MV

Machine Vision General Catalog

Lens Vol.001

MORITEX SCHOTT

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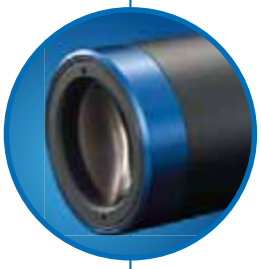
Introduction

Unparalleled Expertise

Machine Vision Systems combine lighting, imaging, and data processing to inspect, monitor, and control industrial production processes. They have been employed in a variety of industries on a multitude of applications.

As experts in providing Lighting and Imaging solutions for today's vast machine vision market, MORITEX and SCHOTT offer standard and customized solutions for illumination, lens design, and front end optical systems.



With decades of experience, and extensive know-how, MORITEX and SCHOTT can provide the total machine vision illumination and imaging solution designed exclusively for you comprised from our vast product portfolio.

MORITEX and SCHOTT are leading global suppliers of illumination and imaging components for machine vision applications. Our unparalleled expertise in these areas makes us uniquely qualified to service all different levels from system design to integrated lighting and imaging system solutions. Please review the products featured in this catalog and let us know how we can best serve you!



Your Global Lighting and Imaging Alliance

Since 2007, MORITEX and SCHOTT have cooperated on a global scale. Our goal has always been to provide the ultimate products and services to our customers worldwide. By utilizing the bundled experience and expertise of these two established companies, we have made this goal a reality.

As an established leader in machine vision systems with an impeccable track record of innovation, MORITEX is the only provider that can service all different levels from system design to integrated system solutions.

The SCHOTT Lighting and Imaging division offers a broad range of LED and fiber optic solutions focusing on illumination, light and image transmission. In addition, SCHOTT also offers superior hybrid solutions utilizing the best of LED and fiber optic technologies.

For the first time, MORITEX and SCHOTT present their entire Machine Vision portfolio together in one catalog at your convenience and reference.

Thank you for taking the time to learn about MORITEX and SCHOTT and how we can provide you with the ultimate in Machine Vision solutions. If you would like more information about any of our products, please don't hesitate to contact us.

MORITEX and SCHOTT, Unparalleled Expertise!

Spanning the Globe

At MORITEX and SCHOTT we're here to serve you!
With locations spanning more then 40 countries across the globe, we're almost guaranteed to have an office near you.

This map represents some of our main offices serving the Machine Vision industry located in Asia, Europe and the USA.
Please don't hesitate to contact us if we can be of service to you. You may refer to the back cover page for contact information.

New Products

High Magnification Machine Micro Lens

SOD-20X-VI

NEW

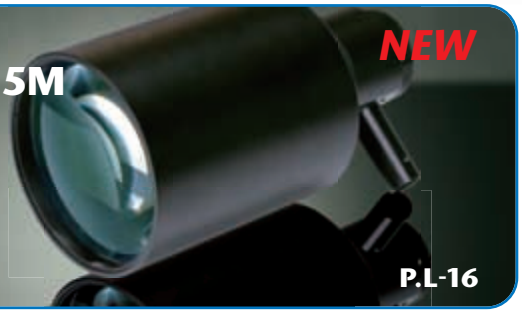
The multifunctional SOD-20X-VI model is the latest addition to the SOD-X Series with an optical magnification of 20x and NA of 0.35 to rival microscope objective lenses while providing a long working distance (WD) of 37.5mm.

P.L-11

MML Fixed Magnification Series

MML014-HR110D-5M

NEW



The MML014-HR110D-5M has the lowest magnification of any MML lens. It is the newest MML-HR5M Series model and is ideal for use with 5MP image sensors having resolving power of 362 lp/mm and achieving very uniform coaxial illumination over a large FOV of up to ø78.5mm.

P.L-16

MML-Standard

MML05-ST300DVI

NEW

To meet the various requirements of machine vision applications, this model features 0.5X magnification, a variable iris, and the longest WD (working distance) of any MML-ST Series lens, 300mm.

P.L-31

Line Scan Lens for 3 Color Line Sensor

ML-F80C-0205

NEW

Designed to address the challenges of color line scan applications, this new large format F4 lens with an 80mm focal distance features RGB chromatic aberration correction to provide excellent performance for line sensors up to 82mm at magnifications of 0.2 to 0.5X.

P.L-66

System Flow Chart

Telecentric Lens

SOD-X *High Magnification Machine Micro Lens Series* **SOD-10X / 20X-VI**

MML

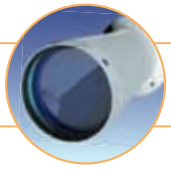
Fixed Magnification Series
MML-High Resolution 5M Series
MML-High Resolution Series
MML-Standard Series
MML Series

For Micro-head Cameras
MML-ST-CM Series

For Near-Infrared Applications
MML-NIR Series

MML Zoom Lens Series

High-Performance Low Magnification Zoom Lens **ML-Z0220D**
Manual Click Zoom Lens **ML-Z0315D**
High Resolution Zoom Lens Series **ML-Z07545HR Series**
Standard Zoom Lens Series **ML-Z07545 Series**



Carl Zeiss *For Distortion-free Imaging* **VISIONMES®**

Non-Telecentric Lens

Macro Lens Series

Non-Telecentric Macro Lens Series **ML-N Series**
Low Magnification Macro Lens Series **WD=90mm Series**

Macro Zoom Lens Series

High Performance Macro Zoom Lens **ML-Z0108**
Varifocal Lens for Large Image Format **ML-0310VF**
Mega Pixel Macro Zoom Lens **MLH-3XMP**
10X Zoom Lens **MLH-10x**

SOD-III *Coaxial Epi-illumination Unit for Objective Lens* **SOD-III**

CCTV Lens Series

Telecentric CCTV Lens **MTE-55**
3 Mega Pixel CCTV Lens **ML-MP3 Series**
Mega Pixel CCTV Lens **ML-MP Series**
CCTV Lens **ML Series**

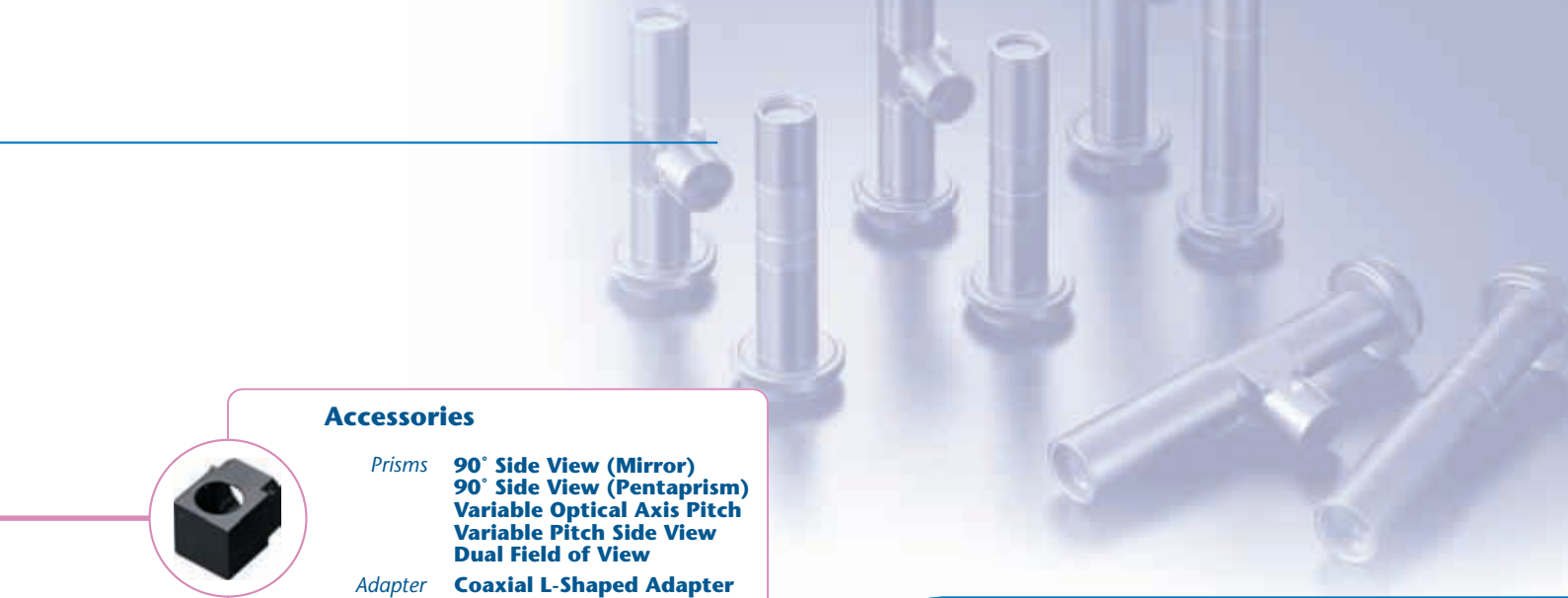
Line Scan Lens Series for Line & Large Format Sensors

Line Scan Lens for 3 Color Line Sensor **ML-F80C-0205**
For 62mm Sensor **ML-L12K5A Series** **ML-L00502**
For 57mm Sensor **ML-L02035/03505**
For 35mm Sensor **ML-L Series**

Fiber Optic Imaging

Fiber Optic Imaging Series

Leached Image Bundles
Wound Fiber Bundles



Accessories

Prisms	**90˚ Side View (Mirror)**
	90˚ Side View (Pentaprism)
	Variable Optical Axis Pitch
	Variable Pitch Side View
	Dual Field of View
Adapter	**Coaxial L-Shaped Adapter**
OEM Products	

Guidance

Telecentric Lens Series

Non-Telecentric Lenses

Line Scan Lens Series

Partner Lens Series

Fiber Optic Imaging Series

Accessories

Converter Lenses	
	MTE-075
	MTE-2

Accessories

Rear Converter Lenses	**ML-X**
90° Mirror Prism	**ML-MLC**
Grass Covers	**ML-GA Series**
Polarizers	**ML-PL Series**
Ring Illumination Attachment Adapters	**ML-FL Series**
Close-Up Rings	**ML-EXR Series**

Telecentric Lens

MORITEX high quality telecentric lenses have become the industry standard for semiconductor, FPD, and other electronics manufacturing applications that require machine vision for recognition, mounting, alignment, or inspection. Our lenses enable high contrast, high resolution and low distortion imaging with optional integrated coaxial illumination that utilizes our proprietary hot spot reduction techniques. Catalog specifications alone cannot convey the high level of MORITEX lens quality.

SOD-X Series

High Magnification Machine Micro Lens
SOD-10X / 20X-VI

The cutting-edge SOD-X Series consists of a unique set of multifunctional telecentric lenses designed with high NA, high magnification, and integrated coaxial illumination while providing a long working distance. They allow for high resolution imaging never seen before in a machine vision lens.

MML Series

Fixed Magnification Series
MML-High Resolution 5M Series
MML-High Resolution Series
MML-Standard Series
MML Series

For Use with Compact Camera
MML-ST-CM Series

For Use with Near-Infrared
MML-NIR Series

Essential in alignment, gauging, and inspection applications, the Machine Micro Lens (MML) Series are the highest quality fixed magnification, compact telecentric lenses available. The Standard (ST), High Resolution (HR), and 5 Megapixel (HR 5M) Series offer solutions for for a wide-range of machine vision systems including the NIR light range.

MML-Zoom Lens Series

High-Performance Low Magnification Zoom Lens
ML-Z0220D

Manual Click Zoom Lens
ML-Z0315D

High Resolution Zoom Lens
ML-Z07545HR Series

Standard Zoom Lens
ML-Z07545 Series

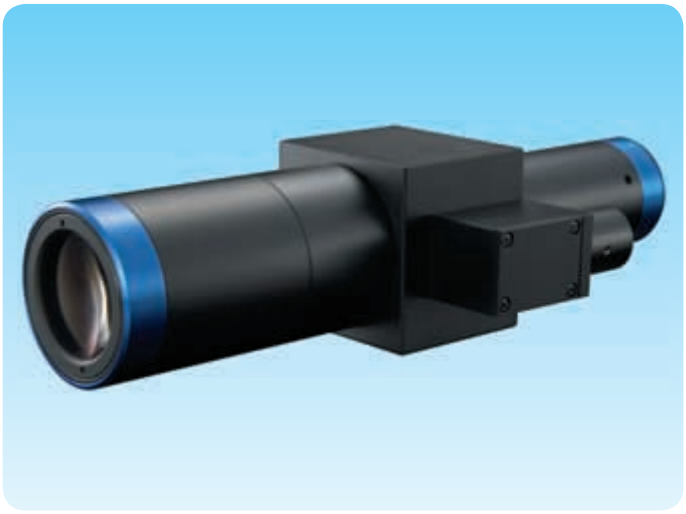
This telecentric zoom lens series is used for high performance inspection and object recognition when a wide range of FOV and long WD are required. The ML-Z and ML-Z HR Series offer integrated coaxial illumination, adapter lenses, and motorized zoom function options.

High Magnification Machine Micro Lens

Super Optical Device — SOD-10X

The SOD-10X is the first telecentric machine vision lens that we introduced with the resolution to rival microscope objectives. The long WD and high NA have made it indispensable for high magnification alignment & inspection applications of 10x or greater.

High performance rear converters allow for magnifications of 15x & 20x to be achieved without changing the working distance allowing microscope type performance in a relatively compact package.

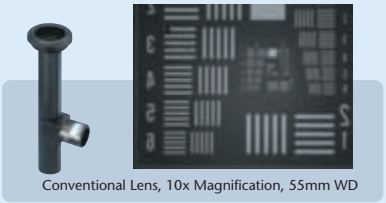


- 10x optical magnification
- Capable of 15x and 20x with rear converter lenses
- High NA of 0.23
- High resolution, 1.5µm
- Compact, integrated design

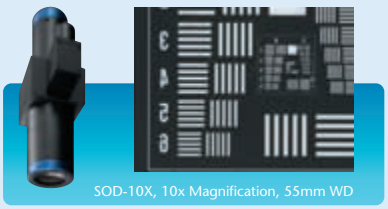
1 Even Better Images

High Resolution and NA

Achievement of high resolution that is beyond comparison with conventional machine vision lenses.



Conventional Lens, 10x Magnification, 55mm WD

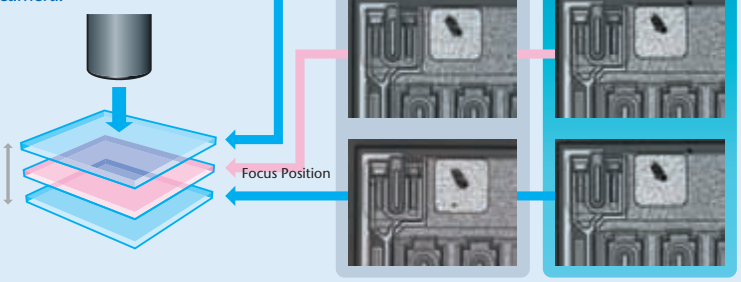


SOD-10X, 10x Magnification, 55mm WD

2 Wide Focus Range

Deep Depth of Field Telecentric Optical System

A high resolution equivalent to an objective lens with even longer depth of field has been sought after and now there is a telecentric optical system that has been implemented to widen the range of focus when viewing objects with a CCD camera.



NEW

High Magnification Machine Micro Lens

Super Optical Device—SOD-20X-VI

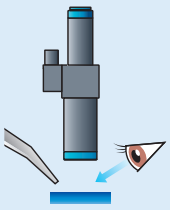
This revolutionary 20x magnification SOD series model has a high NA & resolution that put it in the microscope objective lens class.
In addition, it boasts a long WD of 37.5 mm that provides you with additional space to install Illumination and motion, handling, & transfer systems.
The all-in-one machine vision lens has a compact body with an integrated coaxial epi-illumination also saving space & improving on-axis light quality.

- 20x optical magnification
- Capable of 30x and 40x with rear converter lenses
- High NA of 0.35
- High resolution, 1µm
- Variable iris

3 Ease of Use **Long WD**

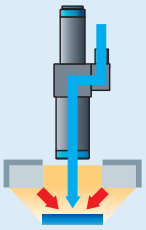
Improved ease of use through longer WD (working distance) while maintaining high resolution.

Sufficient space for tooling and pick-up tools has been provided allowing the performance of operations thought to be impossible with conventional lenses. Operating position and work status can be confirmed by eye resulting in a reduction of operating errors.



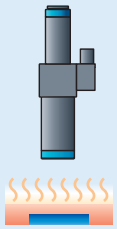
Establishment of operating space
Confirmation of operation status and position possible by eye

Opens the possibility of using not only coaxial but ring and various other types of illumination. This increase in lighting options allows for the imaging of objects previously difficult to view and resolve.



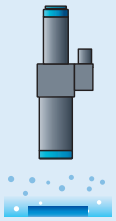
Oblique illumination is possible

Recognition is possible at a location with necessary separation from heat sources. Alignment and inspection are also possible during thermo compression bonding.



Separation from heat source

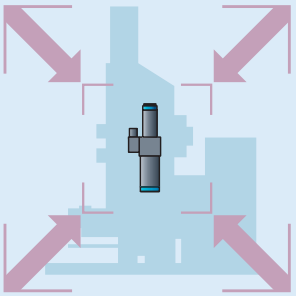
Observation can be performed without any effects from water, oil, and foreign objects generated or moved during processing.



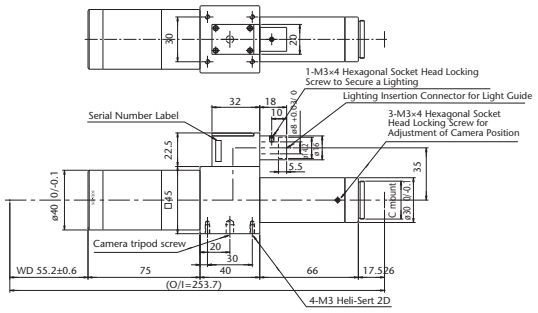
Use in environments where substances such as water & oil are disturbed

4 Compact

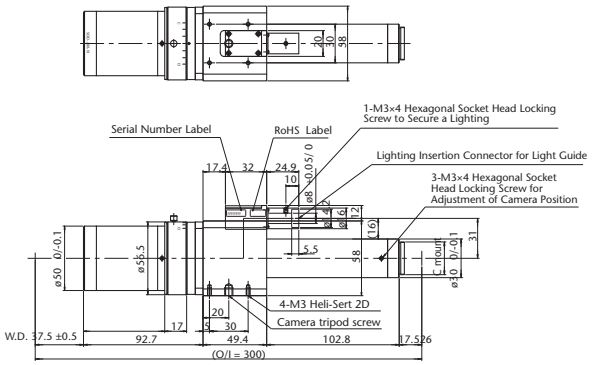
Compact design makes it possible to downsize peripheral parts and machinery.



SOD-10X

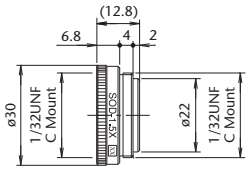


SOD-20X-VI

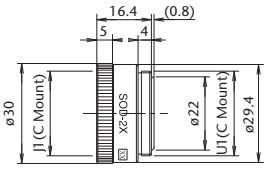


Rear Converter Lens (Option)

SOD-1.5X



SOD-2X

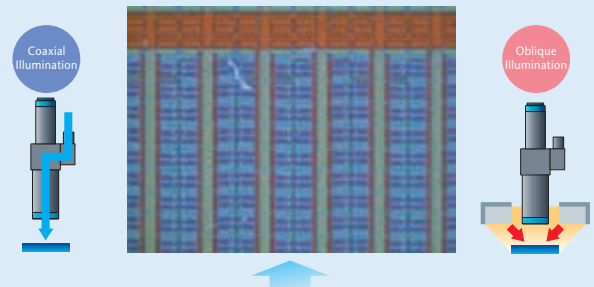


Model	Magnification	WD	Resolution	Depth Of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
SOD-10X	10x	55.2mm	1.5μm	0.017mm	0.23	22	0.01%	2/3"	500g	C Mount	A-0174
SOD-20X-VI	20x	37.5mm	1μm ~ 3μm	0.0057mm ~ 0.026mm	0.35 ~ 0.114	28.3 ~ 88	0.02%	2/3"	930g	C Mount	A-0178
Dedicated Rear Converter Lens											
SOD-1.5X	30x	37.5mm	1μm ~ 3μm	0.0038mm ~ 0.026mm	0.35 ~ 0.114	42.5 ~ 132	0.04%	2/3"	-	C Mount	A-0175
SOD-2X	40x	37.5mm	1μm ~ 3μm	0.0029mm ~ 0.026mm	0.35 ~ 0.114	58.63 ~ 176.9	-0.07%	2/3"	-	C Mount	A-0176

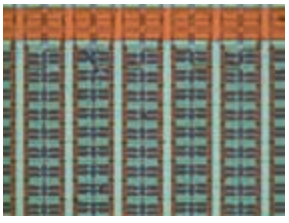
Application Sample

Silicon Wafers

Recognition of wafer patterns using coaxial illumination. Recognition of damage and foreign objects using ring illumination.

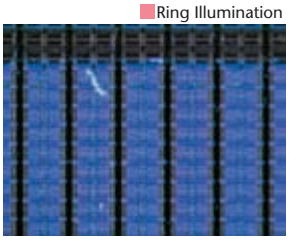


Coaxial Illumination



Wafer (Pattern)

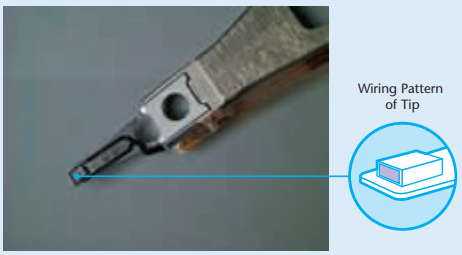
Ring Illumination



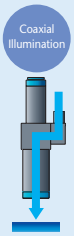
Wafer (Damage)

Hard Disk Reading Head

Highly uneven objects are covered by using a wide focus range.



Coaxial Illumination



MML Series

Essential in alignment, gauging, and inspection applications, the Machine Micro Lens (MML) Series are the highest quality fixed magnification, compact telecentric lenses available. The Standard (ST), High Resolution (HR), and 5 Megapixel (HR 5M) Series offer solutions for a wide-range of machine vision systems including the NIR light range.

MML-High Resolution 5M
MML-HR 5M Series

Top quality product types that boast the best contrast and NA among the entire MML Series. The highest possible image quality can be obtained in combination with high pixel count cameras such as the increasingly popular 5 mega pixel sensors. Various models also include iris control.

MML-High Resolution
MML-HR Series

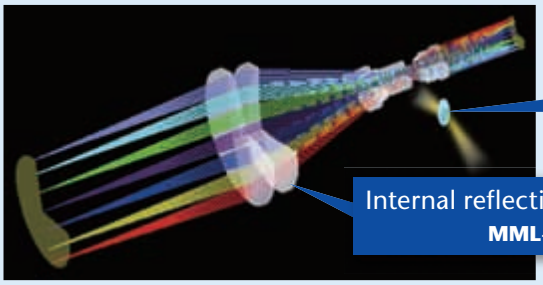
High performance MML Series models designed for cameras with 1.3 million pixels and up (i.e. ~4.65 microns/pixel) with relatively small barrel diameters.

MML-Standard
MML-ST Series

This series offers the highest level of optical performance when coupled with 410 thousand pixel cameras. Compact (ø 16mm) standard models with long DOF (Depth of Field) design.

Provisions made to reduce coaxial illumination hot spots seen in low magnification lenses

patent pending



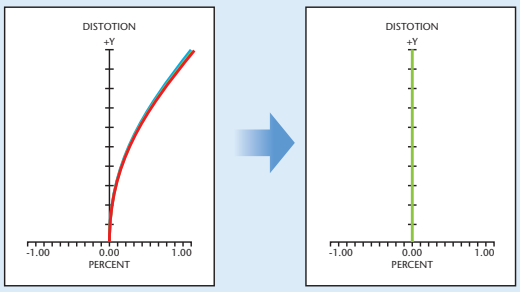
Conventional Design Lens

MML-HR 5M Series

Please note that although the lens is structured to suppress hot spots, hot spots will occur for mat surface work.

Extremely Low Distortion

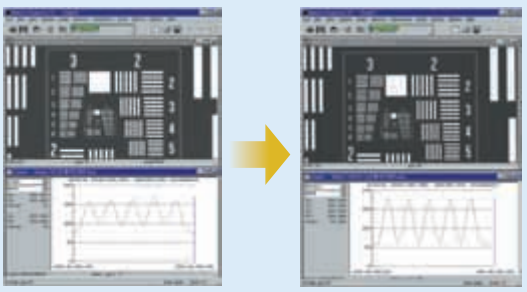
The pursuit of high resolution with no aberration has resulted in the elimination of image bending. This means that it is no longer necessary to consider distortion offsets.



Conventional MML　　MML-HR & MML-ST

High Contrast

Contrast improvement has enabled image recognition with greater emphasis on the black and white shading. By converting the resolution chart image to binary form and then graphing and comparing the brightness levels, the MML-HR greatly emphasizes the difference in brightness between black and white object features when compared to our prior Mega MML.

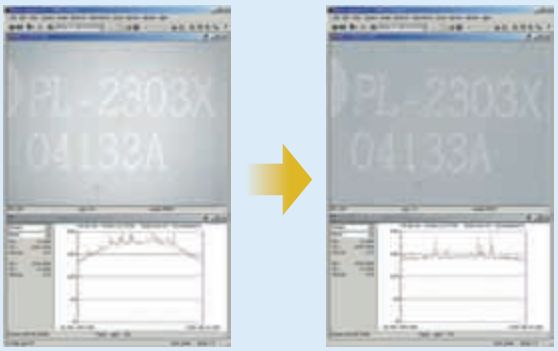


Conventional MML　　MML-HR & MML-ST

Illumination Uniformity

For object recognition on a matte surface with coaxial illumination, only a small amount of light is reflected from the surface requiring the coaxial light intensity to be increased. When this is done, however, the brightness in the center of the image increases due to reflection in the coaxial illumination lensing. The ST and HR Series solve this problem through a hot spot reduction technique that vastly reduces the reflection from the lens. This improves the uniformity of coaxial illumination for even matte surfaces.

Below, OCR using coaxial illumination was performed on a rough, microcomputer chip surface. The MML-ST/HR brightness graph shows a reduction in the variation between the brightness in the center and periphery of the FOV which can also be seen in the sample images.

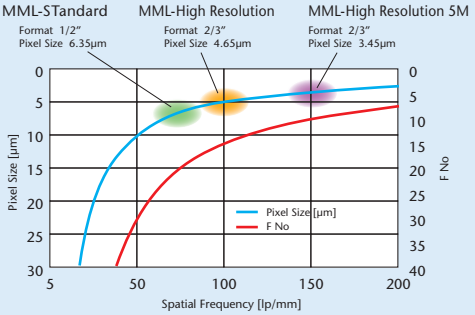


Conventional MML　　MML-HR & MML-ST

Design Concept

Pixel size, resolution limitation frequency, F No relation

The MML HR/ST Series consist of three types of optical design focuses as well as for CCD camera compatibility.



C Mount

3 Different Mount Types

ø34 Ring Type
MML

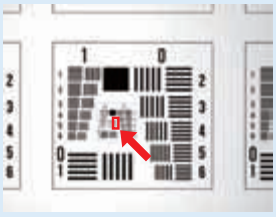
ø30 Ring Type
MML-ST / HR

Set Screw Type
MML-ST / HR

MORITEX provides customized responses to requests for modifications of mounts and special mounts.

Image Comparison for MML Series

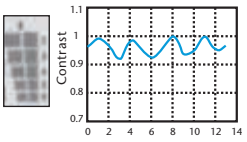
- CCD Camera: 5 million pixels, 3.45µm/pixel
- Lens: Optical magnification 2x WD65 mm
- Test Chart : Resolution 5.563µm (resolving power 179.6 lp/mm)



Field of view 4.4mm

MML-ST Series

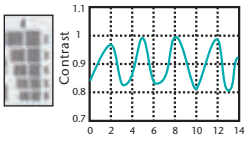
VGA Class



MML2-ST65D

MML-HR Series

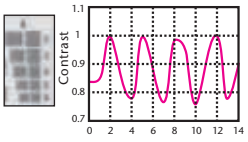
1.3 Mega Class



MML2-HR65D

MML-HR 5M Series

5 Mega Class



MML2-HR65D-5M

MML Fixed Magnification Series

MML-High Resolution 5M Series

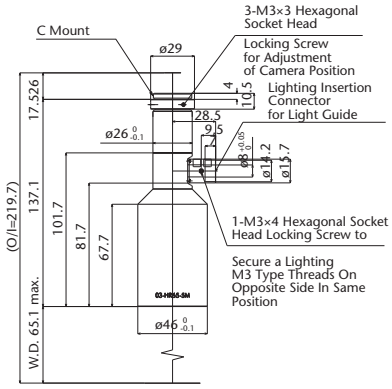
High-resolution models that possess the best contrast and NA of all MML Series. Image acquisition with even higher image quality is realized by combining these lenses with cameras with a high number of pixels, especially emerging 5 megapixel sensors.

