



Jetson Nano, Jetson TX2 NX, and Jetson Xavier NX Camera Module Hardware

Design Guide

Document History

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| 1.0 | November 8, 2019 | Initial Release |
| 1.1 | May 5, 2020 | Added Jetson Xavier NX camera information |
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Chapter 1. Introduction

This design guide contains recommendations and guidelines for engineers to follow to create a product that is optimized to achieve the best performance from the camera connector supported on the NVIDIA® Jetson Nano™, Jetson Nano 2GB, or Jetson Xavier™ NX Developer Kit carrier boards, or on a custom carrier board for Jetson Nano, Jetson™ TX2 NX, or Jetson Xavier NX modules that brings out additional camera interface pins.

1.1 References

Refer to the following documents or models for more information. Always use the latest revision of all documents.

- ▶ *Jetson Nano Developer Kit Carrier Board Specification*
- ▶ *Jetson Xavier NX Developer Kit Carrier Board Specification*
- ▶ *Jetson Nano Product Design Guide*
- ▶ *Jetson TX2 NX Product Design Guide*
- ▶ *Jetson Xavier NX Product Design Guide*

1.2 Abbreviations and Definitions

Table 1-1 lists abbreviations that may be used throughout this design guide and their definitions.

Table 1-1. Abbreviations and Definitions

| Abbreviation | Definition |
|--------------|------------------------------------|
| ADDR | Address |
| AF | Auto Focus |
| B2B | Board-to-Board |
| CSI | MIPI spec. Camera Serial Interface |
| GPIO | General Purpose Input/Output |
| FM | Fast Mode of I2C (400 KHz) |
| I2C | Inter IC |
| MUX | Multiplexer |
| LDO | Low Dropout (voltage regulator) |
| XTAL | Crystal Oscillator |

Chapter 2. Jetson Camera Modules

This design guide is to be used when designing a camera module for use with the Jetson Nano, Jetson Nano 2GB, or Jetson Xavier NX Developer Kit carrier boards or when designing a custom carrier board and camera module(s). The Jetson TX2 NX modules can be used with the Jetson Xavier NX Developer Kit carrier board.

Items to be checked:

- ▶ Power distribution and usage
- ▶ I2C addressing
- ▶ Camera connector pinout table and full module camera interface pin descriptions
- ▶ Mechanical (developer kit connector details)



Note: Refer to the Jetson Nano, Jetson TX2 NX, or Jetson Xavier NX product design guide for CSI routing guidelines. The carrier board PCB routing plus any camera flex cable should meet the requirements.

2.1 System Setup

- ▶ Jetson Nano, Jetson Nano 2GB, or Jetson Xavier NX Developer Kit or custom carrier board
- ▶ Compatible camera sensor module(s)

Figure 2-1. Jetson Nano Developer Kit (A02) Carrier Board

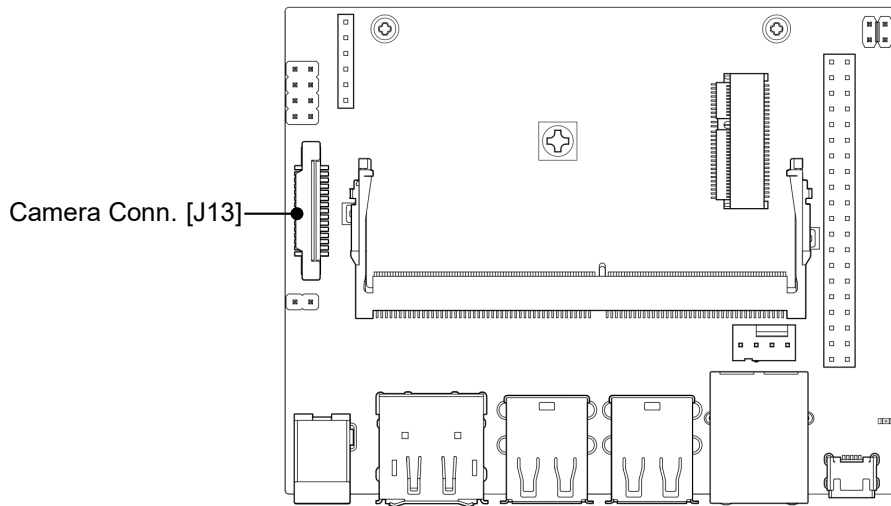
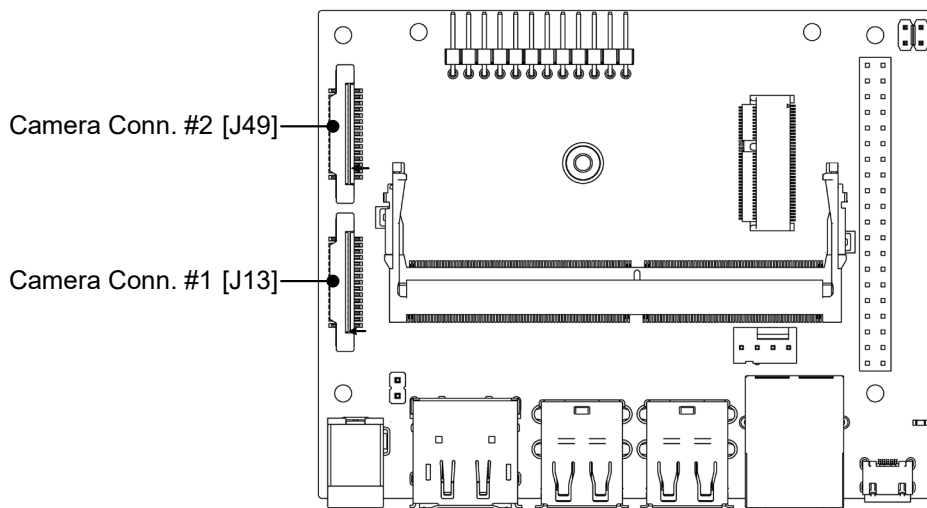


