Copper and Fiber Optic Cables

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Copper cables main characteristics

- The main characteristics of a transmission media are:
  - Vp: Velocity of propagation of the signal expressed as c fraction (speed of the light in the empty space):
    - values included between 0.5 and 0.8 c
  - Z = r+jI impedance of the line
  - conductors' dimension
    - american AWG unit of measurement
      - Diameter, electrical resistance

AWG: American Wire Gage

- Scale to measure the copper wire dimension
- It is a geometrical regression
  - with 39 values in the interval 000 gage (0.460 diameter inch) and 36 gage (0.005 diameter inch)
- Every increase of a gage corresponds to a diameter relationship of:

$$\left(\frac{0.460}{0.005}\right)^{1/39} = 92^{1/39} = 1.229322$$

Copper cables AWG

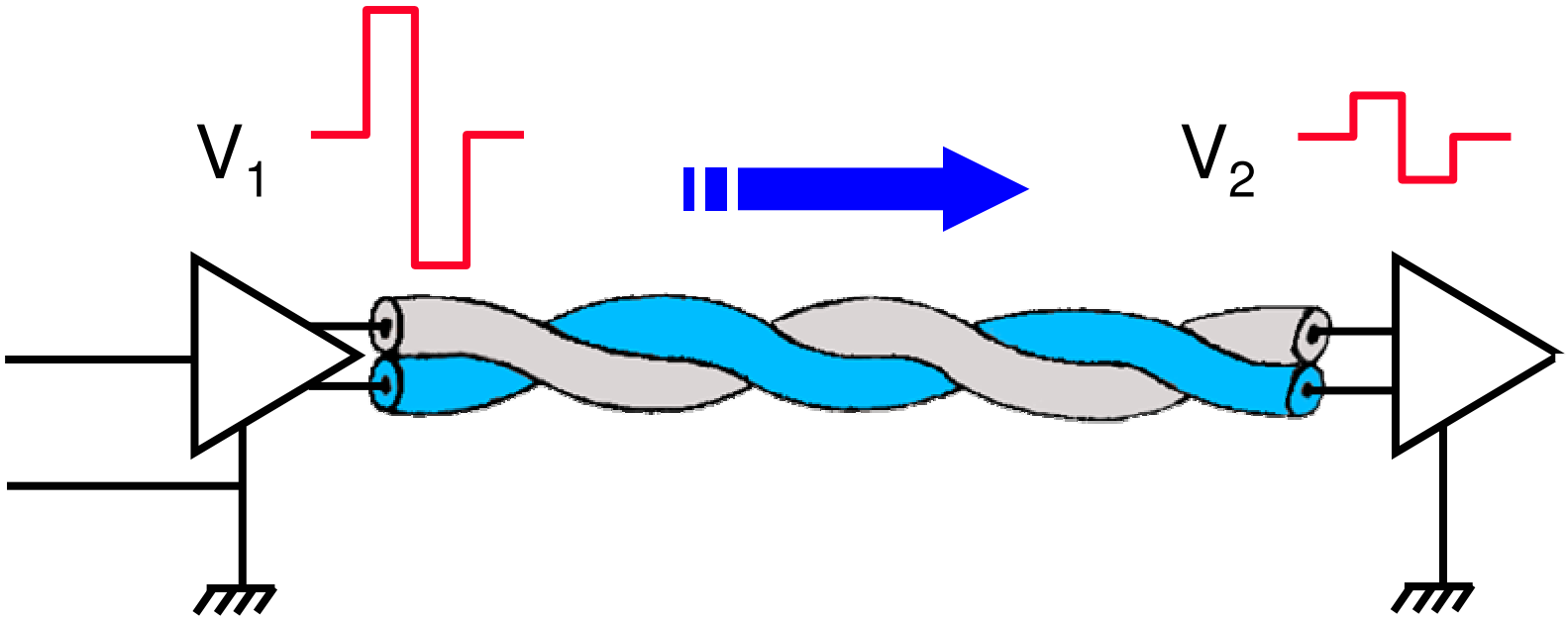
- 24 or 22 AWG for structured cabling system
- 26 AWG for patch cord

AWG	mm (Ø)	mm^2	Kg/Km	Ω/Km
22	0.6438	0.3255	2.894	52.96
23	0.5733	0.2582	1.820	84.21
24	0.5106	0.2047	1.746	87.82
25	0.4547	0.1624	1.414	108.4
26	0.4049	0.1288	1.145	133.9

Copper cable attenuation

- The attenuation is the output signal reduction with respect to the entry signal in the cable:
  - attenuation linearly grows in dB with the length of the cable and the frequency square root
  - to reduce the cable attenuation expanded insulators are used because improve the capacity

Attenuation



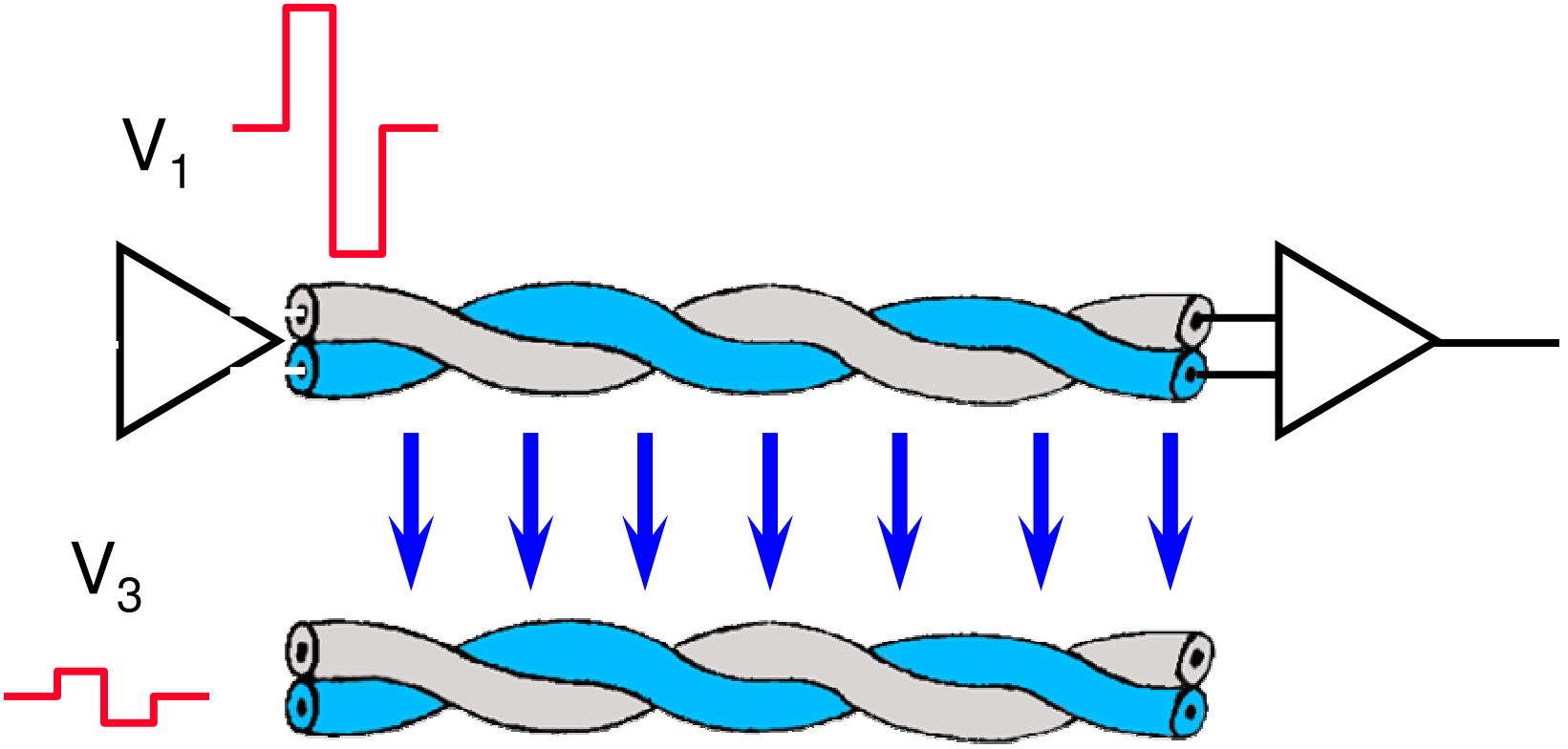
$$\alpha_{dB} = 20 \log_{10} (V_1 / V_2)$$

