



FRAMOS Industrial Depth Camera D400e Series

USER MANUAL

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www.framos.com



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List of Abbreviations

Abbreviation	Explanation
SDK	Software Development Kit
NIC	Network Interface Card
I/O	Input/output
DC	Direct Current
GND	Ground
IN	Input
OUT	Output
RMA	Return material authorization
TBD	To Be Determined
DHCP	Dynamic Host Communication Protocol
LLA	Link-local address



1. Description and Features

1.1 Description

The FRAMOS Industrial Depth Camera D400e Series are built with Intel® RealSense™ technology. The depth cameras have industrial M12 ethernet and M8 power connectors. Its water and dust resistant housing is optimized for industrial environments. The FRAMOS Industrial Depth Camera D400e Series are ideal for OEMs and integrators who need 3D as well as 2D vision in their products and applications. The FRAMOS Industrial Depth Camera D400e Series are compatible with the Cross-platform SDK for Intel® RealSense™ devices, enabling multiple programming languages, wrappers, sample code and tools. FRAMOS D435e camera model features a wide field of view for depth and RGB sensors, and global shutter feature of the depth sensors allows for applications with fast motion.

1.2 Features

Resolution depth	D435e: 1280 x 720 px (global shutter) D415e: 1280 x 720 px (rolling shutter)
Resolution RGB	1920 x 1080 px (rolling shutter)
FOV depth (HxVxD)	D435e: 86° x 57° x 94° (+/- 3°) D415e: 65° x 40° x 72° (+/- 3°)
FOV RGB (HxVxD)	69° x 43° x 77° (+/- 3°)
Projector	Unstructured light in IR spectrum to enhance depth quality
Operating range	0,2m – 10m+
Streaming speed	30 fps for simultaneous RGB and depth streams @ 1280 x 720 px
Power consumption	6W (AUX) / 7W (PoE)
Housing material	Aluminium, anodized
Dimensions (LxHxW)	100mm x 47mm x 38mm
Mounting holes (backside)	4 x M3 ↓ 3,20mm
Connector 1*	M12 Ethernet, X-Coded (Data stream + PoE possible)
Connector 2*	M8, 8 pin, A-Coded (Power supply + GPIO)
Housing Grade	IP66 (IP67 possible on project basis)
Protection glass	AR coating, scratch resistant (6H)
Physical Interface	Gigabit ethernet
Camera weight	Ca. 250 grams

Table 1 – D400e Series Camera Features



1.3 Minimum System Requirements

Host PC Operating System:

- Microsoft® Windows® 10
- Linux Ubuntu 16.04

Host PC Architecture:

- x86_64
- ARM64 (NVIDIA® Jetson™ TX2)

Hardware:

- Gigabit Network Interface Card (NIC)



2. Introduction

2.1 Purpose of this Document

This document captures the specifications and the design—in details for the FRAMOS Industrial Depth Camera D400e Series. This document provides information necessary to understand and implement the camera system.

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.
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.
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.
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 D400e camera, the left imager is 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.
Platform camera	This refers to the two-dimensional (2D) color camera on platform.

Table 2 - Terminology

2.3 Stereo Vision Depth Technology Overview

The FRAMOS Industrial Depth Camera D400e Series use stereo vision to calculate depth. The stereo vision implementation consists of a left imager, right imager, and an optional infrared



projector. The infrared projector projects non-visible static IR pattern to improve depth accuracy in scenes with low texture. The left and right imagers capture the scene and send image data to the vision processor. The vision processor calculates depth values for each pixel in the image by correlating points on the left image to the right image. The depth pixel values are processed to generate a depth frame. Subsequent depth frames create a depth video stream.



3. Component Overview

3.1 Stereo Depth Module

The stereo depth module used in the D435e camera is the Intel® RealSense™ D430, while D415e implements Intel® RealSense™ D410 depth module. Properties of the Intel® RealSense™ depth modules are as follows:

D430	
Baseline	50mm
Left/Right Imagers Type	Wide
Depth FOV HD (degrees)	H:87±3 / V:58±1 / D:95±3
Depth FOV VGA (degrees)	H:75±3 / V:62±1 / D:89±3
IR Projector	Wide
IR Projector FOV	H:90 / V:63 / D:99
Module Dimensions (mm)	X=70.7mm / Y=14mm / Z=10.53mm

Table 3 – D430 Depth Module Properties

D410	
Baseline	55mm
Left/Right Imagers Type	Standard
Depth FOV HD (degrees)	H:65±2 / V:40±1 / D:72±2
Depth FOV VGA (degrees)	H:50±2 / V:40±1 / D:61±2
IR Projector	Standard
IR Projector FOV	H:67 / V:41 / D:75
Module Dimensions (mm)	X=74.7mm / Y=10mm / Z=4.7mm

Table 4 – D410 Depth Module Properties

H – Horizontal FOV, V – Vertical FOV, D – Diagonal FOV, X – Length, Y – Breadth, Z – Thickness

Depth FOV specified at 2 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.



3.2 Left and Right Imagers

D430	
Image Sensor	OmniVision OV9282
Active Pixels	1280 X 800
Sensor Aspect Ratio	8:5
Format	10-bit RAW
F Number	f/2.0
Focal Length	1.93mm
Filter Type	None
Focus	Fixed
Shutter Type	Global Shutter
Horizontal Field of View	91.2 deg
Vertical Field of View	65.5 deg
Diagonal Field of View	100.6 deg
Distortion	<=1.5%

Table 5 – D430 Imager Properties

D410	
Image Sensor	OmniVision OV2740
Active Pixels	1920 X 1080
Sensor Aspect Ratio	16:9
Format	10-bit RAW
F Number	f/2.0
Focal Length	1.88mm
Filter Type	None
Focus	Fixed
Shutter Type	Rolling Shutter
Horizontal Field of View	69.4 deg
Vertical Field of View	42.5 deg
Diagonal Field of View	77.0 deg
Distortion	<=1.5%

Table 6 – D410 Imager Properties



3.3 Infrared Projector

The infrared projector improves the ability of the stereo camera system to determine depth by projecting a static infrared pattern on the scene to increase texture on low texture scenes. The infrared projector meets class 1 laser safety under normal operation. The power delivery and laser safety circuits are on the stereo depth module. The infrared projector is referred as Standard or Wide based on field of projection.

D430	
Projector	Infrared
Pattern Type	Static
Illuminating Component	Vertical-cavity surface-emitting laser (VCSEL) + Optics
Laser Controller	PWM
Optical Power	360mW average, 4.25W peak
Laser Wavelength	850nm \pm 10 nm nominal @ 20°C
Laser Compliance	Class 1, IEC 60825-1:2007 Edition 2, IEC 60825-1:2014 Edition 3
H. Field of Projection	86° \pm 3°
V. Field of Projection	57° \pm 3°
D. Field of Projection	94° \pm 3°

Table 7 – D430 infrared projector properties

D410	
Projector	Infrared
Pattern Type	Static
Illuminating Component	Vertical-cavity surface-emitting laser (VCSEL) + Optics
Laser Controller	PWM
Optical Power	360mW average, 440mW peak
Laser Wavelength	850nm \pm 10 nm nominal @ 20°C
Laser Compliance	Class 1, IEC 60825-1:2007 Edition 2, IEC 60825-1:2014 Edition 3
H. Field of Projection	64° \pm 3°
V. Field of Projection	41° \pm 3°
D. Field of Projection	72° \pm 3°

Table 8 – D410 infrared projector properties



3.4 Color Sensor

The color sensor on the stereo depth module in addition to color image provides texture information. Usages for the texture information include overlay on a depth image to create a color point cloud and overlay on a 3D model for reconstruction.

