Hardware Manual

ZA1type 3D Camera

LA9547A

Ver. 1.0

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Modification History

The modified section is marked with "☆" to indicate that the section is different from the previous version.

ver	Reason for the modification	Modified page, Modification item	Person in charge	Date modified
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Table of Contents

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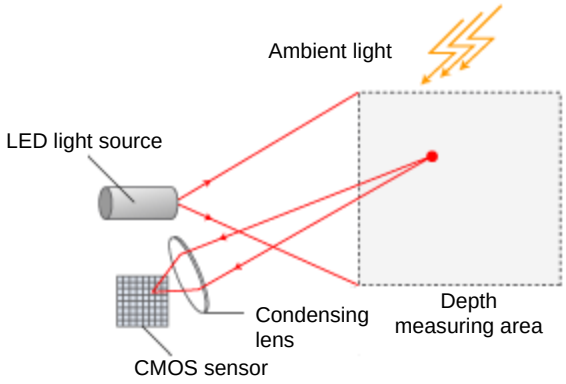
1. Overview

PixelSoleil ZA1 (referred to as the 3D camera henceforth) is a depth image camera of Time of Flight type that acquires three-dimensional information of the target space in real time.

By connecting the 3D camera and a processing unit (referred to as the “host” henceforth) such as PC, the 3D camera control and data transfer are performed.



This manual describes the principle of the 3D camera and the hardware specification.

2. Principle of the Distance Measurement

The 3D camera measures a distance in Time Of Flight (referred to as TOF henceforth) mode.

The modulated light (near infrared radiation) is irradiated from the distance measuring LED and the time (phase difference) spent from reflection of the light from the object to returning to the imaging element of the light receiver of the camera is measured.

The distance is measured for each one of all the elements within the imaging element.

Figure 2-1 Principle of distance measurement

In Figure 2-1, since the distance of the person (near range) and the distance of the tree (far range) are different, the elapsed times until when the reflected light is returned are different between the person (near range) and the tree (far range).

By measuring the distance for each pixel, the depth image can be obtained as shown on the right side of Figure 2-1.

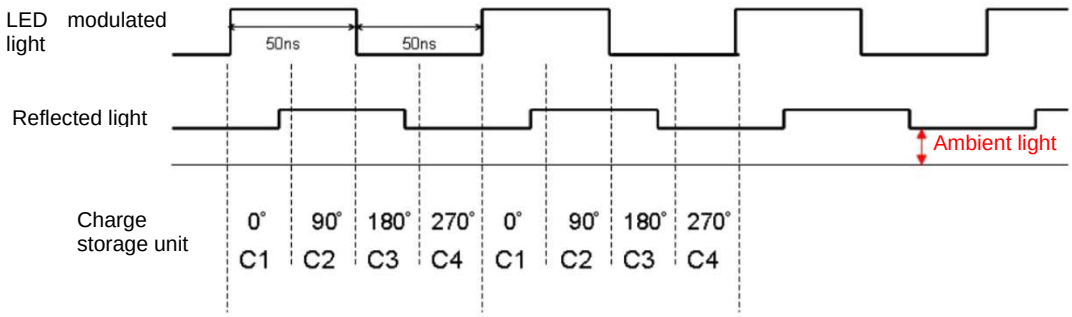


Figure 2-2 Priciple of TOF mode

Figure 2-2 explains the principle of the distance measurement in TOF mode. In this example, LED modulation is performed at 10 MHz and Duty 50%.

The upper waveform in Figure 2-2 shows the modulated light that is irradiated from the LED of the camera and the lower waveform shows the waveform of the reflected light that is returned to the camera.

The reflected light is attenuated according to the reflection rate and the distance of the object and the result of superimposition of the background light (ambient light) components are entered into the camera. The reflected light is accompanied with the delay of the time of flight in proportion to the distance of the object. This light delay (phase difference) is calculated for each pixel.

The filming element inside of the camera is equipped with the feature that distributes the photographically converted charge by the photo-diode of the pixel section to multiple charge storage unit synchronized with the LED modulation.

