Telecentric lenses

2014

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Index

Telecentric lenses

Opto Engineering Telecentric lenses represent our core business:
these products benefit from a decade-long effort in progressive
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 performances 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

Opto Engineering testing procedures have been checked by TÜV Rheinland.

ACCESSORIES

Our TC family is complemented by a full set of accessories:

CLAMPING MECHANICS

RING LED ILLUMINATORS

... AND MORE

Please refer to our website www.opto-engineering.com to browse our complete product range.

TC series

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

Bi-telecentric lenses are the key component of any accurate measurement system based on machine vision technologies.

Compatible with high resolution/small pixel detectors like 5 Mpx 2/3" detectors, these lenses feature very low distortion while their real bi-telecentricity makes them purely telecentric.

It's easy to select the right lens for your application by means of its part number: for any given product part number, i.e. TC xx yyy, "xx" gives the camera sensor format size (13 = 1/3"; 12 = 1/2"; 23 = 2/3") while "yyy" expresses the horizontal 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.

TÜVRheinland®

Opto Engineering testing procedures have been checked by TÜV Rheinland.

DO YOU KNOW?

Opto Engineering provides fully localized documentation of the complete product range, with schematics and in-depth specifications. Available for download at:

www.opto-engineering.com

Part number	Mag. (x)	Image circle (mm)	1/3" w x h 4.80 x 3.60 (mm x mm)	1/2.5" w x h 5.70 x 4.28 (mm x mm)	1/2" w x h 6.40 x 4.80 (mm x mm)	1/1.8" w x h 7.13 x 5.37 (mm x mm) [7]	2/3" - 5 Mpx w x h 8.45 x 7.07 (mm x mm)	W.D. (mm) [1]	F/N [2]	Telecentricity typical (max) (deg) [3]	Distortion typical (max) (%) [4]	Field depth (mm) [5]	CTF @70lp/mm (%)	Mount	Length (mm) [6]	Diam. (mm)
			Object field of view (mm x mm) [8]													
TC 23 004	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	57.1	11	< 0.08 (0.10)	< 0.04 (0.08)	0.23	> 30	C	101.4	28
TC 23 007	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	61.2	11	< 0.08 (0.10)	< 0.03 (0.08)	0.5	> 30	C	78.5	28
TC 23 009	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	63.3	11	< 0.08 (0.10)	< 0.04 (0.08)	0.9	> 25	C	65.0	28
TC 23 012	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	11	< 0.04 (0.10)	< 0.04 (0.10)	1.2	> 25	C	60.3	28
TC 12 016	0.385	8.0	12.5 x 9.36	14.8 x 11.1	16.6 x 12.5	18.5 x 14.0	Ø = 18.4	45.3	8	< 0.04 (0.10)	< 0.04 (0.08)	5	> 40	C	93.0	37.7
TC 23 016	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	45.3	8	< 0.06 (0.10)	< 0.04 (0.07)	2	> 30	C	112.7	37.7
TC 12 024	0.255	8.0	18.8 x 14.1	22.4 x 16.8	25.1 x 18.8	28.0 x 21.1	Ø = 27.7	69.2	8	< 0.04 (0.10)	< 0.04 (0.08)	10	> 45	C	117.8	44
TC 23 024	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	69.2	8	< 0.08 (0.10)	< 0.04 (0.10)	5	> 45	C	137.5	44
TC 13 036	0.133	6.0	36.0 x 27.0	Ø = 32.0	Ø = 36.0	Ø = 40.2	n.a.	103.5	8	< 0.04 (0.08)	< 0.03 (0.08)	38	> 50	C	133.0	61
TC 12 036	0.177	8.0	27.1 x 20.3	32.2 x 24.1	36.1 x 27.1	40.2 x 30.3	Ø = 39.9	103.5	8	< 0.03 (0.08)	< 0.04 (0.10)	21	> 40	C	145.2	61
TC 23 036	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	103.5	8	< 0.04 (0.08)	< 0.04 (0.10)	11	> 40	C	164.9	61
TC 13 048	0.098	6.0	48.8 x 36.6	Ø = 43.5	Ø = 48.8	Ø = 54.6	n.a.	134.6	8	< 0.08 (0.10)	< 0.06 (0.10)	65	> 40	C	167.9	75
TC 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	134.6	8	< 0.07 (0.10)	< 0.06 (0.10)	37	> 40	C	181.5	75
TC 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	134.6	8	< 0.08 (0.10)	< 0.05 (0.10)	20	> 40	C	201.0	75
TC 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	159.3	8	< 0.04 (0.08)	< 0.04 (0.08)	51	> 50	C	205.0	80
