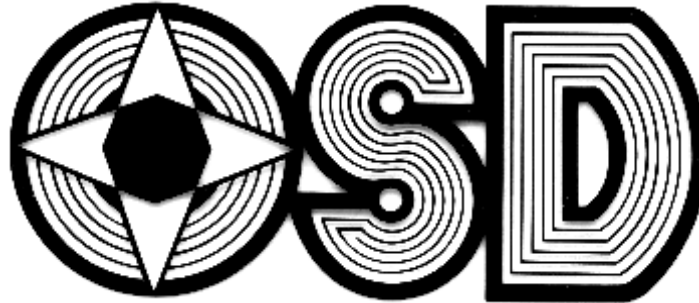


SYNOPSYS™

OPTICAL DESIGN PROGRAM

User's Manual



Optical Systems Design, Inc.

Quick Jumps into the Table of Contents:

[1.0 INTRODUCTION](#)
[2.0 BASIC CONCEPTS](#)
[3.0 LENS DATA INPUT](#)
[4.0 LENS DATA OUTPUT](#)
[5.0 UTILITY FEATURES](#)
[6.0 LENS ANALYSIS ROUTINES](#)
[7.0 LENS ANALYSIS ROUTINES -- PLOTTED](#)
[8.0 IMAGE ANALYSIS ROUTINES -- BASIC SET](#)
[9.0 IMAGE ANALYSIS ROUTINES -- SPECIAL SET](#)
[10.0 AUTOMATIC DESIGN PROGRAM](#)
[11.0 TOLERANCING PROGRAM \(TOL\)](#)
[12.0 BUDGET TOLERANCE PROGRAM \(BTOL\)](#)
[13.0 INTERACTIVE FEATURES](#)
[14.0 ENVIRONMENTAL ANALYSIS PACKAGE](#)
[15.0 ARTIFICIAL INTELLIGENCE FEATURES \(AI\)](#)
[16.0 THIN-FILM PROGRAM](#)
[17.0 POLARIZATION](#)
[18.0 NONSEQUENTIAL RAYTRACING](#)
[Appendices](#)

Table of Contents

[1.0 INTRODUCTION](#)

[2.0 BASIC CONCEPTS](#)

[2.1 Input Commands](#)

[2.1.1 AI Command Format](#)

[2.1.2 Command-level Input](#)

[2.1.3 Character Set](#)

[2.2 Notation Conventions](#)

[2.3 Log Number](#)

[2.4 Coordinate systems](#)

[2.4.1 Surface location options](#)

[2.4.1.1 Relative position](#)

[2.4.1.2 Global position](#)

[2.4.1.3 Local position](#)

[2.4.1.4 External coordinates](#)

[2.4.2 Analysis in other coordinate systems](#)

[2.5 Sign conventions](#)

[2.5.1 Reflections](#)

[2.5.2 Intersections](#)

[2.5.3 Radii](#)

[2.5.4 Ray Angles](#)

[2.6 Stops – Pupils – Vignetting](#)

[2.6.1 Real Pupil Option](#)

[2.6.2 Vignetting](#)

[2.6.3 Wide-Angle Pupils \(WAP\)](#)

[2.6.3.1 Setting Expected Pupil Vignetting \(VFIELD\)](#)

[2.6.4 CSTOP Option](#)

[2.6.5 FILLSTOP Option](#)

[2.6.6 Summary of Pupil Options](#)

[2.6.7 Display of Vignetted Pupil](#)

[2.6.8 FNO option](#)

[2.7 OPD -- Numerical Considerations](#)

[2.8 \(Topic deleted\)](#)

[2.9 Modes of Operation \(ON, OFF\)](#) MSS

[2.9.1 Reset Modes \(RESET\)](#)

[2.10 Version number](#)

[2.11 Project name](#)

[3.0 LENS DATA INPUT](#)

[3.1 RLE Data -- System Input](#)

[3.1.1 Object Input Description](#)

[3.1.1.1 Noncircular Pupil](#)

