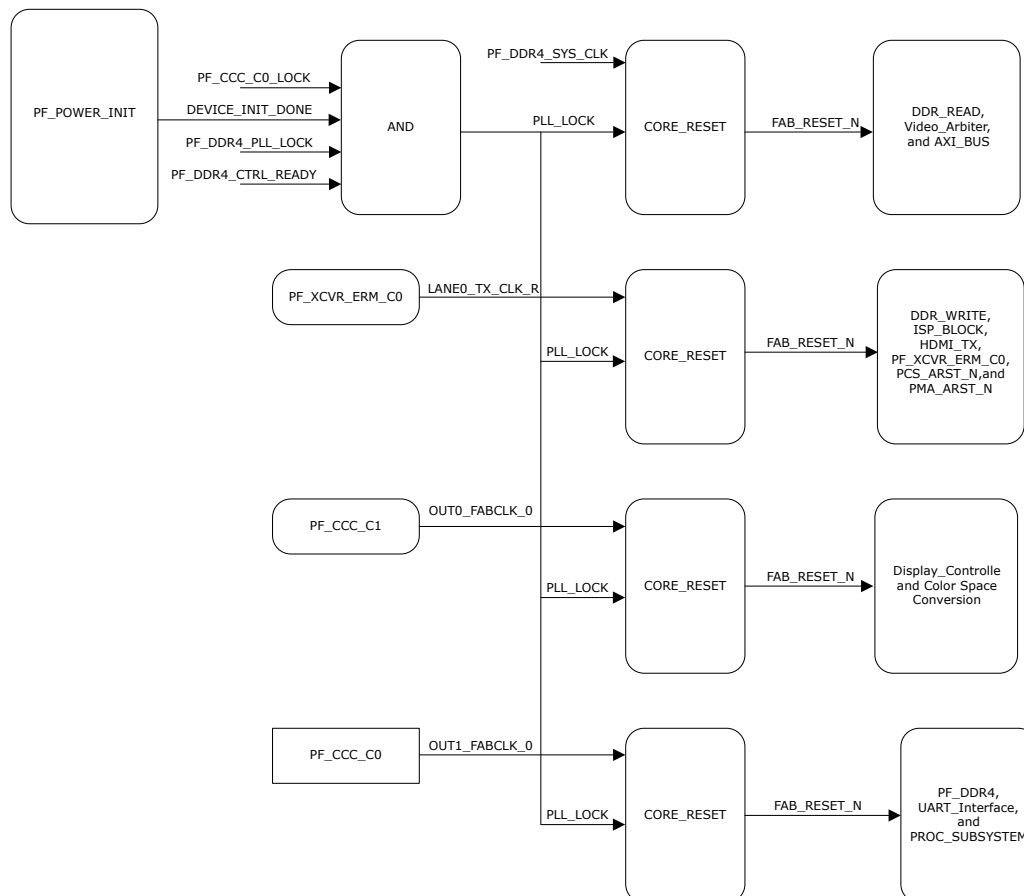
4. Reset Structure (Ask a Question)

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 4-1. Reset Structure



5. Installing the Demo GUI [\(Ask a Question\)](#)

To install the GUI, perform the following steps:

- Extract the contents of the `mpf_an5270_v2024p1_gui.zip` file.
- To install the demo GUI, run the `setup.exe` file with admin rights and follow the on-screen instructions.

The Video Control GUI is now ready for use.



Important:

- At the end of the installation, you may be prompted to download and install the `FPGA_GUI_Pack`, if it is not already available on your system.
 - For any queries encountered while running the installer, contact the Technical Support team.
-

6. Setting Up the Demo [\(Ask a Question\)](#)

Setting up the demo involves the following steps:

- Setting up the Hardware
- Programming the Device using FlashPro Express

6.1 Setting Up the Hardware [\(Ask a Question\)](#)

To set up the hardware, perform the following steps:

1. Connect the Camera: Gently insert the dual camera sensor module into the **J38** interface on the video kit.
2. Connect the Monitors:
 - a. Use an HDMI cable to connect the Full HD HDMI monitor to **J2** (HDMI 1.4 TX port).
 - b. Use another HDMI cable to connect the 4K HDMI monitor to **J1** (HDMI 2.0 TX port).
3. Connect to Your PC: Plug the USB mini cable into **J12** on the video kit and connect the other end to your computer.
4. Power Up: Plug the power supply cable into **J20** on the video kit. Ensure that the jumpers are set correctly, as listed in the following table.

