Study of Bending Losses in Optical Fibers Using COMSOL Multiphysics®

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Abstract

In FTTH, optical fibers are frequently bent at the corners of the walls causing the propagating light in the fiber to radiate away which results in transmission losses and limits reach of the fiber network. A large number of studies have been reported in the literature to compute bend-induced losses in fibers. However, most studies assume simple refractive index profiles such as step-index profile and include the effects of stress due to bending of fiber in an ad hoc manner by modifying the bend radius R to effective bend radius Reff = (1+δ)R, where δ is a number in the range {0.28, 0.31}. For simulations with arbitrary refractive index profiles, which are encountered commonly in practice, the refractive index of the bent fiber is modified into refractive index of an equivalent straight fiber using simple conformal mapping techniques.

In this paper, we present a completely different approach for computing the modified refractive index profile of the bent fiber and compute bending losses. Specifically, we apply the geometrically exact beam theory (GEBT) and stress-optics law to account for stress effect of bent fibers, followed by conformal mapping to account for geometric effect of bending in order to obtain the modified refractive index profile. The modified index is imported to COMSOL® using Interpolation function, which performs linear interpolation of the data. A 2D cross section of the fiber, with core and cladding is defined as the geometry of the model. We use Electromagnetic Waves, Frequency Domain physics, and Mode Analysis study from Wave Optics module for solving the wave equation to obtain the effective index of the propagating modes in the bent fiber. A Perfectly Matched Layer (PML) is included in the geometry to avoid the unwanted interference of mode fields confined in core and reflecting the radiation from cladding interface. We study the effect of PML thickness on effective index and find that the sensitivity is negligible for PML thickness of 7λ. A Physics-Controlled mesh with Fine Element size was applied to the geometry. Bend Loss was computed from the imaginary part of the effective index for bend diameters in the range {5.5, 19.5} mm at 1550 nm. Finally, by comparing our results with those of the literature, we find that our formulas agree well with experiments, especially at low bend diameters.

Figures used in the abstract

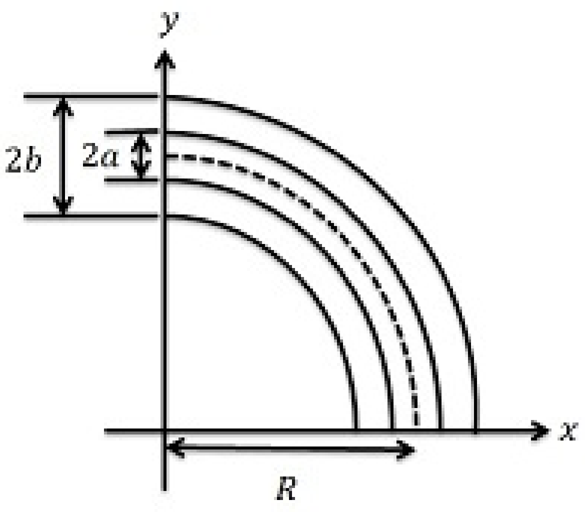

Figure 1: Schematic of Optical Fiber Bent in Planar Loop