

Grating Order Analyzer

Abstract



The analysis of the diffraction efficiencies of gratings is the typical modeling task for gratings. The efficiencies follow from the Rayleigh coefficients. Both quantities are given for each of the diffraction orders of a grating. VirtualLab Fusion enables the calculation of efficiencies and Rayleigh coefficients by the fully vectorial Fourier modal method (FMM, also known as RCWA). With the help of the Grating Order Analyzer, one can display the efficiencies and Rayleigh coefficients of the distinct orders in various ways.

Grating Specification



- For the demonstration of the Grating Order Analyzer for 1D gratings we use a sinusoidal grating with HR coating.
- The grating parameters can be specified within the stack that can be accessed in the edit dialog of the grating component.

Grating Order Analyzer Settings

- After the grating structure has been defined you can configure the Grating Order Analyzer.
- Various output options can be specified.
- This is done through the edit dialog of the analyzer which is opened by double clicking it element in the optical setup view.



General Settings

Edit G	rating	Order Analy	/zer			×
Ger	neral	Single Orders				
	Calcul	ated Orders				
	۲ 🗌	ransmission			Reflection	
	Outpu	t				
	⊘ ()rder Collecti	ons			
	⊘ 9	ingle Order (Output			
	⊘ 9	oummed Trans	smission, Abs	orption, and F	Reflection	
	F	olar Diagram	in x-z-Plane			
		[OK	Cancel	He	elp

- In the General tab, you can select whether transmission and/or reflection shall be analyzed.
- In addition you can specify whether you would like to evaluate the summed transmission, absorption and reflection values, and whether you would like to show a polar diagram.

Single Orders Settings

Edit Grating Order Analy	zer	×
General Single Orders]	
Order Selection Strate	egy	
Selection Strategy	Order Range	\sim
	x	Y
Minimum Order	-1 -1	0
Maximum Order	0	0 🜩
Coordinates		
Spherical Angles	G Carte	sian Angles
Wave Vector Co	mponents 🗌 Positi	ions
Efficiencies		
Rayleigh Coefficients		
Ex	🗌 Ey	🗌 Ez
TE TE	TM	
	0 //	
l	OK Ca	ncel Help

- In the Single Orders tab you can select whether information for single orders shall be logged.
- This option is very helpful if you would like to use the parameter run or the parametric optimization of VirtualLab Fusion to analyze and optimize the grating for specific orders.

Single Orders Settings

Edit Grating Order Analyz	zer		×
General Single Orders			
Order Selection Strate	ду		
Selection Strategy	Order Range	~	
	х	Y	
Minimum Order	-1 🜩	0	
Maximum Order	0 🜩	0	
Coordinates			
Spherical Angles	Carl	tesian Angles	
Wave Vector Con	nponents Pos	itions	
Efficiencies			
Rayleigh Coefficients			
Ex Ex	Ey	Ez	
TE	TM		
C	ОК С	Cancel Help	

Parameter	Description
Order Selection Strategy	The user can define which order shall be evaluated. The user can define whether to analyze All orders, analyze only those orders which have an efficiency Above a Given Threshold or calculate only orders in a manually defined Order Range . Depending on the selection strategy the user has to define additional parameters.
Coordinates	Logging of the coordinates of the orders is also supported. The user can specify whether to show the coordinates in Spherical Angles , Cartesian Angles , Wave Vector Components or Positions . For the Position calculation a z-distance between the grating and the screen has to be specified.
Efficiencies	The user can select whether efficiencies shall be logged.
Rayleigh Coefficients	In addition it is possible to log the Rayleigh coefficients. The user can select to show the coefficient E _x , E _y , E _z , TE or TM .

Outputs in Detector Tab

Detecto	Detector Results						
	Date/Time	Detector	Sub - Detector	Result			
12			Overall Reflection Efficiency	46.719 %			
11	02/24/2010 00-11-50	Gratian Order Applymer #900	Overall Transmission Efficiency	53.281 %			
10	03/24/2013 03.11.00	Grating Order Anaryzer #800	Overall Reflection and Transmission Efficiency	100 %			
9			Absorption	0 %			
8			Spherical Angle Theta R[-1; 0]	18.44°			
7			Spherical Angle Phi R[-1; 0]	٥°			
6			Efficiency R[-1; 0]	1.5446 %			
5	02/24/2019 00:11:50	Grating Order Analyzer #800	Rayleigh coefficient Ex R[-1; 0]	121.05 · exp(-1.695 · i) mV/m			
4	03/24/2013 03.11.30	(Results for Individual Orders)	Spherical Angle Theta R[0; 0]	0°			
3			Spherical Angle Phi R[0; 0]	٥°			
2			Efficiency R[0; 0]	29.348 %			
1			Rayleigh coefficient Ex R[0; 0]	541.74 · exp(-0.11644 · i) mV/m			
Messa	ges Detector Results						

- If the Grating Order Analyzer is processed within the Optical Setup, the single order output values are logged into the detector results tab.
- These values are also available in the parameter run and the parametric optimization.

