

Table of Contents

1. Introduction.....	3
1.1. Hardware Features.....	3
1.2. Demo Requirements.....	4
1.3. Demo Setup	4
1.4. Setting up the Demo.....	7
1.5. Document References.....	9
Microchip FPGA Support.....	11
Microchip Information.....	11
Trademarks.....	11
Legal Notice.....	12
Microchip Devices Code Protection Feature.....	12

1. Introduction

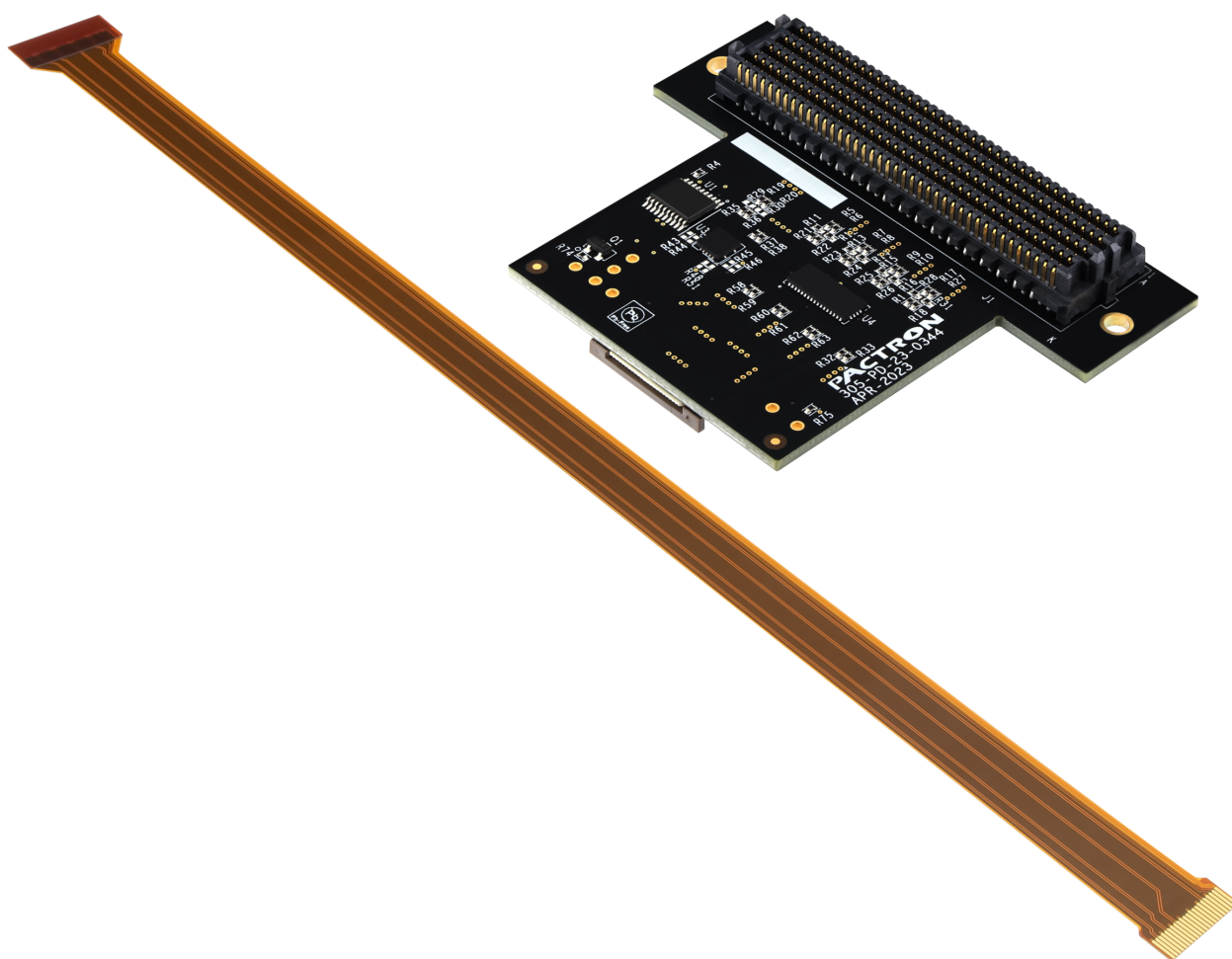
Microchip offers an FPGA-based MIPI CSI-2 transmit reference solution with PolarFire® and PolarFire SoC FPGAs. It is transceiver-enabled, which upgrades our GPIO-based IP solution to support data rates of up to 2.5 Gbps/lane and facilitate 4K video data. It complements our MIPI CSI-2 receiver IP and is part of our extensive Smart Embedded Vision Portfolio of IPs and a popular choice for vision applications at the edge.

