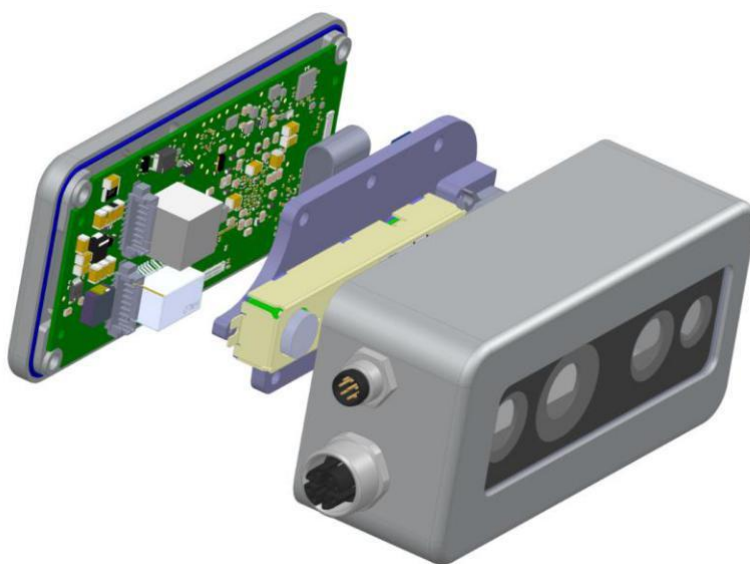


# User Manual

## FRAMOS Industrial Depth Camera D435e

### V1.1





## Revisions

| Version | Datum      | Description   |
|---------|------------|---|
| V1.00   | 05.09.2019 | Initial documentation for zero series release               |
| V1.00   | 20.9.2019  | Added pictures of the camera connectors                     |
| V1.10   | 31.10.2019 | Added chapters on heat management and mounting instructions |
|         |            |   |

## Referenced Documents

1. Intel® RealSense™ D400 Series Product Family, Revision 006, published in June 2019



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## 1. Description and Features

### 1.1. Description

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

### 1.2. Features

|                           |   |
|---------------------------|---|
| Resolution depth          | 1280 x 720 px (global shutter)                                |
| Resolution RGB            | 1920 x 1080 px (rolling shutter)                              |
| FOV depth (HxVxD)         | 86° x 57° x 94° (+/- 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 (Datastream + 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   |

Recommendation: Cable connectors should be fixed with a tool (wrench/key) so that the connectors do not rotate under force.

### 1.3. Minimum System Requirements

- Linux Ubuntu 16.04 / Windows 10
- Gigabit Network Interface Card



## 2. Introduction

### 2.1. Purpose of this Document

This document captures the specifications and the design—in details for the FRAMOS Depth Camera D435e. 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 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.   |
| Platform camera              | This refers to the two-dimensional (2D) color camera on platform.   |
| RMA                          | Return material authorization.  |
| TBD                          | To Be Determined. In the context of this document, information will be available in a later revision.   |
| DHCP                         | Dynamic Host Communication Protocol, it is used for network configurations of clients by a server.  |
| LLA                          | Link-local address, a network address that is valid only for communications within the network segment or the domain that the host is connected to.   |



### 2.3. Stereo Vision Depth Technology Overview

The FRAMOS Industrial Depth Camera D435e uses 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 is the Intel® RealSense™ D430 with the following specification:

|                         |                               |
|-------------------------|-------------------------------|
| 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 |

#### NOTE:

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

|                          |                   |
|--------------------------|-------------------|
| 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%            |

### 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.

|                        |   |
|------------------------|---|
| 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°  |

### 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                   | $\leq$ 1.5%       |

### 3.5. Labels on the Camera

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


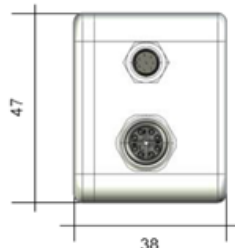
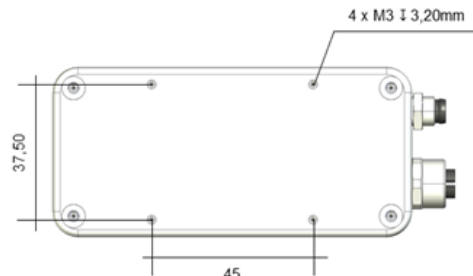
|                    |  |
|--------------------|--|
| PC = Product Code  | With this number you can purchase the exact same product at FRAMOS.                                    |
| SN = Serial Number | This is the unique identifier of a single camera. For support and RMA cases, this number is necessary.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