TC 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	159.3	8	< 0.05 (0.08)	< 0.03 (0.08)	27	> 45	C	225.0	80
TC 13 064	0.074	6.0	65.2 x 48.9	Ø = 58.1	Ø = 65.2	Ø = x 72.9	n.a.	182.3	8	< 0.06 (0.08)	< 0.03 (0.07)	124	> 40	C	212.3	100
TC 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	182.3	8	< 0.05 (0.08)	< 0.04 (0.07)	67	> 50	C	225.9	100
TC 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	182.3	8	< 0.05 (0.08)	< 0.03 (0.07)	35	> 50	C	245.5	100
TC 23 072	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	227.7	8	< 0.04 (0.08)	< 0.03 (0.07)	45	> 40	C	299.2	116
TC 13 080	0.059	6.0	81.2 x 60.9	Ø = 72.4	Ø = 81.2	Ø = 90.9	n.a.	227.7	8	< 0.05 (0.08)	< 0.03 (0.08)	192	> 40	C	259.2	116
TC 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	227.7	8	< 0.03 (0.08)	< 0.04 (0.10)	104	> 50	C	271.5	116
TC 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	227.7	8	< 0.04 (0.08)	< 0.02 (0.10)	55	> 50	C	291.2	116
TC 23 085	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	280.6	8	< 0.04 (0.08)	< 0.02 (0.08)	62	> 45	C	344.5	143
TC 13 096	0.050	6.0	96.0 x 72.0	Ø = 85.5	Ø = 96.0	Ø = 107.4	n.a.	280.6	8	< 0.06 (0.08)	< 0.04 (0.10)	268	> 50	C	303.3	143
TC 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	279.6	8	< 0.06 (0.08)	< 0.03 (0.08)	145	> 45	C	317.0	143
TC 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	279.6	8	< 0.06 (0.08)	< 0.04 (0.08)	77	> 40	C	336.6	143
TC 23 110	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	336.5	8	< 0.06 (0.08)	< 0.03 (0.07)	106	> 40	C	430.4	180
TC 12 120	0.052	8.0	92.1 x 69.1	109.4 x 82.0	122.8 x 92.1	136.7 x 103.0	Ø = 135.5	336.5	8	< 0.06 (0.08)	< 0.04 (0.10)	247	> 45	C	402.7	180
TC 23 120	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	336.5	8	< 0.07 (0.08)	< 0.04 (0.10)	131	> 35	C	422.4	180
TC 23 130	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	398.0	8	< 0.05 (0.08)	< 0.04 (0.10)	146	> 40	C	490.0	200
TC 12 144	0.044	8.0	107.9 x 80.9	128.2 x 96.2	143.9 x 107.9	160.3 x 120.7	Ø = 158.9	398.0	8	< 0.05 (0.08)	< 0.05 (0.08)	339	> 35	C	462.1	200
TC 23 144	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	398.0	8	< 0.05 (0.08)	< 0.04 (0.08)	180	> 40	C	481.9	200
TC 23 172	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	531.0	8	< 0.05 (0.08)	< 0.04 (0.10)	260	> 40	C	630.3	260
TC 12 192	0.033	8.0	144.1 x 108.0	171.1 x 128.3	192.1 x 144.1	213.9 x 161.1	Ø = 212.0	531.0	8	< 0.06 (0.08)	< 0.04 (0.08)	603	> 45	C	602.6	260
TC 23 192	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	531.0	8	< 0.06 (0.08)	< 0.05 (0.08)	320	> 35	C	622.3	260
TC 23 200	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	500.0	8	< 0.06 (0.08)	< 0.05 (0.10)	352	> 40	C	792.0	322
TC 23 240	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	500.0	8	< 0.03 (0.08)	< 0.04 (0.08)	498	> 45	C	775.1	322

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

2 Working F-number: 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.

6 Measured from the front end of the mechanics to the camera flange.

7 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).

8 For the fields with the indication "Ø =", the image of a circular object of such diameter is fully inscribed into the detector.

TC2M-TC4M series

Bi-telecentric lenses for large detectors up to 1.2"

TC2M and TC4M lenses are bi-telecentric lenses designed for detectors larger than 2/3". TC2M lenses cover up to 1" (16 mm diagonal) detectors. TC4M lenses cover up to 21.5 mm detector diagonal and are therefore suitable for 1.2" imagers.

In order to help the selection, some of the most commonly used large matrix detectors are listed in the next page table.

Select the lens that best suits your application: choose the column where the right detector is listed and scroll down until you find the field of view best matching your needs.

