Ultra-Wide Field of View Lens Using DSEARCH

DSEARCH allows for the creation of several starting points for a system if given the initial design parameters. This can be done for a wide variety of systems and can even be used when designing systems with very large fields of view. This study will show you how to begin designing such a lens in SYNOPSYS[™]. These lenses are very popular with photographers for not only the wide field of view, but also the large depth of field, reduced camera shake, and ability to dramatically affect the perspective of objects within the image.

Front-End Design

One limitation of DSEARCH is that it cannot generate new systems whose full FOV exceeds 180°. It can, however, work on existing system that do. So the simple workaround for this is to make a rough front-end for the lens, and then allow DSEARCH to work on that. To do this, create a new lens within SYNOPSYS[™] and set up the system for wide-field imaging. In our case, we have a few design parameters we will be working towards:

- f/4
- Back Focal Distance (BFD) = 5mm
- Total Track Length (TTL) = 35mm
- Full Field of View (FFOV) = 240°

Click on "System Setting > System Declaration" to begin:



Make sure the following settings are the same, and then click the "Open Wavelengths" button at the bottom of this window.

Sys	tem Declaration	_	×
	System Units: C Inches @ mm C cm C M 🗌 Use millimeter (mm) as default (Switch 24)		
	Number of surfaces in the lens (MXSF) 5		
	ID Wide_Angle_Front_End Up to 33 characters of lens identification. For more lines, use the ID command.		
	Activate Vignetting: ^(C) Yes (VIG) ^(C) No (NOVIG)		

System Wavelengths		- 🗆 X
Wavelengths and Weights:		
Use CdF lines		
Enter Wavelengths and Spectral Weights:		
To analyze Third Order Color Aberrations, enter at least 3 wavelengths	Spectrum Wizard	
Color WA1 WT1	- Illumination Source	-
Number	Selected: Uniform	Adjust the number of wavelengths
1 0.656270 1.000000		C Adjust the weights of the present wavelengths
	(• Uniform	
3 0.466130 1.00000	C Blackbody - Temperature:	Wavelength range from .4861 to .6563
	5900 Kelvins (greater than 100)	
J	C Blackbody Options	· · · · · · · · · · · · · · · · · · ·
WA2 WT2	C Discrete Sources	
	Detector	
·	Selected: Uniform	
	6 m 7	
10	(• Uniform	
10	C NSUAI	
Primary, Long, and Short wavelengths: Primary wavelength is used for paraxial raytrace.	C protographic	0.488100 0.528850 0.671200 0.813750 0.856300
Short and Long wavelengths are used for 3rd order chromatic aberration		Wavelength, µM
Primary Color Number: 2	Legends:	
Long Color Number:	 Wavelengths currently in lens Wavelengths currently in lens 	Apply Spectrum Print Bitmap
	- Source spectrum	Appropression france and appropression
Short Color Number: 3	Detector spectrum Source: Combined spectral weights Detectors	Uniform
	Detector:	Uniom
	Y Y Principle, Long, Short Wavelengths	
		Onen Ohiect/Punil/Ston
		open opier opilo op

This window allows you to adjust the wavelength range and weights to your specific use case, but we will just use the default CdF lines. Next, click on the "Open Object/Pupil/Stop" button at the bottom of this window. Here, set our object to be a wide-angle object (OBD) with an angular extent of 120°. This is our Half Field of View (HFOV). Make sure our stop location is the last surface and set the pupil size to be roughly 0.5mm in diameter. Then, click the "Open Spreadsheet" button at the bottom of this window.

