

COURSE OUTLINE

Fundamentals of Digital Communications

- Requirements imposed on broadband wireless access systems
- Classical schemes for radio transmission: single carrier modulation / mapping schemes (BPSK, QPSK, QAM)
- Review of classical schemes for multiple access (TDMA, FDMA)
- Spread spectrum transmission and CDMA
- General model of a digital communications system; sources of degradation

Large-scale and Small-scale Propagation

- Multipath effect and its influence on communications over radio
- Time spread, Doppler spread and angular spread
- Time selectivity, frequency selectivity and spatial selectivity
- Pathloss and shadowing
- Rician and Rayleigh fading, K-factor

OFDM Fundamentals

- Serial vs. Parallel transmission, multicarrier transmission
- Determination of the key OFDM modem parameters
- Continuous and discrete model of OFDM system
- OFDM signal in the time and frequency domains
- OFDM subcarriers and subcarrier separation
- Cyclic Prefix (CP) role, linear and circular convolution, impact on equalization
- IDFT/DFT, IFFT/FFT
- Block structure of the OFDM transceiver
- Equivalent OFDM model of parallel AWGN channels
- High Peak-to-average Power Ratio (PAPR) problem and possible countermeasures
- Advantages and disadvantages of OFDM

OFDMA Fundamentals

- OFDMA as an extension of OFDM
- Exploitation of the multiuser diversity phenomenon
- Creation of the time-frequency resource grid; single time-frequency resource granularity
- Adaptive assignment of time-frequency resources
- Combination with Adaptive Modulation and Coding
- Water-filling concept
- Scheduling and QoS support; example scheduler resource allocation problems
- Scalable OFDMA
- SC-FDMA

- Advantages and disadvantages of OFDMA

Synchronization Problems in OFDMA

- Synchronization mismatches: carrier frequency, phase, symbol timing and sampling clock offsets
- Estimation of synchronization offsets
- Correction of synchronization offsets
- Synchronization methods working in time and frequency domain
- Pilot-based synchronization

OFDM/OFDMA Channel Estimation and Correction

- Pilot types (block, comb, mixed, grid), preambles
- Minimal requirements for pilot separation
- Architecture of OFDM channel estimator and corrector
- Zero-forcing and MMSE equalizer

Combination of MIMO with OFDM/OFDMA

- Introduction to multiple-antennas
- Transmit diversity, spatial multiplexing, single-user and multi-user MIMO, beamforming
- Open-loop and closed-loop MIMO
- Advantages of combining MIMO with OFDM/OFDMA
- 3-dimensional resource (time, frequency and space) allocation problem
- Pilots for MIMO/OFDM/OFDMA
- Combination of STBC and OFDM
- Combination of SFBC and OFDM
- Combination of Spatial Multiplexing and Beamforming with OFDM

OFDMA Under Co-channel Interference

- Overview of co-channel interference control methods
- Interference randomization, avoidance, cancellation and coordination
- Considerations of Single Frequency Network (SFN)
- Integer and fractional frequency reuse concepts
- Comparison of FDD and TDD co-channel interference scenarios

OFDM/OFDMA Applied in Standard Systems

- 3GPP LTE Rel. 8 and 9
- 3GPP LTE Rel. 10 and beyond (LTE Advanced)
- WiMAX (IEEE 802.16d and 802.16e)
- Other systems (WiFi, DAB, DVB)

Note: the course content is subject to minor changes and adaptations to the customer needs.