Image Sensor	OmniVision OV2740
Color Image Signal Processor	Discrete
Active Pixels	1920 X 1080
Sensor Aspect Ratio	16:9
Format	10-bit RAW RGB
F Number	f/2.0
Focal Length	1.88mm
Filter Type	IR Cut Filter
Focus	Fixed
Shutter Type	Rolling Shutter
Horizontal Field of View	69.4 deg
Vertical Field of View	42.5 deg
Diagonal Field of View	77 deg
Distortion	<=1.5%

Table 9 – Color Sensor Properties

3.5 Labels on the Camera

The label on the sticker of the camera indicates two numbers:

PC = Product Code	With this number you can purchase the exact same product at FRAMOS.
SN = Serial Number	This is the unique identifier of a single camera. For support and RMA cases, this number is necessary.

Table 10 – Camera Labels

3.6 Thermal Control

The camera has thermal sensors implemented that prevent the camera from taking damage by overheating. The temperature is mainly regulated by the measured housing temperature. Once it exceeds 60°C, the intensity of the projector is reduced and eventually it will be switched OFF.

Most of the heat is conducted to the rear plate of the camera. Therefore, heat conductive material for mounting the camera is recommended.

3.7 Mechanical Dimensions

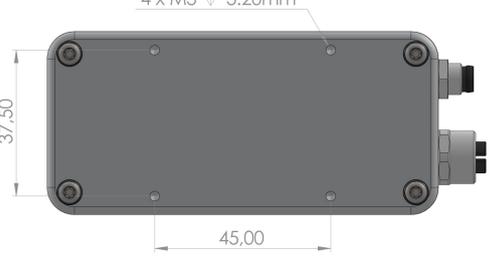
<p>Front View D435e</p>	
<p>Front View D415e</p>	
<p>Side View D435e/D415e</p>	
<p>Back View D435e/D415e</p>	

Table 11 – D400e Series Camera Dimensions

3.8 Storage and Operating Conditions

Condition	Description	Min	Max	Unit
Storage (not operating)	Temperature (Sustained, Controlled)	-20	70	°C
	Relative Humidity	5	95	% non condensing
Case Temperature (operating)	Temperature	0	60	°C

Table 12 – Storage and Operating Conditions

3.9 Connectors and PINs of M12 and M8

3.9.1 Ethernet M12 connector, X-Coded, Female

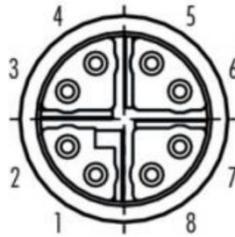


Figure 1 – M12 PIN Layout

M12 Pin	RJ45
1	1 (MX0+)
2	2 (MX0-)
3	3 (MX1+)
4	6 (MX1-)
5	7 (MX3+)
6	8 (MX3-)
7	5 (MX2-)
8	4 (MX2+)

Table 13 – M12 PIN Layout

3.9.2 Power M8 connector, A-Coded, Male

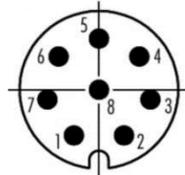


Figure 2 – M8 PIN Layout

M8 Pin	Description
1	DC Power supply, 12-24V DC (+/- 10%)
2	Opto isolated IN
3	Opto isolated OUT
4	GND for opto isolated I/O
5	Direct coupled I/O 1 (optional)
6	Direct coupled I/O 2 (optional)
7	Not used
8	Power GND

Table 14 – M8 PIN Layout

3.10 Power Consumption

Condition	Typical	Max
Power via M8	5.5W	7W
Power via M12 (PoE)	6.9W	8W

Table 15 – D400e Series Camera Power Consumption



4. Optimum Thermal Conditions

4.1 Fundamentals of the Camera's Heat Dissipation

The power consumption of the D400e cameras is the main determining factor for heat creation inside the camera, which depends on the operation mode of the camera. In the case that all available functionality of the camera (i.e. frame rates or projector intensity) is used at maximum capacity, the power consumption and thus the heat generation increases accordingly. Aside from the resource utilization of the camera, the power supply option also has a large effect on power consumption. PoE (power over Ethernet) has a higher power consumption due to the uneven efficiency of circuitry compared to the circuitry used when powering the camera via the M8 connector.

Power Supply Option	Max.
Power via M8	7W
Power via M12 (PoE)	8W

Table 16 – D400e Maximum Power Consumption

Most of the power consumed by the camera is converted to heat and consequently, the camera will generate heat that is released to the ambient via the camera's housing.

Due to the internal structure of the camera, most heat dissipation will happen via the back side. Therefore, this part of the camera body is intended for thermal coupling with an external dissipative element such as a camera holder or stand. In tabletop applications, a simple heatsink element can be used. It is recommended to use metal parts for camera mounts to assure a good thermal conductivity on the back side of the camera body. Four M3 threaded holes are available on the camera back side to attach the camera to a mounting facility. It is recommended to use thermal paste on the contact surface between the camera and the heatsink for maximum thermal conductivity.

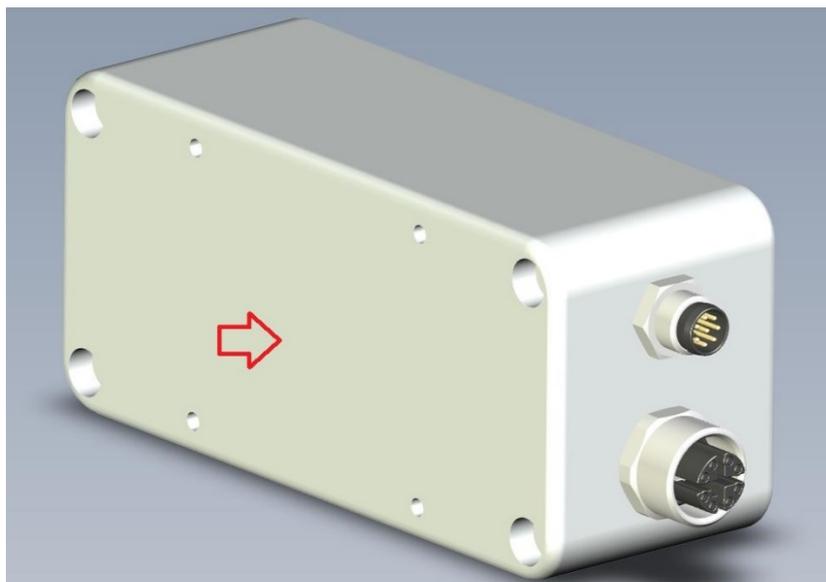


Figure 3 – Hottest Part of the Camera Housing



The maximum allowed operating temperature of the camera is defined as the temperature measured on the camera housing on the back side of the case, as shown in the figure above.

Operating Temperature	Min.	Max.
Temperature of the case (measured on the back side of the camera)	0 °C	60 °C

Table 17 – D400e Operating Temperature

Exceeding the maximum operating temperature defined in the table above can lead to permanent damage of the camera. The thermal dynamic of the camera is relatively slow due to the mass of the housing and its internal construction. Therefore, more than 1.5h of steady operation under an unchanged ambient condition, is necessary for the camera to reach the thermal steady state.

The camera operator should be aware of the camera settings that affect power consumption (framerate, laser usage, ...), the power supply options and environmental conditions, to assure that the camera remains in a safe temperature range at all time. Examples of using appropriate heatsinks are discussed in the following chapter.

