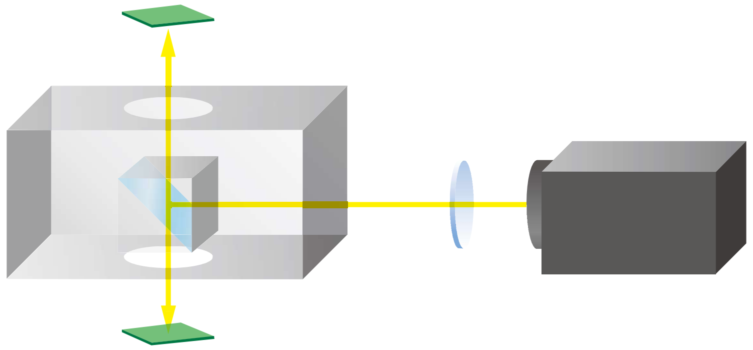
Customize

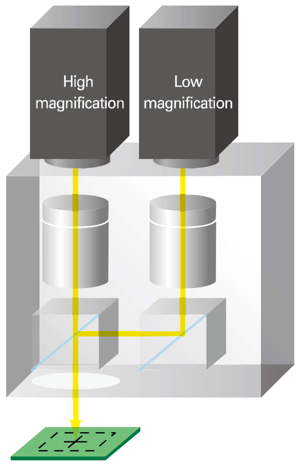
Custom Unit Examples

Up-and-Down View Optical Unit



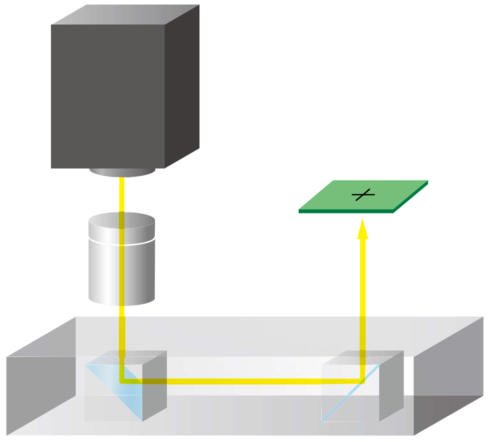
Optical unit recognize up-and-down objects with one camera

Two cameras, two magnification optical unit



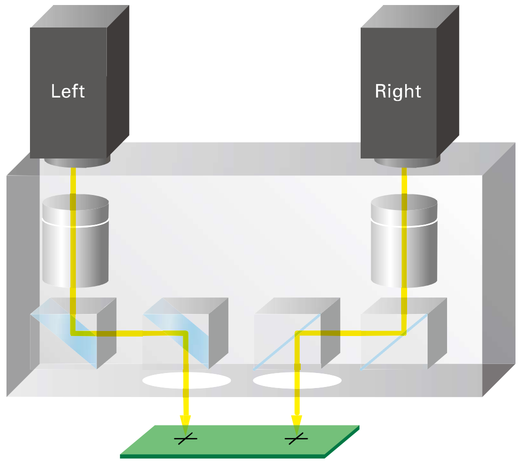
Imaging one target with high and low magnification

Down and back up unit



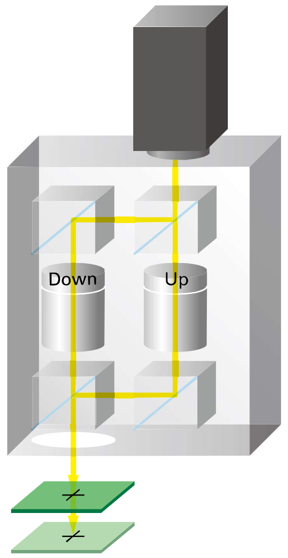
A unit optical path bending in U type Suitable to build in a machine

