

Deptrum[®] Nebula 290

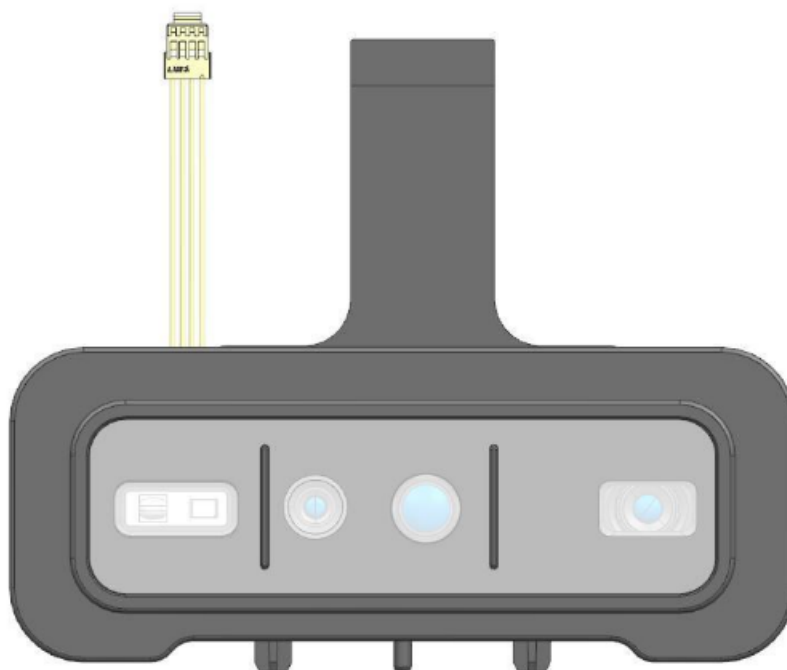
Product Specification

V0.1 - 2026/09/30

Author: tao.hu@deptrum.com

1 Revision History

Version	Description	Date	Revised by
V0.1	Initial release	2026/09/30	Hutao



Product appearance drawing (incl. FPC cable)

2 Product Overview

Product Introduction

The Deptrum® Nebula 290 series depth camera combines 3D structured light technology with modulated ToF technology to capture the 3D structure of objects and spaces, providing both ultra-high-precision depth perception at short range and high-precision depth perception at long range. Paired with a high-performance RGB camera, it ultimately delivers RGBD perception for robot vacuums. Based on Deptrum's self-developed modulated projection light field, the Nebula 290 camera adopts the proprietary structured-light/ToF fusion sToF algorithm and mToF algorithm, effectively eliminating the multipath interference of conventional ToF and greatly improving depth accuracy.¹²

System Requirements

Supports Windows / Linux / Android; point cloud computing power requirement $< 0.6 \times$ A55 @ 1.6 GHz @ 6 Hz; RGB requires ISP tuning.

Product Features

- Ranging range over 10 m on indoor white walls
- A single module meets both short-range obstacle avoidance and long-range SLAM depth requirements
- Multipath interference resistance
- Low motion blur
- Large FOV
- Compatible with ground obstacle segmentation algorithms, 3D SLAM algorithms, and AI recognition algorithms such as stain detection

Applications

- Robot vacuum cleaners

¹sToF: StructureLight + iToF, a 3D algorithm fusing the soft-core structured-light reconstruction algorithm with the iToF algorithm, mainly used for short-range obstacle avoidance;

²mToF: modulated ToF, a speckle iToF technology implemented based on the modulated projection light field of the WFP photonic chip, mainly used for long-range SLAM

