Intel® RealSense™ Product Family D457

Datasheet

Intel® RealSense™ Vision Processor D4 Board V5,
Intel® RealSense™ Depth Camera D457

Revision 005

October 2024

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Revision History

Revision Number	Description	Revision Date
001	Initial release	Sep 2022
002	• Figure 9-3: Change torque value in mechanical drawings • Table 11-1: Update coating recommendations	Jan 2023
003	Update 8.2.11	Sep 2023
004	• Table 3-16: Update Min/Max power • Tables 4-8, 4-9: Update start point	Mar 2024
005	• Regulatory Compliance update: EU contact	October 2024

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1   *Description and Features*

Description

Intel® RealSense™ Depth Camera D457 is an IP65-rated, GMSL 2/FAKRA camera comprised of the D450 optical module with a newly developed GMSL 2/FAKRA Vision Processor D4 board (V5).

It supports the same specification including resolutions, FOV, FPS and configurations as the D455, but over GMSL 2/FAKRA instead of USB.

The small size and ease of integration of the camera sub system provides system integrators flexibility to design into a wide range of products.

The Intel® RealSense™ D400 series also offers complete depth cameras integrating vision processor, stereo depth module, RGB sensor with color image signal processing and Inertial Measurement Unit (IMU). The depth cameras are designed for easy setup and portability making them ideal for makers, educators, hardware prototypes and software development.

The Intel® RealSense™ Camera D457 is supported with the cross-platform and open source Intel® RealSense™ SDK 2.0. In addition, it requires kernel drivers supporting the GMSL MAXIM serializer.

The Intel® RealSense™ Camera D457 is supported with the cross-platform and open source Intel® RealSense™ SDK 2.0. In addition, there is a separate kernel driver package supporting the GMSL MAXIM serializer.

Minimum System Requirement

- GMSL FAKRA de-serializer on the Host

Usages/Markets

- Autonomous mobile robots (AMR)
- Automated Guided Vehicles (AGV)
- Drones
- Collision Avoidance

Features

- Intel® RealSense™ Vision Processor D4
- Up to 1280x720 stereo depth resolution
- Up to 1280x800 RGB resolution
- Diagonal Field of View over 90°
- Dual global shutter sensors for up to 90 FPS depth streaming
- RGB global shutter sensor for up to 60 FPS
- Range 0.4m to over 10m (Varies with lighting conditions)
- Intel® RealSense™ Depth Camera D457 includes Inertial Measurement Unit (IMU) for 6 degrees of freedom (6DoF) data
- GMSL/ FAKRA interface
- IP65 rating

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2   *Introduction*

2.1   Purpose and Scope of this Document

This document captures the specifications and the design–in details for the Intel® RealSense™ Camera D457. This document provides information necessary to understand and implement an Intel® RealSense™ Camera D457 system.

The D457 camera is based on the existing Intel® RealSense™ products: Intel® RealSense™ Vision Processor D4 and Intel® RealSense™ Depth Module D450. Please refer to https://dev.intelrealsense.com/docs/intel-realsense-d400-series-product-family-datasheet for the datasheet describing these components.

2.2   Terminology

Term	Description
6DOF	Six degrees of freedom (6DoF) refers to the freedom of movement of a rigid body in three-dimensional space. Forward/back, up/down, left/right, pitch, yaw, roll
Stereo Depth Baseline	The distance between the center of the left and right imagers in a stereo camera
MIPI CSI-2	The Camera Serial Interface (CSI) is a specification of the Mobile Industry Processor Interface (MIPI) Alliance and CSI-2 is the 2nd generation specification defining the interface between a camera and a host processor
Depth	Depth video streams are like color video streams except each pixel has a value representing the distance away from the camera instead of color information
D4 (DS5)	If the term D4 is used alone, it refers to the entire D4 camera system consisting of various modules and components. If the term D4 is used with an appropriate qualifier (i.e. D4 Vision Processor, D4 Vision Processor Board), it refers to the specific module or component within the D4 camera system.
FAKRA	Fachkreis Automobil, a German standard. FAKRA connectors are SMB based automotive-grade connectors that can operate up to 6 GHz.
FOV	Field Of View (FOV) describes the angular extent of a given scene that is imaged by a camera. A camera's FOV can be measured horizontally, vertically, or diagonally
GMSL	Gigabit Multimedia Serial Link. GMSL serializer and de-serializer (SerDes) are high-speed communication ICs that fully support the high bandwidth, complex interconnect, and data integrity requirements needed to support evolving automotive infotainment and advanced driver assistance systems (ADAS).

Term	Description
Host System	Computer or SOC connected to D4 camera
I2C	I²C (Inter-Integrated Circuit), pronounced I-squared-C, is a multi-master, multi-slave, single-ended, serial computer bus invented by Philips Semiconductor (now NXP Semiconductors). It is typically used to allow easy control and data communication between components.
IR Projector	This refers to the source of infrared (IR) light used for illuminating a scene, object, or person to collect depth data.
Imagers	Depth camera system uses a pair of cameras referred as imagers to calculate depth. They are identical cameras configured with identical settings.
Image Signal Processor (ISP)	Image processing functions to enhance color image quality
Left imager	From the perspective of the stereo camera looking out at the world, the left imager is on the left side of the camera module. Thus, when the user is facing the D4 camera, the left imager is actually on the right side of the camera module.
Lens	This refers to the optical component of an imager in the D4 camera. Its purpose is to focus the incoming light rays onto the CMOS chip in the imager.
MIPI	MIPI (Mobile Industry Processor Interface) is a global, open membership organization that develops interface specifications for the mobile ecosystem
Platform camera	This refers to the two-dimensional (2D) color camera on platform
System On Chip (SoC)	Integrated circuit (IC) that integrates all components of a computer
Stereo Depth Module	This refers to a stiffened module containing at least two imagers. The distance between the imagers, which is referred to as the baseline or intraocular spacing, is typically in the range of 20 mm to 70 mm.
Stereo camera	This refers to a pair of imagers looking at the same subject from slightly different perspectives. The difference in the perspectives is used to generate a depth map by calculating a numeric value for the distance from the imagers to every point in the scene.
SKU	Stock Keeping Unit (SKU) is a unique identifier for distinct products. It is often used in the scope of naming different versions of a device
TBD	To Be Determined. In the context of this document, information will be available in a later revision.

2.3 Intel® RealSense™ Depth Camera D457 Product Components

The table below describes the main components in the D457 camera

Table 2-1. Depth Module Product SKU Descriptions

Component	Subcomponent
Intel® RealSense™ Vision Processor D4	-
Intel® RealSense™ Vision Processor D4 Board V5	Maxim serializer
Intel® RealSense™ Depth Module D450	Wide Stereo Imagers
	Wide Infrared Projector
	RGB color sensor

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3 Component Specification

3.1 Vision Processor D4 Camera System Components

Table 3-1. Component Descriptions

Component	Description
Host Processor	Host Processor that receives Depth and other data streams from Vision Processor D4
Vision Processor D4 (DS5 ASIC)	Depth Imaging Processor with USB 2.0/USB 3.1 Gen 1 or MIPI interface connection to Host Processor
Clock	24MHz clock source for Vision Processor D4
Serial Flash Memory	SPI 16Mb Serial Flash memory for firmware storage
Stereo Depth Module	Camera module with left and Right Imager, Color Sensor, IR projector enclosed in a stiffener
Power Delivery	Circuitry on motherboard/Vision processor D4 Board to deliver and manage power to Vision Processor D4 and Stereo Depth Module.
Stereo Depth Connector and Interposer	50 pin connector on motherboard/Vision Processor D4 Board and Stereo Depth module with interposer for connection

3.2 Host Processor

The host processor interface to Vision Processor D4 is FAKRA/GMSL. It also supports USB 2.0/USB 3.1 for debug purposes only.

3.3 Intel® RealSense™ Vision Processor D4

The primary function of Vision Processor D4 is to perform depth stereo vision processing. The Vision Processor D4 on Host Processor motherboard or on Vision Processor D4 Board communicates to the host processor through USB2.0/USB 3.1 Gen 1 or MIPI and receives sensor data from stereo depth module. The Vision Processor D4 supports MIPI CSI-2 channels for connection to image sensors.

Please refer to https://dev.intelrealsense.com/docs/intel-realsense-d400-series-product-family-datasheet for the datasheet describing the D4 Vision Processor.

3.4   Clock

Vision Processor D4 requires a single 24 MHz clock oscillator. All clocks required by stereo depth module are generated by Vision Processor D4.

3.5   Serial (SPI) Flash Memory

Vision Processor D4 requires 16Mbit Serial Flash Memory for its firmware storage. The recommended part number is IS25WP016 (www.issi.com) or equivalent

3.6   Stereo Depth Module
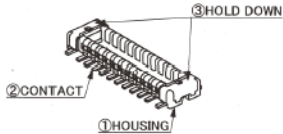
The D457 camera includes the Intel® RealSense™ Depth Module D450, which is also used in the D455 camera.

Please refer to https://dev.intelrealsense.com/docs/intel-realsense-d400-series-product-family-datasheet for the datasheet describing the D450 Depth Module.

3.6.1   Depth Module Connector

The depth module connector provides signal and power interface to the stereo depth module. The connector on stereo depth module is a 50-pin connector plug.

Table 3-2. Depth Module 50-pin Connector Plug Details

Parameter	Description	Diagram
Number of Contacts	50	
Product Name	NOVASTACK 35-P Plug Assembly	
Part Number	20708-050E	
Manufacturer Website	www.i-pex.com	

3.6.2   Stereo Depth Module Label

Table 3-3. Stereo Depth Module Product Labeling
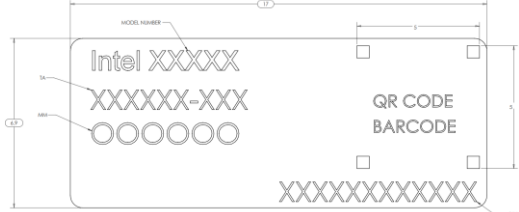
For illustration purpose only, subject to change

	Dimension	Value	Unit
A	Label Width	14	mm
B	Label Height	6	mm
C	Scan Code Width	5	mm
D	Scan Code Height	5	mm

Scan Code Format
XXXXXXXXXXXXOOOOOOXXXXXX-XXX

Table 3-4. Stereo Depth Module Label Fields

Group	Field	Description	Type
Company	Intel	Manufacturer	Static
Model Number	RealSense™ Camera 4XX	Camera Model Number	Static
Product Assembly Number	XXXXXX	Product Identifier Code	Static
	-XXX	Manufacture Configuration Code	Dynamic
	OOOOOO	Product Material Code	Static
Serial Number	XXXXXXXXXXXX	Manufacture Unit Code	Dynamic
Note: Product Material Code (MM code) within the QR code on the label of the device will read "000000". The QR code MM code will be zero.			

Table 3-5. Intel® RealSense™ Depth Module D400 Series Product Identifier Code and Product Material Code

Production	Product Identifier Code-Manufacture Configuration Code	Product Material Code
Depth Module D450	K83121-100	999WCM

3.7   Intel® RealSense™ Vision Processor D4 Board V5

The Vision Processor D4 Board enables an easy and quick option for system integrators to integrate Vision Processor D4 into a system.

Table 3-6. Vision Processor D4 Board

Type	Description
USB Peripheral Type-C	Connects to Host USB 3.1 Gen 1 port through USB Type-C connector and cable. Only one side of the Type-C can be connected. **Note**: When connecting to host system, connect Type-C connection to the camera prior to connecting device to host system port. **Note**: USB is for Debug and production line purposes
FAKRA	Connects to Host FAKRA connector.

Table 3-7. Vision Processor D4 Board Components

Components	Description
Vision Processor D4	Stereo Depth Processing ASIC
16Mb Serial Flash	Vision Processor D4 firmware storage
24MHz Crystal	Clock source for Vision Processor D4
Realtek* ISP with external serial flash	Color image signal processor
Depth Module Receptacle	50 pin receptacle for connection to Stereo Depth Module
USB Type-C	USB peripheral connector for connection to Host USB 2.0/USB 3.1 Gen 1 port
GMSL Serializer and FAKRA Connector	FAKRA connector for connection to GMSL De-Serializer at Host
External Sensor Sync Connector	Interface to external sensor interrupts/sync signals
Voltage Regulators	DC to DC converters powering Vision Processor D4 Board and stereo depth module.
Mounting holes	Vision Processor D4 Board secure mounting

Figure 3-1. Vision Processor D4 Board

USB Peripheral Type-C connector and GMSL connection to FAKRA connector
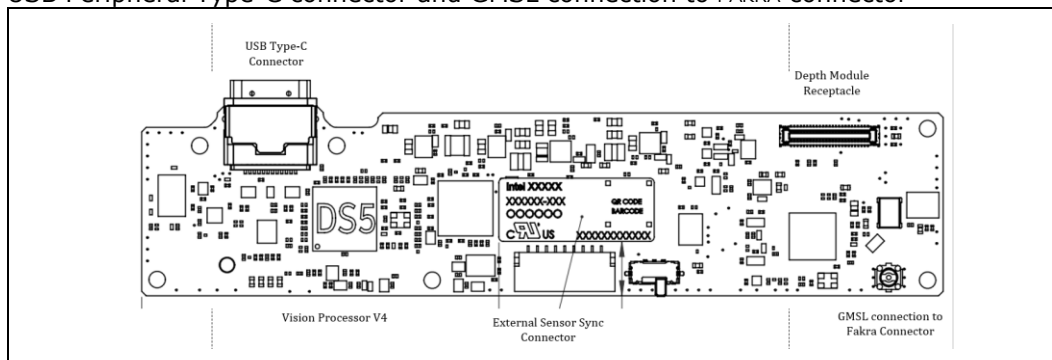
3.7.1   Mechanical Dimensions
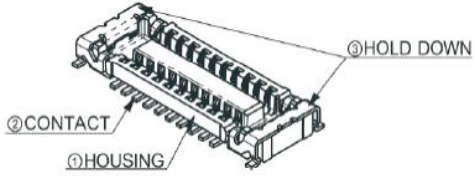
Table 3-8. Vision Processor D4 Board V5 Mechanical Dimensions

Dimension	Min	Nominal	Max	Unit
Width	87.5	87.7	87.9	mm
Height	20.7	20.97	21.2	mm
Depth	3.74	3.94	4.14	mm
Weight				gr

3.7.2   Depth Module Receptacle

The Vision Processor D4 Board interface to stereo depth module is through 50 pin receptacle on the board.

Table 3-9. Depth Module Receptacle Details

Parameter	Description	Diagram
Number of Contacts	50	
Product Name	NOVASTACK* 35-P Receptacle Assembly	
Part Number	20709-050E	
Manufacturer Website	www.i-pex.com	

3.7.3   Flex and Rigid Interposer Interconnect

The high-speed interposer at one end has the 50 pin depth module receptacle to connect into 50 pin depth module plug on stereo depth module and at the other end has the 50 pin depth module plug to connect into 50 pin depth module receptacle on Vision Processor D4 Board. The high-speed flex Interposer is custom developed and procured by system integrator.