Copper pair Cross-Talk

- Signal energy part induction on the near conductors, where a disturb becomes
- The phenomenon increases with increasing it by frequency
- It can be measured in several manners

NEXT: Near End Cross-Talk

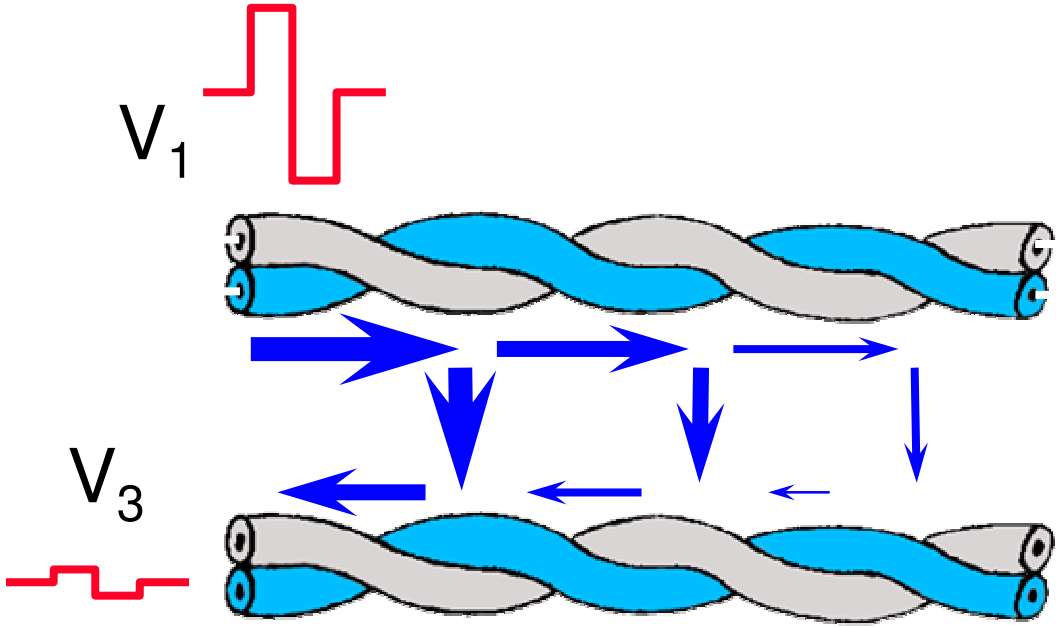
- Cross-Talk measured at the transmitter side



$$NEXT_{dB} = 20 \log_{10} (V_1 \ / \ V_3)$$

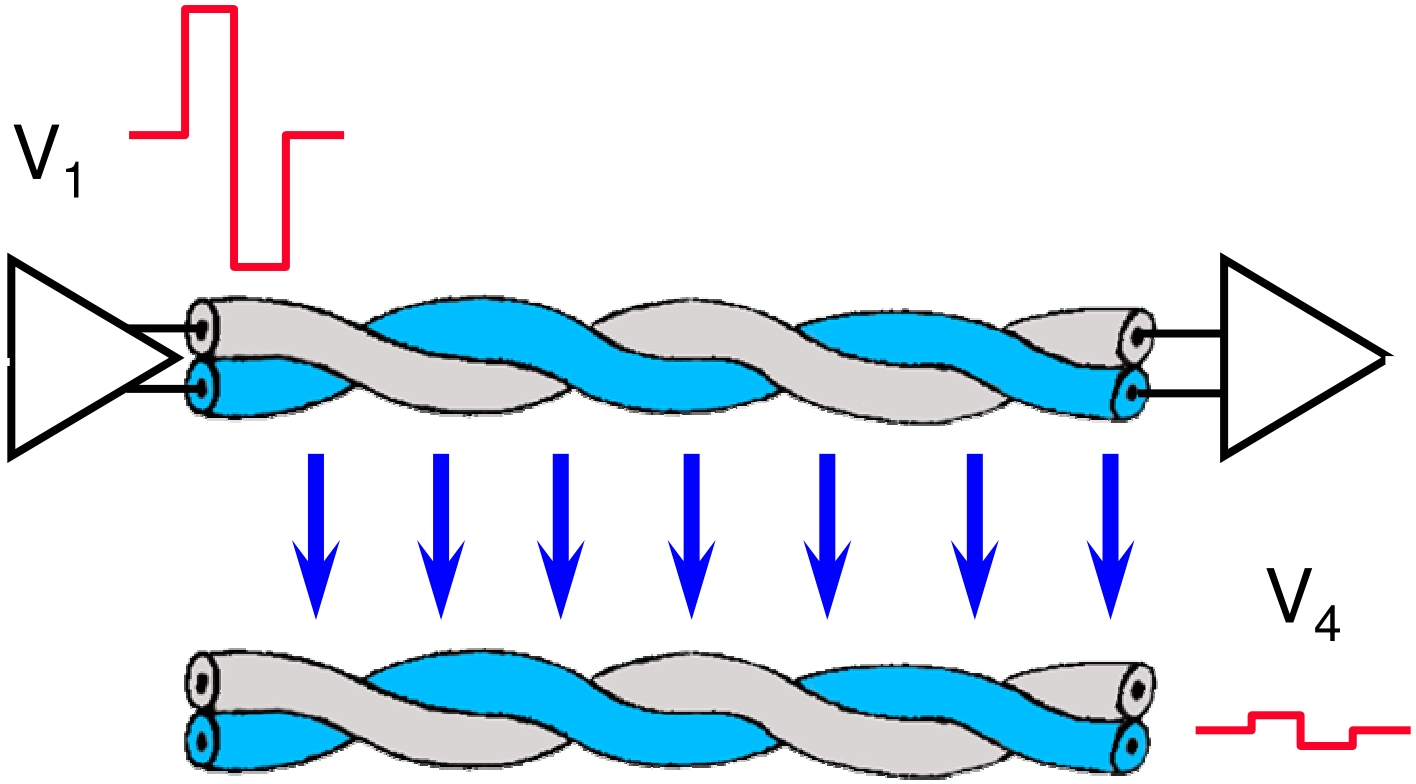
NEXT: Near End Cross-Talk

- The attenuation only makes the NEXT measure significant by the first 20-30 mt of cable
- The measurement is necessary to both ends:
  - dual NEXT



