A Laboratory Manual for

Optical Network & Satellite Communication

(22647)

Semester- VI

Scheme- I

Diploma in Electronics Engineering Group

(EJ)

Bharati Vidyapeeth Institute of Technology,

Navi Mumbai.

Bharati Vidyapeeth Institute of Technology

Navi Mumbai

Certificate

This is to certify that, Mr./ Ms. …….

Roll No. …… of Fifth Semester of Diploma in Electronics Engineering Group of Bharati Vidyapeeth Institute of Technology, Navi Mumbai(Inst.code:0027) has satisfactorily completed the term work in **Optical Network& Satellite Communication (22647)** the subject for the academic year 20…….to 20……. as prescribed in the MSBTE curriculum.

Place: ……... Enrollment No. : ……

Date:…….Exam. Seat No. : …….

Subject Teacher **Head of the Department** **Principal**

Sign:

Name:

Seal of Institution

LIST OF EXPERIMENTS AND PROGRESSIVE ASSESSMENT FORTERM WORK D-3

ACADEMIC YEAR 20 - 20

Course Code :- Sub & Code :

Name of Candidate : Enrollment No : Roll No :

Marks : Max : Min : Name of Staff-

Sr. No	Title of Experiment	Page No	Date of Performance	Date of Submission	Assessment Marks	Dated Sign of teacher with Remark
1	Identify various layers and parts of an optical fiber cable.	1				
2	Test the performance of pulse width modulation and Demodulation (PWM) where optical fiber cable is used as transimmion media.	5				
3	Test the performance of given photo diode (Detector) use LED as an optical source.	8				
4	Test the performance of given photo diode (Detector) use LASER as an optical source.	12				
5	Calculate the Numerical Aperture (NA) of given optical fiber cable.	15				
6	Measure attenuation losses for the given length of optical fiber.	19				
7	Measure bending losses of given optical fiber cable.	24				
8	Connect the given Optical Cable with relevant optical connector and test the performance of cable	28				
9	Demonstrate attenuation losses for given the length of Optical fiber cable with the help OTDR.	31				
10	Join optical Fiber cable using Splicing Machines.	34				
11	Demonstrate the working of OTN.	38				

12	Test the performance of audio satellite link for the specified uplink and downlink frequency.	40				
Total marks out of 120						
Marks out of 25						

Name and Signature of Student **Name and Signature of Staff**

Assessment Scheme

	Performance Indicators	**Weightage in %**
a.	Preparation of experiments set up	**20**
b.	Setting and operation	20
c.	Safety measures	10
d.	Observation and Recording	**10**
e.	Interpretation of result and conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
	Total	**100**

Experiment No. : 1

Title: Identify various layers and parts of an optical fiber cable.

EQUIPMENTS:

Different types of Fiber Optical cable.

THEORY:

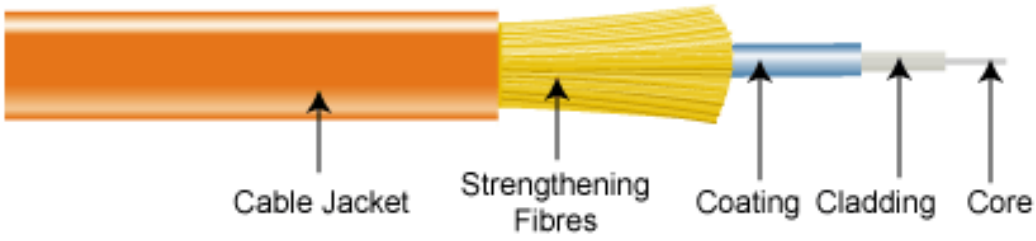


Fig 1.Basic Construction of a fiber Optic Cable

Core:

This is the physical medium that transports optical data signals from an attached light source to a receiving device. The core is a single continuous strand of glass or plastic that's measured in microns (µ) by the size of its outer diameter. The larger the core, the more light the cable can carry.All fiber optic cable is sized according to its core's outer diameter. The three multimode sizes most commonly available are 50, 62.5, and 100 microns. Single-mode cores are generally less than 9 microns.

Cladding:

This is the thin layer that surrounds the fiber core and serves as a boundary that contains the light waves and causes the refraction, enabling data to travel throughout the length of the fiber segment.

Coating:

This is a layer of plastic that surrounds the core and cladding to reinforce and protect the fiber core. Coatings are measured in microns and can range from 250 to 900 microns.

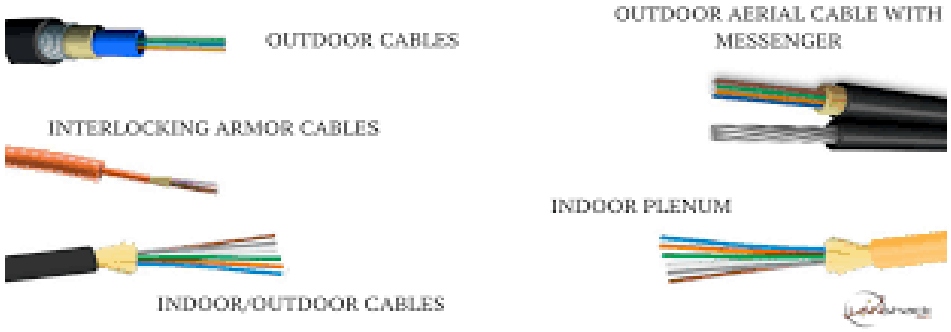
Strengthening fibers:

These components help protect the core against crushing forces and excessive tension during installation. The materials can range from Kevlar® to wire strands to gel-filled sleeves.

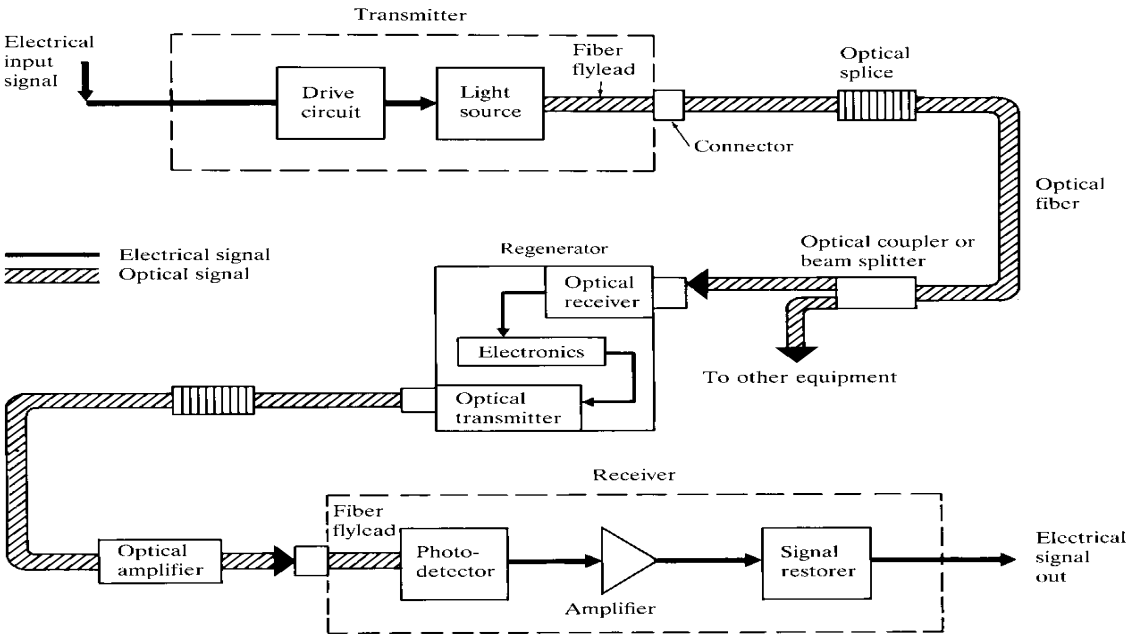
Cable jacket:

