Theia® TECHNOLOGIES

TL1250P-IQ N6 CS
4K Resolution Day/Night lens for 1/1.7” sensors

- ✓ Ultra high resolution for 4K cameras, up to 12.4 megapixel
- ✓ P-iris (stepper motor) for precise aperture control
- ✓ Fully motorized with zoom, focus, iris, IR cut, and limit switches
- ✓ Calibrated focus/zoom curve, focal length, iris, distortion and other data frames (see page 7)
- ✓ IR corrected for true Day/Night cameras
- ✓ Optional motor control board (MCR600 or MCR400) available for easy integration
- ✓ Compact design
- ✓ CS-mount
- ✓ Used for sensor sizes 1/2.5”, 1/2.3”, 1/2" 1/1.8”, and up to 1/1.7” (Sony IMX178, Sony IMX226 for example)

TL1250 lens specifications

Focal length (FL)	12-50mm
Mount type	CS-mount
Iris type	P-iris
Image circle	Ø9.4mm at FL 12mm
Resolution	12.4 megapixel
F/#	F/1.8 @ 12mm - F/2.4 @ 50mm to close
IR Correction	440nm – 950nm (Day/Night)
Focus Range	2.0m - infinity
Lens length (TTL)	64mm TTL
Back focal length (BFL)	8.2mm (in air)
Chief ray angle (CRA)	< 7°
Geometric distortion	< 10% at 12mm, < 2% at 50mm
Relative illumination	>40%
Lens transmission	>80%
Weight	74g
Operating temperature	-20C to 60C (<70% humidity, non-condensing)
Storage temperature	-30C to 70C (<90% humidity, non-condensing)

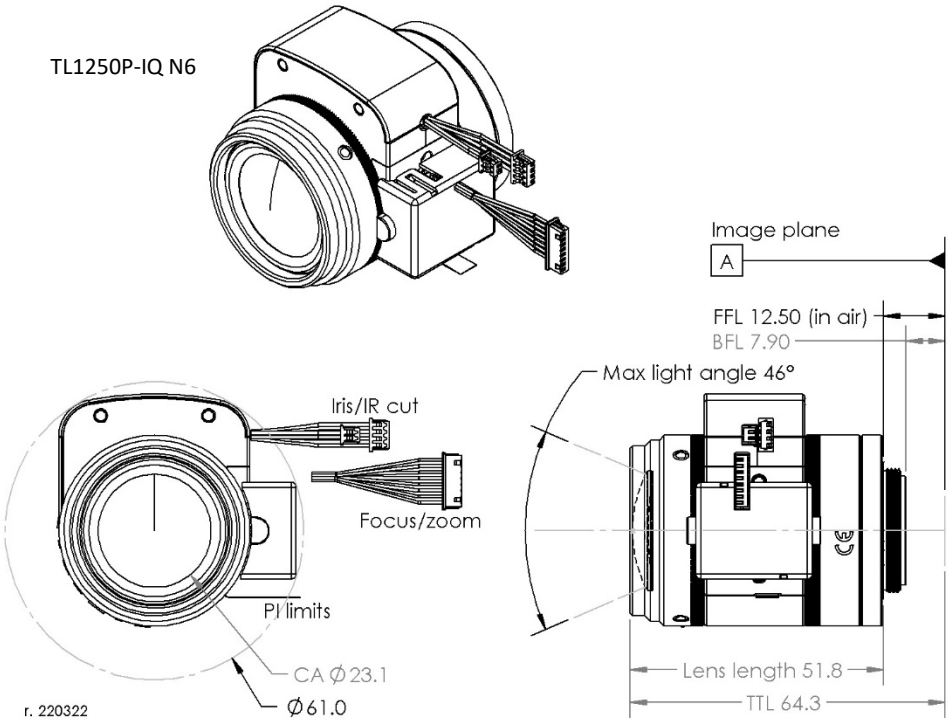
Field of view for sensor sizes (12mm – 50mm)