System Object, Pupil, and Aperture Stop	– 🗆 X
Object	Step-
Skewness of Object:	Surface Number: 5 Real Stop (Pupil) Search
No Skew Rays (1D Object)	Standard Stop: Chief Ray Height at Surface 1 (YP1): -2.094395
C Consider Skew Rays (2D Object)	Use default Aperture Radius
	C User-Defined Aperture
Ubject Field:	Aperture Shape: C Circular (CAO) C Elliptical (EAO) C Rectangular (RAO)
(* Circular (CFUV)	Aperture Size: Y X
C Rectangular (RFOV)	C Adjust the Stop Aperture to pass the Paraxial Marginal Ray (CSTOP)
C Square (SFOV)	C Adjust to pass Real Ray at: Y X MARGIN
Object Specification: Object Height Object Height	C Special Stop: (Stop number will be automatically reset to 1)
Basic object specification (NEFIELD) Distance Y-Axis X-Axis (TDD) (TD	C Telecentric
C Infinite Object (angular) (OBB)	C Implied Stop: Enter Chief Ray Height at Surface 1 (YP1): -2.094395
C Einite Object (linear) (OPA)	
C Finite Object (Incell) (OPC) 100012 1 0	Pupil Shape: Circular (CPUPIL) Cilliptical (EPUPIL) Rectangular (RPUPIL)
	User-Defined Pupil (NOFILL)
(• Wide-Angle (angular) (OBD) 1e+012 120 0	
C Fast Object (linear) (OBF) 1e+012 1 0	C Adjust PUPIL beam size to clear the aperture STOP (FILLSTOP)
C Modify object height to fill image aperture (FFIELD)	Note: the stop must have a fixed aperture size for this feature.
Image Aperture Shape: 🕫 Circular (CAO) 🥂 Elliptical (EAO) 🥂 Rectangular (RAO)	C Adjust paraxial pupil for this object NA (OSNA)
Image Aperture Size: Y 4.32645 X	C Adjust paravial public vield this ENUM at image (ENO)
	Future rups: Fortered pupil size applies to on-axis field only. Measured perpendicular to the optical axis (WAP 0)
	Entered pupilies applies to all fields (on axis and off-axis). Measured perpendicular to the chief on: (MAD 1)
	C. Durit size appression of the noise (or existing of existing of existing and of existing the period of the noise of
	 Fugni size varies with fields to the aperture stop. A user-defined aperture must be assigned to the stop surface (WAP 2).
Activate Vignetting Mode (VIG)	 Pupil size varies with fields to clear all aperture. User-defined apertures must be assigned to every surfaces (WAP 3).
	C Pupil size varies with field angles in accordance to user data (VFIELD).

We want two elements to rough out our front-end design, so set surfaces 1 and 3 to glass models by right-clicking on the Material cell of each surface, select "Material Options...", and click on "Glass Model". The default values that come up are sufficient.

	Surface Type	Surface ID	Radius	Thickness	Material	Index	Coating
0	Wide-Angle Object (angular)		infinite	1e+012	Air	1	
1	Flat		infinite	1	Air	l .	ine
2	Flat		infinite	0	Air	iterial Options	ne
3	Flat		infinite	0	Air	1	None
4	Flat		infinite	0	Air	1	None
5	Flat		infinite	0	Air	1	None

Edit Index Options	×				
Index Option, Surface 1		_			
This index is controlled by a solve or a lo	Edit Lens Data				×
PLASTIC (glass model boundaries) Air	Enter glass model p	arameters, cli	ck OK.		
○ Vacuum ○ Explicit indices> ○ Glass table>	1.6	Nd			
Glass model> Pickup indices>	55.0	Vd			
 Interpolation coefficients> GRIN (gradient-index)> Birefringent> 					
-				OK	Cancel
ОК	Cancel ?	rc)/none	2.5944/0	2.5944/0	
			4 3264570	4 3264570	

Set some reasonable thicknesses for the system to get started with, and then we're ready to begin roughing out a front-end. 1mm for any elements and 5mm for the spacings between elements is appropriate for this case.

	Surface Type	Surface ID	Radius	Thickness	Material	Index	Coating	Aperture Type (Outer/Inner)	Y Semi-Width (Outer/Inner)	X Semi-Width (Outer/Inner)
0	Wide-Angle Object (angular)		infinite	1e+012	Air	1		Def (Circ)/none	0/0	0/0
1	Flat		infinite	1	GLM	1.6	None	Def (Circ)/none	24.0619/0	24.0619/0
2	Flat		infinite	5	Air	1	None	Def (Circ)/none	24.7057/0	24.7057/0
3	Flat		infinite	1	GLM	1.6	None	Def (Circ)/none	33.3659/0	33.3659/0
4	Flat		infinite	5	Air	1	None	Def (Circ)/none	34.0096/0	34.0096/0
5	Flat		infinite	0	Air	1	None	Def (Circ)/none	42.6699/0	42.6699/0

Now we can look at the system on the sketch pad:



This doesn't look like much right now, but with some manipulation using the WorkSheet (WS) editor, we can create a system good enough to allow DSEARCH to generate several starting points for us to work with.



Click on the WS button to begin editing this system. This will allow the easy manipulation of lens parameters to begin making a rough version of a front-end to the system we want to end up designing. This step takes a little bit of time to get used to, so try adjusting some of the options here and get familiar with the effect that changing each parameter has. For our case I find that a rough 1:2 or 1:3 relationship between the first and second curvatures of each element tends to work well. The video component of this tutorial demonstrates how to use this feature.

