

Designing a Mode Converter

Products: BP Mode Solver (or FemSIM FEM),
BeamPROP BPM

Applications: PIC's

Introduction

It is frequently necessary to convert a larger mode, such as a fiber mode, down to the single mode of a Planar Lightwave Circuit (PLC). A mode converter can be used to allow for an adiabatic transition between two optical modes. This example illustrates the design and simulation of a mode converter that consists of two linearly-tapered rib waveguides which transition from a wide multimode waveguide to a smaller single mode Silicon-on-Insulator (SOI) waveguide. Two tapers will be used to convert between these two waveguides. The conversion efficiency of the coupler will be computed.

Structure Overview

The following example structure has been created in the **RSoft CAD Environment**:

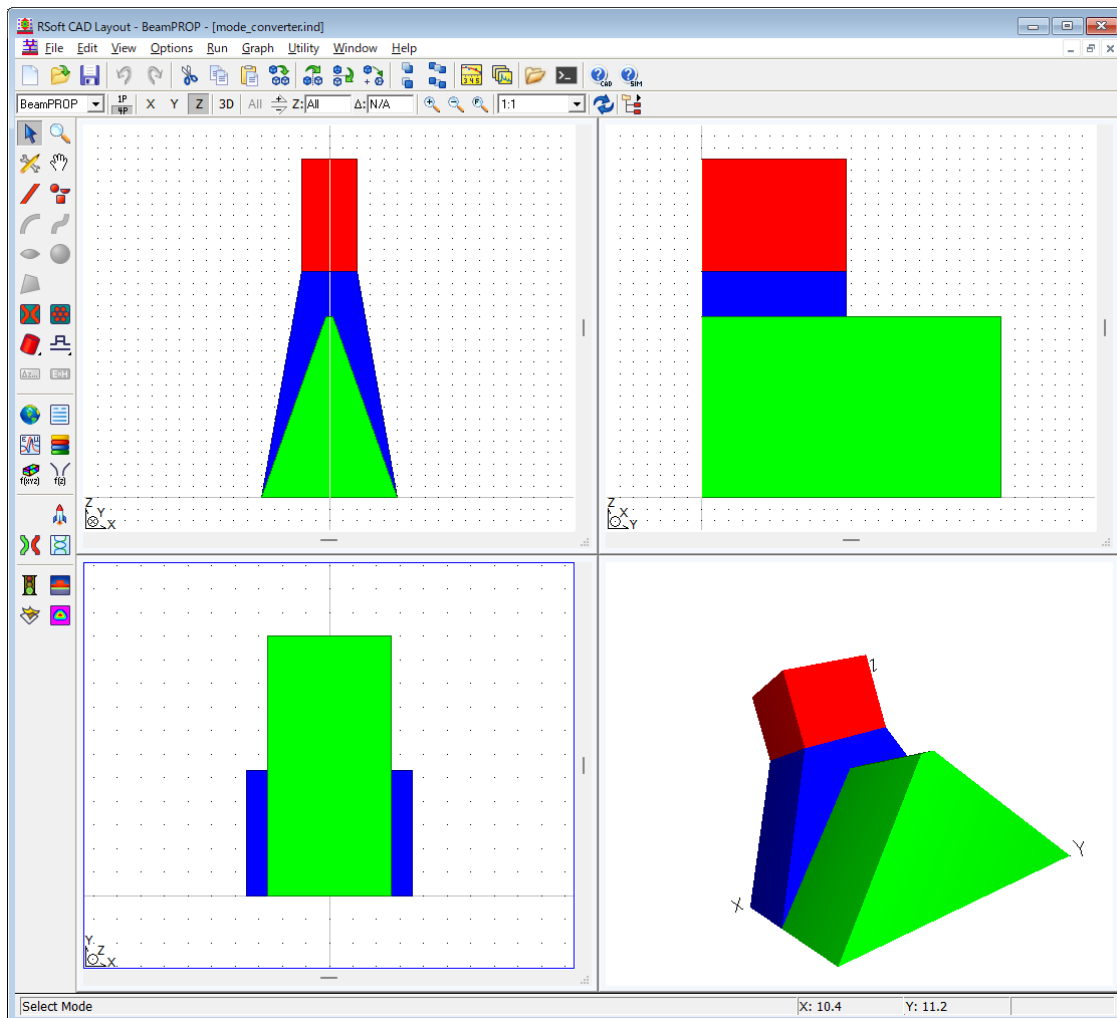


Figure 1. Example mode converter structure created in the RSoft CAD Environment

Please note the following aspects of the design:

- Three multilayer segments are used to create this structure to achieve the SOI structure and the two tapers.
- There are two independent variables: each controls the length of a taper.
- There is also a variable that controls the ending width of the tapers.