3 Core Specifications

Nebula 290 Product Specifications		
Module Parameters	Module dimensions	85.0 × 34.1 × 19.75 mm
	Baseline	Structured light 24 mm; binocular 11.8 mm
	Operating temperature	-10°C ~ +45°C
	Operating humidity	0% ~ 95% RH, non-condensing
	Average power consumption	< 0.6 W (in sToF/10 fps + mToF/10 fps + IR/10 fps mode)
	Mounting height	Recommended horizontal mounting height 5 ~ 7 cm; mounting pitch angle < ±10°, yaw angle < ±5°, roll angle < ±2°
sToF obstacle-avoidance depth image performance ³	sToF obstacle-avoidance working distance ⁴	3 ~ 120 cm
	sToF resolution / frame rate	248 × 180 @ 10 fps
	sToF precision (90% reflectivity white wall test)	≤ 3 mm @ [3 cm, 25 cm]; ≤ 1.5% @ (25 cm, 70 cm); ≤ 1% @ (70 cm, 120 cm)
	sToF precision (20% reflectivity gray wall test)	≤ 3 mm @ [3 cm, 25 cm]; ≤ 1.5% @ (25 cm, 70 cm); ≤ 1% @ (70 cm, 120 cm)
	sToF accuracy (90% reflectivity)	≤ 6 mm @ [3 cm, 25 cm];

³The precision values take the lower limit of the production-line 1 m-high guide-rail verification specification, i.e., the product shipping verification data is not lower than the production-line verification specification

⁴The 3 cm limit range refers to the nearest limit range at which the robot can stably reconstruct while dynamically moving from far to near. The nearest distance with streaming enabled in static conditions is about 5 cm

	white wall test)	$\leq 10 \text{ mm @ (25 cm, 70 cm)}$; $\leq 1\% \text{ @ (70 cm, 120 cm)}$
	sToF accuracy (20% reflectivity gray wall test)	$\leq 6 \text{ mm @ [3 cm, 25 cm]}$; $\leq 10 \text{ mm @ (25 cm, 70 cm)}$; $\leq 1\% \text{ @ (70 cm, 120 cm)}$
	sToF typical obstacle detection precision ⁵	1.2 cm @ 20 cm
	Motion blur	$\leq 1.5 \text{ rad/s}$ without blur
	FOV	Max. H98° × V60° ($\pm 3^\circ$) supported
mToF SLAM depth image performance	mToF SLAM working distance	$\geq 4.0 \text{ m @ 10\% reflectivity gray wall}$; $\geq 5.5 \text{ m @ 20\% reflectivity gray wall}$; $\geq 11 \text{ m @ 90\% reflectivity white wall}$
	mToF resolution / frame rate	248 × 180 @ 10 fps
	mToF precision (90% reflectivity white wall test)	$\leq 3 \text{ mm @ [3 cm, 25 cm]}$; $\leq 1.5\% \text{ @ (25 cm, 70 cm)}$; $\leq 1\% \text{ @ (70 cm, 8 m)}$
	mToF precision (20% reflectivity gray wall test)	$\leq 3 \text{ mm @ [3 cm, 25 cm]}$; $\leq 1.5\% \text{ @ (25 cm, 70 cm)}$; $\leq 1\% \text{ @ (70 cm, 4.5 m)}$
	mToF accuracy (90% reflectivity white wall test)	$\leq 6 \text{ mm @ [3 cm, 25 cm]}$; $\leq 10 \text{ mm @ (25 cm, 70 cm)}$; $\leq 1\% \text{ @ (70 cm, 8 m)}$
	mToF accuracy (20% reflectivity gray wall test)	$\leq 6 \text{ mm @ [3 cm, 25 cm]}$; $\leq 10 \text{ mm @ (25 cm, 70 cm)}$; $\leq 1\% \text{ @ (70 cm, 4.5 m)}$

	FOV	Max. H98° × V60° (±3°) supported
	Spatial angular resolution ⁶	≤ 2.5° @ 6 m (20% reflectivity gray wall)
Synchronization	Synchronization	Supports master-slave mode
System compatibility	System compatibility	Supports Arm Linux
Compatible algorithms	Algorithm support	Point-cloud-matching-based 3D SLAM algorithm, CPU usage < 0.5 × A55 @ 6 fps; stain detection / thin-wire detection algorithms; supports self-calibration algorithm to compensate for accuracy deviation caused by structured light deformation ⁷