Figure 3-2. Flex Interposer (Illustration)
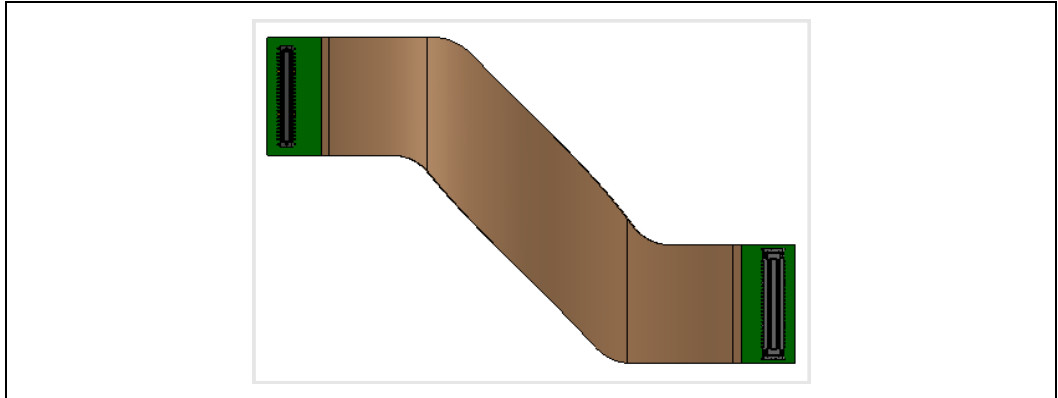
Figure 3-3. Rigid Interposer (Illustration)
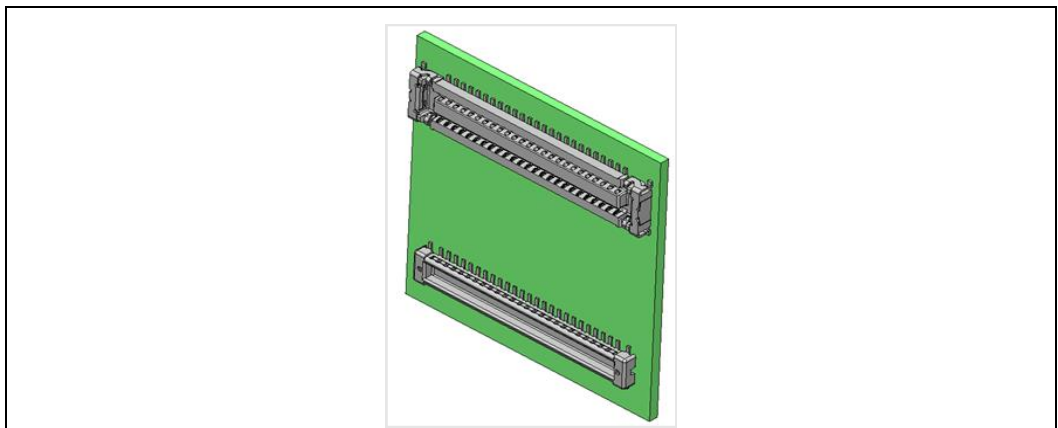
Figure 3-4. Depth Module Receptacle and Plug Connector Pin Position

		52 (VDD 3.3V)		
GND	2	1	RGB_RSTN	
RGB_MDP0	4	3	RGB_XCL	
RGB_MDN0	6	5	GND	
GND	8	7	RGB_FSYNC	
RGB_MCP	10	9	RGB_STROBE	
RGB_MCN	12	11	RGB_SDA	
GND	14	13	RGB_SCL	
MDP0_L	16	15	GND	
MDN0_L	18	17	VDD18V	
GND	20	19	VDD18V	
MCP_L	22	21	LED_PSY	
MCN_L	24	23	DVSYNC	
GND	26	25	NC	
MDP1_L	28	27	XVCLK_L	
MDN1_L	30	29	GND	
GND	32	31	ST_RST_N	
MDP0_R	34	33	FF_RSTn	
MDN0_R	36	35	GND	
GND	38	37	XVCLK_R	
MCP_R	40	39	I2C_SCL	
MCN_R	42	41	I2C_SDA	
GND	44	43	LASER_PWM	
MDP1_R	46	45	LASER_PWRDN	
MDN1_R	48	47	LASER_PWM1	
GND	50	49	FLAGB	
		51 (GND)		

Table 3-10. Interposer Interconnect Signal Description

Position	ASIC Board/ Motherboard	Depth Module	Interconnect Description
1	RGB_RSTN_N	RGB_RSTN_N	RGB Sensor Reset
2	GND	GND	Ground
3	RGB_XCL	RGB_XCL	RGB Sensor Clock
4	RGB_MDP0	RGB_MDP0	RGB Sensor MIPI Data Lane 0 differential pair positive
5	GND	GND	Ground
6	RGB_MDN0	RGB_MDN0	RGB Sensor MIPI Data Lane 0 differential pair negative

Position	ASIC Board/ Motherboard	Depth Module	Interconnect Description
7	RGB_FSYNC	RGB_FSYNC	RGB Sensor Sync
8	GND	GND	Ground
9	RGB_STROBE	RGB_STROBE	RGB Sensor Strobe
10	RGB_MCP	RGB_MCP	RGB Sensor MIPI Clock differential pair positive
11	RGB_SDA	RGB_SDA	RGB Sensor I2C Bus Data
12	RGB_MCN	RGB_MCN	RGB Sensor MIPI Clock differential pair negative
13	RGB_SCL	RGB_SCL	RGB Sensor I2C Bus Clock
14	GND	GND	Ground
15	GND	GND	Ground
16	MDP0_L	MDP0_L	Left Imager MIPI Data Lane 0 differential pair positive
17	VDD18V	VDD18V	1.8V Power
18	MDN0_L	MDN0_L	Left Imager MIPI Data Lane 0 differential pair negative
19	VDD18V	VDD18V	1.8V Power
20	GND	GND	Ground
21	NC	NC	Not Connected
22	MCP_L	MCP_L	Left Imager MIPI Clock differential pair positive
23	DVSYNC	DVSYNC	VSYNC
24	MCN_L	MCN_L	Left Imager MIPI Clock differential pair negative
25	Strobe	Strobe	Strobe from Left Imager
26	GND	GND	Ground
27	XVCLK_L	XVCLK_L	Clock to Left Imager
28	MDP1_L	MDP1_L	Left Imager MIPI Data Lane 1 differential pair positive
29	GND	GND	Ground
30	MDN1_L	MDN1_L	Left Imager MIPI Data Lane 1 differential pair negative
31	ST_RST_N	ST_RST_N	Reset signal to Left and Right Imager
32	GND	GND	Ground
33	FF_RSTn	FF_RSTn	Enable PWM split
34	MDP0_R	MDP0_R	Right Imager MIPI Data Lane 0 differential pair positive
35	GND	GND	Ground
36	MDN0_R	MDN0_R	Right Imager MIPI Data Lane 0 differential pair negative
37	XVCLK_R	XVCLK_R	Clock to Right Imager
38	GND	GND	Ground

Position	ASIC Board/ Motherboard	Depth Module	Interconnect Description
39	I2C_SCL	I2C_SCL	I2C Bus Clock
40	MCP_R	MCP_R	Right Imager MIPI Clock differential pair positive
41	I2C_SDA	I2C_SDA	I2C Bus Data
42	MCN_R	MCN_R	Right Imager MIPI Clock differential pair negative
43	LASER_PWM	LASER_PWM	IR Projector Control Signal
44	GND	GND	Ground
45	LASER_PWRDN	LASER_PWRDN	IR Projector Power Down
46	MDP1_R	MDP1_R	Right Imager MIPI Data Lane 1 differential pair positive
47	LASER_PWM1	LASER_PWM1	IR Projector Control Signal
48	MDN1_R	MDN1_R	Right Imager MIPI Data Lane 1 differential pair negative
49	FLAGB	FLAGB	IR Projector Fault Detect
50	GND	GND	Ground
51	GND	GND	Ground
52	VDD33V	VDD33V	3.3V power

Figure 3-5. Depth Module Connector Orientation and Pin Position
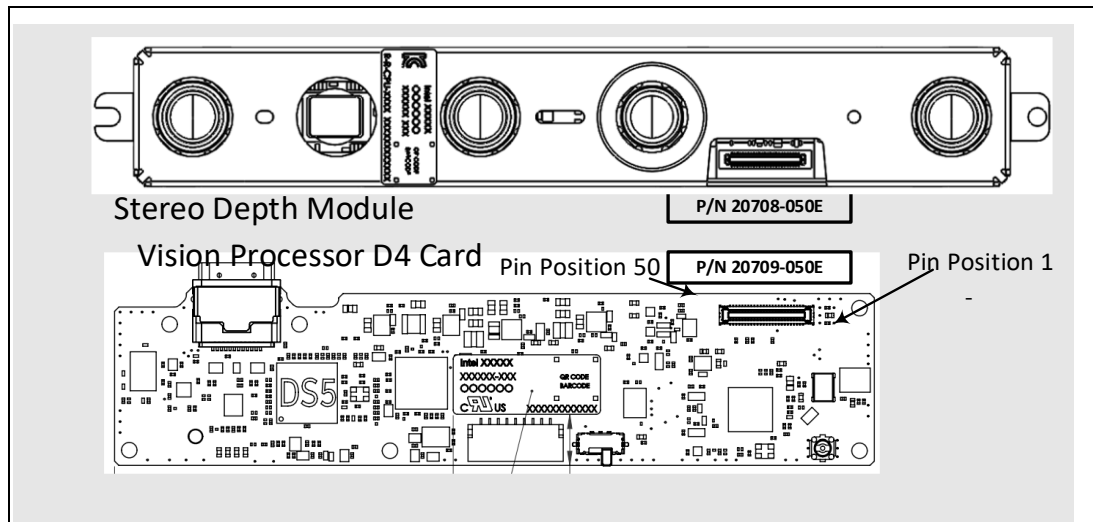
Table 3-11. Custom Flex Interposer Ordering Logistics

Vendor	Sales Contact
COCOM CONSUMER ELECTRONICS LTD.	Janine Langdale email: Janine.Langdale@cc-e.co.uk (O) +44 (0) 1444 461620

	(M) +44 (0) 7905 692131

3.7.4 External Sensor Sync Connector

The external sensor connector provides the interface for external sensors to synchronize to depth output.

Table 3-12. External Sensor Connector Details
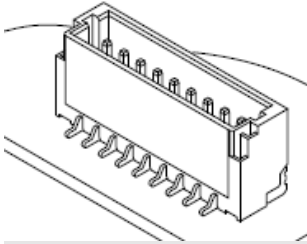
Parameter	Description	Diagram
Number of Contacts	9	
Product Name	9 Positions Header, Shrouded Connector	
Part Number	SM09B-SRSS-TB(LF)(SN)	
Manufacturer Website	www.jst-mfg.com	

Table 3-13. External Sensor Sync Connector Pin List

Pin	Signal	Function	Description
1	DFU_N	DFU_N	Insert Asic in DFU Mode
2	GPIO4	GPIO4	GPIO
3	DSTROBE	DSTROBE	Dstrobe signal from Left imager – output signal to External sync connector
4	GPIO6	GPIO6	GPIO - output signal to External sync connector
5	Z_VSYNC	VSYNC	Depth VSYNC
6	LASER_PWM0	LASER PWM0	Laser control signal- output signal to External sync connector
7	LASER_PWM1	LASER PWM1	Laser control signal- output signal to External sync connector
8	VDD33V	Power	3.3V
9	GND	Ground	Ground

3.7.5 USB Peripheral Connector – Type-C

The USB Type-C connector in the D457 camera is targeted for production and debug purposes only.

Recommend using a certified USB Type-C cable and connector for use with Intel® RealSense™ Camera D400 Series products. Please refer to

https://www.intelrealsense.com/usb-interoperability-testing-for-intel-realsense-cameras for further details.

Figure 3-6. USB Type-C Receptacle Pin Map

Table 3-14. USB Peripheral Connector Pin List

Pin	Signal	Function	Description
A1	GND	Power Delivery	Ground
A2	TX1+	USB 3.1 Gen 1 Data	First SuperSpeed TX Differential Pair Positive
A3	TX1-	USB 3.1 Gen 1 Data	First SuperSpeed TX Differential Pair Negative
A4	VBUS	Power Delivery	5V
A5	CC1	Control	Configuration Channel 1
A6	D+	USB2.0 Data	USB 2.0 differential pair positive
A7	D-	USB2.0 Data	USB 2.0 differential pair negative
A8	SBU1	Sideband	Sideband Use Signal 1
A9	VBUS	Power Delivery	5V
A10	RX2-	USB 3.1 Gen 1 Data	Second SuperSpeed RX Differential Pair Negative
A11	RX2+	USB 3.1 Gen 1 Data	Second SuperSpeed RX Differential Pair Positive
A12	GND	Power Delivery	Ground
B1	GND	Power Delivery	Ground
B2	TX2+	USB 3.1 Gen 1 Data	Second SuperSpeed TX Differential Pair Positive
B3	TX2-	USB 3.1 Gen 1 Data	Second SuperSpeed TX Differential Pair Negative
B4	VBUS	Power Delivery	5V
B5	CC2	Control	Configuration Channel 2
B6	D+	USB 2.0 Data	USB 2.0 differential pair positive
B7	D-	USB 2.0 Data	USB 2.0 differential pair negative
B8	SBU2	Sideband	Sideband Use Signal 2
B9	VBUS	Power Delivery	5V
B10	RX1-	USB 3.1 Gen 1.0 Data	First SuperSpeed RX Differential Pair Negative
B11	RX1+	USB 3.1 Gen 1.0 Data	First SuperSpeed RX Differential Pair Positive
B12	GND	Power Delivery	Ground

3.7.6 Color Image Signal Processor (ISP)

The color sensor data is sent to discrete Image Signal Processor (ISP) on the Vision processor D4 Board for image adjustments, image scaling and processing functions to help compensate for inherent inaccuracy in lens and sensor in providing a better image quality. The processed color image is sent to the Vision Processor D4.

Table 3-15. ISP Properties

Parameter	ISP Properties
ISP Part Number on Vision Processor D4 Board	RTS5845
1M-bit Serial Flash for ISP	Winbond* W25X10CL or equivalent
Interface To Vision Processor D4	MIPI CSI-2, 2X Lanes
Interface To RGB Sensor	MIPI CSI-2, 1X Lane

3.7.7 Vision Processor D4 Board Power Requirements

The Vision Processor D4 Board is powered through VBUS power of the USB connector. The Vision Processor D4 Board in turn power sources the stereo depth module.

Table 3-16. Vision Processor D4 Board Power Requirements

	Parameter	IF	Min	Nom	Max	Unit
VCC	Supply Voltage	FAKRA	10.8	12	13.2	V
ICC	Supply Current	FAKRA		300		mA
VCC	Supply Voltage	USB[*]	4.75	5	5.25	V
ICC	Supply Current	USB[*]			700	mA
	Supply Voltage Ramp Rate	USB[*]	0.5		5	Ms

(*) USB is only used for debug and production line

3.7.8 FAKRA connector /GMSL

FAKRA (Fachkreis Automobil, a German standard) connector is a modified SMB connector with a keyed and color-coded plastic housing and latch, used in the automotive industry [*]. They are available in 14 different mechanical layouts which are color coded for easy identification and mis-matching prevention.

D457 has a C-Coding (blue) connector.

[*] Ref - https://www.everythingrf.com/search/connectors/filters?page=1&country=global&sconnector_type=;FAKRA

Gigabit Multimedia Serial Link (GMSL) is a communication link for video applications in the automotive industry. GMSL is based on SerDes technology meaning using a serializer on the transmitter side and a de-serializer on the receiver side.

3.7.9   Vision Processor D4 Board Thermals

The Vision Processor D4 Board should be screw mounted on to a heat sink or a heat dissipating structure element using screw forks on Board. Thermal conductive tape (electrically non-conductive) should cover the entire back side area (non-component side) of the ASIC Board for thermal transfer onto heat sink or heat dissipating structure element.

3.7.10   Vision Processor D4 Board Storage and Powered Conditions

Table 3-17. Vision Processor D4 Board Storage and Powered Conditions

Condition	Description	Min	Max	Unit
Storage (Ambient), Not Powered	Temperature (Sustained, Controlled)[1]	0	50	ºC
	Temperature (Short Exposure)[2]	-40	70	ºC
	Humidity	Temperature/ RH: 40ºC / 90%		
Case Temperature, Powered [3][4][5]	Temperature	0	50	ºC

NOTE:
(1) Controlled conditions should be used for long term storage of product.
(2) Short exposure represents temporary max limits acceptable for transportation conditions.
(3) Case temperature limits must be met for all temperatures when powered.
(4) Case temperature is specified for the overall Vision Processor D4 Board
(5) Case temperature 0° minimum and lower temperatures is non-condensing

3.7.11   Intel® RealSense™ Vision Processor D4 Board Product Identifier and Material Code

Table 3-18. Vision Processor D4 Board Product Identifier and Material Code

Production	Product Code	Product Identifier Code-Manufacture Configuration Code	Product Material Code	IMU Component
Vision Processor D4 Board V5	82635DSD457ASIC	M78252-110	99C2M4	BMI085

3.8   Intel® RealSense™ Depth Camera D457

Figure 3-7. Intel® RealSense™ Depth Camera D457

Table 3-19. Depth Camera D457 properties

Property	Value
Depth module	Intel® RealSense™ Depth module D450
Baseline	95mm
Left/Right Imagers Type	Wide
Depth FOV HD (16:9) (degrees)	H:87 / V:58 / D:95
Depth FOV VGA (4:3) (degrees)	H:75 / V:62 / D:89
IR Projector	Wide

Property	Value
IR Projector FOV	H:90 / V:63 / D:99
Color Sensor	OV9782
Color Camera FOV	H:90 /V:65 /D:98
IMU	6DoF

NOTE:

- H – Horizontal FOV, V – Vertical FOV, D – Diagonal FOV, X – Length, Y – Breadth, Z – Thickness
- Depth FOV specified at 4 meters
- Due to mechanical tolerances of +/-5%, Max and Min FOV values can vary from lens to lens and module to module by ~ +/- 3 degrees.

3.8.1 Depth Camera D457 Mechanical Dimensions

Table 3-20. Intel® RealSense™ Depth Camera D457 Mechanical Dimensions

Dimension	Min	Nominal	Max	Unit
Width	123.5	124	124.5	mm
Height	28.5	29	29.5	mm
Depth	35.5	36	36.5	mm
Approximated Weight		145		gr
Flatness Tolerance of Back Mounting Surface	0	-	0.1	mm

3.8.2 Depth Camera D457 Thermals

3.8.2.1 Depth Camera D457 Storage and Powered Conditions

Table 3-21. Depth Camera D457 Storage and Powered Conditions

Condition	Description	Min	Max	Unit
Storage (Ambient), Not Powered[5]	Temperature (Sustained, Controlled)[1]	0	50	ºC
	Temperature (Short Exposure)[2]	-40	70	ºC
	Humidity	Temperature/ RH: 40ºC / 90%		
Ambient, Powered[3][4][5]	Temperature, Performance	0	35	ºC

Backside Case Temperature, Powered	Temperature, Performance	0	50	°C

NOTE:

(1) Controlled conditions should be used for long term storage of product

(2) Short exposure represents temporary max limits acceptable for transportation conditions

(3) The camera ambient temperature when powered, 0°C to 35°C is the validated range in which Intel® qualified the camera. This is a standard range in which Intel® qualifies consumer products. The camera's internal thermal solution was designed to keep the internal components at or below their max powered temperatures. As stated in "Stereo Depth Module Components" table 3-25 in D400 Datasheet, the projector temperature and the projector's operation below 60°C is critical to the use of the projector for camera operations (use of projector can be determined by application developer based on necessity in usage model).

