

VICTORIA UNIVERSITY BANGLADESH



Assignment On

Course Name : Optical Fiber Communication

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Submitted By

Name: MD. Abir Hossain

Reg: 2219150051

Batch: 15th

Program: B.scin CSE

Submitted To

Renea Chowdhury Shormi

Department of CSE/CSIT

Lecturer Victoria University Of Bangladesh

Ans. to the Q. NO-01 (a)

a chromatic Dispersion is a phenomenon that is an important factor in optical fiber communication. it is the result of the different colors, or wavelengths, in a light beam arriving at their destination at slightly different times. In multimode optic fiber links we have a similar problem. Different wavelengths of light propagate at different speeds. This material dispersion causes the light to break up and the carrier signal is lost due to this disruption. This is why multimode optical fiber links can not travel as far as single mode fiber links. single mode use a single wavelength and not the full visible spectrum to transmit a signal so they do not suffer from the chromatic dispersion problem.

To understand the effect of chromatic dispersion, we must understand the significance of the propagation constant β . We will restrict our discussion to single mode fiber since in the case of multimode fiber, the effects of intermodal dispersion usually overshadow those of chromatic dispersion. So the propagation constant β in our discussions will be that associated with the fundamental mode of the fiber.

Chromatic dispersion arises for two reasons:

1 The first reason is that the refractive index of silica, the material used to make optical fiber is frequency dependent. Thus different frequency components travel at different speeds in silica. ~~The~~ This component of chromatic dispersion is called material dispersion.

2) Although material dispersion is the principle component of chromatic dispersion for most fibers is a second component, called waveguide dispersion.

The power distribution of a mode between the core and cladding of the fiber is itself a function of the wavelength. More accurately the longer the wavelength, the more power in the cladding. Thus, even in the absence of material dispersion, so that the refractive indices of the core and cladding are independent of wavelength.

Ans. to the Q.No-1(b)

↳ in simple terms, dispersion helps to ~~comph.~~ comprehend the distribution of any given Data.

Ans. to the Q.No-1(c)

↳ in a communication system when the data is being transmitted in the form of pulses (bits), the output produced by the desired bit. This is called as intersymbol interference (ISI).

3

Q Ans: polarization mode dispersion:-

A form of dispersion in an optical fiber where two different polarization states of light travel at slightly different velocities. This is caused by imperfections and asymmetries in the glass fiber core itself and results in random spreading of the optical signal.

Single mode optical fiber consists of one propagation mode, which in turn, is comprised of two orthogonal polarization modes. Asymmetrical differences in the fiber introduce small refractive index variation between two states. This is known as birefringence or double refraction. Birefringence in turn causes slight slight differences in group velocity and phase which is referred to as (pmd)

* Properties of polarized light:

polarization is defined in terms of the electric field, which interacts more strongly with most devices. The electric field of a fully polarized, monochromatic light wave can be ~~described~~ described as issuing from a point charge moving in an elliptical pattern in the plane of the source.

* The origins of PMD: The speed of propagation of a light wave depends on the index of refraction of the transmission medium in the direction of fluctuation of the Electric field.

Consider a short straight length of single-mode fiber. The two waves propagate at slightly different speeds.

Low PMD:^{No Bit Errors} in this illustrative example, the light signal exhibits no sign of PMD, and the subsequent digital signal shows no distortion and therefore no bit errors.

High PMD: multiple Bit Error, in this example, the dispersed light wave ultimately causes a distorted digital signal which leads to transmission errors.

3
(b) Rayleigh scattering:

Rayleigh scattering is the elastic scattering of light by particles much smaller than the wavelength of light. That is the case for gas phase molecules and therefore this method is suited for laser imaging in gases. Rayleigh scattering of sunlight by atmospheric molecules is the reason for the observed blue color of the sky, because the scattering efficiency varies inversely with the fourth power of the wavelength. For a single component gas with known scattering cross section the Rayleigh signal is directly proportional to the gas density. The scattered light is almost at the same wavelength as the incident light. In some cases Rayleigh scattering is stronger for one species than another.

