# SYLLABUS

## 1. Information about the program

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|---|---|
| **1.1** Higher education institution | Universitatea Politehnica Timișoara |
| **1.2** Faculty[1] / Department[2] | Electronics Telecommunications and Information Technologies/ Communications |
| **1.3** Field of study (name/code[3]) | Electronics Telecommunications and Information Technologies Engineering / 20.20.10 |
| **1.4** Study cycle | Master |
| **1.5** Study program (name/code/qualification) | Communications Networks Engineering / 20.20.10 / 2153 |

## 2. Information about discipline

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|---|---|---|---|---|---|---|---|
| **2.1a** Name of discipline/The educational classe[4] | Advanced Topics in Signal Processing /DS | | | | | | |
| **2.1b** Name of discipline in Romanian | Teme Avansate în Prelucrarea Semnalelor | | | | | | |
| **2.2** Coordinator (holder) of course activities | Prof. dr. eng. Corina Nafornita | | | | | | |
| **2.3** Coordinator (holder) of applied activities[5] | Prof. dr. eng. Corina Nafornita | | | | | | |
| **2.4** Year of study[6] | 1 | **2.5** Semester | 1 | **2.6** Type of evaluation | E | **2.7** Regime of discipline[7] | DOB |

## 3. Total estimated time (direct activities (fully assisted), partially assisted activities and unassisted activities[8])

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **3.1** Number of hours fully assisted/week | 4 ,of which: | course | 2 | seminar/laboratory/project | | | 0/1/1 |
| **3.1*** Total number of hours fully assisted/sem. | 56 ,of which: | course | 28 | seminar/laboratory/project | | | 0/14/14 |
| **3.2** Number of on-line hours fully assisted/sem | ,of which: | course | | seminar/laboratory/project | | | |
| **3.3** Number of hours partially assisted/week | ,of which: | project, research | | training | | hours designing M.A. dissertation | |
| **3.3*** Number of hours partially assisted/ semester | ,of which: | project of research | | training | | hours designing M.A. dissertation | |
| **3.4** Number of hours of unassisted activities/ week | 4.93 ,of which: | Additional documentation in the library, on specialized electronic platforms, and on the field | | | | | 2 |
| | | Study using a manual, course materials, bibliography and lecture notes | | | | | 1.93 |
| | | Preparation of seminars/ laboratories, homework, assignments, portfolios, and essays | | | | | 1 |
| **3.4*** Total number of hours of unasssited asctivities/ semester | 69 ,of which: | Additional documentation in the library, on specialized electronic platforms, and on the field | | | | | 28 |
| | | Study using a manual, course materials, bibliography and lecture notes | | | | | 27 |
| | | Preparation of seminars/ laboratories, homework, assignments, portfolios, and essays | | | | | 14 |
| **3.5 Total hrs./week[9]** | 8.93 | | | | | | |
| **3.5* Total hrs./semester** | 125 | | | | | | |
| **3.6 No. of credits** | 5 | | | | | | |

## 4. Prerequisites (where applicable)

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| **4.1** Curriculum | • Mathematics, Information Theory and Coding, Computer Programming, Physics, Electrical and electronic measurements, Signals and systems, Digital Signal Processing, Image Processing, Digital Radio Communications |
| **4.2** Learning outcomes | • Differential calculus, integral calculus, calculus using distributions, electronic circuits analysis, Matlab, statistics |

## 5. Conditions (where applicable)

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| **5.1** of the course | • Laptop, Videoprojector, Whiteboard |
| **5.2** to conduct practical activities | • Laboratory with 8 workstands, equipped with software such as Matlab/Wavelab |