[3.1.1.2 Implied Pupil](#)[3.1.2 Gaussian Input Beam Definition \(OBG\)](#)[3.1.3 Lambertian Object \(OBL\)](#)[3.1.4 Gaussian input profile](#)[3.1.5 Waveguide Object\(OBW\)](#)[3.1.6 Illumination Array \(OBI\)](#)**[3.2 RLE Data-Optional System Input](#)****[3.3 RLE Data -- Surface Input](#)**[3.3.1 Special Surface Options](#)[3.3.1.1 Clear aperture input](#)[3.3.1.2 Other Special Surface Options](#)[3.3.2 Curvature Options](#)[3.3.2.1 Spherical Surfaces](#)[3.3.2.2 Aspheric Surfaces](#)[3.3.2.2.1 Conic Sections](#)[3.3.2.2.2 Power-series Aspherics](#)[3.3.2.2.3 Toric Surfaces](#)[3.3.2.2.4 Biconic Surfaces](#)[3.3.2.2.5 Spline Surfaces](#)[3.3.2.2.6 Zernike Polynomial Surfaces](#)[3.3.2.2.7 Biradial Conics](#)[3.3.2.2.8 Aspheric Toroids](#)[3.3.2.3 Fresnel Surfaces](#)[3.3.2.4 Holographic optical elements \(HOEs\)](#)[Examples of HOE input](#)[3.3.2.5 Gratings](#)[3.3.2.6 Noncircular-zone surfaces \(NCZONE\)](#)[3.3.2.7 Unusual surface shapes USS\)](#)[3.3.2.8 Diffractive optical elements \(DOEs\)](#)[3.3.3 Thickness Options](#)[3.3.4 Index Options](#)[3.3.4.1 Gradient-Index \(GRIN\)](#)[Example of GRIN input](#)**[3.4 Notes on Using Pickups and Solves](#)****[3.5 Examples of RLE Data](#)****[3.6 Changing a lens](#)**[3.6.1 The CHG file](#)[3.6.1.1 Inserting and deleting surfaces](#)[3.6.1.2 Lens Truncation \(MXSF\)](#)[3.6.1.3 Removing Aperture Data \(CFREE\)](#)[3.6.2 Lens editing \(LE\)](#)

[3.6.3 Lens initialization \(NLENS, SLENS\)](#)[**3.7 Storing and Retrieving Lens Data**](#)[3.7.1 The Lens Library MLB](#)[3.7.2 SAVE, FETCH MWL](#)[**3.8 Asymmetrical Data: -- Tilts and Decenters**](#)[3.8.1 Relative, Remote](#)[3.8.1.1 Examples of tilt and decenter input](#)[3.8.2 Global Coordinates](#)[3.8.2.1 Coincident](#)[3.8.3. Local Coordinates](#)[3.8.4. External Coordinates](#)[3.8.5. Group Coordinates](#)[**3.9 Prism Library**](#)[3.9.1 Prism definitions](#)[3.9.1.1 Right-angle prism \(RANGLE\)](#)[3.9.1.2 Amici prism \(AMICI\)](#)[3.9.1.3 Porro prism \(PORRO\)](#)[3.9.1.4 Penta prism \(PENTA\)](#)[3.9.1.5 Dove prism \(DOVE\)](#)[3.9.1.6 Schmidt prism \(SCHMIDT\)](#)[3.9.1.7 Pechan prism \(PECHAN\)](#)[3.9.1.8 Penta-roof prism \(PROOF\)](#)[3.9.1.9 Roof mirror \(MROOF\)](#)[3.9.1.10 Abbe erector \(ABBE\)](#)[3.9.1.11 Double Porro \(DPORRO\)](#)[3.9.1.12 Pechan roof \(PCR\)](#)[3.9.1.13 Double Dove \(DDOVE\)](#)[3.9.2 Examples of prism input](#)[**3.10 Edge Descriptions**](#)[**3.11 Lens Arrays**](#)[**4.0 LENS DATA OUTPUT**](#)[**4.1 Lens Specifications \(SPEC\) MLL**](#)[4.1.1 DWG with SPEC \(DSPEC\) MLL](#)[**4.2 Print Data \(PRT\) MLL**](#)[**4.3 Lens File Output \(LEO\) MLL**](#)[**4.4 Print Options \(POP\) MLL**](#)[**4.5 OUT**](#)[**4.6 Print Asymmetries \(ASY\) MLL**](#)

[4.6.1 Tilts and Decenters \(TDC\)](#)

[4.6.2 Special Surface Data \(SSD\)](#)

[4.7 Specifications, with Element Power \(SPC\)](#) MLL

[4.8 \(Topic deleted\)](#)