### 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

|            |  |
|------------|--|
| Front View |  |
| Side View  |  |
| Back View  |  |



### 3.8. Storage and Operating Condition

| 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               |

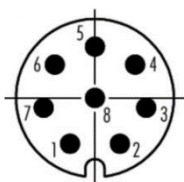
### 3.9. Connectors and PINs of M12 and M8

Ethernet M12 connector, X-Coded, Female



| M12 Pin | RJ 45    |
|---------|----------|
| 1       | 1 (MX0+) |
| 2       | 2 (MX0-) |
| 3       | 3 (MX1+) |
| 4       | 6 (MX1-) |
| 5       | 7 (MX3+) |
| 6       | 8 (MX3-) |
| 7       | 5 (MX2-) |
| 8       | 4 (MX2+) |

Power M8 connector, A-Coded, Male



| 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                            |

### 3.10. Power consumption

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

## 4. Optimum Thermal Conditions

### 4.1. Fundamentals of the camera's heat dissipation

The power consumption of the D435e 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.

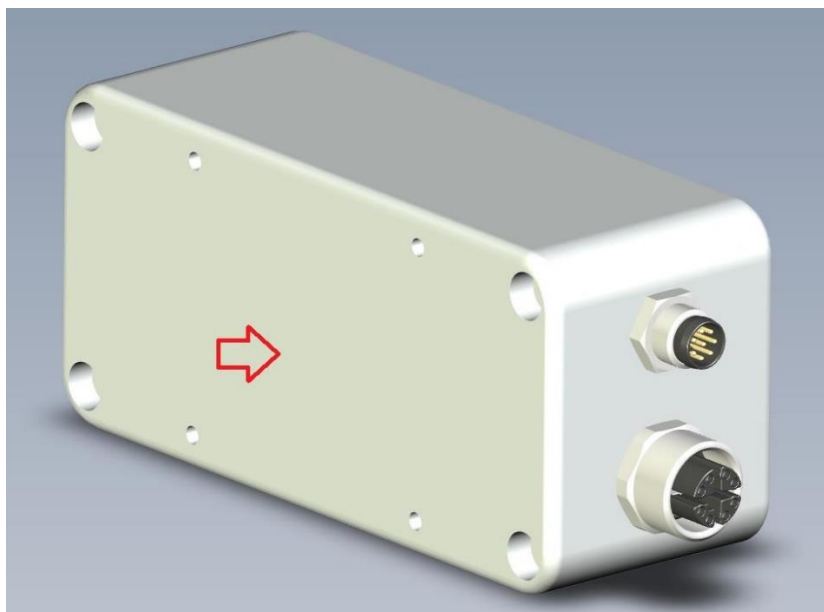
Maximum power consumption

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

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.

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 |

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 resource utilization (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.

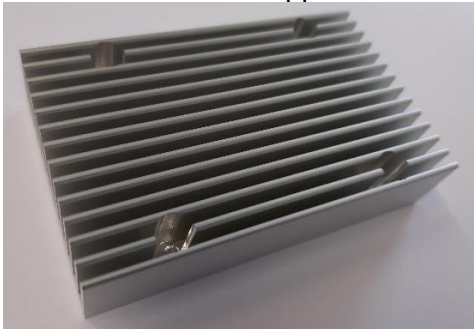
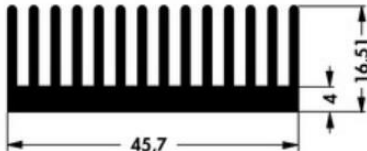
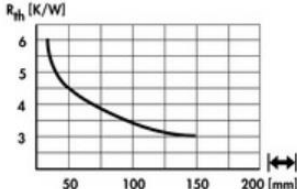
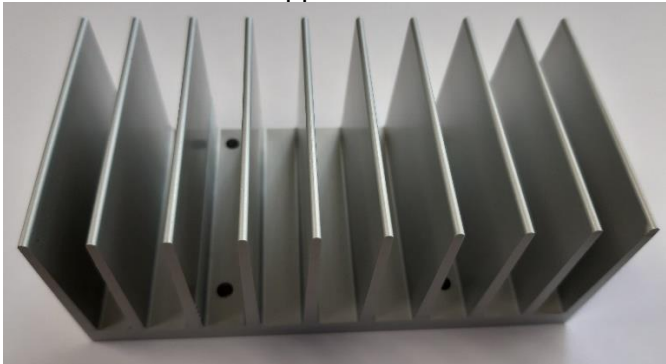

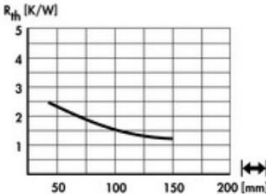
#### 4.2. Operating conditions for different temperatures

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.