(4) Ambient means environment while the camera is attached to a tripod using the camera's tripod screw attachment and is not connected to any mechanical or thermal material

(5) Although all Key Performance Indicators (KPIs) are verified before leaving Intel's factory, KPIs may be negatively impacted by extended exposure to excessive temperatures and humidity

3.8.2.2 Depth Camera D400 Series Thermal Solution Guidance

The Intel® RealSense™ Depth Camera D400 Series camera thermal solution was designed taking into account the necessary thermal and mechanical aspects that goes into producing a standalone peripheral camera. Those aspects include the temperatures for all of the components associated with the module (projector, vision processor, IMU and camera sensors) when powered.

The Intel® RealSense™ SDK 2.0 (https://github.com/IntelRealSense/librealsense) provides temperature sensor readout based on Intel® RealSense™ camera capabilities. The readouts should be used as a reference/guide, but not to be used as a replacement for thermal solutions that comply with the temperatures of the camera. If monitoring the temperature of the cameras is necessary due to thermal concern, it is recommended to monitor librealsense temperature readouts from the application level and act upon the temperatures if within < 5 °C of the max temperatures when powered of the component temperatures that the SDK makes available.

In order to aid in development of thermal solution and heat dissipation, the recommendations below provide some guidance to system integrators.

Recommendations to improve heat dissipation on the D400 Series Depth Cameras

Passive Cooling Recommendations:

- Mounting Bracket Material – Utilize mounting screws (2xM4 screws) and material that is the same or similar in nature (equal or lower thermal resistance or high conductivity) as the peripheral housing that the D400 Series depth cameras are made out of. Material – Aluminum 6000 series.

- Increased Mating Surface – Mounting bracket mating surface with D400 series depth camera can be increased by a factor of 2x. The larger the mounting bracket mating surface to the depth camera the better.

- o Reduction of mating surface imperfections, defects, roughness and gaps is recommended. Any increase in defects in the material can increase the thermal contact resistance reducing effectiveness of heat dissipation of the thermal solution. Attachment options should comprise of epoxy compounds or thermal tape/paste.

- Heat Sink – The addition of a heat sink can also improve heat dissipation from the D400 series depth camera. Use of a material such as Aluminum 6000 series or similar with equal or lower thermal resistance to the mating surface is recommended.

Active Cooling Recommendations:

While heat pipes and liquid cooling solutions offer great advantages, they also increase the complexity of system integration substantially. The use of a fan with direct air flow to the depth camera (back mounting surface 2xM4 screws) is preferable.

3.8.3   Depth Camera D457 Product Identifier and Material Code

Table 3-22. Depth Camera D457 Product Identifier and Material Code

Production	Product Code	Product Identifier Code–Manufacture Configuration Code	Product Material Code
Depth Camera D457	82635DSD457	M63295-110	99AVPN
Depth Camera D457 (Multi Pack)	82635DSD457MP	M63295-110	99AVPP

3.8.4   Camera Lens Cleaning Procedure

1. Do not use any chemical or water on the camera lens
2. Remove dust and dirt as much as possible from the lens with a lens blower brush.
3. Wipe with a dry, clean micro-fiber cloth.

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4 *Functional Specification*

4.1 Vendor Identification (VID) and Device Identification (DID)

Table 4-1. Vendor ID and Device ID Table

Depth Module/Depth Camera	Vendor ID	Device ID
Intel® RealSense™ Depth Module D450	8086	0x0B5C
Intel® RealSense™ Depth Camera D457	8086	0x0B5C

4.2 Vision Processor D4 Data Streams

Intel® RealSense™ Vision Processor D4 Depth imaging system provides high quality depth data to a host system. The depth data is generated with stereo vision technology that is optionally assisted by an infrared projector. The imaging system has the ability to syncronize with color stream.

Table 4-2. Image Formats (FAKRA/GMSL)

Format	Resolution	Frame Rate (FPS)	Comment
Z [16 bits]	1280x720	5,15,30	Depth
	848X480	5,15,30,60,90	
	640x480	5,15,30,60,90	
	640x360	5,15,30,60,90	
	480x270	5,15,30,60,90	
	424x240	5,15,30,60,90	
Y8 [8 bits]	1280x720	5,15,30	Luminance Left and Right Imager
	848X480	5,15,30,60,90	
	640x480	5,15,30,60,90	
	640x360	5,15,30,60,90	
	480x270	5,15,30,60,90	
	424x240	5,15,30,60,90	
YUV422 [16 bits]	1280x800	5,15,30	Color Stream from RGB camera
	848x480	5,15,30,60	
	640x480	5,15,30,60	
	640x360	5,15,30,60	

Format	Resolution	Frame Rate (FPS)	Comment
	480x270	5,15,30,60	
	424x240	5,15,30,60	
Calibration IR Imager Y12I [24 bits]	1280x800	15,25	
Intel® RealSense™ Self-Calibration	256x144	90	Intel® RealSense™ Self-Calibration and Tare format

NOTE:

1. Depth and Color are mapped as separated interfaces. Each one of the interfaces is working independent with the other interface (Virtual channel in MIPI and End Point in USB).

Table 4-3. Simultaneous Image Streams (GMSL/FAKRA)

Depth	RGB	Imager Left	Imager Left & Right	IMU
Z16	YUV422	Y8		Gyro & Accelerometer
	YUV422			Gyro & Accelerometer
Z16	YUV422		Y8i	Gyro & Accelerometer

NOTEs:

1. RGB to depth hardware internal sync is only supported with the same frame rate for all streams.
2. For Depth and RGB camera simultaneous streaming, it is recommended to have color resolution the same or higher than depth resolution.
3. Streaming of Depth, IR left and IR right concurrently is only supported for calibration in a dedicated format with rectified IR (24 bit), as seen in the section 4.2

4.3 Depth Field of View (FOV)

The depth field of view is the common overlap of the individual left and right Imager field of view for which Vision Processor D4 provides depth data

The FOV changes according to the resolution and aspect ratio. HD is at 16:9, while VGA is at 4:3. Check "*Table 3-19. Depth Camera D457* properties" for the FOV values.

4.4   Depth Field of View at Distance (Z)

Depth Field of View (Depth FOV) at any distance (Z) can be calculated using the equation

$$Depth\ FOV = \frac{HFOV}{2} + \tan^{-1}\{\tan\left(\frac{HFOV}{2}\right) - B/Z\}$$

Depth FOV = Depth Field of View

HFOV = Horizontal Field of View of Left Imager on Depth Module

B = Baseline

Z = Distance of Scene from Depth Module

Figure 4-1. Depth Field of View to Depth Map illustration
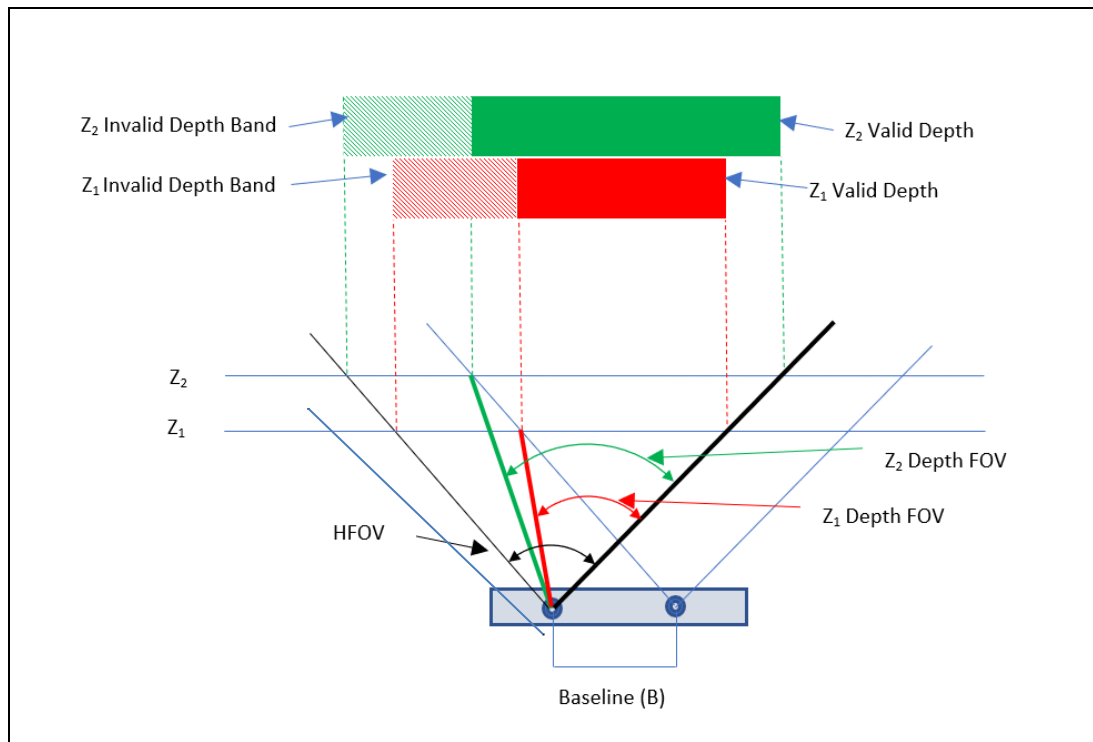
NOTES:

- As the scene distance from the depth module increases, the invalid depth band decreases in the overall depth image. Overall depth image is invalid depth band plus valid depth map.

4.5 Invalid Depth Band

The depth data generated with stereo vision uses the left imager as the reference for stereo matching resulting in a non-overlap region in the field of view of left and right imagers where we will not have depth data at the left edge of the frame. Closer scenes result in a wider invalid depth band than scenes at larger distances.

Figure 4-2. Left Invalid Depth Band
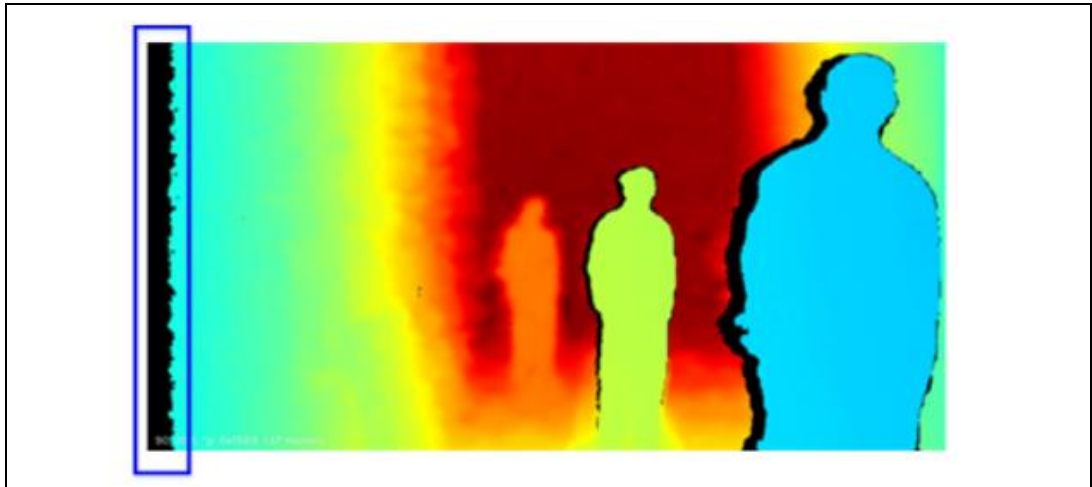
The width of the invalid depth band can be calculated using the following equations:

In terms of horizontal FOV

$$DBR\ (Ratio\ of\ Invalid\ Depth\ Band\ to\ Total\ Horizontal\ Image) = B/(2*Z*\tan(\frac{HFOV}{2}))$$

$$Invalid\ Depth\ Band\ (in\ Pixels) = HRES * DBR$$

In terms of focal length

$$DBR\ (Ratio\ of\ Invalid\ Depth\ Band\ to\ Total\ Horizontal\ Image) = B*F/(Z*HRES)$$

$$Invalid\ Depth\ Band\ (in\ Pixels) = B*F/Z$$

B= Baseline

Z= Distance of Scene from Depth Module

F= Focal length

HFOV= Horizontal Field of View of Left Imager on Depth Module

HRES= Horizontal Resolution

The equations stand valid for a base configuration of camera settings. Default camera configuration in firmware may have settings optimized for depth performance that may impact the actual width of invalid depth band when compared to the calculated width of the invalid depth band from equations.

4.6   Minimum-Z Depth

The Minimum-Z Depth is the minimum distance from depth camera to scene for which Vision Processor D4 provides depth data.

Table 4-4. Minimum-Z Depth

Resolution	D450 Min-Z (mm)
1280x720	520
848X480	350
640x480	320
640x360	260
480x270	200
424x240	180

4.7   Depth Quality Specification

There are a set of standard metrics based on accuracy, data validity, and temporal stability are used to quantify depth quality.

Although the module is designed for a certain depth FOV, the measurements are taken within 80% of this FOV, defined as region of interest (ROI). This ROI will best align with intended usage area and the optical parameters qualification field.

Table 4-5: Depth Quality Metric

METRIC	DEFINITION[1]
Depth Accuracy	Measure the difference for valid pixels relative to a ground truth surface.
Fill Rate	Percentage of pixels that have a valid depth value.
Depth Standard Deviation	Measures the total spatial noise for each valid pixel relative to a best fit plane.
Pixel Temporal Noise	Measures the total temporal noise for each valid pixel relative to a best fit plane.

NOTES:
 (1) Each measurement is taken from a predefined region of interest (ROI) which is within 80% of the depth field of view (FOV).

Table 4-6: Depth Quality Metric Illustration

DEPTH ACCURACY AND DEPTH RMS ERROR	FILL RATE
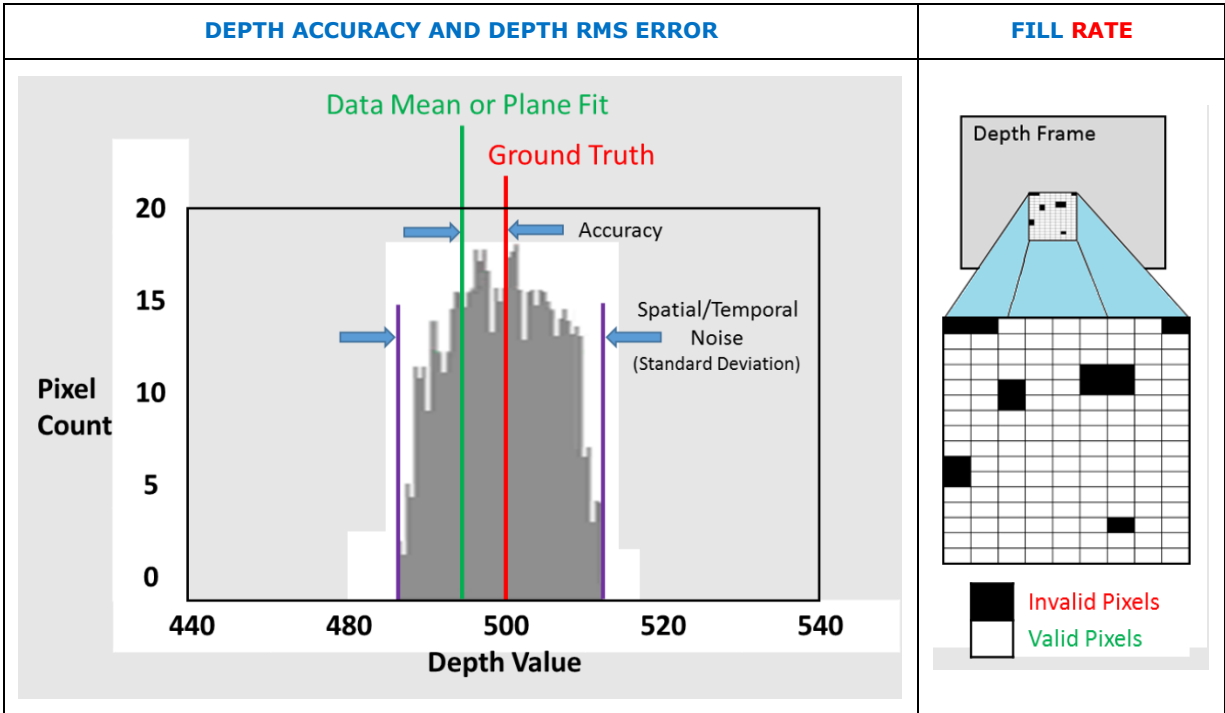
Table 4-7. Depth Quality Specification

Metric	D450/D457 (up to 4 Meters and 80% ROI, HD Resolution)
Z-accuracy (or absolute error)	± 2%
Fill rate	≥ 99%
RMS Error (or Spatial Noise)	≤ 2%
Temporal Noise	≤ 1%
Lifetime	5 years

NOTES:

1) Our Key Performance Indicators (KPIs) are validated at the factory and reflect typical conditions.

2) Over lifetime, our KPIs could be impacted by environmental factors.

