MIPI CSI-2 Transmitter Application Note

AN5494

Introduction (Ask a Question)

Mobile Industry Processor Interface (MIPI) CSI-2 (Camera Serial Interface) transmitter is a fundamental element in camera systems, enabling the rapid transfer of video and image data from the sensor to a processing device. Developed by the MIPI Alliance, CSI-2 is a standard interface widely utilized in devices like smartphones, cars, and drones. This transmitter supports 1 to 4 data lanes for high-speed transmission and utilizes D-PHY for communication. It flexibly handles raw, compressed, and metadata formats, achieving impressive data rates, especially with multiple lanes. The robust protocol employs a packet-based system with commands and handshaking for reliable data transfer. Designed for low-power consumption, this transmitter is crucial for battery-operated devices and is adaptable to support various resolutions and frame rates. In essence, the MIPI CSI-2 transmitter plays a pivotal role in modern camera technology, facilitating the efficient and high-quality capture and transmission of visual data.

Microchip FPGAs present a cost-optimized and powerful platform for meeting the following edge computing requirements for intelligent vision systems:

- Power efficiency with two times more performance per watt
- Smaller form-factors as small as 11x11 mm
- Exceptional reliability with zero configuration upsets
- Military-grade security with best cyber and anti-tamper security

Microchip's PolarFire SoC and PolarFire FPGAs integrate camera sensor interfaces like MIPI and Scalable Low-Voltage Signaling (SLVS), an image signal processing unit, and transport interfaces like CoaXPress, HDMI, 10GigE Vision, SDI, and wireless connectivity. They are ideally suited for applications involving embedded vision and deep learning inference. They seamlessly support as well as integrate diverse protocols and interfaces with minimal developer effort as part of a complete system solution.

This application note demonstrates generating MIPI CSI-2 video using the PolarFire® FPGA Video and Imaging Kit and MIPI TX FMC card, and receiving and displaying the video using Raspberry Pi 4 Model B.

- The Raspberry Pi 4 Model B uses a 2 lane MIPI configuration to transfer video at 800 Mbps/lane, transmitting Full HD RAW8 video at 30 fps.
- It provides a reference design with 4 lane MIPI configuration to transfer video at 2.5 Gbps/lane, transmitting 4K RAW8 video at 120 fps.

MIPI CSI-2 Transmitter IP supports two output modes: One Byte mode with IOD interface and Two Byte mode with Transceiver interface. This demo showcases the MIPI CSI-2 transmitter design using the Two Byte mode configuration with the Transceiver Interface. It highlights the system's ability to transmit data at 2.5 Gbps per lane through a transceiver.

Summary (Ask a Question)

The following table provides a summary of the MIPI CSI-2 Transmitter IP characteristics.

Table 1. MIPI CSI-2 Transmitter IP Characteristics

Core Version	This document applies to MIPI CSI-2 Transmitter v5.0
Supported Device Families	• PolarFire® SoC • PolarFire
Supported Interfaces	• Native Interface • AXI4-Lite Video Interface • AXI4 Stream Video Interface
Licensing	The core is license-locked for clear text RTL. It supports the generation of Encrypted RTL for the Verilog version of the core with no license.

Features (Ask a Question)

The following table lists the supported features of the MIPI CSI-2 Transmitter IP.

Table 2. Supported Features

Supported Features	Description
MIPI Specification Version	This document applies to MIPI CSI-2 v2.0
Data Type	Raw-8, Raw-10, Raw-12, Raw-14, Raw-16, and RGB-888
Lanes	1, 2, 4, and 8 lanes
Speed	2.5 Gbps per lane with Transceiver interface
Output Mode	Supports the following output modes: One Byte mode**:** • Up to 1 Gbps per lane with IOD interface for 1, 2, 4, and 8 lanes • Up to 1.5 Gbps per lane with Transceiver for 1, 2, 4, and 8 lanes Two Byte mode: • IOD interface is not supported • Up to 2.5 Gbps per lane with Transceiver for 1, 2, and 4 lanes
Input Pixels	Supports the following input pixels: • 1: One pixel per clock • 4: Four pixels per clock • 8: Eight pixels per clock (only supported when Two Byte mode is enabled)
Interface	Supports the following interfaces: • Native Interface • AXI4-Lite Video Interface • AXI4 Stream Video Interface
Embedded Data	Embedded packet transmission for 1, 2, 4, and 8 lanes
PHY Interface	D-PHY

The following table lists the unsupported features of the MIPI CSI-2 Transmitter.

Table 3. Unsupported Features

Unsupported Features	Description
LP transactions	IP does not support transactions in Low power mode
Line Short Packet	IP does not support Line Start and Line End short packets as it is optional

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Unsupported Features	Description
Virtual Channel Extension (VCX)	VCX field is not supported
LRTE	Latency Reduction and Transport Efficiency (LRTE) is not supported
USL	Unified Serial Link is not supported
Scrambling	Data scrambling is not supported
SROI	Smart Region of Interest is not supported
Deskew	Deskew Feature is not supported

Important:
- This design configuration utilizes Raw-8 for 4 Lanes, Two Byte mode with 8-input pixels, Native Interface, 4K Resolution at 120 FPS with Transceiver Interface capable of supporting 2.5 Gbps per lane.
- Datawidth for Raw-8, Raw-10, Raw-12, Raw-14, Raw-16, and RGB-888 are: 8, 10, 12, 14, 16, and 24, respectively.

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1. Design Description (Ask a Question)

The MIPI CSI-2 Transmitter is connected to a XCVR, as shown in the following block diagram. The display controller and test pattern generator are the components of the video source that generate Bayer data. The CCC is provided with a reference clock by the on-board 50 MHz clock. Bayer data is received by the MIPI CSI-2 transmitter and pixel data is arranged in Bytes and Lanes format as per D-PHY specifications. XCVR lanes are connected to byte data accordingly.

Important: The reference design shows Test pattern generator connected to MIPI Tx IP as a video source. Alternatively, a camera or another video source could be connected to MIPI Tx IP with corresponding video pipeline.

The following figures show the block diagram of the design.

