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The Effect of the Mode Solver on the Optical Fiber Characteristics

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Abstract

The loss and dispersion of optical fiber are essential characteristics that should be identified in fiber optics design as optical transmission lines. To obtain acceptable Dispersion compensated fiber DCF, one way to achieve high negative dispersion is to modify the refractive index definition of DCF. In this paper, using the optifiber software, the zero dispersion wave length (ZDW) conversion is a transformer by changing the standard single-mode fiber S-SMF standard refractive index profile for single-mode fibers, and then promoting a profile designed to reduce dispersion, bending loss and splice loss. Performance analysis is done using two design of fiber profiles using finite difference method analysis. The achieved results, by compared the characteristics of the step-index with two ring profiles in two different designs analysis, it has been found that better results for dispersion and loss done by decreasing the width of the core and cladding region inside the fiber.

Keywords: Refractive index; Negative dispersion; Dispersion; Loss; Optiwave software

Introduction

In the optical communication system, different types of fiber operate on different applications. Optical fibers are not only used in telecommunication but are also used in the Internet and local area network (LAN) to generate a high signal rate. In optical network, based on the emergence of the optical layer of optical transport networks to prove high capacity and reduce the price for modern applications such as the Internet, video and multi-media interconnection, and digital services complex. But there are linear and nonlinear properties of optical fibers that are important to reaching the goal. Fiber is a dielectric waveguide or medium the information (audio, data or video) is transferred through Fiberglass or plastic, in the form of light. Consists of Transparent core with a single refractive index n_1 surrounded by a transparent cladding of the n_2 indicator is slightly lower. The refractive index of the cladding is less than 1%, less than that of Core. For single standard mode fibers, the polarization mode dispersion is the phenomenon that caused obstacles to achieve a high rate bit rate of amplifying the communication system wave light. The detailed study of the effects of various fibroblasts, temperature, stress, bend radius, elliptic on PMD are done [1,2].

Loss and dispersion are fundamental parameters that should be identified as far as possible in fiber optic design as optical transmission lines. To obtain acceptable compensation for DCF dispersion, one method of achieving high negative dispersion is to modify the definition of the refractive index in DCF.

Dispersion -Shifted Fiber (DSF) is a type of optical fiber that has been manufactured to improve both low dispersion and low attenuation. DSF is a single-mode optical fiber with primary corrosion the index profile is designed to change the wavelength of zero-dispersion from 1300 nm in natural fiberglass to silica minimum window loss at 1550 nm. The total dispersion of single-mode fibers includes both material dispersion and waveguide. The group velocity or total dispersion that dominates the single-mode fiber includes both material dispersion and waveguide [3]. Waveguide Dispersion can be more negative by changing the indicator the profile is therefore used to compensate for the dispersion of stationary materials, shifting or flattening of total muscle dispersion [2].

This is useful because it allows communication that the system has low dispersion and low attenuation. However, when used in the waveform gap multiply systems, dispersion fiber can be transformed from four-wave Confusion that causes independent intermodulation References. The result of non-zero shifted fiber dispersion is turned user manual [3].

In this paper, using the optifiber software, unshifted single-mode fibers(USMF) have the lowest dispersion at 1300 nm wavelength, while the dispersion at 1550 nm is the highest and the attenuation at the lowest value of the ZWD is converted by changing the refractive index definition of S-SMF coil, and then is enhanced low dispersion profile, bending loss and paste loss.

Design and Methodology

Zero dispersion fiber profile design

The Ring- index fiber is characterized by the minimum refractive value in the optical fuse axis. Therefore, the profile refractive has a loop shape. The fiber parameters are the central refractive size in the geometric sense and refraction, the relative thickness of the refractive ring core versus the value of λ. The transmission fibers used in optical communication systems should have as much positive as possible in the third visual communication window. For the purpose of our study is the design of new DSFs with low dispersion tendency and small negative dispersion to preserve the advantages of the original DSFs in the fight against dispersion and nonlinear properties, With the DWDM operating window extended through a low dispersion ramp and improved dispersion Ability to manage through passive dispersion design [4].