This is the outer layer of any cable. Most fiber optic cables have an orange jacket, although some types can have black or yellow jackets.

Different types of Fiber Optical cable.



Block diagram of fiber Optical system.



CONCLUSION:

Questions:

1. Draw block diagram of Optical Fiber Communication System. Describe the function of different sensors used in optical communication system.
2. State advantages and disadvantages of fiber optic cable.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

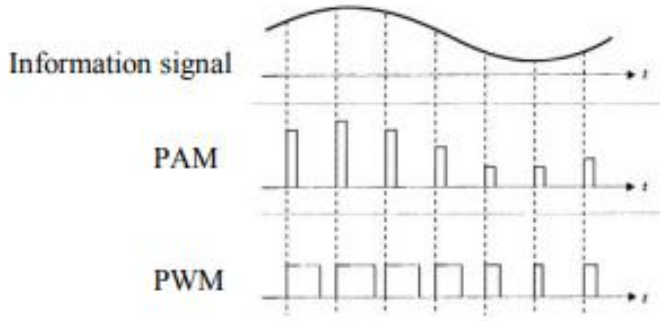
Experiment No. : 2

Title: Test the performance of pulse width modulation and Demodulation (PWM) where optical fiber cable is used as transmission media.

Apparatus: Function Generator, PWM Kit, 20-MHz CRO, Optical fiber cable.

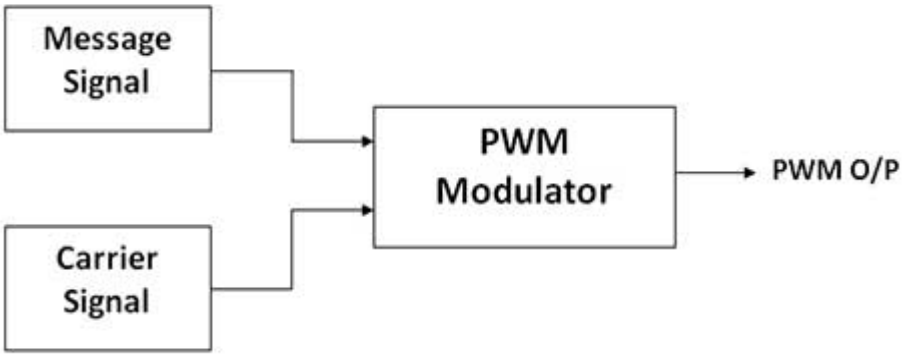
THEORY:

Pulse-width modulation (PWM) is a digital modulation technique in which the width of a pulse carrier is changed according to the instantaneous value of the information signal.

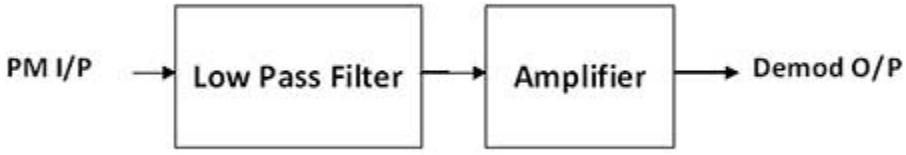


EXPERIMENTAL SET UP:

PWM Modulation



PWM Demodulation



PROCEDURE:

1. Connect the power supply cable with polarity to kit1 and Kit2 while connecting ensure that it is off.

2. Connect the signal generator between PWM(i/p) and ground select frequency 1Khz with amplitude 1Vpp.

3. Switch on the power supply and signal generator.

4. Check that the circuit is properly working by connecting CRO at 32 KHz

5. Now observe the output waveform.

6. Connect the output of PWM at PWM output port to input port

7. Establish the link between ports marked as amplifier (o/p) and transmitter(o/p).

8. Observe the output of detector at the output port.

RESULT:

CONCLUSION:

In PWM the amplitude is varying in accordance with the intensity of sound by means PWM the analog signal is transmitted and received through optical fiber and waveform s are observed and studied.

Questions:

1.

2.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 3

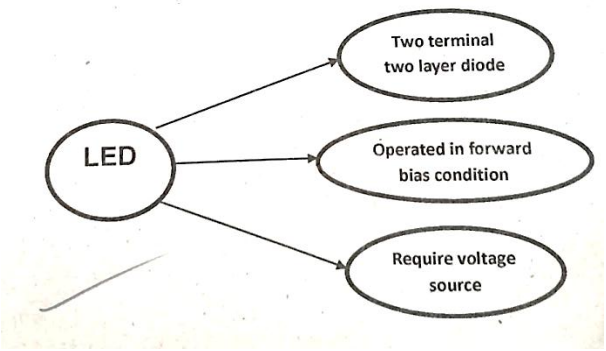
Title: Test the performance of given photo diode (Detector) use LED as an optical source.

Apparatus: Experiment kit, Power supply, micro ammeter, voltmeter, optical power meter/ Lux meter, Digital multimeter.

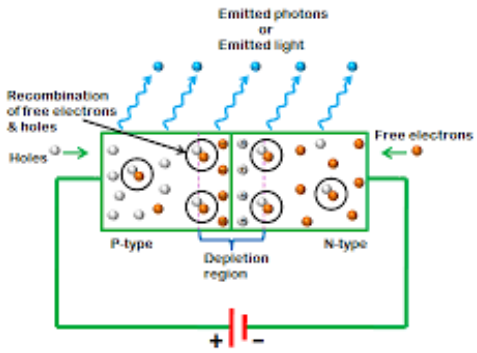
THEORY:

Light Emitting Diode(LED)

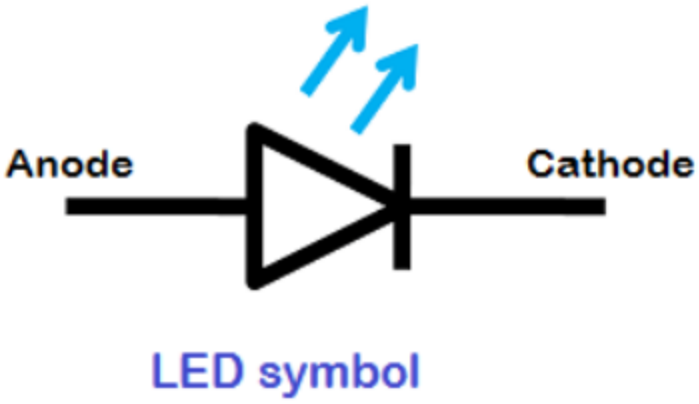
The two terminals, two layer PN junction diode, which emits light when forward biased, is known as a light emitting diode (abbreviated as LED)



LED emits visible and invisible light. LED's radiate visible light in different colour such as red, green, yellow, blue, orange etc. The colour of the emitted light depends on the type of the semiconductor material used.



