Zemax® "User-Defined Surface" DLL for simulation of Piezo-electric Deformable Mirrors (PDM) manufactured by Flexible Optical B.V.

User's Guide

October 31, 2016

1 Introduction

Through user-defined surfaces (UDS) Zemax provides powerful mechanism for simulating of optical elements which are not covered by built-in surface types [2]. UDS is a software module (more specifically DLL, dynamic link library) which internally can simulate any phenomena (reflection, refraction, absorption, diffraction etc.) occurring at the surface of interest.

This particular UDS is designed to simulate piezo-electric deformable mirrors manufactured by Flexible Optical B.V. We provide this UDS to facilitate design by customers of their systems utilizing our deformable mirrors. Thus it is possible to evaluate parameters of a particular model of deformable mirror and assess it applicability to some particular application and setup. Also it makes easier to choose between several available mirror models. It is also possible to test some custom actuator configurations by generating some new configuration files.

The shape of a circular plate under a distributed load can be described by an analytical functions. In the case of a piezo-electric deformable mirror, the distributed load is a set of forces applied by the piezo-electric actuators to the mirror plate. The end user can control the voltages applied to actuators. For a given set of control voltages, a system of linear equations has to be solved in order to find the actuator forces and, subsequently, the shape of the mirror plate.

2 System requirements

Only 64-bit versions of Zemax on Windows platform are currently supported. This software is tested to work with Zemax 13 release 2, but should function properly with any recent version of the software. It exports `UserDefinedSurface4` function and would not work with some [very old] legacy versions of Zemax which expect only `UserDefinedSurface`, `UserDefinedSurface2` or `UserDefinedSurface3`. Please refer to corresponing section of Zemax manual and to thier support for details. The requirements for personal computer hardware and operation system are implied by Zemax software itself, but most resonably modern systems running Windows 7 or newer will work.

3 Files and installation

The library is compatible with both "classic" Zemax and "modern" Zemax OpticsStudio. Since those packages maintain their files in separate directory trees, it is necessary to choose correct directory during installation. If it is desired to use both programs, it is required to either copy the files manually, or run the installer twice, separately for each package.

The main DLL file is named `oko_pdm.dll` and it should be placed into appropriate directory for user defined surfaces within Zemax program tree (default is `c:\Program Files\Zemax\DLL\Surfaces\`). Zemax does not allow to load UDS files from any other place. The DLL requires separate configuration files for each mirror model. The configuration files are named accordingly to the model, have `.txt` extention (for example `pdm_19_30_L0.txt`), and have to be placed into the directory
`My Documents\Zemax\Miscellaneous\oko_pdm\`. The summary of the files incuded is given in Table 1.

The software is supplied in the form of single-file executable installer which copies files automatically (Fig 1). It is also possible to manually extract files with an archiving utility (such as 7-zip) and copy them into desired place. This method might be useful for some non-standard or network installations. Please note that coping files into subfoldres of `Program files` directory normally requires administrator

Table 1: Files included in the distribution

`oko_pdm.dll`	Main executable dll file, required
`PDM_19_30_LO.txt`	Configuration file for PDM 30mm, 19 channels, optimized for low order aberrations correction ([1], section 7.9)
`PDM_19_30_normal.txt`	Configuration file for PDM 30mm, 19 channels ([1], section 7.9)
`PDM_37_30_20mmaperture.txt`	Configuration file for PDM 20mm, 37 channels ([1], section 7.10)
`PDM_37_30_normal.txt`	Configuration file for PDM 30mm, 37 channels ([1], section 7.10)
`PDM_37_50_LO.txt`	Configuration file for PDM 50mm, 37 channels, optimized for low order aberrations correction ([1], section 7.11)
`PDM_37_50_normal`	Configuration file for PDM 50mm, 37 channels ([1], section 7.11)
`PDM_69_50_normal.txt`	Configuration file for PDM 50mm, 69 channels ([1], section 7.11)
`PDM_79_50_normal.txt`	Configuration file for PDM 50mm, 79 channels ([1], section 7.11)
`pdm37_test_sph.zmx`, `pdm37_test_sph.ses`	Example model and session file demonstrating use of a deformable mirror for compensation of spherical aberration caused by a simple plane-convex lens.
`pdm_mf_limit.zpl`	Zemax macro for inserting merit function operators limiting range of control signals to desired values
`us_oko_pdm.pdf`	This User's Guide

access rights, so (depending on the system settings) it might be required to invoke the installer "as administrator".

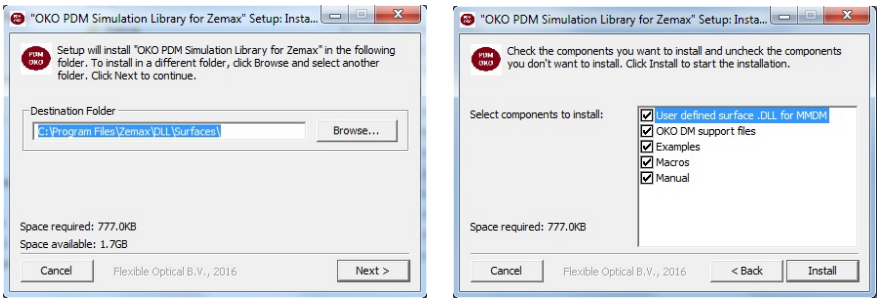

Figure 1: Installation dialog

4 Using the UDS with your model

After adding a new surface into your model, please perform the following steps.