Optical measurement between two points unit

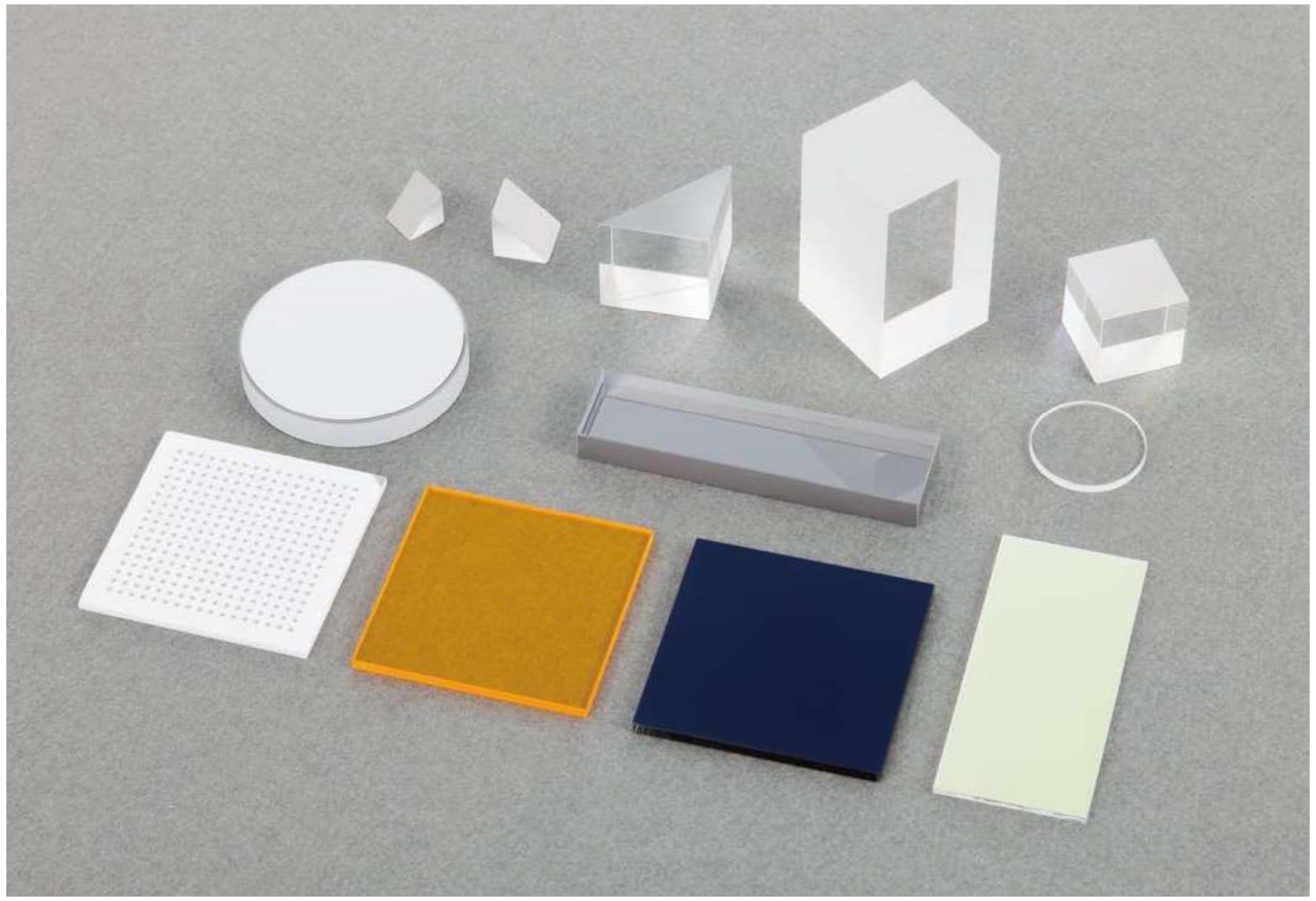


Recognition of two points at the same time

Two focus points unit



Optical system which has two different WD with one camera



Optical Components

Through strong partnerships with differing companies,
VS Technology has access to various optical processing technologies such as sharpening, cutting, polishing, coating, etching and the bonding of optical lens elements.
We can also offer custom solutions for optical parts based on your specification.

【Optical Elements Shaping】

We offer the cutting, rounding, and polishing of various glass materials such as the quartz glass used for transparent pedestals found in LCDs.

【Thin Coatings By Vacuum Deposition】

We can create and apply IR cut, ND, AL mirror, cold mirror, beam splitter, AR and other various coatings.

【Precise Film Etching】

We are capable of etching of production record information, reference charts and other texts on varying materials such as thin metals, plastics, and etc.

【Molding of Materials】

The creation of high quality molds from metal or plastics for the forming of spherical/aspherical lenses, Fresnel lenses, reflectors and other items.

Table for FOV

Table for FOV (mm) Sensor size for VST use

Optical Mag.	4/3" 13.6 x 18.1 (18.1 / 13.6 / 22.6; 2470 x 3300, 5.5µm)	1.1" 10.3 x 14.1 (14.1 / 10.3 / 17.5; 3000 x 4096, 3.45µm)	1" 11.26 x 11.26 (11.26 / 11.26 / 15.9; 2048 x 2048, 5.5µm)	2/3" 7.1 x 8.4 (8.4 / 7.1 / 11; 2054 x 2456, 3.45µm)
0.1x	136.0 x 181.0	103.0 x 141.0	112.6 x 112.6	71.0 x 84.0
0.2x	68.0 x 90.5	51.5 x 70.5	56.3 x 56.3	35.5 x 42.0
0.25x	54.4 x 72.4	41.2 x 56.4	45.0 x 45.0	28.4 x 33.6
0.5x	27.2 x 36.2	20.6 x 28.2	22.5 x 22.5	14.2 x 16.8
0.8x	17.0 x 22.6	12.9 x 17.6	14.1 x 14.1	8.9 x 10.5
1.0x	13.6 x 18.1	10.3 x 14.1	11.3 x 11.3	7.1 x 8.4
1.5x	9.07 x 12.07	6.9 x 9.4	7.51 x 7.51	4.73 x 5.60
2.0x	6.80 x 9.05	5.2 x 7.1	5.63 x 5.63	3.55 x 4.20
4.0x	3.40 x 4.53	2.6 x 3.5	2.82 x 2.82	1.78 x 2.10
10.0x	1.36 x 1.81	1.0 x 1.4	1.13 x 1.13	0.71 x 0.84

