

MORITEX New FA Lens Series

Technical Report



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Introduction of the latest FA lenses from MORITEX Corporation enabling the maximum performance of high-resolution, high-pixel count cameras.

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Aligning with the shift in image sensors to CMOS, MORITEX introduces the ML-XR/UR series for 2.2 μm pixels high density, high resolution enhanced sensors, SR/HR series for popular legacy 3.5/4.5 μm pixel resolutions, and the application specific ruggedized ML-G series and ML-T series for ITS. This document is an introduction to MORITEX's latest FA lens portfolio supporting a variety of applications including general purpose use with diverse image sensors, robot vision, 3D measurement, and ITS.



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Vision Creating Value

Development Background

In the market of Machine Vision, the shift from CCD to CMOS imagers is rapidly increasing in recent years ushering in the so called CMOS era enabling the high-resolution capabilities of small pixel pitch camera sensors, along with imaging at faster speeds in different environments simultaneously. Fine pixel sensors with pixel pitch less than $3\mu\text{m}$, such as $2.2\mu\text{m}$ pixel pitch with sensor size is 1/1.8" (equivalent to 6MP camera), and $2.4\mu\text{m}$ pixel pitch 1" (equivalent to 20MP camera) sensors are starting to be widely used in the vision markets. With high-pixel counts and smaller pixel sizes, the sensors and camera bodies remain the same. Therefore, when most camera manufacturers release 29mm sq sized cameras requiring high-resolution, the compatible lens size remains the same.

MORITEX has developed a new portfolio of both general purpose and application specific FA lenses with high-resolution and compact size as main features to address the requirements for a variety of applications in different market segments. (Fig.1)

Applicable sensor sizes range from the legacy 2/3" to 1.1" for the new portfolio consisting of 6 series, with 35 models in total. For top grade sensors, the ML-MC-XR Series for 1.1" and ML-U-UR Series for 2/3" formats realize not only superior performance characteristics, but are also capable of matching industry leading next-gen sensors made by SONY (Pregius S 4th generation) which has pixel pitch $2.74\mu\text{m}$ (Table.1). Furthermore, all series have adopted a superior vibration resistance mechanical design and wide-range AR coatings, covering VIS to NIR (wavelengths : 400 ~ 1100nm).



Fig.1 MORITEX's Newly Developed FA Lens Family : 6 Series, 35 Types in Total

Table.1 MORITEX's Newly Developed FA Lens Products

Sensor Size	Series Name	Pixel Pitch	Max. Supported Pixel Count	Number of Models	Main Application
Type 1.1 17.6mm	ML-U-SR	3.5 μ m	12MP	6 types	General purpose FA lens
	ML-MC-XR	2.2 μ m	20MP	4 types	Short distance imaging, including precise inspection and alignment
	ML-MC-G	3.5 μ m	12MP	5 types	Vibration resistant environment, including 3D/Robot
	ML-T	3.5 μ m	12MP	7 types	Long range imaging, including ITS
Type 2/3 11mm	ML-M-UR	2.2 μ m	8MP	7 types	General purpose FA lens
	ML-M-HR	4.5 μ m	5MP	6 types	General purpose FA lens



Fig.2 ML-M-UR series, corresponding to 2/3" image format, 2.2 μ m pixel pitch (8MP camera equivalent)



Fig.3 ML-MC-XR series, corresponding to 1.1" image format, 2.2 μ m pixel pitch (20MP camera equivalent)

Features of the Latest FA Lens

1) High resolution and high contrast

MORITEX released the ML-M-UR series (Fig.2) and ML-MC-XR series (Fig.3) as FA lens with finer than 200 lp/mm resolving power. Applicable sensor sizes are type 2/3" and type 1.1", respectively. Fig.4 and Fig.5 represent the contrast corresponding to each image height (MTF) showing the contrast from lens center to lens edge, and highlighting the limited degradation of resolving power from center to edge enable to capture highly clear and superior contrast images. The ML-M-UR is great as a general purpose lens which demonstrates optimized resolving power at approx. WD 500mm, and ML-MC-XR is optimized for short distance imaging (WD 300mm or shorter) for applications such as the precise inspection of parts or alignment.

Fig.6 is cut-out image of the corner-edge of a sample chart where a micro 2D bar-code are aligned, captured by a 1" sensor with pixel pitch 2.4 μm (20MP). Fig.7 shows an image captured by a legacy lens for 9MP for comparison. This image comparison gives demonstrates that sufficient resolving power are achieved even at the edge with the new lens series. This characteristic allows users to capture less degraded images from center to edge which is important for alignment, metrology and precise inspection applications.