Figure 2-2. Jetson Nano Developer Kit (B01) Carrier Board



Note: The camera connector J13 on both the Jetson Nano A02 and B01 developer kit carrier boards receive the same CSI, clock, and power down signals. On B01, the I2C interface passes through an I2C multiplexer, where on A02, CAM_I2C connects directly to the camera connector.

Figure 2-3. Jetson Nano 2GB Developer Kit Carrier Board

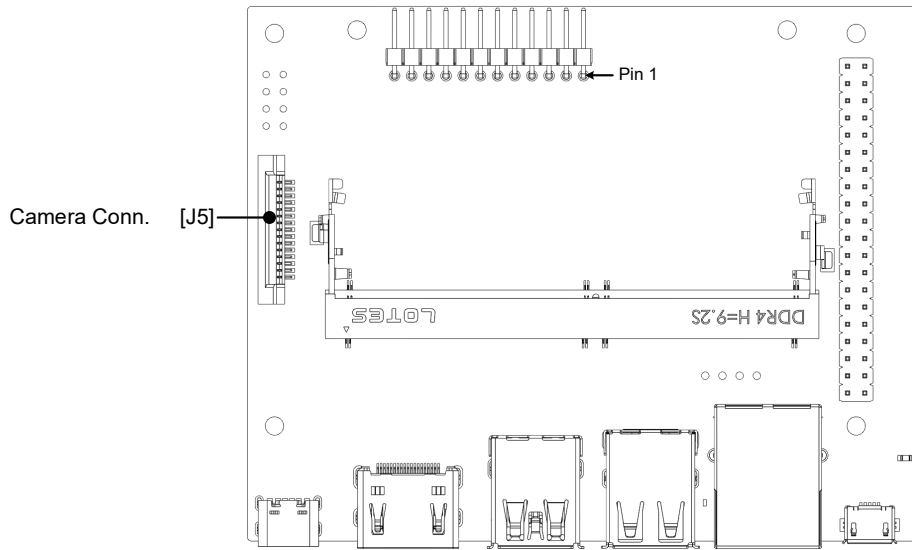
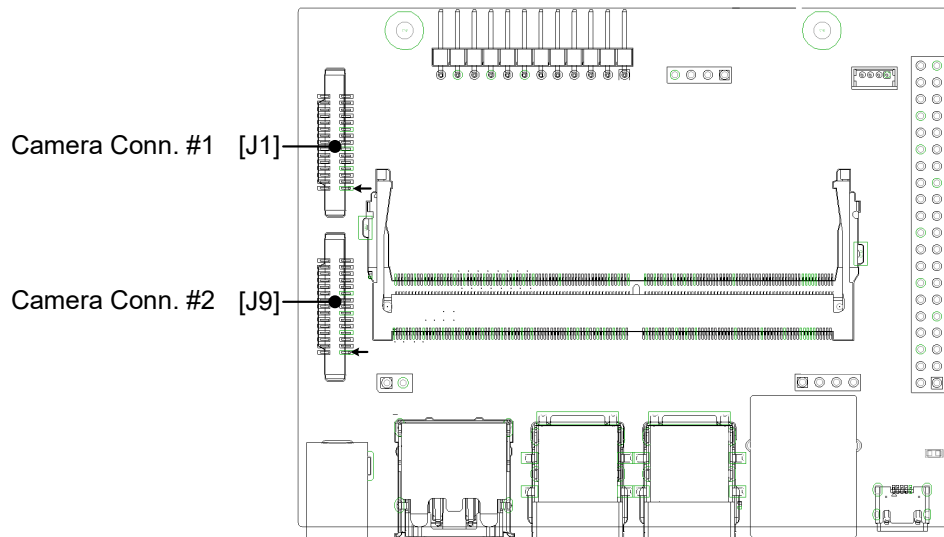


Figure 2-4. Jetson Xavier NX Developer Kit Carrier Board



Note: The position of camera connector #1 (connected to CSI0) and camera connector #2 (connected to CSI2) are swapped on the Jetson Xavier NX Developer Kit compared to the Jetson Nano Developer Kit (B01).

2.2 Camera Connections

The following sections give information regarding the camera connections for use with one of the developer kits or a custom carrier board design.

2.2.1 Developer Kit Camera Sensor Module Case

The Jetson Nano Developer Kit A02 version supports a 2-lane CSI interface which is routed to a single flex connector. The Jetson Nano Developer Kit B01 version or Jetson Xavier NX Developer Kit supports two, 2-lane flex connectors. A camera module could be connected directly if it is compatible with the power and controls provided, otherwise an interposer board of some type would be required.

