TL410P-IQ R6 CS / ML410P-IQ R6 C
4K Resolution Day/Night lenses
up to 1/1.7" sensors

- ✓ **Ultra-high resolution for 4K cameras**, up to 12.4 megapixel, 300lp/mm for 1.55μ pixels
- ✓ P-iris (stepper motor) for precise aperture control
- ✓ **Fully motorized** with zoom, focus, iris, optional IR filters and limit switches
- ✓ Calibrated focus/zoom curve, focal length, iris, distortion and other data sets (see p. 7)

- ✓ NIR corrected for **Day/Night** cameras & multi-spectral imaging
- ✓ Optional MCR IQ™ motor control board for easy integration (sold separately)
- ✓ **Compact and Lightweight Design**
- ✓ **CS mount (TL410), C mount (ML410)**
- ✓ For sensor sizes 1/2.3", 1/1.8" and **up to 1/1.7"** (e.g. Sony IMX178 & IMX226)

Lens specifications

Focal length (FL)	4-10mm
Mount type	CS-mount (TL410), C mount (ML410)
Iris type	P-iris
Image circle	Ø9.4mm at FL 4mm
Resolution	12.4 megapixel
F/#	F/1.4 @ 4mm – F/2.4 @ 10mm to close
Focus Range	0.5m to infinity
IR Correction	440nm – 950nm (Day/Night)
Lens length (TTL)	< 64mm TTL
Back focal length (BFL)	8.4mm (in air)
Chief ray angle (CRA)	< 7°
Geometric distortion	< 61% at 4mm, < 8% at 10mm
Relative illumination	>45%
Lens transmission	>80%
Weight	75g
Operating temperature	-20C to 60C (<70% humidity, non-condensing)
Storage temperature	-30C to 70C (<90% humidity, non-condensing)