Figure 1-1. 2 Lane MIPI Configuration for Raspberry Pi 4 Model B

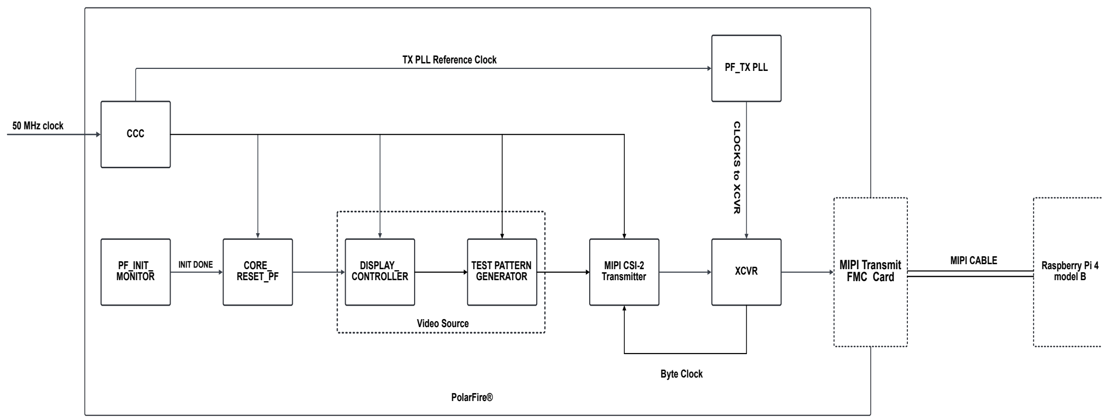
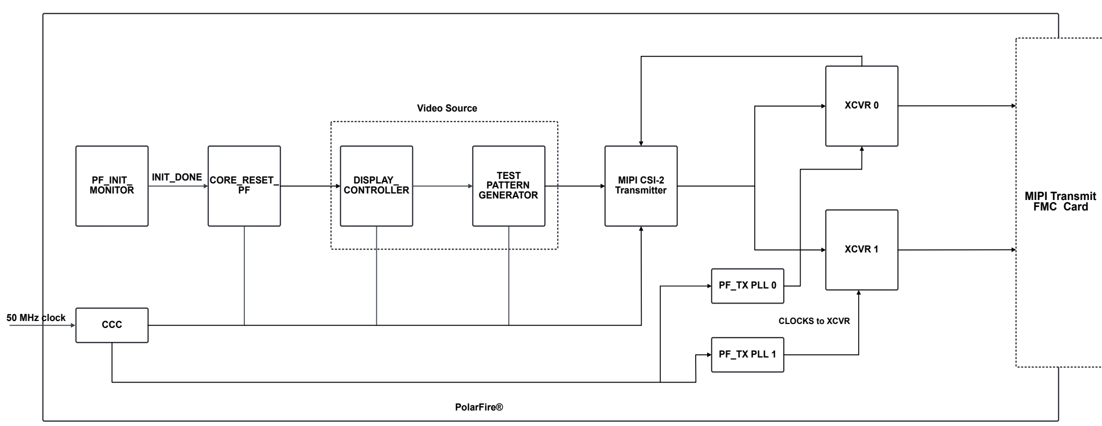


Figure 1-2. 4 Lane MIPI Configuration for Raspberry Pi 4 Model B



1.1 Hardware Implementation (Ask a Question)

The following figures show the Libero® SoC implementation of the top-level SmartDesign.

Figure 1-3. High-Level MIPI CSI-2 Transmitter Design—2 Lane

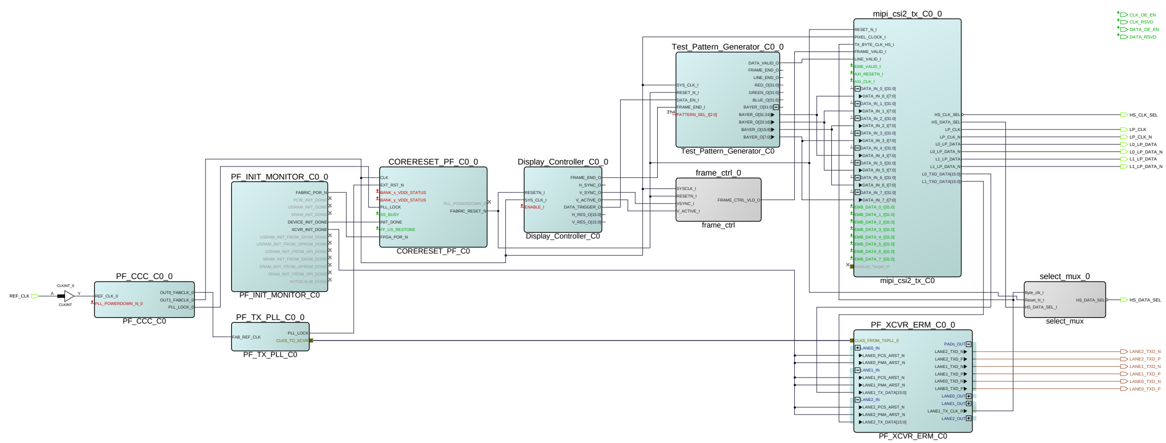
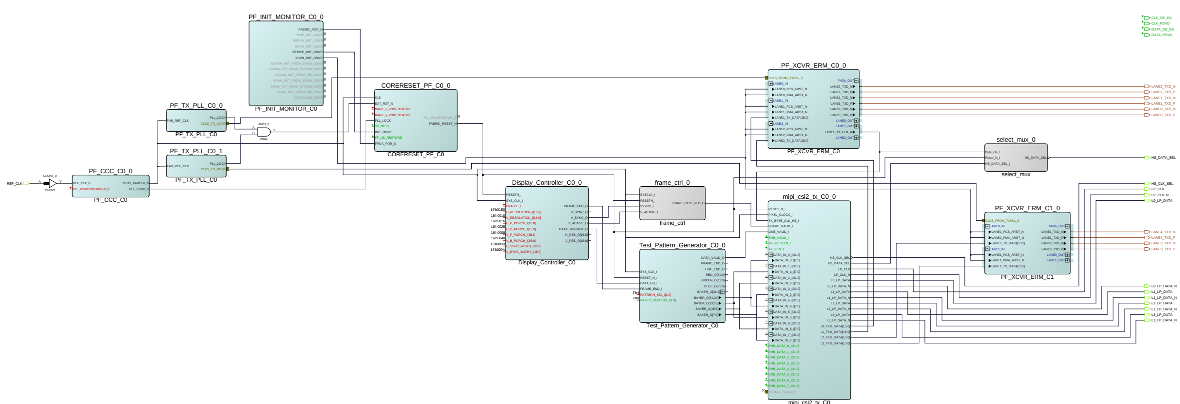


Figure 1-4. High-Level MIPI CSI-2 Transmitter Design—4 Lane



The MIPI CSI-2 Transmitter design includes the following key blocks:

- MIPI CSI-2 Transmitter Configuration
- XCVR Configuration
- Display Controller Configuration
- Test Pattern Configuration

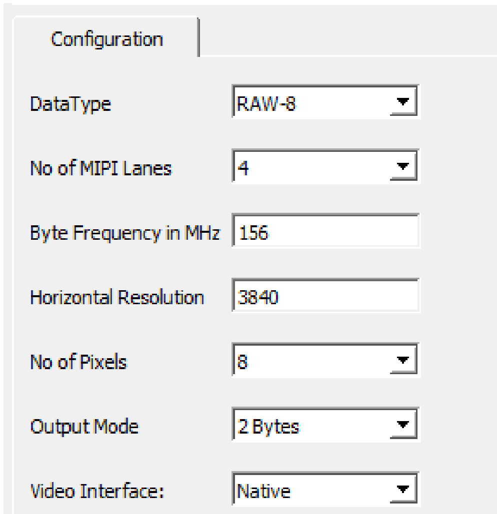
Important: A TX PLL is required to generate the XCVR clocks, that is, byte clock, the MIPI bit clock, and 90° phase shifted bit clock, whose frequency is based on the pixel clock and the number of Lanes used.

