Simulation Study of Macrobending and Microbending Losses of a Single Mode Step Index Optical Fiber

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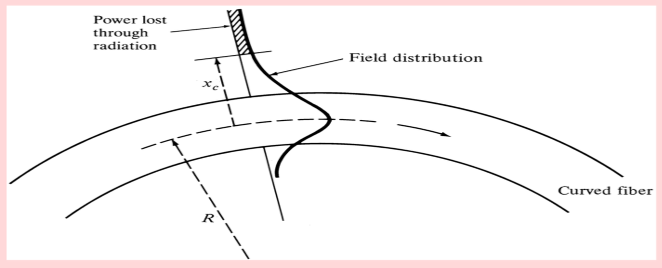
ABSTRACT

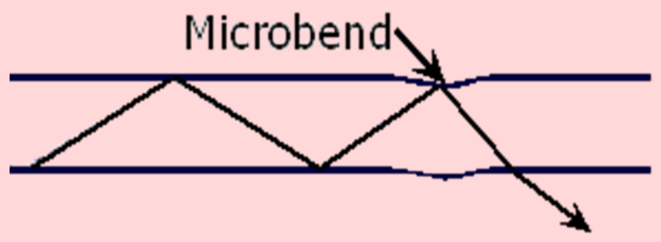
Optical fiber forms the basis of local, national and international network. It is used mostly as a means to transmit light between the two ends of the fiber and wide usage in fiber -optic communications, where they permit transmission over longer distances than copper cables. But the fiber itself has many chances to attenuate the transmitting signal. Macrobending and microbending losses are the important sources of signal loss. Therefore, it is essential to optimize these losses of the transmitting signal. We perform a simulation study of the macrobending and microbending losses of a single mode step index optical fiber. The study has been done by using the software "Understanding Fiber Optics on a PC". From this study, it has been found that the minimum macrobending and microbending losses are obtained at an operating wavelength of 1.3 µm, core radius of 4.0 µm, relative refractive index difference of 0.35% .Using these parameters, a fiber is capable to curve of 7 cm bend radius without any signal loss This result may be an important consideration for designing of a good optical fiber.

INTRODUCTION

•An optical fiber is a transparent conduit as thin as human hair made of silica glass [1].
•It consists of highly refractive index of core, surrounded by a lower refractive index of cladding.
•Now-a day's optical fiber is widely used than electrical copper cables because of its smaller size, high bandwidth, very low transmission loss.
•We perform simulation study of bending and microbending losses for **SMSIF** because it is the best road for telecommunication process [2].
•Bending is the permanent reasons which can increase the fiber attenuation by two mechanisms: **macrobending and microbending.**
•When a fiber is bent through a large angle, the refractive index and critical angle changes on that region and hence signal escape out through cladding. This is referred as macrobending losses of the fiber.
•When a fiber is jacked or cabled; it is subjected to varying pressure at different places due to the surface roughness. This random bend radii causes microbending losses [3].



Macrobend losses due to bend of the fiber



Microbend losses due to external forces

OBJECTIVES

- To find out the effective fiber parameters for signal transmission.
- Reducing the bend loss for both macrobending and microbending.
- To optimize the loss with other fiber parameters for designing a good fiber.

MATERIALS AND METHODS

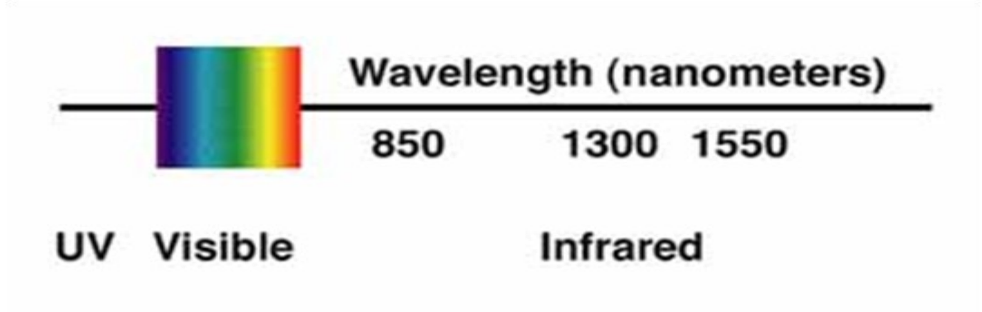
- We use the software ***GST*** of ***"Understanding Fiber Optics on a PC".***

•The software gives numerical appreciation and graphical representations of the characteristics of the optical fiber.
•It allows the user to interactively change the parameters of to create the examples.
•The software is written in a userfriendly manner and based on menus and predefined keys.
•We use the software through the study and prepare the data tables and graphical representations.

IMPORTANT FIBER PARAMETERS

Wavelength of light (λ)

- For glass fibers, light in the infrared regions is generally used, typically around 850, 1300 and 1550 *nm* [4] .



•In the SMF, the operating wavelength of 1300 or 1550 *nm* is widely used for long distance communication [5].

•The wavelength of **1300 *nm*** is used for the present work where the attenuation is lowest.

