ENSEA

Beyond Engineering

RF Engineering

Graduate/Master Program

ENSEA – Semester 9 ESC - French-Taught

Edition 2023

RF Engineering
ENSEA - ESC 3rd Year Academic Track

Level	**Second year of Master's Degree/Graduate/Semester 9**		
Period	Fall semester (September to January)		
Language of tuition	French		
ECTS	30		
Courses	Code	Course	ECTS
	ESC_1	**RF Communication Systems [Composed of:]**	**6**
	ESC_3961	Wireless Communication Systems	
	ESC_3940	Antennas	
	ESC_3910	Guided Waves	
	ESC_2	**Electronics for High-Speed Communication [Composed of:]**	**5**
	ESC_3950	High-Speed Electronics	
	ESC_3920	RF Semiconductor Devices	
	ESC_3	**RF device design [Composed of]**	4
	ESC_3931	Non-linear RF Design	
	ESC_3930	Linear RF Design	
	ESC_4	**Project [Composed of:]**	5
	ESC_3901	Circuit Project	
	ESC_5	**Acquisition Systems [Composed of:]**	**5**
	ESC_3900	System Project	
	ESC_3902	CAD and Measuring Tools	
	ESC_3970	Conferences	
	SH-3EME	**Humanities [Composed of:]**	**5**
	DSH_3000	Human Resources Management and International Management	
	DSH_3060	English	
	DSH_3061	FLE (French for foreigners) or Spanish or German	

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ESC_1 RF Communication Systems (6 ECTS)

ESC_3961 Wireless Communication Systems (Lectures: 10h / Tutorial classes: 10h / Lab: 16h)
This course introduces the basics of formatting signals (modulation, coding), and the RF front-end structures. The knowledge provided by this course allows the student to analyze the functioning of a real system and to evaluate its performance. Experiments in labs give a first training with measuring and simulation methods.
- Constant-envelope or nonconstant-envelope modulations
- Amplitude, Phase, Frequency, OFDM, Spectrum
- Transmitter/receiver architecture
- RF segment constraints and defects
- System simulation: behavioral models, co-simulation

ESC_3940 Antennas (Lectures: 14h / Tutorial classes: 10h / Lab: 16h)
This course introduces the general concept of antennas, and studies key antennas from main technologies. This course has an interest in different methods of modeling antennas, especially the plane wave spectrum decomposition. Simulation models are presented. Practices in lab illustrate the theory by measuring specific antennas (quarter wave antennas …), in anechoic chamber or in free space, and it uses 2.5D electromagnetic simulations.
- Plane waves. Radiated power. Decomposition into plane wave spectrum
- General properties of antennas. Link budget, radiation pattern, gain, directivity, polarization....
- Study of some particular antennas: electric dipole, half-wave dipole, aperture antennas, slots and horns, patch antennas.
- Antenna array. Array factor and directivity.

ESC_3910 Guided Waves (Lectures: 10h / Tutorial classes: 10h / Lab: -h)
This course gives the basics of guided waves propagation, in order to prepare for the generalized concept of power waves. The electromagnetic functioning of waveguides is studied, millimeter-wave integrated circuits in particular. Then it explains dispersion and parasitic modes.
- Classical closed guides. Rectangular and circular guides.
- Miniature and integrated guides (triplate, microstip, coplanar guides).
- Electromagnetic simulation 2.5 D and 3D (TD)
Key words : Guided propagation, transmission lines, wave guide

ESC_2 Electronics for High-Speed Communication (5 ECTS)

ESC_3950 High-Speed Electronics (Lectures: 10h / Tutorial classes: 10h / Lab: 16h)
This course studies different modules of electronic interfaces (SFI-4) for optical communications at 10 Gb/s (SONET OC 192, SDH STM-64). The course also focuses on analog / digital interfaces for high speed electronics and measuring techniques. There is also practical work on CAD workstations, allowing students to design typical circuits using Cadence software.

ESC_3920 RF Semiconductor Devices (Lectures: 12h / Tutorial classes: 4h / Lab: 16h)
This course gives a qualitative presentation on how the components work, in order to suggest models and characterization techniques, together with equivalent circuits, linear or not, and of noise, for microwave circuits design.
It is illustrated by a Lab class on machines aiming at determining the elements of the linear equivalent diagram of a FET transistor from the Sij parameters as well as applied training of characterization with the network analyzer and measurement of the noise parameters.- Schottky and Varicap diodes,- MESFET, MOSFET, HEMT, HBT transistors.
Key words : Components, semiconductors, modeling, characterization.

