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	Master
1.6 Program of study / Qualification	Integrated Systems and Circuits
1.7 Form of education	Full time
1.8 Subject code	*48*

2. Data about the subject

2.1 Subject name	Smart Sensors and IoT						
2.2 Subject area	Theoretical area Methodological area Analytic area						
2.3 Course responsible	Prof Ramona Voichita Galatus, PhD eng., ramona.glatus@bel.utcluj.ro						
2.4 Teacher in charge with seminar / laboratory / project	Prof Ramona Voichita Galatus, PhD eng., ramona.glatus@bel.utcluj.ro Lecturer Lorant Szolga, PhD eng., Drd Loredana Buzura, loredana.buzura@bel.utcluj.ro Drd Adriana Potarniche, ioana.potarniche@bel.utcluj.ro						
2.5 Year of study	IV	2.6 Semester	2	2.7 Assessment	Exam	2.8 Subject category	O/DF

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	100	of which: 3.5 course	28	3.6 seminar / laboratory	28
Distribution of time					hours
Manual, lecture material and notes, bibliography					12
Supplementary study in the library, online specialized platforms and in the field					5
Preparation for seminars / laboratories, homework, reports, portfolios and essays					12
Tutoring					10
Exams and tests					5
Other activities:					

3.7 Total hours of individual study	44
3.8 Total hours per semester	100
3.9 Number of credit points	4

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	Theoretical knowledge (what the student must	After completing the discipline, students will learn: - specific information related to the smart sensors, system installation, measurement, operations, and specific design software. - phenomenology governing optical transmissions. - most optoelectronic devices	
	Acquired skills (what the student is able to do):	After completing the discipline, students will be able to: - to use a specific simulator (ex. Matlab, Liekki Application Designer, Optiwave OptiPerformer, WEB online simulators) - to choose components, parts, equipment to design an smart sensors based system integrated for a wide range of applications. - they will know to make the data interpretation using setup with smart sensors, optoelectronic components s.a.	
	Acquired abilities: (what type of equipment the student is able to	After completing the discipline, students will be able to: - Use laboratory equipment (power supplies, digital oscilloscopes, fiber optics, optoelectronic components). - Use the specific optoelectronic hardware and software tools; - To know how to measure and interpret experimental results.	
	In accordance with Grila1 and Grila2 RNCIS	C4 Conceperea, implementarea si operarea serviciilor de date, voce, video, multimedia, bazate pe întelegerea si aplicarea notiunilor fundamentale din domeniul comunicatiilor si transmisiunii informatiei	C4.1 Identificarea conceptelor fundamentale referitoare la transmisiunea informatiei si la comunicatiile analogice si digitale C4.2 Rezolvarea de problem practice utilizând cunostinte generale privind tehnicile multimedia C4.3 Explicarea si interpretarea principalelor cerinte si tehnici specifice de abordare pentru transmisiile de date, voce, video, multimedia C4.3 Rezolvarea de problem practice utilizând cunostinte generale privind tehnicile multimedia C4.4 Utilizarea principalilor parametri specifici în evaluari bazate pe conceptul de calitate a serviciilor în comunicatii C4.5 Dezvoltarea unor servicii simple de comunicatii C4.6 Sustinerea si promovarea unei probe vizând caracteristicile principale ale serviciilor uzuale de comunicatii

		C6 Rezolvarea problemelor specifice pentru retele de comunicatii de banda larga: propagare în diferite medii de transmisiune, circuite si echipamente pentru frecvente înalte (microunde si optice).	C6.1 Identificarea/ Definirea/ Prezentarea legilor câmpului electromagnetic în abordarea problemelor specifice propagarii si transmisiei, precum si a circuitelor specifice C6.2 Explicarea metodelor specifice de implementare a tehnicilor de comunicatii C6.3 Rezolvarea de problem practice utilizând metode de proiectare a circuitelor de microunde, planificare, acoperire, selectie si amplasarea echipamentelor de emisie receptie C6.4 Utilizarea principalilor parametri de calitate si a tehnicilor de masura specifice mediilor de propagare si transmisie C6.5 Elaborarea de proiecte de complexitate mica/ medie privind echipamentele de emisie-receptie C6.6 Sustinerea si promovarea unei probe vizând principiile de functionare si utilizarea echipamentelor de emisie receptie
Cross competences (Grila1 and Grila2 RNCIS)		CT2 Definirea activităţilor pe etape şi repartizarea acestora subordonaţilor cu explicarea completă a îndatoririlor, în funcţie de nivelurile ierarhice, asigurând schimbul eficient de informaţii şi comunicarea interumană CT3 Adaptarea la noile tehnologii, dezvoltarea profesională şi personală, prin formare continuă folosind surse de documentare tipărite, software specializat şi resurse electronice în limba română şi, cel puţin, într-o limbă de circulaţie internaţională	

