PolarFire DisplayPort Tx Solution with Camera Video Output Application Note

AN4576

Introduction (Ask a Question)

This application note demonstrates how to implement the DisplayPort Transmitter (Tx) technology on the PolarFire® FPGA, compliant with the VESA DisplayPort Standard 1.4 protocol. DisplayPort is a digital interface used to connect display devices, such as monitors and projectors, to host systems like computers and gaming consoles. The DisplayPort Tx IP on the PolarFire FPGA supports data rates from 1.62 Gbps to 8.1 Gbps, catering to a wide range of display application requirements.

This document presents a demonstration of video streaming over DisplayPort Tx, using the PolarFire Video kit and a dual-sensor camera module, showcasing the integration of DisplayPort Tx for advanced embedded vision applications. Microchip's Libero® SoC software supports rapid prototyping, facilitating efficient development and testing of PolarFire FPGA in embedded systems. This integrated solution offers engineers a streamlined approach to prototyping display and video signal transmission systems, providing a robust platform for evaluating DisplayPort Tx IP in practical applications.

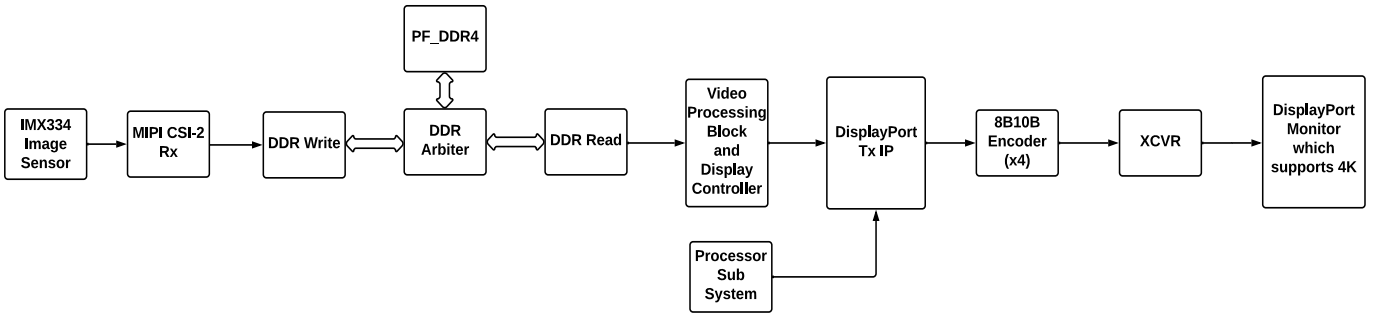
For DisplayPort Tx IP characteristics, features, unsupported features and device utilization, see DisplayPort Tx User Guide.

Table of Contents

1. Design Description (Ask a Question)

The following figure shows the high-level block diagram of the design.

