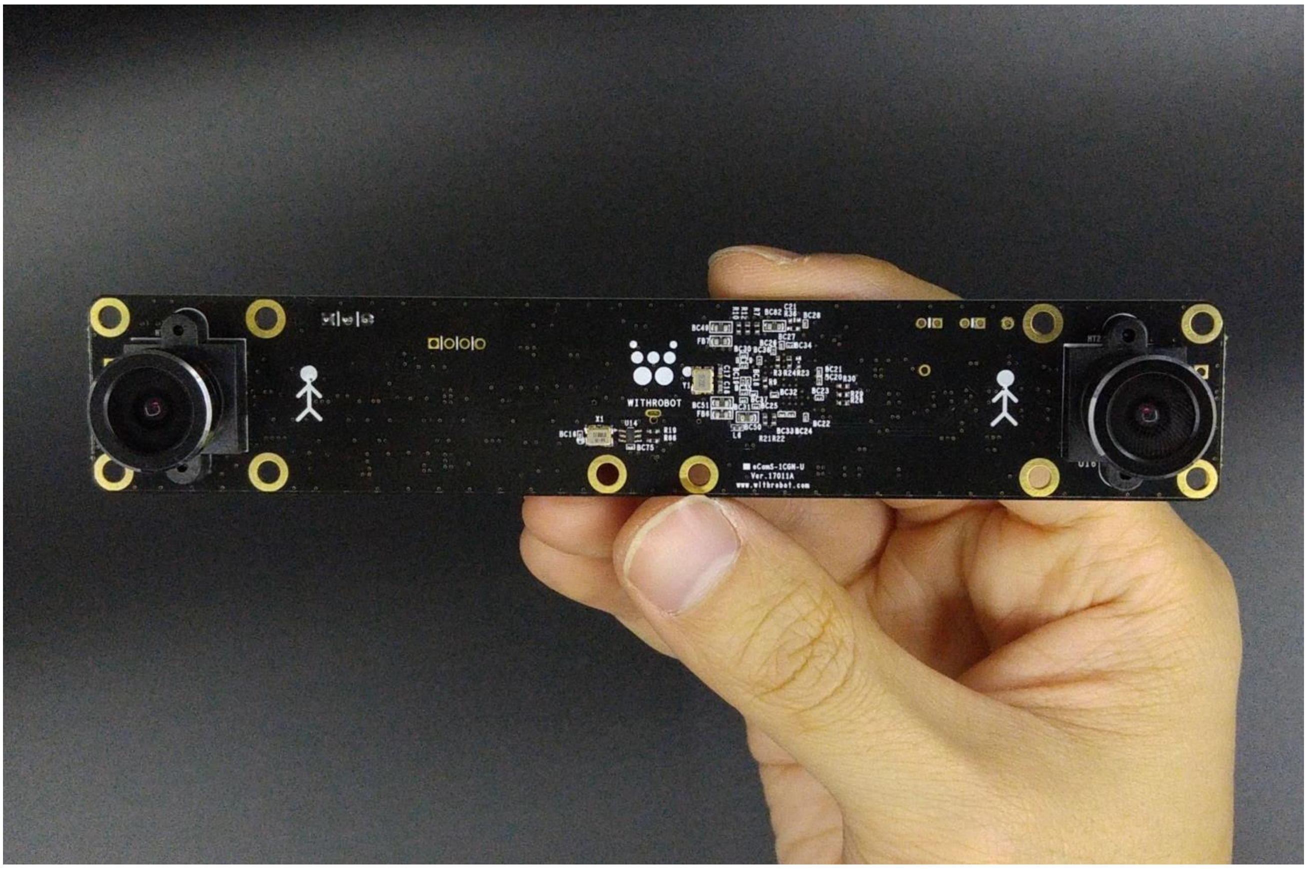
oCamS-1CGN-U™ Getting Started



2018. 4.

WITHROBOT Inc.

Revision History

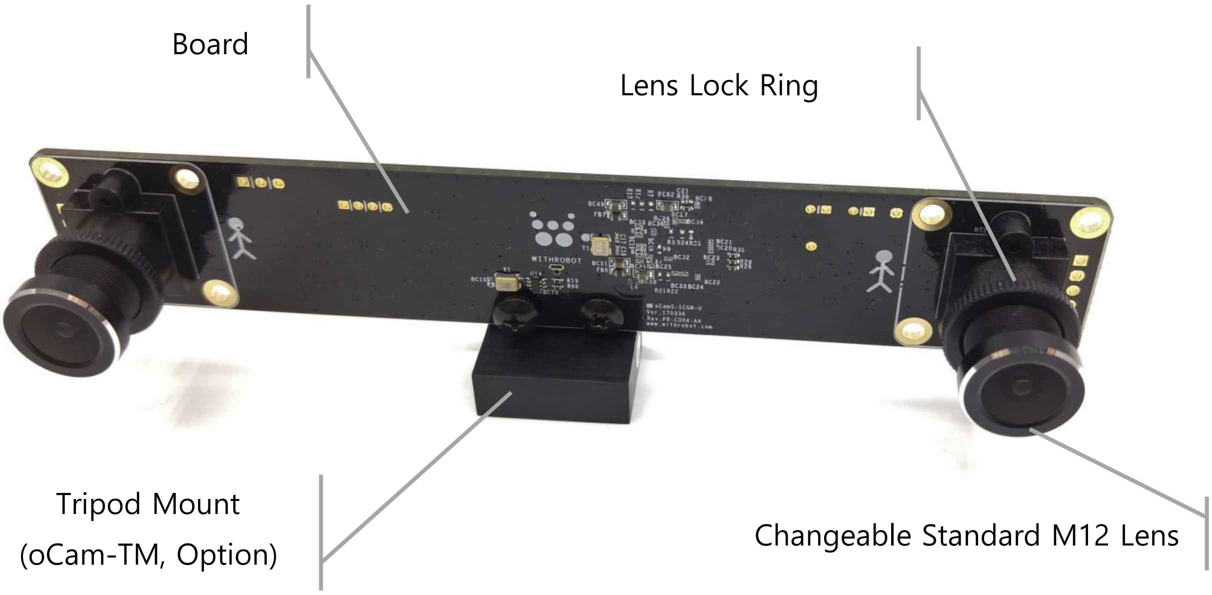
Rev	Date	Description	Author
1.0	2018.02.17	1st Release	SDKim

This product is for indoor use only and is susceptible to electrostatic discharge. It should be handled with care accordingly.

