UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	ELECTRONICS ENGINEERING
INTEGRATED COURSE	MICROWAVE ELECTRONICS - INTEGRATED COURSE
CODE	20525
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	ING-INF/01
HEAD PROFESSOR(S)	STIVALA SALVATORE Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	STIVALA SALVATORE Professore Associato Univ. di PALERMO
CREDITS	12
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**STIVALA SALVATORE** Thursday 15:00 17:00 viale delle Scienze, Ed. 9 (ex-DEIM), II piano

DOCENTE: Prof. SALVATORE STIVALA

PREREQUISITES	GENERAL NOTE: The two modules of this Integrated Course must be followed in the same chronological order in which they are provided, since the first module is by necessity propedeutic to the second one. For the first module (Microwave Components) the prerequisites concern the theoretical and applicative bases of Electromagnetism and Electromagnetic Propagation, with special reference to: - Maxwell's equations - Boundary conditions - Energy and power of the electromagnetic field; Poynting's theorem - Fundamental theorems (uniqueness theorem, Lorentz's reciprocity theorem) - Plane waves - Transmission lines - Modes of guided propagation (TE, TM and TEM) - Phase velocity, group velocity and energy velocity - The rectangular waveguide, the circular waveguide, the coaxial cable. For the second module (Microwave Circuits), in addition to the study of the first module topics, the prerequisites comprise the following additional ones: - Adequate knowledge of semicondutor devices (Diodes, FET, BJT, etc.) and of Analog Electronics (circuits and systems); - Adequate knowledge of the basic concepts pertaining to Electronic CAD and a sufficient competence of the practical use of circuit simulation tools.
LEARNING OUTCOMES	KNOWLEDGE AND COMPREHENSION CAPABILITY: After attending the first module, the student will be able to deal with electromagnetic phenomena characterized by a wavelength comparable to the circuit size or to objects in which the electromagnetic field exhibits. Moreover, the student will learn to analyze and describe microwave circuits, as well as the working principle of both active and passive microwave components. The student, at the end of the second module, will possess knowledge and methods for the analysis and the design, through the use of dedicated ECAD software, of Microwave Integrated Circuits (MIC) in both hybrid (HMIC) and integrated (MMIC) technology. Such knowledge of the main circuit building blocks of such technologies will enable the student to better understand the problems associated to the practical hardware implementation of electronic circuits for Telecommunications, Telemetry, Data Transmission, etc., thaught in other Courses, with special attention to the physical/technological limits that influences their current performances and future development routes. In order to reach this goal, the course will include frontal lectures. In order to assess the achievement of this objective, the examination includes the discussion of the topics covered during the course. CAPABILITY OF APPLYING KNOWLEDGE GAINED AND COMPREHENSION: The student, at the end of the first module, will acquire the knowledge of the measurement instrumentation and test benches employed to evaluate the typical performance of microwave components and circuits. At the end of the first module, the student will be thus able to carry out measurements of parameters of interest in the field of microwaves, such as wavelength, power, Standing Wave Ratio, reflection coefficient, quality factor, phase shift. The student, at the end of the second module, will be able to apply the gained technical knowledge in the qualitative and quantitative analysis of the performances of circuits operating at very high frequencies, adopting for that purpose the wise adoption of the most recent ECAD software tools dedicated to the specific analysis of Microwave circuits. In order to reach this goal, the course will include: exercises and problems solving sessions; laboratory tutorials; the writing of a report on the simulations and on the measurements carried out. In order to assess the achievement of this objective, the examination will include: the discussion of the topics covered during the exercises and problems solving sessions. TECHNICAL JUDGMENT AUTONOMY: The student, at the end of the first module, will acquire the knowledge of both advantages and limits in terms of performance reached using the different technologies available up-to-now. The student will be able to decide, in the design phase, which one to adopt and, in case, the need for a development. Thanks to the theoretical-experimental methodological approach, acquired during this module, the student will be able to express an autonomous judgment on the problems related to microwave components. The student, at the end of the second module, will be able to fully understand the motivations that guide the development lines of the Microwave Electronics technology, evaluating autonomously the pros and cons of the various solutions to the same technical problem at hand. He will also be able to understand the architectural choices that the constrains set up by the individual constitutive