The material dispersion can be found by:

$$D_m = \frac{d}{d\lambda}\left[\frac{1}{v_g}\right] = -\frac{\lambda}{c} \times \frac{d^2 n}{d\lambda^2} \text{---------------(1)}$$

Where λ, is the wavelength, c: is the velocity, n: is the refractive index.

By using optifiber software the effective refractive index of the core and cladding region is express as:

$$n_{eff} = \frac{n_{ec} + n_{er}}{2} \pm \sqrt{k^2 + \left(\frac{n_{ec} + n_{er}}{2}\right)^2} \text{-----------(2)}$$

Where n_{ec}=effective refractive index of the core.n_{er} = effective index of the ring region.

K=coupling strength between core and cladding modes.

The Total dispersion express as the following [4]:

$$D = -\frac{\lambda}{C} \times \frac{d^2\left(n_{eff}\right)}{d\lambda^2} \text{------------(3)}$$

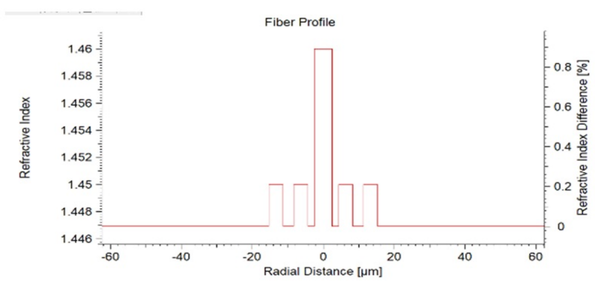

Figure 1: Step-index fiber profile.

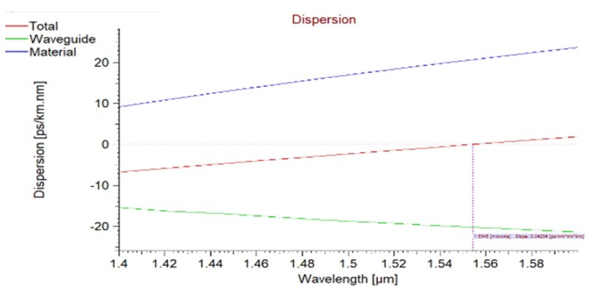

Figure 2: Dispersion of the step-index fiber.

Figure 1, shows the step-index with two ring profiles for zero-dispersion wavelength (ZDW), which consists of six index regions. The region 1 has a radius of 2.5 µm, with the refractive index 1.46. The cladding is divided in five regions 2, 3, 4, 5 and 6 with different radius of 1.32, 1.5, 1.32, 1.5, 53.87 µm respectively.

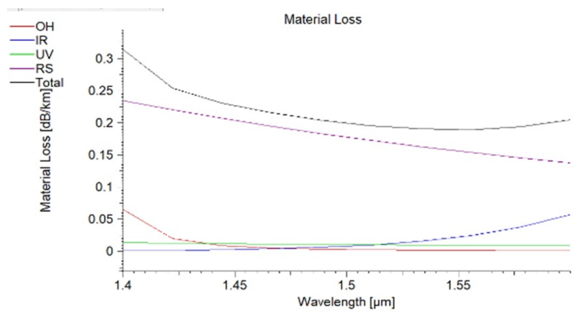

Figure 3: Relationship between attenuation and wavelength for step-index fiber.

The index of cladding regions is 1.44692, 1.45, 1.44692, 1.45, and 1.44692 respectively. In total, the diameter of the fiber is 125 µm. Figure 2 shows the dispersion properties of the step-index appear with two ring profiles, Indicating wavelength at 1.5545 µm. The dispersion slope is obtained as 0.04294 ps/nm.nm.km (Figures 3-5) shows the material, bending, splice loss, respectively.

