**ZMX File Format**

All optical systems designed in Zemax are saved in the file format known as ZMX file which has .zmx as extension. ZMX files can be opened by Zemax in order to load any saved system. The ZMX file is basically text file which follows certain format. In order to import Zemax lens data to external program it is necessary to know the format and have automatic tool for importing. But ZEMAX has took off the chapter describing the ZMX file formats from its user manual starting from version 9, after which it has made significant changes on the file format. In this paper I have tried to reverse engineer the ZMX file formats from sample .zmx files (version Zemax13 release 2).

At the end of the paper I have described an automatic tool written in Matlab to import .zmx lens files to Matlab toolbox without using DDL (which requires running Zemax software each time).

**ZMX File Commands**

**Remarks: ZMX command of ZEMAX@13 as compared to that of ZEMAX V9.0 for which the documentation exists.**

**X (Does not exist), E (Edited), N (New), U (Unchanged)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Remark** | **Category** | **ZMX Command** | **Description** |
| **U** | **GENER** | **VERS 130724 1 23203** | **The version number of Zemax file used to create the .zmx file.** |
| **E** | **MULTI CONFIG** | **MNUM n ??1** | **Number of configuration** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **E** | **SURF** | **HIDE hideRays noEdgesDraw noSurfDraw rowColor noHyperHemisph surfIgnore edgeDrawType skipRays drawLocalAx ??0** | **Setting to show/hide surface comps.**  **hideRays: is 1 if “Hide Rays To This Surface” is selected otherwise is 0.**  **noEdgesDraw: is 1 if “Don’t Draw Edges From This Surface” is selected otherwise is 0.**  **noSurfDraw: is 1 if “Don’t Draw This Surface” is selected otherwise is 0.**  **rowColor: 0(Default),1(Color 1),…,24(color 24),25(no color).**  **noHyperHemisph: is 1 if “Surface Can’t Be Hyperhemispheric” is selected otherwise is 0.**  **surfIgnore: is 1 if “Ignore This Surface” is selected otherwise is 0.**  **edgeDrawType: 0(Squared to Next Surface),1(Tapered To Next Surface),2(Flat To Next Surface)**  **skipRays: is 1 if “Skip Rays To This Surface” is selected otherwise is 0.**  **drawLocalAx: is 1 if “Draw Local Axis” is selected otherwise is 0.**  **??0** |
| **N** | **SURF** | **POPS autoResample useRays don'tRescaleBeamSize UseAngSpectProp OutputPilotRad DrawBeamFile Resample XSamp 1=32,2=64,...) YSamp XWidth YWidth ??0 XRad YRad useXAxisRef** | **Physical optics propagation data**  **autoResample: is 1 if “Auto Resample” is selected and 0 otherwise.**  **useRays: is 1 if “Use Rays To Propagate To Next Surface” is selected and 0 otherwise.**  **don'tRescaleBeamSize: is 1 if “Don not Rescale Beam Size Using Ray Data” is selected and 0 otherwise.**  **UseAngSpectProp: is 1 if “Use Angular Spectrum Propagator” is selected and 0 otherwise.**  **OutputPilotRad: 0:Best fit 1:shorter 2:longer 3:X 4:Y 5:Plane 6:User**  **DrawBeamFile: is 1 if “Draw Beamfile On Shaded Model” is selected and 0 otherwise.**  **Resample: is 1 if “Resample After Refraction” is selected and 0 otherwise.**  **XSamp: X-Sampling 1=32,2=64,...10=16384**  **YSamp: Y-Sampling 1=32,2=64,...10=16384**  **XWidth: X-Width**  **YWidth: Y-Width**  **??0**  **XRad: X-Radius**  **YRad: Y-Radius**  **useXAxisRef: is 1 if “Use X-Axis Reference” is selected and 0 otherwise.** |
| **N** | **SURF** | **MIRR substShape substThick** | **The mirror substrate.**  **substShape: 0(None),1(Flat),2(Curved)**  **substThick: substrate thickness** |
| **N** | **SURF PARAM** | **PARM n val** | **Parameter n is the value of "val".** |
