

Multi-focus DOE lens design with SYNOPSYS™

Multi-focus DOE design and optimization

Using DOE, we can design lens with multiple focal points: different focus positions for different diffraction orders.

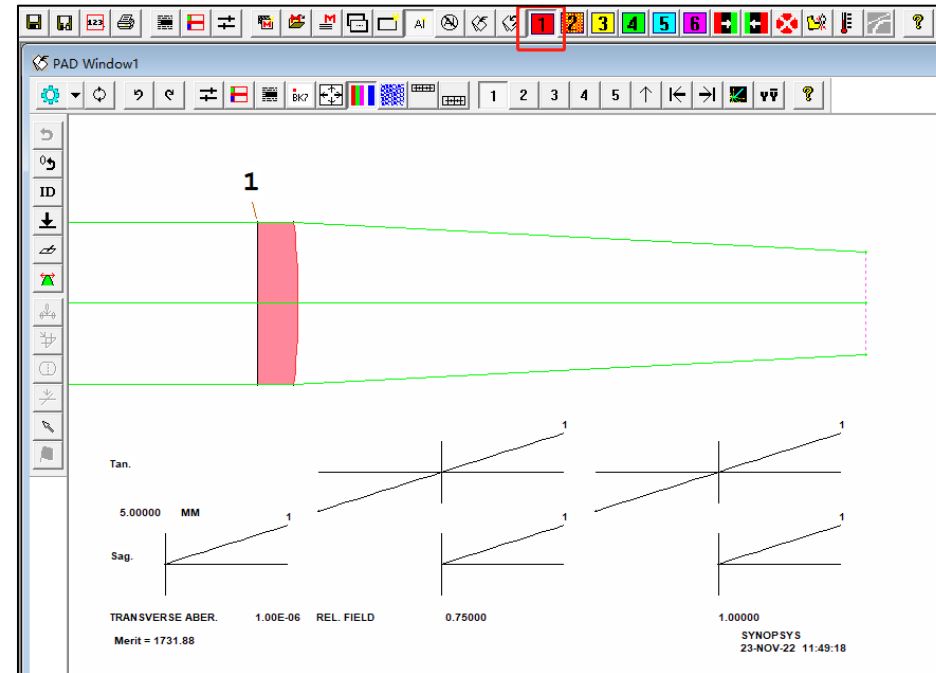
This Application Note demonstrates how to design and optimize a multi-focus DOE lens using the multi-configuration setting in SYNOPSIS™.

If you have a valid Customer Service Contract with us, and you want to obtain a copy of the macro and lens files discussed in this document, please send an email to office@osdoptics.com, with your key number included in the email subject line.

Initial Structure

File: DOE_ACON1_1.RLE

This is the initial lens and we will first put it in configuration 1 (ACON 1). Surface 1 is set up with USS 25 DOE with diffraction order -1.



Surface type: Transmitter

Radius of Curvature: Infinite
Conic Constant: 0

Surface Type: HYPERHEMISPHERE Normal

Surface ID	Surface Type	Radius	Thickness	Material
0	Infinite Object (angular)	infinite	infinite	Air
1	USS Type 25	infinite	5	N-BK7
2	Spherical	-100	70	Air
3	Flat	infinite	0	Air
4				
5				
6				
7				
8				

Flat Polarizer
Non-Circular Zone Plate
 Unusual Surface Shapes (USS)
 Diffractive Element (DOE)

