User Manual for Lenses

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VA Imaging Lenses

User Manual

The purpose of this manual is to provide comprehensive, step-by-step guidance on the correct installation, operation, and maintenance of lenses designed specifically for machine vision applications.

Thank you for choosing VA Imaging, experts in industrial cameras, lenses, and machine vision lighting. Our products are designed to meet high standards of reliability and performance in demanding environments. The purpose of this manual is to provide comprehensive, step-by-step guidance on the correct installation, operation, and maintenance of lenses designed specifically for machine vision applications. Lenses are a critical component in any imaging system, as they directly influence the quality and accuracy of captured images. This manual serves as an essential resource to:

- educate users on the types and features of lenses available for machine vision systems.
- provide detailed instructions for installation and adjustments, including focus, aperture, and alignment.
- offer maintenance guidelines to ensure the longevity and performance of lenses.
- troubleshoot common issues that may arise during use, such as distortion, chromatic aberration, or vignetting.

This manual is designed to meet the needs of various professionals who work with machine vision systems, including:

- **Technicians:** Individuals responsible for installing and maintaining lenses within machine vision setups. This includes tasks such as aligning the lens with the camera sensor, securing mounts, and performing routine cleaning.
- **Engineers:** Professionals tasked with designing and integrating imaging systems for industrial, medical, or research applications. Engineers will benefit from detailed specifications and guidelines for selecting the right lens for their projects.
- **System Integrators:** Specialists who incorporate machine vision components, including lenses, into complex systems such as automated inspection lines, robotics platforms, or security systems.
- **Researchers and Developers:** Those exploring innovative imaging applications or conducting experiments that require precision and adaptability in lens selection and usage. Whether you are setting up a new system, optimizing an existing one, or troubleshooting performance issues, this manual provides the necessary knowledge and tools to support your work.

The key benefits of this manual are to:

- Minimize downtime and optimize imaging performance by following proven guidelines.
- Learn how to reduce errors like distortion and misalignment for clearer, more reliable results.
- Avoid common mistakes and reduce the need for troubleshooting and replacement parts

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1. Introduction

1.1 Overview of Machine Vision Lenses

Machine vision lenses are essential components in any vision-based automation system, responsible for capturing images that are analyzed by machine vision software to perform tasks such as quality control, object detection, and dimensional measurement. These lenses differ significantly from standard photography lenses because they are optimized for industrial and scientific imaging tasks, offering superior precision, minimal distortion, and enhanced durability.

In this guide, we cover a wide range of lens types like C mount lenses, M12 lenses, Telecentric Lens, AFZ Varifocal, F mount/M42/M48, SWIR lens, Motorized Focus Lens, Microscope lens and UV lens that are used in machine vision systems, detailing their specifications, capabilities, and recommended use cases.

1.2 Applications

Machine vision lenses are integral to achieving accurate and reliable imaging results across a wide variety of industries and use cases. Vision lenses come in a variety of types as mentioned above, each suited for specific applications like

- **Industrial Inspection:** Ensuring quality control and detecting defects in manufacturing processes, such as inspecting circuit boards, identifying flaws in assembly lines, or verifying product dimensions.
- **Robotics:** Enabling autonomous robots to navigate environments, identify objects, and perform tasks such as sorting, picking, or assembly with precision.
- **Medical Imaging:** Capturing detailed and high-resolution images for use in diagnostics, surgical procedures, and laboratory research.
- **Research and Development:** Supporting scientific experiments and prototype development, including imaging for material analysis, biological studies, and innovation testing.
- **Surveillance and Security:** Monitoring areas with high precision, ensuring clear imagery in both low-light and high-motion scenarios, such as public safety systems and traffic monitoring.
- **Agriculture and Environmental Monitoring:** Assisting in applications like crop health

analysis, drone imaging, and remote sensing.

- **Logistics and Transportation:** Enhancing automated sorting, barcode scanning, and tracking systems in warehouses and distribution centers. By addressing these diverse applications, the manual equips users with the knowledge and techniques to select, configure, and maintain lenses for optimal performance, regardless of the specific industry or task.

1.3 Compatibility Information

This manual is designed for lenses that work seamlessly with a wide range of machine vision camera systems. While most lenses are compatible with standard systems, some setups may require additional adapters or accessories. For specific compatibility details, refer to the respective section for each lens type.

1.4 History and Industry Context

VA Imaging has a long-standing reputation for innovation and excellence in optical solutions. Our lenses are developed using cutting-edge technology and rigorous testing to meet the demands of modern machine vision applications. This manual reflects our dedication to supporting our users with the highest quality resources and tools.

2.Safety Guidelines

2.1 General Safety Instructions

Proper handling and care of machine vision lenses are essential for optimal performance and longevity. Follow these simple guidelines to ensure your lenses remain in good condition:

- **Handle with Care**: Lenses are delicate; avoid impacts or scratches that can affect image quality.
- **Prevent Contamination**: Keep lenses clean by using protective covers when not in use. Avoid touching the lens surface with bare hands.
- **Use Protective Gear**: Wear gloves and take anti-static precautions when working in environments with dust or static electricity.
- **Electrical Safety**: If the lens is part of a motorized system (focus or zoom), power off the system before maintenance to avoid electrical shock.
- **Proper Storage**: Store lenses in a clean, dry place. Use original packaging or protective cases to prevent damage from dust, moisture, or physical impacts.