Mie scattering: Mie scattering is elastic scattered light of particles that have a diameter similar to or larger than the wavelength of the incident light. The Mie signal is proportional to the square of the particle diameter. Mie scattering is much stronger than Rayleigh scattering and therefore, a potential source of interference for this weaker light scattering process. There is a strong angular dependency of the scattering intensity, especially for smaller particles which has to be considered for successful Mie imaging experiments.

Ans to the Q. No-3 (c)

Q
The group velocity:

optical wave are travelling as wave packets. These wave packets have group velocity v_g .

$$v_g = \frac{d\omega}{d\beta} = \frac{c}{N_g}$$

where c = velocity of light = 3×10^8 m/sec

N_g = group index of guide/core.

Ans. to the Q. No-4(a)

* a Differentiate between SRS and SBS in fibers:

SRS	SBS
<p><u>The Effect</u>: interaction between optical signal and optical phonons through Raman scattering causing a shift in signal wavelength.</p>	<p><u>The Effect</u>: Interaction between acoustic phonons and the optical signal through Brillouin scattering. Interference between the forward-propagating signal and back-scattered light creates a highly efficient reflector to the optical signal.</p>
<p><u>The problem</u>: parasitic effect in high-peak-power fiber lasers where wavelength control is mandatory.</p>	<p><u>The problem</u>: Limits the power per unit bandwidth and is a major limited limitation in the scaling to higher power.</p>
<p><u>To reduce</u>: (a) materials with reduced hyper-polarizabilities/$\text{km}(\text{m}^2)$ (b) Replace materials with high Raman gain, and (c) Higher quench rates yield more disordered glass structure.</p>	<p><u>To reduce</u>: increase mass density, acoustic velocity and Brillouin spectral width or lower photoelastic constant (P_{22}) and refractive index.</p>

b bending loss:

* optical fibers suffer radiation losses at bends or ~~curve~~ curves on their paths.

* This is due to the energy in the evanescent field at the bend exceeding the velocity of light in the cladding and hence the guidance mechanism is inhibited, which causes light energy to be radiated from the fiber.

* as this is not possible, the energy associated with this part of the mode is lost through radiation.

* The loss can generally be represented by a radiation attenuation coefficient which has the form,

$$\alpha \propto \alpha_n = e_1 \exp(-e_2 R)$$

* where R is the radius of curvature of the fiber bend and e_1, e_2 are constants which are independent of R .

Q Dispersion in optical fiber:

* Dispersion: any phenomenon in which the velocity of propagation of ~~any~~ any electromagnetic wave is wavelength dependent.

* In communication, dispersion is used to describe any process by which any electromagnetic signal propagating in a physical medium is degraded because the various wave characteristic of the signal have different propagation velocities within the physical medium.

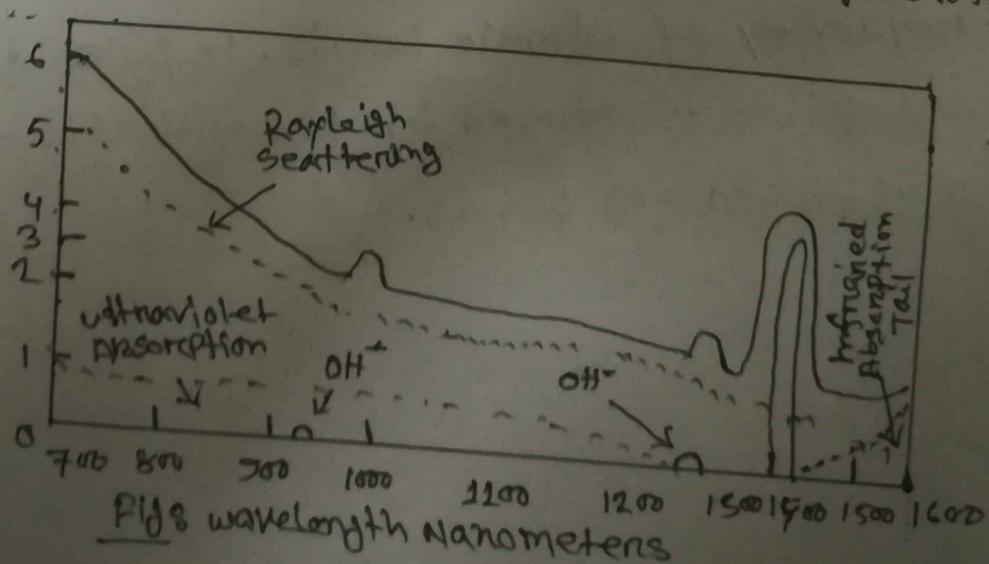
* There are 3 dispersion types in optical fibers, in general:-

