Asian Photonics Association

Learning Optics and Photonics with the Asian Photonics Association

Welcome to learning Optical Communication and Computing with Dr. Muhammad Hassan Sayyad, Former Professor of Photonics and Dean, Faculty of Engineering Sciences (FES), GIK Institute, Topi, Pakistan.

This course is designed for senior undergraduate and graduate students doing or have done BS, MS and PhD in Electronics Engineering, Telecommunication Engineering, Computer Science, Optical Engineering, Photonics Engineering and Physics.

The course will comprise both the theory lectures, simulation & modeling and hands-on-fabrication of printed optoelectronic devices. After completion of the course, the students will be able to submit 1-2 research articles on the simulation based design and analysis of optical communication systems.

Please fill out the following registration form to secure your spot in the course:

Registration Form

APA475 Optical Communication and Computing (3 Credit Hours) – Spring 2024	
Duration:	15 Weeks
Cost:	Free
Instructor:	Prof. Dr. Muhammad Hassan Sayyad, Former Professor of Photonics and Dean, Faculty of Engineering Sciences (FES), GIK Institute, Topi, Pakistan
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Course Introduction

Optical telecommunications has revolutionized the way we receive information and communicate with one another. This course will provide an understanding of the fundamental principles of optical fibre communication systems. It starts with a description of optical fibre propagation characteristics and transmission properties. We will then consider light sources

and the fundamental principles of laser action in semiconductor and other lasers including distributed feedback lasers, quantum well lasers, and also the characteristics of optical transmitters based on semiconductor and electro-optic modulation techniques. The characteristics of optical amplifiers will also be discussed. On the receiver side, the principles of photodetection and optical receiver sensitivity will be presented. Other aspects such as fibre devices and wavelength division multiplexing techniques will also be discussed. Finally, the complete optical fibre communication system will be studied to enable the design of data transmission optical systems, local area networks and multi-channel optical systems.

Simulation is used to provide insight into the practical optical fiber systems and their design and analysis.

Course Contents

1. **Overview of optical fiber communication:**
   Historical development, The general system, Advantages and disadvantages of optical fiber communication
2. **Optical fiber waveguides:**
   Introduction, Ray theory transmission, Cylindrical fiber, Single-mode fibers, Photonic crystal fibers
3. **Transmission characteristics of optical fibers:**
   Introduction, Attenuation, Material absorption losses in silica glass fibers, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, Mid-infrared and far-infrared transmission, Dispersion, Chromatic dispersion, Intermodal dispersion, Overall fiber dispersion, Dispersion-modified single-mode fibers, Polarization, Nonlinear effects, Soliton propagation
4. **Optical fibers and cables:**
   Introduction, Preparation of optical fibers, Types of optical fibers, Optical fiber cables, Cable design
5. **Optical fiber connections: joints, couplers and isolators**
   Introduction, Fiber alignment and joint loss, Fiber splices, Fiber connectors, Expanded beam connectors, Fiber couplers, Optical isolators and circulators
6. **Principles of fiber optic communication:**
   Modulation and multiplexing

