

4.5 Optical Fiber Communication Systems

- **Optical Fibers — extremely wideband channels**

See Fig. 10.1, p. 381 of Ref [C]

- **3 low-loss windows for fibers**

See Fig. 1.7, p. 12 of Ref [C]

- **4 key components of optical fiber communications**

See Fig. 1.3, p. 7 of Ref [C]

Fibers

- **Structure of a fiber : core, cladding, buffer coating**

See Fig. 2.9, p. 36 of Ref [C]

- **Index Profiles, Ray Paths**

- single mode/multi-mode
- step index/graded index

See Fig. 2.10, p. 37 of Ref [C]

Fibers

· **Pulse Broadening — Dispersion**

See Fig. 3.10, p. 105 of Ref [C]

- mode dispersion : eliminated in single mode fibers
- material dispersion : different group velocity for different wavelength, and an optical source produces light with a finite spectral width σ_λ
- waveguide dispersion : 20% of optical power propagating in the cladding travels faster than the other 80% in the core
- in units of ps/(nm) • (km) : σ_d

See an Example in Fig. 3.16, p. 113 of Ref [C]

- specially designed single mode fibers with low dispersion at desired wavelength :
dispersion-shifted, dispersion flattened

See Examples in Figs. 3.22, 3.23, 3.24, pp. 124, 125, 126 of Ref [C]

· **Data rate/Bandwidth – Distance Product**

$$\sigma_d \cdot \sigma_\lambda \cdot L \leq b \cdot T$$

σ_λ : spectral width

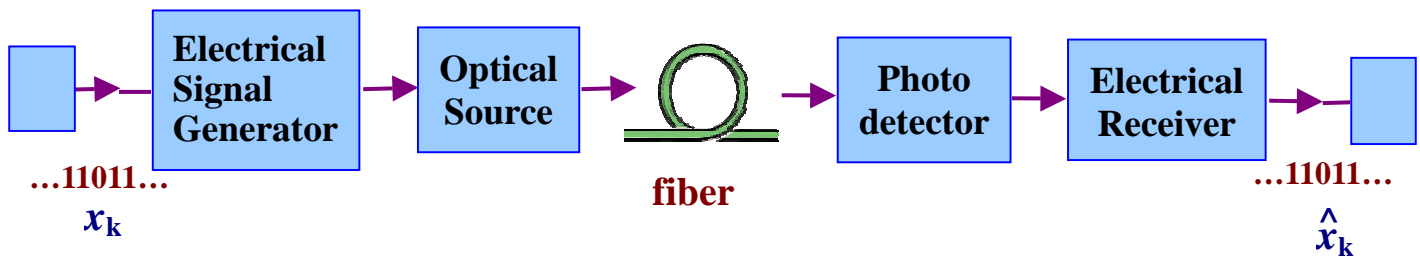
L : distance

$\frac{1}{T} = r$: data rate

b : some constant

$$r \cdot L \leq \frac{b}{\sigma_d \cdot \sigma_\lambda} \quad (\text{km} \cdot \text{bps})$$

Fiber Data Transmission System



- **Different noise distributions for 1 and 0**
 - due to dispersion, optical amplifier, etc.
See Fig. 7.5, p. 283 of Ref [C]
- **System Design considering attenuation and dispersion**

See an Example in Fig. 8.6, p. 334 of Ref [C]

Wavelength Division Multiplexing (WDM)

- each optical signal transmission only uses a very small portion of the transmission bandwidth of a standard fiber
- multiplexing many signals operating at different wavelength to be transmitted in a single fiber

See Fig. 10.1, 10.2 pp. 381, 383 of Ref [C]

- dense WDM (DWDM)
- WDM Networks : WDM-based switching, routing, etc.
- WDM undersea cable networks

See an Example in Fig. 1.4, p. 9 of Ref [C]

Characteristics of Optical Fiber Communications

- Extremely high capacity/wide bandwidth/high data rate**
- Small size, light in weight, easy cabling/spatial arrangements**
- Nonconductive, noninductive**
- Zero mutual interference**
- Small amount of materials, rich of resources**
- Fixed, no mobility**

Ref:

- 1. Ref[C]: Gerd Keiser, “Optical Fiber Communications”, 3rd Ed., 2000, McGraw-Hill, 1.2, 1.3, 2.3, 3.2, 3.5, 7.2, 8.1, 10.1*
- 2. “Special Issue on Optical Networking Solutions for next Generation Internet”, IEEE Communications Magazine, Sept. 2000*