

# 3GPP LTE Physical Layer

## SYLLABUS

### Introduction to 3GPP Long Term Evolution

- Key LTE system parameters
- Harmonisation of LTE with WCDMA
- LTE Downlink : OFDMA
- LTE Uplink : SC-FDMA

### LTE Physical Layer Overview

- Physical channels
- LTE Generic Frame Structure
- Downlink and uplink slot formats
- Channel coding
- Modulation
- Resource elements & resource blocks
- Mapping of symbols to physical resources

### Spectral Efficiency in LTE

- Link Adaption techniques
- Adaptive Modulation and Coding
- Control channels and their system role
- Hybrid-ARQ implementation
- Multi-user scheduling
- Resource allocation algorithms
- Frequency Reuse planning
- Uplink Ranging
- FDD / TDD specifics

### OFDMA

- Review of Multiple Access (MA) techniques
- OFDMA basics
- Advantages over other MA techniques
- Examples of standards that use OFDMA: e.g. 802.16, 802.20
- Pitfalls of OFDMA

### SC-FDMA

- Motivation for the use of SC-FDMA
- Localised SC-FDMA
- Interleaved SC-FDMA
- Peak to Average Power Ratio of SC-FDMA
- SC-FDMA Equalisation

### MIMO

- Spectral efficiency and capacity
- Single user and multi-user MIMO
- Spatial Multiplexing
- Narrowband vs wideband MIMO
- Space-time diversity
- The Alamouti Scheme
- MIMO Receivers

### OFDM Communications Theory

- 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 Practical Considerations

- Multipath interference on an OFDM symbol
- Windowing to reduce out of band emissions
- Upconverting an OFDM signal
- Oversampling
- The use of channel coding COFDM
- OFDM dynamic range considerations
- Peak-to-average power ratio (PAR)
- Techniques for Reducing PAR

### OFDM Receiver Design

- Inter-Carrier Interference (ICI)
- Sensitivity to synchronisation errors
- Symbol timing recovery
- Carrier frequency recovery
- Frequency domain equalisation
- Use of training symbols and the cyclic prefix
- Frame Synchronisation

### WCDMA Review

- Direct Sequence Spread Spectrum Comms
- UMTS / WCDMA Overview
- Frequency Division Duplex (FDD) mode
- Time Division Duplex (TDD) mode
- Uplink and Downlink Physical Channels
- HSPA & Link Adaption

### Frequency Domain & The FFT

- Fourier Series Review
- The Discrete Fourier Transform (DFT)
- The Fast Fourier Transform (FFT)
- The Inverse FFT (IFFT)
- Spectral leakage
- Danielson-Lanczos lemma
- Cooley-Tuckey algorithm
- Other FFT algorithms

### Single Carrier Communications Review

- Digital amplitude and phase modulation
- Quadrature amplitude modulation (QAM)
- Pulse shaping
- Matched filtering techniques
- Complex signal representations
- Inter-Symbol Interference (ISI)
- Orthogonal carrier principles

### Propagation Channels

- Time & frequency channel dispersion
- AWGN and Multipath Propagation Channels
- Delay Spread Values and Time Variations
- Loss of orthogonality in OFDM signals
- Fast and slow fading environments
- Complex baseband multipath channels