Machine vision

Always in focus
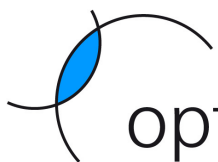
optotune Focus **tunable** lenses

Technology

Bobbin with voice coil

Membrane
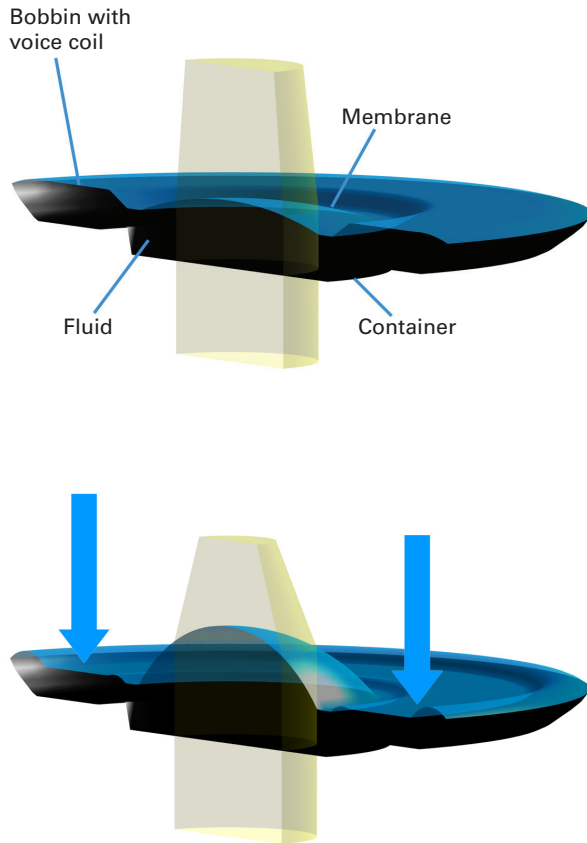
Fluid

Container

Optical Technology

Optotune's core technology is based on the principle of a shape-changing lens. It consists of a container, which is filled with an optical fluid and sealed off with an elastic polymer membrane. An electromagnetic actuator is used to exert pressure on the container, which leads to a deflection of the lens. As a result, the focal length of the lens is controlled by the current flowing through the coil of the actuator. The relationship between current and optical power is linear, which is easy to manage and calculate.

- Clear apeture: 3 mm, 10 mm and 16 mm for machine vision
- Long lifetime: More than one billion cycles
- Abbe number >100: Good for poly-chromatic applications
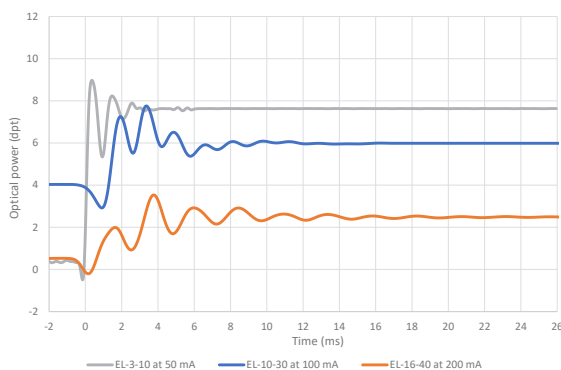
Response within milliseconds

Optotune's lenses respond within milliseconds and settle after 4 to 25 ms, depending on the size of the lens. The oscillations due to excitation of resonant frequencies can be suppressed by using low-pass filtered drive signals.

Large working distance
Front lens configuration

Vision systems of 8 mm to 50 mm focal length can be equipped with a tunable lens in the front, typically mounted on the filter thread. In this configuration, it is possible to focus from infinity (tunable lens at 0 diopters) down to about 100 mm (tunable lens at 10 diopters) or less if spacers are added. Especially compact systems can be realized in combination with M12 board lenses, whereas the tunable lens can be mounted directly on the C-mount camera.
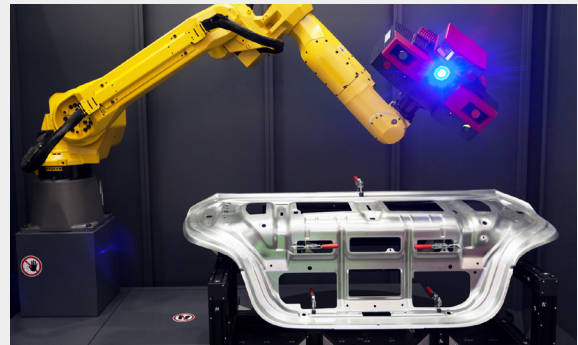
Applications

