SYLLABUS

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Electronics, Telecommunications and information Technology
1.3 Department	Basic Electronics
1.4 Field of study	Electronic Engineering, Telecommunications and Information Technologies
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Telecommunications Technologies and Systems/ Engineer
1.7 Form of education	Full time
1.8 Subject code	TST-E53.10

2. Data about the subject

2.1 Subject name	Optoelectronics Systems in Telecommunications						
2.2 Subject area	Theoretical area Methodological area Analytic area						
2.3 Course responsible	Prof. Ramona Voichita Galatus, Ph.D, ramona.galatus@bel.utcluj.ro						
2.4 Teacher in charge with seminar / laboratory / project	Prof. Ramona Voichita Galatus, Ph.D, ramona.galatus@bel.utcluj.ro						
2.5 Year of study	IV	2.6 Semester	8	2.7 Assessment	Exam	2.8 Subject category	DS/DO

3. Estimated total time

3.1 Number of hours per week	4	of which: 3.2 course	2	3.3 seminar / laboratory	2 lab
3.4 To Total hours in the curriculum	56	of which: 3.5 course	28	3.6 seminar / laboratory	28

Distribution of time	hours
Manual, lecture material and notes, bibliography	26
Supplementary study in the library, online specialized platforms and in the field	15
Preparation for seminars / laboratories, homework, reports, portfolios and essays	21
Tutoring	4
Exams and tests	3
Other activities:	0

3.7 Total hours of individual study	69
3.8 Total hours per semester	125
3.9 Number of credit points	5

4. Pre-requisites (where appropriate)

4.1 curriculum	Optoelectronics Lectures, 3rd year of study - bachelor
4.2 competence	Optoelectronics Lab, 3rd year of study - bachelor

5. Requirements (where appropriate)

5.1. for the course	Amphitheatre, Cluj-Napoca
5.2. for the seminars / laboratories / projects	Laboratory, Cluj-Napoca

6. Specific competences

Professional competences	**C4. Design, implementation and operation of data, voice, video and multimedia services. This is based on the understanding and the application of fundamental concepts in telecommunications and transmission of information** **C5. Selecting, installing, configuring and operating fixed or mobile telecommunications equipment. Equipping a site with usual telecommunications networks** **C6. Solving specific problems of the broadband communications networks: propagation in different environment, circuits and equipment for high frequencies (microwaves and optical).**
Transversal competences	N / A

7. Discipline objectives

7.1 General objective	Development of professional skills in analysis, design, simulation and testing of optoelectronic systems for telecommunications in smart city.
7.2 Specific objectives	1. Obtain the theoretical knowledge for the design and simulation of optoelectronic systems using advanced simulation programs (Optiwave, Matlab). 2. Obtaining skills and practical abilities required for the analysis, implementation, measurement and operation of telecommunications optoelectronic systems.

8. Contents

8.1 Lecture (syllabus)	Teaching methods	Notes
Presentation discipline. Recap of the main topics in Optoelectronics; Optical communication: a 1rst encounter. Optical phenomena and corresponding communication components (an overview). *Perspective 2020- Photonics 21: Europe's Age of Light (Photonic Solutions).*	Presentation, heuristic conversation, exemplification, problem presentation, teaching exercise, case study, formative evaluation	Use of .ppt presentation, projector, blackboard
Studies of propagation – Historical perspective; Light propagation in free space, light guides, propagation modes; Types of fibers and optical cables. Comparative analysis, specifying optical fibers and cables. Connectors, splicing techniques.		
Optical fibers: materials, absorption, configuration, index profiles, light attenuation. The telecom wavelength ranges. Optical fiber manufacturing; Types of optical fibers and their characteristics; Special optical fibers; POF-plastic optical fibers (short distance communication, instead of coax		