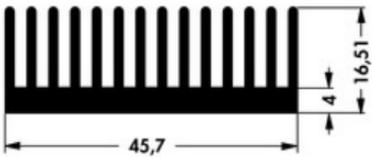
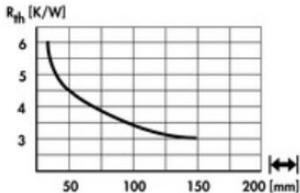
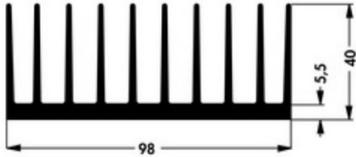
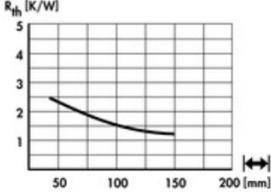
4.2 Operating Conditions for Different Temperatures

Depending on the ambient conditions, the camera can either operate without any additional heat dissipation element or with an adequate heatsink attached. The allowed maximum ambient temperatures are given for different operating modes of the camera, to indicate at which configuration the camera can run in several application use cases.

Use case:	Description:
Typical1	Power supply: M8, 12V Exposure time: 5 ms Framerate: 30 fps Laser projector power: 150 mW
Typical2	Power supply: M12, PoE Exposure time: 5ms Framerate: 30 fps Laser projector power: 150mW
Max1	Power supply: M8, 12V Exposure time: 30 ms Framerate: 30 fps Laser projector power: 360 mW
Max2	Power supply: M12, PoE Exposure time: 30 ms Framerate: 30 fps Laser projector power: 360 mW

Table 18 – Operating Conditions for Different Temperatures

The table below lists several heat dissipation elements that can be used to keep the camera in a safe operation mode.

Heatsink:	Description:
H0	No heatsink attached
H1 - passive	<p>SK 424 75 ME Heatsink length: 75 mm Thermal resistance: approx. 3.8 K/W</p>   
H2 - passive	<p>SK 408 50 ME Heatsink length: 50 mm Thermal resistance: approx. 2.3 K/W</p>   
H3 - passive	<p>SK 530 100 AL Heatsink length: 100 mm Thermal resistance: approx. 0.38 K/W</p>

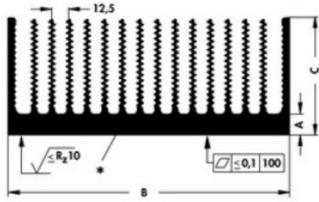
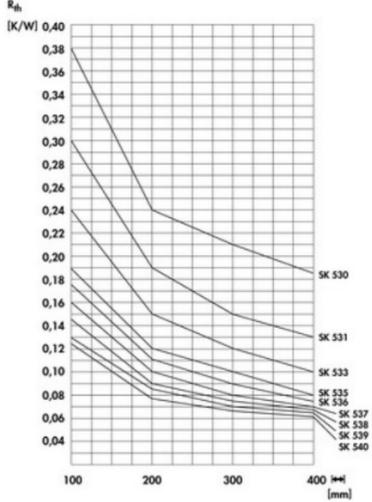
	   <p>A: 15 mm B: 200 mm C: 84 mm</p>
<p>H4 - active</p>	<p>SK 424 75 ME Heatsink length: 75 mm Cooling fan: Xilence XPF40</p> 

Table 19 – Heat Dissipation Elements



4.3 Maximum Operating Ambient Temperatures

The table below is showing maximal allowed ambient temperatures that keep the camera working within its safe operating temperature range. These results can be used when defining a cooling solution for a specific camera use case.

The given information is based on testing the camera in its thermal steady state using a thermal test chamber. In the chamber, there was no airflow at all. A temperature measurement error of $\pm 1^\circ\text{C}$ is possible.

Operating mode Cooling option	Typical1	Typical2	Max1	Max2
H0 – no heatsink	32 °C	28 °C	26 °C	25 °C
H1 – passive	37 °C	33 °C	33 °C	31 °C
H2 – passive	45 °C	44 °C	44 °C	42 °C
H3 – passive	53 °C	52 °C	52 °C	51 °C
H4 – active	54 °C	53 °C	53 °C	52 °C

Table 20 – Maximum Operating Ambient Temperatures

4.4 Summary of Operating Conditions and Temperatures

Depending on the operation mode of the camera and the applied heat dissipation elements, ambient temperatures between 25°C and 54°C are possible. Table 20 shows that camera can operate in normal indoor environments (up to 31°C – 37°C) with very small heatsink such as H1. For moderately increased ambient temperatures, larger heat sinks must be used. H2 is showing the tradeoff between heatsink size and maximal allowed ambient temperatures at 42°C – 45°C. For very high ambient temperatures either large heatsink elements (H3) or active cooling (H4) must be used.

Without any heatsink attached, the camera can sustain ambient temperature 25°C – 32°C, depending on its utilization rate. Considering the fact, that in most cases the camera will be fixed on a mount, the inherent heat dissipation will likely be better than shown in H0. Consequently, the allowed ambient temperature will be higher than indicated in the H0 column. By choosing the appropriate camera holder, sufficient thermal conductivity for most typical applications can be achieved.

The specific customer application will differ from the examples shown above and every solution will require a thermal analysis to ensure safe and reliable operation of the camera. Given information should be used as a guideline at customers system design time.



Recommendation: Use metal camera mount to assure optimal heat conductivity (avoid plastic mounts).



Recommendation: In case there is a problem with overheating rather use external power supply than PoE.



Recommendation: Minimize the resource utilization (i.e. fps, exposure, projector intensity) of the camera, which will positively affect heat generation and longevity of the product.



5. Mounting and Deployment

5.1 Camera Mounting

D400e cameras are designed to support mounting on the back side of the housing. The internal structure of the device is designed to dissipate most of the generated heat through this part of camera housing. Therefore, it is recommended to use a holder or stand which will ensure good mechanical stability of the camera but also act as a thermal drain. For this purpose, metal parts with high thermal conductivity and which are physically connected to a large part of the camera back side, are recommended. Please avoid materials like plastic, rubber or similar materials with high thermal resistance.

On the back side of the camera body, four M3 thread holes are available for mounting. Since the housing is made of aluminum and M3 thread holes depth is 3.2mm, care is required when tightening the screws to avoid thread damage. Applied tightening torque should not exceed 100 cNm for these screws.

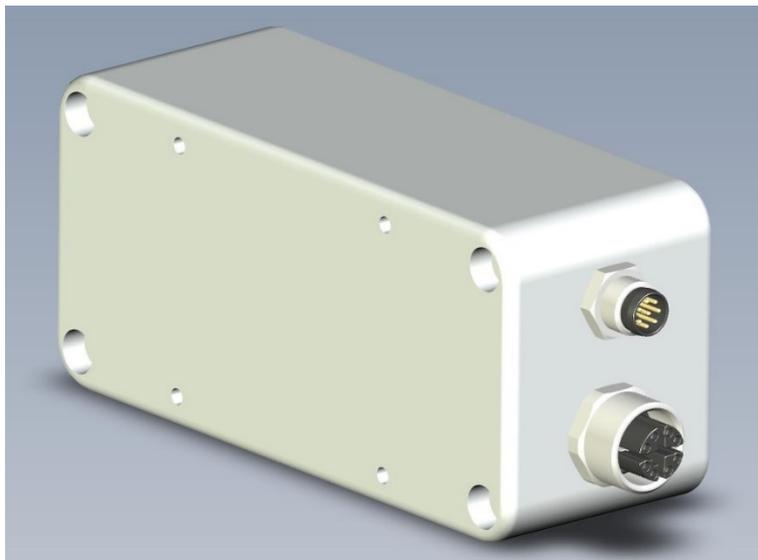


Figure 4 – D400e Series Camera Body Back Side

The camera is constructed for operation in industrial environments and can be used with moving objects. For this purpose, it is tested and compliant according to: EN 60068-2-6, EN 60068-2-64 and EN 60068-2-27 norms. However, stronger shock and vibration can lead to damage of sensitive optical and electronic components inside the camera. Dropping the camera or colliding it with any surface can lead to severe damage.

