ORBBEC

Gemini 435Le Datasheet

Version 1.0

Revision History

Version	Description	Revision Date
V1.0	● Initial release	2025-05-09

Contents

Glossary

Terms	Descriptions
AMR	Autonomous Mobile Robots (AMRs) refer to a type of robots that can navigate and perform tasks autonomously. Equipped with sensors and control systems, AMRs can move and operate in complex environments without human intervention.
ASIC	Application-specific Integrated Circuit.
Baseline	The distance between the optical centers of the two cameras used for depth calculation.
D2C	Depth to Color, this spatial alignment maps each pixel on a depth map to the corresponding color image according to the intrinsic and extrinsic parameters of the depth camera and color camera.
Depth	Depth video streams are similar to color video streams except each pixel has a value representing the distance away from the sensor instead of color information.
Depth Camera	Includes depth imaging module and external interface, of which the former is generally composed of an infrared projector, infrared cameras, and a depth engine processor.
FOV	Field of View, the value describes the angular extent of a given scene that is captured by a camera, which can be measured in the horizontal, vertical, and diagonal.
I2C	Refers to a simple bi-directional two-wire synchronous serial bus developed by Philips.
IMU	Inertial Measurement Unit.
IR	Light in the infrared spectrum, which ranges from 700 nm and above.
IR Camera	A camera capable of seeing light in the IR spectrum.
ISP	Image signal processor, which is used for image post-processing.
LDM	Laser Diode Module.
LRM	Laser Ranging Module.
MIPI	Mobile Industry Processor Interface (MIPI) Alliance. MIPI is an open standard and specification formulated by the MIPI Alliance for mobile application processors.
PCBA	PCBA (Printed Circuit Board Assembly) refers to a fully assembled printed circuit board (PCB) that includes all the electronic

	components mounted and soldered onto it.
Point Cloud	A discrete set of object points in the 3D space.
RGBM/ RGB Module	RGB Camra or Color Camera.
ROI	Region of Interest (ROI) in image processing refers to a specific area selected from the entire image.
SOM	A System on Module (SOM) provides various core components of an embedded processing system on a single printed circuit board, including the processor core, communication interfaces, and memory modules. A typical example of this is the NVIDIA Jetson series products.
SBC	A Single Board Computer (SBC) is a microcomputer where all the logic circuits, timing circuits, internal memory, and external interfaces are integrated onto a single printed circuit board. A typical example is the Raspberry Pi.
SoC	System on Chip, an integrated circuit (IC) that integrates all components of a computing system.
UVC	USB Video Class (UVC) is a protocol standard defined for USB video capture devices and has become one of the USB.org standards.
VCSEL	Vertical-Cavity Surface-Emitting Laser (VCSEL) is a type of semiconductor laser where the laser light is emitted perpendicular to the surface of the device.
DoF	Degree of Freedom, In an Inertial Measurement Unit(IMU), 6DoF means the device can measure all six degrees of freedom.
dToF	Direct Time-of-Flight(dToF) achieves high-precision distance measurement by directly tracking light pulse travel time.
TBD	To Be Determined. Information will be provided in a later revision.

1. Product Brief

The Gemini 435Le is the newest addition to Orbbec's 3D camera family. Building upon the exceptional depth-sensing capabilities of the Gemini 435L, it further expands the application boundaries for robotics. Designed with industrial-grade hardware and featuring high-reliability interfaces with IP67-rated protection, this product meets the demands of even the most challenging industrial environments. Its powerful 3D vision system delivers high-precision, real-time depth data for logistics robots and large outdoor robotic systems, ensuring stable and reliable operation in complex scenarios such as logistics sorting robotic arms, intelligent forklifts, and outdoor autonomous mobile robots (AMRs).

The Gemini 435Le utilizes standard network communication protocols for rapid multi-platform deployment and offers the following key advantages:

- **Active/Passive Stereo Vision**: Adapts to dynamic environments with stable and reliable depth perception
- **High-Precision Depth Measurement**: Achieves spatial relative accuracy better than 0.4% at 2m range
- **Wide Field of View**: 90° (H) × 65° (V) for broader coverage
- **All-Environment Operation**: IP67-rated for reliable indoor/outdoor performance
- **Industrial-Grade Reliability**: Complies with stringent industrial certification standards
- **Long-Distance Stable Transmission**: Supports PoE power delivery and 100m cable transmission for flexible deployment
- **Multi-Camera Synchronization**: Enables hardware synchronization and RS485 communication for cluster operations
- **Robust Industrial Connectivity**: High-reliability interfaces ensure stable data transmission

2. Product Specifications

Parameter	Gemini 435Le
Use Environment	Indoor & Outdoor
Technology	Stereo Vision
Baseline	95mm
LDM Wavelength	850nm
Working Range[1]	0.31 -20m+
Ideal Range[2]	0.31 - 10m
Spatial Precision[3]	≤ 0.4% (1280 x 800 @ 2 m & 90% x 90% ROI) ≤ 0.8% (1280 x 800 @ 4 m & 80% x 80% ROI)
Depth Resolution @ Frame Rate	Up to 1280 x 800 @ 10fps 640 x 400 @ 20fps
Depth FOV	90° x 65° ± 3° @ 2m (1280 x 800)
Depth Filter	Visible + NIR-Pass
Sensor Type	IR: Global Shutter Color: Global Shutter
RGB Resolution @ Frame Rate	Up to 1280 x 800 @ 10fps MJPEG/I420 640 x 400 @ 20fps MJPEG/I420
RGB FOV	Aspect ratio 16:10 94° x 68° ± 3° Aspect ratio 16:9 94° x 62° ± 3° Aspect ratio 4:3 82° x 66° ± 3°
Depth confidence map	Supported
IMU	6 DoF; Gyroscope/Accelerometer Sample range: 50 - 1,000Hz
Data Connection	Gigabit Ethernet
Network Protocol	TCP/IP、RTSP
Interface	M12, 8-pin, X-coded connector for data transmission and POE M12, 8-pin, A-coded connector for DC Power in, Sync in/out and RS485
Power Supply	POE: IEEE 802.3af DC: ≥2A @ 9V - 24V
HDR Depth	To be supported in subsequent software upgrades

ESD	Class A Contact discharge: ±8kV, Air discharge: ±15kV
RE	≥6 dB
Power Consumption	DC: Average < 6.5W (Peak < 11.0W) PoE: Average < 8.0W (Peak < 15W)
Operating Environment	-10℃ - 50℃ 5% ~ 90 % RH (non-condensing)
Storage Environment	Short Term: -20℃ - 70℃, 5%~90% RH (non-condensing) Long Term: 0℃ - 60℃, 5%~90% RH (non-condensing)
Operating BacksideCase Temperature	-10℃ - 65℃
Protection	IP67
Supported Functions	Hardware Spatial Alignment of Depth to Color Hardware Timestamps, Multi-camera Sync RS485
Dimensions	138.5mm x 40.5mm x 70.0mm
Weight	520g
Installation	Back：4x M4, Max Torque: 0.4 N.m, Max Insertion Depth: 6mm Bottom：4x M4, Max Torque: 0.4 N.m, Max Insertion Depth: 6mm Top：4x M4, Max Torque: 0.4 N.m, Max Insertion Depth: 6mm

[1] Measure object reflectivity > 10%, up to 20m distance depth data. Theoretical maximum depth ranges up to 65 meters, but the actual accuracy varies with the distance and the object to be measured.

[2] The minimum operating distance may vary depending on different offset configurations and Preset configurations. For specific details, please refer to the detailed specifications in Table 4-7-1.

[3] The depth performance of each 3D camera is validated at the production line before shipping to customers. The metrics reflect the depth performance under typical conditions. External impact factors over 3D cameras' whole lifespan may have significant impacts on their depth performance. For more detailed depth performance metrics, please refer to section 5.1.2.

3. Product Information

3.1 Product Pictures

Table 3-1-1 Product pictures for Gemini 435Le

Front View		Back View	
Top View		Bottom View	
Left View		Right View	

3.2 Product Dimensions & Weight & Drawings

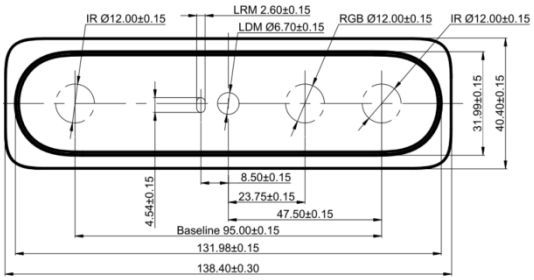
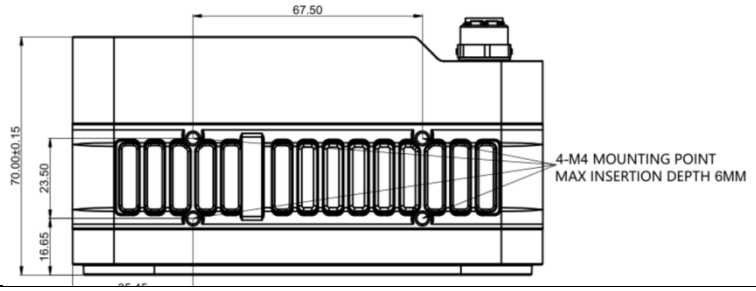
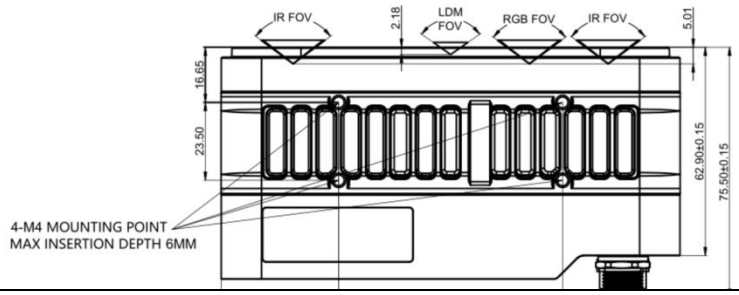
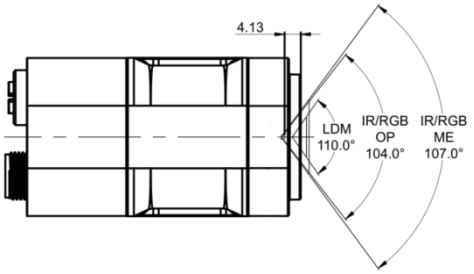
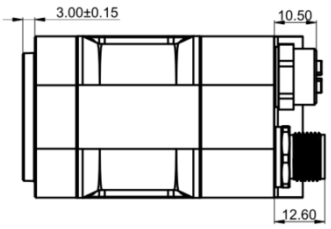
3.2.1 Product Dimensions & Weight for Gemini 435Le