All the lenses listed in the table are available with C or F-mount (ordering code: "part number–F" for F-mount and "part number–C" for C-mount, e.g. TC4M 064-F for an F-mount TC4M 064 lens).

ORDERING CODE

The lens mount must be specified by indicating -F, for F-mount or -C, for C-mount options instead of -X at the end of the part number.

Customized mounts also available upon request.

			Detector type				Optical specifications						Dimensions		
Part number	Mag.	Image circle	KAI 2020 14.8 mm diag. w x h 11.8 x 8.88	KAI-04050 16 mm diag. w x h 12.8 x 9.64	KAI4022/4021 21.5 mm diag. w x h 15.2 x 15.2	KAI-08050 22.6 mm diag. w x h 18.1 x 13.6	W.D.	F/N	Telecentricity typical (max)	Distortion typical (max)	Field depth	CTF @50lp/mm	Mount	Length		Diam.
	(x)	(mm)	(mm x mm)	(mm x mm)	(mm x mm)	(mm x mm) **7**	(mm) **1**	**2**	(deg) **3**	(%) **4**	(mm) **5**	(%)		(mm) **6**		(mm)
TC2M lenses			Object field of view (mm x mm) **8**											C	F	
TC2M 016-X	0.769	16.0	15.4 x 11.5	16.7 x 12.5	Ø = 19.7	Ø = 17.7	45.3	16	< 0.08 (0.10)	< 0.08 (0.10)	1.9	> 30	C or F	198.0	170.1	45
TC2M 024-X	0.510	16.0	23.2 x 17.4	25.2 x 18.9	Ø = 29.7	Ø = 26.7	69.2	16	< 0.08 (0.10)	< 0.07 (0.10)	4	> 30	C or F	242.7	214.7	45
TC2M 036-X	0.354	16.0	33.4 x 25.1	36.3 x 27.2	Ø = 42.8	Ø = 38.4	103.5	16	< 0.03 (0.10)	< 0.04 (0.10)	9	> 30	C or F	250.4	222.3	61
TC2M 048-X	0.268	16.0	44.2 x 33.2	48.0 x 36.0	Ø = 56.6	Ø = 50.8	134.6	16	< 0.05 (0.10)	< 0.08 (0.10)	16	> 30	C or F	286.5	257.4	75
TC2M 056-X	0.229	16.0	51.8 x 38.8	56.2 x 42.1	Ø = 66.3	Ø = 59.5	159.3	16	< 0.04 (0.10)	< 0.02 (0.10)	22	> 30	C or F	309.8	280.7	80
TC2M 064-X	0.200	16.0	59.2 x 44.4	64.2 x 48.1	Ø = 75.7	Ø = 67.9	182.3	16	< 0.04 (0.10)	< 0.05 (0.10)	29	> 30	C or F	330.9	301.8	100
TC2M 080-X	0.161	16.0	73.7 x 55.3	80.0 x 60.0	Ø = 94.3	Ø = 84.6	227.7	16	< 0.04 (0.10)	< 0.07 (0.10)	45	> 30	C or F	376.6	347.5	116
TC2M 096-X	0.136	16.0	87.0 x 65.3	94.4 x 70.8	Ø = 111.4	Ø = 99.9	279.6	16	< 0.05 (0.10)	< 0.06 (0.10)	62	> 30	C or F	422.1	393.0	143
TC2M 120-X	0.104	16.0	113.5 x 85.2	123.2 x 92.4	Ø = 145.3	Ø = 130.4	336.5	16	< 0.07 (0.10)	< 0.05 (0.10)	106	> 30	C or F	507.7	478.6	180
TC2M 144-X	0.089	16.0	133.1 x 99.8	144.4 x 108.3	Ø = 170.4	Ø = 152.9	398.0	16	< 0.05 (0.10)	< 0.07 (0.10)	145	> 30	C or F	567.2	538.1	200
TC2M 192-X	0.067	16.0	177.7 x 133.2	192.8 x 144.6	Ø = 227.4	Ø = 204.0	531.0	16	< 0.08 (0.10)	< 0.04 (0.10)	259	> 30	C or F	706.6	678.5	260
TC4M lenses																
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	C or F	206.4	178.4	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	C or F	183.5	155.4	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	C or F	170.0	142.0	45
TC4M 016-X	1.056	22.0	11.2 x 8.41	12.2 x 9.13	14.4 x 14.4	17.1 x 12.9	45.3	16	< 0.08 (0.10)	< 0.04 (0.10)	1	> 30	C or F	217.7	189.7	45
