Draft Study Material

विद्यया ऽमृतमश्नुते

एन सी ई आर टी
NCERT

OPTICAL FIBRE TECHNICIAN

(Job Role)

(Qualification Pack: Ref. Id. TEL/Q6401)
Sector: Telecom

(Grade XII)

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
(a constituent unit of NCERT, under Ministry of Education, Government of India)
Shyamla Hills, Bhopal - 462 002, M.P., India

Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

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Date: 19 September, 2024

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Module 1 Introduction to Telecom Industry

Module Overview

The telecommunications industry is a dynamic sector that plays a crucial role in connecting individuals, businesses, and communities around the globe. This session introduces students to the fundamental concepts of the telecom industry, exploring its structure, components, and the technologies that drive communication.

Students will learn about the various services provided by telecom companies, including voice, data, and video communication, and how these services have evolved with technological advancements. The session will cover the key players in the industry, such as mobile network operators, internet service providers, and equipment manufacturers, as well as the regulatory frameworks that govern them.

Additionally, we will discuss the impact of telecommunications on society, economy, and culture, emphasizing its role in facilitating globalization and digital transformation. By understanding the telecom industry's significance, students will be better equipped to appreciate its influence on everyday life and future innovations.

Learning Outcomes

After completing this module, you will be able to:

- Understand the role of telecommunications in connecting people and facilitating communication across various platforms and technologies.
- Identify and compare different types of transmission media, including copper, fiber optic, and wireless, for effective data communication.
- Explain the principles of optical fiber technology, including light propagation, structure, and advantages over traditional communication methods.

Module Structure

Session 1: Telecommunication and Telecom Industry

Session 2: Transmission Media

Session 3: Basics of the optical Fiber

Session 1: Telecommunication and Telecom Industry

Aamay went to market with his mother. At the billing counter of a shop, his mother paid the bill using a card. He saw in a few seconds a receipt of payment generated. This quick transfer of money by using a swiping machine created a curiosity in his mind. He asked his mother, “How is the payment done so fast?” She explained to him about the high-speed internet and advanced telecommunication technologies, which are involved in the transaction process. This illustrates the importance of telecommunication in our day-to-day life as shown in Figure 1.1.

Fig. 1.1: Payment by card-swiping machine

In this chapter you will understand the concept of telecommunication and the scope of telecom industry in India. Optical Fiber Technician is working for installation, troubleshooting and maintenance of Optical Fiber Cable (OFC). The necessity of trained manpower in this area and their job description with skills is also explained in this chapter.

Telecommunication

Telecommunication means electronic transmission of information over distances. The information may be in the form of voice telephone calls, data, text, images, or video. It includes mobile communication, microwave communication and optical fibre communication. In a telephonic conversation, a person who is calling acts as a transmitter and a person receiving a call will act as receiver. This telecommunication process is shown in Figure 1.2. As shown in fig. 1.2, Person A calls Person B. His call signal is sent to the nearest mobile tower. Mobile tower sent the signal to MTSO (Mobile Tower Switching office). From MTSO, Signal is sent to the mobile tower that is nearest to B. Now B receives a call and communication gets started.

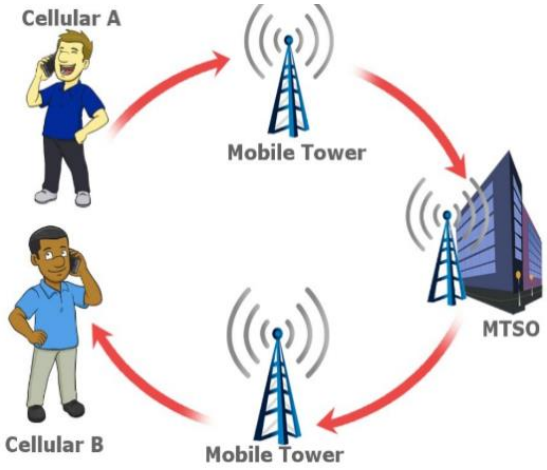


Fig.1.2: Basic telecommunication process

In the above example, the wireless method of the telecommunication process is shown. In case of wired media, cables such as coaxial cable, copper cable or fiber optics cable (OFC) are used as a medium of communication. OFC is the fastest cable media used for communication in the modern age. India is one of the biggest consumers of data worldwide.

Modern Telecommunication Tools

Modern telecommunications tools are telephone including mobile telephone, radio and television, internet, and communications networks such as LAN and WAN.

1. Telephone – A fixed line telephone connected in the telephone network. The caller is connected to the person to talk through switches at various telephone exchanges. The switches form an electrical connection between the two users and the setting of these switches is determined electronically when the caller dials the number.

2. Mobile Phones – Mobile phones have a significant impact on telephone networks. Mobile phone subscriptions are increasing as compared to fixed-line telephones.

3. Radio and television – In a broadcast system, the central high-powered broadcast tower transmits a high-frequency electromagnetic wave to numerous low-powered receivers. The high-frequency wave sent by the tower is modulated with a signal containing visual or audio information. The receiver is then tuned, so as to pick up the high-frequency wave. A demodulator is used to retrieve the signal containing the visual or audio information. The broadcast signal can be either analog or digital.

4. Internet – The Internet is a worldwide network of computers. Computers connected to the Internet have a unique IP address, through which they can communicate with each other.

5. Local Area Networks, (LAN) And Wide Area Networks (WAN) – Computers connected through cables within the limited geographical area form a network called as LAN, while computers connected in the network at the larger distance form a WAN. LAN or WAN form a private secured network and are fully protected from hackers, when they are not connected to the Internet.

Telecommunication as an Industry

Telecom is the fifth largest and fastest-growing industry in the world. Telecommunication plays an important role in the world economy. The telecommunications industry can be classified as: the equipment sector and the service sector.

The equipment sector manufactures products that are used to access and deliver telecommunications services. The equipment sector includes satellite and broadcast network equipment, wireless and wireline equipment, as well as computer networking equipment. Service sector comprises wired, wireless services, internet and other broadband services.

Telecommunication Sector

The telecommunication sector consists of companies that transmit data in words, voice, audio, or video across the globe. It is done through the phone or Internet, through airwaves or cables, through wires or wirelessly. The infrastructure is created to transmit the data (voice, audio, or video) anywhere in the world. The largest companies in this sector are telephone (both wired and wireless) operators, satellite companies, cable companies, and Internet service providers (ISP).

The telecommunications sector consists of three basic sub-sectors: telecom equipment (the largest), telecom services (next largest), and wireless communication. Telecom sector is mainly focused on video, text, and data, instead of voice. The telecom sector has shown stable long-term growth, as it has become an increasingly important basic industry today.

Wireless communication is another very fast-growing sector in telecommunications. More and more communications, mobile devices and cloud-based technology. Data connectivity speed, higher resolution, quick video streaming, and multimedia applications are some of the challenges in this sector. The continuous improvement in technology is taking place to meet the needs for faster and better connections.

Evolution of the Telecommunication Sector

The telecommunications industry began in the 1830s, with the invention of the first mechanical communication device, telegraph. Currently everyone knows how quickly modern mobile technology can transfer data within seconds. The industry is continuously evolving with each new invention: the telephone, radio, television, computer and mobile device. This technological advancement changed lives and business. Initially, physical wires were used to connect the computers. But now in the modern era, wireless digital technology is primarily used for communication.

Telecom Sector in India

India became the world's second-largest telecommunication market due to policies of the Government of India, strong consumer demand and rapid growth in this sector. The total subscriber base in the country stood at 1,183.49 million, as of January 2021. In 2019, India surpassed the US to become the second largest market in terms of number of app downloads.

The Government has enabled easy market access to telecom equipment, fair and regulatory framework, that has ensured availability of telecom services to consumers at affordable prices. The deregulation of Foreign Direct Investment (FDI) norms has made the sector one of the fastest growing and the top five employment opportunity generators in the country.

Today, telecom networks are the backbone of India's digital economy with 4G and 5G technology. It covers almost all areas including transportation, education, banking, real estate, media and healthcare. The country-wide lock-down due to COVID-19 established the centrality of communications in maintaining economic activity.

Major Telecom Companies

Currently, India is the world's second-largest telecommunications market with a subscriber base of 1.16 billion and has registered strong growth in the last decade. The total subscriber base, wireless subscriptions as well as wired broadband subscriptions have grown consistently. Tele-density stood at 84.88%, as of April 2022, total broadband subscriptions grew to 788.77 million until April 2022 and total subscriber base stood at 1.16 billion in April 2022.

Over the next five years, rise in mobile-phone penetration and decline in data costs will add 500 million new internet users in India, creating opportunities for new businesses. By 2025, India will need ~22 million skilled workers in 5G-centric technologies such as Internet of Things (IoT), Artificial Intelligence (AI), robotics and cloud computing. The major telecom companies of India are as follows.

Bharti Airtel

Bharti Airtel Limited is a leading global telecommunications company with operations in 16 countries across Asia and Africa. It is headquartered in New Delhi, India. The company ranks amongst the top three mobile service providers globally in terms of subscribers. In India, the company's product offerings include 2G, 3G, 4G and 5G wireless services, mobile commerce, fixed line services, high speed home broadband, DTH, enterprise services including national and international long-distance services to carriers. In the rest of the geographies, it offers 2G, 3G, 4G, 5G wireless services and mobile commerce.

Company Website: https://www.airtel.in

Reliance Jio Infocomm

Reliance Jio is an entire ecosystem that allows Indians to live the digital life to the fullest. This ecosystem consists of powerful broadband networks, useful applications, best-in-class services and smart devices distributed to every doorstep in India. Jio's media offerings include the most comprehensive libraries and programmes of recorded and live music, sports, live and catch up television, movies and events. Jio is about creating connected intelligence for 6 billion global minds to unleash the power of a young nation. The three-pronged focus on broadband networks, affordable smartphones and the availability of rich content and applications has enabled Jio to create an integrated business strategy from the very beginning, and today, Jio is capable of offering a unique combination of telecom, high speed data, digital commerce, media and payment services.

Company Website: https://www.jio.com

Bharat Sanchar Nigam Limited (BSNL)

BSNL is a technology-oriented company and provides all types of telecom services namely telephone services on wireline, wireless local loop (WLL) and mobile, broadband, internet, leased circuits and long-distance telecom service. The company has been in the forefront of technology with a 100% digital technology switching network. BSNL's nation-wide telecommunications network covers all district headquarters, sub-divisional headquarters, Tehsil headquarters and almost all the block headquarters.

As of April 2019, it had about 29.63-million-line basic telephone capacity, 1.39 million WLL capacity, 114.62 million GSM capacity, 31,611 fixed exchanges, 1,46,172 GSM BTSs, 95 Satellite Stations, 8,49,990 route kilometre (RKm) of OFC, 2,548 RKm of microwave network.

Company Website: http://www.bsnl.co.in

Market Size

India ranks as the world's second largest market in terms of total internet users. The total number of internet subscribers increased to 836 million in June 2022. The total wireless or mobile telephone subscriber base increased to 1170 million in May 2022, from 1,153.77 million in December 2020. Gross revenue of the telecom sector stood at Rs. 68,228 crores (US$ 9.35 billion) in the third quarter of FY21. Over the next five years, rise in mobile-phone penetration and decline in data costs will add 500 million new internet users in India, creating opportunities for new businesses.

References: Media Reports and Press Releases, Cellular Operators Authority of India (COAI), Telecom Regulatory Authority of India (TRAI), Department of Telecommunication (DoT), Department for Promotion of Industry and Internal Trade (DPIIT), India Services Sector Report by Deloitte.

Future of Telecommunication

The telecom industry has a bright future. This will provide advanced services such as download facility with gigabytes per second, 3D video, ultra-high-definition screen, self-driving car, smart home, smart city, enhanced voice quality and unbreakable connectivity.

Broadband – The lifeline of Digital India

The focus of the Government is to build Digital India through broadband highways connecting every household, village, panchayat, universities, and Government departments. It will go a long way in providing solutions to the never-ending problems of rural India and to create smarter villages. Digital forces of social media, mobility, analytics, and cloud are shaping the new virtual world today. Undoubtedly, broadband is the lifeline of the Digital India project of the government.

November, 2014, Hemant Joshi, www.deloitte.com/in

Broadband Industry

In the present Global context, telecommunication is playing a key role in changing the whole dimension and taking the progress to the next level. Telecommunication is not only influencing urban scenarios; it is also changing the economy and operations in rural parts of the country. Indian telecom is bringing considerable revenue by increasing its customer range across the country. The Government of India has recognized this fact and has taken various measures over the years to stabilize the telecom sector. The Indian telecom sector stands in 2nd position after the China wireless market.

The global broadband services are expected to grow at a compound annual growth rate (CAGR) of 9.0% from 2020 to 2027. The e-commerce for retail goods and services, digitalization of hospital records, e-government initiatives, and rapidly rising platforms for media and entertainment content need broadband services. According to the Organization for Economic Co-operation and Development (OECD), the number of wireless subscribers has a major growth.

The COVID-19 pandemic has reflected the need for digitalization to stay connected, run businesses, and education have rapidly shifted to online learning. Most businesses have transformed their strategies towards digital channels and offices have adopted a work-from-home strategy. The Digital transformation of industry has generated the strong requirement for uninterrupted broadband connectivity.

The term "broadband" commonly refers to high-speed internet access. Broadband is the transmission of wide bandwidth data over a high-speed internet connection. Broadband provides high speed internet access via multiple types of technologies including fiber optics, wireless, cable, Digital Subscriber Line (DSL) and satellite.

The broadband internet has a minimum 25 Mbps download and 3 Mbps upload speeds. The speeds of the broadband plans are 40 Mbps, 100 Mbps, 150 Mbps, 300 Mbps and more. Streaming HD videos, gaming and downloading large files require more bandwidth. So, the plans of the speed 100 Mbps and above will be better for such applications. For activities like streaming music, surfing and video conferencing, 25 to 40 Mbps is enough.

Bandwidth – The maximum amount of data transmitted over an internet connection in a given amount of time. Bandwidth is actually the volume of information that can be sent over a connection in a measured amount of time – calculated in Megabits per second (Mbps).

Streaming – The technology of transmitting audio and video files in a continuous flow over a wired or wireless internet connection. Streaming refers to any media content – live or recorded – delivered to computers and mobile devices via the internet and played back in real time. Podcasts, webcasts, movies, TV shows and music videos are common forms of streaming content.

Live streaming – Live streaming is the broadcast of an event over the internet as it happens. Webinars, conferences, awards show, sports, matches, video games and one-time events are the popular types of live streaming. You can live stream on any compatible smartphone, tablet, TV, computer or gaming console with a relatively fast internet connection.

Define range for low, medium and high bandwidth. It is difficult to get the bandwidth mentioned in table 1.1.

Table 1.1 shows the requirement of bandwidth as low, medium and high for various activities.

Table 1.1: Broadband speed required for various activities

Category	Traditional	New Model	Bandwidth
News and Information	Local / regional / national, News channels, Radio, Newspaper, Magazines	e-Papers, NewsHunt IBNLive	Low/ Medium
Banking	Bank Branches, Post Offices	m-Pesa, State Bank FreedoM, ICICI iMobile	Medium

Ticketing	Ticket Counters, Agents, Manual Payment	MakeMyTrip, BookMyShow, Expedia, IRCTC, RedBus	Medium
Ad-Posting Classifieds	Newspaper, Weeklies, Paper Classifieds, Magazines	OLX, Quikr, Matrimony sites, Real estate sites	Low/ Medium
Files and folders	Print copies, storage cabinets and colour tabs	Dropbox, Google Drive, OneDrive	High
HealthCare	Primary health centers, Community Health centers, Private hospitals	Sehat Sathi, Electronic health records, Narayana health using telemedicine	Medium/High
Education	Classrooms / Lectures / Libraries	Khan academy, Edu comp's Smart School, Massive Open Online courses	High
Shopping/ Bill payments	Shops, Malls, Cash payments at utility provider	Flipkart, Amazon, PayTM, Freecharge, BillDesk, MobiKwik	Medium

Types of broadband connections

The term broadband commonly refers to high-speed Internet access that is always on and faster than the traditional dial-up access. It is commonly used today in small businesses and homes for sending and receiving emails, downloading files, and browsing the internet. Selection of broadband internet service depends on a number of factors. individual needs, preferences, cost and place. It includes the availability as per location, speed, cost and services. Several broadband transmission technologies available today are as follows.

1. Digital Subscriber Line (DSL)
2. Cable Modem
3. Fiber
4. Wireless
5. Satellite
6. Broadband over Powerlines (BPL)

1. Digital Subscriber Line (DSL)

DSL is a wireline transmission technology that transmits data faster over traditional copper telephone lines. DSL-based broadband provides transmission speeds ranging from several hundred Kbps to millions of bits per second (Mbps). Figure 1.3 (a) and (b) shows that the data carried over telephone lines are modulated to digital signals by DSL Modem, which is being used in digital devices like computers. It is used in short distance communication with data transmission speed from 10 Mbps to 35 Mbps. It does not share bandwidth. Faster forms of DSL typically available to businesses include:

- High data rate Digital Subscriber Line (HDSL); and
- Very High data rate Digital Subscriber Line (VDSL).

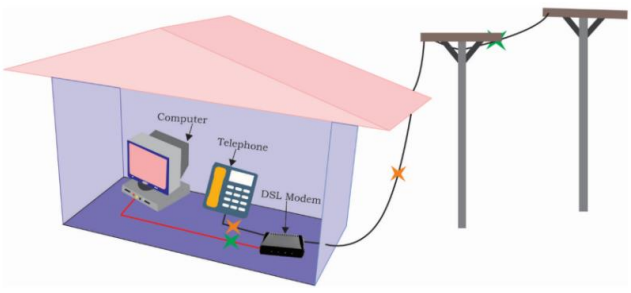


Fig. 1.3: (a) DSL modem connection distributing the voice and internet signal

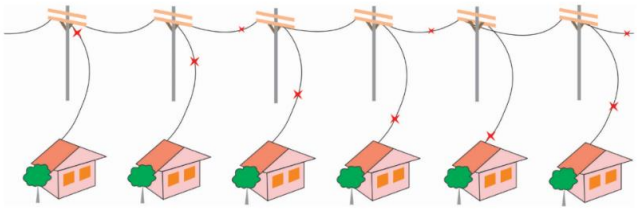


Fig.1.3: (b) DSL having a dedicated line for every user

2. Cable Modem

Cable broadband utilizes already installed coaxial cable lines. With a simple cable modem installation, the same lines that deliver audio and video to television sets will deliver internet access to computers. Modem converts an analog signal to a digital signal and vice versa. Most cable modems are external devices that have two connections: one to the cable wall outlet, the other to a computer. Cable broadband is much faster than DSL and offers speeds ranging from 10 Mbps to 1 Gbps. Figure 1.4 shows that a modem allows computers to establish connection with Internet Service Provider (ISP).

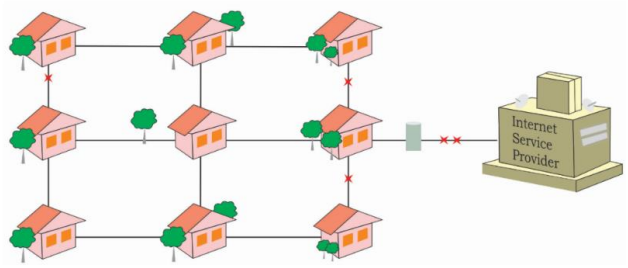


Fig. 1.4: Internet service provider connected to all users through single line

3. Fiber Broadband

Fiber broadband is the fastest of all the broadband internet connections with speed ranging from 4 Gbps to 100 Gbps. It uses optical fiber cable (OFC) for data transmission. Fiber optic technology converts electrical signals carrying data to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber optics carry large amounts of data using pulses of light through strands of fiber at the fastest speeds. Optical fibre has many advantages over copper wire. Figure 1.5 shows the data difference between copper cable and fibre optic cable.

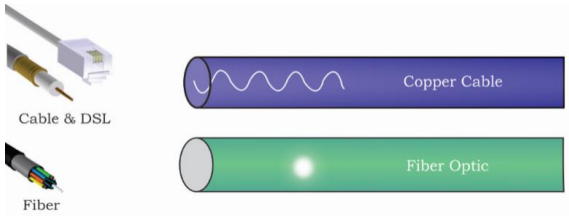


Fig. 1.5: Comparison of fibre optics cable with copper wire

Figure 1.6 shows setup of broadband communication using broadband cable link.

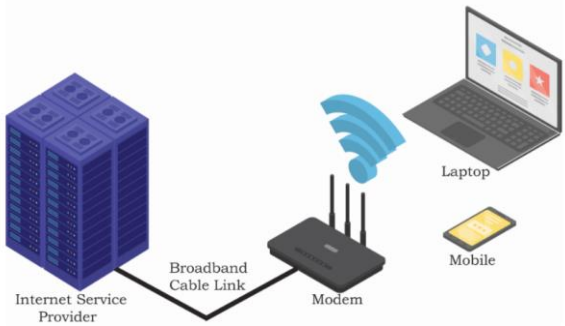


Fig. 1.6: Broadband communication

4. Wireless Broadband

Wireless broadband (Wi-Fi) is modern technology which offers wireless connectivity to devices. It uses radio waves to connect the devices via an antenna – to a service provider's facility and then to the internet. Wireless broadband internet connections are used primarily in remote areas where telephone and cable lines do not exist. The antenna needs to have a "line of site" to the service provider's facility to be effective. Speeds are comparable to DSL. An external antenna is usually required for connectivity. Figure 1.7 shows setup of wireless broadband network.

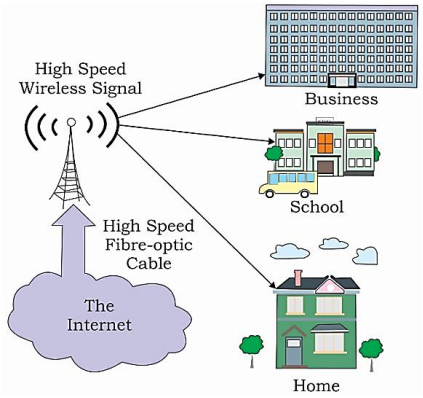


Fig. 1.7: Wireless broadband network

5. Satellite Broadband

Internet connectivity via satellite is provided by communication satellites. It is the best option in rural areas. It is another form of wireless broadband, and is also useful for providing services in remote and populated areas. But the speed is critically low. The download speed is about 500 Kbps and upload speed is about 80 Kbps. These speeds may be slower than DSL and cable modem, but 10 times faster than the dial-up Internet access. Figure 1.8 shows that satellites orbiting the earth provide links to telephone and television services links for broadband.

Fig. 1.8: Satellite broadband connection

Know More...

BharatNet, also known as Bharat Broadband Network Limited, is a telecom infrastructure provider. It is a setup formed by the ministry of communication, under the department of Telecommunication. Aim of this network is to establish, manage, and operate National Optical Fibre Network. This network can provide a minimum speed of 100 Mbps broadband connectivity using OFC. It has a target to connect 2,50,000 gram – panchayats, covering nearly 6,25,000 villages, to improve telecommunication sector in India. It has been implemented to promote Digital India. It is a joint venture of state government and private sector with the objective of facilitating the service of e-governance, e-health, e-education, e-banking, internet and other services to the rural India as shown in Figure 1.9 (a), (b), (c), (d).

Fig.1.9: (a) e-learning, (b) Wi-Fi technology (c) e-commerce, (d) e-banking

Optical Fibre in Digital India and Broadband Industry

Optical Fibre is going to play a crucial role in Digital India. The existing Fibre-To-The-Home (FTTH) is the infrastructure in the 21st century. As per the recent global survey, 71% of users are expected to switch on FTTH by 2025. The combination of fibre and wireless technology will meet the need for wide bandwidth. Under Digital India, the Indian government is aiming to provide internet access throughout the country to connect 6,00,000 rural citizens. This will bridge the gap between cities and villages through an optical fibre network.

Optical fibre uses light instead of electric signals to carry the information. Before OFC, copper cables were used as a medium to carry information. Copper cables are capable of handling high bandwidth for short distances. In a few hundred meters, copper cables start degrading their signal carrying capability, which results in loss of information. OFC comprises glass fibres. Information's in the form of light, confined in the core of the fibre and reaches at the far end. Thus, OFC can carry a wide range of bandwidth for longer distances.

Advantages of Optical Fibre Broadband Connectivity:

1. **Long Distance Communication –** OFC broadband provides fast data transfer over long distances, while copper cables cannot maintain the speed over longer distances. This makes OFC a better medium for long distance communication.
2. **High Speed –** OFC carries data in the form of light, and speed of light is very fast. Thus, OFC provides faster internet access to the users.
3. **Low Cost –** In the competitive market, OFC broadband costs as low as other existing broadband connections with high speed and reliability.

4. Role of the Optical Fibre Technician

Optical Fibre Technician, also known as Fiber Optic Technicians are usually employed by telecommunication companies that provide Internet and television services. Technicians install new cable lines, both underground and on telephone poles. They also perform maintenance on existing cables, including evaluation tests and repairing old or malfunctioning cables. They also install and maintain network systems for private lines and determine solutions for any issues preventing the service from operating normally. They provide technical assistance in designing and testing the fiber optics. Fiber optic technicians set up the electrical and electronic testing for the development of new applications. They also look into existing laser and optical fiber devices and systems. Technicians cut and splice fiber optic cables, locate problematic areas and perform their repairs as needed.

Knowledge and Skills required

Many companies now opt for fiber optic technology over old copper cables, because of its advantages to support a higher amount of data. But these new fiber systems require skilled,

experienced technicians. Optical fibre technicians need extensive technical training because they work on complicated switching equipment.

Most positions require a variety of physical skills, such as the ability to lift heavy equipment, climb poles and crawl into small spaces. Technicians also need general knowledge of electrical processes and should be familiar with the tools and equipment used in the field. Good communication skills to interact with the customers and employees of other companies. They are also responsible for promoting company services and ensuring customer satisfaction. A technician should possess strong knowledge of their company and should be able to perform services offered by the company.

The Optical Fiber Technician works for installation, troubleshooting and other technical aspects. They should have proper knowledge of various electronic components and computer operating systems. It is important to have basic knowledge of the operation and application of electrical components and common measurement instruments. They must have experience working with hand and power tools. Optical fibre technician troubleshoots any of the faults in OFC.

Fig. 1.10: Some task performed by optical fibre technician (a) Supervise the trenching (b) Perform ducting and placement of OFC (c) Technician performing splicing (d) Fault identification and maintaining the OFC

Optical Fiber Technician of Job Description

The Optical Fiber Technicians required to perform the following jobs.

- Install, troubleshoot, and maintain optical fibre systems and ensure that they work properly.
- Run OFCs underground and perform cabling.
- Conduct regular inspections of optical fibre systems, locate and repair defects.
- Examine and replace faulty and old fiber optic cables and organize scheduled maintenance routines
- Measure signal strength to ensure adequate performance.
- Take care of fiber splicing and rectify fiber optic problem areas.
- Develop sensor indicators and conduct timely inspections to make sure that faulty fiber optic system does not destabilize its performance.
- Execute premises cabling and take care of the underground and underwater cabling requirements.
- Keep track of the signal strength of different devices such as television, telephone to provide adequate performance.
- Formulate and maintain system records and system designs.

Summary

Telecom industry provides high speed internet connection in communication. By the usage of the internet, the network traffic continues its rapid growth. Video streaming has already created substantial pressure on the transmission and switching capabilities of the system. The exponential growth of 4G and 5G smartphones has also added more pressure on the internet capacity. Hence, more users are accessing streaming videos through smart phones. Furthermore, there is an increase in use of more sensors and actuators in the operation of Internet of Things (IoT) based devices such as Video Surveillance, Smart Buildings, and Smart Cities. As an example, thousands of video surveillance cameras are being deployed in a major city for security and traffic management purposes. These devices introduce additional bandwidth, latency, and security requirements. Therefore, the future Internet will be based on faster data rate, security and will rely on optical networking. In the next chapter, we will discuss optical networking technologies.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following defines the importance of broadband technology? (a) It allows us to rapidly receive and transmit large amounts of textual and visual information over the Internet (b) It has given us many more choices with cable providers (c) It forces the government to deregulate the telecommunications industry (d) It helps companies to challenge traditional media companies. (a)
2. Which of the transmission speeds can be supported by an optical fibre network? (a) Multi-gigabit speed (b) Megabit speed (c) Kilobit speed (d) 100 bit speed (a)
3. Identify the odd one in which optical fibre is not used. (a) Computer network (b) Long-distance telephone system (c) Closed circuit TV (d) Electrical wire (d)
4. Which of the following is the principle followed by optical fibre cable? (a) Reflection (b) Refraction (c) Dispersion (d) Total internal reflection (d)
5. Which of the following is not the guided medium? (a) Radio link (b) Optical fibre cable (c) Twisted pair cable (d) Coaxial cable (a)
6. Broadband refers to as _____. (a) Wide-band of frequencies (b) Narrow band of frequencies (c) Large number of channels (d) Less number of channels (a)
7. Broadband provides the data rate of_____. (a) 1 Kbps (b) 1000 Kbps (c) 128 Kbps (d) 56 ps (b)
8. The “broadband” describes the future of _____ mode of communication. (a) Digital (b) Analog (c) Pulse mode (d) Saw-tooth (a)
9. Optical fibre plays a critical role in realizing the dream of _____ India. (a) Analog India (b) Digital India (c) Modern India (d) Traditional India (c)
10. Which of the following equipment is/are needed to allow personal computers to connect to the internet? (a) Modem (b) Gateway (c) Monitor (d) Peripheral (a)

B. Fill in the blanks

1. Optical fibre technician deals with _____ cable.
2. Satellite broadband is another form of _____broadband, and is also useful for serving remote areas.
3. It converts an _____signal to a _____ signal for the purpose of granting access to the internet.
4. In India, regulatory bodies to monitor the telecom industries are _____.
5. GPRS in telecommunication stands for _____.
6. Mobile network terms are used, namely 3G, 4G. In this, ‘G’ specifies _____.
7. Data transmission speed using optical fibre cable is _____.
8. TRAI stands for Telecom _____ Authority of India.

9. Some technicians are also responsible for promoting company services and ensuring _____ (customer satisfaction).
10. In OFC, data is in the form of light, and the speed of light is very fast. This is the reason using OFC faster _____ can be provided to the users. (internet access)

C. State whether the following statements are True or False

1. Optical fibre cables are not used in telephones and televisions.
2. The optical fibre cable has copper wire and insulation over it.
3. Today optical fibre cable is the media of choice for backbone networks.
4. The highest capacity wireless media is satellite microwave.
5. A wireless network access point is a device that allows computers to access a wired network using radio waves.
6. A telephone modem is a device that connects your computer to your phone line.
7. Wireless communication transmits information over a closed and connected path.
8. Bandwidth refers to the capacity of the communication line.
9. Optical fibre cable is the fastest means of data communication.
10. In the competitive environment of internet services, OFC broadband will cost similar to our existing broadband connections. (T)

D. Short answer questions

1. What is meant by the term telecommunication?
2. List the devices which use DSL broadband technology.
3. List the devices which use cable broadband technology.
4. List the devices which use satellite broadband technology.
5. List the devices that use OFC broadband technology.
6. List the devices that use wireless broadband technology.
7. What is the role of optical fibre in the broadband industry?
8. List various broadband techniques.
9. What are the advantages of fibre broadband connectivity?
10. What is the scope of broadband in India?
11. What are the major tasks performed by optical fiber technicians?

Session 2: Transmission Media

TRANSMISSION MEDIA

A transmission medium is the data communication channel that is used to carry data from transmitter to receiver through the electromagnetic signals. In computing devices, the data is represented in signals. Signals are transmitted in the form of electromagnetic energy. Electromagnetic signals travel through vacuum, air or other transmission mediums to travel from sender to receiver. Figure 2.1 shows that a message is being transmitted from one computing device (sender) to another computing device (receiver) through medium of transmission.

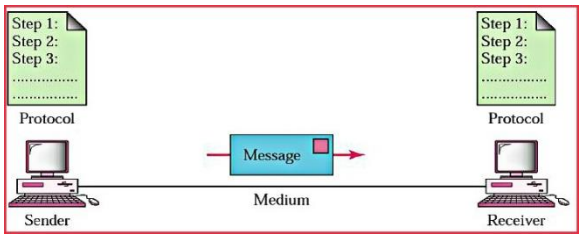


Fig. 2.1 Transmission of data from sender to receiver through a medium

Electromagnetic Spectrum

Electromagnetic energy is a combination of electrical and magnetic fields vibrating in relation to each other. It includes power, voice, radio waves, infrared light, visible light, ultraviolet (UV) light, and X, gamma, and cosmic rays. Each of these constitutes a portion of the Electromagnetic Spectrum as shown in Figure 2.2.

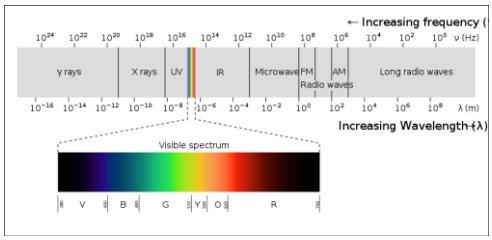


Fig. 2.2 Electromagnetic Spectrum

All portions of the spectrum may not be usable for telecommunications. Voice-band frequencies are generally transmitted as current over metal cables, such as twisted pair or coaxial cable. Radio frequencies can travel through air or space but require specific transmitting and receiving mechanisms. Visible light is used for communication using fiber-optic cable.

Types of Transmission Media

Transmission media is classified into two types namely guided or wired media and unguided or wireless media. The medium characteristics of wired media are more significant but, in wireless media the signal characteristics are important. The quality as well as characteristics of data transmission, can be determined from the characteristics of medium and signal. Wired media include twisted pair cables, coaxial cables, and Optical Fibre Cable (OFC). In a copper cable, the data bits are in the form of electrical signals, whereas, in OFC, the data bits are available in the form of light pulses. The wireless media include electromagnetic waves, such as radio waves. Figure 2.3 shows the types of transmission media.

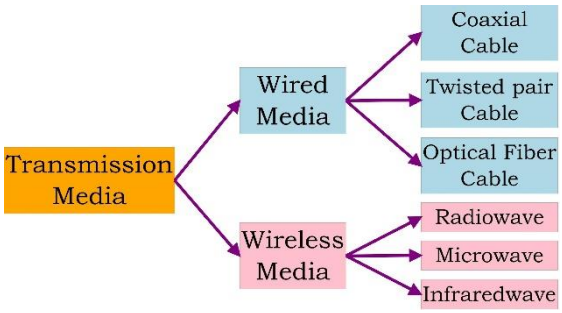


Fig. 2.3 Types of Transmission Media

Guided or Wired Media

The guided media refers to the different types of cables used in the network within physical boundaries. In this type of media, the signal energy is contained and guided within a solid media. The wired media is secure, high-speed and used for point to point communication for a small distance. The selection of networking media depends on various factors such as cost, connectivity, bandwidth and performance in presence of noise and geographical coverage. The signals can be transmitted directly through physical link via Ethernet cabling. For example, two computers are directly connected using the wired media/physical link by the cable as shown in Figure 2.4.

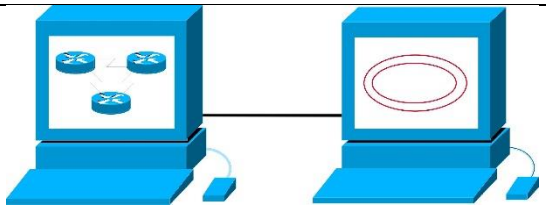


Fig. 2.4: Two computers are directly connected using the wired media by the cable

There are three types of wired media.

1. Twisted pair cable
2. Coaxial cable
3. Fiber optic cable

1. Twisted Pair Cable

A twisted pair cable is the most popular network cable. It is lightweight, easy to install, inexpensive and supports many different types of network. It supports the speed of 100 mbps. It is made of pairs of solid or stranded copper twisted along each other. The twists are done to reduce vulnerability to EMI and crosstalk. The number of pairs in the cable depends on the type. Each pair consists of two copper conductors with separate plastic insulation twisted to each other. One is grounded and the other is used to carry signals from sender to the receiver. Separate pairs are used for sending and receiving. The plastic insulation is color-banded for identification. The twisted-pair cables are used into telephone lines, DSL lines, and LAN (Local Area Network) as shown in Figure 2.5.

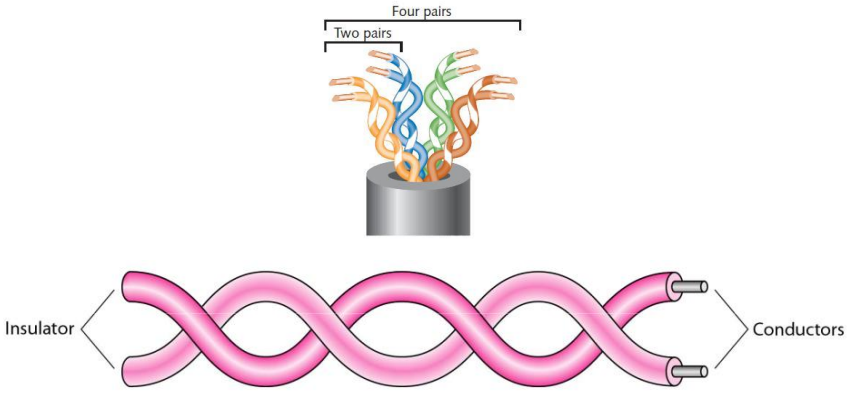


Fig 2.5: Twisted-pair cable

There are two types of twisted pair cable namely Unshielded Twisted Pair (UTP) and Shielded Twisted Pair (STP) with different Ethernet categories.

a. Unshielded Twisted Pair (UTP) – It is the most common type of telecommunication medium used in computer networks for small offices, homes and many commercial networks. Each pair is a twisted copper pair as shown in Figure 2.6. However, there is no metal shield for the protection of twisted pairs. Since, there is no additional metal shield for protection, it is available at a lower cost than STP.

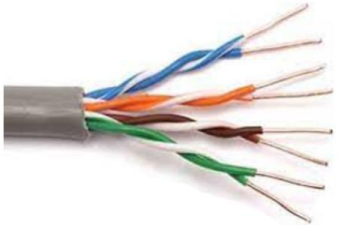


Fig. 2.6: Unshielded Twisted Pair Cable

b. Shielded Twisted Pair (STP)

UTP cable is less expensive, but it may be susceptible to radio and electrical frequency interference. Therefore, a STP is used which can also help to extend the maximum distance of the cables. In this cable, the pairs of wires are surrounded by a metallic shielding like foil or braided-mesh covering that encases each pair of insulated conductors as shown in Figure 2.7 This is known as the metal shield which is normally connected to ground so as to reduce the interference of the noise. But this makes the cable bulky and expensive. The extra coating prevents leakage of electromagnetic interference, which results in high data transmission speeds. These cables are laid underground and are difficult to maintain. So practically UTP is more used than STP.

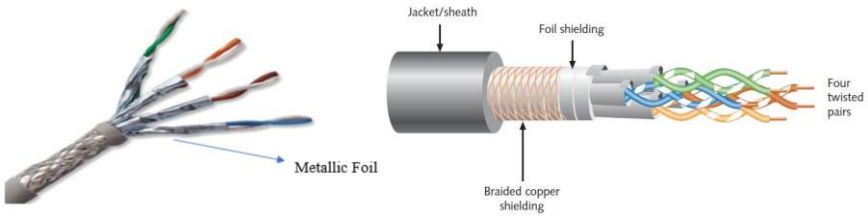


Fig. 2.7: Shielded Twisted Pair Cable

Shielded twisted pair cable is available in three different configurations.

1. Each pair of wires is individually shielded with foil.
2. There is a foil or braid shield inside the jacket covering all wires (as a group).
3. There is a shield around each individual pair, as well as around the entire group of wires (double shielded twisted pair).

Connector used with Unshielded Twisted Pair

The RJ- (Registered Jack) is the standard connector used for UTP pair cabling. It is a plastic connector that looks like a large telephone-style connector as shown in Figure 2.8. A slot allows the RJ-45 to insert only one way. RJ45 is generally used for CAT5 and CAT6 cables.

Fig. 2.8 RJ45 connector with Ethernet cable

All the laptops have Ethernet Port as shown in Figure 2.9. In this port the cable with RJ45 connector is inserted. Thus, you can connect two Laptops or any two devices with the LAN port using the Ethernet cable.

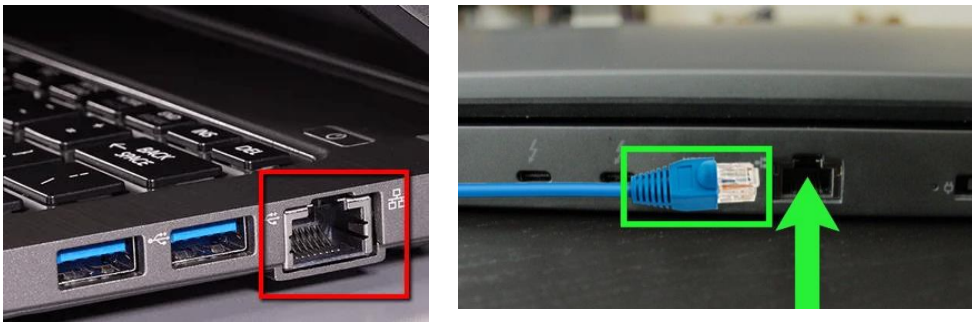


Fig. 2.9 (a) Laptop with Ethernet port (b) Connection of Ethernet cable with the Laptop

The connector can be connected to Ethernet cable using wire stripper. The following activity demonstrates how to prepare cable by connecting the RJ-45 connector.