- 1- material Dispersion
- 2- waveguide Dispersion
- 3- polarization-mode Dispersion

A1

Intrinsic absorption

- * Intrinsic absorption is caused by basic fiber-material properties.
- * If an optical fiber were ~~used~~ absolutely pure, with no imperfections or impurities, then all absorption would be intrinsic.
- * Intrinsic absorption ~~is~~ sets the minimal level of absorption.
- * In fiber optics, silica (pure glass) fibers are used predominately. Silica fibers are used because of their low intrinsic material absorption at the wavelengths of operation



In silica glass, the wavelengths of operation range from 700 nanometers (nm) to 1600 nm.

This wavelength of operation is between two intrinsic absorption regions.

The first region is the ultraviolet region (below 400-nm wavelength). The second region is the infrared region (above 2000-nm wavelength).

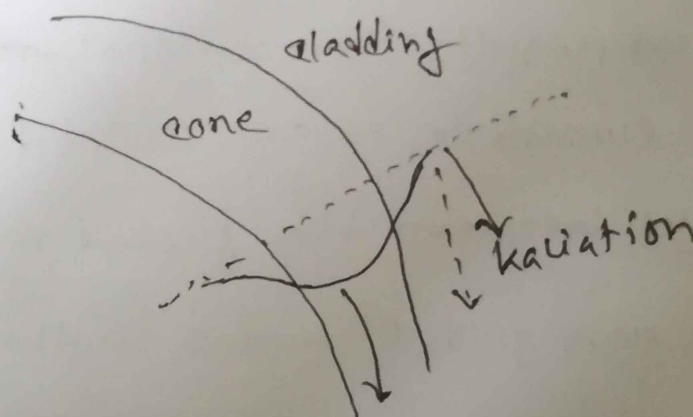
Intrinsic absorption in the ultraviolet region is caused by electronic absorption bands. ~~Basically~~ Basically, absorption occurs when a light particle (photon) interacts with an electron and excites it to a higher energy level.

The main cause of intrinsic absorption in the infrared region is the characteristic vibration frequency of atomic bonds. In silica glass, absorption is caused by the vibration of silicon-oxygen (Si-O) bonds.

Ans. to the Q. No-2(b)

6 macro bending loss: optical fiber suffer from macro-bending loss at bends or curves on their paths. This is due to the energy in the evanescent field at the bend exceeding the velocity of light in the cladding and hence the guidance mechanism is inhibited, which causes light energy to be radiated from the fiber.

This is shown in the fiber following illustration:



The part of mode which is on the outside of the bend is required to travel faster than that on the inside so that a wavefront perpendicular to the direction of propagation is maintained.

Can we minimize this loss: make sure to adapt the high-quality cables with same properties as much possible. choose quality qualified connectors as much as possible, make sure that the insertion loss should be lower than 0.3 dB and the additional loss should be lower than 0.2 dB.

Ans. to the Q. No 2 (c)

≡ minimize micro bending loss: An increase in attenuation results from micro bending because the fiber curvature causes repetitive coupling of energy between the guided modes and the leaky or non guided modes in the fiber.

micro bending losses can be minimized by placing a compressible jacket over the fiber.