1.1.1 MIPI CSI-2 Transmitter Configuration (Ask a Question)

The MIPI CSI-2 Transmitter is configured as follows for 4K (3840 x 2160) resolution.

- Raw-8 Data type
- 4 Lanes
- 2 bytes at output
- 8 input pixels

Figure 1-5. MIPI CSI-2 Transmitter Configuration



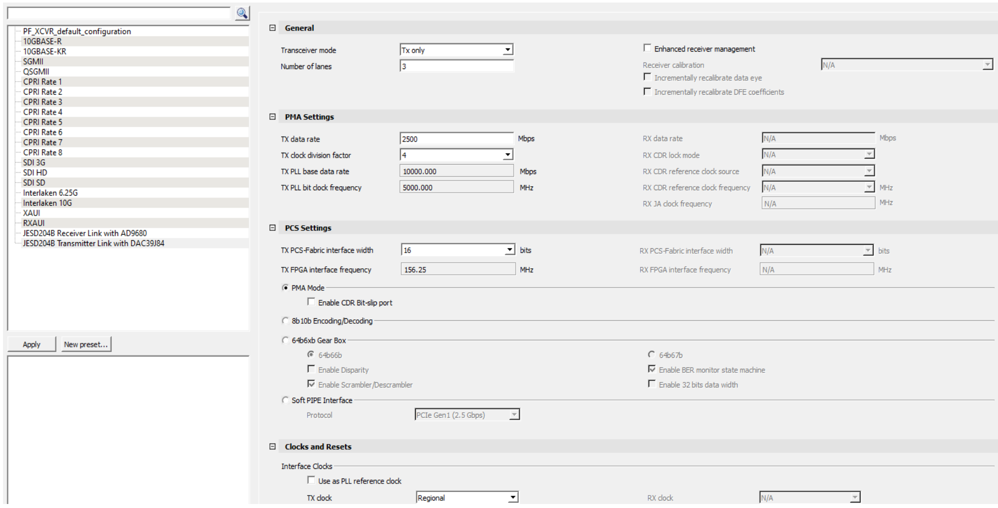
Important: For more information, see MIPI CSI-2 Transmitter IP.

1.1.2 XCVR Configuration (Ask a Question)

The transceiver configuration for the MIPI CSI-2 Transmitter implementation is shown in the following figures. For 4 Lane implementation two XCVR Quads are required.

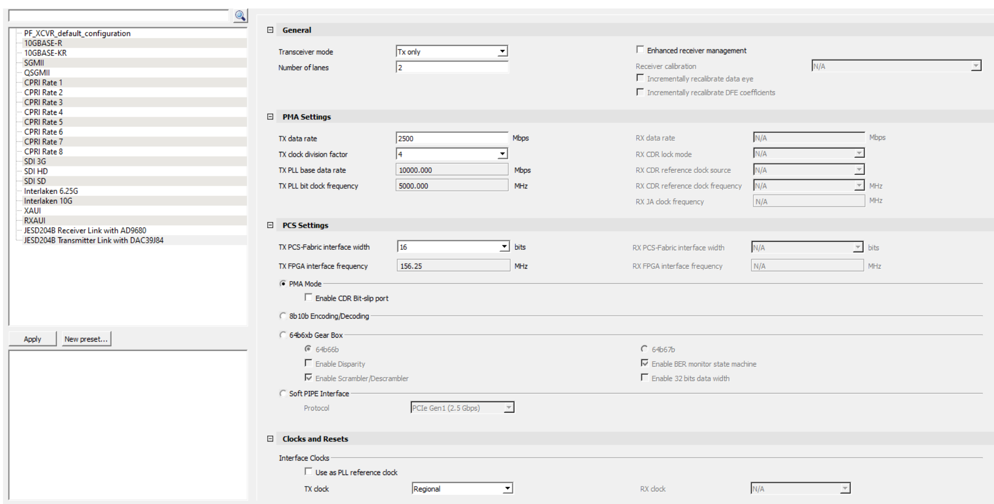
In the following figure, the transceiver is configured in TX only mode in a 3 Lane configuration with one clock and two data lanes. The clock signal is carried by LANE0, while Lanes 1 and 2 carry MIPI CSI-2 Transmitter output data.

Figure 1-6. Transceiver Interface Configuration—Instance 1



In the following figure, the transceiver is configured in TX only mode in a 2 Lane configuration with two output data lanes.

Figure 1-7. Transceiver Interface Configuration—Instance 2



Important:

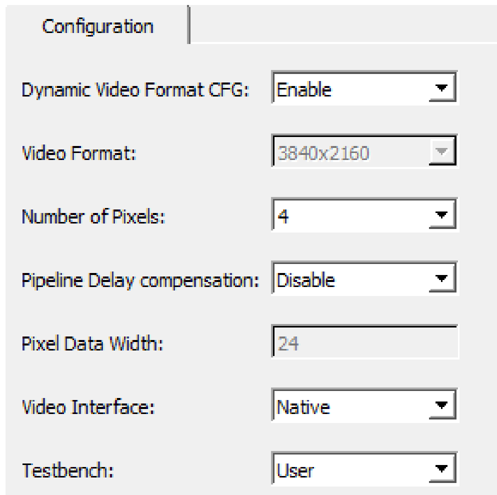
- The outputs within the quad are aligned by enabling TX Lane Alignment in Tx PLL.
- The 90° phase shift between MIPI clock and data lanes within the quad is achieved by oversampling and shifting the clock.
- The outputs of two different quads may not be aligned consistently on every power cycle or reset.
- The total number of XCVR lanes required is n+1, where n is the number of MIPI data lanes and an additional XCVR lane is used for MIPI clock.

1.1.3 Display Controller Configuration (Ask a Question)

The Video and Electronics Standard Association (VESA) standard defines standard timing signals for interfacing with a display such as a monitor. The display controller generates display synchronization signals based on the VESA standard for various display resolutions. It generates the horizontal and vertical sync signals, the horizontal and vertical active signals, and the 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.

4K (3840 x 2160) resolution is configured in the design, as shown in the following figure.

Figure 1-8. Display Controller Configuration



1.1.4 Test Pattern Configuration (Ask a Question)

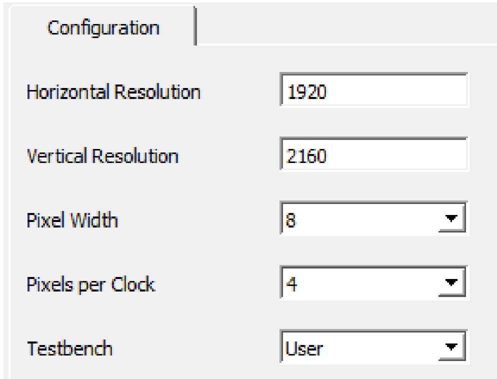
The pattern generator IP generates the test patterns in RGB (red, green, and blue) video format, Bayer format, and is used for troubleshooting and analyzing the video processing pipeline and display. The Bayer format generates video output in RAW format that is identical to a camera sensor output and hence used as a replacement for a camera sensor to test the video processing pipeline.

