SYLLABUS

1. Data about the program of study

1.1	Institution	The Technical University of Cluj-Napoca
1.2	Faculty	Electronics, Telecommunications, and Information Technology
1.3	Department	Bases of Electronics
1.4	Field of study	Electronics and Telecommunications Engineering
1.5	Cycle of study	Master of Science
1.6	Program of study/Qualification	Integrated Circuits and Systems
1.7	Form of education	Full time
1.8	Subject code	12.00

2. Data about the subject

2.1	Subject name					Integrated Circuits for Automotive Industry					
2.2	Subject area					Integrated Circuits					
2.3	Course responsible/lecturer					Lecturer Raul Oneț, PhD - Raul.Onet@bel.utcluj.ro					
2.4	Teachers in charge of applications					Eng. Istvan Kovacs, PhD – Istvan.Kovacs@bel.utcluj.ro Assoc. Prof. Marius Neag, PhD - Marius.Neag@bel.utcluj.ro					
2.5	Year of study	II	2.6	Semester	1	2.7	Assessment	Exam	2.8	Subject category	DA/DI

3. Estimated total time

3.1 Hours per week	3	of which 3.2 lecture	2	3.3 tutorial / laboratory	1
3.4 Total hours in curricula	70	of which 3.5 lecture	28	3.6 tutorial / laboratory	42
Time allocation					hours
Manual, lecture material and notes, bibliography					28
Supplementary study in the library, online and in the field					24
Preparation for seminars/laboratory works, homework, reports, portfolios, essays					25
Tutoring					3
Exams and tests					3

3.7 Total hours of individual study	83
3.8 Total hours per semester	125
Number of credit points	5

4. Pre-requisites (where appropriate)

4.1 Curriculum	Fundamental Electronic Circuits, Analog Integrated Circuits
4.2 Competence	Good understanding of the operation and modeling of electronic devices such as diodes, BJT and MOS transistors. Good understanding of, and ability to use for circuit analysis, the operation and parameters of main analog building blocks: linear circuits (amplifiers, filters, voltage references and regulators, general purpose OAs) and nonlinear circuits (oscillators, comparators, analog multipliers) Working knowledge of circuit theory and signal theory Working knowledge of CAD tools employed in the analysis and design of analog circuits

5. Requirements (where appropriate)

5.1 For lecture	Amphitheatre, Cluj-Napoca
5.2 For applications: Project	Laboratory with standard electronic equipment, Cluj-Napoca

6. Specific competences

Professional competences	After completing this course, the students should know: - Key features specific to the analysis and design of circuits and systems implemented with analog integrated circuits (ICs), RF circuits and mixed signal circuits - The main constraints and system-level design strategies of integrated circuits used in the automotive industry - Integrated radio receiver architectures for wireless communications: key features, modeling methods and analysis of receiver performance; deriving the specifications of the functional blocks of the signal path. - - Typical architectures and circuit implementations as well as systematic design methodologies of the main functional blocks in the signal path of integrated radio receivers, such as: Low noise amplifiers, Frequency conversion mixers, Real and polyphase-channel select filters, Amplifiers with variable/programmable gain - Principle of operation, main parameters and systematic design methodologies of frequency synthesizers based on Phase Locked Loop (PLL) circuits - Principle of operation and key features of integrated circuits used in high-speed serial links - Principle of operation and key features of integrated circuits used in Clock and Data Recovery systems - Analog front-ends for automotive sensors: key features, modeling methods and deriving the specifications of the functional blocks - Typical architectures and circuit implementations as well as systematic design methodologies of the main functional blocks within the analog front-ends for automotive sensors: Low noise instrument amplifiers, Analog filters - Typical architectures and circuit implementations as well as systematic design methodologies of the main functional blocks within power management systems, such as: Voltage references, Linear voltage regulators, switched capacitor DC-DC converters
	After completing this course, the students will be able to: - Analyze the architecture and performance of integrated radio receivers - Analyze and design the main functional blocks within the signal path of an integrated radio receiver, such as: low noise amplifiers, mixers, channel filters, variable/programmable gain amplifiers - Analyze the architecture and performance of frequency synthesizers based on PLLs, - Analyze and design the main functional blocks of frequency synthesizers, such as: voltage-controlled oscillators, charge pumps, frequency dividers - Analyze and design the main functional blocks within the integrated wired transceivers, such as: receivers, transmitters, equalizers

