NVIDIA JETSON CAMERA MODULE

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Hardware Design Guide

DOCUMENT CHANGE HISTORY

DG-08155-001_v05

Version	Date	Description of Change
01	July 25, 2016	Initial Release
02	November 16, 2016	•Updated figures throughout this design guide •Updated Table 3-1 and Table 4-1 •Updated EEPROM (Section 6.1) •Updated camera connector section (Section 6.3)
03	April 14, 2017	•General text fixes •Updated Figure 2-1 •Updated Figure 2-4 •Updated power sources in Table 4-1
04	November 15, 2017	Added EEPROM structure table (Table 6-1)
05	November 28, 2017	•Added Jetson TX2 •Updated Figure 2-2, Figure 2-3, and Figure 9-2

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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 common interfaces supported by the NVIDIA® Jetson™ TX1/TX2 Developer Kit carrier board.

1.1 REFERENCES

Refer to the following documents or models for more information. Use the latest revision of all documents at all times.

- Jetson TX1/TX2 Developer Kit Carrier Board Specification
- Jetson TX1 OEM Product Design Guide
- Jetson TX2 OEM 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
EEPROM	Electrically Erasable Programmable Read Only Memory
GPIO	General Purpose Input/Output
FM	Fast Mode of I2C (400 KHz)
I2C	Inter IC
I2S	Inter-IC Sound
MUX	Multiplexer
LDO	Low Dropout (voltage regulator)
XTAL	Crystal Oscillator
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver Transmitter

Chapter 2.
JETSON CAMERA MODULE

This design guide is to be used when designing a camera module for use with the Jetson TX1/TX2 Developer Kit carrier board.

Items to be checked:

- Power distribution and usage
- I2C addressing
- EEPROM selection and control
- Pinout table
- Mechanical (connector and board outline)

2.1 SYSTEM SETUP

- Jetson TX1/TX2 Developer Kit
- Camera Interposer Module (supports 1 to 6 cameras)
- Camera Sensor Module(s)

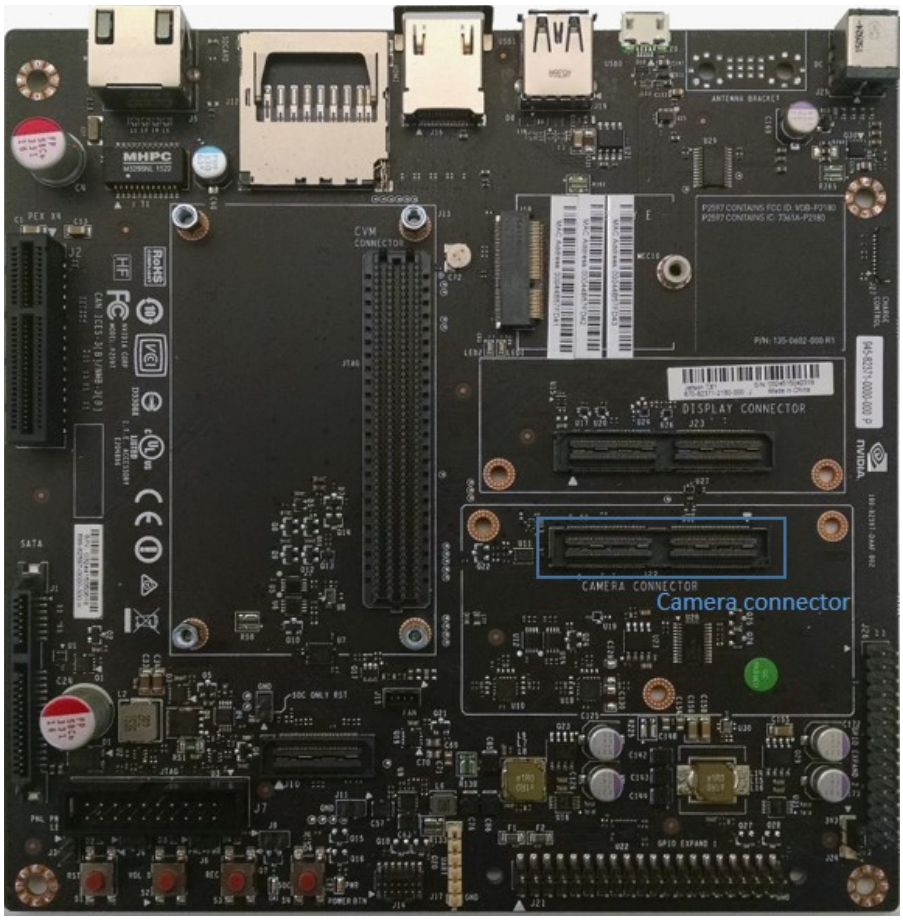

Figure 2-1. Jetson TX1/TX2 Developer Kit

2.2 CAMERA INTERPOSER MODULE

2.2.1 Single Camera Case

When using a single camera sensor, the camera interposer module will be a simple pass-through to the camera sensor module, with no EEPROM or I2C MUX on the interposer.