NEW MML014-HR110D-5M

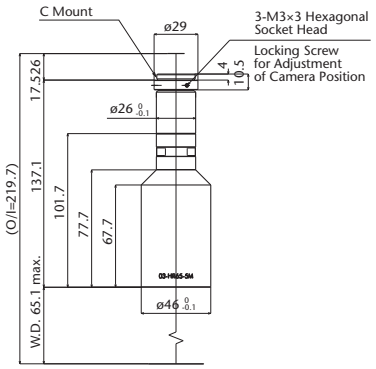
- Highest image quality model of the MMLs Series.
- Supports 5 million pixels (3.34µm/pixel)
  * Except for MML4-HR65DVI-5M
- Use of internal reflection light-scattering design and noise reduction filter for hot spot reduction
- Variable iris available for most models
- Very low distortion

Model	Magnification	WD	Resolution	Depth Of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight (g)	Mount	Product Code
MML03-HR65D-5M	0.3x	65.1mm	15.7µm	6.2mm	0.021	7	0.002%	2/3"	202	C Mount	A-3133
MML03-HR65-5M	0.3x	65.1mm	15.7µm	6.2mm	0.021	7	0.002%	2/3"	198	C Mount	A-3134
MML05-HR65DVI-5M	0.5x	65.3mm	9.3µm~41µm	2.2mm~9.8mm	0.036~0.008	7~30.6	0.006%	2/3"	210	C Mount	A-3137
MML05-HR65VI-5M	0.5x	65.3mm	9.3µm~41µm	2.2mm~9.8mm	0.036~0.008	7~30.6	0.006%	2/3"	210	C Mount	A-3140
MML1-HR65DVI-5M	1x	65mm	4.7µm~19µm	0.56mm~2.2mm	0.071~0.018	7~28	0.028%	2/3"	140	C Mount	A-3138
MML1-HR65VI-5M	1x	65mm	4.7µm~19µm	0.56mm~2.2mm	0.071~0.018	7~28	0.028%	2/3"	135	C Mount	A-3141
MML2-HR65DVI-5M	2x	65mm	2.422µm~15.25µm	0.145mm~0.898mm	0.139~0.022	7.25~44.92	0.035%	2/3"	200	C Mount	A-3139
MML2-HR65VI-5M	2x	65mm	2.422µm~15.25µm	0.145mm~0.898mm	0.139~0.022	7.25~44.92	0.035%	2/3"	190	C Mount	A-3142
MML3-HR65DVI-5M	3x	65mm	2.1µm~10.5µm	0.085mm~0.42mm	0.157~0.032	9.6~47.5	0.004%	2/3"	280	C Mount	A-3156
MML3-HR65VI-5M	3x	65mm	2.1µm~10.5µm	0.085mm~0.42mm	0.157~0.032	9.6~47.5	0.004%	2/3"	275	C Mount	A-3158
MML4-HR65DVI-5M	4x	65mm	2µm~8.2µm	0.06mm~0.24mm	0.167~0.041	12.1~48.6	-0.021%	2/3"	290	C Mount	A-3157
MML4-HR65VI-5M	4x	65mm	2µm~8.2µm	0.06mm~0.24mm	0.167~0.041	12.1~48.6	-0.021%	2/3"	285	C Mount	A-3159
MML014-HR110D-5M	0.14x	110mm	19.2µm	16.4mm	0.018	4	0.001%	2/3"	730	C Mount	A-3165
MML03-HR110D-5M	0.3x	110mm	15.7µm	6.2mm	0.021	7	0.012%	2/3"	212	C Mount	A-3135
MML03-HR110-5M	0.3x	110mm	15.7µm	6.2mm	0.021	7	0.012%	2/3"	209	C Mount	A-3136

MML03-HR65D-5M



MML03-HR65-5M



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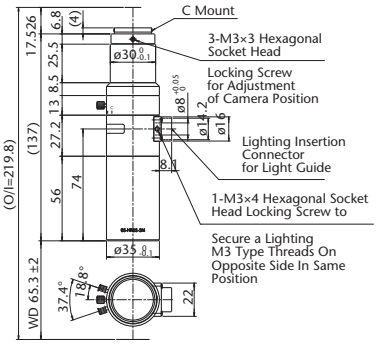
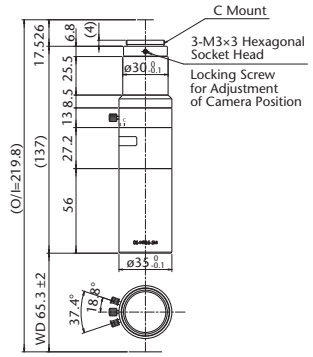
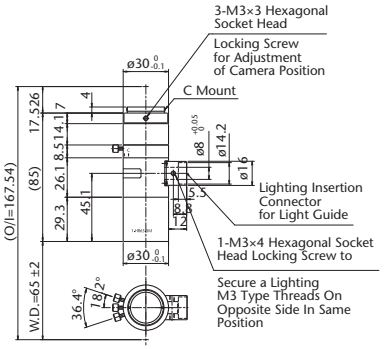


MML05-HR65VI-5M



MML1-HR65DVI-5M



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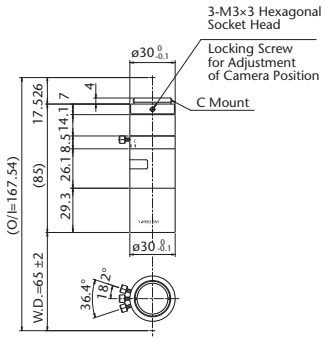

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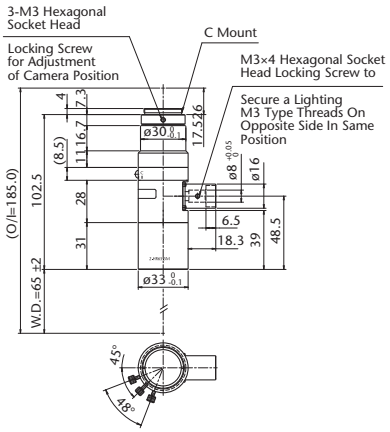

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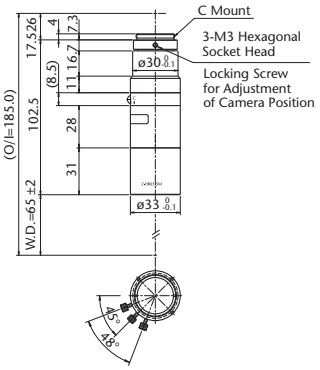

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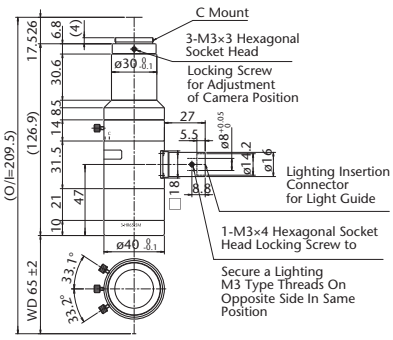

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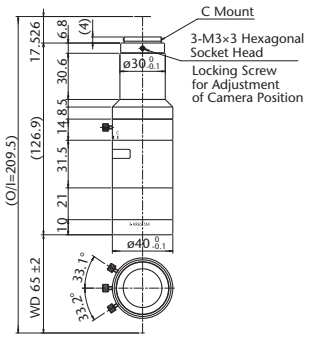

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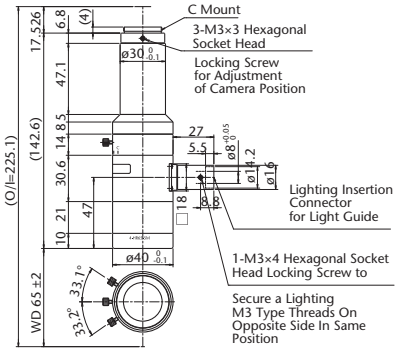

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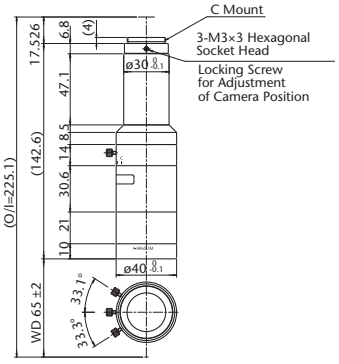

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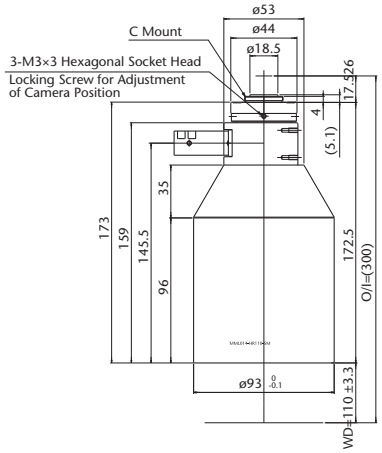

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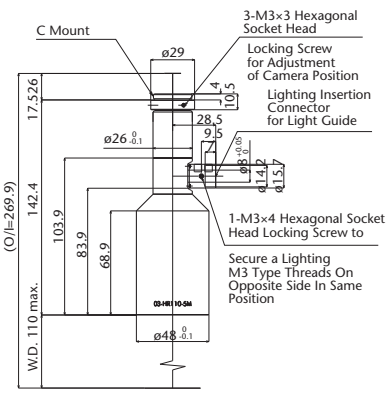

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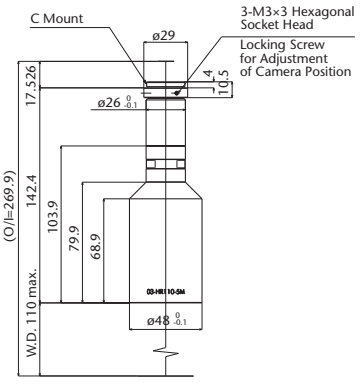


MML-High Resolution

MML-HR Series

The MML-HR Series consists of highly versatile models that support mega pixel cameras with 1.3 million pixels or more (4.65um/pixel).

The entire lineup features a high resolution and contrast design that realizes amazingly high image quality which cannot be shown by numbers alone. This series provides true imaging power in high end inspections and alignment applications.

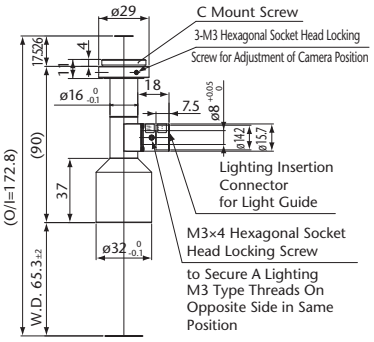
- Supports mega pixel CCDs, 1.3 million pixels or greater
- High resolution throughout the entire field of view
- High NA and contrast
- Most models compatible with 2/3" or smaller CCD elements

WD65mm

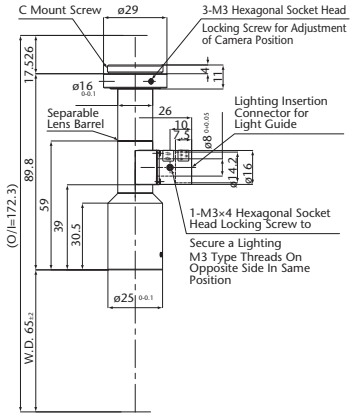
Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML05-HR65D	0.5x	65mm	12.8μm	3.04mm	0.026	9.5	-0.001% or less	2/3"	75g	C Mount	A-3029
MML08-HR65D	0.8x	65mm	8.4μm	1.2mm	0.04	9.9	0.029%	2/3"	64g	C Mount	A-3128
MML1-HR65D	1.0x	65mm	7.5μm	0.88mm	0.045	11	0.043%	2/3"	58g	C Mount	A-3031
MML1.5-HR65D	1.5x	65mm	5.4μm	0.42mm	0.063	12	-0.003%	1/2"	53g	C Mount	A-3032
MML2-HR65D	2.0x	65mm	4.5μm	0.27mm	0.074	13.5	0.013%	2/3"	52g	C Mount	A-3033
MML4-HR65D	4.0x	65mm	3μm	0.09mm	0.112	17.9	-0.060%	2/3"	94g	C Mount	A-3034
MML6-HR65D	6.0x	65mm	3μm	0.06mm	0.112	26.7	-0.110%	2/3"	102g	C Mount	A-3035
MML4-HR65DVI	4.0x	65mm	3~13.3μm	0.09~ 0.53mm	0.112	17.9~79.2	0.053%	2/3"	95g	C Mount	A-3094
MML6-HR65DVI	6.0x	65mm	3~13.9μm	0.06~ 0.58mm	0.112	26.7~124	0.005%	2/3"	102g	C Mount	A-3095

* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2 CCD camera. (Permissible circle of confusion on the image-formation side: 40μm)

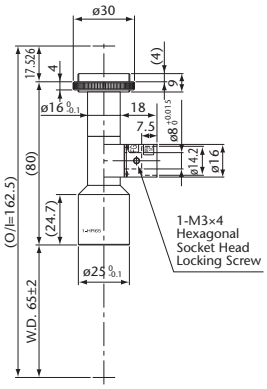
MML05-HR65D



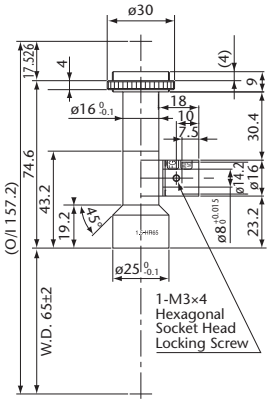
MML08-HR65D



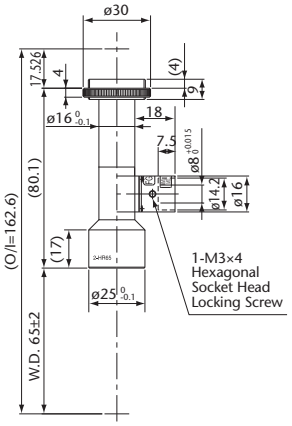
MML1-HR65D



MML1.5-HR65D



MML2-HR65D



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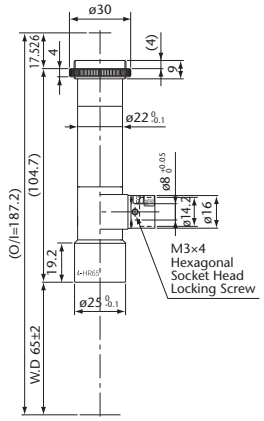

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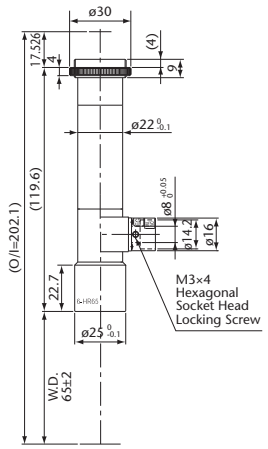

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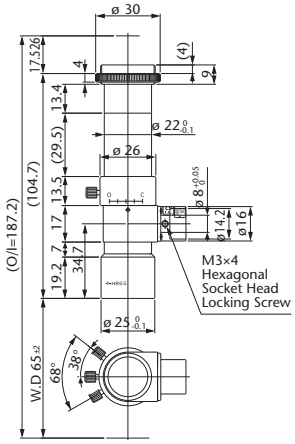

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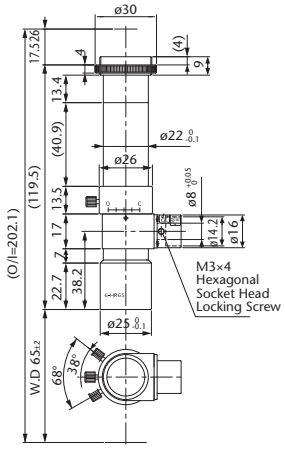
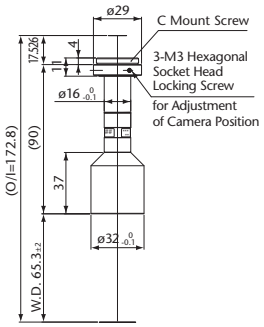
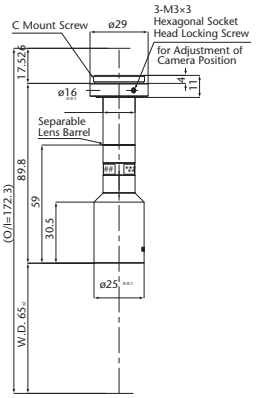


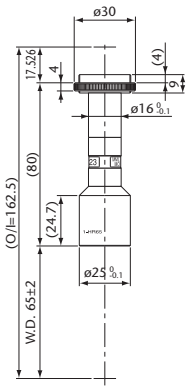
MML05-HR65



MML08-HR65



MML1-HR65



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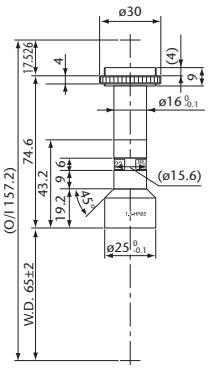

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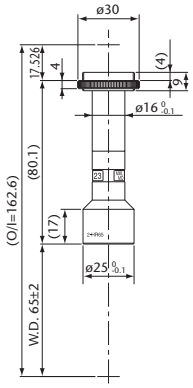

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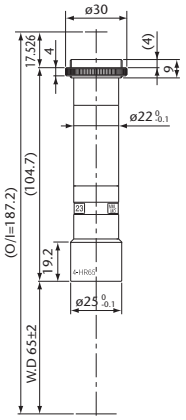

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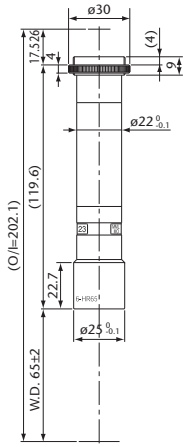


Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML05-HR65	0.5x	65mm	12.8µm	3.04mm	0.026	9.5	-0.001%	2/3"	70g	C Mount	A-3044
MML08-HR65	0.8x	65mm	8.4µm	1.2mm	0.04	9.9	0.029%	2/3"	60g	C Mount	A-3129
MML1-HR65	1.0x	65mm	7.5µm	0.88mm	0.045	11	0.043%	2/3"	50g	C Mount	A-3045
MML1.5-HR65	1.5x	65mm	5.4µm	0.42mm	0.063	12	-0.003%	1/2"	46g	C Mount	A-3046
MML2-HR65	2.0x	65mm	4.5µm	0.27mm	0.074	13.5	0.013%	2/3"	46g	C Mount	A-3047
MML4-HR65	4.0x	65mm	3µm	0.09mm	0.112	17.9	-0.060%	2/3"	86g	C Mount	A-3048
MML6-HR65	6.0x	65mm	3µm	0.06mm	0.112	26.7	-0.110%	2/3"	94g	C Mount	A-3049

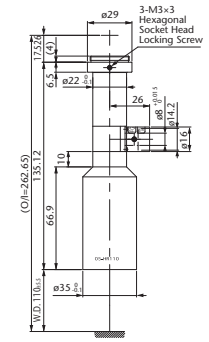
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)

MML-PL25HR

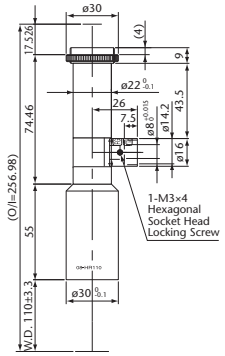
- Dedicated 90˚ prism for MML-HR. See page L-40 for details.

WD110mm

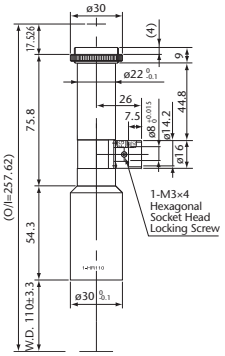
MML05-HR110D



MML08-HR110D



MML1-HR110D



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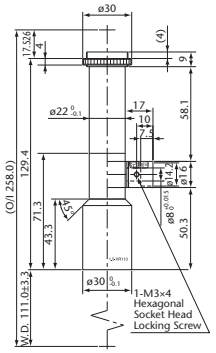

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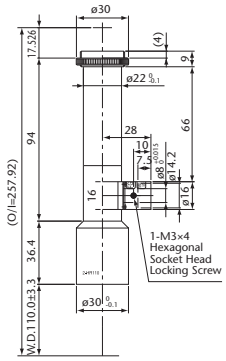
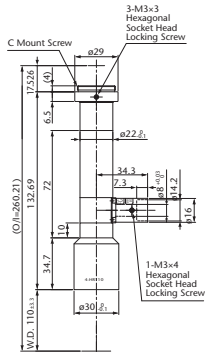


MML4-HR110D



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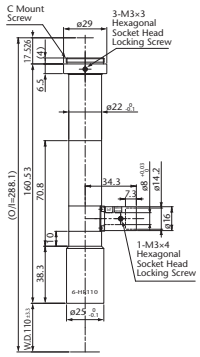
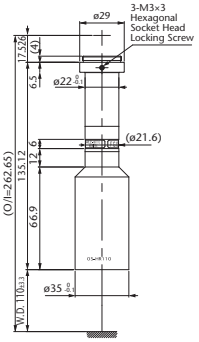
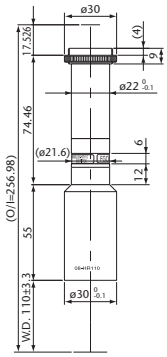


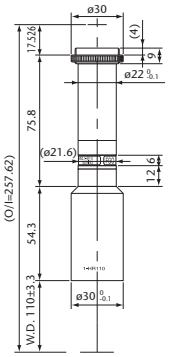
MML05-HR110



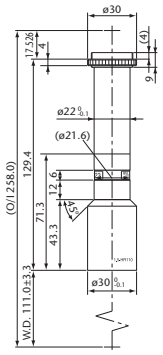
MML08-HR110



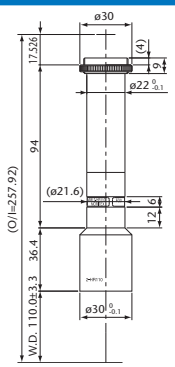
MML1-HR110



MML1.5-HR110



MML2-HR110



Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML05-HR110D	0.5x	110.0mm	12.8μm	3.0mm	0.026	9.5	-0.016%	2/3"	142g	C Mount	A-3037
MML08-HR110D	0.8x	110.0mm	9.3μm	1.4mm	0.036	11	0.005%	2/3"	112g	C Mount	A-3038
MML1-HR110D	1.0x	110.0mm	7.4μm	0.88mm	0.045	11	-0.016%	2/3"	120g	C Mount	A-3039
MML1.5-HR110D	1.5x	111.0mm	5.4μm	0.42mm	0.063	12	0.025%	2/3"	110g	C Mount	A-3040
MML2-HR110D	2.0x	110.0mm	4.5μm	0.27mm	0.074	13.5	0.028%	2/3"	110g	C Mount	A-3041
MML4-HR110D	4.0x	110.0mm	3.7μm	0.11mm	0.09	22.2	-0.025%	2/3"	125g	C Mount	A-3042
MML6-HR110D	6.0x	110.0mm	4.5μm	0.088mm	0.075	39.9	0.011%	2/3"	140g	C Mount	A-3043
MML05-HR110	0.5x	110.0mm	12.8μm	3.0mm	0.026	9.5	-0.016%	2/3"	137g	C Mount	A-3051
MML08-HR110	0.8x	110.0mm	9.3μm	1.4mm	0.036	11	0.005%	2/3"	109g	C Mount	A-3052
MML1-HR110	1.0x	110.0mm	7.4μm	0.88mm	0.045	11	-0.016%	2/3"	116g	C Mount	A-3053
MML1.5-HR110	1.5x	111.0mm	5.4μm	0.42mm	0.063	12	0.025%	2/3"	98g	C Mount	A-3054
MML2-HR110	2.0x	110.0mm	4.5μm	0.27mm	0.074	13.5	0.028%	2/3"	100g	C Mount	A-3055

* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40μm)

MML-Standard

MML-ST Series

Through combination with 410 thousand pixel or greater cameras, the renewed design of the MML-ST Series realizes high level optical performance. These compact models with a diameter of 16mm feature a long depth of field making them ideal for installation in manufacturing equipment.

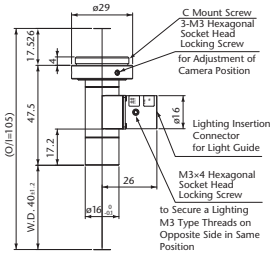
- Compact design with a lens barrel diameter of ø16~
- Long Depth of Field
- Number of pixels: 410 thousand or higher
- CCD Element Size: 1/2" or less in most cases

WD40mm

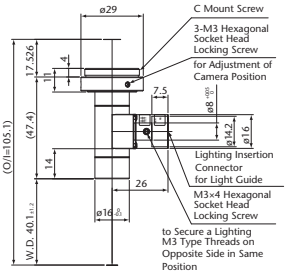
Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML1-ST40D	1.0x	40.0mm	7.2µm	0.88mm	0.046	11.0	0.076 or less	1/2"	31g	C Mount	A-3086
MML1.5-ST40D	1.5x	40.1mm	5.6µm	0.44mm	0.060	12.5	-0.039 or less	1/2"	31g	C Mount	A-3088
MML2-ST40D	2.0x	40.1mm	4.8µm	0.29mm	0.070	14.3	0.003 or less	1/2"	34g	C Mount	A-3090
MML3-ST40D	3.0x	37.9mm	4.8µm	0.19mm	0.070	21.3	0.064 or less	1/2"	33g	C Mount	A-3092
MML4-ST40D	4.0x	40.9mm	4.8µm	0.14mm	0.070	28.5	-0.038 or less	1/2"	36g	C Mount	A-3077
MML6-ST40D	6.0x	40.3mm	4.8µm	0.10mm	0.070	42.8	0.035 or less	1/2"	39g	C Mount	A-3079
MML8-ST40D	8.0x	40.0mm	4.8µm	0.07mm	0.070	57.0	0.032 or less	1/2"	42g	C Mount	A-3081
MML1-ST40	1.0x	40.0mm	7.2µm	0.88mm	0.046	11.0	0.076 or less	1/2"	26g	C Mount	A-3087
MML1.5-ST40	1.5x	40.1mm	5.6µm	0.44mm	0.060	12.5	-0.039 or less	1/2"	26g	C Mount	A-3089
MML2-ST40	2.0x	40.1mm	4.8µm	0.29mm	0.070	14.3	0.003 or less	1/2"	29g	C Mount	A-3091
MML3-ST40	3.0x	37.9mm	4.8µm	0.19mm	0.070	21.3	0.064 or less	1/2"	28g	C Mount	A-3093
MML4-ST40	4.0x	40.9mm	4.8µm	0.14mm	0.070	28.5	-0.038 or less	1/2"	31g	C Mount	A-3078
MML6-ST40	6.0x	40.3mm	4.8µm	0.10mm	0.070	42.8	0.035 or less	1/2"	35g	C Mount	A-3080
MML8-ST40	8.0x	40.0mm	4.8µm	0.07mm	0.070	57.0	0.032 or less	1/2"	37g	C Mount	A-3082

*Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
*Resolution values indicate the theoretical resolution at a wavelength of 550nm.
Caution: The WD 40mm series cannot be used with all prism adapter options.