Table 6-1. Jumper and Switch Settings

Jumper	Default Position	Functionality
J15	Open	SPI Target and Initiator mode selection. Default: SPI Initiator
J17	Open	100K PD for TRSTn. 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	12V input	12V input to the board

5. Turn on both HDMI monitors.
6. To power on the video kit, slide switch **SW4**.
To program the PolarFire device, see [6.2. Programming the Device Using FlashPro Express](#) section.

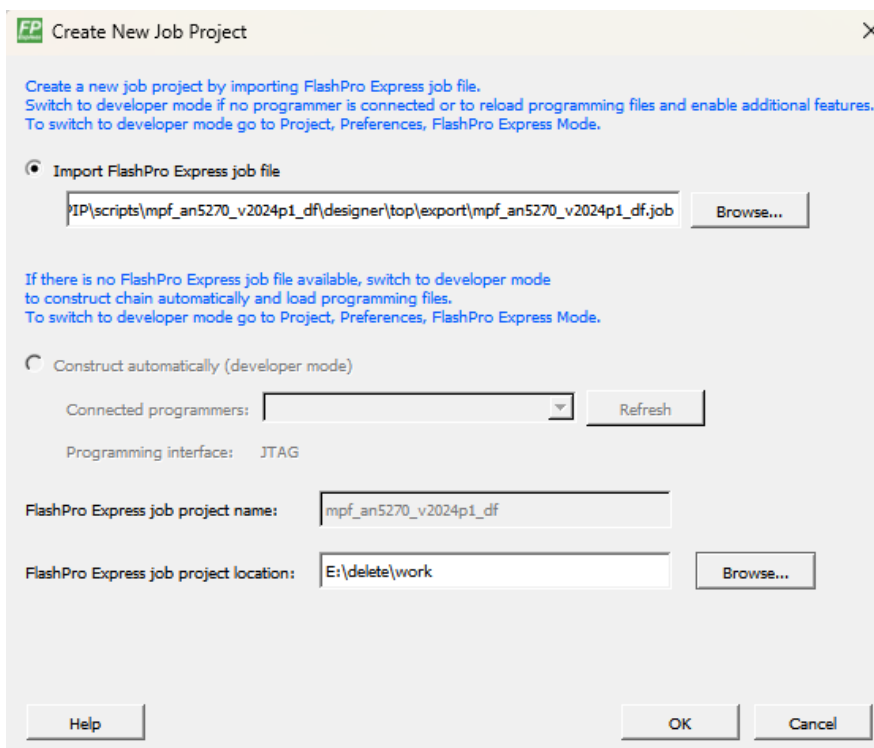
6.2 Programming the Device Using FlashPro Express (Ask a Question)

This section describes how to program the PolarFire device, with the programming job file, using FlashPro Express.

To program the device, perform the following steps:

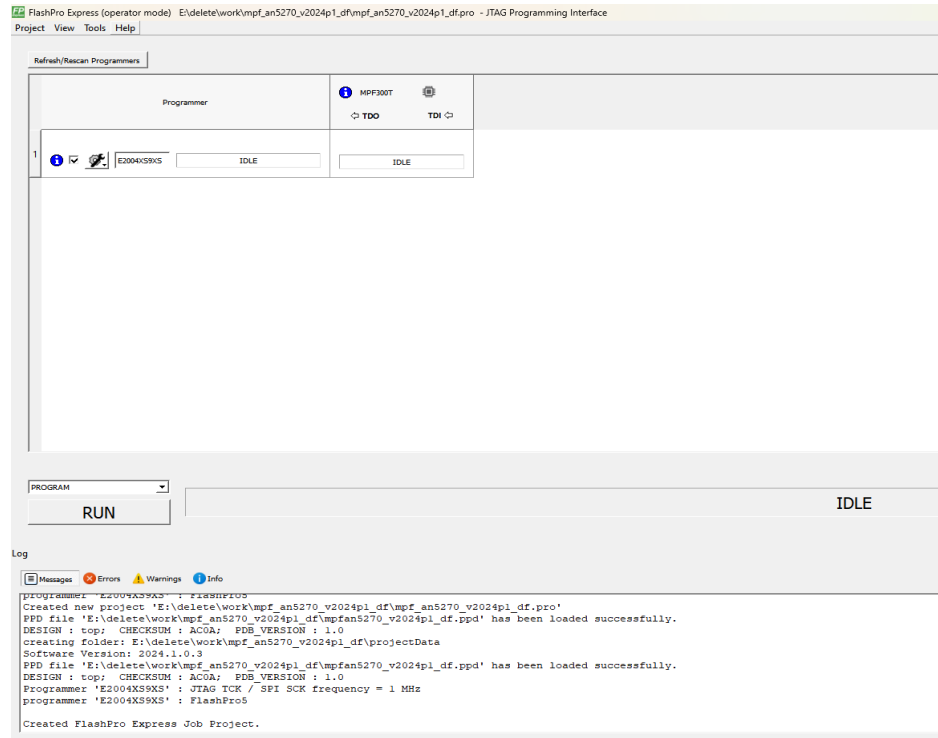
1. On the host PC, launch the **FlashPro Express software**.
2. To create a new job project, click **New** or navigate to the **Project** menu and select **New Job Project from FlashPro Express Job**.
3. In the **New Job Project**, from the **FlashPro Express Job** dialog box, enter the following:
 - **Programming job file:** Click **Browse**, navigate to the location where the **job** file is located, and select the file. The default location is:
<download_folder>\mpf_an5270_v2024p1_jb\mpf_an5270_v2024p1_df.
 - **FlashPro Express job project location:** Click **Browse** and navigate to the FlashPro Express project location.

