## Hands-On

# Fiber Optic Designer (ETA-FOD)



## **Course Description**

Fiber optic systems are a key part of new communications services. Teir success depends upon good design. This Hands-On course will cover the particulars of how fiber optic networks are designed within the context of complete communications systems or construction projects. It will and provide an in depth knowledge of processes in delivering new services and selecting the most appropriate plant for successful fiber optic system.

The focus is geared on the design. This includes network protocols, network configurations, optical cabling, industry communications standards, and determination of fiber count, hardware selection, splicing /termination methods, cable system testing/troubleshooting and proper documentation.

This Fiber Optics Designer course provides detailed instruction and Hands-On labs of fiber optic design throughout the course.

#### Certification(s)

ETA (FOD) Fiber Optic Designer Certification can be administered during this course, upon request.

#### **Students Will Learn**

- Produce a design specification for a Fiber Optic Network Service
- Select the correct kind of Fiber links to match application requirements
- Specify the Physical Plant Layout
- Identify the Network Protocols and Network Configurations to be used
- Implement services using Industry Communications Standards
- Determine Fiber, Splicing, Termination, Testing and Troubleshooting procedures
- · Calculate Link Loss, throughput and availability of the finished service
- Deliver Documentation matching Industry Standards
- OTDR reading results and interpretation documentation
- And More...

## **Target Audience**

Anyone in the design, support and planning of Fiber Optic systems.

# **Prerequisites**

A basic understanding of telecommunications and hands-on experience with Fiber Optic systems is assumed.

This information can be obtained in our courses below or equivalent knowledge

- -Basic Telephony & Telecom Electronics
- -Essential Fiber Optics & Testing

## **Course Outline**

#### MODULE 1. THEORY AND PRINCIPLES OF FIBER OPTICS

Outline the basic structure of optical fiber

Describe the terms:

Core

Cladding

Coating

Describe the principles of operation as the light travels down the fiber

Define the term index of refraction

Describe the angles of incidence and refraction

Describe the principle of total internal reflection

Describe numerical aperture

Describe the system parameters that affect the transmission systems operation

Discuss the properties of electromagnetic signals

Distinguish between the transmitter power and receiver sensitivity ranges

Examine the two key characteristics attenuation and dispersion

Define attenuation

Describe intrinsic attenuation factors controlled by manufacturer

Describe extrinsic factors controlled by fiber optics cable installer

Relate the term microbend loss to extrinsic attenuation

Relate the term macrobend loss to extrinsic attenuation

Discuss the term dispersion and the affect it has on the pulse as it travels down the fiber

Define and describe the three main types of dispersion to include:

Modal dispersion

Chromatic dispersion

Material dispersion

Waveguide dispersion

Polarization mode dispersion

Define the term bandwidth

## MODULE 2. OPTICAL SOURCES

Recall the typical operational wavelengths for communication systems

Compare the output pattern (sometimes referred to as spot size) of the LED and laser light sources

Distinguish the main difference between an LED and a laser regarding emission

Describe the attributes of the laser and how they differ from the LED

Name and describe the different types of LED sources

Name and describe the different types of Laser sources

Define the term chirp that occurs in directly-modulated lasers

Describe the different modulation techniques used with optical sources to include:

Direct modulation

Integrated modulation

External modulation

#### MODULE 3. FIBER TYPES

Outline the types and basic construction of optical fiber

Associate the differences between multimode and single-mode core and cladding diameters

List the common classifications for optical fibers

Describe the four different types of optical fiber material makeup to include:

Multimode step index

Multimode graded index

Single-mode step index

Single-mode segmented core

Describe the differences between over filled launch (OFL) and restricted mode launch (RML) bandwidth measurement specifications

Define differential mode delay effects on conventional 50 ?m and 62.5 ?m optical fibers

Associate the need for a mode conditioning patch cord on gigabit or higher equipment

Summarize the fiber types that correspond to the referenced fiber designations OM1, OM2,

OM3, and OM4 in accordance with ISO/IEC (the International Organization for

Standardization/International Electrotechnical Commission) requirements

Point out that the mode field diameter is a measure of the spot size or beam width of light

propagation in a single-mode fiber

Summarize the fiber types that correspond to the referenced fiber designations OS1, and OS2

in accordance with ISO/IEC (the International Organization for Standardization/International Electrotechnical Commission) requirements

## MODULE 4. CABLE SELECTION IN NETWORK DESIGN

Discuss both Insulated Cable Engineers Association (ICEA) and ANSI/TIA-568-C specifications for the optical fiber cables recognized in premises cabling standards to include:

Inside plant cable

Indoor-outdoor cable

Outside plant cable

Drop cable

Describe the different types of buffers used in fiber optic cables

Tight buffer

Loose tube

Single tube

Describe the temperature effects on loose tube fiber optic cables

Explain why ribbon cables are typically used in high-density, high fiber count applications

Describe the design benefits of single tube fiber optic cables

Recognize the recommended indoor, indoor/outdoor, and outdoor cable types for an application

Determine and select the proper optical fiber cable given an installation scenario

#### MODULE 5. NATIONAL ELECTRICAL CODE

Distinguish the various environments inside a building in which a fiber optic cable is installed

Infer that the National Electrical Code (NEC) is purely advisory and is made available for a wide

variety of both public and private uses in the interest of life and property protection

Identify the point of entrance, NEC Article 800.2, as the point within the building at which the wire or cable emerges from an external wall

Explain that the intermediate metal conduit (IMC) must be connected by a bonding conductor or grounding electrode in accordance with NEC Article 800.100(B)

List the NEC optical fiber cable types including:

Abandoned optical fiber cable

Nonconductive optical fiber cable

Composite optical fiber cable

Conductive optical fiber cable

Describe the NEC listing requirements for:

Optical fiber cables

Optical fiber raceways

Define the maximum distance that an unlisted outside plant communications cable shall be

permitted to be installed in a building (NEC Article 800.48)

Discuss the grounding considerations for fiber optic cable installation inside a building to include

NEC Article 770.100, NEC Article 250, and ANSI/TIA-607 Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

Discuss the NEC Article 645 requirements for cabling information technology equipment

Describe the possible cabling scenarios and considerations to take into account when

developing a cost comparison model

#### MODULE 6. FIBER OPTIC TERMINATION

Define fiber optic termination

Summarize the anatomy of a fiber optic connector

Compare advantages and disadvantages of termination versus splicing

Explain where connectors are used

Discuss the performance of a multimode fiber optic link using the following sections of the

ANSI/TIA-568-C Optical Cabling Components Standard

Section 4.2 cable transmission performance

Section 5.3 optical fiber splice

Annex A (Normative) optical fiber connector performance specifications

Discuss the performance of a single-mode fiber optic link using the following sections of the ANSI/TIA-568-C Optical Cabling Components Standard, ANSI/TIA-758 CustomerOwned Outside Plant Telecommunications Cabling Standard, and

Telcordia GR-326 Core Generic Requirements for Single-mode Optical Connectors and Jumper Assemblies

ANSI/TIA-568-C Section 4.2 cable transmission performance

ANSI/TIA-758 Section 6.3.4.1.2 attenuation

ANSI/TIA-568-C Annex A (Normative) optical fiber connector performance

specifications

Define physical contact (PC) and angled physical contact (APC) finish

Explain how PC and APC finishes affect both insertion loss and back reflectance

Recall how to properly perform a connector endface cleaning and visual inspection in

accordance with ANSI/TIA-455-57B Preparation and Examination of Optical Fiber Endface for

**Testing Purposes** 

Associate how physical contact depends on connector end-face geometry to include the

Telcordia GR-326 three key parameters for optimal fiber contact:

Radius of curvature

Apex offset

Fiber undercut and protrusion

Name and describe the different single fiber termination connector styles

Name and describe the different multi-fiber termination connector styles

Describe the field installable connector technologies
Describe the heat cured epoxy technology
Describe quick cure terminations
Describe no epoxy, no polish terminations
Define pigtail splicing
Describe preconnectorized assemblies and cables

#### MODULE 7. FIBER OPTIC SPLICING

Define a fiber optic splice

Distinguish between a mechanical and fusion splice

Explain where splices are used

List ANSI/TIA-568-C inside plant splice performance requirements

Cite ANSI/TIA-758 outside plant splice performance requirements

Explain the intrinsic factors that affect splice performance

Relate the extrinsic factors that affect splice performance

Describe splicing types and methods

Outline mechanical splice technology

Discuss fusion splice technologies to include:

Local injection and detection (LID)

Lens profile alignment system (LPAS)

Profile alignment system (PAS)

Core detection system (CDS)

Fixed V-Groove

Examine the critical steps involved in splicing

Planning

Work area

Preparing the fiber

**Splicing** 

Protection

## MODULE 8. HARDWARE

Discuss the reasons why and where hardware is used

Compare the differences of hardware designs without cable management and with cable management products