FEXT: Far End Cross-Talk

- Cross-Talk measured at the receiver side

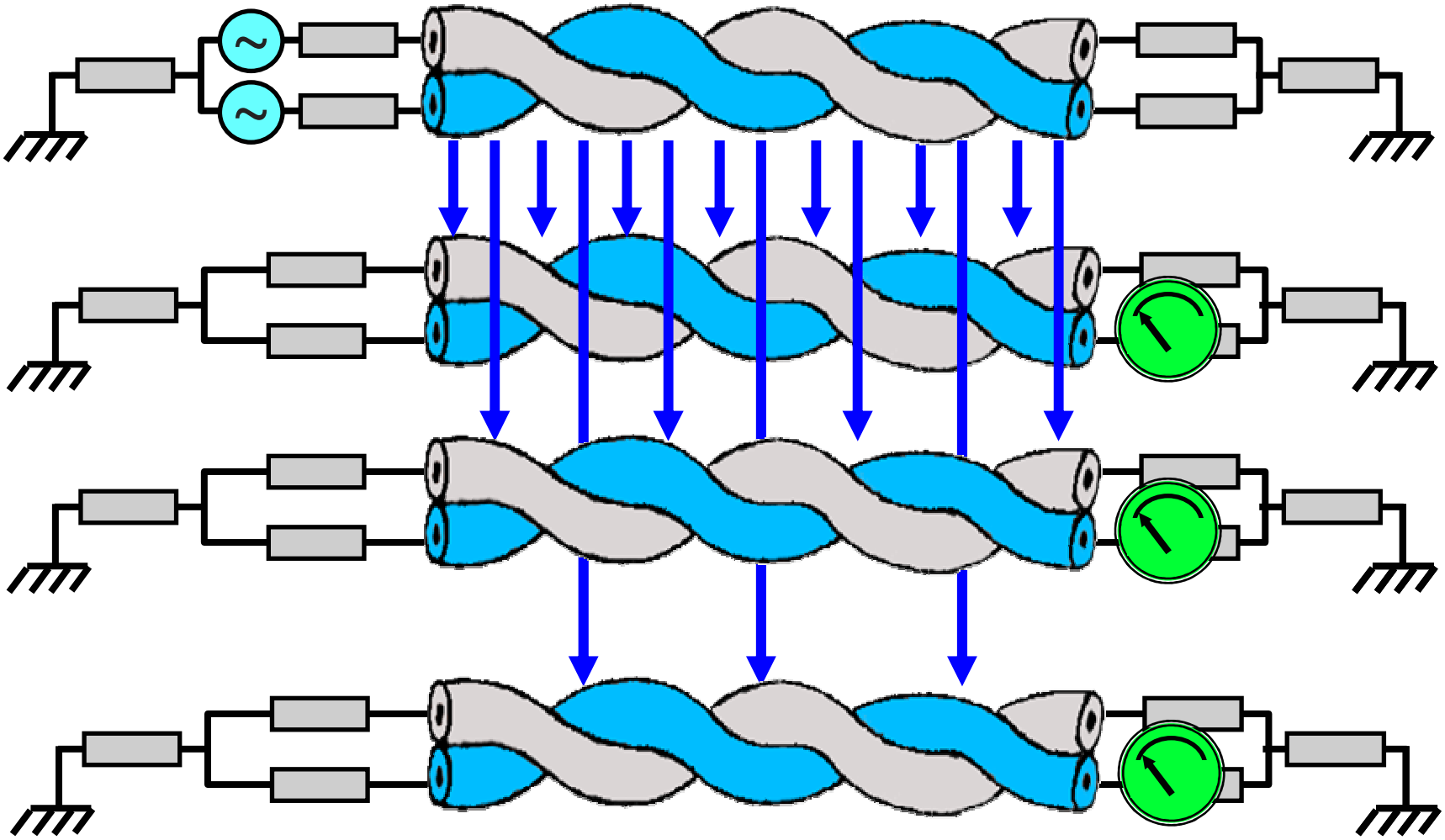


$$FEXT_{dB} = 20 \log_{10} (V_1 / V_4)$$

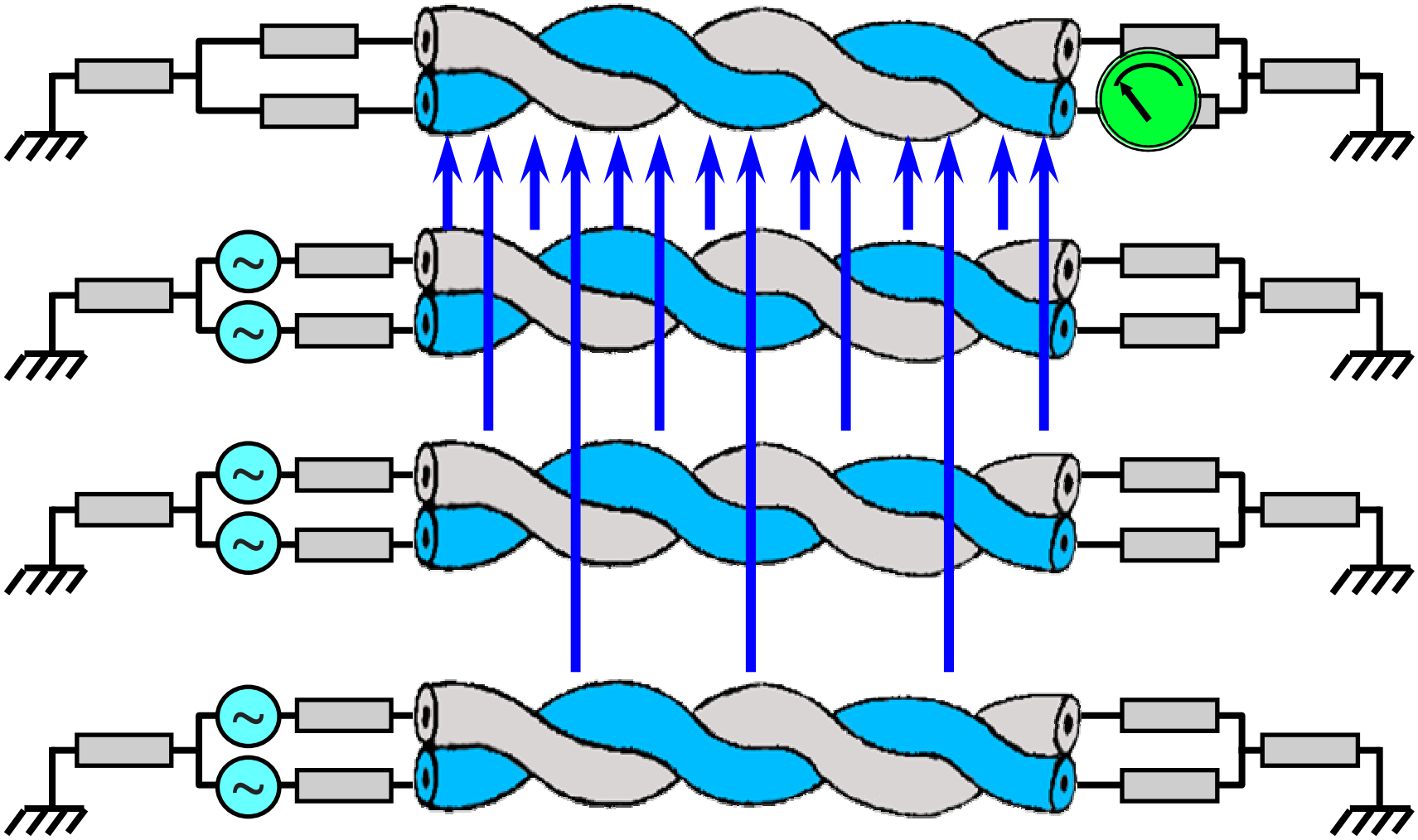
ACR

- ACR (Attenuation to Cross-Talk Ratio)
- Combination of attenuation and NEXT
  - signal to noise ratio
    - noise caused by Cross-Talk
- Required only by ISO and EN normative