The value of these three variables can be optimized to maximize the coupling efficiency.

Solving for the Two Modes

Once the structure is defined, we need to compute the fundamental mode of the large multimode input waveguide and the small single mode waveguide. This can be done with the built-in **BPM mode-solvers** in the RSoft CAD.

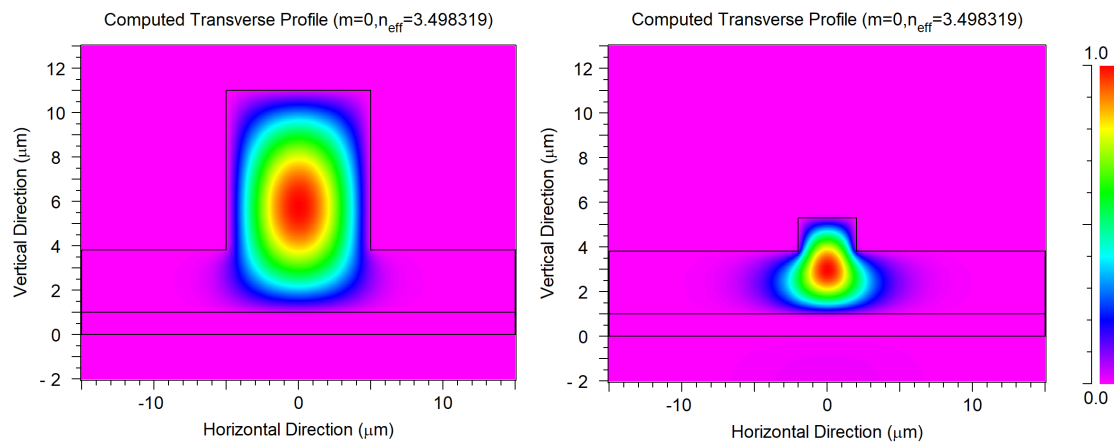


Figure 2. Computed transverse mode profiles

Checking the Index Profile

The index profile at the starting, middle, and end of the structure can be computed:

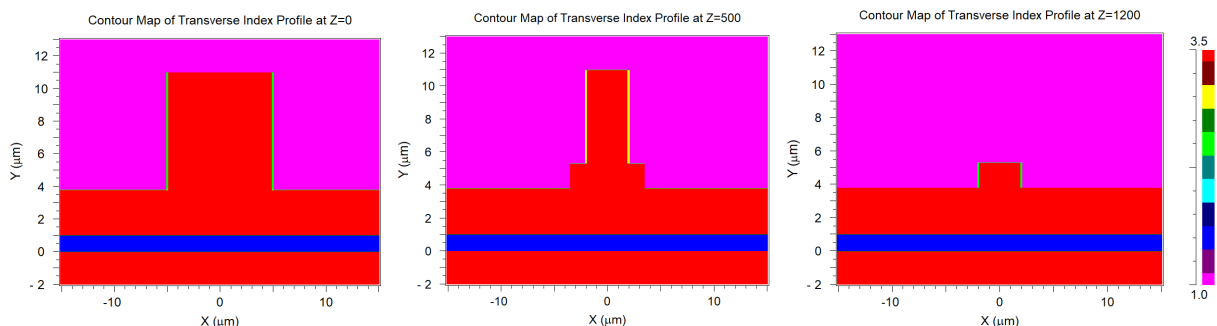


Figure 3. Index profile at the starting, middle, and end of the structure

Note: When calculating the mode, launch field y-position is set to 5.

Simulation

The goal is to get optimal conversion between the two modes, and so it is necessary to measure the power in each mode. Three **BeamPROP** monitors were created to measure the total power in the domain, power in the input mode, and power in the output mode along the structure (along the Z axis).