1. In the lens parameter table double-clik with the left mouse button on the surface type field to invoke surface type dialog. In the field "Surface type" select "User-defined" and in the field "File name" choose "`oko_pdm.dll`". Click "OK" to confirm (Fig 2).

2. In the field "Comment" of the corresponding surface enter the name of the deformable mirror model (it should correspond to the filename without extension) (Fig 3). After typing the file name in the comment field, press "enter". At this moment, the dll reads configuration file and makes prerequisite calculations to define the PDM model in the computer memory. The extra data editor fields are allocated according to the number of mirror actuators.

3. Set Semi-diameter of the surface to correct value (depends on the model of the mirror).

4. Now you can use "Extra data editor" to set control values and variable status (if required) for all control channels (Fig 4). Those parameters represent normalized values and can take values from -1 to 1. If the value outside this range is entered, it is clamped internally, but that change is not reflected in Zemax editor, since there is no technical possibility to pass parameter in from DLL to the main application. Please note that Zemax OpticsStudio has slightly different (supposedly more

"user-friendly") interface compared to original Zemax. It lacks "Extra data editor" and uses lens editor to edit extra parameters. The user needs to scroll right in the window to get access to those columns.

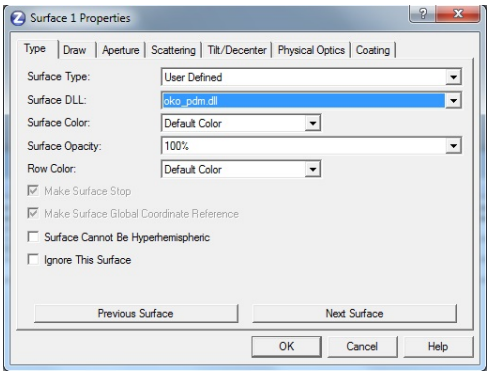

Figure 2: Settings in "Surface type" dialog

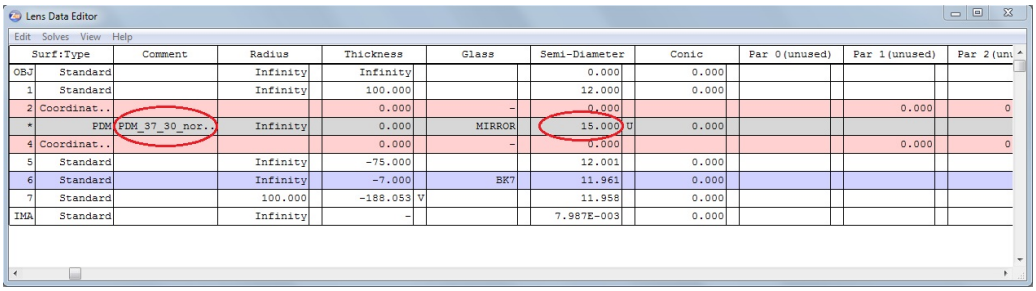

Figure 3: Selecting of DM model

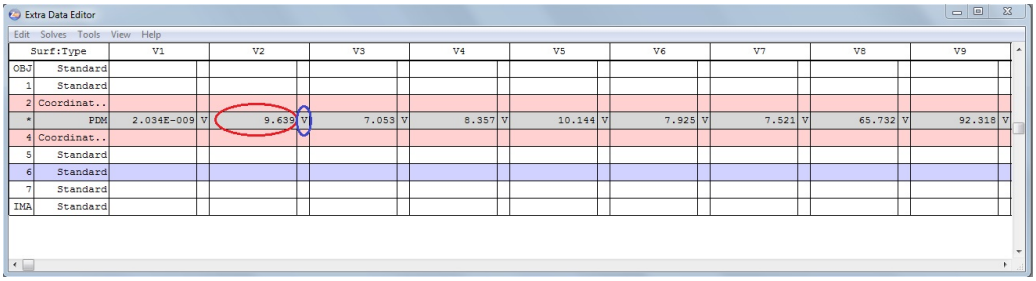

Figure 4: Setting DM control values in "Extra data editor"

5 Usage example

The example Zemax file supplied along with the package demonstrates how to use `oko_pdm.dll` user defined surface in optical design. In this example, parallel beam is reflected by the mirror and focused with a thick plane-convex lens. One can see appreciable amount of the spherical aberration (Fig. 5). After optimization (all deformable mirror control values are taken as variables), focusing quality is drastically imroved and has reached the diffractioin limit (Fig. 6).