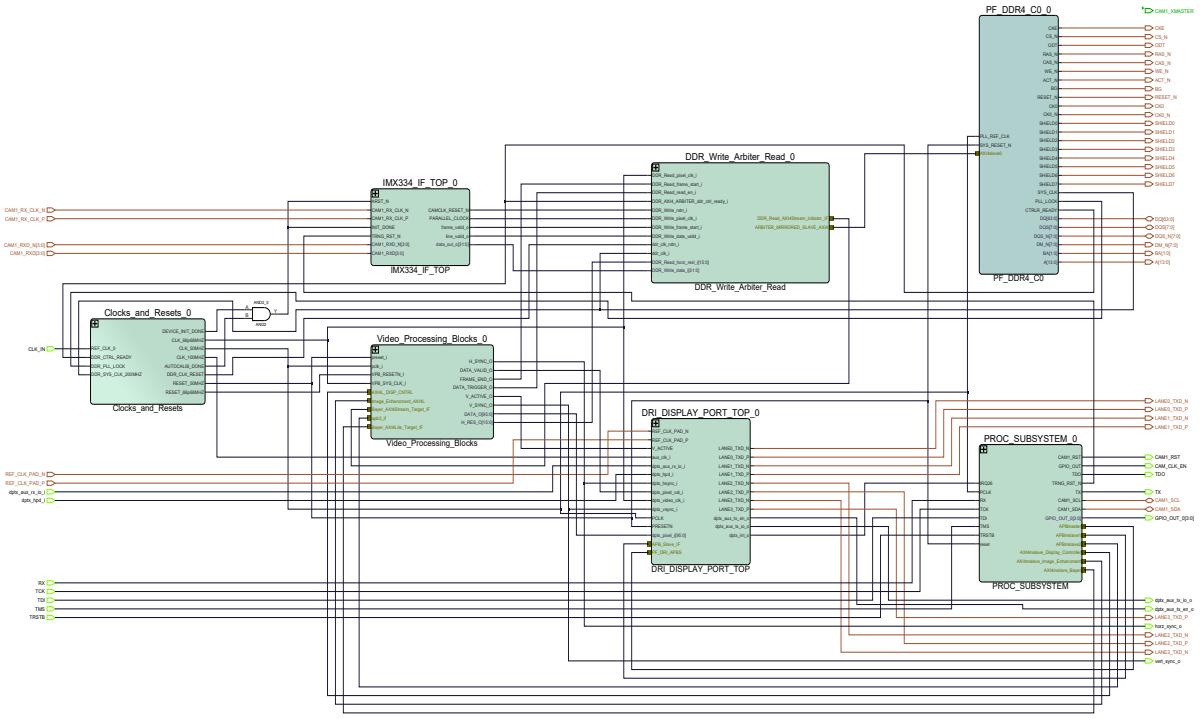
Figure 1-1. Block Diagram



1.1 Hardware Implementation (Ask a Question)

The following figure shows the Libero SoC implementation of the top-level SmartDesign.

Figure 1-2. High-Level DisplayPort Tx Design



The DisplayPort Tx design includes the following key blocks:

- DisplayPort Transmitter (Tx) Configuration
- MIPI CSI-2 Receiver (Rx) Configuration
- XCVR Configuration
- Display Controller Configuration

1.1.1 DisplayPort Transmitter Configuration (Ask a Question)

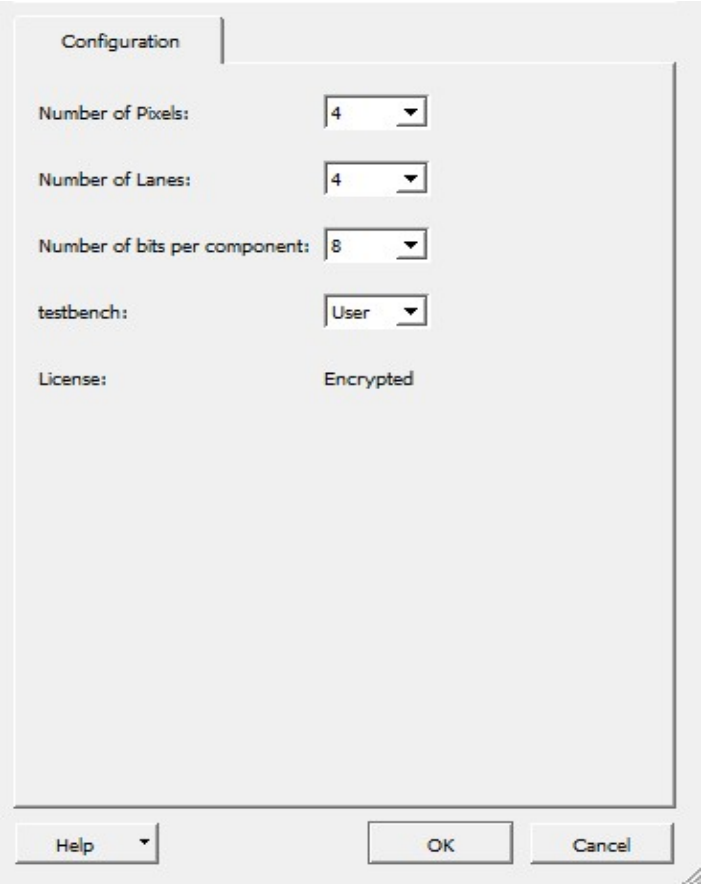
The DisplayPort Tx IP is implemented based on the VESA DisplayPort Standard 1.4 protocol. It supports standard rates of 1.62 Gbps, 2.7 Gbps, 5.4 Gbps and 8.1 Gbps for displays.

