Electromagnetic Design of
flexIble SensOrs

Report 3. Results of analysis in HFSS

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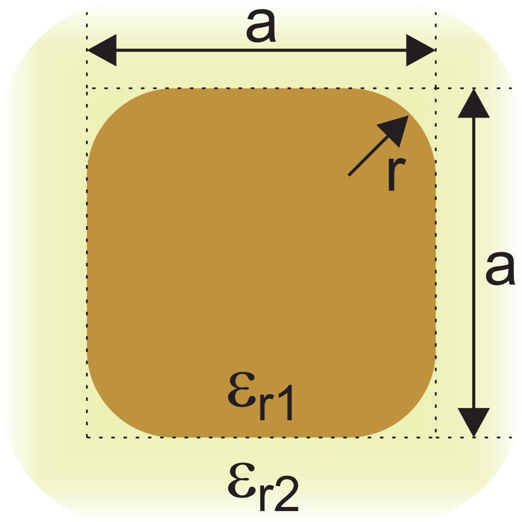

Figure 1: The geometry of the square with rounded corners fiber cross-section. The material parameters: $\varepsilon_{r1} = 8.41$, $\varepsilon_{r2} = 2.4025$.

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1.0	3.07.2017	M. Warecka	created

0.0.1 Introduction

The aim of the report is to show the results of analysis in HFSS, and to compare them with the results of analysis based on field matching method. The commercial software (HFSS) uses finite elements method, and for all the simulations the order of basic functions was set as first order. The waveguide core was coated with a cyllinder with $4\mu m$ external radius, and boundary conditions were set on the side of the coat as radiation. To design the proper shape of cross section in editor, the core was a combination of basic shapes. Rounded corners were obtained by adding a circle with its centre in each corner, and adding a rectangle on each side. To create a proper shape of cross section for simulations, all objects in core of the fiber needed to be unite and the volume of core had to be cut out in the outer volume of the coat. All the geometrical dimensions and permeabilities were in accordance with previous simulations.

0.0.2 Square with rounded corners fiber

The first structure is a dielectric fiber with square cross-section (rounded corners) with the same material parameters as in the previous report (Fig. 1). The cross section of the waveguide core is a combination of one square, four rectangles and four circles. Results of previous analysis are confronted with result of HFSS analysis in Fig. 2. The convergence field matching method analysis is presented in table 2 and HFSS solution is used to calculate the percentage error.

0.0.3 Triangular with rounded corners fiber

The last structure is the triangular fiber with rounded corners (Fig. 3). The cross section of the waveguide core is a combination of one triangle, three rectangles and three circles. Results of previous analysis are confronted with result of HFSS analysis in Fig. 4. The convergence field matching method analysis is presented in table 3 and HFSS solution is used to calculate the percentage error.

0.0.4 Summary

The error between HFSS results and results based on field matching method is under 1 %. The field matching method can be recognized as a well functioning method to find propagation coefficients for

