Optoelectronică

Curs 7

2023/2024

Disciplina 2023/2024

- 2C/1L Optoelectronică **OPTO**
- **Minim 7 prezente curs + laborator**
- Curs – conf. **Radu Damian**
  - an IV μE
  - Marti 14(**:10**)-16:00, P8
  - E – 70% din nota (50%+20%)
    - **20% test (VP) la curs**, saptamana 4-6?
  - probleme + (2p prez. curs)
  - **toate materialele permise**
- Laborator – **drd. Stefan Stoica**
  - an IV μE
    - Marti 16-20 par
    - Max. 7 prezente
  - L – 30% din nota (+Caiet de laborator)

Cuprins

- **Lumina ca undă electromagnetică*** (ecuaţiile lui Maxwell, ecuaţia undelor, parametrii de propagare)
- **Elemente de fotometrie şi radiometrie*** (mărimi energetice/luminoase)
- **Fibra optică** (realizare, principiu de funcţionare, atenuare, dispersie, banda de frecvenţă)
- **Cabluri optice** (tehnologie, conectori, lipire – splice)
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- **Realizarea circuitelor pentru controlul emiţătoarelor optice** (parametri, scheme tipice, controlul puterii, multiplexoare)
- **Dispozitive de captare a energiei solare** (principiu de functionare, utilizare, proiectare)

*** – VP**

Documentatie

RF-OPTO

English | Romana |

Main Courses Master Staff Research Students

Microwave and Optoelectronics Laboratory

We are enlisted in the Telecommunications Department of the Electronics, Telecommunication and Information Technology Faculty (**ETTI**) from the "Gh. Asachi" Technical University (**TUIASI**) in Iasi, Romania

We currently cover inside **ETTI** the fields related to:

- Microwave Circuits and Devices
- Optoelectronics
- Information Technology

Courses

Nr.	Course	Shortcut	Code	Type	Semester	Credits	Weekly	Examination	Link
1	Microwave Devices and Circuits for Radiocommunications	**DCMR**	DOS412T	DOS	7	4	0P,1L,0S,2C	Exam	details
2	Monolithic Microwave Integrated Circuits	**CIMM**	RD.IA.207	DOMS	11	6	1.5L,0S,2C,0P	Exam	details
3	Advanced Techniques in the Design of the Radio-communications Systems	**TAPSR**	RD.IA.103	DIMS	9	6	1.5P,0L,0S,2C	Exam	details
4	Optical Communications	**CO**	DOS409T	DOS	7	5	0P,1L,0S,3C	Colloquium	details
5	Optical Communications	**OC**	EDOS409T	DOS	7	5	0P,1L,0S,3C	Exam	details
6	Satellite Communications	**CS**	RC.IA.104	DIMS	9	6	0L,0S,2C,1.5P	Exam	details
7	Applied Informatics 1	**IA1**	DOF135	DOF	1	4	0P,1L,0S,2C	Verification	details
8	Applied Informatics 1	**AI1**	EDOF135	DOF	1	4	0P,1L,0S,2C	Verification	details
9	Databases, Web Programming and Interfacing	**DWPI**	ITT.IA.601	DIS	11	5	1P,1L,0.25S,1C	Verification	details
10	Web Applications Design	**PAW**	RC.IA.108	DIMS	10	5	1L,0S,1.5C,1P	Exam	details
11	Optoelectronics	**OPTO**	DID405M	DID	8	4	0P,1L,0S,2C	Colloquium	details
12	Microwave Devices and Circuits for Radiocommunications (English)	**MDCR**	EDOS412T	DOS	8	4	0P,1L,0S,2C	Exam	details

Documentatie

- RF-OPTO
  - http://rf-opto.etti.tuiasi.ro
- Fotografie
  - “examen” online
  - necesara la laborator/curs

Bonus (~0.5-4.15)

Disciplina: Optoelectronica, structuri, tehnologii, circuite
An: 2015/2016

Bonus-uri care se aplica la nota de la teza obtinute prin:
- prezenta la curs (0.5p / 3pr)
- 3 miniteste aplicate la curs (max. 3 X 1.5p)
- contributie la site rf-opto (foto <C5=1p, >C5=0.5p)

Nr.	Student	Grupa	Prezente curs	Bonus prezenta	Bonus foto	Bonus T1	Bonus T2	Bonus T3	Total Bonus	Obs.
1	CIOLPAN OCTAVIAN	5306	3	0.5					0.5	-
2	NITA COSTEL-CATALIN	5307	4	0.5	1				1.5	-
3	BARON BOGDAN-IONUT	5405	12	2	1	0.5		0.75	4.25	-

Prezenta

Curs
Laborator

Liste

Studenti care nu pot intra in examen
Bonus-uri acumulate

- **Minim** 7 prezente
- 0.5p/3prez
- 3 teste
- foto <C**7**/<C**9**

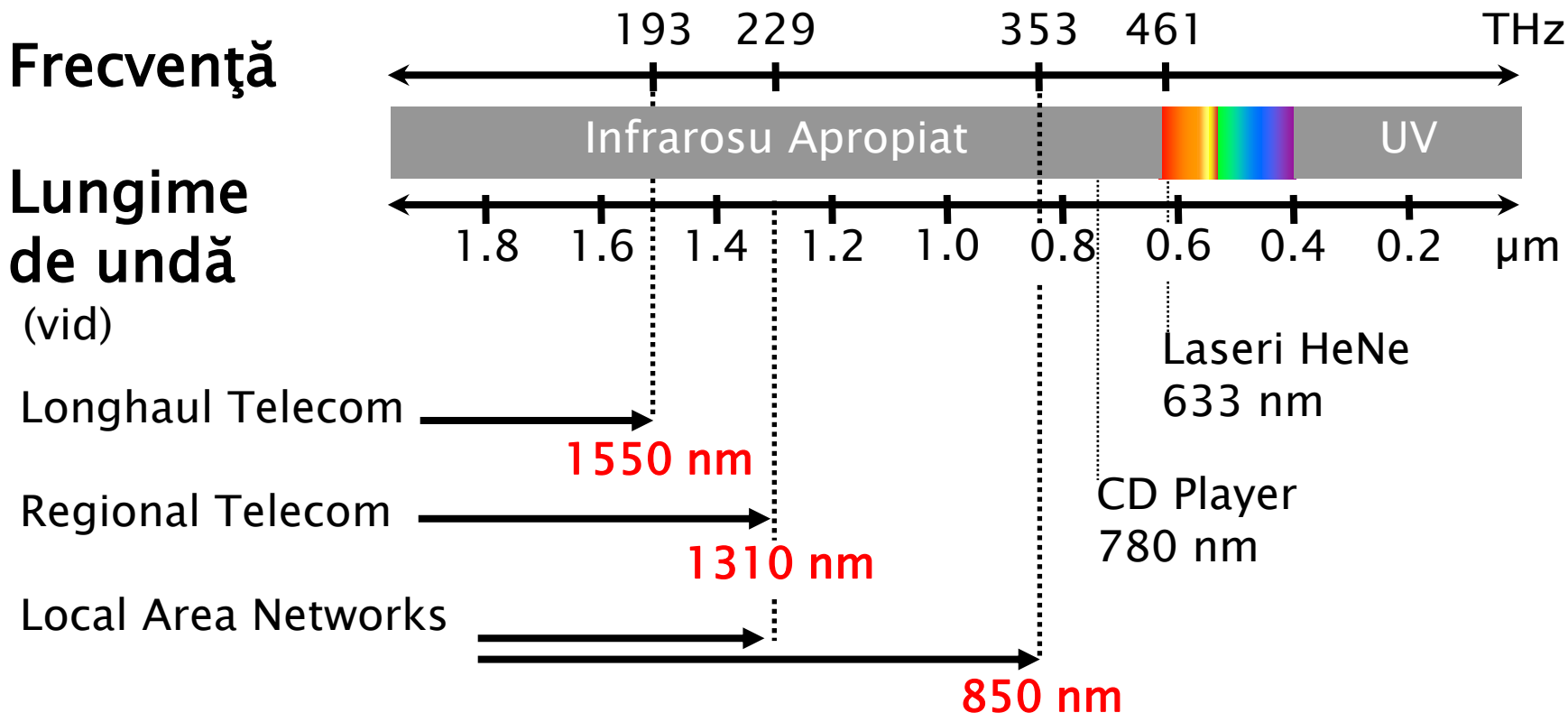
Fibra optică

Capitolul 4

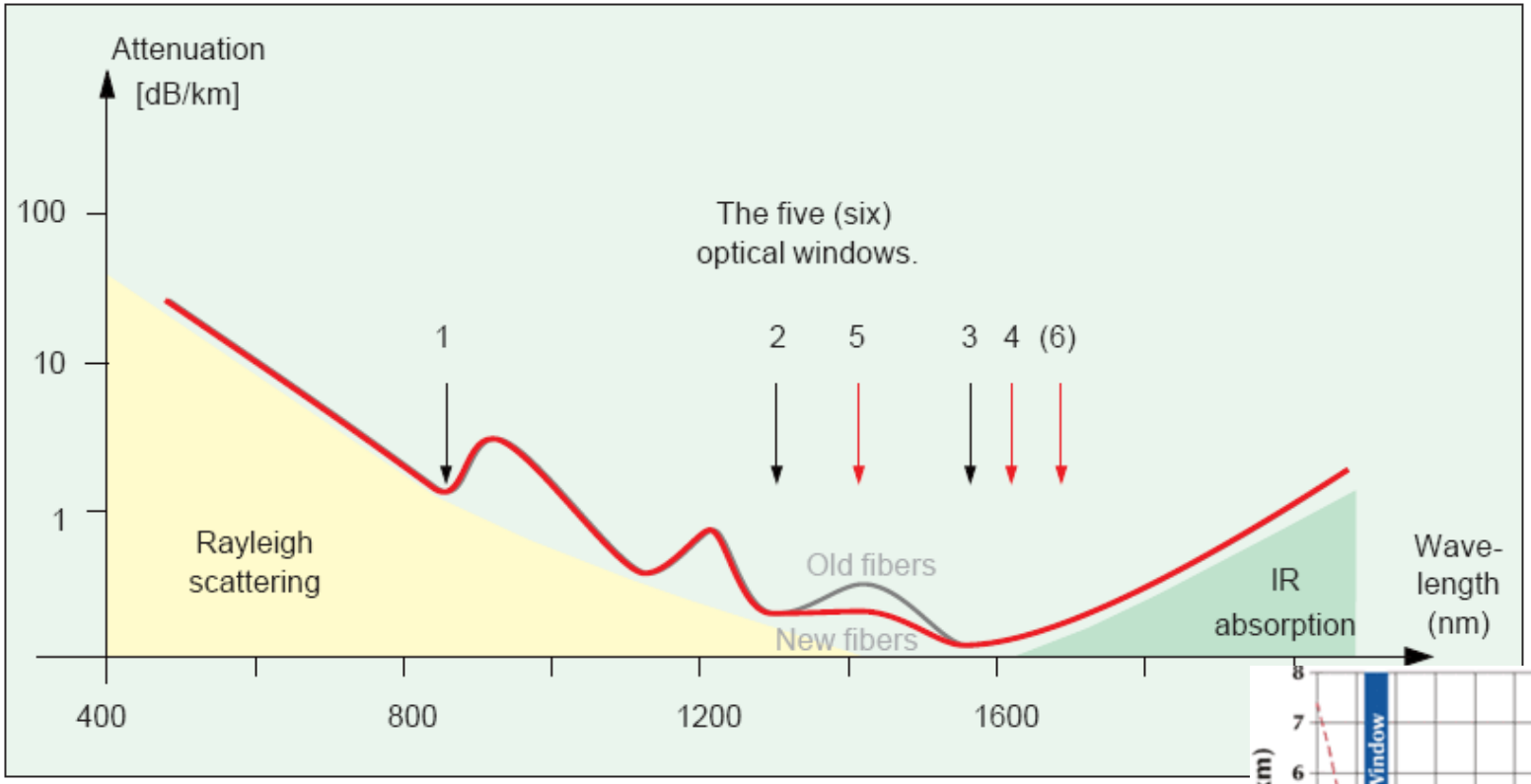
Aplicatii majore

- Comunicatii
  - Infrarosu (InGaAsP)
- Vizibil
  - Spectru vizibil (GaAlAs)
- Iluminare
  - Putere ridicata, lumina alba (GaInN)
- Energie solara
  - Efect fotovoltaic (Si)

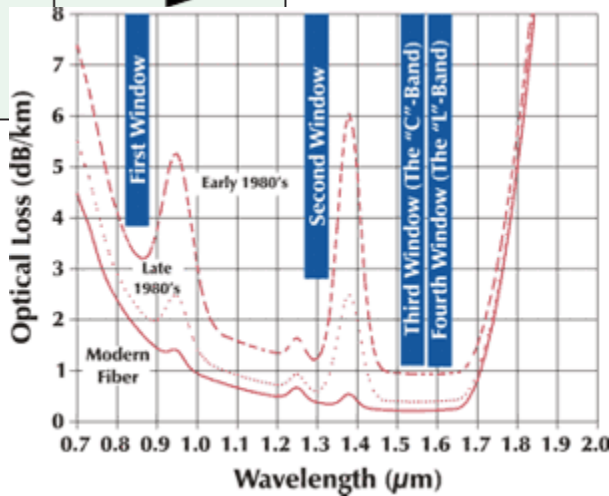
Benzi de lucru in comunicaţiile optice



Atenuarea în fibra optică (SiO_2)



850nm, 1310nm, 1550nm



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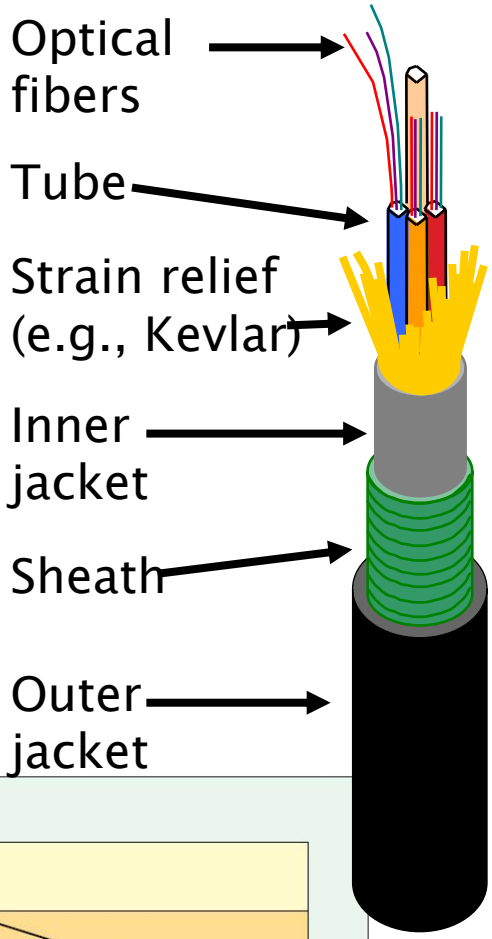
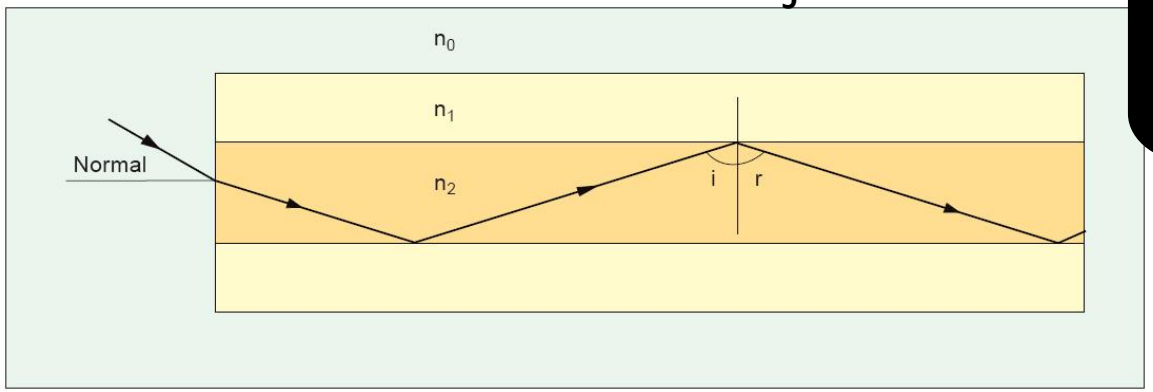
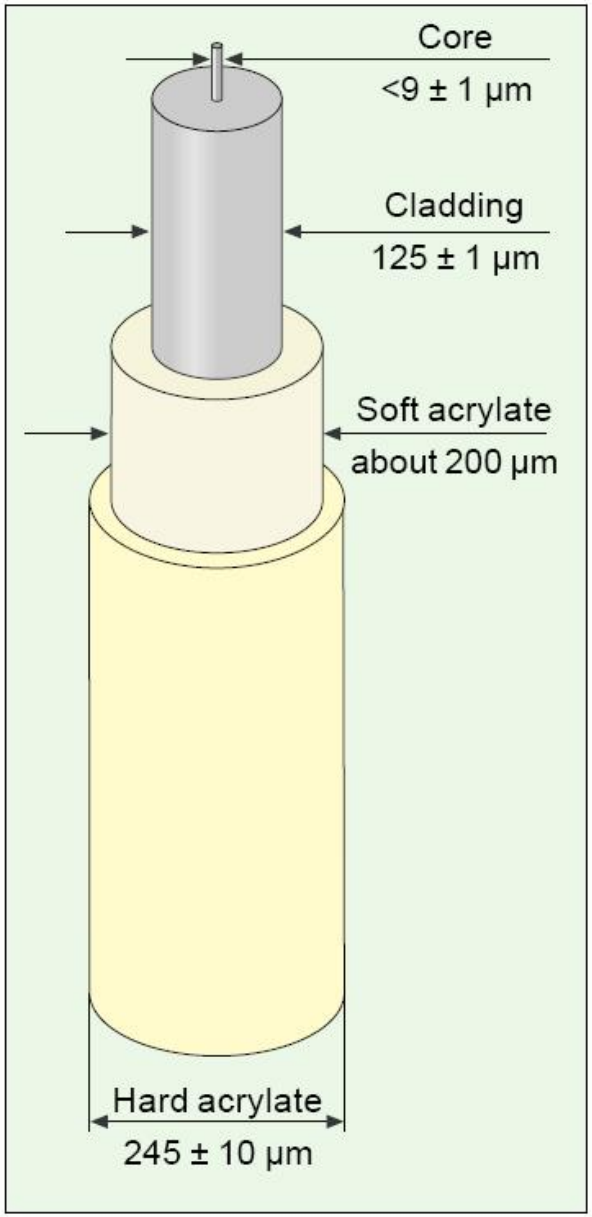
Fibra optica

- un ghid de unda dielectric
  - miez
  - teaca

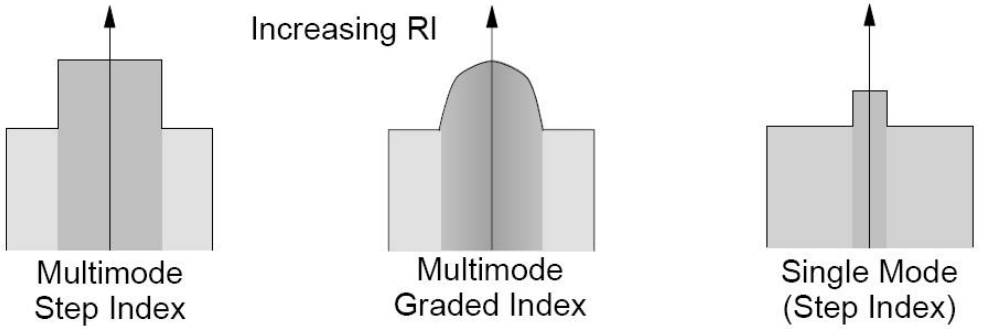


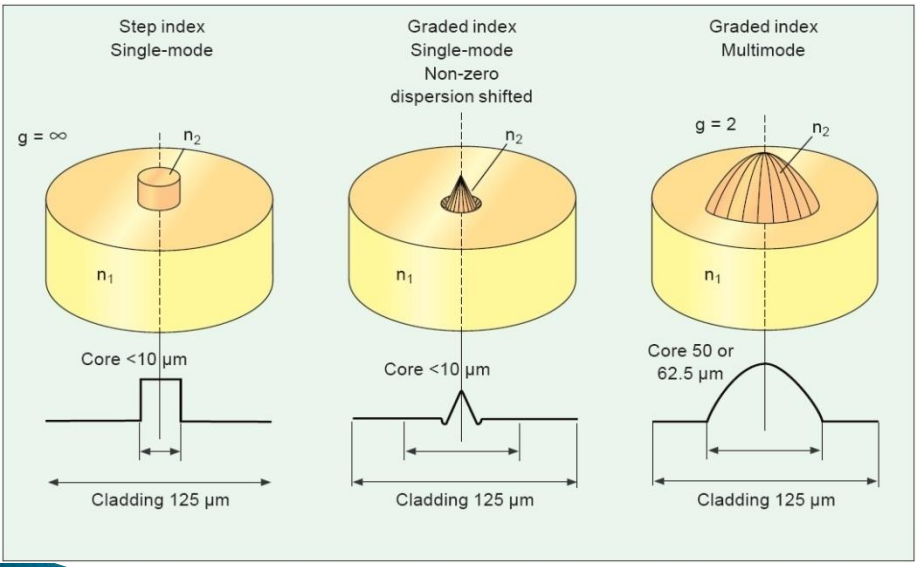


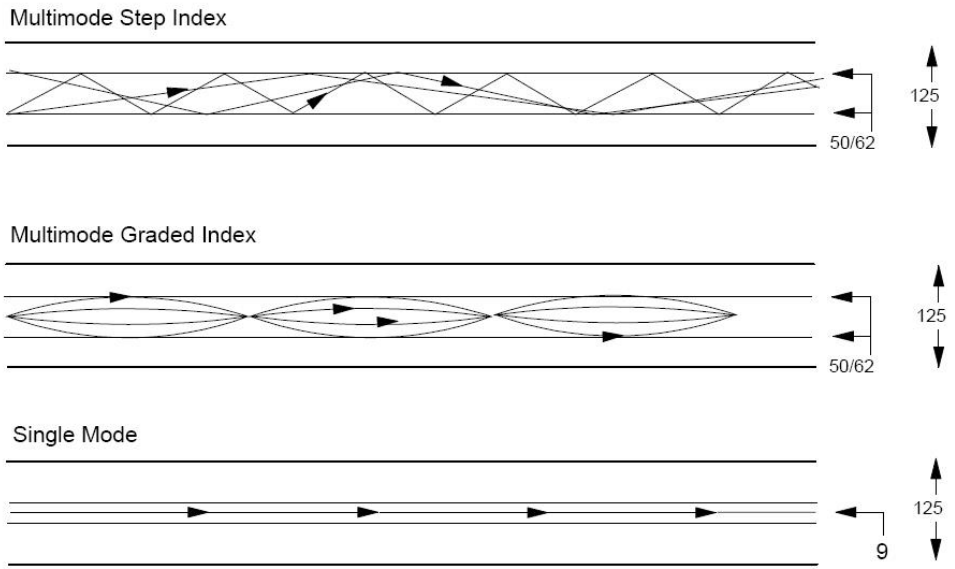


Tipuri de fibra

- Monomod
- Multimod
  - cu salt de indice
  - cu indice gradat

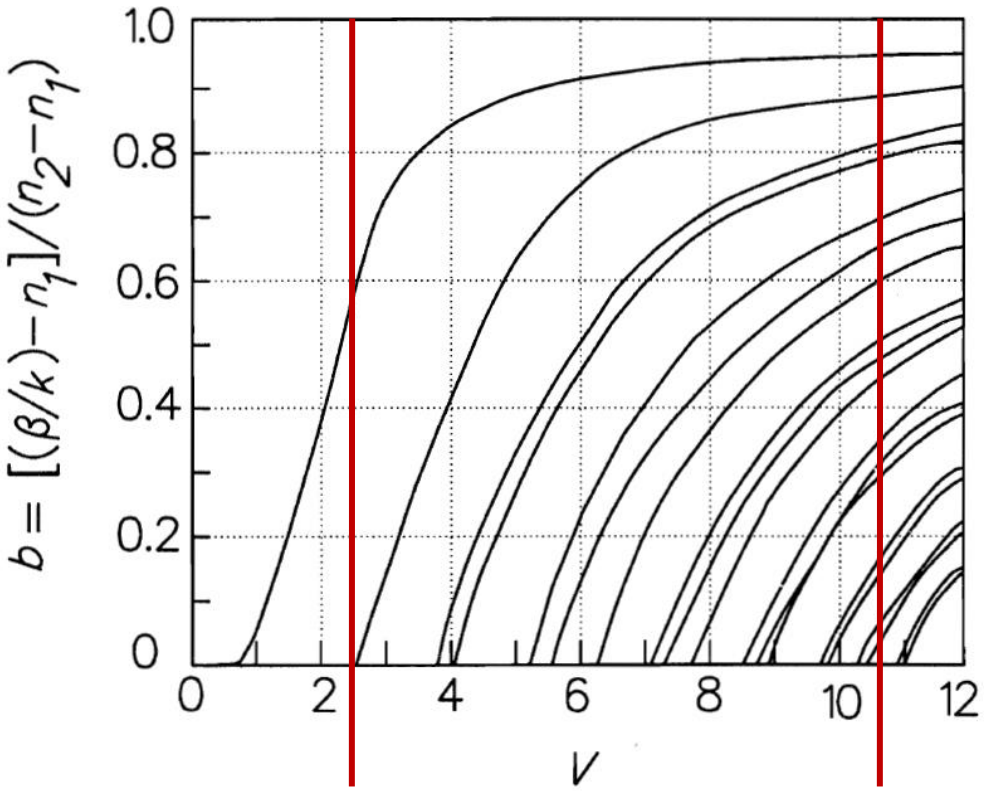






Frecventa normalizata – monomod

- Fibre monomod



b – coeficient de propagare modal relativ

$$V \le V_C = 2.405$$

exista un **singur** mod (solutii fc. Bessel)

$$\lambda \ge \lambda_C = \pi \frac{2a}{V_C} NA = \pi \frac{2a}{2.405} NA$$

Exemplu:

2a = 8.5μm

NA = 0.11

$$\lambda_C = \pi \frac{8.5}{2.405} 0.11 = 1210\text{nm}$$

Fenomene de interes

- Cat de departe pot transmite semnalul luminos pe fibra
  - **atenuare**
- Cat de rapid pot transmite informația
  - dispersie

Atenuare

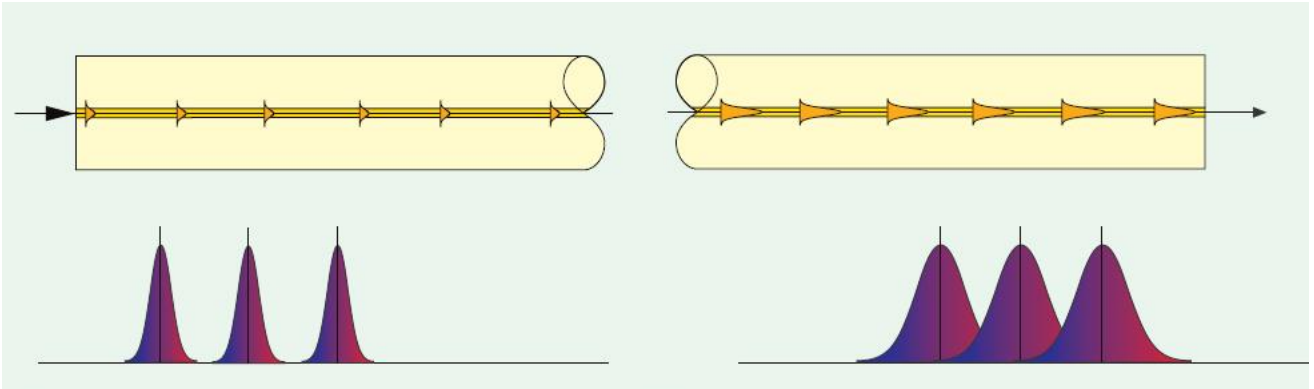
- Macrocurburi
  - utilizator, **localizat**, dB
- Discontinuitate in fibra
  - utilizator, **localizat**, dB
- Microcurburi
  - **distribuit**, tehnologie, dB/km
- Imprastiere
  - **distribuit**, tehnologie, dB/km
- Absorbtie
  - **distribuit**, material, dB/km

Fenomene de interes

- Cat de departe pot transmite semnalul luminos pe fibra
  - atenuare
- Cat de rapid pot transmite informația
  - **dispersie**

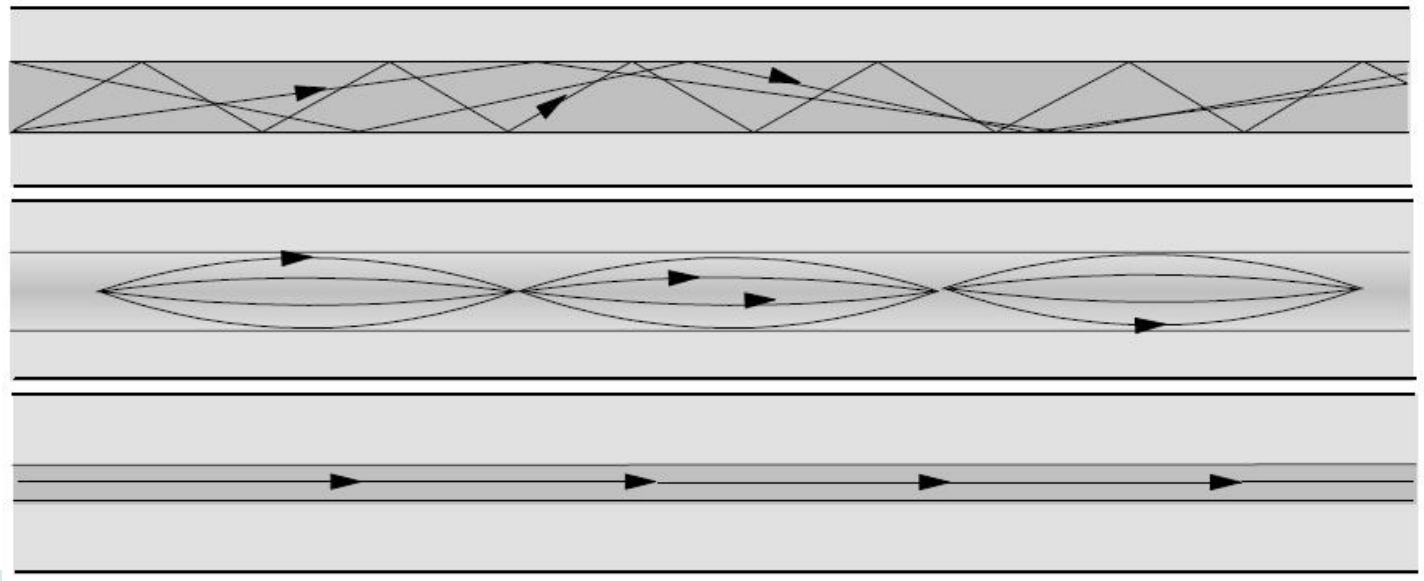
Dispersia

- Propagarea cu viteze diferite a radiatiilor cu trasee/lungimi de unda diferite
  - intermodala (**modala** – depinde de prezenta modurilor)
  - intramodala (**cromatica** – depinde de lungimea de unda)
    - de material
    - de ghid



Dispersia modala

- Mai mare la fibre multimod cu salt de indice
- Mai mica la fibre multimod cu indice gradat
  - traseele mai lungi trec prin zone cu indice mai mic
- **Inexistenta** la fibrele monomod



Dispersia

- Dispersia modala
  - salt de indice

$$\Delta\tau_{\text{mod}} \cong \frac{L \cdot n_2 \cdot \Delta}{2\sqrt{3} \cdot c} \approx \frac{L \cdot NA^2}{4\sqrt{3} \cdot c \cdot n_2}$$

  - indice gradat

$$\Delta\tau_{\text{mod}} \cong \frac{L \cdot n_2 \cdot \Delta^2}{4\sqrt{3} \cdot c} \cong \frac{L \cdot NA^4}{16\sqrt{3} \cdot c \cdot n_2^3}$$

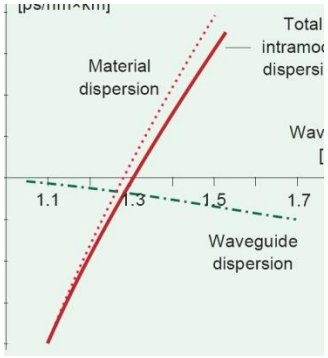
$$\Delta = 0.01 \div 0.02 << 1$$

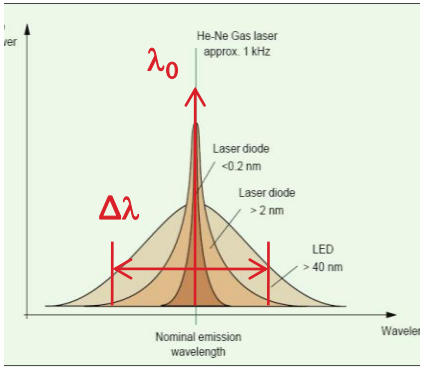
$$NA = 0.1 \div 0.2 < 1$$

- Dispersia cromatica

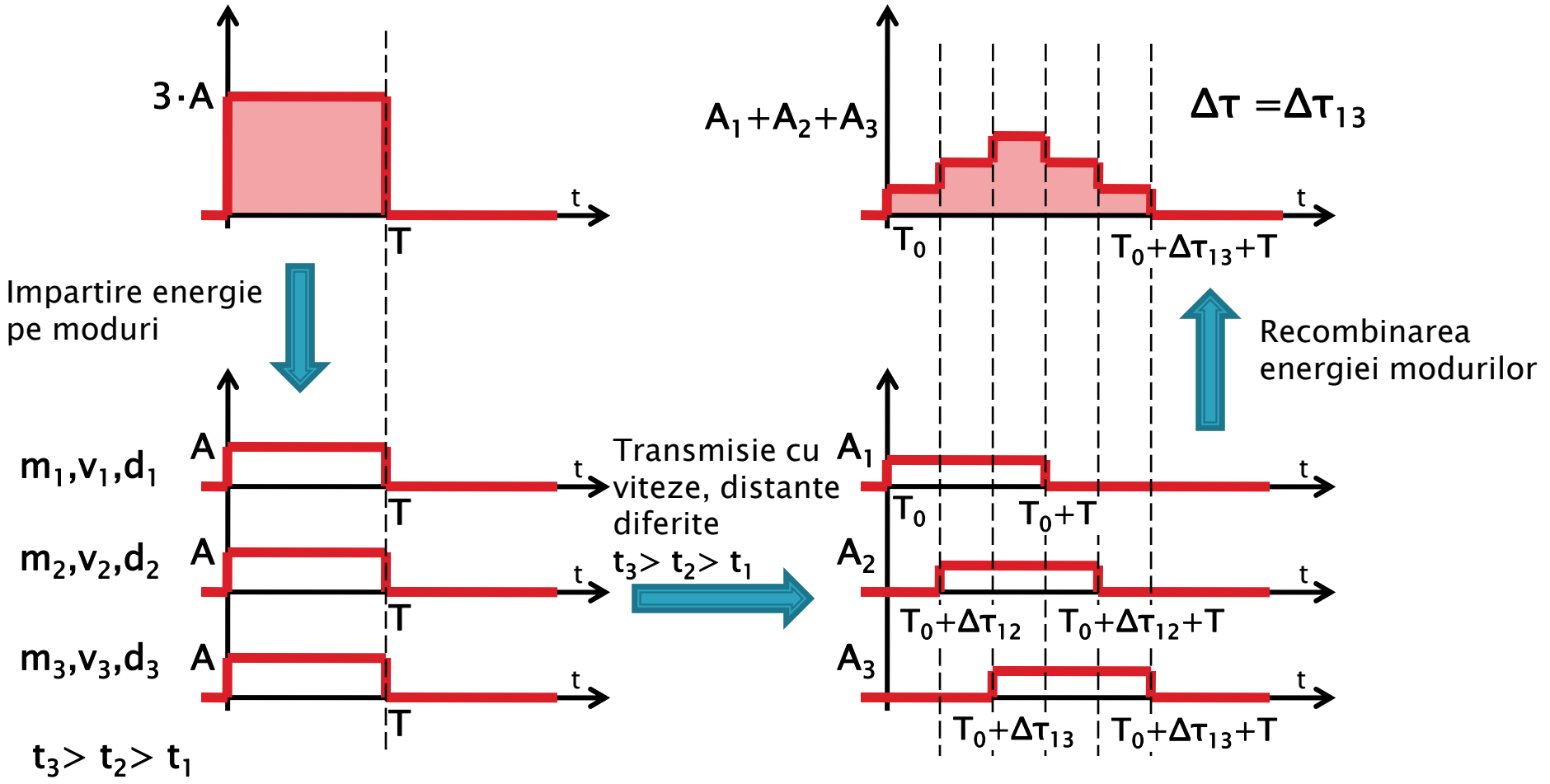
$$\Delta\tau_{cr} = D(\lambda) \cdot \Delta\lambda \cdot L$$

$$\mathrm{D}(\lambda) = \frac{\mathrm{S}_0}{4} \cdot \left(\lambda - \frac{\lambda_0^4}{\lambda^3} \right)$$



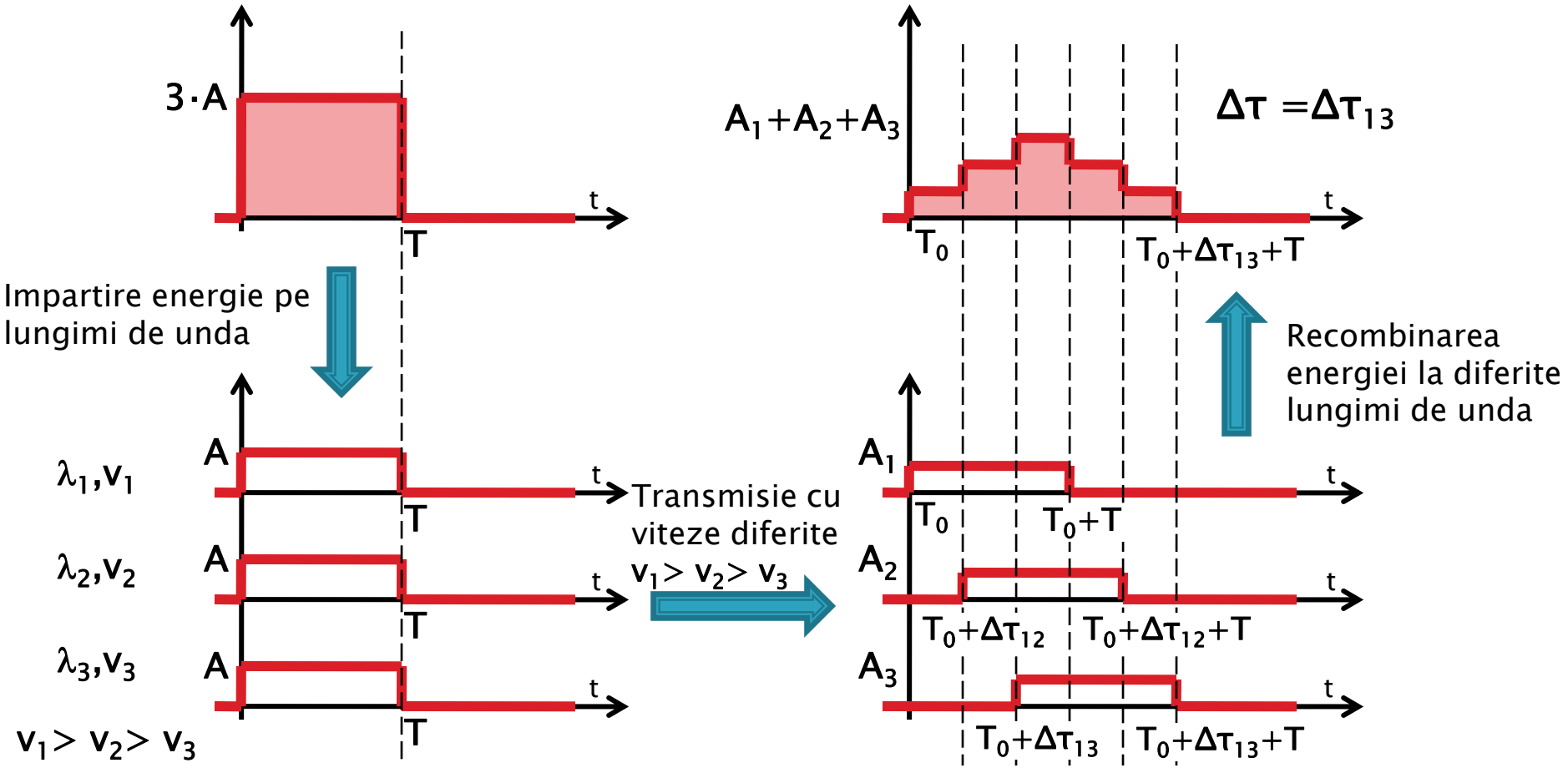


Dispersia modala



Conceptual→ $f(t)=\int_{-\infty}^{\infty} g(\omega)\cdot e^{j\omega t}d\omega$

Dispersia cromatica (gh+mat)

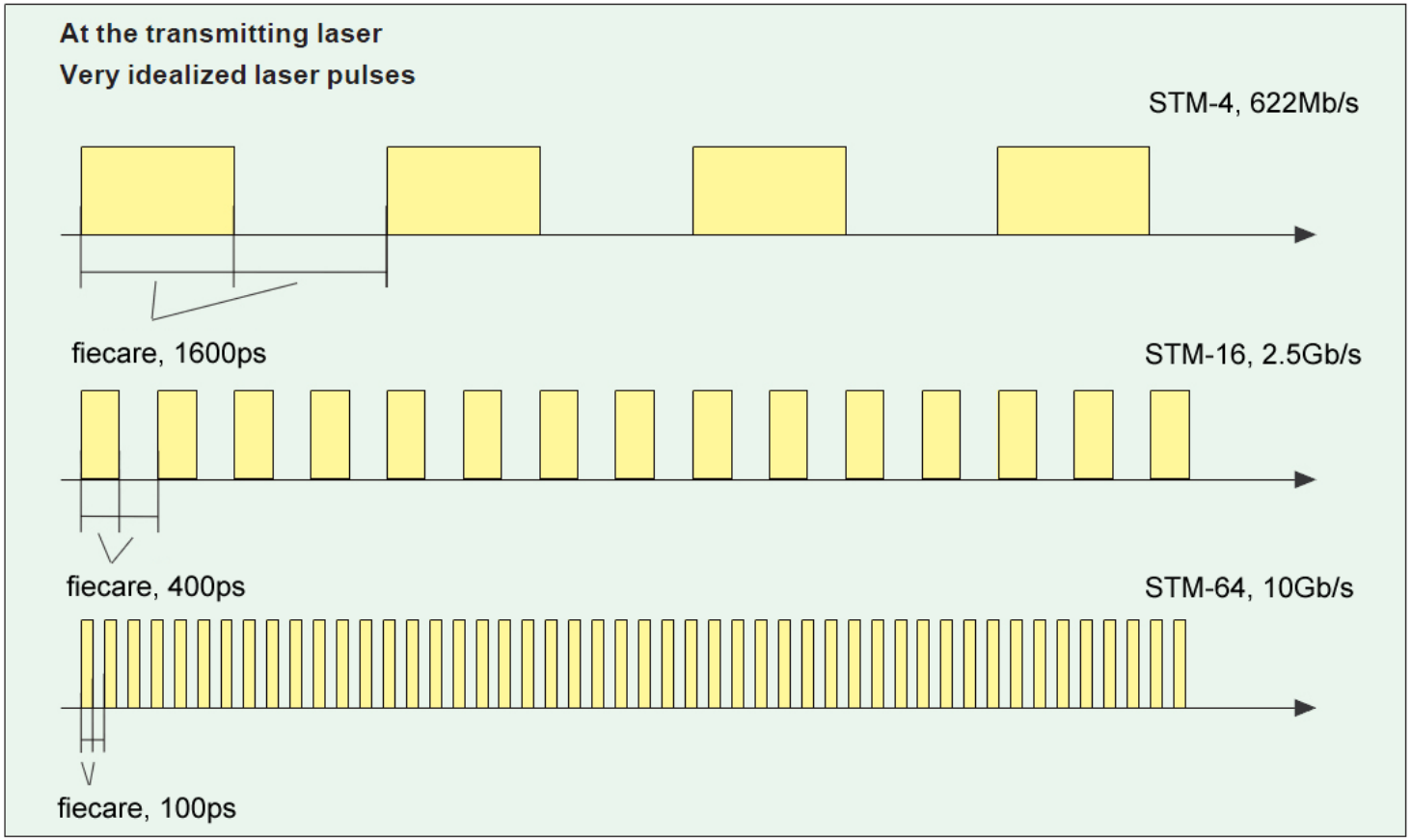


Efectiv→ $f(t)=\int_{-\infty}^{\infty} g(\omega)\cdot e^{j\omega t}d\omega$

Dispersie exemplu – 1

- transmisii cu viteze diferite

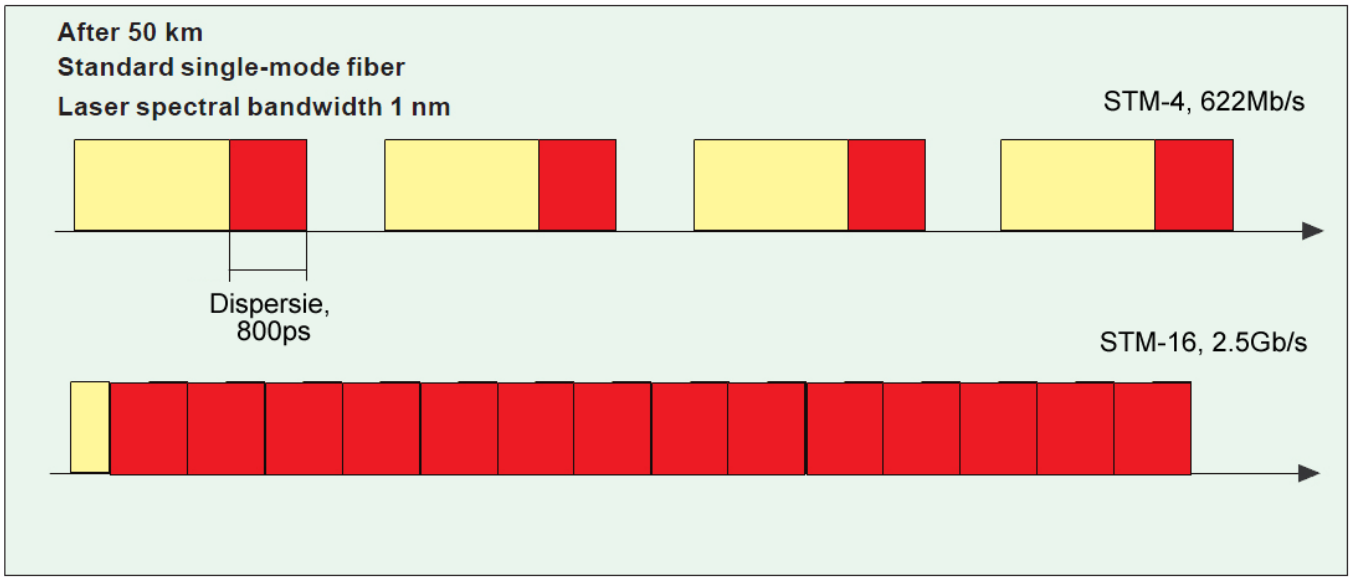
$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$



Dispersie exemplu – 2

- 1550nm
- Efectul **sursei**
  - fibra monomod cu dispersia 16ps/nm/km@1550
  - latimea spectrala a sursei Δλ=1nm
  - 50km

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$



$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 16\cdot 1\cdot 50\,ps = 800\,ps$$

$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$

100<400<800<1600

Dispersie exemplu – 3

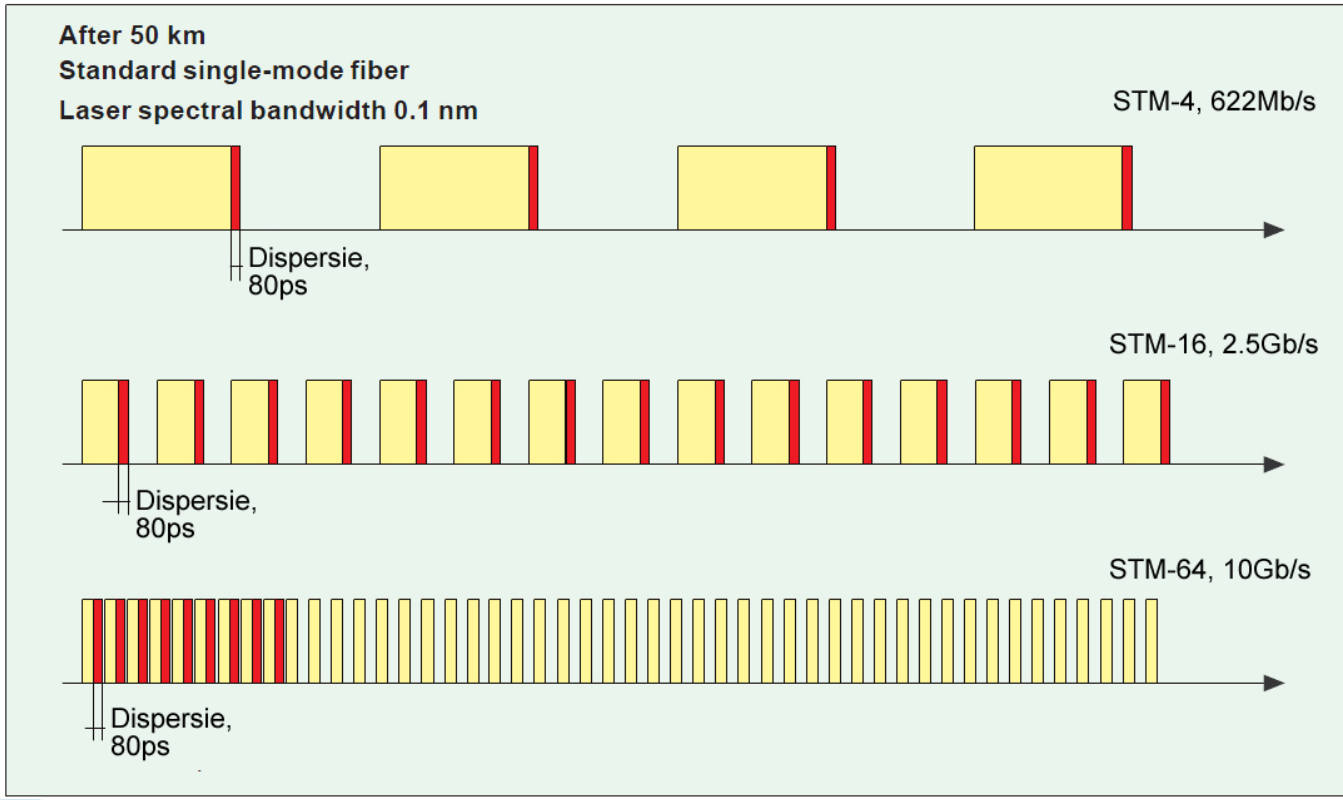
$$\Delta\tau_{cr} = D(\lambda)\,\Delta\lambda\,L$$