Optical Mag.	1/1.8" 5.4 x 7.1 (7.1 / 5.4 / 8.9; 1536 x 2048, 3.45µm)	1/2" 4.8 x 6.4 (6.4 / 4.8 / 8; 1040 x 1360, 4.65µm)	1/2.5" 4.2 x 5.7 (5.7 / 4.2 / 7; 1944 x 2592, 2.2µm)	1/3" 3.6 x 4.8 (4.8 / 3.6 / 6; 768 x 1024, 4.65µm)
0.1x	54.0 x 71.0	48.0 x 64.0	42.0 x 57.0	36.0 x 48.0
0.2x	27.0 x 35.5	24.0 x 32.0	21.0 x 28.5	18.0 x 24.0
0.25x	21.6 x 28.4	19.2 x 25.6	16.8 x 22.8	14.4 x 19.2
0.5x	10.8 x 14.2	9.6 x 12.8	8.4 x 11.4	7.2 x 9.6
0.8x	6.8 x 8.9	6.0 x 8.0	5.3 x 7.1	4.5 x 6.0
1.0x	5.4 x 7.1	4.80 x 6.40	4.2 x 5.7	3.6 x 4.8
1.5x	3.60 x 4.73	3.20 x 4.27	2.80 x 3.80	2.40 x 3.20
2.0x	2.70 x 3.55	2.40 x 3.20	2.10 x 2.85	1.80 x 2.40
4.0x	1.35 x 1.78	1.20 x 1.60	1.05 x 1.43	0.90 x 1.20
10.0x	0.54 x 0.71	0.48 x 0.64	0.42 x 0.57	0.36 x 0.48

※Accurate sensor size may vary, Depends on the camera manufacturer.

Table for FOV (mm) Reference for market sensor size

Optical Mag.	1" 11.46 x 11.46 (11.46 / 11.46 / 16.2; 4096 x 4096, 2.8µm)	1" 8.7 x 13.1 (13.1 / 8.7 / 15.7; 5472 x 3648, 2.4µm)	8.6 x 11.46 (11.46 / 8.6 / 14.4; 4096 x 3072, 2.8µm)	1/1.2" 7.1 x 11.4 (11.4 / 7.1 / 13.4; 1936 x 1216, 5.86µm)
0.1x	114.6 x 114.6	87.0 x 131.0	86.0 x 114.6	71.0 x 114.0
0.2x	57.3 x 57.3	43.5 x 65.5	43.0 x 57.3	35.5 x 57.0
0.25x	45.8 x 45.8	34.8 x 52.4	34.4 x 45.8	28.4 x 45.6
0.5x	22.9 x 22.9	17.4 x 26.2	17.2 x 22.9	14.2 x 22.8
0.8x	14.3 x 14.3	10.9 x 16.4	10.8 x 14.3	8.9 x 14.3
1.0x	11.5 x 11.5	8.7 x 13.1	8.6 x 11.5	7.1 x 11.4
1.5x	7.6 x 7.6	5.80 x 8.73	5.73 x 7.64	4.73 x 7.60
2.0x	5.7 x 5.7	4.35 x 6.55	4.30 x 5.73	3.55 x 5.70
4.0x	2.9 x 2.9	2.18 x 3.28	2.15 x 2.87	1.78 x 2.85
10.0x	1.1 x 1.1	0.87 x 1.31	0.86 x 1.15	0.71 x 1.14