The MIPI Transmit FMC Card works with the [PolarFire® Video and Imaging Kit](#) and [PolarFire SoC Video Kit](#).

Table 1-1. VIDEO-DC-MIPITX Contents

Description	Quantity
MIPI TX FMC daughter board	1
Quickstart Card	1
Flexible Printed Circuit (FPC) Cable, 200 mm: 22 to 15 Pin	1

Figure 1-1. VIDEO-DC-MIPITX Board



1.1 Hardware Features

The MIPI TX FMC daughter card supports the following hardware features:

- D-PHY 2.5 Gbps
- Nine GPIOs
- 4 × Transceivers

1.2 Demo Requirements

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

Table 1-2. Hardware and Software Requirements

Requirement	Description
Hardware	
PolarFire® video kit	MPF300-VIDEO-KIT-NS kit contents: <ul style="list-style-type: none"> • PolarFire video and imaging board with MPF300T-1FCG1152E device • HDMI cable • 12V power pack/AC adapter • USB 2.0 A male to mini-B
MIPITx FMC daughter card	VIDEO-DC-MIPITX
MIPI cable	MIPI 22 to 15-pin cable
Raspberry Pi	Raspberry Pi 4 model B
USB keyboard and mouse	USB keyboard and mouse as input devices for Raspberry Pi
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 0) of any class
Micro HDMI cable	Micro HDMI to HDMI type to connect to monitor to Raspberry Pi
HDMI monitor	To connect Raspberry Pi Micro HDMI (port 0 or port 1) to HDMI of monitor
Software	
Linux®	Ubuntu v20.4 For more details about running the demo, see Raspberry Pi SD Card Setup and Run section.
Libero® SoC Design Suite	FlashPro Express is installed as part of Libero SoC Design Suite version 12.0 or later releases.

1.3 Demo Setup

Before you begin with demo, ensure to download the following files from [AN5494: MIPI CSI-2 Transmitter](#):

- [mpf_an5494_v2024p1_jb](#) – Job file to test on Raspberry Pi
- [mipi_csi2_tx_using_rpi.zip](#) - Raspberry Pi image file

Demo setup comprises two parts:

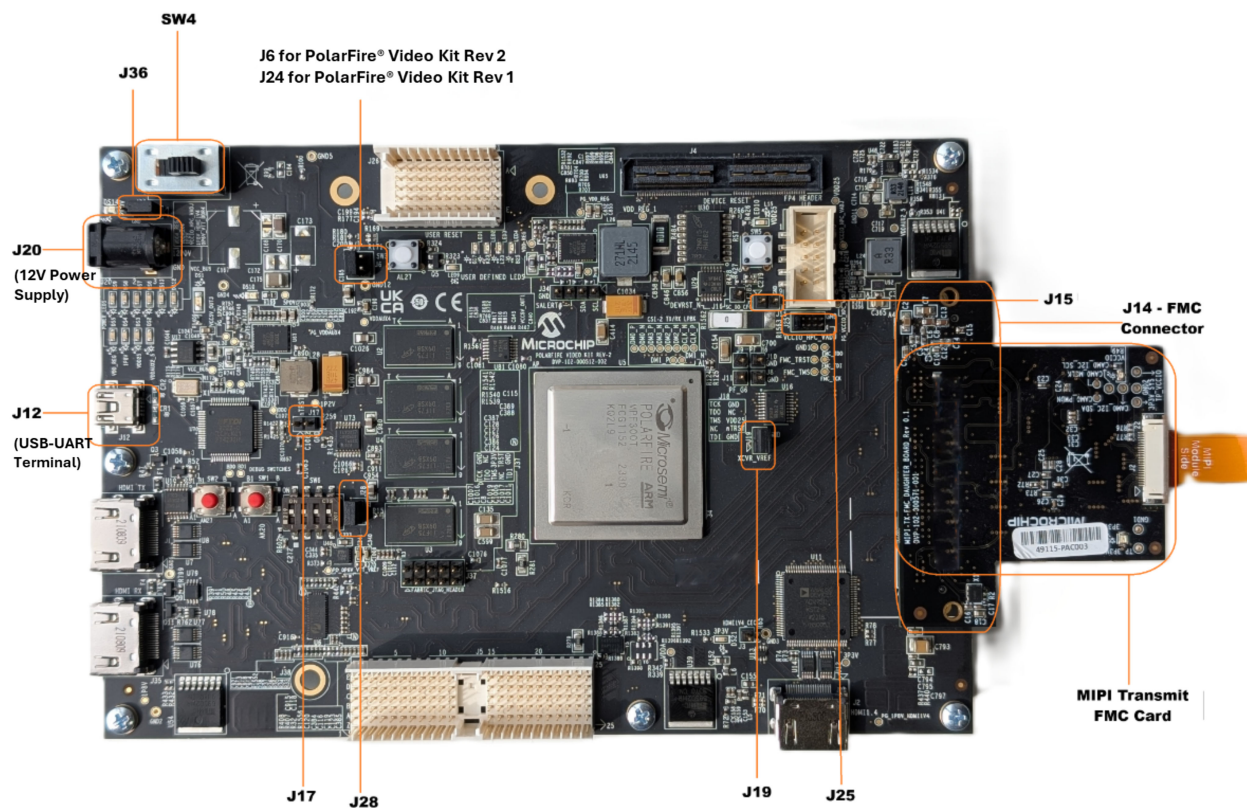
- Setting up the hardware
- Programming the device

1.3.1 Setting up the Hardware

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.

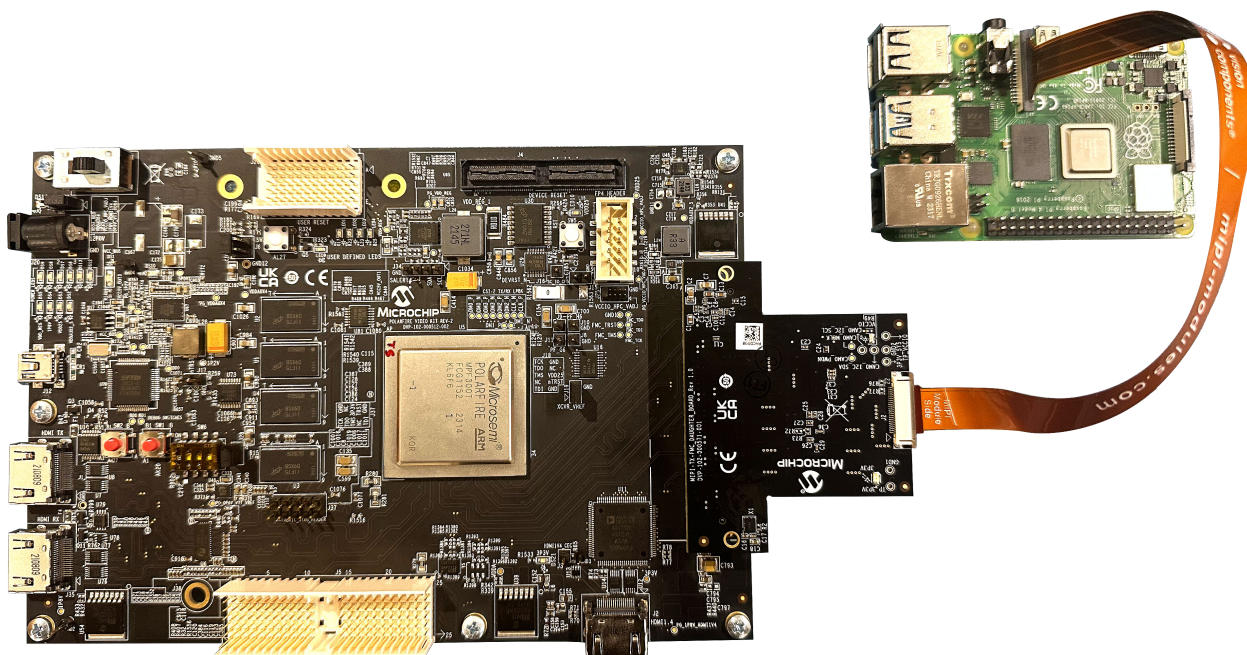
The following figure shows the MIPITX call out.