2. Coaxial Cable

Coaxial cable (or coax) was the foundation for Ethernet networks in the 1970s and remained a popular transmission medium for many years. The twisted pair and fiber-optic cabling have replaced coax in modern LANs. Coaxial cable carries signal of higher frequency ranging from 100 kHz to 500 Mhz than twisted pair cable. Coaxial cable has a single copper conductor at its center as shown in Figure 2.10.

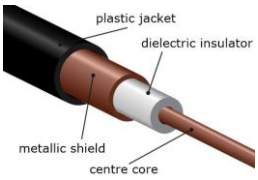


Fig. 2.10: Coaxial cable

It has two parallel conductors, a central copper conductor in the form of a solid line surrounded by PVC insulating layer, a conducting metal shield, and then outermost plastic jacket. The plastic jacket was used as a shield against the noise and for a conductor. The metal shield prevents outside interference from fluorescent lights, motors, and other computers. They are also highly resistant to signal interference. They are difficult to install but at the same time supports greater cable lengths between network devices than twisted pair cable. Cable TV and analog televisions mainly use coaxial cables. Coaxial cables have better resistance to cross talk than twisted pair cables. They are used for long distance communication.

Coaxial cable Connector

The Bayonet Neill-Concelman (BNC) connector, shown in Figure 2.11 is the most common connector used with coaxial cable. BNC connectors come with a variety of adapters, including a T connector, barrel connector, and terminator.

Fig. 2.11: BNC Connector

3. Optical Fibre Cable (OFC) – OFC consists of center glass or plastic core surrounded by several layers of protective materials. The construction of an optical fiber cable consists of core and cladding, buffer and outer jacket as shown in Figure 2.12. Typically, Core is a thin glass center of the fiber where light travels. Cladding is an outer optical material surrounding the Core. Buffer Coating is a plastic coating that protects the fiber from moisture. The entire cable is encased in an Outer Jacket.

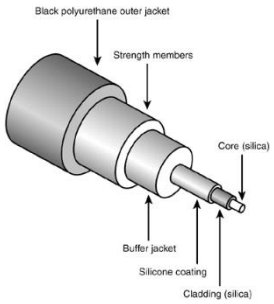


Fig. 2.12 Construction of an optical fiber cable

A fiber optic cable contains a few to hundreds of optical fibers within a plastic casing, as shown in Figure 2.13.

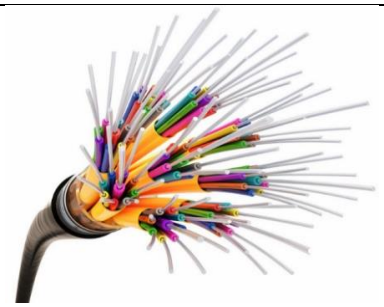


Fig. 2.13 Optical fibers within a plastic casing

OFC uses light waves for transmission and hence eliminates the problem of electrical interference. Fiber optic cable has the ability to transmit signals over much longer distances with high speed than coaxial and twisted pairs. This capability is useful for video conferencing and interactive services.

There are two common types of fiber cables – single mode and multimode. Multimode cable has a larger diameter. Single mode can provide more distance, but it is more expensive.

Connectors of OFC

There are four types of connectors commonly used in OFC.it is shown in Figure 2.14.

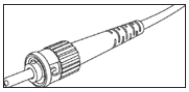
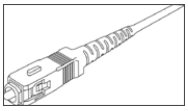
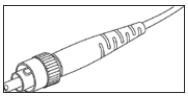
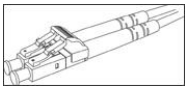
	**ST (Straight Tip connector) –** It is similar to a BNC connector. It has a 2.5mm ferrule in a simplex format. Its locking mechanism has a key which does not allow the ferrule to rotate when installed.
	**SC (Subscriber connector) –** It has a 2.5 mm ferrule, comes in a duplex format. It generally has two connectors and two fibers to send and receive transmission. Its push-pull coupling mechanism allows for quick insertion and removal. It reduces the chance for end-face damage.
	**FC (Ferrule Connector) –** It has a 2.5mm ferrule in a simplex format. This screw-on type connector has the advantage of being pull-proof and wiggle-proof when it's being installed. It is widely used in testing equipment and other similar areas where a fixed connection is critical.
	**LC (Lucent Connector) –** are the most widely used fiber connectors in the industry. These connectors feature push-release systems and will ensure a secure connection. It looks like a mini SC connector. Standard LC connectors are equipped with detachable side release clips. This makes it easier for quick polarity changes in the field.

Fig. 2.14 Connectors of OFC

Unguided or Wireless Media

An unguided media or wireless communication, does not use a conductor or wire as a communication channel. The electromagnetic spectrum used for wireless communication with air or vacuum as a medium to carry the information from transmitter to receiver. The signal from sender to receiver travels in the form of electromagnetic radiation through air. The transmitter first converts the data signal into Electromagnetic waves and transmits them by using a suitable antenna. The receiver receives them using a receiving antenna and converts the EM waves into data signals again. It is shown in Figure 2.15.

Fig. 2.15 (a)

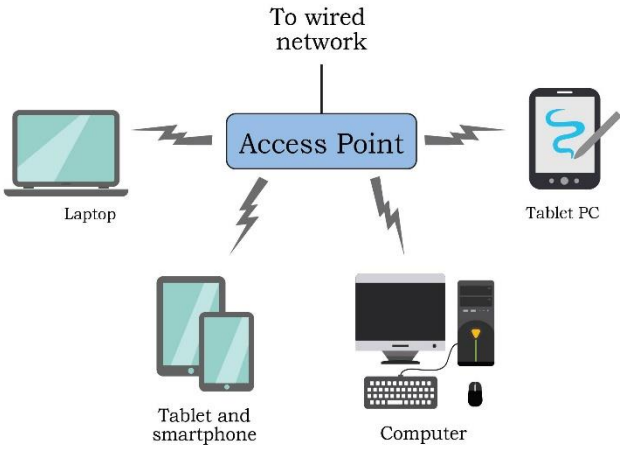


Fig. 2.15 (b)

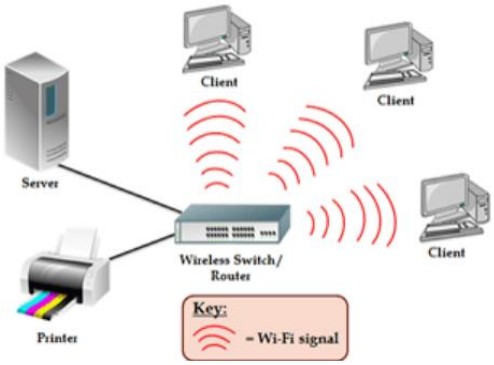


Fig. 2.15 (c) Devices connected to the network using wireless technology.

The section of the electromagnetic spectrum defined as radio communication is divided into eight ranges, called bands. These bands are rated from very low frequency (VLF) to extremely high frequency (EHF), shown in Figure 2.16.

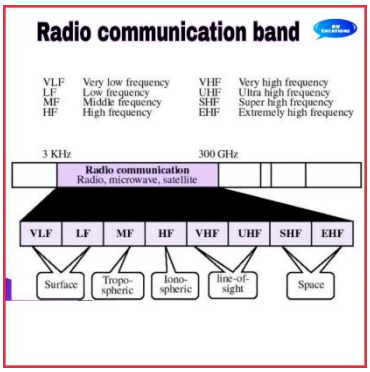


Fig. 2.16 Radio communication band

The wireless media is not in the form of an electrical or optical conductor. The earth's atmosphere is used as the physical path to carry data. Wireless media is used when it is not possible to use cable media due to the distance or obstructions.

Types of Unguided/Wireless Media

There are following types of Unguided or Wireless Media communication Channels.

1. Radio Wave

These are electromagnetic waves that travel at the speed of light in vacuum. It is using the radio frequency modulation for data transmission in wireless communication. Radio waves have the lowest frequency and highest wavelength in the spectrum. The radio waves have a frequency range from 3 KHz to 1 GHz. These waves are easy to generate and they can travel long distances. These waves are omni directional in nature which means that they can travel in all the directions.

They are widely used for communication between both indoor and outdoor because they have the property that they can penetrate through the walls very easily. Radio waves are generally used for transmitting sound, images that include both voice signal and television signals. Figure 2.17 shows that the antenna broadcasting the radio signal is received by the receiver antenna of Radio. Radio waves are used for directing the movement of ships and aircraft with the help of radio compass or radio time signals.

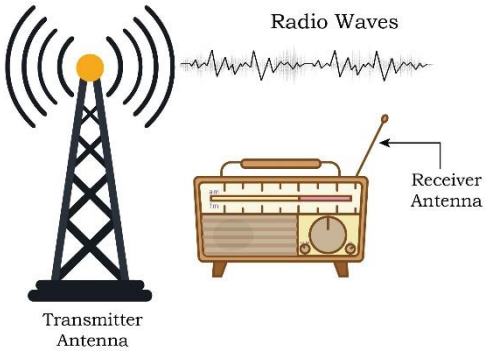


Fig. 2.17: Antenna broadcasting the radio signal to Radio station

2. Microwaves

Microwaves are electromagnetic waves which have a frequency range between 1 GHz to 300 GHz. These can travel along long distances. These are unidirectional in nature which means that they can travel only in a straight line. At very high frequencies that cannot penetrate into walls. It needs line-of-sight propagation i.e. both communicating antennas must be in the direction of each other. Microwave transmission is used for long-distance telecommunication, where installation of physical transmission media is not possible and line-of-sight transmission is available. These waves are usually used for one to one communication between sender and receiver, such as cellular phones, satellite networks, and wireless LAN. It provides a very large information-carrying capacity. Figure 2.18 shows Microwaves used in mobile tower for signal transmission

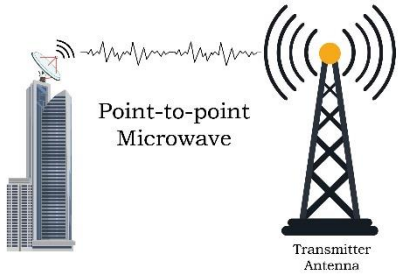


Fig. 2.18: Microwaves are used in mobile tower for signal transmission

There are two types of Microwave Transmission – Terrestrial Microwave and Satellite Microwave

(i) Terrestrial Microwave – Terrestrial microwaves require a line-of-sight path between the sender and the receiver as shown in Figure 2.19. Hence, the physical route of transmission is the line of sight. It needs directional parabolic antennas to broadcast and receive signals in the lower gigahertz range. They are used for both voice and TV transmission.

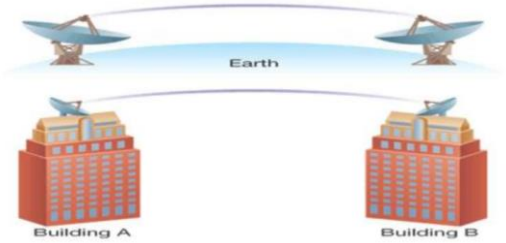


Fig. 2.19: Terrestrial Microwave

(ii) Satellite Microwave – It can transmit signals from any point on that globe by using satellite transmission as shown in Figure 2.20. The satellite receives the signal transmitted from earth station, and amplifies these signals. The amplified signal is re-transmitted to another earth station in straight lines. It provides high quality transmission to and from any location on the earth. It is used in a variety of applications such as radio/TV signal broadcasting, weather forecasting, mobile communication and wireless communication applications.

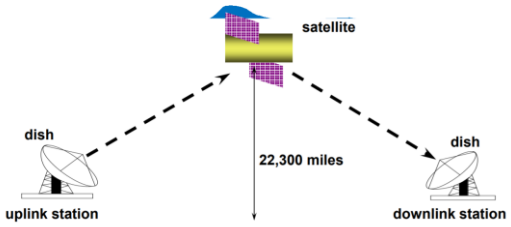


Fig. 2.20: Satellite Microwave

3. Infrared Waves

These are very high frequency electromagnetic waves of frequency ranging from 300GHz – 400THz. They cannot penetrate solid objects such as walls. They also use line-of-sight of propagation. It is used for short-distance point-to-point communication such as mobile-to-mobile, mobile-to-printer, remote-control-to-TV, and Bluetooth-enabled devices to other devices like mouse and keyboard. The remote control uses infrared light waves to control electronic appliances as shown in Figure 2.21.

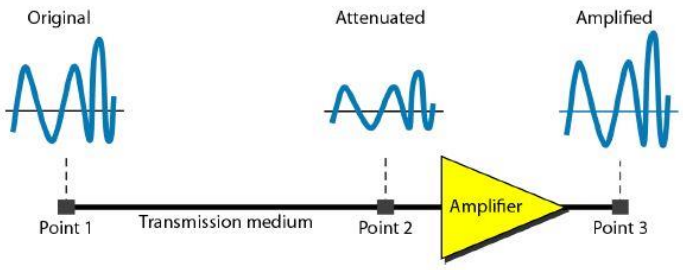
Fig. 2.21: Infrared light wave used in television remote

Related Concepts

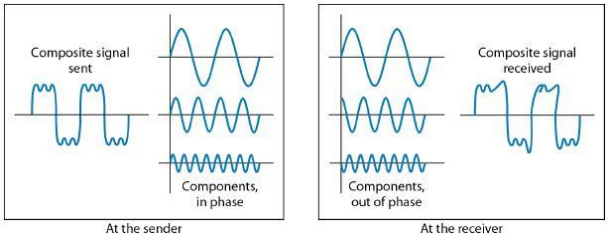
Transmission impairment

There are basically three causes of transmission impairment

Attenuation – It means a loss of energy. When a signal travels through a medium, it loses some of its energy due to resistance of the medium. To compensate for this loss, amplifiers are used to amplify the signal. It is measured in units of decibel (dB). The decibel is negative if a signal is attenuated and positive if a signal is amplified.



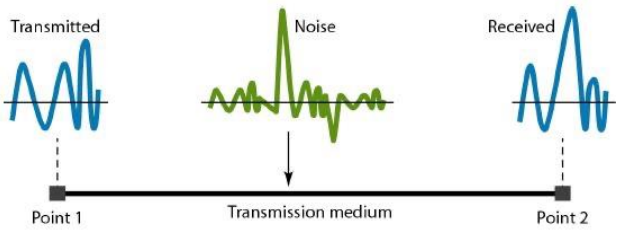
Distortion – It means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies. Each signal component has its own propagation



speed through a medium and, therefore, its own delay in arriving at the final destination. Differences in delay may create a difference in phase. The shape of the composite signal is therefore not the same.

Noise – Noise is any unwanted disturbance in data communication. The most common types of noise are electronic noise, thermal noise, intermodulation noise, cross-talk, impulse noise, shot noise and transit-time noise.

Network Throughput – It is the amount of packets passing through a particular link, physical or virtual. It is measured as Bits per second (bps), Kilobit per second (Kbps), Megabits per second (Mbps), Gigabit per second (Gbps), and so on. For example, if a packet with a size of 100 bytes



takes 1 second to flow from Computer A to Computer B, we can say the throughput between the two devices is 800 bps.

Add the line below to explain how it comes to 800 bps.

(1 byte is equal to 8 bits. Therefore, 100 bytes is 800 bits, resulting in the throughput calculation of 800 bits per second.)

Bandwidth and Throughput

Bandwidth is the maximum capacity of the media while Throughput is the actual amount of flow through per unit time. Therefore, bandwidth will set a limit on throughput and throughput can be affected other factors such as

Latency (Delay) – The latency or delay is the time taken for an entire message to completely arrive at the destination from the first bit is sent out from the source. It includes four components.

Latency = propagation time + transmission time + queuing time + processing delay

Propagation time – It is the time required for a bit to travel from source to destination. The propagation time is calculated by dividing the distance by the propagation speed.

Propagation time = Distance / (Propagation Speed)

The propagation speed of electromagnetic signals depends on the medium and frequency of the signal. For example, in a vacuum, light is propagated with a speed of 3 × 108 m/s. It is lower in air and much lower in cable.

Example – What is the propagation time if the distance between the two points is 12,000 km? Assume the propagation speed to be 2.4 × 108 m/s cable.

The propagation time is calculated as

Propagation time = (12000 * 1000) / (2.4 × 108) = 50 ms

The example shows that a bit can go over the Atlantic Ocean in only 50 ms if there is a direct cable between the source and the destination.

Transmission time – In data communications we don't send just 1 bit, we send a message. The first bit may take a time equal to the propagation time to reach its destination; the last bit also may take the same amount of time. However, there is a time between the first bit leaving the sender and the last bit arriving at the receiver. The first bit leaves earlier and arrives earlier; the last bit leaves later and arrives later. The transmission time of a message depends on the size of the message and the bandwidth of the channel.

Transmission time = (Message size) / Bandwidth

Example – What are the propagation time and the transmission time for a 2.5-KB (kilobyte) message (an email) if the bandwidth of the network is 1 Gbps? Assume that the distance between the sender and the receiver is 12,000 km and that light travels at 2.4 * 108 m/s.

The propagation and transmission time is calculated as:

Propagation time = (12000 * 1000) / (2.4 * 108) = 50 ms

Transmission time = (2500 * 8) / 109 = 0.02 ms

Note that in this case, because the message is short and the bandwidth is high, the dominant factor is the propagation time, not the transmission time. The transmission time can be ignored.

Example – What are the propagation time and the transmission time for a 5-MB (megabyte) message (an image) if the bandwidth of the network is 1 Mbps? Assume that the distance between the sender and the receiver is 12,000 km and that light travels at 2.4 * 108 m/s.

The propagation and transmission time is calculated as:

Propagation time = (12000 * 1000) / (2.4 * 108) = 50 ms

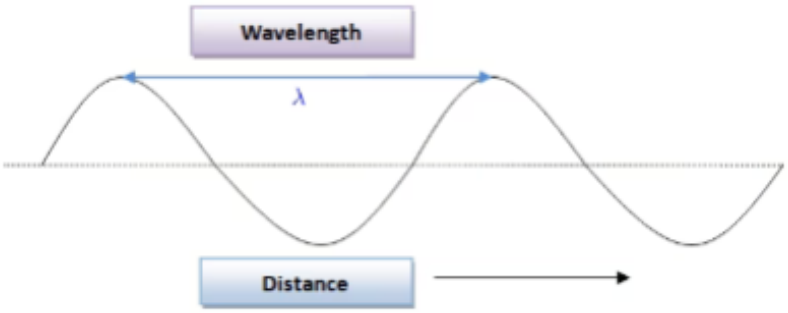
Transmission time = (5000000 * 8) / 106 = 40 s

Note that in this case, because the message is very long and the bandwidth is not very high, the dominant factor is the transmission time, not the propagation time. The propagation time can be ignored.

Queuing Time – It is the time needed for each intermediate or end device to hold the message before it can be processed. The queuing time is not a fixed factor; it changes with the load imposed on the network. When there is heavy traffic on the network, the queuing time increases. An intermediate device, such as a router, queues the arrived messages and processes them one by one. If there are many messages, each message will have to wait.

Processing delay – It is the time it takes nodes to process the packet header. Processing delay is a key component in network delay. During processing of a packet, nodes may check for bit-level errors in the packet that occurred during transmission as well as determining where the packet's next destination is.

Wavelength –It is a measure of distance a signal can travel in a period. It is the distance between corresponding points. The units of wavelength are meter, centimetres.



Important Terminologies

Signal – Frequency representation which conveys information could be a form of simple data or in complex message format.

Signalling – Signalling is the process of connecting source and destination by doing authentication of the service and users and authorizing the session.

Frequency – The number of times in a second an electric signal or electromagnetic wave, completes a cycle.

Network – Group of systems interconnected in a fashion where they could share, exchange data, and communicate the necessary.

Mode – Fashion/ way of propagation in a media, in specific to Fiber cable mode is the light patterns which are made to travel across.

Multimode fiber – Kind of mode in which more than one light signal can travel across is called multimodal fiber. It is naturally a little bigger than single mode fiber. (Almost always 50 or 62.5 microns – a micron is one millionth of a meter).

Single mode fiber – Fiber which allows a single Light wave to travel across is termed as Single mode fiber. It has a smaller core compared to multimodal fibers (about 8-9 microns). Single mode is mostly preferred for telecommunication services like telephony, fiber to the home and CATV.

Fiber ID – Based on the fiber inner and outer core construction Fiber ID tagged for identification. Core and cladding diameters are expressed in microns; most multimode and single mode fibers have an outside diameter of 125 microns. Fiber IDs are internationally standardized with specifications that include all characteristics.

Plastic optical fibers (POF) – One type of multimodal fibers. Normally preferred for short distance for networks which run effectively with low speed.

Cable – Cables come in various colors and sizes. These protect the fiber from weather, provides protection from stress. Cables are manufactured based on the number of fibers to be accommodated. There are many types of cables few in the list are tight buffers (with hard plastic coating on fiber preferred for mainly indoors), loose-tube, (light coating on fiber), ribbon (fibers made ribbons).

Jacket – The outermost cover on the cable is termed a jacket. These jackets provide additional safety to the cables.

Strength members – The supportive element used for safety and operations.

Armor – Armor Discourages rodents from chewing through it.

Connector – Device used for connecting fibers. The connectors could be kept in the system and could be disconnected based on requirement.

Ferrule – A tube which holds a fiber for alignment, usually part of a connector. / No need to change.

Splice – Joining fibers /broken fibers is carried out with a tool termed as splicer and a process called as splicing. This joint (splice) between two fibers made will be permanent.

Hardware – Terminations and splices require hardware for protection and management patch panels, splice closures, etc.

Attenuation – Loss in the power while signal travels across is termed as attenuation. Mostly expressed in decibels (dB). For fibers, considerable is attenuation coefficient or attenuation per unit length with unit of dB/km.

Bandwidth – Group of frequencies could be termed as Bandwidth. The difference between the frequency's ranges transmitted is considered as Delta Frequency in turn called as bandwidth.

Decibels (dB) – A unit of measurement of optical power which indicates relative power. A -10 dB means a reduction in power by 10 times, -20 dB means another 10 times or 100 times overall, -30 means another 10 times or 1000 times overall, & so on.

dB – An absolute Optical power measurement referring to 1 milli watt.

Optical Loss – The amount of optical power lost as light is transmitted through fiber, splices, couplers, etc., expressed in "dB"

Switch – A mechanical or electronic device that opens or closes circuits completes or breaks an electrical path or selects paths or circuits.

Multiplexing – Process of mixing of multiple signals before transmitting over media.

Optical Power – Capacity of optical signal strength represented in terms of power, measured in dBm/decibels.

Scattering – Dispersion of light rays due to obstacles. Tag name given for the light ray changing the path of travel and splitting energy into multiple angles this will cause majority of loss in optical fibers and is used to make measurements by an OTDR.

Wavelength – Wavelength is a term for the color of light, usually expressed in nanometres (nm) or microns (m). Fiber is mostly used in the infrared region where the light is invisible to the human eye. Most fiber specifications (attenuation, dispersion) are dependent on wavelength.

Dispersion – Pulse spreading caused by modes in multimode fiber (modal dispersion), the difference in speed of light of different wavelengths (CD or chromatic dispersion in multimode or single mode fiber) and polarization (PMD or polarization mode dispersion in single mode)

PSTN (Public Switched Telephone Network) – Traditional wired phone service. It refers to the standard telephone service, e.g., BSNL.

BTS (Base Transceiver Station) – It is a wireless interface with a mobile handset in mobile communication. It has an antenna mounted on a tower and a trans-receiver.

BSC (Base Station Controller) – BTS are administered by a BSC Signalling.

MSC (Mobile Switching Center) – It is the hub of the mobile communication network. It connects mobile stations to PSTN.

Roaming – Realization of all frequency ranges in sequential manner.

Spectrum – Device used for the TRX operations from the user end.

Telephony – Word used to describe the science of transmitting voice over a telecommunications network.

Modem – A device that both modulates and demodulates signals.

NLD – National Long-Distance Telephony – pertains to calls outside the local area, to any place in India.

ILD – International Long-Distance Telephony – outside India.

SDCA – Short Distance Charging Area – There are a total of 2647 SDCA in India, each having a unique STD code.

LDCA – Long Distance Charging Area. A few SDCAs make a LDCA. A call beyond 50 km distance is considered a long-distance call.

Service Plan – The plan under which it operates to publicize the service lists to users is termed as service plan. This plan may have altered over time.

Tariff – Services offered to users are categorized based on the subscription and categories known as tariff.

Check Your Progress

A. Multiple Choice Questions

1. The Unshielded Twisted Pair (UTP) type of cabling used in the computer networks for a) small office, home and many commercial networks b) Cable TV c) In industries for linking networks across buildings d) Television remote (a)
2. L band is also known as a) Long-wavelength band b) Short-wavelength band c) Extended-wavelength band d) Ultra-long wavelength band (a)
3. While installing the cable remember to follow the guidelines such as a) Always have less cable than you think you'll need b) Don't keep a minimum of 3 feet away from fluorescent light boxes and other electrical interference sources c) Each cable should be labelled on both ends d) If cable must be routed across the floor, don't cable protectors to safeguard the cable (c)
4. The O-band have the wavelength in the range of (a)1360-1460 nm (b) 1460-1530 nm (c)1530-1565 nm (d)1260-1360 nm
5. The LC (Lucent Connector) is used in (a) Optical fiber cables (b) Coaxial cables (c) Shielded Twisted pair cable (d) Unshielded Twisted pair cable (a)
6. In STP cable the pairs of wires is (a) surrounded by a metallic shielding (like foil) (b) has two parallel conductors, a central copper conductor in the form of solid line wire, surrounded by PVC insulating layer, a conducting metal shield, and then outermost plastic jacket (c) consists of a glass or plastic core at the center of the cable that is surrounded by several protective layers (d) there is no metal shield for the protection of twisted pairs (a)
7. Category3, Category 5, Category 5e belongs to the which type of cable (a) UTP b) STP c) Fiber optics cable d) UTP/STP (a)
8. The Bayonet Neill-Concelman (BNC) connector is the most popular form of (a) coaxial cable connector (b) UTP connector (c) STP connector (d)OFC connector (a)
9. The core of the OFC cable at the center of the cable is made up of (a) Copper (b) glass or plastic (c) Iron (d) Brass (b)
10. 100 Base SX is a specification for (a) Multimode Fiber (b) Single mode Fiber (c) Unshielded Twisted Pair (d) Thin Coaxial

B. Fill in the blanks

1. Fiber optic cable is a _____ transmission media (wired or guided)
2. UTP stands for _____ (Unshielded Twisted Pair)
3. The cost of the UTP cable is _____ than STP.
4. In Shielded Twisted Pair cable, the pairs of wires are surrounded by a metallic shielding (like foil).
5. RJ-45 connector is used in an ethernet network (ethernet).
6. The straight through is _____ used to connect computers in local area networks. (twisted pair cable).
7. A twisted pair cable is also called _____ (patch cable).
8. A crossover cable is used to connect two computing devices of the same type via NIC (network interface card) such as connecting computer to computer, router to routers, or hub to hub.
9. Coaxial cables have better resistance to cross talk than twisted pair cables.

10. The requirements for thin coaxial cable carrying Ethernet signals are known as _____ (10Base2)
11. The requirements for thin coaxial cable carrying Ethernet signals are known as _____ (10Base5)

C. State whether the following statements are True or False

1. The optical fibre cable has copper wire and insulation over it. (F)
2. Optical fibre cable is the fastest means of data communication. (T)
3. 10BaseT Ethernet cable has the speed of 10,000 Mbps. (F)
4. RJ-45 connector looks like a telephone-style connector. (F)
5. Unshielded Twisted Pair (UTP) is the most common type of cabling used in the computer networks for small office, home and many commercial networks. (T)
6. Guided Transmission Media is a cabling system that guides the data signals. It is also known as wired or bounded media. (T)
7. The Bayonet Neill-Concelman (BNC) connector is the most popular form of OFC connector. (F)
8. ST (Straight-tip connector) is a type of OFC connector. (T)
9. Radio Waves are electromagnetic waves that travel at the speed of light in vacuum. They are omnidirectional in nature. (T)
10. Microwaves are used for unicast communication such as cellular phones, satellite networks, and wireless LANs. (T)

D. Short answer questions

1. What is transmission media?
2. What are the types of transmission media?
3. What is the difference between UTP and STP type of cables?
4. Give examples of transmission media?
5. Mention the most commonly used transmission media in homes?
6. Explain the connector used for Twisted pairs of cables?
7. How to make the Ethernet cable with the connector?
8. What is Coaxial cable? How is it better than a Twisted pair cable?
9. What is the difference between the thin coaxial cable and thick coaxial cable?
10. What do you mean by the OFC? Where is it used?
11. What are the various bands of the OFC?
12. What do you mean by the wireless Network?
13. What is the difference between the radio waves and Microwaves?

Session 3: Basics of Optical Fiber

Sita's class teacher assigned her a project work in which she has to write all the information about the COVID19. Her project must cover important points like -

- The type of vaccine developed
- The state in which the largest number of deaths occurred.
- The Lock-down situation in each place.

To complete her project, she needs an internet connection with a laptop. So, she connected her laptop with the Wi-Fi at her home. She easily downloaded all the data related to her project and completed her assignment. But one day her Wi-Fi router stopped working. So, she found another way to connect her laptop. She took the Ethernet cable of her Telephone line and connected its port to the laptop. Her laptop now was easily accessed to the internet. So, by using both the means she used the internet connection.

In this chapter, the basics of optical fiber communication covered in class XI will be reviewed. The structure of optical fiber, its classification, losses of light and optical fiber communication will be discussed in brief. The various methods of data transmission, its cable types and connection both wired and wireless are explained.

OPTICAL FIBER

Optical fiber is a thin transparent fiber made up of glass or plastic. It is like a human hair that is used to transmit a light signal. The light signal passed through one end of this cable can be seen at the other end. The light ray travels to this fiber at a very long distance of several kilometers.

Metal wire is used to transmit electrical signals from one end to another. In an optical fiber, the signal is transmitted in the form of light at a very long distance with high bandwidth. When the signal is transmitted in the form of light, then there is a very low loss to the signal as compared to transmitting the signal in the form of an electrical signal. So, all modern communication systems make use of the optical fiber for communication. This means any connection at phone or a broadband connection at home is made available through the optical fiber cable. It is used with CCTVs, cable TV, and local area network (LAN).

Optical fibers are used as a medium for telecommunication and networking because it is flexible and can be bundled as cables. They are useful for long-distance communication because in optical fiber attenuation of the light signal is less as compared to an electrical signal in copper fiber. A typical optical fiber is shown in Figure 3.1.

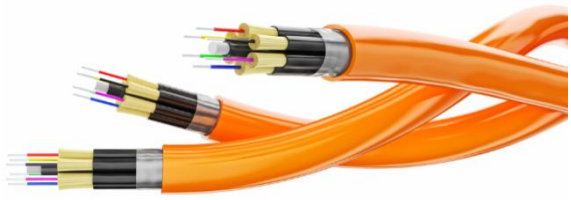


Fig. 3.1: Optical fibre cable (OFC)

Structure of Optical Fiber

The structure of an optical fiber will consist of a small core, cladding, buffer and outer jacket. The diameters of these are very small and they are in micrometres i.e., 10^{-6} meters. The core is the central part of the optical fiber. This is the part of the optical fiber through which the light ray travels. This part is either made up of glass or plastic. The diameter of the core is very small (about 8μm.) The cladding is the supporting or surrounding part of the core which is also made of glass or plastic. The diameter of the cladding is more than that of a core, it is about 125 μm .

It is observed that the refractive index of the cladding is less than that of the core. The buffer is the plastic coating that surrounds the fiber. It is used for the protection of the fiber. The outer jacket is the outermost part of the fiber. This jacket is also made up of plastic and it is also used for the protection of the core and cladding of the fiber.

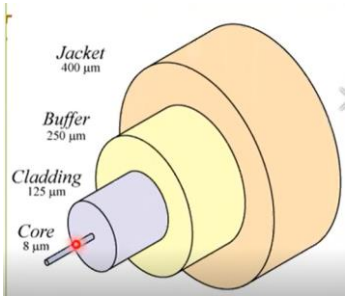


Fig. 3.2: Structure of optical fibre

Classification of Fiber

Fiber can be classified into different categories. The classification is done based upon the material used, number of modes of fiber used for the propagation of light ray and the refractive index of the material. As per the material, the optical fiber can be classified as glass or plastic fiber. The number of modes is the way the light can be propagated through fiber. There is a single modal fiber, or multi-mode fibers. The refractive index of the material used is also a basis for the classification of the optical fiber. The fiber can be a step index fiber, where the refractive index of core can change in step only, or graded index fiber where the refractive index of fiber will not change step, but it will change gradually. The whole classification of optical fiber cable is shown in Figure 3.3.

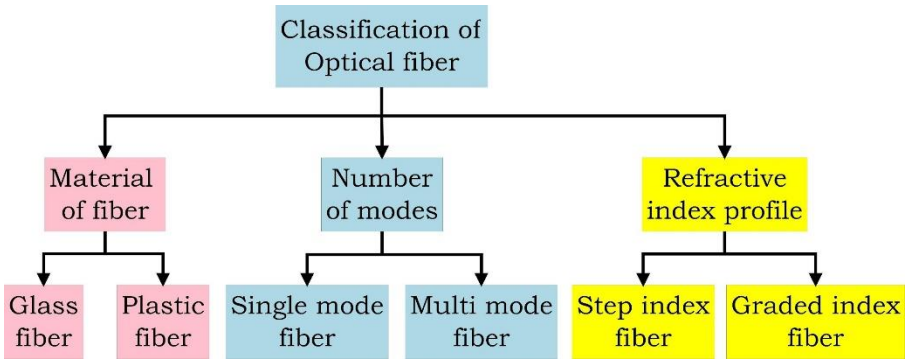


Fig. 3.3: Classification of optical fibre cable

ACCEPTANCE ANGLE AND NUMERICAL APERTURE

In this section, we will see the acceptance angle, numerical aperture and also obtain an expression for acceptance angle and numerical aperture of the optical fiber.

Acceptance angle of the optical fiber – as we know that light can be propagated through optical fiber. When a light ray is passed through fiber, it will travel from one end to the other end of fiber, if the condition of total internal reflection is satisfied. All the light rays that are incident on the fiber are not propagated to the fiber. Only certain rays that are considered within a certain angle only will be propagated through the fiber, while all of the rays will be rejected by the fiber or they will be absorbed by the cladding. So, the light rays that are incident in the fiber with certain angles, will be propagated through the fiber. Hence this angle is called an acceptance angle**.** The light ray which incident within the acceptance angle of the optical fiber will be propagated through optical fiber i.e., they trace the zigzag path through the optical fiber.

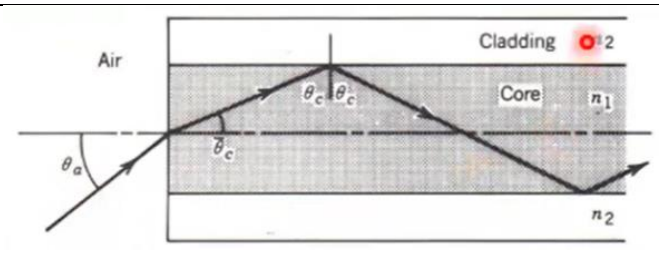


Fig. 3.4 Core with refractive index

Figure 3.4 shows the core having refractive index n_1 and the cladding having refractive index n_2 and the light rays are incident from air into the fiber. So, this angle is called an acceptance angle θ_i. The acceptance angle of an optical fiber is the maximum external angle against the fiber axis hitting the fiber core that allows the propagation of light into the fiber. It is required to propagate the light ray through the fiber. This angle is unique for each fiber and it will depend upon the material used for the construction of the fiber and also it will depend upon the core diameter of the fiber.

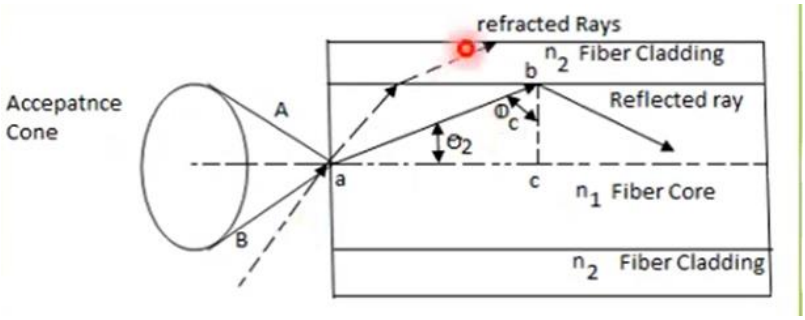


Fig. 3.5

Now, when the light rays are incident on both the sides of the axis of the fiber then the cone will be formed by the acceptance angle on both the sides of the fiber axis and this cone is called the acceptance cone. As shown in the diagram the light ray is incident below the axis as well as both axis and therefore there will be a kind of cone formed and this cone is called an acceptance cone. So, the light rays which are incident on to the fiber with the acceptance cone will be propagated through the fiber while all other light rays which are outside the cone will be refracted into the cladding and they will be absorbed in the cladding.

Let's go for the discussion of one important parameter that is associated with the fiber and this parameter is known as the numerical aperture. It is defined as the light collecting capacity of the fiber. The light collecting capacity of any fiber then can be measured by using a parameter called the numerical aperture.

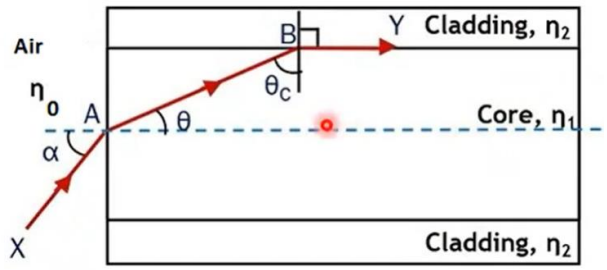


Fig. 3.6

$$\sin\alpha = \sqrt{1 - (\frac{n_2}{n_1})^2}$$

$$\sin\alpha = \sqrt{\frac{n_1^2 - n_2^2}{n_0}}$$

For example, a fiber having the core of refractive index n_1 and cladding having refractive index n_2 and n_1 is greater than and n_2. Suppose the light rays are incident from the air, where its refractive index is n_0.

Applying Snell's law to air-core interface: $n_0 \sin\alpha = n_1 \sin\theta$

But from the figure, you can write $\theta = \frac{\pi}{2} - \theta_c$

Substituting the value, we get

$$n_0 \sin\alpha = n_1 \sin$$
$$n_0 \sin\alpha = n_1 \cos\theta_c$$
$$\sin\alpha = \frac{n_1}{n_0} \cos\theta_c$$

Also, $\cos\theta_c = \sqrt{\sin^2\theta_c}$

Applying Snell's Law to the core-cladding interface (see figure….)

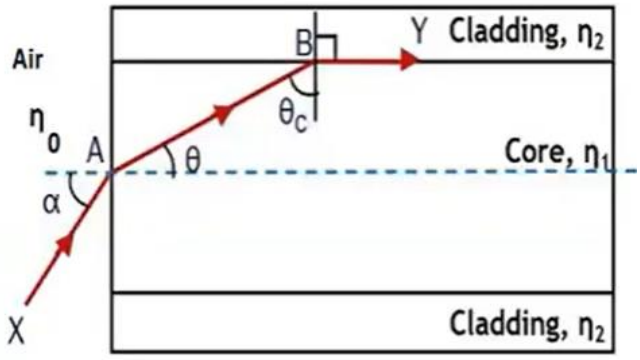


Fig. 3.7

$$n_1 \sin\theta_c = n_2 \sin 90^0$$
$$n_1 \sin\theta_c = n_2$$
$$\sin\theta_c = \frac{n_2}{n_1}$$
$$\cos\theta_c = \sqrt{1 - (\frac{n_2}{n_1})^2}$$

The Refractive index for air is $n_0 = 1$

Rewriting the equation as:

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

Now, equation can also be written as

$n_1^2 - n_2^2 = (n_1 + n_2)(n_1 - n_2) = \frac{(n_1+n_2)}{2} \frac{(n_1-n_2)}{n_1} 2n_1$

We can take approximately $\frac{(n_1+n_2)}{2} \approx n_1$ because refractive index of core and cladding are almost same and since again $\Delta = \frac{(n_1-n_2)}{n_1}$ where the Δ is the fractional difference between the core and the cladding.

$$n_1^2 - n_2^2 = 2n_1^2\Delta$$

So, if you know the value of Δ then it is possible to compute the NA for the optical fiber by using this relation. Let's understand this more clearly by using a solved example

Problem 1. A typical relative refractive index difference for an optical fiber designed for long distance transmission is 1%. Estimate the numerical Aperture and the solid acceptance angle in the air for the fiber when the core index is 1.46. Further, calculate the initial angle at the core-cladding interface within the fiber.

