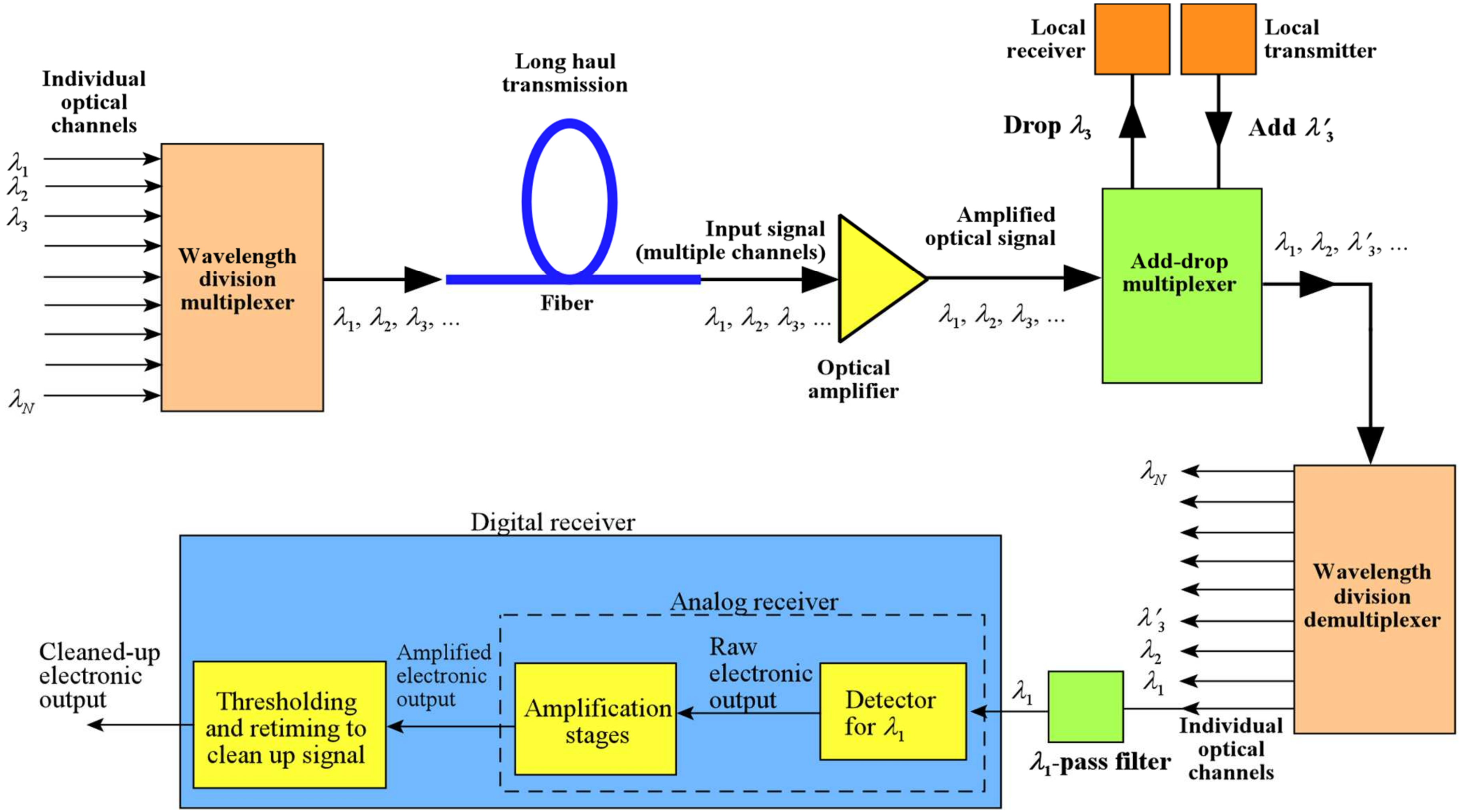
Sistema de comunicação ótica com amplificador ótico