| **E** | **SURF APER** | **CLAP min max surfPickup** | **Circular Aperture min and max radius. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APER** | **ELAP xHalfWid yHalfWid surfPickup** | **Elliptical aperture x and y half width. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APER** | **ELOB xHalfWid yHalfWid surfPickup** | **Elliptical aperture x and y half width. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APER** | **FLAP 0 semiDiam surfPickup** | **Floating Aperture**  **semiDiam: Semi-diameter**  **surfPickup: Index of Pickup surface otherwise 0.** |
| **U** | **SURF APERT** | **OBDC xdec ydec** | **Aperture and Obscuration decenter in x and y direction.** |
| **E** | **SURF APERT** | **OBSC min max surfPickup** | **Circular Obscuration min and max radius. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APERT** | **SPID widArms numbArms surfPickup** | **Spider width of Arm and number of arms. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APERT** | **SQAP xHalfWid yHalfWid surfPickup** | **Rectangular aperture x and y half width. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APERT** | **SQOB xHalfWid yHalfWid surfPickup** | **Rectangular Obscuration x and y half width. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APERT** | **UDAD I x y z** | **User defined aperture data. The first line is always <UDAD 0 “name.uda” UDAsclae>, then for I = 1,2,… the x and y data points corresponding to the user defined aperture are presented.** |
| **E** | **SURF APERT** | **USAP min max surfPickup** | **User aperture. Index of Pickup surface otherwise 0.** |
| **E** | **SURF APERT** | **USOB min max surfPickup** | **User Obscuration.** |
| **U** | **SURF COAT** | **COAT name** | **The name of coating (if any)** |
| **U** | **SURF COMM** | **COMM comment** | **Comment on the surface.** |
| **U** | **SURF CONIC** | **CONI val** | **Conic constant of the surface.** |
| **U** | **SURF CONIC** | **VCON** | **Variable conic constant.** |
| **E** | **SURF CONIC** | **PKUP Surf scale Col** | **Conic Constant pickup.**  **Surf: From Surface index**  **Scale: Scale factor**  **Col: Pickup Column. 0(current),1(radius),2(thickness),3(conic),4(semidiameter),5(** |
| **E** | **SURF CURV** | **CURV val solveType param1 param2 param3 param4** | **The surface curvature.**  **Val: value of the curvature**  **solveType = 0 (fixed), 1(variable),2,3,… indicating the solve types (see the solves chapter from Zemax manual)**  **param1…4 : Solve parameters** |
| **N** | **SURF GENER** | **SCOL colIndex transparency** | **Surface Color.**  **colIndex: 0(default), 1-24(d/t color index)**  **transparency: (100 - Surface Opacity%)/10** |
| **U** | **SURF GENER** | **SLAB val** | **Surface labels.**  **Val: unique integer assigned to each surface to identify the surface as new surfaces are inserted or old ones deleted. This can be used to know where a surface has moved to in the list of surfaces.** |
| **U** | **SURF GENER** | **STOP** | **Marks Stop Surface.** |
| **U** | **SURF GENER** | **SURF index** | **Surface index starting from 0 @ object surface.** |
| **E** | **SURF GENER** | **TYPE surfType** | **surfType = STANDARD,EVENASPH,ODDASPHE,ALTERNAO,PARAXIAL,PARAX\_XY,TOROIDAL,BICONICX,TOROGRAT**  **CUSPLINE,HOLOGRM1,HOLOGRM2,COORDBRK,POLYNOMI,FRESNELS,ABCDSURF,ALTERNAT,DGRATING,**  **CONJUGAT,TILTSURF,IRREGULA,GRINSUR1,GRINSUR2,GRINSUR3,GRINSUR4,GRINSUR5,GRINSUR6,**  **GRINSUR7,GRINSUR8,GRINSUR9,GRINSU10,FZERNSAG,FZERNPHA,SZERNSAG,XPOLYNOM,BINARY\_1,**  **BINARY\_2,XCUSPLIN,XASPHERE,XOSPHERE,VARLSGRT,ELLIGRAT,ELLIGRA2,SUPERCON,XFRESNEL,**  **GRID\_SAG,GRID\_PHA,GEN\_FRES,PERIODIC,TOROHOLO,JONESMAT,ATMOSPHR,ZONEPLAT,USERSURF,**  **BIRE\_\_IN,BIRE\_OUT,OFABHOL1,NONSEQCO.** |
| **U** | **SURF GLAS** | **GLAS name code psurf nd vd pd vnd vvd vpd io ao** | **Glass**  **name: The name of the glass or "\_\_\_BLANK" if glass name is not given or "MIRROR" if mirror.**  **code: The glass type used. 0(Fixed or Mirror),1(Model),2(Pickup),3(Substitute),4(Offset)**  **psurf: Pickup Surface index. Only used for pickup surfaces and 0 otherwise.**  **nd,vd and pd: The index, abbe number and partial disperssion for the glass (but used only for model glass).**  **vnd,vvd and vpd: Variablity status of nd,vd and pd.**  **io and ao: Offset values (index offset and abbe offset)** |
