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	Bachelor of Science
1.6	Program of study/Qualification	Telecommunications Technologies and Systems/Engineer, Applied Electronics/Engineer
1.7	Form of education	Full time
1.8	Subject code	TST-E32.00, EA-E32.00

2. Data about the subject

2.1	Subject name					Systems with Analog Integrated Circuits							
2.2	Subject area					Integrated Circuits							
2.3	Course responsible/lecturer					Assoc. Prof. Marius Neag, PhD							
2.4	Teachers in charge of applications					Assist.Prof. Raul Onet, PhD.							
2.5	Year of study	III	2.6	Semester	1	2.7	Assessment	Exam	2.8	Subject category	DID/DOB		

3. Estimated total time

Year/ Sem.	Subject name	No. of weeks	Course	Applications			Course	Applications			Indiv. study	TOTAL	Credits
			[hours/week]				[hours/sem.]						
				S	L	P		S	L	P			
III / 1	Systems with Analog Integrated Circuits	14	2	-	2	-	28	-	28	-	74	130	5

3.1	Number of hours per week	4	3.2	of which, course	2	3.3	applications	2
3.4	Total hours in the curriculum	56	3.5	of which, course	28	3.6	applications	28

Individual study	Hours
Manual, lecture material and notes, bibliography	40
Supplementary study in the library, online and in the field	-
Preparation for seminars/laboratory works, homework, reports, portfolios, essays	28
Tutoring	3
Exams and tests	3
Other activities	0

3.7	Total hours of individual study	74
3.8	Total hours per semester	130
3.9	Number of credit points	5

4. Pre-requisites (where appropriate)

4.1	Curriculum	N / A
4.2	Competence	Good understanding of the operation and parameters of main analog building blocks: amplifying stages with one- and two-transistors, the differential pair, current mirrors, voltage references; Working knowledge on the internal structure of general purpose OAs.

5. Requirements (where appropriate)

5.1	For the course	Amphitheatre, Cluj-Napoca
5.2	For the applications	Laboratory, Cluj-Napoca

6. Specific competences

Professional competences	Theoretical knowledge (what the student must know):	- Main non-idealities and the related parameters of general-purpose Operational Amplifiers (OAs); their effects on the performance of typical OA-based circuits and standard solutions to minimize and/or compensate them; - Implementation solutions for standard linear and nonlinear applications with OAs: amplifiers, filters, precision rectifiers, peak detectors, signal comparators and generators; methods for their systematic analysis. - Principle of operation of current-mode active devices such as the Current-Feedback Operational Amplifier (CFB-OA and the linear transconductor (Gm-cell); their main parameters and the standard models used for analyzing circuits based on them; examples of linear and non-linear applications with these devices. - Principle of operation, main parameters and typical applications for specialized integrated circuits such as: instrument amplifiers, comparators, multipliers, signal generators, timers, V-F and F-V converters - Principle of operation and main parameters of Integer-N frequency synthesizers based on Phase Locked Loop (PLL) circuits;
	Acquired skills (what the student is able to do):	After completing the discipline, the students will be able to: - Analyze the stability of closed-loop systems based on general-purpose OAs analytically and through small-signal simulations; design networks for frequency compensation; - Estimate the effects of main OA nonidealities over the performance of OA-based circuits and design circuits to minimize and/or compensate them; - Analyze and design typical linear and nonlinear applications with OAs such as: amplifiers, filters, precision rectifiers, peak detectors, signal comparators and generators; - Analyze and design circuits based on current-mode devices such as the CFB-OA and the linear transconductor (Gm-cell); - Analyze applications based on, and design circuits with, specialized integrated circuits such as: instrument amplifiers, analog multipliers, comparators and signal generators; - Analyze and design Integer-N frequency synthesizers based on integrated PLL circuits. - Design and implement simple testbenches for the functional verification of analog systems through SPICE-based simulations and for estimating their parameters.
	Acquired abilities: (what type of equipment the student is able to handle)	After completing the discipline, the students will be able to: - Use standard CAD tools that include SPICE-based simulators for the design and verification of analog circuits and systems - Use the standard lab instrumentation (power supplies, oscilloscope, function generator, multi-meter) for the experimental study of analog systems with OAs and specialized integrated circuits; - Design and build test setups for experimental validation and characterization of analog circuits and systems; - Perform methodically circuit simulations and laboratory experiments in order to obtain accurate data, then process and analyze them

	In accordance with Grila1 and Grila2 RNCIS	C1. To use the fundamental elements regarding electronic devices, circuits, systems, instrumentation and technology C2. To apply basic methods for signal acquisition and processing C4. To design, implement and operate data, voice, video and multimedia services, based on the understanding and application of fundamental concepts from the field of communications and information transmission. C5. To select, install, configure and exploit fixed and mobile telecommunications equipment. To equip a site with common telecommunications networks.
Cross competences (Grila1 and Grila2 RNCIS)		N.A.

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

7.1	General objectives	Develop students' competences on the analysis and design of analog systems implemented with general-purpose operational amplifiers (OAs) and specialised integrated circuits (ICs).
7.2	Specific objectives	1. Understand the operation and main limitations of voltage-and current-mode OAs and their effect on OA-based circuits; 2. Understand the operation of, and be able to recognize the standard implementations of OA-based basic analog signal processing blocks; 3. Develop the skills and abilities the students need to analyse and design OA-based circuits for analog signal processing. 4. Understand the operation and parameters of specialized analog ICs; develop skills and abilities required for analyzing circuits based on them and develop new applications with them.