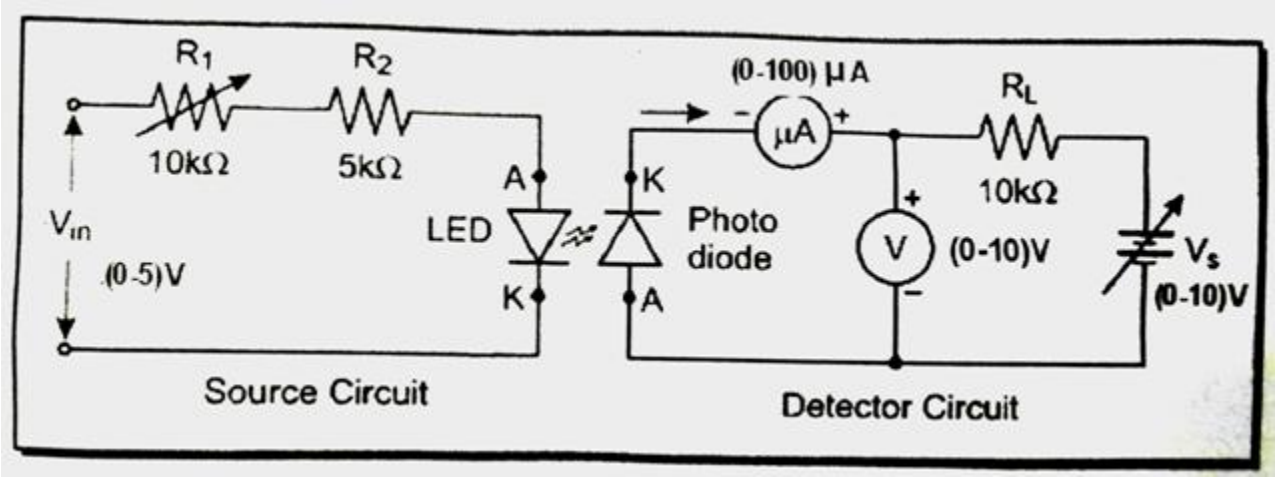
Light Emitting Diode (LED)



LED symbol

Photodiode: A photodiode is a semiconductor device that converts light into an electrical current. The current is generated when photons are absorbed in the photodiode. Photodiodes may contain optical filters, built-in lenses, and may have large or small surface area.

EXPERIMENTAL SET UP:



PROCEDURE:

1. Select the components as per the circuit diagram.

2. Connect the component of source circuit and detector circuit as per the diagram.

3. Align source and detector close to each other such that light of LED will be incident on the photodiode.

4. Adjust the resistance R1 (Position I) such that LED will not emit the light, measure the photo currentIpin the detector circuit.

5. Change the position of R1 (Position II) and increase the intensity of light. At this position measure Ip.

6. Again change the position of R1 (Position III) , and measure Ip for high intensity of light.

7. Repeat the step 6 for one more position. Note the readings.

Observation Table/Results

Sr. No	Light intensity	Photo current Ip
1	Position I No light condition	
3	Position II Low light condition	
5	Position III Medium light condition	
6	Position IV High light condition	

RESULT:

Conclusion:

As intensity of incident light increase, the photo current …….(increase / decrease/ remains constant.)

Questions:

1.Distinguish between LED and LASER. (4 points)

2. What are different types of source available for optical fiber.

3. Why does the photo current increase when intensity of light inreases.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 4

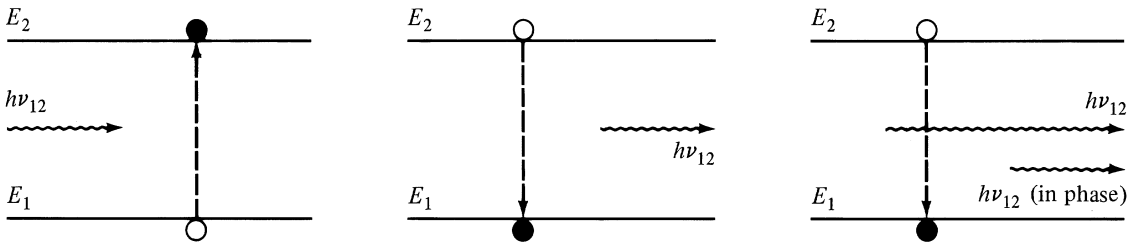
Title: Test the performance of given photo diode (Detector) use LASER as an optical source.

Apparatus: Experiment kit, Power supply, micro ammeter, voltmeter, optical power meter/ Lux meter, Digital multimeter.

THEORY:

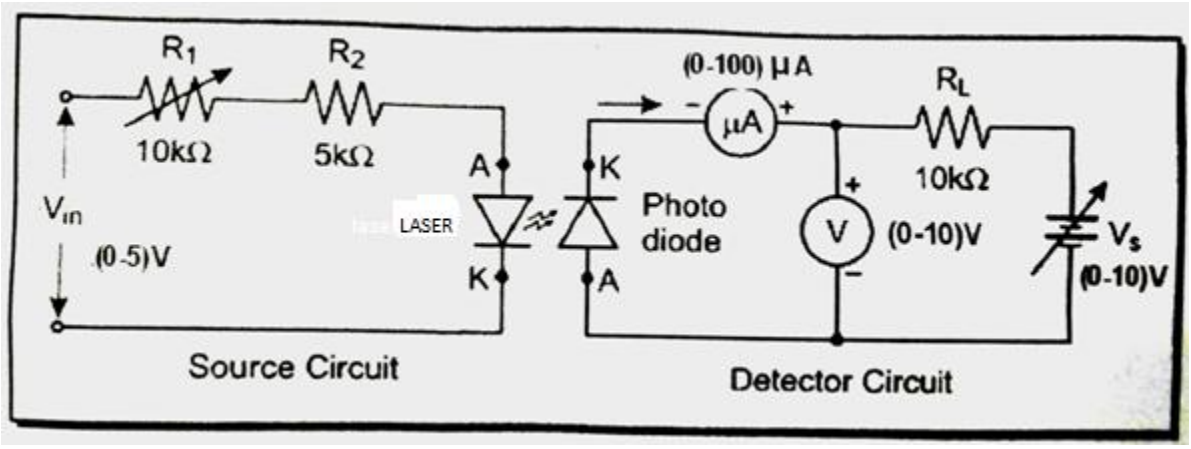
Light Amplification by Stimulated Emission of Radiation(LASER Diode

From the fabrication process LED can be improved to LASER diode which works with the photon absorption, spontaneous emission and stimulated emission. In LASER two ends are made of RI causing the number of reflections of photon until a resonant LASER beam comes out, the emission is continuous.