5.2 Application of External Cabling

The camera interface has a M8 and a M12 industrial grade connector. The M8 connector is used for power supply and external synchronization while the M12 connector serves for data transmission



and power over Ethernet (in case the M8 connector is not used for power supply). Both are receptacles for relatively large external cable connectors.

When connecting the camera with external cable connectors (either M8 or M12), the corresponding camera connector nut should be held with an appropriate wrench. In case the nut is not held by a wrench, the respective connector could be turned together with cable, when force is applied. This should be prevented as it could cause damage to the internal camera wiring. At the time of camera delivery, the M8 connector will be covered with a protective plastic cap. This cap should stay on in the case that the camera is used with a power over Ethernet (PoE) supply, and protect the unused connector against impurities and moisture, keeping it ready for future use.



Recommendation: When attaching M8 and M12 cables to camera, connectors should be fixed with a tool (wrench/key) so that the connectors do not rotate under force.

5.3 Cleaning Procedures

Depending on the operating environment, the camera needs to be cleaned from time to time. For cleaning the camera housing, it is recommended to use a soft camera cleaning brush or a soft cleaning cloth.

Using an eyeglass cleaning cloth is recommended for cleaning the camera glass window. Although the hardness of used glass is grade 6H, special attention is required when cleaning the window to prevent long term decreasing of optical properties. Using inadequate cleaning materials can cause micro scratches of the camera window.

Ethyl alcohol can be used for light wiping of the entire camera housing. Using strong solvents is not recommended and can lead to aesthetic or functional damage of the camera.



6. Functional Specification

6.1 Stream Configurations Possible

The theoretical maximum throughput on a Gigabit Ethernet link is 125 MB/s. To calculate the bandwidth required for specific stream configuration on D400e camera use the following formula:

$$\begin{aligned}
 BPP &= \text{Bytes per pixel} \\
 Depth_{BPP} &= 2 BPP \\
 Infrared1_{BPP} &= 1 BPP \\
 Infrared2_{BPP} &= 1 BPP \\
 RGB_{BPP} &= 2 BPP
 \end{aligned}$$

$$\begin{aligned}
 Bandwidth_{REQ} &= Depth_{BPP} * Depth_{WIDTH} * Depth_{HEIGHT} * Depth_{FPS} + \\
 &Infrared1_{BPP} * Infrared1_{WIDTH} * Infrared1_{HEIGHT} * Infrared1_{FPS} + \\
 &Infrared2_{BPP} * Infrared2_{WIDTH} * Infrared2_{HEIGHT} * Infrared2_{FPS} + \\
 &RGB_{BPP} * RGB_{WIDTH} * RGB_{HEIGHT} * RGB_{FPS}
 \end{aligned}$$

Example of a bandwidth calculation is given below (Depth profile 640x480@30fps with both left and right infrared streams enabled, RGB profile 848x480@30fps):

$$\begin{aligned}
 Depth_{WIDTH} &= Infrared1_{WIDTH} = Infrared2_{WIDTH} = 640 \\
 Depth_{HEIGHT} &= Infrared1_{HEIGHT} = Infrared2_{HEIGHT} = 480 \\
 RGB_{WIDTH} &= 848 \\
 RGB_{HEIGHT} &= 480 \\
 Depth_{FPS} &= Infrared1_{FPS} = Infrared2_{FPS} = RGB_{FPS} = 30
 \end{aligned}$$

$$\begin{aligned}
 Bandwidth_{REQ} &= 2 * 640 * 480 * 30 + \\
 &1 * 640 * 480 * 30 + \\
 &1 * 640 * 480 * 30 + \\
 &2 * 848 * 480 * 30 = \\
 &61286400 B/s = 61.29 MB/s
 \end{aligned}$$

Depth	RGB	60fps	30fps	25fps	15fps	6fps
1280x720	1920x1080	-	-	-	ok	ok
1280x720	1280x720	-	ok	ok	ok	ok
848x480	960x540	ok	ok	ok	ok	ok
848x480	848x480	ok	ok	ok	ok	ok
848x480	1920x1080	-	-	-	ok	ok
640x480	640x480	ok	ok	ok	ok	ok
640x360	640x360	ok	ok	ok	ok	ok
424x240	424x240	ok	ok	ok	ok	ok

Table 21 – Example of Possible Streams on Gigabit Ethernet Network



6.2 Depth Field of View (FOV)

Format	FOV D435e	FOV D415e
Horizontal FOV (VGA 4:3)	74°	48°
Vertical FOV (VGA 4:3)	62°	40°
Diagonal FOV (4:3)	88°	60°
Horizontal FOV (HD 16:9)	86°	64°
Vertical FOV (HD 16:9)	57°	41°
Diagonal FOV (HD 16:9)	94°	72°

Table 22 – Depth FOV



Information: The Depth FOV specified is at 2 meters distance. Due to mechanical tolerances of +/-5%, Max and Min FOV values can vary from lens to lens and module to module by ~ +/- 3 degrees.

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

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

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

6.3 Minimum-Z Depth

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

Resolution	D435e Min-Z (mm)	D415e Min-Z (mm)
1280x720	280	450
960x540	195	310
848x480	175	310
640x480	150	240
640x360	120	180
424x240	105	160

Table 23 – Minimum-Z Depth



6.4 Depth Accuracy

For depth accuracy and the optimum settings of the camera, please refer to *Best-Known-Methods for Tuning Intel® RealSense™ D400 Depth Cameras for Best Performance* [Ref-5].

Generally, z-accuracy (or absolute error) of the camera should be < 2% of the measured distance.

6.5 Depth Camera Functions

Control	Description	Min	Max
Manual Exposure(1) (µs)	Control sensor exposure period	1	165000
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	Auto Exposure on a selected ROI	T-0 L-0 B-1 R-1	T-719 L-1279 B-720 R-1280

Table 24 – Depth Camera Functions

NOTES:

(1) – Not supported in Auto Exposure Mode

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

6.6 Color Camera Functions

Control	Description	Min	Max
Auto-Exposure Mode	Automatically sets the exposure time and gain for the frame.	0	1
Auto Exposure ROI	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 (100µs unit)	Sets the absolute exposure time when autoexposure is disabled.	1	10000



Brightness	Sets the amount of brightness applied when autoexposure 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 autoexposure 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
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	4
Backlight Compensation	Sets a weighting amount based on brightness to the frame.	0	1
Low Light Comp	Low Light	0	1

Table 25 – Color Camera Functions

6.7 D400e Camera Specific Features

6.7.1 Packet Size

The Packet Size feature specifies the stream packet size in bytes. It can be configured separately for Depth and RGB streams. Optimum value of the Packet Size feature is automatically calculated by the software, but it can be manually overridden. Increasing Packet Size is generally beneficial for the overall system performance. For more information please refer to *FRAMOS Industrial Depth Camera D400e Series - Tuning System For Best Performance* [Ref-4].