The test pattern IP generates the following eight different types of video test patterns.

- Color boxes pattern with 8 x 8 grid
- Only red
- Only green
- Only blue
- Horizontal eight color bars
- Vertical eight color bars
- Vertical graded bars from black to white
- Horizontal graded bars from black to white

Currently, vertical graded bars from black to white are configured in the 4-lane design.

Figure 1-9. Test Pattern Configuration



2. Design Prerequisites (Ask a Question)

Before you begin, perform the following steps:

- Download the design files from AN5494: MIPI CSI-2 Transmitter.
- Download and install the Libero® SoC Design Suite from Libero SoC Software Downloads.

2.1 Libero License (Ask a Question)

The demo design supports Libero® version 2024.1 and above. To get 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 MIPI Transmit FMC (VIDEO-DC-MIPITX) card with the PolarFire Video kit, along with the MIPI cable. For more information, see https://www.microchip.com/en-us/development-tool/VIDEO-DC-MIPITX.

Figure 3-1. MIPI TX Daughter (FMC) Rev 1 Card—Front Side Image

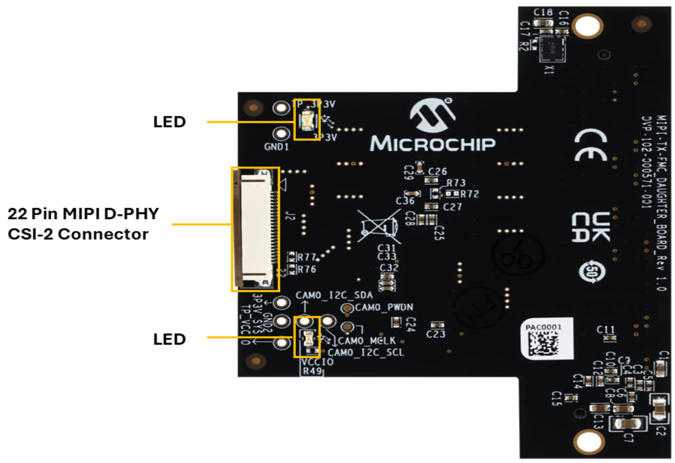
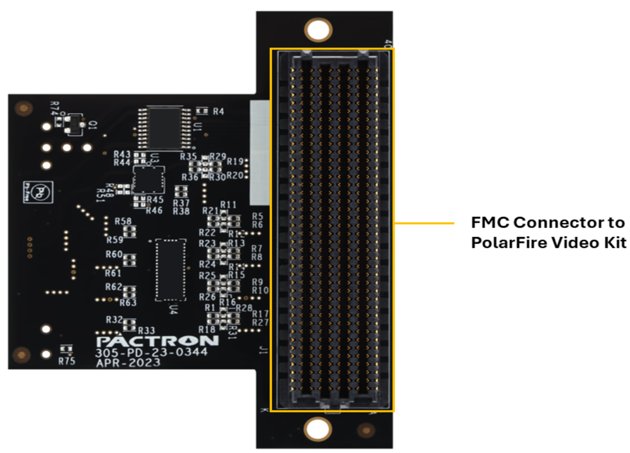
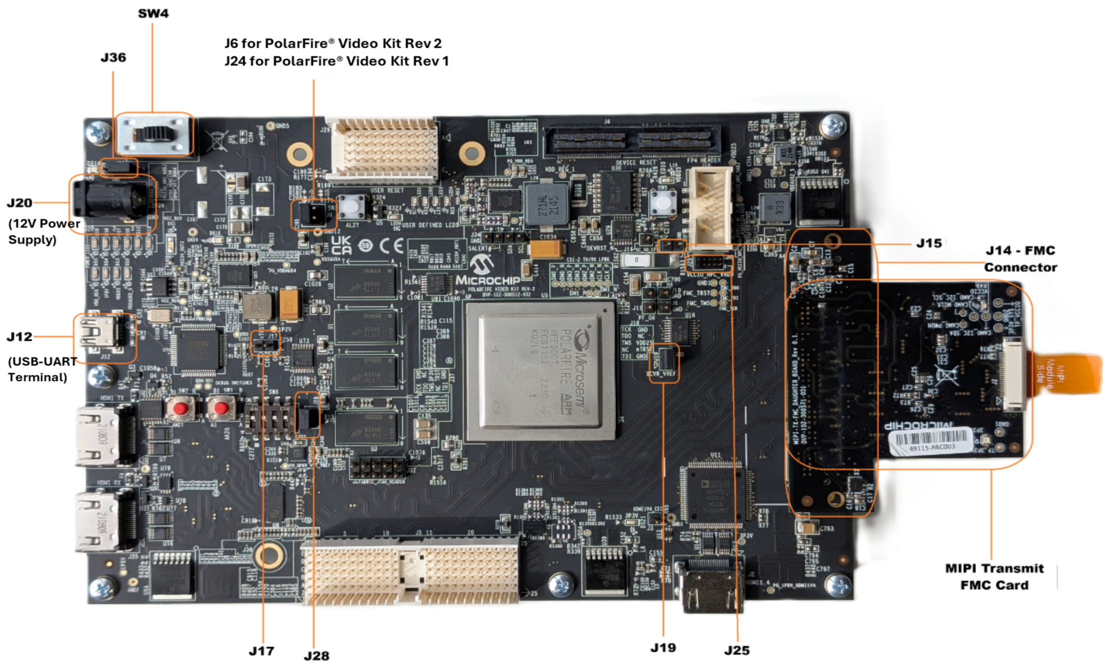


Figure 3-2. MIPI TX Daughter (FMC) Rev 1 Card—Back Side Image



The following figure shows the hardware setup of the MIPI CSI-2 Transmitter 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	SPI Target and Initiator mode selection. By default, select SPI Initiator
J14	MIPI Transmit FMC	MIPI Transmit FMC to be connected
J17	Open	100K PD for TRSTn
J19	Pin 1 and 2	Default: XCVR_VREF is connected to ground
J28	Pin 1 and 2	Default: Programming through the FTDI
J6 - For PolarFire Video kit Rev-2 J24 - For PolarFire Video kit Rev-1	Pin 1 and 3	Default: VDDAUX4 voltage is set to 2.5V
J25	Pin 9 and 10	Bank4 voltage
J36	Pin 1 and 2	Default: Board power-up through the SW4
SW4	OFF or ON	Power On or Off slide switch
J20	12 Volts Input	12V input to the board
J12	USB-UART	USB-UART mini cable

To set up the hardware, perform the following steps:

1. Ensure that the following jumper settings are set on the video kit, as shown in the preceding table.
2. Connect the MIPI TX daughter card to **J14** of the FMC connector of the PolarFire Video kit, as shown in the preceding figure.
3. Connect the ribbon cable between the MIPI Transmit FMC card and the Raspberry Pi **J3** camera connector as shown in the Figure 4-1.

