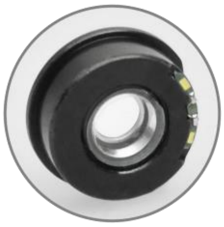
Fast Electrically Tunable Lens EL-3-10



The compact EL-3-10 lens was designed for OEM integration into optical systems for various applications. The working principle is based on the well-established shape-changing lens technology. The curvature of the lens is adjusted by applying an electrical current. Thereby, the focal length is tuned to a desired value within very few milliseconds. The lens architecture is "push pull" which means that the lens curvature is deflected from concave to convex. With actuators based on proven voice-coil technology, the EL-3-10 focus tunable lens is extremely reliable and robust, well suited even for applications in harsh environments over large temperature ranges.

Option	EL-3-10-NOC	EL-3-10-VIS	EL-3-10-NIR
Cover glass coatings	No coating	VIS[1]	NIR[2]

Mechanical specifications

Clear aperture	3.1	mm	
Outer diameter	10	mm	11mm on flange
Height	4 +0/-0.2	mm	
Weight	1.25	g	
Lifecycles (10-90% sinusoidal)	>1'000'000'000	CL	

Electrical specifications

Control current (typical)	-120 to +120	mA	
Operating voltage	-1…1	V	
Coil resistance at 30°C	~10	Ohm	
Power consumption	0 to 120	mW	
Settling time	<2	ms	Low pass filtered

Optical specifications

Optical specifications	EL-3-10-XXX-26D	
Focal tuning range (@20°C)	-77 to +77	mm
Focal power range (@20°C)	-35 to +35	dpt
Wavelength range	420 to 1600	nm
Wavefront error @525nm (vertical/horizontal)	<0.15/<0.15	λRMS
Refractive index n_D (589.3nm)	1.300	
Abbe number V_d	100	
Optical damage threshold	>3	W/cm^2
Operating temperature	-20 to +65	°C
Storage temperature	-50 to +85	°C

Overview of standard products

Standard products	Tuning range[2]	Refractive index	Cover glass coating	Wavefront error[3]
EL-3-10-NOC-26D	-13 to +13 dpt	1.30	No coating	<0.15/<0.15 λ
EL-3-10-VIS-26D	-13 to +13 dpt	1.30	420 – 900 nm	<0.15/<0.15 λ
EL-3-10-NIR-26D	-13 to +13 dpt	1.30	850 – 1600 nm	<0.15/<0.15 λ

[1] 420-900 nm T>94%
[2] 850-1600 nm T>94%
[3] Wavefront error in RMS l @525 nm, 0 mA current with optical axis vertical / horizontal