Recommendation: Enable Jumbo Frames in the Network Adapter Advanced settings to allow using larger Packet Size values. This reduces the number of packets sent by the camera, thus reducing the packet overhead and workload of the host NIC.



6.7.2 Inter Packet Delay

The Inter Packet Delay is the delay introduced by the camera between sending two consecutive packets on the stream channel. This delay reduces the effective network load (on NIC or switch) and creates timeslots for processing packets from other devices on the network. The Inter Packet Delay is very useful when multiple cameras are streaming to one PC on the same Network Interface Card (NIC). For more information please refer to *FRAMOS Industrial Depth Camera D400e Series - Tuning System For Best Performance* [Ref-4].

6.7.3 Heartbeat Time

Heartbeat mechanism is used to determine whether the logical link between D400e camera and application running on host is active. Host sends the heartbeat command to the camera in regular intervals and the camera sends a response. If the camera does not respond in a certain interval, the host considers the camera disconnected. If the camera does not receive a heartbeat command in the same interval, it considers the host disconnected.

For more information please refer to document `d400e_api_extensions.md` (part of the D400e software package).

6.7.4 Intercam Sync Mode

Enables synchronous streaming of multiple cameras and stream synchronization to an external event. D400e camera provides the following Inter Cam Sync modes:

- Default
- Master
- Slave
- External Event

Inter Cam Sync Mode feature in conjunction with Output Trigger Enabled and User Output Level features defines the state of the M8 power connector pin 3 (Opto-Isolated Output).

For more information please refer to *FRAMOS Industrial Depth Camera D400e Series - External Event Camera Synchronization* [Ref-2] and *FRAMOS Industrial Depth Camera D400e Series - Multi-Camera Synchronization* [Ref-3].

6.7.5 Output Trigger Enabled

Output Trigger Enabled feature switches between the synchronization signal VSYNC (described in *FRAMOS Industrial Depth Camera D400e Series - External Event Camera Synchronization* [Ref-2]) and user controllable output.

When enabled VSYNC is selected as M8 Pin 3 driver. VSYNC drives pin in all Inter Cam Sync modes.

When disabled, user can change the state of the M8 Pin 3 with the User Output Level feature.

6.7.6 User Output Level

Enables the user to set the signal level of a M8 Pin 3 (Opto-Isolated Output) to the low or high voltage level. This can be used to control the external lighting or other devices.

User Output Level is active in all Inter Cam Sync modes when Output Trigger Enabled is disabled.

Output Trigger Enabled and User Output Level features behavior are shown in Figure 5.

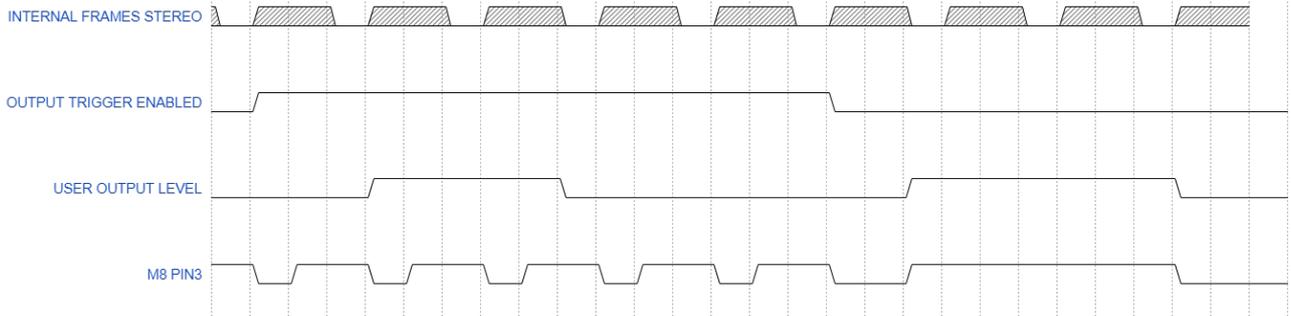


Figure 5 – D400e M8 Pin 3 Behavior

6.7.7 Line Debouncer Time

The Line Debouncer Time feature defines the minimum interval in microseconds that an input signal on M8 Pin 2 (Opto-Isolated Input) must remain active to be recognized as a valid trigger. The Line Debouncer Time is used to prevent possible unwanted trigger events as it eliminates short noises that could easily be interpreted as a trigger signal.

Line Debouncer Time functionality is shown in Figure 6. Trigger signal has three glitches that are ignored because the width of these signals is shorter than the Line Debouncer Time. The fourth signal is accepted as a valid trigger signal as its width is longer than the Line Debouncer Time.

The Line Debouncer Time effectively increases delay time between the external trigger (signal on M8 Pin 2) and the internal trigger which is used to start the camera event, so it should be set large enough to filter unwanted glitches, but small enough to keep the delay as small as possible.

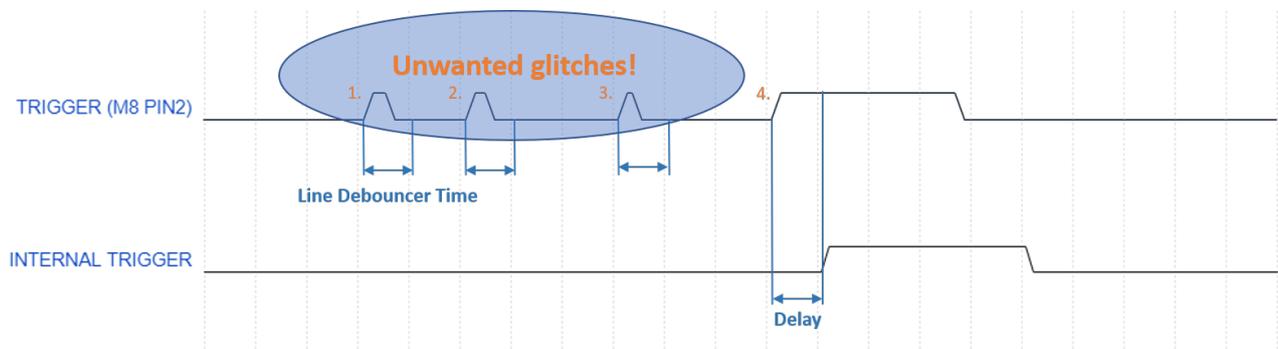


Figure 6 – D400e Line Debouncer Time



Information: The Line Debouncer Time feature affects the camera when it is operating in "Slave" or "External Event" Inter Cam Sync mode. Always set Line Debouncer Time to a value smaller than the width of the signal applied on M8 Pin 2 (Opto-Isolated Input).

6.7.8 RGB/Stereo Synchronization

By default, FRAMOS D400e camera operates in the "Default" operating mode, with asynchronous streams from the RGB and Stereo sensor. For explanation on the camera operating modes please refer to *FRAMOS Industrial Depth Camera D400e Series - Multi-Camera Synchronization* [Ref-3].

To achieve synchronization between the RGB and Stereo stream make sure of the following:

- Inter Cam Sync Mode is set to "Default Mode" or "External Event Mode"
- RGB Auto Exposure Priority option is disabled
- RGB and Stereo framerates matches

When streams are synchronized, there is a constant delay between the frames as shown in Figure 7.