Edit Lens Data

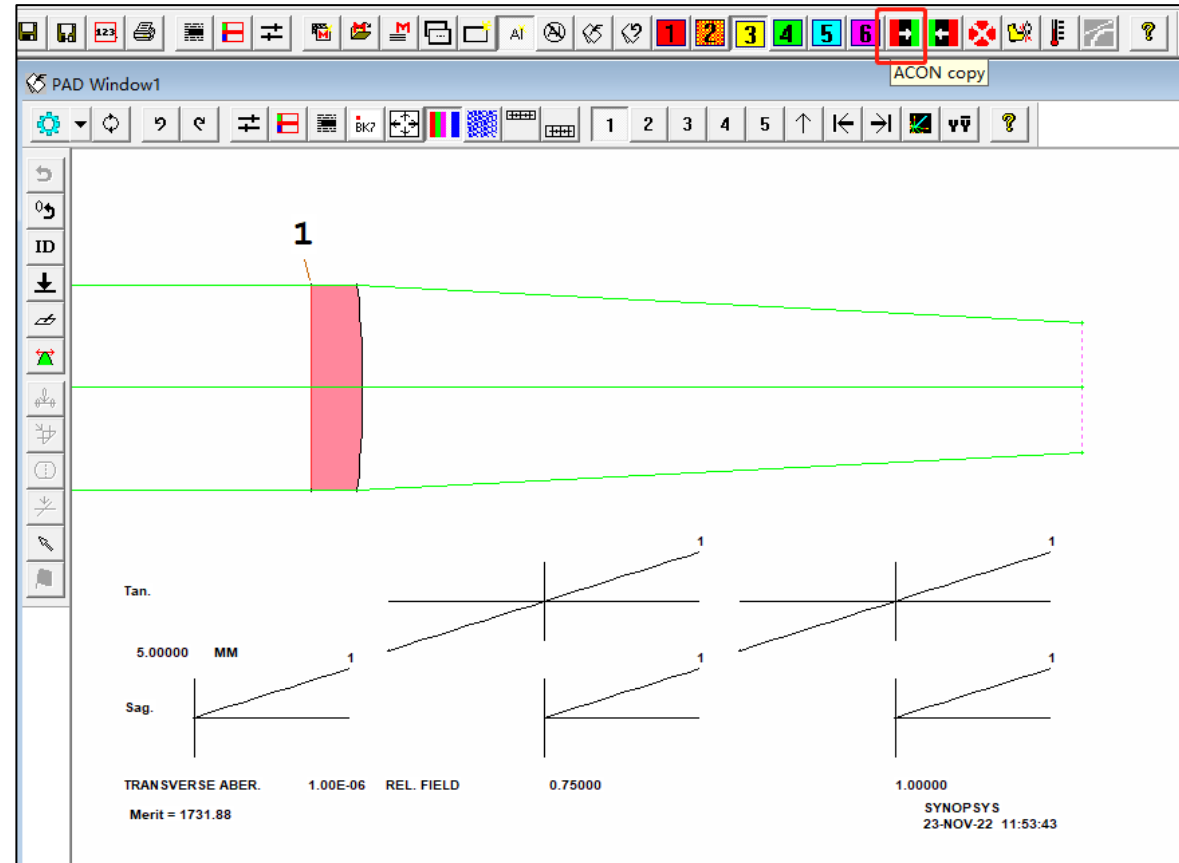
Enter coefficients to define this USS surface.

Value	Term
0.6328	CWAV
-1	Order
6	Reserved
0	Reserved
0	Reserved
0	Reserved
1000	Reserved
0	Reserved
0	Reserved
0	Reserved
1000	Reserved

- Type 1 Conic plus Power Series
- Type 2 Power Series with Cross-Terms
- Type 3 Fresnel DY
- Type 4 Fresnel DS
- Type 5 Power Series; Symmetric in X
- Type 6 Cosine Rings
- Type 7 Odd Powers
- Type 8 Dual Zone
- Type 9 Forbes A
- Type 10 Diffuser
- Type 11 Forbes B
- Type 12 Forbes C
- Type 13 Aspheric Cylinder
- Type 14 Bezier Spline
- Type 15 NURBS Surface
- Type 16 Simple DOE
- Type 17 Biconic Biradial
- Type 18 DLL-Defined Surface
- Type 19 Y-Series Surface
- Type 20 Multilayer DOE
- Type 21 Even and Odd Powers
- Type 22 Legendre Polynomial
- Type 23 Curved Fresnel
- Type 24 XNURBS
- Type 25 Extended DOE
- Type 26 3-LAYER DOE
- Type 27 PLANE GRATING
- Type 28 Isolated Bump
- Type 29 8th-Power Polynomial

ACON COPY

Click ACON copy to copy the lens to configurations 2 and 3 (ACON 2 and ACON 3).