TC4M 024-X	0.700	22.0	16.9 x 12.7	18.3 x 13.8	21.6 x 21.6	25.9 x 19.4	69.2	16	< 0.06 (0.10)	< 0.07 (0.10)	2	> 30	C or F	242.5	214.6	45
TC4M 036-X	0.487	22.0	24.3 x 18.2	26.4 x 19.8	31.1 x 31.1	37.3 x 27.9	103.5	16	< 0.04 (0.10)	< 0.06 (0.10)	5	> 30	C or F	269.9	242.0	61
TC4M 048-X	0.368	22.0	32.2 x 24.2	35.0 x 26.2	41.2 x 41.2	49.3 x 37.0	134.6	16	< 0.08 (0.10)	< 0.08 (0.10)	9	> 30	C or F	306.1	278.2	75
TC4M 056-X	0.314	22.0	37.7 x 28.3	40.9 x 30.7	48.2 x 48.2	57.7 x 43.3	159.3	16	< 0.04 (0.10)	< 0.05 (0.10)	12	> 30	C or F	329.4	301.5	80
TC4M 064-X	0.275	22.0	43.1 x 32.3	46.7 x 35.0	55.1 x 55.1	65.9 x 49.5	182.3	16	< 0.04 (0.10)	< 0.06 (0.10)	15	> 30	C or F	350.5	322.6	100
TC4M 072-X	0.245	22.0	48.4 x 36.3	52.5 x 39.4	62.0 x 62.0	74.1 x 55.6	227.7	16	< 0.05 (0.10)	< 0.06 (0.10)	19	> 30	C or F	404.2	376.3	116
TC4M 080-X	0.221	22.0	53.7 x 40.2	58.2 x 43.7	68.7 x 68.7	82.2 x 61.6	227.7	16	< 0.03 (0.10)	< 0.06 (0.10)	24	> 30	C or F	396.2	367.2	116
TC4M 085-X	0.207	22.0	57.2 x 42.9	62.0 x 46.5	73.2 x 73.2	87.5 x 65.6	280.6	16	< 0.03 (0.10)	< 0.04 (0.10)	27	> 30	C or F	449.5	421.6	143
TC4M 096-X	0.187	22.0	63.4 x 47.5	68.8 x 51.6	81.1 x 81.1	97.0 x 72.8	279.6	16	< 0.05 (0.10)	< 0.06 (0.10)	33	> 30	C or F	441.6	412.7	143
TC4M 110-X	0.159	22.0	74.6 x 55.9	80.9 x 60.7	95.5 x 95.5	114.2 x 85.6	336.5	16	< 0.08 (0.10)	< 0.08 (0.10)	46	> 30	C or F	537.4	509.4	180
TC4M 120-X	0.143	22.0	82.7 x 62.0	89.7 x 67.3	105.8 x 105.8	126.6 x 94.9	336.5	16	< 0.08 (0.10)	< 0.05 (0.10)	56	> 30	C or F	527.4	489.3	180
TC4M 130-X	0.135	22.0	87.4 x 65.6	94.9 x 71.2	111.9 x 111.9	133.9 x 100.4	398.0	16	< 0.03 (0.10)	< 0.08 (0.10)	63	> 30	C or F	594.9	566.8	200
TC4M 144-X	0.122	22.0	96.9 x 72.7	105.2 x 78.9	124.0 x 124.0	148.4 x 111.3	398.0	16	< 0.05 (0.10)	< 0.08 (0.10)	77	> 30	C or F	586.9	557.8	200
TC4M 172-X	0.101	22.0	116.7 x 87.5	126.6 x 95.0	149.3 x 149.3	178.6 x 134.0	531.0	16	< 0.33 (0.10)	< 0.05 (0.10)	112	> 30	C or F	735.3	707.2	260
TC4M 192-X	0.092	22.0	129.3 x 97.0	140.3 x 105.3	165.5 x 165.5	198.0 x 148.5	531.0	16	< 0.08 (0.10)	< 0.04 (0.10)	137	> 30	C or F	727.3	699.2	260
TC4M 200-X	0.087	22.0	135.7 x 101.7	147.2 x 110.4	173.6 x 173.6	207.7 x 155.8	500.0	16	< 0.08 (0.10)	< 0.08 (0.10)	151	> 30	C or F	897.0	868.9	322
TC4M 240-X	0.073	22.0	161.4 x 121.0	175.1 x 131.3	206.5 x 206.5	247.0 x 185.3	500.0	16	< 0.08 (0.10)	< 0.08 (0.10)	214	> 30	C or F	880.1	852.0	322

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

2 Working F-number: 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.

6 Measured from the front end of the mechanics to the camera flange.

7 With KAI-08050 (22,6 mm diagonal) detectors, the FOV of TC4M yyy lenses may show some vignetting at the image corners, as these lenses are optimized for 1.2" detectors (21.5 mm diagonal).