(*a*) Absorption (*b*) Spontaneous emission (*c*) Stimulated emission

EXPERIMENTAL SET UP:



PROCEDURE:

1. Select the components as per the circuit diagram.

2. Connect the component of source circuit and detector circuit as per the diagram.

3. Align source and detector close to each other such that light of Laser will be incident on the photodiode.

4. Adjust the resistance R1 (Position I) such that Laser will not emit the light. Measure the photo currentIpin the detector circuit.

5. Change the position of R1 (Position II) and increase the intensity of light. At this position measure Ip.

6. Again change the position of R1 (Position III) , and measure Ip for high intensity of light.

7. Repeat the step 6 for one more position. Note the readings.

Observation Table/Results

Sr. No	Light intensity	Photo current Ip
1	Position I No light condition	
2	Position II Low light condition	
3	Position III Medium light condition	
4	Position IV High light condition	

RESULT:

Conclusion:

As intensity of incident light increase, the photo current …….(increase / decrease/ remains constant.)

Questions:

1.Compare on the basis of any four factors optical fiber communication with radio wave communication.

2.Describe working and principle of avalanche photodiode with a neat sketch.

Space for Answer

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 5

Title: Calculate the Numerical Aperture (NA) of given optical fiber cable.

Apparatus:.Experiment kit, optical fiber cable

THEORY:

Numerical Aperture (NA):

It is the numeric value expressing the amount of light that can enter the cone, because ray incident on the cone axis at an angle less than the critical angle (θc) only can undergo total internal reflection. Rest of the rays is scattered. Numerical aperture is an important factor in design of communication links.

Formula for calculation of NA (Theoretical concept):

1. NA = $\sqrt{n1^2 - n2^2}$

   Where n1 –refraction index of core

   n2 –refraction index of cladding

2. NA = $n_0 \sin\theta_a$

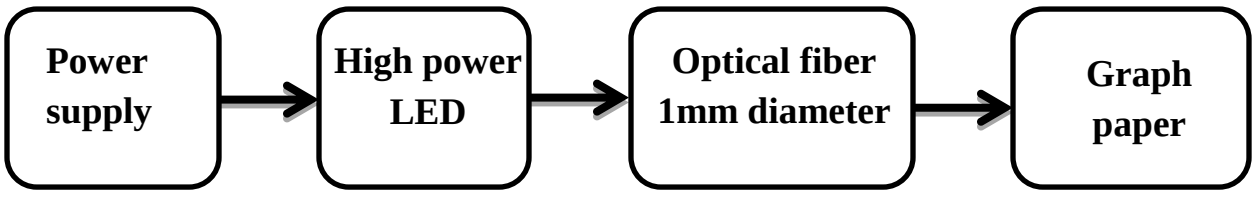
   n_0= 1 (for air)

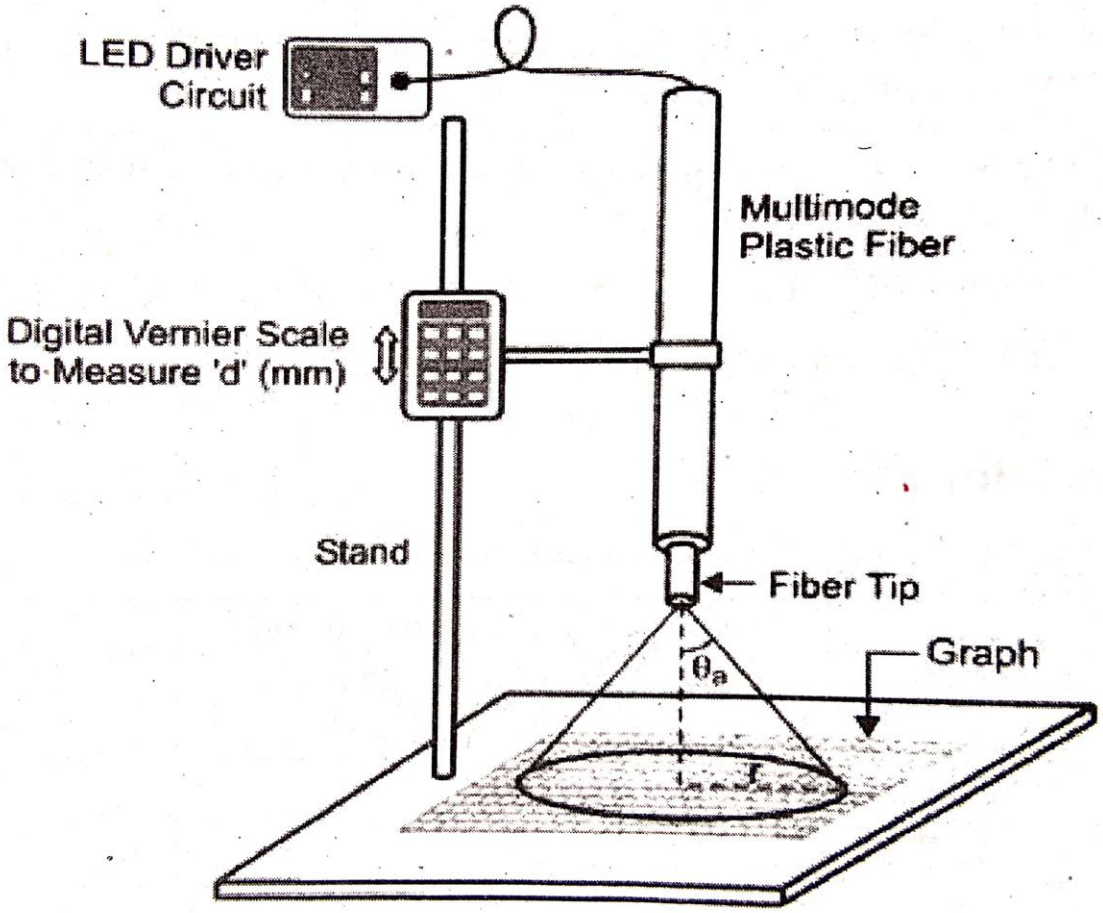
   Where θ_a- Semi angle of the acceptance cone

It is the formula based on radius of spot and vertical tip and other thing like refractive index of core n1, refractive index of cladding n2 are ignored.

EXPERIMENTAL SET UP:

Block diagram:





Procedure:

1. Take the circuit board and connect power supply to LED.
2. Connect one end of optical fiber in vertical manner over the graph paper and other end very close to light source with coupler.
3. Vary the diameter between graph paper and optical fiber such as 2mm, 3mm, 4mm and so on, to get concentrated cone of light.
4. Mark the circle of light area falling on the graph paper through optical fiber using sharp pencil.
5. Measure the diameter (D) of circle. Calculate the radius (r) using the relation r = D/2.