Sensor size	1/1.7”	1/1.8”	1/1.8” 4K*	1/2”	1/2.3”	1/2.5”
Horizontal	36° - 8.6°	36° - 8.6°	35° - 8.5°	30° - 7.4°	30° - 7.2°	27° - 6.7°
Vertical	26° - 6.5°	23° - 5.8°	17° - 4.3°	23° - 5.6°	22° - 5.5°	20° - 5.0°
Diagonal	46° - 11°	44° - 10°	40° - 9.5°	39° - 9.2°	38° - 9°	34° - 8.3°

*4K format = 4000 x 2000 pixels

Visit Theia’s website for more information about the lenses.

Lens drawing

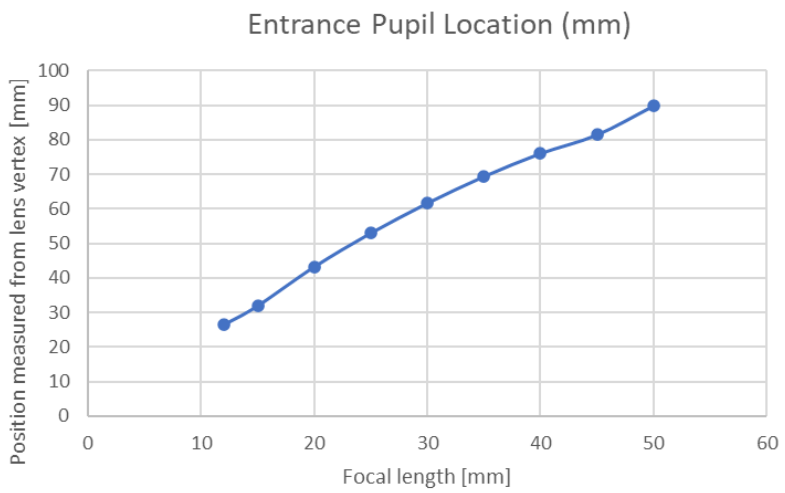


CAD models can be downloaded from TheiaTech.com/1250CAD

Entrance pupil location

The entrance pupil location is located inside the lens and for the longer focal length, even behind the image sensor position. It is measured from the vertex of the lens at the input side. The lens vertex is 0.5mm below the plastic front ring of the lens.

Focal Length	Entrance Pupil Location (mm)
12	26.35
15	31.88
20	43.18
25	52.97
30	61.65
35	69.40
40	76.08
45	81.49
50	89.85



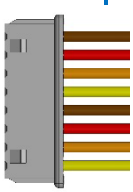
Zoom/Focus motor specifications

Drive	Stepper motor 2 phase bipolar drive
Operation voltage	3.3V (2.5-3.5V range)
Maximum motor temperature*	Do not let motor temperature exceed 120°C
Coil resistance	30.0Ω
Zoom number of steps	3227 steps between hard stops
Zoom speed range**	Up to 1200pps
Zoom cam rotation	75°
Focus number of steps	8390 steps between hard stops
Focus speed range**	Up to 1200pps
Focus cam rotation	195°
Focus/zoom connectors	Housing: Molex 51021-0800 Terminal: Molex 50058-8000
Cable length	150mm