ELFEXT: Equal Level FEXT



PSELFEXT (Power Sum ELFEXT)



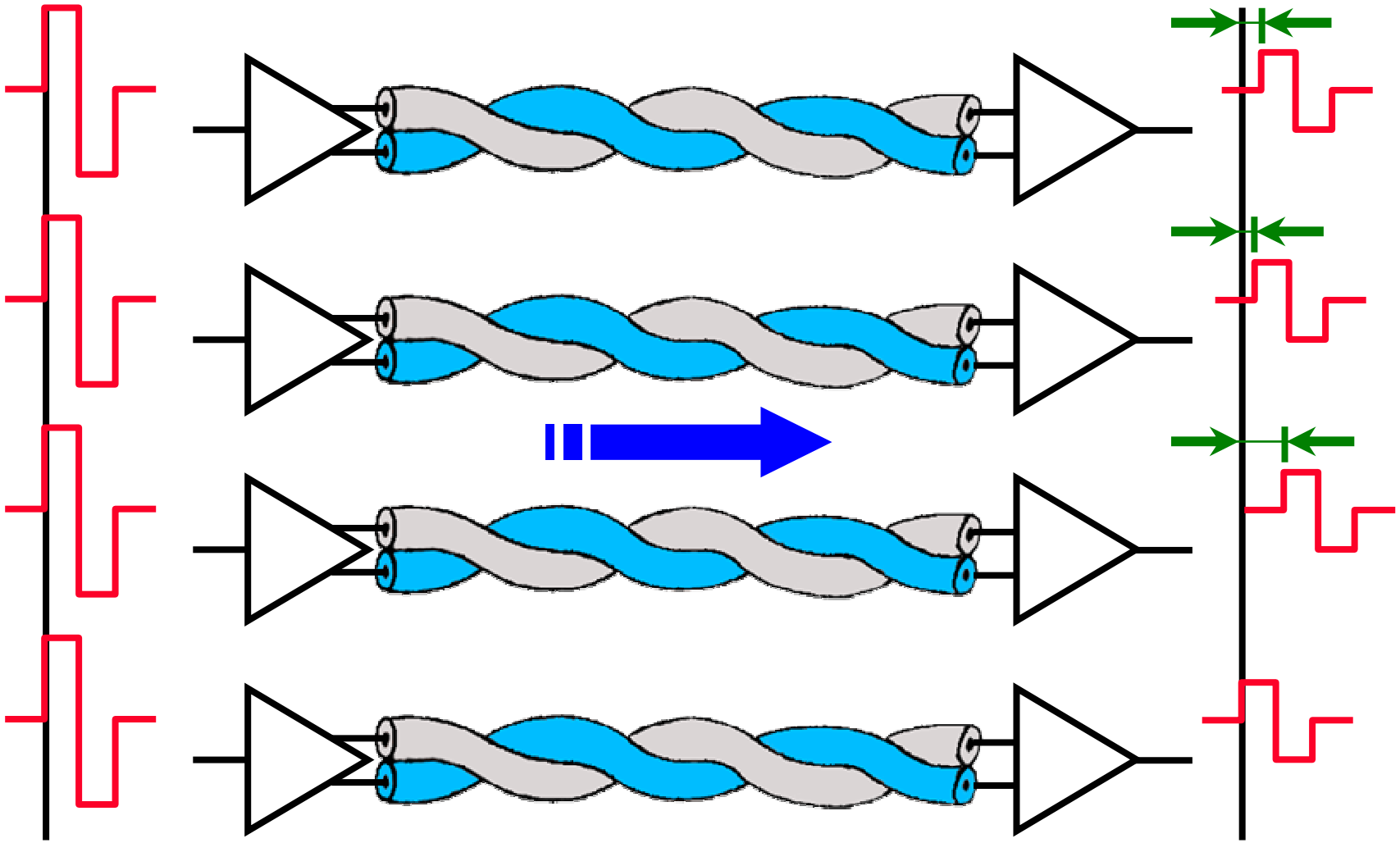
Velocity of propagation (Vp)

- The propagation velocity of the signals on the transmission means is high, but not infinite, so the propagation time is little but not null
- It is necessary to ensure that delays do not exceed certain maximum values to ensure the protocol working