Observations:

Measurement of spot diameter for various distances.

Sr. No.	Distance (d) (mm)	Diameter (D) (mm)	Radius (r=D/2) (mm)	$X=\sqrt{d^2+r^2}$	NA= r/x
1	2mm				
2	3mm				
3	4mm				
4	5mm				
5	6mm				
6	7mm				
7	8mm				

Calculations:

$X=\sqrt{d^2+r^2}$

= ……

NA =sin θ_a

= r/x

= ……...

Conclusion:

1. As distance between graph paper and fiber tip increase the diameter of spot…… (Increases / decreases / remains same).
2. As the distance between graph paper and fiber tip increases the NA…….(Increases / decreases / remains same).

Questions:

1. Define w.r.t Optical fiber a) Numerical aperture b) Acceptance angle.

2. A silica optical fibre with core diameter large enough to be considered by ray theory analysis has corerefractive index of 1.50 and cladding refractive index of 1.47 calculate i)critical angle ii)NA of fibre iii)Acceptance angle in air for fibre.

Space for Answer

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 6

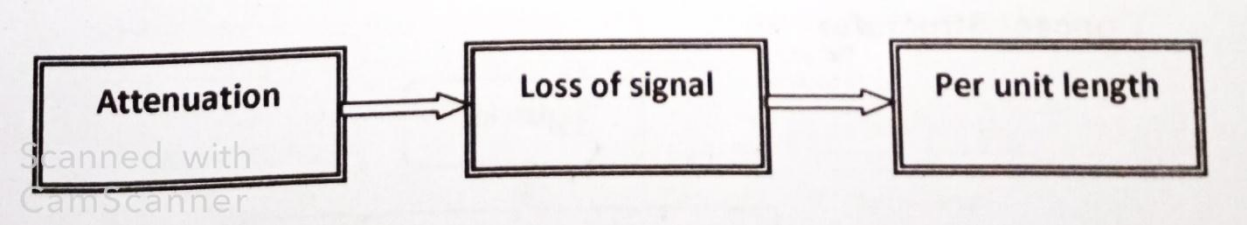
Title: Measure attenuation losses for the given length of optical fiber.

Apparatus: Experiment kit, optical fiber cable

THEORY:

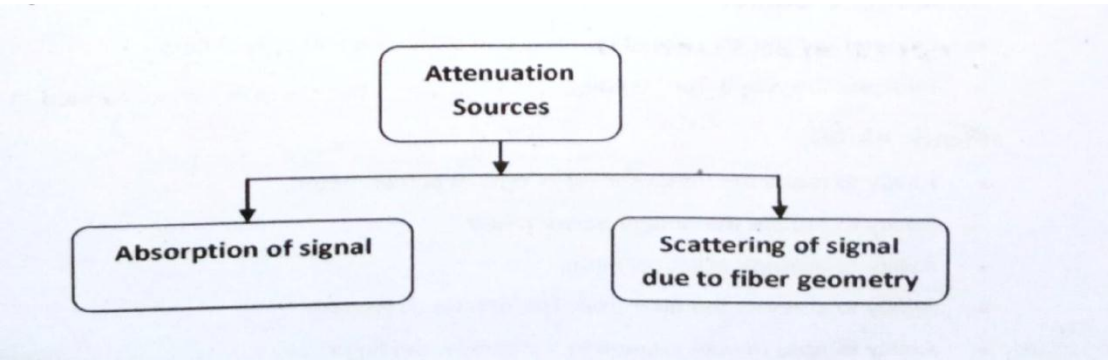
Attenuation:

The attenuation is the loss or the fading of signal. It is an important parameter of theoptical communication system as it determines distance of transmission.



Source of attenuation:

- Absorption.
- Scattering and radiation losses.



Absorption:
Absorption is mainly caused due to the two different mechanism of atomic defects in theused in optical fiber.

Extrinsic Absorption: Absorption due to impurities in the glass material.

Intrinsic Absorption: Absorption due to basic constituent atoms of the glass matenial.

α(db/km) = 10 log (pi/po)

$\alpha.L = 10 \log (pi/po)$

where,

α = signal attenuation.

L = fiber length.

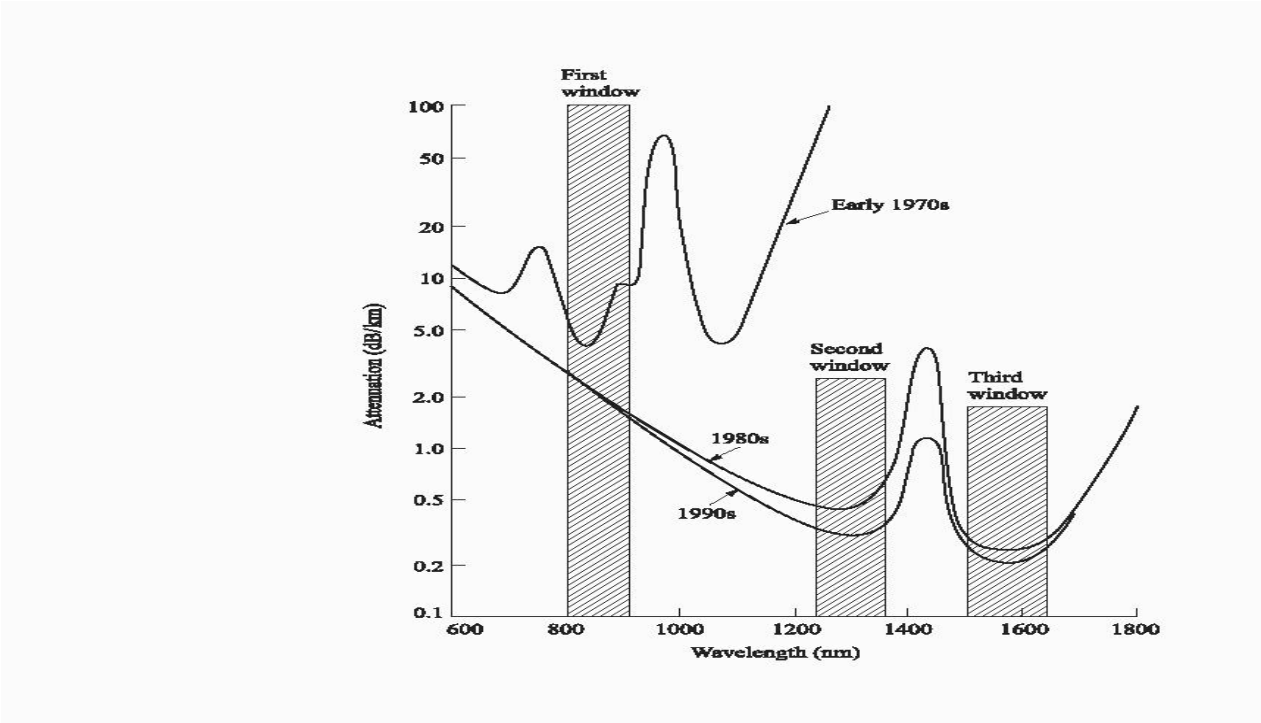


Fig.1 Attenuation v/s Wavelength

a) Extrinsic absorption: In practical, optical fiber prepared by conventional melting technology where the transition metal impurities causes losses in optical fiber and this loss is called as Extrinsic absorption.

b)Absorption by atomic defects in glass composition: atomic defects are imperfections in atomic structure of fiber material such as missing of molecules, high density clusters of atom groups defects in the glass structure. This loss is significant when the fiber is exposed in space mission, nuclear radiation medical radiation therapy etc.

