

# TELECENTRIC LENSES

8 - 31	1/3" TO 2/3" SENSORS
32 - 42	UP TO 4/3" SENSORS
44 - 49	VERY LARGE & LINESCAN SENSORS

Outstanding optical performance.  
Unmatched customer service.

Opto Engineering® telecentric lenses are our core business: these products benefit from a decade-long effort in continuous research & development, resulting in an extensive range of part numbers for a diverse and ever-growing number of applications.

## These products deliver the highest optical performance available on the market:

- extra-telecentricity for thick object imaging
- very low distortion for accurate measurements
- excellent resolution for small pixel cameras
- wide field depth for large object displacements
- pre-adjusted back focal length and working distance
- compact and robust design, tailored for industrial environments

## TC lenses for matrix detectors also feature:

- bi-telecentric design
- detailed test report for each lens



Refer to specific datasheets available at [www.opto-engineering.com](http://www.opto-engineering.com) for product compliancy with regulations, certifications and safety labels.



INTERNATIONAL  
**PATENT**  
PENDING

# TC series

Bi-telecentric lenses for matrix detectors up to 2/3"



**TC series bi-telecentric lenses** represent the key component of any measurement system powered by machine vision: these lenses can truly take advantage of high-resolution detectors such as 5 Mpix - 2/3", acquiring images with exceptional fidelity and precision.

The Opto Engineering® bi-telecentric design makes these optics truly telecentric: no magnification change occurs when an object is moved closer to or away from the lens, making TC series ideal for measurement applications of mechanical parts ranging from extruded aluminium profiles to tiny clock gears.

No other lenses can offer the same optical performance in terms of telecentricity and distortion: additionally you can further enhance depth of field and optical accuracy by pairing our TC lenses with LTCLHP telecentric illuminators.

All of our TC lenses are rigorously tested and supplied with a detailed Test Report: We guarantee that 100% of our TC lenses meet or exceed our written specifications.

Opto Engineering® TC series offers the best performance to price ratio available today and is the ideal choice when no compromise can be accepted in terms of reliability and ease of use.

Additionally we supply useful accessories including CMHO clamping mechanics and CMPT mounting plates: mechanical support systems for easy integration in industrial environments, where a solid and secure assembly is mandatory.

NEW

Camera phase adjustment available on selected models for easy and hassle-free integration.

## KEY ADVANTAGES

**High telecentricity** for thick object imaging.

**Nearly zero distortion** for accurate measurements.

**Excellent resolution** for high resolution cameras.

**Simple and robust design** for industrial environments.

**Easy filter insertion.**

**Detailed test report with measured optical parameters.**

FOR HIGHER MAGNIFICATION LENSES SEE ALSO	
	TCHM series <span style="float: right;">p. 30</span>
FULL RANGE OF COMPATIBLE ILLUMINATORS	
	LTCLHP CORE series <span style="float: right;">p. 110</span>
FULL RANGE OF COMPATIBLE ACCESSORIES	
	Mounting mechanics CMHO and CMPT <span style="float: right;">p. 200-202</span>



Part number	Mag. (x)	Image circle (mm)	Detector type					Optical specifications					Mechanical specs				
			1/3"	1/2.5"	1/2"	1/1.8"	2/3" - 5 Mpx	WD	wF/#	Telecentricity	Distortion	Field	CTF	Mount	Phase adj.	Length	Diam.
			w x h	w x h	w x h	w x h	w x h	(mm)		typical (max)	typical (max)	depth	@70lp/mm			(mm)	(mm)
Object field of view (mm x mm) <b>8</b>																	
TC23004	2.000	11.0	2.40 x 1.80	2.85 x 2.14	3.20 x 2.40	3.56 x 2.68	4.22 x 3.55	56.0	11	< 0.08 (0.10)	< 0.04 (0.08)	0.23	> 30	C		101.4	28
TC23007	1.333	11.0	3.60 x 2.70	4.28 x 3.21	4.80 x 3.60	5.35 x 4.03	6.34 x 5.30	60.1	11	< 0.08 (0.10)	< 0.03 (0.08)	0.5	> 30	C		78.5	28
TC23009	1.000	11.0	4.80 x 3.60	5.70 x 4.28	6.40 x 4.80	7.13 x 5.37	8.44 x 7.06	62.2	11	< 0.08 (0.10)	< 0.04 (0.08)	0.9	> 25	C		65.0	28
TC23012	0.735	11.0	6.54 x 4.90	7.77 x 5.82	8.72 x 6.54	9.71 x 7.31	11.5 x 9.62	53.9	14	< 0.04 (0.10)	< 0.04 (0.10)	1.2	> 25	C		60.3	28
TC13016	0.290	6.0	16.6 x 12.4	∅ = 14.8	∅ = 16.6	∅ = 18.5	n.a.	43.1	8	< 0.04 (0.10)	< 0.04 (0.08)	8	> 40	C		80.9	37.7
TC12016	0.385	8.0	12.5 x 9.36	14.8 x 11.1	16.6 x 12.5	18.5 x 14.0	∅ = 18.4	43.1	8	< 0.04 (0.10)	< 0.04 (0.08)	5	> 40	C		93.0	37.7
TC23016	0.528	11.0	9.09 x 6.82	10.8 x 8.10	12.1 x 9.09	13.5 x 10.2	16.0 x 13.4	43.1	8	< 0.06 (0.10)	< 0.04 (0.07)	2	> 30	C		112.7	37.7
TC13024	0.192	6.0	25.0 x 18.7	∅ = 22.3	∅ = 25	∅ = 28	n.a.	67.2	8	< 0.08 (0.10)	< 0.04 (0.08)	19	> 45	C		105.6	44
TC12024	0.255	8.0	18.8 x 14.1	22.4 x 16.8	25.1 x 18.8	28.0 x 21.1	∅ = 27.7	67.2	8	< 0.08 (0.10)	< 0.04 (0.08)	10	> 45	C		117.8	44
TC23024	0.350	11.0	13.7 x 10.3	16.3 x 12.2	18.3 x 13.7	20.4 x 15.3	24.1 x 20.2	67.2	8	< 0.08 (0.10)	< 0.04 (0.10)	5	> 45	C		137.5	44
TC13036	0.133	6.0	36.0 x 27.0	∅ = 32.0	∅ = 36.0	∅ = 40.2	n.a.	102.5	8	< 0.04 (0.08)	< 0.03 (0.08)	38	> 50	C		133.0	61
TC12036	0.177	8.0	27.1 x 20.3	32.2 x 24.1	36.1 x 27.1	40.2 x 30.3	∅ = 39.9	102.5	8	< 0.03 (0.08)	< 0.04 (0.10)	21	> 40	C		145.2	61
TC23036	0.243	11.0	19.7 x 14.8	23.4 x 17.6	26.3 x 19.7	29.3 x 22.1	34.7 x 29.0	102.5	8	< 0.04 (0.08)	< 0.04 (0.10)	11	> 40	C		164.9	61
TC13048	0.098	6.0	48.8 x 36.6	∅ = 43.5	∅ = 48.8	∅ = 54.6	n.a.	133.4	8	< 0.08 (0.10)	< 0.06 (0.10)	65	> 40	C		167.9	75
TC12048	0.134	8.0	35.9 x 26.9	42.5 x 31.9	47.8 x 35.9	53.3 x 40.1	∅ = 52.8	132.9	8	< 0.07 (0.10)	< 0.06 (0.10)	37	> 40	C		181.5	75
TC23048	0.184	11.0	26.1 x 19.6	31.0 x 23.3	34.8 x 26.1	38.8 x 29.2	46.0 x 38.4	132.9	8	< 0.08 (0.10)	< 0.05 (0.10)	20	> 40	C		201.0	75
TC13056	0.084	6.0	57.1 x 42.8	∅ = 50.9	∅ = 57.1	∅ = 63.9	n.a.	157.8	8	< 0.04 (0.08)	< 0.04 (0.08)	93	> 50	C		191.5	80
TC12056	0.114	8.0	42.0 x 31.5	49.9 x 37.4	56.0 x 42.0	62.3 x 46.9	∅ = 61.8	157.8	8	< 0.04 (0.08)	< 0.04 (0.08)	51	> 50	C		205.0	80
TC23056	0.157	11.0	30.6 x 22.9	36.3 x 27.2	40.7 x 30.6	45.4 x 34.2	53.8 x 45.0	157.8	8	< 0.05 (0.08)	< 0.03 (0.08)	27	> 45	C		225.0	80
TC13064	0.074	6.0	65.2 x 48.9	∅ = 58.1	∅ = 65.2	∅ = 72.9	n.a.	181.9	8	< 0.06 (0.08)	< 0.03 (0.07)	124	> 40	C		212.3	100
TC12064	0.100	8.0	48.0 x 36.0	57.0 x 42.7	64.0 x 48.0	71.2 x 53.6	∅ = 70.6	181.8	8	< 0.05 (0.08)	< 0.04 (0.07)	67	> 50	C		225.9	100
TC23064	0.138	11.0	34.9 x 26.2	41.5 x 31.1	46.6 x 34.9	51.9 x 39.0	61.4 x 51.4	181.8	8	< 0.05 (0.08)	< 0.03 (0.07)	35	> 50	C		245.5	100
TC23072	0.122	11.0	39.2 x 29.4	46.6 x 35.0	52.3 x 39.2	58.3 x 43.9	69.1 x 57.8	226.7	8	< 0.04 (0.08)	< 0.03 (0.07)	45	> 40	C	Yes	299.2	116
TC13080	0.059	6.0	81.2 x 60.9	∅ = 72.4	∅ = 81.2	∅ = 90.9	n.a.	225.9	8	< 0.05 (0.08)	< 0.03 (0.08)	192	> 40	C		259.2	116
TC12080	0.080	8.0	59.8 x 44.8	71.0 x 53.2	79.7 x 59.8	88.7 x 66.8	∅ = 88.0	226.7	8	< 0.03 (0.08)	< 0.04 (0.10)	104	> 50	C		271.5	116
TC23080	0.110	11.0	43.5 x 32.6	51.7 x 38.8	58.0 x 43.5	64.6 x 48.7	76.5 x 64.0	226.7	8	< 0.04 (0.08)	< 0.02 (0.10)	55	> 50	C		291.2	116
TC23085	0.104	11.0	46.3 x 34.8	55.1 x 41.3	61.8 x 46.3	68.8 x 51.8	81.5 x 68.2	279.7	8	< 0.04 (0.08)	< 0.02 (0.08)	62	> 45	C	Yes	344.5	143
TC13096	0.050	6.0	96.0 x 72.0	∅ = 85.5	∅ = 96.0	∅ = 107.4	n.a.	279.6	8	< 0.06 (0.08)	< 0.04 (0.10)	268	> 50	C		303.3	143
TC12096	0.068	8.0	70.6 x 52.9	83.8 x 62.9	94.1 x 70.6	104.8 x 78.9	∅ = 103.9	278.6	8	< 0.06 (0.08)	< 0.03 (0.08)	145	> 45	C		317.0	143
TC23096	0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.4 x 75.6	278.6	8	< 0.06 (0.08)	< 0.04 (0.08)	77	> 40	C		336.6	143
TC23110	0.079	11.0	60.5 x 45.4	71.8 x 53.9	80.6 x 60.5	89.8 x 67.6	106.4 x 89.0	334.5	8	< 0.06 (0.08)	< 0.03 (0.07)	106	> 40	C	Yes	430.4	180
TC13120	0.038	6.0	125 x 93.9	∅ = 111.6	∅ = 125.2	∅ = 140	n.a.	334.5	8	< 0.06 (0.08)	< 0.04 (0.10)	450	> 45	C	Yes	398.1	180
TC12120	0.052	8.0	92.1 x 69.1	109.4 x 82.0	122.8 x 92.1	136.7 x 103.0	∅ = 135.5	334.5	8	< 0.06 (0.08)	< 0.04 (0.10)	247	> 45	C	Yes	402.7	180
TC23120	0.072	11.0	67.0 x 50.3	79.6 x 59.7	89.4 x 67.0	99.5 x 75.0	117.9 x 98.7	334.5	8	< 0.07 (0.08)	< 0.04 (0.10)	131	> 35	C	Yes	422.4	180
TC23130	0.068	11.0	70.9 x 53.2	84.2 x 63.2	94.5 x 70.9	105.3 x 79.3	124.7 x 104.3	396.0	8	< 0.05 (0.08)	< 0.04 (0.10)	146	> 40	C	Yes	490.0	200
TC13144	0.033	6.0	146.7 x 110.1	∅ = 130.8	∅ = 146.7	∅ = 164.2	n.a.	396.0	8	< 0.05 (0.08)	< 0.04 (0.10)	606	> 45	C	Yes	448.8	200
TC12144	0.044	8.0	107.9 x 80.9	128.2 x 96.2	143.9 x 107.9	160.3 x 120.7	∅ = 158.9	396.0	8	< 0.05 (0.08)	< 0.05 (0.08)	339	> 35	C	Yes	462.1	200
TC23144	0.061	11.0	78.6 x 58.9	93.3 x 70.0	104.8 x 78.6	116.7 x 87.9	138.3 x 115.7	396.0	8	< 0.05 (0.08)	< 0.04 (0.08)	180	> 40	C	Yes	481.9	200
TC23172	0.051	11.0	94.6 x 71.0	112.4 x 84.3	126.1 x 94.6	140.5 x 105.8	166.5 x 139.3	526.9	8	< 0.05 (0.08)	< 0.04 (0.10)	260	> 40	C	Yes	630.3	260
TC13192	0.025	6.0	195.8 x 146.9	∅ = 174.6	∅ = 195.8	∅ = 219.1	n.a.	527.0	8	< 0.06 (0.08)	< 0.04 (0.10)	1050	> 45	C	Yes	589.2	260
TC12192	0.033	8.0	144.1 x 108.0	171.1 x 128.3	192.1 x 144.1	213.9 x 161.1	∅ = 212.0	526.9	8	< 0.06 (0.08)	< 0.04 (0.08)	603	> 45	C	Yes	602.6	260
TC23192	0.046	11.0	104.9 x 78.6	124.6 x 93.4	139.8 x 104.9	155.7 x 117.3	184.5 x 154.4	526.9	8	< 0.06 (0.08)	< 0.05 (0.08)	320	> 35	C	Yes	622.3	260
TC23200	0.044	11.0	110.0 x 82.5	130.7 x 98.0	146.7 x 110.0	163.3 x 123.0	193.5 x 161.9	492.8	8	< 0.06 (0.08)	< 0.05 (0.10)	352	> 40	C	Yes	792.0	322
TC23240	0.037	11.0	130.8 x 98.1	155.4 x 116.6	174.4 x 130.8	194.3 x 146.3	230.2 x 192.6	492.8	8	< 0.03 (0.08)	< 0.04 (0.08)	498	> 45	C	Yes	775.1	322

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5.5 µm.

- Measured from the front end of the mechanics to the camera flange.
- With 1/1.8" (9 mm diagonal) detectors, the FOV of TC 12 yyy lenses may show some vignetting at the image corners, as these lenses are optimized for 1/2" detectors (8 mm diagonal).
- For the fields with the indication "∅ =", the image of a circular object of such diameter is fully inscribed into the detector.
- Indicates the availability of an integrated camera phase adjustment feature. If missing, it can be supplied upon request (except for TC23004, TC23007, TC23009, TC23012).

### Ordering information

It's easy to select the right lens for your application: our part numbers are coded as **TC xx yyy**, where **xx** defines the camera sensor size (13 = 1/3", 12 = 1/2", 23 = 2/3") and **yyy** refers to the width dimension of the object field of view (FOV), in millimeters. For instance, a TC 12 064 features a field of view of 64 (x 48) mm with a 1/2" camera sensor.

# TC CORE series

Ultra compact bi-telecentric lenses up to 2/3"



## KEY ADVANTAGES

### Excellent optical performance

TC CORE bi-telecentric lenses deliver excellent optical performance as other comparable Opto Engineering® bi-telecentric lenses.

### Extremely compact

TC CORE lenses are up to 70% smaller than other telecentric lenses on the market.

### Designed for flexibility and smart integration

TC CORE lenses integrate a camera phase adjustment and can be mounted on multiple sides with or without clamps, allowing you to cut costs.

### Save you money

Systems integrating TC CORE lenses take much less space, resulting in lower manufacturing, shipping and storage costs.

### Boost your sales

A smaller vision system or measurement machine is the solution preferred by the industry.

### Detailed test report with measured optical parameters.

**TC CORE** bi-telecentric lenses for sensors up to 2/3" feature a truly revolutionary ultra compact opto-mechanical design.

These lenses deliver high-end optical performance and at the same time are up to 70% smaller than other double-sided telecentric lenses on the market, thus allowing you to significantly downsize a vision system.

The unique shape has been expressly developed for maximum mounting flexibility.

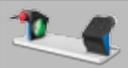
TC CORE lenses can be mounted in different directions using any of the 4 sides even without clamps, allowing you to cut the system's cost, and can be easily fitted or retrofitted even into very compact machines.

TC CORE bi-telecentric lenses can also be coupled with the new ultra compact LTCLHP CORE series telecentric illuminators to build super small yet extremely accurate measurement systems.



Comparison of a "classic" telecentric lens present on the market and a TC CORE bi-telecentric lens: TC CORE lens delivers best optical performance and is extremely compact.

## SEE ALSO

	TCBENCH CORE series	p. 27
<b>FULL RANGE OF COMPATIBLE ILLUMINATORS</b>		
	LTCLHP CORE series	p. 110
<b>FULL RANGE OF COMPATIBLE ACCESSORIES</b>		
	Mounting mechanics CMHOCR and CMPTCR series	p. 203



Multiple lens surfaces can be used for direct mounting without clamps, thanks to the M6 threaded holes located on 4 sides. This also allows you to cut costs.

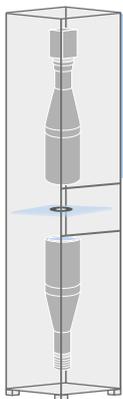


Front CMHOCR clamp available for added mounting flexibility.



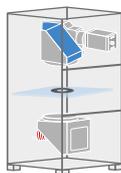
Built-in phase adjustment makes it easy to align the camera sensor.

**Off-line precision measurement systems:**



Integrates a classic telecentric lens and a classic telecentric illuminator present on the market.

Save up to **70%** in height



Integrates a TC CORE bi-telecentric lens and LTCLHP CORE telecentric illuminator.

**ADVANTAGES**



**Save more**

- Lower manufacturing cost due to less material employed
- Less space required for storage and use
- Lower shipment expenses due to smaller size
- Lower transportation risks

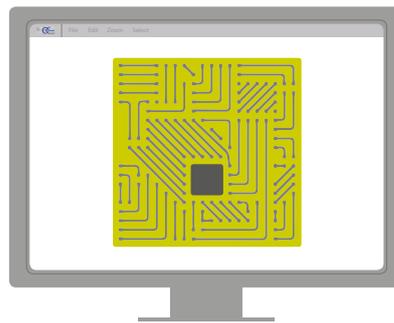
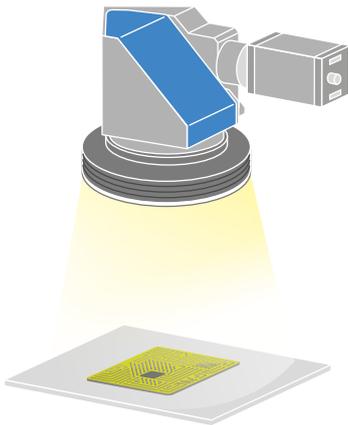
**Sell more**

- A smaller vision system or measurement machine is preferred by the industry

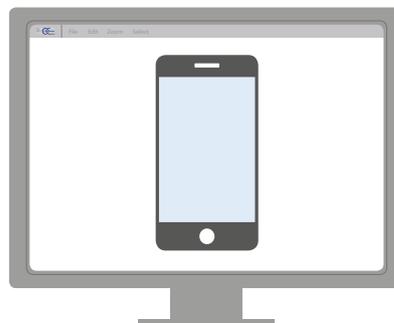
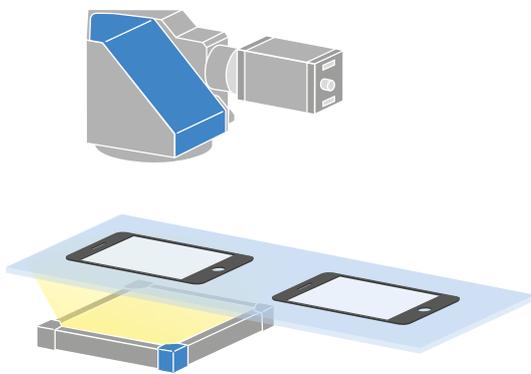
# TC CORE series

Ultra compact bi-telecentric lenses up to 2/3"

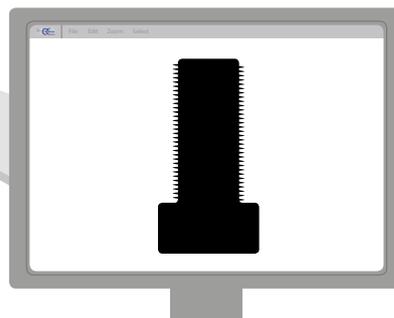
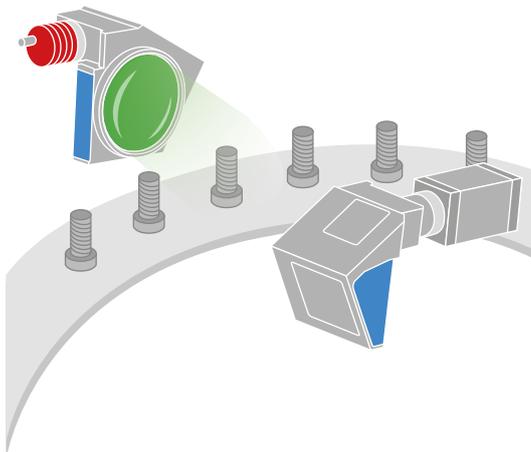
## Application examples



Electronic board inspection:  
TC CORE with top ringlight.