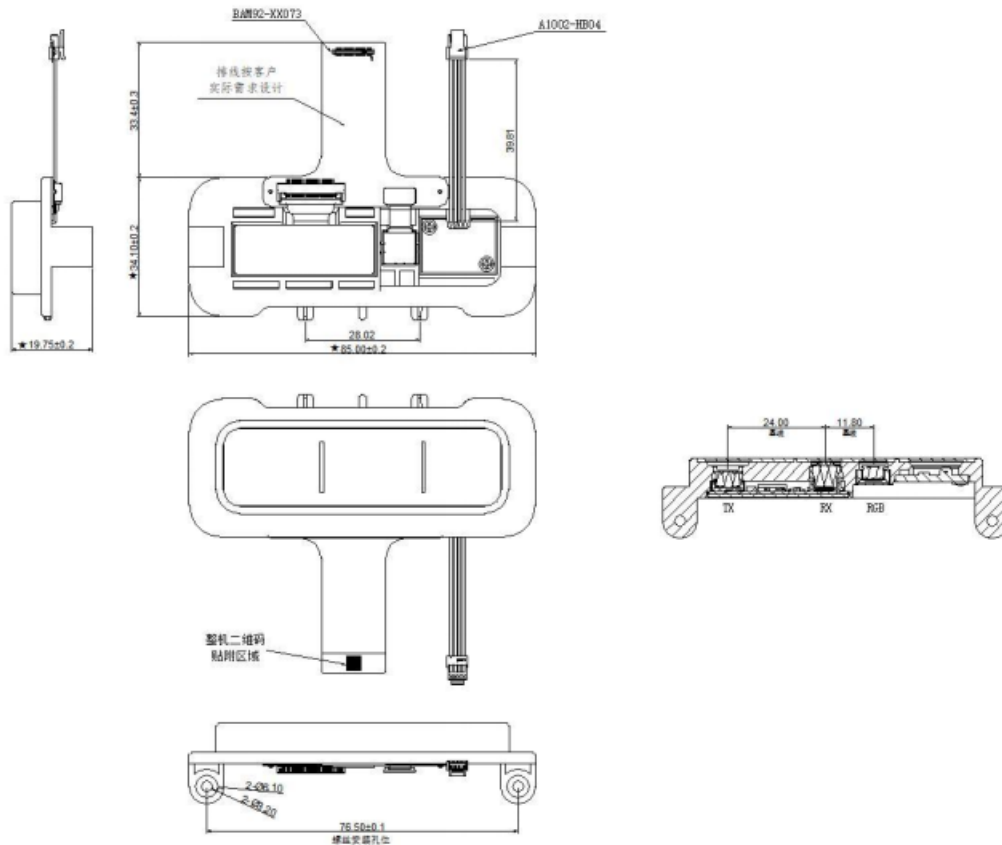
4 Image performance notes in real-world scenarios

- The mToF SLAM image performance suffers some ranging range loss in ground scenes due to ground glare and crosstalk.
- Subjective scenario: 10% reflectivity gray board, mToF maximum ranging range and accuracy: ≤ 3.5 m @ 80% valid point rate. Test conditions: host device with cover glass, optical center height 5 cm, spliced tile and wood floor.

⁶Spatial angular resolution: perform Delaunay triangulation on valid depth points and calculate the mean of the spatial angular resolutions corresponding to all edge lengths.

⁷Self-calibration algorithm: the mass-production SDK includes a deformation self-calibration algorithm. Within a certain module deformation range caused by collision, torsion, thermal shock, etc., it can automatically trigger self-calibration in scenes such as the bow-shaped cleaning path of a robot vacuum when facing a white wall at about 35 cm, correcting structured-light accuracy issues caused by slight module deformation and improving short-range perception accuracy to meet the shipping standard.

