

Subject

FTTx Installer

Vol.01

 **Empowering Youth!**



Skill & Assessment Partner
NASSCOM[®]

FTTx Installer

Submitted to :- Bihar Skill Development Mission, Labour Resources Department, GoB	Submitted By :- Sterlite Technologies Ltd
	Session : 2022-23

Course name:

- Course Id-
- Candidate Eligibility : Diploma/ Graduate
- Course Duration: (In hours) 550

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FTTX INSTALLER

STUDENT GUIDE



About the Student Guide

The student guide contains modules which will help you to acquire relevant knowledge and skills (generic and domain-specific skills) related to the 'FTTx Installer' job role. Knowledge in each module is easily understood and grasped by you before you move on to the next module. Comprehensible diagrams & images from world of work have been included to bring about visual appeal and to make the text lively and interactive for you. You can also try to create your own illustrations using your imagination or taking the help of your trainer.

Let us now see what the sections in the modules have for you.

Section 1: Learning Outcome

This section introduces you to the learning objectives and knowledge criteria covered in the module. It also tells you what you will learn through the various topics covered in the module.

Section 2: Relevant Knowledge

This section provides you with the knowledge to achieve relevant skill and proficiency to perform tasks of the FTTx Installer. The knowledge developed through the module will enable you to perform certain activities related to the job market. You should read through the textual information to develop an understanding on the various aspects of the module before you complete the exercise(s).

Section 3: Exercises

Each module has exercises, which you should practice on completion of the learning sessions of the module. You will perform the activities in the classroom, at home or at the workplace. The activities included in this section will help you to develop necessary knowledge, skills and attitude that you need for becoming competent in performing the tasks at workplace. The activities should be done under the supervision of your trainer who will guide you in completing the tasks and also provide feedback to you for improving your performance.

Section 4: Assessment Questionnaire

The review questions included in this section will help you to check your progress. You must be able to answer all the questions before you proceed to the next module.

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MODULE 1 BASICS OF OPTICAL FIBER

Section 1: Learning Outcomes

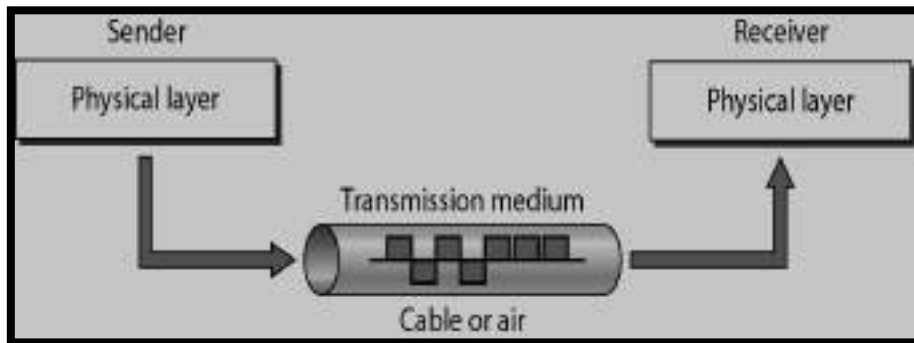
After completing this module, you will be able to:

- Differentiate between various types of Transmission Media
- Explain Geometry of Optical Fiber
- Explain Principle of Fiber Optics - Total Internal Reflection
- Describe Optical Fiber Communication System
- State Applications and Advantages of Optical Fiber
- Explain the Mode Theory and Waveguide Equations
- Explain concept of Cut-off Wavelength and Mode Field Diameter (MFD)
- Tell History of Fiber Optic Communication
- Classify Optical Fibers
- Describe Optical Fiber Communication Wavelengths and their properties
- Explain performance parameters of optical fiber viz. Attenuation and Dispersion
- Distinguish between characteristics and application of different Grades of Optical Fiber
- Differentiate between various Bend Insensitive Fibers

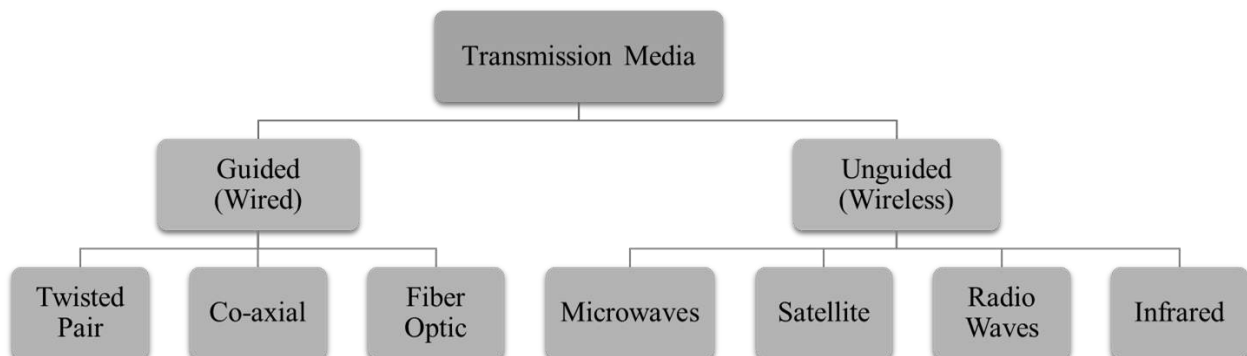
Section 2: Relevant Knowledge

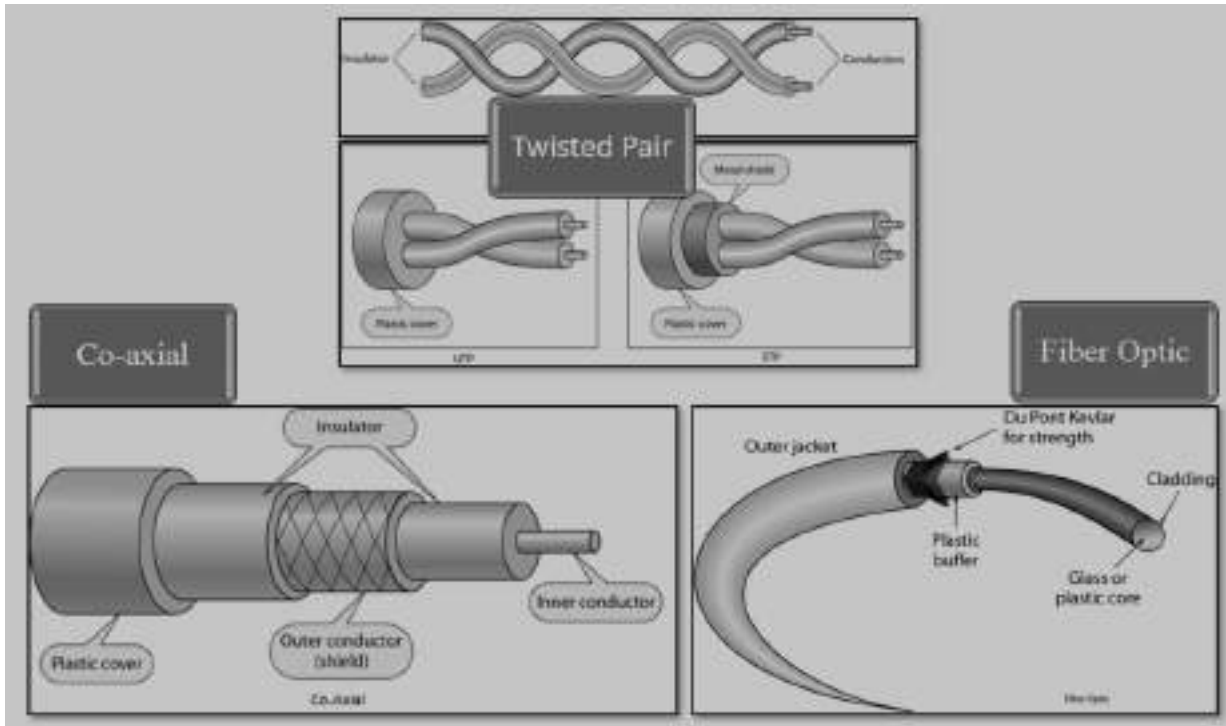
1.1 Transmission Media

Transmission media or medium is a pathway that carries the information from sender to receiver.



Classification of Transmission Media





<i>Band</i>	<i>Range</i>	<i>Propagation</i>	<i>Application</i>
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite

- Microwaves (6, 7, 10, 15, 18, 23 GHz)
 - Point to Point communication
 - Line of Sight (LOS)
- Satellites (C: 4-8 GHz, Ku: 10-18 GHz, K: 18-26 GHz, Ka: 26-30 GHz)
 - Commonly used for News channels, DTH television broadcast etc.
 - Very expensive
 - Delay in transmission
- Radio waves (300 MHz – 5 GHz)
 - Diversified applications – AM, FM, Mobile communication etc.
 - Used for mass communication
- Infrared (1-100 THz)
 - Remote controls, toys etc.
 - Used for Short distance applications
 - Prone to error

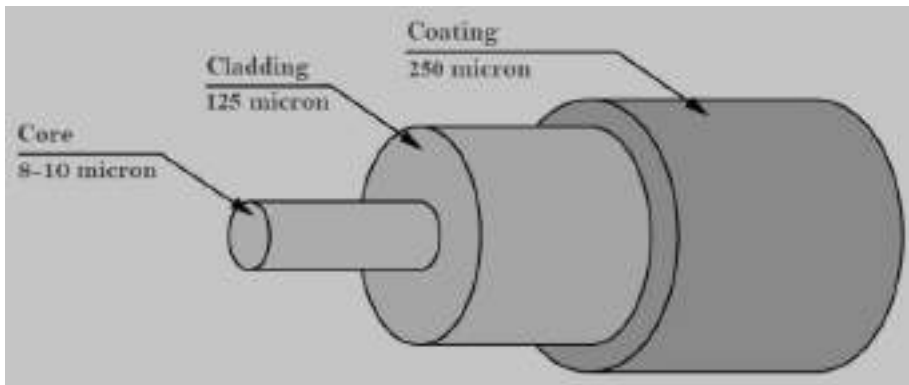
1.2 Geometry of Optical Fiber

Definition of Optical Fiber

Optical Fiber is a composite material, usually consisting of a silica-based core and cladding surrounded by one or two layers of protective polymeric material.



What is Optical Fiber?



- ∅ An optical fiber is a waveguide for light.
- ∅ It consists of a Core and a Cladding that surrounds the core.
- ∅ Works on phenomenon of “Total Internal Reflection”.
- ∅ Light signals are sent down a plastic or glass hair-thin fiber called the Core.
- ∅ Each core is coated with a material called Cladding to prevent light from escaping.
- ∅ The cladding is coated with additional material or a buffer, which protects the fiber from physical damage and moisture.

1.3 Principle of Fiber Optics - Total Internal Reflection

Refractive Index

- ∅ Light travels at 299,792,458 meters per second in vacuum. This speed of light in vacuum is usually denoted by c .
- ∅ But light travels more slowly when it passes through a transparent material.
- ∅ The degree of slowing down depends on the material’s refractive index.
- ∅ Refractive index (n) of a transparent material (denoted by n) is defined as:

$$n = c / v$$

where c is the speed of light in vacuum, v is the speed of light (velocity) in this transparent material.

$$\text{Refractive Index} = \frac{\text{Speed of Light in Vacuum}}{\text{Speed of Light in Medium}}$$

Medium	Refractive Index (Approx.)
Vacuum	1
Water	1.33
Glass	1.5
Plastic	1.3 to 1.6
Diamond	2.42

- ∅ The refractive index of water is 1.33, meaning that light travels 1.33 times as fast in a vacuum than it does in water.
- ∅ The refractive index of air at atmospheric pressure and room temperature is 1.000293.

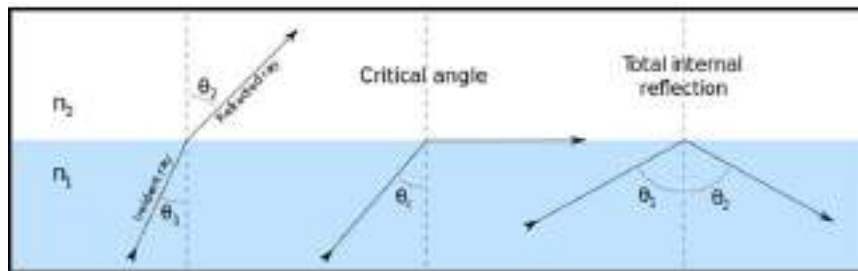
Cladding	n_2
Core	n_1
Cladding	n_2

Clad : Glass with Lower Refractive Index (n_2)
Core : Glass with Higher Refractive Index (n_1)

$$n_1 > n_2$$

In typical optical fiber, the refractive index of the core is 1.68 and the refractive index of clad is 1.44.

- ∅ When light is incident on a medium of lesser Refractive Index, the ray is bent away from the normal i.e. exit angle is greater than the incident angle.
- ∅ On increasing the incident angle, the exit angle will approach 90° . This incident angle is called Critical Angle (θ_c).
- ∅ For all incident angles greater than the critical angle, there will be Total Internal Reflection.



Critical Angle (θ_c) is the largest angle of incidence for which refraction can occur

Total Internal Reflection

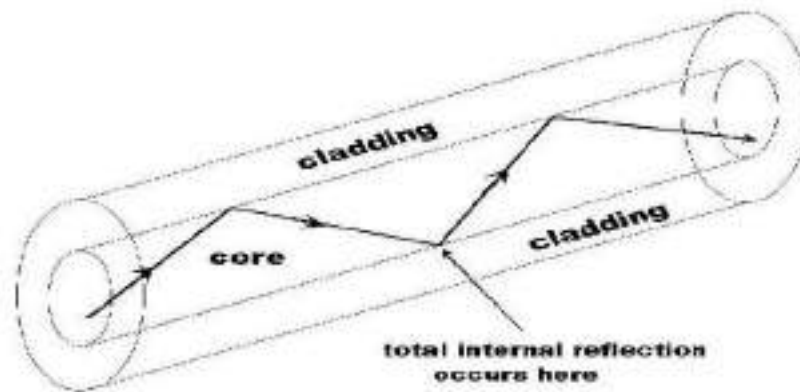
- ∅ There is a critical angle at which no light can be refracted at all, so 100% of the light is reflected.
- ∅ Light is trapped in the water and cannot escape into the air.
- ∅ This works with any dense medium, such as plastic or glass, the same way it works with water



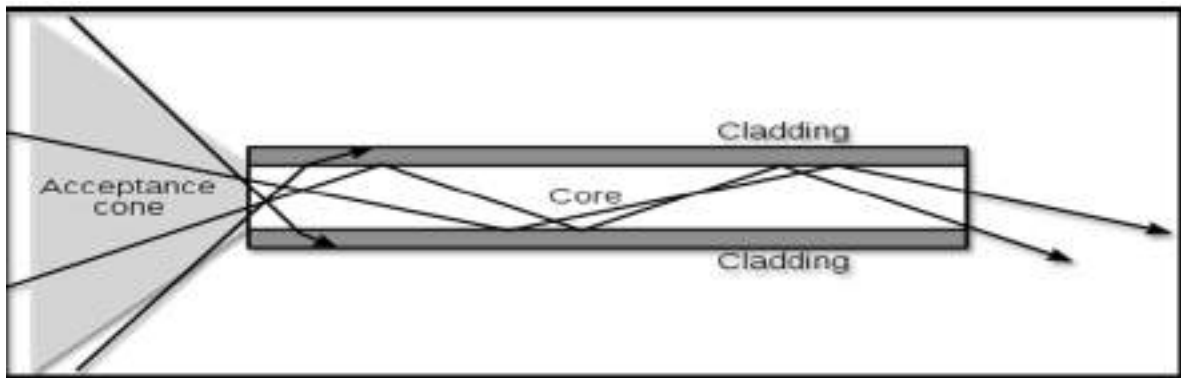
How Light Travels in Fiber

TIR conditions in Optical Fiber:

∅ The index of refraction of Core should be greater than Clad



∅ The angle of incidence of the light ray within the Acceptance Cone must exceed the Critical angle.

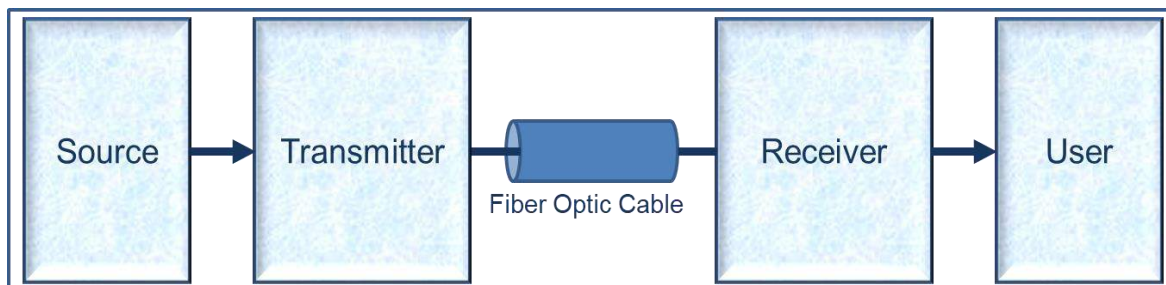


1.4 Optical Fiber Communication System

Typical Communications System

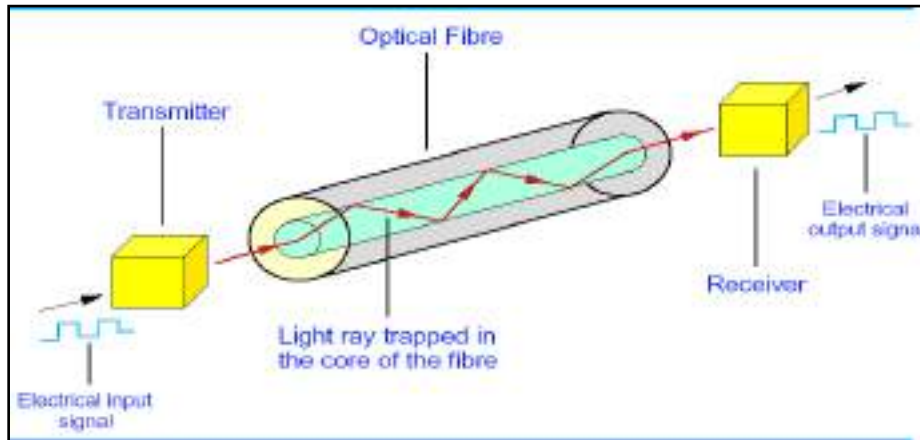
A basic communications system consists of:

- A Transmitter
- A Receiver
- An Information Channel / Optical Fiber



Journey through the “Optical Tunnel”

- ∅ Light-Emitting Diode (LED) or Laser Diode (LD) acts as optical source that converts electrical signal-data rate-into optical signal.
- ∅ Avalanche Photodiode (APD) is generally used as optical detector.



1.5 Applications and Advantages of Optical Fiber Why Optical Fiber?



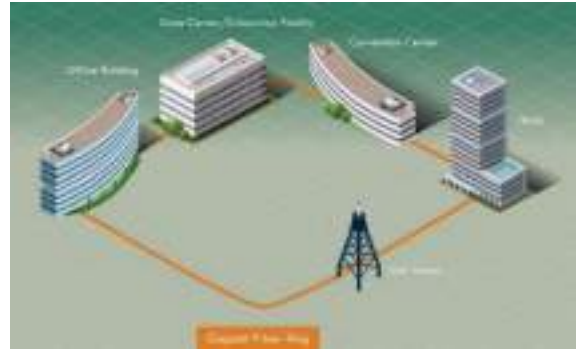
Application of Fiber Optic Communication

- ∅ Telecommunication Networks (Terrestrial and Submarine)
- ∅ Electrical Power Line Communication
- ∅ Fiber To The Home (FTTH)
- ∅ Cable Television
- ∅ Medical Imaging Tools and Surgeries
- ∅ Computer Networking
- ∅ Control Systems





Submarine Cables



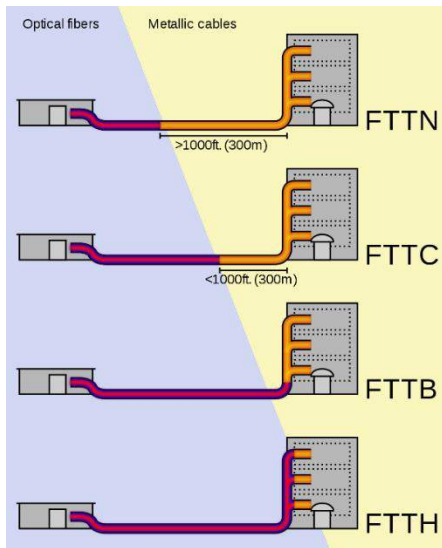
Telecom Network



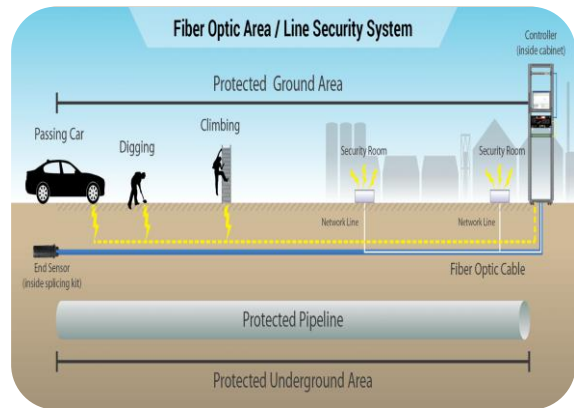
Electrical Power lines Communication



Computer Networking



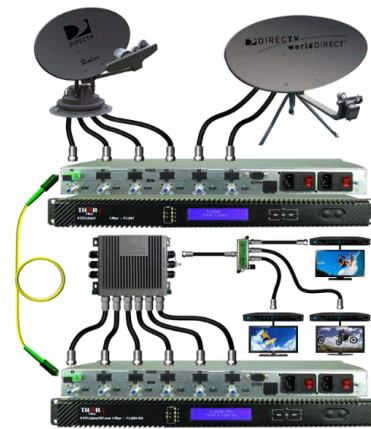
Customer Premise Communications Network



Control Systems



Medical Imaging Tools and Surgery

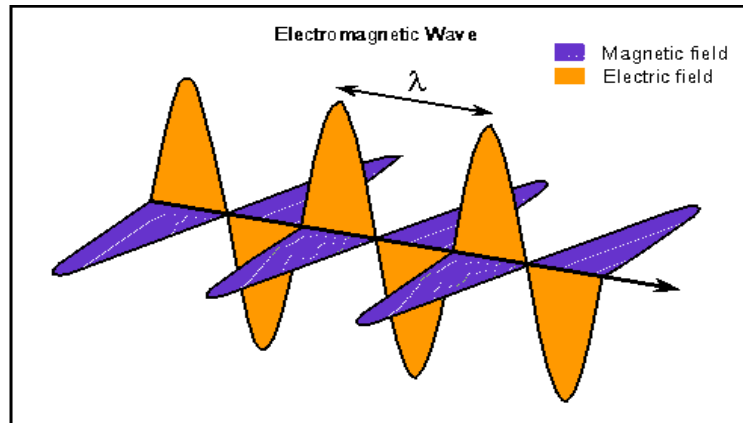


Cable Television

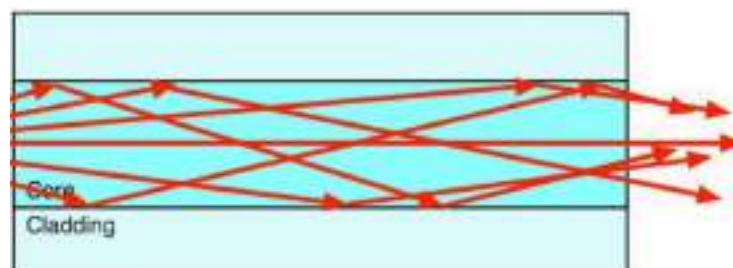
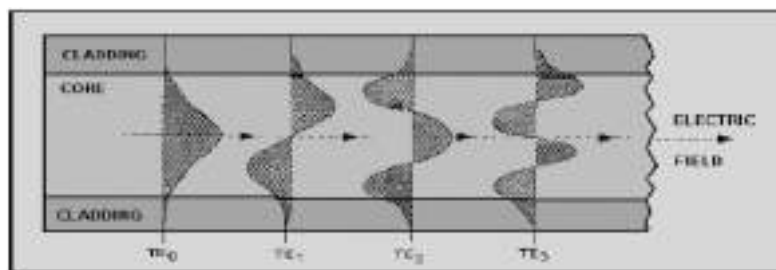
1.6 Mode Theory and Waveguide Equations

Mode Theory

- ∅ The mode theory is used to describe the propagation of light along an optical fiber.
- ∅ The mode theory uses electromagnetic wave behavior to describe the propagation of light in the fiber.
- ∅ A set of guided electromagnetic waves is called the Modes of the fiber.
- ∅ Light as a variety of EM vibrations: Electric and Magnetic field at right angle to each other and perpendicular to direction of propagation.



- ∅ The TE (Transverse Electric) mode field patterns shown in below figure indicate the order of each mode.
- ∅ The order of each mode is indicated by the number of field maxima within the core of the fiber.
- ∅ For example, TE₀ has one field maxima. The electric field is a maximum at the center of the waveguide and decays toward the core cladding boundary.
- ∅ TE₀ is considered the fundamental mode (Single Mode).
- ∅ As the number of field maxima increases, the order of the mode is higher. (In below figure TE₂ has 3 field maxima, that means it has 3 modes (Multimode) are propagating in the fiber.
- ∅ Generally, modes with more than a few (5-10) field maxima are referred to as high-order modes.
- ∅ High-order modes cross the axis of the fiber at steeper angles. Low-order and high-order modes are shown in below figure.



Types of Modes

Fibers can support different types of modes:

- ∅ Guided modes: Light distributions limited to the core and its immediate vicinity. Possess small propagation losses.
- ∅ Leaky Mode: Concentrated around the core but lose some power into the cladding.
- ∅ Cladding modes: Light intensity fill the full cladding region, thus also reaching the outer surface of the cladding, where they often experience large power losses.

In general, the number of guided modes increases with decreasing wavelength

Principle of Waveguiding in Optical Fiber

- ∅ A waveguide is a material structure that can “guide” light, i.e., let it propagate while preventing its expansion in one or two dimensions.
- ∅ Fibers are waveguides that guide in two dimensions and can effectively be used as flexible pipes for light.

Numerical Aperture

- ∅ Total internal reflection at the interface occurs, if the external beam angle θ (in air) fulfills the condition:

$$\sin \theta < NA \equiv \sqrt{n_{\text{core}}^2 - n_{\text{cladding}}^2}$$

- ∅ Where, NA is called the numerical aperture of the fiber and n is refractive index of the material

V Number

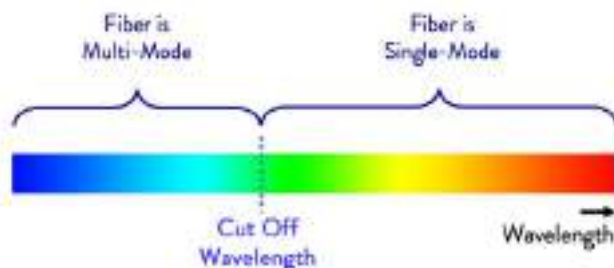
$$V = \frac{2\pi}{\lambda} a NA = \frac{2\pi}{\lambda} a \sqrt{n_{\text{core}}^2 - n_{\text{cladding}}^2}$$

The V number determines the number of guided modes in fiber at different wavelengths and refractive index of the fiber.

- For example, single-mode propagation is obtained when V is smaller than 2.405.
- The V number depends on the wavelength.

Cut-Off Wavelength

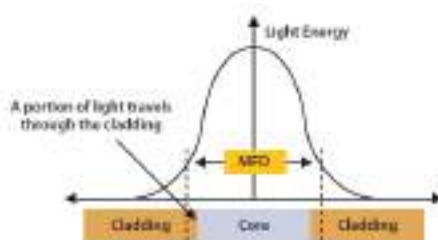
- ∅ The cut-off wavelength of a single mode fiber is the wavelength below which the fiber propagates more than modes.
- ∅ Above cut-off, the fiber will transmit only one mode.
- ∅ An optical fiber that is single-moded at a particular wavelength may have two or more modes at wavelengths lower than the cutoff wavelength.



- ∅ The effective cutoff wavelength of a fiber is dependent on the length of fiber and its deployment and the longer the fiber, the lower the effective cutoff wavelength.
- ∅ The smaller the bend radius of a loop of the fiber is, the lower the effective cutoff wavelength will be.
- ∅ If a fiber is bent in a loop, the cutoff is lowered.
- ∅ The cutoff wavelength of a fiber is reduced when it is cabled.

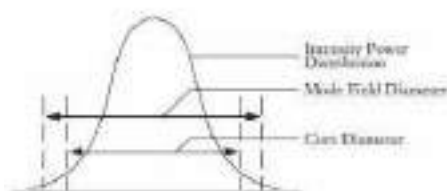
Mode Field Diameter

- ∅ The mode field diameter (MFD) describes the width of the fiber area in which light travels.



The mode field diameter (MFD) of singlemode fiber

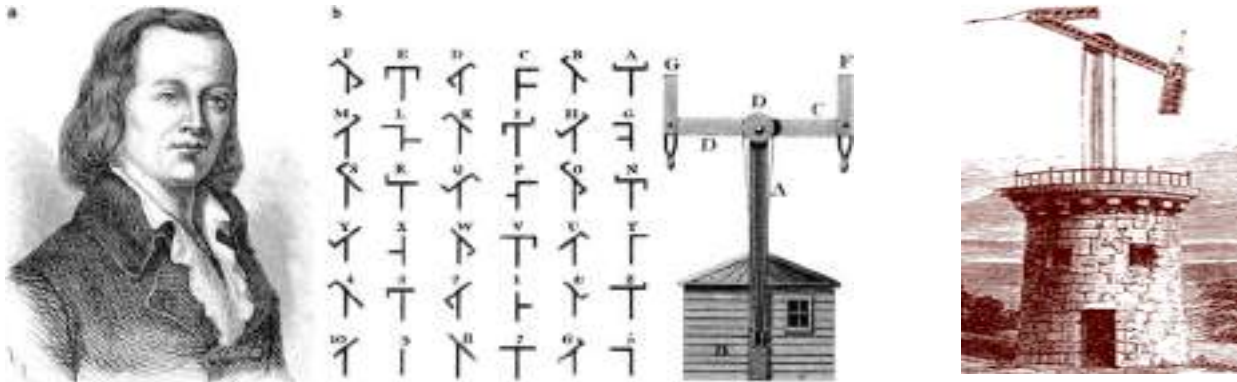
- ∅ MFD is determined by the numerical aperture (NA) and cut-off wavelength of the fiber and is related to the diameter of the fiber core.
- ∅ In general, MFD is greater than the physical diameter of the fiber core - which means that some optical power travels in the fiber cladding.
- ∅ The MFD is typically larger than the core diameter.
- ∅ For fiber operated above cut-off wavelength, the core diameter might be around 9 μm , and the MFD is around 10.4 μm .
- ∅ From these equations, you can see that MFD increases as cut-off wavelength increases (as does core-size).



1.7 History of Optical Fiber Communication

1790 – Use of Semaphores

- ∅ The french used semaphores to transmit messages.
- ∅ Later systems also sent optical signals through the air, but clouds, rain, and other atmospheric disturbances can disrupt optical signals sent through the air.



Claude Chappe, his coding scheme and the mechanical device used for making optical telegraphs

1841 – Total Internal Reflection

Jean-Daniel Colladon, a 38-year-old Swiss professor at University of Geneva, demonstrated light guiding or TIR for the first time.

1854 – Refraction through stream of water

- ∅ John Tyndall demonstrated first guided transmission of light.
- ∅ He used basin with hole in bottom to direct stream of water.
- ∅ Sunlight was refracted through the stream of water.



John Tyndall

1880 - Photophone

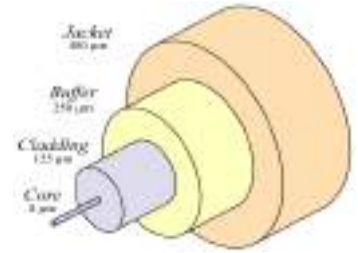
- ∅ Alexander Graham Bell Invented the photophone, a device to carry voice signals through the air instead of wires. He transmitted a voice signal on a single beam of light.



Alexander Graham Bell with his Photophone

1920 - Television images through transparent pipes

- Ø John Logie Baird (England) and Clarence W. Hansell (U.S.) demonstrated a method to carry television images through transparent pipes.
- Ø Images were transmitted in 1933.
- Ø It was a very short distance, but the quality was very, very low.



1954 – Fiber With Cladding

- Ø Abraham Van Heel, Hopkins & Kapany invented modern optical fiber by covering a bare glass fiber with a transparent coating, later called cladding. It had a lower refractive index than the bare fiber. The result was that the light was contained in the fiber and did not leak out.
- Ø The bundle, which the authors called the Fibroscope, had several hundred fibers of 75 cm in length. It Reduces cross-talk from fibers in bundles.
- Ø Kapany coined the term fiber optics, wrote a 1960 article in Scientific American that introduced the topic to a wide audience, and wrote the first book about the new field.



Dr. Narinder Singh Kapany

1960 - Medial Imaging Invention of the Laser Fiberscope

- Ø Fibroscope allowed inspection of boilers and medical imaging. Glass-clad fibers were now available for medical instruments, to look inside the body.
- Ø The glass was unable to transmit light far enough for communications, because of impurities.
- Ø Optical Fibers had losses of 1 dB/meter.

1965 – First working fiber-optic data transmission system

The first working fiber-optic data transmission system was demonstrated by German physicist Manfred Börner at Telefunken Research Labs in Ulm.



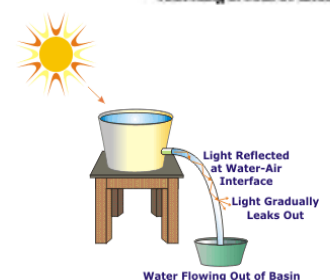
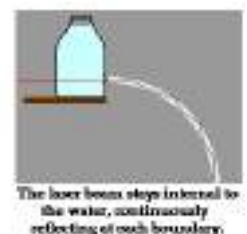
Manfred Börner

1966 – Higher bit rate transmission

- Ø Charles K. Kao proposed that communications were possible with single mode fiber.
- Ø He correctly and systematically theorized the light-loss properties for optical fiber and pointed out the right material to use for such fibers, that is, silica glass with high purity.
- Ø He developed a fiber that could transmit 1 GHz (One billion bits per second).
- Ø Attenuation of less than 20 dB/km was possible with optical fiber.
- Ø This discovery earned Kao the Nobel Prize in Physics in 2009.



Charles K. Kao



1968 – Fiber optics in the television cameras

NASA used fiber optics in the television cameras that were sent to the moon.

1970 – Low-attenuation silica glass fibers

- Ø Corning scientists developed low-attenuation silica glass fibers.
- Ø They used Single mode fiber at 633 nm wavelength.
- Ø Attenuation was below 20 dB/km.

1977 – First metropolitan fiber optic cable deployment with repeaters

- Ø The first metropolitan fiber optic cable being deployed in Turin, Italy in 1977 by Italian research center, CSELT working with Corning.
- Ø Telephone signals used infrared light with a wavelength of 850 nm to send data at 6.2 Mbps and 45 Mbps. Loss was 2 dB per km.
- Ø Repeaters were required every few kilometers. The repeaters were electro-optical – converting the light to electricity and then back to light.



1986 – Fiber Amplifiers

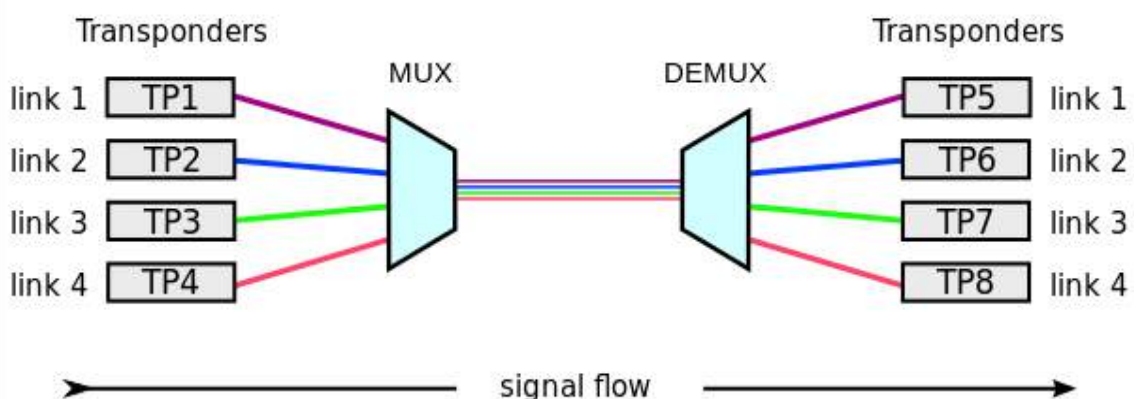
- Ø Fiber was replacing the copper, microwave and satellite links.
- Ø The erbium-doped fiber amplifier, which reduced the cost of long-distance fiber systems by reducing or eliminating optical-electrical-optical repeaters, was developed at Bell Laboratory.
- Ø Fiber amplifier amplifies light without changing it to an electrical signal first.

1992 – Lower attenuation systems

- Ø 1550 nm systems appear for the first time.
- Ø Fiber attenuation now at 0.2 dB/km at 1550 nm.
- Ø Community antenna television (CATV) CATV started using fiber to enhance the reliability of their networks.
- Ø CATV companies also discovered they could offer phone and Internet service on that same fiber and greatly enlarged their markets.

1994 – Wave Division Multiplexing

Several signals can be sent through the same fiber simultaneously by using different wavelengths (colors) of light. That means, more bandwidth—more data per second.



1996 - The Internet boom begins

- ∅ Dense Wave Division Multiplexing (DWDM) systems become widely available.
- ∅ Some systems have an aggregate capacity of 10 Gb/second.
- ∅ Optical fiber is placed in the ground at phenomenal rates.
- ∅ Digital Subscriber Lines become available at much faster rates than dial-up connections.
- ∅ Dot.com boom shows no signs of stopping.

1980

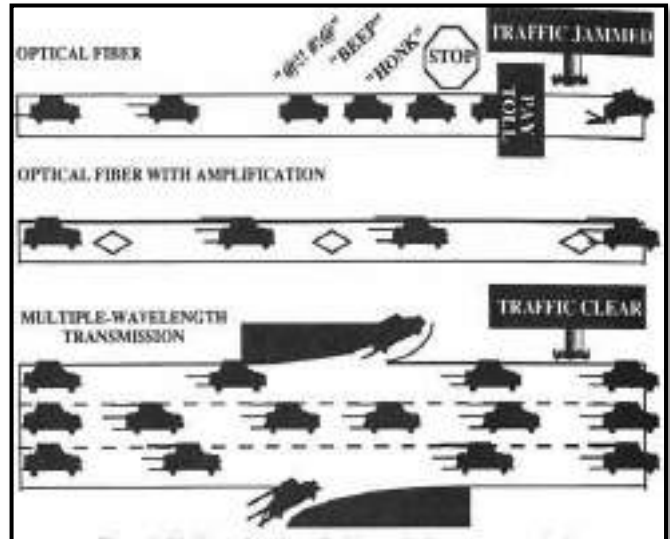
- 565 Mbps
- Electro-optical repeaters

1996

- 2.5 Gbps
- Optical amplifiers

1998

- 20 Gbps
- WDM with 8 wavelengths



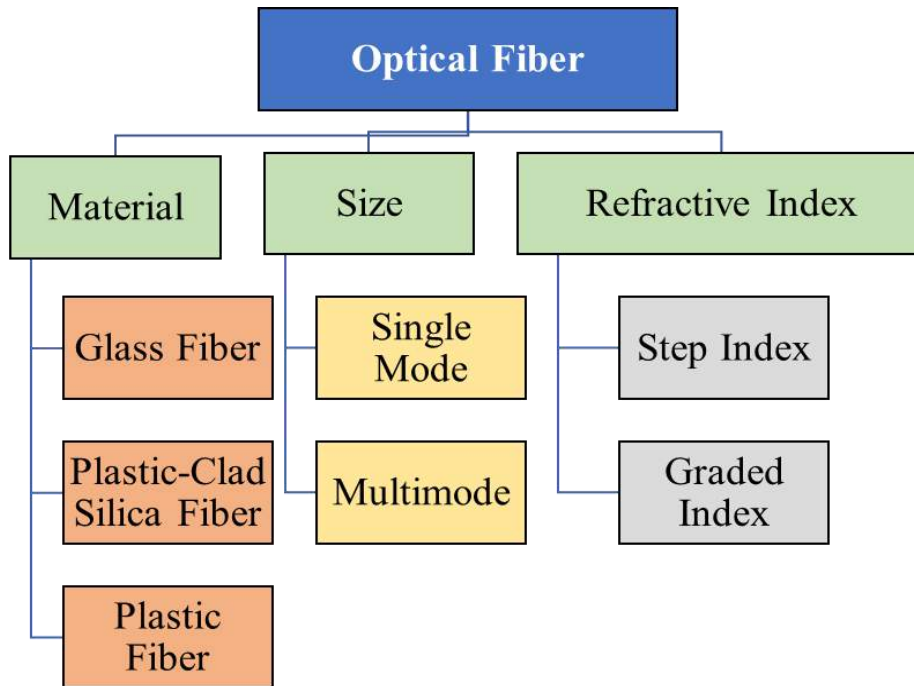
2000 - Photonic crystal fibers

- ∅ The field of photonic crystals led to the development in 1991, which guides light by diffraction from a periodic structure, rather than by total internal reflection. The first photonic crystal fibers became commercially available in 2000.
- ∅ Photonic crystal fibers can carry higher power than conventional fibers and their wavelength-dependent properties can be manipulated to improve performance.

2022 - 100s of Gbps

- ∅ Today, fiber is present in virtually every nation on the Earth, forming the absolute backbone of the modern communications infrastructure.
- ∅ Attenuation in modern optical cables is far less than in electrical copper cables, leading to long-haul fiber connections with repeater distances of 70–150 kilometers. Maximum data rates achieved are in 100s of Gbps with minimum attenuation of 0.2 dB per km in long distance communication.

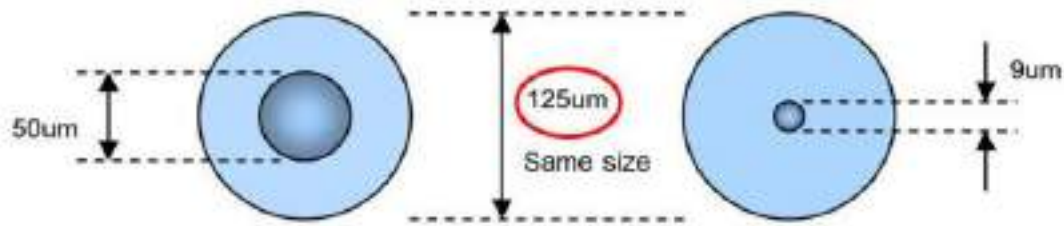
1.8 Classification of Optical Fiber



Classification According to Material

	<p>Glass Optical Fiber (GOF) Core- Silica Clad- Silica ò Used in long haul links ò Lower transmission loss ò More prone to damage</p>
	<p>Plastic Clad-Silica Fiber (PCSF) Core - Silica Clad- Plastic ò Used in short haul links ò Higher transmission losses ò Industrial, medical or sensing applications</p>
	<p>Plastic Optical Fiber (POF) Core - Plastic Clad- Plastic ò Used in indoor links and decoration ò Higher transmission losses ò Robust under bending and stretching</p>

Classification According to Size



- ∅ Mode is a path for light ray through an optical fiber.
- ∅ If an optical fiber supports only one mode, it is called as single mode fiber. Multimode supports more than one mode.

Multi-mode Fiber

- ∅ Multi-mode Fiber are characterized by relatively large core diameters.
- ∅ Typical values of core diameters are 50 and 62.5 micrometers
- ∅ A multi-mode fiber supports more than one propagating mode.

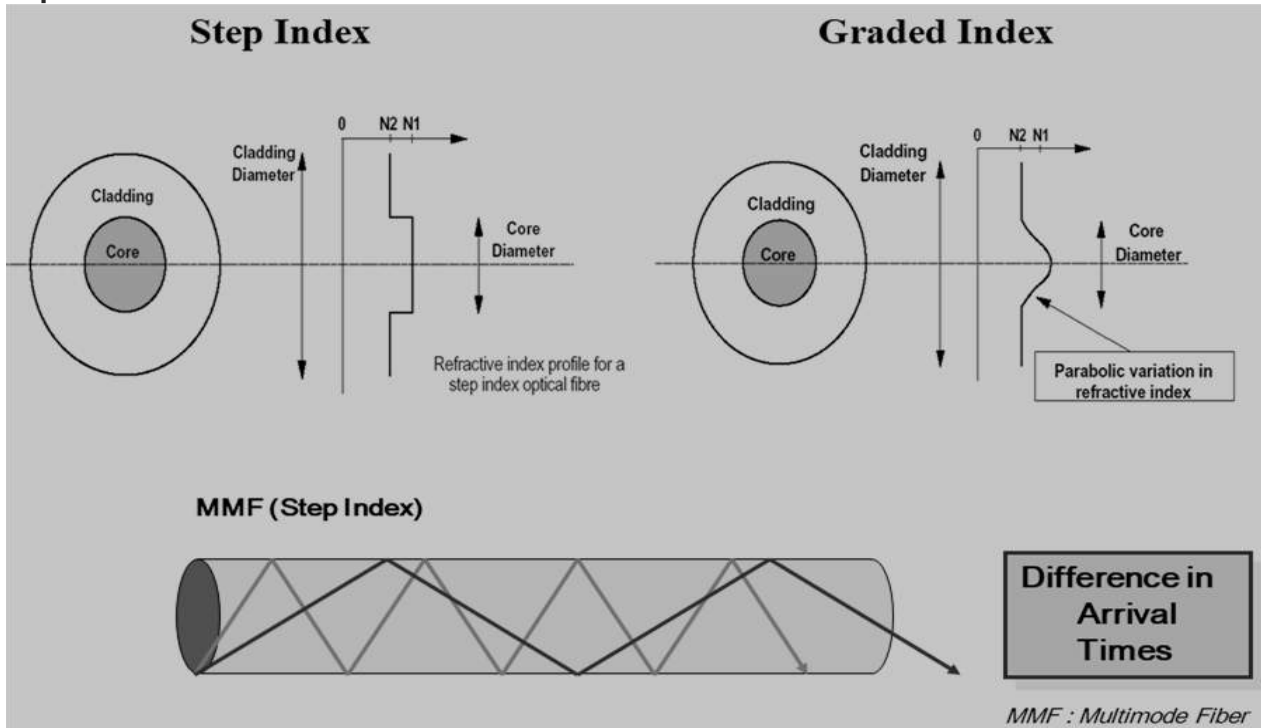
Single Mode Fiber

- ∅ Single Mode Fiber supports only a single propagating mode.
- ∅ It is characterized by small core diameters ranging from 3 to 10 micrometers.
- ∅ For the purpose of understanding the concept we shall define the mode simply as a path that a light ray can follow in traveling down a fiber.

Multimode Fiber	Single-mode Fiber
Large Core Diameter	Small Core Diameter
More Light Modes	Single Light Mode
High Loss	Low Loss
Used in Short Distance Links	Used in Long Distance Links

Classification According to Refractive Index

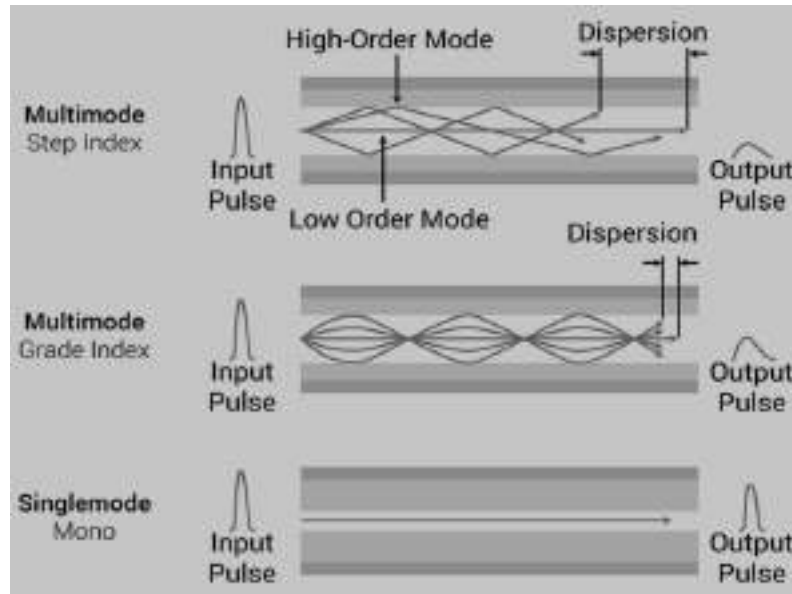
Step-Index Fiber



- ∅ In step-index fibers, the index of refraction changes radically between the core and the cladding.
- ∅ The step-index fiber is characterized by a uniform index throughout the core material.
- ∅ The profile shows a sharp step at the junction of the core and cladding.
- ∅ The step index fiber gets its name from the step like index profile of the core.
- ∅ The transmission capacity is limited by the modal dispersions (different modes travel through the fiber with different delays, causing signal distortion).
- ∅ Step-index fibers are available with core diameters of 100 to 1500 μm . They are well suited to applications requiring high power densities, such as medical and industrial laser power delivery.

Graded Index Fiber

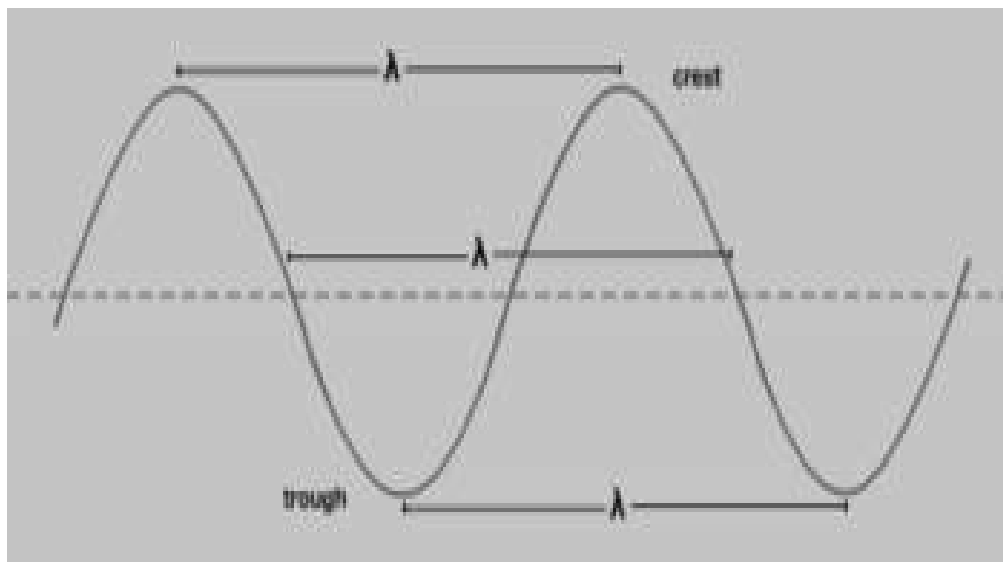
- ∅ In contrast, the graded index has a non-uniform core.
- ∅ Graded-index fiber is a compromise multimode fiber, but the index of refraction gradually decreases away from the center of the core
- ∅ Graded-index fiber has less dispersion than a multimode step-index fiber.
- ∅ Graded Index Profile can only be designed for Multimode Fibers
- ∅ The index is highest at the centre and it gradually decreases until it matches that of the cladding.
- ∅ In graded index fiber, the light rays are also guided down the fiber in multiple pathways.
- ∅ Due to the parabolic refractive index profile, modal dispersion is reduced to minimum (different modes propagate through the fiber with the same delay).
- ∅ The modal dispersion can be reduced by using graded-index fiber.
- ∅ The graded-index (or GRIN) fiber has a core material whose refractive index varies with distance from the fiber axis.
- ∅ Index is maximum at the core center and decreases gradually towards the core-cladding interface.
- ∅ Those rays that follow the longest path by travelling near the outside of the core, have a faster average velocity.
- ∅ The light travelling near the axis of the core has the slowest average velocity.
- ∅ As a result of this, all rays tend to reach the end of the fiber at the same time.



1.9 Optical Fiber Communication Wavelengths

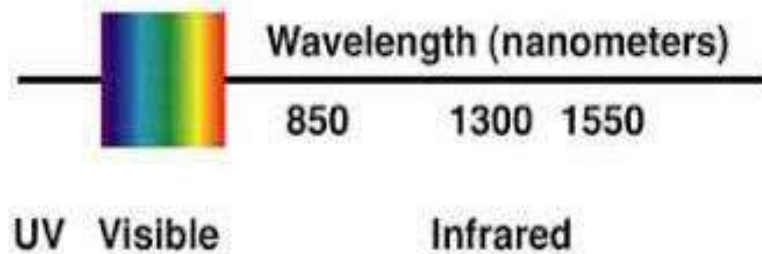
Wavelength

- ∅ Wavelength is the distance between two nearest amplitude positive peaks.
- ∅ The amplitude rises from 0 to a positive peak, goes through 0, goes to negative peak, then returns back to 0.
- ∅ This is a complete cycle and the distance light travels during this cycle is called a wavelength.
- ∅ It is usually represented by the symbol λ and defined in Nanometers (nm).

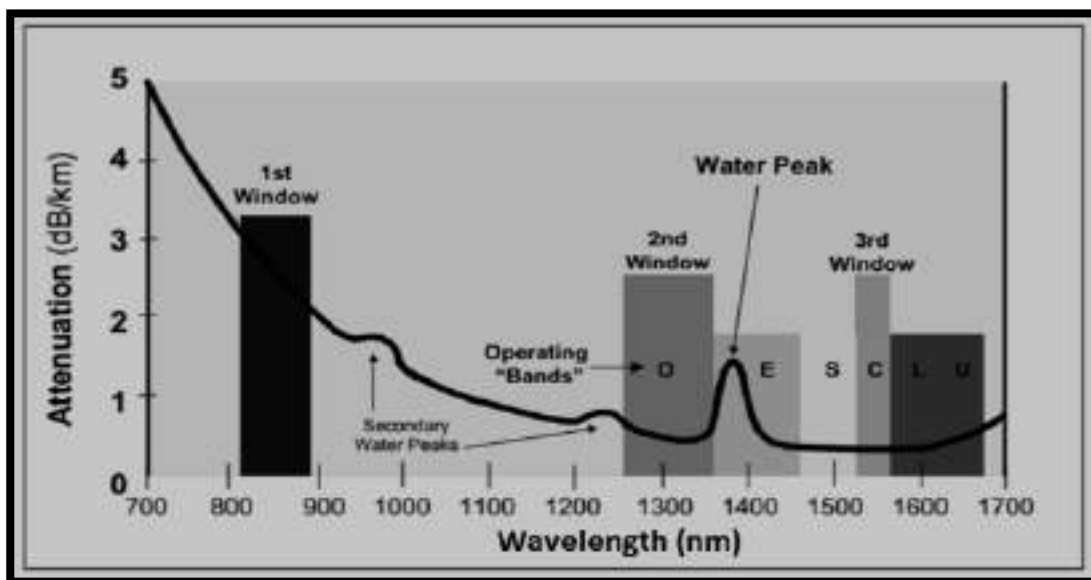


Optical Fiber Spectral Bands

- ∅ Our eyes are sensitive to light whose wavelength is in the range of about 400 nm to 700 nm, from the violet to the red.
- ∅ For fiber optics with glass fibers, we use light in the infrared region which has wavelengths longer than visible light.
- ∅ The 850-nm-band is the primary wavelength for multimode fiber optical communication systems



- ∅ The three main wavelengths used for fiber optic transmission are 850, 1310 and 1550 nanometers.
- ∅ These wavelengths are used in fiber optics because they have the lowest attenuation of the fiber.
- ∅ Multimode fiber is designed to operate at 850 nm and 1300 nm, while single-mode fiber is optimized for 1310 nm and 1550 nm.



Band	Wavelength (nm) Range
O – Original	1260-1360
E – Extended	1360-1460
S – Short Wavelength	1460-1530
C – Conventional	1530-1565
L – Long Wavelength	1565-1625
U – Ultra Long Wavelength	1625-1675

1.10 Attenuation in Optical Fiber

Decibel (dB)

- ∅ A decibel (dB) is a unit used to express relative differences in signal strength.
- ∅ Decibel is a logarithmic scale of power abbreviated as dB.

$$dB = 10 \log \left(\frac{\text{Measured Power}}{\text{Reference Power}} \right)$$

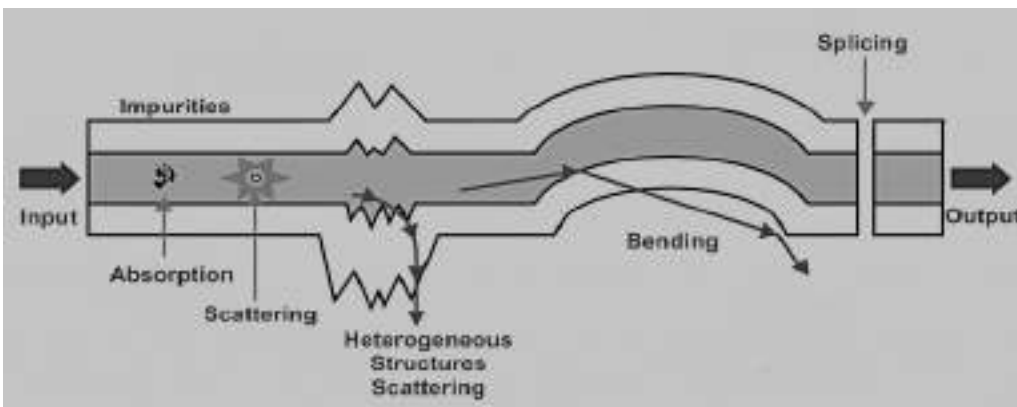
- ∅ In the case of fiber optic cable, we compare the power injected (reference power) at one end of the cable to the power received (measured power) at the other end.
- ∅ A loss of 10 decibels means only 10% of the light is received.
- ∅ A loss of 20 dB means 1% of the light is received.

Attenuation

- ∅ Attenuation is the loss of optical power as light travels along the fiber. It is expressed in dB (decibel).
- ∅ Attenuation in an optical fiber is caused by:
 - Absorption
 - Scattering
 - Bending

- ∅ If the optical power injected was -20 dBm and the power received at the other end -21 dBm, then the attenuation of the link would be $-20 - (-21) = 1$ dB

Signal attenuation is defined as the ratio of optical input power (P_i) to the optical output power (P_o). Optical input power is the power injected into the fiber from an optical source. Optical output power is



the power received at the fiber end or optical detector.

One cause of attenuation is through something called absorption. Light signals can be lost through absorption by

small amounts of water vapor, or trace metals, present in the glass. The most absorption takes place in specific wavelengths, known as water bands. In between the water bands are windows where the wavelengths have the least attenuation. It just so happens that these wavelengths are also ideal for building transmission lasers and signal detectors.

The attenuation of glass optical fiber is caused by two factors: absorption and scattering. Absorption occurs in several specific wavelengths called water bands due to the absorption by minute amounts of water vapor in the glass. Scattering is caused by light bouncing off atoms or molecules in the glass.

3dB Power Loss

∅ If light travels over 12 km of optical fiber with loss of 0.25 dB/km, what is the total loss?

3 dB

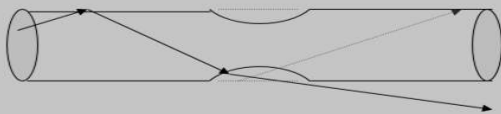
∅ On 3 dB loss in signal, the optical power is reduced by **Half**.



Fiber Bending

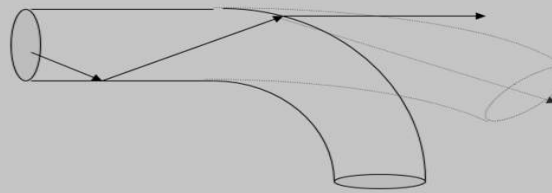
Micro Bending

Deformation of fiber axis (axial \ distortion) during fiber and cable manufacturing causes light to couple out of the fiber.



Macro Bending

Loss due to excessive bending manually.



Bends are bad for Single Transmission. Small Bends can increase loss. Bending the fiber also causes attenuation. Bending loss is classified according to the bend radius of curvature: microbend loss or macrobend loss. Microbends are small microscopic bends of the fiber axis that occur mainly when a fiber is cabled. Macrobends are bends having a large radius of curvature relative to the fiber diameter. Microbend and macrobend losses are very important loss mechanisms. Fiber loss caused by microbending can still occur even if the fiber is cabled correctly. During installation, if fibers are bent too sharply, macrobend losses will occur.

Microbend losses are caused by small discontinuities or imperfections in the fiber. Uneven coating applications and improper cabling procedures increase microbend loss.

External forces are also a source of microbends. An external force deforms the cabled jacket surrounding the fiber but causes only a small bend in the fiber. Microbends change the path that propagating modes take, as shown in figure 2-24. Microbend loss increases attenuation because low-order modes become coupled with high-order modes that are naturally lossy.

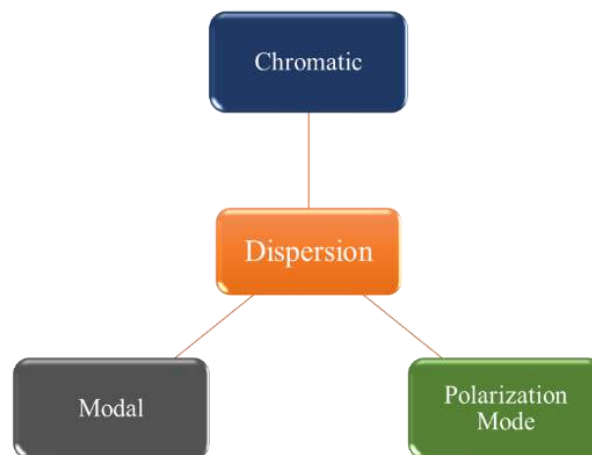
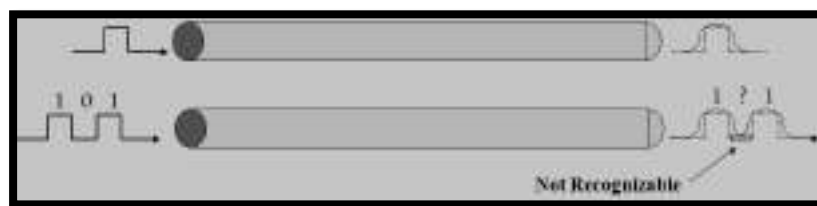
Macrobend losses are observed when a fiber bend's radius of curvature is large compared to the fiber diameter. These bends become a great source of loss when the radius of curvature is less than several centimeters. Light propagating at the inner side of the bend travels a shorter distance than that on the outer side. To maintain the phase of the light wave, the mode phase velocity must increase. When the fiber bend is less than some critical radius, the mode phase velocity must increase to a speed greater than the speed of light. However, it is impossible to exceed the speed of light.

This condition causes some of the light within the fiber to be converted to high-order modes. These high-order modes are then lost or radiated out of the fiber.

Fiber sensitivity to bending losses can be reduced. If the refractive index of the core is increased, then fiber sensitivity decreases. Sensitivity also decreases as the diameter of the overall fiber increases. However, increases in the fiber core diameter increase fiber sensitivity. Fibers with larger core size propagate more modes. These additional modes tend to be more lossy.

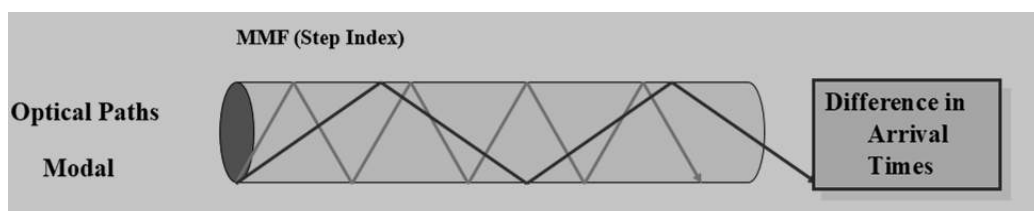
1.11 Dispersion in Optical Fiber

- ∅ Dispersion is the spreading or broadening (distortion) of light pulses as they propagate through the fiber.
- ∅ Too much dispersion gives rise to bit-errors at the receiver (i.e., the inability to distinguish a 0 from a 1).



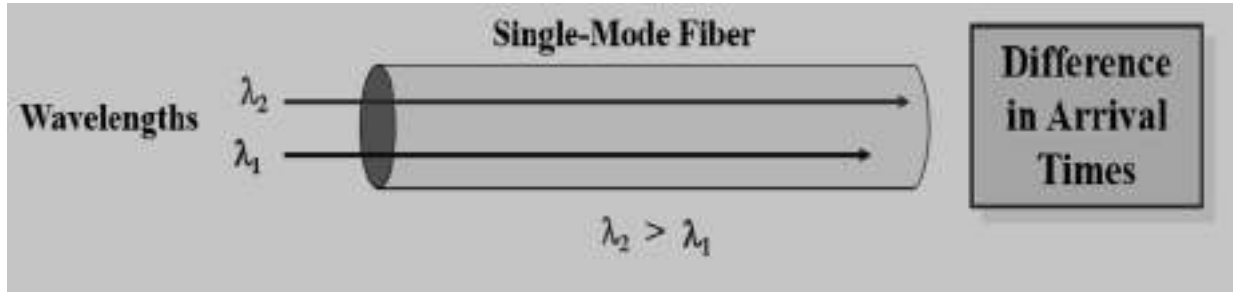
Modal Dispersion

- ∅ Dispersion caused due to different paths the light rays take to travel from one end to the other.
- ∅ This is prominent in Multimode Fibers.



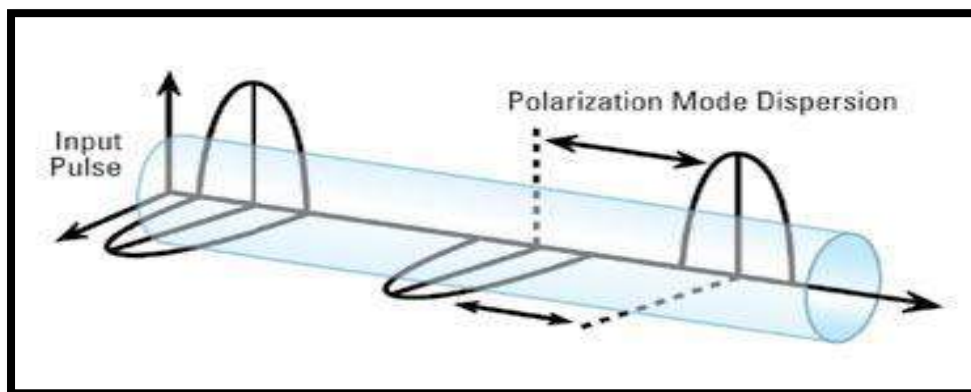
Chromatic Dispersion

- ∅ Dispersion caused due to the variation in velocities of different wavelength w.r.t. the refractive index of the material.
- ∅ This is prominent in Singlemode Fibers.



Polarization Mode Dispersion

- ∅ PMD effect occurs due to:
 - Asymmetry in Fiber Geometry
 - Mishandling of Fiber
 - Environmental Conditions
- ∅ PMD is troublesome and affects High Data Rate Channel



Polarization mode dispersion (PMD) is a form of modal dispersion where two different polarizations of light in a waveguide, which normally travel at the same speed, travel at different speeds due to random imperfections and asymmetries, causing random spreading of optical pulses.

1.12 Grades of Optical Fiber

Optical Fiber Grades

- ∅ International Telecommunication Union - Telecommunication (ITU-T) is responsible for developing new standards and revising existing standards of telecommunications and Information Communication Technology (ICTs) on a worldwide basis.
- ∅ The international standards that are produced by the ITU-T are referred to as "Recommendations", as they become mandatory only when adopted as part of a national law.
- ∅ ITU-T optical fiber grades, describe the geometrical properties and transmissive properties of multimode and single-mode optical fiber.

Fiber Grade	Characteristics	Applications
G. 651.1	<ul style="list-style-type: none"> • Graded-index multimode fiber • Wavelength - 850nm and 1300nm 	Fiber to The Home and other Indoor Applications
G. 652D	<ul style="list-style-type: none"> • Zero-dispersion at 1310 nm • Lower attenuation at 1550 nm 	Public Network (Both Short and Long Distance)
G. 653 (Dispersion Shifted Fiber)	<ul style="list-style-type: none"> • Zero-dispersion at 1550 nm with minimum attenuation • Lower attenuation at 1550 nm 	Long Distance Submarine & Terrestrial Networks
G. 654	<ul style="list-style-type: none"> • Zero-dispersion at 1310 nm with minimized loss • Lower attenuation at 1550 nm 	Long Distance Submarine & Terrestrial Networks
G. 655 (Non-zero Dispersion Shifted Fiber)	<ul style="list-style-type: none"> • Performance specified at 1550 nm and 1625 nm • Chromatic dispersion is less at 1550nm 	WDM and Long Distance Systems
G. 656	<ul style="list-style-type: none"> • Attenuation is low at 1460nm -1625nm • Not suitable for 1460nm to 1530nm wavelengths 	WDM Systems
G. 657	<ul style="list-style-type: none"> • Bend-insensitive single-mode fiber • Bend Radius of G675A < G657B 	Fiber to The Home and other Indoor Applications

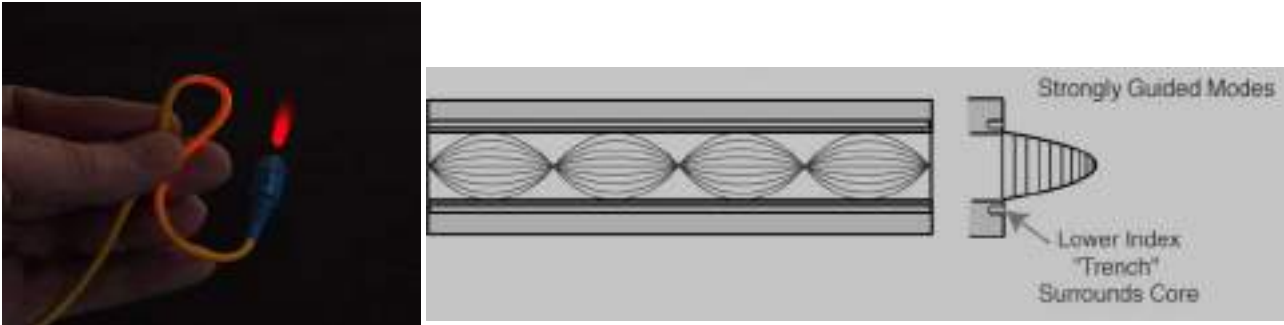
G652D and G655 Losses and Dispersion

Attributes	Wavelength (nm)	Fiber Grade	
		G652D	G655
Attenuation (dB/km)	1310	≤ 0.36	Doesn't Support*
	1550	≤ 0.22	≤ 0.24
	1625	≤ 0.25	≤ 0.26
Chromatic Dispersion (ps / (nm x km))	1310	≤ 3.5	Doesn't Support*
	1550	≤ 18	2 – 6
	1625	≤ 22	4.5 –11

Below 1450nm, G655 Single-mode fiber behaves like Multimode Fiber

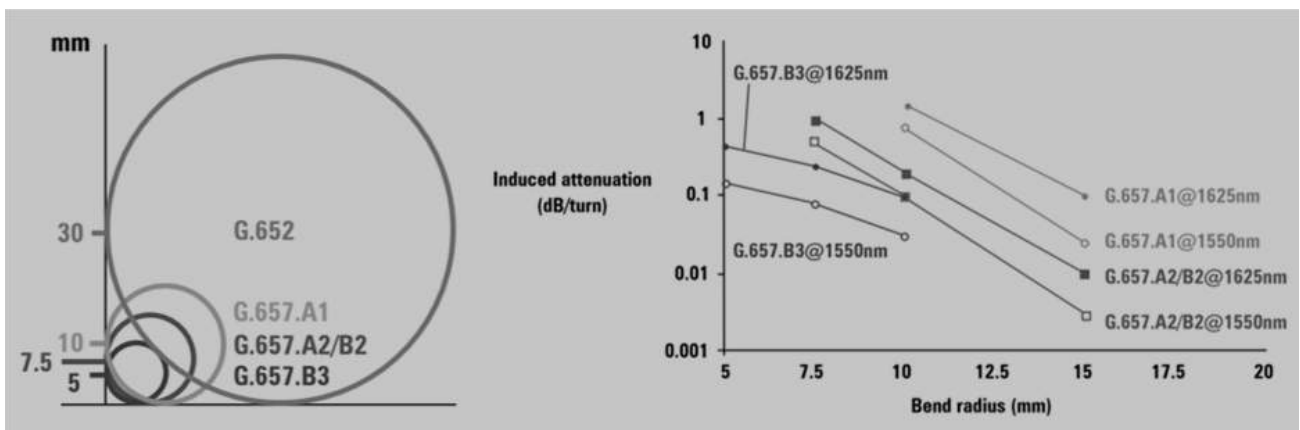
1.13 Bend Insensitive Fibers(G.657)

- Ø Optical fiber is sensitive to stress, particularly bending. When stressed by bending, light in the outer part of the core is no longer guided in the core of the fiber so some is lost, coupled from the core into the cladding, creating a higher loss in the stressed section of the fiber.
- Ø Bend-insensitive fiber adds a layer of glass around the core of the fiber which has a lower index of refraction that lost light back into the core.
- Ø An optical "trench" - a ring of lower index of refraction material than core and higher than clad reflects the lost light back into the core.



- Ø Bend-insensitive single-mode fibers used for access networks and customer premises.
- Ø ITU-T G.657 optical fiber cable offers flexible characteristics for easier deployment in streets, buildings and homes.
- Ø Increased flexibility in optical fiber cables, allowing improved installation in tight corners of buildings.

G.657 Fiber Category	Application	Sub-categories	Minimum specified bending radii
Category A	Access networks (Short distance Outside Building)	A1	10 mm
		A2	7.5 mm
Category B	Short distances at the end of access networks in bending-rich environments (e.g., buildings)	B2	7.5 mm
		B3	5 mm



- Ø G.657.A1 and G.657.A2 fibres are fully compliant with G.652.D fibers. *Compliance here means adherence to the referenced Recommendation (G.652, category D) meeting or exceeding the values of the specified attributes.*
- Ø G.657.B2 and G.657.B3 fibres are fully compatible with G.652.D fibres. *(only small differences in chromatic dispersion and polarization mode dispersion (PMD)).*

Optical Fiber Grades – Comparison

- Ø G.651.1, G.657A, and G.657B all define bend-insensitive fibers made for FTTH systems. However, G.651.1 multimode fiber has higher data rates for short-distance communications.
- Ø G.657A fiber is backward compatible with the existing G.652D fiber.
- Ø A full installation is needed when deploying G.651.1 and G.657B fibers, thereby an increase in cost.
- Ø The advantage of G.657B fiber is its superior bend-insensitivity.
- Ø G.652D, G.655, and G.656 fibers support either CWDM or DWDM systems, each fiber has its weaknesses and strengths in long-haul transmission.
- Ø G.655 fiber has low chromatic dispersion and supports long-haul systems that use CWDM in the wavelength range from 1550 nm to 1625 nm.