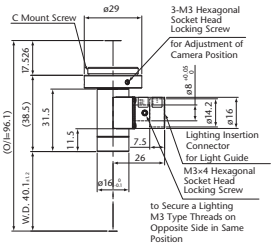
MML1-ST40D



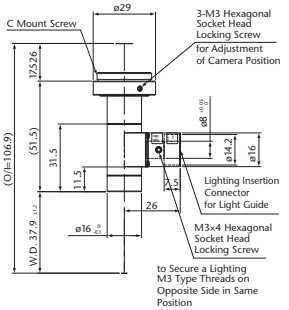
MML1.5-ST40D



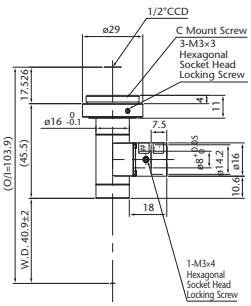
MML2-ST40D



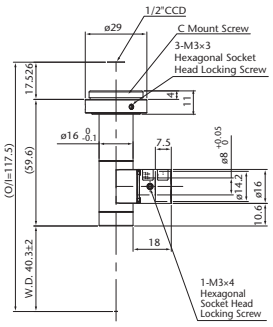
MML3-ST40D



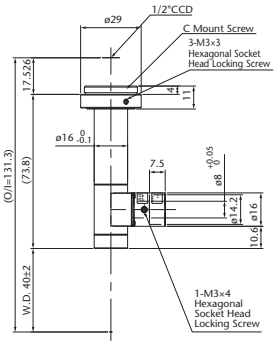
MML4-ST40D



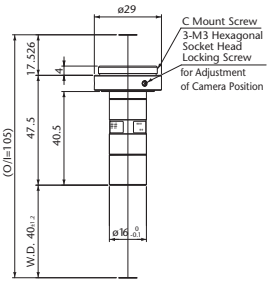
MML6-ST40D



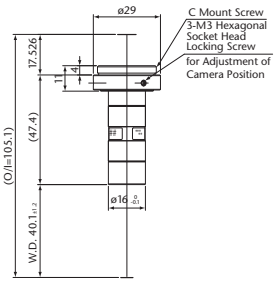
MML8-ST40D



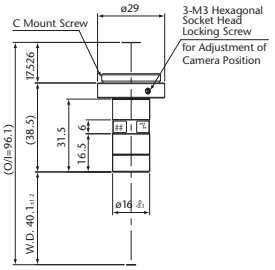
MML1-ST40



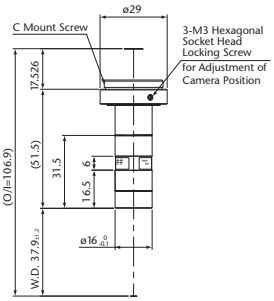
MML1.5-ST40



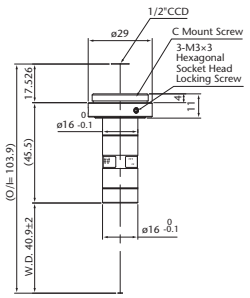
MML2-ST40



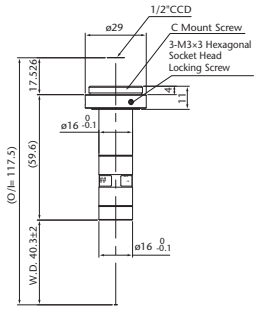
MML3-ST40



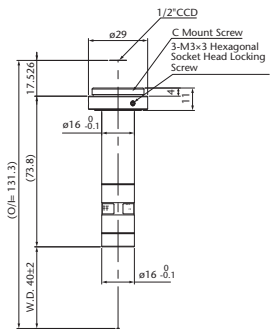
MML4-ST40



MML6-ST40

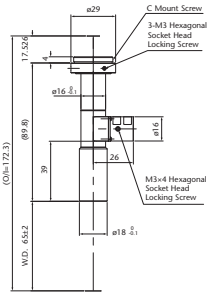


MML8-ST40

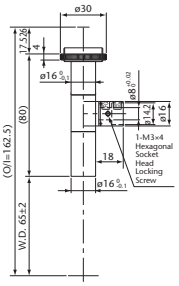


WD65mm

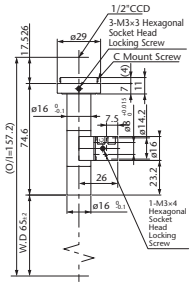
MML08-ST65D



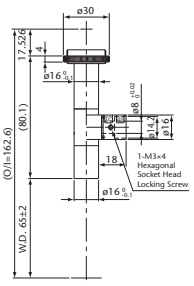
MML1-ST65D



MML1.5-ST65D



MML2-ST65D



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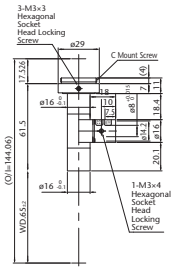
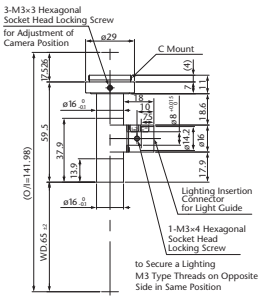


MML3-ST65DS



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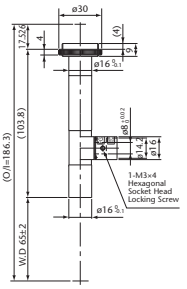
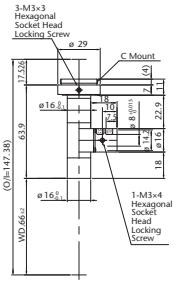
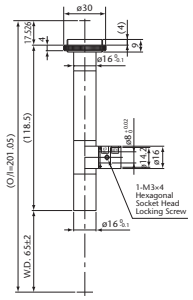


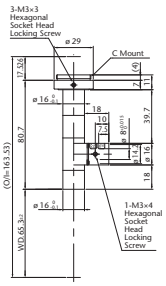
MML4-ST65DS



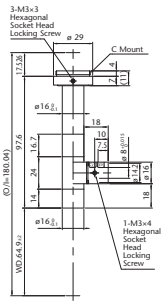
MML6-ST65D



MML6-ST65DS



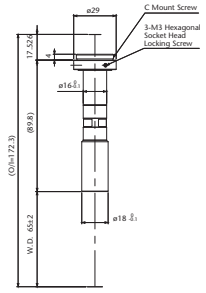
MML8-ST65DS



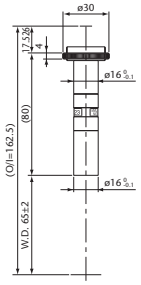
Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML08-ST65D	x0.8	65mm	12.4µm	1.86mm	0.027	14.9	0.0003%	1/2"	49g	C Mount	A-3011
MML1-ST65D	x1	65mm	12.5µm	1.49mm	0.027	18.6	-0.047%	1/2"	44g	C Mount	A-3012
MML1.5-ST65D	x1.5	65mm	7µm	0.56mm	0.048	15.5	0.035%	1/2"	43g	C Mount	A-3062
MML2-ST65D	x2	65mm	5.8µm	0.35mm	0.057	17.3	-0.037%	1/2"	44g	C Mount	A-3013
MML2-ST65DS	x2	65mm	5.6µm	0.35mm	0.06	17.3	0.004%	1/2"	37g	C Mount	A-3101
MML3-ST65DS	x3	65mm	4.7µm	0.19mm	0.069	21.9	-0.034%	1/2"	35g	C Mount	A-3102
MML4-ST65D	x4	65mm	4.6µm	0.135mm	0.073	27	0.003%	1/2"	55g	C Mount	A-3014
MML4-ST65DS	x4	66mm	4.4µm	0.13mm	0.076	25.9	0.006%	1/2"	41g	C Mount	A-3103
MML6-ST65D	x6	65mm	4.6µm	0.091mm	0.073	40.9	-0.109%	1/2"	60g	C Mount	A-3015
MML6-ST65DS	x6	65.3mm	4.4µm	0.09mm	0.076	39.3	0.003%	1/2"	43g	C Mount	A-3104
MML8-ST65DS	x8	64.9mm	4.4µm	0.07mm	0.076	50	0.012%	1/2"	46g	C Mount	A-3081

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

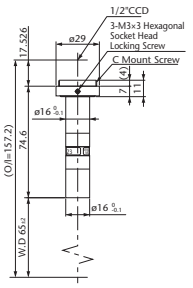
MML08-ST65



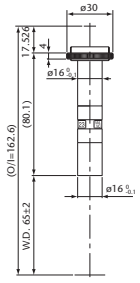
MML1-ST65



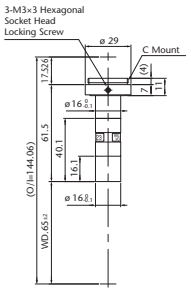
MML1.5-ST65



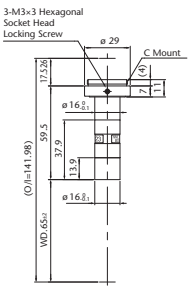
MML2-ST65



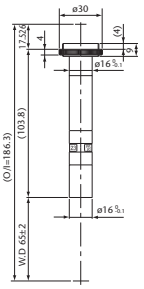
MML2-ST65S



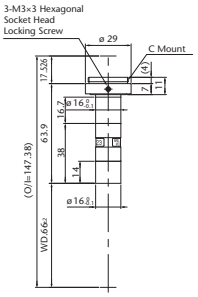
MML3-ST65S



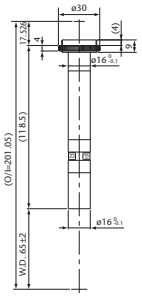
MML4-ST65



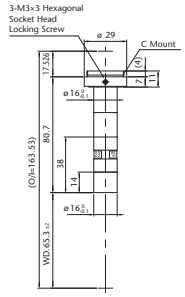
MML4-ST65S



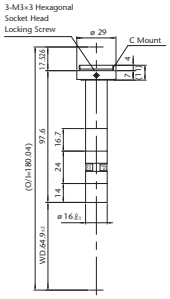
MML6-ST65



MML6-ST65S



MML8-ST65S



Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML08-ST65	x0.8	65mm	12.4µm	1.86mm	0.027	14.9	0.0003%	1/2"	44g	C Mount	A-3085
MML1-ST65	x1	65mm	12.5µm	1.49mm	0.027	18.6	-0.147%	1/2"	38g	C Mount	A-3025
MML1.5-ST65	x1.5	65mm	7µm	0.56mm	0.048	15.5	0.035%	1/2"	36g	C Mount	A-3063
MML2-ST65	x2	65mm	5.8µm	0.35mm	0.057	17.3	-0.037%	1/2"	38g	C Mount	A-3026
MML2-ST65S	x2	65mm	5.6µm	0.35mm	0.06	17.3	0.004%	1/2"	32g	C Mount	A-3105
MML3-ST65S	x3	65mm	4.7µm	0.19mm	0.069	21.9	-0.034%	1/2"	30g	C Mount	A-3106
MML4-ST65	x4	65mm	4.6µm	0.135mm	0.073	27	0.003%	1/2"	50g	C Mount	A-3056
MML4-ST65S	x4	66mm	4.4µm	0.13mm	0.076	25.9	0.006%	1/2"	36g	C Mount	A-3107
MML6-ST65	x6	65mm	4.6µm	0.091mm	0.073	40.9	-0.109%	1/2"	55g	C Mount	A-3057
MML6-ST65S	x6	65.3mm	4.4µm	0.09mm	0.076	39.3	0.003%	1/2"	38g	C Mount	A-3108
MML8-ST65S	x8	64.9mm	4.4µm	0.07mm	0.076	50	0.012%	1/2"	42g	C Mount	A-3081

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

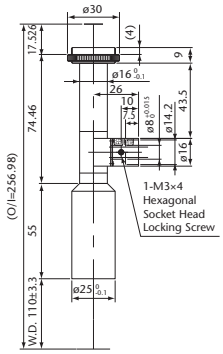
Optical Specifications for Recommended Combinations of MML Models and Rear Converter Lenses

Model	Converter Lenses	Magnification	Resolution	Depth of Field	Effective F No
MML1-ST65D/65	**SOD-1.5X**	1.5 X	12.5µm	0.99mm	27.9
	SOD-2X	2.0 X	12.5µm	0.74mm	37.2
MML1.5-ST65D/65	**SOD-1.5X**	2.25X	7µm	0.37mm	23.4
	SOD-2X	3X	7µm	0.28mm	31.3
MML2-ST65D/65	**SOD-1.5X**	3 X	5.8µm	0.23mm	26
	SOD-2X	4 X	5.8µm	0.17mm	34.6

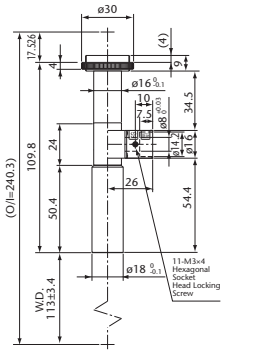
Caution: If combinations other than those recommended are used, dirt and scratches on the rear converter may be noticeable in the resulting images. For this reason, we do not recommend the use in any other setup for optimal performance.

WD110mm

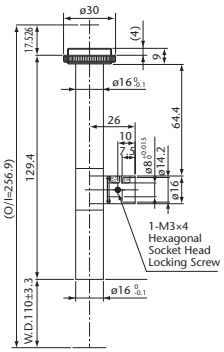
MML08-ST110D



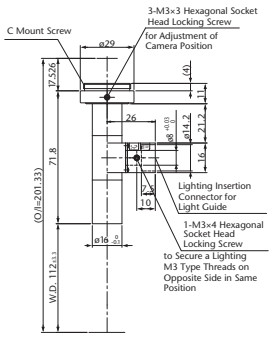
MML1-ST110D



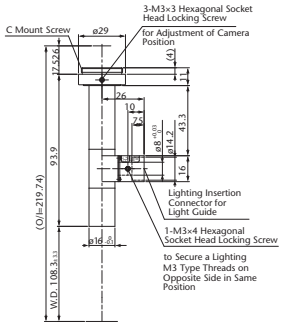
MML2-ST110D



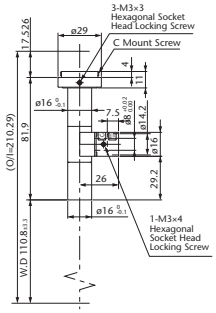
MML2-ST110DS



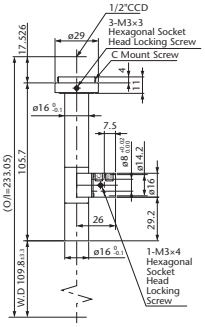
MML3-ST110DS



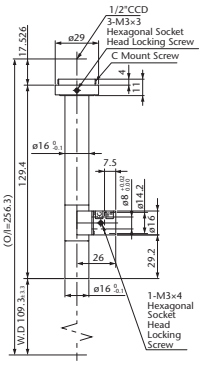
MML4-ST110D



MML6-ST110D

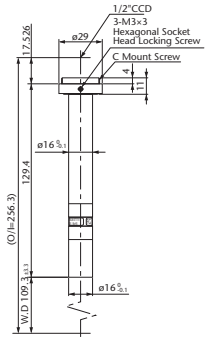


MML8-ST110D

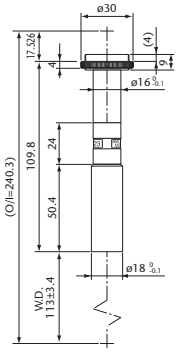


Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML08-ST110D	0.8x	110.0mm	13.5μm	2.00mm	0.024	16.1	0.016%	1/2"	85g	C Mount	A-3002
MML1-ST110D	1x	113.0mm	14μm	1.68mm	0.024	20.9	0.005%	1/2"	58g	C Mount	A-3003
MML2-ST110D	2x	110.0mm	11μm	0.66mm	0.03	33.2	0.031%	1/2"	55g	C Mount	A-3004
MML2-ST110DS	2x	112.0mm	11.2μm	0.66mm	0.03	33.2	0.008%	2/3"	39g	C Mount	A-3109
MML3-ST110DS	3x	108.3mm	11.2μm	0.44mm	0.03	49.7	0.008%	2/3"	43g	C Mount	A-3110
MML4-ST110D	4x	110.8mm	7μm	0.164mm	0.045	44.4	-0.006%	1/2"	43g	C Mount	A-3005
MML6-ST110D	6x	109.8mm	7μm	0.164mm	0.045	66.4	-0.008%	1/2"	48g	C Mount	A-3006
MML8-ST110D	8x	109.3mm	7μm	0.17mm	0.045	88.4	-0.007%	1/2"	54g	C Mount	A-3007

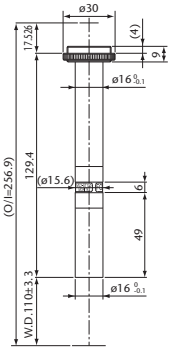
MML08-ST110



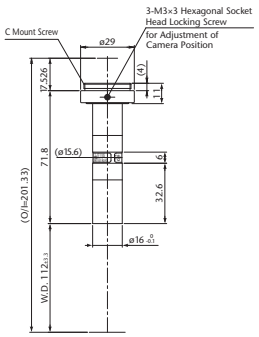
MML1-ST110



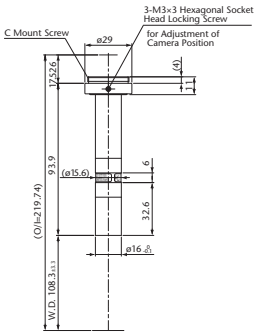
MML2-ST110



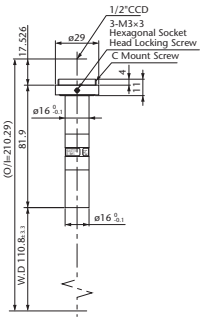
MML2-ST110S



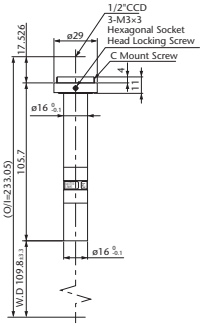
MML3-ST110S



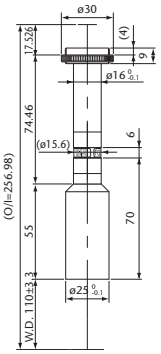
MML4-ST110



MML6-ST110



MML8-ST110



Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML08-ST110	0.8x	110.0mm	13.5µm	2.00mm	0.024	16.1	0.016%	1/2"	78.5g	C Mount	A-3019
MML1-ST110	1x	113.0mm	14µm	1.68mm	0.024	20.9	0.005%	1/2"	50g	C Mount	A-3020
MML2-ST110	2x	110.0mm	11µm	0.66mm	0.03	33.2	0.031%	1/2"	50g	C Mount	A-3021
MML2-ST110S	2x	112.0mm	11.2µm	0.66mm	0.03	33.2	0.008%	2/3"	34g	C Mount	A-3111
MML3-ST110S	3x	108.3mm	11.2µm	0.44mm	0.03	49.7	0.008%	2/3"	37g	C Mount	A-3112
MML4-ST110	4x	110.8mm	7µm	0.164mm	0.045	44.4	-0.006%	1/2"	38g	C Mount	A-3064
MML6-ST110	6x	109.8mm	7µm	0.164mm	0.045	66.4	-0.008%	1/2"	43g	C Mount	A-3065
MML8-ST110	8x	109.3mm	7µm	0.17mm	0.045	88.4	-0.007%	1/2"	49g	C Mount	A-3066

Optical Specifications for Machine Types Recommended for Combination with the Rear Converter

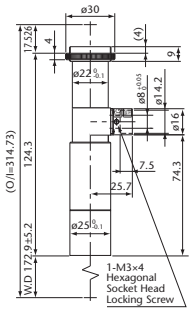
Model	Converter Lenses	Magnification	Resolution	Depth of Field	Effective F No
MML08-ST110D/110	**SOD-1.5X**	1.2 x	13.5µm	1.34mm	24.2
	SOD-2X	1.6 x	13.5µm	1.00mm	32.2
MML1-ST110D/110	**SOD-1.5X**	1.5 x	14µm	1.11mm	31.4
	SOD-2X	2.0 x	14µm	0.84mm	41.8
MML2-ST110D/110	**SOD-1.5X**	3 x	11µm	0.44mm	49.8

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

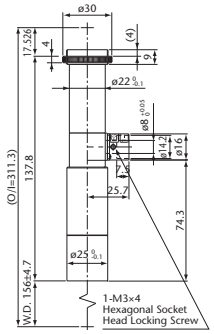
Caution: If combinations other than those recommended are used, dirt and scratches on the rear converter may be noticeable in the resulting images. For this reason, we do not recommend the use in any other setup for optimal performance.

WD150mm

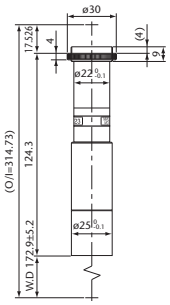
MML08-ST170D



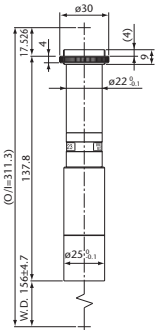
MML1-ST150D



MML08-ST170



MML1-ST150



Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML08-ST170D	0.8x	172.9	12µm	1.79mm	0.028	14	0.005%	1/2"	80g	C Mount	A-3008
MML1-ST150D	1x	156.0	8.8µm	1.05mm	0.038	13	0.153%	1/2"	90g	C Mount	A-3009
MML08-ST170	0.8x	172.9	12µm	1.79mm	0.028	14	0.005%	1/2"	76g	C Mount	A-3022
MML1-ST150	1x	156.0	8.8µm	1.05mm	0.038	13	0.153%	1/2"	84g	C Mount	A-3023

* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)

Optical Specifications for Machine Types Recommended for Combination with Rear Converter

Model	Converter Lenses	Magnification	Resolution	Depth of Field	Effective F No
MML08-ST170D/170	**SOD-1.5X**	1.2x	12µm	1.17mm	21
	SOD-2X	1.6x	12µm	0.88mm	28
MML1-ST150D/150	**SOD-1.5X**	1.5x	8.8µm	0.69mm	19.5
	SOD-2X	2.0x	8.8µm	0.52mm	26

Caution: If combinations other than those recommended are used, dirt and scratches on the rear converter may be noticeable in the resulting images. For this reason, we do not recommend the use in any other setup for optimal performance.

WD300mm

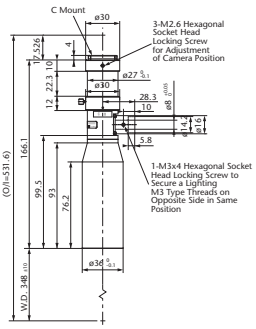
Lenses with a very long working distance of 300mm for are available with optical magnifications of 0.5X, 1X, 3X, & 4X for long stand-off applications. Improved flexibility and ease-of-use is achieved with variable iris control.

- Magnifications: 0.5x, 1x, 3x, & 4x
- WD=300 mm
- With variable iris of 22.7-C32
- Slim body with external diameter of ø27.

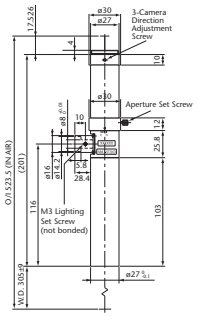
NEW **MML05-ST300DVI**

NEW

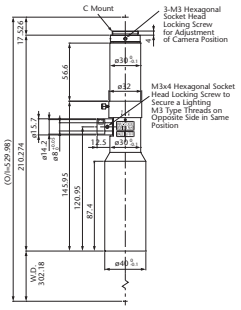
MML05-ST300DVI



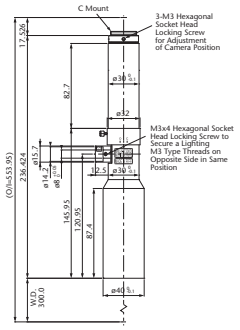
MML1-ST300D



MML3-ST300DVI



MML4-ST300DVI



Model	Magnification	WD	Resolution	Depth Of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML05-ST300DVI	0.5x	344.5mm	15.3μm~24.0μm	3.6mm ~ 5.7mm	0.022 ~ 0.014	11.4~17.9	0.06%	1/2"	200g	C Mount	A-3179
MML1-ST300D	1x	305mm	16.6μm~21.5μm	1.98mm ~ 2.56mm	0.020 ~ 0.016	24.72~32	-0.019%	1/2"	150g	C Mount	A-3061
MML3-ST300DVI	3x	302mm	7.5 μm~15 μm	0.3mm ~ 0.65mm	0.045 ~ 0.023	33~66	0.015%	1/2"	310g	C Mount	A-3166
MML4-ST300DVI	4x	300mm	7.5 μm~15 μm	0.3mm ~ 0.65mm	0.045 ~ 0.023	44~88	0.01%	1/2"	320g	C Mount	A-3167

* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40μm)

Optical Specifications for Recommended Combinations of MML Models & Rear Converters

Model	Converter Lenses	Magnification	Resolution	Depth of Field	Effective F No
MML1-ST300D	**SOD-1.5X**	1.5x	15μm	1.21mm	341
	SOD-2X	2.0x	15μm	0.91mm	45.4

Caution: If combinations other than those recommended are used, dirt and scratches on the rear converter may be noticeable in the resulting images. For this reason, we do not recommend the use in any other setup for optimal performance.

For Micro-head Cameras (ø17mm) Made-to-order
MML-ST-CM Series

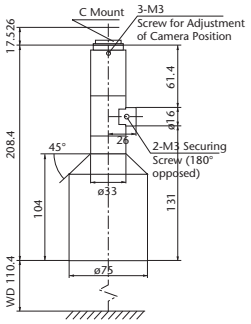
The MML-ST-CM Series consists of small diameter, lightweight models which save space and achieve a fine pitch when used with micro-head cameras with smaller mounts.

MML

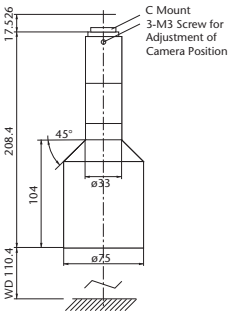
MML Series

WD110mm

MML018-110D



MML018-110

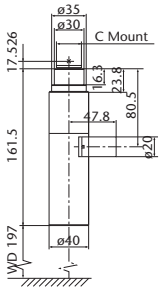


Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML018-110D	0.18x	110.4mm	24µm	15.73mm	0.014	6.4	0.024% or less	2/3"	700g	C Mount	A-0041
MML018-110	0.18x	110.4mm	24µm	15.73mm	0.014	6.4	0.024% or less	2/3"	700g	C Mount	A-0040

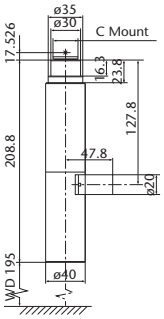
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

WD195mm

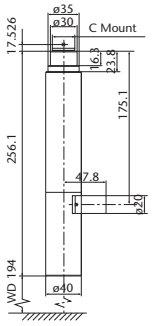
MML4-195D



MML6-195D



MML8-195D

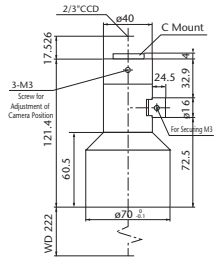


Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML4-195D	4x	197mm	3.97µm	0.12mm	0.084	23.976	0.062 or less	2/3"	480g	C Mount	A-0061
MML6-195D	6x	195mm	3.94µm	0.08mm	0.085	35.736	-0.016 or less	2/3"	490g	C Mount	A-0062
MML8-195D	8x	194mm	3.92µm	0.06mm	0.086	47.431	-0.021 or less	2/3"	500g	C Mount	A-0063

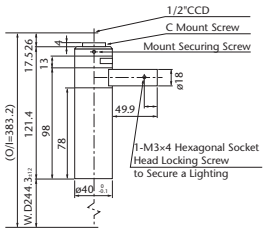
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)

WD200mm~

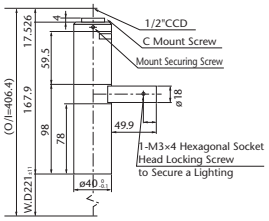
MML02-220D



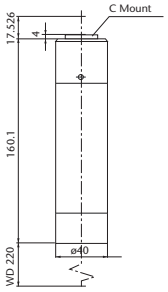
MML1-244D



MML2-221D



MML2-220



Model	Magnification	WD	Resolution	Depth of Field	NA	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount	Product Code
MML02-220D	0.2x	222	16.7µm	10mm	0.02	5	0.067 or less	2/3"	450g	C Mount	A-0073
MML1-244D	1x	244.3	7.4µm	0.88mm	0.045	11	0.067 or less	2/3"	260g	C Mount	A-0075
MML2-221D	2x	221	7.4µm	0.44mm	0.045	21.9	0.143 or less	2/3"	320g	C Mount	A-0076
MML2-220	2x	220	6.09µm	0.358mm	0.055	18	-0.078 or less	2/3"	400g	C Mount	A-0074

* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)

For Near-Infrared (770nm~1200nm)Applications

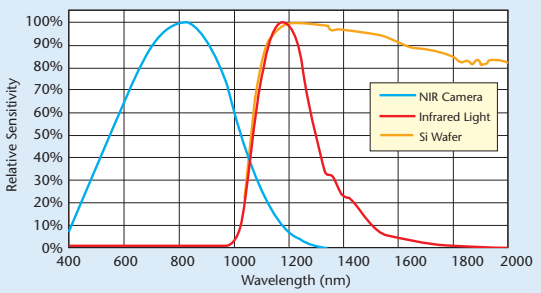
MML-NIR Series

The MML-NIR Series is designed for a wavelength band of 770 to 1200nm.
This series provides special use MML lenses that allow the observation of in-wafer defects and rear patterns when combined with an infrared camera and illumination.

Model	MML4-80D-IR	MML6-80D-IR	MML8-80D-IR
Magnification	4x	6x	8x
WD	82.4mm	81.5mm	81mm
Resolution		4.0µm	
Depth of Field	50µm	33µm	27µm
NA		0.15	
Effective F No	13.3	20.1	26.9
Optical Distortion	0.024%	0.022%	0.062%
Largest Compatible CCD		2/3"	
Weight	90g	100g	110g
Mount		C Mount	
Product Code	A-0235	A-0236	A-0237

* Depth of field is calculated assuming a horizontal 435TV resolution using a 2/3" CCD camera. (Permissible circle of confusion on the image-formation side: 30µ)
* Resolution values indicate the theoretical resolution at a wavelength of 985nm.

Spectral Characteristics



High-Performance Low Magnification Zoom Lens

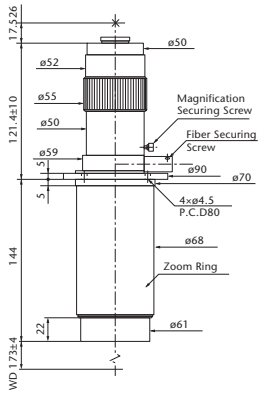
ML-Z0220D

Manual Type

With the largest zoom ratio of any standard telecentric zoom lens, this manual zoom type model covers a wide range of FOVs (Field of Views). It also offers integrated coaxial lighting & filters.