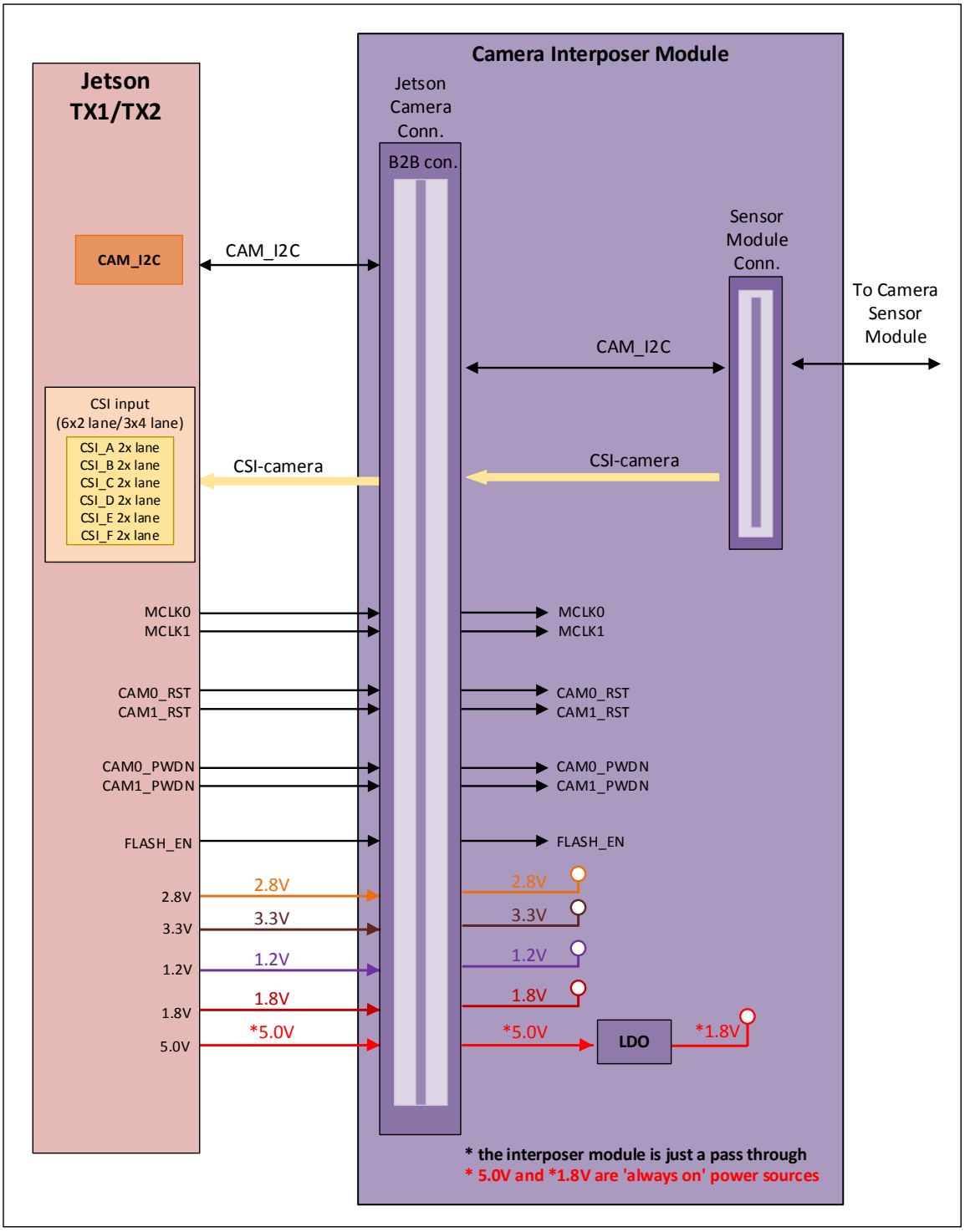

Figure 2-2. Single Camera Case Block Diagram

2.2.2 Multiple Camera Case

When multiple camera sensors are used (up to 6), a camera interposer module with EEPROM and I2C MUX is required to support the camera sensors.