Zoom: Wide -> Tele
Focus: Near -> ∞

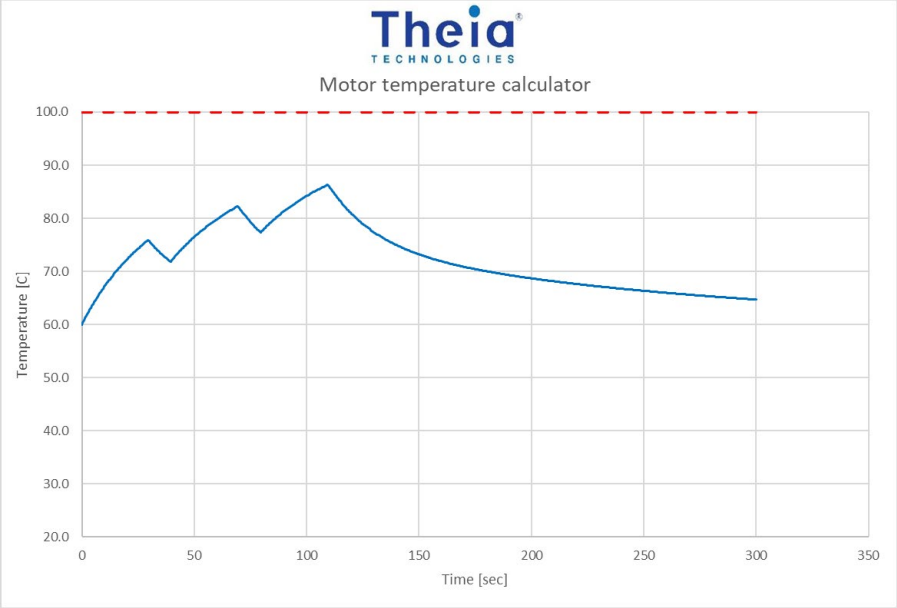
Step	A+	A-	B+	B-
0	H	L	H	L
1	L	H	H	L
2	L	H	L	H
3	H	L	L	H

Pin	Color	Function	Motor
1	Brown	A+	Focus
2	Red	A-	Focus
3	Orange	B+	Focus
4	Yellow	B-	Focus
5	Brown	A+	Zoom
6	Red	A-	Zoom
7	Orange	B+	Zoom
8	Yellow	B-	Zoom



*Theia's motor temperature calculator can be used to estimate the focus and zoom motor temperatures after a set number of run/ cool down cycles. This can be downloaded from Theia's website (see the QR code below). These motorized lenses are **not intended for continuous use** of the motors as in PTZ applications due to potential over-heating of the lens motors.

The example below shows 60C ambient temperature and 3.5V motor. The motor is driven for 30 seconds (which would generally be longer than normal) with 10 seconds cool down between moves. After 3 moves, the motor is allowed to cool down which takes about 3 minutes.



Motor temperature calculator
TheiaTech.com/calculators

**Zoom and focus motor positions may be affected by backlash and lost steps during movement. Lost steps are affected by the driving conditions. It is best to drive the motor between 200pps and 1200pps. Within these limits, the lost steps should be <5 steps per full zoom/focus range.

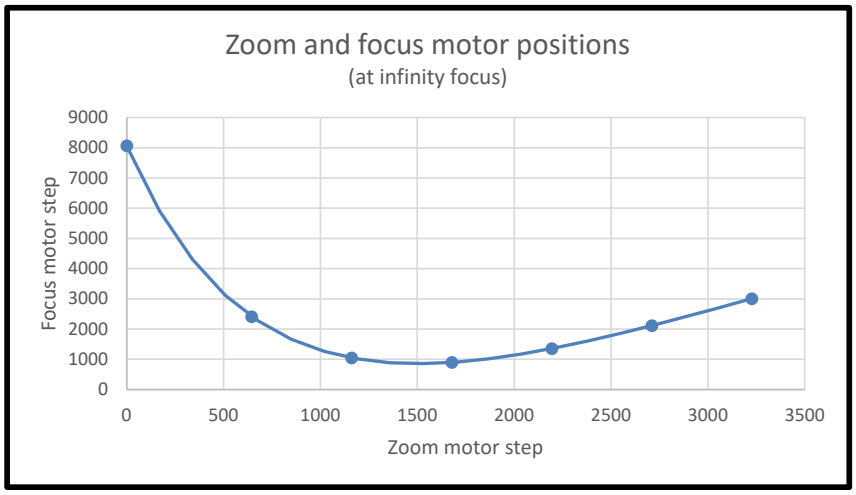
Backlash is variable from lens to lens but should be consistent for each movement of the lens motors. For zoom, expected backlash is approximately 15-20 steps and for focus it is approximately 30-40 steps.