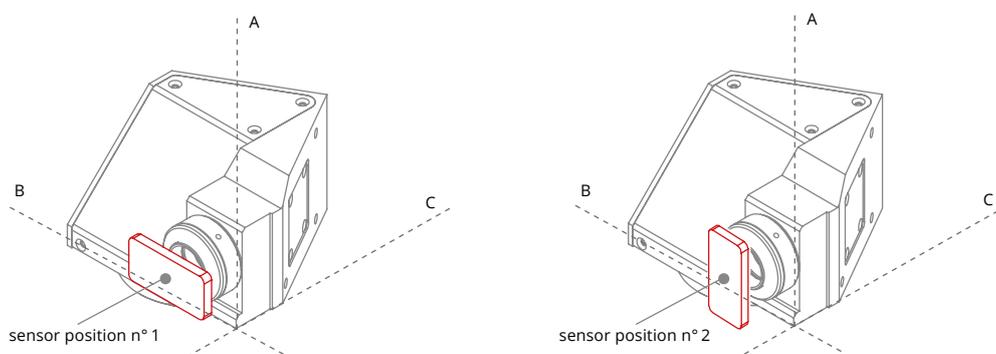
Smartphone glass inspection:  
TC CORE mounted directly  
on a plate and a flat backlight.



Screw measurement on a rotary  
glass table: TC CORE lens  
and LTCLHP CORE illuminator.



**TC CORE lens dimensions (A, B, C) and correct position of the sensor in relation to the lens:**



The long side of sensor has to be aligned along axis B (position n°1) or axis A (position n°2).

Part number	Mag.	Image circle Ø (x) (mm)	Detector type					Optical specifications					Mechanical specs					
			1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	2/3" - 5 MP w x h (mm x mm)	WD (mm)	wF/#	Telecentricity typical (max) (deg)	Distortion typical (max) (%)	Field depth (mm)	CTF @70 lp/mm (%)	Mount	Phase adj. 7	Dimensions (mm) A B C		
<b>Object field of view (mm x mm) 6</b>																		
TCCR 12 048	0.134	8.0	35.9 x 26.9	42.5 x 31.9	47.8 x 35.9	53.3 x 40.1	Ø = 52.8	132.9	8	< 0.07 (0.10)	< 0.06 (0.10)	37	> 40	C	Yes	77	106	115
TCCR 23 048	0.184	11.0	26.1 x 19.6	31.0 x 23.3	34.8 x 26.1	38.8 x 29.2	46.0 x 38.4	132.9	8	< 0.08 (0.10)	< 0.05 (0.10)	20	> 40	C	Yes	77	106	135
TCCR 12 056	0.114	8.0	42.0 x 31.5	49.9 x 37.4	56.0 x 42.0	62.3 x 46.9	Ø = 61.8	157.8	8	< 0.04 (0.08)	< 0.04 (0.10)	51	> 50	C	Yes	94	110	125
TCCR 23 056	0.157	11.0	30.6 x 22.9	36.3 x 27.2	40.7 x 30.6	45.4 x 34.2	53.8 x 45.0	157.8	8	< 0.05 (0.08)	< 0.03 (0.10)	27	> 45	C	Yes	94	110	145
TCCR 12 064	0.100	8.0	48.0 x 36.0	57.0 x 42.7	64.0 x 48.0	71.2 x 53.6	Ø = 70.6	181.8	8	< 0.05 (0.08)	< 0.04 (0.10)	67	> 50	C	Yes	101	122	133
TCCR 23 064	0.138	11.0	34.9 x 26.2	41.5 x 31.1	46.6 x 34.9	51.9 x 39.0	61.4 x 51.4	181.8	8	< 0.05 (0.08)	< 0.03 (0.10)	35	> 50	C	Yes	101	122	153
TCCR 12 080	0.080	8.0	59.8 x 44.8	71.0 x 53.2	79.7 x 59.8	88.7 x 66.8	Ø = 88.0	226.7	8	< 0.03 (0.08)	< 0.04 (0.10)	104	> 50	C	Yes	119	145	159
TCCR 23 080	0.110	11.0	43.5 x 32.6	51.7 x 38.8	58.0 x 43.5	64.6 x 48.7	76.5 x 64.0	226.7	8	< 0.04 (0.08)	< 0.02 (0.10)	55	> 50	C	Yes	119	145	172
TCCR 12 096	0.068	8.0	70.6 x 52.9	83.8 x 62.9	94.1 x 70.6	104.8 x 78.9	Ø = 103.9	278.6	8	< 0.06 (0.08)	< 0.03 (0.10)	145	> 45	C	Yes	139	172	183
TCCR 23 096	0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.4 x 75.6	278.6	8	< 0.06 (0.08)	< 0.04 (0.10)	77	> 40	C	Yes	139	172	197

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.

- At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5.5 µm.
- For the fields with the indication "Ø =", the image of a circular object of such diameter is fully inscribed into the detector.
- Indicates the availability of an integrated camera phase adjustment feature.
- Due to the special shape of TCCR120xx it might be necessary to check the mechanical compatibility with your camera.

# TCUV series

UV bi-telecentric lenses



**TCUV series** bi-telecentric lenses are specifically designed to ensure the highest image resolution today available in the machine vision world.

No other lenses in the market can efficiently operate with pixels as small as 2 microns. For this reason TCUV bi-telecentric lenses are a MUST for all those using high resolution cameras and seeking for the highest system accuracy.

Common lenses and traditional telecentric lenses operate in the visible light (VIS) range. The maximum resolution of a lens is given by the cut-off frequency, that is the spatial frequency at which the lens is no longer able to yield sufficient image contrast.

Since the cut-off frequency is inversely proportional to the light wavelength, common optics are useless with very small pixel sizes (such as 1.75 microns) which are becoming increasingly popular among industrial cameras.

## Application examples



Image captured with a lens operating in the visible range.

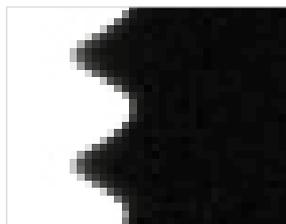


Image taken with a TCUV bi-telecentric lens.

## KEY ADVANTAGES

**Extremely high resolution** for cameras with very small pixels.

**High telecentricity** for thick object imaging.

**Nearly zero distortion** for accurate measurements.

**Detailed test report with measured optical parameters.**

## FULL RANGE OF COMPATIBLE ACCESSORIES



CMHO series

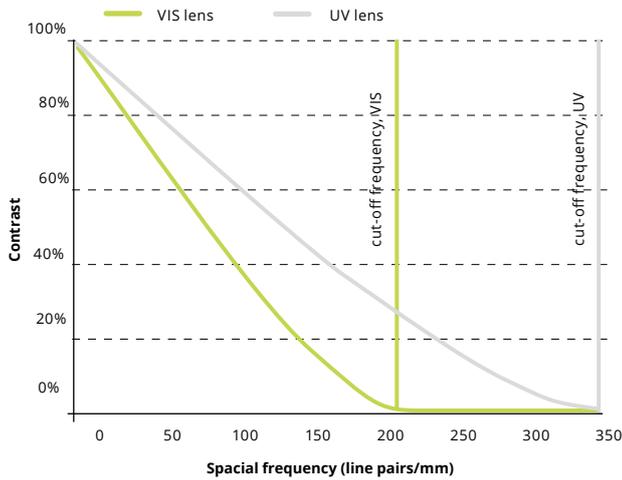
p. 200

## FULL RANGE OF COMPATIBLE CAMERAS

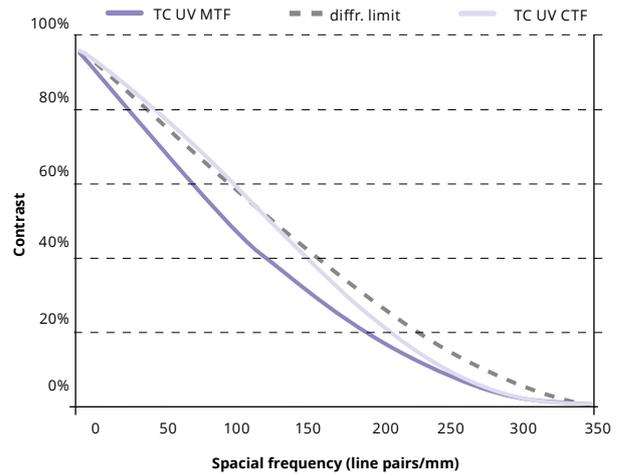


Area scan cameras

p. 180-185



The graph shows the limit performance (diffraction limit) of two lenses operating at working F/# 8. The standard lens operates at 587 nm (green light) while the UV lens operates at 365 nm.



The CTF function, which expresses the contrast ratio at a given spatial frequency is much higher with TCUV lenses. The vertical bars show the cut-off frequencies of each lens: TCUV lenses still yield some contrast up to 340 lp/mm.

Part number	Mag. (x)	Detector type					Optical specifications						Mechanical specs		
		1/3"	1/2.5"	1/2"	1/1.8"	2/3"	WD (mm)	wF/#	Telecentricity typical (max) (deg)	Distortion typical (max) (%)	Field depth (mm)	CTF @70lp/mm (%)	Mount	Length (mm)	Diam. (mm)
		w x h (mm x mm)													
<b>Object field of view (mm x mm) 9</b>															
TCUV 12 036	0.175	27.4 x 20.5	32.2 x 24.1	36.5 x 27.4	40.6 x 30.6	∅ = 37.6	98.7	8	< 0.1	< 0.08	21.0	> 60	C	142.3	61.0
TCUV 23 036	0.241	19.9 x 14.9	23.4 x 17.6	26.6 x 19.9	29.6 x 22.3	36.5 x 27.4	98.7	8	< 0.1	< 0.08	11.0	> 60	C	160.4	61.0
TCUV 12 048	0.133	36.0 x 27.0	42.5 x 31.9	47.9 x 36.0	53.4 x 40.2	∅ = 49.4	130.7	8	< 0.08	< 0.08	37.0	> 60	C	176.1	75.0
TCUV 23 048	0.183	26.2 x 19.6	31.0 x 23.3	34.9 x 26.2	38.9 x 29.3	48.0 x 36.0	130.7	8	< 0.08	< 0.08	20.0	> 60	C	160.4	75.0
TCUV 12 056	0.114	42.0 x 31.5	49.9 x 37.4	56.1 x 42.0	62.4 x 47.0	∅ = 57.8	154.0	8	< 0.1	< 0.08	51.0	> 60	C	198.4	80.0
TCUV 23 056	0.157	30.6 x 22.9	36.3 x 27.2	40.8 x 30.6	45.4 x 34.2	56.1 x 42.1	154.0	8	< 0.1	< 0.08	27.0	> 60	C	160.4	80.0
TCUV 12 064	0.100	48.0 x 36.0	57.0 x 42.7	64.0 x 48.0	71.3 x 53.7	∅ = 66	176.0	8	< 0.08	< 0.08	66.0	> 60	C	219.7	100.0
TCUV 23 064	0.137	34.9 x 26.2	41.5 x 31.1	46.6 x 34.9	51.9 x 39.1	64.1 x 48.0	176.0	8	< 0.08	< 0.08	35.0	> 60	C	160.4	100.0
TCUV 12 080	0.080	59.8 x 44.8	71.0 x 53.2	79.7 x 59.8	88.8 x 66.9	∅ = 82.2	221.0	8	< 0.08	< 0.08	102.0	> 60	C	264.3	116.0
TCUV 23 080	0.110	43.5 x 32.6	51.7 x 38.8	58.0 x 43.5	64.5 x 48.6	79.7 x 59.8	221.0	8	< 0.08	< 0.08	54.0	> 60	C	160.4	116.0

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- At the borders of the field depth the image can be still used for measurement but, to get a very sharp image, only half of the nominal field depth should be considered.
- Nominal value.
- Measured from the front end of the mechanics to the camera flange.
- With 1/1.8" (9 mm diagonal) detectors, the FOV of TCUV 12 XX lenses may show some vignetting at the image corners, as these lenses are optimized for 1/2" detectors (8 mm diagonal).
- For the fields with the indication "∅ =", the image of a circular object of such diameter is fully inscribed into the detector.

# TCSM series

3D bi-telecentric lenses with Scheimpflug adjustment



## KEY ADVANTAGES

### Unique Scheimpflug adjustment

No other lens can perform oblique measurements.

### The image is radially undistorted

Linear extension can be perfectly calibrated.

### Compatible with any C-mount camera

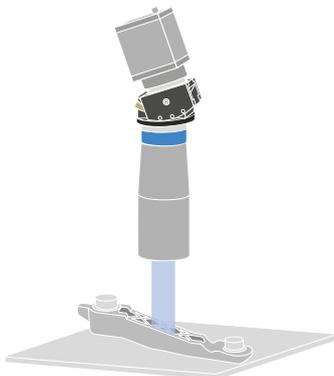
C-mount standard compliant.

### Detailed test report with measured optical parameters.

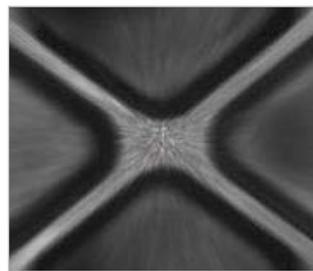
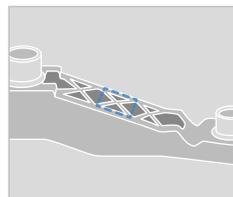
**TCSM series** is a unique family of bi-telecentric lenses for extremely accurate 3D dimensional measurement systems. All TCSM lenses are equipped with a high-precision Scheimpflug adjustment mechanism that fits any type of C-mount camera. Besides achieving very good focus at wide tilt angles, bi-telecentricity also yields incredibly low distortion. Images are linearly compressed only in one direction,

thus making 3D-reconstruction very easy and exceptionally accurate. The available magnifications ranges from 0.5x to 0.1x while the angle of view reaches 30°-45° to meet the measurement needs of triangulation-based techniques. The Scheimpflug mount tilts around the horizontal axis of the detector plane to ensure excellent pointing stability and ease of focus.

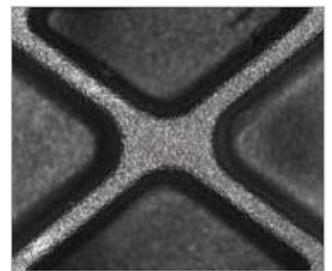
## Examples of high-end 3D measurements



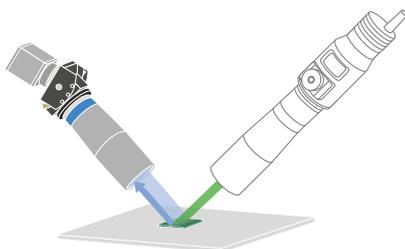
TCSM imaging and measuring sloped objects.



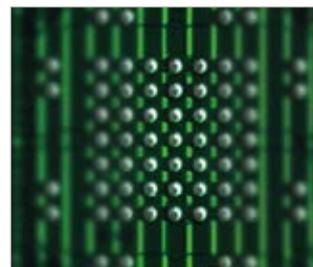
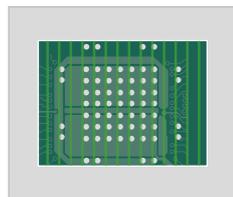
Without tilt adjustment, the object is not homogeneously focused.



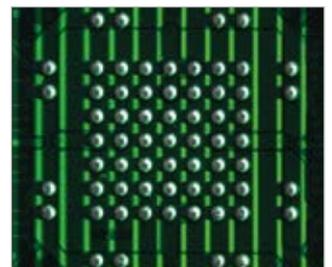
At the Scheimpflug angle, the image becomes sharp.



Scheimpflug telecentric optics for both projection and imaging at 90°.



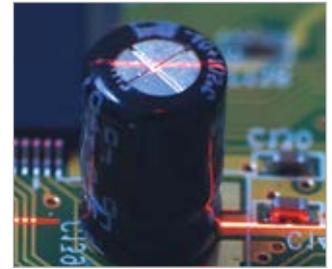
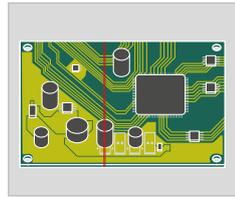
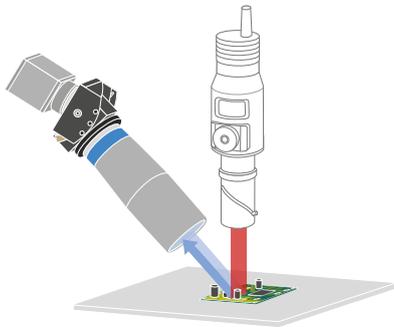
Without tilt adjustment, the object is not homogeneously focused.



At the Scheimpflug angle, the image becomes sharp.



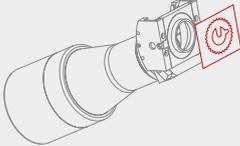
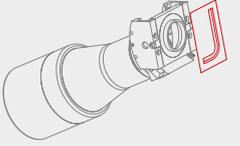
SEE ALSO		
	MCSM1-01X	p. 74
FULL RANGE OF COMPATIBLE PRODUCTS FOR 3D APPLICATIONS		
	LED pattern projectors	p. 146
FULL RANGE OF COMPATIBLE ACCESSORIES		
	CMHO series	p. 200



TCSM series lens for straight telecentric pattern projection.

Without tilt adjustment, the object is not homogeneously focused.

At the Scheimpflug angle, the image becomes sharp.

Part number	Object tilt (deg)	Mount tilt (deg)	WD (mm)	Horizontal mag (x)	Vertical mag (x)	Mount	Phase adj.	Long detector side horizontal			Long detector side vertical			
								1/3" w x h	1/2" w x h	2/3" w x h	1/3" w x h	1/2" w x h	2/3" w x h	
								1						2
								Field of view - w x h (mm x mm)			Field of view - w x h (mm x mm)			
														
TCSM 016	0.0	0.0	43.1	0.528	0.528	C	Yes	9.09 x 6.82	12.1 x 9.09	16.7 x 12.5	6.82 x 9.09	9.09 x 12.1	12.5 x 16.7	
	10.0	5.3		0.528	0.522			9.09 x 6.89	12.1 x 9.19	16.7 x 12.6	6.82 x 9.20	9.09 x 12.3	12.5 x 16.9	
	20.0	10.9		0.528	0.506			9.09 x 7.15	12.1 x 9.53	16.7 x 13.1	6.82 x 9.49	9.09 x 12.7	12.5 x 17.4	
	30.0	17.0		0.528	0.478			9.09 x 7.54	12.1 x 10.1	16.7 x 13.8	6.82 x 10.0	9.09 x 13.4	12.5 x 18.4	
TCSM 024	0.0	0.0	67.2	0.350	0.350	C	Yes	13.7 x 10.3	18.3 x 13.7	25.1 x 18.9	10.3 x 13.7	13.7 x 18.3	18.9 x 25.1	
	15.0	5.4		0.350	0.338			13.7 x 10.6	18.3 x 14.2	25.1 x 19.5	10.3 x 14.2	13.7 x 18.9	18.9 x 26.0	
	30.0	11.4		0.350	0.308			13.7 x 11.7	18.3 x 15.6	25.1 x 21.4	10.3 x 15.6	13.7 x 20.8	18.9 x 28.5	
	45.0	19.3		0.350	0.262			13.7 x 13.7	18.3 x 18.3	25.1 x 25.2	10.3 x 18.3	13.7 x 24.4	18.9 x 33.6	
TCSM 036	0.0	0.0	102.5	0.243	0.243	C	Yes	19.7 x 14.8	26.3 x 19.7	36.2 x 27.1	14.8 x 19.7	19.7 x 26.3	27.1 x 36.2	
	15.0	3.7		0.243	0.235			19.7 x 15.3	26.3 x 20.4	36.2 x 28.1	14.8 x 20.4	19.7 x 27.2	27.1 x 37.4	
	30.0	8.0		0.243	0.213			19.7 x 17.0	26.3 x 22.6	36.2 x 31.1	14.8 x 22.6	19.7 x 30.1	27.1 x 41.4	
	45.0	13.6		0.243	0.177			19.7 x 20.4	26.3 x 27.2	36.2 x 37.4	14.8 x 27.1	19.7 x 36.2	27.1 x 49.7	
TCSM 048	0.0	0.0	132.9	0.185	0.185	C	Yes	26.0 x 19.5	34.7 x 26.0	47.7 x 35.7	19.5 x 26.0	26.0 x 34.7	35.7 x 47.7	
	15.0	2.8		0.185	0.181			26.0 x 20.1	34.7 x 26.8	47.7 x 36.9	19.5 x 26.5	26.0 x 35.3	35.7 x 48.6	
	30.0	6.1		0.185	0.161			26.0 x 22.4	34.7 x 29.9	47.7 x 41.1	19.5 x 29.8	26.0 x 39.8	35.7 x 54.7	
	45.0	10.5		0.185	0.133			26.0 x 27.1	34.7 x 36.2	47.7 x 49.8	19.5 x 36.1	26.0 x 48.2	35.7 x 66.2	
TCSM 056	0.0	0.0	157.8	0.157	0.157	C	Yes	30.6 x 22.9	40.8 x 30.6	56.1 x 42.0	22.9 x 30.6	30.6 x 40.8	42.0 x 56.1	
	15.0	2.4		0.157	0.152			30.6 x 23.7	40.8 x 31.7	56.1 x 43.5	22.9 x 31.6	30.6 x 42.2	42.0 x 58.0	
	30.0	5.1		0.157	0.136			30.6 x 26.4	40.8 x 35.2	56.1 x 48.4	22.9 x 35.2	30.6 x 46.9	42.0 x 64.5	
	45.0	8.8		0.157	0.112			30.6 x 32.1	40.8 x 42.8	56.1 x 58.8	22.9 x 42.8	30.6 x 57.0	42.0 x 78.4	
TCSM 064	0.0	0.0	181.8	0.137	0.137	C	Yes	34.9 x 26.2	46.6 x 34.9	64.0 x 48.0	26.2 x 34.9	34.9 x 46.6	48.0 x 64.0	
	15.0	2.1		0.137	0.133			34.9 x 27.1	46.6 x 36.2	64.0 x 49.8	26.2 x 36.1	34.9 x 48.2	48.0 x 66.3	
	30.0	4.5		0.137	0.119			34.9 x 30.2	46.6 x 40.3	64.0 x 55.4	26.2 x 40.2	34.9 x 53.6	48.0 x 73.7	
	45.0	7.8		0.137	0.098			34.9 x 36.8	46.6 x 49.0	64.0 x 67.4	26.2 x 49.0	34.9 x 65.3	48.0 x 89.8	
TCSM 080	0.0	0.0	226.7	0.110	0.110	C	Yes	43.6 x 32.9	58.2 x 43.6	80.0 x 60.0	32.7 x 43.6	43.6 x 58.2	60.0 x 80.0	
	15.0	1.7		0.110	0.107			43.6 x 33.8	58.2 x 45.0	80.0 x 61.9	32.7 x 45.0	43.6 x 60.0	60.0 x 82.5	
	30.0	3.6		0.110	0.096			43.6 x 37.6	58.2 x 50.2	80.0 x 69.0	32.7 x 50.2	43.6 x 67.0	60.0 x 92.1	
	45.0	6.3		0.110	0.078			43.6 x 45.9	58.2 x 61.2	80.0 x 84.2	32.7 x 61.2	43.6 x 81.7	60.0 x 112.3	
TCSM 096	0.0	0.0	278.6	0.093	0.093	C	Yes	51.4 x 38.5	68.5 x 51.4	94.2 x 70.7	38.5 x 51.4	51.4 x 68.5	70.7 x 94.2	
	15.0	1.4		0.093	0.090			51.4 x 39.9	68.5 x 53.2	94.2 x 73.1	38.5 x 53.2	51.4 x 70.9	70.7 x 97.5	
	30.0	3.1		0.093	0.081			51.4 x 44.4	68.5 x 59.2	94.2 x 81.5	38.5 x 59.2	51.4 x 79.0	70.7 x 108.6	
	45.0	5.3		0.093	0.066			51.4 x 54.4	68.5 x 72.5	94.2 x 99.7	38.5 x 72.4	51.4 x 96.6	70.7 x 132.8	

1 Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.