In this design, DisplayPort Tx IP is configured with the following settings:

- **Number of Pixels:** 4
- **Number of Lanes:** 4
- **Number of bits per component:** 8

The following figure shows DisplayPort Tx configuration.

Figure 1-3. DisplayPort Tx Configuration



Important: For more information, see DisplayPort Tx User Guide.

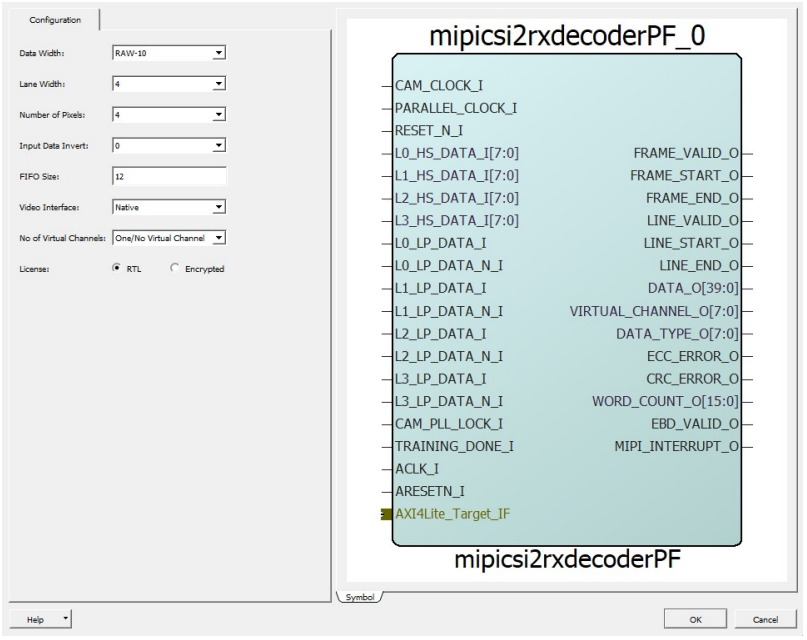
1.1.2 MIPI CSI-2 Receiver Configuration (Ask a Question)

The MIPI CSI-2 Rx is configured with the following settings:

- **Data Width:** RAW-10
- **Lane Width:** 4 Lanes
- **Number of Pixels:** 4

The following figure shows MIPI CSI-2 Rx configuration.