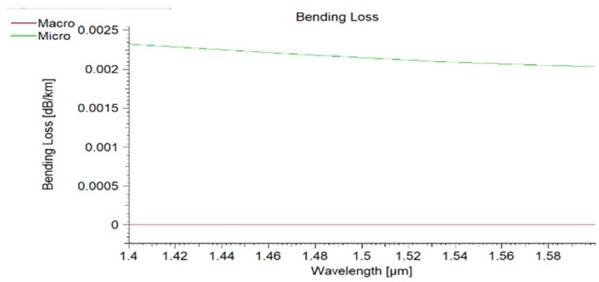

Figure 4: Relationship between bending loss and wavelength for step-index fiber.

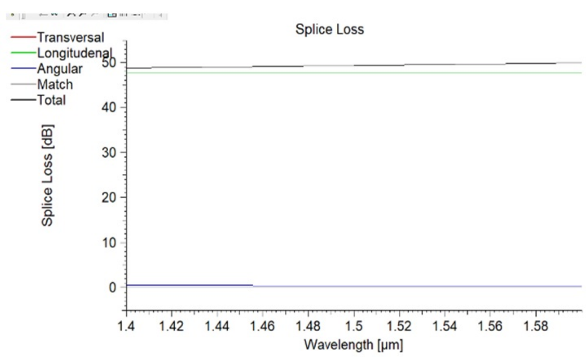

Figure 5: Relationship between splice loss and wavelength for step-index fiber.

By increasing the distance between the ring and the core centre, the zero-dispersion wavelength (ZDW) shifted at 1.4288 µm. The width for the cladding radius is increased to, 1.8, 4, 3, 4, 47.2 µm, respectively. The total diameter of the optimized fiber still 125 µm. The index of cladding regions is 1.44692, 1.45, 1.44692, 1.45, 1.44692 respectively the new fiber profile shown in Figures 6 and 7, to indicate zero-dispersion wavelength at 1.4288 µm, with dispersion slop is 0.04815 ps/nm^2.km as shown in Figure 8. Figures 9 and 10 shows the material, bending, splice loss, respectively.

Bending loss

Bending in optical fiber also causes loss which is divided into two types: macro bending loss and micro bending loss. Macrobends are curves with a large radius of curvature relative to fiber diameter, where the fibers are subjected to full bending, which leads to the non-reflection of certain situations and thus causes loss of cladding [5].

While the micro bends happen when, either the core or the cladding are subject to slight curvature on its surface. It causes the reflection of light at angles when there is no additional reflection [6]. The Bending loss is shown in Figures 4-9.

The macrobening loss model in dB comes from [6],

$$\alpha_{macro} = \frac{10}{L} log\frac{p_{in}}{p_{out}} = \frac{10}{L} log[exp(\gamma L)] = \frac{10}{ln(10)} \text{--------(4)}$$

The micro bending loss is found by:

$$\alpha_{micro} = a\left(kn_1 d_n\right)^2 \left(kn_1 d_n\right)^p \text{-------(5)}$$

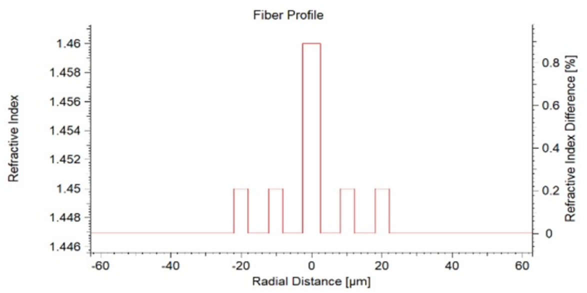

Figure 6: Optimized step-index profile.

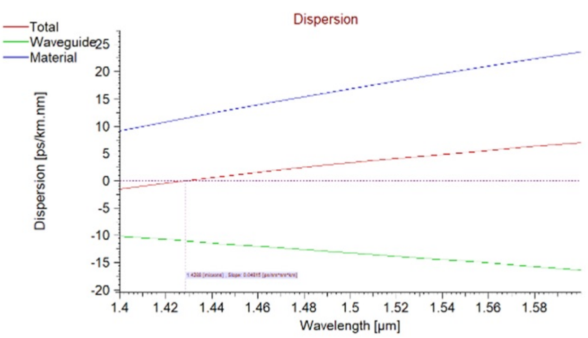

Figure 7: Dispersion of the optimized step-index fiber.