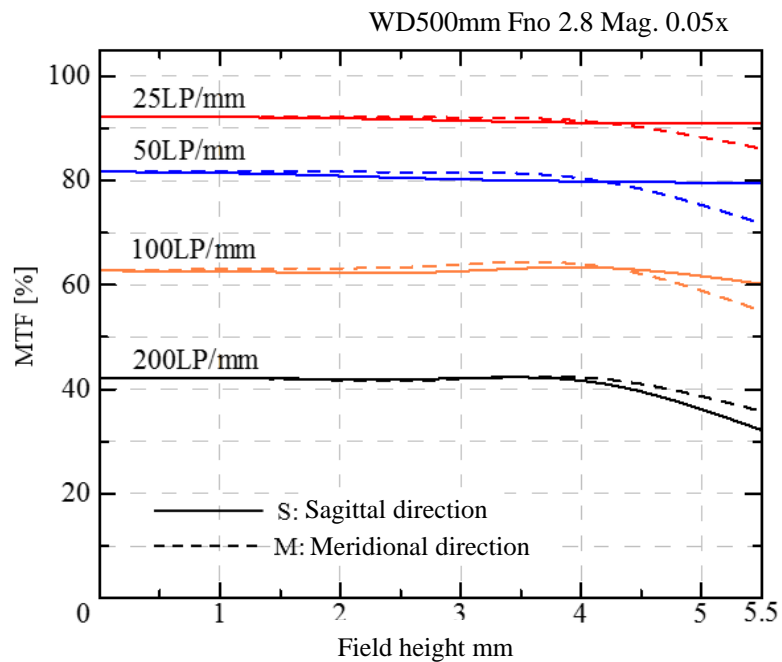


Fig.4 ML-M-UR MTF Data for 2/3"

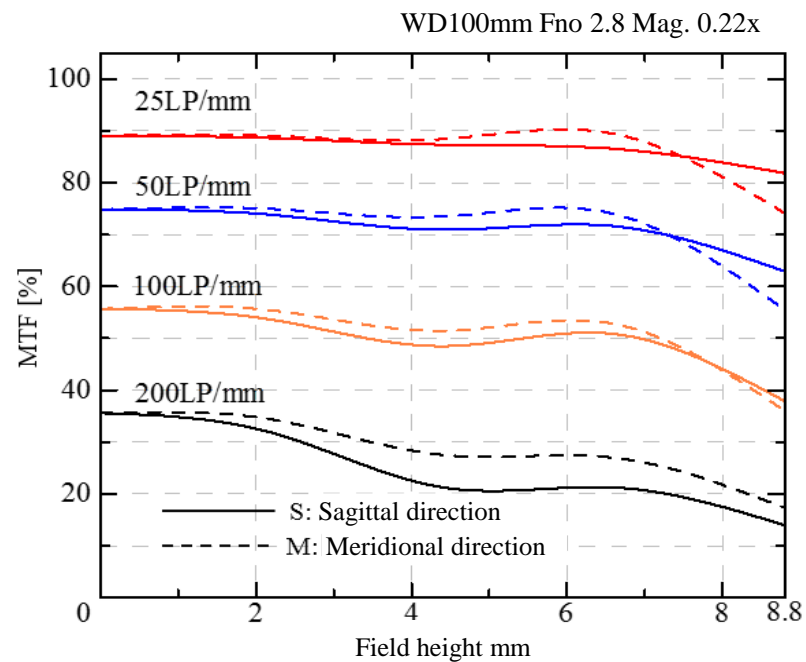


Fig.5 ML-MC-XR MTF Data for 1.1"