2 Indicates the availability of an integrated camera phase adjustment feature.

# TCLWD series

Long working distance telecentric lenses for 2/3" detectors



**TCLWD** is a range of telecentric lenses specifically designed for electronic and semiconductor Automated Optical Inspection (AOI) and tool pre-setting machines.

All these lenses feature a working distance of 135 mm and offer excellent optical resolution, high telecentricity and low distortion, thus matching and even exceeding the industrial requirements for the target applications.

The long working distance allows for extra space, which is essential if you need to install illumination, pick-up tools or provide the necessary separation from hazardous production processes.

In addition to the long working distance, TCLWD optics have a numerical aperture large enough to take advantage of high resolution / small pixel size cameras, making these lenses a perfect match for general-purpose 2D measurement systems.

## KEY ADVANTAGES

### Long working distance

Perfect for electronic components inspection and tool pre-setting machines.

### High numerical aperture

For small pixel size / high resolution detectors.

### Easy rotational phase adjustment

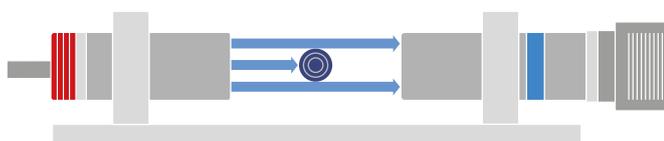
Robust and precise tuning of the lens-camera phase.

### Full range of compatible products

Fits LTCLHP telecentric illuminators, CMHO clamping supports and LTRN ring illuminators.

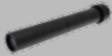
**Detailed test report with measured optical parameters.**

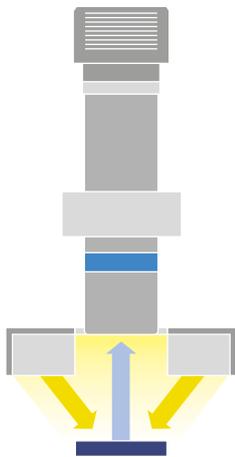
## Application examples



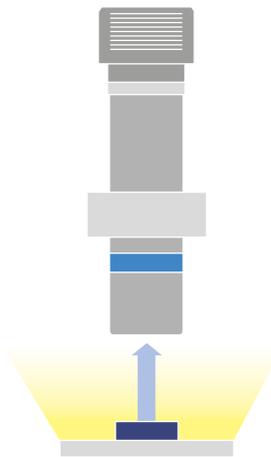
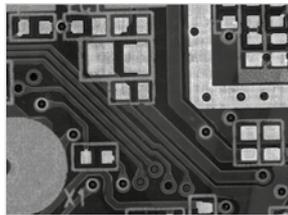
A TCLWD050 lens assembled with a CMHO016 clamping mechanics and back-illuminated by a LTCLHP016-G telecentric illuminator forming an inspection system for measurement of mechanical components such as milling tools and screws.



FOR OTHER LONG WORKING DISTANCE TELECENTRIC LENSES, SEE ALSO		
	TCLWD series	p. 30
FULL RANGE OF COMPATIBLE ILLUMINATORS		
	Backlights LTBP, LTBC, LTBFC series	p. 134-140
COMPATIBLE CLAMPING MECHANICS		
	Mounting clamp CMH0016	p. 200



A TCLWD lens in combination with LTRN016 ring illuminator inspecting an electronic board.



A TCLWD lens measuring a clock gear with backlight illumination.



Part number	Mag. (x)	Image circle (mm)	Detector type					Optical specifications					Mechanical specs				
			1/3"	1/2.5"	1/2"	1/1.8"	2/3"- 5 Mpx	WD	wF/#	Telecentricity	Distortion	Field depth	CTF	Mount	Phase adj.	Length	Diam.
			w x h	w x h	w x h	w x h	w x h	(mm)		typical (max)	typical (max)	(mm)	@35lp/mm			(mm)	(mm)
			Object field of view (mm x mm)														
TCLWD 050	0.50	11.0	9.60 x 7.20	11.4 x 8.56	12.8 x 9.60	14.3 x 10.7	16.9 x 14.1	132.3	12	0.04 (0.06)	0.1 (0.20)	4	> 60	C	Yes	130.7	37.7
TCLWD 066	0.66	11.0	7.27 x 5.45	8.64 x 6.48	9.70 x 7.27	10.8 x 8.14	12.8 x 10.7	132.3	12	0.04 (0.06)	0.1 (0.20)	2.3	> 58	C	Yes	149.3	37.7
TCLWD 075	0.75	11.0	6.40 x 4.80	7.60 x 5.71	8.53 x 6.40	9.51 x 7.16	11.3 x 9.43	132.3	12	0.04 (0.06)	0.1 (0.20)	1.8	> 55	C	Yes	155.0	37.7
TCLWD 100	1.00	11.0	4.80 x 3.60	5.70 x 4.28	6.40 x 4.80	7.13 x 5.37	8.45 x 7.07	132.3	12	0.04 (0.06)	0.05 (0.10)	1	> 60	C	Yes	126.0	37.7
TCLWD 150	1.50	11.0	3.20 x 2.40	3.80 x 2.85	4.27 x 3.20	4.75 x 3.58	5.63 x 4.71	132.3	16	0.04 (0.06)	0.05 (0.10)	0.6	> 50	C	Yes	140.4	37.7
TCLWD 250	2.50	11.0	1.92 x 1.44	2.28 x 1.71	2.56 x 1.92	2.85 x 2.15	3.38 x 2.83	132.3	20	0.04 (0.06)	0.05 (0.10)	0.3	> 40	C	Yes	157.0	37.7
TCLWD 350	3.50	11.0	1.37 x 1.03	1.63 x 1.22	1.83 x 1.37	2.04 x 1.53	2.41 x 2.02	132.3	24	0.04 (0.06)	0.05 (0.10)	0.2	> 30	C	Yes	174.7	37.7

- 1 Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- 2 Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- 3 Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- 4 Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- 5 At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5.5 µm.
- 6 Measured from the front end of the mechanics to the camera flange.
- 7 Indicates the availability of an integrated camera phase adjustment feature.

**Ordering information**

It's easy to select the right lens for your application: our part numbers are coded as **TCLWD xxx**, where **xxx** defines the magnification (050 = 0.50, 066 = 0.66, 075 = 0.75, ... ). For instance, a TCLWD 050 features a 0.50 magnification.

# TCCX series

Telecentric lenses with built-in coaxial illumination



## KEY ADVANTAGES

### Large numerical aperture

For small pixel size camera resolution.

### Long working distance

Tailored for electronic components inspection.

### Compact built-in illumination

Ideal for high-end applications in the semiconductor industry.

### Easy rotational phase adjustment

Robust and precise tuning of the camera phase.

### Detailed test report with measured optical parameters.

**TCCX series** is a range of lenses designed for measurement and defect detection on flat surfaces. They feature the same magnifications and working distance of TCLWD series while adding integrated coaxial light.

Such lighting configuration is required to homogeneously illuminate uneven surfaces and detect small surface defects such as scratches or grooves, finding application in many industries, from the electronics and semiconductor industries to the glass and metal fabrication industries.

All these lenses operate at a working distance of 135 mm while their large numerical aperture enables the superior resolution needed for small pixel cameras, matching and even exceeding the industrial requirements of on- and off-line applications.

The built-in LED source, equipped with advanced electronics, provides excellent illumination stability and homogeneity, key factors for the reliability of any machine vision system.

The unique optical design minimizes the internal reflection issues of conventional coaxial illumination systems: this makes TCCX lenses the perfect choice especially when inspecting highly reflective flat surfaces (approx. > 30% reflectance).

Typical application include recognition of silicon wafers pattern and inspection of LCD displays, polished metal surfaces, plastic and glass panels, and many other.

## FOR OTHER MAGNIFICATIONS COAXIAL TELECENTRIC LENSES SEE ALSO



TCCXHM, TCCXLM series

p. 31

## FULL RANGE OF COMPATIBLE ILLUMINATORS



Backlights LTBP, LTBC, LTBCF series

p. 134-140

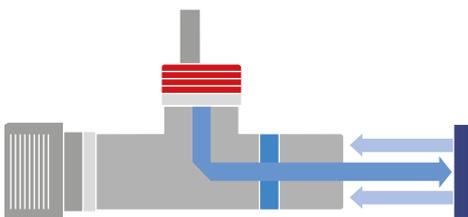
## FULL RANGE OF COMPATIBLE ACCESSORIES



Mounting mechanics CMH0016

p. 200

## Application examples



TCCX lens inspects objects using coaxial illumination.

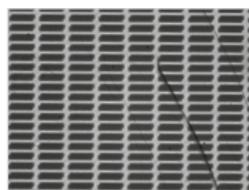
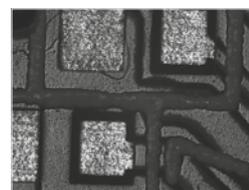
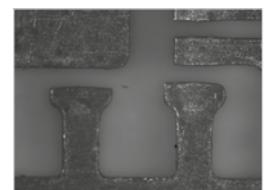


Image of an LCD display taken with a TCCX250 lens.



Details of an electronic board imaged with a TCCX lens with green illumination.



Scratches on a stainless steel surface emphasized by coaxial illumination.



### Precise light intensity tuning

Easily and precisely tune the light intensity level thanks to the leadscrew multi-turn trimmer positioned in the back.



### Direct LED control

The built-in electronics can be bypassed in order to drive the LED directly for use in continuous or pulsed mode. When bypassed, the built-in electronics behaves as an open circuit allowing for direct control of the LED source.



## Electrical specifications

Part number	Light color, wavelength peak	Device power ratings			LED power ratings			
		DC voltage		Power consumption (W)	Max LED fwd current (mA)	Forward voltage		Max pulse current (mA)
		min (V)	max (V)			typ. (V)	max (V)	
<b>TCCXxxx-G</b>	green, 520 nm	12	24	< 2.5	350	3.3	4.00	2000
<b>TCCXxxx-W</b>	white	12	24	< 2.5	350	2.78	n.a.	2000

- 1 Tolerance ± 10%.
- 2 Used in continuous (not pulsed) mode.
- 3 At max forward current. Tolerance is ±0.06V on forward voltage measurements.
- 4 At pulse width ≤ 10 ms, duty cycle ≤ 10% condition. Built-in electronics board must be bypassed (see tech info online).

Part number	Mag.	Image circle (x) Ø (mm)	Detector type					Optical specifications					Mechanical specs				
			1/3"	1/2.5"	1/2"	1/1.8"	2/3"- 5 Mpx	WD	wF/#	Telecentricity	Distortion	Field	CTF	Mount	Phase	Length	Diam.
			w x h (mm x mm)	(mm)		typical (max) (deg)	typical (max) (%)	depth (mm)	@35lp/mm (%)	adj.	(mm)	(mm)					
<b>Object field of view (mm x mm)</b>																	
<b>TCCX 050-G</b>	0.50	11	9.60 x 7.20	11.4 x 8.56	12.8 x 9.60	14.3 x 10.7	16.9 x 14.1	132.3	12	0.04 (0.06)	0.1 (0.20)	4	> 60	C	Yes	131.2	37.7
<b>TCCX 050-W</b>	0.50	11	9.60 x 7.20	11.4 x 8.56	12.8 x 9.60	14.3 x 10.7	16.9 x 14.1	132.3	12	0.04 (0.06)	0.1 (0.20)	4	> 60	C	Yes	131.2	37.7
<b>TCCX 066-G</b>	0.66	11	7.27 x 5.45	8.64 x 6.48	9.70 x 7.27	10.8 x 8.14	12.8 x 10.7	132.3	12	0.04 (0.06)	0.1 (0.20)	2.3	> 58	C	Yes	149.8	37.7
<b>TCCX 066-W</b>	0.66	11	7.27 x 5.45	8.64 x 6.48	9.70 x 7.27	10.8 x 8.14	12.8 x 10.7	132.3	12	0.04 (0.06)	0.1 (0.20)	2.3	> 58	C	Yes	149.8	37.7
<b>TCCX 075-G</b>	0.75	11	6.40 x 4.80	7.60 x 5.71	8.53 x 6.40	9.51 x 7.16	11.3 x 9.43	132.3	12	0.04 (0.06)	0.1 (0.20)	1.8	> 55	C	Yes	155.5	37.7
<b>TCCX 075-W</b>	0.75	11	6.40 x 4.80	7.60 x 5.71	8.53 x 6.40	9.51 x 7.16	11.3 x 9.43	132.3	12	0.04 (0.06)	0.1 (0.20)	1.8	> 55	C	Yes	155.5	37.7
<b>TCCX 100-G</b>	1.00	11	4.80 x 3.60	5.70 x 4.28	6.40 x 4.80	7.13 x 5.37	8.45 x 7.07	132.3	12	0.04 (0.06)	0.05 (0.10)	1	> 60	C	Yes	132.9	37.7
<b>TCCX 100-W</b>	1.00	11	4.80 x 3.60	5.70 x 4.28	6.40 x 4.80	7.13 x 5.37	8.45 x 7.07	132.3	12	0.04 (0.06)	0.05 (0.10)	1	> 60	C	Yes	132.9	37.7
<b>TCCX 150-G</b>	1.50	11	3.20 x 2.40	3.80 x 2.85	4.27 x 3.20	4.75 x 3.58	5.63 x 4.71	132.3	16	0.04 (0.06)	0.05 (0.10)	0.6	> 50	C	Yes	147.2	37.7
<b>TCCX 150-W</b>	1.50	11	3.20 x 2.40	3.80 x 2.85	4.27 x 3.20	4.75 x 3.58	5.63 x 4.71	132.3	16	0.04 (0.06)	0.05 (0.10)	0.6	> 50	C	Yes	147.2	37.7
<b>TCCX 250-G</b>	2.50	11	1.92 x 1.44	2.28 x 1.71	2.56 x 1.92	2.85 x 2.15	3.38 x 2.83	132.3	20	0.04 (0.06)	0.05 (0.10)	0.3	> 40	C	Yes	163.9	37.7
<b>TCCX 250-W</b>	2.50	11	1.92 x 1.44	2.28 x 1.71	2.56 x 1.92	2.85 x 2.15	3.38 x 2.83	132.3	20	0.04 (0.06)	0.05 (0.10)	0.3	> 40	C	Yes	163.9	37.7
<b>TCCX 350-G</b>	3.50	11	1.37 x 1.03	1.63 x 1.22	1.83 x 1.37	2.04 x 1.53	2.41 x 2.02	132.3	24	0.04 (0.06)	0.05 (0.10)	0.2	> 30	C	Yes	181.5	37.7
<b>TCCX 350-W</b>	3.50	11	1.37 x 1.03	1.63 x 1.22	1.83 x 1.37	2.04 x 1.53	2.41 x 2.02	132.3	24	0.04 (0.06)	0.05 (0.10)	0.2	> 30	C	Yes	181.5	37.7

- 1 Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- 2 Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- 3 Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- 4 Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- 5 At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5.5 µm.
- 6 Measured from the front end of the mechanics to the camera flange.
- 7 Indicates the availability of an integrated camera phase adjustment feature.

### Ordering information

It's easy to select the right lens for your application: our part numbers are coded as **TCCX xxx-y**, where **xxx** defines the magnification (050 = 0.50, 066 = 0.66, 075 = 0.75, ...) and **y** defines the source color ("G" stands for "green light", "W" stands for "white light"). For instance, a TCCX 050-G features a 0.50 magnification with a green light source.

# TCCXQ series

High resolution telecentric assemblies with coaxial illumination



**TCCXQ optical assemblies** combine the high optical performance of TC telecentric lenses and the LTCLHP series ability to provide accurate and reliable illumination.

Pairing these two Opto Engineering® flagship products results in a system completely free from straylight and back-reflections, while marking superior optical performance (in terms of resolution, telecentricity and distortion) even at the highest magnifications.

This optical layout also minimizes the overall height of the system, also allowing the user to easily adjust the camera orientation and back focal distance of the lens.

TCCXQ assemblies can be successfully employed in high accuracy measurement applications as well as Automated Optical Inspection (AOI) setups.

## KEY ADVANTAGES

### Completely free from stray-light

Compatible with both reflective and diffusive surface objects.

### High resolution

For sharp edge imaging and small imperfections detection.

### Bi-telecentric design

Same degree of measurement accuracy as standard bi-telecentric lenses.

### Optimal light collimation

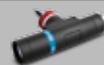
For precise direct light measurement applications.

### Detailed test report with measured optical parameters.



TCCXQ 066-G, formed by TCLWD 066, CMBS 016, LTCLHP 016-G.

## FOR OTHER COAXIAL SOLUTIONS SEE ALSO



TCCX series

p. 20



LTCXC series

p. 145

## FULL RANGE OF COMPATIBLE CAMERAS



Area scan cameras

p. 180-185



## Electrical specifications

Part number	Light color, wavelength peak	Device power ratings			LED power ratings			
		DC voltage		Power consumption (W)	Max LED fwd current (mA)	Forward voltage		Max pulse current (mA)
		min (V)	max (V)			typ. (V)	max (V)	
TCCXQ xxx-G	green, 520 nm	12	24	< 2.5	350	3.3	4.00	2000
TCCXQ xxx-W	white	12	24	< 2.5	350	2.78	n.a.	2000

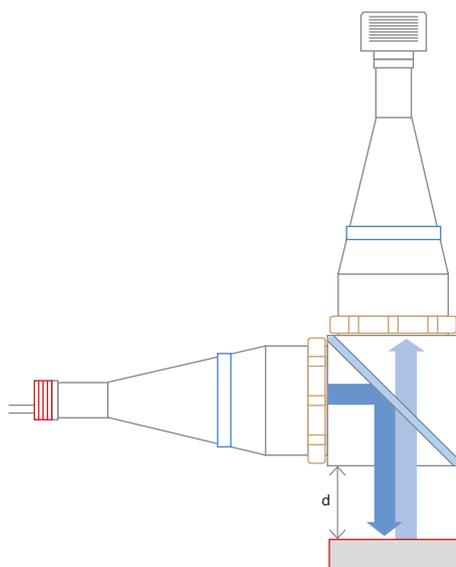
1 Tolerance ± 10%.

2 Used in continuous (not pulsed) mode.

3 At max forward current. Tolerance is ±0.06V on forward voltage measurements.

4 At pulse width ≤ 10 ms, duty cycle ≤ 10% condition.

Built-in electronics board must be bypassed (see tech info online).



TCCXQ 011-x

Part number (*)	Mag. (x)	Image circle Ø (mm)	Available colours		Detector type					Optical specifications Object distance d (mm)	Mechanical specifications				
			G	W	1/3"	1/2.5"	1/2"	1/1.8"	2/3" - 5 Mpx		Mount	Phase adj.	Length (mm)	Height (mm)	Width (mm)
					w x h (mm x mm)										
Object field of view (mm x mm)															
TCCXQ 150-x	1.50	11	x	x	3.20 x 2.40	3.80 x 2.85	4.27 x 3.20	4.75 x 3.58	5.63 x 4.71	82.8	C	155.0	64	198.9	
TCCXQ 100-x	1.00	11	x	x	4.80 x 3.60	5.70 x 4.28	6.40 x 4.80	7.13 x 5.37	8.45 x 7.07	82.8	C	155.0	64	182.5	
TCCXQ 075-x	0.75	11	x	x	6.40 x 4.80	7.60 x 5.71	8.53 x 6.40	9.51 x 7.16	11.3 x 9.43	82.8	C	155.0	64	213.5	
TCCXQ 066-x	0.66	11	x	x	7.27 x 5.45	8.64 x 6.48	9.70 x 7.27	10.8 x 8.10	12.8 x 10.7	82.8	C	155.0	64	207.8	
TCCXQ 050-x	0.50	11	x	x	9.60 x 7.20	11.4 x 8.56	12.8 x 9.60	14.3 x 10.7	16.9 x 14.1	82.8	C	155.0	64	189.2	
TCCXQ 024-x	0.24	11	x	x	19.8 x 14.8	23.4 x 17.6	26.3 x 19.8	29.3 x 22.1	34.8 x 29.1	20.1	C	235.9	88	252.4	
TCCXQ 018-x	0.18	11	x	x	26.1 x 19.6	31.0 x 23.3	34.8 x 26.1	38.8 x 29.2	45.9 x 38.4	37.0	C	285.2	102	303.2	
TCCXQ 016-x	0.16	11	x	x	30.6 x 22.9	36.3 x 27.2	40.8 x 30.6	45.4 x 34.2	53.8 x 45.0	50.7	C	319.2	108	336.7	
TCCXQ 014-x	0.14	11	x	x	34.8 x 26.1	41.5 x 31.1	46.4 x 34.8	51.7 x 38.9	61.2 x 51.2	63.8	C	350.3	128	367.6	
TCCXQ 011-x	0.11	11	x	x	43.6 x 32.7	51.7 x 38.8	58.2 x 43.6	64.8 x 48.8	76.8 x 64.3	90.1	C	415.6	144	433.1	

1 Indicates the availability of an integrated camera phase adjustment feature. If missing, it can be supplied upon request.