> Barcode reading
> Package sorting
> Robot vision
> Bottle inspection

Components

Camera	C-mount camera (up to 1.1")
Fixed Focal lens	Focal length 8 to 50 mm
Optotune Tunable lens	EL16-40-TC-VIS-5D-M25.5 EL16-40-TC-VIS-5D-M27 EL16-40-TC-VIS-5D-M30.5
Lens driver	Optotune lens driver 4i
Cable	CAB-6-100

Performance

		Fixed lens focused at 500 mm		
Tunable lens diopter	(dpt)	3	0	-2
Working distance	(mm)	200	500	
Horizontal FOV*	(mm)	118	287	Infinity
Vertical FOV*	(mm)	96	233	

* 2/3" sensor (8.47 mm x 7.09 mm)

2/3" C-mount camera

Fixed focal lens
(Focal length 16 mm)

EL-16-40-TC-VIS-5D-M27

Small working distance
Back lens configuration

Placing the lens between camera and C-mount lens acts like adding a spacer. This makes sense for lenses with focal lengths of 35 mm or more and offers very nice macro possibilities. While this configuration usually provides less optical leverage (smaller WD ranges) than the front lens configuration it can offer better resolution and reproducibility of the focus plane. When applying this back lens configuration to M42 mount lenses, image circles of up to 30 mm are achievable.
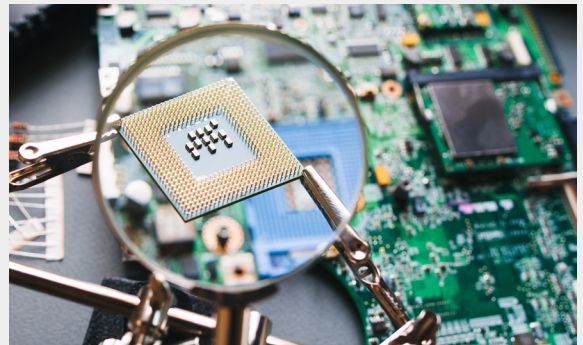
Applications

> Electronics inspection
> Contact lens inspection
> Diamond inspection

Components

Camera	C-mount/M42 camera (up to 30 mm diagonal)
Fixed Focal lens	Focal length > 35 mm
Optotune Tunable lens	EL-16-40-TC-VIS-5D-C EL-16-40-TC-VIS-5D-M42
Lens driver	Optotune lens driver 4i
Cable	CAB-6-100

Performance

		Fixed lens focused at infinity		
Tunable lens diopter	(dpt)	3	0	-2
Working distance	(mm)	166	185	209
Horizontal FOV	(mm)	37.2	39.0	41.1
Vertical FOV	(mm)	29.5	31.0	32.5

* 1" sensor (12.4 mm x 9.8 mm)

1" C-mount camera

EL-16-40-TC-VIS-5D-C

Fixed focal lens
(Focal length 50 mm)

Compact and Large FOV
Front lens configuration with S-mount lens

Thanks to the compact design of S-mount lenses and short distance to the tunable lens, this configuration allows for particularly large fields of view. The nominal WD is set by the distance from S-mount lenses to camera, and the Z-range is tuned by the assist of tunable lenses. This configuration is more cost-effective and it can be applied to situations where the size is particularly important.

Applications

> Package sorting
> Robot vision

Components

Camera	C-mount camera
Fixed Focal lens	S-mount lens with focal length >6 mm
Optotune Tunable lens	EL-16-40-TC-VIS-5D-C
Lens driver	Optotune lens driver 4i
Cable	CAB-6-100

1/2.5" C-mount camera

S- to C-mount adapter
7.2 mm S-mount lens (inside)

EL-16-40-TC-VIS-5D-C

Performance

|		7.2 mm lens focused at 500 mm		
Tunable lens diopter	(dpt)	3	0	-2
Working distance	(mm)	200	500	
Horizontal FOV*	(mm)	169	411	Infinity
Vertical FOV*	(mm)	125	305	