Section 3: Exercises

Exercise 1: Match the Column

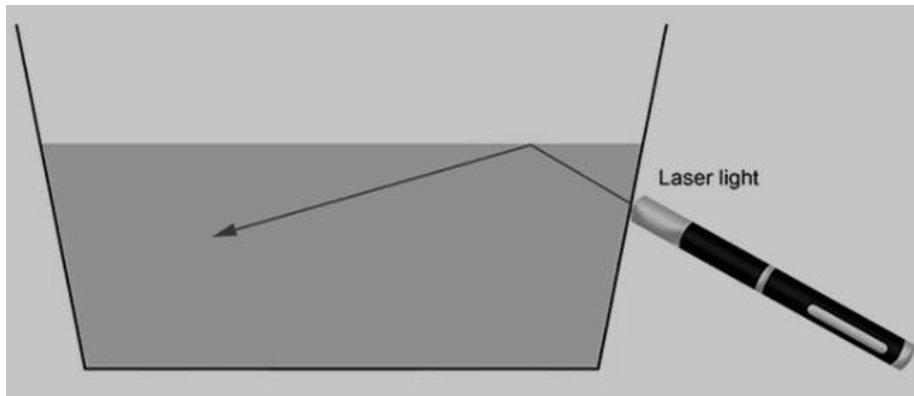
Exercise 2: On a plain paper, make a chart showing classification of transmission media.

Exercise 3: Perform experiment of Total Internal Reflection Phenomenon.

Match the Column		
A	Optical wavelength band that offers lower optical power loss	1
B	Principle on which optical fiber works	2
C	Type of fiber suitable for long haul links (On the basis of mode of fiber)	3
D	Dispersion that occurs due to difference in wavelength of signals	4
E	The typical loss/km in fiber at 1310nm	5
F	Dispersion caused due to different paths the light rays take to travel	6
G	Optical fiber suitable for WDM Channel transmission	7
H	Optical wavelength band that has Zero dispersion	8
I	Diameter of core of the singlemode fiber	9
J	Diameter of core of the multimode fiber	10
K	The typical loss/km in fiber at 1550nm	11
L	Dispersion that takes place due to separation of EM field components	12
M	Fiber bending results in	13
N	Optical source used in fiber optic communication	14
O	Optical receiver used in fiber optic communication	15
P	Optical spectral band that has greater sensitivity to fiber stress and bending	16

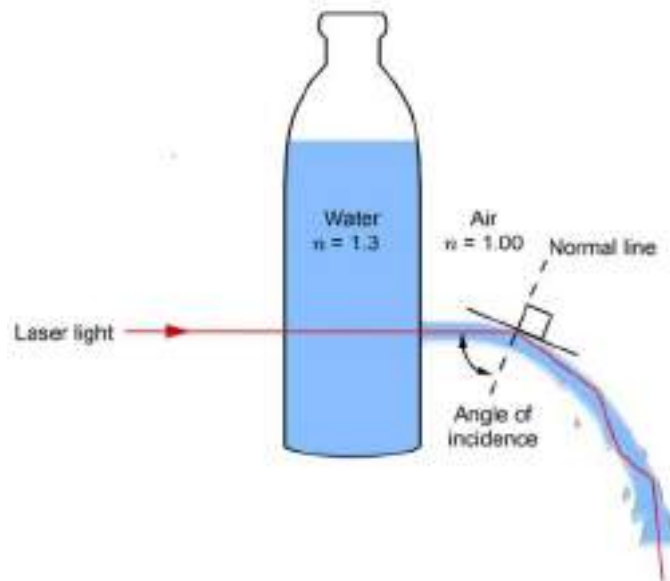
a) Tank of water

Fill a perspex tank with water. Angle a directed ray of light to the underneath of the surface and total internal reflection can be seen (it is easier to see with the lights off).



b) Large bottle of water

Take a large plastic bottle, drill a hole in the side and fill the hole with a cork. Fill the bottle with water, shine a laser through the bottle and pull out the cork. Direct the laser light into the stream of water, as shown below.



Exercise 4: Make a chart of the grade of the optical fibers showing their characteristics and applications.

Section 4: Assessment Questionnaire

1. _____ is a pathway that carries the information from sender to receiver.
2. Which type of media is Fiber optic communication?
3. Unguided Transmission media is also known as:
4. Which Unguided Transmission media has highest frequency range?
5. On which principle, Optical Fiber works?
6. What is speed of light in vacuum?
7. What is Formula of Refractive Index?

8. What is Refractive index in Vacuum?
9. When light is incident on a medium of lesser Refractive Index, the ray is bent away from the normal, then exit angle is _____ than the incident angle.
10. For occurrence of Total Internal Reflection, Index of refraction of clad should be _____ than clad.
11. What is full form of LED?
12. Is APD a transmitter or a receiver?
13. Give any application of Optical Fiber.
14. What is expanded form of FTTH?
15. A set of guided electromagnetic waves is called _____ of the fiber.
16. Which types of waves are used in Mode theory?
17. As per mode theory, at what angle Electric and Magnetic field travel?
18. Write formulae for V Number.
19. The V number depends on the wavelength of light. True or False?
20. In what year, Semaphores were used?
21. Who invented Semaphores?
22. Who gave theory of Total Internal Reflection (TIR)?
23. Who demonstrated the refraction of light through stream of water?
24. Who invented photophone?
25. When was photophone invented?
26. _____ demonstrated a method to carry television images through transparent pipes.
27. When was Fibroscope invented?
28. The first working fiber-optic data transmission system was demonstrated by:
29. Who proposed that long distance communications were possible with single mode fiber?
30. The first metropolitan fiber optic cable was deployed in:
31. What is full form of CATV?
32. Wavelength Division Multiplexing (WDM) was first time used in:
33. Dense Wave Division Multiplexing (DWDM) was first time used in:
34. What is core size of Multimode fiber?
35. What is core size of Multimode fiber?
36. Which mode of fiber has higher loss?
37. Which fiber are used for long distance transmission?
38. _____ is the distance between two nearest amplitude positive peaks.
39. What is unit of wavelength commonly referred in fiber optics?
40. Match the following.

Band	Wavelength (nm) Range
O – Original	1360-1460
E – Extended	1260-1360
S – Short Wavelength	1625-1675
C – Conventional	1565-1625
L – Long Wavelength	1530-1565
U – Ultra Long Wavelength	1460-1530

41. What is unit of Attenuation?
42. _____ is the loss of optical power as light travels along the fiber.
43. If light travels over 20 km of optical fiber with loss of 0.25 dB/km, what is the total loss?
44. What is the typical optical power loss of G. 652D fiber at 1550nm?

45. Deformation of fiber axis (axial \ distortion) during fiber is example of which type of bending?
46. Spreading of light pulses in a fiber is called:
47. If you bend a fiber, what will happen, attenuation or dispersion?
48. Dispersion caused due to different paths the light rays take to travel from one end to the other is called:
49. In which mode of fiber Chromatic Dispersion occurs?
50. Modal Dispersion occurs in:
51. What is full form of PMD?
52. What is full form of ITU-T?
53. Where can we use G.657 Fiber?
54. Which fiber is commonly used in long distance optical communication?
55. Which grade of fiber has chromatic dispersion near to zero value?
56. Which part of bend insensitive optical fiber makes it bend insensitive?
57. What are the categories of G.657 fiber?
58. Which category of G.657 fiber has minimum bend radius?
59. Where should we use Category A fiber and Category B fiber?
60. G.651.1, G.657A, and G.657B all define bend-insensitive fibers made for FTTH systems. However, _____ multimode fiber has higher data rates for short-distance communications.

-----End of the Module-----

MODULE 2

GPON TECHNOLOGY AND FTTx ARCHITECTURE

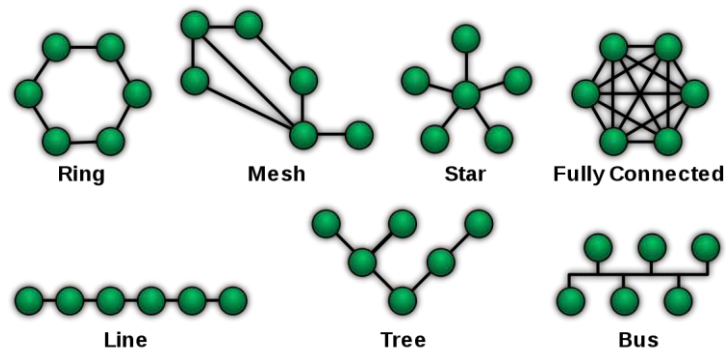
Section 1: Learning Outcomes

After completing this module, you will be able to:

- Differentiate between various Network Topologies
- Describe FTTx Architectures
- Explain concept of Passive Optical Network (PON)
- Describe the Design and Architecture of the GPON
- Explain GPON Data Multiplexing

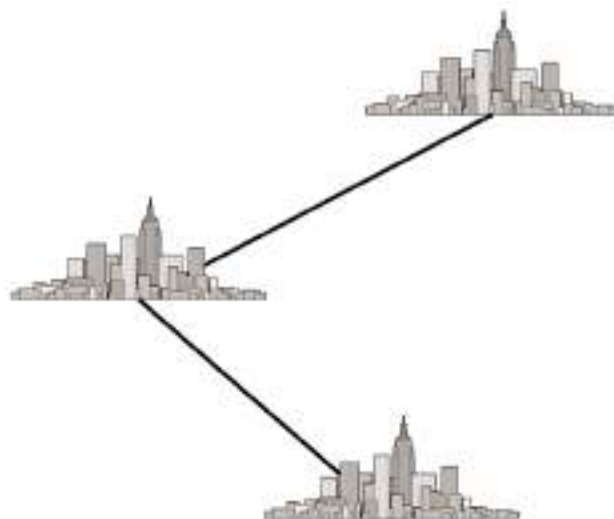
Section 2: Relevant Knowledge

2.1 Network Topologies



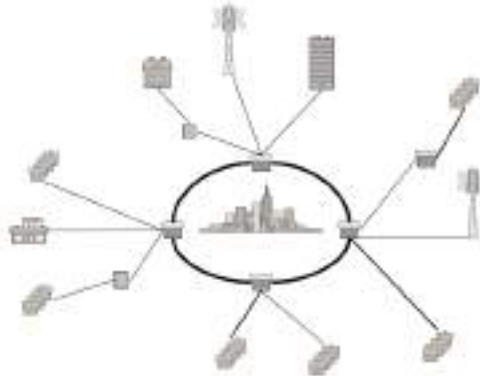
Transport Network

- Ø Fiber "trunks" between cities/regions/nations
- Ø Small to medium fiber count
- Ø Most common used traditional duct cables aerial, submarine and direct buried cables



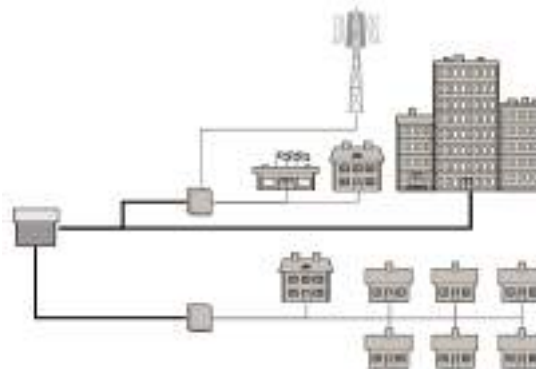
Metropolitan Network

- Ø Within a city and/or region
- Ø Medium to high fiber count
- Ø Common used traditional duct, aerial and microcables/ducts

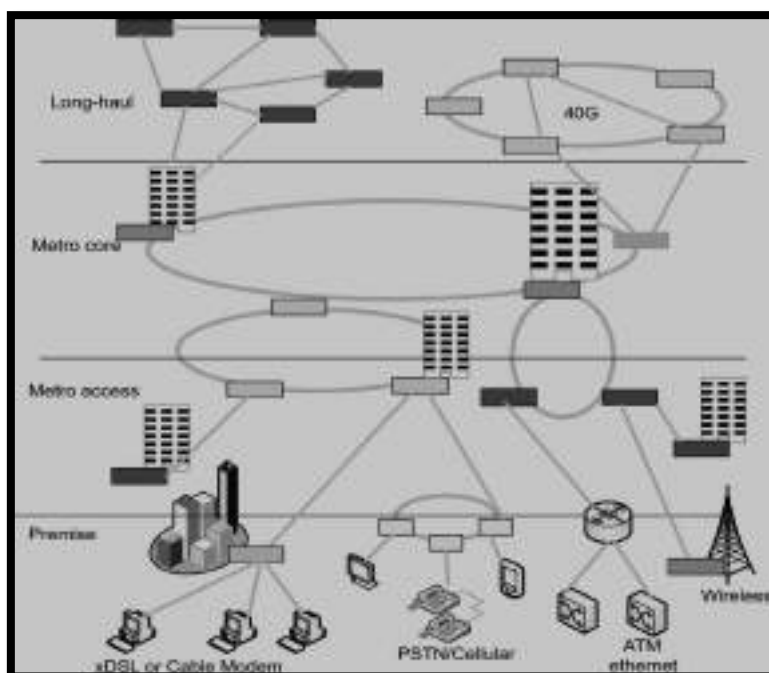


Access Network

- Ø For FTTH, FTTC, FTTB and FTTA
- Ø Medium to high fiber count
- Ø Usually traditional duct cables, aerial, drop cables, multiduct/microcables and air blown fiber (ABF)



Global Network Hierarchy

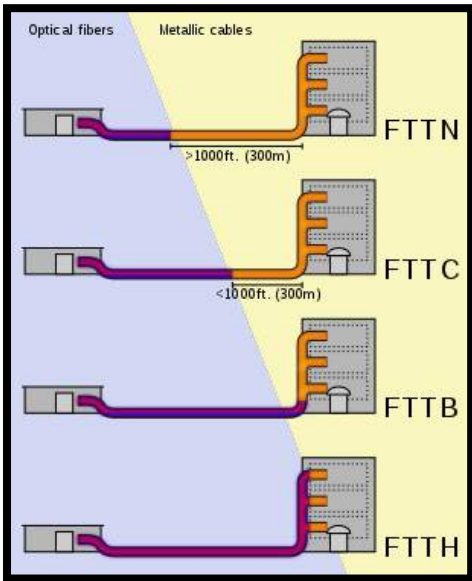


2.2 FTTH Architectures

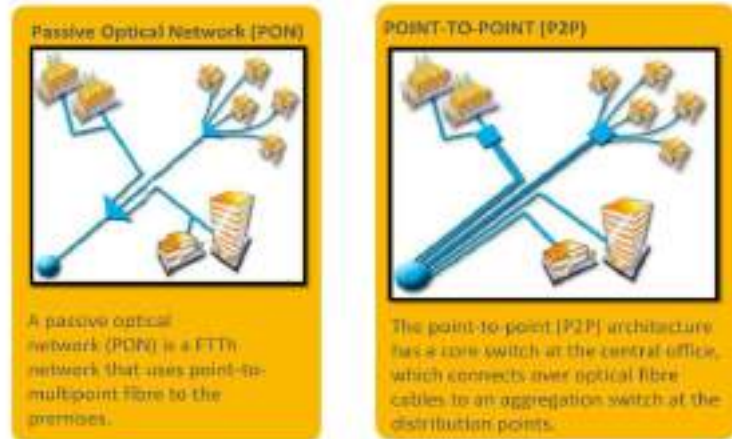
FTTx is an optical fiber broadband network architecture.

FTTx comprises:

- Ø Fiber to the home (FTTH)
- Ø Fiber to the building (FTTB)
- Ø Fiber to the node (FTTN)
- Ø Fiber to the curb or cabinet (FTTC)
- Ø Fiber to the premise (FTTP)
- Ø FTTx: for those who can't decide what to call it or are referring to all varieties!

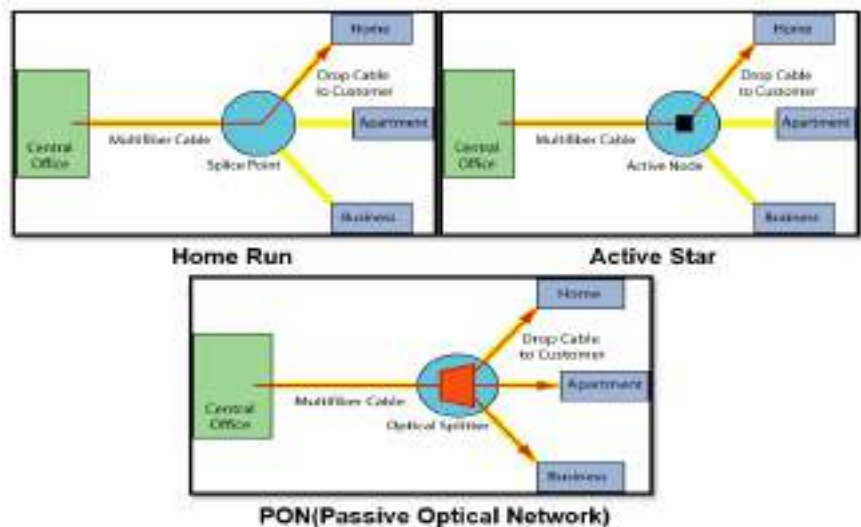


There are two type of FTTH architectures:



- Ø Telcos are suffering with aging copper cable plants.
- Ø Telcos are losing broadband customers to CATV and landline customers to cell phones and VoIP.
- Ø New services are becoming available to enhance revenue and customers demand them
- Ø New technology (PON) and cheaper components makes FTTx cheaper
- Ø Many telcos are realizing that the alternatives to FTTx are inadequate for future bandwidth needs:
 - DSL won't have the bandwidth
 - Wireless won't have the bandwidth

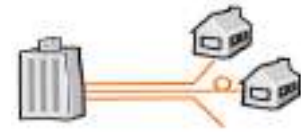
CATV: Cable Television
VoIP: Voice Over Internet Protocol
PON: Passive Optical Network
DSL: Digital Subscriber Link



2.3 PON (Passive Optical Network) Common Network architectures

Point To Point, P2P

∅ Dedicated fiber to each user



Point to Multipoint, P2MP

∅ The fiber is shared

∅ Active Optical Networks, AON

∅ Passive Optical Network, PON



Decimal Multiple of Bits

Decimal multiples of bits are:

- Kbps: Kilo bits per second
 - 1 Kbps = 1024 bits per second
- Mbps: Mega bits per second
 - 1 Mbps = 1024 Kilo bits per second
- 1 Byte = 8 bits (Note the lower casing of the 'b')



Example:

How long will it take to download a 5 GB file when the internet speed is 100 Mbps?

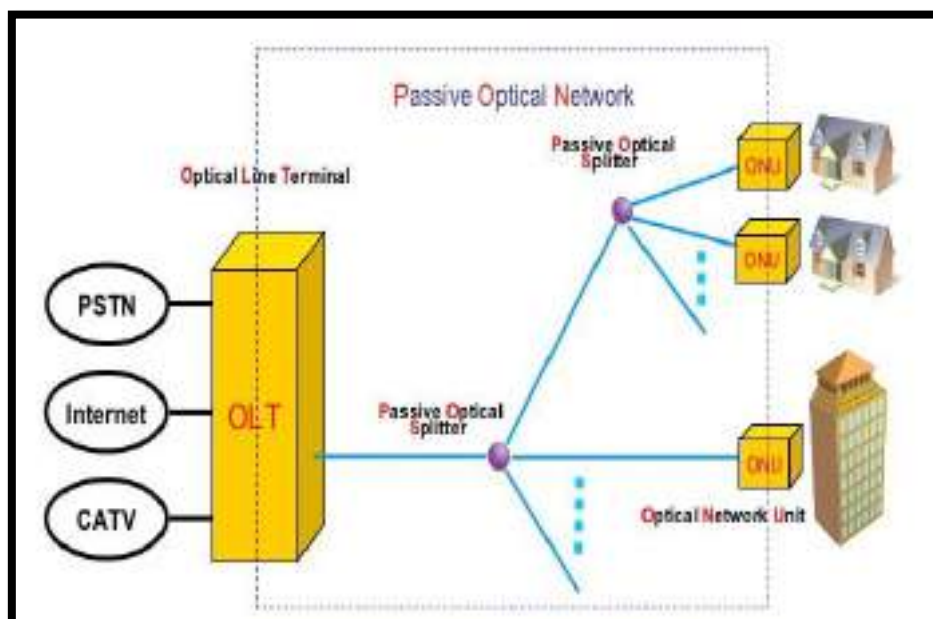
Answer:

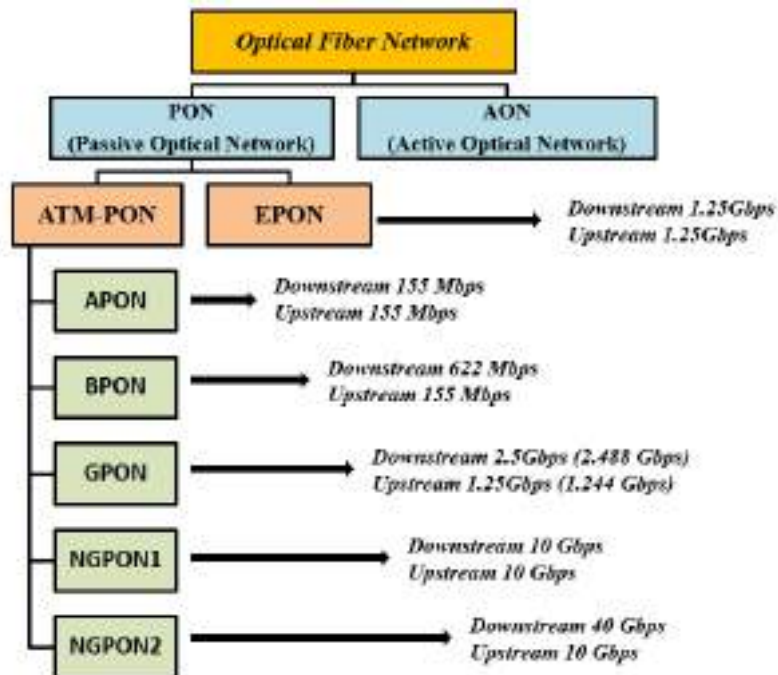
File Size:
5 GB = 5 × 1024 = 5120 MB (1 GB = 1024 MB)
Internet Speed:
100 Mbps (100/8 MBps)
Required Time:
File Size divided by Internet Speed = 5120*8/100 = 408 seconds = 6.8 minutes

PON – Passive Optical Network

PON is a point to multi-point technology used to provide fiber to the end consumer, both domestic and commercial.

Passive Devices - Splitter, Combiners, Connectors, etc.

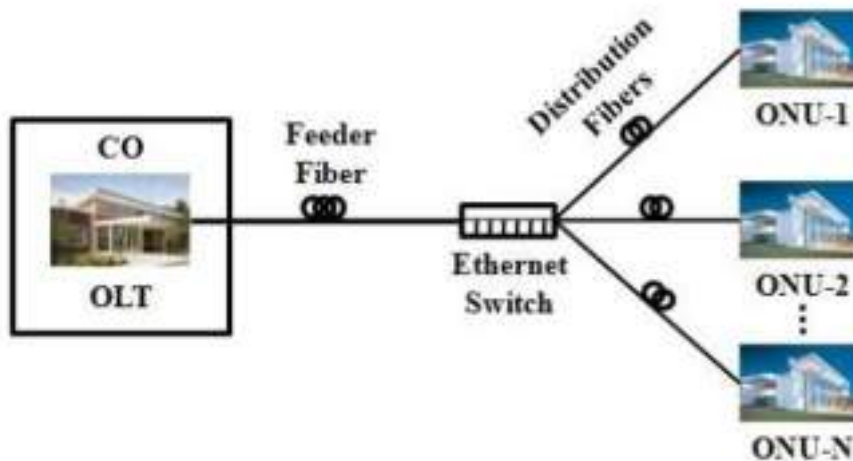




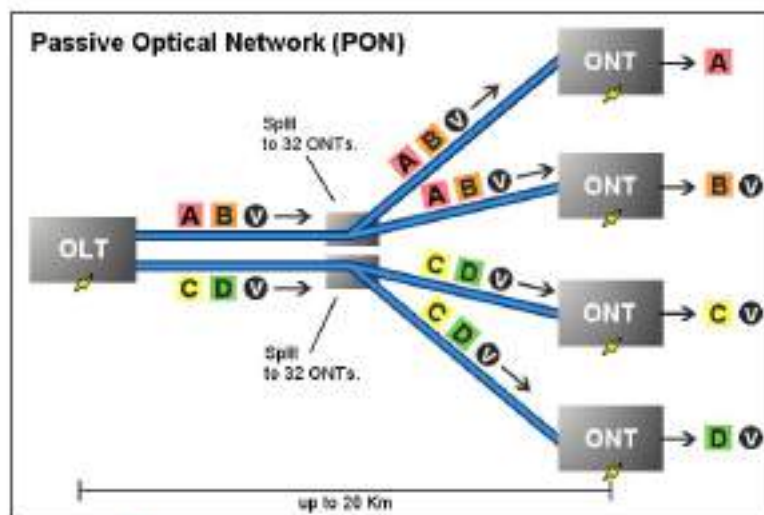
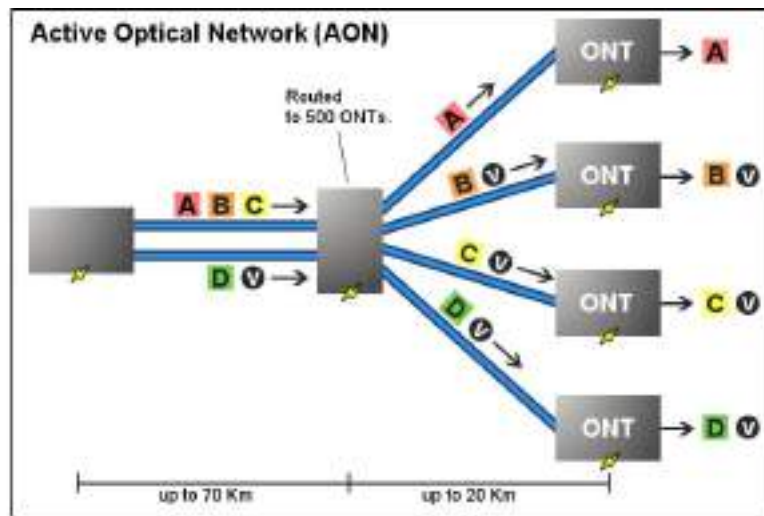
Active Optical Network (AON)

- ∅ AON is an Active Optical Network, which mainly uses a point-to-point (PTP) network architecture, and each user can have a dedicated optical fiber line.
- ∅ In an active optical network, electrical switching equipment are deployed, such as a router or a switch, to manage signal distribution and route data to proper different user terminals.

Active Devices - Amplifiers, Switches, Repeaters, Shifters, etc.



Difference between AON and PON



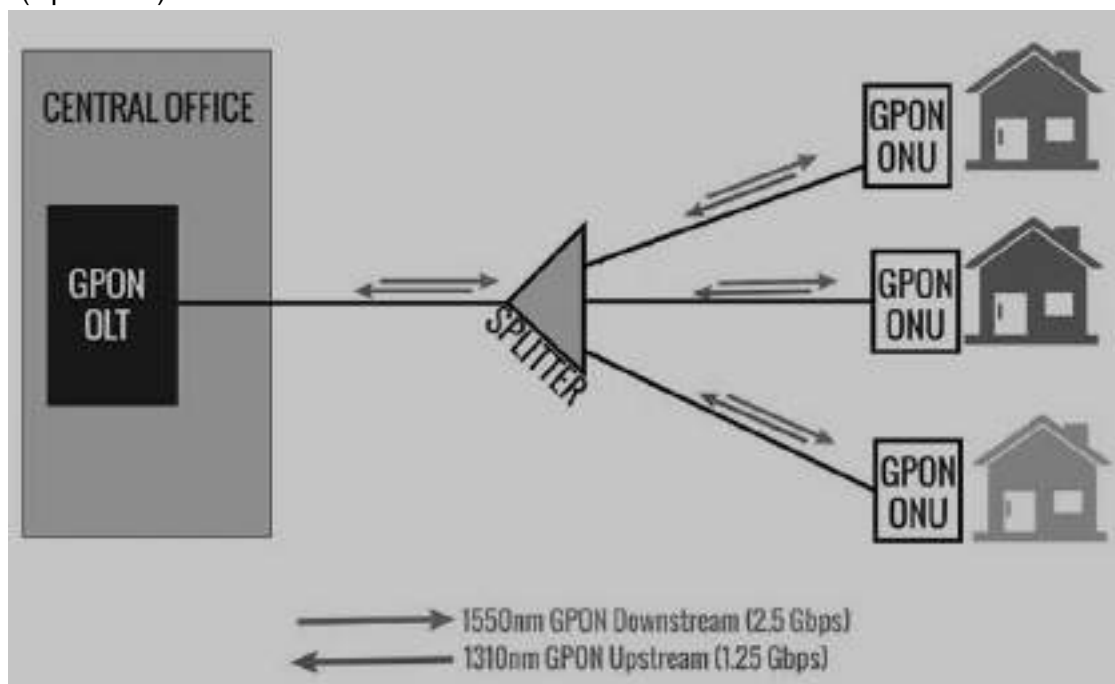
Key: **A** - Data or voice for a single customer. **V** - Video for multiple customers.

PON Passive Optical Network	VS	Active Optical Network AON
▷ Cost less to install and operate		▷ Costs more to install and operate
▷ Same signal to all end users		▷ Sends unique signal to end users
▷ Last-mile installations (20km)		▷ Can cover larger distances
▷ More reliable		▷ Provides max speed regardless of user amount.

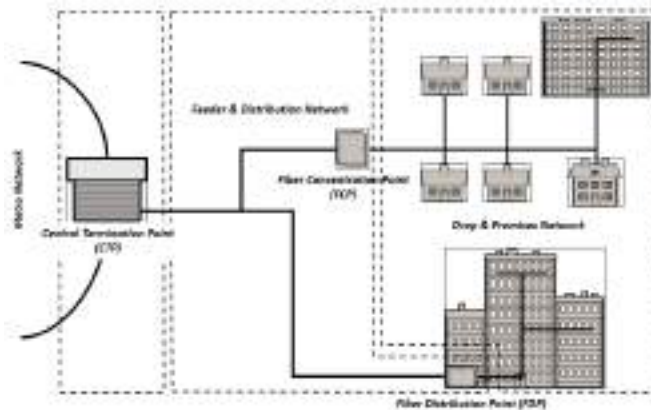
	PON	P2P
Deployment	Easier, Faster	Difficult, Time Consuming
Architecture	Simpler	More Complex
Bandwidth	Shared	Dedicated
Bandwidth	Asymmetrical	Symmetrical
Bandwidth Per Customer	Less	Maximum
Rollout Time	Less	More
Losses @Optical splitters	More	Less
Fiber & Splicing requirement	Less	More
Cost of electronics per Customer	Less	High

2.4 GPON (Gigabit Passive Optical Network)

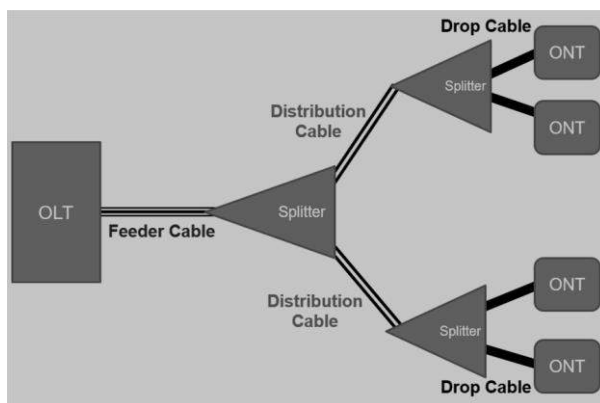
- ∅ GPON is a point-to-multipoint access mechanism.
- ∅ It mainly consists of three components viz.,
 1. Optical Line Termination (OLT)
 2. Optical Network Unit (ONU) or Optical Network Termination (ONT)
 3. Optical Distribution Network (ODN) that contains splitters
- ∅ GPON supports triple-play services, high-bandwidth, long reach etc.
- ∅ It provides 2.5 Gb/s of downstream bandwidth and 1.25 Gb/s upstream.
- ∅ 1550nm band is used from OLT to ONT (Downstream) and 1310nm band is used from ONT to OLT (Upstream) communication.



- ∅ GPON adopts Wavelength Division Multiplexing (WDM) technology, facilitating bi-directional communication over a single fiber.
- ∅ To separate upstream/downstream signals of multiple users over a single fiber, GPON adopts two multiplexing mechanism:
 - In downstream direction, data packets are transmitted in a broadcast manner
 - In upstream direction, data packets are transmitted in a TDMA manner



GPON Fiber Cabling



GPON – Triple Play

∅ Triple play service includes High Speed Internet Access, Television and Telephone services over a single broadband connection.



∅ GPON also supports all types of Ethernet protocols.

∅ GPON supports triple-play (Data, Voice & Video) through following services:



Pros and Cons of GPON Technology

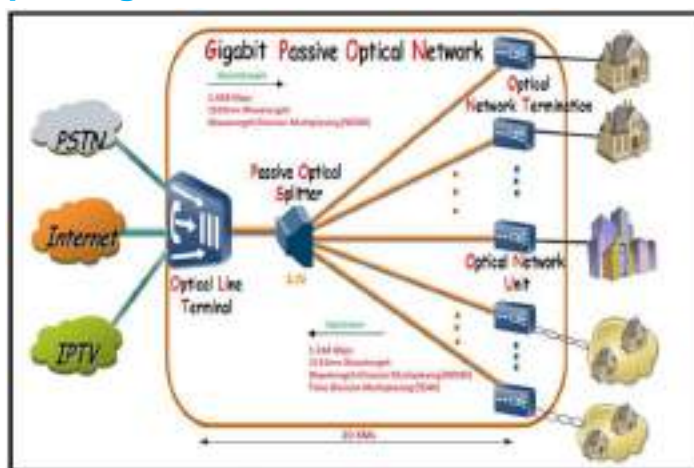
Pros:

- GPON reduces equipment requirement compared with point-to-point architectures.
- Higher bandwidth enabling faster digital communications.
- GPON has a low building and maintenance cost relative to active optical networks.

Cons:

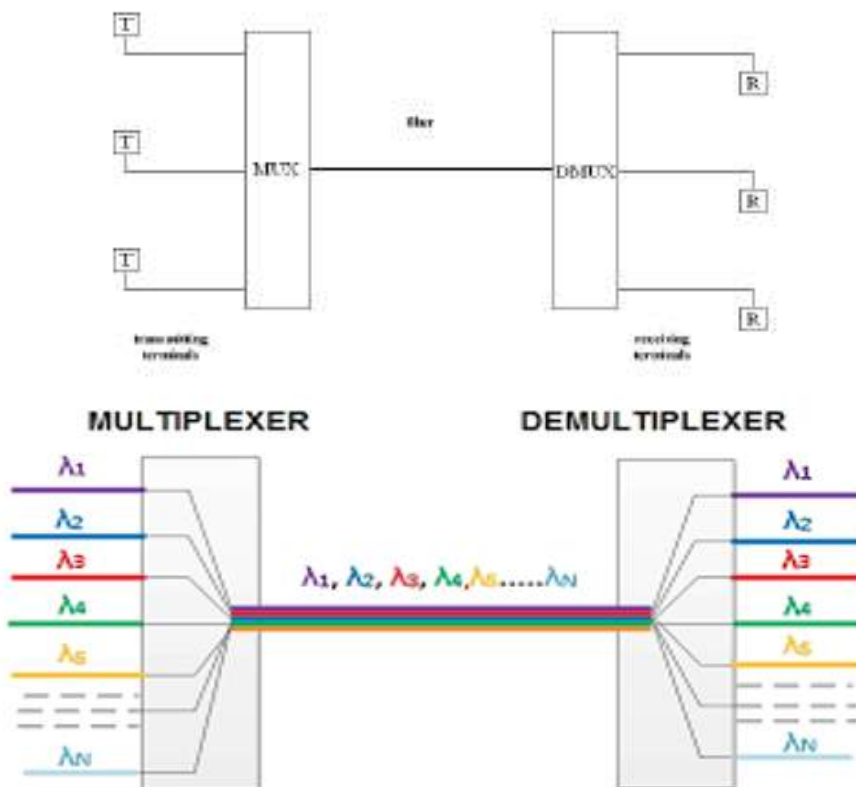
- GPON has less range than an active optical network (Max. 20Kms).
- It is difficult to isolate a failure in GPON network.
- Data transmission speed may slow down during peak usage times.

GPON Data Multiplexing



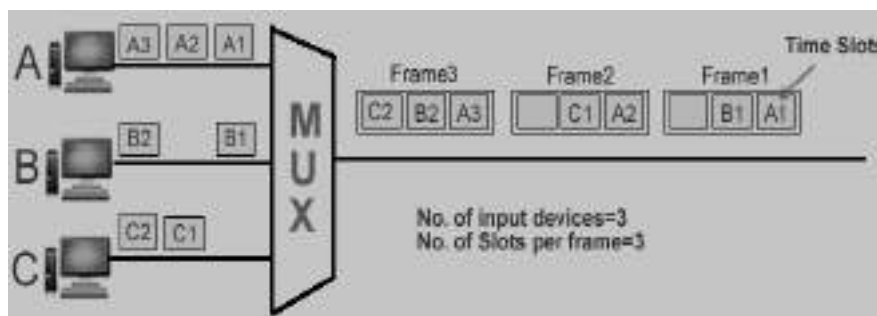
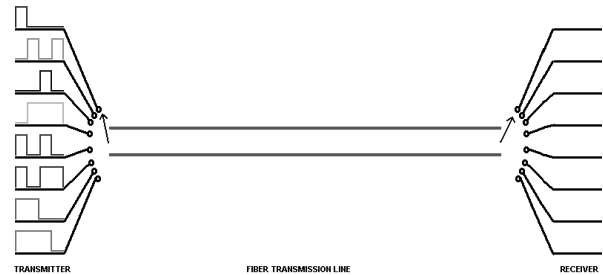
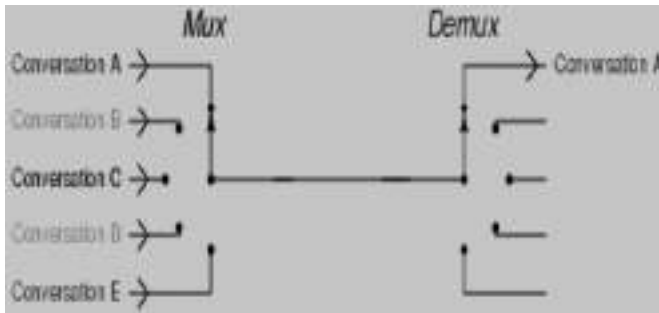
Wavelength Division Multiplexing (WDM)

Number of optical carrier signals of different wavelengths are transmitted onto a single optical fiber.



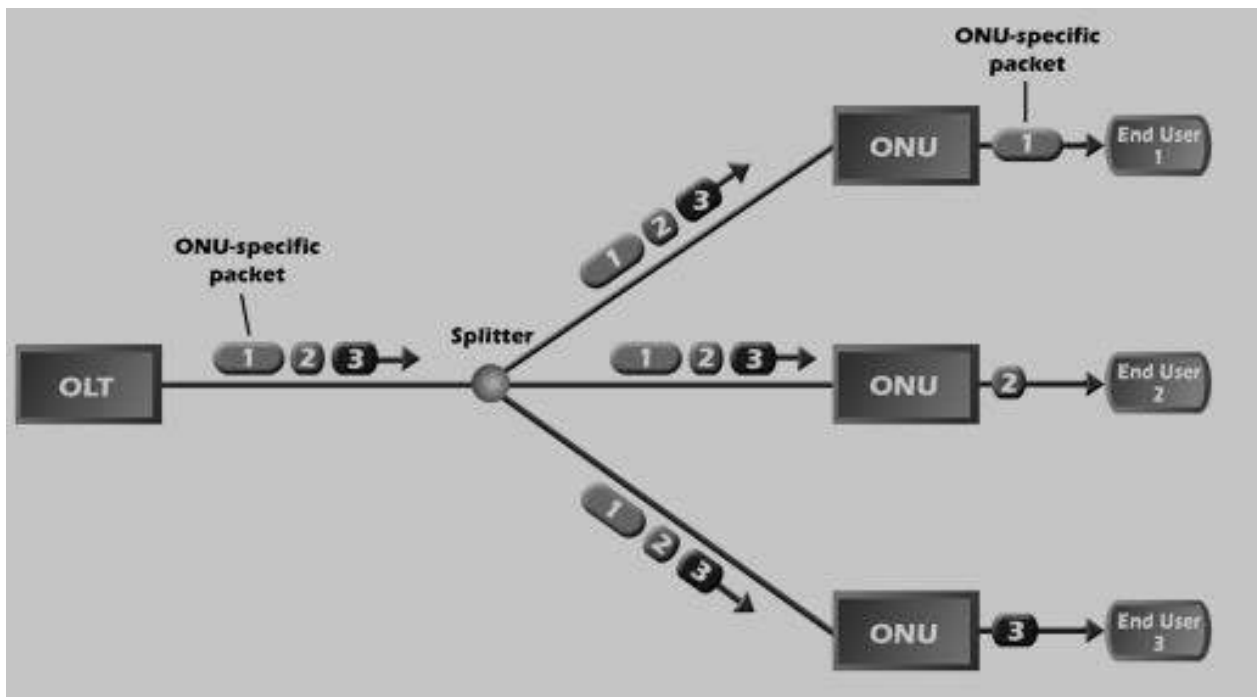
Time Division Multiplexing (TDM)

Signals from different sources are transmitted over a common channel having equal fixed-length time slots for each source.



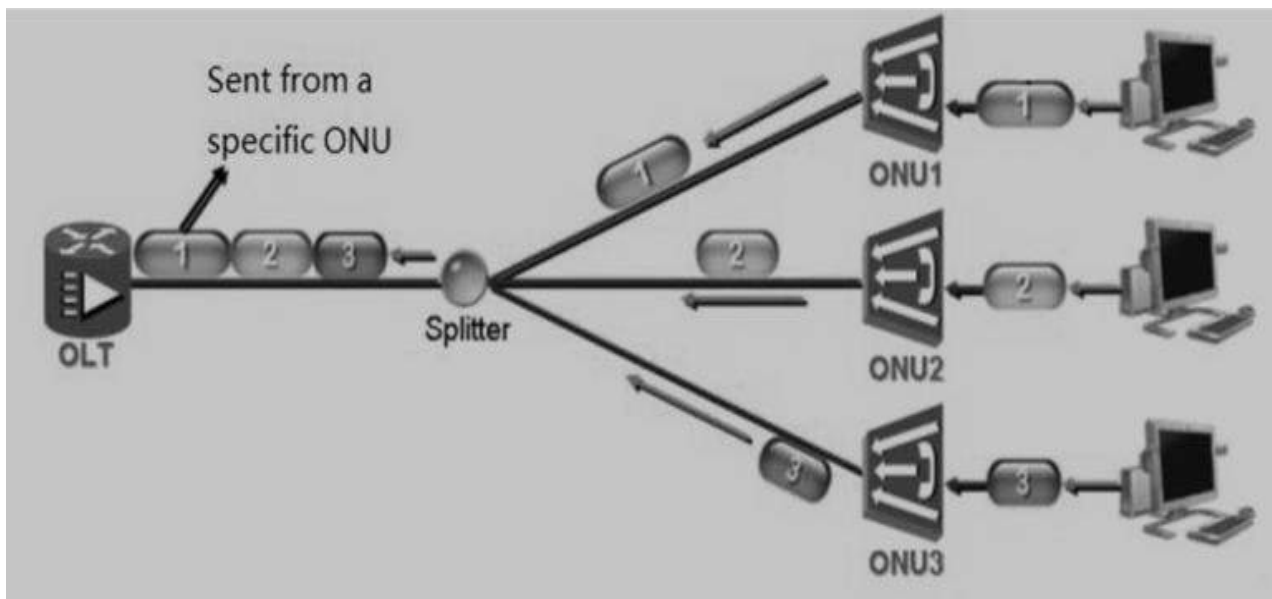
Downstream Data Flow in GPON

Downstream - Broadcasting Mode



Upstream Data Flow in GPON

Upstream - Time Mode

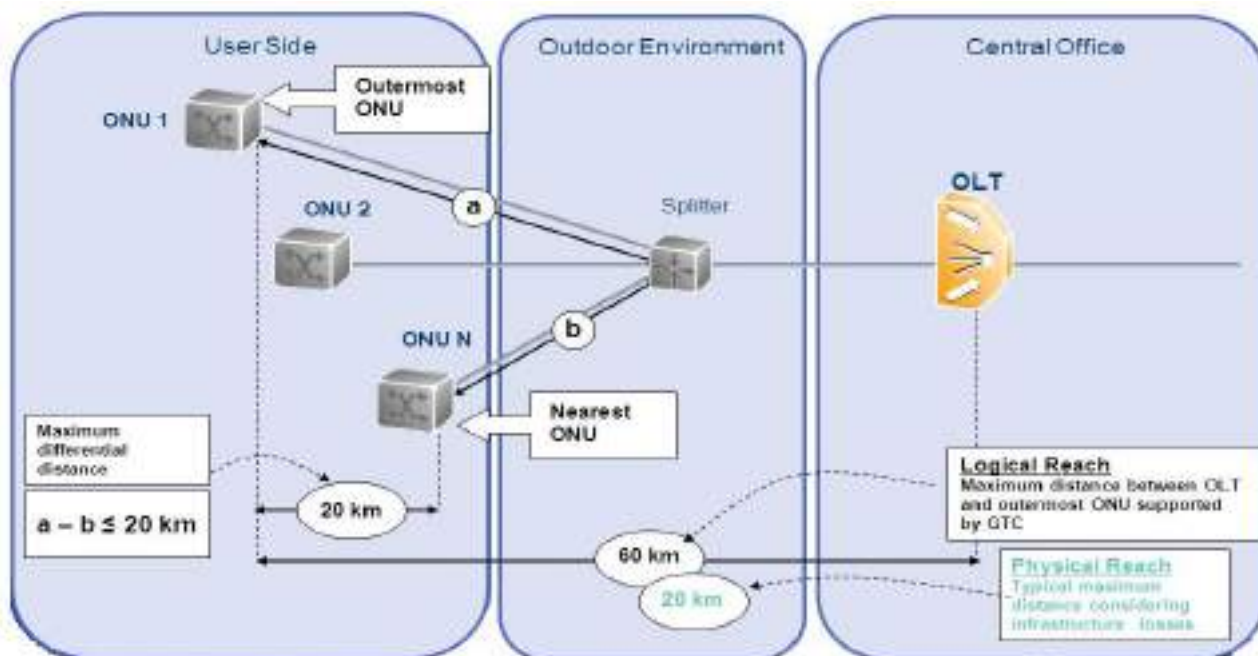


OLT-ONT Distance

∅ Max. Logical Reach: 60 km (Regardless of the optical budget)

∅ Max. Physical Reach: 20 km (Considering optical losses with 1x128 optical splitter)

∅ Max. Differential Reach: 20 km (Due to maximum equalization delay ~250 microseconds.)



Section 3: Exercises

Exercise 1: On a plain paper, draw different network topologies.

Exercise 2: Draw a Gigabit Optical Passive Network diagram.

Exercise 3: Draw GPON Fiber Cabling Diagram.

Exercise 4: Differentiate between PON and P2P.

Exercise 5: Participate in group discussion on following topics:

- a) Network Topologies
- b) FTTx Architecture
- c) GPON Data Multiplexing
- d) Evolution of PON

Section 4: Assessment Questionnaire

1. Bandwidth of _____ network more than metropolitan network.
2. FTTx comprises:
FTT_
FTT_
FTT_
FTT_
FTT_
3. What are the two types of FTTx architectures?
4. 1 Kbps = ____ bps
5. 1 Mbps = ____ Kbps
6. 1 Gbps = ____ Mbps
7. 1 Byte = ____ Bits
8. Passive devices are:
9. Active devices are:
10. What is the downstream and upstream data rates of data rates of GPON?
11. In downstream direction, data packets are transmitted in a _____.
12. In upstream direction, data packets are transmitted in a _____.
13. Triple play service includes:
14. Triple Play = _____, _____, _____.
15. What are the Pros and Cons of GPON technology?

-----End of the Module-----

MODULE 3

FIBER OPTIC CABLE TYPES & HANDLING PRACTICES

Section 1: Learning Outcomes

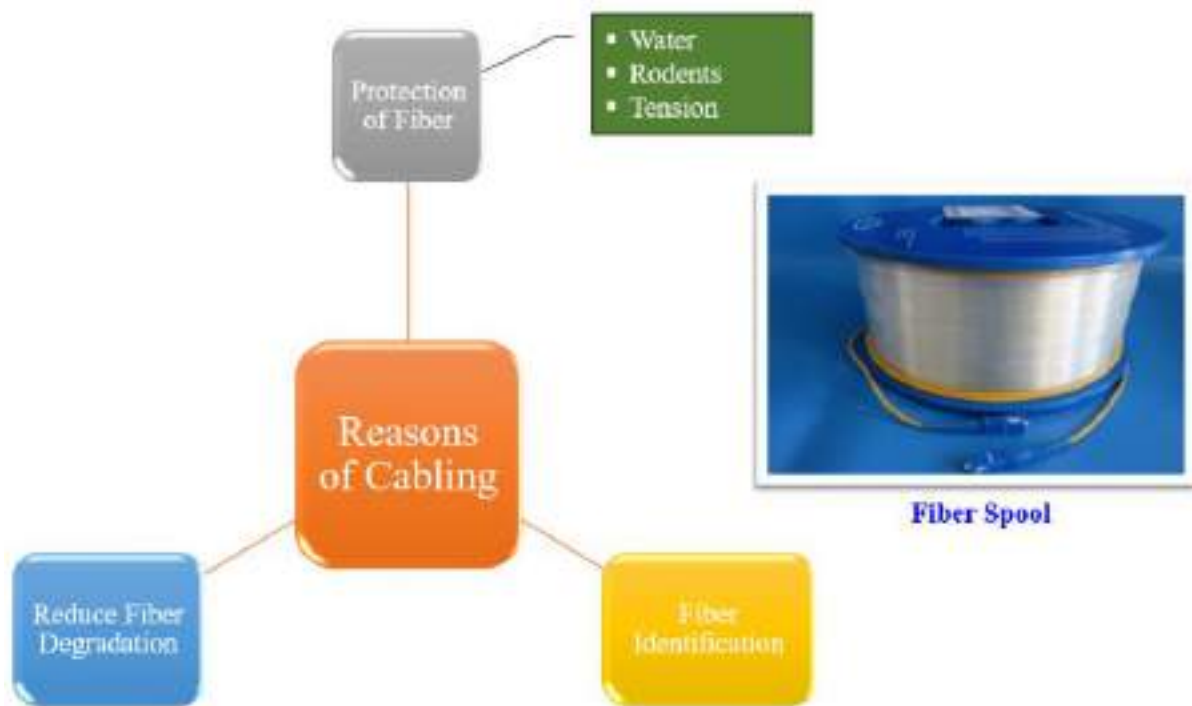
After completing this module, you will be able to:

- Describe the components of optical fiber cable and their properties
- Identify colour codes of optical fiber, cable jacket and connectors
- Classify fiber optic cables
- Describe various types of fiber optic cables used in FTTx networks
- Explain the cable selection criteria
- Distinguish between various fiber optic connectors and their properties
- Perform inspection and cleaning of optical connectors
- Describe good practices of cable drum handling & storage
- Explain the concept of cable bending radius and pulling tension

Section 2: Relevant Knowledge

3.1 Components of Optical Fiber Cable

Reasons of Cabling



Key Design Parameters of Cable



Fiber optic cable core:

- ∅ A fiber optic's center is made of glass, and this tube carries the cable's light signals.
- ∅ Depending on the type of fiber optic cable (single mode or multi-mode), the core varies in size.

Fiber optic cable cladding layer:

Also constructed of glass, this "core cover" is used to keep the light in the core.

Fiber optic cable buffer:

- ∅ Also called the buffer coating, this sleeve protects the core and cladding from foreign material such as outside light, moisture, dirt and other substances.
- ∅ More often than not, the buffer is made of plastic.

Strength Members:

- ∅ Strength members which are typically used in fiber optic cable include Tapes, Binders, Aramid yarn, Fiberglass Epoxy Rods (FGE), and Steel Wire.
- ∅ It also plays a vital role in enhancing the tensile strength of the cable.

Aramid Yarn

- Ø Aramid yarn is a yellow color, fiber looking material.
- Ø It is strong and is used to bundle and protect the loose tubes or fibers in the cable.
- Ø It is the strength member to provide tensile strength along the length of the cable during and after installation.
- Ø When a cable is pulled into a duct, the tension is applied to the aramid yarn instead of the fibers.



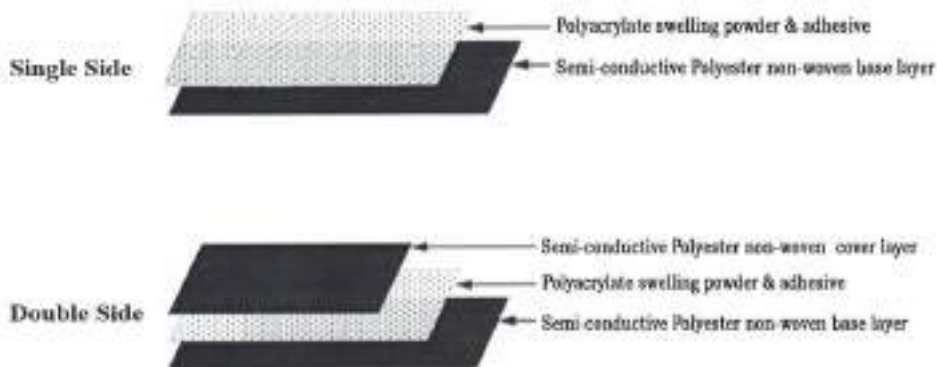
Fiberglass Reinforce Plastic (FRP)

- Ø FRP is a Fiberglass-Reinforced Plastic material that has the strength of steel at the fraction of the weight. FRP won't corrode, rot, warp, attract insects, or rust.
- Ø FRP is a common reinforcement to provide strength and durability in fiber optic drop cable.
- Ø FRP reinforcement is not the messenger, but in a common configuration will straddle the optical cable within the jacket.



Water Blocking Tape:

- Ø It is a combination of tape, yarn, or coating to prevent penetration of water into the cable.
- Ø Water blocking tapes and water swellable tapes rapidly absorb liquid at the point of insulation failure and quickly swell to block any further ingress.



Fiber Optic Cable Jacket:

- Ø The cable jacket is typically made of tough, durable polyurethane.
- Ø It resists water entry
- Ø It provides a smooth, low friction surface for cable placement.
- Ø It is made of material that will allow the cable to remain flexible and serviceable
- Ø It resists abrasion during installation. It also provides, along with the cable's strength members, the mechanical strength required to survive its environment and installation forces.

Popular Cable Jacketing Materials

Sheath Material	Features
PE - Polyethylene ² MDPE - medium density PE HDPE - high density PE	<ul style="list-style-type: none"> ● Primary outside jacket material. ● Good resistance to UV (sun light) due to carbon black. ● Good flexibility over wide range of temperatures. ● Good abrasion and crack resistance.
Anti-tracking PE	<ul style="list-style-type: none"> ● Use in all dielectric self-supporting cable in high voltage aerial fields exceeding 12 kV, but not exceeding 50 kV applications. The anti-tracking jacket withstands a condition known as dry arcing.
PVC - Polyvinyl chloride	<ul style="list-style-type: none"> ● Provides good mechanical protection. ● Flexible at normal installation temperatures. ● Flame retardant. (typical riser material) ● Used for many indoor applications. ● Can be protected against sunlight with various UV inhibitors.
LSZH - Low smoke, zero halogen	<ul style="list-style-type: none"> ● Flame Retardant with low smoke and no halogenated materials ● For use in unventilated areas exposed to public, e.g., subways and tunnels. ● Good mechanical performance.
PVDF - Polyvinyl difluoride	<ul style="list-style-type: none"> ● Flame retardant. (typical plenum material) ● It produces low smoke and low flame propagation.

Most Outside Plant optical cables are made from medium density or high-density polyethylene with carbon black for UV stabilization

Outer Jacket Colour Code

- ∅ Colored outer jackets or print may be used on outside plant and premises fiber cables, e.g., fiber distribution cables, fiber optic patch cords, etc.
- ∅ In EIA/TIA-598, the fiber color code defines the jacket color codes for different fiber types.

Fiber Type	Patch Cord / Cable Outer Jacket Color Code
OM1 62.5/125µm Multimode	Orange
OM2 50/125µm Multimode	Orange
OM3 50/125 µm (850 nm Laser-Optimized) Multimode	Aqua
OM4 50/125µm (850 nm Laser-Optimized) Multimode	Aqua/Violet
100/140µm Multimode	Orange
OS1/OS2 Single Mode	Yellow
Polarization Maintaining Single Mode	Blue



Inner Tubes Color Code

- ∅ Inside a multi-fiber cable, individual fibers are compliant to fiber color code and they are distinguished from one another by color-coded of tubes.
- ∅ Inner fibers are color coded in a group of 12 fibers and they are counted in a clockwise direction.

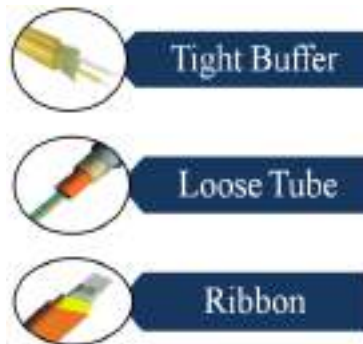


There are two situations for multi-fiber cables:

- ∅ For cables that consist of multiple buffer tubes each with 12 or less strands, each tube will be numbered or colored following the same fiber color code, e.g., 1st tube is blue, 2nd is orange, etc.
- ∅ For cables that consist of more than 12 strands, the fiber optic cable color code repeats itself. Each group of 12 fibers is identified with some other means. For example, 24 strand groups are with the fiber color code repeating with some variation, e.g., the 1st group of 12 strands are solid colors and the 2nd group is a solid color with a stripe or some other identifying marks.

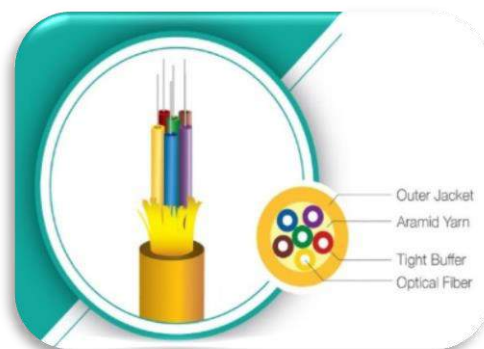
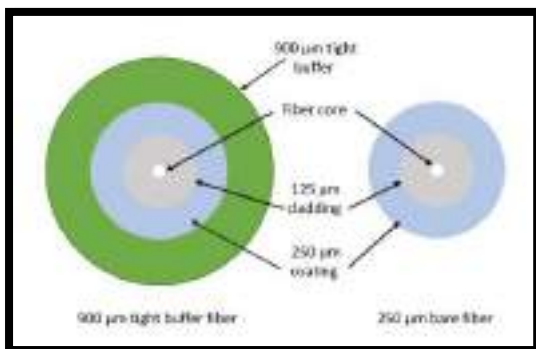


3.3 Classification of Fiber Optic Cable



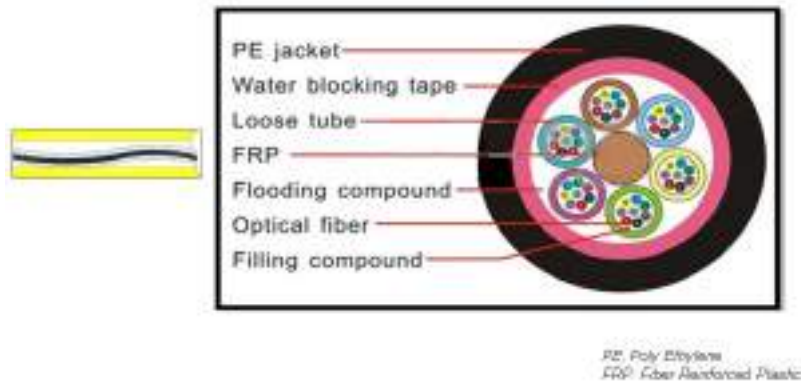
Tight Buffer Structure

- ∅ Useful in Indoor applications, such as Pigtail and Patch Cord
- ∅ Higher flexibility
- ∅ Easy to connectorize and terminate



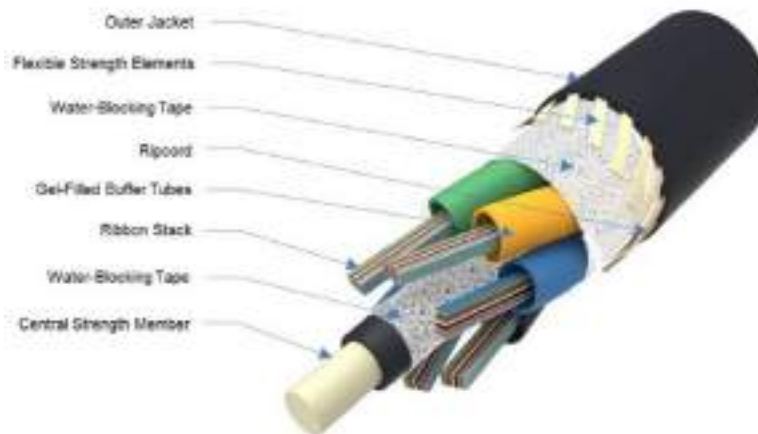
Loose Tube Structure

- Ø Useful in outdoor applications.
- Ø Long term reliability due to Jelly filled design. Jelly is a cable filling compound that provides a watertight environment and protection against corrosion and potential dielectric problems in the fiber.
- Ø Fiber is protected from moisture and temperature.
- Ø Best suited for Armoured Applications, Direct Buried Applications, Underground and Aerial applications.



Ribbon Cable

- Ø Fibers are arranged in strips
- Ø Provides higher fiber density within a cable
- Ø All fibers in the Ribbon can be spliced together using ribbon fiber splicing machine.



Ribbon Identification

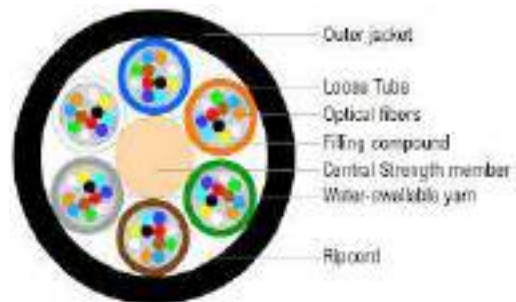


3.4 Fiber Optic Cables used in FTTx Networks

PARAMETER	FEEDER CABLE	DISTRIBUTION CABLE	DROP CABLE
Fiber Count	High (96F to 288F)	Less than Feeder (6F to 96F)	Less than Distribution
Cable Length	Higher (in Kms)	Less than Feeder	Less than Distribution
Cable Type	Loose Tube or Ribbon	Loose Tube or Ribbon	Tight Buffer or Messenger Cable
Strength Members	Armour, Aramid Yarn, Tapes, FRP	Armour, Aramid Yarn, Tapes, FRP	FRP, Tight Buffer

Microcable Cable

- Ø Microcables are very high-density cables with greatly reduced cable diameter and high fiber count.
- Ø Used to make deployment faster and less costly, especially in locations where space is minimum.
- Ø Microcables are specifically optimized for air-blown applications.

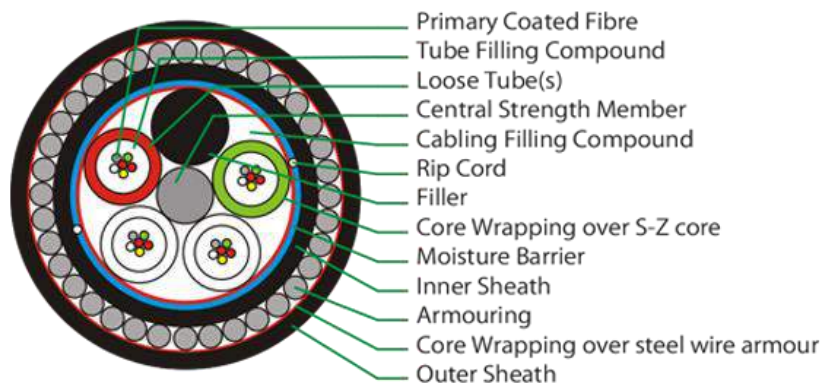
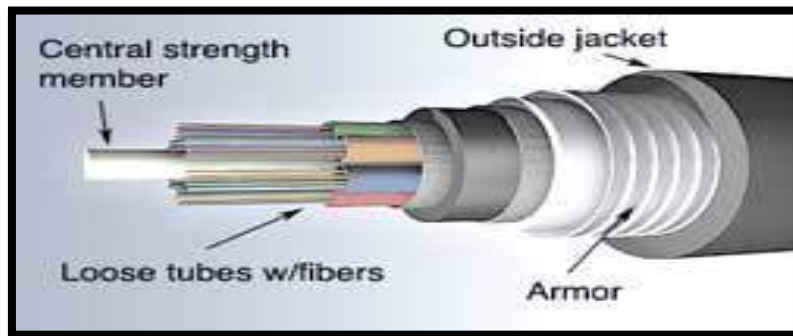
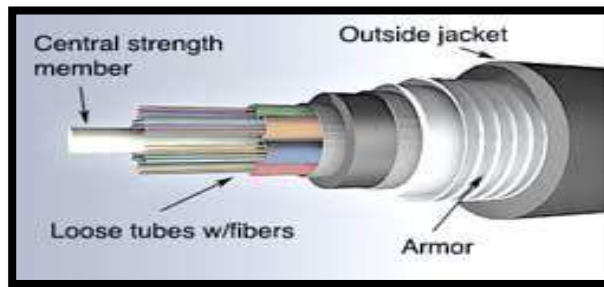


- Ø A 144 fiber loose tube cable is typically 15-16mm diameter while a comparable micro cable is only about 8 mm diameter - half the size and about one-third the weight.
- Ø Microcables are available for both premises and outside plant installations.
- Ø Microcables generally have a large stiff strength member in the center to allow installation by blowing the cable into microducts.



Armoured Cable

- ∅ Contains Aluminium or steel alloys for armouring
- ∅ Provide rugged, rodent and crush resistance
- ∅ Armoured cable is conductive, so it must be grounded properly
- ∅ It's applications includes:
 - Direct burial application
 - Need of high cable life
 - Protection of cable from animal, human or harsh environment



All-Dielectric Self-Supporting (ADSS) Cable



- Ø Non-metallic cable with small diameter and light weight
- Ø Supports its own weight without the use of wires or messenger cables
- Ø Protection from UV rays and moisture
- Ø Used for aerial installation over short, medium and long span distances

Tight Buffer Drop Cable

- Ø Small size and light weight cable
- Ø Contains several tight-buffered fibers bundled under the same jacket with Kevlar strength members.
- Ø Used in FTTX and indoor applications

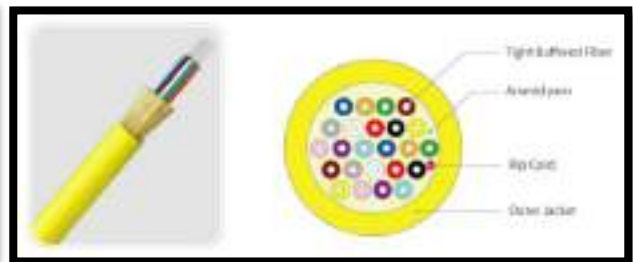
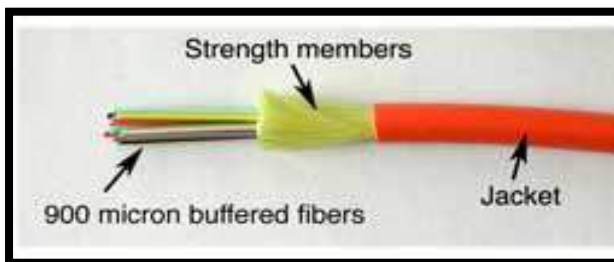
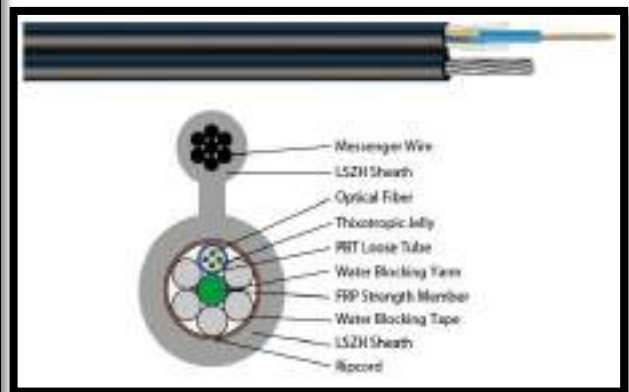
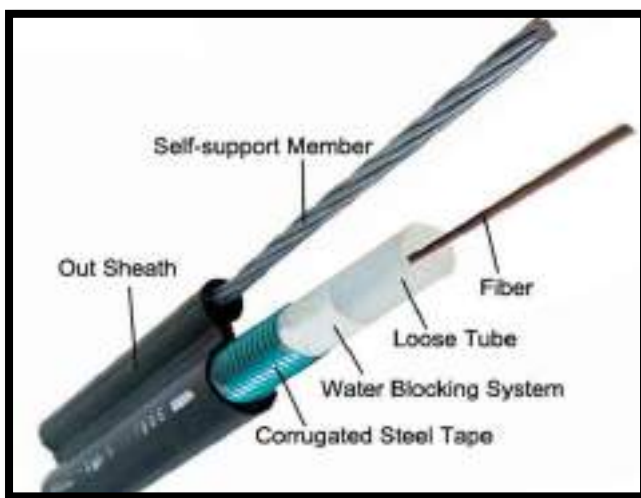
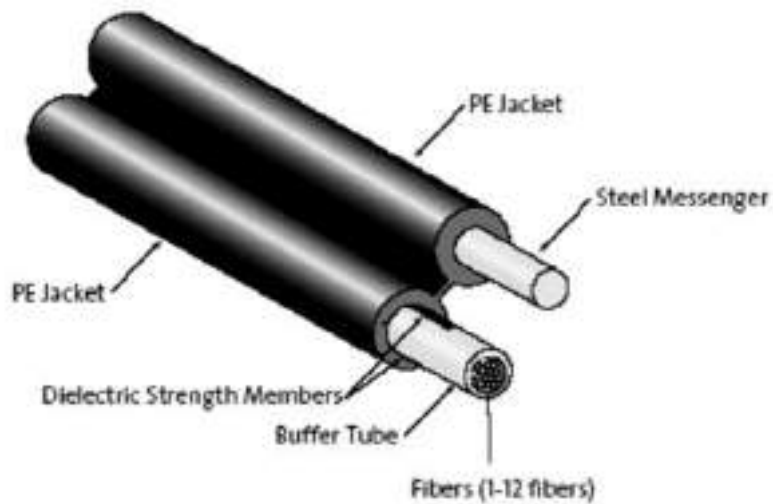


Figure-8 Drop Cable



- Ø It features a built-in support wire for tensile strength and stability.
- Ø The support wire is typically galvanized steel messenger, flooded to inhibit corrosion.
- Ø It provides robust self-support aerial deployment and quick one-step installation.

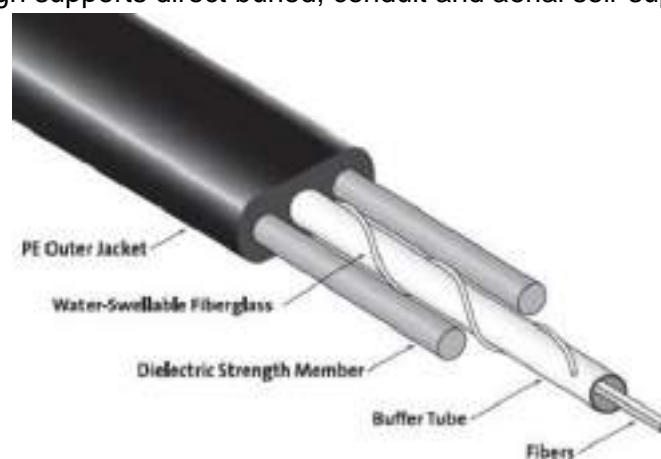
- Ø Figure-8 optical drop cables are composed of two distinct subcomponents, a central tube cable fixed to a steel wire.
- Ø This cable design is to combine the installation of the messenger wire and optical cable into a single process.
- Ø This cable is typically used in aerial applications.



- Ø Easy Cable Entry and Preparation
- Ø Flexible Routing and Termination
- Ø Quick Installation & Robust
- Ø Reliable Lifetime Performance

All-dielectric Optical Drop Cable

- Ø All-dielectric optical drop cables have the optical fibers placed in a centrally located buffer tube.
- Ø This drop cable design supports direct buried, conduit and aerial self-support application.



Armoured Optical Drop Cable

- Ø Armoured optical drop cables also have the optical fibers placed in the centrally located buffer tube.
- Ø A protective metallic foil surrounds the buffer tube and provides an additional protective barrier for the optical fibers.



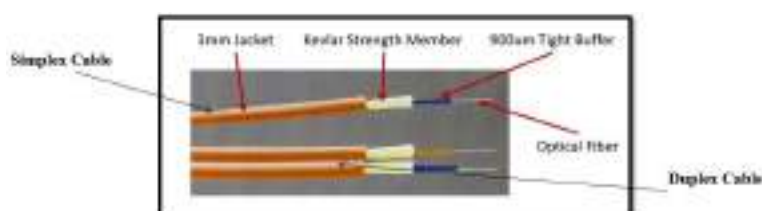
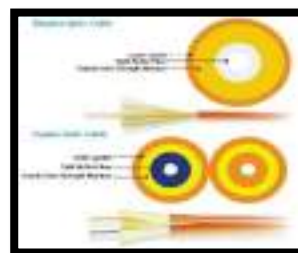
Pigtail & Patch Cords

A patch cord is a fixed length piece of cable with fiber connectors on each end while fiber pigtail has fiber connectors on only one end of the cable. Fiber optic patch cords can be cut into shorter lengths to make two pigtails.



Simplex Cable & Duplex Cables

- Ø Simplex fiber optic cable consists of a single fiber and used in applications that only require one way data transfer.
- Ø Duplex fiber optic cable consists of two fibers and used in applications that require simultaneous, bidirectional data transfer.



Cables	Applications
Tight Buffer Cables	<i>Indoor communication system</i>
	<i>Jumpers, Pigtails, Patch cords</i>
Loose Tube Cables	<i>Outdoor Applications</i>
	<i>NLD Routes</i>
ADSS / Fig-8 Cables	<i>Aerial Deployment</i>
	<i>FTTX</i>
Armoured Cable	<i>Direct Buried Applications</i>
	<i>Rodent Protection Requirement</i>
	<i>Physical Damage Prone Areas (Mechanical Protection)</i>
Distribution Cables	<i>Indoor Applications (FTTX)</i>

3.5 Cable Selection Criteria

- Ø Length of the Link
- Ø Data Rate Requirements
- Ø Type of the Network (Long Haul, FTTX, etc.)
- Ø Network Construction and Maintenance Budget
- Ø Fiber Route Terrain
- Ø Ease of Installation
- Ø Number of Communication Channels Required
- Ø Future Expansion Needs
- Ø Environmental Factors



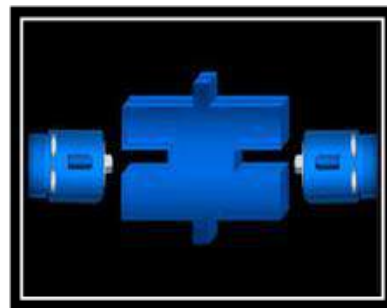
3.6 Fiber Optic Connectors

Types of Fiber Optic Connectors

An optical fiber connector terminates the end of an optical fiber.

∅ The connectors mechanically couple and align the cores of fibers so light can pass.

∅ Fiber Optic Couplers are used to align two connectors facing each other.