CONTENTS

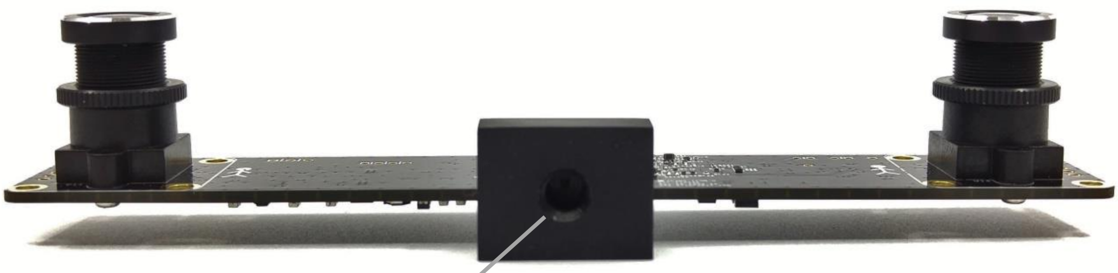
1. INTRODUCTION

Parts



Picture 1. Front

Picture 2. Back



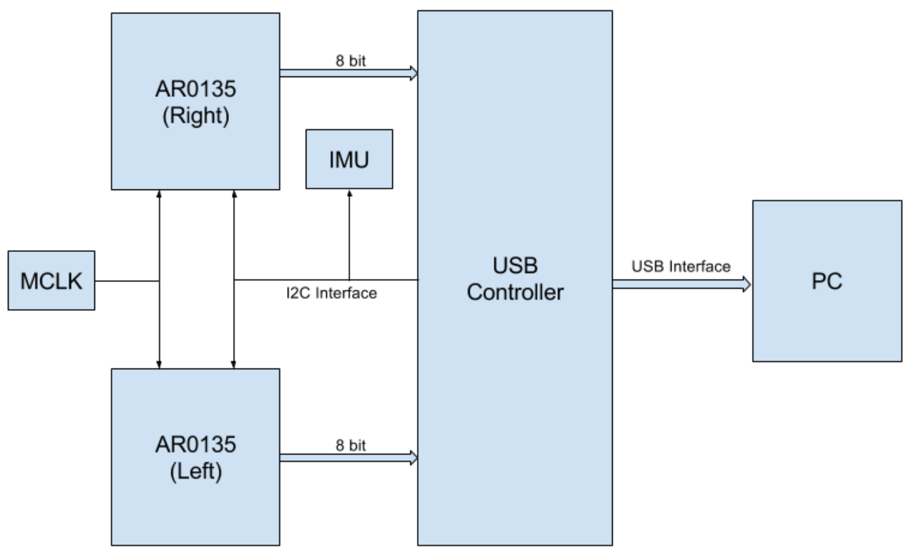
Picture 3. Bottom

Picture 4. Side

Features

The oCamS-1CGN-U is a stereo camera with two image global shutter sensors of 1 mega pixels. It is compliant with UVC (USB video class) standard and supports USB 3.0 interface. The camera contains IMU sensors including 3-axis accelerometer, 3-axis gyroscope and 3-axis geomagnetic sensor. The two images from the two image sensors are acquired in exact time-synchronized manner for accurate stereo image processing.

As it support UVC standard of version 1.1, no additional device driver is required to be installed on Linux and Windows operating systems. Sample programs in source code format including necessary libraries are provided for easy handling of acquisition of the stereo images and the separation of one video stream into two camera images.



Picture 5. Functional Block Diagram

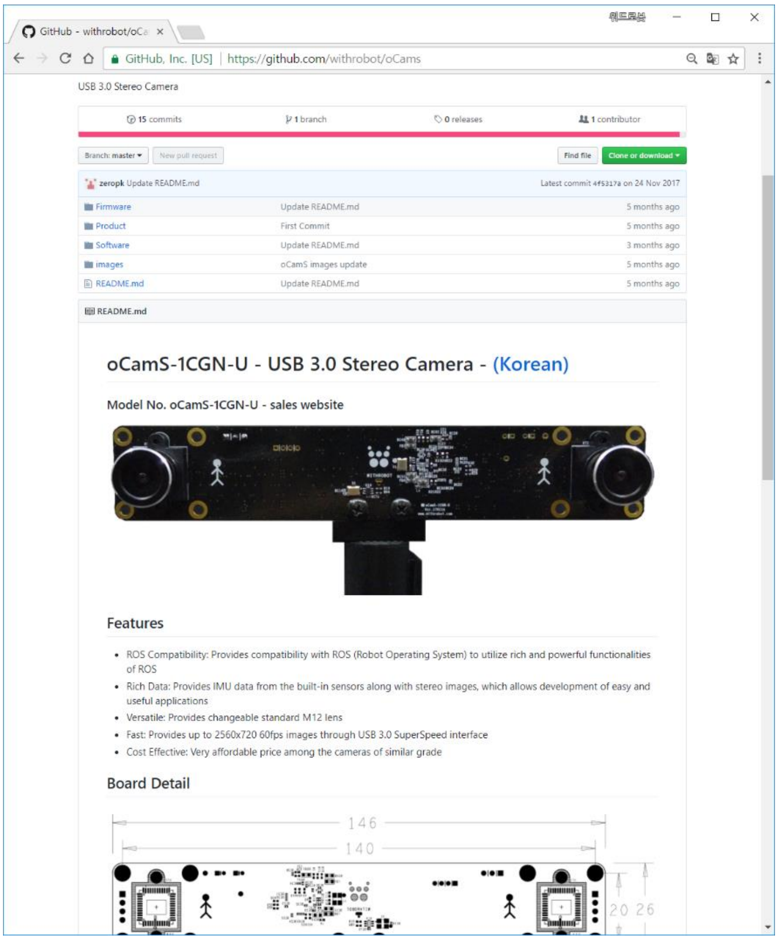
The oCamS-1CGN-U provides various image resolutions and frame rates to be used for various applications adequately. A suitable field-of-view can be obtained using te changeable lens structure with which any M12 standard lens can be used.

The camera posture information is obtained using the onboard IMU sensor in time-synchronized manner and is sent through the same USB 3.0 interface to a host system where the video stream and the posture data stream are separated easily as they are recognized as two different USB devices.

The oCamS-1CGN-U supports the ROS(Robot Operating System) so that the freely available abundant ROS packages can be used for various applications. Further details can be found at the ROS site (http://www.ros.org/).

Additional Technical Information

Further technical information along with the latest firmware and sample programs are available at an online site, https://github.com/withrobot/oCams.



