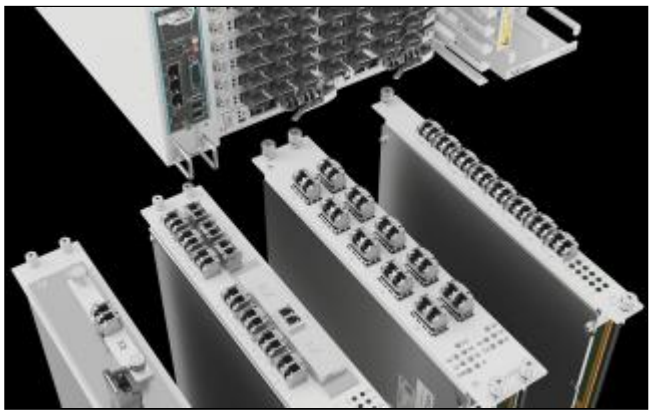
Hands-On

High Capacity Optical Networks: ROADM, DWDM, CWDM, COHERENT OPTICAL SYSTEMS & RAMAN AMPLIFICATION

Fundamentals, Technology, Tests and Current Issues

Course Description



WDM technology (Wavelength Division Multiplexing) has revolutionized the telecommunications market in the whole world by offering a phenomenal cost-effective increase in the fiber transmission capacity. DWDM (Dense WDM) became commercial in 1995 while CWDM (Coarse WDM) emerged after 2000, stimulated by the telecom crisis. CWDM brings simpler technological concepts as compared to DWDM, cutting down prices, but fits just the lower transmission capacity markets, such as the metro and enterprise networks.

More recently, new paradigmatic revolutions have made their way into the optical communication market ROADM (Reconfigurable Optical Add-Drop Multiplexing), Raman Amplification and Coherent Optical Systems. While these optical technologies are the perfect solutions to satisfy the growing demand for bandwidth they also provide radical cost reduction in the information transmission market.

Students Will Learn

- **Evolution of optical communications**
- **Usual multiplexing techniques in optical communications**
- **SDH & SONET (Synchronous Digital Hierarchy) Brief description**
- **Other transmission protocols and respective data rates**
- **Impairments in Optical Communications**
- **Optical attenuation**
- **Chromatic dispersion**
- **Polarization Mode Dispersion - PMD**
- **Optical non-linearities**
- **Optical signal to noise rati0**
- **(OSNR) and EDFA noise**
- **Optical amplification**

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- **Chromatic dispersion compensation in high capacity optical transmission systems**
- **Challenges for implementing modern optical transmission technologies**
- **WDM Technology**
- **DWDM and CWDM driving factors**
- **Alternatives for increasing transmission capacity**
- **Evolution of the WDM technology**
- **Wide-Band WDM (WWDM), Coarse WDM (CWDM) and Dense WDM (DWDM)**
- **DWDM - Technical, economical and logistic advantages**
- **Technologies that made DWDM technology possible**
- **CWDM - Characteristics, standardization and applications**
- **CWDM - Technical, economical and logistic advantages**
- **Comparisons between DWDM and CWDM**
- **Network investments - important evaluations in the decision making process**
- **New optical fibers for DWDM and CWDM - Which to choose?**
- **Dispersion characteristics, effective area, second order dispersion**
- **Advantages and disadvantages in DWDM and CWDM**
- **TDM versus CWDM & DWDM, TDM-x versus TDM-4x in DWDM**
- **Which and/or when each alternative is better**
- **Open architecture versus closed architecture in DWDM**
- **Wavelength Converting Transponders**
- **Protection, restoration and reliability in the optical layer**
- **Interoperability between suppliers**
- **Network design methodology**
- **ROADM, Coherent Optical Communications & Raman Amplification**
- **ROADM - Reconfigurable Optical Add-Drop Multiplexing**
- **Coherent Optical Communications**
- **Raman Optical Amplification**
- **Tests and Measurements in WDM Networks**
- **Spectral measurements in WDM**
- **Essential characteristics of the OSA**
- **Technologies of spectral analysis**
- **Required tests and measurement parameters**
- **Use of OSA in the installation, monitoring and fault repairing of WDM networks**
- **WDM test equipment suppliers**
- **Specialized diagnostics of optical networks**
- **PMD audits in the American and Brazilian fiber plants**
- **WDM Optical Networking**
- **WDM Market**

Target Audience

Anyone working on or wanting an understanding of ROADM, DWDM, CWDM, COHERENT OPTICAL SYSTEMS & RAMAN AMPLIFICATION systems.

Prerequisites

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A basic understanding of telecommunications is highly suggested.

