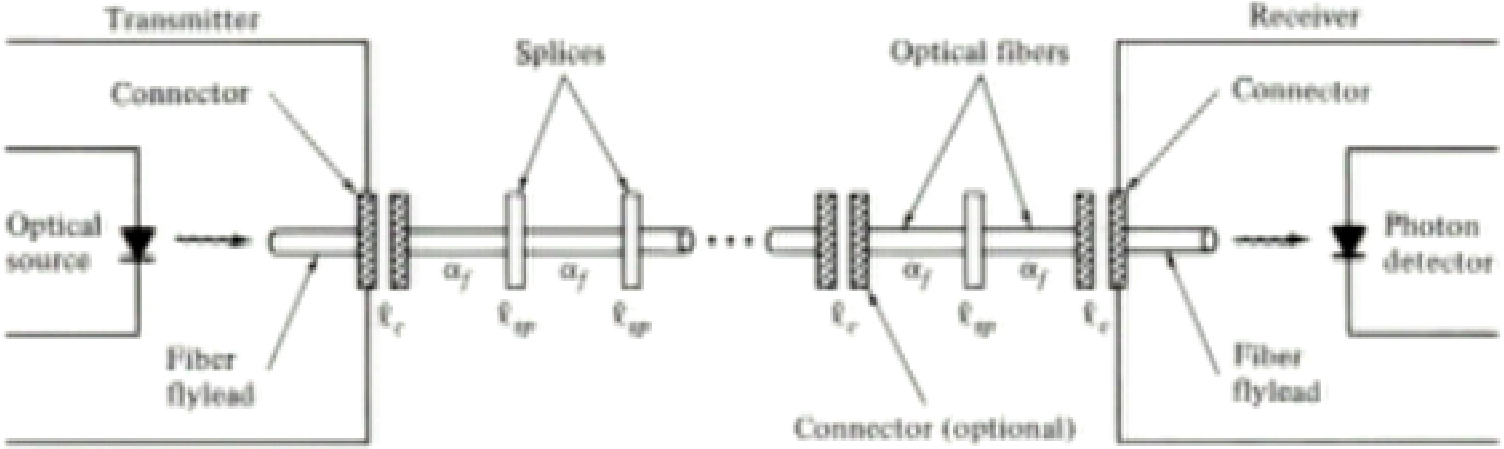
Fiber Optic Link Design

- **Primary Design Criteria**
  - Bit Rate (Dispersion Limitation)
  - Link length (Attenuation Limitation)

- **Additional Design Parameters**
  - Modulation format eg Analog/digital
  - System fidelity: BER, SNR
  - Cost : Components, installation, maiteanance
  - Upgradeability
  - Commercial availability