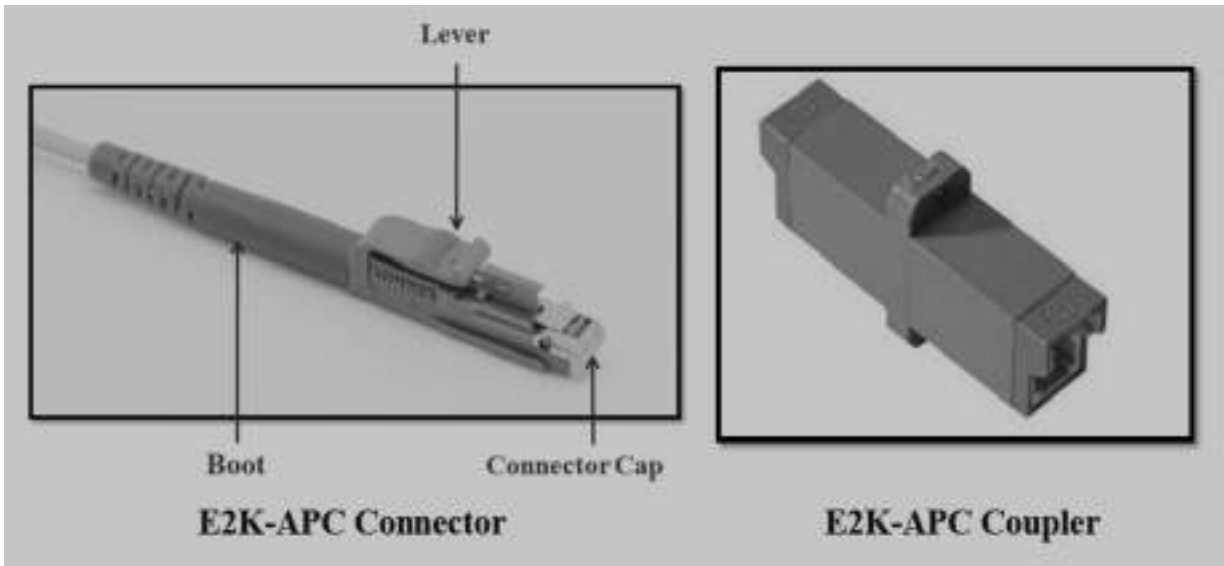
Fiber Optic Coupler



Particulars	PC	APC
Expanded Name	Polished Connector	Angular Polished Connector
Body Colour	Blue	Green
Insertion Loss (per connector pair)	0.5 dB (Approx.)	0.35 dB (Approx.)
Fiber Polishing	Straight	Angular (8°)



Fiber Optic Connectors : E2000 (E2K-APC)



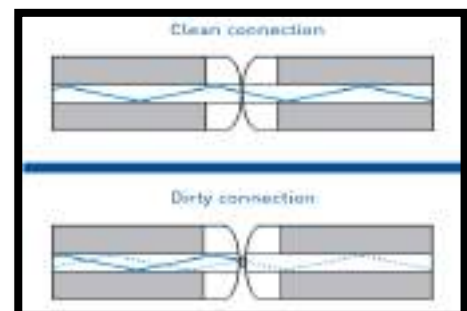
Fiber Optic Connectors



Fiber Optic Connector Hygiene

Common Mistakes:

- Ø Leaving a connector uncapped
- Ø Touching the connector end face
- Ø Using unsuitable cleaning methods or products
- Ø Assuming that connectors protected by dust caps are clean
- Ø Not cleaning both connector end faces before making a connection



Inspection of Optical Connector



- Ø Fiber Optic Microscope Scope 400x Magnification.
- Ø Handheld fiber microscope can check out depression, scratches, contamination and other conditions on fiber connectors.
- Ø The image of fiber end is very clear.
- Ø It not only can test PC end, but also can test APC end.

Cleaning of Optical Connector



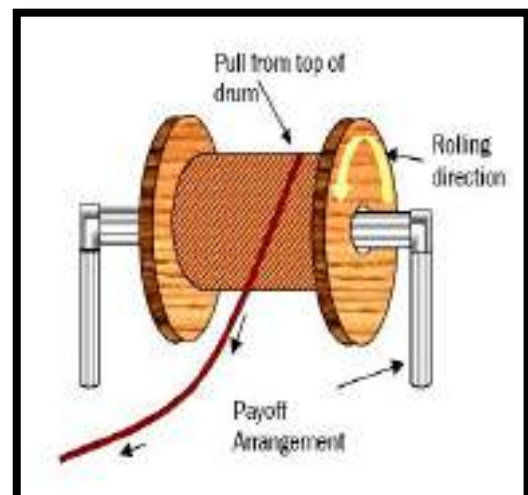
Cable Drum Handling & Storage

- Ø Generally, underground fiber optic cable in a drum for long distance routes are supplied in length of 1, 2, 3 and 4 Kms.
- Ø Aerial cable drums are of shorter length i.e.1 or 2 Kms.
- Ø It is ensured that cable should not be twisted and bent while uncoiling and to be mounted on cable drum jack.



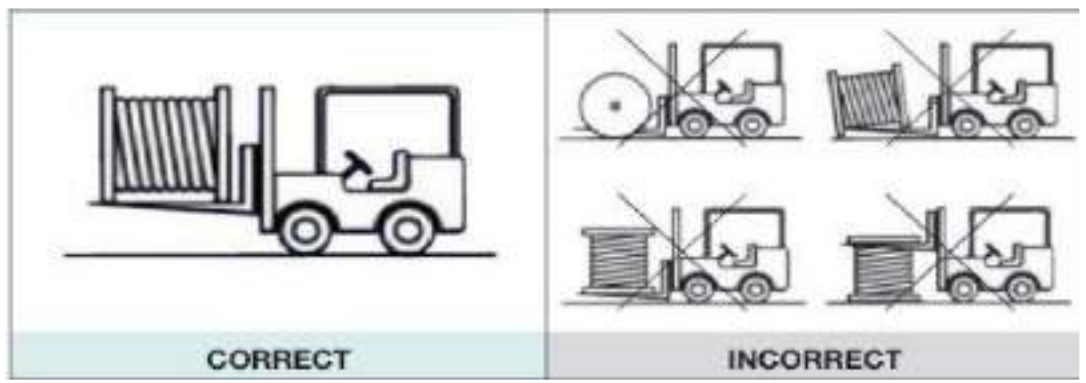
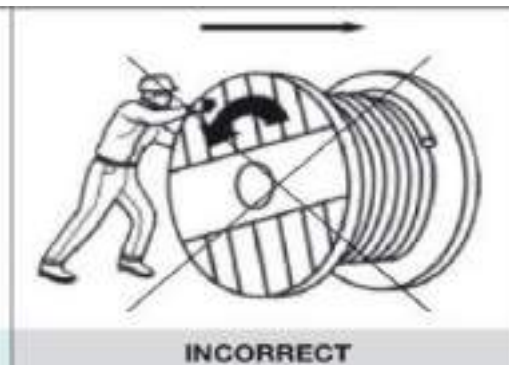
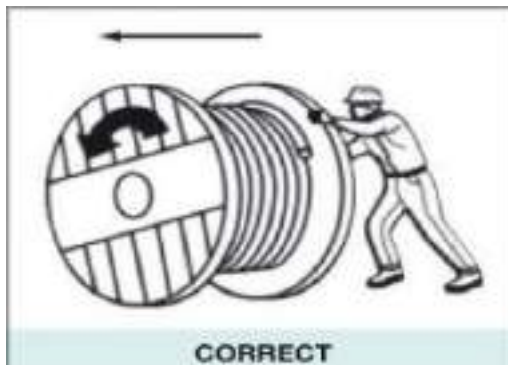
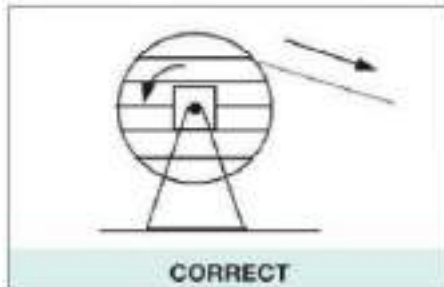
Drum Mounting

- Ø The drum is jacked up with a drum axle to such a height that the plank needed for breaking can not jam.
- Ø Heavy drums should jacked up with hydraulic drum pedestals.
- Ø To prevent the product rubbing against drum flanges keep the drum leveled.
- Ø Orient the drum so that the natural payoff direction is towards pulling direction.
- Ø Pull the product from the top of the drum
- Ø The maximum recommended unwinding speed is 35 meters per minute.
- Ø Suitable provisions should be made to break the drum.



3.7 Cable Drum Handling and Storage

- Ø Drum should never be given any shock by dropping.
- Ø Drum should not be rotated on flanges.
- Ø Cable should not be twisted and bent while uncoiling.

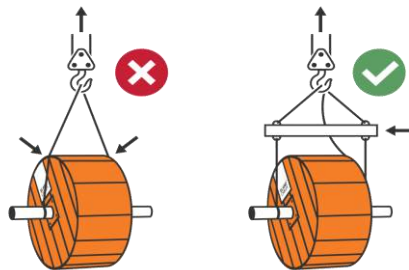


Drum Storage Environment

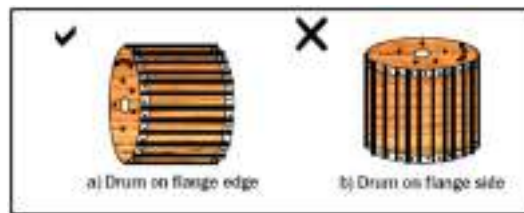
- Ø Drums should be on the area free from up-down surface, water, mud, stone etc.
- Ø Due to environment surrounding the drums, the wood degrades over a period of time, so, indoor storage is recommended.
- Ø If drums are stored outdoor, the storing surface should be hard and no moist soil should come in contact with wood.
- Ø During storage, the drum should be rolled once in every three months.



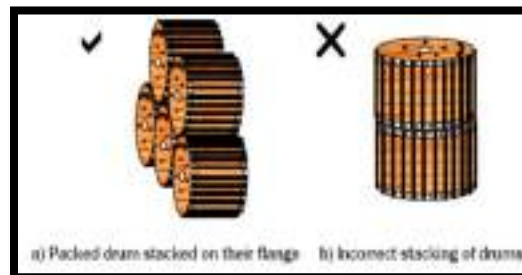
Drum Storage



- Ø The drums should always be stored in an upright position. Storage of drums in an alternative position can lead to winding defects.



- Ø If storage place is limited and it becomes necessary to stack, stack completely wrapped drums on their flanges edge.



- Ø Rolling edge should be lined up in rows with the flanges touching each other so that the flanges do not overlap with the product and accidentally damage it.

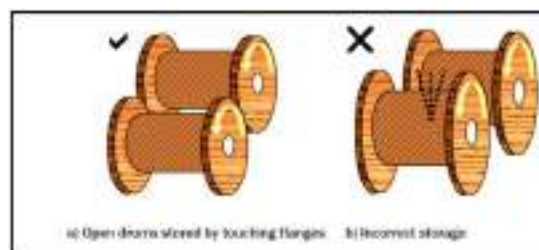


Figure Eight

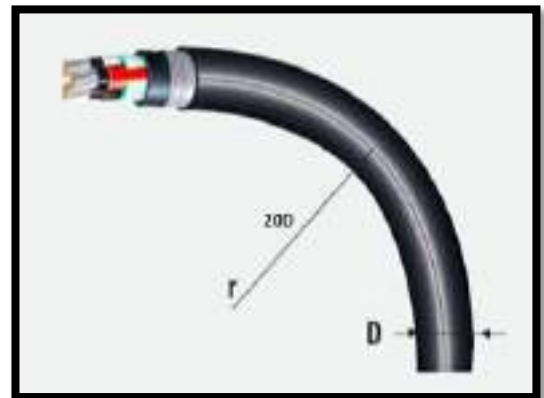
- Ø Mark two adjacent circles of 1.5 to 2 meter diameter on floor in such a way that it makes figure eight.
- Ø Loop requires minimum three persons one at center & one at each end of circle.



3.8 Cable Bending Radius and Pulling Tension

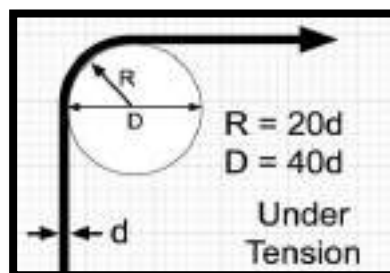
Cable Bending Radius

- Ø Bend radius is the curvature an optical fiber can bend without damage or shortening its lifespan via kinking.
- Ø The smaller the bend radius, the more flexible the fiber.
- Ø If no recommendations are available from the cable manufacturer, the cable should not be installed into a bend radius smaller than 20 times the cable diameter.
- Ø After completion of the pull, the cable should not have any bend radius smaller than 10 times the cable diameter.
- Ø For example, a cable with an outer diameter of 5mm, should not be bent smaller than 100mm radius during installation.



Cable Pulling Tension

- Ø Exceeding the Cable Pulling Tension above the defined value in the Cable Data sheet / Specification can alter cable's and fiber's characteristics leading to increased attenuation.



- Ø Tensile strength is maximum load that a cable can bear without fracture when being stretched.
- Ø The tensile strength for stranded loose tube cable and ribbon cable is approx. 2,700 Newtons (2700 Kg.m/s² in MKS system).

Section 3: Exercises

Exercise 1: Make a chart of optical fiber colour codes.

Exercise 2: Participate in group discussion on following topics:

- a) Classification of Fiber Optic Cable
- b) Various Types of Fiber Optic Cable

Exercise 3: Identify the types of optical fiber connectors in following image:



Exercise 4: Determine cable bend radius (After Pulling and Under Tension) of following cables:

Cable Diameter:

- a) 20mm
- b) 14mm
- c) 16mm
- d) 23mm
- e) 12mm

Exercise 5: Fill the cable type in following tables.

Cable Marking	Cable Type
OFNP	
OFCP	
OFNR	
OFCR	
OFNG/OFN	
OFNG/OFN	

PARAMETER	FEEDER CABLE	DISTRIBUTION CABLE	DROP CABLE
Fiber Count			
Cable Length			
Cable Type			
Strength Members			

Section 4: Assessment Questionnaire

1. How to identify fibers and buffer tube in a cable?
2. What is the colour code of fiber number 4?
3. What is colour for jacket of OM2 50/125µm Multimode fiber?
4. In which direction colour coding is placed in loose tube cable?
5. Classify Optical Fiber according to its structure?
6. Which type of fiber cable is used for higher flexibility and indoor deployment?
7. Where we should use Loose Tube Fiber?
8. Can a ribbon consist of any numbers of fibers?
9. What are advantages of Armoured Optical Fiber Cable?
10. What material is used for Armouring?
11. What are uses of distribution fiber cable?
12. Jacket of which cable used in serial deployment provides protection from UV rays and moisture?
13. What are the applications of Figure 8 Cable?
14. ADSS cable does not support its own weight without the use of wires or messenger cables. True /False.
15. Which cable has a built-in support wire for tensile strength and stability?
16. Which material is used for supporting wire in Figure-8 Cable?
17. What are features and benefits of Figure-8 Cable?
18. In which fiber cable, ribbon fibres are laid in the slotted core without tubes?
19. What are the benefits of Slotted Core Cable?
20. Where can we use Slotted Fiber Cable?
21. Give some points for cable selection criteria?
22. What is colour of PC connector?
23. Which connector has green Colour?
24. What is the insertion loss of PC and APC connector?
25. What are some common mistakes which affect hygiene of fiber optic connector?
26. Should we rotate drum on flanges?
27. Cable should be pulled less than the recommended tensile strength. True or False?
28. _____ is the curvature an optical fiber can bend without damage or shortening its lifespan via kinking.
29. Which equipment is used to inspect optical connector?
30. What do you call the cable that has bare fiber at one end and connector at other end?
31. What are the reasons of cabling?
32. What are the key parameters to be considered while design optical fiber cable?
33. Name some strength members used in the optical fiber cable.
34. What are some properties of FRP?
35. How water blocking tape works?
36. Fill in the blanks:
 - a) A Plenum area is _____ .
 - b) A Riser area is _____ .
 - c) A general-purpose area is _____ .
37. What are the types of optical fiber drop cables?
38. Where should you use Figure-8 cable?
39. In armoured optical cable protective _____ surrounds the buffer tube and provides an additional protective barrier for the optical fibers.
40. What are the properties of Aramid Yarn?

-----End of the Module-----

MODULE 4

HDPE DUCT, ITS ACCESSORIES & STORAGE

Section 1: Learning Outcomes

After completing this module, you will be able to:

- Explain the properties, advantages and disadvantages of HDPE
- Describe the dimensions, use and specifications of HDPE duct
- Identify and use HDPE duct and its accessories
- Couple two HDPE ducts efficiently using Pushfit Coupler
- Distinguish between different duct protection pipes
- Explain working of Micro Ducts and Its Accessories
- Store the HDPE ducts using best practices

Section 2: Relevant Knowledge

4.1 Introduction to High Density Polyethylene (HDPE)

- Ø High-density polyethylene (HDPE) is thermoplastic polymer.
- Ø It exhibits attributes of toughness, flexibility, chemical resistance and non-conducting electrical properties.
- Ø It is used in highway drainage pipes since the early 1970s.
- Ø Since then, growing out of applications for agricultural drainage, Toys, utensils, films, bottles and processing equipment. Wire and cable insulations.



HDPE – Advantages and Disadvantages

Advantages:

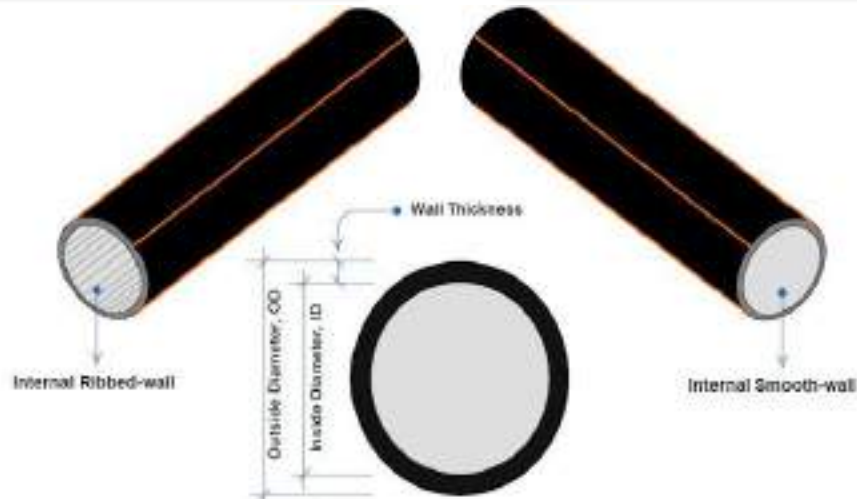
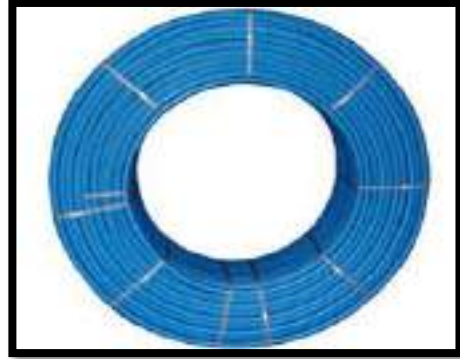
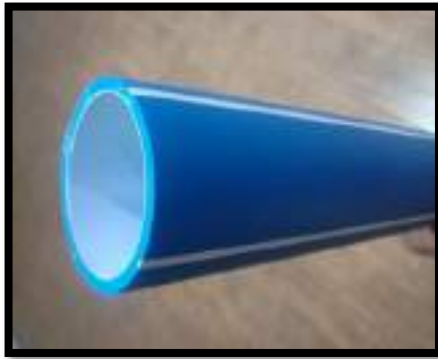
- Ø Low cost
- Ø Impact resistant from -40 °C to 90°C
- Ø Moisture resistance
- Ø Good chemical resistance
- Ø Readily processed by all thermoplastic methods

Disadvantages and Limitations:

- Ø High thermal expansion
- Ø Subject to stress & cracking
- Ø Difficult to bond
- Ø Flammable
- Ø Poor temperature capability

4.2 High Density Polyethylene (HDPE) Ducts

- Ø HDPE (High Density Poly Ethylene) Duct is a pipe, used to protect fiber optic cable.
- Ø Outer layer being HDPE and Inner layer is a solid permanent lubricant (PLB) to reduce the cable friction during cable blowing.
- Ø In telecom, HDPE duct is laid underground and optical fiber cable is blown inside the HDPE duct.



Commonly used HDPE duct in telecom has:

- Ø Outer diameter: 40mm
- Ø Wall Thickness: 3.5mm
- Ø Duct roll length: 500m and 1000m
- Ø Colour: As desired



Marking on Duct

Distinct, clear and easily visible size of ink marking with following information at every meter of interval:

User Name :
Duct Manufacturer Name:
Duct Type :
Duct Size :
Duct Serial/Part Number
Date of Manufacture
Length Marking in Meters

Check Points for Ducts

During inspection of duct, ensure that duct is:

Ø Smooth, rounded and clean



Ø Free from defects like holes and damage

Ø Uniformly colored

Ø Marked as per standard



4.3 HDPE Duct Accessories & Tools

Duct Decoiler

How to use Decoiler?

- Ø Place the decoiler along the side of the trench
- Ø Duct should be uncoiled from the bottom
- Ø Drive the reel slowly to avoid over spinning
- Ø Avoid the twist and kinks



End Cap and End Plug

- Ø **End Cap:** Made of hard rubber/suitable plastic material, fitted onto both end of duct coil after manufacturing the duct.
- Ø **End Plug:** Used for sealing of ends of the empty duct prior to installation of OFC to prevent entry of dirt, water moisture etc.



Simplex Plug

Simplex Plug: Used to seal the end of the duct, after cable is installed. It is required, where cable has come out of duct.



Use of End Plug



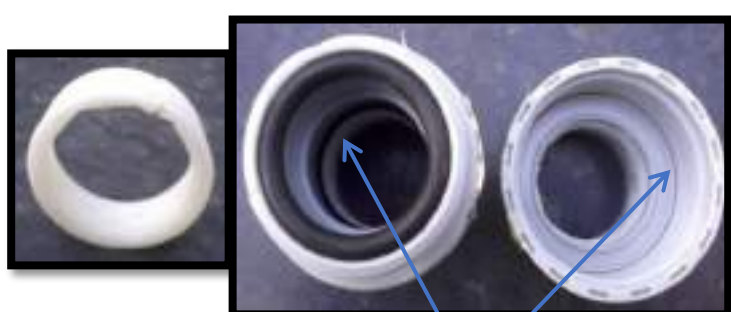
Rotator Duct Cutter

Used to cut duct ends squarely without any burr or notch.



Push Fit Duct Coupler

Ø Used to couple two duct ends. They are easy to install and provide air/water tight joint between two duct ends.



Ø C Spanner is used to tighten/open push fit coupler.



Chamfering Tool

The Chamfering Tool must be used to sharpen the face of duct so that the duct is inserted into the push fit coupler easily without damaging the rubber (O-Ring) inside coupler.



Blade

Using the Chamfering Tool

∅ Chamfering tool reduces the outer dia of the duct to less than inner dia of the “O-Ring”.



4.4 Duct Coupling Cutting the Ducts

∅ Duct should be cut with about 30mm overlap with duct cutter at 90 degrees. Mark the “Cut Mark” using a Measuring Tape and a Marker.



- ∅ The duct overlap is to allow duct shrinkage while pressing down.
- ∅ If ducts are cut neck to neck, then while pushing the ducts into the coupler duct may come out.
- ∅ Use chamfering tool

Remember: Before cutting the duct push it towards the root

Cleaning and Lubricating the Duct

- Ø Clean both the duct-ends with water and waste cloth. There should be no dirt on the duct-ends.
- Ø Mark both duct-ends with 60mm "Insertion Mark", with a permanent marker pen.
- Ø Apply "a drop of shampoo", as a soap-based lubricant, on the inner side of O-Ring inside the coupler, without opening the coupler.

Coupler Fitting.....



- Ø Initially, insert one duct-end into the coupler with a gentle push.
- Ø Duct-end should slip inside the rubber O-Ring with a "tik" sound and come to the center of the coupler.
- Ø Confirm that "Insert Mark" line is just outside the coupler.
- Ø Repeat the process from other end of the coupler.

Cutting of duct without proper planning:

- Ø **Gap in ducts**- due to this the duct-ends will not cross the "O" Ring and leakage will occur. Plan for an overlap of 20~30 mm.
- Ø **Shrinkage**- Avoid the coupling immediately just after pulling the duct by HDD, possibility of shrinkage may appear and leakage can occur.
- Ø Do not use the "**Chinese Figure**" applied portion in the duct coupling.
- Ø Coupler shall not be installed along the bent portion of duct/trench in both horizontal as well as vertical direction.
- Ø Avoid the coupler installation in Horizontal or Vertical Zigzag portion of the duct.
- Ø Couplers should not rotated while fitting otherwise the Teeth & O-Ring of the coupler will get damaged. Do not use hammer on Coupler while installing.
- Ø Damaged Teeth Ring may weaken the joint and tightness of coupler will be affected.
- Ø Coupler shall not be opened during fitting as it is designed for "Push-Fit".

What are the reasons of leakage in couplers during DIT??

- Ø Most likely reason for coupler leakage is the Damaged "O-Ring"

Push Fit Couplers



Reasons of Leakage:

- Ø Use of incorrect tools, specially “Hacksaw Blade”. An unclean cut damages the O-Ring.
- Ø Duct cut exactly at 90 degrees (Square-Cut) can damage the O-Ring.
- Ø Not Chamfering and using heavy force to push the duct can damage the O-Ring.
- Ø Penetration of dust while coupler fitting/handling. The duct should be properly cleaned before starting the coupling process.

Can we open the coupler and reuse successfully?

- Ø Yes, coupler can be opened and re-used using opening tool (C Spanner).
- Ø Coupler teeth-ring is widened and removed so that teeth remained sharp enough for grip and same. way while closing, precaution should be taken for placing the teethered ring over the duct.

4.5 Duct Protections

Double Walled Corrugated Pipe

- Ø DWC pipe (a Pipe within a Pipe) is a double layer pipe with the outer layer having corrugation and the inner layer with a smooth surface.



DWC Pipe



DWC Coupler

Material	Anti Rodent Plastic
Nominal Dia (mm)	50/38, 63/50, 77/63, 90/76, 120/103, 145/126, 160/136, 175/148
Length	3 and 6 meters
Colour	Orange or Blue

RCC/GI Pipe

- Ø RCC and GI pipe is also used to protect the duct at less depths or crossings
- Ø Commonly preferred specifications of RCC and GI pipe in telecom are:



RCC Pipe

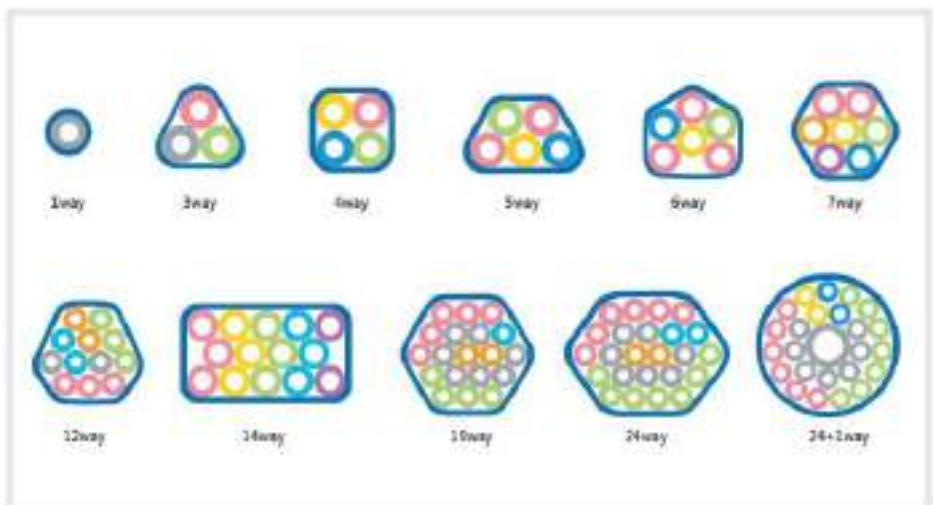


Particular	GI Pipe	RCC Pipe
Material	Galvanized Iron	Reinforced Cement Concrete
Outer Dia	65mm or 76 mm	100 / 150 mm
Length (mtrs)	2 or 3 Meters	2 or 3 Meters
Class	B (Medium duty)	NP3 (Medium duty)

4.6 Micro Ducts & Its Accessories

Micro ducts

- Ø Micro ducts are small ducts, used for the installation of small microduct fiber optic cables.
- Ø Micro ducts are typically small-diameter, flexible, or semi-flexible.
- Ø It provides clean, continuous, low-friction paths for placing optical cables that have relatively low pulling tension limits. (Generally, it has low friction antistatic inner surface)
- Ø Micro ducts can be pre-installed within a larger conduit, or simply pushed into existing conduits already in place.



- Ø **DIRECT BURIED (DB):** In applications, where the Micro ducts will be directly buried, or bundled, it is recommended to use thicker walled Micro ducts to maintain the optimum fill ratios and have faster, easier installations.
- Ø **DIRECT INSTALL (DI):** In applications, where the Micro ducts are placed inside an existing conduit, it is recommended to use thinner walled product where protection is provided by the existing conduit and space is more sensitive.



Microcables in micro ducts compared to a normal cable in duct

Micro Ducts: Anti Rodent (Direct Bury)

- Ø The Anti-Rodent (Direct Bury) type ducts:
- Ø Are designed to withstand and repel rodent attacks.
- Ø Have a fiber glass layer encased in inner and outer PE sheaths prevents rodents from causing costly damage.



Micro Ducts: Anti Termite (Direct Bury)

- Ø Are used where termite activity is likely
- Ø Have Nylon12 and aluminum layers encased in inner and outer PE sheaths to provide mechanical and chemical protection against attack by termites and ants (and their formic acid).

Micro Ducts: Chemical Resistant

- Ø Are used in environments at risk of chemical contact.
- Ø Have maximum chemical resistance provided through four layers of protection; an initial aluminum layer, an inner PE sheath, a chemical resistant layer and an outer PE sheath.



Micro Ducts: Direct Install Metal Free

- Ø Can be installed directly into a duct or sub-duct where a non-metallic solution is required (such as an area with a risk of lightening).
- Ø Have single PE sheath.
- Ø Have optional non-metallic moisture barrier (water blocking tape).



Micro Ducts: Direct Install Aluminum

- Ø Can be installed directly into a duct or sub-duct
- Ø Can be provided with moisture protection by a 150-micrometre layer of aluminum
- Ø Have single PE sheath
- Ø Are integral ripcord for easy sheath removal



Micro Ducts: Low Smoke Zero Halogen (LSZH) Tubes

- Ø Fire retardant and halogen free tubes which meet indoor fire regulations
- Ø Permanent low friction inner coating for enhanced blowing performance
- Ø Smooth or ribbed inner wall
- Ø Solid white colour as standard



Micro Ducts: Aerial

- Ø Are used for aerial installation where underground access is not possible or would be less economical
- Ø Are self-supporting
- Ø Are UV stabilized
- Ø Have figure of 8 construction with steel strength member



Cable Fill Ratio in Duct

Calculate $(d/D) * 100 = \% \text{ Cable Fill Ratio}$
 $(\text{OD CABLE} / \text{ID MICRODUCT}) * 100 = \% \text{ CABLE FILL RATIO}$



- Ø To calculate the fill ratio, divide the cable diameter (d) by the interior dimension (D) of the Micro duct.
- Ø To achieve maximum jetting performances, it is recommended to maintain a fill ratio between 50% and 75%.
- Ø Several factors impact jetting performance, including the condition of route, bends, and equipment.

Recommended Fiber Fill Ratios

MICRODUCT SIZE (MM)	FIBER COUNT	FIBER CABLE OD RANGE (MM)
5/2.5	UP TO 12	1.8 - 2.8
7/5.5	UP TO 48	2.8 - 4.1
8.5/6	UP TO 96	3.0 - 4.5
10/8	UP TO 96	4.0 - 6.0
12.7/10	UP TO 144	5.0 - 7.5
14/10	UP TO 144	6.0 - 7.5
16/12	UP TO 192	6.0 - 9.0
16/13	UP TO 288	6.5 - 9.8
18/10	UP TO 144	5.0 - 7.5
18/14	UP TO 288	7.0 - 10.5
22/16	UP TO 432	8.0 - 12.0
27/20	UP TO 432	10.0 - 15.0

Micro Couplers

- Ø Micro Couplers are used to join two segments of Micro ducts.
- Ø They are available in multiple sizes, starting from 5 mm dia.
- Ø Micro Couplers are designed specifically for Fiber to the Home (FTTH) networks.

Features:

- Easy assembly/disassembly, no tools required
- Provide an air and water tight connection
- Color coded by size
- Resistant to high pressures for blowing micro cables through guide tubes
- Resistant to corrosion and most chemicals



Micro Duct Cutter

The Micro Duct cutter is used to make a 90° cut of the Micro Duct.



Micro End Caps

- Ø Micro end caps are used to seal the ends of the Micro Ducts.
- Ø Easy assembly/disassembly, no tools required.
- Ø Provide an air and water tight connection; keep debris out of Micro Duct pathway.
- Ø Color coded by size.



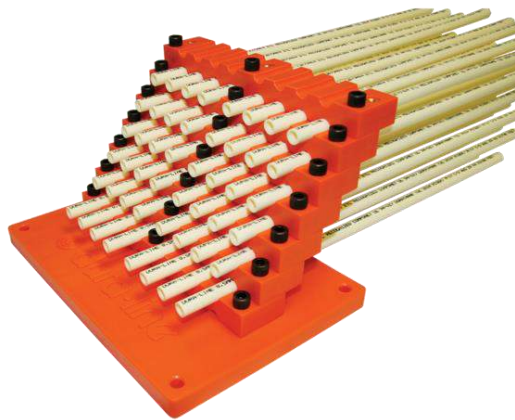
Divisible Duct Seal Kits

- Ø Divisible Duct Seals provide an air and water tight seal between the cable OD and Micro duct ID.
- Ø The hard outer cover is divisible so it can be easily installed around an existing cable.
- Ø Inner seals are color coded to quickly differentiate between cable OD's.
- Ø Available for Micro duct sizes 5mm - 18mm.



Micro Duct Mounting Bracket

- Ø The Micro duct mounting bracket is designed to organize Micro ducts at termination.
- Ø It's small and compact, requiring a minimum amount of mounting space.
- Ø The modular design allows ordering additional brackets as needed.



Gas Block Connector

- Ø The Gas Block Connectors provide a simple and effective gas seal between the Micro Duct and the fiber cable.
- Ø Its size ranges from 5mm - 16mm accommodating different fiber cable size ranges.



Duct Branch Closure

- ∅ The Duct Branch Closure is intended for fast and easy branching of direct buried micro duct assemblies for air blown fibers.
- ∅ The Duct Branch Closure minimizes installation cost by eliminating the need for time consuming fiber splicing in various branch points.
- ∅ The closure is intended for mounting directly into the ground or in manholes, but can also be installed above ground.



Distribution Closure



T Closure



Y Closure

4.7 Duct Storage

- ∅ Place the material in the manufacturer's premises (till it is required in field) so that it will not affect the performance of the product.
- ∅ Coil the duct in suitable size for delivery.
- ∅ Use standard moving equipment for loading, unloading and handling.



Section 3: Exercises

Exercise 1: Identify following HDPE duct accessories.

- a) End Plug
- b) Simplex Plug
- c) Duct Coupler
- d) C Spanner
- e) Duct Cutter
- f) Chamfering Tool

Exercise 2: Participate in group discussion on following topic.

- a) HDPE Duct Protections (DWC, GI and RCC Pipe)
- b) HDPE Duct Dimensions, Marking and Check Points

Section 4: Assessment Questionnaire

1. What are qualities of HDPE Duct?
2. What are applications of HDPE Duct?
3. What are advantages of HDPE?
4. What are Limitations of HDPE?
5. What is marked on HDPE Duct used in telecom cable conduiting?
6. What are check points during inspection of HDPE Duct?
7. Which equipment is used to unwind the duct roll?
8. Identify the item shown in image below.



9. _____ is used to seal the end of the duct, after cable is installed.
10. What can be Used to cut duct ends without any burr or notch?
11. Why Chamfering tool is used?
12. Can we open the coupler and reuse?
13. _____ is a double layer pipe with the outer layer having corrugation and the inner layer with a smooth surface?
14. _____ is also used to protect the duct at less depths or crossings.
15. Which tool is used to open the duct coupler?
16. _____ are installed in micro ducts.
17. In which application thicker walled micro ducts are installed?
18. In which application thinner walled micro ducts are installed?
19. What is formula for % cable fill ratio?
20. The _____ is intended for fast and easy branching of direct buried micro duct assemblies for air blown fibers.

-----End of the Module-----

MODULE 5 UNDERGROUND OFC LAYING PRACTICES

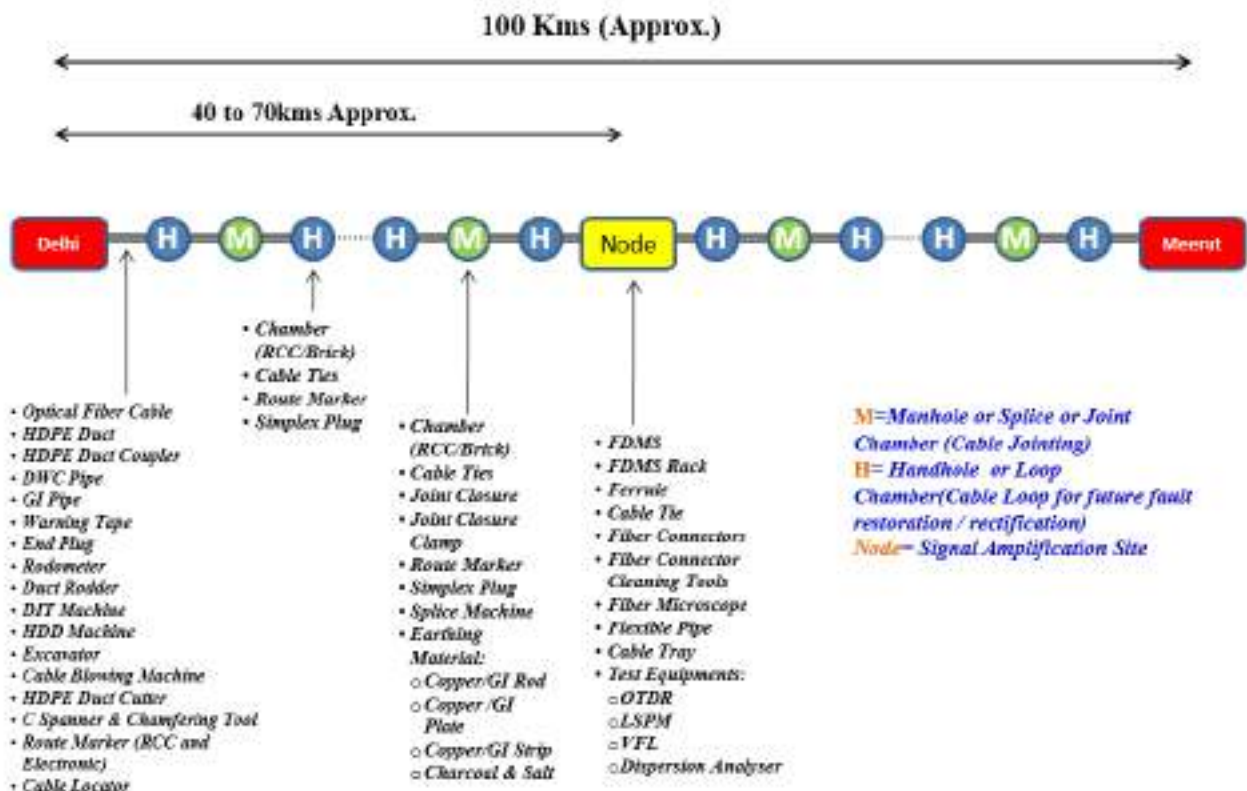
Section 1: Learning Outcomes

After completing this module, you will be able to:

- Explain the fundamentals of OFC Route Survey and Right of Way (RoW)
- Describe the various process of Trenching viz. Open, Micro, HDD and Moling
- Explain the procedure of Direct Buried Cable Installation
- Describe the process of Ducting and Backfilling
- Use duct protections at different types of crossings (Bridge/Culvert/Road/Railway)
- Install Manhole and Handhole chambers
- Install Route Markers
- Perform Duct Integrity Test (DIT)
- Pull and blow cable in installed duct

Section 2: Relevant Knowledge

OFC Link Illustration



5.1 Flowchart of Optical Network Construction Process



5.2 OFC Route Survey

Survey shall cover the following:

- Ø Details of Route
- Ø Right of Way (RoW) Demarcation
- Ø Soil Strata
- Ø Crossings (Bridge/Road/Railway)
- Ø Existing Underground Utilities
- Ø Cost Estimation
- Ø Any other Criticalities or Risk Factors

Survey Report

Route Description

This route starts from Point A.... and goes through then from goes to road viaand turn left and route is proposed left.....upto point and then turns right towards road and then turns left road and then goes to and then turns right and goes to and route from is proposedRHS end point of B.

Soil Strata of OFC Route

The general condition of the soil is varies from Normal to Soft & hard rocky. On the basis surface survey and as per strata seen visually, the tentative length and depth Chart as given below:

Type of Soil	Length in KM
Normal	
Mix Soil	
Sandy	
Hard Rock	
Other (if any)	
TOTAL	

Depth Bifurcation

Chainage (in Kms)	Bifurcation of Depth in CM					Aerial Cable
	Culvert/ Bridge/ Road Crossing	Less than 60 CM	Greater than and equal to 60 CM and less than 120CM	Greater than and equal to 120 CM and less than 165 CM	Greater than and equal to 165	
0-10						
10-15						

Crossing Details

SN	Type of Crossing	Details of Location	Method (HDD/OT/ Clamping)	Length in Mtr
	Culvert	At chainage 15.2		
	Gas			
	Railway			
	Road			
	Any other			
	TOTAL			

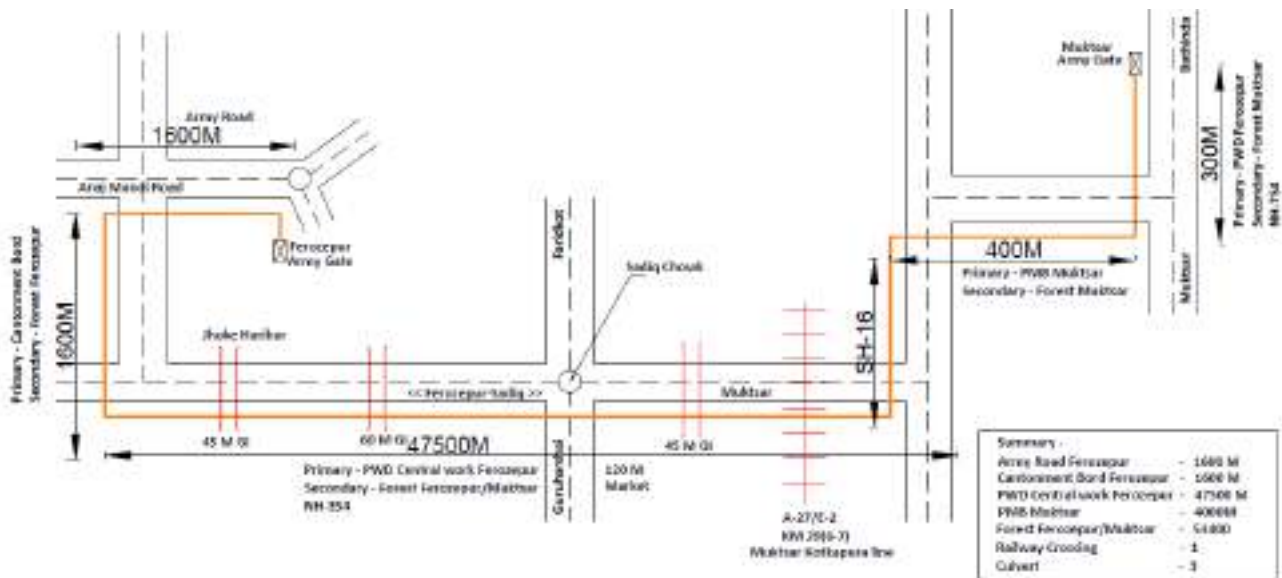
Details of ROW authority

Authority Name	Length in KM
NH	
SH	
Railway	
PWD	
CPWD	
Gas authorities	
Forest	
Any Other as per OFC route	
TOTAL	

Name of Amplifier Locations

Particular	Location No.1	Location No.2	Location No.3	Any other ...
Name				
Distance (KM) (From Start Point to Amplifier location)				

Route Survey: Pre-Construction Map



Comparative Route Survey: Sample Checklist

FORMAT A					
COMPARATIVE ROUTE SURVEY					
Sl. No.	Description	Route-I	Route-II	Route-III	Remarks
1	Route Marks				
2	Route Sections				
3	Start and End point of the route				
4	Total Route Length				
5	Major towns/ commercial establishments				
6	Villages and Towns				
7	Rivers / Streams				
8	Bridges / Culverts				
9	Railway Crossings				
10	Road Details				
	a) Mt				
	b) MTA				
	c) St				
	d) PWD				
	e) MC				
	f) Others				
11	Soil Strata / Terrain				
12	Forest Details				
13	Water Logged Area				
14	D/E / Loose Cables				
15	Gas Pipeline Crossings				
16	Water Pipeline				
17	Future Expansion Plan				
18	Industrial Units				
19	Subvert Affected Area				
	Recommendation				
					Survey Corrector Name
					Signature
					Name
					Date

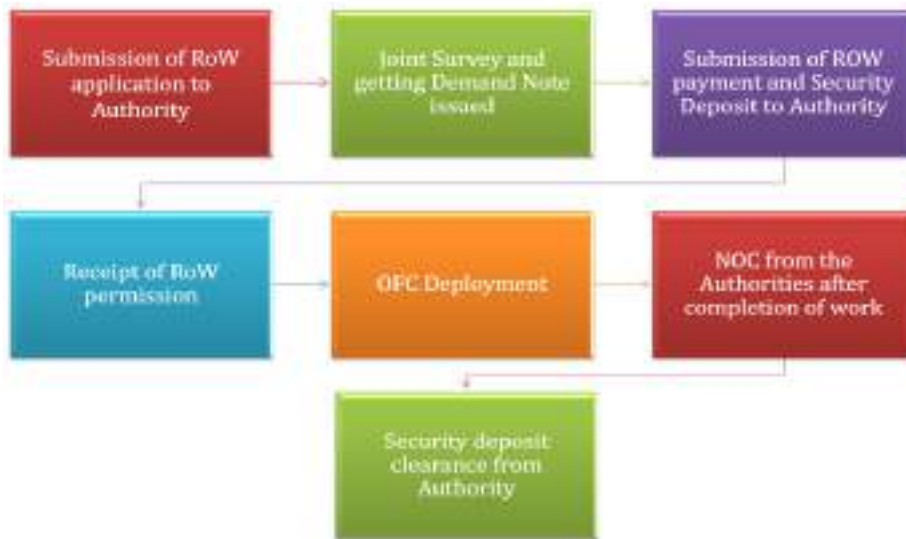
5.3 Right of Way

RoW is to be obtained from central/ state/ local authorities as per the route approved after the survey

- Ø State Highways
- Ø National Highway Authorities
- Ø Forest Department
- Ø Railway Department
- Ø PWD Roads & Buildings Department
- Ø Municipal Corporations
- Ø Panchayat
- Ø Irrigation Department
- Ø Cantonments etc.

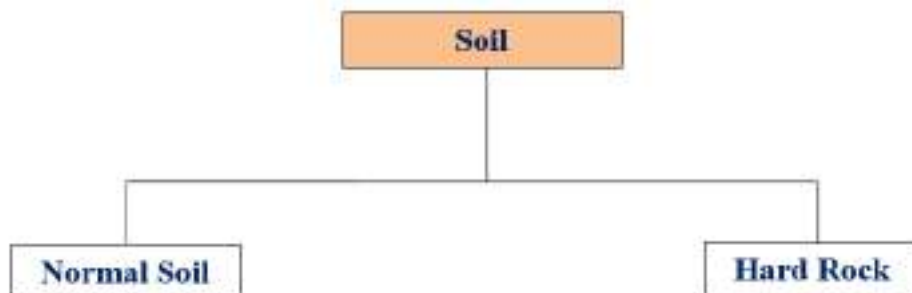


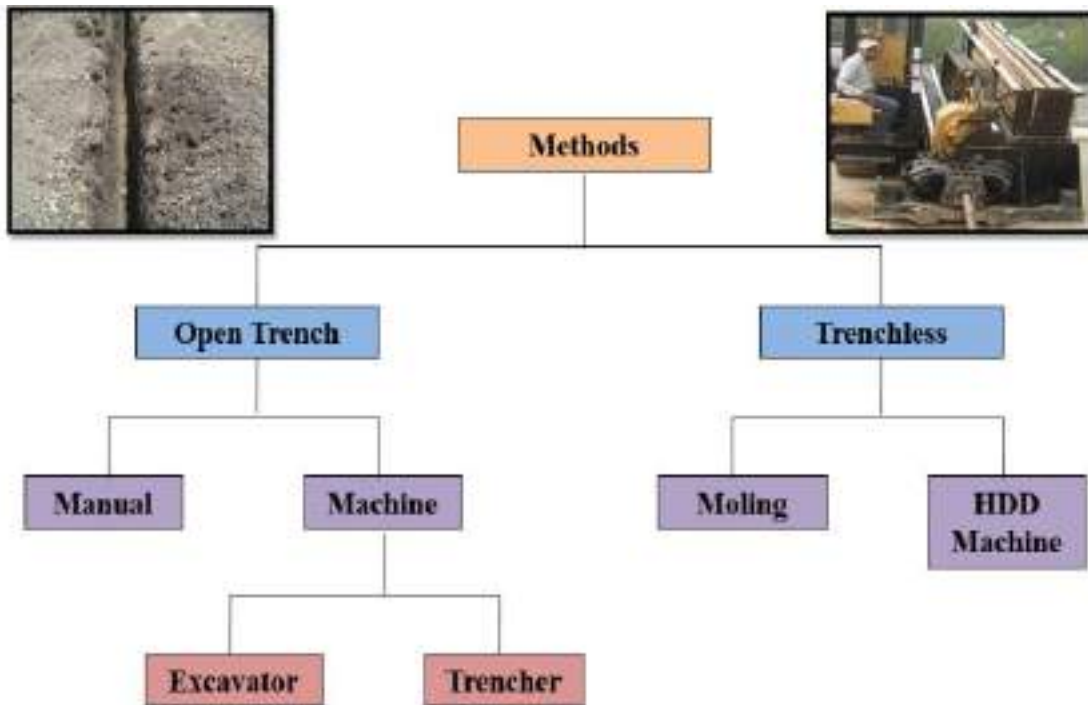
RoW Process



5.4 Open Trenching Trenching

- Ø The process of continuous digging following a single line with specific dimensions is called Trenching.
- Ø The depth of the trench may vary as per soil strata & specification.





Trenching Specifications – General

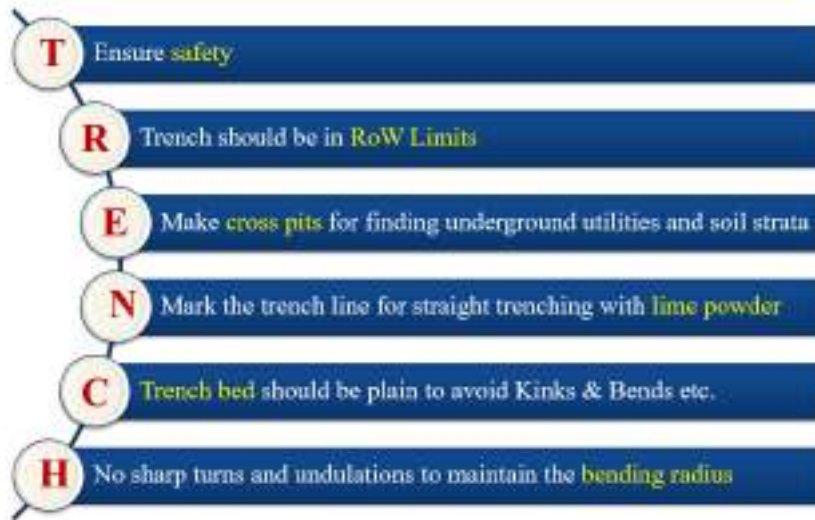
Ø Top width 450mm and Bottom width 300mm

PROTECTION FOR LESS DEPTH	
Depth	Type of Protection
0 Cm to 30 Cm	Not Permitted
30 Cm to 60 Cm	GI Pipe Dia. 65 mm with Concrete PCC
60 Cm to 120 Cm	DWC Dia. 78 mm
> 120 cm	No Protection

STANDARD DEPTH (FROM TOP OF SURFACE)	
Terrain	Depth (Cms)
Normal Soil	165
Rocky Terrain	120

Ø Wherever achieving full depth is not possible due to site constraints such as rocky area, presence of underground utilities like pipelines, power cables etc., less depth may also be resorted with prior permission of user.

Prerequisite for Trenching



Making of Cross Pit



Cross Pit and Lime Powder Marking

Proper way of Trenching



5.5 Micro-Trenching

- Ø Micro-trenching is the process of installing HDPE ducts within the edges of the roads to place fiber optic cables.
- Ø A quick, low-impact deployment method, fiber optic cabling is inserted into a small slot-cut trench without damaging or disrupting existing infrastructure and traffic.
- Ø It uses diamond tipped saw blades, which allow efficient cuts through asphalt and concrete.

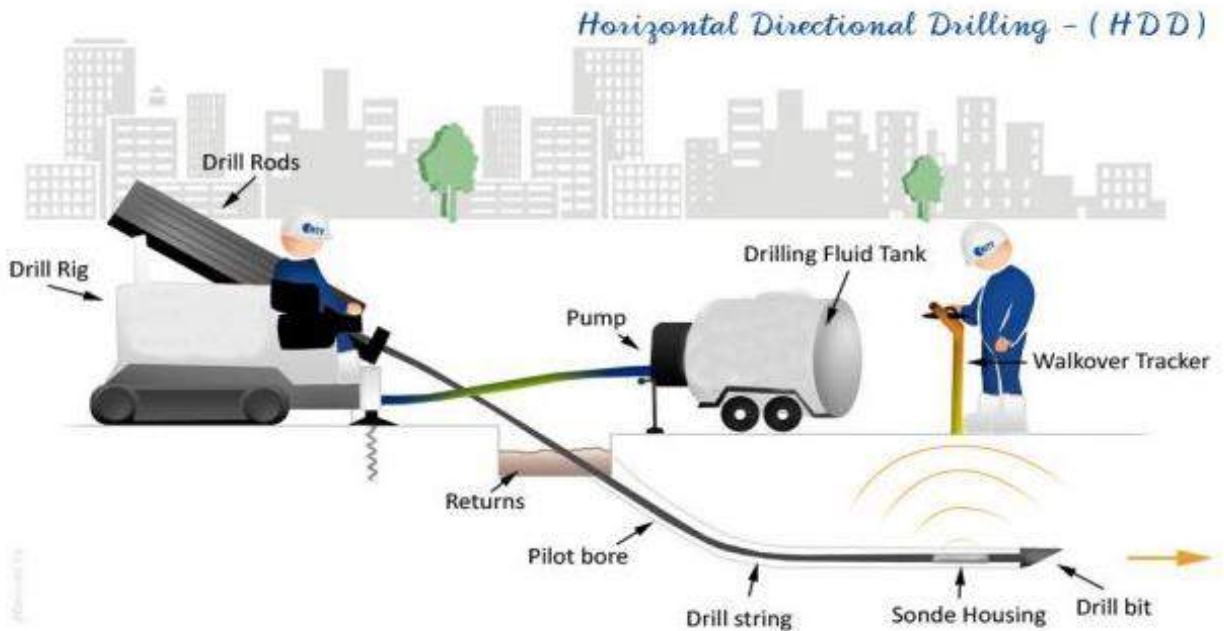


5.6 Horizontal Directional Drilling (HDD)

This is a trenchless method providing limited disturbance, fast & economical installation of duct.

Ø Applicable for drilling of < 250m stretch.

Ø Preferred for Road / River / Culvert /Railway crossing.

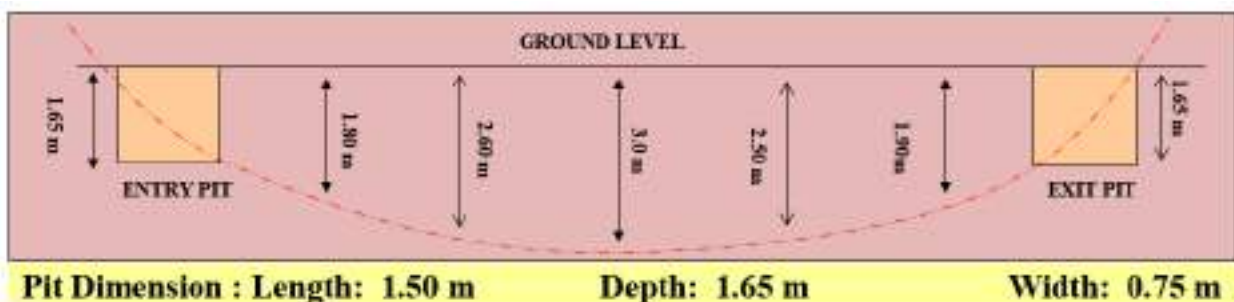


Drilling

Ø Appropriate Entry and Exit Pits are to be made.

Ø During drilling operation, continuous monitoring and plotting of the pilot drill shall be recorded.

Ø The tracking system is used for determining Alignment, Depth and Position of pilot.



Pilot Locating System

The tracking system shall provide information on:

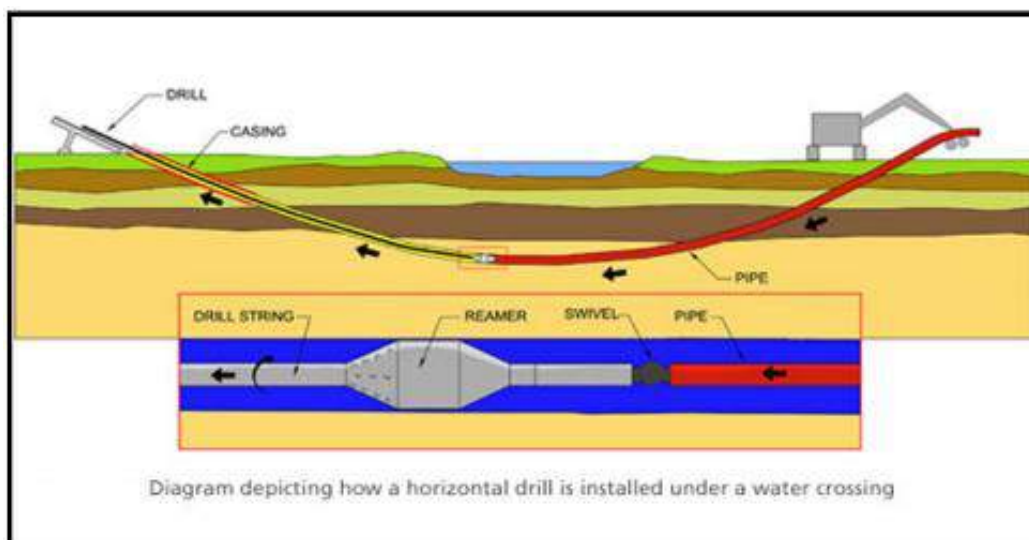
- Ø Alignment
- Ø Depth
- Ø Position

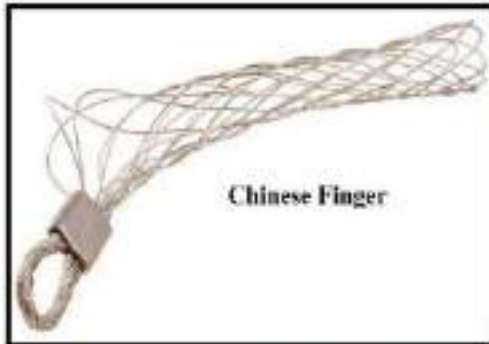


HDD Process

Two stages of HDD:

- Ø Pilot drilling (Tracking system is used to determine Alignment, Depth and Position of pilot)
- Ø Reaming and pulling back the duct





HDD Fluids

- Ø Drilling fluid is a mixture of water and specialized additives used in the drilling process.
- Ø Drilling fluid cools the drill head and transmitter.
- Ø Bentonite is added to drilling fluid to seal the drilled bore from water ingress downwards and at the sides of the bore.



HDD: Do's & Don't

- Ø Entry/Exit pit should have proper depth & size.
- Ø Lime powder marking should be done for drilling in straight line.
- Ø Debris/bushes must be cleared.
- Ø Duct de-coiling should be done using duct de-coiler only.



HDD: General Safety

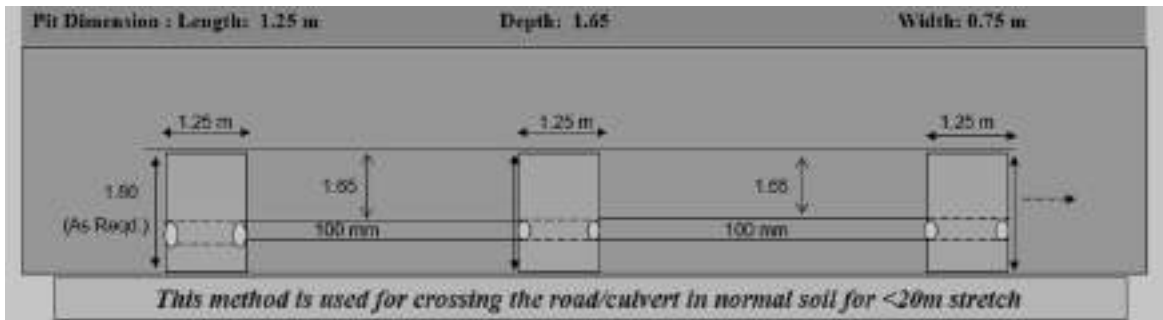


HDD Operator : PPEs



5.7 Moling

- Ø Moling is a trenchless process in which trenchless operation from pit to pit is done by sectional pipes manually.
- Ø Successful only in places having normal soil strata.
- Ø Unsuccessful/unsuitable for more than 20m stretch.
- Ø Moling method is used for crossing under the road.



5.8 Direct Buried Cable Installation

Generally, Armoured type cables are selected for direct burial which offers:

- Ø Higher crush resistance
- Ø Additional protection from ground rodents
- Ø Easy localization

Methods:

- Ø Plowing
- Ø HDD
- Ø Direct Placement in Micro-Trench

While installation take care of:

- Ø Maximum pulling tension of cable
- Ø Minimum bend radius of cable
- Ø Crush resistance of the cable



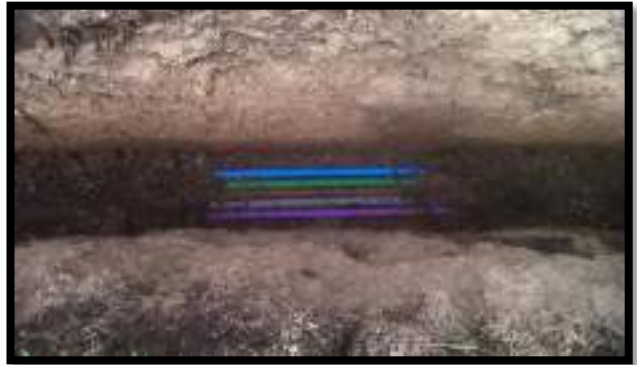
Cautions

- Ø Take care to avoid cable damage during pulling, bending and crushing forces.
- Ø Fiber optic cable should be coiled in a continuous direction in Figure '8'.
- Ø Ensure straight and levelled trench bed.
- Ø Potential problems should be identified and resolved in advance.
- Ø Take care of the underground utilities.
- Ø Ensure timely and effective grounding.
- Ø Ensure continuous monitoring of cable during installation.

5.9 Ducting

Ducting is the process of placing duct in the trench

- Ø Check the roll of the duct for any physical damage
- Ø Always decoil the duct using Decoiler
- Ø No Water/Mud should be present in trench while laying the Duct/DWC pipe
- Ø Place the duct in the trench as per guidelines
- Ø The ducts should not overlap to each other
- Ø Ensure coupling before backfilling and cap the end



Ducting Practices: Cautions

Decoiler Not Used



Bending Radius Not Maintained during Laying



5.10 Backfilling

Backfilling Practices

Refilling of excavated area with soil is called Backfilling.



Warning Tape

Warning tape should be placed in the trench at 0.75m depth from the ground level.



Reinstatement of Excavated Trench

Beware of **Kinks & Punchers** on duct

Crowning shall be made over the trench

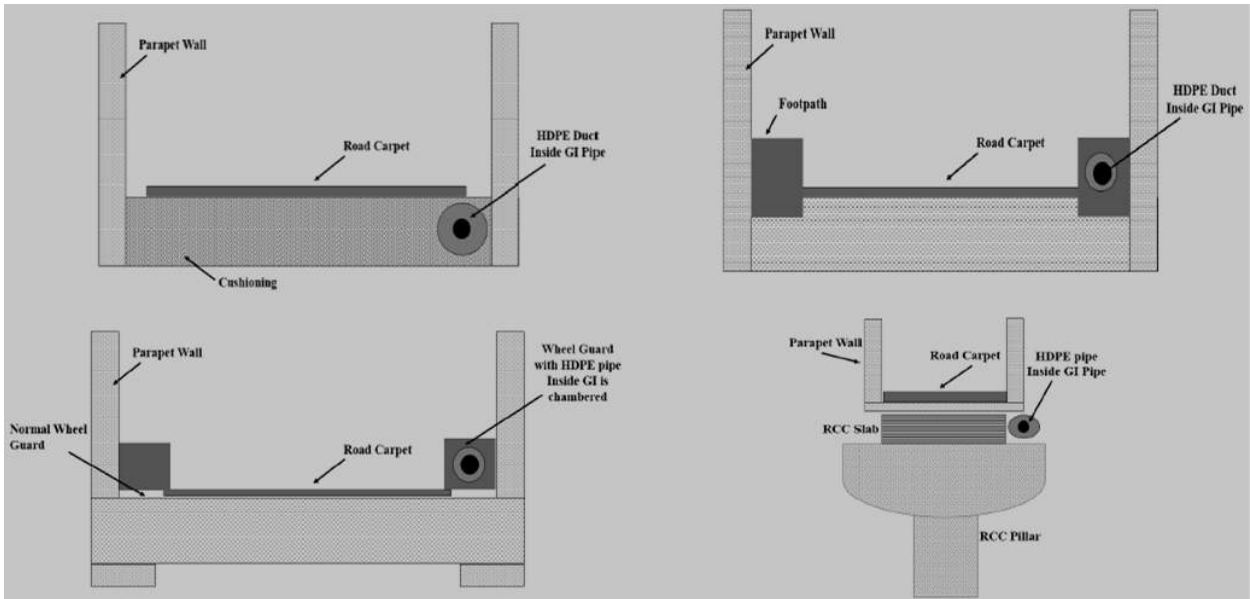
Every layer of backfill, about 25 to 30 cm, should be **compacted** with water to achieve adequate compaction

Debris should be removed after completion of work.

Heavy stones should not be put over the duct



5.11 Crossings Protection Guidelines (Bridge/Culvert/Road/Railway)



Guidelines for Bridge / Culverts Crossings

- Ø G.I. pipes should be extended up to depth of 1.55m in case duct running on bridge.
- Ø G.I. pipes to be extended up to 2m length from edges of the bridge/culvert.
- Ø DWC/RCC pipes should be used parallel to dry culvert. For wet culvert G.I. protection and concrete encasement to be provided.
- Ø Outside the railing, G.I. clamps with nuts bolts should be of 12mm diameter.
- Ø On bridge, the G.I. pipe should be encased with M15 concrete (1:2:4 mix) all around the G.I. pipes.

Guidelines for Bridge Crossing





Bridge Crossing by DWC & PCC

Guidelines for Railway / Road Crossing

G.I./RCC pipes should be extended for 2m on both sides from the end of the road.

Ø G.I. or RCC pipes should be joined by using collars.

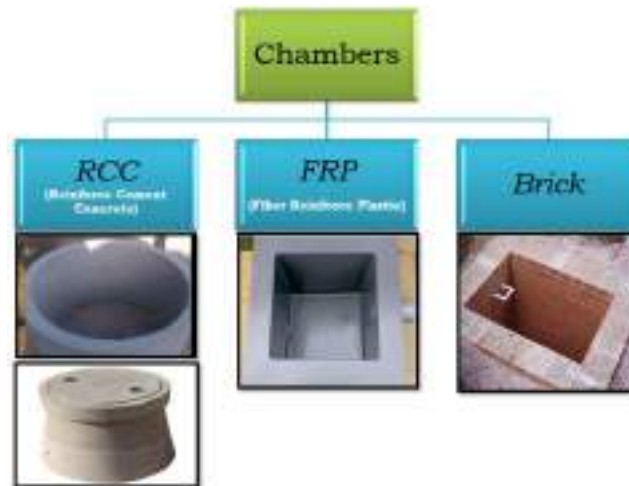
Ø HDD or Moling methodology to be used for railway crossing.

Ø Loop chamber to be provided on one/both side of track.

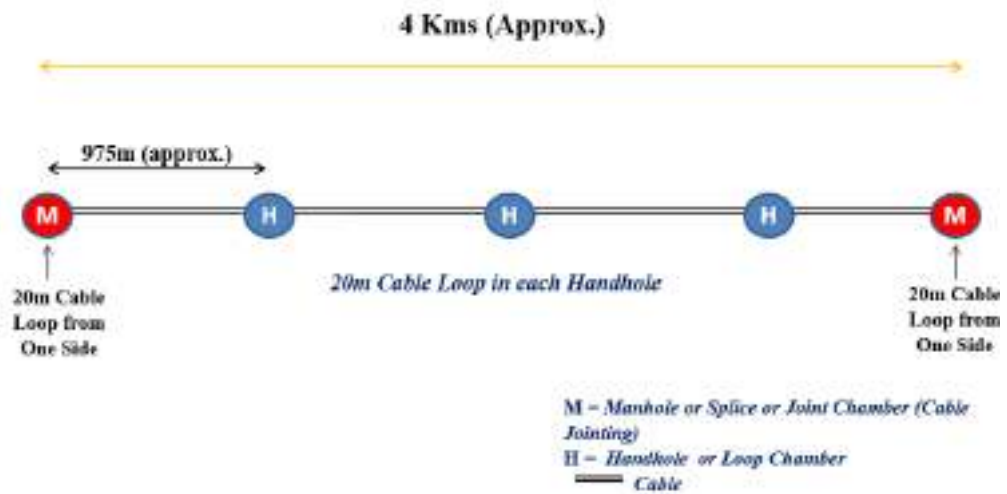




5.12 Manhole / Handhole Installation
Types of Chambers



Chamber Locations



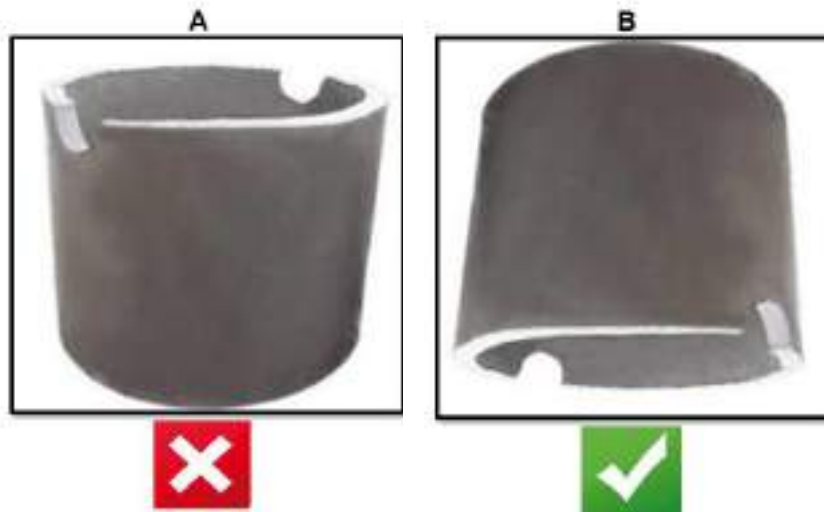
Chamber distances may vary as per ground conditions and requirements

RCC Cylindrical Chamber

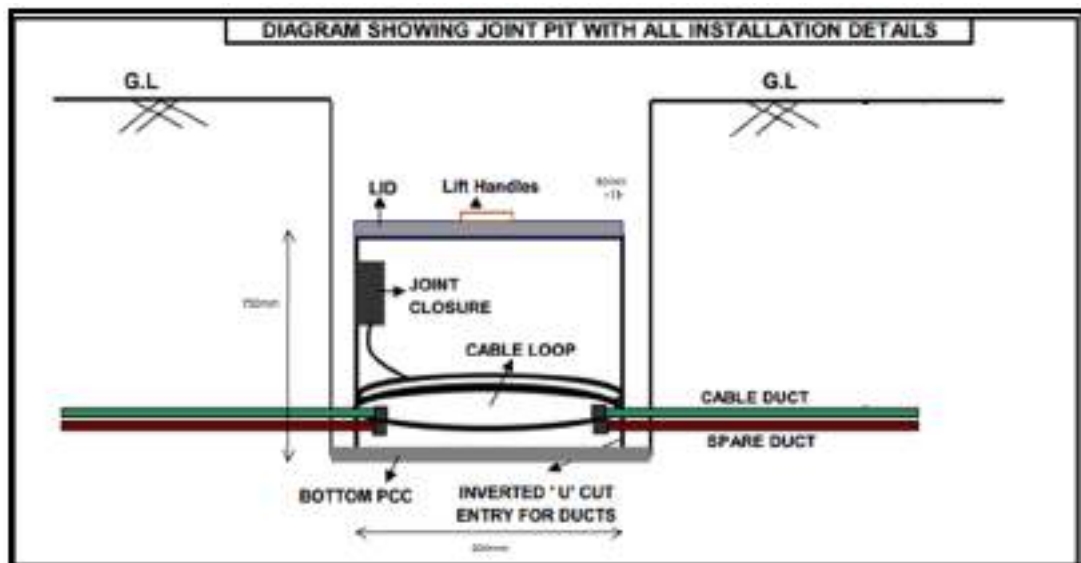
- ∅ The duct length inside the chamber should be 5-10 cm.
- ∅ Duct entry hole should be sealed with cement mortar 1:2.
- ∅ Backfilling of joint chamber pit with excavated soil can be carried out.



Chamber Installation Practices

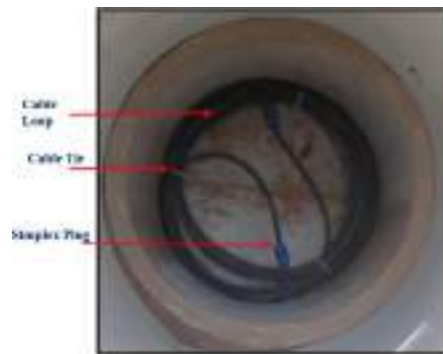


Joint Pit & Loop Pit



- ∅ Manhole (Joint Chamber) location depends on length of cable in a drum and Handhole (loop Chamber) location may as per user's decisions.
- ∅ Cable loop in Manhole and Handhole can be between 10 to 30m.