2.1 Handling and Storage Precautions

Proper storage is key to maintaining the performance of your lenses:

- **Avoid Harsh Environments**: Keep lenses away from extreme temperatures, high humidity, or chemicals that could damage the lens coating.
- **Use Lens Caps**: Always replace lens caps when not in use to protect the lens from dust, scratches, and impacts.
- **Transport Carefully**: When moving lenses, ensure they are packed in padded, shock-resistant containers to prevent damage.
- **Long-Term Storage**: Store lenses upright in a controlled environment. If not in use for extended periods, inspect them periodically for dust or moisture.

By following these steps, your machine vision lenses will continue to deliver reliable, high-quality performance.

3. Appendices

3.1 Glossary of Terms

Machine Vision	The use of computer algorithms and cameras to enable a machine to interpret and understand visual data for tasks such as inspection, object detection, and navigation.
Image Processing	The manipulation or analysis of images through algorithms to extract useful information, such as identifying objects, measuring sizes, or finding defects.
Resolution	The level of detail an image contains, usually measured in pixels (width x height).
Frame Rate	The number of frames a camera can capture per second (frames per second, fps).
Illumination	The lighting system used to illuminate the object or scene being captured by the camera.
Field of View (FOV)	Observable area captured by a camera lens.
Pixel	The smallest unit of an image representing a single color or brightness value.
Focal Length	Distance between the lens and image sensor when the subject is in focus.
Aperture	The opening in the lens that allows light to pass through. The size of the aperture affects the exposure and depth of field.
Depth of Field (DOF)	The range of distance in the image that appears sharp.
Distortion	A lens characteristic where straight lines appear curved in an image.
Magnification	The ability of a lens to enlarge an object.
Lens Resolution	The ability of the lens to produce clear, sharp images at various distances.
Optical Zoom	The ability to change the focal length of the lens to zoom in or out without losing image quality, as opposed to digital zoom, which simply crops the image.
Chromatic Aberration	A type of distortion that occurs when a lens fails to focus different colors of light at the same point, leading to color fringes around the image edges.
Working Distance	The distance between the lens and the object being observed or inspected.
Lens Mount	The mechanism by which the lens is attached to the camera body.
Autofocus (AF)	A feature that allows the lens to automatically adjust to achieve focus on the subject.

4.Product Overview

4.1 Key Features of our Machine Vision Lenses

Machine vision lenses are designed to meet the rigorous demands of industrial, scientific, and commercial applications. Below are the primary features that define the performance and suitability of machine vision lenses

- High Precision and Minimal Distortion: Important for applications like measurement, quality inspection and robotic guidance where accuracy is crucial.
- Wide Aperture (Low F-number): Allows more light to enter the lens, improving image brightness and clarity.
- Optimized for Automation: Features like motorized zoom, focus and aperture control are offered. Used in environments where quick adjustments are needed without manual intervention.
- Variety of Mount Types: good compatibility with various camera systems ensuring easy integration with existing equipment.
- Telecentricity: Constant Magnification regardless of the object's position in the FOV. This is especially important in measurement applications where precise and distortion-free imaging is needed.
- Wide Range of Focal Lengths: Allows users to select the best lens to achieve the desired field of view and depth of field for their specific application.
- High Optical Resolution: Resolve fine details, ensuring that the captured images can be processed with high accuracy.
- Low Distortion and Consistent Focus: Vital in high-precision applications like 3D reconstruction, metrology, and dimensional inspection, where even minor distortions can lead to inaccuracies.
- Durability and Reliability: Built to be robust and reliable, with metal housing and anti-scratch coating. This construction is ideal for industrial environments where vibration, shock, and harsh conditions are common.

4.2 Lens Construction and Components

VA Imaging lenses incorporate advanced engineering to deliver exceptional optical performance. Below is an overview of the primary components:

- Lens Barrel: Durable metal housing ensures stability, protects internal components, and provides a secure mounting interface.
- Optical Elements: Precision-crafted glass lenses arranged to reduce distortions and maximize clarity. (Convex Lenses: Focus light to a point; Concave Lenses: Diverge light or correct aberrations.
- Aperture (Iris): Controls light transmission and influences depth of field, adjustable for optimal image quality.
- Focusing Mechanism: Enables precise adjustments for sharp images, with options for manual or motorized focus.
- Zoom Mechanism: Found in varifocal lenses, it allows focal length adjustments without changing the lens.
- Sensor Interface and Mount: Includes various mounts (e.g., C-mount, M12) designed for compatibility and proper back focal distance.
- Coatings: Anti-reflective and protective coatings improve light transmittance, reduce glare, and protect against environmental factors.
- Thermal Compensation: Maintains consistent performance in fluctuating temperatures by countering material expansion or contraction.
- Motorized Components: Integrated stepper motors for remote control of focus, zoom, and aperture, enhancing efficiency in automated systems.