Figure 1-4. MIPI CSI-2 Rx Configuration

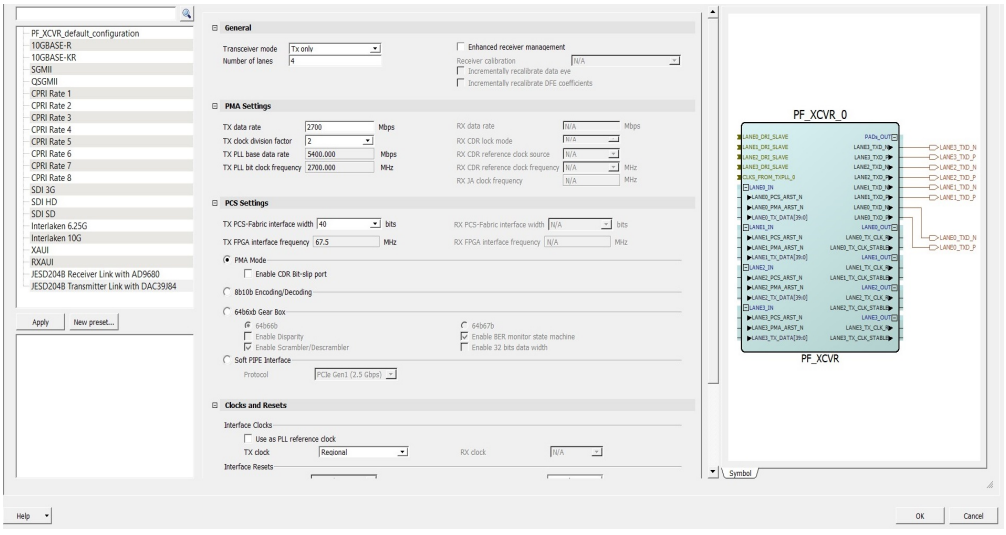


Important: For more information, see PolarFire MIPI CSI-2 Receiver Decoder IP User Guide.

1.1.3 XCVR Configuration (Ask a Question)

The transceiver configuration for the DisplayPort Tx implementation is shown in the following figure. The transceiver is configured in Tx only mode, in a 4-Lane configuration. The clock signal is carried by LANE0, while Lanes 1, 2 and 3 carry DisplayPort Tx output data.

Figure 1-5. XCVR Interface Configuration



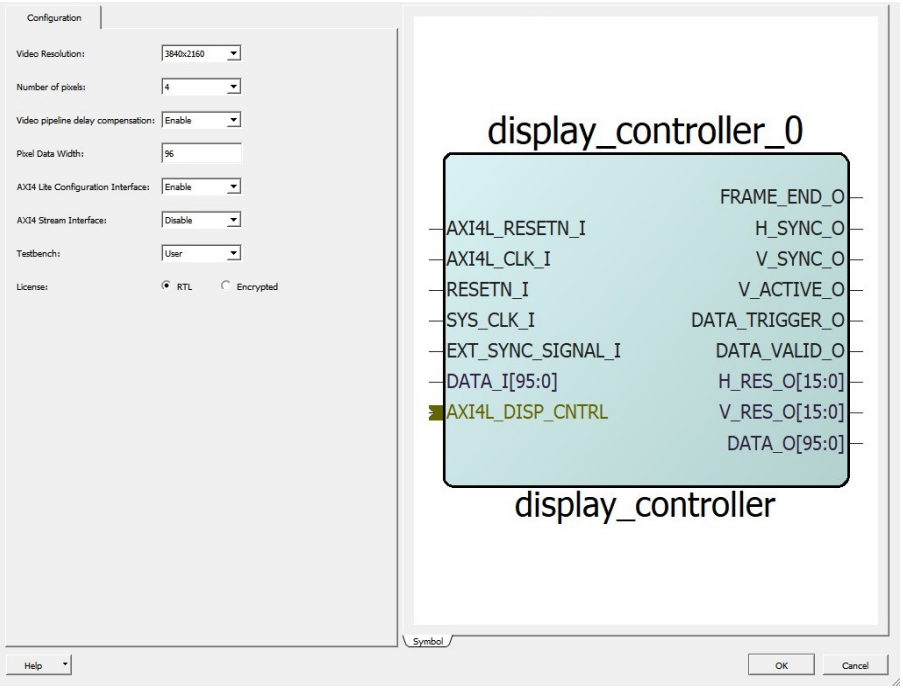
1.1.4 Display Controller Configuration (Ask a Question)

The VESA standard defines the timing signals for interfacing with displays, such as monitors. The display controller generates synchronization signals, based on the VESA standard, for various

display resolutions. It generates horizontal and vertical sync signals, horizontal and vertical active signals, and frame end and data enable signals. The timing parameters for standard resolutions are predefined in the IP, and the resolutions are selected from the configuration options.