(\*) The last digit of the part number "-x" defines the source colour.

# TCZR series

8x bi-telecentric zoom lenses with motorized control



**TCZR series** is a leading edge optical solution for imaging and measurement applications requiring both the flexibility of zoom lenses and the accuracy of fixed optics.

By means of a very accurate mechanism, these lenses ensure unequalled magnification, focusing and image center stability when switching from a magnification to another, thus avoiding recalibration at any given time.

Four different magnifications, featuring a total zoom range of 8x, can be selected either by means of the onboard control keyboard or via computer through a specific remote control software.

Bi-telecentricity, high resolution and low distortion make these zooms able to perform the same measurement tasks as a fixed magnification telecentric lens.

#### FOR OTHER MULTI-MAGNIFICATION OPTICS SEE ALSO



MCZR series

p. 76

#### FULL RANGE OF COMPATIBLE ILLUMINATORS



Backlights LTBP, LTBC, LTBFC series

p. 134-140

#### FULL RANGE OF COMPATIBLE ACCESSORIES



CMHO TCZR

p. 200

#### MANUAL AND SETUP

Please refer to our website for the updated TCZR manual and for a complete technical documentation of the setup process.

[www.opto-engineering.com](http://www.opto-engineering.com)

#### KEY ADVANTAGES

##### Perfect magnification constancy

No need to re-calibrate after zooming.

##### Perfect parfocality

No need to refocus when changing magnification.

##### Bi-telecentricity

Very accurate measurement is possible.

##### Excellent image center stability

Each magnification maintains its FOV center.

##### Full motorization control

Zoom magnification can be set either manually or via software.

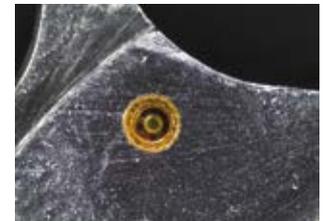
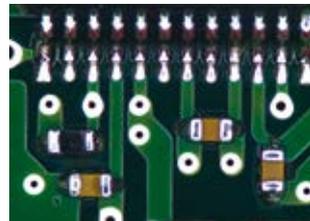
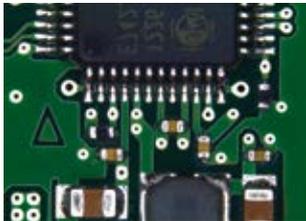
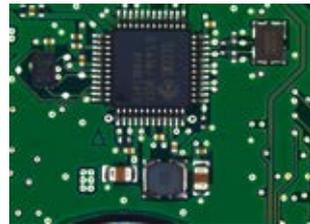
##### Detailed test report with measured optical parameters.



TCZR series can be coupled with LTCLHP and LTRN series illuminators and CMHO TCZR precision clamp.



## Application examples



Electronic board images taken with TCZR 036 at four different magnifications.

Hard disk arm images taken with TCZR 072 at four different magnifications.

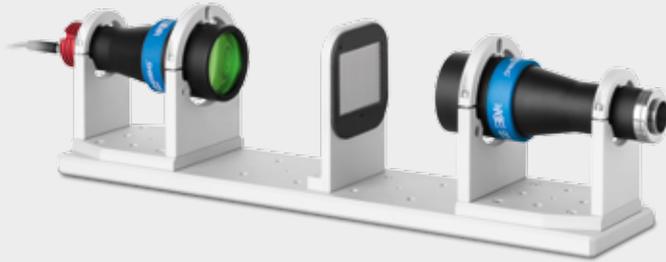
Part number	Mag. (x)	Image circle Ø (mm)	Detector type					Optical specifications					Mechanical specs				
			1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	2/3"-5 Mpx w x h (mm x mm)	WD (mm)	wF/#	Telecentricity (deg)	Distortion (%)	Field depth (mm)	CTF @70lp/mm (%)	Mount	Phase adj.	Length (mm)	Diam. (mm)
			Object field of view (mm x mm)					1		2		3		4			
TCZR 036	0.250	11.0	19.2 x 14.4	22.8 x 17.1	25.6 x 19.2	28.5 x 21.5	33.7 x 28.2	74.0	16	< 0.05	< 0.05	11	> 40	C	Yes	212.0	56
	0.500		9.60 x 7.20	11.4 x 8.50	12.8 x 9.60	14.2 x 10.7	16.8 x 14.1				< 0.04	2.8	> 35				
	1.000		4.80 x 3.60	5.70 x 4.20	6.40 x 4.80	7.10 x 5.30	8.40 x 7.00				< 0.04	0.7	> 40				
	2.000		2.40 x 1.80	2.80 x 2.10	3.20 x 2.40	3.50 x 2.60	4.20 x 3.50				< 0.08	0.2	> 35				
TCZR 072	0.125	11.0	38.4 x 28.8	45.6 x 34.2	51.2 x 38.4	57.0 x 49.0	67.6 x 56.5	157.8	16	< 0.05	< 0.10	45	> 35	C	Yes	279.7	99
	0.250		19.2 x 14.4	22.8 x 17.1	25.6 x 19.2	28.5 x 21.5	33.7 x 28.2				< 0.08	11	> 40				
	0.500		9.60 x 7.20	11.4 x 8.50	12.8 x 9.60	14.2 x 10.7	16.8 x 14.1				< 0.05	2.8	> 40				
	1.000		4.80 x 3.60	5.70 x 4.20	6.40 x 4.80	7.10 x 5.30	8.40 x 7.00				< 0.07	0.7	> 35				

- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of principal rays inside the lens: converted in milliradians, it gives the maximum measurement error for any millimeter of object displacement.

- At the borders of the field depth, the image can be still used for measurement, but to get a perfectly sharp image only half of the nominal field depth should be considered. Pixel size used for calculation is 3.9 µm.
- Indicates the availability of an integrated camera phase adjustment feature.

# TCBENCH series

TC optical bench kits for easy measurements



## KEY ADVANTAGES

### Pre-assembled setup

Just attach your camera, and the bench is ready for measurement.

### Best optical performance

The bench is pre-set to provide unpaired measurement accuracy.

### Tested system

The bench is quality tested as a whole system.

### Detailed test report with measured optical parameters.

#### FULL RANGE OF COMPATIBLE ACCESSORIES



Optical filters

p. 212

#### FULL RANGE OF COMPATIBLE CAMERAS



Area scan cameras

p. 180-185

**TCBENCH series** are complete optical systems designed for hassle-free development of demanding measurement applications.

### Each kit integrates:

- 1 TC bi-telecentric lens for 2/3" detectors
- 1 LTCLHP telecentric illuminator (green)
- 2 CMHO mechanical clamps
- 1 CMPT base-plate
- 1 PTTC chrome-on-glass calibration pattern
- 1 CMPH pattern holder

The benches come ready for use, pre-assembled and pre-aligned to assure the best accuracy that a telecentric measurement system can deliver.

The collimated light source is set in order to optimize both illumination homogeneity and relevant optical parameters such as distortion, telecentricity and resolution.

Coupling a LTCLHP illuminator with a telecentric lens increases the natural field depth of the lens; this is particularly true for 2/3" detector lenses where the acceptance angle of ray bundles is much larger than the divergence of the collimating source.

For this reason these benches feature unmatched image resolution and field depth.

Opto Engineering® measures the optical performance of each TCBENCH and provides an individual test report. TCBENCH series also benefits from a special price policy, combining high-end performance with cost effectiveness.

Part number	Mag.	Image circle (x) Ø (mm)	Detector type					Optical specifications					Mechanical specifications					
			1/3"	1/2.5"	1/2"	1/1.8"	2/3"- 5 Mpx	WD	Optical Accuracy	Optical Accuracy	Field Depth	CTF	Mount	Phase adj.	Length	Width	Height	Weight
			w x h	w x h	w x h	w x h	w x h	(mm)	(µm)	(%)	(mm)	@70lp/mm (%)			(mm)	(mm)	(mm)	(g)
			Field of view (mm x mm)															
<b>TCBENCH 009</b>	1.000	11.0	4.80 x 3.60	5.70 x 4.28	6.40 x 4.80	7.13 x 5.37	8.44 x 7.06	62.2	< 5	< 0.06%	1.2	> 35	C		282.0	56.0	78.5	900
<b>TCBENCH 016</b>	0.528	11.0	9.09 x 6.82	10.8 x 8.10	12.1 x 9.09	13.5 x 10.2	16.0 x 13.4	43.1	< 8	< 0.05%	2.9	> 40	C		297.0	65.5	81.2	1200
<b>TCBENCH 024</b>	0.350	11.0	13.7 x 10.3	16.3 x 12.2	18.3 x 13.7	20.4 x 15.3	24.1 x 20.2	67.2	< 13	< 0.05%	7.0	> 55	C		391.0	65.5	78.5	1340
<b>TCBENCH 036</b>	0.243	11.0	19.7 x 14.8	23.4 x 17.6	26.3 x 19.7	29.3 x 22.1	34.7 x 29.0	102.5	< 22	< 0.06%	14	> 50	C		529.0	103.0	140.5	4150
<b>TCBENCH 048</b>	0.184	11.0	26.1 x 19.6	31.0 x 23.3	34.8 x 26.1	38.8 x 29.2	46.0 x 38.4	132.9	< 31	< 0.06%	24	> 50	C		636.0	117.0	147.5	5600
<b>TCBENCH 056</b>	0.157	11.0	30.6 x 22.9	36.3 x 27.2	40.7 x 30.6	45.4 x 34.2	53.8 x 45.0	157.8	< 36	< 0.06%	33	> 55	C		701.0	122.0	150.0	7300
<b>TCBENCH 064</b>	0.138	11.0	34.9 x 26.2	41.5 x 31.1	46.6 x 34.9	51.9 x 39.1	61.4 x 51.4	181.8	< 40	< 0.06%	43	> 65	C		845.0	143.0	160.5	8700
<b>TCBENCH 080</b>	0.110	11.0	43.5 x 32.6	51.7 x 38.8	58.0 x 43.5	64.6 x 48.7	76.5 x 64.0	226.7	< 55	< 0.07%	67	> 55	C		915.0	158.0	168.0	11100
<b>TCBENCH 096</b>	0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.4 x 75.6	278.6	< 70	< 0.07%	94	> 50	C		1053.0	206.5	185.0	15300

**1** Working distance: distance between the front end of the lens mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution.

**2,3** Maximum measurement error without software calibration; standard image correction libraries yield close to zero measurement error.

**4** Indicates the availability of an integrated camera phase adjustment feature. If missing, it can be supplied upon request (except for TCBENCH009)

# TCBENCH CORE series

Ultra compact TCCORE optical benches for precision measurements



## KEY ADVANTAGES

### Multi-level cost cutting

Saves money on manufacturing and transportation costs.

### Downsized vision system

Allows you to reduce the length of your measurement system.

### Pre-assembled setup

Just add a camera and measurement software and you're ready to go.

### Best optical performance in a super tight space

A complete optical system designed for hassle free development of demanding precision measurement applications.

### Detailed test report with measured optical parameters.

**TCBENCH CORE series** are complete and super compact optical systems offering superior performance for highly demanding measurement applications in a super compact assembly.

The benches come pre-mounted and pre-aligned, ensuring the best accuracy that a telecentric measurement system can deliver.

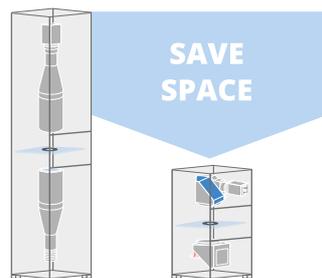
### Each TCBENCH CORE integrates:

- 1 TC CORE bi-telecentric lens for 2/3" sensors
- 1 LTCLHP CORE telecentric illuminator (green)
- 1 CMPTCR base plate

TCBENCH CORE systems deliver the same optical performance as our TCBENCH systems in a very reduced space.

### Non-contact measurement machine example

Technical specs	Standard components	TCBENCH CORE	Comparison
Camera sensor (mm)	8.45 x 7.07	8.45 x 7.07	High-end performance of both systems
FOV (mm)	90.4 x 75.6	90.4 x 75.6	
Field depth (mm)	94	94	
CTF 70 lp/mm (%)	> 50	> 50	
Height (m)	1.65	0.77	54% volume difference
Length (m)	0.45	0.45	
Width (m)	0.41	0.41	
Volume (m <sup>3</sup> )	0.30	0.14	



Example of off-line measurement systems with "classic" telecentric lens and illuminator (left) and TCBENCH CORE (right).

### FULL RANGE OF COMPATIBLE ACCESSORIES

	LTDV1CH-17V strobe controller	p. 222
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Part number	Mag.	Image circle (x) Ø (mm)	Detector type					2/3" - 5 Mpx w x h (mm x mm)	Optical specs			Mechanical specifications				
			1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	2/3" - 5 Mpx w x h (mm x mm)		WD (mm) 1	Field Depth (mm) 2	CTF @70lp/mm (%)	Mount	Phase adj. 3	Length (mm)	Width (mm)	Height (mm)
<b>Field of view (mm x mm)</b>																
TCCRBENCH 048	0.184	11.0	26.1 x 19.6	31.0 x 23.3	34.8 x 26.1	38.8 x 29.2	46.0 x 38.4	132.9	24	> 50	C	Yes	352	134	118	3849
TCCRBENCH 056	0.157	11.0	30.6 x 22.9	36.3 x 27.2	40.7 x 30.6	45.4 x 34.2	53.8 x 45.0	157.8	33	> 55	C	Yes	424	144	122	5392
TCCRBENCH 064	0.138	11.0	34.9 x 26.2	41.5 x 31.1	46.6 x 34.9	51.9 x 39.1	61.4 x 51.4	181.8	43	> 65	C	Yes	474	152	134	6260
TCCRBENCH 080	0.110	11.0	43.5 x 32.6	51.7 x 38.8	58.0 x 43.5	64.6 x 48.7	76.5 x 64.0	226.7	67	> 55	C	Yes	578	182	162	10965
TCCRBENCH 096	0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.4 x 75.6	278.6	94	> 50	C	Yes	696	200	189	15207

- 1 Working distance: distance between the front end of the lens mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- 2 At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5.5 µm.

- 3 Indicates the availability of an integrated camera phase adjustment feature.

# TCKIT case

Telecentric optics selection for machine vision labs



The **Opto Engineering® TCKIT case** includes a selection of some of the most commonly used telecentric optics in measurement applications.

A kit of four C-mount telecentric lenses covers FOVs ranging from 9 mm to 64 mm, offering good coverage of many measurement applications. These lenses are suitable for detectors up to 2/3", so that most cameras can be used in combination with this set of optics. In addition, a LTCLHP 036-G collimated light source (green color) is included in the box; this illuminator can be coupled with the

three smaller telecentric lenses in order to demonstrate the several benefits of collimated illumination.

The telecentric kit case is a very helpful tool for system integrators and research centers that are frequently dealing with new machine vision applications.

The TCKIT case also benefits from our special educational price: you should seriously consider buying this kit for your laboratory and discover the advantages of bi-telecentric optics!



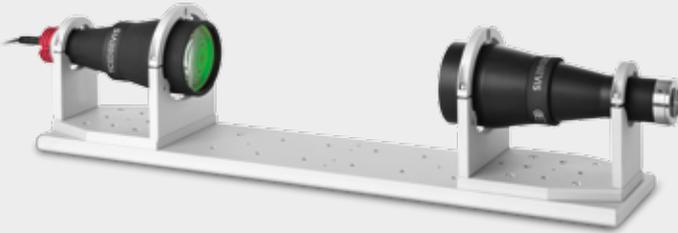
Part number	Products included	Description
TCKIT	TC 23 064	Bi-telecentric lens for 2/3", 64 x 48 mm FOV
	TC 23 036	Bi-telecentric lens for 2/3", 36 x 27 mm FOV
	TC 23 016	Bi-telecentric lens for 2/3", 16 x 12 mm FOV
	TC 23 009	Bi-telecentric lens for 2/3", 8.8 x 6.6 mm FOV
	LTCLHP 036-G	Telecentric HP illuminator, beam diameter 45 mm, green

#### FULL RANGE OF COMPATIBLE ACCESSORIES

	CMHO series clamping mechanics	p. 200
	LTDV1CH-17V strobe controller	p. 222
<b>FULL RANGE OF COMPATIBLE CAMERAS</b>		
	Area scan cameras	p. 180-185

# TCEdgeVIS

Telecentric system for defect detection on flat transparent materials



## KEY ADVANTAGES

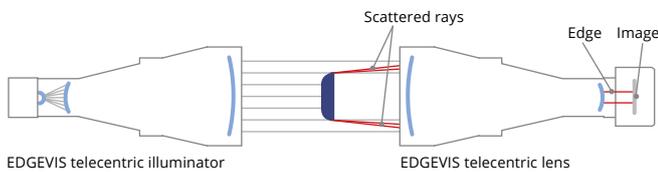
Revolutionary method for inspecting flat transparent surfaces (clear glass, plastic films) and for OCR/OCV applications:

- Extreme contrast
- Even the smallest defects can be seen
- Supplied as a ready-to-use optical bench

**TCEdgeVIS telecentric** optical systems provide a truly revolutionary approach to the inspection of flat transparent materials. The special optical design ensures that only the light rays deflected by an object's edge are imaged on the sensor: edges are automatically extracted without the need of software algorithms. This technique allows the detection of extremely tiny defects, particles and surface

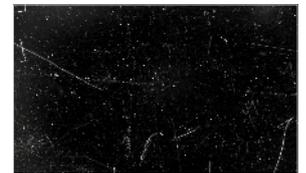
discontinuities that would be impossible to see with traditional lens systems. This approach is also suitable for OCR/OCV applications on clear glass, plastic films etc.

TCEdgeVIS optical systems include an EDGE telecentric lens, EDGE telecentric illuminator and mounting mechanics and are supplied as fully tested and pre-aligned optical benches.



Working principle: when light rays encounter an object they get scattered from its edges. The TCEdgeVIS optical system filters these rays to form an image of the object's profile with much higher contrast than traditional optical methods.

## Display inspection:



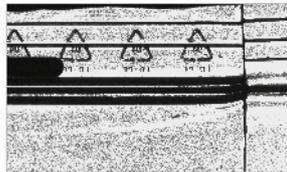
Detection of tiny scratches, bubbles and inclusions on smartphone glass screen.

## Particle analysis:



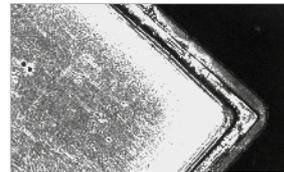
Checking dust deposits on a glass surface.

## Packaging:



Seal integrity inspection at the highest contrast.

## Packaging:



Seal quality inspection on transparent plastics and soldering joint.

## OCR and OCV:



Transparent text on clear plastic surface.

Part number	Mag. (x)	Image circle Ø (mm)	Detector type					Optical specifications		Mechanical specifications				
			1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	2/3" - 5 Mpx w x h (mm x mm)	WD (mm)	Light color, peak wavelength (nm)	Mount	Phase adj.	Length (mm)	Width (mm)	Height (mm)
<b>Object field of view (mm x mm)</b>														
TCEV 23 036-G	0.243	11.0	19.7 x 14.8	23.4 x 17.6	26.3 x 19.7	29.3 x 22.1	34.7 x 29.0	102.5	green, 520	C	No	549	103.0	140.5
TCEV 23 048-G	0.184	11.0	26.1 x 19.6	31.0 x 23.3	34.8 x 26.1	38.8 x 29.2	46.0 x 38.4	132.9	green, 520	C	Yes	657	117.0	147.5
TCEV 23 056-G	0.157	11.0	30.6 x 22.9	36.3 x 27.2	40.7 x 30.6	45.4 x 34.2	53.8 x 45.0	157.8	green, 520	C	Yes	715	122.0	150.0
TCEV 23 064-G	0.138	11.0	34.9 x 26.2	41.5 x 31.1	46.6 x 34.9	51.9 x 39.1	61.4 x 51.4	181.8	green, 520	C	Yes	848	143.0	160.5
TCEV 23 080-G	0.110	11.0	43.5 x 32.6	51.7 x 38.8	58.0 x 43.5	64.6 x 48.7	76.5 x 64.0	226.7	green, 520	C	Yes	936	158.0	168.0
TCEV 23 096-G	0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.4 x 75.6	278.6	green, 520	C	Yes	1087	206.5	185.0

**1** Working distance: distance between the front end of the lens mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.

**2** Indicates the availability of an integrated camera phase adjustment feature.

# TCHM series

High magnification telecentric lenses for detectors up to 2/3"



Part number	Mag. (x)	Image circle (mm)	Max detector size	Detector type					Optical specifications					Mechanical specs			
				1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	2/3"- 5 MP w x h (mm)	WD (mm)	wF/#	Distortion (%)	Field depth (mm)	Nominal resolving power (μm)	Mount	Phase adj.	Length (mm)	Diam. (mm)
				Object field of view (mm x mm)													
Working distance (WD) 71 mm																	
RT-HR-6M-71	6.00	11	2/3"	0.8 x 0.6	1.0 x 0.7	1.1 x 0.8	1.2 x 0.9	1.4 x 1.2	71.00	41.1	0.27	0.10	4.60	C	Yes	108	18
RT-HR-4M-71	4.00	11	2/3"	1.2 x 0.9	1.4 x 1.1	1.6 x 1.2	1.8 x 1.3	2.1 x 1.8	71.00	29	0.24	0.10	4.90	C	Yes	100	18
RT-HR-2M-71	2.00	11	2/3"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	3.6 x 2.7	4.2 x 3.5	71.00	18.5	0.21	0.30	6.20	C	Yes	97	18
RT-HR-1M-71	1.00	11	2/3"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	7.1 x 5.4	8.5 x 7.1	71.00	15.6	0	0.90	10.50	C	Yes	116	18
Working distance (WD) 110 mm																	
RT-HR-6M-110	6.00	11	2/3"	0.8 x 0.6	1.0 x 0.7	1.1 x 0.8	1.2 x 0.9	1.4 x 1.2	110.00	55.6	0.25	0.20	6.20	C	Yes	114	18
RT-HR-4M-110	4.00	11	2/3"	1.2 x 0.9	1.4 x 1.1	1.6 x 1.2	1.8 x 1.3	2.1 x 1.8	110.00	39.2	0.54	0.20	6.60	C	Yes	95	18
RT-HR-2M-110	2.00	11	2/3"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	3.6 x 2.7	4.2 x 3.5	110.00	23.8	0.78	0.40	8.00	C	Yes	87	18
RT-HR-1M-110	1.00	11	2/3"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	7.1 x 5.4	8.5 x 7.1	110.00	6.7	0.04	1.00	11.20	C	Yes	125	18

- 1 Working F-number (wF/#): the real F-number of a lens when used as a macro.  
 2 Indicates the availability of an integrated camera phase adjustment feature.