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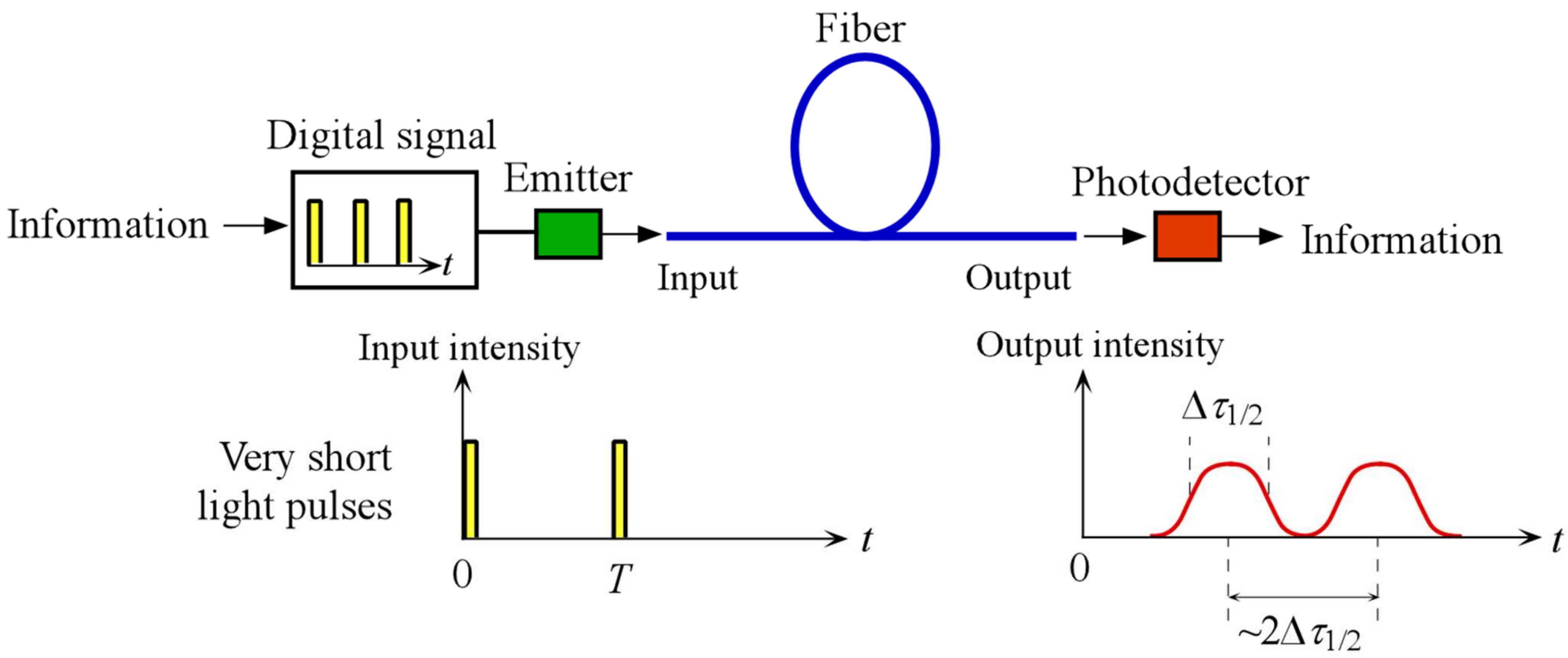
Sistema de comunicação ótica básico



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Sistema de comunicação ótica básico