| **E** | **SURF SEMI** | **DIAM val solveType param1 param2 param3 param4** | **The surface semidiameter.**  **Val: value of the curvature**  **solveType = 0 (automatic), 1(fixed),2(pickup),3(maximum),4(zpl macro)… indicating the solve types (see the solves chapter from Zemax manual)**  **param1…4 : Solve parameters** |
| **E** | **SURF SEMI** | **SDMA marigin% fastsmd marigin** | **Semidiameter.**  **Marigin: Semi diameter margin meters**  **marigin%: Semi diameter margin %**  **fastsmd : is 1 if “Fast Semi-Diameters” is selected otherwise it is 0.** |
| **E** | **SURF THICK** | **CHZH hgt ??0** | **Thickness chief ray height solve.** |
| **U** | **SURF THICK** | **DISZ val** | **The Z thickness of the surface.** |
| **U** | **SURF THICK** | **EDGE thi rad** | **Thickness edge thickness solve.**  **Thi: Thickness**  **Rad: Radial Height** |
| **U** | **SURF THICK** | **MAZH hgt zone** | **Thickness marginal ray height solve. Hgt: Height**  **Zone: Pupil Zone** |
| **U** | **SURF THICK** | **OPDZ opd pupZone** | **Thickness OPD solve.**  **Opd: OPD**  **pupZone: pupil zone** |
| **E** | **SURF THICK** | **PZUP surf scale offset col** | **Thickness pickup.**  **Surf: From Surface index**  **Scale: Scale factor**  **Offset: Offset**  **Col: Pickup Column. 0(current),1(radius),2(thickness),3(conic),4(semidiameter),5(parameter0 ...)** |
| **E** | **SURF THICK** | **TCOC surf ??0** | **Thickness Center of Curvature solve.** |
| **U** | **SURF THICK** | **TCOM surf thickness** | **Thickness Compensator Solve.**  **Surf: Reference Surface**  **Thickness: Sum** |
| **U** | **SURF THICK** | **TOLE surf length** | **Thickness position solve.**  **surf: From Surface index**  **length: Length** |
| **N** | **SURF THICK** | **TPUP ??0 ??0** | **Thickness Pupil Position solve.** |
| **E** | **SURF THICK** | **VDSZ ??0 ??0** | **Thickness is variable.** |
| **N** | **SURF TILT** | **SCBD beforeAfter order pickupType decX decY tiltX tiltY tiltZ** | **SCBD => ??Surface Coordinate Break Data**  **beforeAfter: 1(before surface) , 2(after surface)**  **order: 0(Decenter,Tilt), 1(Tilt,Decenter)**  **pickupType:0(Explicit), 1(Pick This Surf), 2(Reverse This Surf), 3(Pick This Surf-1), 4(Reverse This Surf-1),..., 2n+1(Pick Surf - n), 2n+2(Reverse Surf - n )**  **decX decY tiltX tiltY tiltZ** |
| **??** | **SURF EXTRA** | **XDAT ??** | **Extra data associated with the surface** |
| **U** | **SYST CONFIG** | **ENPD val** | **Entrance Pupil Diameter Value** |
| **E** | **SYST CONFIG** | **ENVD temp pres on** | **Environment data. The temp and pres values are in**  **degrees c and atmospheres, respectively. On = 0 or 1: Indicate whether to adjust index to environment data (1) or not (0).** |
| U | **SYST CONFIG** | FLOA val | Float by stop size. val is just ignored |
| U | **SYST CONFIG** | FNUM val I | I = 0:Image Space F/# Value I = 1:Paraxial Working F/# |
| **E** | **SYST CONFIG** | **FTYP type ??0 nfieldpts nWavelength fieldnorm ??0 ??0** | **Field Type.**  **Type = 0,1,2,3 for Angle, Object Height, Paraxial Image Height, and Real Image Height respectively.**  **Nfieldpts: number of field points selected.**  **nWavelength: number of wavelengths selected.**  **Fieldnorm: 0,1 for Radial and Rectangular field normalization.** |
| **U** | **SYST CONFIG** | **FWGN val1 val2 val3...** | **Field weights (total 12)** |
| **U** | **SYST CONFIG** | **GCAT name1 name2 name3 ...** | **Indicates which glass catalogs are used by the lens.** |
| **U** | **SYST CONFIG** | **GFAC val type** | **Apodization factor value and type. The type code is 0**  **for none, 1 for Gaussian, and 2 for cosine cubed.** |
| **E** | **SYST CONFIG** | **GLRS surf f#comp** | **Global Surface**  **Surf: index of global surface.**  **f#comp: 0,1 if method to compute F/# = “tracing rays” and “pupil size/position” respectively.** |
