UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2020/2021
MASTER'S DEGREE (MSC)	ELECTRICAL ENGINEERING
SUBJECT	MODELLING AND ELECTRO-MAGNETIC COMPATIBILITY
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50363-Ingegneria elettrica
CODE	18233
SCIENTIFIC SECTOR(S)	ING-IND/31
HEAD PROFESSOR(S)	ALA GUIDO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**ALA GUIDO** Monday 10:00 11:00 ufficio 2022, edificio 9, viale delle Scienze, Palermo

DOCENTE: Prof. GUIDO ALA

PREREQUISITES	Sufficient knowledge of circuit theory, steady-state electromagnetic behavior, applied mathematics.
LEARNING OUTCOMES	Knowledge and understanding In solving a real world problem, be able to distinguish the stage of mathematical modelling, the stage of discretization of the continuous model, the numerical solution in a totally automatic way. Have a general knowledge of analytical and numerical models applied in Computational Electromagnetics for steady-state and frequency domain analysis, time domain via frequency domain analysis. Have the knowledge of the basic skills related to electromagnetic compatibility: identification and modeling of sources and receivers with regard to the emission and susceptibility radiated and conducted. Be able to assess the environmental impact of electromagnetic fields in the national and international regulatory framework. Overall, the student will be able to process and/or apply original ideas in interdisciplinary contexts. Verification of this objective is made through the continuous interaction with the teacher and through the oral examination. Applying knowledge and understanding Be able to perform electromagnetic simulation in steady state, sinusoidal and in the time domain, in order to evaluate the performance and to optimize the design of devices and systems used in industry. Be able to identify the problems of electromagnetic compatibility associated with the operation of equipment and systems in the industrial sector. Be able to identify useful solutions to satisfy electromagnetic compatibility requirements established by the rules and the laws. Overall, the student will apply knowledge and skills acquired in order to solve new issues also in interdisciplinary contexts. Verification of this objective is made through continuous interaction with the teacher and throughthe oral exam. Making judgements Have the autonomy of choice to select the analytical or the approximate models and to select the numerical methods useful for electromagnetic analysis, also integrating knowledge and managing complexity, and making judgments also based on limited or incomplete information. Have acquired the autonomy to be able to critically interpret the results, in order to obtain the electromagnetic compatibility compliance of equipment and systems,also integrating knowledge and managing complexity, and making judgments also based on limited or incomplete information. The acquisition of autonomy of judgement will be verified through the continuous interaction with the teacher during the course and throughthe oral examination. Communications skills Be able to argue clearly and rationally, with specialists and non-specialists, in support of the model used and the numerical algorithms designed by assessing critically the results obtained. Acquire the ability to highlight clearly and rationally, with specialists and non-specialists, the main aspects regarding the electromagnetic compatibility in the industry, so justifying the choices made. The acquisition of communicative skills will be verified, through the continuous interaction with the teacher and through the oral examination. Learning skills Acquire the ability to learn continuously and autonomously the different aspects of Computational Electromagnetics, with reference to new problems that necessarily will meet at work. Acquire the ability to learn continuously and autonomously the fundamental aspects of electromagnetic compatibility which is constantly evolving, in connection with the continuous technological progress. The learning skills will be tested during the final exam in which the student will give evidence of the awareness achieved and the critical capacity of analysis and synthesis of theoretical and practical aspects of the discipline studied.
ASSESSMENT METHODS	The assessment is carried out through an interview. During the interview the student is involved in the discussion of the coded algorithms implemented during the course and in the response/discussion to two open questions. At the end of the interview a 30-point scale rating is proposed. The evaluation criteria are described below. Rating: 30 with distinction (Learning outcomes have been achieved to an excellent level. The student possesses excellent knowledge and ability to understand the topics, great ability to apply the acquired knowledge, he demonstrates full autonomy of judgment, he is fully aware and he has full capacity analysis and synthesis of critical methodological aspects and