Solution – Given the refractive index Δ =1%=0.01, n_1=1.46,

1. $NA\sqrt{n_1^2 - n_2^2} = n_1\sqrt{2\Delta}$ =1.46$\sqrt{2 \times 0.01}$ =0.21
2. Acceptance angle θ= $\sin^{-1}NA = \sin^{-1}0.21$ = 12.12 degree =12.12×$\frac{\theta}{180}$
3. Relative Refractive index $\Delta = \frac{(n_1 - n_2)}{n_1}$ =$1 - \frac{n_1}{n_2}$

Therefore, $\frac{n_1}{n_2} = 1 - \Delta$ =1-0.01= 0.99

4. Critical angle: $\sin\theta_c = \frac{n_2}{n_1}$

Therefore, $\theta_c = \sin^{-1}\frac{n_2}{n_1}$ =$\sin^{-1}0.99$= 81.9 degrees.

Assignment

- The light enters from air into the optical fiber core having an acceptance angle of 20^0

1. What will be the NA of the fiber (in the air)?
2. If any optical fiber has the refractive index of the core =1.4n_1 and refractive index of cladding =1.3n_2. Calculate the NA of the fiber.?
3. An optical fiber has a core refractive index of 1.36 and the fractional refractive index is 0.025. Find the

   (i) refractive index of the cladding

   (ii) the NA

   (iii) Acceptance angle

Note: Numerical aperture (NA) is an important parameter for optical fiber because it will decide the application of the optical fiber. In order to achieve short distance communication, one can make use of the optical fiber where numerical aperture can be in the range of 0.4 to 0.5 where as to achieve a very long-distance communication of several km, make use of optical fiber NA in the range of 0.1 to 0.3. Once the NA became small then it became difficult to launch the optical power in the fiber. If the numerical aperture is more than it is quite easy to launch the optical power in the fiber.

Dispersion in Optical Fiber

When the light is propagated through the optical fiber there are different types of distortions that appear in the propagation of the light rays.

Distortions in optical fiber – Whenever the light is propagated through the optical fiber then there are two common types of distortions that appear for the propagation of light ray. The first distortion is called dispersion and the second distortion is called attenuation.

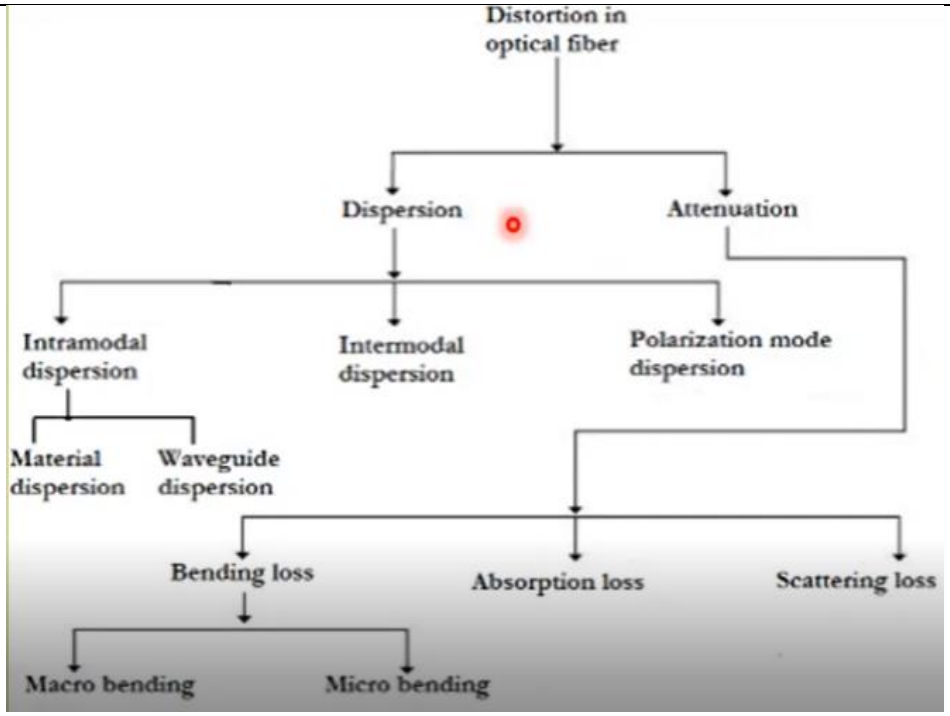


Fig. 3.8

The attenuation is a kind of resistance to the propagation of light through the optical fiber. This resistance or attenuation appears due to the bending of the fiber, absorption of light or scattering of light to the fibre. Due to this light gets lost when propagated through optical fibre. There is another type of dispersion that appears to propagate light. When the light pulse is propagated then the original pulse will change its shape and it will get wider and that is called the dispersion.

This dispersion can be of different types, such as intramodal dispersion, intramodal dispersion and polarized board dispersion. Intramodal dispersion may be due to material or it can be either a waveguide dispersion. So, let's understand what is meant by Dispersion of the light ray in the fiber. As discussed earlier when the light is propagated through the fiber it will suffer from the various processes and these distortions are mainly either dispersion or attenuation. Dispersion could be considered as spreading of the light. So, whenever the light is propagated through the fiber and then the light ray will have to travel a long length to the fiber. Sometimes the fiber length is several kilometers. In such a case there is a spreading of the light when it is propagated through the fiber and this spreading of the light is called as dispersion

Let us understand this by example:

Example – We have an input pulse of which the width is w_1 and when this fall is propagated through the fiber then at the end, we will receive a pulse of which the width is w_2. So, one can easily observe that the width w_2 is higher than that of the input pulse width w_1. This effect is called a dispersion and the dispersion effect is also called the pulse broadening effect because here one can easily observe that the original pulse speed is being extended and therefore this is called as a pulse broadening effect.

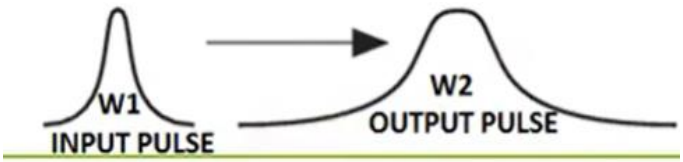


Fig. 3.9

The pulse that appears at the output is wider than that of the input pulse. so, if w_1 is the width of the input pulse and w_2 is the width of the output pulse then one can easily observe that due to dispersion, $w_2 > w_1$. So, we can define

$$\text{fiber dispersion} = \sqrt{W_2^2 - W_1^2}$$

Dispersion is measured in the terms of units of time and many times it is measured in the form of nanoseconds or picoseconds. Again, the dispersion in the fiber will depend upon the length of the fiber. Therefore, the dispersion is written as nanosecond/ kilometer.

So, the dispersion can be rewritten as = length of the fiber X dispersion/kilometer so as the length goes on increasing then the dispersion will also go on increasing.

Dispersion is very important attenuation because it will limit the bandwidth for the information carrying capacity of the fiber. So, every attempt must be made to keep this dispersion small because if this dispersion is small then we can have a larger bandwidth optical fiber.

Types of dispersion

Inter-modal dispersion – It will result from the fact that the light wave propagates through the fiber in different modes at different group velocities. We know that whenever the light is injected into the fiber then some of the light rays will travel along the axis of the fiber, some of the light rays will trace the Zig Zag path along with the fiber. Hence, when the light rays are propagated in the fiber, they are located at different modes and therefore they will have different velocities and therefore whenever they reach the other end of the fiber then we will find that there will be a spreading of the light ray.

Intramodal dispersion – intramodal dispersion can be further classified into material dispersion and waveguide dispersion.

Material dispersion – It will result from the fact that the refractive index of the medium changes with the wavelength of the light. So if the wavelength is changed then the refractive index of the medium will also get changed. Because of this, some kind of dispersion is introduced in the propagation of light called material dispersion.

Waveguide dispersion – Another dispersion that appears in the fiber is called waveguide dispersion because whenever we propagate the different wavelengths then every different wavelength will have a kind of different delay when it reaches the other end of the fiber. Therefore, the dispersion is introduced as waveguide dispersion.

Polarized mode dispersion – the polarized mode of dispersion appears in the optical fiber because of a change in the propagation of direction of light. So, whenever the light rays are propagated through the fiber then there is a change in the direction of the light and this direction of the light gets changed because of change in the refractive index and the change in the refractive index is due to polarization. Therefore, such dispersion is called the polarized mode dispersion

5. Losses in Optical Fiber

As discussed earlier, when the light ray is propagated through the optical fiber then there are many attenuation which means that will cause the loss of the light in the optical fiber. We know that when the light ray is propagated through the fiber, it will suffer various attenuation. This attenuation to the light ray when it is propagated through the optical fiber is called fiber losses. There are certain reasons behind the loss of the light in the optical fiber. There are three major causes for the loss of the light in the optical fiber-the material loss, the scattering loss, and the third loss is called bending loss.

Material Loss – The material that is being used for the construction of the fiber may absorb the light and it will cause the loss of the light when it is propagated through the fiber. Absorption loss is less and it can be reduced by better manufacturing of the fiber.

Scattering loss – Light is scattered by the molecules of the material due to structural imperfections or impurities. Such losses are called scattering losses.

Bending loss – Bending loss is caused by the deformation of the fiber structure.

Note: All losses of the fiber depend on the wavelength of light and hence it should be chosen carefully.

As shown in Figure 3.10 suppose we have included the optical rays of light ray. If it is the optical fiber then there is a material and this material will absorb certain rays and because of which it finds that there is a loss of the light. Sometimes there is a splicing loss, bending of the optical fiber or scattering of the light takes place within the fiber and because of all such things when we receive the light at the output then it does not exactly have the same power to that of input.

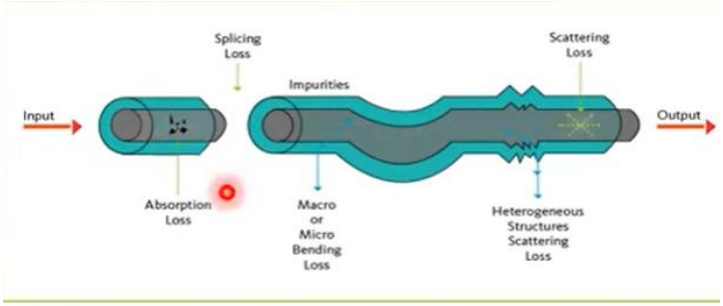


Fig. 3.10

Calculation of Losses

Suppose the power P_i is the power input to the fiber and P_o is power output.

Fig. 3.11

We can calculate the fiber loss as the ratio of the output power to the input power

Fiber Loss= $10\log\frac{Po}{Pi}db$

Let's understand this by an example:

Example 1. The input power to the optical fiber is 10 micro watt and output power of the optical fiber is 9 micro watt and suppose the fiber length is 150 meters then we can calculate the fiber loss and the loss per km.

Solution:

fiber loss = $10\log\frac{9}{10} = -0.458dB$

hence the loss per km is $-0.458 \times \frac{1}{0.15} = -3.053Db/km$

The loss in the optical fiber will affect the choice of the wavelength that is the light propagated through the optical fiber.

Assignment. The input power to the optical fiber is 20 micro watt and output power of the optical fiber is 8 micro watt and suppose the fiber length is 100 meters then we can calculate the fiber loss and the loss per km.

Choice of Wavelength

The wavelength of light is chosen carefully considering minimum attenuation or losses and minimum dispersion.

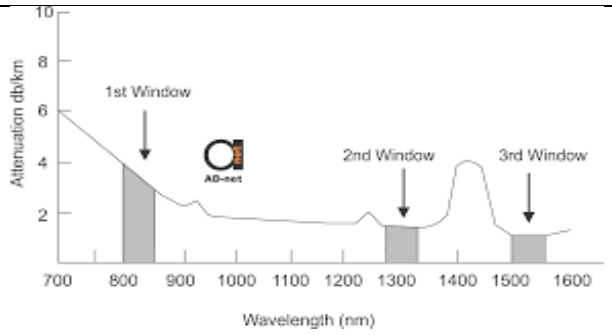


Fig. 3.12

As seen from the above diagram, the curve is plotted considering the wavelength on the x-axis and attenuation which is measured in dB/km. Also, it goes on changing the attenuation will also goes on change so there are three low-loss windows

There are three low loss windows:

1. 820- 880nm.....loss of 2.2 dB/km
2. 1250-1350 nm.....loss of 0.6 dB/km
3. 1550-1610nm.....loss of 0.2 dB/km

The third window has the lowest loss but the higher dispersion. The second window is more suitable for low dispersion. In these three Windows one can easily observe that the loss is minimum in the third window so the third window has the lowest loss but discussed while selecting the wavelength it is necessary to choose the wavelength in such a way that there will be a minimum loss and minimum dispersion so the third window has the lowest loss but it has the higher dispersion and therefore many times the people choose the second window because it will have a comparatively no loss and also it will have a low dispersion

Optical Fiber Communication

Figure 3.13 shows the block diagram of the fiber optic communication system. It consists of a coder, the light source, the receiver, and the decoder.

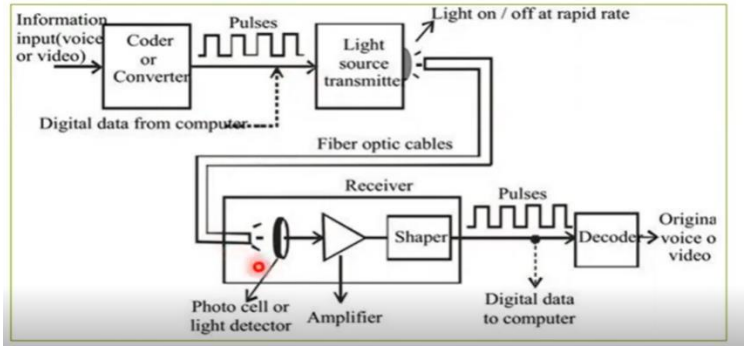


Fig. 3.13 Block diagram of fiber optic communication system

It is a method of transporting the information from one place to another place and in the form of light through the optical fiber. In the conventional communication system, transfer of information is in the form of electronic signal or electrical signal by using twisted pair cable. This can be replaced by using the optical fiber. In optical fiber, a pulse of light needs to be sent to send some information. The light is being modulated to carry the information. This type of communication is being used for transmission of information such as video or voice or telemetry through the LAN or it is also possible to transmit the information over a long distance. At present different countries are connected with fiber optic cable which are useful to send the data from one country to another country.

The block diagram shows the initial information the voice, video is connected to the first block and this block is called a coder or converter. The purpose of this block is to convert the input

analogue information into the form of square pulses, that is the input information is converted into digital form then the output of the converter is connected to a light source transmitter. So according to these pulses of light will be either on or it will go off. So much light signal is connected to the optical fiber cable through which it is transmitted over a long distance at the receiver. The cable is being connected to the photocell or light detector by using a photocell or like detector. It is possible that we can convert the light information or light signal into the electrical signal. This electrical signal is going to be amplified by using an appropriate amplifier and then it is connected to a shaper circuit and will use the appropriate shape to these electrical pulses so at the output of the receiver will get the digital pulses. These digital pulses can be stored to store it in digital devices such as computers where you can connect these digital pulses to the decoder circuit where we can obtain the original voice information for video information.

Optical Fiber Technology

As discussed earlier, the wired mode of communication in which the transmitter and receiver are connected by a physical link is based on one of the advanced processes. This advanced process is Optical fiber technology. This method contains physical links made up of optical wires through which communication can be done with the speed of light. Now let's learn about optical fiber communication, its components, how it is made. Nowadays this optical fiber technology has shown enormous growth in the telecom industry.

What is the speed of light which is received from the sun?

Optical Fiber Market Overview

An optical fiber is a transparent and flexible fiber. It is made of glass or plastic, which is used to transmit light. The optical fiber has wide usage in optical fiber communication, where they allow transmission of data over longer distances and at higher bandwidths than copper wire or cables. Optical fiber is adopted to send signals with less amount of loss. Its use has increased over the years, which drives the growth of the market.

Role of Optical Fiber in Digital India

Optical Fiber is going to play a critical role in the digitalization of India. The existing Fibre-To-The-Home (FTTH) is the infrastructure in the 21st century. As per the recent global survey, 71 % of users are expected to switch on FTTH by 2025. The combination of fiber and wireless technology will meet the need for wide bandwidth. Under Digital India, the Indian government is aiming to provide internet access throughout the country. They aim to connect 6,00,000 rural citizens. This will bridge the gap between cities and villages through an optical fiber network.

Role of Optical Fiber in Broadband Industry

Optical fiber uses light instead of an electric signal to carry information. Before OFC, copper cables were used as a medium to carry information. Copper cables are capable of handling high bandwidth for a short distance. In a few hundred meters copper cables start to degrade their signal carrying capability, which will result in loss of information. OFC comprises glass fibers. Information in the form of light is confined in the core of the fibre and reaches at the far end. Thus, OFC can carry a wide range of bandwidth for longer distances.

Advantages of optical fiber broadband connectivity

1. **Distance –** Biggest advantage of OFC broadband is to provide fast data transfer over long distances. Copper cables cannot maintain the speed over a longer distance, which makes an OFC better medium for long distance communication.
2. **Faster Internet –** In OFC, data is in the form of light and the speed of light is very fast. This is the reason using OFC faster internet access can be provided to the users.
3. **Affordable Price –** In the competitive environment of internet services, OFC broadband will cost similar to our existing broadband connections.

Check Your Progress

A. Multiple Choice Questions

1. The classification of optical fibre is based upon the (a) material used, (b) number of modes of fiber used for the propagation of light ray (c) refractive index of the material (d) all of the above (d)
2. Acceptance angle of optical fiber is depend upon the (a) material used for fiber (b) core diameter of the fiber (c) both a and b (d) none of above (c)
3. Attenuation appears due to (a) bending of fibre (b) absorption of light by fibre (c) scattering of light (d) any of the above
4. Which of the following is the major cause for the loss of the light in the optical fiber (a) material loss, (b) scattering loss, (c) third loss (d) all of the above.
5. Which of the following is not type of dispersion (a) Internal dispersion (b) Material dispersion (c) Waveguide dispersion (d) Polarized mode dispersion (a)
6. The wavelength of light is chosen (a) considering minimum attenuation (b) losses (c) minimum dispersion (d) all of the above (d)

B. Fill in the blanks

1. Core of optical fibre is made up of _____ or_____. (glass, plastic)
2. The diameter of the core is about _____ (8μm).
3. The diameter of the cladding is about _____ (125 μm)
4. Acceptance angle of optical fiber is the _____ angle against the fiber axis (maximum external)
5. Two common type of distortion are _____ and _____(dispersion, attenuation)
6. Dispersion is measured in _____ or _____ (nanoseconds, picoseconds)
7. The dispersion in fiber depend upon the _____ of the fiber. (length)

C. State whether the following statements are True or False

1. The optical fiber cable has copper wire and insulation over it. (F)
2. Optical fiber cable is the fastest means of data communication. (T)
3. Optical fiber transmits an electrical signal. (F)
4. The refractive index of the cladding is equal to that of the core. (F)
5. The core is the central part of the optical fiber. (T)
6. Light rays travel through the core of the optical fiber. (T)
7. The diameter of the core is smaller than that of cladding. (T)
8. The cladding is the surrounding part of the core which is also made of glass or plastic. (T)
9. The outer jacket of the fiber is made up of glass. (F)
10. All the light rays that are incident on the fiber are propagated to the fiber. (F)
11. Acceptance angle of optical fiber is required to propagate the light ray through the fiber. (T)
12. Acceptance angle is unique for each fiber. (T)

D. Short answer questions

1. What do you mean by the OFC? Where is it used?
2. What is an acceptance cone?
3. What is numerical aperture?
4. What is dispersion in optical fibre?
5. What are the types of dispersion?
6. What is fibre loss?
7. What are the advantages of optical fiber broadband connectivity?

Module 2 Installation and Commissioning of Fiber Optic Cable

Module Overview

The installation and commissioning of fiber optic cable is a crucial process in establishing efficient and high-speed telecommunications networks. This procedure involves several key steps, starting with site assessment and planning, where technicians evaluate the environment to determine the best routing for the cables. Proper handling of fiber optic cables is essential to avoid damage; thus, technicians must follow strict guidelines during installation, including ensuring minimal bending and maintaining the correct tensile strength.

Once the cables are installed, commissioning begins with testing for signal integrity and performance using specialized equipment like Optical Time-Domain Reflectometers (OTDR). These tests help identify any potential faults or losses in the system. Additionally, technicians perform splicing and termination of the fibers to connect them to network devices. Effective installation and commissioning ensure reliable communication, reduced signal loss, and optimal network performance, making it vital for modern telecommunication infrastructure.

Learning Outcomes

After completing this module, you will be able to:

- Assess potential installation sites and determine optimal routes for fiber optic cable deployment.
- Understand the proper techniques for handling and storing fiber optic cable drums to prevent damage.
- Identify and demonstrate the use of essential tools and equipment required for fiber optic cable installation.
- Explore capable of executing the installation process of optical fiber cables while adhering to industry standards and safety practices.

Module Structure

Session 1. Site Visit and Route Inspection
Session 2. Optical Fibre Cable Drum Handling
Session 3. Optical Tools and Equipment
Session 4. Installation of Optical Fibre Cable

Session 1. Site Visit and Route Inspection

Tina and her classmates started taking a deeper interest in optical fibre communication. Their teacher is helping them in learning more about this by answering all their queries. Their teacher also explained to them about the tools and equipment required for handling optical cables as well as making joints and connections between optical cables so that the cables can be spread over long distances. The entire class got to know that their teacher is planning to take them for a site visit so that they can get the real-life experience of how the optical fibres are laid down at different sites.

This chapter will help the students learn about the site visit and route inspection for the installation of OFC.

1.1 Site Visit

Installation of optical fibre cable requires proper planning and the first step towards installation is to plan and visit the proposed site. Visiting the site is important to understand the real situation of the site. It provides a fair idea about what all changes are to be made in the proposed work.

A Site visit helps in preparing the action plan. A well-planned action list is useful while installing the cable and helps avoid uncertainties. Visiting the site helps to identify any obstruction at the site, observe the climatic conditions and identify any hurdles in transportation.

All these observations are useful while creating the installation plan. After the site visit, identify the actual equipment locations, route for excavation, and conduits. It will help in overcoming any constructional challenges like reaching the vehicle to the installation site and environmental conditions.

Fig.1.1: Installation team discussing the site conditions

Pre-Planning Before Visiting the Site – It is always good to be pre planned with all the details, checklists, and prerequisites that may be required while visiting the site or inspecting the route. Thus, pre-planning will help the technicians and engineers in deciding the kind of cable to be installed and the key points that need to be kept in mind.

1. An up-to-date site plan should be prepared well in advance which should have all the details about the location.
2. A comprehensive and effective instruction plan should be prepared for the technicians, who will be visiting the site for inspection.
3. A network plan should also be prepared well in advance before route inspection to gain an understanding of how the cable network needs to be laid down on the site.

Benefits of Site Visit – Following There are several benefits of site visit, some of them are – better mapping, saving time and money as well as understanding climatic conditions.

Different Site Conditions

In India, the geographical area varies every few kilometres. Keeping this fact in mind helps the installation team to plan accordingly. They should prepare the plan as per the requirement of the site condition.

Some site conditions commonly found includes – Rocks, Plateaus, Mountains/Hills, Rivers, Highways, Railway tracks, Farms and Forest. These areas must be checked for transportation reachability so that the vehicle can easily reach the installation site to transfer the raw material and the machinery for excavation from the warehouse. The site conditions are shown in Figure 1.2.

Fig. 1.2: Different site conditions

1.2 Route Inspection

After performing the site visit, the next step is to perform a route inspection. Route inspection helps to inspect the actual paths to be followed for cable laying. It also helps to identify the small hurdles, which may intervene during trenching such as electric poles, water pipes, Liquid Petroleum Gas (LPG) pipelines. It also covers the inspection of a land surface. This inspection helps in identifying the requirement of conduit type that can be used.

Depending on the type of soil at the installation site, trenching can be done manually or by using machinery. In rural areas, trenchers are preferred, whereas, in urban areas, manual trenching is performed. In addition, route inspection also helps to know about the nearby resources for raw material and transportation required during the cable installation.

Fig. 1.3: Effective route planning

Following steps required to perform for route inspection.

1. Obtain an OFC route plan.

2. Verify the plan through a route walk.
3. Take corrective actions

1.2.1 Obtain an OFC Route Plan – In a route plan, the planning team suggests the proposed route for cable laying. This route plan contains information of physical locations such as premises, building, complex, multiplex along the way of cable laying buried cables such as telephone cable, electrical cable.

Fig. 1.4 Physical location on the way of OFC

Note – The areas which are free from the other utility cables are preferred to avoid damage to existing infrastructure.

Fig. 1.5 (a) Underground cables (b) Telephone line junction box along the road

It includes the various departments such as state electricity board, water, and sanitation department, municipal corporation and obtains permissions to carry out the installation of OFC cable. Special protection equipment is suggested for the installation team to work in an unhygienic site. Figure 1.6 shows an example of an unhygienic situation at the installation site.

Fig. 1.6 Unhygienic site

Note – The areas, which are free from the other utility cables, are preferred to avoid damage to existing infrastructure. It includes the various departments such as state electricity board, water, and sanitation department, Municipal Corporation and have to obtain permissions to carry out the installation of OFC cable.

1.2.2 Verify the Plan through a Route Walk – Preliminary survey shall be carried out for finalising the drawing for the route of OFC as a part of project planning and execution. The following points may be verified through route walk.

a. Plan the installation. Create a detailed, written plan of installation. Major problems can be eliminated by creating proper planning for the site.

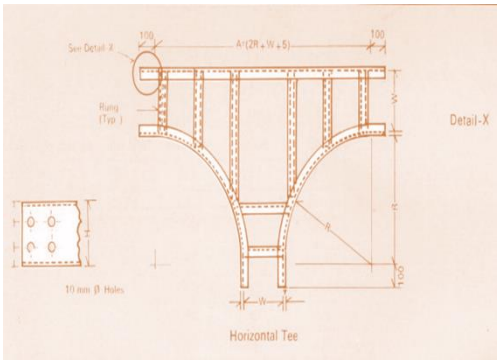


Fig. 1.7: Mapping of the optical fibre cable route

b. Written documentation may be prepared that includes a list of equipment, technical data-sheet of the OFC, installation guidelines, problems associated with the total area to be covered, safety measures to be incorporated, and the total budget or cost involved.

c. It can be prepared as shown in Table 1.1.

Table 1.1

Name	**Required Quantity**
OFC length	
Type of cable	
Type of excavation machine	
Warehouse for cable storage	
Technical datasheet of cable reels	
Number of slicing points	
Safety measures	
Total budget	
Raw material for installation	

d. Check the working space for heavy vehicles, which are going to be used in the installation. Also, check the ground surface on which they are going to be operated.

Fig.1.8: (a) Excavation in the open area (b) Excavation in the narrow area using a mini excavator

e. Avoid laying cable close to the track of gas pipes, water pipes, and adjacent to the cultivated fields or areas which are prone to waterlogging.

f. Avoid laying of cable close to the track of gas pipes or water pipes.

Fig. 1.9: (a) OFC close to water pipe (b) Water pipe damage in the excavation

g. Avoid laying the cable adjacent to the cultivated Fields.

Fig.1.10: Avoid laying of cable adjacent to cultivating field

h. Avoid laying the cable inside the ground, where soil is composed of cinders, coal, and ashes.

Fig. 1.11: Ash on the installation ground surface

i. Avoid areas, which are prone to waterlogging.

Fig. 1.12 Avoid the water logging area

j. Avoid the areas near industries because such industries can discharge poisonous chemicals which can damage the cable.

Fig.1.13: Area near to the chemical industry

k. Avoid the areas which require cutting of large rocks or dense jungle.

Because it will be difficult to approach such areas.

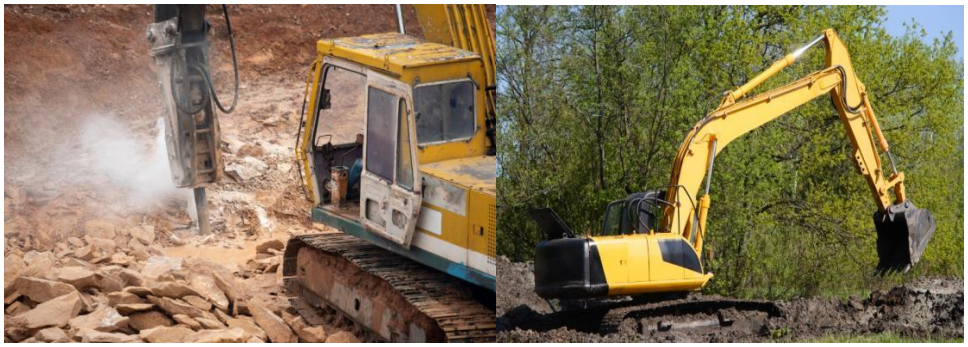


Fig. 1.14 (a) Excavation in rock (b) Excavation in forest

l. Avoid the area where mega projects, such as highway projects, are likely to be constructed soon as they might damage the buried OFC.

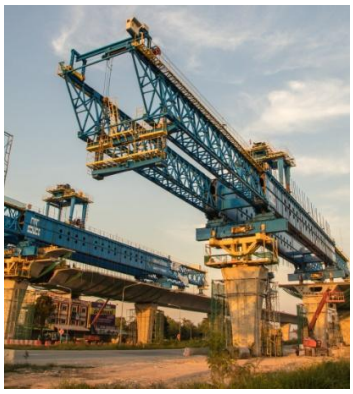


Fig.1.15: Mega structure highway project

m. To protect the cable from corrosion or moisture damage, it is better to determine the composition of the soil.

Fig. 1.16: Performing the soil testing

n. The requirement of transport vehicles like loading truck, dumper, excavator, trencher for the execution of the work must be considered.

Fig.1.17: Transport vehicles involved in the OFC installation

a) Verify the plan for accessibility and availability of material as per design.

b) Verify construction methods, tools and equipment, and splice locations.

c) Check for material storage areas and ventilation.

Fig. 1.18: Warehouse storage and ventilation

a. Avoid proximity to AC power station areas to avoid electric shock.

Fig. 1.19: Electrical substation and transmission tower

b. In case, the installer has to be working near the electrical panel or electrical wire, the installer must wear safety gear.

Fig. 1.20 Precautionary measures must be performed near the electric panel

c. After verifying the above points, sketch as per the route walk.

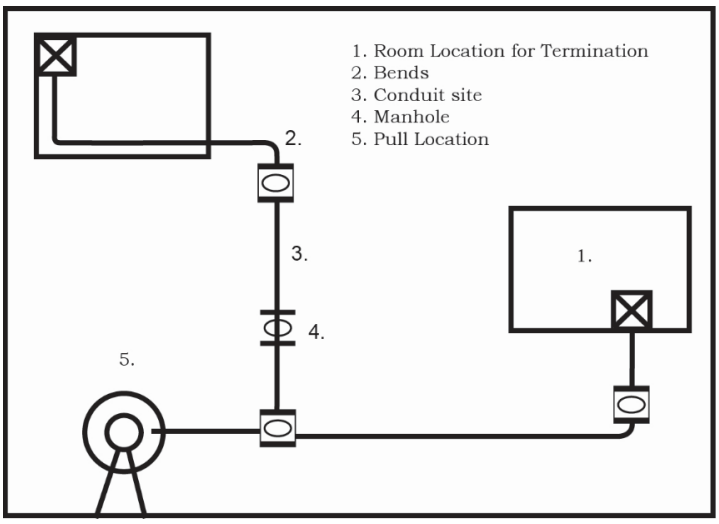


Fig. 1.21: OFC route walk sketch

1.1.3 Corrective Action – Next task is to prepare the site for installation by taking corrective action. If require step for corrective actions are:

1. Take permissions from other departments.
2. Revise route of the cable, splice location, storage location.
3. Arrange for the availability of any special tools required, such as a stone drilling machine.
4. Remove any obstruction along the route. Prepare the site for better productivity.
5. If the route contains sections where the optical cable is subject to high temperatures, provide the necessary protection.
6. Take measures to prevent optical cables from direct stress.
7. Determine the location where cable reels can be positioned during the installation.
8. Locate and check the accessibility of the storage house.

Benefits of Route Inspection – Proper route inspection provides the following benefits:

- The issues such as obstructions cannot be known without conducting 'inspection'.
- It helps to identify the gaps in the plan and actually physical location.
- It helps to maintain the correct bend radius of the cable.
- It helps to identify the hazards and safety to be followed during installation.
- Any rework due to lack of a proper plan is avoided.
- Accidents are avoided due to proper planning.

Route Inspection Report – The team submits the survey report to the concerned authority or manager/supervisor. The report contains all the information of inspection and the most suitable routes for all the optical fibre links along with details. The authority will give the preliminary approval for the route, subject to obtaining the required clearances.

On approval, the team shall carry out a detailed survey of the selected routes and submit the final survey report for approval before implementation. The final survey report shall include the following:

a) A drawing of the proposed route indicating all details of the route including relevant details of soil type, bridge, rail over/under bridges, a defence area, an underground pipeline of gas, oil, water, power, and communication cable routes with other important landmarks.

b) The distance of the OFC route from the centre of the road/rail/river/bridge shall be indicated in the route maps as well as documented in tables.

c) Sections of the links where trenchless digging may be required.

d) Sections where Galvanised Iron (GI) or Reinforced Cement Concrete (RCC) pipe may be required.

e) Location and number of permanent and temporary manholes.

f) Location of all turns, bends, and major landmarks.

g) Type, quantity, and location of all the splice joints. Care must be taken to minimize the number of splice joints.

h) Section lengths of the underground OFC, the total length of each link, and drum supply scheduling for all the links.

i) It shall be the responsibility of the team to propose the alternate route if the proposed route is not suitable for installation due to the condition of soil or the non-availability of clearances.

The final survey report has to be approved by the authority and requisite clearances need to be obtained before the team commences the cable installation work.

Route Inspection Report Project name: _____ Team members: _____ Route: _____ to _____ Route length in Km: _____	
Soil type	
Different areas to be covered	Defence area: Railway track: Road: River: Forest: Mountain:
	Building:
OFC type to be use	
Landmarks	
Number of Bends or turn	
Number of bridges	
Warehouse location	
Type of digging to use	
Number of splice joint required	

Length of OFC required	
Type of ducting required	
Number of manpower required	
Name: _____ Designation: _____ Authorized Signature:	

Safety Precautions while Visiting the Site

Some safety precautions to be taken while on a site visit is:

a) Do not eat food, drink or smoke in an area near bare fibre cables, to avoid causing fire or any other accidents. Bare glass fibres can result in splinters, which are very difficult to identify and remove. These splinters can mix with food and can cause severe damage to the internal body parts.

b) Before pulling the cable, all ducts, cable vaults should be reviewed carefully, and observed that they are not damaged.

c) Ducts should be used for placing the OFC. It should not be mixed along with the copper cables.

d) Cut the OFC correctly.

e) Ensure that vehicles do not pass over the cables, to avoid harm to the glass core of fibre cables.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is not a necessary requirement for OFC installation (a) Skilled labors (b) Equipment (c) Technicians (d) Splicing machine
2. Optical cables are comprised of (a) Copper (b) Fibres (c) Twisted Wires (d) Shielded wires
3. Which of the following is not required for the installation of OFC. true in respect of optical fibre cables? (a) Site survey (b) OFC (c) Splicing machine (d) Route inspection
4. What is the first requirement to install the OFC underground (a) Route plan (b) Permission from various governing bodies (c) Site visit (d) OFC
5. Which of the following is not a step in the route inspection? (a) Obtain an OFC route plan (b) Verify the plan through a Route Walk (c) Take corrective actions (d) Site visit
6. Which of the following cannot be a benefit of performing a site visit? (a) Approximate idea of the area where cable has to be laid (b) How much overall area to be covered (c) What obstacles have to be faced like encountering of building or trees (d) Verify the plan through a route walk
7. Which of the following cautions need to be performed in underground cable installation? (a) Bury the cable below the frost line to prevent the damage by ground frost heaves (b) Do not keep the trench as straight as possible (c) Do not bury fibre cable warning labels (d) Properly ground of cables is avoided
8. Moisture in the environment can result in (a) fibre breakage (b) increased fibre strength (c) decreased attenuation rate (d) increased fibre strength
9. Cable placement defines (a) Installing the cable without pulling it (b) Installing the cable by pulling it (c) Uninstalling the cable without pulling it (d) Uninstalling the cable by pulling it
10. Which of the following reports is final? (a) Site visit report (b) Route walk report (c) Data specification report (d) Route inspection report

B. Fill in the blanks

1. Underground cable laying are basically two most common types of installation named as _____ and _____
2. Fibre is stronger than _____when you pull it straight, but it breaks easily when bent_____
3. Direct burial installation is most common for _____.
4. Most commonly used direct burial installation cable is_____.
5. The issues such as obstructions cannot be known without conducting **'inspection'.**
6. In case, the installer has to be working near the electrical panel or electrical wire, the installer must wear **safety gears**.
7. To protect the cable from corrosion or moisture damage, it is better to determine the **composition** of the soil
8. The areas which are free from the other utility **cables** are preferred to avoid damage to existing infrastructure.
9. Depending on the type of soil at the installation site, trenching can be done manually or by using **machinery**.]
10. Site visit helps in preparing the **action** plan

C. State whether the following statements are True or False

1. Cable installation cannot be done with coaxial cables.
2. OFC installation requires the proper planning where installation can take place.
3. Optical fibre cable can be installed in the water logging area.
4. When working in extremely hot conditions, you need to follow safe work practices to combat working in extreme temperatures.
5. All workers need not wear safety helmets at all times in all designated areas.
6. Gas pipelines can also be used for deploying optical fibre networks without causing major disruption and requiring extensive road works to the community, which is the norm in the case of conventional cut and fill techniques.
7. Steel capped boots or equivalent cannot be worn at all times on site, except where the site foreman or safety supervisor has approved certain trades to use other footwear.
8. Ducts dedicated for placing the optical fibre should be used. It should not be mixed along with the copper cables.
9. Trenching uses machinery to create either a large cut through the pave or a slender cut within the high of the pave to put the fibre cable.
10. Drinking water pipes cannot be used for the deployment of optical fibre cables.

D. Short answer questions

1. What is the requirement of a site visit?
2. Why is route inspection necessary? Write the steps to follow route inspection.
3. Write the safety precautions to be followed to perform route inspection?
4. What is route inspection?
5. What are the benefits of route inspection?
6. Briefly explain the three steps of route inspection.
7. How to install the cables near existing pipelines?
8. Write at least 6 steps to execute the job at the site safely.
9. What are the benefits of Route Inspection?
10. Briefly explain the three steps of route inspection.
11. List out precautions to be taken to install fibre.
12. How to do a site visit to install the cables.
13. What are the benefits of a route plan?

Session 2: Handling of Optical Fibre Cable

Tina and her classmates were excited about their field visit. During their site visit, they got to know about the different types of sites where optical fibres were laid. They were surprised to know that optical fibres can be laid down under sea/water bodies as well.

While visiting one of the sites where the task of laying down optical fibres was going on, one of the students asked the teacher about the big cylindrical drums lying on the site. Their teacher told them that these are big fibre cable drums on which the optical cables are rolled up.

She further explained that at the time of transportation, during loading and unloading, or while handling the cable drums at the installation site, cables can get damaged. Such damage can degrade cable performance to the extent that replacement is necessary. Considering these facts, one must correctly handle the cable drum.

In this chapter, you will understand the different optical fibre handling techniques and drum handling at various installation sites.

2.1 Cable Drum

For many years, cable reels, sometimes known as drums, have been used to transport electric cables, fibre optic cables, and wire goods. It is shown in Figure 2.1.

Fig. 2.1: Cable Drum

Plastic, plywood, wood, and steel are some of the materials used in designing cable drums. Wooden drums are made of resinous wood and are capable of carrying high loads. Discarded wooden drums can be found for less money and are utilised as furniture. Optical fibre cable drums are bulky and heavy to move. Hence, a mechanical crane is used for placing the cable drum at the respective place at the installation site as shown in Figure 2.2.

Fig.2.2: Crane carrying Cable Drum

When the cables are carried on the drum some points should be kept in mind while handling optical fibre cable drums. Hence following considerations should be taken into account:

The mass of the drum
The dimension/size of the Drum
Cable Drum Unloading
Cable Drum Handling
Cable Drum Unwrapping

Cable Storage
Environmental Storage Issues
Pre-Installation Drum Inspection
Unwrapping the Drum
Cable Inspection
Preparation of the Drum

2.1.1 The mass of the drum

Cable drums come in different weights/masses depending on the materials they are made of. Materials such as plywood, timber, plastic, or metal are used to make cable drums. Hence depending on the weight and type of cable, they are expected to support they are designed to be reusable and/or returnable. Additionally, the choice of material for the drums depends on whether the drums and cables are being stored indoors or outdoors.

2.1.2 Cable Drum Dimensions

Drum sizes are typically determined by:

- The flange height or drum diameter (D)
- The inside width (b)
- The drum barrel or drum core(d)
- The width of the drum (B)

The following Figure 2.3 shows the various parameters of the cable drum.

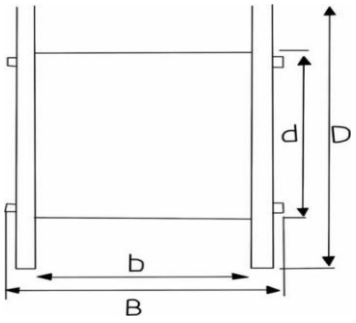


Fig. 2.3: Various dimensions on the cable drum

Typically:

- Plastic drums range from 400 mm to 1000 mm. They carry loads of up to 850 kgs.
- Plywood reels range from 125 mm to 1500 mm. They carry loads of up to 2 tones.
- Wooden drums range from 250 mm to 4500 mm. They carry loads of up to 60 tones. Steel drums can vary in size from 630mm to 10000 mm and carry loads of up to 250 tones.