Refractive index of the core n_1 = **1.470 µm**

Radius of core, a (µm): 4.0

***V*- number: < 2.405**

SPOT-SIZE

Spot-size is the parameter which is different for different profile and different V- values. It represents the transverse extent of the field.

Spot-size related to transverse offset → $W_\infty\,(\mu m)$

Spot-size related to Bending loss → $\overline{W}\,(\mu m)$

Mathematical Formula

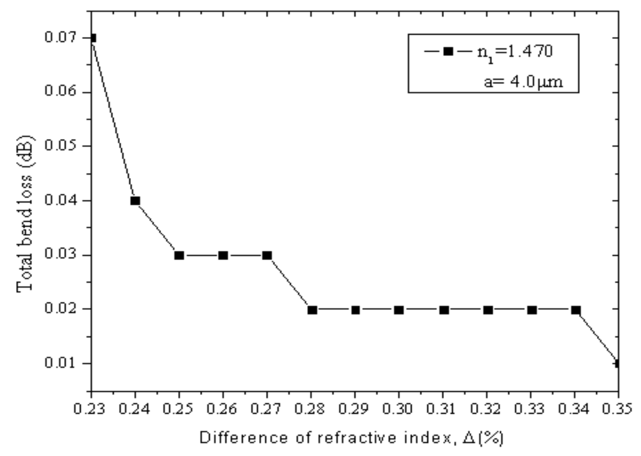
***V*-numberDifference of refractive index(Δ)** → $V = \frac{2\pi}{\lambda} a\sqrt{(n_1^2 - n_2^2)}$

Maximum acceptance angle → $i_m = \sin^{-1}\sqrt{(n_1^2 - n_2^2)}$

RESULTS AND DISCUSSION

The following Figure shows how bend loss changes in terms of refractive index diffeences between core and cladding. Here we fix the following values.

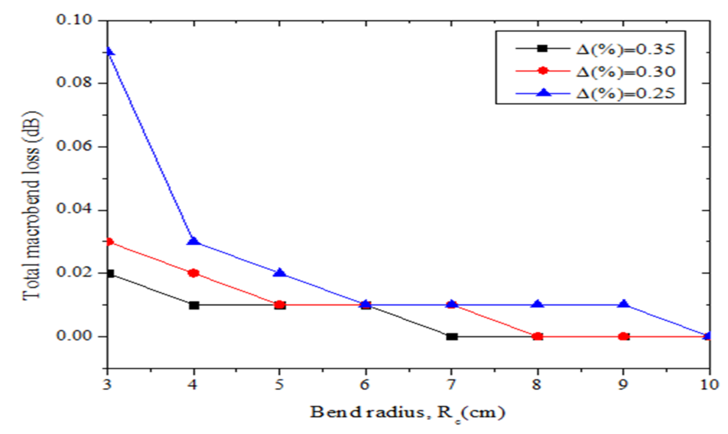
- Wavelength, λ= 1300 nm
- Refractive index of core=1.470
- Radius of core, a = 4.0 µm



Total bend loss vs difference of refractive index

- From this it is observed that for larger refractive index differences (0.35%), bend loss becomes minimum.
- Alternatively for smaller refractive index difference (0.23%), bend loss becomes very high.

TOTAL MACROBEND LOSS IN TERMS OF BEND RADIUS



Total macrobend loss vs bend radius

- From this figure it is observed that when Δ (%)=0.35, total macrobend loss becomes zero at 7 cm of bending radius.
- When Δ(%)=0.30, bend loss becomes zero at 8 cm of bending radius.
- Again when Δ(%)=0.25, bend loss becomes zero at 10 cm of bending radius.

MICROBEND LOSS IN TERMS OF SPOT- SIZE

$\lambda(\mu m)$	$a(\mu m)$	n_1	$\Delta(\%)$	W_∞	$\overline{W}$	$W_\infty/\overline{W}$
1.3	4.0	1.470	0.35	4.648	4.360	1.06
1.3	4.0	1.470	0.30	5.265	4.610	1.14
1.3	4.0	1.470	0.25	6.152	4.951	1.24

From this table it is observed that for 0.35% refractive index differences, the values of spot-sizes becomes smaller and also it's spot-sizes ratio becomes very close to unity. So for that case microbend loss will reduce to zero than the others

TOTAL MACROBEND AND MICROBEND LOSS

$\lambda(\mu m)$	$a(\mu m)$	$\Delta(\%)$	i_m (deg	V	$R_c(cm)$	Bend loss (dB)	$W_\infty/\overline{W}$
1.3	4.0	0.35	7.10	2.388	7	0.00	1.06
1.3	4.0	0.30	6.60	2.222	8	0.00	1.14
1.3	4.0	0.25	5.98	2.105	10	0.00	1.24

CONCLUSION

•A small change of refractive index cause small amount of bending loss.
•Larger refractive index difference between core and cladding gives lower loss of macrobending.
•Smaller refractive index difference between core and cladding gives higher loss of macrobending.
•Larger spot-size gives higher loss of microbending.

REFERENCES

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