1) Scattering losses :

Scattering is characterized in two different types

a)Rayleigh scattering :

It results due to fluctuation in Refractive Index (R.I). fluctuation in R.I occurs because glass material is composed of randomly connected network of molecules i.e. there are some regions in which molecular density is either higher or lower than the average density in the glass.

a) Mie scattering :

It results due to the structural inhomogeneities present in the fiber such as irregularities in the core cladding interface, imperfect cylindrical structure, core cladding R.I differences along fiber length, strains and bubbles etc.

Procedure:

1.Switch on the power supply.

2. Connect the 1m fiber between optical transmitter and receiver without bending and measure the voltage.

3. Connect the 5m fiber between optical transmitter and receiver without bending and measure the voltage.

Observations:

Sr. No	Length of Fiber (m)	Output(V)
1		
2		

Calculation:

Attenuation $\alpha_{Db} = 10/ L^* \log 10(Pin / Pout)$ Db/m

OR

$$V_{1/} V_{2=} e^{-\alpha} (L1+L2)$$

Conclusion:

As the length of optical fiber increases,output Voltage..... (Increases / decreases / remains same)

Questions:

1. Describe coupling losses occur in optical fiber communication with neat diagrams.
2. Explain the applications of FOC in industrial and commercial field.
3. How to minimize the attenuation in fiber?

Space for Answer

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. :7

Title: Measure bending lossesof given optical fiber cable.

Apparatus: Experiment kit, optical fiber cable.

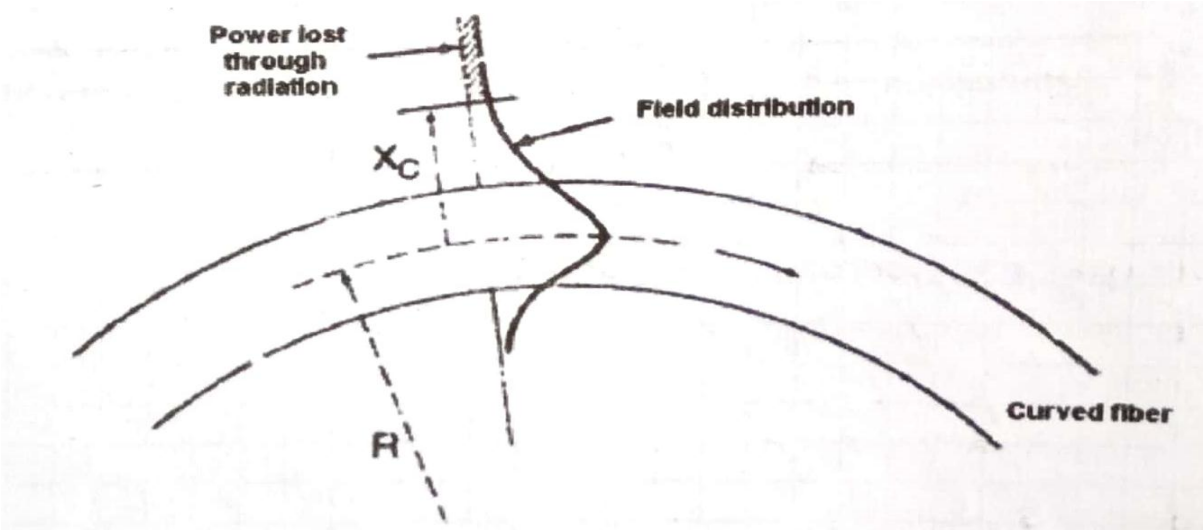
Theory:

Bending losses :

Bending losses occurs whenever optical fiber undergoes a bend of finite curvature radius. There are two types of bend

Macroscopic bend :

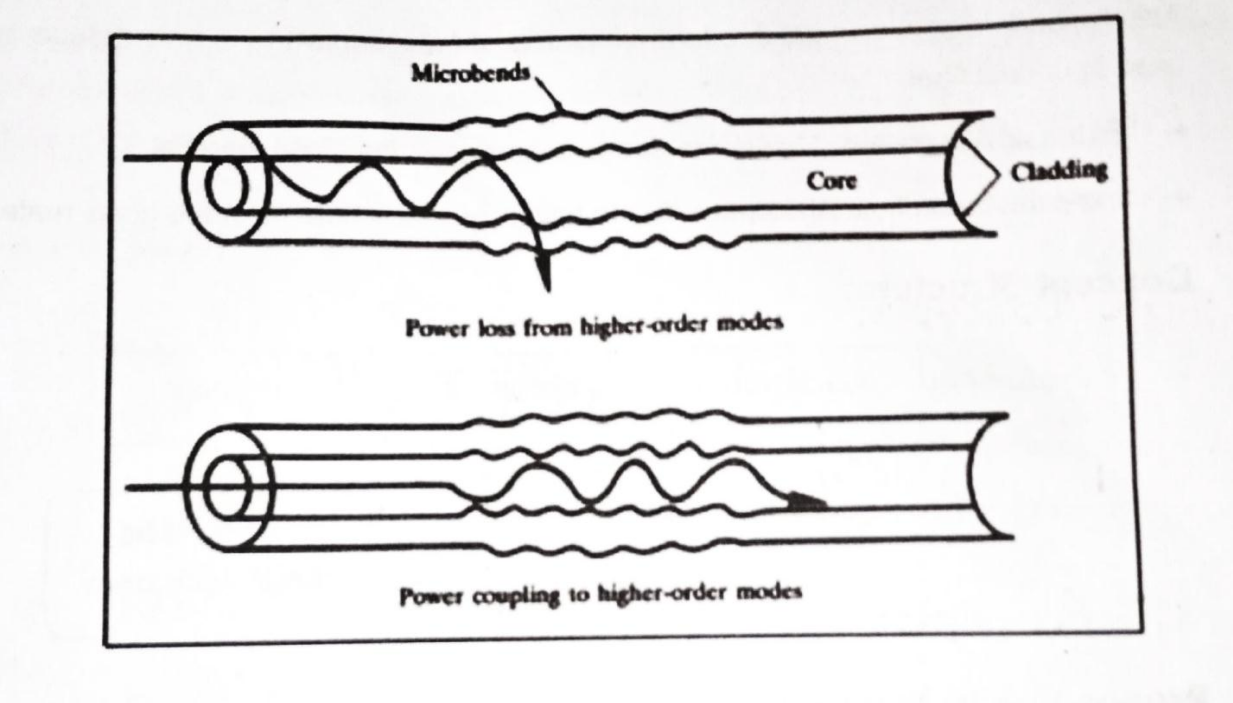
The bend having radii that are very as compared to the fiber diameter. Due to the curved cables, the power is lost due to radiations. This loss is large after the threshold point.