Course Outline

Brief review of optical communications:

- Introduction
- Evolution of optical communications
- Some essential components
    - Optical fibers (types, attenuation and dispersion characteristics)
    - Optical splitters, combiners and couplers
    - Optical filters, multiplexers, demultiplexers
    - Transmitters and receivers
- Usual multiplexing techniques in optical communications
    - TDM - Time-Division Multiplexing
    - WDM - Wavelength Division Multiplexing
- SDH & SONET (Synchronous Digital Hierarchy) Brief description
- Other transmission protocols and respective data rates

Impairments in Optical Communications:

- Optical attenuation
- Chromatic dispersion
- Polarization Mode Dispersion - PMD
- Optical non-linearities
- Optical signal to noise rati
- (OSNR) and EDFA noise
- Optical amplification:
    - Fundamental characteristics
    - Basic configurations
    - Semiconductors amplifiers
    - Praseodymium doped fiber amplifiers (1.3mm)
    - Erbium doped fiber amplifiers (1.5mm)
    - Applications
    - Raman amplification
- Chromatic dispersion compensation in high capacity optical transmission systems
- Challenges for implementing modern optical transmission technologies

WDM Technology:

- DWDM and CWDM driving factors
- Alternatives for increasing transmission capacity
- Evolution of the WDM technology
- Wide-Band WDM (WWDM), Coarse WDM (CWDM) and Dense WDM (DWDM)
- DWDM - Technical, economical and logistic advantages
    - Bandwidth, scalability, transparency to bit-rate and modulation format, cost, investment risks, installation, future proof
- Technologies that made DWDM technology possible
    - EDFA optical amplifiers
    - DFB Lasers with narrow and stable line widths
    - Fiber Bragg gratings

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    - AWG - Arrayed Waveguide Grating
    - Main DWDM network components
    - Fixed and tunable transmitters
    - Optical receivers
    - Flat gain EDFA amplifiers
    - Wavelength multiplexers and demultiplexers
    - Fixed and configurable optical Add-Drop multiplexers
    - Optical Cross-Connects
    - Bidirectional DWDM
    - Considerations about channel separation and channel selection
    - Channel selection and cross-talk
    - Channel spacing and channel count
    - Differences between DWDM and CWDM channel spacing
    - ITU standardization and frequency grid
    - Chromatic dispersion management and dispersion compensation in WDM systems
    - WDM impairments due to optical non-linearities
    - Raman Scattering and Brillouin Scattering
    - Self phase modulation and cross phase modulation
    - Four-wave mixing
- CWDM - Characteristics, standardization and applications
- CWDM - Technical, economical and logistic advantages
- Comparisons between DWDM and CWDM
- Network investments - important evaluations in the decision making process
- New optical fibers for DWDM and CWDM - Which to choose?
- Dispersion characteristics, effective area, second order dispersion
- Advantages and disadvantages in DWDM and CWDM
- TDM versus CWDM & DWDM, TDM-x versus TDM-4x in DWDM
- Which and/or when each alternative is better
- Open architecture versus closed architecture in DWDM
- Wavelength Converting Transponders
- Protection, restoration and reliability in the optical layer
- Interoperability between suppliers
- Network design methodology
- Case studies

ROADM, Coherent Optical Communications & Raman Amplification:

- ROADM - Reconfigurable Optical Add-Drop Multiplexing
    - Introduction to ROADM
    - The evolution towards photonic networks and all optical networking
    - Optical layer, optical routing and elements of all-optical networking
- Coherent Optical Communications
    - Introduction to coherent optical communications
    - Use of Digital Signal Processing for alleviating chromatic dispersion, polarization mode dispersion and OSNR impairments
    - New optical modulation schemes for 40 - 400Gb/s transmission
    - DP-QPSK
    - Coherent optical transmission above 100Gb/s
    - Super-channels
- Raman Optical Amplification
    - Characteristics, advantages and disadvantages
    - Comparison with EDFA (traditional optical amplifiers)
    - Hybrid EDFA-Raman Optical Amplification
    - ROPA - Remote Optically Pumped Amplification Systems
    - Design aspects of Raman optically amplified networks
    - Special care in operation and maintenance of optical networks employing Raman amplification

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Tests and Measurements in WDM Networks:

- Spectral measurements in WDM
- Essential characteristics of the OSA
- Technologies of spectral analysis
    - The Optical Spectrum Analyzer (OSA)
    - Wavelength Meter
    - Tunable filter based equipments
- Required tests and measurement parameters
    - Components
    - System performance
    - Field installation and maintenance
- Use of OSA in the installation, monitoring and fault repairing of WDM networks
- WDM test equipment suppliers
- Specialized diagnostics of optical networks
- PMD audits in the American and Brazilian fiber plants

Current Issues in WDM Optical Networking:

- Networks centered in voice services versus networks centered in data services
- IP over WDM and The optical internet
- GMPLS and ASON
- DWDM and CWDM in Metropolitan Area Networks (MAN's)
- The LAN invades the WAN and WAN invades the LAN
- L-band EDFA optical amplifier (1570-1620nm)
- Ultra-wide band EDFA optical amplifier (1530-1620nm)
- DWDM in dispersion shifted (DS) fibers
- Optical TDM & 40Gb/s, 100Gb/s, 200Gb/s and 400Gb/s TDM
- Link PMD
- PMD compensation
- Forward Error Correction - FEC
- Alien Wave

Comments on WDM Market:

- DWDM & CWDM market driving factors
- Market euphoria, crisis and recovering
- Historic evolution of the worldwide WDM market
- Current market scenarios

Delivery Method

Instructor-Led with numerous exercises and case-studies.

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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

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