$$V_P \cong 2/3\ c$$

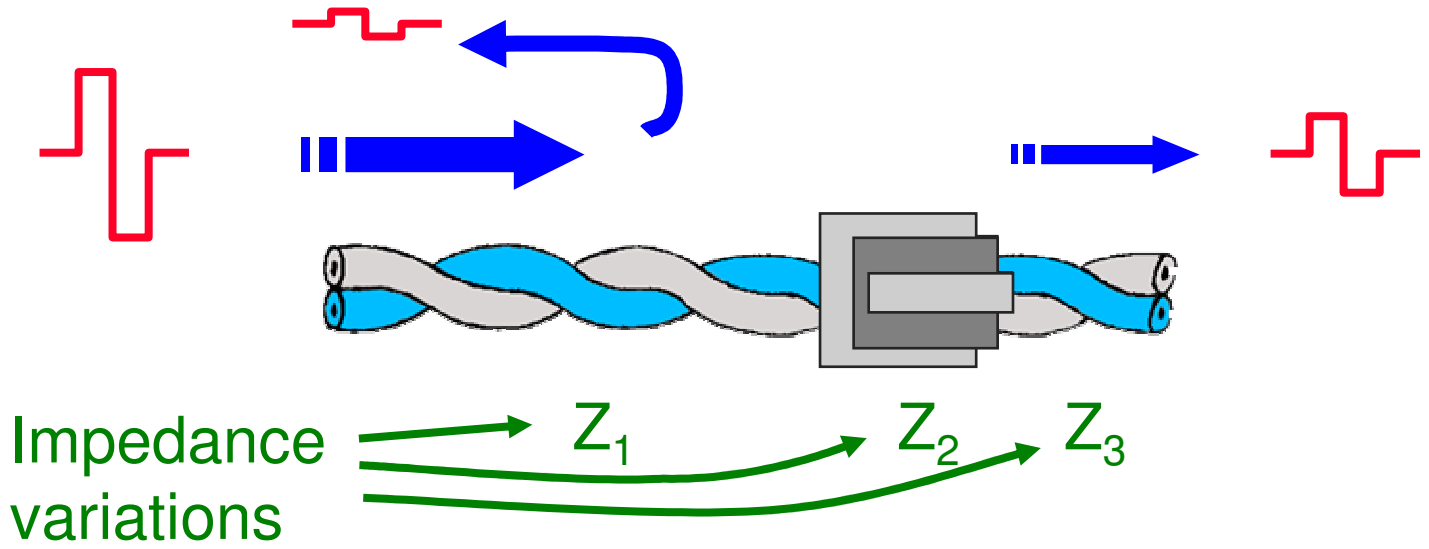
*(**c** is speed of the light in the empty space* $\cong 3 \bullet 10^8$ *m/s)*

Delay skew



Return loss

- Il return loss = reflections measurements



Shielded cable

- The shield presence can involve:
  - bigger immunity to the electromagnetic disturb
  - disturb radio emission reduction
  - bigger constancy of the impedance
  - if applied to single pair reduces the crosstalk
- It is necessary to make a correct screen grounding:

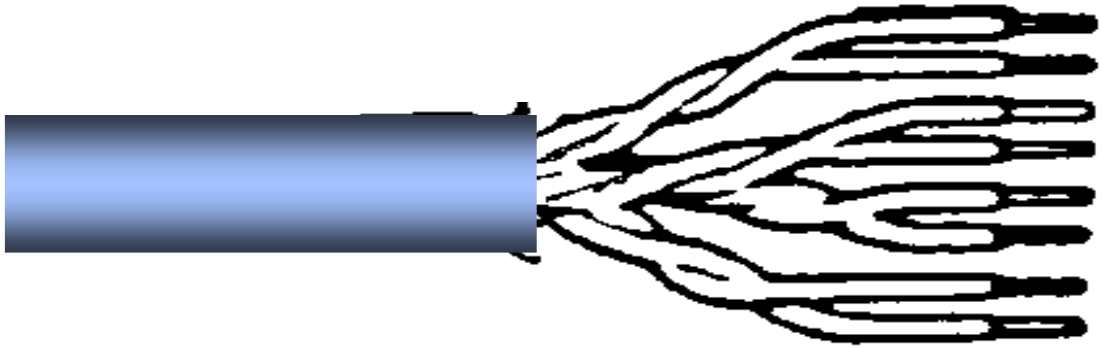
Twisted pair cable

- Constituted by one or more twisted pair of copper conductors
- Used for voice, local nets, structured cabling system
- the electrical characteristic required for LAN are definitely higher than those for voice
- Lower bandwith than the coaxial one
- Reduced costs and simple installation

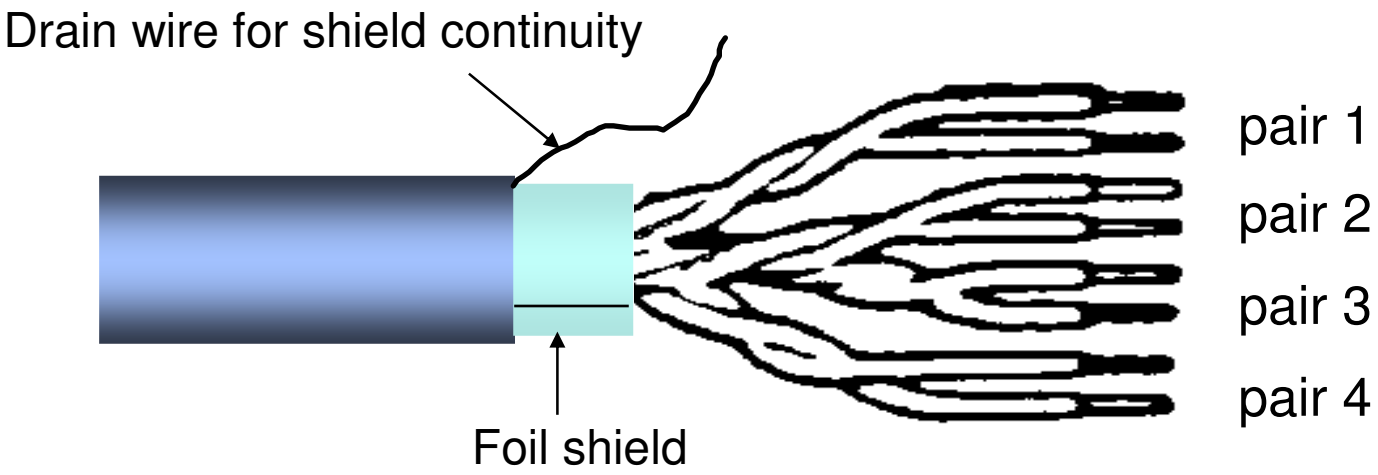
Twisted Pair cable types

- UTP (Unshielded Twisted Pair):
  - (Z = 100 Ω)
- FTP (Foiled Twisted Pair):
  - (Z = 100 Ω)
- S-UTP o S-FTP:
  - (Z = 100 Ω)
- STP (Shielded Twisted Pair):
  - (Z = 150 Ω)

