



EL DOFDE
ORGANIZATION

Optical Fiber Sheet Answers (Zatoona)

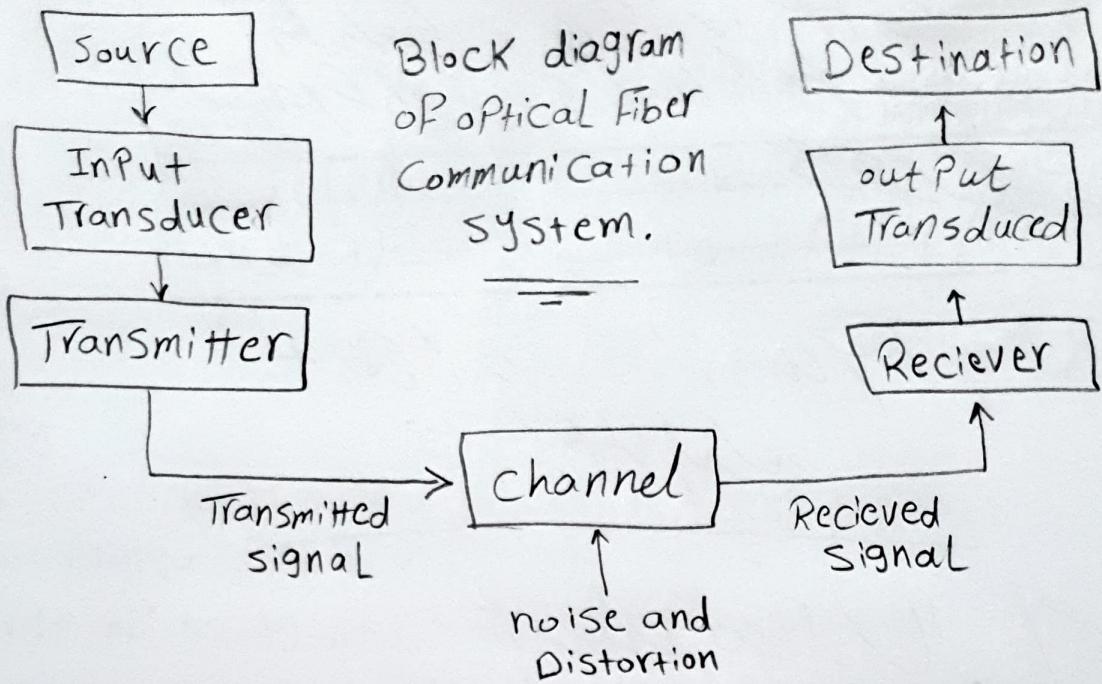
References
Hamed Lecturs

Electromagnetic
Waves 2

No Excellence
Just Pass

optical Fiber sheet

1



The units distinguish optical Fiber system From electrical Communication system

① Electrical to the optical Converter (E/O) :-

it is at the end of transmitter and is called Light Source such as LED or ILD.

② optical to the electrical Converter (o/E) :-

it is at the beginning of the receiver and is called Photo detector (PD) such as avalanche Photodetector.

③ Connector :- it is a loose or demountable joint.