- 1550nm
- Efectul **sursei**
  - fibra monomod cu dispersia 16ps/nm/km@1550
  - latimea spectrala a sursei **Δλ=0.1nm**
  - 50km

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 16\cdot 0.1\cdot 50\,ps = 80\,ps$$

$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$



100≈80<400<1600

Dispersie exemplu – 4

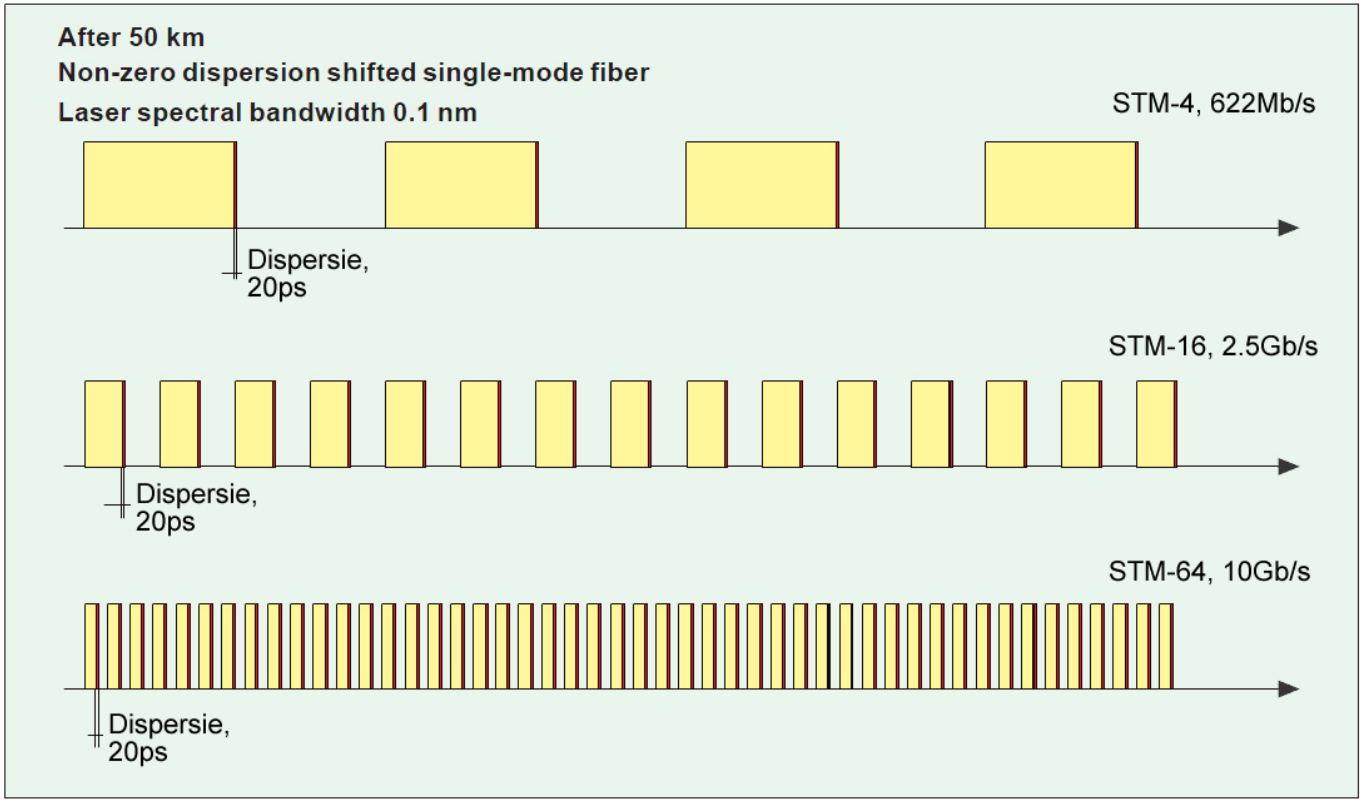
$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

- Efectul **fibrei**
  - fibra cu dipersie deplasata: **4ps**/nm/km@1550
  - latimea spectrala a sursei Δλ=0.1nm
  - 50km

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 4\cdot 0.1\cdot 50\,ps = 20\,ps$$

$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$



20<100<400<1600

Dispersie exemplu – 5

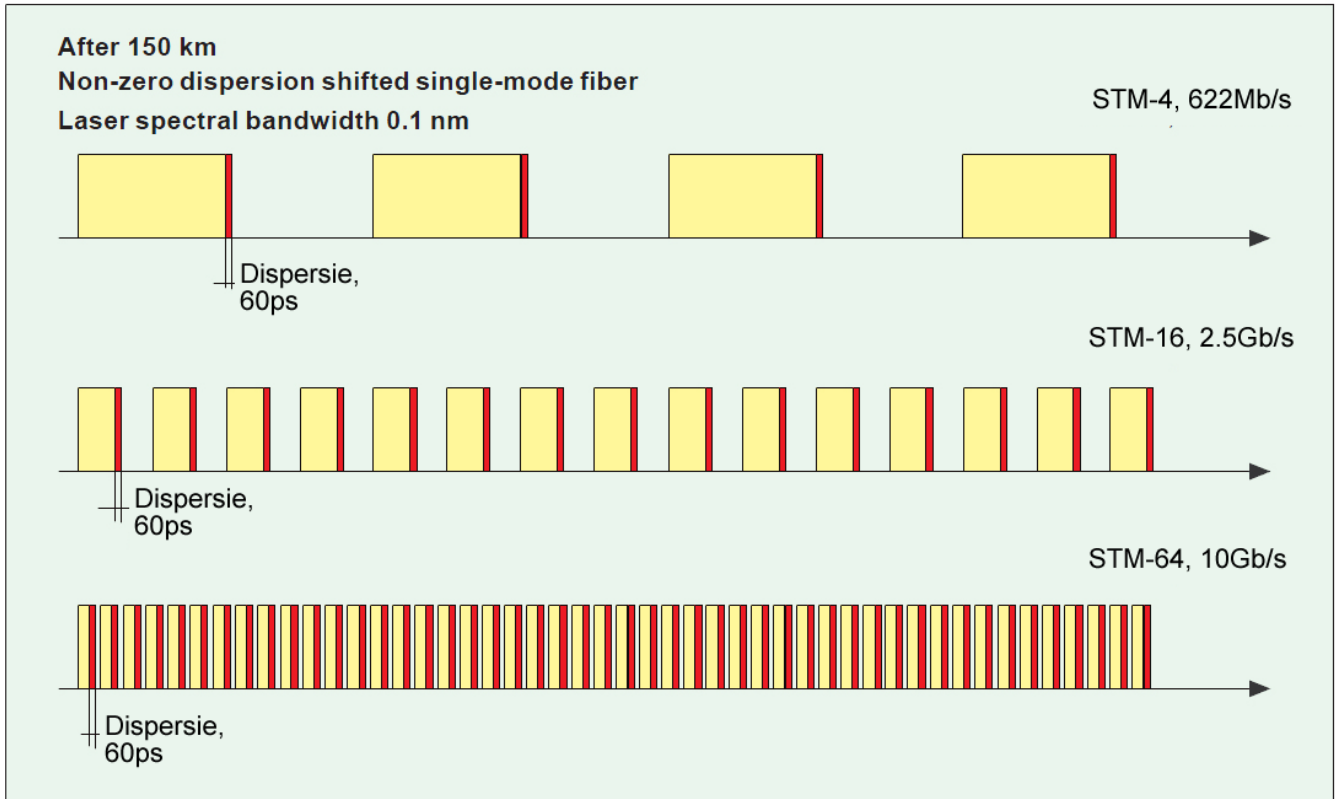
$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

- Efectul **fibrei**
  - fibra cu dipersie deplasata: 4ps/nm/km@1550
  - latimea spectrala a sursei Δλ=0.1nm
  - **150km**

$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$\Delta\tau_{cr} = 4\cdot 0.1\cdot 150\,ps = 60\,ps$$

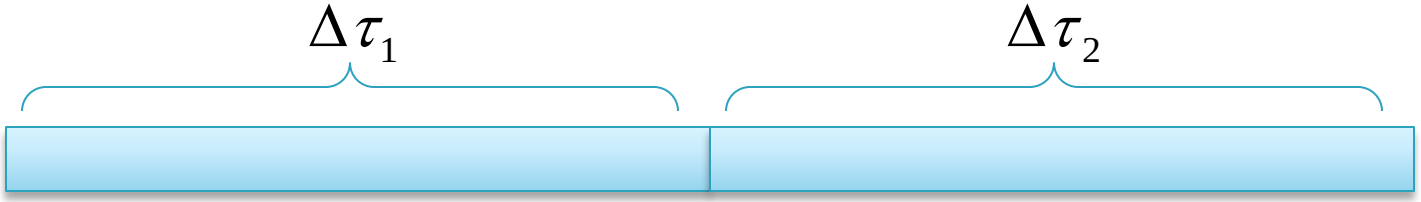
$$[\Delta\tau_{cr}] = \frac{ps}{nm\cdot km}\cdot nm\cdot km = ps$$



60<100<400<1600

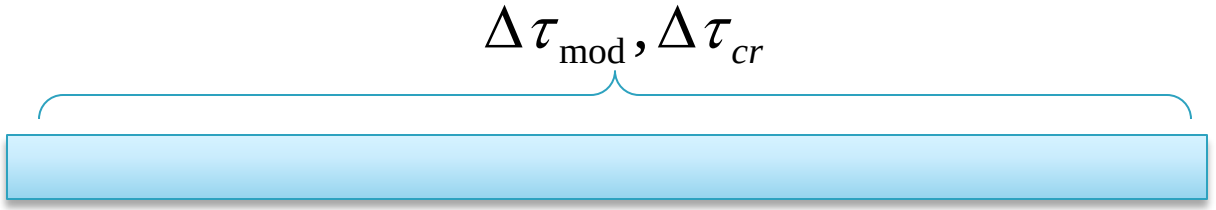
Sumarea efectelor

- efecte **succesive** se adună liniar



$$\Delta\tau_{tot} = \Delta\tau_1 + \Delta\tau_2$$

- efecte **simultane** se adună pătratic



$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\mathrm{mod}}^2}$$

Dispersia

- Dispersia modala
  - salt de indice

$$\Delta\tau_{\text{mod}} \cong \frac{L \cdot n_2 \cdot \Delta}{2\sqrt{3} \cdot c} \approx \frac{L \cdot NA^2}{4\sqrt{3} \cdot c \cdot n_2}$$

  - indice gradat

$$\Delta\tau_{\text{mod}} \cong \frac{L \cdot n_2 \cdot \Delta^2}{4\sqrt{3} \cdot c} \cong \frac{L \cdot NA^4}{16\sqrt{3} \cdot c \cdot n_2^3}$$

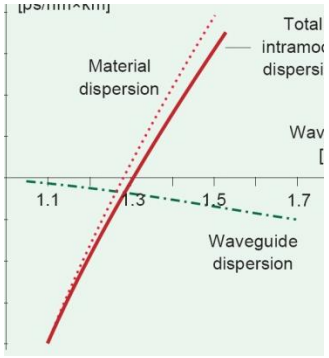
$$\Delta = 0.01 \div 0.02 << 1$$

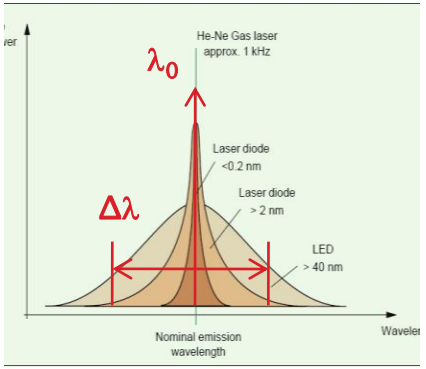
$$NA = 0.1 \div 0.2 < 1$$

- Dispersia cromatica

$$\Delta\tau_{cr} = D(\lambda) \cdot \Delta\lambda \cdot L$$

$$\mathrm{D}(\lambda) = \frac{\mathrm{S}_0}{4} \cdot \left(\lambda - \frac{\lambda_0^4}{\lambda^3} \right)$$





$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\text{mod}}^2}$$

Banda

- Dispersia totala

$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\mathrm{mod}}^2} \quad \text{sau} \quad \Delta\tau_{tot} = \Delta\tau_1 + \Delta\tau_2$$

- Banda

$$B_{opt} \cong \frac{0.44}{\Delta\tau_{tot}[ns]} \quad [GHz]$$

- Banda optica la 3 dB corespunde unei benzi electrice la 6 dB
  - $P_{opt} \sim I; \quad P_{el} \sim I^2 \qquad B_{opt} = \sqrt{2} B_{el}$
- Viteza legaturii

$$V[Gb/s] \cong 2 \cdot B_{el}[GHz]$$

Produs Banda · Distanta

$$\Delta\tau_{\text{mod}} \cong \frac{L \cdot n_2 \cdot \Delta}{2\sqrt{3} \cdot c} \approx \frac{L \cdot NA^2}{4\sqrt{3} \cdot c \cdot n_2}$$

$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\text{mod}}^2}$$

$$\Delta\tau_{cr} = D(\lambda) \cdot \Delta\lambda \cdot L$$

$$\Delta\tau_{tot} = const \cdot L$$

$$B_{opt} = \frac{0.44}{\Delta\tau_{tot}[ns]} \quad [GHz] \qquad B_{opt} = \sqrt{2} B_{el} \qquad V[Gb/s] \cong 2 \cdot B_{el}$$

$$V[Gb/s] \cong \frac{const}{L}$$

$$V[Gb/s] \cdot L[km] \cong const$$

Produs Banda · Distanta

$$\Delta\tau_{\text{mod}} \sim L \qquad \Delta\tau_{cr} \sim L \qquad \Delta\tau_{tot} \sim L$$

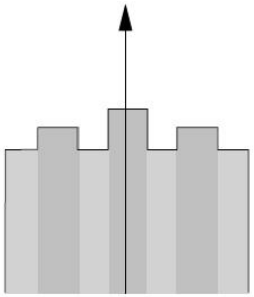
$$V[Gb/s] \sim B_{el}[GHz] \sim \frac{1}{\Delta\tau_{tot}} \sim \frac{1}{L[km]}$$

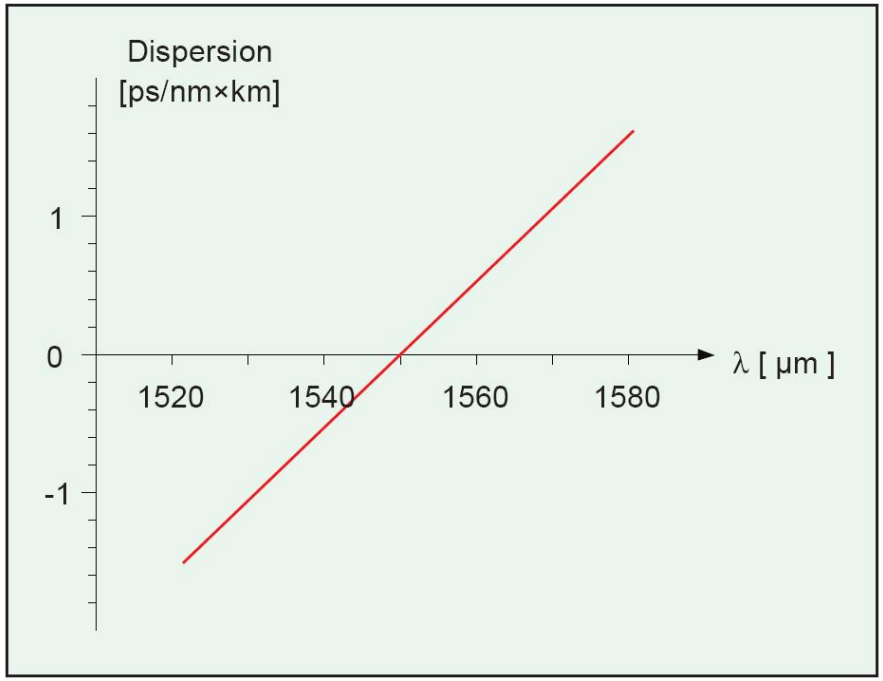
$$V[Gb/s] \times L[km] = \text{ct.}$$

$$B_{el}[MHz] \times L[km] = \text{ct.}$$

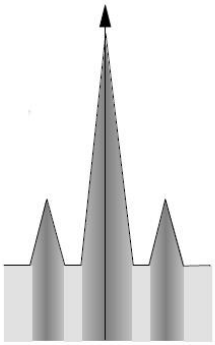
Dispersion shifted fibers

- Sticla are (nativ) dispersie cromatica 0 la 1310nm
- Atenuarea e mai mica la 1550 nm
- EDFA (Erbium doped fibre amplifiers) opereaza in banda 1550nm
- Sistemele WDM (Wavelength division Multiplexing) necesita banda larga amplificata