- Magnification range: 0.2x~2x (zoom ratio of 10:1)
- WD=173mm
- Includes a uniform coaxial illumination function that covers the entire view.
- Dedicated, integrated coaxial light guide (super random type), L = 800mm, & color filters are attached (red & green).

ML-Z0220D



Model	Magnification Range	WD	Motor Option	Magnification	Effective F No	Depth of Field	Resolution	Optical Distortion	NA	Largest Compatible CCD	Weight	Mount	Product Code
ML-Z0220D	0.2x~2x (Zoom Ratio of 10:1)	173mm ±4	None Available (Manual Zoom)	at 0.2x	3.6	7mm	12µm	0.03% or less	0.03	1/2"	1100g	C Mount	A-0110
				at 1x	11.5	0.9mm	7.8µm	0.15% or less	0.04				
				at 2x	20	0.4mm	7µm	0.13% or less	0.05				

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

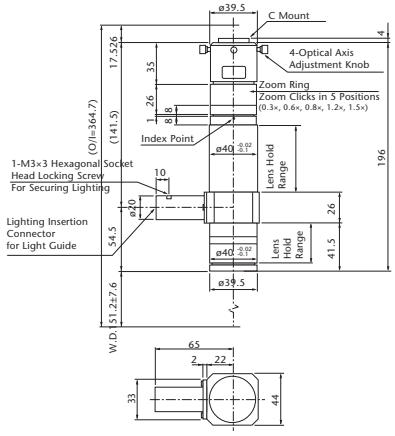
Manual Click Zoom Lens

ML-Z0315D

By employing a manual click (detent) feature in the zoom system, a ±0.5% magnification reproducibility is realized. Magnification can be adjusted between five different levels.

- Magnification range: 0.3x~1.5x (in 5 clicks)
- WD=151.2mm
- Includes a uniform coaxial illumination system that covers the entire view

ML-Z0315D



Model	Magnification Range	WD	With/Without Motor	Magnification	Effective F No	Depth of Field	Resolution	Optical Distortion	NA	Largest Compatible CCD	Weight	Mount	Product Code
ML-Z0315D	0.3x~1.5x (Zoom Ratio of 5:1)	151.2mm ±7.6	Without (Manual Click Zoom)	at 0.3x	9.3	8.2mm	20.8µm	-0.09%	0.02	1/2"	520g	C Mount	A-0112
				at 0.6x	11.1	2.4mm	12.4µm	-0.05%	0.03				
				at 0.8x	12.4	1.5mm	10.4µm	-0.02%	0.03				
				at 1.2x	14.7	0.8mm	8.2µm	0.03%	0.04				
				at 1.5x	16.5	0.6mm	7.4µm	0.06%	0.05				

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

High Resolution Zoom Lens

ML-Z07545HR Series

To exploit the full potential of high pixel count cameras, this unique high NA, high resolution telecentric zoom lens series has a long working distance and wide zoom ratio as well as adjustable iris & focus. Available with an integrated coaxial illumination system as well as other options, this lens series is versatile and ideal for extremely accurate gauging and inspection applications at various field of views (FOVs).

- Zoom Ratio 6:1 0.75x – 4.5x
- Effective F No 8.4 – Variable Aperture
- Focus Range +/- 3mm
- NA 0.12 (4.5x)
- Working Distance = 70.9 mm

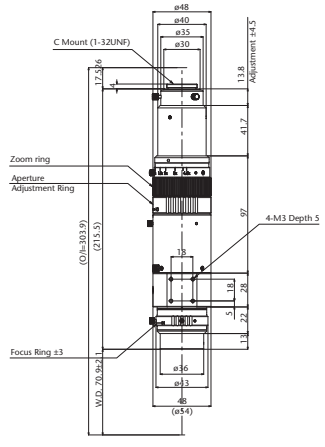
Lineup : 3 Models

ML-Z07545HR

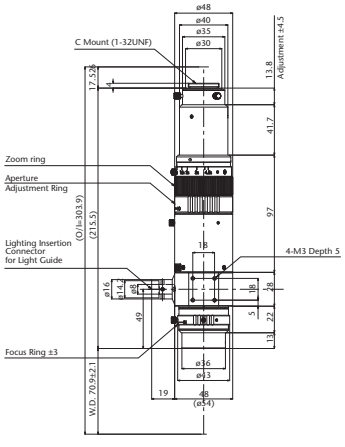
Coaxial Illumination Model D

90°, Side View Model-L

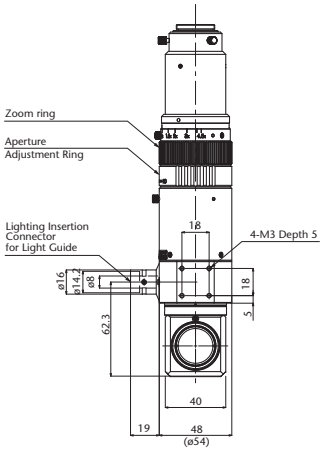
ML-Z07545HR



ML-Z07545HRD



ML-Z07545HRD-L



Model	Magnification Range	WD	Focus Position	Magnification	Effective F No	Depth of Field	Resolution	Optical Distortion	NA	Weight	Largest Compatible CCD	Mount	Product Code
ML-Z07545HR	0.75x ~ 4.5x	70.9mm ±2.1	±3mm	at 0.75x	8.4	1.2mm	7.5µm	-0.02%	0.04	Approx. 650g	1/2"	C Mount	A-3143
ML-Z07545HRD				at 2x	12	0.2mm	4.0µm	0.01%	0.08				A-3144
ML-Z07545HRD-L			—	at 4.5x	19	0.07mm	2.8µm	0.02%	0.12				A-3145

* Effective F No indicates designed value when iris is open
* Calculated based on permissible circle of confusion on the image-formation side:40µm

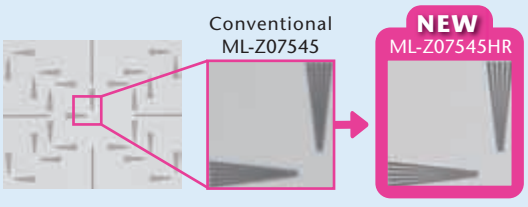
Converter Lens (Optional)

Attach to the end of the lens to change magnification and WD.

Model	Focus Position	Magnification Range		WD	Product Code
		Low	High		
None	Near	0.75x ~ 4.53x		74mm	—
	Middle	0.75x ~ 4.53x		77mm	
	Far	0.75x ~ 4.53x		80mm	
ML-Z025HR	Near	0.21x ~ 1.30x		201.5mm	A-3146
	Middle	0.19x ~ 1.14x		243mm	
	Far	0.16x ~ 0.97x		299mm	
ML-Z03HR	Near	0.25x ~ 1.52x		170mm	A-3147
	Middle	0.23x ~ 1.36x		200mm	
	Far	0.20x ~ 1.21x		237mm	
ML-Z05HR	Near	0.39x ~ 2.38x		107mm	A-3148
	Middle	0.38x ~ 2.27x		118mm	
	Far	0.36x ~ 2.16x		131mm	
ML-Z075HR	Near	0.57x ~ 3.46x		76.4mm	A-3149
	Middle	0.56x ~ 3.40x		81.7mm	
	Far	0.55x ~ 3.35x		87.1mm	
ML-Z135HR	Near	1.00x ~ 6.05x		37mm	A-3150
	Middle	1.01x ~ 6.12x		38.6mm	
	Far	1.02x ~ 6.17x		40mm	
ML-Z20HR	Near	1.45x ~ 8.80x		17mm	A-3151
	Middle	1.49x ~ 9.02x		18mm	
	Far	1.53x ~ 9.25x		18.8mm	

* Indicated values are based on caluculation and not guarranteed values.
* When you used ML-Z025HR,ML-Z03HR,ML-Z05HR,ML-Z075HR,coaxial illumination does not cover entire view.

HR Series Improves Resolution



Standard Zoom Lens

ML-Z07545 Series

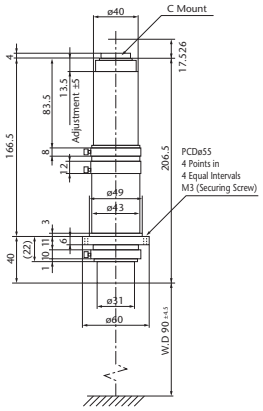
* Motorized zoom solution available.

Standard model zoom lens with outstanding functionality. Adjustment of magnification and working distance is possible through combination with optional optics.

- Magnification range : 0.75x~4.5x (zoom ratio of 6:1)
- WD=90mm
- Includes a uniform coaxial illumination function that covers the entire view.
- Equipped with built-in focus adjustment function (WD can be adjusted to -6 mm)

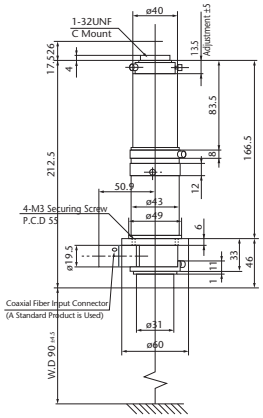
Manual Zoom

ML-Z07545



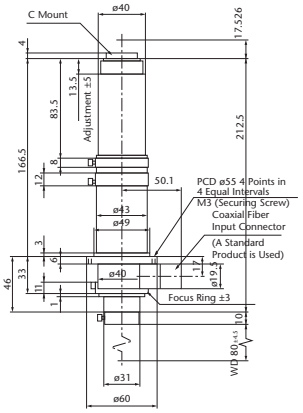
Zoom with Coaxial Illumination

ML-Z07545D



Zoom with Coaxial Illumination & Deflection Function

ML-Z07545D-PL



All models equipped with focus, aperture, and zoom.

Model	Magnification Range	WD (mm)	Focus Position	Motor Option	Magnification	Effective F No	Depth of Field	Resolution	Optical Distortion	NA	Operation Function	Weight	Largest Compatible CCD	Mount	Product Code
ML-Z07545	0.75x~4.5x (Zoom Ratio of 6:1)	90±4.5	0~ -6mm	None Available (Manual Zoom)	0.75x time	11	1.6mm	9.9µm	0.02% or less	0.03	All models equipped with focus, aperture, and zoom.	Approx. 440g	1/2"	C Mount	A-0118
ML-Z07545D					2x time	16	0.3mm	5.4µm	0.01% or less	0.06		Approx. 470g			A-0119
ML-Z07545D-PL		80±4.5			4.5x time	28	0.1mm	4.2µm	-0.02% or less	0.08		Approx. 490g			A-0120

* Depth of field is calculated assuming a horizontal 240 TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.
* Effective F No indicates a value when the iris is open.

Standard Zoom Lens

Options

Front Converter Lens

ML-Z Series

Attach to end of lens to change magnification and working distance.

Model	Product Code
ML-Z03	A-8025
ML-Z04	A-8026
ML-Z05	A-8027
ML-Z07	A-8028
ML-Z14	A-8029
ML-Z20	A-8030

Model	Focus Position	ML-Z07545 Magnification Range MIN	ML-Z07545 Magnification Range MAX	ML-Z07545 WD	ML-Z07545 Matching Chart	ML-Z07545D Magnification Range MIN	ML-Z07545D Magnification Range MAX	ML-Z07545D WD	ML-Z07545D Matching Chart
ML-Z03	Near	0.24x	1.43x	255mm	○	0.23x	1.4x	263mm	▲ Coaxial Illumination Cannot Cover the Entire View
	Middle	0.23x	1.36x	283mm		0.22x	1.33x	292mm	
	Far	0.21x	1.28x	315mm		0.21x	1.25x	325mm	
ML-Z04	Near	0.31x	1.87x	195mm	○	0.31x	1.84x	200mm	▲ Coaxial Illumination Cannot Cover the Entire View
	Middle	0.3x	1.81x	211mm		0.3x	1.81x	216mm	
	Far	0.29x	1.72x	229mm		0.29x	1.72x	234mm	
ML-Z05	Near	0.38x	2.27x	160mm	○	0.37x	2.25x	163mm	▲ Coaxial Illumination Cannot Cover the Entire View
	Middle	0.37x	2.24x	170mm		0.37x	2.21x	174mm	
	Far	0.36x	2.2x	181mm		0.36x	2.17x	185mm	
ML-Z07	Near	0.52x	3.17x	114mm	○	0.52x	3.16x	115mm	▲ Coaxial Illumination Cannot Cover the Entire View
	Middle	0.53x	3.16x	119mm		0.52x	3.16x	121mm	
	Far	0.53x	3.17x	125mm		0.52x	3.16x	126mm	
ML-Z14	Near	1.03x	6.21x	53.4mm	○	1.03x	6.21x	53.8mm	○
	Middle	1.05x	6.33x	54.7mm		1.06x	6.37x	55.1mm	
	Far	1.08x	6.49x	56.1mm		1.08x	6.49x	56.5mm	
ML-Z20	Near	1.45x	8.77x	32.1mm	○	1.46x	8.77x	32.3mm	○
	Middle	1.49x	9.01x	32.7mm		1.5x	9.09x	32.9mm	
	Far	1.54x	9.26x	33.4mm		1.54x	9.35x	33.6mm	

*Magnification and working distance can be altered slightly by turning the focus adjustment ring (N⇔F) Indicated values are based on calculation formulas. Actual measurement may differ depending on tolerance. Cannot be mounted on ML-Z07545D-PL.

Rear Converter Lens

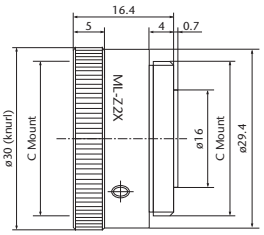
ML-Z2X

Specially designed 2x rear converter. Mounting this between a lens and CCD camera can double the magnification easily without changing working distance.

*May decrease the resolution.

Model	Product Code
ML-Z2X	A-8036

ML-Z2X

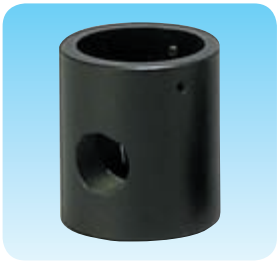


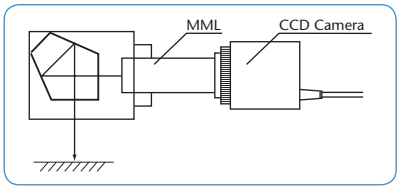
Prism Adapter

MML-P5

90° side view pentaprism type adapter. Monitor images are shown in an upright, normal position by the pentaprism.

Model	Product Code
MML-P5	A-8009



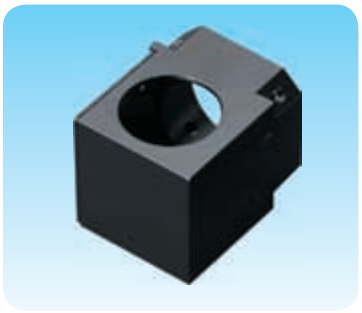


Prism Adapters

Prism adapters make it possible to bend the optical axis at a right angle of 90°, and to perform mark recognition for microscopic objects by modifying the pitch between 2 MML lenses to a fine pitch.

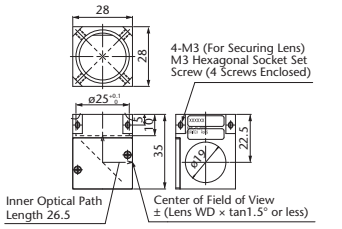
90° Side View Mirror Type Prism for MML-HR
MML-PL25HR

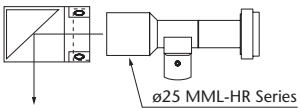
When used in optical systems, images may blur or bend due to the strong effects of profile irregularity of prisms. A clear image can be acquired, however, even for HR type lenses with large NA by sorting and removing prisms with high profile irregularity during the QC process.



- Exclusive MML-High Resolution
- Lens barrel diameter ø25
- Length of inner optical path length 26.5mm

MML-PL25HR

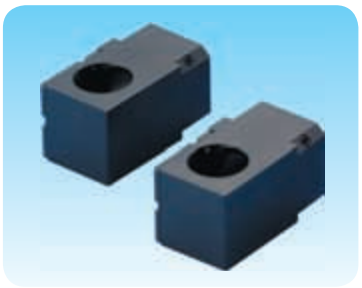




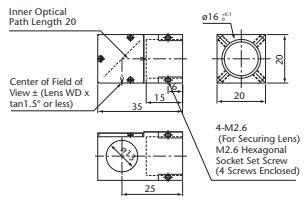
Model	MML-PL25HR
Specifications	90° Side View Mirror for HR For ø25
Product Code	A-8013

90° Side View Mirror Type Prism
MML-PL Series

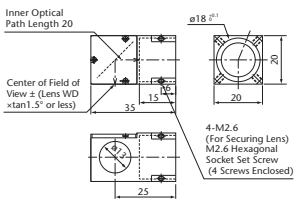
Using these prisms, the optical axis can be bent at a 90° right angle which is useful when space is limited. Resulting images become mirror images.



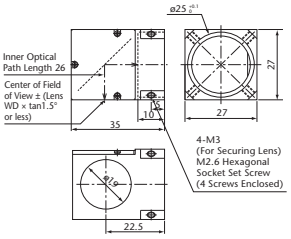
MML-PL16

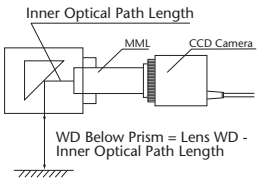


MML-PL18



MML-PL25



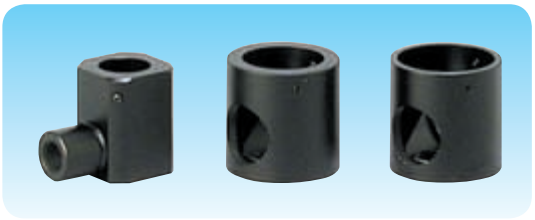


Cover Glass

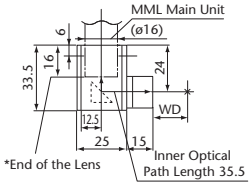
Model	Compatible Sizes	Inner Optical Path Length	Product Code
MML-PL16	For ø16 Lens	20mm	A-8004
MML-PL18	For ø18 Lens	20mm	A-8005
MML-PL25	For ø25 Lens	26mm	A-8006
MML-GA20	Cover Glass ø20 t=1mm		A-8062

90° Side View Mirror Type Prism
MML-P1,3,4

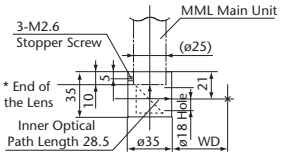
Resulting images become mirror images



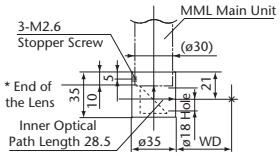
MML-P1
For ø16 Lens



MML-P3
For ø25 Lens



MML-P4
For ø30 Lens

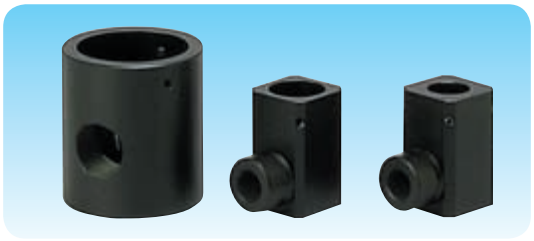


Model	Product Code
MML-P1	A-8001
MML-P3	A-8002
MML-P4	A-8003

*WD in the diagrams is the lens working distance minus the inner optical path length.

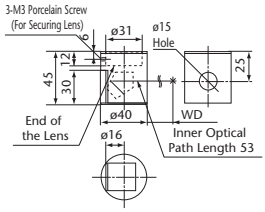
90° Side View Pentaprism Type Prism
MML-P5,6,8

Resulting images are shown in an upright, normal position by the pentaprism.

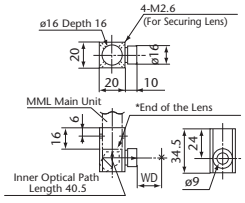


For ML-Z07545

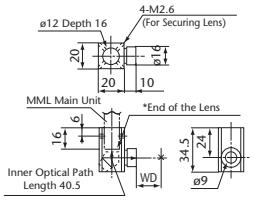
MML-P5
For ø31 Lens

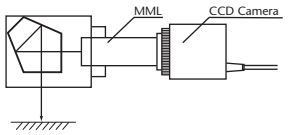


MML-P6
For ø16 Lens



MML-P8
For ø12 Lens



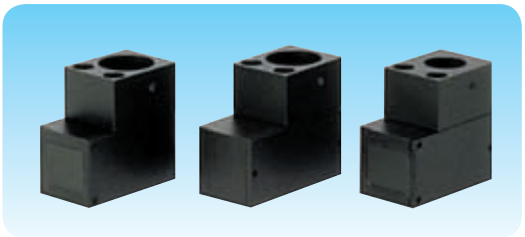


Model	Product Code
MML-P5	A-8009
MML-P6	A-8010
MML-P8	A-8011

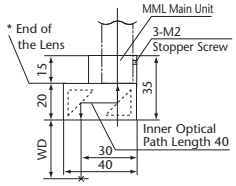
*WD in the diagrams is the lens working distance minus the inner optical path length.

Variable Optical Axis Pitch Type
MML-P2,7,9

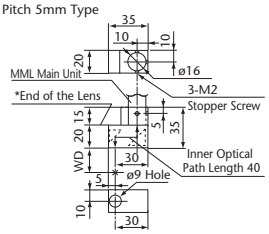
Mark recognition is possible for fine pitch between 2 points of microscopic objects.



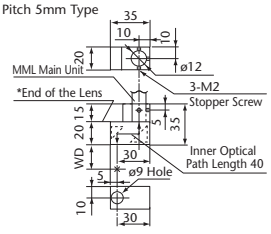
MML-P2
For ø16 Lens
Pitch 10mm Type

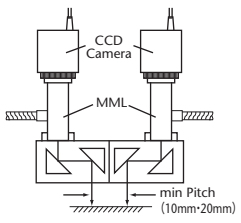


MML-P7
For ø16 Lens
Pitch 5mm Type



MML-P9
For ø12 Lens
Pitch 5mm Type





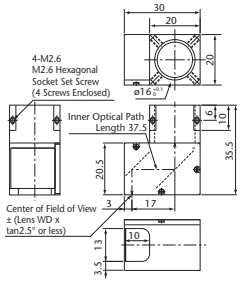
Model	Product Code
MML-P2	A-8017
MML-P7	A-8018
MML-P9	A-8019

*WD in the diagrams is the lens working distance minus the inner optical path length.

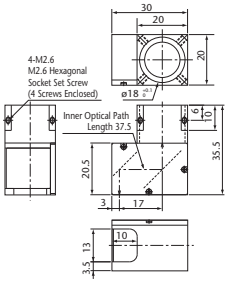
Variable Optical Axis Pitch Type (Pitch 3mm)

MML-PP Series

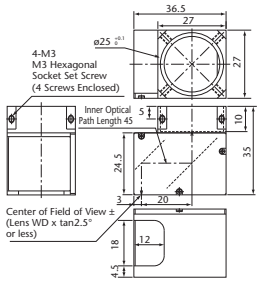
MML-PP16

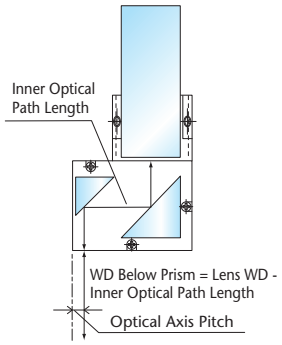


MML-PP18



MML-PP25



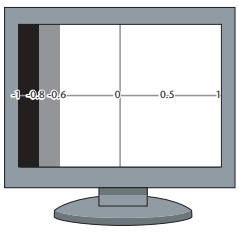


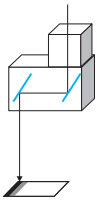
Model	Specification	Inner Optical Path Length	Optical Axis Pitch	Product Code
MML-PP16	For ø16 Lens	37.5mm	3mm	A-8020
MML-PP18	For ø18 Lens	37.5mm	3mm	A-8021
MML-PP25	For ø25 Lens	45mm	3mm	A-8022
MML-GA1411	Cover Glass 14 x 11 t=1mm			A-8063
MML-GA1913	Cover Glass 19 x 13 t=1mm			A-8064

Variable Optical Axis Prism
MML-PP Series Field of View Vignetting Chart

Because of its narrow-pitch design, the MML-PP Series is subject to vignetting.
Since vignetting varies depending on the object, illumination etc., in the environment that the customer uses, the prism must be tested in the actual machine.
*This is a calculated value only and is not guaranteed. For reference only.

MML1-ST65D+1/2"CCD





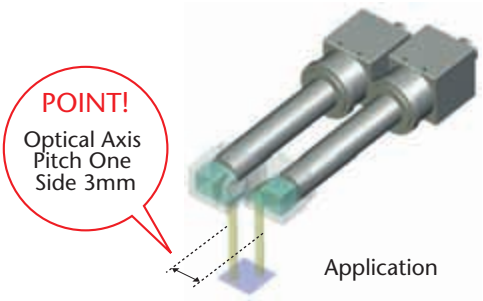
Model	Field of View (Horizontal Field of View Divided into 20 Equal Sections)																					
	CCD	-1	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
MML08-ST65D/65	1/2"	-100	-100	-100	-100	-82	-50	-18														
	1/3"	-100	-99	-82	-58	-33	-11															
MML1-ST65D/65	1/2"	-100	-100	-92	-70	-43	-18	-1														
	1/3"	-100	-100	-43	-24	-8																
MML2-ST65D/65	1/2"	-34	-28	-22	-17	-12	-7	-3	-1													
	1/3"	-19	-15	-12	-8	-5	-3	-1														
MML4-ST65D/65	1/2"	-15	-13	-11	-9	-7	-6	-4	-3	-2	-1											
	1/3"	-10	-9	-7	-6	-5	-4	-3	-2	-1	-1											
MML6-ST65D/65	1/2"	-9	-7	-6	-5	-4	-3	-3	-2	-1	-1											
	1/3"	-6	-5	-4	-4	-3	-2	-2	-1	-1												
MML08-ST110D/110	1/2"	-100	-100	-96	-83	-67	-50	-33	-17	-4												
	1/3"	-90	-80	-67	-54	-41	-28	-17	-7													
MML1-ST110D/110	1/2"	-93	-83	-72	-60	-47	-34	-22	-12	-3												
	1/3"	-66	-56	-47	-37	-28	-19	-12	-5	-1												
MML2-ST110D/110	1/2"	-37	-32	-27	-22	-17	-13	-9	-6	-3	-1											
	1/3"	-24	-21	-17	-14	-11	-8	-6	-3	-1												
MML4-ST110D	1/2"	-25	-24	-22	-21	-19	-18	-16	-15	-14	-12	-11	-10	-8	-7	-6	-5	-4	-3	-2	-2	-1
	1/3"	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-7	-6	-5	-4	-4	-3
MML6-ST110D	1/2"	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-11	-10	-9	-8	-7	-7	-6	-5	-4	-4	-3
	1/3"	-17	-17	-16	-15	-15	-14	-13	-13	-12	-11	-11	-10	-9	-9	-8	-8	-7	-6	-6	-5	-5
MML8-ST110D	1/2"	-17	-16	-16	-15	-14	-14	-13	-12	-12	-11	-10	-10	-9	-9	-8	-7	-7	-6	-6	-5	-5
	1/3"	-15	-15	-14	-14	-13	-13	-12	-12	-11	-11	-10	-10	-9	-9	-9	-8	-8	-7	-7	-6	-6
MML1-ST150D/150	1/2"	-70	-65	-60	-54	-49	-43	-38	-32	-27	-22	-17	-13	-9	-5	-2						
	1/3"	-57	-53	-49	-44	-40	-36	-32	-28	-25	-21	-17	-14	-11	-8	-5	-3	-1				
MML08-ST170D/170	1/2"	-88	-81	-74	-66	-58	-50	-42	-34	-26	-19	-12	-6	-2								
	1/3"	-70	-64	-58	-52	-46	-40	-34	-28	-22	-17	-12	-8	-4	-1							

Lowering of Light Quantity
-100% -70% -40% -20% 0%

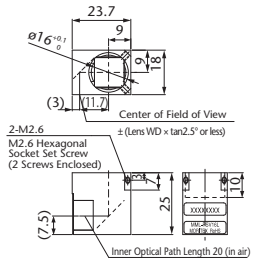
Variable Pitch Side View Prism
MML-PSV16L/R

Fine pitch and small space observation at a 90° angle are possible for alignment marks. Because of the prism's compact design, 40mm working distance lenses can also be used.

