2.5.1. Mechanism of internal/ external assessment is transparent and the grievance redressal system is time- bound and efficient.

S.No.

VAAGDEVI INSTITUTE OF TECHNOLOGY & SCIENCE

(Affiliated to JNTUA, Anantapur and approved by AICTE, New Delhi)
PEDDASETTI PALLI, PRODDATUR - 516 360. A.P.

INTERNAL EXAMINATION MAIN ANSWER BOOK

Mid Examination I	II	III	I
Name	P. Reshma		
H.T.No.	21L21A0427		
Class & Branch	III ECE - A/s		
Subject	Optical communication		
Sign of Student	P. Reshma		
Sign of invigilator with Date			

Q.No.	a	b	c	Total
1	2	2	6	10
2				
3	2	2	5	9
4				
5				
6	2	2	6	10
Grand Total Marks				29/30

1

a) Critical angle

The maximum angle of incidence for which the light can propagate within the fibre by total internal reflection is called as Critical angle

(or)

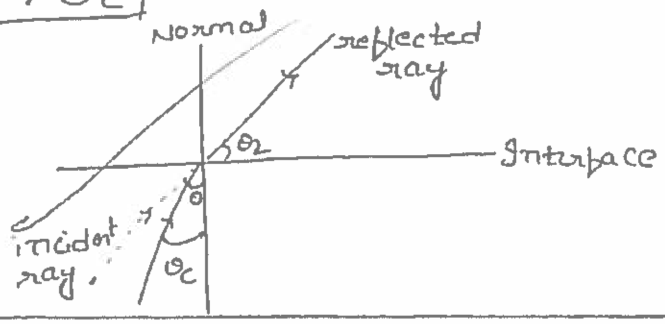
when the angle of refraction is 90, then the refracted ray is parallel to surface btw the two mediums Then the angle of incidence is called as Critical angle

∴ Critical angle $\theta_c = \sin^{-1}\left[\frac{n_2}{n_1}\right]$

1. b) Total internal Reflection

when the angle of incidence is greater than the critical angle then total internal reflection takes place

$\theta > \theta_c$



1.C) Elements in optical fibre transmission line

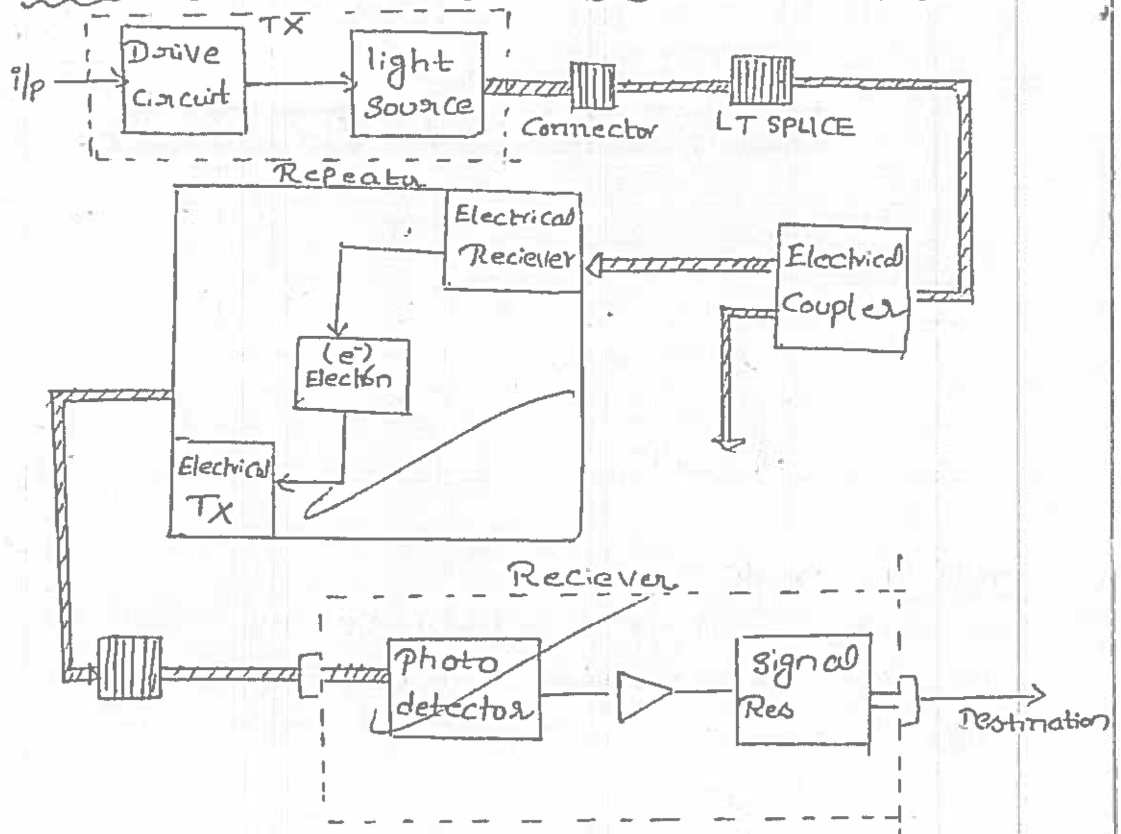


fig: Major elements in optical fibre transmission line.