cables)		
Studies of optical propagation: waveguides 2D and 3D optical guides, optical phenomena; Linear and Nonlinear attenuations (intermodal dispersion, chromatic dispersion, Kerr, Raman, Brillouin etc)		
Photonic components for telecommunications - introduction: passive (modulators, filters, splitters) and active components; How to fabricate PIC (photonic integrated circuits); Examples of PIC in nowadays applications (quantum computing).		
Optoelectronic integrated circuits (OEICs) for telecom – part 2: *Simple passive:* integrated lenses, splitters, couplers, optical switches, resonators. Structure, operation, engineering; *Advanced:* optical isolators, polarizers, circulators, multiplexers, DMUX-demultiplexers, routers AWG. Diffraction gratings inscribed in fiber IFG (In-Fiber Gratings). FBG (fiber bragg grating) diffraction grating filters. Guides diffraction gratings 2D / 3D. Structure, operation, achievements. Applications.		
Functional OEICs- optoelectronic integrated circuits – part 3: electro-optical, acoustic-optical, magneto-optical, electro-optical, and thermo-optical. Manufacture of integrated optoelectronic circuits.		
Photonic sources: LEDs, LDs, modulating semiconductor lasers. The lasing condition, the resonance equation, efficiency; LED for LIFI (wireless optical communication); Lasers for telecommunications (VCSELs, DFB/ DBRs, external cavity lasers, tunable leasers, fiber lasers. Drivers); Allocation of lambda DWDM ITU Grid; Optical filters (microrings) for lasers.		
Optical Amplifiers: fiber doped, EDFA; Optical components for WDM: AWG, MUX, DMUX, ADMUX (Add-Drop MUX), Tunable filters, star couplers, Wavelength converters		
Fiber receivers: Photodetectors *pin*, APD: basics, SNR (signal per noise ratio), pin-diode response. Transceivers for fiber optic communications; How to find optical components in catalogs. Receivers for digital communication systems: noise, diode-preamplifiers, eye-diagram, detection threshold. Operation, structure, engineering.		
Fiber communication systems: Step index optical fiber. Guide dispersion, material dispersion, DSF (dispersion shifted fibers), flat dispersion fibers. Graded index fibers. Modes, trajectories, dispersion compensation. Single-mode fiber : the electromagnetic field, optical power, MFD (mode field diameter), effective area; Point to point links; Signal amplification; Flow Budget, SNR, BER, attenuation and dispersion compensation solutions for optical link (Ericsson). Fiber link installation procedure. Optical networks; FTTH - Fiber to the home. Cable networks (video, data – CaTV). Sizing the link based on signal-map, attenuation and dispersion (Ericsson).		
Advanced Software for optical telecommunications: Zemax, Liekki Application Designer, VPIPhotonics, Optiwave, Comsol (examples of simulations); Fiber communication systems. Point to point links. Long-houl transmission. Distance between repeaters-regenerators. Flux budget, SNR, BER.		
Optoelectronic sensors for Smart City, with *remote control* – part 1 with application examples (LIDAR, Raman *optical fiber distributed sensors*, Brillouin *optical fiber distributed sensors*).		
Optoelectronic sensors for Smart City, with *remote control* – part 2		

application examples (Fiber Bragg Gratings and Interferometers and Gyroscopes for high sensitivity applications etc). Review of the theoretical aspects presented in the SOT lectures (questions and answers)		

Bibliography

Multimedia course materials

Galatus Ramona – PPT lecture files

Basic:

1. Gerd Keiser - Optical fiber communication, McGraw Hill, 4th edition, 2013
2. Ivan Kaminow , Tingye Li, et al. Optical Fiber Telecommunications Volume VIB: Systems and Networks (Optics and Photonics), May 13, 2013
3. T. L. Singal, Optical Fiber Communications: Principles and Applications, 2017
4. **Telecom catalog 2019**: Hamamatsu,Thorlabs, Edmund Optics, Arris, C-COR, Scientific Atlanta, Cisco, JDSU s.a.; Photonics Spectra, Lasers, IEEE Photonics Technology, IEEE Journal of Quantum Electronics
5. Nathan Blaunstein (BenGurion University), Fiber Optic and Atmospheric Optical Communication, Wiley **IEEE Press, 2020**
6. **Photonics IEEE** database for Essay preparation (University IP access)
7. Photonics21- Vision-Paper-Final Europe's Age of Light 2021, EU Brussels, 2019

8.2 Seminar / **laboratory** / project	Teaching methods	Notes
Introduction- Recap of main topics in optoelectronics, instrumentation laboratory presentation, work safety rules. General – basic knowledge about optics and optoelectronics *Introduction to simulation tool*: Optiwave OptiPerformer (Free University Curricula - open access)	Simulations with Optiwave OptiPerformer Free University Curricula and practical implementation (Educational Kits) and devices.	Optional activities are related to the most efficient students that finish the activities in less than 2h, dedicated to the obligatory tasks
Simulation: Optiwave OptiPerformer : Introduction_OptiPerformers.osp *Practical activities*: Spectrometers and Optical Spectrum Analyzer (OSA), using K-MAC VIS – parameter visualization for emitters and end-of-transmission optical fiber setup.		
Simulation: Dispersion Limited Fiber Length in OptiPerformer *Practical activities:* Interferometer implementation – Michelson (setup Educational Kit from Industrial Fiber Optics.) and *Simulation - optional:* Mach-Zehnder (design). Mach-Zehnder interferometer as a modulator electro-static and dynamic optic: simulations using ray mathematical formalism implementation (Beam Propagation Method, implemented in Optiwave OptiBPM – trial version)		
Simulation: OptiPerformer Dispersion Compensation *Practical Activities:* Effects of polarization – setup Educational Kit from Industrial Fiber Optics; Holographic film, visualization with He-Ne Laser.		
Seminar: Basics on optical fiber propagation: Problems with monomode and multimode fibers, parameter calculations *Practical activities:* Photometer - parameter visualization for emitters (coherence visualization for light signal). Special active optical fibers (fluorescent gain)		
Simulation: Methods of designing an optical system with catalog data (Thorlabs – eCatalog version 21, 2019) - flow budget equation. *Part 2:* Statistical Design methods implementation using Excel (resolved problems are available as demo)		