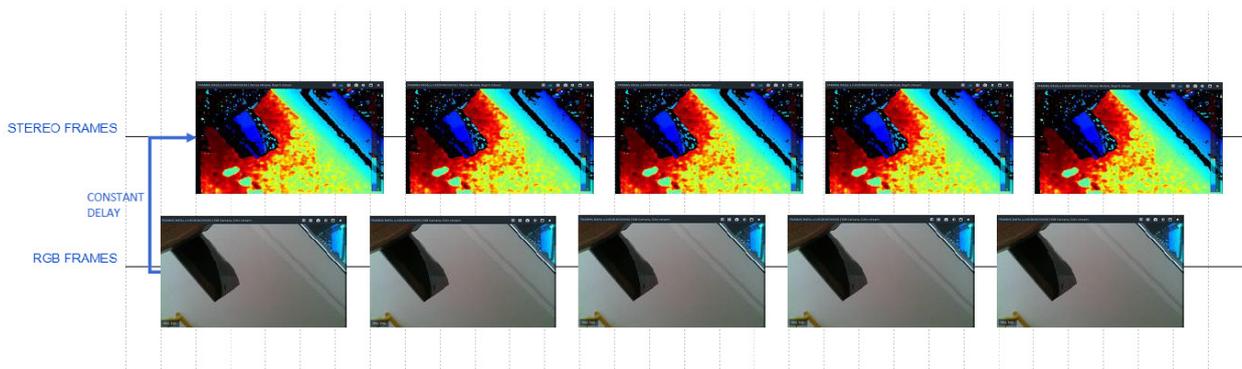


Figure 7 – D400e Series Camera Synchronized Streams

With streams out of synchronization, RGB and Stereo streams drift apart over time as shown in Figure 8.

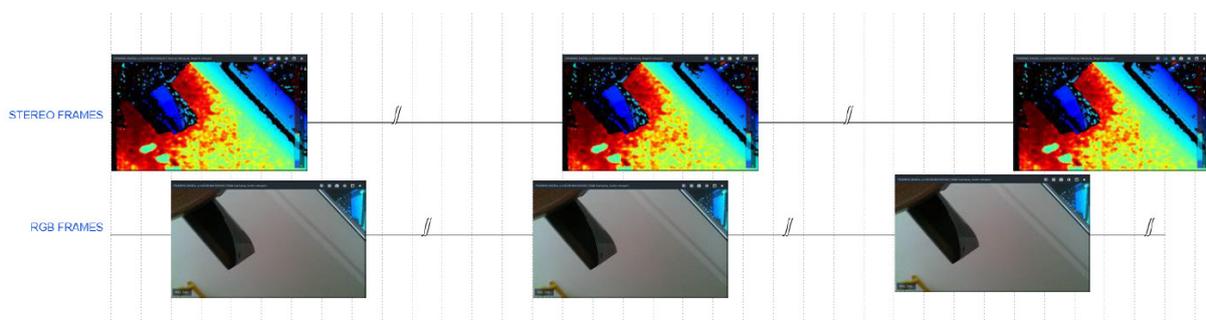


Figure 8 – D400e Series Camera Streams out of Synchronization



Recommendation: Use synchronization with Auto Exposure option enabled for both RGB and Stereo sensor.

6.7.9 Syncer Mode

D400e cameras have a possibility to synchronize streams to an external event (using Inter Cam Sync Mode External Event operating mode).

As the frequency of external events is not known in front, "syncer module" in librealsense2 is extended to handle this case. Available syncer options in the librealsense2 API are listed in the `rs2_syncer_mode` enumeration available in the `librealsense2/h/rs_types.h` header file:

```
// Syncer Mode
typedef enum rs2_syncer_mode
{
    RS2_SYNCER_MODE_DEFAULT, //default syncer mode
    RS2_SYNCER_MODE_WAIT_FRAMESET, // wait-for-full-frameset syncer mode
    RS2_SYNCER_MODE_COUNT
};
```

The `RS2_SYNCER_MODE_DEFAULT` enumerator represents the default working mode of the syncer module (original librealsense2 syncer implementation) in which the same frame, in certain situations, can be returned in consecutive framesets by "wait_for_frames" call, as shown in Figure 9.

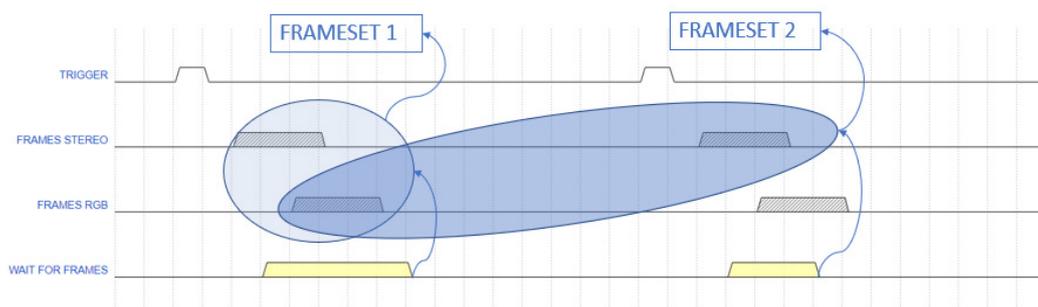


Figure 9 – Syncer Default Mode

The `RS2_SYNCER_MODE_WAIT_FRAMESET` enumerator represents the wait-for-full-frameset mode of the syncer module with the support for external events specific to D400e cameras. In this mode, syncer returns synchronized frameset only when frames from all enabled streams have arrived, as shown in Figure 10.

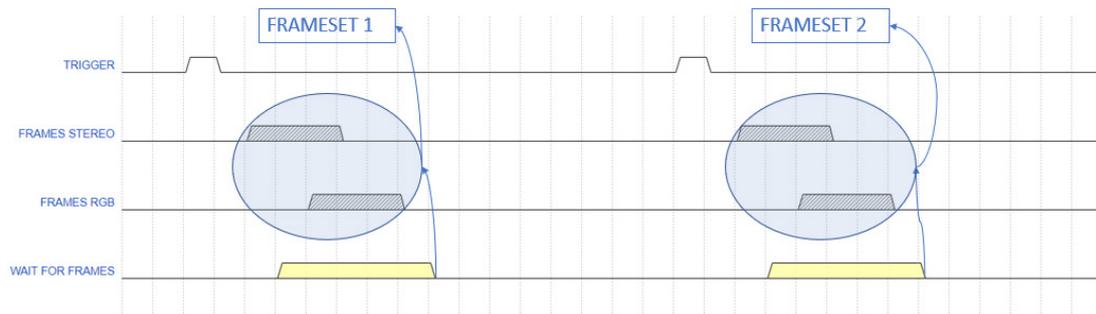


Figure 10 – Syncer Wait-For-Frameset Mode

Syncer mode can be set only through API using the following code snippets:

```

`cpp
rs2::config cfg; //config object
cfg.set_syncer_mode(RS2_SYNCER_MODE_WAIT_FRAMESET);
`

`c
rs2_error* e = 0;
rs2_config* config = rs2_create_config(&e);
check_error(e);
rs2_config_set_syncer_mode(config, RS2_SYNCER_MODE_WAIT_FRAMESET, &e);
`

`python
config = rs.config()
config.set_syncer_mode(rs.syncer_mode.wait_frameset)
`

```



7. Firmware Updates

The firmware contains the operational instructions. Firmware on the camera can be upgraded via Ethernet interface. This allows implementing new features and potential bug fixes using the firmware update tool.

UpdateFirmware tool

The UpdateFirmware tool is used to update the firmware on FRAMOS Industrial Depth Cameras. The firmware update file is verified by the tool for compatibility with selected camera before firmware update process is initiated.