④ SPlice :- Permanent joint

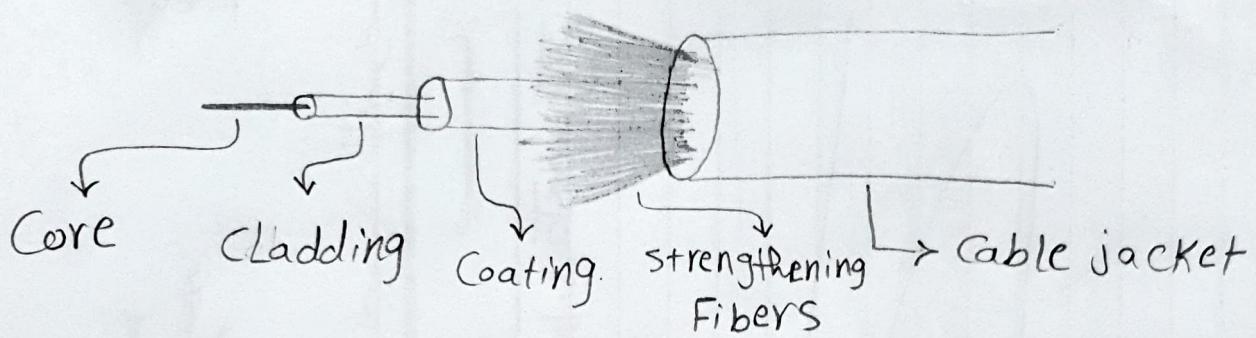
⑤ Splitter or Combiner

⑥ classical repeater

⑦ optical Fiber :- the communication medium.

⑧ optical amplifier.

2 Optical Fiber Structure



① Core:-

- Physical medium that transmits Light signals From transmitter to receiver.
- made of glass whose width is in microns.
- the bigger the Core, the more Light the Cable can convey.

② Cladding:-

expelled over the Core and fills in as the limit that contains the Light waves.

③ Coating:-

- Plastic cover over the Cladding to strengthen the Fiber Core.
- give additional protection against extreme cable curves.

④ Strengthening Fibers:-

helps ensure the core against Pounding Powers and over the top strain during establishment.

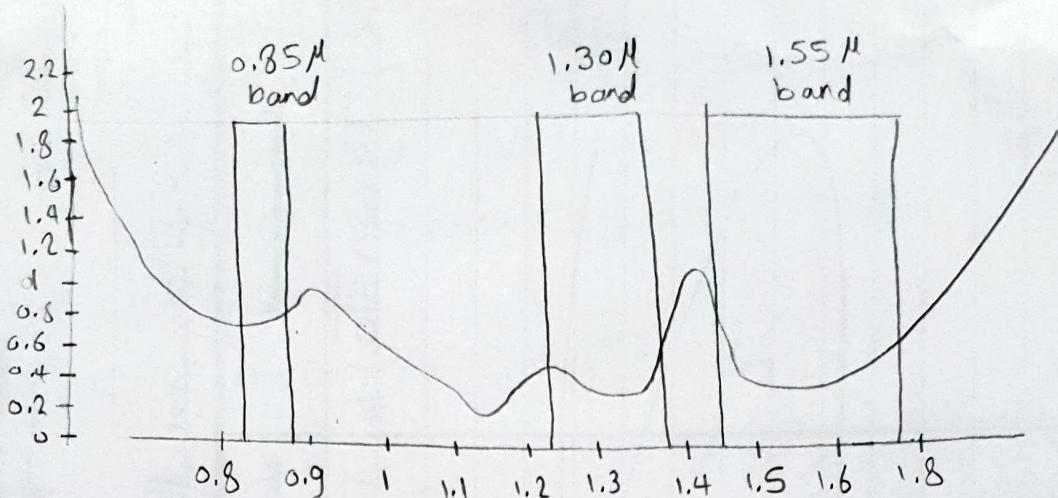
⑤ Jacket:-

outer Layer of the cable, it shields the cable from natural perils.

3

Optical Fiber attenuation curve versus wavelength

3

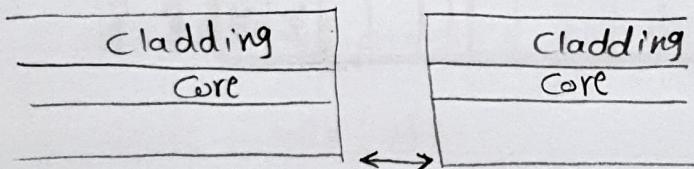


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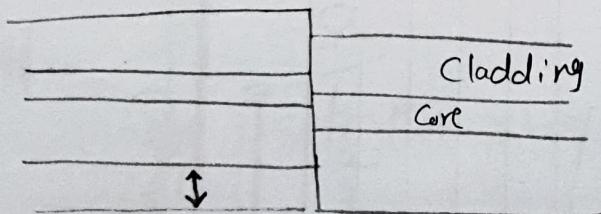
Coupling Losses