#### FULL RANGE OF COMPATIBLE PRODUCTS



LTRNDC series LED direct ringlights

p. 128

# TCVLWD series

Very long working distance (WD) telecentric lenses for detectors up to 1/1.8"



Part number	Mag. (x)	Image circle (mm)	Max detector size	Detector type				Optical specifications					Mechanical specs			
				1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	WD (mm)	wF/#	Distortion (%)	Field depth (mm)	Nominal resolving power (μm)	Mount	Phase adj.	Length (mm)	Diam. (mm)
				Object field of view (mm x mm)												
RT-TV-1M-150	1.00	8.0	1/2"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	-	156.00	16.7	0.15	1.00	12.00	C	Yes	159.0	24
RT-TV-2M-150	2.00	8.0	1/2"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	-	156.00	25.0	0.07	0.44	9.00	C	Yes	168.0	24
RT-TV-3M-150	3.00	8.0	1/2"	1.6 x 1.2	1.9 x 1.4	2.1 x 1.6	-	156.00	37.5	0.05	0.34	9.00	C	Yes	171.8	24
RT-TV-1M-220	1.00	8.0	1/2"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	-	218.20	20.0	0.10	1.24	14.00	C	Yes	218.0	27
RT-TV-2M-220	2.00	8.0	1/2"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	-	218.20	33.0	0.10	0.67	11.00	C	Yes	227.0	27
RT-TV-3M-220	3.00	8.0	1/2"	1.6 x 1.2	1.9 x 1.4	2.1 x 1.6	-	218.20	43.0	0.10	0.41	9.60	C	Yes	230.8	27
RT-TV-1M-290	1.00	8.0	1/2"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	-	290.70	20.0	0.10	1.24	13.00	C	Yes	203.7	27
RT-TV-2M-290	2.00	8.0	1/2"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	-	290.70	33.0	0.10	0.67	11.00	C	Yes	212.7	27
RT-TV-3M-290	3.00	8.0	1/2"	1.6 x 1.2	1.9 x 1.4	2.1 x 1.6	-	290.70	43.0	0.10	0.41	9.60	C	Yes	216.5	27
RT-TV-05M-400	0.50	8.0	1/2"	9.6 x 7.2	11.4 x 8.6	12.8 x 9.6	-	400.00	13.9	0.35	3.07	18.60	C	Yes	149.6	34
RT-TV-1M-400	1.00	8.9	1/1.8"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	7.1 x 5.4	400.00	25.0	0.30	1.69	16.80	C	Yes	166.2	34
RT-TV-2M-400	2.00	8.9	1/1.8"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	3.6 x 2.7	400.00	33.3	0.07	0.64	11.20	C	Yes	176.5	34
RT-TV-05M-800	0.50	8.9	1/1.8"	9.6 x 7.2	11.4 x 8.6	12.8 x 9.6	14.3 x 10.7	800.00	16.7	0.04	3.89	22.40	C	Yes	279.6	58
RT-TV-1M-800	1.00	8.9	1/1.8"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	7.1 x 5.4	800.00	20.0	0.09	1.24	13.40	C	Yes	296.7	58

- 1 Working F-number (wF/#): the real F-number of a lens when used as a macro.

- 2 Indicates the availability of an integrated camera phase adjustment feature.

# TCCXHM series

High magnification telecentric lenses with built-in coaxial illumination for detectors up to 2/3"



Part number	Mag. (x)	Image circle (mm)	Max detector size	Detector type					Optical specifications					Mechanical specs			
				1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	2/3" - 5 MP w x h (mm)	WD (mm)	wF/#	Distortion (%)	Field depth (mm)	Nominal resolving power (μm)	Mount	Phase adj.	Length (mm)	Diam. (mm)
				Object field of view (mm x mm)													
Working distance (WD) 71 mm																	
RT-HR-6F-71	6.00	11	2/3"	0.8 x 0.6	1.0 x 0.7	1.1 x 0.8	1.2 x 0.9	1.4 x 1.2	71.00	41.1	0.27	0.10	4.60	C	Yes	107.9	18
RT-HR-4F-71	4.00	11	2/3"	1.2 x 0.9	1.4 x 1.1	1.6 x 1.2	1.8 x 1.3	2.1 x 1.8	71.00	29.0	0.24	0.13	4.90	C	Yes	100.0	18
RT-HR-2F-71	2.00	11	2/3"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	3.6 x 2.7	4.2 x 3.5	71.00	18.5	0.21	0.30	6.20	C	Yes	97.0	18
RT-HR-1F-71	1.00	11	2/3"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	7.1 x 5.4	8.5 x 7.1	71.00	15.6	0	0.90	10.50	C	Yes	116.1	18
Working distance (WD) 110 mm																	
RT-HR-6F-110	6.00	11	2/3"	0.8 x 0.6	1.0 x 0.7	1.1 x 0.8	1.2 x 0.9	1.4 x 1.2	110.00	55.6	0.25	0.16	6.20	C	Yes	114.2	18
RT-HR-4F-110	4.00	11	2/3"	1.2 x 0.9	1.4 x 1.1	1.6 x 1.2	1.8 x 1.3	2.1 x 1.8	110.00	39.2	0.54	0.20	6.60	C	Yes	94.6	18
RT-HR-2F-110	2.00	11	2/3"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	3.6 x 2.7	4.2 x 3.5	110.00	23.8	0.78	0.40	8.00	C	Yes	87.4	18
RT-HR-1F-110	1.00	11	2/3"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	7.1 x 5.4	8.5 x 7.1	110.00	6.7	0.04	1.00	11.20	C	Yes	125.2	18

- 1 Working F-number (wF/#): the real F-number of a lens when used as a macro.  
 2 Indicates the availability of an integrated camera phase adjustment feature.

#### FULL RANGE OF COMPATIBLE LED SOURCES



LDSC series

p. 229

# TCCXLM series

Telecentric lenses with built-in coaxial illumination for detectors up to 2/3"



Part number	Mag. (x)	Image circle (mm)	Max detector size	Detector type					Optical specifications					Mechanical specs			
				1/3" w x h (mm x mm)	1/2.5" w x h (mm x mm)	1/2" w x h (mm x mm)	1/1.8" w x h (mm x mm)	2/3" - 5 MP w x h (mm)	WD (mm)	wF/#	Distortion (%)	Field depth (mm)	Nominal resolving power (μm)	Mount	Phase adj.	Length (mm)	Diam. (mm)
				Object field of view (mm x mm)													
RT-TCL0400-F	0.40	11	2/3"	12.0 x 9.0	14.3 x 10.7	16.0 x 12.0	17.8 x 13.4	21.1 x 17.7	78.50	8 - 40	-0.02	2.10	15.00	C		187.5	44
RT-TCL0300-F	0.30	11	2/3"	16.0 x 12.0	19.0 x 14.3	21.3 x 16.0	23.8 x 17.9	28.2 x 23.6	108.20	8 - 40	0.01	3.70	20.00	C		224.4	49
RT-TCL0200-F	0.20	11	2/3"	24.0 x 18.0	28.5 x 21.4	32.0 x 24.0	35.7 x 26.9	42.3 x 35.4	167.00	8 - 40	0.01	8.40	31.00	C		297.2	68

- 1 Indicates the availability of an integrated camera phase adjustment feature.

#### FULL RANGE OF COMPATIBLE LED SOURCES



LDSC series

p. 229

# TC2MHR-TC4MHR series

High-resolution telecentric lenses for large detectors up to 4/3"



**TC2MHR and TC4MHR series** are high resolution telecentric lenses designed for detectors larger than 2/3": TC2MHR lenses cover up to 1" detectors (16 mm diagonal) while TC4MHR lenses cover up to 21.5 mm detector diagonal (e.g. suitable for 4/3" detectors), making them the perfect choice for advanced metrology applications.

The TC2MHR-TC4MHR series delivers unmatched resolution, low distortion and homogeneous image quality while offering the best performance to price ratio.

TC2MHR-TC4MHR feature a compact and robust design that allows for easy integration in industrial environments. Additionally, the camera phase can be easily adjusted by simply loosening the set screws positioned in the eyepiece part.

In order to help the selection, some of the most commonly used large matrix detectors are listed: select the product that best suits your application by choosing the column where the your detector is listed and scrolling down the table until you find the field of view best matching your needs.

## KEY ADVANTAGES

**Wide image circle** for detectors larger than 2/3".

**Excellent resolution and low distortion.**

**Simple and robust design** for industrial environments.

**Detailed test report with measured optical parameters.**

C, F and M42X1 (-E) **mount options** with easy phase adjustment.



Mount C



Mount E = M42x1



Mount F



FOR COAXIAL TELECENTRIC LENSES UP TO 1" DETECTORS SEE ALSO		
	TCCX2M series	p. 42
FULL RANGE OF COMPATIBLE ILLUMINATORS		
	Backlights LTBP, LTBC, LTBCF series	p. 134-140
FULL RANGE OF COMPATIBLE ACCESSORIES		
	CMMR series	p. 206

Part number	Mag.	Image circle (x) Ø (mm)	Detector type				Optical specifications						Mechanical specifications						
			KAI 2020 14.8 mm diag. w x h (mm x mm)	KAI-04050 16 mm diag. w x h (mm x mm)	KAI-4022/4021 21.5 mm diag. w x h (mm x mm)	KAI-08050 22.6 mm diag. w x h (mm x mm)	WD (mm)	wF/#	Telecentricity typical (max) (deg)	Distortion typical (max) (%)	Field depth (mm)	CTF @50lp/mm (%)	Phase adj 9	Length (mm)			Diam. (mm)		
														1	2	3	4	5	C
<b>TC2MHR lenses</b>			<b>Object field of view (mm x mm) 8</b>																
TC2MHR 016-x	0.767	16.6	15.4 x 11.6	16.7 x 12.5	Ø = 19.8	Ø = 17.7	43.8	16	< 0.08 (0.10)	< 0.04 (0.10)	2.0	> 30	Yes	145.5	147.0	116.5	45	52	64
TC2MHR 024-x	0.508	16.9	23.3 x 17.5	25.2 x 18.9	Ø = 29.9	Ø = 26.8	67.2	16	< 0.08 (0.10)	< 0.04 (0.10)	4.6	> 40	Yes	170.4	171.9	141.4	45	52	64
TC2MHR 036-x	0.353	16.7	33.5 x 25.2	36.3 x 27.2	Ø = 43.1	Ø = 38.5	102.6	16	< 0.08 (0.10)	< 0.08 (0.10)	10	> 30	Yes	197.7	199.2	168.7	61	61	64
TC2MHR 048-x	0.268	16.9	44.2 x 33.1	47.8 x 35.8	Ø = 56.7	Ø = 50.7	133.4	16	< 0.08 (0.10)	< 0.08 (0.10)	17	> 30	Yes	232.8	234.3	203.8	75	75	75
TC2MHR 056-x	0.228	16.8	51.9 x 38.9	56.1 x 42.1	Ø = 66.7	Ø = 59.6	157.8	16	< 0.04 (0.08)	< 0.05 (0.10)	23	> 40	Yes	257.1	258.7	228.1	80	80	80
TC2MHR 064-x	0.200	16.8	59.3 x 44.5	64.1 x 48.1	Ø = 76.1	Ø = 68.1	181.9	16	< 0.04 (0.08)	< 0.05 (0.10)	30	> 40	Yes	278.3	279.8	249.3	100	100	100
TC2MHR 080-x	0.160	16.9	74.0 x 55.5	80.0 x 60.0	Ø = 95.0	Ø = 85.0	226.8	16	< 0.04 (0.08)	< 0.05 (0.10)	46	> 40	Yes	324.0	325.5	295.0	116	116	116
TC2MHR 096-x	0.137	16.9	86.6 x 65.0	93.6 x 70.2	Ø = 111.2	Ø = 99.5	278.6	16	< 0.05 (0.10)	< 0.07 (0.10)	64	> 40	Yes	396.4	397.9	367.4	143	143	143
TC2MHR 120-x	0.104	16.5	113.8 x 85.4	123.1 x 92.3	Ø = 146.2	Ø = 130.8	334.6	16	< 0.07 (0.10)	< 0.07 (0.10)	110	> 40	Yes	451.4	452.9	422.4	180	180	180
TC2MHR 144-x	0.089	16.8	133.5 x 100.1	144.3 x 108.2	Ø = 171.4	Ø = 153.3	396.0	16	< 0.05 (0.10)	< 0.05 (0.10)	151	> 40	Yes	510.8	512.4	481.8	200	200	200
TC2MHR 192-x	0.067	16.8	178.0 x 133.5	192.5 x 144.4	Ø = 228.6	Ø = 204.5	527.5	16	< 0.05 (0.10)	< 0.04 (0.10)	268	> 40	Yes	649.2	650.8	620.2	260	260	260
TC2MHR 240-x	0.053	16.2	223.8 x 167.9	242.0 x 181.5	Ø = 287.3	Ø = 257.1	492.9	16	< 0.05 (0.10)	< 0.04 (0.10)	424	> 40	Yes	812.2	813.7	783.2	322	322	322
<b>TC4MHR lenses</b>																			
TC4M 004-x	4.000	22.0	2.96 x 2.22	3.21 x 2.41	3.79 x 3.79	4.53 x 3.40	57.1	22	< 0.08 (0.10)	< 0.08 (0.10)	0.1	> 30	Yes	206.4	n.a.	178.4	45	n.a.	45
TC4M 007-x	2.667	22.0	4.44 x 3.33	4.82 x 3.61	5.69 x 5.69	6.80 x 5.10	61.2	22	< 0.08 (0.10)	< 0.06 (0.10)	0.2	> 30	Yes	183.5	n.a.	155.4	45	n.a.	45
TC4M 009-x	2.000	22.0	5.92 x 4.44	6.42 x 4.82	7.57 x 7.57	9.06 x 6.80	63.3	22	< 0.08 (0.10)	< 0.05 (0.10)	0.3	> 30	Yes	170.0	n.a.	142.0	45	n.a.	45
TC4MHR 016-x	1.055	21.2	11.2 x 8.4	12.1 x 9.1	14.4 x 14.4	17.2 x 12.9	43.8	16	< 0.08 (0.10)	< 0.04 (0.10)	1.1	> 30	Yes	169.6	171.1	140.6	45	52	64
TC4MHR 024-x	0.700	21.6	16.9 x 12.7	18.3 x 13.7	21.7 x 21.7	25.9 x 19.4	67.2	16	< 0.08 (0.10)	< 0.04 (0.10)	2.4	> 30	Yes	194.8	196.3	165.8	45	52	64
TC4MHR 036-x	0.486	21.4	24.4 x 18.3	26.3 x 19.7	31.3 x 31.3	37.2 x 28.0	102.6	16	< 0.05 (0.10)	< 0.08 (0.10)	5.0	> 30	Yes	222.0	223.6	193.0	61	61	64
TC4MHR 048-x	0.369	21.7	32.1 x 24.1	34.7 x 26.0	41.2 x 41.2	49.1 x 36.9	133.4	16	< 0.08 (0.10)	< 0.08 (0.10)	8.7	> 40	Yes	257.1	258.6	228.1	75	75	75
TC4MHR 056-x	0.314	21.6	37.7 x 28.3	40.8 x 30.6	48.4 x 48.4	57.6 x 43.3	157.8	16	< 0.05 (0.10)	< 0.04 (0.10)	12.0	> 40	Yes	280.7	282.2	251.7	80	80	80
TC4MHR 064-x	0.275	21.6	43.1 x 32.3	46.6 x 34.9	55.3 x 55.3	65.8 x 49.5	181.9	16	< 0.05 (0.10)	< 0.04 (0.10)	15.7	> 40	Yes	301.8	303.4	272.8	100	100	100
TC4MHR 080-x	0.221	21.7	53.7 x 40.3	58.0 x 43.5	68.9 x 68.9	82.0 x 61.7	226.8	16	< 0.05 (0.10)	< 0.04 (0.10)	24.4	> 40	Yes	347.6	349.1	318.6	116	116	116
TC4MHR 096-x	0.186	21.6	63.5 x 47.6	68.7 x 51.5	81.6 x 81.6	97.1 x 73.0	278.6	16	< 0.05 (0.10)	< 0.04 (0.10)	34.2	> 35	Yes	392.8	394.3	363.8	143	143	143
TC4MHR 120-x	0.143	21.2	82.6 x 62.0	89.3 x 67.0	106.1 x 106.1	126.3 x 94.9	334.6	16	< 0.05 (0.10)	< 0.04 (0.10)	57.8	> 30	Yes	475.2	476.7	446.2	180	180	180
TC4MHR 144-x	0.122	21.6	96.9 x 72.7	104.7 x 78.6	124.4 x 124.4	148.1 x 111.3	396.0	16	< 0.05 (0.10)	< 0.04 (0.10)	79.5	> 30	Yes	537.7	539.2	508.7	200	200	200
TC4MHR 192-x	0.092	21.6	129.4 x 97.0	139.9 x 104.9	166.1 x 166.1	197.8 x 148.6	527.6	16	< 0.05 (0.10)	< 0.04 (0.10)	141.8	> 30	Yes	679.1	680.7	650.1	260	260	260
TC4MHR 240-x	0.073	21.1	161.7 x 121.3	174.9 x 131.1	207.7 x 207.7	247.3 x 185.8	492.9	16	< 0.05 (0.10)	< 0.05 (0.10)	221.5	> 30	Yes	827.3	828.8	798.3	322	322	322

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5 µm.
- Measured from the front end of the mechanics to the camera flange.
- With KAI-08050 (22,6 mm diagonal) detectors, the FOV of TC4MHR yyy lenses may show some vignetting at the image corners.
- For the fields with the indication "Ø =", the image of a circular object of such diameter is fully inscribed into the detector.
- Indicates the availability of an integrated camera phase adjustment feature.

**Ordering information**

It's easy to select the right lens for your application: our part numbers are coded as **TC2MHR yyy-x** or **TC4MHR yyy-x** where **yyy** refers to the width dimension of the object field of view (FOV) in millimeters and **-x** refers to the mount option:  
 - C for C-mount  
 - F for F-mount  
 - E for M42X1 mount (flange distance FD 16 mm).  
 Eg. TC4MHR064-F for an F-mount TC 4MHR 064 lens. Customized mounts are also available upon request.

# TC2MHR-TC4MHR CORE series

Ultra compact high-resolution telecentric lenses up to 4/3"



## KEY ADVANTAGES

### Excellent optical performance

TC2MHR-TC4MHR CORE telecentric lenses deliver excellent optical performance as other comparable Opto Engineering® telecentric lenses.

### Extremely compact

TC2MHR-TC4MHR CORE lenses are up to 70% smaller than other telecentric lenses on the market.

### Designed for flexibility and smart integration

TC2MHR-TC4MHR CORE lenses integrate a camera phase adjustment and can be mounted on multiple sides with or without clamps, allowing you to cut costs.

### Save you money

Systems integrating TC2MHR-TC4MHR CORE lenses take much less space, resulting in lower manufacturing, shipping and storage costs.

### Boost your sales

A smaller vision system or measurement machine is the solution preferred by the industry.

### Detailed test report with measured optical parameters.

**TC2MHR CORE and TC4MHR CORE series** are ultra compact telecentric lenses tailored for high-resolution sensors up to 4/3".

TC2MHR CORE and TC4MHR CORE lenses deliver excellent optical performance in a super compact shape. Thanks to the unique opto-mechanical design, these lenses offer very high resolution, nearly zero distortion and high field depth while saving up to 70% in length compared to similar FOV lenses on the market.

TC2MHR CORE and TC4MHR CORE lenses ensure hassle-free integration in a measurement system. The rear phase adjustment allows the user to easily align the camera sensor to the sample.

These lenses can be mounted in several orientations thanks to the M6 threads located on multiple sides, even without clamps. For maximum flexibility, a special front mounting clamp is also available.

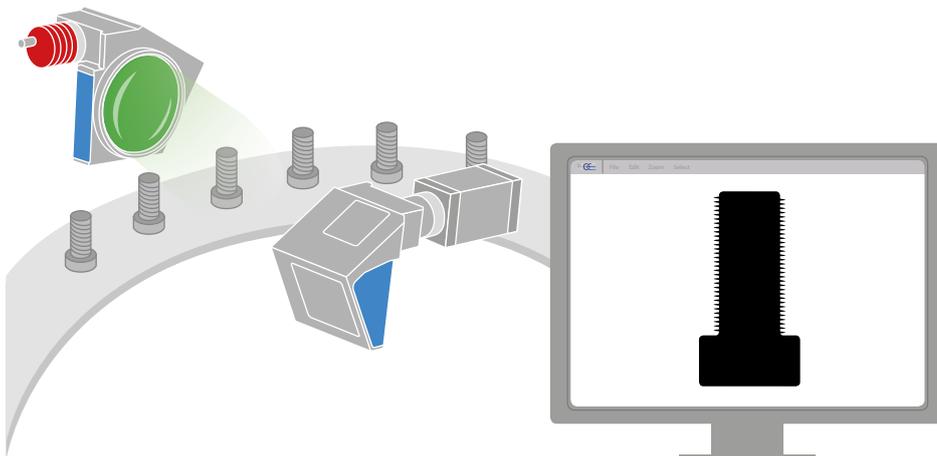


Comparison of a "classic" telecentric lens and a TC CORE telecentric lens: TC CORE lens delivers best optical performance and is extremely compact.