Figure 2-5. Jetson Nano Developer Kit Carrier Board (A02) Camera Sensor Connector

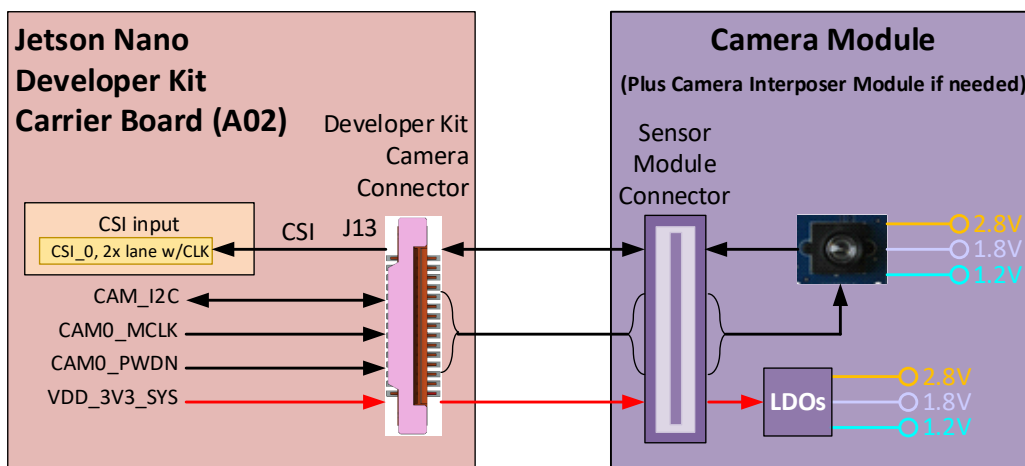


Figure 2-6. Jetson Nano Developer Kit Carrier Board (B01) Camera Sensor Connectors