5.Lens Models and Compatible Accessories

This section covers the different types of machine vision lenses available from VA Imaging. Each lens type has been designed to meet specific requirements for various applications, offering users flexibility and precision in their vision systems. Below, you'll find an overview of lens categories and detailed descriptions for each mode.

5.1 C- Mount Lenses

C-mount lenses are designed for industrial applications, offering high durability, reliability, and optical performance. Their standardized thread and compact design make them compatible with all our industrial C-mount cameras, ensuring precise and reliable performance even in harsh environments.

5.1.1 Key Features

- Suitable for image sensors up to 1.4"
- Manual Adjustments: Includes manual adjustments for aperture(iris) for precise light control and focus setting for sharper images
- Equipped with screws to lock the iris and focus settings in place securely.
- Designed for quick and secure mounting.
- Selected lenses feature apertures up to F1.4, ideal for low-light conditions.
- Highly durable lenses delivering sharp, high-quality image and custom solutions for specific needs

5.1.3 Types of C-Mount Lenses

- Fixed Focal Length Lenses: fixed magnification, focal length cannot be changed, adjustable focus and aperture, optimized for better light sensitivity, fewer mechanical parts.
- Zoom lenses: variable magnification, wide range of FOV, adjustable working distance

without moving the camera, available in manual, motorized and autofocus modes.

- Macro Lenses: close-up imaging with high resolution, short minimum focusing distance and shallow depth of field, focal lengths: 25mm, 35mm, 50mm, 75mm supporting 12 MP resolution.
- Telecentric Lenses: consistent magnification with minimal perspective distortion, ensure parallel light rays for accurate measurements and superior image quality.

5.1.4 Selecting a C-Mount Lens

C-mount lenses are available in various focal lengths to suit different applications. Fixed Focal Length Provides stability in applications, ensures high resolution and excellent contrast in captured images. Our lenses have a fixed focal length making it ideal for industrial environments where fixed parameters like working distance and field of view are critical. Fixed-focus lenses are relatively low-cost, making them suitable for large-scale industrial production.

When selecting the right C-mount lens for your machine vision application, take the following into account:

- Field of View (FOV): Determine the desired area to be captured.
- Working Distance: The distance between the lens and the object being imaged.
- Sensor Size: Ensure compatibility with your camera's sensor size.
- Required Focal Length: The focal length impacts the FOV and image magnification.

Use our Lens Calculator [3.3] to simplify this process. It helps you determine the right focal length based on your field of view and other parameters.

Additionally, ensure the lens resolution matches the pixel size of your industrial camera for optimal image quality. For detailed guidance, refer to [3.2] where relationship between best lens resolution and pixel size is explained.

5.2 M12 Lenses / S-Mount Lenses

M12 lenses, also known as S-mount lenses, are compact and versatile optical components widely used in industrial and board-level camera applications. Their small form factor and compatibility with various sensors make them ideal for space-constrained environments.

5.2.1 Key Features

- Supports relatively large image sensors, ranging from 1/2.5" to 2/3", ensuring flexibility for various imaging needs.
- Starting at a focal length of 1.85mm, our M12 lenses provide wide-angle solutions tailored to diverse applications.
- Certain models offer resolutions up to 16MP, catering to high-definition imaging needs.

5.2.2 Using an M12 lens with a C-Mount Camera

M12 lenses are not directly compatible with C-mount cameras due to differences in their design and mounting systems. M12 lenses are specifically designed for board-level cameras with an M12 mount, while C-mount lenses are tailored for industrial cameras.

- The mount diameter of M12 lenses differs from that of C-mount lenses. This issue can be resolved with an adapter that bridges the size difference.
- C-Mount Lenses have a fixed FFD (the distance between the lens mount and the image sensor). But M12 lenses feature a variable FFD that changes with the focus setting. This variability can cause M12 lenses to collide with the protective glass on C-mount cameras, making proper focus impossible.

To overcome these challenges, VA Imaging has developed a C-mount to M12 mount adapter. This innovative adapter allows seamless use of M12 lenses on C-mount cameras.

<u>Features of the Adapter:</u>

- It can also be mounted on CS-mount cameras, offering a versatile solution for various camera types.
- Designed for straightforward installation and reliable performance.

This adapter ensures M12 lenses can be effectively utilized on C-mount or CS-mount cameras without compromising functionality or image quality.

5.3 Telecentric Lenses

Telecentric lenses are important tools in machine vision systems. They reduce perspective errors and ensure consistent magnification and perspective across the entire image. These lenses are designed to allow only parallel light rays to enter, so the light reaching the image sensor is always straight and perpendicular. This is made possible by a special part inside the lens called the telecentric stop, which controls the direction of the light.

This design allows for accurate measurements and detailed feature analysis, making telecentric lenses ideal for tasks like quality control, inspection, and maintenance in many industries.

5.3.1 Key Features

- Reduced Image Distortion: Ensures straight and undistorted lines in the image.
- Constant Magnification: Maintains consistent magnification across the field of view.
- High Resolution: Captures fine details with exceptional clarity.
- No Perspective Errors: Eliminates parallax effects for precise measurements.
- Uniform Light Intensity: Provides even illumination across the entire field of view, eliminating lens shading.