**6. Learning outcomes** acquired through this discipline

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|---|---|
| Knowledge | • C1. The student/graduate knows research methods, techniques and paradigms; C5. The student/graduate knows concepts and methodologies from several fields; C6. The student/graduate understands algorithms and structures for data processing; C8. The student/graduate knows the terminology and conventions of technical communication<br>• C9. The student/graduate knows ways to integrate knowledge from various fields; CT1. The student/graduate knows ethical norms and citation rules; CT3. The student/graduate understands the structure and style of academic and technical texts |
| Skills | • A1. The student/graduate applies qualitative and quantitative methodologies; A4. The student/graduate processes, eliminates or corrects errors in a data set and interprets complex data; A5. The student/graduate integrates interdisciplinary methods and perspectives; A7. The student/graduate presents ideas and results in academic/professional contexts |
| Responsibility and autonomy | • RA1 The student/graduate independently manages a research process and critically evaluates the results<br>• RA4 The student/graduate ensures the correctness and relevance of the conclusions drawn; RA7 The student/graduate ensures the quality and compliance with academic norms; RA8 The student/graduate adapts to various professional communication contexts |

**7. Objectives of the discipline** (based on the grid of learning outcomes acquired)

- Developing advanced skills in signal processing by deepening fundamental concepts and modern methods of analysis, estimation and detection, with applicability in imaging, communications, radar and navigation
- This course is intended to give knowledge and competences in using wavelets in signal processing, to introduce the problem of statistical signal processing, estimation and detection. Other major goals are to introduce the problem of radar used in automotive (problems of estimation of range and velocity and tracking), some notions in satellite navigation and in SAR image processing. These topics are present in almost all M.Sc. telecommunications curricula, worldwide. The importance of using wavelets and statistical signal processing in communication engineering and other related fields is obvious. This course offers an essential support for other courses dealing with transmission over fading channels and multipath channels and for the general theory of digital modulation

**8. Content**

| **8.1** Course | Number of hours | Of which online | Teaching methods |
|---|---|---|---|
| Wavelets. The concept of multiresolution. DWT transform. Wavelet/WaveLab toolboxes.<br>Cramer-Rao Lower Bound. Minimum Variance unbiased estimation; Cramer-Rao theorem. Examples<br>Maximum Likelihood Estimation. The likelihood function. The concept of estimation with maximum likelihood. Algorithms for ML estimation. Examples<br>Least Squares Estimation. The estimation problem in the case of lack of any statistical properties. Computer minimization techniques of the cost function. Basics on Kalman filtering. Some examples<br>Neyman-Pearson Detection Strategy. The constant false alarm criterion. Detection threshold. Probability of correct detection. Some applications in image processing, database searching, RADAR/SONAR | 28 | | Slides, writing on whiteboard, Q&A |

| | | | |
|---|---|---|---|
| Bayesian Detection Strategy. The risk function. Detection using the minimum risk rule. ML Bayesian detection and MAP Bayesian detection. Examples of using the Bayesian strategy in communications. ML and MAP receivers<br>Radar: Target detection. Estimation of range and velocity, for relative short distance, applicable in automotive. Tracking techniques in radar, especially Kalman-filtering based ones<br>Selected topics in satellite navigation: EGNOS | | | |
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| Bibliography[10] | Steven M. Kay, Fundamentals of Statistical Signal Processing, Prentice Hall, 1993 (vol. I), 1998 (vol. II).<br>Petre Stoica, Randolph Moses, Spectral Analysis of Signals, Prentice Hall, 2005.<br>Mark A. Richards, Fundamentals of RADAR Signal Processing, 2nd Edition, McGraw Hill Education, 2014.<br>Corina Nafornița, Digital Watermarking in the Wavelet Domain, Editura Politehnica, 2005.<br>Corina Nafornița, Alexandru Isar, Signals and Systems, vol. 1 și 2, Editura Politehnica, 2009, 2016.<br>Sidney Burrus, Ramesh A. Gopinath, Haitao Guo, "Introduction to Wavelets and Wavelet Transform: A Primer", Prentice Hall<br>C. Oliver, S. Quegan, Understanding Synthetic Aperture Radar Images, SciTech Publishing, 2004.<br>P. Misra, P. Enge, Global Positioning System: Signals, Measurements and Performance, 2nd ed., 2012.<br>Phil Kim, Kalman Filter for Beginners: with MATLAB Examples, 2011.<br>SM Patole et al., Automotive Radars: A Review of Signal Processing Techniques, IEEE SPS Magazine, 2017.<br>Eds Yonina Eldar, Gitta Kutyniok, Compressed Sensing: Theory and Applications, Cambridge University Press, 2012 |