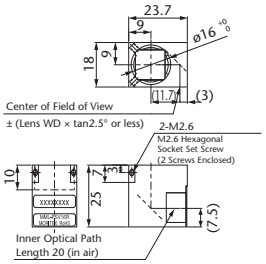
- MML-Standard for ø16
- Optical axis pitch 3mm
- Length of inner optical path length: 20mm
- WD=40mm lens can also be attached



MML-PSV16L



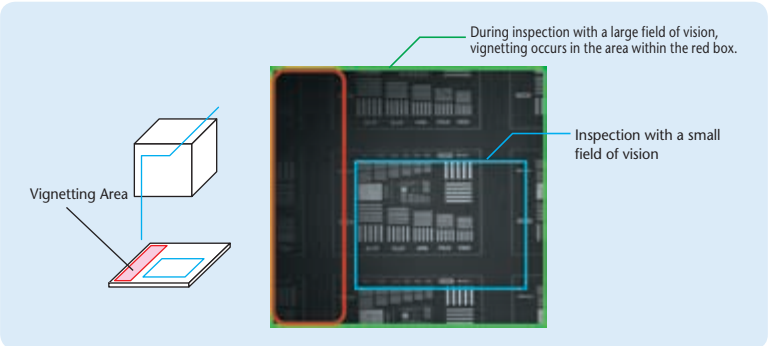
MML-PSV16R



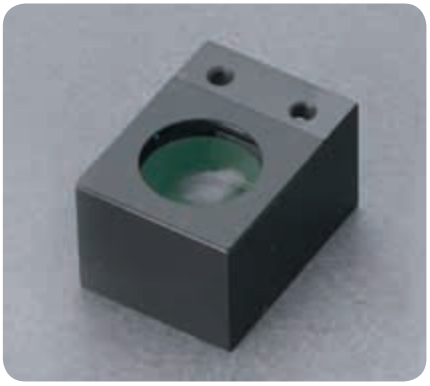
Model	Specifications	Optical Axis Pitch	Product Code
MML-PSV16R	Side View Prism for ST Series (Right Side)	One Side 3mm	A-8007
MML-PSV16L	Side View Prism for ST Series (Left Side)	One Side 3mm	A-8008

MML-PSV 16L/R Vignetting Reference Data

Note that the MML-PSV16 is designed for fine pitch which may cause vignetting in a portion of the screen when observation is performed with a wide field of view. (Differences exist depending on the kind of lens or camera being used.)

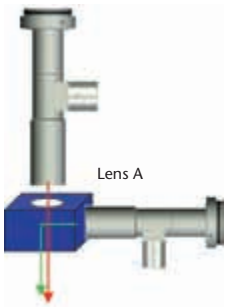


Dual Field of View Prism
MML-P2S16



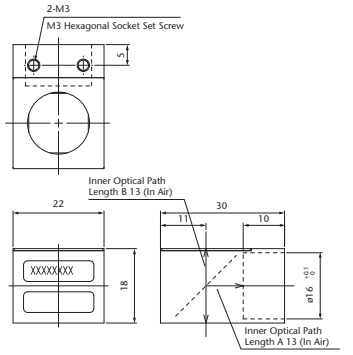
2 different fields of view type for ML-PL Series. This half-mirror prism can be used to view two different field of views (FOV) on the same optical access.

- Same object with two fields of view, same field of view at different working distances, etc.
- Lens A should have a diameter of 16mm

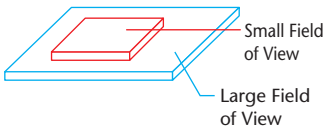


Model	Specifications	Product Code
MML-P2S16	ST Series, 2 field of views (FOV) prism for ø16mm	A-8012

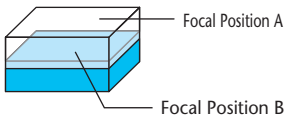
MML-P2S16



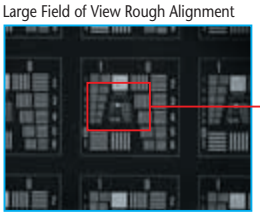
Low Magnification · High Magnification Alignment



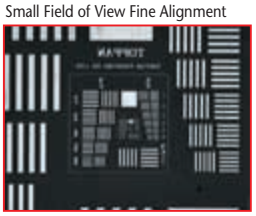
Two Focus Point Alignment



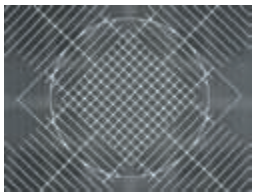
Large Field of View Rough Alignment



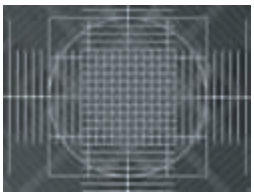
Small Field of View Fine Alignment



Focal Position A



Focal Position B



High Accuracy Two Fields of View Optical Unit
ML-2PLBOX

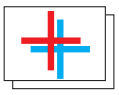
Made-to-order

Two field of views and two focus points can be observed using two lenses & cameras. MORITEX adjusts CCD cameras and optical units to positions desired by customers to provide support to meet specific customer requirements for lenses and illumination, condition of optical units, etc. These adjustments and quality inspection ensure high accuracy of mounted components and the resulting images.

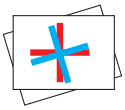
MML-ST110mm

MML-ST65mm

MORITEX performs adjustment and inspection to ensure high accuracy CCDs, prisms and lenses.



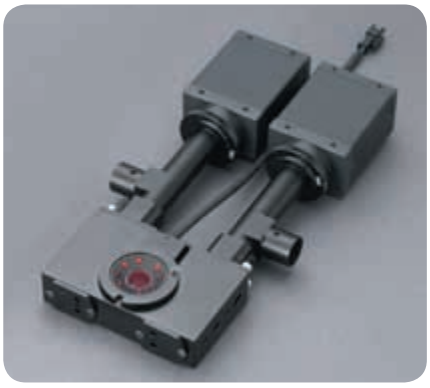
Center Position Accuracy
±(Lens WD × Tan1.5°)



Rotation Alignment Accuracy
Relative Position Within ±0.5°

High Accuracy Two Fields of View Optical Unit
ML-W1000

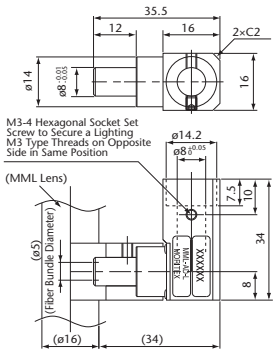
Made-to-order



Coaxial L-Shaped Adapter
MML-AD-L

By connecting to a len's coaxial input, illumination can be inserted at right angles. A very convenient adapter for small spaces.

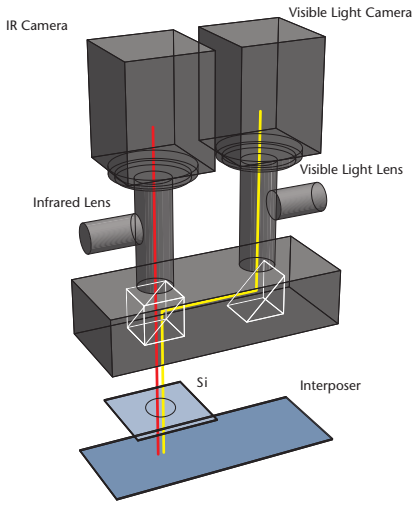
MML-AD-L



Model	Specifications	Product Code
MML-AD-L	L-Shaped Coaxial Adapter	A-8049

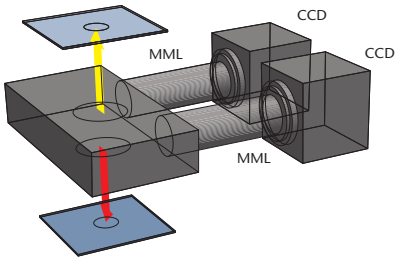
Total Optical Illumination System

Infrared & Visible Ray Transmission System



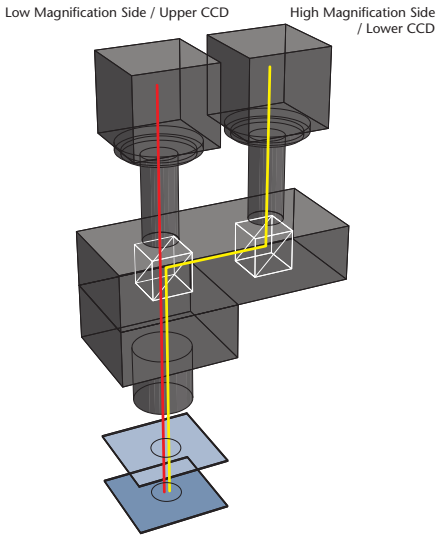
A complete lens and lighting system which uses infrared rays to transmit through a Si, GaAs, or Ge substrate to recognize IR penetration patterns.

Top and Bottom Dual Field Optical System (2CCD Type)



A space-saving optical system for attaching 2 opposite-facing objects with accuracy.

Twin-View, Dual Magnification/Twin-View, Dual Focal Optical System



A space-saving optical system that is used to simultaneously observe an object at two focus distances, and two magnifications on one optical path utilizing a specific prism structure.

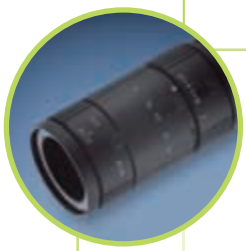
Various OEM applications are available with combinations of more than 100 standard products and lights. Please contact us with inquiries.

Non-Telecentric Lens

Macro Lens

ML-N Series
WD=90mm Series

These short, compact non-telecentric lenses with high performance and reasonable cost are an alternative to our MML and CCTV lenses for alignment and inspection applications.



Macro Zoom Lens

ML-Z0108
ML-0310VF
MLH Series

The Macro Zoom Lens Series are flexible, quality lenses with a number of options that can be used for a variety of vision applications.

CCTV Lens

MTE-55
ML-MP3 Series
ML-MP Series
ML Series

The most common machine vision lenses, we offer Standard, Megapixel (ML-MP), 3 Megapixel (ML-MP3) and a telecentric CCTV lens models.

Non-Telecentric Macro Lens

ML-N Series

ML-N Series lenses were developed to be compact, high performance models. Based on many years of experience producing MMLs (Machine Micro Lens), MORITEX adopted the non-telecentric optical system as the lens design for this series. By limiting the number of lenses in each layer to less than 3, we have succeeded in developing high performance models at reasonable prices.
Magnification and working distances can be tailored to your needs by using an optional close-up ring adapter.

- Compact body of ø16
- High resolution, low optical distortion
- Reasonable prices
- Best matching with peripherals

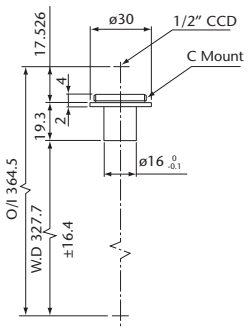
Model	Magnification	WD	Resolution	Depth of Field	Effective F No	Optical Distortion	Largest Compatible CCD	Weight	Mount (Sold Separately)	Product code
ML01-327N	0.1x	327.7mm	33.9µm	37.66mm	4.71	0.4% or less	1/2″	10g	C Mount	A-0133
ML03-181N	0.3x	181.3mm	14.6µm	5.43mm	6.11	0.2% or less	1/2″	15g	C Mount	A-0134
ML05-132N	0.5x	132.5mm	11.7µm	1.95mm	6.08	0.08% or less	1/2″	18g	C Mount	A-0131
ML05-250N	0.5x	250mm	13.3µm	2.27mm	7.1	0.06%	1/2″	90g	C Mount	A-0135
ML1-89N	1.0x	89.6mm	7.9µm	0.7mm	8.82	0.04% or less	1/2″	15g	C Mount	A-0132

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

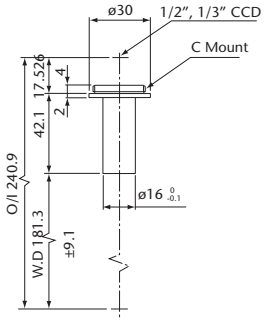
Magnification conversion table

	Close-Up Ring Thickness	0mm	1mm	2mm	5mm	7mm	10mm	15mm	17mm	20mm
ML01-327N	Magnification	0.1x	0.13x	0.17x	0.27x	0.33x	0.43x	0.6x	0.67x	0.77x
	WD	327.7mm	253mm	204mm	138.8mm	118.6mm	97.5mm	77.7mm	72.5mm	67.2mm
ML03-181N	Magnification	0.3x	0.32x	0.35x	0.42x	0.47x	0.54x	0.65x	0.7x	0.77x
	WD	181.3mm	170mm	162mm	140.7mm	131mm	119mm	104.6mm	100mm	94.6mm
ML05-132N	Magnification	0.5x	0.53x	0.55x	0.62x	0.66x	0.73x	0.85x	0.9x	0.97x
	WD	132.5mm	128.4mm	125mm	116.3mm	111.3mm	105.2mm	97.4mm	94.2mm	91mm
ML05-250N	Magnification	0.5x	0.51x	0.52x	0.56x	0.58x	0.62x	0.68x	0.71x	0.74x
	WD	250mm	246mm	242.3mm	232mm	225.8mm	217.5mm	205.6mm	201.5mm	195.7mm
ML1-89N	Magnification	1x	1.02x	1.05x	1.12x	1.16x	1.2x	1.35x	1.4x	1.47x
	WD	89mm	88mm	87mm	85mm	83.5mm	81.5mm	78.5mm	77.3mm	75.9mm

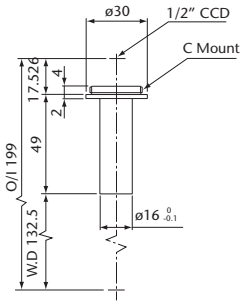
ML01-327N



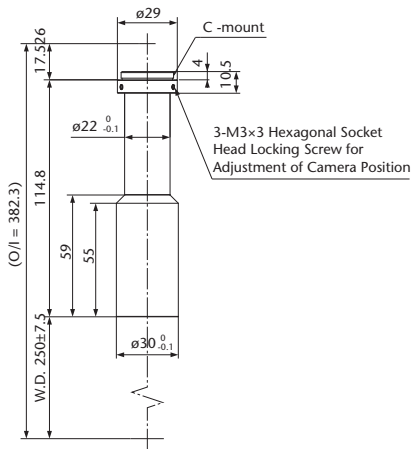
ML03-181N



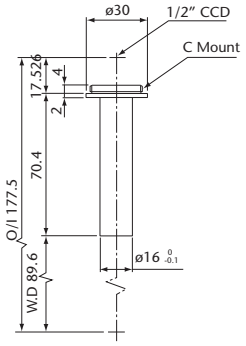
ML05-132N



ML05-250N

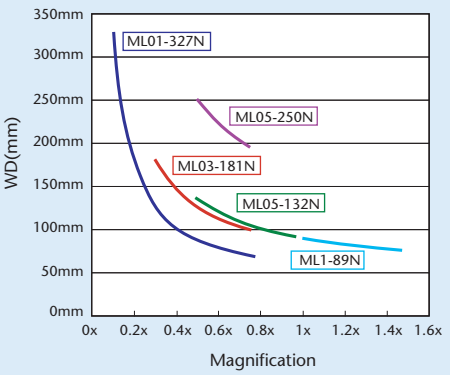


ML1-89N



The magnification can be changed by using the ML-EXR Series close-up ring.

Reference magnification and WD data for close-up ring combinations

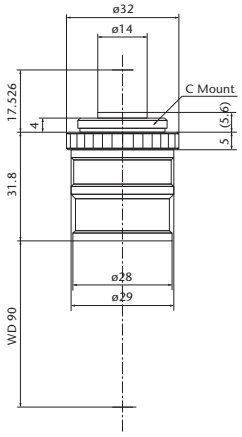


Low Magnification Macro Lens

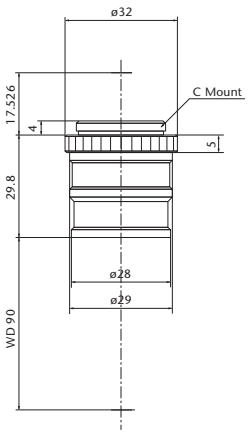
WD=90mm Series

Small, high-resolution macro lenses to be mounted directly on machines.
WD=90mm for all models.

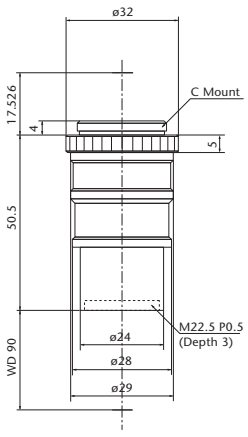
ML-15014



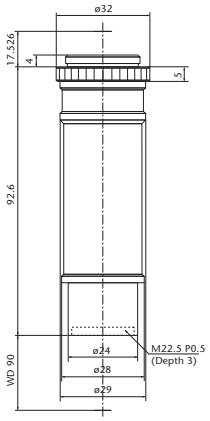
ML-24030



ML-3505



ML-5010



Model	Magnification	Effective F No	WD	Depth of Field	Resolution	Optical Distortion	Weight	Largest Compatible CCD	Mount	Product Code
ML-15014	0.14x	4.6	90mm	18mm	36µm	0.1% or less	28g	2/3"	C Mount	A-0127
ML-24030	0.3x	7.3	90mm	6.5mm	21µm	0.1% or less	39g	2/3"	C Mount	A-0128
ML-3505	0.5x	8.4	90mm	2.7mm	13µm	0.1% or less	55g	2/3"	C Mount	A-0129
ML-5010	1x	8	90mm	0.6mm	6.3µm	0.1% or less	68g	2/3"	C Mount	A-0130

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

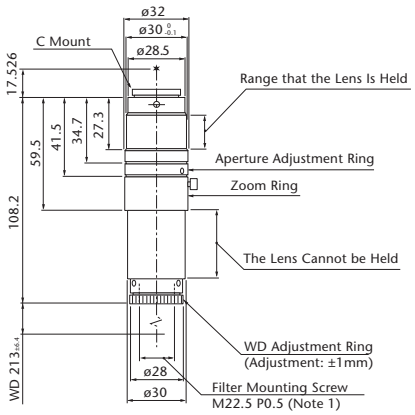
High Performance Macro Zoom Lens

ML-Z0108

High performance macro lens with 8:1 magnification ratio and long working distance. By using the focus ring on the end, working distance can be changed within a range of 20mm.

- Zoom ratio of 8:1. Magnification range of 0.1x~0.8x
- WD=213mm
- Focus adjustment ±20mm (magnification variation ±13%)
- Iris, focus, and zoom are adjustable.
- Equipped with locking screws.

ML-Z0108

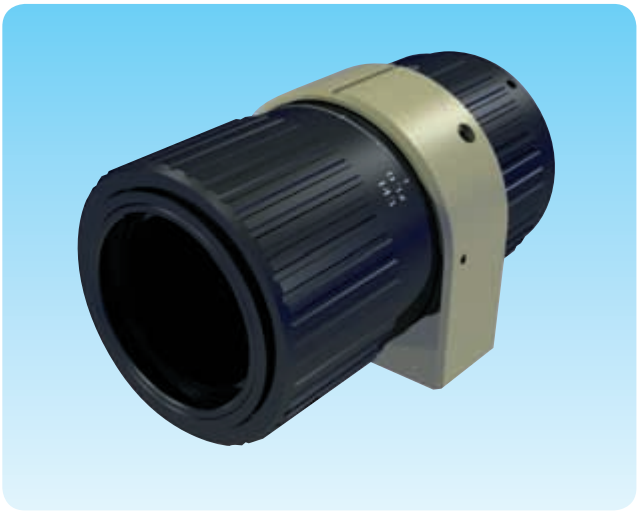


Model	Magnification	WD	Focus Position	Motor	Effective F No	Depth of Field	Resolution	Optical Distortion	Operation Function	Weight	Largest Compatible CCD	Mount	Product Code
ML-Z0108	0.1x to 0.8x (Zoom Ratio of 8:1)	213mm	Without (Manual Zoom)	at 0.1x	8.2	32.8mm	55µm	-0.02% or less	Manual (Adjusting Aperture, Zoom, and Focus)	140g	1/2"	C Mount	A-0155
				at 0.4x		2.1mm	14µm	0.18% or less					
				at 0.8x	9.3	0.6mm	8µm	0.17% or less					

* Depth of field is calculated assuming a horizontal 240TV resolution using a 1/2" CCD camera. (Permissible circle of confusion on the image-formation side: 40µm)
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

Varifocal Lens for Large Image Format

ML-0310VF



Varifocal lens with optimized magnification and working distance for FA. The key features of this lens are the support of large, up to 1.2" CCD elements and the varifocal, variable magnification for wide field of views. This lens is great for high speed and high resolution image recognition.

- Supports camera format of up to 1.2" max. (15.15mmx15.15mm)
- Varifocal magnification variation of 0.3x~1x
- Equipped with variable aperture
- Equipped with screws to lock movable parts for FA
- Wide wavelength transmission

Chart for Field of View According to CCD Element Size • WD

Magnification	0310VF	VF03	1/3 (3.6x4.8)	1/2 (4.8x6.4)	2/3 (6.6x8.8)	1.1 (12x12.3)	1.2 (15.15x15.15)
0.1x	-	414.5mm	36x48	48x64	66x88	120x123	151.5x151.5
0.15x	-	288.5mm	24x32	32x42.7	44x58.7	80x82	101x101
0.2x	-	220.3mm	18x24	24x32	33x44	60x61.5	75.8x75.8
0.25x	-	180.9mm	14.4x19.2	19.2x25.6	26.4x35.2	48x49.2	60.6x60.6
0.3x	143mm	155.8mm	12x16	16x21	22x29.3	40x41	50.5x50.5
0.4x	114mm	127.1mm	9x12	12x16	16.5x22.0	30x30.8	37.9x37.9
0.5x	97mm	113.0mm	7.2x9.6	9.6x12.8	13.2x17.6	24x24.6	30.3x30.3
0.6x	87mm	107.2mm	6x8	8x10.7	11x14.7	20x20.5	25.3x25.3
0.65x	83mm	106.4mm	5.5x7.4	7.4x9.8	10.2x13.5	18.5x18.9	23.3x23.3
0.7x	81mm	-	5.1x6.9	6.9x9.1	9.4x12.6	17.1x17.6	21.6x21.6
0.8x	77mm	-	4.5x6	6x8	8.3x11.0	15x15.4	18.9x18.9
0.9x	76mm	-	4x5.3	5.3x7.1	7.3x9.8	13.3x13.7	16.8x16.8
1x	75mm	-	3.6x4.8	4.8x6.4	6.6x8.8	12x12.3	15.2x15.2

Optical Specifications

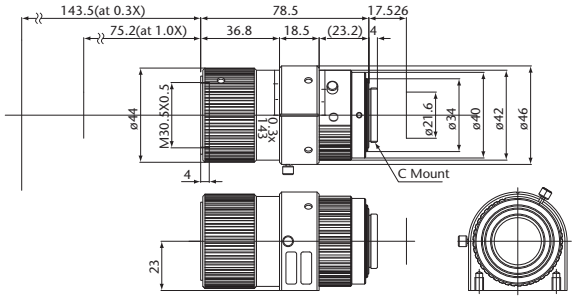
Model	Magnification	WD	Resolution	Depth of Field	Optical Distortion	Weight	Mount (Sold Separately)	Compatible Camera Size	Product Code
ML-0310VF	0.3x	143.5mm	15.3µm	6.0mm	0.07% or less	Approx. 180g	C Mount	Supports Maximum size of 1.2" (15.15mmx15.15mm)	A-3127
	0.65x	83.2mm	8.8µm	1.6mm	0.02% or less				
	1.0x	75.2mm	7.1µm	0.7mm	0.01% or less				

Option Proxar Lens

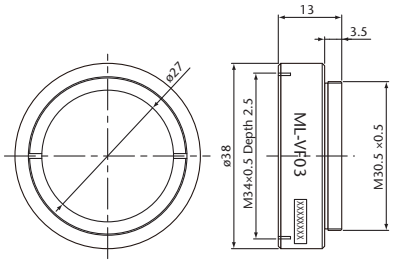
Model	Magnification	WD	Resolution	Depth of Field	Optical Distortion	Product Code
ML-VF03	0.1x	414.4mm	44.0µm	54.4mm	-0.1% or less	A-8034
	0.37x	133.4mm	15.3µm	4.9mm	-0.06% or less	
	0.65x	106.3mm	10.8µm	2.0mm	-0.03% or less	

* Calculated from permissible circle of confusion diameter of 40µm.
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

ML-0310VF

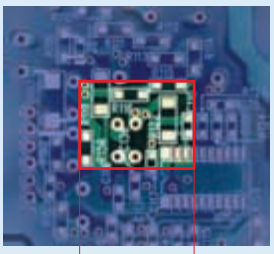


ML-VF03



ML-0310VF Examples of Field of View

1/2 CCD at 0.3x



21mm

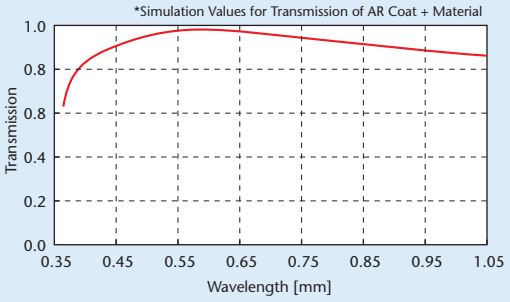
1.2 CCD at 0.3x

50.5mm

Benefits of Using a Large Element Camera

- Achieves a large field of view with one camera
- Bright pictures due to large pixel size

Chart for Spectral Transmission



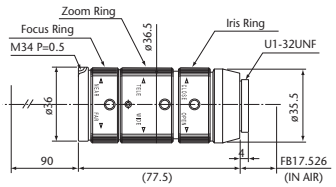
Mega Pixel Macro Zoom Lens

MLH-3XMP

This high-performance macro zoom lens supports CCD cameras of the 1 million pixel class. The zoom range is 0.3x~1x by optical magnification. The resolution of 100/mm or more is realized at the center and periphery of the entire zoom range. Combination with a mega pixel CCD realizes wide-range image recognition with excellent contrast.

- Zoom: Optical magnification of 0.3x~1x
- WD=90mm
- Variable focus
- Variable iris Effective NO4.5~Close
- Equipped with screws to lock movable parts (Zoom, focus, and iris)
- Maximum compatible camera format ~2/3"
- C mount

MLH-3XMP



Model	MLH-3XMP
Magnification	0.3x to 1x (Manual Zoom)
WD	90mm
Aperture (F No)	F4.5~Close
Filter Screw	M34 P=0.5
Weight	150g
Largest Compatible CCD	2/3"
Camera Mounts	C Mount
Product Code	A-0220

10x Zoom Lens

MLH-10X

A wide zoom ratio lens developed for large field of view imaging. Zoom ratio of 10:1 at a working distance of 150mm to 450mm by adjusting the focus. This lens can be used for FA, laboratory work, weak eyesight correction, and environment-related projects.

- Zoom ratio of 10:1
  (Magnification range: 0.084x(min)~0.84x(max))
- WD=450mm(min)~150mm(max)
- Iris, focus, and zoom are adjustable.
- Equipped with locking screws.

MLH-10X

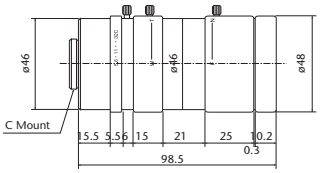


Chart for Field of View

WD	Magnifications	Field of View	
		1/2"(Length mm x Width mm)	1/3"(Length mm x Width mm)
150mm	0.086x ~ 0.84x	55.8 x 74.4 ~ 5.7 x 7.6	42 x 56 ~ 4.3 x 5.7
200mm	0.06x ~ 0.58x	80 x 107 ~ 8.3 x 11	60 x 80 ~ 6.2 x 8.3
250mm	0.045x ~ 0.44x	107 x 142 ~ 10.9 x 14.5	80 x 107 ~ 8.2 x 10.9
300mm	0.037x ~ 0.36x	130 x 173 ~ 13.3 x 17.8	97 x 130 ~ 10 x 13.3
350mm	0.031x ~ 0.3x	155 x 206 ~ 16 x 21.3	116 x 155 ~ 12 x 16
400mm	0.02x ~ 0.25x	185 x 246 ~ 19.2 x 25.6	138 x 185 ~ 14.4 x 19.2
450mm	0.023x ~ 0.22x	209 x 278 ~ 21.8 x 29.1	157 x 209 ~ 16.4 x 21.8

Model	MLH-10X
Magnification	0.084x to 0.84x (Zoom Ratio of 10:1)
WD	150~450mm
Iris	F5.6~Close
Filter Size	M46 P=0.75
Weight	233g
largest Compatible CCD	1/2"
Camera Mount	C Mount
product Code	A-0149

Telecentric CCTV Lens

MTE-55

The MTE-55 lens adopts F2.8/ f-55mm telecentric optical system that reduces angle and magnification errors when observing objects. Accurate telecentric performance is achieved when combined with the optional lens MTE2 with at a magnification of 0.4x ~ 0.9x. Although no telecentric effect is achieved at the magnification of infinity ~ 0.4x, it is designed to correct aberrations far better than regular lenses.

