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Non-concentric single-mode optical fiber dispersion

Saktioto[1,*], Doni Basdyo[1], Yoli Zairmi[1], Haryana Hairi[2], Mohamed Fadhali[3,4], Preecha Yupapin[5]
[1]Department of Physics, Universiti Riau, Pekanbaru, Indonesia
[2]Department of Physics, Universiti Teknologi MARA, Shah Alam, Malaysia
[3]Department of Physics, Jazan University, Jazan, Saudi Arabia
[4]Department of Physics, Ibb University, Ibb, Yemen
[5]Department of Electrical Technology, IVNE - Region 2, Sakonnakhon, Thailand

ABSTRACT

The application of wave transmission in telecommunication optical fiber still has problems in the form of dispersion. For this reason, it is necessary to design and operate optical fiber dispersion that is shifted or not concentric with simulation as the first step in designing which is easier, cheaper and has a high level of accuracy. The purpose of this study was to analyze the design and operation of the displaced optical fiber dispersion and determine the wavelength value at the minimum dispersion value using OptiFiber software. The input parameters consist of the refractive index of the optical fiber in the range of 1.4615 to 1.44692 and the wavelength range of 1.4 µm to 1.5 µm. The dispersion result obtained is a minimum wavelength of 1.5506 µm. This result is close to the theoretical value of 1.55 µm with attenuation and dispersion at one wavelength point. The results of this study can be used for validation in experiments.

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*** Corresponding Author**
E-mail address: saktioto@lecturer.unri.ac.id

1. INTRODUCTION

Telecommunications optical fiber is a material used today because of its wide application and many benefits. Insulating material from optical fiber is very safe and it is possible that this product will become a product of future communication systems. Systems that transmit information by sending light pulses through optical fibers form a fiber optic communication system [1]. The widening of light pulses propagating in an optical fiber is a speed difference known as optical fiber dispersion [2]. One of the efforts to reduce the occurrence of dispersion is to simulate the design and operation of the displaced fiber dispersion.

Optical fiber is a very clear transparent material that functions to transmit light waves [3] and has a frequency range that is close to the 10^{13} Hz to 10^{16} Hz spectrum [4]. Optical fiber transmission is generated through the source to the optical detector through the process of light reflection that occurs in the optical fiber. Based on the difference in core diameter, optical fiber consists of two types of optical fiber, namely single-mode fiber (SMF) which has a core diameter of 7 µm to 10 µm and multiple mode fiber which has a core diameter of 50 µm [5]. The light entering the optical fiber will be reflected by the mantle layer with a change in the refractive index of the layer from the direction of the light entering the fiber core [6-8]. Flashes of light in the optical fiber and at the receiving end propagate back into an electrical signal using a photoelectric cell [9].

Dispersion causes the light pulses to become wider, the pulses overlap each other, the information carried by the light pulses is increasingly damaged [10]. Speed and time have different transmission signal effects. Optical fiber dispersion is formed from modal dispersion and chromatic dispersion [11]. Dispersed fiber is a fiber that has a zero dispersion shift value of 1.55 µm from the minimum attenuation wavelength [12]. The tiered index fiber uses a triangular core profile with a reduced matel area, the dispersion curve for longer wavelengths with zero wavelength dispersion can move up to 1.50 µm [13]. Optical communication systems operating at a wavelength of 1.55 µm have low power losses and experience normal chromatic dispersion [14]. The minimum loss that occurs at a wavelength of 1.55 µm with many fiber communication systems operating, some systems use special fibers that have a zero dispersion shift at 1.55 µm to operate an optimal data transmission signal [15]. The dispersion problem can be minimized by using the displaced fiber dispersion by adjusting the propagation of light pulses caused by the dispersion material and the wave dispersion guide [16], the offset is used to adjust the existing fiber dispersion system, the dispersion waveguide is offset by the dispersion material at 1.31 µm in the SMF tiered index [17, 18].

In this research, it is necessary to design and operate the displaced fiber dispersion in SMF with simulation as the first step in designing a method that is easier, cheaper and has high accuracy. The purpose of this study was to analyze the design and operation of the displaced fiber dispersion and determine the wavelength value at the minimum dispersion value using OptiFiber software.

2. RESEARCH METHODS

This The SMF simulation methodology with two-dimensional micro-rings and other parameters was determined using OptiFiber software. SMF design is done by specifying four refractive index regions in the dialog box ranging from 0 to 3 with predefined input parameters with an area of 3.1 µm, which can be solved by the formula:

Linear profile:

$$n(x) = n(0) + x\left(\frac{n(w) - n(0)}{w}\right) \quad (1)$$

Constant profile:

$$n(x) = constant \quad (2)$$

Determination of region 0 aims to form a core layer in the form of a linear function. The range of refractive index used is 1.4615 to 1.44692. Determination of region 1 aims to obtain a constant deep mantle layer with an image width of 0.6 µm with a refractive index of 1.44692. Determination of area 2 is determined by a profile width of 1.5 µm with a refractive index of 1.45 with a constant determination of the refractive index of the image to obtain the outer core layer. Determination of region 3, the width of the profile used is 57 µm with a constant image with a refractive index of 1.44692 to obtain the outer mantle layer. The simulated wavelength is 1.3 µm. In addition, the total dispersion of the material can be determined using the following equation:

$$D_{total} = -\frac{z}{c}\lambda\left(\frac{d^2 N_{eff}}{d\lambda^2}\right) \quad (3)$$

The zero dispersion wavelength can be adjusted by setting the linear polarization mode to recalculate the input. The basic mode setting aims to enter the optical fiber parameter value at a distance of 1.4 µm to 1.6 µm at 50 steps to observe the wavelength dispersion of the displaced SMF. The next step is to optimize the image with zero dispersion wavelength by setting the basic mode property by selecting the base mode. In region 1 enter parameter values from 0.1 µm to 3.1 µm with 30 steps. In region 2 it is set by changing the dispersion width value to 1.32 µm and resetting the basic mode property. Then. in region 3 the parameter value is changed from 1.4 µm to 1.6 µm with 50 steps.