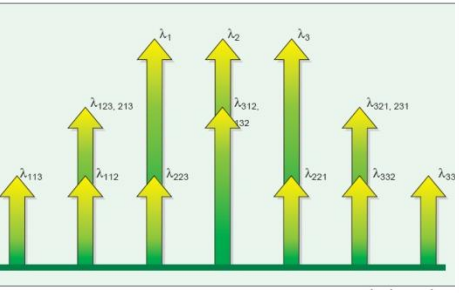


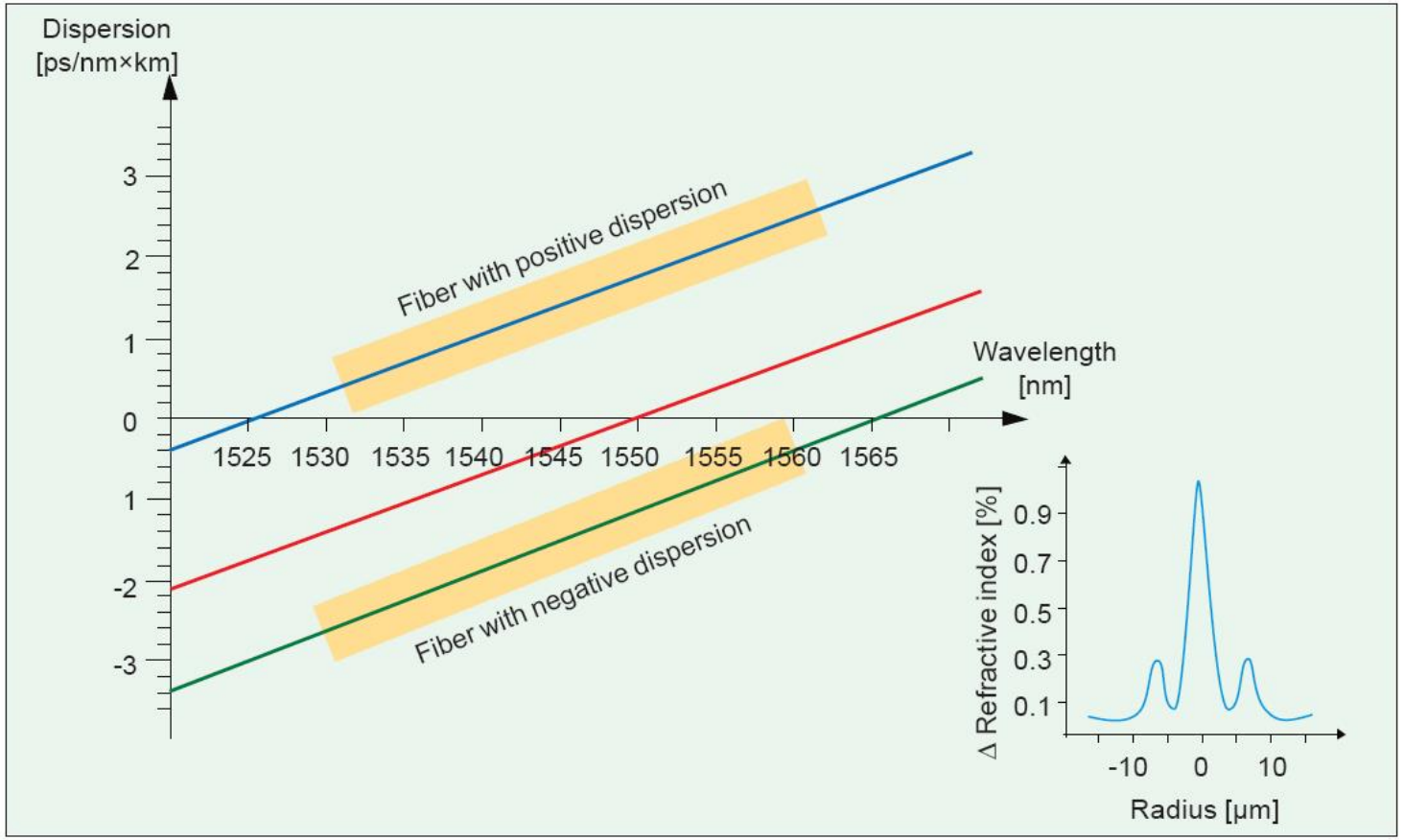


Non-zero Dispersion shifted fibers

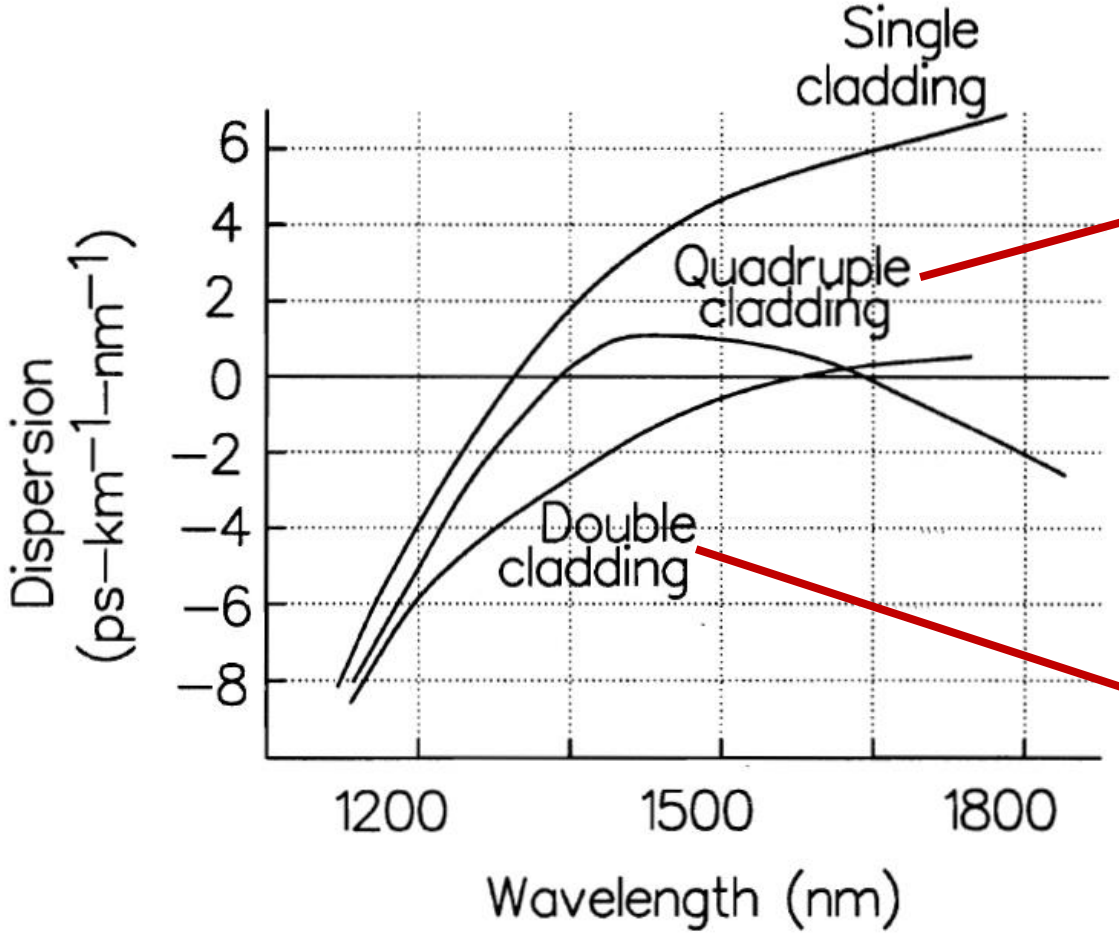


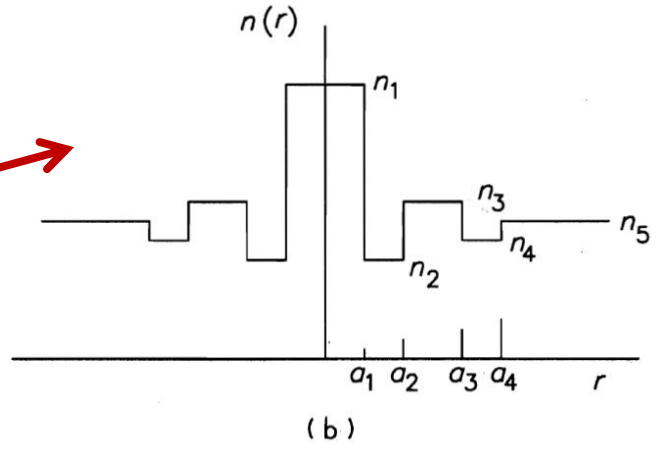
FWM

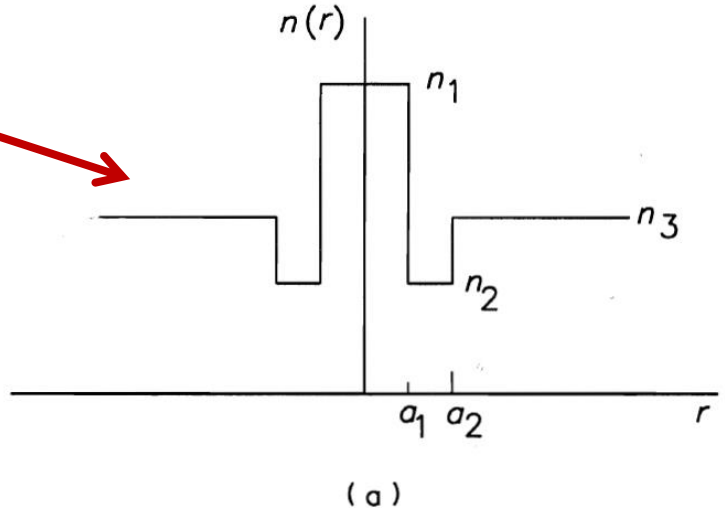




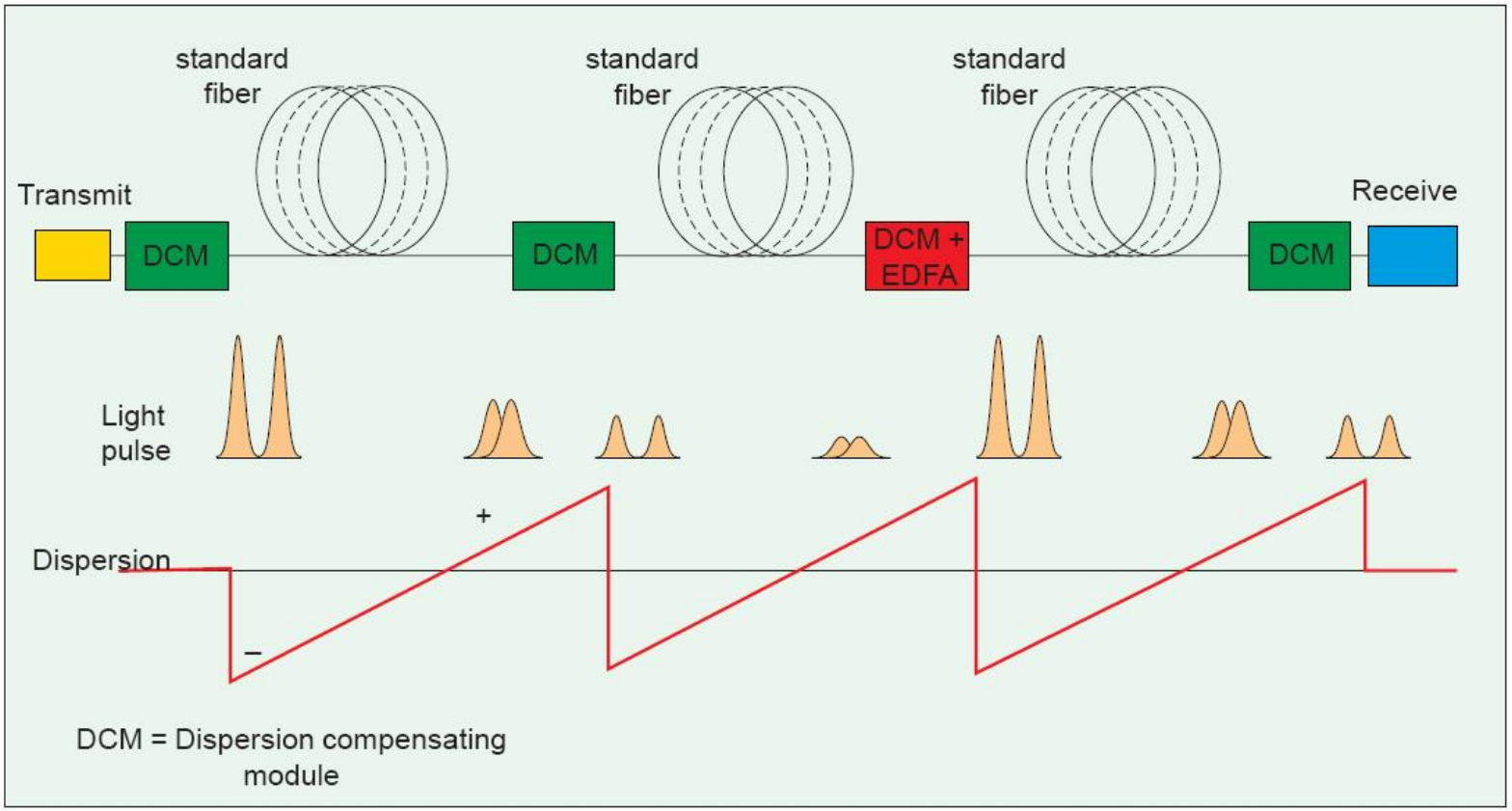
Dispersion shifted fibers







Fibra pentru compensarea dispersiei



- Dispersie: -100 ps/nm/km
- Atenuare 0.5 dB/km

Catalog – monomod

$$D(\lambda) = \frac{S_0}{4} \cdot \left(\lambda - \frac{\lambda_0^4}{\lambda^3} \right)$$

How to Order

Contact your sales representative, or call the Optical Fiber Customer Service Department:
Ph: 607-248-2000 (U.S. and Canada)
+44-1244-287-437 (Europe)
Email: opticalfibcs@corning.com
Please specify the fiber type, attenuation and quantity when ordering.

Mechanical Specifications

Proof Test
The entire fiber length is subjected to a tensile stress ≥100 kpsi (0.7 GPa)*.
*Higher proof test levels available.

Length
Fiber lengths available up to 50.4* km/spool.
*Longer spliced lengths available.

Performance Characterizations

Characterized parameters are typical values.

Core Diameter	8.2 µm
Numerical Aperture	0.14 *NA is measured at the one percent power level of a one-dimensional [illegible] at 1310 nm.*
Zero Dispersion Wavelength (λ_0)	1317 nm
Zero Dispersion Slope (S_0)	0.088 ps/(nm²•km)
Effective Group Index of Refraction (N_{eff})	1310 nm: 1.4670 1550 nm: [illegible]
Fatigue Resistance Parameter (N_d)	20
Coating Strip Force	Dry: 0.6 lbs. (3N) Wet, 14-day room temperature: 0.6 lbs. (3N)
Rayleigh Backscatter Coefficient (for 1 ns Pulse Width)	1310 nm: -77 dB 1550 nm: -82 dB
Stimulated Brillouin Scattering Threshold	20 dBm[1]

Notes:
(1) When characterized with a transmitter specifying 17 dBm SBS threshold over standard single-mode fiber. While absolute SBS threshold is a function of distance and signal format, NexCor fiber offers a 3 dB improvement over standard single-mode fiber independent of these variables.

Formulas

Dispersion

$$\text{Dispersion} = D(\lambda) = \frac{S_0}{4}\left[\lambda - \frac{\lambda_0^4}{\lambda^3}\right] \text{ ps/(nm•km)}$$

for 1200 nm ≤ λ ≤ 1625 nm

λ = Operating Wavelength

Cladding Non-Circularity

$$\text{Cladding Non-Circularity} = \left[1 - \frac{\text{Min. Cladding Diameter}}{\text{Max. Cladding Diameter}}\right] \times 100$$

Corning Incorporated
www.corning.com/opticalfiber
One Riverfront Plaza
Corning, NY 14831
U.S.A.
Ph: 800-525-2524 (U.S. and Canada)
607-786-8125 (International)
Fx: 800-519-3632 (U.S. and Canada)
607-786-8344 (International)
Email: cofic@corning.com

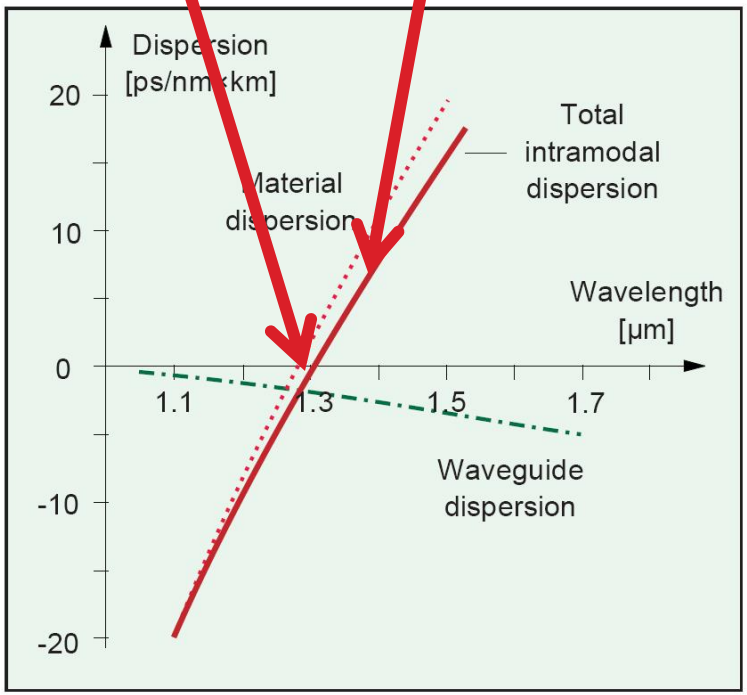
Europe
Ph: 00 800 6620 6621 (U.K., Ireland, France, Germany, The Netherlands, Spain and Sweden)
+1 607 [illegible] (All Other Countries)
[illegible] 786 8344

Asia Pacific
Australia
Ph: 1-800-148-690
Fx: 1-800-148-568
Indonesia
Ph: 001-803-015-721-1261
Fx: 001-803-015-721-1262
Malaysia
Ph: 1-800-80-3156
Fx: 1-800-80-3155
Philippines
Ph: 1-800-1-116-0338
Fx: 1-800-1-116-0339
Singapore
Ph: 800-1300-955
Fx: 800-1300-956
Thailand
Ph: 001-800-1-3-721-1263
Fx: 001-800-1-3-721-1264

Latin America
Brazil
Ph: 000817-762-4732
Fx: 000817-762-4996
Mexico
Ph: 001-800-235-1719
Fx: 001-800-339-1472
Venezuela
Ph: 800-1-4418
Fx: 800-1-4419

Greater China
Email: CCCofic@corning.com
Beijing
Ph: (86) 10-6505-5066
Fx: (86) 10-6505-5077
Hong Kong
Ph: (852) 2807-2723
Fx: (852) 2807-2152
Shanghai
Ph: (86) 21-3222-4668
Fx: (86) 21-6288-1575
Taiwan
Ph: (886) 2-2716-0338
Fx: (886) 2-2716-0339

Zero Dispersion Wavelength (λ_0)	1317 nm
Zero Dispersion Slope (S_0)	0.088 ps/(nm²•km)
Effective Group Index	1310 nm: 1.4670



Catalog – multimod

$$D(\lambda) = \frac{S_0}{4} \cdot \left(\lambda - \frac{\lambda_0^4}{\lambda^3} \right)$$

+

Bandwidth

Standard Bandwidth Cells
850/1300 nm (MHz•km)
400/400
400/600
400/1200
500/500
600/600
600/1000

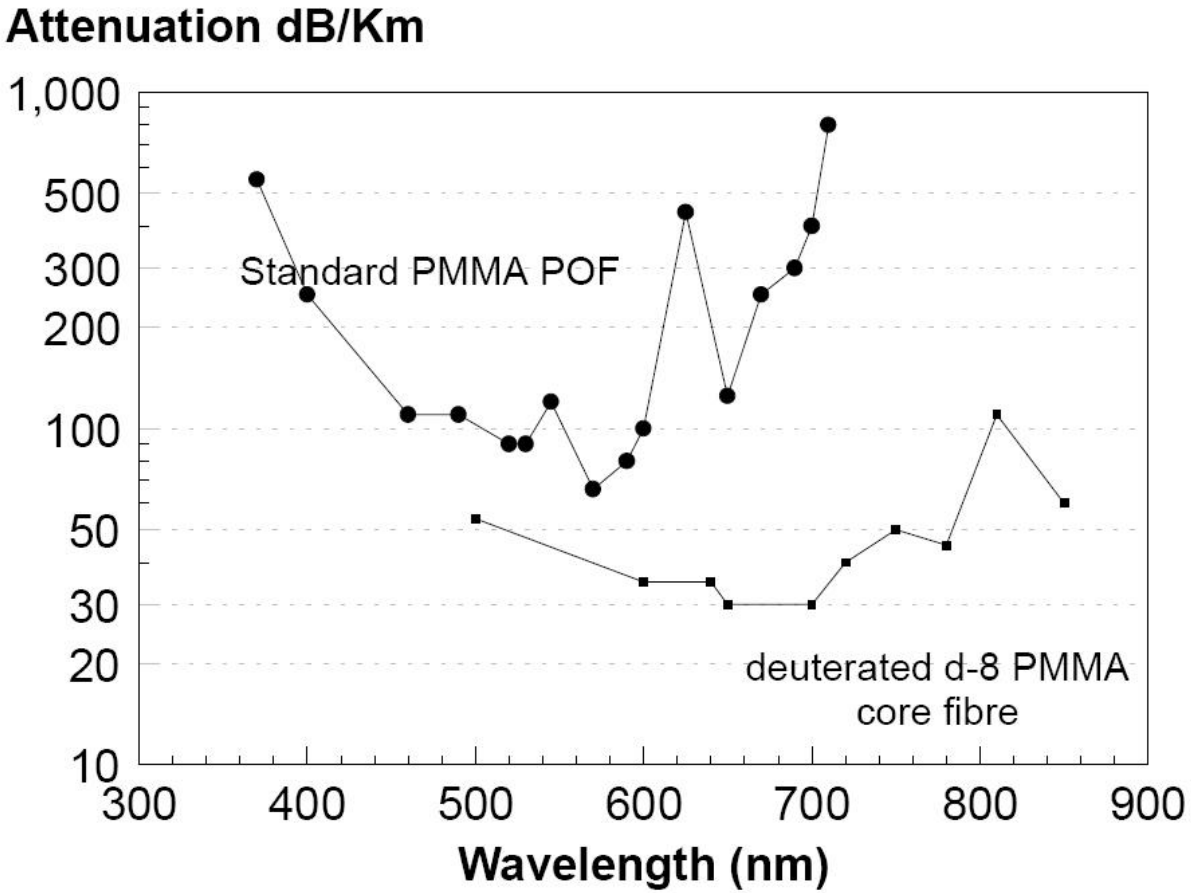
Other bandwidth cells available upon request.

Fibra standard ITU G.652

- Diametru teaca = 125 µm
- MFD = 9÷10 µm la 1300 nm
- λ_C = 1100÷1280 nm
- Pierderi de curbura (la 1550 nm) mai mici de 1 dB pentru 100 spire de fibra rulata pe un mosor cu 7.5 cm diametru
- Dispersia in banda 1300 nm (1285-1330 nm) mai mica de 3.5 ps/nm/km. La 1550 nm dispersia trebuie sa fie mai mica de 20 ps/nm/km
- Viteza de variatie a dispersiei (panta dispersiei S_0) mai mica de 0.095 ps/nm^2/km

ITU (International Telecommunication Union) is the United Nations specialized agency for information and communication technologies – ICTs

Fibra optica din plastic (POF)



- Atenuare 180 dB/km
- NA = 0.3
- Diametru 1 mm
- Banda 125MHz (100m)

Fibra optică – Tehnologie

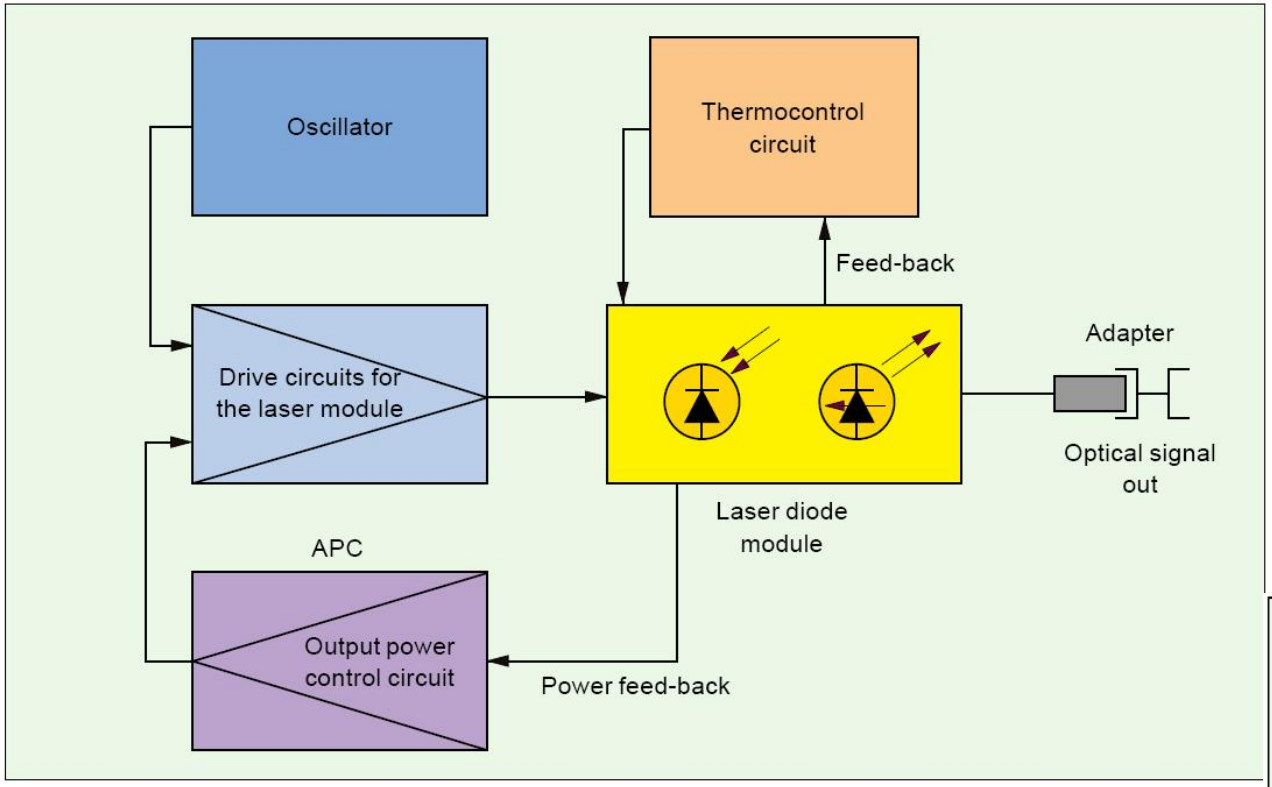
Capitolul 5

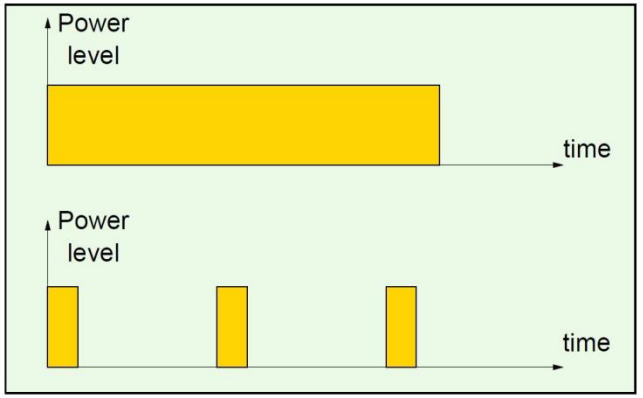
Cuprins

- **Lumina ca undă electromagnetică** (ecuaţiile lui Maxwell, ecuaţia undelor, parametrii de propagare)
- **Elemente de fotometrie şi radiometrie** (mărimi energetice/luminoase)
- **Fibra optică** (realizare, principiu de funcţionare, atenuare, dispersie, banda de frecvenţă)
- Cabluri optice (tehnologie, conectori, lipire – splice)
- **Proiectare sistemică a legăturii pe fibra optică** (bandă de frecvenţă, balanţa puterilor)
- **Emiţătoare optice** (LED şi dioda laser – realizare fizică şi functionare)
- **Receptoare optice** (dioda PIN, dioda cu avalanşă – realizare fizică şi functionare)
- **Amplificatoare transimpedanţă** (parametri, scheme tipice, TIA în buclă deschisă, cu reacţie, diferenţiale, control automat al câştigului)
- **Realizarea circuitelor pentru controlul emiţătoarelor optice (**parametri, scheme tipice, controlul puterii, multiplexoare**)**
- **Dispozitive de captare a energiei solare** (principiu de functionare, utilizare, proiectare)