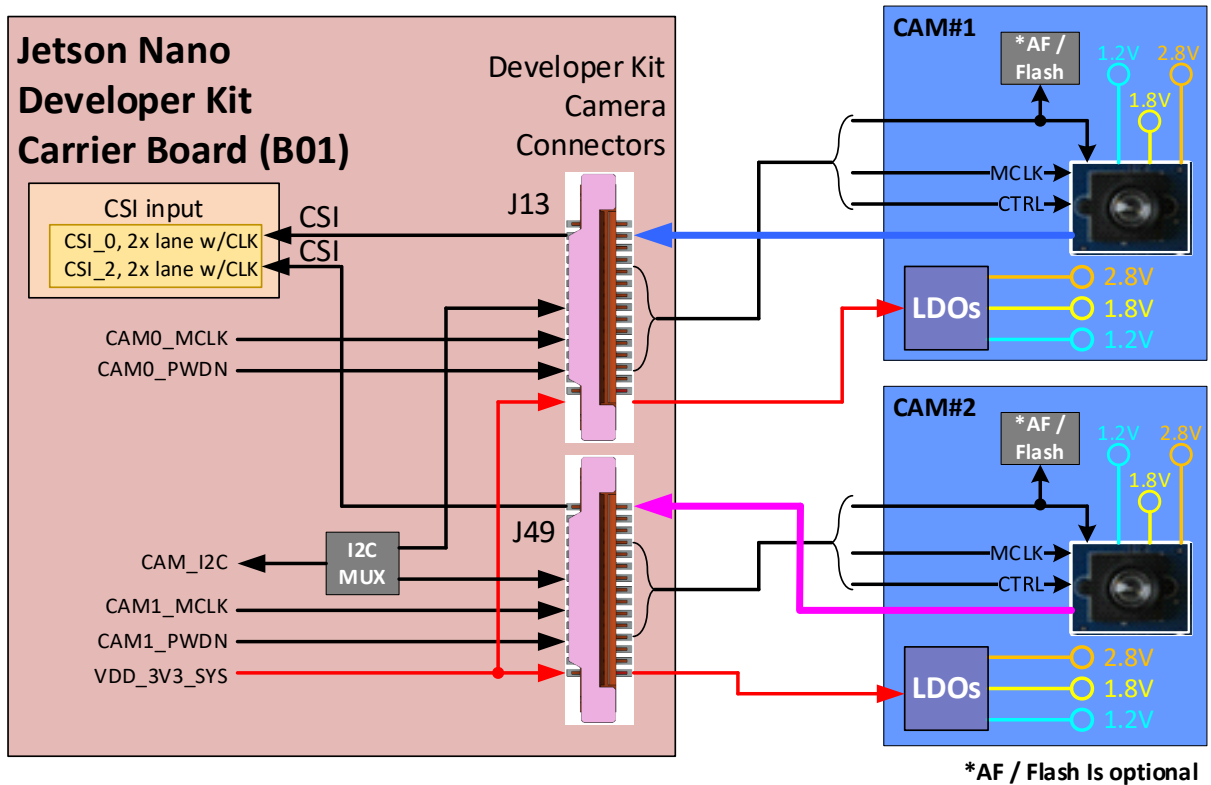


Figure 2-7. Jetson Nano 2GB Developer Kit Carrier Board Camera Sensor Connector

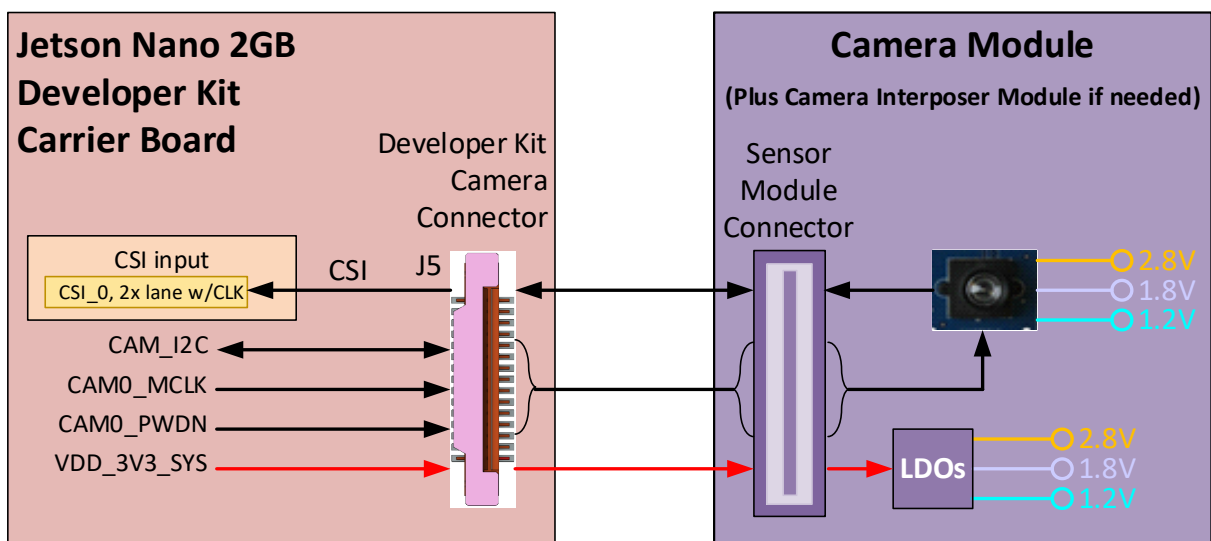
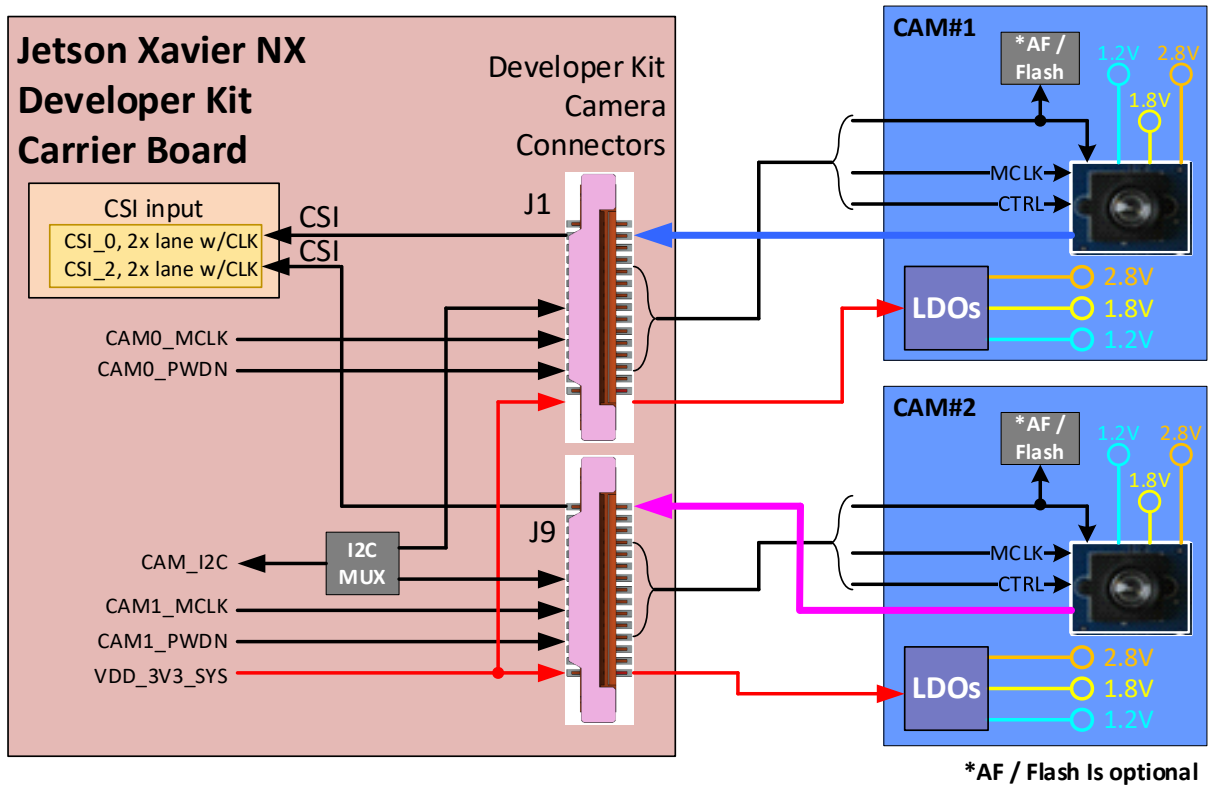


Figure 2-8. Jetson Xavier NX Developer Kit Carrier Board Camera Sensor Connectors



2.2.2 Custom Carrier Board Multiple Camera Case

The Jetson Nano module supports 12 CSI lanes and can support the following configurations:

- ▶ 3 x4 lane cameras
- ▶ 2 x4 lane cameras plus 2 x2 lane cameras
- ▶ 1 x4 lane camera plus 3 x2 lane cameras
- ▶ 4 x2 lane cameras