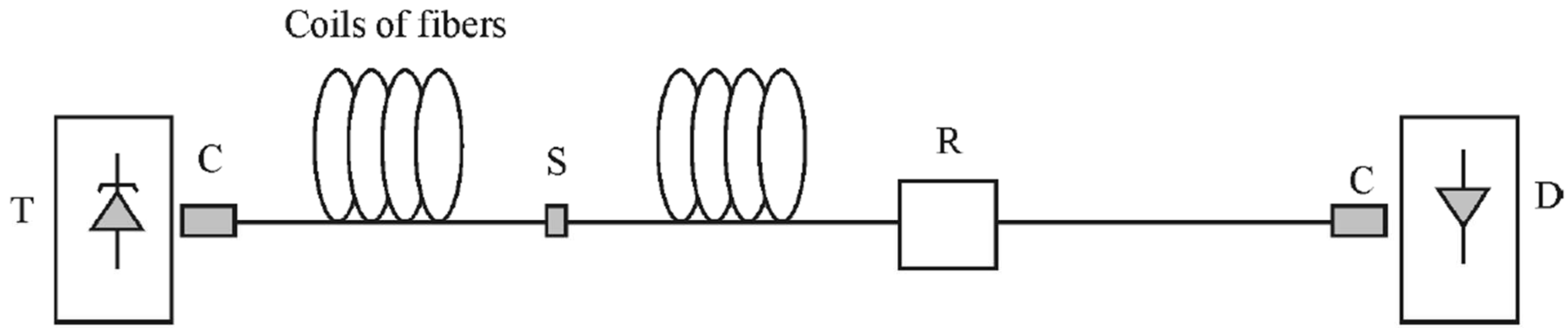


Figure 4-2 *A typical fiber optic communication system: T, transmitter; C, connector; S, splice; R, repeater; D, detector, and coils of fibers*

Problemas típicos:

The Basic Fiber Optic Link

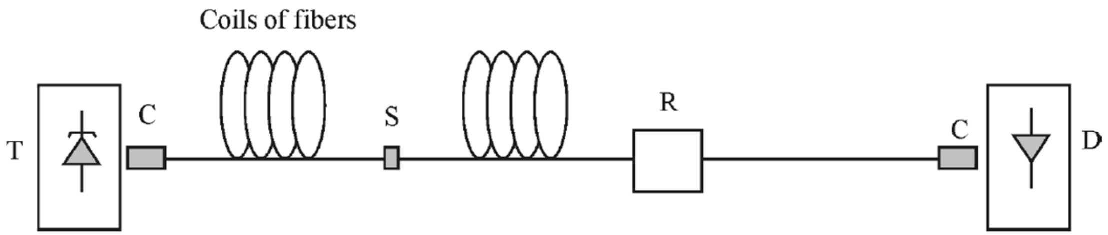


Figure 4-2 *A typical fiber optic communication system: T, transmitter; C, connector; S, splice; R, repeater; D, detector, and coils of fibers*

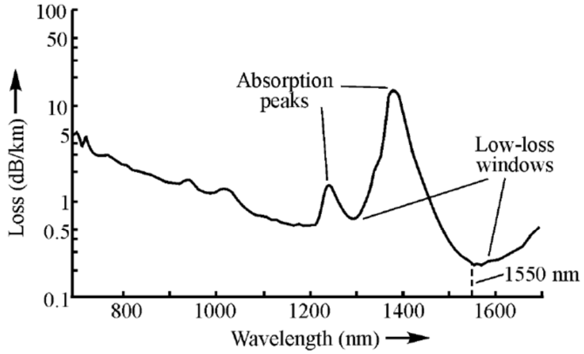


Figure 4-9 *Typical wavelength dependence of attenuation for a silica fiber. Notice that the lowest attenuation occurs at 1550 nm*

Example 1: A fiber of 50 km length has Pin=10 mW and Pout=1 mW. Find the loss in dB/km.