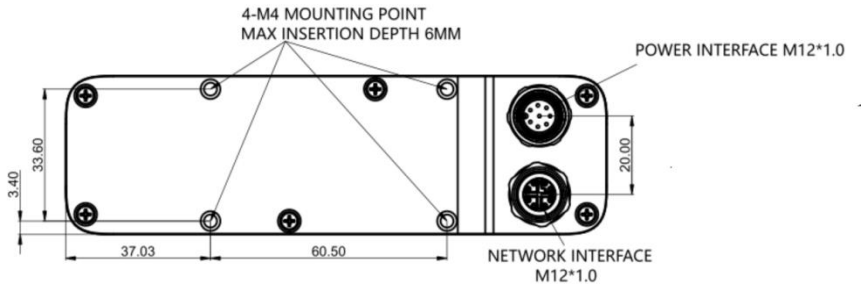
Table 3-2-1 Product dimensions & weight for Gemini 435Le

Name	Gemini 435Le
Width/mm	138.5
Height/mm	40.5
Depth/mm	70
N.W/g	520

3.2.2 Product Drawings for Gemini 435Le

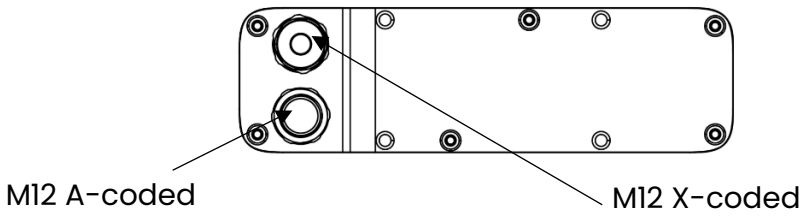
Table 3-2-2 Product drawings for Gemini 435Le

Name	Gemini 435Le
Front View	
Top View	
Bottom View	
Left View	
Right View	

Rear View	

3.3 Product Interfaces

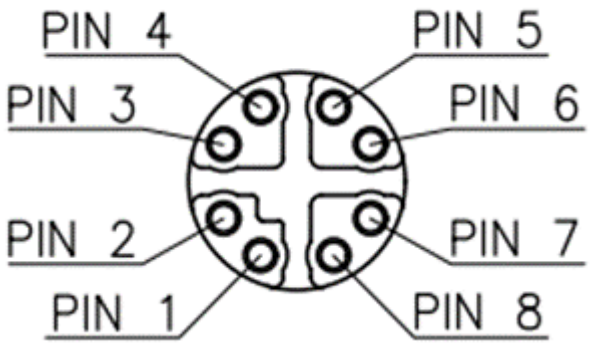
Table 3-3 Product interfaces for Gemini 435Le

Interfaces	DC power in & sync in/out & RS485	Data & PoE
Connector	M12 A-coded	M12 X-coded
Illustration		

3.3.1 Ethernet M12 connector, X-coded, Female

The Ethernet interface provides configuration access to the camera and is also used for image data transmission.

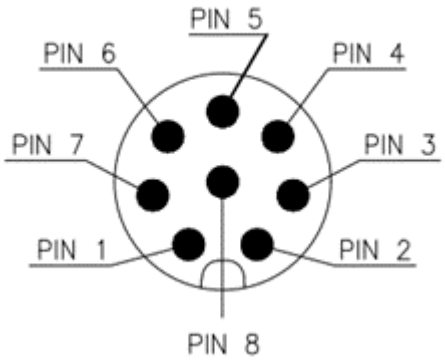
Table 3-3-1 M12 Connector PIN Definition

M12 PIN	Description	PIN Layout
1	Bi-directional pair A+	
2	Bi-directional pair A-	
3	Bi-directional pair B+	
4	Bi-directional pair B-	
5	Bi-directional pair D+	
6	Bi-directional pair D-	
7	Bi-directional pair C-	
8	Bi-directional pair C+	

3.3.2 Power M12 connector, A-coded, Male

Beside the Ethernet interface for communication and data transmission, Gemini 435Le cameras is equipped with M12 connector providing I/O-interface and power input.

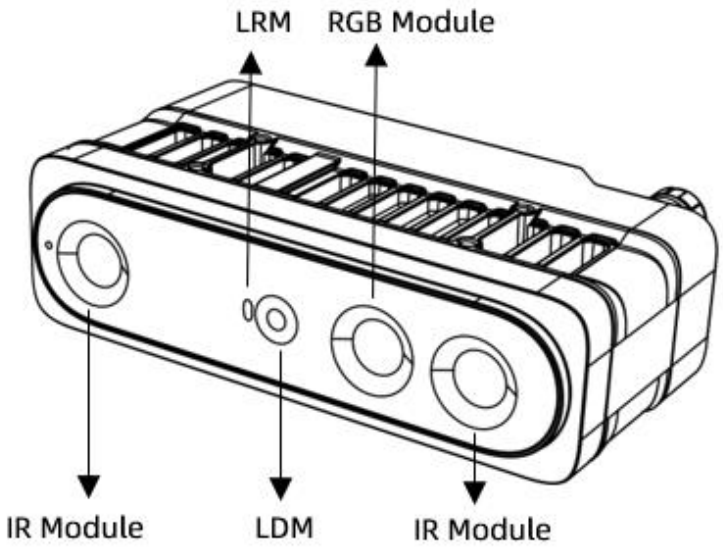
Table 3-3-2 M12 Connector PIN Definition

M8 PIN	Description	PIN Layout
1	POWER IN 9-24V	
2	VSYNC VCC 3.3-24V	
3	VSYNC IN 3.3-24V	
4	VSYNC OUT 3.3-24V	
5	SIGNAL GND	
6	RS485B	
7	RS485A	
8	POWER GND	

3.4 Product Components

3.4.1 Overview of Product Components for Gemini 435Le

Table 3-4-1 Overview of product components for Gemini 435Le

Name	Gemini 335Le
Overview	

3.4.3 Laser Diode Module

The laser module (LDM) comprises an array of vertical cavity surface emitting lasers and other optic components. It enhances the depth camera system's ability to detect depth information by projecting static infrared patterns onto the scene, adding texture to low-texture scenes. The Gemini 435Le laser module is a Class 1 Laser Product under normal conditions.

Table 3-4-3 LDM parameters

LDM	Gemini 435Le
Type	Infrared
Component	Vertical Cavity Surface Laser Emitter (VCSEL) + Optics
Laser Controller	Pulse
Wavelength	850nm ± 6nm
Laser Compliance*	Class 1, IEC 60825-1:2007 Edition 2, IEC 60825-1:2014 Edition 3 FDA number: 2420619-000
Laser Power-down Temperature*	73℃
Horizontal FOV	101°
Vertical FOV	72.5°
FOV tolerance	±3.0°

Note: * LDM is considered Class 1 when integrated into Orbbec's 3D Cameras.

* LDM will power down while the NTC tested temperature is ≥73℃.

3.4.4 Infrared Module

Table 3-4-4 Infrared module parameters

IR Module	Gemini 435Le
Filter Type	Visible + NIR-pass Filter
Active Pixels	1280 x 800
Sensor Aspect Ratio	16:10
Focus Type	Fixed
Shutter Type	Global Shutter
Horizontal FOV	94°
Vertical FOV	68°
Diagonal FOV	104°
FOV tolerance	±3.0°
Distortion	<1.5%

3.4.5 RGB Module

Table 3-4-5 RGB module parameters

RGB Module	Gemini 435Le
Filter Type	IR-cut
Active Pixels	1280 x 800
Sensor Aspect Ratio	16:10
Focus Type	Fixed
Shutter Type	Global Shutter
Horizontal FOV	94°
Vertical FOV	68°
Diagonal FOV	104°
FOV tolerance	±3.0°
Distortion	<1.5%

3.4.6 Laser Ranging Module

The Gemini 435Le 3D cameras come equipped with a single-point laser ranging module (LRM). Essentially, it is a single-point dToF (direct time-of-flight) sensor that calculates relative distance by measuring the time it takes for light to travel from emission to reception. It is used for close-range ranging, helping the 3D camera to fill in blind spots at short distances and enhances the overall ranging performance of the depth camera.

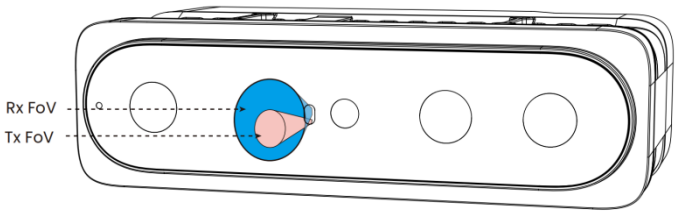
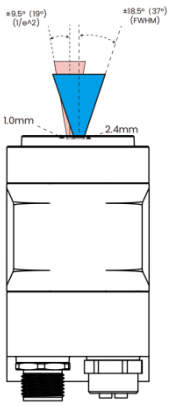
Table 3-4-6a LRM parameters

Parameters	Gemini 435Le
Type	Infrared
Wavelength	940nm（typical value）
Projector DFOV	19°
Receiving DFOV	37°
FOV tolerance	±2.0°

Table 3-4-6b Gemini 435Le LRM Ranging Accuracy Reference Value

	Distance	Value	Unit
LRM Accuracy	1mm — 100mm	±15	mm
	100mm — 200mm	±10	mm
	200 mm — 400mm	±5%	N/A

Table 3-4-6c LRM Ranging FOV

Name	Gemini 435Le
Rear View	
Side View	

3.4.7 Transmittance vs. Wavelength for Depth Camera

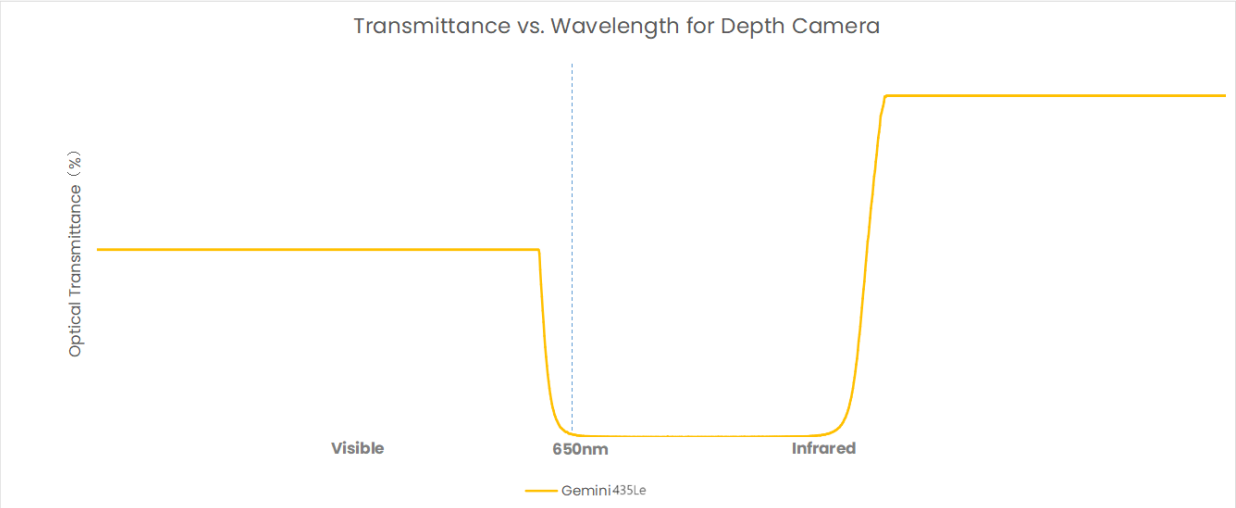


Figure 3-4-7 Transmittance vs. Wavelength for Depth Camera

3.4.8 IMU

Table 3-4-8 Gemini 435Le IMU Specifications

Timestamp Unit		us (the same hardware clock is utilized for IMU, IR, RGB and Depth streams)
Transmittance Protocol		I2C
X/Y/Z Axis		The X, Y, and Z axis point right, downward, and forward relative to the camera front
Gyroscope	Format	3 x 16-bit
	Range	±17.45 rad/s (1000dps)
	Frequency (Hz)	50/100/200/500/1000
Accelerometer	Format	3 x 16-bit
	Range	± 39.2m/s² (4g)
	Frequency (Hz)	50/100/200/500/1000
Temperature	Format	1 x 16-bit
	Range	-40 ~ 85℃
	Frequency (Hz)	Follows the gyroscope and accelerometer frequency

