UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria		
ACADEMIC YEAR	2023/2024		
MASTER'S DEGREE (MSC)	ELECTRONICS AND TELECOMMUNICATIONS ENGINEERING (FULLY ONLINE)		
SUBJECT	DIGITAL SIGNAL PROCESSING		
TYPE OF EDUCATIONAL ACTIVITY	C		
AMBIT	20925-Attività formative affini o integrative		
CODE	20523		
SCIENTIFIC SECTOR(S)	ING-INF/03		
HEAD PROFESSOR(S)	CROCE DANIELE	Ricercatore a tempo determinato	Univ. di PALERMO
OTHER PROFESSOR(S)			
CREDITS	6		
INDIVIDUAL STUDY (Hrs)	108		
COURSE ACTIVITY (Hrs)	42		
PROPAEDEUTICAL SUBJECTS			
MUTUALIZATION			
YEAR	1		
TERM (SEMESTER)	1° semester		
ATTENDANCE	Not mandatory		
EVALUATION	Out of 30		
TEACHER OFFICE HOURS			

DOCENTE: Prof. DANIELE CROCE

PREREQUISITES	The course is self-consistent. However, it is recommended to have some basics notions on signal theory and Fourier transform.
LEARNING OUTCOMES	Knowledge and understanding The student at the end of the course will have acquired the main techniques of digital signal processing, with particular regard to transformation and filtering of signals. This knowledge will enable him to understand the role of each of the basic algorithms within a numerical processing system. To this end, during the course the main basic operations on discrete-time signals will be presented and discussed in the classroom. This will involve both the introduction of some tools of theoretical analysis of discrete-time signals, and the presentation of specific algorithms, on which a critical discussion will be carried out, with the active contribution of the students. To achieve this goal, the course includes: video-recorded lectures, teacher-led discussions of case studies; theoretical and filter design exercises. Ability to use knowledge and understanding The student will be able to apply the acquired knowledge to solve problems in numerical systems, with particular regard to numerical filters; it will also be able to apply this knowledge to accomplish basic performance evaluation such as computational complexity, memory requirements and the quality of the results obtained with respect to the desired specifications. In order to achieve this objective, some lessons and practical applications are planned in the course; this will include comparative discussions of alternative solutions to the same problem, with the active contribution of the students, as well as discussions on topics previously proposed to them. The verification of the achievement of this objective will be obtained through the final exam, which will include both a simple project design and topics that have been the subject of classroom exercises. Judgements The student will be able to judge and compare multiple solutions of the same problem based on quantitative assessments of the main characteristics of each solution. To achieve this objective, the course offers video lectures with examples of system design solutions, in which alternative solutions are critically compared, with the active contribution of the students. In them, we discuss the strengths and weaknesses of each of the possible solutions from different points of view, such as for example the computational cost, the requested memory, the precision achieved. Communication skills The student will be able to clearly communicate problems and solutions related to digital signal processing. In particular, he will be able to motivate the choices made in solving design or project problems. To achieve this goal, the student can rely on the video lectures and on the interactions with the tutor. Learning skills The student will be able to independently investigate issues not addressed directly in lectures, through the personal study of new topics. To achieve this goal, the course includes: video lectures illustrating specific design problems; readings from the scientific literatures; technical debates on the class forum about emerging topics among student.
ASSESSMENT METHODS	EXAM ORGANIZATION A written test and an oral test. For the oral exam it is necessary to pass the written one. The written test is assessed in a note over 10. The minimum grade to pass the written test is 6/10. The oral exam is assessed in a note over 30. The final grade is the combination of the written test and the oral exam. DESCRIPTION OF THE TESTS The written test lasts 2 hours. The test is devised to evaluate: - The knowledge and understanding levels of the z-transform, FFT algorithms and other DSP tools, with specific applications to the design of filters; - The capability of applying the acquired knowledge to solve autonomously