FULL RANGE OF COMPATIBLE ILLUMINATORS		
	LTCLHP CORE series	p. 110
FULL RANGE OF COMPATIBLE PRODUCTS		
	CMHOCR series	p. 203
FULL RANGE OF COMPATIBLE CAMERAS		
	Area scan cameras	p. 180-185



### Application example



Standard solution with a 4/3" camera, TC4MHR CORE lens and a LTCLHP CORE illuminator.

# TC2MHR-TC4MHR CORE series

Ultra compact high-resolution telecentric lenses up to 4/3"



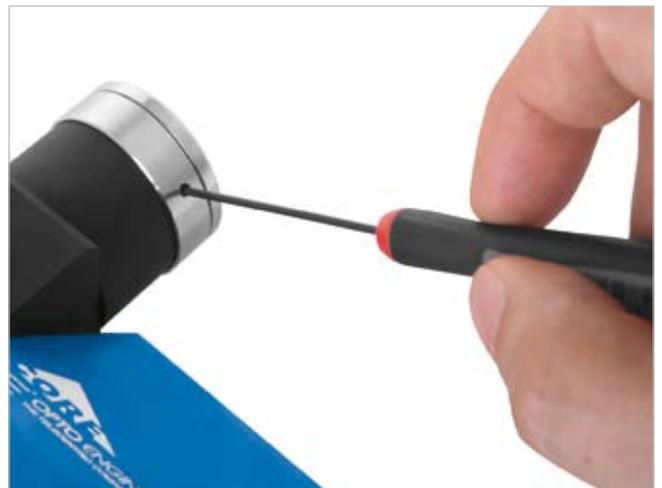
TCCR2M080-C  
with C Mount



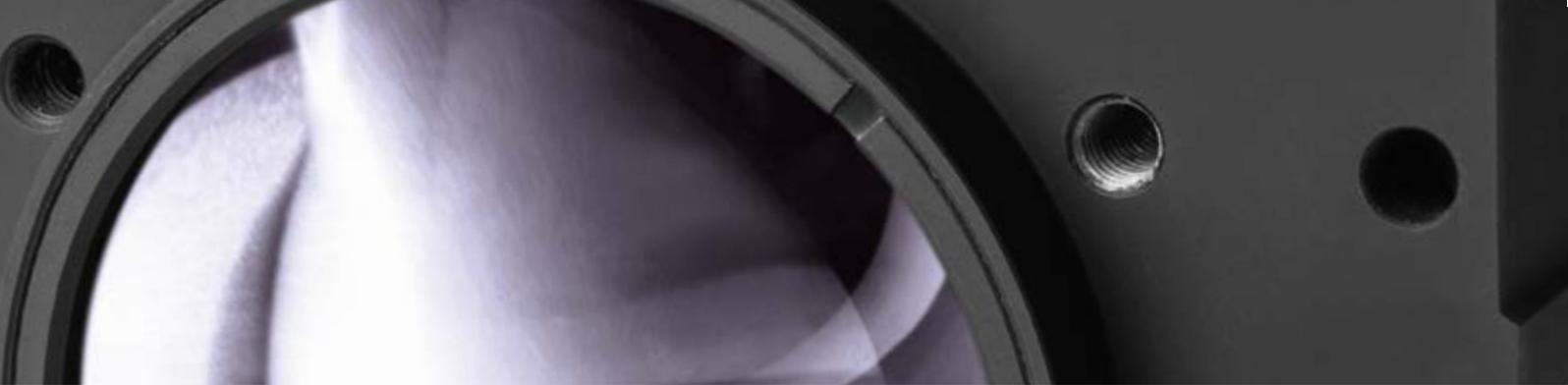
TCCR4M096-E  
with E Mount (M42x1)



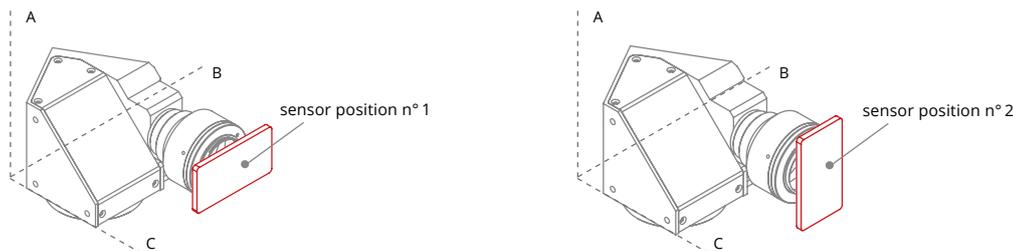
TCCR4M056-F  
with F Mount



Built-in phase adjustment makes it easy to align the camera sensor.



**TC2MHR-TC4MHR CORE lens dimensions (A, B, C) and correct position of the sensor in relation to the lens:**



The long side of sensor has to be aligned along axis B (position n°1) or axis A (position n°2).

Part number	Mag. (x)	Image circle Ø (mm)	Detector type				Optical specifications					Mechanical specifications					
			1"		1.2"		WD (mm)	wF/#	Telecentricity typical (max) (deg)	Distortion typical (max) (%)	Field depth (mm)	CTF @50lp/mm (%)	Mount	Phase adj.	Dimensions (mm)		
			14.8 mm diag. w x h (mm x mm)	16 mm diag. w x h (mm x mm)	21.5 mm diag. w x h (mm x mm)	22.6 mm diag. w x h (mm x mm)									1	2	3
<b>TCCR2MHR</b>			<b>Object field of view (mm x mm) 7</b>														
TCCR2M 048-C	0.268	16.9	44.2 x 33.1	47.8 x 35.8	Ø = 56.7	Ø = 50.7	133.41	16	< 0.08 (0.10)	< 0.08 (0.10)	17	> 30	C	Yes	77	109	168
TCCR2M 048-E	0.268	16.9	44.2 x 33.1	47.8 x 35.8	Ø = 56.7	Ø = 50.7	133.41	16	< 0.08 (0.10)	< 0.08 (0.10)	17	> 30	M42x1 FD 16	Yes	77	112	170
TCCR2M 056-C	0.228	16.8	51.9 x 38.9	56.1 x 42.1	Ø = 66.7	Ø = 59.6	157.79	16	< 0.04 (0.08)	< 0.05 (0.10)	23	> 40	C	Yes	94	112	178
TCCR2M 056-E	0.228	16.8	51.9 x 38.9	56.1 x 42.1	Ø = 66.7	Ø = 59.6	157.79	16	< 0.04 (0.08)	< 0.05 (0.10)	23	> 40	M42x1 FD 16	Yes	94	114	178
TCCR2M 064-C	0.200	16.8	59.3 x 44.5	64.1 x 48.1	Ø = 76.1	Ø = 68.1	181.86	16	< 0.04 (0.08)	< 0.05 (0.10)	30	> 40	C	Yes	101	125	185
TCCR2M 064-E	0.200	16.8	59.3 x 44.5	64.1 x 48.1	Ø = 76.1	Ø = 68.1	181.86	16	< 0.04 (0.08)	< 0.05 (0.10)	30	> 40	M42x1 FD 16	Yes	101	127	187
TCCR2M 080-C	0.160	16.9	74.0 x 55.5	80.0 x 60.0	Ø = 95.0	Ø = 85.0	226.76	16	< 0.04 (0.08)	< 0.05 (0.10)	46	> 40	C	Yes	119	145	205
TCCR2M 080-E	0.160	16.9	74.0 x 55.5	80.0 x 60.0	Ø = 95.0	Ø = 85.0	226.76	16	< 0.04 (0.08)	< 0.05 (0.10)	46	> 40	M42x1 FD 16	Yes	119	149	207
TCCR2M 096-C	0.137	16.9	86.6 x 65.0	93.6 x 70.2	Ø = 111.2	Ø = 99.5	278.62	16	< 0.05 (0.10)	< 0.07 (0.10)	64	> 40	C	Yes	139	172	230
TCCR2M 096-E	0.137	16.9	86.6 x 65.0	93.6 x 70.2	Ø = 111.2	Ø = 99.5	278.62	16	< 0.05 (0.10)	< 0.07 (0.10)	64	> 40	M42x1 FD 16	Yes	139	172	232
<b>TCCR4MHR</b>																	
TCCR4M 048-C	0.369	21.7	32.1 x 24.1	34.7 x 26.0	41.2 x 41.2	49.1 x 36.9	133.41	16	< 0.08 (0.10)	< 0.08 (0.10)	8.7	> 40	C	Yes	77	109	193
TCCR4M 048-F	0.369	21.7	32.1 x 24.1	34.7 x 26.0	41.2 x 41.2	49.1 x 36.9	133.41	16	< 0.08 (0.10)	< 0.08 (0.10)	8.7	> 40	F	Yes	77	118	163
TCCR4M 048-E	0.369	21.7	32.1 x 24.1	34.7 x 26.0	41.2 x 41.2	49.1 x 36.9	133.41	16	< 0.08 (0.10)	< 0.08 (0.10)	8.7	> 40	M42x1 FD 16	Yes	77	112	195
TCCR4M 056-C	0.314	21.6	37.7 x 28.3	40.8 x 30.6	48.4 x 48.4	57.6 x 43.3	157.80	16	< 0.05 (0.10)	< 0.04 (0.10)	12.0	> 40	C	Yes	94	112	202
TCCR4M 056-F	0.314	21.6	37.7 x 28.3	40.8 x 30.6	48.4 x 48.4	57.6 x 43.3	157.80	16	< 0.05 (0.10)	< 0.04 (0.10)	12.0	> 40	F	Yes	94	119	173
TCCR4M 056-E	0.314	21.6	37.7 x 28.3	40.8 x 30.6	48.4 x 48.4	57.6 x 43.3	157.80	16	< 0.05 (0.10)	< 0.04 (0.10)	12.0	> 40	M42x1 FD 16	Yes	94	115	204
TCCR4M 064-C	0.275	21.6	43.1 x 32.3	46.6 x 34.9	55.3 x 55.3	65.8 x 49.5	181.86	16	< 0.05 (0.10)	< 0.04 (0.10)	15.7	> 40	C	Yes	101	124	208
TCCR4M 064-F	0.275	21.6	43.1 x 32.3	46.6 x 34.9	55.3 x 55.3	65.8 x 49.5	181.86	16	< 0.05 (0.10)	< 0.04 (0.10)	15.7	> 40	F	Yes	101	129	180
TCCR4M 064-E	0.275	21.6	43.1 x 32.3	46.6 x 34.9	55.3 x 55.3	65.8 x 49.5	181.86	16	< 0.05 (0.10)	< 0.04 (0.10)	15.7	> 40	M42x1 FD 16	Yes	101	127	211
TCCR4M 080-C	0.221	21.7	53.7 x 40.3	58.0 x 43.5	68.9 x 68.9	82.0 x 61.7	226.76	16	< 0.05 (0.10)	< 0.04 (0.10)	24.4	> 40	C	Yes	119	146	228
TCCR4M 080-F	0.221	21.7	53.7 x 40.3	58.0 x 43.5	68.9 x 68.9	82.0 x 61.7	226.76	16	< 0.05 (0.10)	< 0.04 (0.10)	24.4	> 40	F	Yes	119	152	199
TCCR4M 080-E	0.221	21.7	53.7 x 40.3	58.0 x 43.5	68.9 x 68.9	82.0 x 61.7	226.76	16	< 0.05 (0.10)	< 0.04 (0.10)	24.4	> 40	M42x1 FD 16	Yes	119	148	231
TCCR4M 096-C	0.186	21.6	63.5 x 47.6	68.7 x 51.5	81.6 x 81.6	97.1 x 73.0	278.62	16	< 0.05 (0.10)	< 0.04 (0.10)	34.2	> 35	C	Yes	139	172	254
TCCR4M 096-F	0.186	21.6	63.5 x 47.6	68.7 x 51.5	81.6 x 81.6	97.1 x 73.0	278.62	16	< 0.05 (0.10)	< 0.04 (0.10)	34.2	> 35	F	Yes	139	175	225
TCCR4M 096-E	0.186	21.6	63.5 x 47.6	68.7 x 51.5	81.6 x 81.6	97.1 x 73.0	278.62	16	< 0.05 (0.10)	< 0.04 (0.10)	34.2	> 35	M42x1 FD 16	Yes	139	173	256

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5 µm.
- M42x1 mount has a flange distance of 16 mm.
- For the fields with the indication "Ø =", the image of a circular object of such diameter is fully inscribed into the detector.
- Indicates the availability of an integrated camera phase adjustment feature.

# TCDP PLUS series

Dual magnification telecentric lenses



## KEY ADVANTAGES

### Perfect measurement accuracy

TCDP PLUS telecentric lenses produce two images at different magnifications to cover an extended range of product sizes with the same accuracy.

### Revolutionary flexibility

281 possible combinations allow you to personalize and order the TCDP PLUS lens fitting YOUR needs.

### Smart cost reduction

Solving two vision tasks with one lens involves less components and lowers the vision system cost.

### Off-the-shelf lenses tailored for your needs

Get a standard product customized for your application with no increase in price or lead time.

### Detailed test report with measured optical parameters.

**TCDP PLUS series** are dual magnification telecentric lenses supporting two cameras to measure objects with different magnifications. They are the perfect choice for measuring components of different sizes but also for applications where an entire sample and some of its smaller features have to be measured with the same accuracy. The fixed design of these lenses ensures perfect repeatability with no need to recalibrate after each magnification change.

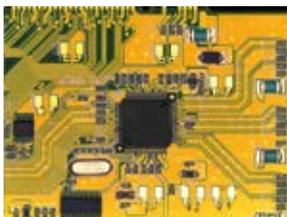
TCDP PLUS lenses help cut the cost of your vision system: you only need to integrate one lens, one illuminator and one mount.

TCDP PLUS lenses are compatible with CMHO clamping mechanics and LTCLHP collimated illuminators, as well as LTRN ring illuminators designed for the standard TC series.

## Application examples



TCDP23C4MC096 imaging an electronic board with two different cameras.



Full FOV image with lens lower magnification.



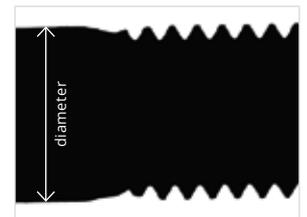
2x magnified image of the object central area.



TCDP23C4XC144 imaging a screw with two different cameras.



Full FOV image with lens lower magnification.



4x magnified image of the object central area.



TCDP23C4XC096 coupled with LTCLHP 096 telecentric illuminator and LTRN 096 NW ring light.

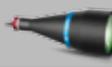
TCDP PLUS revolutionary design can easily meet any of your application needs: 281 possible combinations allow to create the perfect lens for you, also benefiting from the price and lead time of off-the-shelf components.

TCDP PLUS lenses come in 5 different sizes and can be configured with 2 different eyepieces out of the 7 available. They are compatible with several different camera sensors from 1/3" to 4/3" and are available with C-, F- or M42x1 (FD 16mm) camera mounts.

In the tables below you'll find a wide range of TCDP PLUS lenses. On our website you'll find a simple tool that allows you to create and order your own TCDP PLUS lens based on your camera sensor and desired fields of view.



Built-in phase adjustment makes it easy to align the camera sensor.

FOR OTHER MULTI-MAGNIFICATION OPTICS SEE ALSO		
	MCZR series	p. 76
FULL RANGE OF COMPATIBLE ILLUMINATORS		
	LTCLHP series collimated illuminators	p. 108
FULL RANGE OF COMPATIBLE ACCESSORIES		
	CMHO series	p. 200

**SETUP**

Please check our website for all 281 possible combinations.

[www.opto-engineering.com](http://www.opto-engineering.com)

# TCDP PLUS series

Dual magnification telecentric lenses

Part number	Mount	Mag. (x)	Image circle Ø (mm)	Detector type																
				1/3"	1/2.5"	1/2"	1/1.8"	2/3" - 5 Mpx	KAI-2020	1"	1.2"	4/3"								
				w x h 4.80 x 3.60 (mm x mm)	w x h 5.70 x 4.28 (mm x mm)	w x h 6.40 x 4.80 (mm x mm)	w x h 7.13 x 5.37 (mm x mm)	w x h 8.45 x 7.07 (mm x mm)	14.8 mm diag w x h 11.84 x 8.88 (mm x mm)	16 mm diag w x h 12.8 x 9.60 (mm x mm)	21.5 mm diag w x h 15.20 x 15.20 (mm x mm)	22.6 mm diag w x h 18.1 x 13.6 (mm x mm)								
				Object field of view (mm x mm)																
<b>1</b>																				
TCDP 2MF 4MF 096	F	0.137	16.9	35.1 x 26.3	41.7 x 31.3	46.8 x 35.1	52.2 x 39.3	61.8 x 51.7	86.3 x 65.0	93.6 x 70.2	111.2 x 111.2	Ø = 99.5								
		0.186	21.6	25.8 x 19.3	30.6 x 23.0	34.3 x 25.8	38.3 x 28.8	45.3 x 37.9	63.3 x 47.6	68.7 x 51.5	81.6 x 81.6	97.1 x 73.0								
TCDP 23C 4XC 096	C	0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.5 x 75.7	Ø = 95.1	Ø = 102.8	n.a.	n.a.								
		0.374	11.0	12.8 x 9.6	15.3 x 11.5	17.1 x 12.8	19.1 x 14.4	22.6 x 18.9	Ø = 23.8	Ø = 25.7	n.a.	n.a.								
TCDP 23C 4MC096	C	0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.5 x 75.7	Ø = 95.1	Ø = 102.8	n.a.	n.a.								
		0.186	21.6	25.8 x 19.3	30.6 x 23.0	34.3 x 25.8	38.3 x 28.8	45.3 x 37.9	63.3 x 47.6	68.7 x 51.5	81.6 x 81.6	97.1 x 73.0								
TCDP 12C 23C 096	C	0.068	8.0	70.6 x 52.9	83.8 x 62.9	94.1 x 70.6	104.9 x 79.0	Ø = 104.0	n.a.	n.a.	n.a.	n.a.								
		0.093	11.0	51.4 x 38.5	61.0 x 45.8	68.5 x 51.4	76.3 x 57.5	90.5 x 75.7	Ø = 95.1	Ø = 102.8	n.a.	n.a.								
TCDP 2MF 4MF 120	F	0.104	16.5	46.2 x 34.6	54.8 x 41.2	61.5 x 46.2	68.6 x 51.6	81.3 x 68.0	113.5 x 85.4	123.1 x 92.3	146.2 x 146.2	Ø = 130.8								
		0.143	21.2	33.5 x 25.1	39.8 x 29.9	44.7 x 33.5	49.8 x 37.5	59.0 x 49.3	82.3 x 62.0	89.3 x 67.0	106.1 x 106.1	126.3 x 94.9								
TCDP 23C 4XC 120	C	0.072	11.0	67.0 x 50.3	79.6 x 59.8	89.4 x 67.0	99.6 x 75.0	118.0 x 98.7	Ø = 124.0	Ø = 134.0	n.a.	n.a.								
		0.286	11.0	16.8 x 12.6	19.9 x 14.9	22.3 x 16.8	24.9 x 18.7	29.5 x 24.7	Ø = 31.0	Ø = 33.5	n.a.	n.a.								
TCDP 23C 4MC 120	C	0.072	11.0	67.0 x 50.3	79.6 x 59.8	89.4 x 67.0	99.6 x 75.0	118.0 x 98.7	Ø = 124.0	Ø = 134.0	n.a.	n.a.								
		0.143	21.2	33.5 x 25.1	39.8 x 29.9	44.7 x 33.5	49.8 x 37.5	59.0 x 49.3	82.3 x 62.0	89.3 x 67.0	106.1 x 106.1	126.3 x 94.9								
TCDP 12C 23C 120	C	0.052	8.0	92.1 x 69.1	109.3 x 82.1	122.8 x 92.1	136.8 x 103.0	Ø = 135.6	n.a.	n.a.	n.a.	n.a.								
		0.072	11.0	67.0 x 50.3	79.6 x 59.8	89.4 x 67.0	99.6 x 75.0	118.0 x 98.7	Ø = 124.0	Ø = 134.0	n.a.	n.a.								
TCDP 2MF 4MF 144	F	0.089	16.8	54.1 x 40.6	64.3 x 48.3	72.2 x 54.1	80.4 x 60.5	95.3 x 79.7	133.0 x 100.1	144.3 x 108.2	171.4 x 171.4	Ø = 153.3								
		0.122	21.6	39.3 x 29.5	46.6 x 35.0	52.4 x 39.3	58.3 x 43.9	69.1 x 57.9	96.6 x 72.7	104.7 x 78.6	124.4 x 124.4	148.1 x 111.3								
TCDP 23C 4XC 144	C	0.061	11	78.6 x 58.9	93.3 x 70.1	104.8 x 78.6	116.7 x 87.9	138.3 x 115.7	Ø = 145.4	Ø = 157.1	n.a.	n.a.								
		0.244	11	19.6 x 14.7	23.3 x 17.5	26.2 x 19.6	29.2 x 22.0	34.6 x 28.9	Ø = 36.3	Ø = 39.3	n.a.	n.a.								
TCDP 23C 4MC 144	C	0.061	11.0	78.6 x 58.9	93.3 x 70.1	104.8 x 78.6	116.7 x 87.9	138.3 x 115.7	Ø = 145.4	Ø = 157.1	n.a.	n.a.								
		0.122	21.6	39.3 x 29.5	46.6 x 35.0	52.4 x 39.3	58.3 x 43.9	69.1 x 57.9	96.6 x 72.7	104.7 x 78.6	124.4 x 124.4	148.1 x 111.3								
TCDP 12C 23C 144	C	0.044	8.0	107.9 x 81.0	128.2 x 96.2	143.9 x 107.9	160.3 x 120.8	Ø = 159.0	n.a.	n.a.	n.a.	n.a.								
		0.061	11.0	78.6 x 58.9	93.3 x 70.1	104.8 x 78.6	116.7 x 87.9	138.3 x 115.7	Ø = 145.4	Ø = 157.1	n.a.	n.a.								
TCDP 2MF 4MF 192	F	0.067	16.8	72.2 x 54.1	85.7 x 64.4	96.2 x 72.2	107.2 x 80.8	127.1 x 106.3	177.4 x 133.5	192.5 x 144.4	228.6 x 228.6	Ø = 204.5								
		0.092	21.6	52.5 x 39.3	62.3 x 46.8	69.9 x 52.5	77.9 x 58.7	92.3 x 77.3	129.0 x 97.0	139.9 x 104.9	166.1 x 166.1	197.8 x 148.6								
TCDP 23C 4XC 192	C	0.046	11.0	104.9 x 78.7	124.5 x 93.5	139.8 x 104.9	155.8 x 117.3	184.6 x 154.5	Ø = 194.0	Ø = 209.7	n.a.	n.a.								
		0.183	11.0	26.2 x 19.7	31.1 x 23.4	35.0 x 26.2	39.0 x 29.3	46.2 x 38.6	Ø = 48.5	Ø = 52.5	n.a.	n.a.								
TCDP 23C 4MC 192	C	0.046	11.0	104.9 x 78.7	124.5 x 93.5	139.8 x 104.9	155.8 x 117.3	184.6 x 154.5	Ø = 194.0	Ø = 209.7	n.a.	n.a.								
		0.092	21.6	52.5 x 39.3	62.3 x 46.8	69.9 x 52.5	77.9 x 58.7	92.3 x 77.3	129.0 x 97.0	139.9 x 104.9	166.1 x 166.1	197.8 x 148.6								
TCDP 12C 23C 192	C	0.033	8.0	144.1 x 108.0	171.1 x 128.5	192.1 x 144.1	214.0 x 161.2	Ø = 212.2	n.a.	n.a.	n.a.	n.a.								
		0.046	11.0	104.9 x 78.7	124.5 x 93.5	139.8 x 104.9	155.8 x 117.3	184.6 x 154.5	Ø = 194.0	Ø = 209.7	n.a.	n.a.								
TCDP 2MF 4MF 240	F	0.053	16.2	90.7 x 68.1	107.8 x 80.9	121.0 x 90.7	134.8 x 101.5	159.7 x 133.6	223.1 x 167.9	242.0 x 181.5	287.3 x 287.3	Ø = 257.1								
		0.073	21.1	65.6 x 49.2	77.9 x 58.5	87.4 x 65.6	97.4 x 73.4	115.4 x 96.6	161.2 x 121.3	174.9 x 131.1	207.7 x 207.7	247.3 x 185.8								
TCDP 23C 4XC 240	C	0.037	11.0	130.8 x 98.1	155.4 x 116.7	174.4 x 130.8	194.3 x 146.4	230.3 x 192.7	Ø = 242.0	Ø = 261.7	n.a.	n.a.								
		0.147	11.0	32.7 x 24.5	38.8 x 29.1	43.5 x 32.7	48.5 x 36.5	57.5 x 48.1	Ø = 60.4	Ø = 65.3	n.a.	n.a.								
TCDP 23C 4MC 240	C	0.037	11.0	130.8 x 98.1	155.4 x 116.7	174.4 x 130.8	194.3 x 146.4	230.3 x 192.7	Ø = 242.0	Ø = 261.7	n.a.	n.a.								
		0.073	21.1	65.6 x 49.2	77.9 x 58.5	87.4 x 65.6	97.4 x 73.4	115.4 x 96.6	161.2 x 121.3	174.9 x 131.1	207.7 x 207.7	247.3 x 185.8								
TCDP 23C 2MC 240	C	0.037	11.0	130.8 x 98.1	155.4 x 116.7	174.4 x 130.8	194.3 x 146.4	230.3 x 192.7	Ø = 242.0	Ø = 261.7	n.a.	n.a.								
		0.053	16.2	90.7 x 68.1	107.8 x 80.9	121.0 x 90.7	134.8 x 101.5	159.7 x 133.6	223.1 x 167.9	242.0 x 181.5	287.3 x 287.3	Ø = 257.1								

