CS20-P Datasheet

Revising the historical rendition			
Date	Version	Description	Author
June 12th, 2023	V1.0	First draft	Terry
July 24th，2023	V1.1	1. Revise the adapter description; 2. Included a referral link for the DC adapter in the adapter section	Terry
November 28th ，2023	V1.2	Revised specifications and description of exterior dimensions	Terry
April 18th，2024	V1.3	Added frame rate description	Terry

Contents

1. Description and characteristics

Product description

The CS20-P is an Ethernet depth camera equipped with a high-resolution 320*240 ToF image sensor, utilizing ToF technology to acquire three-dimensional information of objects and space. It boasts exceptional performance in terms of long-range capability and low power consumption, providing users with convenient and efficient 3D perception capabilities.

Power supply and Ethernet data transmission are primarily facilitated through the 6-core aviation head interface, with specific details regarding its usage outlined in Chapter 3.2.

Product features

- Centimeter-level Measurement Accuracy
- Measuring range: 0.1-5 m@90% reflectance
- Aviation head power supply and Ethernet data transmission

Applications

- Smart buildings
- Anti-tailgating
- People counting

Figure 1-1. The CS20-P depth camera's exterior view.

2. Introduction

2.1 The purpose of this document

This document outlines the specifications of the Ethernet depth camera CS20-P, providing users with pertinent information necessary for comprehending and utilizing the CS20-P Ethernet depth camera.

2.2 Overview of ToF (Time-of-Flight) Technology

ToF technology calculates the distance of an object from the camera through the flight time of light. First, the ToF sensor gives the light source to drive the chip modulation signal, and then the modulation signal emits high-frequency modulated near-infrared light through the control laser, and when the light encounters the measured object, it is diffusely reflected back to the sensor receiving end, and the depth information is calculated by the time difference between transmitting and receiving light.

The CS20-P Ethernet depth camera utilizes continuous wave modulation (CW-iToF) in i-ToF (indirect Time of Flight). By analyzing the proportional relationship between the energy values collected by the sensor at different time intervals, the signal phase is parsed to indirectly measure the time difference between transmitted and received signals, thereby obtaining depth information.

Continuous wave modulation (CW-iToF)

The sine wave modulation method is typically employed, where the phase offset of the sine wave at both the receiving and transmitting ends is directly proportional to the distance of the object from the camera. The measurement of distance is accomplished through analysis of this phase offset.

$$\varphi_{TOF} = \operatorname{atan}\left(\frac{C_1 - C_3}{C_2 - C_4}\right)$$

$$D = \frac{c}{2} * \frac{\varphi_{TOF}}{2\pi * f_m} + D_{offset}$$

Formula 2-1. Distance calculation

The phase offset (φ) and depth (D) are determined through the analysis of integrated energy values obtained from equations C1, C2, C3, and C4. These equations represent the energy collected by receiving windows with different phase delays corresponding to sampling at 0°, 90°, 180°, and 270° phase sampling points.

$$C_1 = A\sin(\varphi)$$

$$C_2 = A\sin(\varphi + 90°) = A\cos(\varphi)$$

$$C_3 = A\sin(\varphi + 180°) = -A\sin(\varphi)$$

$$C_4 = A\sin(\varphi + 270°) = -A\cos(\varphi)$$

Formula 2-2. Energy value vs. Phase

Where A is the amplitude of the received sinusoidal signal.

The accuracy of CW-iToF is primarily constrained by random noise, which is inversely proportional to the Signal to Noise Ratio (SNR) of the received optical signal, and quantization noise, which decreases with increasing sine wave modulation frequency. Therefore, in order to enhance accuracy, CW-iToF typically employs high-power short integration time sampling to improve the SNR of the received optical signal. Simultaneously, the modulation frequency is increased to suppress quantization noise.

In terms of range, the phase range that CW-iToF can resolve is [0~2π]. Therefore, its maximum range can be calculated as Dmax=c/(2fm). This implies that as the frequency increases, the accuracy improves while the range decreases. However, beyond this depth of range, periodic phase wrap occurs and leads to incorrect measurements falling within [0~Dmax].

