Introduction

## Modelling of Optotune's tunable lenses in Zemax

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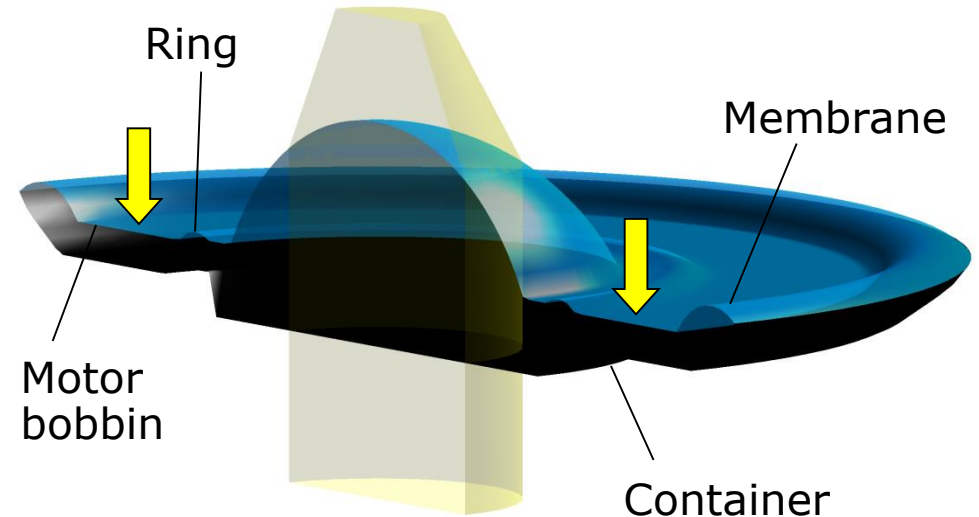Mark Ventura, VP Marketing and Sales

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Actuation principle of Optotune's electrically tunable lenses

Ring

Membrane

Motor
bobbin
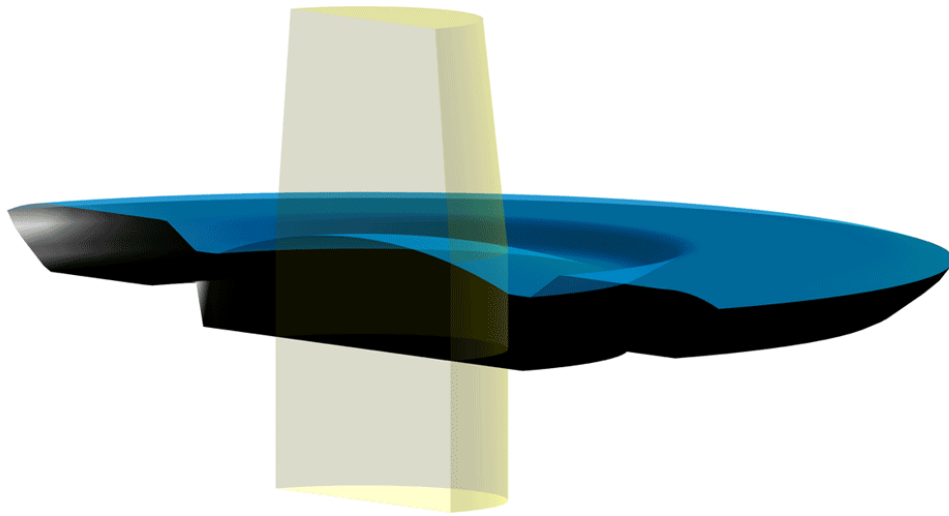
Container

- The electrically tunable lenses from Optotune are shape-changing lenses. The core of the lens consists of a container, which is filled with an optical fluid and sealed off with an elastic polymer membrane.

- An electromagnetic actuator is integrated in the lens which controls a ring that exerts pressure on the container and squeezes more liquid into the lens volume. This leads to a bulging of the membrane.

- Therefore, the focal length of the lens can be controlled by the current flowing through the coil of the actuator.

Videos are available on www.optotune.com

Note: Animation for illustration purpose only. Proportions and degrees of deflection can vary.