	blocks performance on the realization of the complex systems nowadays devoted to the transmission and processing of electrical signals (both of analog and digital type). In order to reach this goal, the course will include: exercises and problems solving sessions and laboratory activity focused on design issues. In order to assess the achievement of this objective, the examination will include the discussion on design aspects. ABILITY TO TECHNICALLY COMMUNICATE: The student will gain the capability of communicating and expressing complex concepts associated to the field of Microwave Electronics with proper technical jargon, eve in a highly specialized context. He will be able to interact effectively with other specialists in the field or other technicians, in a multi-disciplinary research team or in one of the many existent application fields of microwave technology. In order to reach this goal, the course will include classroom discussions and guided debates on treated topics. In order to assess the achievement of this objective, the exam will include the oral discussion on treated topics. ABILITY TO LEARNING: The student, at the end of the first module, will be able to understand problems related to the use of microwave components. The student, at the end of the second module, will strengthen the attitude to cope with difficult engineering problems, in a methodologically rigorous manner and with the adoption of adequately complex models. The stimulus toward the application of the studied theory to practical problems will reinforce the student's need for the autonomous analysis of the problem at hand and the search (also using the facility of the vast technical documentation available on the Internet) for solutions to it not necessarily limited by the previously acquired knowledge. In order to reach this goal, the course will include: frontal lectures, exercises and problems solving sessions, circuit simulations and laboratory activity. In order to assess the achievement of this objective, the examination will include: discussion on the topics covered during the course; discussion of the report on simulation and laboratory activity.
ASSESSMENT METHODS	The assessment method involves one oral test, aimed at ascertaining the theoretical knowledge and the practical competences gained. More precisely, the student is asked to answer questions dealing with all the topics covered during the two modules, with explicit reference to the treatment developed in the suggested texts. In addition, the student is asked to provide and discuss a report on the experimental lab sessions. On the basis of the oral test, the final outcome of the exam (mark) is proposed to the student, following the logical guidelines illustrated in the following synopsis table: EVALUATION (MARK) CHARACTERISTICS EVIDENCED BY THE EXAMINEE: Excellent (30 - 30 honors): Excellent knowledge of taught topics, very good and accurate technical jargon, good analytic ability: the student is autonomous and fully capable of applying acquired knowledge in the solution of proposed problems; Very good (26 - 29): Good knowledge of taught topics and of technical jargon: the student is capable of applying acquired knowledge toward the solution of proposed problems; Good (24 - 25): Basic knowledge of taught topics, adequate technical jargon, limited capability of applying acquired knowledge toward the solution of proposed problems; Satisfactory (21 - 23): The student has not the full mastery of taught topics but has some knowledge of them, sufficient technical jargon, quite limited capability of applying acquired knowledge for the solution of proposed problems; Sufficient (18 - 20): Minimal knowledge of taught topics and technical jargon, minimal or no capability of applying acquired knowledge for the solution of proposed problems; Insufficient (/): The student has not reached an acceptable knowledge of the main topics treated in the Course
TEACHING METHODS	For the first module (Microwave Components), the teaching activity comprises frontal lectures and experimental classes in laboratory. The latter are aimed at reinforcing the theoretical concepts presented during classes, through their practical application to real world devices, characterized through appropriate

	sets of measurement. This activity will be carried out in a didactic laboratory, set up for the purpose with microwave components and instrumentation, with which the students will be asked to interact. For the second module (Microwave Circuits), the teaching activity comprises classroom lessons and computer simulation sessions, for exercising. In view of the application-oriented nature of the Course, during exercises, but often also during lessons, extensive use is made of interactive didactic tools and, in particular, of software tools dedicated to the Electronic Computer-Aided Design (ECAD) using personal computers. This approach allows the Teacher to illustrate - soon after the presentation of the theory - its practical application in a realistic design environment, without the need to over-simplify the examples worked out (e.g., by limiting only to analytically solvable problems) which mimics, to a reasonable scale, the great complexity of all design problems encountered in the real-world realization of the high-frequency circuits at study.

MODULE
MICROWAVE CIRCUITS

Prof. SALVATORE STIVALA

SUGGESTED BIBLIOGRAPHY

- G. Gonzalez: "Microwave Transistor Amplifiers: analysis and design", Prentice Hall, 1996, seconda edizione (ISBN 0132543354).
- R. Sorrentino e G. Bianchi: "Microwave and RF Engineering", Wiley & Sons, Ltd, 2010, prima edizione (ISBN 978047075862) - e-book disponibile presso UniPa Discovery Service.
- Ulteriori sussidi didattici a cura del Docente (distribuiti agli studenti in formato elettronico).