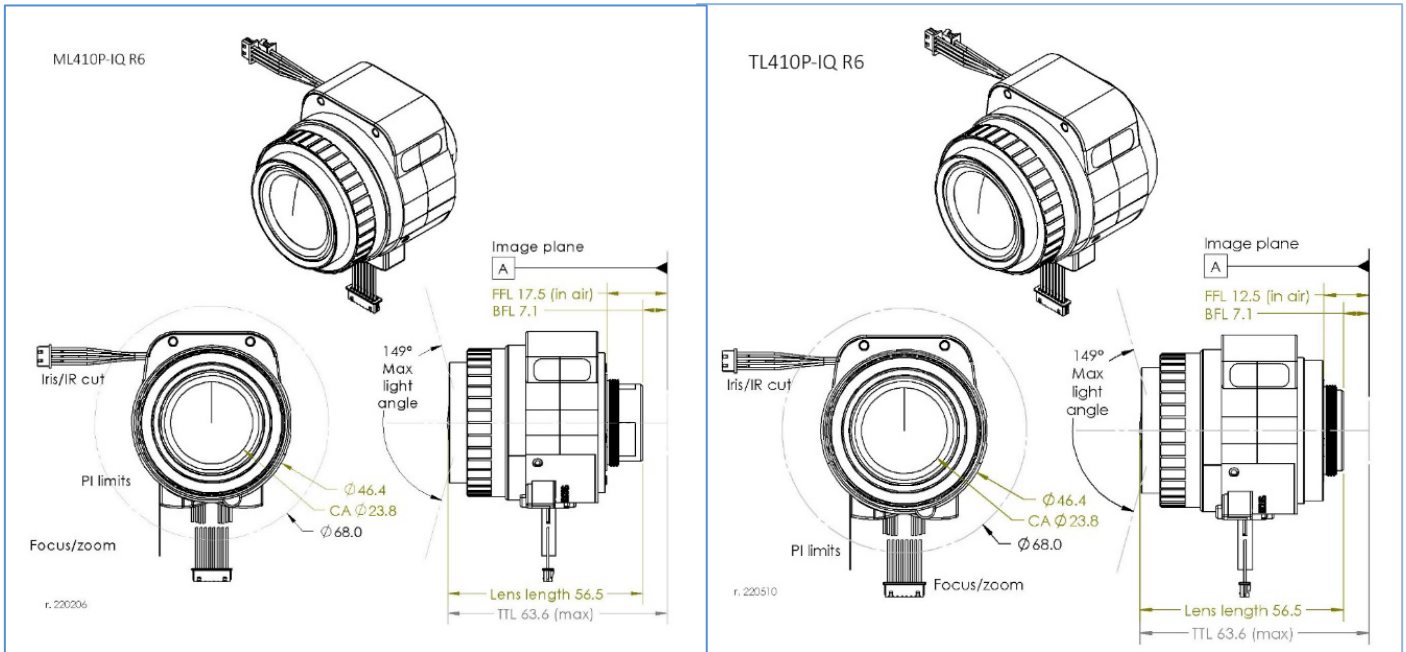## Field of view for sensor sizes

Sensor size	1/1.7"	1/1.8"	1/1.8" 4K*	1/2"	1/2.3"	1/2.5"
Horizontal	112° - 44°	110° - 43°	110° - 43°	93° - 37°	90° - 36°	83° - 33°
Vertical	81° - 33°	71° - 29°	52° - 21°	68° - 28°	67° - 27°	60° - 25°
Diagonal	149° - 55°	139° - 52°	126° - 48°	120° - 46°	117° - 45°	106° - 42°

*4K format = 4000 x 2000 pixels
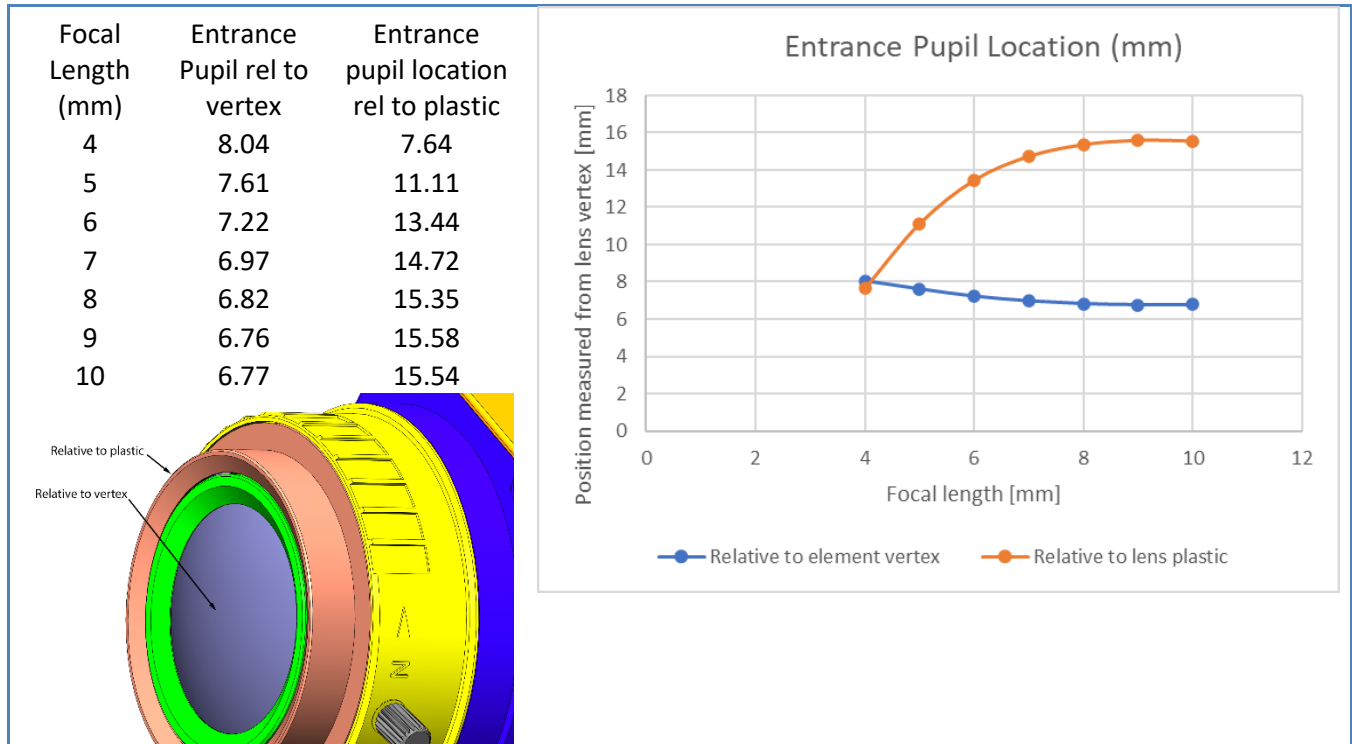
Visit Theia's website for more information about the lenses.

