Application Scenario 20.01: Modeling of single mode fiber coupling system

Abstract
This application scenario demonstrates the simulation of a spherical (ball) lens used for coupling of light into a single mode fiber and shows the optimization of the fiber position via parameter run.

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Keywords: Fiber Coupling, Fiber Coupling Efficiency, Single Mode Fiber, Parameter Run, Ball Lens
Requirements: VirtualLab version 4.10.2 or higher – **Starter Toolbox**
Scenario Version: 2.1
Sample Files: Corresponding files can be found here.

Modeling Task

A simple optical system for fiber coupling with a spherical lens (see Fig. 1 for the setup) has to be modeled and simulated.

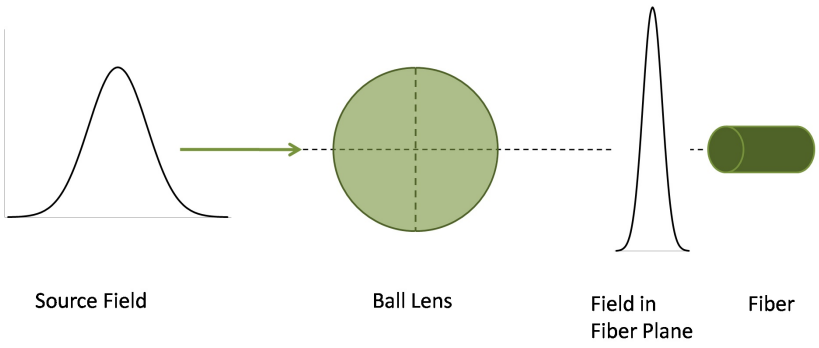

Figure 1. *Schematic diagram of the optical system.*

The lens in this example is a simple spherical ball lens made of SCHOTT's

N-SK5 glass. Only the front and the back segment of the lens are considered here as the first and the second surface as shown in Fig. 2.

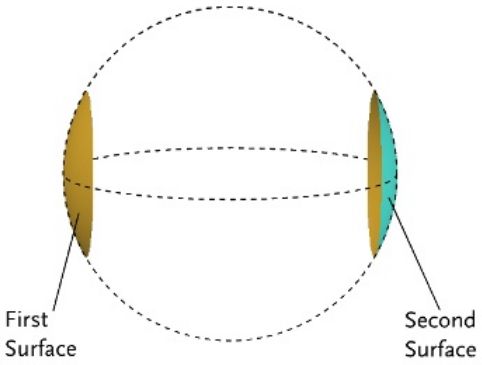

Figure 2. *Surfaces of the ball lens.*

Furthermore, the distance between lens and fiber has to be optimized for a maximum fiber coupling efficiency.

Solution with VirtualLab

The spherical lens is modeled here via two Conical Interfaces, that represent the spherical front and back surface of the lens.
The fiber coupling efficiency is determined by the Fiber Coupling Efficiency detector which calculates the overlap integral of the fiber mode and the light distribution. The mode of the fiber is calculated automatically from its numerical aperture (NA=0.11 in the example).
In order to find the optimal distance between lens and fiber one could examine the spherical phase of the field behind the lens' back side (so we placed a Virtual Screen here) or use the Parameter Run which is delivered as sample file to vary the distance and find the maximum coupling efficiency.

Results

If you load the sample Light Path Diagram and click *Go!*, you will see the resulting light distribution in the front plane of the fiber on a screen. The fiber coupling efficiency is printed to the Detector Results window at the bottom of the VirtualLab window. In the example it is 74.6%.
How to find the optimal distance between fiber and lens? If one examines the spherical phase of the field behind the lens' back surface (by fitting a spherical phase function to the phase of this field via menu Detector > Spherical Phase Radius) one will get a radius of $R_{sph} = 312\,\mu m$. But due to aberrations, caused by the lens, the use of this value as distance will not lead to the best result.
Instead of this procedure, the better way is the variation of the distance via Parameter Run. If you load the corresponding sample file, click till the page

"Results" and press *Output from Selection* after selecting the second table row, you will get the diagram shown in Fig. 3.

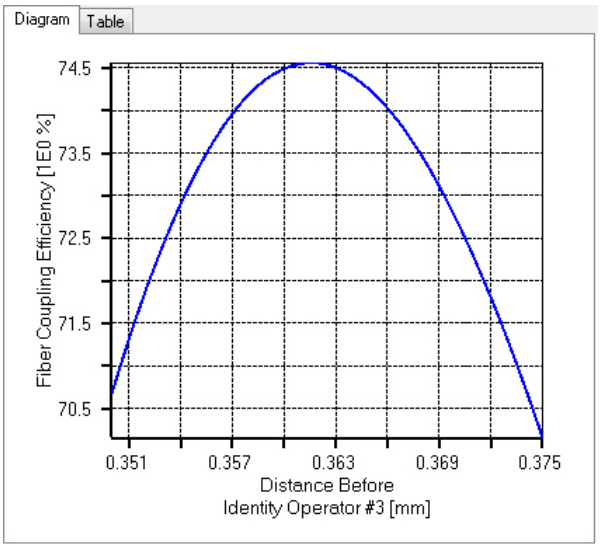

Figure 3. *Dependency of the fiber coupling efficiency on the distance between lens and fiber.*

In this diagram you can see the dependency of the fiber coupling efficiency on the distance between lens and fiber. The maximum is at $362\,\mu m$, so this distance is used in the sample Light Path Diagram.

Technical Support

If you have any questions, remarks or problems concerning this application scenario, or in using VirtualLab in general, please do not hesitate to contact us by E-Mail support@lighttrans.com.

Please use the update service to install the current version of VirtualLab. Alternatively you can use the latest **Trial Version** of VirtualLab which is available at our download site. If you have been registered already for an older trial version, just contact us by E-Mail.

To ensure that this application scenario gives the same results as described, set the global settings to the default values. In VirtualLab this can be done in the Extras > Global Options dialog with the *Reset All* button.