Stabilized light source
Optical power meter

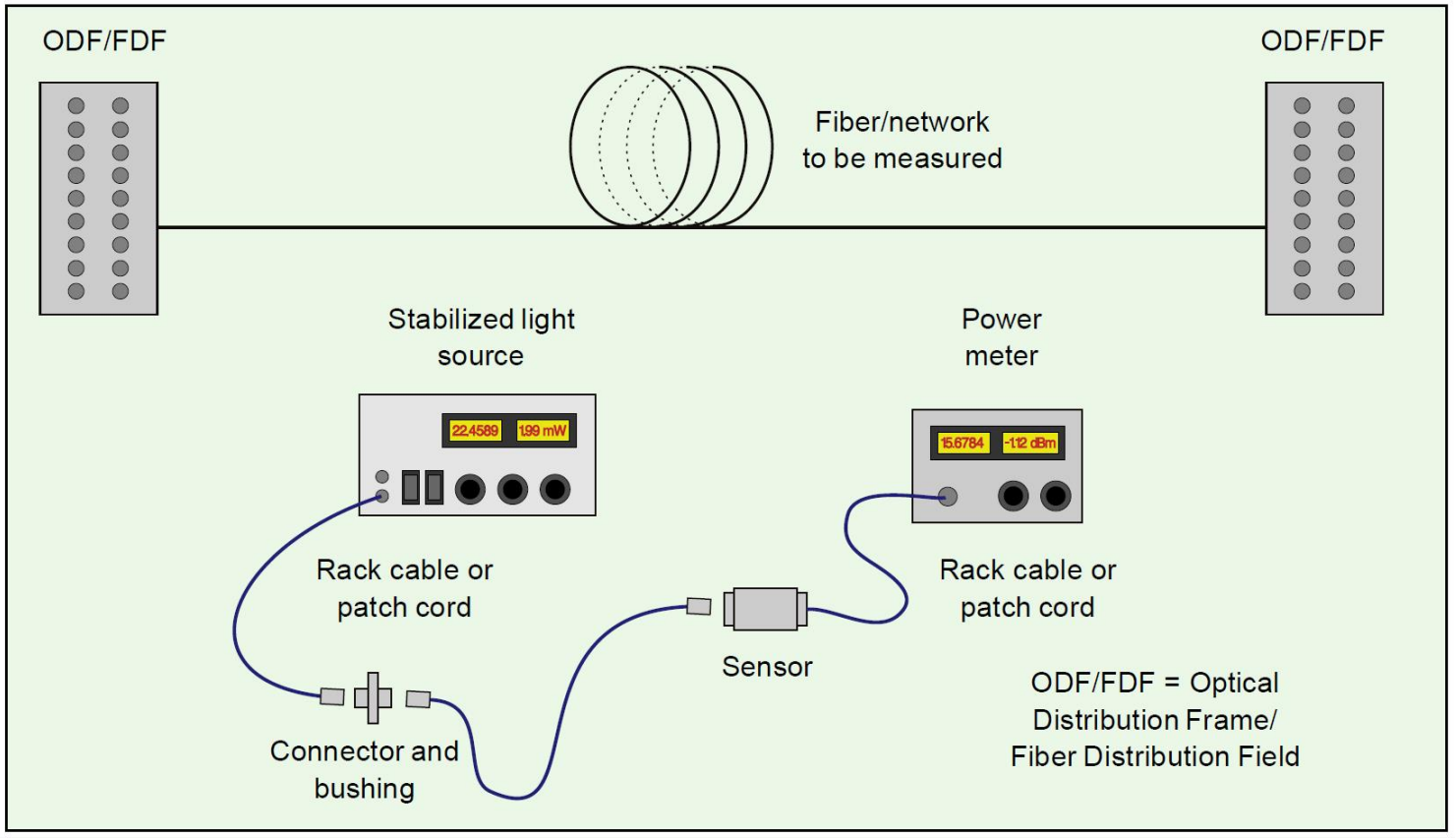
- Masurarea puterii si atenuarii





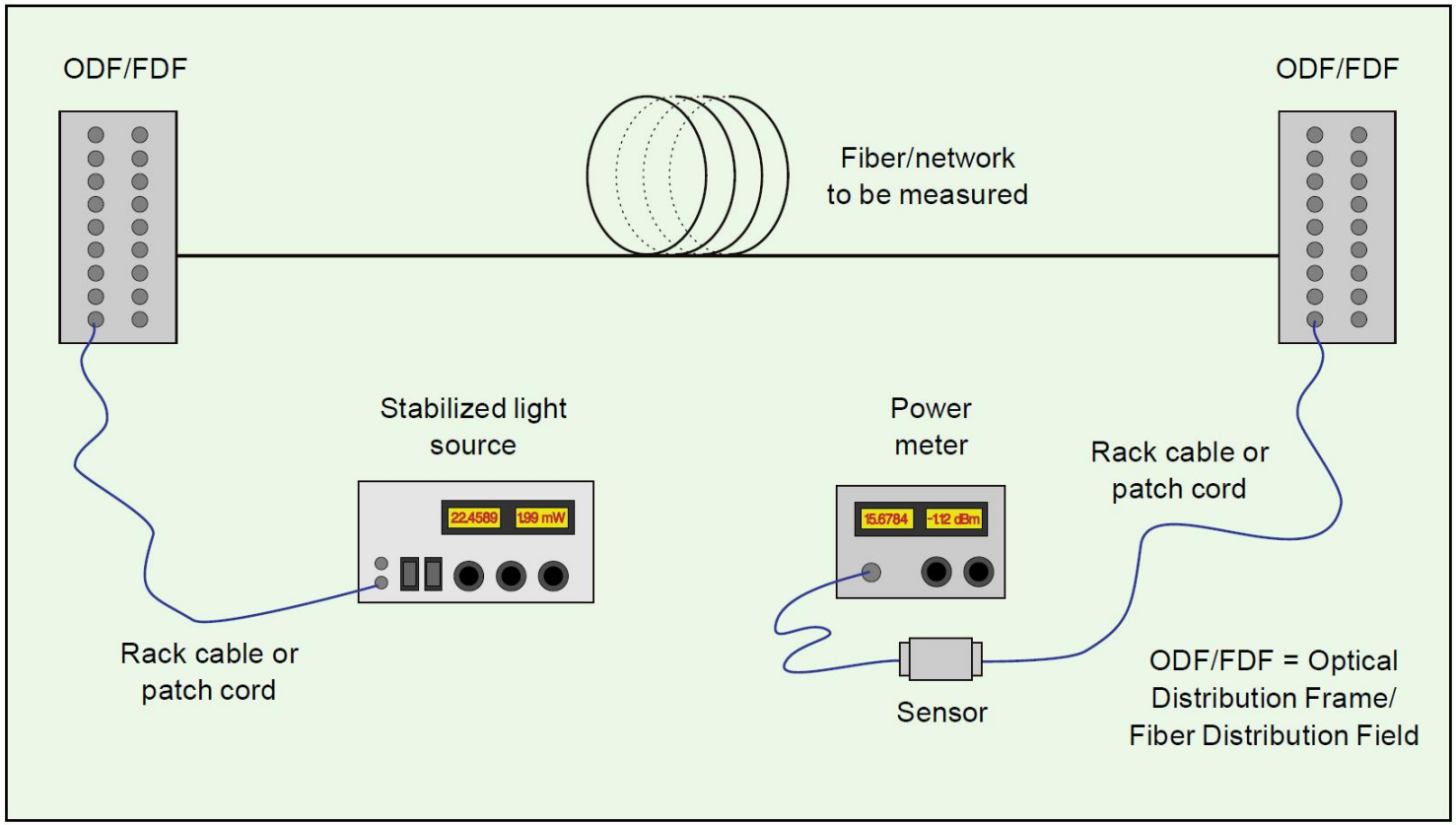
Masurarea puterii si atenuarii

- Masuratoare referinta



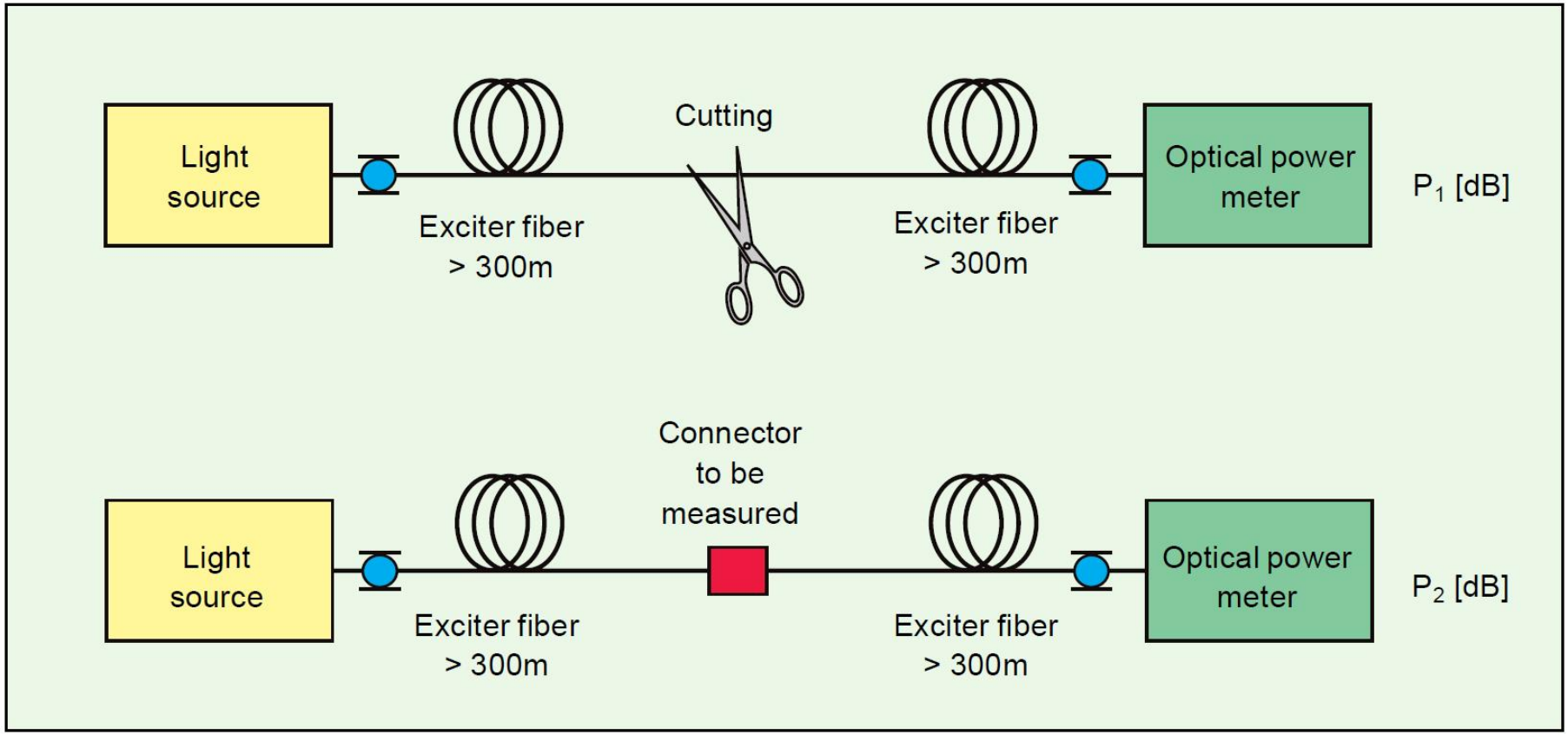
Masurarea puterii si atenuarii

- Masuratoare instalatie



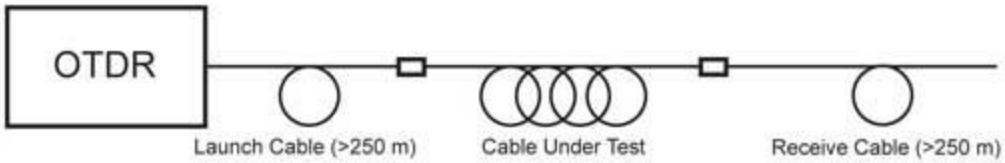
Masurare conectori si splice

- Se elimina efectele fibrei



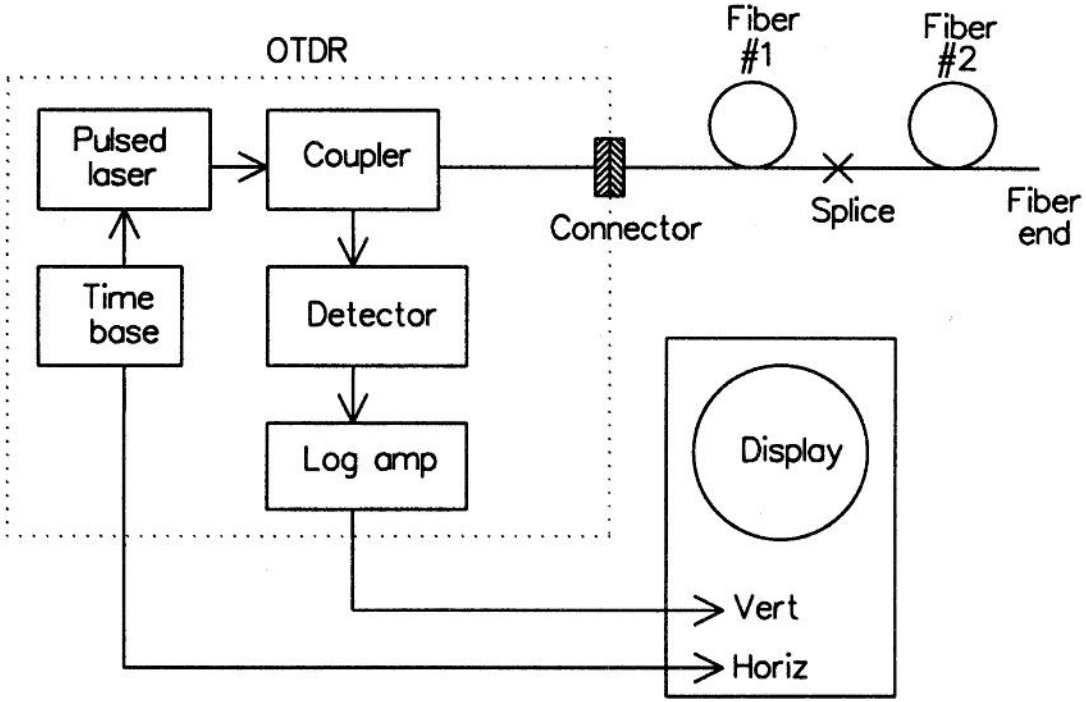
OTDR

- Optical Time-Domain Reflectometer
- Localizarea defectelor

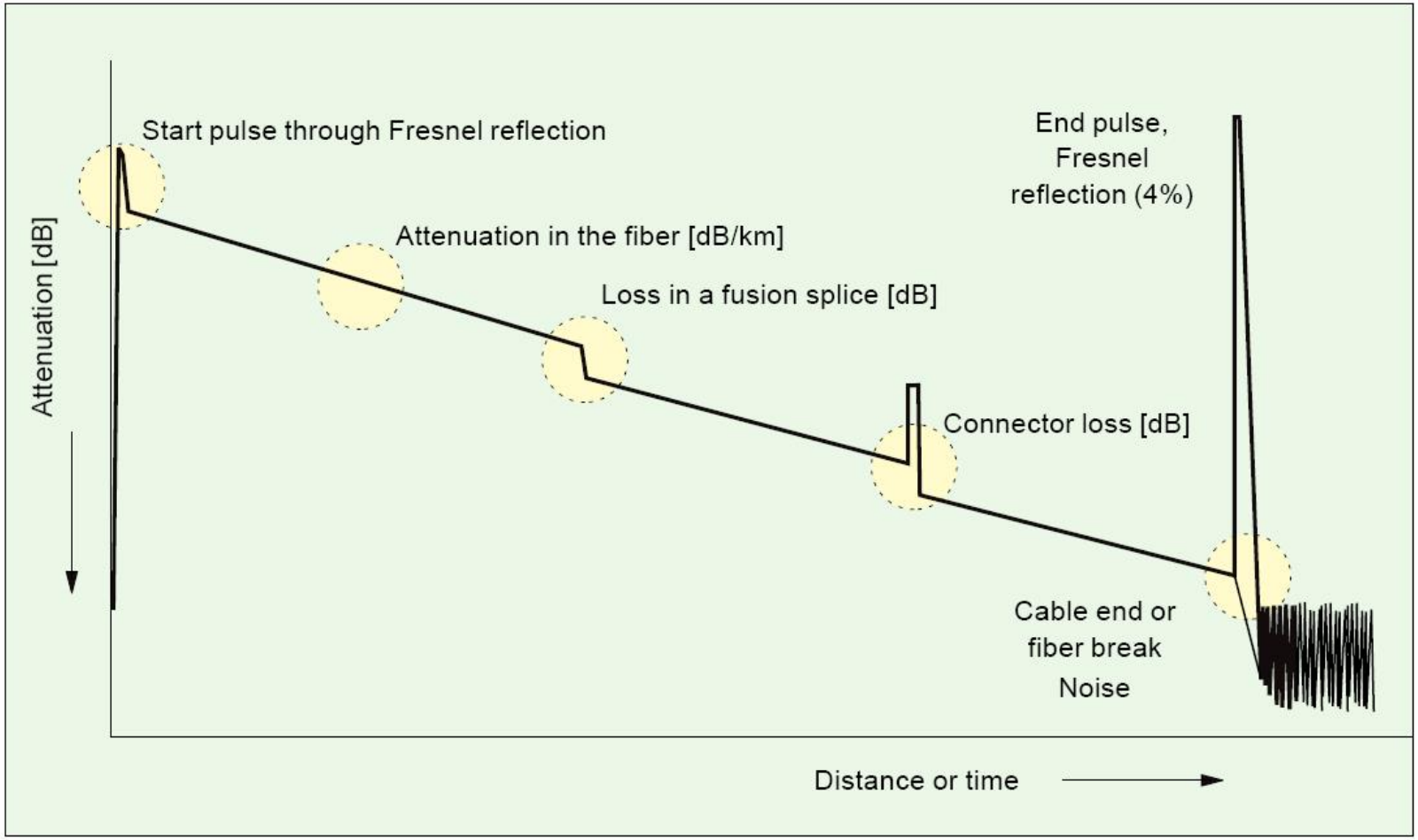


OTDR

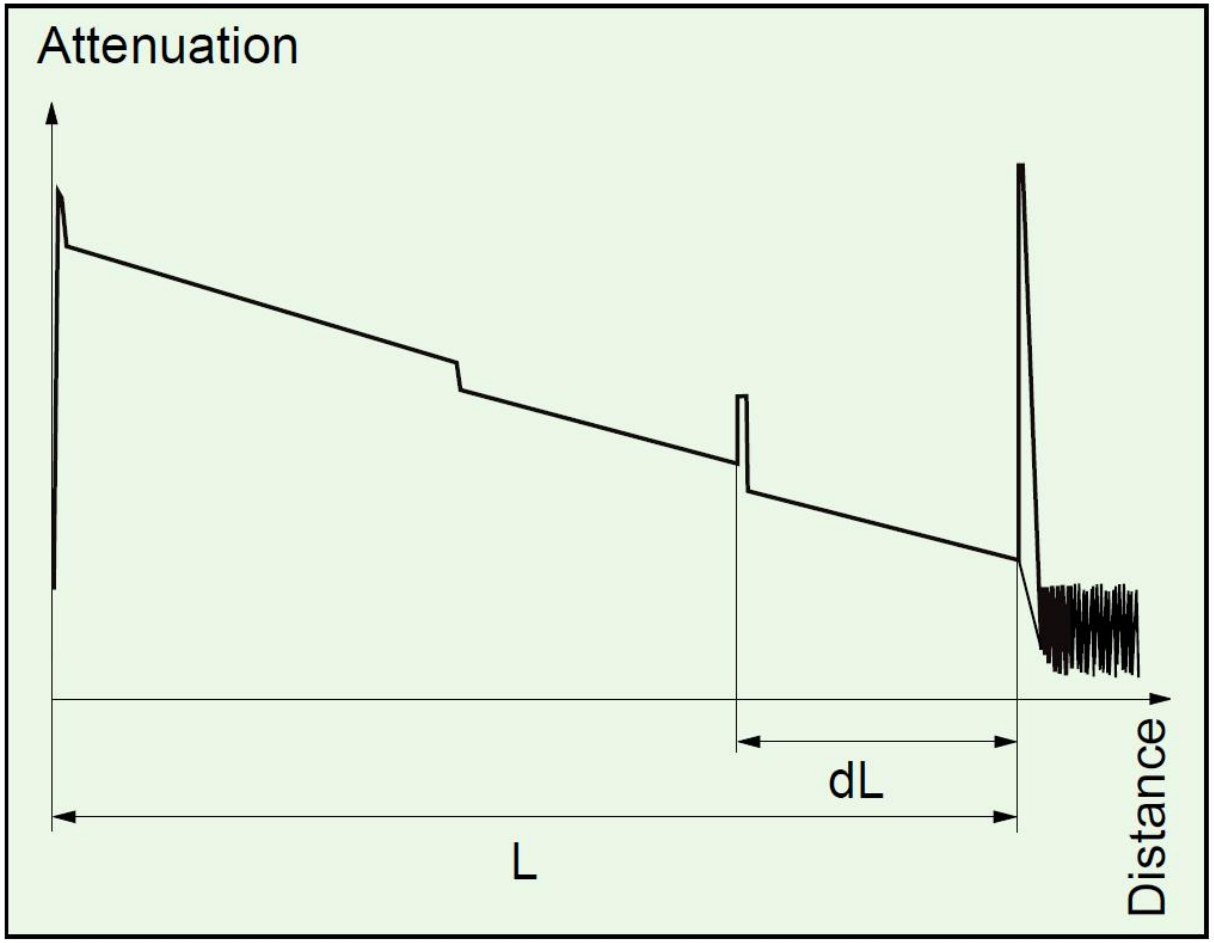
- Optical time-domain reflectometer
- Localizarea defectelor



Rezultat grafic al OTDR



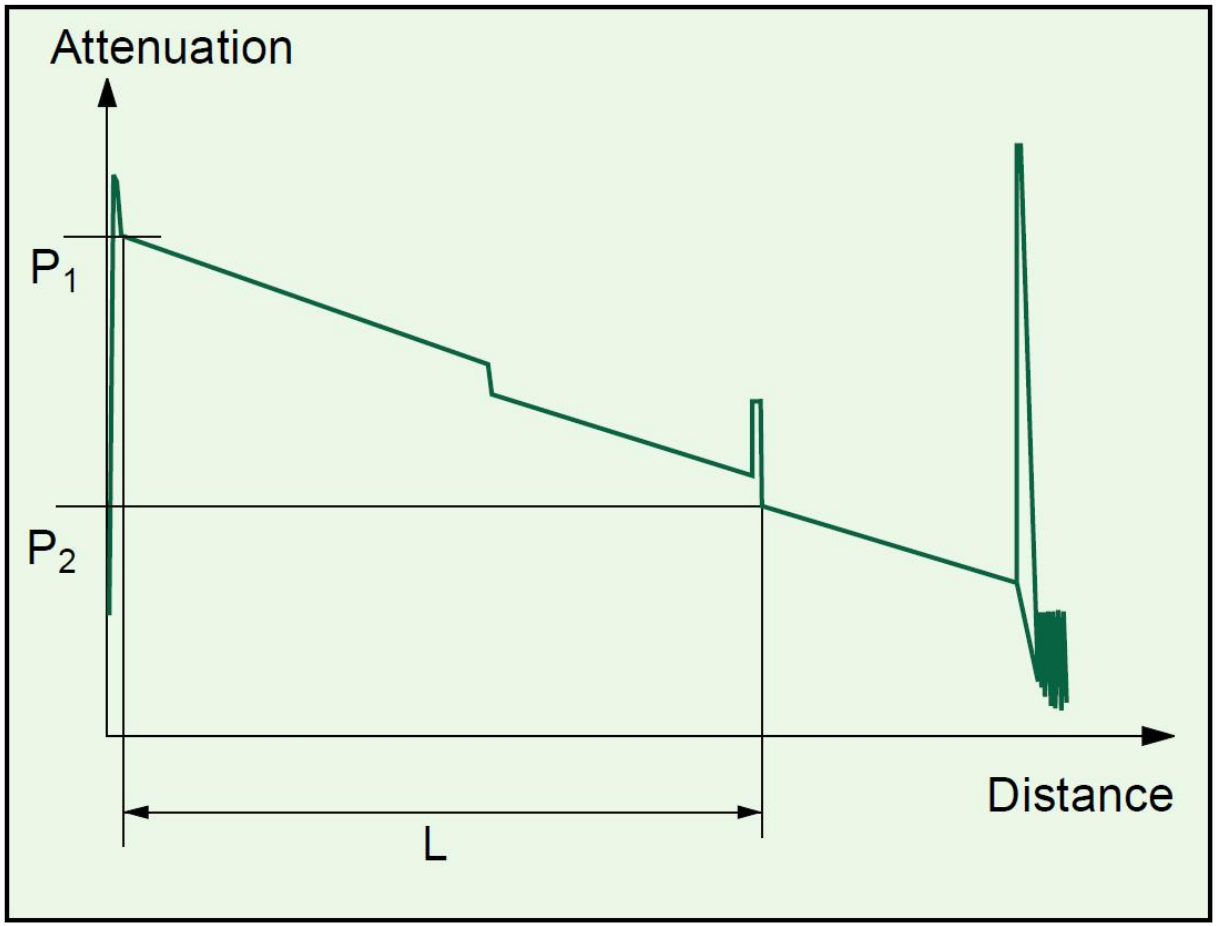
Efecte vizibile OTDR



$$2 \cdot L = c \cdot t$$

$$L = \frac{c_0}{n} \cdot \frac{t}{2}$$

Efecte vizibile OTDR



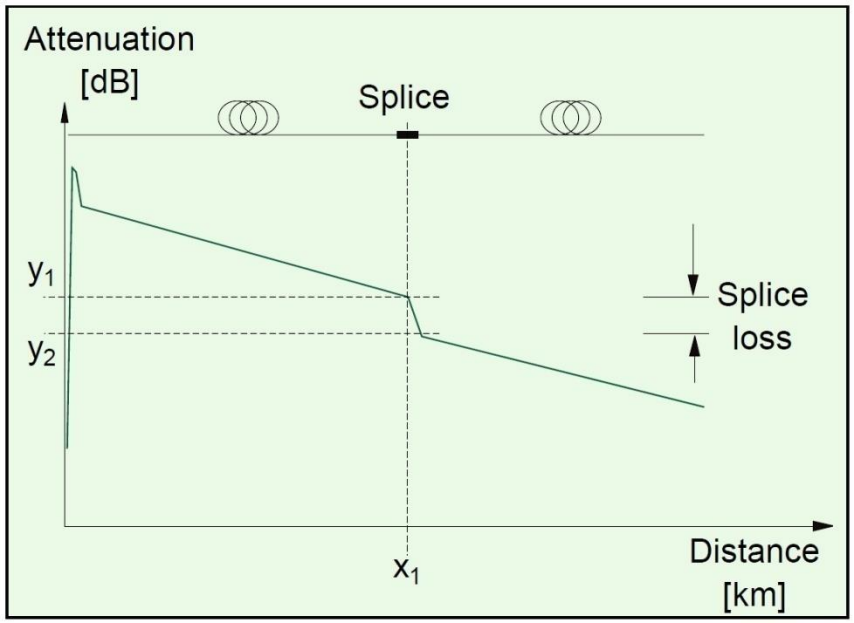
$$A[dB] = \frac{P_1 - P_2}{2}$$

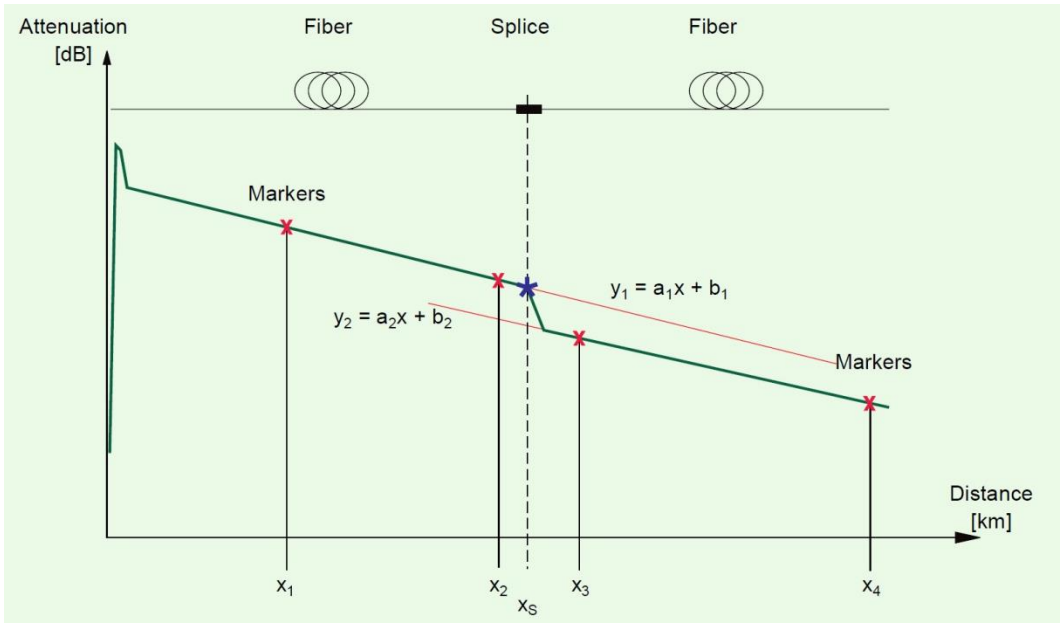
$$A[dB/km] = \frac{P_1 - P_2}{2 \cdot L}$$

panta curbei

Efecte vizibile OTDR – Splice

- splice loss – A(s)