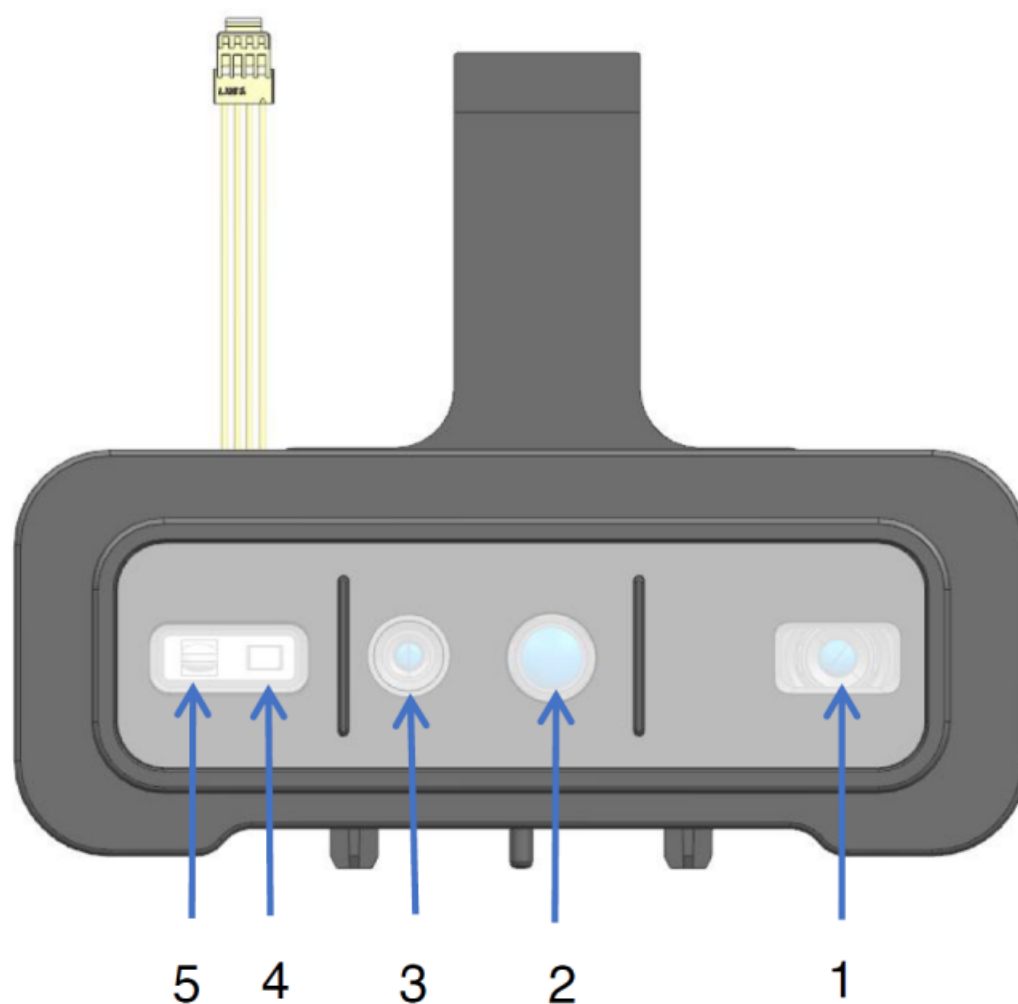
5 Module Dimensions & Structure



Module dimension drawing (incl. full-housing mounting hole spacing 78.50 ± 0.1 , structured light baseline 24.00, binocular baseline 11.80)

5.1 Module Description

The Nebula 290 module consists of a dot projector, a ToF camera, an RGB camera, an IR LED, and a white LED; the FPC cable can be flexibly customized to customer requirements. Structured light baseline 24.00 mm, binocular baseline 11.80 mm, full-housing mounting hole spacing 78.50 ± 0.1 mm; refer to the module dimension drawing for details.