The major elements of optical fibre transmission line are

1. Transmitter
2. Reciever
3. Repeater
4. Optical fibre cable.

1. Optical fibre cable

→ The cable in optical fibre is most important element in the transmission

→ The optical cables is used as interconnection and system network.

→ The optical fibre are may be electrical and as well as optical signal.

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→ Now-a-days coaxial cables are not used in transmission.

2. Transmitter

* The input is given to the transmission line
* The output is obtained by drive circuit by varying the light source
* The electrical signal may be converted into optical signal

→ The mostly used transmitters in optical fibres are LED's and laser diodes

3. Repeater

* The optical signal is converted into electrical signal which given to electrical recievers
* Then it changes the shape of attenuated and distored signal and given to transmitter
* The electrical signal is converted into optical signal back.
* The connectors and splice is used to connect the fibres for long distance communication

4. ~~Tra~~ Reciever

→ At reciever the photo diode and signal restorer is used.

→ The photo detector detects the signal and reshape then it convert optical signal into electrical signal.

→ The mostly used photo detectors are PIN and ADP'S

~~Refractive Index~~

~~Refractive Index can be def~~

Advantages of optical fibre transmission line

1. Potential low cost
2. Small size
3. Electrically isolation
4. wide bandwidth
5. more stronger.

3

a) Refractive Index

Refractive Index can be define as the ratio between the speed of light in vaccum and speed of light in medium

∴ Refractive Index $n = \frac{c}{v}$

Where, $c = 3 \times 10^8$ m/s

The Refractive index of air is 1

The Refractive index of glass is 1.5

3.

b) Acceptance angle

The maximum angle occur when the signal is propagated in medium is called as "Acceptance angle"

$$\therefore \text{Acceptance angle} = \sin^{-1}\left(\sqrt{n_1^2 - n_2^2}\right)$$

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

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3

c) Given data

Refractive index of core $n_1 = 1.50$

Refractive index of cladding $n_2 = 1.47$

Formulae

→ Critical angle $\theta_c = \sin^{-1}\left[\frac{n_2}{n_1}\right]$

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

→ Acceptance angle $AA = \sin^{-1}\sqrt{n_1^2 - n_2^2}$

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

To find

(i) Critical angle = ?

(ii) Numerical Aperture = ?

(iii) Acceptance angle = ?

Solution

(i) Critical Angle

$\theta_c = \sin^{-1}\left[\frac{n_2}{n_1}\right]$

$= \sin^{-1}\left[\frac{1.47}{1.50}\right]$

$\boxed{\theta_c = 78.52^\circ}$

(ii) Numerical aperture

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

$= \sqrt{(1.5)^2 - (1.47)^2}$

$= \sqrt{2.25 - 2.1601}$

$\boxed{NA = 0.298}$ $\approx$ $\boxed{NA = 0.3}$

(iii) Acceptance Angle

$$AA = \sin^{-1}\left[\sqrt{n_1^2 - n_2^2}\right]$$

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

$$= \sin^{-1}(0.3)$$

$$\boxed{AA = 17.45}$$

Result

(i) Critical Angle $\theta_c = 78.52°$

(ii) Numerical Aperture $NA = 0.3$

(iii) Acceptance Angle $AA = 17.45$ //

6

a) Wave guide dispersion

→ Wave guide dispersion is a Intramodel dispersion

→ Wave guide dispersion can effect on the finite spectral width.

→ It can caused by Inhomogenities present in the fibre

6 b) Polarization mode dispersion

Polarization mode dispersion defined as dispersion "When the electric signal is propagated through a medium

When the signal is propagating in the medium there are two types of orthogonal polarization mode dispersion.

1. Vertical polarization mode dispersion
2. Horizontal Polarization mode dispersion.

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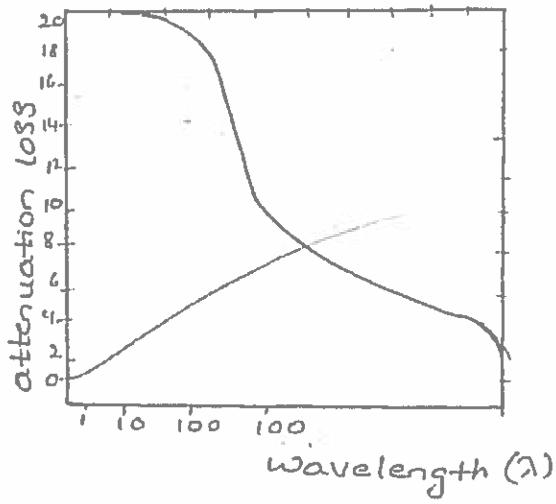
6.c) Material dispersion

The material dispersion can be caused by impurities present in the fibre

-> The material dispersion can effects on the single mode wave guide and laser system

-> The output spectrum of the ~~dis~~ laser system is greater than the dispersion.



The attenuation is a inversely proportional to the wavelength

-> The attenuation can be defined as the power decreases exponentially when there is a increase in distance.

-> The analysis of material dispersion is given below.

