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THORLABS

MVTC23024 - June 7, 2019

Item # MVTC23024 was discontinued on June 7, 2019. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

BI-TELECENTRIC LENSES FOR MACHINE VISION

- Ideal for Machine Vision Applications
- Provide Constant Magnification Independent of Object Location
- Lenses Available with Magnification of 0.051X or 0.243X

MVTC23024
0.243X Bi-Telecentric Lens

MVTC23005
0.051X Bi-Telecentric Lens

Hide Overview

OVERVIEW

Features

- Bi-Telecentric Lenses Offer Constant Magnification Across the Depth of Field
- Magnifications Available: 0.051X or 0.243X
- Compatible with C-Mount Cameras with Sensors up to 2/3" Format
- Each Lens Ships with Individual Metrology and Performance Data

Thorlabs has collaborated with Navitar to design and manufacture a line of telecentric lenses for machine vision applications. With bi-telecentric lenses, the magnification in both image and object space is independent of distance (within the depth of field) or the position in the field of view. This attribute is ideal for machine vision applications: when measuring dimensions, a telecentric lens will yield the same measurement regardless of changes in object distance or position. For more details on telecentric lenses and their differences from standard lenses, please see the *Telecentric Tutorial* tab above.

The Limited STOCK items on this page will be retired without replacement when stock is depleted. If you require any of these parts for line production, please contact our OEM Team.

Thorlabs offers telecentric lenses with magnification levels of 0.051X or 0.243X. Each lens has an adjustable iris that varies the f/#. The lenses are designed for 2/3" format sensors, such as those on our scientific CCD cameras. Sensors smaller than 2/3", such as those in our other CCD and CMOS cameras, can also be used but with reduced field of view (field of view values for various sensor formats can be found on the *Specs* tab). The lens housing features external C-Mount (1.000"-32) threading on the image side of the lens, which is also compatible with our cameras. By using an SM1A10 thread adapter, the C-Mount can be mated to internal SM1 (1.035"-40) threads for compatibility with our Lens Tubes or other SM1-threaded mounts.

Each individual lens ships with a detailed test report showing the exact specifications and graphs for the lens; PDF samples are available in the table below. Graphs showing typical performance for field curvature, distortion, relative illumination, and Modulation Transfer Function (MTF) can be found on the *Graphs* tab above.

Please note that due to the size and weight of the MVTC23005, users must take care to properly mount and support this lens.

Key Specifications[a]		
Item #	MVTC23005[b]	MVTC23024
Magnification	0.051X	0.243X
Working Distance[c]	530 mm	103 mm
Depth of Field[d]	±260 mm	±11 mm

Field of View for 2/3" Format Sensor (Full)[e]	214 mm	45.2 mm
Modulation Transfer Function (MTF)[f]	>51%	>51%
Sample Test Report		
Lens Mount	C-Mount (1.000"-32)	
Lens Length[g,h]	24.84" (630.8 mm)	6.36" (161.6 mm)
Lens Housing Diameter at Largest Point[h]	Ø9.44" (Ø239.8 mm)	Ø2.60" (Ø66.0 mm)
Weight	13.0 kg (28.7 lbs)[b]	0.61 kg (1.34 lbs)

a. Complete specifications may be found on the *Specs* tab.
b. The MVTC23005 is shipped in a heavy-duty carrying case.
c. Working distance is defined from the center of the depth of field to the first mechanical surface of the lens housing.
d. Specified at 20 lp/mm, 50% MTF, at the max aperture setting.
e. The field of view is specified in the direction along the sensor diagonal. Field of view values for additional sensor formats may be found on the *Specs* tab.
f. Specified at 70 lp/mm, across the field.
g. Not including the threaded C-Mount.
h. For more details, please see the Support Documents by clicking the red Docs icon next to an item number below.