* 1/2.5" sensor (5.76 mm x 4.29 mm)
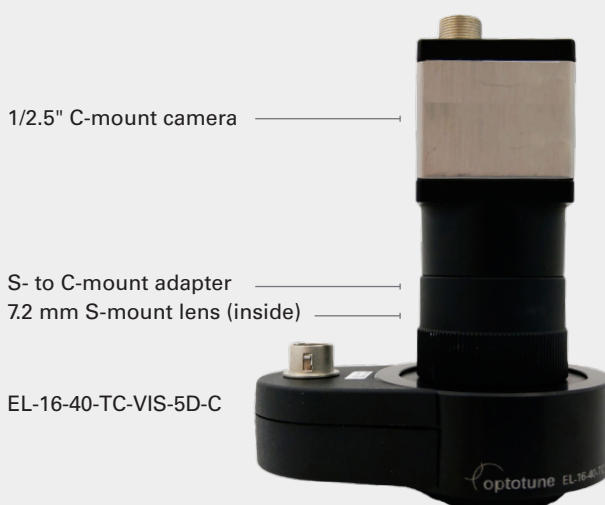
Telecentric

EL at the pupil position with telecentric lens

Great results are also achieved when the tunable lens is integrated into telecentric lenses. The best position for the integration is right behind the aperture stop, which optimizes for large z-ranges and small magnification changes. For example, a z-range of 20 mm is achievable at 1X and 10 mm is achievable at 2X magnification, whereas the magnification change over that entire range is in the order of 5%. As both the working distance and magnification change linearly with optical power of the tunable lens a simple two point calibration can be performed to use the system for accurate measurements.
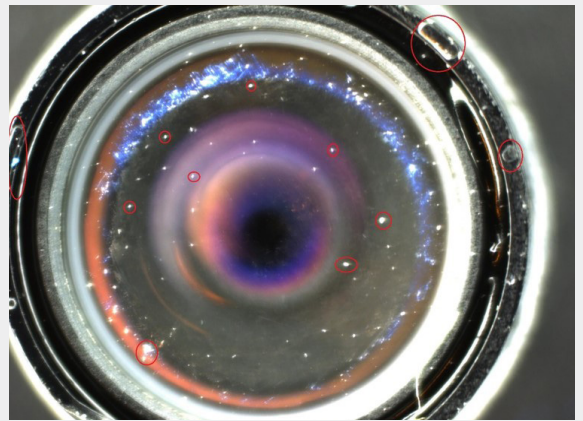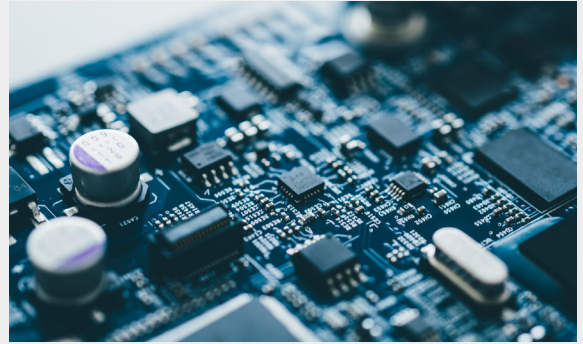
Applications

> PCB inspection
> LCD inspection
> Camera inspection
> Phone lens inspection

Components

Camera	up to 1″
Telecentric lens (Mag.)*	From 0.13 to 10.0
Optotune Tunable lens	EL-16-40-TC-VIS-5D-C
Lens driver	Optotune lens driver 4i
Cable	CAB-6-100

Performance

1X Telecentric lens		1" Sensor		2/3" Sensor	
Tunable lens diopter	(dpt)	3	-2	3	-2
Magnification	(mm)	0.9	1	0.9	1
Working distance	(mm)	107.3	121.7	107.3	121.7
Horiz. FOV	(mm)	13.8	12.4	9.3	8.4
Vertical FOV	(mm)	10.9	9.8	7.9	7.1

1" C-mount camera

EL-16-40-TC-VIS-5D-C

1X telecentric lens

* A wide selection of models is offered with our partners. The magnifications currently available are as follows: 0.13, 0.15, 0.19, 0.19, 0.24, 0.29, 0.31, 0.34, 0.37, 0.37, 0.50, 0.58, 0.66, 0.75, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 10.0.