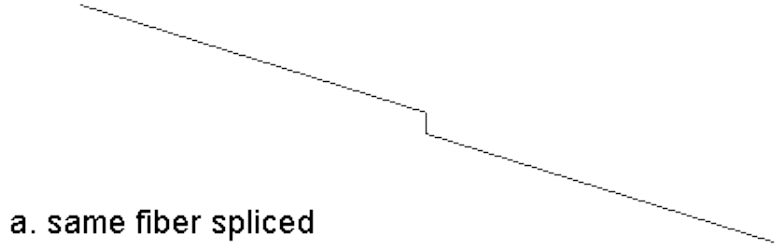




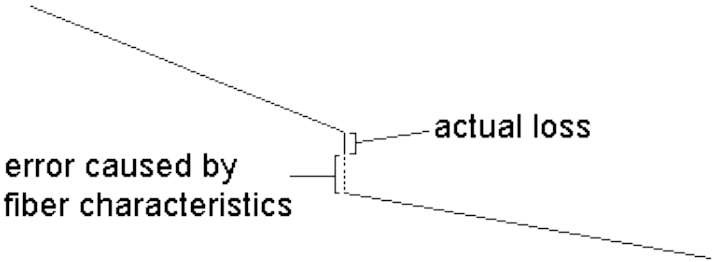
$$A(s) = y_1 - y_2$$

$$A(s) = y_1 - y_2 = x_s \cdot (a_1 - a_2) + (b_1 - b_2)$$

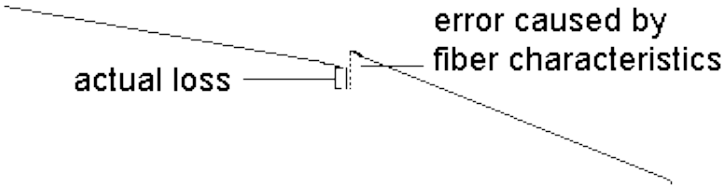
Efecte vizibile OTDR – Splice



a. same fiber spliced



b. high loss fiber spliced to low loss fiber

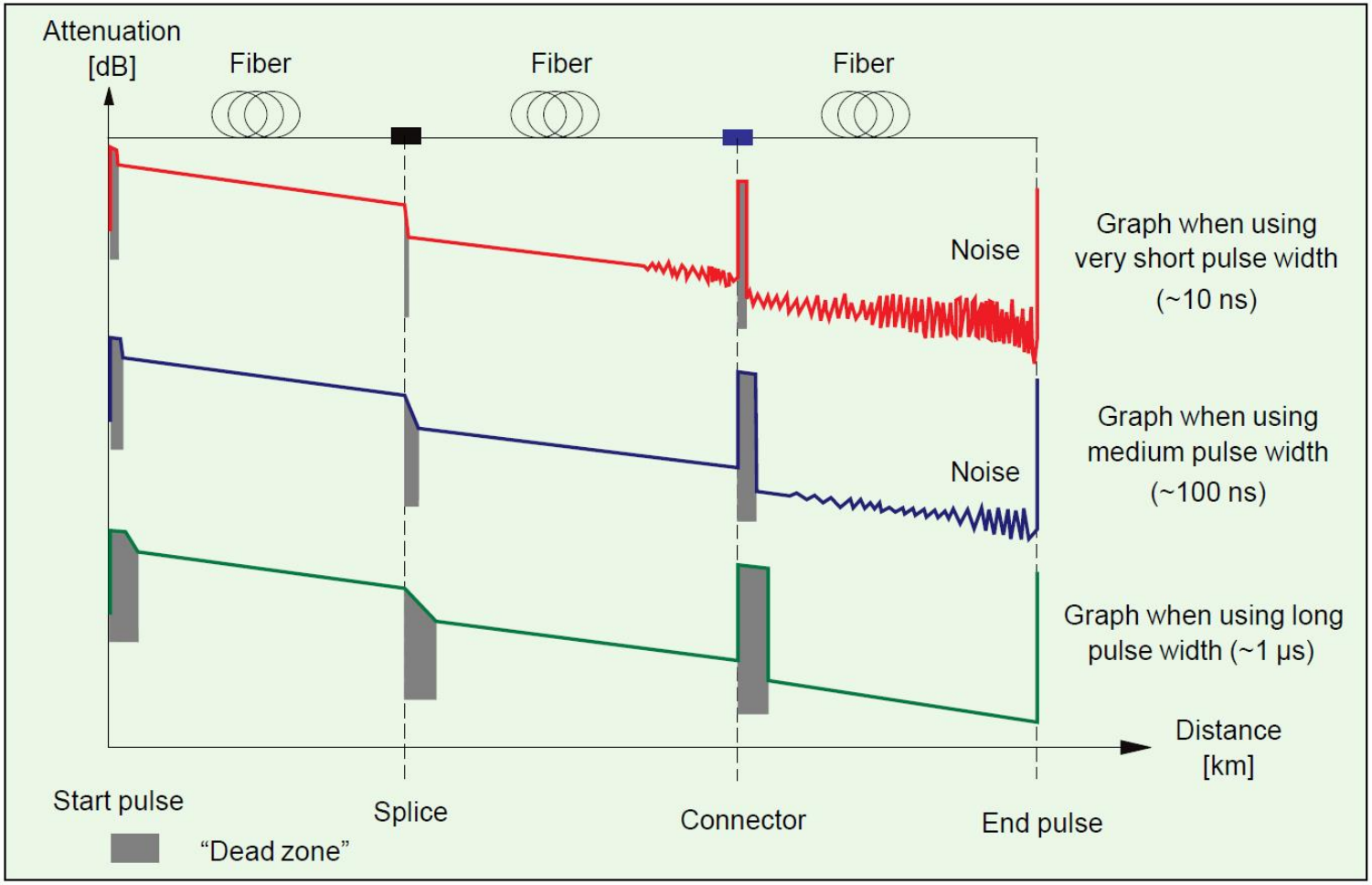


c. low loss fiber spliced to high loss fiber
can cause an apparent gain at a splice

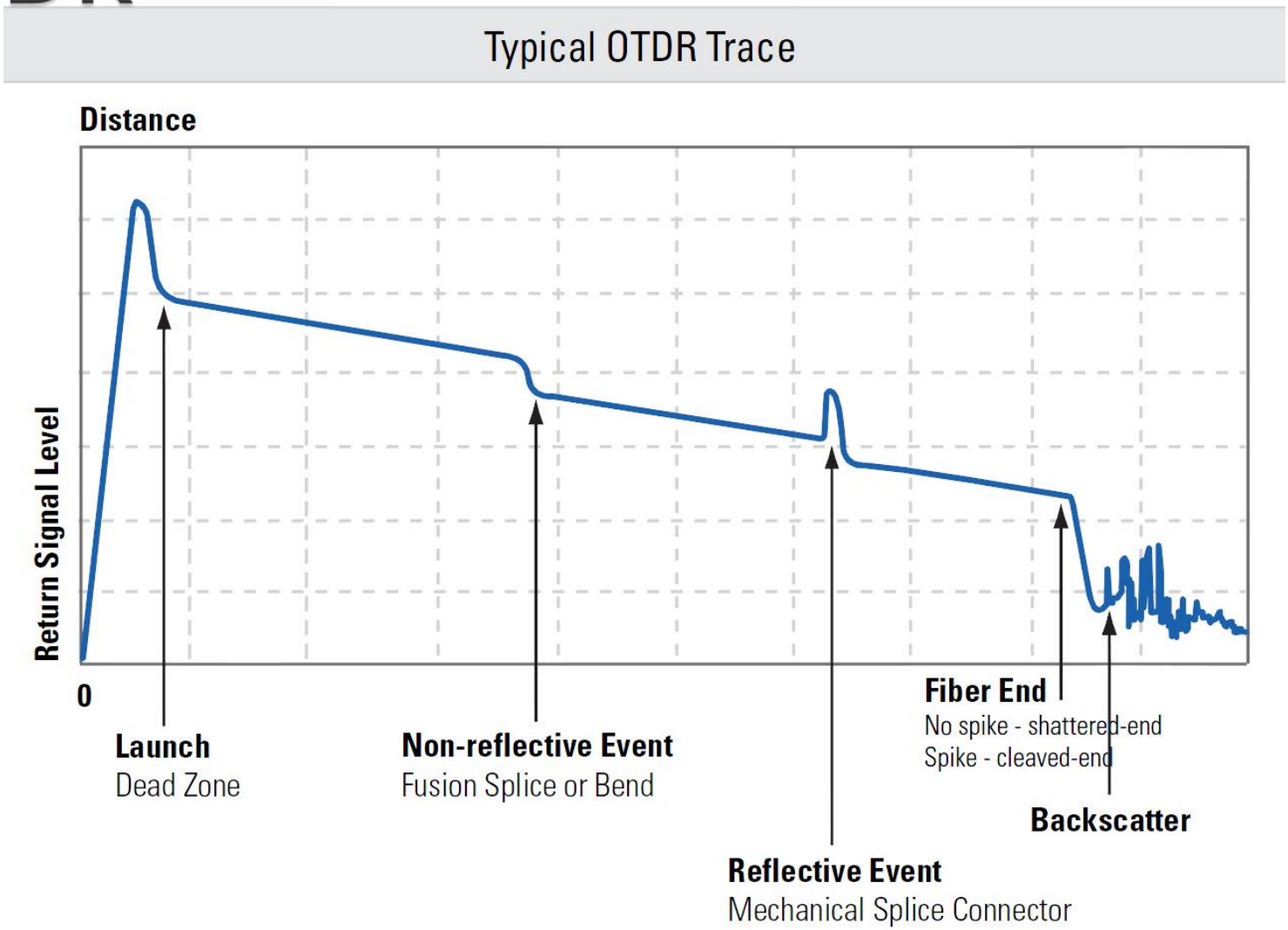
$$A(s) = \frac{A(s)_{A\to B} + A(s)_{B\to A}}{2}$$

Rezultat grafic al OTDR

- latimea pulsurilor luminoase

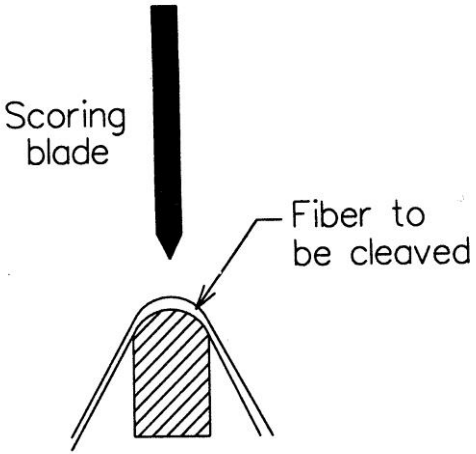


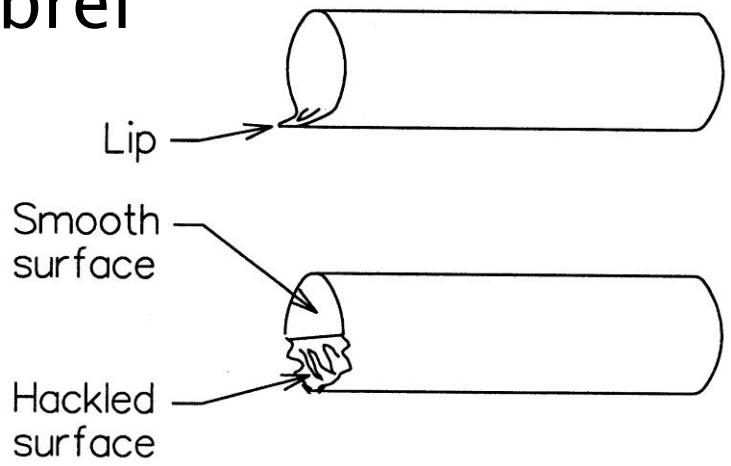
OTDR


Typical OTDR Trace
Distance
Return Signal Level
0
Launch
Dead Zone
Non-reflective Event
Fusion Splice or Bend
Reflective Event
Mechanical Splice Connector
Fiber End
No spike - shattered-end
Spike - cleaved-end
Backscatter

Taiere – Cleaving

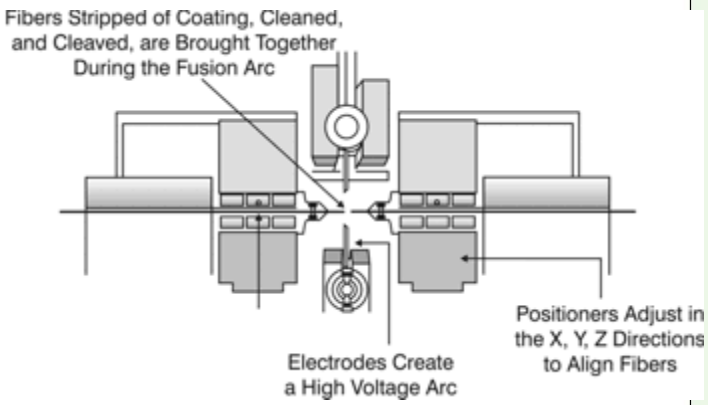
- Tehnici necesare pentru a asigura o taiere perpendiculara pe axa fibrei