[4.9 Refractive index data \(RIN\)](#) MLL

5.0 UTILITY FEATURES MUT

[5.1 Surface Shape Routines \(SAG\)](#) MUT

[5.1.1 Surface Profile \(SPROFILE\)](#)

[5.2 Element Weight Calculation \(WGT\)](#) MUT

[5.3 Flux Calculation \(FLUX\)](#) MUT

[5.4 Narcissus \(NAR\)](#) MFT

[5.5 GHOST](#)

[5.5.1 Analyzing a Ghost Image with PGHOST](#)

[5.5.2 Analyzing a Ghost Image with RGHOST](#)

[5.5.3 Plotted Ghost Image Features \(GHLOT\)](#)

[5.6 GLASS](#)

[5.7 SFIT Surface Fit to Data](#)

[5.8 SCALE](#) MUT

[5.9 Thermal Soak Program \(THERM\)](#)

[5.10 Annotating output \(\\$, TEXT, MSG\)](#)

[5.11 Lens Reversal \(REVERSE\)](#) MUT

[5.12 Gaussian Beam Trace \(BEAM\)](#) MFT

[5.13 Buried Ghost Image \(BGI\)](#) MFT

[5.14 Combine Two Lenses \(COMBINE\)](#)

[5.15 Time and date \(TIME\)](#)

[5.16 Closest-fitting sphere \(ADEF, ADSTAT\)](#)

[5.17 Object point search \(OCALC, FCALC\)](#)

[5.18 Aligning components along a ray \(AIM\)](#)

[5.19 FOLD, UNFOLD](#)

[5.20 Custom Glass Table](#)

[5.21 Adjusting Magnification \(MSET\)](#)

[5.22 Flipping a Range of Surfaces \(FLIP\)](#)

[5.23 Insert Real Glass \(IRG\)](#)

[5.24 Creating a VFIELD \(FVF\)](#)

[5.25 Print Glass Attributes \(PGA\)](#)

[5.26 ASAP Input File \(ASAP\)](#)

[5.27 Inserting, Deleting surfaces and elements](#)

[5.28 GRIN Statistics](#)

[5.29 WAIT](#)[5.30 DOE fringe Pattern DMASK](#)[5.31 Search for Best Glasses \(GSEARCH\)](#)[5.32 F/number Calculation \(FN\)](#)[5.33 V-number Calculation \(VNUM\)](#)[5.34 Glass transmission \(GTRANS\) MTR](#)[5.35 DOE OPD table \(DSAG\)](#)[5.36 Transmission along a ray \(RTRANS\) MRR, MTR](#)[5.37 Illumination systems](#)[5.38 Clocking Element Wedge Errors](#)[5.39 T/number Calculation \(TN\) MTR](#)[5.40 Lens Blank Cost \(GCOST\) MUT](#)[5.41 Lens Spacer Length \(SPACERS\) MUT](#)[5.42 Zemax Input File Converter \(ZMCONVERT\)](#)[5.43 Duplicate and Mirror \(DMIRROR, CMIRROR\)](#)[5.44 Slope Analysis \(SLOPE\) MUT](#)[5.45 Fresnel Transmission Loss \(FTRANS\) MTR](#)[5.46 Multicore Operation \(CORE\)](#)[5.47 Automatic Real Glass Insertion \(ARGLASS\)](#)[5.48 Code-V Input File Converter \(CVCONVERT\)](#)[5.49 Free-Form Surface Utilities \(FFA\)](#)[5.50 Find Glass Transmission \(FGT\)](#)[5.51 Find Superachromat Triplets \(FST\)](#)[5.52 Oslo Input File Converter \(OSCONVERT\)](#)[6.0 LENS ANALYSIS ROUTINES](#)[6.1 Paraxial Raytrace \(PXT\) MFT](#)[6.2 Clear Aperture Programs](#)[6.2.1 CAP MLL](#)[6.2.2 Edge Thickness \(EDGE\) MUT](#)[6.3 Raytrace \(RAY\) MRR](#)[6.3.1 Targetted Raytrace \(TARGET\) MRR](#)[6.3.2 Global Raytrace \(GRAY\) MRR](#)[6.3.3 External Raytrace \(ERAY\)](#)[6.4 Ray Fans \(SFAN, TFAN, FANS\) MRR](#)[6.5 First-Order Analysis \(FIRST\) MFT](#)[6.6 Third-order Analysis \(THIRD, NTHIRD\) MFT](#)[6.7 Fifth-order analysis \(FIFTH\) MFT](#)[6.8 Feathering Point \(FEATHER\) MUT](#)[6.9 Strain Evaluation \(STRAIN\)](#)

