Transmission Characteristics of Optical Fiber Cables:

The transmission characteristics of optical fiber cables play a major role in determining the performance of the entire communication system. **Attenuation** and **bandwidth** are the two most important transmission characteristics when the suitability of optical fiber for communication is analyzed. The various attenuation mechanisms are **linear scattering, non linear scattering, material absorption** and **fiber bends** etc. The bandwidth determines the number of bits of information transmitted in a given time period and is largely limited by signal dispersion within the fiber.

1- Attenuation in Optical Fibers:

Attenuation is defined as the loss of optical power over a set distance, a fiber with a lower attenuation, will allow more power to reach to the receiver than a fiber with higher attenuation. Signal attenuation within optical fiber is usually expressed in decibel per unit length (i.e. dB/km).

$$\text{Loss in decibel (dB)} = 10 \log_{10}(Po/Pi)$$

Where,

Pi and Po: are the transmitted and output optical power respectively.

Figure5 shows optical fiber attenuation as a function of wavelength

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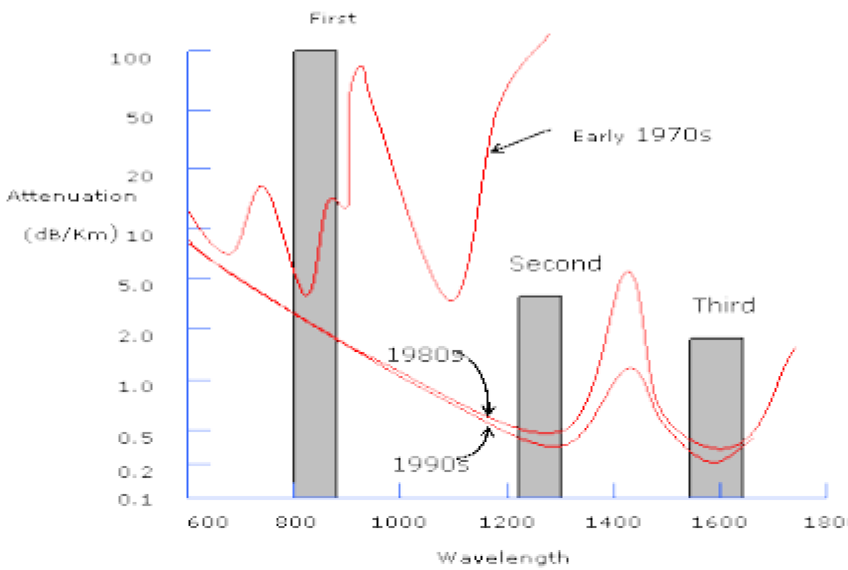

Figure (11): Attenuation to wavelength diagram of optical fiber.

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2- Linear scattering losses:

Through this mechanism a portion/total optical power within one propagating mode is transferred to another. Now when the transfer takes place to a leaky or radiation mode then the result is attenuation. It can be divided into two major categories namely **Mie scattering** and **Rayleigh scattering**.

2.1- Mie Scattering :

Non perfect cylindrical structure of the fiber and imperfections like irregularities in the core-cladding interface, diameter fluctuations, strains and bubbles may create linear scattering which is termed as Mie scattering.

2.2- Rayleigh Scattering :

The dominant reason behind Rayleigh scattering is refractive index fluctuations due to density and compositional variation in the core. It is the major intrinsic loss mechanism in the low impedance window. Rayleigh scattering can be reduced to a large extent by using longest possible wavelength.

3- Non linear scattering losses:

Specially at high optical power levels scattering causes disproportionate attenuation, due to non linear behaviour. Because of this non linear scattering the optical power from one mode is transferred in either the forward or backward direction to the same, or other modes, at different frequencies. The two dominant types of non linear scattering are :

a) Stimulated Brillouin Scattering and

b) Stimulated Raman Scattering.

