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	33.00

2. Course information

2.1 Course title	**Signal Processing**				
2.2 Course lecturer	SL.dr.ing. Mircea ȘUȘCĂ – mircea.susca@aut.utcluj.ro				
2.3 Seminar / Laboratory / Project Lecturer	*Ing. Baciu Alexandrina (Emerson)* *Ing. Cioata Andrei (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		Project	
			CO		0		0		2		
3.2 Number of hours per semester	56	of which:	HEI	Lecture	28	Seminar		Laboratory		Project	
			CO		0		0		28		

3.3 Distribution of time allocation (hours per semester) for:	HEI	CO
(a) Study based on textbook, course support, bibliography, and notes	10	16
(b) Additional documentation in library, specialized electronic platforms, and fieldwork	6	19
(c) Preparation of seminars/laboratories, assignments, papers, portfolios and essays	0	8
(d) Tutoring	3	2
(e) Examinations	3	2
(f) Other activities:		
3.4 Total individual study hours (sum (3.3(a)... 3.3(f)))	22	47
3.5 Total hours per semester (3.2+3.4)	50	75
3.6 Number of credits per semester	2	3

(HEI = Higher Education Institution, CO = Company)

4. Prerequisites (where applicable)

4.1 Curriculum Prerequisites	• Linear Algebra, Calculus, Special Mathematics, Statistics and Numerical Calculus
4.2 Competency Prerequisites	• Differential and difference equations, Laplace, Z and Fourier Transforms, Basic software and computer programming skills

5. Conditions (where applicable)

5.1. Course Organization Conditions	• Amphitheatre, Technical University of Cluj-Napoca
5.2. Seminar / Laboratory / Project organization conditions	• Laboratory, Emerson. Attendance to the laboratory is mandatory.

6. Specific Competencies Acquired

Professional Competencies	• PC02 Analyse test data • PC08 Design automation components • PC09 Design prototypes • PC19 Prepare production prototypes • PC20 Record test data • PC26 Use information technology tools • PC27 Execute analytical mathematical calculations • PC30 Design control systems
Transversal Comp	• TC01 Apply knowledge of science, technology and engineering • TC05 Interpret mathematical information

7. Learning outcomes

Knowledge:	• Understanding of signal types, properties, and their representation in analog and digital systems. • Understanding of LTI systems, convolution, system response, and system interconnections. • Use of mathematical tools including Fourier series, Fourier transforms (1D & 2D), Laplace, Z, Mellin, and Hilbert transforms. • Comprehension of sampling theorems, aliasing, and signal modulation techniques. • Familiarity with signal processing applications in control systems, communication protocols, and image processing.
Skills:	• Analyze, model, and simulate signal behavior in continuous and discrete-time domains. • Design and interpret Bode plots, frequency responses, and apply filter design principles. • Apply and compute discrete transforms (FFT, DFT, STFT, wavelet) in real-world signal scenarios. • Implement and evaluate control systems using signal-based feedback mechanisms. • Develop and troubleshoot modulation, transmission, and error-correction schemes in communication systems. • Perform practical signal analysis using computational tools (e.g., MATLAB, Python).
Responsibility and autonomy:	• Independently analyze complex signal systems and propose appropriate processing or control strategies. • Demonstrate autonomy in selecting and applying transform methods suited to specific engineering problems. • Take responsibility for validating system performance under various signal conditions and ensuring signal integrity. • Collaborate effectively in interdisciplinary projects involving signal-based automation, control, and communication systems. • Maintain ethical and professional standards in signal acquisition, processing, and reporting within engineering contexts.

8. Course Objectives

8.1 General objective of the course	• Develop a comprehensive understanding of signal and system theory fundamentals. • Analyze and apply key signal processing techniques such as convolution, Fourier analysis, and transformations. • Utilize software tools like MATLAB and Simulink to implement, simulate, and test signal processing and control strategies, linking theoretical concepts with practical applications.

	• Ability to connect signal processing principles with communication protocols, modulation, and process control, enhancing interdisciplinary understanding and readiness for industry challenges.
8.2 Specific objectives	• Understand the different types of signals (analog, digital, periodic, aperiodic) and systems (LTI, causal, stable) and analyze their properties and behaviors in control automation contexts. • Demonstrate knowledge of sampling theorem, aliasing effects, and the use of sample-and-hold circuits and analyze their implications for real-world signal acquisition and processing. • Represent signals using Fourier series, Fourier transforms, DFT, and FFT, and apply these techniques to analyze system frequency response and design digital filters in automation systems. • Use Laplace, Z, Mellin, and Hilbert transforms to analyze system stability, response characteristics, and to develop and evaluate control algorithms in automation and computing applications. • Analyze feedback control systems' stability, gain, and phase margins using Bode plots, and design PID controllers for process regulation. • Use P&ID notation and understand communication protocols for transmitting signals (e.g., modulation, error correction) in automation environments, ensuring clarity and reliability in signal transmission.