Figure 1-2. MIPITX Call Out



The following figure shows the demo setup for the MIPI Transmit FMC (VIDEO-DC-MIPITX) card.

Figure 1-3. Setting up the Demo



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

Table 1-3. 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	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

For setting up the hardware, perform the following steps:

1. Ensure that the preceding jumper settings in table are set on the video kit. For more details, see [Figure 1-2](#).
2. Connect the MIPI TX daughter card to **J14** of the FMC connector of the PolarFire video kit, see [Figure 1-2](#).
3. Connect the ribbon cable between the MIPI Transmit FMC card and the Raspberry Pi J3 camera connector (see [Figure 1-3](#)).
4. Connect the host PC and the video kit through **J12** of the video kit using the USB mini cable.
5. Connect the 12V power supply cable to the **J20** on board DC jack of the video kit.
6. Power-up the board using the SW4 slide switch.
7. Connect the 5V power supply cable to the USB type C Power In socket of the Raspberry Pi.

8. Connect the USB keyboard and USB mouse to the Raspberry Pi.
9. Power-up the Raspberry Pi and HDMI monitor. (Raspberry Pi splash screen on the HDMI monitor appears.)
10. After the power-up, program the PolarFire Video Kit device. For more information, see the [Programming the PolarFire Device](#) section.
11. After programming the PolarFire device, the Raspberry Pi SD card setup needs to be done, and the test pattern generator starts streaming the video data as seen in when running the demo, see [Raspberry Pi SD Card Setup and Run](#) section.

1.3.2 Programming the PolarFire Device

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 is provided in the [AN5494: MIPI CSI-2 Transmitter](#).

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**.

1.4 Setting up the Demo

The following sections describe the demo set up and run process.

1.4.1 Setting up the Raspberry Pi 4

For setting up Raspberry Pi 4, perform the following steps:

1. Connect the HDMI monitor to the HDMI0 port of the Raspberry Pi.
2. Connect the ribbon cable between the MIPI Transmit FMC card and the Raspberry Pi J3 camera connector as shown in the Fig 1.3
3. Connect the 5V power supply cable to the USB type C Power In socket of the Raspberry Pi 4 Model B.
4. Connect the USB keyboard and USB mouse to the Raspberry Pi 4 Model B.
5. Power-up the Raspberry Pi 4 Model B and HDMI monitor.
Raspberry Pi SD card setup needs to be done. For information about the steps related to setup, see [Raspberry Pi SD Card Setup and Run](#) section.

1.4.2 Raspberry Pi SD Card Setup and Run

The following steps and associated commands are necessary to enable the Raspberry Pi to detect the PolarFire-based MIPI TX as a camera source.

