# 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