5.3.2 Mounting a Telecentric Lens

Our telecentric lenses are C-mount or M58 compatible, fitting most standard C-mount machine vision cameras. For larger telecentric lenses mounted horizontally, a support bracket (provides a stable platform, reducing vibrations and enhancing image sharpness) is essential to prevent excessive tension on the C-mount of the camera.

- Vertical Mounting: Technically, a support bracket is not required when mounting vertically. However, to address potential vibration issues, mechanical designers often use a support bracket for added stability.
- Horizontal Mounting: Always use a support bracket to minimize tension and ensure proper functionality.

5.3.3 Using Telecentric Lens with Coaxial Light

Our telecentric lenses can be equipped with coaxial light input for simplified integration. When an LED coaxial light is connected, a half-transparent mirror inside the lens projects a uniform light through the lens directly onto the object. This eliminates the need for external lighting, offering a compact and efficient setup.

5.3.4 Choosing the Right Telecentric Lens

Our user-friendly lens calculator [3.3] simplifies the process of selecting the perfect telecentric lens:

- Field of View (FOV): Input lens magnification, sensor resolution (horizontal and vertical), and pixel size to calculate the FOV.
- Lens Magnification: Enter the sensor resolution and pixel size, then adjust the magnification to achieve the desired FOV.

5.4 AFZ / Varifocal Lens

AFZ (Auto Focus Zoom) or Varifocal Lenses offer adjustable focal lengths, providing flexibility for a wide range of machine vision applications. These lenses are ideal for systems that need to adapt to different product types, sizes, or changing operational conditions.

5.4.1 Key Features

- Adjustable Focal Length: Precise control over focus and focal length for versatile usage.
- Manual Varifocal Lenses: Adjustments are made manually.
- Motorized Zoom Lenses: Feature integrated motors that automatically adjust focus, focal length, and/or aperture, depending on the model.
- Automatic Adjustment: Motorized lenses optimize settings automatically when conditions change or for different product types, eliminating the need for manual adjustments.

5.4.2 Working of a Varifocal Lens

- This is manually adjustable zoom lens that allows you to control the focal length.
- When zooming out, the opening angle becomes larger and when zooming in, the opening angle becomes smaller.
- As a result, the lens can focus on objects at various distances (i.e. multiple working distances). Hence, there is no need to switch lenses for different WD.

- During installation, the focal length (zoom settings) is optimized. Once set, the settings remain fixed during operation for consistent performance.

5.4 3 Working of an AFZ Lens

- This is an Automatic Focus Zoon Lens that can automatically adjust the focus to always keep the image sharp.
- The zoom and focus lens can be controlled automatically as well, enabling remote operation
- By default, focus and zoom are not automatic unless configured for remote control.

5.4. 4 Motorized Zoom Lens

- They have multiple tiny integrated motors to adjust focus, focal length and / or aperture based on the lens model.
- Optimizes the lens settings for different product types and sizes without manual intervention and allows MV systems to adapt to changing conditions, etc.
- To control the motorized lens, a lens controller unit is designed. This supports control of up to 3 motors via a USB or RS32 signal. With this board, control of individual lens parameters is possible, and offer up to 10 preset configurations.

5.5 F-Mount / M42 Mount Lenses

Our F-mount / M42-mount lenses are designed for machine vision cameras, supporting image sensors up to 35mm. The lenses offer better optical performance compared to consumer SLR lenses, making them ideal for industrial applications. Built to withstand harsh industrial conditions, these lenses are engineered for long-term reliability. They are well-suited for high-end machine vision applications requiring large sensors and high resolution.

5.5.1 Key Features

- Large image circle up to 43mm, suitable for very large image sensors up to 35mm.
- High Resolution Lenses supporting 65 MP resolution and 4K line scan sensors.
- Some lenses have a distortion of less than 0.2%
- Designed to withstand industrial conditions and offer long-term availability.

5.5.2 F-mount vs C-Mount for your application

- Larger Image Circle: F-mount and M42 mount lenses have a much larger diameter than C-mount lenses. The larger diameter allows F-mount lenses to illuminate larger image sensors (up to 35mm) compared to C-mount lenses, which can only illuminate up to 4/3-inch sensors.
- Suitable for Larger Sensors: C-mount lenses have a maximum image circle of 21.5mm (for 4/3" sensors). F-mount lenses have a minimum image circle of 43mm (suitable for 35mm sensors). This means the F-mount image circle is twice as large, making them ideal for very large image sensors.
- Our F-mount / M42 lenses are perfectly compatible with high-performance cameras, including USB3, GigE, and 10GigE cameras that use large image sensors.

5.6 SWIR Lenses

SWIR lenses are specifically designed for capturing images across shortwave infrared (SWIR) wavelengths. Wavelengths Range for SWIR Lenses: 900nm – 1700nm. This range is special because it can pass through certain materials and weather conditions, making it great for clear, detailed imaging.
A Visible + SWIR lens enables simultaneous imaging in both SWIR and visible light, making it ideal for applications such as multispectral imaging, where data from different parts of the spectrum is combined for more comprehensive analysis. Wavelength Range for Visible + SWIR Lenses: 400nm – 1700nm, supporting both visible light and SWIR imaging.

