430/530 Fiber Communications and Systems

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Class Meeting: 12:00-12:50 AM; MWF; HARV 332B
Office Hours: 4:00-5:00 PM; MWF; Room 556E

INTRODUCTION:
Fiber optics is a rapidly growing technology for ground based communications systems. This course is intended to provide students with a background in the topics required to understand key elements of fiber optic communications systems. A proper background includes exposure to both the physical principals of optical signal generation, transmission, and detection, and the communications theory aspects of this problem. The course will be divided into two modules. The first will cover physical parameters related to fiber optic devices and the second with communication aspects of optical fiber systems. Each of these sections will be followed by an exam. The third segment of the course will cover fiber optic systems. During the third segment students are expected to work on a system design project in which they incorporate earlier concepts presented in lecture.

Prerequisites: ECE 381 and 352 or equivalent. ECE 459/559 or equivalent is strongly recommended for ECE students.

Administration:

Text:
2. Class notes will be available on the class website: www.ece.arizona.edu/~ECE430

Recommended:

Grades: Under Grads Grads
HWK: 20% 10%
Midterms (2) 35% 35%
Class Project 0% 10%
Final Exam 45% 45%
**Lecture Topics:**

1. Introduction to fiber properties
   - TIR, NA, V#
   - Modes
   - Fiber fabrication
   - Attenuation in silica optical fibers

2. Field propagation in planar waveguides
   - Asymmetric and symmetric waveguides
   - Even and odd modes
   - Propagation constants
   - Phase velocity and group velocity in planar waveguides

3. Field propagation in cylindrical waveguides
   - Field solutions with cylindrical boundary conditions
   - TE, TM, HE, EH modes and cut off conditions
   - Linearly polarized modes
   - Multi mode fibers – SI and GI
   - Single mode fibers – SI, mode power distribution

4. Dispersion in fibers
   - modal dispersion
   - waveguide dispersion
   - material/chromatic dispersion
   - polarization mode dispersion
   - introduction to nonlinearities in optical fiber – FWM, SPM, XPM, SBS, and SRS

5. Optical sources used in fiber optic systems
   - Basic principles of semiconductor diode lasers
   - Modulation characteristics of LDs
   - Noise characteristics
   - Spectral characteristics
   - Frequency chirp
   - Injection current and external modulation
   - Basic laser structures and output characteristics

(Mid Term Exam)

6. Optical detectors for fiber optic systems
   - Sensitivity and responsivity
   - PN, PIN, APD, MSM photodiodes
   - Frequency response
• Detector circuit models, 3dB BW, RT, TIA
• Noise in the detection process, thermal, shot
• Bit error rate (BER), minimum received optical power
• Quantum detection limit, minimum photons/bit

7. Error Correction Codes
   i. Channel BER and User BER
   ii. Block encoder
   iii. Channel and user SNR
   iv. Probability of getting exactly m-errors in a bit stream

8. Optical Amplifier Characteristics
   i. Amplifier types
   ii. EDFA configurations and properties
   iii. Spectral properties, gain saturation, amplification factor
   iv. Large signal amplification, output saturation power
   v. Noise in an amplifier, SNR, noise figure
   vi. EDFA used as a pre-AMP to a RX, noise components
   vii. Basic principles of Raman amplifiers and configurations

(Mid Term Exam)

9. System Design I
   i. Power and rise time budgets
   ii. Modulation schemes, RZ, NRZ, SCM
   iii. Spectral efficiency, capacity limits
   iv. Coherent systems
   v. Synchronous and asynchronous ASK, PSK, FSK formats

10. System Design II
    i. Minimum detectable power with loss of contrast
    ii. Low photon count – Poisson statistics
    iii. Power penalty
    iv. Dispersion limit on propagation distance; laser chirp limitation
    v. EDFA gain saturation –limit imposed on system
    vi. Cascaded amplifier gain optimization
    vii. Intro to WDM
    viii. Inter channel crosstalk; power penalty
    ix. Chromatic dispersion limits with NRZ and RZ modulation formats
    x. Dispersion compensating fiber and fiber Bragg gratings

11. WDM Devices and Systems
    i. Basic description
    ii. Affects of optical nonlinearities on WDM systems
    iii. Fiber Bragg gratings
    iv. Add-drop filters, circulators
v. Basic DWDM network considerations

12. Fiber Optic Networks
   - LANs
   - Metropolitan area networks
   - Long haul networks

Tentative Mid Term Exam Dates: 2/18/09; 4/1/09