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Mechanical drawing

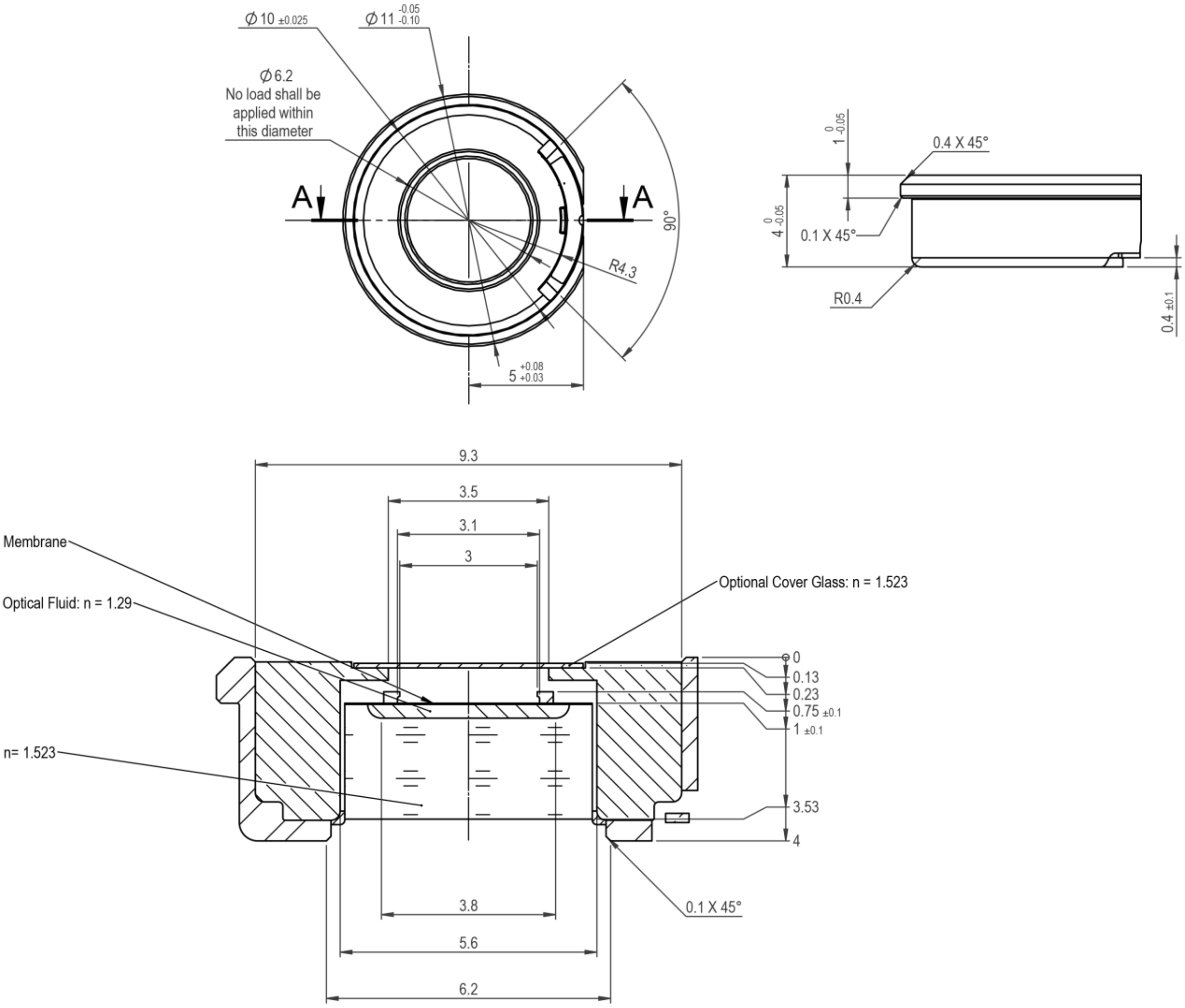

Figure 1: Mechanical drawing of the EL-3-10 lens

Mounting

To mount the lens, it is clamped on the flange. The orientation is defined by the D-cut. For the NOC (no coating) version of the lens, on the bottom aperture, no cover glass is mounted. Hence the membrane is exposed to the environment. Therefore the lens needs to be integrated in a clean environment (e.g. clean room) and designed into an optical system so that the bottom interface is protected against dust. The VIS and NIR version have a cover glass integrated with the corresponding coating to protect the lens membrane.

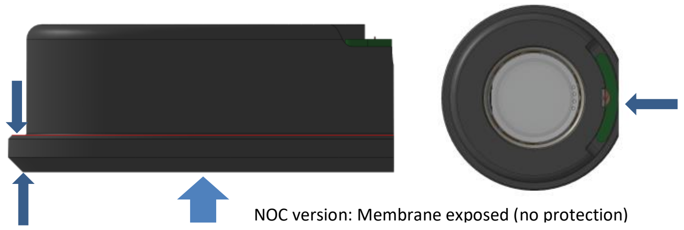

Figure 2: EL-3-10 mounting

Electrical connection

On the two PCB solder pads, wires can be connected. Alternatively, spring loaded pins can be used for the contact on the PCB solder pads (for example TE 1551631-5).

Figure 3: Soldering pads with spring loaded pins

For initial prototyping, the EL-3-10 is available with a flex cable, compatible with Optotune's lens driver 4, as shown in Figure 4.

Figure 4: EL-3-10 with flex cable

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Working principle

The working principle of the EL-3-10 is based on Optotune's well-established technology of shape-changing polymer lenses. The core that forms the lens contains an optical fluid, which is sealed off with an elastic polymer membrane as shown in Figure 5. An electromagnetic actuator is used to exert pressure on the container and therefore changes the curvature of the lens. By changing the electrical current flowing through the coil of the actuator, the optical power of the lens is controlled.

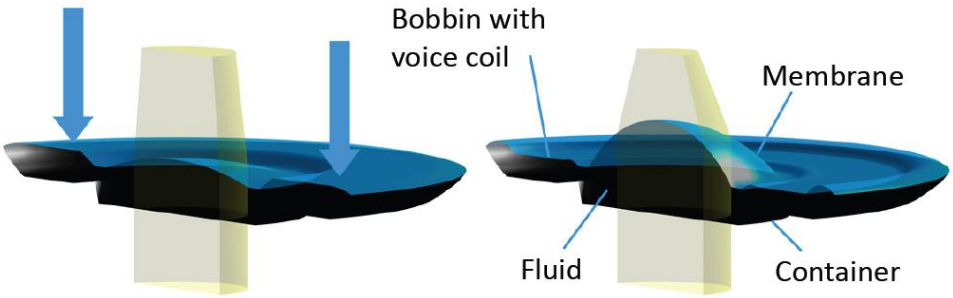

Figure 5: Scheme of the sealed lens container filled with an optical fluid and embedded in an EL-3-10 housing

Optical power versus current

The optical power of the EL-3-10 increases with positive current and decreases with negative current as shown in Figure 6. The achievable optical power range is from +13 to -13 diopters for a control current from +120 to -120 mA.