7.0 LENS ANALYSIS ROUTINES – PLOTTED

7.1 Lens drawing (DWG) MPL

[7.1.1 Zoom lens drawing \(ZDWG, ZPER\)](#)

7.2 Perspective Drawing, Solid Model (PER, RPER, SOLID) MPE

7.3 Ray Fans, Plotted (RPT, RPO) MRR

[7.3.1 Short-form input](#)

[7.3.2 Long form input](#)

7.4 Field Curvature (FCV) MRR

7.5 Distortion Curve (DIS) MRR

[7.5.1 AFOCAL distortion](#)

7.6 Plot Utilities (saving, EPL)

7.7 Lens Element Drawing (ELD) MPL

7.8 Edge description file (EFILE, ELIST)

7.9 Three-Parameter Plots (PA3)

7.10 Combining Lens Drawings (CDWG)

7.11 Graphical System Summary (GSS) MGS

7.12 Grid Distortion (GDIS) MRR

7.13 Adding Tolerances to your Drawings

7.14 Longitudinal Spherical Aberration (LSA) MRR

7.15 Forward Scattering (FSC) MFS

8.0 IMAGE ANALYSIS ROUTINES – BASIC SET

8.1 Dialog-driven Image Analysis Features

8.2 Multicolor Analysis

8.3 Influence of Apertures on Image Analysis

8.4 Footprint Options MFP

[8.4.1 Footprints with other drawing programs](#)

[8.4.2 Examples of Footprint Analysis](#)

8.5 Geometric Analysis MGI

[8.5.1 Spot Diagrams MGI](#)

[8.5.1.1 Spot Diagram \(SPT\) MGI](#)

[8.5.1.2 Through-focus Spot Diagram \(TFS\) MTS](#)

[8.5.2 Knife-edge Trace \(KNI\) MGI](#)

[8.5.3 Geometric MTF \(GMTF\) MOP, MFM](#)

[8.5.4 Through-Focus Geometric MTF \(TFG\) MTG](#)

[8.5.5 RMS Focusing \(FOCUS\) MGI](#)

[8.5.6 RMS Spot Size MGI](#)

[8.5.7 Image Model \(GMODEL\) MMO](#)

[8.5.8 Examples of Geometric Image Evaluation Input](#)

[8.5.9 Field Blur](#)

[8.5.10 Multi-field Geometric MTF \(MGMTF\)](#)

[8.5.11 Foucault Knife-edge Tool \(MFK\)](#)

[8.5.12 Illumination Pattern \(IPAT\)](#)

[8.5.13 Over-field Spot diagrams \(OFSPOT\)](#) MSF

8.6 Diffraction Analysis

[8.6.1 Exit Pupil Wavefront Map \(PUPIL\)](#) MDI

[8.6.1.1 Interferogram plot](#)

[8.6.1.2 Fringes at intermediate surface \(FIS\)](#) MDI

[8.6.2 Point-Spread Function \(PSPRD\)](#) MDI

[8.6.3 Diffraction MTF](#)

[8.6.3.1 Convolution MTF options \(MTF, ZMTF, MFF, MZMTF\)](#) MOP

[8.6.3.2 Single field of view convolution MTF](#) MOP

[8.6.3.3 Multifield MTF plots \(MFF\)](#) MMF

[8.6.3.4 Fourier-transform diffraction MTF \(DMTF, M2F\)](#) MOP, MFM

[8.6.3.5 Through-focus diffraction MTF \(TFMTF\)](#) MTM

[8.6.3.6 MTF over field \(MOF\)](#) MOP

[8.6.4 Diffraction Image Model \(DMODEL, WMODEL\)](#) MMO

[8.6.5 Diffraction Pupil Function \(DPF\)](#)

[8.6.6 Coefficients of Wavefront Polynomial \(COE\)](#)

[8.6.6.1 Zernike Wavefront Polynomial \(ZCOE\)](#)