Usage example on Linux:

```
./UpdateFirmware FRAMOS_D435e_r1111_v1_7_0_0.fw_update
```

```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./UpdateFirmware FRAMOS_D435e_r1111_v1_7_0_0.fw_update

FRAMOS Camera Firmware Update Tool (v1.3.1.0)
=====
Index  Vendor  Model  IP          MAC          Version      Available
  0     Framos  D435e  192.168.1.10 6C:D1:46:03:00:37 HW:1.1_FW:1.7.0.0 Yes

Connect on camera by entering index number. Rescan? [Y/n]
Index: █
```

Figure 11 - Tool UpdateFirmware Part1

Select camera from list, and confirm to initiate firmware update procedure:

```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./UpdateFirmware FRAMOS_D435e_r1111_v1_7_0_0.fw_update

FRAMOS Camera Firmware Update Tool (v1.3.1.0)
=====
Index  Vendor  Model  IP          MAC          Version      Available
  0     Framos  D435e  192.168.1.10 6C:D1:46:03:00:37 HW:1.1_FW:1.7.0.0 Yes

Connect on camera by entering index number. Rescan? [Y/n]
Index: 0

Successfully connected to device:

Vendor  Model  IP          Version
Framos  D435e  192.168.1.10 HW:1.1_FW:1.7.0.0

Loaded Firmware Update file from disk:
FRAMOS_D435e_r1111_v1_7_0_0.fw_update

Download above Firmware Update file to connected device? [y/N]
y
Firmware Update procedure begins...
Completion: 7%
Completion: 15%
Completion: 23%
Completion: 30%
Completion: 38%
Completion: 46%
Completion: 53%
Completion: 54%
█
```

Figure 12 – Tool UpdateFirmware Part2

When the progress information reaches 100%, firmware update is complete. Firmware update procedure on Windows is identical.



7.1 Parallel Firmware Update

The UpdateFirmware tool can upgrade multiple cameras at the same time.

Usage example on Linux:

```
./UpdateFirmware FRAMOS_D415e_r1111_v1_3_0_0.fw_update
```

Enter keyword “all” to select all available cameras:

```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./UpdateFirmware FRAMOS_D415e_r1111_v1_3_0_0.fw_update
FRAMOS Camera Firmware Update Tool (v1.3.1.0)
=====
Index   Vendor   Model    IP          MAC          Version      Available
  0     Framos   D415e    192.168.1.6  6C:D1:46:03:0D:30  HW:1.1_FW:1.3.0.0  Yes
  1     Framos   D415e    192.168.1.5  6C:D1:46:03:0D:29  HW:1.1_FW:1.3.0.0  Yes
Connect on camera by entering index number. Rescan? [Y/n]
Index: all
```

Figure 13 - Tool UpdateFirmware Parallel Part1

Firmware update procedure will start on all cameras that are compatible with the selected firmware update file. If there are cameras in the list that are not compatible with firmware update file, the UpdateFirmware tool will simply ignore these cameras and will inform user about incompatibility at the end of the firmware update procedure.

```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./UpdateFirmware FRAMOS_D415e_r1111_v1_3_0_0.fw_update
FRAMOS Camera Firmware Update Tool (v1.3.1.0)
=====
Index   Vendor   Model    IP          MAC          Version      Available
  0     Framos   D415e    192.168.1.6  6C:D1:46:03:0D:30  HW:1.1_FW:1.3.0.0  Yes
  1     Framos   D415e    192.168.1.5  6C:D1:46:03:0D:29  HW:1.1_FW:1.3.0.0  Yes
Connect on camera by entering index number. Rescan? [Y/n]
Index: all
Filter-out devices? [y/N]
n
[6CD146030D30] (HW:1.1_FW:1.3.0.0)
[6CD146030D29] (HW:1.1_FW:1.3.0.0)
Firmware update will be executed on a selected devices above, continue? [y/N]
(FRAMOS_D415e_r1111_v1_3_0_0.fw_update)
y
Firmware update started. It can take couple of minutes (~4) ...
(assure there is no power disruption for the whole duration of the procedure)
>>>>>>>>
```

Figure 14 – Tool UpdateFirmware Parallel Part2

On firmware update procedure completion, the UpdateFirmware tool will list cameras with corresponding firmware update status message (firmware update pass / fail).



Recommendation: When performing firmware update on multiple cameras, it is recommended to perform firmware update on smaller batch first and verify result, and then update firmware on other cameras.



8. Software

Instructions how to quickly start up the camera can be found in the quick start guide:

FRAMOS Industrial Depth Camera D400e Series - Getting Started [Ref-6].

8.1 FRAMOS Camera Suite SDK

The FRAMOS CameraSuite Software Development Kit (SDK) provides a set of tools, guides and samples, used for configuration and image acquisition from GigE Vision cameras. The CameraSuite SDK consists of the following components:

- CameraSuite API - Application Programming Interface (API) for configuration and image acquisition from GigE Vision cameras
- FRAMOS GigE Vision filter driver - High-performance network filter driver designed to ensure optimal performance of the GigE Vision cameras
- Sample code - Example source code for various CameraSuite API functions
- Tools - tools used for operating the FRAMOS Industrial Depth Cameras

FRAMOS CameraSuite API, assisted by FRAMOS GigE Vision filter driver, acts as a middleware between FRAMOS Industrial Depth Camera D400e Series and Intel® RealSense™ SDK 2.0, allowing D400e Series camera to be used by tools based on the Intel® RealSense™ SDK 2.0.

8.1.1 Set IP Configuration

ConfigureIP tool is used to configure the IP address of a FRAMOS Industrial Depth Camera. Supported IP configurations are:

- Persistent IP - fixed IP address which is stored in camera non-volatile memory
- DHCP - camera attempts to acquire IP address via DHCP protocol
- LLA - camera attempts to acquire IP address via LLA protocol, always enabled

The camera and network interface card (NIC) that is used to connect to the camera need to be on the same subnet for the camera to be accessible by the software. For this reason, the ConfigureIP tool allows to temporarily change the current IP address of the camera. This is useful in situations where NIC and camera are on different subnets, and IP configuration of the NIC cannot be changed.

There are two ways to use ConfigureIP tool. One is to start it as is, following the text interface to make the desired changes, the other is to pass arguments to the tool based on which it changes the specified option to the inputted value. To learn more about which arguments can be passed to the tool, call it with the argument [-help].

Usage example on Linux - setting persistent IP address, disable DHCP:

```
./ConfigureIp
```



```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./ConfigureIp
FRAMOS Camera Set IP Tool (v2.0.3.0)
=====
Index   Vendor   Model   IP           MAC           Version      Available
  0     Framos   D435e   192.168.1.10 6C:D1:46:03:00:37 HW:1.1_FW:1.7.0.0 Yes
Connect on camera by entering index number. Rescan? [Y/n]
Index: █
```

Figure 15 – Tool ConfigureIp Part1

Select camera from list, and then set the desired IP configuration:

```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./ConfigureIp
FRAMOS Camera Set IP Tool (v2.0.3.0)
=====
Index   Vendor   Model   IP           MAC           Version      Available
  0     Framos   D435e   192.168.1.10 6C:D1:46:03:00:37 HW:1.1_FW:1.7.0.0 Yes
Connect on camera by entering index number. Rescan? [Y/n]
Index: 0
Vendor   Model   IP           Version
Framos   D435e   192.168.1.10 HW:1.1_FW:1.7.0.0
-----
| FRAMOS D435e [6CD146030037]
-----
| Device current IP configuration
| [X] LLA
| [X] DHCP
| [ ] PermanentIP
| Device current IP
| Address      192.168.1.10
| Subnet Mask  255.255.0.0
| Gateway      0.0.0.0
-----
| (enter "1" to Set Temporary IP)
| (enter "2" to Set Permanent IP)
| (enter "3" to Toggle DHCP)
| (enter "4" to Toggle Permanent IP)
| (enter "5" to Restart Device)
| (enter "6" to Show Network Interfaces)
| (enter "7" to Show Main Menu)
| (enter "8" to Exit)
> █
```

Figure 16 – Tool ConfigureIp Part2

Note that the newly set IP configuration will not be active until camera is restarted.