Model	MTE-55
Magnification	Infinity to 0.5x (when dedicated converter is used. 1.0x at max)
Focal Distance f (mm)	55
F No	2.8~close
Photographing Distance	Infinite to 140mm
Oprical Distortion	0.6% at max
Marginal Light Quantity	78.50%
Mount	C Mount
Filter Size	M43 P0.75
Largest Compatible Camera	2/3"
Weight	320g
Product Code	A-0212

MTE-55

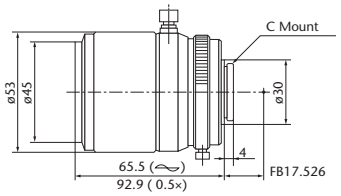


Chart for Field of View by CCD Camera Size (MTE-55)

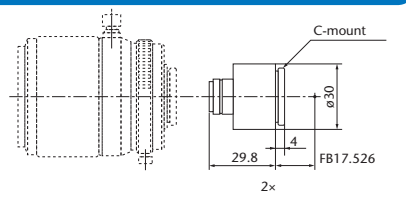
WD (mm)	MTE-55			
	2/3" (Length x Width)	1/2" (Length x Width)	1/3" (Length x Width)	Optical Magnification
5000	550x733	415x550	300x400	x0.012
3000	330x440	240x320	170x220	x0.02
1000	132x176	090x120	61x82	x0.05
500	55x73	40x53	30x40	x0.12
300	31x41	24x32	17x22	x0.21
200	22x29	15x20	11x15	x0.3
140	13x18	10x13	7x10	x0.48

Options

x2 Converter Lens **MTE2**

Dedicated x2 Converter Lens	Product Code
MTE2	A-8083

MTE2



x0.75 Converter Lens **MTE075**

Dedicated x0.75 Converter Lens	Product Code
MTE075	A-8084

MTE075

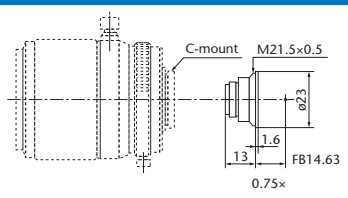


Chart for Field of View by CCD Camera Size(MTE-55+MTE2)

WD (mm)	MTE-55 +2xConverter Lenses (MTE2)			
	2/3" (Length x Width)	1/2" (Length x Width)	1/3" (Length x Width)	Optical Magnification
5000	275x366	207x275	150x200	x0.024
3000	165x220	120x160	85x110	x0.04
1000	66x88	45x60	30x41	x0.1
500	27x36	20x26	15x20	x0.24
300	15x20	12x16	8x11	x0.42
200	11x14	07x10	5x7	x0.6
140	6x9	5x6	3x5	x0.9

Chart for Field of View by CCD Camera Size(MTE-55+MTE075)

WD (mm)	MTE-55 +0.75xConverter Lenses (MTE075)			
	2/3" (Length x Width)	1/2" (Length x Width)	1/3" (Length x Width)	Optical Magnification
5000	733x977	553x733	400x533	x0.009
3000	440x586	320x426	226x293	x0.015
1000	176x234	120x160	081x109	x0.03
500	73x97	53x70	40x53	x0.09
300	41x54	32x42	22x29	x0.15
200	29x38	20x26	14x20	x0.22
140	17x24	13x17	9x13	x0.36

3 Mega Pixel CCTV Lens

ML-MP3 Series

The ML-MP and ML-MP3 Mega Pixel CCTV Series are lenses developed for wide view image recognition with higher definition. The ability of the lenses to realize a resolution of higher than 100lp/mm both at the center and periphery when imaging at close distances is a particularly strong feature. In combination with a mega pixel camera, imaging with higher resolution and contrast than conventional CCTV lenses is achieved. With all models, the variable iris and focus can be set with locking screws as needed(*1). The lenses also support small FOV imaging when combined with close-up rings and rear converter lenses(*2).

The 3 Mega Pixel (ML-MP3) Series is our newest lineup of high end CCTV lenses addressing the needs of applications using high pixel count image sensors.

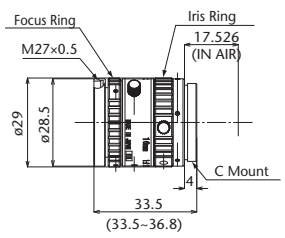
- High resolving power of 3 mega pixels or higher
- Supports 2/3" lenses
- Close distance (0.2 meters or greater) design suitable for machine vision
- Low distortion : 0.1% or less
- High image quality through improved marginal light quantity ratio
- Includes focus lock screws and iris lock screws
- Lens OD: 29mm
- Uniform filter mount M27 P0.5

(*1) Vibration resistance is not considered in design.
(*2) If a close-up ring and a rear converter lens are used, individual differences in product performance, or image deterioration occurs due to an enlargement of lens tolerance.
(Images must be checked when using the lenses. Contact us if uncertain.)
Note: Product performance is guaranteed only if the product is used without additional attachments.

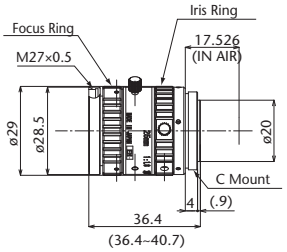
Support for Special Orders

Fixed Aperture / Focus Lock Type

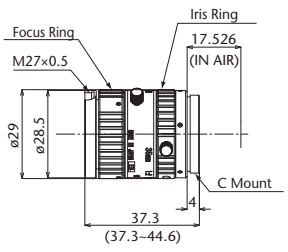
ML-M1620MP3



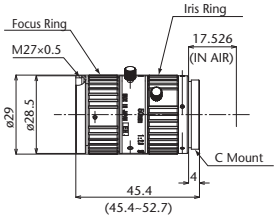
ML-M2518MP3



ML-M3520MP3



ML-M5028MP3



Model	Focal Distance	F No	Field of View(HxV)	Closest Distance	Filter Screw	Weight	Largest compatible CCD	Mount	Product Code
ML-M1620MP3	16mm	F2.0 - 16	23.3° x 30.7°	0.2m	M27 P0.5	53g	2/3"	C mount	A-0229
ML-M2518MP3	25mm	F1.8 - 16	15° x 19.9°	0.2m	M27 P0.5	60g	2/3"	C mount	A-0230
ML-M3520MP3	35mm	F2.0 - 16	10.7° x 14.3°	0.2m	M27 P0.5	59g	2/3"	C mount	A-0231
ML-M5028MP3	50mm	F2.8 - 16	7,5° x 10.0°	0.2m	M27 P0.5	69g	2/3"	C mount	A-0232

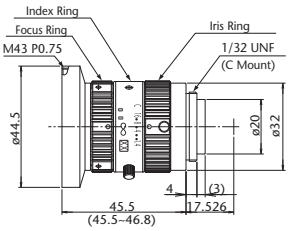
Mega Pixel CCTV Lens

ML-MP Series

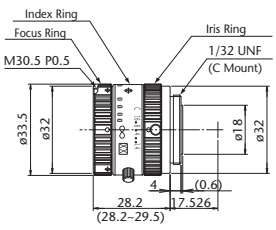
Compact CCTV lenses with high resolution design for use with 1 mega pixel or higher count sensors.

- Lineup of 6 models (f = 5~50mm)
- Compatible with mega pixel cameras
- Variable focus and iris
- Equipped with screws to lock movable parts (focus and iris)
- Maximum compatible camera format ~2/3"
- C mount

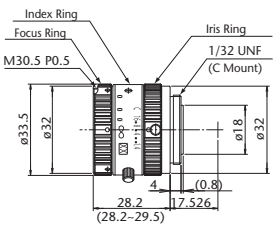
ML-H0514MP



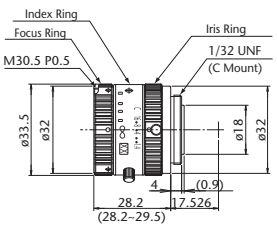
ML-M0814MP



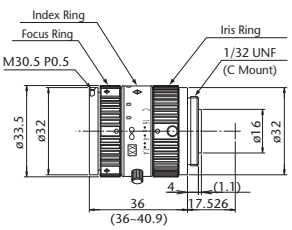
ML-M1214MP



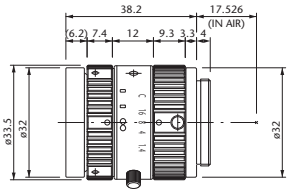
ML-M1614MP



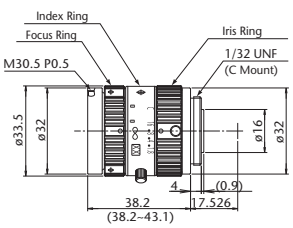
ML-M2514MP



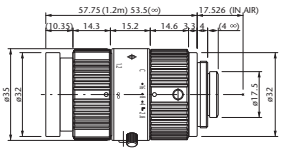
ML-M3514MP



ML-M5018MP



ML-M7528MP



Model	Focal Distance	F No	Field of View(HxV)	Closest Distance	Filter Screw	Weight	Largest compatible CCD	Mount	Product Code
ML-H0514MP	5mm	F1.4 - 16C	51.4° x 65.5°	0.3m	M43 P0.75	107g	1/2"	C mount	A-3100
ML-M0814MP	8mm	F1.4 - 16C	43.7° x 56.3°	0.1m	M30.5 P0.5	70g	2/3"	C mount	A-0221
ML-M1214MP	12mm	F1.4 - 16C	30.8° x 40.4°	0.15m	M30.5 P0.5	65g	2/3"	C mount	A-0222
ML-M1614MP	16mm	F1.4 - 16C	23.4° x 30.8°	0.3m	M30.5 P0.5	65g	2/3"	C mount	A-0223
ML-M2514MP	25mm	F1.4 - 16C	15.1° x 20°	0.3m	M30.5 P0.5	75g	2/3"	C mount	A-0224
ML-M5018MP	50mm	F1.8 - 16C	7.9° x 10.5°	0.5m	M30.5 P0.5	90g	2/3"	C mount	A-0225

CCTV Lens

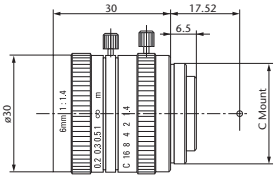
ML Series

CCTV (Closed Circuit Television) lenses were developed to recognize images in a wide field of view. With all models, the variable iris and focus can be set with locking screws as needed.(*1) The lenses also support micro imaging in combination with close-up ring and rear converter lenses.(*2)

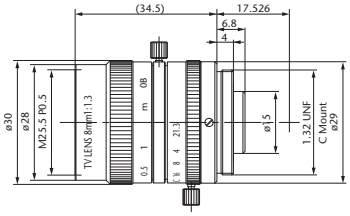
- A wide range of products from f=6mm to 100mm.
- Variable focus and iris equipped with lock screws.
- Camera mount: C mount

(*1) Vibration resistance is not considered in design.
(*2) Image quality may be distorted with enlargement of lens tolerance.

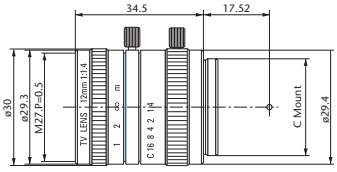
ML-0614



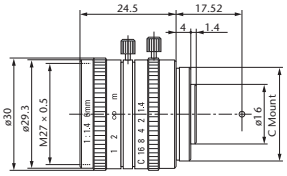
ML-0813



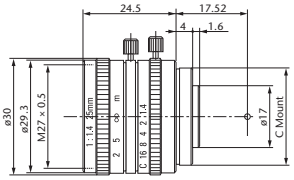
ML-1214



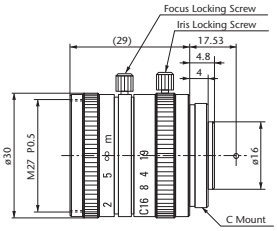
ML-1614



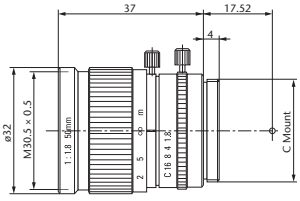
ML-2514



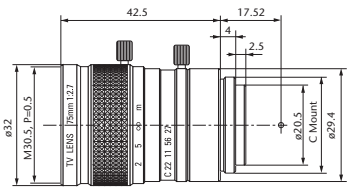
ML-3519



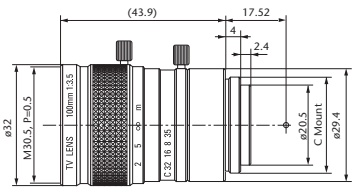
ML-5018



ML-7527



ML-10035



Model	Focal Distance	F No	Field of View(HxV)	Closest Distance	Filter Screw	Weight	Largest compatible CCD	Mount	Product Code
ML-0614	6mm	F1.4 - close	42.3° x 54.6°	0.2m	M27 P0.5	60g	1/2"	C mount	A-0198
ML-0813	8mm	F1.3 - close	45.0° x 57.8°	0.2m	M25.5 P0.5	60g	2/3"	C mount	A-0199
ML-1214	12mm	F1.4 - close	21.9° x 29.0°	0.3m	M27 P0.5	60g	1/2"	C mount	A-0200
ML-1614	16mm	F1.4 - close	23.0° x 30.4°	0.4m	M27 P0.5	40g	2/3"	C mount	A-0201
ML-2514	25mm	F1.4 - close	21.6° x 28.5°	0.5m	M27 P0.5	45g	1"	C mount	A-0202
ML-3519	35mm	F1.9 - close	10.8° x 14.4°	0.5m	M27 P0.5	50g	2/3"	C mount	A-0203
ML-5018	50mm	F1.8 - close	7.9° x 10.5°	1m	M30.5 P0.5	60g	2/3"	C mount	A-0204
ML-7527	75mm	F2.7 - close	4.9° x 6.5°	1m	M30.5 P0.5	65g	2/3"	C mount	A-0205
ML-10035	100mm	F3.5 - close	3.8° x 5.1°	1m	M30.5 P0.5	65g	2/3"	C mount	A-0206

Field, WD, and Magnification when a Close-Up Ring is Used

Close-Up Ring (mm)	ML-0614				ML-0813				ML-1214			
	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification
0	165 x 221	124 x 165	200	0.03x	96 x 128	72 x 96	148	0.05x	103 x 137	77 x 103	248	0.05x
0.5	44 x 58	33 x 44	43	0.11x	43 x 57	32 x 43	59	0.11x	55 x 73	41 x 55	125	0.09x
	60 x 79	45 x 60	63	0.08x	77 x 102	57 x 77	115	0.06x	119 x 159	89 x 119	289	0.04x
1	25 x 34	19 x 25	19	0.19x	27 x 37	21 x 27	34	0.18x	38 x 50	28 x 38	80	0.13x
	30 x 40	22 x 30	25	0.16x	38 x 51	29 x 38	52	0.13x	59 x 79	45 x 59	136	0.08x
1.5					20 x 27	15 x 20	22	0.24x	29 x 38	21 x 29	57	0.17x
					26 x 34	19 x 26	31	0.19x	40 x 53	30 x 40	85	0.12x
2									23 x 31	17 x 23	42	0.21x
									30 x 40	22 x 30	59	0.16x

Close-Up Ring (mm)	ML-1614				ML-2514				ML-3519			
	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification
0	109 x 145	82 x 109	358	0.04x	87 x 115	65 x 87	458	0.06x	66 x 87	49 x 66	500	0.07x
0.5	64 x 86	48 x 64	206	0.07x	64 x 85	48 x 64	338	0.08x	55 x 73	41 x 55	422	0.09x
	156 x 208	117 x 156	515	0.03x	242 x 322	181 x 242	1270	0.02x	335 x 447	251 x 335	2459	0.01x
1	45 x 61	34 x 45	143	0.11x	50 x 67	38 x 50	269	0.10x	47 x 63	35 x 47	366	0.10x
	78 x 104	58 x 78	252	0.06x	121 x 161	91 x 121	637	0.04x	168 x 223	126 x 168	1240	0.03x
1.5	35 x 47	26 x 35	108	0.14x	42 x 56	31 x 42	223	0.12x	41 x 55	31 x 41	324	0.12x
	52 x 69	39 x 52	164	0.09x	81 x 107	60 x 81	425	0.06x	112 x 149	84 x 112	834	0.04x
2	29 x 38	22 x 29	86	0.17x	36 x 47	27 x 36	191	0.13x	37 x 49	28 x 37	291	0.13x
	39 x 52	29 x 39	120	0.12x	60 x 81	45 x 60	320	0.08x	84 x 112	63 x 84	631	0.06x
5	14 x 18	10 x 14	35	0.35x	19 x 25	14 x 19	103	0.25x	22 x 30	17 x 22	185	0.22x
	16 x 21	12 x 16	42	0.31x	24 x 32	18 x 24	130	0.20x	34 x 45	25 x 34	265	0.14x
10	7.3 x 9.7	5.4 x 7.3	14	0.66x	11 x 14	8.0 x 11	60	0.45x	13 x 18	10 x 13	121	0.36x
	7.8 x 10	5.8 x 7.8	15	0.62x	12 x 16	9.1 x 12	66	0.40x	17 x 22	13 x 17	143	0.29x
15					7.4 x 9.8	5.5 x 7.4	43	0.65x	9.5 x 13	7.2 x 9.5	93	0.50x
					8.1 x 11	6.0 x 8.1	45	0.60x	11 x 15	8.4 x 11	103	0.43x
20					5.6 x 7.5	4.2 x 5.6	34	0.85x	7.4 x 9.9	5.6 x 7.4	78	0.65x
					6.0 x 8.1	4.5 x 6.0	35	0.79x	8.4 x 11	6.3 x 8.4	82	0.57x
25									6.1 x 8.1	4.6 x 6.1	68	0.79x
									6.7 x 8.9	5.0 x 6.7	70	0.72x

Close-Up Ring (mm)	ML-5018				ML-7527				ML-10035			
	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification	Field of View (Length x Width) 1/2"	Field of View (Length x Width) 1/3"	WD (mm)	Magnification
0	90 x 120	68 x 90	943	0.05x	60 x 80	45 x 60	1000	0.08x	46 x 62	35 x 46	1000	0.10x
1.5	57 x 76	43 x 57	610	0.08x								
	154 x 205	115 x 154	1577	0.03x								
2	51 x 67	38 x 51	548	0.10x	43 x 57	32 x 43	776	0.11x				
	115 x 154	86 x 115	1193	0.04x	184 x 246	138 x 184	3189	0.03x				
5	31 x 41	23 x 31	347	0.16x	30 x 40	23 x 30	607	0.16x	27 x 37	21 x 27	724	0.18x
	46 x 61	35 x 46	503	0.10x	74 x 98	55 x 74	1422	0.07x	95 x 127	71 x 95	2413	0.05x
10	18 x 25	14 x 18	226	0.26x	20 x 27	15 x 20	475	0.24x	19 x 26	15 x 19	609	0.25x
	23 x 31	17 x 23	273	0.21x	37 x 49	28 x 37	833	0.13x	48 x 63	36 x 48	1432	0.10x
15	13 x 18	10 x 13	174	0.37x	15 x 20	11 x 15	408	0.32x	15 x 20	11 x 15	546	0.32x
	15 x 21	12 x 15	196	0.31x	25 x 33	18 x 25	636	0.20x	32 x 42	24 x 32	1105	0.15x
20	10 x 14	7.7 x 10	145	0.47x	12 x 16	9 x 12	369	0.40x	12 x 16	9 x 12	505	0.39x
	12 x 15	8.6 x 12	158	0.42x	18 x 25	14 x 18	538	0.26x	24 x 32	18 x 24	941	0.20x
25	8.4 x 11	6.3 x 8.4	126	0.57x	10 x 14	7.6 x 10	342	0.47x	10 x 14	8 x 10	478	0.46x
	9.2 x 12	6.9 x 9.2	134	0.52x	15 x 20	11 x 15	479	0.33x	19 x 25	14 x 19	843	0.25x
30	7.1 x 9.4	5.3 x 7.1	113	0.68x	8.7 x 12	6.5 x 8.7	323	0.55x	9.0 x 12	6.7 x 9.0	458	0.54x
	7.7 x 10	5.8 x 7.7	119	0.63x	12 x 16	9.2 x 12	440	0.39x	16 x 21	12 x 16	778	0.30x
35	6.1 x 8.2	4.6 x 6.1	104	0.78x	7.6 x 10	5.7 x 7.6	309	0.63x	7.9 x 11	5.9 x 7.9	443	0.61x
	6.6 x 8.8	4.9 x 6.6	108	0.73x	11 x 14	7.9 x 11	412	0.46x	14 x 18	10 x 14	731	0.35x
40	5.4 x 7.2	4.1 x 5.4	97	0.89x	6.7 x 9.0	5.1 x 6.7	297	0.71x	7.1 x 9.4	5.3 x 7.1	430	0.68x
	5.8 x 7.7	4.3 x 5.8	100	0.83x	9.2 x 12	6.9 x 9.2	391	0.52x	12 x 16	8.9 x 12	696	0.40x
45					6.1 x 8.1	4.6 x 6.1	289	0.79x	6.4 x 8.5	4.8 x 6.4	421	0.75x
					8.2 x 11	6.1 x 8.2	375	0.59x	11 x 14	7.9 x 11	669	0.45x
50					5.5 x 7.4	4.1 x 5.5	281	0.87x	5.8 x 7.8	4.4 x 5.8	412	0.82x
					7.4 x 9.8	5.5 x 7.4	361	0.65x	9.5 x 13	7.1 x 9.5	647	0.50x
60									5.0 x 6.6	3.7 x 5.0	400	0.97x
									7.9 x 11	5.9 x 7.9	614	0.61x

- Indicated values are based on calculation and actual measurements may differ. Use values as a reference.
- Accuracy of the products is guaranteed only when used without additional attachments.
  Please note that when using in combination with a close-up ring or other equipment
  Working distance and image will be distorted due to enlargement of the lens tolerance.

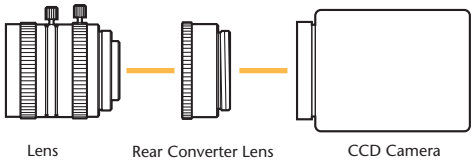
Rear Converter Lens

ML-X

Attaching these lenses between a CCTV lens and a CCD camera enables the adjustment of magnification without changing the working distance of the system.
*May decrease the resolution.

Model	Product Code
ML-1.5X	A-8090
ML-2X	A-8091
ML-2.5X	A-8092
ML-3X	A-8093
ML-4X	A-8094

Configuration



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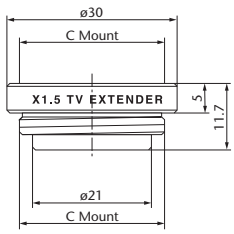

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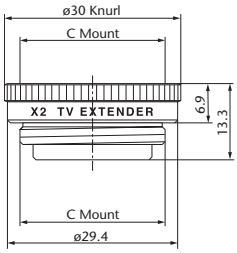

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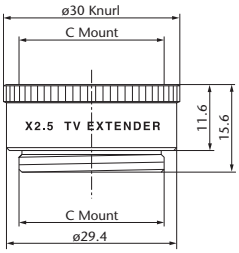
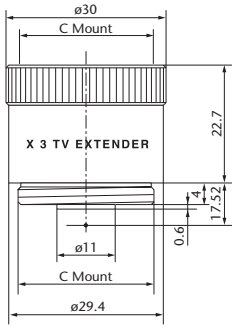
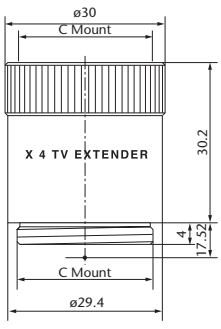


ML-3X



ML-4X



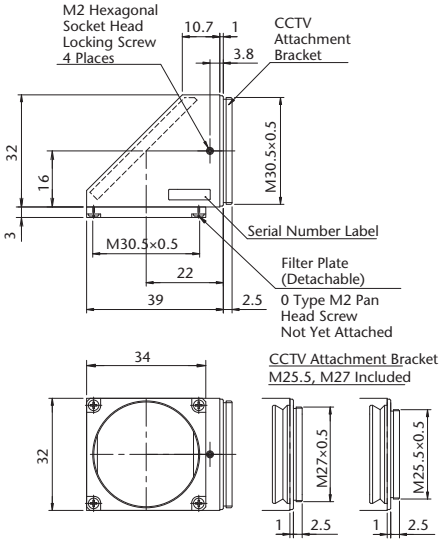
90° Mirror Prism

ML-MLC

- Fully supports CCTV M25.5, 27, and 30.5.
- Equipped with screws to attach filters.

Model	Product Code
ML-MLC	A-8014

ML-MLC



Options for CCTV Lenses

Glass Covers

ML-GA Series

A cover glass adapter for preventing the adhesion of dirt and foreign objects to the lens surface.

Polarizers (Analyzers)

ML-PL Series

A polarizer (analyzer) adapter with revolution function for suppressing glare from objects and localized flare when used as a set with polarizer illumination.

Ring Illumination Attachment Adapters

ML-FL Series

Ring illumination adapter ML-FL.

Options

Screw Pitch	255		270		305	
	Model	Product Code	Model	Product Code	Model	Product Code
Glass Covers	ML-GA255	A-8059	ML-GA270	A-8060	ML-GA305	A-8061
Polarizer	ML-PL255	A-8067	ML-PL270	A-8068	ML-PL305	A-8069
Polarizer (With Locking Screw)	ML-PL255LB	A-3130	ML-PL270LB	A-3131	ML-PL305LB	A-3132
Red Filter	ML-R60-25	A-8031	ML-R60-27	A-8032	ML-R60-30	A-8033
Sharp Cut Filter	ML-R64-25	A-9055	ML-R64-27	A-9056	ML-R64-30	A-9057
Close-Up Ring	ML-EXR					

Close-Up Ring

ML-EXR Series

Used when using the CCTV lens at a close distance or when enlarging the magnification.
See comparison table on page P.L-63 for the field of view, working distance, and magnification when close-up ring is attached.

Model	Remarks	Product Code
ML-EXR	Set of 7 (0.5, 1, 2, 5, 10, 20, 40)	A-8100
ML-EXR05	0.5mm	A-8101
ML-EXR1	1mm	A-8102
ML-EXR2	2mm	A-8103
ML-EXR5	5mm	A-8104
ML-EXR10	10mm	A-8105
ML-EXR15	15mm	A-8106
ML-EXR20	20mm	A-8107
ML-EXR25	25mm	A-8108
ML-EXR30	30mm	A-8109
ML-EXR40	40mm	A-8110
ML-EXR50	50mm	A-8111
ML-EXR100	100mm	A-8112
ML-EXR1520	Variable Type (15 to 20 mm)	A-8113
ML-EXR3042	Variable Type (30 to 42 mm)	A-8114

Coaxial Epi-illumination Unit for Objective Lens

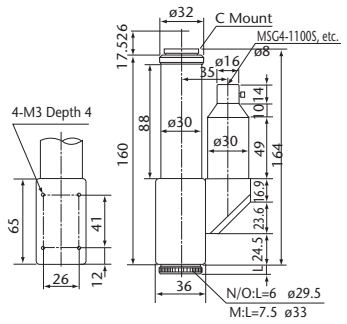
SOD-III Series

The SOD-III is an optical unit used for coaxial illumination with objective lenses. If you are using a metallurgical microscope, this unit is effective for image input because it produces video of the same level. It is designed for infinity corrected objective lenses (bright vision) and can be used with the lenses listed below. In addition to the monocular type, the 5-hole revolver type (manual and electric) is available, which can be mounted with 5 objective lenses,

- Compact design
- Compatible with various bright field lenses
- Enables horizontal and various other kinds of mountings

Model	Product Code
SOD-III	A-0171

SOD-III



Compact Objective Lens

Mitsutoyo

Model	NA	WD (mm)	Product Code
M Plan Apo 2 x	0.055	34	A-8132
M Plan Apo 5 x	0.14	34	A-8133
M Plan Apo 10 x	0.28	33.5	A-8134
M Plan Apo 20 x	0.42	20	A-8137
M Plan Apo SL 20 x	0.28	30.5	A-8135
M Plan Apo SL 50 x	0.42	20.5	A-8136

Nikon

Model	NA	WD (mm)	Product Code
CF IC EPI Plan 2.5 x	0.075	8.8	A-8143
CF IC EPI Plan 5 x	0.13	22.5	A-8144
CF IC EPI Plan 10 x A	0.3	16.5	A-8148
CF IC EPI SLWDPlan 10 x A	0.21	20.3	A-8145
CF IC EPI SLWDPlan 20 x A	0.35	20.5	A-8146
CF IC EPI SLWDPlan 50 x A	0.45	13.8	A-8147

Line Scan Lens for Line & Large Format Sensors

With the increasing number of line scan and large format applications, we have continued to expand our product offering beyond the compact telecentric lenses that have become an industry standard for area scan applications. We offer an assorted range of lens solutions designed for large format high resolution line and area scan cameras used for Glass, Web, TFT inspection and other applications which call for a high performance and low distortion lens. Our models support line image sensors from 2k to 12k with models compatible up to 90 mm wide and a pixel pitch of down to 5 µm.

Image Format

- Up to 90mm
- Up to 82mm
- Up to 62mm
- Up to 58mm
- Up to 35mm

Compatible Camera Pixel

- 5µm/Pixel
- 7µm/Pixel
- 10µm/Pixel

82 mm
10µm

NEW

Line Scan Lens for 3 Color Line Sensor

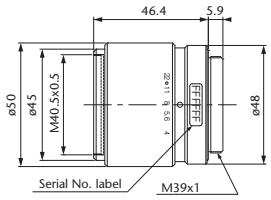
ML-F80C-0205

Designed to address the challenges of color line scan applications, this new low-magnification line scan lens features RGB chromatic aberration correction to provide excellent performance for line sensors up to 82mm. By utilizing flange focal distance magnification control, magnifications of 0.2X – 0.5X are achievable over varying working distances without the added cost of a complex zoom system.