9. Contents

9.1 Lectures	No. of hours	Teaching methods	Obs.
1. The concept of signal. The concept of system. Examples of signal processing in control automation	2	Theoretical presentation, discussions, interpretations, proofs. Applications and examples.	Exposition using the video-projector and the board
2. Signal classification and properties. Analog and digital signals. Analog and digital inputs/outputs in distributed control systems. Unified signals	2		
3. System properties and interconnections. LTI systems. Causality, stability, interconnection of LTI systems.	2		
4. Convolution of signals. Representing signals in terms of impulses. Discrete LTI systems. Sampling and aliasing. Sample and hold circuits. Practical implications	2		
5. Vector spaces and projections. Mathematical foundations: projections on orthogonal function systems	2		
6. Fourier Series and signal approximation. Representation of periodic signals. Truncated Fourier series, convergence, and application scenarios	2		
7. Frequency response of LTI systems. Bode plots. Continuous and discrete linear filters. Applications	2		
8. Fourier transform and applications. Discrete Fourier Transform and Fast Fourier Transform algorithm. Nyquist frequency	2		

9. 2D convolution. Sampling theorem and aliasing. 2D Fourier transform. Applications in image processing	2		
10. Short-time Fourier transform. Time versus frequency resolution. Rayleigh frequency. Wavelet transform	2		
11. Advanced transform techniques. Review of Laplace and Z transforms. Mellin, Hilbert transforms. Applications in automation and computer science	2		
12. Communication protocols. Signal modulation. AM, FM, phase modulation, error detection/correction algorithms.	2		
13. Feedback LTI systems: a circuit theory overview. Stability analysis, frequency response, Bode plots, gain and phase margins. Sensitivity analysis	2		
14. Process control: P&ID notation. P, PI, PID controllers. Course overview through case studies	2		

Bibliography

1. A.V. Oppenheim, A.S. Willsky, S.H. Nawab, Signals & Systems, Prentice Hall Signal Processing Series, Second Edition, 1996.
2. A. Mateescu, Semnale, circuite și sisteme, București: Editura Didactică și Pedagogică, 1984.
3. J. G. Proakis, D. K. Manolakis. Digital Signal Processing: Principles, Algorithms and Applications. 3rd Edition, Prentice-Hall, Inc. 1996.
4. G.F. Franklin, J.D. Powell, M.L. Workman, Digital Control of Dynamic Systems, Addison-Wesley, 1998.
5. J. Love, Process Automation Handbook: A Guide to Theory and Practice, Springer, 2007.
6. C.-T. Chen, Linear System Theory and Design, Oxford University Press, Third Edition, 1999.
7. G.K. McMillan, D.M. Considine, Process/Industrial Instruments and Controls Handbook, Fifth Edition, McGraw-Hill, 1999.
8. L.R. Rabiner, B. Gold, Theory and Application of Digital Signal Processing, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1975.
9. E.S. Gopi. Algorithm Collections for Digital Signal Processing Applications Using Matlab, Springer, 2007.

9.2 Seminar / laboratory / project	Hours HEI	Hours CO	Teaching methods	Obs.
1. Using MATLAB for signal processing. Standard functions for declaring, analyzing and manipulating signals		4	Development of software applications in MATLAB/ Simulink	
2. Continuous-time and discrete-time convolution. Elementary signals. Outputs of LTI systems. Properties and interconnections of LTI systems		4		
3. Periodic signals. Fourier series. MATLAB representation and compression		4		
4. Discrete Fourier Transform and Fast Fourier Transform algorithm. Applications using sensor data. Frequency response of LTI systems. Bode plots		4		
5. 2D convolution. Sampling and aliasing. Short-time Fourier transform and Wavelet transform. Time- and frequency-domain KPIs for industrial applications		4		
6. Signal modulation. AM, FM, phase modulation, error detection/correction algorithms. Applications in industrial communications		4		
7. End-of-semester evaluation based on problem solving using pen and paper, alongside MATLAB		4		

Bibliography

1. S. Chapman, MATLAB Programming for Engineers, Thomson, 2008.

2. A.V. Oppenheim, A.S. Willsky, S.H. Nawab, Signals & Systems, Prentice Hall Signal Processing Series, Second Edition, 1996.
3. J. Love, Process Automation Handbook: A Guide to Theory and Practice, Springer, 2007.
4. G.F. Franklin, J.D. Powell, M.L. Workman, Digital Control of Dynamic Systems, Addison-Wesley, 1998.

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

- The course covers essential signal processing techniques, including Fourier analysis, system identification, filters, and transforms, which are fundamental for designing, analyzing, and optimizing control systems. These skills are directly applicable in advanced automation platforms, digital twins, predictive analytics, and cybersecurity in industrial settings, reflecting current industry trends and standards promoted by organizations such as ISA (International Society of Automation) and IEEE (Institute of Electrical and Electronics Engineers).
- Employers seek engineers proficient in modeling, analyzing, and implementing control systems in complex environments. The course's emphasis on real-world applications—like control system stability, digital communication protocols, and the integration of signal processing within automation—prepares students to meet these expectations, especially in fields requiring expertise in industrial data analytics, automation solutions, and embedded systems.
- Coupled with related courses such as "System Identification," "Power Electronics in Automation," and "Cybersecurity for Industrial Automation," the course equips students with a comprehensive understanding of how signal processing underpins various aspects of automation engineering, from hardware integration to software control, thus fulfilling the multidisciplinary nature expected by professional bodies.
- The curriculum's inclusion of modern topics like digital transformation, data analytics, and system testing supports professional growth and certification pathways by providing essential knowledge aligned with current and future industrial requirements.

11. Evaluation

Activity Type	**Evaluation criteria**	**Evaluation methods**	**Weight in final grade**
11.1 Lecture	Acquired theoretical knowledge	Written exam	50 %
11.2 Seminar/ Laboratory/Project	Acquired practical skills	Practical exam	50 %
11.3 Minimum Performance Standard			

Date of completion: 14.05.2025	Lecturers	Title First Name LAST NAME	Signature
	Course	SL.dr.ing. Mircea ȘUȘCĂ	

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