

FIBER OPTICS AND SWITCHING NETWORKS

SYLLABUS

TELECOMMUNICATIONS SYSTEMS ENGINEER COURSE (TSEC) US Army School of Information Technology, Fort Gordon, GA

Tuesday, Nov 1, 2011 – Friday, Nov 10, 2011

INSTRUCTOR: A. R. M. ZAGHLOUL, PhD, Eur Ing, C Eng, FIET
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INSTRUCTIONAL DESIGNER: Mr. Wayne Hodges

DATES: Ten Sessions Nov 1 – 10, 2011
Lecture Hours: 8:30 AM – 12:30 PM
Office Hours: 1:30 PM – 3:30 PM
One Review Session Nov 10, 2011 1:30 PM – 5:30 PM
Final Exam Session Nov 11, 2011 8:30 AM – 12:30 PM

LOCATION: Room 127A, Building – Cobb Hall, Fort Gordon, GA

COURSE DESCRIPTION:

The course discusses switching systems. It is composed of three major components: Networks, switching, and signaling. We discuss the operation and design of different types of networks and switching systems. Analog, digital, packet, and optical switching are all considered. In-class minor projects are used to consolidate concepts learned in lectures. We discuss switching as it developed through different phases: manual, electromechanical, electronic, and optical. The functions are the same, but are done using different technologies.

TEXTBOOKS:

1. Roger L Freeman, *Telecommunication System Engineering*, 4th Ed, Wiley – IEEE, 2004.
2. Jeff Hecht, *Understanding Fiber Optics*, 5th Ed, Prentice Hall, 2006.
3. Richard A Thompson, *Telephone Switching Systems*, Artech House, 2000.

REFERENCES:

1. Shuo-Yen R Li, *Algebraic Switching Theory and Broadband Applications*, Academic Press, 2001.

GRADING:

Homework Assignments	30%
Final Exam	70%
Total	100%

- Homework assignments are used to reinforce concepts discussed in class.
- One homework problem will be given, as appropriate, as a quiz to help students recognize their class standing.
- Homework solutions will be distributed to students.
- Final Exam is closed book/closed notes: A single 8½x11 formula sheet will be allowed: handwritten, no photocopies.
- According to TSEC policy, a passing grade is 70% of final exam in addition to a 70% course average.

COURSE TOPICS:

Tuesday

11/1/11

Module 1: Introduction

Readings: Lecture Slides

- Topics
 - Telecom model
 - Switch Board
 - Bell System Divestiture
 - PSTN Architecture: ILEC, CLEC, LATA, IXC
 - IXC Architecture
 - 1996 Telecom Act

Module 2: Telephony, Traffic, and Communication Networks

Readings: RLF Ch. 1 (1 – 16, 25 – 38)

Ch. 2 (41 – 70)

RAT Ch. 3 (69 – 70)

Ch. 5 (123 – 126)

Lecture Slides

- Topics
 - PSTN
 - Network Topology and Transmission
 - Attenuation and Delay
 - Traffic: Blocking and Number of Servers
 - Traffic Measurements
 - Blockage
 - Grade of Service
 - Availability
 - Lost Calls
 - Call Arrivals and Holding Times
 - Dimensioning a Route
 - Concentration
 - Economy of Scale
 - Efficiency
 - Alternate Routing

Wednesday 11/2/11

Module 3: Switching Fundamentals , Fabrics, and Control

Readings: RLF Ch. 3 (73 – 108)
RAT Ch. 7 (173 – 181, 186 – 187)
Lecture Slides

- Topics
 - Basic Requirements
 - Numbering and Switching
 - Concentration and Expansion Fabrics
 - One-Stage Fabrics
 - Two-Stage Fabrics
 - Three-Stage Fabrics
 - Nonblocking Fabrics
 - Switching Concepts
 - Electromechanical Switching
 - Multiples and Links
 - Degeneration, Availability, and Grading
 - Crossbar Switch
 - Controls
 - Concentrators, Outside Modules, Remote Switching, and Satellites
 - Call Charging
 - Numbering Plan

Thursday 11/3/11

Module 4: Signaling, Signaling System 7, and Intelligent Network

Readings: RLF Ch. 4 (111 – 136)
Ch. 17 (681 – 734)
Lecture Slides

- Topics
 - Types of Signaling: Supervisory, AC, Address, and Compelled Signaling
 - Link-by-Link and End-to-End Signaling
 - Effects of Numbering
 - Associated and Dissociated Channel Signaling
 - Subscriber Loop Signaling and Trunk Signaling
 - Overview of SS7
 - SS7 and OSI
 - SS7 Structure and Management
 - Layer 1: Data Link
 - Layer 2: Signaling Link
 - Layer 3: Network Functions and Messages
 - Signaling Network Structure and Performance
 - Numbering Plan for International Signaling
 - SCCP: Signaling Connection Control Part
 - User Parts
 - SS7 and the Internet

Friday 11/4/11

Module 5: Transmission, Technology Impairments, Multiplexing, and Long-Distance Networks

Readings: RLF Ch. 5 (139 – 155)