Placement of Cable Loop in Handhole



HANDHOLE

Placement of Joint Closure in Manhole



MANHOLE

Chamber Installation Documentation

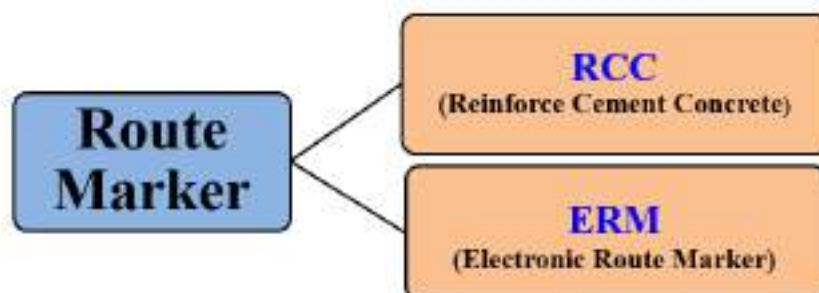
Chamber Documentation:

- Ø Type of Chamber
- Ø Location of Chamber (lat/long details)
- Ø Numbering on Chamber
- Ø Depth of Chamber covers from ground level
- Ø Details of cable slack left at each chamber



5.13 Installation of Route Marker

Route Markers





RCC Route Markers Installation Guidelines

- Ø RCC Route markers are installed at every 200 m along the route.
- Ø Route markers offset should be 1m from the trench away from the road center.
- Ø Route markers should be provided on both sides of bridge/culvert.
- Ø Route markers should be straight and facing the road side.
- Ø Route Indicators are to be placed where OFC changes directions like road crossing, etc.

Electronic Route Markers (ERM)

- Ø ERM is used to locate the underground cable.
- Ø It is placed 2 to 3 ft. deep from ground level over the PLB duct or chamber at every 200m.
- Ø It is a ball type ERM with specific operating frequency.
- Ø ERM Locator of specific frequency is used to find the ERM.

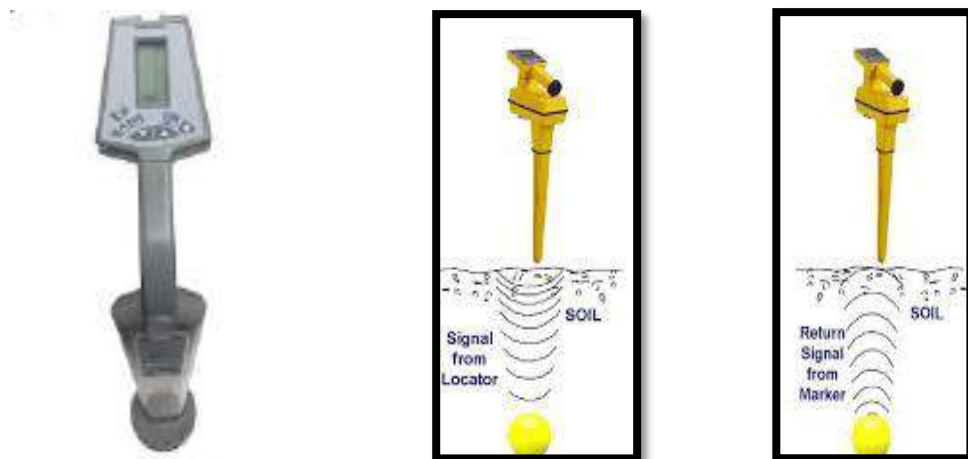


Passive ERM



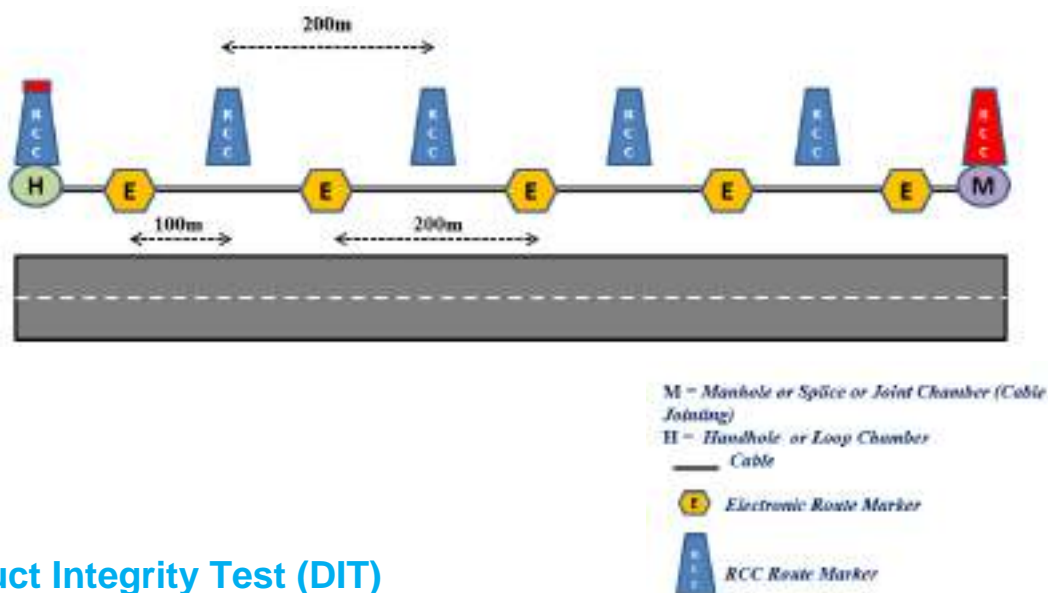
ERM Locator

How Electronic Locator System Works?



- ∅ The locator transmits a specific frequency signal to buried ERM.
- ∅ The ERM, tuned to same frequency, reflects the signal back to locator.
- ∅ The locator indicates the signal strength bar graph and depth value of ERM on visual display with audible tone.

Route Marker Placement



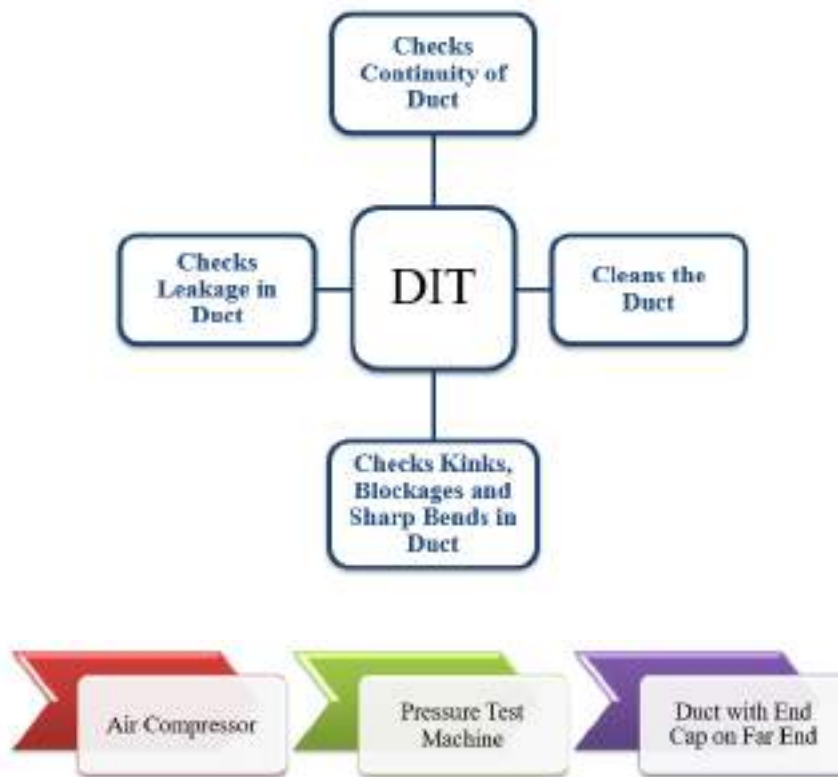
5.14 Duct Integrity Test (DIT)

Purpose:

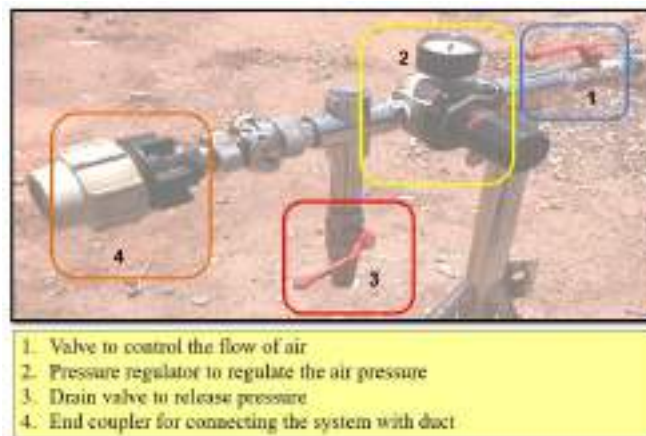
Purpose of Duct Integrity Test is to ascertain and ensure the suitability of duct for optical fiber cable installation through air blowing.

What is DIT?

- ∅ DIT is a series of tests performed on the underground duct.
- ∅ It is the intermediate step between duct laying and cable blowing.
- ∅ Duct Integrity Test is performed to ensure that duct is ready to use for blowing the cable.



Pressure Test Machine



Duct Integrity Test

The Duct Integrity Test involves:



Air Blowing Test



- Ø Pass the compressed air at 5 to 8Kg/Sq.cm and clean the duct from deposits like mud and small stones.
- Ø Pressure fall should not be >50% in 1 hour.....Test Passed.
- Ø No Air flow/Low Air/Back PressureTest Failed.

Reasons for Failure:

- Ø Duct Overlap-Coupler missing
- Ø Blockage (mud, plastic, etc.)

Pressure values and test passing criteria could change as per user standards

Sponge Test

- Ø Insert a medium density sponge into the duct and push it with compressed air of standard pressure.
- Ø The sponge ejected with full force.....Test Passed.
- Ø The sponge not ejected at far end.....Test Failed.
- Ø If the test fails..... Blow Transmitter



Reasons for Failure:

- Ø Kink or dent

Shuttle Test

- ∅ The shuttle is made of hard rubber, polished wood or plastic.
- ∅ It should be of cylindrical shape with length of 15 cm and diameter equals 75% of duct diameter.
- ∅ At the receiving end, a shuttle catch box must be used.
- ∅ The shuttle ejected with full force.....Test Passed.
- ∅ The shuttle not ejected at far end.....Test Failed.

Reasons for Failure:

- ∅ Bending radius not maintained



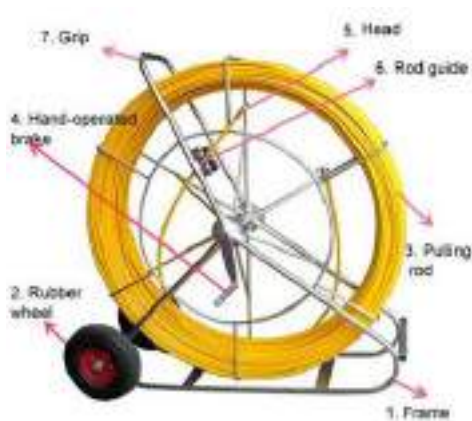
DIT : Safety

- ∅ Do not go inside the pit while DIT is being performed.
- ∅ Do not open couplers and DIT machine connections before pressure is released completely.
- ∅ Use caution tape and traffic cones wherever pits are opened for testing and machinery is placed.
- ∅ On completion of test, seal the duct ends with end plugs.

5.15 Cable Pulling and Blowing

Cable Pulling using Duct Rodder

Duct Rodder is used to pull the cable in duct for distances upto 300m. It is made of Fiber Reinforce Plastic (FRP).

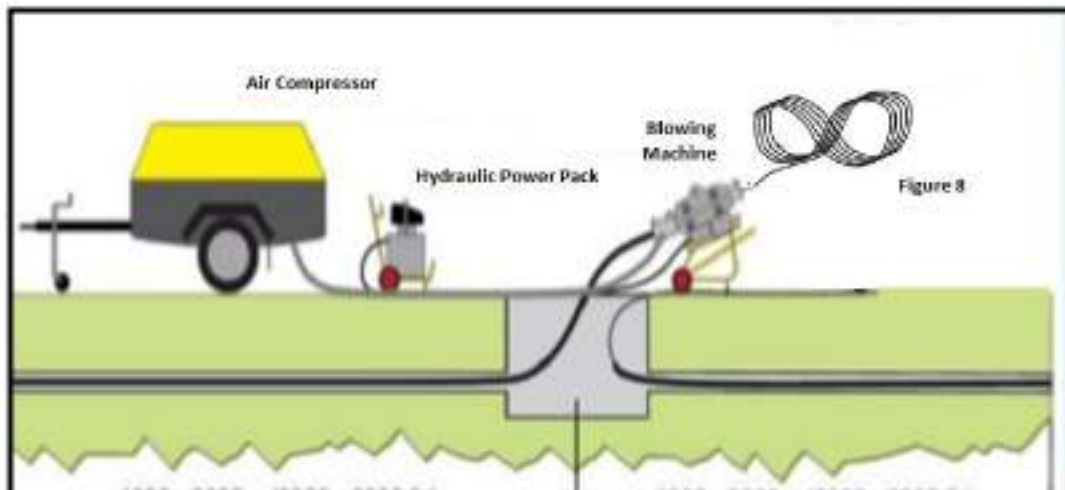


Step 1 : Unlock the duct rodder hand brake and position the duct rodder

Step 2 : Insert the duct rodder Bullet into the duct until it reaches the other end

Step 3 : Attach the cable with Bullet and pull duct rodder Bullet to install OFC cable inside duct

- Blowing is the process of installing the OFC cable in underground duct with the help of air pressure
- Ø Cable blowing is done with the help of Air Compressor, Hydraulic Power Pack, Cable Blowing Machine (Super Jet Machine)
 - Ø Drum should be kept approximately at the center of two adjacent manholes.



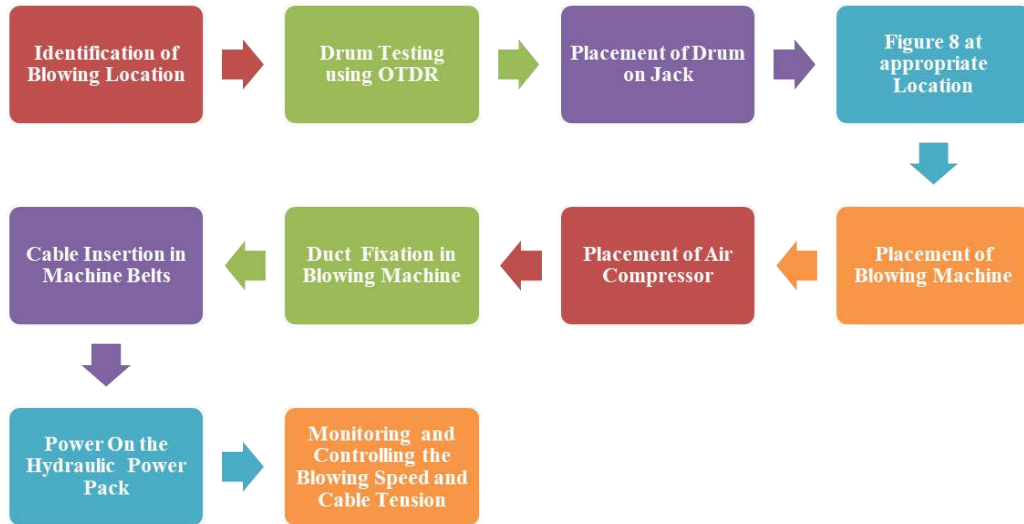
Drum Test and Figure 8

- Ø Each fiber in the cable is tested using OTDR before blowing.
- Ø Cable drum should be mounted on jack, kept on a plain surface with cable stored in figure of "8".

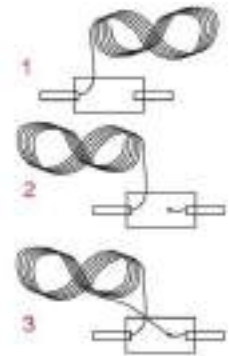


Cable Blowing Process

- Ø Cable blowing is done with the help of compressor, hydraulic power pack, blowing machine (Super Jet Machine).
- Ø Ensure the OFC drum tested using OTDR.
- Ø Drum should be kept approximately at the center of two adjacent manholes.

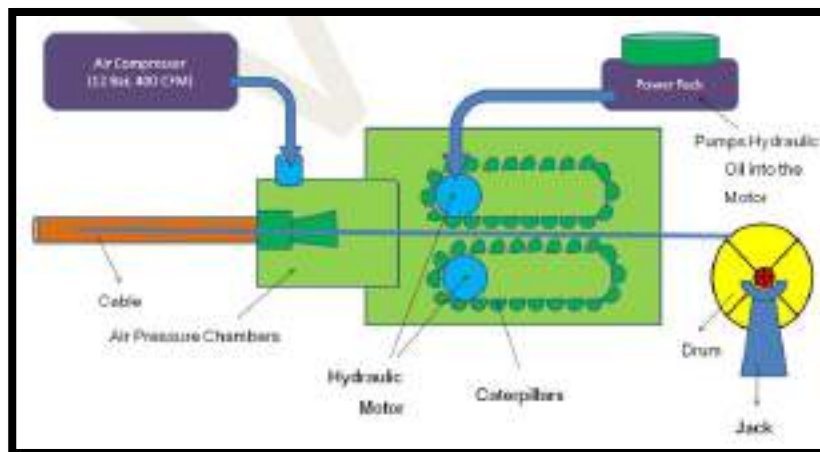


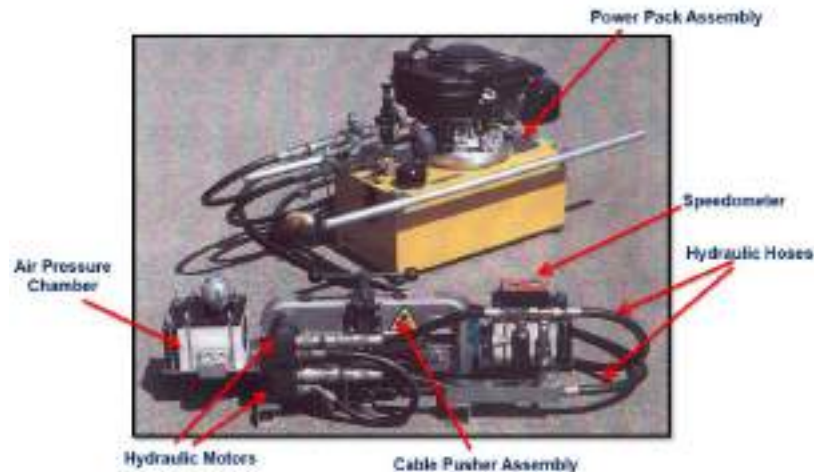
- Ø Divide long pulls into several shorter pulls, using the figure 8 technique for storing cable at the intermediate locations.



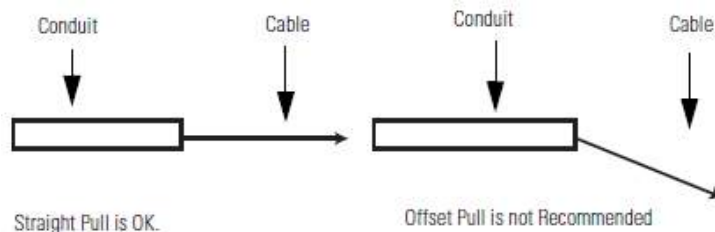
Blowing Technique : Super Jet Machine

- Ø Hydraulic Super-jet Machine is driven by two hydraulic motors. Power is supplied by a hydraulic power pack, which is driven by Petrol Engine.
- Ø Hydraulic Super-jet Machine can blow the cable of Dia 14mm to 32mm at the speed upto 60m/min upto 2km length (cable) at a time.
- Ø Cable blowing compressor should deliver pressure equal to or less than pressure deployed for DIT.





- Ø Never exceed the maximum pulling load rating.
- Ø Never exceed the cable bend radius.
- Ø Never twist the fiber cable. Putting a twist in the cable can stress the fibers too.
- Ø Pull, do not push cables.
- Ø When installing long runs, communicate and monitor along the path of the installation.
- Ø Use fiber optic cable lubricant. Lubricate the cable when installing in conduits. Lubrication reduces the pulling load and the chance of breakage.
- Ø The lubricant has to be compatible with the cable jacket material.



- Ø Use the figure 8 technique.
- Ø Install a cable in locations in which the temperature range imposed is within the temperature operating range.
- Ø Avoid placing cable reels on their sides or subjecting them to shock from dropping.
- Ø Fiber optic cables should be placed in their own dedicated ducts or trays.
- Ø Do make every effort to pull cables from a conduit in as straight an angle as possible. Pulling on an angle can cause damage to the cable.
- Ø Follow the blowing equipment suppliers blowing distance recommendations; 3000 to 6000 feet is a typical blowing length.

5.16 Splicing

Splicing of Fibers

- Ø The cable ends shall be prepared after the cable entry into the closure at every 2/4 Kms or as per cable drum length.
- Ø The strength member shall be fixed to its fixing mechanism provided in the joint closure.



Sealing of Joint Closure

- Ø After completion of splicing, the base and the dome of the closure and the cable entry shall be air sealed.
- Ø It shall be ensured that the splice closures are air tight and water proof.

Re-instatement of Pit

- Ø After completion of splicing arrangements, the pit is to be filled with sand/soil incorporating warning bricks/stone etc. as per standard procedures.



Section 3: Exercises

Exercise 1: Word Search Puzzle.

Find the answer of the following questions in the word search puzzle.

- Answer words can go in any direction.
- Answer words can share letters as they cross over each other.

Question	Answer Hint
1. Component used to join ducts	7 Letters Word
2. Name of cable blowing machine	8 Letters Word
3. A component that is used to join HDD drill bit and duct	6 Letters Word that starts with 'S'
4. A type of trenchless method	6 Letters Word that ends with 'G'
5. Method of making hump on backfilled trench	8 Letters Word that starts with 'C'
6. Name of the chamber used for placing fiber cable joints	7 Letters Word that starts with 'M'
7. A type of Route Marker	10 Letters Word that ends with 'C'
8. A type of Duct Integrity Test	7 Letters Word that starts with 'S'
9. Process of making a small slot-cut trench	14 Letters Word that starts with 'M'
10. Device used to blow air in the duct	10 Letters Word that ends with 'R'

Z A R R Z J W N L M Z N C N D
 N N U G O P S Z Y G H O I G C
 Y R U G I K O N R Y U K N R O
 P S U P E R J E T M B D O A M
 P F E O Q G B H B O Q W R S P
 V W E P M U R S P L N J T H R
 G Y W D P E W F C I M K C M E
 N D F I L V L L N N V R E G S
 S V D P U R Z G V G F L L D S
 I W U E L O H N A M T X E Q O
 A O I P E B I N A T Y A P Q R
 C O X V F R J R U U K N Y Y F
 P K N X E C Z H T Z C L O D Z
 C D Y V L L S G T G D U P M S
 M I C R O T R E N C H I N G N

Exercise 2: Make a flow chart of Right of Way (RoW) process.

Exercise 3: Draw a flow chart of cable blowing process.

Exercise 4: Participate in group discussion on following topics:

- Types of Route Markers and its Placement Procedure
- Duct Integrity Tests (DIT)

Section 4: Assessment Questionnaire

1. What details do we capture in route survey?
2. What are some problems encountered during RoW process?
3. The process of continuous digging following a single line with specific dimensions is called:
4. What are various methods of trenching?
5. Why cross pits are made during trenching?
6. During micro-trenching, what can be used which allow efficient cuts through asphalt and concrete.
7. What is full form of HDD?
8. What is the typical shot distance of HDD method?
9. What information is provided on Pilot Locating System?
10. What is used to connect the duct with HDD machine pilot?
11. Name some components used in HDD operations.
12. _____ is a mixture of water and specialized additives used in the drilling process.
13. What is use of drilling fluid?
14. Why bentonite is added in drilling fluid?
15. The trenchless process in which trenchless operation from pit to pit is done by sectional pipes manually is called:
16. Which type of cables can be used in Direct Buried Cable Installation?
17. What precautions are taken during Direct Burring Cable Installation?
18. The process of placing duct in the trench is called:
19. Refilling of excavated area with soil is called:
20. At what depth warning tape is generally placed?
21. Which pipe is used while crossing the wet culvert?
22. Where we should not install DWC Pipe?
23. G.I. or RCC pipes should be joined by using:
24. Identify the type of chamber.



25. What are various types of Chambers?
26. Duct entry hole should be sealed with cement mortar of mix ratio:
27. What should be the duct length inside the chamber?
28. Cable loop in Manhole and Handhole can be between:
29. What is used to fill-in the Manhole chambers?
30. What are two types of Route Markers?
31. RCC Route markers are installed at every _____ along the route.
32. Why do we use ERM?
33. RCC route marker should be straight up and facing road side. True or False?
34. What is purpose of DIT?
35. What equipment and accessories do we need for DIT?
36. At what rate air is pressured in Air blowing test?

37. What may be reasons of failure of Shuttle Test?
38. In what test sponge is inserted in duct?
39. Air pressure during DIT is less than the cable blowing pressure. True or False?
40. What material can be used to make shuttle for shuttle test?
41. What should be the shape of shuttle used in DIT?
42. What should be diameter of shuttle for shuttle test?
43. Use of water is essential to perform DIT. True or False?
44. What are precautions to keep in mind while conducting DIT?
45. _____ is used to pull the cable in duct for distances upto 300m.
46. What material is used to make rod of Duct Rodder?
47. _____ is the process of installing the OFC cable in underground duct with the help of air pressure.
48. Name the machine used for cable blowing process?
49. What is speed of Hydraulic Super-jet Machine used commonly?
50. Cable blowing compressor should deliver pressure equal to or _____ than pressure deployed for DIT.
51. The process of jointing two fibers is called:
52. What material is required for earthing of Joint Enclosure?
53. Unarmoured cable should be earthed /grounded at every 8 Kms. True or False?
54. Arrange following activities of obtaining ROW in correct order:
 - a) Collect the DD / BG for submitting to the ROW authority
 - b) Obtaining ROW permission for the entire Route
 - c) Submission of ROW applications authority wise
 - d) Follow-up with the ROW authority for obtaining Demand Note
55. In normal soil condition, open trench depth is generally:
56. Arrange the following lengths in ascending order for a link:
Duct Length, Cable Length, Fiber Length, Surface Length
57. Purpose of cable loop in loop chamber is to:
58. Which factor will determine the distance between manhole?
59. Why crowing is done over the backfilled trench?
60. What information is depicted in pre-construction route survey report and map?

-----End of the Module-----

MODULE 6

AERIAL OFC INSTALLATION PRACTICES

Section 1: Learning Outcomes

After completing this module, you will be able to:

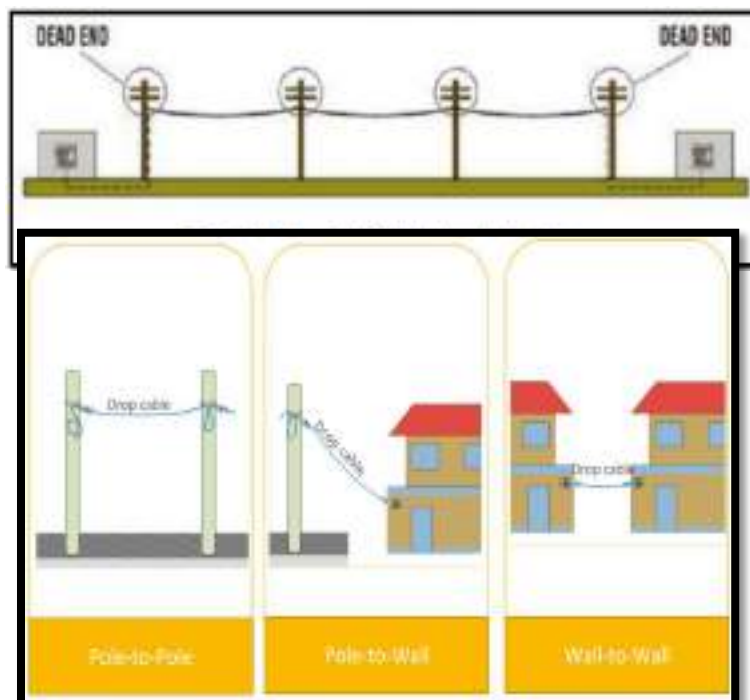
- State the need of Aerial Cabling and various Customer Serving Areas
- Install the Aerial Cable using various installation methods
- Differentiate between various Types of Aerial Assemblies
- Install the Figure 8 cables on poles
- Install Aerial Cable using Anchoring Clamps (Wedge Clamps) Assembly
- Install Aerial Cable Suspension and Tension Assembly
- Adhere safety guidelines while installing Aerial Assemblies

Section 2: Relevant Knowledge

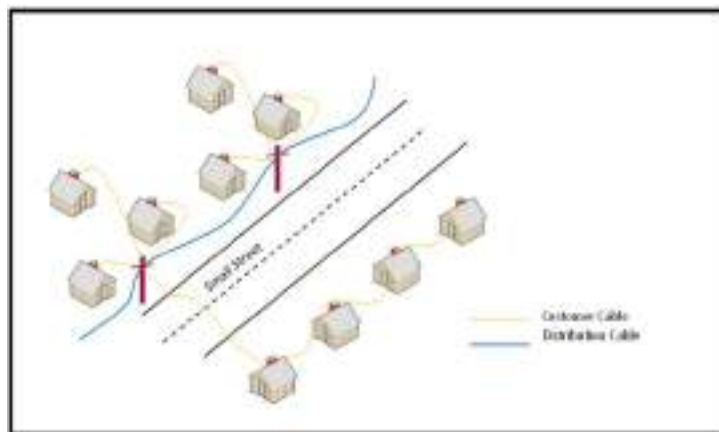
6.1 Introduction to Aerial Cabling

Aerial Installation

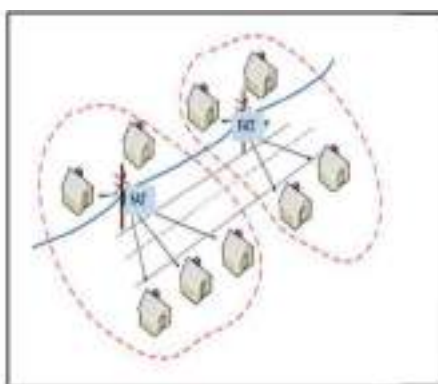
- Ø Alternative solution to underground OFC installation.
- Ø Optical Fiber Cable can be hung from:
 - Pole to Pole
 - Pole to Building/Wall
 - Building to Building (Wall to Wall)
- Ø All Dielectric Self Supporting (ADSS) Optical Fiber cable is installed.



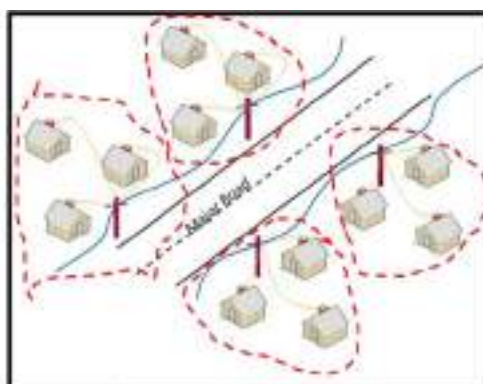
Customer Serving Area – Road Crossing Pole to Building



Customer Serving Area – Aerial Distribution



For aerial distribution along small streets, FAT or OTB at pole serve the buildings or customers on both sides.



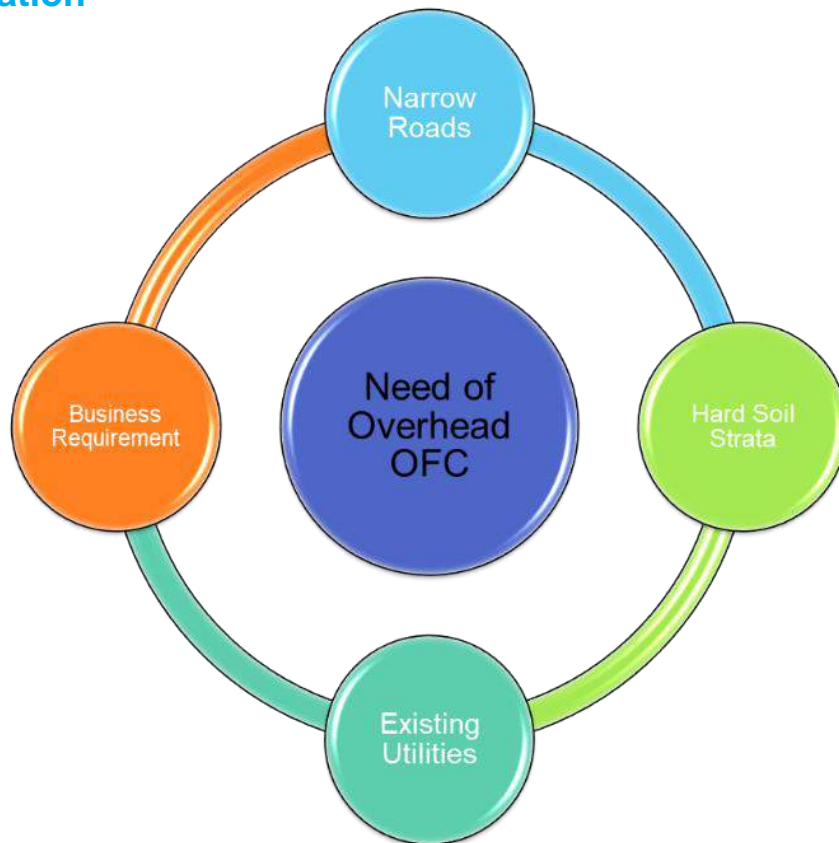
For aerial distribution along major public roads, FAT or OTB at pole serve buildings or customers on same side of the pole.



Customer Serving Area – Road Crossing & Building to Building



Have a building to building distribution on the same side of road. This scenario is applicable for the buildings that are located in the same compound. In this scenario, underground road crossing is done and aerial cabling is done to connect buildings buildings on the is done on same side of road.

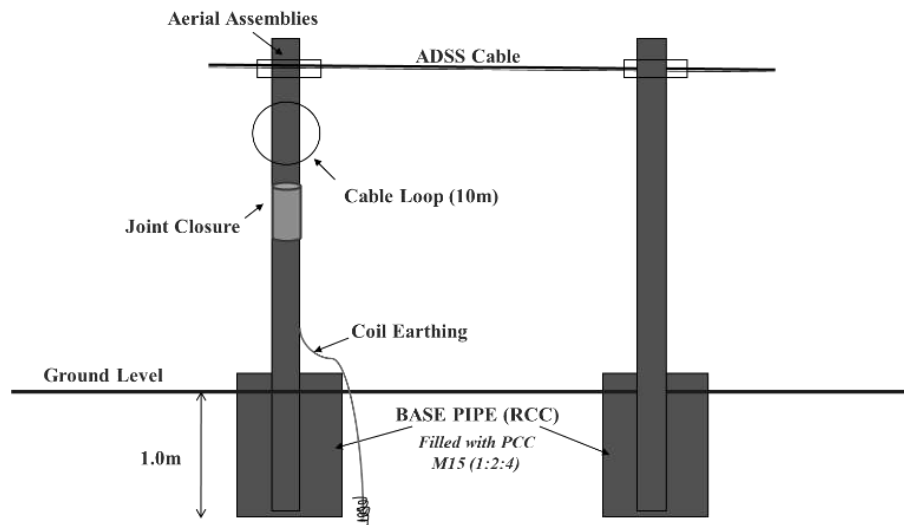


Aerial Installation is Non- feasible in Stormy or Heavy Wind Area and Ice Land

Aerial vs Underground Cabling

Execution Method	Underground Installation	Aerial Installation
Fiber Protection	More	Less
Supervision & Maintenance	Difficult	Easy
Installation Speed	Low	High
Material Cost	More	Less

Aerial Cabling Practices



- Survey of the aerial route should be carried out pole to pole.
- The span length must not exceed above recommendations as per cable.
- Ground clearance of 12 to 15 feet in a section should be kept.
- Cable loop of atleast 10m is recommended at splice location.
- The splice box can be stored aerially or buried underground.
- The cable should be brought down through a GI pipe clamped on the pole.
- Earthing of each pole is recommended.


Pole to Pole Deployment

Existing poles of utilities such as SEBs, Telephones, PWD or Municipal bodies to be used. If required and subject to permission Poles can be owned and installed.

Existing Pole Deployment

- Ø When using existing pole, it shall be ensured that Optical Fiber Cable is installed below existing/ future power lines running on such poles.
- Ø Minimum separation between electrical cable/ fittings and Aerial Optical Fiber Cable shall be ensured:
 - a) From insulated electrical cable : **600mm**
 - b) From non-insulated electrical cables/ wires : **1500mm**
 - c) From light-fittings/ conduits and stay fittings : **100mm**
 - d) At crossing of Low Voltage power lines : **1000mm**
 - e) At crossing of High Voltage power lines : **3000mm**

- Existing Poles
- Pole Height
- Normal Span



Existing poles of utilities such as State Electricity Boards (SEBs), Telephones, Public Works Department (PWD) or Municipal bodies to be used.

- Existing Poles
- Pole Height
- Normal Span



- Pole height should meet requirements of ground clearance
- It should not obstruct any construction or traffic movement in the area

- Existing Poles
- Pole Height
- Normal Span

- Normal span of poles will be 30-35 m
- In exceptional cases the span can be maximum 50 m
- New poles can be installed to meet span requirements

6.2 Aerial Cable Installation Methods

- Ø Figure 8 cables feature a built-in support wire for tensile strength and stability.
- Ø The support wire is typically a ¼ inch 7-strand, Extra High Strength (EHS) galvanized steel messenger, flooded to inhibit corrosion.
- Ø There are two methods of Aerial cable installation:

The Moving Reel (or “Drive Off”) Method:

It is used when the entire route is accessible by support vehicles. The route must be free of trees, limbs, and guy wires to allow full vehicle access. Support vehicles are used to pay off and raise the fiber cable to temporary support hardware. Once the cable is in position, it is transferred to the permanent support hardware.

The Stationary Reel Method:

It is typically used when the route is not fully accessible by support vehicles. The cable is pulled into place from a stationary reel located at one end of the section run, and supported by temporary hardware. Once the cable is in position, it is transferred to the permanent support hardware.

Limitations and Precautions

- Ø Installation crews must be sensitive to the limitations of the fiber cable regarding maximum tension, minimum bend radius, and crush resistance, and take action throughout the installation process to prevent exceeding these limits.
- Ø Leave the lagging or other protective wrap on the cable reel until the reel is delivered to the installation site to prevent handling damage.
- Ø Ensure the curvature of the support device is greater than the minimum bend radius of the cable to prevent damaging the cable.
- Ø Avoid surges in cable tension during reel payout.
- Ø To avoid damage to the cable jacket, do not drag the cable over fixed surfaces.
- Ø Slack coils may be assembled in a continuous direction loop configuration or a “figure eight” (not to be confused with figure 8, the cross-section of the cable).

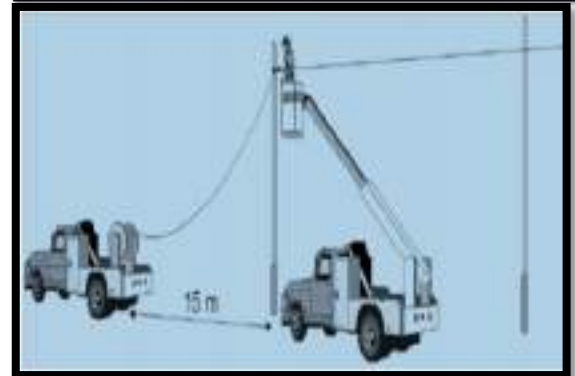
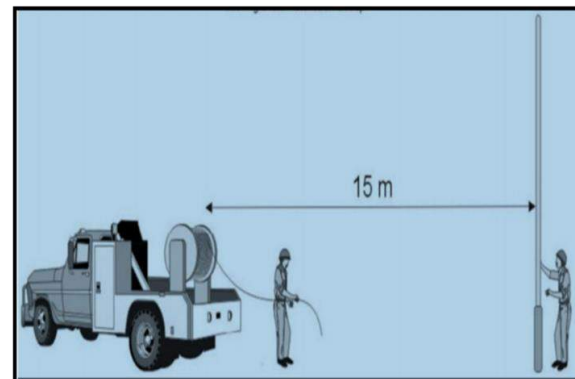
Construction Planning

- Ø Perform a detailed site survey of the aerial cable route to identify potential issues, determine accessibility, and create an installation plan. Site survey should include analysis of the following:
 - Route accessibility
 - Right of way/permitting issues
 - Determination of installation technique
 - Condition of poles and guying support
 - Location of fiber cable splice points
 - Locations for equipment setup
 - Clearances to existing power lines and other cables
- Ø Cable splice locations must be selected with consideration of splice vehicle accessibility.
- Ø For fiber cable(s), slack must be added to both cable ends at each splice location to allow for splicing.
- Ø Cable slack must allow the cables to reach ground level and into a splice truck plus 30 feet (9 meters) minimum.

Moving Reel Method

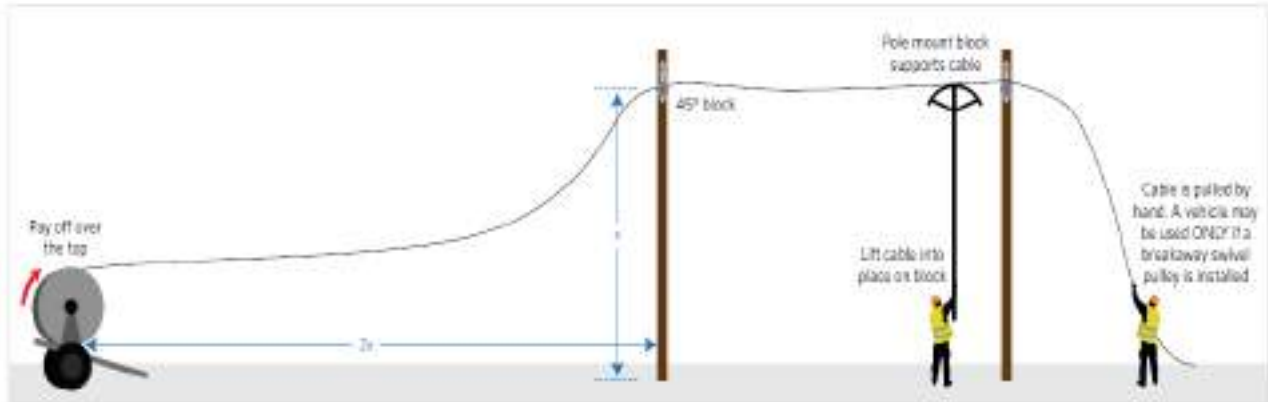


- Ø Cable pulled directly from drum mounted on moving vehicle
- Ø Vehicles selected for use using this method must provide full accessibility on the placement side of the poles along the entire section run.
- Ø Radio communication must be established between the cable reel payoff unit and the ground crew.
- Ø Cable Drum mounted with proper support for easy Cable pay-off.
- Ø Cable raised and placed on J-hook or block fitting for temporary support.
- Ø Procedure continued till dead end pole where Cable is terminated using Termination assembly sets and tensioned using turnbuckles to maintain cable sag.
- Ø In most cases, the moving drum method is the fastest and less expensive method of installing aerial cable.
- Ø Pole mounted hooks are the only temporary support devices required. Manpower required is less than by other methods.
- Ø This method requires vehicular access to the placement side of the pole line and a right-of-way clear of tree limbs, guy wires, and other obstructions.
- Ø To begin installation, park the vehicle with the cable drum approx. 15 meters away from the pole facing away from it down the pole line.
- Ø The cable must pay off from top of the drum towards the rear of the vehicle.
- Ø Install the termination supports and temporary J-hooks on the poles at the starting point and subsequent poles as per plan.
- Ø Pull off the necessary amount of slack, lift the dead-end to the top of the pole and mount on the termination assembly.
- Ø Pay out additional length of cable as it is lifted to the fixing location.
- Ø Start driving the drum-carrying vehicle down the placement side of the pole line, paying out cable off the back of the truck.
- Ø Once the drum is approx. 15 meters past each pole, lift the cable up the pole and place it on J-hook till the vehicle reaches end of the span with another termination assembly set.
- Ø Once the cable is fixed at both ends with at the terminating assemblies, carry out tensioning.
- Ø After the cable section is properly tensioned and secured at both ends lift the cable out of the J-hooks at each of the intermediate pole and support it with the suspension set assemblies.
- Ø Repeat the process for each of the span between two terminating assemblies.



Stationary Drum Method

- Ø In the stationary drum method of aerial cable installation, the cable is pulled along the cable route through temporary support hardware installed for this purpose.
- Ø The Stationary Drum installation method is more time consuming than the Moving Drum Method.
- Ø This method can be useful when the cable is to be installed where vehicular access may be limited or unobstructed Right-of-Way is not available.



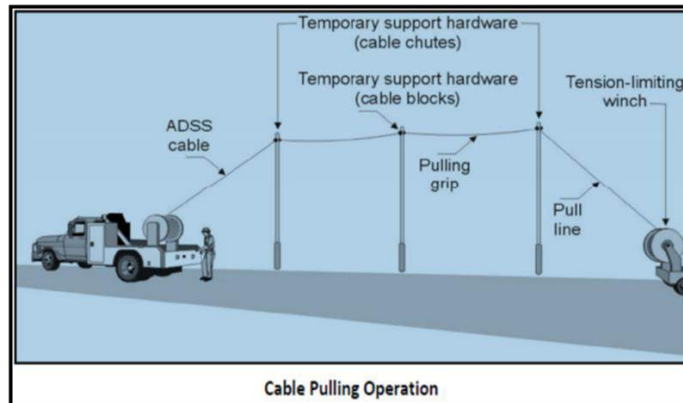
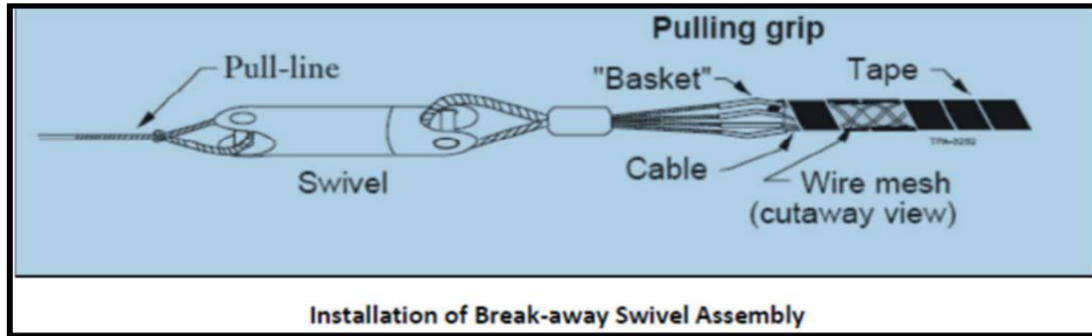
- Ø Stationary drum installation method requires installation of temporary support hardware such as pulley blocks and cable chutes for stringing the cable by pulling through such block.
- Ø The first step in the installation by this method is to install the temporary hardware described above at each of the pole within a span of terminating ends at desired height.
- Ø These supports are to be hung at the same height as final position of the cable after installation. Permanent pole clamps can be used for hanging these temporary supports.
- Ø The hardware shall ensure minimum bending radius (normally $20D$ where D is diameter of the cable) is not exceeded.
- Ø A rope wound on the tension limiting winch is passed through each of string blocks and chutes and connected to the cable on the drum installed on a stand which allows free rotation of the drum.
- Ø Where tension limiting winch is not available, as an alternative, breakaway swivels of appropriate rating shall be installed between pulling rope and cable.



Swivel



Pulling Grip

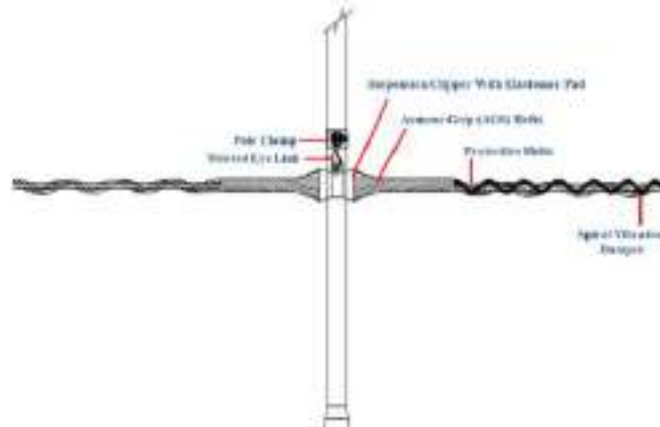


- Ø Once the system is ready for pulling, the winch start pulling the rope thus pulling the cable through the temporary stringing hardware.
- Ø This method requires a very careful monitoring of the pull force during cable pulling operations and sophisticated pulling winch or use of break-away swivel joints.
- Ø Length of cable that can be pulled in one go depends on the cable characteristics and quality of temporary support hardware.
- Ø The pulling load should normally not exceed 60% of the maximum permissible cable tension recommended by cable supplier.
- Ø A careful planning of location for the cable drum and pulling winches is a must. The cable drum and winch locations must have vehicular access.
- Ø It is always better to pull downhill if there are significant elevation differences along the route.
- Ø The cable drum should always be placed on leveled ground so that its flanges are vertical thus avoiding rubbing of cable against flanges.
- Ø The orientation should be such that the cable pay-off is directly in the direction of pull. Always pay-out the cable from top of the drum and not from bottom.
- Ø Cable pay-out needs to be controlled (by hand or by breaks) to prevent free running or jerking.
- Ø It is important to have a two-way communication between the cable pay-out area and pulling area for proper coordination and safety of pulling operations.
- Ø Sufficient number of personnel needs to be deployed to monitor entire operation.
- Ø At the end of the pull i.e. when the cable has reached the winch, it should not be wound onto winch drum unless winch drum radius is more than bend radius permissible for the cable.
- Ø Once the cable is completely pulled end to end, it is then ready for installation of permanent supporting system of terminating and suspension set assemblies at required locations and tensioning for sag control.
- Ø A low-elasticity pull line, such as an aramid yarn or wire rope, is recommended to minimize elastic-induced surges during the pulling process.

6.3 Aerial Cable Installation Assemblies Suspension and Tension Assembly

Suspension Assembly

The Suspension Assembly is installed on the pole when cable is to be installed straight on OFC path

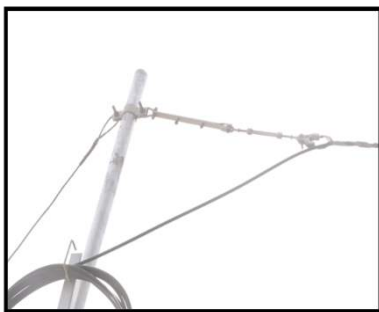


Tension Assembly

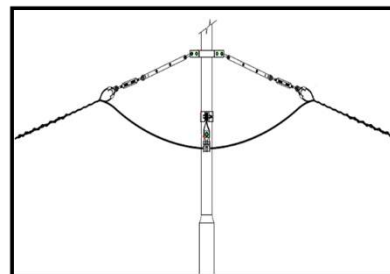
∅ This assembly is installed where:

- Cable route direction is changed
- Cable needs to be terminated (Start/Dead End)
- Cable is routed Underground to Overhead and vice versa
- Splice and Cable Loop is required in OFC path

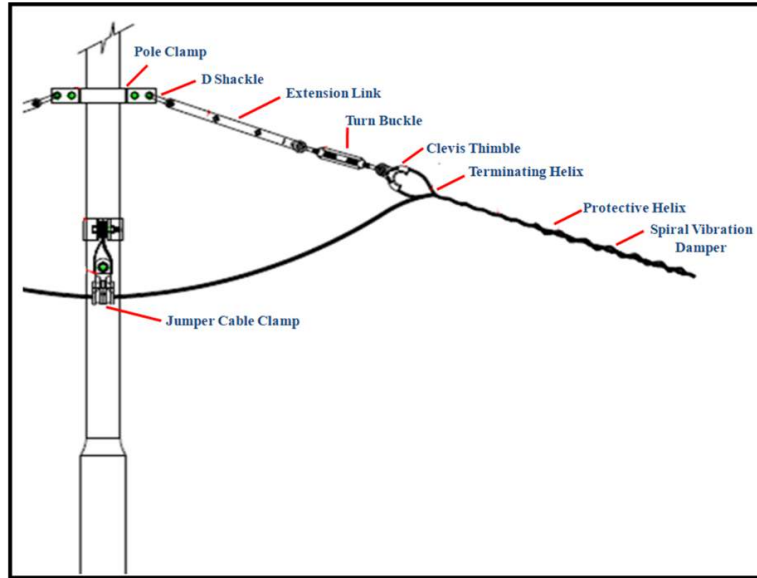
∅ Every fifth pole is planned be a tension pole in straight alignment with 10m cable loop.



Single Sided Tension Assembly



Double Sided Tension Assembly



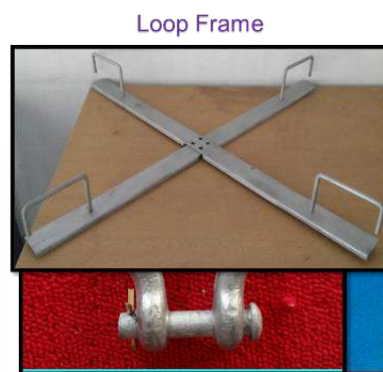
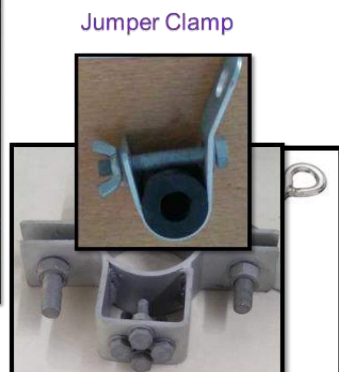
Components of Aerial Assemblies



Suspension Assembly



Tension Assembly



6.4 Anchoring Clamp (Wedge Clamp) Assembly

Stainless Steel Strap

- Ø Stainless Steel Straps with high corrosion resistance and tensile strength
- Ø Can be mounted on poles of any geometry
- Ø Easy and safe Installation
- Ø Supplied in a plastic case for easy handling with indication of strap length



Stainless Steel Strap Lock Buckle Wedge Clamp/Dead End/Anchoring



Clamp

- Ø Used to grip the cable
- Ø Specially designed teeth for clamping the steel core of Fig-8 cable
- Ø Aluminum alloy body and thermoplastic wedges climate resistant
- Ø Flexible wire rope to take care of the vibration on spans



PCL Ratchet Type Strap Binding Tool

Fitting tool for Stainless Steel Strap



Universal Bracket

- Ø Pole bracket for anchoring, suspension and stay wires
- Ø Made of high strength aluminum alloy
- Ø Mountable on poles with steel straps or bolts



Suspension Clamp

- Ø Fully Insulated plastic body for protection
- Ø Heat & UV resistant, Anti corrosive parts
- Ø No tools or bolt tightening required for Installation



Adjustable Loop Frame

Pulling and Lifting Machine



Step 1

Estimate the necessary strap length according to pole width and cut it



Step 2

Mark on the Steel Strap



Step 3

Insert the buckle inside the Steel Strap



Step 4

Bend the Strap end and the buckle ears



Step 5

Insert the buckle universal bracket in strap



Step 6

Tight the strap on pole adjusting the universal bracket



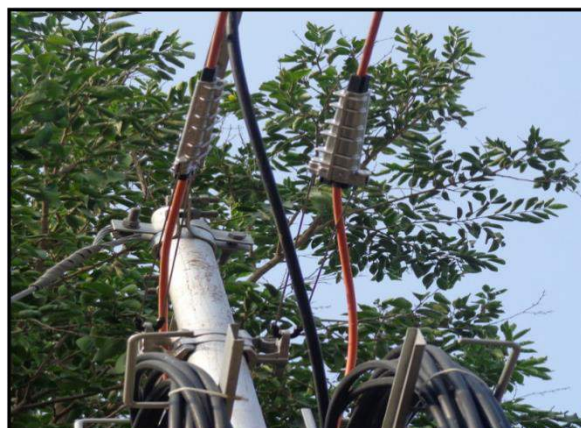
Step 7

Insert the wedge clamp in universal bracket



Step 8

Tight the wedge clamp appropriately



Step 9



Step 10

Tight the strap having suspension clamp on pole



Step 11

Install the loop frame wherever required



Step 12



Step 13

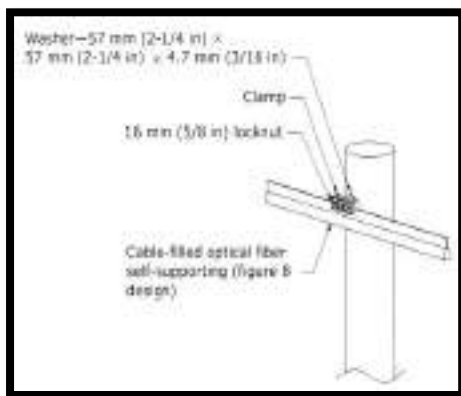
Provide suggested tension to the cable to get desired sag



Step 14

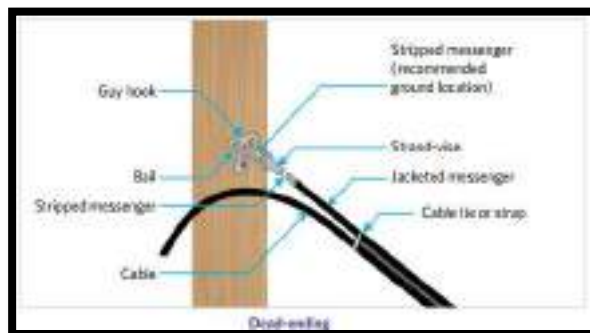


Anchoring & Tension Clamps



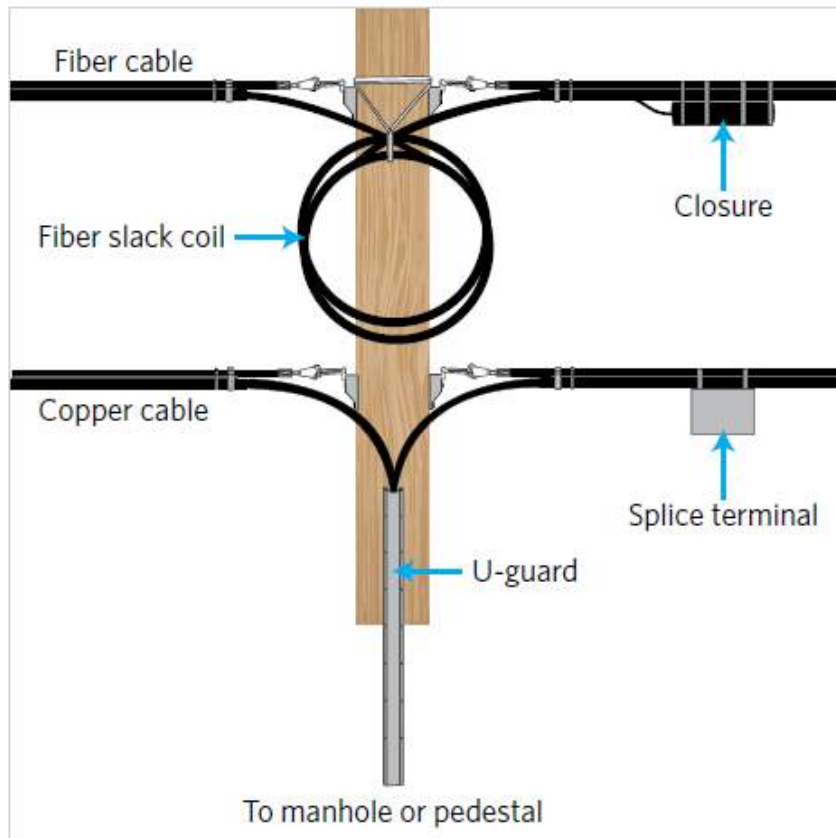
Features

- Ø For both figure-8 and concentric ducts
- Ø Wedge clamp type, easy and quick installation
- Ø Installation span 40–70 m



Slack Storage and Splice Locations

- Ø Location of splice closures and terminals are best located at or very near a pole location for easier access and workman safety.
- Ø By dead-ending the cable at the pole and removing the messenger, the cable will be lighter and easier to route for slack storage and into a splice closure.



Grounding of Messenger

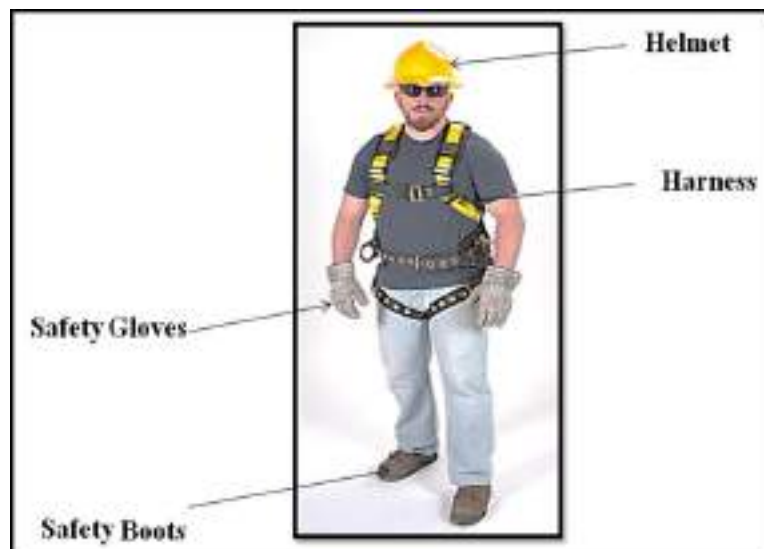
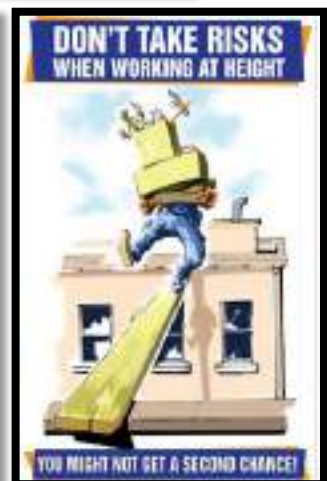
- Ø The messenger is required to have electrical continuity throughout the cable run.
- Ø At dead-end poles where the messenger is attached to pole fixtures, install a bonding clamp and follow appropriate safety standard or code.
- Ø At intermediate poles where bonding to the power ground neutral is required, follow appropriate safety standard or code.



6.5 Aerial Installation Safety Precautions for Aerial Cabling

Near Electrical Lines	Crossing Electrical Lines	Ground Clearance
<p>The minimum separation between optical fibre cable and other elements:</p> <ul style="list-style-type: none"> Uninsulated power main conductor—1500 mm (4.92 ft) Light fittings, conduits and stay fittings—100 mm (0.33 ft) Insulated power main conductors or service leads—1000 mm below (3.28 ft) <p>Any power earth wires to be insulated between ground and 1000 mm (3.28 ft) above the uppermost optical fibre attachment or fitting.</p>	<p>During aerial cabling, when crossing electrical power lines:</p> <ul style="list-style-type: none"> Ensure that optic fibre cables do not cross above aerial, power lines Ensure that there is a minimum vertical separation of 1 metre (3 ft) where aerial cables cross under LV lines in span Avoid using shared poles in a parallel route with power lines except if the owner of the pole has authorised the joint-use arrangement in writing Maintain a minimum separation of 600 mm between the optic fibre cable and any insulated mains power conductor or service lead 	<p>Minimum ground clearance that aerial cables should maintain is:</p> <ul style="list-style-type: none"> 2.5 metres (8.2 ft) for customer premises land (if vehicles cannot enter) 4.0 metres (13.1 ft) for residential driveway 4.9 metres (16.1 ft) for commercial/industrial driveway or private roadway 6.5 metres (21.3 ft) or as per directive of the local bodies, corporations, etc. for public footpath or roadway

Dos	Don'ts
<ul style="list-style-type: none"> Test and ensure that all cables, tools and installation equipment are in proper condition Use proper Personal Protective Equipment Use a wooden ladder for Pole-to-Pole aerial cabling Ensure adequate supervision Maintain safe distance while working near Low Tension (LT)/High Tension (HT) lines and cables Strictly follow your supervisor's instructions Strictly follow safe operating procedure guidelines 	<ul style="list-style-type: none"> Don't ignore Lock Out/Tag Out signage and warnings Do not work during high winds and heavy rains Do not ignore safety instructions Do not work alone Use buddy system for high-risk jobs Do not indulge in horse play (fighting/unnecessary stoppage) during work



Section 3: Exercise

Exercise 1: Enlist components of suspension and tension assembly.

Exercise 2: Enlist components of wedge clamp assembly.

Exercise 3: Participate in a group discussion on following topics:

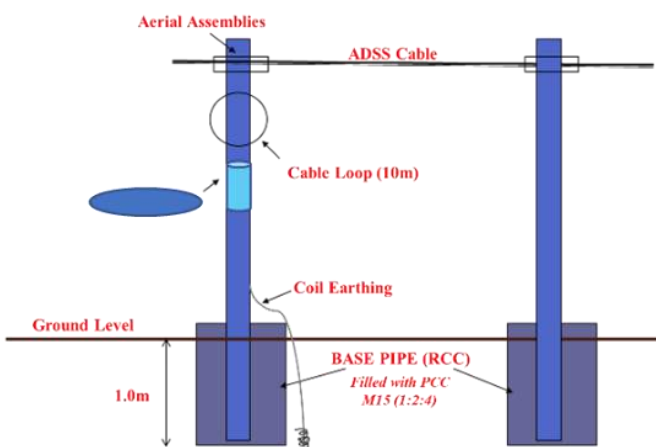
- Moving Reel Method
- Stationary Drum Method
- Aerial Installation Safety

Section 4: Assessment Questionnaire

- Is it possible to install OFC on Poles?
- In how many ways optical Fiber Cable can be installed?
- Which type of OFC is used in Aerial Installation?
- Which passive device is Installed on Poles to serve the buildings or customers on both sides?
- When Aerial Installation is preferred over Underground installation?
- Aerial Installation is non-feasible in:
- Fill the blank column:

Execution Method	Underground Installation	Aerial Installation
Fiber Protection	More	
Supervision & Maintenance	Difficult	
Installation Speed	Low	
Material Cost	More	

- Identify the item in below picture.



- Ground clearance of _____ feet in a section should be kept.
- Cable loop of at least _____ is recommended at splice location.
- The cable should be brought down through a ____ clamped on the pole.
- Earthing is not recommended for poles. True/False?

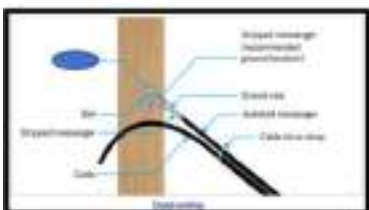
13. What should be the minimum separation between insulated electrical cable and Aerial Optical Fiber cable?
14. What should be the normal span of poles?
15. What are two methods of Aerial cable installation?
16. The curvature of the support device should be _____ than the minimum bend radius of the cable to prevent damaging the cable.
17. _____ may be assembled in a continuous direction loop configuration.
18. Cable slack must allow the cables to reach ground level and into a splice truck plus _____ minimum in construction planning.
19. Which type of communication must be established between the cable reel payoff unit and the ground crew?
20. In moving reel method, cable is raised and placed on _____ for temporary support.
21. _____ assembly is installed on the pole when cable is to be installed straight on OFC path.
22. Every fifth pole is planned be a tension pole in straight alignment with _____ cable loop.
23. Which component of aerial assembly is installed over protective helix to control cable vibrations?
24. Identify the item.



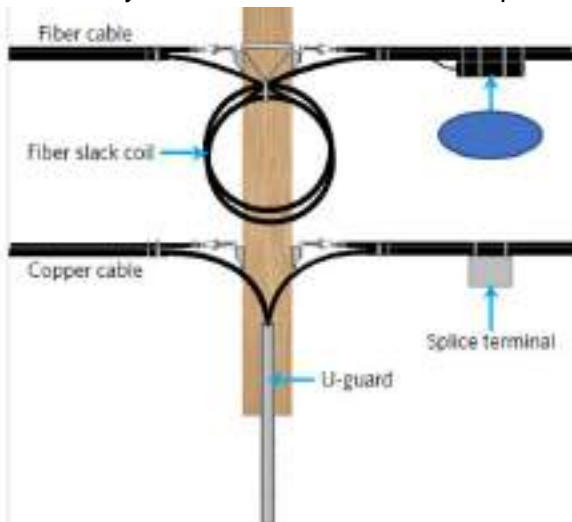
25. Why do we use wedge clamp?
26. What materials are used for body of wedge clamp?
27. Identify the below item?



28. Can we mount Universal Bracket on poles?
29. Where do we use Anchoring & Tension Clamps?
30. What should be installation span in case of using anchoring and tension clamps?
31. Name the missing item in below picture?



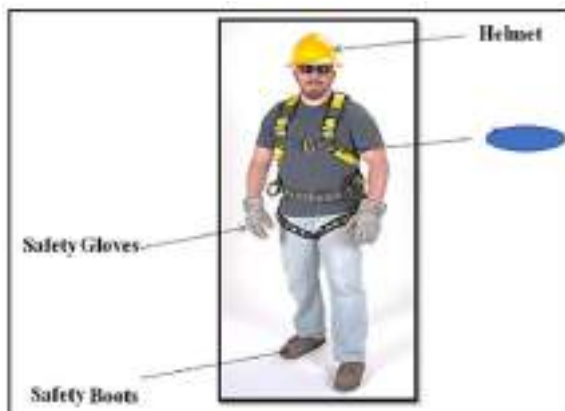
32. Identify the encircled item in below picture?



33. The messenger is required to be grounded? True or False.

34. Should we use wooden ladder for pole to pole aerial cabling?

35. Name the missing item.



-----End of the Module-----

MODULE 7 FIBER SPLICING TECHNIQUES

Section 1: Learning Outcomes

After completing this module, you will be able to:

- Differentiate between various Types of Splicing Techniques
- Prepare Loose Tube Optical Fiber Cable
- Distinguish between various types of Splicing Machines
- Perform Fiber Stripping, Cleaning and Cleaving
- Splice the Single and Ribbon Fibers
- Protect the Splices
- Follow Splicing Safety Guidelines
- Maintain the Splicing Machine
- Prepare checklist for Performing Fiber Splicing

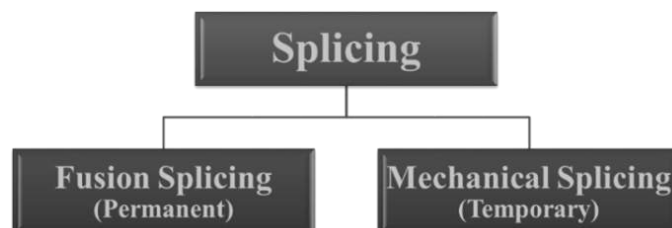
Section 2: Relevant Knowledge

7.1 Introduction to Splicing

Splicing is the act of joining two optical fibers end-to-end.

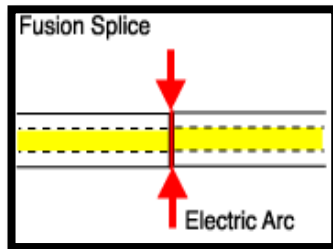
- ∅ Fiber optic cable that is available is not sufficiently long for the required run.
- ∅ Optical fibers may be connected to each other by connectors or by splicing to form a continuous optical media.
- ∅ The OFC drums are of approx. 2/4 kms in length, hence optical fiber need to be joint at approx. every 2/4 kms.

7.2 Types of Splicing



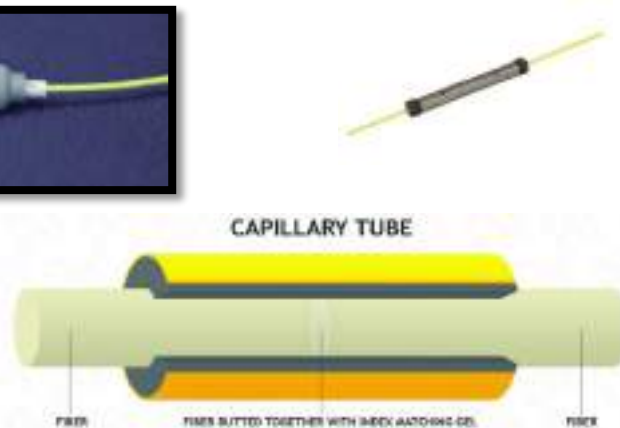
Fusion Splicing

- ∅ This splice is made by fusing or melting the two ends of fiber together.
- ∅ It uses an electric arc to weld two optical fibers using specialized equipment.



Mechanical Splicing

- ∅ A mechanical splice is a small fiber connector that precisely aligns two bare fibers, securing them mechanically.
- ∅ Used when splices need to be made quickly and easily.
- ∅ Insertion Loss is Approx. 0.5dB.



- ∅ V-groove is the most commonly used alignment mechanism for mechanical fiber splices. It consists of a base plate in which a precise V-groove is etched.
- ∅ Cleaved fibers are placed into the groove and their ends are butt-coupled into contact.
- ∅ Index matching gel is used to bridge the gap between the two ends to prevent gap loss thereby reducing attenuation.
- ∅ A locking mechanism then holds the fibers in position and provides mechanical protection for the fibers.
- ∅ Index matching epoxy can be used in place of index matching gel. The epoxy is usually cured with ultraviolet light, the epoxy can hold the fibers in place.
- ∅ The epoxy is usually cured with ultraviolet light, the epoxy can hold the fibers in place.
- ∅ Mechanical splices are then placed in a tray.

Advantages of Mechanical Splicing

There are some significant advantages of using a mechanical fiber splice rather than fusion splices. Here are a few of them:

- ∅ Mechanical splices require no power supplies.
- ∅ Many mechanical fiber splice designs require no extra tools beyond a fiber stripper and fiber cleaver.
- ∅ They can be used in situations where fusion splicing is not practical or impossible.
- ∅ Mechanical splices can be made within a couple of minutes, this makes it ideal for temporary connections.

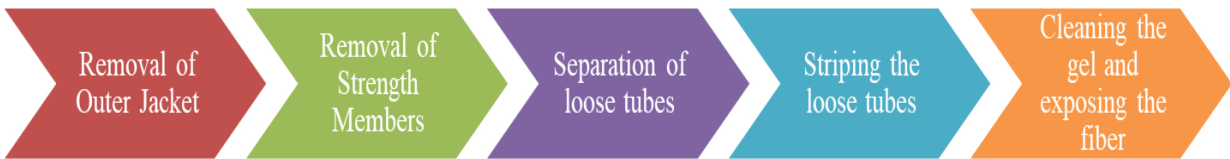
Disadvantages of Mechanical Splicing

- Ø The typical insertion loss for a mechanical splice is about 0.3dB to 0.5 dB which is significantly higher than the 0.02dB loss for a typical fusion splice.
- Ø Mechanical splices are typically used for multimode fibers. The tough alignment tolerance for single mode fibers makes it hard for mechanical splices to meet the required power in an optical link.
- Ø Due to variation in refractive index of index matching compounds with temperature, the performance of a mechanical splice can be sensitive to ambient temperature.
- Ø Mechanical splices are not thought to be as reliable as fusion splices over long periods of time.
- Ø Mechanical splices can be used only in relatively benign environments such as inside an office building.

Fusion vs Mechanical Splicing

Fusion Splicing	Mechanical Splicing
Fibers are Fused/Welded	Fibers are only Aligned
Permanent Connection	Temporary Connection
Typical loss: 0.02 dB	Typical loss: <0.5 dB

7.3 Cable Preparation: Loose Tube



Using a sample of loose tube OSP cable:

- Ø Remove the outside jacket
- Ø Separate the buffer tubes
- Ø Cut strength members
- Ø Strip the tube for which fibers are to be spliced
- Ø Expose the fibers. If the cable is gel-filled, use cleaner to remove the gel

Cable Preparation Tools

- Ø Cable Cutter is used to cut the cable, if required.
- Ø Round cutter is used to make circular and lateral cuts in the cable.
- Ø The cable is stripped of their outer and inner sheath using cable sheath stripper.



Cable Cutter



Round Cutter



Cable Sheath Stripper

Cable Preparation Steps

Step 1: Removal of outer jacket

a) Using Round cutter make circular cut in the cable at about 3 meters distance from end of the cable.



b) Use cable sheath stripper to make lateral cut in the cable jacket.



c) Use cable rip cord to cut through the fiber jacket



d) Carefully peel back the jacket and expose the strength members such as armour or yarns.



Step 2: Removal of strength members

Cut away exposed yarn and sheath using scissor. Leave enough of the strength member to properly secure the cable in the joint closure.



Step 3: Separation of loose tubes

Separate the fiber loose tubes carefully.