For slight microbe dingradiative loss is negligible i.eupto certain critical curvature radius the loss is not significant but if radius is made smaller than critical curvature radius then bending losses becomes extremely large.

Microscopic bend :

It means bending of fiber arise when the fibers are incorporated in the cable. This bending occurs due to cabling or packaging.



The microbends are caused either by non-uniformities in the manufacturing of the fiber or non-uniform lateral pressures created during cabling of the fiber.

Procedure:

1. Switch on the power supply.
2. Connect the 5m long fiber between optical transmitter and receiver without bending.
3. Note the output power without bending the fiber (V1).

5. Connect one end of fiber to optical transmitter and other to optical receiver.

6. Measure the output power (P2) on display, with bending of fiber.

7. Observe the change in output power P1 and P2.

Observations:

A. For bending loss

1. Current I = 40mA

2. Optical voltage without bending of fiber V1 = ...

3. Optical voltage with bending of fiberV2 =.....

Calculation:

1. Optical power without bending of fiber P1 = (V1 x I) =.....

2. Optical power with bending of fiber P2 =..(V2 x I) = ...

Bending loss = P1- P2 =.....

Conclusion:

Questions:

1. List the different losses occur in optical fiber. Describe any one loss with diagram.
2. Illustrate modal dispersion loss. Where it occurs and how it can be controlled.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 8

Title: Connect the given Optical Cable with relevant optical connector and test the performance of cable

EQUIPMENTS: Experiment kit, optical fiber cable,connectors.

THEORY:

Optical fiber connector:

An optical fiber connector terminates the end of an optical fiber, and enables quicker connection and disconnection than splicing. The connectors mechanically couple and align the cores of fibers so light can pass. Better connectors lose very little light due to reflection or misalignment of the fibers.

There are several types of fiber optic connectors available today. The most common are: ST, SC, FC, MT-RJ and LC style connectors. All of these types of connectors can be used with either multimode or single mode fiber.

Procedure:

1. Switch on the power supply of kit.

2. Connect the 5m long fiber between optical transmitter and receiverwith different connector.

3. Note the output the fiber (V1).

4. Measure the output (V2) on display, with other connector of fiber.

5. Observe the change in output V1 and V2.

Observations:

1. Optical output with ----------connector of fiber V1 = ...

2. Optical output with ----------connector of fiber V2 = ...

Conclusion-

Questions:

1.Distinguish between splicing and connectors of fiber optic cable.

2.Compare on the basis of any four factors optical fiber communication with radio wave communication

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 9

Title: Demonstrate attenuation losses for given the length of Optical fiber cable with the help OTDR.

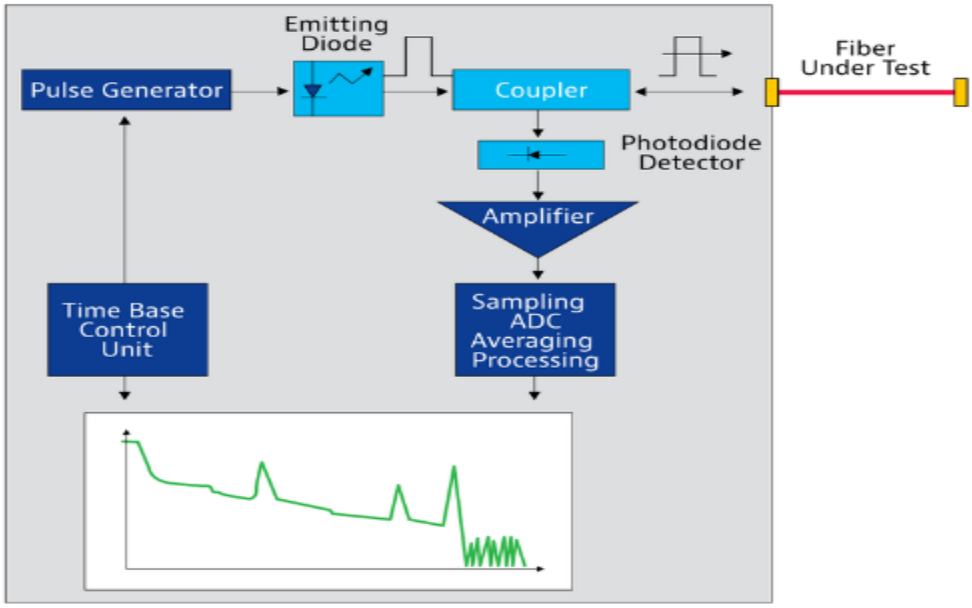
EQUIPMENTS: Experiment kit, optical fiber cable

THEORY:

OTDR:

An Optical Time Domain Reflectometer (OTDR) is a fiber optic instrument used to characterize, troubleshoot and maintain optical telecommunication networks. OTDR testing is performed by transmitting and analyzing pulsed laser light traveling through an optical fiber. The measurement is said to be unidirectional as the light is insert at extremity of a fiber optic cable link.

An OTDR contains a laser diode source, a photodiode detector and a highly accurate timing circuit (or time base). The laser emits a pulse of light at a specific wavelength, this pulse of light travels along the fiber being tested, as the pulse moves down the fiber portions of the transmitted light are reflected/refracted or scattered back down the fiber to the photo detector in the OTDR. The intensity of this returning light and the time taken for it to arrive back at the detector tells us the loss value (insertion and reflection), type and location of an event in the fiber link.



PROCEDURE:

Virtual lab/Demonstration in industry /video can be used in case of non – availability of the splicing machine in the lab

Conclusion:

Questions:

1. Draw and explain the block diagram of OTDR
2. Give application of OTDR.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 10

Title: Join optical Fiber cable using Splicing Machines.

EQUIPMENTS: Splicing Machines, optical fiber cable

THEORY:

Splicing Techniques:

Fiber splice is a permanent joint formed between two individual optical fibers in the field of factory.