The resolution of the display controller is dynamically configured, as shown in the following figure.

Figure 1-6. Display Controller Configuration



Important: For more information, see Display Controller User Guide.

2. Design Prerequisites (Ask a Question)

Before you begin, download and install Libero® SoC Design Suite from Libero SoC Software Downloads.

2.1 Libero License (Ask a Question)

The demo design supports Libero® v2024.2 and above. To get a silver license, see www.microchipdirect.com/fpga-software-products.

3. Setting Up the Hardware (Ask a Question)

Setting up the hardware involves verifying the jumper settings and interfacing the DisplayPort FMC (VIDEO-DC-DP) card with the PolarFire Video kit. For more information, see www.microchip.com/en-us/development-tool/VIDEO-DC-DP.

The following figures show the DisplayPort daughter card.

Figure 3-1. DisplayPort Daughter (FMC) Card—Front Side Image

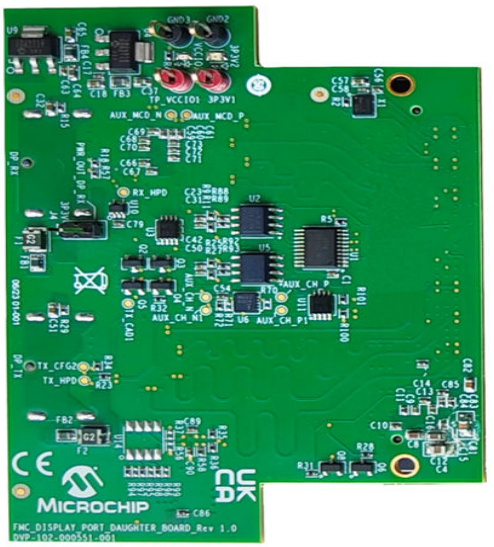
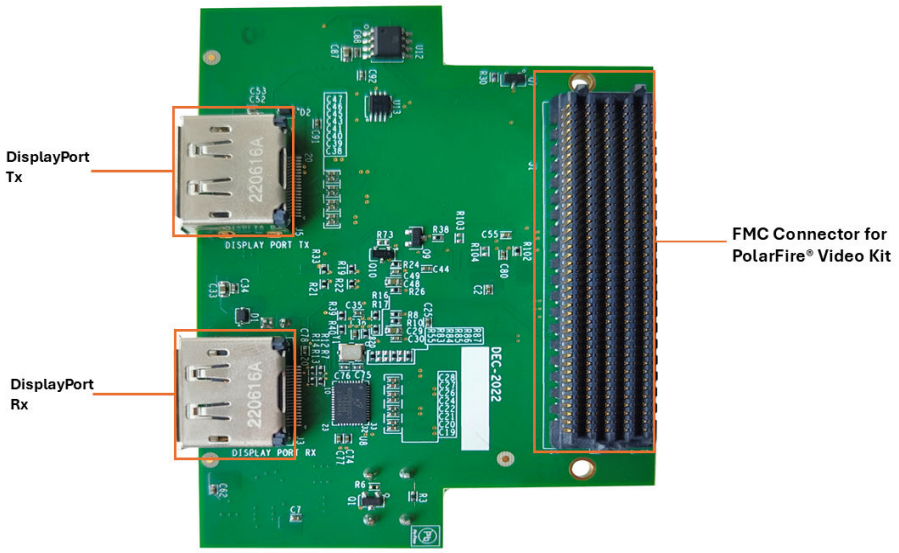
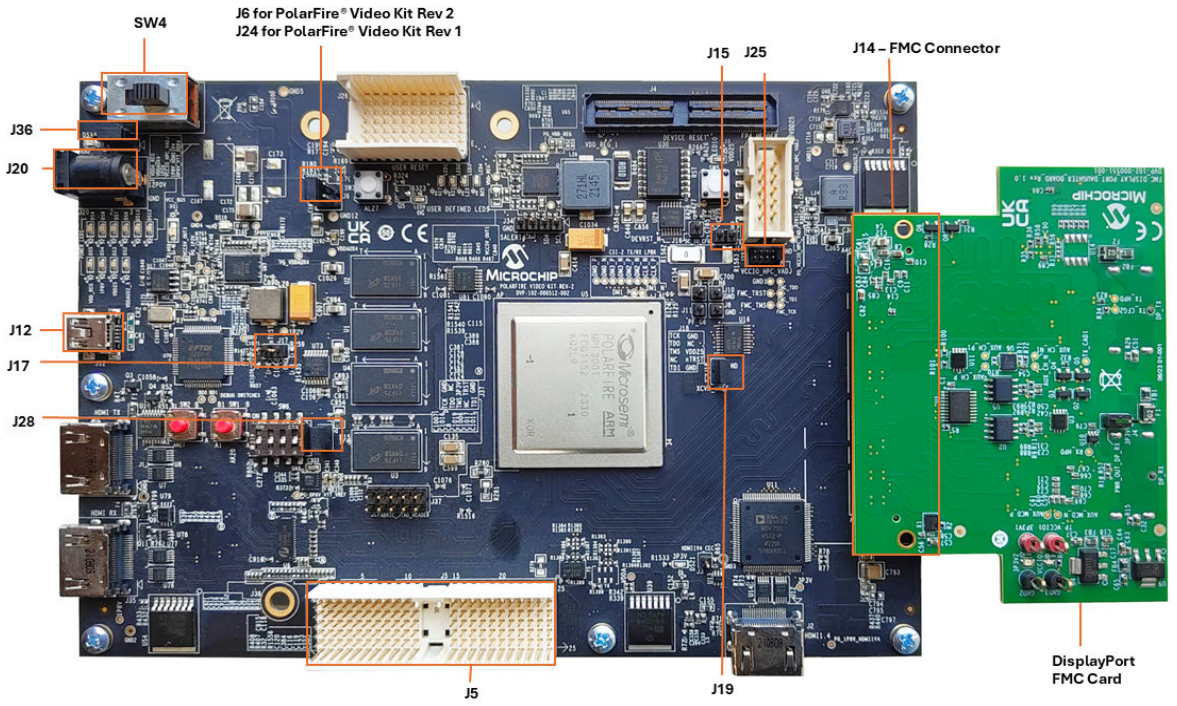


