



Teaching	RF and Microwave Systems for Communications
Level and course of study	Master's Degree in Electronic Engineering (LM-29)
Academic discipline (SSD)	IINF-02/A (ex ING-INF/02)
Academic year	2025-2026
Course year	2
Total number of credits	9
Prerequisites	None
Teacher	Michela Longhi Faculty: Engineering Email: michela.longhi@unicusano.it Office hours: Consult the calendar on the following page of our website by checking the Videoconference times http://www.unicusano.it/calendario-lezioni-in-presenza/calendario-area-ingegneristica
Presentation	The main objective of the course of RF and Microwave Systems for Communications is to provide knowledge related to the operation of the main microwave systems (radar systems, wireless communication systems, microwave heating systems, etc.) and the main hardware components that constitute them. Some of the elements present in a microwave system, already introduced in previous courses in the same scientific-disciplinary sector (antennas, transmission lines, etc.), will be taken up to highlight the systemic aspects. Particular emphasis will also be given to the understanding of the fundamental design criteria of a microwave system and the individual components that constitute it.
Learning objectives	The course of RF and Microwave Systems for Communications has the following educational objectives: 1. Introduce microwave systems and their main components; 2. Recall the concepts related to antennas and transmission lines with particular reference to systemic aspects; 3. Illustrate the design techniques typically used for an impedance matching network; 4. Illustrate the design techniques typically used for microwave filters; 5. Provide the tools necessary for the design of microwave components or circuits.
Prerequisites	Attendance at the course also requires knowledge of the fundamental concepts of electromagnetic fields and antennas .
Expected learning outcomes	Knowledge and understanding At the end of the course, the student will have knowledge of the main microwave systems and the components that typically compose them. In particular, the student will be able to understand the implications of the different components on the performance of the overall system. In addition, through the Etivities, students will acquire the ability to formulate electromagnetism problems within the CST Microwave Studio software. Application of knowledge The student will be able to design the main devices and apparatuses that make up a microwave system. He will therefore be able to approach the design of a simple radio frequency transmission and reception system, using commercially available simulation tools. Ability to draw conclusions The student will be able to identify the most appropriate models to describe and design the individual functional blocks of a complex microwave system (e.g. generator, transmission line, radiating element, etc.) and to apply critical verification methods to evaluate the goodness of the design itself. Communication skills The student will be able to present the project results through discussion in technical language or written report on the activities carried out. Learning skills

	At the end of the course the student will be able to read technical documents from which to obtain the information necessary for the design of different microwave components and to apply the knowledge acquired for the resolution of unfamiliar problems concerning the design of microwave systems.
Course structure	The course is developed through pre-recorded audio-video lessons that compose, together with slides and handouts, the study materials available on the platform. Self-assessment tests are then proposed, asynchronously, which accompany the pre-recorded lessons and allow students to ascertain both the understanding and the degree of knowledge acquired of the contents of each of the lessons. Interactive teaching is carried out in the "virtual classroom" forum and includes 2 Etivities that apply the knowledge acquired in the theory lessons. In particular, the RF and Microwave Systems for Communications Course includes 9 training credits. The total study load for this teaching module is around 170 hours, divided as follows: • Approximately 150 hours for viewing and studying the videotaped material. • About 20 hours of Interactive Teaching for the elaboration and delivery of 2 Etivities and for the execution of self-assessment tests. It is advisable to spread the study of the subject evenly over a period of 6 weeks, about 25 hours of study per week.
Course programme	Module 1 – Introduction to Microwave Systems (Week 1 – 25-hour commitment) Recalls of antennas with particular emphasis on systemic aspects (radiation diagram, noise temperature...); wireless communication systems (Friis formula, link budget, architecture of a radio receiver, characterization in terms of noise, examples...); radar systems (radar equation, radar cross section; types of radar); radiometric systems; microwave propagation (effects of the atmosphere, effects of the soil, effects of plasma); other applications (microwave heating, power transfer, biological effects and safety). Module 2 – Transmission Line Reminders and Smith's Card Usage (Week 2 – 25-hour commitment) From Maxwell's equations to telegraphists' equations; solution of telegraphists' equations; reflection coefficient and adaptation in transmission lines; Smith paper: introduction and operation; frequency behavior of simple circuits; basic operations on the Smith chart. Module 3 – Impedance Matching (Week 3 – 25-hour commitment) Adaptation with concentrated elements (L-shaped networks, analytical solution and with Smith's paper); single stub adaptation (series and parallel connection); double stub adaptation (analytical solution and with Smith paper); quarter-wave transformer; theory of small reflections; binomial multisection transformer; Chebyshev multisection transformer (Chebyshev polynomials and transformer design); tapered lines (exponential, triangular and Klopfenstein taper); Bode-Fano criterion. Module 4 – Microwave Filters (Week 4 – 25-hour commitment) Periodic structures (analysis of infinite periodic structures, finite periodic structures, scatter diagrams); design of filters through the insertion loss method (characterization through the power loss ratio, maximally flat low-pass prototype, equal-ripple low-pass prototype, linear phase low-pass prototype); filter transformations (impedance and frequency scaling, bandpass transformations and band elimination); implementation of filters (Richards transformations, Kuroda identities, impedance and admittance inverters); stepped-impedance low-pass filter; coupled line filters (filtering properties of a coupled line section, coupled line bandpass filter design); filters with coupled resonators (bandpass and bandpass filters with quarter-wave resonator; bandpass filter with capacitively coupled series resonator, bandpass filter with capacitively coupled parallel resonator). Module 5 – Active RF and Microwave Devices (Week 5 – 25-hour commitment) Diode and diode circuit boosters. Recalls of Schottky diodes and detectors. Recalls of PIN diodes and control circuits. Varactor diodes. Recalls of bipolar junction transistors. Recalls of bipolar junction transistors. Field-effect transistor references. Combination of power. Recalls of heterojunction bipolar transistors. Recalls of metal semiconductor field-effect transistors. High electron mobility transistor recalls. Microwave integrated circuits. Hybrid microwave integrated circuits. Monolithic microwave integrated circuits. Microwave amplifiers. Module 6 – Electromagnetic Simulation Software (Week 6 – 25-hour commitment)