3) Please follow the best-known methods to get optimal camera performance over lifetime. Refer to white paper "Intel® RealSense™ Stereo Camera Best Known Methods to Get Optimal Camera Performance over Lifetime" - https://www.intelrealsense.com/best-known-methods-for-optimal-camera-performance-over-lifetime

4) For Depth Quality metric definitions and test methodology, refer to white paper "Intel® RealSense™ Camera Depth Testing Methodology"

5) Laser Power: 150mW, Exposure: Auto Exposure

6) Lifetime: operating in default settings within the supported temperature for up to 16 hours a day [66%]

4.8   Depth Start Point (Ground Zero Reference)

The depth start point or the ground zero reference can be described as the starting point or plane where depth = 0. For depth camera D457, this point is referenced from front of camera cover glass

Figure 4-3. Depth Module Depth Start Point Reference
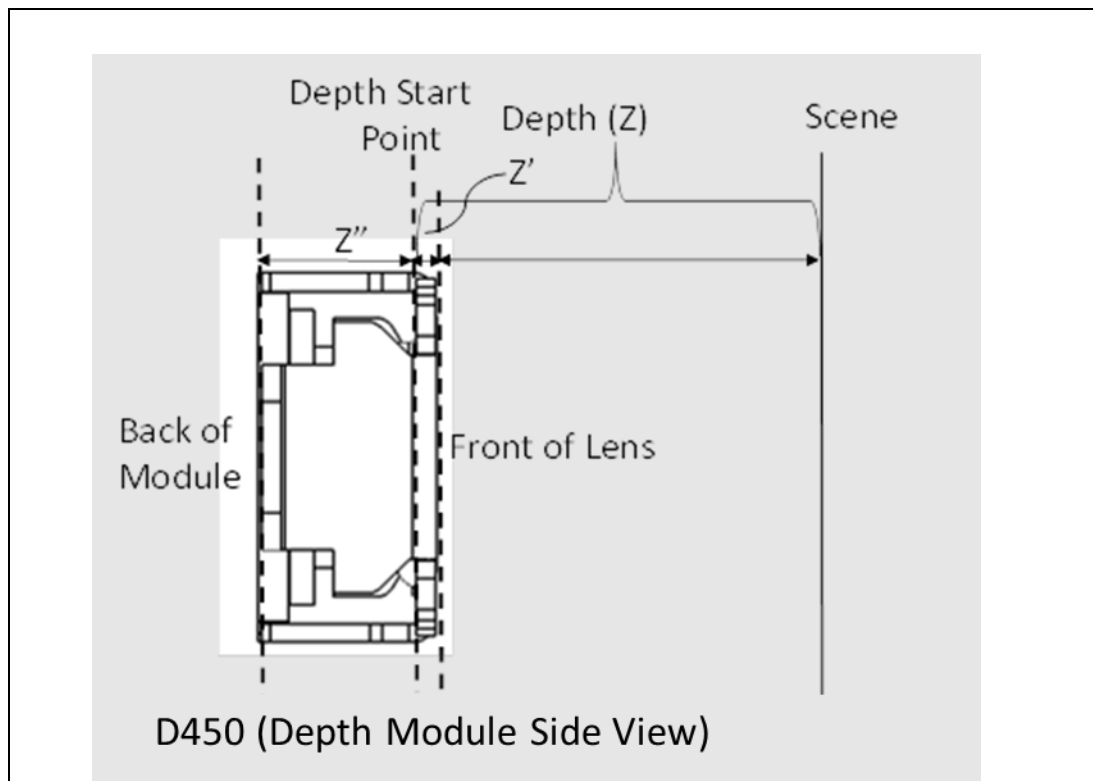
Table 4-8. Depth Module Depth Start Point

Depth Module	Front of Lens (Z')	Back of Module (Z")
D450	-3.2 mm	7.5 mm

NOTES:

If depth measurement reference is front of lens, then |Z'| should be added to measured value to determine Ground Truth. If depth measurement reference is back of module, then |Z"| should be subtracted to determine Ground Truth.

Figure 4-4. Depth Camera Depth Start Point Reference
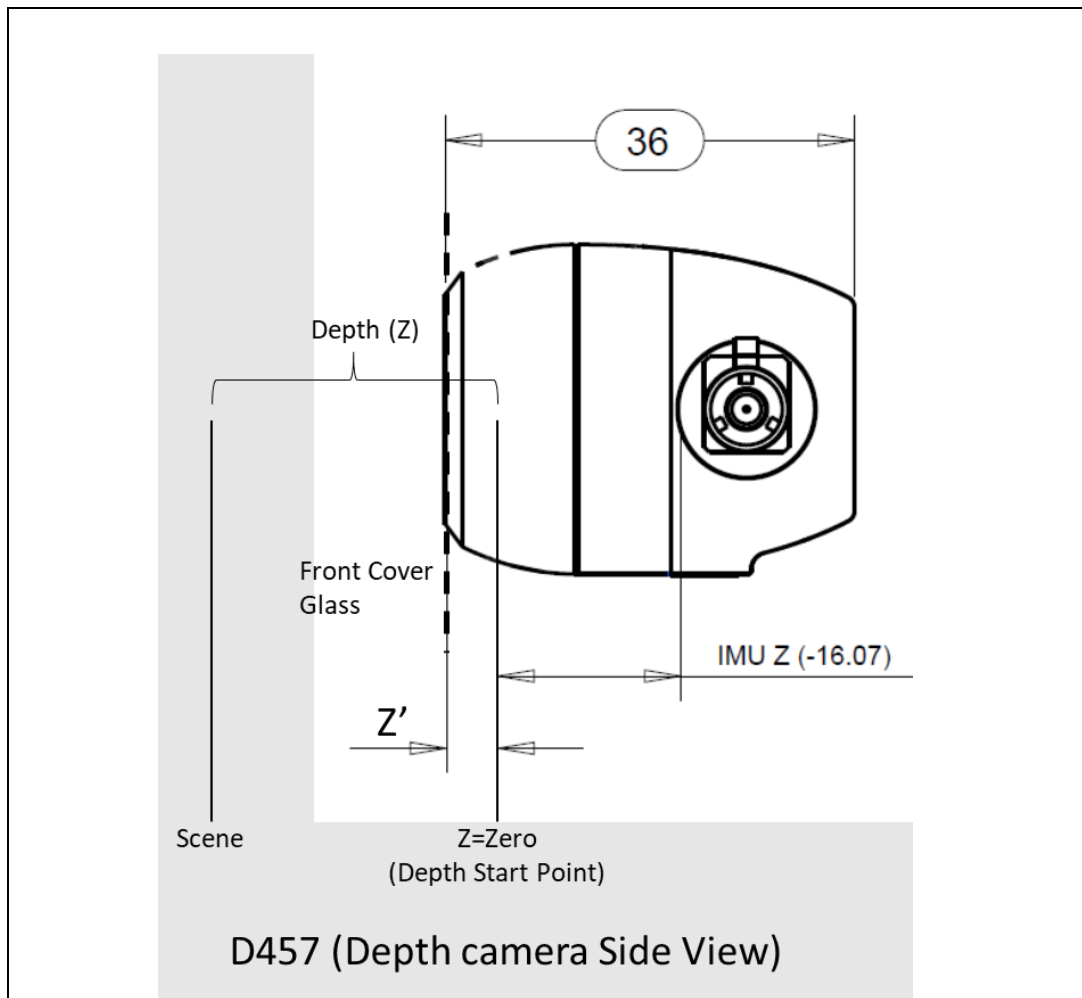
Table 4-9. Depth Cameras Depth Start Point

Depth Camera	Camera Front Glass (Z')
D457	-4.55 mm

NOTES:

If depth measurement reference is front cover glass, then |Z'| should be added to measured value to determine Ground Truth.

4.8.1 Depth Origin X-Y Coordinates

The depth origin X-Y coordinates is the X-Y center of left imager.

Figure 4-5. Depth Module X-Y Depth Origin Reference
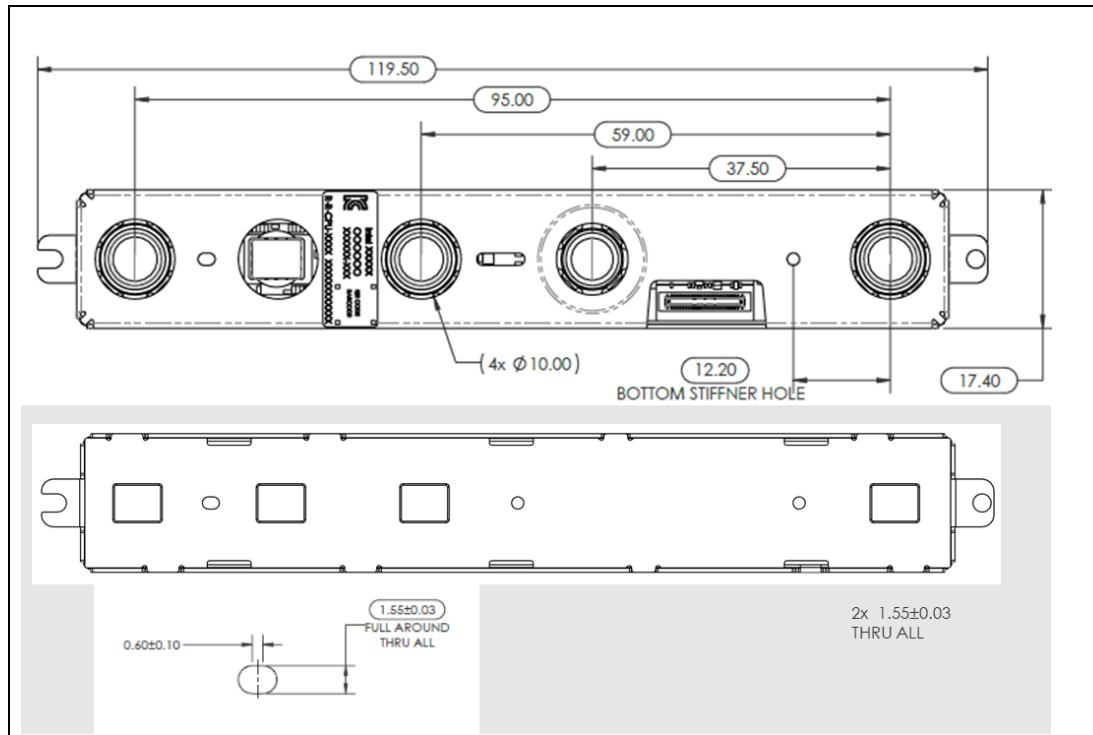
Table 4-10. Depth Module X-Y Depth Origin Coordinates

Depth Module	Left Alignment hole[1] to Left imager Center
D450	12.2mm

NOTES:

1. Left alignment hole on bottom stiffener of depth module

2. Left alignment hole and left imager center is on depth module centerline.

Figure 4-6. Depth Camera X-Y Depth Origin Reference
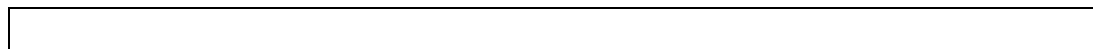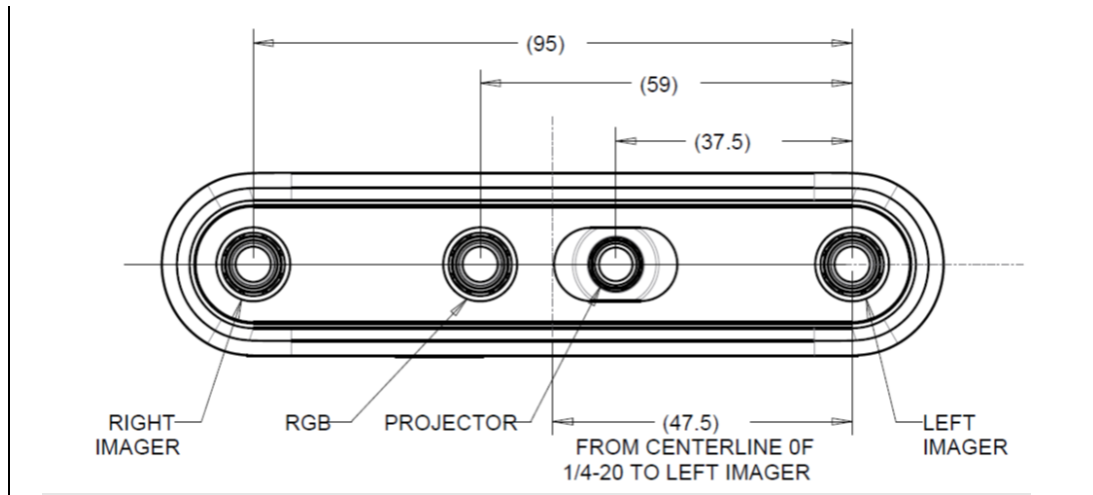
Table 4-11. Depth Camera X-Y Depth Origin Coordinates

Depth Camera	From Centerline of ¼-20[1] To Left Imager
D457	47.5±0.1mm

NOTES:

1. Center of tripod mounting hole (1/4-20)

4.9   Depth Camera Functions

D4 exposes the following Depth image settings.

Table 4-12. Depth Camera Controls

Control	Description	Min	Max
Manual Exposure[1] (ms)	Control sensor exposure period (400/410)	20	200,000
Manual gain[1] (Gain 1.0 = 16)	Control sensor digital gain.	16	248
Laser Power (on/off) (On = 1)	Power to IR Projector	0	1
Manual Laser Power (mW)	Laser Power setting (30mW steps)	0	360
Auto Exposure Mode (Enable = 1)	Auto Exposure Mode. When Auto Exposure is enabled, Exposure and Gain are set based on the environment condition	0	1
Auto Exposure ROI	Perform Auto Exposure on a selected ROI	T-0 L-0 B-1	T-719 L-1279 B-720

Control	Description	Min	Max
		R-1	R-1280
Preset	Set Controls parameters based on Camera Usage		
Meta Data Control	Enable/Disable Metadata	0	1

NOTES:

(1) – Not supported in Auto Exposure Mode

T - Top, L – Left, B - Bottom, R – Right

4.10   Color Camera Functions

Table 4-13. RGB Exposed Controls

<u>Note</u>: The RGB controls are not supported in the current SDK version

Control	Description	Min	Max
Auto-Exposure Mode	Automatically sets the exposure time and gain for the frame.	0x1	0x8
Auto Exposure ROI	Perform Auto Exposure on a selected ROI	T-0 L-0 B-1 R-1	T-1079 L-1919 B-1080 R-1920
Manual Exposure Time	Sets the absolute exposure time when auto-exposure is disabled.	1	10000
Brightness	Sets the amount of brightness applied when auto-exposure is enabled.	-64	64
Contrast	Sets the amount of contrast based on the brightness of the scene.	0	100
Gain	Sets the amount of gain applied to the frame if auto-exposure is disabled.	0	128
Hue	Sets the amount of hue adjustment applied to the frame.	-180	180
Saturation	Sets the amount of saturation adjustment applied to the frame.	0	100
Sharpness	Sets the amount of sharpening adjustment applied to the frame.	0	100
Gamma	Sets amount of gamma correction applied to the frame.	100	500

Control	Description	Min	Max
White Balance Temperature Control	Sets the white balance when AWB is disabled.	2800	6500
White Balance Temperature Auto (AWB)	Enables or disables the AWB algorithm.	0	1
Power Line Frequency	Specified based on the local power line frequency for flicker avoidance.	0	3
Backlight Compensation	Sets a weighting amount based on brightness to the frame.	0	1
Low Light Comp	Low Light Compensation	0	1

NOTES:

T - Top, L – Left, B - Bottom, R – Right

4.11   IMU Specifications

Table 4-14. IMU Specifications – BMI085

Camera	Parameter	Properties
Intel® RealSense™ Depth Camera D435i, Intel® RealSense™ Depth Camera D455 Intel® RealSense™ Depth Module D450+Intel® RealSense™ Vision Processor D4 Board V5	Degrees of Freedom	6
	Acceleration Range	±4g
	Accelerometer Sample Rate[1]	100, 200 (Hz)
	Gyroscope Range	±1000 deg/s
	Gyroscope Sample Rate[2]	200, 400 (Hz)
	Sample Timestamp Accuracy	50 usec

NOTES:

1. The sample rate may differ from the absolute specified sample rate by ±5%. It is advised to rely on the sample timestamp.
2. The sample rate may differ from the absolute specified sample rate by ±0.3%.

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5   *Firmware*

The firmware contains the operation instructions. Upon runtime, Vision Processor D4 loads the firmware and programs the component registers. If the Vision Processor D4 is configured for update or recovery, the unlocked R/W region of the firmware can be changed.

5.1   Update

D457 firmware can be updated through USB in USB debug mode, or through I2C in MIPI/GMSL mode. During a firmware update, the firmware utility will issue a device firmware update command to the Vision Processor D4. The Vision Processor D4 will then reset into firmware update mode. The firmware utility uses a single binary file to maintain the firmware image. The firmware utility compares the firmware version installed on the camera to the firmware version file to be updated. Based on the comparison, the firmware utility will downgrade, upgrade, or skip if the versions match.

5.1.1   Update Limits

The firmware update engine does not allow infinite update cycles between older and current versions of firmware. The engine will establish a baseline version of firmware based on the latest firmware version installed. The engine will allow a return to a previous version or baseline version of firmware up to 20 times. After the 20th update, the engine will only allow an update to a firmware revision higher than the baseline version.

5.2   Recovery

A read only boot sector is built into firmware which enables basic operation regardless of the integrity of the operation instructions region. This ensures the imaging system can function in the case of firmware not be written properly. When a firmware recovery is required, the firmware utility will communicate with the recovery driver to set the DFU pin low and reset the imaging system in recovery mode.

Firmware Recovery can also be externally triggered by having controllable interrupt connected to the Vision Processor D4 DFU (Device Firmware Update) pin.

The firmware recovery sequence will be triggered by the firmware client utility. This client utility will communicate through ACPI _DSM to trigger the controllable interrupt (GPIO) at the appropriate times.   The firmware recovery requires an ACPI _DSM interface to control the interrupt GPIO in configuring to firmware recovery state. The _DSM methods and BIOS use the Write to GPIO functions to set the controllable interrupt.