[8.6.7 Partial Coherence Analysis](#) MPA

[Theory](#)

[8.6.8 Wavefront Variance \(VAR\), VFOCUS](#) MDI

[8.6.9 Perturbed Exit Pupil \(GPP\)](#)

[8.6.10 Through-focus PSPRD \(TFP\)](#) MTP

[8.6.11 Over Field PSPRD \(OFP\)](#) MOF

[8.6.12 Variance-MTF Relationship \(VMR\)](#)

[8.6.13 Over ZOOM PSPRD \(ZPSPRD\)](#) MPZ

[8.6.14 Pupil plots over field](#) MDI

[8.6.15 Over Spectrum PSPRD \(OSP\)](#) MPS

8.7 Generic Image Analysis

8.8 Mapping Function (MAP) MMA

[8.8.1 Examples of MAP input](#)

9.0 IMAGE ANALYSIS ROUTINES -- SPECIAL SET

9.1 Generating the Image Model

[9.1.1 Composite image model](#)

[9.1.2 Image model coordinate Systems](#)

9.2 IFOV-Detector Efficiency (DETECTOR)

[Examples of DET input](#)

[9.2.1 Find Detector Size \(FDS\)](#)

9.3 Image Dissection (FOR...) MFO

[Examples of FOR Input](#)

9.4 Diffraction Program (DIFF) MDF

[9.4.1 Prompted DIFF input](#)

[9.4.2 Examples of DIFF input](#)

9.5 Image Illumination (ILLUM) MGI, MTR

9.6 Diffractive Propagation (DPROP)

9.7 Extended Image Analysis (EIA)

10.0 AUTOMATIC DESIGN PROGRAM MOM

10.1 Mathematical Method

[10.1.1 Metric Input, Variable Metric](#)

10.2 Parameter Input (PANT)

10.3 Aberration Input (AANT)

[10.3.1 Ray Aberrations, settings](#)

[10.3.1.1 Automatic generation of ray aberrations](#)

[10.3.1.2 User-specified ray aberrations](#)

[10.3.1.3 Variance-based aberrations](#)

[10.3.1.4 Wavefront coefficient aberration](#)

[10.3.1.5 Ghost image control](#)

[10.3.2 Paraxial aberrations](#)

[10.3.2.1 Paraxial section aberrations](#)

[10.3.2.2 Third- and fifth-order aberrations](#)

[10.3.2.3 Section third- and fifth-order aberrations](#)

[10.3.3 Construction parameter aberrations](#)

[10.3.3.1 Holographic Optical Element Parameters](#)

[10.3.4 Extended format](#)

[10.3.5 Limit and Correction Input](#)

[10.3.5.1 Limit input](#)

[10.3.5.2 Correction input](#)

[10.3.6 STA -- GTA \(storing aberration set\)](#)

[10.3.7 Edge feathering control \(AEC\)](#)

[10.3.8 Center thickness control \(ACC, ACM\)](#)

[10.3.9 MTF Aberrations](#)

[10.3.10 Composite aberrations](#)

[10.3.10.1 Zn parameters in optimization](#)

[10.3.11 CLINK command link to aberrations](#)

[10.3.12 Surface slope control \(ASC\)](#)

[10.3.13 Critical-angle control \(ACA\)](#)

[10.3.14 Automatic aperture control \(AAC\)](#)

[10.3.15 Automatic zoom lens airspace control \(AZA\)](#)

[10.3.16 Automatic monitor of diameter/thickness ratio \(ADT\)](#)

[10.3.17 Automatic monitor of meniscus lenses center of curvature separation \(AMS\)](#)

10.4 The SYNOPSIS Command

10.5 Modes of Operation of SYNOPSIS

[10.5.1 Derivatives](#)

[10.5.2 Evaluate only](#)

10.6 Examples of Lens Design Input

10.7 ZOOM Lenses, Multiconfigurations

[10.7.1 ZFILE zoom lenses](#)

[10.7.1.1 Optimizing ZFILE zoom lenses](#)

[10.7.1.2 CAM curve calculation](#)

[10.7.2 Alternate Configurations](#)

[10.7.2.1 Examples of Multiple Configuration Input](#)

[10.7.3 Zoom Lens Search \(ZSEARCH\)](#)