WS WorkSheet Lens-Edit Window	×
> 5 (H B G G K B H H K	II → ···> Update SEL. Close
1 CV 0.00000000000 TH 1.00000000 1 GLM 1.600000000 55.00000000	Curvature 0.000000 Fast Bending 0.000000 Spacing 1.000000 Slide element can't do TH0 Offset
	√ To SpreadSheet
< > > > > > > > > > > > > > > > > > > >	

Something along these lines is sufficient to begin using DSEARCH to work on. It doesn't need to be particularly exact because we will let DSEARCH handle the fine-tuning.



Below is a system that can be used as a starting point. You can use these numbers to follow along, or you can create your own front-end. Keep in mind that creating your own front-end may result in a final system that is different from the one demonstrated in this tutorial.

Surface Type	Surface ID	Radius	Thickness	Material	Index	Coating	Aperture Type (Outer/Inner)	Y Semi-Width (Outer/Inner)	X Semi-Width (Outer/Inner)
Wide-Angle Object (angular)		infinite	1e+012	Air	1		Def (Circ)/none	0/0	0/0
Spherical		23.6205582	1	GLM	1.6	None	Def (Circ)/none	17.0952/0	17.0952/0
Spherical		9.58626504	5	Air	1	None	Def (Circ)/none	9.29698/0	9.29698/0
Spherical		11.4034451	1	GLM	1.6	None	Def (Circ)/none	6.92831/0	6.92831/0
Spherical		3.43274519	5	Air	1	None	Def (Circ)/none	3.39279/0	3.39279/0
Flat		infinite	0	Air	1	None	Def (Circ)/none	3.62751/0	3.62751/0
	Surface Type Wide-Angle Object (angular) Spherical Spherical Spherical Spherical Flat	Surface Type Surface ID Wide-Angle Object (angular) Spherical Spherical Spherical Spherical Flat	Surface TypeSurface IDRadiusWide-Angle Object (angular)infiniteSpherical23.6205582Spherical9.58626504Spherical11.4034451Spherical3.43274519Flatinfinite	Surface TypeSurface IDRadiusThicknessWide-Angle Object (angular)infinite1e+012Spherical23.62055821Spherical9.586265045Spherical11.40344511Spherical3.432745195Flatinfinite0	Surface TypeSurface IDRadiusThicknessMaterialWide-Angle Object (angular)infinite1e+012AirSpherical23.62055821GLMSpherical9.586265045AirSpherical11.40344511GLMSpherical3.432745195AirFlatinfinite0Air	Surface TypeSurface IDRadiusThicknessMaterialIndexWide-Angle Object (angular)infinite1e+012Air1Spherical23.62055821GLM1.6Spherical9.586265045Air1Spherical0.1.40344511GLM1.6Spherical3.432745195Air1Flat0Airit11	Surface TypeSurface IDRadiusThicknessMaterialIndexCoatingWide-Angle Object (angular)infinite1e+012Air1Spherical23.62055821GLM1.6NoneSpherical9.586265045Air1NoneSpherical11.40344511GLM1.6NoneSpherical3.432745195Air1NoneFlatinfinite0Air1None	Surface TypeSurface IDRadiusThicknessMaterialIndexCoatingAperture Type (Outer/Inner)Wide-Angle Object (angular)infinite1e+012Air1Def (Circ//none)Spherical23.62055821GLM1.6NoneDef (Circ//none)Spherical9.586265045Air1NoneDef (Circ//none)Spherical11.40344511GLM1.6NoneDef (Circ//none)Spherical3.432745195Air1NoneDef (Circ//none)Flatinfinite0Air1NoneDef (Circ//none)	Surface TypeSurface IDRadiusThicknessMaterialIndexCoatingAperture Type (Outer/Inner)Y Semi-Width (Outer/Inner)Wide-Angle Object (angular)infinite1e+012Air1Def (Circ)/none0/0Spherical23.62055821GLM1.6NoneDef (Circ)/none17.0952/0Spherical9.586265045Air1NoneDef (Circ)/none9.29698/0Spherical11.40344511GLM1.6NoneDef (Circ)/none6.9231/0Spherical3.432745195Air1NoneDef (Circ)/none3.39279/0Flatinfinite0Air1NoneDef (Circ)/none3.6251/0

From here, we can begin setting up our DSEARCH parameters to get some starting points for this wide-angle lens.

