SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

OPTICAL AND MICROWAVE ENGINEERING

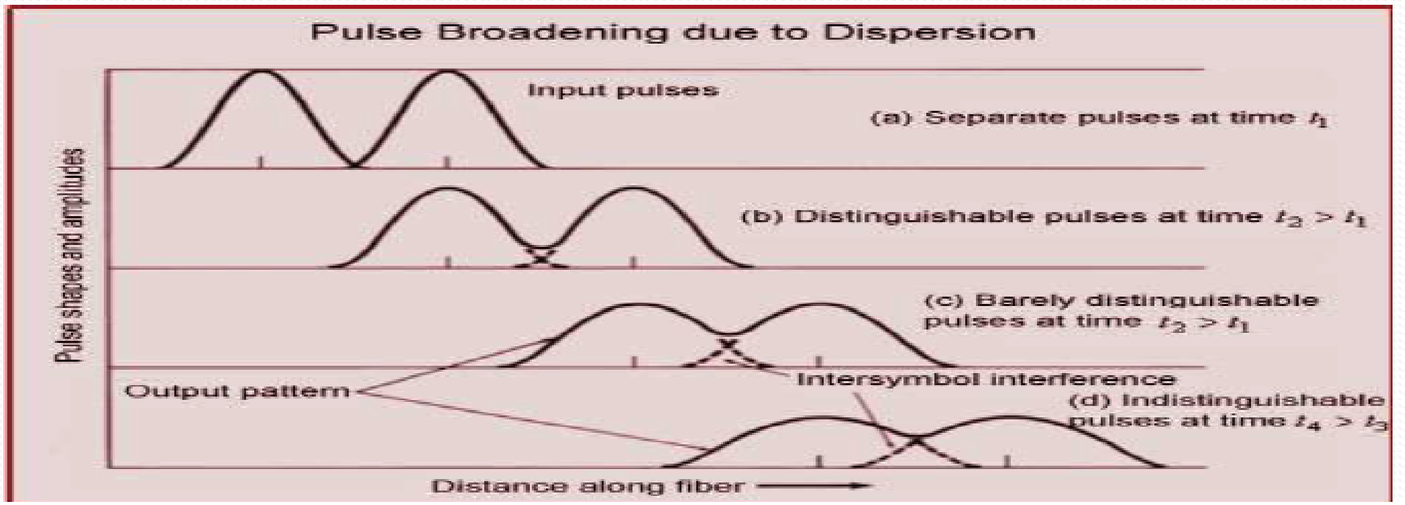
III YEAR/ VI SEMESTER

UNIT 4 – OPTICAL COMMUNCATION

TOPIC – OPTICAL FIBERS AND DEVICES-DISPERSION AND LOSSES

DISPERSION

- 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 characteristics (i.e., frequencies) of the signal have different propagation velocities within the physical medium.
- The dispersion cause that optical pulses to broaden as they travel along a fiber, the overlap between neighboring pulses, creating errors in the receiver output, resulting in the limitation of information-carrying capacity of a fiber.



Types of Dispersion

Intermodal dispersion: Different modes propagate at different group velocities.

Intramodal or Chromatic Dispersion

Material dispersion: The index of refraction of the medium changes with wavelength.

Waveguide dispersion: The index change across waveguide means that different wavelengths have different delays.

Polarization mode dispersion: If waveguide is birefringent. Birefringent is a optical property of a material having a refractive index that depends on the polarization and propagation direction of light.