Lens drawings

ML410P-IQ R6

Image plane
A
FFL 17.5 (in air)
BFL 7.1
149° Max light angle
Iris/IR cut
PI limits
Focus/zoom
Ø 46.4
CA Ø 23.8
Ø 68.0
Lens length 56.5
TTL 63.6 (max)
r. 220206

TL410P-IQ R6

Image plane
A
FFL 12.5 (in air)
BFL 7.1
149° Max light angle
Iris/IR cut
PI limits
Focus/zoom
Ø 46.4
CA Ø 23.8
Ø 68.0
Lens length 56.5
TTL 63.6 (max)
r. 220510

CAD models can be downloaded from TheiaTech.com/410CAD

Entrance pupil location

The entrance pupil location is inside the lens. The first lens element vertex or the lens plastic can be used as a reference to find the location.

Focal Length (mm)	Entrance Pupil rel to vertex	Entrance pupil location rel to plastic
4	8.04	7.64
5	7.61	11.11
6	7.22	13.44
7	6.97	14.72
8	6.82	15.35
9	6.76	15.58
10	6.77	15.54

Relative to plastic
Relative to vertex

Entrance Pupil Location (mm)

Relative to element vertex — Relative to lens plastic

Theia
TECHNOLOGIES

Zoom/Focus motor specifications

| Drive	Stepper motor 2 phase bipolar drive
Operation voltage	3.3V (range 2.6~4.8V)
Maximum motor temperature*	Do not let motor temperature exceed 92°C
Coil resistance	28.5Ω (±7%)
Zoom number of steps	4073 steps between hard stops
Zoom speed range	600pps to 1000pps
Zoom cam rotation	85°
Focus number of steps	9354 steps between hard stops
Focus speed range	600pps to 1000pps
Focus cam rotation	196°
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	Yellow	B+	Focus
4	Gray/Orange	B-	Focus
5	Brown	A+	Zoom
6	Red	A-	Zoom
7	Gray/Orange	B+	Zoom
8	Yellow	B-	Zoom
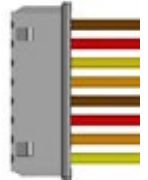
*Theia's motor temperature calculator can be used to estimate the focus and zoom motor temperatures after a set number of run/ cool down cycles. This can be downloaded from Theia's website (see the QR code below).

The example below shows 60C ambient temperature and 3.5V motor. The motor is driven for 10 seconds with 10 seconds cool down between moves. After 3 moves, the motor is allowed to cool down which takes about 4 minutes.