Table 2.1: Based on the dimensions of the cable Drum sizes of the drum are calculated

Size of the Drum	Diameter of the Drum(D)	Diameter of Drum Core d mm	Width of Drum B mm	Width between Sides b mm	Nominal Drum Weight Kg
6	630	315	440	315	24
7	710	355	525	400	30
8	800	400	575	450	38
9	900	450	575	450	45
10	1000	500	685	560	56
12	1250	630	810	630	102

2.1.3 Cable Drum Unloading – Cable drums must be unloaded with care. While loading or unloading cable drums, care must be taken to prevent collision with other drums. Improper unloading of the drum can cause damage like broken drums or visible or invisible damage to the cable itself. The main danger comes from invisible damages leading to unusable cables.

Therefore, some base guidelines should be followed. The cable itself must always be protected and may not be touched improperly during transport and storage. Special unloading procedures may be necessary

The precautions that need to be taken during cable unloading are:

The cable drum should not drop on the floor, as the weight of the drum and cable may cause flattening deformation or damage to the cable. Rather, roll the drum from a truck onto the receiving platform, which should be at the same height as the tailgate of the truck, or forklift can also be used for unloading the cable drum as shown in Figure 2.4, Figure 2.5 and Figure 2.6.

Fig. 2.4: Wrong way of unloading the cable drum by dropping it.

Fig. 2.5: Unloading of cable drum using a forklift.

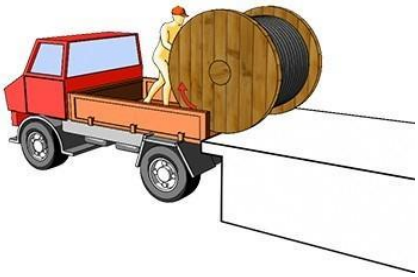


Fig. 2.6: Unloading of cable drum by rolling onto the receiving platform.

While shifting the cable drum from one place to another, a mechanical crane should be used. The correct way to lift the cable drum is shown in the following figure 2.7.

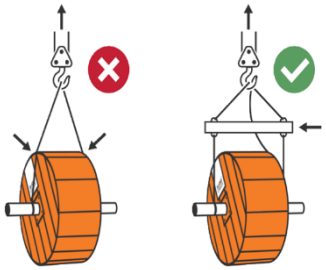


Fig. 2.7: (a) Way to lift and place the cable drum

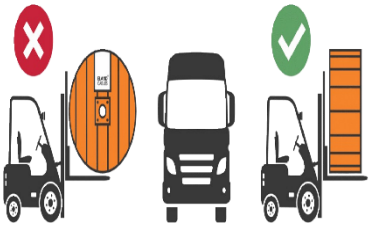


Fig. 2.7: (b) Way to lift and place the cable drum

Fig. 2.7: (c) Way to lift and place the cable drum

On an inclined surface or ramp, carefully roll a drum, as shown in Figure 2.8 so that it should not go out of control. Also, roll one cable drum at a time and place it in the safe storage area.

Fig. 2.8: Inclined surface to roll the drum

Here we will demonstrate the simple Practical Activity to Unload the Cable Drum from the Truck

Practical Activity 2.1 – To Unload the Cable Drum from the Truck

Step to be followed: Take s Ramp on which the drum can be rolled and place it below the Drum as shown in Figure 2.9.

Fig. 2.9: Cable Drum being unloaded from the Ramp carefully

Note – Never drop the Drum from the height as shown in Figure 2.10. It will damage the Drum**.**

Fig. 2.10: Wrong method of unloading the Drum

2.1.4 Cable Drum Handling

Cables are very costly. The drum, and hence the Cable wound over it, can be destroyed if the handling is not done appropriately. Damage may not be noticed until after installation, at which point repairs might be complex and expensive. The damage can be avoided by following proper handling procedures:

Keep the drum upright

1. Try not to roll the drum for a long distance. If in some special case, it is necessary to roll the cable drum for a long distance, then it should roll in the correct way. As shown in Figure 2.11 and Figure 2.12.

Fig. 2.11: Correct way to roll the cable drum

Fig. 2.12: Incorrect way to roll the cable drum

2. The cable drum should never be stored or placed on its one flange as shown below. It should be placed in such a way that both the flanges are the same level.

Fig. 2.13:Correct way to place the cable

Fig. 2.14: Incorrect way to place the

drum **cable drum**

3. Cable drum should always be stored on a flat surface with blocks placed under the flanges to prevent rolling in either direction.

Fig. 2.15: Cable drum blocked using a flange

4. All screws holding the flanges of the drum must be checked and tightened before moving the drums. When the weather is dry and hot screws have to be tightened as required to compensate for the shrinking of wood. Tightening of screws is done with a torque wrench as shown in Figure 2.16. The force shall be as mentioned on the drum or as follows:

Drum size	Force
700–1400 mm	80 Nm
1600–2200 mm	100 Nm
2500–2800 mm	120 Nm

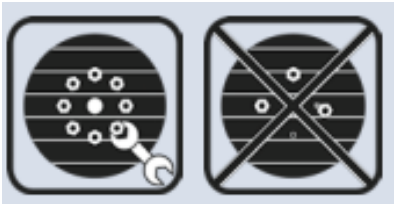


Fig. 2.16: All screws holding the flanges of the drum are tightened

2.1.5 Cable Drum Unwrapping

Some points that need to be considered at the time of cable unwrapping are:

1. Wrap on a cable drum plays an important role in protecting the cable from damage during transportation. All drums are wrapped with wooden laggings to protect the cable from minor impacts caused due to rolling the drum over the rough surface a shown in Figure 2.17.

Fig. 2.17: Wooden wrapping on the drum

Do not remove the wrap from the cable drum until the cable is ready to install.

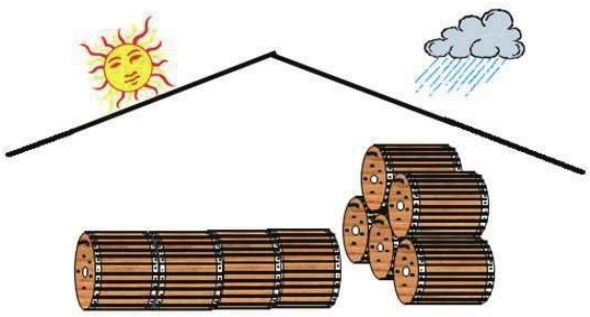
2.1.6 Cable Storage

At the beginning of the installation of optical fibre cable, several cable drums were purchased. However, on a day-to-day basis, few of them are required at the installation site. The rest of them have to be stored in warehouses or shaded secured places. While storing the cable drum, some points that should be considered are:

The drums should always be stored in the correct position. Failing to do so, may damage the cable.	 **Fig. 2.18: Cable drum in the warehouse**
If storage space is limited, then it becomes necessary to stack or orderly arrange the cable drums in such a manner that optimum space utilization is done.	 **Fig. 2.19: Correctly organised cable drums**
If the wrapper is removed from the drum, then their flanges should be lined up in such a way that flanges do not damage the cable of adjacent drums. The unaligned cable drum is shown in the image in Figure 2.20.	 **Fig. 2.20: Unaligned flanges**

2.1.7 Environmental Storage Issues

Optical fibre cable is wound on wooden drums. Due to the environmental effects, wooden drums degrade with time. Effective ways to resolve this problem are:

To avoid such degradations in wood during its storage period, in house storage is recommended.	 **Fig. 2.21: Cable drum in a storage house**

If there is a requirement to store the cable drums in the open area, then they should be placed on a flat and hard surface and should be moisture free. This will minimise the damage to the wood of the cable drums. In addition, it will avoid the generation of harmful insects in the wood.

Fig. 2.22: Cable drums are placed in an open area

2.1.8 Pre-Installation Drum Inspection

When the cable drum is unloaded, it should be properly checked for any damage. This will assure correct product delivery. These genuine products will provide long-life work assurance. Some points that should be checked in the cable drums are:

1. Before taking the cable drum to the site, test the cable for optical continuity. In addition, inspect for any damages due to improper handling and check the attenuation level of the signal in the cable.

2. Make sure that specification about the cable size and its type must be mentioned on the flange of the cable drum.

3. Specification on the flange includes information such as cable manufacturer name, cable length, cable type, bend radius.

Fig. 2.23 Information about cable, printed on the cable drum

4. Check drums for the above points as per plan before dispatching them to the installation site.

2. If any fault or mismatching is observed in the information printed on the flanges of cable drums, then immediately propose a request for the replacement of a particular cable drum.

2.1.9 Unwrapping the Drum

Open the drum carefully keeping the following points in mind.

1. All cable drums are closed by nailing wooden battens on their respective flanges with the help of aluminium or iron strip to avoid any damage to the cable during transportation.

2. To take out the cable for installation or testing, the batten should be removed carefully without damaging any portion of cable.

3. Carefully, cut the iron strip-using cutter.

4. Put the screwdriver in the gap of batten, and press it down to remove the batten from flange.

2. Remove the batten carefully without damaging the optical fibre cable.

4. Remove the thermal wrapper applied over the cable.

2.1.10 Cable Inspection

After inspecting the cable drum and relevant information imprint on the cable drum flange, the next one needs to inspect the cable wound on the drum. Check for the following points while inspecting the optical fibre cable.

1. Test optical fibre cable for optical signal continuity, optical fibre cable length, and attenuation.
2. If there is any shipping damage found, inform the supplier.
3. Locate the inner and outer end of the optical fibre cable.
4. Check that there must be a cable cap at both the terminals of the optical fibre cable.

2.1.11 Preparation of the Drum

After inspecting the cable drum and cable for any damage, the drum should be prepared for installation. The preparation of the drum includes the following steps:

1. At the time of cable installation, correct alignment of the cable drum is required.
2. Make a setup for drum payoff. To avoid cable rubbing against the flanges, orient the cable drum in such a way that the natural payoff direction is towards the pulling direction.
3. When there is a sharp turn at the time of cable laying, it is tough to pull the cable. In that case, make a chamber at the turning point, first pull the cable from one side, and then feed the cable to another side as shown in the following figure.

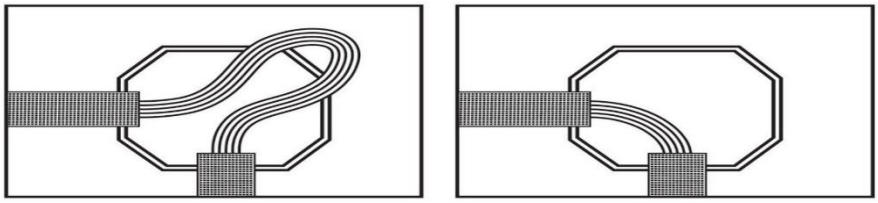
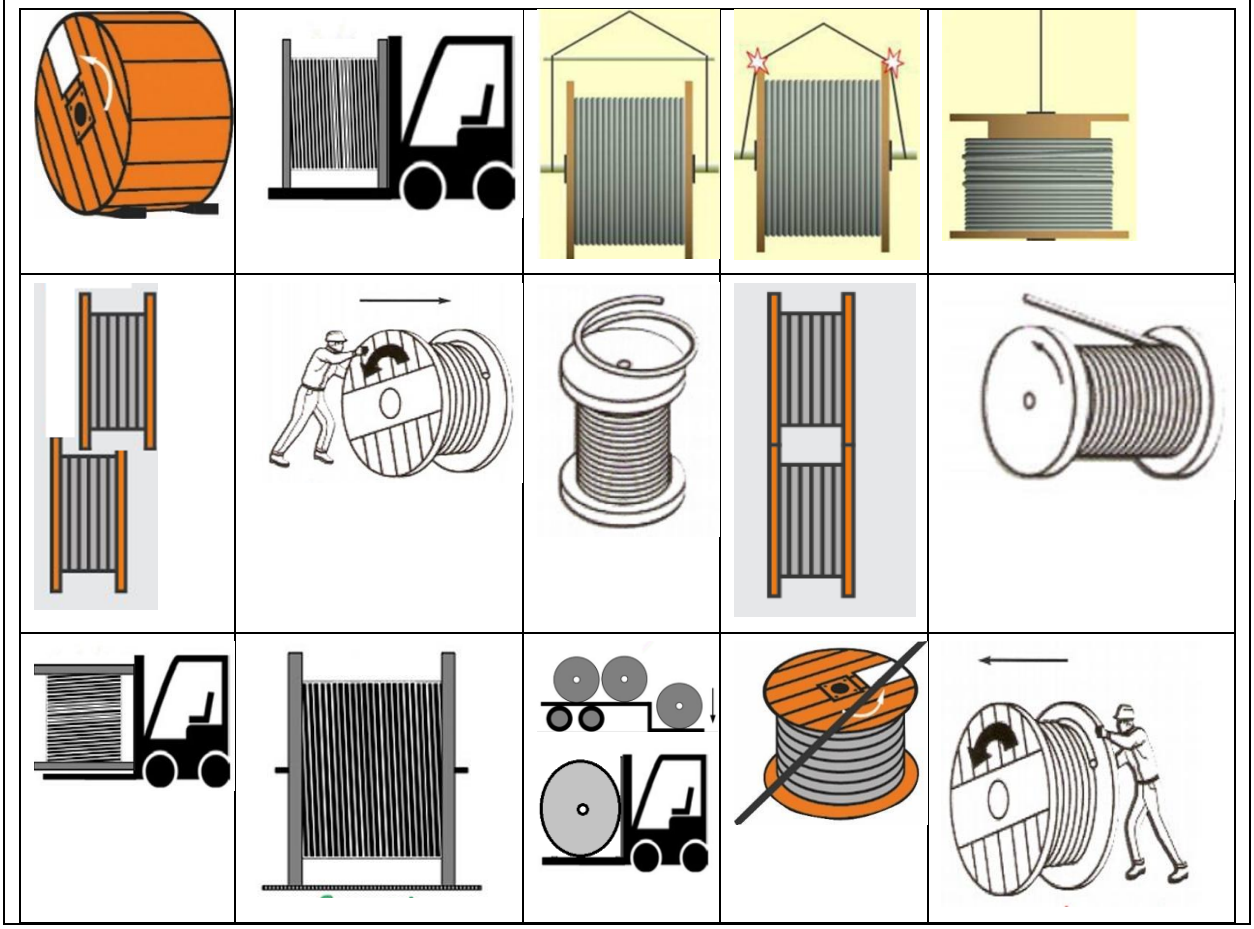


Fig. 2.24: Correct and incorrect way to place the optical cable in turning

Assignment 1

Observe the picture of the cable drum and mark it as correct or incorrect.



Check Your Progress

A. Multiple Choice Questions

1. Which of the following machinery is used to lift the cable drum? (a) Crane (b) Truck (c) Lorry (d) Tractor
2. For the easy rolling of cable drums, the pulling direction and the payoff orientation should be in _____ direction. (a) Same (b) Different (c) Straight (d) Vertical
3. The position of the drum in the Figure below _____. (a) Incorrect, upright position using wedges in the heels of the flanges (b) Correct, upright position using wedges in the heels of the flanges (c) Incorrect using wedges in the heels of the flanges (d) Correct, using wedges in the heels of the flanges

4. Which of the following is used to bind the drums onto the trucks? (a) Ropes crossing through the central hole (b) Wires crossing through the central hole (c) Ropes crossing through the edges (d) Ropes crossing through the base of the drum
5. Which of the following is used to seal the cable drum? (a) Iron sheet (b) Wooden batten (c) Plastic frame (d) Thermal wrap
6. Wooden drums are not suitable for long-term storage outdoors unless protected from _____. (a) Moisture (b) Water (c) Heat (d) Voltage
7. Which of the following is used to fasten the cable drum? (a) Wrench (b) Wire (c) Chain (d) Wedge
8. Which of the following is used to tie up the cable drum on the truck? (a) Nails (b) Screw (c) Slings and Chain (d) None of the above
9. Which of the following term is not associated with cable drum? (a) Flange of drum diameter (b) Drum barrel or drum core (c) Width of the drum (d) Drum Clad

B. Fill in the blanks

1. Wooden battens should be taken out safely using a tool called _____.
2. OFC is protected by enclosing it with wooden batten nailing on the _____.
3. To load and unload the cable drum on the truck _____ machine is used.
4. OFC is prone to damage due to improper_____ and such damages can degrade the cable performance.
5. Cable drums should be placed on the _____ and _____ surface.

D. Short answer questions

1. State the factors, which can damage the cable at the time of transportation of cable drum?
2. Write the steps to inspect the cable drum.
3. What are the environmental issues that need to be considered in the storage area of cables?
4. What points need to be considered while handling the cable drum?
5. List the specification and information printed on the flange of the cable.

Session3: Optical Tools and Equipment

Tools and equipment are the backbones for commissioning the installation of optical fibre cables (OFC). They play an important role in setting up the cable as per the plan. Correctly handling tools and equipment ensures correct installation and repair of OFC. Thus, equipment also helps to identify the faults that occurred in the OFC.

It is recommended to keep a complete set of tools required for digging, installation, splicing, connecting, troubleshooting and testing. The optical tool kit as shown in Figure 3.1, primarily consists of a splicing machine, test equipment, cable handling tools, termination/splicing tools and consumables.

In this chapter, you will understand about various tools and equipment used in the installation of OFC.

Fig. 3.1 Optical fibre tool kit and testing equipment

3.1 General Tools and Equipment

Tools are the same for different cables but may vary in size and shape as per their brands. We should refer to the manual for the appropriate size of tool for OFC installation. The toolkit contains essential tools for carrying out termination and polishing of OFC at the work sites. It is portable and equipped with various tools and accessories used for termination work. Some of the tools are:

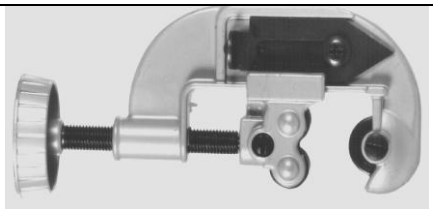
I. Kevlar Cutter
II. Round Cable Stripper
III. Polishing Products
IV. Connector Cleaner and wipes
V. Epoxy Products
VI. Test Equipment such as compact 200X Microscope with 2.5 mm and 1.25 mm universal adapter

In addition, the toolkit also includes accessories used to clean and polish the ST/SC/FC/LC/MU connectors.

3.2 Cable Cutting and Stripping Tools

The cable cutting and stripping tools are listed in Table 3.1.

Table 3.1: Cutting and stripping tools

Rotary Cable Slitter – It is used to cut the outer jacket of the cable. Its blade can be adjusted from 0.187inch to 2.75 inch.	 **Fig. 3.2: Rotary cable slitter**
Armoured Cable Cutter – It is used with the larger diameter metallic-armoured cables for cutting the outer jacket and armour of the cable.	 **Fig. 3.3: Armoured cable cutter**
Optical Fibre Cleaver – It is used to cut the optical fibre to provide a clean and precise end face for optical splicing to minimize optical loss.	 **Fig. 3.4: Optical fibre cleaver**
Buffer Tube Stripper – It is used to strip the jacket and buffer coating of the optical fibre cable. It can support optical fibre cables up to 1/8 inch in diameter.	 **Fig. 3.5: Buffer Tube Stripper**
Nose Plier – It is used for grabbing and pulling pull-cords, or ripcords. It provides a firm grip to pull or hold the cord.	 **Fig. 3.6: Nose plier**
Aramid Yarn (Kevlar) Scissor – These scissors are used for cutting the tough Kevlar fibres which are used as strength members in optical fibre cable. They are made up of hard stainless steel or ceramic to withstand repetitive cutting of the Kevlar fibres.	 **Fig. 3.7: Aramid yarn scissor**

3.3 Optical Fibre Polishing Tools

These tools are used to polish the end face of optical fibre connectors for better optical fibre connection and low optical loss. These are available in different sizes and are made with two types of materials – aluminium oxide or silicon carbide material. Some of these tools are shown in Table 3.2.

Table 3.2: Polishing tools

Polishing Plate – It provides a work surface for the polishing work of the optical fibre connector.	 **Fig. 3.8: Polishing plate**
Polishing Pad – It can provide a cushioned surface support to carry out the polishing works and to prevent the polishing film from getting stripped off.	 **Fig. 3.9: Polishing pad**
Mat – It is used as a working mat for the optical fibre connector polishing work and as a working surface for optical fibre stripping. It is always preferable to have it in black colour.	 **Fig. 3.10: Working mat**
Polishing Puck – It is used for hand-held polishing of optical fibre ends of connectors and any ferrule of 2.5 mm diameter. It can be used for multi-mode glass or plastic core fibre material.	 **Fig. 3.11: Working mat**
Optical Fibre Polishing Disc – It is a tool made up of highly precise machined metal or plastic material to carry out polishing work to the optical fibre connector. It comes with different types to support optical fibre connector types such as FC, LC, SC and ST.	 **Fig. 3.12: Optical fibre polishing disc**

3.4 Optical Fibre Cleaning Tools

For an optimal optical fibre connection, the optical fibre connectors and other optical accessories to be used must be free from dust particles or other impurities. The optical fibre cleaning tools and supplies are designed to be deployed in the cleaning of these accessories to prevent scratching. Some of these tools are shown in Table 3.3.

Table 3.3: Cleaning tools

Connector Cleaner – It is a cleaning media used to remove impurities from the end face of the optical fibre connector. A rubber pad is located under the cleaning media to prevent scratching.	 **Fig. 3.13: Optical fibre connector cleaner**
Optical Fibre Swabs – These are used to remove impurities such as dirt or oil from the ferrules of the optical fibre connectors. These optical fibre swabs range from 1.25mm to 2.5mm to provide more targeted cleaning to remove contamination. It can be used wet or dry to clean up impurities.	 **Fig. 3.14: Optical fibre swabs**
One-Click Ferrule Mate Cleaner – It is deployed to remove contamination from the ferrules of the optical fibre connectors as well as the alignment sleeves of the optical fibre adapters. Cleaning is done by inserting the nozzle of the one-click Ferrule Mate Cleaner into the optical fibre adapters.	 **Fig. 3.15: Optical fibre connector cleaner**
Gloves – They are used to protect the hand at the time of performing the splicing.	 **Fig. 3.16: Optical fibre connector cleaner**
Trash Bin – It is used to dispose of the scraps of optical fibre cable and used wipes.	 **Fig. 3.17: Optical fibre connector cleaner**

3.5 Optical Fibre Epoxy Adhesive Tools

These tools consist of adhesive tools and are deployed in termination of the optical cable from an optical fibre connector. Some of these tools are shown in table 3.4.

Table 3.4: Adhesive tools

Epoxy for Connectorization – Epoxy is used in the curing process, in which the optical fibre is glued onto the ferrule of the optical fibre connector, so that there is no movement of the optical fibre, once it is terminated onto the optical fibre connector.	 **Fig. 3.18: Optical fibre connector cleaner**
Epoxy Application Syringe – It comes with both a syringe body and needle dispenser. It is designed to inject the epoxy for connectorization into the optical fibre connectors. A needle dispenser is available together with the syringe body.	 **Fig. 3.19: Optical fibre connector cleaner**

3.6 Fibre Splicing Equipment

Fibre splicing equipment are the key tools required for connecting broken optical fibre cables. Splicing equipment is quite expensive. All though it is better to purchase the best quality equipment, as it will be a one-time investment.

Also, the connection or joint prepared by the equipment will be strong and long lasting.

There are two methods of splicing the fibre cable – Fusion Splicing and Mechanical Splicing.

These splicing methods are covered in details in the next chapter.

3.7 Optical Fibre Connector

Optical fibre cables can be terminated in either of the two ways—by joining the optical fibres with the optical fibre connectors or by splicing the optical fibres together.

Optical fibre connectors are used to connect and align the optical fibres, so that the optical light signals can be transmitted without any interference. They are widely used in telecommunication, data communication networks, for customer premises wiring, and in outside plant applications to connect equipment and cables, or to cross-connect cables.

Some of the commonly used connectors are shown in Table 3.5.

Table 3.5: Optical fibre connectors

FC Connector – It is designed to work with the screw-type mating mechanism.	 **Fig. 3.20: FC Connector**

LC connector – It is designed to work with the snap-in coupling mechanism.	 **Fig. 3.21: LC Connector**
SC connector – It is designed with a push-pull coupling mechanism.	 **Fig. 3.22: SC Connector**
ST Connector – It is designed to work with the thread coupling mechanism.	 **Fig. 3.23: ST Connector**

The most common connectors available in the market are SC and LC connectors. The major difference between various types of connectors are methods of mechanical coupling and dimensions.

Some features of a good optical connector are:

I. Low inversion loss
II. High return loss (low amounts of reflection at the interface)
III. Ease of installation
IV. Low cost
V. Reliability
VI. Low environmental sensitivity
VII. Ease of use

3.8 Other tools

There are other tools and equipment which are used while handling the optical fibre cables. These include in Table 3.3.

Table 3.6: Other Tools and Equipment

Optical Fibre Adapter – They are utilized in the optical fibre network connection by connecting with the optical fibre connectors. They are designed for both single-mode and multi-mode optical fibre cables. Optical fibre adapters are usually used to connect with optical fibre connectors of similar kinds.	 **Fig. 3.24: Optical fibre adapter**

Optical Fibre Pigtail – It is used to terminate the optical fibre cable. At one end of the optical fibre pigtail, a connector is pre-installed and the other end is open. This open end can be connected to the other optical fibre cable, which is to be terminated. The connection of optical fibre pigtail and optical fibre cable can be done via fusion or mechanical splicing. The optical fibre pigtails are available with various kinds of optical fibre connectors and the most common types are FC, LC, SC and ST.

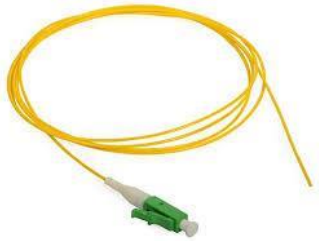


Fig. 3.25: Optical fibre pigtail

Optical Patch Cord – Optical fibre patch cable often called optical fibre patch cord or fibre jumper cable is an optical fibre cable terminated with optical fibre connectors on both ends. They are used in optical fibre networking.

Fig. 3.26: Optical fibre pigtail

Optical Fibre Attenuator – Sometimes, the optical signals may be too strong for an optical fibre receiver to accept in optical fibre network transmission and this will cause damage to the receiving device. The optical fibre attenuator is utilised in this situation to reduce the transmission signal power level to a certain level.

Fig. 3.27: Optical Fibre Attenuator

Direct Termination Kit – It is used to house the bare optical fibres. The direct termination kits also protect the optical fibres for termination with the optical fibre connectors. A breakout kit is used to directly terminate the bare optical fibre.

Fig. 3.28: Direct Termination Kit

Splice Enclosure – It is used to protect stripped optical fibre cable and optical fibre splices from the environment. Outdoor optical fibre enclosures are usually weatherproof with watertight seals.

Fig. 3.29: Splice enclosure

Practical Activity 3.1 – Demonstrate to make the pigtail out of the patch cord.

MaterialRequired:

Optical fibre patch cable terminated with optical fibre connectors on both ends, Plier

Procedure

Step 1. First take the patch cord of 5 to 10-meter-long as shown in Figure 3.30.

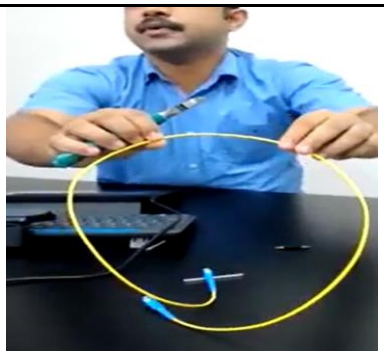


Fig. 3.30: Patch cord of the fiber optics cable

Step 2. Take a plier and cut it from somewhere in the middle as shown in Figure 3.31.

Fig. 3.31 Cutting of the patch cord to form the pigtail

Step 3. The two pigtails are made out of the patch cord as shown in Figure 3.32. Hence each piece can be used as a pigtail.

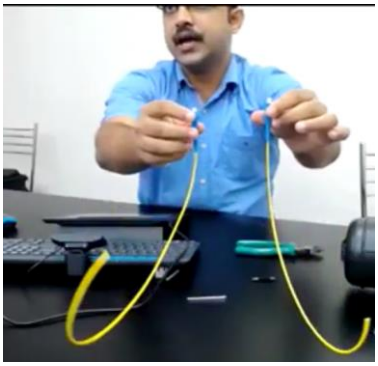


Fig. 3.32 Formation of the two pigtail

Assignment: Students are required to take the patch cord and make the pigtail out of it.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following tools is used to cut the end of the core smoothly? (a) Optical fibre stripper (b) Nose plier (c) Precision Cleaver (d) Scissor
2. Electric splicing is also known as (a) Mechanical splicing (b) Fusion splicing (c) Arc splicing (d) Soldering
3. Which of the following part of the fusion splicing machine is used to monitor the core alignment (a) V-groove (b) LCD display (c) Cap (d) L-groove
4. Which of the following is the most commonly used alignment mechanism for mechanical fibre splices? (a) Cleaning swab (b) V-groove (c) Matching gel (d) Clamp spring

5. Which of the following is not the type of connector? (a) LC Connector (b) SC Connector (c) ST Connector (d) HT Connector
6. Which of the following is not the function of microscopy? (a) Identify any faults (b) Identify any cracks (c) Identify any scratches (d) Identify any breaks
7. Visual fault locator has _____ modes. (a) Continuous mode (b) Flashing mode (c) Delay mode (d) Both (a) and (b)
8. Which of the following is not a cutting tool? (a) Rotary slitter cutter (b) Armored cable cutter (c) Epoxy syringe (d) Optical fibre stripper
9. Which of the following is not an equipment? (a) Optical power meter (b) Kevlar scissor (c) Laser power source (c) Optical Time Domain Reflectometer
10. Which of the following is not a tool? (a) Precision cleaver (b) Nose plier (c) Rotary slitter cutter (d) Crimper

B. Fill in the blanks

1. For making the permanent joint of optical fibres _____ is used.
2. Kevlar scissors are made up of hard _____ or ceramic material.
3. For grabbing and pulling pull-cords, or ripcords of optical fibre cable _____ is used.
4. Hard crystal that is used to scratch or mark the point on the fibre for _____.
5. To strip the jacket and buffer coating of the optical fibre cable _____ is used.
6. To monitor the splicing in the fusion splice machine ____ is used.
7. To visualize the end face of a connector to adjust the focus of _____.
8. In order to find the insertion loss _____ optical power meter is used.
9. One-click ferrule is used to remove _____ from the ferrule.
10. Breakout kit is used to directly terminate the _____ optical fibre.

C. State whether the following statements are True or False

1. Precision cleaver cuts the fibre at an angle less than 90 degree.
2. Mechanical splicing machine has an LCD display for monitoring.
3. Fibre stripper cannot be used for thick cables.
4. Inspection microscopy is used for the monitoring of the fibres.
5. OTDR stands for Optical Time Domain Reflectometer.
6. Optical fibre pigtail has a pre-installed connector on both the ends.
7. Isopropyl solution is used to clean the fibre.
8. Visual fault locator is used to connect the two optical fibres.
9. Optical power meter measures the wavelength of the optical signal.
10. Crimping is performed at the terminal point of optical fibre.

D. Short answer questions

1. Define the terms (a) Fibre Stripper (b) Cleaning Swab (c) Rotary Slitter
2. Define the connectors (a) LC Connector (b) FC Connector (c) SC Connector (e) ST connector
3. Name the tools and equipment used for fibre splicing.
4. How can the jacket of the metallic-armoured cables be removed?
5. What is the role of optical time domain reflectometer in optical fibre network?
6. Difference between the optical fibre pigtail and optical fibre patch cord.
7. How is fusion splicing different from mechanical splicing?
8. Write the steps to measure the insertion loss in the optical fibre.
9. List the accessories required to clean the optical fibre at the time of installation.
10. List the tools present in the optical fibre installation kit?

Session 4: Installation of Optical Fibre Cable

In our day-to-day life, we deal with several devices, which require high speed, and a secure network to execute the various internet-based services. One finds high demand for such devices as the number of users is uncountable. Therefore, to establish secure and fast connection one needs to install a medium. One such medium is optical fibre cable. The installation team acts as an installer to establish a network, which provides the required services to the users.

In previous chapters, you have learned about the basics of telecommunication, tools, equipment, site visit, route inspection, drum handling techniques. In this chapter, you will understand the installation of optical fibre cables.

4.1 Installation Methods

Installation of optical fibre cable is performed by the team. Optical fibre technician plays a major role in the installation. After the completion of the site visit and route inspection, the authorities approve the survey. Then technicians perform the installation, testing, troubleshooting, documentation, and restoration. The technicians utilize their experience for the network installation. As it is a planned process, several factors are considered while performing the installation. Optical Fibre Cable (OFC) installation can be performed using two methods namely Underground Installation, and Aerial Installation.

1. Underground Installation

It is also known as the trenching method. It is a planned process; therefore, some factors have to be considered while performing the installation. Following are the stages involved in the underground installation method.

a) Trenching
b) Duct Placement
c) Cable Placement
d) Cable Pulling and Blowing
e) Cable Termination and Splicing

Trenching – It is a process for making narrow excavations. Trenching is performing for short distances as well as long distances. It is a process of making an underground way for cable placing. Figure 4.1 shows the trench area.

Fig. 4.1: Trenching

Trenches can be formed manually using hand tools or using excavation machinery. Figure 4.2 (a) shows that laborers are making the trench using hand tools. Figure 4.2 (b) shows that a machine is used for making the trench.

Fig. 4.2 (a) Trenching using hand tools (b) Trenching using machinery

Once the trench is completed, it should be visually inspected for correct depth and width. In addition, it should be verified with pre-planned size. Make sure that it does not contain any rocks or sharp objects as shown in Figure 4.3, that may damage the optical fibre cable.

Fig. 4.3 Removing of Rocks and sharp stones during the trenching

Fig. 4.4 Photo shooting Uneven trench width and depth

Manual trenching needs more manpower and time. But it is the more effective installation method for short distances. Whereas, for longer distance trenching using the machine is a correct option. For example, the trench is preferable in those areas, where excavation using the machine is tough. In urban areas, the trench is formed using manpower. But, in rural areas machines are preferred. Figure 4.5 shows manual trench in an urban area.

Fig. 4.5 Photo shooting Manual digging in an urban area

As machinery is involved in the installation, this will be a fast approach for optical fibre cable laying. This will reduce manpower and time. Thus, make it suitable for long-distance optical fibre

cable installation. This can make a deeper trench as compared to trench formed using manual trenching. A deeper channel will provide better protection to the cable. Ultimately, channel depth varies according to the application and type of cable used.

Know More...

Trenching can be performed using a trencher. There are three types of trenchers which are as follows:

I. Rock wheel trenchers for a rocky area

II. Chain trencher for soil

III. Top cutter for cutting tarmac & concrete

Fig. 4.6 (a) Rock wheel trencher (b) Chain trencher (c) Top cutter

Trenchers use tungsten carbide tipped digging teeth to "cut" the ground as it moves along. Trenching reduces the requirement of additional manpower on construction sites and allows for a quicker and safer working environment.

Know More....

Hazard in Trench

While making a trench some deadly accident may happen, if the installation team does not take precautionary measures. If the walls of the trench collapse then this may cause serious injury to the worker working in the trench. Common hazards in the trench are hazardous atmosphere, sliding raw material or objects, water accumulation, damaged underground utilities. Figure 4.7 shows some of the common accidents that may occur in making the trench. To follow the guideline for making the trench safely refer to practical activity 4.1.

Fig.4.7 (a) Accident in the trench (b) Collapsing of the wall in the trench

Practical Activity 4.1 – Demonstrate safety measures that need to be implemented in trenching.

Material Required

Marking pointer, notepad, pen.

Procedure

Step 1. A hazardous atmosphere can be deadly while performing the excavation. Gases such as hydrogen sulphide, methane, and carbon monoxide settle in the trench.

Step 2. These gases can cause poisoning, suffocation, or death.

Step 3. Material and objects can slide down in trench which can cause serious injuries to the worker.

Step 4. Material such as dirt, rock, stones, including objects such as tools, pipes, and other equipment must be kept 2 ft away from the place of excavation to avoid any accident.

Step 5. Water accumulated in the trench due to rainfall or leakage in the water pipe. This will weaken the trench and can cause hazards to the worker.

Step 6. Water must be pumped out of the trench.

Step 4. Workers must not stand in the water-logged trench.

Step 8. Damaged underground utilities can expose workers to the hazard that can cause an electric shock if an underground electric cable is struck, or may cause explosion if gas pipeline is struck, or waterlogging if water pipe line is struck.

Step 9. Thus, before digging it is required to contact the local utility owner. Mark the area of gas pipeline, water pipeline, underground electric cable. This will make it easy while making the trench.

Practical Activity 4.2 – Demonstrate the way of making the trench.

Material Required

Trenching machine, manpower, shield and excavation equipment.

Procedure

Step 1. In the initial stage of trenching inspect the soil as shown in Figure 4.8.

Fig. 4.8: Testing the type of soil

Step 2. The Test will determine the soil type, refer Table 1.

Table 1: Soil type

Type of Soil	Level of Stabilization
Type A	Most stable type of soil for making trench
Type B	Next stable type of soil for making trench
Type C	Least stable type of soil for making trench

Step 3. After determining the soil type, the safe depth level of the soil will be decided.

Step 4. Next, a trench of correct depth will be formed.

Step 5. While making trench use sloping, benching, shielding to protect the collapsing of the sidewall of the trench.

Fig. 4.9: Shielding of trench

Fig. 4.10: Slope in the trench

Fig. 4.11: Bench in the trench

6. These practices will avoid the collapse of the sidewall.

Duct Placement – It is a placement of hollow tubes in the trench. Duct helps in the pulling of OFC and at the same time, they protect the OFC from environmental effects. After completion of trenching, ducts are placed in the trenches. There are various types of ducts available in the market and duct selection will depend on the characteristics of the soil on which installation is performed. They can be made up of materials such as concrete, plastic, metals, and many more. Placing a duct in a trench can avoid repetitive trenching. In addition, it will be easy to pull the cable again in the future. A Duct made up of concrete is shown in Figure 4.12.

Fig.4.12: Duct made up of concrete is placed to pull the optical fibre cable

Cable Placement – At the time of installation of optical fibre cable, cable tension is the considerable part while pulling it through the duct. If the cable tension exceeds the limit, then it may damage the cable. To maintain the pulling tension in the optical fibre cable, the extra cable is pulled out first from the cable drum, and then that cable is kept on the floor in the pattern of eight. The pattern of eight prevents the twisting of the cable. Figure 4.13 shows placing the cable in the trench.

Fig. 4.13: Placing the cable in the trench

Figure 4.14 shows the wrong way to place the cable.

Fig. 4.14: Wrong way to put the optical fibre cable on the floor

Figure 4.15 shows cable is placed in a pattern of eight.

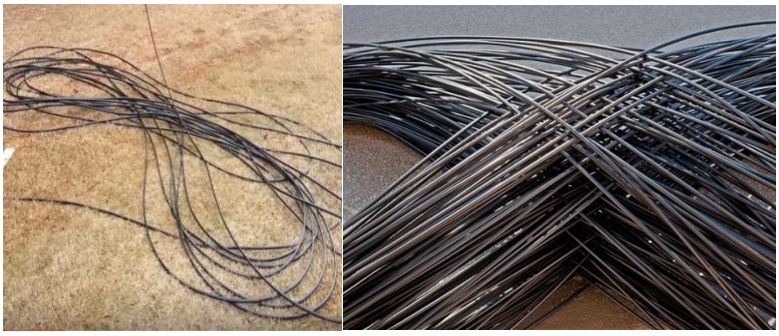


Fig. 4.15: Right way to put the optical fibre cable on the floor

Following steps may be performed to form to place the optical fibre cable in the pattern of eight:

i. To create a Figure of eight optical fibre cables, draw two adjacent circular patterns of diameter 1.5 meter to 2 meters.

ii. Pull the optical fibre cable from the drum or payoff trailer. And place it over the circumference of the circle.

iii. Place the cable in the shape of numeric digit 8.

iv. To create a Figure 8 pattern loop for heavy optical fibre cables, three persons are required, one at a stand at the joining point of the circles and one each will stand beside both circles.

Practical Activity 4.3 – Demonstration of cable placement in the pattern of eight.

Material Required

Optical fibre cable of length 100 feet, hand gloves

Procedure

Step 1. Arrange for an open and flat surface area.

Step 2. Wear hand gloves for protection as one is going to handle optical fibre cable.

Step 3. Now, place a cable drum on the cable stand.

Fig. 4.16: Cable drum stand

Step 4. Start pulling the optical fibre cable.

Fig. 4.17: Pulling the cable

Step 5. Firstly, the cable, which is pulled from the drum, is kept on the ground surface in a circular pattern.

Step 6. In this circular pattern, if one pulls the cable, it will be entangled.

Step 4. Again, repeat step 4. And place the optical fibre cable in the pattern of eight, if one pulls the cable, it will not be entangled.

Fig. 4.18: Right way of placing the cable

Step 8. This specifies the importance of placing the cable in the pattern of eight.

Cable Pulling and Blowing – In the installation of optical fibre cable, safely placing fibre in the duct is a critical process. To perform this task precise techniques are used as per the requirement. Commonly used techniques for cable placement in the duct are cable pulling, cable blowing.