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Example of Zemax modelling
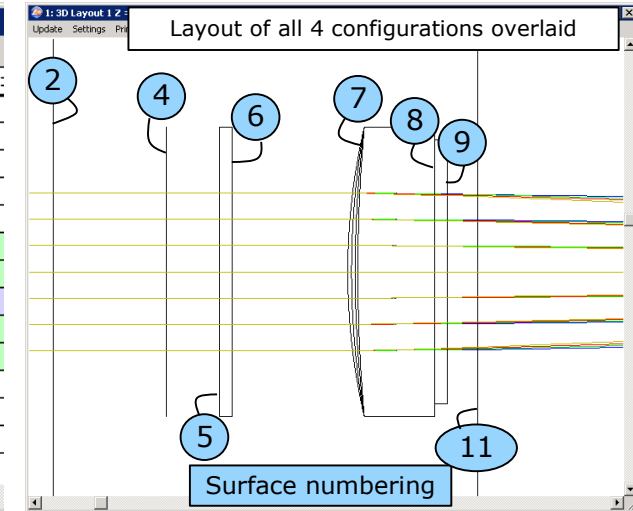
Glass model of optical liquid (included in Optotune's .AGF glass catalog)

Layout of all 4 configurations overlaid

Surface numbering

Adaptive (tunable) surface

Non-optical surfaces are modelled if they indicate dimensions or FOV-relevant apertures of the lens

The multi-configuration editor allows toggling between the different focus states (curvatures of the adaptive surface) of the lens. The configurations correspond to different actuation currents.

Layout of all 4 configurations separated

Edge thickness solves are used for modelling the fact, that Optotune lenses have a moving vertex and a fixed lens edge defined by the so called lens shaper

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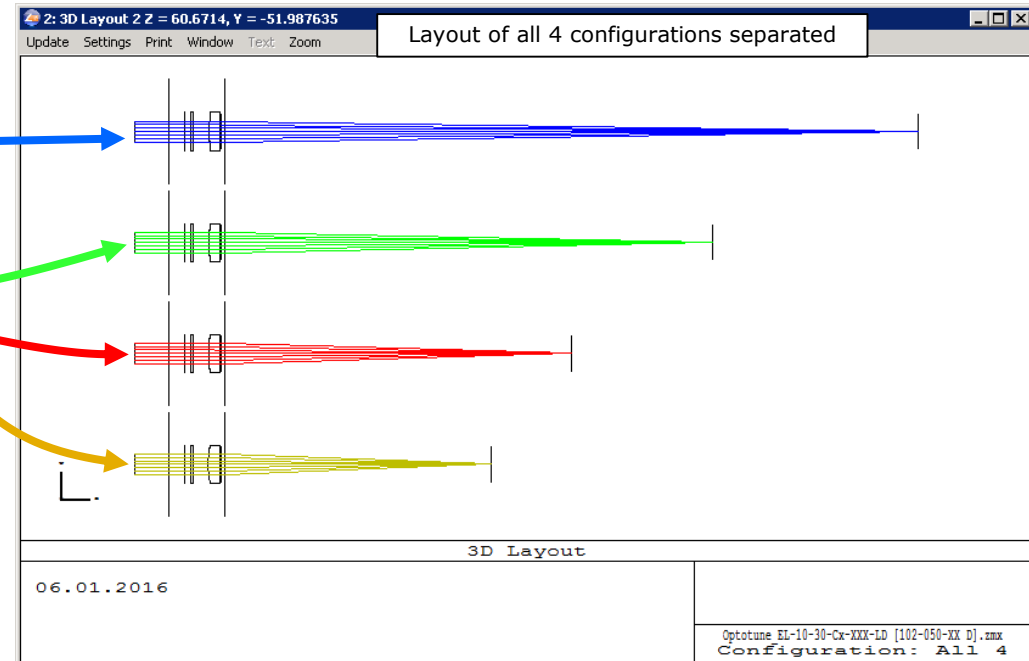
Datasheet values and Zemax model