4- Material Absorption losses :

When there happens to be some defect in the material composition and the fabrication process of optical fiber, there is dissipation of optical power in the form of heat in the waveguide. Here also there are two types of absorption losses in the fiber such as **intrinsic absorption** and **extrinsic absorption.** When the absorption is caused by interaction with one or more components of glass it is termed as intrinsic absorption whereas if it is due to impurities within the glass like transition metal or water then it is called the extrinsic one.

5- Dispersion :

It is defined as the spreading of the light pulses as they travel down the fiber. Because of the spreading effect, pulse tend to overlap, making them unreadable by the receiver which is a critical problem to deal with. It creates distortion for both digital and analog transmission. Dispersion limits the maximum possible bandwidth attainable within a particular fiber. Pulse broadening is a very common problem created by dispersion in digital transmission. To avoid it, the digital bit rate must be less than the reciprocal of the broadened pulse duration.

5.1- Intermodal Dispersion :

The propagation delay difference between different modes within multimode fibers is responsible for intermodal dispersion and hence pulse broadening. In fact, the different group velocities with which the modes travel through the fiber creates the main problem. Multimode step index fibers exhibit a large amount of intermodal dispersion whereas in a pure single mode fiber there is no intermodal dispersion. By adopting an optimum refractive index profile (parabolic profile in most graded index fibers), we can drastically reduce intermodal dispersion.

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5.2- Intramodal Dispersion :

This type of dispersion takes place due to the fact that optical sources do not emit a single frequency but a band of frequencies and there happens to be propagation delay differences between these spectral components. This kind of pulse broadening occurs in almost every type of optical fibers. When the dispersive characteristics of the waveguide material are responsible for the delay differences then it's known as **material dispersion**. On the other hand if imperfect guidance effect is behind the pulse broadening then it's termed as **waveguide dispersion**. There is almost zero waveguide dispersion in multimode fibers.

6- Fiber bending losses:

Light energy gets radiated at the bends on their path through the fiber and eventually is lost. This is the mechanism known as fiber bend losses. There are two types bending causing this loss namely micro bending and macro bending. If the fiber is sharply bent so that the light traveling down the fiber can not make the turn and gets lost then it's macro bending as shown in figure 12(a). When small bends in the fiber created by crushing, contraction etc causes the loss then it is called micro bending as shown in figure 12(b). These bends are not usually visible with naked eye.

Figure 12 a

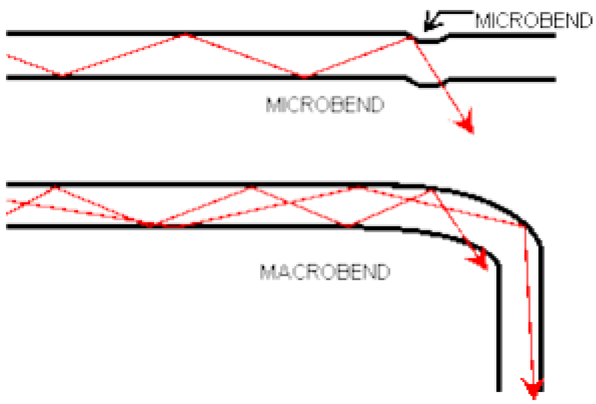

Figure 12 b

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Advantages and Disadvantages of Optical Fibres

Although there are many benefits to using optical fibers, there are also some disadvantages. Both are discussed below:

Advantages:

Capacity

Optical fibers carry signals with much less energy loss than copper cable and with a much higher bandwidth. This means that fibers can carry more channels of information over longer distances and with fewer repeaters required.

Size and Weight

Optical fiber cables are much lighter and thinner than copper cables with the same bandwidth. This means that much less space is required in underground cabling ducts. Also they are easier for installation engineers to handle.

Security

Optical fibers are much more difficult to tap information from undetected; a great advantage for banks and security installations. They are immune to Electromagnetic interference from radio signals, car ignition systems, lightning etc. They can be routed safely through explosive or flammable atmospheres, for example, in the petrochemical industries or munitions sites, without any risk of ignition.

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