A) Extrinsic Coupling Loss

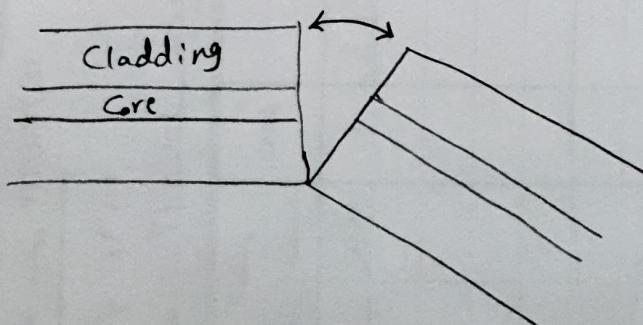
① Longitudinal misalignment Loss



② Lateral misalignment Loss



③ Angular misalignment Loss



(B) Intrinsic Coupling Loss

- ① Core diameter mismatch
- ② Cladding diameter mismatch
- ③ Numerical aperture (NA) mismatch
- ④ Core-cladding concentricity differences
- ⑤ Core ellipticity
- ⑥ Refractive index profile difference

5 Types of Optical Fiber

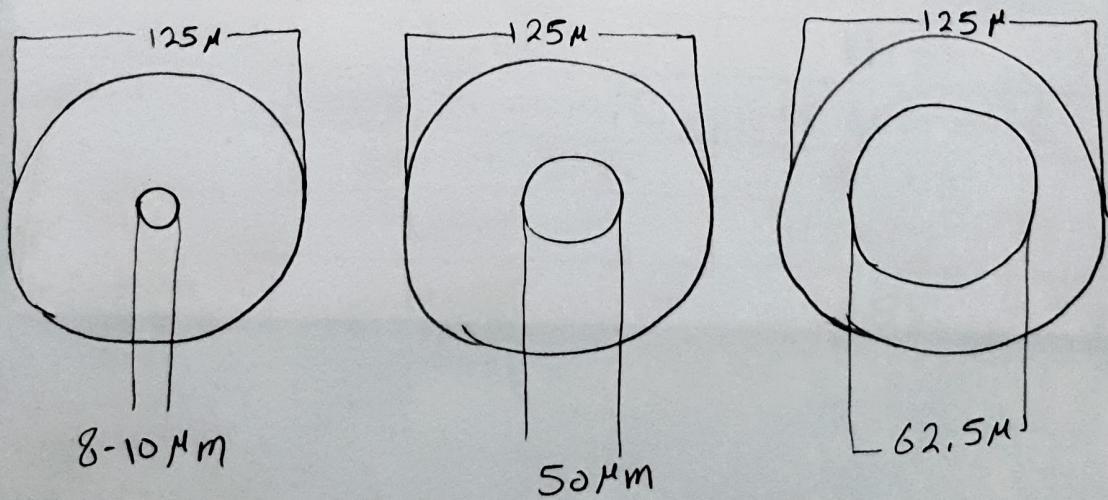
⇒ according to number of supported modes:-

① Single-mode Fiber (SMF):-

it permits only one mode of light to be transmitted per time. it has core diameter of 8 to 10 μm and cladding diameter of 125 μm

② Multi-mode Fiber (MMF) :-

- it can transmit more than one modes per time, it has bigger core from 50 to 62.5 μm and cladding diameter of 125 μm .
- multi-mode used for short distance.



single mode

multi-mode

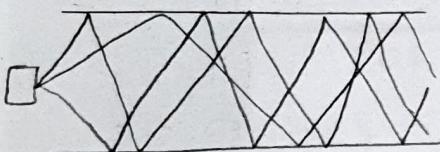
→ according to refractive index profile

① Step Index

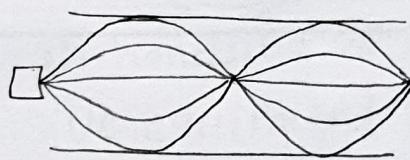
The refractive index is uniform in the cladding and experiences an unexpected change at the cladding limit. Then, becomes uniform in the core.