Analysis of material dispersion

we know that the constant β is given by,

$$\boxed{\beta = \frac{2\pi n}{\lambda}} \quad \text{——— (1)}$$

Differentiating eq(1) w.r.t λ

$$\frac{d\beta}{d\lambda} = 2\pi\left[-\frac{n}{\lambda^2} + \frac{1}{\lambda}\frac{dn}{d\lambda}\right]$$

$$\frac{d\beta}{d\lambda} = 2\pi\left[\frac{-n}{\lambda^2} + \frac{\lambda}{\lambda^2}\frac{dn}{d\lambda}\right]$$

Multiply and Dividing with λ in abov eq. ie,

$$\frac{d\beta}{d\lambda} = 2\pi\left[\frac{-n}{\lambda^2} + \frac{\lambda}{\lambda^2}\frac{dn}{d\lambda}\right]$$

$$= \frac{2\pi}{\lambda^2}\left[-n + \lambda\frac{dn}{d\lambda}\right] \qquad \left(\because N = n - \lambda\frac{dn}{d\lambda}\right)$$

$$\boxed{\frac{d\beta}{d\lambda} = -\frac{2\pi}{\lambda^2}\left[-\lambda\frac{dn}{d\lambda} + n\right]} \quad \text{——— (2)}$$

w.k.T group Velocity,

$$V_g = \left[\frac{d\beta}{d\omega}\right]^{-1} \quad \text{——— (3)}$$

Multiply and divide $d\lambda$ to eq (3)

$$V_g = \left[\frac{d\beta}{d\omega}\,\frac{d\lambda}{d\lambda}\right]^{-1}$$

$$\boxed{V_g = \left(\frac{d\beta}{d\lambda}\,\frac{d\lambda}{d\omega}\right)^{-1}} \quad \text{——— (4)}$$

w.k.T. $\omega = 2\pi f$

$$\omega = 2\pi\frac{c}{\lambda} \quad \text{——— (5)}$$

Differentiat eq (5) w.r.t λ

$$\frac{d\omega}{d\lambda} = \frac{-2\pi c}{\lambda^2}$$

$$\Rightarrow \boxed{\frac{d\lambda}{d\omega} = \frac{-\lambda^2}{2\pi c}} \quad \text{——— (6)}$$

sub eq ② and ⑥ in eq ④

eq ④ $\Rightarrow v_g = \left[\frac{d\beta}{d\lambda} \cdot \frac{d\lambda}{d\omega}\right]^{-1}$

$$= \left[-\frac{2\pi}{\lambda^2}N \cdot \frac{-\lambda^2}{2\pi c}\right]^{-1}$$

$$= \left[\frac{-N}{-c}\right]^{-1}$$

$$\boxed{V_g = \left[\frac{-c}{N}\right]^{-1}} \Rightarrow \boxed{V_g = \frac{N}{c}}$$

Now, material dispersion,

$$T_{mat} = L \cdot V_g = L \cdot \frac{N}{c}$$

$$\boxed{T_{mat} = \frac{LN}{c}}$$

Now, $N = n - \lambda \frac{dn}{d\lambda}$

$$\therefore \boxed{T_{mat} = \frac{L}{c}\left(n - \lambda \frac{dn}{d\lambda}\right)}$$

Hall ticket number: 21L21A0427

10/10

P. Reshma

Sri Sri Sri Mookambika Educational Society's
VAAGDEVI INSTITUTE OF TECHNOLOGY & SCIENCE
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(Approved by A.I.C.T.E., New Delhi, Affiliated to JNTUA, Anantapuramu)

I Mid Examination [Objective Paper]

Year / Semester	:	III/II	Branch / Section	:	ECE/A&B
Course code / Title	:	(20A04604c) /OPTICAL COMMUNICATIONS	Date/Session	:	14/03/2024(FN)
Total Marks	:	10	Duration	:	20Mins

Answer all the questions (20 X 0.5 marks = 10 Marks)

Q. No.	Question				Answer Choice	CO
1.	Optical fiber works on the principle of ---------				C	CO1
	A .Interference	B. Diffraction	C. Total internal reflection	D. Total internal refraction		
2.	For total internal reflection, the angle of incident is greater than				C	CO1
	A. Angle of reflection	B. Angle of refraction	C. Critical angle	D. All		
3.	If the refractive index for core is N1 and refractive index for cladding is N2 then				A	CO1
	A. n1>n2	B. n1<n2	C. n1=n2	D. n1 not equal to n2		
4.	The maximum angle of incidence for which the light can propagate within the fiber by total internal reflection is called as				B	CO1
	A. Acceptance Angle	B. Critical angle	C. Angle of Refraction	D. None		
5.	The light gathering capability is called as				D	CO1
	A. Acceptance angle	B. Critical angle	C. Fractional refractive angle	D. Numerical Aperture		
6.	Multimode step index fiber has				B	CO1
	A. Large core diameter & large numerical aperture	B.Large core diameter and small numerical aperture	C.Small core diameter and large numerical aperture	D. Small core diameter & small numerical aperture		
7.	The performance characteristics of multimode graded index fibers are				A	CO1
	A. Better than multimode step index fibers.	B. Same as multimode step index fibers.	C. Lesser than multimode step index fibers	D. Negligible		
8.	The fibers mostly not used now a days for optical fiber communication system are				C	CO1
	A. Single mode fibers	B. Multimode step fibers	C. Coaxial cables	D. Multimode graded index fibers		
9.	In single mode fibers, the most beneficial index profile is				B	CO1
	A. step index	B. Graded index	C. Step &Graded index	D. Coaxial Cable		
10.	Which type of fibers is used in short distance communication?				B	CO1
	A. Glass fibers	B .Plastic fibers	C .Polymer clad silica fibers	D. None of these		
11.	Intermodal dispersion occurring in a large amount in multimode step index fiber results in				C	CO2
	A. Propagation of the fiber	B. Propagating through the fiber	C. Pulse broadening at output	D. Attenuation of waves		
12.	What does ISI stands for in optical fiber communication?				C	CO2
	A. Invisible size interference	B. Infrared size interference	C. Inter-symbol interference	D. Inter-shape interference		
13.	In waveguide dispersion, refractive index is independent of				A	CO2
	A. Bit rate	B. Index difference.	C. Velocity of medium	D. Wavelength		
14.	Which of the following statements best explain the concept of material absorption?				A	CO2
	A loss mechanism related to the material composition and fabrication of fiber.	B. transmission loss for optical fibers.	C. Results in attenuation of transmitted light.	D. Causes of transfer of optical power		
15.	Absorption losses due to atomic defects mainly include-				B	CO2
	A. Radiation	B. Missing molecules, oxygen defects in glass	C. Impurities in fiber material	D. Interaction with other components of core		