Zoom/Focus motor key steps.

Zoom motor		*Focus motor*	
Note	*Step*	*Note*	*Step*
Hard stop (wide)	3227	Hard stop (far)	8390
Wide design position	3227		
PI position	3119	PI position	7959
Tele design position	0		
Hard stop (tele)	0	Hard stop (near)	0

Zoom/Focus synchronizing map (observe min/max motor speeds). Due to internal lens variations and back focal length variations in the camera the observed focus motor step will be different than the design position shown below. The motor positions should be calibrated at several zoom/focus positions so these calibrated values can be used to offset the design curve at the set focal lengths to find the corrected zoom/focus curve for the lens.

Focal length	***Zoom motor note***	***Zoom motor step number***	***Focus motor step number***
[mm]		*[#]*	*[#]*
12.36	Wide end	3227	3008
14.83		2710	2117
18.05		2194	1356
22.28		1678	895
27.86		1161	1046
35.20		645	2413
49.00	Tele end	0	8067



Notes:
These motorized lenses are intended for integration into cameras and require motor drivers and controllers. Typically, Theia works with the camera manufacturer to ensure that the camera motor controller matches the lens. It is possible to supply your own motor controller, but Theia cannot guarantee that your motor controller will not damage the lens. Theia does not offer any warranty on the suitability of these motorized lenses for any particular camera. Theia offers motor control boards that are suitable to control motorized lenses with P-iris.

P-iris motor specifications

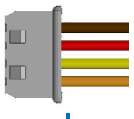
Drive	Stepper motor 2 phase bipolar drive
Operating voltage	4V (+/-1)
Number of steps	75 (open to closed)
Basic step angle	18°
Maximum response freq.	200pps
Coil resistance	30Ω

P-iris: open->close				
Step	A+	A-	B+	B-
0	H	L	H	L
1	L	H	H	L
2	L	H	L	H
3	H	L	L	H

Connector type 1 (Molex)

Connector type	Housing: Molex 51021-0400 Terminal: Molex 50058-8000
Cable length	150mm

Pin	Color	Function
1	Brown	B+
2	Red	B-
3	Yellow	A+
4	Orange	A-



P-iris motor map

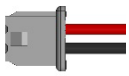
Step	Aperture Size [mm2]	F/# (at FL=12mm)
1	95.0	1.84
5	90.8	1.88
10	82.1	1.98
15	72.8	2.10
20	63.4	2.25
25	54.0	2.43
30	44.9	2.67
35	36.0	2.98

Step	Aperture Size [mm2]	F/# (at FL=12mm)
40	27.7	3.39
45	20.0	3.98
50	13.2	4.90
55	7.5	6.52
60	3.1	10.10
65	0.8	19.34
70	0.1	69.29
72	0.0	Closed
75	0.0	Closed

IR Cut/ selectable optical filter specifications

Electrical specifications	
Drive	DC
Operating voltage	4.0V
Drive coil resistance	130Ω
Connector type	Housing: Molex 51021-0200 Terminal: Molex 50058-8000
Cable length	150mm

Mode	Pin 1	Pin 2
Filter 1	L	H
Filter 2	H	L
Wire color	Red	Black

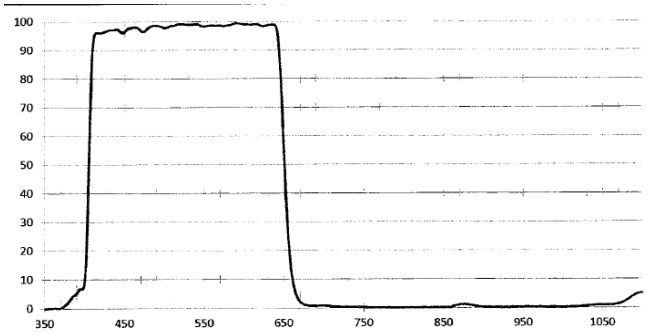


Filter optical specifications

The lens has 2 internal optical filters which can be selected electronically.