8. Contents

8.1. Lecture (syllabus)		Teaching methods	Notes
1	Overview: objectives, content, methodology. Stability of closed-loop systems based on general-purpose OAs. Methods for internal and external frequency compensation of OAs.	Presentation, heuristic conversation, exemplification, problem presentation, teaching exercise, case study, formative evaluation	Use of .ppt presentation, projector, blackboard
2	Static and dynamic OA limitations; main parameters of OAs.		
3	Noise in analog circuits: types of electrical noise, modeling and analysis methods. Noise models for passive and active devices. Effects of OA nonidealities in linear applications with OAs; methods for minimising and compensating for these effects		
4	Current-Mode active devices - the Current-Feedback Operational Amplifier and the Transconductor (Gm cell): operation; internal structure; modeling; parameters; main applications; comparison with traditional (voltage-mode) OA.		
5	Controlled-gain amplifiers implemented with voltage- and current-mode active devices		
6	Precision and instrumentation amplifiers: features, parameters; classical implementation solutions in voltage-mode.		
7	Current-mode instrumentation amplifiers: main principles and features of current-mode circuits; examples of current-mode implementation of instrumentation amplifiers; comparison with voltage-mode amplifiers.		
8	Continuous-time filters: main topologies and synthesis methods; implementation of 1st and 2nd order sections with voltage- and current-mode active devices		
9	Circuits with non-linear transfer characteristics: precision rectifiers; peak detectors; sample-and-hold amplifiers.		
10	Integrated voltage comparators: internal structures; main parameters and limitations. Applications: summing and differential comparators; window comparators; Schmitt triggers.		

11	Signal generators: main features and implementation techniques. OA-based generators: sine-wave; triangular & rectangular - wave; saw-tooth wave generators.		
12	Analog Multipliers - main features and implementation techniques: controlled MOS resistor; PWM; log/antilog; variable transconductance. Examples of and applications with integrated analog multipliers.		
13	Integrated circuits able to implement complex analog functions: timers, V-F and F-V converters.		
14	PLL circuits – fundamentals: basic architecture and principle of operation; modeling and analysis; main parameters, implementation examples and applications		
8.2. Applications (lab)		Teaching methods	Notes
1	Stability analysis of OA-based feedback circuits. Methods for internal and external frequency compensation of OAs.	Didactic and experimental proof, didactic exercise, team work	Use of laboratory instrumentation, experimental boards, computers, white/magnetic board
2	Limitations and parameters of general-purpose OAs: small-signal operation		
3	Limitations and parameters of general-purpose OAs: DC errors and large-signal operation		
4	Current-Feedback Operational Amplifiers and Transconductors: parameters and applications.		
5	Controlled-gain amplifiers.		
6	Voltage-mode Instrumentation Amplifiers.		
7	Current-mode Instrumentation Amplifiers.		
8	First- and second-order continuous-time filters		
9	Precision half- and full-wave rectifiers		
10	Voltage comparators implemented with general-purpose OAs and with integrated comparators.		
11	Signal generators.		
12	Analog Multipliers and applications		
13	Integrated circuits with complex functions: timers, V-F and F-V converters.		
14	Integer-N frequency synthesizer based on integrated PLL circuits		

Bibliography

1. M. Neag, *Sisteme cu Circuite Integrate Analogice*, Mediamira, 2008
2. M. Neag, A. Fazakas, *Circuite Integrate Analogice*, Casa Cărţii de Ştiinţă, 1999
3. L. Feştilă, S. Hintea, M. Neag, E. Gaura, N. Pop, "Circuite Integrate Analogice. Culegere de Probleme" Lito UTCN, Cluj – Napoca, Lito UTCN, 1997
4. P. R. Gray, R. G. Meyer, *Analysis and Design of Analog Integrated Circuits,* John Wiley and Sons, 2001
5. S. Franco – Design with Operational Amplifiers and Analog Integrated Circuits, McGraw-Hill, 1998, 2001, 2014
6. S. Franco – Analog Circuit Design: Discrete & Integrated, McGraw-Hill, 2014
7. D. Johns, K. Martin - Analog Integrated Circuit Design, John Wiley & Sons, 1997
8. B. Razavi - *Design of CMOS Analog Integrated Circuits*, McGraw-Hill, 2001
9. K. Laker, W. Sansen – *Design of Analog Integrated Circuits and Systems*, McGraw-Hill, 1994

On – line references

1. M. Neag, Systems with Analog IC – course site: http://www.bel.utcluj.ro/ci/eng/saic/index.html

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

Competences acquired will be used in the following COR occupations (Electronics Engineer; Telecommunications Engineer; Electronics Design Engineer; System and Computer Design Engineer; Communications Design Engineer) or in the new occupations proposed to be included in COR (Sale Support Engineer; Multimedia Applications Developer; Network Engineer; Communications Systems Test Engineer; Project Manager; Traffic Engineer; Communications Systems Consultant).

10. Evaluations

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
Course	The level of acquired theoretical knowledge and practical skills	- Homework (problem solving) - Summative evaluation written exam (theory and problems)	- H, max 10 pts. 10% - E, max 10 pts. 70%
Applications	The level of acquired abilities	- Continuous formative evaluation - practical lab test	- L, max. 10 pts. 20%
10.4 Minimum standard of performance			
$L \geq 4.5$ and $E > 5$ and $0.7E + 0.2L + 0.1H \geq 5$			

Date of filling in	Course responsible	Teacher in charge of applications
1.10.2018	Assoc. Prof. Marius Neag, PhD	Assist.Prof. Raul Onet, PhD