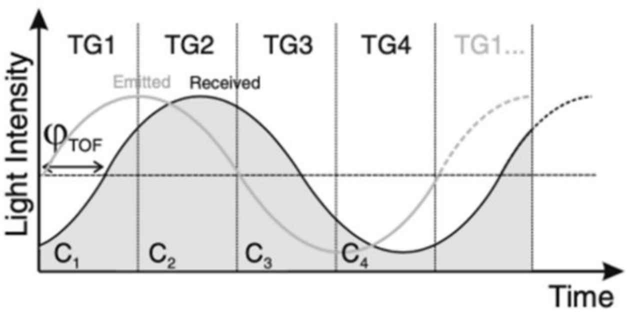

Figure 2-1. Light flight time and light intensity

2.3 Block diagram of the camera system

The CS20-P Ethernet depth camera hardware system comprises two main components: a processor motherboard and a ToF module. The ARM processor is situated on the motherboard, while the ToF module is securely attached to the motherboard via connectors.

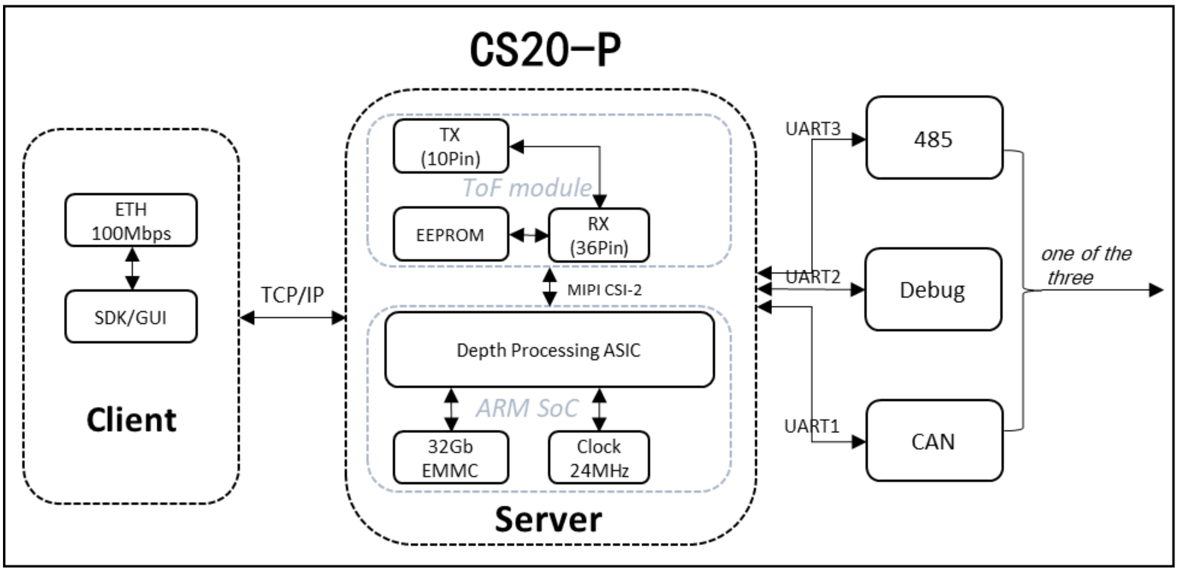

Figure 2-2. Block diagram of the CS20-P Ethernet depth camera system

2.4 Technical Parameters

Technical parameters		
Depth image	Resolution	320*240@30fps
	FOV	H100°xV75°
Basic parameters	Working distance	0.1-5m, indoor
	VCSEL wavelength	940nm
	Accuracy	0.1~0.5m: ±3cm; 0.5~5m: ±2% @ 90% reflectivity
	Size	103.6mm*70mm*30mm
	Data transmission	TCP/IP Interface
	Power supply mode	12-24V/2A
	Power consumption	average 3.0W
	Operating system	Windows，Linux，ROS1/ROS2
	Operating temperature	-10 ~ 50℃
	Security	LASER CLASS1

3. Component specifications

3.1 ToF module

Compose	Description
ToF imager	Time of light image sensor
ToF emitter	Class 1 laser compliant (optional)
Other Components	Laser Driver, EEPROM, Voltage Regulators, FPC, Connector etc.