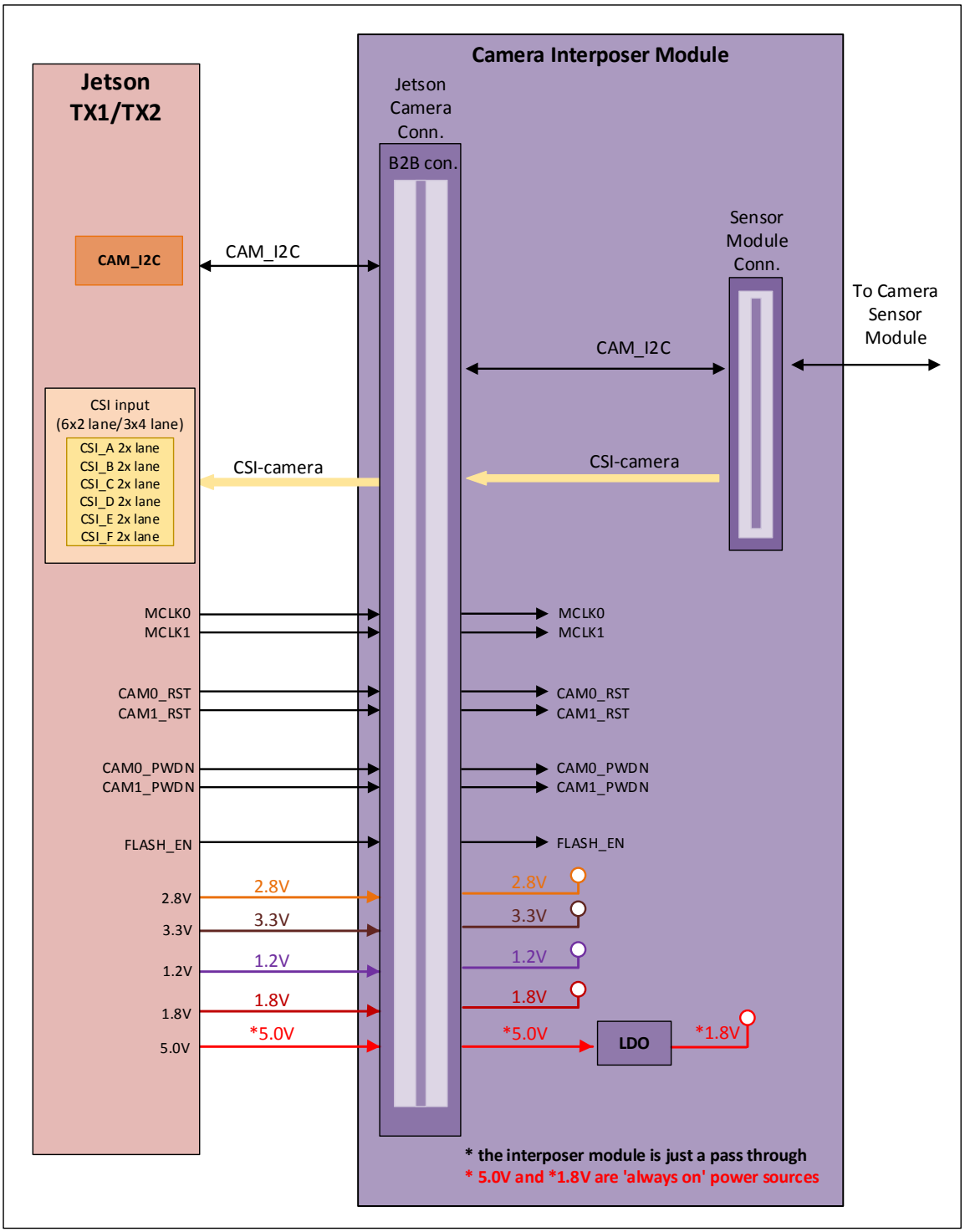

Figure 2-3. Multiple Camera Case Block Diagram

2.3 CAMERA SENSOR MODULE

Figure 2-4 is the block diagram for a camera sensor module when there are multiple camera sensors.

