SYLLABUS

1. Program Information

1.1 Higher education institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Automation and Computer Science
1.3 Department	Department of Automation
1.4 Field of study	Automation, Applied Informatics and Intelligent Systems
1.5 Cycle of studies	Bachelor
1.6 Study Programme/Qualification	Intelligent Automation Systems (dual, in English language)
1.7 Form of education	IF – full-time education
1.8 Course code	35.00

2. Course information

2.1 Course title	**Power Electronics in Automation**				
2.2 Course lecturer	Assoc.Prof.Eng. Roxana Rusu-Both, PhD – *Roxana.Both@aut.utcluj.ro*				
2.3 Seminar / Laboratory / Project Lecturer	Assoc.Prof.Eng. Roxana Rusu-Both, PhD – *Roxana.Both@aut.utcluj.ro* *Eng. Adrian Mudure (Emerson)*				
2.4 Year of study	3	2.5 Semester	1	2.6 Type of assessment	E
2.7 Course status	Formative category *(DF, DS, DC)*				DS
	Optionality *(DOB, DOP, DFac)*				DOB

3.Total estimated time

3.1 Number of hours per week	4	of which:	HEI	Lecture	2	Seminar		Laboratory	1	Project	
			CO		0		0				1
3.2 Number of hours per semester	56	of which:	HEI	Lecture	28	Seminar		Laboratory	14	Project	
			CO		0		0				14

3.3 Distribution of time allocation (hours per semester) for:	HEI	CO
(a) Study based on textbook, course support, bibliography, and notes	14	
(b) Additional documentation in library, specialized electronic platforms, and fieldwork	7	7
(c) Preparation of seminars/laboratories, assignments, papers, portfolios and essays	7	14
(d) Tutoring	2	8
(e) Examinations	3	7
(f) Other activities:		
3.4 Total individual study hours (sum (3.3(a)... 3.3(f)))	33	31
3.5 Total hours per semester (3.2+3.4)	75	50
3.6 Number of credits per semester	3	2

(HEI = Higher Education Institution, CO = Company)

4. Prerequisites (where applicable)

4.1 Curriculum Prerequisites	• Fundamentals of Electronic Circuits, • Electrotechnics, • Digital Electronics, • Introduction to System Theory and Control Systems
4.2 Competency Prerequisites	• Understanding of semiconductor devices (diodes, BJTs, MOSFETs, thyristors) • Familiarity with analog and digital circuits and their applications • Basic simulation and modeling skills • Ability to interpret and analyze switching waveforms

5. Conditions (where applicable)

5.1. Course Organization Conditions	• Lecture room equipped with video projector, internet access, and simulation software (e.g., MATLAB/Simulink or other equivalent software). • Students should have access to online references.
5.2. Seminar / Laboratory / Project organization conditions	Laboratory equipped with: • Power electronic converter kits (buck, boost, inverters) • Oscilloscopes, signal generators, power supplies • MATLAB/Simulink and other equivalent software for simulation • Digital controllers (e.g., Arduino/DSP kits, PLCs)

6. Specific Competencies Acquired

Professional Competencies	• PC02 Analyse test data • PC08 Design automation components • PC10 Develop electronic test procedures • PC20 Record test data • PC25 Use technical drawing software • PC28 Use testing equipment • PC31 Use remote control equipment
Transversal Competencies	• TC01 Apply knowledge of science, technology and engineering • TC02 Think analitically

7. Learning outcomes

Knowledge:	Upon completion of the course, the student will: • Understand and describe the behavior and role of power semiconductor devices • Explain and apply topologies such as buck, boost, flyback, and inverters • Interpret converter modeling methods in both small-signal and averaged domains • Understand power loss mechanisms and thermal/magnetic design principles
Skills:	Students will be able to: • Design and simulate switching converters using modern tools • Develop and test control strategies for converters (analog/digital) • Analyze and interpret waveforms in practical setups • Work on integrated hardware-software projects
Responsibility and autonomy:	At the end of the course, students will: • Demonstrate autonomy in converter project design, testing, and improvement • Document and present technical solutions using academic and industrial standards • Follow safety rules and test plans when working with high-power circuits

8. Course Objectives

8.1 General objective of the course	To provide students with advanced knowledge and skills in power electronics, focusing on the modeling, control, and design of converter-based systems using both theoretical frameworks and industrial practices (via Emerson collaboration).

8.2 Specific objectives	• Understand converter switching principles and topologies • Apply modeling techniques to analyze converter behavior • Design analog and digital controllers for DC and AC converters • Perform simulations and implement practical lab tests for various converter types • Carry out project-based learning with industry-relevant use cases

9. Contents

9.1 Lectures	No. of hours	Teaching methods	Obs.
1. **Introduction to Power Electronics**: scope, applications, and historical development	2	Comprehensive slides Blackboard annotations Oriented discussions on the subject	
2. **Ideal Switches and Switching Concepts**: switching behavior, power loss mechanisms	2		
3. S**emiconductor Devices**: BJT, MOSFET, IGBT, diode characteristics and switching losses	2		
4. **DC-DC Step-Down (Buck) Converter**: steady-state and dynamic behavior, efficiency	2		
5. **DC-DC Step-Up (Boost) and Buck-Boost Converters**: inductor design, voltage stress	2		
6. **Isolated Converters**: Flyback, Forward, Push-Pull topologies, transformer design	2		
7. **Output Rectification and Filtering**: continuous and discontinuous conduction modes	2		
8. **AC-DC Conversion**: single and three-phase rectifiers, power factor correction (PFC)	2		
9. **DC-AC Conversion**: inverter operation, PWM strategies	2		
10. **Modeling of Converters**: averaged switch modeling, small-signal transfer functions	2		
11. **Control of Power Converters**: feedback loop design, compensator selection	2		
12. **Digital Implementation Considerations**: sampling, quantization, delays	2		
13. **Thermal Management and Magnetic Components**: core loss, winding loss, EMI	2		
14. **Review and Case Studies**: EV charging, UPS systems, industrial applications	2		

