**COURSE OUTLINE**

## (1) GENERAL

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|---|---|---|---|
| **SCHOOL** | SCHOOL OF ENGINEERING | | |
| **ACADEMIC UNIT** | DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING | | |
| **LEVEL OF STUDIES** | UNDERGRADUATE | | |
| **COURSE CODE** | EEE.7-2.3 & EEE.7-3.3 | **SEMESTER** | 7 |
| **COURSE TITLE** | Digital Signal Processing | | |

| **INDEPENDENT TEACHING ACTIVITIES**<br>*if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits* | **WEEKLY TEACHING HOURS** | **CREDITS (ECTS)** |
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| Lectures | 4 | 6 |
| Laboratory | 1 | |
| *Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).* | | |

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| **COURSE TYPE**<br>*general background, special background, specialised general knowledge, skills development* | Special Background Course (SBC) |
| **PREREQUISITE COURSES:** | Signals and Systems |
| **LANGUAGE OF INSTRUCTION and EXAMINATIONS:** | Greek |
| **IS THE COURSE OFFERED TO ERASMUS STUDENTS** | YES (in English) |
| **COURSE WEBSITE (URL)** | https://eee.uniwa.gr/en/studies/undergraduate/curriculum |

## (2) LEARNING OUTCOMES

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| **Learning outcomes**<br>*The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.*<br>*Consult Appendix A*<br>• *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*<br>• *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*<br>• *Guidelines for writing Learning Outcomes* |
| The course is all about concepts and methods of processing discrete time as well as digital signals. Examples range from digital filtering methods up to spectral analysis. Its aim is to provide the |

postulates and methods of Digital Signal Processing by means of: a) the fundamental concepts for representing discrete time or digital signals and systems, in both time and frequency domains and b) the signal-system interactions with emphasis to specific designs.
Having successfully completed the course module, the students will possess advanced knowledge, skills and competences in the subject of Digital Signal Processing that enable them to:

1. Describe generic as well as specific DSP processes by block diagrams.
2. Select the appropriate form of digital system description, among alternatives, for the problem at hand.
3. Perform spectral analysis of digital signals and systems using simulation tools for the computation of the digital output signal.
4. Interpret the results of spectral analysis of digital signals and systems, so as to conclude on their characterization and classification.
5. Analyze signal processing problems under realistic application scenarios (processing of audiovisual / biomedical / telecom signals) and derive solutions (design digital systems) on the basis of methods taught in the course.
6. Collaborate with fellow students in a team, in order to thoroughly address complex DSP problems (analysis – synthesis) and to critically evaluate alternative solutions, leading to decisions as to the feasibility of hardware implementations.

***Keywords**: Discrete time signals and systems, Auto and Cross-correlation, impulse response, FIR, IIR digital filters, DFT, FFT, Spectral Analysis.*

**General Competences**

*Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?*

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| *Search for, analysis and synthesis of data and information, with the use of the necessary technology* | *Project planning and management* |
| *Adapting to new situations* | *Respect for difference and multiculturalism* |
| *Decision-making* | *Respect for the natural environment* |
| *Working independently* | *Showing social, professional and ethical responsibility and sensitivity to gender issues* |
| *Team work* | *Criticism and self-criticism* |
| *Working in an international environment* | *Production of free, creative and inductive thinking* |
| *Working in an interdisciplinary environment* | *……* |
| *Production of new research ideas* | *Others…* |
| | *…….* |

By the end of the course, you will be familiar with the most important methods in DSP, including digital filter design and time – frequency transform-domain processing as well as spectral analysis. As a result, the following skills are endorsed:

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Production of free, creative and inductive thinking

## (3) COURSE CONTENT

*Lectures*

**UNIT I: Introduction (2 weeks)**

1. An introduction to “*the universe of DSP*” topics under the framework of the electrical and electronics engineer. Survey of major modern DSP applications, with emphasis on telecoms.
2. Basic mathematics background revisited (Laplace, Z and Fourier Transforms and Inverses). Discrete-time versus continuous-time signals and systems. Discrete Fourier Transform and Inverse, properties.
3. Methods for simulation and visualization of discrete-time signals and systems realized in popular software (e.g. Matlab).

**UNIT II: Codecs (A/D and D/A conversion) (2 Weeks)**

1. Fundamental theorems and methods, electronic circuits, survey of contemporary hardware available (A/D and D/A convertors, DSP boards) and selection criteria.
2. Introduction to A/D and D/A devices and systems using modern hardware; application to speech and audio signals. Experimental acquaintance with the fundamental characteristics of A/D conversion and their impact on digital signal quality.

**UNIT III: Elementary DSP functions and properties (2 Weeks)**

1. Elementary DSP operations and functions: convolution, (auto-)correlation); methods for their computation in the time and the frequency domains.
2. Use of popular simulation software tools for evaluating the correlation and the convolution of digital signals / systems.