	applications of the course; he has full ability to communicate knowledge, analyses and conclusions, with an excellent level of clearness, fluency and correct use of language; he also shows full evidence for autonomously undertaking further studies). Rating: 28-30 (Learning outcomes have been achieved to a good level. The student possesses good knowledge and ability to understand the topics, good ability to apply the acquired knowledge, he demonstrates good autonomy of judgement, he has good awareness and good critical analysis and synthesis capabilities of methodological aspects and applications of the course; he has good ability to communicate knowledge, analyses and conclusions, with a good level of clearness, fluency and correct use of language; he also shows good evidence for autonomously undertaking further studies). Rating: 25-27 (Learning outcomes have been achieved to a moderate level. The student possesses moderate knowledge and ability to understand the topics, moderate ability to apply the acquired knowledge, he demonstrates moderate autonomy of judgement, he has discrete awareness and moderate critical analysis and synthesis capabilities of methodological aspects and applications of the course; he has moderate ability to communicate knowledge, analyses and conclusions, with a moderate level of clearness, fluency and correct use of language; he also shows moderate evidence for autonomously undertaking further studies). Rating: 21-24 (Learning outcomes have been achieved to a satisfactory level. The student possesses satisfactory knowledge and ability to understand the topics, satisfactory ability to apply the acquired knowledge, he demonstrates a satisfactory autonomy of judgement, he has satisfactory awareness and satisfactory critical analysis and synthesis capabilities of methodological aspects and applications of the course; he has satisfactory ability to communicate knowledge, analyses and conclusions, with a satisfactory level of clearness, fluency and correct use of language; he also shows a satisfactory evidence for autonomously undertaking further studies). Rating: 18-20 (the student possesses sufficient knowledge and ability to understand the arguments, a sufficient ability to apply the knowledge acquired, is expressed with sufficient property of language and demonstrates sufficient autonomy of judgement, has sufficient knowledge and sufficient critical capacity for analysis and synthesis of methodological aspects and applications ofcourse; he also shows sufficient evidence for autonomously undertaking further studies).
EDUCATIONAL OBJECTIVES	Knowledge and ability to apply analytical and numerical methods for the analysis of electromagnetic systems. Acquisition of useful skills necessary for the evaluation of the basic aspects of electromagnetic compatibility of devices and systems in an industrial environment.
TEACHING METHODS	The teaching activities are organized as follows. Lectures and exercises of coding algorithms, carried out in the classroom by the teacher; coding algorithms carried out independently by students, both individually and in groups: in this case the teacher interacts directly with the individual student by supporting the elaboration of knowledge and its application, the learning skills and independence of judgement; interaction and continuous dialogue between teacher and students during the lectures, through questions posed so impromptu and aimed at stimulating attention, communication skills, property of language, the autonomy of judgement.
SUGGESTED BIBLIOGRAPHY	-Dispense fornite dal docente, disponibili tramite portale studenti UniPA -C. R. Paul: “Introduction to Electromagnetic Compatibility”, Second Edition, Wiley-Interscience, 2006. -C.R. Paul: "Compatibilita' elettromagnetica", Hoepli – 1992 -F.M. Tesche, M.V. Ianoz, T. Karlsson: “EMC Analysis Methods and Computational Models”, Second Edition, John Wiley & Sons. Inc., 1997. -J.J.H. Wang: "Generalized moment methods in electromagnetics", Wiley – 1991 -C.M. Arturi: "Elettromagnetismo Applicato e Metodi di Calcolo", Societa' Editrice Esculapio – 2012 - Holly Moore: "MATLAB per l'ingegneria" - Pearson - 2008 --- -S. Ramo, J.R. Whinnery, T. Van Duzer: "Campi e onde nell’elettronica delle comunicazioni", Franco Angeli - 1990 -C.R. Paul, K.W. Whithes, S. A. Nasar: "Introduction to electromagnetic fields", III ed., McGraw-Hill - 1998 -M. D’Amore: "Compatibilita' elettromagnetica", Ed. Scientifiche Siderea, Roma - 2003