4. Connect the host PC and the video kit through **J12** of the video kit using the USB mini cable, as shown in the preceding figure.
5. Connect the 12V power supply cable to the **J20** on PolarFire Video kit DC jack, as shown in the preceding figure.
6. Power-up the board using the **SW4** slide switch.
7. After the power-up, program the PolarFire Video kit device. For more information, see Programming the PolarFire Device section.
8. The test pattern generator will start streaming once the PolarFire device is programmed. The Raspberry Pi SD Card Setup and Run section guides you through the steps required to display video data on the monitor using Raspberry Pi 4.

3.1 Programming the PolarFire Device (Ask a Question)

This section describes how to program the PolarFire Video Kit device with the `.job` file using FlashPro Express. The `.job` file `mpf_an5494_v2024p1_jb` to test on Raspberry Pi 4 Model B is provided in the Test Setup Prerequisites 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:
   – **Programming job file**: Click **Browse** and navigate to the location where the job file is located and select the file.
   – **FlashPro Express job project location**: Select **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, verify 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**.

4. Test Setup: MIPI CSI-2 Transmitter as Camera and Raspberry Pi 4 Model B as MIPI CSI-2 Receiver (Ask a Question)

This section describes the test setup for the MIPI CSI-2 transmitter, which uses a 2-lane MIPI configuration to transfer video at 800 Mbps per lane. It transmits Full HD RAW8 video at 30 fps, with the Raspberry Pi 4 Model B as receiver.

> **Important:** Connecting the MIPI output of this device to a GPU or Snapdragon platform will require the development of additional drivers to recognize the MIPI output as a camera source.

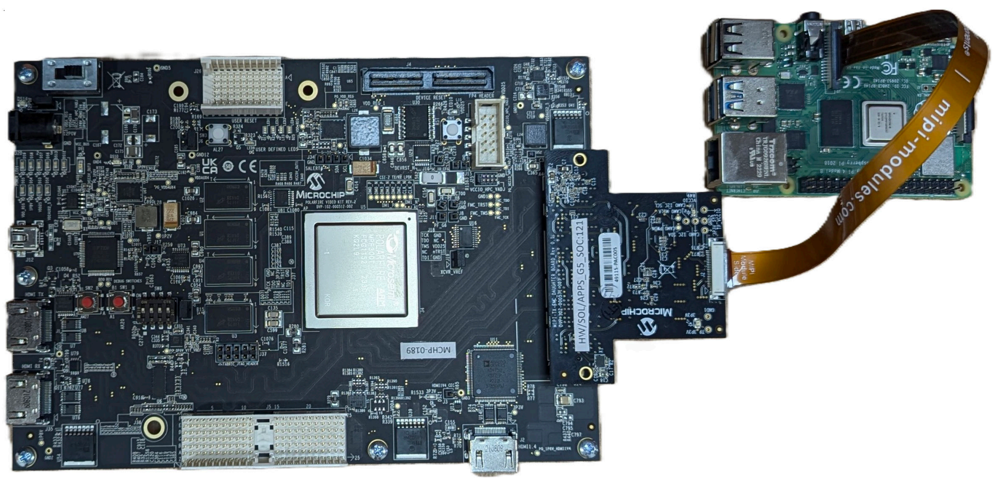
For more instructions on setting up the Raspberry Pi 4 Model B, see www.raspberrypi.com/documentation/computers/getting-started.html.

4.1 Test Setup Requirements (Ask a Question)

PolarFire MIPI CSI-2 Transmitter design is demonstrated using a PolarFire Video kit, a MIPI Transmit FMC card, and a MIPI cable that is connected to a Raspberry Pi 4 Model B, which is capable of receiving and decoding MIPI CSI-2 Transmitter data as listed in the following table.

The following figure shows the setting up the hardware.

Figure 4-1. Setting up the Hardware—PolarFire Video Kit with Raspberry Pi 4 Model B



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

Table 4-1. Hardware and Software Requirements

Requirement	Description
Hardware and Accessories	
PolarFire® Video Kit	MPF300-VIDEO-KIT-NS Kit Contents: • PolarFire Video and Imaging board with MPF300T-1FCG1152E Device • HDMI cable • 12V power pack/AC adapter • USB 2.0 A male to mini-B
VIDEO-DC-MIPITX	MIPI Transmit FMC card

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Requirement	Description
MIPI cable	MIPI 22 to 15 pin cable
Raspberry Pi	Raspberry Pi 4 model B
USB keyboard and USB mouse	USB keyboard and USB mouse as input devices for Raspberry Pi 4 Model B
5V power pack/AC adapter	Power adapter with type C cable that supports 5V/3A, or as per RPi's minimum requirements
SD Card	SD Card (16 GB or above), any class
Micro HDMI cable	To connect Raspberry Pi 4 Model B Micro HDMI (port 0 or port 1) to HDMI of monitor
HDMI monitor	1920 x 1080, 60 Hz resolution monitor for the HDMI 2.0 transmitter (Tx) port
Software	
Linux®	Ubuntu v20.4
Libero® SoC	FlashPro Express is installed with Libero SoC.

4.2 Test Setup Prerequisites (Ask a Question)

Before you begin, ensure to download the following files from AN5494: MIPI CSI-2 Transmitter:

- `mpf_an5494_v2024p1_jb` - Job file to test on Raspberry Pi 4 Model B
- `mipi_csi2_tx_using_rpi.zip` - Raspberry Pi 4 Model B image file

Important: This job file is designed to test the MIPI CSI-2 Transmitter with the Raspberry Pi 4 Model B. It is configured for a data rate of 800 Mbps per lane, supporting Full HD resolution at 30 FPS (1920 x 1080 at 30 FPS), and uses a 2-lane MIPI configuration.

4.3 Running the Demo (Ask a Question)

This section serves as a guide to help configure the Raspberry Pi 4 Model B to receive MIPI data when connected to the PolarFire Video kit, enabling real-time video streaming and analysis. It outlines the process of setting up image data streaming on a Raspberry Pi 4 Model B connected to a PolarFire Video kit through the MIPI Transmit FMC card.

- Demo Design: The demo showcases a Full HD (1920x1080 30 Hz) output using a display controller when the PolarFire Video kit is active.
- Data Generation: The demo simulates camera data by generating MIPI Tx pattern data, which is transmitted to the XCVR and mapped to the MIPI Transmit FMC card.
- Streaming Setup: This guide covers installing the Raspberry Pi OS on a Linux® system (Ubuntu) and provides commands to establish a live data stream on the Raspberry Pi 4 Model B.

4.3.1 Raspberry Pi 4 Model B SD Card Setup and Run (Ask a Question)

The following steps and associated commands are required to configure the Raspberry Pi 4 Model B to detect the PolarFire-based MIPI Tx as a camera source:

1. Download and extract the `mipi_csi2_tx_using_rpi.zip` file to obtain the `mipi_csi2_tx_using_rpi_v1.img` file.
2. Download and install the Rpi-imager from the Raspberry Pi Website for the host system's operating system, which can be either Windows® or Linux.
3. Insert an SD card (at least 16 GB) into the host system, which can be either Windows or Linux running the Rpi-imager.
4. Run Rpi-imager and perform the following steps:
   a. Click **CHOOSE DEVICE** option and then select Raspberry Pi 4 Model B.