The Jetson TX2 NX module supports 12 CSI lanes and can support the following configurations:

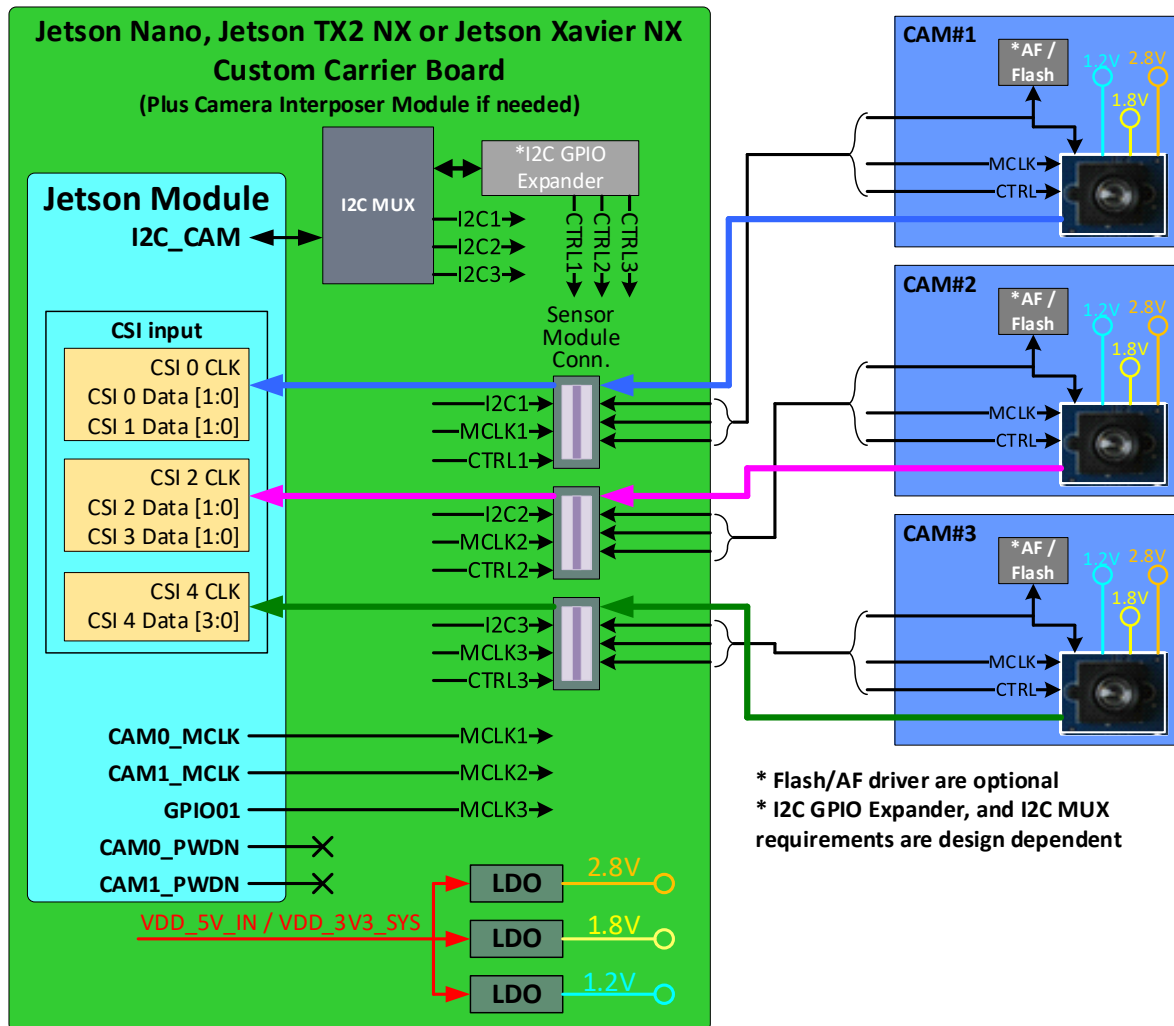
- ▶ 3 x4 lane cameras
- ▶ 2 x4 lane cameras plus 2 x2 lane cameras
- ▶ 1 x4 lane camera plus 4 x2 lane cameras
- ▶ 5 x2 lane cameras

The Jetson Xavier NX module supports 14 CSI lanes (12 can be used in a design) and can support the following configurations:

- ▶ 3 x4 lane cameras
- ▶ 2 x4 lane cameras plus 2 x2 lane cameras
- ▶ 1 x4 lane camera plus 4 x2 lane cameras
- ▶ 6 x2 lane cameras

Any of the x2 lane interfaces can be used to support a single x1 lane camera as well. The CSI lanes, clock(s) and control signals can be brought to camera module connectors on the carrier board, or to a main connector that an interposer board connects to. In the following example, 3 x4 lane camera modules connect to a custom carrier board or carrier board/interposer as required. Jetson Nano, Jetson TX2 NX, and Jetson Xavier NX all support two MCLKs and two GPIOs for power-down or other purposes. There are two additional pins on the Jetson modules that can be used to support two more camera MCLKs. These are GPIO01 and GPIO11. A clock buffer may be needed if more than 4 cameras are supported, or if this will improve routing and signal integrity. An I2C mux would likely be required unless the camera modules have unique I2C addresses and the routing on a single I2C interface would not adversely affect the signal quality.