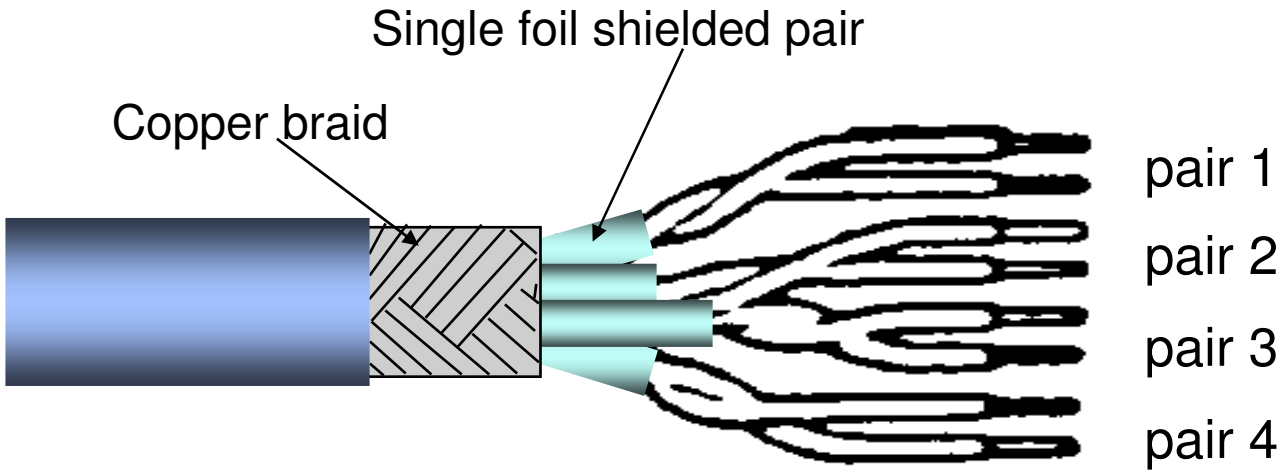
UTP 100 Ω



FTP 100 Ω

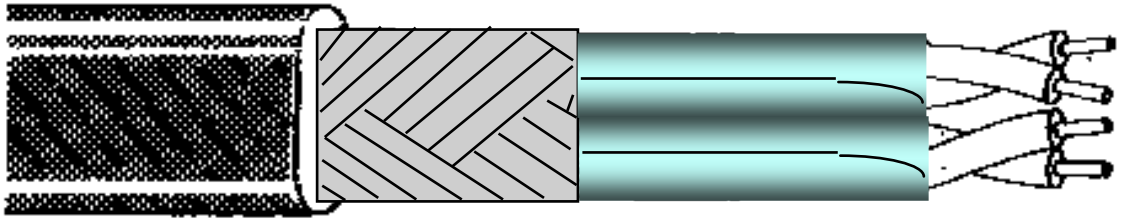


S-UTP or S-FTP 100 Ω



STP 150 Ω

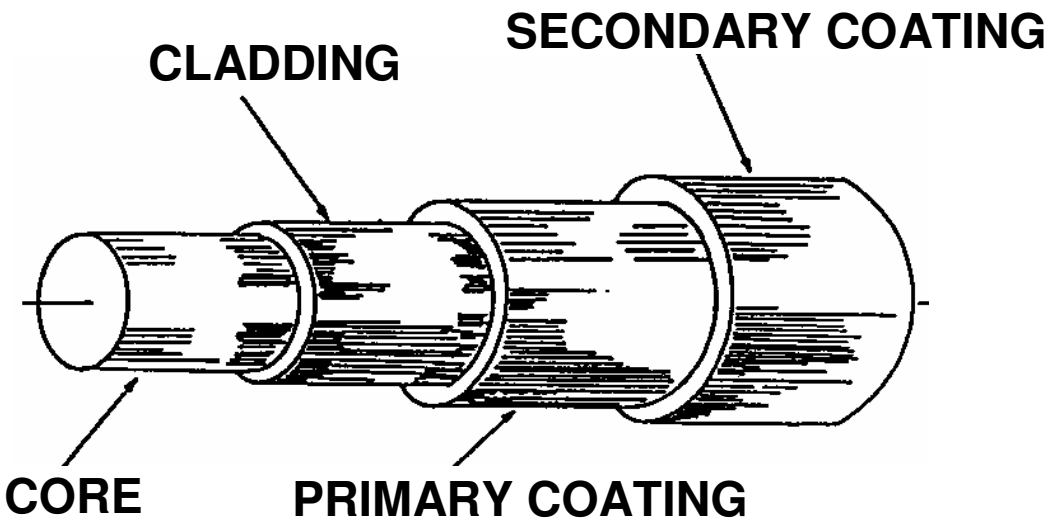
- Know as Type 1 IBM
  - 22 AWG



GLASS FIBER OPTIC

Glass Fiber Optic

- It is a tiny and flexible glass material thread:
  - an internal part called core
  - an outside part called cladding
  - core and cladding have different refraction indexes to border the light inside core

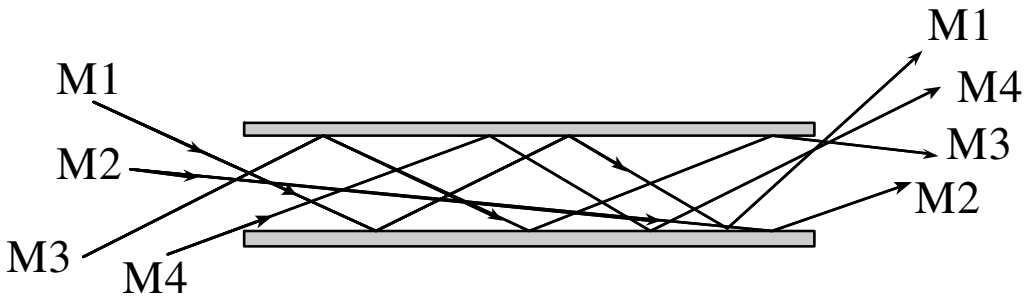


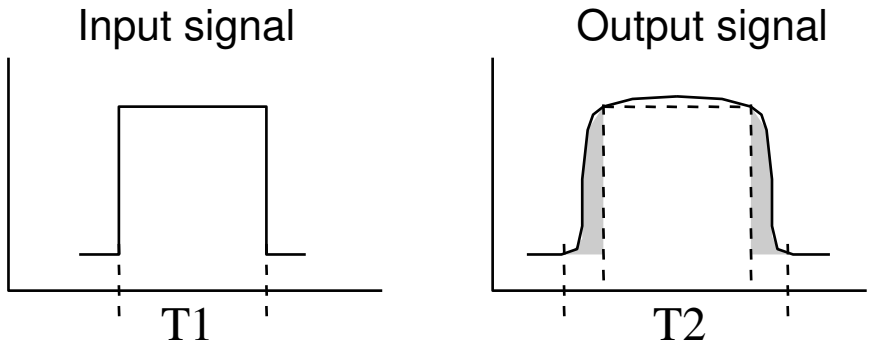
Glass Fiber Optic characteristics

- The optic fibers are just suitable for point point links
- Total immunity to the electromagnetic troubles
  - Characterized by two numbers n/m where:
  - diameter n of the leading internal light part
  - diameter m of the outside part
- Typical values in micron
  - multimode 50/125, 62.5/125, 100/140
  - singlemode 8-10/125

Step-index multimode fiber

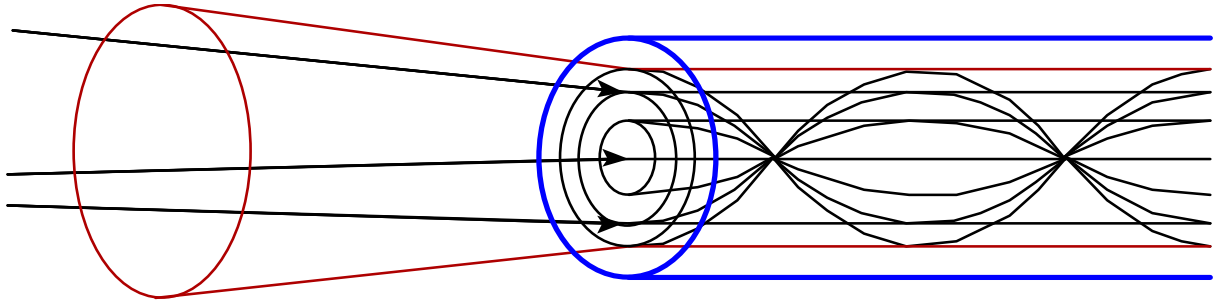
- Characteristics
  - High modal dispersion
  - Low bandwith