Simple point-to-point link

Optical power-loss model



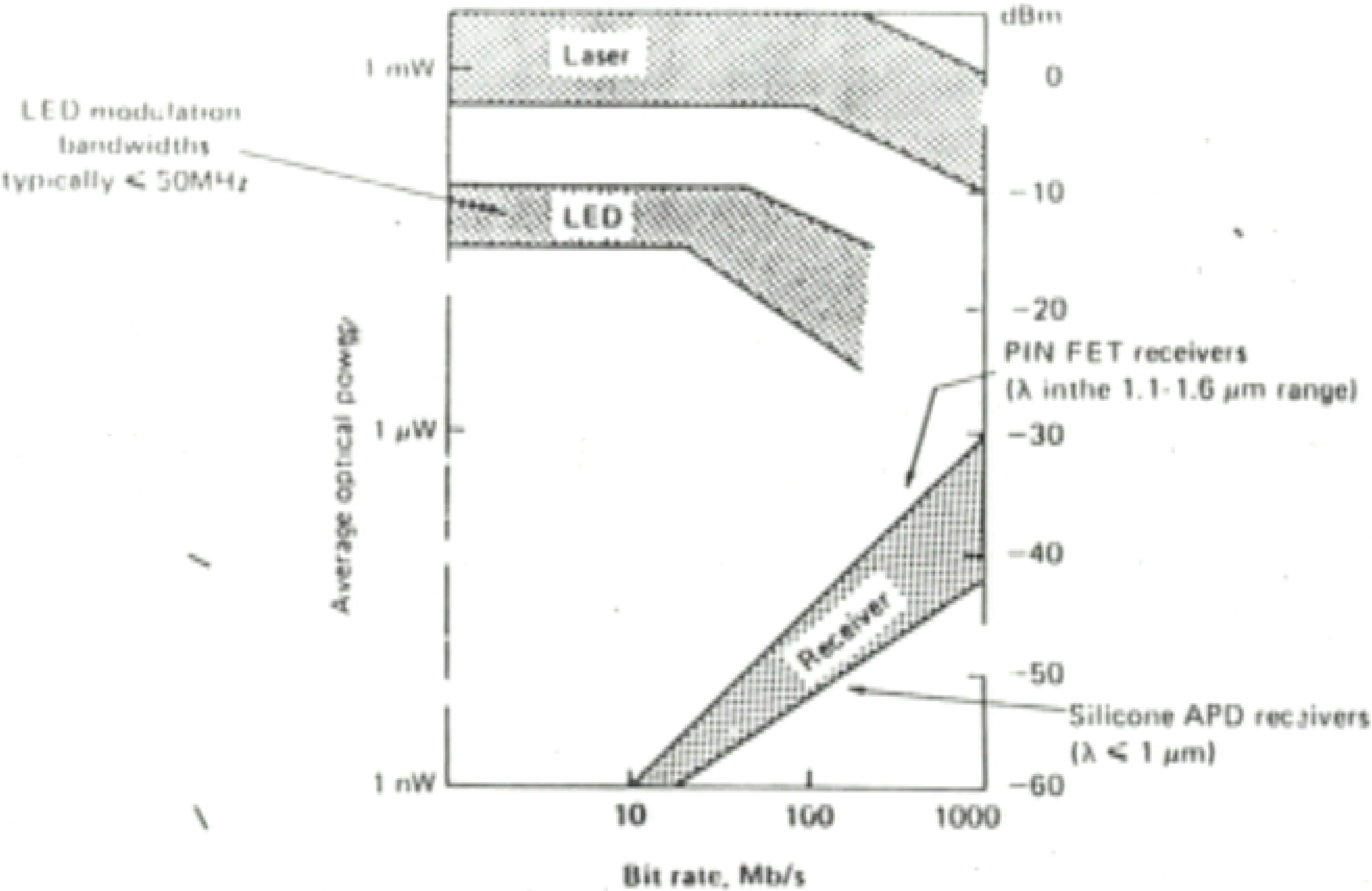
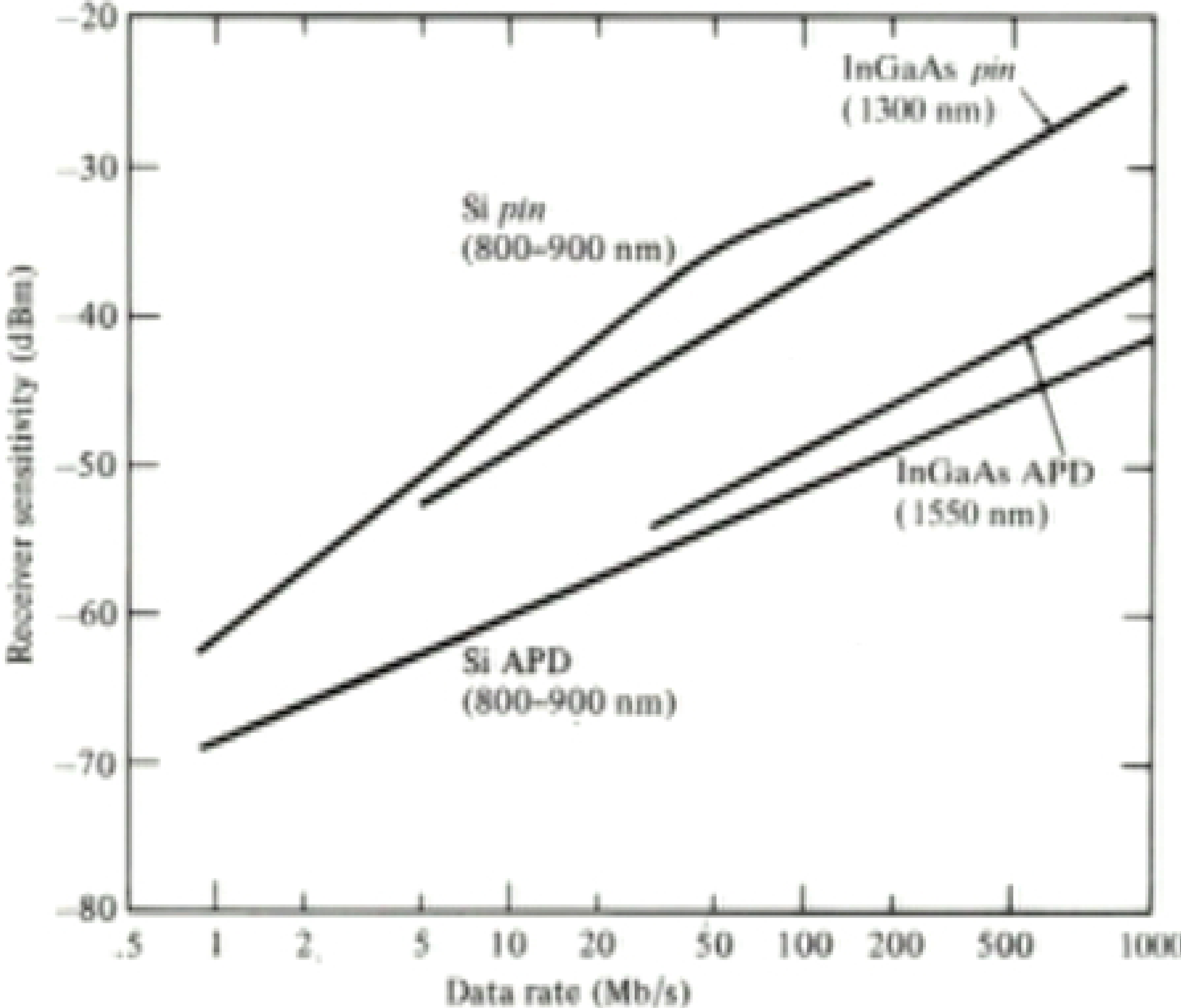