DSEARCH Script

To begin, click on "Optimization + Design Search > DSEARCH"



When the DSEARCH dialog opens, make sure to check the boxes shown below and set the starting surface number to the last surface in the system (5). Since the front-end we made was just a rough estimate, we want DSEARCH to optimize these elements as well. You'll notice the MACro being generated on the right as we adjust settings within this dialog.

p 1: Search Method Step 2: System Declaration er of Cores (CORE) 12 n Method:
er of Cores (CORE) 12 (1 - 12) n Method: Design Search (DSEARCH) IV Append search system to current system, starting from the surface nur
Check this box if you want the current system to be varied during th Saddle-point build (SPBUILD) Conduct Saddle-Point Build based on current system (USE CURREN (Optional) specify the portion of the system will be subjected to the saddle Starting Surface (USSS): Ending Surface (USPS): Uibrary location to store the best search results (LLIB): IET mode Select this to suppress all output to the current Command V

Step 1: Search Method Step 2: System Declaration Step 3: Goals Command Line: CORE 12 Core 14 DSEARCH 1 OUIET USE CURRENT 5 ALL GOALS Enter the lens identification. BACK 0 SET TOT L0 Wavelengths: 0.6563 0.5976 0.4981 Enter 3 wavelengths: Long, Middle, Short, in um TOT L0 Define Object: O Object at infinity (OBB) O Object at this distance (OBA): (TH0) TOT 0.0 Object Size (Height or Angle): 1 (UPP0 or YPP0) TO 5 QUICK 10 10 Entering beam size (semi-diameter) from on-axis field point 1 (YMP1) System Units: © MM C Inches Lens Is: © Focal A Focal SPCCUL PANT END SPC GO Enter any special system requirements here, such as WAP selection. SPCCUL ANT END	Step 4: Optional Special C	Intimization Goals	Step 5: Launch Search		
Corp 1: Occurs incluse Oright : System Declaration CORE 12 DSEARCH I QUIET USE CURRENT 5 ALL GOALS Lens ID Ultra_Wide_Lens Enter the lens identification. Wavelengths: 0.6563 0.5876 0.4981 Define Object Object at infinity (OBB) Object at this distance (OBA): (TH0) Object Size (Height or Angle): 1 (UPP0 or YPP0) Entering beam size (semi-diameter) from on-axis field point 1 (YMP1) System Units: MM C Inches SPC Cult ANT Lens Is: © Focal C AFocal SPC Cult ANT GO Speter any special system requirements here, such as WAP selection. GO	Sten 1: Search Method	Step 2: System Declaration	Sten 3' Goals	Command Line:	
	Lens ID Ultra_Wide_Lens Wavelengths: 0.6563 0.5 Define Object: Object at in Object Size (Height or Angle): Entering beam size (semi-dian System Units: OMM C Lens Is: Focal C Enter any	Enter the lens id Enter the lens id Enter the lens id Enter 3 wavelengths: Lo finity (OBB) C Object at this distance (C 1 (UPP0 or YPP0) neter) from on-axis field point 1 Inches AFocal r special system requirements here, such as	entification. ong, Middle, Short, in um DBA): (TH0) (YMP1) s WAP selection.	CORE 12 DSEARCH 1 QUIET USE CURRENT 5 ALL GOALS ELEMENTS 3 FNUM 5 BACK 0 SET TOTL 0 0 STOP MIDDLE STOP FREE COLORS 3 FOV 0.0 0.75 1.0 0.0 0.0 FWT 5.0 3.0 1.0 1.0 1.0 RT 0.5 QUICK 10 10 NPASS 10 ANNEAL 200 20 Q 10 SNAPSHOT 10 END SPECIAL PANT END SPECIAL PANT END GO	

Because we are appending the search to the current system, the settings on this page are overwritten by the parameters we defined when first setting up the system. You'll notice that none of these options don't make their way over to the generated MACro, so there's no need to worry here.