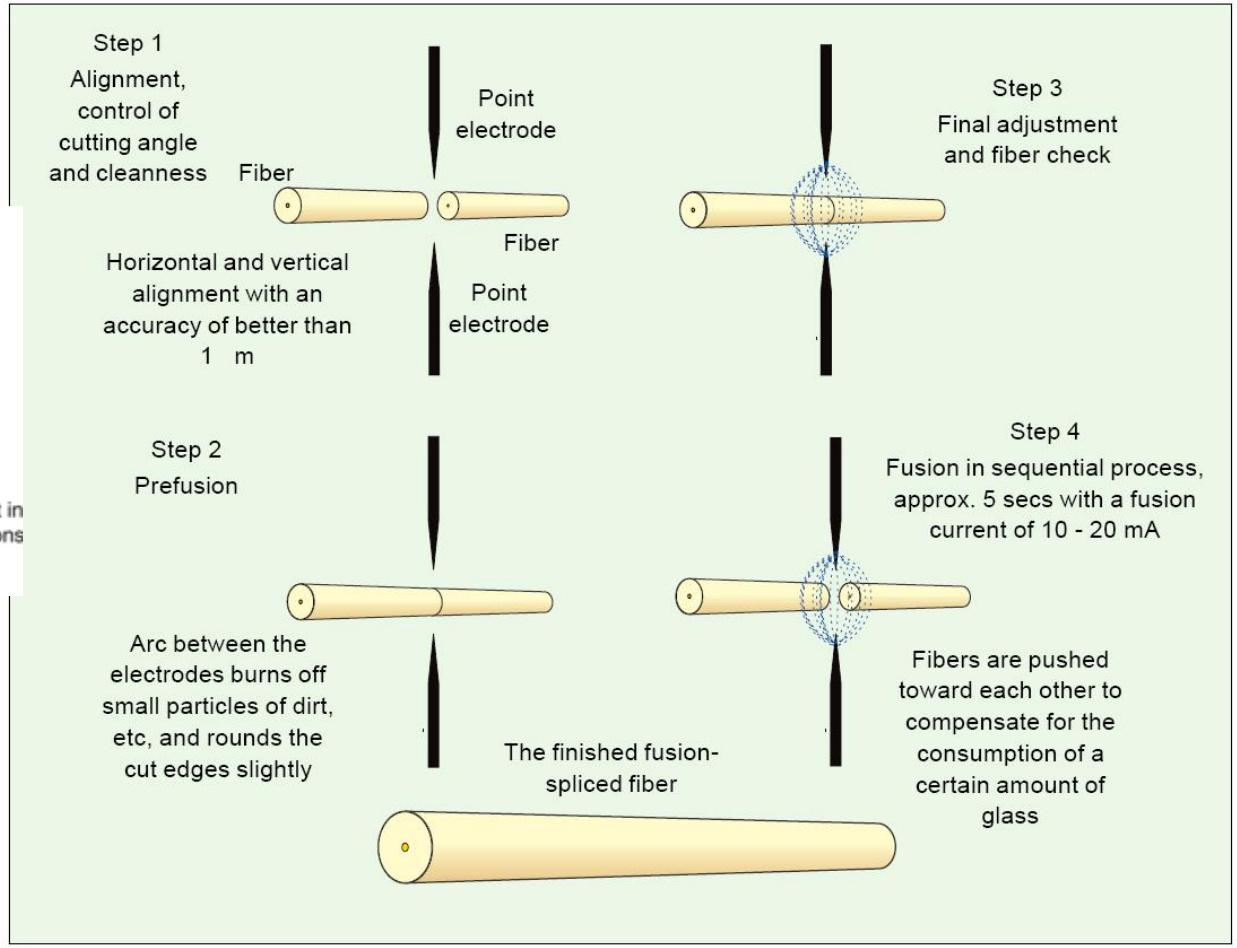




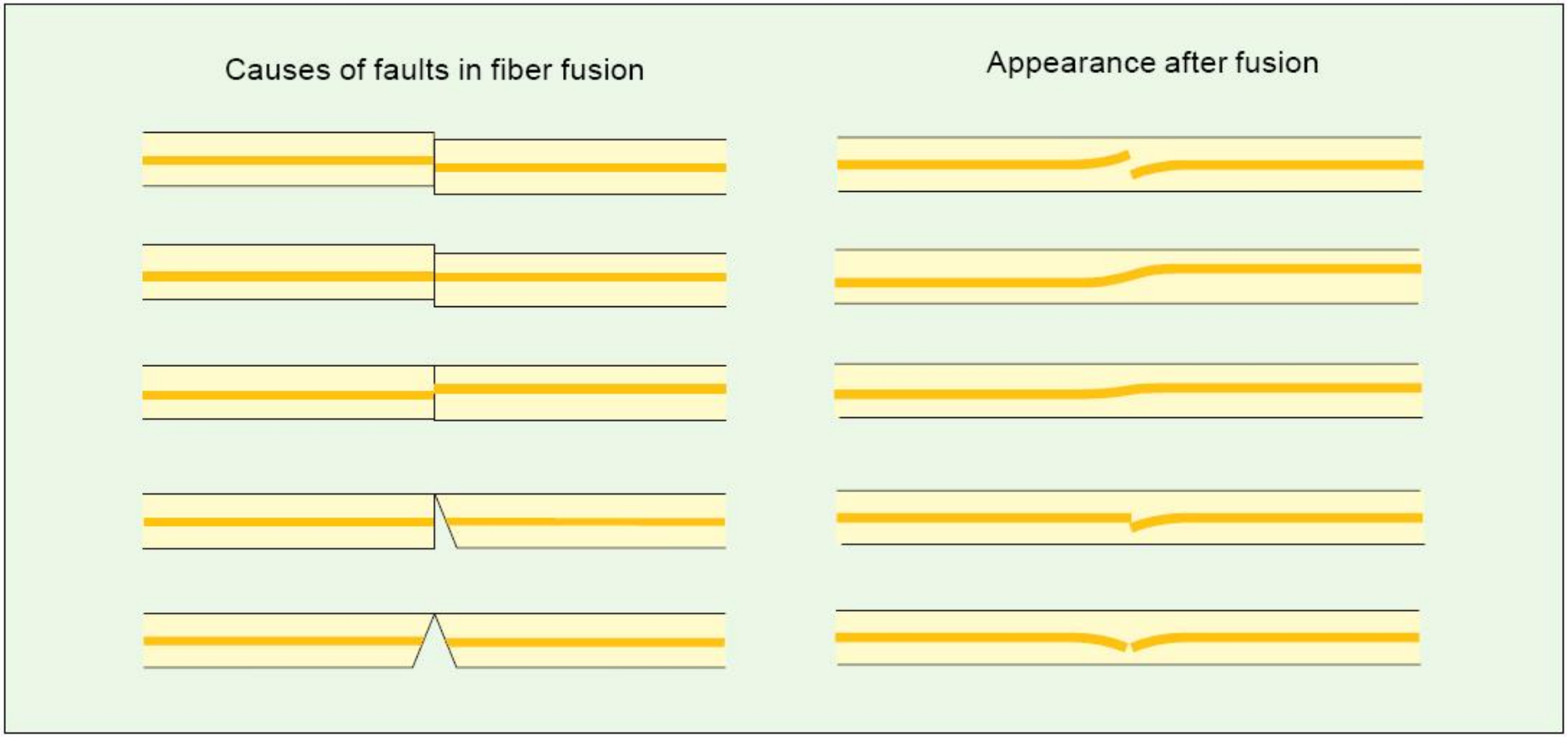
Lipire prin fuziune

Splice prin fuziune

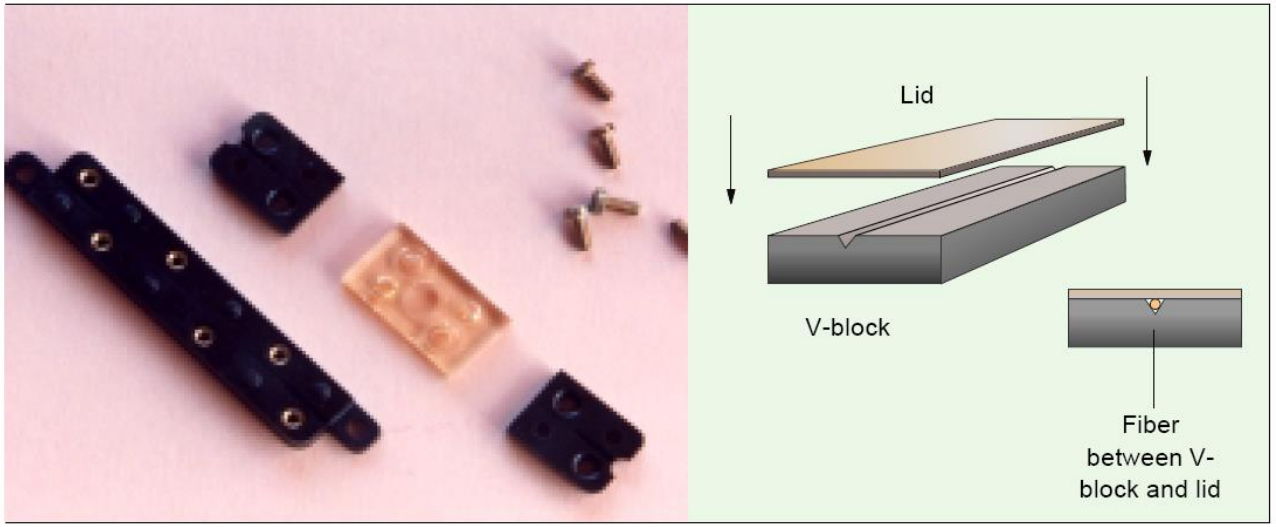


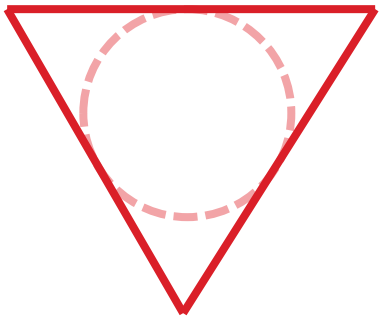


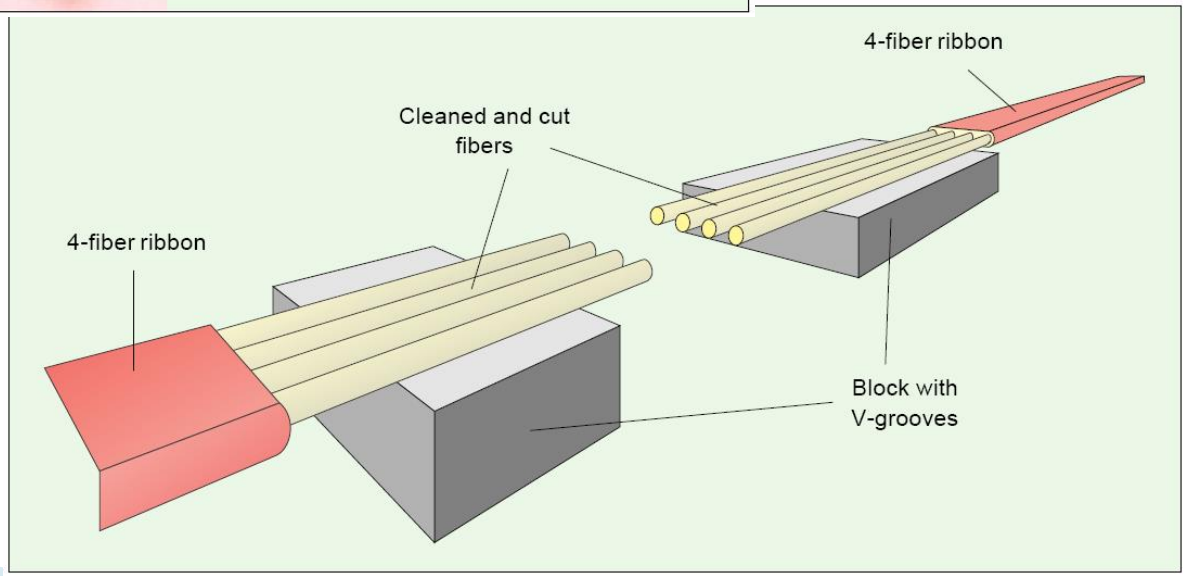
Splice prin fuziune



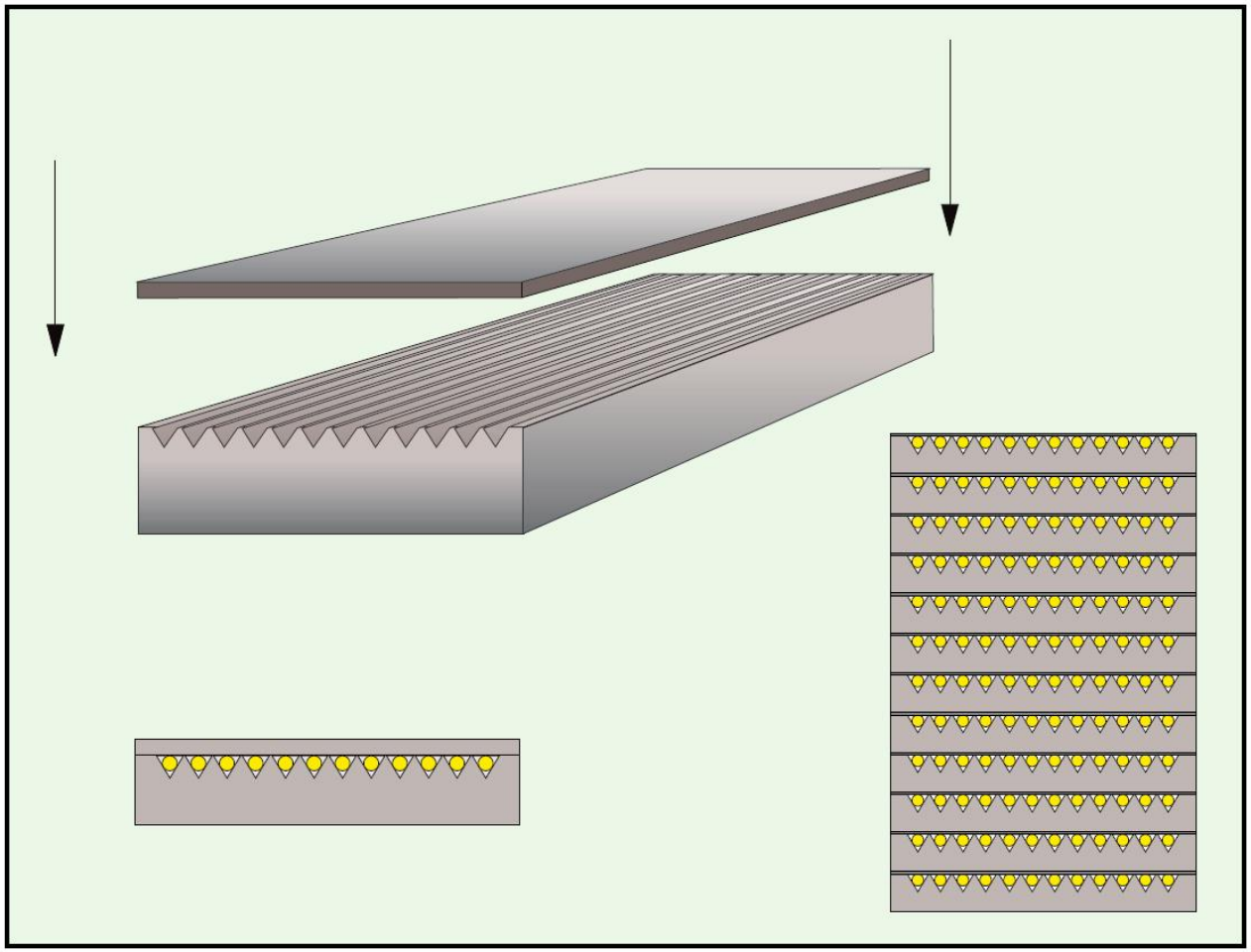
Splice mecanic – bloc V



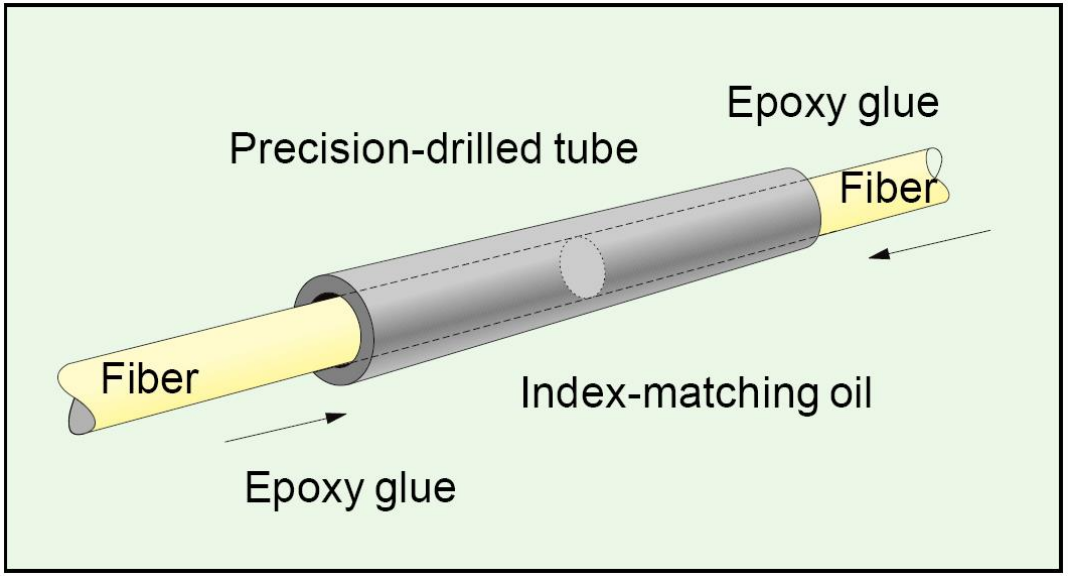


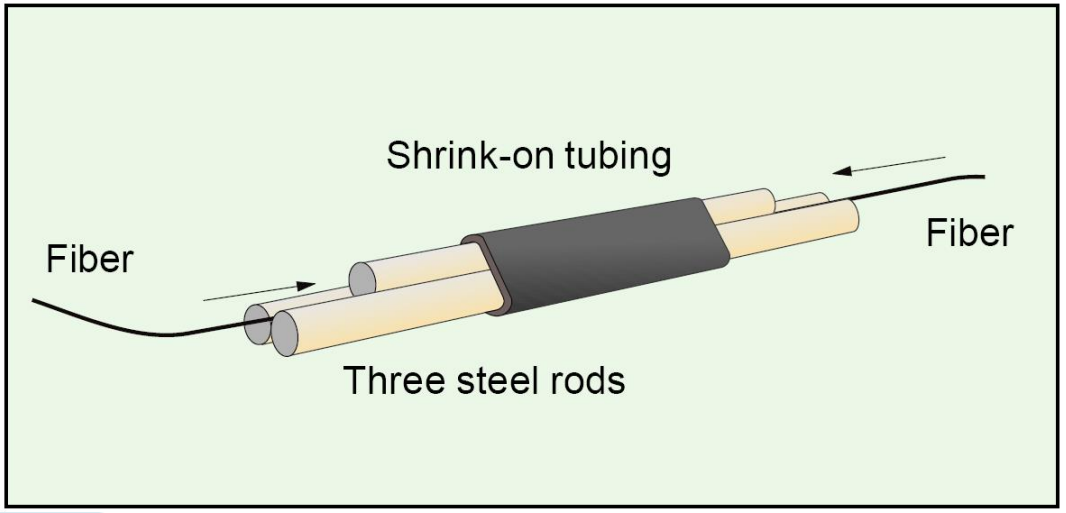


Splice mecanic – bloc V



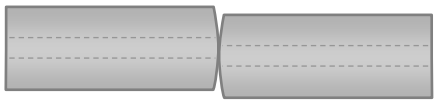
Splice mecanic



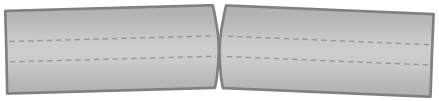


Probleme Fibre/Conectori

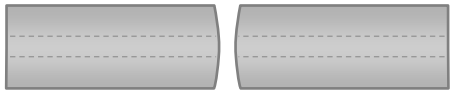
Offset



Angular Misalignment



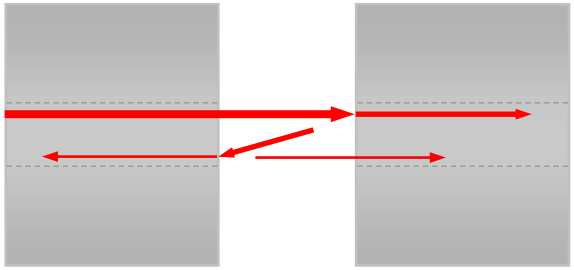
Separation



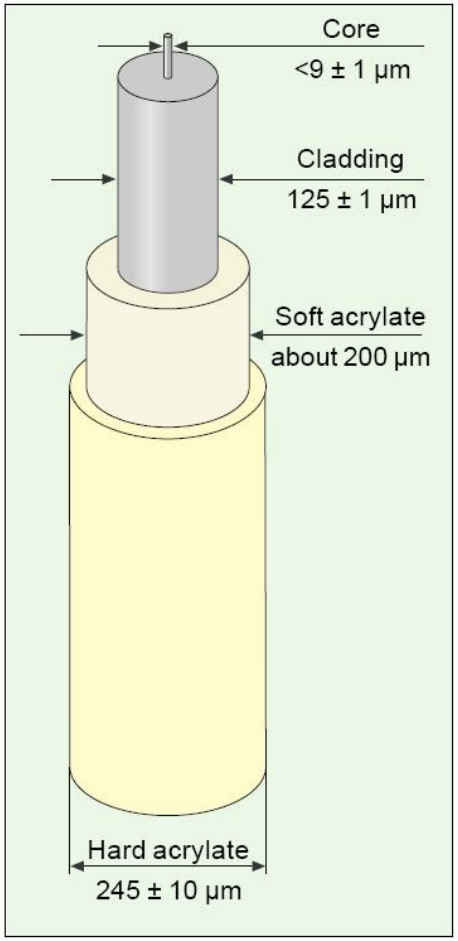
Core Eccentricity

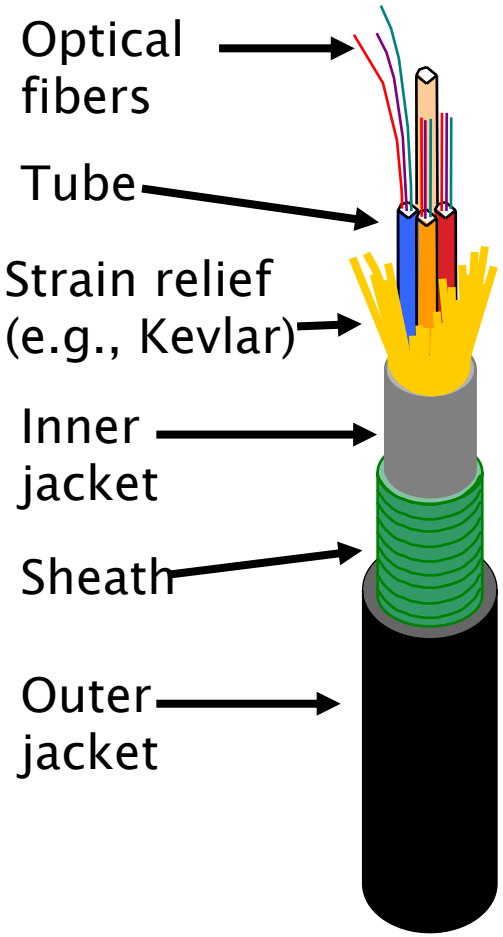
Core Ellipticity

Reflections & Interference

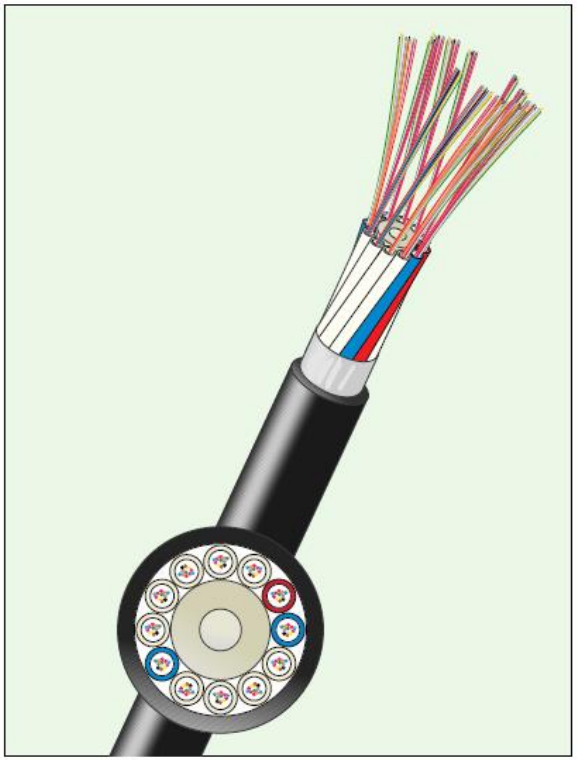


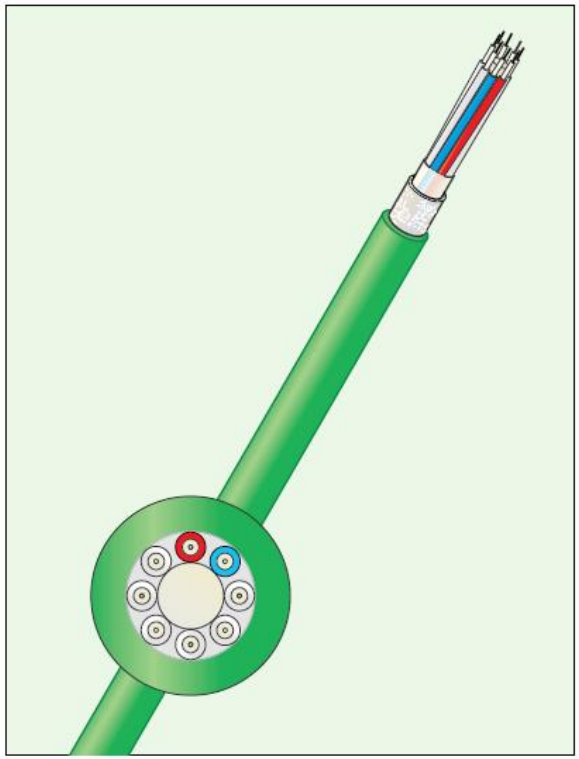
Cabluri

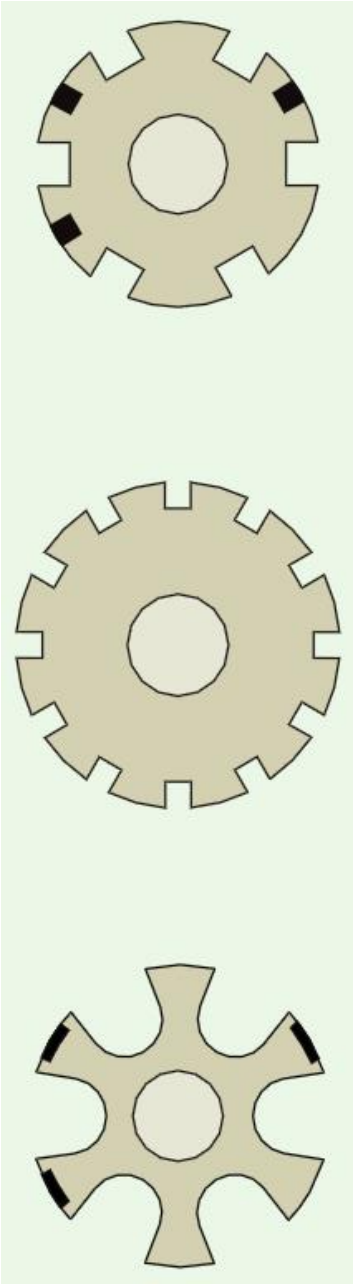

Core
<9 ± 1 µm
Cladding
125 ± 1 µm
Soft acrylate
about 200 µm
Hard acrylate
245 ± 10 µm


Optical fibers
Tube
Strain relief (e.g., Kevlar)
Inner jacket
Sheath
Outer jacket

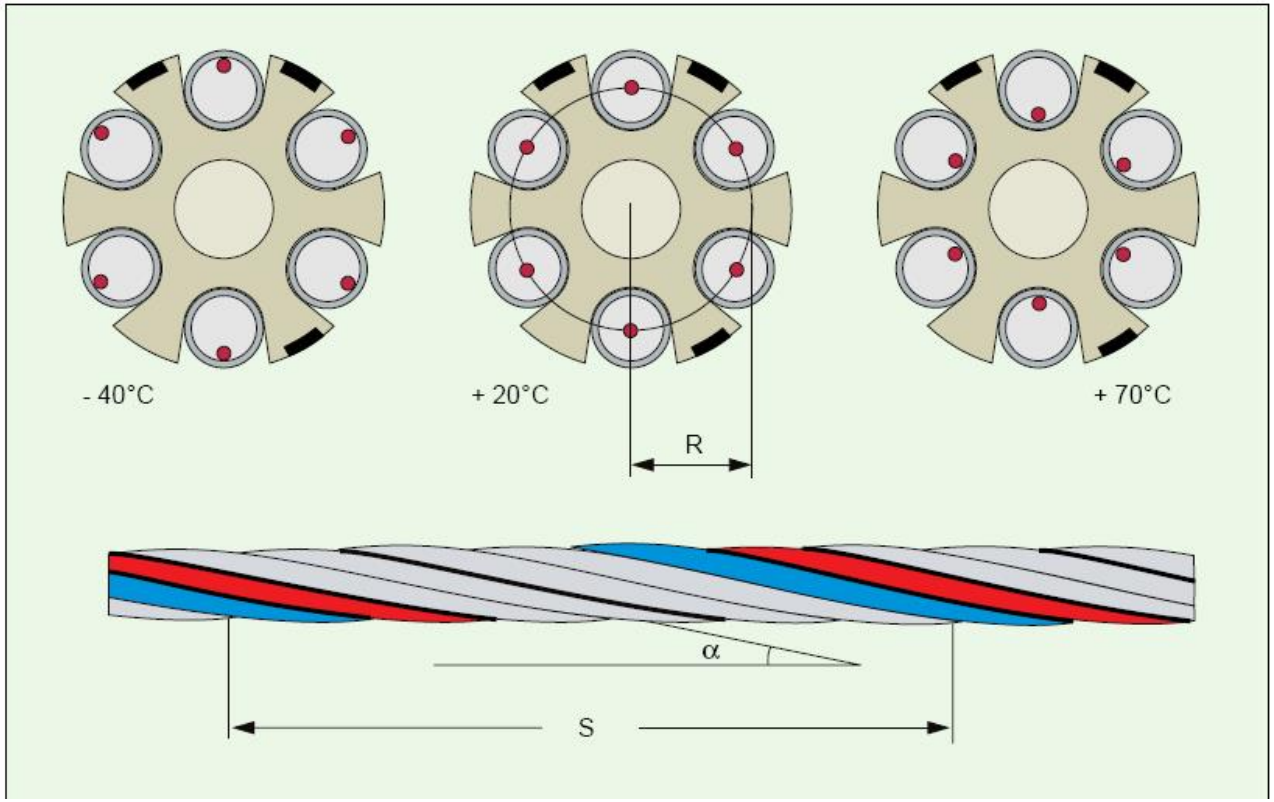
Cabluri

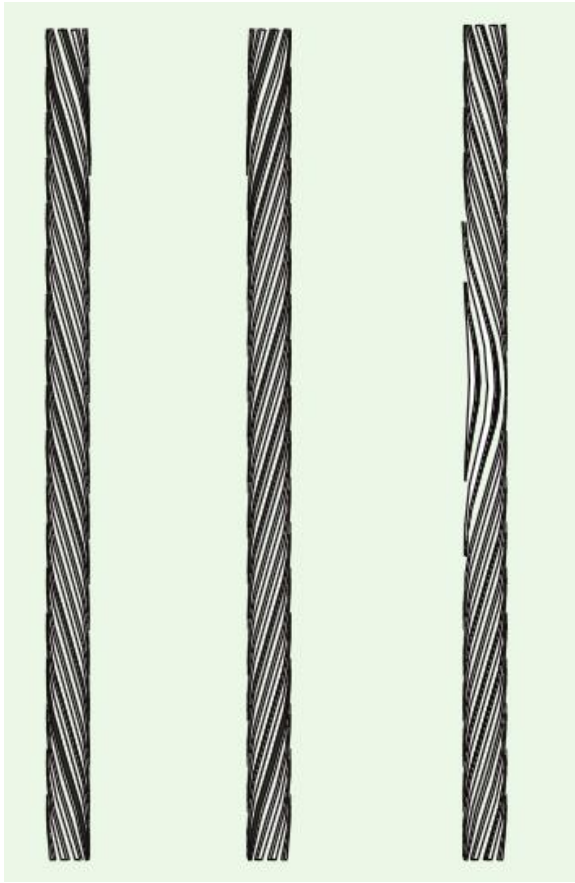






Cabluri

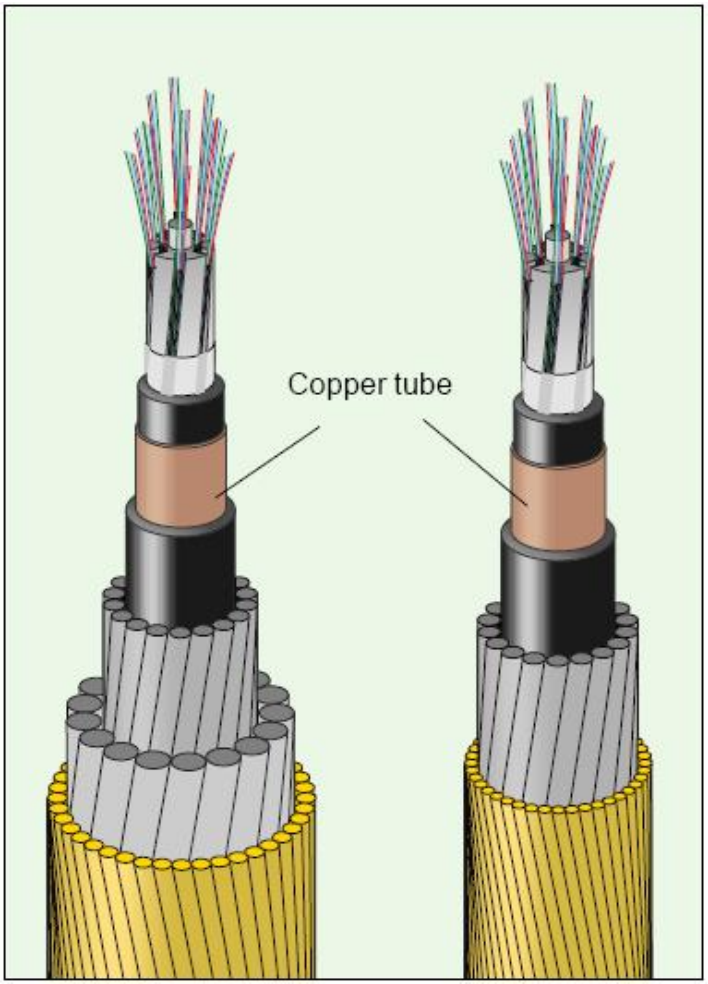


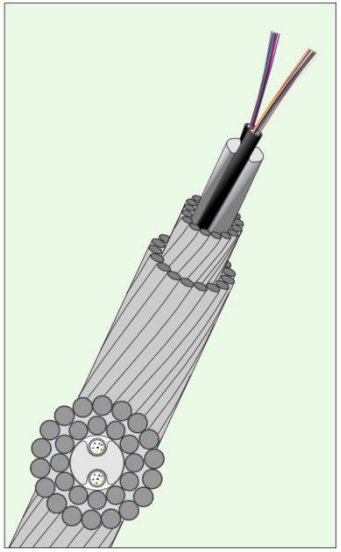


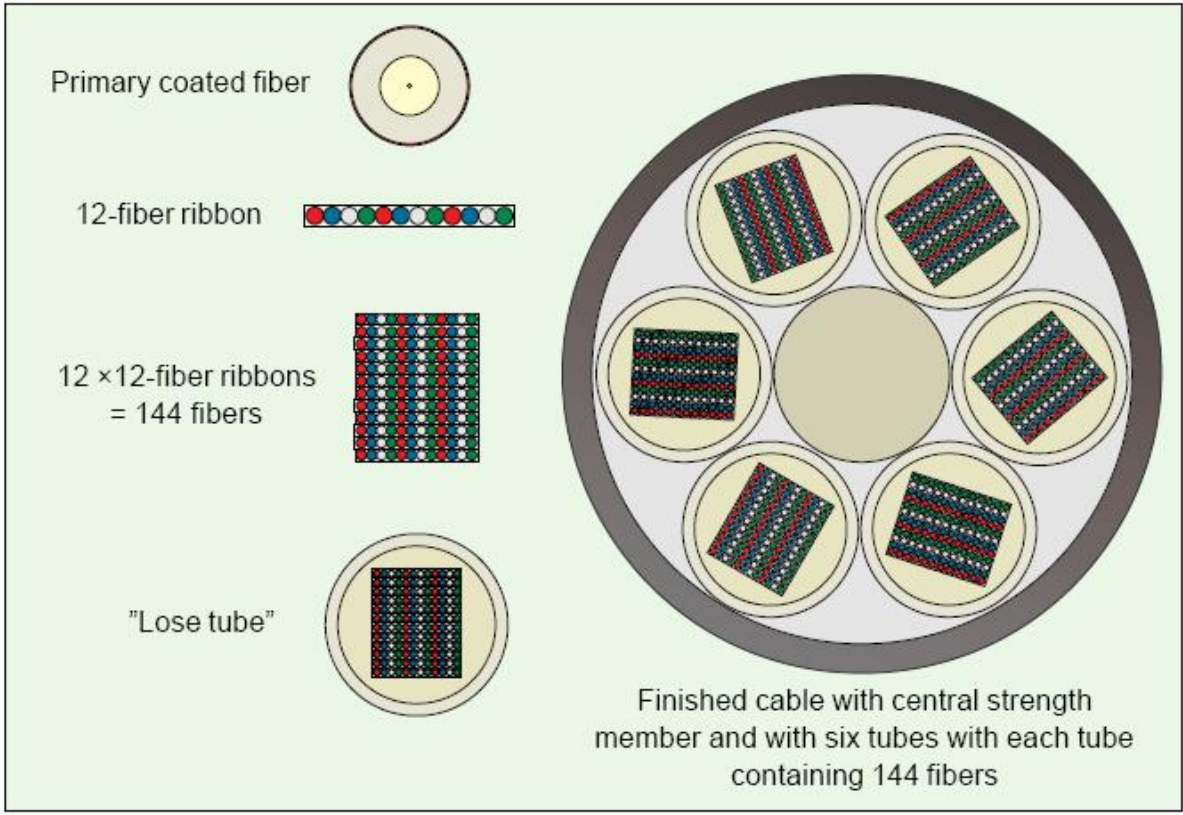
$$S' = S \cdot \sqrt{1 + \left(\frac{2\pi \cdot R}{S}\right)^2}$$