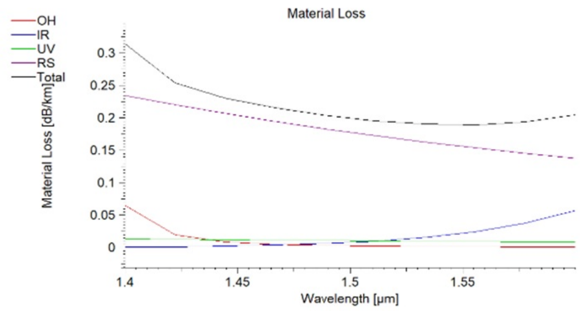

Figure 8: Relationship between attenuation and wavelength for optimized step-index fiber.

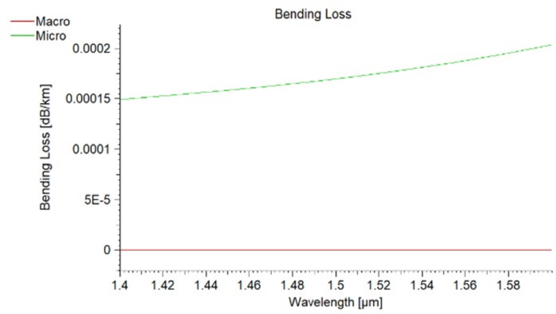

Figure 9: Relationship between bending loss and wavelength for optimized step-index fiber.

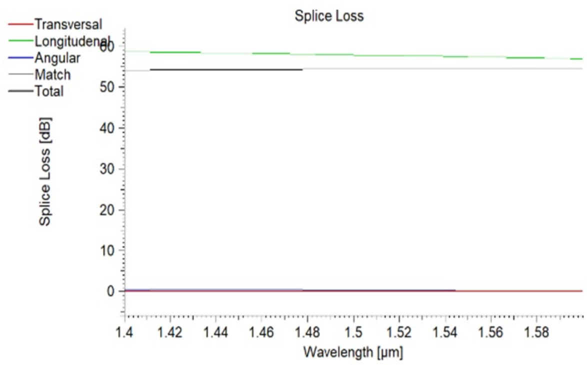

Figure 10: Relationship between splice wave length for optimized step-index fiber.

Splice loss

Defined as the link indicates that a portion of the optical power is not sent over the link and radiates of fibers. The total loss in decibels is given in the following equation:

$$\alpha_{splice} = 10\log_{10}\frac{p_{in}}{p_{trans}}\text{----------(6)}$$

Where pin is the total power incident on the fusion splice and Ptrans is the desirable portion of the optical power transmitted across the fusion splice [7]. The splice loss is shown in Figures 5-10.

Results and Discussion

In Figures 2 and 7 shows the relationship materials, waveguide, total dispersion with wavelength for step-index with two ring (ZDW) fiber profile before and after optimizing. The total attenuation and the macro bending, micro bending loss of the (ZDW) fiber profile designed are plotted in Figures 3, 4, 8 and 9, before and after optimized respectively. The relation between the splice loss and the wavelength for ZDW shown in Figures 5 and 10 before and after optimized respectively. The dispersion of the two ring step-index profile is plotted in Figure 6; the ZDW is shifted from 1.5545 µm to 1.4288 µm. The comparison of designed parameters recorded in the Tables 1 and 2.