5.6.1 Understanding SWIR

- The visible light spectrum ranges from 400nm - 780nm, while light beyond 780nm up to 1000µm is called infrared light.
- SWIR (Short-Wave Infrared) is a type of infrared light near the visible range, covering wavelengths from about 900nm - 2500nm.
- SWIR lies between visible light and thermal infrared, making it unique.
- For instance, SWIR imaging is used in tasks like silicon wafer inspection, where it performs better than visible or thermal infrared light.

5.6.2 Key Features

- Optimal Compatibility and Performance: Tailored to perfectly match or SWIR Cameras.
- Available in various focal lengths, making it easy to select the right one for your specific needs.
- When paired with our SWIR cameras, they deliver high-quality images especially for industrial and scientific applications.
- Built to withstand harsh and challenging conditions, ensuring consistent performance in demanding applications.

5.7 Microscope Lens

Microscope lenses provide precise inspection and analysis with high magnification. Our lenses are carefully chosen to ensure excellent image quality and minimal distortion. The right level of magnification depends on your application. High-power lenses offer the highest magnification, while lower magnification lenses provide a wider field of view. If you need to easily add a light source, choose the version with a coaxial input.

5.7.1 Key Features

- Works with USB3, GigE, and 10GigE machine vision cameras
- Available in models with or without coaxial light input for flexible lighting configurations
- Short working distance: Requires the object to be very close to the lens for optimal focus
- High resolution: Enables capture highly detailed, magnified images
- Designed to be mounted directly on C-mount industrial cameras and Compatible with sensors up to 1.1" in size

5.7.2 Microscope Lens for C-Mount Camera

Microscope lenses are designed for C-mount fittings and can be directly attached to our machine vision cameras with sensor sizes up to 1.1”. We offer models with or without a coaxial light input for extra illumination. They are compatible with our C-mount industrial cameras, allowing you to easily turn an industrial camera into a digital microscope. With these lenses, you can capture clear, high-resolution magnified images. Our C-mount microscope lenses work perfectly with any of our USB3, GigE, and 10GigE machine vision cameras.

5.7.3 Magnification in Microscope Lens

- High Magnification: Microscope lenses offer much higher magnification than regular machine vision lenses, typically ranging up to 50x. This helps you see tiny details of objects clearly.
- Fixed Magnification: Unlike some machine vision lenses that can zoom in and out, microscope lenses usually have a fixed magnification. So, you need to choose the right lens based on the size of the features you want to inspect.
- Working Distance: Microscope lenses have a short working distance, meaning the lens needs to be very close to the object being viewed. This can be a challenge if your setup requires more space between the lens and the object.

5.7.4 Microscope Lens with / without Coaxial Light

Some microscope lenses offer the option for a coaxial light input:

- If the lens part number ends with -CO, it includes a coaxial light input.
- If the part number ends with -NI, it does not include a coaxial light input.

The lens with coaxial light input offers more flexibility in lighting configuration, making it suitable for tasks requiring different lighting setups. It is particularly useful for illuminating flat, shiny surfaces like metal and printed circuit boards (PCBs).
The lens without coaxial light input has a more compact design, which can be beneficial for certain applications with limited space.

5.8 UV Lenses

UV lenses for industrial machine vision cameras are specialized optical lenses designed to allow ultraviolet (UV) light to pass through. These lenses are used in machine vision systems that rely on UV light to capture specific types of information or perform tasks that require UV illumination.

5.8.1 Key Features

- High UV Light Transmission: Designed to transmit UV light (200 nm to 400 nm)
- Provides minimal distortion and high resolution for accurate inspection
- Captures UV light even in low-light conditions, improving performance in challenging environments.

5.8.2 Understanding UV

UV lenses are designed to help you inspect objects using ultraviolet (UV) light. Unlike standard lenses that only work with visible light or infrared, UV lenses can capture details in the lower wavelengths that standard lenses can't detect. This allows you to perform inspections and analyses that aren't possible with regular lenses.
When using a UV camera, it's important to choose a lens that is specifically designed for the UV wavelength range. Using a standard lens made for visible light can result in lower image quality and resolution. Our lenses are specially made with materials optimized for the UV spectrum, ensuring high performance and maximum light transmission in the UV range.

5.9 Lens Filters

Lens filters are designed to attach to the front of a machine vision lens. These filters serve two primary purposes:

- Selective Light Filtering: Lens filters block specific wavelengths of light (colors), ensuring that only the desired light wavelengths are captured by the machine vision camera. This improves image clarity and enhances the camera's ability to focus on the relevant details in the scene.
- Lens Protection: In addition to their optical function, lens filters also act as a protective cover, shielding the lens from dust, debris, and potential damage during



operation.

5.9.1 Types of Lens Filters

- Bandpass Filter (BP Filter) Lets through only a specific range of light wavelengths, like blue, red, or green, while blocking all other colors.
- Long-pass Filter (LP Filter) Allows light starting from a specific wavelength to pass through and blocks shorter wavelengths. Example: An LP420 filter lets through all light above 420 nm (blue, green, red, and infrared) but blocks light below 420 nm (like UV).
- Short-pass Filter (SP Filter) Lets through light up to a specific wavelength and blocks light beyond that point. Example: An SP420 filter allows light below 420 nm (like UV) and blocks light above 420 nm (blue, green, red, and infrared).
- Special Filters Designed for specific tasks. For example, the UVIR-Cut filter blocks UV and infrared light but allows visible light to pass, making it great for capturing true-to-life colors.