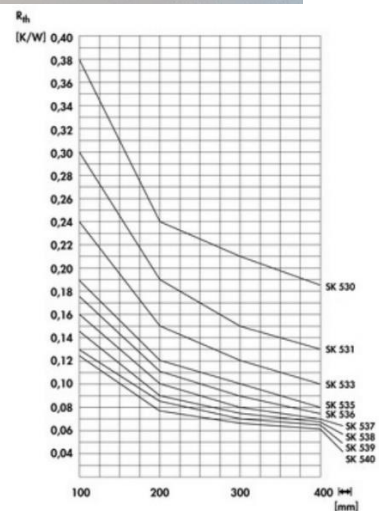
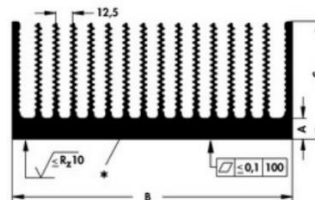
| Use case: | Description:   |
|-----------|--|
| Typical1  | Power supply: M8, 12V<br>Exposure time: 5 ms<br>Framerate: 30 fps<br>Laser projector power: 150 mW   |
| Typical2  | Power supply: M12, PoE<br>Exposure time: 5ms<br>Framerate: 30 fps<br>Laser projector power: 150mW    |
| Max1      | Power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

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<br/>Heatsink length: 75 mm<br/>Thermal resistance: approx. 3.8 K/W</p>         |
| H2 - passive | <p>SK 408 50 ME<br/>Heatsink length: 50 mm<br/>Thermal resistance: approx. 2.3 K/W</p>    |

H3 - passive

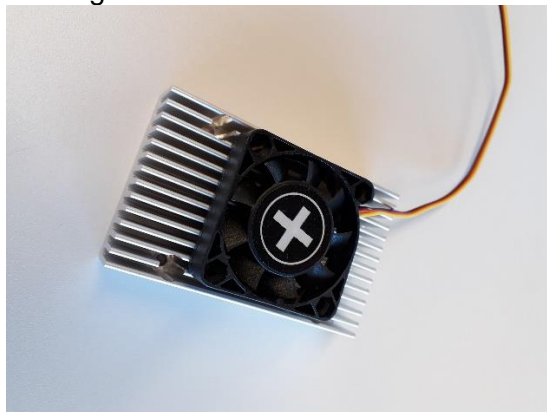
SK 530 100 AL  
Heatsink length: 100 mm  
Thermal resistance: approx. 0.38 K/W



A: 15 mm  
B: 200 mm  
C: 84 mm

H4 - active

SK 424 75 ME  
Heatsink length: 75 mm  
Cooling fan: Xilence XPF40



### 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<br>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 |

### 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 2-3 shows that camera operation in normal indoor environments (up to 31°C – 37°C) can be possible with very small heatsinks 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 be 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 thermal analysis to ensure safe and reliable operation of camera. Given information should be used as a guideline at customers system design time. Our general recommendations are:

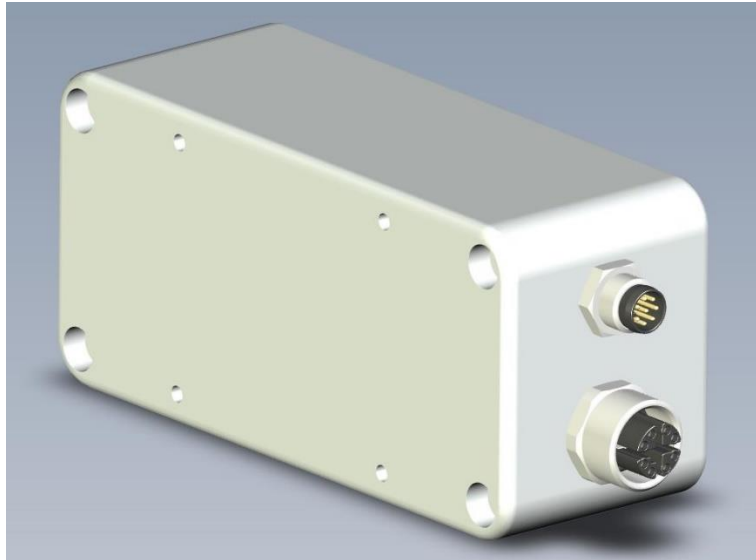
- Use of a metal camera mount to assure heat conductivity (and avoid plastic)
- In case there is a problem with overheating rather use external power supply than PoE
- Minimize the resource utilization (i.e. fps, exposure, projector intensity) of the camera, which will positively affect heat generation and also longevity of the product