Bibliography:
1. Kassakian, John G., David J. Perreault, George C. Verghese, and Martin F. Schlecht. *Principles of Power Electronics*. Cambridge University Press, 2024.
2. Frede Blaabjerg, Control of Power Electronic Converters and Systems, Academic Press, Elsevier, 2021
3. Trzynadlowski Andrzej M., Power Electronic Converters and Systems, New York, 2015
4. Seddik Bacha et al., Power Electronic Converters Modeling and Control, Springer, 2014
5. Nicolae-Corvin Palaghiță, Incursiuni prin automatică și electronică de putere, Risoprint, 2024
6. Clement Festila, Roxana Both, Electronica: Indrumator de lucrari, UTPRESS, 2009
7. Roxana Rusu-Both, Clement Festila, Electronica de putere – indrumator de lucrari, Mediamira, 2018

9.2.1. Laboratory	Hours HEI	Hours CO	Teaching methods	Obs.
1. Safety rules. Switching waveform characterization of BJTs and MOSFETs	2		Guided practical, Hands-on experiments, Live analysis, Task-based exercise	
2. Buck and Boost converter experiments	2			
3. Gate drivers for thyristors and TRIACs	2			
4. Controlled rectifiers: PFC circuits and EV battery charging methods	2			
5. Flyback converter design and simulation	2			
6. Inverter testing and field-oriented control (FOC)	2			
7. Lab exam	2			

Bibliography

1. Roxana Rusu-Both, Clement Festila, Electronica de putere – Indrumator de lucrari, Mediamira, Cluj-Napoca, 2018
2. Kassakian, John G., David J. Perreault, George C. Verghese, and Martin F. Schlecht. *Principles of Power Electronics*. Cambridge University Press, 2023.
3. Frede Blaabjerg, Control of Power Electronic Converters and Systems, Academic Press, Elsevier, 2021
4. Trzynadlowski Andrzej M., Power Electronic Converters and Systems, New York, 2015
5. Seddik Bacha et al., Power Electronic Converters Modeling and Control, Springer, 2014

9.2.2. Project - PAS ELECTRONIC MARSHALLING CABINET Design	Hours HEI	Hours CO	Teaching methods	Obs.
1. Topology selection based on specifications and best practice		2	Collaborative work, Template-based design, Implementation Visual modeling, Scenario setup, Execution and debug, Oral presentation and defense	
2. Component selection and positioning (AutoCAD Electric)		2		
3. Power and heat dissipation calculations		2		
4. Electrical diagram design (AutoCAD Electric)		2		
5. Bill of materials report		2		
6. Assembly example		2		
7. Presentation and peer review		2		

Bibliography

1. Roxana Rusu-Both, Clement Festila, Electronica de putere – Indrumator de lucrari, Mediamira, Cluj-Napoca, 2018
2. Kassakian, John G., David J. Perreault, George C. Verghese, and Martin F. Schlecht. *Principles of Power Electronics*. Cambridge University Press, 2023.
3. Frede Blaabjerg, Control of Power Electronic Converters and Systems, Academic Press, Elsevier, 2018
4. Trzynadlowski Andrzej M., Power Electronic Converters and Systems, New York, 2015
5. Seddik Bacha et al., Power Electronic Converters Modeling and Control, Springer, 2014
6. DeltaV BookOnline
7. E&I 001 – Hardware engineering level 1

10. Correlation of course content with the expectations of the epistemic community representatives, professional associations, and major employers in the field related to the program

This course content aligns with academic best practices and industry needs, particularly Emerson’s expectations for automation and energy efficiency. The curriculum supports automation engineer, hardware design engineer and power electronics design engineer roles, addressing technical skills such as switching converter control, simulation proficiency, and integration with embedded platforms.

11. Evaluation

Activity Type	Evaluation criteria	Evaluation methods	Weight in final grade
11.1 Lecture	Conceptual understanding and design formulation	Written exam	50%
11.2.1 Laboratory	Practical circuit analysis, implementation, reporting	Continuous in-lab evaluation + final report	20%
11.2.2. Project	Functional project design and technical presentation	Oral presentation + report	30%
11.3 Minimum Performance Standard			
• Final exam >=5 • Lab grade>=5 mandatory to be able to take the final exam • Project grade>=5 mandatory to be able to take the final exam **50% Final exam + 20% Lab Grade + 30% Project grade > 5**			

Date of completion: 15.09.2025	Lecturers		Signature
	Course	Assoc.Prof.Eng. Roxana Rusu-Both, PhD	
	Applications	Assoc.Prof.Eng. Roxana Rusu-Both, PhD	

Date of approval by the Department of Automation Council 24.11.2025	Director of the Department of Automation Prof.dr.ing. Honoriu VĂLEAN
Date of approval by the Faculty of Automation and Computer Science Council 28.11.2025	Dean Prof.dr.ing. Vlad MUREȘAN