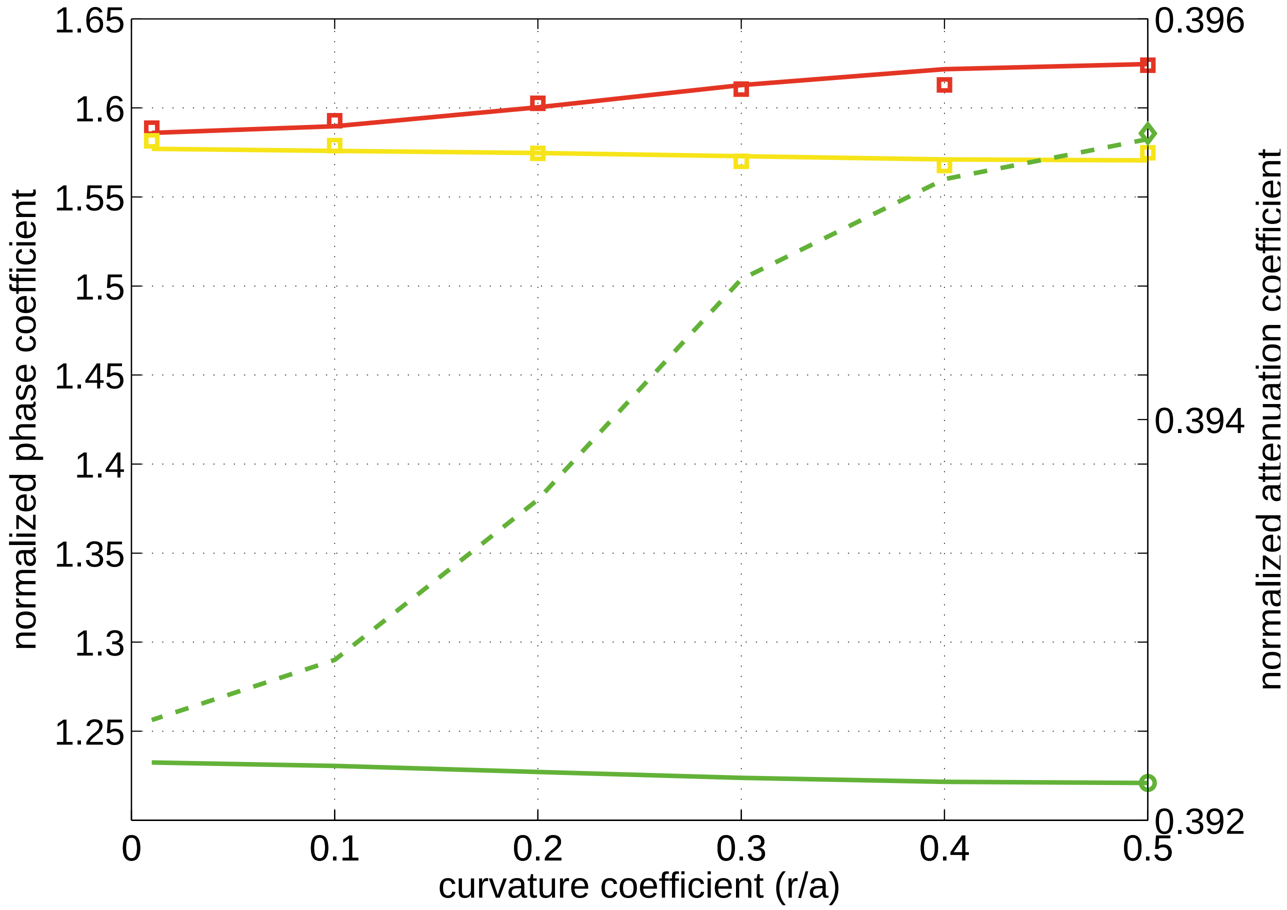

Figure 2: The propagation coefficients for the square fiber in function of corner curvature. Solid line - normalized phase coefficients; dashed line - normalized attenuation; squares - HFSS results; circles and diamonds analytical results.

Table 2: Convergence of the method for the square fiber (values of propagation coefficients). Percentage error in brackets with respect to HFSS solution.

M	$P = 90$	$P = 180$	$P = 360$	$P = 720$
5	1.5763 (-0.1628%)	1.5764 (-0.1564%)	1.5764 (-0.1564%)	1.5765 (-0.1501%)
6	1.5763 (-0.1628%)	1.5765 (-0.1501%)	1.5765 (-0.1501%)	1.5765 (-0.1501%)
7	1.5763 (-0.1628%)	1.5764 (-0.1564%)	1.5764 (-0.1564%)	1.5765 (-0.1501%)
8	1.5779 (-0.0614%)	1.5781 (-0.0488%)	1.5781 (-0.0488%)	1.5781 (-0.0488%)
9	1.5779 (-0.0614%)	1.5781 (-0.0488%)	1.5781 (-0.0488%)	1.5781 (-0.0488%)
10	1.5779 (-0.0614%)	1.5781 (-0.0488%)	1.5781 (-0.0488%)	1.5781 (-0.0488%)

guided modes. The advantage of the method is that it can easily find propagation coefficients for complex and leaky modes.

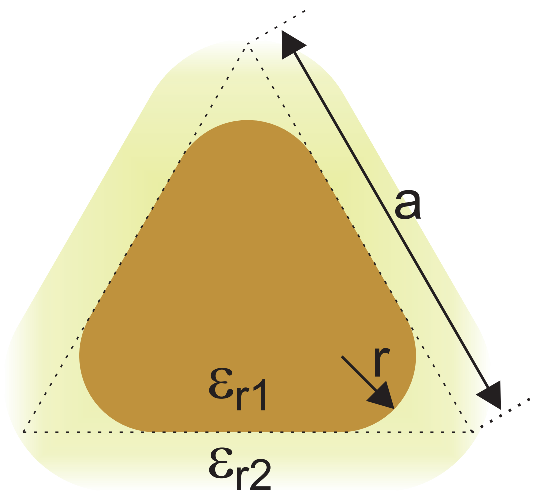

Figure 3: The geometry of the triangular with rounded corners fiber cross-section. The material parameters: $\varepsilon_{r1} = 8.41$, $\varepsilon_{r2} = 2.4025$.

Table 3: Convergence of the method for the triangle fiber (values of propagation coefficients). Percentage error in brackets with respect to HFSS solution.