8 For the fields with the indication "Ø =", the image of a circular object of such diameter is fully inscribed into the detector.

TC16M series

Bi-telecentric lenses for 35 mm and 4 k / 8 k pixel line detectors

TC16M series bi-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 Mpx.

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 determine the diameter of cylindrical objects: for example shafts, turned metal parts, machine tools, etc.

Besides the standard F-mount any other mechanical interface can be easily supplied upon request.

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

Part number	Mag. (x)	Image circle (mm)	Detector type				Optical specifications						Dimensions		
			line - 2 kpx 2 k x 10 µm 20.5 (mm)	line - 4 kpx 4 k x 7 µm 28.7 (mm)	line - 8 kpx 8 k x 5µm 41.0 (mm)	35 mm w x h 36.0 x 24.0 (mm x mm)	W.D. (mm) **1**	F/N **2**	Telecentricity typical (max) (deg) **3**	Distortion typical (max) (%) **4**	Field Depth (mm) **5**	CTF @50lp/mm (%)	Mount	Length (mm) **6**	Diam. (mm)
			Object field of view (mm)												
TC16M 009	4.000	43.3	5.12	7.17	10.2	9.00 x 6.00	57.8	22	< 0.03 (0.05)	< 0.03 (0.05)	0.15	> 20	F	487.9	45
TC16M 012	3.000	43.3	6.83	9.56	13.7	12.0 x 8.00	57.8	18	< 0.03 (0.05)	< 0.03 (0.05)	0.2	> 30	F	378.7	45
TC16M 018	2.000	43.3	10.2	14.3	20.5	18.0 x 12.0	57.8	16	< 0.03 (0.05)	< 0.03 (0.05)	0.3	> 40	F	259.6	45
TC16M 036	1.000	43.3	20.5	28.7	41.0	36.0 x 24.0	103.0	16	< 0.03 (0.05)	< 0.02 (0.03)	1	> 30	F	309.0	61
TC16M 048	0.751	43.3	27.3	38.2	54.6	47.9 x 32.0	127.0	16	< 0.06 (0.10)	< 0.05 (0.10)	2	> 30	F	315.2	75
TC16M 056	0.641	43.3	31.9	44.7	63.9	56.1 x 37.4	150.0	16	< 0.04 (0.08)	< 0.04 (0.10)	2.5	> 40	F	338.5	80
TC16M 064	0.561	43.3	36.5	51.1	73.1	64.2 x 42.8	171.0	16	< 0.04 (0.08)	< 0.06 (0.15)	4	> 30	F	359.6	100
TC16M 080	0.463	43.3	44.2	61.9	88.4	77.7 x 51.8	198.0	16	< 0.03 (0.08)	< 0.09 (0.20)	5	> 30	F	406.4	116
TC16M 096	0.380	43.3	53.9	75.4	107.7	94.7 x 63.1	263.0	16	< 0.06 (0.08)	< 0.07 (0.15)	9	> 40	F	449.2	143
TC16M 120	0.289	43.3	70.9	99.3	141.9	124.7 x 83.1	333.0	16	< 0.05 (0.08)	< 0.05 (0.10)	15	> 40	F	538.1	180
TC16M 144	0.245	43.3	83.6	117.0	167.1	146.9 x 97.9	398.0	16	< 0.05 (0.08)	< 0.08 (0.20)	19	> 40	F	597.8	200

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

2 Working F-number: 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.

6 Measured from the front end of the mechanics to the camera flange.

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 the very high resolution featured by this lens family makes TC12K Series the solution of choice for 12 k and 16 k pixel 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 for large mechanical parts accurate measurement.

In addition to the standard M72x0.75 mount TC12K lenses can be easily equipped with any other type of camera mount at no extra cost.