Hide Specs

SPECS

Item #	MVTC23005	MVTC23024
Magnification	**0.051X**	**0.243X**
Magnification Error	± 1%	± 1%
Image Diagonal	11 mm (2/3" Format)	
Working Distance[a]	530 mm	103 mm
Depth of Field[b]	±260 mm	±11 mm
Working f/#[c]	f/8	f/8
System f/#	f/7.7 - f/22	f/6.5 - f/22
Field of View for 2/3" Format Sensor (Full)[d]	214 mm	45.2 mm
Telecentricity	0 ± 0.03°	0 ± 0.04°
Max Distortion	0 ± 0.03%	0 ± 0.02%
Modulation Transfer Function (MTF)[e]	>51%	>51%
Coherent Transfer Function (CTF)[e]	>63%	>63%
Image NA	0.0614	0.062
Object NA	0.00315	0.015
Lateral Color	R-G: <1.7 µm B-G: <0.08 µm	R-G: <1 µm B-G: <1 µm
Average Transmittance	96%[f]	97%[f]
Lens Mount	C-Mount (1.000"-32)	
Lens Length[g,h]	24.84" (630.8 mm)	6.36" (161.6 mm)
Lens Housing Diameter at Largest Point[h]	Ø9.44" (Ø239.8 mm)	Ø2.60" (Ø66.0 mm)
Lens Weight	13.0 kg (28.7 lbs)	0.61 kg (1.34 lbs)

a. Working distance is defined from the center of the depth of field to the first mechanical surface of the lens housing.
b. Specified at 20 lp/mm, 50% MTF, at the maximum aperture setting. Depth of field values for different aperture settings are given in the table below.
c. The working f/# is the value used for determining the other specifications unless otherwise stated.
d. The field of view is specified in the direction along the sensor diagonal. Values for additional sensor formats can be found in the tables below.
e. Specified at 70 lp/mm, across the field.
f. Specified Over 460 nm - 630 nm.
g. Not including the threaded C-Mount.
h. For more details, please see the Support Documents by clicking the red Docs icon next to an item number below.

Depth of Field

Depth of Field for MVTC23005 0.051X Telecentric Lens

f/#	Depth of Field
7.7	±260 mm
11	±370 mm
16	±540 mm
22	±740 mm

Field of View

Field of View for MVTC23005 0.051X Telecentric Lens	
Sensor Format	Field of View (Full)
1/3"	118 mm
1/2"	156 mm
1/1.8"	174 mm
2/3"	214 mm

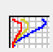
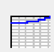
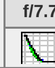
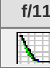
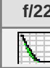
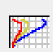
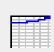
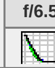
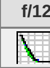
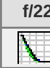
Depth of Field for MVTC23024 0.243X Telecentric Lens	
f/#	Depth of Field
6.5	±11 mm
12	±20 mm
18	±30 mm
22	±37 mm

Field of View for MVTC23024 0.243X Telecentric Lens	
Sensor Format	Field of View (Full)
1/3"	24.7 mm
1/2"	32.9 mm
1/1.8"	37.0 mm
2/3"	45.2 mm

Hide Graphs

GRAPHS

Click on the icons in the table below to see performance graphs for each telecentric lens. These graphs show the theoretically calculated modeling results from Zemax for the field curvature, distortion, relative illumination, and Modulation Transfer Function (MTF) for our telecentric lenses. Each lens ships with an individual test data sheet that contains test data for the lens, including plots of the MTF and distortion.

Item #	Lens Magnification	Field Curvature	Distortion	Relative Illumination @ 588 nm	MTF		
MVTC23005	0.051X				f/7.7	f/11	f/22
							
MVTC23024	0.243X				f/6.5	f/12	f/22
							

Hide Telecentric Tutorial

TELECENTRIC TUTORIAL

Telecentric Lenses

Telecentric lenses are designed to have a constant magnification regardless of the object's distance or location in the field of view. This attribute is ideal for many machine vision measurement applications, as measurements of an object's dimension will be independent of where it is located.

Types of Telecentric Lenses

In order to achieve a telecentric lens design, all of the chief rays (rays from an off-axis point that pass through the center of the aperture stop) have to be parallel to the optical axis in either image space or object space, or both. For an object space telecentric lens, the chief rays will be parallel to the optic axis on the object's side of the lens (object space). This is accomplished by setting the aperture stop at the front focal plane of the lens, which results in an entrance pupil at infinity. Since chief rays are directed towards the center of the entrance pupil, the chief rays on the object side of the lens will be parallel to the optical axis. An example of an object space telecentric lens is shown in Figure 1.