Figure 4-2. Rpi-Imager Window

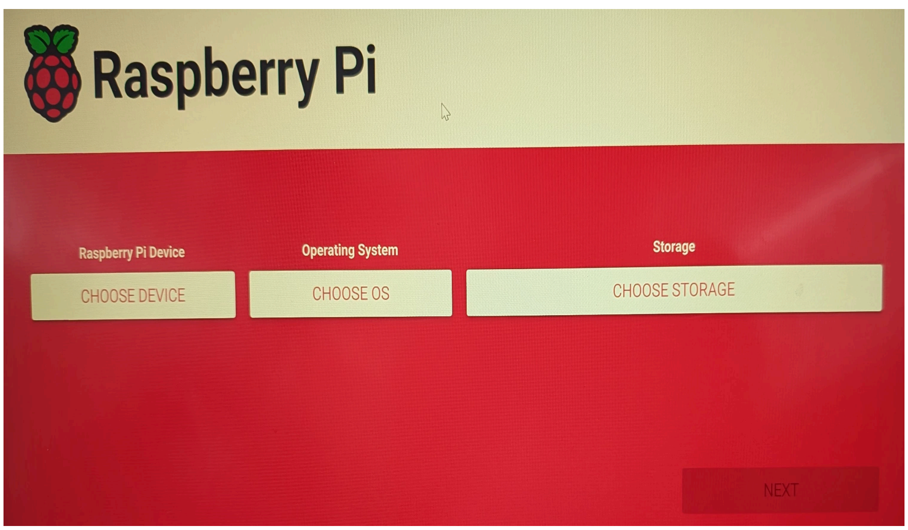
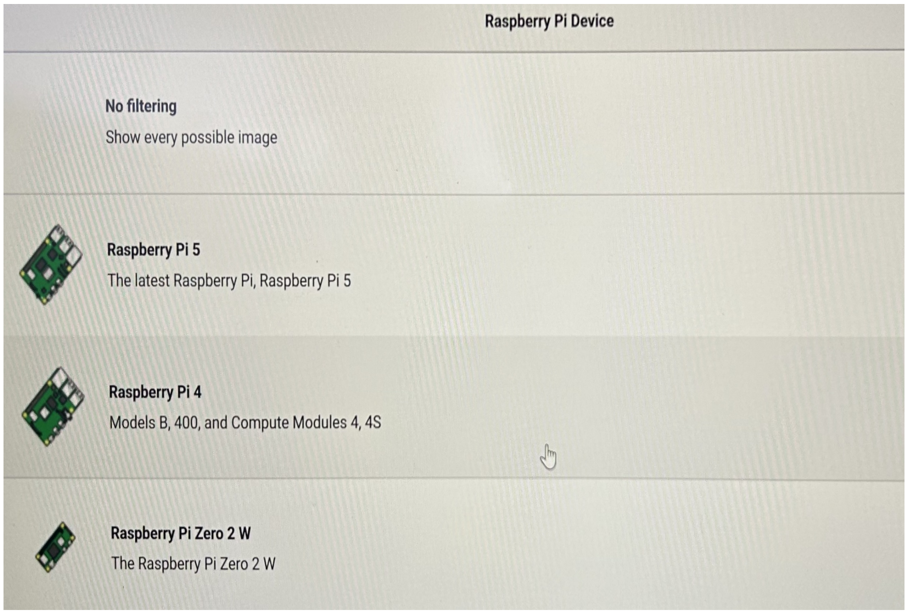


Figure 4-3. Rpi-Imager—CHOOSE DEVICE



b. Click **CHOOSE OS** under **Operating System** field and then select **Use custom** option. Navigate to and select the extracted Raspberry Pi image.

Figure 4-4. Rpi-Imager—CHOOSE OS

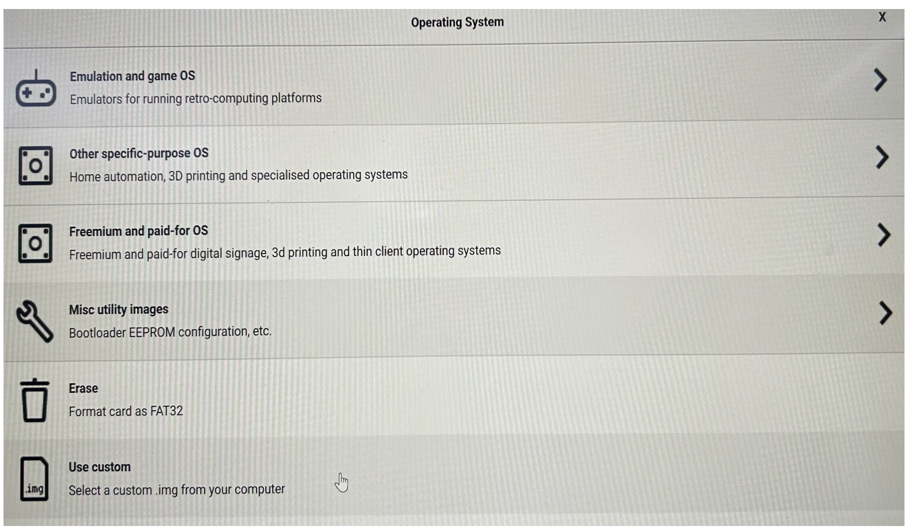
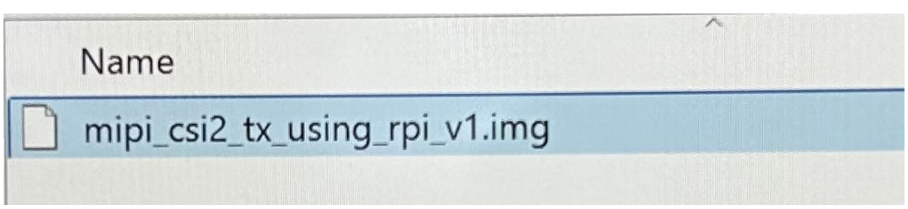
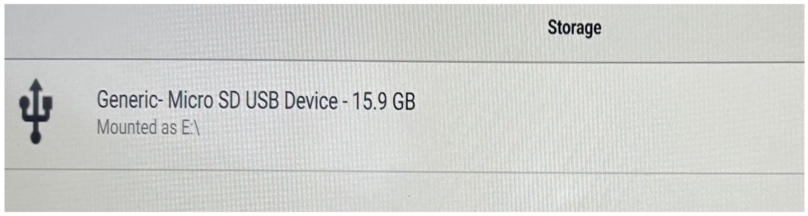


Figure 4-5. Select Rpi Image File



c. Click **CHOOSE STORAGE** under **Storage** field and select SD card that is inserted to the system.