4. Functional Specifications

4.1 Vendor Identifier (VID) and Product Identifier (PID)

Table 4-1-1 VID & PID table

Name	Model	VID	PID
Gemini 435Le	G30056-370	0x2BC5	0x0815

4.2 Platform and System Requirements

Gemini 435Le connect to the host computer using Ethernet, which is compatible with various platforms and system requirements.

Table 4-2-1 Gemini 435Le Recommended Platforms and Systems

Chip	x86/x64		ARM
OS	Windows 10/11	Ubuntu 20.04 / 22.04	Ubuntu 20.04 / 22.04
Ethernet	Gigabit Ethernet	Gigabit Ethernet	Gigabit Ethernet
CPU	Quad-core, 2.9GHz	Quad-core, 2.9GHz	Quad-core, A57
Reference model	Intel i7 10700	Intel i7 10700	NVIDIA AGX Orin/Orin NX/Orin Nano
Network adapters	Intel ® Ethernet Controller (11) I219-LM	Intel ® corporation Ethernet connection （14）I219-LM（rev 11）	RTL8111/8168/8411 PCI Express Gigabit Ethernet Controller（rev 15）
RAM	8GB RAM and above	4GB RAM and above	8GB RAM and above

4.3 Camera system Framework

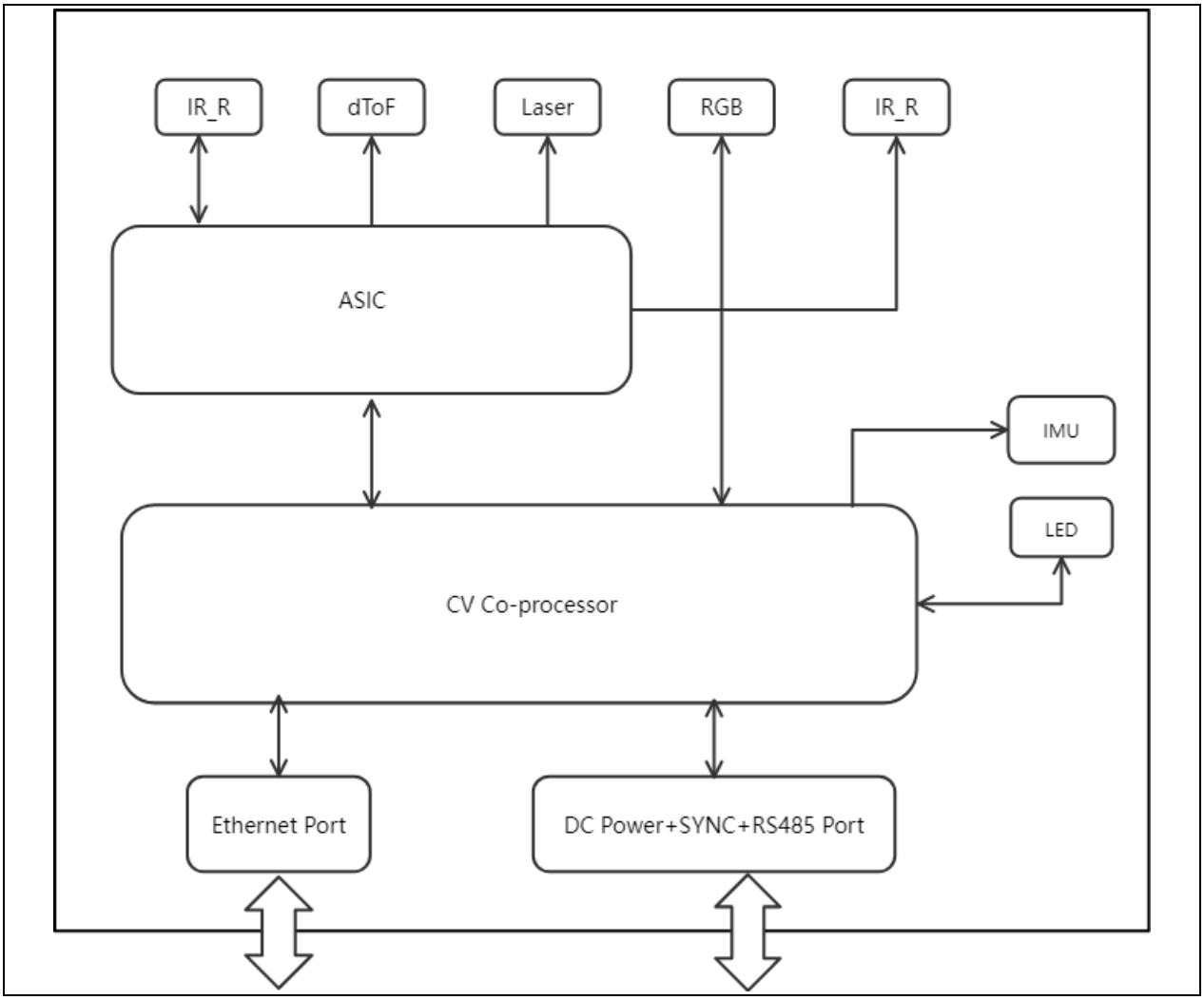


Figure 4-3-1 Gemini 435Le System Framework Diagram

4.4 Image Data Stream

The Gemini 435Le delivers high-quality, multi-resolution depth and IR streams alongside HD color video streams. The camera outputs depth data in Y16 or RVL format, color images in I420 or MJPEG format, and IR images in Y8 format. The software SDK additionally supports RGB/BGR/BGRA formats for color streams.

Table 4-4-1 Output data streams (Gigabit Ethernet)-Gemini 435Le

Gemini 335Le (Gigabit Ethernet)	Data Format	Aspect Ratio	Resolution	Frame Rate
Depth	Y16	16:10	1280 x 800	5,10
			640 x 400	5,10,15,20
	RVL	16:10	1280 x 800	5,10
			640 x 400	5,10,15,20
IR	Y8	16:10	1280 x 800	5,10,15,20
			640 x 400	5,10,15,20
Color	I420	16:10	1280 x 800	5,10,15,20
			640 x 400	5,10,15,20
		16:9	1280 x 720	5,10,15,20
			640 x 360	5,10,15,20
		4:3	800 x 600	5,10,15,20
	MJPEG	16:10	1280 x 800	5,10,15,20
			640 x 400	5,10,15,20
		16:9	1280 x 720	5,10,15,20
			640 x 360	5,10,15,20
		4:3	800 x 600	5,10,15,20

Note: A single data stream output can support all resolutions and frame rates. However, when simultaneously outputting two, three, or four streams of depth and color stream, some combinations may not be supported due to the actual bandwidth limitations of camera's Gigabit or Fast Ethernet and the performance of the host device.

4.5 Field of View

4.5.1 Definition of Depth Field of View

The image below shows the depth camera field-of-view, or the angles that the sensors "see". We use the IR cameras for illustration.

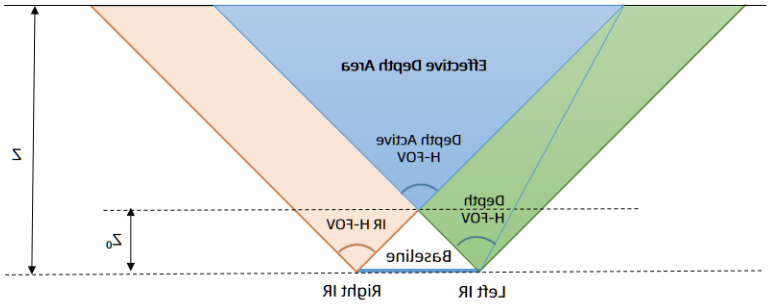


Figure 4-5-1 Depth Field of View to Depth Map illustration

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

Table 4-5-1 Depth FOV calculation formulas

Calculation formulas	Definitions
$\text{Depth H} - \text{FOV} = \arctan\left(\frac{cx}{fx} - \frac{B}{Z}\right) + \arctan\frac{width - 1 - cx}{fx}$	1. cx = X-direction image coordinates of the principle point of the depth image 2. fx= Depth camera focal length 3. cy= Y-direction image coordinates of the principle point of the depth image 4. fy=Depth camera focal length 5. width= Depth image width 6. Height=Depth image height 7. Depth active H-FOV =Left IR H-FOV
$\text{Depth Active H} - \text{FoV} = \arctan\frac{cx}{fx} + \arctan\frac{width - 1 - cx}{fx}$	
$Z_0 = \frac{B}{2*\tan(\frac{\text{Depth Active H} - \text{FOV}}{2})}$	
$\text{Depth V - FOV} = \arctan\left(\frac{cy}{fy}\right) + \arctan\frac{height\text{-}1\text{-}cy}{fy}$	

Note:

1. *cx, fx,* and width parameters are obtained through the SDK Depth Intrinsic for the relevant camera parameters, and each depth camera parameters are not the same.