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6   *Software*

6.1   Intel® RealSense™ Software Development Kit 2.0

Intel® RealSense™ SDK 2.0 is a cross-platform library for working with Intel® RealSense™ D400 Series. It is open source and available on https://github.com/IntelRealSense/librealsense

The SDK at a minimum includes:
- **Intel® RealSense™ Viewer** - This application can be used view, record and playback depth streams, set camera configurations and other controls.
- **Depth Quality Tool** - This application can be used to test depth quality, including: distance to plane accuracy, Z accuracy, standard deviation of the Z accuracy and fill rate.
- **Debug Tools** - These command line tools gather data and generate logs to assist in debug of camera.
- **Code Examples** - Examples to demonstrate the use of SDK to include D400 Series camera code snippets into applications.
- **Wrappers** – Please refer to the documentation on https://www.intelrealsense.com/ and https://github.com/IntelRealSense/librealsense for the supported wrappers over MIPI.

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7 *System Integration*

The small size of the stereo depth module and the separate placement of Vision Processor D4 provides system integrators flexibility to design into a wide range of products. Because the camera uses stereo vision technology, it is crucial that the stereo depth module does not flex throughout its service life. This creates unique mechanical and thermal implementation guidance. This section explains how to correctly integrate D4 depth camera into a system.

7.1 System Level Block Diagram

Figure 7-1. System Block Diagram
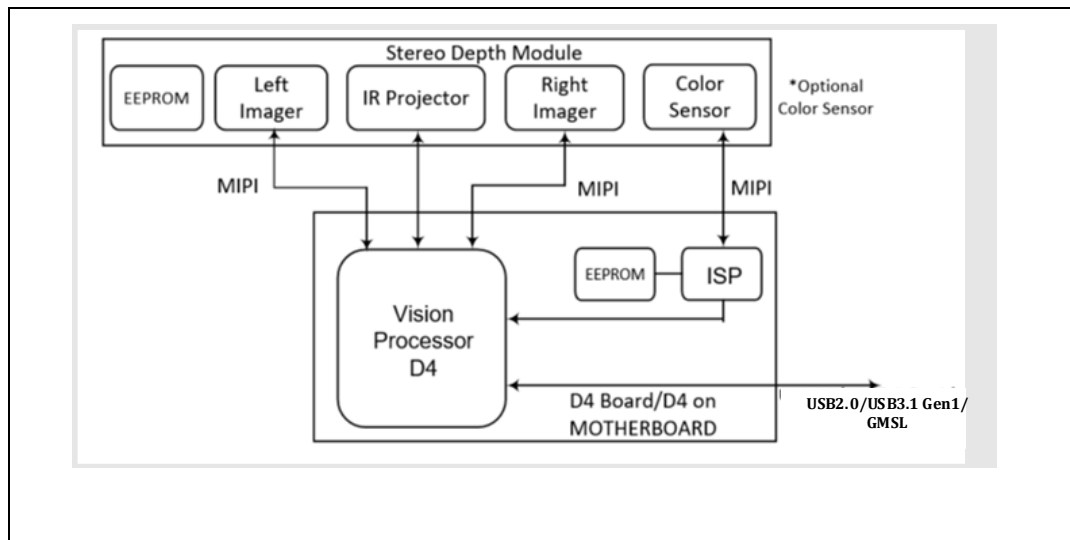
7.2 Vision Processor D4 System Integration

To integrate Vision Processor D4 into a system, customers can either use D457 cameras directly or build customized enclosure and mount the D4 ASIC card and optical module inside the enclosure.

7.2.1 Vision Processor D4 Board

The Vision Processor D4 Board has a standard USB Type-C connector and requires an appropriate USB Type-C cable to connect to a standard USB 2.0/USB 3.1 Gen 1 external port. This USB port is for debug only.

Figure 7-2. Intel® RealSense™ Vision Processor D4 Board V5
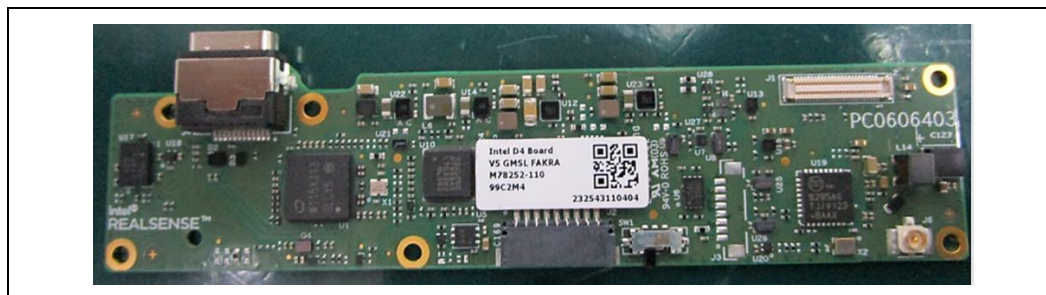
7.2.2   Vision Processor D4 on Motherboard

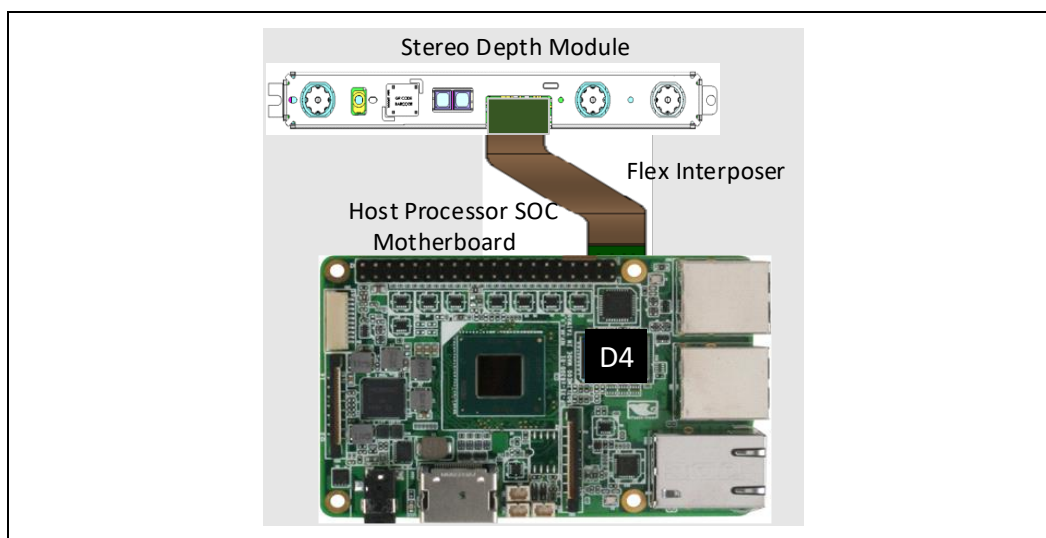In the Vision Processor D4 on Motherboard option, Vision Processor D4 and support components are directly placed on the host processor motherboard. The depth module receptacle is on the host processor motherboard for connection to the stereo depth module.

Figure 7-3. Vision Processor D4 on Motherboard (Illustration)

7.3   D4 Camera System Power Delivery

D4 camera system **MUST** keep stereo depth module and the Vision Processor D4 on the same power rails. The stereo depth module holds a safety region in EEPROM that is configured by firmware protected region. Keeping all components on the same rail prevents malicious software reset of the stereo depth module without causing a reset to the ASIC. By this protection we make sure that all the safety logic is kept locked as long as the device is active. Ensure power delivery implementation recommendation in Chapter 12 are followed in the design of D4 camera system.

Figure 7-4. D4 Camera System Power Scheme
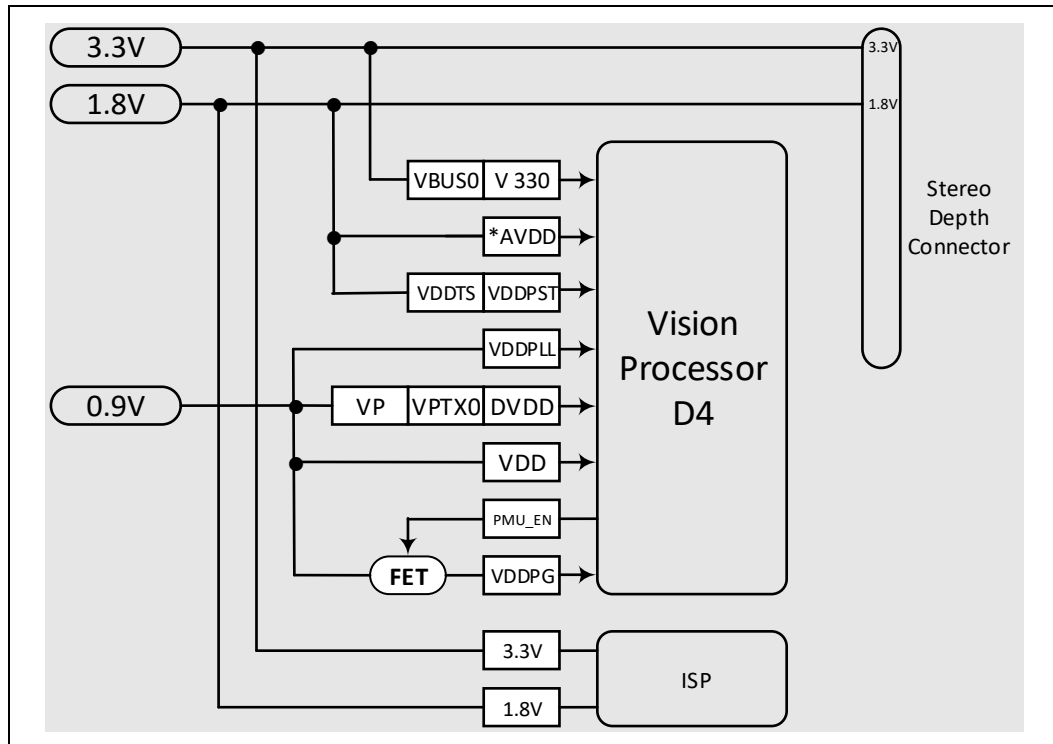
7.4   Thermals

The system thermal design must ensure the component case temperature are not exceeded. Thermal models for Vision Processor D4 board and Depth modules are available to conduct a thermal evaluation and validate the system thermal design.

A few notes for the power and TDP tables below:

1. Max. Operating Mode at max resolution of the Depth and RGB imagers at 30FPS.

2. The IR projector TDP is lower than power due to a percentage of energy dissipated as photonic emissions rather than heat.

3. Voltage Regulator power is included as part of the individual component power

Table 7-1. Vision Processor D4 Board V5 – Component Power and TDP at Max Operating Mode[1]

Component	Power	TDP	Unit
Vision Processor D4	618	618	mW
Color Camera ISP	197	197	mW
Voltage Regulators/Other	500	500	mW
GMSL	250	250	mW

All Components	1565	1565	mW

Table 7-2. Stereo Depth Module (D450) – Component Power and TDP at Max Operating Mode[1]

Component	Power	TDP	Unit
Left Imager	177	177	mW
Right Imager	177	177	mW
RGB Imager	177	177	mW
IR Projector	1620	1260	mW
EEPROM + Thermal Sensor	4	4	mW
All Components	2155	1795	mW

Table 7-3. Stereo Depth Camera (D457) – Component Power and TDP at Max Operating Mode[1]

| Component	Power	TDP	Unit
Left Imager	177	177	mW
Right Imager	177	177	mW
RGB Imager	177	177	mW
IR Projector	1620	1260	mW
EEPROM + Thermal Sensor	4	4	mW
Vision Processor D4 Board	1565	1565	mW
All Components	3720	3360	mW

NOTE:

Max. Operating Mode = Depth Resolution 848 x 480 @ 90 FPS, Color Resolution - 848 x 480 @ 60FPS, laser 360mW

Table 7-4. Vision Processor D4 Board Components – Case Temperature Limits (Still Air)

Component	Min	Max[1]	Unit
Vision Processor D4	0	85	℃
Color Camera ISP	0	70	℃

For the Depth Modules, case temperature is specified for the overall depth module and the thermocouple test location is any point on bottom metal stiffener

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Figure 7-5. Bottom Stiffener Depth Module D450
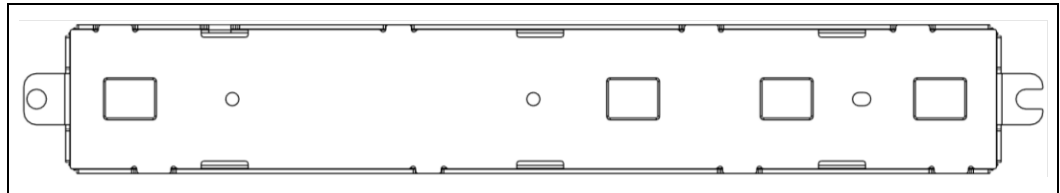
7.5 Stereo Depth Module Flex

It is critical that stereo depth module does not experience flex during system integration or during use after integration. Micron level flexing of the module can render the calibration incorrect and will result in poor performance or nonfunctional depth data. It is important for system designers to isolate the module from any chassis flex the system may encounter. While the module has a reinforcement housing, the housing is not intended to counter loads from chassis flex. The primary function of the housing is to prevent loss of calibration from handling and operating environments.

It is possible for the module to recover depth performance after experiencing permanent deformation. However, the module's ability to recover is dependent on the amount of deformation experienced.

It is required, due to the high probability that some flex will be experienced by the module during system integration, to perform OEM calibration procedure after the stereo depth module is fully integrated into its final housing/location.

7.6 Stereo Depth Module Mounting Guidance

There are a few mounting options depending on the SKU. The paragraphs below describe the various options.

7.6.1 Screw Mounting/End Mounting

This section applies to the following SKUs: D450.
The stereo depth module incorporates a screw hole and a screw fork for module mounting. The stereo depth module should be mounted on a large heat sink or a heat dissipating structure element using M2x4mm (Torx) screw at the screw hole and fork. The recommended torque for both screws is 1.6Kgf*cm. Thermal interface material should be used on backside region of IR projector and two stereo imagers between camera module and heat sink or heat dissipating structure element for thermal transfer.

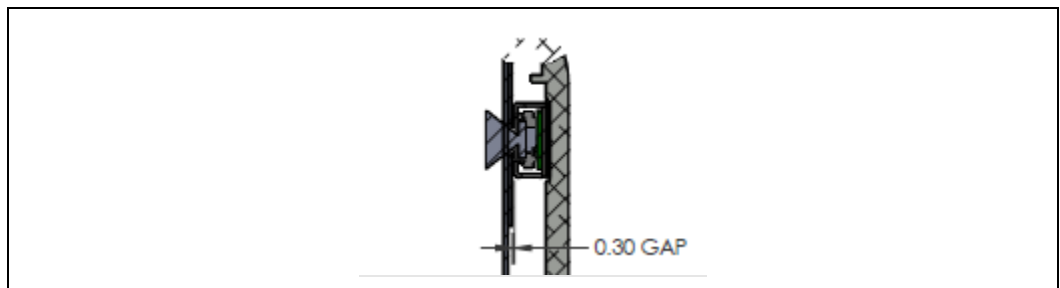**Note:** Thermal double-sided adhesive is recommended.

Figure 7-6. Stereo Depth Module Screw Mounting/End Mounting – D450
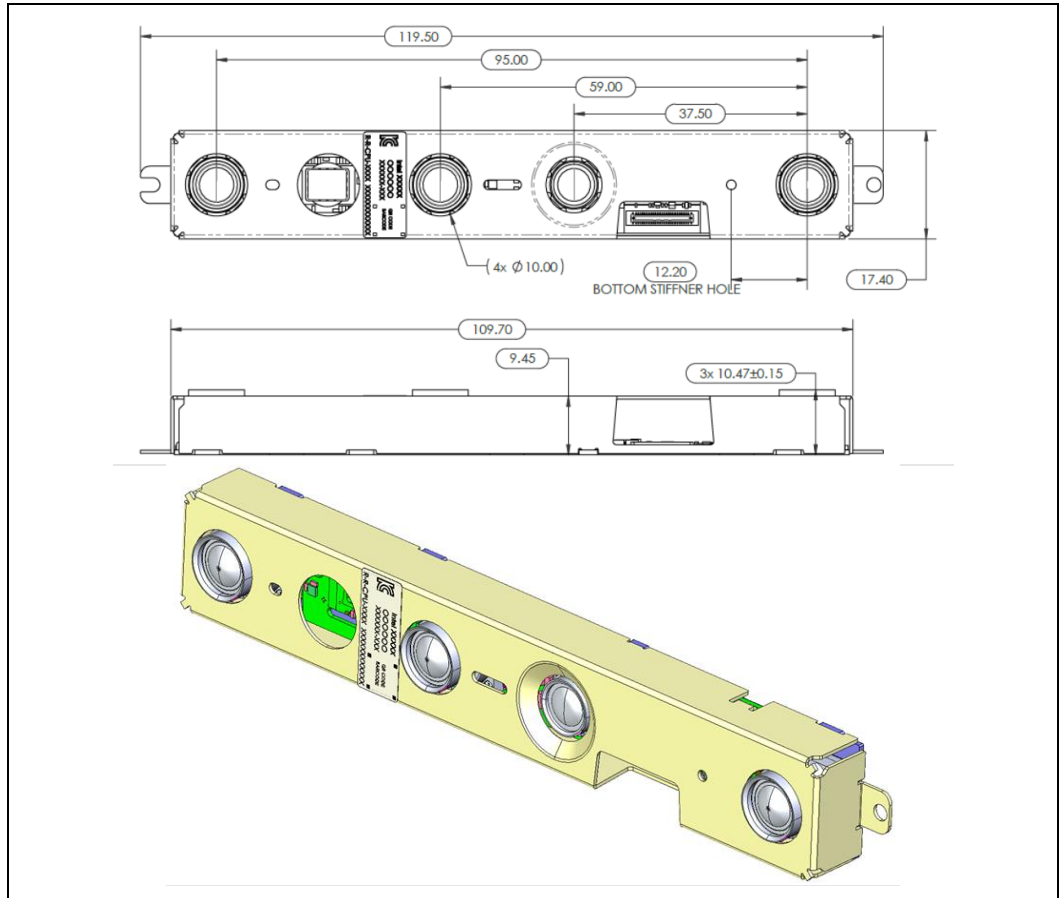
7.6.2   Stereo Depth Module Air gap

A minimum 0.3mm air gap is recommended between highest components on the stereo depth module to the cover window

Figure 7-7. Stereo Depth Module Air Gap

7.7   Thermal Interface Material

Thermal interface material, specifically thermal paste/grease is recommended to be inserted between the stereo depth module and the heat dissipating structure (heat sink) to improve the thermal coupling between these two components. A thermal paste with thermal conductivity in the 3-4W/mK range is recommended. This paste must be applied in a thin layer on the back side of the IR projector and also under the left and right imagers filling up the air gap under the Imagers.