Module layout diagram (numbers correspond to the System Components table)

System Components	No.
Dot projector	1
ToF Camera	2
RGB Camera	3
IR LED	4
White LED	5

6 Key component specifications

Item	Key parameter	Specification
ToF Sensor	Active Array Size	240 × 180
ToF Sensor	Pixel Size	10 × 10 μm
ToF Sensor	QE @ 850 nm	50%
ToF Sensor	Operating Temperature Range	-20°C ~ +85°C
ToF RX lens	F/NO	1.4
ToF RX lens	FOV	98.3°(H) × 79.2°(V) × 115.6°(D)
ToF RX lens	EFL	1.09 mm
ToF RX lens	TTL	7 mm
TX	Center Wavelength	850 nm
TX	Eye Safety	Class I
TX lens	FOV	101.1°(H) × 83.6°(V) × 117.3°(D)
TX lens	EFL	0.695 mm
TX lens	TTL	4.8 mm
TX lens	F/NO	2.4
TX lens	Center Wavelength	850 nm
IR LED	FOV	130°(D)
IR LED	Center Wavelength	850 nm
White LED	FOV	H120° × V98°
RGB Sensor	Active Array Size	2592 × 1944
RGB Sensor	Pixel Size	1.12 μm × 1.12 μm

RGB Sensor	Optical Format	1/5 inch
RGB lens	TTL	4.04 mm
RGB lens	EFL	1.4 mm
RGB lens	F/NO	2.2 $\pm$ 5%
RGB lens	FOV	95°(H) $\times$ 76°(V) $\times$ 115°(D)
RGB lens	TV Distortion	< 11%

7 Module Electrical Requirements

7.1 PIN Definition

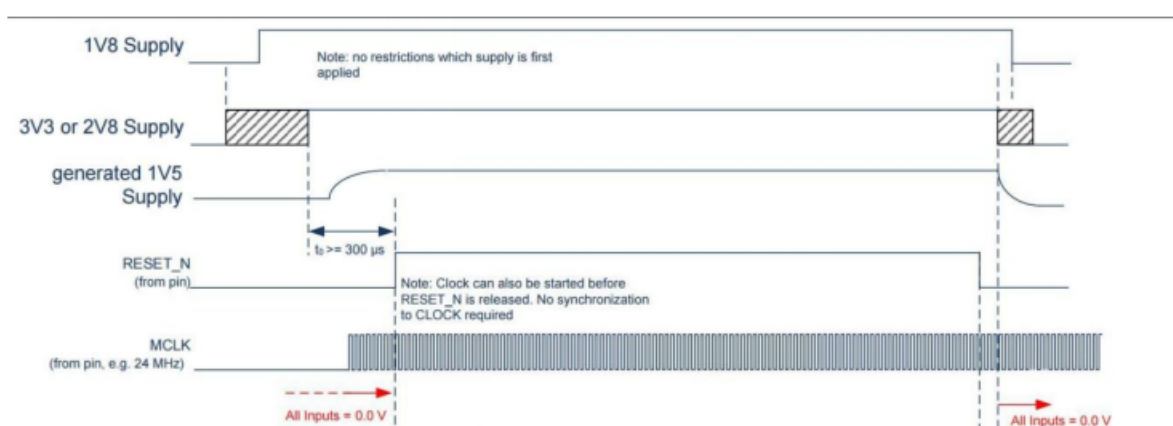
PIN NO.	Name	Type	Description
1	RGB_DVDD	P	RGB DVDD power 1.2 V (Imax = 200 mA)
2	GND	G	Ground (0 V)
3	RGB_AVDD	P	RGB sensor power for analog circuit 2.8 V (low noise, high PSRR, Imax = 200 mA)
4	GND	G	Ground (0 V)
5	RGB_MD0N	O	RGB sensor MIPI data lane 0 (negative)
6	RGB_MD0P	O	RGB sensor MIPI data lane 0 (positive)
7	GND	G	Ground (0 V)
8	RGB_MCN	O	RGB sensor MIPI clock lane (negative)
9	RGB_MCP	O	RGB sensor MIPI clock lane (positive)
10	GND	G	Ground (0 V)
11	RGB_MD1N	O	RGB sensor MIPI data lane 1 (negative)