2. At different depth values, the depth FOV is different. The farther the depth, the greater the depth FOV.

4.5.2 Typical Depth Intrinsics

Table 4-5-2 Typical Depth Intrinsics of Gemini 435Le

Baseline	Resolution：Width x Height		cx/pixel	cy /pixel	Fx & fy/pixel
	Width/pixel	Height/pixel			
95mm	1280	800	640	400	620.0 & 620.0
	640	400	320	200	310.0 & 310.0

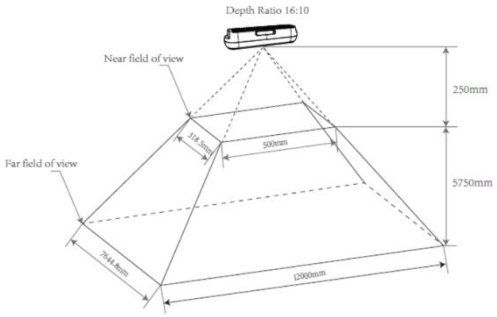
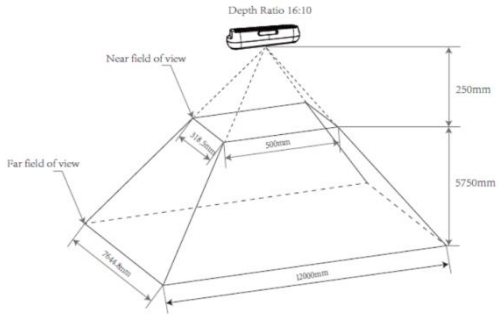
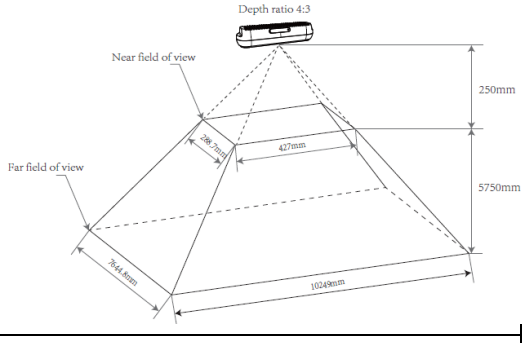
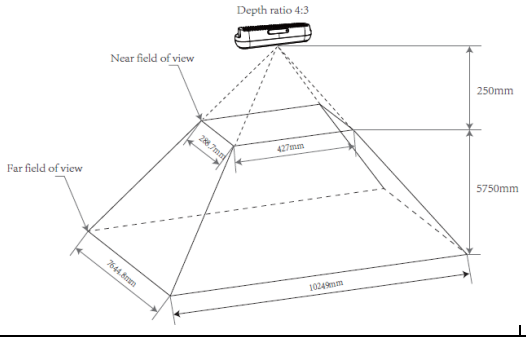
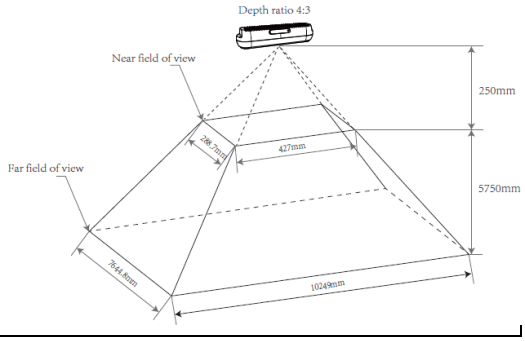
4.5.3 Overview of Stream FOV

Table 4-5-3 Stream FOV for Gemini 435Le

FOV	Image ratio	Gemini 435Le
Depth @ 2m	16:10	H 90° V 65°
	4:3	H 81° V 65°
IR	16:10	H 91° V 65°
	4:3	H 81° V 65°
RGB	16:10	H 94° V 68°
	16:9	H 94° V 62°
	4:3	H 82° V 68°
D2C FOV @ 2m	16:10	H 90° V 65°
	16:9	H 90° V 60°
	4:3	H 81° V 65°

4.5.4 FOV Illustrations for Gemini 435Le

Table 4-5-4 Gemini 435Le Depth FOV

Aspect ratio	Depth FoV Before D2C	Depth FOV After D2C
16:10		
16:9	**N/A**	
4:3		

4.6 Depth to Color Alignment

Depth to Color, a pixel-by-pixel geometric transformation of a depth image, results in the spatial alignment of a depth image with its corresponding color image through the D2C transformation, allowing us to locate any pixel of a color image by its image coordinates in the depth image after D2C by the same image coordinates. The depth information of the color pixel can be located in the depth image after D2C by using the same image coordinates. We generate a depth image of the same size as the target color image after D2C, and the image content is the depth data in the color camera coordinate system. In other words, a depth image is reconstructed that is "taken" using the origin and size of the color camera, where each pixel matches the coordinates of the corresponding pixel of the color camera.

Table 4-6-1 Gemini 435Le Depth to Color Alignment by software

Depth Image before D2C	Color Image	Depth Image After D2C	Aspect Ratio
1280 x 800/640 x 400	1280 x 800	1280 x 800	16:10
	640 x 400	640 x 400	
1280 x 800/640 x 400	1280 x 720	1280 x 720	16:9
	640 x 360	640 x 360	
1280 x 800/640 x 400	640 x 480	640 x 480	4:3

Table 4-6-2 Gemini 435Le Depth to Color Alignment by hardware

Pre-D2C Depth Image	Color Image	Post D2C Depth Image	Aspect Ratio
1280 x 800/640 x 400	1280 x 800	1280 x 800	4:3
	640 x 400	640 x 400	
1280 x 800/640 x 400	1280 x 720	1280 x 720	16：10
	640 x 360	640 x 360	
1280 x 800/640 x 400	640 x 480	640 x 480	16：9

4.7 Minimum-Z Depth

The minimum working distance of a depth camera refers to the closest detectable planar distance from the camera's depth origin. This distance is determined by the disparity search range and image resolution.
The Gemini 435Le adjusts its minimum working distance by configuring depth offset values. The achievable minimum distance may also vary across different Preset modes. The camera provides flexible configuration options to adapt to diverse application needs.

Table 4-7-1 Minimum-Z Depth for Gemini 435Le

Camera		Gemini 435Le		
Perset	Resolution	offset	Max（mm）	Min（mm）
Perception	1280 x 800	0	∞	310
		32	1855	266
	640 x 400	0	∞	155
		32	928	133
Dimensioning	640 x 480	0	∞	310
		64	928	233
		128	463	187

4.8 Coordinate System

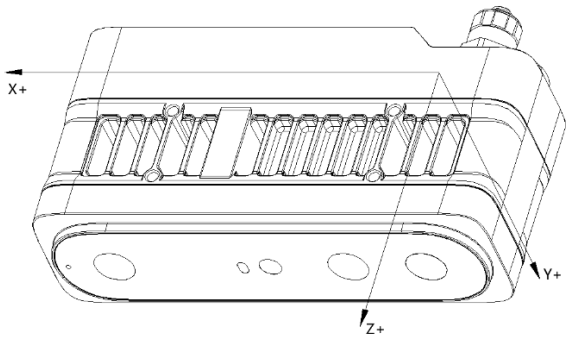
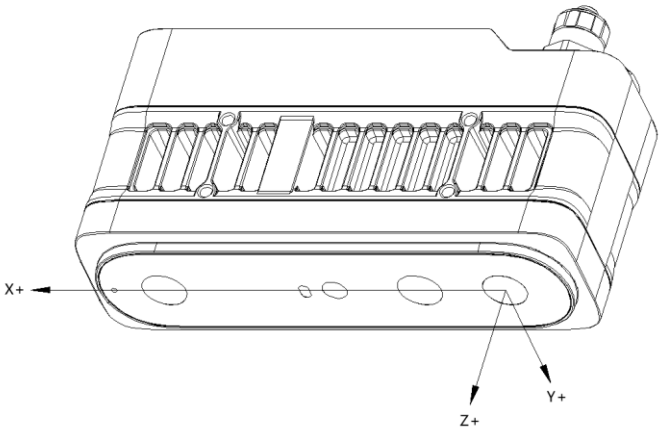
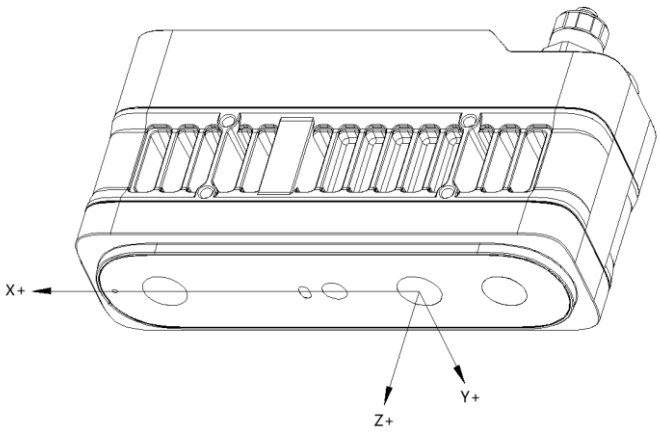
The Gemini 435Le 3D camera defines its coordinate systems as follows: The label surface is the bottom, the glass cover is the front, and the RGB module's direction relative to the LDM module is left. The IMU coordinate origin aligns with the sensor's physical center behind the RGB module, with +X right, +Y down, and +Z forward. The depth image origin is at the left IR module's optical center, while the color image origin is at the RGB module's optical center, both sharing the same axis orientation. The depth camera origin (0,0,0) serves as the default reference point, with the world coordinate system recommended to use the rear left mounting hole center. Reference positions for all origins are provided in accompanying diagrams.

Table 4-8-1 Gemini 435Le Coordinate System Position Reference

Camera	Coordinate System	Position in the 3D camera coordinate system		
		X（mm）	Y（mm）	Z(mm)
Gemini 335Le	Depth	0	0	0
	Color	23.75	0	0
	IMU	15.48	0	-55.60

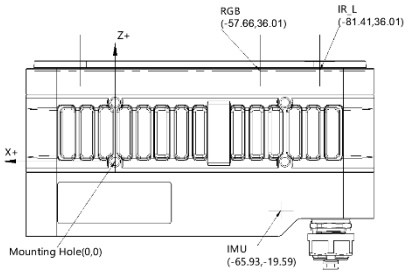
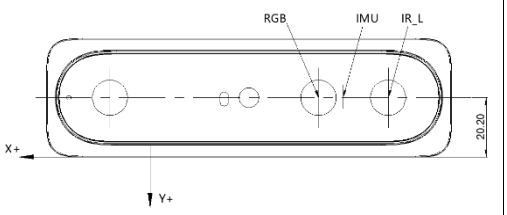
Note: If the alignment of the depth and color cameras is enabled, the origin of the depth coordinate system will automatically switch to the origin of the color coordinate system, and the intrinsics will also change accordingly.

Table 4-8-2 Gemini 435Le Coordinate System Schematic

	Gemini 435Le
IMU	
Depth	
RGB	

The relative coordinate system relationship between the installation positions and Depth/Color/IMU of Gemini 435Le.

Table 4-8-3 Gemini 435Le Coordinate System Position Reference

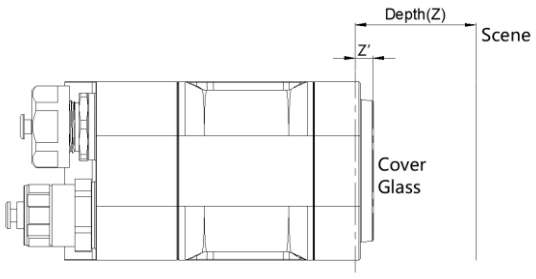
Camera	Coordinate System	Position in the 3D camera coordinate system		
		X（mm）	Y（mm）	Z(mm)
Gemini 335Le	Mounting hole	0	0	0
	Depth	-81.41	-20.20	36.01
	Color	-57.66	-20.20	36.01
	IMU	-65.93	-20.20	-19.59
				

Note：All reference points are at the centers of the components or positions.