3. RESULTS AND DISCUSSIONS

The number of iterations greatly affects the formation of the refractive index of the inner layer because it can refine the shape of the triangular ring graph generated in the inner core layer as shown in Figure 1. There is a decrease and increase in the delay time for an increase in the simulated wavelength. Figure 2 shows a linear increase in total dispersion at the zero position in the 1.5134 µm wavelength band with a cut point of 0.05583 ps/nm^2-km. The purpose of this step is to determine the zero dispersion wavelength. Based on previous research conducted by [19], the wavelength value is 1.513 µm. These results indicate that the difference in wavelength values obtained is not much different from the simulation results obtained by 0.0004 µm.

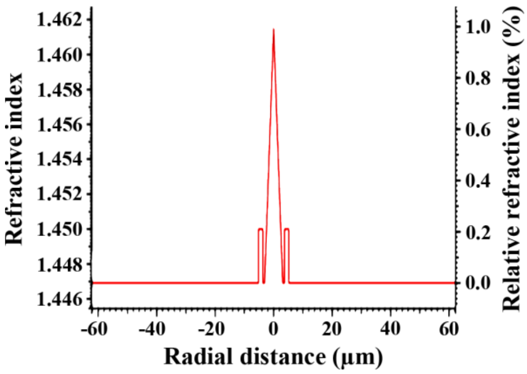

Figure 1. Refractive index profile of the displaced SMF dispersion

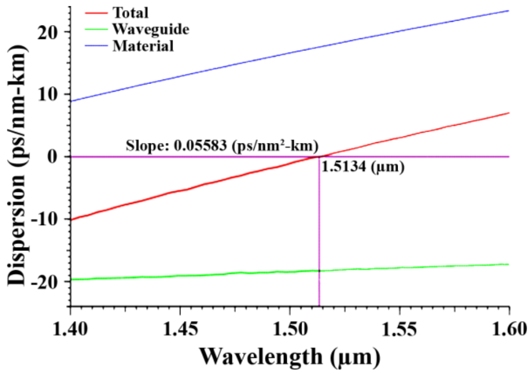

Figure 2. Linear increase in the total wavelength dispersion in the zero region region

The resulting graph in Figure 3 is derived from the exponential decrease in total dispersion and waveguide dispersion, this process aims to optimize zero wavelength dispersion. Comparison of width with SMF dispersion produces a graph of the exponential decrease from 0.1 µm to 3.1 µm width parameter range. The dispersion value will be smaller with increasing the value of the width of the material and the waveguide. The simulation results of the stranded SMF dispersion design in Figure 4 show the dispersion value at the minimum value indicating the resulting wavelength is 1.5506 µm with a cut point of 0.0545 ps/nm^2-km. The wavelength value does not reach the value of 1.55 µm because the addition of large iterations can produce a difference in wavelength of 0.0006 µm. The simulation results show that the speed of the chromatic dispersion group of light pulses that are feasible to propagate is 0 because the resulting wavelength is at 0 dispersion. An increase in the dispersion of the waveguide is used to provide the dispersion material and the chromatic wavelength shift is zero by 1.55 µm [20].

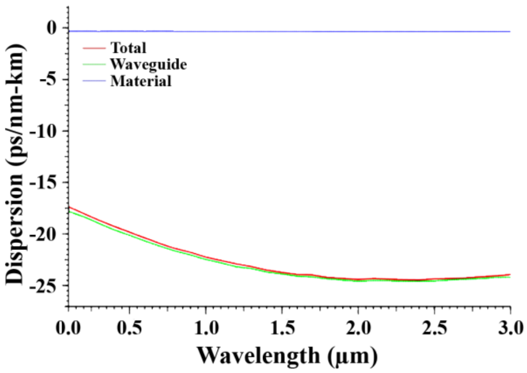

Figure 3. Optimization of the total SMF wavelength dispersion in the zero region

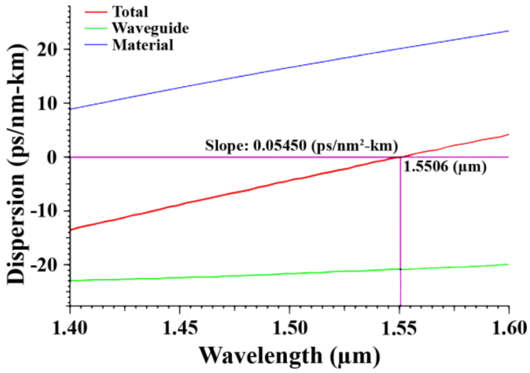

Figure 4. Displaced SMF dispersion graph at a wavelength of 1.5506 µm

4. CONCLUSION

The number of iterations greatly affects the formation of the refractive index of the inner layer because it can refine the shape of the triangular ring graph produced in the inner core layer. The linear increase in total dispersion at the zero position is in the 1.5134 µm wavelength band with a cut point of 0.05583 ps/nm^2-km. Comparison between fiber width and dispersion produces a graph of exponential decline from 0.1 µm wide parameter range to 3.1 µm. The simulation results of the displaced SMF dispersion design show a minimum value of 0 which indicates the wavelength produced is at 1.5506 µm with a cut point of 0.0545 ps/nm^2-km.

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