bandwidth & attenuation - Fiber Optic

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From a transmission point of view, the two most important fiber parameters are bandwidth and attenuation. The fundamental reason we are using fiber instead of copper cable is the increased bandwidth. Bandwidth is the difference between the highest and the lowest frequency information that can be transmitted by a system. A higher bandwidth implies a greater capacity for a channel to carry information. Bandwidth is tested using a very fast laser and a sensitive receiver. Software analyzes the difference between the input and the output pulses, and calculates the bandwidth of the fiber.

Bandwidth is also design dependent—for example, the bandwidth of a step-index multimode fiber _~125MHz_ is lower than for a gradedindex multimode fiber _~500 MHz_. Table 1.1 shows bandwidth variations on two 100 m lengths of FDDI-grade fiber with different mid-span connections—connector, mechanical splice, and fusion splice. As noted earlier, multimode fibers are generally specified by their bandwidth in a 1 km length, which ranges from 100MHz to 1 GHz. For example, a Bandwidth Range 1.28–1.34 GHz 1.09–1.66 GHz 0.83–1.41 GHz 62.5/125 fiber cable jacket may be labeled as “500 MHz-km,” meaning that over a distance of 1 km the fiber can support a minimum bandwidth of 500 MHz. If the same fiber is required to carry a signal at twice this rate, or 1 GHz, we would only be able to use a link half as long, or 0.5 km, before the signal become unrecognizable due to bandwidth limits in the channel.

Bandwidth is inversely proportional to dispersion (pulse spreading), with the proportionality constant dependent on pulse shape and how bandwidth is defined. We have already mentioned that single-mode fiber is used at longer distances because it does not have intermodal dispersion. Other forms of dispersion are material dispersion (because the index of refraction is a function of wavelength) and waveguide dispersion (because the propagation constant of a fiber waveguide is a function of wavelength). Detailed mathematical descriptions of these properties are beyond our scope.

Attenuation is a decrease in signal strength caused by absorption, scattering, and radiative loss. The power or amplitude loss is often measured in decibels (dB), which is a log scale.

dB = 10 log _power level in W 1W_ (1.7)

If the power levels are defined per mW, the same equation is used but the scale is now decibels/milliwatt or dBm. Attenuation in an optical fiber is a function of the operating wavelength. Typically, silica glass fibers have an attenuation minimum near 1.5 micron wavelength (about 0.25 dB/km), which is commonly used for long haul telecommunications and WDM applications. The attenuation is somewhat higher at 1.3 micron wavelength (around 0.5 dB/km), although this range is often used for data communication and other applications with maximum distances less than about 10 km because silica fiber has a dispersion minima at this wavelength. Thus, applications whose performance is likely to be dispersion limited, rather than loss limited, should operate at this point. The loss is significantly higher (around 3–4 dB/km) near 850 nm wavelength, however low cost, high reliability optical sources are readily available at this 16 Fiber Optic Essentials wavelength, making it popular for distances less than 1 km. There are also a number of specialty optical fibers available which have been optimized to have lower loss and higher bandwidth at different wavelengths.

#	Connector	Mechanical splice	Fusion splice
Bandwidth Range	1.28–1.34 GHz	1.09–1.66 GHz	0.83–1.41 GHz