The technique are of two types:

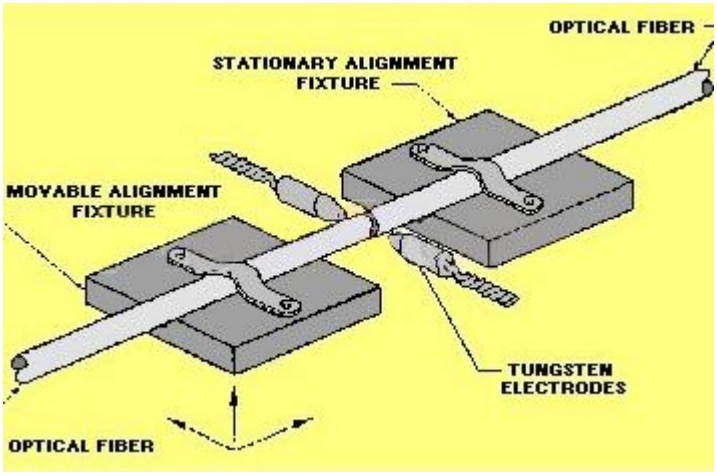
1. Fusion splicing or welding

2. Mechanical splicing

Fusion splicing or welding:

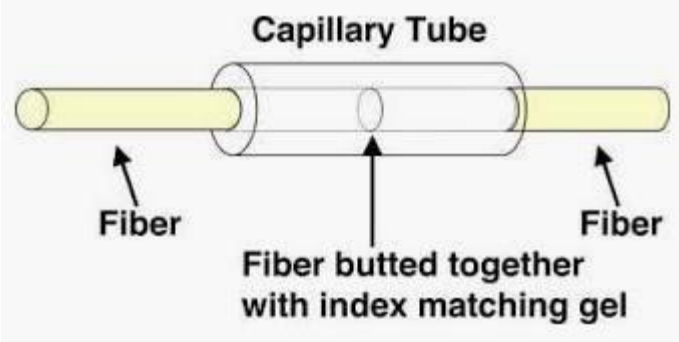
It is accomplished by applying localized heating i.e by a flame or an electrical arc at interference between two butted, pre aligned fiber ends.

This technique involves heating of two prepared fiber ends to their fusing point by applying sufficient axial pressure between the two optical fibers. For heating most widely source is electric arc.



Mechanical splicing:

In this method accurately produced rigid alignment tube is used to bond the prepared fiber ends permanent.



PROCEDURE:

Virtual lab/Demonstration in industry /video can be used in case of non – availability of the splicing machine in the lab

Conclusion:

Questions:

1.List different types of splicing techniques. Describe any one method.
2.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 11

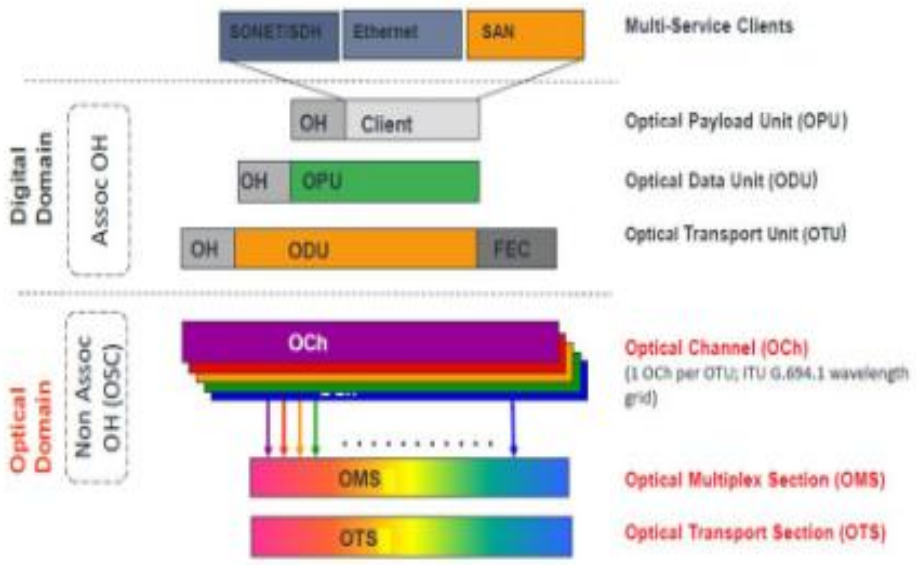
Title: Demonstrate the working of OTN

EQUIPMENTS: Experiment kit, optical fiber cable

THEORY:

OTN—or Optical Transport Networking—is a next-generation, industry-standard protocol that provides an efficient and globally accepted way to multiplex different services onto optical light paths.

OTN architecture:



PROCEDURE:

Virtual lab/Demonstration in industry /video can be used in case of non – availability of the in the lab

CONCLUSION:

Questions:

1. Define optical network. State its need.

2. Explain with neat diagram optical network elements.

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	

Experiment No. : 12

Title: Test the performance of audio satellite link for the specified uplink and downlink frequency.

EQUIPMENTS: 1.Uplink Transmitter 2. Dish Antennas 3. Downlink Receiver 4. Connecting cables.

PREREQUISITE: Basics of Satellite Communication System.

THEORY: Satellite communications is one of our most rapidly growing and evolving technologies bringing with it a multitude of business opportunities in the decades to come.

A communications Satellite is a spacecraft that carries aboard communications equipment, enabling a communications link to be established between distant points. An all embracing definition of a spacecraft would include deep-space probes such as the Voyager series, but here only those Satellites that orbit the earth will be considered. Satellites that orbit the earth do so as a result of the balance between centrifugal and gravitational forces. Johannes Kepler (1571-1630) discovered the laws that govern Satellite motion. Although Kepler was investigating the motion of planets and their moons (so-called heavenly bodies), the same laws apply to the artificial Satellites launched for communications purposes.

PROCEDURE:

1. Connect the Satellite Uplink transmitter to AC Mains.
2. Switch ON the transmitter and frequency display will come on.
3. The transmitting frequency can be selected by frequency selection switch. The frequency can be changed from 2450-2468 MHz.
4. The transmitter ON-OFF toggle switch will switch on - off the transmission.
5. Connect X1 Antenna to Uplink transmitter with BNC -BNC lead.
6. Set the O/P gain of Uplink transmitter to maximum.
7. Place Downlink Receiver at a convenient distance of 5- 7m. (It can go even up to 10m.).
8. Connect the Downlink Receiver to the AC Mains and switch it ON by mains switch.
9. The Downlink Receiver Frequency can be changed from 2414-2432 MHz.
10. The Downlink receiver ON-OFF toggle switch will switch on - off the receiver.
11. Attach R2 Antenna to the Downlink receiver with BNC - BNC lead.
12. Align both the Transmitter and Receiver Antenna's in line.
13. Keep the uplink transmitter and downlink receiver frequency to the same frequency.
14. Now connect Tone out signal to Tone input of the Uplink transmitter by patch cord.

15. Keep Downlink receiver voice switch in the ON position and you will be able to hear tone in the speaker of receiver.

16. This is a test link for direct communication between transmitter and receiver.

17. Connect any other audio signal to the Audio II of Uplink transmitter and you will hear the music in the speaker of Downlink Receiver.

Results:

A clear music indicates that the microwave link has been successfully setup between uplink transmitter and Down link receiver directly.

CONCLUSION:

The communication link is established and tested.

Questions:

1. What is uplink and downlink frequency? State reason for difference in uplink and downlink frequency in satellite communications.

2.Define the following terms w. r.t. satellite i. Footprint ii. Orbit iii. Azimuth angle iv. Elevation angle

Space for Answers

Marks obtained			Dated sign. Of Teacher
Process Related(10)	Product Related(15)	Total(25)	