Example of applications

| Flat panel inspection | Large mechanical parts | Electronic board inspection |
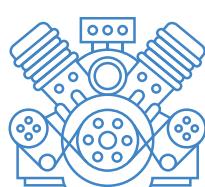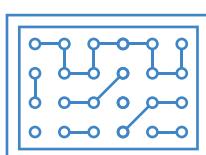
Part number	Mag.	Image circle	line - 8 kpx 8 k x 7 µm 57.3	line - 16 kpx 16 k x 3.5 µm 57.3	line - 12 kpx 12 k x 5 µm 61.4	line - 12 kpx 12 k x 5.2 µm 62.4	W.D.	F/N	Telecentricity typical (max)	Distortion typical (max)	Field depth	CTF @50lp/mm	Mount	Length	Diam.
	(x)	(mm)	(mm)	(mm)	(mm)	(mm)			(deg)	(%)	(mm)	(%)		(mm)	(mm)
							1	**2**	**3**	**4**	**5**			**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	> 35	M72 x 0.75	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	> 35	M72 x 0.75	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	> 40	M72 x 0.75	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)	5.5	> 40	M72 x 0.75	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)	10	> 35	M72 x 0.75	857.5	260

Column group headers: **Detector type** (line detectors), **Optical specifications** (W.D., F/N, Telecentricity, Distortion, Field depth, CTF), **Dimensions** (Mount, Length, Diam.)

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

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.
6 Measured from the front end of the mechanics to the camera flange.

LTCL series

Collimated (telecentric) LED illuminators

CE RoHS COMPLIANT

KEY ADVANTAGES

Complete light coupling
All the light emitted by a LTCL source is collected by a telecentric lens and transferred to the camera detector, ensuring a very high signal-to-noise ratio.

Border effects removal
Diffused back-illuminators often make objects seem smaller than their actual size because of light reflections on the object sides, while collimated rays are much less reflected.

Field depth and telecentricity improvement
Collimated illumination increases the field depth and telecentricity of a telecentric lens far beyond its nominal specs.

LTCL collimated illuminators have been specifically designed to back illuminate objects imaged by telecentric lenses.

This type of illumination is strongly recommended for high accuracy measurement of round or cylindrical parts where diffusive back lighting would offer poor performances.

The following light colors are available:

R= red, peak at 630 nm
G= green, peak at 520 nm
B= blue, peak at 460 nm
W= white

For example the part number "LTCL 064-G" defines a LTCL 064 type collimated source equipped with green (-G) LEDs.
Green light is recommended for high precision measurement applications: ensuring the lowest distortion and the highest telecentricity, also delivering the highest signal/noise ratio and the best image resolution.
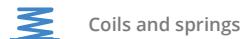
Coils and springs		Tubes and shafts
Screws and nuts		Seals and o-rings

Examples of measurement applications where LTCL illuminators are needed.

COMING SOON

LTCLHP LED illuminators, with an all-new energy source, improving output stability.

Part number (*)	Beam diameter (mm)	Available colours				Optical specs	Mechanical specs		Compatible telecentric lenses						
		R	G	B	W	Working distance range (mm)	Length (mm)	Outer diameter (mm)	TC 13 yyy yyy=	TC 12 yyy yyy=	TC 23 yyy yyy=	TC4M yyy yyy=	TC2M yyy yyy=	TC16M yyy yyy=	TC12K yyy yyy=
LTCL 023-X	16	x	x	x	x	45 ~ 90	83.6	28	n.a.	n.a.	00x, 012	004, 007, 009	n.a.	n.a.	n.a.
LTCL 016-X	20	x	x	x	x	35 ~ 70	86.7	38	n.a.	016	016	016	016	n.a.	n.a.
LTCL 024-X	30	x	x	x	x	45 ~ 90	115.5	44	n.a.	024	024	024	024	009, 012, 018	n.a.
LTCL 036-X	45	x	x	x	x	70 ~ 140	138.9	61	036	036	036	036	036	036	n.a.
LTCL 048-X	60	x	x	x	x	90 ~ 180	174.0	75	n.a.	048	048	048	048	048	n.a.
LTCL 056-X	70	x	x	x	x	100 ~ 200	197.3	80	n.a.	056	056	056	056	056	n.a.
LTCL 064-X	80	x	x	x	x	120 ~ 240	218.4	100	064	064	064	064	064	064	064
LTCL 080-X	100	x	x	x	x	150 ~ 300	264.0	116	n.a.	080	072, 080	072, 080	080	080	080
LTCL 096-X	120	x	x	x	x	200 ~ 250	309,0	143	096	096	085, 096	085, 096	096	096	n.a.
LTCL 120-X	150	x	x		x	220 ~ 440	395.0	180	n.a.	120	110, 120	110, 120	120	120	120
LTCL 144-X	180	x	x			270 ~ 540	454.0	200	n.a.	144	130, 144	130, 144	144	144	144
LTCL 192-X	250	x	x			350 ~ 700	595.0	260	n.a.	192	172, 192	172, 192	192	n.a.	192
LTCL 240-X	300	x	x			350 ~ 700	756.0	322	n.a.	n.a.	200, 240	200, 240	n.a.	n.a.	n.a.