5.9.2 How to attach Lens Filters

Lens filters are screwed onto the front of machine vision lenses using a filter thread. Different lenses have different thread sizes, with larger lenses typically having larger threads.

Common Filter Thread Sizes:
M25.5xP0.5 , M27xP0.5 , M30.5xP0.5 , M35.5xP0.5

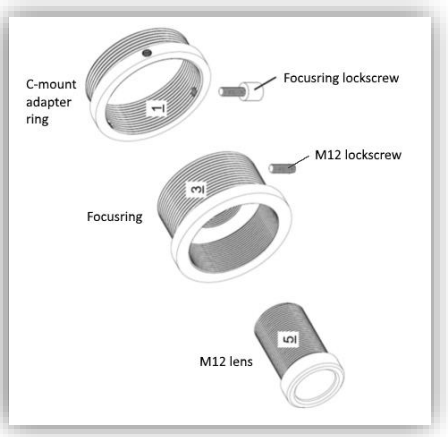
5.9.3 How to use C-Mount Filters

For lenses without filter threads, a C-mount filter can be used. This filter is placed between the camera and the lens by screwing it into the camera's C-mount. It's commonly used with USB3 or GigE cameras and works well when a lens without a thread is needed.

The KNIPEX tool, VA-TOOL-KNIPEX-CMT-FLT, helps you remove the glass window yourself at your own risk. This can also help with mounting the C-Mount Filter inside the C-mount camera.

5.10 Lens Adapters and Extenders

Mount adapters, extension rings, and focal length extenders are used in situations where standard lens solutions do not provide the ideal field of view at the desired working distance. These accessories help adjust the lens setup to achieve the required performance for specific applications, such as improving focus, adjusting magnification, or modifying the working distance to better suit the task.



5.10.1 M12 or C-Mount Extension Rings

Extension rings are used to shorten the minimum working distance of a C-mount or M12 lens. Most industrial lenses have a working distance of 100mm or more, but by adding extension rings, you can bring the lens closer to the object, reducing the working distance. However, reducing the working distance also reduces the depth of field. Additionally, using extension rings can lower the optical performance of the lens and decrease its light sensitivity. Because of these effects, M12 or C-mount extension rings are typically used only in specific industrial applications where these trade-offs are acceptable.

5.10.2 Focal Length Extender

Focal length extenders allow you to increase the focal length of a lens by a factor of 2 or 4. By using a focal length extender with a 35mm, 50mm, or 75mm C-mount lens, you can achieve longer focal lengths such as 70mm, 100mm, 150mm, 200mm, or 300mm. This helps you capture images from a greater distance or achieve higher magnification with your existing lens.

6. Installation and Setup

6.1 Unboxing and Inspection

When you first receive your VA Imaging lens, carefully unbox it to ensure no damage occurred during shipping. Follow these steps:

- Inspect the Packaging: Ensure the lens packaging is intact and free from external damage.
- Check the Lens: Inspect the lens for any visible scratches, dust, or damage.
- Included Accessories: Verify that all accessories included (e.g., lens caps, lens filters, adapters) are present.

If you find any issues, please contact VA Imaging customer support for assistance.

6.2 Mounting the Lens

- Carefully align the lens mount with the camera's lens interface.
- If necessary, attach a mount adapter to ensure compatibility with the camera.
- Twist the lens gently to attach it to the camera mount (C-mount, F – Mount, etc..)
- Do not force the lens into position.

