Losses in Fiber Optics

- Attenuation, dispersion-intermodel, Intramodel, bend loss-micro macro scattering losses-Linear, Non linear, Absorption
- Link Budget, Power Budget
- Block diagram and working of OTDR

Attenuation

- Attenuation means loss of light energy as the light pulse travels from one end of the cable to the other.
- It is also called as signal loss or fiber loss.
- It also decides the the number of repeaters required between transmitter and receiver.
- Attenuation is directly proportional to the length of the cable.

Attenuation

- Attenuation is defined as the ratio of optical output power to the input power in the fiber of length L.
- $\alpha = 10\log_{10} Pi/Po$ [in db/km]

where, Pi= Input Power

Po= Output Power, α is attenuation constant

The various losses in the cable are due to

- Absorption
- Scattering
- Dispersion
- Bending

Bending losses

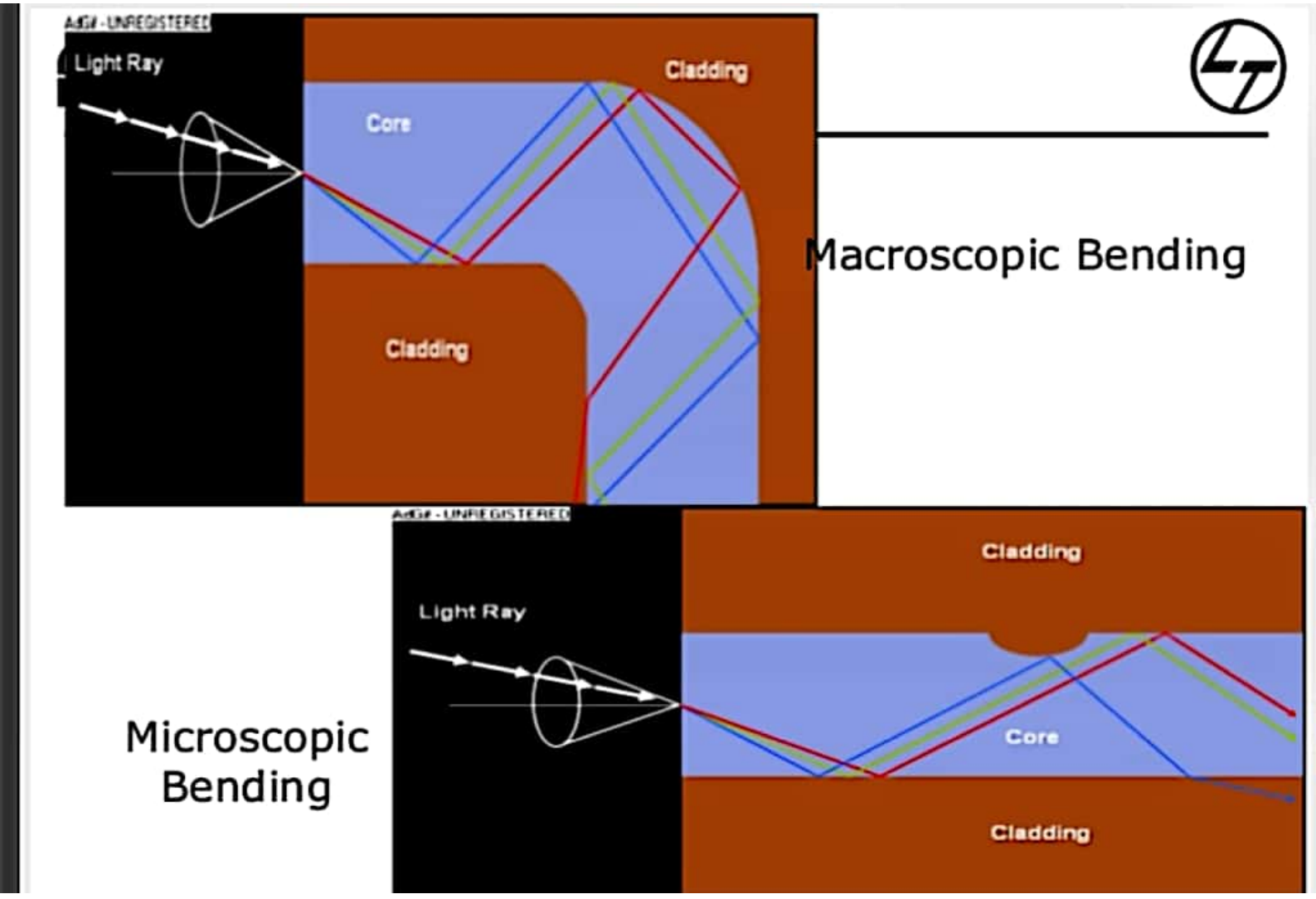
- The loss which exists when an optical fiber undergoes bending is called bending losses.
- There are two types of bending

i) Macroscopic bending

Bending in which complete fiber undergoes bends which causes certain modes not to be reflected and therefore causes loss to the cladding.

ii) Microscopic Bending

Either the core or cladding undergoes slight bends at its surface. It causes light to be reflected at angles when there is no further reflection.



Absorption Loss

Absorption of light energy due to heating of ion impurities results in dimming of light at the end of the fiber.

Two types:

1. **Intrinsic Absorption**
2. **Extrinsic Absorption**

Intrinsic Absorption:

- **Caused by the interaction with one or more components of the glass**
- **Occurs when photon interacts with an electron in the valence band & excites it to a higher energy level near the UV region.**

Extrinsic Absorption:

- **Also called impurity absorption.**
- **Results from the presence of transition metal ions like iron, chromium, cobalt, copper & from OH ions i.e. from water.**

Dispersion Loss

- As an optical signal travels along the fiber, it becomes increasingly distorted.
- This distortion is a sequence of intermodal and intramodal dispersion.
- Two types:

1. Intermodal Dispersion
2. Intramodal Dispersion

Intermodal Dispersion:

- **Pulse broadening due to intermodal dispersion results from the propagation delay differences between modes within a multimode fiber.**

Intramodal Dispersion:

- **It is the pulse spreading that occurs within a single mode.**
  - **Material Dispersion**
  - **Waveguide Dispersion**

1) **Material Dispersion:**

- **Also known as spectral dispersion or chromatic dispersion.**
- **Results because of variation due to Refractive Index of core as a function of wavelength, because of which pulse spreading occurs even when different wavelengths follow the same path.**

2) **Waveguide Dispersion:**

- **Whenever any optical signal is passed through the optical fiber, practically 80% of optical power is confined to core & rest 20% optical power into cladding.**

Scattering Losses

- It occurs due to microscopic variations in the material density, compositional fluctuations, structural in homogeneities and manufacturing defects.
- Linear Scattering
  - Rayleigh Scattering losses
  - Mie Scattering Losses
  - Waveguide Scattering Losses
- Non-linear Scattering
  - Stimulated Brillouin Scattering(SBS)
  - Stimulated Raman Scattering(SRS)

i) Linear Scattering

a) **Rayleigh Scattering Losses:**

- These losses are due to microscopic variation in the material of the fiber.
- Unequal distribution of molecular densities or atomic densities leads to Rayleigh Scattering losses
- Glass is made up of several acids like SiO_2, P_2O_5,etc. compositions, fluctuations can occur because of these several oxides which rise to Rayleigh scattering losses