Line Sensor Size

【2K sensor】

2048×10µm 20.5mm

2048×14µm 28.7mm

【4K sensor】

4096×7µm 28.7mm

4096×10µm 41.0mm

【6K sensor】

6144×7µm 43.0mm

【7K sensor】

7450×4.7µm 35.0mm

【8K sensor】

8192×7µm 57.3mm

8192×10µm 81.9mm

【12K sensor】

12288×3.5µm 43.0mm

12288×5µm 61.4mm

12288×7µm 86.0mm

【16K sensor】

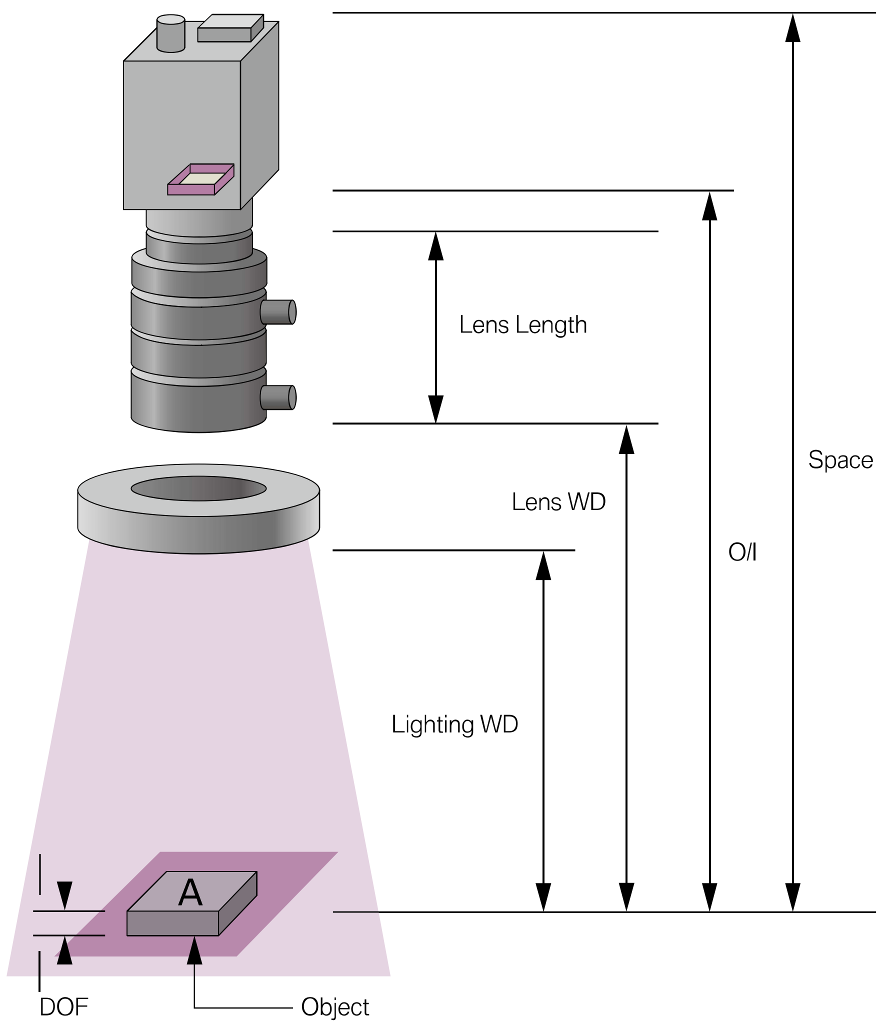
16384×3.5µm 57.3mm

16384×5µm 81.9mm

※Accurate sensor size may vary, Depends on the camera manufacturer.

Points for choosing a Lens

It is critical to consider the required conditions for your application which is key for choosing the correct imaging devices. Common parameters and dimensions are shown. (Refer to FIGURE1)



Camera
Area sensor or Line sensor
Sensor size / Flange back
Lens mount / B · W or Color etc

Lens
Type of Lnes (depend on application)
Fixed iris or adjustable
Fixed Mag or adjustable
Lens size etc

Illumination
Type of light source
Lighting Method
Lighting WD etc

Environment
Vibration, Shock
Unnecessary Light
Dust, Water
Temperature, Humidity

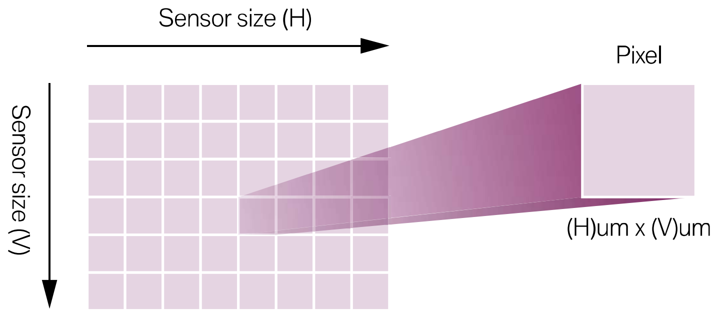
FIGURE1

Sensor Size

Sensor size = Pixel size (V) or (H) x Effective Pixel amount (V) or (H)

ex)
Pixel size: 4.4um x 4.4 um
Effective Pixel amount : 1600 x 1200

Sensor size(V) = 0.0044 x 1200 = 5.28mm
Sensor size(H) = 0.0044 x 1600 = 7.04mm
Sensor size = 7.04 x 5.28mm

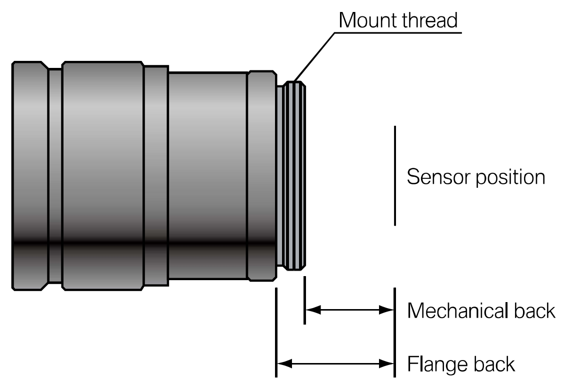


Camera Mount

Each camera mount has a different size thread and flange back
(FB: distance from sensor to lens flange)
Common camera mount FB are shown below.

Area Camera

C-mount	FB (mm)	Line Camera	FB (mm)
CS-mount	17.526	F-mount	46.5
M-mount	12.526	M42-mount	※1
S-mount	M15.5/P0.5	M72-mount	※1
	M10.5/P0.5		



※1. FB size depends on the camera manufacturer.
You need to make sure both mount thread and FB are correct to get the correct image .

VST mainly offers C, F and M72 mount but also some special mounts for remote head cameras.
Please contact us for more details if you have a special lens mount.

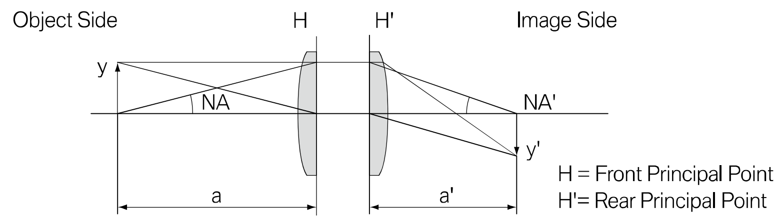
Optical Magnification

Magnification is a ratio between FOV and Camera sensor size.