| **8.2** Applied activities[11] | Number of hours | Of which online | Teaching methods |
|---|---|---|---|
| Laboratory: The student will implement in Matlab/Python a chosen algorithm, starting with a reference paper in the field of statistical signal processing. Example of topics are: texture retrieval using wavelets, simulation of range-Doppler map for radar in order to detect multiple targets (pedestrians for example), based on the rapid chirp waveform. tracking for automotive radars, SAR image processing, EGNOS navigation improvement. Here the students will benefit from access to the data collected by the ESA Romanian network at three technical universities of Timisoara, Cluj and Iasi | 14 | | Matlab/Python implementation, Report, presentation, Q&A |
| Project: The student will make a report regarding a chosen topic, starting with a reference paper, which will contain the theoretical part. Example of topics are given above. | 14 | | |
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Bibliography[12] IEEE SPS Magazine


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H. Rohling, "RADAR CFAR Thresholding in Clutter and Multiple Target Situations", IEEE Transactions in Aerospace and Electronic Systems, 1983.

*Steffen Heuel, Radar Waveforms for A&D and Automotive Radar , White Paper, Rohde&Schwarz, 2013,*

*SM Patole, M Torlak, D Wang, M Ali, Automotive Radars: A review of signal processing techniques, IEEE Signal Processing Magazine, 2017*

*Adrian Macaveiu, Corina Nafornita, Alexandru Isar, Andrei Campeanu, Ioan Nafornita, A Method for Building the Range-Doppler Map for Multiple Automotive Radar Targets, 11th Int. Symposium on Electronics and Telecommunications (ISETC), 2014, 14-15 Nov. 2014*

*Adrian MACAVEIU, Andrei CAMPEANU, Ioan NAFORNITA, Kalman-Based Tracker for Multiple Radar Targets, pp 69-72. May 29-31, 2014, Bucharest, 10th International Conference on Communications*

*Corina Nafornita, A. Isar, N. Matanie and Cristian Caba, Solution of a Big Data Problem. Simulator for Denoising of Single Look Complex SAR Images, 13-th Int. Symp. on Signals, Circuits and Systems, ISSCS 2017, July 13-14, 2017, Iasi, Romania*

*P. Misra, and P. Enge, Global positioning system: Signals, measurements and performance, 2nd edition, Ganga-Jamune Press, USA, Massachusetts, 2012*

*C.Nafornita et al. Romania Monitoring Station Network to Support EGNOS Services in Eastern Europe, 2018 International Symposium on Electronics and Telecommunications (ISETC), Nov 8-9, 2018, Romania*


**9. Evaluation**

| Type of activity | **9.1** Evaluation criteria[13] | **9.2** Evaluation methods | **9.3** Share of the final grade |
|---|---|---|---|
| **9.4** Course | Written exam, open book | The evaluation is based on the written exam which is the treatment of a topic with a minimum of three bibliographical references referenced in the text | 1/4 |
| **9.5** Applied activities | **S:** | | |
| | **L:** Ability to understand and implement an existing algorithm in language such as Matlab or Python | The evaluation is based on laboratory reports (theory and simulations) | |
| | **P:** Ability to present a report on a chosen topic | The evaluation is based on the final project (documentation, analysis and implementation) | 1/4 |
| | **Pr:** | | 1/4 |
| | **Tc-R[14]:** | | |
| **9.6** Minimum performance standard (minimum amount of knowledge necessary to pass the discipline and the way in which this knowledge is verified[15] | | | |
| • Ability to understand and write a report on a given subject, with proper references for exam; ability to understand and present the subject chosen for the laboratory and project | | | |

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|---|---|---|
| **Date of completion**<br>23.09.2025 | **Course coordinator (signature)** | **Coordinator of applied activities (signature)** |
| **Head of Department (signature)** | **Date of approval in the Faculty Council** [16]<br>07.10.2025 | **Dean (signature)** |