Dispersion Effect in Optical Fiber

Intermodal Dispersion

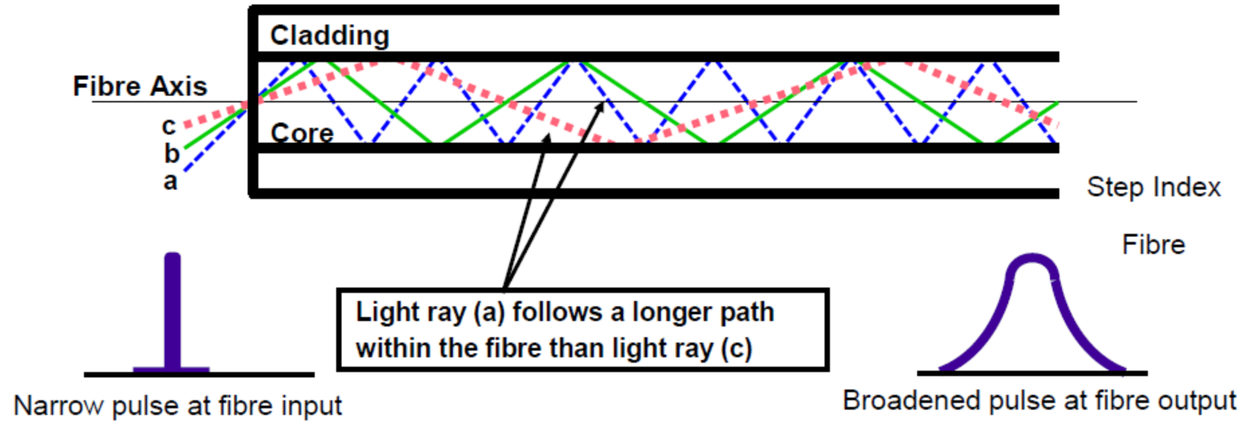
In a multimode fiber different modes travel at different velocities.

If a pulse is constituted from different modes then intermodal dispersion occurs.

Modal dispersion is greatest in multimode step index fibers.

The more modes the greater the modal dispersion.

Typical bandwidth of a step index fiber may be as low as 10 MHz over 1 km.

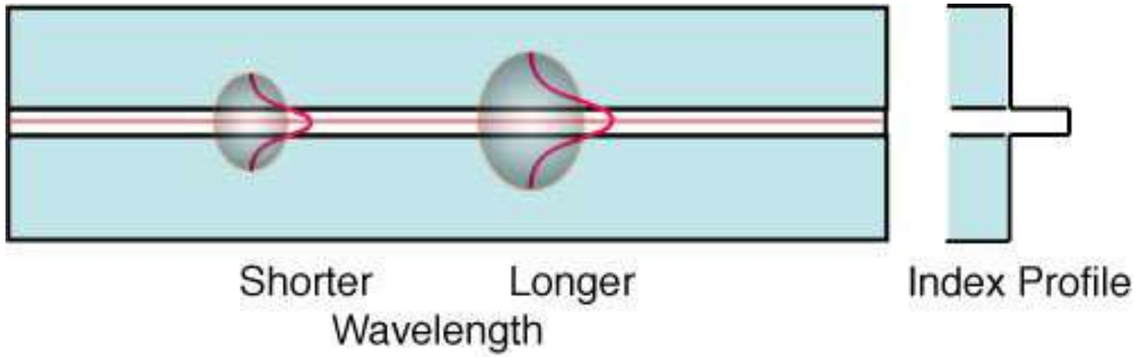


Intramodal or Chromatic Dispersion

Waveguide Dispersion

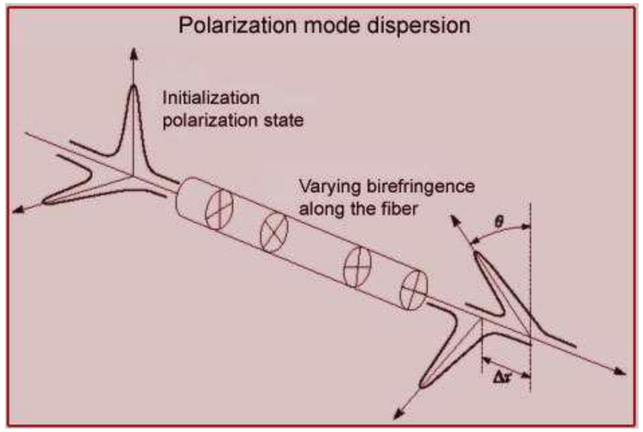
This is due dispersive nature of the bound medium. In a bound medium like the optical fiber, the velocity is a function of frequency.

