# POLITEHNICA University of Bucharest

# Faculty of Electronics, Telecommunications and Information Technology

**COURSE DESCRIPTION**

**1. Program identification information**

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| 1.1 Higher education institution | POLITEHNICA University of Bucharest |
| 1.2 Faculty | Electronics, Telecommunications and Information Technology |
| 1.3 Department | Applied Electronics and Information Engineering |
| 1.4 Domain of studies | Computers and Information Technology |
| 1.5 Cycle of studies | Bachelor’s degree |
| 1.6 Program of studies/Qualification | Information Engineering |

**2. Course identification information**

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| 2.1 Name of the course | | | | Digital Signal Processing | | | |
| 2.2 Lecturer | | | | Prof. dr. ing. Victor-Emil Neagoe | | | |
| 2.3 Instructor for practical activities | | | | S.l. dr. ing. Adrian-Dumitru Ciotec | | | |
| 2.4 Year of studies | III | 2.5 Semester | II | 2.6 Evaluation type | Exam | 2.7 Course choice type | Compulsory |

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

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| 3.1 Number of hours per week, out of which | 5 | | 3.2 course | 3 | 3.3 practical activities | 2 |
| 3.4 Total hours in the curricula, out of which | 70 | | 3.5 course | 42 | 3.6 practical activities | 28 |
| Distribution of time | | | | | | hours |
| Study according to the manual, course support, bibliography and hand notes | | | | | | 45 |
| Supplemental documentation (library, electronic access resources, in the field, etc) | | | | | | 5 |
| Preparation for practical activities, homeworks, essays, portfolios, etc. | | | | | | 15 |
| Tutoring | | | | | | 0 |
| Examinations | | | | | | 5 |
| Other activities | | | | | | 0 |
| 3.7 Total hours of individual study | | 70 | | |  |  |
| 3.9 Total hours per semester | | 140 | | |  |  |
| 3. 10 Number of ECTS credit points | | 4 | | |  |  |

**4. Prerequisites (if applicable)**

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| 4.1 curricular | 1. Special Mathematics;  2. Signals and Systems; |
| 4.2 competence-based | Programming skills in Matlab environment. |

**5. Requisites (if applicable)**

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| 5.1 for running the course | Not the case. |
| 5.2 for running of the applications | Compulsory attendance at labs. |

**6. Specific competences**

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| Professional competences | C6.1  Characterization of signals in the time domain and the frequency domain  C6.2  Proper use of the methods for aquisition and processing of analog signals  C6.3  Use of simulation environments for digital signal analysis and processing  C6.4  Use of specific methods and tools for signal analysis  C6.5  Design of elementary functional blocks for digital signal processing |
| Transversal  competences | CT1. Honorable, responsible, ethical and in the spirit of law behavior to ensure the reputation of the profession |

**7. Course objectives (as implied by the grid of specific competences)**

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| 7.1 General objective of the course | The main purpose of this subject is to develop the student abilities to understand and apply the general knowledge of digital signal processing, particularly for signals specific to telecommunications (according to grid 1L of specific competences). The course presents the basic principles for discrete time signal processing: theory, algorithms, architectures, and applications. |
| 4.2 Specific objectives | *– For courses:*  The students will obtain the following abilities:  • to analyze and process the data sequences  • to represent data sequences in the frequency domain and in the Z domain  • to analyze and design digital filters  • to estimate power spectrum of data sequences  *– For applications:*  The students will learn to work with the following Matlab applications :  • to implement 1D and 2D Fourier Transform as well as Z transform  • to analyze, design and implement digital filters  • to design and implement a spectral estimator |