Although this lens can be used for a wide-range of monochrome line sensor applications, the minimization of axial chromatic aberration and chromatic aberration of magnification make it ideal for high end LCD glass inspection, patterned wafer inspection, and web printing applications that call for a high performance, low distortion lens with minimal peripheral brightness fall-off for use with a 3 CCD color sensor.

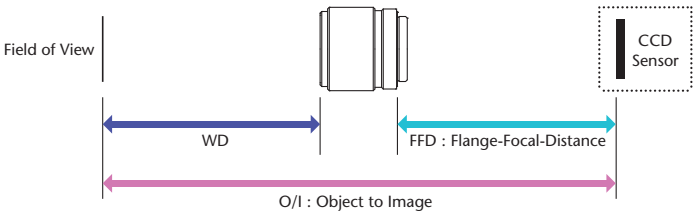
- Magnification adjustable 0.2 to 0.5x with flange focal distance adjustment
- Designed with RGB chromatic correction
- Maximum applicable sensor size: 82mm
- Variable iris

ML-F80C-0205



Magnification Range

Magnification control between 0.2x and 0.5x can be done by adjusting the flange focal distance.



Specifications at Different Magnifications

Magnification	WD (mm)	Field of View* ø(mm)	O/I (mm)	FFD (mm)
0.20x	476.83	410	601.75	78.56
0.25x	392.27	328	521.42	82.79
0.30x	335.9	273.33	469.28	87.02
0.35 x	295.64	234.29	433.25	91.25
0.40 x	265.44	205	407.27	95.47
0.45 x	241.95	182.22	388.02	99.7
0.50 x	223.16	164	373.45	103.93

*FOV for 62mm sensor in use

Formulas for calculating the magnification and WD of the ML-F80-0205

WD=(1 + M) f / M – A

FFD=(1 + M) f – B

f=84.55
A=30.50
B=22.90

Model	Focal Distance	Magnification	WD	Effective F No	Optical Distortion	Weight	Image Format	Mount	Product Code
ML-F80C-0205	84.55mm	0.2x ~ 0.5x	476.83mm~223.16mm	4~22	0.2%	186g	82mm	M39 x1	A-3180

* Mount adaptor is available on request. (i.e. BTO)

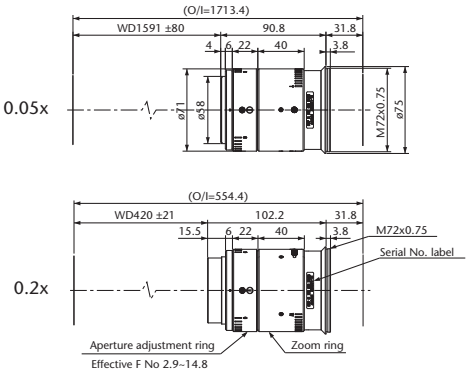
Line Scan Lens for 62mm Sensor

ML-L00502

This new low-magnification model ML-L series is suitable for of a wide range of applications with its adjusted magnification of 0.05 to 0.2x and WD of 420 to 1,590 mm. It can be used with image sensors of up to ø62 mm and was designed for image processing that requires peripheral light volume ratio of 80% or more with optical distortion of 0.1% or less.
The lens comes standard with a M72-FB31.8mm camera mount and optional mounting adapters such as M72-6.56/19.55 & TFL2 are available. Mounts for large format area scan cameras can also be provided.

- 0.05 to 0.2x magnification
- WD from 1590 to 420mm
- Supports 62mm sensors
- F2.9
- High uniformity >80%
- Low distortion, <0.1%
- Variable iris

ML-L00502



Model	Focal Distance	Magnification	WD	Effective F No	Optical Distortion	Weight	Image Format	Mount	Product Code
ML-L00502	78mm	0.05x ~ 0.2x	1590mm ~ 420mm	2.9~16.5	0.1%	-	62mm	M72 FB31.8	A-3164

62mm 5µm

Line Scan Lenses for 62mm Sensor

ML-L12K5A Series

The 12K5 Series consists of high resolution models with a large format design compatible with 12,000 bit, 5µm pixel line sensor cameras. Utilizing the various lens barrel & mount adapters, a large number of lens variations are possible allowing for flexibility. Very high light uniformity, low distortion, and high resolution are achieved by these models making them ideal for line scan and large format area scan applications.

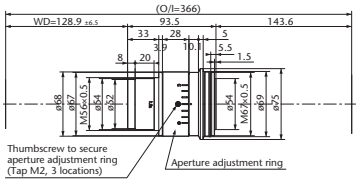
- A high-resolution model compatible with Pixel size 5µm.
- Maximum imager size of ø61.4.
- Equipped with base lens and various lens barrels making it compatible with all types of cameras.
- The barrel is equipped with camera adjustment ring.

Barrel Part

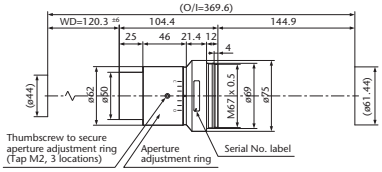
Model	Product Code
12K5-M72-6.56	A-3154
12K5-M72-31.8/19.55	A-3155
★ **12K5-FMT**	A-3160

★Made-to-order

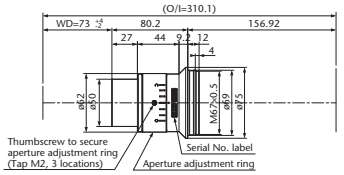
ML-L1.2-12K5A



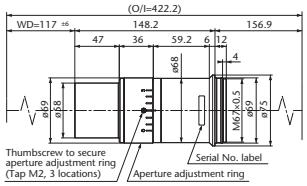
ML-L1.4-12K5A



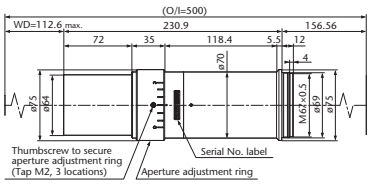
ML-L1.75-12K5A



ML-L2.4-12K5A



ML-L3.0-12K5A



Base Lens

Model	Focal Distance	Magnification	WD	Effective F No	Optical Distortion	Weight	Image Format	Mount	Product Code
★ **ML-L1.2-12K5A**	103.5mm	1.2x	128.9mm	7.4 - 44	0.05%	650g	62mm	Mount Adapter 12K5	A-3163
ML-L1.4-12K5A	100mm	1.4x	120mm	6.8 - 35	0.07%	850g	62mm	Mount Adapter 12K5	A-3152
ML-L1.75-12K5A	101mm	1.75x	73mm	7.4 - 24	0.09%	980g	62mm	Mount Adapter 12K5	A-3153
★ **ML-L2.4-12K5A**	98.5mm	2.4x	117mm	8.9- 55	0.03%	900g	62mm	Mount Adapter 12K5	A-3161
★ **ML-L3.0-12K5A**	112mm	3x	112.6mm	9.5 - 67.7	0.05%	1500g	62mm	Mount Adapter 12K5	A-3162

★Made-to-order

58 mm 7µm

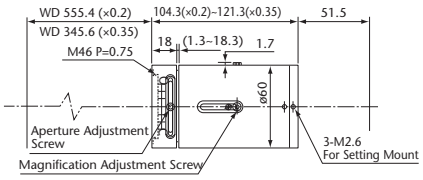
Line Scan Lenses for 57mm Sensor

ML-L02035/03505

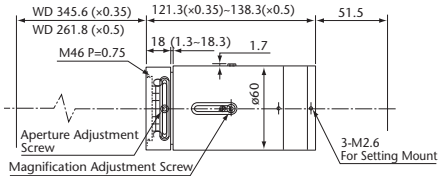
These are high performance lenses for use with 8,000 pixel Line Scan CCDs with element length of 57.3mm. Flexibility is provided by the variable magnification and focus adjustment included. Outstanding performance is achieved by minimizing the chromatic aberration and distortion.

- Advanced optical design for maximum 8000-bit (57.3mm)
- Advanced optical design for 1" mega pixel (2 million pixels~) area CCD
- Designed with variable magnification (0.2x~0.35x or 0.35x~0.5x)
- Low chromatic aberration and low distortion
- Designed for various mountings

ML-L02035



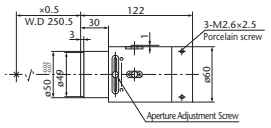
ML-L03505



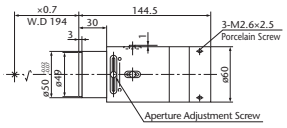
Model	Focal Distance	Magnification	WD	Effective F No	Optical Distortion	Weight	Image Format	Mount	Product Code
ML-L02035	100mm~101.6mm	0x2 ~ 0.35x	555.4mm ~ 345.6mm	5.8~36.6	0.1%	750g	58mm	Mount Adapter MT-S	A-0184
ML-L03505	101.6mm~103mm	035 x~ 0.5x	345.6mm ~ 261.7mm	6.6~41	0.1%	800g	58mm	Mount Adapter MT-S	A-0185

- Optimal for high speed processing of large fields of view.
- Low optical distortion, all models less than 0.1%
- Low marginal rays difference
- High resolution, high contrast
- Suitable for long working distance applications

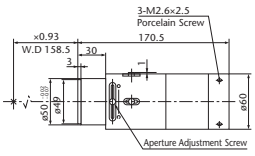
ML-L05



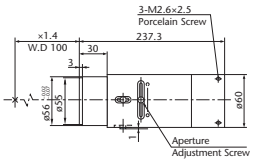
ML-L07



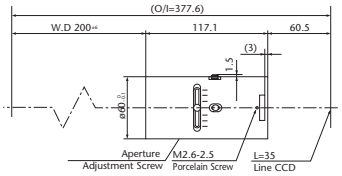
ML-L09



ML-L14



ML-L047-200 Made-to-order



Model	Focal Distance	Magnification	WD	Effective F No	Optical Distortion	Weight	Image Format	Mount	Product Code
ML-L05	102mm	0.5x	250.5mm	5.9 - 28	0.1%	700g	35mm	Mount Adapter MT	A-0179
ML-L07	103mm	0.7x	194mm	6.7 - 32	0.1%	800g	35mm	Mount Adapter MT	A-0180
ML-L09	104mm	0.933x	158.5mm	7.7 - 37	0.1%	800g	35mm	Mount Adapter MT	A-0181
ML-L14	103mm	1.4x	100mm	9.5 - 45	0.1%	800g	35mm	Mount Adapter MT	A-0182
ML-L047-200	95mm	0.47x	200mm	5.9 - 32	0.01%	720g	35mm	Mount Adapter MT	A-0183

* Depth of field is calculated based on resolution.
* Resolution values indicate the theoretical resolution at a wavelength of 550nm.

Camera Mount (Optional)

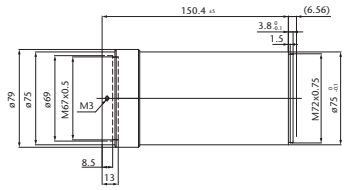
Reference Chart for Line Scan Lens Selection

	Image Format / Pixel Size				Mount						
	35mm/7μm	58.4mm/7μm	61.4mm/5μm	82mm/10μm Color	C-mount	F-mount	M72			TFL2	M39
							DALSA Piranha2	DALSA Piranha3	NED		
ML-F80C-0205	○	○	○	○	○ *1	○ *1	○ *1	○ *1	○ *1	○ *1	○ *2
ML-L12K5A Series	○	○	○	×	○ *1	○	○	○	○	×	×
ML-L00502	○	○	○	×	○ *1	×	○	○	○ *2	○	×
ML-L02035/03505	○	○	△ *3	×	○	○	○	△ *3	×	×	×
ML-L Series	○	×	×	×	○	○	×	×	×	×	×

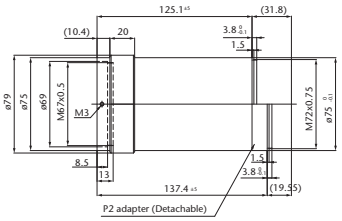
*1 Mount adaptor is available on request. (i.e. BTO)
*2 Directly mountable as standard.
*3 Optional camera mounts available, but the imaging area may be affected by relatively small image circle of the lens.

For ML-L12K5A

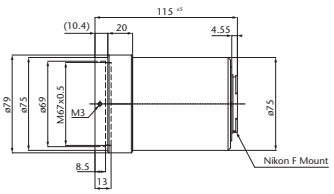
12K5-M72-6.56



12K5-M72-31.8/19.55



12K5-FMT

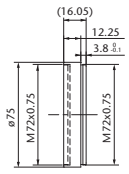


Model	12K5-M72-6.56	12K5-M72-31.8/19.55	12K5-FMT ★
Mount Name	DALSA Piranha3 Mount	NED Mount/DALSA Piranha 2 Mount	Nikon F Mount
Product code	A-3154	A-3155	A-3160

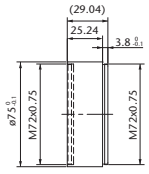
★Made-to-order

For ML-L00502

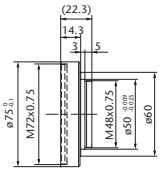
L00502-M72-19.55



L00502-M72-6.56



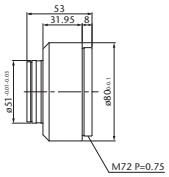
L00502-TFL2



Model	L00502-M72-19.55	L00502-M72-6.56	L00502-TFL2
Mount Name	DALSA Piranha 2 Mount	DALSA Piranha3 Mount	TFL2 Mount
Product code	A-3168	A-3169	A-3170

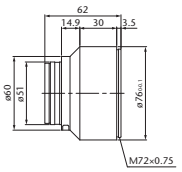
For ML-L02035/03505

P2MT-S



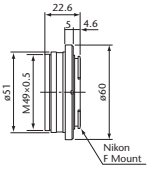
DALSA Piranha 2 Mount

P3MT-S



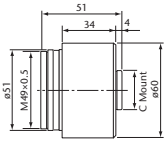
DALSA Piranha 3 Mount

FMT-S



Nikon F Mount

CMT-S



C Mount

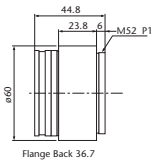
*MORITEX can also provide mounts from various other manufacturers.

Model	P2MT-S ★	P3MT-S ★	FMT-S	CMT-S
Mount Name	DALSA Piranha 2 Mount	DALSA Piranha 3 Mount	Nikon F Mount	C Mount
Product code	A-0195	A-0196	A-0193	A-0194

★Made-to-order

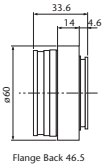
For ML-L Series

MMT



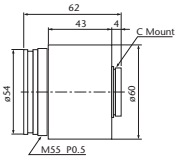
NED Compatible Mount

FMT



Nikon Mount

CMT



C Mount

Model	MMT	FMT	CMT
Mount Name	NED Compatible Mount	Nikon Mount	C Mount
Product code	A-0191	A-0189	A-0192

Carl Zeiss

VISIONMES®

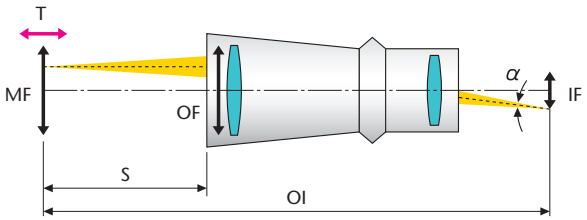
For Distortion-free Imaging

VISIONMES® Telecentric Lens

Carl Zeiss

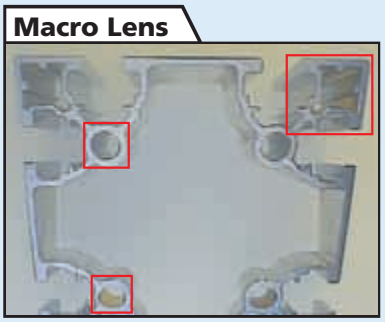
Ultimate Measuring Environment with Outstanding Performance

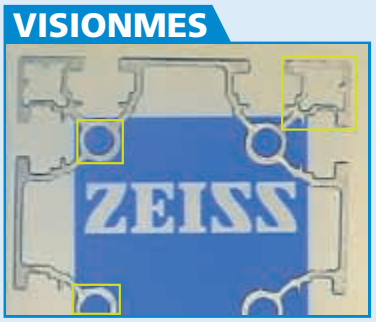
- The ultimate in distortion-free images.
- Able to recognize accurate images of the structure and form of complicated objects.
- A high performance optical lens that presents quality at the HDTV level.
- High numerical aperture (NA) enables the achievement of a bright image even in a short exposure time.
- Lineup offering a maximum diameter of ø300mm.

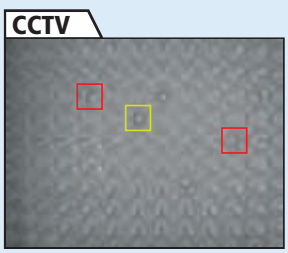


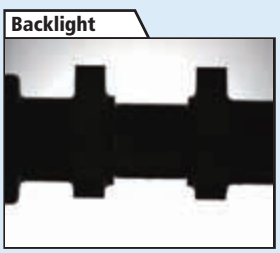
MF	Measurement Field	Measurement range (Length × Width)
OF	Object Field	Lens opening diameter at object side (ø mm)
IF	Image Field	CCD element surface
OI	Distance Between Object & Image	Distance from object surface to CCD element
S	Working Distance	Distance from end of metal material to focus position
T	Telecentric Range	Range in which measurement of an accurate image is possible if the object moves up and down
Sin α	Numerical Aperture	
Mag.	Magnification	Image field ÷ Object field

Sample Images

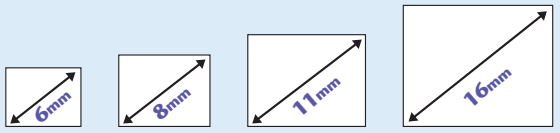




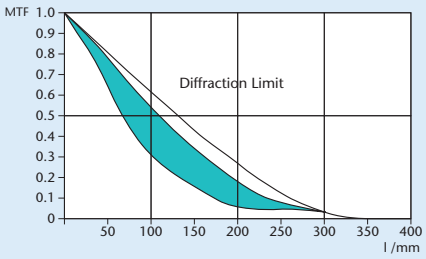




CCD Image Field



HDTV Level High Image Quality



Application

Early detection of defects by performing batch inspections at various inspection points on the production line.

Molding • Casting	Wide-range, 3D inspection for dimension measurements (internal diameter, external form, diameter, concentricity)
Semiconductors	Inspection for uneven surfaces and damage in silicon wafers, pattern verification
Various Parts	Mass batch inspection without contact for bolts, wipers, screws, plastic parts, plastic bottles and rubber products

Optical Specifications

Telecentric Lens for 1/3" CCD Camera (Angle 6mm)

Model	Object Field (mm)	CCD (mm)	Image Side NA	Working Distance WD (mm)	Telecentric Range (mm)	Depth of Field (mm)	Magnification (x)	Measurement Field (mm)
18/6/0.05	18	6	0.05	66	+/–10	+/–3	0.33	10x14
35/6/0.1	35	6	0.1	67	+/–2.5	+/–7.5	0.17	20x27
70/6/0.1	70	6	0.1	113	+/–13	+/–25	0.086	41x55
105/6/0.1	105	6	0.1	182	+/–16	+/–50	0.057	62x82

Telecentric Lens for 1/2" CCD Camera (Angle 8mm)

Model	Object Field (mm)	CCD (mm)	Image Side NA	Working Distance WD (mm)	Telecentric Range (mm)	Depth of Field (mm)	Magnification (x)	Measurement Field (mm)
11/8/0.01	11	8	0.01	160	+/–9	+/–6	0.72	6x8
35/8/0.1	35	8	0.1	64	+/–2	+/–4	0.228	21x28
70/8/0.1	70	8	0.1	103	+/–10.5	+/–16	0.114	43x55
105/8/0.1	105	8	0.1	171	+/–12	+/–33	0.076	65x83
150/8/0.1	150*	8	0.1	225	+/–35	+/–75	0.05	93x118
225/8/0.1	225*	8	0.1	340	+/–55	+/–165	0.035	140x177
300/8/0.1	300*	8	0.1	450	+/–75	+/–300	0.026	187x236

Telecentric Lens for 2/3" CCD Camera (diagonal 11 mm)

Model	Object Field (mm)	CCD (mm)	Image Side NA	Working Distance WD (mm)	Telecentric Range (mm)	Depth of Field (mm)	Magnification (x)	Measurement Field (mm)
11/11/0.02	11	11	0.02	54	+/–2.5	+/–1.25	1	6x8
11A/11/0.02	11A (Made-to-Order)	11	0.02	17	+/–5	+/–1.25	1	6x8
11B/11/0.02	11B (Made-to-Order)	11	0.02	54	+/–5	+/–1.25	1	6x8
13/11/0.01	13	11	0.01	65	+/–2	+/–1	0.846	8x10
22/11/0.05	22	11	0.05	66	+/–2.5	+/–2	0.5	13x17
22A/11/0.05	22A	11	0.05	56	+/–5	+/–2	0.5	13x17
35/11/0.1	35	11	0.1	58	+/–1.4	+/–2	0.314	21x28
70/11/0.1	70	11	0.1	75	+/–8	+/–9	0.157	43x55
105/11/0.1	105	11	0.1	121	+/–10	+/–20	0.104	65x83
150/11/0.1	150*	11	0.1	165	+/–25	+/–38	0.07	90x120
225/11/0.1	225*	11	0.1	250	+/–44	+/–90	0.048	135x180
300/11/0.1	300*	11	0.1	335	+/–55	+/–150	0.036	180x240

Telecentric Lens for 1" CCD Camera (Angle 16mm) (Made-to-Order)

Model	Object Field (mm)	CCD (mm)	Image Side NA	Working Distance WD (mm)	Telecentric Range (mm)	Depth of Field (mm)	Magnification (x)	Measurement Field (mm)
8/16/0.08	8*	16	0.08	50	+/–1	+/–0.05	2	3x4
16/16/0.1	16*–LD	16	0.1	92	+/–2	+/–0.2	1	6x9
32/16/0.1	32*	16	0.1	78	+/–4	+/–0.8	0.5	13x17
70/16/0.1	70*	16	0.1	58	+/–4	+/–4	0.23	40x40
150/16/0.1	150*	16	0.1	110	+/–20	+/–17	0.1	86x86
300/16/0.1	300*	16	0.1	230	+/–40	+/–60	0.05	172x172

Telecentric Lens for 1.1" CCD Camera (Angle 18mm)

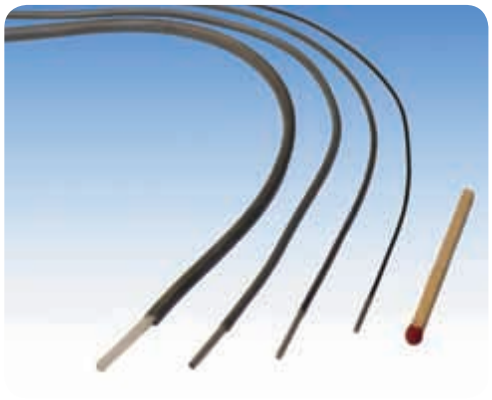
Model	Object Field (mm)	CCD (mm)	Image Side NA	Working Distance WD (mm)	Telecentric Range (mm)	Depth of Field (mm)	Magnification (x)	Measurement Field (mm)
6/18/0.029	6	18	0.029	85	+/–1	+/–0.1	3	2x3

A = Object side lens (90° L-shaped type)
B = Imaging side lens (90° L-shaped type)

* = Variable aperture model
LD = Long working distance

For Flexible Imaging Applications

Leached Image Bundles



Leached Fiber Bundles are used primarily in endoscopes for medical, veterinary or industrial applications. Custom Leached Fiber Bundles are available on demand.

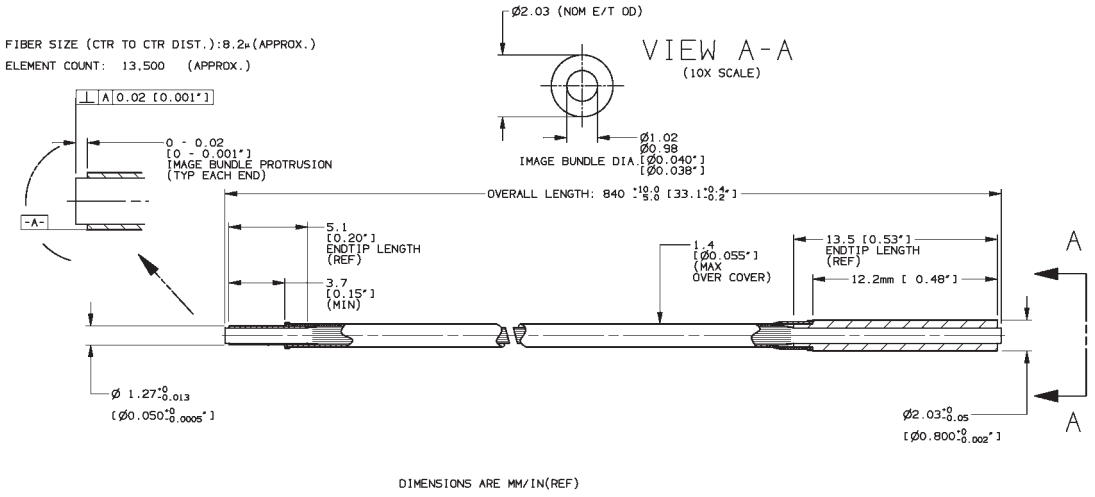
- Very flexible, coherent image guides
- They are built by multiple draws of a high index core glass, with a lower index clad glass and an acid-soluble second cladding.
- Bundle diameter from 0.53 mm to 1.93 mm that can be used in endoscopes for space limited medical and industrial imaging applications.
- Bundle length up to 2000 mm
- High resolution image transfer with fiber sizes from 7µm

Part #	Bundle Diameter (mm)	Bundle Length (mm)	Quality Area A (mm)	Quality Area A Spec	Quality Area B (mm)	Quality Area B Spec	Pixel	Pixel Count	Distal	Proximal	Sheathing Internal Diameter / Wall Thickness mm
1233268	0.45	1000	0.38	6/2/1/0	0.19	2/0/0/0	7.4µ	3.5k	0.55 x 4 .80	0 .64 x 11.80	0.56/0.03
1248848	0.53	1000	0.43	6/2/1/1	0.22	2/0/0/0	7.5µ	4.5k	0.65 x 4.50	1.00 x 12.00	0.6/0.03
1249048	0.53	1050	0.43	6/2/1/1	0.22	2/0/0/0	7.5µ	4.5k	0.65 x 4.50	1.00 x 12.00	0.66/0.03
1249050	0.57	840	0.45	6/2/1/1	0.23	2/0/0/0	8.0µ	4.5k	0.77 x 5.00	1.05 x 15.00	0.9/0.1
1249180	0.57	1000	0.45	6/2/1/1	0.23	2/0/0/0	8.0µ	4.5k	0.77 x 5.00	1.05 x 15.00	0.76/0.1
1246781	0.70	535	0.58	6/2/1/1	0.29	2/0/0/0	7.5µ	8.2k	0.84 x 4.00	0.96 x 12.00	0.86/0.05
1245159	0.70	760	0.58	6/2/1/1	0.29	2/0/0/0	7.5µ	8.2k	0.88 x 5.00	1.56 x12.50	0.86/0.03
1230772	0.70	1000	0.58	6/2/1/1	0.29	2/0/0/0	7. 5µ	8.2k	0.83 x 5.00	0.94 x 12.00	1.0/0.1
1249311	1.00	670	0.80	6/2/1/1	0.40	2/0/0/0	8.2µ	13.5k	1.27 x 5.10	2.03 x 13.50	1.3/0.1
1249600	1.00	840	0.80	6/2/1/1	0.40	2/0/0/0	8.2µ	13.5k	1.27 x 5.10	2.03 x 13.50	1.3/0.1
1249347	1.00	840	0.80	6/2/1/1	0.40	2/0/0/0	8.2µ	13.5k	1.16 x 5.10	1.60 x 10.00	1.3/0.1
1249605	1.00	890	0.80	6/2/1/1	0.40	2/0/0/0	8.2µ	13.5k	1.27 x 5.10	2.03 x 13.50	1.3/0.1
1249626	1.00	890	0.80	6/2/1/1	0.40	2/0/0/0	8.2µ	13.5k	1.16 x 5.10	1.60 x 10.00	1.3/0.1
1249753	1.00	1000	0.80	6/2/1/1	0.40	2/0/0/0	8.2µ	13.5k	1.27 x 5.10	2.03 x 13.50	1.3/0.1
1233216	1.05	540	0.90	6/2/1/1	0.45	2/0/0/0	7.6µ	18k	1.22 x 5.60	1.22 x 12.80	1.4/0.1
1250722	1.05	760	0.89	6/2/1/1	0.45	2/0/0/0	7.4µ	18k	1.22 x 5.60	1.22 x 12.80	1.4/0.1
1251172	1.10	670	0.90	6/2/1/1	0.45	2/0/0/0	8.0µ	18.k	1.27 x 5.00	2.03 x 13.50	1.47/0.1
1251338	1.10	690	0.90	6/2/1/1	0.45	2/0/0/0	8.0µ	18.k	1.27 x 7.00	2.03 x 13.50	1.47/0.1
1251343	1.10	840	0.90	6/2/1/1	0.45	2/0/0/0	8.0µ	18.k	1.27 x 5.00	2.03 x 13.50	1.47/0.1
1251348	1.10	895	0.90	6/2/1/1	0.45	2/0/0/0	8.0µ	18k	1.27 x 5.00	2.03 x 13.50	1.47/0.1
1250875	1.2	520	1.05	6/2/1/1	0.53	2/0/0/0	8.4µ	18k	1.38 x 4.00	1.60 x 10.00	1.6/0.1
1233217	1.2	580	1.05	6/2/1/1	0.53	2/0/0/0	8.4µ	18k	1.38 x 4.00	1.38 x 10.00	1.6/0.1
1244311	1.3	545	1.15	6/2/1/1	0.575	2/0/0/0	9.1µ	18K	1.42 x 5.00	1.42 x 14.00	1.6/0.1
1251040	1.50	1350	1.30	6/2/1/1	0.65	2/0/0/0	10.6µ	18.k	1.84 x 6.50	1.98 x 15.00	2.03/0.1
1251167	1.65	1350	1.45	6/2/1/1	0.73	2/0/0/0	11.6µ	18.k	2.19 x 7.80	2.46 x 15.00	2.2/0.1

Leached Fiber Bundle

Dimensions: in (mm); not to scale

Leached Fiber Bundle, 1249600



For Ruggedized Flexible Imaging Applications

Wound Fiber Bundles

Wound Fiber Bundles are used in a wide range of applications, including industrial remote vision systems, ordered array detectors, hazardous environment imaging, defense and research. Custom Wound Fiber Bundles are available on demand.