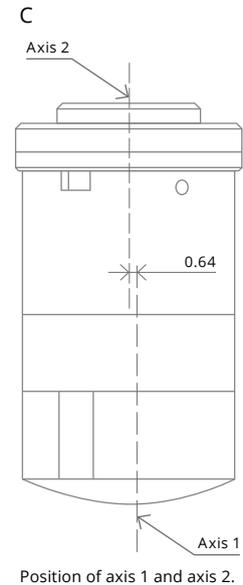
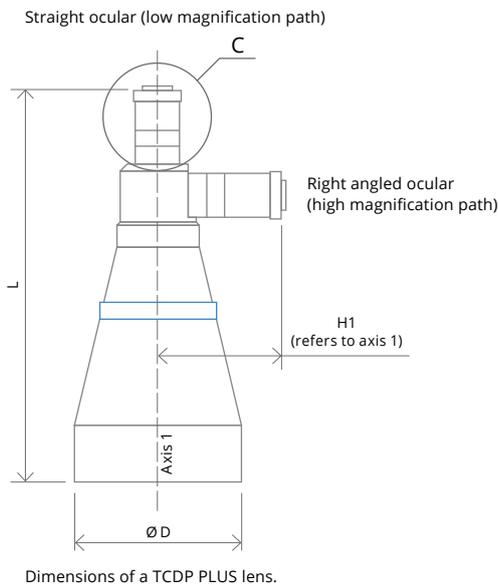
1 TCDP Series has been replaced by TCDP PLUS series.  
Please check our website for the list of replaced products.

## TCDP PLUS lens dimensions:

**L** = length of the lens from the front end to its straight ocular (low magnification path)

**H1** = distance from the end of the right angled ocular (high magnification path) to the middle of the lens (axis 1)

**D** = lens diameter



Part number	Mag. (x)	Optical specifications						Mechanical specifications				
		WD (mm)	F/N	Telecentricity (deg)	Distortion typical (max) (%)	Field depth (mm)	CTF @70lp/mm (%)	Mount	Phase adj.	Length L (mm)	H1 (mm)	Diam. D (mm)
<b>TCDP 2MF 4MF 096</b>	0.137	278.6	16.0	< 0.05 (0.10)	< 0.07 (0.10)	64.0	> 40	F	Yes	341.6	117.1	143.0
	0.186	278.6	16.0	< 0.05 (0.10)	< 0.04 (0.10)	34.2	> 35					
<b>TCDP 23C 4XC 096</b>	0.093	278.6	8.0	< 0.06 (0.08)	< 0.04 (0.08)	77.0	> 40	C	Yes	337.7	192.1	143.0
	0.374	278.6	12.0	< 0.06 (0.10)	< 0.07 (0.10)	7.0	> 40					
<b>TCDP 23C 4MC 096</b>	0.093	278.6	8.0	< 0.06 (0.08)	< 0.04 (0.08)	77.0	> 40	C	Yes	337.7	146.0	143.0
	0.186	278.6	16.0	< 0.05 (0.10)	< 0.04 (0.10)	34.2	> 35					
<b>TCDP 12C 23C 096</b>	0.068	278.6	8.0	< 0.06 (0.08)	< 0.03 (0.08)	145.0	> 45	C	Yes	318.0	89.2	143.0
	0.093	278.6	8.0	< 0.06 (0.08)	< 0.04 (0.08)	77.0	> 40					
<b>TCDP 2MF 4MF 120</b>	0.104	334.5	16.0	< 0.07 (0.10)	< 0.07 (0.10)	110.0	> 40	F	Yes	427.3	118.9	180.0
	0.143	334.5	16.0	< 0.05 (0.10)	< 0.04 (0.10)	57.8	> 30					
<b>TCDP 23C 4XC 120</b>	0.072	334.5	8.0	< 0.07 (0.08)	< 0.04 (0.10)	131.0	> 35	C	Yes	423.4	192.1	180.0
	0.286	334.5	12.0	< 0.08 (0.10)	< 0.05 (0.08)	12.0	> 35					
<b>TCDP 23C 4MC 120</b>	0.072	334.5	8.0	< 0.07 (0.08)	< 0.04 (0.10)	131.0	> 35	C	Yes	423.4	147.8	180.0
	0.143	334.5	16.0	< 0.05 (0.10)	< 0.04 (0.10)	57.8	> 30					
<b>TCDP 12C 23C 120</b>	0.052	334.5	8.0	< 0.06 (0.08)	< 0.04 (0.10)	247.0	> 45	C	Yes	403.7	91.1	180.0
	0.072	334.5	8.0	< 0.07 (0.08)	< 0.04 (0.10)	131.0	> 35					
<b>TCDP 2MF 4MF 144</b>	0.089	396.0	16.0	< 0.05 (0.10)	< 0.05 (0.10)	151.0	> 40	F	Yes	486.7	118.9	200.0
	0.122	396.0	16.0	< 0.05 (0.10)	< 0.04 (0.10)	79.5	> 30					
<b>TCDP 23C 4XC 144</b>	0.061	396.0	8.0	< 0.05 (0.08)	< 0.04 (0.08)	180.0	> 40	C	Yes	482.8	192.1	200.0
	0.244	396.0	12.0	< 0.08 (0.10)	< 0.05 (0.08)	17.0	> 35					
<b>TCDP 23C 4MC 144</b>	0.061	396.0	8.0	< 0.05 (0.08)	< 0.04 (0.08)	180.0	> 40	C	Yes	482.8	147.8	200.0
	0.122	396.0	16.0	< 0.05 (0.10)	< 0.04 (0.10)	79.5	> 30					
<b>TCDP 12C 23C 144</b>	0.044	396.0	8.0	< 0.05 (0.08)	< 0.05 (0.08)	339.0	> 35	C	Yes	463.1	91.1	200.0
	0.061	396.0	8.0	< 0.05 (0.08)	< 0.04 (0.08)	180.0	> 40					
<b>TCDP 2MF 4MF 192</b>	0.067	527.0	16.0	< 0.05 (0.10)	< 0.04 (0.10)	268.0	> 40	F	Yes	627.2	118.9	260.0
	0.092	527.0	16.0	< 0.05 (0.10)	< 0.04 (0.10)	141.8	> 30					
<b>TCDP 23C 4XC 192</b>	0.046	527.0	8.0	< 0.06 (0.08)	< 0.05 (0.08)	320.0	> 35	C	Yes	623.2	192.1	260.0
	0.183	527.0	12.0	< 0.08 (0.10)	< 0.05 (0.08)	30.0	> 35					
<b>TCDP 23C 4MC 192</b>	0.046	527.0	8.0	< 0.06 (0.08)	< 0.05 (0.08)	320.0	> 35	C	Yes	623.2	147.8	260.0
	0.092	527.0	16.0	< 0.05 (0.10)	< 0.04 (0.10)	141.8	> 30					
<b>TCDP 12C 23C 192</b>	0.033	527.0	8.0	< 0.06 (0.08)	< 0.04 (0.08)	603.0	> 45	C	Yes	603.5	91.1	260.0
	0.046	527.0	8.0	< 0.06 (0.08)	< 0.05 (0.08)	320.0	> 35					
<b>TCDP 2MF 4MF 240</b>	0.053	492.8	16.0	< 0.05 (0.10)	< 0.04 (0.10)	424.0	> 40	F	Yes	788.8	95.0	322.0
	0.073	492.8	16.0	< 0.05 (0.10)	< 0.04 (0.10)	424.0	> 40					
<b>TCDP 23C 4XC 240</b>	0.037	492.8	8.0	< 0.03 (0.08)	< 0.04 (0.08)	498.0	> 45	C	Yes	784.9	192.1	322.0
	0.147	492.8	12.0	< 0.06 (0.10)	< 0.08 (0.10)	47.0	> 45					
<b>TCDP 23C 4MC 240</b>	0.037	492.8	8.0	< 0.03 (0.08)	< 0.04 (0.08)	498.0	> 45	C	Yes	784.9	147.8	322.0
	0.073	492.8	16.0	< 0.05 (0.10)	< 0.05 (0.10)	221.5	> 30					
<b>TCDP 23C 2MC 240</b>	0.037	492.8	8.0	< 0.03 (0.08)	< 0.04 (0.08)	498.0	> 45	C	Yes	784.9	124.0	322.0
	0.053	492.8	16.0	< 0.05 (0.10)	< 0.04 (0.10)	424.0	> 40					

- TCDP Series has been replaced by TCDP PLUS series. Please check our website for the list of replaced products.
- Working F-number (wF/#): the real F/# of a lens when used as a macro.
- Maximum slope of principal rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement.

- At the borders of the field depth the image can be still used for measurement but, to get a very sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5.5 µm.
- Indicates the availability of an integrated camera phase adjustment feature.

# TCCX2M series

Telecentric lenses with built-in coaxial illumination for detectors up to 1"



Part number	Mag.	Image circle	Max detector size	Detector type						Optical specifications					Mechanical specs			
				1/3"	1/2.5"	1/2"	1/1.8"	2/3" - 5 MP	KAI-04050	WD	wF/#	Distortion	Field depth	Nominal resolving power	Mount	Phase adj.	Length	Diam.
				w x h	w x h	w x h	w x h	w x h	w x h	16 mm diag								
			(x) Ø (mm)	(mm x mm)	(mm x mm)	(mm x mm)	(mm x mm)	(mm x mm)	(mm x mm)	(mm)		(%)	(mm)	(µm)			(mm)	(mm)
				Object field of view (mm x mm)														
RT-MP-4F-65	4.00	16	1"	1.2 x 0.9	1.4 x 1.1	1.6 x 1.2	1.8 x 1.3	2.1 x 1.8	3.2 x 2.4	65.00	16.7	0.23	0.04	2.80	C	Yes	165.5	29
RT-MP-2F-65	2.00	16	1"	2.4 x 1.8	2.9 x 2.1	3.2 x 2.4	3.6 x 2.7	4.2 x 3.5	6.4 x 4.8	65.00	10	0.40	0.10	3.40	C	Yes	127.0	29
RT-MP-1.5F-65	1.50	16	1"	3.2 x 2.4	3.8 x 2.9	4.3 x 3.2	4.8 x 3.6	5.6 x 4.7	8.5 x 6.4	65.00	7.5	0.50	0.11	3.40	C	Yes	114.6	29
RT-MP-1F-65	1.00	16	1"	4.8 x 3.6	5.7 x 4.3	6.4 x 4.8	7.1 x 5.4	8.5 x 7.1	12.8 x 9.6	65.50	8	-0.10	0.28	5.40	C	Yes	133.1	32
RT-TCL0750-FU	0.75	16	1"	6.4 x 4.8	7.6 x 5.7	8.5 x 6.4	9.5 x 7.2	11.3 x 9.4	17.1 x 12.8	60.70	12 - 60	-0.03	0.80	11.00	C		206.4	38
RT-TCL0600-FU	0.60	16	1"	8.0 x 6.0	9.5 x 7.1	10.7 x 8.0	11.9 x 9.0	14.1 x 11.8	21.3 x 16.0	78.50	12 - 60	-0.02	1.30	13.50	C		228.5	44
RT-TCL0450-FU	0.45	16	1"	10.7 x 8.0	12.7 x 9.5	14.2 x 10.7	15.8 x 11.9	18.8 x 15.7	28.4 x 21.3	108.20	12 - 60	0.01	2.20	18.00	C		265.4	49
RT-TCL0300-FU	0.30	16	1"	16.0 x 12.0	19.0 x 14.3	21.3 x 16.0	23.8 x 17.9	28.2 x 23.6	42.7 x 32.0	167.00	12 - 60	0.01	5.00	27.00	C		338.2	68

- 1 Working F-number (wF/#): the real F-number of a lens when used as a macro.  
 2 Indicates the availability of an integrated camera phase adjustment feature.

FULL RANGE OF COMPATIBLE LED SOURCES	
	LDSC series <span style="float: right;">p. 229</span>
FULL RANGE OF COMPATIBLE POWER SUPPLIES	
	RT-PSP-12122-LV-xx power supply <span style="float: right;">p. 227</span>
FULL RANGE OF COMPATIBLE CAMERAS	
	Area scan cameras <span style="float: right;">p. 180-185</span>

Opto Engineering

**CORE**  
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THE TELECENTRIC COMPANY

# TC16M series

Telecentric lenses for 35 mm and 4 k / 8 k pixel line detectors



**TC16M series** telecentric lenses have been specifically designed to fit 35 mm format (36 x 24 mm) detectors with very high resolution, such as 11, 16 or 29 Mpix. This combination is the typical choice for extremely accurate measurement of large items such as engine parts, glass or metal sheets, PCBs and electronic components, LCDs, etc.

TC16M lenses are also perfectly suitable for 4 kpx and 8 kpx linescan cameras and can be successfully used to measure the diameter of cylindrical objects: for example shafts, turned metal parts, machine tools, etc.

Besides the standard F and M58x0.75 mount options, any other mechanical interface can be supplied upon request.

## KEY ADVANTAGES

**Wide image circle** for large detectors up to 43.3 mm.

**Excellent resolution and low distortion.**

**Simple and robust design** for industrial environments.

**Detailed test report with measured optical parameters.**



Mount F



Mount Q = M58x0.75

FULL RANGE OF COMPATIBLE ILLUMINATORS		
	LTCLHP CORE series	p. 110
FULL RANGE OF COMPATIBLE CLAMPING MECHANICS		
	CMHO series	p. 200
FULL RANGE OF COMPATIBLE CLAMPING MECHANICS		
	CMMR series 45° mirrors	p. 206

## DO YOU KNOW?

Why Opto Engineering® telecentric lenses don't integrate an iris?  
Check the answer to this and other FAQ directly on our web page at:  
[www.opto-engineering.com/faqs](http://www.opto-engineering.com/faqs)



Part number	Mag. (x)	Image circle Ø (mm)	Detector type					Optical specifications						Mechanical specifications			
			Line 2 kpx	Line 4 kpx	Full frame APS-C	Line 8 kpx	Full frame 35 mm	WD	wF/#	Telecentricity	Distortion	Field Depth	CTF	Mount	Phase adj.	Length	Diam.
			2 k x 10 µm	4 k x 7 µm	w x h	8 k x 5 µm	w x h	(mm)		typical (max)	typical (max)	(mm)	@50lp/mm			(mm)	(mm)
<b>Object field of view (mm)</b>																	
<b>TC16M 009</b>	4.000	43.3	5.12	7.17	5.90 x 3.93	10.2	9.00 x 6.00	57.8	22	< 0.03 (0.05)	< 0.03 (0.05)	0.15	> 20	F		487.9	64
<b>TC16M 009-Q</b>	4.000	43.3	5.12	7.17	5.90 x 3.93	10.2	9.00 x 6.00	57.8	22	< 0.03 (0.05)	< 0.03 (0.05)	0.15	> 20	M58X0.75 FD 6.56		527.9	64
<b>TC16M 012</b>	3.000	43.3	6.83	9.56	7.87 x 5.23	13.7	12.0 x 8.00	57.8	18	< 0.03 (0.05)	< 0.03 (0.05)	0.2	> 30	F		378.7	64
<b>TC16M 012-Q</b>	3.000	43.3	6.83	9.56	7.87 x 5.23	13.7	12.0 x 8.00	57.8	18	< 0.03 (0.05)	< 0.03 (0.05)	0.2	> 30	M58X0.75 FD 6.56		418.7	64
<b>TC16M 018</b>	2.000	43.3	10.2	14.3	11.8 x 7.85	20.5	18.0 x 12.0	57.8	16	< 0.03 (0.05)	< 0.03 (0.05)	0.3	> 40	F		259.6	64
<b>TC16M 018-Q</b>	2.000	43.3	10.2	14.3	11.8 x 7.85	20.5	18.0 x 12.0	57.8	16	< 0.03 (0.05)	< 0.03 (0.05)	0.3	> 40	M58X0.75 FD 6.56		299.5	64
<b>TC16M 036</b>	1.000	42.0	20.5	28.7	23.6 x 15.7	41.0	36.0 x 24.0	102.6	16	< 0.03 (0.05)	< 0.02 (0.03)	1.0	> 30	F		309.0	64
<b>TC16M 036-Q</b>	1.000	43.3	20.5	28.7	23.6 x 15.7	41.0	36.0 x 24.0	102.6	16	< 0.03 (0.05)	< 0.02 (0.03)	1.0	> 30	M58X0.75 FD 6.56		348.9	64
<b>TC16M 048</b>	0.751	43.3	27.3	38.2	31.1 x 20.7	54.6	47.9 x 32.0	125.6	16	< 0.06 (0.10)	< 0.05 (0.10)	2.0	> 30	F		315.2	75
<b>TC16M 048-Q</b>	0.750	43.3	27.3	38.2	31.1 x 20.7	54.6	47.9 x 32.0	125.6	16	< 0.06 (0.10)	< 0.05 (0.10)	2.0	> 30	M58X0.75 FD 6.56		355.2	75
<b>TC16M 056</b>	0.641	43.3	31.9	44.7	36.8 x 24.5	63.9	56.1 x 37.4	148.6	16	< 0.04 (0.08)	< 0.04 (0.10)	2.5	> 40	F		338.5	80
<b>TC16M 056-Q</b>	0.640	43.3	31.9	44.7	36.8 x 24.5	63.9	56.1 x 37.4	148.6	16	< 0.04 (0.08)	< 0.04 (0.10)	2.5	> 40	M58X0.75 FD 6.56		378.5	80
<b>TC16M 064</b>	0.561	43.3	36.5	51.1	42.1 x 28.0	73.1	64.2 x 42.8	170.6	16	< 0.04 (0.08)	< 0.06 (0.15)	4.0	> 30	F		359.6	100
<b>TC16M 064-Q</b>	0.560	43.3	36.5	51.1	42.1 x 28.0	73.1	64.2 x 42.8	170.6	16	< 0.04 (0.08)	< 0.06 (0.15)	4.0	> 30	M58X0.75 FD 6.56		399.6	100
<b>TC16M 080</b>	0.463	43.3	44.2	61.9	50.9 x 33.9	88.4	77.7 x 51.8	197.3	16	< 0.03 (0.08)	< 0.09 (0.20)	5.0	> 30	F		406.4	116
<b>TC16M 080-Q</b>	0.460	43.3	44.2	61.9	50.9 x 33.9	88.4	77.7 x 51.8	197.3	16	< 0.03 (0.08)	< 0.09 (0.20)	5.0	> 30	M58X0.75 FD 6.56		446.4	116
<b>TC16M 096</b>	0.380	43.3	53.9	75.4	61.2 x 41.3	107.7	94.7 x 63.1	262.3	16	< 0.06 (0.08)	< 0.07 (0.15)	9.0	> 40	F		449.2	143
<b>TC16M 096-Q</b>	0.380	43.3	53.9	75.4	61.2 x 41.3	107.7	94.7 x 63.1	262.3	16	< 0.06 (0.08)	< 0.07 (0.15)	9.0	> 40	M58X0.75 FD 6.56		489.1	143
<b>TC16M 120</b>	0.289	43.3	70.9	99.3	81.8 x 54.4	141.9	124.7 x 83.1	331.6	16	< 0.05 (0.08)	< 0.05 (0.10)	15.0	> 40	F		538.1	180
<b>TC16M 120-Q</b>	0.290	43.3	70.9	99.3	81.8 x 54.4	141.9	124.7 x 83.1	331.6	16	< 0.05 (0.08)	< 0.05 (0.10)	15.0	> 40	M58X0.75 FD 6.56		578.1	180
<b>TC16M 144</b>	0.245	43.3	83.6	117.0	96.3 x 64.1	167.1	146.9 x 97.9	397.4	16	< 0.05 (0.08)	< 0.08 (0.20)	19.0	> 40	F		597.8	200
<b>TC16M 144-Q</b>	0.250	43.3	83.6	117.0	96.3 x 64.1	167.1	146.9 x 97.9	397.4	16	< 0.05 (0.08)	< 0.08 (0.20)	19.0	> 40	M58X0.75 FD 6.56		637.7	200
<b>TC16M 192</b>	0.187	43.3	109.5	153.3	126.0 x 83.8	219.0	192.0 x 128.0	457.5	16	< 0.06 (0.08)	< 0.05 (0.10)	33.0	> 40	F	Yes	742.0	260
<b>TC16M 192-Q</b>	0.190	43.3	109.5	153.3	126.0 x 83.8	219.0	192.0 x 128.0	457.5	16	< 0.06 (0.08)	< 0.05 (0.10)	33.0	> 40	M58X0.75 FD 6.56	Yes	781.5	260
<b>TC16M 240</b>	0.150	43.3	136.5	191.1	157.8 x 105	273.1	240.0 x 160.0	542.8	16	< 0.06 (0.08)	< 0.08 (0.15)	52.0	> 40	F	Yes	899.0	322
<b>TC16M 240-Q</b>	0.150	43.3	136.5	191.1	157.8 x 105	273.1	240.0 x 160.0	542.8	16	< 0.06 (0.08)	< 0.08 (0.15)	52.0	> 40	M58X0.75 FD 6.56	Yes	938.7	322

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F/#: the real F/# of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.
- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- At the borders of the field depth the image can be still used for measurement but, to get a very sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 4.8 µm.
- FD stands for Flange Distance (in mm), defined as the distance from the mounting flange (the "metal ring" in rear part of the lens) to the camera detector plane.
- Measured from the front end of the mechanics to the camera flange.
- Indicates the availability of an integrated camera phase adjustment feature.