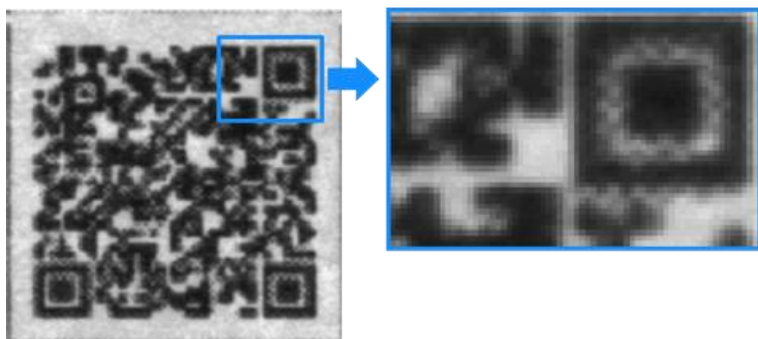


Fig.6 ML-MC-XR lens, 20MP Camera Compatible

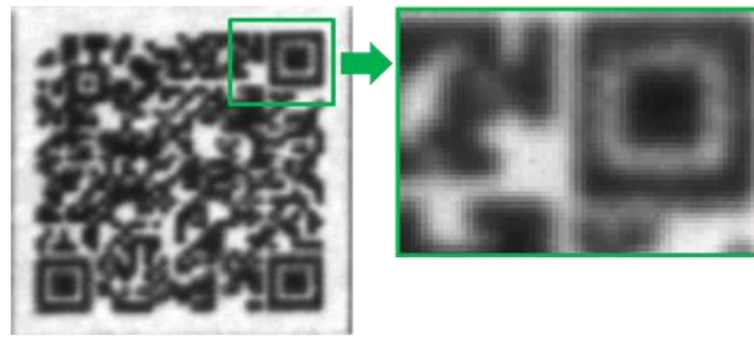


Fig.7 Conventional 9MP Camera Compatible Lens

2) Compact Design

The latest CMOS sensors realize high resolution by adopting a finer pixel pitch, yet in the same traditional image formats, so the camera body size changes less as the pixel count increases. Therefore, lens size requirements from the customers remains the same as ever, and it is essential to maintain compact a form factor. MORITEX developed lenses realize both high resolving power and compact size by utilizing our optical and mechanical design expertise for a unique, condensed configuration. Following the 29mm square housing size released by many camera manufacturers in the past, the ML-M-UR and ML-M-HR series are designed with a 29.5mm O.D. limit. This design ensures the flexibility to be adopted in inspection equipment where compactness and high performance are required, and can replace legacy optics. (Fig.8)



Fig.8 Left : ML-M-UR Series

Right : Size Comparison Between ML-M-UR Series and 29mm Sq Camera

3) Vibration Resistance Characteristics

In general, vibration resistant characteristics of machine vision lenses consisting of multiple mechanical parts is 5G or less, and may have some issues for image capturing under high vibration environments. Adopting a unique mechanical structure and simplified design to our latest FA lens, the ML-M-UR/HR, ML-MC-XR, and ML-T Series achieve vibration resistance of 10G. Fig.9 shows the results of vibration resistance test. The MTF “before & after” shown in Fig.10 exhibit the capability of stable image capturing under 10G vibration environments. Additionally, MORITEX recommends that customers apply a screw lock agent after fixing the lens at two spots with included screws.

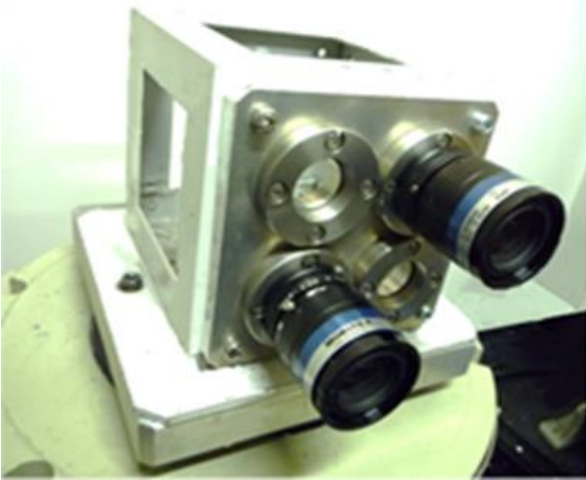


Fig.9 Vibration Resistant Environment Test Bench

Table 2. Vibration Resistant Test Condition

Items	Test condition
Frequency	Sweep range 10-200 Hz
Max. Acceleration	10G
Max. Amplitude	0.5mm
Lens Fixing Method	Applying screw lock agent after fixing the lens at two spots with associated hexagon socket set screws with the products.