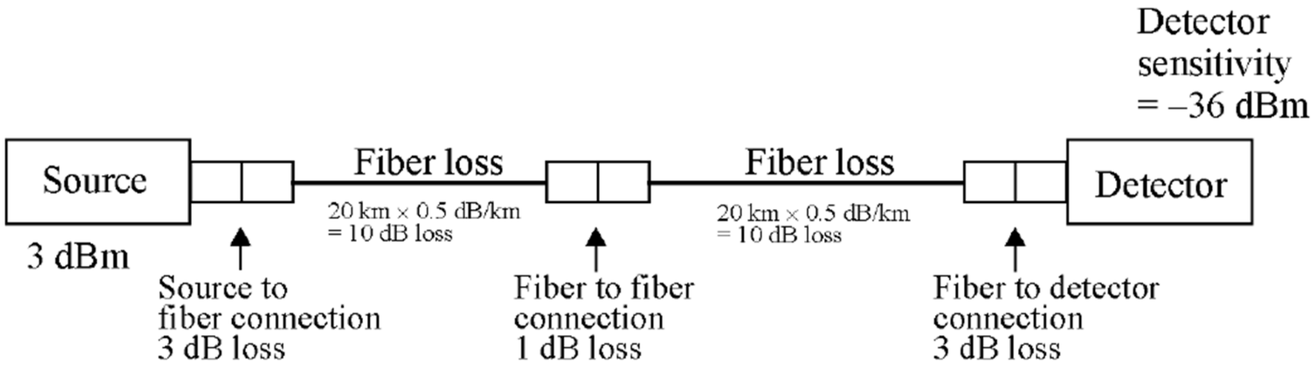
Ans. Loss(dB)=10log[1 mW/10mW]=-10 dB. The loss per unit length of the fiber is: Loss(dB/km)=(-10 dB/50 km)=-0.2 dB/km.

Example 2: A 10 km fiber optic communication system link has a fiber loss of 0.3 dB/km. Find out the output power if the input power is 20 mW.

Ans. Loss(dB)=0.3 dB/km x 10 km = 3 dB. Pout=20 mWx10^(-3/10)=10 mW.

Problema típico: "link power budget"

Example 3: A optica comunication system system has the following characteristics:



Find the loss margin (Lm).

R: The system has the following characteristics:

Source power (P_L) = 2 mW (3 dBm)

Source to fiber loss (L_{sf}) = 3 dB

Fiber loss per km (F_L) = 0.5 dB/km

Fiber length (L) = 40 km

Connector loss (L_{conn}) = 1 dB (one connector between two 20-m fiber lengths)

Fiber to detector loss (L_{fd}) = 3 dB

Receiver sensitivity (P_s) = –36 dBm

Problema típico: "link power budget"

Example 3: A optica comunication system system has the following characteristics:

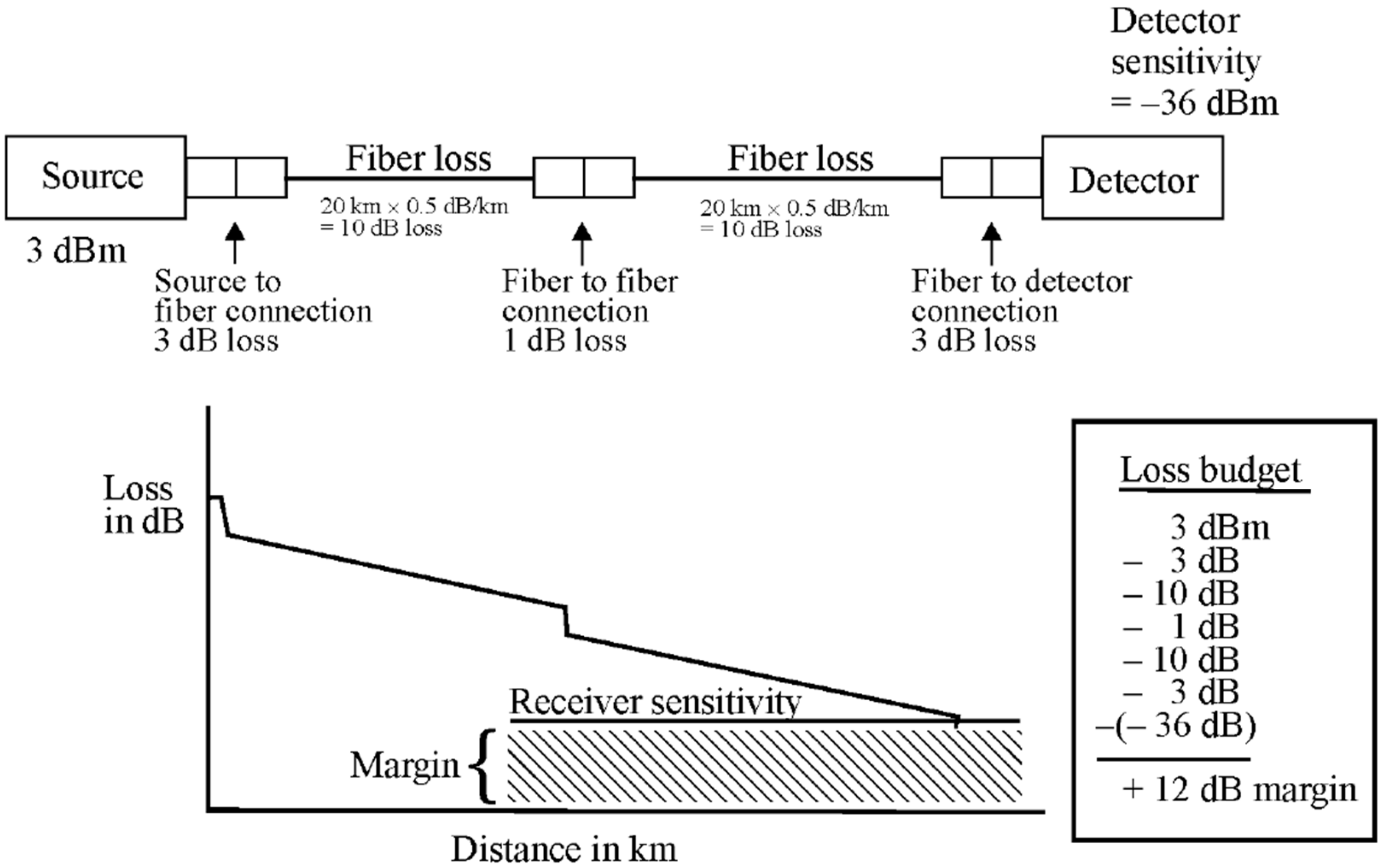


Figure 4-12 *Fiber optic loss budget*

Lm (dB)=3 dBm -3 dB -(40 km x 0.5 dB/km) -1 dB -3 dB - (-36 dBm) = 12 dB.

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Problema típico:

Example 4: A receiver has a sensitivity Ps of -45 dBm for BER of E-12. What is the minimum power that must be incident on the detector?

Ans. -45 dBm = 10log(P/1 mW). P = 1 mW x 10^-4.5 = 31.6 uW.

Dispersion and fiber bandwidth (BW)

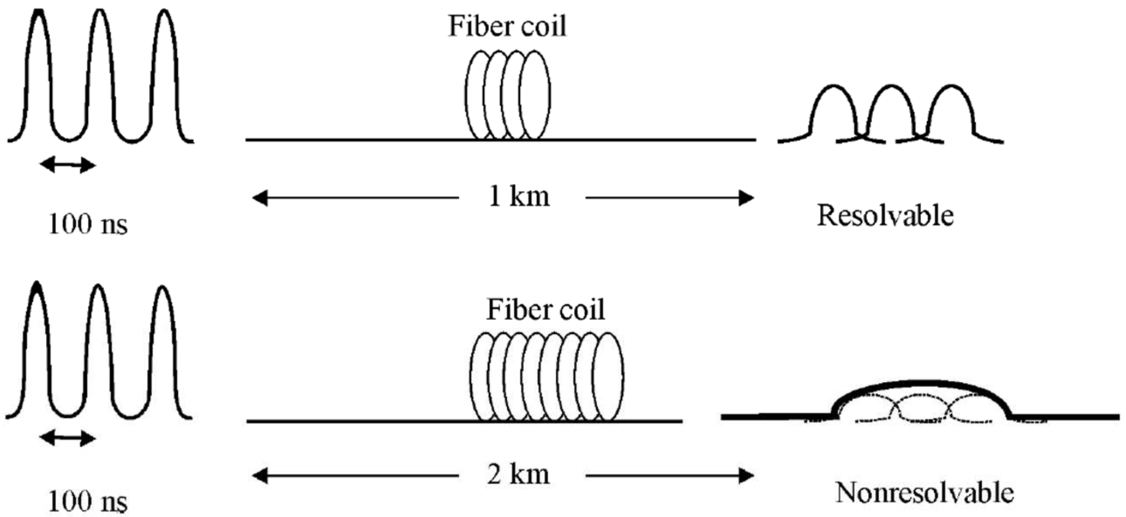

Figure 4-19 *Pulses separated by 100 ns at the input end would be resolvable at the output end of 1 km of the fiber. The same pulses would not be resolvable at the output end of 2 km of the same fiber.*