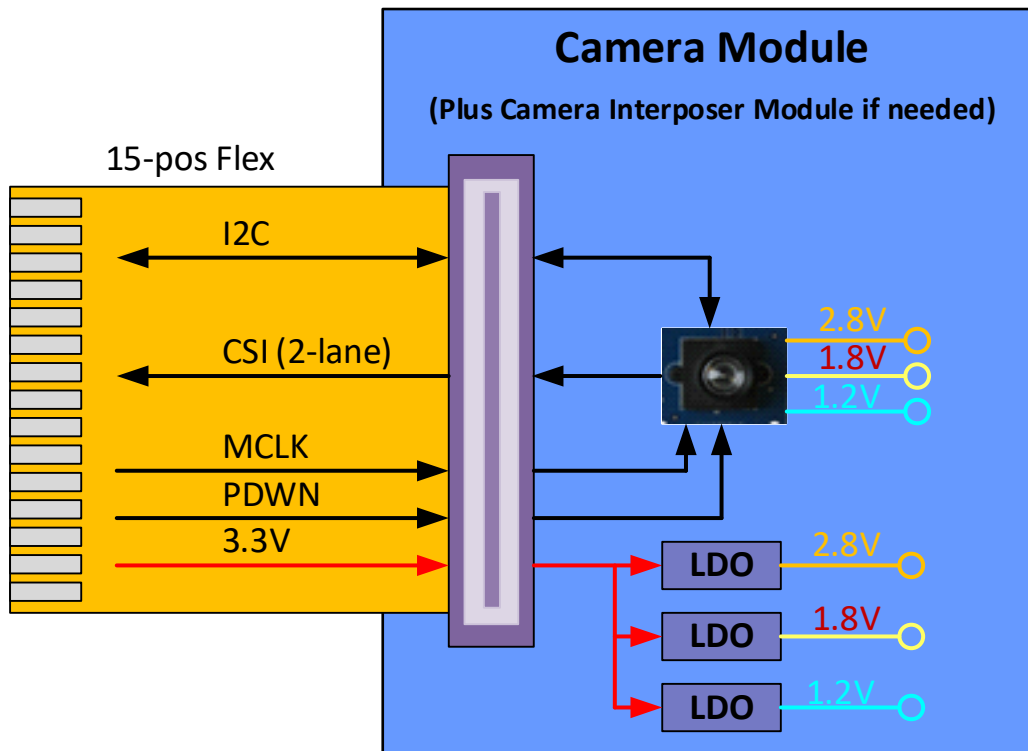
Figure 2-9. Custom Carrier Board Multiple Camera Connections



2.3 Camera Sensor Modules

Figure 2-10 is a high-level block diagram for a camera sensor module compatible with the developer kit carrier board camera connectors.

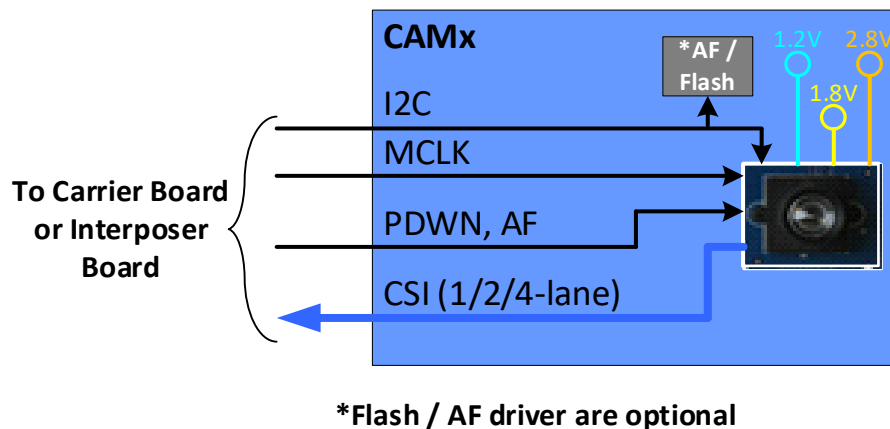
Figure 2-10. Developer Kit Camera Sensor Module



Note: LDO supplies shown are for example only - actual voltages required on camera module depend on sensor and other circuitry implemented on the module.

Figure 2-11 is the high-level block diagram for a camera sensor module for use on a custom carrier board when there are multiple camera sensors.

Figure 2-11. Custom Carrier Board Camera Sensor Module



Chapter 3. Camera Interface Details

This chapter contains the camera connector pinouts for Jetson Nano, Jetson Nano 2GB, and Jetson Xavier NX developer kits. Also included are camera related pin descriptions for Jetson Nano, Jetson TX2 NX, and Jetson Xavier NX modules.



Note: In Table 3-1 through Table 3-3, “Output” is to the camera module and “Input” is from the camera module.