FIGURE 9.6 Transmission margin vs. bit rate for a digital fiber-optic communication system. (*From D. C. Gloge and T. Li,*[2] **© 1980 IEEE,** *with permission.*)

Receiver sensitivities vs bit rate



Power Budget Calculations

Ps = Power from the Transmitter in dBm

Pr = Sensitivity of receiver in dBm for given BER

Maximum allowable loss $\alpha_{max} = P_s - P_r$

$$\alpha_{max} = \alpha_{fiber} + \alpha_{conn} + \alpha_{splice} + \alpha_{syst}$$

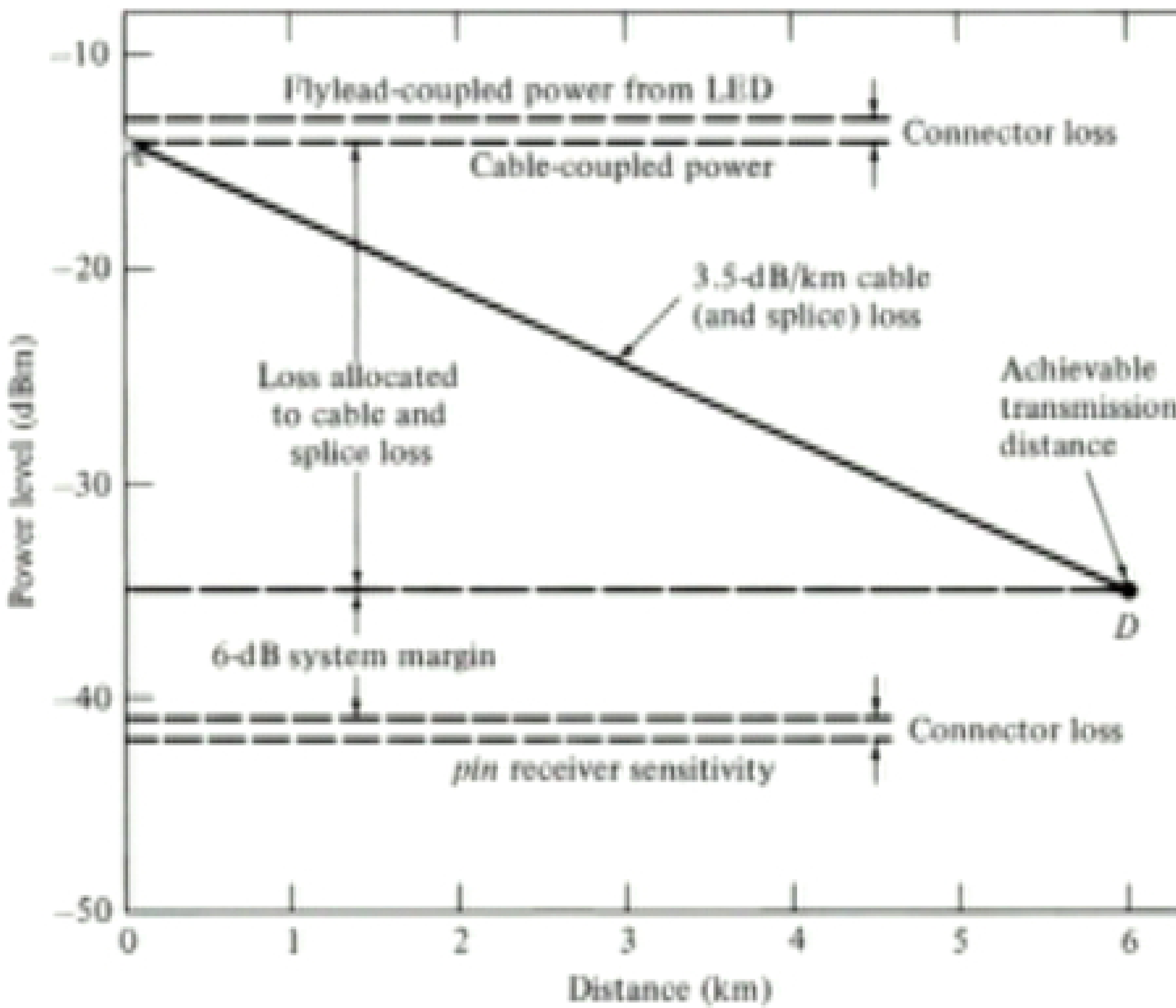
$$\alpha_{fiber} = \alpha_{max} - (\alpha_{conn} + \alpha_{splice} + \alpha_{syst})$$