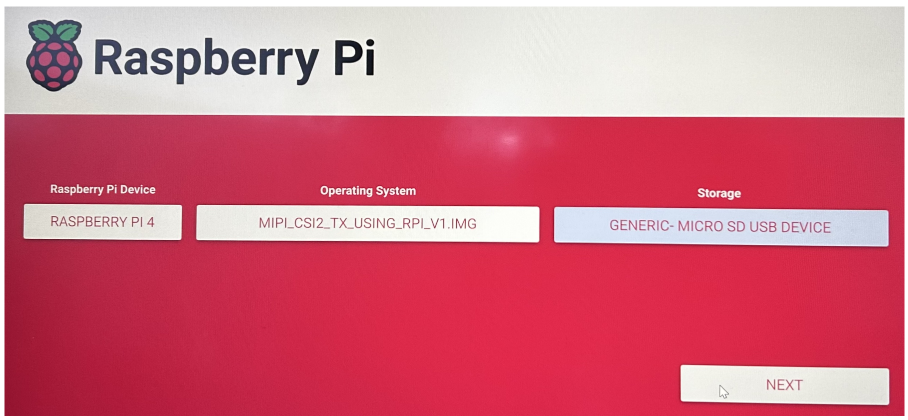
Figure 4-6. Rpi-Imager—CHOOSE STORAGE



Important:

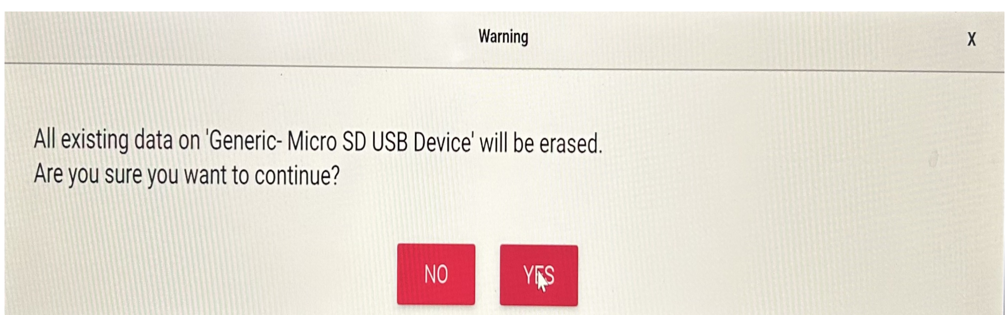
i. After choosing Device, OS, and Storage, the **Rpi-imager** window appears as shown in the following figure. Click **NEXT** to proceed.

Figure 4-7. Rpi-Imager Window



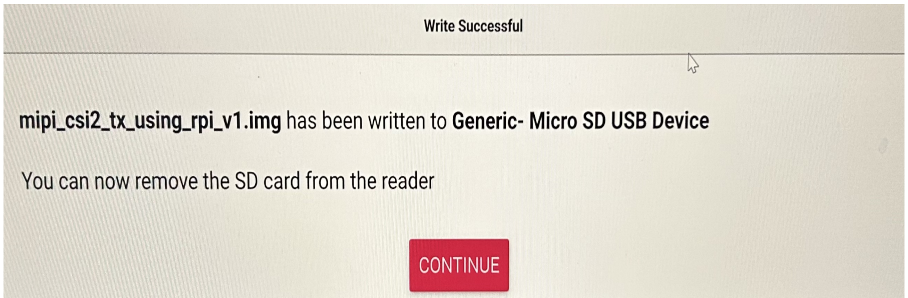
ii. If you receive a warning stating "All existing data on 'Generic– Micro SD USB Device' will be erased", as shown in the following figure, click **YES** to continue.

Figure 4-8. SD Card Warning



d. To start writing the image to the SD card, click **WRITE**. This process may take 15 to 20 minutes. Upon completion, the following window appears.

Figure 4-9. Rpi Image Write Successful

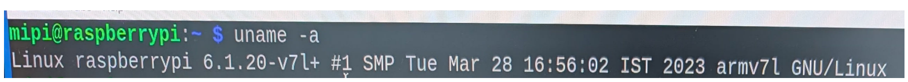


5. Insert the SD card into the SD card slot of the Raspberry Pi 4 Model B.
6. Connect a 5V power supply cable to the USB Type-C Power In socket of the Raspberry Pi 4 Model B.
7. Ensure that the jumper settings for the video kit are configured as specified in Table 3-1.
8. Connect the USB keyboard and USB mouse to the Raspberry Pi 4 Model B.
9. Power on the Raspberry Pi 4 Model B and the HDMI monitor.
10. Once the Raspberry Pi has finished booting, log in to the system.

This section provides the commands that need to be executed on a Raspberry Pi.

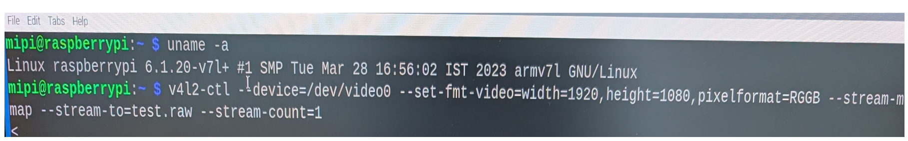
1. Open Ubuntu terminal and enter the following command.
   `uname -a`
   The output should be `6.1.20v71+`, as shown in the following figure.

   Figure 4-10. RPI Image

2. Execute the following V4L2 command to configure and wait for CSI data reception.
   a. `v4l2-ctl --device=/dev/video0 --set-fmt-video=width=1920,height=1080,pixelformat=RGGB --stream-mmap --stream-to=test.raw --stream-count=1.`

   Figure 4-11. How to Configure CSI Data Reception

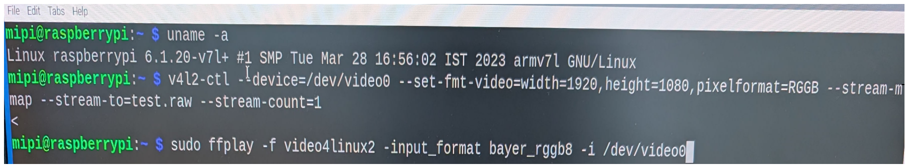
   

   Important: If the command gets stuck and does complete, it indicates that data reception is not functioning properly.

   b. Do not stop or terminate the command. While the command is running, restart the PolarFire device using the SW4 switch and verify if data is received. If data not received even after restarting the board at least 10 times, recheck the ribbon cable connection, ensure that every step is followed correctly.
   c. If the command returns with the "<" symbol, it indicates that data reception is successful.
3. Execute the following command to stream live data from the PolarFire Video kit board, with the output displayed on the monitor as shown in the Figure 4-13.

```
sudo ffplay -f video4linux2 -input_format bayer_rggb8 -i /dev/video0.
```