	- Analyze and design the main functional within the analog front-ends for automotive sensors: Low noise instrument amplifiers, Analog filters - Analyze and design the main functional within power management systems, such as: Voltage references, Linear voltage regulators, switched capacitor DC-DC converters
	By completing the discipline, the students will acquire practical skills such as: - Employ standard lab instrumentation (power supplies, oscilloscope, function generator, multi-meter) for the experimental analysis and verification/characterization of analog systems; - Design and build test setups for the experimental validation and characterization of analog circuits and systems; - Performing methodically circuit simulations and laboratory experiments in order to obtain valid data on the devices-under-test, then process and analyse those data - Employ standard numerical modelling programs for the system-level analysis and design of the analog sections of the studied systems: from level-plan to Matlab and Simulink models - Employ standard CAD tools that include SPICE-based simulators for the analysis, design and verification/characterization of analog circuits and systems, like the Virtuoso Cadence tools (Schematic Entry, ADE, Spectre)
Transversal competences	- Know and be able to use methodologies for analysis and design of systems with Integrated Circuits: understand top requirements and convert them into block-level specifications; analyze comparatively possible implementation solutions and identify design trade-offs, generate models able to reflect limitations/non-idealities inherent to ICs - Effective use of various sources of information and computer-aided education, including on-line lectures and tutorials, databases, etc.

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

7.1 General objectives	Develop students' competencies regarding the analysis, design, verification and characterization of analog integrated circuits used in the automotive industry, from system-level to block-level implementation.
7.2 Specific objectives	1. Acquire the knowledge and skills necessary for systematic analysis, modeling, design and simulation of integrated circuits used in the automotive industry, both at system-level and at block-level 2. Develop the skills and abilities necessary to design, implement and make use of testbenches for functional verification and characterization of integrated circuits used in the automotive industry

8. Contents

8.1. Lecture (syllabus)	Teaching methods	Notes
Overview: objectives, content, methodology. Current trends in integrated circuits used in the automotive industry	Presentation, heuristic conversation, exemplification, problem presentation, teaching exercise, case study, formative evaluation	Use of PowerPoint presentation, projector, blackboard
Frequency synthesizers based on PLL circuits: principle of operation, main parameters, system level analysis and design		
Frequency synthesizers based on PLL circuits: circuit implementation. Analysis and design of phase detectors, charge pumps, voltage-controlled oscillators, frequency dividers		
Integrated radio receivers: principle of operation, architectures, main parameters		
The cumulative effect of noise and non-linearity of blocks in the signal path of a radio receiver. Determining the key parameters of the functional blocks from the system-level specs		
Low noise amplifiers (LNA) and frequency-conversion mixers: function and features, parameters, main design issues, classical implementation solutions		
Baseband circuits: channel select analog filters, controlled-gain amplifiers		
Transceivers for serial communications. Analog sections of high-speed serial communication systems: function and features, general requirements		
Clock-and-Data Recovery (CDR) Systems		

Analog front-ends for automotive sensors: principle of operation, main parameters, system level analysis and design and circuit implementation. Analysis and design of low-noise precision and instrumentation amplifiers and continuous-time analog filters		
Analog front-ends for automotive sensors - Design example: Analog front-end for Hall sensors used in automotive systems		
Power management for automotive sensors: principle of operation, main parameters, system level analysis and design and circuit implementation.		
Voltage references and linear voltage regulators: function and features; key parameters; main ideas for circuit implementation		
Switched-capacitor DC-DC converters: function and features; key parameters; main ideas for circuit implementation		