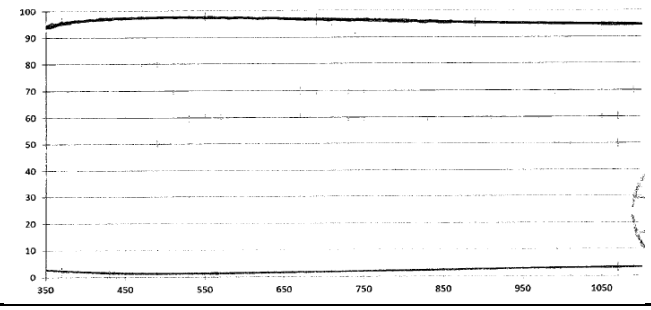
Visible bandpass filter

Type	Visible transmission notch filter
Spectrum	405 +/- 10nm: T = 50% 420 – 600nm: T >= 93% ave 650 +/- 10nm: T = 50% 700 – 1000nm: T < 5% max 1000 – 1100nm: T < 10% ave



Clear glass filter

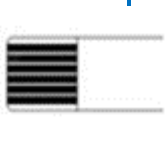
Type	AR coated clear glass
Spectrum	400 – 650nm: t >= 95% 650 – 1050nm: t >- 93.5%



Zoom/Focus limit switch

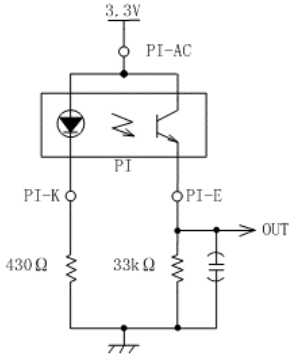
Type	Photo interrupter phototransistor
Part model	Sharp GP1S396HCPSF
Operating voltage	3.3V
Output level	>2.2V HIGH <0.6V LOW
Connector type	FPC cable
Board-side mating connector type (not supplied)	Molex 52746-0671 Molex 52745-0697 Molex 52559-0652
Cable length	150mm

Pin*	Function	Motor
1	Emitter	Focus
2	Anode/Collector	Focus
3	Cathode	Focus
4	Emitter	Zoom
5	Anode/Collector	Zoom
6	Cathode	Zoom



*cable side pin designation matches Molex 52746-0671 bottom side contacts connector

Recommended circuit for each photo interrupter



Calibration data frames

Theia offers a Python software module (available with lens purchase) to read, analyze, and convert calibrated lens data. The module will allow easy conversion to and from motor steps and engineering units. For example, engineering units include field of view, focal length, object distance, aperture, and other data frames (shown below) and are entered in meters, degrees, etc. This data allows image resolution optimization for fast and accurate machine vision applications and ease of setting the back focal length adjustment for each camera. Knowing the relationship between zoom motor position and focal length, and the best focus motor step position for each focal length can increase the speed of setting up and adjusting the image parameters. The data can also be used to enhance image processing (for image stitching, mapping, navigation) by correcting for distortion in the lens.

The calibration data is provided in a specially formatted and machine readable .json file that is maintained and updated based on the current manufacturing conditions of the lenses. A royalty free license is granted to the integrator to use the data file and software with the purchase of an IQ Lens. The latest data file can be downloaded from Theia's cloud storage.

In combination with this IQ Lens software, Theia offers a motor control board[1] and a TheiaMCR Python module that can take the output from the software above and control the lens motor positions. This set of software, lens, and control board makes it very easy and intuitive to integrate motorized lenses into your application.