(i) Cable Pulling – In some situations, the hand-pulling method can be used to place the optical fibre cable for a short straight path. To do so, a cable strength member is tied to the pulling rope as shown in Figure 4.19. Then, slowly optical fibre cable will be pulled through the duct.

Fig. 4.19: Cable Puller machine and a pulling rope

In this operation, a pulling machine can also be used. This pulling method is generally preferred where underground ducts are not continuous for more than 200 to 300 meters.

Fig. 4.20: Pulling machine pulling the optical fibre cable

Under this condition, there will be manholes to pull the cable. At each manhole, an extra bunch of optical fibre cables is left. Figure 4.21 shows a bunch of optical fibre cables in the manhole.

Fig. 4.21: Optical fibre cable kept in a manhole in the form of a coil

Hence, optical fibre cable installation into a duct using a pulling method is suitable to apply for short distances.

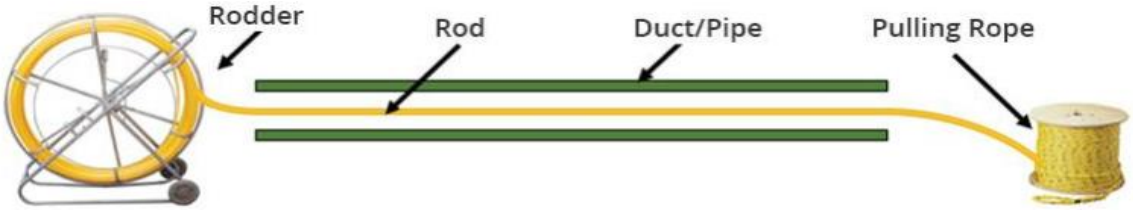


Fig. 4.22: Pulling the optical fibre cable using a rope

(ii) Cable Blowing – In this type of installation method, an optical fibre cable is fed into the duct along with high-speed compressed air. High speed compressed air reduces the friction inside the duct which will help in feeding the optical fibre cable into a duct. Standard optical fibre cables can be installed by using this method. This method applies to continuous lengths of more than 1000 meters. Figure 4.23 shows the concept of the air blowing method.

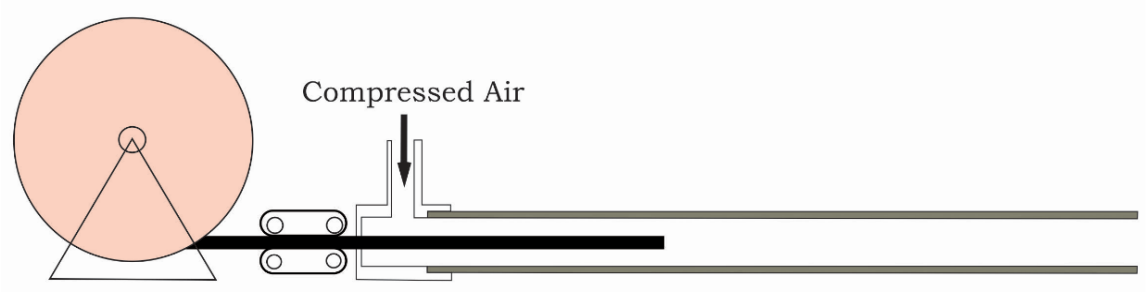


Fig. 4.23: Air Blowing Method

Let us understand the air blowing method using the following practical activity 4.4.

Practical Activity 4.4 – Demonstrate the insertion of optical fibre cable into the micro duct using the air-blowing method.

Material Required

Air-blowing machine, optical fibre cable, drum handling equipment, lubricant, paper, pen

Procedure

Step 1. Consider a micro duct of any size such as 16/12 mm and 14/10 mm, as shown in Figure 4.24.

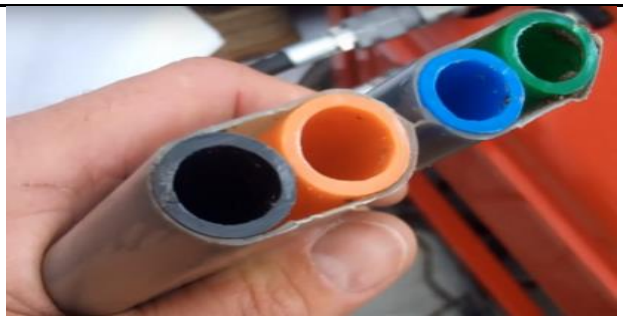


Fig. 4.24: 16/12 mm and 14/10 mm micro duct

Step 2. Clean the micro duct by blowing a sponge through them. Firstly, a dry sponge is blown. Then, the sponge is soaked in lubricant for smearing. This sponge will go into the micro duct.

Fig. 4.25: (a) Sponge soaked with lubricant (b) Inserting soaked sponge into micro duct

Step 3. Set up the air-blowing machine on the field as shown in Figure 4.26.

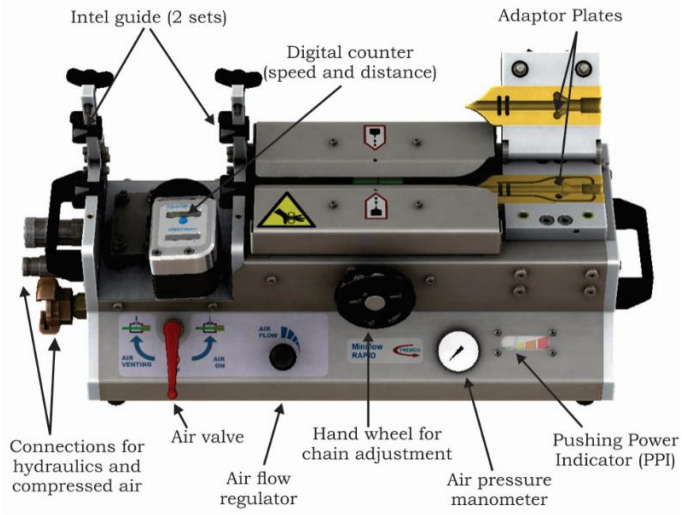


Fig. 4.26: Air-blowing machine

Step 4. Connect the hydraulic machine to the control valve of the air blowing machine as shown in Figure 4.24.

Fig. 4.27: Hydraulic machine

Step 5. Check that there should not be any fibre cable in the blowing machine.

Step 6. Check that the chains are not in contact with each other.

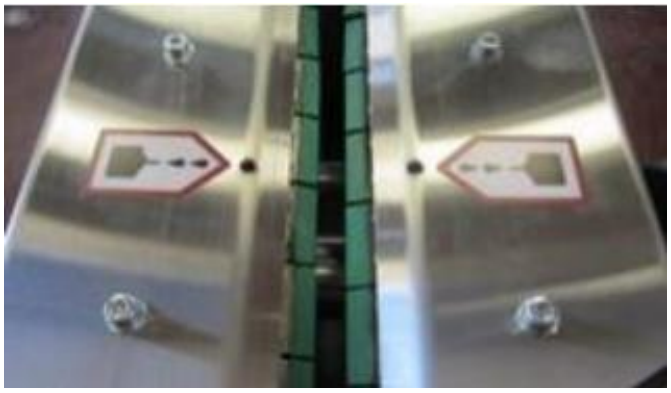


Fig. 4.28: Chain in the air blow machine

Step 4. Take the optical fibre cable, fit it into the micro duct. Now fix this arrangement in the slot of the blowing machine as shown in Figure 4.29.

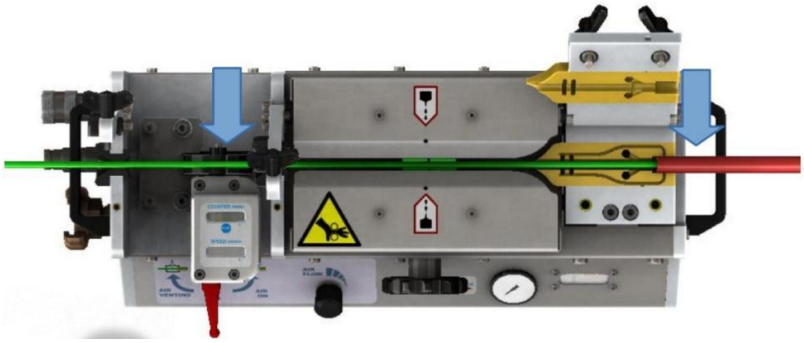


Fig. 4.29: Top view of the machine showing the slot

Step 8. Start the hydraulic power unit according to operating instructions.

Fig. 4.30: Starting the hydraulic engine

Step 9. Forward the joystick to start the operation.

Fig. 4.31: Moving the joystick

Step 10. Make sure that there should not be any air leakage.

Step 11. Regulate the speed of the blowing machine.

Step 12. Note down the reading on the paper using the two-meters i.e. one shows the total distance in meters covered by the cable into the duct and seconds shows the speed in meter/minute.

Fig. 4.32: Meter shows the distance and speed of the cable into the micro duct

Step 13. After some time, the optical fibre will be inside the micro duct.

Step 14. Observe and note down the reading of the meter display.

Cable Termination and Splicing – This is the last stage of the underground cable laying process. Termination refers to an end. Therefore, cable termination is the point where the optical fibre network ends. At the terminating point of the cable, a cap is placed to protect the core and cladding from the damage. If there is a requirement to expand the optical network, then splicing can be performed to spread the optical network. Let us understand, in more detail using the practical activity. Fig. 4.33: Shows refilling the trench.

Fig. 4.33: Refilling the trench

Every cable termination point will be sealed and protected by protective caps.

Route markers and warning tape are used to protect the underground cables from future excavation. The underground cable will be buried under a standard depth to avoid accidental damages.

Fig. 4.34: Route marker and warning tape on the ground surface

Note... If there is a requirement to expand the optical network, the technician performs the splicing to spread the optical network. After splicing, the optical fibre splicer performs the testing of installed optical fibre cable. Splicer checks for continuity of optical signal. If there is any fault or problem, it is resolved. Splicing has been explained in the previous chapter.

The following points should be remembered while performing underground installation:

1. Hazardous climatic conditions can also harm the worker. Deficiency of oxygen at some critical workplaces may create a breathing issue.
2. Gases such as methane, carbon monoxide, carbon-di-oxide can cause poisoning, suffocation or death.
3. Materials and objects can fall in the excavated portion, this can cause serious injuries, it may strike a worker working in the trench.
4. Materials such as dirt, rock, stones, including objects such as tools, pipes, and other equipment must be kept 2ft from the place of excavation to avoid any accident.
5. Water may accumulate at the excavation site during the rainy season or due to leakage in the water pipe. This will weaken the excavation wall making them unstable. This may cause hazards to the workers.
6. Water must be kept away or pumped out of the trench.
7. Workers must not stand in the water-logged trench.
8. Damaged underground utilities can expose workers to hazards and can cause electric shock if an underground electric cable is struck, or may cause an explosion if a gas pipeline is struck, or waterlogging if a water pipe line is struck.
9. Before digging, it is recommended to contact the local utility owner. Mark the area of gas pipeline, water pipeline, underground electric cable. This will make it easy while making the trench.
10. Trench route should be selected after considering the future development planning in the area of installation. For example, road widening should not disturb the installed fibre cable.
11. At the time of completing the trench at maximum speed, trenching width and depth should not exceed the requirement.

2. Aerial Installation

The word aerial defines operating in air, or we can say that working above the ground. This optical fibre installation method is common nowadays. The aerial method is also known as pole-to-pole installation. To adjust the harsh outdoor environment and prevent fibre theft. The aerial optical fibre cables are made up of different materials. These materials are not the same as typical optical fibre cable.

Aerial cable is a type of optical fibre cable used to install the cable on poles as shown in Figure 4.35. As the cable is mounted on the pole, therefore, aerial optical fibre cable must protect from natural calamities, theft, and other damage. The aerial cable laying method is not hard to implement as it can utilize the existing overhead pole line for installation. This will save the construction cost and installation time. Fig 4.35 shows aerial cable mounted on the pole.

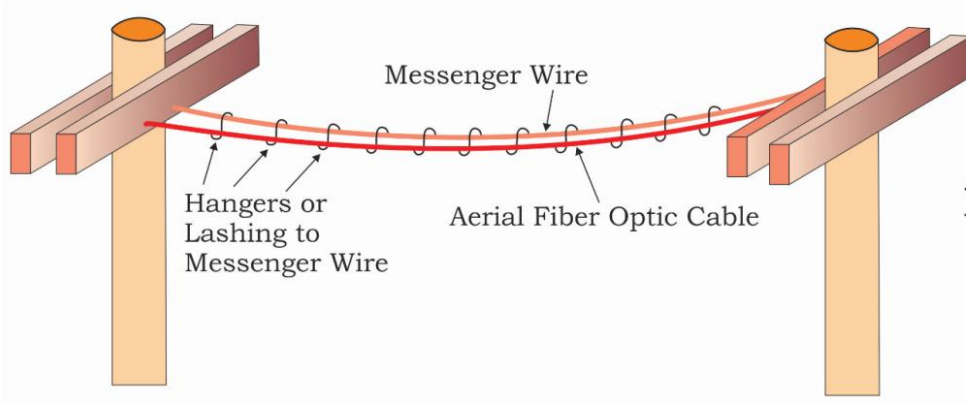


Fig. 4.35: Aerial cable mounted on the pole

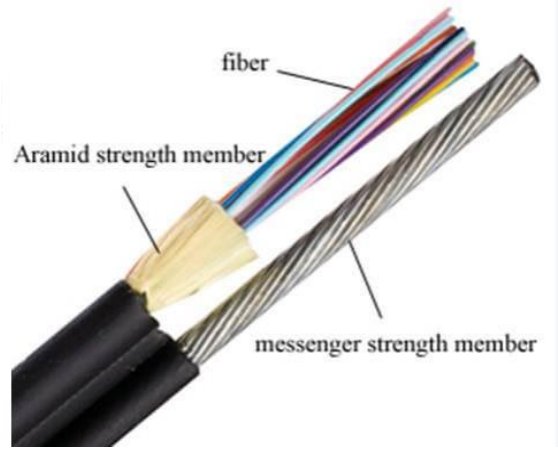


Fig. 4.36: Aerial cable

The failure rate of aerial fibre optic cables is higher than the underground fibre optic cables. As aerial cabling is affected by natural disasters, such as storms, snowfalls, floods. These external forces may weaken the mechanical strength of the overhead cables. Two common methods for aerial optical fibre cable installation are as follows:

I. Moving reel method

II. Stationary reel method

Moving Reel Method – It is the simplest way to install aerial optical fibre cable. Whenever there is an installation of new lines, it is the primarily used cable placement method. At the time of installation of cable, the way of the installation vehicle must be clear. Figure 4.37 shows a typical moving reel method.

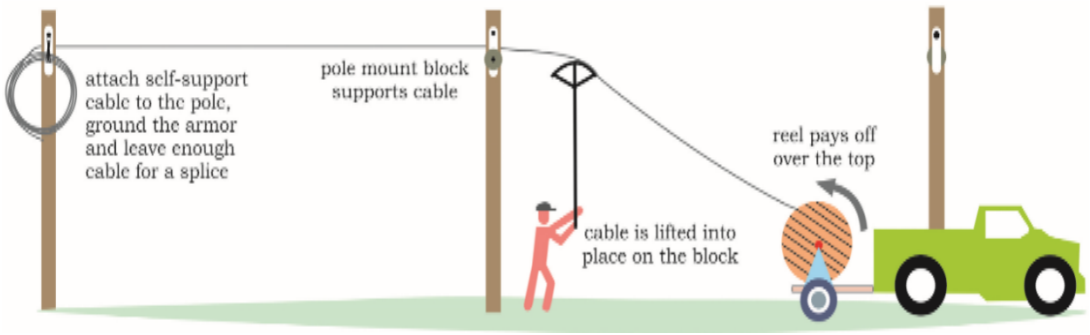


Fig. 4.37: Moving reel method of aerial cabling

Stationary Reel Method – Stationary reel method contains three steps as cable rolls set-up, pulling set-up, cable block placement.

(a) Cable Rolls Set-up – Cable roll should be positioned in-line with the pole. A cable roll must be kept at a distance from the pole. This distance between the cable roll and pole must be twice the height of the pole as shown in Figure 4.38. Place protective barriers and cones as needed to protect pedestrians.

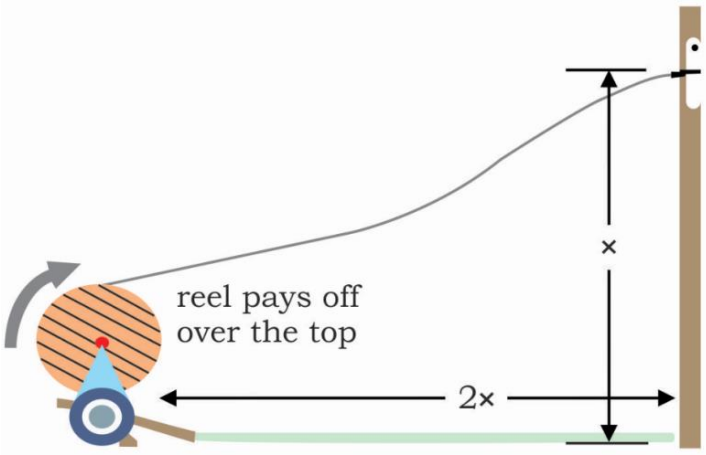


Fig. 4.38: Cable rolls Set-Up

(b) Pulling Set-Up – Attach the correct size cable grip. Then attach a swivel to the cable and then pull the OFC. While pulling the optical fibre cable cautious for pulling tension of the cable. It must be correctly managed. Fig. 4.39 shows swivel for cable pulling.

Fig. 4.39 Swivel for cable pulling

(c) Cable Block Placement – Cable blocks are fixed on the poles by the manufacturer. First, pull the cable and then, lift it upward to place it in the cable blocks. This can be done using a cable lifter or by hand from a bucket truck as shown in Figure 4.40. Typical cable blocks are shown in Figure 4.39.

Fig. 4.40 Cable blocks

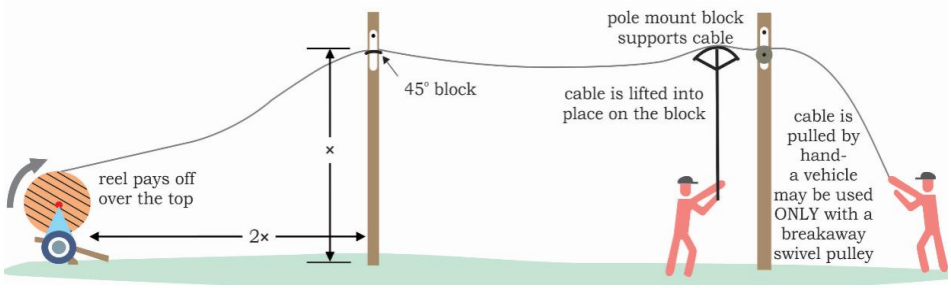


Fig. 4.40 Cable Block Placement

More to Know...

Dark Fiber

The term dark means unused network infrastructure. When data is sent across fibre optic networks, light passes through the cables. No light waves are moving along the cable if no data is being transmitted, hence the fibre is dark. Previously, businesses tended to future-proof their fibre optic networks. It was done by installing more cabling than actually required, to be prepared for exponential data growth. Many fibre optic networks are not being used to their full capacity as a result of this overestimation. As a result, dark fibres were developed to take advantage of this extra capacity. Dark fiber gives extremely good performance, security and super-fast speeds.

Reporting and Documentation

It is necessary to create reports and document everything in a proper manner for future references and troubleshooting. The whole installed optical fibre network of a premise or area has to be mapped on paper for future upgradation and maintenance. The benefits of reporting and documentation are as follows:

I. The cable laying process will be faster, including cable pulling and installation.

II. Tracing links & finding faults.

III. Speed up the pulling process if the routing and terminations are already documented.

IV. The test data should be documented with the previous information to get the acceptance from the end user.

V. After the installation, if there is any repositioning of equipment the documentation will help to re-routing to the exact end points.

The detailed information about the cable, splice, fibre, paths is necessary and should be recorded as follows:

Cable Information: Record Cable information such as:

1. Manufacturer, Type, ID, Length and Drum number.
2. The distance at which the splices and termination point are done.
3. Optical fibre type & size, splice and connectors position, losses.
4. Route of cable placement.
5. Optical fibre cable route, loss and test results on the cable should be noted.
6. All these data should be kept with the documents of component, connection and the test results.
7. OTDR test results will be stored separately for maintenance purposes in the future. It can be printouts or in digital format. The digital data file should be stored in the database in an arranged manner to make maintenance easy.

All the cable drums should be marked with type, installation method to be followed, the total number of fibres in the wrapped cable, and the total length of the cable.

Special requirements should be specified (type of application and installation requirements) to estimate the total manpower and cost required.

Record test data on each fibre run. It will reduce the complexity of troubleshooting.

Documentation will let one know about things that are required for a cable installation, like where cable goes, the distance between access points, the areas in which installation takes more time and many more. Testing information gives the way to find out the degradation over time.

Merely, recording is not enough, its storage is also essential. The following points have to be considered to maintain the data record.

I. Documentation of data in plant location is very essential.
II. Databases have to be stored in different data formats, paper printouts or digital files should have multiple copies stored in several locations and make sure that the data is accessible for every team to review.
III. Ensure it is available to all the authorities for review.
IV. Along with maintaining proper records and documents, it is also important to maintain following reports and fill them on a regular basis.
V. Report on the status update
VI. Pending issues
VII. Challenges
VIII. Faults & Serviceability
IX. NOC for cable installation
X. Final closure of the job

Check Your Progress

A. Multiple Choice Questions

1. Splice enclosure used for ____. (a) Whenever a fibre has been spliced (b)When a splice must be placed underground (c) When a splice must be placed underwater (d) When a splice must be placed above the ground
2. FDF stands for _____. (a) Fibre Distribution Frame (b) Fibre Digital Frame (c) Frame Display Fibre (d) Frame Distribution Fibre
3. Which of the following is not the type of FDF? (a) Rack mount FDF (b) Side mount FDF (c) Wall mount FDF (d) Floor mount FDF
4. Which of the following is used to hold and protect the spliced fibre cable? (a) FDF (b) Ducts (c) Plastic cover (d) Splice tray
5. In air blowing installation technique of optical fibre _____ is used. (a) Compressed air (b) Uncompressed air (c) Mixed air (d) Air at atmospheric pressure
6. The word aerial defines operating in air, or we can say that working **(a) above the ground.** (b) below water(c) on air (d)inside the residence
7. OTDR test results will be stored separately for maintenance purposes in the future. It can be printouts or in (a) analog format **(b) digital format** c) word format d) pdf format
8. Failure rate of aerial fibre optic cables is higher than _____ fibre optic cables **(a) underground** (b) Aerial (c) near the road (d) on the land surface
9. Manual trenching needs more _____and time **(a) manpower** (b) energy (c) work (d)machinery
10. Duct Placement is the placement of hollow tubes in the trench. Duct helps in the pulling of OFC and at the same time, they protect the OFC from **(a) environmental effects** (b)water (c)air (d) rust

TSSC Book Questions

1. Upgradation and troubleshooting will be effective if ---------- has been done in planning. (a) Good workmanship (b) Low loss connectors (c) Safe workplace procedures (d) Proper documentation
2. Installation of OSP cable can be_____. (a) a. Pulling in underground in conduit (b) Direct burial (c) Aerial suspension (d) All of the above
3. Which protective gear is essential in optical fiber installation and maintenance operation? (a) Eye protection (b) Plastic apron (c) Gloves (d) Shoe covers
4. What is the use of fiberglass rod inside many fiber optic cables? (a) Increasing the pulling tension (b) Limit bend radius to preventing kinking (c) Winding the fibers around (d) Tying to messenger cables
5. What is the significance of the 'figure 8' pattern in optical fiber laying? (a) Keep it from getting tangled with the pull rope (b) Make it easier to spray on lubricant (c) Keep workers from walking on it (d) Prevent it from twisting
6. At the time of installation process, the bend radius should be _____. (a) times the cable diameter (b) 10 times the cable diameter (c) 20 times the cable diameter (d) 50 times the cable diameter
7. What is the standard depth of trench for the underground duct cables? (a) 3-4 feet (1-1.2 meters) (b) 1-2 feet (0.3-0.5 meter) (c) 6-8 feet (2-2.5 meters) (d) As deep as the local building codes allow
8. Select the correct way of using cable tie (a) Should be tightened firmly to prevent cable movement (b) Can be used to hang cables from J-hooks or cable trays (c) Should be rated for the weight of the cables (d) Can harm cables if too tight, so they should be hand-tightened
9. In the following options, what will decide the speed of direct burial installation? (a) Local permit (b) Ground (c) Cost (d) Cable
10. For immediate testing after splicing, which method will be utilized? (a) OLTS (b) OTDR (c) VFL (d) CD test set
11. Which test method will use for testing splice point in an installed optical link? (a) OLTS (b) OTDR (c) VFL (d) CD test set
12. Select correct option in following, before installing cables in utility poles (a) Look for other installation options (b) Have the power cables shut down (c) Notify the proper authorities (d) Notify the owners of other cables
13. Long cable pulls in conduit may require _____ or _____ (a) Heavy-duty mechanical pullers (b) Trucks or tractors to pull the cable (c) Lubricants (d) Intermediate pulls
14. Most fiber optic cables do not have sufficient strength to allow direct aerial installation, but _____ or _____ can be used to install them aerially. (a) Rubber clamps (b) Pole-mounted grips (c) Lashing to another cable (d) Lashing to messenger strands

B. Fill in the blanks

1. ____ refers to cable installation into a pre-installed underground duct by manual pulling or by a puller machine.
2. Duct is like a _____.
3. Cable blocks are built up by the manufacturer in the ____.
4. Aerial fibre optic cable installation procedures include _____ and _____.
5. Trenching can be performed using _____.
6. Trench defines a _____.
7. Cable installation by using high speed air flow combined with additional mechanical pushing force is called as _____.

8. At the time, maintenance of optical fibre cable network ____ and _____ is necessary.
9. Compressed air in the cable blowing method reduces the _____.
10. Trenching using a machine is called as _____

Read the following statement carefully and decide true or false:

One should be able to rely on the contractor to not only do the installation but to assist in the design of the network and help choose components and vendors. (True / False)

C. State True or False

1. Water accumulates in the trench due to rainfall or leakage in the water pipe. (T)
2. A deeper channel will not provide better protection to the cable. (F)
3. While making a trench some deadly accident may happen, if the installation team does not take precautionary measures. (T)
4. Underground Installation is also known as trenching method. (T)
5. After the completion of the site visit and route inspection is not necessary. (F)
6. Installation team acts as an installer to establish a network, which provides the required services to the users. (T)
7. Cable Blowing is a type of installation method; an optical fibre cable is fed into the duct along with high-speed compressed air. (T)
8. Cable termination is the point where the optical fibre network does not end. (F)
9. Every cable termination point will be sealed and protected by protective caps. (T)
10. Hazardous climatic conditions can also harm the worker. (T)

D. Short answer questions

1. Explain the cable pulling method?
2. Explain the cable blowing method?
3. What is trenching?
4. Explain the procedure for pulling the cables?
5. How is the duct prepared for the installation using an air blowing method?
6. Explain the aerial fibre optic cable installation procedures?
7. How the conduct is done using the Figure 8'ing'.
8. How is the trimming of the buffer tube done?
9. Write the steps for the OFC preparations?
10. What is the purpose of fibre optic cable pull boxes?

Module 3	Installation and Commissioning of Fiber Optic Cable

Module Overview

The installation and commissioning of fiber optic cables are crucial steps in establishing efficient telecommunication networks. This process begins with a thorough site survey to assess the environment and determine the optimal route for cable installation. Proper handling of fiber optic cable drums is essential to prevent damage during transport and storage. Students will learn about various optical tools and equipment used in the installation process, including fusion splicers, optical time domain reflectometers, and visual fault locators.

Once the route is determined and the equipment is prepared, students will engage in the actual installation of the fiber optic cables, ensuring adherence to safety protocols and industry standards. Commissioning involves testing the installed cables to confirm signal integrity and performance, ensuring that the network operates effectively. By mastering these skills, students will be well-equipped to contribute to the growing telecommunications industry and understand the importance of fiber optics in modern communication systems.

Learning Outcomes

After completing this module, you will be able to:

- The procedures for diagnosing faults and implementing corrective maintenance on fiber optic systems effectively.
- Understand how to analyze link performance metrics to ensure optimal operation of fiber optic communication systems.
- Gain skills in testing optical fiber links to verify performance, integrity, and compliance with industry standards.

Module Structure

Session 1: Corrective Maintenance and Fault Restoration
Session 2: Link Performance Analysis
Session 3: Testing Optical Fibre Link

Session 1: Corrective Maintenance and Fault Restoration

Once the OFC installation is completed, the next task is to maintain the installed optical fiber network setup. There are several reasons, which can result in faults. Testing is employed to check the performance of OFC. Testing confirms their performance specifications. In this chapter, we will understand the concepts of fault notification, fault localization, fault rectification fault restoration in the installed OFC.

1.1 Fault Notification

In OFC, light is used to transmit information. But a small bend or crack in the protecting layers of OFC results in leakage of light. These faults are difficult to identify through naked eyes as OFC are placed underground. Fault defines an unattractive or unsatisfactory feature in optical fibre communication. Fault notification defines the action of notifying the fault. Special equipment is required to identify the faults. In Figure 1.1, when there is a fault in the customer's premise, they register their problem in the network operation center. Intimate the network operation center regarding the fault in the link, cable ends, and connector. These issues are shared with the network operation maintenance team by the network operation center. The maintenance team rectifies the cause of the fault.

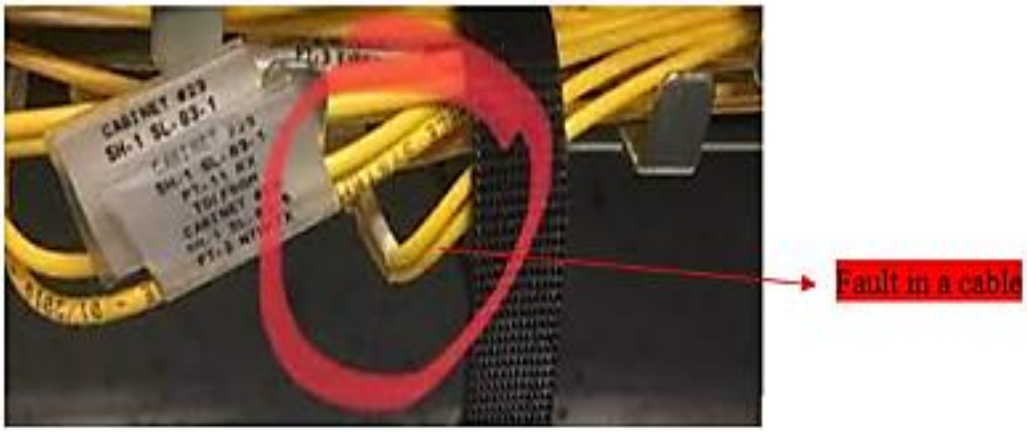


Fig. 1.1: Fault in a fiber optics cable

1.2 Fault Notification Guidelines

Once the network team gets the fault notification, the following points have to be executed by the network team.

Cross check the correctness of fault.

- Confirm the service level agreement, it defines commitment between a network team and customer.
- Set the priority with the team members.
- Get in touch with all stakeholders involved in fault rectification.
- Arrange for permits or approvals and equipment if needed.
- Prepare a document for reason and report of fault in OFC.

1.3 Fault Localization

As we know OFC laying is a very complicated process. In case any fault occurs, the team will try to localize and rectify the fault. When the network team is unable to rectify the fault, in that case, the team will go for the replacement of the particular link of OFC. For the effective use of OFC, it is necessary to detect and localize the fibre failures without delay. The methodology used to

find out and localize the failures of fibre is termed as *fault localization*. It is not enough to just detect and locate the fault. It is required to rectify the fault, known as *fault rectification*.

1.4 Fault Rectification

It is a process to correct the fault at a location in the OFC. Understanding and adherence to the following are mandatory for fault rectification.

1. Following are the important questions of consideration before starting the fault rectification:
   - How long is the route?
   - Cabling type?
   - What sort of fault locator is available?
   - Available team members.
2. Following challenges are encountered during fault rectification:
   - Without any link leakage, the transmission signal is difficult to measure.
   - Specific devices/ instruments are brought into practice for localization/ identification of optical fibre fault.
   - Route lengths can be very long e.g., 100 Km.
   - Unavailability of skilled staff.
3. Instruments used for locating faults:

Specific device/ instruments used in practice for localization/identification of optical fibre fault:

- Optical Time Domain Reflectometer (OTDR)
- Optical Power Meter (OPM)
- Visual Fault Locator (VFL)
- Optical Microscope

Fig. 1.2 Fault measuring instruments

1.5 Process of Fault Rectification

After getting the intimation regarding the fault from the customer end, the network team will perform the necessary action to find the exact location of the fault. Following steps are to be followed to fix the fault.

1. Network team will record and locate the customer location.
2. Then after the network, the team will trace the link, which is going towards the customer location.
3. Use a transceiver, which will transmit the light signal in that particular link, which is going towards the customer location.

4. Transceiver after a few seconds will receive a reverse signal, which will come back from the faulty location.
5. Network team then analyses the power of the received signal and identifies the type of fault at the remote end. In addition, the network team also calculates the exact distance of the fault.
6. This way the fault location will get fixed.
7. Immediately, information about the fault in the OFC link and location is conveyed to the fault maintenance team.
8. Fault maintenance team soon reaches the fault location and performs the necessary action to rectify the fault.
9. Fault maintenance team after rectifying the fault, acknowledges back the completion of the task.
10. Then they will again pass a signal through that link and calculate the signal level of the received signal.
11. Once getting the satisfactory result, the network team intimate the customer regarding the rectification of the fault.

Practical Activity 1.1 – Demonstrate the repairing of underground OFC.

Material required

OTDE, fusion splice machine, cleaning kit, digging equipment

Procedure

Step 1. Consider an OFC link for testing. Connect OTDR in the cable link. It can work like radar, likewise, it sends a light pulse into the OFC. It shows the deflection in its display screen when there is a breakage in the OFC link. It helps the technician to know about the location of breakage in OFC.

Step 2. Once the damage or break in the OFC is detected, digging will start at that particular location. Then, strip the fibre around 5 feet of the cable using ripcord. Peel the jacket gently, so that optical fibre tubes can be exposed. Then, clean that cable gel using cable gel remover and cut sheath and yarn.

Fig. 1.3 Technician repairing the optical fibre cable after identifying the fault

Step 3. Next, strip the fibre by using an optical fibre stripper. Trim any damage on the fibre ends using a high-precision fibre cleaver. Then clean the stripped fibre using wipes which are soaked in alcohol.

Step 4. Now, place the fibre ends within the fusion splice machine. Perform the fusion splicing. Observe the screen of the splice machine for correct alignment. Then put back those splices into the splice enclosure. Close the enclosure.

Step 5. Cross check the spliced fault area through OTDR.

Step 6. This will complete the restoration of fault in the OFC link.

1.6 Optical Fibre Cable System Fault

In OFC, there can be a number of causes for a fault to occur. Some of the faults that can occur in the cable are as follows.

Fault	Cause	Equipment to Identify	Remedy
Bad connector	Dirt or damage	Inspection Microscope	Cleaning/ Polishing
Bad Pigtail	Pigtail Kinked	Visual Fault Locator	Straighten Kink

Localized Cable Attenuation	Kinked Cable	Optical Time Domain Reflectometer	Straighten Kink
Increase in Cable Attenuation	Defective Cable or Installation Specifications Exceed	Optical Time Domain Reflectometer	Reduce Stress / Replace
Loose Splice	Increase in splice loss due to fibre stress enclosure	Optical Time Domain Reflectometer, Visual Fault Locator	Open and Redress
Fibre Break	Damage in Cable	Optical Time Domain Reflectometer, Visual Fault Locator	Repair/Replace

Fig. 1.4: Inspection Microscope

Fig. 1.5: Visual Fault Locator

Fig. 1.6: Optical Time Domain Reflectometer

More to know

Points of difference of different testing tools

Visual Fault Locator (VFL) – Using the VFL you can only inspect the continuity of the Fiber manually between the transmitter and the receiver. The losses within the Fiber can't be checked. It emits red Laser light which can be seen by the human eye. It can be operated at the wavelength of 650nm.

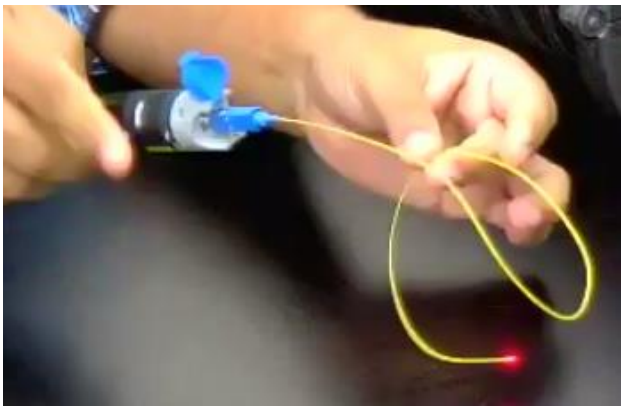


Fig. 1.7: VFL checking the continuity of the optical fiber

Optical Light Source and Optical Power Meter – These two devices are combined to check the optical network. It checks the exact losses in the Fiber cable. The invisible LASER light is emitted by the Optical light source. It works in the wavelength of 1310nm and 1550nm. This can be used for both the single mode and multimode fiber. A power meter can measure the losses up to 1.4db.

Fig. 1.8: Light source and power meter combination to check the total loss in the fiber

Note:

Both light source and power meter should have to save the wavelength selected otherwise it will not work.

Don't see the Optical light source directly otherwise it can damage the eye's retina.

VFL can't be used with the Power meter because of the difference in the wavelength.

One of the drawbacks of the Optical light source and power meter is that it can't measure the distance of the losses instance. Only the total losses can be measured.

OTDR:

It can measure the distance of the occurrence of the losses.

Individual losses in the optical network can be identified and can be calculated.

It is like a mini computer.

1.7 Fault Restoration

After rectifying the fault, the next task is to restore the optical fibre to its initial state, this process is called *optical fibre restoration.* Points to be remembered while restoring the optical fibre cable are as follows:

- Rapidly act as per the problem detected.
- Technicians must have the knowledge of the part on which one is working.
- Technicians must work on the correct portion of optical fibre cable.
- Correct planning will lead to the minimization of the problem.

1.8 Work Instructions – It is essential to follow the work instructions for better quality and enhanced efficiency.

1. Following are the *'Work Instructions'* for mobilization:
   - Drivers shall be available for 24 Hrs.
   - Drivers should move only on the instructions of designated persons.
   - On receiving information about the fault in the cable, visit the site.
   - Driver should be ready with a van equipped with all the installation and repairing tools/equipment and also should check the fuel in the van.
   - At the site to measure the fault, the technician must use OTDR measurement and perform a visual inspection.
   - Labours from the nearest location should be picked up.
2. Following are the 'Work Instructions' for travelling:

   Before leaving – driver/technician to note kilometre reading.

   a) Ensure minimum travel time, by taking alternate routes.

   b) Avoid routes having a chance of traffic jams.

   c) Reach safely at the fault location.
3. Following are the 'Work Instructions' for localization:
   - Team members should move along the OFC route to locate the fault. A Team member should move the exact distance as measured by the OTDR.
   - Teams should carry route plans of OFC with them & should have proper knowledge of the OFC route. Teams look for any digging activity going on nearby locations in the area where the fault is located.

- If cut or breakage is not found, team members should walk to locate the fault. If cut or breakage is not visible, in that case team members should locate the nearest manhole and take traces again.
- Once the team reaches the fault location, they instruct labour to dig the particular area. Digging should be done on either side of OFC.

4. Following are the 'Work Instructions' for OTDR trace measurement:

- During OTDR trace measurement check live fibres first.
- Care should be taken while handling OTDR, Connector. Team members should carry a spare connector & patch cords with them.

Practical Activity 1.2 – Study trace of Optical Time Domain Reflectometer.

Materials Required

OTDR

Procedure

Step 1. OTDR as shown in Figure 1.9 above is like a mini-computer. Select OTDR from the available options. Power ON the device.

Step 2. After selecting the OTDR from the options available a display of the OTDR appears as appears in Figure 2. The OTDR displays time or distance on the horizontal axis and amplitude on the vertical axis. Observe the horizontal axis which displays distance in feet, meters, or kilometres. The vertical axis displays relative power in dB.

Fig. 1.9 OTDR displays

Step 2. Select the wavelength of 1310nm or 1550 nm. Select the distance on the screen tab. Select the pulse width. Select the type of mode (single mode or multimode) and wavelength in nm you want to test the working (eg. 1310 nm or 1550 nm) using tab buttons on the screen.

Step 3. Take an optical fiber cable to be tested and connect it to the OTDR as shown in Figure 1.10.

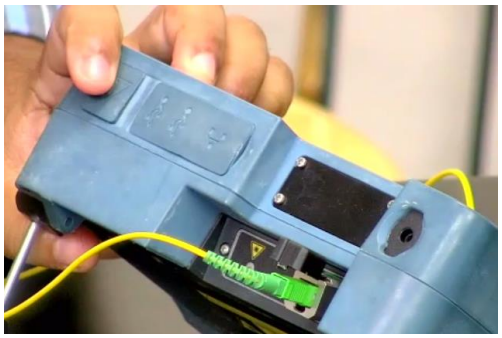


Fig. 1.10 Connection of the optical fiber with OTDR

The fibre cable connected has one mechanical splice and another end open.