$$\text{Opt.Mag} = \frac{\text{Sensor size (H) or (V)}}{\text{FOV (H) or (V)}}$$

ex.)
Sensor size = 6.8 x 4.8 mm
FOV = 12.8 x 9.6 mm

Opt. Mag= 6.8/12.9 = 0.5 x

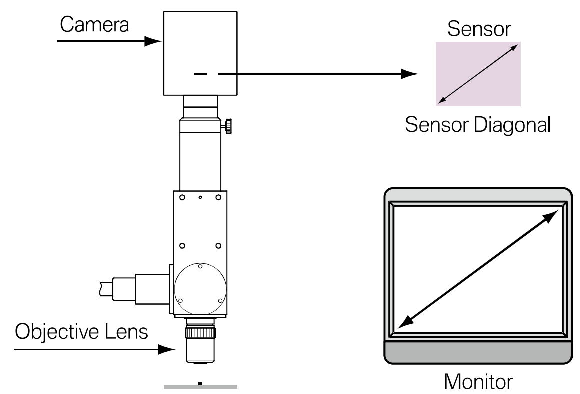


Monitor Magnification

When the image is displayed on a monitor, the diagonal of the sensor is expanded and shown to the diagonal of the monitor. The magnification on monitor is varied by sensor size and monitor display size.

$$\text{Monitor.Mag} = \frac{\text{Monitor Diagonal}}{\text{Sensor Diagonal}} \times \text{Opt. Mag}$$

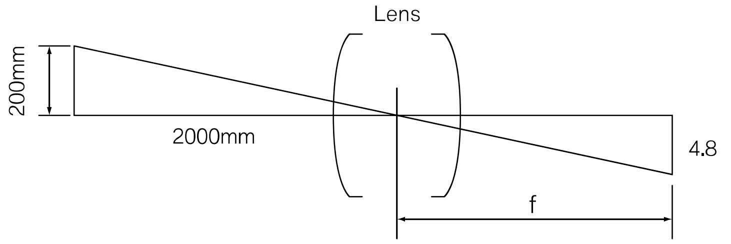
※Calculation is based on Underscan mode of monitor.
It will be slightly different when monitor is on Overscan mode.



Focal Length (f)

Distance from rear principal point (H2) to the image plane.
Required lens focal length of your application can be calculated by FOV, WD and sensor size.
This is to get approximate focal length idea only.
Please contact us for choosing a lens.

$$f(mm) = \frac{WD \times \text{Sensor size (H) or (V)}}{\text{FOV (H) or (V)}}$$



ex.)
WD: 2000mm
Object height: 200mm
Sensor size: 1/2" (4.8 x 6.4mm)

$$f(mm) = \frac{2000 \times 4.8}{200} = 48mm$$

If WD is fixed, FOV will be lager when using a shorter focal lens, and smaller when using a longer focal length lens.
If FOV is fixed, WD will be shorter when using shorter focal length lens, and longer when using a longer focal length lens.

Field of View (FOV)

$$\text{FOV (H) or (V)} = \frac{\text{Sensor size (H) or (V)}}{\text{Opt. Mag}}$$

ex.) Sensor size : 1/3" (H) 4.8mm, Opt.Mag : 2.0x

$$FOV(H) = \frac{4.8}{2.0} = 2.4mm$$

※ In specification tables of this catalogue, FOV is calculated by standard size of CCD sensor. To get an exact FOV of your image, please calculate by effective pixel amount and pixel size of the sensor.

WD (Working Distance)

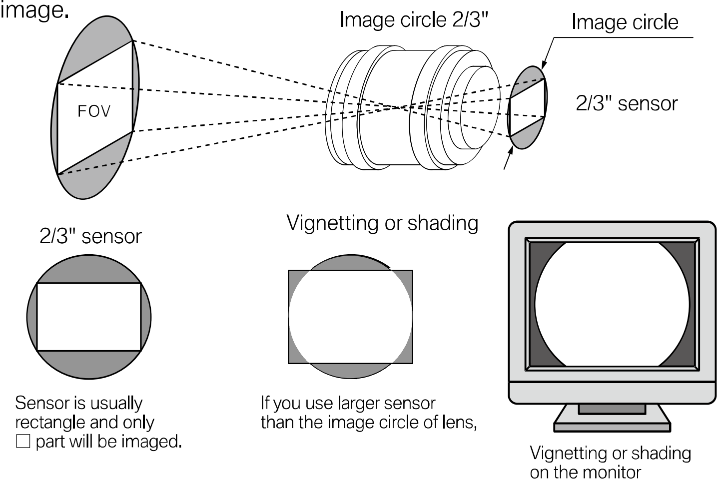
The distance between the object and front of the lens.

O/I (Object to Imager)

The distance between the object and sensor.

Image Circle , Shading

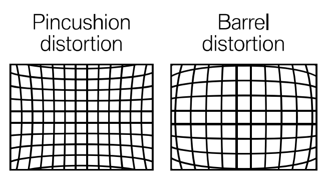
A lens has the ability to support a certain sensor size to image.
The maximum sensor area that the lens can support it defined as Image Circle.If the sensor size is too large, it causes "Shading" or "Vignetting".

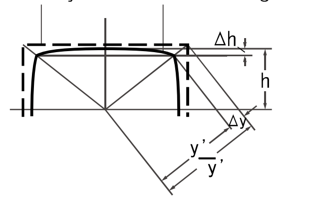


TV Distortion (TV.D)

The ratio of amount of bending against actual object straight line in a longitudinal direction.
Expressed in percentage.