1. Download and extract the [mipi_csi2_tx_using_rpi.zip](#) to get `mipi_csi2_tx_using_rpi_v1.img` file.
2. Download and install [rpi-imager](#) from raspberry pi website based on your Operating System (OS), that is, Windows® or Linux®.
3. Insert SD card (atleast 16 GB) to the host system. The host system can be either windows or Linux which runs the rpi-imager.
4. Run rpi-manager and perform the following steps:
 - a. Click on **CHOOSE OS** under **Operating System** field and then select the option **Use custom**. Navigate and select the extracted raspberry pi image mentioned in step1.
 - b. Click on **CHOOSE STORAGE** under **Storage** field and select SD card that is inserted to the system.
 - c. To start writing image to the SD card, click on **WRITE**. This process may take 15 to 20 min.
5. Insert SD card in the Raspberry Pi SD card slot.
6. Power on Raspberry Pi and login once Raspberry Pi boots.

This section describes the following commands that must be run on a Raspberry Pi.

1. Open Ubuntu terminal.
2. To view the kernel release number, enter `uname -r` command.
The output appears as `kernal release: 6.1.20v71+`.
3. Issue 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`
Note: If the command is stuck and does not finish executing, it means data reception is not working.
 - b. Do not stop or kill the command. While the command is running, restart PolarFire device using SW4 switch and check if data is received. If data not received even after restarting the board at least ten times, recheck the ribbon cable connection (given that every step is followed correctly.)
 - c. If the command returns with the "<" symbol, it means data reception is successful.
Note: Before power cycling the video kit, "<" may appear. It is acceptable.
 - d. Issue the following command to stream the data live from the PolarFire video kit board.
`sudo ffplay -f video4linux2 -input_format bayer_rggb8 -i /dev/video0`
 - e. Another window appears with the test pattern from the video kit. For more details, see [MIPI CSI-2 Transmitter Validation](#) section.

1.4.2.1 MIPI CSI-2 Transmitter Validation

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.

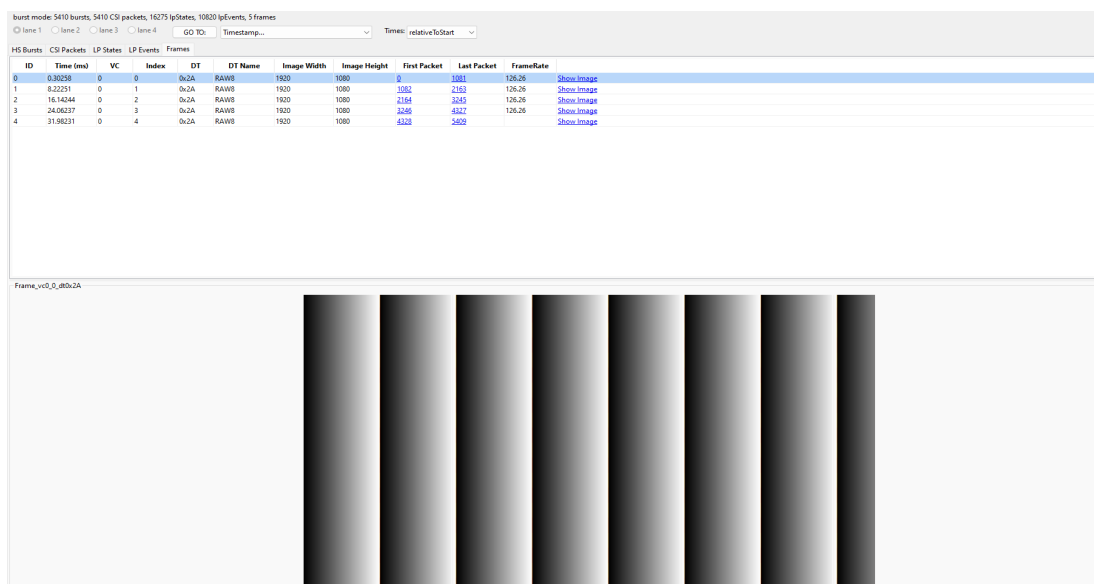
Figure 1-4. Test Pattern—RPI



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 1-5. 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.

1.5 Document References

For more information including schematics and user guides, refer to the following links:

- [MIPI Tx FMC Daughter Card kit](#)

- [PolarFire Video kit](#)

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