Figure 3-2. DisplayPort Daughter (FMC) Card—Back Side Image



The following figure shows the hardware setup of the DisplayPort FMC with the PolarFire Video kit.

Figure 3-3. Setting up the Hardware



The following table lists the jumper and switch settings of PolarFire Video kit.

Table 3-1. Jumper and Switch Settings of PolarFire Video Kit

Jumper and Switch	Position	Description
J15	Open (default)	SPI Target and Initiator mode selection By default, select SPI Initiator
J14	DisplayPort FMC	DisplayPort FMC to be connected
J17	Open	100K PD for TRSTn
J19	Pin 1 and 2 (default)	Default: XCVR_VREF is connected to the ground.
J28	Pin 1 and 2 (default)	Default: Programming through the FTDI
J24 (for Video Kit Rev1) J6 (for Video Kit Rev2)	Pin 1 and 3	Default: VDDAUX4 voltage is set to 2.5V.
J25	Pin 5 and 6	Bank4 voltage, which is set to 1.8V
J36	Pin 1 and 2 (default)	Default: Board power-up through the SW4
SW4	OFF or ON	Power On or Off slide switch
SW6	OFF	User slide switch Default position: Off
J20	12V Input	12V input to the board
J12	USB-UART	USB-UART mini cable

To set up the hardware, perform the following steps:

1. Connect the DisplayPort daughter card to **J14** of the FMC connector of the PolarFire Video kit.
2. Connect the DisplayPort cable to the DisplayPort Tx on the DisplayPort FMC daughter card.
3. Connect the Host PC and the video kit, using the USB mini cable, through **J12** on the video kit.