8.2 Project		Teaching methods	Notes
1	Project specs; design methodology	Didactic and experimental proof, didactic exercise, team work	Use of laboratory instrumentation, experimental boards, computers, white/magnetic board
2	System-level design of PLL-based frequency synthesizers: determining the specs of the functional blocks		
3	Block-level sizing of the loop filter and frequency divider, targeting an optimum tradeoff between bandwidth and noise performance		
4	Time-domain analysis of the frequency synthesizer: determine the lock time and phase noise		
5	Transistor-level implementation of the functional blocks: phase detectors, charge pumps, voltage-controlled oscillators, frequency dividers		
6	Optimization of the designed frequency synthesizer, targeting the minimization of power consumption and phase noise. Functional verification and characterization		
7	Project presentation and grading		

Bibliography

1. M. Neag, I. Kovacs, Integer-N Frequency Synthesizers - An IC Designer's Guide, Editura UTPress Cluj-Napoca, 2022, ISBN 978-606-737-573-2
2. Marius Neag, Sisteme cu Circuite Integrate Analogice, Editura Mediamira, 2008, ISBN 978-973-713-208-6, 200pag,
3. M. Neag, A. Fazakas, Circuite Integrate Analogice, Editura Casa Cartii de Stiinta, 1999
4. B.Razavi, RF Microelectronics, Editura Prentice Hall, 1998, (2011), ISBN: 0138875715.
5. T. H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, Cambridge University Press, 2nd Edition, 2004
6. P. R. Gray, R. G. Meyer, Analysis and Design of Analog Integrated Circuits, Editura John Wiley and Sons, 2001
7. W. Sansen, Analog Design Essentials, Editura Springer, 2006, ISBN: 978-0387257464.
8. B. P. Lathi, Zhi Ding, Modern Digital and Analog Communication Systems, The Oxford Series in Electrical and Computer Engineering, 4th Edition, 2009
9. M. Steyaert, A.H.M. van Roermund, H. Casier (Editors) - Analog Circuit Design: High-speed Clock and Data Recovery, High-performance Amplifiers, Power Management, Springer 2009

On – line references

1. M. Neag, Raul Onet, Integrated Circuits for Automotive Industry – lecture notes and presentations, posted on the course website
2. Access to the Virtuoso Cadence integrated circuit design environment and modern CMOS technologies, CMOS 150nm and 180nm.

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 those set up by similar courses organized by top universities in Romania and abroad; also, they meet the requirements set by professional organizations and government agencies in this field, as well as the expectations of companies involved in the design, implementation and testing & characterization of integrated circuits in the automotive industry, such as the potential employers where students carry out practical placements and internships.

10. Evaluations

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Lecture	The level of acquired theoretical knowledge and skills in analysis and design of integrated circuits in automotive industry	- Summative evaluation exam (theory and problems)	- E, max 10 pts. 50%
10.5 Applications (lab and tutorial classes)	The level of acquired practical abilities and problem-solving skills	- Individual project (same system to be designed, individual specs)	- L, max. 10 pts. 50%
10.6 Minimum standard of performance			
• Active attendance of lectures • Attendance of, and active involvement in, all project classes, resulting in fulfillment of all project assignments + project fully completed • Gain at least 5 points (out of 10) at the exam and at least of 5 (out of 10) for the project • E ≥ 5* and P ≥ 5** = pass - E ≥ 5* means getting at least half the maximum points allocated to each part of the exam. The main sections of the exam verify that key theoretical points - such as principle of operation, design trade-offs, parameters and models – are known and understood, and assess the ability to solve circuit-analysis & circuit-sizing exercises. - P ≥ 5** means getting at least half the maximum points allocated to the project • If all the conditions above are met the final mark is calculated as follows: Mark = 0.5 E + 0.5L			

Date of filling in:	**Responsible**	**Title Surname NAME**	**Signature**
	Course	Slr.dr.ing. Raul Oneț	
	Aplications	Dr.Ing. Kovacs Istvan	
		Conf.Dr.Ing. Marius Neag	

Date of approval in the Department of Bases of Electronics ________________________	Head of Department Prof. Sorin HINTEA, PhD eng
Date of approval in the Council of Faculty of Electronics, Telecommunications and Information Technology ________________________	Dean Prof. Gabriel OLTEAN, PhD eng