SYLLABUS

Hrs	Frontal teaching
2	General information on electromagnetic compatibility; conducted and radiated emission, immunity, susceptibility, circuit and full-wave models. Technical and economic considerations. The mathematical model as a tool for evaluating radiated and conducted electromagnetic interference. Concentrated and distributed systems: electric system size. The direct and indirect lightning strikes as an example of electromagnetic interference. General information on field approach for transient analysis complex grounding systems (e.g. those used in high voltage electrical systems). General information on the use of numerical methods for the solution of electromagnetic problems. Methods based on discretization of differential equations, methods based on discretization of integral equations; domain methods and boundary methods.
2	Maxwell's equations in differential and integral form, phasor form. Electromagnetic constitutive relations in an isotropic linear, homogeneous, time invariant media. Poynting's theorem. Field wave equations in the time domain and in the phasor form. Helmoltz's equation.
4	General characterization of sinusoidal fields: polarization, wavefronts, wave vector. Plane, cylindrical, spherical waves. Phase velocity . Plane and spherical wave functions: analysis of fundamental properties. Temporal averages of sinusoidal fields.
4	The method of separation of variables and its application in electromagnetic field analysis.
3	Plane waves in linear homogeneous, isotropic media. Distribution of electromagnetic field in 3D solid semi-undefined: skin effect, depth of penetration. Distribution of electromagnetic field in solid cylindrical conductor.
5	Introduction to antennas. Wave equations of retarded potentials. Generalized Lorentz gauge. Electric dipole and magnetic dipole as elementary antennas: electromagnetic field, radiated power, radiation resistance. Basic parameters of an antenna. The electric dipole of finite size. Radiation pattern. Numerical examples. Notes on dipole array antennas.
4	The method of moments (MoM) for the analysis of electromagnetic problems in frequency domain. The frequency domain mathematical model of complex shaped earth electrodes: the Fredholm integral equation of the first kind: thin-wire formulation. Setting the discretization procedure.
3	Elements of signal processing: use of the Fourier series and the Fourier transform. Discrete Fourier transform. Sampling. Use of delta-Dirac. Aliasing and ripple. Use of the transfer function in linear systems. Use of frequency analysis for evaluation of transient behavior of a ground electrode using the MoM.
3	Conducted and radiated electromagnetic interference. General aspects of "electromagnetic compatibility directive", European standards (EN55022, CISPR 22) and US standards. Compatibility requirements. Emission levels. Use of semi-anechoic room and open area test site (OATS). Common mode and differential mode. General information on the use of the LISN (line impedance stabilization network) for the assessment of conducted disturbance. Structure of power passive filter and effect on the differential and common-mode current.
2	Electromagnetic fields and public helath: low frequency (ELF) and high frequency (RF/IF/MW) fields. National and international regulatory framework. Dosimetric and radiometric quantities. Radiometric measurements in broadband and narrowband.
2	Non-ideal behavior of components: modelling of wires, lines and tracks, resistors, capacitors, inductors; effect of leading wires on components; frequency response in terms of equivalent impedance from the terminals. Common mode Choke "; ferrite cores. Frequency response of ferrites in common use.
1	Radiated emission models for wires and circuit boards: comparison of common mode and differential mode currents. Examples. Radiated susceptibility model for wires: use of distributed generators driven by the external EM field.

Hrs	Practice
2	Tutorial on MATLAB. Fundamental of programming
5	Simulation codes implementation related to the application of the method of separation of variables.
4	MoM - the point matching method for the detection of the solving linear system. Geometric considerations required for the pre-processing phase. Post-processing of results: evaluation of electromagnetic field components anywhere in the external medium. Analytical considerations and implementation.
8	Transient behavior simulation code implementation of a simple earth electrode by applying the method of moments.