The Hebrew University of Jerusalem

Syllabus

AN INTRODUCTION TO OPTRONICS - 83879

Last update 03-09-2023

HU Credits: 5

Degree/Cycle: 1st degree (Bachelor)

Responsible Department: Applied Physics

Academic year: 0

Semester: 2nd Semester

Teaching Languages: Hebrew

Campus: E. Safra

Course/Module Coordinator: Prof Uriel Levy

Coordinator Email: ulevy@mail.huji.ac.il

Coordinator Office Hours: By email

Teaching Staff:

Prof Uriel Levy,
Mr. Yonatan Uziel

Course/Module description:

The subject matter of the course "Introduction to Optoelectronics" is the device physics of optoelectronic (OE) devices, and the analysis methodology for quantifying the performance of the systems in which they are embedded. Specifically, the topics that are included in the course are detectors that convert optical signals to electronic signals, and also modulators of optical signals that are driven by electronic signals. Additional topics that are covered include OE imaging systems, and thermal imaging systems.

Course/Module aims:

The goal of the course "Introduction to Optoelectronics" is twofold:
a. To teach the students how to produce a performance analysis of OE systems that is based on understanding the underlying principles of operation of the devices from which they are built.
b. To teach the students how to design an OE system with a given performance specifications by selecting and assembling the devices that will serve as the building block for its construction.
To that end, the course will imbue in the students two complementary areas of expertise:
a. The analysis methodology of the performance of OE systems which are applicable in particular for systems that convert optical signals to electronic signals, and for systems that modulate optical signals according to electronic control signals.
b. The device physics of a series of OE devices, including the physical mechanisms that govern their underlying principles of operation, focusing on two classes of devices: (i) detectors and detector arrays; and (ii) Electro optical modulators

Learning outcomes - On successful completion of this module, students should be able to:

a. Profound knowledge of the type and characteristics of noise mechanisms in OE devices and systems, including the capability to produce a quantitative evaluation of the effect of noise on the performance of these devices and systems.
b. Profound knowledge of the underlying principles of operation of detectors and detector arrays and the ability to apply this knowledge to produce the performance of these devices and systems. This chapter will focus in particular on photomultiplier tubes, photoconductive detectors, photodiodes and thermal detectors.
c. Profound knowledge of the underlying principles of operation of thermal imaging systems, and the figures of merit that quantify their performance.
d. Profound knowledge of optics of crystals, i.e. the theory of electromagnetic wave propagation in anisotropic media.

e. Profound knowledge of the electrooptic and effect, and the crystals in which they are manifested, including the ability to evaluate how this effect affect the propagation of EM waves in these crystals.
f. Profound knowledge of the architectures and performance specifications of optical modulators and beam deflectors that are based on the electrooptic effect.

Attendance requirements(%):
Attendance is not mandatory, however it is highly recommended.

Teaching arrangement and method of instruction: Lecture, TA and exercises.

Course/Module Content:
1) Introduction
• Optoelectronic systems structural design: principles and examples
• Linear time invariant systems
2) Noise mechanisms
• Wiener Khinchin theorem
• Carson theorem
• Shot noise
• Johnson noise
3) Noise filtering and optical detection methods
• Video detection
• Heterodyne detection
• Lock-in amplifier
4) Photonic detectors
• Photomultiplier
• Photoconductive detectors
• PN photodiode
• PIN photodiode
• Avalanche photodiode
5) Noise mechanisms in optoelectronic systems
• Shot noise and Johnson noise in photonic detectors
• Noise Figure, Noise Factor and Noise Temperature
• Generation-Recombination noise
6) Detectors parameters
• Responsivity
• Noise equivalent power (NEP)
• Detectivity, Specific Detectivity (D)*
7) Thermal imaging systems
• Black and grey bodies
• Atmospheric windows
• Noise equivalent temperature difference (NETD)

• Time delayed integration (TDI)
• BLIP
• Uncooled thermal detectors
8) Electromagnetic propagation in anisotropic media
• Index ellipsoid
• The electro-optic effect
• Electro-optic modulators
• Electro-optic deflectors

Required Reading:
NA

Additional Reading Material:
Photonics – Amnon Yariv & Pochi Yeh
Chapter 10 - Noise in Optical Detection and Generation
Chapter 11 - Detection of Optical Radiation
Chapter 1 - Electromagnetic Fields and Waves
Chapter 9 - Electro-optic Modulation of Laser Beams

Or:
Optical Electronics – Amnon Yariv

Photonics - Bahaa E. A. Saleh & Malvin Carl Teich

Grading Scheme:
Written / Oral / Practical Exam 75 %
Submission assignments during the semester: Exercises / Essays / Audits / Reports / Forum / Simulation / others 15 %
Mid-terms exams 10 %

Additional information:
Final exam (75%), Exercises (15%), Mid-terms exams (10%).