Change the DOE diffraction order to 0 in configuration 2 (ACON 2) and 1 in configuration 3 (ACON 3)

SPS -- SYNOPSIS SpreadSheet

Enter coefficients to define this USS surface.

	Value	Term
1	0.6328	CWAV
2	0	Order
3	6	Reserved
4	0	Reserved
5	0	Reserved
6	1000	Reserved
7	0	Reserved
8	0	Reserved
9	0	Reserved
10	1000	Reserved

- Type 1 Conic plus Power Series
- Type 2 Power Series with Cross-Terms
- Type 3 Fresnel DY
- Type 4 Fresnel DS
- Type 5 Power Series; Symmetric in X
- Type 6 Cosine Rings
- Type 7 Odd Powers
- Type 8 Dual Zone
- Type 9 Forbes A
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- Type 21 Even and Odd Powers
- Type 22 Legendre Polynomial
- Type 23 Curved Fresnel
- Type 24 XNURBS
- Type 25 Extended DOE**
- Type 26 3-LAYER DOE
- Type 27 PLANE GRATING
- Type 28 Isolated Bump
- Type 29 8th-Power Polynomial

Surface Number: 1

Force listing (TAG):

Force intersection: AUTOMATIC

Prism flag: Retain

Surface type: Transmitter

HYPERHEMISPHERE Normal

Surface Type	Surface ID
Infinite Object (angular)	0
USS Type 25	1
Spherical	2
Flat	3

SPS -- SYNOPSIS SpreadSheet

Enter coefficients to define this USS surface.

	Value	Term
1	0.6328	CWAV
2	1	Order
3	6	Reserved
4	0	Reserved
5	0	Reserved
6	1000	Reserved
7	0	Reserved
8	0	Reserved
9	0	Reserved
10	1000	Reserved

- Type 1 Conic plus Power Series
- Type 2 Power Series with Cross-Terms
- Type 3 Fresnel DY
- Type 4 Fresnel DS
- Type 5 Power Series; Symmetric in X
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- Type 23 Curved Fresnel
- Type 24 XNURBS
- Type 25 Extended DOE**
- Type 26 3-LAYER DOE
- Type 27 PLANE GRATING
- Type 28 Isolated Bump
- Type 29 8th-Power Polynomial

Surface Number: 1

Force listing (TAG):

Force intersection: AUTOMATIC

Prism flag: Retain

Surface type: Transmitter

HYPERHEMISPHERE Normal

Surface Type	Surface ID
Infinite Object (angular)	0
USS Type 25	1
Spherical	2
Flat	3

Optimization macro

File: DOE_MULT_OP.MAC

In this example, we want the back focal of order -1 (ACON 1) to be about 70mm, order 0 (ACON 2) about 100mm and order 1 (ACON 3) about 160mm

We will set up an optimization macro as shown to the right to design and optimize the DOE lens from its initial structure.

Make sure you switch back to configuration 1 before running this macro. It's important!



The declaration, ACON 2 and 3 PICKUPS PCV at the top of the macro, keeps the curvature and DOE coefficients of surfaces 1 and 2 of the DOE lens remain the same in all three configurations

In the PANT section (optimization variables), DOE coefficients of surface 1 and radius of surface 2 are used as variables (while maintaining the same values for all the 3 configurations)