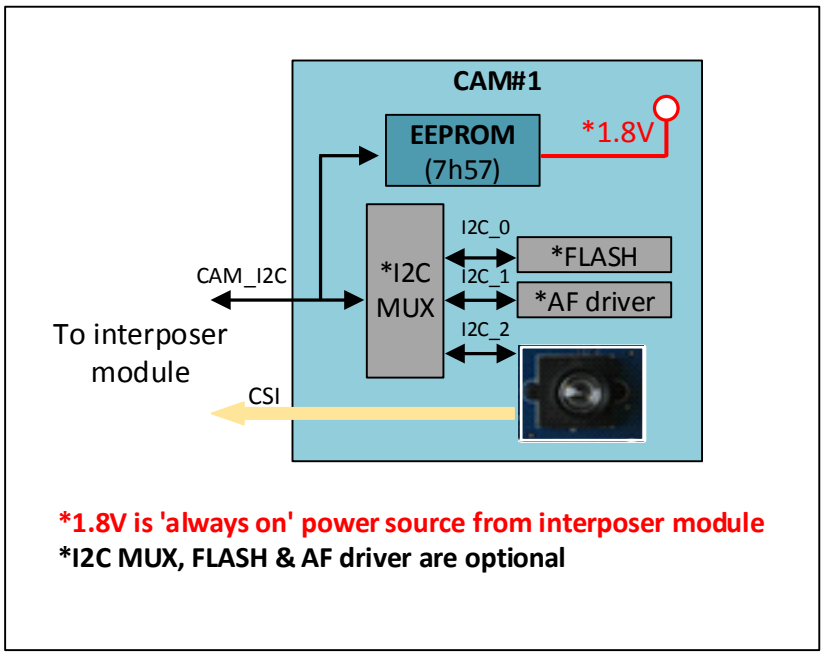

Figure 2-4. Camera Sensor Module Block Diagram

Chapter 3. JETSON CAMERA CONNECTOR PINOUT TABLE

This chapter contains the pinout table which provides the camera's connector pins listing and description.

Table 3-1. Jetson Camera Connector (2 x 60) Pinout Table

Pin	Description	Volt	Direction for Sensor	Signal Name		Signal Name	Direction for Sensor	Volt	Description	Pin
1	CSI Controller A Lane 0	1.2V	Output	CSI_A_D0_P		CSI_B_D0_P	Output	1.2V	CSI Controller B Lane 0	2
3		1.2V	Output	CSI_A_D0_N		CSI_B_D0_N	Output	1.2V		4
5			-	**GND**		**GND**	-			6
7	CSI Controller A Clock	1.2V	Output	CSI_A_CLK_P		CSI_B_CLK_P	Output	1.2V	CSI Controller B Clock	8
9		1.2V	Output	CSI_A_CLK_N		CSI_B_CLK_N	Output	1.2V		10
11			-	**GND**		**GND**	-			12
13	CSI Controller A Lane 1	1.2V	Output	CSI_A_D1_P		CSI_B_D1_P	Output	1.2V	CSI Controller B Lane 1	14
15		1.2V	Output	CSI_A_D1_N		CSI_B_D1_N	Output	1.2V		16
17			-	**GND**		**GND**	-			18
19	CSI Controller C Lane 0	1.2V	Output	CSI_C_D0_P		CSI_D_D0_P	Output	1.2V	CSI Controller D Lane 0	20
21		1.2V	Output	CSI_C_D0_N		CSI_D_D0_N	Output	1.2V		22
23			-	**GND**		**GND**	-			24
25	CSI Controller C Clock	1.2V	Output	CSI_C_CLK_P		CSI_D_CLK_P	Output	1.2V	CSI Controller D Clock	26
27		1.2V	Output	CSI_C_CLK_N		CSI_D_CLK_N	Output	1.2V		28
29			-	**GND**		**GND**	-			30
31	CSI Controller C Lane 1	1.2V	Output	CSI_C_D1_P		CSI_D_D1_P	Output	1.2V	CSI Controller D Lane 1	32
33		1.2V	Output	CSI_C_D1_N		CSI_D_D1_N	Output	1.2V		34

Pin	Description	Volt	Direction for Sensor	Signal Name		Signal Name	Direction for Sensor	Volt	Description	Pin
35			-	**GND**		**GND**	-			36
37	CSI Controller E Lane 0	1.2V	Output	CSI_E_D0_P		CSI_F_D0_P	Output	1.2V	CSI Controller F Lane 0	38
39		1.2V	Output	CSI_E_D0_N		CSI_F_D0_N	Output	1.2V		40
41			-	**GND**		**GND**	-			42
43	CSI Controller E Clock	1.2V	Output	CSI_E_CLK_P		CSI_F_CLK_P	Output	1.2V	CSI Controller F Clock	44
45		1.2V	Output	CSI_E_CLK_N		CSI_F_CLK_N	Output	1.2V		46
47			-	**GND**		**GND**	-			48
49	CSI Controller E Lane 1	1.2V	Output	CSI_E_D1_P		CSI_F_D1_P	Output	1.2V	CSI Controller F Lane 1	50
51		1.2V	Output	CSI_E_D1_N		CSI_F_D1_N	Output	1.2V		52
53			-	**GND**		**GND**	-			54
55			-	RSVD_DVDD		RSVD_DVDD	-			56
57										58
59	Camera UART present		Output	UART_PSNT_L		NC				60
61	Camera UART TXD	1.8V	Input	CAM_UART_TXD		SPI_SCK	Input	1.8V	SPI clock	62
63	Camera UART RXD	1.8V	Output	CAM_UART_RXD		SPI_MISO	Output	1.8V	SPI MISO	64
65	Camera UART CTS	1.8V	Output	CAM_UART_CTS		SPI_CS	Input	1.8V	SPI Chip Select	66
67	Camera UART RTS	1.8V	Input	CAM_UART_RTS		SPI_MOSI	Input	1.8V	SPI MOSI	68
69			-	**GND**		**GND**	-			70
71	DMIC input clock	1.8V	Input	DMIC_IN_CLK		I2S_CLK	Input	1.8V	I2S clock	72
73	DMIC input data	1.8V	Input	DMIC_IN_DAT		I2S_LRCLK	Input	1.8V	I2S frame	74
75	Camera I2C clock	1.8V	Input	CAM_I2C_SCL		I2S_SDIN	Output	1.8V	I2S data input	76
77	Camera I2C data	1.8V	Bidirectional	CAM_I2C_DAT		I2S_SDOUT	Input	1.8V	I2S data output	78
79			-	**GND**		**GND**	-			80
81	AVDD camera power	2.8V	Power Input	AVDD_CAM		AVDD_CAM	Power Input	2.8V	AVDD camera power	82
83						VDD_3V3_SLP	Power Input	3.3V	DVDD sleep power	84
85	Camera AF power down	1.8V	Input	CAM_AF_PWDN		CAM_VSYNC	Input	1.8V	Camera VSYNC	86
87	Power	1.8V	Input	I2C_PM_CLK		CAM1_MCLK	Input	1.8V	Camera1 clock	88