7.8   Heat Sink

The heat sink or heat dissipating structure element used to mount stereo depth module and ASIC Board should be a minimum of 2-3mm in thickness. It is advisable to extend the heat sink by a few mm beyond the edges of the stereo depth module. It is also recommended to have thermal fins on the back side of the heat dissipating structure. In applications where weight is a concern, high thermal conductivity graphite tape can be attached to the back side of the heat sink. This graphite tape must be at least as big as the metal heat sink and extended out beyond the metal as much as possible for optimal cooling. Heat sink metal must be a high conductivity aluminum alloy or copper.

In cases where the module is expected to operate at high ambient temperatures, additional airflow may be required to ensure temperature limits are not exceeded. These are guidelines for thermal integration of the D4 camera in the system, however actual testing or system level thermal modeling is recommended before finalizing solution.

7.9   Cover Design and Material Guidance

The stereo depth module components must be covered to minimize dust and humidity. The transparent cover material stack-up used must provide acceptable transmission based on the component wavelengths. Anti-reflective coatings can help increase the transmission of cover material. Cover material that reduces light transmission can result in poor depth performance and will decrease the working range of the camera. Nominally flat, non-distorting and low scattering cover material should be used.

Table 7-5. Component Transmission

Component	Wavelength	Unit
Left and Right Imager (Intel® RealSense™ D450)	400 to 700 (Visible and Infrared) and 840 to 860 @ 95% transmission rate or higher at all viewing and transmitting angles	nm
IR Projector	850nm ± 15 nm @ 98% transmission rate or higher at all viewing and transmitting angles	nm

NOTES:

Higher transmissions @ 98% transmission rate or higher is recommended and not a requirement.

Intel RealSense Camera 400-Series provides control over laser power and sensor exposure. Minor loss of transmission due to cover material transmissivity might be compensated by

increasing exposure when less light is able to reach the sensors and by increasing laser power for IR projector pattern projection loss.

Uncoated clear acrylic (plexiglass) plastic cover is an example for cover material

Anti-reflective coatings can help increase the transmission of cover material.

If different cover material is used in front of the cameras and the IR projector to maximize transmission based on component wavelengths, cover design considerations should ensure that the FOV of the cameras and FOP of the IR projector are not impacted.

7.10   Gaskets

Gaskets are recommended for providing optical isolation and dust protection. However, gaskets can impede FOV and place unwanted stress on the module or the individual sensor lens holders.

Gasket static force can deform the cosmetic baffle/lens holder resulting in poor image quality and permanent damage to the camera. Gaskets placed on the module stiffener can transfer chassis flex into the camera module causing loss of depth data. Gasket thickness has a large effect on the static force applied to the module surface. The thinner the seal, the greater the static force applied. Once the gasket is compressed, the static force will increase exponentially.

Figure 7-8. Illustration of Gasket Placement and Cover Material
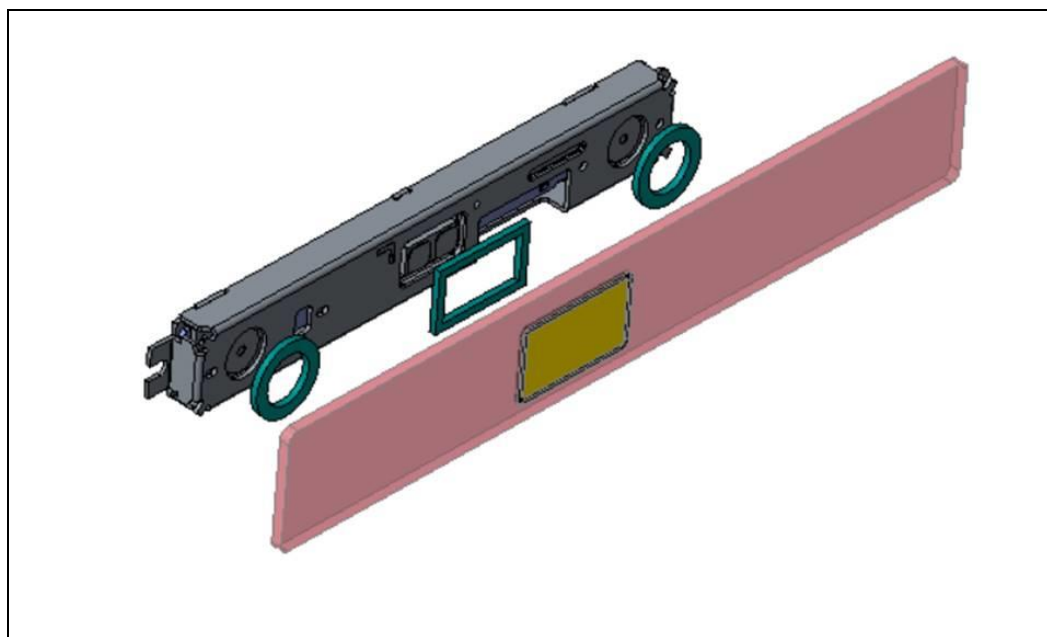
7.10.1   Optical Isolation

It is recommended to isolate the left/right imagers and IR projector from each other to prevent reflections off the cover material. Not properly isolating the cameras can result in leakage light as shown in Figure 7-9. Example of Light Leakage Effects

To prevent light leakage, it is recommended to use a gasket material in between the cover holes and the module. The gasket material needs to be compliant so that it does not transmit chassis flex forces to the module.

Figure 7-9. Example of Light Leakage Effects


7.10.2   Dust Protection

Dust particles can accumulate over the camera lenses which can be visually unappealing and degrade image quality.

7.11   Firmware Recovery

To support firmware recovery, a 1.8V controllable interrupt must be connected to the Vision Processor D4 DFU (Device Firmware Update) pin

The ability to recovery the image system if the firmware becomes corrupted requires D4 reset and DFU pin driven high for 160ms. The DFU pin should remain high when D4 is out of reset for D4 to boot in DFU mode. The 160ms ensures that the DFU pin is held high through the reset sequence.

Figure 7-10. Firmware Recovery Sequence

Sequence	Timing Diagram
Firmware Recovery	Reset (PRSTN Pin) ⎯⎯⎯ DFU Pin ⎯⎯ ◄⎯⎯ 160ms ⎯⎯►
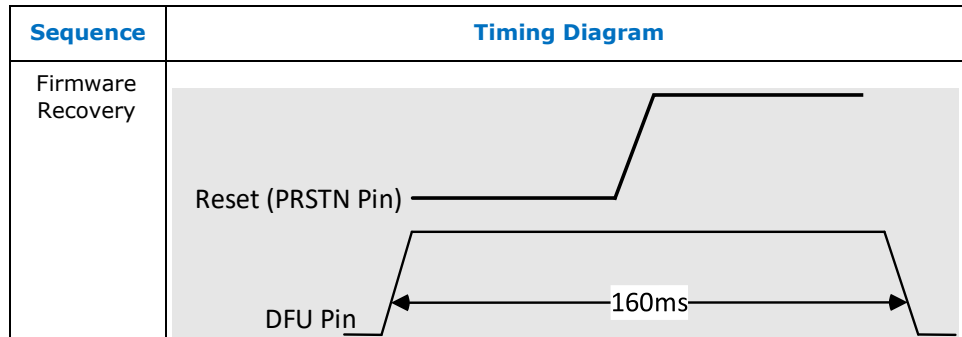
7.12 Calibration Support

It is required to have an accessible USB port to access the host system. The accessible USB port would allow to stream images reliably to an external PC to determine calibration parameters and to write back camera calibration parameters via the host system

The USB port should be able to be configured in a mode where the USB port can access the host. The access to USB port is required at manufacturing and not intended to be available on shipped product or to end user.

7.13 Multi-Camera Hardware Sync

Intel® RealSense™ D400 Series supports hardware sync signal for multi-camera configuration. Multiple cameras are hardware synchronized as to capture at identical times and frame rates. For multiple D457s, all of them can work in slave mode; the external trigger is applied to the camera through the GMSL cable from the host side. There are two triggers, one for depth camera and one for RGB camera. The depth and RGB cameras can be triggered at both the same and different supported frame rates.

Figure 7-11. External Sensor Sync Connector Location on D4 Vision Processor D4 Board
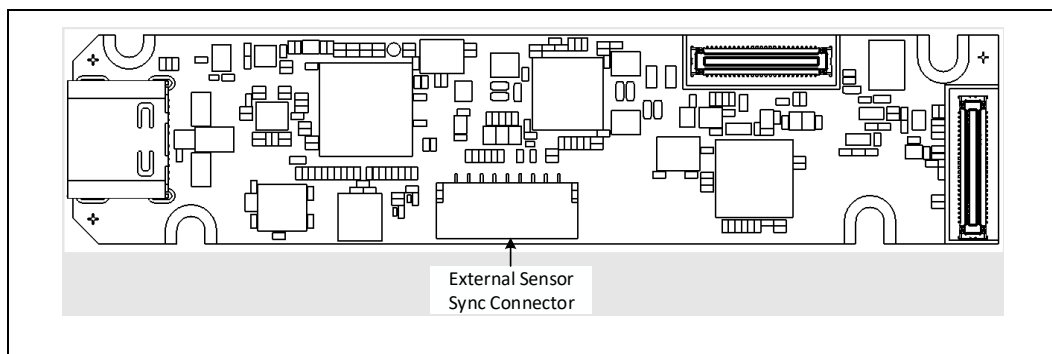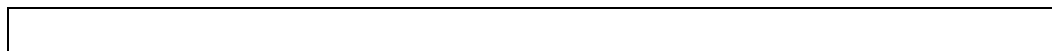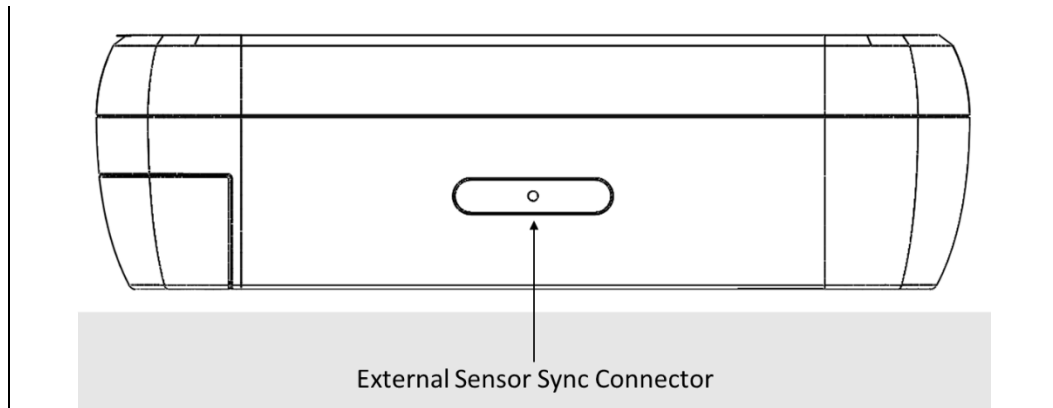

External Sensor
Sync Connector

Figure 7-12. External Sensor Sync Connector Location on Depth Camera D457

External Sensor Sync Connector

For additional details on how to implement the multi-camera hardware sync feature, please refer to multi-camera white paper at https://realsense.intel.com/intel-realsense-downloads/#whitepaper.

7.14   Handling Conditions

Table 7-6. Electrostatic Discharge Caution

To provide a consistent ESD protection level during D4 system assembly and rework, it is recommended that the JEDEC JESD625-A requirements standard be incorporated into the ESD environment controls.

8   *Regulatory Compliance*
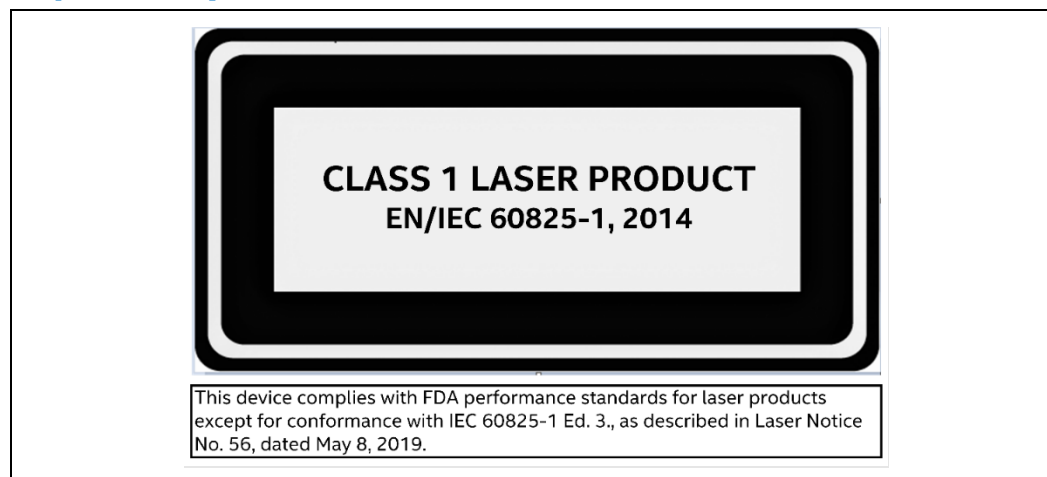
8.1   System Laser Compliance

Certification for the Intel® RealSense™ Depth Cameras and Depth Modules paired with Intel® RealSense™ Vision Processor D4 Board following integration guidelines, is transferable to the system and no system recertification is required. However, the following statements and labels must be included in the user manual of the end product.

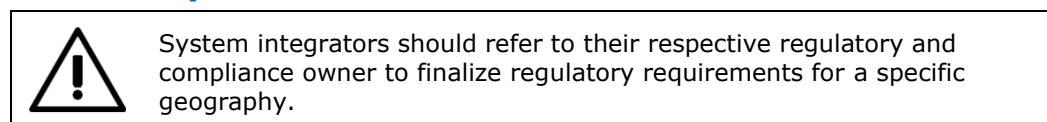### 8.1.1   Certification Statement

This product is classified as a Class 1 Laser Product under the EN/IEC 60825-1, Edition 3 (2014) internationally.

This product complies with FDA performance standards for laser products except for conformance with IEC 60825-1 Ed. 3 as described in Laser Notice No. 56, dated May 8, 2019.

8.1.2   Explanatory Label

CLASS 1 LASER PRODUCT
EN/IEC 60825-1, 2014

This device complies with FDA performance standards for laser products except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.

8.1.3   Cautionary Statements

System integrators should refer to their respective regulatory and compliance owner to finalize regulatory requirements for a specific geography.

> ⚠️ **Caution** - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

> ⚠️
> - Do not power on the product if any external damage was observed.
> - Do not attempt to open any portion of this laser product. There are no user serviceable parts.
> - Invisible laser radiation when opened. Avoid direct exposure to beam.
> - There are no service/maintenance, modification, or disassembly procedures for the stereo module and infrared projector. The system integrator must either notify Intel or return modules before any failure analysis is performed.
> - Modification or service of the stereo module, specifically the infrared projector, may cause the emissions to exceed Class 1.
> - Do not try to update camera firmware that is not officially released for specific camera module SKU and revision.

8.1.4   US FDA Accession Number

Table 8-1. U.S. FDA Accession Number

Component	U.S. FDA accession numbers
Intel® RealSense™ Depth Camera D457	1420260

This accession number should be entered into Box B.1 of the Food and Drug Administration (FDA) 2877 Declaration for Imported Electronic Products Subject to Radiation Control Standards.

8.2   Regulatory Compliance

8.2.1   Manufacturer's Information

Attn: Corp. Quality
Intel Corporation
2200 Mission College Blvd.
Santa Clara CA 95054-1549
USA

8.2.2   EU Single Place of Contact

Intel Deutschland GmbH
z. H. Corp. Quality
Dornacher Str. 1
85622 Feldkirchen

GERMANY

8.2.3   UK Single Place of Contact

Intel Corporation (UK) Ltd.
Attn: Corp. Quality
Pipers Way
Swindon
Wiltshire
SN3 1RJ
UNITED KINGDOM

8.2.4   FCC Part 15 Declaration of Conformity

Intel® RealSense™ Depth Camera D457

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Attn: Corp. Quality, Intel Corporation: 2200Mission College Blvd, Santa Clara, CA 95054-1549, USA

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.
• Increase the separation between the equipment and receiver.
• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
• Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

CAUTION: To comply with the limits of the Class B digital device, pursuant to Part 15 of the FCC Rules, this device must be installed with computer equipment certified to comply with Class B limits. All cables used to connect to the computer and peripherals must be shielded and grounded. Operation with non-certified computers or non-shielded cables may result in interference to radio or television reception.