10.8 Comments about the SYNOPSIS Optimization Program

[10.8.1 Initial evaluation](#)

[10.8.2 Derivative calculation](#)

[10.8.3 High-order aspherics](#)

[10.8.4 When correcting OPD's](#)

[10.8.5 When "OPTIMUM" is not good enough](#)

[10.8.6 Altering a good design](#)

10.9 Final Results

[10.9.1 Summary of optimization](#)

[10.9.2 Change summary](#)

[10.9.3 Messages](#)

10.10 Automatic Testplate Matching (TPM) MMT

10.11 Naming aberrations: the AFILE, ALIST

10.12 Simulated Annealing

10.13 Tolerance Desensitization

10.14 Design Search (DSEARCH) MDS

10.15 Automatic Aspheric Assignment (AAA)

10.16 Automatic Element Deleting (AED)

10.17 Saddle-point Build (SPBUILD, AEI) MDS

10.18 Bend Flip Optimization (BFO)

10.19 Automatic DOE Assignment (ADA)

11.0 TOLERANCING PROGRAM (TOL)

[11.1 Examples of Tolerancing Input](#)

[12.0 BUDGET TOLERANCE PROGRAM \(BTOL\)](#)

[12.1 BTOL Input -- General Format](#)

[12.1.1 Variable attributes](#)

[12.1.1.1 Cemented elements and BTOL](#)

[12.1.2 BTOL Adjustments](#)

[12.1.2.1 Fabrication adjustment with REOPTIMIZE](#)

[12.1.2.2 Finding the best adjustments](#)

[12.1.3 BTOL Quality descriptors](#)

[12.1.3.1 BTOL Wavefront quality descriptor](#)

[12.1.3.2 BTOL Spot size quality descriptor](#)

[12.1.3.3 BTOL Strehl ratio quality descriptor](#)

[12.1.3.4 BTOL MTF quality descriptor](#)

[12.1.3.5 Additional quality descriptors](#)

[12.1.4 Multiconfiguration BTOL analysis](#)

[12.2 BTOL Image quality evaluation](#)

[12.3 Statistical considerations](#)

[12.3.1 Segmented tolerancing](#)

[12.4 BTOL example](#)

[12.5 Monte-Carlo tolerance analysis](#)

[12.5.1 Example Monte-Carlo run](#)

[12.5.2 Including other quantities in MC](#)

[12.5.3 Fabrication Adjustment with FAMC](#)

[12.6 Lens Tolerancing Today](#)

[12.7 BTOL Format Summary](#)

[13.0 INTERACTIVE FEATURES](#)

[13.1 Help Files](#)

[13.1.1 Instant HELP](#)

[13.1.2 ToolTip Help](#)

[13.2 The MACro Editor](#)

[13.2.1 Startup Macro \(SYSTART.MAC\)](#)

[13.2.2 Other MACro commands](#)

[13.3 The SketchPAD](#)

[13.3.1 SketchPAD graphics](#)

[13.3.2 The WorkSheet program](#)

[13.3.3 The LE Lens editor](#)

[13.3.4 SnapShot](#)

[13.3.5 The Glass Table](#)

[13.3.6 The Y-YBAR diagram](#)

13.4 BELL command

13.5 Graphics tools

13.6 Interactive Directory (DIR)

13.7 The SYNOPSIS menu dialog tree

13.8 Rotating drawingS (RPER, RSOLID)

13.9 Saving a plot as an HPGL, DXF, or Postscript file

13.10 Capturing printout (PON, POFF)

13.11 Command Window options (CCW, NCW, PCW)

13.12 Output toggle (QUIET, LOUD)

13.13 Scrolling to recently-typed commands

13.14 Displaying several plots on a single page

13.15 Displaying error messages

13.16 Program updates

13.17 Lens cell editor

13.18 UNDO and REDO

13.19 License utility

13.20 The TrayPrompt

13.21 The Format Coach

13.22 Dual Monitor Support

13.23 Annotation Strings (ASn)

14.0 ENVIRONMENTAL ANALYSIS PACKAGE

14.1 Thermal-Optical-Structural-Program (TOSP)

[14.1.1 Generating the perturbation table](#)

[14.1.2 Creating TOSP data with separate programs](#)

15.0 ARTIFICIAL INTELLIGENCE FEATURES (AI)

15.1 Natural Language Processing

[15.1.1 Grammatical Considerations](#)