4.9 Camera Start Point Reference

The camera start point, or ground zero datum can be described as a start point or plane with depth = 0. For the Gemini 435Le 3D camera, the distance of the depth/RGB/LRM zero point relative to the front cover glass of the camera are listed in the table below.

Table 4-9-1 Camera Start Point Illustrations

Position	Camera Start Point （Z'）	Illustrations
Depth	4.040mm	
RGB	4.040mm	
LRM	0mm	

4.10 Streaming Mode

The Gemini 435Le offers flexible methods for acquiring IR, Depth, and RGB image data, with the streaming mode being the most common approach. In this mode, users configure the target frame rate, resolution, and image format for each data type before sequentially activating the corresponding streams. The camera then captures and outputs image data according to these user-defined parameters.
Users can select specific frame rates (5fps, 10fps, 15fps, or 20fps) from predefined options based on the camera's current depth mode and resolution configuration, then acquire image data at the chosen rate.

4.11 Triggering Mode

The Gemini 435Le supports a free-running trigger mode with configurable frequency parameters. In this operational mode, the camera remains in standby state until receiving valid external trigger signals that meet configuration requirements. Each triggered acquisition cycle completes before the system resets for subsequent triggers.

1. **Flexible Timing Control:** 1) No fixed interval required between consecutive triggers. 2) Minimum requirement: Trigger interval > single acquisition cycle duration
2. **Trigger Sources:** 1) Software triggers via network commands (host-initiated). 2) Hardware triggers through M12 A-coded sync interface
3. **Frame Rate Configuration:** 1) Mandatory unified frame rate setting for all streams (IR/Depth/RGB). 2) Available frame rates: 5/10/15/20 fps (fixed). 3) Minimum trigger interval must be preconfigured
4. **Frequency Limitations:** 1) See Table 4-11-1 for correlations between(Fixed frame rates/Minimum trigger intervals/Maximum allowable trigger frequencies). 2) The camera only processes triggers within validated frequency ranges

This passive acquisition architecture enables adaptive triggering at any frequency within operational constraints while ensuring system stability.

Table 4-11-1 Table of Arbitrary Frame Rates Allowed to be Passively Triggered

Set The Camera's Fixed Frame Rate(fps)	Supportable Passive Trigger Interval (ms)	Supportable Passive Trigger Frequency (Hz)
20	≥100	0 - 10
15	≥ 133.4	0 - 7.5
10	≥200	0 – 5
5	≥ 400	0 – 2.5

4.12 Multi-camera Synchronization

For a multi-camera use case, one camera can be initialized as primary, and the rest configured as secondary. Alternatively, an external signal generator can also be used as the primary trigger with all cameras set to secondary mode. When applying an external sync pulse, the HW SYNC input requires a 100-microsecond positive pulse at the nominal camera frame rate, e.g. 50 ms for a 20 Hz frame rate. Inputs are high impedance,3.3V CMOS voltage levels. However, it is important to make sure to use a high-resolution signal generator. The frequency of the signal generator needs to exactly match the sensor frame rate. For example, if the sensor is set up as 20 FPS, the real frame rate may be 20.015 FPS. You may need to use an oscilloscope to measure the real frame rate and configure the signal generator to the same frequency. For this reason, it may be better to just use one additional camera as the primary sync signal generator.

Advantages of multi-camera setup：

- Increase camera coverage in a given space and fill in the occlusions where a single camera may have blind spots
- Capture multiple images of the same scene and scan objects from different angles
- Increase the effective frame rate to greater than 30 FPS

Using an 8-pin connector and matching cable, a multi-camera and multi-sensor network can be designed. (Please follow the instructions in the SDK).

Multi-camera frame synchronization in two topologies is supported, including depth image synchronization and RGB image synchronization (time difference ≤ 5ms, when auto exposure off), using the multi-camera synchronization function.

Table 4-12-1 Topologies schematic diagram

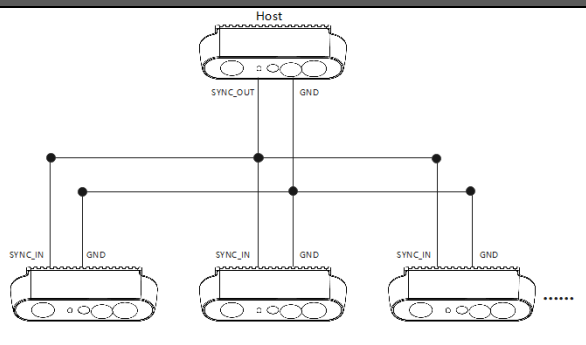
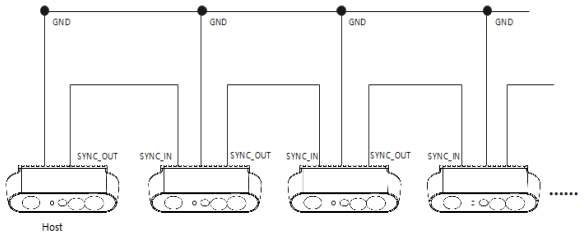
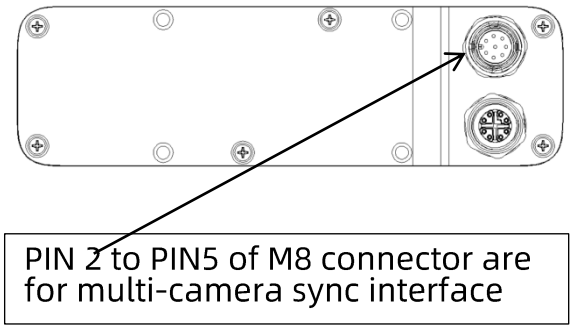
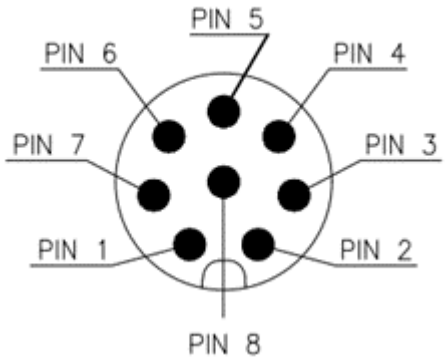
Star Topology	Daisy-chain Topology
	

Table 4-12-2 Synchronization Interfaces of Gemini 435Le

M8 Connector	Definitions	Description
Pin_2	SIGNAL VCC	When SYNC_VCC is not connected to an external power source, VSYNC_OUT defaults to a 3.3V logic level. To achieve different voltage domains for VSYNC_OUT, a target voltage between 3.3V and 24V can be supplied to the SYNC_VCC input.
Pin_3	VSYNC_IN	The synchronization trigger signal (from upstream devices) supports 3.3V to 24V level input, with rising-edge triggering and a minimum pulse duration of 1ms.
Pin_4	VSYNC_OUT	Synchronous trigger signal: Active high. The high level provides the triggering signal for the secondary devices.
Pin_5	SIGNAL GND	Ground

Table 4-12-3 Gemini 435Le Multi-camera Synchronization Pin Placement

Multi-camera Sync interface	Illustration
	

Detailed operating instructions for multi-camera synchronization, please refer the document of [Set up cameras for external synchronization]

4.13 Camera Functions

4.13.1 Depth Camera Functions

Gemini 435Le expose the following Depth image settings.

Table 4-13-1 Depth camera control

Control	Description	Settings	Default Setting
Mirror	Image mirror is an image processing technique that creates a symmetrical effect by flipping the image along a specific axis (usually vertical or horizontal).	Disable, Enable	Enable
Flip	Inverting images or data, such as flipping an image horizontally or vertically.	Disable, Enable	Enable
Rotate	Turning an image by a specific angle.	0°,90°,180°,270°	0°
Laser Power Level		0,1,2,3,4,5,6	6
Laser Control	Laser control on or off	Laser On, Laser Off	On
Auto Exposure	Auto Exposure Mode. When Auto Exposure is enabled, Exposure and Gain are set based on the environment condition.	Disable, Enable	Enable
AE Max Exposure(us)	AE Max Exposure	1 - 199000	60616 (15fps)
Mean Intensity Set Point	Mean Intensity Set Point for Gemini	0 - 255	60
AE ROI	Perform Auto Exposure on a selected ROI	T:0 - 799, B:0 -799 L:0 - 1279, R:0 -1279 (Resolution:1280 x 800)	T:0, B:399 L:0, R:639 (Resolution: 640 x 400)
Manual Exposure (1) (us)	Sets the absolute exposure time when auto-exposure is disabled	1 - 199000	3000
Gain(Gain 1.0=16)	Control sensor digital gain	16 -248	16
Depth Unit(millimeter)	Depth Measurement Standard Units	0.001 - 10	1
Disparity to Depth	Disable, Hardware, Software	Disable, Hardware, Software	Hardware
Post Processing	post-processing filters to enhance the quality of depth data and reduce noise levels	Disable, Enable	Enable

Note: (1) Not supported in Auto Exposure Mode

Definitions: T = Top, L = Left, B = Bottom, R = Right

4.13.2 Color Camera Functions

Gemini 335Le expose the following Color image settings.

Table 4-13-2 Color camera control

Control	Description	Settings	Default setting
Mirror	Image mirror is an image processing technique that creates a symmetrical effect by flipping the image along a specific axis (usually vertical or horizontal).	Disable, Enable	Disable
Fli	Inverting images or data, such as flipping an image horizontally or vertically.	Disable, Enable	Disable
Rotat	Turning an image by a specific angle.	0°, 90°, 180°, 270°	0°
Auto Exposure Priority		Disable, Enable	Enable
Auto Exposure	Automatically sets the exposure time and gain for the frame	Disable, Enable	Enable
AE Max Exposure (100us)	Maximum correction value for AE exposure that limits the corresponding frame rate	1 - 1999	665(15fps)
AE ROI	Perform Auto Exposure on a selected ROI	T:0 - 779, B:0 -779 L:0 - 1279, R:0 -1279 (Resolution: 1280 x 800)	T:0, B:399 L:0, R:639 (Resolution: 640 x 400)
Manual Exposure (1) (100us)	Sets the absolute exposure time when auto-exposure is disabled	1 - 33333	156
Gain	Sets the amount of gain applied to the frame if auto-exposure is disabled	0 – 128	16
Brightness	Sets the amount of brightness applied when auto-exposure is enabled	-64 – 64	0
Auto White Balance	Enables or disables the AWB algorithm	Disable, Enable	Disable
White Balance/ K	Sets the white balance when AWB is disabled	2800 – 6500	4600
Sharpness	Sets the amount of sharpening adjustment applied to the frame	0 – 100	50
Saturation	Sets the amount of saturation adjustment applied to the frame	0 - 100	64
Contrast	Sets the amount of contrast based on the brightness of the scene	0 - 100	50

Hue	Sets the amount of hue adjustment applied to the frame	0 – 100	0
Powerline Frequency	Specified based on the local power line frequency for flicker avoidance	Auto, 50, 60, Disabled	Auto

Note: (1) Not supported in Auto Exposure Mode

Definitions: T = Top, L = Left, B = Bottom, R = Right

5. Performance

5.1 Depth Performance

5.1.1 Depth Quality Assessment

Calculation of Depth Accuracy (Z-accuracy):
Depth accuracy (Z-accuracy) refers to the difference between the depth of effective pixels on a fitted plane and the true value plane, which can be either positive or negative.
Calculation method: Use a flat plate parallel to the x-axis of the module, and measure the distance with a laser rangefinder or tape measure as the Ground Truth (GT) surface. Collect the depth map at the current distance, and obtain the difference between the effective pixels in the ROI area and the true values to create an error map. Use the median of the error map as the Z-accuracy of the current depth map. To avoid errors from single measurements, take N depth maps and calculate the average or the ratio of the average to the true values as the final Z-accuracy.