## 5. Mounting and Deployment

### 5.1. Camera mounting

The d435e camera is 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.



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.

### 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. Image Formats

#### Possible Streams with Gigabit Ethernet

| Depth    | RGB       | 90fps | 60fps | 30fps | 25fps | 15fps | 6fps |
|----------|-----------|-------|-------|-------|-------|-------|------|
| 1280x720 | 1920x1080 | -     | -     | -     | -     | ok    | ok   |
| 1280x720 | 1280x720  | -     | -     | ok    | ok    | ok    | ok   |
| 960x540  | 960x540   | -     | -     | ok    | ok    | ok    | ok   |
| 848x480  | 848x480   | -     | ok    | ok    | ok    | ok    | ok   |
| 848x480  | 1920x1080 | -     | -     | -     | -     | ok    | ok   |
| 640x480  | 640x480   | ok    | ok    | ok    | ok    | ok    | ok   |
| 640x360  | 640x360   | ok    | ok    | ok    | ok    | ok    | ok   |
| 424x240  | 424x240   | ok    | ok    | ok    | ok    | ok    | ok   |

NOTE: The zero series firmware (v.1.3.4) will have only 1280x720 @ 30fps implemented. The other options will follow with later firmware releases.

### 6.2. Depth Field of View (FOV)

| Format                   | FOV |
|--------------------------|-----|
| Horizontal FOV (VGA 4:3) | 74  |
| Vertical FOV (VGA 4:3)   | 62  |
| Diagonal FOV (4:3)       | 88  |
| Horizontal FOV (HD 16:9) | 86  |
| Vertical FOV (HD 16:9)   | 57  |
| Diagonal FOV (HD 16:9)   | 94  |

#### NOTE:

Due to mechanical tolerances of +/-5%, Max and Min FOV values can vary from lens to lens and module to module by ~ +/- 3 degrees.

The Depth FOV specified is at 2 meters distance.

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

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

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 | Min-Z (mm) |
|------------|------------|
| 1280x720   | 280        |
| 960x540    | 195        |
| 848x480    | 175        |
| 640x480    | 150        |
| 640x360    | 120        |
| 424x240    | 105        |

NOTE: The zero series firmware (v. 1.3.4) will have only 1280x720 @ 30fps implemented. The other options will follow with later firmware releases.

### 6.4. Depth Accuracy

For depth accuracy and the optimum settings of the camera, please refer to:

<https://dev.intelrealsense.com/docs/tuning-depth-cameras-for-best-performance>

Generally, z-accuracy of the camera should be < 2% of the measured distance.

### 6.5. Depth Camera Functions

| Control                            | Description   | Min                      | Max                                |
|------------------------------------|---|--------------------------|------------------------------------|
| Manual Exposure(1) (ms)            | Control sensor exposure period  | 1                        | 165                                |
| Manual Gain(1)<br>(Gain 1.0 = 16)  | Control sensor digital gain   | 16                       | 248                                |
| Laser Power (on/off)<br>(On = 1)   | Power to IR Projector   | 0                        | 1                                  |
| Manual Laser Power<br>(mW)         | Laser Power setting (30mW steps)  | 0                        | 360                                |
| Auto Exposure Mode<br>(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<br>L-0<br>B-1<br>R-1 | T-719<br>L-1279<br>B-720<br>R-1280 |

#### 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.              | 0x1  | 0x8   |
| Manual Exposure Time                 | Sets the absolute exposure time when autoexposure is disabled.            | 41   | 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    | 3     |
| Backlight Compensation               | Sets a weighting amount based on brightness to the frame.                 | 0    | 1     |
| Low Light Comp                       | Low Light   | 0    | 1     |



## 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.

### Firmware update tool

The firmware update 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_3_4_0.fw_update
```