# TC4K series

Flat telecentric lenses for 4 k pixel linescan cameras



## KEY ADVANTAGES

### Compact design

"Flat" shape for easy integration.

### Easy rotational phase and focus adjustment

Robust and precise tuning of FOV phase angle and best focus position.

### Compatible LTCL4K telecentric illuminators

with matching flat design.

### Dedicated CMMR4K mirrors

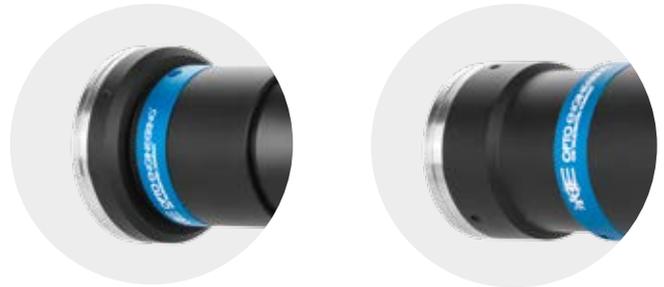
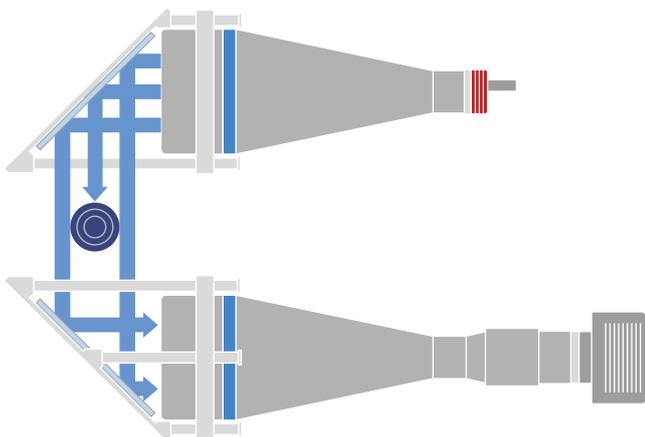
90° right angle attachment for easy integration in tight spaces.

**Detailed test report with measured optical parameters.**

**TC4K series** telecentric lenses have been designed for measurement applications using linescan cameras with detectors up to 28.7 mm (e.g. 4096 pixels with pixel size 7  $\mu\text{m}$ ). Dimensional constraints are often a major issue when designing line scan systems where the sample or the camera itself must be moved: TC4K series is the Opto Engineering® solution for applications and machines with tight dimensional constraints. Compatible LTCL4K illuminators with matching flat design and dedicated accessories allow for optical combinations that fit most geometrical measurement configurations.

TC4K series feature standard F or M42 mount to fit common linescan camera interfaces; additional mounts are available upon request. Moreover, the lens-camera interface provides both fine detector phase adjustment and a precise focusing mechanism. Detector phase adjustment allows the user to precisely position the linear FOV at 90° from the object movement direction.

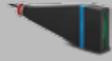
## Application examples



Mount F

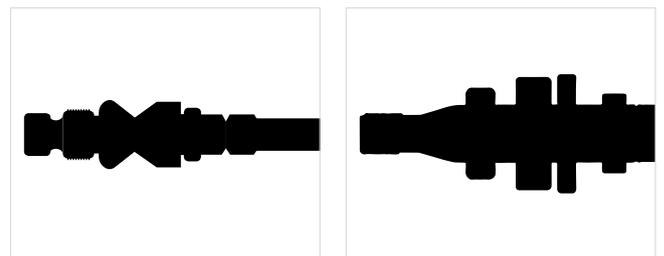
Mount N = M42x1

## FULL RANGE OF COMPATIBLE ILLUMINATORS

	LTCL4K series	p. 114
	LTBRDC series	p. 141

## FULL RANGE OF COMPATIBLE MIRRORS

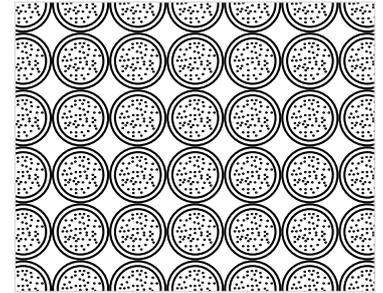
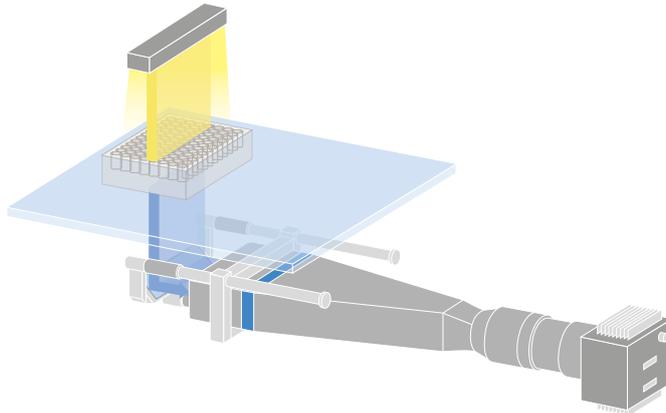
	CMMR4K series	p. 208
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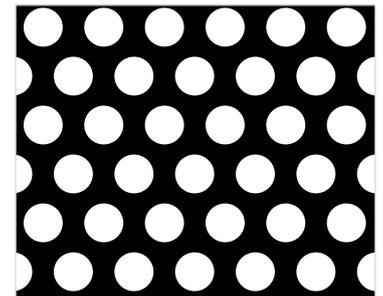
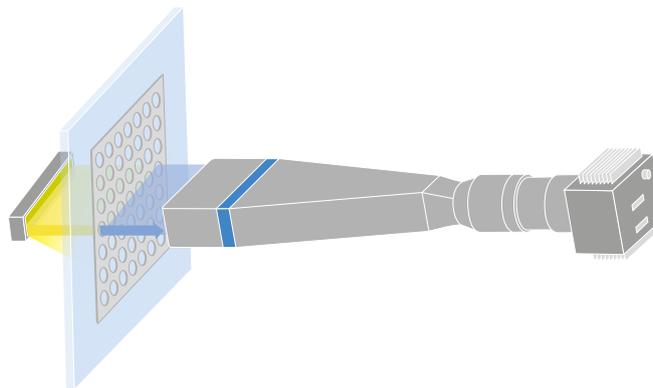
Engine shaft measurement performed with TC4K lens coupled to LTCL4K telecentric illuminator by means of two CMMR4K deflecting mirrors.



Cell count in a Petri dish performed with TC4K lens used in combination with CMMR4K deflecting mirror and a back light.



Metal sheet measurement performed by TC4K lens and diffused backlight illumination.



Part number	Mag. (x)	Image width (mm)	Detector type		Optical specifications						Mechanical specifications								
			Line - 2 kpx 2k x 10 µm	Line - 4 kpx 4k x 7 µm	WD (mm)	wF/#	Telecentricity (deg)	Distortion typical (max) (%)	Field depth (mm)	CTF @50lp/mm (%)	Phase adj. 7	Flange distance		Length		Width		Height	
			20.5 (mm)	28.7 (mm)	1	2	3	4	5	6		F	N	F	N	F	N	F	N
			Object field of view (mm)																
TC4K 060-x	0.48	28.7	42.8	60.0	174.0	16	0.06 (0.10)	0.05 (0.08)	7.3	> 30	Yes	46.5	10.6	319.2	355.2	83	83	64	52
TC4K 090-x	0.32	28.7	64.3	90.0	174.0	16	0.05 (0.10)	0.05 (0.08)	16.4	> 30	Yes	46.5	10.6	360.7	396.6	114	114	64	52
TC4K 120-x	0.24	28.7	85.4	119.6	174.0	16	0.10 (0.12)	0.08 (0.10)	29.2	> 25	Yes	46.5	10.6	337.3	373.2	114	114	64	52
TC4K 180-x	0.16	28.7	128.6	180.0	254.0	16	0.08 (0.10)	0.08 (0.10)	65.6	> 30	Yes	46.5	10.6	522.4	558.4	208	208	64	52

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement. Typical (average production) values and maximum (guaranteed) values are listed.

- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.
- At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 7 µm.
- Measured from the front end of the mechanics to the camera flange.
- Indicates the availability of an integrated camera phase adjustment feature.

#### Ordering information

It's easy to select the right lens for your application: our part numbers are coded as **TC4K yyy -x** where **yyy** refers to the field of view (FOV) in millimeters and **-x** refers to the mount option:  
 - **F** for F-mount  
 - **N** for M42x1 mount (flange distance FD 10.56 mm).  
 E.g. TC4K060-N for a TC4K060 with M42x1 mount.

# TC12K series

Telecentric lenses for 12 k and 16 k pixel linescan cameras

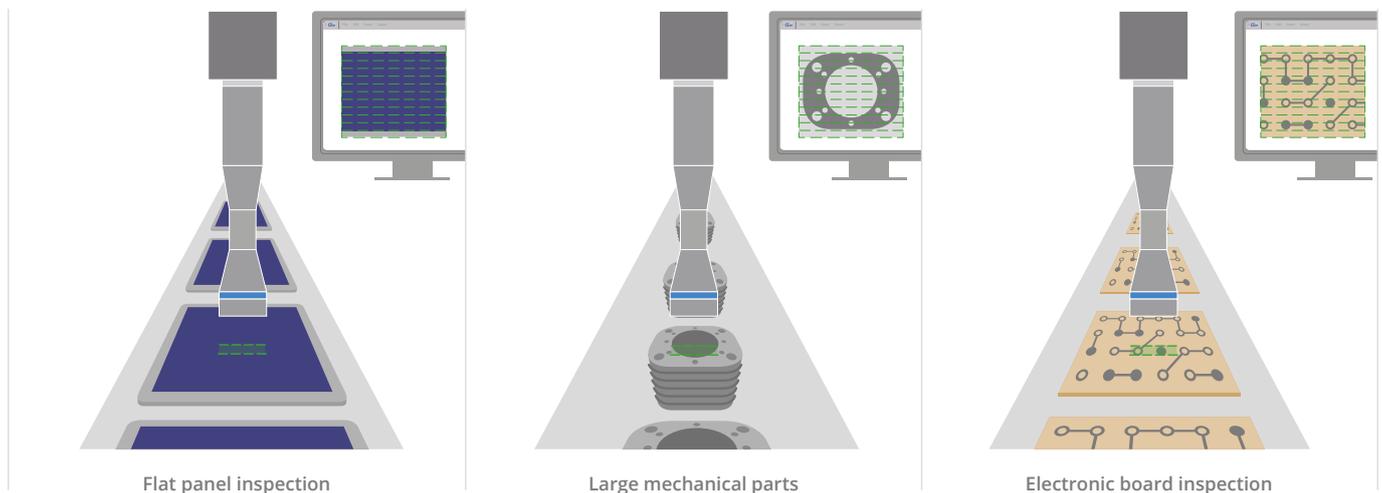


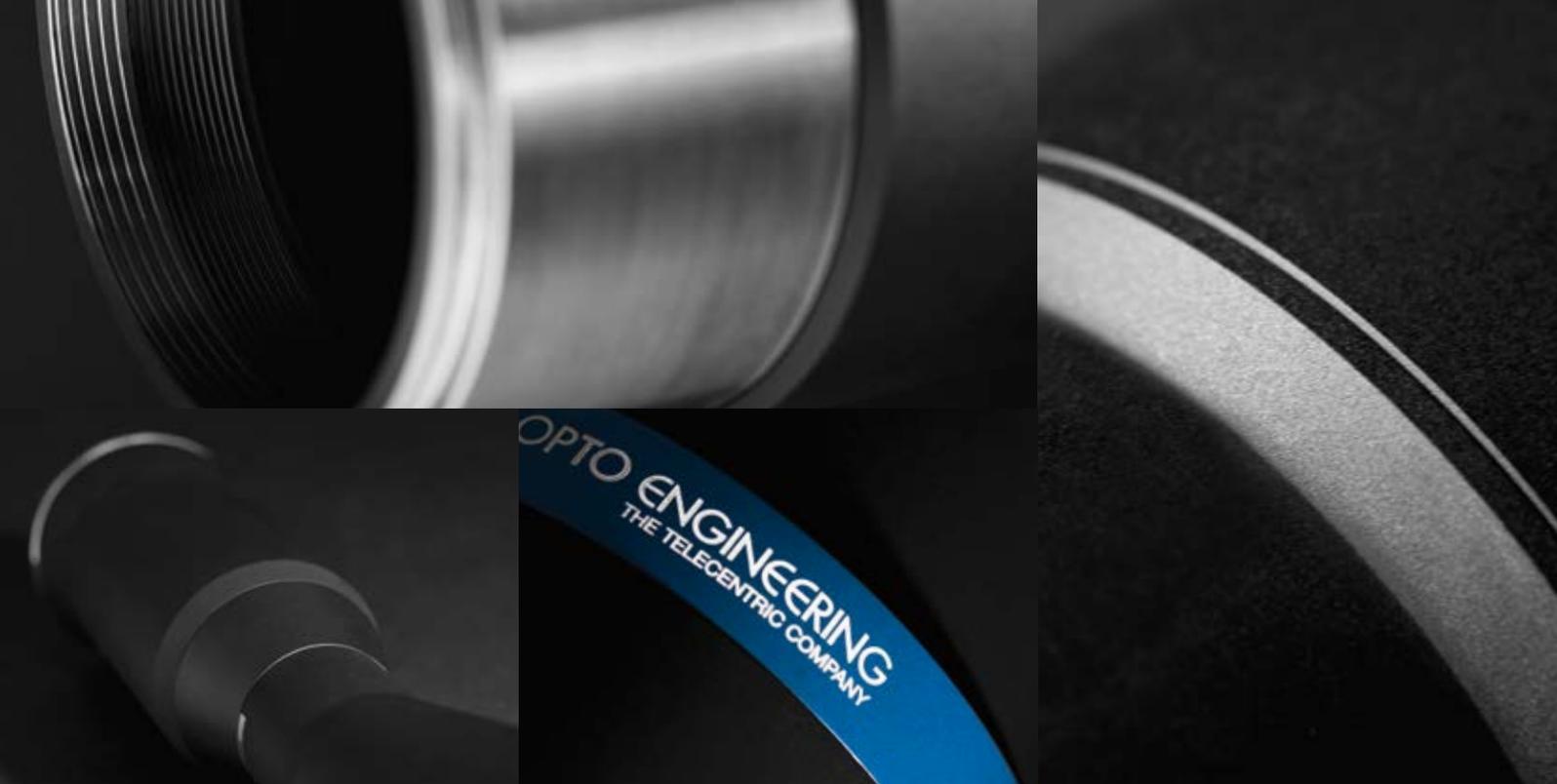
**TC12K series telecentric lenses** are designed to fit very large line detector cameras. An image circle diameter larger than 62 mm combined with very high resolution makes the TC12K series ideal for 12 k and 16 k resolution cameras.

Flat panel display, solar cell and electronic board inspection are among the most common applications of these optics in the electronics industry; at the same time the optical specifications make them perfectly suitable to accurately measure large mechanical parts. In addition to the standard M72x0.75 mount, TC12K lenses can be equipped with other camera mounts at no additional cost ensuring wide compatibility with most common linescan cameras.

FULL RANGE OF COMPATIBLE ILLUMINATORS		
	LTBRDC series	p. 141
	LTCLHP CORE series	p. 110
FULL RANGE OF CLAMPING MECHANICS		
	CMHOTC12K series	p. 200

## Application examples





### Wide image circle

TC12K is optimized for line scan sensor sizes up to 62.4 mm.

SENSOR SIZE								UP TO 62.4 mm
2048 px x 10 $\mu$ m	2048 px x 14 $\mu$ m	4096 px x 7 $\mu$ m	4096 px x 10 $\mu$ m	7450 px x 4.7 $\mu$ m	6144 px x 7 $\mu$ m	8192 px x 7 $\mu$ m	12288 px x 5 $\mu$ m	
20.5 mm	28.6 mm	28.6 mm	35 mm	41 mm	43 mm	57.3 mm	62 mm	

TC12K

### Phase adjustment

Adjusting the phase of the camera mounted on TC12K telecentric lenses is easy: simply loosen the three set screws and rotate the camera mount until you achieve the desired angular alignment.



Part number	Mag. (x)	Image circle $\varnothing$ (mm)	Detector type				Optical specifications					Mechanical specifications				
			Line - 8 kpx	Line - 16 kpx	Line - 12 kpx	Line - 12 kpx	WD	wF/#	Telecentricity	Distortion	Field depth	CTF	Mount	Phase adj.	Length	Diam.
			8 k x 7 $\mu$ m	16 k x 3.5 $\mu$ m	12 k x 5 $\mu$ m	12 k x 5.2 $\mu$ m	1	2	3	4	5	7	8	6		
			Object field of view (mm)													
TC12K 064	0.960	62.4	59.7	59.7	64.0	65.0	162.8	16	< 0.06 (0.08)	< 0.08 (0.10)	1.3	> 35	M72 x 0.75 - FD 6.56	Yes	566.7	100
TC12K 080	0.698	62.4	82.2	82.2	88.1	89.5	157.4	16	< 0.06 (0.08)	< 0.08 (0.10)	2.5	> 35	M72 x 0.75 - FD 6.56	Yes	541.9	116
TC12K 120	0.529	62.4	108.4	108.4	116.1	117.9	254.0	16	< 0.06 (0.08)	< 0.06 (0.08)	4.3	> 40	M72 x 0.75 - FD 6.56	Yes	722.1	180
TC12K 144	0.439	62.4	130.6	130.6	140.0	142.2	237.9	16	< 0.06 (0.08)	< 0.07 (0.10)	6.2	> 40	M72 x 0.75 - FD 6.56	Yes	743.3	200
TC12K 192	0.320	62.4	179.4	179.4	192.3	195.3	265.5	16	< 0.06 (0.08)	< 0.08 (0.10)	11.7	> 35	M72 x 0.75 - FD 6.56	Yes	857.5	260
TC12K 240	0.260	62.4	220.5	220.5	236.3	240.0	492.8	16	< 0.06 (0.08)	< 0.08 (0.10)	17.8	> 35	M72 x 0.75 - FD 6.56	Yes	1072.8	322

- Working distance: distance between the front end of the mechanics and the object. Set this distance within +/- 3% of the nominal value for maximum resolution and minimum distortion.
- Working F-number (wF/#): the real F-number of a lens when used as a macro. Lenses with smaller apertures can be supplied on request.
- Maximum slope of chief rays inside the lens: when converted to milliradians, it gives the maximum measurement error for any millimeter of object displacement.
- Percent deviation of the real image compared to an ideal, undistorted image: typical (average production) values and maximum (guaranteed) values are listed.

- At the borders of the field depth the image can be still used for measurement but, to get a perfectly sharp image, only half of the nominal field depth should be considered. Pixel size used for calculation is 5  $\mu$ m.
- Measured from the front end of the mechanics to the camera flange.
- FD stands for Flange Distance (in mm), defined as the distance from the mounting flange (the "metal ring" in rear part of the lens) to the camera detector plane.
- Indicates the availability of an integrated camera phase adjustment feature.