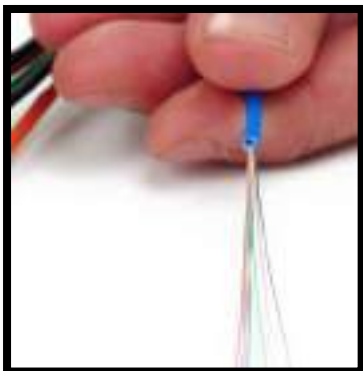
Step 4: Stripping the loose tubes

Cut the central strength member (metal or plastic). Strip away about 2 meters of fiber tube using a buffer tube stripper and expose the individual fibers.



Step 5: Cleaning the gel and exposing the fiber

Carefully clean all fibers in the loose tube of any filling gel with cable gel remover or lint free tissue.



7.4 Fusion Splicing Process: Single Fiber

Single Fiber Splicing Process

Before Stripping, take the Splice Protection Sleeve and slide over one of the ends of fiber.



7.5 Fiber Stripping and Cleaning

Placement of Protection Sleeve in Single Fiber

Before starting the splicing operation, place the protection sleeve in any one of the fiber to be spliced.



Fiber Stripping Tool

Stripping tool provides a quick, easy, and reliable way to cut and remove the buffer from an optical fiber.



Tri-Hole Fiber Optic Stripper

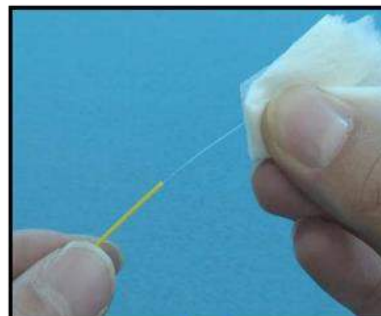
- Ø The First hole strips the 2~3mm jacket to expose 600~900µm buffer.
- Ø The Second hole strips the 600~900µm buffer to expose 250µm coating.
- Ø The Third hole strips the 250µm coating to expose 125µm cladding.

Stripping and Cleaning Fiber

- Ø Strip the fiber using stripper to remove 250 micron coating to reach down to the 125 micron glass fiber/clad.
- Ø Clean the fiber with Isopropyl Alcohol moistened gauze or lint-free tissue thoroughly.



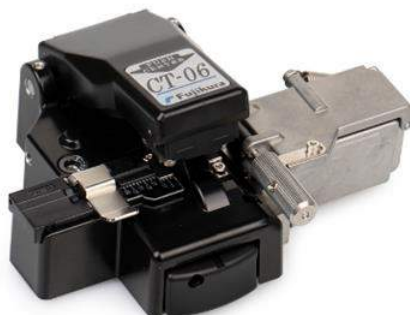
Stripping



Cleaning

7.6 Cleaving

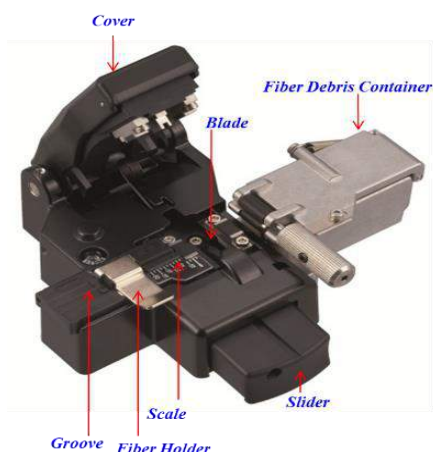
- Ø Cleaving is the process of cutting Optical Fiber perpendicular using cleaver.
- Ø It is intended to create a perfectly flat endface precisely for splicing.



Fiber Cleaver

Fiber Cleaving Process

- Ø **Step 1:** Close the slider.
- Ø **Step 2:** Place the fiber into the groove and close the fiber holder. *(For 40mm sleeve, end of stripped fiber coating should be placed at 15mm marking on scale, whereas, for 60mm sleeve, end of stripped fiber coating should be placed at 20mm marking on scale.)*
- Ø **Step 3:** Press down the cutting lever.
- Ø **Step 4:** Release the pressure on the cutting lever. A spring force will bring it to its open position.
- Ø **Step 5:** Open the fiber holder and remove the fiber from the cleaver.



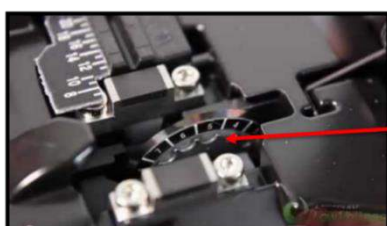
Cleaving Quality



Good Cleave



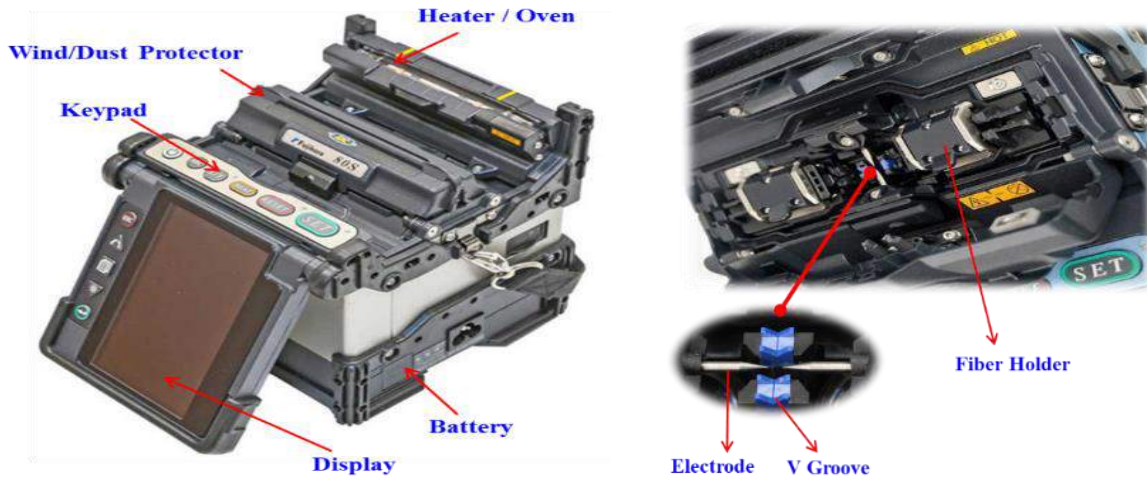
Bad Cleave



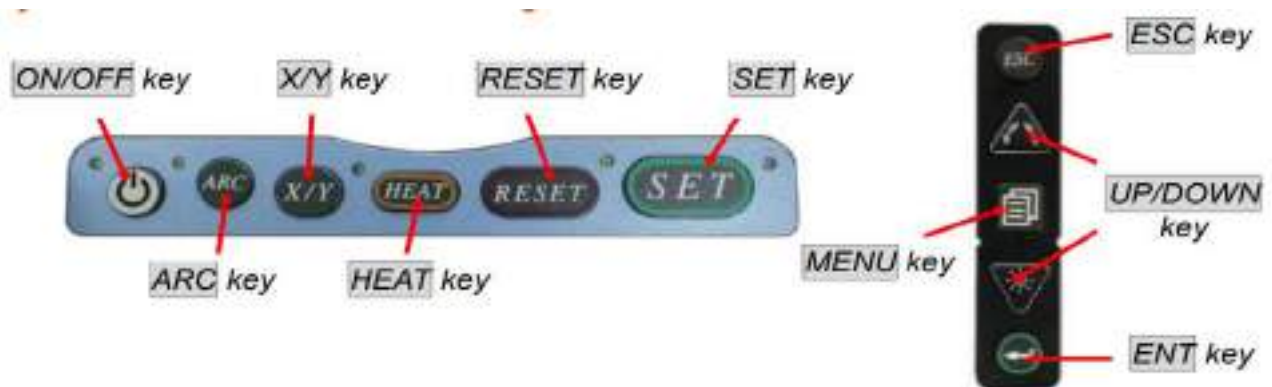
Rotate the blade periodically for maintaining good cleaving quality

7.7 Introduction to Splicing Machine Single Fiber Fusion Splicing Machine

Ø Fusion splicing machine is a device that generate electric arc to melt endface of optical fiber.



Operation of Keys



Key	Key Function
ON/OFF	To turn ON/OFF the power
ARC	Arc discharge manually
X/Y	Change the X/Y images
HEAT	To start the heating process by the tube heater
RESET	To quit from any state except the heating process
SET	To start/pause the splicing operation and move the cursor direction of arrow at menu state
ESC	To display the data at the "Ready", "Pause", "Finish" state. and to escape from any menu.
Up/Down	Brightness adjustment, wind protector automation and Cursor Movement
MENU	Open Main menu and go to next page
ENT	To open the menu at the "Ready" state. To select any parameter.

Accessories

A standard package of splicing machine may contain following accessories:

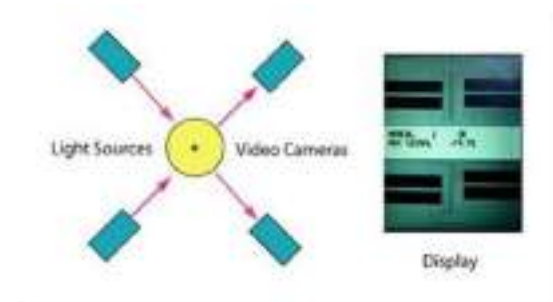
Fusion Splicer	USB cable
AC adaptor/battery charger	Quick reference guide
AC power cord	Cooling Tray
Spare Electrodes	Fiber Stripper
Fiber Cleaver	Protection Sleeves
Battery Pack	Car Battery Cable
Battery Charging Cord	Carrying Case

7.8 Types of Splicing Machine

Below given is different fiber alignment technologies in several types of fusion splicers:

Core Alignment Machine

- ∅ Optical fiber core fusion splicers use multiple cameras to inspect the two cleaved fibers before fusing and allow for multiple axis movement of the fibers.
- ∅ The two fibers are illuminated from two directions, 90 degrees apart.
- ∅ From the multiple video cameras, the machine recognizes the core of the fibers and aligns them automatically using movable stages.
- ∅ Light injection technology and imaging software line up the fiber cores so maximum light passes from one fiber to the other, ensuring minimal splice loss.
- ∅ This provides for precise fiber alignment, resulting in a typical splice loss of only 0.02dB.
- ∅ Ribbon splicers typically use core alignment.



Clad Alignment Machine

- ∅ In clad alignment machines, the fibers sit in a holder or V-groove and are lined up “physically”, based on the outer diameter of the fiber’s cladding.
- ∅ Just because the outer diameters are aligned, doesn’t mean the cores will be perfectly aligned.
- ∅ Such units typically produce higher loss splices and lack the features and flexibility of higher end splicers.
- ∅ Clad alignment splicers also have multiple cameras but only allow for single axis movement of the fiber.
- ∅ Alignment is aided by a fixed v-groove.
- ∅ The typical loss for this type of splice is 0.05dB. Clad alignment splicers are best suited for multimode applications.

Handheld Machine

- Ø A revolution in splicing came about with the introduction of battery powered handheld fusion splicers.
- Ø These popular devices are compact and portable, yet offer performance on a par with bench top models.
- Ø The handheld fusion splicer features a 14 second splice (high speed mode), built in shrink oven, and other desirable features.
- Ø Handheld splicers are great for working in confined spaces and aerial applications.
- Ø They are ideal for FTTx, LAN, backbone and long-haul installations.

7.9 Single Fiber Splicing Procedure

Loading the Fiber

- Ø Open the wind-protector and fiber holder.
- Ø Once the fiber ends are prepared, they are placed in V- groove of fusion splicer.
- Ø Be careful not to contact the fiber tips to maintain fiber end-face quality.
- Ø Place the fiber holders into guide-pins.
- Ø Prepare and load left and right fibers into the splicer.
- Ø Close the wind-protector.

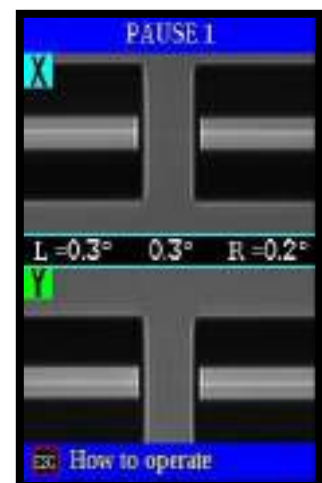


Cleave and Endface Check

- Ø Press the "SET" key, splicer starts the splice procedure automatically.
- Ø Fibers loaded in the splicer move forward toward each other.
- Ø Cleave angle and end-face quality are checked.
- Ø If Cleave angle is not ok or greater than set threshold or fiber chipping is detected, the buzzer will sound an error message.

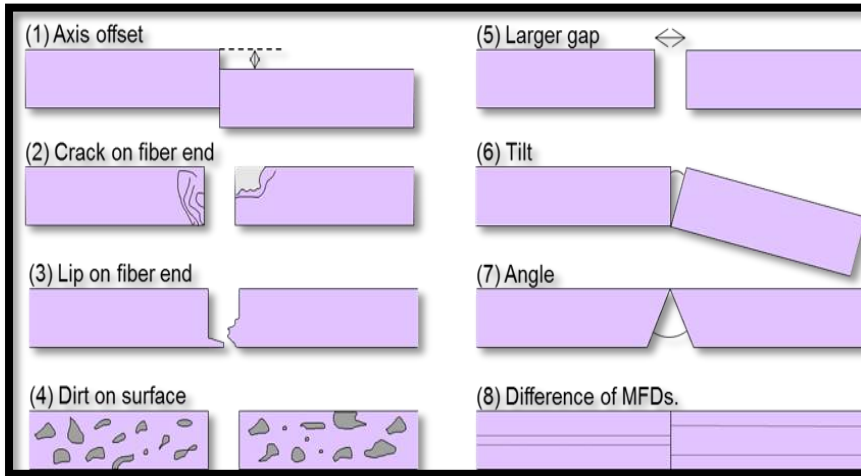
Splice Loss

- Ø After fiber inspection, the fibers are aligned core-to-core or cladding-to-cladding and then arc discharge is performed to splice the fibers.
- Ø Estimated splice loss is displayed upon completion of splicing.
- Ø "OK" beeps to remove the splice from the machine.
- Ø It is ensured to achieve individual splice loss less than 0.2 dB.



Loss in Fusion Splice

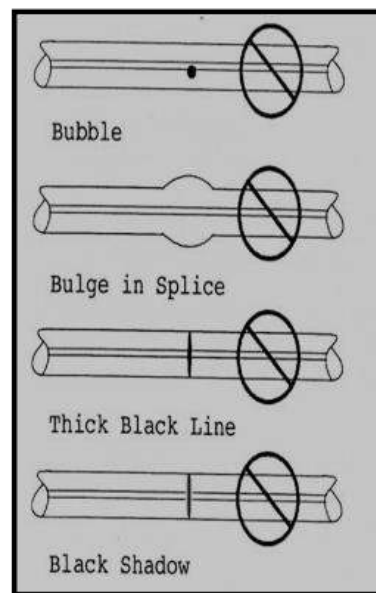
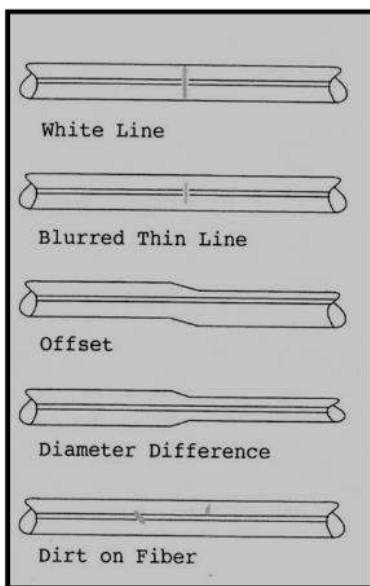
Factors that influence the loss in a Fusion Splice



Evaluating Splices

Acceptable (if loss in under limit)

Not Acceptable at any Circumstances



Removal of Spliced Fiber from Machine

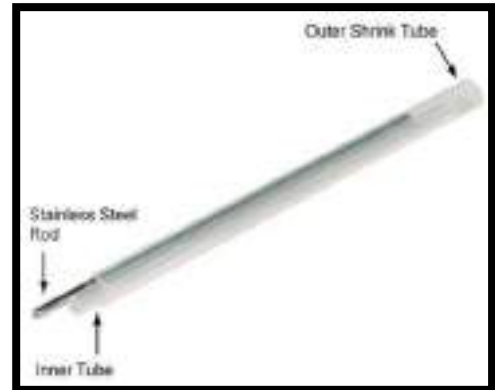
Ø Open wind protector and fiber holders to remove the splice carefully



7.10 Splice Protection

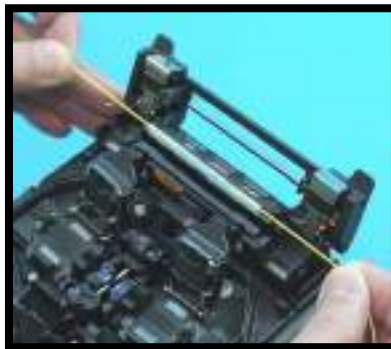
Protection Sleeve

- Ø Placing the Protective Sleeve gives physical protection to the splice.
- Ø Protection Sleeves are composed of an outer and inner sleeve reinforced by an internal member made of stainless steel or ceramics.
- Ø Protection sleeves of 40mm and 60mm sizes are generally used in field.
- Ø Varieties of protection sleeves are available to accommodate single and ribbon fiber.
- Ø It is ensured that splice point is located at the center of the protection sleeve.



Splice Protection

- Ø Place the sleeve in heater unit (Tube heater lids automatically get closed).
- Ø Press the 'HEAT' key to start sleeve heating.
- Ø On completion of heating process, buzzer sounds and heater lid gets open automatically.



Single Fiber Splice

7.11 Ribbon Fiber Splicing Procedure

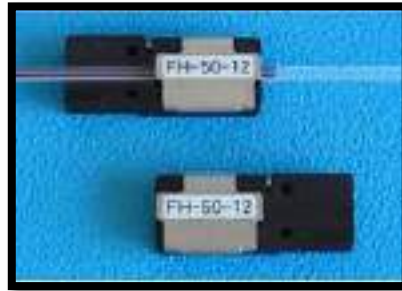


Ribbon Fiber Splicing Procedure

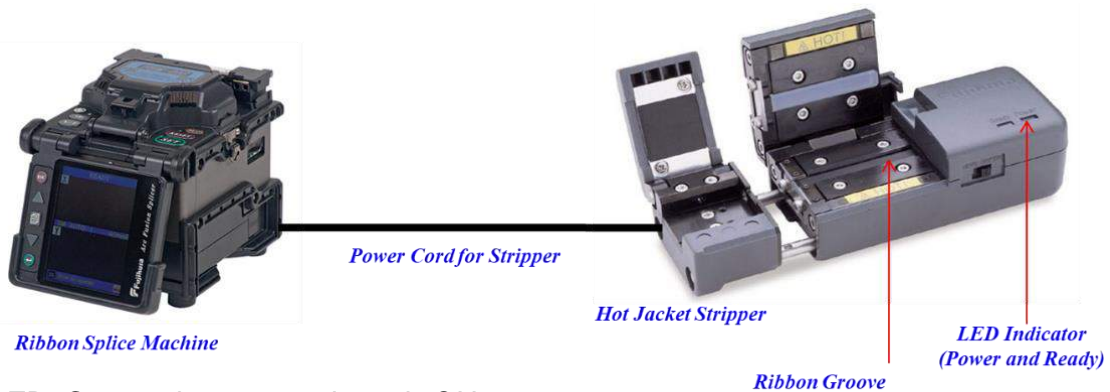
Step 1: Protection Sleeve Insertion in Ribbon



Step 2: Placement of Ribbon in Holder



Step 3: The holder is inserted in an Auto Stripper (Hot Jacket Stripper) that uses heat to make stripping easier.



Power LED: Green when auto stripper is ON

Ready LED: Orange: Fiber Ribbon heating in progress

Green: Signal for performing stripping operation

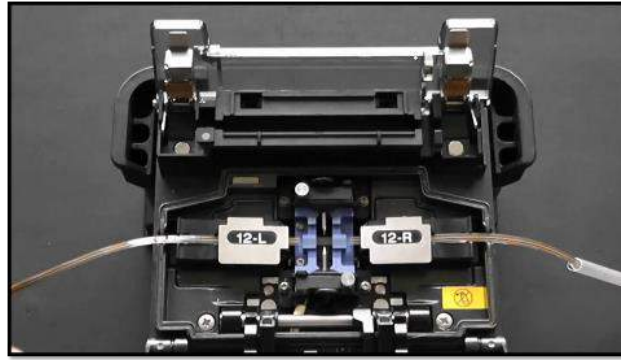
Ribbon Fiber Cleaver

Step 4: Cleaving of all 12 fibers together using ribbon cleaver.



Placing the Ribbon in Machine

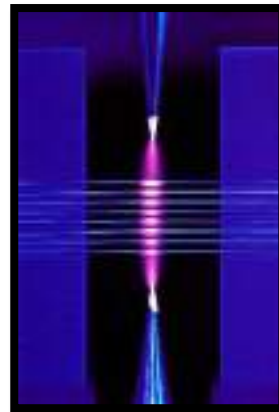
Step 5: The fixture with all the cleaved fibers is placed in the splicing machine.



Ribbon Fiber Display

Step 6: All 12 fibers are displayed on magnifying screen on machine.

Step 7: On pressing the 'SET' Key, splicer aligns all the fibers and starts the splice procedure automatically.



Spliced Ribbon Fiber

Step 8: Spliced ribbon is protected using 40mm protection sleeve using heater mode of the machine. Before providing protection to spliced fibers, splice loss is ensured to be within the permissible range.



7.12 Housekeeping of Splice Machine

Check Points : Fusion Splicer

- Ø Alignment check - Verifies that fiber are correctly aligned
- Ø End face check - Verifies that both fibers are cleaved to the tolerance required by splicer
- Ø Electrode check - Automatic reminder to clean electrodes after a certain number of splice
- Ø Arc check - Tests the current conditions to warn if arc current need to be adjusted
- Ø Battery Warning - Warns of impending low battery to give user time to change batteries

Not every splicing machine performs all these checks

Fusion Splicer Calibration

- Ø Arc Calibration
- Ø Electrode Stabilization and Replacement
- Ø Diagnostic Test:
 - LED Check
 - Dust Check
 - I/O Port Check
 - Memory Check
- Ø Motor Calibration

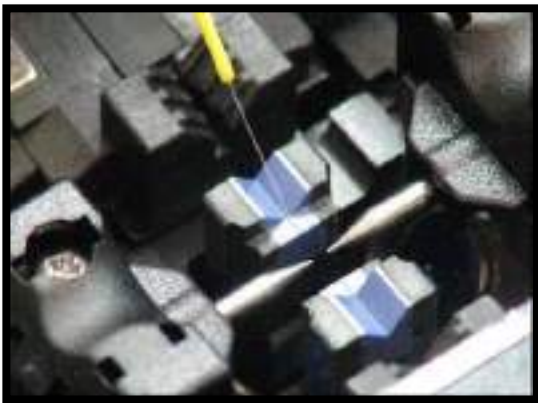


Fusion Splicer Cleaning Practices

- Ø Clean Mirrors - Microscope lenses
- Ø V-grooves
- Ø Fiber holders
- Ø Dust Check - Stuff Check - LED Check - Motor Check
- Ø Optical adapter and head cleaning
- Ø Battery reconditioning and replacement
- Ø Dirty mirrors
- Ø Cleaver cleaning

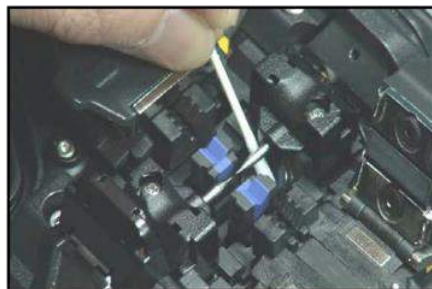
Cleaning V- Grooves

- Ø Clean and Check the V-grooves before Splicing



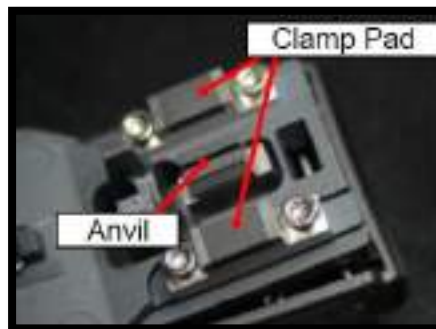
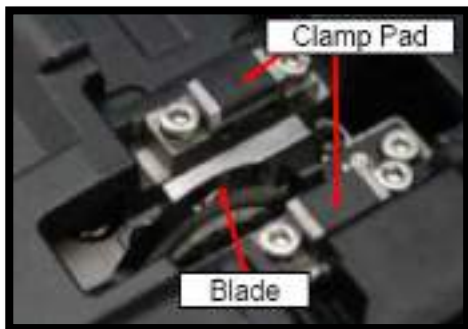
Cleaning of Lens

- Ø Clean the Microscope Lens.
- Ø Electrodes need not to be removed from the machine for cleaning microscope lens.



Cleaning Fiber Cleaver

Ø Cleaning the circular blade or clamp pads with cotton swab moistened with Iso-Propyl Alcohol (IPA).



Replacement of Electrodes

- Ø The message prompting to replace the electrodes is displayed after turning on the power.
- Ø Electrodes are replaced after approx. 3,000 arc discharges.
- Ø Electrode can be removed and clean to get additional arcs. However, electrode replacement is better practice.



S

Try to work in **clean area**.

A

Wear **Apron** and **Safety Gears**.

F

Perform splicing work on **Black Safety Mat** to easily identify fiber debris.

E

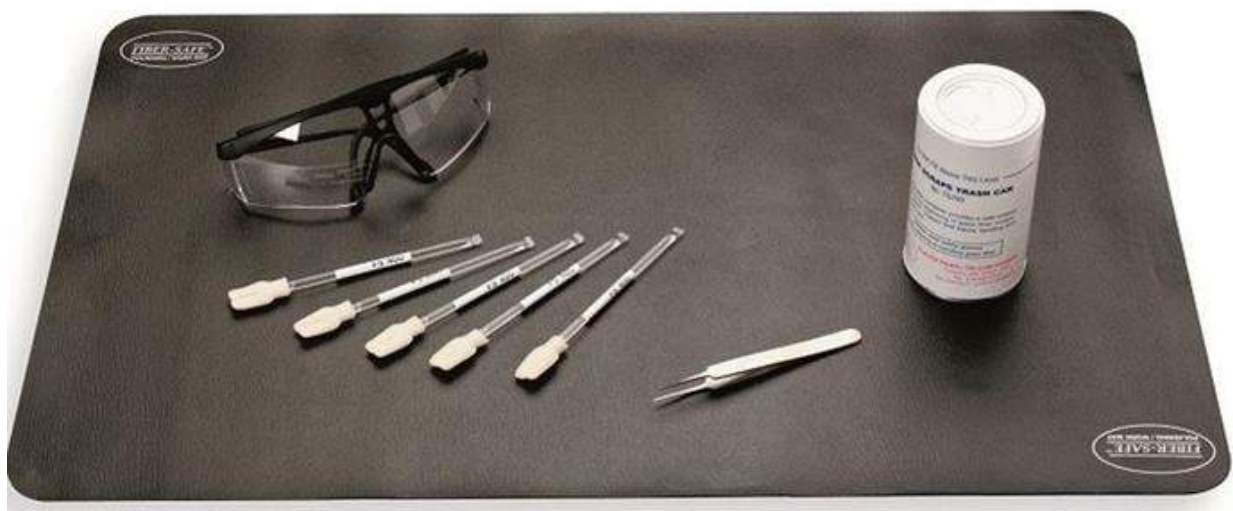
Always keep **dust caps** on **Connectors**.

T

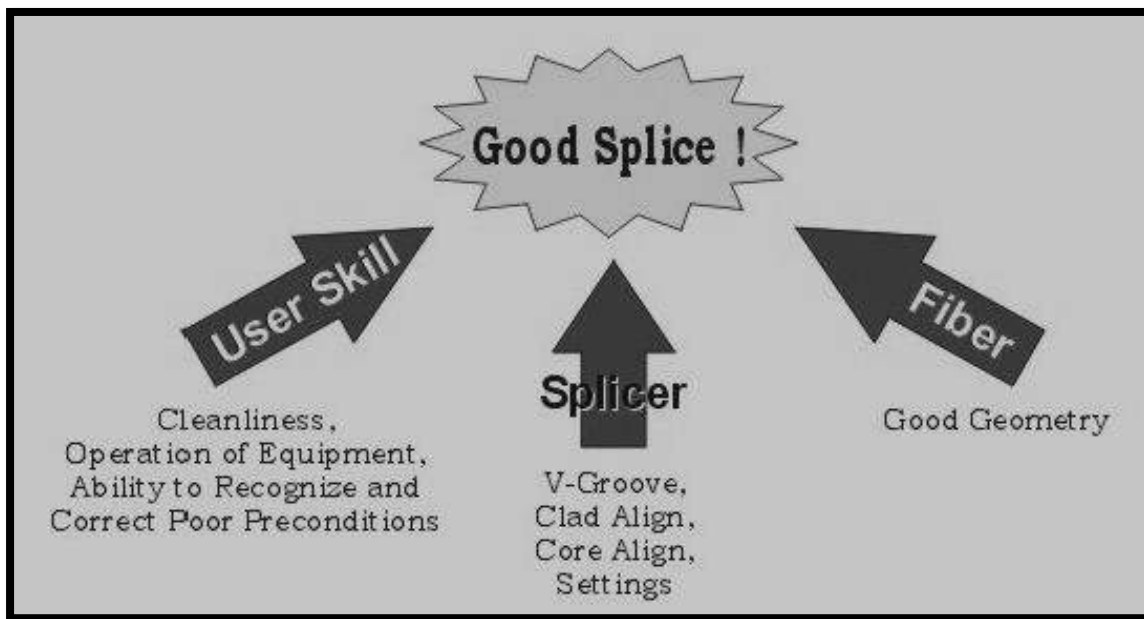
Always use **Isopropyl Alcohol** to clean the fiber with **Lint Free Tissues**.

Y

Dispose the fiber ends at designated area.



Factor Affecting Splice Loss



7.13 Checklist for Performing Fiber Splicing

Fusion Splicing Machine	Cable Sheath Stripper
Mechanical Splices	Plier Set
Cleaver	Screw Driver Set
Battery Charger	Loose Tube Cutter (Rolling Knife)
Additional Battery for Splice Machine	Nipper Cutter
Splice Protection Sleeves	Duct Cutter
Iso-propyl Alcohol	Chamfering Tool for Duct
Lint Free Tissues	Coupler Spanner
Cotton Buds	Joint Closure
Fiber Stripper	Heath Shrink Sleeve
Knife	Aluminum Foil
Tweezers	Branching Clips
Scissor	LPG Butane Cylinder
Allen Key Set	Tape Line
Cable Cutter	Marker Pen
Round Cutter	Carry Bag

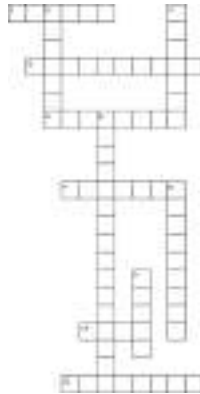
Section 3: Exercises

Exercise 1: Participate in group discussion on following topics:

- Types of Fiber Splicing
- Splicing Safety Guidelines
- Types of Splicing Machine
- Housekeeping of Splicing Machine

Exercise 2: Solve the Crossword Puzzle given below.

Across (Left to Right)	Down (Up to Down)
1. Splice that uses arc to join the fibers	2. It provides protection to splice
4. A temporary splicing technique	3. It is used to cut the fiber perpendicularly
5. It is used to remove the fiber coatings to reach upto 125 microns	6. Liquid used to clean the fiber
7. Cleaved fiber is placed on it to perform fusion splicing; a part of splice machine	8. It generates arc in a splice machine
10. Part of joint closure	9. Colour of LED on hot jacket stripper when it is ready for stripping
11. Process of joining two fibers	



Exercise 3: Enlist the tools required to perform fiber splicing and manage fiber in joint closure.

Exercise 4: Analyse the below image and tell what do you infer?



Section 4: Assessment Questionnaire

1. _____ is the act of joining two optical fibers end-to-end.
2. What are two types of splicing?
3. In which splicing fiber is melted?
4. Which part of splicing machine produces electric arc?
5. Which type of splicing method has higher loss?
6. Arrange in correct order of splicing process:
Cleaving, Stripping, Cleaning, Splicing, Protection
7. Which method make permanent splicing?
8. Fiber Cleaver is used to:
9. What are advantages of Mechanical Splicing?
10. What are disadvantages of Mechanical Splicing?
11. Which tool is used to cut cable in circular and lateral direction?
12. _____ provides a quick, easy, and reliable way to cut and remove the buffer from an optical fiber.
13. Which solution is used for cleaning the fiber?
14. The individual splice loss shall be less than:
15. Fusion splicing machine is a device that generate _____ to melt end face of optical fiber.
16. What is the use of SET key in splicing machine?
17. What are the various types of splicing machines?
18. Auto stripper gets the power from:
19. What do we use for protection of spliced fiber?
20. Which size of protection sleeve is generally used in ribbon splicing?
21. What are some diagnostic tests carried out on Fusion Splicing Machine?
22. What are some Fusion Splicer Cleaning Practices?
23. Electrodes are generally replaced after _____ arc discharges.
24. What are some splicing safety practices?
25. Why black safety mat is used in splicing process?
26. Joint closure is supplied in configuration of _____ in a cable.
27. What are the factors that influence the loss in a Fusion Splice?
28. What accessories are contained in a standard package of splicing machine?
29. For 40mm sleeve, end of stripped fiber coating should be placed at 15mm marking on scale, whereas, for 60mm sleeve, end of stripped fiber coating should be placed at 20mm marking on scale. True or False?
30. In a three-hole fiber stripper:
 - a. The First hole strips the _____
 - b. The Second hole strips the _____ buffer
 - c. The Third hole strips the _____
31. Before Stripping, take the _____ and slide over one of the ends of fiber.
32. What are the cable preparation steps of loose tube cable?
33. In fusion splice fibers are _____ and in mechanical splice fibers are _____.
34. It is ensured that splice point is located at the _____ of the protection sleeve.
35. Can 12 fiber ribbon fiber machine splice single fiber?

-----End of the Module-----

MODULE 8 JOINT CLOSURE

Section 1: Learning Outcomes

After completing this module, you will be able to:

- Identify different parts of Joint Closure
- Manage the fiber in Joint Closure
- Install Pole Mount Joint Closure
- Perform Earthing of Joint Closure

Section 2: Relevant Knowledge

8.1 Introduction to Joint Closure

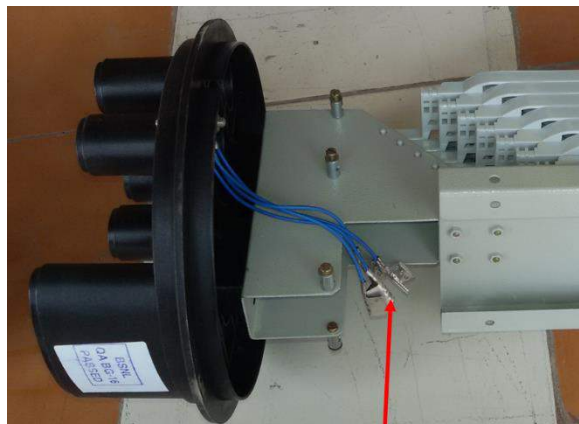
- Ø Physical protection to the splice is provided by placing the splice in splice tray.
- Ø The cover is a cylindrical plastic enclosure with corrosion resistant metal hardware.
- Ø The splice tray is used for storing optical fibers and the splice holders are used for securing fusion splices.
- Ø Carefully place the finished splice into the splice tray and loop excess fiber around its guides.
- Ø Ensure that the fiber's minimum bending radius is not compromised.
- Ø Joint closure is supplied in configuration of fiber counts in a cable, i.e., 24 / 48 / 96 fiber etc.
- Ø It is waterproof and dust proof and suitable for outdoor aerial hanged, pole mounted, wall mounted, duct, buried application.
- Ø It can be opened after sealing and can be reused without changing sealing material.



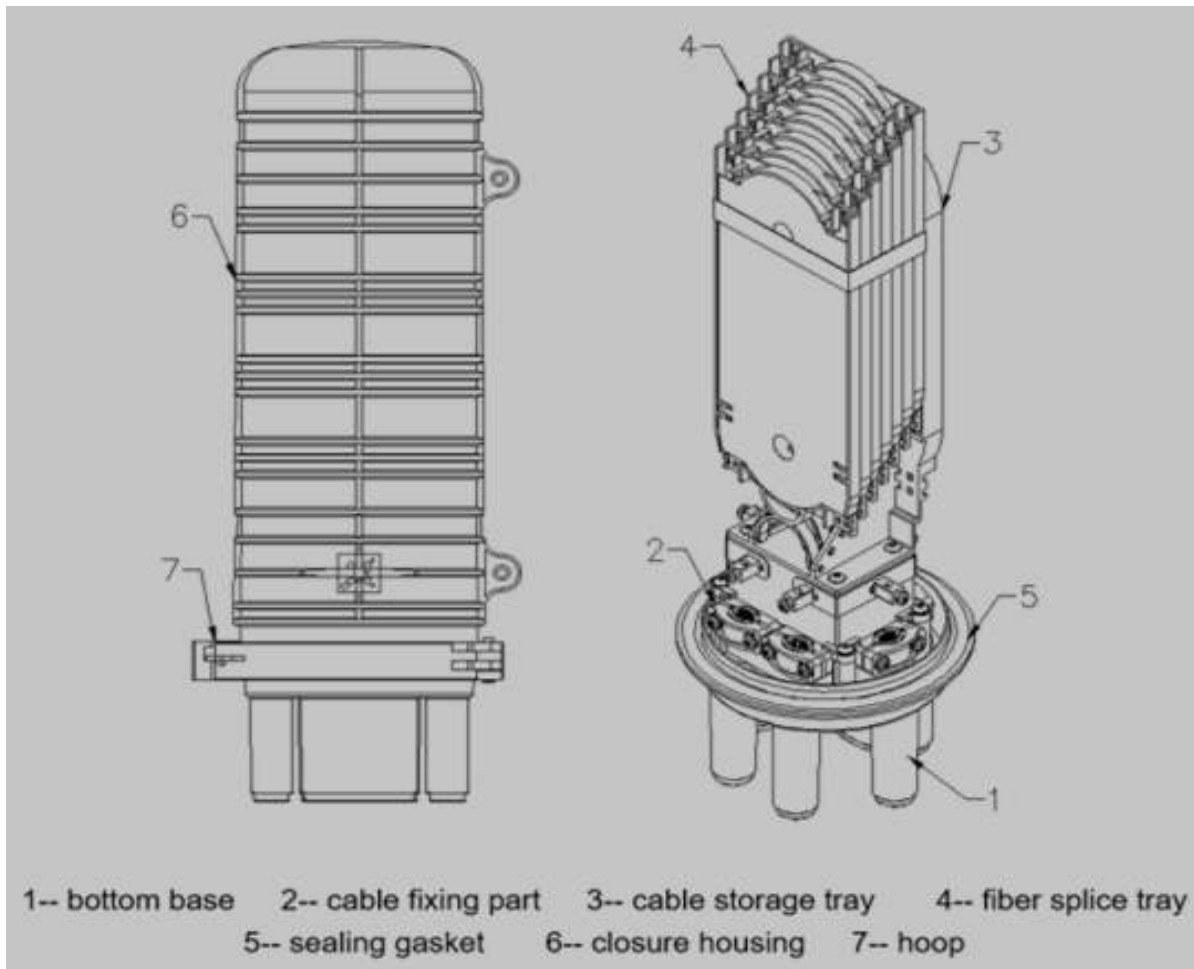


Cable/FRP/Tube Holder

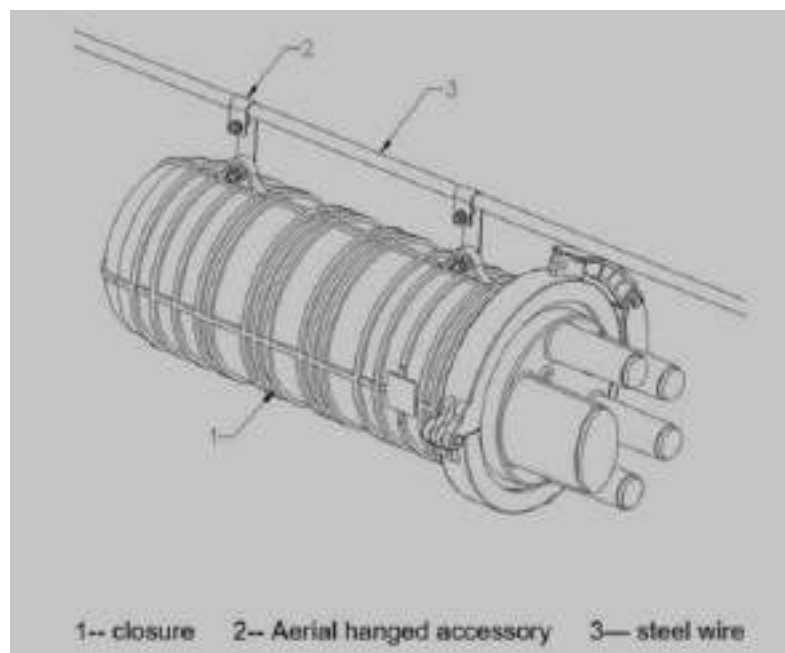
Splice Trays

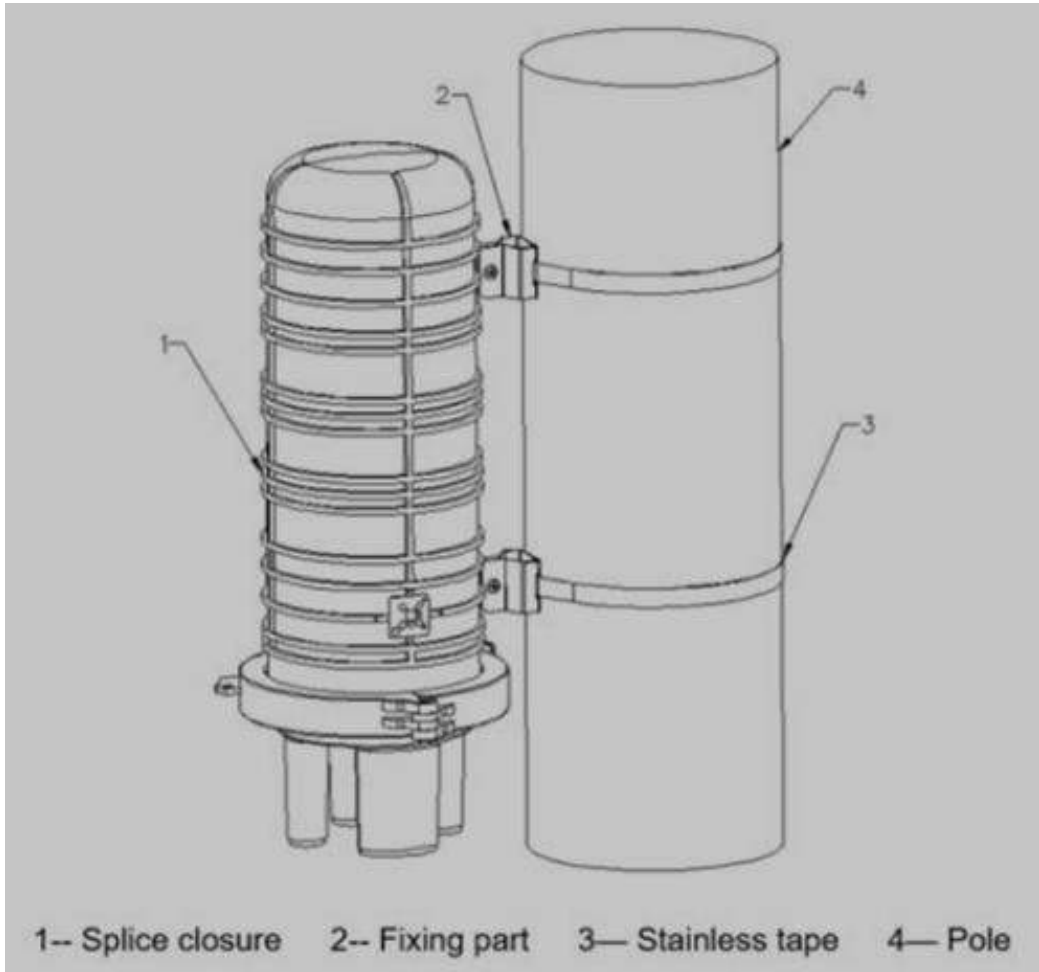


Crocodile Clip for Earthing



Aerial Hanged





Features of Joint Closure

IP 68 Sealing

Fully mechanical

Compact size

UV stable

Can accommodate desired numbers of trays Loop Storage basket

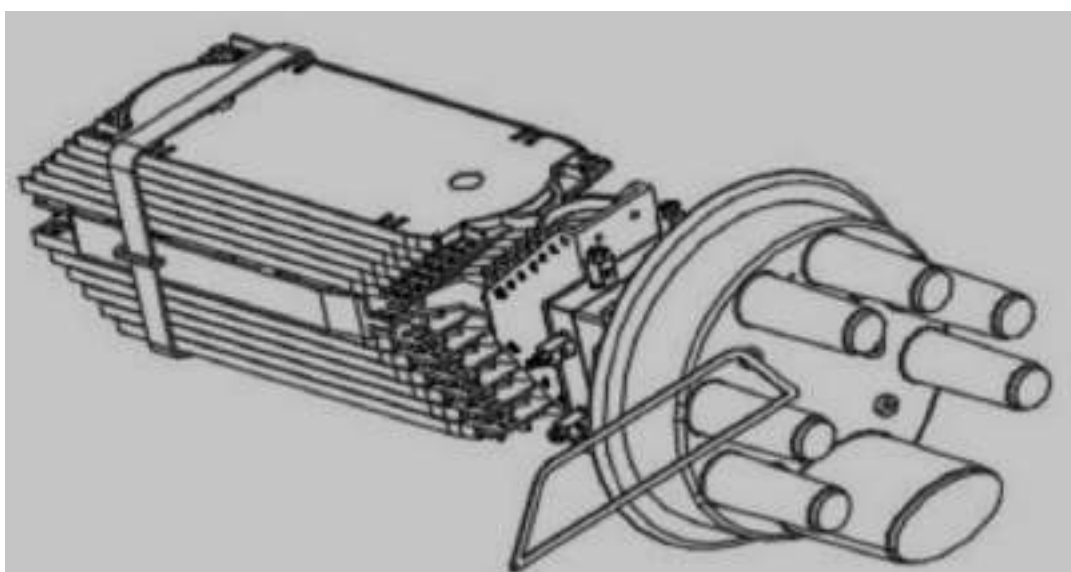
Air Valve for pressure testing

8.2 Fiber Management in Joint Closure

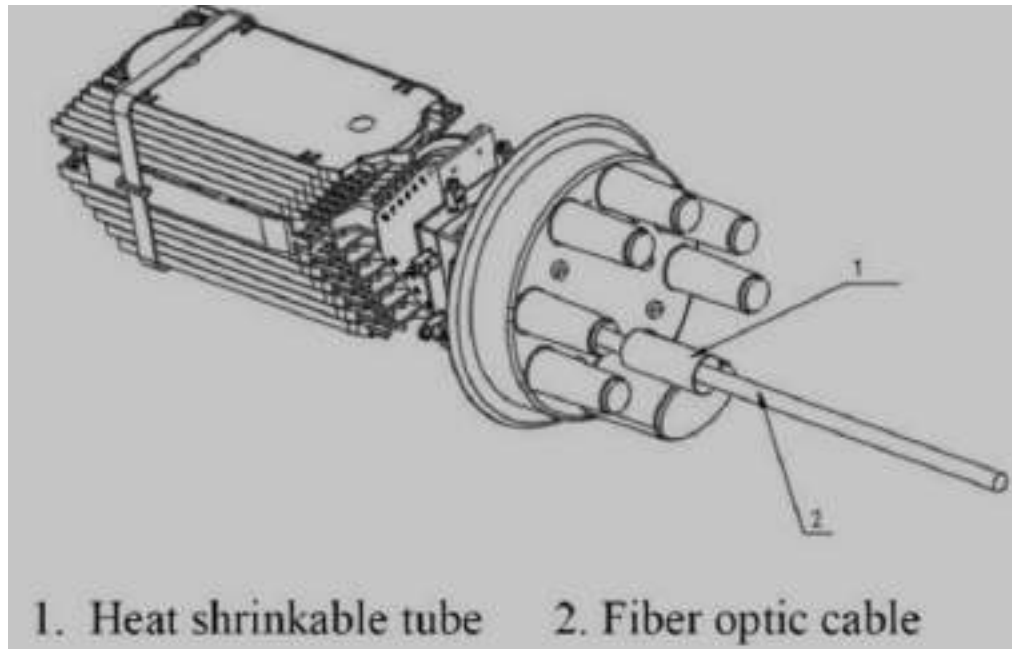
Make sure the optical fiber cable length in enclosure and break out length are enough.



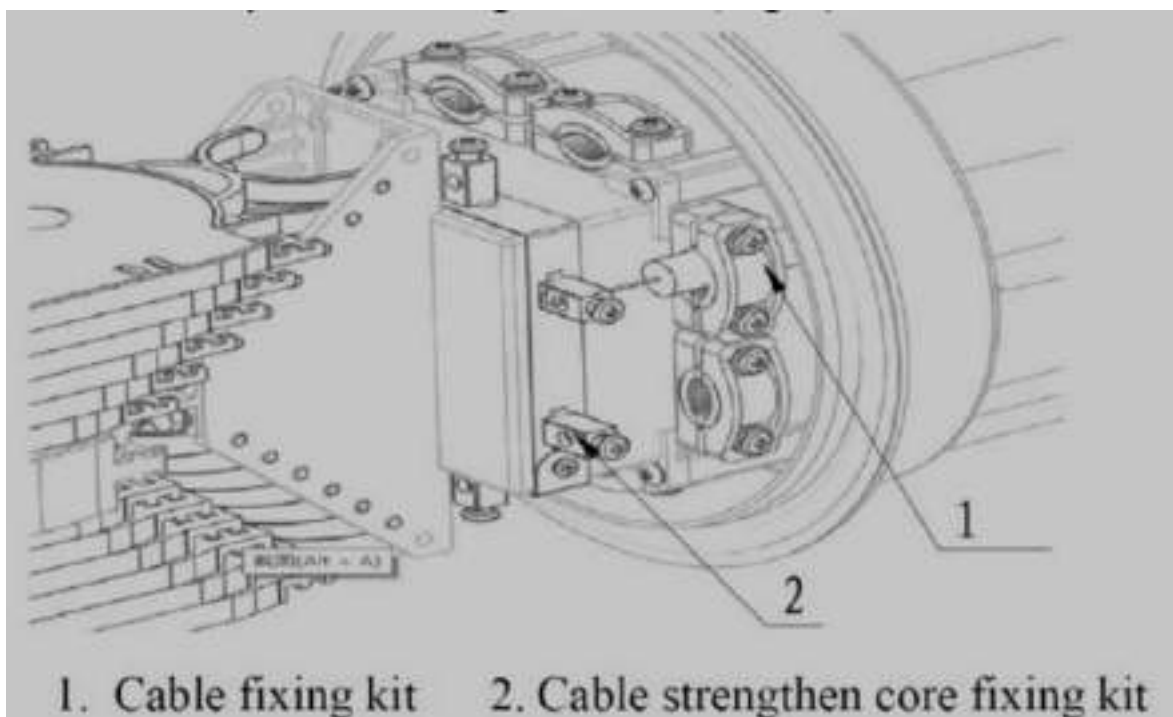
A— cable fixing length B-- Cable with jacket length inside closure
C— Cable mini. length inside closure D— Break out cable length



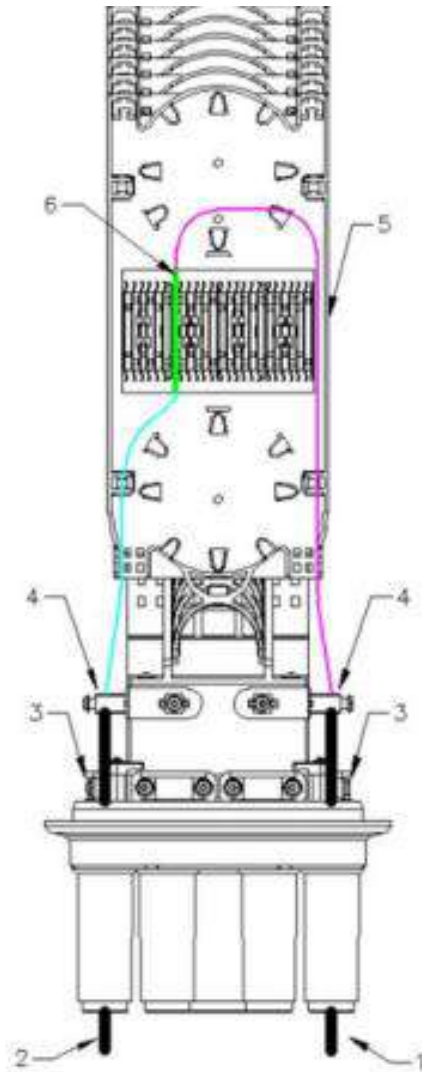
- Ø Strip out cable outside jacket by pipe cutter and longitudinal stripper.
- Ø Cut off the cable port by hacksaw (recommended hacksaw cut position: approximately 10.0mm to 20.0mm hacksaw cut from tip of cable port), then open the cable port
- Ø Put the stripped optical cable get through the heat shrinkable tube, closure cable port.



- Ø Fix the cable strengthen core by cable fixing column.



Ø Put the stripped optical fiber into fiber splice tray, do splicing and storage.



1. cable port

2. cable port

3. cable fixing part

4. Cable fixing column

5. Splice tray

6. Heat shrinkable protection sleeve

Ø Single fiber splice placed in the splice tray

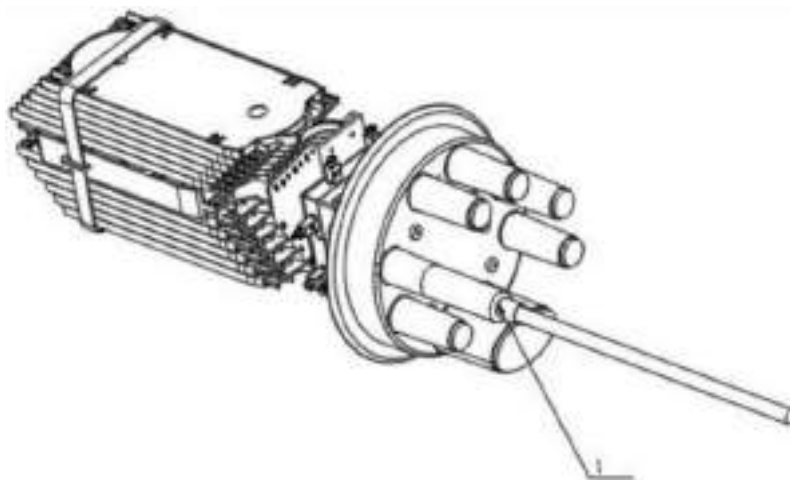


Ø Ribbon fiber splice placed in the splice tray



Optical Cable Heat Shrink Sealing

- Ø Wrapping aluminium foil paper on the optical cable, then put the heat shrink tube on cable port and junction of cable.
- Ø Heat the shrinkable tube by air gun or alcohol burner, then the heat shrink tube fix the cable-on-cable port tightly.
- Ø If two cables entry one cable port, put the branch kit between the two cable, let the metal part of branch kit fixed outside the heat shrink tube, then heat it.



1. Heat shrinkable tube

Optical Cable Heat Shrink Sealing

It is ensured that the splice closures are air tight and waterproof.



Heat Shrink Sleeve

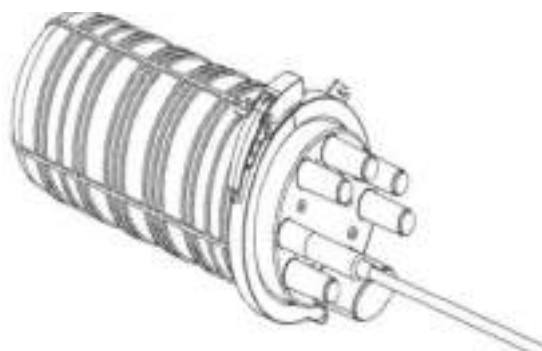


Heat Shrink Sleeve and Aluminum foil is used to seal the joint closure



Closure Sealing & Housing

- Ø The cable with jacket should be fixed by cable tie in the entry of splice tray.
- Ø Check the splice tray if close tray cover.
- Ø Check the inside fixing part if they are fixed tightly.
- Ø Check the sealing parts are in good condition.
- Ø Check the heat shrinkable tube sealing if tightly and completely.
- Ø Put the closure housing close the splice tray and connect the closure base.
- Ø Fixed the closure housing and closure base by hoop.



Section 4: Assessment Questionnaire

1. Physical protection to the splice is provided by placing the splice in _____.
2. What is the use of Splice holders?
3. Can we reuse Joint Enclosure?
4. Identify the hidden item.



5. Identify the hidden item.



6. What are some features of Joint Enclosure?
7. How can we seal joint closure?
8. Is bending radius for fiber is maintained in Joint closure?
9. What are qualities of Joint closure?
10. Where can we use Joint closure?
11. The splice tray is used for _____
12. Why do we use crocodile clip in Joint closure?
13. Name the item no 3 in below picture.



14. Why joint enclosure is used in field?
15. _____ is used for connecting cable earthing in joint closure.
16. _____ is used for pressure testing of joint closure.
17. Joint closure cannot be installed on pole. True or False?
18. Oval ports of joint closure is used for placing _____ cables.
19. Number of spliced trays may vary in every joint closure. True or False?
20. In IP 68 standard of joint closure sealing. What does IP stand for?

-----End of the Module-----

MODULE 9 FTTx NETWORK COMPONENTS

Section 1: Learning Outcomes

After completing this module, you will be able to:

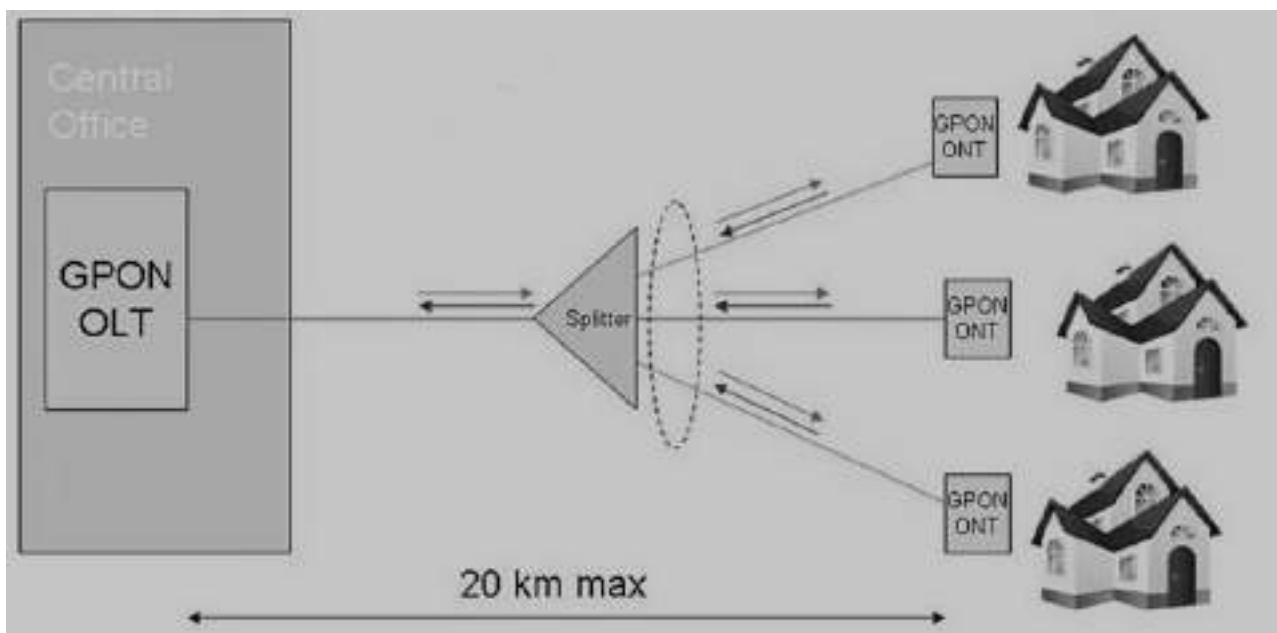
- Describe the functions of Optical Line Terminal (OLT)
- Differentiate between various Types of Optical Splitter
- Install Optical Splitter
- Install Fiber Distribution Terminal (FDT)
- Explain functions of Fiber Access Terminal (FAT)
- Mount Optical Terminal Box (OTB)
- Explain functions of different interfaces of Optical Network Terminal (ONT)
- Describe ports, indicators and connection of ONT

Section 2: Relevant Knowledge

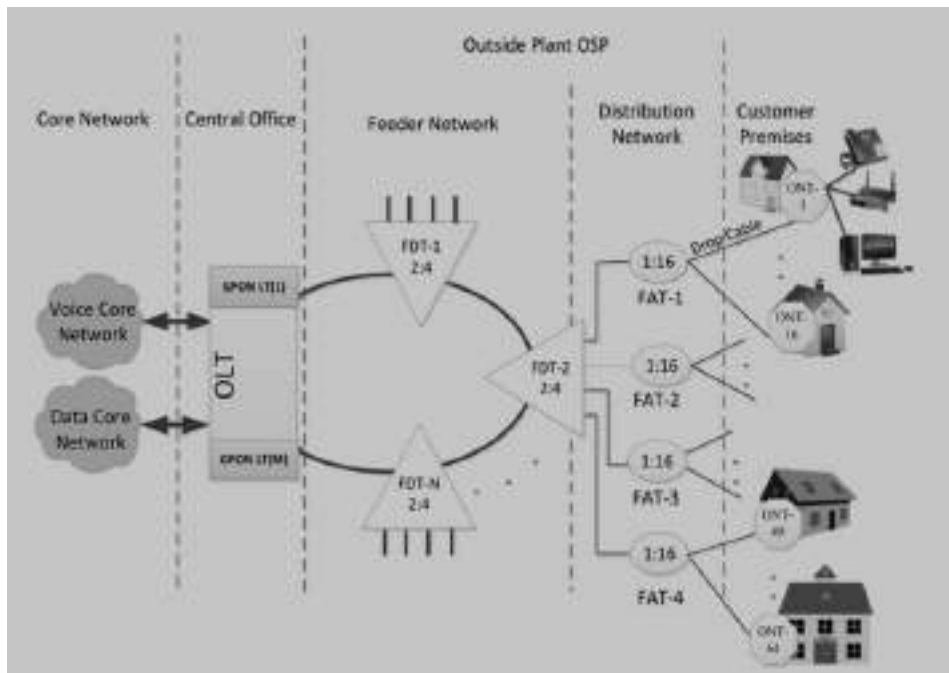
9.1 FTTx Network Components

There are three basic components in passive network:

- Ø Optical Line Terminal (OLT)
- Ø Optical Splitters
- Ø Optical Network Terminal (ONT)



Passive Network Components



9.2 Optical Line Terminal (OLT)

- Ø An OLT (optical line terminal), also known as optical line termination, acts as the endpoint hardware device in a passive optical network.
- Ø OLT is an active device that is usually located in a data center or the main equipment room. It is the engine that drives the FTTH system.
- Ø OLT at one side is connected to internet world (exchange) and on other side connected to splitter to transfer data from service provider to the user.



It provides two main functions:

- Ø To perform conversion between the electrical signals used by the service provider's equipment and the fiber optic signals used

by the passive optical network.

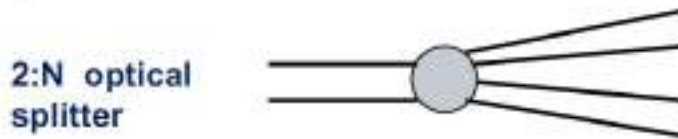
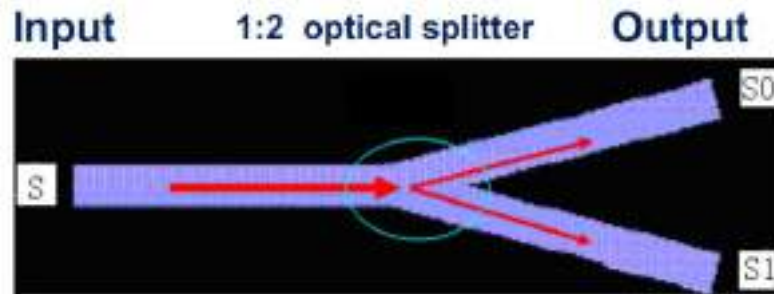
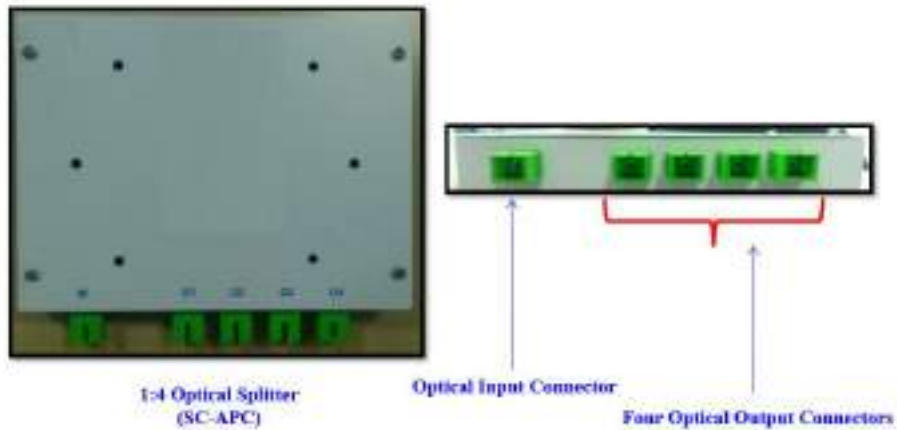
- Ø To coordinate the multiplexing between the conversion devices on the other end of that network (called either optical network terminals or optical network units).
- Ø Control, manage, measure the distance to customer terminal devices like ONU.

OLT generally consists of:

- Ø Control board. Normally there are 2 boards involving main and backup boards on an OLT
- Ø DC power supply board
- Ø Fan unit. It's mainly used to dissipate heat and monitor the environment.
- Ø Service frame
- Ø Other uplink boards

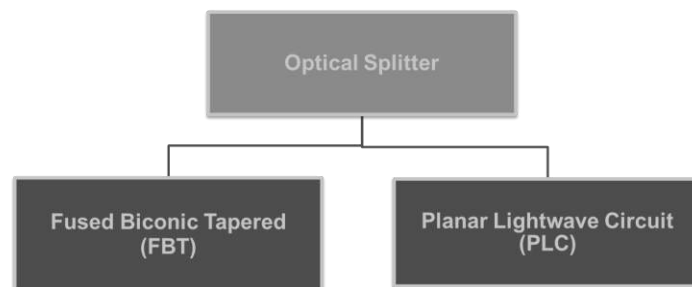
9.3 Optical Splitters

- ∅ Fiber optic splitters enable a signal on an optical fiber to be distributed among two or more fibers.
- ∅ The passive optical splitter can split, or separate, an incident light beam into several light beams at a certain ratio. It does not require electrical power.
- ∅ Few split ratios are 1:2, 1:4, 1:8, 1:16, 1:32, 1:64, 1:128.
- ∅ The fiber output ends for splitters with connectors shall be equipped with PC/APC type of connector configuration.
- ∅ Splitters are actually coupler devices as well because they combine the signals in the upstream direction as well as they split the downstream.



Split Ratio	Attenuation (Loss)
1:2	3 dB
1:4	6 dB
1:8	9 dB
1:16	12 dB
1:32	15 dB
1:64	18 dB
1:128	21 dB

Types of Optical Splitters



Fused Biconic Tapered (FBT) Splitters

- Ø In this splitter, two or more than two fibers are welded closely together by applying heat.
- Ø FBT splitter is based on traditional technology to weld several fibers together from the side of the fiber.
- Ø Fibers are aligned by heating for a specific location and length.
- Ø Because the fused fibers are very fragile, they are protected by a glass tube made of epoxy and silica powder. And then a stainless-steel tube covers the inner glass tube and is sealed by silicon.

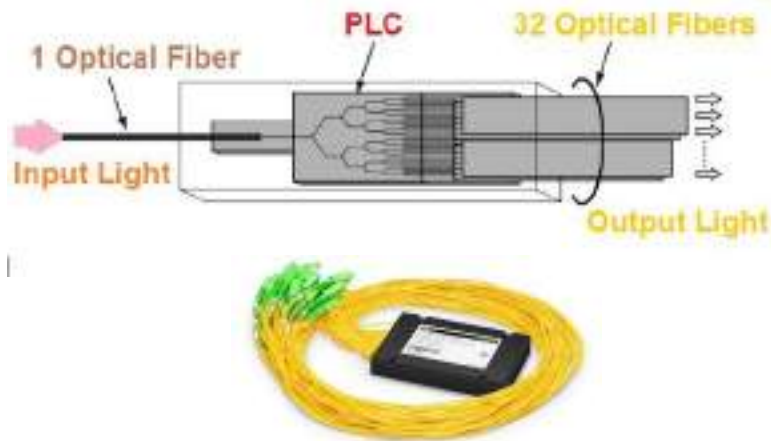


- Ø They are applicable for both single-mode and multi-mode fibers.
- Ø Widely accepted and used in passive networks, where the split configuration is smaller (1x2, 1X4, 2x2, etc.).
- Ø FBT splitters only support three wavelengths (850/1310/1550 nm), meaning that they are unable to operate on other wavelengths.

Advantages	Disadvantages
<ul style="list-style-type: none"> • FBT splitter is made out of materials that are easily available and low-price, so it is cheaper. • Splitter ratios can be customized. 	<ul style="list-style-type: none"> • Restricted to its operating wavelength (850nm, 1310nm, and 1550nm). • The maximum insertion loss will vary depending on the split and increase substantially for those splits over 1:8. • Because an exact equal ratio cannot be ensured, the transmission distance can be affected. • High Temperature Dependent Loss (TDL). • Susceptible to failure due to extreme temperatures or improper handling.

Planar Lightwave Circuit (PLC) Splitters

- ∅ PLC splitters are fabricated by using semiconductor technology.
- ∅ It comprises three layers: a substrate, a waveguide, and a lid.
- ∅ The waveguide plays a key role in the splitting process which allows for passing specific percentages of light. So, the signal can be split equally.
- ∅ PLC splitters offer a better solution for applications where larger split configurations are required.



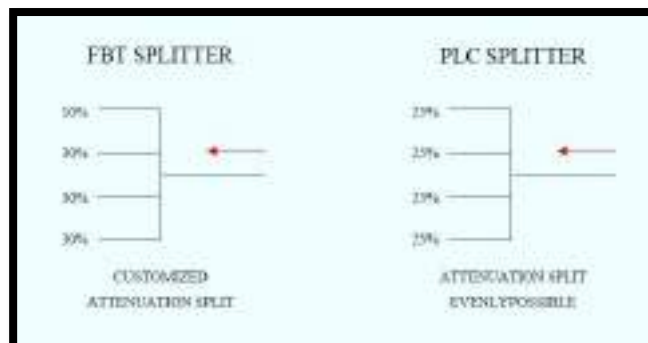
- ∅ PLC splitters offer very accurate and even splits with minimal loss.
- ∅ PLC splitters are now the ideal solutions for larger split configurations (1x32, 1x64, 2x4, 2x8, 2x16 etc).
- ∅ It supports wavelengths from 1260 to 1650 nm.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Suitable for multiple operating wavelengths (1260nm - 1650nm). • Equal splitter ratios for all branches. • Compact configuration, smaller size, small occupation space. • Good stability across all ratios. • High quality, low failure rate. 	<ul style="list-style-type: none"> • Complicated production process. • Costlier than the FBT splitter in the smaller ratios.

FBT vs PLC Splitter

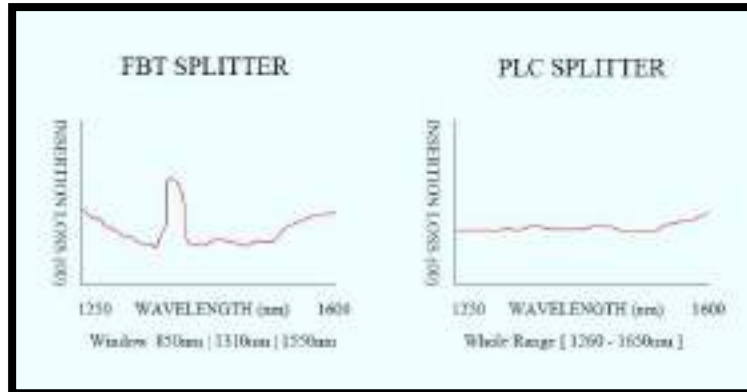
Asymmetric Attenuation Per Branch:

- ∅ The signal processed by FBT splitters cannot be split evenly due to a lack of management of the signals, so its transmission distance can be affected.
- ∅ PLC splitter can support equal splitter ratios for all branches, which can ensure a more stable optical transmission.



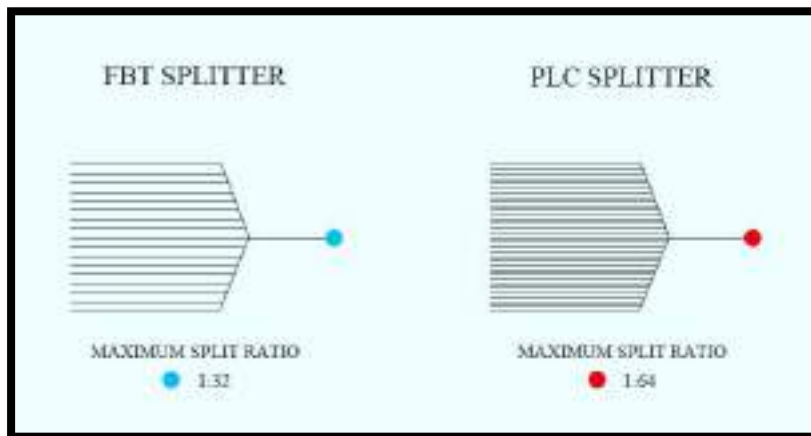
Operating Wavelength:

- ∅ FBT splitter only supports three wavelengths: 850nm, 1310nm, and 1550nm
- ∅ The PLC splitter can support wavelengths from 1260 to 1650nm.



Splitting Ratio:

- ∅ The maximum split ratio of FBT splitter is up to 1:32.
- ∅ The maximum split ratio of PLC splitter is up to 1:64.



Temperature-Dependent Loss:

- ∅ FBT splitter can work stable under the temperature of -5 to 75°C.
- ∅ PLC splitter can work at a wider temperature range of -40 to 85 °C, providing relatively good performance in the areas of extreme climate.

Failure Rate

- ∅ When FBT splitter splitting ratio is larger than 1:8, more errors will occur and cause a higher failure rate.
- ∅ The failure rate of PLC splitter is much smaller.

