Common Module
Signal Processing
Module Description

Implementation Group	
Doc.:	EuCTSds/ EI-01
Date :	30 06 2023
Origin:	EuCTSds Project

Countries	Institutions	Common Module	ECTS
Romania **Poland** **Greece** **France** **Bulgaria**	Military Technical Academy "Ferdinand I" Military University of Technology Hellenic Air Force Academy French Air Force Academy "Vasil Levski" National Military University	**Signal Processing** *European Common Technical Semester for Defence and Security*	**3.0**

Service	**Minimum Qualification of Instructors**
Technical/ALL	• **Officers or civilian Lecturers:** ○ English: Common European Framework of Reference for Languages (CEFR) Level B2 or min. NATO STANAG 6001 Level 3. ○ Expertise in relevant topics. ○ Relevant academic publications.
Language **English**	

Prerequisites for international participants	**Goal of the Module**
• English: Common European Framework of Reference for Languages (CEFR) Level B1 or NATO STANAG Level 2. • At least 1 year of national (military) higher education. • Basic knowledge in technical systems for security and defence	• Discover and understand basic principles of signals & systems, as well as of signal processing. • Learn about signals & systems and signal-processing techniques: basic techniques of time-/frequency-domain processing for deterministic and random signals. • Deepen knowledge of the practical applications of radars, telecommunications, image processing and pattern recognition.

Learning outcomes		
	Know-ledge	• Mastering the different steps of sampling, digitalization and reconstruction of signals. • To be able to calculate and analyze the spectrum and power/energy spectral density of a signal. • Knowing how to synthesize an analogue/digital filter and to apply techniques for denoising.
	Skills	• Performing spectral analysis and filtering of digital signals using analytical methods and numerical/simulation tools. • Giving examples of real applications and practical problems to underline how the topics treated in the course are used within engineering activity. • Mastering the different steps of digitalization chain and reconstruction.
	Respon-sibility and autonomy	• Has in-depth knowledge of digital signal processing concepts and methods. • Can design a digital filter with specific characteristics. • Can perform digital signal processing using software.

Verification of learning outcomes:

- **Observation**: Throughout the Module students will meet with the systems applications, and they will discuss the given topics in the plenary and present teamwork results. During this workshop, students will be evaluated to verify their competencies.
- **Project**: Teamwork project and project defence.
- **Test**: Final examination at the end of the module.

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Module details		
Main Topic	**Recom-mended WH**	**Details**
Continuous-Time Fourier Transform (CTFT)	**6**	**Lectures** CTFT and Inverse CTFT, CTFT requirements and properties, common CTFT pairs, CTFT and LTI systems, frequency response of LTI systems, CT convolution and CTFT, filters. **Exercises/Labs** Computations of CTFT. Applications of CTFT for spectral analysis of signals and systems. LTI filters and applications. Teamwork for group project.
Discrete-Time Fourier Transform (DTFT)	**6**	**Lectures** DTFT and Inverse DTFT, DTFT requirements and properties, common DTFT pairs, DTFT and LTI Systems, frequency response of DT LTI systems, DT convolution and DTFT, DT filters. **Exercises/Labs** Computations of DTFT. Applications of DTFT for spectral analysis of signals and systems. Teamwork for group project.
Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT)	**8**	**Lectures** From DTFT to DFT, DFT and Inverse DFT, DTFT requirements and properties, the FFT idea, FFT implementations. **Exercises/Labs** Computations of DFT. Applications of DFT for spectral analysis of signals and systems. FFT decimation in time/frequency. FFT implementations. Spectral leakage and windowing. FFT applications. Teamwork for group project.
Sampling and Reconstruction	**6**	**Lectures** Shannon/Nyquist theory, signal sampling, sampling theorem, signal reconstruction, aliasing phenomena and anti-aliasing filters, practical sampling and reconstruction. **Exercises/Labs** Practical sampling and reconstruction. Anti-aliasing filters. Teamwork for group project.
Z-Transform (ZT)	**12**	**Lectures** ZT pairs, relation between ZT and DTFT, ZT of common DT sequences, ZT requirements and properties, ZT applications, digital filters and applications. **Exercises/Labs** ZT applications. FIR/IIR digital filters. Teamwork for group project.
Levinson Recursion, Autoregressive (AR) Models	**4**	**Lectures** Topelitz matrices, Levinson-Durbin recursion, linear prediction, parameter estimation, AR models. **Exercises/Labs** AR digital filters. Teamwork for group project.
Total WH	**42**	

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Module details

Main Topic	Recommended WH	Details
Additional hours (WH) to increase the learning outcomes		
Self-Studies and syndicate work	33	• Enhancing knowledge by studying specific documents. • Individual preparation for group project. • Teamwork for group project. • Self-study hours comprise work of students in laboratories and exercises to improve skills and consolidate knowledge
Total WH	**75**	

BIBLIOGRAPHY:

- L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall, 1975.
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- A. Palamides and A. Veloni, Signals and Systems Laboratory with Matlab, CRC Press, 2011.
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- L. Tan and J. Jiang, Digital Signal Processing – Fundamentals and Applications [2nd Edition], Elsevier, 2013.
- O. Alkin, Signals and Systems – A Matlab Integrated Approach, CRC Press, 2014. □ L. F. Chaparro, Signals and Systems Using Matlab [2nd Edition], Elsevier, 2015.
- Schaum's Outline of Signals and Systems [3rd Edition], McGraw Hill, 2014.
- Schaum's Outline of Digital Signal Processing [2nd Edition], McGraw Hill, 2011.
- Schaum's Outlines of Theory and Problems of Signals and Systems [4th Edition], McGraw Hill, 2019.

List of Abbreviations:

B1, B2 ..... CEFR Levels

CEFR ..... Common European Framework of Reference for Languages

ECTS ..... European Credit Transfer and Accumulation System

DSP ..... Digital Signal Processing

WH ..... Working Hour

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