	Introduction to electromagnetic simulation; generic electromagnetic simulation process (moment method, FEM method, finite difference time domain, comparison between different simulators); main electromagnetic simulation software (Momentum, FEKO, HFSS, CST Microwave Studio,...); tutorial for using CST Microwave Studio. Etivity 1 – Design of an adaptation network and its implementation within the CST Design Studio software (10 hour commitment – Week 6) Etivity 2 – Design of a microwave filter and its implementation within the CST Design Studio software (10 hour commitment - Week 6)
Study materials	Teaching materials by the teacher The teaching material on the platform is divided into 5 modules. They cover the entire program and each of them contains handouts, slides and video lessons in which the teacher comments on the slides. This material contains all the elements necessary to deal with the study of the subject. Recommended texts: • David M. Pozar, "<i>Microwave Engineering</i>," John Wiley & Sons, Inc., 4rd edition. • Robert E. Collin, "<i>Foundations for Microwave Engineering</i>," Wiley-IEEE Press, 2nd edition
Assessment methods	The exam consists of a written test aimed at ascertaining the ability to analyze and rework the concepts acquired and a series of activities (E-activities) carried out during the course in virtual classes. The evaluation of the Etivity from 0 to 5 points is carried out, in itinere, during the duration of the course. The exam is evaluated for the remaining from 0 to 25 and can be taken in written form both at the Rome campus and at the teaching centers upon reservation by the student. The written test (lasting 90 minutes) includes the theoretical discussion, in written form, of two topics of the course. Each answer will be evaluated on the basis of the following parameters: relevance to the question, completeness of the information, method of development of the topic. The expected learning outcomes about the knowledge of the subject and the ability to apply them are assessed by the written test, while communication skills, the ability to draw conclusions and the ability to self-study are assessed in itinere through the Etivity. Furthermore, e-activities must be carried out individually by each student and delivered to the teacher via message on the platform at least one week before the exam for which the student has booked. PLEASE NOTE: EXEMPTIONS We inform you that starting from the January 2020 session (both for the Rome campus and for the external campuses), the Faculty of Engineering has introduced the possibility of taking the exam through two partial exams (or exemptions). Exemptions can only be made during the exam sessions, published on the website, and no other examination methods will be provided other than those communicated. The partial exams will cover the following course materials: • Exemption 1 – Module 1, Module 2. Partial exam 1 will be evaluated up to a maximum of 30 points. • Exemption 2 – Module 3, Module 4, Module 5, e-tivity 1, and e-tivity 2. Partial exam 2 will be evaluated up to a maximum of 30 points (including the evaluation of e-activities 1, and 2). The exam will therefore consist of 4 theoretical questions. The first two theoretical questions will focus on topics of the first 2 modules (2 CFU), while the other two questions will focus on topics of the remaining 3 modules (4 CFU). It will therefore be possible to take the exam in the following ways: • Full exam (6 CFU): in this case the exam will take place on the entire course program, answering the first and third questions of the assignment. The questions to be answered will also be explicitly indicated on the text of the assignment itself. It is not possible to arbitrarily choose the two questions to be answered (out of the 4 present). • Partial exam: in this case it will be possible to carry out only the part on the first 2 modules (first two questions) and then on the last 3 modules (third and fourth questions). Within the exam there will be a space to indicate which type of exam you have chosen to take (Partial test 1, Partial test 2 or Full exam). If you choose the partial test, i.e. if you choose to take only one part of the exam (modules 1 and 2 or modules 3, 4 and 5) the remaining part will not be corrected. A multiple choice or no choice will automatically result in the exam being marked in full form. In the event that the student chooses to take only a part of the exam and for that part reaches the sufficiency, the student will receive a positive judgment for the test in question which can be supplemented by a subsequent positive judgment (to be obtained in a subsequent session) on the remaining part of the program.

	If you choose to take the exam through partial tests, upon passing both, an exam grade will be recorded, which will take into account the activities carried out in itinere (e-tivity) and the evaluation obtained in the two partial tests. In the event of rejection of this grade, the positive judgments previously obtained will be reset. The judgment reported in the first partial test will remain valid for the following (6 months). In the event of failure to pass and/or take the second test, the judgment reported in the first test will be cancelled.
Criteria for the assignment of the final paper	The assignment of the final paper will take place on the basis of an interview with the teacher in which the student will express his or her specific interests in relation to some topic he or she intends to deepen; there are no preclusions to the request for assignment of the thesis and there is no particular average to be able to request it.