Press the start button. Wait for 30 sec and let the graph appear on the screen. The OTDR can

horizontally and vertically zoom in on any section of the trace. This permits a more detailed inspection of the optical fibre or event.

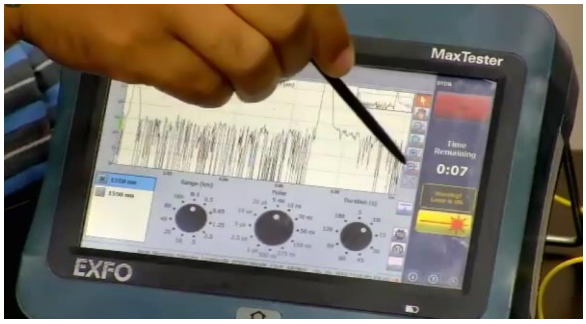


Fig. 1.11 Graph appears on the screen

The slope of the fibre trace shows the attenuation coefficient of the fibre and is calibrated in dB/km.

Step 4. The minimum length is up to 100 meters, afterward, it shows the performance of fibre. It can show the losses maximum up to 160 Km the first spike shows neither reflection nor attenuation is due to the first connector and is regarded as a dead zone. Under the dead zone, no splicing is seen.

Fig. 1.12 OTDR graph

Step 5. The rest spike shows the reflections through the connector. If fibre is connected to another fibre by splicing and OTDR shows a spike value in dB. The trace shows event loss, event reflectance, and optical Fibre attenuation rate. The losses due to the connector are reflective and the spike will go upwards. On the other hand, when the splice loss is, their graph will show a downwards spike.

1.6 Determining fault position of underground cable

Suppose there is damage in the underground cable. Then digging the whole path and finding the fault which is practically impossible. So, measuring devices such as OTDR and pipe cameras are used to handle such situations.

Figure 1.13 shows the optical network layout drawing. Two tests are performed to find the faults. OTDR test and a pipe camera investigation.

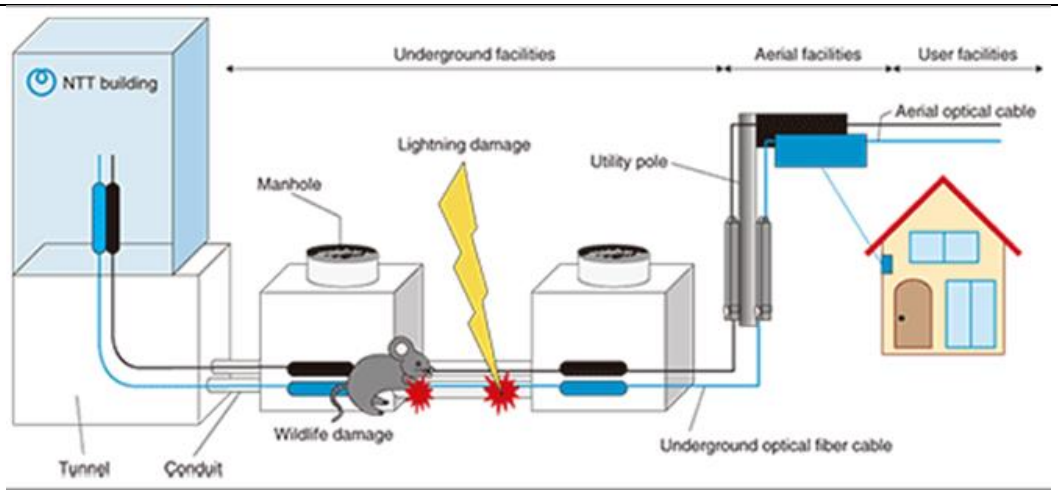


Fig. 1.13: Optical network with underground and aerial Optical Fiber Cable

OTDR test – The OTDR waveform helps to analyse the fault in the cable. It determines the position and the distance of the fault by interpreting its waveforms. For example, the waveform of the faulty optical fiber is shown in Figure 1.14. By looking at the waveform of OTDR the anomalies are observed at a distance of about 990m from the building.

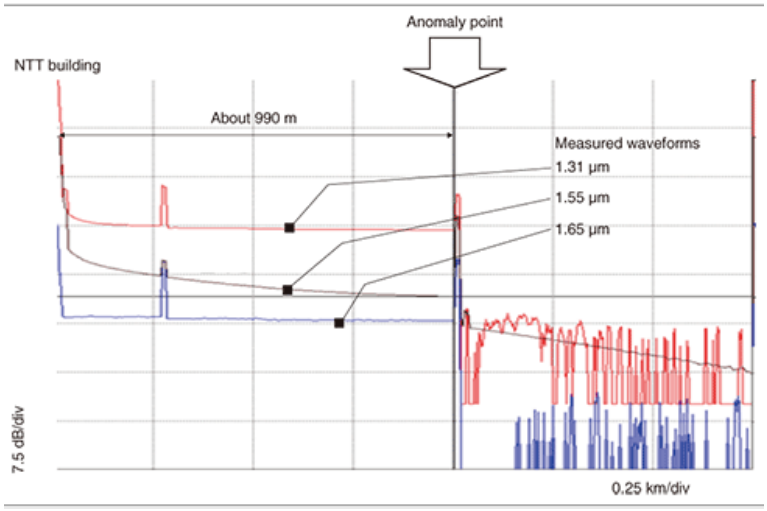


Fig. 1.14: OTDR waveform to determine the fault position

Pipe camera investigation – Once the fault point is located by the OTDR Waveform a pipe camera is inserted from the nearest manhole to the fault location. The camera takes the images and determines the distance and cause of the fault in the cable as shown in Figure 1.15 and Figure 1.16. If the outer sheath of the optical fiber cable is cut and the fiber within the cable is damaged, then the pipe camera will show images of the visible light leakage from the part where it is cut.

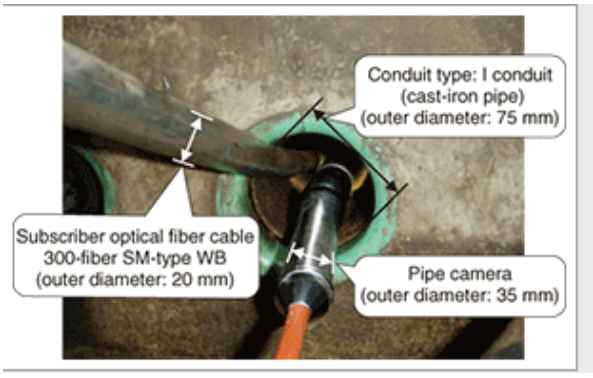


Fig. 1.15: Pipe Camera inserted from the manhole

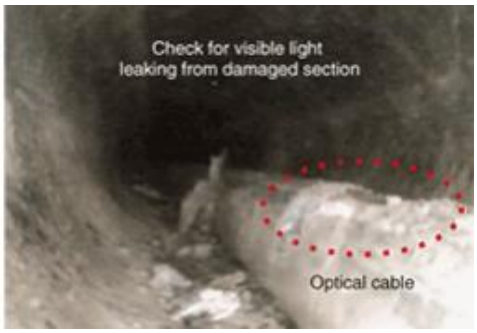


Fig. 1.16 Check cable using the visible light source

Practical Activity 1.3 – An experiment is done to analyse the effectiveness of the above method of the fault location. The setup is done as shown in Figure 1.

Step 1. A 300-fiber SM-type (Single-Mode fiber, Water-Blocking) cable with a total length of about 110 m is laid.

Step 2. A cut is created artificially to create a fault in the cable at a distance of about 30 m from the manhole. A fiber cut is determined about 990 m from the building. A manhole nearest this location of cut was about 30 m away.

Step 3. Now the aim is to determine the fault position.

Step 4. Take an OTDR and from its waveform determine the distance of the fault position.

Step 5. From the nearest manhole insert the pipe camera and inspect the condition of the cable from the obtained images. Images revealed that the cable was damaged at two locations near the 30-m point from the manhole. The pipe camera images showed two damaged at distances of 26.0 and 26.4 m from the manhole.

Step 6. Finally, the visible light is injected into the faulty cable to check the light leaking from the fiber. It is found from one damage point the light is leaking. It means from that point the fiber inside the cable sheath is damaged. From the other point, the light is not leaking means only the cable sheath is damaged

This demonstrated the effectiveness of the method.

Step 7. The obtained information is used to decide such as replacing the cable or repairing it by digging that particular area underground.

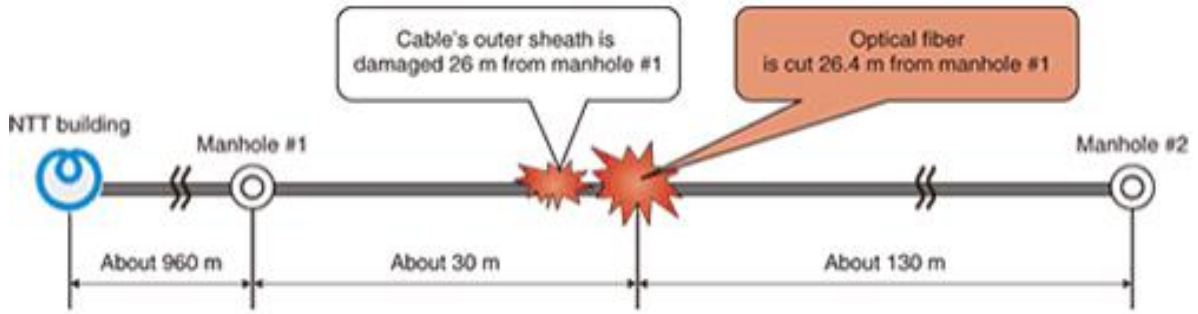


Fig. 1.17 Setup of the field experiment

1.7 Fault Cases of the Optical Fiber Cable Caused by Wildlife

Wildlife that damages the cable is classified into three groups (rodents, insects, and birds). There are different types of damages and suitable countermeasures are taken to prevent the cable. These damages are caused by rain, wind, lightning, and other natural phenomena.

Fault cases

Wildlife that causes damage can be broadly classified into (1) rodents (squirrels, flying squirrels, rats, etc.), (2) insects (moth larvae, cicadas, ants, etc.), and (3) birds (crows, woodpeckers, etc.). These kinds of wildlife can be found throughout the country.

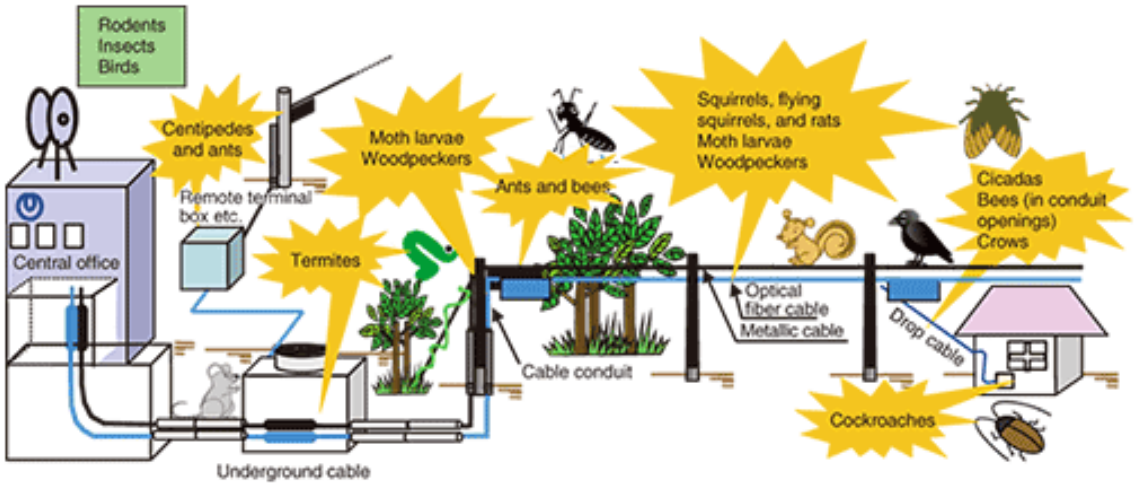


Fig. 1.18: Illustration of places of the cable that can be damaged by wildlife

Rodents – Rodents can be squirrels, black rats, and house mice. They chew on telecommunication cables and connection closures and damage fibers inside optical cables. Damage frequently occurs along aerial cable routes in mountainous areas and damage caused by mice occurs in underground cable routes.

Fig. 1.13: Damage by a squirrel

Countermeasures

One method for preventing the problem is to use a high-strength-sheath cable that has an internal stainless-steel layer. Another effective method is to use a squirrel-proof cover or squirrel-proof tape that has both a layer of stainless steel affixed to a PVC (polyvinyl chloride sheet).

Fig. 1.14: Appearance of high-strength sheath cable

Fig. 1.15: Squirrel-proof cover

Fig. 1.16: Squirrel-proof tape

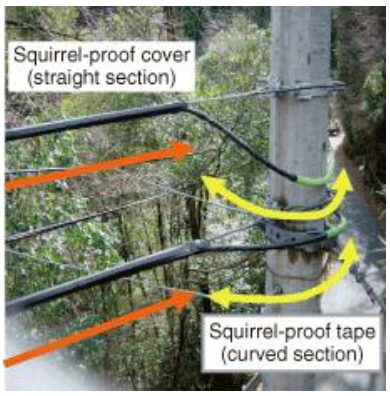


Fig.1.17: Construction of squirrel-proof cover and tape

Faults due to Insects

Faults due to Moth larvae

Moth larvae burrow into trees and the ground and live in holes. The larvae mistake telecommunication cables for plants hence they damage the cable by chewing as shown in Figure 1.11.

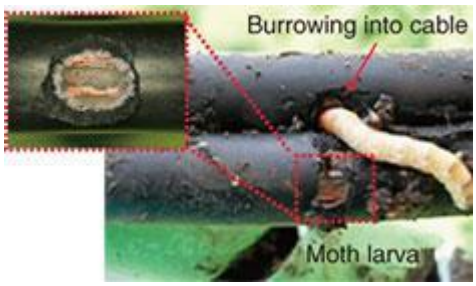


Fig. 1.18: Damage to an optical fiber cable (by a moth larva)

Faults due to Cicadas

Cicadas generally lay their eggs in dead trees. They also try laying their eggs in a drop cable by piercing the sheath of the cable. This damages an optical fiber inside the cable.

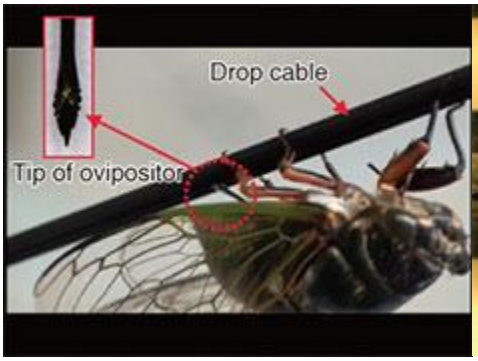


Fig. 1.19: Cicada eggs

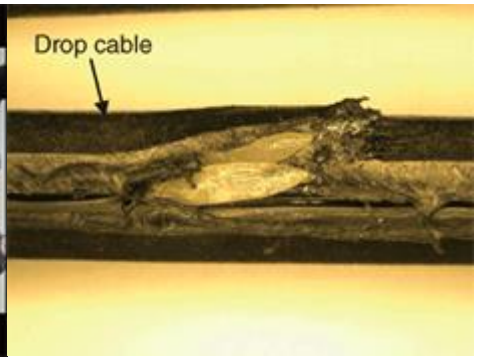


Fig. 1.20: Cicada egg laying

Faults due to Other insects

Other insects like ants and bees enter cable conduits through very small gaps to build nests. This damages the cable by getting burned up by coming into contact with package terminals.

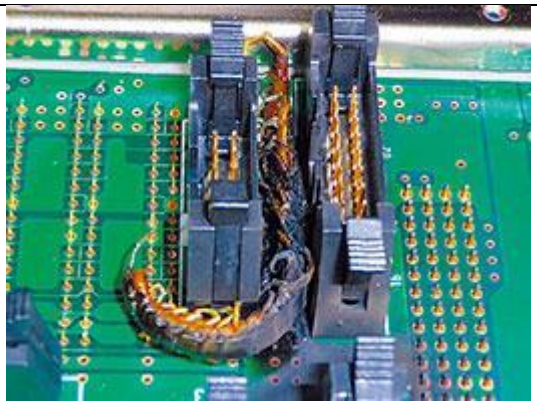


Fig. 1.21: Centipede (charred body) found inside an outdoor remote subscriber module

Countermeasures for insects

The countermeasures taken against moth larvae are similar to those for rodents. Another effective method for preventing cable damage is to eliminate or block the intrusion paths. It is also effective to use commercial anti-ivy products on the stay. By cutting down trees in contact with cables, they deny larvae a path to cables. In the outdoor equipment, gaps are likely to be found at cable entryways or ventilation holes. Cable entryways can be hermetically sealed and a metal mesh can be attached over ventilation holes.

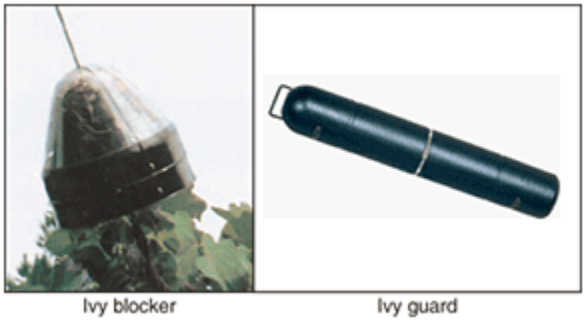


Fig. 1.22: Commercial anti-ivy products

Countermeasure for Birds

Crows build a nest by gathering slim, sturdy materials like twigs or wires. These crows may use their beaks to bite around a cable's water-draining section (where the supporting wire separates from the optical fiber section) and damage the optical fiber inside.

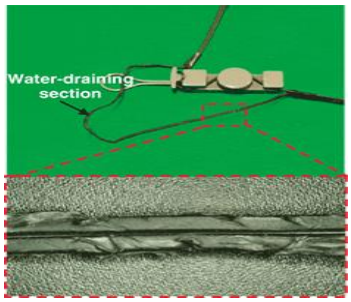


Fig. 1.23: Damage to a drop cable (by a crow)

An effective measure for preventing damage caused by crows is to wrap them with a PVC protective cover.

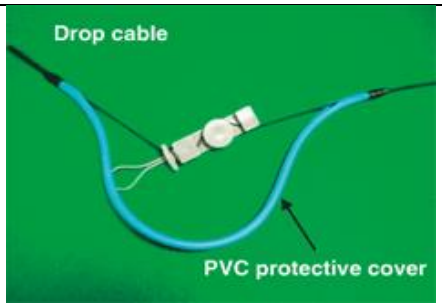


Fig. 1.24 PVC protective cover for optical cable

Countermeasure for Woodpeckers

Woodpeckers engage in drumming (knocking on a tree trunk with their beaks) to prey upon insects or to assert territory or mating rights. They may also do this on telecommunication cables, opening up holes in the sheath and damaging copper wires.

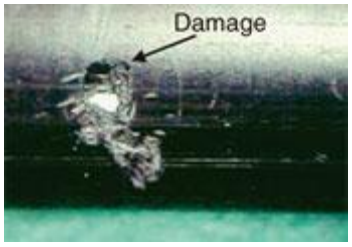


Fig. 1.25: Damage to a metallic cable (by a woodpecker)

Damage caused by woodpeckers can be prevented by using a squirrel-proof cover and by installing squirrel-proof tape in the straight and curved sections of the cable. It is also effective to use high-strength-sheath cable for aerial cables.

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. After getting the information about the cut or breakage in optical fibre cable technician must do _____. (a) Immediately proceed to the site (b) Carry all the relevant tools and spares (c) Move in a van after checking it thoroughly for fuel. (d) All of the above (d)
2. Which is the correct sequence for dealing with fault notification: (a) Fault acknowledge, receive and clear (b) Fault receive, acknowledge and clear (c) Fault acknowledge, clear and receive (d) None of the above (d)
3. Which of the following is the reason for the bad connector fault? (a) Kinked cable (b) Splice loss (c) Cable damage (d) Dirt or damage
4. If a fibre breaks, the most suitable remedy is: (a) Reduce stress on cable (b) Repair and replace of cable (c) Cleaning and polishing of cable (d) All of the above (d)
5. Cleaning and polishing is an ideal remedy for ____. (a) Bad pig-tail (b) Damaged Fibre (c) Bad connector (d) All of the above (d)
6. Which of the following equipment is used to identify bad connector faults? (a) Optical Time Domain Reflectometer (b) Microscope (c) Visual fault locator (d) None of the above (d)
7. Fibre breaks can be identified using _____ equipment. (a) Optical Time Domain Reflectometer (b) Microscope (c) Visual fault locator (d) Both a and c (d)
8. Bad pig-tail faults can be identified using _____ equipment. (a) Optical Time Domain Reflectometer (b) Microscope (c) Visual fault locator (d) None of the above (d)

9. What is the remedy to be taken for localized cable attenuation? (a) Polishing /cleaning (b) Reduce stress / replace (c) Straighten kink (d) None of the above (d)
10. Which of the following is necessary for quick and efficient fault restoration? (a) Rapidly find the problem (b) Knowing how to fix it (c) Have the right parts (d) All of the above (d)

B. Fill in the blanks

1. The installation involves first laying a rod for cables and using the rod to lay _____.
2. Methodology applied to find out and localize the failures of fibre is termed as _____.
3. To rectify and repair the fault is known as _____.
4. _____ defines an unattractive or unsatisfactory feature in optical fibre communication.
5. Loss splice is determined by the equipment _____
6. Wildlife that damages the cable is classified into three groups _____ (rodents, insects, and birds)
7. Moth larvae burrow into trees and the ground and live in _____ (holes).
8. Other insects like ants and bees enter cable conduits through very small gaps to _____ (build nests)
9. The OTDR waveform helps to analyse the fault in the cable. It determines the position and the distance of the _____by interpreting its waveforms. (fault)
10. The pipe camera takes the _____ and determines the distance and cause of the fault in the cable. (images)

C. Match the following

Fault	**Equipment to Test the Fault**
1. Bad Connector	a. OTDR, Visual Fault Locator
2. Bad Pigtail	b. Visual Fault Locator
3. Localized Cable Attenuation	c. OTDR, Visual Fault Locator
4. Distributed increase in Cable Attenuation	d. OTDR
5. Loss Splice	e. OTDR
6. Fibre Break	f. Inspection Microscope

D. State True or False

1. After rectifying the fault, the next task is to restore the optical fibre to its initial state, this process is called *optical* fibre restoration. (T)
2. The OTDR displays time or distance on the horizontal axis and amplitude on the vertical axis. (T)
3. Correct planning will lead to maximization of the problem. (F)
4. Once the team reaches the fault location, they do not labour to dig the particular area. (F)
5. The losses due to the connector are reflective and the spike will go upwards. (T)
6. Using the VFL you can only inspect the continuity of the Fiber manually between the transmitter and the receiver. (T)
7. Optical Light Source and Optical Power Meter are two devices that are combined together to check the optical network.
8. OTDR is like a mini-computer. (T)

9. When there is a fault in the customer premises, they register their problem in the network operation centre.
10. These faults are tough to identify through naked eyes as the OFC are placed underground. (T)

E. Short answer questions

1. What is a Fault?
2. List the fault notification process.
3. What are the workmanship guidelines to be followed?
4. What is fault localization?
5. What is fault rectification?
6. List the problem identification steps.
7. What kind of challenges you might face while locating faults?
8. Name the tools one would use for fault localization.
9. What is an OFC restoration?
10. List the work instructions to be followed while mobilization, travelling, OTDR trace measurement & localization.

Session 2: Link Performance Analysis

The preceding chapters have presented the fundamental characteristics of the individual building blocks of an optical fibre transmission link. These include the optical fibre transmission medium, optical source – transmitter, the photo-detector-associated receiver, and the connectors used to join individual fibre cables to each other and the source and detector.

In this chapter, you will understand how these individual parts can be put together to form a complete optical fibre transmission link. The first discussion involves the simplest case of a point-to-point link. This will include examining the components that are available for a particular application and seeing how these components relate to the system performance criteria, such as dispersion and attenuation. For a given set of components and a given set of system requirements, carry out a power budget analysis to determine, whether the optical fibre link meets the attenuation requirements or if repeaters are needed to boost the power level.

2.2 Optical Fibre Link

A link is a signal pathway between two points using some kind of generic cable. The pathway includes a means to send the signal into the cable and a way to receive it at the other end in a useful way. Any time you send a signal from one point to another over a wire, you are using a link. For example, a simple intercom consists of a sending station, the wire. The signals are transmitted over the wire. The sending station converts voice into electrical signals and the receiving station converts the electrical signal back into voice. Links are often described in terms of their ability to send and receive signals as part of a communication system. Links can be classified as simplex and duplex. Simplex means that the link can only send at one end and receive at the other end. In other words, the signal goes only one way. Duplex means that the link has a transmitter and a receiver at each end. A half-duplex system allows signals to go only one way at a time, similar to an intercom system. A full-duplex system allows users to send and receive at the same time. A telephone is a common example of a full-duplex system.

2.3 Point-To-Point Links

An optical fibre link is like any other link, except that it uses optical fibre instead of wire. The simplest transmission link is a point-to-point line having a transmitter at one end and a receiver on the other, as is shown in Figure 2.1.

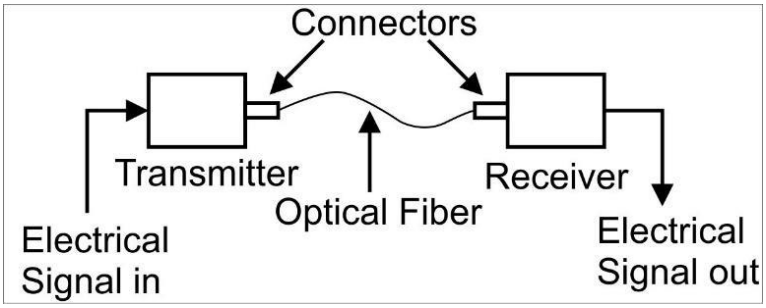


Fig. 2.1 Simple point-to-point link

An optical fibre link comprises four basic components.

1. Transmitter to convert a data signal into light signal and send the light signal.
2. Receiver to capture the light signal and convert it back to a data signal.
3. The optical fibre that carries the light.
4. The connectors that link the cable to the transmitter and receiver.

Now, we have seen the components required for an optical fibre link, let's look at some of the key system requirements needed in analysing a link:

1. The desired (or possible) transmission distance

2. The data rate or channel bandwidth

3. The Bit Error Rate (BER)

To fulfil these requirements the designer has a choice of the following components and their associated characteristics:

1. Multimode or Single-mode optical fibre

(a) Core size

(b) Core refractive-index profile

(c) Bandwidth or dispersion

(d) Attenuation

(e) Numerical Aperture

2. LED or Laser diode optical source

3. Pin or Avalanche photo-diode

Analysis is usually carried out to ensure that the desired system performance can meet the above requirements. This analysis is done by link power budget analysis.

In the link power budget analysis, first determines the power margin between the optical transmitter output and the minimum receiver sensitivity needed to establish a specified BER. This margin can then be allocated to connector, splice, and fibre losses, plus any additional margins required for expected component degradation or temperature effects. If the choice of components did not allow the desired transmission distance to be achieved, the components might have to be changed or repeaters might have to be incorporated into the link. Let's examine this analysis in more detail.

2.4 System Considerations

In carrying out a link power budget steps are as follows:

1. Decide at which wavelength to transmit and then choose components operating in this region. If the distance over which the data is to be transmitted is not too far, one may

decide to operate in the 800-nm to 900-nm region. On the other hand, if the transmission distance is relatively long, it takes wavelengths around 1300 or 1550 nm.

2. Having decided on a wavelength, one next interrelates the system performance of the three major optical link building blocks, that is, the receiver, transmitter, and optical fibre.
3. The designer chooses the characteristics of two of these elements and then computes those of the third to see if the system performance requirements are met. If the components have been over or under specified, design iteration may be needed. The procedure one shall follow here is first to select the photo-detector. And then, choose an optical source and see how far data can be transmitted over a particular fibre before a repeater is needed in the line to boost up the power level of the optical signal.

2.5 Link Power Budget

An optical power loss model for a point-to-point link is shown in Figure 2.2. The optical power received at the photodetector depends on the amount of light coupled into the fibre and the losses occurring in the fibre and at the connectors and splices. The link loss budget is derived from the sequential loss contributions of each element in the link. Each of these loss elements is expressed in decibels (dB) as

Loss=10 Log P_{out} / P_{input}

Where, P_{input} and P_{out} are the optical powers coming in and out of the loss element, respectively.

In addition to the link loss contributors shown in Figure 2.2, a link power margin is normally provided in the analysis to allow for component aging, temperature fluctuations, and losses arising from components that might be added at future dates. A link margin of 6 to 8 dB is generally used for systems that are not expected to have additional components incorporated into the link in the future.

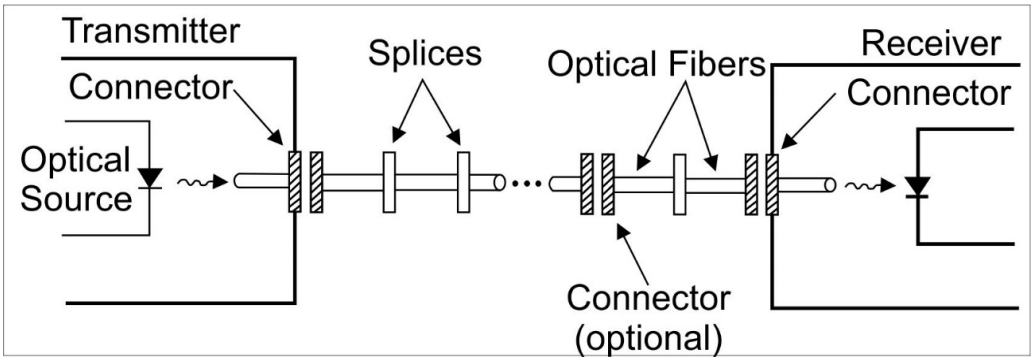


Fig.2.2 Optical power loss model for a point-to-point link. The losses occur at connectors at splices and in the fibre

The link loss budget simply considers the total optical power loss P is allowed between the light source and the photodetector, and allocate loss to cable attenuation, connector loss, splice loss, and system margin.

P_s is the optical power emerging from the end of a fibre transmitter, light source, and if P_R is the receiver sensitivity, then

$P_T = (P_S - P_R)$ + System Margin

Here, P_S consists of the connector loss of the fibre

P_R consists of the attenuation (dB/km), L=transmission distance, and the system margin is nominally taken as 6 dB, assuming that the cable of length L has connectors only on the ends and in between. The splice loss is incorporated into the cable loss for simplicity.

Practical Activity 2.1 – Calculate optical fibre link loss budget.

Material Required

Optical fibre components, Connector, Splice, System transmitter, System receiver

Procedure

Make the test set as shown in Figure 2.3 using the components of the optical fibre.

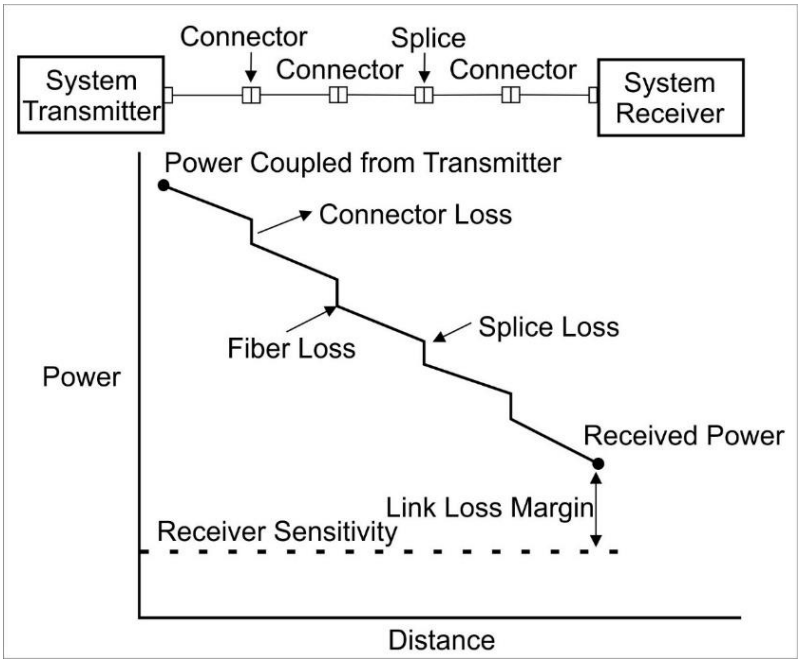


Fig. 2.3 : Optical fibre link loss budget

Cable plant passive component loss

Consider the link shown in Figure 2.3 for operation at 1300 nm on multimode fibre.

Step 1. Fibre loss at the operating wavelength.

Cable length (km)	2.0 Km			
Typical fibre loss				
Fibre type	Multimode		Single mode	
Wavelength (nm)	850nm	1300nm	1300nm	1550 nm
Fibre attenuation (dB/km)	3	1	0.5	0.4
Total fibre loss for system operating on multimode fibre at 1300 nm	2.0			

Step 2. Connector Loss.

Typical connector loss	0.5 dB
Total number of connector pairs	5 (including connectors on ends of the cable)
Total connector loss	5 x 0.5 = 2.5 dB

Step 3. Splice Loss.

Typical splice loss	0.2 dB
Total number of splices	1
Total splice loss	0.2 x1=0.2dB

Step 4. Total Cable Plant Attenuation.

Total fibre loss (dB)	2.0
Total connector loss (dB)	2.5
Total splice loss (dB)	0.2
Other (dB)	0
Total link loss (dB)	2.0+2.5+0.2+0=4.7

Equipment Link Loss Budget Calculation

Step 5. From the manufacturer's specification for active components.

Operating wavelength (nm)	1300
Fibre type	Multi-Mode
Receiver sensitivity (dBm)	-31
Average transmitter output (dBm)	-18
Dynamic range (dB)	13 (Receiver Sensitivity-Transmitter output)
Recommended excess margin (dB)	3
Maximum cable plant loss (dB)	10

Step 6. Loss margin calculation.

Dynamic range (dB)	10
Cable plant link loss (dB)	–4.7
Link loss margin (dB)	10+ (-4.7) =5.3

This calculation must be verified by testing with a source of the proper wavelength and a power meter after installation. In some cases, where the equipment may be operating on two different wavelengths or future upgrades are planned, testing at two wavelengths may be required. If the calculated and tested values differ considerably, but all the tested fibres in the cable are similar in loss, remember the specifications used for calculations are not exact. As long as proper operating margins are available, the cable plant should be acceptable.

2.6 How to choose the right optical fiber cable

The design and manufacture of optical fiber cable are in several ways comparable to the design and manufacture of copper cable. These resemblances have made it possible for the development of copper cable to begin parallel manufacture of optical fiber cable. Primarily at the beginning of the production process, the physical properties of glass have demanded the creation of an optical fiber cable. From the properties of the conductors, the principal differences between copper cable and optical fiber cable production have raised themselves: copper versus glass. Special care must be taken in designing the optical fiber cable to ensure that the fiber is not bent too much since:

- it can break easily
- it becomes a very bad light guide ie light leaks out and is lost and attenuation increases.
- increases the risk of cracks and breaks if the fiber is subjected to longitudinal forces.
- subjected to radial forces, since compression of the fiber increases attenuation

It is not practical to use optical fiber without the different types of protection provided by the cable construction. As far as possible the designing of an optical fiber cable thus involves packaging a very fragile light guide of glass. Fifteen years of research have resulted in the development of special designs for different areas of application to reduce stresses on the optical fiber. Development of the standard cable designs have been done for the following areas of application:

- Indoor cable
- Rack cable (flexible, often single fiber, patch cords, pig-tails)
- Duct cable
- Aerial cable
- Direct burial cable
- Submarine cable

2.7 Parameters

Many parameters that are involved in the choice of the correct optical fiber cable are illustrated in Figure 2.4. Every large project has different specifications. To meet all compulsory parameters and still be within a cable that manufactures a standard range of optical fiber cables might be a

terrible task. A close relationship between customer and manufacturer is therefore very important. Early co-operation between customers, cable manufacturers, and subcontractors will, in most cases, result in an optical fiber network. This fulfils specifications and is installed and "up-and-running" according to plans. Hence a major step (choice) is taken in choosing the right optical fiber cable.

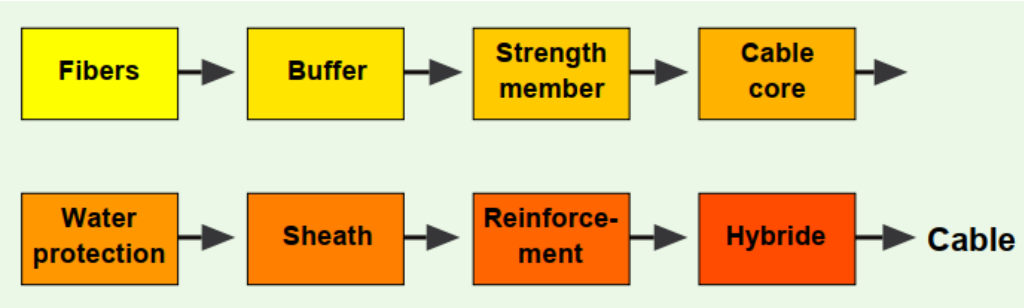


Fig. 2.4: General outline of the parameter involved in choosing the right optical fiber cable design

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. When beginning a basic optical fibre system design, what should be the first things considered? (a) Data rate, transmission distance (b) Cable diameter, cable length (c) Inside plant, outside plant (d) Buffer type, jacket material
2. Optical fibre offers _____ bandwidth and _____ attenuation than twisted pair or coaxial cable. (a) Less, more (b) Equal, more (c) Greater, more (d) Greater, less
3. To connect the internet from Fibre Termination Point to PC, there is a need to install Fibre 1. (a) Termination Point and Optical Network Router (b) Modem (c) Termination point (d) Optical network router
4. FTTX defines fibre to the 'X' or ___. (a) Fibre to the loop (b) Coaxial cable to the loop (c) Twisted cable to the loop (d) Unshielded twisted pair cable to the loop
5. Multiplexing is the process of transmitting many channels of information over ____. (a) One link or circuit (b) Two link or circuit (c) Three link or circuit (d) Four link or circuit
6. The ONT terminates the FTTH optical network at the subscriber premises and includes (a) Electro-optical converter (b) Electro-magnetic converter (c) Electro-electro converter (d) Optical-optical converter
7. The OTO is a fixed connecting device where the optical fibre. (a) Indoor cable terminates (b) Outdoor cable terminates (c) Underground cable terminates (d) Submarine cable terminates
8. The link loss budget simply considers the total optical power loss P is allowed between ____. (a) The light source and the photodetector (b) The light source (c) The photodetector (d) Splicers and connectors
9. The transmission of channels via television is through___. (a) Multiplexing process (b) Serial processing (c) Serial to parallel process (d) Parallel to a serial process
10. The link loss budget is derived from the sequential loss contributions of each element in the link and each of these loss elements is expressed in (a) Decibels (dB) (b) Meters (c) Kilometres (d) Centimetres

B. Fill in the Blanks

1. The full form of POP is _____ and it acts as a starting point for the optical fibre path to the _____.
2. The full form of FCP is _____, which connects a feeder cable, and will eventually be converted to smaller drop cables. At this stage, the feeder cable fibres are separated and spliced into smaller groups for further routing via _____.
3. Fibre in the Home cabling links the _____ to the _____.
4. The OTO is a fixed connecting device where the fibre-optic indoor cable _____
5. FTTC/N defines _____
6. FTTP defines _____
7. Transmitter to convert a data signal into _____and send the _____
8. Receiver to capture the _____and convert it back to a _____.
9. Optical Fibre cables in the public network such as a house, premises, building, etc. plays a key method to drive _____.
10. Simplex means that the link can only send at one end and receive at the other end. In other words, the signal goes only_____ way.

C. State True or False

1. The design and manufacture of optical fiber cable are in several ways comparable to the design and manufacture of copper cable. (T)
2. The optical power received at the photodetector depends on the amount of light coupled into the fibre and the losses occurring in the fibre and at the connectors and splices. (T)
3. In the link power budget analysis, it is not necessary to determine the power margin between the optical transmitter output and the minimum receiver sensitivity needed to establish a specified BER. (F)
4. Duplex means that the link can only send at one end and receive at the other end. (F)
5. Links are often described in terms of their ability to send and receive signals as part of a communication system. (T)

D. Short answer questions

1. What is power budget analysis?
2. Which is point-to-point link analysis?
3. Draw the Reference Model of fibre network in the Home Cabling
4. State the step of system Considerations in carrying out a link power budget?
5. Name the various types of losses the optical fibre cable has while performing the link analysis
6. To calculate optical fibre link loss budget
   Cable length: 3 km
   Number of connections: 2
   Number of splices: 1
   Operating wavelength: 1300 nm
   Fibre type: multi-mode
   Receiver sensitivity: –35 dbm
   Average transmitter output: –25 dbm
   a. Connector loss: _____
   b. Total cable plant loss: _____
   c. Maximum allowable loss (with excess margin factored in): _____
   d. Link loss margin: _____
   e. Will the above fibre link loss be acceptable if the wavelength was changed to 850 nm? Assume the transmitter and receiver specifications remain the same.
   _____ Yes _____ No

Session 3: Testing Optical Fibre Link

After connecting the fibre cable through splicing or connector, it is important to test these joints to ensure that there's no transmission loss. During installation, connectors may get broken and the optical fibre may get damaged. It can cause failure in the optical fibre transmission system. This will result in direct economic loss as well as social impact as it brings inconvenience to the life of people. Therefore, it is important to ensure the wellness of optic fibre cables. Testing optical fibre cable plays a significant role in monitoring and restoring the faults in optical fibre communication systems.