Figure 6-1. New Job Project from FlashPro Express Job



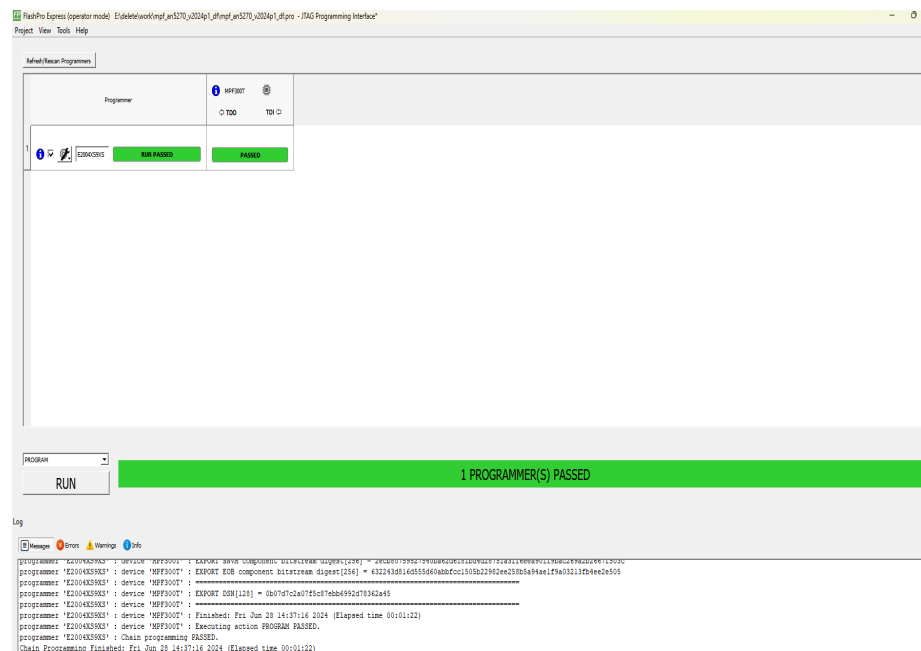
4. Click **OK**. The required programming file is selected and ready to be programmed in the device.
5. The **FlashPro Express** window appears as shown in the following figure. Confirm that a programmer number appears in the **Programmer** field. If it does not, confirm the board connections and click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

Figure 6-2. Programming the Device



- Click **RUN**. When the device is programmed successfully, a **RUN PASSED** status is displayed, as shown in the following figure. See [7. Running the Demo](#).

Figure 6-3. FlashPro Express—RUN PASSED



- Close **FlashPro Express** or in the **Project** tab, click **Exit**.
The PolarFire device is now programmed.

7. Running the Demo (Ask a Question)

The PolarFire® Video Kit Picture-In-Picture (PIP) demonstration showcases the ability to process the MIPI Rx data from two 4K cameras operating at 30 fps. The captured frames are stored in DDR memory and then transferred to the display, in accordance with the display controller's timing specifications. The display uses a sophisticated image processing pipeline, which includes Bayer interpolation, Gamma correction, Histogram equalization, and image enhancement Intellectual Properties (IPs) to improve the raw camera output. In addition, the demo includes an automatic exposure control for the cameras, which adjusts to the ambient light conditions.