In Figure 2-2, the charge is distributed to four phases, 0 degree, 90 degrees, 180 degrees, and 270 degrees. The following expression shows how the phase difference ϕ is determined based on the information of these four phases.

$$\phi = A\tan\left(\frac{C1-C3}{C2-C4}\right) \quad \cdots \text{Expression 2-1}$$

The expression for calculating distance D from phase difference ϕ is provided below.

$$D = \frac{\phi}{2\pi} \times \frac{c}{2f} \quad (C: \text{speed of light}: \ 3 \times 10^8 \text{m/s}) \quad \cdots \text{Expression 2-2}$$

The expression for determining the amplitude component equivalent to intensity I of reflected light is provided below.

$$I = \sqrt{(C1-C3)^2 + (C2-C4)^2} \quad \cdots \text{Expression 2-3}$$

3. Specification

Figure 3-1 Main Specfication

Item	Specification
Service temperature range	-10°C to ＋50°C
Valid number of pixels	126×126 （Total number of pixels 128×128）
Frame rate	30fps
Communication interface	Ethernet（10/100Base-TX）

4. Frame Configuration and Various Images

4.1 Frame Configuration

The 3D camera generates three types of images, namely, depth image, brightness image (monochrome), and intensity image at 30 fps (30 frames per second).

The depth image and intensity image are generated based on the charge information that is acquired at the same time and the brightness image is generated from the charge information that is acquired at a different time within the frame.

4.2 Depth Image

The depth image is output as 14-bit data (0x0000 to 0x3FFF: 0 to 16383) as the phase delay information. When the LED modulation frequency *f* is 10.0MHz, output information 0 to 16383 corresponds to the distance measurement range 0 to 15 m.

To convert the output data D of the depth image to the actual distance Z (m), use the following expression by using the LED modulation frequency *f* (MHz).

$$Z = \frac{150}{f} \times \frac{D}{16384} \quad \cdots \text{Expression 4-1}$$

When the distance of the target object is further than the distance measurement range (0 to 15m @*f* =10.0 MHz), the distance is calculated as a value from 0 m again. This means that the distance of the object at 22.5 m as shown in Figure 4-1 is output as 7.5 m.

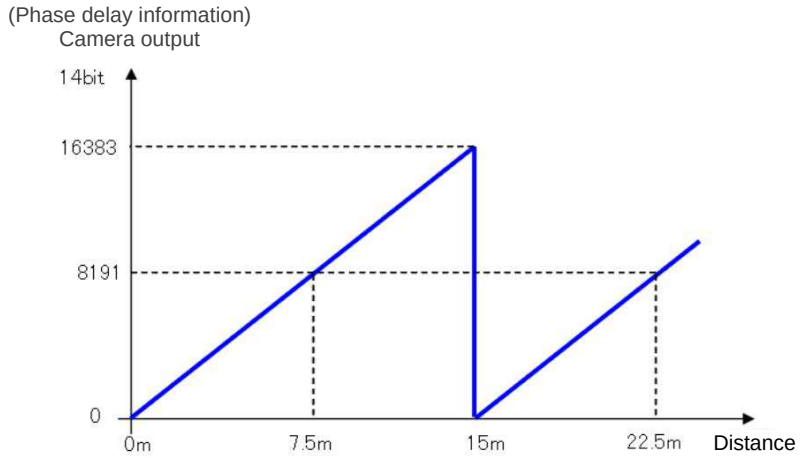


Figure 4-1 Actual distance and depth image output value (f=10.0MHz)

4.3 Brightness Image

A brightness image is output as 14-bit data (0x0000 to 0x3FFF: 0 to 16383). Since the brightness image of the 3D camera is a near infrared image, it is output as a monochrome image.

The lower the value of the brightness image is, the lower the brightness becomes (dark place), and the brighter the place is, the higher the value becomes.

At brightness image generation, the distance measurement LED is lit for lighting. Under the environment of a high volume of infrared rays, such as outdoor at daytime, the light of the LED is reduced or extinguished.

4.4 Intensity Image

An intensity image is the image of the value that indicates the degree of the LED modulated light that is irradiated at distance measurement and is returned after reflecting on the light receiver. (See Expression 2-3.)

An intensity image is output as 14-bit data (0x0000 to 0x3FFF: 0 to 16383).

The lower the intensity of the modulated light that is received, the greater are the temporal variations of the distance values of the pixel, and the higher the intensity of the modulated light, the smaller are the temporal variations of the distance values of the pixel.

Therefore, the intensity information of the intensity image indicates the reliability of the distance value of the pixel.

5. Functions

The 3D camera has many functions. Please refer "LX9657A ZA1 type 3D Camera Communication Interface Specification".

6. Usage Precautions

6.1 Interference

Since the 3D camera measures a distance by irradiating modulated infrared light, interference occurs, causing distance value abnormality if the same modulated lights of the same frequency exist.