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Dispersion and fiber bandwidth (BW)

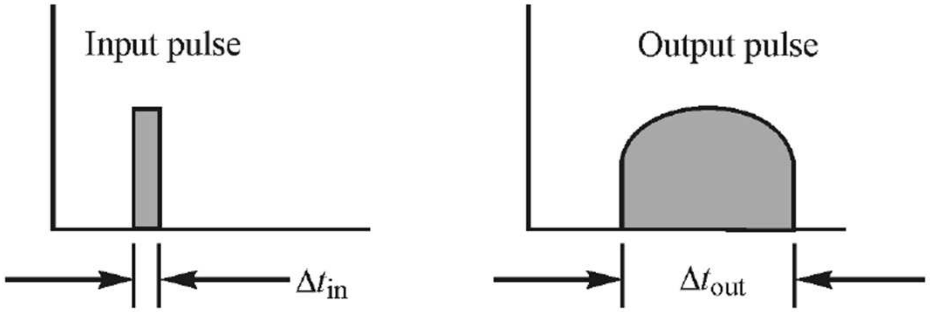

Figure 4-20 *Pulse broadening caused by dispersion*

Dispersion Δt $\quad \Delta t = (\Delta t_{out} - \Delta t_{in})^{1/2}$

$$\Delta t_{chromatic} = \Delta t_{material} + \Delta t_{waveguide}$$

$$\Delta t_{total} = \sqrt{\Delta t^2_{modal} + \Delta t^2_{chromatic}}$$

$$\Delta t_{total} = L \times (\text{Dispersion/km})$$

Fiber bandwidth (BW): $\text{BW (Hz)} = 0.35/\Delta t_{total}$

Problemas típicos:

Example 5: a 2 km length multimode fiber has a modal dispersion of 1 ns/km and a chromatic dispersion of 100 ps/km-nm. It is used an LED of linewidth 40 nm. a) What is the total dispersion? b) calculate the bandwidth (BW) of the fiber.

Ans. (D=dispersion)

a) Dt modal = 2 km x 1 ns/km = 2 ns; Dchromatic = 2 km x 100 ps/km x 40 nm = 8 ns. Dtotal = 8.25 ns.

b) BW = 0.35/Dtotal = 42.42 MHz. BW x distance = 85 MHz-km.

Example 6: 50 km SMF, material dispersion of 10 ps/km and waveguide dispersion of -5 ps/km. Laser diode with a linewidth of 0.1 nm. a) What is the chromatic dispersion? b) What is Dtotal? c) Calculate the BW of the fiber.

Ans. (D=dispersion)
a) Dchromatic =10 ps/km nm – 5 ps/km nm = 5 ps/km nm.
b) Dtotal = 50 km x 5 ps/km nm x 0.1 nm = 25 ps.
c) BW = 0.35/Dtotal = 14 GHz. BW x distance = 700 GHz-km.