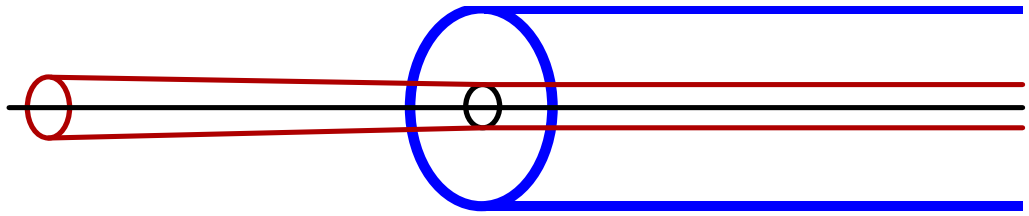
Graded-index multimode fiber

- Graded-index fiber have a bandwith higher than step-index
- work in 1st and 2nd window (850 and 1300 nm)

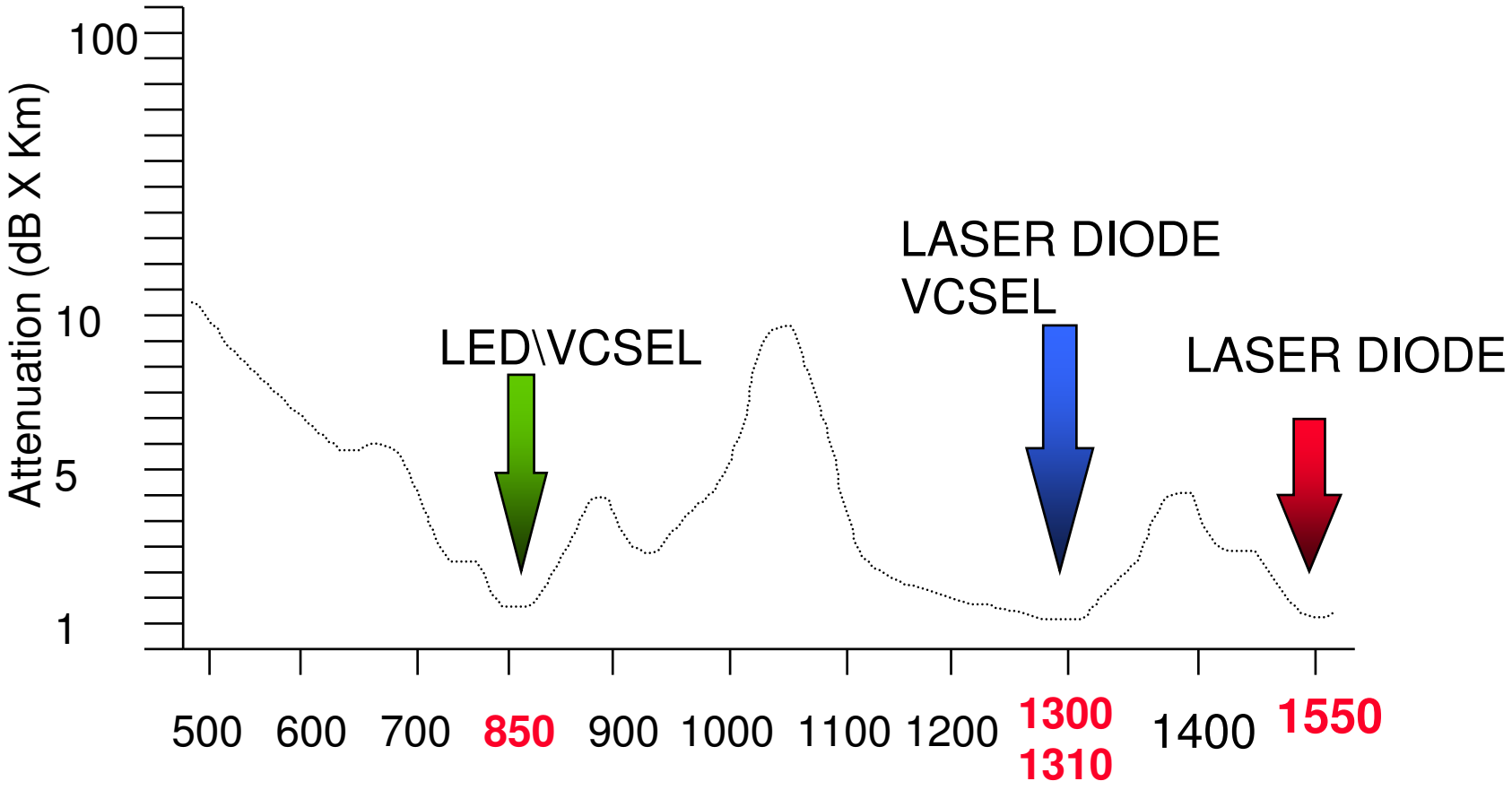


Singlemode fiber

- The fiber behaves like a wave guide admitting a single propagation mode:
  - does not have modal dispersion
  - the bandwith is very high, of the order of hundreds of GHz*Km
  - work in 2nd and 3th window (1300 and 1500 nm)