4. Connect the 12V power supply cable to the **J20** onboard DC jack on the video kit.
5. Ensure that the jumper settings on the video kit are correctly configured according to the preceding table.
6. Power-up the board using the **SW4** slide switch.
7. After the powering up, program the PolarFire Video kit device. For more information, see the Programming the PolarFire Device using FlashPro Express section.

Once the PolarFire device is programmed, the live feed will start streaming the camera video data.

3.1 Programming the PolarFire Device using FlashPro Express (Ask a Question)

This section describes how to program the PolarFire Video kit, with the `.job` file, using FlashPro Express. The `.job` file `mpf_an4576_v2024p2_jb` to test on PolarFire Video kit is provided in the Test Setup Requirements section.

To program the PolarFire device, perform the following steps:

1. On the host PC, start the **FlashPro Express** software from its installation directory.
2. To create a new job project on the **Project** menu, click **New** or **New Job Project from FlashPro Express Job** .
3. In the **New Job Project from FlashPro Express Job** dialog box, perform the following steps:
   a. **Programming job file**: Click **Browse**, navigate to the location where the `.job` file is located and select the file. The default location is `<$designfiles download directory>\mpf_an4576_v2024p2_df\VKPFC1DPTX\designer\VIDEO_KIT_TOP\export\dp_tx_demo.job`.
   b. **FlashPro Express job project location**: Click **Browse** and navigate to the location where you want to save the project.
4. Click **OK**. The required programming file is selected and ready to be programmed in the device. The FlashPro Express window appears.
5. Verify that a programmer number appears in the **Programmer** box. If it does not, confirm the board connections and click **Refresh/Rescan Programmers**.
6. To program the device, click **RUN**. When the device is programmed successfully, a **RUN PASSED** status is displayed.
7. To close FlashPro Express, click **Project** > **Exit**.
   The PolarFire device and SPI Flash are programmed.

Power cycle the board using the **SW4** switch. After power cycling, the full HD DisplayPort monitor displays the camera feed.

4. Test Setup (Ask a Question)

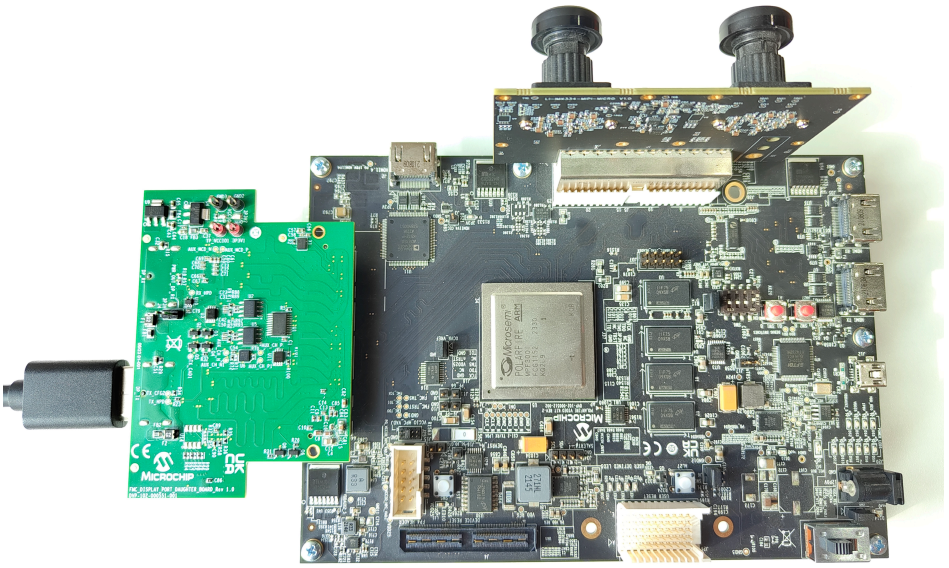
This section describes the test setup.

