Dispersion Analysis of Optical Fiber Using MATLAB

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Abstract- Optical fiber is a dielectric waveguide, cylindrical in shape. It confines electromagnetic energy in the form of light within its surface and guides light by multiple internal reflections, provided the angle of incidence onto the core cladding interface is greater than the critical angle θ_c. Dispersion of the transmitted optical signal causes distortion for both digital and analog transmission along optical fibers. When considering the major implementation of optical fiber transmission which involves some form of digital modulation, then dispersion mechanisms within the fiber cause broadening of the transmitted light pulses as they travel along the channel.

Index Terms— Dispersion, single mode fiber, multimode fiber.

I. INTRODUCTION

DISPERSION ANALYSIS OF FIBER

1.1 Dispersion for single mode fiber

The Material Dispersion of fiber is evaluated from the given expression [15];

$$\sigma_m = \frac{L}{c}\lambda\frac{d^2n(\lambda)}{d\lambda^2}\sigma_\lambda$$

For pure silica, the material dispersion curve goes to zero at 1.27 μm [1].The waveguide dispersion is obtained from the expression:

$$\sigma_{wg} = -\frac{n_2 L\Delta\sigma_\lambda}{c\lambda}V\frac{d^2(V_b)}{dV^2}$$

Where σ_λ the source spectral width and Δ is is the relative refractive index difference between the core and cladding. The waveguide dispersion is computed using directly fitting the curve. The dispersion analysis for single mode fiber is carried out by varying the wavelength against different types of dispersion such as material dispersion, waveguide dispersion and total dispersion.

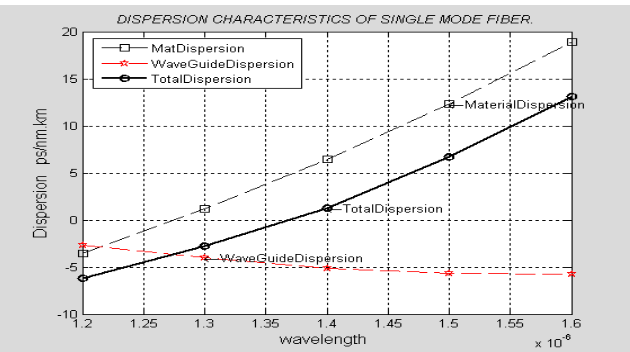

Fig. 1.1 Dispersion characteristics of single mode fiber

Fig 1.1 shows the variation of dispersion Vs wavelength for single mode fiber. The dispersion is measured in ps/nm.km. The range is given from -10 to 20 ps/nm.km. The wavelength is in μm and the range is between 1.2 to 1.6 μm.

Sr. No.	Wavelength in μm	Dispersion for single mode fiber in ps/nm.km		
		Material Dispersion	Waveguide Dispersion	Total Dispersion
1	1.2	- 3.5	- 2.68	- 6.2
2	1.25	- 1.15	- 3.35	- 4.5
3	1.3	1.2	- 4	- 2.8
4	1.35	3.82	- 4.6	- 0.76
5	1.4	6.3	- 5	1.27
6	1.45	9.37	- 5.4	4
7	1.5	12.3	- 5.62	6.68
8	1.55	15.6	- 5.7	9.9
9	1.6	19	- 5.8	13.16

Table I: Dispersion characteristics of single mode fiber

From table I, it is seen that, the total dispersion is addition of material dispersion and waveguide dispersion. Here, for waveguide dispersion, all negative values are obtained for different wavelengths. In single mode fiber, it is observed that, waveguide dispersion is not zero.
It is also observed that material dispersion curve goes to zero at 1.27 μm [1].

II. DISPERSION FOR MULTIMODE FIBER

The Material Dispersion of fiber is evaluated from the given expression [15];

$$\sigma_m = \frac{L}{c}\lambda\frac{d^2n(\lambda)}{d\lambda^2}\sigma_\lambda$$

Where σ_λ the source spectral width and Δ is is the relative refractive index difference between the core and cladding. The dispersion analysis for multimode fiber is also carried out by varying the wavelength against different types of dispersion such as material dispersion, waveguide dispersion and total dispersion. The plot for the dispersion analysis of multimode fiber is shown below in fig. 5.19.

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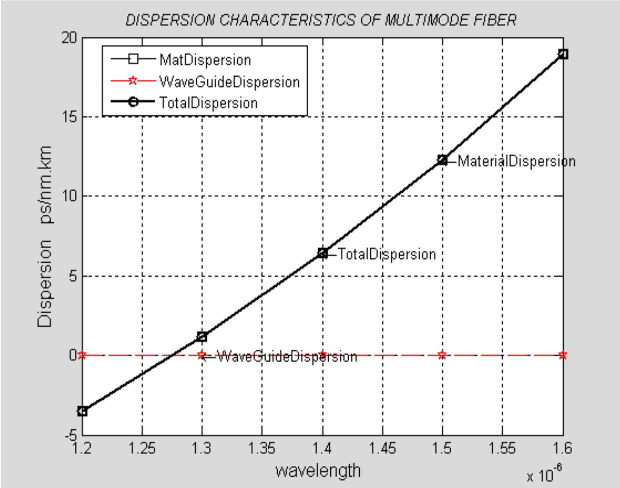

Fig. 1.2 Dispersion characteristics of multimode fiber

Fig 1.2 shows the variation of dispersion Vs wavelength for multimode fiber. Table XIV, shows the different readings for material dispersion, waveguide dispersion and total dispersion.

Sr. No.	Wavelength in µm	Dispersion for multimode fiber in ps/nm.km		
		Material Dispersion	Waveguide Dispersion	Total Dispersion
1	1.2	- 3.5	0	- 3.5
2	1.25	- 1.15	0	- 1.15
3	1.3	1.2	0	1.2
4	1.35	3.82	0	3.82
5	1.4	6.44	0	6.44
6	1.45	9.37	0	9.37
7	1.5	12.3	0	12.3
8	1.55	15.6	0	15.6
9	1.6	18.92	0	18.92

Table II: Dispersion characteristics of Multimode fiber

From table II, it is seen that, in multimode fiber waveguide dispersion is zero which is not obtained in single mode fiber. Hence, in multimode fiber, the total dispersion is equal to material dispersion. It is also observed that material dispersion curve goes to zero at 1.27 µm.

III. CONCLUSION

From above figures & tables, it is concluded that, in Single mode fiber, waveguide dispersion is not zero. But in multimode fiber, waveguide dispersion is zero. Total dispersion is addition o material dispersion & waveguide dispersion. It is also seen that, the material dispersion is zero at 1.27 µm. In single mode & in multimode optical fibers, Chromatic dispersion is different.

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