Pin	Description	Volt	Direction for Sensor	Signal Name		Signal Name	Direction for Sensor	Volt	Description	Pin
	manage I2C								input	
89	Power manage I2C	1.8V	Bidirectional	I2C_PM_DAT		CAM1_PWDN	Input	1.8V	Camera1 power down	90
91	Camera0 clock input	1.8V	Input	CAM0_MCLK		CAM1_RST_L	Input	1.8V	Camera1 reset	92
93	Camera0 power down	1.8V	Input	CAM0_PWDN		-	-	-	RSVD	94
95	Camera0 reset	1.8V	Input	CAM0_RST_L		-	-	-	RSVD	96
97	Camera flash enable	1.8V	Input	FLASH_EN		-	-	-	RSVD	98
99			**-**	**GND**		**GND**	**-**			100
101	DVDD camera power	1.2V	Power Input	DVDD_1V2		DVDD_CAM_1V8	Power Input	1.8V	DVDD IO camera power	102
103	Flash inhibit	1.8V	Input	FLASH_INHIBIT		TORCH_EN	Input	1.8V	Torch enable	104
105	General Purpose I2C	1.8V	Input	I2C_GP_CLK		FLASH_STROBE	Input	1.8V	Flash strobe input	106
107	General Purpose I2C	1.8V	Bidirectional	I2C_GP_DAT		VDD_3V3_SLP	Power Input	3.3V	DVDD sleep power	108
109	5.0V system power	5.0V	Power Input	VDD_5V0						110
111	-	-	-	RSVD_IR_READY		MOTION_INT_L	Output	1.8V	Motion/Gyro interrupt	112
113	-	-	-	RSVD_IR_TRIG		RSVD_IR_EN	-			114
115			**-**	**GND**		**GND**	**-**			116
117	Camera FSIN interrupt		Output	CAM_FSIN_INT		VDD_5V0	Power Input	5.0V	5.0V system power	118
119	system enable input	1.8V	Input	VDD_SYS_EN						120

Chapter 4. POWER

Power sources from the Jetson connector are listed in Table 4-1.

Table 4-1. Power Sources

Net Name	Specification	Note
VDD_5V0	5.0V	This is 'always on' power and to be used as the source of 'always on 1.8V' for EEPROM and I2C MUX, so it is not recommended to use it as a power source requiring power sequence
VDD_3V3_SLP	3.3V, 4A (maximum)	3.3V system power
AVDD_CAM	2.8V, 3A (maximum)	2.8V analog power
DVDD_CAM_1V8	1.8V, 2A (maximum)	1.8V digital IO power
DVDD_1V2	1.2V, 300mA (maximum)	1.2V digital circuit power

Proper power sequence is required in order not to damage the Jetson TX1/TX2 module.

- All camera powers except 1.8V for EEPROM should be 'Off' by default
- Powers should be controlled by Jetson TX1/TX2

Chapter 5. I2C ADDRESS

This chapter provides the I2C address description for the camera interposer module and camera sensor module.