Price:

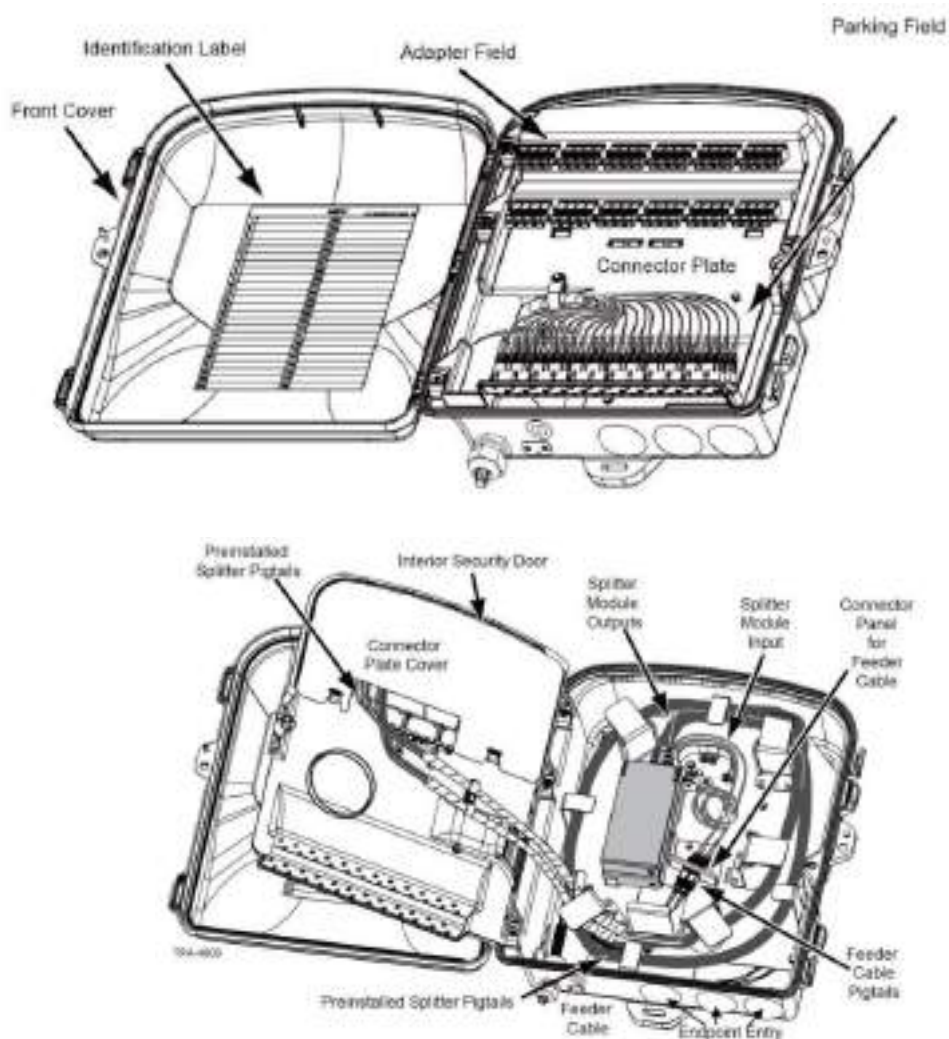
- ∅ Owing to the complicated manufacturing technology of PLC splitter, its cost is generally higher than the FBT splitter.
- ∅ If your application is simple and short of funds, FBT splitter can provides a cost-effective solution.

Use of Optical Splitter in PON

A specific 1xN split ratio in a PON can be achieved in two main ways:

- Ø Single stage, built with a single optical splitter.
- Ø Multiple stages or distributed splitting, built with the cascade of several splitters of lower range located in different locations.
- Ø In practice, 2 stages are very common, but PON rarely exceeds 3 splitting stages.
- Ø Splitters create a broadcast distribution network. The same optical signal is received by all ONTs. Security and confidentiality concerns might need to be addressed.
- Ø Splitters limit the optical reach of the transmission. As the incoming optical power is split in several branches, the splitter insertion loss is high and the optical power available in each branch is considerably low, limiting the optical distance to reach. The higher the split ratio 1:N, the less the power in every branch and the lower the optical reach.
- Ø Splitters limit the bandwidth available for each user. Bandwidth is shared among all the users connected to a particular splitter. The higher the split ratio, the less the average available bandwidth per ONT.

Wall Mount Splitter Housing



Installation of Wall Mount Splitter

Step 1

Select the appropriate location for the housing to be installed according to your installation plan. Choose a vertical surface near approved ground but away from downspouts, permanent water sprinklers, or other water sources. Ensure the housing is easily accessible from the front to allow technicians to connect customers as they subscribe for service.

Step 2

Using the housing as a template, ensure the unit is square and mark the locations for the mounting hardware. Install appropriate anchors (not provided) to the surface to which the housing will be attached. Use shims (not provided) on uneven surfaces to ensure the housing is square and to prevent warpage. Place the unit on the mounting surface over previously determined mounting location.

Step 3

Insert the mounting hardware through the mounting ears and tighten securely to the mounting surface/wall before installing cable into the cabinet.

Step 4

Remove the hole plug for the feeder entry port. Install an appropriate size fitting and conduit (if conduit is used) per standard local practices and ensure proper sealing. Feed the end-point cables into the housing through the fitting.



Step 5

Strip 65 inches of the feeder cable jacket with proper cable entry tools.



Step 6

Route one loop of the fiber around the radius guides in clockwise direction.

Step 7

Bring fibers to splitter pigtail connection in inside center of housing.

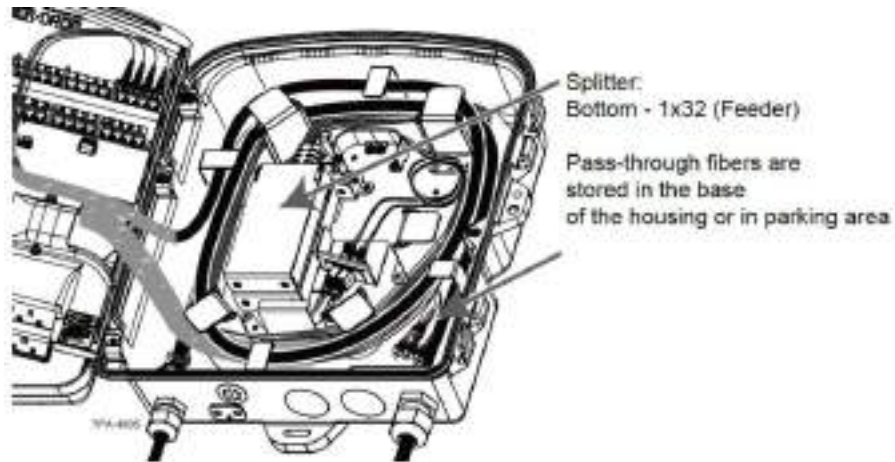


Step 8

Terminate fiber and connect to splitter input adapter.

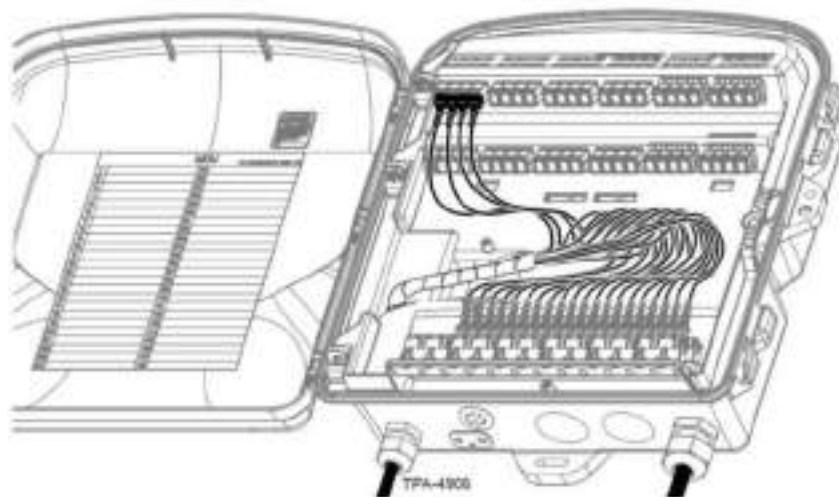
Step 9

Route and secure spare fibers so they will not be damaged.



Step 10

Select the appropriate connector from the parking area.



Step 11

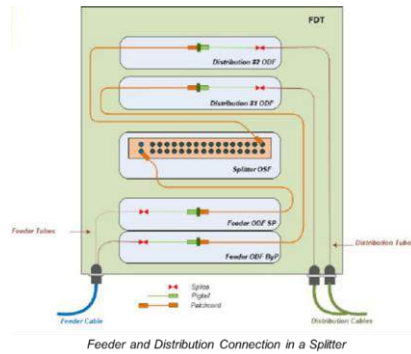
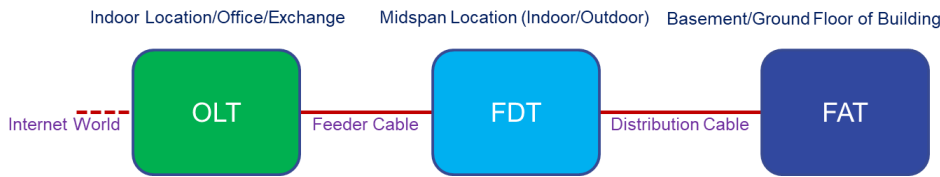
Remove the dust cap from the appropriate connector adapter, clean each adapter before mating and install the connector into the adapter.

Step 12

Close the front cover, secure it by tightening the external security screw with the can wrench. Route and secure spare fibers so they will not be damaged.

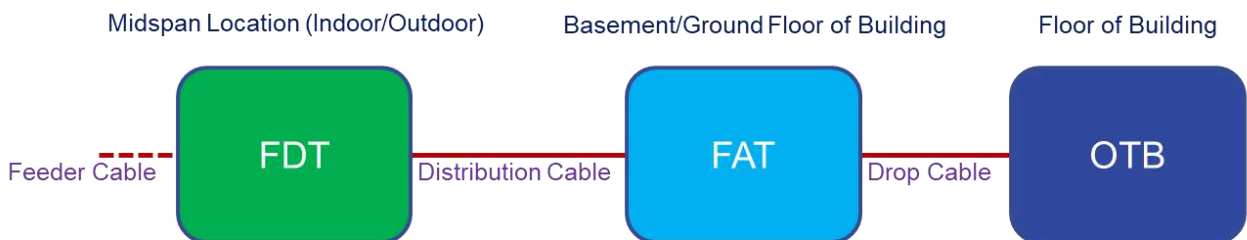
9.4 Fiber Distribution Terminal (FDT)

- Ø Fiber Distribution Terminal (FDT) also called as Optical Distribution Frame (ODF) is a hub where all the fiber from the telecom provider's central office is split and distributed to the end users.
- Ø The fiber distribution terminal is used in FTTH networks to connect feeder cables and distribution cables. Thus, it carries high fiber density within it.
- Ø The device can be used to fix and protect optical cables, terminate and splice fibers, distribute and dispatch fibers, and protect other parts.
- Ø FDT is designed to provide cross-connects or interconnects between incoming fiber-optic cables and equipment.



9.5 Fiber Access Terminal (FAT)

- Ø FAT is a distribution point in the distribution end that distribute all drop fibers to each customer. It can also divide the house to distribute drops in homes and offices.
- Ø The FAT provides various types of connections like branch, pass through and also facilitates distribution for large number of fibers.
- Ø It contains splitters of certain ratio and installed in distribution network.
- Ø It is an interface between Distribution Cable and Drop Cable in a FTTH network. Thus, used for splitting of distribution and drop cables.
- Ø When the FAT can be equipped with optical splitters.



Functions of Fiber Access Terminal (FAT)

- ∅ The function of the FAT is to provide the fusion splicing of the:
 - Optical fiber and the optical fiber
 - Optical fiber and the pigtail
- ∅ It also provides mechanical protection and environmental protection for the optical fiber and its components, and allows proper inspections to maintain the highest standards of optical fiber management.
- ∅ **Fixing function:** After the optical cable enters the rack, its outer sheath and reinforcing core should be mechanically fixed, ground wire protection components should be installed, end protection processing, and optical fiber grouping and protection.
- ∅ **Splicing function:** After the optical fiber drawn from the optical cable is spliced with the tail cable, the excess optical fiber is coiled and stored, and the spliced joint is protected.
- ∅ **Allocation function:** Plug the connector attached to the tail cable to the adapter, and realize the optical connection with the optical connector on the other side of the adapter. Adapters and connectors should be able to be flexibly inserted and removed; the optical path can be freely deployed and tested.
- ∅ **Storage function:** Provide space for storage of various cross-connected optical cables between racks, so that they can be placed in a regular and orderly manner. There should be an appropriate space and method in the FAT to make the wiring of this part of the optical connection line clear, easy to adjust, and meet the minimum bending radius requirements.

FAT has the following characteristics:

- ∅ Fully enclosed structure, good dustproof performance, moisture proof, beautiful appearance.
- ∅ Suitable for indoor wall installation and desktop installation
- ∅ The anti-theft lock mechanism is adopted to effectively protect and manage the optical cable.
- ∅ Made of high-quality metal or plastic, standard size, light weight, easy to install
- ∅ Overall processing of feeder and leather cable, optical fiber connection, fixation, storage, distribution, etc.
- ∅ Suitable for FC, SC, LC, ST and other adapters, pigtails.

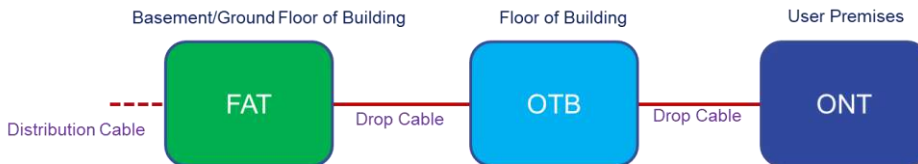
Fiber Access Terminal (FAT)

- ∅ Water-proof design with Ingress Protection
- ∅ Integrated with splice cassette and cable management system
- ∅ Manage fibers in a reasonable fiber radius condition
- ∅ Easy to maintain and extend the capacity
- ∅ Fiber bend radius control
- ∅ Suitable for the fusion splice or mechanical splice
- ∅ 1*N Insertion Module Splitter can be installed
- ∅ N number of ports cable entrance for FTTH Drop Cable



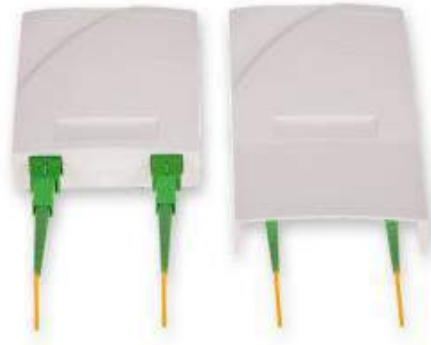
9.6 Optical Terminal Box (OTB)

- ∅ An Optical Terminal Box (OTB) also called as Access Terminal Box (ATB) is used to connect drop cables and passive ONU devices.
- ∅ It can be installed at each floor of the building to distribute the FTTH service to each home.
- ∅ It is installed on indoor walls to provide fiber sockets.
- ∅ OTB supports fusion splicing, mechanical splicing, and optical connectors.



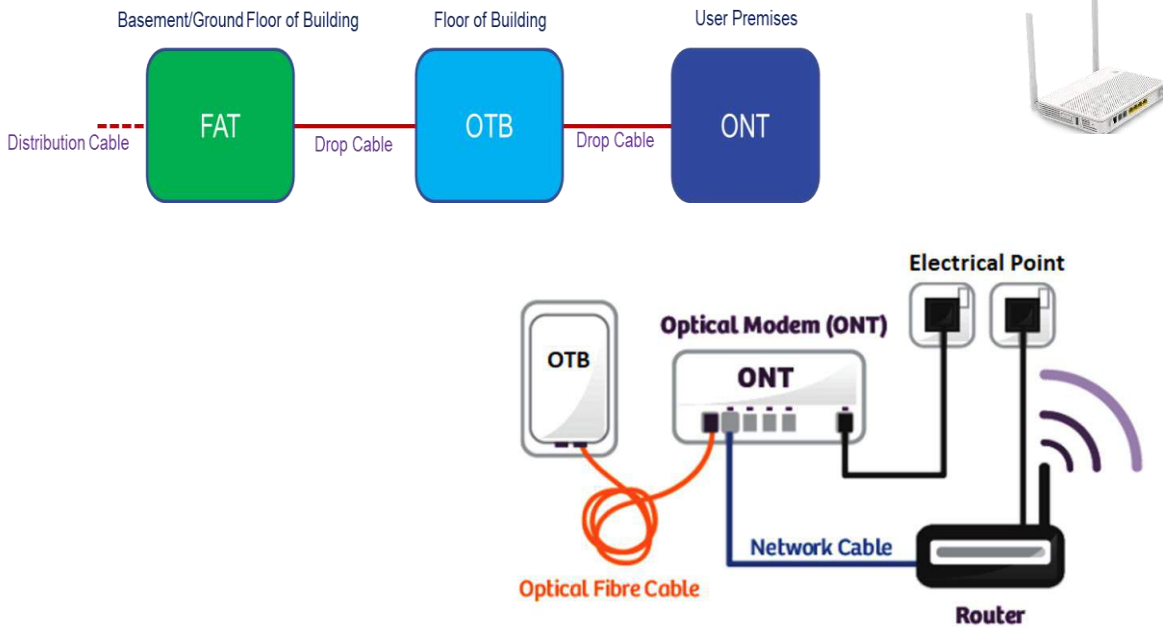
Features of Optical Terminal Box (OTB)

- ∅ It is designed to terminate an optical network using very less (2 to 4 nos.) optical fibers.
- ∅ Connector holder are generally SC or LC
- ∅ Attractive design for indoor usage
- ∅ Installing on a surface or flush-mounting box
- ∅ Simple optical management
- ∅ Direct fiber termination by a connector
- ∅ Standard socket dimensions
- ∅ Input possibility of fiber with connector
- ∅ Use only for fibers G657
- ∅ Possibility of pre-assembled ftth socket to minimize installation time at the customer (cable FLAT DROP 2x3.1 mm)



9.7 Optical Network Terminal (ONT)

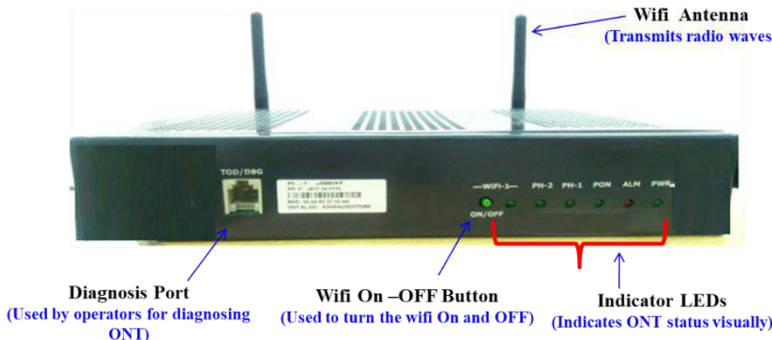
ONT is a media converter (Optical to Electrical and Optical to Radio Frequency) typically installed outside / indoors or designed to deliver multi-line POTS, data and video.



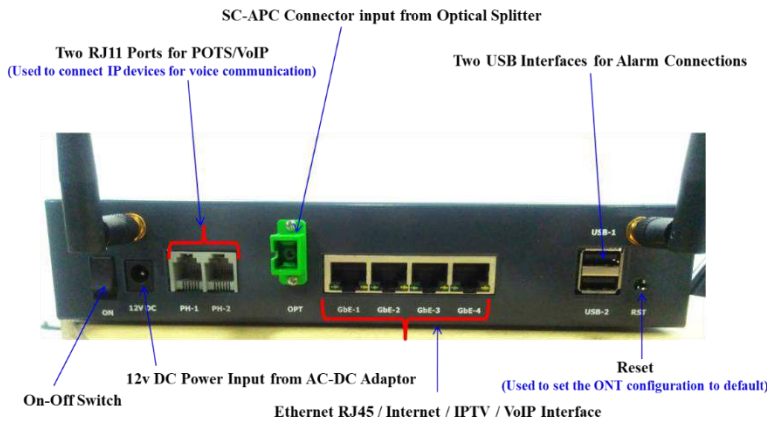
Front View

Some ONTs have built-in router

- Ø Most ONTs system receives 12V through DC power jack.
- Ø DC jack can handle DC power upto 60W and works in non-AC environment.
- Ø To work with 160-270V AC 50 Hz supply, AC-DC adaptor is required.
- Ø Typical ONT Rx Power: -10dBm to -27dBm (May differ for different manufacturers).



Rear View



LED Indicators

- ∅ When the ONT is turned on the power LED glows green.
- ∅ Presence of alarm make the alarm LED glow red.
- ∅ Blinking PON port indicates ONT is not activated. Once activated the LED constantly glows green, It is in activated state.
- ∅ After configurations the POTS port LED glows green. OFF hook-POTS port starts blinks.
- ∅ If WIFI is ON the WIFI LED glows green.



Section 3: Exercises

Exercise 1: Draw a network diagram of GPON.

Exercise 2: Tabulate the Split Ratio and corresponding attenuation of optical splitter.

Exercise 3: Draw diagram of front and rear view of ONT.

Exercise 4: Draw a connection diagram of OTB, ONT and Router.

Exercise 5: Participate in group discussion on following points.

- a) FBT vs PLC Splitters
- b) Differentiate between functions of FDT, FAT, OTB and ONT

Section 4: Assessment Questionnaire

1. What are three basic components in passive network?
2. The engine that drives the FTTH system is called _____.
3. OLT at one side is connected to internet world (exchange) and on other side connected to _____ to transfer data from service provider to the user.
4. Which equipment is used to distribute a signal among two or more fibers?
5. Tell some split ratios in Optical Splitter.
6. What is the value of attenuation when the split ratio is 1:16?
7. 21 dB loss occurs, when split ratio is _____
8. What are the 2 types of Optical Splitters?
9. How many fibers are welded in FBT?
10. Fibers are aligned by _____ for a specific location and length.
11. Which type of splitter is applicable for both single-mode and multi-mode fibers?
12. FBT splitters can operate in multiple wavelengths. True/False?
13. We cannot customize splitter's ratio in FBT splitters. True/False?
14. _____ splitter can support equal splitter ratios for all branches, which can ensure a more stable optical transmission.
15. Which technology is used in fabrication of PLC Splitters?
16. What are the three layers in PLC Splitters?
17. Can we use PLC Splitters where larger split configuration is required?
18. What are some disadvantages of PLC Splitters?
19. FBT splitter only supports three wavelengths _____, _____, _____ whereas, the PLC splitter can support wavelengths from _____ to _____.
20. What is the maximum split ratio for PLC Splitters?
21. Which equipment is designed to provide cross-connects or interconnects between incoming fiber-optic cables and equipment.
22. _____ is a distribution point in the distribution end that distribute all drop fibers to each customer.
23. The function of the FAT is to provide the fusion splicing of _____.
24. What is the other name of Optical Terminal Box (OTB)?
25. OTB is installed on indoor walls to provide _____.
26. The media converter (Optical to Electrical and Optical to Radio Frequency) is called _____.
27. Presence of alarm make the alarm LED glow _____ colour in ONT.
28. ONT works on _____ power supply.
29. To connect landline phone to ONT, _____ port is used.
30. Drop cable is installed from _____ to _____.

-----End of the Module-----

MODULE 10 IN-BUILDING CABLING

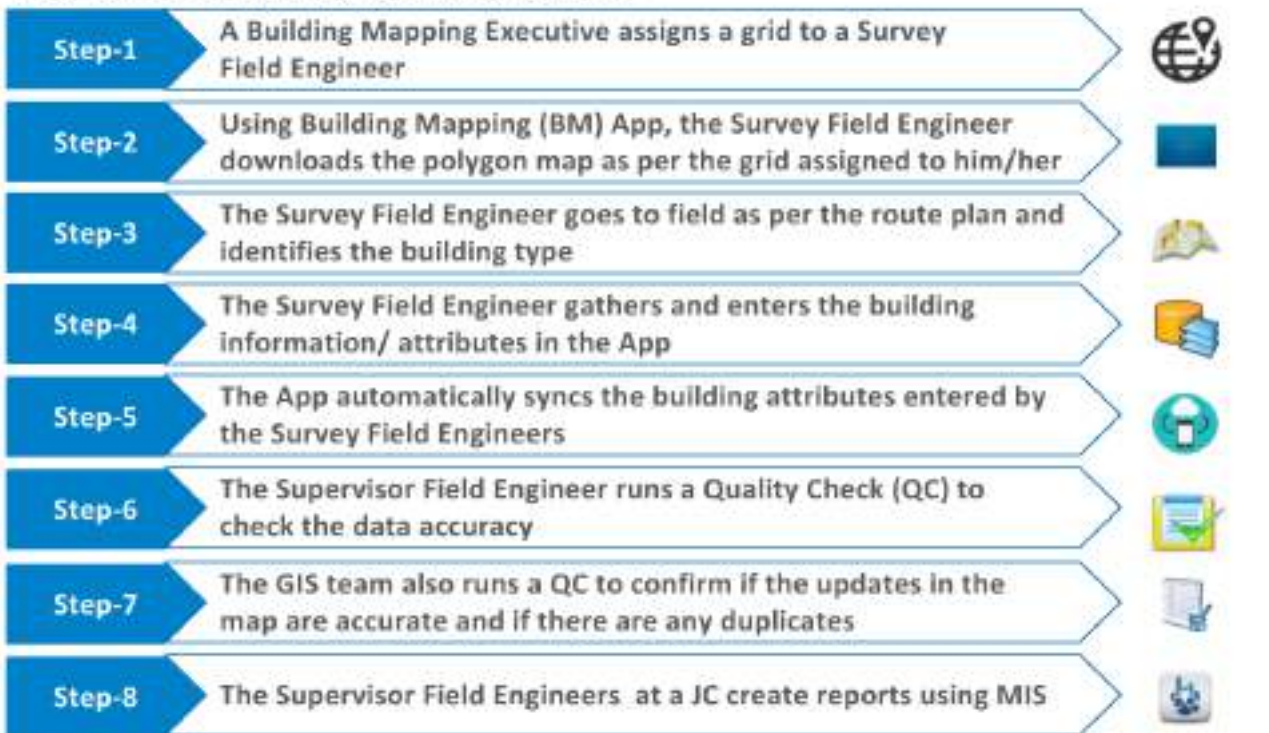
Section 1: Learning Outcomes

After completing this module, you will be able to:

- Perform building mapping to conduct indoor cable installation
- Make Cable Laying Plan for Multi Dwelling Units (MDUs) and Single Dwelling Units (SDUs)
- Perform in-building ducting and conduiting
- Blow and Pull Microcable in Microducts and Conduits
- Differentiate between various Cable Pulling Methods
- Drill a wall to fix the cable trays and FTTx devices
- Calculate load on Cable Tray
- Place and perform cabling of ONT
- State in-building cabling cautions

Section 2: Relevant Knowledge

Building mapping begins after the areas are prioritized. The most important areas will be mapped first. Let's see the process for building mapping.



10.1 Building Mapping Process

Identify Type of Building on Field

When you have reached a building, you need to identify and record the type of the building. There might be different types of buildings in an area. Here are some of these types.



Residential



Commercial



Residential and
Commercial



Bungalow



Row House



Chawl



Hospital



School



Railway Station



Bus Terminal



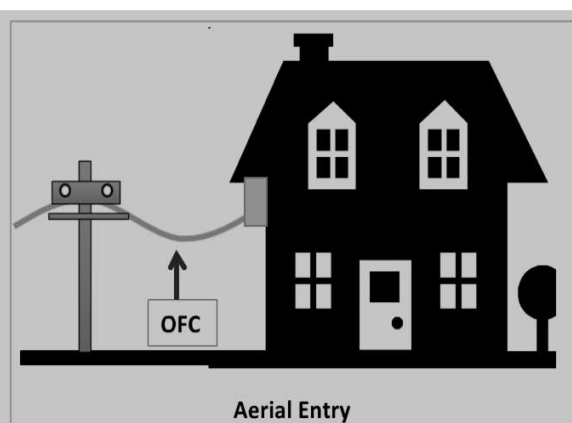
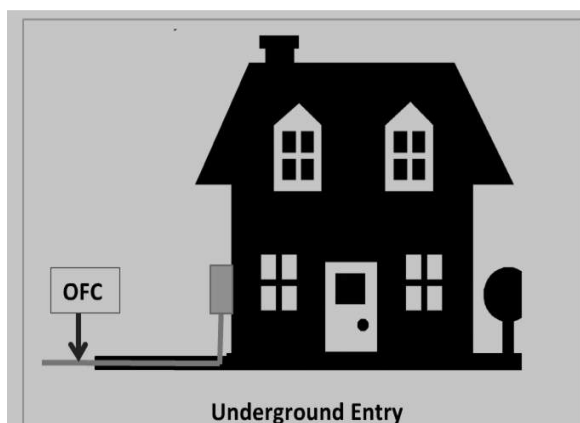
Airport



Police Station

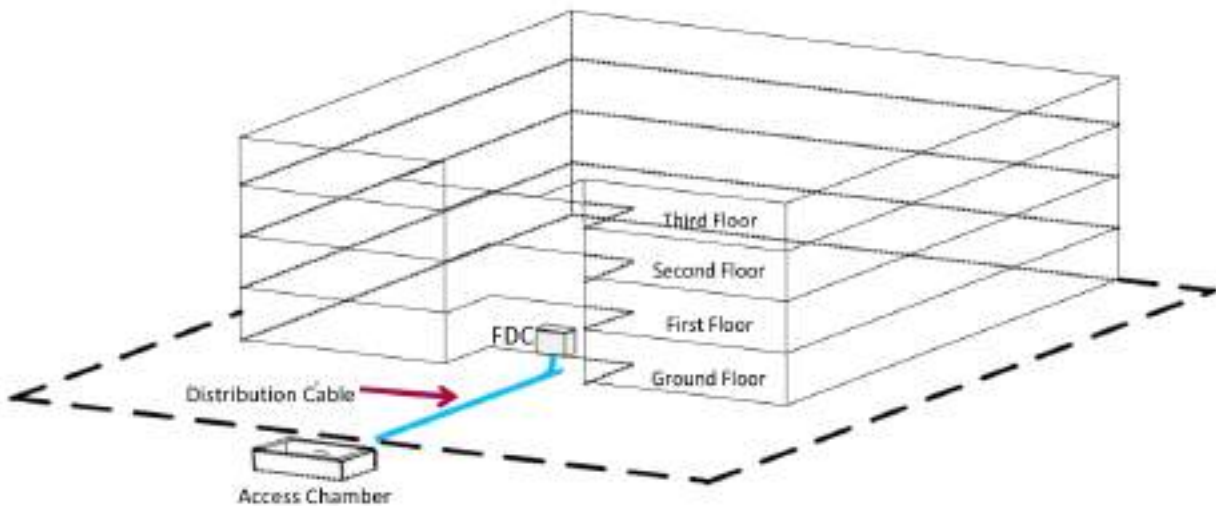
Entering a Building

- ∅ The lead-in path in a building starts from manhole/handhole located outside the building or ends at the building entry point.
- ∅ OFC can enter a building via two methods:
 - Underground
 - Aerial



Underground Lead-in Method

- ∅ Conduct a feasibility route survey.
- ∅ Discuss the proposed route and the deployment method with the building authorities.
- ∅ Identify the path for laying the ducts. If the building has existing ducts, cable trays, raceways, cable-trench, reuse them.
- ∅ Else, go for micro-trenching, clamping on wall, moling and chipping on concrete surfaces.
- ∅ Begin only after obtaining a mutual agreement with the building authorities.



Aerial Lead-in Method

- ∅ Conduct a feasibility route survey.
- ∅ Discuss the proposed route and the deployment method with the building authorities.
- ∅ If underground cabling is not feasible, identify the path for laying the aerial cables.
- ∅ If the building has existing poles inside the compound and clamping on the building wall, reuse them.
- ∅ Begin only after obtaining a mutual agreement with the building authorities.



10.1 Cable Laying Plan for Multi Dwelling Units (MDUs) Multi Dwelling Units (MDUs)

Multi Dwelling Unit

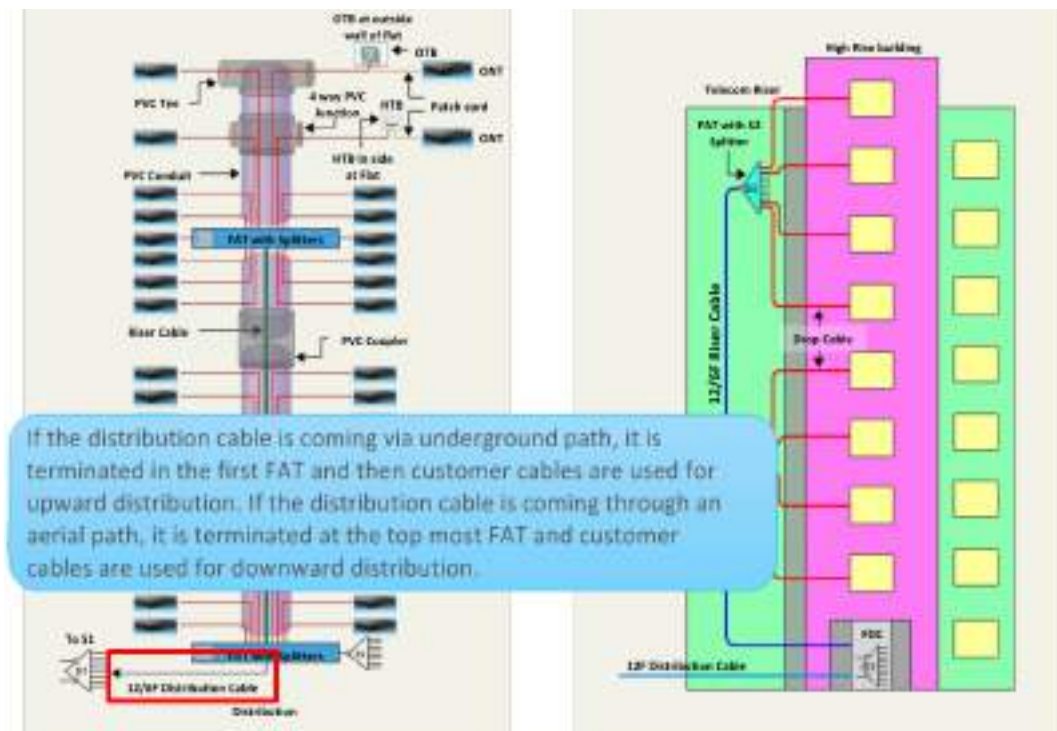
- The stand-alone floor or podium
- A group of such compound walls
- Every individual
- Every Society will have a Unique Society ID.



Buildings,
it, ground

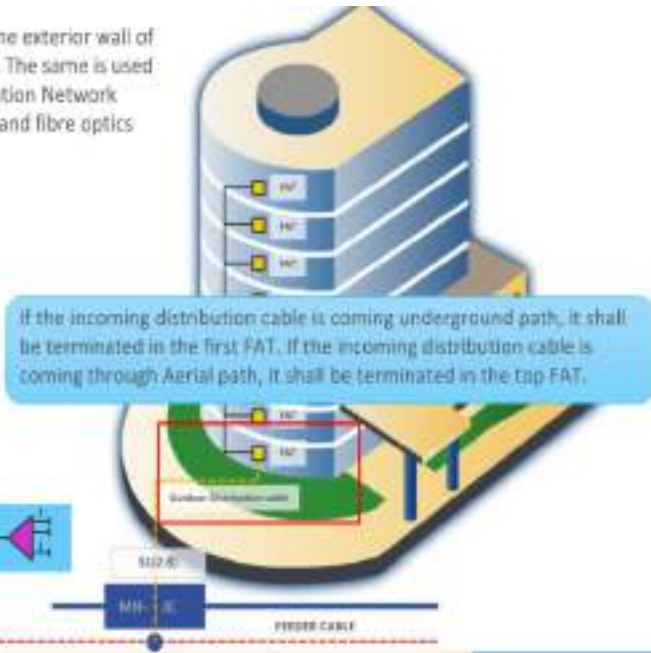
Common

Distributed Splitter Scenario

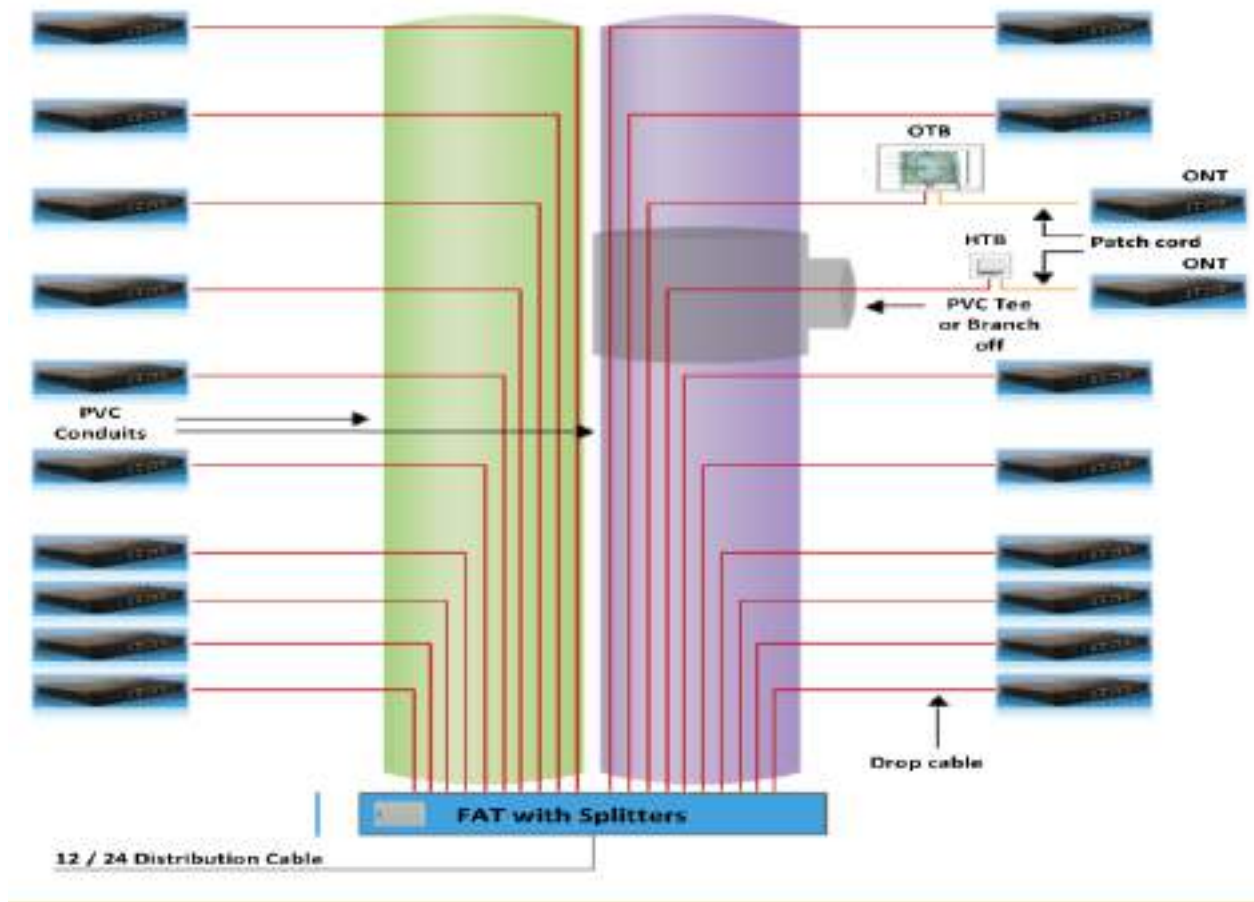


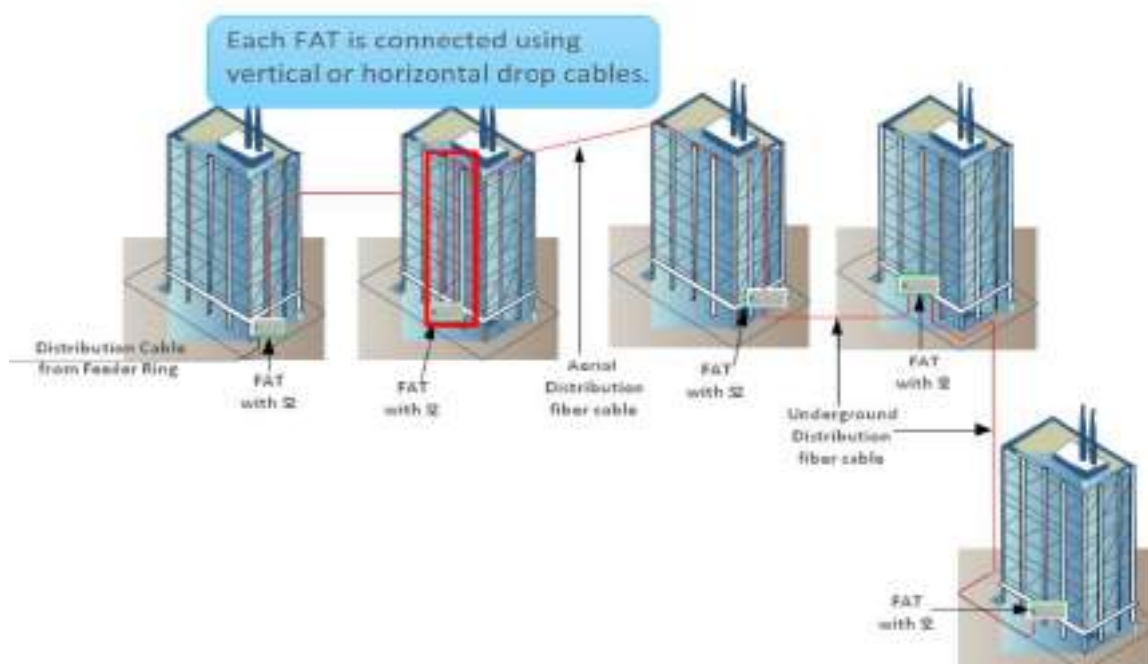
Distributed Splitter Scenario and Outside Cabling FAT in

The face of the building or the exterior wall of the building is called façade. The same is used for installing Optical Distribution Network elements including physical and fibre optics used for connection.

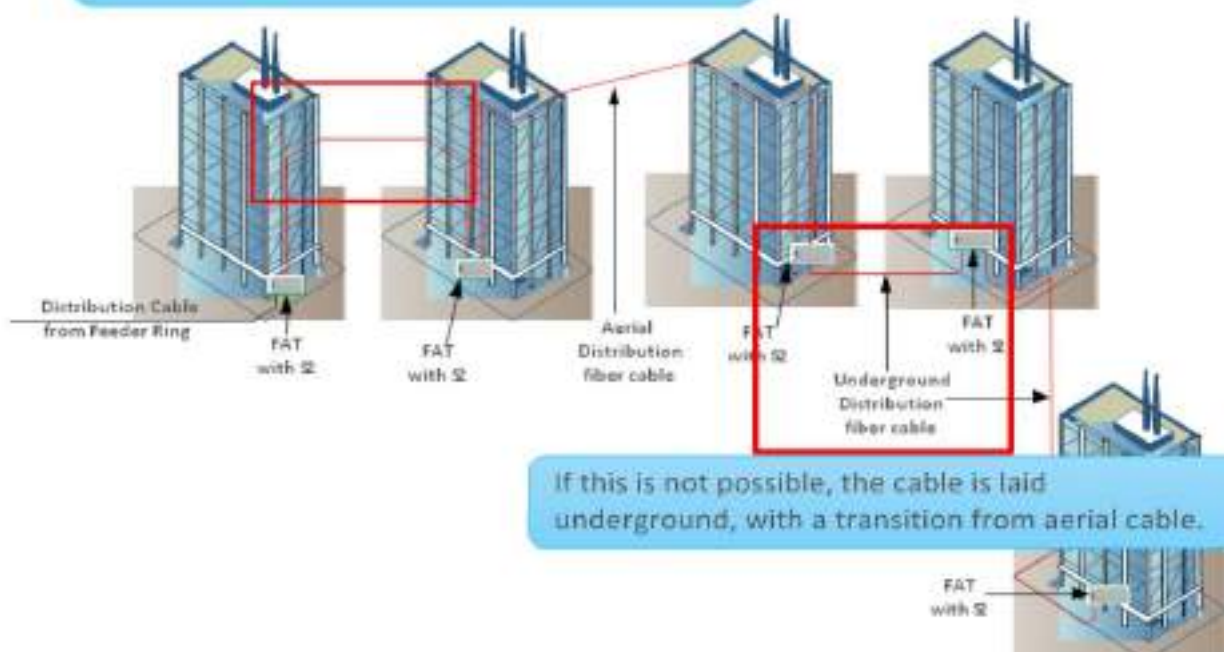


Basement Scenario





In cases where a fibre cable is required to cross a road between buildings, minimum vehicle clearance height of 5 meters is maintained.



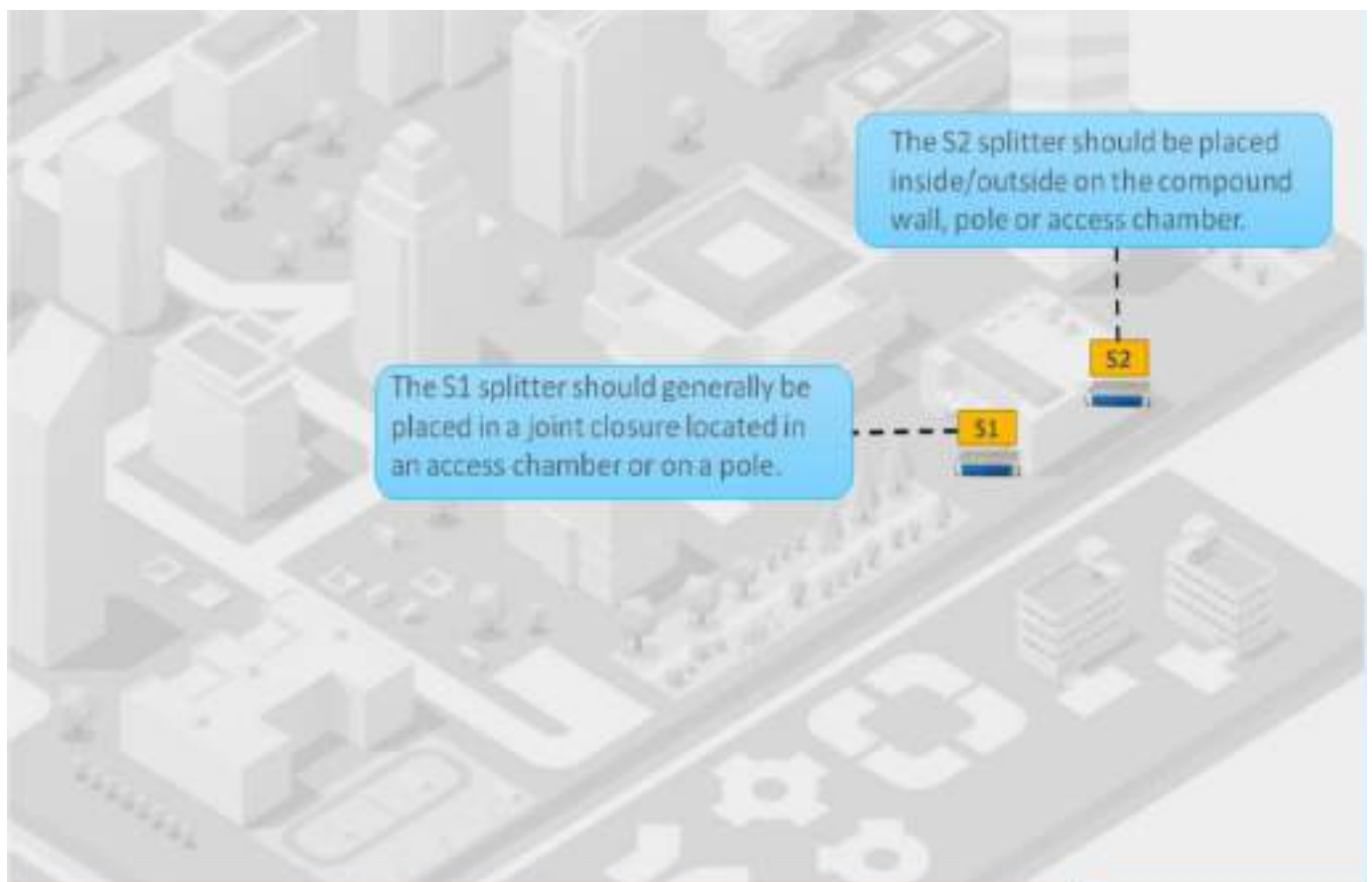
If this is not possible, the cable is laid underground, with a transition from aerial cable.

10.2 Cable Laying Plan for Single Dwelling Units (SDUs)

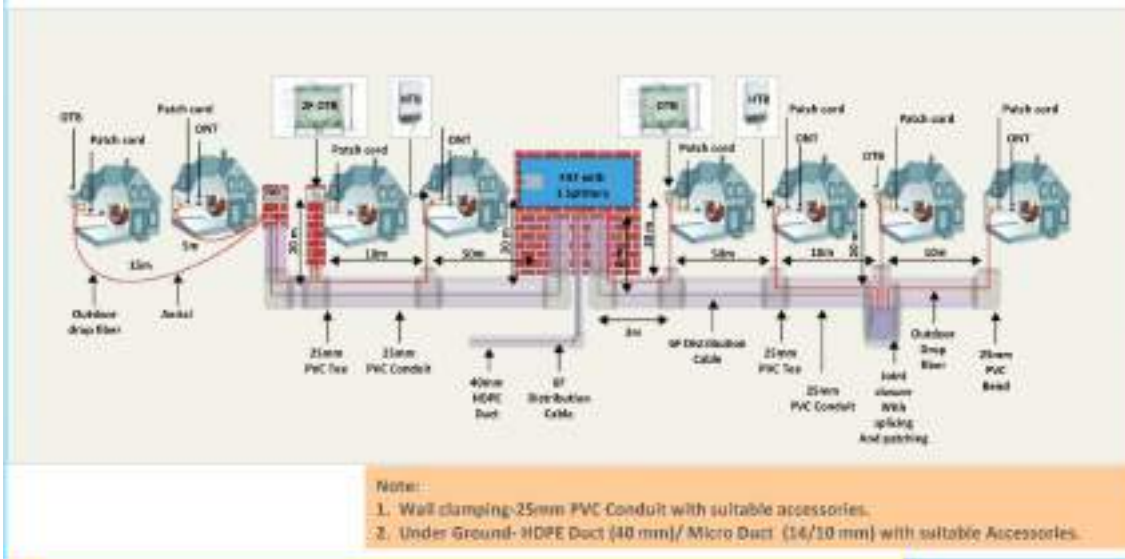
Single Dwelling Units (SDUs) are typically low rise buildings that have up to a maximum of two floors. They may be standalone or part of a group of similar buildings forming a gated community or campus. For every 8 to 16 home pass, there should be one FAT; and for 6 to 8 home pass, there should one Optical Termination Box.



Splitter Location and Underground Cabling

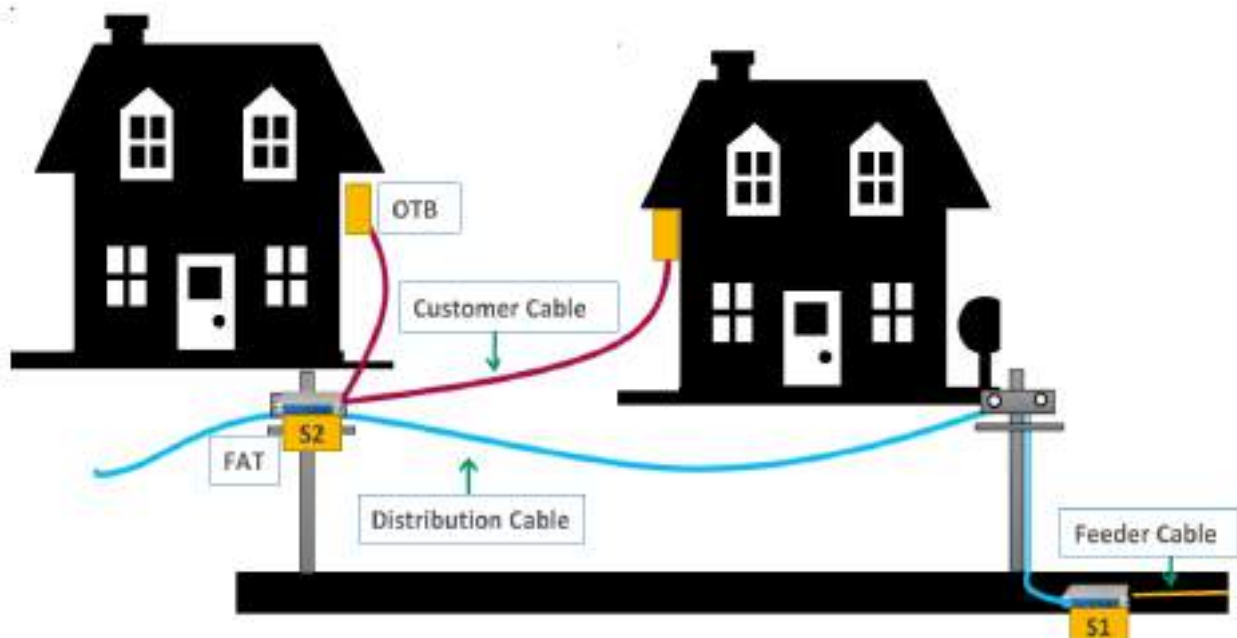


OTBs are used to extend the sub-distribution from nearby FATs.



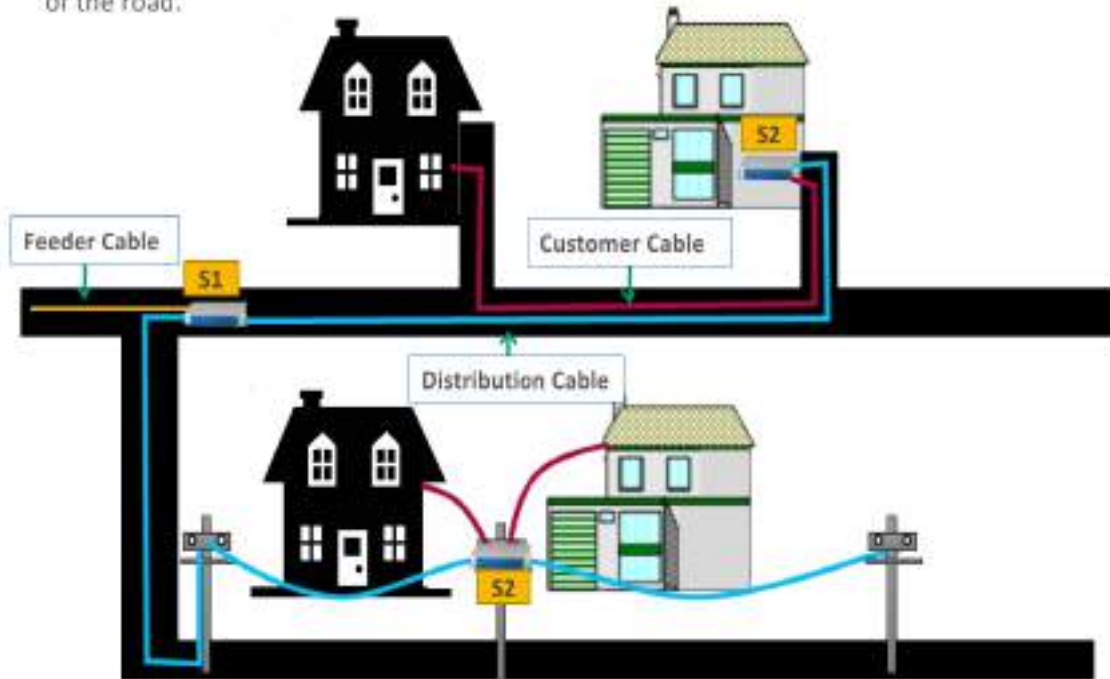
Distributed Splitter Location and Aerial Customer Cabling

In a distributed splitter scenario where the customer cables take the aerial route, the FAT with S2 splitter and OTB should be placed on a pole. Outdoor aerial customer cable should be used to connect the individual customers.



Distributed Splitter Location with Underground and Aerial Customer Cabling

S2 splitters at multiple locations should be placed in FAT on wall or in joint closure either in an access chamber or on a pole. Trenching (micro trenching, open trenching, shallow trenching or Molding) should be carried on one side of the road and should be used for connecting all buildings on same side of the road.

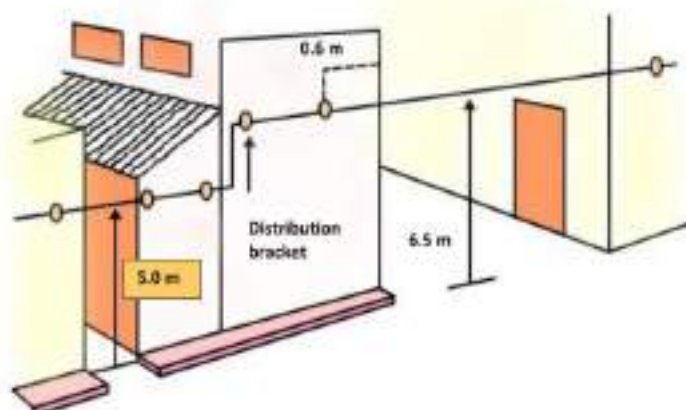


SDUs and Blocks – Wall to Wall Façade

Where possible, aerial fibre cables should run in straight lines, vertically and/or horizontally and be placed in such a way that they are as close to walls/supports as possible.

In cases where a fibre cable is required to cross a road access between buildings, minimum vehicle clearance of 5 meters height should be achieved. If this cannot be achieved, then an underground road crossing should be done.

This scenario is also applicable where multiple SDU blocks or buildings are located side by side.



SDUs Scenario Matrix

The table shows the different SDU scenarios based on S1, S2 locations and construction methods.

Splitter's Location	S2 (FAT) on Wall	S2 (Joint Closure) on Pole
S1 in Access Chamber (Joint Closure)	Scenario 1	Scenario 2
	Construction Methodology 1. Aerial <ul style="list-style-type: none"> • Pole to Pole • Building to Building 2. Underground <ul style="list-style-type: none"> • Micro Trenching • Shallow Trenching (Open cut) • Hand Trenching/Micro slitting 3. Wall Clamping 4. Combination of 1, 2, 3	Construction Methodology 1. Aerial <ul style="list-style-type: none"> • Pole to Pole • Building to Building 2. Underground <ul style="list-style-type: none"> • Micro Trenching • Shallow Trenching (Open cut) • Hand Trenching/Micro slitting 3. Wall Clamping 4. Combination of 1, 2, 3

10.3 In-building Ducting and Conduiting Process



Conduits are critical and are used to protect the cables from wear and tear, and from getting exposed to weather conditions.

- Standard length of each conduit is 10 feet or 3 metres



Safety Measures for In-building ducting and Conduiting

Below are some of the safety measures to be taken during in-building ducting and conduiting:

- Take care of the existing electrical wiring
- Take care while preparing for hanging on the wall
- Ensure that the screwdriver arm is insulated
- Ensure that length of each conduit length does not exceed 3 metres, if needed, cut it using a hacksaw



In-building Ducting and Conduiting –Scenario

The in-building ducting and conduiting process consists of the following scenarios:

Scenario 1 : Vertical Profile

Where we lay ducts and conduits in a vertical position



Scenario 2 : Horizontal Profile

Where we lay ducts and conduits in a horizontal position



Performing in-
building ducting
and conduiting

In-building Ducting and Conduiting

Shown below are some examples of in-building ducting and conduiting with a horizontal profile:



Horizontal Profile

Vertical Profile

Shown below are some examples of in-building ducting and conduiting with a vertical profile:



The following are the types of vertical scenarios:

1. Using existing shafts
2. Using existing conduits if available
3. Floor to floor cutting (core cutting)
4. Running through the staircase or around the staircase
5. From outside the building (scaffolding)

Never use electrical shafts of the building for cable laying

Tools

Following are the tools used for in-building ducting and conduiting:

Clamps:

- A **clamp** is a fastening device to hold the ducts tightly to the wall to prevent movement or separation through the application of inward pressure
- A clamp needs to be fixed to a duct after every 1 metre measured using a measuring tape



Conduit (UV protected) with ONLY following specifications are to be used:

- 25 mm PVC Conduit in Vertical (In Black, Grey and Ivory colours)
- 40 mm PVC Conduit in Horizontal (In Black, Grey and Ivory colours)

Couplers:

- A **duct coupler** is a device with one or more input ducts and one or several output ducts.
- A coupler is used to couple 2 ducts measuring 6 feet



Bends: Bends help in connecting two conduits. **All conduit bends are prefabricated.**

Flexible bends can be of 25 and 40 mm. It should be 20 times diameter of the cable. The bend should not exceed 20 degrees.

Saddles: Saddles help to fix a conduit to a flat surface such as a wall.

The size of the saddle will depend on the conduit diameter.

Flexible Bend



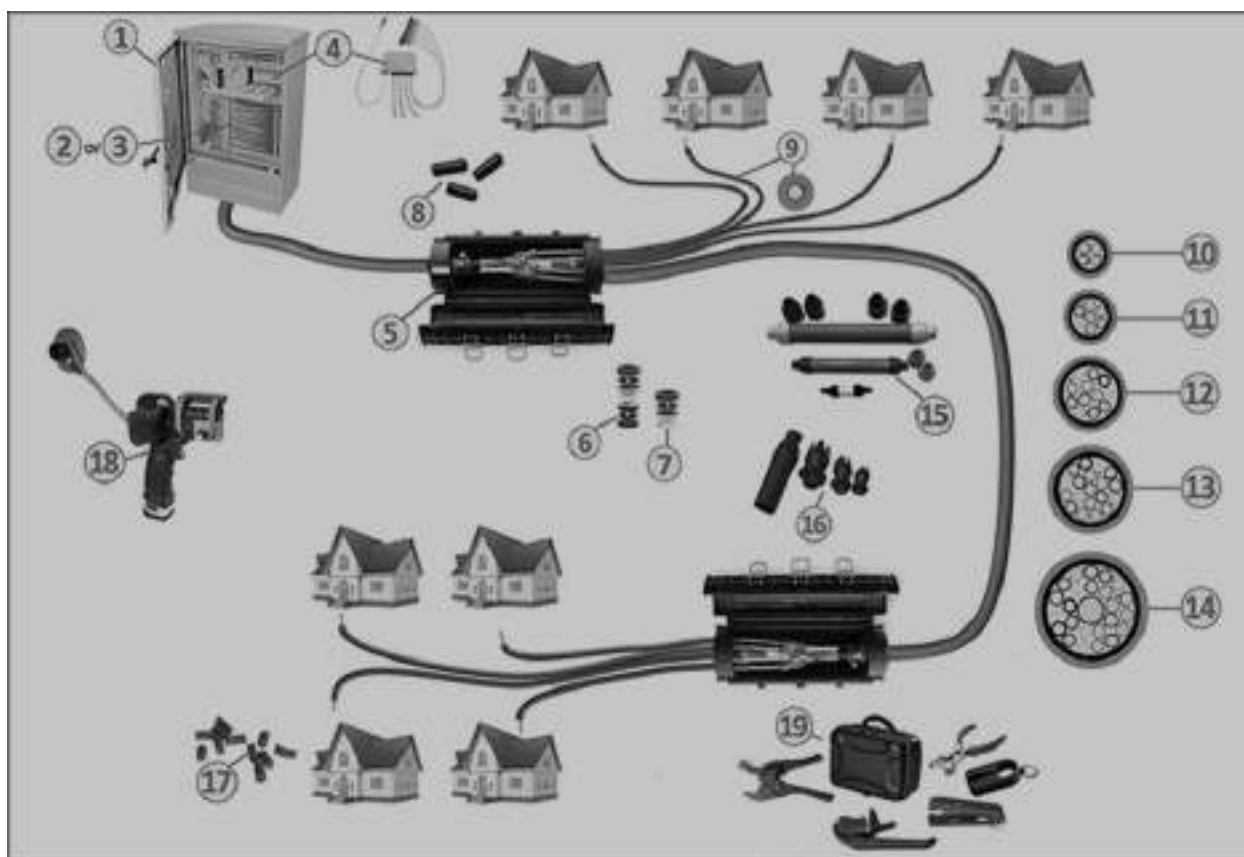
T Bend



Saddles



10.4 Microcable Blowing



#	Description
1	FDT
2	Fiber Adapter Tray (Empty)
3	Fiber Adapter Tray with 24XSC/APC Pigtails
4	Splitter
5	Duct Branch Off Closure, 4- or 8-way
6	Connector, 5 or 10 mm
7	Endstop Connector, 5 or 10mm
8	End Caps for Microducts, 10mm (temporarily above ground)
9-14	Direct Buried Microduct, multiple sizes
15	Straight Duct Joint (8 dimensions)
16	End Sleeves, temporarily seal
17	Cleaning Sponges 3.5 and 8mm
18	Blowing Tool
19	Installation Tools (Duct Cutters, Stripping Tool, etc.)

Fiber Blowing Tool

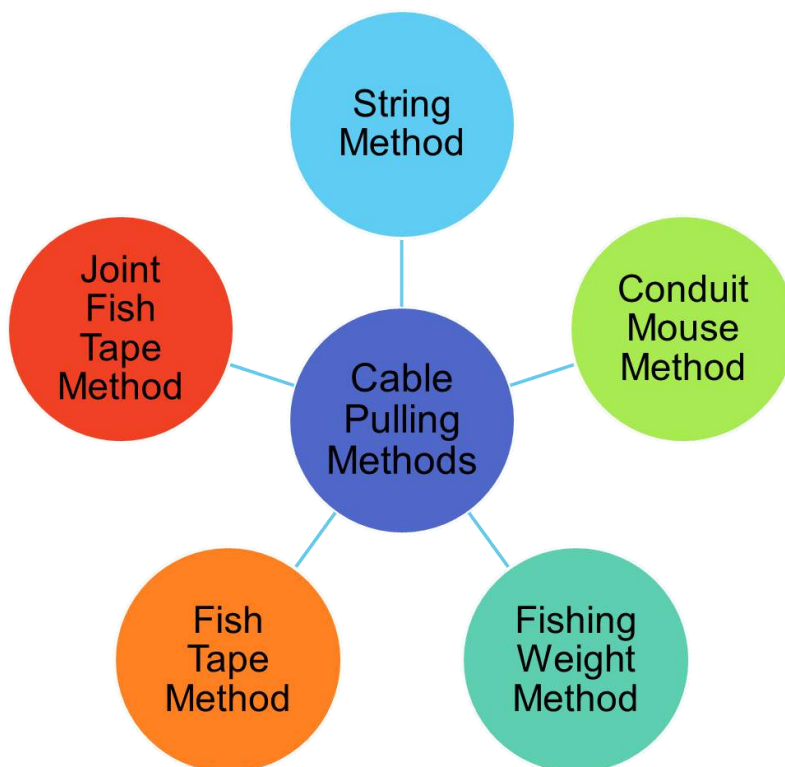
This technique involves using compressed air to blow a fiber or a cable in micro duct.

Features

- Ø Smallest and fastest
 - Handheld, battery
 - Pre-connected fiber drum directly attached to the tool
 - Friction clutch to eliminate fiber damage
- Ø With compressed air, up to 1000m
- Ø Without compressed air, 50–70m



10.5 Cable Pulling Methods



String Method

The string method is the simplest technique for pulling wire through conduit and relies on a strong string called a pull string. The method works as follows:

1. **Tie the string:** Tie a strong string to a long, inflexible rod.
2. **Push the rod:** Push the rod through the conduit, tied end first. Continue pushing until the string emerges from the opposite side of the conduit.
3. **Attach the wire:** Tie the fiber cable to the string.
4. **Pull the wire:** Pull the rod and string through the conduit, pulling the wire along with them.

This method works best on pieces of conduit that are short and straight. Longer pieces of conduit or lengths with more curvature will require an alternative method.

Conduit Mouse Method

∅ The mouse method uses a tool called a conduit mouse or conduit piston instead of a rod.

∅ This tool is a small foam cylinder that is slightly smaller in diameter than the interior of the conduit.

∅ The method for using this tool is detailed below:

- **Tie the string:** Take the conduit mouse and tie a strong, light string to it. There should be a wire loop running through the mouse for this purpose.
- **Insert the mouse:** Place the mouse into the conduit opposite from the side you plan to pull from. Fit the mouse so that it fills the conduit space and so that the string follows behind it.
- **Apply the vacuum:** Take the shop vacuum and apply it to the opposite end of the conduit. Make sure that the vacuum hose is fitted to the conduit so that it creates the best suction.
- **Pull the mouse:** Turn on the vacuum and apply it until the mouse is sucked to the end of the conduit. Turn off the vacuum and remove the mouse.
- **Attach the wire:** Untie the string from the wire loop on the mouse and secure it to the wire.
- **Pull the wire:** Pull the opposite end of the string to pull the wire into the conduit. For longer conduits, have a partner feed the wire into the conduit.

∅ This method is very useful for conduit with more complex twists and turns but can be limited by the length of the conduit.

Fishing Weight Method

∅ The **fishing weight method** uses a heavy fishing weight to guide wiring directly through a conduit. The method works as follows:

- **Tie the weight:** Tie a heavy fishing weight to the end of the wires using string or fishing wire to give the weight a 2- to 3-inch lead in front of the wiring. Be sure to choose a fishing weight that is thin enough to run through the conduit but heavy enough to pull lubricated wire.
- **Insert the weight:** Place the fishing weight inside the conduit and adjust the placement of the wiring so that it can easily move behind the weight.
- **Drop the weight:** Drop the fishing weight into the conduit. If you are working with a free-moving length of conduit, lift the end of the conduit higher than the weight so that gravity can pull the weight along. When necessary, adjust the conduit orientation to get the weight around curves in the conduit. Continue this process until all the wire has been pulled through the conduit.

∅ This method is somewhat limited in its applicability. It works best for straight, vertically-run conduit, though it can be applied to almost any conduit that is free to move around. It is not ideal for a conduit that is fixed in a horizontal position or has excessive curves.

Fish Tape Method

- Ø Fish Tape is a long, thin and flat metal wire wound inside a spool with a hook at the end.
- Ø The fish tape method can be applied to nearly all types of conduit.
- Ø Fish tape is available in a range of lengths from 25 feet to 200 feet, so be sure to get one appropriate for your application.
- Ø For shorter lengths or small jobs, nylon tape is an economical option that works just as well.



Step 1: Unreel Fish Tape

Start to unreel a few inches of the fish tape out of the plastic housing. You may need to push a button to release the tape. Other types of fish tape do not have buttons; you simply pull the tape out.



Step 2: Feed the Fish Tape

Push the fish tape forward to feed it into the conduit or through the holes in the studs. Feed the tape until a foot or two are exposed at the other end.



Step 3: Attach Cable/Wire to Fish Tape

Rip sheathing from the electrical cable to expose several inches of wire. Strip the ends of the wires to expose the copper. Twist together the wires. Attach one of the wires to the end of the fish tape. Bend the wire to form a complete loop.



Step 4: Wrap Cable/Wire to Fish Tape

Wrap the cable with electrical tape. Start where the wires attach to the end of the fish tape and end at the start of the cable sheathing. Wrap tightly. Do not use more than one layer of tape. Be sure the open end of the double loop is on the end of the fish tape. Otherwise, it can get stuck on couplings and be pulled back.



Step 5: Pull Fish Tape

Pull the fish tape slowly back. Work slowly, as a helper unspools the cable on the other end.



Step 6: Detach Cable from Fish Tape

Reel back all of the fish tape until the cable appears. Make sure that about a foot or more of the cable is exposed to prevent it from retracting back and being lost. Unwrap the tape and remove it. Untwist the wires from the fish tape and remove them.



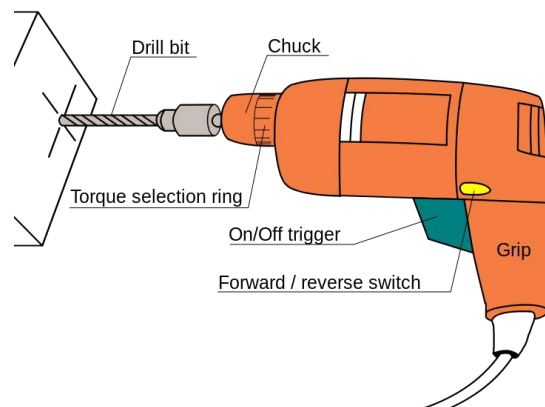
Joint Fish Tape Method

- ∅ In some cases you may encounter conduit with 90 degree turns or existing wires both of these can prove problematic.
- ∅ Pulling wire through conduit with existing wires is difficult because any technique you use may get caught on the existing wires — the conduit mouse and fishing weight method are completely unusable in these cases for this reason.
- ∅ Pulling cable through conduit bends can also prove problematic.
- ∅ For most conduit, the more severe the angle, the more difficult it is to get a pull string or fish tape in place.
- ∅ This problem is even more pronounced with PVC conduit, as the angle joints can easily catch fish tape as it works through the conduit.
- ∅ One method to get around these problems uses two fish tapes run at each end of the conduit. Note that this method does require working with a partner.
- ∅ The method goes as follows:
 - **Create loops:** Take one of the fish tapes and expose the end. Use strong string to create a bundle of loops around the end of the fish tape and firmly attach it using electrical tape.
 - **Create a hook:** Take the second fish tape and make a hook at the end of it. Test the two ends to make sure that they can easily catch on one another.
 - **Feed the tapes:** Have you and your partner stand at the two ends of the conduit, each with one of the two modified fish tapes. Begin to feed the tapes at each end. Plan it so that your tapes meet at the problem point in the conduit.
 - **Hook and pull:** When the tapes meet, spin the hooked end so that it is more likely to grab one of the loops. Once you think you have caught the other line, tug to test. When the two lines are attached, pull one end of the fish tape to pull the other all the way through the conduit.
- ∅ Once you've caught and pulled one fish tape through the entire conduit, you can continue with the normal fish tape technique for pulling wires through. It's important to note that conduit with severe turns or existing wires will require thorough lubrication to get the wires all the way through without catching.

10.6 Electric Drilling on Wall

Electric Drill Machine

- ∅ A **electric drill** is a fastening tool used to make hole to secure screws or bolts



- ∅ **Trigger** switch activates electric motor, which in turn drives a rotating chuck connected to sharp drill bit

Drill Bits

Drill bits are cutting tools used to remove material to create holes, almost always of circular cross-section.

- Metric drill bit sizes define the diameter of the bit in terms of millimeter(mm).
- British Standard BS 328 defines sizes from 0.2 mm to 25.0 mm.



