Assessment On

Course Title: Optical Fiber Communication

Course Cord: CSE-441

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CSE-441

Ans to the Q. No-1 (a)

chromatic Dispenation is a phenomenon that is an important factor in optical fiber communication. It is the result of the different colors, or wavelengths in alright 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 materials 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 visiable spectrum to transmit a signal to they do not suffer from the chromatic dispersion problem. To understand the effect of chromadic dispersion, we must understand the significance of the propogation constant

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

β. we will restrict our discussion to single mode fiber since in the case of multimode. fiber. the effects of intermodel dispersion usually overshadow those of chromatic dispersion. So the propagation constant β in your discussion will be that associated with the fundamental mode of the fiber.

chromatic dispration arises for two reasons:-

① The first reasons is that the refractine index of silica the material used to make optical fiber is frequency dependent. Thuse different frequency components travel at Different speeds in silica, this components of chromatic dispersion is called material dispersion

② Although material dispersion is the principle component of chromatic dispersion for most fiber 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 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)

Ans to the Q. No-3(a)

polarization mode dispersion:—
A form of dispersion in an optical fiber weher two different polarization states of light travel at slightly different velocities. This is caused by impenfections and asymmetries in the glass fiber core itself and result in random spreading of the optical signal.
~~Sigto~~ Single mode optical fiber consists of one propagation mode, which in turn

is comprised of two orthogonal polarization modes. Asymmetrical difference in the fiber introduce small refractive index variation between two states. This is known as birefrigence or double refraction. Birefringence in turn cause 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 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 referaction of the transmission medium in the direction of fluctuation of the Electric field. Consider short straight lenght 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 shows no distortion and therefore no bits errors.

* High PMD :-

Multiple Bit Error, in this example the dispersed light wave ultimately causes a distroted digital signal which leads to transmission Errors.

Ans to the Q. No-3(b)

Rayleigh scattering :

Rayleigh scattering is the elastic scattering of light by particles much simillar than the wavelengh 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 moleules is the reason of sunlight for the deserved blue color of the sky, because the scattering efficiency varies inversley with the fourth power of the wavelength for a single component gas with known scattering cross section ~~component~~ gas with ~~to~~ 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 speies than another.

<u>mie scattering</u> : mie sciattering is elastie scattered light of particles that have a diameter similar to or longer than the wavelength of the incident light. The mie signal is propantional to the square of the pantieal diameter. mie seattening is much strongh than Rayleigh seattening and therefore a potential sounee of intenfenence for this weaken light seattening process. There is a strong anguler dependency of the seattening indensital exspecilly for smaller pantielas which has to be considened for successfull mie imaging expeniments.

Ans to the Q. No-3(c)

ii group velocity:

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

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

Where, c = velocity at light $= 3 \times 10^8$ m/sec

N_g = group index at guide/core.

Ans to the Q. No - 4(a)

Differentiate between SRS and SBS in fiber:

SRS	SBS
The effect: interaction between optical singal and optical phonons through Raman seattering causing a shift in signal wavelength.	The Effect: Interaction between acoustic phonons and the optical signal through Brillouin seattering interference between the forword propagating signal and back scattered light creates a highly efficient reflection to the optical signal.
The problem: parasitic effect in high-peak power fiber Lasers where wavelength control is mandatory.	The problem: Limits the power per unit Bandwidth and is a major Limitation in the sealing to higher power.
To reduce: (a) materials with reduced hyper polarizabilities/nm (n_2). (b) Replace materials with high Raman gain and (c) higher quench rates yield more disordered glass structure.	To reduce: increase mass density acoustic velocity and Brillouin spectral width or lower photoelastic constant (P_{22}) and refractive index.

Ans to the Q.No-4(b)

bending loss:

* optical fiber suffer radiation lose 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 cause light energy to be raduated 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 atenuation coefficient which has the form.

* $\alpha_r = c_1 \exp(-c_2 R)$

* where R is the radius of curvature of the fiber bend and c_1, c_2 are constants which are independent of R.

Ans to the Q. No-4(c)

Dispersion in optical fiber:

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

* In communication, dispersion is used to describe any process by which any electro-magnetic, 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

Ans to the Q. No-2(a)

Intrinsic absorption:

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

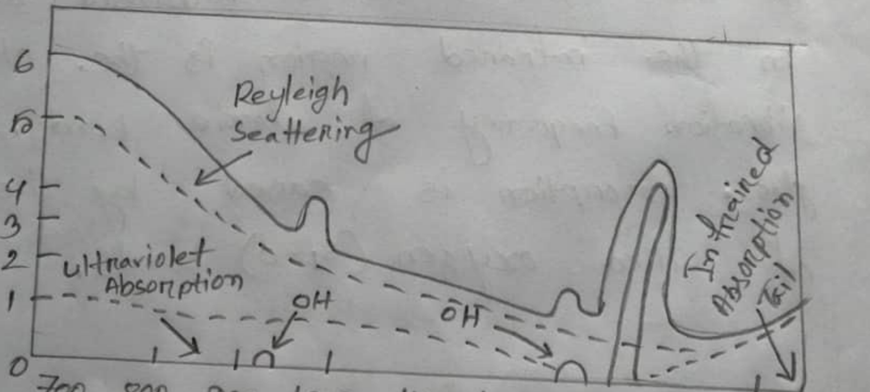


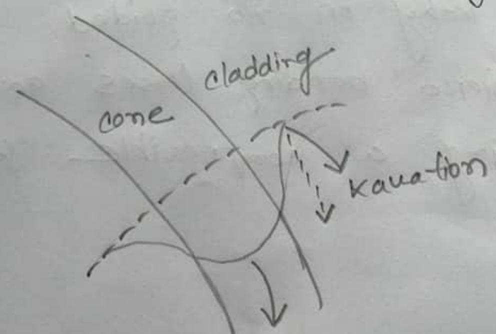
Fig: Wavelength Nanometers.

in silica glass, the wavelengths of operations range from 700 nanomiters (n/m) to 1600 nm.
This wavelength of operation is between two intrinsic absorption regions.
The first region is the ultraviolet regions (below) 400-nm wavelength). The second region is the infrazed region (above 2000 nm wavelength).
Intrinse absorption in the ultraviolet region is cased by electronic absorption bands. Basically absorption occures when alight partical (photon) Interacts with an electron and excites it to a higen energy level.
The main cause of intrinsic absorption in the infraned region is the characteristic vibration frequency of atomic bonds. In silica glass, absorption is caused by the vibration of silica oxygen (Si-O) bonds.

Ans to the Q. No-2(b)

Macro bending loss: optical fiber suffer from macro bending loss at bends or corner on their paths. This is due to the energy in the evanescent filed at the bend exceeding the velocity of light in the cladding and hence the guidance mechanism is inhibited which cayes light energy to be radiated from the fiber.

This is shown in the 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 propog proportise as much possible. choose qualified connectors as much as possible. make sure that the insention loss should be lower then 0.3dB and the additional loss should be lower than 0.2dB.

Ans to the Q. No-2(c)

minimize micro bending loss: An increase in attenuation result from micro bending because the fiber curvature ease repetitive capling leaky or no guided modes in the fiber. micro bending losses can be minimized by placing a compressible jacket over the fiber.