Table 5-1. I2C Address

Jetson TX1/TX2	Camera Interposer Module		Each Camera Sensor Module	
CAM_I2C	EEPROM, AT24C02D	7'h54	EEPROM, AT24C02D	7'h57
	I2CMUX, TCA9546A	7'h70	*Flash driver IC (optional)	
	*I2C GPIO Expander (optional)		*Auto focus driver (optional)	

Chapter 6. COMPONENTS

6.1 EEPROM

- Camera interposer module EEPROM power rail should be 'ON' by default
- The EEPROM in all camera sensor modules can have the same I2C address
- Features:
  - 2-Kbit (256 × 8)
  - I2C-compatible up to 400 KHz (FM) at 1.8V
  - AT24C02D from Atmel is recommended
- The EEPROMs allow Jetson to dynamically detect the interposer board and the camera module(s) connected to it, and to load the corresponding device tree files
- The mentioned recommendation and configuration for EEPROM is required when multiple camera sensors are used, but is not required for a single camera module

Table 6-1. EEPROM Structure

EEPROM Byte Absolute Address	Description	Data	Comments
Byte - 0	Version - Major	0x00	Major Version of BoardID Contents (Integer) - increments on backwards-incompatible changes
Byte - 1	Version - Minor	0x02	Minor Version of BoardID Contents (Integer) - increments on backwards-compatible changes within Major Version
Byte - 2 thru 19	**RESERVED**	0xFF	
Byte - 20 Thru 49	Product Part Number		**Asset Tracker for Customer board design**: Byte-20 = 0xCC, Bytes 21-49: Customer assigned unique string with zero-termination. Eg: Company Name/Stock Ticker

			followed by design/rev. This field should contain characters A-Z, a-z, 0-9 and dash ONLY (Eg: NVDA-12345)
Byte - 50 Thru 88	**RESERVED**	0xFF	
User Data Section			
Byte - 89	Camera Interposer Board I2C MUX-1	0x70	I2C MUX-1 7-bit Address
Byte - 90		0x01	I2C MUX Type (Refer to table below in this tab for Type Code Vs Part# Mapping)
Byte - 91 thru 254	**RESERVED**	0xFF	
Byte - 255	CRC		CRC-8 Computed for Bytes 0 thru 254.
I2C MUX Type Code Vs Part# Mapping			
MUX Type Code	**Part#**		**Description**
1	**TCA9548A**		8 Channel I2C MUX

6.2 I2C MUX

- I2C MUX must be used to isolate all camera sensor modules
- Features:
  - 4-Channel outputs
  - I2C-compatible up to 400 KHz (FM) at 1.8V
  - TCA9548PWR from TI is recommended

6.3 JETSON CAMERA CONNECTOR

B2B connector on Jetson TX1/TX2: Samtec's QSH-060-01-H-D-A-K-TR

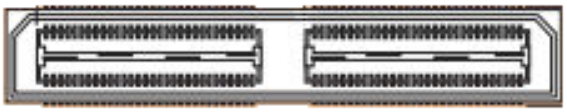

Figure 6-1. Jetson Camera Connector

Mating terminal connector to be used:

- For recommended board outline: QTH-060-01-F(H)-D-A-x

For extended board outline which overhangs the display module: QTH-060-04-F(H)-D-A-x

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 two clock outputs from Jetson TX1/TX2: MCLK0, and MCLK1
- It is recommended to use the clocks from Jetson, but a clock buffer can be used to drive multiple clocks from single source
- XTAL can be used if dynamic frequency switching from AP is not needed for the sensor

Chapter 8. MECHANICAL

Recommended outline for interposer module.

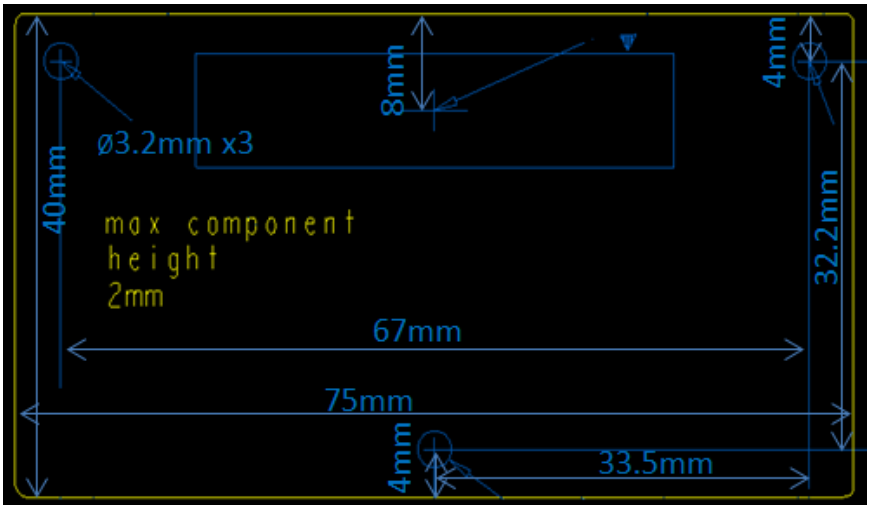

Figure 8-1. Recommended Interposer Module Outline

These mechanical limits will ensure fit on Jetson TX1/TX2 Developer Kit carrier board.