16.	The effects of intrinsic absorption can be minimized by-				C	CO2
	A. Ionizatio	B. Radiation	C. Suitable choice of core and cladding components	D.Melting		
17.	Rayleigh scattering and Mie scattering are the types of				A	CO2
	A. Linear scattering losses	B. Non-linear scattering losses	C. Fiber bend loss	D. Splicing losses		
18.	Mie scattering has in-homogeneities mainly in				C	CO2
	A. Forward direction	B. Backward direction	C. All direction	D. Core-cladding interface		
19.	What is dispersion in optical fiber communication				B	CO2
	A. Compression of light pulses	B. Broadening of transmitted light pulses along the channel	C. Overlapping of light pulses on compression	D. Absorption of light pulses		
20.	What is pulse dispersion per unit length if for a graded index fiber, 0.1us pulse broadening is seen over a distance of 13 km?				D	CO2
	A. 6.12ns/km	B. 7.69ns/km	C. 10.29ns/km	D. 8.23ns/km		

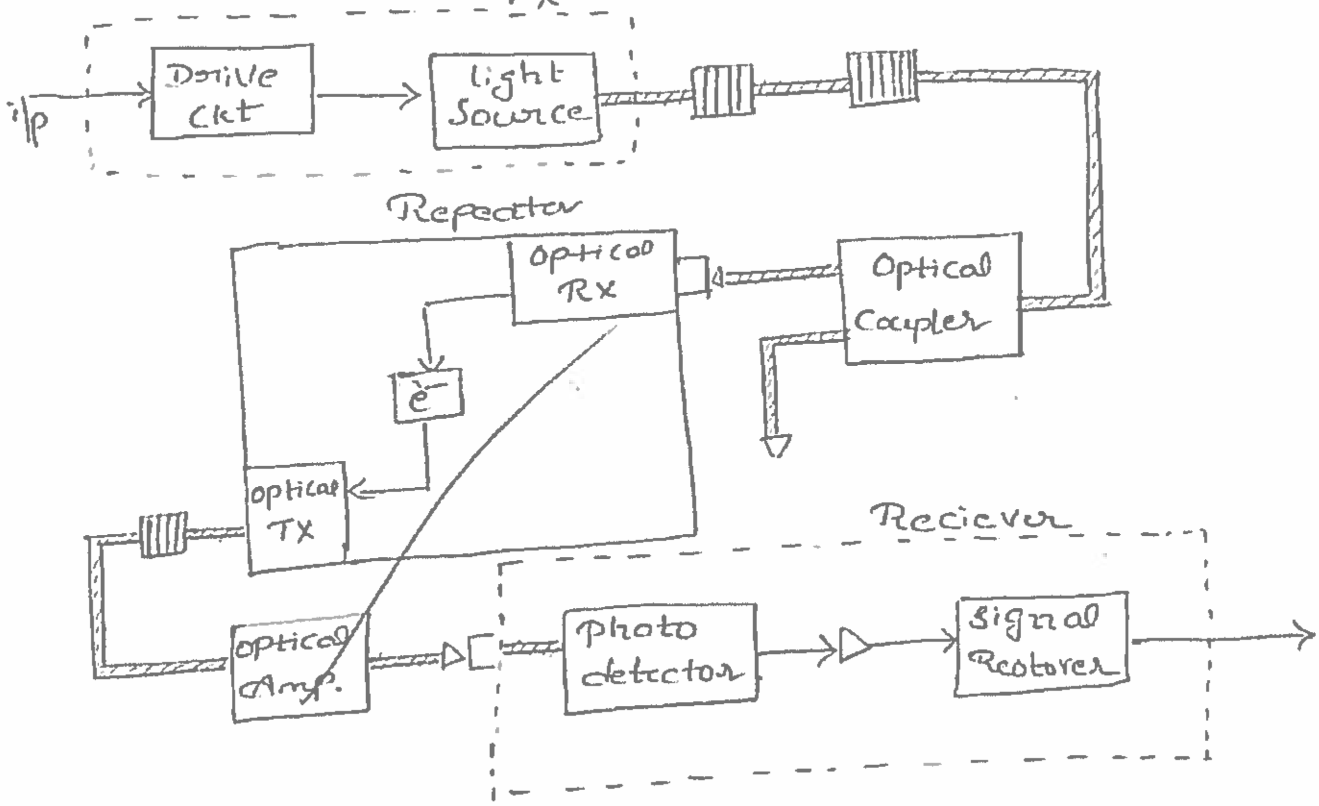
B. Priyanka/ Asst Professor/ ECE

Name : P. Reshma
Roll No. : 21L21A0427
Class & Branch : III ECE-A1s
Subject : Optical Communication