Wave length [µm]	Group Delay	Waveguide Disp.	Material Disp.	Total Disp.	Macro Bend loss
1.2	4.93E+06	-8.03E+00	-1.13E+01	-2.00E+01	9.48E-71
1.24444	4.92E+06	-9.69E+00	-5.94E+00	-1.63E+01	1.17E-63
1.28889	4.92E+06	-1.14E+01	-1.11E+00	-1.31E+01	3.05E-57
1.33333	4.92E+06	-1.30E+01	3.27E+00	-1.03E+01	1.98E-51
1.37778	4.92E+06	-1.47E+01	7.29E+00	-7.96E+00	3.62E-46
1.42222	4.92E+06	-1.63E+01	1.10E+01	-5.81E+00	2.10E-41
1.46667	4.92E+06	-1.76E+01	1.45E+01	-3.77E+00	4.32E-37
1.51111	4.9227513+006	-1.91E+01	1.77E+01	-1.85E+00	3.45E-29
1.55556	4.92E+06	-2.03E+01	2.08E+01	4.59E+02	1.16E-29
1.6	4.92E+06	-2.14E+01	2.37E+01	1.91E+00	1.80E-26

Table 1: The parameters for step- index with two ring fiber.

Wavelength [µm]	Group Delay	Waveguide Disp.	Material Disp.	Total Disp.	Macro Bend loss
1.2	4.93E+06	-4.66E+00	-1.13E+01	-1.66E+01	5.32E-66
1.24444	4.9258437+006	-5.81E+00	-5.97E+00	-1.23E+01	5.04E-59
1.28889	4.93E+06	-7.02E+00	-1.15E+00	-8.70E+00	1.09E-52
1.33333	4.93E+06	-8.28E+00	3.23E+00	-5.54E+00	6.18E-47
1.37778	4.92E+06	-9.56E+00	7.25E+00	-2.68E+00	1.05E-41
1.42222	4.92E+06	-1.08E+01	1.10E+01	-3.15E+01	5.94E-37
1.46667	4.92E+06	-1.22E+01	1.44E+01	1.92E+00	1.24E-32
1.51111	4.92E+06	-1.36E+01	1.77E+01	3.81E+00	1.04E-28
1.55556	4.93E+06	-1.49E+01	2.07E+01	5.42E+00	3.77E-25
1.6	4.93E+06	-1.64E+01	2.37E+01	6.98E+00	6.39E-22

Table 2: The parameters for optimized step-index with two ring fiber.

Conclusion

In this paper, after using two different fibers design (single step with two rings), we conclude that when increasing the distance between the ring and the core center of the fiber, the zero-dispersion wavelength (ZDW) shifted from (1.5545 µm) to (1.4288 µm) with macro bending (1.16429-029), (5.93565e-037) respectively. The lower macro bending losses inversely proportional to higher negative dispersion. When observing the results and comparing the refractive coefficients of two different designs, we note that the total dispersion in the 1.5545 µm is (4.59047e+002) while in the 1.4288 µm is (-3.14914e+001), therefore the best design after compression is the single step with two rings after increasing the distance in the fiber between the core and ring.

References

1. Bhuiyan MSA, Mondal HM (2013) Profile optimization of dispersion shifted fiber based on Optifiber design, simulation and performance analysis. Proc IEEE Int Conf Informatics Electron & Vision.
2. Madden S, Jin Z, Choi D, Debbarma S, Bulla D (2013) Low loss coupling to sub-micron thick rib and nanowire waveguides by vertical tapering. Opt Exp 21: 3582-3594.
3. Narottam D (2014) Advances in optical communication, UK. Intechopen Limited.
4. Kawanisihi T, Kanno A, Yoshida Y (2013) Impact of wave propagation delay on latency in optical communication systems. Optical Metro Networks and Short Haul Systems.
5. Mazzarese D (2011) Minimizing latency in long-haul network. Light waves.
6. Helfert ST (2016) Modelling the coupling of electromagnetic waves to cylindrical waveguides with the method of lines. Quantum Electron 48: 1-14.
7. Daubenschuz M, Gerlach P, Michalzik R (2015) Epitaxy-based electro-thermal simulation approach for vertical cavity Emitting laser structures. The European conference on laser and electro optics.