Layout

Mechanical layout

Optical layout

Housing

Housing
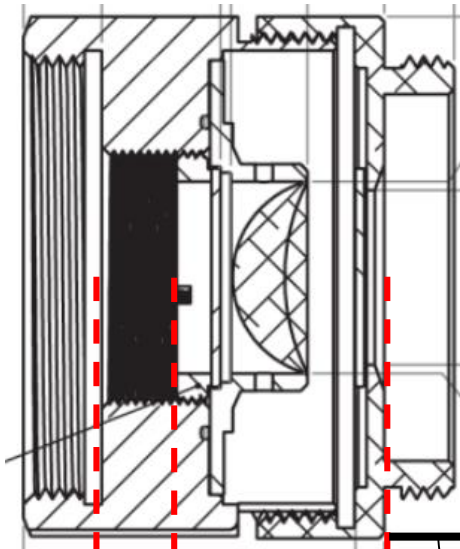
Note: Tuning range in data sheet is specified as back flange focal length/power (BFFL/BFFP) and measured from here

Note: Non-optical surfaces are modelled in Zemax if they indicate the outer dimensions or field-of-view-relevant apertures of the lens.

Note: The surfaces named 'Housing' in the Zemax Lens Data Editor define the boundary surfaces from where on you can modify the Optotune model in order to embed the Optotune lens in your system.
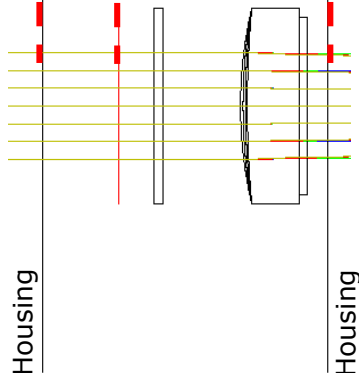
Focus states

Tuning range from datasheet

Overview of available standard products

Standard products	Tuning range[2]	Refractive index	Cover glass coating	RMS wave-front error[3]	Integrated offset lens	Tempera-ture sensor
EL-10-30-VIS-LD	+8.3 to +19.9 dpt	1.30	400 – 700 nm	<0.50 λ	No	No
EL-10-30-NIR-LD	+8.3 to +19.9 dpt	1.30	700 – 1100 nm	<0.50 λ	No	No
EL-10-30-VIS-HR	+16.5 to 44.5 dpt	1.56	400 – 700 nm	<0.50 λ	No	No
EL-10-30-C-VIS-LD	+5 to +10 dpt	1.30	400 – 700 nm	<0.25 λ	No	Yes
EL-10-30-C-NIR-LD	+5 to +10 dpt	1.30	700 – 1100 nm	<0.25 λ	No	Yes

Membrane curvatures in Zemax Multi-Configuration Editor

Multi-Configuration Editor

Edit Solves Tools View Help

Active : 4/4	Config 1	Config 2	Config 3	Config 4*
1: MOFF 0	No current	Any current	Max EL-E-4	Abs. Max
2: CRVT 7	0.0163	0.0230	0.0320	0.0410

Back flange focal length as indicated in Zemax

Infinity	0.5000	BI
Infinity	1.1500	
Infinity	0.0000	
Infinity	200.0000	M
Infinity	–	

Infinity	0.5000	BI
Infinity	1.1500	
Infinity	0.0000	
Infinity	100.0000	M
Infinity	–	

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Relation between current, curvature & optical power

Example for two lens types

	EL-10-30-Ci-VIS-LD			EL-16-40-TC-VIS-5D					Unit	Relation
	No current	Max EL-E-4	Abs. Max	Abs. Min	Min EL-E-4	No current	Max EL-E-4	Abs. Max		
Current	0	250	400	-500	-250	0	250	500	mA	
Curvature	0.017	0.033	0.043	-0.015	-0.007	0.002	0.010	0.018	1/mm	1/r
Radius	60.0	30.0	23.1	-66.7	-150.0	600.0	100.0	54.5	mm	f*(n-1), 1/c
Focal length	200	100	77	-222	-500	2'000	333	182	mm	r/(n-1), 1/OP
Optical power	5.0	10.0	13.0	-4.5	-2.0	0.5	3.0	5.5	Dpt	1/f

Note:

- EL-10-30-Ci-VIS-LD-MV achieves -1.5 to +3.5 Dpt by adding a -150mm (-6.67 Dpt) offset lens to the EL-10-30-Ci-VIS-LD

Troubleshooting: Optical material is missing in Zemax

- The required glass catalog is called "OPTOTUNE_LENSMAT_[CUSTOMER02].AGF"

- Check Zemax preferences for correct file location

Optotune's glass catalog has to be copied into this folder
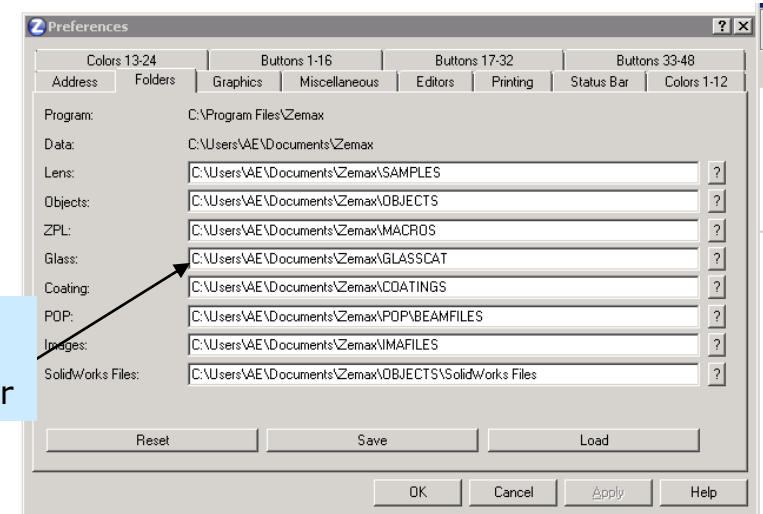
- Check in Zemax -> General that Optotune's catalog is listed

- Note the empty space between the different catalogs

Optotune's glass catalog has to be listed as glass catalog
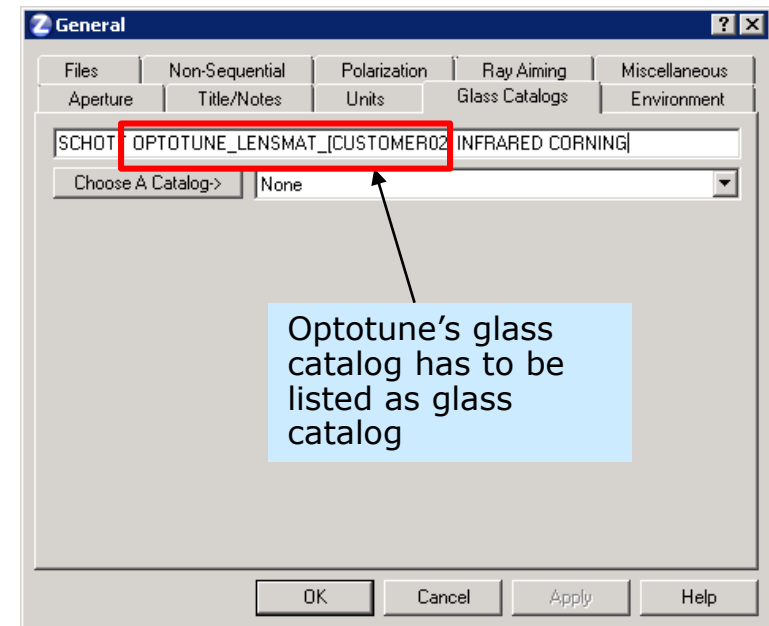
Troubleshooting: Optical material is missing in Zemax

- As an example, the OL1024_UV_VIS_NIR material is listed correctly (red box)

- All glass materials are listed in the glass catalog

- The glass catalog can be opened with a standard text editor

- You can double check directly in the file if the required glass exists (e.g. OL1042_UV_VIS_NIR)

OL1042_UV_VIS_NIR, among others, is listed as a glass

Troubleshooting: Optical material is missing in Zemax

- When using older Zemax versions, the encoding can be important

- Check in Zemax preferences what encoding is used

Change encoding from Unicode to ANSI can help

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