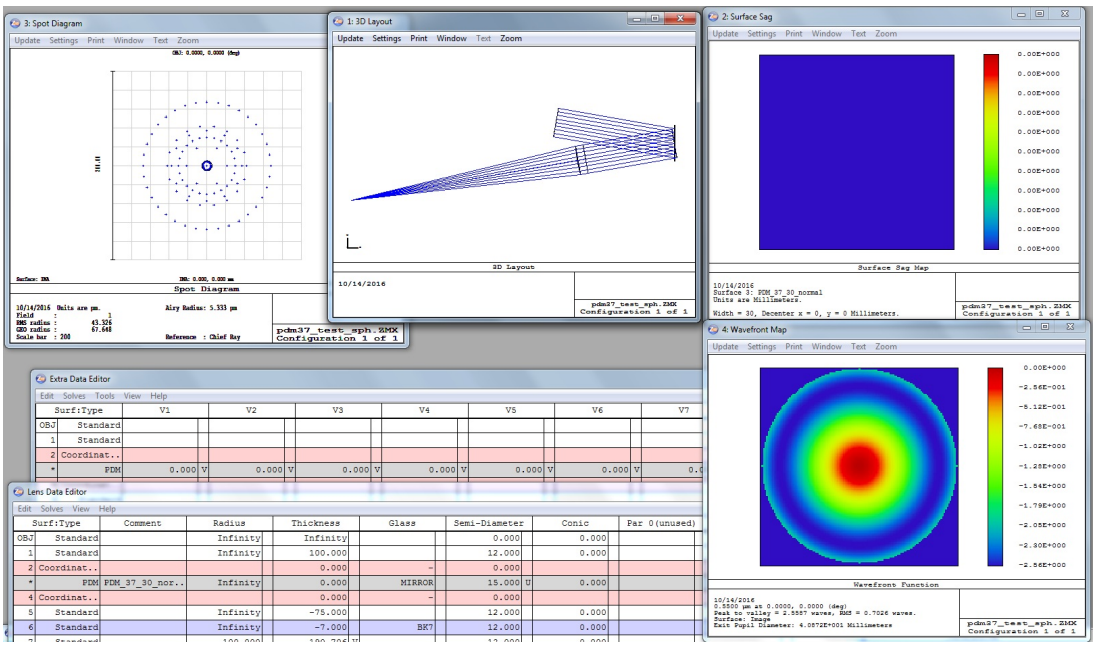

Figure 5: Example pdm37_test_sph. Initial state, appreciable amount of spheric aberration is clearly visible.

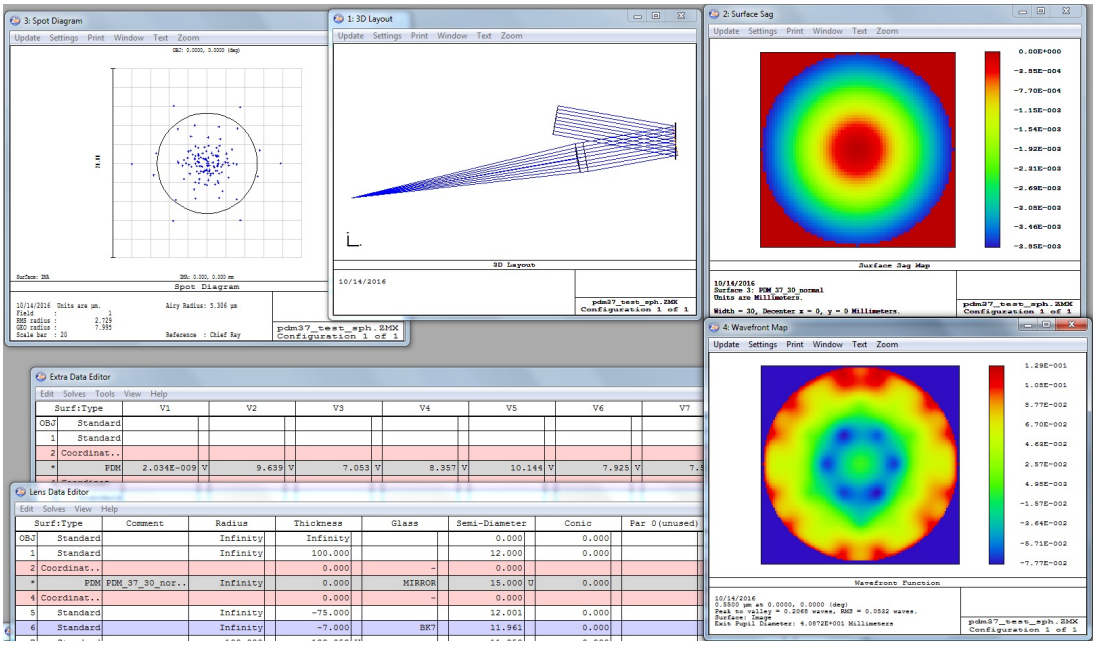

Figure 6: Example pdm37_test_sph. Deformable mirror control channeles were set as variables. After optimization the spot diagram and wavefront map indicate that almost difraction quality of focusing is achieved.

References

[1] Flexible Optical B.V. OKO guide to adaptive optics. http://www.okotech.com/images/pdfs/catwww4.pdf, 2013.

[2] Zemax LLC. Zemax 13 optical design program. User's manual. (supplied with the software), 2014.