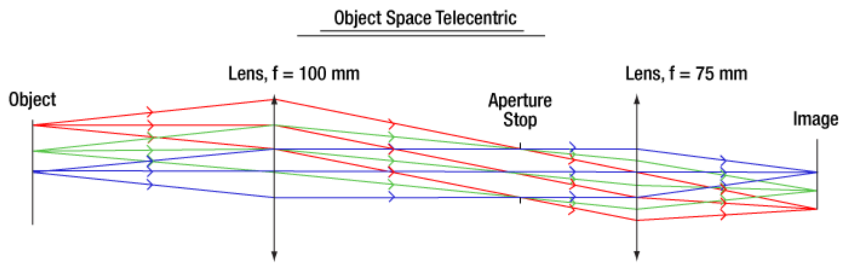


Figure 1: A ray trace through an idealized object space telecentric lens system. Note that the chief rays (the center ray of each color) is parallel to the optical axis in object space, but in image space, the chief rays form an angle with the optical axis.

For an image space telecentric lens, the chief rays will be parallel to the optical axis on the image's side of the lens (image space). This is accomplished by setting the aperture stop at the back focal plane of the lens, which results in an exit pupil at infinity. Since the chief rays must pass through the center of the exit pupil, the chief rays on the image side of the lens must be parallel to the optical axis. For a double telecentric, or bi-telecentric, lens, the front and back focal planes are made to overlap so that the aperture stop is located where both the entrance and exit pupils are at infinity. In a bi-telecentric lens, neither the image or object location will affect the magnification. Thorlabs' telecentric lenses are all bi-telecentric designs. Figure 2 shows an example ray trace through a telecentric lens and illustrates how the chief rays pass through the system.

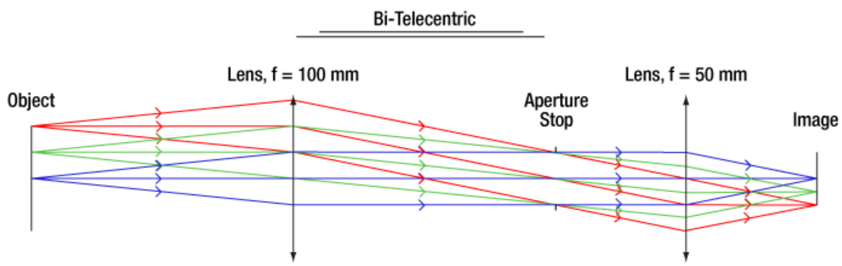


Figure 2: A ray trace through an idealized bi-telecentric lens system. Note that the chief rays (the center ray of each color) is parallel to the optical axis in both image and object space, which means that the magnification will remain constant regardless of object distance.

Conventional Lenses
In conventional lenses, the entrance and exit pupils are not located at infinity, so the chief rays will not be parallel to the optical axis. In this case, the magnification of the object depends on its distance from the lens and its position in the field of view. Figure 2 shows an example ray trace through a conventional camera lens; notice how the chief rays are angled with respect to the optical axis in both image and object space. Note that both Figures 2 and 3 feature the same lens design; only the aperture stop location was varied to shift the telecentric system to a non-telecentric one.

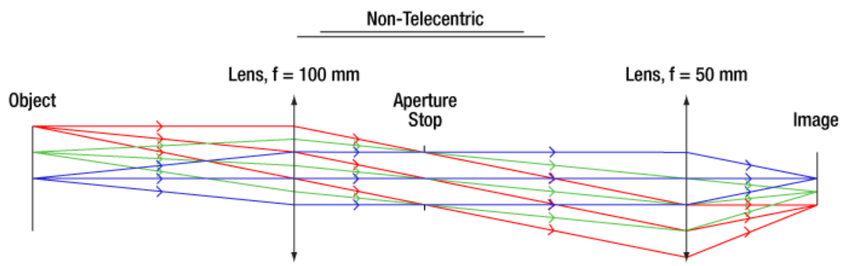


Figure 3: A ray trace through an idealized conventional camera lens system. Note that the chief rays (the center ray of each color) is not parallel to the optic axis in both image and object space, which means that the magnification will vary with object distance.

Example Images
Figures 4 and 5 show photographs taken with a telecentric lens and a standard camera lens, respectively. With the telecentric imaging system, the height of the two screws appears to be the same, even though the object planes are separated by approximately 45 mm along the optical axis. With the conventional imaging system, the two screws appear to be different heights, and therefore a machine vision system based on this lens will lead to incorrect dimensional measurements.

Click to Enlarge

Figure 4: An image of two identical 8-32 cap screws imaged with our previous generation MVTC23013 0.128X Telecentric Lens. Although the screws appear to be the same size and in the same object plane, they are actually separated by a distance of approximately 45 mm along the optical axis.