Picture 6. Online Site for Further Technical Information

2. SPECIFICATIONS

Image Specifications

Item	Value
Output Format	• YUV422 for Composite Stereo Image • Bayer RGB for Separated Image
Frame Rates	• 1280 (x 2) x 960 (45fps) • 1280 (x 2) x 720 (60fps) • 640 (x 2) x 480 (45fps) • 640 (x 2) x 360 (60fps)
Shutter	• Global Shutter
Camera Control	• Gain • Exposure (Absolute) • White Balance RED • White Balance BLUE
Auto Exposure	• Supported
Auto White Balance	• Not Supported
External Trigger	• Not Supported
Lens Correction	• Not Supported
White Balance Auto Setup	• Not Supported

Table 1. Image Specification

Frame Rates for Each Resolution

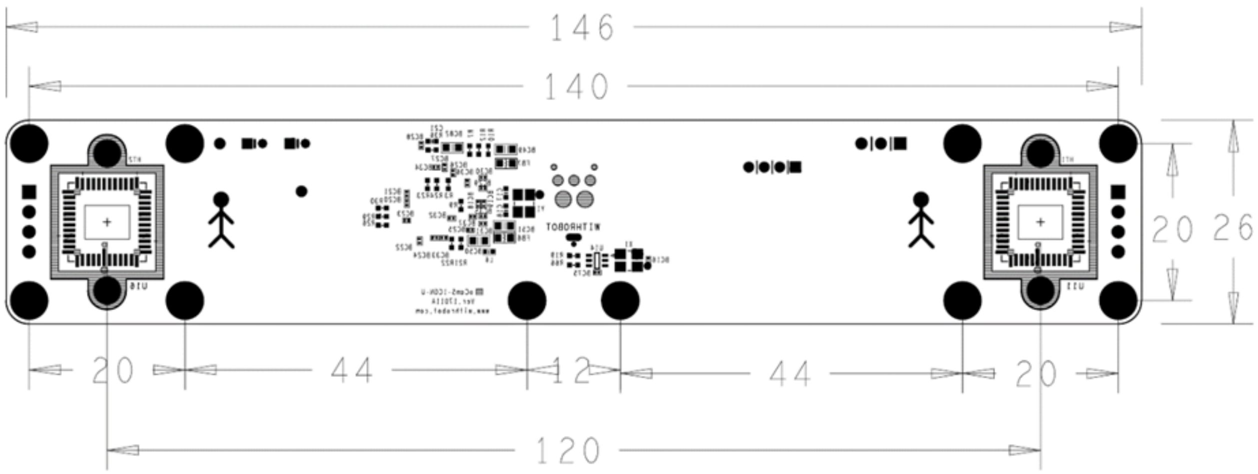
Resolution	Frame Rates for USB 3.0	Frame Rates for USB 2.0
1280 (x 2) x 960	45/30/25/20/15/10 fps	x
1280 (x 2) x 720	60/50/45/30/25/20/15/10 fps	x
640 (x 2) x 480	45/30/25/20/15/10 fps	45/30/25/20/15/10 fps
640 (x 2) x 360	60/50/45/30/25/20/15/10 fps	60/50/45/30/25/20/15/10 fps

Table 2. Frame Rates for Each Resolution

Electrical Specifications

Item	Min	Max	Unit
Input Voltage		5.0	V
Current Consumption	110(Stand-By)	320(Video and IMU Out)	mA
Operating Temperature	0	70	℃

PCB Dimension



Picture 7. PCB Dimension (unit: mm)

LED Display

LED Color	Meaning
Green	Power On
Red	Video Out

3. HOW TO SET-UP

Preparation for Connection

The oCamS-1CGN-U is connected to a host system with a USB cable. Both of USB 2.0 and USB 3.0 cables can be used, however USB 3.0 should be used for higher resolution images.

The connectors for USB 2.0 and USB 3.0 are different on a host system, so that the right connector should be selected for optimal operation.

	
USB 3.0 Cable	USB 2.0 Cable

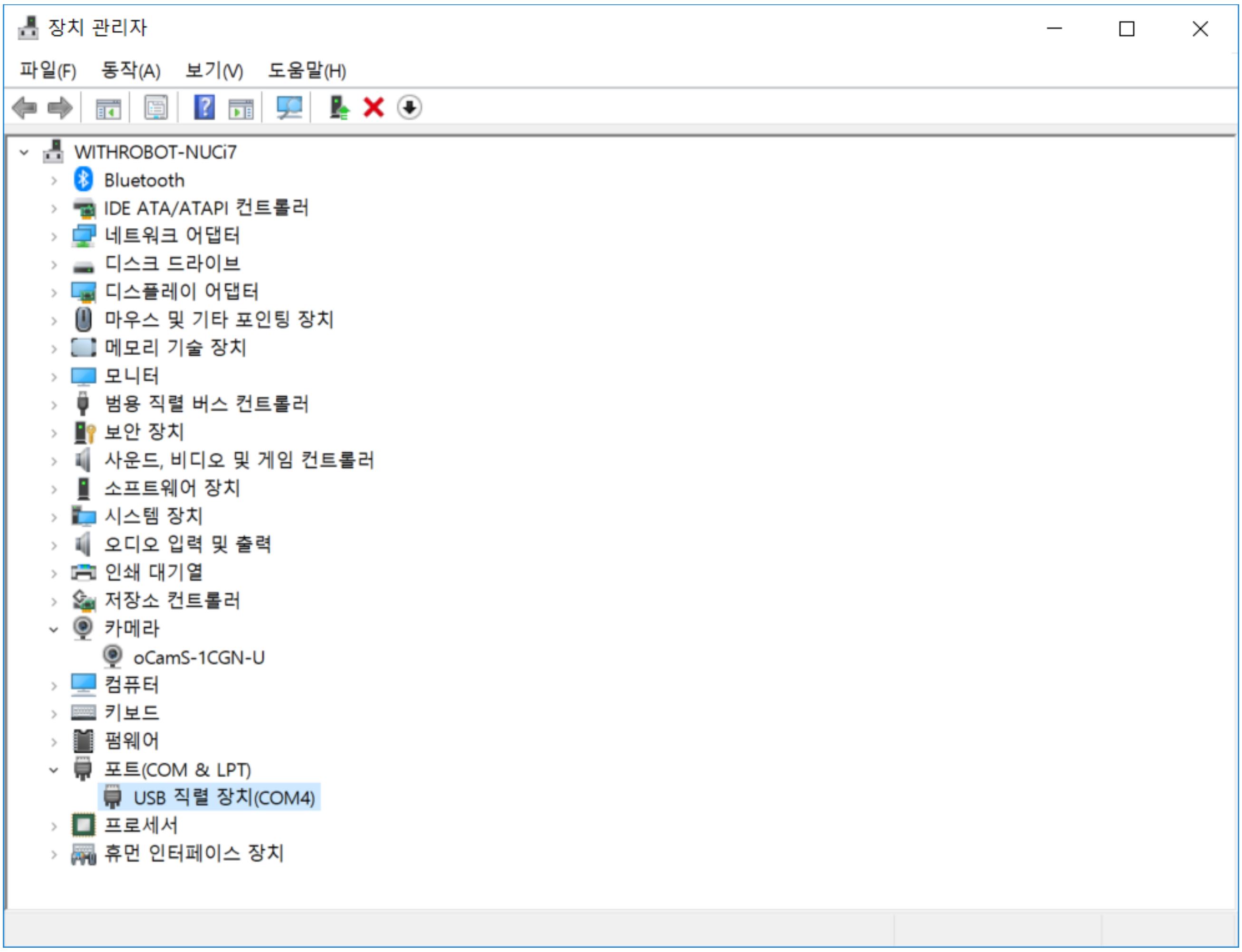
Picture 8. Supported USB Cable Types

4. CONNECTION TO WINDOWS SYSTEM

How to Connect to Windows System

After connecting the oCamS-1CGN-U, the connection can be checked by reviewing the device manager.