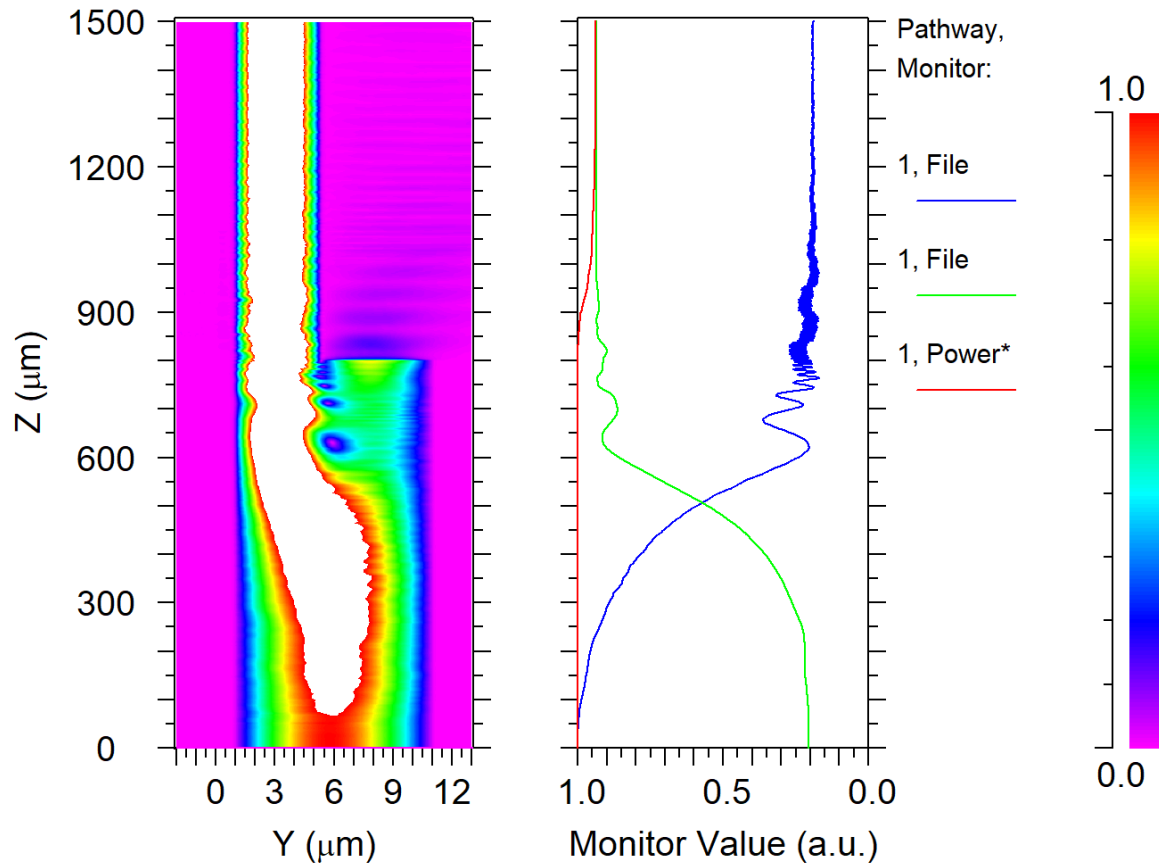


Figure 4. The simulation results. Left: Cross-section of the fields. Right: Monitor results

Figure 4 shows the simulation results with a cross-section of the fields shown on the left and the monitor results shown on the right. The monitor that gives the power in the output mode is the green line, and it shows about a 93% conversion efficiency. The blue line is a monitor that takes the overlap integral of the input mode and the propagating field, and the red line is a special monitor that calculates the total power in the simulation domain. All data produced by this simulation is saved in a simple text format that can easily be accessed for further study

Conclusion

This application note demonstrates the design of a silicon photonic mode converter using Keysight RSoft Photonic Device Tools, including BP Mode Solver and BeamPROP BPM. The converter employs tapered rib waveguides to efficiently transition light from a input waveguide to a single-mode SOI waveguide. Mode profiles, index distributions, and optical propagation are analyzed to optimize taper dimensions and maximize coupling efficiency. Simulation results show approximately 93% mode conversion efficiency, highlighting the effectiveness of the design methodology. This workflow provides an efficient approach for modeling, simulating, and optimizing PIC mode converters for integrated photonics applications.

Example files

Designing a Mode Converter

This example is located in the following RSoft example folder:

<RSoft installation folder>\RSoft\examples\BeamPROP\tutorial\tut10\mode_converter.ind

References

Keysight Optical Solutions Multi-Physics Utilities User Guide

- BeamPROP BPM Simulation » 9 Tutorial Examples » Tutorial 10: Designing a Mode Converter



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