Furthermore, the demonstration includes an HDMI Rx input that supports a resolution of 1920 x 1080p at 60 Hz. When an HDMI source is connected to the Rx port, the video is displayed on an HDMI monitor.

Within the demo's architecture, two display controllers are used to deliver dual video outputs:

- A Full HD output, with a resolution of 1920 x 1080 at 60 Hz
- A 4K output, with a resolution of 3840 x 2160 at 30 Hz

The Full HD output is equipped with features such as Picture-in-Picture (PIP), Panning, Edge Detection, and various image enhancements including adjustments for contrast, brightness, color balance, and alpha blending. The 4K output is also capable of image enhancements. A single GUI controls the image enhancement settings for both video outputs. To run the demo, users must verify the imaging and video configurations using the Video Control GUI, and then view the outcomes on the HDMI monitor.

After power cycling, observe the following on the two monitors:

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

To check the HDMI pass-through, perform the following steps:

1. 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 x 1080p at 60 Hz.

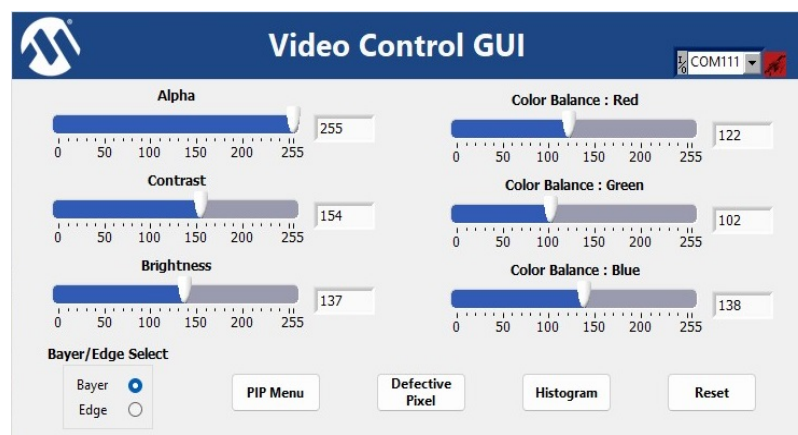
The video in the HDMI monitor is automatically switched to the video from HDMI input source.

2. To switch back to camera video, disconnect the HDMI RX cable.

To use the demo GUI, perform the following steps:

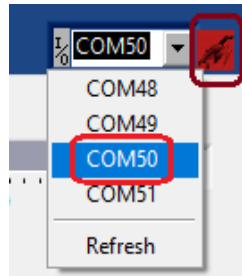
1. Start the **Video Control GUI** from the programs, see the following figure.

Figure 7-1. Video Control GUI



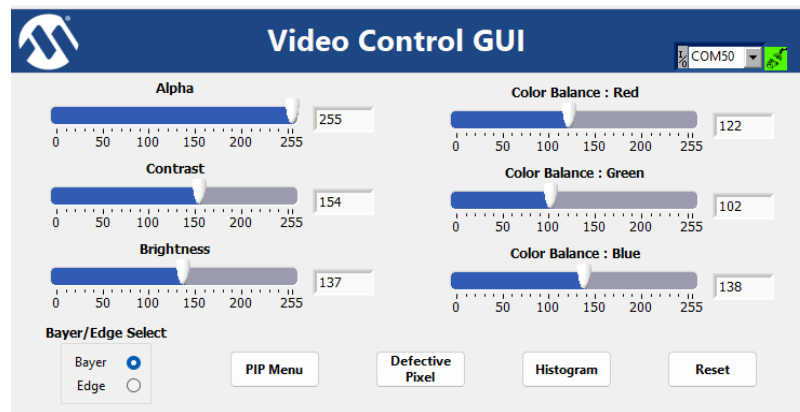
- From the I/O list, click the second largest **COM** port, and then click the **Connect** button.