Spade bit

Lip and spur (brad point) bit

Masonry bit

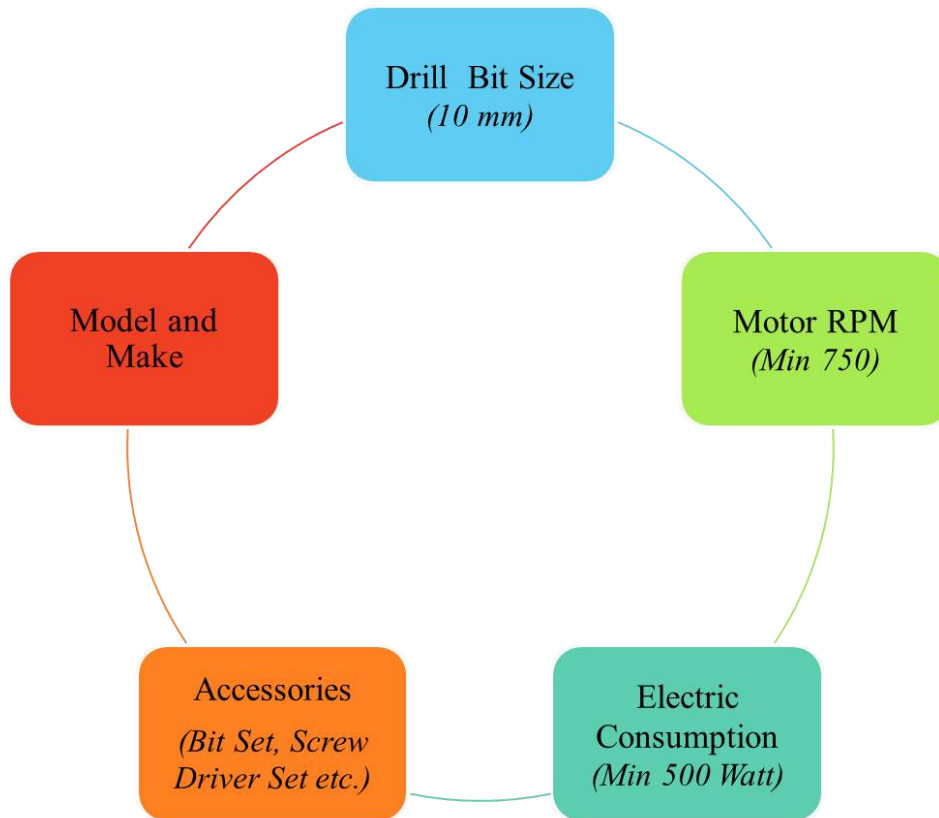
Twist drill bit

Drill Bit Sizes

Conversion Table

gauge	in	mm	gauge	in	mm	gauge	in	mm	gauge	in	mm	gauge	in	mm
104	0.0031	0.079	78	0.016	0.406	52	0.0635	1.613	26	0.147	3.734	A	0.234	5.944
103	0.0035	0.089	77	0.018	0.457	51	0.067	1.702	25	0.1495	3.797	B	0.238	6.045
102	0.0039	0.099	76	0.020	0.508	50	0.070	1.778	24	0.152	3.861	C	0.242	6.147
101	0.0043	0.109	75	0.021	0.533	49	0.073	1.854	23	0.154	3.912	D	0.246	6.248
100	0.0047	0.119	74	0.0225	0.572	48	0.076	1.930	22	0.157	3.988	E	0.250	6.350
99	0.0051	0.130	73	0.024	0.610	47	0.0785	1.994	21	0.159	4.039	F	0.257	6.528
98	0.0055	0.140	72	0.025	0.635	46	0.081	2.057	20	0.161	4.089	G	0.261	6.629
97	0.0059	0.150	71	0.026	0.660	45	0.082	2.083	19	0.166	4.216	H	0.266	6.756
96	0.0063	0.160	70	0.028	0.711	44	0.086	2.184	18	0.1695	4.305	I	0.272	6.909
95	0.0067	0.170	69	0.0292	0.742	43	0.089	2.261	17	0.173	4.394	J	0.277	7.038
94	0.0071	0.180	68	0.031	0.787	42	0.0935	2.375	16	0.177	4.496	K	0.281	7.137
93	0.0075	0.191	67	0.032	0.813	41	0.096	2.438	15	0.180	4.572	L	0.290	7.366
92	0.0079	0.201	66	0.033	0.838	40	0.098	2.489	14	0.182	4.623	M	0.295	7.493
91	0.0083	0.211	65	0.035	0.889	39	0.0995	2.527	13	0.185	4.699	N	0.302	7.671
90	0.0087	0.221	64	0.036	0.914	38	0.1015	2.578	12	0.189	4.801	O	0.316	8.026
89	0.0091	0.231	63	0.037	0.940	37	0.104	2.642	11	0.191	4.851	P	0.323	8.204
88	0.0095	0.241	62	0.038	0.965	36	0.1065	2.705	10	0.1935	4.915	Q	0.332	8.433
87	0.010	0.254	61	0.039	0.991	35	0.110	2.794	9	0.196	4.978	R	0.339	8.611
86	0.0105	0.267	60	0.040	1.016	34	0.111	2.819	8	0.199	5.055	S	0.348	8.839
85	0.011	0.279	59	0.041	1.041	33	0.113	2.870	7	0.201	5.105	T	0.358	9.093
84	0.0115	0.292	58	0.042	1.067	32	0.116	2.946	6	0.204	5.182	U	0.368	9.347
83	0.012	0.305	57	0.043	1.092	31	0.120	3.048	5	0.2055	5.220	V	0.377	9.576
82	0.0125	0.318	56	0.0465	1.181	30	0.1285	3.264	4	0.209	5.309	W	0.386	9.804
81	0.013	0.330	55	0.052	1.321	29	0.136	3.454	3	0.213	5.410	X	0.397	10.08
80	0.0135	0.343	54	0.055	1.397	28	0.1405	3.569	2	0.221	5.613	Y	0.404	10.26
79	0.0145	0.368	53	0.0595	1.511	27	0.144	3.658	1	0.228	5.791	Z	0.413	10.49

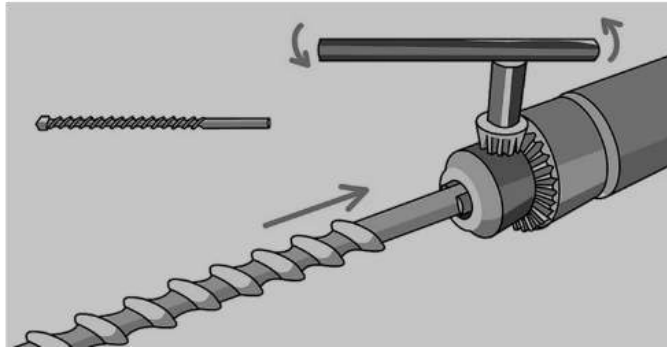
Drill Machine Selection Criterion



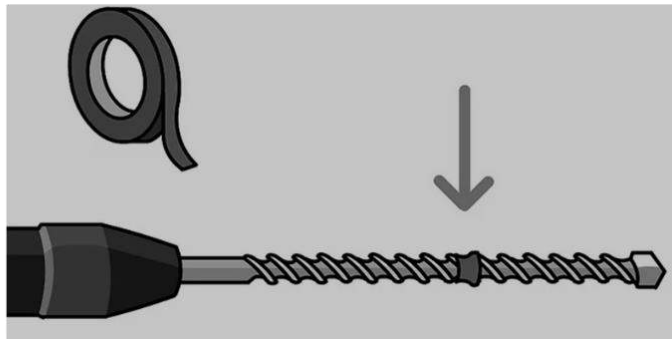
Drill Bit Selection

Type of drill bit	Material of manufacture	Special features and characteristics	Materials drilled
Concrete drill	Tungsten carbonate ; carbide	Tip 2, 3 or 4 cutting edges; Carbide tip	Concrete, reinforced concrete, cinder block, stone
Metal drill	HSS; tungsten carbonate ; titanium	Rectified or laminated drill	Non-ferrous metals
	Cobalt	Rectified or laminated drill; Affutable	Ferrous and non-ferrous metals, stainless steel etc.
	Monobloc Carbide	Rectified or laminated drill	All steel
Wood drill	Steel	Flat wick	Woodworking
		Three-point wick	
		Spiral wick	Lumber
Tile wick	Tungsten carbonate ; diamond	Conical wick	Floor tile ; Ceramic; tile
Glass wick	Tungsten carbide and diamond	Conical wick	Glass

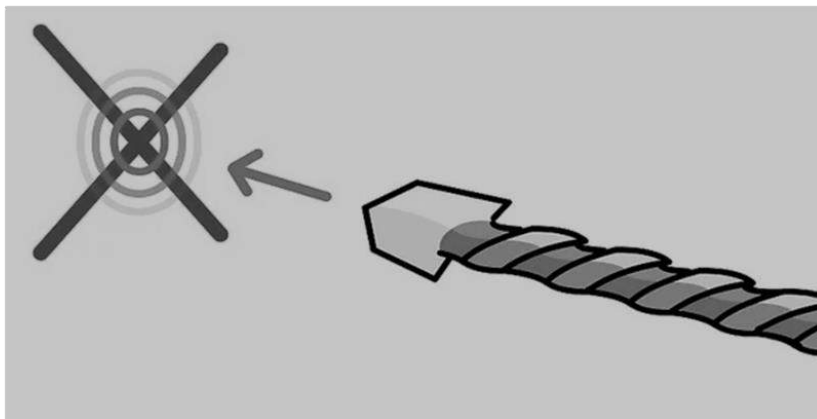
Insert a high quality masonry drill bit



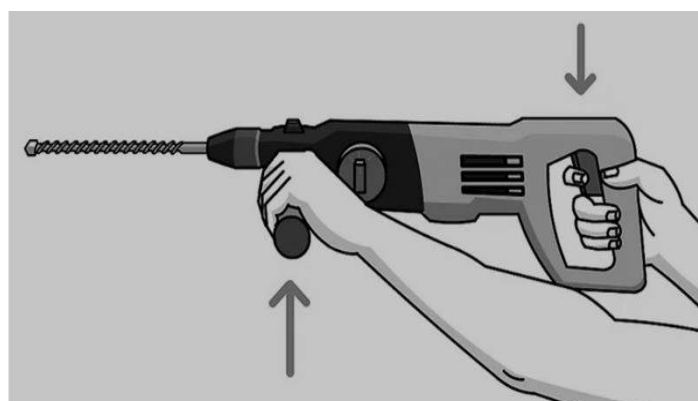
Set the depth



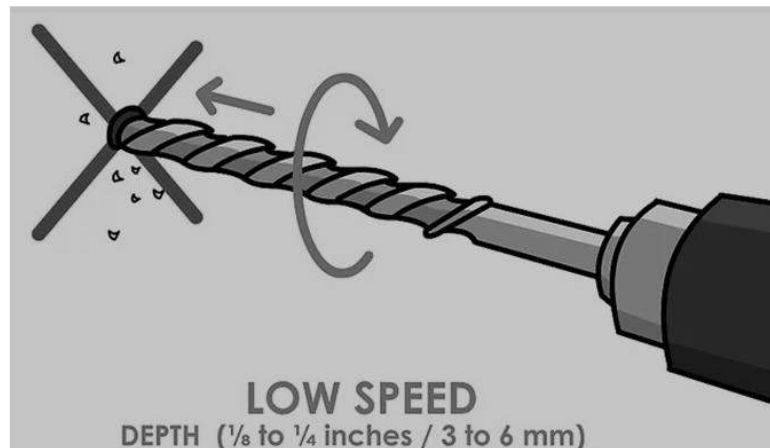
Mark the drilling spot



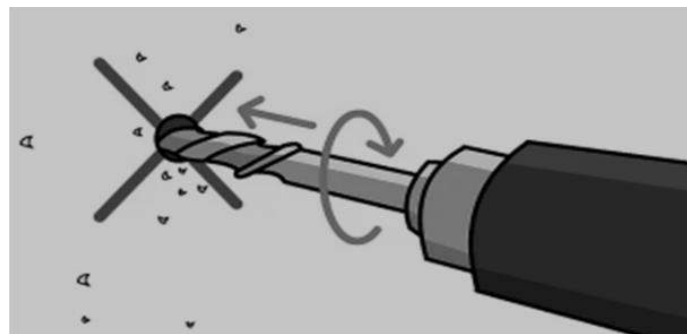
Hold the drill properly



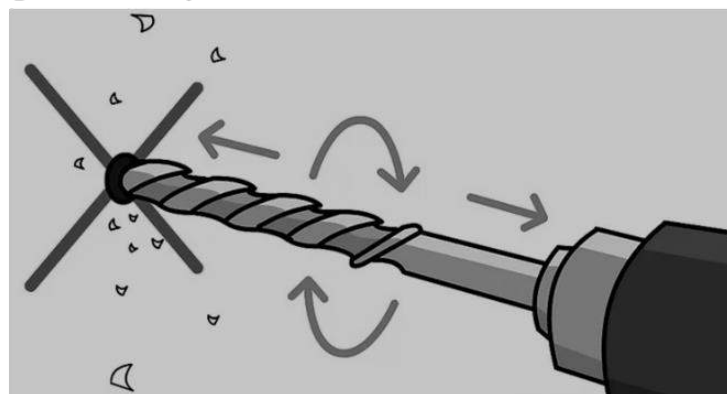
Drill a pilot hole



Continue drilling with more power



Pull the drill out periodically



Break through obstructions with a masonry nail and Blow out the dust



Drilling Safety Practices

- Ø Inspect chuck segments for wear, nicks or distortion, and ensure chuck is secure.
- Ø Inspect drill bit – ensure that segments are not overly worn or chipped, and that drill stem is clean and undamaged.
- Ø Use correct chuck key to tighten chuck – nip all positions to ensure chuck is tight.
- Ø Adopt comfortable posture when using drills – avoid bending where possible.
- Ø Always use the auxiliary handle to ensure maximum control over torque reaction or kick back.
- Ø Always ensure that the tool is properly aligned with the spot to be drilled.
- Ø Use leg or load support when using large drill to drill into walls, etc.
- Ø Keep floor area clear of leads or hoses, and do not allow dust to accumulate.
- Ø Provide sound working platform with fall prevention when working above ground.
- Ø Suitable protective equipment must be worn when drilling stone, brick or concrete. Wear eye protection, dust mask, and hearing protection.
- Ø Keep hands clear of rotating drill bit.
- Ø Check for cables, conduits or pipes in or behind walls, etc, before drilling.



- Ø Always hold this tool by its insulated gripping surfaces.
- Ø Always use protective gloves to remove a bit from the tool.
- Ø Store tools in case provided or in clean secure area protected from weather.
- Ø Store drill bits in a manner which will prevent damage to cutting segments.

10.7 Calculation of Load on Cable Tray

Cable Tray

- Ø Cable trays are a mechanical support system that can support cables used for power distribution, control, and communication.
- Ø They are the perfect solution for running large quantities of power or data cables overhead or under-floor.



Load on a Cable Tray

- ∅ The standard classes of cable trays are manufactured with maximum design loads.
- ∅ Costs vary between different load classes.

Cable Load:

- ∅ The cable load is the total weight, expressed in (kg/m), of all the cables that will be placed in the cable tray.

Tray Size:

The width or height of a cable tray is a function of the number, size, spacing and weight of the cables in the tray. Available nominal widths are 6, 9, 12, 18, 24, 30, 36 and 42 inches.

When specifying width, it is important to remember that the load rating does not change as the width increases. Even with six times the volume, a 36 in. wide tray cannot hold any more weight than a 6 in. wide tray. If the load rating of the tray permits, cable can be piled deeper in the tray

LOAD kg/m
37
67
74
97
112
149
179
299

Cable Tray Parameters

- ∅ The sum of the cross-sectional areas of all cables cannot exceed 50% of the trays fill area.
- ∅ The cable tray sizing equals the width times the loading depth.
- ∅ Total weight per meter of all cables laying in tray should not exceed recommended cable loading specifications.
- ∅ Space between cables must be equal to 2.15 times one cable diameter.

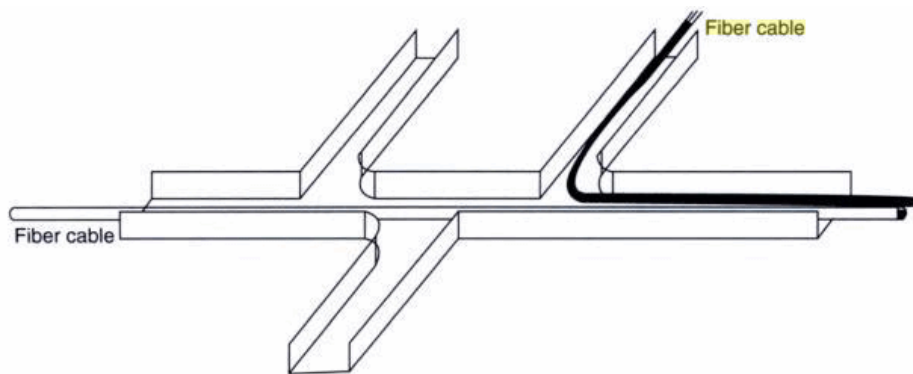
Total Outer Diameter of all Cable Passing in to Cable Tray = Sum of Diameter of All Cables laying in Tray

Total Weight of Cables Passing in to Cable Tray = Sum of Weight of All Cables laying in Tray

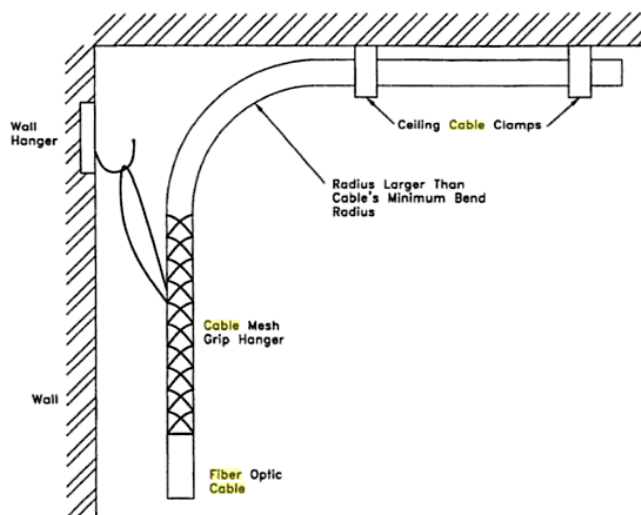
Total Width of all Cables = (Total No of Cable X Distance between Each Cable) + Total Cable Outer Diameter

Cable Laying on Cable Tray

- Ø Indoor fiber cables should be placed in conduits or trays.
- Ø Most fiber cables are non-conductive so they can be placed alongside high voltage cables without any special insulation.
- Ø Properly fiber rated fiber cables can use the same cable tray or raceway with conductors for electric light, power or Class 1 circuits 600V or less.
- Ø The main concern for planning indoor fiber cable routes is to avoid any cutting edges and sharp bends. This includes corners and exit slots of trays.
- Ø When fiber cables are placed in the same tray or duct as large and heavy electrical cable, you must take care to avoid placing excessive weight on the fiber cables.
- Ø All bends must have smooth curves.
 - Ø When a fiber cable is pulled into a conduit or cable tray, the conduit's bending radius must be larger than the cable's minimum bending radius for loaded conditions.



- Ø Cables in ducts and trays are not subjected to tensile forces.
- Ø But for vertical runs, this must be carefully designed to minimize the tensile force applied to the vertical run fiber cables.
- Ø Long vertical runs must be clamped at intermediate points to prevent excessive tensile loading on the fiber cable.
- Ø The clamping force should be applied over as long a length of the fiber optic cable as practical.
- Ø If frequent clamping is not possible, cable hangers can be used at the top of the vertical rises and at intermediate locations along the vertical rises.
- Ø A popular choice for this situation is the mesh grip or split mesh grip hanger as shown below.



Use of Cable Ties on Cable Tray

Ø Cables are tied down in cable trays using cable ties:

- To keep the cables in the cable tray:
- To maintain spacing between cables
- To segregate or confine certain types of cables to specific locations



10.8 Installation and Cabling of ONT

Placing the Device

- Ø Do not install the ONT outdoors or in an outdoor cabinet.
- Ø The ONT can be mounted onto a wall or placed on a desk. Do not install the ONT in other modes, such as ceiling.
- Ø Keep 10 cm clearance on all sides to ensure adequate ventilation.
- Ø It is recommended that the computer and ONT be put far away from electric appliances that generate strong magnetic or electric fields, such as microwave ovens.

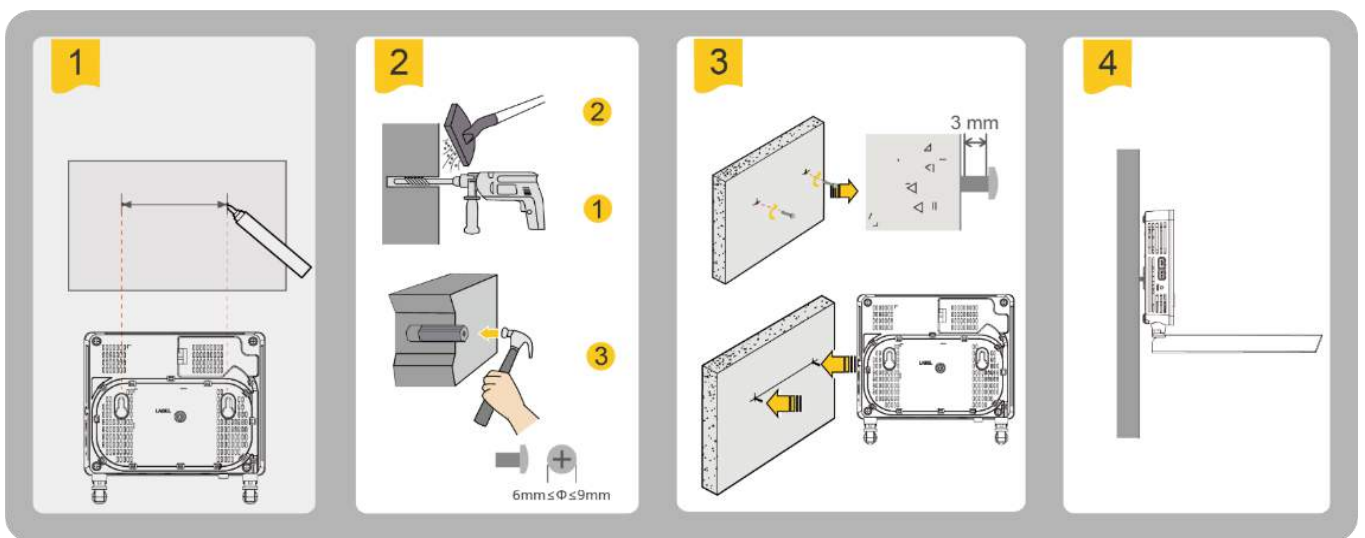
Mounting an ONT on the desk

The figure below shows an ONT that is horizontally placed on a desk:

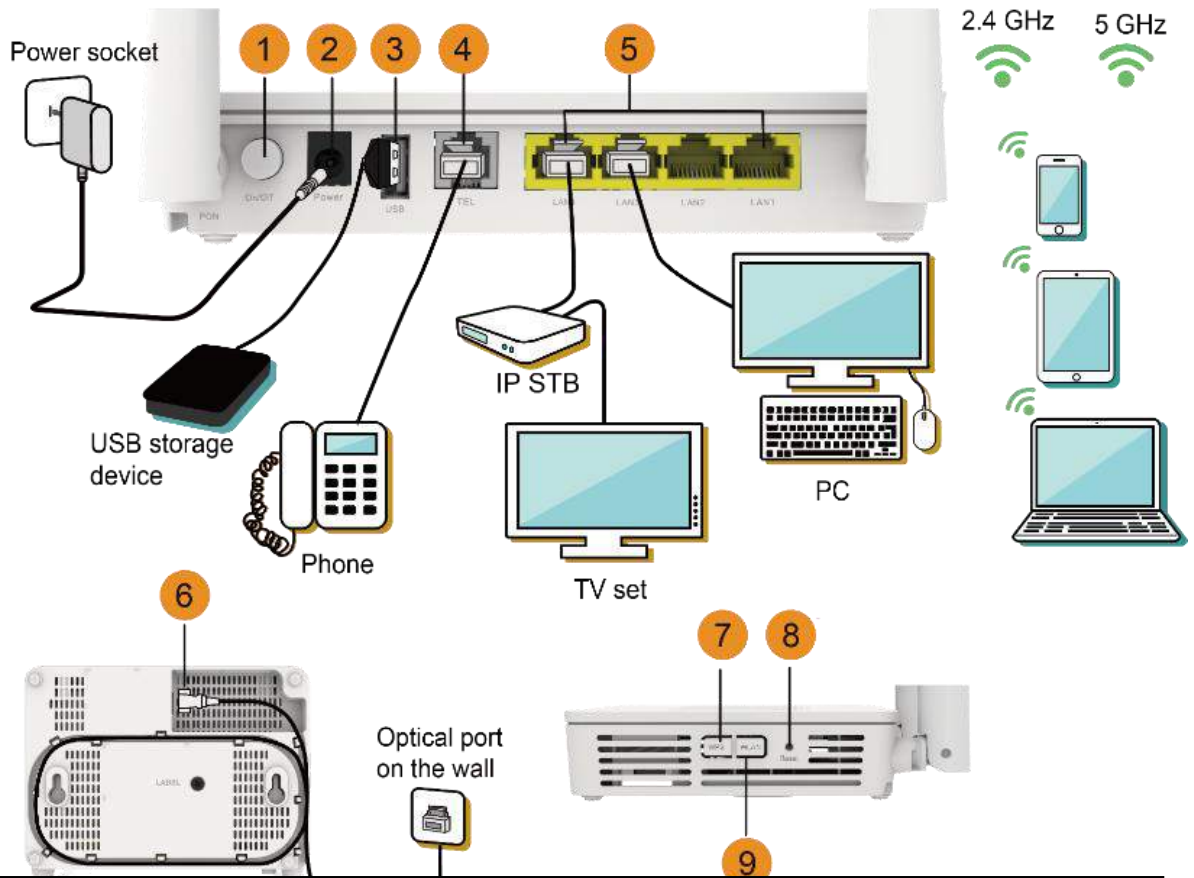


Mounting an ONT on the wall

- Ø Mark two positions with the same spacing as that between the two mounting holes of the ONT using a marker on a wall.
- Ø Select a proper drill bit according to the outer diameter of the screws. Use a hammer drill to drill the marked positions on the wall. Then clean the holes and install two expansion bolts.
- Ø Use a screwdriver to fasten the screws into the expansion bolts, reserving 3 mm ends out of the wall, and mount the ONT onto the screws.
- Ø It is recommended that the screw be about 4 mm in diameter and longer than 20 mm



Ports and Cabling



No.	Item	Description
1	On/Off	Powers the ONT on or off.
2	Power	Connects to a power adapter.
3	USB	Connects to USB storage devices.
4	TEL	Connects to the ports on a telephone or fax machine.
5	LAN1-LAN4	Connects to PCs or IP set-top boxes (STBs).
6	Optical port	The optical port is equipped with a rubber plug and connected to a fiber for upstream transmission. The type of the optical connector connected to the optical port can be SC/APC.
7	WPS	When the WLAN is on, press the WPS button (> 3s) and release the button to start Wi-Fi protected setup (WPS) negotiation.
8	Reset	Press the button for a short time to reset the device, or press the button for a long time (longer than 10s) to restore the device to the default settings and reset the device. NOTE: Reset Huawei ONTs with caution. Otherwise, the ONTs may fail to access the Internet. If an ONT cannot access the Internet after a reset, contact your Internet service provider.
9	WLAN	Used to enable or disable the WLAN function •When the WLAN is disabled, press the WLAN button (> 3s) and release the button to enable the WLAN. •When the WLAN is enabled, press the WLAN button (> 3s) and release the button to disable the WLAN.

2.4 Ghz vs 5 Ghz Wifi Connection

2.4 GHz

- Ø The 2.4 GHz frequency of the wifi router offers the wifi user a wide coverage area and is better at penetrating solid objects with a usable speed of 50 -70 Mbps (subject to real world scenarios).
- Ø On the other hand, it has a lower data range and is highly prone to interference and disturbance.

5 GHz

- Ø The 5 GHz frequency facilitates the customer with a higher data range with negligible interference and offers a great deal when it comes to the internet speeds for wifi for home.
- Ø Contrary to this benefit, it has a narrow coverage area and is not a successful band when it comes to penetrating solid objects.



10.9 In-building Cabling Cautions

- Ø Never directly pull on the fiber itself.
- Ø Never exceed the maximum pulling load rating.
- Ø Never exceed the cable bend radius.
- Ø Always roll the cable off the spool instead of spinning it off the spool end.
- Ø Make sure your fiber cable is long enough for the run.
- Ø Indoor cables can be installed directly, but you might consider putting them inside innerduct.
- Ø Pull, do not push cables.
- Ø Monitor the supply reel to prevent violation of minimum bend radius.
- Ø Communicate along the path of installation.

Section 3: Exercises

Exercise 1: Participate in group discussion on following topics:

- Cable laying plan for multi-dwelling units
- Cable laying plan for single-dwelling units
- In-building ducting and conduiting process
- 2.4 GHz vs 5 GHz Wifi Connection

Exercise 2: Enlist types of cable pulling methods.

Exercise 3: Make a list of drill machine selection criteria.

Exercise 4: Write formulae for calculation of:

- Total Outer Diameter of all Cable Passing in to Cable Tray
- Total Weight of Cables Passing in to Cable Tray
- Total Width of all Cables

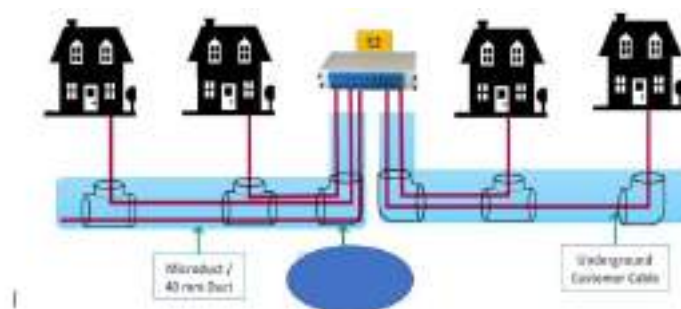
Exercise 5: Make a diagram of ports and cabling of ONT.

Exercise 6: Write the functions of following in an ONT.

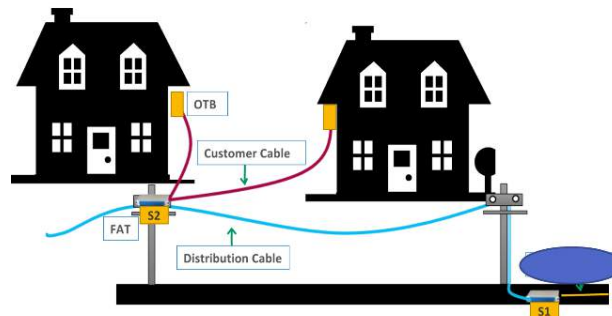
- On/Off
- Power
- USB
- TEL
- LAN1-LAN4
- Optical port
- WPS
- Reset
- WLAN

Section 4: Assessment Questionnaire

- What are the two methods by which OFC can enter a building?
- Which type of OFC can be used in Aerial Lead-in method?
- Which equipment is used to terminate incoming distribution cable?
- The face of the building or exterior wall of building is called:
- What minimum vehicle clearance height is maintained when OFC is required to cross a road between buildings?
- How many floors are there in Single Dwelling Units?
- Which type of duct are used for wall clamping?
- Identify the marked item in below image:



9. _____ are used to extend the sub-distribution between FAT and ONT.
10. Identify the hidden cable in below picture.



11. What are the basic steps for In-building Ducting and Conduiting Process?
12. What is standard length of conduit pipe?
13. Name the two positions in which conduit pipes can be installed.
14. We should always prefer electrical shafts of building for cable laying. True/False?
15. Name some accessories used in In-building Ducting and Conduiting Process.
16. What are some features of Fiber Blowing Tool?
17. What are some methods used for cable pulling process?
18. _____ is the simplest technique for pulling wire through conduit.
19. What is the first step in string method for cable pulling process.
20. The mouse method uses a tool called a _____ or _____ instead of a rod.
21. The _____ uses a heavy fishing weight to guide wiring directly through a conduit.
22. Fish Tape is a long, thin and flat metal wire wound inside a spool with a _____ at the end.
23. Fish tape is available in a range of lengths from _____ to _____.
24. What is the first step to be done in fish tape method?
25. Which cable pulling method is used, if we encounter conduit with 90 degree turns?
26. What are 4 basic steps to be carried out in Joint fish Tape method?
27. A _____ is a fastening tool used to make hole to secure screws or bolts.
28. _____ activates electric motor, which in turn drives a rotating chuck connected to sharp drill bit.
29. Name some types of bits used for electric drilling.
30. British Standard BS 328 defines bit sizes from _____ to _____.
31. What are selection criteria for Drill Machine?
32. _____ are a mechanical support system that can support cables used for power distribution, control, and communication.
33. What is unit of cable load?
34. Available nominal widths of cable trays are _____
35. The sum of the cross-sectional areas of all cables cannot exceed _____ of the trays fill area.
36. Space between cables must be equal to _____ times one cable diameter.
37. What is the main concern for planning indoor fiber cable routes?
38. What is the use of cable ties in cable tray?

-----End of the Module-----

MODULE 11

OPTICAL LINK TESTING PROCEDURES

Section 1: Learning Outcomes

After completing this module, you will be able to:

- Differentiate between various types of optical link testing equipment
- Calculate optical link budget for long distance links and FTTx Links
- Explain functions and working principle of OTDR
- Configure the OTDR for link testing
- Read and understand the information on OTDR trace and test results
- Describe OTDR performance parameters
- State OTDR undesirable properties
- Perform bi-directional analysis using OTDR
- Perform Light Source-Power Meter (LSPM) test
- Perform fiber test using Visual Fault Locator (VFL)
- Use fiber detection meter
- Distinguish between various optical attenuators
- Test the OFC Drum
- Housekeep the OTDR

Section 2: Relevant Knowledge

11.1 Link Testing Equipment

Link Test shall be carried out on OFC section terminated at both ends.

S. No.	Test Instrument	Test Parameter
1	Optical Time Domain Reflectometer (OTDR)	<ul style="list-style-type: none"> ▪ Continuity ▪ Length ▪ Location Identification ▪ Fiber Faults ▪ Splice Loss ▪ Overall Loss
2	Optical Power Loss measuring Equipment (Light source & Power meter)	<ul style="list-style-type: none"> ▪ Continuity ▪ Overall Loss ▪ Fiber Identification (Swap)
3	Visual Fault Locator (VFL)	<ul style="list-style-type: none"> ▪ Continuity ▪ Fiber Identification (Swap)

Fiber Swap takes place when two fibers of different numbers are spliced or connected

11.2 Optical Link Budget Calculation for Long Distance Links

Insertion Loss

- ∅ Insertion loss is the amount of light that a signal loses as it travels along a fiber cable link.
- ∅ Insertion loss is measured in decibels (dB)
- ∅ It can be called as attenuation as well.
- ∅ Each component in a fiber link has its own insertion loss. Typical insertion loss of few components of fiber link is tabulated below:

Fiber Link Component	Typical Insertion Loss
G. 652D Fiber at 1310 / 1550 / 1625 nm	0.36 / 0.22 / 0.25 dB
Optical Connector	0.5 dB
Fusion Splice	0.1 dB

dBm

- ∅ The units dB and dBm stand for decibel and decibel milliwatt, respectively.
- ∅ dBm is a unit of power used to indicate an Output power, Input power and Receiver Sensitivity in optical systems.
- ∅ Power injected or power received in the fiber optic cables is expressed in dBm.
- ∅ It is the power level with reference to one milliwatt (mW).

$$x = 10 \log_{10} \frac{P}{1mW}$$

- ∅ A measurement of 0 dBm using an optical power meter indicates 1 milliWatt of power.
- ∅ It is used in radio, microwave and fiber-optical communication networks as a convenient measure of absolute power because of its capability to express both very large and very small values in a short form.

Optical Link Budget Calculation

- ∅ The optical link budget is the amount of loss that a cable link should have if it is installed properly.
- ∅ It is just a theoretical calculation and may differ from actual link loss given by testing instruments.
- ∅ It is calculated by adding the estimated average losses of all the components used in the cable link to get the estimated total loss of the link.

$$\begin{aligned}
 &\textbf{Link Loss} \\
 &= \\
 &\textbf{[Fiber Length (km) X Fiber Attenuation per km]} \\
 &+ \\
 &\textbf{[Splice Loss X no. of OFC Joints]} \\
 &+ \\
 &\textbf{[Connector Loss X no. of Connectors]}
 \end{aligned}$$

1	Standard for connector loss	0.5 dB
2	Typical cable attenuation at 1310 nm	0.36 dB/km
3	Typical cable attenuation at 1550 nm	0.22 dB/km
4	Typical cable attenuation at 1625 nm	0.25 dB/km
5	Typical splice attenuation	0.1 dB/km
6	Typical safety margin	3 dB

Theoretical link loss is calculated using following formula:

$$\begin{aligned}
 &\textbf{Value in dB at 1310 or 1550 or 1625nm} \\
 &= \\
 &\textbf{No. of connector pairs X 0.5} \\
 &+ \\
 &\textbf{No. of splices X 0.1} \\
 &+ \\
 &\textbf{Distance in Km X 0.36 or 0.22 or 0.25}
 \end{aligned}$$

Example 1:

Assume a 10 km single mode fiber link at 1310nm with 2 connector pairs and 4 splices.

$$\begin{aligned} \text{Link Budget} &= [10\text{km} \times 0.36\text{dB/km}] \\ &+ \\ &[0.5\text{dB} \times 2] \\ &+ \\ &[0.1\text{dB} \times 4] \\ &= \\ &5 \text{ dB} \end{aligned}$$

Example 2:

Assume a 60 km single mode fiber link at 1550nm with cable drum length of 4 Kms installed in the link.

$$\begin{aligned} \text{Link Budget} &= [60\text{km} \times 0.22\text{dB/km}] \dots \text{loss at 1550nm is } 0.22\text{dB/km} \\ &+ \\ &[0.5\text{dB} \times 2] \dots \dots \dots 2 \text{ connectors at each end} \\ &+ \\ &[0.1\text{dB} \times 16] \dots \dots \dots 16 \text{ splices (15 drums + 1 splice behind FMS)} \\ &= \\ &15.8 \text{ dB} \end{aligned}$$

11.3 Optical Link Budget Calculation for FTTx Links

- Ø Conventional PON based FTTH the minimum transmitter power and minimum receiver sensitivity is set as 0 and -34 dBm.
- Ø 34dBm power value or power budget is generally considered for the design architecture.
- Ø Dynamic range also consider 31dBm with margin of 3dBm but you should remember that total allowed optical budget from the OLT to the ONT is 28dB.
- Ø All FTTH design losses from OLT to ONT cannot be bigger than 26.5db (5% margin).

Average Losses to Calculate Link Budget		
dB Loss	Type	Location
3.5	Splitter 1:2	Exchange
0.35	ODF Connector (each)	
0.1	Splice Loss/splice	OSP
0.4	Cable Loss/ km	
17.5	Splitter 1:32	Cab/Bldg
0.35	ODF Connector Loss	
0.4	Drop cable loss per KM	Sub Premises
0.35	Fast Connector Loss	

∅ Because of these losses, the maximum average distance that this FTTH-GPON network can reach is about 15 Km with 1:64 splitting ratio (20 km with 1:32).

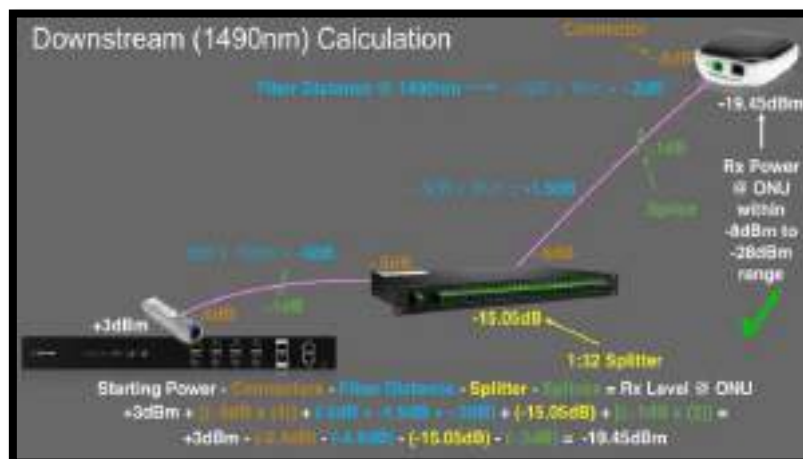
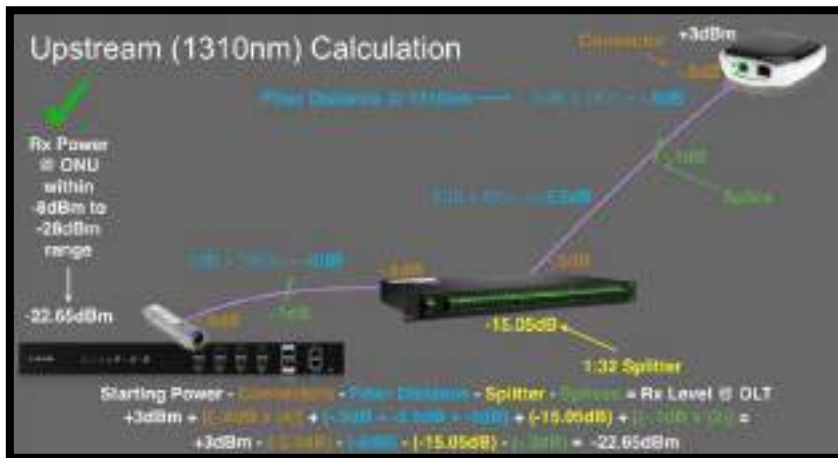
∅ The actual maximum distance depends on the brand and type of FTTH equipment used.

Budget loss calculation = (Fiber cable + Connectors + Splices + Splitter) Losses

Where:

- Fiber attenuation = 0.4 dB/Km for (1310 – 1490) nm; and 0.25 dB/Km for 1550 nm.
- Connector Loss = 0.35 dB SC/UPC & = 0.25 dB for SC/APC connectors
- Fusion Splice Loss = 0.1 dB
- Splitter losses = 4 – 20.1 dB, depending on ratio; should be provided by the vendor.

Optical Component	dB	Quantity	Result (dB)
Splitters:			
Splitter 1 x 64	20.1		0
Splitter 1 x 32	17.4	1	17.4
Splitter 1 x 16	13.8		0
Splitter 1 x 8	10.5		0
Splices:			
Access splices	0.1	2	0.2
Mating splices	0.1	5	0.5
Maintenance splices	0.1	2	0.2
Fiber:			
1285 – 1330 nm in dB/km	0.4	20	8
1480 – 1575 nm in dB/km	0.2	0	0
Aging margin	0.7	1	0.7
Other Losses:			
Measurement Error	0.4	1	0.4
Connectors	0.35	2	0.7
WDM (for RF-video only)	1.3	0	0
			28.1



11.4 Introduction to OTDR (Optical Time Domain Reflectometer)

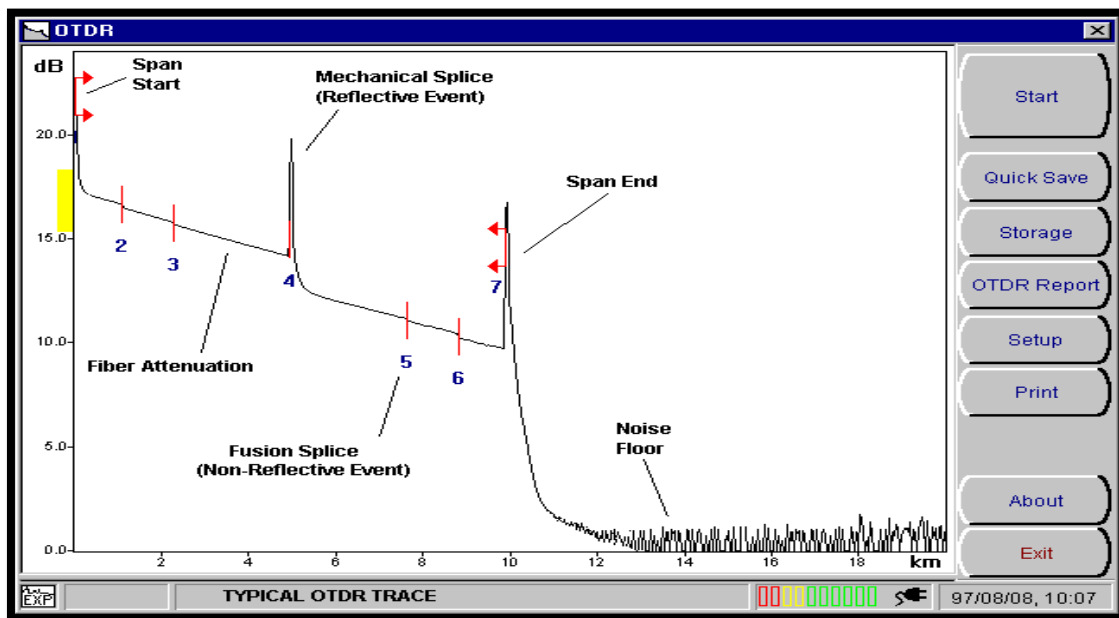
The Optical Time Domain Reflectometer (OTDR) is a test equipment used for measuring fiber length, attenuation in optical fiber cable (OFC) and event loss (reflective and non-reflective).

- Ø Generates a baseline trace: A “visual” of the link.
- Ø Can identify and evaluate specific events in the link.
- Ø Cable acceptance tool
- Ø Fault localization tool
- Ø Excellent documentation



Purpose of using OTDR

- Ø To have a visual representation of the fiber link (Loss vs Distance Graph).
- Ø To detect and locate the cut in fiber, attenuation, splice, connector and bending loss in the fiber link.
- Ø To perform optical network testing and troubleshooting.



Functions of OTDR

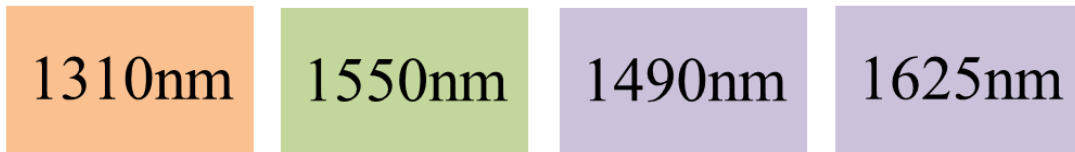
A typical OTDR can locate and determine optical fiber's:

- Ø Attenuation characteristics along length of fiber
- Ø Splice Loss
- Ø Connector Loss
- Ø Bending Loss
- Ø Section Loss
- Ø Total Loss in the fiber
- Ø Fiber Cut Distance



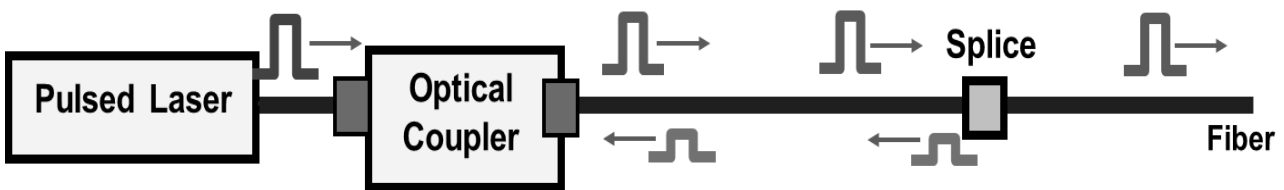
OTDR Wavelengths

OTDRs commonly operate at following spectral bands.



- Ø 1310, 1550, and 1625 nm is required for DWDM testing.
- Ø The wavelength 1490 nm is used for FTTx network.
- Ø 1625nm wavelength gives better display of the fiber bends in the link and used for testing purpose only, not communications.

Working Principle of OTDR



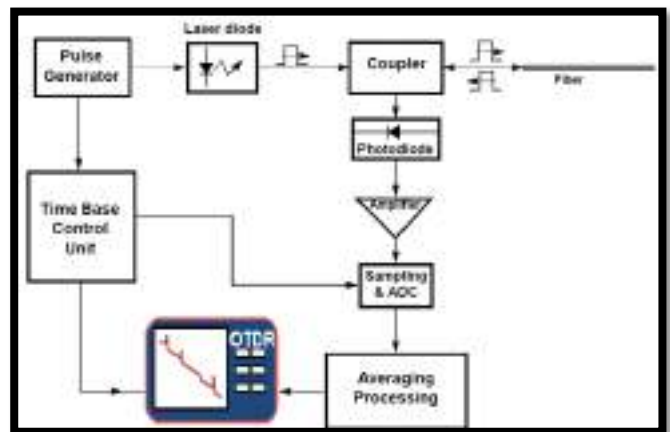
- Ø An OTDR sends light pulses into the fiber.
- Ø The light pulses reflect back to OTDR due to discontinuities such as:
 - Change in Refractive Index of fiber
 - Change in Medium (Connector, Mechanical Splice)
 - Events like splices, bends and fiber cut
- Ø OTDR then calculates the travel time and power of reflected pulses to determine event distance using following formula.

$$\text{Fault Distance} = \text{Speed of Light in Optical Fiber} \times \frac{\text{Travel Time of Reflected Pulse}}{2}$$

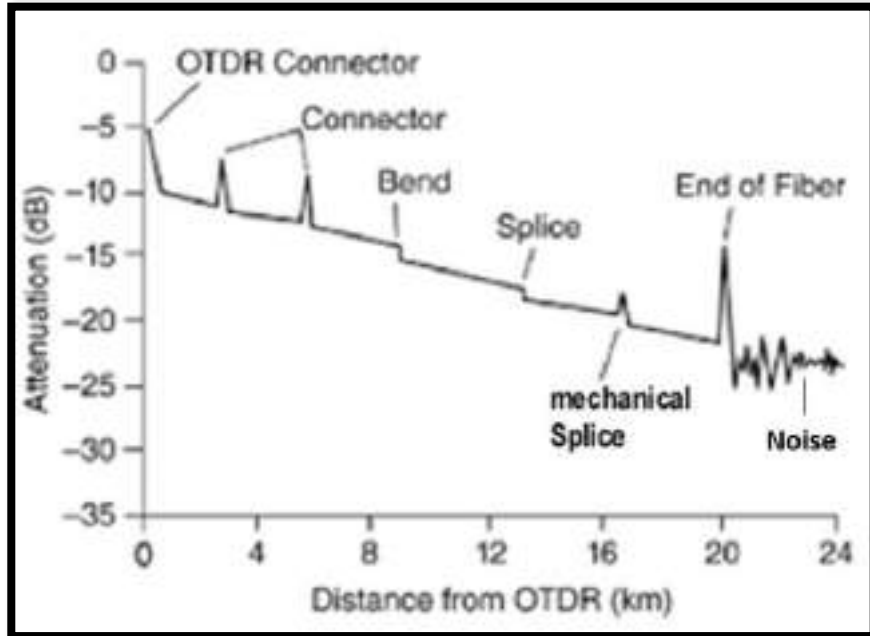
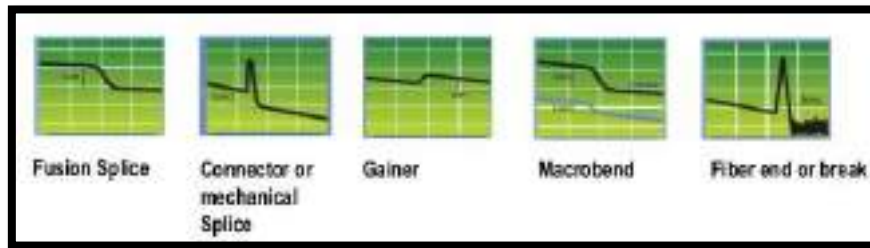
Speed of Light in Optical Fiber (approx.) = 2×10^5 Km/Sec

Inside the OTDR

- Ø The laser diode injects the light pulses of selected pulse width into the fiber.
- Ø The returning light pulses due to discontinuities in fiber is fed to the photodiode by the coupler to convert optical signal into electrical signal.
- Ø The electrical signal is then amplified and sampled.
- Ø OTDR processes the resulting data to display trace on the screen.



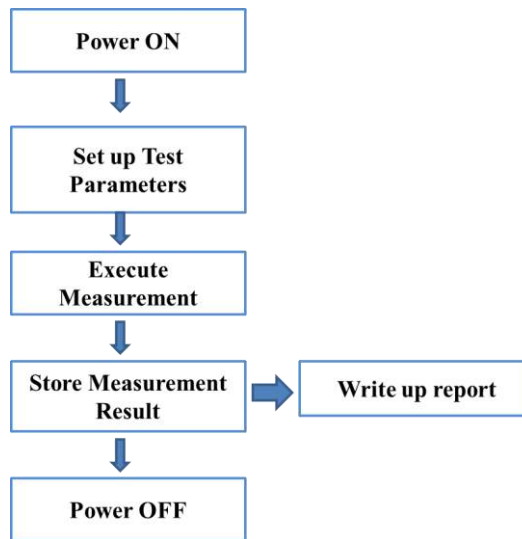
Information on OTDR Display



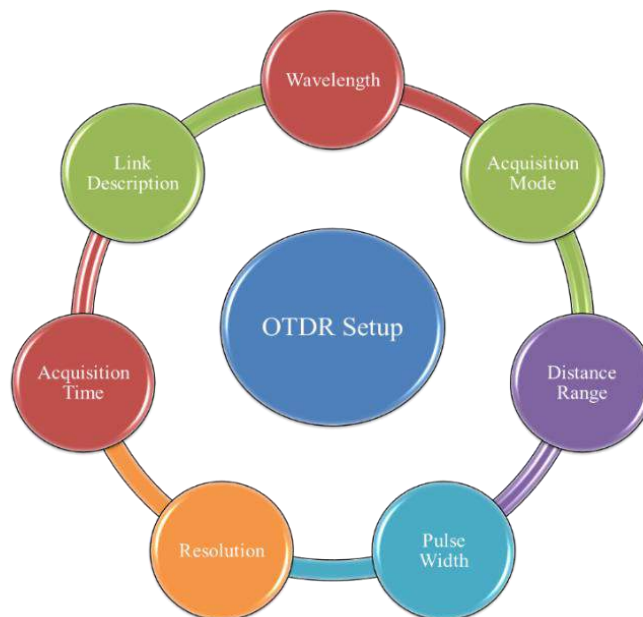
OTDR Trace with Summary



11.5 OTDR Test Parameters Configuration OTDR Measurement Flow Chart



OTDR Test Parameters Configuration



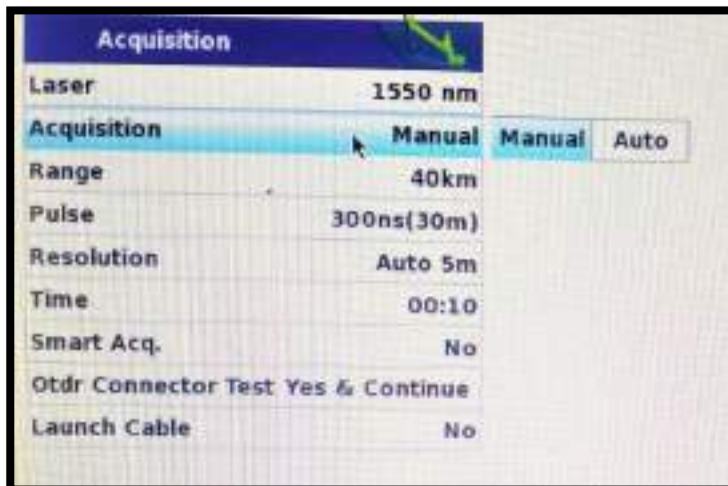
Wavelength Settings

- Ø The desired test wavelength should be selected in OTDR.
- Ø Higher wavelengths are more sensitive to bends.
- Ø Fiber bend is identified by testing the fiber on two wavelengths.



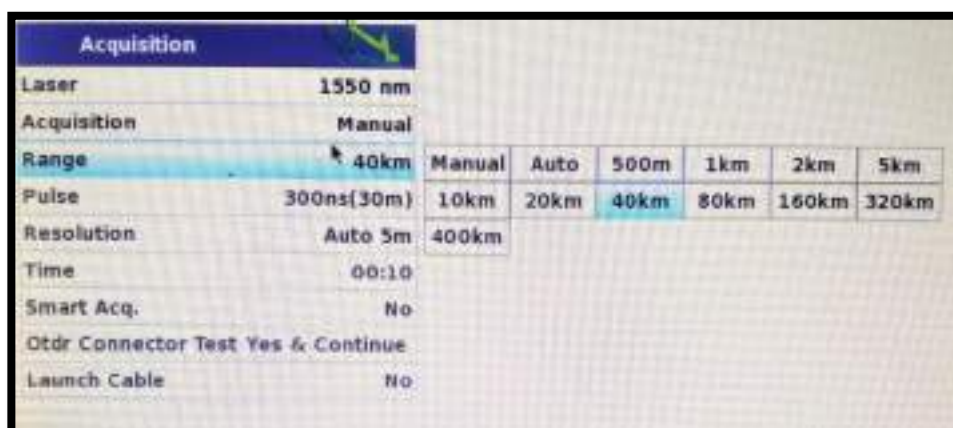
Acquisition Mode

- Ø 'Manual' Mode - OTDR setup can be done manually.
- Ø 'Auto' Mode - OTDR automatically sets the test parameters



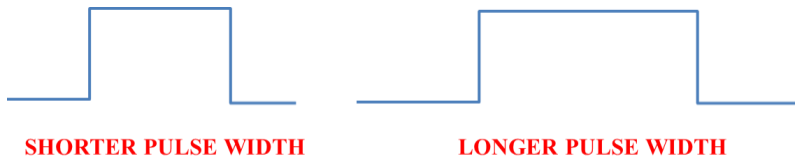
Distance Range

- Ø 'Manual' - Fiber length can be entered manually.
- Ø 'Auto' - OTDR automatically sets the fiber length and corresponding pulse width.
- Ø User may select other available distances, if fiber length is known.



Pulse Width

Pulse Width is the time duration of Pulse that is launched into the fiber. In OTDR, it is mentioned in microseconds and nanoseconds.

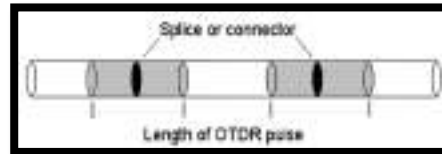
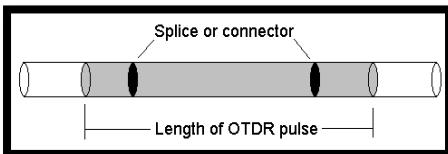


Pulse Width	Energy	Distance Range
Shorter	Low	Shorter
Longer	High	Longer

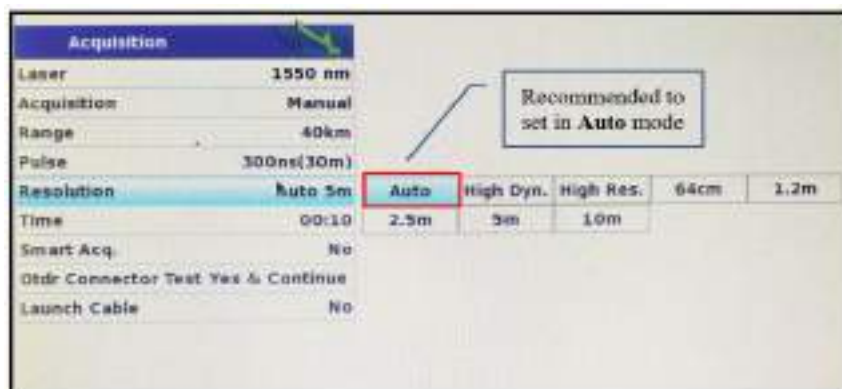


Resolution

Resolution is the ability of OTDR to distinguish between two events in the fiber.



Pulse Width	Resolution	Outcome
Shorter	High	Closer events may appear as separate events
Longer	Low	Closer events may appear as single event



Acquisition Time

Acquisition time is the time taken by OTDR to calculate the results and show trace on the screen.

Acquisition Time	Link Length	Noise
Less	Short	High
High	Long	Low



Acquisition Time	Link Length	Noise
Less	Short	High
High	Long	Low

To enter the Acquisition Time manually

Link Description

Link parameters can be saved in OTDR to track the trace in future and fill the link information in export file.



11.6 OTDR Performance Parameters

Dynamic Range

- Ø Dynamic Range is the parameter that signifies the maximum optical loss an OTDR can measure in a fiber link.
- Ø Typical Dynamic Range of OTDR is 20 to 45 dB.
- Ø Bigger the dynamic range (in dB), the longer the distance reached.
- Ø Larger pulse width provides larger Dynamic Range.

Accuracy

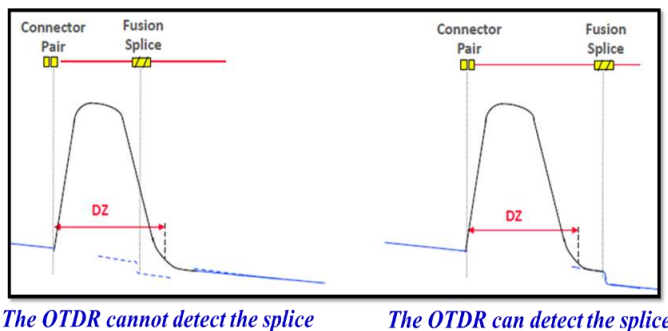
- Ø Accuracy of OTDR represents the correctness of the measured value with respect to the true value of Loss and Distance measurements.
- Ø The Distance Accuracy depends on:
 - Fiber Refractive Index setting in OTDR
 - OTDR Calibration

Index Of Refraction	
Preset Index	G652 G657
1310 SM	1.46750
1360-1520 SM	1.46800
1550 SM	1.46800
1590-1650 SM	1.46850
Section AB	25391.5
Link Length	12610.0

Dead Zone

When there is a strong reflection, the power received by the OTDR can saturate the photodiode. In such times, it will not detect the backscattered signal accurately. The length of fiber, within which, fiber is not able to detect any event and losses is termed as Dead Zone.

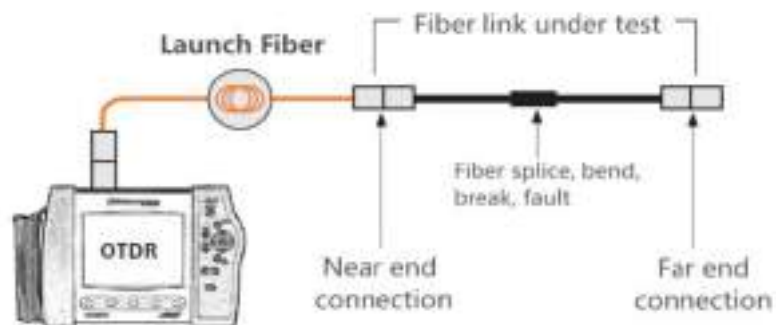
$$\text{Dead Zone} = \text{Pulse Width} + \text{Receiver Recovery Time}$$



Countering the effect of Dead Zone

Dead Zones can be reduced by:

- Ø Configuring Lower Pulse Width
- Ø Inserting a Launch Cable of known fiber length between the OTDR and the link under test



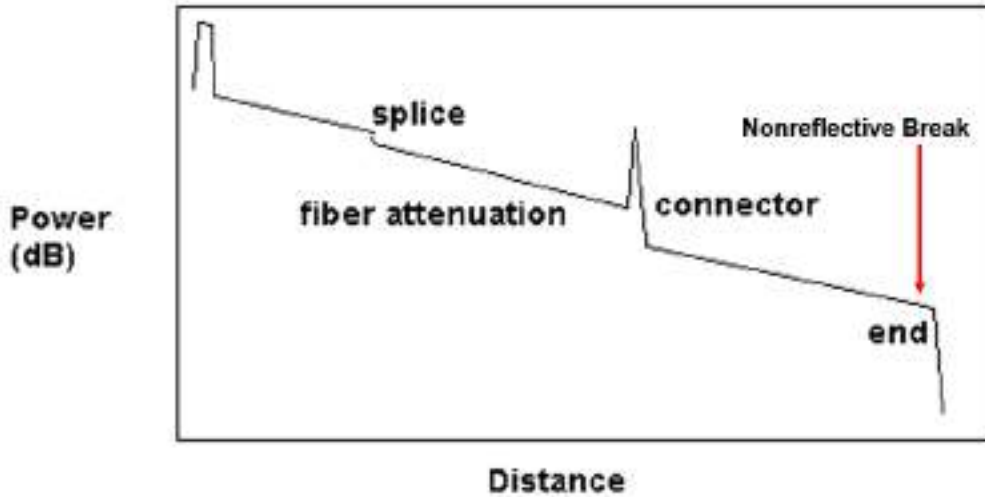
Spool length must be longer than the pulse width setting used for the OTDR test

11.7 OTDR Undesirable Properties

Non-reflective Break

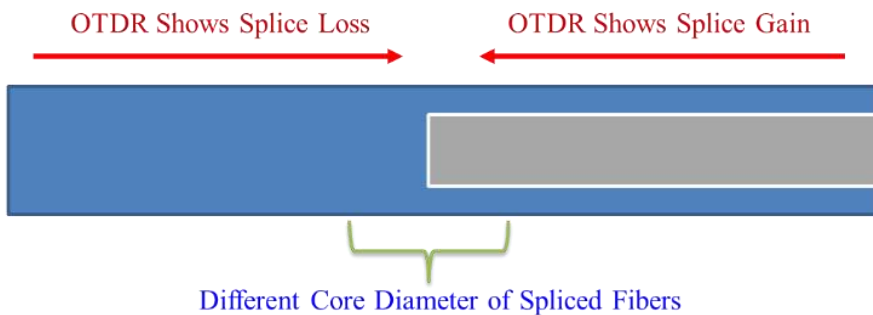
This occurs when:

- ∅ Fiber is cut and fiber end is bent excessively
- ∅ Fiber is cut and immersed in liquid

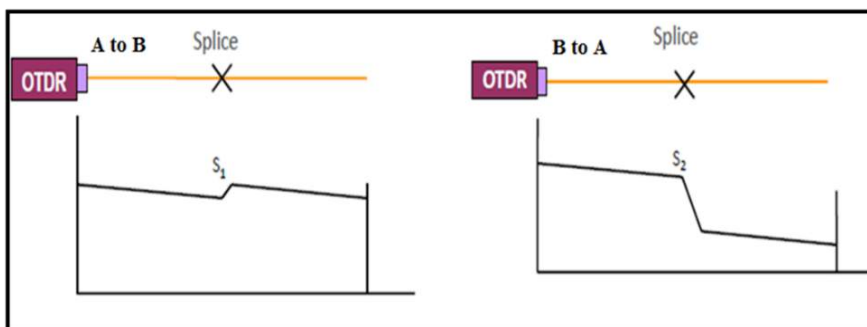


OTDR Undesirable Properties Gainer

- ∅ When two fibres with different core diameter are spliced and measured with OTDR, splice shows gain from one direction and loss from opposite direction.



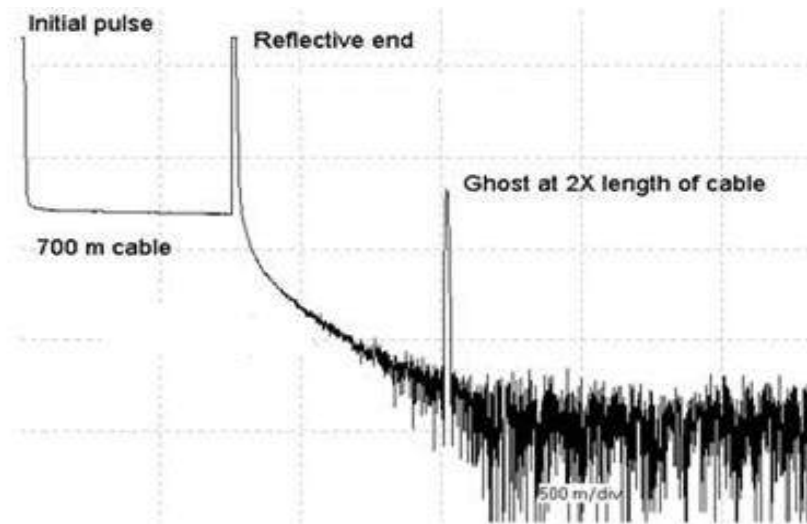
- ∅ This loss measurement error is overcome by taking Bidirectional OTDR Measurements and calculate Average of the Splice Losses recorded from both the directions.



$$\frac{S_1 + S_2}{2}$$

Ghost

- Ø Ghosts are repetitions of a trace or portion of a trace.
- Ø The most common cause of 'ghosts' is an 'echo' of light reflected back and forth multiple times.
- Ø Correct Distance Range needs to be selected to avoid Ghost in the OTDR trace.



OTDR Type 1 and Mini Type B

Parameters	OTDR Type 1	Mini OTDR
Wavelength (nm)	Triple (1310, 1550, 1625)	Double (1310 & 1550nm)
Dynamic Range	45 dB	34 dB
Touch Screen Size	7 Inches	5 Inches
Internal Memory	2 GB	1 GB



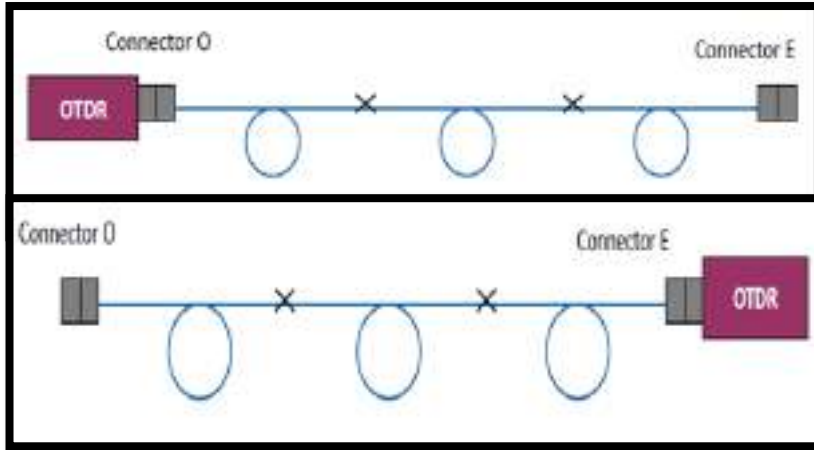
OTDR Type 1



Mini OTDR

11.8 Bi-directional Analysis using OTDR

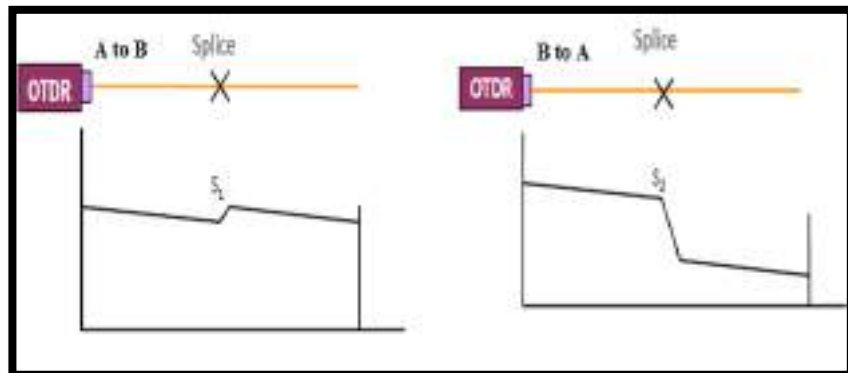
- Ø OTDR tests are often performed in both directions and the results are averaged, resulting in bidirectional event loss analysis.
- Ø Bi-directional analysis determines correct measurement of anomalies such as splice gains.



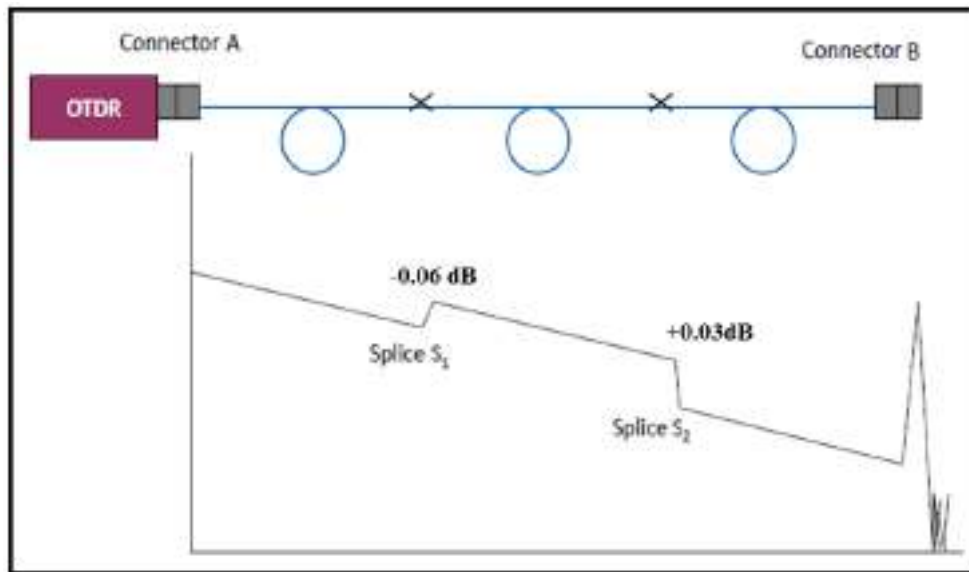
Analyzing Splice Gains

- Ø Splice Gain can occur when two fibers have different core sizes or backscatter coefficients.
- Ø Splice loss of each fiber at every splice location shall be measured from both ends of fibers.
- Ø To arrive at splice loss, average of algebraic sum of splice loss measured from both ends shall be taken.
- Ø Splice loss at any fiber joints at any location shall not exceed 0.1 db.
- Ø Splices that show a gain in one direction will always have a higher loss, if tested in the opposite direction.
- Ø The average splice loss values can be calculated using the following expression:

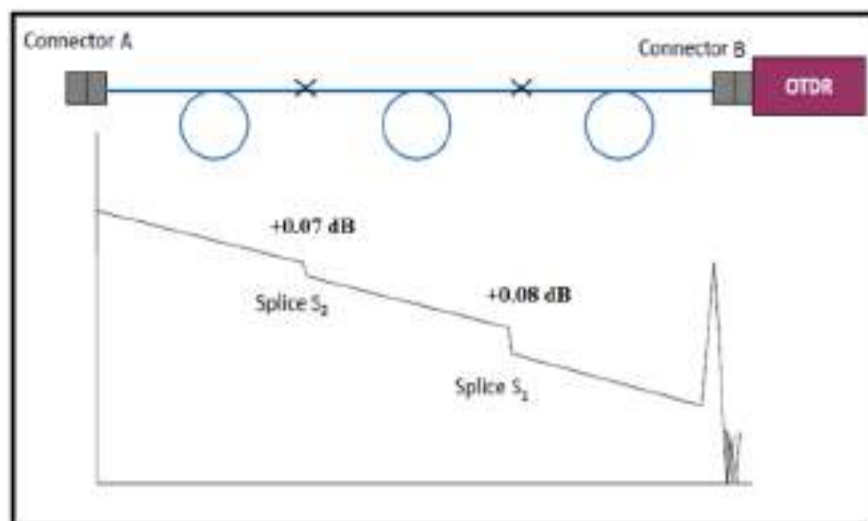
$$S = \frac{S1 + S2}{2}$$



OTDR measurement from connector A to connector B (A -> B)



OTDR measurement from connector B to connector A (B -> A)



Actual Loss

The actual loss of each splice is found by taking the average of the measurement in each direction.

Event	A B	B A	Actual Loss
Splice S ₁	-0.06	+0.08	0.01
Splice S ₂	+0.03	+0.07	0.05

11.9 Light Source and Power Meter (LS & PM)

Single Mode Light Source

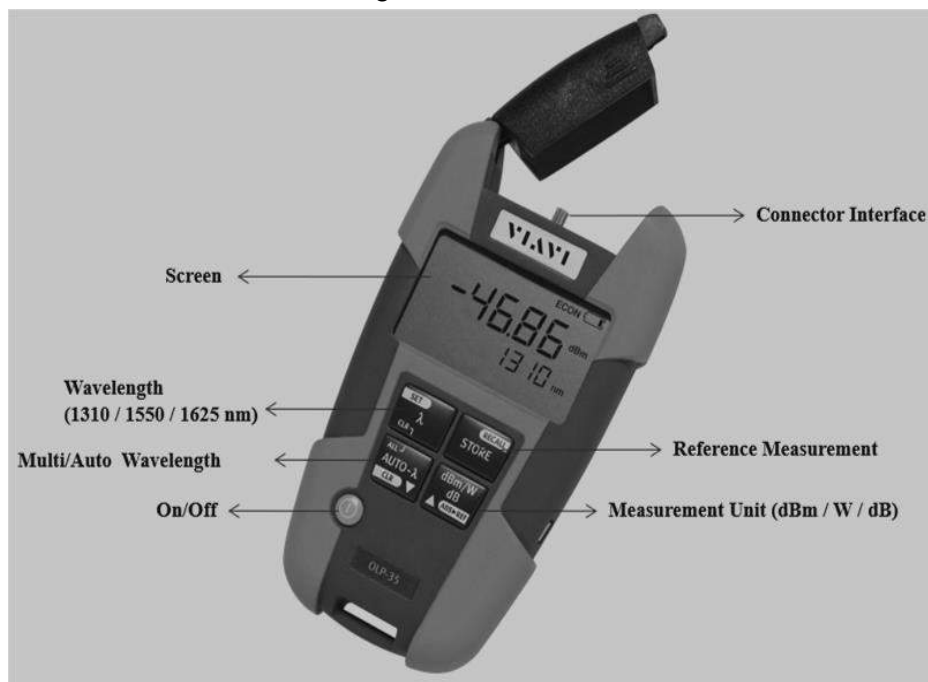
This device is used to insert optical power in fiber. It is a singlemode source with 3 wavelengths on one port for testing networks at 1310 nm, 1550 nm and 1625 nm.