| **N** | **SYST CONFIG** | **MODE SEQ** | **SEQ = Sequential Mode or Hybrid**  **NSQ = Non-sequential Mode** |
| **U** | **SYST CONFIG** | **NAME DOUBLE GAUSS** | **Name of the lens** |
| **E** | **SYST CONFIG** | **NOTE I Notes...** | **Notes related to the lens**  **I = {0, 4} ??** |
| **N** | **SYST CONFIG** | **NSCD maxInter maxSeg minAbsInt minRelInt maxObj glueDist retrace ??0 ??0 ??0 misdRayDrawDist ??1 maxSrcRay simpRaySplit ??2** | **Non-sequential data**  **maxInter:maximum intersection per ray**  **maxSeg: maximum segments per ray**  **minAbsInt: minimum absolute ray intensity**  **minRelInt: minimum relative ray intensity**  **maxObj: maximum nested/touching objects**  **glueDist: glue distance in lens units**  **retrace: 1 if “Retrace source rays upon file open” is selected and 0 otherwise**  **??0 ??0 ??0**  **misdRayDrawDist: missed ray draw distance in lens units**  **??1**  **maxSrcRay: maximum source file rays in memory**  **simpRaySplit: 1 if “Simple ray splitting” is selected and 0 otherwise**  **??2** |
| U | **SYST CONFIG** | OBNA val I | I = 0:Object Space NA and I=1: object cone angle |
| **U** | **SYST CONFIG** | **PICB i** | **Paraxial Ignore Coordinate Breaks, i = 0 is false, i = 1**  **is true. Default is true.** |
| **E** | **SYST CONFIG** | **POLS unpol Ex Ey Phax Phay thinfilmtorayconvert refMethod** | **Dafault polarization state used.**  **Unpol is 1 if “Unpolarized” is selected otherwise it is 0.**  **Thinfilmtorayconvert is 1 if “Convert thin film phase to ray equivalent” is selected otherwise it is 0.**  **refMethod is 0,1,2 for X-, Y- and Z-Axis reference method.** |
|  |  |  |  |
| **E** | **SYST CONFIG** | **PUSH pupilshiftz pupilshifty pupilshiftx scalepupilshift pupilcompressx pupilcompressy** | **Pupil shift. All values indicate the corresponding values in the General system window.**  **Scalepupilshift is 1 if “Scale Pupil Shift factors by field” is selected else it is 0.** |
| **U** | **SYST CONFIG** | **PWAV ind** | **Primary wavelength index (starts from 1).** |
| **E** | **SYST CONFIG** | **RAIM tol type ??** **fastasphere usecache grinaper robust threadingoff dontprintcoordbreak opd2modpi** | **The ray aiming and a few other settings.**  **Fastasphere is 1**  **if the "Fast Asphere Trace" is selected, otherwise it is**  **0.**  **Threadingoff is 1 if “Turn Off Threading” is selected, otherwise 0.**  **Grinaper is 1 if "Check Grin**  **Aper" is selected, otherwise it is 0.**  **Dontprintcoordbreak is 1 if “Don’t Print Coordinate Break Data” is selected, otherwise 0.**  **Tol is**  **no longer used, but some value (such as zero) must**  **be present as a placeholder.**  **Type is 0, 1, or 2 for**  **None, Paraxial, or Real ray aiming.**  **opd2modpi is 1 if “OPD Modulo 2 pi” is selected, otherwise 0.**  **Usecache is 1 if "Use Ray Aiming Cache" is**  **selected, otherwise it is 0.**  **Robust is 1 if**  **"Robust Ray Aiming" is selected, otherwise it is 0.** |
| **U** | **SYST CONFIG** | **ROPD i** | **Reference OPD setting. For i = 0, 1, 2, and 3, the**  **reference point is Absolute, Infinity,Exit Pupil, and Absolute 2 respectively. Use Exit Pupil as the default.** |
| **N** | **SYST CONFIG** | **SCAT model fraction angle ??“”** | **Scattering**  **Model: Scattering model. 0(No Scattering),1(Lamberitian),2(Gaussian),3(ABg),4(ABg file),5(BSDF),6(IS Scatter Catalogue),7(User Defined)**  **Fraction: Scatter fraction**  **Angle: Angle**  **??“”** |
| **E** | **SYST CONFIG** | **UNIT LensUnit SourceUnitPrefix SourceUnit AnalysisUnitPrefix AnalysisUnit AfocalModeUnit MTFUnit** | **LensUnit {MM,CM,IN,METER}**  **SourceUnitPrefix {F,P,N,U,M,X,K,E,G,T}**  **SourceUnit{W,L,J}**  **AnalysisUnitPrefix{F,P,N,M,G}**  **AnalysisUnit{MM,CM,IN,ME,FT}**  **AfocalModeUnit{UR,MR,RR,AS,AM,DG}**  **MTFUnit{CPMM,CPMR}** |