4.1 Test Setup Requirements (Ask a Question)

The PolarFire DisplayPort Transmitter design is demonstrated using a PolarFire Video kit, a DisplayPort FMC card and a DisplayPort cable.

The following figure shows the hardware setup of the PolarFire Video Kit with DisplayPort FMC.

Figure 4-1. Hardware Setup—PolarFire Video Kit with DisplayPort FMC



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

Table 4-1. Hardware Requirements

Requirement	Description
Hardware and Accessories	
PolarFire® Video Kit	MPF300-VIDEO-KIT-NS Kit Contents: • PolarFire Video and Imaging board with MPF300T-1FCG1152E Device • Dual Camera Sensor board – VIDEO-DC-DUALCAM • HDMI cable • 12V power pack/AC adapter • USB 2.0 A male to mini-B
DisplayPort FMC card	VIDEO-DC-DP
DisplayPort cable	DisplayPort A Male-to-Male cable
Monitor which supports DisplayPort as input (4kp30)	3840 x 2160, 30 Hz resolution monitor for the DisplayPort Tx (that is, monitor must accept the DisplayPort data)
Host PC with USB port	PC with Windows® 11/10
Software	

.....continued	
Requirement	**Description**
`Program_Debug_v24.2_win.exe`	This executable file installs FlashPro Express, which is used to program the FPGA.
Design Files	Link to the design files: www.microchip.com/en-us/application-notes/an4576
`mpf_an4576_v2024p2_jb`	`.job` file to test on PolarFire Video kit

4.2 Running the Demo (Ask a Question)

The demonstration showcases the process of receiving MIPI Rx data from a 4K camera. The frames are stored in the DDR memory and then transmitted to the DisplayPort output, as per the display controller's timing parameters. An image processing pipeline, including Bayer interpolation, Gamma correction and Image enhancement IPs, is used to enhance the raw images from the camera. The demo uses automatic camera exposure control, based on the lighting conditions.

Once the board is powered on and connections are configured, the live video feed from the camera is displayed on the connected DisplayPort monitor, as shown in the following figure.

Figure 4-2. DisplayPort Monitor Displaying the Live Camera Feed

This concludes the demo.

The PolarFire DisplayPort Tx solution is tested with the following monitors, at a 4K resolution of 30 fps:

- LG 27UL500-W
- ASUS TUF Gaming VG28UQL1A
- Acer KG281K Bmiipx
- Acer Nitro VG270 M3

5. Appendix: Running the Tcl Script (Ask a Question)

Tcl scripts are provided in www.microchip.com/en-us/application-notes/an4576.

To run Tcl, perform the following steps:

1. Launch the Libero software.
2. From the menu bar, click **Project** > **Execute Script...**.
3. In the downloaded directory `mpf_an4576_v2024p2_df`, locate and select the `script.tcl` file.
4. To execute the selected Tcl script, click **Run**.

After successful execution of the Tcl script, the Libero project is created within the top directory of `mpf_an4576_v2024p2_df`. You can verify the process by reviewing the log file, see `mpf_an4576_v2024p2_df_log`.

For more details about the folder structure and details of the Tcl scripts and commands, see `TCL_Scripts_readme.txt` file and the Tcl Commands Reference Guide. Contact Technical Support for any queries about running the Tcl script.

6. 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 6-1. Revision History

Revision	Date	Description
C	02/2025	The following is the list of changes made in revision C of the document: • Updated Introduction section. • Updated Hardware Implementation as follows: – Updated Figure 1-2. – Added DisplayPort Transmitter Configuration, MIPI CSI-2 Receiver Configuration, XCVR Configuration and Display Controller Configuration sections. • Added Libero License section. • Updated Figure 3-1, Figure 3-2 and Figure 3-3 in the Setting Up the Hardware section. • Added Test Setup section.
B	03/2023	The following is the list of changes made in revision B of the document: • Updated Figure 1-2
A	05/2022	Initial Revision

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