※ Distortion (D) : Refer to Diagram2





$$TV.D = \frac{\Delta h}{2h} \times 100 \qquad D = \frac{y' - y}{y} \times 100$$

F Number (F/#)

F number defines the brightness of lens at infinity imaging. Smaller number lens has generally brighter image.
F/# = Focal Length / Diameter of Entrance Pupil (Effective Aperture)

Working F/# (W.F/#)

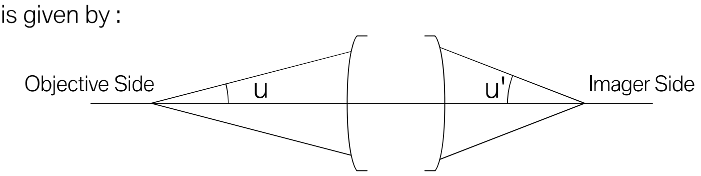
Working F# defines the brightness at a certain magnification.

W.F/# = (1+Opt Mag.) x F/# = Opt Mag. / 2NA

NA (Numerical Aperture)

Measure of the cone of light accepted by a lens. NA is given by :

Object side NA = sin u x n
Imager side NA' = sin u' x n'



The half angle of objective side entrance pupil is u,
the half of image side of exit pupil is u', and objective side refractive index is n, image side refractive is n'

※ For macro lenses, NA is defined by: NA=M/2xF, NA'=1/2F, relation of NA and NA' is NA=NA'x Opt Mag.

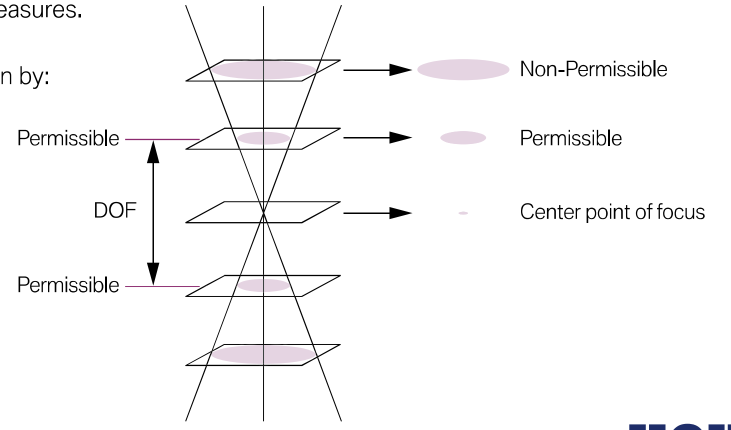
Depth of Field (DOF)

DOF is a range of object distance, which the image appears to be sharp and focused.
Also a parameter describing the distance of imaging side (sensor side) is called depth of focus.
Tolerable level of blur is called Permissible Circle of Confusion, or Permissible COC.
This represents the smallest diameter of a bundle of rays when being focused on an image plan.
The diameter of Permissible COC will be definedby each application,
pixel size of camera and the person who actually measures.

The amount of DOF shown in this catalogue is given by:

DOF = 2 {(Permissible COC ×W.F#/Opt Mag. }

$$DOF = \frac{\text{Permissible COC}}{\text{(Nax Opt Mag.)}}$$



※We use Permissible COC at 0.04mm in this catalogue.

Relative Illuminance

Relative Illuminance is a ratio of brightness between center and corner of the image.
It is expressed in percentage against the center in 100%.

Airy Disk and Resolution

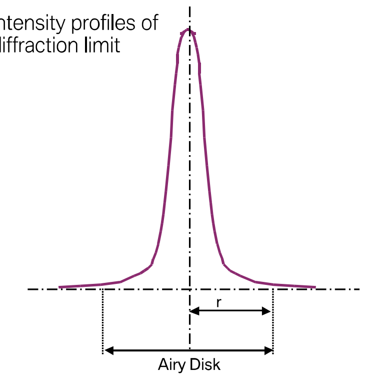
Even an ideal lens without any aberrations cannot reproduce an object detail.
Diffration will limit the resolution possible. The smallest achievable spot from a lens is called Airy Disk.
The radius r of the spot is given by wavelength λ and numerical aperture NA:

$$r = 0.61 \times \lambda / NA$$

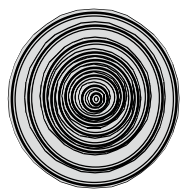
The longer wavelength of the illuminating light has larger spot.

ex)
A lens with NA0.07 at wavelength 550nm.
r = 0.61 x 0.55 / 0.07 = 4.8um.

The resolution on the specification sheet of VST is given by this equation.