Click to Enlarge

Figure 5: The same two screws photographed with our MVL7000 conventional zoom lens. In this image, the perspective error due to the separation of the screws would lead to incorrect height measurements.

Hide Bi-Telecentric Lenses

Bi-Telecentric Lenses

Part Number	Description	Price	Availability
MVTC23005	**0.051X Bi-Telecentric C-Mount Camera Lens for Sensor Formats up to 2/3"**	**$5,358.06**	**Today**
MVTC23024	**0.243X Bi-Telecentric C-Mount Camera Lens for Sensor Formats up to 2/3"**	**$1,343.72**	**Today**

THORLABS

Optical Test Report

Lens Information

Part Number:	MVTC23024
Serial Number:	491216
Test Date:	1/22/2014
Tested By:	MHC
N° Horizontal Pixels:	2108
N° Vertical Pixels:	2108

Working Distance

Distance between the object and the first mechanical surface of the lens.

W.D., Nominal (mm):	103.2
W.D., As Tested (mm):	103.1
W.D. Error (%):	0.10%

Magnification

Measured on-axis from a square target of a known size in both the tangential and sagittal directions and averaged.

Mag., Nominal:	0.243
Mag., As Tested:	0.244
Mag. Error (%):	0.41%

Telecentricity

Measured by moving the target between the borders of the field depth test range and recording the change in field heights. The chief ray is then calculated from the ratio of the field height change to the total target displacement.

Maximum (deg):	-0.128

Radial Distortion

Characterized by measuring the field heights from the center of the field to the edge and calculating the deviation of the measure values from the on-axis magnification.

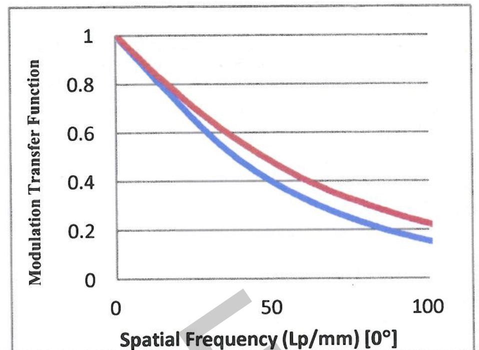
Avg Radial Distortion (%):	-0.02%

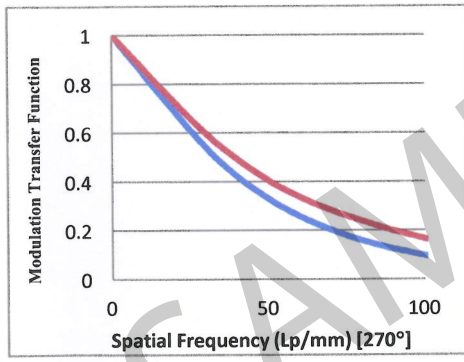
Test Conditions

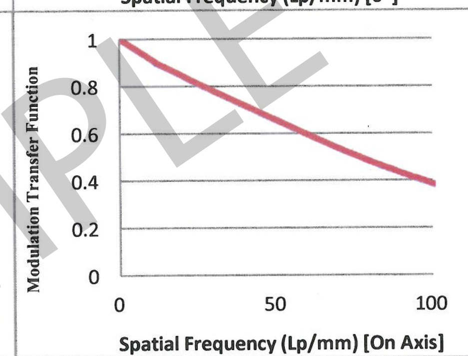
Target: Chrome-on-glass .25mm dots
Illumination: 450-650nm white LED telecentric back light source
Camera: Grasshoper3 USB3.0 mono, 1" sensor cropped to 2/3" format, 3.69 micron pixel size

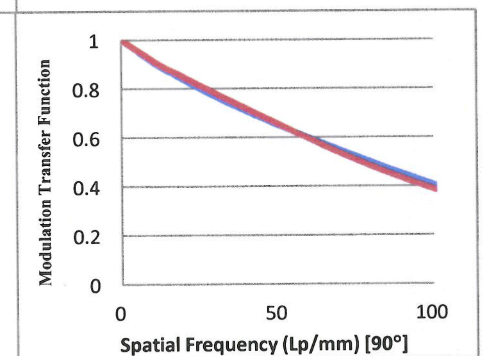
Modulation Transfer Function

The loss of contrast determined from imaging an object, expressed in spatial frequency. The higher the ratio, the higher the contrast. MTF measured on-axis and at four quadrants in the field in both tangential and sagittal directions.









Note: Tangential lines are blue. Sagittal lines are red.