② Graded-Index

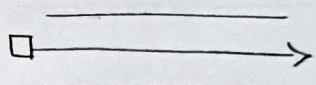
The refractive index is uniform in the cladding and increases until it reaches maximum at the fiber center. Then, it decreases as the radial distance from the fiber axis increases.



multimode
step index



multi mode
Graded index



single mode
step index

6

Comparison between optical fiber as transmission medium and copper based transmission media

P.O.C	optical Fiber	Copper-based
Transmission Loss	Low	High
Economic	more economic	less economic
size	smaller size	Bulky
weight	Light	Heavy
Bandwidth	Huge	Less
Data rate	Higher	Lower
Capacity	Higher	Lower
Feasibility to be stolen	Not feasible to be stolen	Feasible to be stolen
Security	more secure	Not secure

7 advantages of optical Fiber

- ① Low transmission loss and long distance signal transmission.
- ② Light weight and small size
- ③ Large bandwidth
- ④ Signal security
- ⑤ Immunity to electro magnetic interference (EMI)
- ⑥ Cheap raw material
- ⑦ More resistive to environmental extremes

disadvantages of optical Fiber

- ① Needs care when handling or maintained
- ② Requires expensive equipment for interfacing and specialized tools for maintenance and repairing

8 single mode Fiber (SMF)

- ① Only one mode propagates via the core
- ② 8; 10 μm Core diameter / 125 μm Cladding diameter
- ③ Laser diode is used as a photo source
- ④ Used for longer distances
- ⑤ Support higher data rate
- ⑥ Expensive, difficult to maintain

multimode Fiber (MMF)

- ① Many or several modes propagate via the core
- ② 50; 62.5 μm Core diameter / 125 μm Cladding diameter
- ③ Light emitting diode (LED) used as a photo source

- ④ used for shorter distance up to 4KM
- ⑤ support lower data rate
- ⑥ cheap, simple to manufacture

9 Light emitting diode (LED)

used as Photo source in multi mode Fiber (MMF) due to large core diameter.

Laser diode (LD)

used as Photo source in single mode Fiber (SMF) due to small core diameter

11 Numerical aperture (NA)

it is a figure of merit describes the light collecting ability of optical fibers. it is dimensionless.

$$NA = \sqrt{n_1^2 - n_2^2}$$

n₁ :- core refractive index
n₂ :- cladding refractive index

acceptance angle

- it is the maximum angle at which light may enter the fiber in order to get propagated.
- it is the angle between the incident ray and the fiber axis

$$\theta_{\max} = \sin^{-1}(NA)$$

Refractive index (n)

it is the speed of light in vacuum divided by the speed of light in a material

$$n = c/v$$

Fiber attenuation (α_f)

(8)

It is the loss of optical power as a result of absorption, scattering and other loss mechanisms as the light travels through the fiber.

Normalized Frequency (V Parameter)

It is a dimensionless parameter, it determines the number of the modes that can be supported by.

If $V \leq 2.405$, then the fiber is single mode fiber (SMF)

If $V > 2.405$, then the fiber is multi mode fiber (MMF)

12 Step index (SI) single mode fiber (SMF)

advantages :-

- ① Low dispersion and high bandwidth
- ② Low Loss
- ③ High Power Laser source

disadvantages :-

- ① Costly
- ② Difficult to make
- ③ Difficult to couple light

Step index (SI) multimode fiber (MMF)

- ① It has high dispersion
- ② Low Bandwidth ③ Low data rate
- ④ Signal is propagate in zigzag path
- ⑤ Cost lower than graded index

Graded index (GI) multimode fiber (MMF)

- ① has less dispersion ② Low Bandwidth
- ③ Data Rate is high according to step index
- ④ Cost higher than step index
- ⑤ signal will follow predictable path.

Erbium doped Fiber amplifier (EDFA)

(9)

- it is a piece of optical fiber about ten meters of single mode fiber (SMF)
- it amplifies the optical signal directly without need to first convert it to an electrical signal.

SEA-ME-WE series

- it is family of submarine cables
- these cables transfer large volume of data on a global scale.
- they are carry telephone, internet, multimedia and broad band applications

FTTH (Fiber to the Home)

it can offer the highest bandwidth and the highest data rate but on the other hand it is the most expensive.