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# Digital Communications A

## Finalità

The course aims to present error control and bandpass modulation techniques for digital transmission systems, as well as the relevant design elements.

## Programma

### **Error control coding techniques**

Schemes for error detection and correction - Schemes for automatic repeat request (ARQ). Schemes for forward error correction (FEC). Repetition codes. Parity check codes. Coding gain and cost. Bit interleaving. Code vectors and Hamming distance. Error control properties of a given code. Code rate and redundancy. Performance analysis of FEC systems. ARQ retransmission procedures. Performance analysis of ARQ systems. Outline of hybrid ARQ systems.

Block codes - Linear systematic block codes. Matrix representation of a linear block code. Hamming codes. Maximum likelihood syndrome decoding. Example decoding of a Hamming (7,4) code. Cyclic codes. Cyclic shifts and code polynomials. Generator polynomial of a cyclic code. Systematic codes. Coding and decoding as the remainder of polynomial divisions. Example of a Hamming (7,4) code. Circuit implementation of encoders and decoders for cyclic codes. Outline of BCH and CRC codes. Outline of M-ary and Reed-Solomon codes.

Convolutional codes - Tree, trellis and state diagrams of convolutional codes. Generator polynomials. Free distance. Transfer function and weight distribution of a convolutional code. Estimation of error probability. Coding gain. Decoding of convolutional codes. Viterbi decoding. Sequential decoding. Outline of majority logic decoding. Outline of punctured codes. Soft-decision decoding. Examples of convolutional codes and their performance.

Tecniche avanzate - Outline of concatenated and turbo codes.

### **Bandpass digital modulations**

Modulation schemes and their power spectral density - Amplitude shift keying (ASK) and its spectral efficiency. Quadrature amplitude modulation (QAM) and its spectral efficiency. PAM-VSB modulation. Phase modulation (PSK) and its spectral efficiency. Examples of PSK constellations (QPSK and 8-PSK). Offset quadrature phase shift keying (OQPSK). Frequency shift keying (FSK) and its spectral efficiency. Example of binary modulation. Orthogonal M-ary FSK. Continuous phase FSK (CPFSK).

Coherent detection of binary bandpass digital modulations - Coherent and noncoherent detection of digital modulations. Optimal receiver and error probability. Performance analysis of OOK and BPSK modulations. Performance analysis of binary FSK modulation. Outline of symbol and phase synchronization.

Noncoherent detection of binary bandpass digital modulations - Distribution of the envelope of a sinusoid in noise. Performance analysis of noncoherent OOK. Performance analysis of noncoherent FSK. Differential encoding and detection of PSK differenziale (DPSK). Comparison of the performance of binary transmission systems.

M-ary quadrature modulations - Performance analysis of QPSK. Outline of phase synchronization recovery by non linear devices. Performance analysis of M-PSK. Differential encoding and detection of M-ary PSK (M-DPSK). Performance analysis of M-QAM. Comparison of the performance of M-ary bandpass transmission systems: energy and spectral efficiency.

Trellis coded modulation (TCM) - Principles of TCM coded modulation.

## Attività d'esercitazione

Training is based on classroom solutions of periodical homework assignments.

## Modalità d'esame

For those who attend the course: overall evaluation based on written tests (midterm and final) and possible oral examination.

For anyone: evaluation based on written and oral examinations.

## Propedeuticità

"Comunicazioni elettriche A" is a suggested prerequisite.

## Testi consigliati

A. Bruce Carlson, Paul B. Crilly, and Janet C. Rutledge: Communication systems, 4th edition, McGraw Hill, 2002.