$$\frac{\Delta L}{L_0} = \sqrt{1 + \left(\frac{2\pi \cdot R}{S}\right)^2} - 1$$

Cabluri


Copper tube

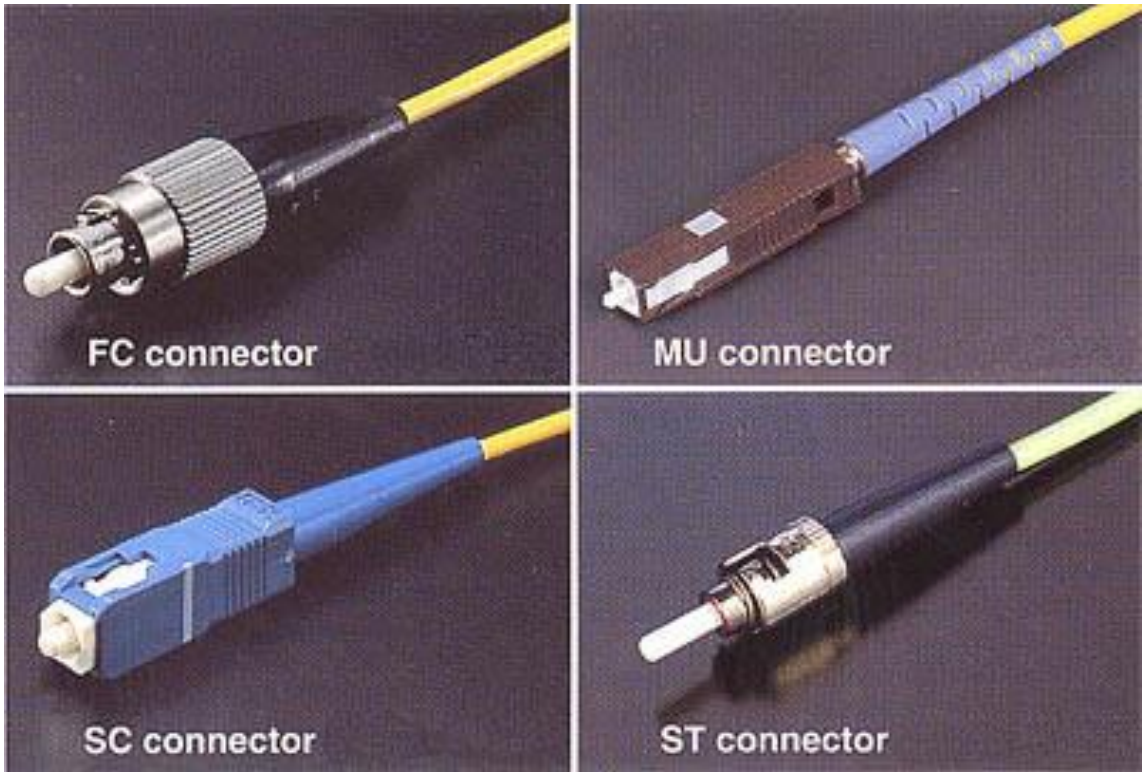



Primary coated fiber
12-fiber ribbon
12 ×12-fiber ribbons
= 144 fibers
"Lose tube"
Finished cable with central strength member and with six tubes with each tube containing 144 fibers

Conectori


FC - PC/PM
FC - APC/PM
DIN - PC
DIN-APC/HRL10
SC - PC
SC - APC
AVIO - PC
AVIO - APC
ST - PC
E2000 - PC
E2000 - APC

Conectori

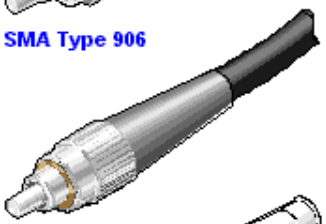


ST

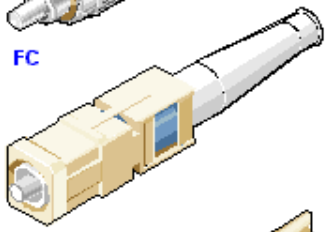
All fiber-optic connectors use ferrules to hold the ends of the fiber and keep them properly aligned.

SMA Type 906

The ST connector uses a half-twist bayonet type of lock, while SMA and FC use threaded connections.



FC

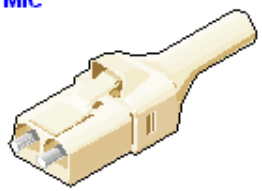


SC

The SC uses a push-pull connector similar to common audio and video plugs and sockets.

MIC

The MIC is the standard FDDI connector.



Fiber Jack

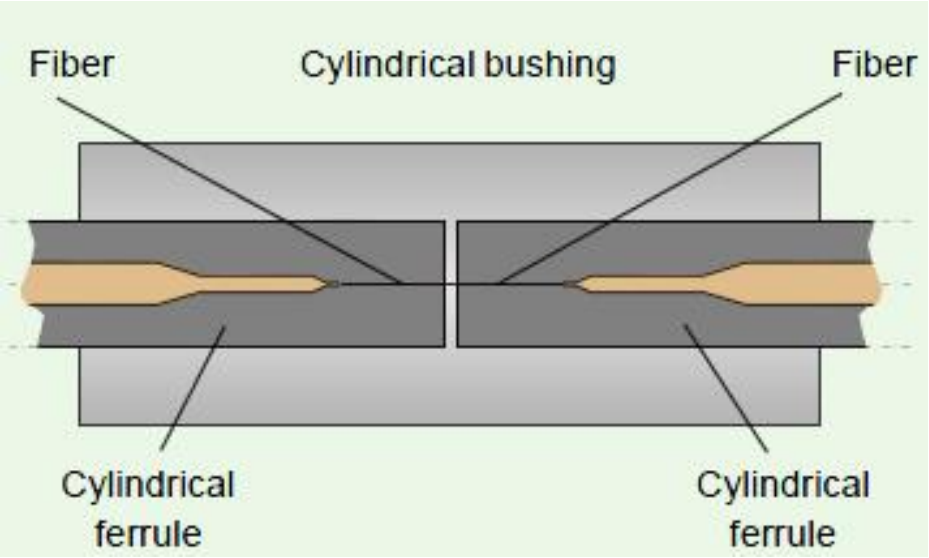
The Fiber Jack connector attaches two fibers in a snap lock connector similar in size and ease of use as an RJ-45 connector.

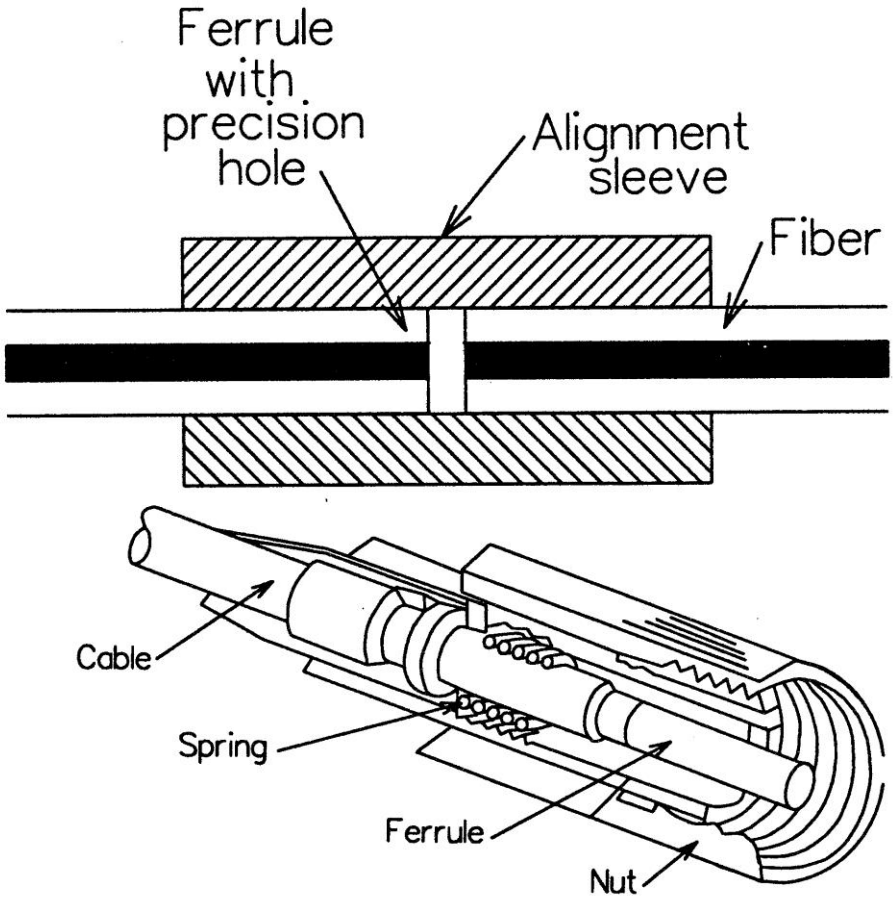
MT-RJ

MT-RJ is a popular connector for two fibers in a very small form factor.

Conectori

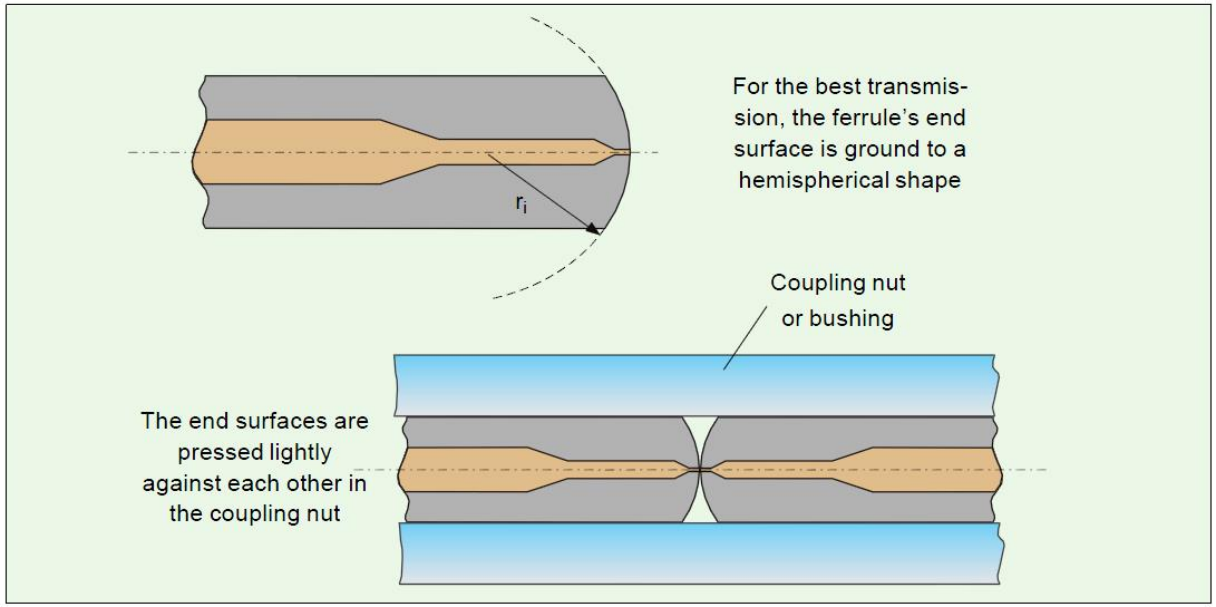
- Verificati http://rf-opto.etti.tuiasi.ro





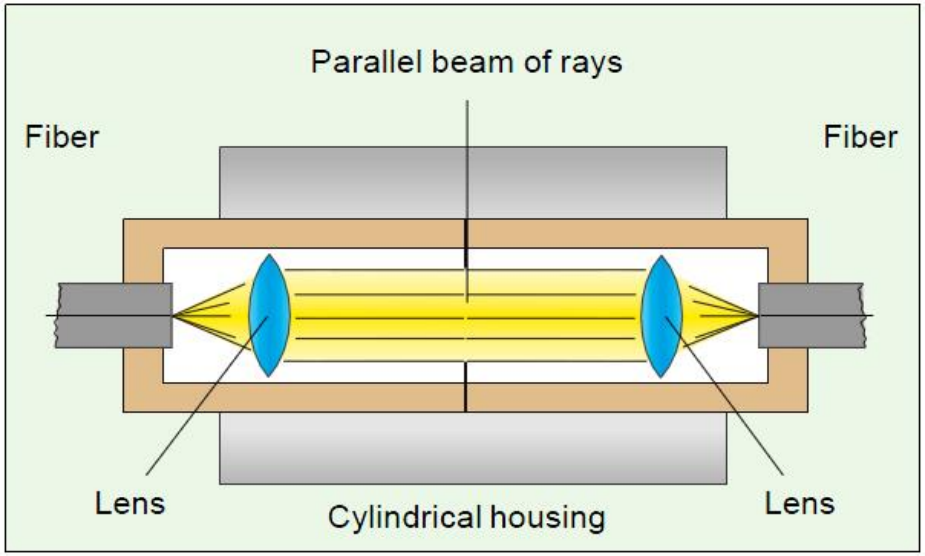
Conectori

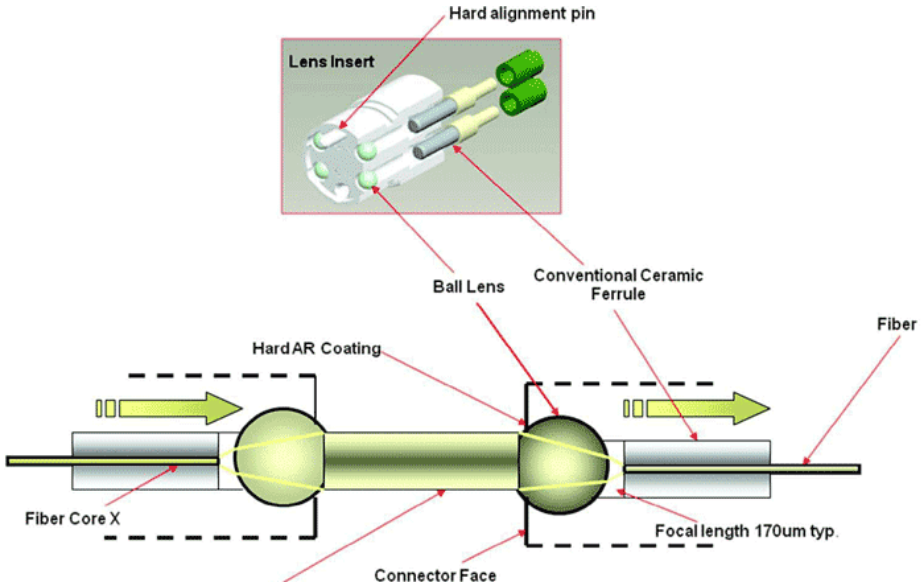
- Ferula semisferica
  - 20mm
  - 60mm



- Conectori multifibra

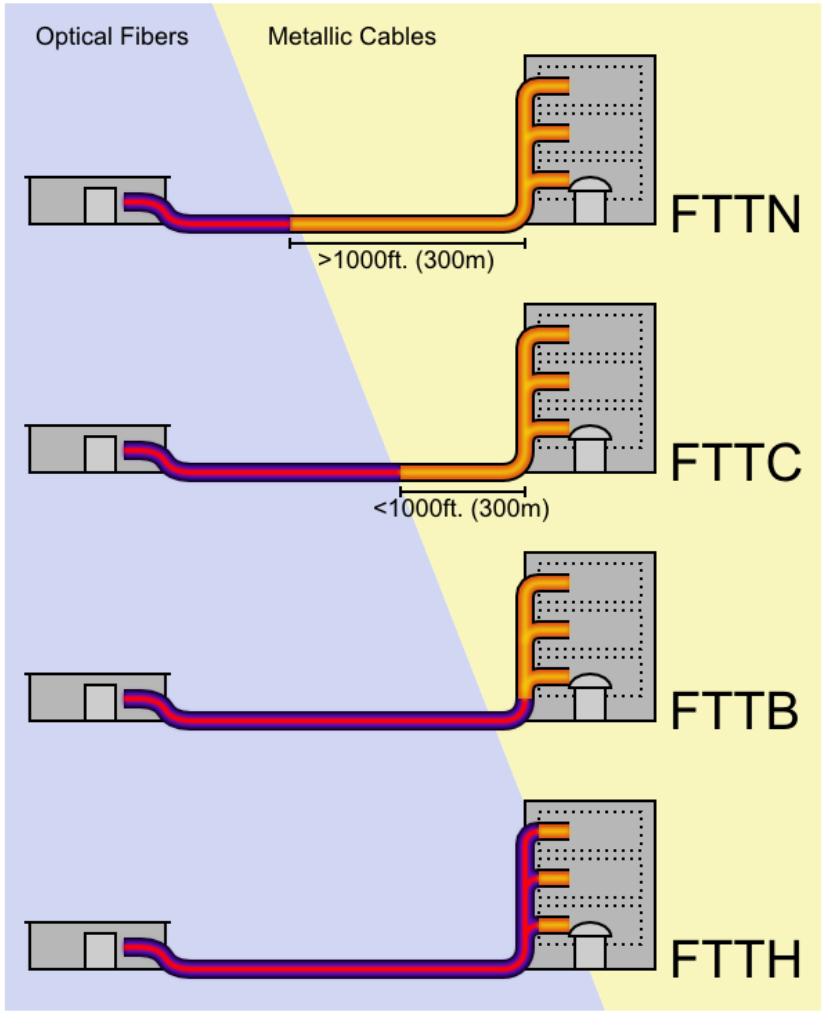
Expanded beam connector





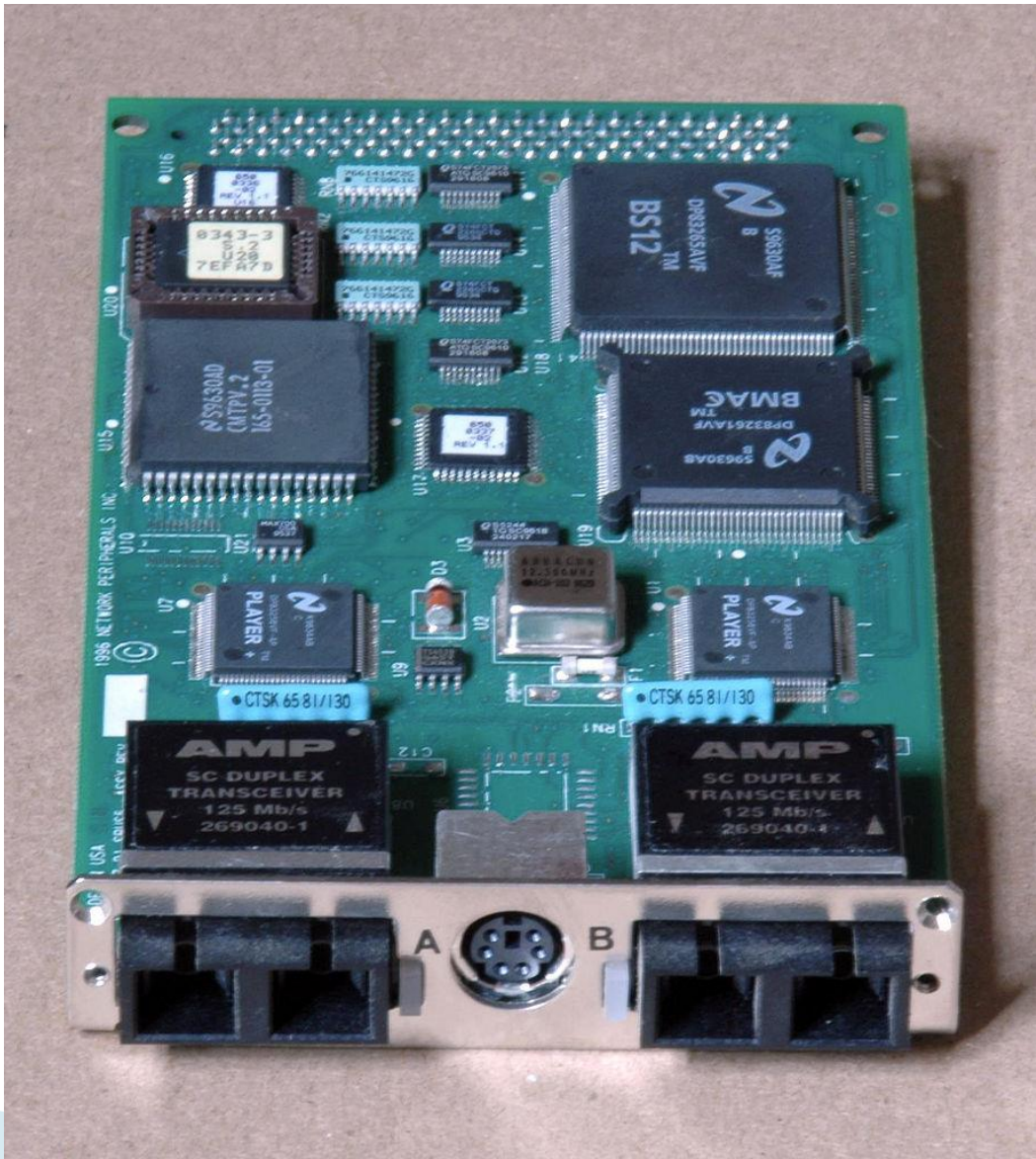
FTTH

- FTTN: Fiber to the node, neighborhood
- FTTC: Fiber to the curb
- FTTB: Fiber to the building
- FTTH: Fiber to the home



FDDI

- Fiber Distributed Data Interface



Cabluri, Conectori, rf-opto

Contact

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- rdamian@etti.tuiasi.ro