			1	
Step 4: Optional Special Opti	mization Goals Step	5: Launch Search	Command Line:	
Step 4: Optional Special Opti Step 1: Search Method GOALS Leave blank any fields you do not ELEMENTS 5 Desir Target Value FNUM 4 3 BACK 5 TOTL 30 Specify weightings for fields: Fields: 0.0 QC STOP first C STOP telecentric Qbject m Gobject m G 3-Colors Major color onl RSTART THSTART Thickne ASTART Airspac Aperture-dependent weight 0.1	mization Goals Step Step 2: System Declaration care about, except number of elements, and red number of elements (Required) eight (Required) (Enter target of zero to bypass BACK) (Enter target of zero to bypass TOTL) 15 0.75 1 4 2 1 5 0.75 1 4 2 1 5 0.75 Plast STOP free to mov study be at finite distance (OBA)) by C All Colors Fadii of Curvatures ses	5: Launch Search Step 3: Goals	Command Line: CORE 12 DSEARCH 1 QUIET USE CURRENT 5 ALL GOALS ELEMENTS 5 FNUM 4 3 BACK 5 SET TOTL 30 1 STOP MIDDLE STOP FREE COLORS 3 FOV 0.0 0.25 0.5 0.75 1 FWT 5.0 4 3.2 1 RT 0.5 QUICK 10 10 NPASS 10 ANNEAL 200 20 Q 10 SNAPSHOT 10 END SPECIAL PANT END GO	

Here we set the main parameters of the system we want to find. The ELEMENTS cell near the top is the number of elements generated *after* the front-end we've already designed. This means our full system will consist of 7 elements. Changing this number will result in different potential solutions that could be helpful to look at in some instances. We want the FNUM to be very close to 4, so we give this value a large weighting to make DSEARCH prioritize this. Our track length must be 35mm, but the TOTL value is only the distance from the first surface to the last surface of the last element and does not include the BFD. Because of this, we set TOTL to be 30 to give us a track length of 35mm.

Design Search / Saddle-Point Build	×
Step 1: Search Method Step 2: System Declaration Step 3: Goals	Command Line:
Step 4: Optional Special Optimization Goals Step 5: Launch Search SPECIAL PANT Enter any special variable regiests, in PANT format. TLIMIT 100.1 SUMIT 100.1 SUMIT 100.1 SPECIAL AANT Enter any special aberrations to be controlled, in AANT format. Acc 0.12.0.01 Acc 3.11 Ack 465 1.10	Command Line: CORE 12 DSEARCH 1 QUIET USE CURRENT 5 ALL GOALS ELEMENTS 5 FNUM 4 3 BACK 5 SET TOTL 30 1 STOP MIDDLE STOP FREE COLORS 3 FOV 0.0.025 5 0.75 1 FWT 5.0.4 3 2 1.0 RT 0.5 QUICK 10 10 NPASS 10 ANNEAL 200 20 Q 10 SNAPSHOT 10 END SPECIAL PANT TLIMIT 100 0.1 END SPECIAL AANT ACM 0.7 1 0.07 AEC 0.1 2 0.01 ACC 31 11 ACA 65 1 10 END GO
	Make a MACro Close

Here, special variables and constraints can be defined that are not present in the DSEARCH dialog to fine-tune your search. These extra commands are necessary due to the nature of our system. The **TLIMIT** and **SLIMIT** commands change the limits of the element thickness and airspace thickness respectively. Because our system must lie within 35mm, some of our elements will get quite thin and need to get smaller than the default minimum thickness of 1mm.

Each item in the AANT section for this case is defined as:

Item Target Weighting Window

ACM controls the minimum center thickness. We've set that to 0.7mm with a weighting of 1, and an allowed window of ±0.07mm

AEC controls edge thickness to be a minimum of 0.1mm

ACC controls the maximum allowed center thickness of each element to be no more than 3mm. This prevents unreasonably large lenses to be used

ACA prevents solutions being found where rays enter/exit elements at extreme angles to prevent ray failing. In this case, we want to try to limit the entering/exiting angle to be less than 65 degrees measured from the surface normal.

Design Search / Saddle-Point Build	– 🗆 X
Step 1: Search Method Step 2: System Declaration Step 3: Goals	
Step 4: Optional Special Optimization Goals Step 5: Launch Search	Command Line:
Other options/Goals for the DSEARCH/Saddle-Point Build: Random search, cycles 200 Select this option only if you want to do a RANDOM search. Outick Mode Quick Passes 10 Real Passes 10 REVERT to quick mode start Revert to quick mode start 10 Real Passes 10 Quick Mode NPASS 40 Number of optimization passes in final MACro Quict Passes 10 Passes 30 QUIET mode If mode SNAPSHOT Passes 10 Cooling 20 Passes 30 QUIET mode If SAMPLE generate a single sample 10 Replace progress bar with monitor window displaying the current and best merit function values SAMPLE generate a single sample	CORE 12 DSEARCH 1 QUIET USE CURRENT 5 ALL GOALS ELEMENTS 5 FNUM 4 3 BACK 5 SET TOTL 30 1 STOP MDDLE STOP FREE COLORS 3 FOV 0.0 0.25 5 0.75 1 FWT 5.0 4 3 2 1.0 RT 0.5 NPASS 40 ANNEAL 200 20 Q 30 SNAPSHOT 10 END SPECIAL PANT TLIMIT 100 0.1 SLIMIT 100 0.1 SLIMIT 100 0.1 ACC 3 1 1 ACA 65 1 10 END GO
	Make a MACro Close

Here we input the final search parameters. We won't be using quick mode during this search because we want SYNOPSYS[™] to spend extra time searching/optimizing solutions, and the quick search is unlikely to help us find better solutions in our case.

