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	Bases of 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 Applied Electronics/Engineer
1.7 Form of education	Full time
1.8 Subject code	TST-E30.00/EA-E30.00

2. Data about the subject

2.1 Subject name	Systems with Analog Integrated Circuits						
2.2 Subject area	Integrated Circuits						
2.3 Course responsible	Assoc. Prof. Marius NEAG, Ph.D. - Marius.Neag@bel.utcluj.ro						
2.4 Teacher in charge with laboratory / project	Assoc. Prof. Marius NEAG, Ph.D. - Marius.Neag@bel.utcluj.ro Assist. Prof. Raul ONET, Ph.D. - Raul.Onet@bel.utcluj.ro Eng. Cosmin PLESA, Ph.D. – Cosmin.Plesa@bel.utcluj.ro Eng. Nicolae BRAIC, Ph.D. student – Nicolae.Braic@bel.utcluj.ro Eng. Paul COSTE, Ph.D. student – Paul.Coste@bel.utcluj.ro						
2.5 Year of study	III	2.6 Semester	5	2.7 Assessment	E	2.8 Subject category	DD/DI

3. Estimated total time

3.1 Number of hours per week	5	of which: 3.2 course	2	3.3 laboratory/project	3
3.4 To Total hours in the curriculum	70	of which: 3.5 course	28	3.6 laboratory/project	42

Distribution of time	hours
Manual, lecture material and notes, bibliography	15
Supplementary study in the library, online specialized platforms and in the field	8
Preparation for seminars / laboratories, homework, reports, portfolios and essays	25
Tutoring	2
Exams and tests	5
Other activities:	

3.7 Total hours of individual study	55
3.8 Total hours per semester	125
3.9 Number of credit points	5

4. Pre-requisites (where appropriate)

4.1 curriculum	Fundamental Electronic Circuits, Analog Integrated Circuits
4.2 competence	1. Good understanding of the operation and modeling of electronic devices such as diodes, BJT and MOS transistors. 2. Good understanding of, and ability to use for circuit analysis, the operation and parameters of main analog building blocks: amplifying stages with one- and two-transistors, the differential pair, current mirrors, voltage

	references; general purpose OAs 3. Working knowledge of circuit theory and signal theory 4. Working knowledge of CAD tools employed in the analysis and design of analog circuits

5. Requirements (where appropriate)

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

6. Specific competences

Professional competences	C1. Use of the fundamental elements related to devices, circuits, systems, instrumentation and electronic technology C2. Applying the basic methods for the acquisition and processing of signals 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
Transversal competences	N/A

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

7.1 General objective	Develop students' competencies regarding the analysis, design, verification and characterization of a wide range of analog systems implemented with OAs, Gm-cells and application-specific integrated circuits (ASICs).
7.2 Specific objectives	1. Understand the operation and main limitations of general-purpose and specialized OAs and Gm-cells and be able to estimate the effects those limitations have on circuits implemented with OAs and Gm-cells 2. Understand the operation of, and be able to assess the circuit function and main parameters of a wide range of analog systems based on OAs and Gm-cells 3. Understand the operation and main features resulted from datasheet information of application-specific integrated circuits (ASICs); develop skills and abilities required for analyzing circuits based on ASICs, use them properly and develop new applications with them. 4. Acquire the knowledge and skills necessary for systematic analysis and design of systems implemented with OAs, Gm-cells and ASICs 5. Develop the skills and abilities necessary to design, implement and make use of testbenches for functional verification and characterization of analog systems based on OAs, Gm-cells and ASICs