| **E** | **SYST CONFIG** | **VANN val1 val2 val3...** | **VAN vignating factors (total 12)** |
| **E** | **SYST CONFIG** | **VCXN val1 val2 val3...** | **VCY vignating factors (total 12)** |
| **E** | **SYST CONFIG** | **VCYN val1 val2 val3...** | **VCX vignating factors (total 12)** |
| **E** | **SYST CONFIG** | **VDXN val1 val2 val3...** | **VDX vignating factors (total 12)** |
| **E** | **SYST CONFIG** | **VDYN val1 val2 val3...** | **VDY vignating factors (total 12)** |
| **E** | **SYST CONFIG** | **WAVM N wavlen weight** | **Wavelength**  **N = 1,2,…24 indicating the wavelength index**  **Wavlen: the waveleght value**  **Weight: corresponding weight** |
| **X** | **SYST CONFIG** | **WWGT val1 val2 val3...** | **The wavelength weights.** |
| **E** | **SYST CONFIG** | **XFLN val1 val2 val3...** | **The x field values (total 12)** |
| **E** | **SYST CONFIG** | **YFLN val1 val2 val3...** | **The y field values (total 12)** |
| **X** | **X** | **APLA** | **Curvature aplanaticsolve.** |
| **X** | **X** | **CHIA val** | **Curvature chief ray angle solve value.** |
| **X** | **X** | **CNOR** | **Curvature chief ray normal** |
| **X** | **X** | **MARA val** | **Curvature marginal ray angle solve value.** |
| **X** | **X** | **MNOR** | **Curvature marginal ray normal.** |
| **X** | **X** | **PCUP n val** | **Curvature pickup solve from surface n times val** |
| **??** | **??** | **GDAT ix iy dx dy** | **Defines the grid data header for the surface. The**  **values are the number of x and y pixels, and the delta**  **x increment and delta y increment.** |
|  |  |  |  |
| **N** | **GENER** | **BLNK** | **??** |
|  | **MERIT** | MFDS ?? | **Merit Function Definitions** |
|  | **MERIT** |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  | **TOLE** | **TOL ??** | **Tolerance Data** |
| **N** | **SYST CONFIG** | **COFN COATING.DAT SCATTER\_PROFILE.DAT ABG\_DATA.DAT PROFILE.GRD** | **??** |
| **N** | **SYST CONFIG** | **COFN QF "COATING.DAT" "SCATTER\_PROFILE.DAT" "ABG\_DATA.DAT" "PROFILE.GRD"** | **??** |
| **N** | **??** | **GSTD 0 100.000 100.000 100.000 100.000 100.000 100.000 0 1 1 0 0 1 1 1 1 1 1** | **??** |
| **??** | **??** | **??** | **Thickness ZPL Macro Solve.** |
| **??** | **??** | **GARR i sag dx dy dxdy** | **Used for defining the grid surface data. "i" is the array**  **index, starting at 0. The other values are the sag, the**  **derivative of the sag in the x direction, the derivative**  **of the sag in the y direction, and the second cross**  **derivative. Must follow after the GDAT command.** |
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**Merit Function in ZMX File**

All optimization merit functions defined for a given system are simply appended at the end of the ZMX file. All merit functions follow the same format

OPER int1 int2 hx hy px py target weight value %contribution

If OPER is not “BLNK”, all the 10 arguments will be provided even though some are not necessary for the current merit function.

**Multi-configuration Data in ZMX File**

Similarly with the merit functions, all the multi-configuration data of an optical system is appended at the end of the ZMX file. The format is not constructed yet.

**ZMX File Structure**

A typical ZMX file has the following structure.

* **Header Block:**

It begins with VERS and ending with COFN keyword. It defines all system parameters and other data which is not related to any surface in the system.

* **Surface Data Block**

After the header block SURF 0 keyword comes and indicates that everything which follows this line till it gets the next SURF keyword corresponds to the surface index 0. The SURF keyword increments the surfaces counter by 1 and the number following the SURF keyword is just ignored.

* **Merit Functions Definition Block**

It begins with MFDS keyword

* **Tolerance Data Block**

It begins with TOL keyword.

* **Multi-Configuration Data Block**

It begins with MNUM keyword.