On successful connection, the oCamS-1CGN-U should be appeared under the camera devices, and the IMU should be appeared as USB serial device with the assigned COM port number under the COM & LPT port.



Picture 9. Device Manager on Successful Connection

Note

On Windows 7, the IMU of the oCamS-1CGN-U is not detected, but only detected as a camera device.

How to Use the oCamViewer for Windows

A viewer program for Windows is provided as a sample source code along with an executable binary file.

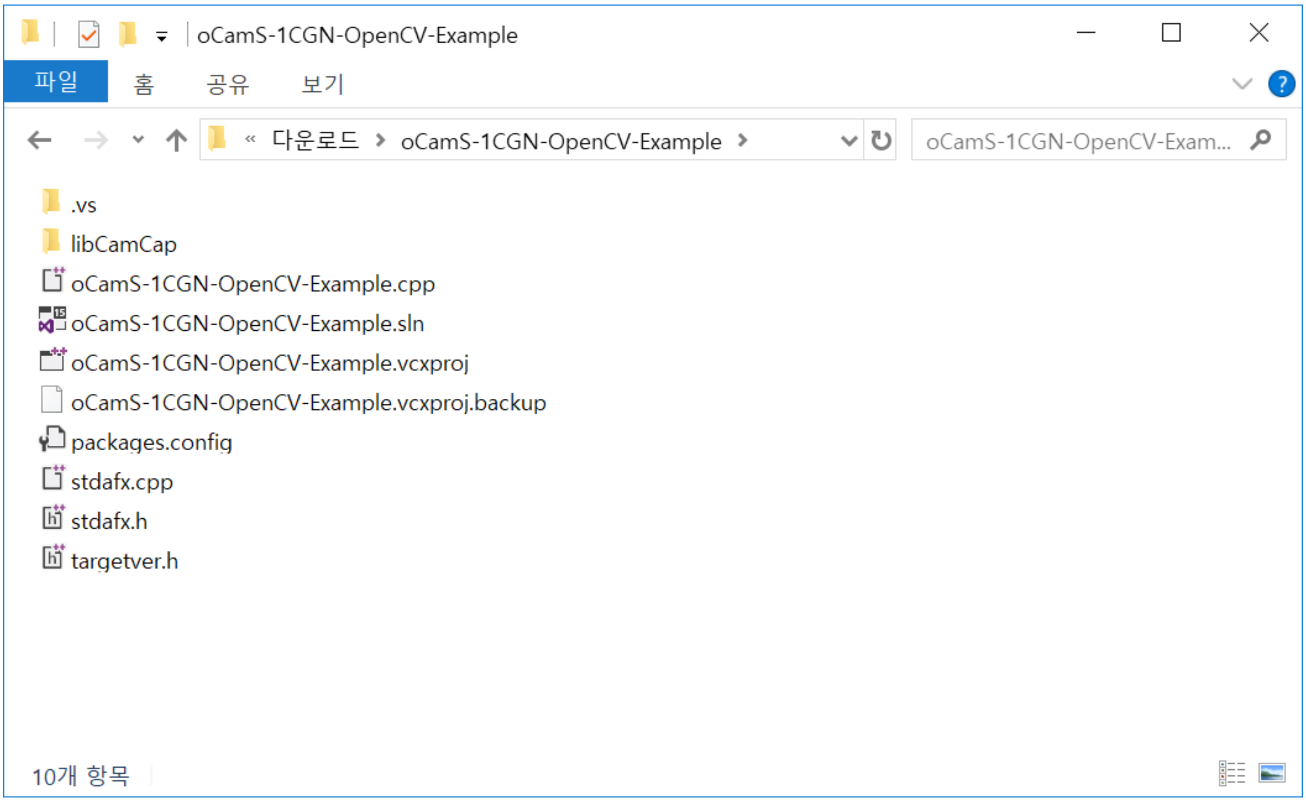
Follow the procedure described below to download and build the viewer program written in C++ with OpenCV libraries. This program requires the Visual Studio installed before the build.