	design problems and optimizations; - The ability to communicate knowledge, analyses and conclusions, and justify the design choices. LEARNING OUTCOMES In order to provide the overall evaluation, we will estimate the results achieved in the following course objectives. Knowledge and understanding: Evaluation of knowledge, understanding and integration of principles, concepts, methods and techniques of the discipline. Applying knowledge: Evaluation of capabilities in applying theoretical and technical knowledge for tackling and solving problems; evaluation of the autonomy level and originality of proposed solutions. Making judgements: Evaluation of logical, analytical and critical abilities for reaching appropriate judgments and decisions, based on available information and data. Communication skills and learning skills: Evaluation of the ability to communicate knowledge, analysis and conclusions, with a good level of clearness, fluency and correct use of language. GRADES 30-30 cum laude: Excellent. Full knowledge and understanding of concepts and methods of the discipline, excellent analytical skills even in solving original problems; excellent communication and learning skills. 27-29: Very good. Very good knowledge and understanding of concepts and methods of the discipline; very good communication skills; very good capability of concepts and methods applications. 24-26: Good. Good knowledge of main concepts and methods of the discipline; discrete communication skills; limited autonomy for applying concepts and methods for solving original problems. 21-23: Satisfying. Partial knowledge of main concepts and methods of the discipline; satisfying communication skills; scarce judgment autonomy. 18-20: Acceptable: Minimal knowledge of concepts and methods of the discipline; minimal communication skills; very poor or null judgement autonomy. Non acceptable: Insufficient knowledge and understanding of concepts and methods of the discipline.
EDUCATIONAL OBJECTIVES	The course implements the objectives set by the SUA-CdS of the Master's Degree in Electronics and Telecommunications Engineering with regards to Digital Signal Processing. The graduates will find employment in particular in the areas of telecommunications engineering and electronics engineering, in which the skills acquired in the area of digital signal processing play a central role. In accordance with the expected learning results reported by the SUA-CdS, the graduate in Electronics and Telecommunications Engineering will have acquired, through the course in question, the knowledge of the main techniques Digital Signal Processing
TEACHING METHODS	The course is organized in 4 modules, each one including a set of video lectures (pre-recorded) and a set of e-tivity: More into details, the list of modules is the following one: 1) Discrete-time signals and discrete Fourier transform; 2) the Z-transform and its properties; 3) Fast Fourier transform (FFT) and linear phase filters; 4) Design of digital filters: impulse invariance and bilinear transform, Butterworth and Chebyshev approximations; For each module, we propose a set of exercises as additional learning activities, also devised to facilitate the self-assessment of the learning outcomes. We expect that each student will dedicate about 21 hours for these activities. About one half of the activities are proposed as activities to be carried out autonomously by the students, while another half will be supervised or led by the course tutor. More into details, the interactive activities planned for each module are the following one: 1)Examples of Fourier transforms, fast convolution methods; 2)Z-transforms and inverse Z-transforms; 3)FFT examples and FIR filters implementation; 4)Butterworth e di Chebyshev filter design. The activities will be organized on the on-line learning platform, also exploiting discussion forums and interactive meetings for the organization of the laboratorial activities. The overall number of hours for the individual study activities is estimated equal to additional 87 hours, which include 21 hours for replaying the video lectures.
SUGGESTED BIBLIOGRAPHY	Oppenheim A.V. – Schafer R.W.: digital signal processing. Prentice Hall, 2nd Edition ISBN: 0137549202, ISBN 0132141078, ISBN 0132146355, disponibile gratuitamente nel Sistema Bibliotecario di Ateneo (free book available at UNIPA

	library) Lecture notes and slides

SYLLABUS

Hrs	Frontal teaching
5	Module 1: 3h Introduction to the course. Discrete-time signals and related analysis techniques: Fourier transform of discrete-time signals, finite duration signals, DFT and its fundamental properties 2h Discrete time systems described by input-output relations, impulse response and transfer function, linear convolution and cyclic convolution.
5	Module 2: 2h z-transform and its fundamental properties. 3h inverse z-transform.
6	Module 3: 3h FIR and IIR systems, representation of a system by signal flow graph, canonical realizations, linear phase filters, design of a linear phase FIR filter using the frequency sampling method, 3h Fast Fourier transform (FFT) and fast convolution techniques: time and frequency decimation, fast convolution methods ("overlap and sum" and "overlap and save")
5	Module 4: 3h Design of IIR filters: analog filter versus numerical filter specifications, typical schemes (low-pass filter, band-pass etc.), approximation problems, methods of impulse invariance and of the bilinear transformation 2h Butterworth and Chebyshev approximations, design techniques

Hrs	Practice
21	Practice (e-tivity) 5 hours, Fourier transforms, fast convolution methods 5 hours, Z-transforms and inverse Z-transforms 5 hours, FFT examples and FIR filters implementation 6 hours, Butterworth e di Chebyshev filter design