UNICUSANO
ROME

**Italian code: ING-INF/03** **Credits: 9**
**Course: Fundamentals of Telecommunications**
**Main language of instruction:** Italian
**Other language of instruction:** English

**Head instructor**
**Professor Fabio Mangini - Fabio.mangini@unicusano.it**

## Objectives

The course is aimed at providing the student with technical skills in the field of communication systems. In particular, the student will acquire both the ability to size radio links from an energy point of view and knowledge of the main problems related to the transfer of information through electrical, electromagnetic or optical signals. The course consists of three parts. The first part consists of a high-level description of the world of telecommunications, focusing on the electronic devices that constitute a communication system, both radio frequency and optical. The second part introduces the student to both linear (amplitude) and non-linear (frequency and phase) analog modulations. Finally, the third part focuses on Information Theory and digital modulations, both in baseband and passband.

## Course structure

- *presentation of the main aspects related to a telecommunication system;*
- *qualitative and quantitative description of the noise present in the electronic devices of a telecommunication system;*
- *description of the equations for dimensioning a radio channel;*
- *introduction to the representation of signals in the passband and their demodulation;*
- *presentation of the main techniques of analog modulation both linear (i.e. of amplitude) and non-linear (i.e. of phase and frequency) and description of the reception schemes;*
- *introduction to the Theory of Information with particular emphasis on the concept of channel capacity, entropy, mutual information and decipherable codes;*
- *description of the main techniques of digital modulation both in baseband and in passband and of the decision rules for the reconstruction of the transmitted message.*

## Competencies

1. Knowledge and understanding.
   The students will acquire analytical capabilities concerning the information transmission methods in both analog and digital communications. Furthermore, the student will be able to master the analytical tools for the representation of signals in the passband and for their demodulation and decoding.
2. Applying knowledge and understanding.
   the student will be able to apply the acquired skills to the analysis of telecommunication systems. Specifically, he will be able to size radio communication channels from an energetic point of view, to build codes with an average length close to the source entropy, to evaluate the spectral characteristics of communication signals, to statistically characterize the receiver of a digital transmission system.
3. Making judgements.
   The student will be able to fully understand and motivate the observed processing in order to select the right actions leading to the expected objectives.
4. Communication skills.
   The student will acquire the technical-scientific language required to interact with other experts in the field of telecommunications systems.
5. Learning skills.
   The course will provide knowledge and methodological tools which might be exploited in subsequent education and professional paths concerning analysis of new issues related to telecommunications and, more generally electronic, engineering.

## Syllabus

*Programme of the course:*

**Subject 1. Introduction**
Transmission of information. Types of information. The communication channel. Historical notes. Communication schemes (analog transmission and digital transmission). Transmission lines. Radio links (Link Budget) and Radar equation. Noise. Noise figure. Amplifiers and attenuators. System cascade.

**Subject 2. Representation of Signals**

Bandpass signals. Analytical signal and complex envelope. The Hilbert transform. Hilbert filter. Bandpass magnitude and phase estimation. Bandpass systems. Bandpass random processes.

**Subject 3. Analog modulations**
Amplitude modulations: DSB-AM, DSB-SC-AM, SSB-AM, VSB-AM. Multiplexing. Angle modulations: FM, PM. Phase-locked demodulator (PLL). Superheterodyne receiver. Noise in modulations.

**Subject 4. Digital transmission**
Introduction to Information Theory. Coding. Discrete communication channel. Channel capacity. Continuous sources. Gaussian additive channel. Energy signal space. Decision rules: MAP and ML. Multivector channel and Irrelevance Theorem. Reversibility Theorem. Waveform channels. Matched filter.

**Subject 5. Baseband digital modulations**
Baseband Digital Modulations PAM, PPM, and Simplex Baseband: Error Probability and In-Band Efficiency Considerations. Band-Limited Low-Pass LTI Channel. Intersymbol Interference. Precoding.

**Subject 6. Digital modulations in passband**
ASK modulation (passband PAM): receiver, error probability and energy considerations. PSK modulation: receiver, error probability and energy considerations. QAM modulation: receiver, error probability and energy considerations. Synchronization and differential coding. Coherent and incoherent FSK modulation: receiver, error probability and energy considerations.

## Evaluation system and criteria

The examination consists in solving three problems with a maximum score of 10 for each of them. The maximum final score is 30.

## Bibliography and resources

1. *Materials to consult*

*S. Haykin e M. Moher, Introduction to Analog And Digital Communications,John Wiley & Sons Inc, 2006.*