8. Contents

8.1 Lecture (syllabus)	Teaching methods	Notes
1. Overview: objectives, content, methodology. General-purpose voltage-voltage operational amplifier (OA): principle of operation, static and dynamic limitations and corresponding parameters.	Presentation, heuristic conversation, exemplification, problem presentation, teaching exercise, case study, formative evaluation	Use of PowerPoint presentation, projector, blackboard
2. Stability of closed-loop systems based on general-purpose OAs. Methods for internal and external frequency compensation of OAs Noise in analog circuits: types of electrical noise, modeling and analysis methods. Noise models for passive and active devices.		
3. Effects of OA nonidealities in linear applications with OAs; methods for minimizing and compensating for those effects		
4. Current-Mode active devices - the Current-Feedback Operational Amplifier (CFB-OA) and the linear transconductor (Gm cell): operation; internal structure; modeling; parameters; main applications; comparison with traditional OA.		
5. Voltage references and linear voltage regulators: function and features; key parameters; main ideas for circuit implementation		
6. Continuous-time filters: main types, topologies and synthesis methods; implementation of 1st and 2nd order sections by using voltage- and current-mode active devices, particularly the AO-RC and Gm-C techniques		
7. Controlled-gain amplifiers implemented with voltage- and current-mode active devices		
8. Precision and instrumentation amplifiers: function & features, parameters; classical implementation solutions in voltage- and current mode.		
9. Circuits with non-linear transfer characteristics: precision rectifiers; peak detectors; sample-and-hold amplifiers.		
10. Integrated voltage comparators: structure and applications. Internal structures; main limitations and corresponding parameters. Circuit implementation of: summing and differential comparators; window comparators; Schmitt triggers.		
11. Signal generators based on bi-stable circuits and on harmonic oscillators: main features and implementation techniques. Examples of OA-based harmonic oscillators, triangular & rectangular – wave and saw-tooth wave generators.		
12. Analog Multipliers and dividers - main features and implementation techniques; examples of, and applications with, integrated analog multipliers.		
13. Integrated radio receivers: principle of operation, architectures, main parameters, examples of circuit implementation		

14. Frequency synthesizers based on PLL circuits: principle of operation, main parameters, examples of circuit implementation for main functional blocks		

Bibliography
1. P. R. Gray, R. G. Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley and Sons, 2009
2. S. Franco – Design with Operational Amplifiers and Analog Integrated Circuits, McGraw-Hill, 2014
3. D. Johns, K. Martin - Analog Integrated Circuit Design, John Wiley & Sons, 1997
4. B. Razavi - Design of CMOS Analog Integrated Circuits, McGraw-Hill, 2001
5. W. Sansen – Analog Design Essentials, Springer, 2006
6. M. Neag, Sisteme cu Circuite Integrate Analogice, Mediamira, 2008
7. M. Neag, A. Fazakas, Circuite Integrate Analogice, Casa Cărţii de Ştiinţă, 1999

On – line references
8. M. Neag, Systems with Analog IC – lecture notes and presentations, posted on the course site: http://www.bel.utcluj.ro/ci/eng/saic/index.html

8.2. Laboratory	Teaching methods	Notes
1. Limitations and parameters of general-purpose OAs: DC and large-signal operation	Didactic and experimental proof, didactic exercise, team work	Use of laboratory instrumentation, experimental boards, computers, white/magnetic board
2. Stability analysis of OA-based feedback circuits. Methods for internal and external frequency compensation of OAs.		
3. Noise in analog circuits: noise analysis and methods for reducing noise impact on OA-based circuits.		
4. Effects of OA limitations on OA-based linear circuits; methods for reducing the impact on the overall circuit performance		
5. Current-Feedback Operational Amplifiers and linear transconductors: parameters and applications.		
6. Voltage references and linear voltage regulators		
7. Continuous-time filters based on first- and second-order sections implemented by using the AO-RC and Gm-C techniques		
8. Precision and Controlled-gain amplifiers.		
9. Instrumentation Amplifiers.		
10. Precision half- and full-wave rectifiers; peak detectors; sample & hold		
11. Voltage comparators implemented with general-purpose OAs and with integrated comparators		
12. Signal generators based on bi-stable circuits and on harmonic oscillators.		
13. Analog Multipliers and applications		
14. Voltage-to-frequency converters for frequency synthesizers based on PLL circuits.		