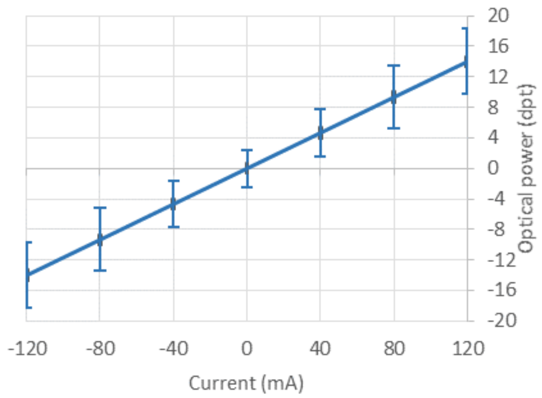

Figure 6: EL-3-10 current vs optical power graph

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Response time

The rise time when applying a current step is <1 ms and it takes only about 4 ms until the lens has fully settled. The graphs of the step response measurements below show the optical response of the EL-3-10 lens. Low pass filtering of the drive signal to the lens allows to damp the oscillations seen in the step response graphs below and as a result drive a controlled 80% step in <2ms.

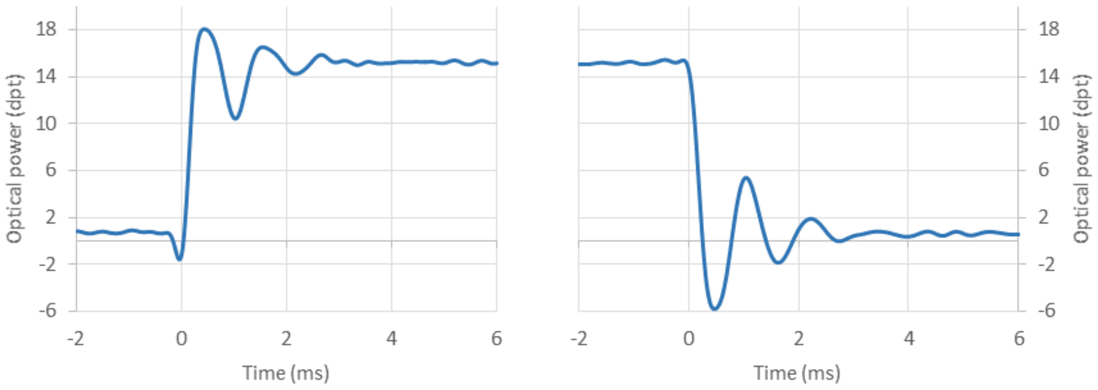

Figure 7: 80% step response of the EL-3-10 lens

Temperature effects

Residual temperature effects influence the long term drift of optical power. These temperature effects are quantified by the temperature sensitivity, giving the change in optical power per degree Celsius. Depending on the optical power, the temperature sensitivity of the EL-3-10 increases or decreases according to the graph in Figure 8. For repeatable optical power driving across the whole temperature and optical power range, additional active temperature compensation is necessary. As illustrated in Figure 8, the temperature sensitivity decreases with increasing optical power. Hence, it is recommended to work in the positive optical power range, where temperature sensitivity is lowest.

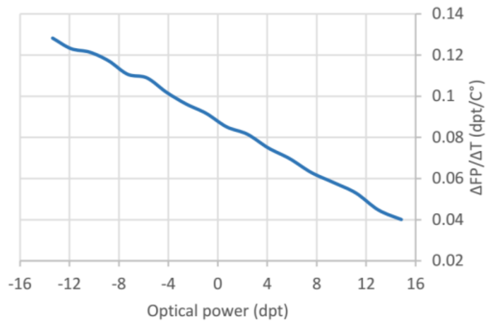

Figure 8: EL-3-10 temperature sensitivity across the optical power range

Optical layout

Zemax simulations to model the EL-3-10 lens within an optical design are available upon request.

Safety and compliance

The product fulfills the RoHS and REACH compliance standards. The customer is solely responsible to comply with all relevant safety regulations for integration and operation.

For more information on optical, mechanical and electrical parameters, please contact sales@optotune.com.

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