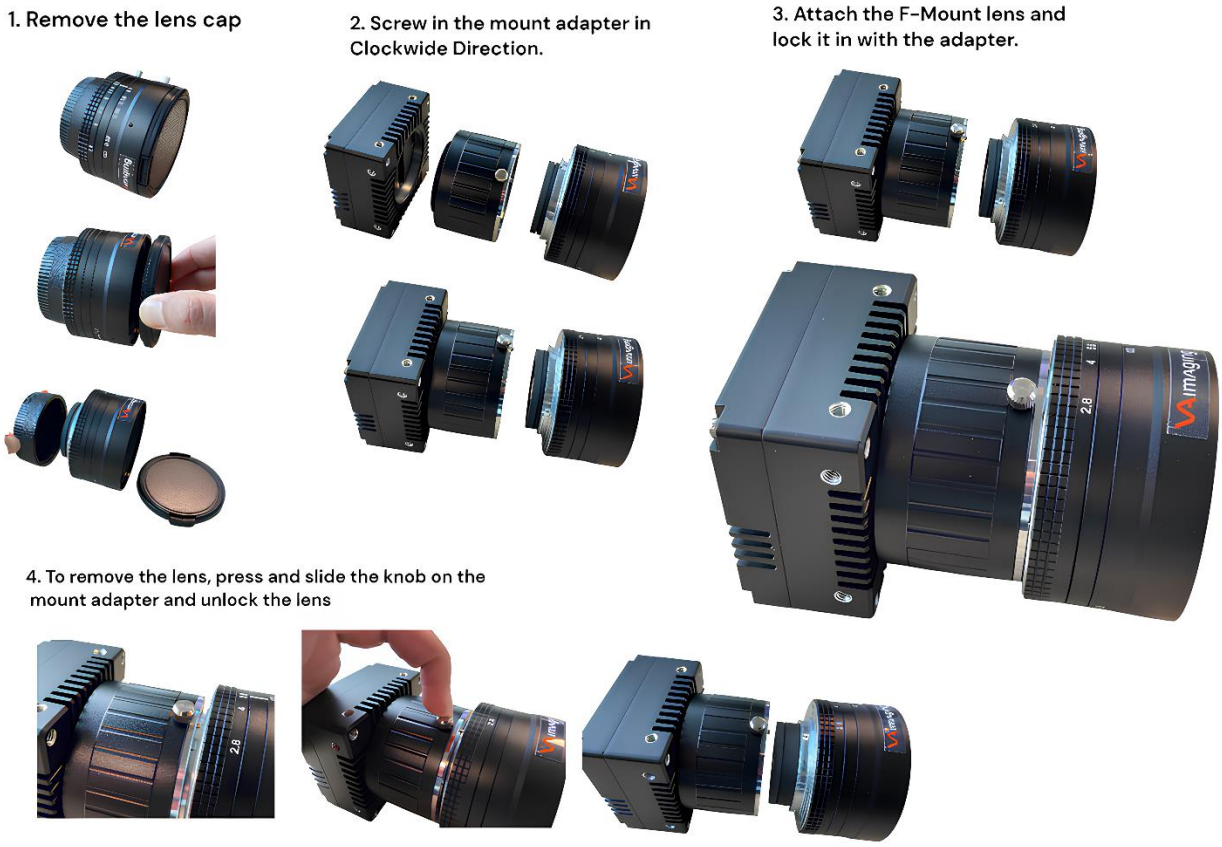
6.2.1 Mounting a C-Mount Lens

- Remove the lens cap and align the lens mount with the camera’s lens interface.
- Screw the lens gently in counterclockwise direction to attach it to the camera mount.
- To remove the lens, twist the lens in clockwise direction, remove and add lens cap.

6.2.2 Mounting an F-Mount Lens

- Remove the lens caps and align the lens mount to the camera's lens interfaces. In some cases, a mount adapter may be required.
- First, screw in the mount adapter in clockwise direction.
- Attach the F-mount lens and lock it in with the adapter.
- To remove the lens, press and slide the knob on the adapter and rotate the lens simultaneously to unlock it.

Installing an F-Mount Lens with an Industrial Camera using mount adapter



6.3 Compatibility with Cameras

Please refer to lens models [5] for compatibility information.

- Check that the lens mount (e.g., C-mount, M12, F-mount) is compatible with your camera interface.
- Verify that the lens's image circle size is appropriate for the camera's sensor size.
- Check if the lens's resolution capabilities match or exceed the camera's pixel size requirements.
- For specialized applications, confirm compatibility with any additional features (motorized focus, iris control, etc.)

6.4 General Guidelines

- Always check the lens' back focal length and ensure it is compatible with the camera's mount depth
- When using adapters, ensure they don't interfere with lens controls and camera functions
- Adjust back focus and aperture after mounting for precise applications.
- Industrial settings, consider using lens covers for protection

6.5 Best Practices for Image Optimization

- Proper Lighting: Ensure adequate lighting conditions to avoid underexposure or overexposure.
- Adjust Focus: Regularly check the focus, especially in dynamic environments.
- Choose Correct Aperture: Use a smaller aperture (higher f-stop) for more depth of field and a larger aperture (lower f-stop) for better performance in low light.
- Minimize Vibration: Stabilize your camera system to reduce image blurring caused by movement or vibrations.

7. Maintenance and Cleaning

7.1 Cleaning the Lens Elements

- Remove dust or debris from the lens surface with a soft brush or air blower.
- Use a microfiber cloth to gently wipe the lens. Apply a lens cleaning solution if needed but avoid using harsh chemicals.
- Handle the lens by its mount or barrel to prevent fingerprints or oils from affecting the lens surface.

7.2 Preventive Maintenance Tips

- Keep the lens in a clean, dry, and dust-free environment.
- Regularly inspect the lens for cracks, scratches, or wear that may affect performance.
- Recalibrate the lens if any changes in focus or image distortion occur.
- Keep lens caps on when the system is not in use

7.3 Storage Recommendations

- Store the lens in its original packaging or in a padded case when not in use.
- Store lenses away from direct sunlight and in a temperature-controlled environment
- Always replace the lens caps when not in use to protect the lens from dust and scratches.

8. Performance Metrics

Understanding the optical performance metrics of a lens is important to evaluate its suitability for your application. It is also important to consider some mitigating tips to optimize image quality.

8.1 MTF (Modulation Transfer Function)

MTF is s acritical measure of lens resolution and sharpness in machine vision systems. It quantifies how well a lens can reproduce fine details of an object onto the image sensor. It measures the contrast at varying spatial frequencies.