Outputs in Polar Diagram



172	20.734	2.3447 %
T+3	40.639°	17.76 %
T+4	60.271°	3.6834 %
R-3	71.612°	0.80371 %
R-2	39.244°	6.3375 %
R-1	18.44°	1.5446 %
R0	0°	29.348 %
R+1	-18.44°	1.5446 %
R+2	-39.244°	6.3375 %
R+3	-71.612°	0.80371 %

- The polar diagram output of the Grating Order Analyzer plots the efficiencies of both the reflected and the transmitted orders versus the angles in the xz-plane.
- It also provides a table of all angles and efficiencies of the displayed orders.

Polar Diagram Settings



- You can zoom into the polar diagram with the mouse wheel, the Property Browser and the ribbon.
- You can configure which orders are shown by rightclicking on the diagram.

Select Diffra	action Orders to	Show		×			
Type of Orders to Show							
Incident Wave Transmitted Orders Reflected Orders							
Minimum A	ngle -71.61	2 Maxim	um Angle	71.612°			
	- <u> </u>	_	-				
Use Stride							
Order	Angle	Efficiency		^			
Order	Angle 0°	Efficiency 100 %		^			
Order I T-4	Angle 0° -60.27°	Efficiency 100 % 3.683 %		^			
Order ✓ I ✓ T-4 ✓ T-3	Angle 0° -60.27° -40.64°	Efficiency 100 % 3.683 % 17.76 %		Â			
Order ✓ I ✓ T-4 ✓ T-3 ✓ T-2	Angle 0° -60.27° -40.64° -25.73°	Efficiency 100 % 3.683 % 17.76 % 2.345 %		^			
Order ✓ I ✓ T-4 ✓ T-3 ✓ T-2 ✓ T-1	Angle 0° -60.27° -40.64° -25.73° -12.54°	Efficiency 100 % 3.683 % 17.76 % 2.345 % 0.8165 %		^			
Order ✓ I ✓ T-4 ✓ T-3 ✓ T-2 ✓ T-1 ✓ T0	Angle 0° -60.27° -40.64° -25.73° -12.54° 0°	Efficiency 100 % 3.683 % 17.76 % 2.345 % 0.8165 % 4.072 %		^			
Order ✓ I ✓ T-4 ✓ T-3 ✓ T-2 ✓ T-1 ✓ T0 ✓ T+1	Angle 0° -60.27° -40.64° -25.73° -12.54° 0° 12.54°	Efficiency 100 % 3.683 % 17.76 % 2.345 % 0.8165 % 4.072 % 0.8165 %		^			
Order ✓ I ✓ T-4 ✓ T-3 ✓ T-2 ✓ T-1 ✓ T0 ✓ T+1 ✓ T+2	Angle 0° -60.27° -40.64° -25.73° -12.54° 0° 12.54° 25.73°	Efficiency 100 % 3.683 % 17.76 % 2.345 % 0.8165 % 4.072 % 0.8165 % 2.345 %		^			

> 1	Card and Clark		
	vindow Size	400, 420	
√ y	-Axis		
N	/laximum	25 %	
N	/linimum	0 %	

Outputs in Order Collection



- The Grating Order Collection object is used to visualize the calculated grating efficiencies or the Rayleigh coefficients over different coordinates.
- The user can configure the data that shall be shown by setting diverse options via the property browser.

Order Collection Settings

	w Data Array	a to Show View	Data
		General	~
Number Coording	pe Order Num	Coordinate Type	
lcy	Efficiency	Data to Show	
	tion Strategy	Order Selection	~
Efficiency Threshold	Above Effi	Strategy	
172	eshol: 1E-08 %	Efficiency Thresh	
Data to			
Order S			
C+			

ate Type This property can be used to define the coordinates over which the data shall be visualized. Currently the order collection supports the visualization over **Cartesian Angles**, Spherical Angles, Wave Number Vectors and Positions. Show It is possible to select the different data values that should be shown. The user can select to display the efficiency or the Rayleigh coefficient over the selected coordinate type. For Rayleigh coefficients E_x , E_y , E_z , TM and TE are supported. election The user can define which order shall be displayed. The user can define whether to show All, show only orders which have an efficiency Above a Given Threshold or show only orders for a manually defined **Order Range**. Depending on the selection strategy the user has to define additional parameters.

