Lightguide Systems
Fiber Optics Training Topics

Communications theory and terminology
- wavelength
- data rate
- information capacity
- carrier frequency
- digital and analog communications
- degradation of signals
- multiplexing
  - combining signals for transmission
  - time division multiplexing

Optical theory
- wavelength
- optical properties
- reflection and refraction
- spectrum / spectral width
  - spectrum of typical sources
  - spectral width filtering
- index of refraction
- reflection at an interface
- Interference
- Coherence
- Polarization

Optical fibers - Part 1
- Attenuation in optical fibers
  - Mechanisms
  - Typical values of attenuation
- modes in optical fibers
- single and multimode fibers
  - why use single mode?
  - why use multimode?
  - Single and multimode attenuation
- dispersion and bandwidth of optical fibers
  - modal dispersion
  - Material/chromatic dispersion
- Standard single mode fiber
- Dispersion shifted fiber
  - Description
- optical fiber bending loss

Optical fibers - Part 2
- Mode field diameter
  - Mode field diameter mismatch
- Details of single mode dispersion

- Material dispersion
- Waveguide dispersion
- Dispersion slope
- Dispersion shifted fiber
  - Standard DSF
  - Non-zero DSF
    - commercial examples
- Polarization mode dispersion
  - What it is
  - How it is minimized

Non_linear effects in optical fibers
- Cause of non linear effects
  - High optical power density
- Non linear phenonmenon
  - Self_phase modulation
  - Cross phase modulation
  - Four wave mixing
  - Stimulated Brillouin scattering
  - Stimulated Raman scattering
- Avoiding or minimizing non_linear effects

Cable constructions
- Protecting optical fibers
- Tight buffer cables
  - Breakout, fanout cables
  - Riser, MIC cables
- Loose buffer cables
  - Multiple layer loose tube cable
  - Undersea loose tube cable
  - Ribbon cables
- Applications for various cable designs

Fiber connections
- Required alignment precision
- Cleaving optical fibers
  - Cleaving equipment
- Fiber optic splicing techniques
  - Fusion splicing
    - equipment
    - splice loss estimation
    - splicer features
  - Mechanical splicing
- Optical fiber connectors
  - Connector attachment methods
    - epoxy-polish
    - quick termination connectors
  - Connector polishing
    - back reflection (return loss)
    - PC, UPC, APC designs

- Connector inspection
  - inspection methods
  - inspection criteria
- Industry standard connectors
  - SC, ST, FC, APC, and others
  - multifiber connectors
- Connector mounting in panels and on PCBs

Light sources and detectors
- Generating light for fiber optics
- Principles
  - Spontaneous emission
  - Stimulated emission
- Light emitting diodes (LEDs)
  - Characteristics
  - Drive circuit considerations
  - Areas of application
- Laser diodes
  - Characteristics
    - Fabry-Perot lasers
    - distributed feedback lasers (DFB)
  - Drive circuit considerations
  - Areas of application
- Analog vs. Digital modulation considerations
- Light source to fiber interfacing
  - Packaging of sources and receivers
  - Pigtailed devices vs. Integral connectors
- Physical mounting of devices
- Photodetectors
  - Principles
  - PIN photodiodes
  - Avalanche photodiodes
  - Receiver circuitry

Fiber passive and active components
- Optical fiber components
  - Grin (graded index) lens devices
  - attenuators, couplers, others
- Optical fiber couplers
  - fused tapered coupler
    - performance
    - wavelength dependence
- Optical fiber attenuators
  - Fixed
  - Variable
- Wavelength division multiplexers
  - 1 x 2 devices
    - fused, tapered couplers
    - other devices
    - uses for signal wavelengths

- uses in optical amplifiers for pump and signal
- 1 x n devices
  - gratings for high numbers of channels, close spacing
    - construction
    - performance
  - integrated optics
- Optical fiber switches
  - 1 x 2, 2 x 2 (bypass), on/off, multi 1 x n
    - mechanical switches (manual or electrical)
    - electro_optic switches