Calculation of Spatial Precision:
The spatial precision is calculated as the percentage of the root mean square error (RMS Error) between each valid pixel and the optimal fitting plane compared to the true value (GT).

Calculation of Temporal Precision:
The temporal precision measures the variation in depth values over time within a ROI. The quality of a depth image can be assessed based on its temporal consistency, high-quality depth images should exhibit smooth and stable over time. This method is defined as the STD of depth values across a specific number of frames (for example, 30). The quantification of temporal noise is carried out on a per-pixel basis, followed by calculating the STD of each pixel over a specified time.

Depth Fill Rate Calculation:
The fill rate is used to calculate the proportion of valid pixels to total pixels within the target area (ROI region), primarily used to measure the completeness of depth.

Detailed calculation principle can be found in document "Depth Quality Metrics".

5.1.2 Typical depth performance for Gemini 435Le

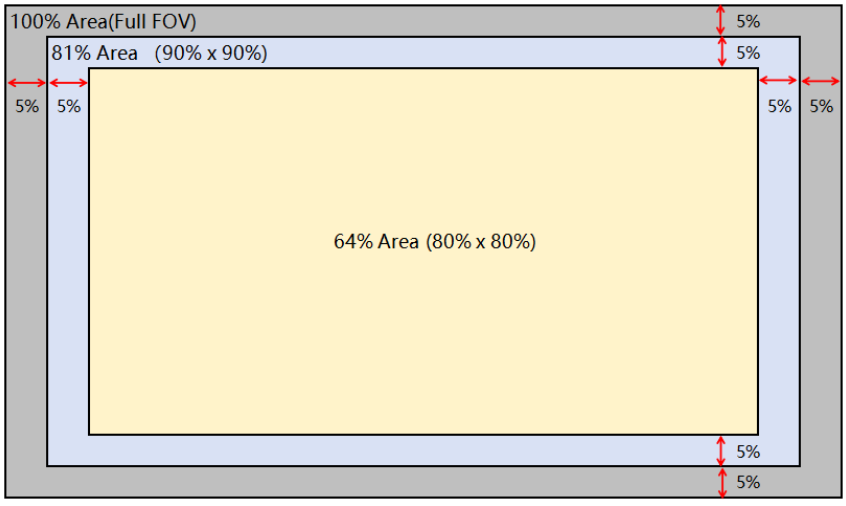
Typical depth performance for Gemini 435Le is shown in the table below:

Table 5-1-1 Typical Depth Performance for Gemini 435Le

Depth Performance	Gemini 435Le
Depth Accuracy	**≤±1%** (1280 x 800 @ 2 m & 90% x 90% ROI) **≤±2%** (1280 x 800 @ 4 m & 80% x 80% ROI)
Spatial Precision	**≤ 0.4%** (1280 x 800 @ 2 m & 90% x 90% ROI) **≤ 0.8%** (1280 x 800 @ 4 m & 80% x 80% ROI)
Temporal Precision	**≤ 0.1%** @2m (1280 x 800)
Fill Rate	**≥99.5%** (1280 x 800 @ 2 m & 90% x 90% ROI)

Note:

1. The actual working range and accuracy may vary with the ambient illumination and the objects being measured.
2. The test object is a reflectivity > 80% plane, and the reference range is 81% FOV (81% FOV is the remaining center 81% of the depth map area after cropping 5% from the top, bottom, left and right of the depth map) or 64% FOV (64% = 80% x 80% and of a similar definition).



3. The depth performance of each 3D camera is validated at the production line before shipping to customers. The metrics reflect the depth performance under typical conditions. External impact factors over 3D cameras' whole lifespan may have significant impacts on their depth performance.