ESC_3 RF device design (4 ECTS)

ESC_3931 Non-linear RF Design (Lectures: 10h / Tutorial classes: 8h / Lab: 8h)
This course presents the basics of designing nonlinear RF devices ("harmonic balance method"). In particular, methods for designing power amplifiers, oscillators and microwave mixers will be studied.- Power amplification: classes of operation, advanced architectures: distributed, Doherty and envelope tracking amplifier.- Oscillators: Design methods, dielectric resonator oscillators, tunable oscillators.- Mixers- Non-linear stability analysis
Keywords: High efficiency power amplifier, microwave oscillators, mixers and nonlinear stability analysis

ESC_3930 Linear RF Design (Lectures: 10h / Tutorial classes: 6h / Lab: 8h)
This course presents the general methods for analyzing circuits (S parameters, multipoles). It also presents the main methods to design passive circuits (filters, couplers) and active circuits (amplifiers, oscillators).
There are some exercises using Computer-Aided Design (CAD). The tutorials use CAD to consider parameters and phenomena too complicated to handle without CAD.
- General analysis methods. S-parameters, fluence graphs, passive and active quadrupoles, multipoles, linear stability criteria, noise parameters.
- RF amplifiers. Narrow band amplification (+TP), broadband amplification, reactive matching, noise factor.

ESC_4 RF Project (5 ECTS)

ESC_3901 Circuit Project (Lectures: -h / Tutorial classes: 6h / Lab: 36h)
It is about designing a simple circuit of a communication system such as antennas and amplifiers for radio frequency applications. The study is preceded by a bibliographic research related to the subject. The circuit is then designed, made, and measured. A project defense presents the results.

ESC_5 Acquisition Systems (5 ECTS)

ESC_3900 System Project (Lectures: -h / Tutorial classes: -h / Lab: 40h)
This project develops the skills necessary to implement a system or part of an acquisition or instrumentation system as well as a wireless communication system. Students will use acquisition and transmission cards (use of programming software such as LabVIEW).

ESC_3902 CAD and Measuring Tools (Lectures: 4h / Tutorial classes: -h / Lab: 24h)
This module presents the tools necessary for the use of specific measuring equipment and software for simulation commonly used in this field.
- Line theory. Reduced impedance, Smith chart, impedance matching
- Microwave measurements. Network analysis, correction of errors, noise factor measurement
- Presentation of CAD software, methods of analysis and optimization

ESC_3970 Conferences (Lectures: 10h / Tutorial classes: -h / Lab: -h)
The lectures are delivered by professionals from the field. The subjects covered may vary from one year to the next. The following topics are only a sample of possible themes.
MMIC technology and applications. Evolutions and recent developments in the field of video. Radar. Wireless applications: GSM, DECT, Wifi, Bluetooth, RFID, Satellite telecommunications…

SH_3EME Humanities (5 ECTS)

DSH_3000 Responsible and sustainable management of human resources in a complex environment

(Lectures: 16h / Tutorial classes: 6h / Lab: -h)

The course presents the evolution of organizations in a complex environment (team management, corporate culture in a multicultural context, professional project through the dynamics and management of evolutions). It emphasizes the strategic role of human resources management in a CSR context (Quality of Life at Work - OHS) in order to prepare engineering students (guided by the 26000 standard) for their role as project managers, project leaders or employees of a project team.

It introduces the notions of labor law that are essential for engineers (employment contracts, expatriation, work environment in the company) by integrating the social and societal concerns of the company.

The practical courses allow, through an edutainment approach (or in the form of a serious game):

- to implement an HRM that values responsibility and ethics (Remuneration, Training, Skills management, Health and Safety at work).
- Identify good practices to implement a CSR policy.

DSH_3060 English (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The objective of the third-year courses is to make the students able to work in English and have a good command of the language.

The goal is achieving a professional use and to reach, at least, a B2 level requested do obtain the degree.

Two third-year options are grouped together for English courses. Level groups can be formed. The students will be able to work on different aspects of life professional (communication in different settings, in the office, abroad, in seminars, through writing, orally, case studies...), by carrying out work groups and putting in practice the knowledge they have acquired throughout their training.

DSH_3061 FLE (French for foreigners) (Lectures: -h / Tutorial classes: 24h / Lab: -h)

The main goal of this class is training the foreign students through communication fundamentals for everyday life, proposing them an introduction to French culture and civilization and more advanced knowledge in order to work in a French company during the final internship period.