COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Electronic Devices, Circuits and Architectures**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Microelectronics, Optoelectronics and Nanotechnologies

2. Date despre disciplină

2.1 Course name (ro) (en)				Compatibilitate electromagnetică Electromagnetic Compatibility			
2.2 Course Lecturer				S.l./Lect. Dr. Ing. Valentin-Gabriel Voiculescu			
2.3 Instructor for practical activities				S.l./Lect. Dr. Ing. Valentin-Gabriel Voiculescu			
2.4 Year of studies	3	2.5 Semester	I	2.6. Evaluation type	V	2.7 Course regime	Op
2.8 Course type		D	2.9 Course code	04.D.05.A.021		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	3	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	42.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	14
Distribution of time:					hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.					30
Tutoring					0
Examinations					3
Other activities (if any):					0

3.7 Total hours of individual study	33.00
3.8 Total hours per semester	75
3.9 Number of ECTS credit points	3

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Fundamentals of Electrical Engineering Digital Integrated Circuits Analog Integrated Circuits Signals and Systems
4.2 Results of learning	Basic knowledge of signal and circuit analysis in time and frequency domains, of electromagnetic field theory, of filters, transmission lines, analog and digital circuits.

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	The course will be held in a room equipped, preferably, with a video projector and internet access (to allow simultaneous use in the form of a Teams video conference).
5.2 Seminary/ Laboratory/Project	Attendance of laboratory sessions is mandatory (as stated by the regulations for undergraduate university studies).

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

The discipline has as general objective to familiarize the students with general methods and techniques to eliminate parasitic electromagnetic interferences in the process of physical implementation of electronic circuits and systems. In the practical sessions (laboratory) the students visualize and measure noise signals that appear in typical circuits for each type of parasitic coupling, in order to retain the order of magnitude of these signals and apply the methods to eliminate interferences while following their efficiency.
Based on knowledge accumulated from this course, the future electronics engineer will be able to implement correctly various electronic circuits/systems and reach the technical parameters of the specification.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	**C6.1.** Creation of abilities to physically implement electronic circuits with imposed technical parameters, taking into account the parasitic couplings that appear in practical realisation of electronic modules and devices **C6.2.** Knowledge of the general methods of eliminating undesired interferences between the components of an electronic device/system, of its protection from external perturbations, as well as the reduction of intrinsic emissions of perturbing signals.
Transversal (General) Competences	**CT3** Ability for documenting in Romanian as well as a language of international circulation, for the purpose of professional and personal development, through continuous training

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* List the four fundamental types of internal parasitic coupling and highlight the similarities and differences between them. Describe, for each of the four types of coupling, the principle of occurence, the factors impacting the voltage noise produced by the coupling, the typical disturbed (victim) and disturbing (aggressor) circuits. The general methods of eliminating couplings, as well as other notions specific to the discipline. It highlights the influence of the factors upon which the noise voltage depends and the noise reduction methods on this voltage in the circuits.
Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* Identifies victim and aggressor circuits in real or chosen circuits, apparatus or systems used for study in the session. Based on these specific circuits, it identifies the type or types of coupling existing in the schematic and proposes the appropriate coupling reduction measures. It solves applications with circuits that present one or more parasitic couplings, calculating by specific methods the electrical parameters of voltage noise or/and useful signal obtained and proposes ways to reduce the noise. Work as a team to perform laboratory measurements. Uses laboratory equipment (generators, multimeters, oscilloscopes) to perform the measurements provided in the laboratory manual. Adequately interpret the relationships related to the coupling principle to validate the results of the experimental measurements in the laboratory session. Formulate argumented observations and conclusions on the measurements made.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Demonstrate openness for new learning contexts. Conspect in advance the course and laboratory materials, to the extent that they are made available. In case of missing attendance, go through the course material taught, made available, on your own. Select the proper laboratory guide according to the current work and analyze it individually. Select the necessary information from the materials provided for solving homework applications and obtain the solution autonomously, respecting the principles of academic ethics. Demonstrates autonomy and team spirit in organizing the context of the laboratory session in order to carry out the experimental work, by manipulating the devices and planning the measurements, as well as in other learning situations or problem situations to be solved for other applied scenarios.