Optional: Simulation: Agrawal - Chapter 5: PowerBudget in OptiPerformer		
Practical activities: Hologram inscription on sensitive substrate: LitiHolo KIT, US. Hologram 3D visualization: smartphone compatible prism, Educational Kit from Industrial Fiber Optics, US (Observation: training for next generation displays)		
Practical activities: Infrared Camera applications using SEEK Thermal compact camera (PCB diagnosis) *Optional Simulations:* Agrawal – Ch 6 (DMUX, FBG, Star Couplers), Ch 7 (Amplifiers) in OptiPerformer		
Simulation: Nonlinear Noise Agrawal - Ch2 - Attenuation coefficient in OptiPerformer, Ch2 - Fiber dispersion, Ch 2 – SPM, Ch 2-XPM, Ch 2-FWM *Practical activities:* diffraction gratings (Mosaic diffraction – practical experiment with - Educational Kit from Industrial Fiber Optics); FBG – fiber Bragg diffraction as optical filter (DMUX in optical communication systems,1550nm), using Mid IR spectrometer		
Simulation: Agrawal - Chapter 3: Emitters *Practical activities:* 3D LED holographic projector (smartphone video holograms)		
Simulation: Agrawal - Chapter 4: Receivers *Practical activities:* Tango project – tablet with LIDAR *Optional:* 1. Audio A/D Transmission System over plastic optical fiber- Educational Kit from Industrial Fiber Optics. 2. Garmin LIDAR 1R DEMO		
Practical activities: OTDR equipment for optical network maintenance - monitoring events over the optical transmission networks (40km outdoor fiber – optical link with ODF – different patch-cords) *Simulation:* using TraceView Tool, interpretation of the events in the attenuation graphics (files recorded with OTDR)		
Practical activities: HFC study and implementation of an optical transmission system with optical node (Dolce Telekom setup, RF converter, Laser Modulator – MachZehnder interferometer – 1550nm)		
Evaluation of the students (20% from final score). *Optional:* Applications with VR glasses (distance monitoring) and Kinect (Laser and IR sensors)		
Bibliography 1. Agrawal's Book chapters: Fiber-Optic Communication Systems, Wiley series in microwave and optical engineering, 4th Edition, 2010		

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The discipline content and the acquired skills are in agreement with the expectations of the professional organizations and the employers in the field, where the students carry out the internship stages and/or occupy a job (in the field of *Optoelectronics, Photonics and Optical Communication*), and the expectations of the national organization for quality assurance (ARACIS).

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	The level of acquired theoretical knowledge and practical skills	- after 7 courses, preliminary exam (oral examination) -optional - Summative evaluation written exam (theory and problems) – 14 subjects, one from each lecture (for the students with preliminary exam – 7 subjects)	*80% as follows:* - T, max 10 pts. 20% - E, max 10 pts. 60%
10.5 Seminar/ Laboratory	The level of acquired knowledge and abilities	- Continuous formative evaluation - Practical lab test	*20% as follows:* -Practical activities, max 10pts. (10%) -Written reports, max 10pts. 10%
10.6 Minimum standard of performance			

Final score: 0,6E+0,20L+0,20T ≥ 4.5 (Lab (L) ≥ 4.5 and Essay (E) ≥ 4.5 and Exam (T) ≥ 4.5)
Quality level: The presence of the course is considered activity and chronic nonattendance (less than 4 lectures) requires further verification of material lost (at the written exam – supplementary questions). Presence in all laboratories, obtaining a minimum of 4.5 notes in laboratory activities, and written reports.
Minimal knowledge requirements (lecture):

- ✓ *To know the optical phenomena (dualism wave-corpuscle of light)*
- ✓ *To explain the working principles of the photonics components that are used in SOT (emitters, receivers and optical fibers)*

Minimal competence requirements (lab):

- ✓ *To enumerate and recognize optical components (types of emitters, receivers and optical fibers) that are used in optical communication*
- ✓ *To design an optical communication link (power budget)*
- ✓ *To know how to make interpretation with OTDR*

Date of filling in:	**Responsible**	**Title Surname NAME**	**Signature**
29.09.2020	Course	Prof. Ramona Voichita Galatus, Ph.D	
	Applications	Prof. Ramona Voichita Galatus, Ph.D	

Date of approval in the Department of Communications 30.09.2020	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval in the Council of Faculty of Electronics, Telecommunications and Information Technology 30.09.2020	Dean Prof. Gabriel OLTEAN, Ph.D.