UNIVERSITÀ DI PISA

COMUNICAZIONI DIGITALI

MARCO LUISE

Anno accademico	2018/19
CdS	INGEGNERIA DELLE TELECOMUNICAZIONI
Codice	536II
CFU	12

Moduli	Settore/i	Tipo	Ore	Docente/i
COMUNICAZIONI DIGITALI	ING-INF/03	LEZIONI	120	MARCO LUISE LUCA SANGUINETTI

Obiettivi di apprendimento

Conoscenze
The course deals in general with the different techniques for the transmission of information in digital form. Starting form the basics of Information Theory about source and channel encoding, it gives a working knowledge of the main narrowband and wideband digital signalling techniques (including multicarrier and spread spectrum) as well as of channel coding. This is also complemented by notions about the main impairments deriving from signal transmission over the physical media (mainly the wireless radio channel), together with the main detection and signal processing techniques that are used to counteract such phenomena.

Modalità di verifica delle conoscenze
Written test and interview

Capacità
The student who successfully completes the course will have the ability to understand the main communication standards for the delivery of digital information in the Future Internet. It will master digital signalling and formatting for wireless and wired communications in 3G and 4G cellular networks and in ADSL, and will have a fundamental knowledge about the issues of digital encoding of information and exploitation of communication resources like energy and bandwidth. She/he will also acquire the capability to understanbd the building blocks of a modem for wired or wireless digital links. In some cases, the student will also be able to perform a simple/baisc system design of a moded.

Modalità di verifica delle capacità
As above

Prerequisiti (conoscenze iniziali)
Basic knowledge of signals, systems, and fundamental of communication technologies.

Programma (contenuti dell'insegnamento)
WIRELESS CHANNELS MODELING: Multipath Propagation. Frequency-flat and frequency-selective fading. Bit Error Rate and Outage Probability on the Rayleigh fading channel. Diversity techniques.
WIDEBAND MULTICARRIER SIGNALING: Multicarrier signaling on frequency-selective channels. Orthogonal Frequency Division Multiplexing (OFDM). Spectral density and optimum receiver for the OFDM signal. Digital implementation of an OFDM modem: virtual carriers, cyclic prefix, frequency-domain equalization, pilot-aided channel estimation.
SPREAD_SPECTRUM COMMUNICATIONS and CDMA: Direct-Sequence vs. Frequency-hop spread spectrum. Spreading factor. Maximal-Length spreading codes. Detection of DS/SS signals on the Gaussian channel. Narrowband and wideband jamming. Rake receiver for frequency-selective channels. Code-Division Multiplexing and Multiple Access (CDMA). Multiple Access Interference. Comparison with TDMA and FDMA. Brief review of UMTS.

INFORMATION THEORY AND CHANNEL CODING: Information Source classification and definition of Shannon entropy. Lossless compression of memoryless sources. Shannon-Fano and Huffman codes. Shannon theorem on lossless compression. Channel coding, parallel-concatenated turbo codes with iterative decoding. LDPC codes and message passing decoding. Noisy information-transfer channels. Mutual information, equivocation, irrelevance. Shannon capacity of the channel. BSC, BEC, AWGN channels and their capacity. Shannon's plane of efficiencies.
xDSL TECHNOLOGIES: Access network technologies for the last mile. ADLS duplexing and coexistence with PSTN. NEXT and FEXT.

Shannon capacity of the Gaussian colored channel. Water filling power/bit allocation.
MIMO COMMUNICATIONS: MIMO channel modeling, MIMO-OFDM. Diversity and multiplexing gain, spatial multiplexing, transmit diversity (Alamouti code). Genereal Space/Time codes. Shannon capacity of the MIMO channel, ergodic capacity.

Bibliografia e materiale didattico

J. Proakis: "Digital Communications", 5th Revised edition, McGraw-Hill, Jan 2008.
Notes and material prepared by the teacher at the course webite:

- Introduzione al corso
- Presentazione Assinform 2017
- J. Proakis: "Digital Communications", 5th Revised edition, McGraw-Hill, Gennaio 2008.
- C.E. Shannon, A Mathematical Theory of Communication, *Bell System Technical Journal*, vol. 27, pp. 379-423 and 623-656, July and October, 1948
- Codifica di Shannon-Fano ed estensione di una sorgente di informazione
- Prestazioni dei codici Turbo/LDPC e capacità di Shannon(slides)
- Introduzione all'OFDM (Prof. Luise, osservazioni e correzioni gradite !)
- Lo standard DVB in versione semplificata (Centro Ricerche RAI)
- Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television (ETSI European Standard)
- LDPC Coding for DVB-S2 (Hughes Original Paper)
- MIMO Communications: Modellistica elementare e capacità di Shannon (Prof. Luise)(slides, .pdf)
- l'ABC dei Segnali Spread Spectrum (in forma di Slides)
- Tecnologie DSL per l'ultimo miglio

Modalità d'esame

Mandatory written exam: 3 problems to be solved in 1.5 hours on the main topics of the course, mainly regarding numerical/practical applications of the different technologies. Minimum mark 16/30 to be admitted to the subsequent oral exam.
Mandatory oral exam (pending admission): 30 min. discussion about two main topics suggested by the examiner, and that the student must be capable to master in detail.

Pagina web del corso

http://www.iet.unipi.it/m.luise/#comdig

Altri riferimenti web

Teacher's Home Page: http://www.iet.unipi.it/m.luise/

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