Airy Disk pattern

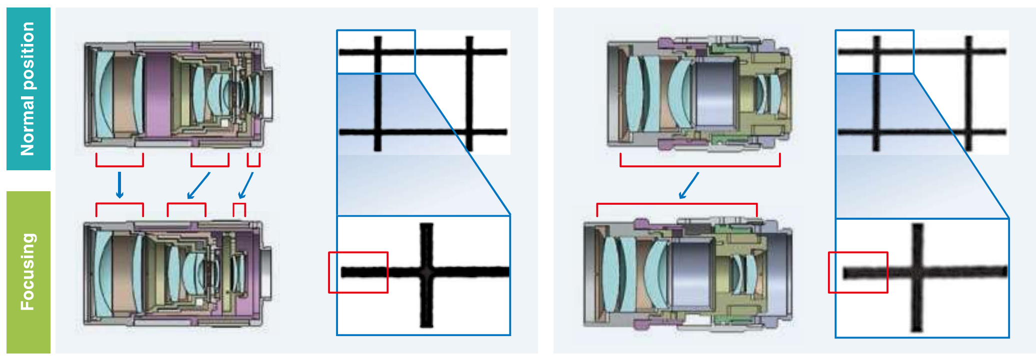


Resolving Power

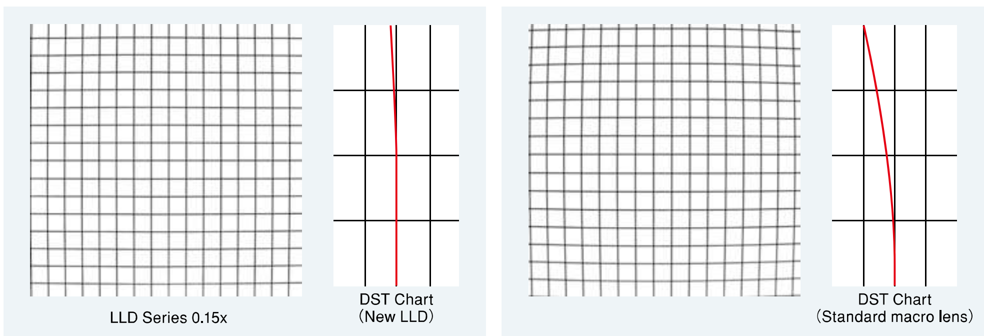
Resolving power is expressed in terms of the number of line-pairs per millimeter (lp/mm) - the most number of black and white lines in one millimeter to be distinguished. The contrast level of image has to be defined to avoid differences between individuals.

Floating System

Normal lenses shift just a single group of elements for focusing. Additional floating elements (see picture below) can improve the close-focus performance significantly. Because the floating component is separate to the focusing lens group, aberrations caused by lens extensions are significantly reduced. Benefits are particularly great in macro lenses because they cover a wide range of focus distances and in wide-angle.



Furthermore, our advanced designed for Distortionless machine vision macro lens



MTF and Resolution

The modulation transfer function (MTF) describes how the contrast varies with respect to spatial frequency. MTF represents the ability of a lens to transfer information from the object to the image.
The contrast is usually measured by a spatial frequency test target with black and white line pairs and if the intensity between black and white is perfectly described, contrast (modulation) is 100%. (Figure 1)

If the features between black and white (gray level) cannot be resolved, the contrast is too low. Higher spatial frequency is usually imaged with less contrast because of aberrations of lens.

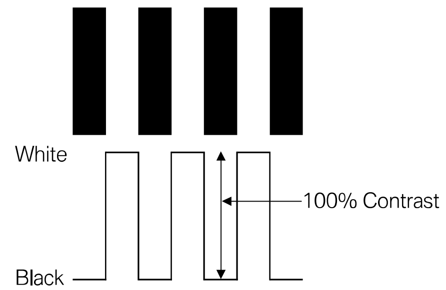
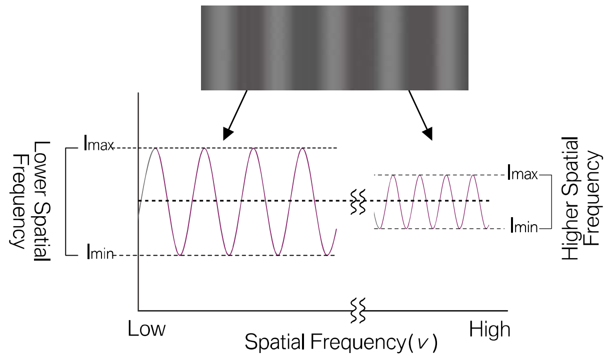
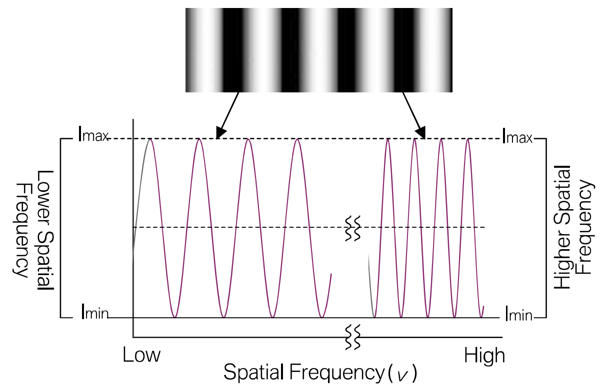


Figure 1



$$B = \frac{Imax - Imin}{Imax + Imin}$$

Figure 2(Object side)



$$A = \frac{Imax - Imin}{Imax + Imin}$$

Figure 3(Image side)

Figure 2 and 3 shows the spatial frequency against gray level at object side A and image (sensor) side B. The contrast (MTF) is given by ratio of A and B.
Resolution is the ability of lens to distinguish between two features that are close together. It is generally expressed in micrometers but it is affected by contrast, too. MTF express the relation between resolution and contrasts.
Lens has lower MTF at higher frequency and MTF below 0.1 is normally not able to be resolved black and white which is usually lower resolution number than calculated.