Define the typical usage areas of rack (frame) mounted patch panel hardware

Explain how to provide for and install horizontal cable management products

Explain how to provide for and install vertical cable management products

Discuss the different styles of hardware adapter (connector) panels

Define the different types and typical usage areas of wall mountable housing hardware

Describe work area outlet hardware types

Define distributed zone architecture

Describe a fiber zone box (FZB)

Define other hardware options such as splice closures and splice trays

#### MODULE 9. CROSS-CONNECT

Explain that a cross connection is the termination point of a system

Describe the numerous factors, which will affect how to terminate a cross connection design

including:

Location

Growth

Capacity

Cable type

Fiber count

Identify the strategy or process used to determine a cross connect fiber termination capacity including:

Type of optical connector

Number of terminations per connector panel

Number of connector panels

Patch panel density and size

Identify the strategy or process used to determine a cross connect splice capacity including:

Number of trays a housing can accommodate

Number and types of splices a tray can accommodate

Number and types of cable a tray may accommodate

Explain the strategy and factors involved in the process of determining space allocation including:

Growth strategy

Connectivity scheme (interconnect or cross-connect)

Cable routing and jumper management capabilities

Hardware dimensions

Hardware access requirements

Explain the strategy and factors involved in the process of determining layout including:

Network size

Segregation requirements

Define the basic rules of fiber jumper management

#### MODULE 10. ANSI/TIA-568 BUILDING CODES

Identify the major telecommunication standards and governing bodies

Interpret ANSI/TIA-568-C.0 Generic Telecommunications Cabling for Customer Premises to include:

Telecommunications cabling system structure

Cabling installation requirements

Cabling transmission performance and test requirements

Understand ANSI/TIA-568-C.1 Commercial Building Telecommunications Cabling Standard to include:

Entrance facilities

Equipment rooms

Telecommunications rooms and telecommunications enclosures

Backbone cabling (cabling subsystem 2 and cabling subsystem 3)

Horizontal cabling (cabling subsystem 1)

Work area

Cabling installation requirements

Interpret ANSI/TIA-568-C.3 Optical Fiber Cabling Components Standard including: 10.4.1 Optical fiber cable transmission performance and physical requirements 10.4.2 Connecting hardware

Optical fiber patch cords and optical fiber transitions

Define structured optical fiber cabling distances

Describe structured cabling architecture

Define open office design practices using multi-user telecommunications outlet assemblies (MUTOAs)

## MODULE 11. LOGICAL NETWORKS

Define a logical topology

Describe logical bus network topology 11.1.2 Describe logical ring network topology 11.1.3 Describe logical star network topology 11.1.4 Describe logical mesh network topology

#### MODULE 12. INTERNETWORKING

Compare and contrast characteristics of internetworking physical media to include:

Physical media

Logical architectures

Communication technologies

In the network describe the role of a:

Repeater 12.2.2 Hub 12.2.3 Bridge 12.2.4 Switch 12.2.5 Router

Identify differences between switched and routed network design considerations

#### **MODULE 13. ETHERNET**

Describe the genesis of Ethernet (IEEE 802.3)

Explain Carrier Sense Multiple Access/Collision Detection (CSMA/CD) technology

Describe the various Physical Layer Medium Dependent (PMD) speeds at which a

standards-based implementation of Ethernet operates

Describe the features, functions and components of the 1000 Mbps Gigabit Ethernet

Describe the features, functions and components of the 10 Gigabit Ethernet

Define differential mode delay and the purpose of a Mode Conditioning Patch Cord

Differentiate between the operating ranges for Ethernet IEEE 802.3 series to include:

Physical Medium Dependent (PMD) options 13.7.2 Nominal speed

Light source and wavelength

Overfilled Launch Bandwidth (OFL)

Effective Modal Bandwidth (EMB) 13.7.6 Maximum supportable distances

FOD Competencies 5

## MODULE 14. FIBRE CHANNEL

Explain Fibre Channel technology as a computer communications protocol in accordance with the ANSI/International Committee for Information Technology Standards (INCITS)

Define the different applications and technologies that Fibre Channel supports

Describe the different physical cabling topologies of a Fibre Channel network to include:

Point-to-Point (FC-P2P)

Arbitrated Loop (FC-AL)

Switched Fabric (FC-SW)

Describe the various Physical Interfaces (PI) speeds at which a standards-based implementation of Fibre Channel operates

Differentiate between the operating ranges for ANSI/INCITS Fibre Channel series to include:

Fibre Channel Physical Interface (FC-PI) options

Nominal speed

Light source and wavelength

Overfilled Launch Bandwidth (OFL)

Effective Modal Bandwidth (EMB)