In AANT (merit functions), add imaging quality targets and BACK targets to each of the three configurations (ACON 1, 2, 3)

```
DOE_MULT_OP.MAC
ACON 2 PICKUPS
1 PCV 1
2 PCV 2
END
ACON 3 PICKUPS
1 PCV 1
2 PCV 2
END

PANT
VY 1 DOE
VY 2 RAD
ACON 1
VY 2 TH
ACON 2
VY 2 TH
ACON 3
VY 2 TH
END

AANT
ACON 1
M 0 1 A P YA 0 0 1
M 0 1 A P XA 0 1 0
GNR 0 1 7 P 0
M 70 0.1 A BACK

ACON 2
M 0 1 A P YA 0 0 1
M 0 1 A P XA 0 1 0
GNR 0 1 7 P 0
M 100 0.1 A BACK

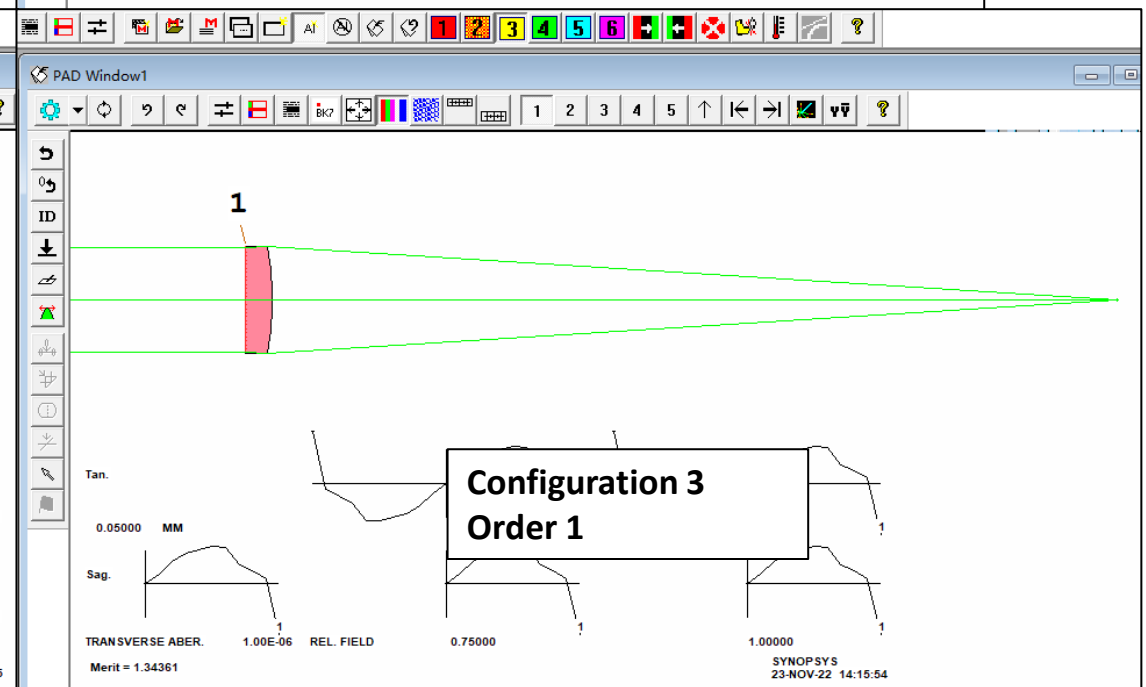
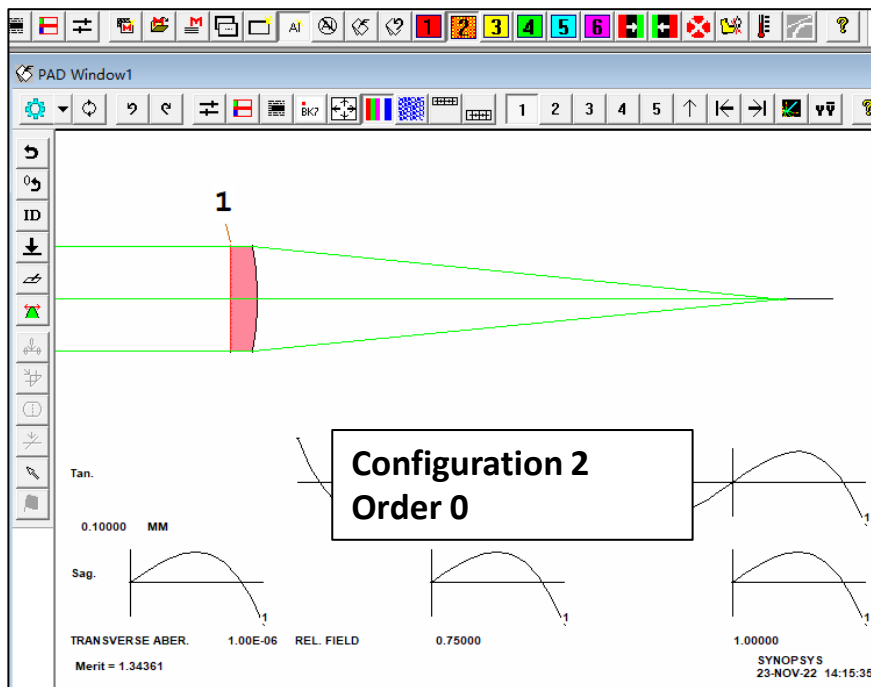
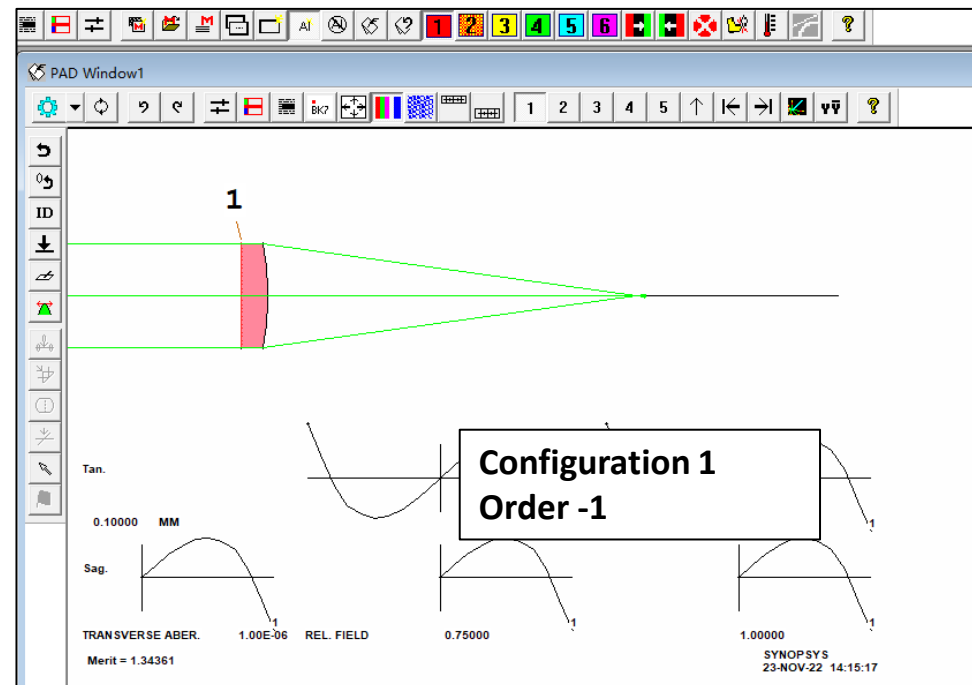
ACON 3
M 0 1 A P YA 0 0 1
M 0 1 A P XA 0 1 0
GNR 0 1 7 P 0
M 160 0.1 A BACK
END

SYNO 50 MULTI
```