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

Built-in electronics

You can easily adjust the light intensity of any LTCL illuminator thanks to the built-in electronics board, which ensures a constant current flow through the LED source. This delivers excellent illumination stability and increases the product lifetime.

To do so, just connect the black and brown cables to your 12/24V power supply.

Direct LED control

The inner circuitry can be bypassed in order to drive the LED directly for use in continuous or pulsed mode. To do so, simply connect the black and blue cables to your power supply or external strobe controller.

Make sure that the maximum rates are not exceeded to avoid electrical shorts.

## Easy and precise alignment with bi-telecentric lenses

Every collimated source up to LTCL 144-X can be mounted on the same clamping mechanics (CMHO series) used to fix and align our telecentric lenses. You can create the perfect optical bench for any precision measurement application by interfacing our bi-telecentric lenses and LTCL collimated illuminators with these precision clamps.
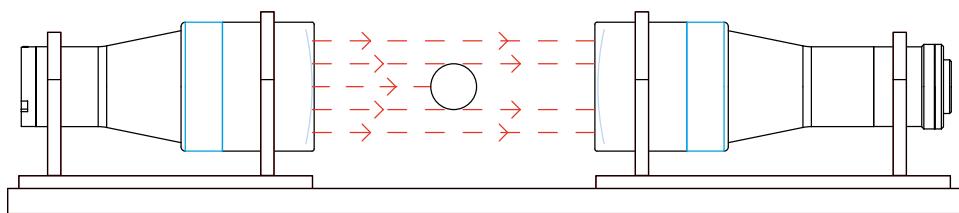
Typical emission spectrum of white LEDs
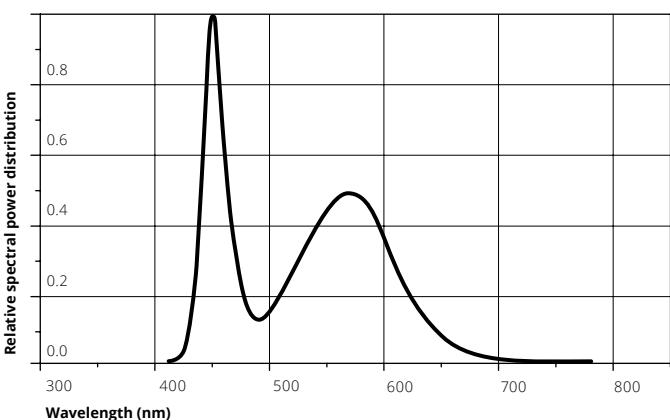
Typical emission spectrum of R,G,B LEDs
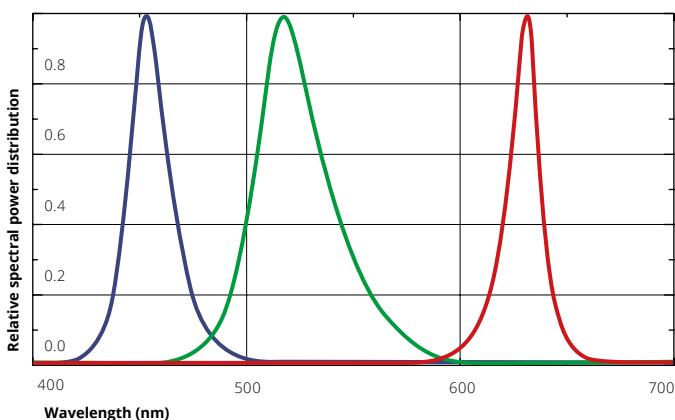
Visible light	Light color, peak wavelength	Device power ratings			LED power ratings		
		Min DC voltage	Max DC voltage	Power consumption	Forward voltage	Forward current	Max pulse current @10% duty / 1kHz
		(V)	(V)	(W)	(V)	(mA)	(mA)
-R type	red, 630 nm	12	24	< 2	2,5	300	< 1800
-G type	green, 520 nm	12	24	< 2	3,5	350	< 1800
-B type	blue, 460 nm	12	24	< 2	3,5	350	< 1800
-W type	white	12	24	< 2	3,5	350	< 1800