- Coherent, flexible fiber optic bundle used in applications where images must be transmitted from remote locations
- They are composed of individual multi fibers, wound one layer at a time on a drum, bound only at the ends and flexible in the middle.
- Bundle formats from 2 mm x 2 mm up to 40 mm x 35 mm. May be divided into - or made up of - multiple branches transmitting to a single output, or input.
- Their numerical aperture is typically 0.60 and standard lengths range from 610 mm to 4500 mm.
- We can also produce custom image guide assembles in any vertical or horizontal format required to meet nonstandard Wound Fiber Bundles imaging applications.

Wound Fiber Bundles

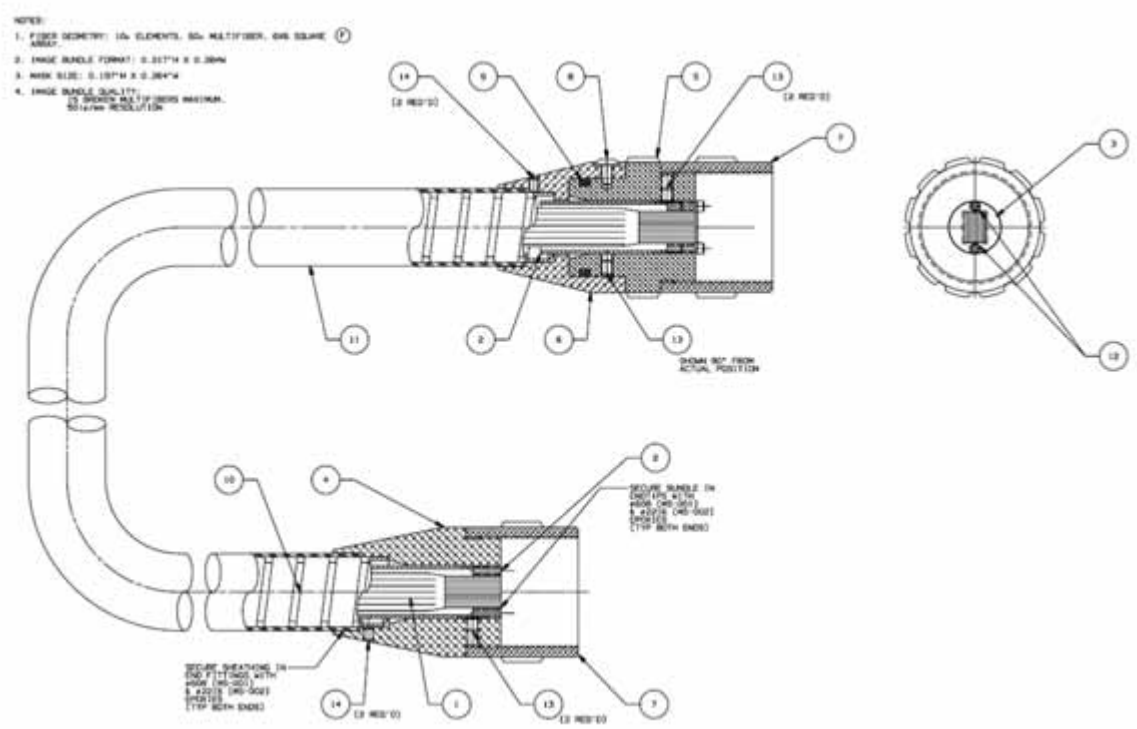
Wound Fiber Bundles Typical Specifications:

Glass Type	SCHOTT 75 Glass
Quality Area	1.8 mm x 1.8 mm - 38 x 33 mm with custom capabilities
Format Size	2 mm x 2 mm up to 40 mm x 35 mm
Single Fiber Size	10µm elements 6 x 6 array
Numerical Aperture	0.60
Resolution	45 lp/mm
Transmission	40% @ 500 nm - 1200 nm
Bending Radius	Determined by bundle diameter and sheathing
Temperature Resistance	- 40 °C to +125 °C (-40 °F to + 257 °F) up to 150 °C (302 °F) with alternative jacketing
Chemical Rsistance	Select sheathing resistant against oil, grease, bases acid, fuel, water and PVC

Wound Fiber Bundles

Dimensions: in (mm); not to scale

WoundFiber Bundle 1119683



Wound Fiber Bundles 4 mm x 4 mm Format

Description	Part No.	Length (mm)	Flexible length (mm)
Flexible .500" diameter cable 4 mm x 4 mm Format +/- .2mm	1119691	606	530
	1119690	906	830
	1119689	1216	1140
	1119688	1826	1750
	1119687	2756	2680
	1119693	3806	3730
	1119692	4566	4490

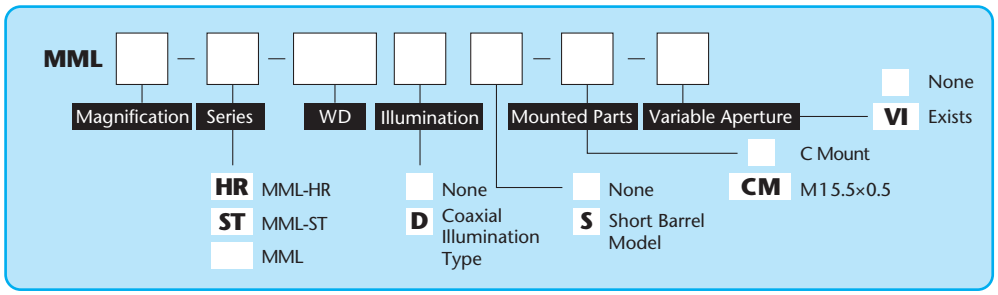
Wound Fiber Bundles 5 mm x 6.7 mm Format

Description	Part No.	Length (mm)	Flexible length (mm)
Flexible 1.300" diameter calbe 5 mm x 6.7 mm Format +/- .2 mm	1119683	886	810
	1119682	1116	1040
	1119681	1796	1720
	1119680	2716	2640
	1119686	3776	3700
	1119685	4536	4460
	1119692	4566	4490

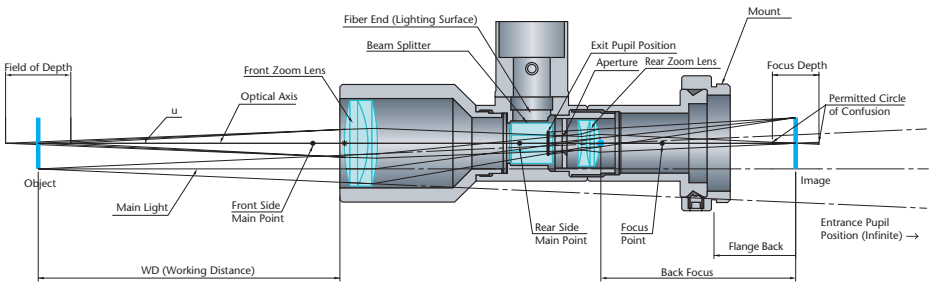
Wound Fiber Bundles 8 mm x 10 mm Format

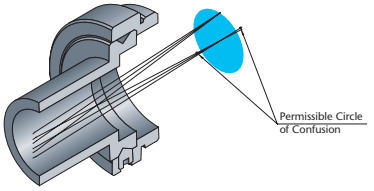
Description	Part No.	Length (mm)	Flexible length (mm)
Flexible 1.300" diameter calbe 8 mm x 10mm Format +/- .2 mm	1119148	886	810
	1119147	1216	1140
	1119145	1796	1720
	1119144	2716	2640
	1119150	3776	3700
	1119149	4536	4460
	1119692	4566	4490

Explanation of Model Code



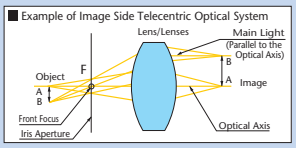
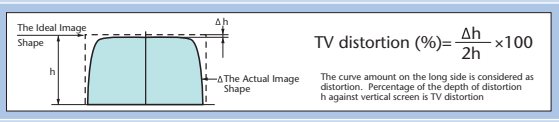
Data and Glossary





*This diagram is intended for the purpose of explaining technology. The positions and distances shown in this diagram are not necessarily accurate.

Performance

Telecentric Optics	An optical system where the principal ray is parallel to the lens optical axis. An optical system where the light comes from an object toward a lens and stays parallel to the optical axis, even outside the axis, is called object side telecentric optics. A system where the light comes from a lens toward an image and stays parallel to the optical axis, even outside the axis, is called image side telecentric optics. Telecentric optics indicated in this catalog are object side telecentric optics. 
Resolution (μm)	Resolution is a measured by how closely 2 points can be before they cannot be distinguished. For example, 1μm resolution means that 2 points that are 1μm away from each other can be distinguished. Resolution values in this catalog are theoretical resolutions for the lenses. The following is a formula to calculate theoretical resolution based on a lens's ray diffraction with no aberration. (Rayleigh formula) $\text{Resolution}=\frac{0.61\times\lambda}{NA}$ λ : Wavelength 0.61: Fixed Number
Resolving Power (Lines/ mm)	Resolving power indicates the number of black and white lines distinguished within 1mm in an image through a black and white grid-like chart lens. Resolving power is expressed by lines/ mm. For example, 100 lines/mm means that black and white pitch 1/100mm (10μm) can be distinguished. Width of both the black and white lines is 1/200mm (5μm).
Horizontal TV Resolution (TV lines)	The total number of black and white horizontal stripes in the width, equivalent to the height of the vertical height on a TV monitor screen. The total stripes in the horizontal width would be 3/4, because the ratio of vertical and horizontal length of the screen is usually 3:4. When the horizontal TV resolution is 240TV lines, total stripes in the horizontal width of the TV monitor would be 320 lines. When measuring resolution of a lens, a pair of black and white lines is counted as one line. However, for TV lines, one pair is counted as 2TV lines.
Distortion (%)	Distortion is the aberration of a lens where a straight object outside of the optical axis appears curved. Distortion of a straight line towards the center is called pincushion distortion, while distortion expanding outwards is called barrel distortion 
TV Distortion (%)	Image distortion on a TV monitor. The closer to zero, the better the performance. 
Aperture EfficiencyMarginal Light Quantity (%)	Aperture efficiency indicates the brightness difference between the optical axis of the image formation plane and its surrounding area when an evenly bright object is captured with a lens. It is expressed by percent (%) assuming that the center brightness is 100. It is one of the optical characteristics of a lens. Marginal light quantity in this catalog indicates aperture efficiency.
Shading (%)	Shading is the brightness difference between the center of a TV monitor and its edges when an evenly bright object is captured with a lens and a CCD-TV camera. It is expressed by percent (%). Generally, this percentage is calculated based on power ratio of light receiving elements and CCD elements. Shading indicates comprehensive performance of a lens and TV camera. To make shading smaller, telecentric optics is used.
Chromatic Aberration	In lens optics, positions where images are formed and image magnification differ according to the light's wavelength. Rays of different wavelengths have different colors. This is called chromatic aberration. Aberration on the optical axis is called chromatic aberration on the axis, and magnification difference is called magnification chromatic aberration.

Distance

WD (Working Distance) (mm)

Distance from the front end of a lens system to the object under inspection.

Focal Distance f (mm) Back Focus / Front Focus

Focal distance is the distance from the optical system's principle point to the focal point. Distance from the vertex of the last lens to the back focal point is called back focus. Distance from the vertex of the first lens to the front focal point is called front focus.

Depth of Field

Depth is the distance between the nearest and farthest points that appear in acceptably sharp focus when an object is shifted back and forth from the best focal point. Depth range of the object side is called depth of field.

Depth of Field = 2 (Permissible Circle of Confusion x Effective F No Magnification^2)

Images through lenses theoretically form as points. Acceptable blur on an acceptably clear image is called the permissible circle of confusion

Depth of Focus

Depth is the distance between the nearest and farthest points that appear in acceptably sharp focus when a CCD is shifted back and forth from the best focal point. Depth range of the image side is called depth of focus.

Flange Back (mm)

Distance from the front of the camera mount plane to the image.

C-Mount Specifications

Name	Standard External Diameter	No. of Screw Threads (for 25.4mm)	Flange Back
U1	25.400mm	32 Threads	17.526mm

Brightness

Numerical Aperture NA, NA'

When the half angle that an object makes on the entrance pupil is u, and refractive index is n, n x sin u is called object side numerical aperture, NA.
When the half angle that an image makes on exit pupil is u', and refractive index is n', n' x sin u' is called image side numerical aperture, NA'.
NAs in this catalog indicate object side numerical apertures. Numerical aperture is an important value that expresses lens resolution and brightness.

NA=n x sin u NA'=n' x sin u'

The higher the NA, the greater the resolution and brightness are of the lens.

F Number F No

The value indicates lens brightness. It is calculated by dividing the focal distance of the lens by its effective diameter (entrance pupil diameter D mm) looking from its object side. It can also be calculated by NA and the lens' optical magnification (β). The smaller the number the brighter the lens is.

F No=f/D

Effective F No

The value indicates lens brightness when an object is located in finite distance, the value which indicates the brightness when actually operated. The higher the optical magnification (β), the darker the lens is.

Effective F No=β /(2 x NA)=1/(2 x NA')
Effective F No= (1+β) x F No*

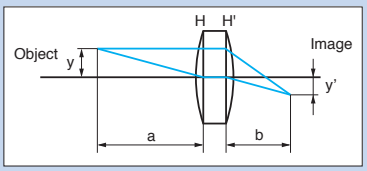
*Approximation for Thin-Walled Systems

Magnification

Optical Magnification β

Image size ratio against the object size.

β =y'/y
=b/a
=NA/NA'
=CCD Camera Element Size / Actual Size of Dield of View



Electronic Magnification

Electronic magnification is the magnification of an image on a CCD camera when it is displayed on a monitor screen.

Monitor Magnification

Monitor magnification is the magnification of an object displayed on a monitor screen through a lens.

Monitor Magnification = (Optical Magnification β) x (Electronic Magnification)

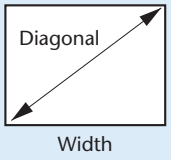
(Calculation Example) Optical Magnification β= 0.2x, CCD Size 1/2" (Diagonal Line 8mm), Monitor 14" :
Electronic Magnification =14 x 25.4 β 8 = 44.45 (Times)
Monitor Magnification = 0.2 x 44.45= 8.89 (Times) (1 Inch = 25.4mm)

Field of View

Field of view is the size of an object that can be shot when the lens is attached to a CCD-TV camera.
The size of field of view is (CCD format size) ÷ (optical magnification β).

(Calculation Example) Optical Magnification β=0.2x, CCD Size 1/2" (4.8mm Long, 6.4mm Wide) :
Size of Field of View Length =4.8/0.2=24 (mm)
Width =6.4/0.2=32 (mm)

Size of CCD Camera Elements



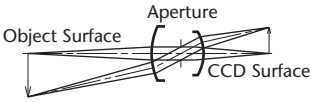
Type	Aspect Ratio	Length mm	Width mm	Diagonal mm
1/6"	4:3	1.73	2.3	2.878
1/4"	4:3	2.4	3.2	4
1/3"	4:3	3.6	4.8	6
1/2"	4:3	4.8	6.4	8
1/1.8"	4:3	5.3	7.2	8.9
2/3"	4:3	6.6	8.8	11
1"	4:3	9.6	12.8	16
4/3"	4:3	13.5	18	22.5

Formula

Resolution (μm)	=	0.61(Fixed Number)×0.55(Design Wavelength)÷NA
Effective F No	=	Magnification / 2NA
Depth of Field (mm)	=	2 (Permissible Circle of Confusion Diameter × Effective F No ÷ Magnifications^2)
Light Flux Diameter (ø)	=	2NA × Height from Object + Size of Field of View (Angle)

Features of Telecentric Optical System

Non-Telecentric Lens



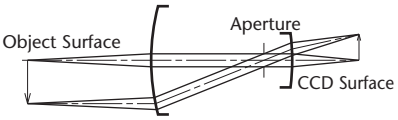
Advantages

Smaller size.
Cost-saving because the number of lenses is fewer.

Disadvantages

Object size or position varies as the object surface moves up and down.

Object Side Telecentric Lens



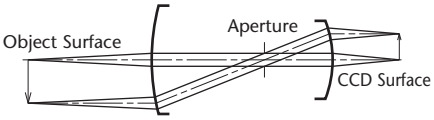
Advantages

Object size does not change even when the object surface moves up and down.
Smaller size is possible when coaxial illumination is used.

Disadvantages

Larger than regular lenses when coaxial illumination is not used.

Double-Sided Telecentric Lens



Advantages

Similar to MML. However, accuracy improves when the size of camera flange back differs greatly.

Disadvantages

Similar to MML. However, higher cost than MML.

Example of Attachment

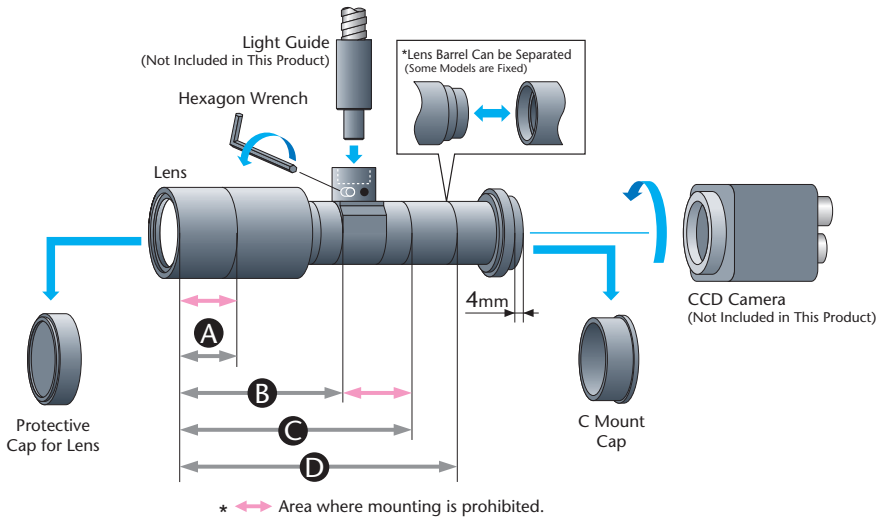


Chart for Positions That Cannot be Held, and That Can be Separated

Model	A	B	C	D
MML-HR 5M Series				
MML03-HR65D-5M	20	68	111	102
MML03-HR65-5M	20	68	111	102
MML05-HR65DVI-5M	10	65	105	—
MML05-HR65VI-5M	10	65	105	—
MML1-HR65DVI-5M	16	36	64	—
MML1-HR65VI-5M	16	36	64	—
MML2-HR65DVI-5M	27	39	68	—
MML2-HR65VI-5M	27	39	68	—
MML3-HR65DVI-5M	10	37	90	—
MML3-HR65VI-5M	10	37	90	—
MML4-HR65DVI-5M	10	37	89	—
MML4-HR65VI-5M	10	37	89	—
MML014-HR110D-5M	20	96	—	—
MML03-HR110D-5M	20	69	114	104
MML03-HR110-5M	20	69	114	104

Model	A	B	C	D
MML-HR Series				
MML05-HR65D	10	25	69	61
MML05-HR65	10	25	69	61
MML08-HR65D	15	35	64	59
MML08-HR65	15	35	64	59
MML1-HR65D	15	33	53	53
MML1-HR65	15	33	53	53
MML1.5-HR65D	11	23	41	44
MML1.5-HR65	11	23	41	44
MML2-HR65D	15	25	46	46
MML2-HR65	15	25	46	46
MML4-HR65D	20	26	47	86
MML4-HR65	20	26	47	86
MML6-HR65D	20	30	47	101
MML6-HR65	20	30	47	101
MML4-HR65DVI	20	26	58	86
MML6-HR65DVI	20	30	62	101
MML05-HR110D	11	67	102	93
MML05-HR110	11	67	102	93
MML08-HR110D	20	65	91	82
MML08-HR110	20	65	91	82
MML1-HR110D	30	64	95	81
MML1-HR110	30	64	95	81
MML1.5-HR110D	13	50	76	72
MML1.5-HR110	13	50	76	72
MML2-HR110D	20	43	70	68
MML2-HR110	20	43	70	68
MML4-HR110D	20	44	120	107
MML6-HR110D	15	48	120	110

Model	A	B	C	D
MML-ST Series				
MML1-ST40D	11	17	34	37
MML1-ST40	11	17	34	—
MML1.5-ST40D	10	14	30	34
MML1.5-ST40	10	14	30	—
MML2-ST40D	9	12	27	32
MML2-ST40	9	12	27	—
MML3-ST40D	9	12	27	32
MML3-ST40	9	12	27	—
MML4-ST40D	10	10	27	31
MML4-ST40	10	10	27	—
MML6-ST40D	10	10	27	31
MML6-ST40	10	10	27	—
MML8-ST40D	10	10	27	31
MML8-ST40	10	10	27	—
MML08-ST65D	15	39	62	59
MML08-ST65	15	39	62	59
MML1-ST65D/-CM	15	33	53	53
MML1-ST65/-CM	15	33	53	—
MML1.5-ST65D/-CM	11	23	41	44
MML1.5-ST65/-CM	11	23	41	—
MML2-ST65D	15	25	46	46
MML2-ST65	15	25	46	—
MML2-ST65DS/-CM	20	20	40	40
MML2-ST65S/-CM	20	20	40	—
MML3-ST65DS/-CM	17	17	47	38
MML3-ST65S/-CM	17	17	47	—
MML4-ST65D	20	26	47	85
MML4-ST65	20	26	47	—
MML4-ST65DS/-CM	18	18	34	55
MML4-ST65S/-CM	18	18	34	—
MML6-ST65D	20	30	47	100
MML6-ST65	20	30	47	—
MML6-ST65DS/-CM	18	18	55	55
MML6-ST65S/-CM	18	18	55	—
MML8-ST65DS	18	18	55	55
MML8-ST65S	18	18	55	—
MML08-ST110D	20	65	93	85
MML08-ST110	20	65	93	85
MML1-ST110D	20	50	75	75
MML1-ST110	20	50	75	75
MML2-ST110D	20	44	68	64
MML2-ST110	20	44	68	—
MML2-ST110DS/-CM	12	27	50	48
MML2-ST110S/-CM	12	27	50	—
MML3-ST110DS/-CM	12	27	50	48
MML3-ST110S/-CM	12	27	50	—
MML4-ST110D/-CM	15	29	68	49
MML4-ST110/-CM	15	29	68	—

Model	A	B	C	D
MML6-ST110D/-CM	15	29	68	49
MML6-ST110/-CM	15	29	68	—
MML8-ST110D/-CM	15	29	68	49
MML8-ST110/-CM	15	29	68	—
MML12-ST110D	15	29	68	49
MML1-ST150D	10	74	91	91
MML1-ST150	10	74	91	91
MML08-ST170D	10	74	91	91
MML08-ST170	10	74	91	91
MML05-ST300DVI	14	99	134	—
MML1-ST300D	25	100	150	190
MML3-ST300DVI	23	87	171	—
MML4-ST300DVI	23	87	171	—

Chart for Field of View

Magnification	Sensor Size											
	2/3"			1/1.8"			1/2"			1/3"		
	Length	Wides	Angle	Length	Wides	Angle	Length	Wides	Angle	Length	Wides	Angle
0.1x	66.00	88.00	110.00	53.19	71.76	89.32	48.00	64.00	80.00	36.00	48.00	60.00
0.14x	47.14	62.86	78.57	37.99	51.26	63.80	34.29	45.71	57.14	25.71	34.29	42.86
0.16x	41.25	55.00	68.75	33.24	44.85	55.83	30.00	40.00	50.00	22.50	30.00	37.50
0.18x	36.67	48.89	61.11	29.55	39.87	49.62	26.67	35.56	44.44	20.00	26.67	33.33
0.2x	33.00	44.00	55.00	26.60	35.88	44.66	24.00	32.00	40.00	18.00	24.00	30.00
0.3x	22.00	29.33	36.67	17.73	23.92	29.77	16.00	21.33	26.67	12.00	16.00	20.00
0.4x	16.50	22.00	27.50	13.30	17.94	22.33	12.00	16.00	20.00	9.00	12.00	15.00
0.5x	13.20	17.60	22.00	10.64	14.35	17.86	9.60	12.80	16.00	7.20	9.60	12.00
0.6x	11.00	14.67	18.33	8.87	11.96	14.89	8.00	10.67	13.33	6.00	8.00	10.00
0.7x	9.43	12.57	15.71	7.60	10.25	12.76	6.86	9.14	11.43	5.14	6.86	8.57
0.75x	8.80	11.73	14.67	7.09	9.57	11.91	6.40	8.53	10.67	4.80	6.40	8.00
0.8x	8.25	11.00	13.75	6.65	8.97	11.17	6.00	8.00	10.00	4.50	6.00	7.50
0.9x	7.33	9.78	12.22	5.91	7.97	9.92	5.33	7.11	8.89	4.00	5.33	6.67
1x	6.60	8.80	11.00	5.32	7.18	8.93	4.80	6.40	8.00	3.60	4.80	6.00
1.5x	4.40	5.87	7.33	3.55	4.78	5.95	3.20	4.27	5.33	2.40	3.20	4.00
2x	3.30	4.40	5.50	2.66	3.59	4.47	2.40	3.20	4.00	1.80	2.40	3.00
2.5x	2.64	3.52	4.40	2.13	2.87	3.57	1.92	2.56	3.20	1.44	1.92	2.40
3x	2.20	2.93	3.67	1.77	2.39	2.98	1.60	2.13	2.67	1.20	1.60	2.00
3.5x	1.89	2.51	3.14	1.52	2.05	2.55	1.37	1.83	2.29	1.03	1.37	1.71
4x	1.65	2.20	2.75	1.33	1.79	2.23	1.20	1.60	2.00	0.90	1.20	1.50
4.5x	1.47	1.96	2.44	1.18	1.59	1.98	1.07	1.42	1.78	0.80	1.07	1.33
5x	1.32	1.76	2.20	1.06	1.44	1.79	0.96	1.28	1.60	0.72	0.96	1.20
6x	1.10	1.47	1.83	0.89	1.20	1.49	0.80	1.07	1.33	0.60	0.80	1.00
7x	0.94	1.26	1.57	0.76	1.03	1.28	0.69	0.91	1.14	0.51	0.69	0.86
8x	0.83	1.10	1.38	0.66	0.90	1.12	0.60	0.80	1.00	0.45	0.60	0.75
9x	0.73	0.98	1.22	0.59	0.80	0.99	0.53	0.71	0.89	0.40	0.53	0.67
10x	0.66	0.88	1.10	0.53	0.72	0.89	0.48	0.64	0.80	0.36	0.48	0.60
11x	0.60	0.80	1.00	0.48	0.65	0.81	0.44	0.58	0.73	0.33	0.44	0.55
12x	0.55	0.73	0.92	0.44	0.60	0.74	0.40	0.53	0.67	0.30	0.40	0.50
15x	0.44	0.59	0.73	0.35	0.48	0.60	0.32	0.43	0.53	0.24	0.32	0.40
20x	0.33	0.44	0.55	0.27	0.36	0.45	0.24	0.32	0.40	0.18	0.24	0.30

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