```
framos@Ubuntu16x64:/usr/src/framos/camerasuite/Tools$ ./UpdateFirmware ~/Desktop/FRAMOS_D435e_r1111_v1_3_4_0.fw_update
FRAMOS Camera Firmware Update Tool (v1.1.0.0)
=====
Index      Vendor   Model    IP          MAC          Version      Available
  0         Framos   D435e    169.254.43.1 6C:D1:46:03:00:2A HW:1.1_FW:1.3.4.0 Yes

Connect on camera by entering index number (enter "r" for device rescan).
Index: 
```

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

```
framos@Ubuntu16x64:/usr/src/framos/camerasuite/Tools$ ./UpdateFirmware ~/Desktop/FRAMOS_D435e_r1111_v1_3_4_0.fw_update
FRAMOS Camera Firmware Update Tool (v1.1.0.0)
=====
Index      Vendor   Model    IP          MAC          Version      Available
  0         Framos   D435e    169.254.43.1 6C:D1:46:03:00:2A HW:1.1_FW:1.3.4.0 Yes

Connect on camera by entering index number (enter "r" for device rescan).
Index: 0

Successfully connected to device:

Vendor      Model      IP          Version
Framos      D435e     169.254.43.1 HW:1.1_FW:1.3.4.0

Loaded Firmware Update file from disk:
/home/framos/Desktop/FRAMOS_D435e_r1111_v1_3_4_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%
Completion: 55%
Completion: 56%
Completion: 57%
Completion: 58%
Completion: 59%
Completion: 60%
Completion: 61%
Completion: 69%
```

When the progress information reaches 100%, firmware update is complete.



## 8. Software

Instructions how to quickly start up the camera can be found in the quick start guide: [LINK](#)

### 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 D435e and Intel® RealSense™ SDK 2.0, allowing D435e camera to be used by tools based on the Intel® RealSense™ SDK 2.0.

#### 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.

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

./ConfigureIp

```
framos@Ubuntu16x64:/usr/src/framos/camerasuite/Tools$ ./ConfigureIp
FRAMOS Camera Set IP Tool (v1.0.0.0)
=====
Index   Vendor   Model    IP          MAC          Version      Available
  0      Framos   D435e    169.254.43.1 6C:D1:46:03:2A HW:1.1_FW:1.3.4.0 Yes
Connect on camera by entering index number (enter "r" for device rescan).
Index: █
```

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



```
framos@Ubuntu16x64:/usr/src/framos/camerasuite/Tools$ ./ConfigureIp
FRAMOS Camera Set IP Tool (v1.0.0.0)
=====
Index   Vendor   Model   IP           MAC           Version       Available
  0     Famos   D435e   169.254.43.1 6C:D1:46:03:00:2A HW:1.1_FW:1.3.4.0 Yes

Connect on camera by entering index number (enter "r" for device rescan).
Index: 0

Vendor   Model   IP           Version
Famos    D435e   169.254.43.1 HW:1.1_FW:1.3.4.0

Set temporary IP? [Y/n]
n
Enable DHCP? [Y/n]
n
Enable permanent IP? [Y/n]
y
Enter IP address [169.254.43.1]
169.254.43.2
Enter subnet mask [255.255.0.0]
Enter default gateway [0.0.0.0]

IP address sucessfully set.
Press enter to continue ...

framos@Ubuntu16x64:/usr/src/framos/camerasuite/Tools$
```

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

## 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: [LINK](#)

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 -Software wrappers supporting common programming languages and environments such as ROS, Python, Matlab, node.js, LabVIEW, OpenCV, PCL, .NET and more.

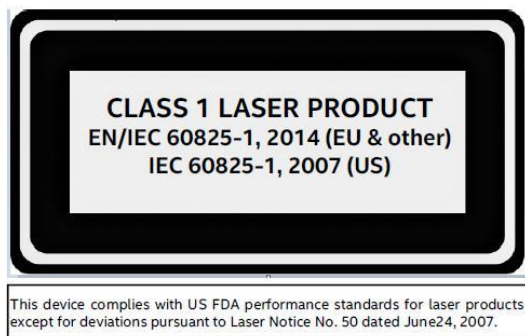
Additional documentation and instructions on the Intel SDK can be found here:

<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.





[support@framos.com](mailto:support@framos.com)

#### Other Certifications



**RoHS**

#### 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-speciality-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>)