AMBIT	50364-Ingegneria elettronica
INDIVIDUAL STUDY (Hrs)	102
COURSE ACTIVITY (Hrs)	48

EDUCATIONAL OBJECTIVES OF THE MODULE

Goal of this module is to provide a fundamental knowledge of Microwave Electronic Circuits methods and techniques.
Such knowledge stems from the combination of competences acquired in other propedeutic Courses/modules (in particular, the first module of this same Course, focused on devices and components for microwave frequencies) with specific and more advanced competences of Applied Electronics pertaining both hybrid (HMIC) and monolithic (MMIC) Microwave Integrated Circuits. To this purpose, topics already addressed in the Undergraduate (Bachelor) degree will be examined more deeply, to perfect the students' competences and to make them applicable to practical and more realistic design problems. In particular, the following topics will be treated in detail: the gain and noise characterization of microwave devices, the design techniques adopting distributed circuit elements (Microstrips and the like) and the study of the specific circuit configurations adopted in the very high frequency range for the realization of amplifiers, oscillators and mixers employing solid-state active devices. In so doing, extensive use will be made of microwave design oriented ECAD software tools, especially during classroom exercises, with the purpose of making the student acquainted to their use (so that they can take advantage of it both before and after the graduation in this Master Degree program).

SYLLABUS

Hrs	Frontal teaching
1	Introduction to the module: topics, objectives, methods and organization
3	Gain and Noise (linear) characterization and modeling of microwave active devices
3	Gain and Noise (non-linear) characterization and modeling of microwave active devices
4	Layout problems in HMIC and MMIC circuits and their solution using EM simulation tools
6	Theoretical bases of computer-aided design techniques for low-noise microwave amplifiers
6	Theoretical bases of computer-aided design techniques for high-power microwave amplifiers
4	Problems and methods in the stability analysis of microwave active circuits
5	Microwave oscillators
4	Microwave mixers and complex HMIC/MMIC systems

Hrs	Practice
12	Examples and Exercises on the analysis and design, through ECAD software tools, of the various circuit classes illustrated during the Lessons

MODULE
MICROWAVE COMPONENTS

Prof. SALVATORE STIVALA

SUGGESTED BIBLIOGRAPHY

- R. Sorrentino and G. Bianchi: "Microwave and RF Engineering". John Wiley & Sons, 2010 (ISBN: 978-0-470-75862-5) - e-book disponibile presso UniPa Discovery Service
- R. E. Collin: “Foundations for Microwave Engineering”, 2nd Edition. McGraw-Hill, 2001 (ISBN: 978-0-7803-6031-0)
- J. W. Gewartowski, Hugh A. Watson, "Principles of electron tubes". Van Nostrand (ISBN 10: 0442026501)
- A. S. Gilmour, "Principles of Traveling Wave Tubes" Artech House Radar Library (ISBN-10: 0890067201)

AMBIT	50364-Ingegneria elettronica
INDIVIDUAL STUDY (Hrs)	102
COURSE ACTIVITY (Hrs)	48

EDUCATIONAL OBJECTIVES OF THE MODULE

The main educational objectives of this module consist in the acquisition, by the student, of knowledge, methodologies and techniques to study and analyze both active and passive microwave components. Moreover, the student will be able to evaluate their performance by using proper measurement systems.

SYLLABUS

Hrs	Frontal teaching
1	Introduction to Microwaves and radio frequencies
1	Brief review of electromagnetic theory and electromagnetic propagation
2	The stripline, the microstrip line and the coplanar waveguide
6	Circuit theory for waveguide systems
8	Passive microwave devices and components: attenuators; phase shifters; directional couplers; power dividers.
2	Non-reciprocal microwave components: isolators, gyrators; circulators.
4	Resonators and cavities
6	Microwave filters and periodic structures
1	Basic parts of a linear microwave tube
2	Electron gun: cathodes used for vacuum tubes; optics for beam control up to the entrance of the interaction structure; beam modulation systems (grids, focus and anodes)
2	Interaction structures for Klystron: interaction mechanism between electron beam and RF field (bunching); cavity structure
2	Interaction structures for TWT: dispersion diagram and interaction impedance for fundamental structures (helix, coupled cavitiy and folded-waveguide)
2	Softwares for Klystron and TWT design: description and use
1	Magnetic focusing structures
2	Multistage collectors for TWT

Hrs	Practice
12	Experimental classes in laboratory on the main topics presented during the lessons