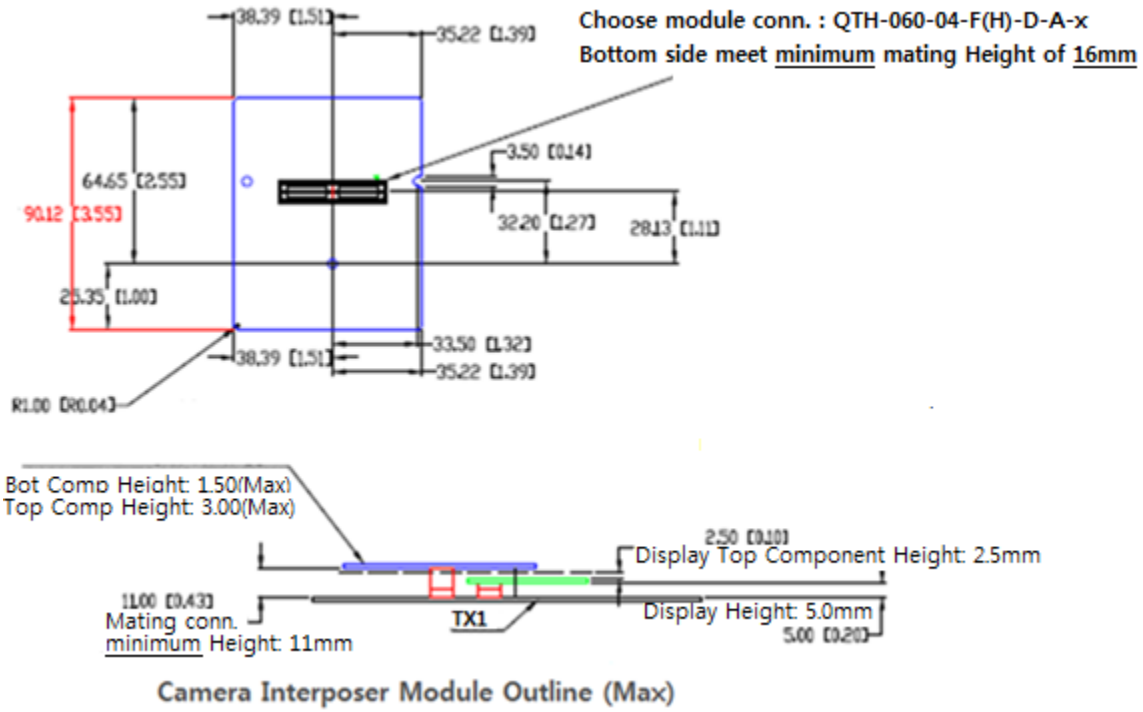

Figure 8-2. Mechanical Limits of Interposer Module Outline

Note: Minimum mating height should be over 16 mm when overhangs display module.

Chapter 9. EXAMPLE

- Example setup with up to 3 cameras with 4 CSI lane cameras
- Three cables with plug are also needed to connect interposer module to sensor modules
- Each connector needs to accommodate the following signals
  - Powers:
    - VDD_3V3_SLP
    - AVDD_CAM
    - DVDD_CAM_1V8
    - DVDD_1V2
  - CSI_CLK and CSI_DAT : 1 × 4 lanes or 2 × 2 lanes
  - MCLK or clock from local XTAL on interposer module
  - CAM_I2C (CLK, DAT)
  - CAM_RST
  - CAM_PWDN
  - FLASH_EN (*optional)
  - Other control signals as needed
- Ex) I-PEX connector
  - Ex. 20525-030-02C

Figure 9-1 is an example connector between the camera sensor module and the camera interposer module.