Assignment - 1.

1) With neat sketch, Explain the elements of an optical transmission line.

Major elements in an optical transmission line



1. Cabled optical fibre
1. It is one of the most important element in an optical fibre link
2. It is used to protecting glass fibre during installation and services. the cable may contain copper wire for power repeaters.
3. The installation of optical fibre cables can be either aerial, buried directly ground or under c.
4. The individual cable length ranges from several 100mts to several km

Transmitter

1. The electric input signal to the transmitter can be either analog or digital signals.
2. The transmitter circuity converts electrical signal to an optical signal by vary current flow through light source.
3 LED & laser diodes are suitable for transmitter sources for this purpose

Reciever

1. After optical signal btw launched into fibre, it will become attenuated and distorted with increasing the distance.
2. The photodetector convert recieved optical power directly into an electric current o/p PIN and APD's are photo detector used in fibre optical link.

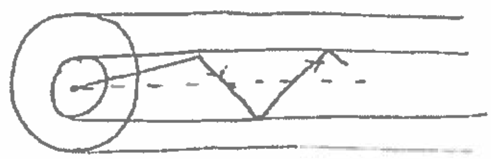
Repeater

1. An optical Repeater consists of a reciever and transmitter placed back to back.
2. The reciever section detect optical signal and convert it into electric signal, which is amplified, reshaped and sent to electric input of Tx section
3. The transmitter section convert this electrical signal back to an optical signal and sent it down the optical fibre wave guide.

(2) Write in brief about the optical fibre modes & configuration?

Optical fibre Modes

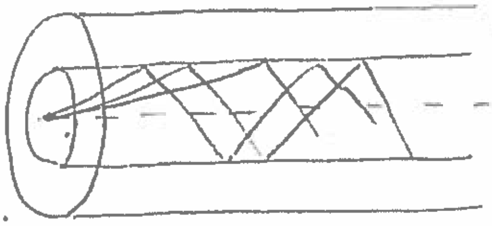
1. Single mode fibres



→ only one path for light propagation through fibre
→ It has high Bandwidth ie, 1000MHz
→ It has large information carrying capacity
→ The fabrication is difficult and costly

→ V number < 2.405
→ No intermodel dispersion

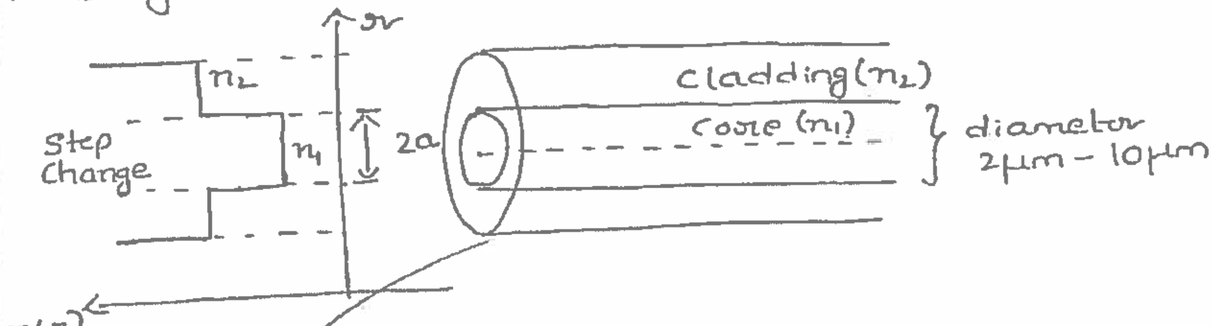
Multimode fibres



→ It has multiple paths to propagate the light inside the fibre
→ It has low Bandwidth i.e 50MHz
→ Larger core diameter
→ Fabrication is easy
→ V Number > 2.405
→ The intermodel dispersion in high

Optical configuration

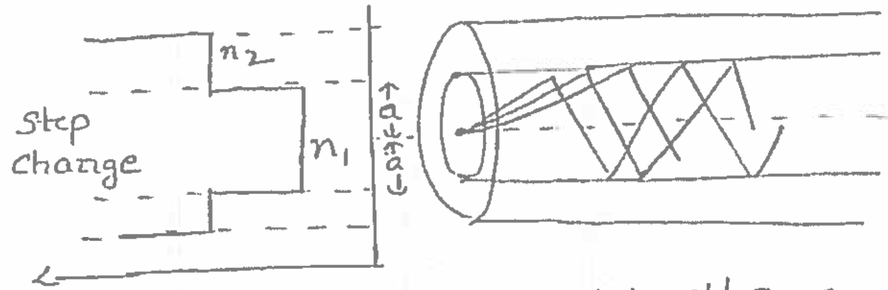
1. Single mode step index



→ In the single mode step index fibre which allow the propagation of only one mode typically HE_{11} mode and hence the core diameter must be order of 1-10μm
→ light rays propagate in only one path without any intermodel discussion in SMSIF
→ If we are having multiple path then each wave can be recieved at the end is different times