Figure 4-12. Data Stream

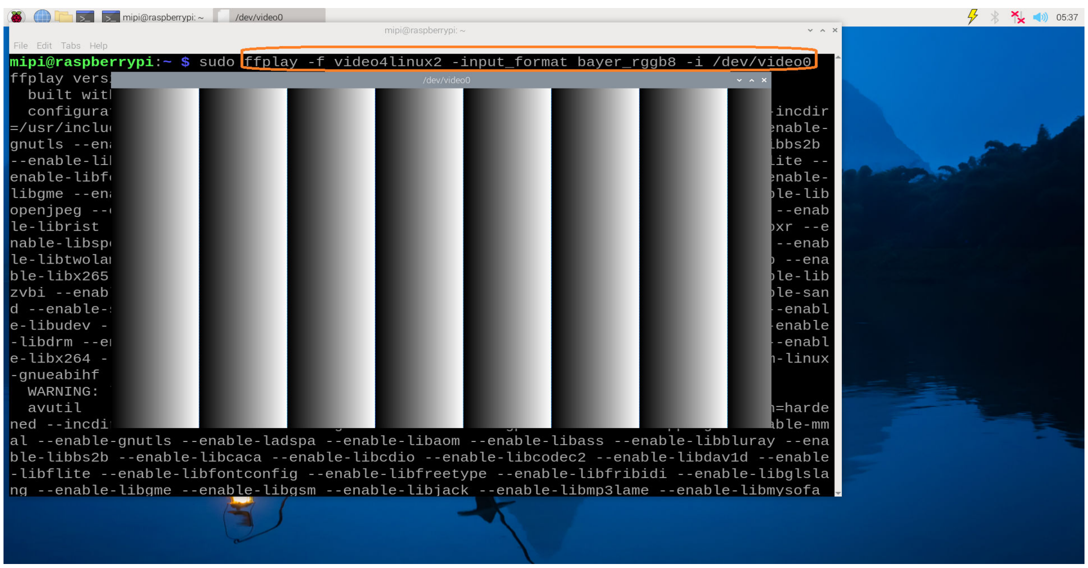


4.3.2 MIPI CSI-2 Transmitter Validation (Ask a Question)

Output Pattern 1:

The following figure shows the output pattern of the MIPI CSI-2 Transmitter with transceiver for a data rate of 800 Mbps/Lane for Full HD resolution at 30 FPS (1920 x 1080 at 30 FPS) and uses a 2 lane MIPI configuration is tested with the Raspberry Pi 4 model B.

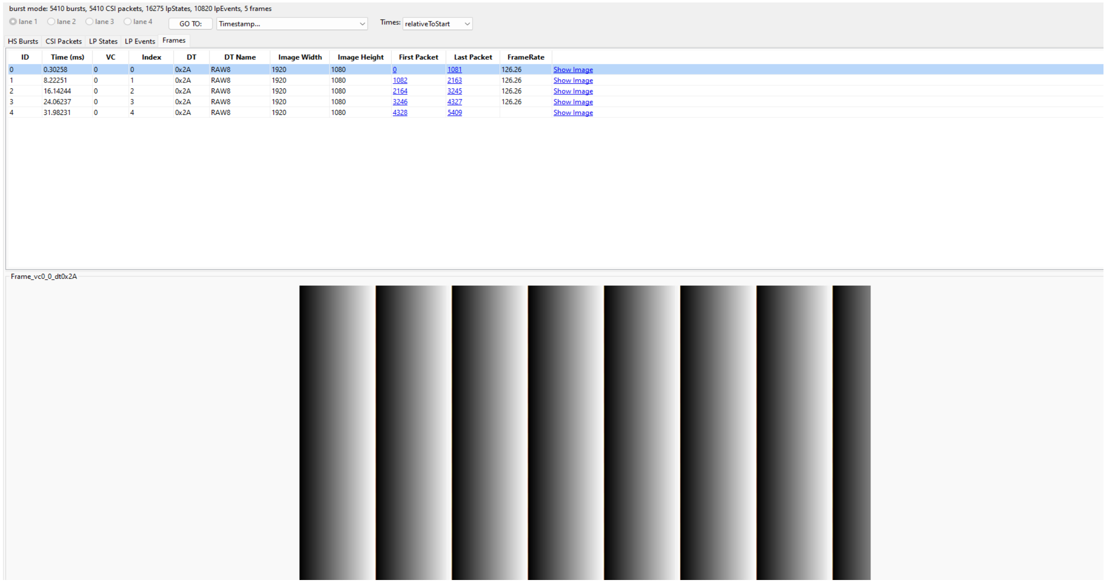
Figure 4-13. Test Pattern—RPi



Output Pattern 2:

The following figure shows the output pattern of the MIPI CSI-2 Transmitter for 2.5 Gbps per lane with XCVR tested with the MIPI Introspect Analyzer (SV3C – DPRX 4-Lane D-PHY Analyzer).

Figure 4-14. Test Pattern—MIPI Analyzer



Important: The MIPI Analyzer capture shows 1920 x 1080 video at 126 FPS using one MIPI CSI-2 lane. At this rate, the four-lane connection supports 4K video at 60 FPS.

4.4 Running the Tcl Script—Reference Design with 4 Lane MIPI configuration (Ask a Question)

Tcl scripts are provided in the PolarFire Video Kit reference design with 4 lane MIPI configuration to transfer video at at 2.5 Gbps/lane, transmitting 4K RAW8 video at 120 fps.

To run Tcl, perform the following steps:

1. Launch the Libero software.
2. Click **Project** > **Execute Script**.
3. In the downloaded `mpf_an5494_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, see the Log file `mpf_an5494_v2024p1_df_log`.

For more details about the folder structure of `mpf_an5494_v2024p1_df` and Tcl scripts and commands, see the `TCL_Scripts_readme.txt` and Tcl Commands Reference Guide. Contact Technical Support for any queries about running the Tcl script.

5. Resource Utilization (Ask a Question)

The following table shows the resource utilization for a 4-lane reference design with MIPI configuration, which transfers video at 2.5 Gbps per lane and transmits 4K RAW8 videos at 120 fps.

Table 5-1. Resource Utilization

Element	Usage in Numbers
DFFs	2806
LUTs	5469
LSRAMs	27
Math Blocks	1

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 current publication.

Table 6-1. Revision History

Revision	Date	Description
C	01/2025	The following is the list of changes in revision C of the document: • Updated to "Raspberry Pi 4 Model B" from "Raspberry Pi" throughout the document. • Updated Figure 3-3 in the Setting Up the Hardware section. • Updated Raspberry Pi 4 Model B SD Card Setup and Run section with Rpi-imager GUI figures.
B	11/2024	The following is the list of changes in revision B of the document: • Updated Introduction section • Updated Figure 1-1 and added Figure 1-2 in the Design Description section • Updated Hardware Implementation as follows: – Added Figure 1-4 and Figure 1-3 – Updated all configuration GUI figures – Added Figure 1-7 and note in the XCVR Configuration section • Added Libero License section • Added Figure 3-1, Figure 3-2, and updated Table 3-1 in the Setting Up the Hardware section • Updated Running the Tcl Script—Reference Design with 4 Lane MIPI configuration section • Updated the weblink of the image file and added steps related to rpi-manager in the Raspberry Pi 4 Model B SD Card Setup and Run section
A	09/2024	Initial release

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