Lens setting accuracy

The tolerance of the sensor position or mount position must also be calibrated for each camera (back focal length calibration adjustment). Lenses have very tight tolerances that affect how accurately they can be set up. The optimal focus position can be affected by small tolerances in the moving groups inside the lens, lost steps when moving motors into position, backlash in the motor gears, as well as the BFL position. For example, a tolerance of 0.1mm between the sensor active area and the lens mounting plane can result in a focus motor position error of >100 steps. This is greater than the typical range for best focus of ±30-50 steps (depending on focal length and F/#) so there could be a noticeable lack of focus if the initial BFL calibration is not done. **Even so, the focus motor position is very sensitive especially at the telephoto end of the lens. As a result, the calibrated focus/zoom curve will approximate the best focus position, but the user may need to perform a fine focus adjustment to find the optimal focus step position to meet the user's requirements.** The physical environment of the lens (temperature, humidity, vibration, etc.) may also affect the best focus range and should be evaluated for each application.

Available calibration data

These calibration data frames are provided in the data file. The calibration curves are monitored from lens lot to lot to verify the continued accuracy of the curves. When a Theia calibrated lens is purchased, the most recent data file is also provided (available from online download).

Data frame	Y axis	X axis
Focus/zoom tracking	Focus motor step	Zoom motor step
Focal length conversion	Zoom motor step	Focal length [mm]
Distortion	Object angle [deg]	Image height [mm]
Relative illumination	Illumination [%]	Image height [mm]
Aperture	Aperture [1/(2*F/#)]	Iris motor step
Iris diameter	Iris short diameter	Iris motor step

Calibrated lens back focal length (BFL) calibration procedure

The Back Focal Length (BFL) calibration procedure is described in application note AN004 (available from Theia's website[2]). The lens focus position must be set visually and compared to the calibrated focus motor step from the data file at several focal lengths. This difference between the best focus position and the calibrated focus position is due to the tolerances in the camera sensor and mount positions. A quadratic curve can be fit to these BFL calibration data points and should be applied to any calculated focus step position to set the estimated best focus position. Depending on the application, a fine focus adjustment may be required for optimal focus.

[1] Theia MCR IQ™ Motor Control Board: MCR IQ™ Motor Control Board

[2] Back focal length calibration procedure application note: AN004: Back Focal Length Procedure

Alternate lens options

There are other lens configurations. The options listed in the table below may or may not be available. Please visit www.theiatech.com to learn more about our other lens options.

Theia ® PN	Varifocal	Mount type	Mount slip ring	Iris type	*CCTV iris con.*	*Molex iris con.*	*IR corrected (day/night)*	*Visible bandpass filter*	*Clear filter (vis + IR)*	*850nm bandpass filter*	*940nm long pass filter*	Zoom motor	Focus motor	*PI limits*	*Focal length*	*MP rating*	*f/#*	*Image circle*	*Biggest sensor format*	*MOD [m]*	*Lens Length (to mount)*	*Lens Length (TTL)*	*Weight [g]*
TL1250P N6-25	✓	25		P		✓	✓	✓	✓			✓	✓	PI									76
TL1250P N5-CS	✓	cs	✓	P	✓		✓					✓	✓	PI									TBD
TL1250P-850V N6-CS	✓	cs	✓	P		✓	✓	✓		✓		✓	✓	PI									74
TL1250P-850C N6-CS	✓	cs	✓	P		✓	✓		✓	✓		✓	✓	PI									74
TL1250P-940V N6-CS	✓	cs	✓	P		✓	✓	✓			✓	✓	✓	PI									74
TL1250P-940C N6-CS	✓	cs	✓	P		✓	✓		✓		✓	✓	✓	PI									74
Related versions without motorized zoom and focus																							
SL1250M	✓	cs	✓	M			✓								12-50	12 (4K)	F/1.8	9.4	1/1.7"	2	52	64.5	65
SL1250P	✓	cs	✓	P	✓		✓																69
SL1250A	✓	cs	✓	A	✓		✓																70

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Revisions:

Version	Change	Reason
240208	Expanded TL1250 template spec to include calibration data	New calibrated lens available
240515	Calibration data frames	Adjusted wording in first paragraphs
	Drawing name	Added overlay to drawing with correct lens name
240813	Removed reference to motor acceleration	Not implemented in Theia's controllers
250826	Calibration data frames	Adjusted wording in first paragraphs