# Program Information

## Lesson:

### *Fiber Optic Transmission Systems and Components*

## Training:

## Fiber Optics

## Time frame:

### 45-60 minutes

# Instruction Section

## Learning Objectives:

# Recognize how fiber optic data links and transmission systems work.

# Identify the components that are used in transceivers.

# Identify the types of sources and detectors used in transceivers.

# Identify performance parameters of fiber optic transmission systems.

## Assessment Tools/Methods:

# Participants should be assessed based on participation in group discussions and activities.

## Learner Prior Knowledge:

## Prior to class, participants will need to read:

## Reference Guide: Fiber Optic Datalinks (<https://www.thefoa.org/tech/ref/appln/datalink.html>)

## Reference Guide: Fiber Optic Transceivers for Datalinks (<https://www.thefoa.org/tech/ref/appln/transceiver.html>)

## Reference Guide: Wavelength Division Multiplexing (<https://www.thefoa.org/tech/dwdm.htm>)

## Reference Guide: FOA Standards (<http://www.thefoa.org/tech/ref/1pstandards/FOA-5.pdf>)

## Prior to class, the participants will need to watch:

## [FOA Lecture 27, Fiber Optic Datalinks](http://www.youtube.com/watch?v=MCFwNsPFka4&feature=youtu.be)

## [FOA Lecture 31, Wavelength Division Multiplexing](http://youtu.be/0ctRKOtXJ5c)

## Instructional Activities:

# Outline the lesson’s objectives and the importance of fiber optic technology in modern telecommunications.

# Activity 1: Fiber Optic Data Links Basics:

# Begin by asking the group to come up with a definition for a fiber optic data link.

# Example definition: A fiber optic data link is a complete system that transmits data using light through optical fibers.

# Have a group discussion about how various components are used.

# Optical Fiber: Transmits light signals

# Transmitters: Convert electrical signals to light signals.

# Receivers: Convert light signals back to electrical signals.

# Connectors and slices: Join fiber ends to create a continuous path for light.

# Discuss transmission modes with the group.

# Singlemode fiber: Used for long-distance communication, such as undersea cables for international communication.

# Multimode fiber: Used for shorter distances, such as Local Area Networks (LANs) in buildings.

# Have participants work in pairs or small groups, to define and give an example for the following performance factors. Note: sample answers are provided.

# Group 1: Loss and Attenuation:

# Definition: Reduction in signal strength as it travels through the fiber.

# Example: Light dimming over distance due to impurities in the fiber.

# Dispersion and Bandwidth:

# Definition: Broadening of light pulses, limiting data rates.

# Example: Using laser-optimized fiber to reduce dispersion.

# Power Budget Calculation:

# Definition: Difference between transmitter output power and receiver sensitivity.

# Example: Calculating power budget for a specific link.

# Have groups share their findings with the class and address any questions regarding their findings.

# Activity 2: Fiber Optic Transmitters and Receivers (Transceivers):

# Explain that a transceiver is a device that includes both a transmitter and a receiver.

# Ask participants to describe the operation of a transceiver; full duplex operation using separate fibers for each direction.

# Hold a group discussion and record the answers that cover the sources for transmitters, including their uses and examples of use below. Note: Sample answers are provided.

# LEDs: *Answer should include*: Lower power, used for shorter distances, such as office LANs.

# Fabry-Perot (FP) Lasers: *Answer should include:* Moderate power and cost, used for moderate distances, such as campus networks.

# Distributed Feedback (DFB) Lasers: *Answer should include:* High power, used for long distances, such as metropolitan area networks (MANs).

# Vertical Cavity Surface-Emitting Lasers (VCSELs): *Answer should include*: High speed, used for high data rates, such as data centers.

# Continue recording responses as the group discusses types of detectors used for receivers and their uses.

# Photodiodes

# Silicon: For short wavelength (650-850 nm)

# InGaAs (indium gallium arsenide): For long wavelengths (1300-1600 nm)

# Avalanche Photodiodes (APDs), used in high-speed systems for better sensitivity.

# Ask the participants if there are any questions regarding the information on transceivers and address issues as needed.

# Activity 3: Wavelength Division Multiplexing (WDM):

# Begin by showing a prism and explain how it separates white light into different colors and relate this to WDM where different wavelengths of light carry separate signals.

# Ask participants to brainstorm why WDM is used in fiber optics.

# Encourage them to think about bandwidth expansion and cost-effectiveness compared to laying more fiber cables.

# Highlight the differences in wavelength spacing and applications between CWDM and DWDM.

# Wavelength spacing: Discuss the physical distance or gap between adjacent wavelengths of light used for multiplexing signals. For example, CWDM (Coarse Wavelength Division Multiplexing) typically spaces wavelengths 20 nanometers apart, while DWDM (Dense Wavelength Division Multiplexing) spaces them much closer together, around 0.8 nanometers apart.