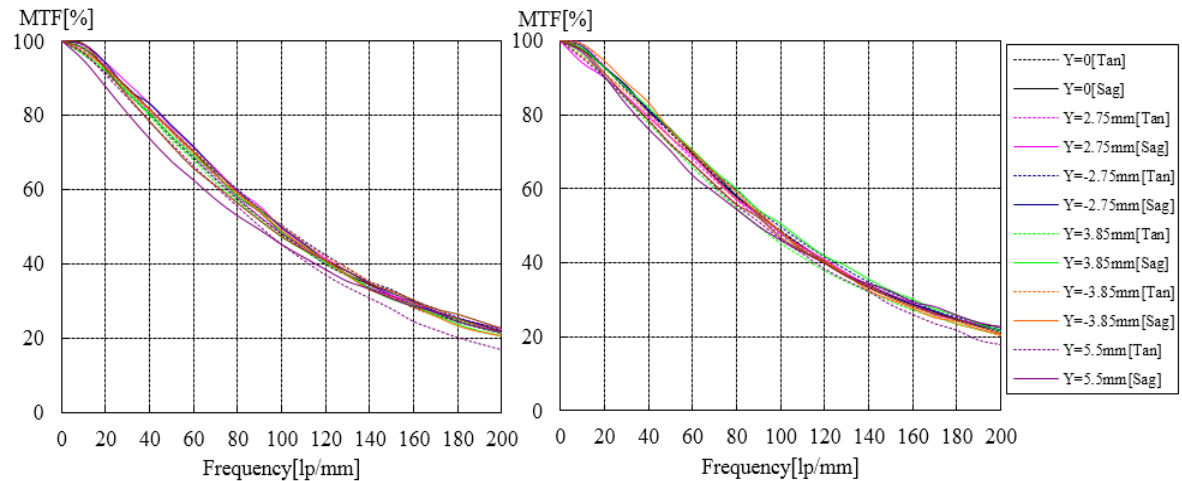


Fig.10 ML-M-UR Series MTF Before & After” Comparison
Left : Before Test Right : After Test

FA Lenses for 3D Robot Vision

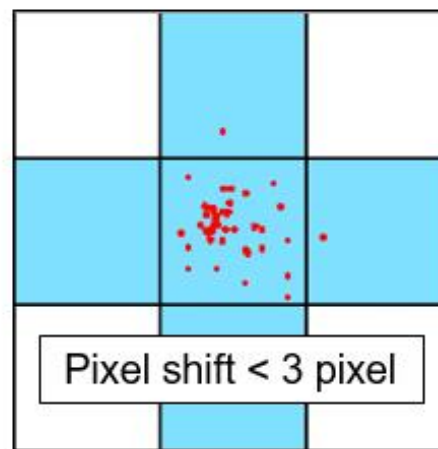
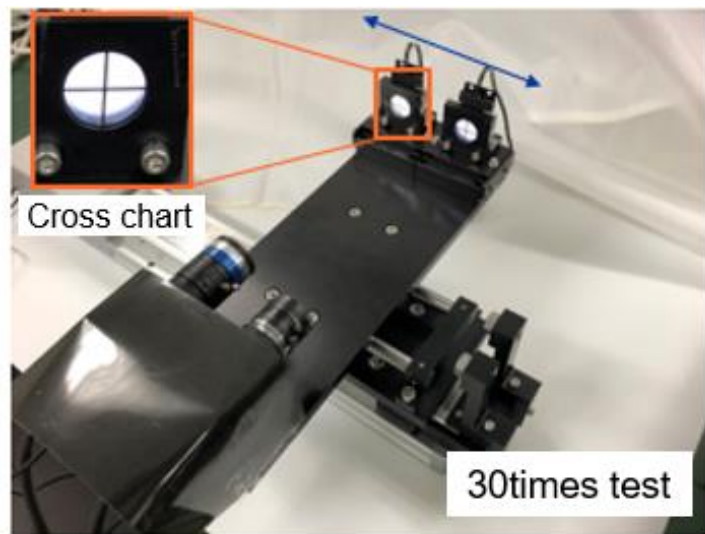
In 3D robot vision and precise measurement applications, micro displacement of optical lenses caused by external vibration and impact introduces the factor of inspection accuracy degradation and a calibration shift in many cases. MORITEX developed the ML-MC-G Series FA lenses for these specific situations. (Fig.11)

The highlight features of the ML-MC-G Series are 15G vibration resistance, 1.1” high pixel count camera (equivalent to 12M pixel) compatibility, and the unique design minimizes pixel shift, caused by vibration or impact, to less than 1 pixel. The optical design is optimized for close to mid-range working distances (around WD 500mm), all lens components are glued to avoid micro displacement of optics, and a double-nuts design is applied to prevent focusing mechanism loosening. Fig.12 provides test result illustrating the amount of pixel shift of both a legacy design and the newly adopted design after applying forces on the lens. Here, The X-direction impact was applied to camera, lens and cross-hair chart installed on a slide table, and the resulting center position plot of the images’ after 30 cycles is shown. The results confirm that this lens structure enables an imaging solution to maintain less than 0.3 pixel displacement.