Table 3-1. ToF module components

3.1.1 ToF module image sensor

Compose	Description
Active Pixels	320*240
Sensor Aspect Ration	4：3
Format	10-bit RAW
Shutter Type	Global shutter
Signal Interface	MIPI CSI-2, 2X Lanes
F Number	1.2
Focal Length	2.534mm
Focus	Fixed
Horizontal Field of View	100.2
Vertical Field of View	75.1
Diagonal Field of View	125.5
TV Distortion	<11.8%

Table 3-2. ToF image sensor parameters

3.1.2 ToF module laser emitter

The ToF laser emitter emits uniform near-infrared (940nm) light towards the object, while complying with Class 1 laser safety requirements during normal operating conditions.

Items	Test Condition	Min	Typical	Max	Unit
Optical Output power	Pulse=5.0A，50℃	-	4.3	-	W
Threshold current	Pulse 50℃	-	-	1	A
Operating Current	Pulse 50℃	-	5	-	A
Operating voltage	Pulse=5.0A，50℃	-	2.0	-	V
Slope efficient	Pulse=5.0A，50℃	-	1	-	mW/mA
Power conversion efficiency	Pulse=5.0A，50℃	-	43	-	%
Angle	Pulse=5.0A，50℃	-	110.25	-	°
	Pulse=5.0A，50℃	-	90.22	-	
Wavelength	If=5.0A，50℃	938	940	942	nm
Wavelength coefficient	Pulse=5.0A	-	0.07	-	nm/℃

Table 3-3. ToF module laser emitter parameters

3.2 Processor mainboard

Components	Description
Vision Processor	Depth Processing ASIC
32Gb EMMC	Vision Processor firmware storage and ToF firmware storage
24 MHz Crystal	Clock source for Vision Processor
Depth Module Receptacle	(36+10)pin receptacle for connection to Depth Module
Ethernet	100Mbps Ethernet port connects to a host or network server through an RJ45 port
Voltage Regulators	DC to DC and LDO converters powering Vision Processor Board and depth module
Mounting holes	Vision Processor Board secure mounting

Table 3-4. Processor Board Components

3.3 Interface description

3.3.1 Tail Description

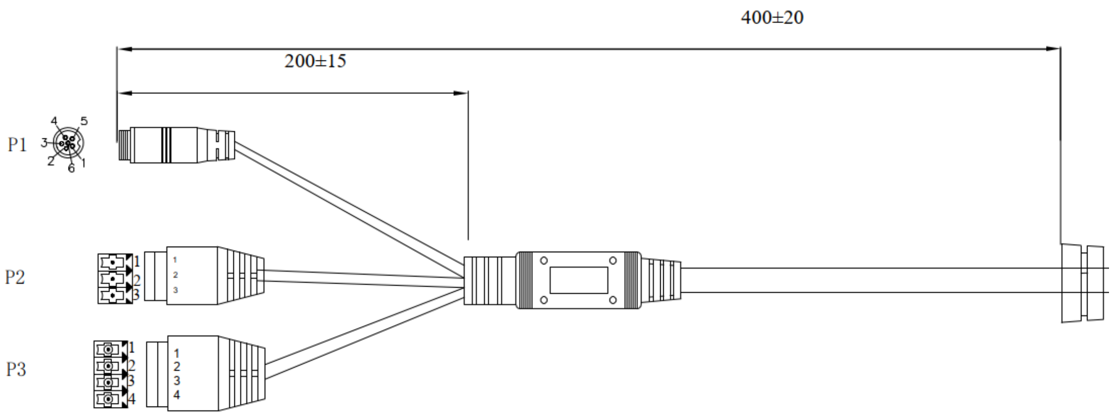

Figure 3-1. Schematic diagram of the CS20-P tail

P1:M12 Aviation Head_6PIN		P2:DGK5.08_3PIN		P3:DGK5.08_4PIN		
Pin Number	Signal Name	Pin Number	Signal Name	Pin Number	Signal Name	
1	100BASE-T：TX-	1	GND	1	GND	
2	100BASE-T：TX+	2	VCSEL_IN	2	RS485_A(P)	
3	V+(12-24V/2A)	3	V+(12-24V/2A)	3	RS485_B（N)	
4	100BASE-T：RX-	Note: P2 Pin1 & Pin3 is a power interface that can be used to power another bypass equipment; Pin2 is an external trigger signal that controls the operating state of the laser		4	GND	
5	100BASE-T：RX+			Note: 485/UART/CAN interface communication, can be configured through software, default 485 interface		
6	EGND					