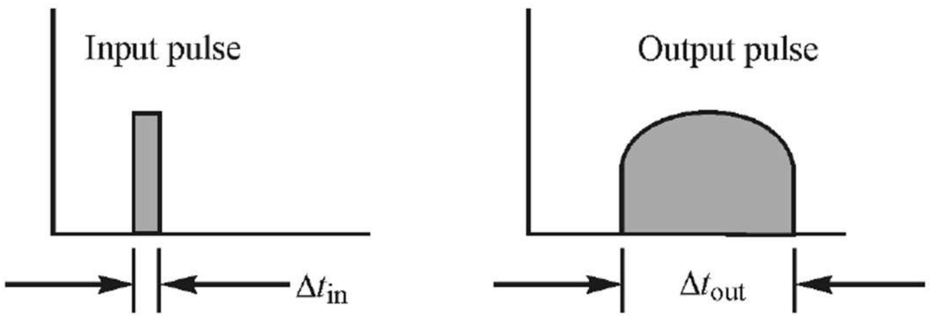

Figure 4-20 *Pulse broadening caused by dispersion*

Dispersion Δt $\quad \Delta t = (\Delta t_{out} - \Delta t_{in})^{1/2}$

$$\Delta t_{chromatic} = \Delta t_{material} + \Delta t_{waveguide}$$

$$\Delta t_{total} = \sqrt{\Delta t^2_{modal} + \Delta t^2_{chromatic}}$$

$$\Delta t_{total} = L \times (\text{Dispersion/km})$$

Fiber bandwidth (BW): $\text{BW (Hz)} = 0.35/\Delta t_{total}$

Dispersion shifted fibers

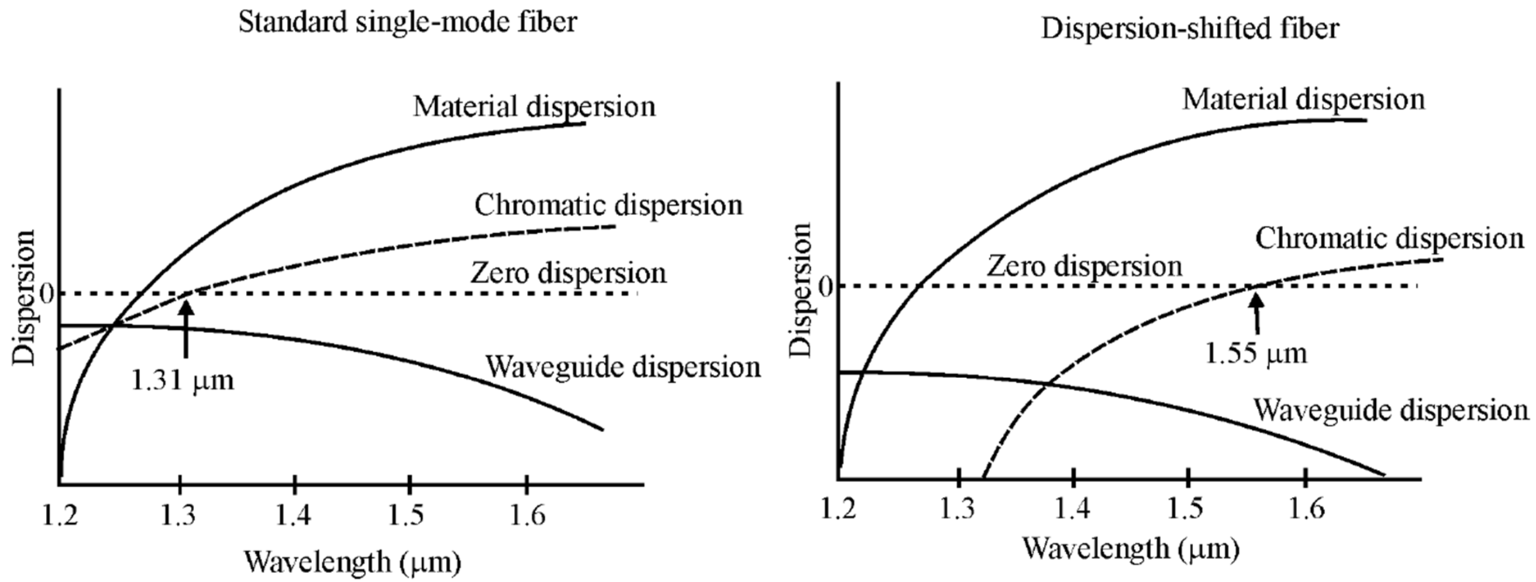

Figure 4-22 *Single-mode versus dispersion-shifted fiber*

Dispersion Δt

$$\Delta t_{total} = L \times (\text{Dispersion/km})$$

Fiber bandwidth (BW):