7. **Optical sources and detectors:**
   Introduction, LED's, LASER diodes, Photo detectors, Photo detector noise, Response time, double hetero junction structure, Photo diodes, comparison of photo detectors.
8. **Optical receiver:**
   Introduction, Optical Receiver Operation, receiver sensitivity, quantum limit, eye diagrams, coherent detection, burst mode receiver operation, Analog receivers
9. **Analog and digital links:**
   Analog links – Introduction, overview of analog links, CNR, multichannel transmission techniques, RF over fiber, key link parameters, Radio over fiber links, microwave photonics. Digital links – Introduction, point–to–point links
10. **System designing:**
    System considerations, link power budget, rise time budget, short wave length band, transmission distance for single mode fibers, Power penalties, nodal noise and chirping.
11. **WDM concepts and components:**
    WDM concepts, overview of WDM operation principles, WDM standards, Mach-Zehender interferometer, multiplexer, Isolators and circulators, direct thin film filters, active optical components, MEMS technology, variable optical attenuators, tunable optical fibers, dynamic gain equalizers, optical drop multiplexers, polarization controllers, chromatic dispersion compensators, tunable light sources.
12. **Optical amplifiers and networks:**
    Optical amplifiers, basic applications and types, semiconductor optical amplifiers, EDFA. Optical Networks: Introduction, SONET / SDH, Optical Interfaces, SONET/SDH rings, High – speed light – waveguides.
13. **Optical fiber measurements:**
    Introduction, Fiber attenuation measurements, Fiber refractive index profile measurements, Fiber cutoff wavelength measurements, Fiber numerical aperture measurements, Fiber diameter measurements, Reflectance and optical return loss, Field measurements
14. **Fiber-to-the-Home (FTTH):**
    Design and analysis
15. **Optical computing:**
    Introduction: Why optics rather than electronics? Basic Components, Fundamental Optics, Optical Processing, Lenses for optical processing, image filtering, pattern recognition, Digital Optical Logic

The above outlines serve only as a rough guideline of the course contents and may be changed as and when deemed necessary by the instructor. The Instructor is at a liberty to best distribute number of lectures to cover the entire course.

Mapping of CLOs & PLOs			
CLOs	**Course Learning Outcomes**	**PLOs**	**Blooms Taxonomy**
CLO1	To explain the principles offiber optics, transmission characteristics of optical fibers, optical fibers, principles of optical fiber communication, fiber optic components, and optical computing building blocks.	PLO1	C2
CLO2	To demonstrate the basic components of optical communication links.	PLO1	C3
CLO3	To design the optical communication system including the desirables and constraints, and perform the link budget calculations involved in the optical link.	PLO3	C5
CLO4	To analyze the difference between various optical communications and networks technologies/standards, and point out challenges related to them.	PLO2	C4
CLO5	**Describe** a relevant engineering application of optical communication which can be useful for the society.	PLO6 **The Engineer and Society**	C3 Applying
CLO6	**Active participation** on the part of the	PLO10 **Communication**	C5 Evaluating

	student. Formally present the results of an investigation/project related to Optical communication.		

Text and Reference Books

Text books:

1. Optical Fiber Communication, Gerd Keiser, 4th Ed., MGH, 2008.
2. Optical Fiber Communications, John M. Senior, Pearson Education. 3rd Impression, 2009.

Reference books:

1. Fiber Optics Communication and Other Applications by H Zanger and C Zanger
2. Fiber-optic Communication Systems, G. P. Agarwal, 3rd Edition.
3. Optical Networks by Rajiv Ramaswami and Kumar N. Sivarajan
4. Basic Concepts of Communication Systems by Gerd Keiser
5. Fiber optic communication – Joseph C Palais: 4th Edition, Pearson Education.

Modern Tool Usage

Students are taught the use of Software's for the simulation, modeling and analysis of devices and systems employed in optical networks.

Lectures Breakdown

Week	Topic
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	infrared transmission, Dispersion, Chromatic dispersion, Intermodal dispersion, Overall fiber dispersion, Dispersion-modified single-mode fibers, Polarization, Nonlinear effects, Soliton propagation
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12-13	**Optical amplifiers and networks:**

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Instructor Biography:

Prof. Dr. Muhammad Hassan Sayyad possesses wide multidisciplinary experience of (1) teaching physics, electronics, lasers, optics and Photonics at O-Level, A-Level, Intermediate, Bachelor, Master and PhD students, (2) research supervision to BS, MS/M.Phil and PhD students at the Dublin City University, Government College University Lahore and the GIK Institute of Engineering Science and Technology, He has written several books, published 100 plus research articles, supervised 100 plus BS, MS and PhD students in research.

He has been honored with the Pak-US and Pak-China research projects, focusing on advancing next-generation solar cell technologies, and has served as a visiting scientist in prestigious universities in the United States, China, and Malaysia.

To see the Instructor CV, please click the following link:

https://sites.google.com/view/cvdrmuhammadhassansayyad/home