8.3 Seminar	Teaching methods	Notes
1. Main limitations of general-purpose OAs and corresponding parameters. Effects of OA nonidealities in linear applications with OAs; methods for minimizing and compensating for these effects	Tutor& student circuit-analysis exercises; examples of systematically sizing a circuit in	Use of PowerPoint presentation, projector, blackboard
2. Voltage references and linear regulators		

3. Continuous-time filters: implementation of 1st and 2nd order sections with voltage- and current-mode active devices	order to achieve set requirements	
4. Precision and instrument amplifiers implemented with voltage- and current-mode active devices		
5. Circuits with non-linear transfer characteristics: precision rectifiers; peak detectors; sample-and-hold amplifiers.		
6. Voltage comparators and signal generators based on bi-stable circuits and on harmonic oscillators.		
7. Analog Multipliers and applications		

Bibliography

1. L. Festila, N. Pop, S. Hintea, M. Neag, “Circuite Integrate Analogice. Culegere de Probleme” Lito UTCN, Cluj – Napoca, 1997
2. T. Danila, N. Cipcea – Amplificatoare Operationale – Aplicatii, probleme rezolvate, Teora, 1994
3. S. Franco – Analog Circuit Design: Discrete & Integrated, McGraw-Hill, 2014

On – line references

4. M. Neag, R. Onet - Systems with Analog IC – material for lab classes, posted on the course site
5. Problems proposed at the National Student Contest “Tudor Tanasescu” – 1979-2019

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 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. 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	- Summative evaluation written exam (theory and problems)	E, max 10 pts. 75%
10.5 Seminar/ Laboratory	The level of acquired knowledge and abilities	- Continuous formative evaluation practical lab test - Homework (problem solving)	L, max. 10 pts. 25%
10.6 Minimum standard of performance			

Qualitative level

Minimum level of knowledge

- ✓ Principle of operation, typical circuit implementations, main non-idealities and the related parameters of general-purpose voltage-mode Operational Amplifiers (OAs) and linear transconductors (Gm cells)
- ✓ Principle of operation, typical circuit implementations and main parameters of commonly-used linear and nonlinear applications with OAs and Gm-cells: voltage references and linear voltage regulators, precision and instrument amplifiers, filters, precision rectifiers, peak detectors, signal comparators and generators; multipliers/dividers, frequency- to-voltage converters

Minimum level of competence

- ✓ Employ standard methods for mathematical analysis of the commonly-used linear and nonlinear

applications with OAs and Gm-cells mentioned above
- ✓ Design and implement testbenches for functional verification and characterization of analog circuits testbenches for, and run SPICE-based simulations on, the commonly-used linear and nonlinear applications with OAs and Gm-cells mentioned above in order to analyze their operation and derive their main parameters and limitations
- ✓ Employ standard laboratory equipment (power supplies, oscilloscope, function generator, multi-meter) for the experimental analysis and verification/characterization of analog systems) to perform experiments for validation and characterization of analog circuits and systems;

Quantitative level
- ✓ Active attendance of most lectures and tutorials
- ✓ Attendance of, and active involvement in, all laboratory classes, resulting in fulfillment of all lab assignments + fully completed homework
- ✓ Obtain at least 5 points (out of 10) at the written exam and at least a mark of 5 (out of 10) for the laboratory and homework assignments
- ✓ The final mark results from the following formulae: 0,75*E + 0,25*L

Data of filling in:	**Responsible**	**Title First name SURNAME**	**Signature**
20.06.2023	Course	Assoc. Prof. Marius NEAG, Ph.D.	
	Applications	Assoc. Prof. Marius NEAG, Ph.D.	
		Assist. Prof. Raul ONET, Ph.D.	
		Eng. Cosmin PLESA, Ph.D.	
		Eng. Nicolae BRAIC, Ph.D. student	
		Eng. Paul COSTE, Ph.D. student	

Date of approval in the Council of the Communications Department 11.07.2023	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval in the Council of the Faculty of Electronics, Telecommunications and Information Technology 12.07.2023	Dean Prof. Ovidiu POP, Ph.D.