$$\text{BW (Hz)} = 0.35/\Delta t_{total}$$

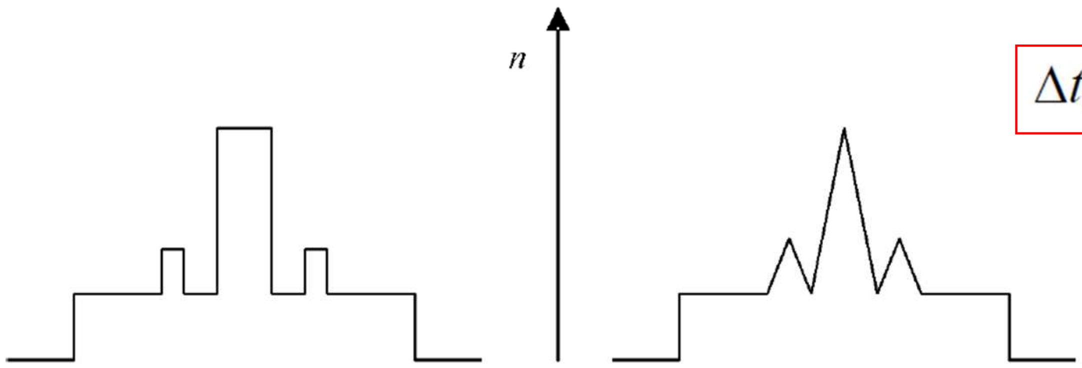

Figure 4-23 *W-profile fibers: (a) step-index, (b) triangular profile*

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Typical problems:

Example 10: a 2 km length multimode fiber has a modal dispersion of 1 ns/km and a chromatic dispersion of 100 ps/km-nm. It is used an LED of linewidth 40 nm. a) What is the total dispersion? b) calculate the bandwidth (BW) of the fiber.

Ans. (D=dispersion)
a) Dt modal = 2 km x 1 ns/km = 2 ns; Dchromatic = 2 km x 100 ps/km x 40 nm = 8 ns. Dtotal = 8.25 ns.
b) BW = 0.35/Dtotal = 42.42 MHz. BW x distance = 85 MHz-km.

Example 11: 50 km SMF, material dispersion of 10 ps/km and waveguide dispersion of -5 ps/km. Laser diode with a linewidth of 0.1 nm. a) What is the chromatic dispersion? b) What is Dtotal? c) Calculate the BW of the fiber.

Ans. (D=dispersion)
a)Dchromatic =10 ps/km nm – 5 ps/km nm = 5 ps/km nm.
b)Dtotal = 50 km x 5 ps/km nm x 0.1 nm = 25 ps.
c)BW = 0.35/Dtotal = 14 GHz. BW x distance = 700 GHz-km.

Typical problems:

Problem 1: You need to transmit data over an optical link of 100 km with ber loss of 0.2 dB/km. The link has five splices with 0.05 dB loss per splice and two connectors with 0.2 dB per connector. The receiver sensitivity is 20 W. Express the minimum transmitter power in both mW and dBm.

Typical problems:

Problem 2: Consider an optical fiber of 50 um diameter, core index n1= 1, 5, and cladding index n2= 1,49 for operation at 1300 nm.

a) What is the numerical aperture (NA) of this fiber?
b) How many modes does this fber support?
c) What would be the pulse spread due to modal dispersion over a distance of 10 km?

Typical problems:

Problem 3: For an optical communications system, the transmitter and receiver operate at 2.5 Gb/sec at a central wavelength of 1550 nm, using a laser with a spectral linewidth of 0,05 nm. The fiber has a dispersion parameter of M=-20 ps/nm.km.

a) Calculate the pulse spread per unit distance (ps/km).

b) What is the maximum length of ber that allows the stated system bit rate?

c) Given the optical bandwidth of 7,07 GHz, then what would be the optical frequency spread in terms of wavelength (nm)

d) What would be the maximum fiber length?