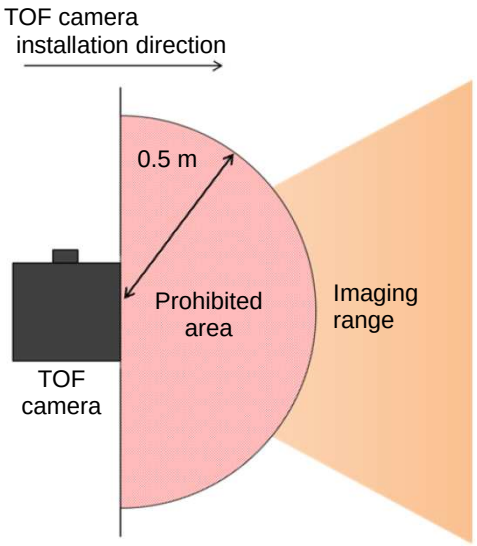
When using multiple 3D cameras in the same space, change the frequencies of modulated light to different frequencies.

A modulation frequency can be changed by using Viewer.exe or the TCS_LEDClockSelect function.

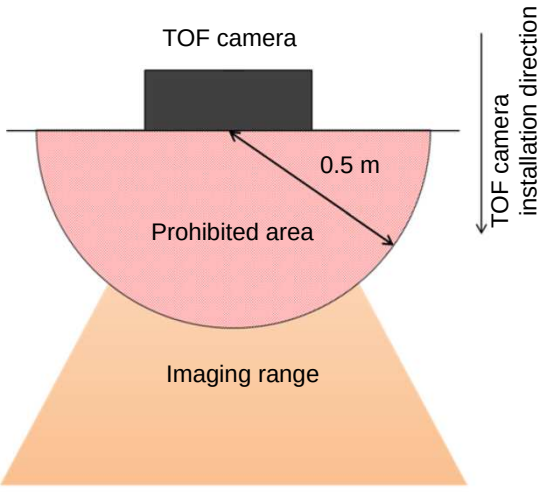
6.2 Installation Environment

The 3D camera measures a distance by using a very small amount of reflected light from the target object. Therefore, if there is an object, a wall, or a desk in the near range (about 0.5 m or less), the distance of the object at a far range shifts to the near range side due to the influence of the strong reflected light from the object at the near range.

Install the 3D camera in the environment where there are no objects within 0.5 m, which is the prohibited area (red area) as shown below.

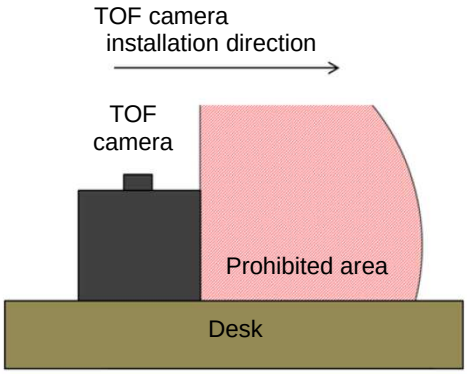


Side view

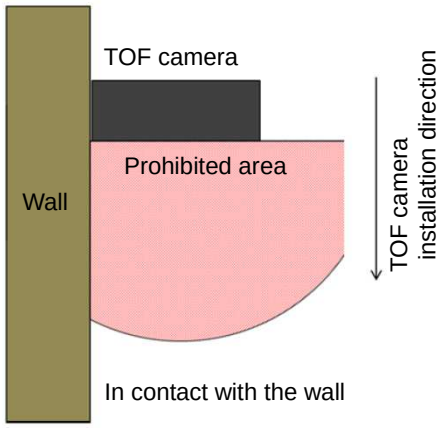


Top view

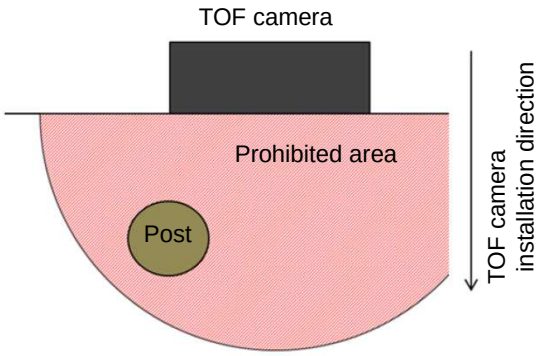
Do not install the 3D camera in the following ways.



Placed directly on the top of the desk



In contact with the wall



There is a post in the prohibited area