1. Access to http://withrobot.com/camera/ocams-1cgn-u/ .

2. Click and download "OpenCV C++ Sample Code (for Windows)".

3. Uncompress the downloaded "oCamS-1CGN-OpenCV-Example.zip".

4. Check the following files:

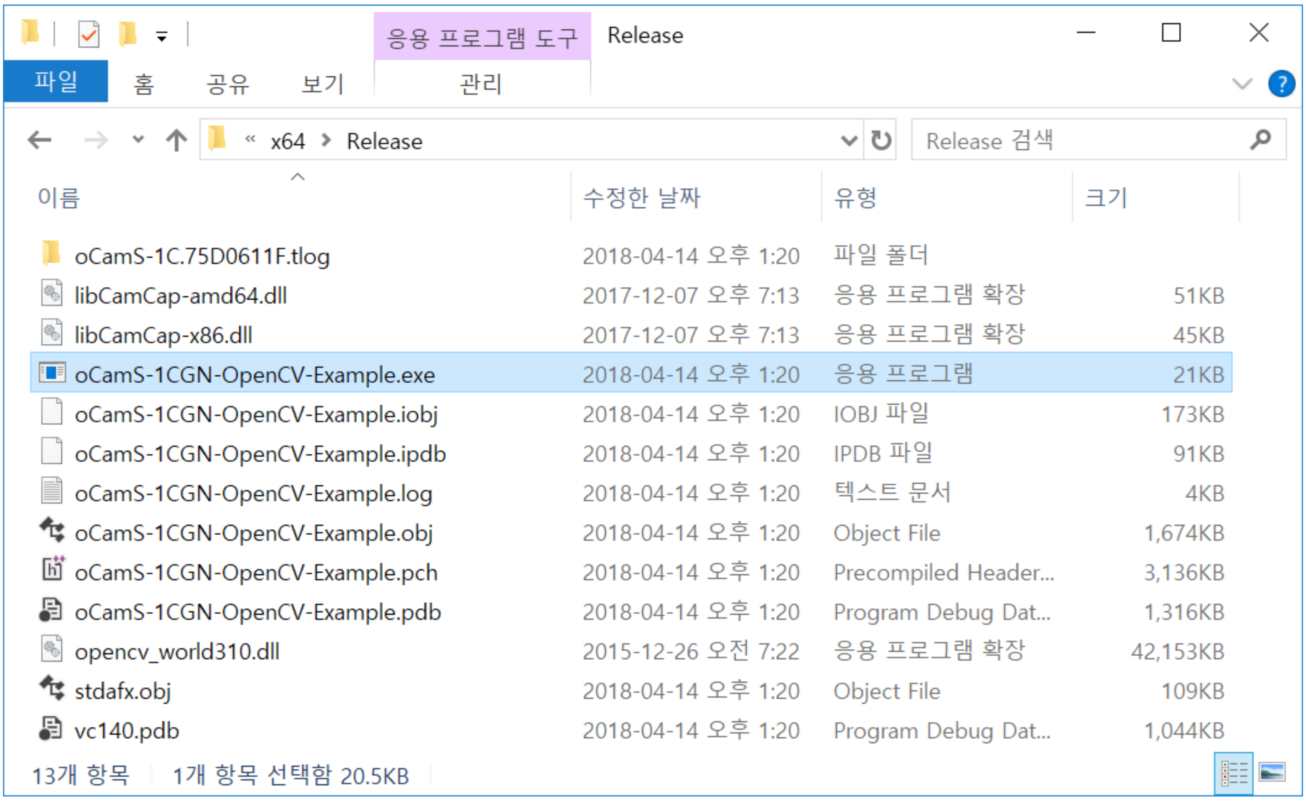


Picture 10. Contents of the oCamViewer Sample Program

5. Click "oCamS-1CGN-OpenCV-Example.sln" and start the Visual Studio.

6. Press Ctrl+Shift+B to build the program.

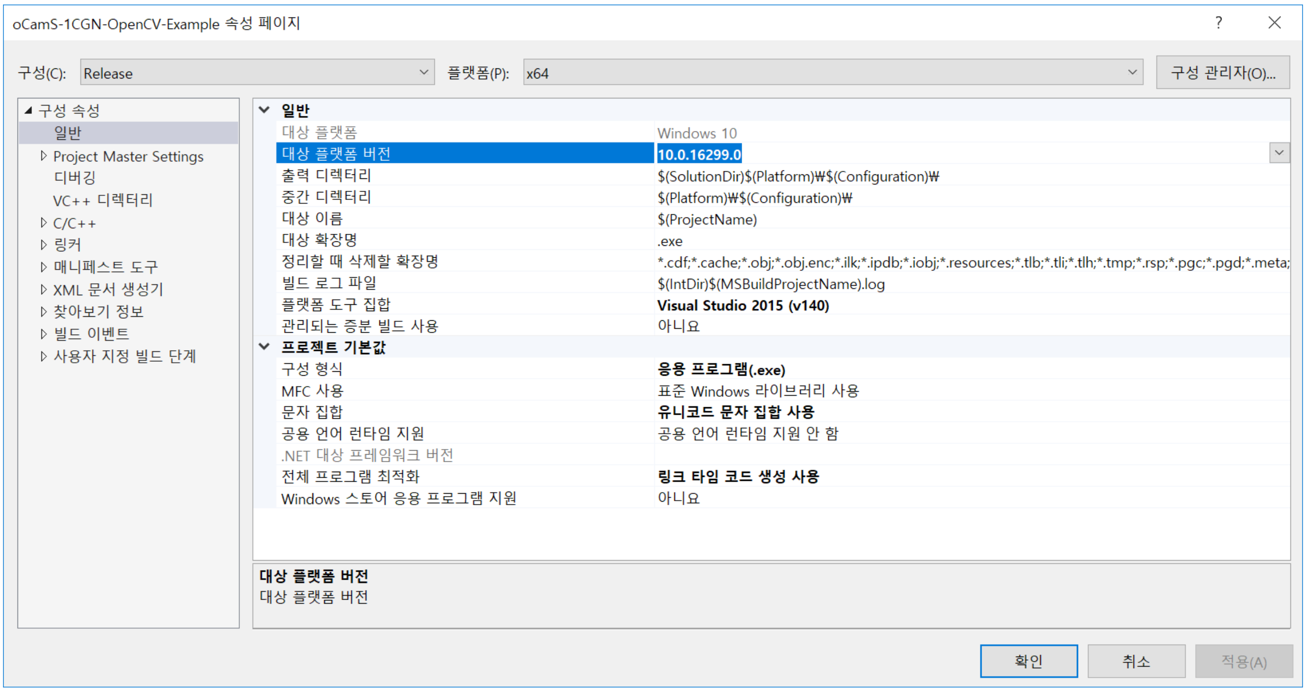
7. On successful Build, the followings are created under the "x64/Release".



Picture 11. After Successful Build

8. Click "oCamS-1CGN-OpenCV-Example.exe" to run the viewer.

9. Depending on the version of Visual Studio, the project property needs to be changed for correct platform version.



Picture 12. Change for Correct Platform Version

10. The following key inputs can be used after clicking “oCamS-1CGN-OpenCV-Example.exe”.

Key Input	Actions
Q or q	Terminate the program
1	Increase the sensor gain
2	Decrease the sensor gain
3	Increase the exposure time
4	Decrease the exposure time
5	Capture and store the current stereo image

5. CONNECTION TO LINUX SYSTEM

How to Connect to Linux System

After connecting the oCamS-1CGN-U, the connection can be checked by using the "lsusb" command.

On successful connection, "Cypress Semiconductor Corp" should appear as follows:

```
$ lsusb

Bus 004 Device 026: ID 04b4:00f9 Cypress Semiconductor Corp.
```

The ID of “04b4:00f9” signifies the connection is made as USB 3.0, and the ID of “04b4:00f8” signifies USB 2.0.

For Linux system of Ubuntu16.04, the device appears as “/dev/video*” and “/dev/ttyACM*”. A super user privilege is required to access to ttyACM devices and further instruction is described on the appendix of this manual.

How to Install the ROS

1. Install Ubuntu 16.04 LTS Version following the instruction at:

   https://tutorials.ubuntu.com/tutorial/tutorial-install-ubuntu-desktop?_ga=2.268754162.2070293869.1505711601-305972367.1479833539

   Note: This instruction assumes only one disk is created on the disk where the Linux is installed.