Testing Optical Fibre

Testing is employed to check the performance of optical fibre elements and systems. Testing is done in different parts such as fibres, connectors, splices, and optical light sources. Testing confirms their performance specifications. However, testing is going to check the performance of optical fibre parts, cables, and systems. To observe the installed system, the installation team frequently takes feedback and test results. To monitor the installed OFC:

1. Verify the individual splices using OTDR to ensure that every splice is working correctly.
2. All fibres must be tested frequently for continuity, correct end-to-end connections, and intermediate losses.
3. Each test is performed depending on the geographical nature of the installation site and the actual layout of the OFC.
4. Lot of time and money can be saved, if the installation team knows the correct signal strength which is to be measured in installed OFC.
5. To verify the correct input and output state of OFC, the technician can measure and compare the transmitted and received power. Some of the commonly used test equipment in optical fibre installation, maintenance, repairing are Optical Power Meter, Optical Fibre Laser Source, Visual Fault Locator (VFL), Inspection Microscope and Optical Time Domain Reflectometer (OTDR).

Testing Equipment for Optical Fibre Cable:

1. Optical Power Meter – It is used to measure power in an optical signal, optical loss, and the quality of the optical fibre networks. It is designed to work with an optical laser source to measure the optical loss on the optical fibre cables, to provide highly accurate measurements on the quality of the optical fibre networks. It is also capable of measuring the quality and continuity of the optical fibre network. A typical optical power meter, as shown in Figure 3.1, consists of a calibrated sensor, measuring amplifier, and display. The sensor primarily consists of a photodiode selected for the appropriate range of wavelengths and power levels. On the display unit, the measured optical power and set wavelength are displayed.

Fig. 3.1: Optical power meter

Let us understand the optical power meter using a practical activity 3.1.

Practical Activity 3.1 – Demonstrate the working of an optical power meter.

Material Required

Optical power meter, OFC with connector, light source.

Procedure

Step 1. Consider an optical power meter and connect the optical fibre cable to its port as shown in Figure 3.2.

Fig. 3.2 Connecting optical fibre cable to its port

Step 2. Connect the other end of the optical fibre cable to the light source as shown in Figure 3.3.

Fig. 3.3 Connecting optical fibre cable to light source

Step 3. Turn ON the light source, a ray of light enters the OFC. Note down the reading from the optical power meter.

Step 4. Now, vary the wavelength of the light beam using a light source.

Step 5. Observe and tabulate the reading from the optical power meter in decibel (dB) and its corresponding wavelength.

2. Optical Fibre Laser Source – It is used to test the optical fibre connection. The optical laser source, as shown in Figure 3.4 is used in conjunction with the optical power meter to measure and provide the attenuation loss of the optical fibre network.

Fig. 3.4: Optical Laser Source

Let us understand the optical fibre laser source using practical activity 3.2.

Practical Activity 3.2 – To measure insertion loss in optical fibre.

Material Required

Optical power meter device, test cable, optical light source, reference cord with a connector at both the ends, optical connector adapter, tissue paper

Procedure

Step 1. Take the reference cord and clean both ends of the connector using tissue paper as shown below in Figure 3.5.

Fig. 3.5 Clean the ends of the reference cord

Step 2. Connect one end of it to the optical power meter and another end to the optical light source as shown below in Figure 3.6.

Fig. 3.6 Connecting reference cord to optical power meter and optical light source

Step 3. Choose the wavelength of 1310nm in the light source as shown in Figure 3.7. Press the "RED" button in the optical power meter to set the reference dB level. At the same time, note down the reading on the power meter display.

Note... '0' dB in the power meter display indicates no loss.

Fig. 3.7 Setting up the optical power meter and light source

Step 4. Now, remove the reference cord end connected to the light source. Take a test cable with connectors. Connect one end of the test cable to the light source and connect another end of the test cable via connector adapter to the reference cord end as shown in Figure 3.8.

Fig. 3.8 Connect the test cable to the light source

Step 5. Repeat step 1 and note down the reading of the optical power meter as shown in Figure 3.8.

Note... There will be -0.18 dB in the power meter display indicating insertion loss.

Fig. 3.8 Reading in the optical power meter

Step 6. Note the reading to observe the insertion loss in the optical fibre test cable.

3. Visual Fault Locator – It uses visible light to check OFC continuity. It can also find faults in the fibre. The laser-powered Visual Fault Locator (VFL) is a cable continuity tester that locates fibres, verifies cable continuity and polarity. This cable continuity tester finds breaks in cables, connectors, and splices. Continuous and flashing modes make for easier identification. It has a long battery life to use for long hours. A typical CFL is shown in Figure 3.9.

Fig. 3.9: Visual Fault Locator

Parts of VFL

Adapter – It is used to connect the optical fibre cable and various connectors such as ST-type, SC-type, LC-type. Generally, in a visual fault locator 2.5mm diameter universal adapter is used.

Battery – The battery is fixed at the back portion of the visual fault locator. Two batteries of voltage 1.5 V are used in the visual fault locator.

Switch – The switch has three modes namely OFF, Continuous Wave (CW), Glint. In a continuous wave (CW), a continuous beam of light will come out. Glint mode helps to find out the correct fibre, having faults, at the other end of optical Fibre if there are various fibres present in the cable.

Let us understand the testing of OFC using VFL in practical activity 3.3.

Practical Activity 3.3 – Demonstrate continuity testing of optical fibre cable with SC connector and LC connector using visual fault locator.

Material Required

Visual fault locator, Optical fibre cable with SC connector, optical fibre cable with LC connector, connector cleaner

Procedure

Continuity Testing of OFC with SC connector

Step 1. Consider an optical fibre with an SC connector and clean it using a 2.5mm SC cleaner as shown in Figure 3.10.

Fig. 3.10: SC Cleaner

Step 2. After cleaning the SC connector, connect the visual fault locator to the SC connector of optical fibre cable as shown in Figure 3.11.

Fig. 3.11: Connecting VFL to SC connector

Step 3. Turn ON the light beam. Observe the light coming out from the end of the optical fibre cable as shown in Figure 3.12. If this happens, it shows the optical fibre cable has no damage.

Fig. 3.12: Turn ON the light beam

Continuity Testing of OFC with LC connector

Step 1. Consider an optical fibre with an LC connector and clean it using a 2.5mm LC cleaner.

Step 2. As learned in the practical activity 3.1, The VFL adapter's diameter is 2.5mm. To connect the VFL adapter to LC-connector, which is of diameter 1.25mm, an interfacing adapter is used as shown in Figure 3.13.

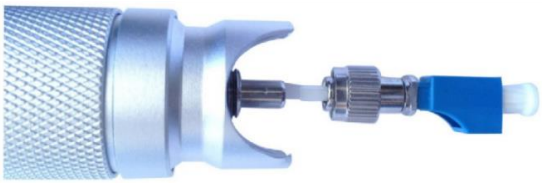


Fig. 3.13: Interfacing adapter to visual fault locator

Step 3. This adapter will convert the VFL 2.5mm diameter to 1.25mm diameter as shown in Figure 3.14.

Fig. 3.14: 2.5mm diameter to 1.25mm adapter or convertor

Step 4. After cleaning the LC-connector, connect the visual fault locator to the LC-connector of the optical fibre cable as shown in Figure 3.15.

Fig. 3.15: LC-connector

Step 5. Turn on the VFL and observe the light coming out of the end of the optical fibre cable, as shown in Figure 3.16. This shows the optical fibre cable has no damage.

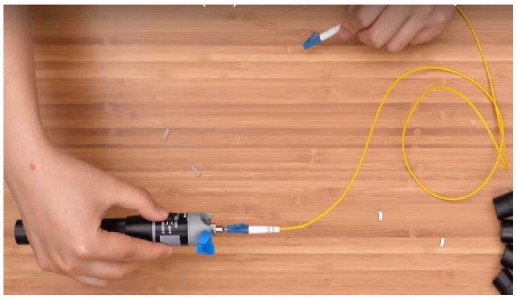


Fig. 3.16: Turn on the VFL to observe the light

4. Inspection Microscope – It is an equipment used to inspect the optical fibre cable and connector for any fault or breakage as shown in Figure 3.17.

Fig.3.17: Inspection Microscope

Parts of inspection microscope

Connector Adapter – They are detectable as per the requirement of the optical fibre connector. SC adapter and LC adapter both can be connected to the microscope.

Eyepiece – The eyepiece has a lens and is used to focus inside the optical fibre cable. The focus of the lens can be adjusted using the knob on the microscope.

Practical Activity 3.4 – Demonstrate the inspection of fibre and connectors ends using inspection microscope.

Material Required

Inspection microscope, optical fibre cable

Procedure

Step 1. Consider an inspection microscope and optical fibre cable. Connect them as shown in Figure 3.18.

Fig. 3.18: Connecting the OFC to inspection microscope

Step 2. If required, adjust the screw of the connector adapter of a microscope to align the optical fibre cable as shown in Figure 3.19.

Fig. 3.19: Adjust the screw of the connector adapter

Step 3. Observe the optical fibre cable through the eyepiece of the microscope, see the image of fibre and connector ends. Check for any contamination in the ends of fibre and connector.

5. Optical Time Domain Reflectometer (OTDR) – It is used to calculate the various types of losses in the OFC. It can identify faults and their location. This advanced diagnostic tool for optical fibres takes a snapshot of a fibre link. OTDR sends short pulses of light down one end of the fibre at a specified repetition rate. The light reflected from fibre is gathered back and this light continuously scattered from the fibre itself travels back to OTDR, where the instrument records the optical power and arrival time. The arrival time of the pulse from a given point in the fibre is related to its distance from the OTDR. With this information, the OTDR graphically displays returned power versus distance. OTDRs are well equipped for troubleshooting problems because they allow to visually locate reflective events like connections and fibre breaks and non-reflective events like splices and tight bends by studying the graphical trace. The power difference between two points on the trace is an estimate of optical loss. A typical OTDR is shown in Figure 3.20.

Fig. 3.20: Optical Time Domain Reflectometer

The data produced by OTDR is used to create a picture called a "trace". This information can be stored. The OTDR analyses the loss at connections and splices. OTDR traces are used for troubleshooting the faults, which occur in the optical fibre cable. Light-reflecting in an optical fibre is the result of reflection or backscatter. Reflections happen when the light travelling through the optical fibre encounters changes in the refractive index. These reflections are called Fresnel reflections, Backscatter, or Rayleigh scattering. It is due to density variations in the optical fibre cable.

Figure 3.21 shows the photons that travel back toward the OTDR and are considered backscattered.

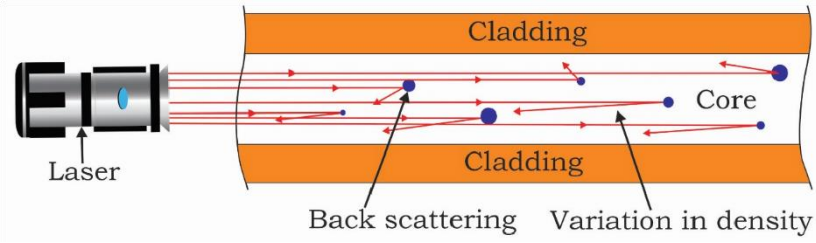


Fig. 3.21: Backscattered Photons

OTDR Operation – A typical OTDR includes eight basic components as shown in the block diagram (Figure 3.22).

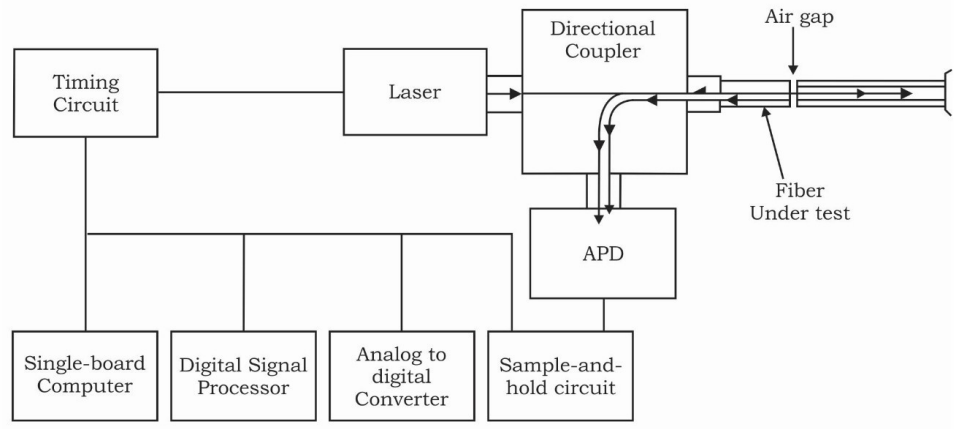


Fig. 3.22: Block representation of OTDR

1. Directional coupler
2. Laser generator
3. Time circuit
4. Signal-board computer
5. Digital Signal Processor (DSP)
6. Analogy to digital converter
7. Sample-and-hold circuit
8. Avalanche photodiode.

The block diagram of the OTDR (Figure 3.22) shows light launched from the laser through the directional coupler into the optical fibre. The directional coupler directs the light, which is returned by the optical fibre to the avalanche photodiode. The avalanche photodiode converts light energy into electrical energy. The electrical energy is sampled at a very high rate by the sample-and-hold circuit. The sample-and-hold circuit converts the electrical value to a numerical value. The numerical value is processed by the digital signal processor and after processing it is stored in memory and then displayed on the screen.

OTDR Display – The OTDR shows the time or distance on the horizontal axis and amplitude on the vertical axis. At the horizontal axis, the measuring unit is meters or kilometres, in the vertical axis the measuring unit is dB (decimal).

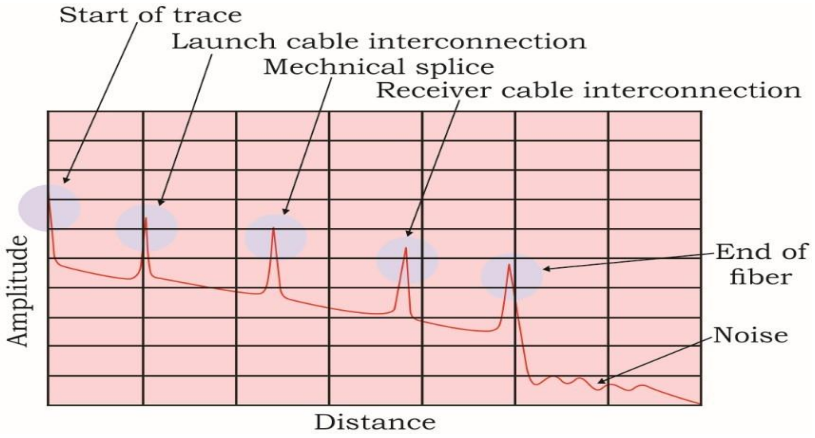


Fig.3.23: Graphical display of signal in OTDR

OTDR Setup – Correct setting leads to a more accurate result. When setting up the OTDR, select the correct fibre type, wavelength, range, resolution, pulse width, refractive index, and backscatter coefficient. For this, understand the various parts of OTDR as shown in Figure 3.24.

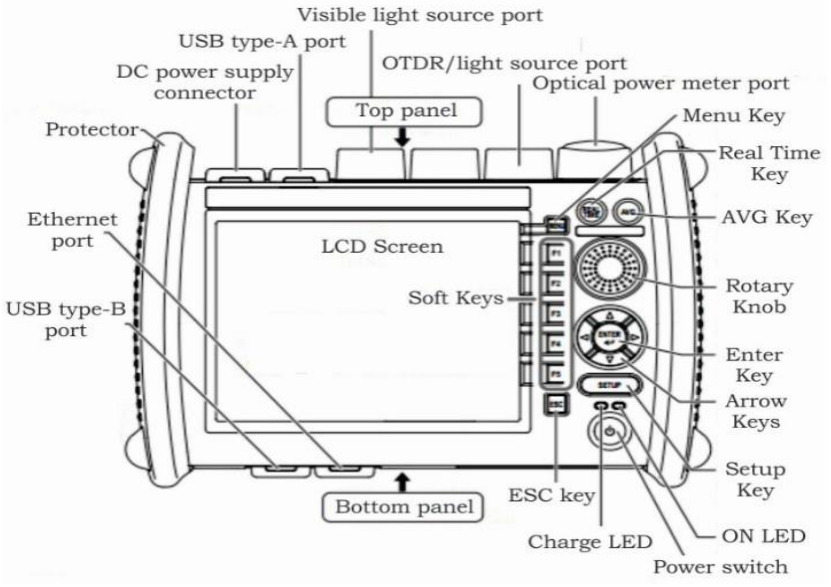


Fig. 3.24: Different parts of OTDR

Functional Keys of OTDR

The functional keys of OTDR are explained in Table 3.1.

Table 3.1: Functional keys of OTDR

Functional Keys	Functions of Keys
Power Port	It is the slot through which AC or DC supply is provided.
USB Type-A Port	It is used to connect a memory device or USB printer.
USB Type-B Port	It is used to connect the OTDR to the personal computer.

Indicator	The charging indicator is used to indicate the charging status of the OTDR. The whereas a power indicator is used to indicate the status of the power supply i.e. ON or OFF.
Ethernet Port	Used to connect to the network.
Display	It shows the graphical view of the traces. It also has some options, which can be controlled by the soft keys.
Escape Key	It is used to return to the previous menu.
Setup Key	It is used to set up the measurement condition, system setup, and file operation menus.
Real-Time Key	It is used to start-stop the real-time optical pulse measurement.
AVG Key	It is used to start-stop the averaged optical pulse measurement.
Rotary Key	It is used to change the features, change settings and move the cursor.
Enter Key	It is used to confirm procedures and settings.
Arrow Keys	It is used to change values, move between digits and move the cursor.
Power Switch	It is used to turn ON or OFF the OTDR

Practical Activity 3.5 – To measure the splice loss in optical fibre cable.

Material Required

OTDR, Optical fibre cable, notepad, pen

Procedure

Step 1. Connect the OTDR with an optical fibre cable.

Step 2. Consider a splice joint in the optical fibre cable.

Step 3. Now, launch the light pulse into the optical fibre cable. Observe the graph in the OTDR.

Step 4. In the graph, look for the splice loss. It can be traced using OTDR.

Fig. 3.25

Step 5. The amount of light loss at the splice joint in the decibel is displayed by the OTDR.

Step 6. Note the reading of splice loss at the splice joint and then, trace the graph.

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. Which of the following is not used as a fault detector in optical fibre cable? (a) Optical time domain reflectometer (b) Visual fault locator (c) Inspection microscopy (d) Connector
2. Which of the following instruments is used to find the distance of the fault occurrence in optical fibre cable? (a) Optical time-domain reflectometer (b) Visual fault locator (c) Inspection microscopy (d) Connector
3. Visual fault locator has _____ mode/modes. (a) Continuous (b) Flashing (c) Delay (d) Both (a) and (b)
4. The word baseline trace or trace is a familiar term used in ____ instrument. (a) Optical time domain reflectometer (OTDR) (b) Visual fault locator (c) Inspection microscopy (d) Power meter
5. Splice loss can be determined using ____ Instrument. (a) Optical time domain reflectometer (OTDR) (b) Visual fault locator (c) Inspection microscopy (d) Power Meter
6. Which of the following instruments has an adjustable knob control? (a) Optical time-domain reflectometer (OTDR) (b) Visual fault locator (c) Inspection microscopy (d) Power Meter
7. What is the size of the adapter used in the visual fault locator? (a) 2.25mm to 1.55mm (b) 2.15mm to 1.50mm (c) 2.5mm to 1.25mm (d) 2.20mm to 1.45mm
8. Which of the following instruments has Ethernet port connectivity? (a) Optical time-domain reflectometer (OTDR) (b) Visual fault locator (c) Inspection microscopy (d) Connector
9. Which of the following is the function of the escape key in OTDR? (a) Go to the next menu (b) Cancel task (c) Start the light pulse (d) Back to the previous menu
10. In which of the following instruments, the term glint is used. (a) Optical-time domain reflectometer (OTDR) (b) Visual fault locator (c) Inspection microscopy (d) Power Meter
11. In which of the following instruments, the term CW or Continuity Wave mode is used. (a) Optical time-domain reflectometer (OTDR) (b) Visual fault locator (c) Inspection microscopy (d) Power Meter
12. Which of the following is a function of microscopy? (a) Identify any faults (b) Identify any cracks (c) Identify any scratches (d) All of the above

B. Fill in the blanks

1. Visual fault locator has _____ modes. (Three)
2. In a continuous mode of visual fault locator, the light beam is _____. (Continuous)
3. Diameter of the LC connector is _____. (1.25 mm)
4. Diameter of the SC connector is _____.
5. Visual microscope uses _____ part to focus the optical fibre cable.
6. To visualize the end face of a connector, we adjust the focus of _____.
7. In a visual microscope, adjustable _____ is used to align the optical fibre cable.
8. In optical time domain reflectometer, _____ is used to connect a memory device or USB printer.
9. In optical time-domain reflectometer, _____ is used to connect the OTDR to the personal computer.

10. In optical fibre cable, reflection due to change in the reflective index is known as _____.
11. In OTDR display, a horizontal axis represents _____ and a vertical axis represents _____.

C. State whether the following statements are True or False

1. Amount of light loss in decibels is displayed by the OTDR.
2. Digital signal processing is not performed by the OTDR.
3. Two batteries of 10V are used in the visual fault locator.
4. Visual microscope is used as a light source in optical fibre communication.
5. Universal connector cleaner is used to clean the SC and LC connectors.
6. Continuous light mode will help to identify a fibre among several of optical fibres.
7. Glint mode will generate the blinking light beam.
8. The eyepiece in the visual microscope is used to visualise the contamination in the ends of fibre.
9. OTDR is used to measure the loss in optical fibre cable, length of optical fibre cable, and locate the fault. Real-time key is used to start-stop the real-time optical pulse measurement.
10. Inspection microscopy is used for the monitoring of the fibres.
11. OTDR stands for Optical Time Domain Reflectometer.
12. Visual fault locator is used to connect the two optical fibres.

D. Short answer questions

1. List the names of different functional keys of OTDR.
2. What is the role of optical time domain reflectometer in optical fibre networks?
3. Explain the working of Visual Fault Locator and Optical Time Domain Reflectometer.

Module 4. Occupational Health and Safety

Module Overview

In this module, we will discuss about Health and safety measures are critical to ensuring a secure working environment, particularly in fields like optical fiber installation and electrical work. Key precautions include wearing appropriate personal protective equipment (PPE) such as insulated gloves, safety boots, helmets, and safety glasses to prevent injuries. Workers should avoid direct contact with live wires and follow proper procedures for handling electrical equipment to minimize the risk of electric shocks or burns.

Regularly inspecting tools and cables for damage, maintaining proper insulation, and using grounding techniques are essential for preventing accidents. Fire extinguishers must be readily accessible, and employees should be trained in their correct usage, especially for different fire types. In the case of emergencies like electric shock or fire, having first-aid knowledge, including CPR, is vital. Ensuring that safety guidelines are followed and ergonomics are considered can significantly reduce work-related injuries, promoting a healthier, safer workplace environment.

Learning Outcomes

After completing this module, you will be able to:

- Safe handling techniques for optical fiber to prevent injuries and ensure the integrity of fiber optic installations.
- Understand the importance of workmanship safety standards and practices to minimize risks during fiber optic installation and maintenance.

Module Structure

Session 1: Optical Fiber Handling Safety

Session 2: Workmanship safety

Session 1. Optical Fiber Handling Safety

The technique of handling optical fibre can have a significant impact on its functionality and reliability. The cost of rework or replacement due to improper handling can also result in monetary losses and increased processing time.

This chapter suggests guidelines for proper handling of the optical fiber. It describes some basic safety measures to Optical fiber cable installation & storage. Optical fiber technicians should be aware of all the Occupational & Health safety regulations, and local regulations along with the company safety practices. Adopting these practices can take care of the health of the workers, their job holding efficiency, and provide a proper working environment.

Introduction

Optical fibre technicians have to perform various tasks on the field depending on their jobs. The variety of work includes handling optical fibre cable (OFC) for laying and installation, handling the optical tools and equipment for splicing, commissioning and maintenance of OFC. The technician must follow safety practices to undertake all these work as per industry standards. Adopting a safe work practice in the workplace can increase productivity.

The fibres are made up of glass material and hence should be handled carefully on site where many workers are working together in coordination with technicians. Mishandling of the cables can create health hazards. There can be several occupational hazards while handling OFC such as sparks from fusion splicing elevated and overhead work, shock hazard and hazards such as harm to corneal or retinal eye sight, infection or skin irritation, burn injuries, electric shocks, physical injuries and fatigue.

Safety in Fiber Optic Installation

Fiber optic installation involves safe handling of OFC, safety in climbing ladders or poles, working with the equipment and processes in outside installations such as underground and aerial cables and working in construction sites. During installation, it is required to avoid exposure of light radiation with the fibre, disposal of fibre scraps produced in cable handling and termination, and safe handling of hazardous chemicals used in termination, splicing or cleaning. While working on the site where electrical power cable is installed, care should be taken to disconnect these cables during the installation of OFC.

Handling Optical Fibre Cable

Optical fibre cables (OFC) handling is one of the common problems while installation as they are sensitive to damage. OFC contains strands of glass fibers inside the insulated casing. It consists of a silica-based core and cladding surrounded by a dual layer acrylate coating. Subsequent handling or processing of the fiber can have a significant impact on its strength, mostly through mechanical contact with the cladding surface. This may cause failure of the fiber.

The broken ends of fibers created during termination and splicing can be dangerous. The ends are extremely sharp and can easily penetrate the skin. They are easy to break off and are difficult to locate and dispose of. Sometimes a pair of tweezers and magnifying glass are required to take them out. Any delay in taking the fiber out of the body could lead to infection.

The technicians handling the cable for installation or splicing work should carry out work as per the given guidelines because they are fragile. The following points should be followed while working with fiber optic cables.

1. Keep the ends of the cable protected. Do not stick the broken ends of fiber into the fingers. The caps help to protect the most sensitive part of OFC.
2. Fiber optic cables can cause tiny splinters in the skin. Since they contain glass shards, avoid touching the face while working with them. Glass shards can penetrate soft skin and the surface of the eye. Wear protective aprons, safety glasses, and gloves, while handling OFC.
3. Store the OFC in a safe place. Keep all running cable off of the floor to avoid potentially damaging it. Arrange all scrap and chippings properly and dispose of the waste mandatory in an effective manner.
4. Although, the glass inside of the fiber cable is designed to be flexible; it can still break if it is not taken care of properly. So, avoid pinching or bending the cable while handling it.

The following safety should be observed while handling OFC.

Cable Bending Radius

Optical fiber cables are designed with particular minimum bending radius. 20D is the highest bending radius limit for cables, where D is the diameter of cable. So, never bend the cable below minimum bending radius at any location. It can result in higher bending losses and/or internal

breaks in the fiber. This can cause damage to the fibers, which cannot be seen from the outer surface of the cable. Later this can lead to expensive restoration of cables.

Cable Pulling Tension

OFC are designed for a particular pulling tension and tensile strength. Exceeding the cable pulling tension above the specified value can alter cable's characteristics. Do not pull the cable above specified pulling tension. Use pulling grips with swivel to attach to the pull rope, lubricants compatible with cable jacket and duct material to achieve maximum pulling distance.

Cable Twisting

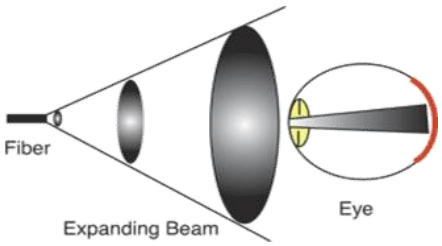
OFC are designed for particular twisting/torsion. Exceeding the cable twisting increases the probability of fiber damage. It is recommended to use an anti-twisting device during cable pulling.

Laser Precaution

Laser beam used in optical communication is invisible and can seriously damage the eyes. Viewing it directly does not cause any pain and the iris of Eye does not close automatically as it does while viewing the bright light. This can cause serious damage to the retina of the eye. Therefore, never look into a fiber having a laser coupled to it. If an eye is accidentally exposed to LASER beam, immediately rush for medical assistance.

Eye Protection

The light that exits an optical fiber is also spreading out in a cone. The light used for signal transmission in fiber optics is generally invisible to the human eye but may operate at power levels that can be harmful to the eye. Viewing it directly can cause serious damage to the retina of the eye. Keeping the eye far away from the end of the fiber will receive the lower amount of power.



Therefore, always follow these precautions to protect the eyes.

I. Never look directly into the end of any optical fiber, unless you are certain that no light is present in the fiber.

II. Use the microscope with infrared filters to reduce the danger of the invisible infrared light. The infrared light present in fiber optic links is at a wavelength that cannot penetrate the eye easily because it is absorbed by water in the eyeball. The light in the 1300-1550 nm range may not damage the retina, but can harm the cornea or lens.

III. Use an optical power meter to verify that no light is present in the fiber. Some mobile phone cameras are sensitive in the infrared and may be used to detect light in optical fibers.

IV. While using an optical tracer or continuity checker, look at the fiber from an angle at least 300 mm (12 in.) away from the eye to determine if a visible light is present.

V. Always wear the safety glasses with side shields.

VI. After handling fiber, wash hands before touching the eyes or contact lenses.

VII. If an eye is accidentally exposed to LASER beam, immediately rush for medical assistance.

Material Safety

The Fiber optic splicing and termination requires various chemical cleaners and adhesives. Follow the safety instructions defined for these substances while working with materials:

I. Always work in the well-ventilated areas.

II. Avoid skin contact with the materials involved in this process as much as possible.

III. Avoid using chemicals that could cause allergic reactions.

IV. Even simple isopropyl alcohol, used as a cleaner, is flammable. So, handle everything appropriately.

Protection from Fiber Scraps

The small scraps of bare fiber resulting from the termination and splicing process must be disposed of in a container designed for this purpose and marked according to the local regulations, as it may be considered hazardous waste.

Do not drop the fiber scraps on the floor where they may stick like carpets or shoes and be carried elsewhere. Place them inside a marked container or stick them to a double-sided adhesive tape on the work surface.

Thoroughly clean the work area when finished working. Do not use the compressed air to clean off the work area. Sweep all the scraps into a disposal container.

Do not eat, drink or smoke near the working area. Fiber particles can be harmful if ingested.

Wash the hands well after working with the fibers.

Carefully inspect the cloths for the fiber scraps when finished working with the fiber.

Safety During Duct Installation

Manhole /Underground Vaults Safety

Manholes may contain explosive gases or vapors, due to leakages of the nearby gas or liquid pipelines. Therefore, before entering any manhole, test the atmosphere inside it with an approved test kit for flammable and poisonous gases.

Avoid the usage of any device that produces a spark or flame in the manhole.

To minimize the risks of an accident in the work area follow the specified rules for setting up barricades, manhole guards and warning signs.

Before pulling the cable directly from the Figure 8 shape, make sure that the area inside the loop of the cable is clear. Failure to do so may result in injury to the personnel or damage to the cable due to entanglement.

Ensure that the tools and equipment used for the cable installation are in proper condition. Corrosion of equipment may damage the cable or cause injury to the two personnel.

Make sure that no electric hazards occur. Check if any electrical lines are passing through the manholes or vaults where installation is being done.

Safety During Aerial Installation

Pole Safety

Before climbing a pole, inspect it for various safety issues like splintering, insect nests, sharp protrusions.

Use the leather gloves while climbing or getting down on a pole and when working with any sharp instruments or materials.

Wear rubber gloves when working near the exposed electrical circuit to avoid an electric shock.

Follow the electrical safety rules when working near a power line.

Cable Pulling Safety

Personnel should normally stay away from the area where a cable is being pulled around a piece of stationary hardware under tension. Appropriate safety measures should be taken while working near the installation site.

Keep hands free from the tools when climbing or getting down on a pole or ladder.

Suitable accessories must be used during the installation to ensure smooth and safe working.

Only the skilled personnel should stay near the installation site during tensioning operations to minimize the risk of injury or death. Nobody should be allowed to climb on the intermediate

poles. While tensioning. Passerby on ground should be kept away from the poles during tensioning. Suitable warning/safety display board should be put on the installation site.

Ground all the metallic components to avoid any electric hazards due to the spark produced by power lines or any other means.

Safety during Stripping, Cleaving and Splicing

Special considerations must be given to fiber handling during the operations of stripping, cleaving and splicing. The practices suggested during such operations are given below.

Stripping

Try to avoid sharing mechanical stripping tools between users. A user may wear the strippers in a distinct pattern, which makes them less efficient or "fiber-friendly" for alternate users.

Do not use mechanical strippers that have been dropped or otherwise damaged until it can be demonstrated that they can provide satisfactory strip strengths.

Users should strip the least amount of coating necessary to facilitate proper cleaving and/or splicing of the fiber. Removing less coating exposes less bare glass, and therefore limits the potential for inducing flaws.

The bare glass exposed after stripping should not be contacted by tools, fingers, etc. The glass should only be contacted by an appropriate lint-free clean cloth, which may be soaked in high-purity isopropyl alcohol. The number of passes over the fiber should be limited (optimally one pass), and the cloth should be discarded and replaced with a new cloth regularly.

The work area and stripping tool should be kept clean of any dust or debris, which can degrade the fiber strength if brought into contact with the cladding surface.

The fiber should be cleaned and cleaved immediately after stripping to reduce the effect of any airborne contaminants.

Cleaving

The fiber must be placed carefully into the cleaving tool, taking care not to abrade or otherwise contact the exposed bare glass.

The work area and cleaving tool should be kept clean of any dirt or dust, which can degrade the fiber strength and cause increased splice losses.

As mentioned above, remnants of stripped coating and cleaved fibers should be cleaned from the work surface regularly.

Splicing

The fiber must be placed carefully into the splicing equipment, taking care not to abrade or otherwise contact the exposed bare glass.

Care should be taken when placing the fiber into equipment not to exceed the recommended stresses as outlined in the stress design guidelines.

Splices must be protected by either splice protectors or recoating of the exposed glass area. These processes should be performed in an area with minimal particulate contamination, and should completely cover the areas of exposed glass fiber.

Splices should be proof tested upon the completion and protection/recoating to ensure that they meet the minimum strength requirements of the application. Optimally, the splices should be deployed in a non-bent state and under minimal tensile stress.

Polished end faces of connectorized fibers should be protected at all times from the contamination (debris, finger oils) and mechanical contact.

Fire Safety

Following optical fiber fire precautions have to be effectively adhered

The fusion splices use an electric spark to make a splice, so ensure that there are no flammable gases in the space where fusion splicing is done.

Splicing should not be done in places of manholes where gases can accumulate.

All parts and devices which are combustible must be kept away from the area.

The cables are brought up to the surface into a splicing trailer where all fiber work is done. So the splicing trailer is temperature-controlled and kept spotlessly clean to ensure good splicing.

Smoking should not be allowed around fiber optic work. The ashes from smoking can contribute to the dust problems in fibers, apart from the danger of explosion posed by them due to the presence of combustible substances.

Electrical Safety

OFC are often installed around electrical cables. The fiber is not conductive, but fiber hardware can conduct electricity or the technician can come in contact with live electrical wires when working in proximity to AC power. So electrical safety guidelines should be followed.

Cleanliness and Other Safety Issues

The small size of optical fibers makes them very sensitive to dust and dirt. Maintain the highest standards of cleanliness when working with fiber to optimize its performance.

Work only in clean and well-ventilated areas. Confined spaces, such as equipment vaults, manholes can contain toxic or explosive gases or insufficient air to sustain life.

Materials and chemicals used in installation processes may be hazardous. Request Safety Data Sheets (SDS) on all chemicals used.

Fusion splicers create an electric arc. Ensure that no flammable vapors and/or liquids are present.

Always keep protective dust caps on connectors, mating adapters, patch panels, or test and network equipment.

Use special cleaning tools made for cleaning optical fiber connectors or use lint-free wipes and pure reagent grade isopropyl alcohol to clean connectors. Other solvents can attack adhesives or leave a residue. Cotton swabs or pads may leave threads behind and are not recommended.

Use dry-cleaning swabs or a source of clean air to blow the dust out of the mating adapters or equipment inputs/outputs. Clean squeeze bulbs are preferred. The compressed air often contains oils that can contaminate the parts. “Canned air” can be used to blow dust but be aware that many types include a propellant that can contaminate equipment. If used, spray away from the area to be cleaned for a few seconds before directing it to the area to ensure no liquid propellant is in the spray.

The test equipment fiber inputs/outputs and test cables should be cleaned periodically.

Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) consists of all equipment including clothing affording protection against the weather, which is intended to be worn or held by a person at work and which protects the user against one or more risks to their health or safety. The examples of PPE include aprons, safety helmets, gloves, safety boots or other footwear, eye protection, high-visibility clothing, warm and weatherproof clothing and safety harnesses or fall arrest systems. In appropriate situations disposable PPE may be provided; eg single-use coveralls. Typical PPE is shown in Figure 1.1.

Fig.1.1: Protection provided by PPE

Head Protection – Safety Helmets, Bumps caps, Caps and Hair nets.

Eye Protection – Goggles, Safety Spectacles, Hand held or freestanding screens.

Face Protection – Face shields, which can be hand held, fixed to helmet or strapped to head.

Respiratory Protection – General-Purpose Dust Respirators, Positive Pressure Powered Respirators, Helmet Contained Positive Pressure Respirators, Gas Respirators, Emergency Escape Respirators, Airline Breathing Apparatus, Self-Contained Breathing Apparatus

Hearing Protection – Ear Plugs, Ear Defenders, Muffs and Pads, Ear Valves, Acoustic Wool.

Skin Protection – Barrier Creams

Body Protection – One Piece and Two-Piece Overalls, Donkey Jackets, Aprons, Warehouse Coats, Body Warmer, Oilskin Over Clothing, Chemical Clothing.

Hand and Arm Protection – General Purpose Fibre Gloves, PVC Fabric Gauntlets, Gloves, Sleeves, Chain Mail Hand and Arm Protectors.

Leg and Foot Protection – Safety Boots, Shoes, Wellingtons, Gaiters and Anklets.

1. Head Protection

Protecting from the potential head injuries while installation of OFC and cable laying is essential for any optical fibre technician. Wearing a safety helmet or hard hat is one of the easiest ways to protect the head from injury. Hard hats can protect from the impact and penetration hazards as well as from electrical shock and burn hazards.

For suitable head protection, it must be of an appropriate size, fit properly, and have an easily adjustable headband. There are four widely used types of head protections:

- **Crash Helmets –** protects against impact with moving objects
- **Industrial Safety Helmets –** protects against falling objects or impact with fixed objects
- **Bump Caps –** protects against scalping or entanglement
- **Caps and Hair nets –** protects scalping or entanglement

Fig. 1.2

Fig. 1.3

Fig. 1.4

2. Eye and Face Protection

A technician working on the installation and splicing work can be exposed to hazards that pose danger to their eyes and face. They should have appropriate eye or face protection to protect from the eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, potentially infected material or potentially harmful light radiation.

Laser light radiation can be extremely dangerous to the unprotected eye and direct or reflected beams can cause permanent eye damage. Laser retinal burns can be painless; therefore, it is essential that all personnel in or around the laser operations wear appropriate eye protection. Laser safety goggles protect the eye from the specific wavelength of the laser and must be of sufficient optical density.

There are four principal forms of eye protection:

- **Safety Spectacles** incorporate optional shields, with lenses manufactured in tough optical plastic, such as polycarbonate, and available with standard or prescription lenses.
- **Eye shields** are designed with frameless one-piece moulded lenses.
- **Safety goggles** are manufactured with toughened glass lenses or wide vision plastic lenses, with flexible plastic frame and elastic headband.
- **Face shields** are fitted with adjustable head harnesses, and provide protection to the face as well as the eyes.

These lenses of eye protectors must be kept clean as dirty lenses restrict vision which may cause fatigue and may be a contributing feature in any accident.

Fig. (a) Side shield type, net type, fitted with blue or clear lenses (b) Panorama, Leather mask, Gas cutting goggles (c) Asbestos hood, Aluminised hood (d) Plastic face shield, welding head shield, welding hand shield

3. Hearing Protection

The hearing protection must be used where exposure to the noise level of 90dbA or above exists. The hearing protection should be comfortable, hygienic and suitable for the working environment. When using ear defenders, ensure not use music headphones or buds simultaneously. A proper training is required to use hearing protectors. There are different types of hearing protectors such as Ear Plugs, Ear defenders, Muffs and Pads and Ear valves.