Table 3-1. Developer Kit Carrier Board Camera Connector #1 Pinout

| Pin | Description | Volt | Type/Dir. | Signal Name | | Pin | Description |
|-----|------------------------|--------|---------------|-------------|--|-----|-------------|
| 1 | Ground | – | – | GND | | 2 | Not used |
| 3 | Camera Lane 0 | 1.2 | Input | CSI0_D0_N | | 4 | Not used |
| 5 | | 1.2 | Input | CSI0_D0_P | | 6 | Not used |
| 7 | Ground | – | – | GND | | 8 | Not used |
| 9 | Camera Lane 1 | 1.2 | Input | CSI0_D1_N | | 10 | Not used |
| 11 | | 1.2 | Input | CSI0_D1_P | | 12 | Not used |
| 13 | Ground | – | – | GND | | 14 | Not used |
| 15 | Camera clock lane | 1.2 | Input | CSI0_CLK_N | | 16 | Not used |
| 17 | | 1.2 | Input | CSI0_CLK_P | | 18 | Not used |
| 19 | Ground | – | – | GND | | 20 | Not used |
| 21 | Camera Power-down GPIO | 1.8 | Output | CAM0_PWDN | | 22 | Not used |
| 23 | Camera MCLK | 1.8 | Output | CAM0_MCLK | | 24 | Not used |
| 25 | Camera I2C clock | 3.3 OD | Bidirectional | CAM_I2C_SCL | | 26 | Not used |
| 27 | Camera I2C data | 3.3 OD | Bidirectional | CAM_I2C_SDA | | 28 | Not used |
| 29 | 3.3V supply | – | – | VDD_3V3_SYS | | 30 | Not used |

Note: Camera Connector #1 is J13 on Jetson Nano and J1 Jetson Xavier NX.

Table 3-2. Developer Kit Carrier Board Camera Connector #2 Pinout

| Pin | Description | Volt | Type/Dir. | Signal Name | | Pin | Description |
|--|------------------------|--------|---------------|-------------|--|-----|-------------|
| 1 | Ground | – | – | GND | | 2 | Not used |
| 3 | Camera Lane 0 | 1.2 | Input | CSI2_D0_N | | 4 | Not used |
| 5 | | 1.2 | Input | CSI2_D0_P | | 6 | Not used |
| 7 | Ground | – | – | GND | | 8 | Not used |
| 9 | Camera Lane 1 | 1.2 | Input | CSI2_D1_N | | 10 | Not used |
| 11 | | 1.2 | Input | CSI2_D1_P | | 12 | Not used |
| 13 | Ground | – | – | GND | | 14 | Not used |
| 15 | Camera Clock Lane | 1.2 | Input | CSI2_CLK_N | | 16 | Not used |
| 17 | | 1.2 | Input | CSI2_CLK_P | | 18 | Not used |
| 19 | Ground | – | – | GND | | 20 | Not used |
| 21 | Camera Power-down GPIO | 1.8 | Output | CAM1_PWDN | | 22 | Not used |
| 23 | Camera MCLK | 1.8 | Output | CAM1_MCLK | | 24 | Not used |
| 25 | Camera I2C clock | 3.3 OD | Bidirectional | CAM_I2C_SCL | | 26 | Not used |
| 27 | Camera I2C data | 3.3 OD | Bidirectional | CAM_I2C_SDA | | 28 | Not used |
| 29 | 3.3V supply | – | – | VDD_3V3_SYS | | 30 | Not used |
| Note: Camera Connector #2 is J49 on Jetson Nano (B01 only) and J9 on Jetson Xavier NX. | | | | | | | |

Table 3-3. Camera Related Pin Descriptions for Jetson Nano, Jetson TX2 NX, and Jetson Xavier NX Modules

| Module Pin | Description | Volt | Direction | Signal Name |
|------------|---|------|-----------|-------------|
| 10 | Camera, CSI 0 Clock | 1.2 | Input | CSI_0_CLK_N |
| 12 | | | | CSI_0_CLK_P |
| 4 | Camera, CSI 0 Data 0 | 1.2 | Input | CSI_0_D0_N |
| 6 | | | | CSI_0_D0_P |
| 16 | Camera, CSI 0 Data 1 | 1.2 | Input | CSI_0_D1_N |
| 18 | | | | CSI_0_D1_P |
| 9 | Camera, CSI 1 Clock (TX2 NX and Xavier NX only) | 1.2 | Input | CSI_1_CLK_N |
| 11 | | | | CSI_1_CLK_P |
| 3 | Camera, CSI 1 Data 0 | 1.2 | Input | CSI_1_D0_N |
| 5 | | | | CSI_1_D0_P |
| 15 | Camera, CSI 1 Data 1 | 1.2 | Input | CSI_1_D1_N |
| 17 | | | | CSI_1_D1_P |
| 28 | Camera, CSI 2 Clock | 1.2 | Input | CSI_2_CLK_N |
| 30 | | | | CSI_2_CLK_P |
| 22 | Camera, CSI 2 Data 0 | 1.2 | Input | CSI_2_D0_N |
| 24 | | | | CSI_2_D0_P |
| 34 | Camera, CSI 2 Data 1 | 1.2 | Input | CSI_2_D1_N |
| 36 | | | | CSI_2_D1_P |
| 27 | Camera, CSI 3 Clock | 1.2 | Input | CSI_3_CLK_N |
| 29 | | | | CSI_3_CLK_P |
| 21 | Camera, CSI 3 Data 0 | 1.2 | Input | CSI_3_D0_N |
| 23 | | | | CSI_3_D0_P |
| 33 | Camera, CSI 3 Data 1 | 1.2 | Input | CSI_3_D1_N |
| 35 | | | | CSI_3_D1_P |
| 52 | Camera, CSI 4 Clock | 1.2 | Input | CSI_4_CLK_N |
| 54 | | | | CSI_4_CLK_P |
| 46 | Camera, CSI 4 Data 0 | 1.2 | Input | CSI_4_D0_N |
| 48 | | | | CSI_4_D0_P |
| 58 | Camera, CSI 4 Data 1 | 1.2 | Input | CSI_4_D1_N |
| 60 | | | | CSI_4_D1_P |
| 40 | Camera, CSI 4 Data 2 | 1.2 | Input | CSI_4_D2_N |
| 42 | | | | CSI_4_D2_P |
| 64 | Camera, CSI 4 Data 3 | 1.2 | Input | CSI_4_D3_N |