[15.1.2 Parametric Plots, Listings](#)

[15.1.2.1 Do MACro Commands](#)

[15.1.2.2 The AIParameter](#)

[15.1.2.3 Automatic Output File \(FILE\)](#)

[15.1.2.4 Replotting the same data \(AGAIN\)](#)

[15.1.2.5 Loop Searching](#)

[15.1.3 Symbol Substitution](#)

[15.1.3.1 Passing values with the AIParameter](#)

[15.1.4 Calculating with AI](#)

[15.1.4.1 Composite aberrations in AI](#)

[15.1.4.2 The Zn parameters](#)

[15.1.4.3 Passing parameters with the Zn array](#)

[15.1.4.4 Examples of Zn calculations](#)

[15.1.5 Other Lens Changes in AI](#)

[15.1.5.1 Matching Vendor-Supplied Elements](#)

[15.1.5.2 Inserting and Deleting a Given Lens With AI](#)

[15.1.5.3 Replacing a Lens With AI](#)

[15.1.5.4 Moving an Element with AI](#)

[15.1.5.5 Selecting A Catalog with AI](#)

[15.1.5.6 Changing Wavelengths in AI](#)

[**15.2 AI Primer**](#)

[15.2.1 Basics](#)

[15.2.1.1 Question Verbs](#)

[15.2.1.2 Nouns – Subjects](#)

[15.2.1.3 Conditions](#)

[15.2.1.4 Change Verbs](#)

[15.2.1.5 Looping in AI – Loop Verbs](#)

[15.2.2 AI Possibilities](#)

[**15.3 Expert Systems**](#)

[15.3.1 Initializing the example file](#)

[15.3.2 Starting a lens from scratch](#)

[15.3.3 Using XSYS with a starting lens](#)

[15.3.4 Entering lens requirements](#)

[15.3.5 Alternate starting points](#)

[15.3.5.1 Rating potential matches](#)

[15.3.5.2 Selecting a potential match](#)

[15.3.5.2.1 Lens matching modes](#)

[15.3.6 Optimizing the selected match](#)

[15.3.7 XSYS example](#)

16.0 THIN-FILM PROGRAM

[**16.1 Common Mode**](#)

[**16.2 Analysis Mode**](#)

16.3 Design Mode

16.4 Example FILM Input

17.0 POLARIZATION

17.1 Polarization Raytracing (PRAY) MRR, MTR

17.1.1 Object polarization

17.2 Modeling Surface Coatings

17.2.1 Standard coatings

17.2.2 Custom coatings

17.2.2.1 Dummy custom coatings

17.2.3 Transmissive coatings

17.2.4 Reflective coatings

17.2.5 Mirror materials

17.2.6 Polarization-active components

17.2.7 Surface coating output

17.3 SYNOPSISYS Features Utilizing Polarization

17.4 Example polarization input

17.5 Birefringent Materials

17.5.1 Birefringent raytracing

17.5.2 Quarter-wave, half-wave plates

18.0 NONSEQUENTIAL RAYTRACING

18.1 Nonsequential surfaces

18.1.1 LOOSE surfaces

18.1.2 CAPTURE surfaces

18.1.3 ILOOSE surfaces

18.1.4 Other nonsequential surfaces

18.1.5 RECTIFY surfaces

18.1.6 MBOUNCE surfaces

18.2 Aperture Considerations in Nonsequential Tracing

18.3 Examples of Nonsequential Raytracing

18.3.1 Telescope mirror with inside aperture

18.3.2 Segmented aperture system

18.3.3 Segmented mirror

18.3.4 A more general nonsequential system

18.3.5 Cavity

18.3.6 Ghost Image Analysis with Nonsequential Rays

[\(Topic deleted\)](#)

[Appendix B Mode Switch Data](#)

[Appendix C Formulation of Conic Sections](#)

[Appendix D Third, Fifth-Order Aberrations](#)

[Appendix E Example SYNOPSIS Files](#)

[Appendix F Glass Model Calculations](#)

[Appendix G Glass Tables](#)

[Schott](#)

[Ohara](#)

[Hoya](#)

[Unusual](#)

[Corning France](#)

[Chinese Guangming](#)

[Russian LZOS](#)

[Sumita](#)

[Appendix H Lens Vendors](#)