8.2.5   Canada

CAN ICES-3 (B)/NMB-3(B)

This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus set out in the Interference-Causing Equipment Standard ICES-003.

Le présent appareil numerique német pas de bruits radio électriques dépassant les limites applicables aux appareils numériques de la classe B prescrites dans la présente norme sur le matériel brouilleur, NMB-003.

8.2.6   European Directives

This product complies with all applicable European directives.

CAUTION: To keep the product in compliance with the European CE requirement, the device must be installed with CE certified computer equipment which meets the Class B limits. Operation with non-certified computers or incorrect cables may result in interference to other devices or undesired effect to the product.

8.2.7   UK

This product complies with all applicable UK regulations.

Due to the very small size of the product, the marking has been placed in this datasheet.

8.2.8   Australia

Due to the very small size of the product, the marking has been placed in this datasheet.

8.2.9   Japan

この装置は、クラスＢ機器です。この装置は、住宅環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。 取扱説明書に従って正しい取り扱いをして下さい。   ＶＣＣＩ－Ｂ

This device is a Class B information technology device. This device is intended for use in a home environment, but if this device is used close to a radio or television receiver it may cause reception interference. Please handle according to the instruction manual correctly. VCCI-B
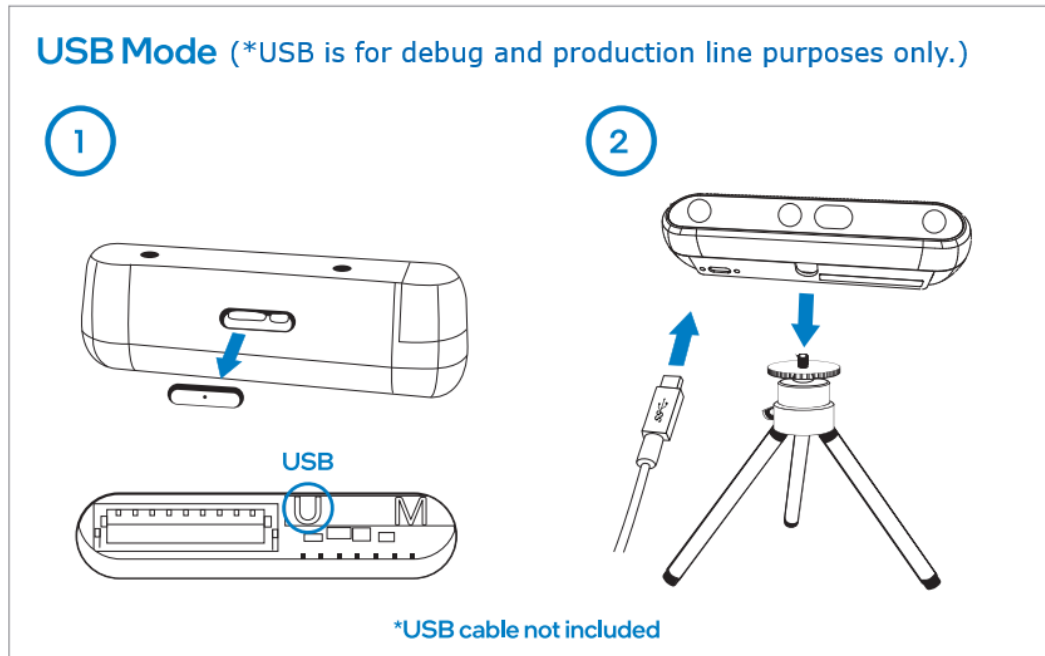
8.2.10   South Korea

인증 번호: R-R-CPU-D457C

제조자: Intel Corporation

337029-011

상품명: Intel® RealSense™ Depth Camera

모델: D457

제조국: 태국, 중국

인증 번호: R-R-CPU-D4BoardV5

제조자: Intel Corporation

상품명: Intel® RealSense™ Vision Processor D4 Board V5

모델: D4 Board V5 GMSL FAKRA

제조국: 중국

8.2.11   Ingress Protection Rating: IP65

D457 has been tested under IEC 60529 and found to be in compliance with IP6X dust test requirement and IPX5 water test requirement.

IP6X - 13.4/13.6 - Dust-Tight - Category 1, with under pressure

IPX5 - 14.2.5 Protected against Water Jets (6.3mm Spray Nozzle)

Notes:
- The USB and FAKRA connectors are IP67 rated
- Use of the HW sync trigger via the 9 pin connector is not IP65 certified, therefore the cap covering it must be closed in order to retain the IP65 enclosure rating

8.3 Ecology Compliance

Please refer to https://www.intelrealsense.com/regulatory-information/ for Material Declaration Data Sheets (MDDS).

8.3.1 China RoHS Declaration

intel   **China RoHS Declaration**

产品中有毒有害物质的名称及含量
Hazardous Substances Table

部件名称 Component Name	有毒有害物质或元素 Hazardous Substance					
	铅 Pb	汞 Hg	镉 Cd	六价铬 Cr (VI)	多溴联苯 PBB	多溴二苯醚 PBDE
相机 Camera	X	○	○	○	○	○
印刷电路板组件 Printed Board Assemblies	X	○	○	○	○	○
三角架 Tripod	○	○	○	○	○	○

○：表示该有毒有害物质在该部件所有均质材料中的含量均在GB/T 26572标准规定的限量要求以下。

○：Indicates that this hazardous substance contained in all homogeneous materials of such component is within the limits specified in GB/T 26572.

×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出GB/T 26572标准规定的限量要求。

×：Indicates that the content of such hazardous substance in at least a homogeneous material of such component exceeds the limits specified in GB/T 26572.

对销售之日的所售产品,本表显示我公司供应链的电子信息产品可能包含这些物质。注意：在所售产品中可能会也可能不会含有所有所列的部件。

This table shows where these substances may be found in the supply chain of our electronic information products, as of the date of sale of the enclosed product. Note that some of the component types listed above may or may not be a part of the enclosed product.

除非另外特别的标注,此标志为针对所涉及产品的环保使用期限标志. 某些可更换的零部件可能会有一个不同的环保使用期限(例如, 电池单元模块).
此环保使用期限只适用于产品在产品手册中所规定的条件下工作.

The Environment-Friendly Use Period (EFUP) for all enclosed products and their parts are per the symbol shown here, unless otherwise marked. Certain field-replaceable parts may have a different EFUP (for example, battery modules) number. The Environment-Friendly Use Period is valid only when the product is operated under the conditions defined in the product manual.

8.3.2 Waste Electrical and Electronic Equipment (WEEE)

"In the EU, this symbol means that this product must not be disposed of with household waste. It is your responsibility to bring it to a designated collection point for the recycling of waste electrical and electronic equipment. For more information, contact the local waste collection center or your point of purchase of this product."

8.3.3 Turkey

Türkiye Cumhuriyeti: EEE Yönetmeliğine Uygundur
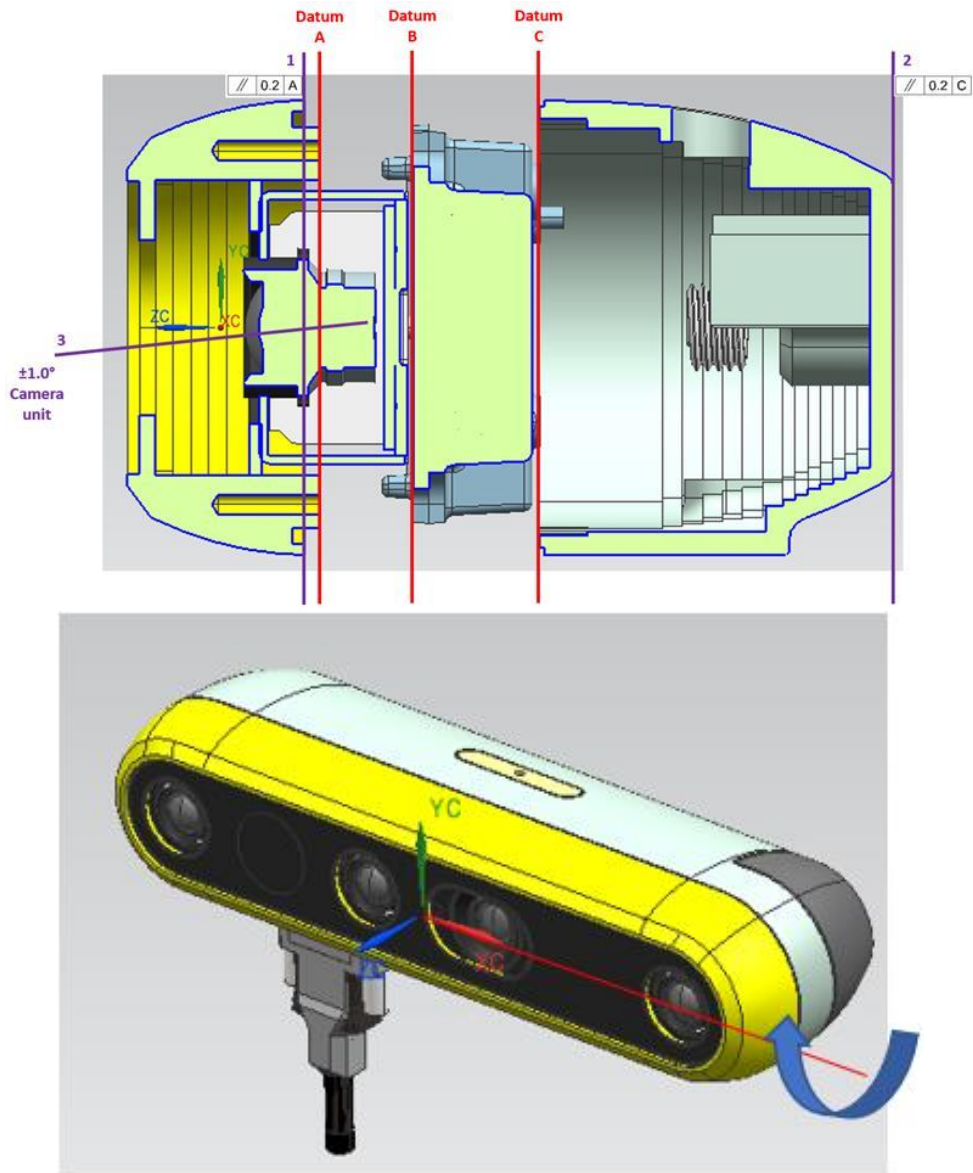
§ §

9   *Mechanical Drawings*

Figure 9-1. Intel® RealSense™ Depth Module D450
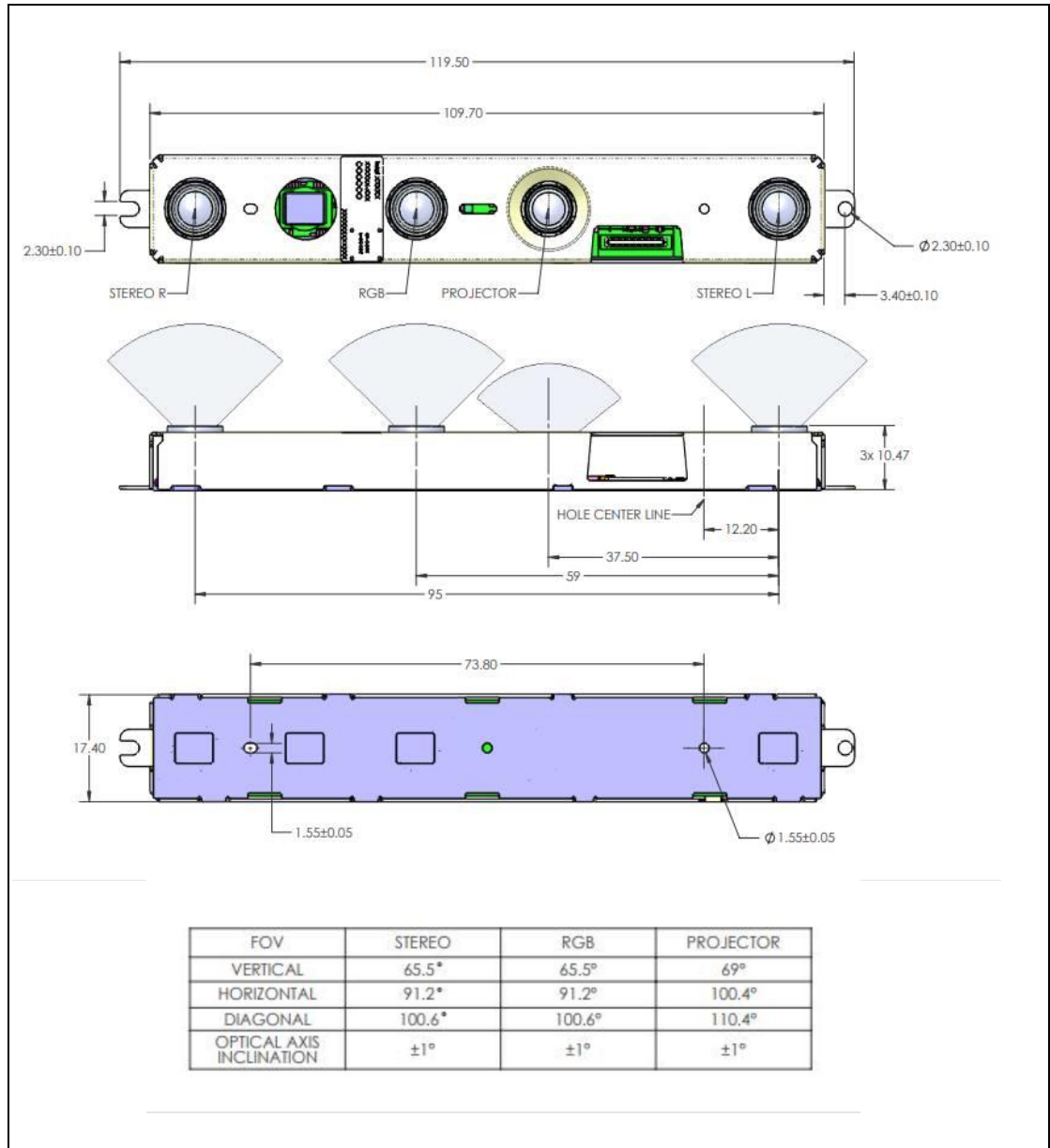
NOTE: ±1° Optical Axis Inclination of the Stereo cameras, RGB camera, and Projector translate to the following inclination into the Rear Mounting Surface:

(1) Camera centerline angle relative to Rear Mounting Surface on Y-Z plane (Pitch): RSS = ±1.14°, worst case: ±1.77°

(2) Camera centerline angle relative to Rear Mounting Surface on X-Z plane (Yaw): RSS = ±1.01°, worst case: ±1.19°
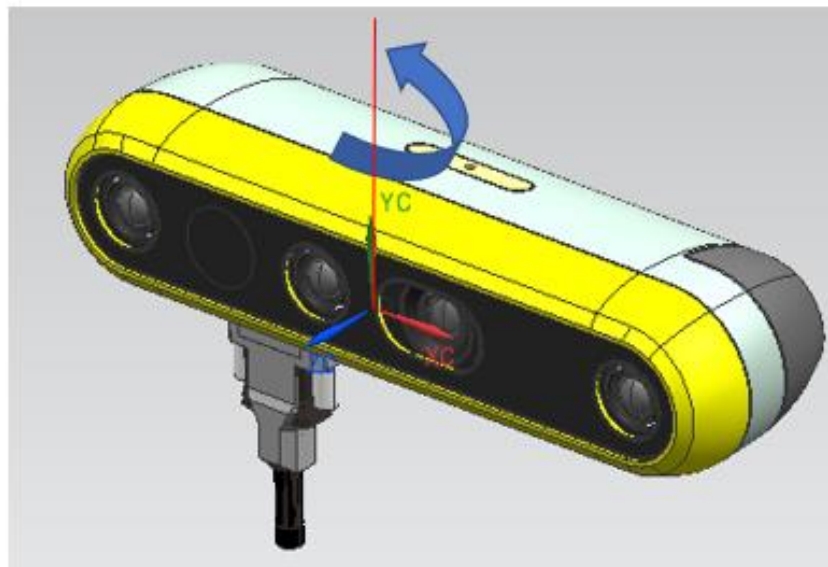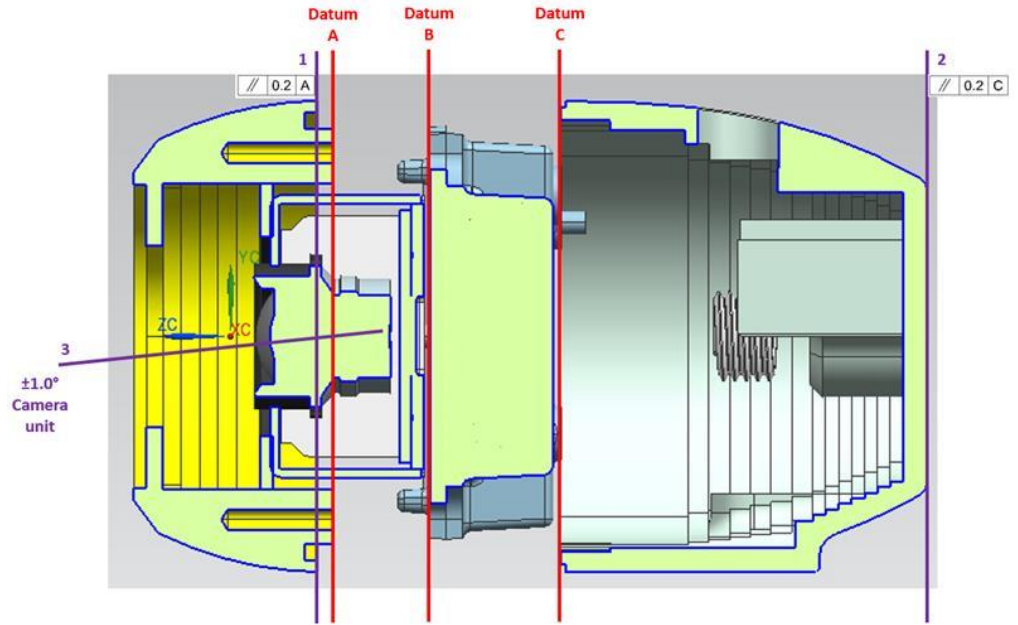
Figure 9-2. Intel® RealSense™ Vision Processor D4 Board V5