Machine vision configuration table

Sensor format & camera		Imaging lens focal length (mm)								
		6	8	12	16	25	35	50	75	100
1/4"	S-mount	30° HFOV	23°	15°	11°	7°	5°	4°	2.5°	2°
	C-mount									
1/3"	S-mount	44°	33°	23°	17°	11°	8°	6°	4°	3°
	C-mount						Front or back lens configuration			
1/2"	S-mount	56°	44°	30°	23°	15°	10°	7°	5°	4°
	C-mount									
2/3"	S-mount	73°	58°	40°	31°	20°	14°	10°	7°	5°
	C-mount									
1"	S-mount	74°	77°	56° **	44°	29° **	21° *	15°	10° *	7°
	C-mount									
30 mm diag.	M42-mount	128°	114°	91°	75°	52°	39°	28°	19°	14°
		Front lens configuration only				Back lens configuration only				

|			
🟥 Not possible	🟧 Possible with custom optics design	🟨 Vignetting with off-the-shelf lens	🟩 Possible with off-the-shelf lens

* Customized designs available ** Customized designs in progress

Ask the experts!

We're happy to recommend an optimal configuration for your application. Please let us know the following requirements:

> Desired sensor size & resolution
> Field of view on object in X & Y (in mm)
> Working distance range to focus over (object height, in mm)
> Constraints in minimum or maximum WD (if relevant)
> F# (if relevant)
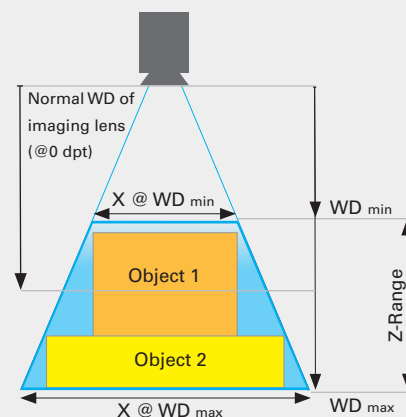
Configure and calculate your setup online: http://configurator.optotune.com

