

# Grating Optimization in VirtualLab Fusion Using optiSLang

#### Abstract



Optimization of a modern optical system often involves a large amount of parameters. As an example, for the optimization of gratings, not only the geometrical paramters of the grating shall be considered, but also the desired incidence directions. That leads to a challenging task with greatly increased number of parameters. For such cases, VirtualLab Fusion provides an interface to the software optiSLang from Dynardo, so that different advanced optimization algorithms can be applied.

#### Interface of VirtualLab Fusion and optiSLang



VirtualLab Fusion is a flexible and customizable platform of modelling tools to simulate complex optical setups like e.g. coupling a set of plane waves into a lightguide.



optiSLang is a software platform of advanced tools for sensitivity analysis, multiobjective and multidisciplinary optimization, robustness evaluation, reliability analysis and robust design optimization.

The combination of both software platforms enables advanced grating structure designs for e.g. smart lightguide coupling

#### VirtualLab Fusion – Initialization of the Optical Setup

- Initial Setup
  - In general, each optical system defined in VirtualLab can be optimized using optiSLang.
  - For this example the optical system consists of a Plane Wave Source and the Lightguide Coupling Detector for periodic media.



- Lightguide Coupling Detection
  - The Lightguide Coupling Detector is a special tool to detect the efficiencies of a periodic structure regarding a specified angular incidence range.
  - The periodic structure can be defined or loaded from catalogs within the Edit Dialog of the detector.

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	Number of Resulting Physical Values (for Optimization)
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- Lightguide Coupling Detection
  - For this example a slanted grating is used.



Filter by...

Light Sources
 Coordinate Break

ኛ 9: Optical Setup View #8 (D:\OneDrive\...\01\_Lightquide Coupling Detector.lpd)\*

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- Lightguide Coupling Detection
  - The angular range of the incidence directions of the input source is specified within the Edit Dialog of the detector.
  - These are defined by minimum and maximum cartesian angles alpha and beta and their number of sampling points.

🥰 9: Optical Setup View	##8 (D:\OneDrive\\01_Lightguide Coupling Detector.lpd)*
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# VirtualLab Fusion – Lightguide Coupling

- Lightguide Coupling Detection
  - From the detected efficiencies, the mean value and the uniformity contrast is calculated and provided in the Detector Results tab.
  - As a result the detector enables the evaluation of a periodic structure within a specified angular space.



Parameter	Value & Unit
Mean value	45.47%
Uniformity contrast	84.48%

# VirtualLab Fusion – Export LPD to OPtiSLang

Export Folder Simulation Engine

Slant

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Validity: 🕑

- Export LPD to optiSLang
  - − File → Export → Export to optiSLang Project



# VirtualLab Fusion – Export LPD to optiSLang

- Export LPD to optiSLang
  - File → Export → Export to optiSLang
     Project
  - The LPD is exported by generating all files necessary for importing the optical setup to optiSLang.



parameters.xml	19.01.2018 09:42	XML-Datei	19 KB
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💿 run_VirtualLab.bat	19.01.2018 09:42	Windows-Batchda	1 KB
📥 system.lpd	19.01.2018 09:42	Light Path Diagram	117 KB
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# VirtualLab Fusion – Export LPD to optiSLang

- Export LPD to optiSLang
  - In the export dialog window
    - the parameter space can be defined including the variation range of the parameters
    - the export folder is chosen, where the files are saved
    - the simulation engine is specified, which is used for the analysis

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			Material Behind (Air)   Constant		Constant Absorption Coefficient	0	1E+300	0
			Fill Factor (Bottom)	$\checkmark$	Fill Factor (Bottom)	10 %	90 %	50 %
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			Slant Angle		Slant Angle	0°	50°	40°

- Setting up the solver system
  - File → New project ...



- Setting up the solver system
  - Next, drag the Solver wizard to the Scenery window.
  - A dialog opens, where several Solver paradigm are listed.
  - The Solver paradigm VirtualLab has to be selected.



- Setting up the solver system
  - Then a file dialog opens, where the system.lpd generated by the VirtualLab export has to be opened.

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- Parametric solver system
  - The parametric solver system consists of the corresponding VirtualLab file and two XML files containing the parameters and results to define the merit function.
  - Please save the project.



- Parametric solver system
  - Run the solver system to check it is working correctly and provides the expected results.



- Parametric solver system
  - Run the solver system to check it is working correctly and provides the expected results.
  - The parameters and the results can be checked by double-clicking on the Parametric solver system window in the Result designs tab.

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- Parametric solver system
  - optiSLang enables the possibility to optimize the optical system using multiple target functions.
  - This can be defined in the Criteria tab of the Parametric solver system configuration.

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- Parametric solver system
  - The first target function is defined by drag the Uniformity Contrast to the Objective Minimize criteria.
  - As a consequence the optimization algorithm tries to minimize the uniformity contrast as best as possible.