Figure 7-2. Connecting the GUI and Video Kit



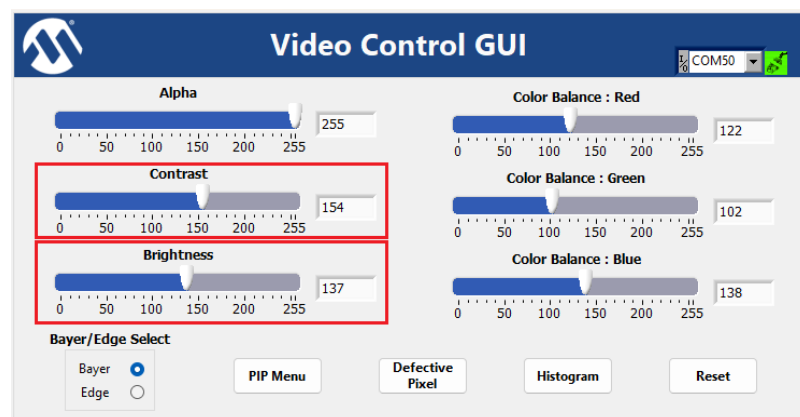
The following figure shows that the **Connect** button turns green indicating a successful connection.

Figure 7-3. Connection Successful



- Move the corresponding sliders appropriately to adjust the contrast and brightness, and observe the change on the HDMI monitor.

Figure 7-4. Adjusting Contrast and Brightness

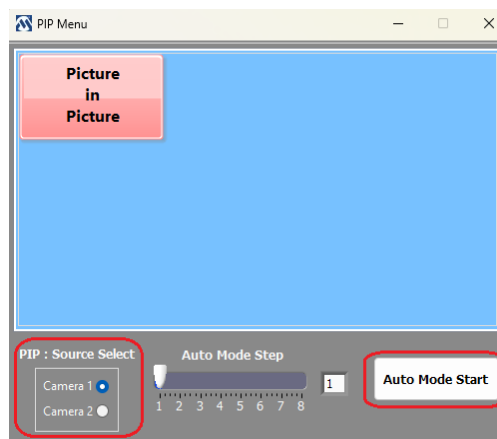


- Similarly, move the sliders to adjust the color balance of the image using the color balance sliders.
- Adjust the Alpha slider. The alpha blending feature enables adjusting the transparency of the PIP image. When the alpha value is adjusted to minimum (0), the image disappears.

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

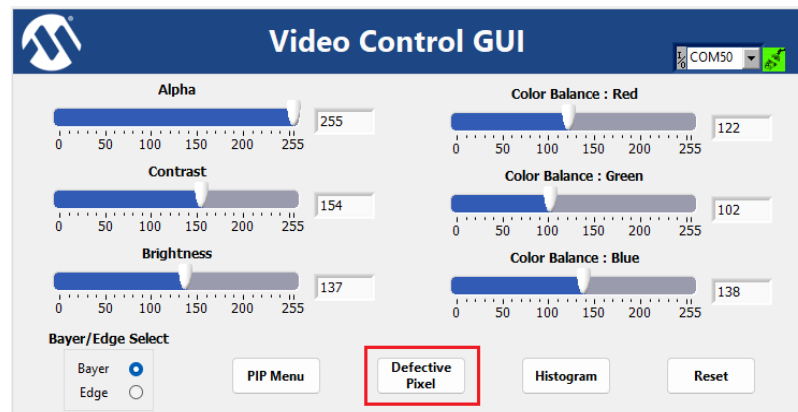
6. Switch to **Edge Detection** mode using the **Edge** option.
In Edge Detection mode, the system will highlight live feed edges and switch the display to black and white to improve edge visualization on the FULL HD Monitor, while a 4KP30 live feed will be shown on a 4K display.
7. Select the **PIP Menu** to change the PIP settings.
8. 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 is controlled using the **Auto Mode Step** slider.

Figure 7-5. PIP Menu



9. Close the **PIP Menu**.

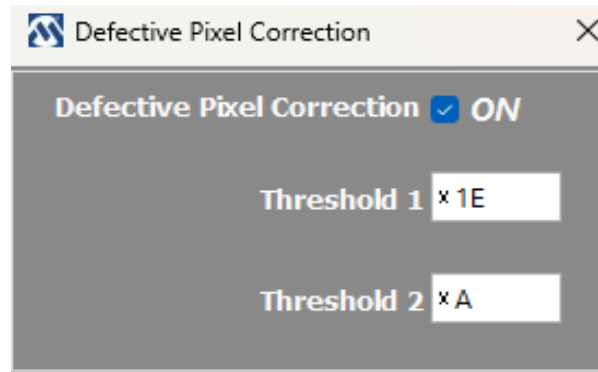
Figure 7-6. Defective Pixel Menu



10. To enable or disable the defective pixel functionality, navigate to the **Defective Pixel Menu**, as shown in the preceding figure, and select the threshold values as listed:
 - **Threshold 1:** The first detection threshold establishes the minimum absolute difference between pixels and their adjacent pixels of the same color.
 - **Threshold 2:** The second detection threshold determines how the difference in pixels compares to the differences in pixels of other colors.