Optical amplifiers
- Optical amplifiers _ why?
  - Regeneration _ the old way
  - Regeneration _ upgrades
  - WDM with regeneration
  - WDM with optical amplifiers
- Erbium doped fiber amplifier designs
  - Counter_pumped
  - Co_pumped
  - EDFA pump wavelengths
    - 980 nm
    - 1480 nm
  - Amplifier gain flatness
  - Optical amplifier applications
    - at light source
    - as a repeater
    - as a preamplifier
  - Gain saturation in optical amplifiers
  - Commercial amplifier specifications and configurations
  - Noise, distance, and jitter limits of amplified systems
  - Raman amplification
    - stimulated Raman scattering
      - can be used to amplify light
    - Raman gain coefficient
  - Commercial Raman amplifiers
  - Raman amplification in a system
    - Raman amplifier performance

Network topologies
- Physical and logical network topologies
  - Bus, star, point_to_point, and ring networks
  - self_healing rings
  - hubbed mesh networks
- Design for automatic restoration
  - UPSR, BLSR_2, BLSR_4 configurations

Fiber optics for local networks
- Network configurations
- Examples of current applications

- Fiber vs. Copper cost comparisons
- Cable routes for flexible systems
    - Patch panels, wiring closets and connection points

Wavelength division multiplexing
- WDM and DWDM
- Theoretical advantages
- WDM components
- Practical hurdles
- ITU standard optical frequency grid
- Dispersion and crosstalk in WDM systems

The All Optical Network
- Switching optical signals vs. switching electrically
- Optical fiber switching technology
    - Electro_optic switching
    - MEMS _ micro_mirror systems
    - Total internal reflection _ bubble switches
    - Other switching technology
        - Thermo-optic, LCD, acousto-optic
- Other technologies for all optical networks
    - Wavelength routing
        - Wavelength conversion
        - Tuneable light sources
    - Optical filter technology
        - Fiber Bragg gratings, Fabry_Perot
        - Tuneable filters
    - Optical storage (buffers)
- Optical control of switching
    - Optical packet switching
    - Optical burst switching
- Multiple access methods
    - Passive optical networks (PONs)
    - Selecting one of many signals transmitted
    - WDMA _ wavelength division multiple access
        - Advantages, considerations
    - TDMA _ time division multiple access
        - Advantages, considerations
        - Formats i.e. ATM PON
    - SCMA _sub_carrier multiple access
        - Advantages, considerations
    - Optical CDMA _ code division multiple access
        - Advantages, considerations

Fiber System Design - Part 1
- Single wavelength systems
    - Loss budget calculations
    - Fiber optic sources and modulation
    - Dispersion calculations

- Dispersion and attenuation limits in single channel systems
- Overall performance limits of single wavelength systems
- physical system design
  - patch panels
  - splice location
  - designing for future flexibility

Fiber System Design - Part 2

- Optically amplified single wavelength systems
  - Distance and dispersion limits
    - Dispersion compensation
  - UDF, DSF, and NZDSF fibers
  - Light source chirp and its effects
  - Amplified system noise limits
- Wavelength multiplexed systems
  - Non-linear effects and limits
  - Dispersion compensation for multiple wavelengths

Long distance telecommunications systems

- Fiber optics advantages for long haul
- Long haul formats and standards
  - plesiochronous digital hierarchy (PDH)
  - synchronous optical network (SONET)
  - synchronous digital hierarchy (SDH)
- Optical characteristics of SONET and SDH
- How SONET and SDH fit with DWDM

Business aspects of fiber and all-optical networks

- Demand vs. supply of bandwidth
- Cost drivers for fiber systems
  - Long distance
  - Metro
  - Local, fiber to the home (FTTH)
  - LAN
- The All-Optical Network
  - How achievable?
  - How desireable?
- Planning for the future
  - Bandwidth demand
  - Cost recovery time frames vs. risk
  - Future competition
- Business opportunities
- Alliances and partnering

Fiber optic testing

- What parameters should be tested
  - Fiber optic loss measurements

- Transmission loss measurements
- Led versus laser sources
- Fiber optic power meters
- Calculating expected loss values
- Accuracy of loss measurements
- Accuracy of loss measurements

Optical time domain reflectometers
- OTDR principles
- Measuring loss with an OTDR
  - Measuring fiber loss
  - Measuring connector and splice loss
- OTDR limitations and anomalies

Using a visible fault locator
Testing installed devices
Generating test procedures and limits
Critical factors for testing accuracy