2. Install the ROS Kinetic Version following the instruction at:

   http://wiki.ros.org/ROS/Tutorials/InstallingandConfiguringROSEnvironment

3. Install the library for the installation of oCamS ROS Package using the following command:

   ```
   $ sudo apt-get install libv4l-dev libudev-dev ros-kinetic-rtabmap*
   ```

4. Install the source tree from the Github:

   ```
   $ cd YOUR_WORKING_DIRECTORY (ex. $ cd ~/catkin_ws/src/)
   $ svn export https://github.com/withrobot/oCamS/trunk/Software/oCamS_ROS_Package/ocams
   ```

5. Build the package:

   ```
   $ cd YOUR_CATKIN_WORKSPACE (ex. $ cd ~/catkin_ws/)
   $ catkin_make
   $ source devel/setup.bash
   ```

6. Configure the Virtual COM Port for IMU using the following commands:

```
$ sudo vi /etc/udev/rules.d/99-ttyacms.rules

ATTRS{idVendor}=="04b4" ATTRS{idProduct}=="00f9", MODE="0666",
ENV{ID_MM_DEVICE_IGNORE}="1"

ATTRS{idVendor}=="04b4" ATTRS{idProduct}=="00f8", MODE="0666",
ENV{ID_MM_DEVICE_IGNORE}="1"

$ sudo udevadm control -R
```

7. Start the package using the following command:

```
$ roslaunch ocams ocams_ros.launch
```

How to Use ROS Packages

- **Calibration**

Use the following command to start the calibration:

```
$ roslaunch ocams calibration.launch
```

Further details can be found at the following site to use the ROS camera_calibration package:

```
http://wiki.ros.org/camera_calibration
```

- **SLAM Package**

Use the following command to start the SLAM:

```
$ roslaunch ocams RTAB-Map_slam.launch
```

Further details can be found at the following site to use the ROS RTAB-MAP package:

```
http://wiki.ros.org/rtabmap_ros
```

- **Camera Control**

Use the following command to start the camera control of the oCamS-1CGN-U:

```
$ rosrun rqt_reconfigure
```

Further details can be found at the following site to use the ROS rqt_reconfigure package:

```
http://wiki.ros.org/rqt_reconfigure
```

6. NOTES

Due to the lens changeable structure of the oCamS-1CGN-U, the focus can be changed unintentionally. To prevent unwanted change of focus, the lens should be tightened using the lens lock ring, especially in the vibration environment.

The video out speed, frames per second (FPS), can be affected by the exposure time. If the exposure time is excessively long, the FPS is reduced accordingly.

Each pixel of a global shutter image sensor has different gain and this difference will be magnified with higher overall sensor gain. To reduce the image noise, it is recommended to use lower overall sensor gain.

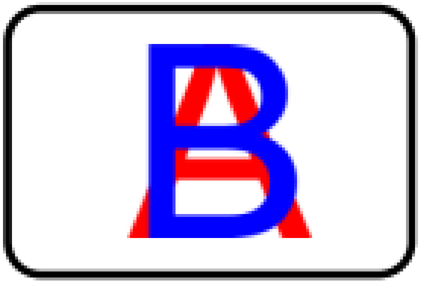
APPENDIX

Stereo Image Output Format

The two time-synchronized images from the two sensors of the oCamS-1CGN-U is multiplexed frame-by-frame to be sent through one USB interface to a host system.

The image data from each image sensor is sent through 8 bits data bus and the multiplexed image data from the two image sensors are sent through 16 bits data bus by the USB controller.

On the oCamS-1CGN-U, the 16 bit YUV2 format of the UVC (USB video device class) is used to transmit the image data, and the host system will get the multiplexed image as shown below:



Picture 13. Multiplexed Image Received by a Host System

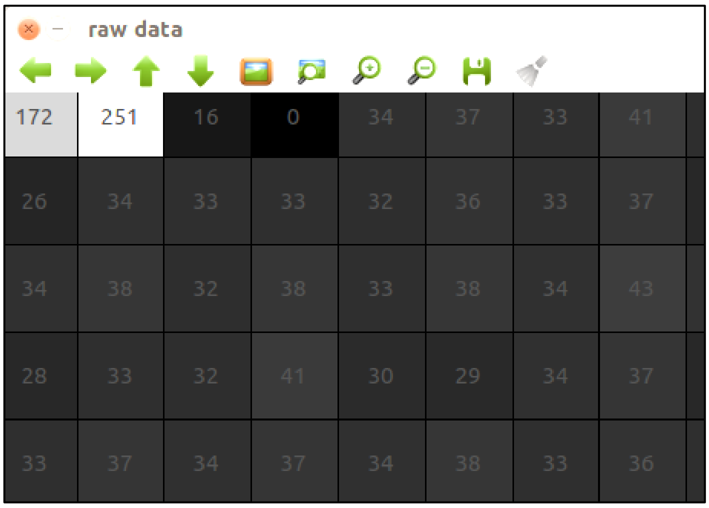
Without proper separation of the received image, a viewer will display the multiplexed image shown below:

Picture 14. Non-separated Image Shown by a Viewer Program

Time Stamp

For numerous applications, it is crucial to have a time-synchronized data from various sensors. On the oCamS-1CGN-U, the time stamp information of the onboard IMU sensor is imposed on the image data.

The time stamp value is generated using an onboard 32 bit counter which counts up on receiving a pulse with 1 millisecond period. This time stamp value is sent using the first four pixel data as shown below:



Picture 15 . IMU Time Stamp Imposed Over Image Data

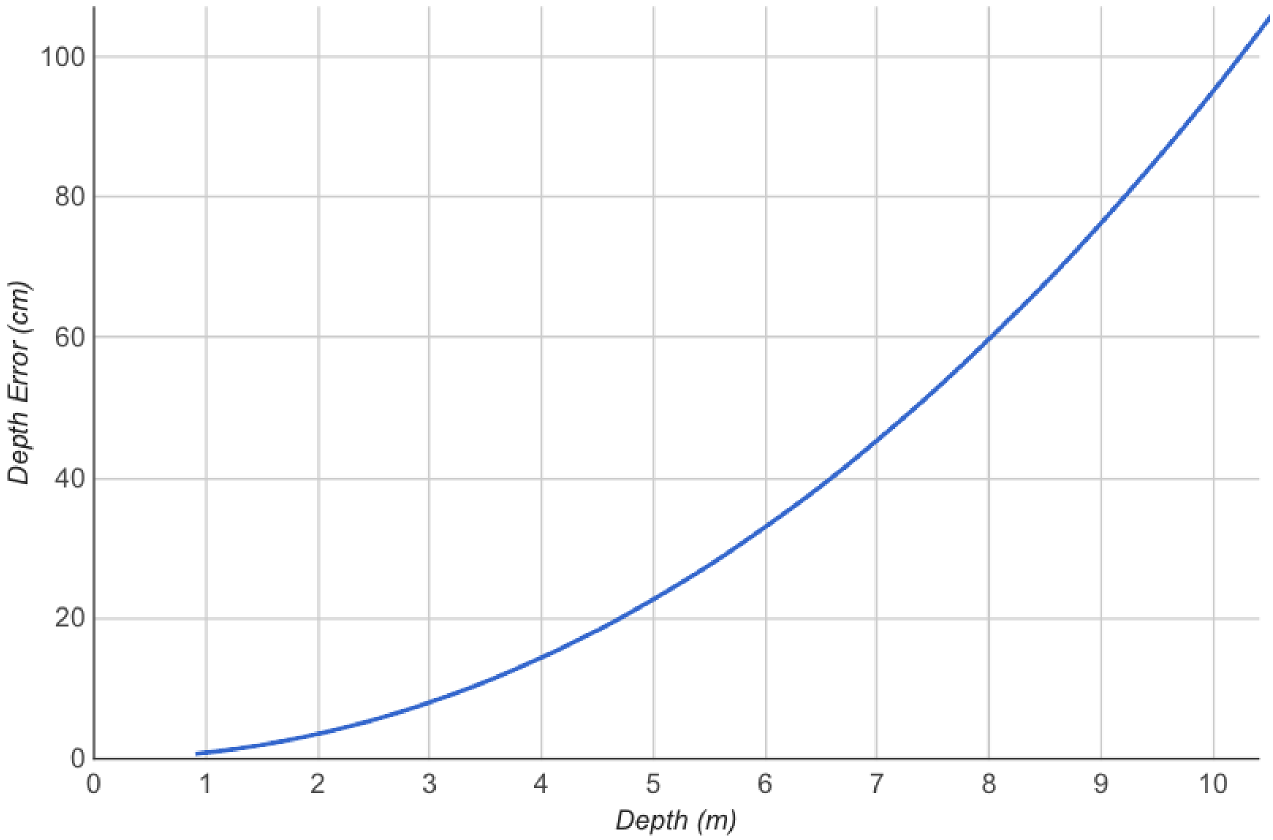
On this example, the four pixel data of the time stamp value are 172, 251, 16, 0 and the time value is calculated by the following formula:

$$(((\mathbf{0} \times 256 + \mathbf{16}) \times 256) + \mathbf{251}) \times 256 + \mathbf{172} = 1{,}113{,}004 \text{ ms}$$

Accuracy of Distance Measurement

The accuracy of distance(= depth) measurement using a stereo camera depends on many factors such as image sensor, lens and the distance between the two cameras, i.e., baseline of the stereo camera. Also, the absolute error grows as the distance to the target objects.

For the oCamS-1CGN-U with the default lens set, the theoretical measurement error is shown as follows:



Picture 16. Distance Measurement Error Curve

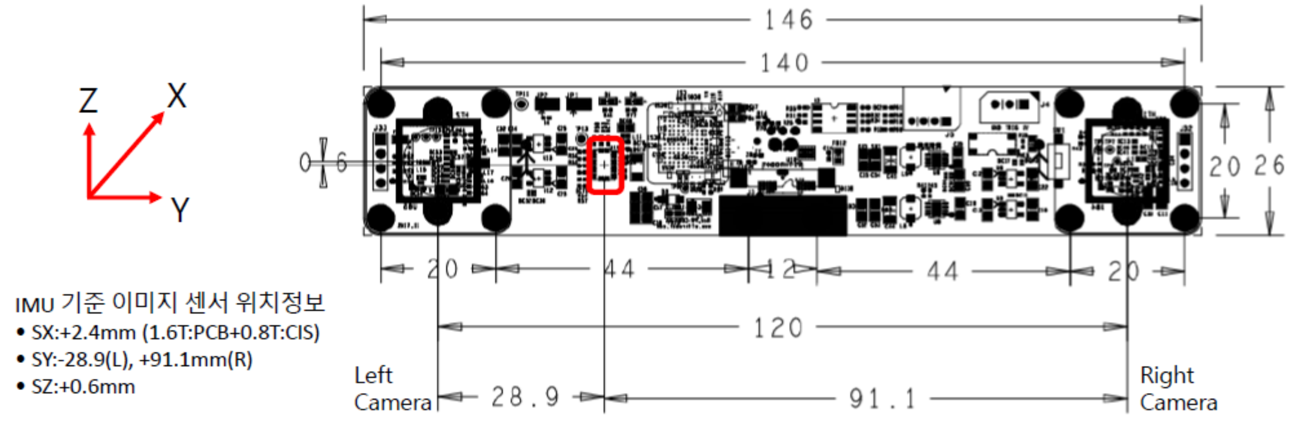
Few specific error values are shown as below:

Distance (m)	0.91	1	2	5	10	20	50
Error (cm)	0.72	0.88	3.53	22.7	95.1	420.0	3,834.0

Table 3. Distance Measurement Error Samples

Coordinate System of the IMU Sensor and the Image Sensor

The position of the image sensor with respect to the IMU sensor.



Picture 17. Image Sensor Positon with respect to the IMU Sensor

Image Sensor	Image Sensor Positon w.r.t the IMU Sensor (unit: mm)
Left	2.4, -28.9, 0.6
Right	2.4, 91.1, 0.6

IMU Data

On Linux system of Ubuntu16.04, the oCamS-1CGN-U and the IMU appear as "/dev/video*" and "/dev/ttyACM*" respectively.

To access to the ttyACM device, a super user privilege is required and it can be obtained following the procedure describe below.

1. Use a text editor (such as vi or gedit) to create a rule file with the name of "99-ttyacms.rules".

   ```
   $ sudo vi /etc/udev/rules.d/99-ttyacms.rules
   ```

2. Enter the followings into the rule file:

```
ATTRS{idVendor}=="04b4" ATTRS{idProduct}=="00f9", MODE="0666",
ENV{ID_MM_DEVICE_IGNORE}="1"
ATTRS{idVendor}=="04b4" ATTRS{idProduct}=="00f8", MODE="0666",
ENV{ID_MM_DEVICE_IGNORE}="1"
```

3. Apply the "udev rule" using the following command:

   ```
   $ sudo udevadm control –reload-rules
   ```

The IMU data will be sent out as a serial data in ASCII format with 4 selectable modes:

Mode	Message Content
$AMGEUL	Accel(x,y,z), Magnetometer(x,y,z), Gyro(x,y,z), Euler(r,p,h)
$AMGQUA	Accel(x,y,z), Magnetometer(x,y,z), Gyro(x,y,z), Quaternion(x,y,z,w)
$LMGEUL	LinearAccel(x,y,z), Magnetometer(x,y,z), Gyro(x,y,z), Euler(r,p,h)
$LMGQUA	LinearAccel(x,y,z), Magnetometer(x,y,z), Gyro(x,y,z), Quaternion(x,y,z,w)