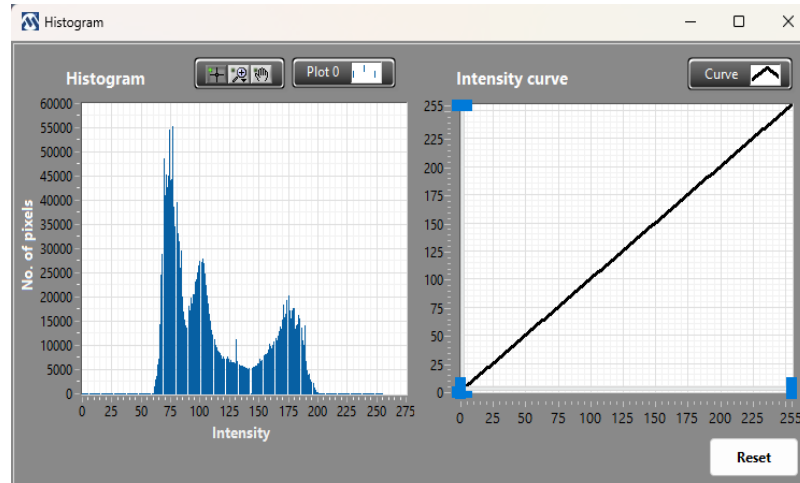
➔ Important: The defective pixel correction feature, when enabled and configured with specified thresholds, adjusts the output video to reduce the impact of dead or stuck pixels on the screen. Each pixel is compared to established threshold values. If the pixel's value falls below the threshold, it is identified as a dead pixel and eliminated.

Figure 7-7. Defective Pixel Correction



11. To return to the main GUI, close the **Defective Pixel Menu**.
12. To view the histogram plot of the live video, navigate to the main video control GUI window, and select the **Histogram** option. The plot on the right side is the intensity curve which can be modified to adjust the intensity of various pixel values, as shown in the following figure.

Figure 7-8. Histogram Plot



13. To return to the main GUI, close the **Histogram** window.
14. To exit from the demo, close the GUI.

This concludes the demo.

8. Appendix: Running the Tcl Script [\(Ask a Question\)](#)

Tcl scripts are provided in the PolarFire Video Kit Reference Design to generate the Libero® project for the reference design.

To run Tcl, perform the following steps:

1. Launch the Libero software.
2. Click **Project > Execute Script**.
3. In the downloaded `mpf_an5270_v2024p1_df` directory, select `script.tcl`.
4. Click **Run**.

After successful execution of the Tcl script, the Libero project is created within the top directory. For more information, check the Log file `mpf_an5270_v2024p1_df_log`.

For more details about the folder structure of `mpf_an5270_v2024p1_df`, Tcl scripts, and commands, see the `TCL_Scripts_readme.txt` and [Tcl Commands Reference Guide](#). For any queries about running the Tcl script, contact Technical Support team.

9. Revision History (Ask a Question)

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

Table 9-1. Revision History

Revision	Date	Description
A	07/2024	<p>The following is the list of changes in revision A of the document:</p> <ul style="list-style-type: none"> • The document was migrated to the Microchip template. • The document number was updated from 50200849 to DS00005270. • The document ID was updated from DG0849 to AN5270. • Updated the document for Libero v2024.1. • Updated 1. Demo Requirements section. • Updated 2. Demo Prerequisites section. • Added a Note and updated 5. Installing the Demo GUI section. • Updated job file location and Figure 6-1, Figure 6-2, and Figure 6-3 in 6.2. Programming the Device Using FlashPro Express section. • Updated 7. Running the Demo section.
5.0	—	<p>The following is the list of changes in revision 5.0 of the document:</p> <ul style="list-style-type: none"> • Added Gamma correction and Histogram plot feature to the design along with the GUI support. • Updated 7. Running the Demo section.
4.0	—	<p>The following is the list of changes in revision 4.0 of the document:</p> <ul style="list-style-type: none"> • Added clocking and reset structure, refer to 3. Clocking Structure and 4. Reset Structure. • The demo was updated to support 1080p video input through HDMI 2.0 Rx port.
3.0	—	The demo was updated to support 4K resolution HDMI output.
2.0	—	Added the image panning feature in 7. Running the Demo .
1.0	—	Initial Revision.

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