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

The teaching materials used are the course notes and presentations, also available in electronic format.
Starting from the analysis of the students' learning characteristics and their specific needs, the teaching process will explore both expository (lecture, exposition), problem-solving and conversational-interactive teaching methods, based on discovery learning models facilitated by direct and indirect exploration of reality (experiment, demonstration, modelling), but also action-based methods such as exercise, practical activities and problem solving.
Lectures will be used in the teaching activity, based on Power Point presentations, which will be presented in front of the students as far as is technically possible, or/and through a videoconferencing environment such as Teams. These materials will be made available to students. Each course will start with a short recap

of the previous lesson to ensure continuity of the concepts covered.
The presentations use, as far as possible, images and diagrams, as well as examples of real-life application of the concepts taught, so that the information presented is easy to understand and assimilate.
In the applied part, the teaching is based on the use of the expository method (covering the communication and demonstrative function). Students work in teams, ensuring the development of collaborative relationships and constructive communication in a climate favorable for learning, necessary in the professional future, perform the measurements specified in the course of the work, having to complete a laboratory sheet during the session and later prepare a report with the measurement results and their interpretations, accompanied by personal comments. The main teaching materials are the laboratory platforms.
Feedback will also be used, as a way of adapting the pedagogical approach to the students' learning needs.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	The general problem of electromagnetic compatibility (EMC) 1.1. The dual character of EMC. The necessity of ensuring EMC in the design phase. 1.2. The critical character of “electromagnetic pollution”; the need to fit into the Romanian and european EMC norms	1
2	Sources of electromagnetic perturbation (EP) 2.1.Classification of perturbations and their characterization in the time/frequency domains. 2.2. Natural and artificial EP. Conducted and radiated, continuous and transitory EP. LF EP, as well as HF EP. Electrostatic discharges. Perturbations transmitted through the AC network grid.	1
3	Galvanic parasitic coupling (GPC) 3.1. GPC through the common ground: principle, factors upon which the noise signal depends on, typical perturbing (aggressor) and perturbed (victim) circuits, general methods of reduction, practical usual cases. 3.2. GPC through the common DC supply source: same problems as in 3.1.	12
4	Field parasitic coupling (FPC) 4.1. FPC through the near field zone: through preponderant electric, as well as magnetic field, factors upon which the parasitic signal induced depends on, typical perturbing (aggressor) and perturbed (victim) circuits. 4.2. Electrical and magnetic shields. Electromagnetic shields; computation of the shielding efficiency. Real shields – practical problems. Systems of electrical shields.	12
5	Recapitulative course	2
	Total:	28

Bibliography:
O.Oltu, V.G.Voiculescu, Compatibilitate Electromagnetică, suport de curs electronic, https://curs.upb.ro/2024/course/view.php?id=3312
C.Christopoulos, Principles and techniques of electromagnetic compatibility, 2nd edition, 2018
H.Ott, Electromagnetic Compatibility Engineering, 3rd edition, Wiley, 2011
R&S, Oscilloscope Days 2022, 2022, https://www.rohde-schwarz.com/us/knowledge-center/webinars/webinar-oscilloscope-days_255400.html
Holland Shielding, 101 EMI Shielding tips and Tricks, 2022, https://hollandshielding.com/Shielding-tips-and-tricks
Y.Zhao et al, Electromagnetic Compatibility - Principles and Applications, Spinger Nature Singapore, 2021

LABORATORY

Crt. no.	Content	No. hours
1	Parasitic coupling through ground in amplifiers	3
2	Parasitic coupling through the common DC supply line	3
3	Parasitic coupling through the electric field	3
4	Parasitic coupling through the magnetic field	3
5	Final verification laboratory	2
	Total:	14