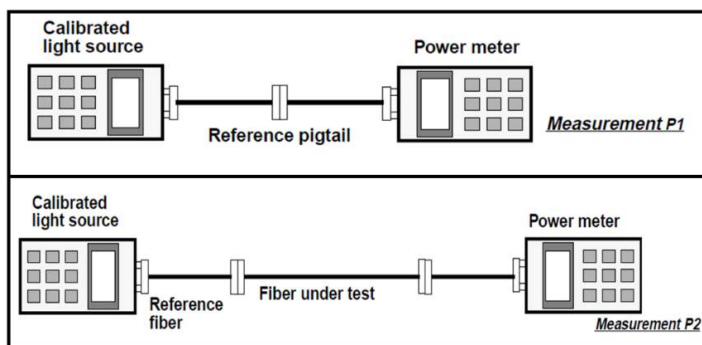
Optical Power Meter

Ø This device is used to measure the power level of optical signal.

Ø Most power measurements are in the range of +10 dBm to -40 dBm.

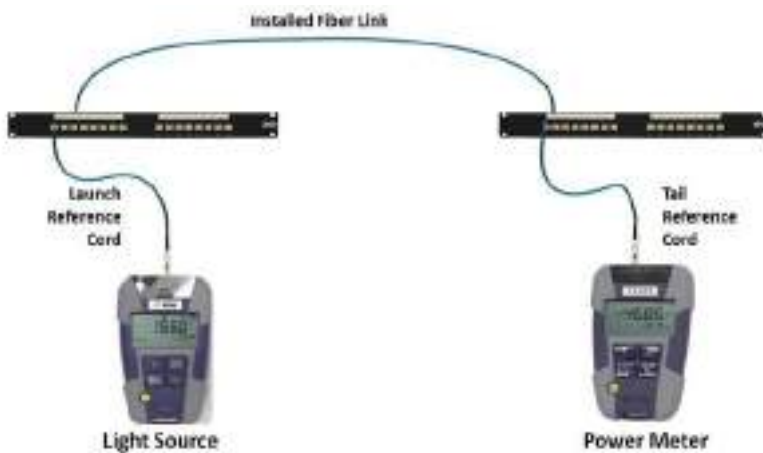


Light Source – Power Meter Test

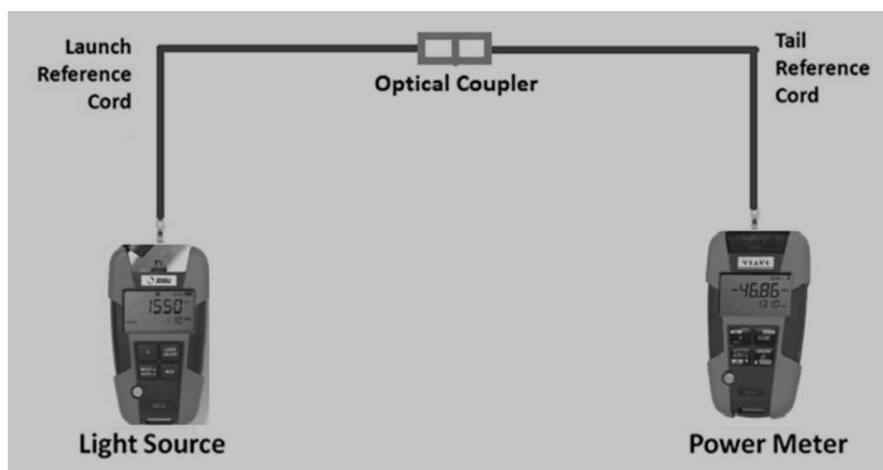


$$\text{Optical Loss} = \text{"Reading P1"} - \text{"Reading P2"}$$

- Ø For Optical Loss Test, a light source and a power meter is needed.
- Ø Measurements are taken at 1310nm and 1550 nm.
- Ø Used in identifying Fiber Swapping and determine Overall Loss.



Step 1:
measurement with patch cords.

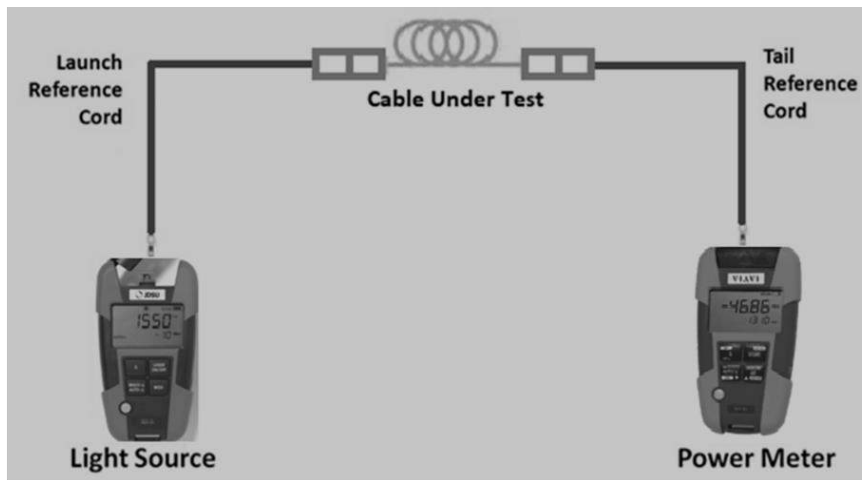


Source Output Power: -7 dBm
Wavelength: 1550nm

Power Meter Reading (Ref): -9 dBm
Wavelength: 1550nm

$$\text{Optical Loss in Patch Cords} = \text{Power Meter Reading (Ref)} - \text{Source Output Power}$$

Step 2: Measurement with installed link.



Source Output Power: -7 dBM
Wavelength: 1550nm

Power Meter Reading (Current) : -30 dBM
Wavelength: 1550nm

$$\text{Total Link Loss} = \text{Power Meter Reading (Current)} - \text{Power Meter Reading (Ref)}$$

Measurement Tips

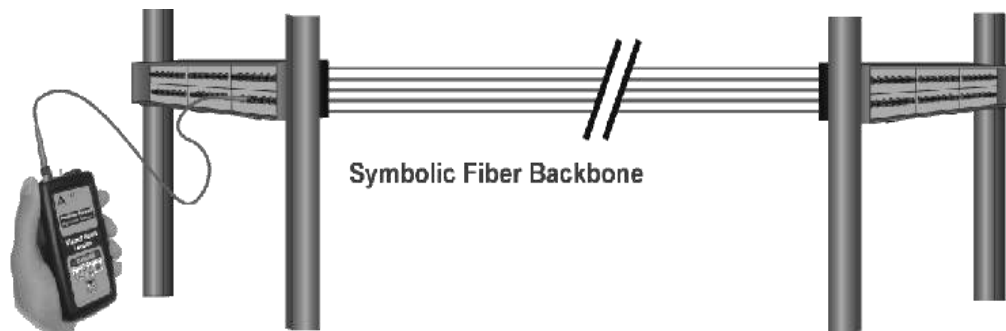
- Ø If a light source is used with an power meter to make link loss measurements, the power meter must be referenced to the light source output power before the loss measurement is made.
- Ø To minimize measurement error, optical patch cords attached to the output port of the light source and power meter for the reference power measurement should remain attached for all link loss measurements for the complete session.
- Ø Always make measurements with alcohol dampened clean connectors.
- Ø Avoid kinking or inducing sharp bends (smaller than a golf ball) into fiber patch cords.
- Ø If no wavelengths are specified for the post-construction measurements, measurements should be made at 1310 nm and 1550 nm.

11.10 Visual Fault Locator (VFL)

- Ø A Visual Fault Locator (VFL) is used to inject visible red laser light into the fiber.
- Ø It helps in visually identifying fiber bends in pigtail and patch cord, fiber breaks, faulty connectors and fiber swap.



- Ø When you test fiber optic cable networks, a VFL is connected to one end of the cable that can be used to verify the transmission to the opposite end. The process is called fiber continuity testing.



11.11 Fiber Detection Meter

- Ø Bends the fiber to detect the light
- Ø Can be used on live fiber without interrupting service
- Ø Can detect a special modulated tone sent down a fiber
- Ø Combined with the Tone Generator, the Fiber Detection Meter enables technicians to identify a specific live fiber without having to disconnect it.
- Ø Induces minimal loss: ≤ 1 dB

This brings key benefits:

- Ø No more network outages as a result of fiber detection/identification procedures.
- Ø The minimized need to access the network helps prevent errors.



11.12 Optical Attenuators

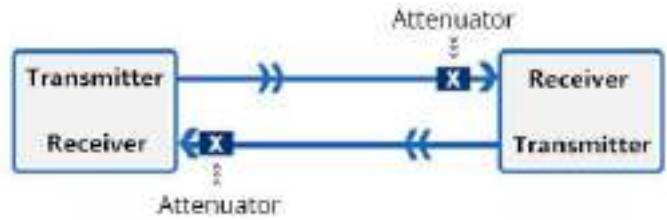
- ∅ An optical attenuator is a device, used to reduce the power level of an optical signal.
- ∅ It temporarily adds calibrated amount of signal loss in order to test the power level margins in a fiber optic communication system.



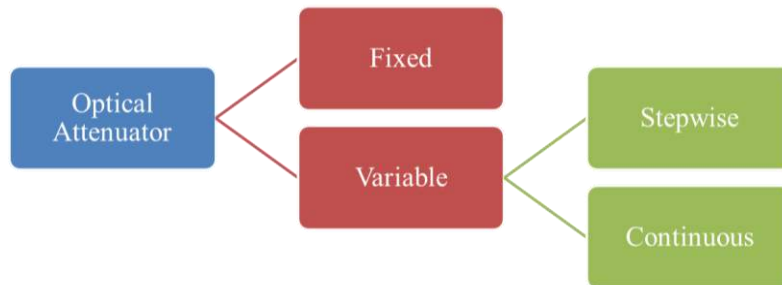
1 dB LC Attenuator



10 dB SC Attenuator

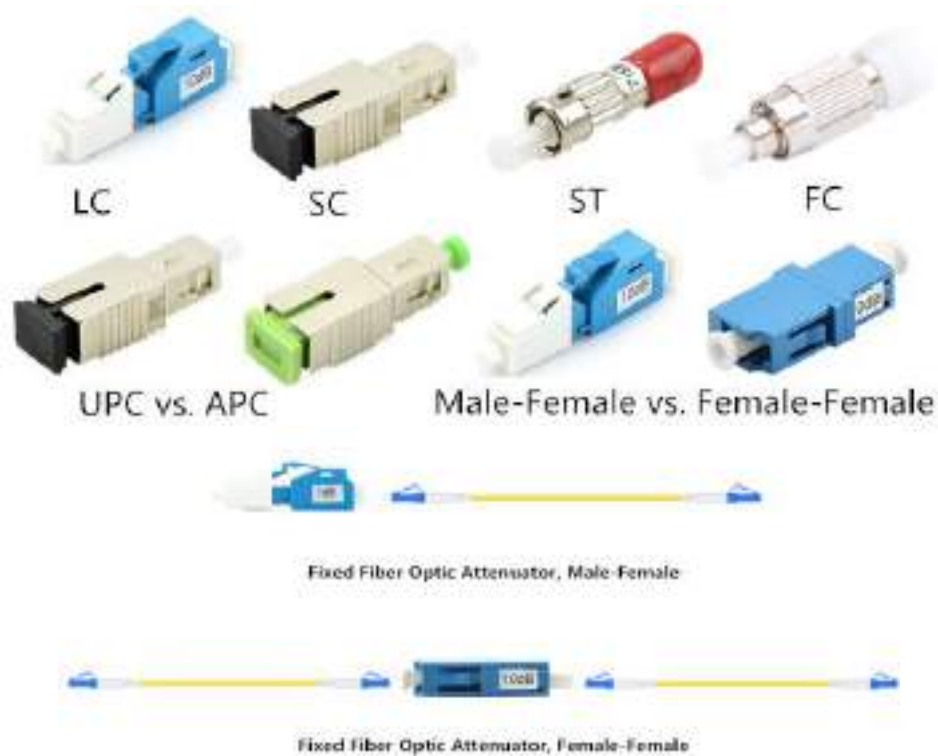


Types of Optical Attenuators



Fixed Optical Attenuator

Fixed attenuators are designed to have a fixed attenuation level.



Variable Optical Attenuator

- Ø Stepwise Variable Attenuator is a device that adjusts the attenuation in known steps such as 0.1 dB, 0.5 dB, or 1 dB etc.
- Ø Continuous Variable Attenuator produces precise level of attenuation for desired wavelength.



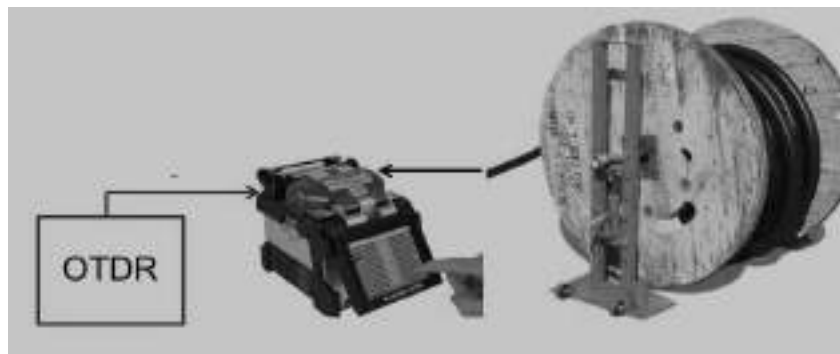
Stepwise Variable Attenuator



Continuous Variable Attenuator

11.13 Test Procedure of OFC Drum

- Ø One end of the cable drum will be prepared by using the proper tools.
- Ø Take the prepared end of the cable inside the splice van to maintain the temperature and dust-free environment
- Ø Make the OTDR ready for testing.
- Ø When the OTDR is ready, strip the fiber and cleave it by means of a diamond-edged cleaver to ensure the cleaving end should be perpendicular.
- Ø Connect the fiber to the OTDR by making a mechanical joint. The mechanical joint will be done by using two connectors coupled to each other through a mechanical coupler.
- Ø Now the fiber is ready for testing. Keep the OTDR in average mode and shoot the laser through the fiber for 10 seconds.



- Ø When the laser will be off, put the cursor "B" at the end of the cable and Cursor "A" at dead zone distance (Commonly cursor A is places at 50 meters from starting).
- Ø Now note the dB/Km loss of the cable.
- Ø If the loss is more than the standard limits, check the mechanical splice or cleave the fiber again and follow the above procedures again.
- Ø Proceed with the same procedure for all the fibers individually.
- Ø All the readings should be witnessed and checked.

11.14 Housekeeping of OTDR

- Ø To clean body of OTDR, use a lint- free cloth moistened with soapy water. Never use product containing Alcohol, as these will erase the printed markings.
- Ø To clean the screen, use an antistatic product.
- Ø To clean the OTDR connector, use spray cleaner containing Iso-Propyl Alcohol.



11.15 Future Developments in OTDR

- Ø A video microscope for fiber end-face inspection
- Ø Weight (less than 2 pounds)
- Ø OTDR with spectral analysis, polarization mode dispersion and chromatic dispersion functions
- Ø Less Deadzones
- Ø Lower Pulse Width
- Ø Improved speed of measurement
- Ø Easy and versatile user interfacing

Section 3: Exercises

Exercise 1: Write the test parameters that can be determined by the following test instruments.

S. No.	Test Instrument	Test Parameter
1	Optical Time Domain Reflectometer (OTDR)	
2	Optical Power Loss measuring Equipment (Light source & Power meter)	
3	Visual Fault Locator (VFL)	

Exercise 2: Calculate the link budget of the following long route links based on the below given details.

- a) Assume a 20 km single mode fiber link at 1550nm with 2 connector pairs and 5 splices.
- b) Assume an 80 km single mode fiber link at 1310nm with cable drum length of 4 Kms installed in the link.

Exercise 3: Draw an OTDR trace showing various events.

Exercise 4: Enlist the common parameters to be configured in the OTDR to test an optical link.

Exercise 5: Find Rx level at ONT having following link details:

Link Length: 10 km single mode fiber

Wavelength: 1550 nm

Transmitter Power: 3 dBm

Splitter Loss: 3 dB

Splices: 10 nos.

Connectors: 4 nos.

Exercise 6: Find Rx level at OLT having following link details:

Link Length: 15 km single mode fiber

Wavelength: 1310 nm

Transmitter Power: 0 dBm

Splitter Loss: 6 dB

Splices: 10 nos.

Connectors: 4 nos.

Exercise 7: Participate in group discussion on following topics:

- a) Fiber Optic Attenuators
- b) Working Principle of OTDR
- c) Pulse Width vs Distance Range vs Resolution

Section 4: Assessment Questionnaire

1. Name the equipment used for Link testing?
2. Which equipment is used to calculate overall loss in fiber using visual trace?
3. What is the unit of Insertion Loss?
4. _____ is the amount of light that a signal loses as it travels along a fiber cable link.
5. The _____ is the theoretical calculated loss that a cable link can have.
6. What are some functions of OTDR?
7. What are some common wavelength available at which OTDR operates?
8. The wavelength 1490 nm is generally used for:
9. OTDR sends _____ along the fiber to identify events?
10. What is the formula that OTDR uses to calculate event distance?
11. What are Test Parameters settings for OTDR configuration?
12. What are two different Acquisition modes?
13. What distance range is selected if length is unknown?
14. _____ is the time duration of pulse that is launched into the fiber. In OTDR, it is mentioned in microseconds and nanoseconds.
15. The ability of OTDR to distinguish between two events in the fiber is called:
16. The time taken by OTDR to calculate the results and show trace on the screen is called:
17. _____ is the parameter that signifies the maximum optical loss an OTDR can measure in a fiber link.

18. Higher the dynamic range lower the distance range. True or False?
19. Larger pulse width provides _____ Dynamic Range.
20. On what factors, accuracy of OTDR depends?
21. The length of fiber, within which, fiber is not able to detect any event and losses is termed as:
22. What is unit of dead zone?
23. How to reduce Dead Zone?
24. Give reasons for occurrence of non-reflective break in OTDR?
25. _____ are repetitions of a trace or portion of a trace.
26. How to avoid Ghost in OTDR trace?
27. When two fibres with different core diameter are spliced and measured with OTDR, splice shows _____ from one direction and _____ from opposite direction.
28. _____ analysis determines correct measurement of splice loss.
29. Which of the following OTDR can detect fiber event at longer distance?
 - a) Dynamic Range: 45 dB
 - b) Dynamic Range: 30 dB
 - c) Dynamic Range: 25 dB
30. If you choose smallest pulse width in OTDR, two closed fiber events can be detected separately. True or False?
31. Using which formula, the average splice loss values can be calculated?
32. Which device is used to insert optical power in fiber?
33. Which equipment is used to measure power level of Optical Signal?
34. In LSPM testing, what is formula of optical loss in patch cords?
35. What is function of VFL?
36. How can we reduce the power level of optical signal?
37. Which mechanism or technique is adopted in attenuators to achieve the desired signal loss?
38. What are two types of optical attenuators?
39. What are two types of Variable Optical Attenuators?
40. Which test equipment can be used to detect fiber swap?
41. Optical attenuators are used in an optical link to decrease the bit rate. True or False?
42. OTDR screen and body should be cleaned using iso-propyl alcohol. True or False?
43. Which equipment is used to test the OFC drum?
44. OTDR trace is a graph between _____ on X axis and _____ on Y axis.
45. Can fiber bend loss be measured by VFL?

-----End of the Module-----

MODULE 12

CONFIGURATION & TESTING OF ONT

Section 1: Learning Outcomes

After completing this module, you will be able to:

- Explain the concept of Internet and IP Addressing
- Describe the term 'Broadband'
- Differentiate between Mbps and MBps
- Set ONT parameters
- Configure the ONT of Tejas Network for BSNL
- Perform Ping test on Windows 10 PC
- Comprehend the results of Ping test
- Test ONT using IP Network

Section 2: Relevant Knowledge

12.1 Basics of Internet

Internet

The Internet is a worldwide, publically accessible series of interconnected computers



Ø **CLIENT** – knows how to communicate with a particular type of server to use the information stored on that server.

Ø **SERVER** – handles requests for data, email, file transfer, and other network services. It stores information to be used by clients.

How did the Internet originate?

In 1969, the US Department of Defence started a project called ARPANet to enable military communication and it is the foundation of the INTERNET.

What is the WWW?

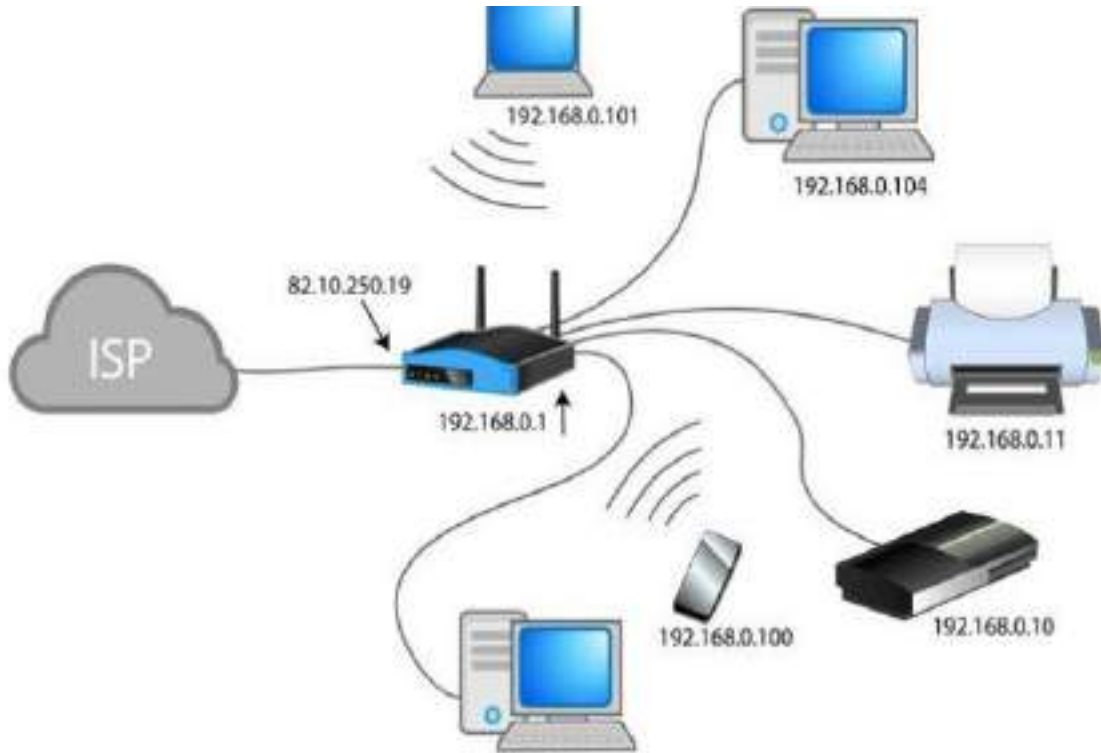
WORLD WIDE WEB. Collection of electronic documents, also called WEB. Each electronic document is called a Web page which contains text, graphics, audio, video, and built-in connections.

What is a Web Browser?

Application software that enables you to access and navigate the Web or the Internet by viewing web pages. ∞ Ex. Mozilla Firefox, Google Chrome, Microsoft Internet Explorer, Opera, Safari etc.

What is IP Address?

- ∅ Internet Protocol (IP) address a unique string of characters that identifies each computer using the Internet Protocol to communicate over a network.
- ∅ Number that uniquely identifies each computer device connected to the internet
- ∅ Four groups of numbers, separated by a dot
- ∅ Number in each group is between 0 and 255
- ∅ Ex. 74.125.71.103



Domain Name is text version of an IP address. (www.google.com)

Broadband

“Broadband is defined as a high bandwidth connection to the Internet. Broadband is easier and faster to use than the traditional telephone and modem as information can be sent and downloaded much quicker”

- ∅ Broadband speed is measured in megabits per second (Mbps)
- ∅ File sizes are measured in megabytes (MB) or gigabytes (GB)
- ∅ There are 8 bits in a byte (10101010)
- ∅ A download speed of 8 bits will shift 1MB per second

Wireless broadband transmits signals to a computer over radio waves.

Mbps vs MBps

- ∅ Mbps is used to specify Internet connection speeds, whereas MBps is used to specify how much of a file is downloaded/uploaded per second.
- ∅ Mbps vs. MBps. Mbps: (Small "b") A megabit per second (Mbit/s or Mbps) is a unit of data transfer rate equal to 1,000,000 bits per second or 1,000 kilobits per second.
- ∅ 8 Megabits per second is equivalent to 1 Megabyte per second (i.e. 8 Mbps = 1 MBps).

12.2 ONT Setting Parameters

SSID (Service Set Identifier)

- Ø People typically encounter a Service Set Identifier (SSID) most often when they are using a mobile device to connect to a wireless network.
- Ø For example, if you take your laptop to a coffee shop and attempt to connect to the local Wi-Fi network, your screen will display a list of SSIDs. This is the names of all the networks that are within range of your mobile device. You will select the name of the local network you want to connect to and then enter the password (if necessary) to connect.



- Ø SSID is the name for a Wi-Fi network. Mobile devices will look for all networks in range when you attempt to connect to local Wi-Fi

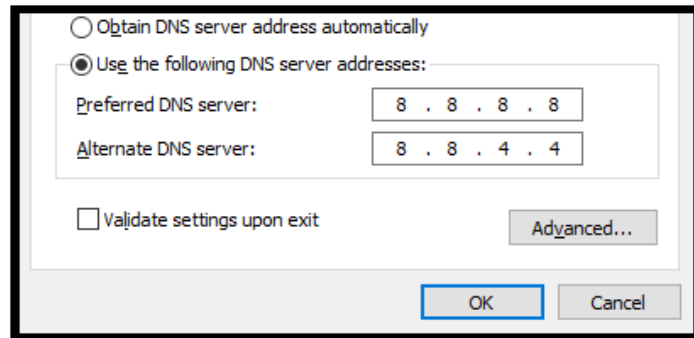
PPoE

- Ø Point-to-Point Protocol over Ethernet (PPPoE) is a network protocol that facilitates communication between network endpoints.
- Ø In turns, a static IP just means it doesn't change and you get the same IP every time your router resets.
- Ø This could mean it is set manually on your equipment or it could mean that it is just statically mapped to always give you the same IP address.
- Ø PPPoE is a connection protocol, not an IP type.
- Ø PPPoE is one of the most preferred means of delivering internet access.



Domain Name Server (DNS)

- Ø The Domain Name System (DNS) is the phonebook of the Internet.
- Ø Humans access information online through domain names, like nytimes.com or espn.com.
- Ø Web browsers interact through Internet Protocol (IP) addresses.
- Ø DNS translates domain names to IP addresses so browsers can load Internet resources.
- Ø Each device connected to the Internet has a unique IP address which other machines use to find the device.
- Ø DNS servers eliminate the need for humans to memorize IP addresses such as 192.168.1.1 (in IPv4), or more complex newer alphanumeric IP addresses such as 2400:cb00:2048:1::c629:d7a2 (in IPv6).



Primary vs Secondary Domain Name Server (DNS)

- Ø A primary DNS server is the first point of contact for a browser, application or device that needs to translate a human-readable hostname into an IP address.
- Ø The primary DNS server contains a DNS record that has the correct IP address for the hostname.
- Ø If the primary DNS server is unavailable, the device contacts a secondary DNS server, containing a recent copy of the same DNS records.
- Ø A secondary server holds a secondary DNS zone—a read-only copy of the zone file, which contains the DNS records.
- Ø Secondary DNS servers are not mandatory—the DNS system can work even if only a primary server is available.

12.3 Configuring the ONT

ONT Configuration (Tejas Networks for BSNL)



Step 1: Power ON ONT.

Step 2: Select the wifi signal of ONT to be configured (if using LAN cable use GbE Port num 4.)

Step 3: Open the web browser

Step 4: Enter IP address 192.168.1.1 to access ONT GUI (Graphical User Interface)

Step 5: UN- admin

PW- admin

Step 6: Restore the ONT to Default state – “Management” > “Settings” > “Restore Default”

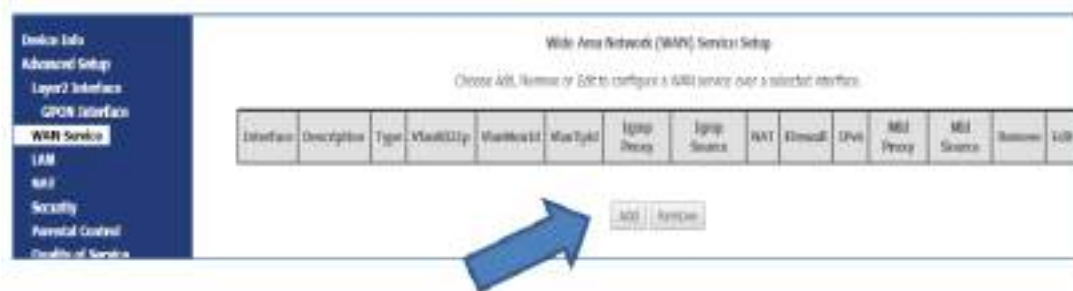
Step 7: On left side menu go to “Advanced Setup” > “Layer2 Interface” > “GPON WAN Interface Configuration” page will appear, click button “Add” > select option “veip0/veip0” > click “Apply/Save”



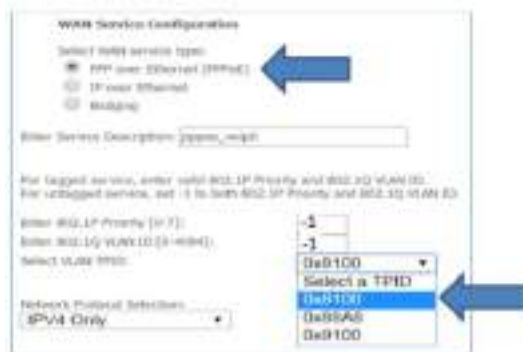
Step 8: Upon completion of the steps you should get view as shown below, Click Add.



Step 9: Click on “WAN Service” > “ADD” > Next Screen select “veip0/veip0” > click “Next”



Step 10: Select the “PPPoE” settings as shown, click “Next” : (-1 is default value in equipment, keep it)



Step 11: Select the “PPPoE” settings as shown and click “Next” :

For example in real scenario it can be as below :

Username : bs29899497_sid@ftth.bsnl.in

Password : password

Primary DNS : 218.248.255.141

Secondary DNS : 218.248.255.139

PPP Username and Password

PPP usually requires that you have a user name and password to be provided to you.

PPP Username: kz2@bsnl.ftth.in

PPP Password: *****

PPPoE Service Name:

Authentication Method: AUTO

Enable Fullcone NAT
ONLY IF REQUIRED — DISABLES NETWORK ACCELERATION AND

Dial on demand (with idle timeout timer)

Username, Password and DNS IP Address to be provided by BBNL/BSNL

Step 12: As shown in below screenshot ‘highlight in blue’ and just click “Next”.

Routing -- Default Gateway

Default gateway interface list can have multiple WAN interface being the highest and the last one the lowest priority if the WAN

Selected Default Gateway Interfaces

Available Routed WAN Interfaces

ppp0.1

->

<-

Step 13: Make the DNS server entries here and click “Next”

DNS Server Configuration

Select DNS Server Interface from available WAN interfaces:

Selected DNS Server Interfaces Available WAN Interfaces

ppp0.1

->

<-

Use the following Static DNS IP address:

Primary DNS server:

Secondary DNS server:

DNS IP Address to be provided by BBNL/BSNL

Step 14: You will get a similar screen click “Apply/Save”

WAN Setup - Summary

Make sure that the settings below match the settings provided by your ISP.

Connection Type:	PPPoE
NAT:	Enabled
Full Cone NAT:	Enabled
Firewall:	Enabled
IGMP Multicast Proxy:	Disabled
IGMP Multicast Source Enabled:	Disabled
MLD Multicast Proxy:	Disabled
MLD Multicast Source Enabled:	Disabled
Quality Of Service:	Disabled

Click "Apply/Save" to have this interface to be effective. Click "Back" to make any modifications.

Step 15:

You can check here if “Internet service is getting through”

On left menu click under “Device Info” > “WAN”

”Status” should show “Connected”

“IPv4 Address” should show “a Address”

Interface	Description	Type	VlanMuxId	IPv6	Icmp Pkg	Icmp Src Enbl	M/D Pkg	M/D Src Enbl	NAT	Firewall	Status	IPv4 Address	IPv6 Address
ppp0.1	pppoe_visp0	PPPoE	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Enabled	Enabled	Connected	117.247.108.138	



Step 16:

To change the name of the ONT, go to Wireless >> Basic >> SSID >> Apply/Save.

Troubleshooting:

- Ø After the service creations, if internet is not appearing:
 - You have to power OFF & power ON Local ONT
 - Check for any optical power issues
 - Change GP ONT side SC-APC patch chord
- Ø In status, if it shows “connecting” troubleshoot on the BSNL-OCLAN side and check if the GP-ONT VLAN is passed till Back-End. BSNL officer will have to coordinate with his NOC, to trace this VLAN.
- Ø If a VLAN/Username detail is used for one GP, same cannot be used for another GP, because once used, these will get locked in central server with original GP MAC ID.

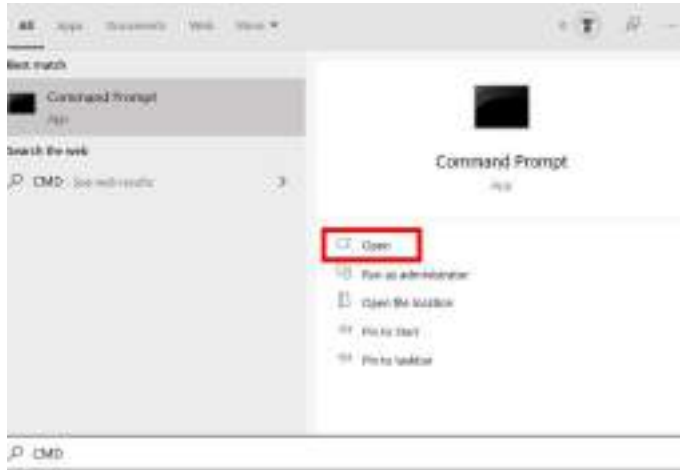
12.4 Testing ONT using IP network

What is a Ping Test?

- Ø A ping test is used to measure latency of internet connection.
- Ø Latency (or Ping) is the reaction time of your connection-how quickly your device gets a response after you've sent out a request.
- Ø It tells you the quality of your connection.
- Ø It is important to have a low latency connection for online gaming, loading web pages quickly, video chatting, and more.
- Ø When you do a ping test, your computer sends a small packet of data to your host, a web domain, or another device in your network.
- Ø The results will show you how fast your computer gets a “pong” response back in milliseconds. You want your ping response time to be as low as possible.

How to Do a Ping Test on a Windows 10 PC

- Ø To do a ping test in Windows 10, open the Windows Search Bar, type CMD, and click Open.
- Ø In the Command Prompt, type ping followed by a space and then the IP address or domain name you want to test and hit Enter.
- Ø **Open the Windows Search Bar.** You can do this by clicking the magnifying glass icon in the **bottom-left corner** of your screen.



- Ø **Then type CMD into the search bar and click Open.** This will open a Command Prompt window with a black background, white text, and a flashing cursor.
- Ø **Type ping followed by a space and an IP address or domain name.** For example, you would enter “ping 192.168.1.1” or “ping hellotech.com”.
- Ø Finally, hit Enter on your keyboard and wait for the ping test results.
 1. Type “cmd” to bring up the Command Prompt.
 2. Open the Command Prompt.
 3. Type “ping” in the black box and hit the space bar.
 4. Type the IP address you’d like to ping (e.g., 192.XXX.X.X).
 5. Review the ping results displayed.

```
Microsoft Windows [Version 10.0.18362.900]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\gabri>ping hellotech.com

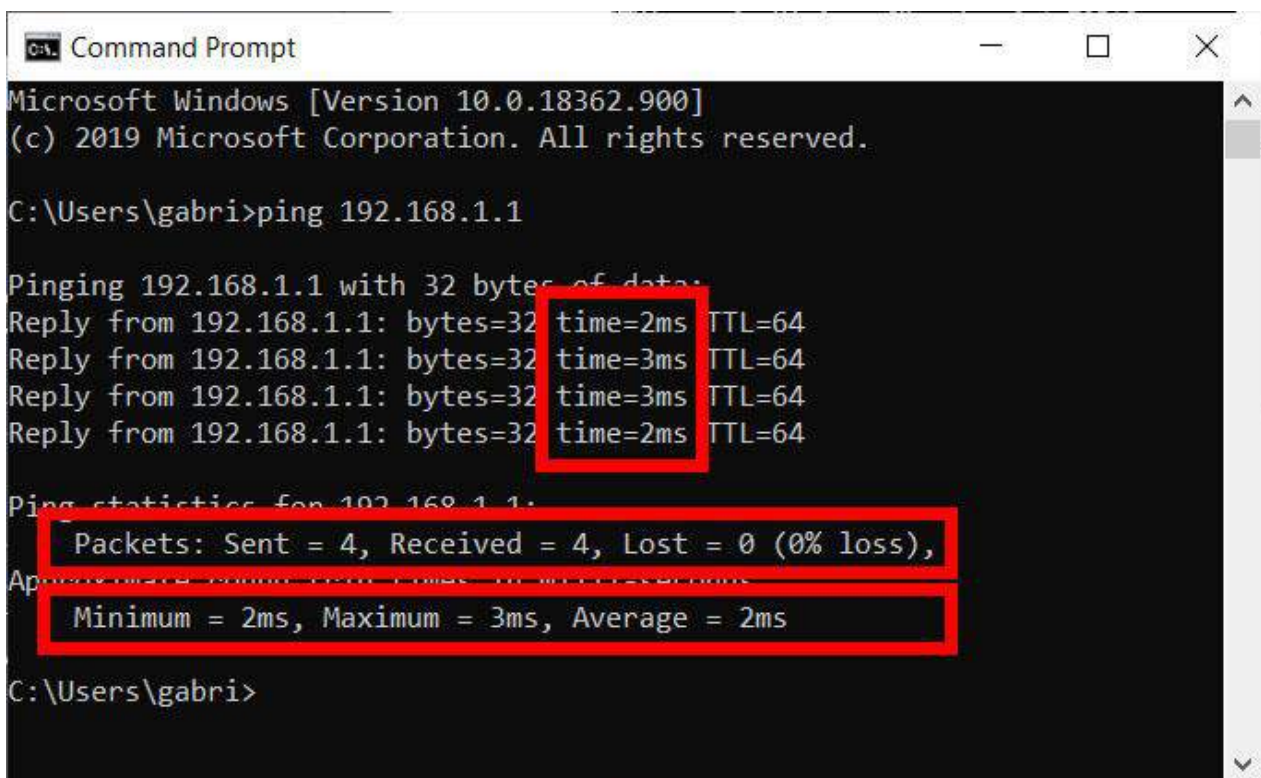
Pinging hellotech.com [35.244.216.127] with 32 bytes of data:
Reply from 35.244.216.127: bytes=32 time=13ms TTL=117
Reply from 35.244.216.127: bytes=32 time=15ms TTL=117
Reply from 35.244.216.127: bytes=32 time=21ms TTL=117
Reply from 35.244.216.127: bytes=32 time=17ms TTL=117

Ping statistics for 35.244.216.127:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 13ms, Maximum = 21ms, Average = 16ms

C:\Users\gabri>
```

Understanding Ping Results

- Ø The first thing you'll see is the server's host name. This will confirm you have an active connection to the server.
- Ø Next are the number of bytes being sent to the server, which will typically show 32.
- Ø The next four lines indicate the response time from the server. You'll see how many bytes of data were sent back, as well as how many milliseconds the response took to return.
- Ø TTL means "time to live" This information shows you the total routers the packet will travel through before stopping.
- Ø If you see "request timed out" it tells you that the packets couldn't find the host, which indicates a connection problem and the destination you're attempting to ping is unreachable.
- Ø The Ping statistics section shows the overall numbers for the process.
- Ø The packets line shows the number of packets sent and received, and tells you if any were lost. If they were, there's like a connection issue.
- Ø Lastly, approximate round-trip times show the connection speed. The higher the time, the worse the connection.
- Ø If you are doing a ping test to check your internet connection, you can ping Google's DNS servers by entering "ping 8.8.8.8".



```
Command Prompt
Microsoft Windows [Version 10.0.18362.900]
(c) 2019 Microsoft Corporation. All rights reserved.

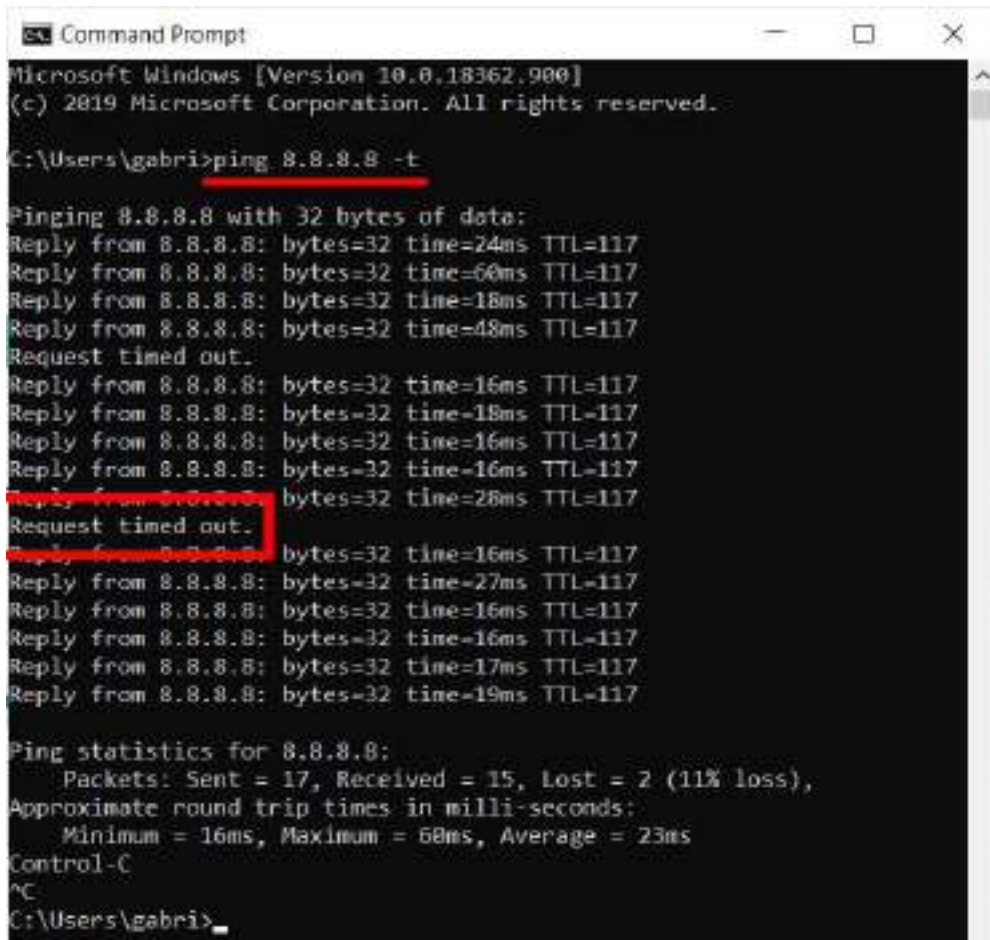
C:\Users\gabri>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:
Reply from 192.168.1.1: bytes=32 time=2ms TTL=64
Reply from 192.168.1.1: bytes=32 time=3ms TTL=64
Reply from 192.168.1.1: bytes=32 time=3ms TTL=64
Reply from 192.168.1.1: bytes=32 time=2ms TTL=64

Ping statistics for 192.168.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milliseconds:
    Minimum = 2ms, Maximum = 3ms, Average = 2ms

C:\Users\gabri>
```

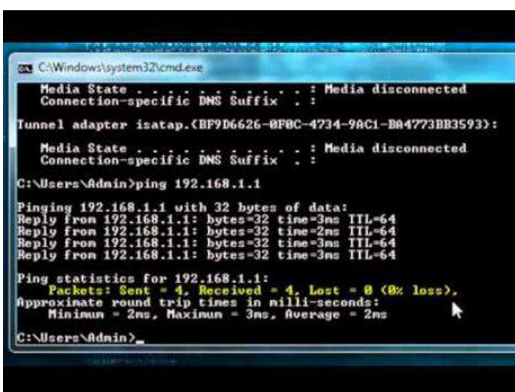
In order to see continuous ping results, you can append your command with “-t”. For example, you can enter “ping 8.8.8.8 -t” to see if your connection to Google’s DNS servers ever times out. Then, to stop the test, simply hit the Control + C keys on your keyboard at the same time.



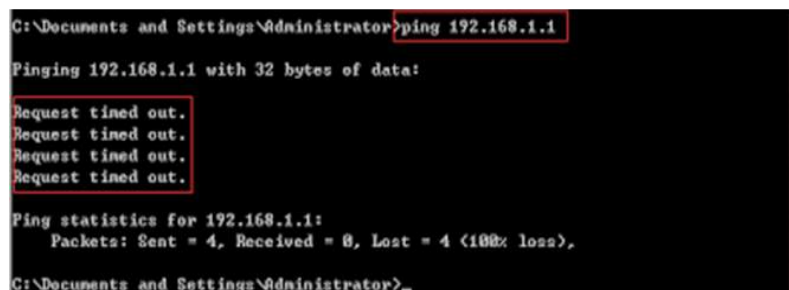
Pinging ONT

- Ø In order to ping ONT, type the IP address of ONT on command prompt.
- Ø For example, you can enter “ping 192.168.1.1” to see if your system is communicating with ONT through Wifi. It doesn’t ensure the system’s network connection to internet.

Connected



Not Connected



Section 3: Exercises

Exercise 1: Draw network architecture of Internet.

Exercise 2: Participate in group discussion on following topics.

- a) Working of Internet
- b) Primary and Secondary DNS
- c) IP Addressing
- d) ONT Setting Parameters
- e) Ping Test Results

Section 4: Assessment Questionnaire

1. In 1969, the US Department of Defence started a project called _____ to enable military communication.
2. Each electronic document is called a _____ which contains text, graphics, audio, video, and built-in connections.
3. Application software that enables you to access and navigate the Web or the Internet by viewing web pages is called:
4. Tell names of some web browsers.
5. Number that uniquely identifies each computer device connected to the internet is:
6. How many groups are there in IP address?
7. Broadband speed is measured in:
8. Wireless broadband transmits signals to a computer over which media?
9. 8 Mbps = ____ MBps.
10. What do we call a network protocol that facilitates communication between network endpoints?
11. PPPoE is a type of IP. Yes/No?
12. What translates domain names to IP addresses so browsers can load Internet resources?
13. What are two types of DNS?
14. Which test is used to check connectivity between two devices on internet?
15. _____ is the reaction time of your connection-how quickly your device gets a response after you've sent out a request.
16. TTL means _____. This information shows you the total routers the packet will travel through before stopping.
17. To configure an ONT, user device can be connected to ONT over which port?

-----End of the Module-----

MODULE 13 OCCUPATIONAL HEALTH AND SAFETY

Section 1: Learning Outcomes

After completing this module, you will be able to:

- Explain the importance of safety
- Types of workplace hazards
- Use various Personal Protective Equipment (PPE) at workplace
- Adhere to optical fiber safety procedures at workplace
- Differentiate between various Laser Classes
- Perform procedures for safety of utilities
- Describe material handling facts
- Manage traffic
- Adhere to travel safety
- Use safety signage and barricading
- Gauge and perform fire safety actions
- Perform medical care at site (First Aid and CPR)
- Encourage safety communication at site

Section 2: Relevant Knowledge

13.1 Introduction to Workplace Safety and Hazards

What is Safety?

Safety is:

- Ø A general condition of being safe
- Ø Living without fear of getting injured
- Ø Being protected from the dangers of our work environment

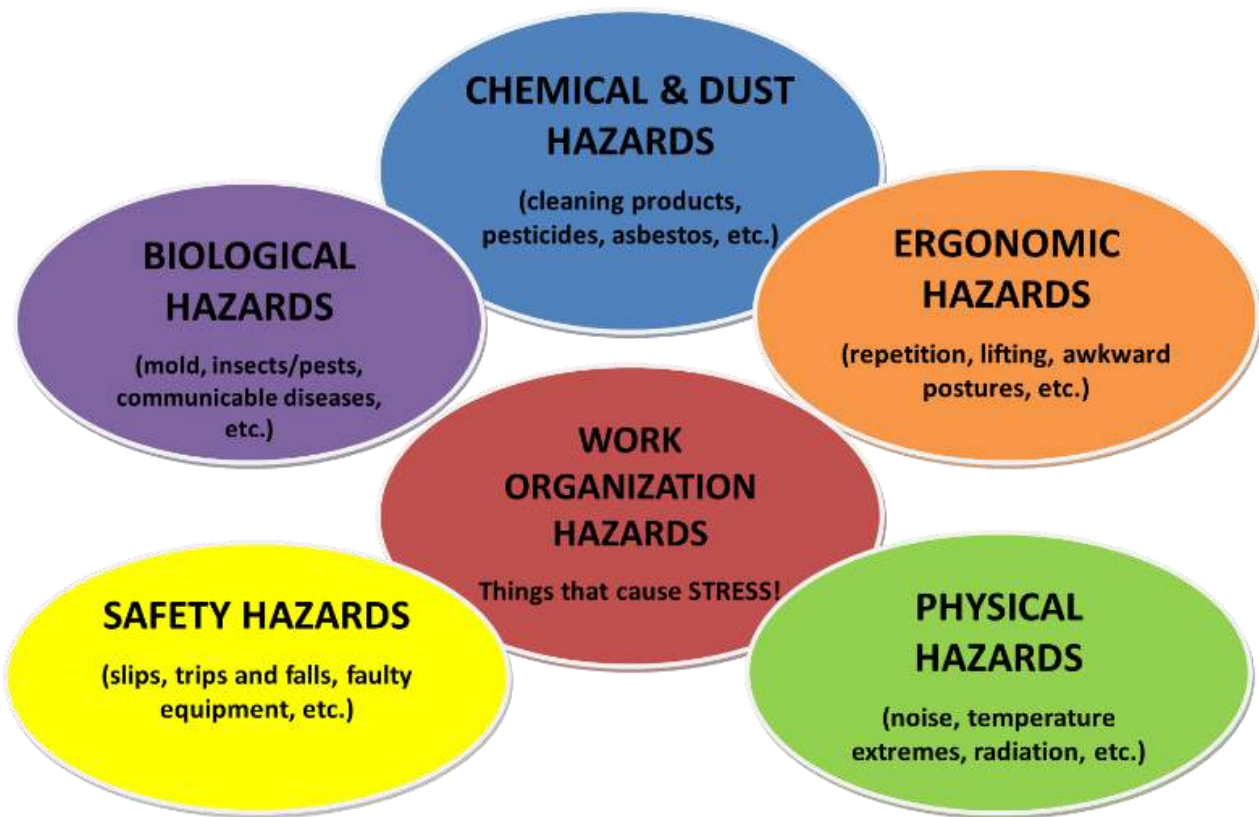


“No work is so important that it, need be done without due consideration for safety”

Safety Basics



Types of Hazards



“Work organization” is at the center of the chart and all the other hazard categories surround it. This is because for many workplace health and safety issues the way our jobs are designed can be a contributing factor to other hazards we might experience.

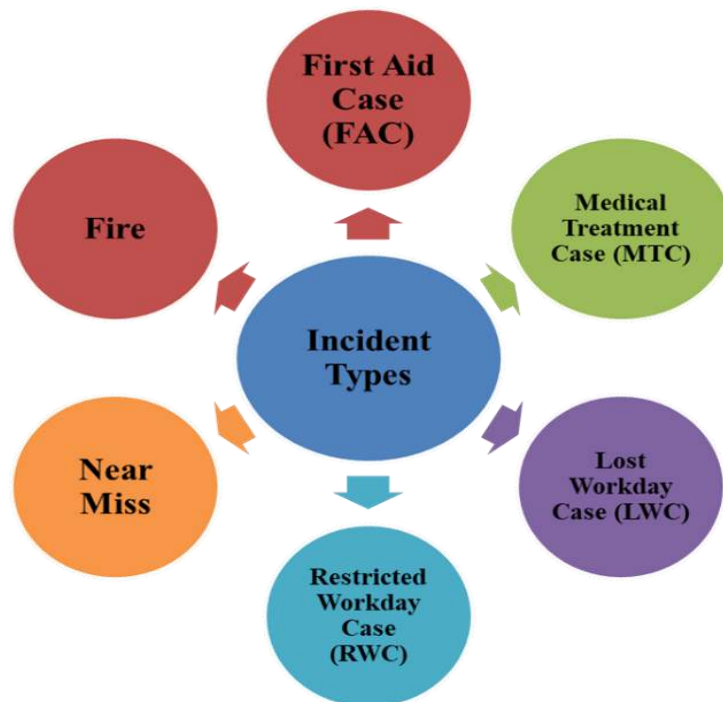
*For example, a staff member may trip and fall in a hallway because they’re rushing to get back to their desk because of an important deadline they must meet. The slip and fall results in an injury but the job demand is the **root of the problem**. We have to keep asking **WHY** something happened until we find the true cause of the problem. In order to start thinking of solutions, we need to know **ALL** of the potential hazards.*

Effective Health and Safety Procedures for the Workplace

- Ø Create a Safety Plan - It's important for every worker, contractor, and visitor to have access to a thorough safety plan
- Ø Record Keeping
- Ø Proper Safety Equipment
- Ø Eliminate Potential Hazards
- Ø Provide Proper Training

Types of Incidents

What are the incident types?



All Incidents irrespective of their nature/magnitude should be reported within 24 hours of occurrence by the respective area in-charge/supervisor

13.2 Personal Protective Equipment (PPE)



Types of PPE

PPE can be categorized by:

- Ø The Area of the Body Protected
- Ø The Types of Hazard
- Ø The Type of Accessory
- Ø Head protection
- Ø Eye and Face protection
- Ø Hearing protection
- Ø Arm and Hand protection
- Ø Respiratory protection
- Ø Foot and Leg protection
- Ø Protective clothing
- Ø Other protection

Recommended PPEs for Optical Fiber Safety



Head Protection

- Ø **Equipment:** Safety Helmet
- Ø **Purpose:** For protection against falling object or when hit against any obstructions
- Ø **Specification:** HDPE helmet as per ISI 2925 standard



Eye Protection

- | | |
|---|---|
| <ul style="list-style-type: none"> ▪ Equipment: Safety spectacles ▪ Purpose: For protection against flying particles or any sudden impact while executing the job ▪ Specification: Clear polycarbonate lens for low energy impact resistant as per EN 166 | <ul style="list-style-type: none"> ▪ Equipment: Laser goggles ▪ Purpose: For protection against radiation from a laser system to eliminate the possibility of potentially hazardous eye exposure. ▪ Specification: Class EN 207 |
|---|---|



Respiratory and Ear Protection

- **Equipment:** Ear plugs
 - **Purpose:** For protection of ear from high noise. Noise level above 85 dB is hazardous for an exposure more than eight hours/day or 48 hours/week.
 - **Specification:** Disposable type Ear plugs made of poly urethane foam with a noise reduction level of 25 dB
- **Equipment:** Dust mask
 - **Purpose:** For protection against fine particulate/dust
 - **Specification:**
 - Particulate Respirator 9004IN
 - AS/NZS P1 and BIS P1, 500/cs



Arm and Hand Protection

- **Equipment:** Cotton knitted gloves
 - **Purpose:** For protection against cuts/abrasion during work execution and material handling
 - **Specification:** Seamless 100% cotton
- **Equipment:** Electrical gloves
 - **Purpose:** For protection against electrocution while working on live line
 - **Specification:** Electrical resistant gloves made of rubber as per EN 609033



Foot and Leg Protection

- **Equipment:** Safety shoes
- **Purpose:** For protection of foot against sudden impact
- **Specification:** Lace shoes with steel toe, as per IS 15298 standards



- **Equipment:** Gum boots
- **Purpose:** Useful during rainy seasons or when work is to be done in wet areas to prevent slippage
- **Specification:** 16" knee boot in rubber material, with durable cotton lining inside and with firm heel



Body Protection

- **Equipment:** Full body harness
- **Purpose:** For any maintenance, repair and inspection work at height more than 6 feet
- **Specification:** Full body harness as per EN 361 with shock absorber as per EN 355 and double lanyard as per EN 354



- **Equipment:** Reflective jackets
- **Purpose:** For field jobs (Excavation/repairs/Night jobs) to raise visibility of the working people
- **Specification:** Made of 100% cotton jacket with fluorescent colour and reflective tape of 2-inch width



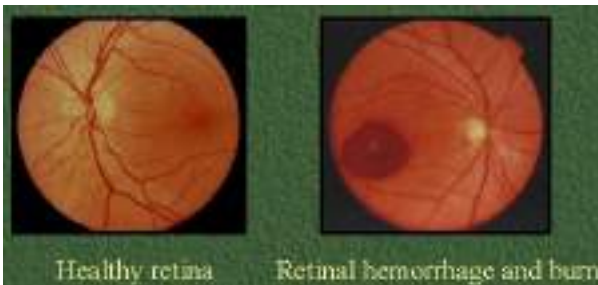


*Helmet, Shoes & Reflective Waist
Provided to every worker*



PPE's available on site for use

13.3 Optical Fiber Risks & Safety



- Ø Never look directly into the fiber. It may burn retina.
- Ø Always cap connectors.
- Ø Glass shards, if injected in skin/body, can cause internal hemorrhages.
- Ø The broken ends of fibers and scraps of fiber should be disposed-off properly.
- Ø Wear protective Apron to avoid fiber particles from attaching to clothing.
- Ø Isopropyl alcohol, used as a cleaner, is flammable and should be handled carefully.
- Ø Keep hands away from face.
- Ø Do not touch your eyes while working with fiber optic systems.
- Ø Mark enclosures with warning labels.
- Ø Laser test sources are dangerous, don't leave them lying around.

Laser Classes

- ∅ Lasers are classified for safety purposes based on their potential for causing injury to humans' eyes and skin.
- ∅ For visible-beam consumer lasers, there are four main classes. Class 2, Class 3R, Class 3B and Class 4 or in Roman numerals (I, II, IIIa, IIIb, IV).
- ∅ The first two Classes are relatively safe for eye exposure; the last two are hazardous.



Chemical Safety

MSDS: Material Safety Data Sheet is a document that lists the risks of a chemical

- ∅ **Alcohol** – Flammable
- ∅ **Adhesives** – Irritate skin, require ventilation
- ∅ **Index matching gel** – Irritate eyes
- ∅ **Silicone adhesives** are used as mechanical sealant – can irritate skin or eyes

13.4 Safety of Utilities

Take inputs from utility owners

Contact concerned person

Find utilities by cross trenching

Do not hide damage

Coordinate with authorities

Use barricading / cautions

13.5 Unsafe Act /Unsafe Condition



CAVE - IN

NO Barricading

CAVE - IN



Cave in / Collapse of Soil

Unsafe Act / Unsafe Condition





13.6 Material Handling

Material Handling Activities

Materials handling involves five types of activities:



Material Handling—Some Facts

- ∅ Material handling accounts for 36% of production cost
- ∅ About 20 % to 80 % of total labour cost goes into labour used in handling and rehandling the material
- ∅ About 2/3 of manufacturing cycle time spent on material handling
- ∅ 40 % of industrial accidents are in material handling
- ∅ About 50 to 100 tons of material is handled and rehandled for every 1 tone of finished product

13.7 Traffic Management and Travel Safety

Traffic Management

- ∅ Use of high visibility waistcoats for protection against speeding vehicular traffic.
- ∅ Legal permission to be obtained by the contractor from the concerned authorities for Traffic Diversion and alternate route selection.



Traffic Safety Equipment



Barricading Tapes



Portable Cone Connecting Bar



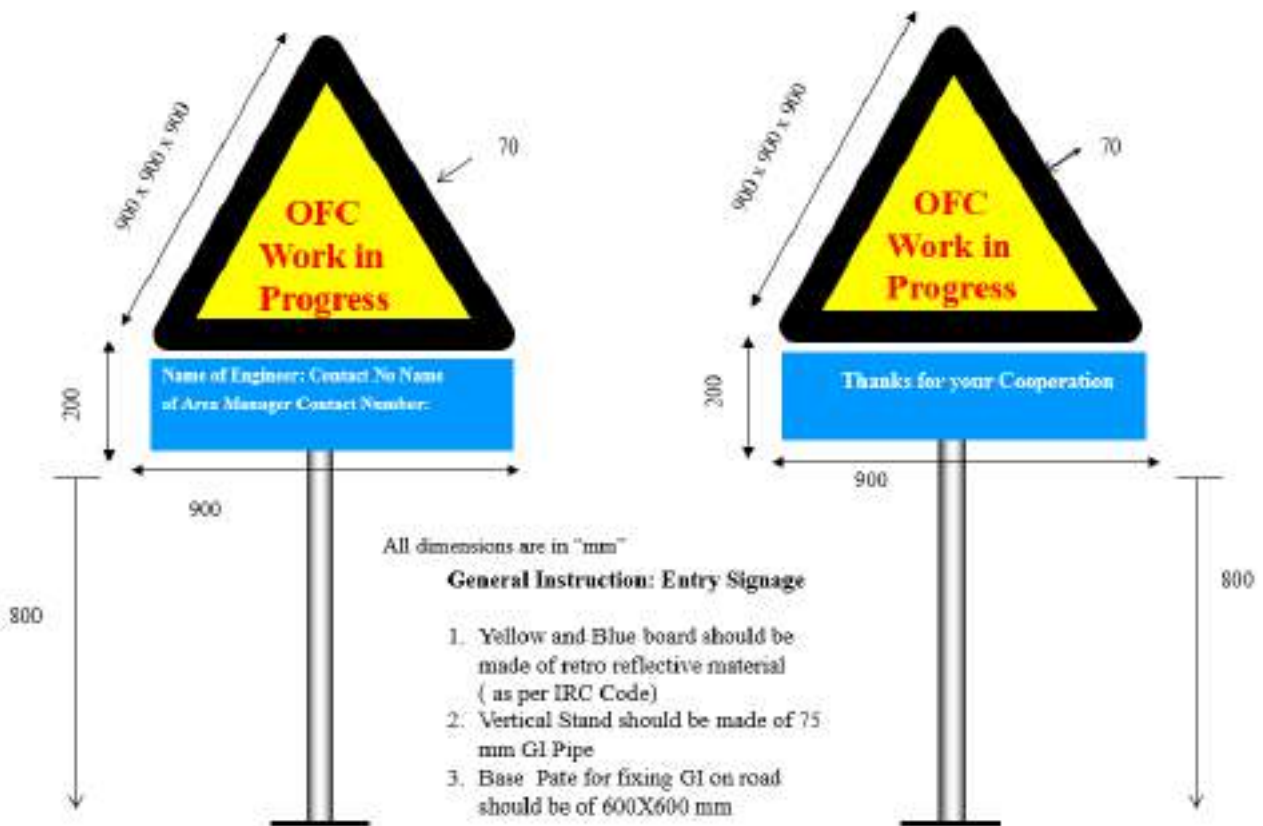
Barricades

Travel Safety

- Ø Do not panic
- Ø Speed control
- Ø Expert driver
- Ø Sleep necessary
- Ø Disturbed area
- Ø Take care during Fog
- Ø Learn driving for emergencies



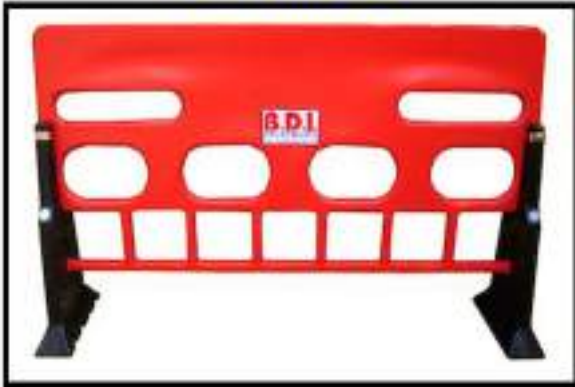
13.8 Safety Signage and Barricading
Project Site – Warning Signage



Safety Signage



Plastic Barricade



Metallic Barricade



Portable Cone Connecting Bar

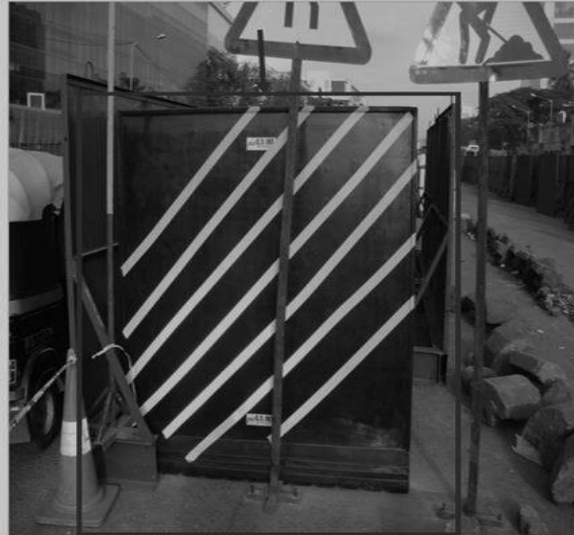


Barricading Tapes

Pathway provided to road users



Barricading Boards for nosing





Retro Reflective Traffic Sign Boards



Illumination at site in night



Safety Signage for trench excavation



Fire Prevention at site

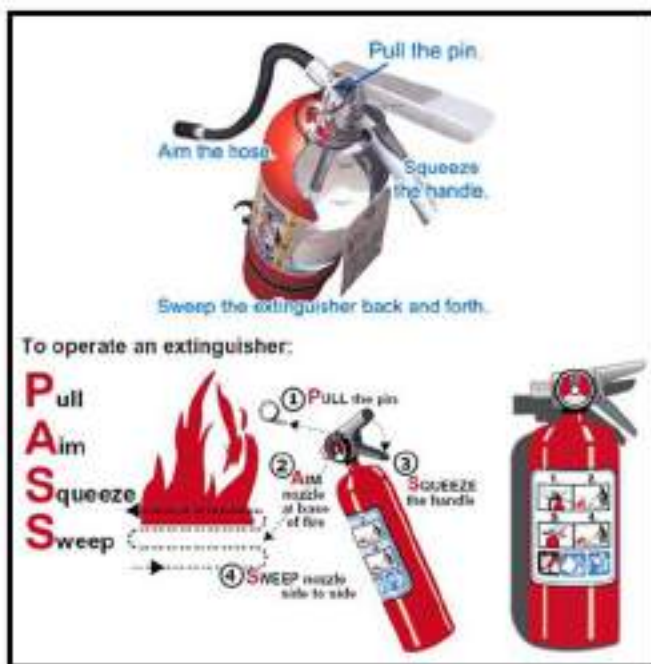
Use of Fire Extinguishers and Fire Buckets help workmen to prevent fire at site.



Types and Classes of Fire Extinguishers

		Fire Extinguisher Type				
Fire Type		Powder	Foam	CO ²	Water	Wet Chemical
CLASS A	Solids (e.g. wood, plastic, paper)	✓	✓	✗	✓	✗
CLASS B	Flammable Liquids (e.g. solvents, paint, fuels)	✓	✓	✓	✗	✗
CLASS C	Gases (e.g. butane, propane, LPG)	✓	✗	✗	✗	✗
CLASS D	Metals (e.g. lithium, magnesium)	✓	✗	✗	✗	✗
ELECTRICAL	Equipment (e.g. computers, servers, TVs)	✓	✗	✓	✗	✗
CLASS F	Cooking Oils (e.g. cooking fat, olive oil)	✗	✗	✗	✗	✓
Some examples of businesses that may need this extinguisher		Outdoor locations, garages, welding workshops, forecourts.	Schools, offices, hotels, shops, hospitals, apartments.	Offices, server rooms.	Schools, hospitals, shops, apartment blocks.	Kitchens, canteens, restaurants.

How to use Fire Extinguishers?



On Discovering Fire

- Ø Inform Fire brigade.
- Ø Break the glass of the nearest pill box.
- Ø Attack the fire with nearest accessible extinguisher.
- Ø Handle the extinguisher only if you know how to operate it.
- Ø Do not use water for extinguishing fire in electrical installations unless power supply is disconnected.
- Ø Ensure that mains & battery is switched OFF in case of fire in equipment/ power distribution system.
- Ø Always position yourself with an exit or means of escape at your back before you attempt to use an extinguisher to put out a fire.



13.10 Medical Care at Site



First Aid Box

First Aid Kit



Cardiopulmonary Resuscitation (CPR)

CPR is a life-saving technique.

- ∅ CPR is administered whenever heart and/or breathing stop (cardiac and/or respiratory arrest).
- ∅ CPR can keep a person alive until more advanced medical procedures can treat the cardiac arrest.

CPR steps are called CAB.

- ∅ **Chest Compression** - Providing artificial circulation via chest compressions.
- ∅ **Airway** - Opening and maintaining the airway.
- ∅ **Breathing** - Providing artificial ventilation through artificial breathing.

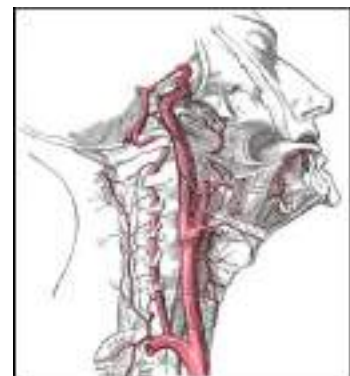


Steps before starting CPR

Within 5 to 10 seconds, check for:

- Responsiveness
 - No breathing [or only gasping]
 - Check responsiveness by gently tapping on shoulders and asking loudly "Are you OK?" or "Do you hear me?"
- ∅ CPR provides circulation of blood to the brain and air to the lungs in order to prevent damage to the brain.
- ∅ If breathing stops → brain damage occurs within few minutes usually 4 minutes, and brain death could occur within 8-10 minutes

Carotid Artery Checking



1. Hands Placements for Compressions:

- ∅ Put the heel of one hand on the center of bared chest over the lower half of the breastbone, then put the heel of the other hand over the top of the first.
- ∅ Your shoulder should be right over your hands and your elbows should be straight/extended *You should deliver compressions in a smooth fashion at a rate of at least 100 compressions per*



minute. At the end of each compression, allow the chest to recoil completely.

2. Airway step

- ∅ Put the victim on his back on a firm surface.
- ∅ Kneel close to the victim neck or shoulders.
- ∅ To open the airway, tilt the forehead backward and the chin upward. (called head-tilt/chin-lift maneuver)



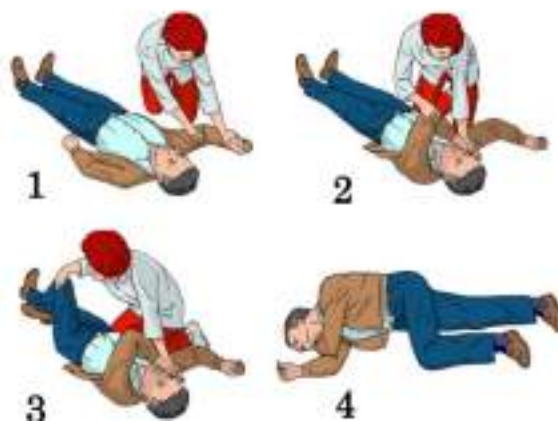
3. Breathing

- ∅ Close the nostril and give 2 breaths (mouth to mouth) and observe the chest rises.
- ∅ Give each breath over one second to allow chest recoil.



After two (2) minutes of “compression: ventilation CPR cycles”

- ∅ If the victim has no pulse, give chest compressions and resume CPR.
- ∅ Check for a pulse every approximately 2 minutes.
- ∅ If the pulse is present BUT breathing is absent, continue artificial breathing only (called rescue breathing).
- ∅ Give 1 breath every 5-6 seconds for about 10-12 breaths/minute.
- ∅ Each breath should be delivered over 1 second, making the chest rise.
- ∅ Re-check the pulse every two minutes.
- ∅ If the pulse and breathing returned to normal, place the victim in recovery position.



When should CPR be Stopped?

- Ø Patient is recovered.
- Ø You are too exhausted to continue.
- Ø The victim is pronounced dead.
- Ø The cardiac arrest continues for 30 minutes (controversial).

Why CPR may fail?

- Ø Improper procedures and techniques (example, forget to pinch nose).
- Ø Delay in administration of CPR procedure.
- Ø Terminal disease or unmanageable disease
- Ø Massive heart attack

13.11 Safety Communication at Site
HSE Communication at Site



**Safety Slogans
&
Safety Posters**

HSE Training at Site

In addition to providing PPEs it is a must to equip the workmen with necessary know how of how to use the PPE and conduct knowledge sharing training sessions to educate them regarding proper use of all equipment and safety guidelines on the whole.



Display Board for Safety, Health & Environment at Site Offices



Emergency Contact Numbers



ID Card for all Workforce



Safety Slogans at Site

Key Points for OFC Workplace Safety

- Ø Keep responsibility of own's and Other's safety
- Ø Prevent accidents from occurring by following guidelines
- Ø Follow rules and no shortcuts
- Ø Don't operate machinery without training
- Ø Use right tools and equipment
- Ø Assess risk before initiating work
- Ø Never wear loose cloths
- Ø Stand away from deep trenches while work is in progress



Section 3: Exercises

Exercise 1: Make a chart of occupational hazards at workplace.

Exercise 2: Enlist the PPEs used in fiber optic industries.

Exercise 3: Enlist first aid kit items.

Exercise 4: Perform a role play on Cardiopulmonary Resuscitation (CPR).

Exercise 5: Participate in group discussion on following topics.

- a) Optical Fiber Risks & Safety
- b) Traffic Management & Travel Safety
- c) Types of Fire Extinguishers
- d) Laser Classes

Section 4: Assessment Questionnaire

1. What are different types of Hazards?
2. What are various types of Incidents?
3. Devices used to protect employees from injury or illness resulting from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards are known as:
4. Categorize PPE kits.
5. What material is used for safety helmet?
6. Which item is used for protection against radiation from a laser system to eliminate the possibility of potentially hazardous eye exposure?
7. Upto which level noise can be reduced by using Ear plugs?
8. Why harness is used?
9. Which protective gear is used for protection against electrocution while working on electric line?
10. What is use of cotton knitted gloves?
11. What material is used for cotton knitted gloves?
12. What safety precautions should be adhered while using optical fiber?
13. Document that lists the risks of a chemical is called as:

14. What is use of Silicon Adhesives?
15. What are effects of Silicon adhesives on human body?
16. How many types of Material Handling activities are there?
17. What can keep a person alive until more advanced medical procedures can treat the cardiac arrest?
18. What do we call the steps of CPR?
19. CPR provides circulation of blood to the brain and air to the lungs in order to prevent damage to the brain. True or False?
20. When should CPR be Stopped?
21. Why CPR could fail?
22. What information is shared in safety training sessions?
23. What are three constituents of fire?
24. Tell some travel safety practices.
25. Which boots are useful during rainy seasons or when work is to be done in wet areas to prevent slippage?
26. Match the Column.

PPE	Application
1. Harness	P. Eye Protection
2. Safety Glasses	Q. HDD Operator Safety
3. Dielectric Gloves	R. Fall Protection

27. What are some good Health and Safety procedures for the workplace?
28. Which chemical can be hazardous while performing fiber splicing?
29. What is difference between caution tape and warning tape?
30. What are various types of fire extinguisher and their classes?
31. Which classes of Laser are relatively safe for eye exposure?

-----End of the Module-----



STL
academy

 **Empowering Youth!**

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