M	$P = 90$	$P = 180$	$P = 360$	$P = 720$
5	1.5907 (-0.6198%)	1.5910 (-0.6010%)	1.5910 (-0.6010%)	1.5910 (-0.6010%)
6	1.5959 (-0.2949%)	1.5963 (-0.2699%)	1.5963 (-0.2699%)	1.5963 (-0.2699%)
7	1.5959 (-0.2949%)	1.5963 (-0.2699%)	1.5963 (-0.2699%)	1.5963 (-0.2699%)
8	1.5959 (-0.2949%)	1.5963 (-0.2699%)	1.5963 (-0.2699%)	1.5963 (-0.2699%)
9	1.5983 (-0.1449%)	1.5987 (-0.1200%)	1.5987 (-0.1200%)	1.5987 (-0.1200%)
10	1.5983 (-0.1449%)	1.5987 (-0.1200%)	1.5987 (-0.1200%)	1.5987 (-0.1200%)

References

[1] P. Kowalczyk, "Complex Root Finding Algorithm Based on Delaunay Triangulation", *ACM Trans. Math. Softw.*, vol. 41,no. 3, pp. 19:1-19:13, Jun. 2015.

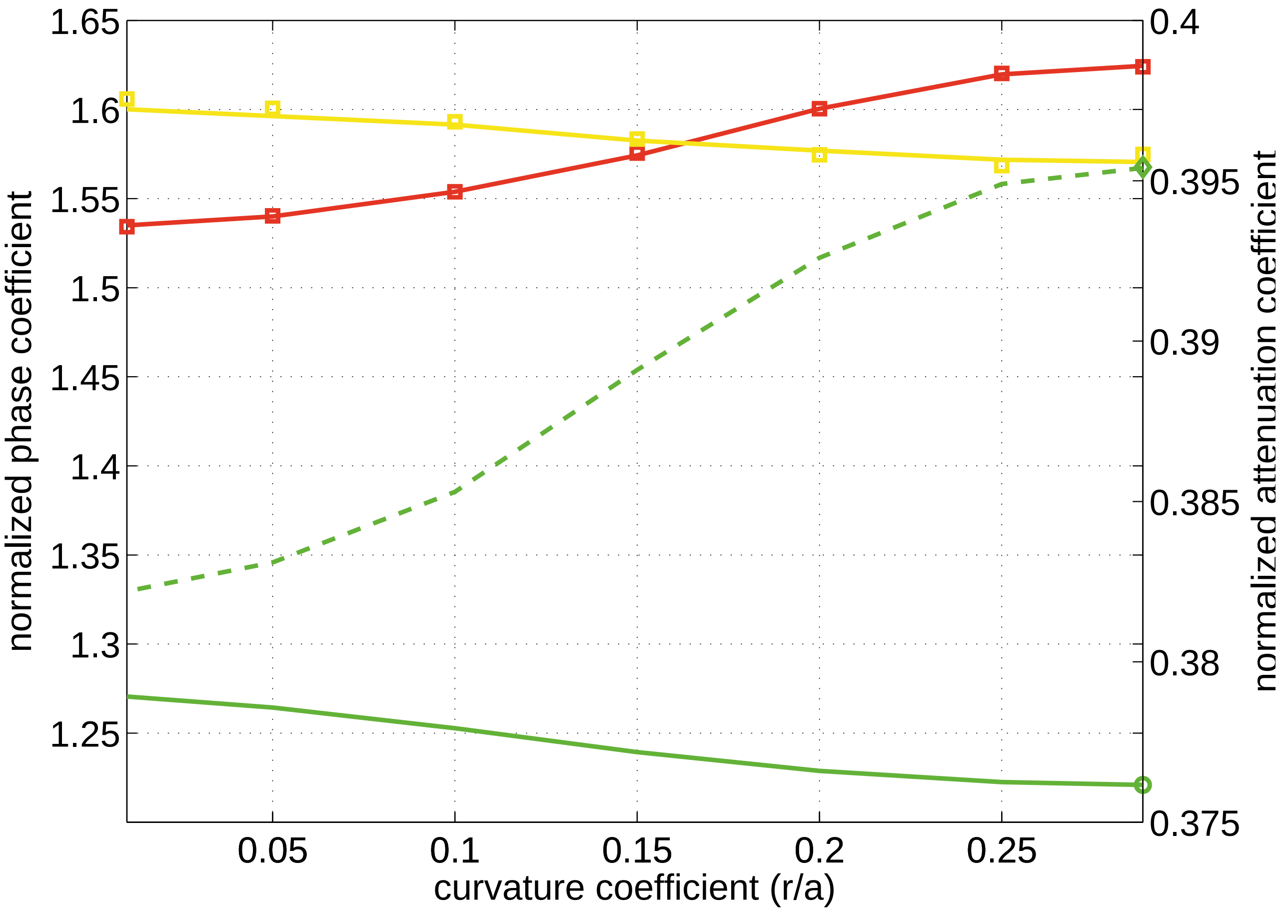

Figure 4: The propagation coefficients for the triangular fiber in function of corner curvature. Solid line - normalized phase coefficients; dashed line - normalized attenuation; squares - HFSS results; circles and diamonds analytical results.