Waveguide dispersion is chromatic dispersion which arises from waveguide effects: the dispersive phase shifts for a wave in a waveguide differ from those which the wave would experience in a homogeneous medium. Waveguide dispersion is important in waveguides with small effective mode areas. But for fibers with large mode areas, waveguide dispersion is normally negligible, and material dispersion is dominant.



Polarization mode dispersion:

- The polarization mode dispersion is due unequal velocities of two orthogonal states of polarization.
- The PMD puts the ultimate restriction on the data rate on the long haul single mode optical fiber.
- The pulse slowly broadens due to the statistical fluctuation of the velocities of the two orthogonal polarizations.



Optical Fiber Losses

Attenuation in Optical Fibers

Attenuation limits the optical power which can reach the receiver, limiting the
operating span of a system.

Once the power of an optical pulse is reduced to a point where the receiver is unable
to detect the pulse, an error occurs.

Attenuation is mainly a result of:

Light Absorption

Scattering of light

Bending losses

$$\alpha(dB/km) = -\frac{10}{L} Log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

Attenuation is defined as the ratio of optical input power (Pi) to the optical output
power (Po).

The following equation defines signal attenuation as a unit of length :

Optical Fiber Losses

Types of Attenuation

Absorption Loss:

 Caused by the fiber itself or by impurities in the fiber, such as water and metals.

Scattering Loss:

 Intrinsic loss mechanism caused by the interaction of photons with the glass itself.

Bending loss:

 Loss induced by physical stress on the fiber.

Optical Fiber Losses

Material Absorption Losses

Material absorption is caused by absorption of photons within the fiber.

– When a material is illuminated, photons can make the valence electrons of an atom transition to higher energy levels

– Photon is destroyed, and the radiant energy is transformed into electric potential energy. This energy can then

- Be re-emitted (scattering)
- Frees the electron (photoelectric effects) (not in fibers)
- Dissipated to the rest of the material (transformed into heat)

In an optical fiberMaterial Absorption is the optical power that is effectively converted to heat dissipation within the fiber.

- Two types of absorption exist:

– **Intrinsic Absorption, caused by interaction with one or more of the** components of the glass.

– **Extrinsic Absorption, caused by impurities within the glass.**

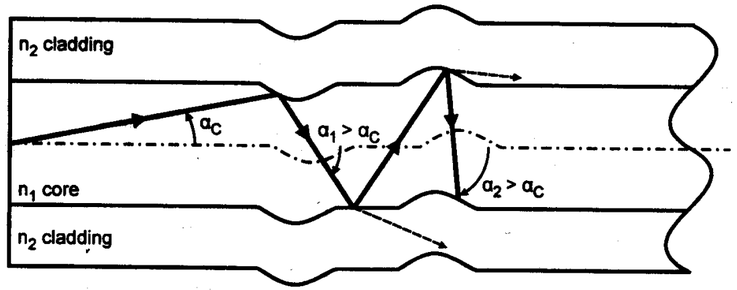
Optical Fiber Losses
Fiber Bend Losses

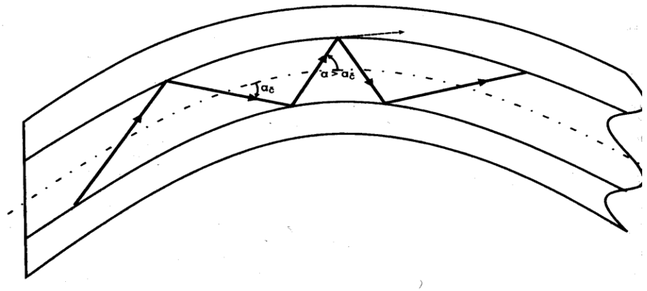
Bending loss is classified according to the bend radius of curvature :

1. Microbend Loss 2. Macrobend Loss

 Microbend Loss are caused by small discontinuities or imperfections in the fiber. Uneven coating applications and improper cabling procedure increases micro bend loss. External forces are also a source of micro bends.

Macrobend Losses are observed when a fiber bend's radius of curvature is large compared to the fiber diameter. These bends are a great source of loss when the radius of curvature is less than several centimeters





THANK YOU