Power Limited Link Length

$$L_{P\max} = \frac{\alpha_{fiber}}{Loss / Km}$$

Beyond this distance the SNR is below the acceptable limit

Example link-loss budget



Rise Time Budget

Rise time analysis gives effective bandwidth of the link

$$t_{sys} = \{t_{tx}^2 + D^2\sigma_\lambda^2 L^2 + t_{rx}^2\}^{1/2}$$

For satisfactory operation of the link

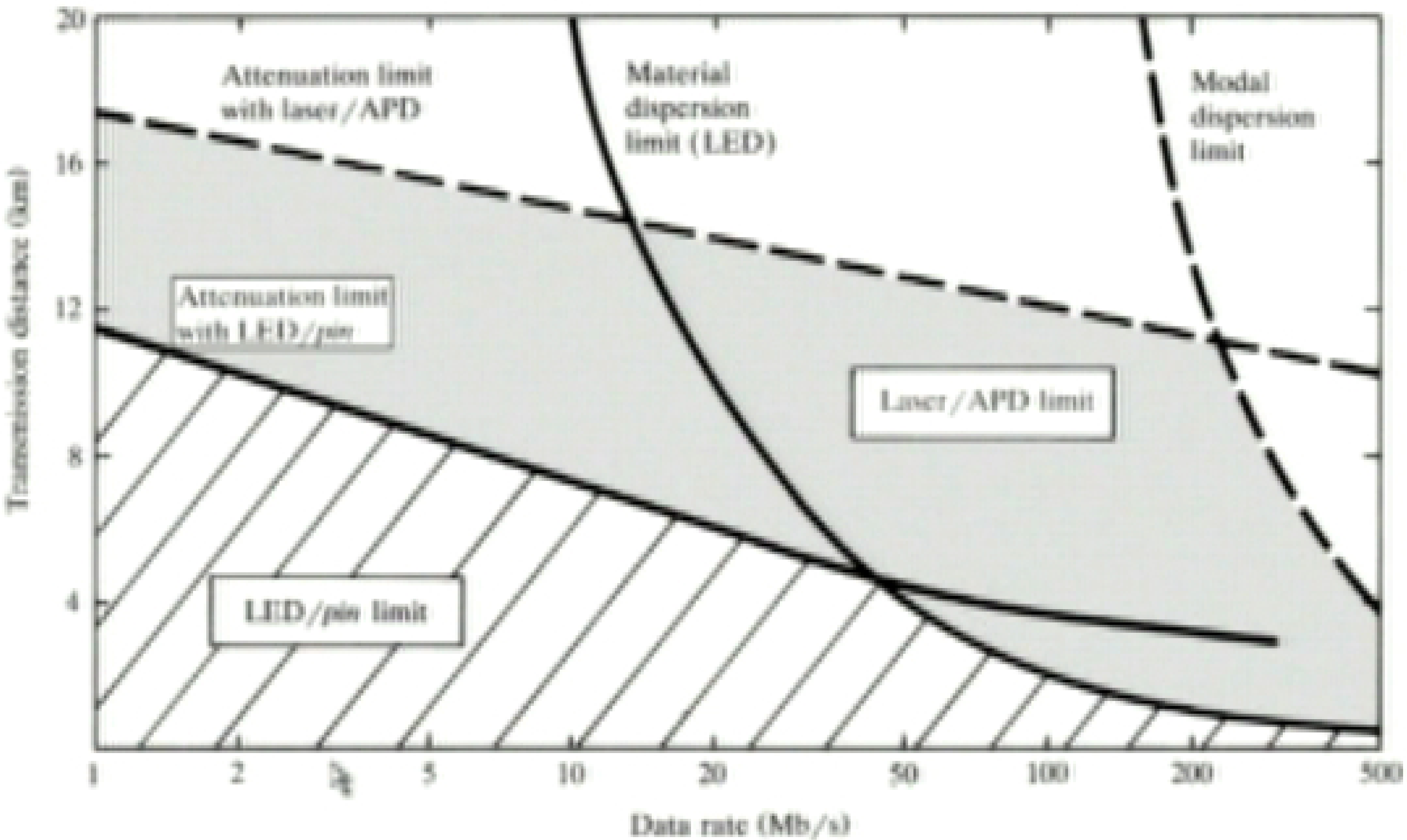
$$t_{sys} \leq 0.7T_b$$

Rise time limited link length

$$L_{RT\max} = \frac{1}{D\sigma_\lambda}\{(0.7T_b)^2 - (t_{tx}^2 + t_{rx}^2)\}^{1/2}$$