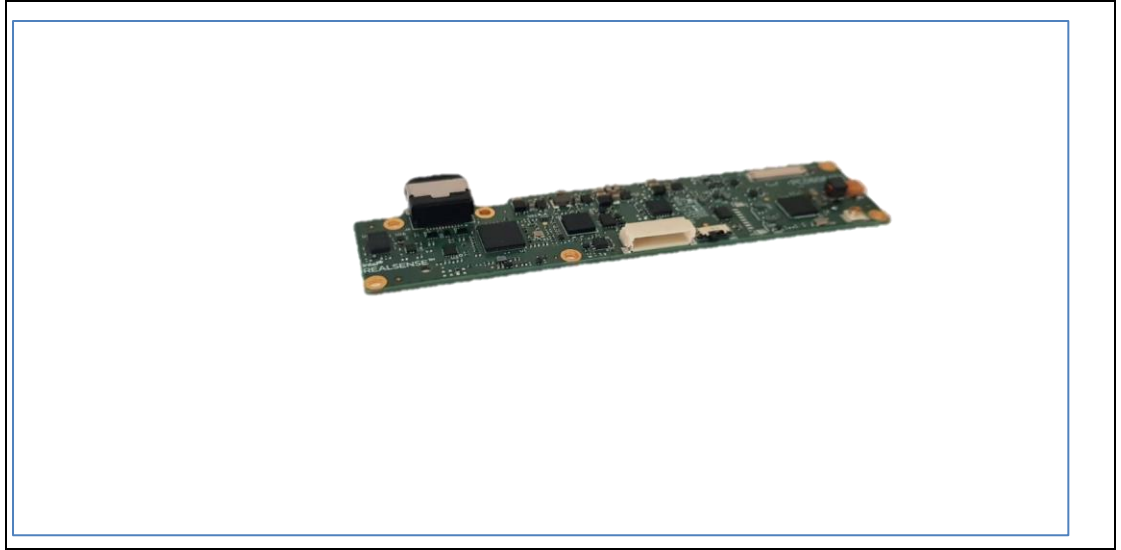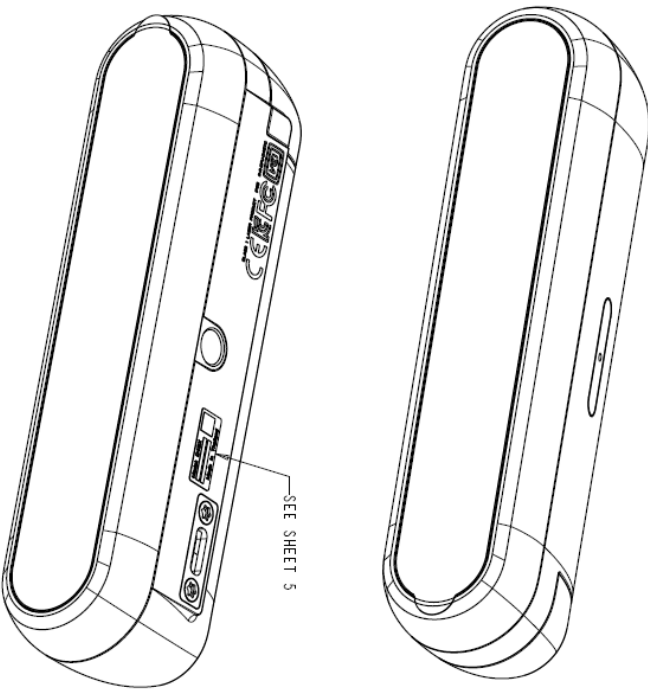**Figure 9-3. Intel® RealSense™ Depth Camera D457**

NOTES: UNLESS OTHERWISE SPECIFIED

MD0604401 NON EAC
3D MODEL DETAIL INFO FROM WINDCHILL

SEE SHEET 5

UNLESS OTHERWISE SPECIFIED
INTERPRET DIMENSIONS AND TOLERANCES
IN ACCORDANCE WITH ASME Y14.5M-2009
DIMENSIONS ARE IN MILLIMETERS
ALL
UNTOLERANCED LINEAR
DIMENSIONS ±0.2
ANGLES ±0.5

THIRD ANGLE PROJECTION

		DATE		
DESIGNED BY	-C.COGBURN	04/28/2021		
DRAWN BY	-C.COGBURN	DATE 04/28/2021		
CHECKED BY	ME:-	DATE DD/MM/YYYY		
	EE:-	DD/MM/YYYY		
APPROVED BY	-M.ARRANZ	DATE 08/30/2022		
MATERIAL SEE BOM	FINISH			

DEPARTMENT -

DESCRIPTION

(intel)

2200 MISSION COLLEGE BLVD.
P.O. BOX 58119 SANTA CLARA,
CA 95052-8119

TA, DS5, DEVKIT, D457

SIZE A2	INTEL IPN MD0604401	REV 05	ITER
SCALE: 2.000	DO NOT SCALE DRAWING	SHEET 1 OF 5	

REVISIONS HISTORY				
REV ITER	DESCRIPTION	REV BY	DATE	APPROVED
01	INITIAL RELEASE	-	21/10/2021	-
02	ADDED REF. DIMS, Z-ZERO DIMS, SHEET 5 W/INU DIMS, ADDED FARPA DIMS, UPDATED VIEWS	C.COGBURN	29/07/2022	
03	UPDATED LASER ETCHING	C.COGBURN	18/08/2022	
04	ADDED REFERENCE DIMENSIONS AND TOLERANCES	C.COGBURN	16/09/2022	
05	ADDED CUSTOMER OUTLINE INFORMATION	E STECK	05/12/2022	

MOUNTING HOLES AND CAMERAS
SHARE CENTERLINE

LENS REMOVED TO SHOW DETAIL

47.50±.10
FROM CENTERLINE OF 1/4-20

95.00±.10

11.50±.10
FROM CENTERLINE OF 1/4-20

38.00±.01
FROM CENTERLINE OF 1/4-20

61.50±.10

REALSENSE
intel

ALL DIMENSIONS AND TOLERANCES FOR REFERENCE ONLY

DEPARTMENT
-

2200 MISSION COLLEGE BLVD.
P.O. BOX 58119
SANTA CLARA, CA 95052-8119

SIZE A2

INTEL IPN
MD0604401

SCALE: 2.000

DO NOT SCALE DRAWING

REV 0.5

SHEET 3 OF 5

MD0604401NOVLENC
3D MODEL DETAIL INFO FROM MMDCELL

NOTES: UNLESS OTHERWISE SPECIFIED

1. THREE DIMENSIONAL CAD GEOMETRY PROVIDED BY INTEL SHALL BE USED FOR CREATION OD THIS PART OR ASSEMBLY. DRAWING SHALL BE USED TO IDENTIFY CRITICAL TOLERANCES AND REFERENCE FEATURES. FEATURES, DIMENSIONS ON DRAWING SHALL BE USED AS REFERENCE ONLY. UNLESS OTHERWISE SPECIFIED ON DRAWING.

2. ALL DIMENSIONS AND TOLERANCES APPLY PER ASME Y14.5M, 1994. IT IS EXPECTED THAT THE SUPPLIER UNDERSTAND AND COMPLY WITH ALL TOLERANCES AS DESCRIBED IN THIS STANDARD AND APPLIED TO THIS DRAWING.

3. WHEN DATUMS ARE SPECIFIED ON A DRAWING, DIMENSIONS ARE RELATED TO DATUM A (AS THE PRIMARY DATUM), DATUM B (SECONDARY), AND DATUM C (TERTIARY).

4. PERFECT ORIENTATION AND/OR PERFECT LOCATION AT MMC REQUIRED FOR THE INTERRELATIONSHIP OF ALL DATUM FEATURES OF SIZE, UNLESS OTHERWISE SPECIFIED ON DRAWING.

5. ALL TOOLING, FIXTURING AND OTHER UNIQUE ITEMS THAT ARE USED TO CREATE THIS PART ARE THE PROPERTY OF INTEL AND SHALL BE PERMANENTLY MARKED WITH INTEL NAME AND APPROPRIATE INTEL PART NUMBER.

6. PART MUST COMPLY WITH THE FOLLOWING REGULATED SUBSTANCE REQUIREMENTS: *EUROPEAN ROHS DIRECTIVE, 2002/95/EC

7. MATERIAL: ***-THERMAL TRANSFER , ***

8. ZEROES ONLY = THE STRING'000000'(6 TIMES '0') SHOULD BE CODED INTO THE 2D MATRIX ON ACTUAL UNIT.
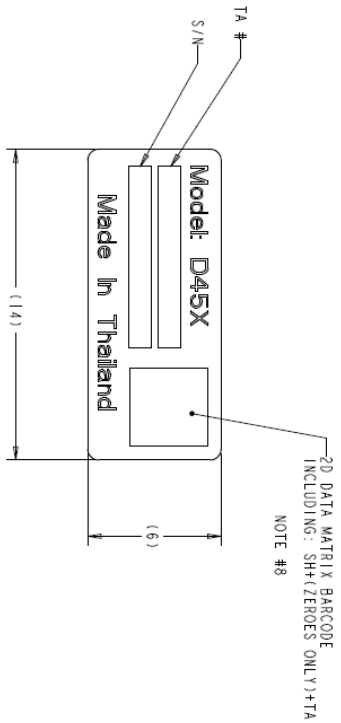
TA #
S/N

Model: D45X

Made In Thailand

(14)

(9)

(6)

2D DATA MATRIX BARCODE
INCLUDING: SN+(ZEROES ONLY)+TA
NOTE #8

MIS000371
3D MODEL DETAIL INFO FROM MARCHILL

DEPARTMENT
-

(intel)

2200 MISSION COLLEGE BLVD.
P.O. BOX 58119
SANTA CLARA, CA 95052-8119

SIZE A2
INTEL IPN
SCALE: 8.000

DO NOT SCALE DRAWING

MIS000371

REV 02

SHEET 5 OF 5

REVISIONS HISTORY

337029-011

Note: The 2x M4 mounting points with screw thread inserts will withstand a MAX torque ≤ 3.0Nm (tested M4 Zinc Plated Class 8.8 SHCS)

§§

10   Connector Drawings

Figure 10-1. Receptacle Mechanical Drawing (50 Pin Depth Module Receptacle)
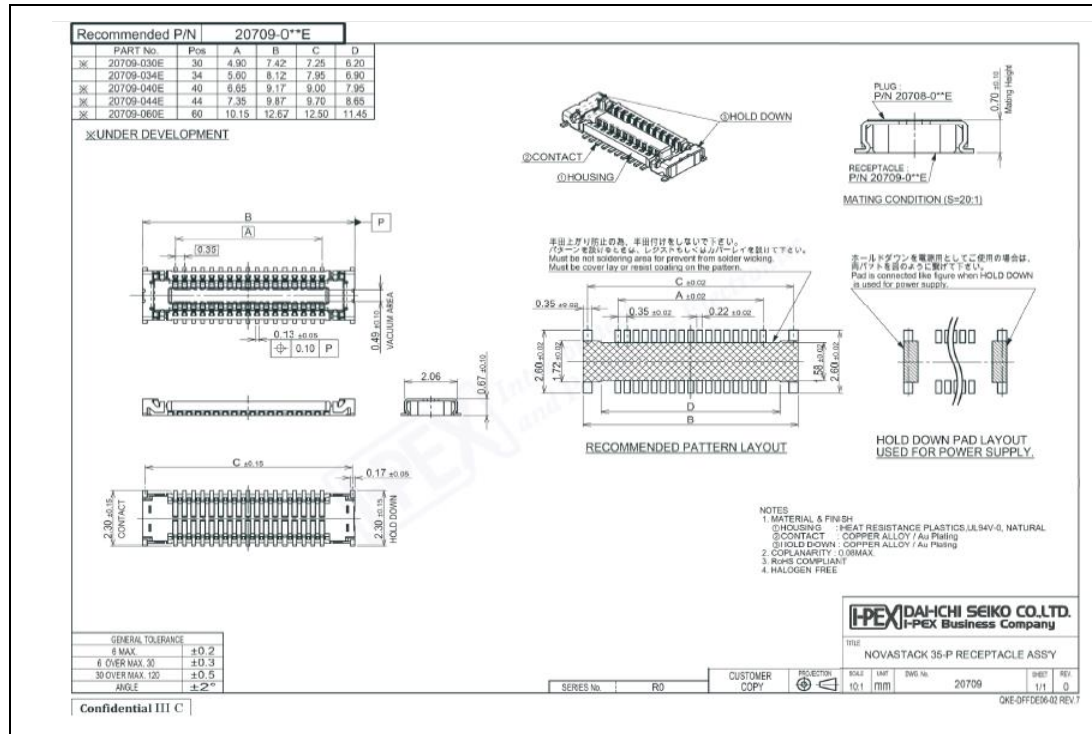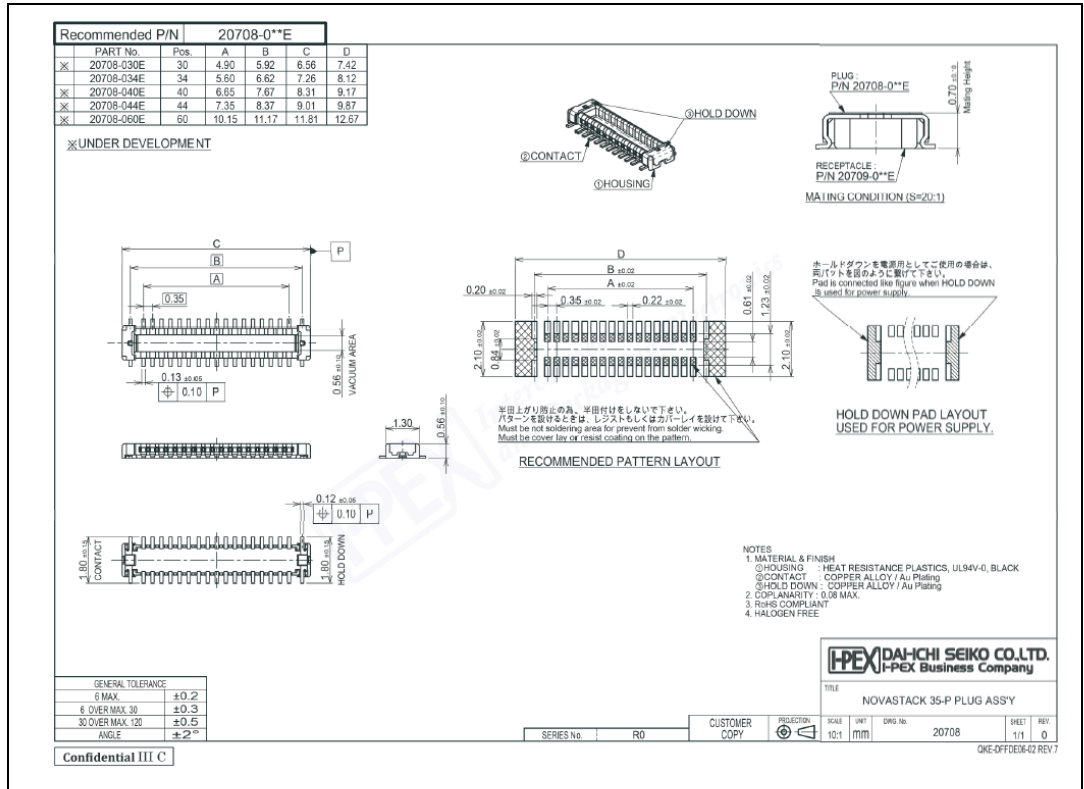
Figure 10-2. Plug Mechanical Drawing (50 pin Depth Module Plug)

§ §

11 *Appendix A- Cover Material*

Cover materials placed over the camera sensor must be carefully selected to avoid impacting software performance. The following parameters are an example of a suitable cover material. Other solutions are also acceptable but careful design and validation work should be done to verify a solution will perform adequately.

Table 11-1. Example: Cover Material Parameters

Specification	Recommendation	Notes
Hardness	6H	Prevent Scratches
Flatness	0.05mm	Minimize Distortion
Distance From Lens to Cover	Less than 8mm (D410/D415) Less than 2mm (D430)	Cover Material not to exceed 1mm thickness
Thickness of Cover	0.55mm ± 0.03mm	Cover Material not to exceed 1mm thickness
Coatings	• AR coating over internal cover window surface (ink surface) • AR+AF coating over external cover window surface (non-ink surface)	Avoid Reflections
Transmission Wavelength Range	400 to 865 (Visible and Infrared) @ 98% transmission rate or higher at all viewing and transmitting angles	
Cover Tilt Tolerance	± 1.0˚	

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