Maximum supportable distances

## MODULE 15. DATA CENTER CABLE DESIGNS

Define a data center

Recognize the different types of data centers to include:

Co-location Hosting Services

Managed Hosting Services

Enterprise

Describe the various functional areas of data centers to include the following:

Main Distribution Area (MDA)

Server Area

Storage Area Network (SAN) Area

Compare and contrast the functionality and major differences between the data center cabling requirements and considerations

Recognize ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers provides information on the factors to consider when planning and preparing the installation of a data center or computer room

Identify ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers telecommunication spaces to include:

Entrance Room

Main Distribution Area (MDA)

Horizontal Distribution Area (HDA)

Zone Distribution Area (ZDA)

Equipment Distribution Area (EDA)

Identify ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers telecommunication cabling to include:

Horizontal cabling

Backbone cabling

Centralized cabling

Explain the difference between Structured versus Un-structured cabling solutions

Outline the zone distribution data center layout utilizing a Zone Distribution Area (ZDA) with star

topology to include the following:

In-cabinet Zone Distribution

Sub-floor Zone Distribution

Overhead Zone Distribution

Discuss the importance of maintaining proper system polarity in the data center design so that the optical fibers connected to a transmitter on one end of an optical fiber link connects to a receiver on the other end

## MODULE 16. DATA CENTER CABLING SOLUTIONS

Define plug and play

Explain and breakdown the major benefits of designing a plug and play system in the data center

Compare the alternatives to a standard plug and play design to include:

Star topology with Main Distribution Area (MDA)

High density truck cables from the Main Distribution Area (MDA) to the Zone

Distribution Area (ZDA)

Describe the ANSI/TIA-942 recommended compliant design (star topology) for the Storage

Area Network (SAN)

## MODULE 17. VOICE NETWORKS

Describe the evolution and components of voice networks

Delineate the transmission process involved in voice communication, both analog and digital

Describe the different multiplexing techniques used in a voice network

Define the basic design rules of voice technologies that apply to a voice network design

Explain Voice over Internet Protocol (VoIP) design considerations

#### MODULE 18. SECURITY VIDEO

Differentiate between a distributed backbone and centralized cabling security video networking design

Describe the distributed backbone security video network design to include:

Reduces fiber count

Increases electronics

Works well with large networks

Placement of video multiplexers will affect fiber allocation

Describe the centralized cabling security video network design to include:

Increases fiber count

Decreases electronics

Works well with small networks

#### MODULE 19. FIBER TYPES AND COUNTS

Describe how to design the cabling infrastructure in accordance with ANSI/TIA-568-C to include:

Location of the main cross-connect (MC), intermediate cross-connects (IC) and horizontal cross-connects (HC)

Determine cable routes

Determine the fiber distances

Describe how to choose the cable routes and physical topology when designing the cabling

infrastructure to include the following: 19.2.1 Ring

Star

Special configurations

Describe how to determine fiber types and fiber counts when designing the cabling infrastructure

Outline the considerations for Gigabit Ethernet (GigE) and 10 Gigabit Ethernet (10 GigE) to include the following:

Length restrictions for Gigabit Ethernet and 10 Gigabit Ethernet

Redundancy requirements

Trunking requirements

## MODULE 20. TESTING AND MEASUREMENTS

Describe the reasons for testing

Identify the optical testing procedures to include:

Connector and splice loss testing

Attenuation testing

Optical Time Domain Reflectometer (OTDR) testing

Outline the ANSI/TIA-568-C and Telcordia testing standards component requirements to include:

Connector pair loss

Splice loss

Connector reflectance

Optical fiber attenuation

Describe the purpose and procedures of end-to-end attenuation testing

Explain the purpose of mandrel wrapping during reference and system test

Determine proper ANSI/TIA-568-C (1, 2, or 3 jumper) reference based on the optical fiber link architecture

Describe the purpose of Optical Time Domain Reflectometer (OTDR) testing

Describe the purpose of chromatic dispersion testing

Describe polarization mode dispersion testing

Breakdown a Link Loss Budget Calculation to include:

Determine fiber loss at operating wavelength 20.10.2 Determine connection loss

Determine splice loss

Determine total system budget loss

# **Delivery Method**

Instructor-Led with numerous case-studies and exercises.

## **Equipment Requirements**

(This apply's to our hands-on courses only)

BTS always provides equipment to have a very successful Hands-On course. BTS also encourages all attendees to bring their own equipment to the course. This will provide attendees the opportunity to incorporate their own gear into the labs and gain valuable training using their specific equipment.

# **Course Length**

5 Days