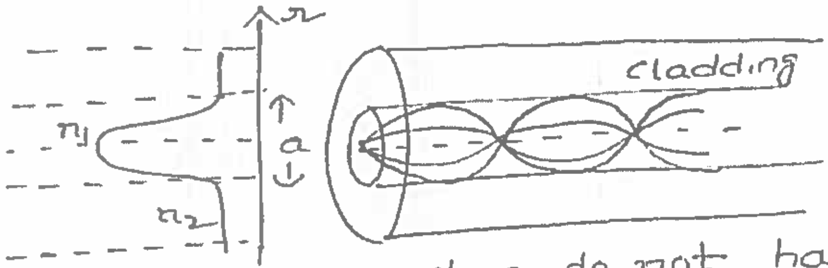
2. Multimode step index fibre

→ In multimode fibres the core diameter is larger than single mode fibres i.e 50-200 μm
→ The larger aperture area allow more light or many modes to enter the cable



→ The light ray propagated in the core in zigzag manner using the total internal reflection principle
→ It has radius of core is 'a'

3. Multimode Graded index fibre



The graded index fibre do not have constant refractive index in the core, but decreasing the core index profile n(r) with radial distance from a max. value of n_1 at the axis to a constant value n_2 beyond core radius 'a' in the cladding

$$n(r) = \begin{cases} n_1\left[1-2\Delta\left(\frac{r}{a}\right)^{\alpha}\right]^{1/2} & ; r<a \\ n_1(1-2\Delta)^{1/2} - n_2 & ; r \geq a \end{cases}$$

Δ = RRID and α = Profile parameter.

(3) Listout different type of attenuation losses.

Attenuation

It represent reduction in amplitude of signal.
It is also called as transmission loss and it represent the reduction in intensity of light propagating through it.
→ It is measured w.r.t distance travelled by light rays in optical cable
→ Attenuation is usually expressed in dB
→ Attenuation loss α_L (dB) is calculated by,

$$\boxed{\alpha_L = 10 \log\left[\frac{P_{in}}{P_{out}}\right]} \text{ dB}$$

where α_L = attenuation loss in dB

P_{in} = input power

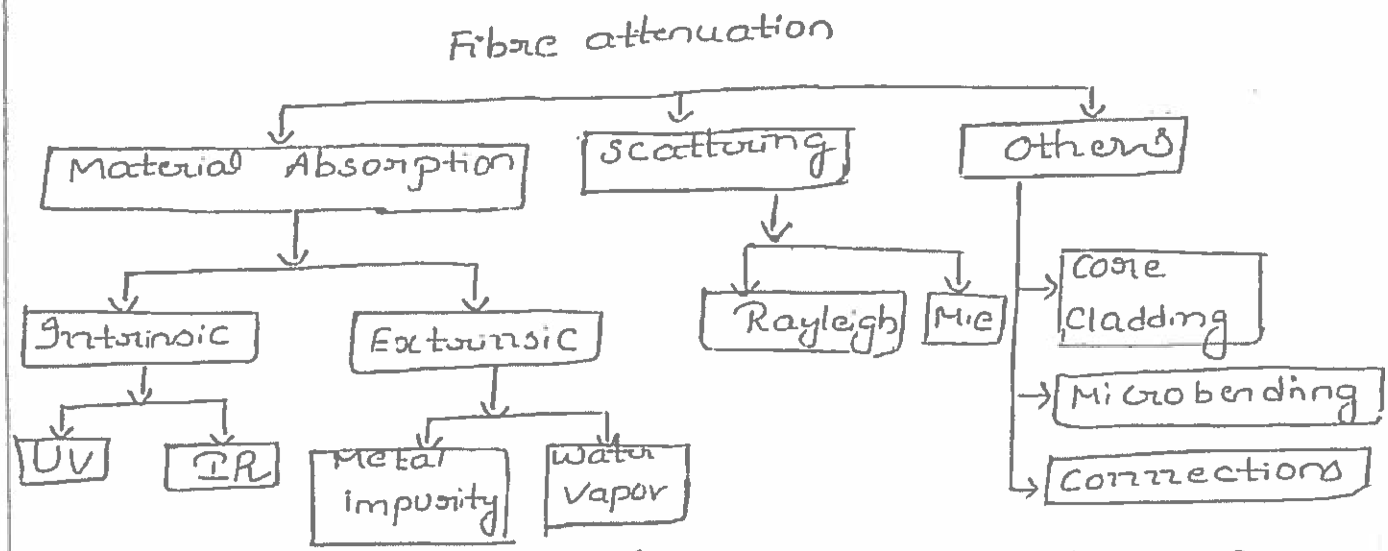
P_{out} = output power

→ Attenuation coeff 'α' dB/km is calculated by

$$\alpha = \frac{10 \log \left[\frac{P_{in}}{P_{out}} \right]}{L} \text{ dB/km}$$

L = length of the fibre.