Beyond this distance the signal distortion is unacceptable

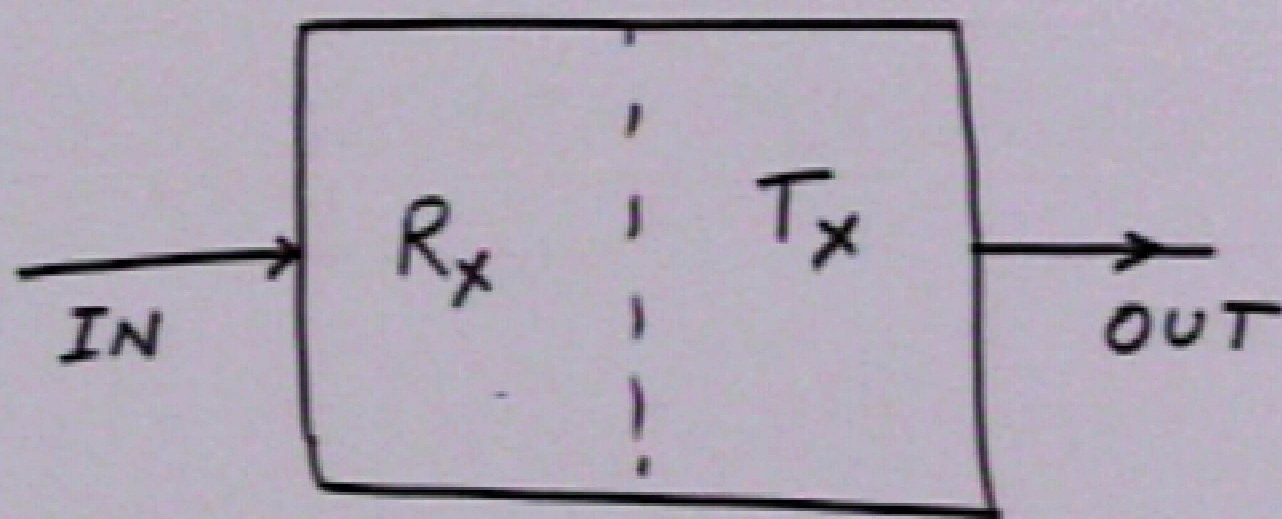
Transmission distance vs data rate



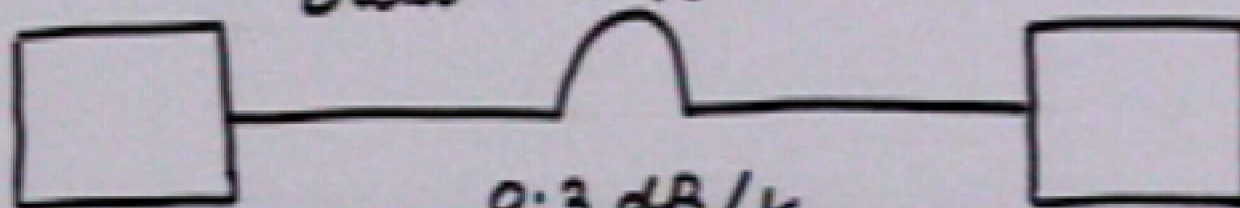
Fiber Optic System Design

1-10 m	10 m-0.1 km	0.1-1K m	1-3K m	3-10K m	10-50K m	50-100 Km	>100K m	
						L	D	10K
	S	L	E	D	M	M		10-100K
		M	M					100K-1M
					LD	GI		1-10M
			G	I				10-50M
L	E	D				L	D	50-500M
LD	L	D			S	M		500M-1000M
MM	G	I						>1G

Optical Repeater



Data 1Gb/s



0.3 dB/km

$t_{tx} \approx 0$ 1 ps/km/nm

$P_s = 0$ dBm $P_r = -40$ dBm

$\sigma_\lambda = 0.1$ nm

$$L_{P\,max} = \frac{0-(-40)}{0.3} \approx 100 \text{ km}$$

$$T_b = 10^{-9}$$

$$L_{RT\,max} \simeq \frac{10^{-9}}{0.1 \times 10^{-12}} = 10^4 \text{ km}$$