Wavelenght and optical components

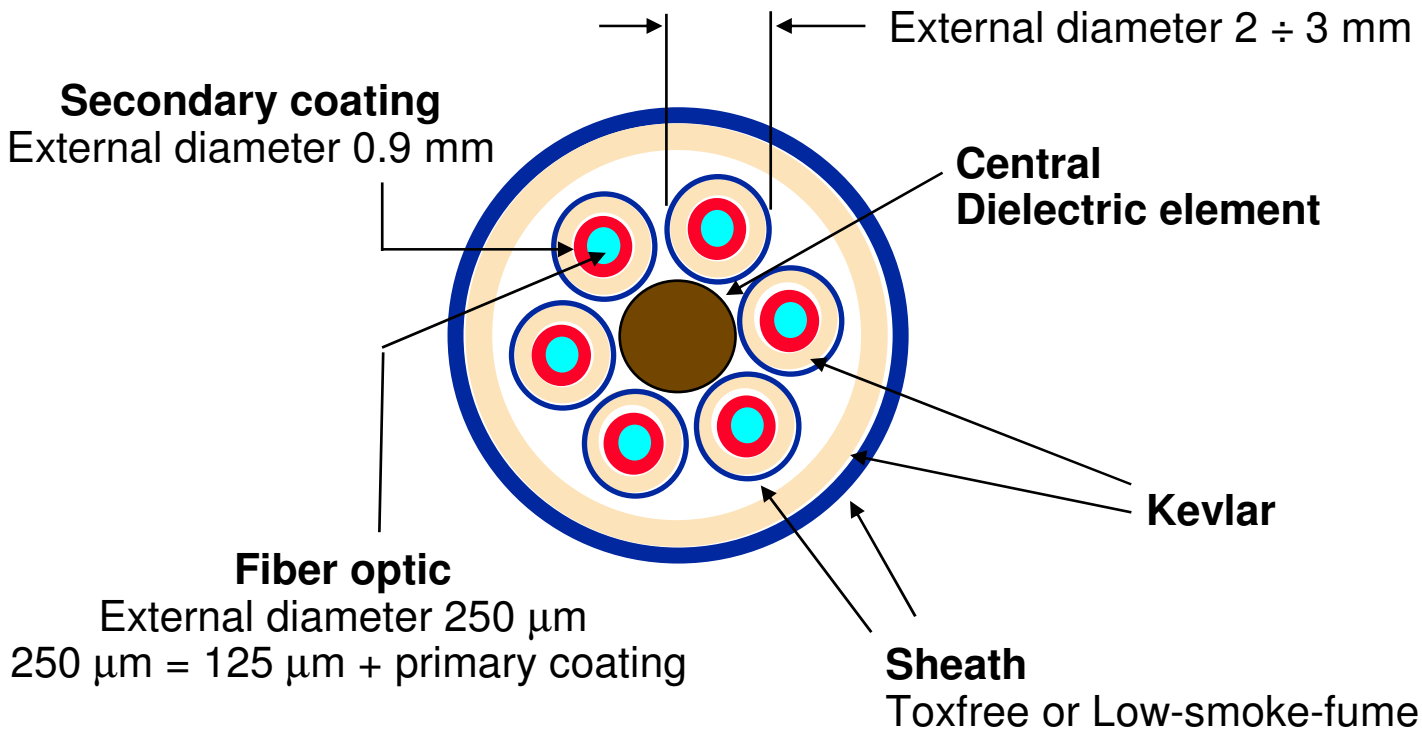


Fiber optic cable types

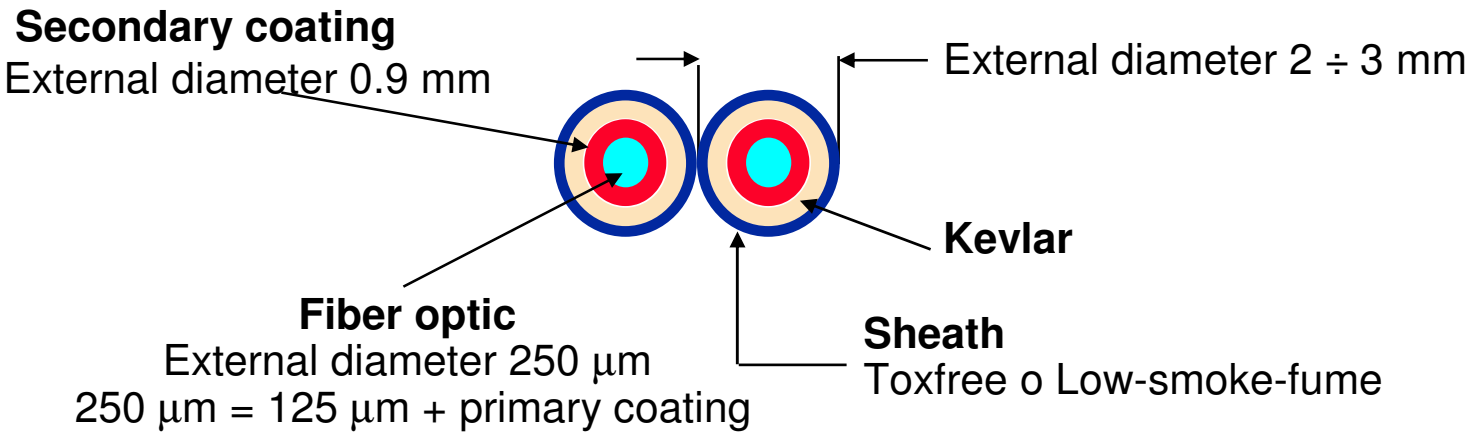
- Tight
  - Break-out
  - dual fiber patch cord
  - Light-duty
- Loose

Break-Out tight fiber optic cable

- Indoor installation

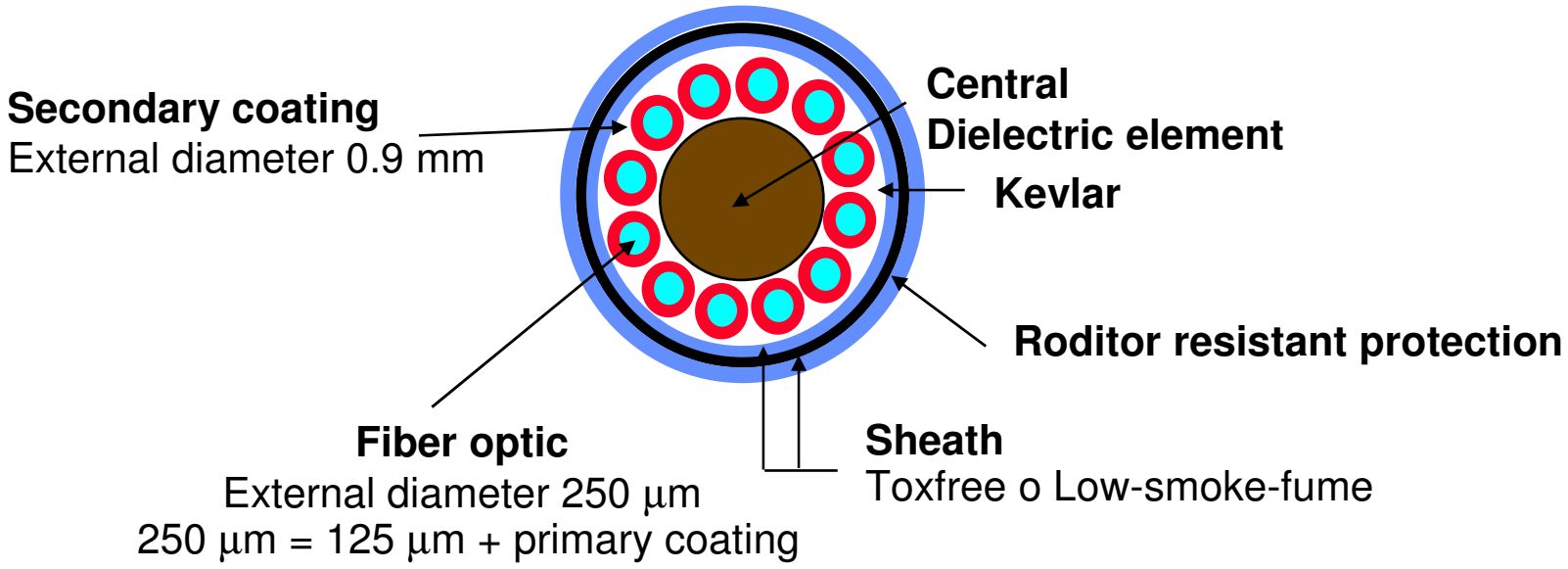


Dual fiber patch cord



Light-duty tight fiber optic cable

- Indoor/Outdoor installation



Loose fiber optic cable

- Outdoor installation