12	RGB_MD1P	O	RGB sensor MIPI data lane 1 (positive)
13	GND	G	Ground (0 V)
14	IR_MD1N	O	IR sensor MIPI data lane 1 (negative)
15	IR_MD1P	O	IR sensor MIPI data lane 1 (positive)
16	GND	G	Ground (0 V)
17	IR_MD0N	O	IR sensor MIPI data lane 0 (negative)
18	IR_MD0P	O	IR sensor MIPI data lane 0 (positive)
19	GND	G	Ground (0 V)
20	IR_MCN	O	IR sensor MIPI clock lane (negative)
21	IR_MCP	O	IR sensor MIPI clock lane (positive)
22	GND	G	Ground (0 V)
23	IR_MCLK	I	IR sensor clock input (value max: DOVDD + 0.3 V)
24	GND	G	Ground (0 V)
25	IR_AVDD	P	IR sensor power for analog circuit 3.3 V (low noise, high PSRR, I _{max} = 300 mA)
26	IRLED_EN	O	IR LED enable control signal, active high
27	IR_SDA	I/O	IR sensor I2C data (value max: DOVDD + 0.3 V)
28	IR_TRGGER	I/O	IR sensor sync output (value max: DOVDD + 0.3 V). This pin can generally also be configured as a sync input.
29	IR_SCL	I/O	IR sensor I2C input clock (value max: DOVDD + 0.3 V)
30	IR_RESET	I	IR sensor master reset, active low

31	GND	G	Ground (0 V)
32	IR_DOVDD	P	I/O power 1.8 V (I _{max} = 300 mA)
33	RGB_DOVDD	P	I/O power 1.8 V (I _{max} = 300 mA)
34	NC	-	Please keep NC, no connection
35	NC	-	Please keep NC, no connection
36	NC	-	Please keep NC, no connection
37	GND	G	Ground (0 V)
38	GND	G	Ground (0 V)
39	GND	G	Ground (0 V)
40	GND	G	Ground (0 V)
41	GND	G	Ground (0 V)
42	GND	G	Ground (0 V)
43	RGB_XSHUTDN	I	RGB sensor master reset, active low
44	RGB_SCL	I	RGB sensor I2C input clock (value max: DOVDD + 0.3 V)
45	RGB_Fsync	I/O	RGB sensor sync output (value max: DOVDD + 0.3 V). This pin can generally also be configured as a sync input.
46	RGB_SDA	I/O	RGB sensor I2C data (value max: DOVDD + 0.3 V)
47	GND	G	Ground (0 V)
48	GND	G	Ground (0 V)
49	GND	G	Ground (0 V)
50	RGB_MCLK	I	RGB sensor clock input (value max:

			DOVDD + 0.3 V)
P1	GND	G	Ground (0 V)
P2	GND	G	Ground (0 V)
P3	VBUS	P	Power for VBUS; 5 ± 0.5 V, $I_{max} = 2$ A
P4	VBUS	P	Power for VBUS; 5 ± 0.5 V, $I_{max} = 2$ A

7.2 Power-on Sequence



Power-on sequence diagram (1V8 corresponds to DOVDD, 3V3 to AVDD, and 1V5 is the sensor internal voltage; 5V is the laser supply voltage, which only needs to be powered on before laser emission; $t_0 \geq 300 \mu s$)

8 Environment & Reliability

Item	Parameter	Specification
Operating environment	Temperature	-10°C ~ +45°C
	Humidity	Relative humidity 0% ~ 95%, non-condensing
	Illuminance	0 ~ 40,000 lux (indoor/by window)
Storage environment	Temperature	-40°C ~ +70°C
	Humidity	Relative humidity 0% ~ 95%,

		non-condensing
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9 Reliability test