Different types of attenuation losses



(4) Explain in detail about the material dispersion with relevant equations.

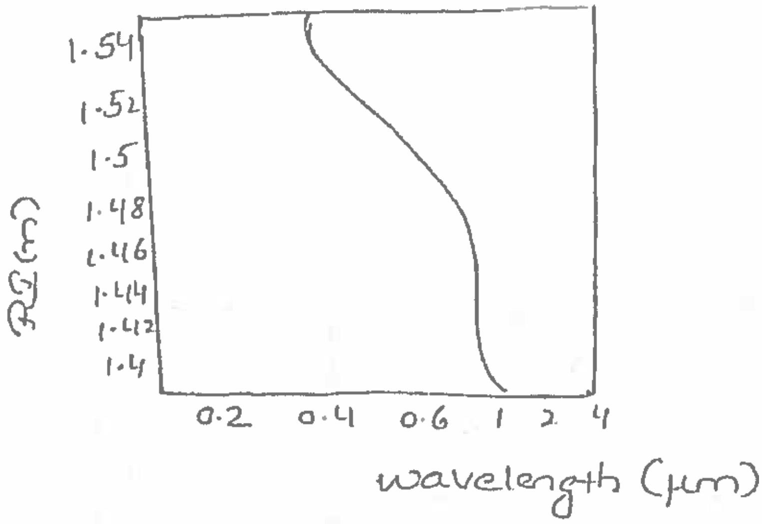
Material dispersion

It occurs because of

a. The refractive index varies as a function of optical wavelength

b. The spectral components of a given mode will travel at different speeds, depend on wavelength

→ It is an intramodel dispersion effects in single mode waveguide and LED system. These has a broader o/p spectrum than a laser diode.



Analysis of material dispersion

The propagation constant,

$$\beta = \frac{2\pi n}{\lambda} \quad \text{--- (1)}$$

diff eq (1) w.r.t λ

$$\frac{d\beta}{d\lambda} = 2\pi \left[\frac{-n}{\lambda^2} + \frac{1}{\lambda} \frac{dn}{d\lambda} \right]$$

$$= 2\pi \left[\frac{-n}{\lambda^2} + \frac{\lambda}{\lambda^2} \frac{dn}{d\lambda} \right]$$

$$\boxed{\frac{d\beta}{d\lambda} = \frac{-2\pi}{\lambda} N} \quad \text{--- (2)}$$

w.k.t. $V_g = \left[\frac{d\beta}{d\omega} \right]^{-1}$ --- (3)

$$V_g = \left[\frac{d\beta}{d\omega} \times \frac{d\lambda}{d\lambda} \right]^{-1}$$

$$V_g = \left[\frac{d\beta}{d\lambda} \cdot \frac{d\lambda}{d\omega} \right]^{-1} \quad \text{--- (4)}$$

$$\omega = 2\pi f = 2\pi \frac{c}{\lambda} \quad \text{--- (5)}$$

Diff. w.r.t λ

$$\frac{d\omega}{d\lambda} = -\frac{2\pi c}{\lambda^2}$$

$$\frac{d\lambda}{d\omega} = -\left[\frac{\lambda^2}{2\pi c} \right] \quad \text{--- (6)}$$

from eq (4)

$$V_g = \left[\frac{d\beta}{d\lambda}\ \frac{d\lambda}{d\omega}\right]^{-1}$$

Sub eq (6) and (2) in (4)

$$V_g = \left[\frac{2\pi}{\lambda^2} N \times \frac{\lambda^2}{2\pi C}\right]^{-1}$$

$$V_g = \left[\frac{-N}{C}\right]^{-1}$$

$$\boxed{V_g = \frac{c}{N}}$$

Total material dispersion,

$$T_{mat} = \frac{L}{V_g} = \frac{L}{\left(\frac{c}{N}\right)} = L\frac{N}{C}$$

$$\boxed{T_{mat} = \frac{L}{C}\left[n - \lambda \frac{dn}{d\lambda}\right]}$$

(5) Explain in detail about scattering losses and core-cladding loss.

Scattering losses

A light signal get scattered in all directions due to the non-uniformities in the optical fibre

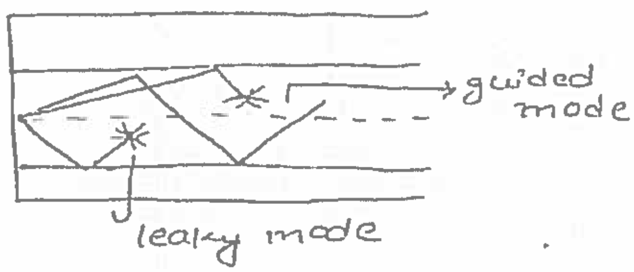
→ In general glass fibre is composed of several oxides and randomly connected network of molecules.