Measure temperature
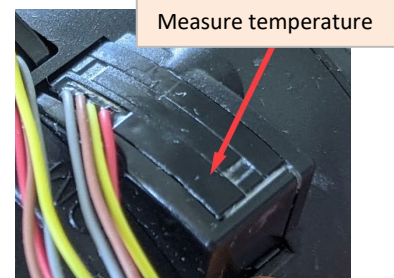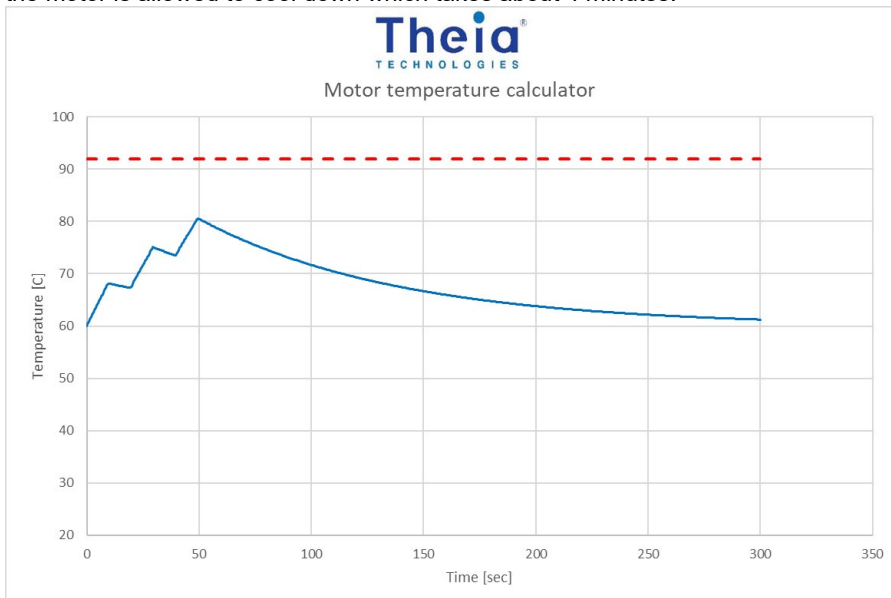
Motor temperature calculator
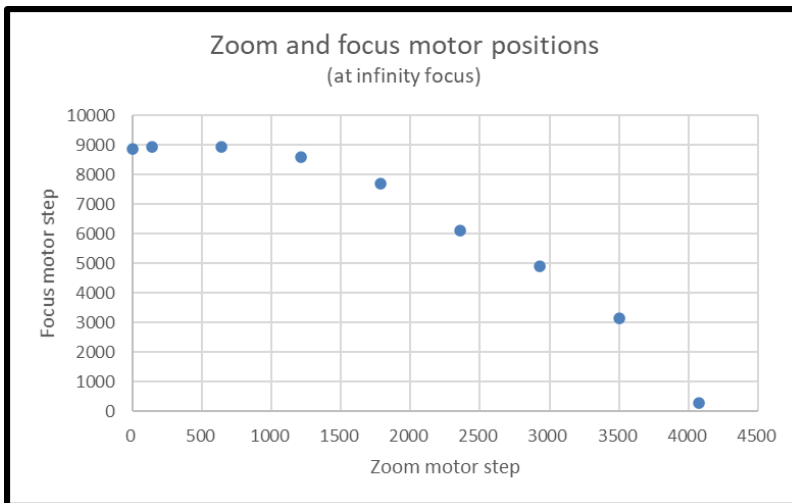TheiaTech.com/calculators

Motor temperature calculator

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 600pps and 1000pps. Within these limits, the lost steps are tested to be <40 steps per full zoom range and <30 steps per full focus range.

Theia
TECHNOLOGIES

Zoom/Focus motor step map (at infinite focus position). PI positions only available with -R5 and -R6 lenses.

Zoom motor		Focus motor	
Note	Step	Note	Step
Hard stop (wide)	4073	Hard stop (far)	9353
Wide design position	4073	PI position	8652
PI position	154		
Tele design position	0		
Hard stop (tele)	0	Hard stop (near)	0

Zoom/Focus synchronizing map (observe min/max motor speeds)

Focal length	Zoom motor note	Zoom motor step number	Focus ring note	Focus motor step number
[mm]		[#]		[#]
4.15	Wide end	4073		288
4.96		3501		3149
5.77		2929		4892
6.58		2356		6125
7.39		1784		7687
8.19		1212		8599
9.00		640		8960
9.70		139		8931
9.90	Tele end	0		8871

Zoom and focus motor positions
(at infinity focus)

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. These motorized lenses are **not intended for continuous use** of the motors as in PTZ applications. Theia offers motor control boards that are suitable to control motorized lenses with P-iris.

Theia
TECHNOLOGIES

P-iris motor specifications

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

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-
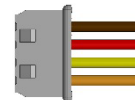
P-iris motor map

Step	Aperture Size [mm2]	F/#	Step	Aperture Size [mm2]	F/#
1	65.0	1.43 (open)	40	27.7	2.26
5	65.0	1.43 (open)	45	20.0	2.65
10	65.0	1.43 (open)	50	13.2	3.26
15	65.0	1.43 (open)	55	7.5	4.34
19	65.0	1.43 (open)	60	3.1	6.71
20	63.4	1.50	65	0.8	12.86
25	54.0	1.63	70	0.1	46.06
30	44.9	1.78	72	0.0	Closed
35	36.0	1.98	75	0.0	Closed

Theia
TECHNOLOGIES

IR Cut specifications

Electrical specifications	
Drive	DC
Operating voltage	4V
Drive coil resistance	130Ω
Connector type	Housing: Molex 51021-0200 Terminal: Molex 50058-8000
Cable length	150mm