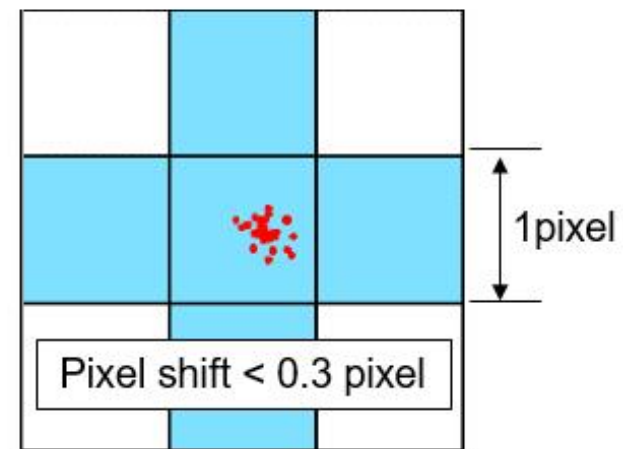


Fig.11 ML-MC-G Lens

FA Lens Compatible with 1.1”, Pixel Pitch 3.5 μ m (12MP camera equivalent) Designed for Close Working Distance Applications



Conventional



ML-MC-G

Fig.12 Pixel Shift Comparison at Impact
Left : Conventional Structured Machine Vision Lens Right : ML-MC-G Series

FA Lens for Transportation

Not only is image capturing at a long distances required, but also imaging in both the VIS and NIR spectrums for use in day & night is demanded in transportation applications (e.g. traffic infrastructure, ADAS system, and drones). MORITEX developed the ML-T Series to handle such applications. (Fig.13) In addition to 10G vibration resistance with a max O.D. 32mm compact design, this series' unique optical design features focus shift calibration between VIS and NIR (Fig.14)



Fig.13 ML-T Series
FA Lens Compatible with 1.1", Pixel Pitch
3.5 μ m (equivalent to 12MP camera)
Design for Long Range Applications.

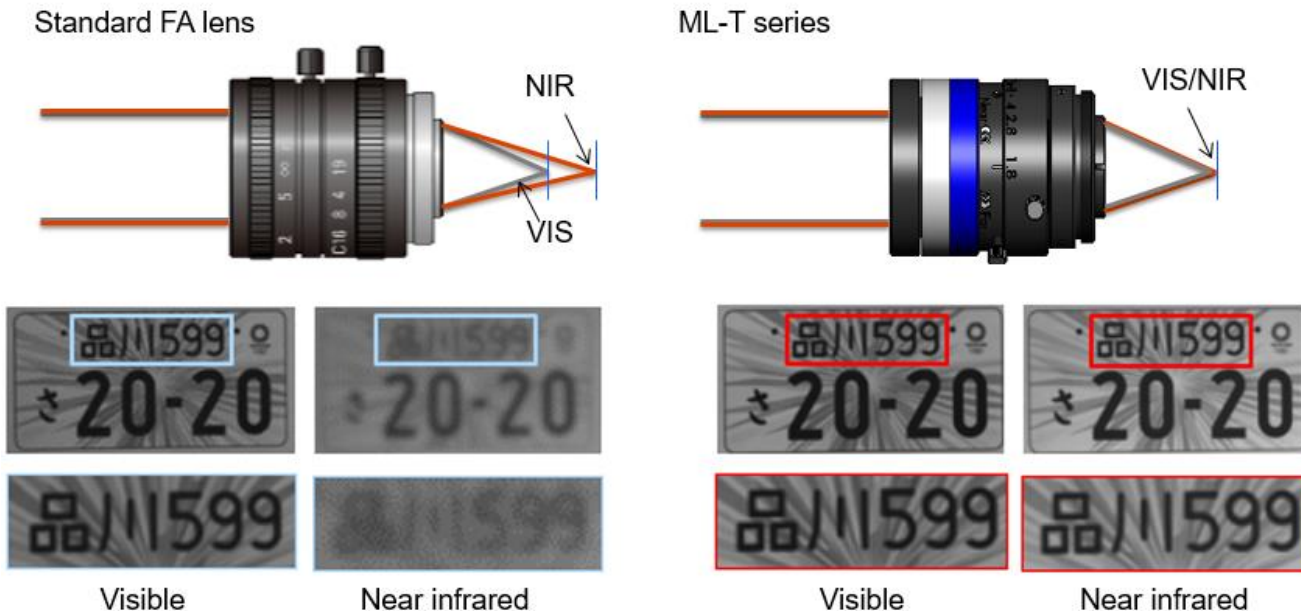


Fig.14 Difference in Focus Between VIS and NIR
Left : Standard FA Lens Right : ML-T Series

In Conclusion

Market demands for high pixel count, high resolving power lenses for not only electronic parts (e.g, mobile devices), but also various applications, such as transportation infrastructure (ITS field), ADAS, autonomous vehicles, vision guided robotics, and drones are increasing. MORITEX is committed to developing lenses which meet or even exceed our customers' needs by utilizing our unique machine vision lens optical and mechanical techniques cultivated over decades of experience.

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