NPASS allows for 40 optimization passes made for each case it searches for.

ANNEAL allows DSEARCH to try to jump out of any potential local minima, to further drive the merit function lower. Higher "temperatures" allow for greater variety in potential solutions, while cooling affects the run speed. Passes defines the number of passes for this process.

SNAPSHOT defines how often the Sketchpad window updates. Larger numbers here mean faster runtime, but it can be useful to watch this as solutions are found.

With this done, we're ready to click on the "Make a MACro" button and begin searching for solutions!

A DSEARCH MACro will pop up on the screen with all the options we've previously set. We just need to add one thing and then we're ready to go. Since we're dealing with such an extreme lens, it can be helpful to vary the conic constant in DSEARCH to allow it to search for potentially better cases. Add this line to the DSEARCH MACro:

TOTL	30 1	L												
STOP	MIDI	DLI	3											
STOP	FREI	5												
ASPH	ERIC	1	3	5	6	7	8	9	10	11	12	13	14	
COLOR	RS 3													

Then, click the Run icon on the top left and watch as SYNOPSYS[™] searches for lenses that fit our specifications.

240DEG_DSEARCH.MAC	8
🔁 🖸 ! 🗶 🛎 🛆 🛞 😵 🖉 🔍 🖬 🖬 🔤 🎒 🖻 🔊 🖸	? [
CORE 12 DSEARCH 1 QUIET	^

The solution that has the lowest merit function will be loaded in, but ten of the other best fitting solutions will also appear in a graphics window. The system loaded in automatically may not actually be the best, so it can be useful to peruse the other options and see if there's a form you would prefer to work with. In my example, the default works fine. Loading in a different result is as simple as typing in "FETCH DSEARCH____" and filling in the blank with the appropriate number.

Due to the random nature of DSEARCH, you will not see the exact same systems shown in this guide, but they likely will have a similar form.



DESIGN SEARCH RESULT	s /
D WDE ANKLE FROMT END SCALE 0.077 X MEMOTI 0.1310 FILE DIBLANCHOL FILE	47
U WOE ANKLE FRONT END BOLLE 6 LITTY FLE DEEMODOINTLE	
D WORE ANGLE FRONT END EXALE A ANGLE X MERT 0.550 FLE DEEMO-KOD R.E	
D NECE ANTRE FRONT END SCALE ANTRE MERT 1001 FLE DEEARDHOI RLE	
EVING ANELE FRONT END SAVET LINTEX FLE DEBANDHORRE	
UNDE ANKLE FRONT FIND SOLLE ALVIS A FUE DEEMICHOZIZLE	
D WOOF ANDLE FRONT END SCALE A ADD X MERT 1377 FLE DEEMISKOR R.E	
D NOCE ANRAE FRONT END BOARD ALARDAY MERRIT LIGGE FLE DEENROHOMSRLE	
D NICE AVELE FRONT END SCALE ALASIS X MERT 14/0 FLE DERARDHOR R.E	
D NING ANRAE FRONT END SOME A LANS X MERT I LANS FLE DEEMISHOT R.E	
TOTAL CASES RUN: 32 CASES SKIPPED: 0	26-OCT-20 05:08:3

As we can see from the ray fans, this lens is a good starting point for this application. It still requires work to bring to a point worth manufacturing. SYNOPSYS[™] has a powerful optimization algorithm that will allow us to greatly improve the lens. Optimization itself is a huge topic that we will explore in the following tutorial. There we will discuss good strategies to tackle this issue and demonstrate the tools that SYNOPSYS[™] has to offer. For right now, you should have a better understanding of how to use DSEARCH to quickly generate starting points for your design and allow the computer to use its resources to do a lot of the basic work for you. This tool is unique to SYNOPSYS[™] and I hope you can get great use out of it.

References

[1] Dilworth, D. (2018). *Lens design: Automatic and quasi-autonomous computational methods and techniques*. Bristol: IOP Publishing.