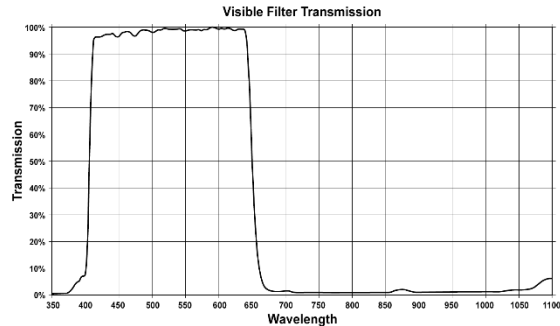| Mode	Pin 1	Pin 2
Day (IR filter)	L	H
Night (clear filter)	H	L
Wire color	Red	Black
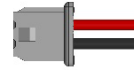
Filter optical specifications

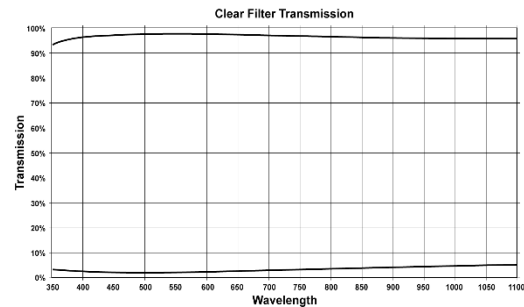The lens has 2 internal optical filters which can be selected electronically.

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

Theia
TECHNOLOGIES
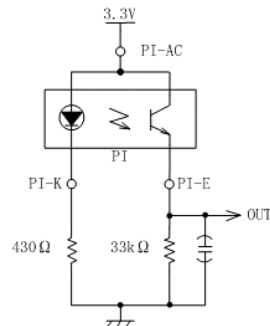
Calibration data frames

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 IQ 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	Iris motor step

*Average measured data
^Design data

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.

Theia
TECHNOLOGIES

Alternate lens options

There are other options for motor configurations, iris types, and mount types. Please visit www.theiatech.com to learn more about our other lens options and to download the data sheets for other lenses.

Theia ® PN	Varifocal	LOT® technology	Mount type	Mount slip ring	Iris type	CCTV iris con.	Molex iris con.	IR corrected (day/night)	IR cut switch	Zoom motor	Focus motor	PI limits	Calibration Data Frames	Focal length	MP rating	f/#	Image circle	Biggest sensor format	MOD [m]	Lens Length (to mount)	Lens Length (TTL)	Weight [g]
TL410A R6 CS	✓		cs	✓	A		✓	✓	✓	✓	✓	PI										78
TL410A R5 CS	✓		cs	✓	A	✓			✓	✓	✓	PI										80
TL410A R4 CS	✓		cs	✓	A		✓	✓	✓	✓	✓											77
TL410P R6 CS	✓		cs	✓	P		✓	✓	✓	✓	✓	PI										75
TL410P R6 25	✓		25		P		✓	✓	✓	✓	✓	PI		4-10	12 (4K)	f/1.4	9.4	1/1.7"	0.5	52	64	78
TL410P R5 CS	✓		cs	✓	P	✓			✓	✓	✓	PI										77
TL410P R4 CS	✓		cs	✓	P		✓	✓	✓	✓	✓											74
TL410P R3 CS	✓		cs	✓	P	✓			✓	✓	✓											76
ML410P R6 C	✓		c	✓	P		✓	✓	✓	✓	✓	PI										TBD
Related versions without motorized zoom and focus																						
SL410M	✓		cs	✓	M				✓													72
SL410P	✓		cs	✓	P	✓			✓					4-10	12 (4K)	f/1.4	9.4	1/1.7"	0.5	52	64	75
SL410A	✓		cs	✓	A	✓			✓													78
ML410M	✓		c	✓	M				✓											47	64	67

Revisions

Version	Change	Reason
250219	Created TL410P-IQ spec version	Adding Calibrated data frame features
250226	Added ML410P-IQ information	Consolidating spec information for two lenses
	Updated drawings	

info@TheiaTech.com
www.TheiaTech.com
+1-503-570-3296

Theia
TECHNOLOGIES