Table 3-5. Buttock line Receptacle Pin Map

3.3.2 Adapter Cable Description

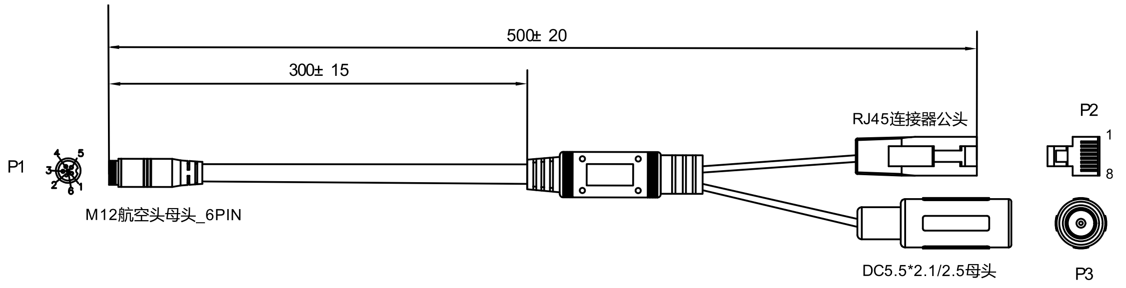

Figure 3-2. Schematic diagram of the adapter cable

<table>
<tr><th colspan="2">P1:M12 aircraft head female _6PIN</th><th colspan="2">P2:RJ45 male</th><th colspan="2">P3:DC5.5*2.5 male</th></tr>
<tr><td>Pin Number</td><td>Signal Name</td><td>Pin Number</td><td>Signal Name</td><td>Pin Number</td><td>Signal Name</td></tr>
<tr><td>1</td><td>100BASE-T：TX-</td><td>1</td><td>100M_TX+</td><td colspan="2" rowspan="6">Note: It needs to be used with DC5.5*2.5 adapter with a power supply range of 12-24V/2A.
Suggested purchase link:
https://item.jd.com/100029626633.html</td></tr>
<tr><td>2</td><td>100BASE-T：TX+</td><td>2</td><td>100M_TX-</td></tr>
<tr><td>3</td><td>V+(12-24V/2A)</td><td>3</td><td>100M_RX+</td></tr>
<tr><td>4</td><td>100BASE-T：RX-</td><td>6</td><td>100M_RX-</td></tr>
<tr><td>5</td><td>100BASE-T：RX+</td><td></td><td></td></tr>
<tr><td>6</td><td>EGND</td><td></td><td></td></tr>
</table>

Table 3-6. Adapter instructions

3.4 Power consumption

State	Imin（mA)	Iavg（mA)	Ipp（mA)
Standby (complete machine)	54	55	56
Mainboard+ToF Module	197	220	527
Supply voltage: V+=12V, measured data based on exposure time=3000us.			

Table 3-7. Ethernet depth camera power consumption specification

4. Performance evaluation

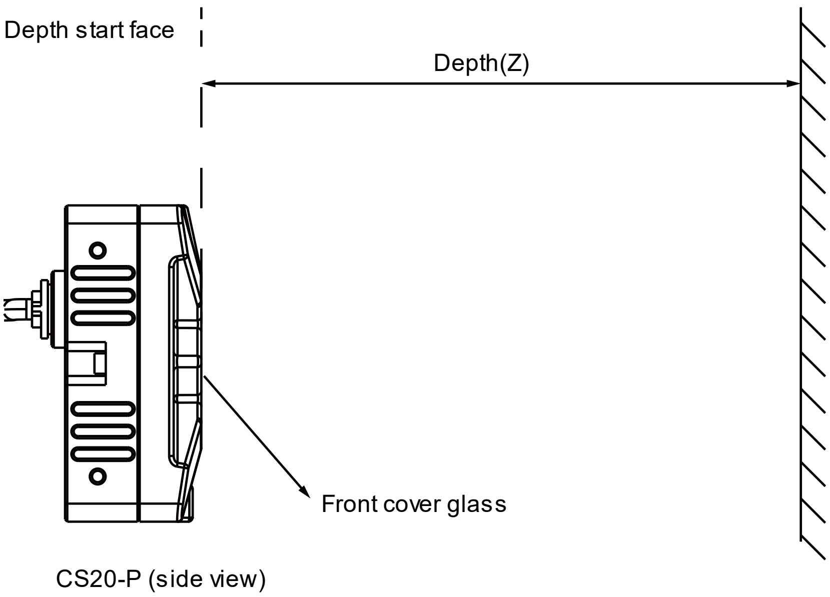

Figure 4-1 CS20-P evaluation starting point

1）The term "absolute accuracy" refers to the discrepancy between measurement result and the true value. It is used to quantify how closely the measurement result aligns with the true value. The formula for absolute accuracy is defined as follows:

$$Accuracy = \left| \frac{\sum_i depth_i}{N} - D \right|$$

2）Inter-frame noise: utilized for assessing the consistency of depth data across multiple frames, the inter-frame noise formula is defined as follows:

$$Temporal\ noise = \frac{1}{N}\sum_i \sqrt{\frac{\sum_j \left(depth_j - \frac{\sum_j depth_j}{M} \right)^2}{M}}$$

3）The point cloud thickness should be evaluated by capturing the white wall at various distances and analyzing the resulting point cloud data.

5. Mechanical structure

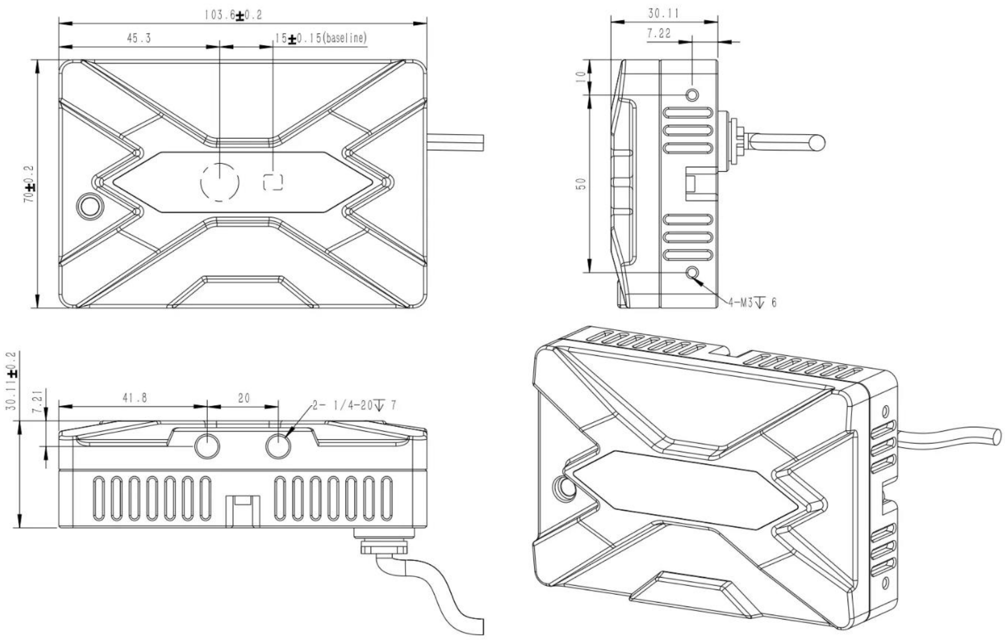

Figure 5-1 Structure Diagram

Dimension	Min	Nominal	Max	Unit
Length	103.40	103.60	103.80	mm
Width	69.80	70.00	70.20	mm
Thickness	29.91	30.11	30.31	mm
Weight	298.00	300.00	302.00	g

Table 5-1. Structural dimensions

6. Storage conditions

Condition	Description	Min	Max	Unit
Storage Temperature		-15	60	°C
	Humidity	Temperature/RH: 40°C/90%		
Work Temperature		-10	50	°C

7．Camera cleaning steps

1. Do not use any chemicals or water on the camera lens.

2. Use the lens purge brush to remove dust and dirt from the lens as much as possible.

3. Wipe with a dry, clean microfiber cloth.

8. Software

- Windows client --- Credimension Viewer

Credimension Viewer is a Windows presentation GUI tool for the Synexens family of products. The tool is mainly used to obtain, display, save Depth, IR, point cloud information, and support viewing device basic information, setting resolution, integration time and other functions.

- SDK---CSAPI

Customers can use the Libsynexens SDK for secondary development, which supports the Windows/Linux platform and x86_64 and ARMv7/ARMv8 architectures, with specific performance optimizations for embedded architectures. For details about how to use it, see the supporting documentation in the SDK.

9. Compliance with Regulations

“ ROHS、CLASS 1 ”

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