**UNIT IV: The Discrete Fourier Transform (DFT) and its fast implementations (FFT) (3 - Weeks)**

1. Discrete Fourier series (DFS), Discrete Time Fourier Transform (DTFT).
2. Discrete Fourier Transform (DFT).
3. Fast Fourier Transform (FFT). Methods for its computation and algorithmic complexity. Hardware implementations.

**UNIT V: Digital Filter Design (3 weeks)**

1. An introduction to Digital filters. Finite Impulse Response, Infinite impulse response. Filter realization techniques.
2. FIR/IIR filter design. Major design methods for FIR and IIR filters. Window functions and windowing.
3. Design and application of digital filters in specific speech and audio processing scenarios. Experimental acquaintance with digital filters design and comparative evaluation of the quality of the results.

**UNIT VI: Hardware implementations (1 week)**

1. DSP processors and boards. Floating and fixed point processors. DSP families of Texas Instruments, Analog Devices, Motorola και AT & T. An introduction to TI DSP’s with emphasis to the C6XXX family: TMS320C6711, C6713, C6416, C6437.

*Laboratory*

The **Matlab** programming language, along with the Texas Instruments Code Compose Studio will also be used. Topics include:

1. Generation of Digital signals and systems.
    a. Dual tone multi-frequency signal generation.
    b. Pole-Zero and Frequency analysis.
2. Use of DSP platforms for filter design and evaluation.
    a. Echo and reverberation (Alien voices generation), e.t.c
    b. Comb digital filters, FIR digital filters, IIR digital filters
    c. Use of DSP platforms for filter design and evaluation.

**(4) TEACHING and LEARNING METHODS - EVALUATION**

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|---|---|
| **DELIVERY**<br>*Face-to-face, Distance learning, etc.* | Face to face lectures in class (Primary)<br>Distance Learning (Auxiliary) |
| **USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY**<br>*Use of ICT in teaching, laboratory education, communication with students* | • Use of electronic presentation with multimedia content in class. Student support through the course webpage and the institutional e-learning platform.<br>• Electronic communication of instructors and students, through the course webpage and by e-mail.<br>• Use of simulation software for digital processes in the lab (Matlab). Use of Integrated Development Environment (IDE) Software for the programming and running of applications on the TMS DSP dedicated hardware in the lab. |
| **TEACHING METHODS**<br>*The manner and methods of teaching are described in detail. Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.*<br><br>*The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS* | Lectures, Laboratory experiments, study. |
| **STUDENT PERFORMANCE EVALUATION**<br>*Description of the evaluation procedure*<br><br>*Language of evaluation, methods* | Final course grade = Lectures part grade x 70% + Laboratory part grade x 30%<br>*Lectures part grade:*<br>Midterm written exam – 2 hours (30%)<br>Final written exam – 2 hours (70%)<br>Final written exam covers all taught material. During the |

| ***Activity*** | ***Semester workload (hours)*** |
|---|---|
| Lectures | 52 |
| Study for lectures | 52 |
| Laboratory experiments | 12 |
| Preparation for lab experiments | 12 |
| Study and preparation for exams | 52 |
| **Course Total** | ***180*** |

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| *of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other Specifically-defined evaluation criteria are given, and if and where they are accessible to students.* | exam, students may consult a list of formulae provided by the examiner as a reminder. Students must prove mastery of the material through stating and interpreting definitions of all quantities, handling relations among quantities and solving of design problems based on specs.<br><br>*Laboratory part grade:*<br>Participation in all lab experiments and oral evaluation – (20%)<br>Mid-term on-line test (40%)<br>End-term on-line test (40%) |

**(5) ATTACHED BIBLIOGRAPHY**


*Essential reading*

1. **Hayes, M.**, Digital Signal Processing, Schaum's Outline Series, 2nd Edition, Paperback 2011. (In Greek)
2. **Kogias G. D**, An introduction to DSP, Athens, 2010. (In Greek)

*Recommended Books*

1. **A. Skodras, V. Anastassopoulos,** Digital Signal Processing, Hellenic Open University, (In Greek)
2. **S. Fotopoulos,** Digital Signal Processing, ISBN: 9609892914. (In Greek)
3. **N. Kalouptsidis,** Systems and Algorithms, Athens, 1993. (In Greek)
4. **J. H. McClellan**, **R. W. Schafer, M. A. Yoder,** DSP First, 2006, (In Greek)
5. **A. Antoniou**, Digital Signal Processing, Signals, Systems and Filters (In Greek).
6. **J. G. Proakis**, **D. G. Manolakis,** Digital Signal Processing, 2010, (In Greek)
7. **E. C. Ifeachor, B. W. Jervis**, Digital Signal Processing, ISBN: 0201596199.
8. J**. G. Proakis, D. G. Manolakis**, Digital Signal Processing, ISBN: 0132287315
9. **A. Oppenheim, R. Schafer**, Digital Signal Processing, ISBN: 0132146355
10. **S. K. Mitra**, Digital Signal Processing, ISBN: 0071244670