TCBENCH series

TC optical bench kits for easy measurements
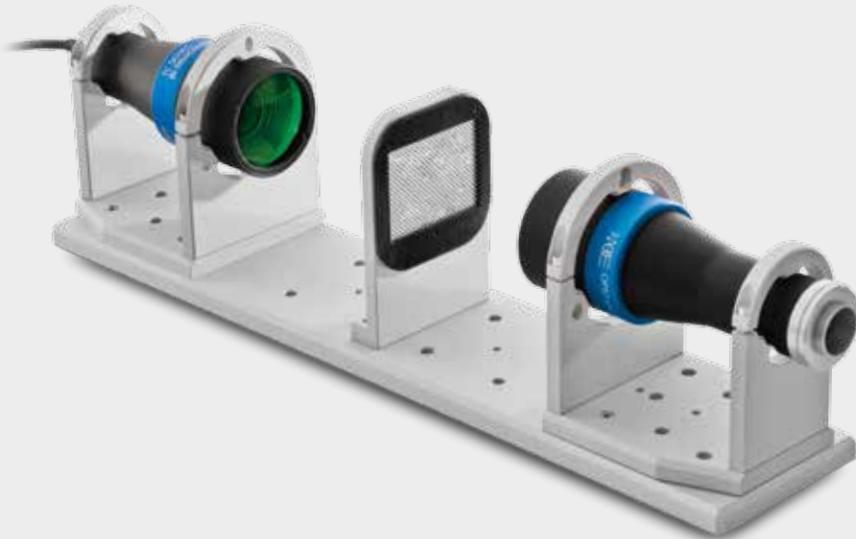
TCBENCH series are complete certified optical systems designed for hassle-free development of demanding measurement applications.

Each kit integrates:
- 1 bi-telecentric lens for 2/3" detectors
- 1 LTCL telecentric illuminator (green)
- 2 CMHO mechanical clamps
- 1 CMPT base-plate
- 1 PT chrome-on-glass calibration pattern
- 1 CMPH pattern holder

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

The collimating source is set in order to optimize both the illumination homogeneity and the relevant optical parameters (distortion, telecentricity, resolution).

Opto Engineering tests the optical performances of each TCBENCH and provides an individual test report certifying the measurement accuracy of the entire system.

Coupling a LTCL 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. TCBENCH also benefit from a special price policy, combining high-end performances with cost effectiveness.

KEY ADVANTAGES

Pre-assembled setup
Just attach your camera, and the bench is ready for measurement.

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

Certified system
The bench is quality tested as a whole system.

Convenient price
The bench costs less than the sum of the cost of the single components.

Part number	Mag.	Image circle	1/2" w x h 6.40 x 4.80	1/1.8" w x h 7.13 x 5.37	2/3" - 5 Mpx w x h 8.45 x 7.07	Optical Accuracy (µm) [1]	Optical Accuracy (%) [2]	Field Depth (mm)	CTF @70lp/mm (%)	Mount	Length (mm)	Width (mm)	Height (mm)	Weight (g)
	(x)	(mm)	(mm x mm)	(mm x mm)	(mm x mm)									
			Field of view (mm x mm)											
TCBENCH 009	1.000	11.0	6.40 x 4.80	7.13 x 5.37	8.44 x 7.06	< 5	< 0.06%	1.2	> 35	C	282.0	56.0	78.5	900
TCBENCH 016	0.528	11.0	12.1 x 9.09	13.5 x 10.2	16.0 x 13.4	< 8	< 0.05%	2.9	> 40	C	297.0	65.5	81.2	1200
TCBENCH 024	0.350	11.0	18.3 x 13.7	20.4 x 15.3	24.1 x 20.2	< 13	< 0.05%	7	> 55	C	391.0	65.5	78.5	1340
TCBENCH 036	0.243	11.0	26.3 x 19.7	29.3 x 22.1	34.7 x 29.0	< 22	< 0.06%	14	> 50	C	529.0	103.0	140.5	4150
TCBENCH 048	0.184	11.0	34.8 x 26.1	38.8 x 29.2	46.0 x 38.4	< 31	< 0.06%	24	> 50	C	636.0	117.0	147.5	5600
TCBENCH 056	0.157	11.0	40.7 x 30.6	45.4 x 34.2	53.8 x 45.0	< 36	< 0.06%	33	> 55	C	701.0	122.0	150.0	7300
TCBENCH 064	0.138	11.0	46.6 x 34.9	51.9 x 39.1	61.4 x 51.4	< 40	< 0.06%	43	> 65	C	845.0	143.0	160.5	8700
TCBENCH 080	0.110	11.0	58.0 x 43.5	64.6 x 48.7	76.5 x 64.0	< 55	< 0.07%	67	> 55	C	915.0	158.0	168.0	11100
TCBENCH 096	0.093	11.0	68.5 x 51.4	76.3 x 57.5	90.4 x 75.6	< 70	< 0.07%	94	> 50	C	1053.0	206.5	185.0	15300

Detector type — Optical specifications — Dimensions

[1,2] Maximum measurement error without software calibration; standard image correction libraries yield close to zero measurement error.

Contact us