Figure 4 shows two different lenses with different spatial frequency in each contrast level. Lens "a" has low resolution level but high contrast at low spatial frequency, however, higher resolution lens "b" has lower contrast at same level of frequency. Thus, lens "b" is higher resolution than lens "a" at high frequency level.
But in actual machine vision applications, lens ability depends on different issues and it is not necessarily appropriate to suggest a lens only by resolution numbers.

$$MTF \quad M(v) = \frac{B}{A}$$

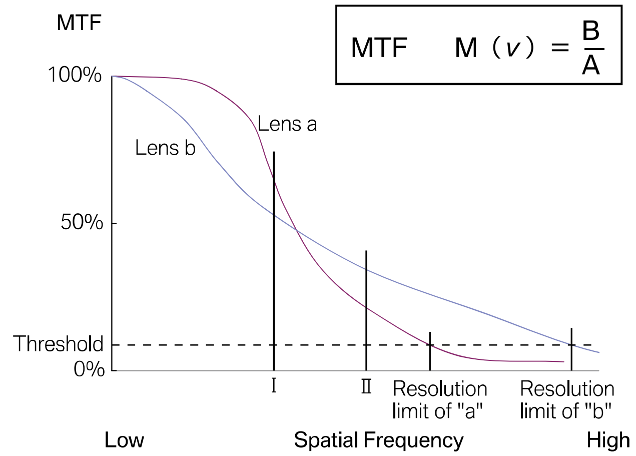
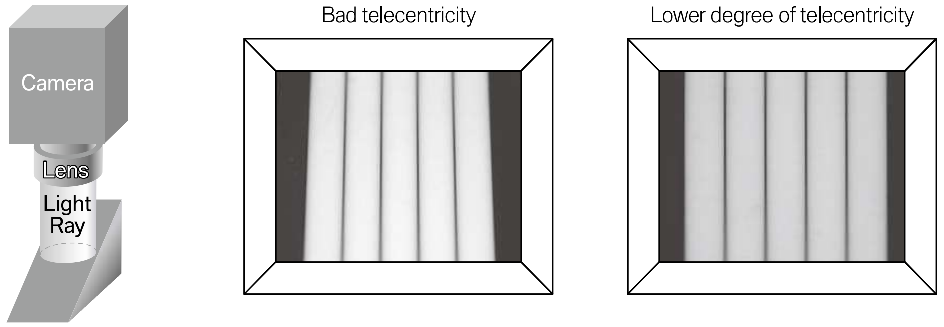


Figure 4

Telecentricity

Telecentricity determines the amount that magnification changes with working distance. Better telecentricity means less magnification changes. Telecentric lens has parallel chief rays to its optical axis and bad telecentricity lenses produce images with higher magnification when the object is closer and the object can be seen differently between center and field of image.
The degree of telecentricity is measured by the chief ray angle in the corner of the image field. You can easily check the telecentricity using a target as shown below. Telecentric lens is very important for gauging threedimensional objects or objects whose working distance is not stable.



Type of Machine Vision Lenses

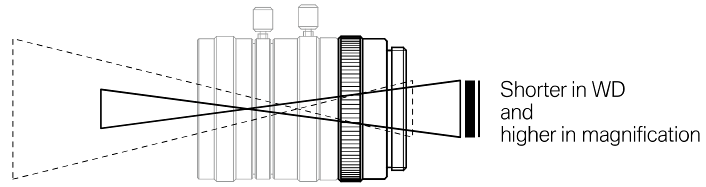
Generally machine vision optics are classified into Macro lens for high magnification and CCTV or photographic lens for infinity imaging.
Telecentric lens is categorized as macro lens. Most of maco lens is spacially designed for short working distance (WD:10mm-500mm) to have high image quality in brightness, distortion, resolution in entire field of view (FOV).
Macro lens is often designed for specific WD without a focus adjustment and you need to set-up the camera position precisely.
The out line of machine vision lenses are shown as below Table.

	Feature	Advantages	Disadvantages
Telecentric Lenses	The chief ray is parallel to its optical axis. Necessary for co-axial illumination	High measurement accuracy in height wise. No perspective error in entire field.	Big in dimensions Expensive
Macro Lenses	Specially designed for short working distance.	Small distortion Compact & Lightweight Vibration resistance	Able to focus in a certain range only. Limited FOV(magnification) range.
Fixed Focal Length Lenses	Able to focus infinity Adjustable focus and iris	Wide range of FOV and WD Low cost Suitable for large FOV	Weak in vibration Distortion in short WD
Line Scan Lenses	Specially designed for long line sensor Usually come with big camera mount	Small distortion and shading Vibration resistance	Big in size and heavy weight
Zoom Lenses	Enable to change magnification without changing WD and camera position.	Suitable for the application which need to change magnifiaction frequently.	Big in dimensions

Extension Tube

Tubes used between lens and camera when you need to focus in shorter WD than the lens MOD(minimum object distance). FOV will be also smaller consequesntly.

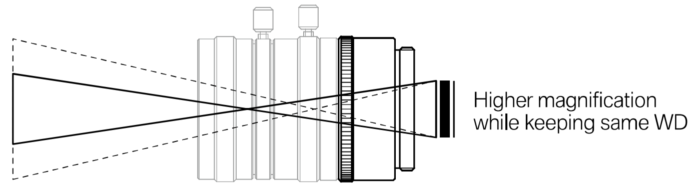
SV-EXR series are available in 12 length type from 0.2mm to 50mm.



Rear Converter Lens

A optional lens used between lens and camera when you need to get higher magnification (smller FOV) without changing WD.

SV-X series are from 1.5x to 5.0x.



The Spec for Environment		
	Oparating : -5 ～ 50℃	80% (Non-condensing)
	Strage : -10 ～ 60℃	90% (Non-condensing)