8.1.2 Manage Camera Calibration Tables

CalibrationTables tool is used to manage calibration tables on FRAMOS Industrial Depth Camera D400e Series. Following actions are supported:

- Read calibration tables from device
- Write calibration tables to device (active)
- Write calibration tables to device (active + gold)
- Reset calibration tables on device to default gold factory settings

Usage example on Linux – running CalibrationTables tool:

```
./CalibrationTables
```



```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./CalibrationTables
FRAMOS Camera Calibration Tables Tool (v1.0.2.0)
=====
Index   Vendor   Model   IP       MAC       Version   Available
  0     Framos   D435e   192.168.1.10  6C:D1:46:03:00:37  HW:1.1_FW:1.7.0.0   Yes
Connect on camera by entering index number. Rescan? [Y/n]
Index: █
```

Figure 17 – Tool CalibrationTables Part1

Select camera from list then choose desired action:

```
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools
framos@framos-Ubuntu16x64: /usr/src/framos/camerasuite/Tools$ ./CalibrationTables
FRAMOS Camera Calibration Tables Tool (v1.0.2.0)
=====
Index   Vendor   Model   IP       MAC       Version   Available
  0     Framos   D435e   192.168.1.10  6C:D1:46:03:00:37  HW:1.1_FW:1.7.0.0   Yes
Connect on camera by entering index number. Rescan? [Y/n]
Index: 0
Successfully connected to device:
Vendor   Model   IP       Version
Framos   D435e   192.168.1.10  HW:1.1_FW:1.7.0.0
OPTION
=====
 1 Read calibration tables from device.
 2 Write calibration tables to device (active).
 3 Write calibration tables to device (active + gold).
 4 Reset calibration tables on device to default gold factory settings.
 5 Exit program.
Input: █
```

Figure 18 – Tool CalibrationTables Part2

8.2 Intel® RealSense™ Software Development Kit 2.0

FRAMOS provides a modified version of the SDK 2.0, which includes a wrapper of the Camera Suite as described above. The modified version of the SDK 2.0 can be downloaded here: <https://www.framos.com/en/industrial-depth-cameras>

The SDK at a minimum includes:

Intel® RealSense™ Viewer - This application can be used to 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 - Software wrappers supporting common programming languages and environments such as ROS, Python, Matlab, node.js, LabVIEW, OpenCV, PCL, .NET and more.

Additional documentation and instructions on the Intel SDK can be found here:

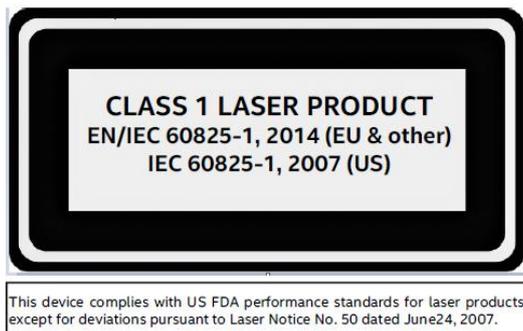
<https://dev.intelrealsense.com/docs/docs-get-started>



9. Regulatory Compliance

Certification statement

This product is classified as a Class 1 Laser Product under the EN/IEC 60825-1, Edition 3 (2014) internationally and IEC60825-1, Edition 2 (2007) in the US. This product complies with US FDA performance standards under 21 CFR 1040.10 for laser products except for deviations pursuant to Laser Notice No. 50 dated June 24, 2007.



Cautionary Statement

Do not power on the product if any external damage was observed.

Do not attempt to open any portion of this laser product.

Invisible laser radiation when opened. Avoid direct exposure to beam.

There are no user serviceable parts with this laser product.

Modification or service of the stereo module, specifically the infrared projector, may cause the emissions to exceed Class 1.

No magnifying optical elements, such as eye loupes and magnifiers, are allowed.

Do not try to update camera firmware that is not officially released for specific camera module and revision.



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.



Other Certifications



Shock

DIN EN 60068-2-27

Vibration

DIN EN 60068-2-6, DIN EN 60068-2-64



10. Accessories

Recommended Cables

M12 - Connector

M12_to_RJ45 cable, 2m (Order Number: 79 9723 020 08):

<https://www.binder-connector.com/en/products/automation-technology-specialty-connectors/m12-d-m12-x/connecting-cable-male-cable-connector-m12-x-1-rj45-male-connector-shielded-ip67/#79972302008>

Connection line M12 X-coded, 2.0 m M12 plug angled - RJ45 plug straight 8-pole, position of coding 225°:

<https://www.metz-connect.com/en/products/142m2xc5020>

M8 - Connector

M8 female cable connector, Contacts: 8, 2m (Order Number: 77 3406 0000 50008-0200):

<https://www.binder-connector.com/en/products/automation-technology/m8/female-cable-connector-overmoulded-screw-type-m8x1-with-hexagonal-die-cast-threaded-ring-pur/#7734060000500080200>

Sensor/actuator cable - SAC-8P- 1,5-PUR/M 8FS SH – 1404147:

<https://www.phoenixcontact.com/online/portal/pi?uri=pxc-oc-itemdetail;pid=1404147&library=pien&tab=1>

M8 Sensor/actuator cable - SAC-8P- 1,5-PUR/M 8FR – 1404191:

<https://www.phoenixcontact.com/online/portal/us/?uri=pxc-oc-itemdetail;pid=1404191&library=usen&pcck=P-18-01-01&tab=1&selectedCategory=ALL>



11. References

1. Intel® RealSense™ D400 Series Product Family, Revision 006, published in June 2019
2. FRAMOS Industrial Depth Camera D400e Series - External Event Camera Synchronization v1.0, FRAMOS GmbH.
3. FRAMOS Industrial Depth Camera D400e Series - Multi-Camera Synchronization v1.0, FRAMOS GmbH.
4. FRAMOS Industrial Depth Camera D400e Series - Tuning System For Best Performance v1.0, FRAMOS GmbH.
5. Best-Known-Methods for Tuning Intel® RealSense™ D400 Depth Cameras for Best Performance v2.0, Intel RealSense.
6. FRAMOS Industrial Depth Camera D400e Series - Getting Started v1.1, FRAMOS GmbH.



12. Revision History

Date	Version	Changes
2020-06-30	1.0.0	Initial version
2020-09-01	1.1.0	Added chapter "Output Trigger Enabled"; Added chapter "User Output Level"; Added chapter "Syncer Mode"; Updated chapter "D400e Camera Specific Features"
2020-10-01	1.2.0	Added chapter "Line Debouncer Time"; Updated chapter "D400e Camera Specific Features"

Table 26 – Revision History

NOTE: *This document replaces and supersedes the user manual "FRAMOS Industrial Depth Camera D435e" v1.1.0.*