Description

Order Collection Settings



- In the View tab of the property browser, the user can set up additional view parameters.
- Most important for the customization of the view are the color settings.
- The user can select the background color for the view as well as the color lookup table that shall be used to define the colors for the displayed data values.

Example of Customized Order Collection Settings



Example of Customized Order Collection Settings



Example of Customized Order Collection Settings



Visualization of Conical Diffraction

Basal Positioning	Isolated Positioning	Position Information	on (Absolute)	
Position this Ele	ement's Input Axes with	Respect to		
Reference Ele	ment 0:	Ideal Plane Wave	~	
Reference Out	tout Channel		~	
Relative Distan	ce on Axis			
Delta Z		0 mm		
Lateral Shift				
Delta X	0 mm		Delta Y	0 mm
Inclination / Ro Orien	tation tation Definition Type Z-Axis Direction [Spherical Angle	2\$ ✓	(:::)
Inclination / Ro Orien	tation tation Definition Type Z-Axis Direction [Angle /	Spherical Angle Definition Axis	s → Value	(:::)
Inclination / Ro Orien	tation tation Definition Type Z-Axis Direction I Angle / Theta (Spheric	Spherical Angle Definition Axis erical) ~	value	(##) 40°
Inclination / Ro Orien	tation Tation Definition Type Z-Axis Direction I Angle / Theta (Spheric	Spherical Angle Definition Axis erical) ~	value	(:::) 40° 40°
Inclination / Ro Orien	tation tation Definition Type Z-Axis Direction I Angle / Angle / Theta (Spheric Phi (Spheric	Spherical Angle Definition Axis erical) ~	rs → Value	(:::) 40° 40°
Inclination / Ro Orien	tation tation Definition Type Z-Axis Direction I Angle / Angle / Theta (Spheric	Spherical Angle Definition Axis erical) ~	value	(:::) 40° 40°
Inclination / Ro Orien	tation tation Definition Type Z-Axis Direction I Angle / Angle / Theta (Spheric Phi (Spheric	Spherical Angle Definition Axis erical) ~	value	(:::) 40° 40°
Inclination / Ro Orien I Swap Order	tation tation Definition Type Z-Axis Direction I Angle / Theta (Spheric Phi (Spheric Rotation About Z Z-Axis Rota	Spherical Angle Definition Axis erical) V cal) V Axis tion Angle	value	(:::) 40° 40°
Inclination / Ro Orien	tation Z-Axis Direction I C-Axis Direction I Angle / Theta (Spheric Rotation About Z Z-Axis Rota	Spherical Angle Definition Axis erical) ~ al) ~ Axis tion Angle	value	(***) 40° 40°
Inclination / Ro Orien	tation tation Definition Type Z-Axis Direction I Angle / Theta (Spheric Phi (Spheric Rotation About Z Z-Axis Rota	Spherical Angle Definition Axis erical) ~ al) ~ Axis tion Angle	value	(:::) 40° 40°

- Within the positions and orientation definition of the grating the user can define an arbitrary orientation.
- This is done in the Position / Orientation tab within the edit dialog of the grating.
- For this use case we use Theta = 40° and Phi = 40°.

Efficiencies vs. Diffraction Order Number

Dat	ta to Show	View	Data Array	Selections		
Y	General					
L	Coordinat	е Туре	Order Num	ber		
	Data to Sh	wor	Efficiency			
~	Order Se	election	Strategy			
	Strategy		Above Effi	ciency Thresho	ld	
	Efficiency	Thresh	ole 1E-08 %			
Co	pordinate T	Гуре				
Co	pordinate T e type of the	ype e coordin	nates.			



Efficiencies vs. Diffraction Order Position



1: Reflection Result – Grating Order Analyzer #800 - • × Order Collection Grating Efficiencies Diagram Table Efficiency in a distance of 1 m [%] 6.4 -0.6 y [m] 3.7 -0.5 0.5 1.5 -1.5 -1 0 1 2 x [m]

result

settings

Efficiencies vs. Diffraction Order Cartesian Angle





title	Grating Order Analyzer
document code	GRT.0002
version	1.1
toolbox(es)	Grating Toolbox
VL version used for simulations	7.4.0.49
category	Feature Use Case
further reading	 Analysis of Blazed Grating by Fourier Modal Method Optimization of Lightguide Coupling Grating for Single Incidence Direction