Ch. 6 (157 – 183)

Lecture Slides

- Topics
 - Impairments to Voice Transmission, and SNR
 - Two-Wire and Four-Wire Transmission
 - Multiplexing
 - FDM
 - TDM: Synchronous and Statistical
 - Design Problems and Link Limitations
 - International and Toll Networks
 - Network Design
 - Traffic Routing
 - Transmission Factors

Optical Communication Systems: Networking and Switching

Monday 11/7/11

Module 6: Introduction, Basics of Fiber Optics, and The Fiber

Readings: JH Ch. 4 (65 – 86)

Ch. 5 (93 – 120)

Ch. 6 (151 -165)

Lecture Slides

- Topics
 - Introduction
 - Bandwidth
 - Multiplexing
 - Transmission Distance
 - Networks and Connectivity
 - Circuit and Packet Switching
 - Generic Optical Communication System
 - Components of an Optical Transmitter
 - Components of an Optical Receiver
 - Fiber Optics System
 - Why Use Fiber?
 - Basics of Fiber Optics
 - Bandwidth
 - Dispersion
 - WDM
 - Fiber Tradeoffs
 - The Fiber
 - Bare Fiber

- Clad Fiber
- Fiber Types
- Optical View
- Waveguide View
- Fiber Attenuation
- Light Coupling Efficiency
- Mode Structure
- Pulse Dispersion
- Nonlinear Effects

Tuesday 11/8/11

Module 7: Light Sources, Transmitters, and Receivers

Readings: JH Ch. 9 (197 – 211)
Ch. 10(227 – 237)
Ch. 11(249 – 254)

Lecture Slides

- Topics
 - Light Sources
 - LEDs
 - The Laser Principle
 - Semiconductor Lasers
 - Fiber Lasers
 - Transmitters
 - Receivers
 - Detectors
 - Receiver Sensitivity

Module 8: Passive and Active Components

Readings: JH Ch. 13(307 – 333)
Ch. 14(339 – 357)
Ch. 15(363 – 386)
Ch. 16(391 – 410)

Lecture Slides

- Topics
 - Passive Optics
 - Couplers and Taps
 - Planar Waveguides
 - Attenuators and Filters
 - WDM
 - Isolators
 - Circulators
 - Active Optical Components
 - Repeaters
 - Regenerators
 - Optical Amplifiers
 - Modulators
 - Optical Switches

Wednesday

11/9/11

Module 9: Why Use Fiber Optics

Readings: Lecture Slides

- Topics
 - Bandwidth
 - Single Channel Data Rates
 - WDM
 - Transmission Distance
 - Networking
 - Immunity
 - Size
 - Applications

Module 10: Optical Networks

Readings: JH Ch. 22(549 – 563)
Ch. 23(573 – 599)
Ch. 24(605 – 617)

Lecture Slides

- Topics
 - Global, Regional, and Metro Networks
 - Services
 - Integration
 - Switching and Multiplexing
 - SONET/SDH
 - Digital Hierarchy
 - ATM
 - IP
 - WDM
 - Global Network Structure
 - Regional Network
 - Metro Network
 - DWDM
 - Local Area Networks
 - Access and The Network Edge
 - Local Telephone Network
 - Fiber to The Home
 - FTTx
 - Fiber LAN Levels
 - Fiber System Design
 - Design Goals
 - Optical Amplifiers and Equalization
 - WDM
 - System Bandwidth
 - Dispersion Management
 - Nonlinear Effects
 - Optical Networking
 - Optical Switching

Module 11: Photonics and Switching Networks

Readings: SYRL Chs. 1 – 3
Lecture Slides

- Topics
 - Photonics and Switching Networks
 - Definitions:
 - Switching Network
 - Switch
 - Non-Blocking Switch
 - Connection States
 - Switching Cell
 - Two-State Switches
 - Interconnection Network
 - Unique-Routing Network
 - Nonblocking Network
 - Alternate-Routing Network
 - Nonblocking Properties of Alternate-Routing Networks
 - Strictly Nonblocking
 - Wide-Sense Nonblocking
 - Multi-Stage Networks
 - Banyan Networks
 - Baseline Networks
 - Omega Networks
 - Divide-and-conquer Networks
 - Recursive Application
 - Central Control

Thursday 11/10/11

Module 12: Multiservice Metro Optical SONET/SDH Network: A Case Study

Readings: Lecture Slides

- Topics
 - Network Design Strategy
 - Design Parameters
 - Customer Demographics
 - Customer Service Requirements
 - Customer Service Levels
 - Fiber Plant
 - Technology Selection
 - Vendor Selection
 - Case Study
 - User Survey
 - Analysis and Design
 1. Requirements Analysis
 2. Capacity Planning
 3. Fiber Plant Analysis
 4. Delay Analysis
 5. Technology Analysis

6. Logical Design
7. Physical Design

Module 13: Structured Review

- Important Concepts: Quick Review
- Examples discussed in class
- Q&A
- Structure of The Final Exam

Final Exam

- 4 hours
- Show all of your calculations