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- Parametric solver system
  - The second target function is defined by drag the Mean to the Objective Maximize criteria.
  - As a consequence the optimization algorithm tries to maximize the mean efficiency as best as possible.
  - This specification is called a multiple target optimization.

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- Optimization wizard
  - As next step the Optimization wizard is applied to the solver system by Drag & Drop.



- Optimization wizard
  - First, the varied system parameters are presented including their specified value range.
  - Furthermore, optiSLang provides a visualization of the value range including a mark for the initial value.
  - Then click on Next.

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- Optimization wizard
  - Second, the criteria for the optimization can be specified, if not already done in the Parametric solver system.
  - There is also the possibility to import the criteria from other documents.
  - Then, click on Next.

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- Optimization wizard
  - Third, the Optimization method has to be selected.
  - optiSLang provides a suggestion for suitable methods by an analogy to a traffic light system
    - Red: unsuitable
    - Yellow: suitable
    - Green: recommended
  - In this example an Evolutionary Algorithm is recommended and used.
  - Then, click on Next.

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Optimization method Specify the optimization	method			৻₩
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- Optimization wizard
  - Next, some additional options might be specified.
  - The option Show postprocessing during algorithm run is recommended to get access to the result data during the optimization run.
  - Then, click on Finish.

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- Advanced Settings
  - By double-clicking the created optimization, the detailed parameters of the optimization algorithm can be adapted.



- Advanced Settings
  - By double-clicking the created optimization, the detailed parameters of the optimization algorithm can be adapted.
  - In the tabs "Initialization", "Selection", "Crossover" and "Mutation" grant access to numerous parameters of the algorithm.

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- Advanced Settings
  - By double-clicking the created optimization, the detailed parameters of the optimization algorithm can be adapted.
  - In the tabs "Initialization", "Selection", "Crossover" and "Mutation" grant access to numerous parameters of the algorithm.
  - In the tab "Others", some predefined parameter sets are provided, which are appropriate for most optimizations (e.g. "EA 10000")



- Advanced Settings
  - Further, as an additional option the auto-save behavior of optiSLang can be adjusted.
  - By default, the project is automatically saved after the calculation of each design iteration.
  - Especially for designs with short calculation times, this can generate a lot of overhead and slows down the optimization.
  - Thus, it is recommended to set the auto-save option to only every 50 or 100 finished designs.



#### **Parallelization of Design Calculation**

- Parallelization Settings
  - Some optimization algorithms allow a parallel computation of designs.
  - For instance in case evolutionary algorithm, the parameters of all member designs of one generation are known and thus can be calculated at the same time in order to reduce the computational time.
  - In order to allow parallel calculation, the execution of more than one solver has to be enabled.
  - By double-clicking the VirtualLab solver, this additional option can be found.
  - The recommendation is, to use between the half number up to all of the real cores of the CPU, depending on the parallelization of the calculation of each individual design.



- Run the optimization
  - Activate the Evolutionary Algorithm window within the Scenery by clicking on it.
  - Start the optimization by pushing the Run button.



# optiSLang – Optimization Results

- Optimization Results
  - After the optimization is finished the results are obtained within an additional window.



# optiSLang – Optimization Results

- Optimization Results
  - The Pareto 2D diagram visualizes both target values, Uniformity contrast and Mean Efficiency, as a point cloud.
  - There the user is able to select the most appropriate design for his application.
  - In this example the design no. 8842 was selected with ~16% uniformity contrast and ~20% mean efficiency.



# optiSLang – Optimization Results

- Optimization Results
  - Each design is stored within the optiSLang project directory in the subfolder ~\Optimization.opd\Evolutionary\_Algorithm.
  - Each folder within this directory, named by the design number, contains all the files necessary to import the design again to VirtualLab.

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Common settings

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### **VirtualLab Fusion – Import Optimization Result**

- Import design result
  - To import the design of interest the Import optiSLang Results feature is used, where the corresponding design folder is chosen.
  - Finally, the imported LPD can be analyzed further in VirtualLab.





• As a summary the table below shows a comparison of the grating parameter and the performance criteria for the initial and the optimized design setup.

Parameter	Value & Unit Initial Setup	Value & Unit Designed Setup
Slanted Grating: Fill Factor	50.00%	80.08%
Slanted Grating: z-Extension	400.00nm	411.96nm
Slanted Grating: Slanted Angle	40.00°	30.08°
Mean value	45.47%	19.49%
Uniformity Error	84.48%	16.32%

title	Grating Optimization in VirtualLab Using optiSLang
document code	LGC.0004
version	1.0
toolbox(es)	Starter Toolbox, Grating Toolbox
VL version used for simulations	7.4.0.49
category	Application Use Case
further reading	<ul> <li>Analysis of Slanted Gratings for Lightguide Coupling</li> <li>Optimization of Lightguide Coupling Grating for Single Incidence Direction</li> <li>RDO-Journal Article: <i>"Innovation in Optics and Photonics – VirtualLab</i> and OptiSLang"</li> </ul>