Products

Overview of tunable lenses

Standarded product and series		Cleat apeture (mm)	Tuning range (dpt)	Reproducibility (dpt)	Response time (ms)*	Offset lens (mm)	Temp. sensor	Cover coating (nm) **	Control current with Driver 4(mA)	Wavefront error (λ RMS)	Top thread	Bottom thread
EL-3-10	EL-3-10-VIS-26D-FPC	3	-13 to 13	Temp. dependant	1/2/4		-	420 to 900	-120 to +120	<0.2/<0.2	None	None
	EL-3-10-NIR-26D-FPC	3	-13 to 13	Temp. dependant	2.5/6/15		-	850 to 1600	-120 to +120	<0.2/<0.2	None	None
EL-10-30	EL-10-30-TC-VIS-12D	10	+8 to +20	+/- 0.1	2.5/6/15	-	•	400 to 700	0 to +250	<0.25/<0.6	None	None
	EL-10-30-TC-NIR-12D	10	+8 to +20	+/- 0.1	2.5/6/15	-	•	700 to 1100	0 to +250	<0.25/<0.6	None	None
	EL-10-30-C-VIS-LD	10	+5 to +10	+/- 0.1	2.5/6/15	-	•	400 to 700	0 to +250	<0.15/<0.25	C-mount male	C-mount female
	EL-10-30-C-NIR-LD	10	+5 to +10	+/- 0.1	2.5/6/15	-	•	700 to 1100	0 to +250	<0.15/<0.25	C-mount male	C-mount female
	EL-10-30-C-VIS-LD-MV	10	-1.5 to +3.5	+/- 0.1	2.5/6/15	-150	•	400 to 700	0 to +250	<0.15/<0.25	C-mount male	C-mount female
	EL-10-30-C-NIR-LD-MV	10	-1.5 to +3.5	+/- 0.1	2.5/6/15	-150	•	700 to 1100	0 to +250	<0.15/<0.25	C-mount male	C-mount female
	EL-10-30-Ci-VIS-LD	10	+5 to +10	+/- 0.1	2.5/6/15	-	•	400 to 700	0 to +250	<0.15/<0.25	C-mount male	C-mount female
	EL-10-30-Ci-NIR-LD	10	+5 to +10	+/- 0.1	2.5/6/15	-	•	700 to 1100	0 to +250	<0.15/<0.25	C-mount male	C-mount female
	EL-10-30-Ci-VIS-LD-MV	10	-1.5 to +3.5	+/- 0.1	2.5/6/15	-150	•	400 to 700	0 to +250	<0.15/<0.25	C-mount male	C-mount female
EL-16-40	EL-16-40-TC-VIS-5D	16	–2 to +3	+/- 0.05	5/12/25		•	400 to 700	-250 to +250	0.25/0.5	None	None
	EL-16-40-TC-VIS-20D	16	–10 to +10	+/- 0.1	5/12/25		•	400 to 700	-250 to +250	<0.5/<0.25	None	None
	EL-16-40-TC-VIS-5D-M25.5	16	–2 to +3	+/- 0.05	5/12/25		•	400 to 700	-250 to +250	0.25/0.5	M25.5×0.5 male	M40.5×0.5 female
	EL-16-40-TC-VIS-5D-M26	16	–2 to +3	+/- 0.05	5/12/25		•	400 to 700	-250 to +250	0.25/0.5	M26×0.706 male	M26×0.706 female
	EL-16-40-TC-VIS-5D-M27	16	–2 to +3	+/- 0.05	5/12/25		•	400 to 700	-250 to +250	0.25/0.5	M27×0.5 male	M40.5×0.5 female
	EL-16-40-TC-VIS-5D-M30.5	16	–2 to +3	+/- 0.05	5/12/25		•	400 to 700	-250 to +250	0.25/0.5	M30.5×0.5 male	M40.5×0.5 female
	EL-16-40-TC-VIS-5D-C	16	–2 to +3	+/- 0.05	5/12/25		•	400 to 700	-250 to +250	0.25/0.5	C-mount male	C-mount female
	EL-16-40-TC-VIS-5D-M42	16	–2 to +3	+/- 0.05	5/12/25		•	400 to 700	-250 to +250	0.25/0.5	M42×1 male	M42×1 female
	EL-16-40-TC-VIS-20D-C	16	–10 to +10	+/- 0.1	5/12/25		•	400 to 700	-250 to +250	<0.5/<0.25	C-mount male	C-mount female

* 10-90% of step / settling time of a controlled step / settling time of rectangular step
** All EL-16-40 models are also available with NIR coated cover glasses (850-1500 nm)

Overview of Lens Drivers

Optotune's electrical lenses are basically current controlled. While it is possible to drive such lenses with a variety of current sources, Optotune's Lens Drivers provide some important additional functionalities. By reading out integrated memory and sensors over an I2C connection, they allow for operation in the so-called "focal power mode", which allows for thermal compensation resulting in best reproducibility. Optotune's electrical lenses can also be driven by the Gardasoft TR-CL180 industrial and CL191 embedded drivers.

	Lens Driver 4 (EL-E-4)	Optotune Driver 4i (EL-E-4i)	Gardasoft TR-CL180	Gardasoft CL191
Dimensions (L x W x H)	77 x 19 x 13 mm	99.05 x 19 x 13.5 mm	120 x 101 x 35 mm	50 x 20 x. 3.7 mm
Lens compatibility	EL-3-10 EL-10-30-TC EL-16-40-TC	EL-10-30 EL-16-40	EL-10-30 EL-16-40	EL-3-10 EL-10-30 EL-16-40
Operation mode	1. Current mode 2. Focal power mode 3. Analog input		1. Focal power mode 2. Analog input 3. Several waveforms available	
Interface to lens	0.5 mm pitch FPC connector	6-pin Hirose connector	6-pin Hirose connector	0.5 mm pitch FPC connector (Hirose* Optional)
Maximum output current	-290 to 290 mA		-400 mA to 400 mA	-250 to +250 mA
Interface to PC	USB Type A		Ethernet, RS232, Front Panel	I2C, UART, USB, RS232, Ethernet
Analog input	0-5 V (applies to current mode only, not focal power mode)		0-10 V	0-10 V
User SDK	C#		Triniti SDK, applications written in C#, C++, VB	None
Operating temperature	-20 to +65 °C		5 to 50 °C	

Tell us about your application. We are happy to support your product development from concept to series. Email us at sales@optotune.com