Bibliography:
O.Oltu, V.G.Voiculescu, Compatibilitate Electromagnetică, suport de curs electronic, https://curs.upb.ro/2024/course/view.php?id=3312
O.Oltu, V.G.Voiculescu, Compatibilitate Electromagnetică, suport de laborator electronic, https://curs.upb.ro/2024/course/view.php?id=3312
C.Christopoulos, Principles and techniques of electromagnetic compatibility, 2nd edition, 2018
H.Ott, Electromagnetic Compatibility Engineering, 3rd edition, Wiley, 2011
R&S, Oscilloscope Days 2022, 2022, https://www.rohde-schwarz.com/us/knowledge-center/webinars/webinar-oscilloscope-days_255400.html
Holland Shielding, 101 EMI Shielding tips and Tricks, 2022, https://hollandshielding.com/Shielding-tips-and-tricks
Y.Zhao et al, Electromagnetic Compatibility - Principles and Applications, Spinger Nature Singapore, 2021

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Knowledge of the means to apply the theory to specific problems	Ongoing homework across the semester	20%
	Knowledge of the fundamental notions, evaluated across the semester	Tests accross the semester	20%
	Knowledge of fundamental notions, final evaluation	Final test	30%

11.5 Seminary/laboratory/project	Practical knowledge of the manifestation of each type of parasitic coupling and the methods of their elimination	Ongoing evaluation across the semester, graded laboratory reports and final laboratory verification.	30%
11.6 Passing conditions			
For each of the four fundamental types of parasitic coupling one is required to know: the principle of appearance, the factors of which the noise voltage induced through the cabling depends upon, the perturbing and perturbed circuits, as well as the general methods of elimination. Obtaining 50% of the score or the minimum score provided by the regulations.			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

In general from the electrical engineers it is expected that they be capable to make hardware and software objects that satisfy certain real needs of the “market”. In the past years one notices an increase in demand for hardware specialists from employers, in the broader context in which the IT&C sector became the second contributor in forming the Romanian GDP.
In the faculty, during the fundamental courses, the students learn to design circuits and systems using idealized models, in which it is assumed that signals only propagate through pathways desired by the designer.
This approach is natural, being common to all systems of technical teaching, due to reasons of learning efficiency. When making physical electronic devices and systems one does the necessary corrections, taking into account the additional problems that appear in this phase. Concretely, one takes into account the so called “parasitic couplings” that can appear between the internal components of the device/system as well as the potential change in behavior made by sources of perturbations external to it. At the same time it is legally mandatory for any electronic product not to emit perturbing signals over certain thresholds imposed for each class of devices.
In the Electromagnetic compatibility course one studies the precise methods by which these criteria can be met during the practical realisation of electronic devices/systems.
Usually technically imposed parameters through the design task of a device can’t be met if one does not take measures to eliminate parasitic couplings since the design phase.
Presently no electronic product can’t be manufactured or commercialized within the European Union if it doesn’t meet the conditions for electromagnetic compatibility imposed through specific standards for each class of devices.
The competencies acquired through this course by the future electrical engineers clearly respond to the demands of the labor market that has in this moment an important demand for specialists in the area of designing and exploiting electronic equipment.

Date	Course lecturer	Instructor(s) for practical activities
	S.l./Lect. Dr. Ing. Valentin-Gabriel Voiculescu	S.l./Lect. Dr. Ing. Valentin-Gabriel Voiculescu

Universitatea Națională de Știință și Tehnologie Politehnica București

Facultatea de Electronică, Telecomunicații și

Tehnologia Informației

Date of department approval	Head of department
31.10.2024	Prof. Dr. Claudius DAN

Date of approval in the Faculty Council	Dean
01.11.2024	Prof. Dr. Mihnea Udrea