the back focus (TH of surface 2) of the three configurations (ACON 1, 2, 3) can vary individually

Optimization results

After optimization, different focal lengths are successfully achieved for the three different configurations.



File: DOE_ACON1.RLE
 DOE_ACON2.RLE
 DOE_ACON3.RLE

The three DOE lenses differ only in
 ORDER and BACK. Other
 parameters are exactly the same

```

DOE_ACON1.RLE
RLE
ID EXAMPLE SINGLET 3
FNAME 'DOE_ACON1.RLE
MERIT 1.34361
LOG 3
WA1 .6328000
WT1 1.00000
APS 1
UNITS MM
OBB 0.0000000 0.0010000 10.0000000 0.00000000000 0.0000000 0.0000000 10.0000000
0 AIR
1 CV 0.000000000000000 TH 5.00000000
1 N1 1.51508379
1 CTE 0.710000E-05
1 GTB S 'N-BK7
1 USS 25
CWAV 0.632800
HIN 1.500000 55.000000
RNORM 1.00000
ORDER -1
1 XDD 1 2.83761824E+00 3.90071751E-03 -3.44577293E-04 1.61275366E-05 -3.96684566E-07
1 XDD 2 5.24920559E-09 -3.52670096E-11 9.42478491E-14 2.83758269E+00 3.90529992E-03
1 XDD 3 -3.44749130E-04 1.61276284E-05 -3.96562830E-07 5.24651249E-09 -3.52439490E-11
1 XDD 4 9.41768497E-14 8.42405491E-04 -3.46819905E-07 -3.63927401E-09 -3.47039439E-07
1 XDD 5 -1.69857398E-08 3.71582463E-10 -3.64087347E-09 3.71931298E-10 -7.81581495E-12
2 RAD -53.1429859937758 TH 72.14883146 AIR
3 CV 0.0000000000000 TH 0.00000000 AIR
END
  
```

```

DOE_ACON2.RLE
RLE
ID EXAMPLE SINGLET 1
FNAME 'DOE_ACON2.RLE
MERIT 1.34361
LOG 1
WA1 .6328000
WT1 1.00000
APS 1
UNITS MM
OBB 0.0000000 0.0010000 10.0000000 0.00000000000 0.0000000 0.0000000 10.0000000
0 AIR
1 CV 0.000000000000000 TH 5.00000000
1 N1 1.51508379
1 CTE 0.710000E-05
1 GTB S 'N-BK7
1 USS 25
CWAV 0.632800
HIN 1.500000 55.000000
RNORM 1.00000
ORDER 0
1 XDD 1 2.83761824E+00 3.90071751E-03 -3.44577293E-04 1.61275366E-05 -3.96684566E-07
1 XDD 2 5.24920559E-09 -3.52670096E-11 9.42478491E-14 2.83758269E+00 3.90529992E-03
1 XDD 3 -3.44749130E-04 1.61276284E-05 -3.96562830E-07 5.24651249E-09 -3.52439490E-11
1 XDD 4 9.41768497E-14 8.42405491E-04 -3.46819905E-07 -3.63927401E-09 -3.47039439E-07
1 XDD 5 -1.69857398E-08 3.71582463E-10 -3.64087347E-09 3.71931298E-10 -7.81581495E-12
2 RAD -53.1429859937758 TH 100.22151076 AIR
3 CV 0.0000000000000 TH 0.00000000 AIR
END
  
```

```

DOE_ACON3.RLE
RLE
ID EXAMPLE SINGLET 3
FNAME 'DOE_ACON3.RLE
MERIT 1.34361
LOG 3
WA1 .6328000
WT1 1.00000
APS 1
UNITS MM
OBB 0.0000000 0.0010000 10.0000000 0.00000000000 0.0000000 0.0000000 10.0000000
0 AIR
1 CV 0.000000000000000 TH 5.00000000
1 N1 1.51508379
1 CTE 0.710000E-05
1 GTB S 'N-BK7
1 USS 25
CWAV 0.632800
HIN 1.500000 55.000000
RNORM 1.00000
ORDER 1
1 XDD 1 2.83761824E+00 3.90071751E-03 -3.44577293E-04 1.61275366E-05 -3.96684566E-07
1 XDD 2 5.24920559E-09 -3.52670096E-11 9.42478491E-14 2.83758269E+00 3.90529992E-03
1 XDD 3 -3.44749130E-04 1.61276284E-05 -3.96562830E-07 5.24651249E-09 -3.52439490E-11
1 XDD 4 9.41768497E-14 8.42405491E-04 -3.46819905E-07 -3.63927401E-09 -3.47039439E-07
1 XDD 5 -1.69857398E-08 3.71582463E-10 -3.64087347E-09 3.71931298E-10 -7.81581495E-12
2 RAD -53.1429859937758 TH 160.46592563 AIR
3 CV 0.0000000000000 TH 0.00000000 AIR
END
  
```