- Higher MTF values indicate better image quality and sharpness
- Evaluate the MTF curve provided in the lens datasheet and choose lenses with high MTF value (0.5 or above) at required spatial frequencies for your application based on the criticality.

8.2 Distortion

Distortion is an optical imperfection that causes straight lines to appear curved in the captured image. Common types include barrel (negative) and pincushion (positive) distortion. Distortion affects the geometric accuracy of images, which is crucial for precision measurements in machine vision. Typically, ±2 to 3% distortion may go unnoticed if measurement algorithms are not used.

- Use lenses with minimal inherent distortion, such as telecentric lenses.
- Apply software-based distortion correction in post-processing or during calibration.

8.3 Chromatic Aberration

Chromatic aberration occurs when different wavelengths of light focus at different points, causing color fringing in high-contrast areas. It reduces image quality by introducing unwanted colors and blurring.

- Minimize using monochrome cameras with bandpass filters for color-sensitive applications.
- Opt for lenses with low-dispersion glass or achromatic design.

8.4 Vignetting

Vignetting is the gradual reduction of image brightness toward the edges of the frame. It can obscure details in the outer regions of the image.

- Use lenses with a large image circle to ensure uniform illumination across the sensor.
- Avoid extreme aperture settings, as smaller apertures reduce vignetting.
- Implement flat-field correction during image processing.

9. Troubleshooting

This section provides guidance for resolving common issues and understanding errors associated with machine vision lenses. If further assistance is required, instructions for contacting technical support are also provided.

9.1 Common issues and their Solution

Issue	Possible Cause	Solution
Image is blurry or not in focus	Incorrect focus adjustment or dirt on the lens	Re-adjust the focus. Clean the lens surface with a microfiber cloth.
Uneven Brightness across the Image	Vignetting or improper alignment	Check for the proper alignment of the lens and sensor. Adjust the aperture settings.
Distorted / warped image	Lens not calibrated correctly or unsuitable lens type	Perform lens calibration or use a telecentric lens for measurement accuracy.
Color Fringing or high contrast edges	Chromatic aberration	Use lenses with low-dispersion glass or apply post-processing corrections.
Dark spots or artifacts in the image	Dust or smudges on the lens or sensor	Clean the lens and sensor carefully using appropriate tools.
Lens not mounting properly	Incorrect lens mount type or damaged threads	Verify the lens mount compatibility. Inspect threads and clean or replace if damaged.
Motorized lens not responding	Power or connection issue, or software configuration error	Check power supply and cables. Verify software settings and reinitialize.
Poor image resolution	Incorrect focal length or insufficient optical quality	Verify that the lens matches the required resolution for the camera sensor
Excessive glare or reflections in image	Strong ambient light or uncoated lens surfaces	Use anti-reflective lens coatings or apply polarizing filters. Shield lens from direct light sources.
Misalignment of the field of view (FOV)	Lens not properly aligned with the camera or object	Re-adjust the lens and camera alignment. Use a mounting system with fine adjustments.

Difficulty achieving sharp focus	Sensor or object is outside the depth of field (DoF)	Select a lens with a suitable aperture or increase the DoF by closing the aperture.
Image shown black	Lens cap left on, incompatible lens, or misaligned sensor	Check for and remove the lens cap. Verify lens-camera compatibility and proper mounting.
Unstable image in a vibrating environment	Lack of proper stabilization for the lens or mounting system	Use vibration-damping mounts or lenses designed for high-vibration environments.
Lens fogging	Rapid temperature changes or high humidity	Allow the lens to acclimate to the environment. Use anti-fog coatings or silica gel in storage.
Peripheral image blur	Insufficient coverage of the camera's sensor by the lens	Ensure the lens image circle matches or exceeds the size of the camera sensor.
Noisy images	Insufficient light or incorrect sensor settings	Increase the aperture or use additional lighting. Adjust the camera's gain settings for better performance.
Software-related lens control failures	Incompatible drivers or outdated firmware	Update the lens drivers and firmware to the latest versions compatible with your system.

9.2 Contacting Technical Support

If the above solutions do not resolve your issue, contact VA Imaging technical support for assistance.
Contact

10. Conclusion

Thank you for choosing VA Imaging lenses for your machine vision applications. This manual has been designed to provide you with comprehensive guidance on the types of lenses we offer, installation, operation, and maintenance of your lens system.

Key points to remember:

- Proper installation and setup are crucial for optimal performance.
- Regular maintenance and cleaning will extend the life of your lens and ensure consistent image quality.
- Understanding and optimizing optical performance metrics will help you achieve the best results for your specific application.
- Should you encounter any issues, our technical support team is here to assist you.

We are committed to supporting your success in machine vision. As technology and applications evolve, we encourage you to stay updated with the latest developments and best practices in the field. For the most current information, product updates, and additional resources, please visit our website, VA Imaging. Your feedback is valuable to us. If you have any suggestions for improving this manual or our products, please don't hesitate to contact us. Thank you for your trust in VA Imaging. We look forward to being a part of your machine vision solutions for years to come.