**8. Contens**

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| 8.1 Lectures | Teaching techniques | Remarks |
| *Sampling theorems.* Variants. Error evaluation. | Most of teaching time (90%) course presentation uses the video projector (corresponding to the communication and demonstrative functions). The oral communications methods are expositive method and questioning method. For explanation or pointing out some details/examples, one has made “zoom” using the old classic method with chalk and sponge on the blackboard (for 10% of time). The lecture notes are given to the students in electronic form. | 2 h |
| *Signals and systems in discrete time.* Discrete-time systems. Linear and invariant discrete-time systems. Stability. Causality. Linear equations with finite differences . Frequency domain representation for discrete time signals and systems. Fourier transform of data sequences. | 6 h |
| *Z Transform.* Definition, convergence domain and properties of the Z transform. The Z transforms of elementary functions. Methods of computation of the inverse Z transform. | 4 h |
| *Frequency response of linear and invariant discrete-time systems.* Frequency response for rational system functions. Minimum phase systems. Linear phase and generalized linear phase systems. | 3 h |
| *Structures of discrete-time systems. Block diagram for systems represented by finite difference linear equations.* Basic structures for digital filters with infinite impulse response (IIR). Basic structures for digital filters with finite impulse response (FIR). Structures for linear phase FIR systems. Effects of coefficient quantization. | 6 h |
| *Design of FIR systems.* Synthesis of linear phase FIR systems. Windows method. Fourier series method. Frequency sampling method. Optimization methods. | 6 h |
| *Design of IIR systems.* Design of IIR systems starting from corresponding continuous systems (method of impulse response invariance; discretization of differential equation characterization the continuous system, biliniar transform, adaptive Z transform, frequency transforms). Optimization methods. | 6 h |
| *Discrete Fourier Transform.* Definition of discrete Fourier transform for periodical sequences. Properties. Discrete cosine transform. Algorithms for fast Fourier transform (FFT). | 3 h |
| *Spectral analysis of sequences.* Definition of periodogram. Periodogram computation. Spectral estimation using estimation of discrete autocorrelation. Linear prediction and correlation. Spectral analysis using AR, MA and ARMA. | 6 h |
| Bibliography  (1) A. V. Oppenheim, R.W. Schafer, Discrete-Time Signal Processing, Prentice-Hall, 2001.  (2) V. Neagoe, "Chebyshev Nonuniform Sampling Cascaded by Discrete Cosine Transform for Optimum Interpolation", IEEE Transactions on Signal, Acoustics and Speech Processing, vol. 38, nr. 10, October 1990, pp. 1812-1816.  (3) V. Neagoe, “A two-dimensional nonuniform sampling expansion model”, Signal Processing, Elsevier, Amsterdam-New York, vol. 33, (1993), 1-21.  (4) Ad. Mateescu, S. Ciochină, N. Dumitriu, Al. Şerbănescu, L. Stanciu, Prelucrarea numerică a semnalelor, Ed. Tehnică, 1997; | | |
| 8.2 Practical applications | Teaching techniques | Remarks |
| Discrete and Continuous-Time Signals | All the laboratory works use Matlab environment simulation. The lab platforms are available for the students in their electronic form. Sometimes one complementary uses the classical method with chalk, sponge and blackboard.  Students independently simulate, implement, test and evaluate same problems by using the computer and software environment. | 2 h |
| Discrete-Time Systems | 2 h |
| Frequency Analysis | 2 h |
| Discrete Fourier Transform | 2 h |
| Discrete-Time Random Processes | 4 h |
| Power Spectrum Estimation | 4 h |
| Digital Filter Design | 4 h |
| Speech Processing | 2 h |
| Image Processing | 2 h |
| Bibliography  http://www.victorneagoe.com/university/dsp/lab.html | | |

9. Bridging the course content with the expectations of the epistemic community representatives, professional associations and employers representatives for the domain of the program

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| The course curriculum corresponds to the present requirements for development and evolution characterizing UE economy and services belonging to the field of Applied Electronics.  Knowledge and techniques included in the curriculum of the course has wide practical applications for various fields: audio signal processing, audio compression, digital image processing, video compression, speech processing, speech recognition, digital communications, seismology and so on.  The curriculum provides to the graduates competences adequate to the present necessities as well as a modern high quality scientific and technical training; this can aid the graduates to fast find a job. The curriculum is in accordance to the policy of the Politehnica University of Bucharest, both from the point of view of their contents and structure and also from the point of view of training and international opening offered to the students. |

**10. Evaluation**

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| Type of activity | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Weight in the final mark |
| 10.4 Lectures |  | Written work for partial examination (1.5 hours in 9th week corresponding to 50% of course contents) | 35% |
| Final written examination (1.5 hours corresponding to the rest 50% of course contents non-included in the first verification) | 35% |
| 10.5 Practical applications | – learning algorithm designing to solve a specific problem;  – learning to write the corresponding Matlab code for a given algorithm  – demonstration of operation for an implemented algorithm  – ability to solve and implement in Matlab an elementary problem  – ability to comparatively analyze the studied techniques and algorithms | Laboratory assessment (last week) | 30% |
| 10.6 Minimal performance standard | | | |
| Simultaneously satisfying the following conditions:  • scoring 50 % out of the total score  • scoring 50 % out of the score of the written work for partial examination  • scoring 50 % out of the total lab score | | | |

Date Lecturer Instructor for practical activities

Prof. dr. ing. Victor Neagoe S.l. dr. ing. Adrian Ciotec

20.10.2015 ............................................. .............................................

Date of department approval Director of Department,

Prof. dr. ing. Sever Paşca

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