

OFDM for Wireless Communications

SYLLABUS

DSP Theory Review

- Sampling
- Anti-alias and reconstructions filters
- z-domain representation and transforms
- FIR and IIR Digital Filters
- Poles and zeroes and the Z-domain
- Linear/non-linear phase
- Minimum/non-minimum phase

Single Carrier Modulation Review

- Single Carrier: Transmit & Receive
- Quadrature amplitude modulation (QAM)
- Symbol Mapping: from QPSK to 256-QAM
- Pulse shaping techniques (RRC)
- Matched filtering techniques
- Channel noise and other imperfections
- QAM - Complex Arithmetic Representations
- Complex baseband multipath channels
- Time & frequency channel dispersion
- Inter-Symbol Interference (ISI)
- Orthogonal carrier principles

DSP OFDM Components

- The generic wireless communication system
- The Discrete Fourier Transform (DFT)
- The Fast Fourier Transform (FFT)
- The inverse FFT (IFFT)
- Windowing for FFTs
- Danielson-Lanczos lemma
- Cooley-Tuckey algorithm
- Other FFT algorithms

OFDM Principles

- Historical perspective: DMT
- Motivation for multi-carrier vs single-carrier
- Introduction to OFDM
- The structure of an OFDM signal
- Sub-carrier symbol structure
- Generation of OFDM symbols using the IFFT
- Cyclic prefix (guard interval)
- OFDM signal bandwidth

Practical Issues with OFDM

- Multipath interference on an OFDM symbol
- Protecting against multipath using cyclic prefix
- Reducing bandwidth (windowing vs filtering)
- Oversampling strategies
- The use of channel coding COFDM
- Generic OFDM transmitter structure

Power Considerations

- OFDM dynamic range considerations
- Peak-to-average power ratio (PAR)
- Crest factor measurements and limits
- RF Amplifier clipping considerations
- Intermodulation components
- General out of band power generation
- Minimising / reducing PAR
- SC-FDMA

Propagation Channels

- AWGN and Multipath Propagation Channels
- Delay Spread Values and Time Variations
- Loss of orthogonality in OFDM signals
- Fast and slow fading environments

Single Carrier Synchronisation and Receiver Design

- Optimal receiver structure
- Maximum Likelihood parameter estimation
- Phase and frequency recovery
- Symbol recovery
- Equalisation techniques
- Error Vector Magnitude (EVM) measurements

OFDM Receiver Design

- Inter-Carrier Interference (ICI)
- Carrier frequency offset
- Sensitivity to timing errors
- Symbol timing recovery
- Frequency domain equalisers (subcarrier)
- Effects of phase noise
- Synchronisation using training symbols
- Synchronisation using cyclic extension

Advanced and Emerging OFDM Architectures

- Beamforming strategies for OFDM
- Flash-OFDM
- MIMO techniques for OFDM
- Multicarrier CDMA (MC-CDMA)
- Frequency hopping OFDMA
- OFDMA vs MC-CDMA

OFDM based Standards

- 3GPP Long Term Evolution (LTE)
- LTE E-UTRA: DL OFDMA and UL SC-FDMA
- 802.11 - Physical Layer and MAC
- 802.16 - Physical Layer and MAC
- WiMax and 802.16e
- 802.20: Mobile Broadband Wireless Access (MBWA)
- 802.20: FDD and TDD Proposals