| Module Pin | Description | Volt | Direction | Signal Name |
|------------|--------------------------------|--------|---------------|-------------|
| 66 | | | | CSI_4_D3_P |
| 76 | Camera, CSI 5 Clock (NX only) | 1.2 | Input | DSI_CLK_N |
| 78 | | | | DSI_CLK_P |
| 70 | Camera, CSI 5 Data 0 (NX only) | 1.2 | Input | DSI_D0_N |
| 72 | | | | DSI_D0_P |
| 82 | Camera, CSI 5 Data 1 (NX only) | 1.2 | Input | DSI_D1_N |
| 84 | | | | DSI_D1_P |
| 213 | Camera I2C clock | 3.3 OD | Bidirectional | CAM_I2C_SCL |
| 215 | Camera I2C Data | 3.3 OD | Bidirectional | CAM_I2C_SDA |
| 116 | Camera 0 Master Clock | 1.8 | Output | CAM0_MCLK |
| 114 | Camera 0 Power-down GPIO | 1.8 | Output | CAM0_PWDN |
| 122 | Camera 1 Master Clock | 1.8 | Output | CAM1_MCLK |
| 120 | Camera 1 Power-down GPIO | 1.8 | Output | CAM1_PWDN |
| 118 | GPIO / Camera 2 Master Clock | 1.8 | Output | GPIO01 |
| 216 | GPIO / Camera 3 Master Clock | 1.8 | Output | GPIO11 |

Note: Rows highlighted are not supported on Jetson Nano but are supported on Jetson TX2 NX and/or Jetson Xavier NX only.

Chapter 4. Power

The Jetson Nano, Jetson Nano 2GB, and Jetson Xavier NX Developer Kit camera connectors provide a single power source (VDD_3V3_SYS). This power source is shared by other devices on the carrier board or connected to the developer kit such as:

- ▶ Level shifters on carrier board
- ▶ VESA® DisplayPort® output display
- ▶ M.2 Key E modules
- ▶ Peripherals connected to 40-pin expansion header

The VDD_3V3_SYS supply is “always on” so it should not be used directly if it must be sequenced with other supplies generated on the connected camera sensor module.

Whether the developer kit or a custom carrier board is used, proper power sequencing is required in order not to damage the Jetson module. The sequencing should be controlled by the Jetson module.

Chapter 5. I2C Address

This chapter provides the I2C address description for the camera interposer module and camera sensor module. The Jetson Nano (B01) and Jetson Xavier NX Developer Kits use a mux to direct CAM_I2C to either of the two camera connectors. This mux does not have an I2C address and selects between the two connectors using a GPIO. An I2C mux (or I2C expander) may be required for a multiple sensor design and a recommended device is included in the following table.

Table 5-1. I2C Address

| Jetson Carrier Board | Camera Interposer | | Each Camera Sensor Module | |
|---|--|-------|-------------------------------|--|
| CAM_I2C | I2CMUX for custom carrier board - TCA9548A | 7'h70 | *Flash driver IC (optional) | |
| | *I2C GPIO Expander (optional) | | *Auto focus driver (optional) | |
| Note: The CAM_I2C interface is connected to the power monitor device on the module which uses I2C address 7'h40 | | | | |

Chapter 6. Components

6.1 I2C MUX

An I2C MUX may be required to isolate the different camera sensor modules, especially if the cameras have the same I2C address. As mentioned previously, the Jetson Nano (B01) and Jetson Xavier NX Developer Kits use a MUX to direct CAM_I2C to either of the two camera connectors that does not have an I2C address and selects between the two connectors using a GPIO. If an I2C MUX (or I2C expander) is required for a multiple sensor design, a recommended device is described with the following features.

- ▶ 4-Channel outputs
- ▶ I2C-compatible up to 400 KHz (FM) at 1.8V
- ▶ TCA9548A from TI is recommended

6.2 Developer Kit Camera Connector(s)

The Jetson Nano, Jetson Nano 2GB, and Jetson Xavier NX carrier board camera connectors are from TE Connectivity (Part Number: 1-734248-5). These connectors are used to mate with flex cables from the camera boards/modules.

Chapter 7. Optional

7.1 I2C GPIO Expander

- ▶ An I2C GPIO expander can be used to expand control signals for camera sensor module(s)
- ▶ Features:
 - 8-bit bi-directional GPIO expansion
 - I2C-compatible up to 400 KHz (FM) at 1.8V

7.2 Clock Buffer and XTAL

- ▶ There are up to four clock outputs from the Jetson module:
 - CAM0_MCLK
 - CAM1_MCLK
 - GPIO01 (MCLK #2)
 - GPIO11 (MCLK #3)
- ▶ It is recommended to use the clocks from Jetson, but a clock buffer can be used to drive multiple clocks from a single source
- ▶ A Crystal can be used if dynamic frequency switching from the SoC is not needed for the sensor

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