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Lecture 7 : Maximum allowable data rate in Optical Fiber

المعدل الاقصى المسموح للبيانات في الليف الضوئي

1. The max data transfer rate for optical fiber cables is ~**10000 Mbps** (Mega bit per second) (10Gbps) . It is said to be the fastest among the other kinds of cables like STP (Shielded Twisted-Pair) cables and co-axial cables. People are now using optical fiber cables instead of STP cables for LANs due to their fast data transfer capability.

2. Relation between bandwidth & data rate

Bandwidth refers to the number of bits per second that a link can send or receive at one time,

whereas **data rate** refers to the actual amount of data transferred.

Example

- Bandwidth is the amount of data that can be sent from one point to another across a given path.
- In simple terms, **bandwidth** allows you to determine how long it will take to download some content over a particular connection.

- It refers to the number of bits per second that a link can send or receive.
- For example, the **bandwidth** of connection is 50 Mbps, but that does not mean it will always send or receive 50 mbps; It is the maximum that can be possible on that link. Bandwidth does not mean data usage (data rate). It is measured in bits per second (bps), megabits per second (Mbps), or gigabits per second (Gbps).
- Data rate is commonly referred to as the transmission speed, or the number of bits per second transferred across a network.
- Continuous efforts have been made by the communication engineers to achieve higher data rates. It is the maximum ability of the channel to transmit bits in a second. So, let's say if you have a 5MHz bandwidth, then the data rate is 5 mbps, but not necessarily. Data rate refers to the speed at which data is transferred from one device to another or between a peripheral device and the computer.

In Summary

Bandwidth refers to the number of bits per second that a link can send or receive at one time, whereas data rate refers to the actual amount of data transferred. Bandwidth is used to measure transmission capacity of a network or Internet connection over a specific period of time, whereas data rate is used to measure how fast data is transferred from one point to another.

Fiber power losses

1. Light traveling in an optical fiber loses power over distance. The loss of power depends on :

a. the wavelength of the light and

b. the propagating material.

For silica glass, the shorter wavelengths are attenuated the most (see Fig. *). The lowest loss occurs at the 1550-nm wavelength, which is commonly used for long-distance transmissions.

2. Transmission of light by fiber optics is not 100% efficient. There are several reasons for this including :

a. absorption by the core and cladding (caused by the presence of impurities),

b. the leaking of light from of the cladding. When light reflects off the cladding /core interface it actually travels for a short distance within the cladding before being reflected back. This leads to attenuation (signal reduction) by up to 2db/Km for a multi-mode fiber. For example, with this level of attenuation, if light travelled over 10km of cable only 10% of the signal would arrive at the following end.

3. The amount of attenuation for a given cable is also *wavelength* dependent.

4. The loss of power in light in an optical fiber is measured in decibels (dB). {Decibel (dB):a unit used to measure the power level of a signal.)

5. Fiber optic cable specifications express cable loss as attenuation per 1-km length as dB/km. This value is multiplied by the total length of

the optical fiber in kilometers to determine the fiber's total loss in dB.

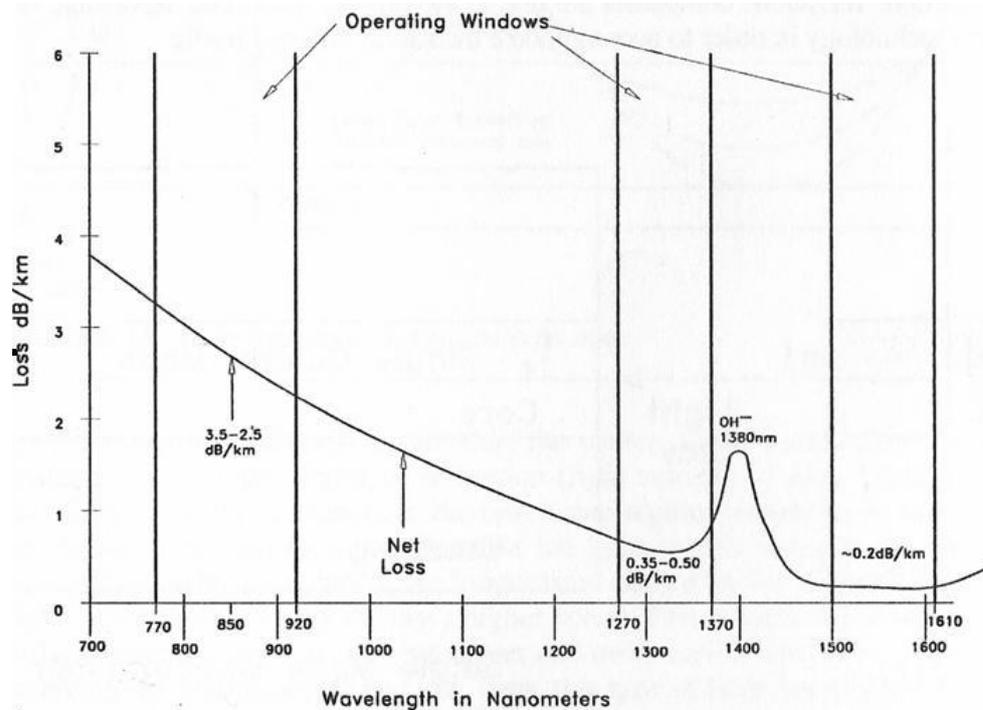


Figure (*) Optical fiber operating wavelengths.

6. **Fresnel Reflection.** Fresnel reflection occurs at any medium boundary where the refractive index changes, causing a portion of the incident light ray to be reflected back into the first medium. The fiber end is a good example of this occurrence. Light, traveling from air to the fiber core, is refracted into the core. However, some of the light, about 4 percent, is reflected back into the air. The amount being reflected can be estimated using the following formula:

RP PHOTONICS ENCYCLOPEDIA

https://www.rp-photonics.com/fresnel_reflections.html

Fresnel reflections

by Dr. Rüdiger Paschotta

Light is reflected at interfaces between different materials, because impedance matching is not given. The reflectivity for such Fresnel reflections can be calculated with Fresnel equations.



4 Reflected Light Power at a Boundary

$$\text{Reflected light (\%)} = 100 \times (n_1 - n_2)^2 / (n_1 + n_2)^2$$

where n_1 = the core refractive index
 n_2 = the air refractive index

OR

$$R = \sqrt{\frac{n_1 - n_2}{n_1 + n_2}} \times 100$$

Q/ Calculate the percent of reflecting light entering the fiber optic core if the refractive index of the core is (1.25) ?

$$R = \sqrt{\frac{n_1 - n_2}{n_1 + n_2}} \times 100$$

$$R = (1.25 - 1 / 1.25 + 1)^{0.5} * 100 = 33\%$$

7. For multimode fiber, the loss is about **3 dB per km for 850 nm sources**, 1 dB per km for 1300 nm. This roughly translates into a

loss of 0.1 dB per 100 feet (30 m) for 850 nm, 0.1 dB per 300 feet(100 m) for 1300 nm.