7. Discipline objectives (as results from the key competences gained)

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

8. Contents

8.1 Lecture (syllabus)	Teaching methods	Notes
1.Smart sensors: WHY? WHERE? How? (e.g. climate and environmental protection, key enabling technology [1], what are smart sensors/ Smart Sensor Basics [2]	Presentation, heuristic conversation, exemplification, problem presentation, teaching exercise, case study, formative evaluation	Use of .ppt presentation, projector, blackboard
2.Introduction to Sensors and Actuators: classification (conversion type, active/passive, linear/non-linear, technology used, type of application (pressure, position, temperature, humidity or others), characteristics (transfer function, accuracy, calibration, repeatability and others), the principle of 'sensing' and the interface with acquisition systems, standardization.[3][4][6]		
3. IoT and the Industry 4.0 standard, for smart sensors [7][13]		
4. Distributed smart sensors		
5. Optoelectronic sensors for Smart City, with *remote control* (IoT) with		

application examples (LIDAR, Raman *optical fiber distributed sensors*, Brillouin *optical fiber distributed sensors* Fiber Bragg Gratings and Interferometers and Gyroscopes for high sensitivity applications etc).		
6. Standards for Smart Sensors		
7. Functional OEICs- optoelectronic integrated circuits.		
8. Advanced Software for smart sensors based systems. Applications examples: flexible sensors, implantable sensors etc.		
9. Sensors data driven approach in artificial inteligence applications [9]		
10. eLogistics and smart sensors applications		
11. Communications for Smart Sensors		
12. Control Techniques		
13. Transceivers, Transponders, and Telemetry		
14. Packaging, Testing, and Reliability Implications of Smarter Sensors		

Bibliography

Multimedia course materials

Galatus Ramona – PPT lecture files

Basic:

Bibliografie:

1. https://www.photonics21.org/ppp-services/photonics-downloads.php
2. Understanding Smart Sensors-3rd edition, Randy Frank, 2013 Artech House, ISBN-13: 978-1-60807-507-2
3. Optical Sensors, Jorg House,2010, Wiley-Verlag, ISBN: 978-3-527-40860-3
4. Fiber Optics Sensors, Fundamentals and Applications, 4th Edition, David Krohn et al, SPIE Press, 2014, ISBN 978-1-6284-1180-5
5. Handbook of optical sensors, Jose Louiz Satos, CRC Press, 2015, Taylor And Francis
6. Industry 4.0, The Industrial IoT, Alasdair Gilchrist, APress 2016, ISBN-13 (electronic): 978-1-4842-2047-4
7. SMART SENSOR SYSTEMS: EMERGING TECHNOLOGIES AND APPLICATIONS, Gerard Meijer, Wiley, 2014
8. Behavior Analysis with Machine Learning and R, A Sensors and Data Driven Approach, Enrique Garcia Ceja, 2020, LEanPub, http://behavior.enriquegc.com.
9. Senzori optici, Ramona Galatus, Tiberu Marita, Niculae Puscas, Casa Cartii de Stiinta, 2015
10. Smart Sensors for Industrial Applications – Krzysztof Iniewski, CRC Press, Taylor&Francis, 2013

Reviste din anul curent: Nature Photonics, Photonics Spectra, Biopohotonics, Lasers, IEEE Photonics Technology, IEEE Journal of Quantum Electronics.

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
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 the simulation programs are based on **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
29.09.2019	Course	Assoc prof Ramona Galatus, PhD eng.	
	Applications	Assoc prof Ramona Galatus, PhD eng	
		Lecturer Lorant Szolga, PhD eng	
		Drd Loredana Buzura	
		Drd Adriana Potarniche	

Date of approval in the Department of Basis of Electronics

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Head of Department
Prof. Sorin HINTEA, PhD eng.

Date of approval in the Council of Faculty of Electronics, Telecommunications and Information Technology

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Dean
Prof. Gabriel OLTEAN, PhD eng.