The units of each IMU data are shown as below:

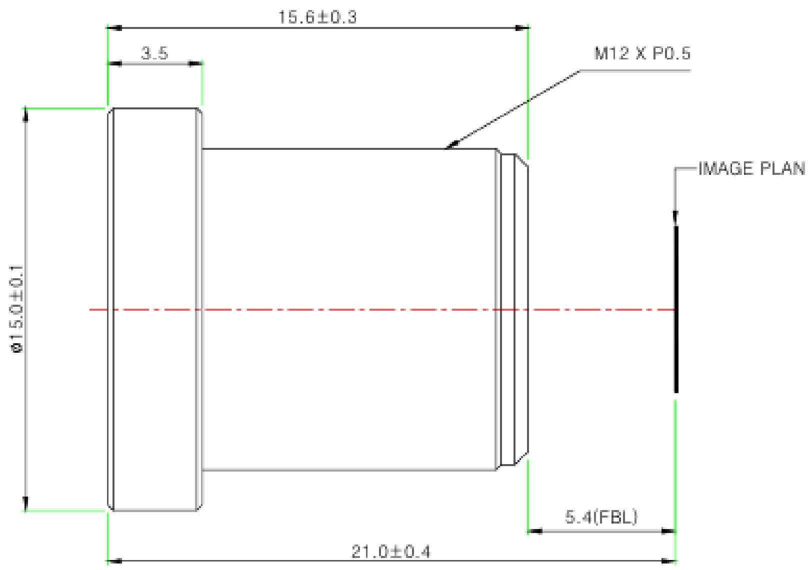
Data	Unit	Expression
Accelerometer	m/s^2	1 m/s^2 = 100 LSB
Magnetometer	μT	1 μT = 16 LSB
Gyroscope	Rps	1 Rps = 900 LSB
Euler Angle	Radians	1 radian = 900 LSB
Quaternion	Quaternion	1 Quaternion = 2^14 LSB

4. The default mode is set as $LMGQUA. The mode can be changed by sending a command to the IMU serial device, COM port or ttyACM, in the following procedure.

- Send the command "@(MODE)₩r₩n" where (MODE) can be one of AMGEUL, AMGQUA, LMGEUL or LMGQUA.
- On successful setting, "~(MODE)₩r₩n" will be replied.
- On failed setting, "~?₩r₩n" will be replied.

5. The LinearAccel data has the value where the gravitational constant is removed. To use the value including the gravitational value, the Accel data format should be used by changing the mode.

Specification of the Default Lens

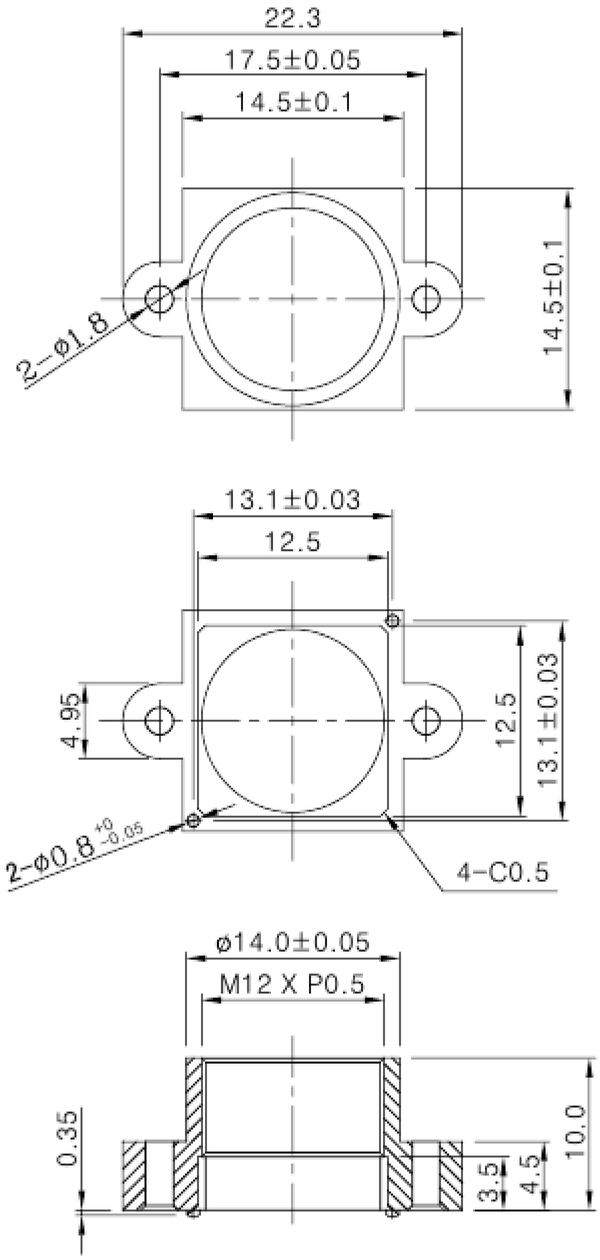


Specifications

USE : The lens is intended for use in 1/2.9", 1/2.7" C-MOS camera.

Focal Length	3.6mm ±5%
Relative Aperture	2.0
Image Size	1/2.9'' 1/2.7"
	1/2.9'' : 50°(V) X 92.8°(H) X 110°(D)
Angle Of View	1/2.7" : 59°(V) X 103°(H) X 125°(D)
Back Focal Length	6.17mm ±5%
Flange Back Length	5.4mm ±0.2mm
Lens Length	15.6mm ±0.3mm
TTL	21.0mm ±0.4mm
MTF on-axis(at 50 lp/mm)	87.5%
0.7F (at 50 lp/mm)	86.2%(R), 78.4%(T)
Relative Illumination	44.5%(Full image circle)
Flange Type	M12 * P0.5
Head Size	¢ 15.0
Operating Temperature Range	-20℃ ~ +70℃ , Under RH 90%
Storage Temperature Range	-25℃ ~ +85℃ , Under RH 99%
Lens Construction	4G [All Glass]
	With Ir Cut Filter(650nm)

Lens Holder Dimension



How to Update the Firmware

The latest firmware can be downloaded from the following site:

https://github.com/withrobot/oCamS/tree/master/Firmware

The firmware update tool (UpdateFW.exe) can be downloaded from the following site:

https://github.com/withrobot/oCamS/tree/master/ Firmware/Update FW

Further details about how to use the UpdateFW.exe can be found at the following site:

https://github.com/withrobot/oCamS/tree/master/Firmware

Contact for Technical Support

- E-Mail: withrobot@withrobot.com

www.withrobot.com