Reliability test item	Conditions	Acceptance criteria
Low-temperature storage	Temperature: $-40^{\circ}\text{C} \pm 3^{\circ}\text{C}$; duration: 72 H	1. No abnormality in appearance or function; 2. Performance meets the shipping standard
High-temperature high-humidity storage	Temperature: $70^{\circ}\text{C} \pm 3^{\circ}\text{C}$; humidity: $93\% \pm 3\% \text{ RH}$; duration: 72 H	1. No abnormality in appearance or function; 2. Performance meets the shipping standard
High/low temperature shock	Temperature: $70^{\circ}\text{C} \pm 3^{\circ}\text{C} \sim -40^{\circ}\text{C} \pm 3^{\circ}\text{C}$; 60 min dwell at each position, 50 cycles in total	1. No abnormality in appearance or function; 2. Performance meets the shipping standard after self-calibration is triggered
High-temperature high-humidity operation	Temperature: $60^{\circ}\text{C} \pm 3^{\circ}\text{C}$; humidity: $93\% \pm 3\% \text{ RH}$; duration: 96 H	1. No abnormality in appearance or function; 2. Performance meets the shipping standard
Low-temperature operation + startup	Temperature: $-10^{\circ}\text{C} \pm 3^{\circ}\text{C}$; stored for 12 H first, then powered on and operated for 36 H, 48 H in total	1. No abnormality in appearance or function; 2. Performance meets the shipping standard
Random vibration test	5 ~ 500 Hz, acceleration 2G, 2 hours per axis on the X/Y/Z axes	1. No abnormality in appearance or function; 2.

		Performance meets the shipping standard
Lifetime (MIPI)	Temperature: 60°C; operating duration: 3000 H	1. No abnormality in appearance or function; 2. Performance meets the shipping standard after self-calibration is triggered

10 Certification

Item	Specification
Environmental certification	RoHS 2.0, REACH
Laser eye safety	IEC60825-1: Class 1

11 EMC

Item	Specification
ESD level	Per IEC 55014-2, following the host device's typical operating conditions, meets performance criterion A or B: contact discharge (± 4 kV) applied to the MIPI module's PIN pins (VCC & GND), 10 times each
RE level	Per IEC 55014-1, following the host device's most stringent operating conditions, meets QP margin ≥ 6 dB; module operating conditions: AVDD 3.3 V, LDVCC 5 V, DOVDD 1.8 V, frame rate @ 6 Hz

12 Software Development

Customers can work with Deptrum on driver integration and point cloud SDK integration as needed to obtain sToF and mToF point cloud data on the target platform, and can also integrate the Hypercube SDK to adapt SLAM algorithms.

13 Disclaimer

The device application information and similar content described in this publication are provided for your convenience only and may be superseded by updated information. It is your responsibility to ensure that your application complies with the technical specifications. Shenzhen Deptrum Technology Co., Ltd. makes no representations or warranties of any kind, whether express or implied, written or oral, statutory or otherwise, including but not limited to representations or warranties regarding the use, quality, performance, merchantability, or fitness for a particular purpose of this information. Deptrum assumes no liability for consequences arising from this information or the use of it. Deptrum products shall not be used as critical components in life support systems without the written approval of Shenzhen Deptrum Technology Co., Ltd. No license is conveyed, implicitly or otherwise, under Deptrum's intellectual property rights.

14 Technical Support

You can obtain support through the following channels:

- Email support: please send your questions to support@deptrum.com
- FAE support: please contact our sales team for FAE support

15 Precautions

- Do not heat this product with any other heat source.

- Do not drop or subject this product to impact, as this may damage internal components and degrade accuracy; improper handling may damage internal components.
- Do not attempt to modify or disassemble this device in any way, as this may damage the module and degrade accuracy.
- The module heats up after a period of use, which is normal; heat dissipation measures can be applied to the back of the module.
- Do not store the module in a high-temperature, high-humidity environment, as this may degrade module accuracy or cause depth reconstruction failure.