# Applications: Discuss where these different wavelength spacing schemes are applied and their respective advantages. For instance, CWDM might be used in applications where cost-effectiveness and simpler equipment are prioritized, such as in metropolitan networks. On the other hand, DWDM's tighter wavelength spacing allows for greater spectral efficiency and is typically used in long-haul and high-capacity applications, like intercontinental data transmission

# Divide the participants into small groups and present the following Case Study Handout to the group.

# Allow participants time to read through the case study and discuss the information presented with their group.

# After groups have had a short discussion time, ask the questions provided on the Case Study Instructor Discussion Guide.

# Allow time for a group discussion and question/answer time between the groups.

# Summarize the main concepts of fiber optic data links and WDM discussed during the lesson.

# Open the floor for final questions and clarifications.

## Resources:

# Whiteboard, markers or display to record discussion points

# Prism (optional)

# Case Study Handout

# Case Study Instructor Discussion Guide

# Reflection Section

Reflect on insights gained and any lingering questions or areas you would like to explore further after completing the lesson. How did the case study activity enhance your understanding of WDM technology?

*This lesson is supplemental to the Fiber Optics lesson within FOA's Fiber U curriculum and not part of the FOA required curriculum to obtain the Certified Premises Cabling Technician certification. If interested in becoming an approved school and/or obtaining a certification, please contact FOA at* [*thefoa.org/contact-foa.html*](https://www.thefoa.org/contact-foa.html)*.*

*Note: AI, specifically ChatGPT 3.5, was used to generate scenarios for this contextualized lesson plan.*

# Case Study Handout

Case Study: WDM in Long-Haul Telecommunications

Scenario: A telecommunications company operates a long-haul fiber optic network spanning thousands of kilometers. The network connects major cities and serves as a backbone for data transmission between regional hubs, data centers, and international gateways.

Challenge: As demand for bandwidth grows exponentially due to increased internet traffic, video streaming, and cloud services, the existing fiber infrastructure faces capacity limitations. Simply laying more fiber optic cables would be costly and disruptive.

Solution: The company adopts Dense Wavelength Division Multiplexing (DWDM) technology to maximize the capacity of their existing fiber network without significant infrastructure expansion. DWDM allows multiple data streams to be transmitted simultaneously over a single fiber optic cable by using different wavelengths of light.

Implementation:

1. Equipment Deployment: DWDM equipment, including multiplexers, demultiplexers, and optical amplifiers, is installed at key points along the network.
2. Wavelength Allocation: Multiple channels, each operating at a specific wavelength (e.g., 1550.12 nm, 1550.32 nm, etc.), are multiplexed onto the same fiber. Each wavelength can carry separate data streams, effectively increasing the network's data capacity.
3. Optical Amplification: Fiber optic amplifiers are strategically placed to boost the signal strength periodically, ensuring that data can travel long distances without significant loss.

Benefits:

* Increased Capacity: DWDM allows the telecommunications company to significantly increase the data transmission capacity of their existing fiber network, supporting higher bandwidth demands.
* Cost Efficiency: Compared to laying new fiber cables, deploying DWDM technology is more cost-effective and minimally disruptive to existing infrastructure.
* Scalability: The modular nature of DWDM systems enables easy scalability. Additional wavelengths can be added as demand grows, future-proofing the network against increasing bandwidth requirements.

Outcome: By implementing DWDM technology, the telecommunications company successfully meets growing customer demands for high-speed data services over their long-haul network. The efficient use of existing infrastructure reduces operational costs and enhances network reliability, positioning them competitively in the telecommunications market.

# Case Study Instructor Discussion Guide

**Question 1:** What are some technical challenges the telecommunications company might face when implementing DWDM technology?

*Answers may include any of the following topics. Feel free to present any information not discussed by the group.*

**Sample Answer:**

1. Dispersion Management: Managing chromatic dispersion and polarization mode dispersion (PMD) becomes crucial, especially in long-haul networks where signal integrit?y over varying fiber types and lengths is a concern.
2. Channel Interference: Avoiding crosstalk and ensuring proper isolation between DWDM channels to maintain signal integrity and minimize noise interference.
3. Equipment Compatibility: Ensuring compatibility between existing network equipment and new DWDM transceivers, amplifiers, and multiplexers to achieve seamless integration without compromising performance.
4. Optical Power Management: Balancing optical power levels across multiple channels to optimize signal transmission and reception without causing signal degradation or loss.

**Question 2:** What could be the potential business impacts of implementing DWDM technology for the telecommunications company?

**Sample Answer:**

1. Increased Bandwidth Capacity: DWDM allows the company to significantly increase its network capacity by transmitting multiple data streams simultaneously over a single optical fiber, meeting growing customer demands for high-speed data services.
2. Operational Efficiency: Consolidating multiple data streams onto fewer fibers reduces the need for additional fiber installations, thereby lowering operational costs associated with fiber deployment and maintenance.
3. Competitive Advantage: Enhancing network performance and reliability positions the company as a provider of robust telecommunications services, attracting more business customers and increasing market share.
4. Future-Proofing: Investing in DWDM technology lays a foundation for scalability and future upgrades, enabling the company to adapt to evolving technological advancements and customer needs without significant infrastructure overhauls.