- **Spatial Precision performance reference vs. Distance**

Typical Depth performance reference of spatial precision for Gemini 435Le

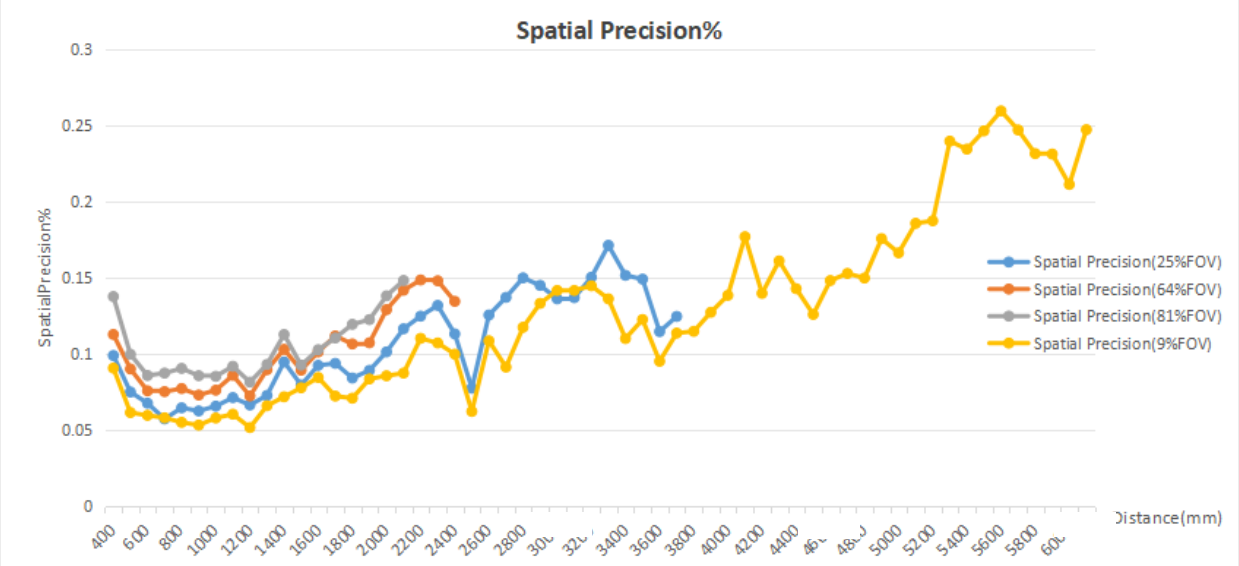


Figure 5-1-1 Spatial Precision chart of Gemini 435Le

- **Temporal Precision performance reference vs. Time**

Typical Depth performance reference of temporal precision for Gemini 435Le

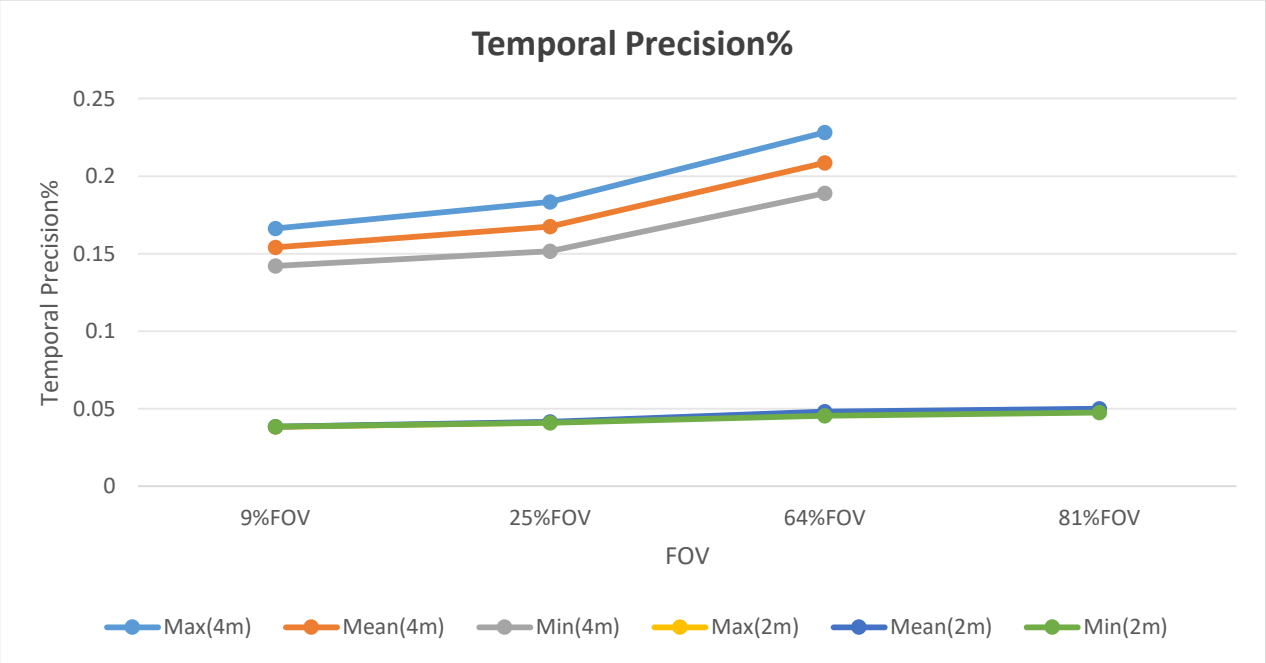


Figure 5-1-2 Temporal Precision chart of Gemini 435Le

- **Fill Rate performance reference vs. Distance:**

Typical Depth performance reference of fill rate for Gemini 435Le

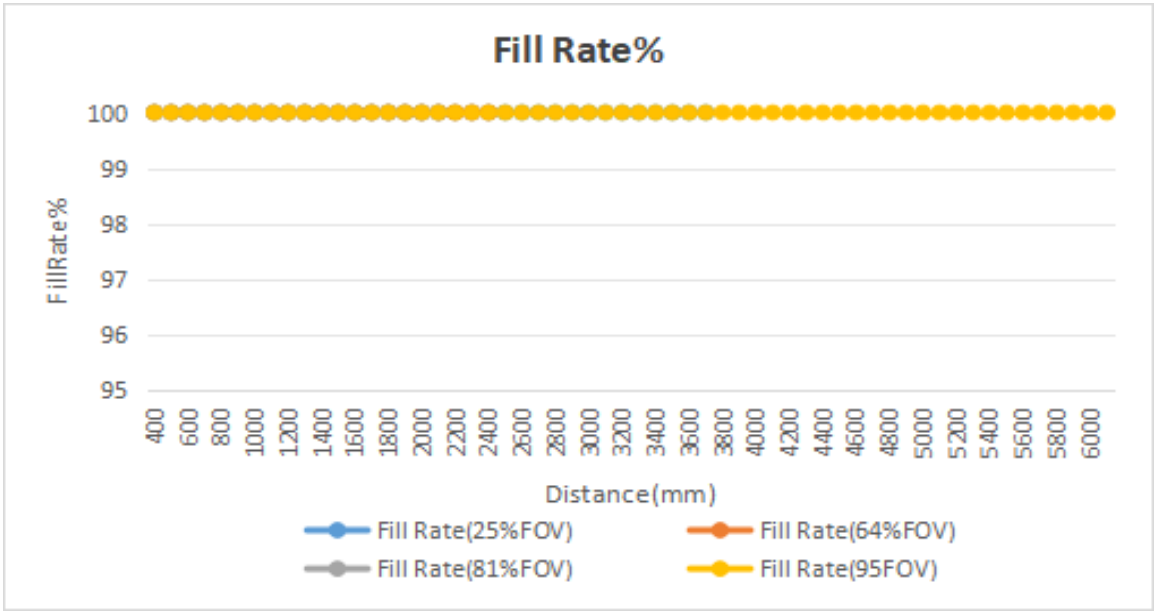


Figure 5-1-3 Fill Rate chart of Gemini 435Le

- **Depth Accuracy performance reference vs. Distance**

Typical Depth performance reference of Depth Accuracy for Gemini 435Le

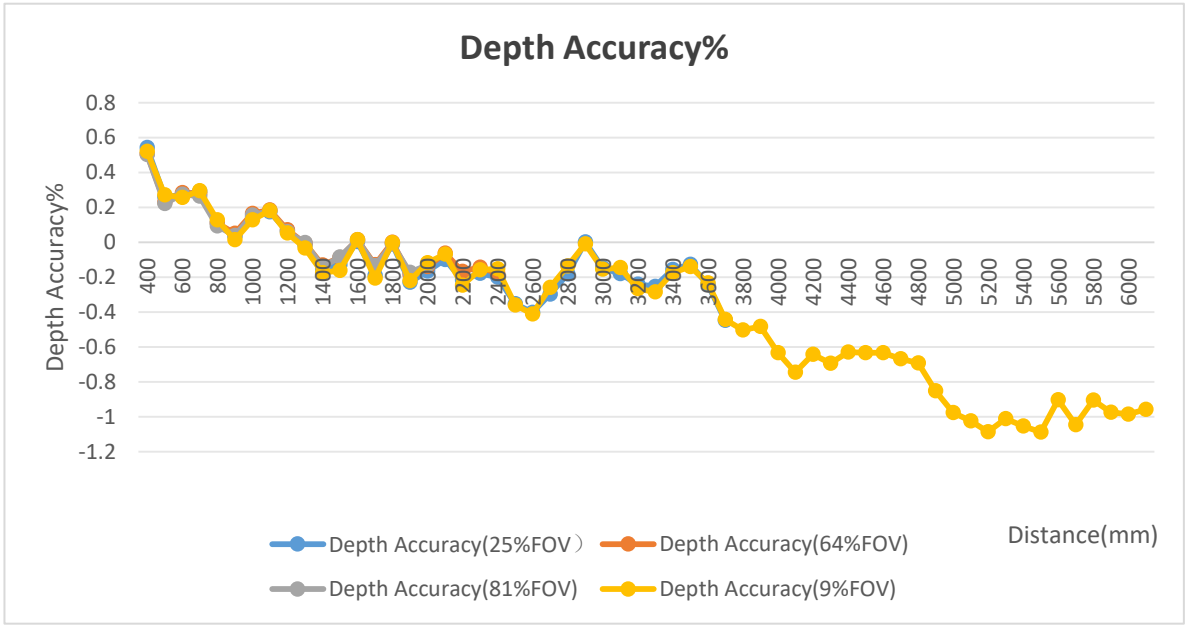


图 5-1-4 Depth Accuracy of Gemini435Le

5.2 Electrical Performance

5.2.1 Power Supply

The Gemini 435Le camera can be PoE/DC powered with the following power requirements:

Table 5-2-1 Gemini 435Le power supply requirements

Power supply method	Requirements
PoE	IEEE 802.3af
DC	≥2A @ 9-24V

5.2.2 Power Consumption

Power consumption varies depending on the selected working mode.

Table 5-2-2 Typical configuration & tested power consumption Reference

Power supply	PoE	DC Power
Typical configuration	Laser power level: 5 D2C：On Operating temperature: 25°C Depth：1280 x 800 @ 10 fps RVL, AE On RGB: 1280 x 800 @ 10 fps MJPEG AE On IR × 2: 1280 x 800 @ 10 fps Y8 AE On IMU ODR (output data rate): 1000Hz	Laser power level: 5 D2C：On Operating temperature: 25°C Depth：1280 x 800 @ 10 fps RVL, AE On RGB: 1280 x 800 @ 10 fps MJPEG AE On IR × 2: 1280 x 800 @ 10 fps Y8 AE On IMU ODR (output data rate): 1000Hz
Average power consumption	7.57W	6.07W

Table 5-2-2 High-Temperature Max Power Configuration & Measured Power Consumption Reference

Power supply	PoE	DC Power
Max Power Configuration	Laser power level: 6 D2C：On Operating temperature: 50°C Depth：1280 x 800 @ 10 fps RVL, AE On RGB: 1280 x 800 @ 10 fps MJPEG AE On IR × 2: 1280 x 800 @ 10 fps Y8 AE On IMU ODR (output data rate): 1000Hz	Laser power level: 6 D2C：On Operating temperature: 50°C Depth：1280 x 800 @ 10 fps RVL, AE On RGB: 1280 x 800 @ 10 fps MJPEG AE On IR × 2: 1280 x 800 @ 10 fps Y8 AE On IMU ODR (output data rate): 1000Hz
Average power consumption	8.08W	6.55W

*Note: The data in the above table are laboratory measurements and are for design reference only.

5.2.3 Storage and Powered Conditions

Table 5-2-3 Gemini 435Le Storage and Powered Conditions

Condition	Description	Min	Max	Unit
Storage (Ambient), Not Powered	Long term storage	0	60	℃
	Short exposure represents temporary max limits acceptable for transportation conditions	-20	60	℃
	Humidity	Temperature / RH: 60℃ / 95%		
Ambient, Powered[1]	The camera ambient temperature when powered	-10	50	℃
LDM Protect Temperature	The LDM temperature when powered	N/A	73	℃
Backside Case Temperature, Powered	The maximum temperature of the backside case occurs when the camera is operated in an ambient temperature of 50°C	-3	65	℃

Notes:

[2] If users require operation over a wider temperature range, additional thermal management measures need to be evaluated.

5.2.4 ESD Performance

Table 5-2-4 Gemini 435Le ESD Performance

Conditions	Powered-On	Powered-Off	Certification Standards
Contact Discharge	±8KV Class A	±8KV Class A	EN 61000-6-2
Air Discharge	±15KV Class A	±15KV Class A	

5.3 Physical Performance

5.3.1 Ingress Protection

The Gemini 435Le supports IP67 level of water and dust resistance and has been factory tested for air tightness. In order to achieve this protection, users should make sure that the M8 A-coded connector is covered with a waterproof cover when using PoE power and use IP67 or higher rated cables.

Gemini 435Le Ingress Protection Information

IP Rating	Power supply	Protection Ability	Conditions
IP67	PoE	①Completely prevents dust from entering the camera ②Completely prevents water up to 1m deep from entering the camera interior for 30 minutes.	①Use an IP67 cable and make sure the M12 X-coded connector is connected well ②Ensure that the M12 A-coded connector cover is in place.
	DC power		①Use network cables and power cables that meet IP67 requirements; ②Ensure that the M12 X-coded and M12 A-coded interfaces are locked at the same time.

6. Firmware

6.1 Firmware Update & Cautions

Gemini 435Le supports update the firmware via online or location, you can upgrade or downgrade as needed. To get the firmware and changelog: **Firmware Release**
Please note the following considerations:

1. You can update the firmware in any working mode or preset;
2. All data streams must be closed when update the firmware;
3. During the firmware update, please ensure that the power supply and data transmission cable connections are stable;
4. The camera will automatically restart after the firmware update is completed. You can also re-plug the cable after completion and restart it manually;

6.2 How to Update Firmware

The simplest way to update the firmware is through the Orbbec Viewer tool, which supports both manual updates and online updates. For detailed instructions, please refer to the documentation: **Update firmware**

6.3 Recovery

Ensure the stability of cable during the update process to avoid upgrade failure. If the update process fails, disconnect the cable, re-insert it, and burn the product again. If re-burning is unsuccessful, the product may be damaged. Orbbec assumes no liability for any damages or losses resulting from the use of this product.

7. SDK

Orbbec SDK is a flexible and modular platform for easy camera setup and runs on multiple platforms with a rich set of APIs. It supports camera access, device setup and configuration, data stream reading, processing, and viewing, RGB-D registration, and frame synchronization.

Its functions include:

Access and control of camera devices

- Control of frame synchronization and alignment
- Acquisition of point cloud data
- Orbbec Viewer for camera testing and evaluation

Please visit **Orbbec SDK** for the latest SDK.

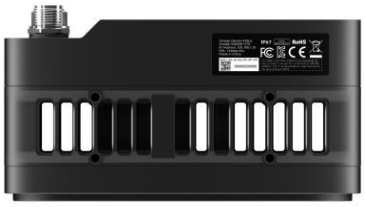
7.1 Temperature Sensor and Recording

The temperature of camera core components can be obtained, including laser temperature, IR sensor temperature, RGB sensor temperature, ASIC temperature and IMU sensor temperature, through API commands.

8. Use Guidance

8.1 Packing List

Table 8-1-1 Gemini 435Le Package List

Package Type	Package List	Gemini 435Le	Notes
Bulk	Camera		Minimum batch packaging quantity: 25pcs
Box	Camera		Minimum batch packaging quantity: 20pcs
	1x Data Cable(2m)		
	1x Power Cable(2m)		
	1x Quick Start Guide		

8.2 Initialization and Operation

- Connect Gemini 435Le via the Data cable to the host PC
- Download Orbbec SDK from **Orbbec SDK**
- Use Orbbec Viewer to validate that images can be streamed from all sensors with the following settings:
    - Depth stream: 1280 x 800(AMR Perceptiom)
    - Color stream: 1280 x 800(AMR Perceptiom)
    - IMU enabled
- If for any reason that the camera is not responding or not being detected, please unplug all cables from the camera and replug the cables for resetting the camera status.