Fig. 1.5 Ear Plugs

Fig. 1.6 Ear Defend

Fig. 1.7 Ear valves

4. Skin Protection

There are many chemical substances such as strong acids and alkalis, chromates and dichromate, formaldehyde, organic solvents, resins, certain adhesives, degreasing compounds

and lubricants, which cause dermatitis and are more commonly used in the workplaces. Paraffin and trichloroethylene remove the natural fats from the skin and render it vulnerable to damage from other substances.

A range of barrier creams is available to meet varying work conditions. The selection shall be based upon the chemical to be handled. They provide skin protection in wet conditions, and for workers handling acids, alkalis and other potentially hazardous substances. The barrier creams must be applied before commencement of work.

5. Body Protection

A wide range of protective clothing for the body are available, including:

- Coverall, Aprons; protects against chemicals & hazardous substances.
- Outfits to protect against cold, heat and bad weather.
- Specific clothing to protect against machinery.

Leather Apron – These provide protection against sharp objects, hot chips, oil spillages and abrasion by rough surfaces or objects. These are generally supplied with tapes and buckles for proper tying.

Asbestos Apron – It is used to protect the body from heat. These may have lint lining or leather lining, depending upon the nature of work for which they are to be used.

PVC Apron – It is used to protect from the chemical spillages, acid splashes, paints and coolants.

Lead Apron –It provides protection from the Ionising radiations e.g. X-rays, gamma rays.

Fig. 1.8

Fig. 1.9

Fig. 1.10

Fig. 1.11

Fig. 1.12

6. Hand and Arm Protection

Damage to hands and arms can arise through the use of machinery and hand tools and in manual handling operations; resulting in cuts and abrasions, through skin irritation, contact with hazardous substances and as a result of exposure to adverse weather conditions. A wide variety of hand and arm protection is available including gloves and gauntlets made of leather, chain mail, PVC fabric and man-made fibres. The gloves should not be used while working with moving machinery such as drills, saws, grinders. These machines may catch the gloves, pull it or with the hand of the worker into the hazardous area.

Leather Gloves – These protect the hands from cuts, bruises and abrasions. These are fit for handling sharp edged materials.

Asbestos Gloves – These provide protection to the hands from heat thereby avoiding burn injuries. These gloves are provided with double-padded lining inside. These may withstand temperatures as high as 10000 C.

Acid and Alkali Proof Gloves – These have a black cover. These protect the workers only against the harmful effects of acid & alkali materials.

Fig. 1.13 (a) Canvas Gloves, Acid and Alkali proof rubber gloves, Leather Gloves, Asbestos Gloves

Electrical Resistant Gloves – The colour of these gloves is Red. These protect against the electric shock. These must be purchased along with their inspection/test certificates.

Canvas Gloves – They provide protection against oil, grease and other dirt.

Lead Gloves – These provide protection against ionising radiations like X-rays and gamma rays.

Hand Sleeves –These are designed to give protection to the full length of hand (from shoulder to arm) of the wearer. Mainly used by the welders for protection against slag and metal spatters while doing position welding.

Fig. 1.13 (b) Aluminised gloves, Crust Leather Gloves (Front & Back View)

Fig. 1.13 (c) Safety Belt-Body harness and Lifeline

7. Leg and Foot Protection

Safety footwear are used for the safety of legs when the installation is done on a construction site, which involves mechanical and manual handling activities, for work in cold and wet conditions, foundry work and forestry.

A wide range of safety footwear is available for providing protection against many hazards to the feet or legs including crushing, slipping, piercing, temperatures, electricity, chemicals, cutting, and chopping.

Safety Boots and Shoes – These are the most common type of safety footwear and commonly incorporate a steel toe cap. They can also have other safety features, such as slip resistant soles, steel insoles and insulation against extreme temperatures etc.

Asbestos Safety Boots – These are Used for heat radiation areas. The upper part is made of asbestos; the remaining part of this boot is made of Asbestos. The remaining parts, material and construction are the same as Safety boots.

Clog – Wooden clogs, frequently fitted with the steel toe caps, are traditionally used in a number of industries.

Conductive Footwear – This type of footwear also prevents the build-up of static electricity, and is particularly suitable for handling sensitive components or substances e.g. Explosive Detonators. It gives no protection against electric shock.

Leg Guard – These are recommended to be used by welders and also to avoid the entering of the sparks inside the safety boot.

Slip-in-type Safety Boots – This is a combination of the safety boots and leg guards; it gives full protection to welders.

Foundry Boots – These incorporate steel toe caps, are heat resistant and designed to protect the foot against molten metal splashes and spillages. They are designed without the external features such as laces which trap the molten and commonly have elasticised sides for quick removal.

Anti-static Footwear – These prevent the build-up of static electricity on the wearer. They reduce the danger of igniting a flammable atmosphere and give some protection against an electric shock.

Conductive Footwear – This type of footwear also prevents the build-up of static electricity, and is particularly suitable for handling sensitive components or substances e.g. Explosive Detonators. It gives no protection against an electric shock.

Leg Guard – These are recommended for us age to welders and also to avoid the entering of sparks inside the safety boot.

Slip-in-type Safety Boots – This is a combination of the safety boots and leg guards; it gives full protection to welders.

Fig. 1.14Aluminized Safety Boot, Asbestos Safety Boot, Gum Boot, Leg Guard, Leather Safety Boot.

8. Respiratory Protection

The use of Respiratory Protective Equipment (RPE) is essential wherever workers are exposed to dangerous concentrations of toxic or dusts, fumes or where they may be working in unventilated or poorly ventilated areas.

Face Masks – These are simple devices for holding filtering media against the nose and mouth to remove coarse nuisance dust particles or non-toxic paint sprays. They should not be used as a means of protection against hazardous or toxic substances. It is recommended to use the face masks for protection from Covid-19 pandemic.

General Purpose Dust Respirator – They take the form of an ori-nasal face mask which has a particulate filter to trap the finely divided solids or liquid particles.

Emergency Escape Respirator – These are especially designed respirators using a chemical filter which will enable people to escape from dangerous atmospheres in an emergency. They are intended for a very short-term use and should never be used for normal protection.

Limitations of personal protective equipment

The PPE should be used with proper knowledge and knowing its limitations. In any hazardous environment the use of a PPE should be considered only as the last line of defence. PPE does not help in any way in removing or reducing the prevailing hazard conditions in the environment, but it only provides limited and time bound protection. The best way of ensuring full protection can only be achieved by eliminating the hazards by proper engineering and administrative control measures.

Use of PPEs need care from a risk angle so that persons wearing the PPEs should not be hurt during the use of PPEs. One simple thumb rule will not be applicable for all types of hazards and PPEs.

Assignment: Conduct the site survey for installation of OFC, assess the hazards and select the appropriate Personal Protective Equipment required in the area. The purpose of the survey is to identify sources of hazards to workers and co-workers. Consideration should be given to the basic hazard categories:

Impact

1. Penetration
2. Compression (Roll-Over)
3. Chemical
4. Heat
5. Harmful dust
6. Light (Optical) Radiation

During the site survey, observe the following:

1. Sources of motion i.e., machinery or process where any movement of tools, machine elements or particles could exist, or movement of personnel that could result in collision with stationary objects;
2. Sources of high temperatures that could result in burns, eye injury of ignition of protective equipment, etc.
3. Types of chemical exposures.
4. Sources of harmful dust.
5. Sources of light radiation, i.e., welding, brazing, cutting, furnaces, heat treating, high-intensity lights, etc.
6. Sources of falling objects or potential for dropping objects.
7. Sources of sharp objects which might pierce the feet or cut the hands.
8. Sources of rolling or pinching objects which could crush the feet.
9. Layout of workplace and location of co-workers. And
10. Any electrical hazards, injury/accident data should be reviewed to help identify problematic areas.

Summary

- Keep all food and beverages out of the work area. A simple drink of water can carry glass shards into the throat and down the esophagus where they can cause internal haemorrhages. Tiny glass fibers can be in the air whenever fiber optics are being created or installed.
- Wear safety glasses – Every person in the area must wear safety glasses with side shields to prevent fiber shards and splinters from entering the eyes. They should also wear the suitable safety Helmets, Safety belts and protective gloves.
- Wear protective aprons – All workers should be clothed in disposable lab aprons to reduce the fiber particles that collect on personal clothing. If particles collect on clothing, they will be ingested later through food, drink or breathing in air.
- Work on a black pad or wear a black apron which makes the slivers of glass easier to spot.
- Handle the fiber optic splinters similar to glass splinters.
- Never look directly through the end of fiber cables till you ensure that there is no light source at the other end. Use a fiber optic power meter to make sure that fiber is dark.

When using an optical tracer or continuity checker, look at the fiber from an angle at least 6 inches away from your eye to determine if the visible light is present.

- Contact lens wearers – After handling the fiber optics, someone who wears contact lenses must wash their hands very thoroughly before handling their contact lenses. Glass shards can lodge in the surface of the eye and cause lacerations.
- Only work in well-ventilated areas – Breathing clean air is an important part of a safe working environment. Fiber optic cables have many tiny glass particles that are dislodged when the cables are moved for any reason. A well-ventilated area will allow the particles to move away from the people working with the fibers.
- No combustible materials – Fusion splicers and curing ovens can cause flammable materials to combust. Keep all combustible materials away from the curing ovens. Caution must be taken to ensure that there are no dangerous materials used near this equipment.
- Dispose of scraps – Tossing unused lengths of fiber on the floor is a safety hazard that must be avoided. Not only can people trip, but walking on those scraps causes particles to be dislodged and enter the air.
- Avoid skin contact to materials involved as much as possible.
- Avoid using chemicals that cause allergic reactions.
- Even isopropyl alcohol, used as a cleaner, is flammable & should be handled carefully.
- The broken ends of fibers created during termination and splicing can be dangerous.
- The ends are extremely sharp and can easily penetrate the skin. They invariably break off and are very hard to find and remove.
- Any delay in taking the fiber out of the body could lead to infection, which is dangerous. A pair of tweezers and magnifying glass would be needed to take them out.
- Do not touch eyes while working with fiber optic systems until they have been thoroughly washed.
- Thoroughly clean work area after completion of the installation and ensure the safety of everyone involved.
- Do not smoke while working with the fiber optic systems.

CHECK YOUR PROGRESS

A. Multiple choice questions

1. The major safety concern regarding fiber optics is _____ (a) high power levels (b) warts (c) bare fiber ends (d) explosion.
2. Double-stick tape can be used for _____ (a) removing fiber splinters (b) protecting bare fiber from dust (c) collecting bare fiber ends (d) none of the above.
3. Fusion splicers should not be used _____ (a) with multimode fiber (b) with single mode fiber (c) in a flammable space (d) near an open flame.
4. The most important installation safety rule is _____ (a) to work quickly when using epoxy or solvents (b) to brush any fiber ends off your clothes (c) to wear safety glasses (d) to work with a partner.
5. Looking directly at the ends of optical fibre cable may damage the _____ (a) Retina (b) Ears (c) Skin (d) Nose
6. Which of the following is used as a source for optical fibre communication? (a) Tube light (b) Sunlight (c) LASER Light (d) Bulb

B. Fill in the blanks

1. A simple drink of water can carry glass shards into the throat and down the _____ where they can cause internal _____. (esophagus, hemorrhages)

2. Wear safety glasses with the side shields to prevent _____ and _____ from entering the eyes (fiber shards, splinters).
3. Fibre particles that collect on personal clothing can be ingested later through _____, _____ or _____ in air (food, drink, breathing).
4. Handle the fiber optic splinters similar to _____ (glass splinters).
5. Never look directly through the end of fiber cables till you ensure that there is no _____ at the other end (light source).
6. Use a fiber optic _____ to make sure that fiber is dark (power meter).
7. He uses an _____ or _____, look at the fiber from an angle at least 6 inches away from your eye to determine if the visible light is present (optical tracer, continuity checker).
8. Glass shards can lodge in the surface of the eye and cause _____ (lacerations).
9. Keep all _____ materials away from the curing ovens (combustible).
10. Isopropyl alcohol is _____ (flammable).
11. The broken ends of fibers created during _____ and _____ can be dangerous (termination, splicing).

C. State True or False

1. The broken ends of fibers created during termination and splicing are extremely sharp. (T)
2. The underground installation of OFC is safe from hazards. (F)
3. It is safe to handle bare fibre (F)
4. Do not wear protective aprons, safety glasses, and gloves, while handling OFC. (F)
5. Do not bend the cable below minimum bending radius. (T)
6. The maximum pulling distance can be achieved by using lubricants. (T)
7. Using the anti-twisting device during cable pulling can damage the fibre. (F)
8. Corrosion of equipment may damage cable or cause injury to personnel. (T)
9. Do not handle the fiber optic splinters similar to glass splinters (F)
10. Fibre optic technicians should wear the complete PPE kit while working for installation of OFC. (F)

D. Short answer questions

1. What is the precaution for handling the optical fiber?
2. What are the laser precautions to be followed?
3. What is material safety and precautions to be taken for it?
4. What are the fire safety precautions to be followed?
5. What is the workmanship related precautions to be followed?
6. Whether electric safety is required during OFC installation. If yes, why?
7. List out the important component of PPE to be used during OFC laying and installation?
8. What is the important component of PPE to be used during splicing?
9. Mention out the important component of PPE to be used during transportation of OFC?
10. Make a list of the important components of PPE to be used during maintenance of OFC?

Session 2. Optical Fiber Workman Safety

While visiting the site, Tina and her classmates saw a few workers wearing a particular kind of clothing. They asked their teacher about the clothing they were wearing. Their teacher told them that it is part of a personal protective equipment (PPE) kit. She further explained that it is important to take safety precautions while installation of optical fibre cables to avoid workplace hazards. It includes hazards ranging from laser light sources to ladders. Optical fibre technicians are responsible for their safety as well as for the safety of co-workers.

In this chapter, you will understand the importance of various safety equipment required while installation or splicing of optical fibre cables. A proper working environment can boost the efficiency of workers. This chapter also describes the types of hazards encountered in the workplace and different methods to work safely.

2.1 Personal Protective Equipment (PPE)

PPE kit is essential for every technician working in the site to protect themselves from electrical and physical hazards. Gloves, helmets, safety glasses, earplugs, and other gears are the various components of PPE. It is important to wear them while working on the site. For safety, signs can be posted near panels reminding employees to wear PPE. Figure 2.1 shows a typical PPE and each component is explained in Table 2.1.

Fig.2.1: Components of PPE

Table 2.1: Various components of PPE kit

Skin protection – A technician generally work with hands. It is necessary to protect the skin of the hand. Hand gloves are used to protect the skin of the palm and hand from hazardous material. Skin damage can occur due to severe cuts, punctures, burns, abrasions, or extreme temperature.	 **Fig. 2.2 Hand Gloves**
Eye Protection – Goggles protect the eyes from injury from small broken glass fiber of the optical cables. It provides better protection against the dusty environment, chemical splashes. Splicing cables generates many fiber scraps. Hence a big disposable bin is required. These fiber scraps can be dangerous. Always wear eye protection goggles, and work on a black mat to see the scraps and pick them up to dispose of them. Prevent the LASER light from entering the eyes.	 **Fig. 2.2 Eyes Goggles**

Hearing protection – About 82% of occupational hearing loss can occur to workers in the manufacturing sector. Hearing protection must be used whenever noise exposure exceeds an 8-hour time-weighted average (TWA) sound level of 90dBA. Noise levels above 115dBA always require control measures. PPE for ear protection consists of earplugs and earmuffs.	 **Fig. 2.3 Ear guards**
Foot Protection – It may be due to exposure of foot to heavy objects such as barrels or tools that might roll onto-or fall on an employee's feet. Safety shoes have impact-resistant toes and heat-resistant soles and may be electrically conductive for use in an explosive atmosphere or non-conductive for protection from electrical hazards.	 **Fig. 2.4 Foot Wear**
Body protection – A flame proof apron may be worn to protect the body from any burn in case **of** fire.	 **Fig. 2.5 Flame Proof Aprons**
Head Protection – A technician should always wear a helmet to protect the head from hazardous and chemical substances.	 **Fig. 2.6 Helmet**
Face Mask – It can be used regularly keeping in view of Covid-19 pandemic and also to prevent ant gaseous substances from entering the body through inhalation.	 **Fig. 2.7 Face Mask**

2.2 Workplace Safety Hazards

The most common definition of hazard is a danger or risk that is associated with something. Something can even be considered a hazard if it would be a trigger for causing another hazard to become present, which could hurt someone or something in the area. Workplace hazards pose potential harm to people at work, and that can cause damage to the work environment and everything else in it. Hazards could cause adverse health effects and losses of property and equipment for organizations.

There is a common way to classify hazards, and not all these are present in all workplaces. In some industries like manufacturing and pharmaceuticals, there are biological and chemical risks

that pose risks to the workers. Physical dangers are present as well in many industries where there is exposure to electricity, radiation, extreme pressures, noises, and magnetic fields.

Physical hazards – It is the risks arising from the physical work environment – floors, facilities, walls, and ceilings. Physical hazards could also mean working with machinery and electricity-operated machines. Work processes or specific assignments could also qualify as areas where physical hazards are present. There is a vast list of physical hazards across all industries, but when we look at one specific sector, these dangers are also particular to the work setting.

Falling off heights, slipping, and tripping – The reasons for falling are attributed to faulty scaffolding and ladders, as a result of contact with electricity, and slipping or crashing into anything that throws the worker off balance. On the other hand, trips and slips happen right on lower levels, particularly the floor, on-ramps, and any uneven surface in the workplace. Various injuries result from simply tripping over things at work, while many more accidents take place when employees slip on the floor, from motorized vehicles, or scaffolding or ladders.

To avoid falls and slips, all things must be arranged properly. Any spilled liquid, food, or other items such as paints must be immediately cleaned to avoid any accidents. Make sure there is proper lighting and all damaged equipment, stairways, and light fixtures are repaired immediately.

Fig. 2.8: Falling off heights, slipping and tripping

Electrical hazards – There are many reasons why workers get electrocuted or suffer from electric shock at work. For the most part, it is due to coming in direct contact with live wires or having indirect contact through a conductor. While not all electrical accidents lead to death, there are many life-threatening, severe and often permanent injuries that could result from it. At work, the common causes of electrical accidents are exposed, worn-out wiring, overloading of electrical outlets, ungrounded or faulty equipment, and unsafe use of electrical equipment. Employees must be provided a basic knowledge of using electrical equipment and common problems. Employees must also be provided instructions about electrical safety such as keeping water and food items away from electrical equipment. Electrical staff and engineers should carry out routine inspections of all wiring to make sure there are no damaged or broken wires.

Health hazards – Health refers to the physical well-being of the workers, and this includes the condition of their skin, eyes, ears, and all other body parts. But it also includes the health situation of what we cannot see upfront – their respiratory and cardiovascular system, and the nervous system. Hazards are present in most workplaces that could impact any part of the human body. For example, a noisy machine or factory environment could damage the sense of hearing of the workers. In the same manner, exposure to bright lights and toxic fumes, and vapour could damage the eyes and nose. There are also more serious and long-term health issues arising from hazardous workplaces, such as damage to the lungs because of exposure to harmful chemicals.

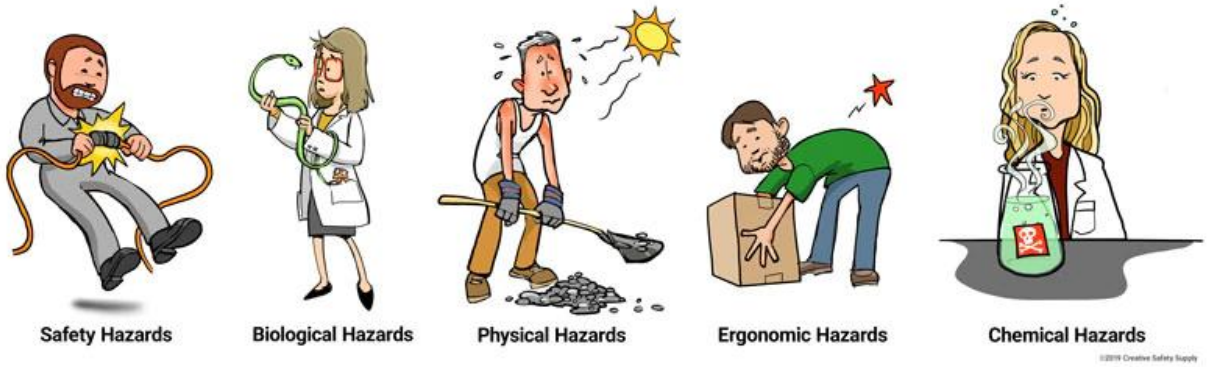


Fig.2.9: Various types of Hazards

Potential Sources of Hazards in an Organization

Bright light sources behind the display screen can create contrast problems, making it difficult to see the work. Apply the following possible solutions to avoid this.

- Use blinds or drapes on windows to eliminate bright light. Blinds and furniture placement should be adjusted to allow light into the room, but not directly into your field of view.
- Use indirect or shielded lighting where possible and avoid intense or uneven lighting in your field of vision. Ensure that lamps have glare shields or shades to direct light away from your line of sight.
- Reorient the workstation so bright lights from open windows are at right angles with the computer screen.
- High contrast between light and dark areas of the computer screen, horizontal work surface, and surrounding areas can cause eye fatigue and headaches. So, use well distributed diffused light.

Hazards using computers – Hazards while using computers include poor sitting postures or excessive duration of sitting in one position. These hazards may result in pain and strain. Making the same movement repetitively can also cause muscle fatigue. In addition, glare from the computer screen can be harmful to the eyes. Stretching at regular intervals or doing some simple yoga in your seat can mitigate such hazards.

Handling office equipment – Improper handling of office equipment can result in injuries. For example, sharp-edged equipment, if not handled properly, can cause cuts. Staff members should be trained to handle equipment properly. A relevant manual should be made available by the administration on handling equipment.

Handling objects – Lifting or moving heavy items without proper procedure or techniques can be a source of a potential hazard. Always follow approved procedures and proper posture for lifting or moving objects.

Stress at work – In today's organisations, you may encounter various stress causing hazards. Long working hours can be stressful and so can aggressively conflict or arguments with colleagues. Always look for ways for conflict resolution with colleagues. Have some relaxing hobbies for stress against long working hours.

Working environment – Potential hazards may include poor ventilation, chairs, and tables of inappropriate height, hard furniture, poor lighting, staff unaware of emergency procedures, or poor housekeeping. Hazards may also include physical or emotional intimidation, such as bullying or ganging up against someone. The staff should be made aware of the organisation's policies to fight against all the given hazards related to a working environment.

2.3 Hazard Control

Hazards that have been identified and assessed as priorities require implementing adequate control measures. Control measures should follow the hierarchy with a strong emphasis on eliminating hazards at the source, whenever possible.

- Take all feasible measures to eliminate the hazard, for example, by substituting or modifying the process.
- If elimination is impractical or remains incomplete, take all feasible measures to isolate the hazard, for example, instituting engineering controls such as insulating noise.
- If it is impossible to eliminate or isolate the hazard, its likelihood to cause injury should be minimized. Ensure that effective control measures are being applied, such as installing proper exhaust ventilation and providing personal protective clothing and equipment that is properly used and maintained, and monitoring exposure among at-risk workers

2.4 Safety Rules for Fiber Optics

Fiber optic cables were designed to enhance voice and data communication in many different applications. The following safety rules may be observed.

No food or drink – Tiny glass fibers can be in the air whenever fiber optics are being created or installed. A simple drink of water can carry glass shards into the throat and down the esophagus where they can cause lacerations and internal hemorrhages.

Wear safety glasses – It is necessary to wear safety glasses with side shields to prevent fiber shards and splinters from entering the eyes.

Wear protective aprons – It is necessary to wear the protective aprons so that the fiber particles may not collect on personal clothing. If particles collect on clothing, they will be ingested later through food, drink or breathing in air.

Avoid fiber ends – Do not look into the end of the fibre cable with naked eyes, as there is visible light coming through the cable. Use an optical tracer or continuity checker to determine if the fiber is dark. A power meter will verify that there is no light source at the other end of the cable.

Washing hands – After handling fiber optics, wash hands very thoroughly before handling their contact lenses. Glass shards can lodge in the surface of the eye and cause lacerations.

Keep hands away from face – While working fiber optics do not touch your hands-on face. Tiny splinters from the fibers can penetrate the soft skin on the face and be very difficult to remove.

Well-ventilated areas – Fiber optic cables have many tiny glass particles. A well-ventilated area is required to move the particles away from the people working with the fibers.

No combustible materials – Fusion splicers and curing ovens can cause flammable materials to combust. So combustible materials should not be used near this equipment.

Dispose of scraps – Dispose of the unused fiber on the floor for safety. walking on those scraps causes particles to be dislodged and enter the air.

Clean up afterward – A systematic cleaning effort for the entire work area will ensure the safety of everyone involved.

2.5 Safety Guidelines Checklist

1. Store all cleaning chemicals in tightly closed containers in separate cupboards.
2. Throw rubbish daily.
3. Make sure all areas have proper lighting.
4. Do not wear loose clothing or jewellery when working with machines.
5. Never distract the attention of people who are working near a fire or with some machinery, tools, or equipment.
6. Where required, wear protective items, such as goggles, safety glasses, masks, gloves, and hair nets.
7. Shut down all machines before leaving for the day.
8. Do not play with electrical controls or switches.

9. Do not operate machines or equipment until you have been properly trained and allowed to do so by your supervisor.
10. Repair torn wires or broken plugs before using any electrical equipment.
11. Do not use equipment if it smokes, sparks, or looks unsafe.
12. Cover all food with a lid, plastic wrap, or aluminium foil.
13. Do not smoke in 'No Smoking' areas.
14. Report any unsafe conditions or acts to the supervisor.

2.6 Medical Emergency and First Aid

Medical Emergency

A medical emergency is a situation in which a worker meets with an accident and needs medical help. It is necessary to keep the provision of a first aid kit, as medical emergencies can occur at any time. The various medical emergency situations are shown in Figure 2.10. It is better to be prepared to use the first aid kit.

Fig. 2.10 Different Medical Emergency

The medical injury may be severe or life-threatening. Some situations where:

I. Person is not inhaling
II. Heart attack or stock
III. Heavy or severe bleeding
IV. Electric Shock
V. In case of Poisoning
VI. Person get somebody Burns

In case of a medical emergency, the person or victim requires immediate help. Sometimes the person needs attention, before calling the emergency helpline.

It is important to know or remember the number of emergency helplines or Emergency Medical Service (EMS) 108 for the safety of self and other workers.

First Aid

In the workplace, many situations require immediate first aid to the victim and many countries have made some regulations, legislation, and guidance which specify the minimum level of first aid to be given to the victim. For this, the worker needs special training and an area for achieving immediate first aid. To achieve this; the training should be given by specialist first aid officers and the learning institute. The training of first aid does not need any type of specific tools and equipment but may involve the improvisation with material offered at the time of training.

Fig. 2.11: First Aid pyramid

While delivering First Aid always remember:

I. To prevent degradation.
II. Act deliberately and confidently with the victim.
III. The timing of Golden Hour should be first 60 minutes after an accident.
IV. The timings of the Platinum Period should be the first 15 minutes following an accident.
V. Prevent body shock and choking.
VI. Stop bleeding from the wound.
VII. Loosen the clothes of the victim.
VIII. Regulate the respiratory system of the victim.
IX. Avoid crowding near the victim.
X. Take the victim to a safe place or hospital near the workplace.
XI. Attend the emergency situation with ease and without fear.
XII. Always remember not to overdo, because the person providing first aid is not a doctor.

2.7 First Aid Kit

First aid is the assistance given to any person suffering a sudden illness or injury with care provided to preserve life, prevent the condition from worsening, or promote recovery.

Fig. 2.12 First Aid Kit

First aid kits vary in contents but most kits have the following items:

1. Band-Aids / Adhesive bandages
2. Gauze pads and tape
3. Scissors, cold pack
4. Wound bandage/compress
5. Eye pad/eye wash solution
6. First aid/burn cream
7. Antibiotic ointment
8. Face shield or barrier mask for providing CPR
9. Forceps/tweezers
10. Disposable thermometers
11. First aid instruction booklet

CHECK YOUR PROGRESS

A. Multiple choice questions

1. Which of the following safety items should be there with the technician while working on the site? (a) Safety boots (b) Fire extinguisher (c) Laser beam (d) First Aid box
2. A medical emergency is a situation in which (a) Worker met in an accident and needs medical help (b) Accident occurs outside the premises (c) Small injuries happen to the workers (d) None of the above
3. Some medical emergencies are (a) Person is not inhaling (b) Heart attack or stock (c) Electric Shock (d) All of the above
4. Number of emergency helpline or Emergency Medical Service (EMS) is (a) 100 (b) 101 (c) 102 (d) 108
5. The PPE should be (a) comfortable for that work activity (b) in accordance with the risk assessment (c) the employer can afford (d) according to recommended guidelines
6. First aid for Fainting (a) Lie down the victim and raise the legs above his heart level (b) Loose the tight clothes like neckties, collars, and belts (c) Check for indication of coughing or breathing problem (d) All of the above
7. First aid for a shock (a) Keep the victims in lying down position (b) Raise the legs 10-12 inches from the ground level (c) Victim is feeling hot then don't make suffocation by covering him (d) All of the above
8. First Aid Pyramid include (a) Preserve Life (b) Prevent further Harm (c) Promote Recovery (d) All of the above

B. Fill in the blanks

1. The medical injury may be _____.
2. In case of a medical emergency, the person or victim requires the _____.
3. First aid is the _____ given to any person suffering a sudden illness or injury.
4. Take the victim to _____ near the workplace.
5. Gloves are an essential PPE for skin protection
6. Splicing cables generate many fiber scraps

C. State True or False

1. If a person is not inhaling, then it is a situation of medical emergency. (T)
2. Optical fibre splicing and termination uses various chemical cleaners and adhesives as part of the processes. (T)
3. The broken ends of fibres and scraps of fibre created during termination and splicing are extremely dangerous. (T)
4. First aid is the immediate treatment given to the injured person. (T)
5. While delivering First Aid do not regulate the respiratory system of the victim. (F)

D. Short answer questions

1. What is a Medical Emergency?
2. What are various safety hazards?
3. When does shock occur in the human body? Write first aid for shock.
4. Explain various health hazards?
5. What is a First Aid Kit? Draw a diagram of the First Aid Pyramid.

Glossary

Attenuation – Attenuation is the reduction in intensity of a number of different things. It is the opposite of amplification. In physics or electronics the change is usually referred to using decibels (dB), noting the number of decibels by which a particular signal is reduced as it passes through a particular medium a certain distance. This concept is used quite a bit in the telecom industry because of its importance in determining where a repeater is needed.

Backbone – A backbone network or network backbone is a part of computer network infrastructure that interconnects various pieces of network, providing a path for the exchange of information between different LANs or subnetworks. A backbone can tie together diverse networks in the same building, in different buildings in a campus environment, or over wide areas.

Bandwidth – Bandwidth is a measure of data flow rate in digital networks typically in bits per second.

Bend Radius – Bend radius, measured to the inside curvature, is the minimum radius one can bend a pipe, tube, sheet, cable or hose to without kinking it, damaging it, or shortening its life.

Conduit – A conduit is a general term for a means of conveying something from one location to another or between persons. An electrical conduit is a purpose-designed electrical piping system used for protection and routing of electrical wiring. Electrical conduit may be made of metal, plastic, fibre, or fired clay. Flexible conduit is available for special purposes.

Core – The Core is the center part of the fiber cable through which light is transmitted. The fiber consists of a core surrounded by a cladding layer.

Decibel (dB) – The standard unit used to express gain or loss of optical power. A standard logarithmic unit for the ratio of two powers, voltages or currents. In fiber optics, the ratio is power.

Ferrule – Ferrule is the protruding portion of a fiber connector. Materials: ceramic, stainless steel, polymer.

Insertion Loss – Insertion Loss is the total power loss caused by insertion of an optical component (such as a connector, splice, or coupler) into a previously continuous path.

Kevlar – Kevlar is the registered trademark for a light, strong synthetic fiber. Kevlar is widely used as a protective outer sheath for fiber optic cable, as its strength protects the cable from damage and kinking.

Multi-mode Fiber – Multi-mode Fiber is a type of optical fiber mostly used for communication over shorter distances, such as within a building or on a campus. Typical multi-mode links have data rates of 10 Mbit/s to 10 Gbit/s over link lengths of up to 600 meters, more than sufficient for the majority of premises applications.

Point to Point – Point to Point refers to when there is a direct connection between two active communications devices (switches to servers, servers to storage, server to server, etc.).

Sheath – A cable is one or more wires or optical fibers bound together, typically in a common protective jacket or sheath.

Single-mode Fiber – Single-mode Fiber optical fiber (SMF) is an optical fiber designed to carry only a single ray of light (mode).

Splice – Fusion splicing is the act of joining two optical fibers end-to-end using heat. The goal is to fuse the two fibers together in such a way that light passing through the fibers is not scattered or reflected back by the splice, and so that the splice and the region surrounding it are almost as strong as the virgin fiber itself. The source of heat is usually an electric arc, but can also be a tungsten filament through which current is passed.

Strength Member – For indoor applications, the jacketed fiber is generally enclosed, with a bundle of flexible fibrous polymer strength members like Aramid (e.g. Twaron or Kevlar), in a lightweight plastic cover to form a simple cable. Each end of the cable may be terminated with a

specialized optical fiber connector to allow it to be easily connected and disconnected from transmitting and receiving equipment.

Tensile Strength – measures the engineering stress applied (to something such as rope, wire, or a structural beam) at the point when it fails. It is an intensive property of the material, which not only depends on the type of material but also the preparation of the specimen and the temperature of the test. In other words, the amount of force the material can withstand when being stretched. (Picture tug-of-war, the amount of force required to break the rope would be it's tensile strength)

Tight Buffer – In Tight Buffer construction the fiber may be embedded in a heavy polymer jacket. These fiber units are commonly bundled with additional steel strength members, with a helical twist to allow for stretching.

Answer

Module 1. Introduction to Telecom Industry

Session 1. Telecommunication and Telecom Industry

A. Multiple Choice Questions

1. (a) 2. (a) 3. (d) 4. (d) 5. (a) 6. (a) 7. (b) 8. (a) 9. (b) 10. (a)

B. Fill in the Blanks

1. Optical fibre 2. Wireless 3. Analog, digital 4. TRAI (Telecom Regulatory Authority of India) 5. General Packet Radio Service 6. Generation 7. Multi-gigabit speed 8. Regulatory 9. Customer satis-faction 10. Internet access

C. State True or False

1. (F) 2. (F) 3. (T) 4. (T) 5. (T) 6. (T) 7. (F) 8. (T) 9. (T) 10. (T)

Session 2. Transmission Media

A. Multiple Choice Questions

1. (a) 2. (a) 3. (c) 4. (d) 5. (a) 6. (a) 7. (a) 8. (a) 9. (b) 10. (a)

B. Fill in the Blanks

1. Wired or guided 2. Unshielded Twisted Pair 3. Less 4. Metallic shielding (like foil) 5. Ethernet 6. Twisted pair cable 7. Patch cable 8. Network interface card 9. Better resistance to cross talk 10. 10Base2 11. 10Base5

C. True or False

1. (F) 2. (T) 3. (F) 4. (F) 5. (T) 6. (T) 7. (F) 8. (T) 9. (T) 10. (T)

Session 3. Basics of the optical Fiber

A. Multiple Choice Questions

1. (d) 2. (c) 3. (d) 4. (d) 5. (a) 6. (d)

B. Fill in the Blanks

1. Glass, plastic 2. 8µm 3. 125µm 4. Maximum external 5. Dispersion, attenuation 6. Nanosec-onds, picoseconds 7. Length

C. True or False

1. (F) 2. (T) 3. (F) 4. (F) 5. (T) 6. (T) 7. (T) 8. (T) 9. (F) 10. (F) 11. (T) 12. (T)

Module 2. Installation and Commissioning of Fiber Optic Cable

Session 1. Site Visit and Route Inspection

A. Multiple Choice Questions

1. (d) 2. (b) 3. (d) 4. (b) 5. (d) 6. (d) 7. (a) 8. (a) 9. (b) 10. (c)

B. Fill in the Blanks

1. Direct burial, trenching 2. Steel, bent 3. Long-distance cable installations 4. OFC (Optical Fiber Cable) 5. Inspection 6. Safety gears 7. Determine the composition of the soil 8. Free from other utility cables 9. Manually or by using machinery 10. Action plan

C. True or False

1. (F) 2. (T) 3. (T) 4. (T) 5. (F) 6. (T) 7. (F) 8. (T) 9. (T) 10. (F)

Session 2. Optical Fibre Cable Drum Handling

A. Multiple Choice Questions

1. (a) 2. (a) 3. (b) 4. (a) 5. (b) 6. (a) 7. (d) 8. (c) 9. (d)

B. Fill in the Blanks

1. Crowbar 2. Flange of the drum 3. Crane 4. Handling 5. Flat, level surface

Session 3. Optical Tools and Equipment

A. Multiple Choice Questions

1. (c) 2. (b) 3. (b) 4. (b) 5. (d) 6. (d) 7. (d) 8. (c) 9. (b) 10. (d)

B. Fill in the Blanks

1. Fusion splicing 2. Steel 3. Needle-nose pliers 4. Cleaving 5. Optical fibre stripper 6.LCD dis-play 7. Inspection microscopy 8. An optical power meter 9. Dust 10. Multi-fiber

C. True or False

1. (F) 2. (T) 3. (T) 4. (T) 5. (T) 6. (F) 7. (T) 8. (F) 9. (F) 10. (T)

Session 4. Installation of Optical Fibre Cable

A. Multiple Choice Questions

1. (a) 2. (a) 3. (b) 4. (d) 5. (a) 6. (a) 7. (b) 8. (a) 9. (a) 10. (a)

TSSC Book Questions

1. (d) 2. (d) 3. (a) 4. (b) 5. (d) 6. (b) 7. (a) 8. (d) 9. (b) 10. (b) 11. (b) 12. (c) 13. (c) 14. (d)

B. Fill in the Blanks

1. Pulling 2. Tube 3. Factory 4. Lashing, Clamping 5. Machine 6. Ditch 7. Cable blowing 8. Repair, Testing 9. Friction 10. Mechanical trenching

C. True or False

1. (T) 2. (F) 3. (T) 4. (T) 5. (F) 6. (T) 7. (T) 8. (F) 9. (T) 10. (T)

Module 3. Maintenance and Testing

Session 1. Corrective Maintenance and Fault Restoration

A. Multiple Choice Questions

1. (d) 2. (b) 3. (d) 4. (b) 5. (c) 6. (a) 7. (d) 8. (b) 9. (b) 10. (d)

B. Fill in the Blanks

1. Fibre cable 2. Fault localization 3. Restoration 4. Fault 5. OTDR 6. Three groups 7. Holes 8. Build nests 9. Fault 10. Images

C. Match the Following

1. (f) 2. (b) 3. (c) 4. (d) 5. (e) 6. (a)

D. True or False

1. (T) 2. (T) 3. (F) 4. (F) 5. (T) 6. (T) 7. (T) 8. (T) 9. (T) 10. (T)

Session 2. Link Performance Analysis

A. Multiple Choice Questions

1. (a) 2. (d) 3. (a) 4. (a) 5. (a) 6. (a) 7. (b) 8. (a) 9. (a) 10. (a)

B. Fill in the Blanks

1. Point of Presence, Subscriber premises 2. Fibre Connection Point, drop cables 3. Network, Customer 4. Terminates 5. Fibre to the Curb/Node 6. Fibre to the Premises 7. Light, Signal 8. Light, Data signal 9. High-speed internet 10. one

C. State True or False

1. (T) 2. (T) 3. (F) 4. (F) 5. (T)

Session 3. Testing Optical Fibre Link

A. Multiple Choice Questions

1. (d) 2. (a) 3. (d) 4. (a) 5. (a) 6. (d) 7. (c) 8. (a) 9. (d) 10. (b) 11. (b) 12. (d)

B. Fill in the Blanks

1. Three 2. Continuous 3. 1.25 mm 4. 2.5 mm 5. Focusing 6. The microscope 7. knob 8. USB port 9. Ethernet port 10. Backscatter 11. Loss/attenuation.

C. True or False

1. (T) 2. (F) 3. (T) 4. (F) 5. (T) 6. (T) 7. (T) 8. (T) 9. (T) 10. (T) 11. (T) 12. (F)

Module 4. Occupational Health and Safety

Session 1. Optical Fiber Handling Safety

A. Multiple Choice Questions

1. (c) 2. (b) 3. (c) 4. (c) 5. (a) 6. (c)

B. Fill in the Blanks

1. Esophagus, Hemorrhages. 2. Fiber shards, Splinters 3. Food, drink, or breathing 4. Glass splinters 5. Light source 6. Power meter 7. Optical tracer or continuity checker, 8. Lacerations 9. Combustible 10. Flammable 11. Termination and splicing

C. True or False

1. (T) 2. (F) 3. (F) 4. (F) 5. (T) 6. (T) 7. (F) 8. (T) 9. (F) 10. (F)

Session 2. Workmanship safety

A. Multiple Choice Questions

1. (a) 2. (a) 3. (d) 4. (c) 5. (b) 6. (d) 7. (d) 8. (d)

B. Fill in the Blanks

1. Serious 2. Immediate attention 3. Initial assistance 4. The nearest hospital 5 skin 6. fiber scraps.

C. True or False

1. (T) 2. (T) 3. (T) 4. (T) 5. (F)