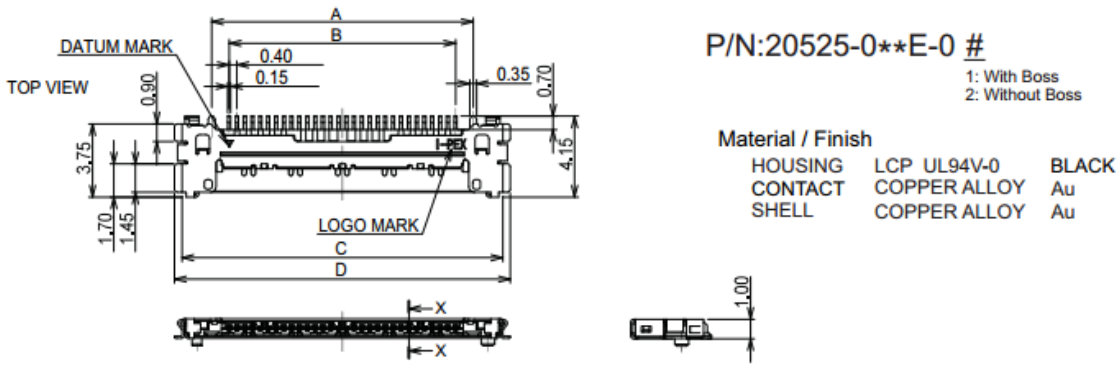

Figure 9-1. I-PEX 30-pin Connector

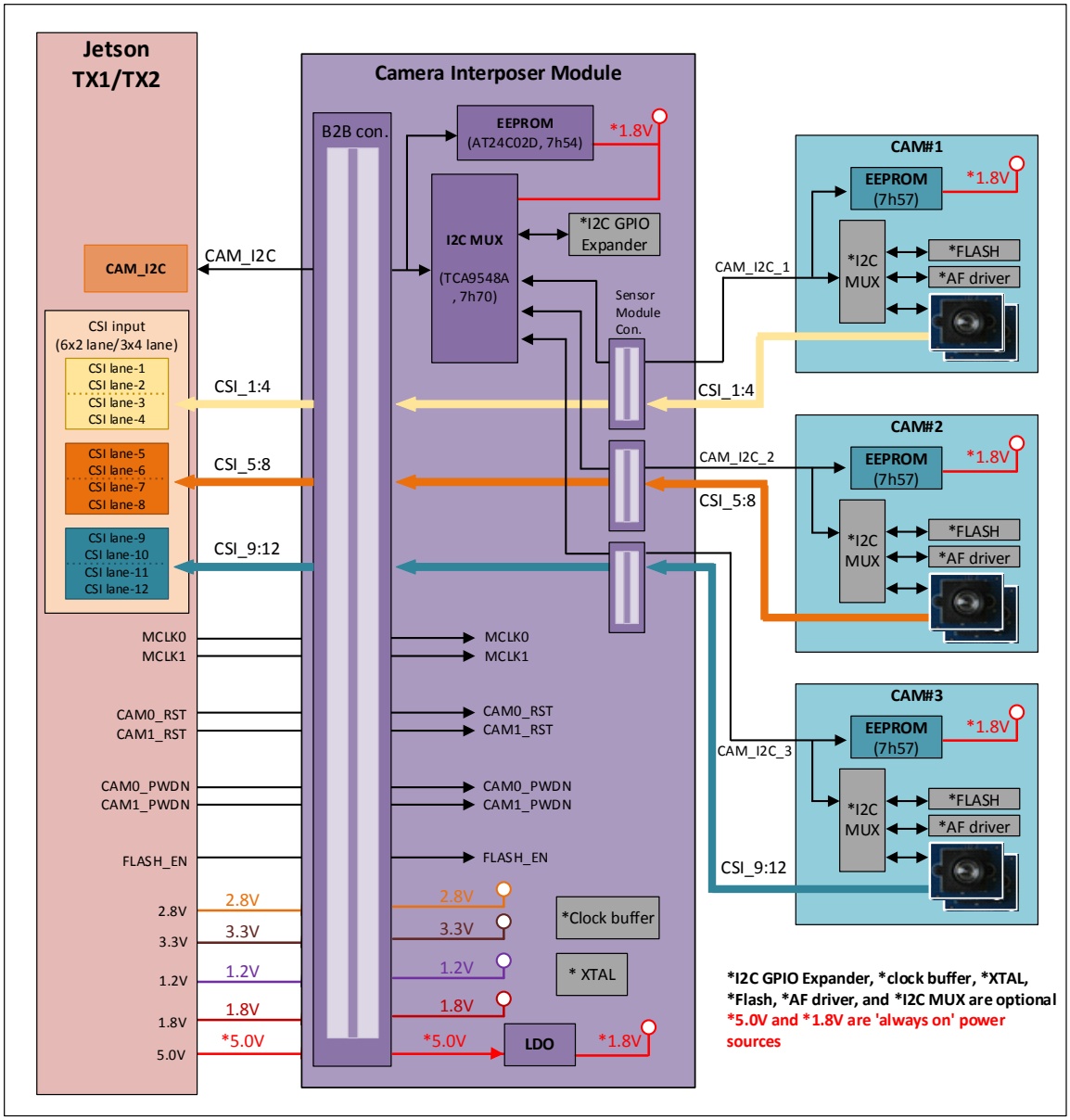

Figure 9-2. Example Block Diagram

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