9. Regulatory Compliance

These products are certified as follows:

9.1 Laser Safety certification

Class 1 Laser Product under the EN/IEC 60825-1:2014	U.S. FDA Accession Number: 2420619-000
CLASS 1 LASER PRODUCT	FDA

9.2 EMC Regulatory Compliance

CE-Declaration	FCC part 15 Declaration of Conformity	KC
CE	FC	KC

9.3 Environment Regulatory Compliance

RoHS	REACH	WEEE
RoHS COMPLIANT	REACH compliant	

10. System Integration Guide

Use outside of the specified conditions could cause the device to fail and/or function incorrectly. These conditions are applicable for the environment immediately around the device under all operational conditions. When used with an external enclosure, active temperature control and/or other cooling solutions are recommended to ensure the device is maintained within these ranges.

10.1 Installation Recommendations

1. When using external housing around the camera for dust proofing, use foam inserts or rubber gaskets between the front of the camera and the external housing.
2. Avoid external forces applied to the camera chassis during installation process.
3. Disassembling chassis will void the warranty.

10.2 Heat Dissipation

1. Avoid direct heat source around the camera.
2. Maximizing the space inside the external housing may help lower operating temperature.

10.3 Cable Design Guide

1. It is recommended to use the included data cable and power cable. If there is a need for longer cable, please select a T568B Ethernet cable that meets CAT6A standards.

11. Cautions

1. Follow the instructions carefully when operating the camera. Improper handling may lead to damage to the internal components.

2. Do not drop the camera or expose the camera to mechanical stress.

3. Do not attempt to modify the camera as such modifications may cause permanent damage or performance degradation.

4. The temperature of the camera may rise during long periods of use.

5. Do not touch the lens. Fingerprints on the lens may affect image quality.

6. Keep the product beyond the reach of children or animals to avoid accidents.

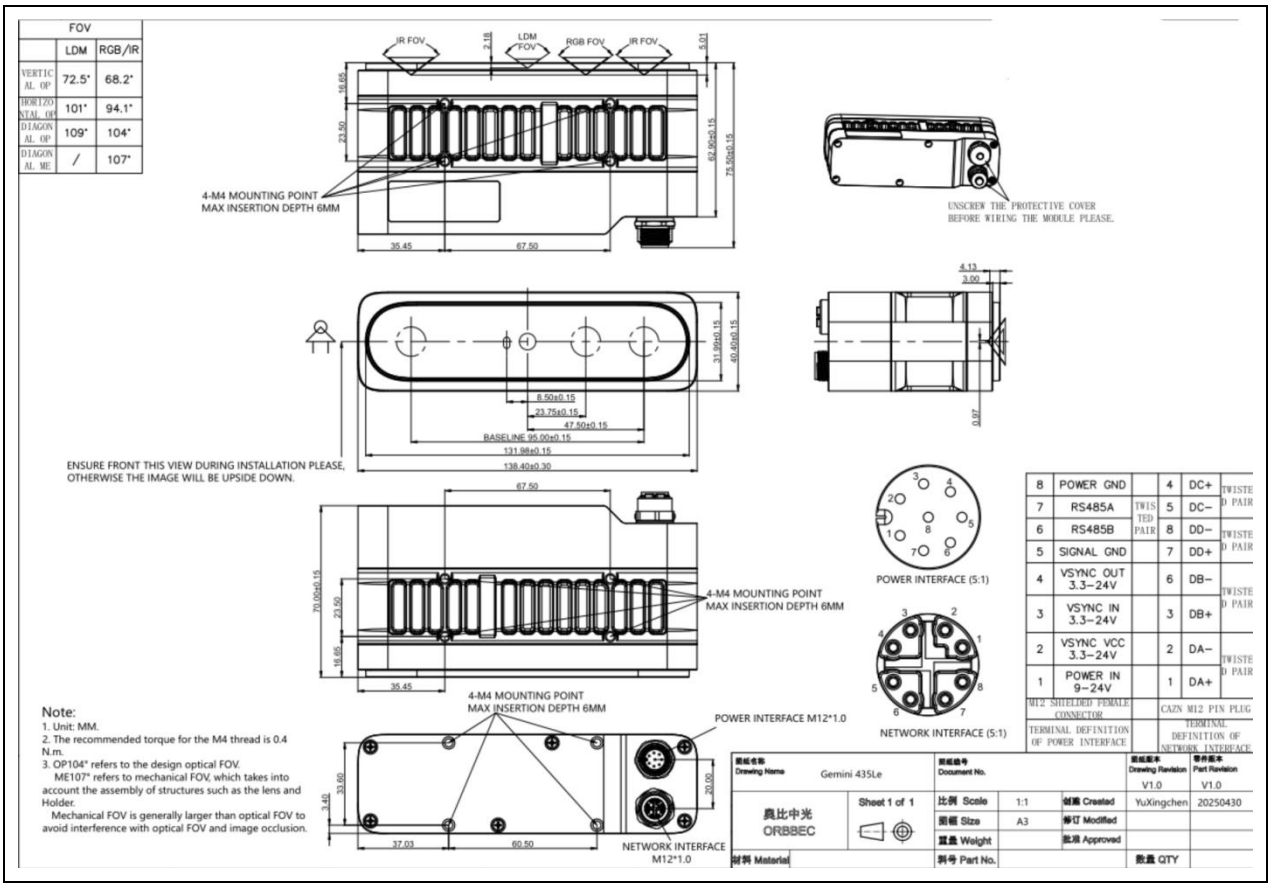
7. If the computer does not recognize the camera, verify that the cables meet the power and data transfer requirements, then replug them into the ports to reconnect.

8. This product is classified as a Class 1 Laser Product under the international standard EN/IEC 60825-1, Edition 3 (2014). Using controls, adjustments, or procedures other than those specified herein may result in hazardous radiation exposure.

Safety and Handling Instructions:

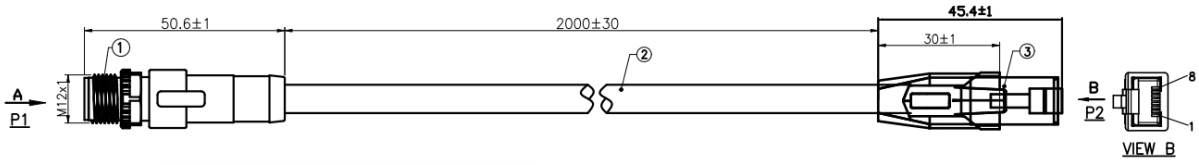
- Avoid powering on the product if any external damage was observed.
- Do not attempt to open any portion of this product. There are no user serviceable parts.
- Be cautious of invisible laser radiation. Avoid direct exposure to the beam.
- To maintain compliance and safety standards, do not modify or service the product. Unauthorized modifications or servicing could result in emissions surpassing the Class 1 safety level.
- Only update the camera firmware with official releases that match the specific module SKU and revision to ensure proper functionality and safety.

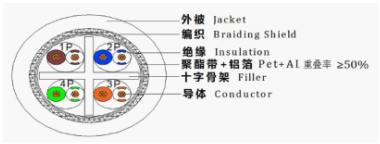
Appendix A Gemini 435Le 2D Mechanical Diagram



Appendix B The cables reference design drawing

Data cable:



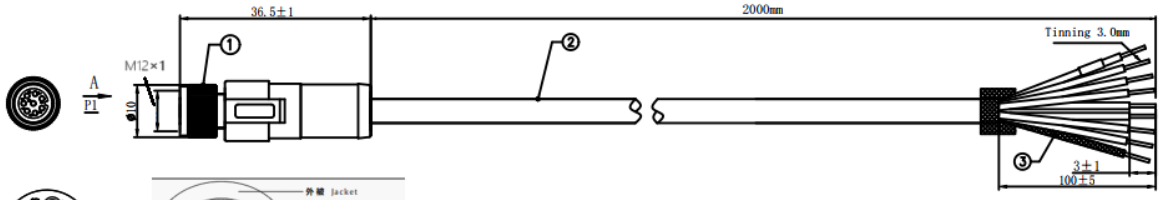


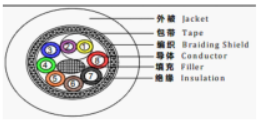
Cable cross section

No.	Specification	Unit	Q'ty
3	CAT6/FTP RJ45 6 Top 2 Bottom long body/T hole 1.06mm, copper covered	pcs	1
2	CAT.6A S/FTP Ethernet Shielded Cable: CAT.6A 4Px26AWG (28/0.08SBC)+PE skeleton filling +PET+AL (overlap rate ≥50%)+ B (24/9/0.1TC, masking rate ≥95%), inner HDPE, OD:0.95, outer black mist surface polyether TPU (fine scrub) OD: 6.5mm(1P: brown, white brown, 2P: blue, white blue 3P: orange, white orange, 4P: green, white green)	pcs	1
1	M12 X coded 12-pin, Female, Shielded type	pcs	1

Connection Definition				
M12	T568B/Color	RJ45	Definition	
1	White/Orange	1	Bi-directional pair A+	Pair twist
2	Orange	2	Bi-directional pair A-	
3	White/Green	3	Bi-directional pair B+	Pair twist
4	Green	6	Bi-directional pair B-	
5	White/Brown	7	Bi-directional pair D+	Pair twist
6	Brown	8	Bi-directional pair D-	
7	White/Blue	5	Bi-directional pair C-	Pair twist
8	Blue	4	Bi-directional pair C+	
Shell	Shield Braid	Shell		

Power cable:





Cable cross section

No.	Specification	Unit	Q'ty
3	Shield Braid, Black heat shrink tube	pcs	1
2	UL20549 1P*26AWG(28/0.08STC)+4C*26AWG(28/0.08STC)+2C*24AWG (41/0.08STC)+ cotton thread filling +AL+B(16/6/0.1TC, masking ratio ≥65%)+ cotton paper, inner core SR-PVC, OD:1.0 of 1P, OD:1.0 of 4C, OD:1.1 of 2C, with black mist surface TPU fine frosted, OD:6.2(1P: purple, yellow; 4C: Blue, green, orange, brown, 2C: red, black)	pcs	1
1	M12 A coded 8-pin, Male, Shielded type	pcs	1

Connection Definition				
M8	Color	OPEN	Definition	
1	Red		POWER IN 9-24V	
2	Orange		VSYNC VCC 3.3-24V	
3	Green		VSYNC IN 3.3-24V	
4	Blue		VSYNC OUT 3.3-24V	
5	Brown		SIGNAL GND	
6	Purple		RS485B	Pair twist
7	Yellow		RS485A	
8	Black		POWER GND	
Shell	Shield Braid