The variation in density of molecules and compositional structural fluctuations. Due to this the loss is occur is called as "scattering loss"

Factors caused for scattering loss

1. Microscopic variations
2. Compositional fluctuations

3. Structural inhomogenities
4. Structural defects in fibre



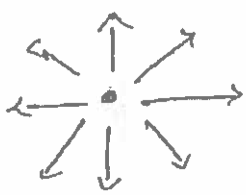
→ when the light signal entered into the fibre then that signal is guide along the core axis is called as guided mode

Rayleigh scattering

Rayleigh scattering is linear scattering loss due to
1. Microscopic fluctuation in molecule density
2. Compositional structural fluctuations

→ The RI variation cause Rayleigh scattering which is similar to light scattering from the sun ie, scattering is almost in all directions.

→ It is more efficient at short wavelengths.



The scattering loss for single component glass fibre

$$\alpha_{scat} = \frac{8\pi^3}{3\lambda^4}(n^2-1)^2 K_B T_f \beta_T \text{ nepers}$$

(or)

$$\alpha_{scat} \times 10 \log e \text{ dB}$$

where n = refractive index
K_B = Boltzman constant
T_f = fictive temperature
β_T = isothermal compressability of material

For multimode glass fibre

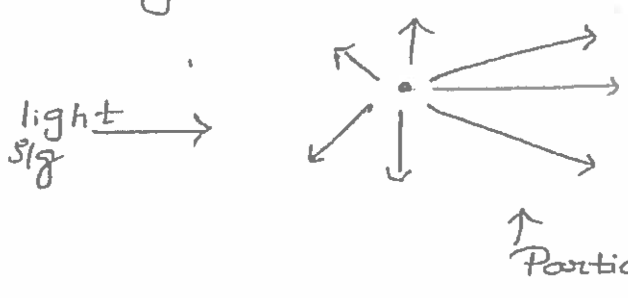
$$\alpha_{scat} = \frac{8\pi^3}{3\lambda^4}(\delta n^2)^2 \delta V$$

Mie Scattering

The linear scattering caused by inhomogeneties in the forward direction is called Mie scattering

Factors Caused by Mie scattering

1. Due to the non-perfect cylindrical structure i.e, large angular dependence
2. Fibre imperfections – diameter fluctuation, core-cladding interface irregularities.

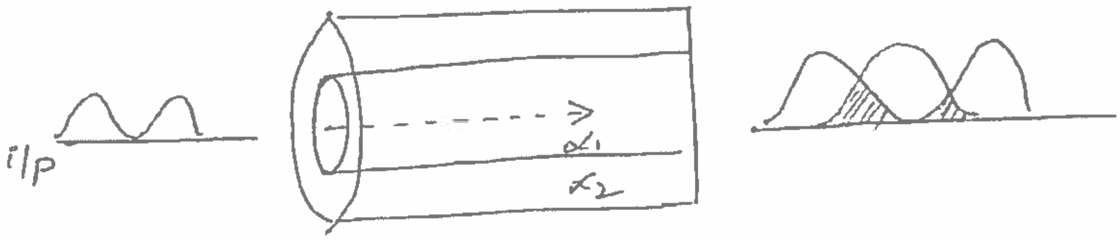


Reduction Mechanism of Mie scattering

We can reduce Mie scattering is,

1. Increasing the RRID difference
2. By removing imperfection in fibre
3. Controlled coating of the fibre.

Core-cladding losses



For step index fibre

$$\alpha_{(v,m)} = \alpha_1 \frac{P_{core}}{P} + \alpha_2 \frac{P_{clad}}{P} \quad \text{--- (1)}$$

α_1, α_2 = attenuation loss of core & cladding

P = total power

$\frac{P_{clad}}{P}$, $\frac{P_{core}}{P}$ = fractional power of core & cladding

For lower order mode,

$$\frac{P_{core}}{P} + \frac{P_{clad}}{P} = 1$$

$$\frac{P_{core}}{P} = 1 - \frac{P_{clad}}{P} \quad \text{--- (2)}$$

sub eq (2) in eq (1)

$$\alpha_{(v,m)} = \alpha_1 \left[1 - \frac{P_{clad}}{P}\right] + \alpha_2 \frac{P_{clad}}{P}$$

$$= \alpha_1 - \alpha_1 \frac{P_{clad}}{P} + \alpha_2 \frac{P_{clad}}{P}$$

$$\boxed{\alpha_{(v,m)} = \alpha_1 + \frac{P_{clad}}{P}(\alpha_2 - \alpha_1)}$$

Sri Sri Sri Mookambika Educational Society's
VAAGDEVI INSTITUTE OF TECHNOLOGY & SCIENCE
Peddasettipalli (V), Proddatur-516360.

(Approved by A.I.C.T.E., New Delhi, Affiliated to JNTUA, Anantapuramu)

Assignment-I Questions

Department of ECE

Academic Year: 2023-2024	**Regulations: R20**
Year/Semester: III/I	**Faculty Name: B.PRIYANKA**
Subject Code/Subject Name: (20A04604c) /OPTICAL COMMUNICATIONS	

Sl. No	Question	CO	MARKS
1.	With neat sketch, explain the elements of an optical fiber transmission line.	CO1	01
2.	Write in brief about the optical fiber modes &Configurations	CO1	01
3.	Explain in detail about intrinsic &Extrinsic dispersion.	CO2	01
4.	List out different types of attenuation losses.	CO2	01
5.	Explain in detail about material dispersion with relevant equations.	CO2	01

B. Priyanka

Asst Prof ,ECE